International Council for the
Exploration of the Sea

CM 1993/B:3
Fish Capture Committee ref H

# REPORT OF THE WORKING GROUP ON FISHERIES ACOUSTICS SCIENCE AND TECHNOLOGY

Gothenburg, Sweden, 21-22 April 1993



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## 1. Introduction

### 1.1 Terms of Reference

In accordance with C Res 1992/2:10 the Working Group on Fisheries Acoustics Science and Technology (Chairman: Mr E J Simmonds) met in Gothenburg, Sweden from 21-22 April 1993 to:

a) Consider the progress in methodology in fisheries and zooplankton acoustics;
b) Review the progress of the study groups on Target Strength Methodology and Research Vessel Noise Measurement.

### 1.2 Opening of the Meeting

The chairman opened the meeting and introduced Dr Carlson, who welcomed members of the working group to Gothenburg on behalf of the Institute of Marine Research.

### 1.3 Order of the Day and Appointment of Rapporteur

The agenda was adopted. D G Reid of the SOAFD Marine Laboratory, Aberdeen, Scotland, was appointed as rapporteur.

## 2. Presentation of Report from the Study Group on Research Vessel Noise Measurement (Chairman Mr R Mitson, UK)

### 2.1 Terms of Reference: ICES Resolution C Res 1992 2:12

"A Study Group on Research Vessel Noise Measurement will be established under the chairmanship of Mr R Mitson (UK) and will meet in Gothenberg, Sweden on 19 April 1993 to specify and summarise available information on the essential noise requirements for Research Vessels with a view to recommending measuring procedures."

### 2.2 Report on Preliminary Findings

A report on the findings to date of the vessel noise study group was presented. It was considered important to reduce noise for two reasons:

a) Instruments can work more effectively - A high level of noise requires an increase in operating threshold and thus reduces the dynamic range for measurement;
b) Increases effectiveness of trawl and acoustic surveys - as noise scares fish!

The main sources of vessel noise are:

High frequency noise - from propeller and water flow - affects instrument performance
Low frequency noise - from propeller, engines and water flow - may scare fish

Underwater radiated noise may be important for fish but it is unclear which are the main characteristics, they could be:

a) Overall pressure level
b) Tones (high levels at a single frequency)
c) Pressure gradients
d) Transients
e) Solitones

Fish Reaction

Some information is available on fish reactions to vessel noise. This suggests that, for instance; a smoother frequency spectrum can improve catch performance. After the *Thallasa* was re-engined she produced high noise levels and had reduced catches. Unfortunately there was no information on the earlier engines. Other problems are caused by the different hearing patterns between fish species and size groups of the same species.

Specific Effects on Acoustic Surveys

a) Fish may be scared away;
b) Propeller noise due to cavitation within bandwidth of sounders, esp 38 kHz.

Methods of Measuring Noise Signatures

Most accepted methods of measuring noise performance are naval in application. It was recommended that noise signatures should be available for all fisheries research vessels:

- Frequencies covered should range from 1 Hz-100 kHz.
- A hydrophone should be selected with adequate range and sensitivity.
- Range from vessel to hydrophone should be measured precisely, to a resolution of 1 m with a minimum range of 50 m. Depth for measurement should be greater than 40 m.
- Ideally measurements should be taken over a wide range of speeds and loadings, especially with variable pitch propellers.
- An optimum noise performance should be defined and all subsequent tests taken against this.

Recommendations

It is recommended that the EK500 should be used in passive mode to measure noise as a routine part of calibration.

It was strongly recommended that a list of vessels for which noise signatures existed should be compiled, along with the conditions and constraints of those tests, plus vessel details, power propeller etc.

A bibliography on the subject should be compiled.

It was also strongly recommended that a mailing should be sent to all operators of fisheries research vessels (and potential charter vessels) for details of existing noise data.

## 3. Presentation of Report from the Study Group on Target Strength Methodology (Chairman Mr E Ona, Norway)

### 3.1 Terms of Reference: ICES Resolution C Res 1992 2:11

"A Study Group on Target Strength Methodology was established under the chairmanship of Mr E Ona (Norway) and will meet in Gothenberg, Sweden on 19 April 1993 to prepare a report, with a view to publication in the ICES Cooperative Report Series on the methodology for Target Strength measurements with special reference to in situ techniques for fish and micro-nekton."

3.2 The study group has produced an outline of the structure of the report. The time table for the completion of the report will be:

First draft: September 1993
Final draft: April 1994
Finished report: September 1994

The document outline is included below:

### 3.3 Outline of Report from the Study Group on Target Strength Methodology

1. Introduction

2. Definitions and terms

3. Single Beam echo sounders
3.1 Principle
3.2 Calibration
3.2.1 On axis sensitivity
3.2.2 Acoustic beam
3.3 Removal of beam effect
3.4 Effect of noise and thresholds involved
3.5 Example in detail

4. Dual Beam echo sounders
4.1 Principle
4.2 Calibration
4.2.1 On axis sensitivity
4.2.2 Acoustic beam
4.3 Removal of beam effect
4.4 Effect of noise and thresholds involved
4.5 Example in detail

5. Split Beam echo sounders
5.1 Principle
5.2 Calibration
5.2.1 On axis sensitivity
5.2.2 Acoustic beam
5.3 Removal of beam effect
5.4 Effect of noise and thresholds involved

5.5 Example in detail

6. Biological sampling
6.1 Recommended biological measurements
6.2 Discussion of sampling errors

7. Brief summary of other methods, integration and catch controlled experiments and analytical methods

8. Specialised measurements
8.1 Tracking
8.2 Multi-frequency methods
8.3 Deep water towed vehicles/transducers

9. Discussion/Recommendations
9.1 Comparisons
9.2 Identified future research

## 4. Plenary Session on Methodology in Plankton and Fisheries Acoustics

The papers fell into two main categories, progress in target strength studies and developments in survey methodology. These topics provided a lively opportunity for discussion and debate.

