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Fish Capture Committee

Report of the Working Group on Fisheries Acoustics Science and Technology

Rostock, German Democratic Republic, 26-27 April, 1990

ICES FAST Working Group Meeting 26-27 April 1990

Rostock, German Democratic Republic

Agenda

Thursday 26 April 1990

0900

1. Opening of the meeting.

2. Welcome by Dr. W. Thiele.

3. Order of the day and appointment of rapporteur.

4. Presentation of Papers.

4.1 Methods

i. Gerlotto, F., C. H. Corujo, and R. Claro

A methodology for acoustic assessment in very shallow waters (less than 8 m).

ii. Bodholt, H.

In situ measurements of small objects.

iii. Degnbol, P., T. F. Jensen, B. Lundgren, and M. Vinther

ECHOANN: an analyzer for echo sounder signals.

iv. Storbeck, F.

Acoustic gain due to schooling behaviour of marine organisms.

v. Ona, E.

Optimal acoustic beam pattern corrections for split beam transducers.

vi. Simmonds, E. J.

Sea bed following: efficient data collection for echo-integration.

4.2 Behaviour Studies

i. Gerlotto, F., D. Petit, and P. Freon

Influence of the light of a survey vessel on TS distribution.

Lunch 1300-1430

1430-1530

4.3 Survey Design

i. Simard, Y. and F. Gerlotto

Exploration of applicability of geostatistics to fisheries acoustics.

4.4 Vessel Design

i. Ona, E. and J. J. Traynor

Hull mounted, protruding transducer for improving bad weather echo integration.

4.5 Surveys

i. Crawford, R.

Observations of shrimp distribution in eastern Hudson Strait, Canada.

ii. Mitson, R.

Plankton sampling using multiple frequencies.

Coffee Break 1530-1630

1630-1800

5. Discussion

5.1 Design of acoustic surveys, methods of data analysis, and the precision of survey results with a view to preparing a document on recommended survey procedures.

5.2 The communication within ICES of problems and advice on topics within the fish capture field and the need for closer links between the several Committees concerned with the exploitation and management of fish and shellfish stocks and report its findings to the relevant Committees.

Friday 27 April 1990

0900-1015

6. Consideration of National Progress Reports.

Coffee Break 1015-1100

1100-1200

7. Recommendations.

8. Meeting Closure.

Report of the ICES Fisheries Acoustic Science and Technology (FAST) Working Group Meeting 26-27 April 1990, Rostock, German Democratic Republic

1. Participants

A list is attached as Appendix A.

2. Terms of Reference

In accordance with C. Res. 1988/2:6 the Working Group on Fisheries Acoustic Science and Technology (Chairman: Dr. J. Traynor) met in Rostock from 25-27 April 1990 to:

a) review and report on acoustic methods applied to research on the distribution and dynamics of plankton;

b) consider the design of acoustic surveys, methods of data analysis, and the precision of survey results, with a view to preparing a report on recommended survey procedures;

c) consider the communication within ICES of problems and advice on topics within the fish capture field, and the need for closer links between the several Committees concerned with the exploitation and management of fish and shellfish stocks, and report its findings to the relevant Committees.

3. Opening of the Meeting

Dr. W. Thiele welcomed the participants.

4. Order of the Day and appointment of rapporteur.

The agenda was adopted with the addition of papers 4.1 vi and 4.5 ii. One paper was withdrawn from the agenda. B. Nakashima, Department of Fisheries and Oceans, St. John's, Newfoundland, Canada was appointed as rapporteur.

5. Presentation

5.1 Methods

i. Gerlotto, F., C. H. Corujo, and R. Claro.

A methodology for acoustic assessment in very shallow waters (less than 8 m).

A methodology for acoustic assessment and data analysis was

proposed for tropical island lagoons having very flat, shallow bottoms (3 to 8 m) and low swell conditions. Methods to measure the sampling angle and deconvolution of in situ TS were adapted from the literature for this particular situation. Application of the methodology in the Gulf of Batabano (SW of Cuba) showed that the best estimates of biomass were obtained by counting fish and that the precision of the results depended directly on external conditions, i.e. surveys conducted at night, no swell, and no moon light. Biomass estimates for the areas surveyed in the Gulf of Batabano varied from 553 to 1991 kg/km^2, however these may have been underestimates due to vessel avoidance behaviour by the fish. The next survey will be conducted during a new moon period and with calm weather to reduce the effects of avoidance. A request was made to recommend more studies on the application of acoustic methods in shallow water conditions.

Some of the problems with working in shallow waters were raised in the discussion following the presentation. In this study surface reflection was considered more important than multiple bottom echoes. The extent of vessel avoidance was difficult to determine but clearly this was an important consideration. Having the transducer mounted on the bow of the vessel may have helped. Concern was raised that in some cases fish may be longer than the beam width which may affect echo counting.

ii. Bodholt, H.

In situ measurements of small objects.

An echogram record from a Simrad EK 500 operated at Breiangen in the Oslo Fjord was presented and described in detail. The echo trace covered the first 100 m at a location where the bottom depth was 200 m. Most of the TS values from 5 to 50 m were between -65 and -70 dB. Between 50 and 80 m a high concentration of biomass was observed and single target echo traces could not be resolved. From 80 to 100 m four single fish echoes between -47 and -44 dB were observed. A high power output of 1000 W at 120 kHz frequency and a narrow beam width made it possible to observe small objects at these depths. No trawl surveys were conducted during this survey to identify the targets, however the patterns observed during the survey are common in the area.

iii. Degnbol, P., T. F. Jensen, B. Lundgren, and M. Vinther.

