

THIS REPORT NOT TO BE CITED WITHOUT PRIOR REFERENCE TO THE COUNCIL (\*)

International Council for  
the Exploration of the Sea

C.M. 1987/B:34

Report of the Working Group on Fisheries Acoustic  
Science and Technology (F.A.S.T)

Seattle, USA 26-28 June 1987

(\*) General Secretary, ICES, Palaegade 2-4, DK-1261, Copenhagen K.,  
Denmark



1. Introduction

1.1 Participants

A list of participants is given as Appendix 1.

1.2 Terms of reference

In accordance with C. Res. 1986/ 2:7 the Working Group on Fisheries Acoustic Science and Technology met in Seattle on 26 and 28 June 1987 under the chairmanship of Professor K Olsen, following a Symposium on Fisheries Acoustics. The working group meeting considered in particular:

- a) methods for measuring fish target strength
- b) target strength values to be used in acoustic surveys of clupeoids and gadoids.

2.-3. Opening, Adoption of the Agenda and Appointment of Rapporteur.

The chairman welcomed all participants to the meeting and announced the agenda.

2. Opening session and general business.

3. Adoption of the agenda and appointment of rapporteur.

4. Progress Reports.

5. Discussion on fish target strength.

6. Fisheries Acoustics Symposium : Chairmans/Rapporteurs Reports.

7. Other Reports.

8. General Comments.

9. Recommendations.

On the proposal of the chairman, Mr R B Mitson of the Fisheries Laboratory, Lowestoft, England, was appointed as the rapporteur for the FAST WG meeting.

#### 4. Progress Reports

##### CANADA

Fisheries acoustic survey work in Canada is concentrated on the east coast in three Federal Government laboratories. Six annual surveys are done from the North East Atlantic Fisheries Center in Newfoundland; three on capelin, one on cod, one on redfish and one on inshore herring. One annual survey is done from the Biological Station at St Andrews, New Brunswick on the south west Nova Scotia herring stock. The results of all these surveys are reported to the Canadian Atlantic Fisheries Advisory Council for consideration in making management recommendations. Development work on equipment and methods consists of development of a dual beam system and a digital data editing system in Newfoundland; development of fish sizing methods from dual beam data and, under planning is an examination of trawl selectivity in Nova Scotia and development of a personal computer based acoustic system for the southwest Nova Scotia herring surveys in New Brunswick.

Support for an acoustic programme on the west coast has decreased in recent years and the future is uncertain.

##### DENMARK

###### Acoustic Surveys

The joint Swedish-Danish survey in division IIIa was conducted as usual in August-September 1986. The main target species is herring.

A survey for pelagic species in the Eastern part of the North Sea in August provided estimates for mackerel, horse mackerel, herring and whiting. This survey will be repeated for the third time in 1989.

An experimental survey for cod in the Bornholm Deep, subdivision 25 was conducted in March 1987. The data have not yet been analysed. The major problem with this survey is the relatively few cod (by number) compared to herring and sprat and hence the difficulty in finding a non-selective trawl. The echo-energy has a significant contribution from the cod however. This survey is a continuation of a pilot study made in 1985.

## Target Strength Measurements

The SIMRAD ES400 split-beam system makes simultaneous integration and TS-measurements possible and much effort has been directed towards establishing the relationship between these two types of data (see Degnbol and Lewy, 1987, Seattle).

The ES400 is sampled on the parallel output, thus passing the echo-selection algorithm and TS calculations. A PDPII/23 with a DMA interface and a specially designed address counter are used for collecting data after TVG and phase detection. The echo detection is then made in the PDPII/23 testing on consistency of the angles ran the front of the peak envelope.

Degnbol and Lewy (1987, Seattle) presented a procedure for obtaining TS distributions).

## Broad-band Analysis

The project was concluded in September 1986 and the results presented by Kjargaard et al. (1987, Seattle). The study demonstrates the complex nature of the back-scattered signal and indicates that there could be a change in the relative importance of the swimbladder as a scatterer compared to the skeleton size in relation to wavelength.

