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International Council for
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Fish Capture Committee
Session Y

REPORT OF THE WORKING GROUP ON
FISHERIES ACOUSTIC SCIENCE AND
TECHNOLOGY (FAST-W.G.).

Tromsø 20-22 May 1985

x) General Secretary, ICES, Palaegade 2-4,
DK-1261, Copenhagen K., DENMARK

Terms of reference, ICES' C.Res. 1984/2:2:

The following Working Groups will meet in Tromsø, Norway, during the week from 20th to 24th May 1985, coordinated the Chairman of the Fish Capture Committee:

- a) the Working Group on Fishing Technology and Fish Behaviour, convened by Mr. D. MacLennan, from 20th - 22nd May, to consider, in particular, equipment and techniques for underwater observations of fish and fishing gear and the general arrangement, deck layout and equipment of fishing vessels in relation to stationary fishing gear and methods;
- b) the Working Group on Fisheries Acoustics Science and Technology, convened by Prof. K. Olsen, from 22 - 24th May, to consider, in particular, the preparation of a calibration manual, target strength functions of Gadoids to be used in the interpretations of acoustic survey results and progress with in situ target strength measurement.

Report from the Fisheries Acoustics Science and Technology Working Group Meeting in Tromsø, Norway May 22 - 24 1985.

Chairman: Kjell Olsen, Norway
Rapporteur: Udo Buerkle, Canada

OPENING

The meeting began with a presentation by the Fish Capture Committee Chairman, Gudni Thorsteinsson, on the organization of sessions at the next Statutory Meeting. A written report, "General Information from the Chairman of the Fish Capture Committee (May 1985)," was distributed.

After a short introduction by the Convenor of the FAST W.G., including appointment of the rapporteur, the meeting directly proceeded with the FTFB/FAST JOINT SESSION.

JOINT SESSION

Chairman: Clem Wardle, Scotland

The topic "Fish behaviour problems in acoustic survey" was introduced by the FAST Working Group Chairman. His first remark that "fish always behave some way and not always nicely" seemed to set the tone for the session.

The problems were divided into two groups: a) those associated with acoustic detection and conversion to biomass; and b) those related to sampling techniques.

Detection problems are seen as those of fish too close to surface or bottom, those of mixing of fish species or other species, the avoidance problems of local density reduction below the survey vessel and changed aspect at longer ranges, the day-night differences due to vertical migrations and associated aspect and changes in swimbladder volumes, the shadowing problems in high densities or vertically extensive schools, and the migration problems associated with fish movements in relation to survey grids.

Sampling problems are those associated with catching unbiased samples of the species contributing to the echo energy. It was pointed out that most fishing gear and methods are designed to be selective for particular species and size ranges. For sampling, the need is for gear that is non-selective for species and size ranges.

Discussion and overhead presentations by a number of contributors demonstrated that for some species at some times the problems listed are real and important. At other times and/or in other areas, the problems may not exist.

Four presentations were made. Two of them:

1. Enai de détermination de l'index de reflexion des poissons par comptage des echos et echo-integration. - N. Diner et Z. G. Kim
2. Some sonar observations of the behaviour of herring schools relative to a fishing vessel. - Asgeir Aglen

described work in France and Norway with omnidirectional sonars to observe fish avoidance of survey vessels. Herring and mackerel were shown to avoid survey vessels during daylight. This raised questions and discussion about the validity of echo sounder surveys under these conditions. It was pointed out that avoidance may not be significant at night and that herring surveys are usually done at night. The importance of attempting to learn something about the behaviour of the surveyed animals and of choosing favourable conditions for survey were stressed.

The other two presentations:

3. The problem of fish attitude and target strength: some possible solutions. - R. Mitson
4. A frame for free drop camera systems. - D. MacLennan

dealt with new equipment. At Aberdeen, a free drop camera frame for photography of in situ fish has been developed. Discussion of this focused on the observed behaviour of the fish being influenced by the presence of the camera and various examples of such influences. The degree and range of influence of the camera on behaviour is a result of the method of deployment and operation of the camera system itself. Sinking rates and rates of flash exposures are thought to be crucial.

