Fisheries Technology Committee

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REPORT OF THE

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

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1 TERMS OF REFERENCE

In accordance with C. Res. 1997/2:18 a joint session between the Working Group on Fisheries Acoustics Science and Technology and Working Group on Fishing Technology and Fish Behaviour met under the chairmanship of Mr J. Masse (IFREMER, France) in La Coruña, Spain, 24 April 1998 to:

a) review the progress of the steering group established to consider how to improve the design of trawls used for biological sampling during acoustic surveys and the use of sampling data in the estimation of biomass;

b) to consider the effect of fish behaviour on stock assessment.

2 MEETING AGENDA AND APPOINTMENT OF RAPPORTEUR

The chairman opened the meeting and Dr P. Fernandes of the Marine Laboratory, Aberdeen, UK, was appointed as rapporteur. The following agenda was adopted:

1. Session on current research on fish behaviour related to fishing and survey operations;

2. Session discussing the report of the Steering Group established to consider how to improve the gears used in acoustic surveys to obtain biological samples and the use of sampling data in the estimation of biomass.

3. Discussion.

4. Recommendations.

3 SESSION ON CURRENT RESEARCH ON FISH BEHAVIOUR RELATING TO FISHING AND SURVEY OPERATIONS

3.1 R. MITSON. Design and noise performance of new Scottish research vessel

The new Scottish research vessel "Scotia" is the first vessel to be built according to the noise specifications recommended by ICES as outlined in Mitson *et al.* (199?). Significant noise reduction measures were taken to meet the specifications in the report; in fact the build contract specified the recommended noise level be reduced by a further 6 dB at frequencies up to 1 kHz (hearing range of fish). The vessel has three diesel engines which develop 3900 h.p. and a dropped keel is employed for the deployment of acoustic transducers. Noise measurements were made as part of the con tract at a military test facility. Measurements at 10.7 knots revealed that the specification had been met. A small noise hump was measured at 200 Hz due to the blower motor and so this component is to be replaced. At higher speeds the noise levels were elevated due to slight singing of the propeller, but overall levels were maintained below recommendations. The noise levels compare favourably with those of another reasonably new and quiet vessel - the Fridtjof Nansen. At higher speed there is also increased levels at the higher frequencies (10's of kHz) which are beyond those recommended. However, the recommended levels are based on the transducer being 15 m from the propeller whereas on "Scotia" this distance is actually 45 m. Noise levels were further elevated during trawling but were not as bad as expected levels which typically can be as much as 25 dB.

3.2 G. ARNOLD. Availability and accessibility of demersal fish to survey gears: Population-wide patterns of behaviour

The use of transponding acoustic tags has proved to be a superior technique to that of video for the study of fish behaviour. The Centre for Environment Fisheries and Aquaculture Science (CEFAS) have deployed a total of 303 tags on plaice (*Pleuronectes platessa*) in the southern North Sea: 50 of these have since been recovered, providing almost 2500 days of data. Preliminary analysis of data from 15 tags has been carried out. The first tags recorded only temperature and pressure every 10 minutes and lasted approximately nine months. However, the track of the fish can be reconstructed using tidal models and appropriate corrections for fish velocities. Analysis of pressure data revealed distinct patterns of behaviour linking vertical movement to both tidal and diurnal cycles. These behavioural patterns can be summarised in acotgram plots, which display the average vertical position for the 15 fish for each day. The fish are active when vertically migrating into pelagic water (vertical movement takes approximately half an hour) where they use tidal streams to augment their horizontal movement. Circadian patterns were dominant in mid-winter with the fish only active at night. In late winter activity was predominantly linked to the tide; at first both by day and night, and later in the season only by night. In spring very little activity was evident at all and by June the fish remain on the bottom. This seasonal pattern can have obvious and significant effects on the availability of fish to bottom trawls during surveys. The results obtained to date indicate that the best time to perform these is in summer (which is, fortunately, when the surveys are carried out).

