Fisheries Technology Committee **ICES CM 2001/B:04**

Report of the

Joint Session of the Working Groups on Fisheries Acoustics Science and Technology and Fishing Technology and Fish Behaviour

Seattle, USA

25 April 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 TERMS OF REFERENCE

A Joint Session of the **Working Group on Fishing Technology and Fishing Behaviour** [WGFTFB] and the **Working Group on Fisheries Acoustics Science and Technology** [WGFAST](Chair: Yvan Simard, Canada, (WGFAST chair) and David Somerton, USA, (WGFTFB chair) met in Seattle, USA on 25 April 2001 to:

a) discuss the impact of fish behaviour on accuracy and precision of stock assessment surveys;

b) discuss the potential for acoustic techniques to provide information about fish behaviour in a wider sense which may be of use in management and assessment, as well as being of biological and ecological interest.

Other points:

- Use of acoustics for detecting aquatic vegetation.
- Organisation of WGFAST & WGFTFB web page and services
- Planning for 2003 meeting

2 MEETING AGENDA AND APPOINTMENT OF RAPPORTEUR

The chairs opened the meeting and Taina Honkalehto of the NOAA Alaska Fisheries Science Center, Seattle, was appointed as rapporteur.

The following agenda items were adopted:

a) Topic a "Impact of fish behaviour on accuracy and precision of stock assessment surveys"

b) Topic b "Potential for acoustic techniques to provide information about fish behaviour for management, and biological and ecological interest"

c) Use of acoustics for detecting aquatic vegetation

d) Organisation of WGFAST and WGFTFB web page and services

e) Planning for 2003 meeting

A list of participants appears as Appendix A.

3 INTRODUCTION: WGFAST AND WGFTFB HISTORIC REVIEWS

3.1 Ole-Arve Misund, Chair of the FisheriesTechnology Committee. Historic overview of ICES

O.-A. Misund provided a historical perspective of ICES which currently makes recommendations on more than 150 stocks of fish and shellfish. After outlining the ICES organizational structure and development, Misund listed several upcoming ICES events. They included the completion of the draft strategic workplan for ICES, two Fisheries Technology Committee-related Theme sessions at the Annual ICES Science Conference in Oslo in 2001, election of a new Fisheries Technology Committee Chair in 2001, an ICES sponsored Fisheries Acoustics Symposium in Montpellier, France, in June, 2002, and an ICES sponsored Fish Behaviour Symposium in Bergen, Norway, in June, 2003.

3.2 Paul Fernandes. Acoustic applications in fisheries science: the ICES contribution

Abstract:

Sound is the most effective medium with which to perceive the marine environment, as evidenced from the evolution of echolocation in cetaceans developed over millions of years. In the 100 years since its inception, ICES has presided over an analogous development in fisheries science: fisheries acoustics. Echosounders were invented in the 1920s and successful attempts to detect fish in the 1930s are recorded in ICES literature. With the proliferation of acoustic instrumentation in the post-war years, "echo surveys" were carried out to map various fisheries resources. The first

symposium on echo-sounding as an aid to fishing was organised by ICES in 1954 and the technique flourished in the 1960s. Progress was reported to ICES committees, and a training course was organised in 1969 in conjunction with FAO. An ICES International Symposium on "Hydro-Acoustics in Fisheries Research" took place in Bergen, Norway in 1973. This was one of four more successful symposia documenting a global view of fisheries acoustics through the proceedings published by ICES. It was largely as a result of the third conference that a specific group was set up to cater for the expanding contributions within the field. The ICES Working Group on Fisheries Acoustics Science and Technology (WG FAST) met for the first time in 1984 and has been active ever since, providing authoritative documentation on important topics in the field. This paper reviews the ICES contributions in the field and describes the general principles of a technique, which has evolved to provide a powerful means for investigating the abundance, distribution, behaviour, and ecology of fish, plankton, and other marine organisms.

Notes

This paper was presented at the ICES History Symposium in Finland, 2000. It will be published soon in the issue of the ICES J. Mar. Sci. related to the Symposium. Fernandes noted that the basic ingredients of active echo sounding systems have not changed in many years. He described development and history of fisheries acoustics through the decades from 1900 to the present. His future fisheries acoustics technology vision included a super lightweight AUV equipped with a 180^o multibeam SONAR with echo classification and bottom typing capability.