## FRANCE

Several research institutes are at present involved in acoustics. The activities of the six most important ones are summarized below in alphabetical order.

### 1. ICPI Lyons

- a) Refinement and development of a multi-beam wide band scanning sonar for use in rivers and lakes.
- b) Statistical analysis of wide band single fish echoes.
- c) Participation, in the framework of the EEC project "HALIOS", in the development of a wide-band echo-sounder.

### 2. IFREMER

- a) Leading the HALIOS project (part of the EEC Eureka project) in collaboration with Spain.
- b) Continuing acoustic surveys in the Channel and Gulf of Cascoigne, in cooperation with Spain.
- c) Finalising the development of a "data logger".

- d) Finalising the development of an "echo-classifier".
- e) Continuing studies of the avoidance behaviour of fish schools using hull mounted, and towed transducers and sonar.
- f) Development of an acoustic system to estimate the sizes of tuna schools concentrated under rafts (Fish Attracting Devices).

3. Institut National Recherche Agronomique (INRA)

- a) Continuation of acoustic surveys in Lake Geneva (Lac Lemman) and Lake Annecy.
- b) Development of survey methodology in the two lakes.

4. INSA (Institut National de Sciences Appliquées), Lyon  
Working on the classification of echoes.

5. ORSTOM (Institut Français de Recherche Scientifique pour le Développement en Coopération)

a) West Africa

- Continuation of acoustic surveys in cooperation with national institutes in Senegal and Mauritania.
- TS estimation in Senegal.
- Fish behaviour studies in Senegal.

b) Caribbean

- The work of the Caribbean Section (IFREMER/ORSTOM/VAG) started in September 1986, as far as acoustics are concerned (based in Martinique).
- The programme of technical support continues in Venezuela (cooperation with the La Salle Foundation).
- Methodological studies will start in 1987 in Venezuela.

c) France

Despite practical problems studies are continuing on the application of high frequency 200-400 kHz wide-band echo-sounders.

6. University of Paris 6

- Participation in the development of a multi-beam echo-sounder in the framework of the project HALIOS.
- Slowing down of the work on the hearing of fishes and luring by acoustic methods.

## Conclusions

The general tendency in France seems to be oriented towards a slight diminishing of acoustic surveys for abundance estimation, in favour of the development of new equipment (especially wide-band systems) and methodological studies (evaluation of the importance of fish behaviour on the estimation by acoustic methods).

## ICELAND

An acoustic survey was carried out in late summer 1986 on the juvenile capelin stock for early management prognosis. Routine acoustic surveys were carried out on the adult stock of herring and capelin in autumn and winter. An additional survey on the juvenile herring was also carried out last year.

An experimental survey of demersal fish, mainly cod and redfish, was conducted on the main fishing grounds NW and N of Iceland. Experienced trawler captains were onboard during the survey, giving valuable information regarding the survey area, fish behaviour, interpretation of echograms and so forth. It is believed that with more experience and effort, surveys of this kind could be complementary to groundfish surveys in the Icelandic area.

A pilot study of the behaviour of herring in different survey situations was carried out in February 1987. A stationary transducer was used to monitor the reaction of the herring to an approaching vessel. Recordings were made using different vessel speeds, with or without working lights. Vessel noise was recorded simultaneously, using a broad-band hydrophone.

Further measurements of the performance of the ES400 split-beam echosounder were carried out. Information available from the parallel data output of the ES400 was used to measure the compensated echo level throughout the beam, as well as the conventional beam pattern. Measurements on a hull-mounted split-beam transducer gave a considerably lower figure for the equivalent beam angle than quoted by the manufacturer. This is in agreement with results obtained by the 'geometric' method, in which the position of the calibration sphere is calculated from detailed knowledge of the geometrical arrangement of its suspension.

The building of a new and more spacious acoustic instrument room onboard RV Bjarni Saemundsson was completed in 1986. Plans are to rebuild the instrument room onboard RV Arni Fridriksson in 1988.

## NORWAY

Acoustics is being developed, refined or used as a fisheries research tool. Applications are listed.