ECHOANN: an analyzer for echo sounder signals.

A thorough description of the hardware and software of ECHOANN was presented. ECHOANN is an instrument designed by the authors to collect, analyze, and store data from hydroacoustic instruments and navigational information. ECHOANN can be operated on several levels of complexity; integrating information from several data sources or as a portable system collecting information from a single echo sounder. Analysis and storage includes a combination of counting and integration. Schools are counted and integrated separately. Integration results are stored as distributions over signal level. Single fish echoes are stored with TS estimates when split beam information is available. The instrument is PC-based but includes hardware for signal preprocessing and parallel processing. Software is open to user modifications as it is written in high level languages and is modular. Data are stored in ASCII files. The instrument has been field tested and will be used during routine surveys this summer.

In the ensuing discussion questions focused on the how the data were collected and analyzed by ECHOANN. During data collection, integration and counting were performed together in parallel such that single target data were removed and stored separately from the integrated data. When biomass was calculated single target data were added to the integrated data to estimate total biomass. There is an advantage to using integration data to enhance knowledge of single targets, however some doubt was expressed as to the value of initially removing single targets from the integrated data. The authors were asked to consider the volume window problem due to the distribution of target signals on the edges of the TS distribution in the beam width. Because the proportion of counting and integration may vary from year to year, the results may be affected. ECHOANN can be used to identify fish schools but to date it can not identify fish species. Most of the work has been directed towards clupeids in the North Sea. Because of the number of systems in use or being developed and the variety of software available, a suggestion was made for the openness of systems to encourage and allow further development in the field.

iv. Storbeck, F.

Acoustic gain due to schooling behaviour of marine organisms.

During an echo integration survey the reflected acoustic signal from marine organisms not only reaches the transducer directly but is also reflected from neighbouring organisms, especially in schooling situations. Energy reflected from other members of the school was termed the schooling factor. Through computer simulations it was observed that the signal increased as the inter-fish distance within a school declined. In this analysis the size of the school was assumed to be small compared to the distance to the transducer.

Concern was expressed that these simulation studies had only considered the effect of reflectance from nearest neighbours and ignored the known effects of signal absorption within schools. It may be possible to observe multiple scattering from individual targets with the EK500. Evidence from studies in the Barents Sea indicated that fish were scattered and hard to see in the morning. In the afternoon backscattering increased, possibly due to the swimbladder filling up during the day. It was suggested that observed changes in schools were not due to reflectance but as a result of changing TS. The effects shown in the model were observed at high densities which were unusual for resting schools of clupeids. This interpretation was dependent on the size of the fish because small fish have closer inter-fish distances than large fish in a school. Both absorption and multiple scattering can lead to underestimation of school biomass. Previous studies have indicated that absorption is very important but the effects of multiple scattering should not be ignored. The EK 500 has no algorithm to correct for this problem but its dynamic range can be used to study the problem. To do this work it was suggested that there should be an effort to openly exchange software among investigators.

v. Ona, E.

Optimal acoustic beam pattern corrections for split beam transducers.

Precise target strength estimates of fish can only be made when the effect of the transducer directivity is totally removed from the recorded target amplitudes. By guiding a standard calibration target through the acoustic beam while simultaneously recording the amplitudes and angular positions of the target, a precise reconstruction of the product of transducer transmit and receiving directivity

can be made. From several thousand measurements taken in a section through the acoustic beam, the recorded data have been fitted to a generalized three dimensional model by the use of nonlinear estimation. The suggested model functions yielded very low residual beam correction error with 95% of the data within about 0.5 dB. The precision and repeatability of the method was demonstrated with seven data sets from four split beam transducers mounted on four different research vessels. These were three ES 400 transducers and one EK 500 transducer working at 38 kHz. The indicated function stabilized the shape of the beam better than earlier suggested functions and reduced the need for elaborate mapping of the beam.

vi. Simmonds, E. J.

Sea bed following: efficient data collection for echo-integration.

Algorithms developed to consider sea bed following or bottom detection for echo integration and data recording were presented. In echo integration the ideal situation is to record all fish and exclude all bottom signals. In data recording the algorithm should detect the bottom even when dense fish schools are on the bottom. Detection of the sea bed is dependent on the range gate chosen by the researcher. For sea bed and weather conditions around Scotland, a range gate of 2 to 5 m has been used. Examples showing how the data recording and echo integration algorithms would function when the sea bed was falling or rising at elevations of 6 m were discussed. Both algorithms are self-locking, ie they do not require operator intervention. The primary requirement for sea bed following algorithms is to be able to respond quickly to dramatic changes in the bottom. One problem with the data recording algorithm occurred when dense fish shoals were encountered on a steeply falling slope.

Data collected by both algorithms were collected at either 38 or 120 kHz by recording on alternate pings. In seismic studies in shallow water the bottom data are stored at a different frequency.

5.2 Behaviour Studies

i. Gerlotto, F., D. Petit, and P. Freon.

Influence of the light of a survey vessel on TS distribution.

In situ experiments at night with a dual beam echo sounder were conducted to evaluate the influence of vessel lights on the inclination and avoidance of fish. Fish densities were twice as high when the lights were off than when they were on. There was no significant difference in mean TS when the lights were on or off, however the number of targets was much higher when the lights were shut off. Fish in the upper layers avoided the vessel by laterally swimming away rather than diving vertically as had been observed in previous experiments. The extent of the avoidance reaction was related to the length and species of fish. Large fish avoided the vessel, whereas small fish tended to remain in a horizontal position as the survey vessel passed above them. The fact that all fish remained in a horizontal position meant that tilt angles were not a factor in estimating biomass.