### 4.1 Target Strength Studies

#### 4.1.1 Reynisson, P. *In situ* target strength measurements of Icelandic summer spawning herring, 1985-1992

This paper reports on the measurement of *in situ* target strength of Icelandic summer spawning herring using split-beam echosounders (Simrad ES-400 and EK-500), collected by three different techniques; serial and parallel data for the ES-400 and serial data for the EK-500. The mean values (and 95% C.I.) for the constant $b_{20}$ were respectively -67.2 (0.5), -66.9 (0.9) and -66.7 (0.3), with -67.1 (0.3) for all techniques. Slightly higher mean values were found either at full cruising speed or trawling speeds than drifting or intermediate speeds. A trend towards lower TS with higher fat content is indicated, a reduction of approximately 0.2 dB for 1% increase in fat content. The authors conclude that the differences can only slightly be ascribed to the different techniques.

#### 4.1.2 Carrera, P., Miquel, J. and M Iglesias. *In situ* target strength measurements. preliminary data of sardine (*Sardina pilchardus* W.) from the Mediterranean Sea

During the pelagic fishing stations of the acoustics survey "Ecomed 91" and "Ecomed 92", carried out in November 1991 and 1992, series on sardine TS were collected using a SIMRAD EK500 38 kHz split-beam echosounder and echointegrator. Only data with similar features in bottom depth, trawling depth and percentage of capture were used. The least-mean-square regression of mean TS on the logarithm of the mean fish length of the form TS = mlog (l) +b was finally applied to 11 data series giving m = 29.73 and b = -74.08 with $r^2 = 0.94$ or, requiring that m = 20, b = -63.34, which is higher than others

to similar species but close to the Love's one. This could be explained for the trawling depth or for the short range of length analysed.

4.1.3 Ness, H. A practical procedure for measuring the maximum target observation range

A traditional echosounder includes a time-varying-gain receiver where the gain is varied in such a way that it just compensates for the path loss at each range. Targets of identical size at different depths should appear as electrical pulses of identical amplitude at the receiver output. However, the gain of a practical receiver is limited to some finite maximum implying that correct compensation for path loss cannot be maintained below a certain maximum depth. Below this maximum depth a target will appear smaller than its real size. Another effect of finite gain is that the background noise floor is never sufficiently amplified to become visible on the display.

The EK500 scientific echosounder uses a different scheme. The receiver merely functions as a power meter with a very large instantaneous dynamic range. Whatever signal level is present at the transducer terminals is just digitised and input to a signal processor CPU performing compensation for path loss in software. Clearly, a finite receiver gain is no longer a limiting factor when performing path loss compensation. Figure 2 illustrates the processing of signal amplitude by the EK500. Correct path loss compensation is performed for targets at all ranges, and the background noise (ambient + receiver noise) floor appears on the display as coloured bands below a certain depth. At first glance therefore the EK500 looks like a "noisy" sounder. However, the EK500 displays the noise that is actually present whereas a traditional sounder just hides this noise. Figure 3 shows echogram printouts for three different vessel speeds.

## 4.2 Survey Methodology

4.2.1 Godø, O.R. and Totland, A. Application of ts- measurements in routine surveys for gadoids

The use of the acoustic methods in abundance estimation of fish is in most cases dependent on trawl catches for transferring acoustic densities to fish abundance. Numerous papers have in recent years been presented to the FAST and FTFB working groups, which describe the serious problems connected to representative sampling. Size and species selection during the catching process and horizontal and vertical distribution introduce considerable uncertainty to the real distribution and composition of fish. Inaccurate sampling will affect the acoustic estimates similarly in the conversion of acoustic density to fish abundance. Therefore, any method which can improve, or reduce our dependency, of trawl sampling should be studied. In recent years studies of target strength distribution of fish has become increasingly important in this respect.

The authors have done some initial studies of target strength measurements to evaluate the possibilities for:

a) Estimation of length distribution;
b) Observing changes in fish size along cruise tracks based on averaging TS under different criterions.

All analysis are based on data collected during routine surveys for cod and haddock in the Barents Sea, and the aim is to improve routines and analysis of data from these surveys.

4.2.2 Mitson, R.B. Results from a two-frequency survey of plankton and fish in the Irish Sea

Data were collected from echosounders working at 38 and 120 kHz during a transect from west to east across the Irish Sea. The MAPS (Holliday and Pieper, 1984) using 21 frequencies from 100 kHz to 10 MHz, was also deployed at intervals along the same transect. Thus there is some interest in looking at data which were obtained continuously from the two low frequencies between the sampling stations to see how they might complement MAPS data.

A two-frequency method of analysis was used and the results for each integrated layer are presented in the paper. It seems that the two-dimensional distribution of the different size classes was very patchy. Data from an ES400 split-beam echosounder were also processed and there is a close correspondence between the two data sets where a limited but useful overlap of organism size occurs.

4.2.3 Masse, J. and Retiere, N. A study area prospected during the acoustic survey DAAG92

A French acoustic survey (DAAG92) was carried out in the Bay of Biscay from 13 to 30 April 1992. Eight transects were covered in a 64 square mile area and eight pelagic hauls made. The data were analysed for biomass in six different combinations to study the effects of different sampling regimes on the global biomass estimate. The authors conclude that:

a) An increase in the number of transects does not increase the accuracy of the global biomass estimate.
b) The position of the hauls in the area has a greater effect on the estimate by species than the number of hauls.
c) The variability of biomass estimates increases when species such as mackerel or sardine (rather than anchovy) are considered.

4.2.4 Lebourges, A., Marchal, E. and Roger, C. A biological structure favourable to tuna concentration underlined by acoustic methods

This paper considered the underlying environmental factors controlling tuna distribution. Tuna, observed by acoustic techniques (Simrad EK 500) were observed to concentrate in the same depths as the majority of the micronekton. During the day the micronekton were restricted to the bottom areas. At night the micronekton were found concentrated under the thermocline (usually at between 300-400 m) and were thus available for tuna predation. The relationship between the hydrography of the area, the behaviour of the principal micronekton species and the tuna was discussed.