Development of a tilt angle sensing transponder tag at Lowestoft was described. The potential for direct determination of tilt angles was discussed and thought to be of great value.

The Chairman of the Joint Session suggested a Working Group recommendation to support this work.

PROGRESS REPORTS

Participants were asked to bring written progress reports but many did not have sufficient copies for distribution and the discussion was delayed until May 24. It was suggested that in future meetings the progress reports be available at the beginning so that they might stimulate discussion among participants. The progress reports presented are listed in alphabetical order; very little discussion or comment took place.

CANADA
(Northwest Atlantic Fisheries Center)

Three hydroacoustic surveys of capelin stocks were completed in 1984. Results of these surveys were presented at meetings of the Canadian Atlantic Fisheries Scientific Advisory Committee and the Northwest Atlantic Fisheries Organization. Three similar cruises are planned for 1985. An investigation into the diurnal movement of capelin schools will be carried out in 1985 with the aim of establishing methods for correcting survey data for these effects. It is felt that diurnal movement may account for a considerable part of the variation in acoustic biomass estimates of capelin stocks.

A small hydrographic dual beam - echo integration system will be tested and evaluated for future assessment of herring and capelin in the inshore area.

The use of hydroacoustics for the enumeration of redfish is being examined. Technical difficulties have been overcome and annual surveys are being conducted in the northern Gulf of St. Lawrence in order to build up a time series of data. The collected data are also being used to examine the diel movements of redfish.

Hydroacoustics are also being used to study the annual inshore migration of cod in relation to capelin movement and their reaction to the cold core of the Labrador current. Two surveys are planned for 1985.

During the past year, HYDAS (Hydroacoustic Data Acquisition System) has been interfaced to the positioning system of the vessel. The navigational information acquired from the positioning system is transferred to the data storage system (9-track magnetic tape) at two-minute intervals. HYDAS also has been modified to use a video display terminal as the system console; previously, a printing terminal had been used. Work has begun on the development of a dual beam data acquisition system. A contract has been let for the design, construction and testing of two dual beam transducers.

(Marine Ecology Laboratory)

The MEL group is continuing investigation of the dual-beam ECOLOG system in field calibration of abundance surveys for demersal fish. Field data collected over two years on a series of cruises show significant differences in field target strength from cruise to cruise. Some of this is related to biological variation and some is related to unavoidable variations in electronic system calibration. Most important, however, appear to be departures of the performance of transducers from the ideal expectations of theory. Our investigations of methods of signal processing based on results of both laboratory and field experiments, suggest that dual-beam systems may be calibrated in the field to correct these biases and to considerably reduce the variance of target strength. The corrected results show strong correlations in estimates of size and density between acoustic transects and net hauls.

(Marine Fish Division, St. Andrews, N.B.)

Methodology for acoustic survey of herring has been developed. The method includes large-scale surveys of the area of the commercial winter fishery and small-scale replicate surveys of the fish concentrations found.

Digitized echo data are separated into individual fish schools by an editing procedure on the echo sounder charts. The average area scattering coefficients of individual schools are obtained by integration within schools. Size of schools is determined from the replicate transects across schools. Acoustic abundance is the product of size and average scattering. The method has been used to determine abundance in a large aggregation of herring in 1984 and 1985.

Continuing work concerns the error bounds for the acoustic abundance estimates, in situ target strength and the relation of abundance in large aggregations to total stock size.

(Pacific Biological Station)

The acoustic program for 1984 continued to use the computer software for processing digitized acoustic data. The comparisons between seine catch and between two acoustic vessel measurements undertaken in 1982 and 1983 were analyzed and are being published. A feasibility study to assess offshore herring was initiated with initial examination of the Hecate Strait region of the B.C. coast. Cooperative work between the Research Branch and the Field Services Branch was directed towards improvement of the acoustic assessment procedures used for real-time management of the herring fishery.