3.3 Stephen J. Walsh, Arill Engås, Richard Ferro, Ronald Fonteyne and Bob van Marlen. Improving fishing technology to catch (or conserve) more fish: the evolution of the ICES Fishing Technology and Fish Behaviour Working Group

Abstract

Even at the turn of this century, ICES was concerned about fishing technology especially the increasing use of trawls and the proportion of undersize fish in the catch. In 1904, the 2nd volume of the "Rapports et Procès Verbaux" includes an article titled 'Draft program for experiments with nets (trawls) by request of the Bureau'. At that time, in response to a memorandum on the subject from Sweden, ICES formed a sub-committee to investigate comparative fishing of several types of trawls. This sub-committee later evolved into the North Sea Sub-Committee on Comparative Fishing. In 1954, after an informal meeting at the Hague between scientists from The Netherlands, Lowestoft, Aberdeen and Hamburg a petition was drawn up to recommend to the Bureau the creation of a full committee to deal with investigations into fishing gears and fishing methodology. This committee was formed in 1955 and became known as the Comparative Fishing Committee.

During the 1950s and 1960s technological advances in underwater photography, acoustics and trawl-mounted instrumentation provided the first means to study fishing gear and the fish capture process in scientific detail. The consequent increase in studies of fishing gear and fish behaviour led in 1967 to the establishment of the Gear and Behaviour Committee. It wasn't till 1973 that long term specific Working Groups were established under the Gear and Behaviour Committee: 1) Working Group on Research and Engineering Aspects of Fishing Gear, Vessels and Equipment and 2) Working Group on Reaction of Fish to Fishing Operations. In 1983 these two groups were combined to form the present Working Group on Fishing Technology and Fish Behaviour (FTFB). The evolution of the activities of this Working Group throughout the history of ICES, whether carried out in earlier times by committees, subcommittees, study groups or short term working groups, closely parallels that of the fishing industry and has played an important role in contributing to the development and implementation of theoretical and applied fisheries science.

Notes

This paper was presented at the ICES History Symposium in Finland, 2000. It will be published soon in the issue of the ICES J. Mar. Sci. related to the Symposium. It chronologically lists the developments of fishing gear technology and the role of ICES from the 1940s to the present. An FTFB vision of the next decade beyond 2001 emphasised increasing the number of fishing gear impact studies to lessen impact on ecosystems. Examples include lighter "friendlier" gear, improved technical measures of conservation, improved knowledge of fish behaviour and improved enumeration studies, integration of commercial fisheries information and sampling studies into stock assessment, and development of closer relationships with other ICES committees and working groups.

4 TOPIC A "IMPACT OF FISH BEHAVIOUR ON ACCURACY AND PRECISION OF STOCK ASSESSMENT SURVEYS"

4.1 Dan Nichol. Diurnal vertical migration of Atka Mackerel, as shown by archival tags, and its effect on bottom trawl estimates of abundance.

Abstract

Atka mackerel display strong diel behaviour with vertical movements occurring almost exclusively during daylight hours and little to no movement at night. Vertical movements occurred at light levels greater than 7.31×10-5 µmoles photons m-2 s-1, or approximately between 9:00 AM and 12:00 midnight during August. Daytime movements were correlated with light intensity, time of day, and current velocity. The proportion of vertical movements tended to increase with increasing light, but decrease with increasing hour of the day. Current velocity appeared to be a limiting factor with decreased surface-directed excursions, and increased movements down a slope, during spring tide periods. Nine of 117 data storage tags, recording temperature and depth, were recovered from Atka mackerel tagged in Seguam Pass, Alaska during September 2000. Fish were tagged externally with each tag secured just below the dorsal fin. Eight fish were at liberty for 42-44 days and one for 65 days. Two of the males displayed nest guarding behaviour for the majority of their time at liberty. Depths for these individuals (115-117 m) were much deeper than previously thought for Atka mackerel spawning grounds. Given that fish are more likely to be on bottom during the night and less likely during the day, assessment surveys (i.e. bottom trawl) used to estimate abundance may benefit by accounting for these diel differences.

Notes

As Atka mackerel have no swim bladder, they are not particularly available to assess with acoustic surveys. Results of tagging showed the tagged fish making vertical excursions that were largely restricted to daytime. This implied a potential for abundance to be underestimated with daytime-only surveys. Survey catchability may increase if tows are made at night, although further investigation is necessary to ensure that night-time habitats are as trawlable as other locations. Archival tags proved a useful tool to study behaviour, and highlighted the need to evaluate survey design. In answer to questions: 1) some catchability studies have begun on these animals, 2) several fish that had exactly the same number of days at liberty were caught by the commercial fishery, and 3) two observations supporting the idea that males were nest guarding were that males were in spawning coloration, and the timing was appropriate.