4.2.5 Reid, D.G., Morrison, J. and Simmonds E.J. Identification of herring spawning grounds by side-scan sonar and image analysis

Herring spawning grounds in many areas are characterised by gravel ripple structures. These gravel beds usually consist of ridges about a metre apart and up to 30 cm deep. Side scan sonar has been successfully used for the location of such spawning grounds in the Clyde estuary for many years. To date the analysis of such echograms has been carried out by eye. The characteristic signature of these beds is, however, an ideal subject for analysis using advanced image processing techniques.

The authors outline an analysis technique using convolution filters which are designed to highlight short-order changes in the echogram. Further image processing techniques are then used to clean up the image. The echo from each transmission is recorded digitally along with time and location (from GPS navigation equipment). When an area of gravel ripples is identified by the above analysis technique, the exact position is recorded in a database, this can then be used to prepare a map of the surveyed area. Previous techniques for mapping this type of spawning ground required the vessel conducting the survey to maintain a constant speed and course, the paper records of the echogram were then assembled to produce the map. The map constructed by the technique described will be independent of the survey vessel's speed or exact course.

4.2.6 Simard, Y. Effects of ESDU size in estimation and mapping of acoustic survey data from geostatistics

The use of classical statistics is limited for the analysis of acoustic populations due to the presence of auto-correlation in the stock. This is usually avoided by using relatively large elementary distance sampling units (EDSU) to remove auto-correlation, however this reduces the resolution. Geostatistics uses the structure of the population and can lead to increased precision, and so requires an EDSU small enough to allow appreciation of the auto-correlation. This paper considers the question of whether EDSU size affects the mapping of the stock and the precision of the biomass estimate, using an example from capelin surveys in the St Lawrence Gulf. The author concludes that EDSU size is not very important in mapping and that the averaging distance used is important. Also EDSU size does not affect the variance estimate when using truncated data (with the effects of skew removed) although there is a small effect when using raw data

4.2.7 Simmonds E.J. Survey Strategies for structured populations part II: Precision of variance estimates

The interaction between survey precision and survey strategy was examined by simulation by Simmonds and Fryer (1992; CM 1992/D:24). They concluded that for surfaces with local positive correlation more precise estimates of the surface mean can often be obtained using stratified random or systematic sampling rather than uniform random sampling. The increase in precision depends on the relationship between spatial correlation and sampling intensity and the region to be sampled. Examples of the effects of different strategies were given for herring populations in the Orkney Shetland area of the North Sea. These indicated decreases in error variance of between two and six times as the strategy was changed from uniform random to systematic with the same effort. It was pointed out that the final choice of strategy depended on the objectives of a survey. The decision may depend not only on the need to estimate the mean but also the need for an estimate of the precision of the mean. This paper provides some insight into the

comparative performance of some methods for estimating variance and the impact of different sampling strategies on this process.

Methods

Simulation of surfaces with a range of statistical properties have been carried out. The surfaces contained elements of local positive correlation, random components and non stationary components. The proportions of these components were varied in order to study the effects of different situations. The local spatial correlation was generated using an auto-regressive function with a variable correlation coefficient $\alpha$ for different conditions. The random component was derived from a independent random number generator. The non stationary component was derived from an autoregressive function with $\alpha$ of 1. For each type of surface 1,000 examples were produced.

Eight different sampling strategies were implemented with a sampling intensity similar to the surveys (40 transects). The sample strategies were:

| | | |
|---|---|---|
| 1. | 40 Transects Uniformly Randomly Located in 1 Stratum | (40/1) |
| 2. | 20 Transects Uniformly Randomly Located in 2 Strata | (20/2) |
| 3. | 10 Transects Uniformly Randomly Located in 4 Strata | (10/4) |
| 4. | 5 Transects Uniformly Randomly Located in 8 Strata | (5/8) |
| 5. | 2 Transects Uniformly Randomly Located in 20 Strata | (2/20) |
| 6. | 1 Transects Uniformly Randomly Located in 40 Strata | (1/40) |
| 7. | 40 Transects with Systematic Spacing and a Random Start | (Sys-Rand) |
| 8. | 40 Transects with Systematic Spacing and Centred | (Sys-Cent) |

From the 40 samples from each strategy the variance was estimated by:-

1. Sample variance

2. Pooled within strata variance (using within strata variance for all strata with two or more samples, and sample pairs for the last three strategies with only one sample per strata.
3. Geostatistical estimation variance using a spherical model with nugget fitted using a least squares fitting procedure by iteration.
4. Geostatistical estimation variance using an exponential model with nugget fitted using a least squares fitting procedure by iteration.

The fitting procedure was carried out using the variogram with pooled samples in 39 intervals weighted by the number of samples per interval and using the calculated mean range of samples within the interval. The results of this were indistinguishable from the fit to the cloud of 780 sample pairs obtained from 40 data values, however it was computational much faster. The fitting procedure was by iteration successively minimising least square error for nugget, range and sill.

In addition to the estimates of variance the sample means were also collected to estimate the real or true error variance and to check for bias.

The variogram of the complete simulated surfaces was also computed to provide a check on the statistics of the surfaces.

From the 1,000 values of variance for each strategy and each method it is possible to obtain mean median and 90% intervals for variance for the different strategies by the different methods. The lower 90% interval, the median and upper 90% interval are obtained by sorting the variance estimates and selecting those in locations 50, 500 and 950 from the 1,000 estimates. These values of variance can be compared to the true error variance obtained from the estimates of surface mean.

Results

The variograms for several of the simulation were shown along with variograms derived from mean and median values of nugget, range and sill. The final simulations were carried out using surfaces which represent something similar to the models derived from data collected on North Sea herring surveys

In all cases the results are generally similar. The Uniform Random strategy, has the highest variance. The variance decreases monotonically to the systematic centred strategy to the right of the graph. The Variance estimators show similar results for each surface type.

The sample variance showed an almost constant value with a slight rise from left to right, the interval is widest for the uniform random strategy decreasing slightly with increasing order in the survey.