The results from these experiments may provide supporting evidence for the acoustic gain model presented earlier. When the light is on fish are close together but when the light is off individuals are further apart. Ambient light levels and water transparencies were not measured. Several suggestions were made to use underwater photography and stationary transducers to study fish behaviour near the survey vessel. Some preliminary stationary studies in the area at night indicated that fish escaping ahead of the vessel were undetected, however those lateral to the vessel had already been insonified.

5.3 Survey Design

i. Simard, Y. and F. Gerlotto.

Exploration of applicability of geostatistics to fisheries acoustics.

The applicability of geostatistics to analyze fisheries acoustics echo integration data was explored with two typical data sets from coastal waters off northern Norway and Venezuela. Departures from stationarity conditions and temporal variations of the spatial structures were discussed with special attention to the effects of 1) using

raw or log transformed data, 2) excluding or including zero values, 3) day and night differences in spatial structure, 4) revisiting some sampled areas, and 5) different communities of fish. All these factors strongly affected the shape of the computed variogram and consequently the biomass estimations also. Care should be taken when using geostatistics to analyze spatial structures and to map or compute biomass estimates. Areas requiring further study were indicated. Discussion of the paper was deferred to the discussion on acoustic survey design.

5.4 Vessel Design

i. Ona, E. and J. J. Traynor.

Hull mounted, protruding transducer for improving bad weather echo integration.

A 38 kHz split beam survey transducer was mounted on the tip of a 4 m vertical protrusile stabilizing keel on the United States NOAA research vessel R/V MILLER FREEMAN. Air blocking problems generally observable on all hull mounted transducers were reduced to a minimum and excellent acoustic conditions were achieved with the new mounting up to wind speeds of 35 knots (19 m/s). Improvements were demonstrated through comparative sequential echo integration of the air close to the transducer with the keel alternating between the retracted and extended positions and through echo recordings on fish. The effects of air bubbles blocking fish echoes were especially apparent 2 to 3 m from the transducer and less so at deeper depths. Reasonable functions for residual air bubble corrections of echo integration data would presumably work well up to wind speeds where target identification by trawling would be problematic because of safety.

For some vessels air blocking problems disappear at distances less than 1.5 m from the transducer. The effective distance will vary according to vessel design. The position of the centreboard may also be a factor. The effect of rolling on the beam width of the transducer should be diminished because the centreboard should aid in stabilizing the vessel. Several examples were given to indicate that air bubble problems can occur at much deeper depths than 4 m. Considerable naval data has been collected on the depth of surface bubbles and their effect on acoustic signals at various frequencies.

5.5 Surveys

i. Crawford, R.

Observations of shrimp distribution in eastern Hudson Strait, Canada.

Acoustics was used in conjunction with a BIONESS plankton sampler and a Sputnick shrimp trawl to examine the horizontal and vertical distribution of shrimp (Pandalus montagui) biomass in eastern Hudson Strait. During part of the study echo integration and the BIONESS were used

simultaneously at two-hour intervals to determine biomass distribution in the water column. BIONESS samples were collected to ground-truth the acoustics and to examine composition of the zooplankton community. Another aspect of the study was to derive independent estimates of shrimp biomass using echo integration and a commercial shrimp trawl. Estimates were compared from the perspective of the amounts of biomass below and above the height of the headrope of the trawl. Results demonstrated a strong diel component in the vertical distribution of shrimp. At night shrimp vertically migrated more than 200 m off the bottom as observed acoustically. The contagious distribution of shrimp was reflected in the variation in catches by the BIONESS. During daylight shrimp biomass was sometimes concentrated near the bottom where it was effectively sampled by the trawl, but at other times biomass was observed well above the bottom, especially at night. During these times trawl samples underestimated the biomass.

While other species may contribute to the backscattering the trawl catches consisted of 97% shrimp. Because large abundances of shrimp were observed on the bottom, the acoustic estimates may be suspect. The bottom window varied from 1.5 to 3.0 m off the bottom which may have resulted in biomass underestimation. One of the conclusions reached was that a combination trawl and acoustic survey would provide the best assessment advice because the trawl would survey the bottom and the acoustics would survey above the headrope of the trawl.

ii. Mitson, R.

Plankton sampling using multiple frequencies.

The results of a study by Dr. Holiday in conjunction with the Lowestoft laboratory using the Multiple Frequency Acoustic Sampling Profiler were reported. The intent of the study was to examine plankton distribution and size classes with depth. A vessel was held on station and the sampler was lowered over the side every two hours. Data were collected at 21 frequencies. Preliminary data were presented on size class distribution with depth and time of day. Biological data to verify the acoustic results had not yet been analyzed.