### Aquaculture

Projects are being conducted to

- (1) determine how to estimate abundance of penned fish by resonance absorption,
- (2) estimate extensive production of cod, in which the unconfined fish is called to the feeding site by a low-frequency sound signal, and the proportion of returning stock is estimated acoustically,
- (3) evaluate reactions of penned fish to stimuli by a computerized system which displays density over a range of cells in the pen,
- (4) measure biomass in fry ponds in a study to estimate natural mortality,
- (5) observe feed wastage at automatic feeding stations in pens, and use such observations in a feedback loop to regulate the degree of feeding.

### Equipment

Two accomplishments concerning the new Simrad split-beam echo-sounder

- (1) extensive mapping of the transducer beam,
- (2) parallel logging of angle and sum-beam data at the full data rate.

Another related project is

- (3) measuring the influence of depth on the response of towed-body transducers.

### Fish scattering

Work is underway to

- (1) determine the extinction effect of schools,
- (2) isolate the effect of noise in the echo-integration equation, transferring the threshold effect from the mean backscattering cross-section to the sampling volume, alias equivalent beam angle,
- (3) measure target strength in situ by means of the split-beam echo sounder,
- (4) measure the depth dependence of target strength,
- (5) model the target strength of small cod on the basis of swim-bladder morphometry,



(6) size and estimate abundance of salmon in pens through resonance absorption.

#### Plankton scattering

(1) A multiple-frequency measurement system is in an advanced state of construction. This may be tested at sea for the first time this September.

(2) Work continues on modelling scattering by plankton.

#### Trawl selectivity

Acoustics are being used extensively in investigating and quantifying effects of trawl selectivity.

Some of this current work and results of other research are reported in contributions to the recent Symposium on Fisheries Acoustics. In one case, this involved a collaboration with a colleague at the Northwest and Alaska Fisheries Center, Seattle. The contributions are classified as follows:

#### Behaviour

Olsen, K. Fish behaviour and acoustic sampling.

#### Equipment

Brede, R. and F. H. Kristensen. A new portable echo-sounder for fishery research.

Brede, R., F. H. Kristensen, H. Solli and E. Ona. Target tracking with a split-beam echo-sounder.

Knudsen, H. P. A depth measurement system for towed bodies in fisheries research.

#### Fish target strength

Foote, K. and J. Traynor. A comparison of walleye pollack target strength estimates determined from in situ measurements and calculations based on swimbladder form.

Ona, E. Physiological factors causing natural variations in target strength.

#### Gear and behaviour

- Engaas, A. and O. R. Godø. Escapement of fish under the fishing line of a Norwegian sampling trawl and its influence on survey results.
- Engaas, A. and E. Ona. Day and night fish distribution pattern in the net mouth area of the Norwegian bottom sampling trawl.
- Misund, O. A. Sonar observations of the horizontal shape and swimming behaviour of herring schools.
- Ona, E. and K. Eger. Sonar observations of trawl performance.
- Ona, E. and O. R. Godø. Fish reaction to trawling noise: the significance to trawl sampling.

#### Plankton measurement

- Dalen, J. and K. E. Kristensen. Comparative studies of theoretical and empirical target strength models of euphausiids in relation to field experiment data.

#### Surveying

- Røttingen, I. Acoustic abundance estimates of 0-group Norwegian spring spawning herring, and their role in the management advice for rebuilding of this stock.
- Strømme, T. and G. Saetersdal. Variability of acoustic survey results as assessed from repeated coverages.

#### SPAIN

Since 1982 a series of acoustic surveys have been carried out to assess the sardine stock distributed in ICES divisions IVa and VIIIc.

In March and November 1986 two surveys were pursued to estimate abundance by age class and distribution in the spawning areas in the first survey and to assess the magnitude of the recruitment in the latest one.

At present, only the February-March 1987 survey has been carried out. There is a second one scheduled for October to obtain the recruitment estimates.

All the assessments since 1986 have been made using a split-beam system. In-situ estimation of target strength for sardine and horse-mackerel has also been essayed.