The pooled variance estimate follows the true variance quite closely in almost all cases from 40 transects in one strata to two transects in 20 strata, the last one for which this is strictly valid. For subsequent strategies the estimate of variance increases, this is similar to the behaviour of the overall sample variance. In these simulations the 90% intervals reduce as the strategy becomes more ordered until the number of transects per strata reduces to two.

## 5. National Reports

National representatives presented the reports of activities. This provided a good basis for discussion of work in progress in different institutes. The progress reports are included in Appendix A.

## 6. Working Group Recommendations

The Working Group made the following recommendations:

6.1 The Working Group recommends that its next meeting be held in Montpellier, France on the 28-29 April 1994. The Working Group will:

a) Review the progress of the study groups on Target Strength Methodology and Research Vessel Noise Measurement.

b) Consider the combination of information obtained from fishing samples and the acoustic measurements in the estimation of abundance, with the aim of identifying the source and magnitude of errors.

6.2 The Working Group also recommends that a joint FTFB-FAST Session meet for one day (27 April) under the chairmanship of G Arnold to discuss two topics:

a) To consider techniques to describe and quantify the behaviour of fish and micronekton ahead of, and in the mouth of trawl nets and plankton samplers, and to measure the related gear geometry.
b) To consider the applications of acoustic methods of seabed classification to fisheries investigations. With special regard to calibration, ground-truthing, repeatability, analysis and interpretation.

6.3 The Working Group recommends that the study group on Target Strength Methodology (chairman Mr E Ona, Norway) will continue to work by correspondence in 1993 and will meet to discuss and edit the report on Methodology for Target Strength Measurements with special reference to *in situ* techniques for fish and micro-nekton in Montpellier, France on the 28-29 April 1994. The study group will report the progress of the report to the FAST Working Group.

6.4 The Working Group recommends that the study group on Research Vessel Noise Measurement (chairman Mr R Mitson, UK) will continue to work by correspondence in 1993 and will meet to discuss and edit the report on the essential noise requirements for research vessels with a view to recommending measuring procedures in Montpellier, France on the 28-29 April 1994. The study group will report the progress of the report to the FAST Working Group.

6.5 The Working Group strongly recommends that all countries forward vessel noise data for vessels used in their research to the chairman of the Research Vessel Noise Measurement study group:

R Mitson
5 Gunton Avenue
Lowestoft, Suffolk
NR32 5DA, United Kingdom

6.6 The Working Group recommends that a workshop be held for acoustic technicians on exchange of ideas and information on practical/technical questions in connection with using hydroacoustic instrumentation. Subjects could include:

a) Selection of cable type
b) Terminations and slip-ring units
c) Practical aspects of calibration and general maintenance

## 7. Closure

The chairman thanked the host institute for their hospitality and thanked the members of the Working Group and study groups for their efforts and contributions.

# APPENDIX A. NATIONAL PROGRESS REPORTS

## A.1 CANADA

### NW Atlantic Fisheries Centre, St John's, Newfoundland

The group continued its strong commitment to acoustics research and application of the methodology to stock assessment of capelin, herring, cod and redfish. Research focused on enclosure experiments on cod target strength/length relationships and the effect of fish behaviour and directivity. Target strength experiments at sea involved two vessels over a 20 day period. Enclosure and *in situ* target strength experiments were also carried out on herring. Acoustics was used in an experiment to examine the effect of trawling on spawning cod. Two cruises were carried out to map and track cod migration using acoustics. Target strength and species identification research was carried out during one of these cruises. Further *in situ* target strength work on cod and capelin included 40 days of continuous tracking of northern cod migration; and 10 days continuous observation of a cod spawning school. Target strength-length relationships were determined for cod (15-60 cm) at 120 and 38 kHz and directivities measured at both frequencies.

A total of eight acoustic surveys were conducted for the purpose of fish stock assessment. Two surveys (120 kHz) were carried out to estimate herring abundance in four of the five stock complexes in the Newfoundland region. Three surveys were conducted for capelin (49 kHz) covering NAFO Divs 2J3K, 3L and 3NO. These surveys continued to show low capelin abundance in Divs 2J3KL. Two surveys (38 kHz) were carried out in order to assess cod in NAFO Divs 2J3KL and a further acoustic survey was conducted on redfish in NAFO Divs 3P, 4V and 4R.

As a result of the Northern Cod Science Programme workshop held in 1991, the region developed plans for standardising on 38 kHz dual beam equipment for offshore groundfish and capelin work and commenced a programme of procurement, development and implementation which will continue into 1994.

### Maurice-Lamontagne Institute, Mont-Joli, Québec

Two acoustic cruises were conducted in the Gulf of St Lawrence using a Biosonics 102 (38 and 120 kHz, dual beam) and a HDPS-9001. The first studied cod migration in Cabot Strait during the ice break-up, and the second was dedicated to the dynamics of capelin and krill aggregations in the Jacques-Cartier Passage in summer. Exploration of geostatistics for mapping and estimation was pursued. Two surveys explored the possibilities of using the ROXANN acoustic bottom-typing system for benthic fauna; results appear promising for species associated with sand substrate. Two other cruises using a 120 kHz EK500 and a HDPS-9001 were dedicated to studies on mackerel migration and distribution in the Gulf of St Lawrence in relation to environmental conditions.

### Bedford Institute/St Andrews Biological Station (DFO Scotia-Fundy)

Acoustic information continued to be collected during standard groundfish trawl surveys on the Scotian Shelf, and during special inshore trawl surveys covering traditionally unfished hard bottoms. Data is collected during sets and while steaming between

stations. The acoustic data will be compared to trawl catches in order to evaluate the feasibility of integrating acoustic and trawl catches in abundance estimates.

The annual Chedebucto Bay herring survey was conducted in January 1993, and preliminary estimates indicate low abundance as per last year.