New tags currently being deployed are smaller, cheaper, contain more memory and incorporate a light sensor which provides more information on location. They record data every four minutes and should last from 15 months to two years (1.5 MB). An EC program aims to deploy 500 of these tags on plaice, cod and rays in the middle of the North Sea to investigate whether these fish use the tidal stream in the same way. Of the 350 tags released last winter, 21 have been retrieved to date. The cost of these tags is US$ 1000 and currently they are approximately 55 x 16 mm, although smaller tags are under development as part of the same EC project.

3.3 P. G. FERNANDES. A spatial analysis of trawl sampling variability in the 1995 North Sea Herring acoustic survey

Trawl data from seven surveys, taken from the 1995 North Sea herring acoustic survey, were analysed to investigate the spatial variability of herring length distributions. A trend was evident in the spatial distribution of mean length of herring, which was confirmed by a linear fit to the variogram of mean length. A new tool, termed the KS-ogram, is introduced. This is a cross between the variogram and the Kolmogorov-Smirnov test and aims to describe the spatial structure of length distributions. The KS-ogram was modelled with a geostatistical nugget and an exponential model, using a semi-automatic weighted least squares fit, restricted to have a sill equal to 1. The difference between the KS-ogram from trawls within surveys (intraship KS-ogram) and that from trawls between surveys (intership KS-ogram) was small. This implies that the difference in length distributions generated from trawling with different vessels is small compared to other factors contributing to the natural variability of length. One of these principal factors is related to the vertical distribution: length distributions were more alike at similar and deeper depths. Increased variability in length distributions at the surface ties in with some of the known biological characteristics of this and other species of fish.

3.4 M. BARANGE. The influence of wind on the vertical distribution of deep water Hake: how to combine acoustics and bottom trawl

Fishermen operating in the hake fishery of the south west cost of South Africa have long known that catches diminish following a south-easterly wind. To investigate this phenomenon an eight day combined acoustic and bottom trawl survey was conducted in the area. Three distinct episodes were observed during the course of the survey. At the start of the survey the wind was northerly, average catches were approximately one ton of hake and fish traces were detected in a strong scattering layer close to the bottom; a small area of less oxygenated water was present at the bottom also. After two days the winds changed to south-easterly, catches were reduced by an order of magnitude and the scattering layer had risen off the bottom; the area of water containing less oxygen had expanded vertically. Three days later the wind had dropped, the fish had returned to the bottom and catches were up again. Current meter measurements indicate that the vertical extent of the low oxygen water close to the bottom is dependant on the poleward current the extent of which varies with the strength of south-easterly winds. This in turn influences the vertical distribution of fish and is, therefore, a clear example where acoustic techniques may be used to correct for any bias due to a change in availability to the trawl.

3.5 O. R. GODO. Survey catchability of north-east Arctic cod and haddock related to varying abundance of capelin

The tuning process in Virtual Population Analyses (VPA) assumes that survey catchability is constant over time. This paper investigates this assumption for the Norwegian north-east Arctic cod and haddock stocks. The investigation is based on the hypothesis that when capelin is present in substantial amounts, the bottom trawl survey reflects a lower proportion of the cod stock compared to when the capelin stock is low. When capelin is abundant, cod may feed more extensively in the pelagic zone out of reach of the bottom trawl. Conversely, the opposite is expected for the acoustic survey data and no trend is expected on haddock, because it is not so dependant on capelin for food. Catchabilities were calculated from VPA and survey estimates of cod and haddock abundance, assuming the VPA to represent actual stock numbers. Capelin abundance was estimated from an acoustic survey.

The catchability of the bottom trawl survey tends to be low when capelin abundance is high (the variation in capelin stock explains 70 % of the variability of bottom trawl catchability), however, the effect for the acoustic survey is more random (5 %). The trend in haddock catchability is similar but much less pronounced (capelin biomass explains less than 10 % of the variability in all cases). The random effect observed in the acoustic survey comparison may be partly due to recent improvements in acoustic methodology and party due to the reduction in detection of cod in capelin layers. It is suggested that in future catchability coefficients are calculated according to estimates of capelin biomass.