6. Discussion

6.1 Survey Procedures

A summary of the meeting in Brest, France of the Study Group on the Applicability of Spatial Statistical Techniques to Acoustic Data was presented by E. J. Simmonds. An official report of the meeting will be given at the ICES Annual Statutory Meeting in October 1990. Participants discussed their computation of acoustic data sets which were provided by K. Foote. The three general methods which the Study Group focused on were kriging and spline techniques, a response surface method which uses polynomial fits to the data, and area averaging techniques which includes transforms. Two types of kriging, a linear interpolation technique, were examined. One was simple kriging which uses fixed means and variances, the other was intrinsic kriging which uses variable means and fixed variances. Both types assume stationary data points. Response surface polynomials were used to incorporate other data sets such as temperature and depth to account for the large density differences encountered during acoustic surveys. Area averaging incorporates many common and simple methods currently in use, however these methods result in the loss of important spatial information. Problems were identified both with the methods themselves and with the acoustic data sets. Most of the methods had difficulty in handling non-stationary data. Temporal changes such as schools moving between transect coverages and day and night effects were also important considerations. Five recommendations arose from the deliberations of the Study Group which were 1) to extend surveys to areas of low or zero concentrations or otherwise bound the distribution, 2) in narrow strata transects should be run across as well as parallel to the largest dimension, 3) if a fish population is dominated by a small number of large schools, the survey should be designed to locate these schools and then to intensively estimate their biomasses, 4) if the mean or variance is related to external factors such as water temperature, depth, species composition, fish size these should be documented for consideration in later analysis, and 5) to hold a workshop in Aberdeen in 1991.

Discussion following the oral summary was primarily to clarify the kriging method and its application to acoustic data. Kriging was originally designed for geological applications. Its use in analyzing acoustic data was to make use of the spatial data. Problems related to surveys with a few instances of high numbers and determining whether zeros represent no fish or inability to detect fish need to be addressed. Aside from the statistical problems, it is important that biologists use the acoustic data to observe fish communities. One way to examine areas of high density would be to resurvey the area. While it is important to have estimates of mean densities and their variances the application of acoustic data to examine distributions and community structures cannot be overlooked.

Whether a single analytical method was capable of providing both was not considered by the Study Group. A suggestion was put forth to consult with users on appropriate spatial and temporal scales to focus the Study Group. However, the Study Group was more involved in understanding the methods as opposed to learning structure.

Discussion then focused on the data collected from the acoustic survey questionnaire by E. J. Simmonds. The previous study should be updated. A recommendation was made to form a study group of 3 to 5 individuals which would complete this report. The report would try to address problems that everyone agreed with rather than trying to examine all aspects of survey design and analysis. A recommendation for a study group chaired by E. J. Simmonds was put forth as described in the Recommendations section.

6.2 Communication of Advice within ICES

Concern was expressed that closer links should be established between special committees and those standing committees which are involved with exploitation and stock assessments. At a previous meeting of ICES some members of the executive questioned whether the Fish Capture Committee was handling specific ICES questions or was the Committee acting as the sponsor of mini-symposia. Generally the role of special committees such as the Fish Capture Committee is to address specific problems via a small group which reports to a working group such as FAST, which in turn makes recommendations to ICES. The Working Group did not feel that the concern of ICES applied to the FAST Working Group. For example at this meeting eleven (11) papers were presented and the remainder of the time was spent discussing issues related to survey design. The recent history of FAST meetings has been to encourage papers in an area of interest to members and to encourage presentations in any aspect of acoustic research. Some members did acknowledge that timeliness in reporting results by special groups was a problem. It was suggested that the study group on survey design and analytical procedures meet prior to the next FAST Working Group meeting to enable it to address specific questions to the Working Group. To facilitate discussion a study group could meet during the FAST meeting and present its report during the meeting. However it was pointed out that there is a difference between the operation of committees dealing with assessments and this Working Group. The FAST Working Group is dealing with methodology, not numbers and as such cannot be expected to provide advice in one meeting. One proposal was to form study groups to discuss specific topics and these would work by correspondence and present the available information at the next

meeting. Coming full circle it was proposed that rather than forming so many study groups it would be better to have very formal symposia with specific topics.

7. National Progress Reports

7.1 Cuba

In Cuba, the real importance of marine research began in 1959. For the development in this field the following research centers were created:

The Marine Research Center, Havana University
The Fisheries Research Center, Ministry of Fisheries Industry
The Institute of Oceanology of the Academy of Science of Cuba

In Cuba, the first step in acoustics was taken in the late 1970's. For this purpose, specialists were trained in Norway and Peru, and equipment was acquired. For technical reasons Cuba has always used acoustics in waters of other countries but this changed with the EEZ and acoustics as an instrument of work lost its value.

At present the Institute of Oceanology in collaboration with ORSTOM of France is making different investigations to use this technique in fish stock assessment under Cuban's shelf conditions.

7.2 Canada

Maurice Lamontagne Institute, Mont Joli, Quebec

Two cruises were conducted in the Gulf of St. Lawrence using a 2 frequency (38 and 120 kHz) dual-beam BioSonics Model 102 System. The first cruise looked at spatial organization of plankton scattering layers and fish echoes on a northern shrimp fishing ground (depth = 200 m) and explored the possibility of detecting shrimp aggregations with hydroacoustics. Samples were collected with bottom trawls and with the Bioness plankton system. Preliminary results indicated that the echoes observed in the first 30 m above the bottom were due to various species of fish and to a euphausiid scattering layer. No clear evidence of back-scattering due to shrimp was observed. A very dense fish aggregation was observed at an intensive feeding site of fin and humpback whales.

The second cruise determined the distribution and abundance of herring in NAFO Division 4R (west coast of Newfoundland) using the stratified random sampling design of parallel transects recommended by the Canadian Atlantic Scientific

Advisory Committee. Stratification was based on the major physical features along the coastline and the known areas of herring school concentration. With this design, the parallel transects were easily randomized to follow the probable density gradient of herring (perpendicular to the coastline) thus minimizing the variances along transects within a stratum. The survey was conducted using a 120 kHz DATASONIC echo sounder with a data acquisition system designed by FEMTO Electronics Ltd.