### Freshwater Institute, Winnipeg, Manitoba

A hydroacoustic study of the spawning migration of broad whitefish (*Coregonus nasus*) in the Arctic Red River, Northwest Territories, was initiated. River profiles were examined to locate suitable sites for a Simrad fixed location, split-beam hydroacoustic system. This newly purchased equipment will be in place in the fall of 1993. Preliminary data on the acoustic size of broad and lake whitefish at various aspects was collected. An imagining sonar system (Imagenex Corp) was tested and determined to be valuable in providing an "acoustic screen" across the entire river profile and quickly rendering a visual record of fish traffic.

### Pacific Biological Station, Nanaimo, British Columbia

A joint Canada/USA survey was conducted on the transboundary hake stocks. Joint calibration test and side-by-side acoustic surveys were conducted to compare and standardise Canadian and US estimates.

Hydroacoustic surveys for wintering herring in the North Coast were continued, and an abundance index from the hydroacoustic survey series will be used for the first time in the 1993 assessment for these stocks. An upward-looking acoustic transducer was developed and used to assess juvenile salmon populations in lakes.

## A.2 DENMARK

### Danish Institute of Fisheries and Marine Research

Hydroacoustic Stock Assessment

Pelagic stocks in the Skagerrak-Kattegat area were surveyed by RV *Dana* in July 1992 as a part of the ICES Coordinated Hydroacoustic Survey of the North Sea. The usual standard calibration of the equipment was done in the Gullmar Fjord in Sweden immediately before the cruise.

Danish scientists participated in the survey of herring and sprat stock in the Western Baltic made by the German RV *Solea* in October 1992.

Image Analysis of Acoustic Data

An image analysis system has been acquired and installed (HIPS2 on a UNIX system and Global Lab Image on a fast PC) and supporting software has been developed for analysis of acoustic data obtained during surveys. The purpose is to extract parameters from the acoustical data, that can be used for species recognition or categorisation. Furthermore, parameters describing spatial distributions of organisms are examined in connection with predation processes.

Other Activities

Equipment for tracking and remote sensing has been acquired in order to monitor activities in free-swimming fish, especially feeding activities. Some preliminary field activities are planned for 1993. An application for an EEC project in cooperation with England and Norway is being prepared.

The work on acoustic detection of blue mussel banks started in 1992 and continues in 1993.

## A.3 FAEROE ISLANDS

### Fisheries Research Institute, Thorshavn, Faeroes

Fish Technology

In 1992 an experiment was undertaken north of the Faeroes to assess the survival of saithe (*Pollachius virens* L) escaping through trawl meshes (145 mm cod-end meshes). Escaped fish were collected in fine meshed net cages mounted aft on a cod-end cover. The net cages were drifting freely with the current in the area north of the Faeroes and located by means of radio tracked buoys. Preliminary results indicate that saithe can withstand almost the same sorting through trawl meshes as cod, with low mortality. However, more experimental work is needed to draw more firm conclusions on survival rates of saithe escaping from a cod-end. Therefore, in July 1993, a similar study will be carried out to statistically assess the survival rate of saithe escaped through a cod-end mesh.

In the annual bottom trawl surveys at Faeroes the standard bottom sampling trawl with the lighter rubber bobbins gear has been used during the last eight years. It was anticipated that the heavier rockhopper gear would be more effective in catching the small cod and haddock than the standard rubber ground gear. Therefore, in spring 1992, a heavy rockhopper ground gear was tested against the standard rubber gear on the Faeroese fishing grounds. The absence of cod at Faeroes for the moment limited the results of the survey. Some data on saithe and redfish were obtained, and they indicate no statistical difference in the two riggings. As a result the standard bottom sampling trawl with the lighter rubber bobbins gear is still in use.

In winter 1992/93 experimental trawling in deep water (500-1,400 m) has been carried out in the southern Faeroese water, on the Hatton Bank and on the Reykjanesridge. Deep water species such as grenadiers, black scabbard fish, sharks, smooth head, orange roughy and oreo dories were caught. A commercial fishery on some of the mentioned species has developed.

Acoustic Surveys

One blue whiting survey was made in 1992. It covered the southern part of Faeroese EEZ of postspawning blue whiting on its way northwards. The 1989 year class is still the dominating year class. These results were reported to the ICES Working Group on Blue Whiting in 1992.

## A.4 FRANCE

### IFREMER

Echo-intégration

Une recherche sur les possibilités de classification automatique des détections de poissons en bancs est en cours dans le cadre d'un contrat européen FAR: projet BIOMASS avec comme partenaire l'ICPl de Lyon, le Marine Laboratory d'Aberdeen et l'IMBC d'Iraklio en Crête. Cette recherche porte sur des paramètres extraits en acoustique classique mais également large-bande. Pour IFREMER, qui recherche des descripteurs classifiants en acoustique bande étroite, c'est le logiciel MOVIES B qui est utilisé. Suite à une première exploitation d'une banque de données de 13,000 bancs, donnant lieu à une classification encore imparfaite, quelques-uns des paramètres calculés ont été modifiés. C'est en particulier les descripteurs énergetiques qui ont été revus.

Parallèlement à ces travaux, une étude spéciale concernant l'identification des détections par chalutage a été menée. Elle a consisté en la mise au pooint d'une poche de chalut "copartimentée" avec des fermetures télécommandées par acoustique. Le dispositif a été mise an oeuvre avec succès lors d'une campagne sur la THALASSA en novembre 92. Il est ainsi possible de mieux cibler les pêches, et, en particulier, d'isoler la capture correspondant à un seul banc de poissons.

Développement de Nouveaux Systèmes

Le sondeur numérique OSSIAN développé par MICREL avec la collaboration d'IFREMER est maintenant parfaitement opérationnel. Il possède la qualité scientifique (TVG numérique jusqu'à 1,500 m) et permet de mener des évaluations de stocks par écho-intégration. Une version bi-fréquence a été testée sur la THALASSA en novembre. Ses fonctionnalités originales et sa souplesse d'utilisation en font un appareil trés apprécié des utilisateurs.

Développé par THOMSON, avec l'aide d'IFREMER pour les essais en mer, dans le cadre du projet EUREKA-HALIOS, un système de positionnement acoustique de chalut sera commercialisé en 1993. Une portée de 1,500 m est visée.