3.6 R. KLOSER. The use of acoustic bottom discriminators in ground surveys

Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) uses acoustic techniques to classify bottom habitat types in waters between 20 and 200 m depth. A number of techniques are available off the shelf for bottom type recognition. Roxanne is one such example: it uses the tail of the first echo to provide an index of roughness and the whole of second echo as an index of bottom hardness. This and other methods require ground truthing. The data should also be checked for biases due to aeration and background noise (which is particularly problematic for roxanne). CSIRO collect acoustic data from the Simrad EK500 echosounder and run their own algorithms corrected for such biases. As there is often a good relationship between ground type and fish abundance the decisions on where trawling should take place could be assisted by an accurate bottom discriminator. The group was reminded that in exceptionally calm weather the ship itself could provide an echo just below the bottom which will add to the perceived hardness.

4 J. MASSÉ. REPORT OF THE STEERING GROUP TO CONSIDER HOW TO IMPROVE THE GEARS USED IN ACOUSTIC SURVEYS TO OBTAIN BIOLOGICAL SAMPLES AND THE USE OF SAMPLING DATA IN THE ESTIMATION OF BIOMASS

4.1 Investigation results

In June 1997 a questionnaire was sent to all FTFB and FAST members in an attempt to collect data on trawling gear and procedures from those actively involved in acoustic surveys. After two follow-up letters, 25 respondents expressed their interest in the joint session objectives. However, only six institutes provided complete answers to the questionnaire:

- IML (Canada)
- ORSTOM (France)
- INRA (France)
- IMR (Sweden)
- MLA (Scotland)
- AFSC (USA)

From personal knowledge and discussions during the Planning Group for Pelagic Acoustic Surveys in ICES Sub-areas VIII and IX data was made available from a further 3 institutes:

- IFREMER (France)
- IEO (Spain)
- IPIMAR (Portugal)

Part of the results are attached in Appendix 2. The principal conclusion from these responses is that the use of gears in acoustic surveys is totally heterogeneous. The wide range of results can be summarised as follows:

Why fishing ?

- to verify the presence of the target species
- to get data in order to split the back scattered energies into species
- to get length distributions for TS estimates
- to collect biological samples

What gears ?

- Pelagic trawl (small, large, small mesh, big mesh)
- Purse seine
- Bottom trawl
- Long line

What strategy ?

- by day
- by night
- both
- with one vessel
- with two vessels (one for acoustics, one for fishing)

- by depth layers (only at the surface, only close to the bottom, only aimed at observed schools)
- for the whole water column
- each time the detection type changes
- only for what is supposed to be the target species
- following systematic grids or statistical areas

What is the link between the acoustic energy (integral) and catches ?

- presence or not of the target species
- only to convert the integral into biomass by using appropriate TS
- direct use of the catch partition (standardised in time)
- use only of the proportions in the catches (weighted by local energies and TS) for splitting the acoustic integral
- calculation of a catchability coefficient
- no linkage ?...

Understandably, no-one could propose a global standardised method (except one suggestion to use purse seines at night only).

4.2 Situation analysis

It appears that the fundamental question is:

"What are the biological targets which have contributed to back scattered energies cumulated along transects ?"

Different methods are used to answer this question which, according to the responses of the questionnaire and to the Echo-Trace Classification Study Group meeting, are:

- implicit knowledge (by experience)
- school classification based on some catches in an area
- systematic and direct use of catch proportions

No single method is satisfactory as systematic bias may occur due to subjectivity, gear selectivity, and poor sampling. A perfect gear type would be one capable of catching all targets (fish, plankton, mermaids,...) which contribute to the echo integral.

As a conclusion, it seems that there is no ideal gear (exhaustive sampling) which is able to answer the question. For the time being at least, the gears which are employed are generally those best adapted to the particular situation: i.e., adapted to the target species (fish only), to the bathymetric configuration, to the team availability. They are not necessarily adapted to answer the question.

4.3 Future approach

Questions seem to be numerous and may be classified in different types:

4.3.1 Which gear and which strategy

- which is the best gear according to the many different conditions ?
- what would be the best fishing strategy along a transect and in an area ?
- what would be the best strategy when performing the fishing operation; i.e., with a pelagic trawl, is it better to try to fish in the whole water column or to do several hauls in different layer ?