Pacific Biological Station, Nanaimo, British Columbia

Hydroacoustic assessments were conducted by Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Region on: the offshore hake populations in relation to the commercial fishery; the inshore hake population in relation to predation on migrating salmon; juvenile herring in the Strait of Georgia; rockfish on untrawlable hard bottom; and limnetic fish populations, as part of the lake enrichment program.

Theoretical work was conducted on the use of side scanning sonar to determine its usefulness in identifying and assessing juvenile salmon schools by depth strata (surface to 60 m). Work was also conducted on the development of acoustic methods to discriminate fish species grouping of rockfish by bottom type and depth.

A study compared assessment of adult sockeye salmon using an active synoptic survey of transects and downward looking acoustic equipment with a passive survey using a fixed, upward looking array of transducers. The comparison also used information from salmon tagged with a depth sensitive sonar tag which allowed tracking the holding patterns of sockeye prior to river entry. The active synoptic survey provided the better estimates because the passive survey could not account for fish moving back and forth across the array during the period when the salmon were holding. The diel migratory behaviour of adult sockeye in rivers and juvenile sockeye in lakes was also studied to determine the impact of this behaviour on assessment estimates.

Bedford Institute of Oceanography, Dartmouth, Nova Scotia

The ECOLOG II dual-beam acoustic system for counting and sizing individual fish targets was built on contract and accepted for use in the marine environment. Field trials identified several problems which are being corrected in an updated version to be delivered by summer 1990.

An analytical model of the echo reflection from fish was

developed. The results agree with empirical observations and existing numerical models in identifying the "perspective" which is the combined effect of the transducer beam pattern and fish tilt angle, as a major source of variation in fish target strength.

St. Andrews Biological Station, St. Andrews, New Brunswick

Acoustic abundance estimates of the 4WX winter herring stock were made from parallel transect surveys in 1989 and early 1990. The herring were usually aggregated in one or more patches a few square miles in area, and were mobile within a range of 4 mi by 24 mi. Diurnal variation in availability of the herring for acoustic detection and the mobility of the patches dictate that the entire distribution range must be surveyed in 12-hr periods. At 8 knots survey speed, and allowing time for midwater trawl sampling, it is possible to run 16 transects during each period. Random transect surveys can miss the herring entirely. Systematic surveys of equidistant transects encounter the herring more reliably but cannot be used to estimate the variance of the mean. The appropriate survey design is a series of synoptic night time surveys that monitor the build-up and decline of the population in the area and estimate the abundance at the optimum time. An effective way to estimate within night variance has not been devised.

Freshwater Institute, Winnipeg, Manitoba

A hydroacoustic study of marine fish abundance and distribution in Barrow Strait, Northwest Territories was completed. Part of this work involved the examination of Arctic cod distribution behaviour in relation to feeding aggregations of marine mammals and sea birds. Fish abundance in six interior lakes was examined as part of the Red Lake Climate Change Study. Studies of herring biomass in Lake Superior's Black Bay, where the fishery remains closed due to low fish abundance, were also continued. An ongoing study estimating the seasonal abundance of forage species in Batchawana Bay, in order to assess appropriate stocking levels for Chinook salmon and their impact on the forage base, revealed an unexpected increase in biomass, likely due to immigration into the bay. Work continues on: the comparison of fisheries acoustics techniques with traditional methods for estimating fish biomass in small lakes, fixed aspect examinations of fish migration through channels and rivers, the development of an acoustically- triggered underwater camera for identifying plankton and nekton beneath ice, and the refinement of a technique for editing and presenting fisheries acoustics data using computer graphics.

Northwest Atlantic Fisheries Center, St. John's, Newfoundland

The Region conducted one inshore and six offshore acoustic surveys. The inshore survey estimated herring biomass in two stock areas. Offshore work included three capelin biomass surveys, one redfish biomass survey, one experimental survey to test the feasibility of winter acoustic surveys on northern cod, and one cod-capelin interaction study using acoustic techniques. A nearshore acoustic study on the migration of cod and capelin in the Avalon Channel was also conducted. In addition, two calibration cruises were completed and individual cod were tracked in Conception Bay using acoustic tags.

Research in acoustics development proceeded along several fronts. Investigations into the sources of variation in calibration measurements from the Hydroacoustic Data Acquisition System (HYDAS) have led to improved procedures for conducting routine calibrations. A stern deployment and retrieval system for conducting acoustic surveys in ice infested waters was successfully tested on GADUS ATLANTICA. In situ experiments to determine target strengths of herring schools were conducted. Work continued on acoustic species identification, including its theoretical basis. Experiments were conducted on spatial and temporal scales of target strength variability. Three papers were published concerning ecological studies on cod based on acoustic observations. The influence of the selectivity of midwater trawls on capelin acoustic biomass surveys was reported in a paper to be published in 1990. Comparative field trials were conducted with the HYDAS and BioSonics acoustic systems, but the results were inconclusive. An investigation of optimal acoustic survey designs was initiated. The laboratory also acquired a second Hydroacoustic Data Editing System (HYED).

7.3 Denmark

Denmark participated in the international acoustic survey in the North Sea in July-August.

An acoustic survey utilizing mobile equipment was executed in the western Baltic in cooperation with the Bundesforschungsanstalt fur Fischerei, Hamburg, Federal Republic of Germany.

A PC based system (ECHOANN) for acoustic data collection, analysis and storage has been developed and implemented on surveys during 1989. The system consists of hardware and software for collection and analysis of data from two scientific sounders, one split beam sounder, a log and navigational instruments. Output includes integration results sorted by depth, dynamic intervals and three categories (integral covered by single fish echoes, schools and a residual group), single echo data, navigational information, and control information.