L'algorithme de détermination de la nature des fonds marins à partir de signaux acoustiques émis par des sondeurs de pêche est opérationnel. La nature du fond est déterminée selon sept classes. Il est prévu de l'implanter dans le sondeur numérique OSSIAN.

Evaluation Acoustique des Stocks

La gestion du stock d'anchois du Golfe de Gascogne a été poursuivie en collaboration avec l'Espagne avec comme support une campagne à la mer en avril.

### ORSTOM

Poursuite de l'activité du Réseau Caraïbes. Ce réseau, qui comprend des laboratoires français (ORSTOM), cubain (Instituto de Oceanologia), vénézuelien (Fundacion La Salle de Ciencias Naturales) et mexicain (Centre des Investigaciones de Quintana Roo) s'est fixé

comme objectif de faciliter les contacts entre chercheurs et la mise en commun d'équipements. Dans ce cadre, on a poursuivi l'étude des concentrations de poissons dans la baie de Batano (Cuba) où une méthodologie particulière d'utilisation de l'acoustique dans les petites profondeurs a été développée (F Gerlotto).

Au Sénégal également, différentes expériences ont été menées sur les fonds de faible profondeur où se concentre une partie très importante des sardinelles. On envisage de développer cette recherche, en collaboration avec l'INRA, notamment en utilisant un sonar haute fréquence (J J Levenez).

En Indonésie, l'étude du comportement des poissons au voisinage des dispositifs de concentration de poissons (DCP) se poursuit dans la mer de Java à l'aide d'un sondeur Biosonics dual-beam (120 kHz) et d'un intégrateur Ines-movies (D Petit).

A Brest, on a commencé à analyser les données multifréquences (24, 38, 50, 80, 120 kHz) récoltées au cours de deux campagnes réalisées au large de la Guinée et le long de la Côte d'Ivoire: l'objectif est d'arriver à une meilleure discrimination des échos des poissons et du plancton. Un sondeur à large-bande (20-80 kHz), en cours de mise au point à l'IFREMER, sera également utilisé (A Lebourges).

A Montpellier, un nouveau programme d'étude des relations entre paramètres océanographiques et fluctuations spatio-temporelles des populations de poissons en Adriatique et Méditerranée nord occidentale débute avec l'Instituto de Ciencias del mar (Barcelone, Espagne) et l'Instituto Ricerca Pesca Maritime (Ancona, Italie) avec un financement CEE (programme AIR). Outre l'écho-intégration "classique", le programme prévoit des recherches sur le comportement et sur la structure des bancs (sonar haute fréquence) (F Gerlotto, P Freon).

La mise en évidence par détection acoustique de structures biologiques particulières dans une zone de l'Atlantique équatorial où se situe une importante pêcherie de thon pendant une partie de l'année a permis d'élucider en partie les causes de cette abondance: il s'agit en fait de concentration de poissons méso-pélagiques qui contrairement au schéma normal ne plongent pas de jour et deviennent ainsi accessibles aux thons qui s'en nourrissent. Les données récoltées au cours de la dernière compagne (EKS - 120 kHz, Ines-Movies) sont en cours d'étude. Elles devraient permettre d'estimer la densité des couches et des bancs de ces poissons méso-pélagiques (E Marchal).

L'approche géostatistique dans l'étude de la répartition spatiale des détections est en cours de développement, avec une attention particulière pour les bancs (P Petitgas).

Le groupe de travail francophone sur l'"Occupation de l'espace par les organismes aquatiques" a tenu sa seconde réunion en mai 92 et se réunira à nouveau en mai 93. Le thème retenu en est l'identification par l'acoustique de structures spatiales. La langue de travail est le français, mais il est ouvert à tout chercheur intéressé par ca thème (F Gerlotto).

## A.5 GERMANY

A hydroacoustic survey of herring and sprat stocks in the western Baltic (ICES subdivision 22 and 24) was carried out in cooperation with Denmark in October/November 1992. The measurements on board RV *Solea* were performed with an EK500 echosounder on 38 kHz and a 38-22 transducer installed in a towed body. The towed body permitted a working speed up to eight knots depending on weather conditions and wave interactions. Sampling distance was chosen to 0.5 nm and Sa-values were measured in 2 m depth channels.

Acoustic small scale surveys were conducted in the Arkona Basin to investigate variations in the spatial distribution of fish concentrations and the effect of day/night migration. Two boxes with an area of 100 $nm^2$ each were measured with the EK500 echosounder on four transects of 10 nm length in a distance of 2 nm. A short sampling distance of 0.1 nm was chosen to find out the auto-correlation of Sa-values. Each box was surveyed five times, three times during night and two times during daytime. Trawl catches were carried out at night to determine the species composition and length distribution.

## A.6 ICELAND

The Icelandic research vessels used in acoustic surveying, *Bjarni Sæmundsson* and *Árni Friðriksson*, are both equipped with 38 and 120 split-beam EK500 echosounders and BI500 postprocessing systems. In addition a third frequency is installed, 12 kHz on *Bjarni* and 200 kHz on *Árni*. An installation of an 18 kHz split-beam system is planned this year on *Bjarni*. The 38 kHz systems are used on all our acoustic surveys but other frequencies on fewer occasions.

The yearly investigations of the Icelandic capelin were undertaken in autumn and winter. In January the spawning stock was surveyed east and northeast of Iceland. In August the juvenile stock in the Iceland-Greenland-Jan Mayen area was surveyed as a part of our traditional 0-group survey. In October a two-ship survey of the adult and juvenile components was carried out in the same area.

An acoustic survey on the Icelandic summer spawning herring was carried out in November and December 1992. An effort was made to cover both the juvenile and adult components of the stock.

A survey of the oceanic-type redfish (*Sebastes mentella*) in the Irminger Sea was carried out in June-July 1992. About 82,000 $nm^2$ were covered between 64°N and 57°N. A similar survey was carried out in 1991. The results are promising, and a survey is planned in September 1993.