4.3.2 How to measure and take into account bias in catches

- how to take into account the evident avoidance of some schools; e.g., with lateral sonar
- how to calculate the variability of identification?
- how to calculate a catchability coefficient ?

4.3.3 How to combine acoustic data and catch data

- how to use the results when only one gear type is used ?
- how to use the results when different gear types are used (for instance pelagic and bottom trawls, or even plankton nets) in the same area ?
- how to combine different sources of information: catches from different gears (bottom, pelagic, hooks...), commercial catches, echotrace classification, etc. ?

4.3.4 What technological progress we can expect

- Are there any technical solutions to build "non selective" gear ? (FTFB have worked for such a long time on "how to progress in selectivity" that they have probably good ideas on "how to do the contrary !")
- which measurements are essential to get bias coefficients
- It is necessary to define what could be the priority in the future, for instance:
- what would be easier to solve as a first step ?
- is it necessary to standardise some elements (gears, strategies, calculation) or what is necessary to take care as soon as possible during our future surveys ?
- which data might be collected as soon as possible by most of us to be able to progress ?

As it seems that a lot of people are conscious of these problems and that acoustic data are more and more taken into account for assessment purposes or others, it appears that this session is the right place to tackle this topic.

The association of technologists, biologists and acousticians is essential to progress on this field.

4.4 Conclusion

It is impossible to solve the above four points, during the Joint Session as it is too short for such a complex and huge problem. The most efficient way could be the creation of a **Study Group** in the near future. As catches are generally used to allocate species to acoustic energies, a preliminary approach is proposed with the following topic:

"Which data can be made available from and during a fishing operation in order to compute a coefficient able to measure how these samples are representative of the biological communities ?"

5 DISCUSSION

According to the results documented by the questionnaire, a general discussion was conducted and the group agreed that, for the time being at least, a definitive answer to the question posed in section 4.4, above, would be difficult to obtain. This is primarily due to the wide variety of trawling strategies and surveying conditions already described. The complex nature of individual trawling operations, which are so in tune with the particular circumstances, render any standard procedure almost obsolete. With regard to trawl representativity, the subject of whole gear selectivity was discussed. This alone is still an ambitious task, and furthermore during an acoustic survey the effect of the ship would have to be included as well as subjective parameters such as the skill and experience of the fishing master. However, a number of technological advances were mentioned which could provide information which may be useful. These included fish school tracking techniques with sonar and trawl monitoring systems and multiple opening and closing nets (CSIRO for example operate a five cod-end pelagic trawl). A simple statistic that could be considered is a check on whether what was caught by the trawl was that which was expected from the acoustic trace; this would then define areas where the problem is most prevalent. Further consideration of the topic is required and the group agreed to focus on aspects of fish behaviour that may affect trawling operations during surveys.

6 JOINT SESSION RECOMMENDATIONS

The WGFAST and WGFTFB Joint Session made the following recommendations:

1. The WGFAST and WGFTFB Joint Session should meet in St Johns, Canada on Wednesday 21 April 1999 to:

   a) consider the reviews given by invited key note speakers on the problems related to fish behaviour in fisheries research surveys;

   b) consider a synthesis of behavioural studies carried out by FAST and FTFB;

c) consider the creation of a study group on the effects of fish behaviour on sampling methods of fisheries surveys.

Justification:

a) Members of the joint session agreed that the problems associated with fish behaviour in relation to trawling operations provided significant concern to merit further discussion on this specific topic. This discussion should be focused by a review carried out by a suitably qualified person, candidates for which were identified. These candidates will be approached over the course of the next year to secure at least one speaker at the meeting. The speaker will be provided with the results of the questionnaire and will focus the review appropriately.

b) Both the FAST and the FTFB working groups recommended review of specific behavioural studies for the next meeting. As most members will attend one or the other of these meetings next year, it was considered important that neither group should miss out on the presentations of these reviews. The joint session is therefore ideal for the presentation to both groups of these reviews.

c) The results of the steering group which considered the use of trawl gears in acoustic surveys were discussed at the current meeting. It was considered that further knowledge was required on the more important aspects of what is considered a very diverse problem. This knowledge may be gained over the course of the next year by which time the group may feel the need for a specific study group to address certain aspects which are considered feasible.