Spanish and Portuguese scientists met in a Planning group held in Uipo (Spain) in February 1987. Since the sardine of interest to Spain also extends along the Portuguese coast, the objective of the meeting was

to standardise the survey methodology as well as to define guidelines for the activity during 1987. The intercalibration of the acoustic gear in the vessels of both countries will be done at the end of the October 1987 survey.

#### SWEDEN

Acoustic surveys were carried out on the herring stocks in the Skagerrak-Kattegat and the most eastern part of the North Sea. The surveys that started in 1979 are carried out in cooperation with Denmark.

In the Baltic area yearly surveys have been carried out as an ICES coordinated survey since 1978. The results of this survey are used as both absolute and relative estimates of fish abundance.

A study using acoustic integration techniques to estimate the spawning stock of cod in the Baltic has revealed several methodological difficulties. These are related to the distribution of the cod and mixing with other species as well as different avoidance and herding between the species.

During ICES' Dateliners Experiment in the Baltic during Spring 1986 acoustic sampling and trawling were carried out along a predetermined transect both day and night over about 14 days. The objectives of the study are to compare spatial and temporal distribution of fish in relation to both biotic and abiotic parameters.

#### UNITED KINGDOM

##### ENGLAND

##### 1. British Antarctic Survey (Cambridge)

During the past year analysis of survey data gathered on krill around South Georgia and the Bransfield Strait was carried out. A computer design study for a new transducer towed body was completed.

Plans for the forthcoming year include a krill TS experiment at South Georgia, construction and field trials of the new towed body and comparison of EK400 results at 38 and 120 kHz.

##### 2. Fisheries Laboratory (Lowestoft)

The regular survey of spawning herring in the Central North Sea was continued and an extensive survey of plankton in the Celtic Sea was carried out in April/May 1987. Transducer calibration was carried out in the acoustic tank with the improved facilities which allow study and measurement of beam patterns.

A design for the measurement of fish tilt angle has been completed and the construction is underway. Cooperative field studies with the Institute for Marine Research in Bergen will be undertaken if the design is successful.

Delivery of the new research vessel CORYSTES has been delayed whilst the shipbuilders investigate problems with the propeller and noise from the propulsion motors.

#### SCOTLAND

Surveys of herring were carried out in the Clyde in spring and autumn and in the Orkney, Shetland and Buchan area in July 1986. The latter survey was in conjunction with the Norwegian research laboratories in Bergen. In addition a survey of herring and mackerel was conducted in November in ICES division IVa. During these surveys data were collected in individual sample format for each transmission and with 0.5 metres range definition.

Dual beam data on herring were collected during July in the Orkney, Shetland and Buchan area and in November in the Clyde.

Target strength work was carried out, at the Laboratory field station at Loch Duich on krangon (brown shrimp) with a length range of 6.4 mm to 14.8 mm with a mean of 9.4 mm. Data were collected at 38 and 120 kHz with a higher target strength at 38 kHz. The data have yet to be fully analysed because of doubts about the serial correlation because of the lack of movement of the shrimp in the cage.

Target strength data on single caged herring was collected using the dual beam system along with stereo photographs to provide position and angle information. This data has yet to be fully analysed relating fish orientation to measured target strength for a caged but free swimming fish.

The wide band system has been further developed to include swept frequency pulses from the transmitter. This system is now capable of producing 0.5, 1.0, 2.0, 4.0 pulses with a uniform spectrum from 27 to 54 kHz. Data have been collected from caged aggregations of cod, saithe, herring and mackerel and the results have been examined for use as a method of species identification. The experimental data from 8 experiments were used to provide mean spectra for each of the four species. The original echo data were then compared to these means, using a least squares comparison for 1000 and 100 independent sample sets. This showed an identification rate of 95% for herring, mackerel and the gadoids for

1000 samples dropping to 90% with 100 samples. The separation of cod and saithe was at the 90% level for 1000 samples and dropped to 72% with 100 samples. This system is showing considerable promise as a method of species identification.