DENMARK

(Institute for Fisheries and Marine Research)

Since the FAST group met in May 1984, the Danish Institute has conducted six surveys with the research vessel DANA using hydroacoustic survey technique:

- 1.1 The joint Danish-Swedish survey of herring in Division III a (Kattegat-Skagerak) was extended to cover the western Baltic in September 1984. This shallow water area was surveyed with a towed body system, where the operation depth of the towed body is 2-4 m. This system is being upgraded the "fish" is replaced by a larger model which should allow integration with 10-12 knots. The new system is under installation at the moment, the first test cruise is planned 28 May 1985. This revision of the hydroacoustic system also covers installation of the split-beam system SIMRAD ES 400.
- 1.2 The reproducibility of a hydroacoustic survey was investigated by repeated integration of a $60 \times 30 \text{ nm}^3$ area in Skagerak. The findings are reported to this meeting (Andersen and Kirkegaard).
- 1.3 Target strength of herring and sprat in the Baltic was measured in October 1984 and is reported to this meeting (Lassen and Staehr).

- 1.4 A first attempt to survey the spawning stock of cod in the Baltic was made in March 1985. These data are not yet analyzed.
- 1.5 - .6 The spacial/time distribution of fish can be obtained hydroacoustically and these distributions may be related to feeding behaviour. On cruises in August 1984 and in March 1985, such distributions and their relation to feeding (stomach content) was studied. The results for the Blue Whiting/krill system investigated in August 1984 are presented in this meeting (Degnbol).
2. Laboratory studies of wide-band transducers applied in fish identification were continued. There are no results to report yet.
3. A major effort was directed towards streamlining the evaluation of routine hydroacoustic surveys. Internal manuals (in Danish) on survey strategies and techniques and calibrations were written. Computer programs for a VAX 11/750 were made and a menu-oriented command systems to handle these programs and their data files were implemented. This later project is reported to this meeting (Degnbol and Bangsborg).

FAROE ISLANDS

Each year since 1978, three echo-abundance surveys have been carried out on blue-whiting, and this will be continued in the foreseeable future.

Since 1981, the instruments used are the SIMRAD EK-400 38 kHz echosounder with a hull mounted transducer, connected to the SIMRAD QD integrator.

For calibration, the method suggested by Foote et al. (1982) is used (60 mm copper-sphere).

Adoption of a towed body is considered.

During two surveys, one in April and one in May 1985, a buoy containing an echosounder was used to obtain an indication of the avoidance reaction of blue-whiting on the ship. Five different trials indicated no reaction at 300-400 m depth.

B. Thomsen

FRANCE

Acoustic surveys

Acoustic evaluations have been conducted by IFREMER in the Bay of Biscay in April-May (sardine, anchovy, horse-mackerel), in the Gulf of Lion (Mediterranean) in August (sardine, anchovy), and in the North Sea and Eastern Channel in November (herring). The main efforts concentrated on data processing methods as well as detection identification by trawling. Due to the multispecific structure of biomass in these regions, special effort has been developed on the evaluation of the respective parts of the principal species in the total biomass.

ORSTOM is involved in regional activities in cooperation in tropical areas (Senegal, Mauritania, Indonesia, and Caribbean area). One of the objectives is to test indirect methods of target identification.

Behaviour studies

The installation in October 1984 aboard the R/V THALASSA of an omnidirectional sonar allowed observation of strong avoidance behaviour in November during a herring survey as well as in April-May in the Bay of Biscay. This kind of equipment seems to be very interesting for the study of behaviour in pelagic fish.

A national group (IFREMER/ORSTOM/University) has been created in Martinique (French West Indies) during August 1984. An important part of its objectives is the study of tropical fish behaviour induced by fishing operations, and especially of the incidence of the school behaviour on echo integration results.

A study of the influence of noise and acoustic spectrum of fishing vessels is being conducted by the University of Paris and CNRS with special attention to the tuna fisheries. Another study on fish concentrations with an acoustically instrumented raft is conducted mainly in tropical tuna fishing areas.

Technology

IFREMER is designing an echo classifier based on the direct identification from echogram structural features.

A wide-band transducer (50-250 kHz) is being studied by the University of Paris VI, and the prototype should be achieved in 1986.