7.4 France

IFREMER

Le systeme INES-MOVIES de traitement (numerisation, stockage, integration) des donnees sondeur par ordinateur compatible PC a ete termine. Son industrialisation a ete realisee et il est commercialise par une societe de la region brestoise.

Suite aux premiers essais concluants du prototype de sondeur multifaisceaux concu pour la peche (24 voies de 2°), l'industrialisation est actuellement en cours, dans le cadre du projet EUREKA-HALIOS, par des societes francaise et espagnole.

Des essais preliminaires de la maquette d'un sondeur large-bande (20 a 80 kHz) ont ete effectues. Le developpement continue et ce sondeur devrait etre pleinement operationnel en mer en juin 90.

Lors d'une campagne methodologique en acoustique, des premieres donnees interessantes sur les index de reflexion de poissons pelagiques dans le golfe de Gascogne ont ete acquises grace au systeme Dual Beam Biosonics de l'ORSTOM.

La gestion du stock d'anchois du golfe de Gascogne a ete poursuivie, en collaboration avec l'Espagne, avec comme support une campagne d'echointegration effectuee en avril-mai.

ORSTOM

L'ORSTOM a poursuivi ses travaux en hydroacoustique suivant quatre orientations: 1) evaluation des stocks de pelagiques par echo-integration grace a des campagnes effectuees en Mauritanie, Senegal, Secteur Caraibe (Venezuela, Cuba); 2) identification des biais introduits par l'utilisation de l'acoustique dans les evaluations de stocks; 3) etude du comportement de structures agregees (distributions internes, deplacements, dispersions, agregations); et 4) identification d'especes a partir d'emission large-bande.

L'issue des traitements statistiques est tres encourageante dans les 2 bandes de frequence etudiees (50 a 145 kHz et 140 a 430 kHz) avec toutefois des resultats moins spectaculaires dans la seconde.

7.5 Faroe Islands

In February 1989, an acoustic survey was conducted south of the Faroe Islands. This was the first survey with other countries. A side-scanning sonar (330 kHz, 50 m range) was used to collect data by passively drifting in the area. No salmon targets were identified during the 40 hours of equipment use.

7.6 German Democratic Republic

A joint hydroacoustic survey of pelagic fish stocks was carried out in the Baltic proper in October and November 1989. The vessels ARGOS/Sweden, ISSLEDOVATEL BALTIKI/USSR, and EISBAER/GDR participated. R/V EISBAER investigated ICES SD 24, 26, and 28. A three-ship intercalibration on dispersed night concentrations showed satisfactory correlation of the results.

Young herring and sprat stocks in the Arkona Basin (SD 24) were surveyed in January and December 1989. In December the course tracks were investigated twice; by day and once more by night. The measured values give a good correspondence. This result is remarkable insofar as the targets are distributed by day close to the bottom and therefore frequently underestimated.

Shallow water investigations have been started in Lake Mueritz. An EY-M echo sounder has been connected to a computer based integration system. This portable system has been designed especially for small boat applications. The mean squared echosignal is measured for 50 depth channels within short selectable sampling distances. The data will be stored on audio tape for further processing by a PC.

At present the new EK 500 system is under installation onboard R/V ERNST HAECKEL. A split-beam (38 kHz) and a single beam (120 kHz) transducer are hull mounted. A further 38 kHz channel is provided for a towed transducer. Working mode and data flow of the EK 500 will be operated under computer control via RS 232 link. A second computer is connected by an Ethernet line for fast data transfer and advanced signal processing. The first sea trial is planned for the joint survey in the Baltic in October 1990.

A new version of towed body designed for the transducer type 38-26 is under construction. Its towing depth will cover the range from the surface down to 50 m. The lateral distance to the ship of about 50 m keeps the transducer away from bubbled keelwater. The towed body shows stable behaviour at a wide range of ship's speeds and weather conditions.

7.7 Norway

Abundance estimation of fish - deep-towed transducer

This project aims at improving acoustic estimates of the abundance of fish in deep water, exceeding 500 m depth, and along steeply sloped bottoms, e.g., along the edge of the Continental Shelf. In the course of the first phase of the project, both mechanical and electronic components of a current towed vehicle have been adapted, replaced or upgraded. At the end of 1989 the new system was ready for full-scale testing.

Sonar measurement of fish

The aim of this project is development of a sonar and method for abundance estimation of fish in near-surface schools. The system is being developed in collaboration with SIMRAD and SINTEF. As a foundation for specification of the measurement system, a dual system analysis has been undertaken by users and by engineers. New sonar data on school echoes have been gathered, and a programme package with a sound propagation model has been procured.

Effect of seismological investigations on fish

As a consequence of injuries to farmed fish from light seismic work and mine detonation in a fjord, the Institute of Marine Research has become strongly engaged in the overall problem. To a considerable degree the Institute has acted in a consulting role. It is also contributing to new research projects in this area by acting as a coordination resource.

Expanded split-beam transducer

An expanded split-beam transducer, with both narrow and wide beams, has been built by SIMRAD. Considerable amplitude-weighting or shading applied to the non-core elements has resulted in a reduction of performance compared to the specified design. The transducer has been mounted on R/V G. O. SARS. Its calibration in December 1989 was successful. The transducer is ready for field use.

Acoustic sampling volume for cod

Computations have been carried out to show how echo integrator values should be adjusted or compensated when the echo threshold effect is significant.