Experimental measurements of a Simrad ES400 system using a copper sphere indicate deviations of  $\pm 3$ dB due to deviations of actual and required compensation functions with phase.

The work on the target strength of individual herring is continuing this year.

It is hoped to develop the hardware and software of the wide band system to make it suitable for use at sea.

Experiments are continuing on the extinction effects of dense fish aggregations.

## USA

Northwest and Alaska Fisheries Center, Seattle.

### Echo Integration Surveys

Acoustic survey efforts at the NWAFC are focussed on two species - walleye pollock (Theragra chalcogramma) and Pacific whiting (Merluccius productus).

In the eastern Bering Sea, surveys have been carried out in the Summers of 1979, 1982, and 1985, with biomass estimates of walleye pollock ranging from 8 to 12 million tonnes. The next survey will be carried out in 1988. We are in the preliminary stages of planning a survey of the spawning population in the eastern Bering Sea and Aleutian Basin in springtime 1988 or 1989.

In the Gulf of Alaska, surveys of the spawning stock of walleye pollock in Shelikof Strait have been carried out annually since 1980 (except 1982). The stock biomass was about 4 million tonnes and has decreased since that time to a level of only about 600,000 tonnes (apparently mainly due to environmental variation). At least one of the incoming year classes is well above normal and the biomass trend is expected to reverse within a year or two.

Off the west coast of the USA, Pacific whiting stocks have been surveyed in the Summers of 1977, 1980, 1983 and 1986, with biomass estimates ranging from 1 to 2 million tonnes. The next survey of this region is planned for 1989.

## Research

1) We expect to continue target strength measurements using the split beam/dual beam system in as many behavioural situations as possible.

2) During each survey that we carry out, we expect to make 1 to 4 standard target calibrations at all depths where we expect to use the transducer.

3) We are investigating the application of spatial statistics to survey design and error of abundance estimates.

## Hardware

1) We are currently having a new split beam transducer constructed by Biosonics. The new design should have less depth dependence system response.

2) We expect to convert our entire assessment system from Hewlett Packard-based to IBM-based. We expect to use the a pc-based board level integrator and dual beam processor, if they meet our requirements.

## 5. Fish target strength

A reminder was given of the terms of reference for the FAST WG and the reasons for its foundation. An important subject for the WG to consider is fish target strength and methods for measuring this. TS values are used in ICES stock assessment working groups as part of their deliberations and the acoustic estimates are used as an index of population size. Sometimes the latter are used to obtain total mortality rates.

A paper was presented by Dr Foote, on 'Fish target strength values for use in echo-integrator surveys'. Data were extracted from published information on independent measurements of tethered, caged and freely aggregated fish in addition to theoretical computations based on swimbladder form.

From in situ data the derived physoclist regression equation has a standard error of 2.3 dB which is most likely due to differences in species and behaviour. For physotome species (clupeoids etc) the SE is less (1.1) but the general equation appears to give TS-length values of the order of 0.7 dB lower than that currently recommended for use in ICES coordinated surveys of herring and sprat.

Discussion took place on the definitions of TS which apply in different circumstances, for example, mean values are needed for echo-integrator surveys but maximum values are derived from many experiments.

In the WG discussions of this subject strong evidence has been presented for accepting a general "20 log l" (l = fish length) dependence in the TS-length regression equation. More concern has therefore been given to the question of obtaining a precise intercept. When establishing TS equations based on in-situ measurements there seems to be a need to define the scope of the TS equations to indicate, for instance, if measurements were made by day or night and in what area. It may be necessary to emphasise that TS is not a fixed value, because of physiological changes with depth and that the same fish in different waters may have a different TS.

There is also a need for all groups working in the field to write down their methods and procedures for taking TS measurements. The present assumptions regarding the equivalent beam angle may need to be examined

and the actual sampling volume defined relative to size of target and noise level.

Due to non-standardised methods there are still problems in comparing surveys from different areas partly because of different methods of data collection and processing. Procedures are given in FAO Report 240 but these may now need some revision or updating. The use of the echo-integration technique plus survey design might be a worthwhile subject for a manual in the future.