FEDERAL REPUBLIC OF GERMANY
(BFA für Fischerei, Institut für Fangtechnik)

From November 1984 to April 1985 two combined echo and trawl surveys have been carried out in the south Atlantic along the antarctic peninsula. During these cruises, the geographical and seasonal variations in the distribution pattern of the antarctic krill E. superba have been studied. The acoustic work was carried out by means of a Hewlett Packard Digital Data Acquisition System linked to a commercial ELAC echosounder:

- | | | |
|----------------------|---------|--|
| 1. RV POLARSTERN | cruise: | ANT III/2 from 4.11.84
to 3.1.85 |
| | sonder: | ELAC 150 kHz with hull
mounted transducer |
| 2. RV WALTHER HERWIG | cruise: | WH 68/1 and WH 68/2
from 22.1. to 16.4.85 |
| | sonder: | ELAC 50 kHz with hull
mounted transducer. |

Some work on the data acquisition software has led to an improved Online data evaluation and representation.

Minor developments have been made in the construction of a towed 3-frequency system.

H. Klindt

GREAT BRITAIN
(MAFF, Fisheries Laboratory, Lowestoft)

The new concrete tank 3 x 4 m by 3.5 m deep has been completed and provided with a 1.5 tonne hoist capacity on a travelling gantry. Moveable walkways can be placed across the width of the tank which can be filled with either fresh water or filtered seawater.

Ceramic transducers with circular beam patterns have been tested. Results are good for response and symmetry of beam pattern but the back radiation is higher than the -50 dB measured by the manufacturer.

Routine surveys have continued on herring in the Central and Southern North Sea. Three updated QM integrators are used alongside a QD and all data logged on an Apricot microcomputer.

The specification for an acoustic tag to measure tilt angles of fish has been prepared and some development of two types of sensor has been undertaken. It appears that a resolution of 1° is possible over a range of $\pm 30^\circ$, but a wider range of angle could be used if a lower resolution is accepted. The smallest tilt tag capable of being manufactured using the existing technology at MAFF is likely to be 20 mm long by 7 mm diameter and have a weight in air of 1.2 g. It works at 300 kHz.

Either a transponder or a pinger can be used, with a predicted life of up to 5 days, for the former and 7 days for the latter. Range of operation depends on the frequency chosen and the receiving system available. For frequencies lower than 300 kHz, the size and weight of tag is much greater.

R. Mitson

(Marine Laboratory, Aberdeen)

Stereo camera techniques for monitoring caged fish behaviour during target strength experiments have been further developed. A camera pair mounted below the fish cage is used to estimate the fish tilt angle at the same time as the target strength is measured, without the cameras interfering with the acoustic signal. This work is being done in cooperation with the University College of North Wales.

Target strength experiments were conducted on sandeels. The TS was found to be in the range of -45 to -55 dB re 1 kg of fish. This is similar to the TS of mackerel, not a surprising result since neither fish has a swimbladder. It was necessary to use large quantities of sandeels to generate sufficient signal, up to 17 kg per cubic metre of cage. The sandeel TS also exhibited a diurnal variation similar to that reported earlier for mackerel. A drop camera system for collecting tilt angle data from fish schools in the wild is being developed.

The dual beam system for *in situ* TS measurement has been used during a herring survey off the east coast of England, in cooperation with the Fisheries Laboratory, Lowestoft. The results showed a multi-modal TS distribution with two or three peaks. These have been tentatively identified as being due to planktonic organisms, herring and large cod, respectively.

Investigation of calibration errors has shown that the standard target method, as presently applied to the 38 kHz echo sounders used on acoustic surveys, is capable of $\pm 3\%$ accuracy at the 95% confidence level. This error applies to the performance of all the system hardware - the transmitter, the transducer (including the equivalent beam angle), the receiver (including the TVG) and the integrator. Statistical methods for estimating the overall confidence limits on acoustic survey results are being investigated.

A wide band sounder operating between 27 and 54 kHz has been developed. The beam pattern has been measured using both hydrophone and standard target methods. Trials have been conducted on caged cod. The results show some changes in the frequency response of target strength between fish in acclimatised and pre-acclimatised states.