Trials of a new commercial echo sounder

The new SIMRAD EK 500 scientific echo sounding system is still under development, but it has been used by the Institute of Marine Research for ordinary fish stock surveys since summer 1989. A number of errors in the system have been identified and others are being investigated. Included among these, inter alia, are the following: 1) mixing of ASCII and binary data in datagrams sent out by the EK 500 over Ethernet to a workstation-based postprocessing system, 2) jitter due to the receiver processor alone which is at least 0.6 dB in magnitude, 3) incorrect compensation of values of SA for rejected echoes, when the bottom echo is not detected, and 4) display of the angular position of single-fish echoes in a circular PPI which covers only a fraction of the indicated area for the kinds of transducer beamwidths used in fisheries research.

Data system for research vessels

Development of the Bergen Echo Integrator continues. The following functions or "windows" have now been integrated: main window with the echogram, interpretation window, and target strength window. Three other windows have been constructed: fish station window, STD window, and navigation window, but these await integration.

Software development for split-beam echo data

Software is being developed for detailed analysis of raw data derived from the parallel data ports of the SIMRAD EK 400 echo sounder. This has been documented for 1) logging and calibration of the echo sounder, 2) beam-pattern compensation and calibration, and 3) determining single fish echo selection criteria based on the effective pulse duration and angle stability.

7.8 Sweden

During 1989 Sweden carried out two hydroacoustic surveys. The first survey was carried out as an ICES cooperative survey on herring in the North Sea and Division IIIa. Sweden covered Kattegat and the western part of Skagerak. The second survey for herring and sprat in the Baltic proper was carried out in cooperation with GDR, USSR, and Poland. An intercalibration was made between R/V ARGOS/Sweden, R/V EISBAER/GDR, and R/V ISSLEDOVATEL BALTIKI/USSR. Intercalibration was also performed between R/V ARGOS and R/V PROFESOR SIEDLECKI/Poland.

A database containing hydroacoustic survey data (1983-present) was taken into production in 1989. SIABAS II is used as DataBase Management System (DBMS).

7.9 United Kingdom - Lowestoft

The Multi-frequency Acoustic Profiling System (MAPS) developed by Dr. D. V. Holliday was successfully deployed 71 times in April/May during a cruise of the R/V CIROLANA in the Irish Sea. The MAPS team was sponsored by the National Science Foundation and the Office of Naval Research in the U.S.A. The system uses 21 discrete frequencies in the range 100 kHz to 10 MHz and was used to assess plankton abundance versus depth, density distribution, and size distribution. Measurements were made along transects between Gt Ormes Head and Dundalk Bay and also at stations near Port Erin, Isle of Man, where data were collected at 2 hourly intervals. The purpose was to study diel patterns in zooplankton distributions in relation to physical structure and phytoplankton abundance. Analyses of the MAPS data by the MAPS team are nearing completion and plankton sample analysis is well advanced at Lowestoft. Both 38 kHz and 120 kHz EK 400/QD echo-integrator systems were also run during the cruise. The dominant scattering varied between these two frequencies with a tendency for higher peaks at 38 kHz.

An acoustic survey was carried out between the trawl stations of a groundfish survey in the North Sea during August using the 38 kHz EK 400 and ES 400 systems. Results look sufficiently interesting to encourage further work.

A high frequency (192 kHz) system is being developed for the detection and counting of herring larvae in an experiment to be carried out in the River Blackwater.

Some investigation of the detectability of partially buried scallops was undertaken using very high frequencies. The

results showed that, for light coverings of sand, the signals were very distinctive. Where the scallops are well-covered, much lower frequencies are needed.

7.10 United Kingdom - Scotland

Surveys of herring were carried out 1) in the Clyde and 2) in the Orkney, Shetland and Buchan areas in July 1989. The latter survey was in conjunction with the Norwegian and the Danish fisheries research laboratories. In addition, a survey of herring was conducted in ICES Division IVa. During these surveys data were collected in individual sample format for each transmission and with 0.5 m range definition.

Dual-beam data on herring were collected during July in the Orkney, Shetland, and Buchan area and on an additional survey cruise following the main survey in the Clyde. Analysis of data has not yet been completed.

Routine measurements (bi-annual) of survey transducer beam patterns continue and so far no long term changes have been found.

Target strength data were collected, at the field station at Loch Duich, from single caged herring using the dual beam system along with stereo photographs to provide position and angle information. These data are being analyzed relating fish orientation to measured target strength for a caged but free swimming fish. Initial analysis shows a variable relationship between fit angle and target strengths.

Experiments are continuing on the extinction effects of caged dense fish aggregations. Measurements were carried out on aggregations of herring, mackerel, and cod. Results of this work are published in the proceedings of the Institute of Acoustics.

Work is continuing on the process of integration of echo trace rather than by layer.

7.11 U.S.A.

Alaska Fisheries Science Centre (AFSC) in Seattle has continued research on pollock (Theragra chalcogramma) and whiting (Merluccius productus) in the Northeast Pacific Ocean. During 1988 and 1989, acoustic surveys of the spawning population of pollock have been carried out in January-March in the deep water portion (>1000 m) of the Bering Sea, and, in 1989 including shelf waters of the eastern Bering Sea. Annual surveys of the Gulf of Alaska spawning stock in the Gulf of Alaska have continued through 1990. During 1990, in the Gulf of Alaska, the AFSC began survey operations with a Simrad E/K 500 echo sounder and Bergen echo integrator. During this survey, the old echo sounding and echo integration system was run in parallel with the new Simrad system. Tests are now being conducted to compare the results from the two survey systems. Target strength studies of fish using the split beam technique continue and standard sphere calibration has become the primary calibration technique. Cooperative surveys of pollock in the Bering Sea with the Japanese Fisheries Agency have continued under the sponsorship of the International North Pacific Fisheries Commission (INPFC). The fifth in a series of triennial surveys of Pacific whiting off the west coast of the U.S.A. was completed in 1989.