An example of this difficulty is that the RV Dr Fridtjof Nansen has had to use one value of TS for all fish during surveys in recent years. Now, however, it should be possible to use the split-beam system to determine TS during the course of surveys in each area.

A situation where dual-beam/split-beam techniques cannot be used occurs during the survey of tightly packed schools where there are no stragglers on the edges. When this happens an equation should be available to fall back on. If countries do not have the facilities to make their own TS measurements they should use the (derived) values in Dr Foote's paper to this meeting.

In general efforts should be concentrated on making in-situ measurements as these seem to give the most relevant results.

## 6. Fisheries Acoustic Symposium: Chairman's/Rapporteurs Reports

The symposium session chairman/rapporteurs who were present for the FAST meeting gave brief reports.

### 6.1 Fish Behaviour and Acoustic Sampling

Further evidence was given of the avoidance by fish of certain vessels. Catch efficiency is related to noise, the quieter vessels having higher catching power. Surveys may also be biased by biological factors. In some circumstances deck lights also cause avoidance reactions.

Because of the variable efficiency and bias of trawl sampling the results of trawling must be used with care when relating to acoustic measurements. Sampling strategy is difficult when the distribution is patchy.

A variety of techniques were described for obtaining detailed information on behaviour studies.



## 6.2 Fish Behaviour/Physiology and Target Strength Measurement

A point worth following up is the suggestion that there will be gas in parts of the fish other than the swimbladder. The overall gas volume will change with depth. Condition factor and fat content are also important.

In considering fish densities a nearest neighbour distance is required, related to fish length.

## 6.3 Calibration

The small number of papers perhaps reflect the fact that the subject is now well recognised and understood. Work presented was all in line with accepted methods with further emphasis on the difficulty of measuring hull-mounted transducer from beneath research vessels.

## 6.4 Acoustic Estimation of Zooplankton Abundance

In addition to the symposium session a special meeting on krill assessment was held. From this emerged the need for a reliable TS. Methods to obtain this were discussed, including cage measurements and models which it is believed may help to provide quantitative information. Different species of zooplankton require different models but there is difficulty in measuring density and sound speed contrasts of living organisms.

In-situ measurements are needed by adaptation of split-beam, dual-beam techniques with different pulse length criteria to those set for fish.

## 6.5 Target Strength Measurements and Techniques

Dual-beam and split-beam methods are becoming routine. Three points emerged in relation to dual beam measurements,

(a) there may be problems when sensing TS in the vicinity of nulls in scattering directivity patterns,

(b) symposium paper 029 showed differences between the models of fish target strength to fish length obtained from the author's data, to those reported elsewhere.

The explanation put forward referred to interaction of the fish beam pattern with the dual-beam transducer pattern and that, directivity correction for the latter is based on the response of an ideal sphere, which may not be appropriate for fish. No agreement was reached on this matter but it is considered essential for the situation to be clarified.

(c) the performance is distinctly worse than split-beam when noise is present.

Target strength versus tilt angle is an important problem for many species including walleye pollack. Tropical species pose special problems in relation to TS measurements.

There was concern at the presentation of caged fish experiments without the support of related behaviour studies.

#### 6.6 Species Identification

Some possible major advances were evident in the papers. Under wide-band conditions, achieved by non-linear and linear systems, several species of fish were studied in a variety of experiments. Despite the low efficiency of non-linear systems it appears that detection is possible at practicable depths, for some fish stocks, by this technology.

School classification was shown by discriminant analysis and the identification of schooled species is sufficiently encouraging for work to continue. Ground truth data are obtained, not to test, but to help analysis.

#### 6.7 Survey Design and Data Analysis

Patch discrimination is needed to identify acoustic populations. One paper showed a consistency of survey results which were particularly good.

There was a controversial paper on common misconceptions in survey design which should keep statisticians busy for sometime.

The necessity of ensuring that all points are surveyed with the same degree of probability was emphasised.

#### 6.8 Other Symposium Matters

An unusual application was the survey for clams which highlighted an increasing interest in detecting and measuring close to the bottom.