A computer-based system for recording acoustic survey data on magnetic tape has been developed and is now in regular use. The data are collected as one digital sample per transmission for every 0.5 m of depth. The recordings cover the depth range from 5 m below the transducer to 10 m below the sea bed and include time, date and position information at 20-second intervals. An analysis system based on a graphics display with 1 K by 1 K addressable area and 8 bits per pixel is under development.

Acoustic surveys have been conducted for North Sea sprat, mackerel to the northwest of Scotland and herring in the North Sea and Clyde areas. The Marine Laboratory participates in the annual ICES coordinated North Sea herring survey.

D. MacLennan

ICELAND

In autumn 1984 and winter 1985, routine acoustic assessment surveys were carried out on the spawning stocks of capelin and herring, for fisheries management. In the last three years, additional acoustic surveys have been conducted in order to assess the abundance of the juvenile capelin stock component. The results seem promising for management purposes, but more experience is needed.

Limited "in situ" target strength measurements were carried out in 1984 using an indirect method. Continued measurements of the target strength of herring and capelin are planned in autumn/winter 1985/86 using a split-beam echo-sounder (SIMRAD).

In connection with these measurements, the Institute plans further investigations on the behaviour of herring in different survey situations, and its reaction to the survey vessel.

In the last two years, a method has been developed for measuring the equivalent beam angles of hull mounted transducers. The method relies on the possibility of calculating the displacement of a standard target in the sound beam from the geometric configuration of the set-up. Ratios between different acoustic systems based on standard target

calibrations and the measured equivalent beam angles, as compared to intercalibrations on scattering layers, indicate that this method could give reliable results. The method should at least be useful in monitoring the directivity of hull mounted transducers, without having to dismount them. A report will be submitted at ICES CM 1985.

Further investigations are planned using split-beam echo-sounders.

Pall Reynisson

ITALY

In 1984 the system, used since 1979 for acoustic surveys in the Adriatic Sea and described in (1), has been upgraded. The system, newly installed on the R/V S. L. Bianco, is being put into operation in June 1985 for a large-scale research project that aims to assess the Italian pelagic resources. The program is financed by Italian government (2).

The hardware configuration of the system is characterized by a high flexibility. In the basic configuration the acoustic information is collected from two transducers, a 38 kHz transducer installed in the vessel and a 120 kHz transducer installed in a towed body, and it is processed separately with two different techniques: echo integrator technique (using SIMRAD instruments) and dual beam technique (using BIOSONICS instruments). Moreover the basic system components include two linked minicomputers (H.P.), processing in real time continuous (school) and pulsed (single) waves, a digital recorder to file on cassettes the most significant echo signals for further data analysis, a sonar and a sonar scope, to gather school data from surface layers. The software design for both in real time and off-line data processing has been a costly and time consuming process. The real-time programs let the operator interact in different ways with the system (changing parameters, plotting histograms, testing hypothesis, etc.) mostly for species/size identification (3) and fish behaviour study (4). Moreover, the procedures tend to avoid delays or interruptions in a running acoustic survey, through a high versatility of the programs and flexibility in the configuration of the system.

The off-line programs let the users ask a wide variety of questions (biomass assessment, target strength estimation, comparison with catch data, geographical distribution of different stocks, etc.). The versatility also in those programs has been the principal aim of the design.

In 1984 a new tank and a new cage frame has been built to calibrate on live fish the acoustic system. The tank is equipped with two cameras and an apparatus (ACQAMEX) to study behaviour and activity of fish before they are placed in the cage.

The cage is equipped with photocameras aimed at its top and side; it is built in monofilament line and tied to a special fiberglass frame. The newly built tank and cage will be tested in July 1985. In 1984 some acoustic data collected in the surveys carried since 1976 have retrieved and reprocessed using only night time or day time data. As a result,

the assessment based on night time data is nearly twice as high as those based on day time data. The paper (4) shows that the forms of pelagic fish spatial distribution are strongly affected by light and perhaps they bias the statistics of the received echo signals. Therefore, they should be considered in processing acoustic data for biomass assessment.