4.2 E.Ona, I. Svellingen and J.E Fosseidengen. Target strength of herring during vertical excursions

Abstract

The pressure component of the freshly suggested new target strength equation for herring have been investigated experimentally using a large, 4500 m3 cage, within which the herring can swim freely while remotely monitored from a pressure stable 38 kHz split beam transducer. The cage, herring and transducer rig was carefully lowered from surface to 100 meters depth, with regular stops at discrete depths for prolonged target strength observations. The mean backscattering cross section with associated statistics was computed at each depth interval, as well other derivatives from target tracking as swimming speed and swimming angle. Regular monitoring of the herring tilt angle distribution with underwater video camera was also made. The measured backscattering cross section was fitted with non-linear regression to the pressure term equations, and showed a slightly larger pressure effect than earlier reported from ***in situ*** data, but still much lower than expected from bubble free- compression theory. The comparison of the equations are discussed.

Notes

Results showed a reduction of TS with depth for herring in a large, at-sea, experimental cage. Observed tilt angle was nearly the same for herring at the surface and at 100 m. A suggested correction for herring TS was proposed: $\langle TS\rangle = 20 \mathrm{Log}\, L - 66.3 - 3.5 \log(1+ Z/10)$. Discussion supported those herring buoyancy-reduction calculations. Swimbladder cross-sectional area measurements under pressure are planned for the future. Impact of these TS results on recent cruises depends on fish distribution by depth and affects fish closer to the surface. The need to also account for vessel avoidance, which would tend to have an opposite effect to that of correcting for these TS results, was mentioned. The potential effect of herring losing buoyancy and their subsequent behaviour, perhaps drifting downward while correcting position and swimming (tilting) upward, as it would affect tilt angle assumptions, was discussed.

4.3 Paul Walline, John Horne, Elliot Hazen. Characterizing variation in distributions of Bering Sea walleye pollock.

Abstract

Do movements by walleye pollock during acoustic surveys influence density and abundance estimates? We compared horizontal scale-dependent spatial variability (using centered spectral analysis) and changes in spectral density as a function of time among three sets (2 night, 1day) of 8 nautical mile transects made during the summer 2000 NMFS pollock acoustic survey. Pollock distribution on these replicated transects was compared to that on the five nearest regular daytime survey transects. Aggregations of pollock were identified using the SHAPES module in Echoview to characterize schools in replicated and regular survey transects. We will report spatial and temporal variance in pollock distributions and implications for pollock survey design.

Notes

Three sets of transects (2 night, 1 day) orthogonal to the main survey transects were each repeated 4 times. Comparison of results showed that within the four repeats of any one transect, although the number of schools changed, all school descriptors remained the same, i.e. the type of schools formed remained the same. Spectral density plots of transect repeats were similar to one another, although peaks at small scales did not line up. Examination of temporal changes showed no trend with time; there was no change in abundance over 4 hours, day or night. Preliminary conclusions for this eastern Bering Sea shelf data set were that zooplankton should be scrutinized at a resolution of at least 0.1 nm and fish at least 1.0 nm. Sampling design can be the same day or night. At least four hours are available to break transects for trawling. Transect direction was not important.

5 TOPIC B "POTENTIAL FOR ACOUSTIC TECHNIQUES TO PROVIDE INFORMATION ABOUT FISH BEHAVIOUR FOR MANAGEMENT, AND BIOLOGICAL AND ECOLOGICAL INTEREST"

5.1 John Horne. Using backscatter models and visualization to examine fish behaviour

Abstract

Variability in acoustic measures is largely due to the choice of carrier frequency and organism behaviour. Animal orientation (i.e. tilt, roll, direction), shoaling, and schooling are three behaviours that influence amplitude of echoes received from individual or aggregations of aquatic organisms. Kirchhoff-ray mode (KRM) backscatter models of individual fish were combined with tilt and roll tank observation data to predict and visualize backscatter from individual and groups of walleye pollock (*Theragra chalcogramma*). Model predictions were compared to *in situ* target strength measurements at 38 kHz in the Bering Sea. Visualization of backscatter model results provides an alternate way to interpret echoes logged in acoustic data files. Incorporating individual and group behaviours in model calculations and visualizations dynamically illustrates fish kinematics and the resulting acoustic backscatter. Addition of orientation and interaction rules as attributes of objects within animations leads to the development of virtual acoustic ecosystems.