A transducer with a flat top beam pattern response was said to suffer from low source level and lack of depth compensation.

Only one paper at the symposium linked acoustics to the management of fisheries.

Despite its increasing importance there was only one paper on squid.

## 7. Other Reports

### 7.1 Report from Australia

#### Tracking Studies

A meeting was held in Sydney during May 1987 to discuss the tagging of animals in Australia. Amongst the techniques being used are electromagnetic tags for lobsters and crabs and acoustic tags for rock lobsters. Departments involved are the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Fisheries, Deakin University in Melbourne and a group in Queensland.

There is a need to check the hypothesis relating to the migration of Southern Bluefin tuna. CSIRO has partly funded a feasibility study at the Lowestoft Laboratory on a pop-up tag which would give its position via satellite having become detached from the fish at a pre-determined time.

#### Acoustic Survey

A stock of orange roughy estimated to be at least 100,000 tonnes is located off Tasmania and is to be managed. The Antarctic Division of CSIRO is interested in the survey of krill.

In Australian aquaculture of fish there is an urgent need for the estimation of numbers and size.

## 8. General Comments

Comments were made about problems of depth effects on transducers. These are thought to be due to pressure release material used at the rear, or cavitation through applying too much power when the transducer is at a shallow depth.

It seems that an investigation may be needed of the ambiguity in fish species which cannot compensate adequately when diving. Clupeoids exhibit artificial depth excursions.

Although the analysis is not yet complete some comparative results of 38 and 120 kHz measurements on krill were presented. The MVBS showed a constant difference of about 20 dB below 100 m depth (the 120 kHz TVG stops at 100 m). Different beam angles were used so the near surface results could be expected to be different.

The calibration manual (ICES Coop. Res. Rep. 144) has been published.

## 9. Recommendations

It is recommended that the work of the group is continued at a meeting in Ostend during 20-22 April 1988. A joint session would be held with the Fish Capture Group on 20 April.

The working group recognises a difficulty in making specific recommendations for the target strength of clupeoids and gadoids at this time. This is because new measurement technology and techniques are being introduced and are undergoing intensive assessment. The WG therefore recommends no change in the currently applied TS for clupeoids and gadoids at present.

It is recommended that the WG should continue the study of fish target strength, including methods of measurement at the next meeting.

Acoustic survey design and data analysis for stock estimation purposes should be considered at the next meeting.

Zooplankton research by means of acoustics is recommended for inclusion amongst the topics relevant to the FAST working group.

Appendix 1. List of Participants in the FAST Working Group

|                |   |   |                                      |
|----------------|---|---|--------------------------------------|
| Australia      | F Harden Jones  | Hobart  | Observer                             |
| Canada         | U Beurkle<br>P Boudreau<br>L Dickie<br>D Miller                     | St Andrews<br>Dartmouth<br>"<br>St Johns                  |                                      |
| Denmark        | P Degnbol<br>E Kirkegaard<br>H Lassen                               | Hirtshals<br>Charlottenlund<br>"                          |                                      |
| France         | J Levenez<br>M Zakharia   | Dakar<br>Lyon   |                                      |
| Iceland        | P Reynisson   | Reykjavik   |                                      |
| Italy          | S Venema  | FAO Rome  |                                      |
| Norway         | J Dalen<br>K Foote<br>K Olsen<br>E Ona<br>A Knudsen<br>K Kristensen | Trondheim<br>Bergen<br>Tromso<br>Bergen<br>"<br>Trondheim | Observer<br>"                        |
| Spain          | C Porteiro  | Vigo  |                                      |
| Sweden         | O Hagström  | Lysekil   |                                      |
| United Kingdom | I Everson<br>D MacLennan<br>R Mitson<br>E Simmonds                  | Cambridge<br>Aberdeen<br>Lowestoft<br>Aberdeen            |                                      |
| USA            | W Karp<br>J Traynor<br>N Williamson<br>C McClain                    | Seattle<br>"<br>"<br>"                                    | Observer<br><br>Observer<br>Observer |