- 1) M. AZZALI, 1979 - The use of on line minicomputer for hydroacoustical echosignal processing. Meeting on hydroacoustical methods for the estimation of marine fish population, 35-29 June. The Charles Stark Draper Laboratory, Inc., Cambridge, Mass. U.S.A. pp. 439-453.
- 2) M. AZALLI, 1983 - Progetto de ricerca per la valutazione delle risorse pelagiche nei mari italiani. Research project for stock assessment of Italian government pp. 39.
- 3) M. AZALLI, 1982 - Regarding the possibility of relating echo signal features to classes of marine organisms: tests carried out in the north and middle Adriatic sea. Contribution No. 23 to Symposium on Fisheries Acoustic. Bergen, Norway, 21-24 June, pp. 47.
- 4) M. AZZALI, 1985 - Relationship between the forms of pelagic fish distribution and nictemeral periods. A tentative model of behaviour. Contribution to F.A.S.T. Working Group, Norway, Tromso, 22-24 May, pp. 15.

M. Azzali

NORWAY

The acoustic abundance estimation method is currently being applied to almost all fish stocks in Norwegian waters. These include Barents Sea capelin, Arcto-Norwegian cod and haddock, blue whiting, Norwegian spring spawning herring, North Sea herring, and sprat in coastal waters. Absolute abundance estimates are being made for each of the mentioned fish stocks. Improvements in acoustic techniques are being attempted through a number of projects.

Fish behaviour in relation to acoustic observations

In order to study and quantify the reaction of fish to surveying vessels, two investigations have been undertaken. Their aims, methods, and results are the following:

- 1) To observe and record herring school behaviour by videotaping the display of the multi-beam sonar in vessel-approach situations. Different patterns of school avoidance were observed. (BERGEN)
- 2) To observe differences in fish behaviour by echo sounding with two upward-looking transducers, one of which is suspended directly beneath the vessel track, while the other is suspended at a distance where the same aggregation remains undisturbed. No unambiguous behaviour differences were observed. (TROMSØ)

Measurements on encaged fish have been carried out for target strength - directivity studies as functions of insonifying angle and spatial distribution of the fish. (TROMSØ)

Fish behaviour in relation to seismic surveys has been studied to investigate the scaring effect on fish from airguns during three-dimensional seismic surveys (North Sea, block 34/7, summer 1984). The main conclusion is that fish partly migrate to the bottom and out of the surveyed area. (BERGEN)

Studies to evaluate the representativity of species and size compositions in trawl catches in relation to acoustic estimates in mixed species situations are being made. (TROMSØ)

Analysis of the herring swimbladder for use with the fish-sizing resonance model demonstrated a reduction in swimbladder volume with depth or ambient pressure. Both the depth and fat content of the fish, which is strongly correlated with the swimbladder volume, will affect the target strength in a manner that has yet to be quantified. Both daily and seasonal variations in the herring target strength are to be expected. (BERGEN)

Acoustic method

The Bergen contribution to the ICES-requested "Calibration Manual" is complete in its first draft. This contains detailed information on the performance of a standard-sphere calibration. (BERGEN)

A mathematical model of sound scattering from fish, based on the exact swimbladder shape, is in press (J. Acoust. Soc. Am.). Theoretical and measured target strength functions of tilt angle of the same fish are in good agreement. (BERGEN)

In situ target strength measurements have been collected on North Sea herring, spawning cod in the Lofoten area, and young cod and haddock in the Barents Sea using the new SIMRAD split-beam echo sounder. Plans for detailed studies of the herring TS-length dependence, including depth dependence, have been made. (BERGEN)

Work has begun on a multi-frequency sonar and integrator system for size classification and abundance estimation of zooplankton. (TRONDHEIM/HORTEN)

Pilot experiments for measuring the equivalent beam angle on hull-mounted transducers, both by tilting the transducer platform and by trimming the vessel when measuring a copper sphere, have been made. (BERGEN)

Egil Ona

PORTUGAL

During 1984, an experimental survey on R/V "NORUEGA" was carried out with two main objectives:

- 1) To study the distribution and to estimate the abundance of the sardine off the portuguese coast and its structure by age and length groups.
- 2) To study the diurnal variation in sardine behaviour and try to establish a conversion factor (day/night) to be applied on the integrated values.