Material for the determination of *in situ* target strength of the species encountered in our acoustic surveys is collected when conditions are favourable. The target strength of oceanic redfish was determined from data collected in the 1991 and 1992 surveys and was used in the consequent conversion of the integrated echo energy into biomass. Similar material on herring was collected in 1992 and analysis of this data is almost completed.

Measurements of the beam pattern of the mounted survey transducers have been carried out using a technique which depends on a detailed knowledge of the geometrical

arrangement of suspension of the calibration sphere. Agreement with data supplied by the manufacturer is good in the case of the 38 kHz systems. More extensive measurements are required at other frequencies.

Calibration of split-beam systems have shown that at 38 kHz the internal target strength compensation is quite adequate. At 120 kHz measurements have shown that the nominal "angle sensitivity" and "3 dB beamwidth" give quite unsatisfactory results, but reasonably good beam compensation can be obtained by adjusting these parameters.

## A.7 SWEDEN

### Institute of Marine Research, Lysekil, Sweden

Acoustic surveys are carried out routinely in the Baltic proper as well as in the inland lakes of Sweden. The Baltic surveys are an integrated part of the ICES coordinated surveys for estimating the herring and sprat stocks.

## A.9 NORWAY

### Institute of Marine Research, Bergen, Norway

Surveys

The acoustic systems EK500 and BI500 have been used on our research vessels for about 1,000 survey days in 1992.

Development Projects/Activities

Sonar project

The sonar Simrad SA-950 was installed on board RV *GO Sars*, summer 1992, and have been tested on several surveys. Interface towards a workstation for downloading graphical information, and some software for this have been developed. A new sonar project has been defined in connection with the new research vessel *Dr Fridjof Nansen*, continuing a development towards a sonar for biomass estimation. Contact persons: O A Midsund, A Aglen, J Dalen.

Towed body project, phase 1 and 2

Further development on the deep towed body concept continued in 1992, but will be delayed by financial reasons in 1993. Most of the work in connection with bringing parts of the EK500 into a pressure resistant nose of the body is finished, as well as the communication part to the vessel over an optical/electrical cable. Contact persons: J Dalen IMR, H Bodholt Simrad.

Mapping and charting module, BI500

The first version of the mapping/charting module for BI500 is now being tested, and further work will also involve more advanced tools and geographical software routines for displaying and analysis of survey data. Contact persons: A Raknes IMR, H Næs Simrad.

Database development, IMR

IMR is now finished modelling a larger relational database to handle all our scientific data, ie hydrographical, chemical, acoustical and biological data. The database, Ingres V6.3, was partly operational for testing in 1992, served by two HP 9000/mod750. A test report of the database is now available, and groups for quality assurance and data imbedding are now working steadily with entering the data. Contact person: E Ona IMR.

Seismics and Fish

Several projects concerning seismic activity and fish were run in 1992, and are now in the reporting phase. These are:

a) Two projects to determine the effect of air gun sounds on eggs and larvae, one experimental and one combined field and modelling project. Contact person: J Dalen.

b) One project to determine the effect of seismic investigations with air guns on catch rate success and fishing availability. Contact person: A Engås.

c) One project to determine harmful effects on fish from explosives. Contact person: S Olsen.

## A.10 UNITED KINGDOM

### Marine Laboratory, Aberdeen, Scotland

Surveys of herring were carried out 1) in the ICES area VIa North and 2) in the Orkney, Shetland and Buchan areas, in July 1991. These surveys were in conjunction with the Norwegian, Danish and Dutch fisheries research laboratories. Survey data were collected using the Simrad EK500 and recorded on a Sun computer using the BI500 software at frequencies of 38, 120 and 200 kHz. Data on Temperature, Salinity and Seabed type (ROXANNE) are collected during the survey. The relationships between stock depth, temperature, salinity, and seabed are being investigated from this data.

Work on the automatic identification of shoals from recorded echo traces has developed. The system has been transferred to Sun computer system. The echo sounder output is treated as an image and loaded using Imaging Technology high speed image processing cards. Development has been concentrated on menu driven inputs and conversion of BI500 data files for analysis. A hardware object extraction card has also been included in the system.

Work on wide-band acoustics has been restarted with the development of an improved transducer, and a new computer controlled receiver and transmitter. Studies on

reflectivity continue with measurements on cod, saithe, haddock, horse mackerel and mackerel. The data are under analysis. This work is supported under the EC FAR program and is being carried out in cooperation with ICPI Lyon, IFREMER Brest and IMB Crete.

Work on survey design methods has continued. The series of simulations to investigate the precision of estimates with different survey methods has been developed to include consideration of variance as well as abundance. The results are encouraging and indicate that systematic designs have some advantages in survey precision. Use of geostatistical estimators for variance allows examination of survey strategies. Automatic fitting procedures for variograms are being tried in order to obtain better understanding of the precision of the variance estimates.

**British Antarctic Survey**

An acoustic survey was conducted at the end of 1992 from RRS *Discovery* in the marginal ice edge zone (MIZ) in the Bellingshausen Sea, an area not previously surveyed by BAS. The Simrad EK500 sounder operating at 38 and 120 kHz in conjunction with a Biosonics echointegrator was used. Transducers were mounted in a towed body. Some targets were detected on the runs just to the south of the Antarctic polar front. A few scattered marks were seen on the 38 kHz run for Potter Cove down the Bransfield Strait. On arrival at the MIZ study area, no significant targets were detected until the ship steamed south of about 67°30′S. Most echotraces were characteristic of krill swarms in appearance, but no large layers or concentrations were found, and only a few large swarms. There was a total absence of the diffuse layer type targets that are common around South Georgia (for instance) and which usually turn out to be copepods or small species of euphausiid. Some swarms were clearly associated with chlorophyll patches and some were being preyed on by minke whales. The area where krill swarms were found was south of a front found during a grid survey with a SeaSoar undulator. There was a clear association of krill with watermass.

Concurrently acoustic studies on krill were being carried out on the RRS *James Clark Ross* at the ice margin, using Simrad EK500 split beam 120 kHz and 38 kHz hull-mounted sounders, logging integrated data to a PC. In-house software written using LabWindows saved raw and converted integrated data and messages to separate files. Although small numbers of krill were seen by divers, ice often prevented the collection of useful acoustic records.