Notes

Discussion included questions about net selectivity when ground truthing targets—are we losing smaller fish? Should this be treated by thresholding with the transducer, or by weighting the population for predicted TS? The backscatter modeling methods presented here do not yet capture frequency-dependent directional backscatter from individual fish. Backscatter from the body may produce smaller modes at low TS (compared to predicted TS) observed on plots of in situ TS data. Perhaps there are phase differences within the body of a fish—the authors have not tried to model this yet. Observations of true tilt angle of fish in survey conditions are difficult to obtain. Thus far tilt angle observations come from experiments (cage, tethered, tanks) and tags. Trace tracking may help but has some problems. Perhaps use tilt sensors in archival tags.

5.2 Emma Jones, Phil Copland and Dave Reid. Combined acoustic and video observations of fish behaviour in a survey trawl.

Abstract

Trawl surveys provide indices of fish abundance, which track, on a relative scale, changes in annual abundance. The purpose of this project is to quantify survey gear performance so that greater use can be made of these data. Therefore, as a first step we are testing a variety of new techniques for evaluating whole gear selectivity. The results of a short development cruise on board FRV Scotia are presented. The potential of a high resolution, multibeam sonar, the Reson Seabat 6012 on a towed vehicle for observing fish behaviour in conjunction with information collected using conventional low-light cameras.

Notes

Long term goals were to determine trawl efficiency by size and age of fish. Short term goals were to try out new techniques of observation using the multibeam sonar. Conclusions were that for now Seabat is a good behavioural tool, it has potential use for biomass estimation, and its narrow beam provides precise range estimation.

6 CONCLUSIONS ON TOPICS

Recommendations:

Discussion of topics a, "Impact of fish behaviour on accuracy and precision of stock assessment surveys", and b, "Potential for acoustic techniques to provide information about fish behaviour for management, and biological and ecological interest", included some of the following:

The discussion of acoustics, fish behaviour, and stock assessment surveys began with questions and comments on a paper which showed that herring TS decreased significantly with depth. It was noted that the herring data discussed here were collected on 30 caged fish in an undisturbed setting, and thus do not account for potential effects of vessel avoidance. It was further noted that these results would only affect surveys estimating population indices if herring aggregations changed significantly in depth from year to year. In one case, the application of a depth-dependent TS to a survey resulted in only a 5% difference in the index. However, it was noted that Atka mackerel make multiple vertical excursions within one day; therefore significant day/night effects would be expected. Herring can also be very dynamic, with large behavioural (i.e., distributional) changes from year to year. Will the new proposed equation improve the situation? Numerous models of TS exist, and numerous variables potentially affect it (i.e. gonad development, fat content). Some of these are currently incorporated into survey techniques, and some are not. Perhaps we would benefit by observing the residuals from expected results, and tracking how they vary under different survey and/or experimental settings.

7 USE OF ACOUSTICS FOR DETECTING AQUATIC VEGETATION

7.1 Janus Burczynski, J. Hoffman, P.Schneider and B. Sabol. Sonar system for assessment of submerged aquatic vegetation and bottom substrata classification

Abstract

Underwater acoustics can be used for monitoring and mapping of ecosystem. Information on bottom substrata and also on submerged aquatic vegetation is encoded in echo signal. This information can be decoded from survey data as well as information on fish and plankton distribution and size. BioSonics has developed two sets of algorithms and data analysis software packages for this purpose: (a) SAVEWS (Submerged Aquatic Vegetation Early Warning System was developed under joint research program with USACE and (b) VBT (Seabed Classifier). In both programs we started with theoretical studies on appropriate method of echo signal processing. The second step was testing of various processing algorithms by acquiring ground truth (verified) data on submerged plants and bottom categories using digital echosounders DT series. After testing of processing algorithms we developed user-friendly software packages. Survey data can be acquired in geographical context and survey maps can be generated. Echo signal processing algorithms are described. Detection performance of the system and few case studies in marine environment and also in freshwater are discussed.

Notes

This ecosystem monitoring study used a single platform combining two single beam transducer frequencies, GPS, an echosounder for characterisation of fish abundance and distribution, and algorithms and analysis software packages for vegetation height determination and bottom typing from the acoustic data. Case studies were on Lake Washington and in the Hood Canal, Puget Sound, Washington State. Results were supported by extensive ground-truthing. Acoustic techniques were used to characterise seagrass beds. The sea bottom signal was effectively separated from vegetation and the percent cover and height of plant material were characterised in transect sections. Monitoring with GIS to integrate multiple data types was both fast and cost effective. Biomass estimation and the use of different frequencies are under development. In response to a discussion question the author commented that sea grasses with air bladders (e.g., *Elodea*) had been sampled in the past, but more difficulty had ensued with dense mats of milfoil near the water surface.