This year we intend to go further in the study of diurnal behaviour of the sardine and try to get a statistic day/night conversion factor to be applied in future surveys.

There will also be a survey for the sardine distribution off portuguese coast and its structure by age and length groups during the recruitment season, and if possible to study the spatial distribution of blue whiting in order to know its availability to the estimation by acoustic methods.

SWEDEN

During 1984, Sweden has carried out three hydroacoustic surveys.

A joint Danish-Swedish survey on herring and sprat in the Skagerak-Kattegat area was extended to cover the Western Baltic. The survey area was stratified according to depth.

In the Baltic a joint survey with DDR and Polen was carried out. The target species were herring and sprat.

A pilot study on the possibility to use hydroacoustic technique to estimate the spawning stock of cod was started in 1983. Preliminary results from the 1983 survey indicate that one of the main problems in acoustic survey on this stock will be how to sample the mixture of cod, herring and sprat. A second survey was carried out in 1984 to further study this problem. Data from this survey are not yet analysed.

During 1984 a new integrator system was used onboard the Swedish research vessel ARGOS. The system includes echosounder EK 400 with 38 and 120 kHz and a NORD 10 computer for integration. The integrator programs are the same as used onboard Norwegian research vessels. The new acoustic system will also include the new split beam sounder ES 400 and a towed body.

CONTRIBUTED PAPERS

In contrast to the first meeting of the FAST Working Group last year when only a few papers were presented, the Working Group this year received 16 contributions. The material covered a wide range of topics and presented some difficulty in arranging for presentation by subject groups. The contributions are listed in the order presented:

1. Diurnal migration and feeding of blue whiting in the Skagerrack.
Paul Dengbo1 and Stein Munch-Petersen
- a pilot study for methods of measuring natural mortality by using acoustic data, illustrating that more than biomass estimates can be derived from acoustics.
2. Target strength of Baltic herring and sprat measured in-situ.
Hans Lassen and Karl-Johan Stackr
- emphasizing Danish workers' preference for direct measurement of target strength.
3. Field calibration of acoustic surveys for demersal fish using the dual beam ECOLOG.
L. M. Dickie, P. R. Budreau, and R. G. Dowd
- a method for the estimation of in-situ target strengths, fish lengths and abundance for demersal species.
4. Geostatistics applied to fish distribution as derived from acoustic surveys.
F. Gokin
- a method for using variograms to estimate the variance of acoustic abundance estimates.
5. The use of a digital echo-integrator to describe the echograms.
E. Marchal and F. Gerlotto
- more than acoustic abundance information can and should be derived from acoustic data.
6. The concept of acoustic population as an aide for biomass Identification.
F. Gerlotto and E. Marchal
- a number of criteria of acoustic data can be used to identify and separate species and populations for better biomass estimates.
7. Relationship between the forms of pelagic fish distribution and nictemeral periods, a tentative model of behaviour.
M. Azzali
- a categorisation of echo data into schooling, aggregation and dispersed distributions and a model to describe behaviour.
8. Target strength measurements of sand eel.
D. MacLennan
- results of experiments at Loch Duich suggest sand eels have target strengths of the same order of magnitude as mackerel.
9. Some observations of sound attenuation within schools of herring.
K. Olsen
- preliminary report of measurements of a well recognized but little known phenomenon
10. The estimation of acoustic abundance in a large aggregation of Herring.
U. Buerkle
- acoustic abundance varies with time by as much as a factor of 3.

11. Statistical analysis of a repeated acoustic survey.
K. P. Andersen and E. Kirkegaard
- due to systematic changes in fish behaviour, estimates of abundance vary with time by as much as 2 dB.
12. Target strength experiments in gadoids.
E. J. Simmonds
- more results in encaged cod at 38 kHz
TS = $-1.5 \log L - 25.4$. (weight norm. TS).
13. In-situ target strengths derived with a split-beam echo sounder.
K. G. Foote
- data indicate that split-beam technology may be the answer to in-situ target strength determinations.
14. Modelling fish target strengths.
K. G. Foote
- target strength-aspect functions have been calculated using mathematical models, results agree well with measurements in the same fish.
15. Some results from equivalent beam angle measurements of hull mounted transducers.
P. Reynisson
- a method for suspending a reference sphere from a ship and measurement results.
16. Preliminary tests on directivity of hull mounted transducers.
E. Ona
- used a suspended sphere and rolled the boat by shifting fuel to obtain athwartship directivity functions.