In January 1993 surveys were made to study krill, smaller zooplankton and fish larvae with the EK500 on RRS *James Clark Ross* both on and off the shelf to the north of South Georgia. Dense concentrations of small krill were found and surveyed acoustically and fished using a novel multiple net. Acoustic targets were identified by several different fishing methods and included layers of salps and mixed small zooplankton. Especially dense concentrations of krill were found both on the shelf and just off the shelf break. Results will be analysed with respect to bathymetry and measurements of surface temperature, salinity and chlorophyll and current data collected using an ADCP operating at 152/153 kHz.

## A.11 USA

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 and again in 1991-93, acoustic surveys of the spawning populations of pollock have been carried out in January-March in the deep water portion (>1,000 m) of the Bering Sea, and, in 1989, 1991-93 including shelf waters of the eastern Bering Sea. In 1993, in a multi-national effort, the survey area was expanded to include the western Bering Sea and the Aleutian Basin. Annual surveys of the Gulf of Alaska spawning stock in the Gulf of Alaska have continued through 1993. Target strength studies of fish using the split beam technique continue and standard sphere calibration is 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 sixth triennial survey of Pacific whiting off the west coast of the US was completed in the summer of 1992 (contact persons: Bill Karp, Jim Traynor, Neal Williamson).

The Southeast Fisheries Centre continued assessment and experimental work using a 38 and 120 kHz dual beam system. Survey activities include a trawl/acoustic survey of small pelagics in the North-Central Gulf and a feasibility study using the acoustic assessment system for reef fish assessment and comparing the results with data collected using a video camera. Differences in densities obtained by the two systems were attributed to multiple counting of targets by the video system and in some locations, fish found too close to bottom for acoustic assessment. A Gulf-wide survey is planned for May-June 1993 (contact person: Chris Gledhill).

The Oceans Research Branch of the Naval Research Laboratory Stennis Space Centre is investigating ways to improve predictions of sound scattering from dispersed and aggregated fish, with major emphasis on swimbladder resonance at 0.5 to 10 kHz. Measurements are made using a near-surface explosive device and a downwardly directional receiver. A new experimental effort is aimed at using satellite remote sensing and historical fisheries data bases to predict the distribution of fish stocks, volume scattering and biological targets. This programme includes the development of new techniques to measure low frequency scattering on shelf environments and theoretical and experimental studies of resonance scattering from individual fish and schools (contact persons: Redwood Nero, Richard Love).

Scientists at the Woods Hole Oceanographic Laboratory have been working on the frequency dependence of acoustic backscattering from zooplankton and micronekton and the development of appropriate scattering models. Laboratory measurements have been made of a decapod shrimp species, a copepod species and various machined objects using a laboratory sonar (50 kHz to 5 MHz) under development by Tim Stanton. The data are used to develop and test scattering models of finite length elongated bodies with realistic boundary conditions. The results show that the target strength of elongated zooplankton can be predicted very well using a bent cylinder model. Later this year, they plan to use the equipment to make measurements at sea of freshly captured specimens (contact persons: Peter Wiebe, Tim Stanton).

Scientists at the University of Wisconsin continue work on the development of models for biological scatterers. Recent work centres about different methods for approximating the return from fish swim bladders (contact person: Clarence Clay).

At the University of Maryland, work continues with the incorporation of acoustically-derived abundance estimates into ecological models of growth in fresh water environments (contact person: Stephen Brandt).

Scientists at Woods Hole Oceanographic Institute and Cornell University have been jointly working on three projects associated with acoustic observations of zooplankton. 1) They are currently examining 120 and 420 kHz data collected over Fieberling Seamount, 500 nm west of San Diego in the Pacific Ocean. The data were collected both from a towed fin and using an acoustics package mounted on the submersible ALVIN. This work was designed to enable the scientists to visualise the development of biological gaps over the tops of seamounts and to study their structure and dynamics; 2) They participated in the Georges Bank Stratification Variability Experiment by conducting bioacoustical studies of volume backscattering and target strength of plankton. This experiment was designed to investigate the stratification processes and their effects on cod and haddock larvae on Georges Bank. Measurements were made with BIOSPAR (bioacoustic sensing platform and relay) adjacent to physical oceanographic mooring sites and time series measurements were made with 120 and 420 kHz dual beam systems linked to shore via radio and satellite instrumentation. High resolution data for comparison to MOCNESS (multiple opening/closing net and environmental sensing system) and BIOSPAR data were collected with a 420 kHz dual beam system in a towed fin; and 3) They have constructed a MOCNESS electronics package and modified a dual beam system for deployment on the MOCNESS net. The 420 kHz and 1 MHz transducers were mounted in a training mechanism which allowed the two transducers to be positioned anywhere on a hemisphere looking forward of the net. To be able to utilise both the acoustics and a video system, the MOCNESS communicated via a fibre optics cable (contact persons: Peter Wiebe, Charles Green).

Progress continues in the development of sensors to quantify the abundance and size spectra of small zooplankton in aquatic environments. The University of Southern California and Tracor Applied Sciences, operating under the sponsorship of ONR and NSF are currently operating a mooring in 100 m water depth off the southern California coast. The mooring includes several acoustical sensors which operate at frequencies of 165 kHz and 1.1 MHz. Those sensors are spaced at discrete depths throughout the water column and also include the capability of measuring water temperature and downwelling irradiance. Development of several other sensors with different frequency suites and various processing algorithms is continuing at this pilot site. The data are telemetered to a shore station daily and are accessed via a conventional modem/phone system. Two way telemetry allows modification of operating parameters in response to the changing ocean environment and also allows modification of computer codes in the mooring system's computers during this development phase of the programme. Plans to expand the system to include additional sensors are being developed, as is the implementation of a similar system for use during a US GLOBEC field project on Georges Bank. That programme is part of the larger international GLOBEC programme and of the ICES sponsored Cod and Climate Programme.