7.2 Patrick Schneider and Janusz Burczynski. Results from submerged aquatic plant assessment using digital echosounder technique

Abstract

The coverage with two species of Zostera, *Z. marina* (L.) and *Z. noltii* (Hornem.) in the river Asón estuary near Santoña, Cantabria/Spain has been assessed between August and October 2000, using a BioSonics DT 6000 208kHz split beam digital echosounder in combination with a DGPS receiver and a reference station. A surface of roughly 4sqkm has been covered with transects spaced 20m on average, resulting in a total track length of about 250km, taking some 800,000 samples (pings). A pre-release version of a specific software, based on SAVEWS (Submersed Aquatic Vegetation Early Warning System), developed by Bruce Sabol, USACE Waterways Experiment Station, Vicksburg, and currently under further development through BioSonics, Inc., Seattle, was deployed in order to process the split beam raw data (only single beam data is read by the program). Previous to the survey, a number of fixed position observations over a frame (50x50cm) were done in order to dispose of data for calibration purposes. Afterwards the frame area has been fully sampled physically. Data on existence of plants as detected by the program was verified comparing the findings with the echograms. The percentage of plant detection over a cycle of 8 pings as a measure for the density or coverage of detected plants and plant mean height are also available from the program output. These parameters have been interpolated and subsequently presented on maps. Additionally, ground truth data from 100 physical field samples is available to verify findings. The desire to distinguish the two species present in the area, *Zostera marina* and *Zostera noltii*, was not yet achieved based on the obtained data. Due to the specific configuration of the equipment during data acquisition, TS analysis with common tools are not easily done. An empirical approach to separate species based on a combination of height and depth has not yet concluded. Finally, a series of problems, as for example the inclination of plants due to currents, are discussed.

Notes

Results from this first of its kind project in Europe were detailed maps of seagrass beds that were quick and easy to obtain. Detection of plants was good and reliable, and maps were accurate once the correct post-processing software was applied. Physical samples compared well in heights and depths. Classification into two *Zostera* species was not yet achieved, although some aerial delineation was possible using average heights. Deep water sometimes posed a problem for this technique, and currents were a problem in height determination. Seagrass biomass estimation would be possible, although this technique is not a complete substitute for aerial photography. Entrapped O_2 in aquatic vegetation could potentially pose a problem or bias.

8 ORGANISATION OF WGFAST & WGFTFB WEBPAGE AND SERVICES

Peter Munro presented an overview of the current Website status, asked questions about Website organisation based on practical matters that arose during its development and use prior to this week's WG meetings in Seattle, and made suggestions for further discussion.

Recommendation:

Participants in the Joint Session recommend establishing a topic group with a member from WGFTFB and WGFAST, and the FTC secretary, to develop an active Web page that functions within the formal rules of ICES.

Justification:

WGFTFB and WGFAST have developed a Web page that is becoming an increasingly effective and active tool in communicating relevant matters and organising the WG meetings. It is important that further development and operation of the Web page are realised within the formal rules of ICES.

9 PLANNING FOR 2003 MEETING

The hosting committee for the Fish Behaviour Symposium to be held 23-26 June, 2003 in Bergen, Norway, extended an invitation to host the 2003 FTFB and FAST meetings in conjunction with the symposium. FTFB agreed; FAST will discuss their 2003 meeting further and decide whether to meet there as well, or to meet separately at another time.

10 ADDITIONAL CONTRIBUTION

10.1 Hans Petter Knudsen. New G. O. Sars.

A new Norwegian research vessel was described that was designed to meet ICES recommendations for both maximum ship noise and trawling specifications. It uses drop keel design for sonar and echosounding equipment and has diesel/electric propulsion. A suggestion was made to intercalibrate the new vessel with other Norwegian vessels in the future. For more information contact H. P. Knudsen at email address hansk@imr.no.

11 CLOSURE OF WGFAST AND WGFTFB JOINT SESSION

There will be no WGFAST and WGFTFB Joint Session in 2002 because of the June 2002 ICES Acoustics Symposium in Montpellier, France.

The chairs closed the meeting.

APPENDIX A: LIST OF PARTICIPANTS TO THE 2001 WGFAST & WGFTFB JOINT SESSION.

The following addresses have been checked by the participants and should be up to date, for April 2001

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