Discussion summary

The discussions following the various contributions dealt with a number of central problems in fisheries acoustics. In particular aspects of target strength measurements were discussed in relation to fish behaviour and new and improved methods of TS measurements.

Of great interest in TS work are the results obtained with a new split beam echo sounder equipment (Norway). The results show fair consistence with earlier TS measurements on gadoid species, but more species and wider size ranges of fish ought to be investigated.

The following result on TS/fish length relation on gadoid species was reported:

$$\bar{TS} = 20 \log \bar{l} - 66.8$$

where \bar{TS} is the mean target strength of gadoids of mean length \bar{l} (cm).

In situ target strength measurements made by dual beam systems (Scotland/Canada) have also provided new and promising results for discovering multi-modal TS distributions of mixed fish concentrations.

The still present discrepancies between results obtained with different methods and between old and new investigations, however, definitely shows the need for such work to be continued.

The present work on fish target strength, both observational and theoretical, is expected to benefit significantly from uses of the new acoustic transponding tilt-angle measuring tag under development at the Fisheries Laboratory in Lowestoft. Such a technique may contribute greatly to the problem of describing fish behaviour, as for example under passage of the survey vessel.

Target strength measurements of herring, following up the special topic on the former FAST muting, is now reported by the equation: $\bar{TS} = 20 \log \bar{l} + b$, where the constant b is currently estimated to lie in the range from - 73 to - 71 dB, probably on the particular survey condition, including depth and behaviour.

The work on modelling of fish target strength both including physical characteristics of fish (size, sw. bladder, condition etc.), behaviour and spatial orientation (Norway, Italy, France) is proceeding and the results so far are promising.

Interpretation of echo records may well be improved by use of rationalized statistics. Practical applications and computations within this formalism, more commonly used in geo-statistics, are awaited.

Improvements in the general acoustic method are also been sought through precise measurements of the equivalent beam angle. Formal reports on the new measurements, which are being performed in Iceland and Norway are expected at the 1985 Council Meeting.

CALIBRATION MANUAL FOR ECHO-SOUNDERS AND INTEGRATORS

The collaborative effort at Bergen and Aberdeen to produce a calibration manual is making good progress. Three preliminary reports have been produced and were distributed. The authors asked for review and comments from Working Group participants. The feeling was that the three preliminary reports did contain the information required in a calibration manual.

Discussion then centered on the format for a draft manuscript of the manual. In the reports presented the Bergen method and the Aberdeen method of calibration are presented separately from beginning to end. At the conclusion of discussion the Working Group proposed an outline plan for the manual format containing the following sections:

Introduction

Theory - in general terms

On axis sensitivity - Bergen
- Aberdeen

Equivalent beam - Bergen
- Aberdeen

Time varied gain - Bergen
- Aberdeen

Dynamic range - Bergen
- Aberdeen

Accuracy - overall

Intercalibration

This is thought to be a functional arrangement where potential users may refer to any particular section and see how it is handled at Bergen or Aberdeen. The Working Group requested the authors of the manual to produce a draft manuscript which is hoped to be finished at the ICES Council Meeting 1985.

RECOMMENDATIONS

1. The Working Group feels it is important to continue this work and recommends that the next meeting should be held in Hull, from 14-16 May, 1986 in conjunction with the FTFB Working Group meeting.
2. The Working Group recommends that the special topic to be discussed at the next meeting be species identification and size classification in relation to acoustic abundance estimation.
3. The Working Group recommends that sampling gear and behaviour problems in relation to acoustic surveys be the topic for a joint session with the FTFB Working Group.
4. The Working Group applauds the development of an acoustic tag to measure fish tilt angles by the Fisheries Laboratory, Lowestoft. It recommends completion of the work.

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