The Southwest Fisheries Center (SWFC) in La Jolla, California, continues annual Antarctic krill investigations using acoustic and net techniques. The SWFC has up to this time been using BioSonics echo sounders and custom-designed echo integration techniques. They are now considering the purchase of a new system to carry out these surveys of Antarctic krill.

The Southeast Fisheries Center (SEFC) group in Pascagoula, Mississippi, has conducted initial tests on the application of quantitative acoustic surveys of midwater stocks in the Gulf of Mexico.

7.12 USSR

VNIRO, Moscow (with Sebastopol Department)

Echo surveys were conducted on mackerel and horse-mackerel in the South Pacific, myctophids in the South Atlantic, some species in the Black Sea, and in inland waters. Experimental surveys in different fishing areas used acoustic and oceanographic data to evaluate the possible catch of commercial vessels. Computer data base was constructed of all known target strength data of fishes and other objects. Investigation of biomass assessment precision using computer stimulation of density fields was conducted. Experimental work on fish behaviour using acoustic tags was performed on free fish farming using sound control signals.

PINRO, Murmansk

Eight research vessels are equipped with acoustic instruments. About 15 echo surveys of 9 North Atlantic species are carried out every year. Work is starting on computer processing of survey data. Training of biologists and other specialists in echo surveys.

AtlantNIRO, Kaliningrad

Four vessels with acoustic equipment have conducted 12 surveys of more than 40 species of Central and South Atlantic in 1989. Research activity is connected to the planning of echo surveys using satellite information (SST) and investigation of statistical parameters of fish space distribution.

TINRO, Vladivostok

Echo surveys of most important Pacific commercial species: walleye-pollock, sardine-ivashi, herring of Ochotian Sea. Development of computer processing of acoustic data together with oceanography, ichthyology, and others. Training of hydroacoustics in echo surveying.

8. Recommendations

The Working Group recommended that a study group be set up under the Chairmanship of E. J. Simmonds to review acoustic survey design practices and analysis procedures for abundance estimation in member countries, to identify research needs, and to identify currently acceptable practices. Operating initially by correspondence, the study group will meet prior to the FAST

Working Group meeting in 1991 to finalize a draft report for consideration by the FAST Working Group and report its findings to the Fish Capture Committee with reference to the Pelagic, Shellfish, Demersal, and Statistics Committees at the Statutory Meeting in 1991. Although the work of this study group complements the work of the Study Group on the Applicability of Spatial Techniques to Acoustic Survey Data, there is a separate need to document the current status of survey design and analysis, separate from the work of that study group. Contact will be maintained between the two study groups.

The Working Group reaffirmed their opinion of the importance of obtaining information on the causes and effects and magnitude of vessel avoidance on assessment surveys and recommended that this subject be proposed as a special topic for the joint meetings of the FTFB and FAST Working Groups in 1991. The group expressed the opinion that the joint session proceeded more effectively when a separate chairman for that meeting was established and P. A. M. Stewart agreed to a request from the Working Group to chair this session.

The Working Group encouraged studies to investigate acoustic survey problems associated with organisms near boundaries such as shallow water and near surface conditions and suggested this as a special topic for the 1991 Working Group meeting.

9. Next Meeting

The Working Group recommended that the 1991 meeting be held in Ancona, Italy on April 15-16, 1991.

A Chairman's note following the meeting indicated that the dates agreed to during the Working Group meeting coincide with the World Fisheries Congress which is scheduled for 14-19 April 1991. Accordingly alternate dates for the next FAST Working Group meeting will have to be considered at the Statutory Meeting in 1990.

Appendix A

Attendance at FAST Working Group Meeting
April 26-27, ROSTOCK, German Democratic Republic

Country	Name
BELGIUM	Fonteyne, R.
CANADA	Crawford, R. Koeller, P. MacPhee, St. Nakashima, B.S. Simard, Y. Walsh, St.J. Warren, W.G.
CUBA	Corujo, C.H.
DENMARK	Degnbol, P. Lundgren, B. Vinther, M.
FAROE ISLANDS	Jacobsen, J.A.
FEDERAL REPUBLIC OF GERMANY	Lange, K.
FRANCE	Gerlotto, F. Guillard, J.
GERMAN DEMOCRATIC REPUBLIC	Goetze, E. Hamann, K. Jesper, A. Kaestner, D. Oeberst, R. Rothbarth, H. Scheel, R. Stengel, H. Stuewe, G.-E. Thiele, W. Trost, G.
NETHERLANDS	Buys, A.M. Storbeck, F. v. Marlen, B.
NORWAY	Bodholt, H. Dalen, J. Godo, O.R. Olsen, K.

SWEDEN	Hakansson, N.
UNITED KINGDOM	Bone, D.G. Everson, I. Mitchell, C. Mitson, R.B. Simmonds, E.J. (Scotland) Stewart, P.A.M. (Scotland)
USA	Traynor, J.
USSR	Berdichevsky, Z. Bondarenko, B. Jarwik Kamarauskas, A. Schirokow Tesler, V. Toliusis, S.