7 CLOSURE

The chairman thanked the staff of the Instituto Español de Oceanografía, La Coruña, for their hospitality, and members of the Working Group and Study Groups for their efforts and contributions.

8 PARTICIPANT LIST

See Appendix 1

APPENDIX 1 – PARTICIPANT LIST

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APPENDIX 2 – GEAR TYPES AND USE

Institutions	Gear type	Gear name	Vertical net opening	Mesh size	Control system	Why	When	How	Use of data
ORSTOM FRANCE	Pelagic trawl					Identification of species and size	Opportunistic Day and night	Separate schools (day) dense layers (night)	Species identification TS/size relation ship
AFSC USA	Pelagic trawl Pelagic trawl Pelagic trawl Bottom trawl Bottom trawl	Aleutian Wings 30/26 Method trawl Marinovich trawl Polyethylene Nor'eastern high-opening bottom trawl 83/112 bottom trawl	25 m 2.27m 4m 9m 3.5 m	3.25 m to 89 mm in the codend 2*3 mm to 1 mm in the codend 7.6 cm to 0.32 cm in the codend 13 cm to 89 mm in the codend 10.2 cm to 3.2 cm in the codend	Net-sonde Video display Depth sensor Micro bathythermograph	Species identification Collecting biological data Demographic structure	Opportunistic Day and Night	Specific aggregations Separate schools	To share energies to have a better use of TS relationship
IMR SWEDEN	Pelagic trawl	Fotö pelagic trawl (1988–1996), Makro 4 pelagic trawl (1997-)	14.2m	1.6 m to 18–20 mm stretch mesh in the codend	Depth sensor	Species identification and proportion Length, weight and age measurements	Systematic Night and day	Appropriate depth layer	Species identification, size and year classes
INRA FRANCE	Pelagic trawl	beam trawl	3m	30m to 5 mm in the codend	Bathymetric profiler	Species identification, collecting biological data, length/TS relationship	Opportunistic Night	Only on specific aggregations	TS/size relationships Ecological studies

Institutions	Gear type	Gear name	Vertical net opening	Mesh size	Control system	Why	When	How	Use of data
MLA UK	Pelagic trawl	PT160	25m	90 cm to 36 mm codend	Scanning netsonde	Allocation of echo traces to species and/or mixtures Collection of biological data Length, weight, sex, maturity and age measurements	Opportunistic Day and Night	Specific aggregations, Separate schools	Assign echo-integrals from specific schools to species. Integrals between species Provision of length-frequency data TS/size relationships Ecological studies
IML CANADA	Purse seine	Commercial purse seiners				Stock identification and size composition	Opportunistic Night		Allocate backscatter to stocks
IFREMER FRANCE	Pelagic trawl Pelagic trawl Bottom Trawls	76/70 PTGM158E GOV 4FF176	22 m 17 m 5 - 6 m 7 m	8000 mm 10 mm in codend 8000 mm 10 mm in codend	netsonde PACHA Scanmar netsonde	allocation of echotraces to species (generally mixtures biological communities mapping Collection of biological data Length (for TS/relation ship), weight, sex, maturity and age measurements	opportunistic each time aggregation structure or transect changes	global water column where detections are present, OR stratified successive hauls when structures are stratified	allocation back scattered energies to species according to catch proportions weighted by energy around haul and specific target strength (from length) (Massé & Retiere 1995 - ALR)
IEO SPAIN	Pelagic trawl Bottom Trawls	76/70 GOV	22 m 5 - 6 m	8000 mm 10 mm in codend	netsonde PACHA Scanmar	Fish species identification length distribution	opportunistic Day	specific aggregation separate schools	echo allocation
IPIMAR PORTUGAL	Pelagic trawl Bottom Trawls		8 - 10 m	100 mm 4 mm in codend	netsonde	Fish species identification Biological data length distribution T.S. analysis split beam	opportunistic Day	specific aggregation separate schools	species identification TS/size and split beam energies.