

International Council for the
Exploration of the Sea

CM 1983/B:34
Fish Capture
Committee

REPORT OF THE WORKING GROUP
ON REACTIONS OF FISH TO FISHING OPERATIONS; 1983

Note This Report has not yet been approved by the International Council for the Exploration of the Sea; it has therefore at present the status of an internal document and does not represent an advice given on behalf of the Council. The proviso that it shall not be cited without the consent of the Council should be strictly observed.

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Date: 5-6 May 1983

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General Aims of the Working Group

The aims of the Working Group have not changed since its first meeting at Nantes in 1973. They are: to discuss current practical problems in fishing operations particularly those that might involve aspects of fish behaviour, to keep in touch with techniques and facilities used to observe the reaction of fish to fishing operations, to maintain an up to date knowledge of relevant studies of fish physiology and behaviour including hearing and vision studies, to discuss interpretation of fish behaviour in relation to fishing operations, and to identify and encourage cooperative experimental work where this seems worthwhile.

Summary of Past Meetings

The first meeting, in Nantes in 1973, defined the aims of the Working Group.

The second meeting, in Aberdeen in 1974, gave special attention to the swimming performance of fish and generated a special ad hoc meeting at Texel which published a 76 page report on design and practical operation of research aquarium systems (Gear and Behaviour Committee, CM 1975/B:3).

The third meeting in Ostend in 1975 concentrated on the effect of electric fields on fish (CM 1975/B:19 and B:20).

The fourth meeting in Hull in 1976 as well as producing a general report (CM 1976/B:2) held a joint session with the Engineering Working Group and produced a special joint session report on the methods for observing gear and reaction of fish to gear (CM 1976/B:3).

At Hamburg (CM 1977/B:4) the special subject discussed was methods of attracting fish.

At Bergen in 1978, Council Resolutions (C Res 1975/4:11 and C Res 1976/5:5) relating to acoustic methods for pelagic and demersal stock assessment were considered and the effect of fish behaviour patterns on the echo target strength was examined at length as the special subject recommended by the Council Resolution 1977/2:12(b).

At Goteborg the Working Group discussed "schooling behaviour in relation to the catching process" and Council Resolution (C Res 1978/2:206) confirmed that the subjects included in the general aims of the Working Group should continue to be updated and the subject of the reaction of fish to rope trawls discussed.

At Reykjavik the Working Group discussed Selectivity in Fishing Gears and the possibilities of Species Specific fishing (C Res 1979/5:1b) and a summary of the discussion was included in CM 1981/B:23 p 11-13 Fish Capture Committee.

At Nantes in May 1981 the Working Group discussed the behavioural aspects of low energy fishing methods and concluded that nearly all research and development observation and understanding of the reaction in fishing gears is directed towards making practical fishing techniques more efficient and selective. The more knowledge and explanation we have of the reactions and behaviour of the fish the more cunning will be the applications (CM 1981/B:23).

At Aberdeen in May 1982, following C Res 1981/2:10b, the subject "Biology of escaping fish" was taken as the special subject and the conclusions summarised in the Working Group report CM 1982/B:40.

Agenda for the meeting at IJmuiden

1 General Business

- a) Consider proposals for the future of the Working Group.
- b) Define the subject area of "fisheries acoustics" to be dealt with by the Working Group.
- c) Consider a proposal for an ad hoc study group to examine the biology of line fishing and baits.

2 Progress Reports

Presentation of each countries progress report and programme outlining all research projects relevant to the Working Group. This includes a survey of research on fisheries acoustics and marine electric fishing.

3 General Contributions

Papers expanding the subjects of the Working Group including:

- a) fish reactions, and
- b) fishery acoustics

4 The Special Subject

"Behavioural aspects of fish attraction to submerged and floating structures and artificial devices".

5 Other business and conclusions

Progress Reports

Belgium

No research was carried out.

Canada

Selectivity studies are being conducted on different coloured purse seines, salmon gill nets with various hanging ratios, and for escapement of under-size animals from lobster and cod traps. Juvenile cod bycatch has been successfully released from capelin and squid traps. An off-bottom shrimp trawl is being developed to minimise capture of juvenile redfish and shrimp trawls are being appraised as survey tools for flatfish. A correlation between shrimp catches and tidal currents has been noted. A similar correlation with finfish is suspected and an instrumented gear study is planned, particularly to learn more for trawl surveys. A study on a square mesh codend displays improved selectivity.

The development of hydroacoustic survey methods continues. The digital logging system HYDAS is being routinely used on capelin and, with a deep towed body, on redfish. The potential of a dual beam transducer for counting groundfish is being studied. A towed transducer body which shears from the vessel path is nearing final trials in an effort to observe near-surface herring. BRUTIV is being used to obtain in situ tilt angle data on herring for more accurate echo-strength interpretations. Acoustics are being used successfully to survey juvenile salmon in lakes.

Denmark

No report was presented.

Faroe Islands

Emphasis is on hydroacoustics and two acoustic surveys are currently being conducted.

France

Indirect observations of fish behaviour within a trawl are being made during a study of a selective shrimp trawl being carried out with a fisherman on the northern French coast. The object is to separate shrimp, fish and trash within the trawl. A cooperative acoustic survey of the pelagic stocks off the coast of Algeria was performed in an effort to make a preliminary evaluation of their size.

Germany, F R G

A low light underwater television system has recently been acquired for the study of fish reaction to passive, low energy, fishing gear. An acoustic survey of Arctic fish stocks was carried out and the results are being analysed.

Iceland

A private company has purchased an underwater television system and a towed vehicle in order to observe the reaction of *pandalus* to a trawl and to check the performance of the trawl itself. Initial trials took place in May in northwestern Iceland. Attempts have been made to determine the fate of herring which escape from drift nets and bottom set gill nets. No results were obtained due to poor catches, but further study will be done with television observations. Using an underwater still camera, the efficiency of conventional Chlamys dredges has been found to be 17%. Future observations will determine how the selectivity of the bag and the lower edge of the frame effect efficiency and how behaviour influences escapement.

In cooperation with other ICES nations, acoustic stock size estimates have been made for the Icelandic summer spawning herring stock, capelin and blue whiting. The importance of acoustic measurements for 0-group surveys is increasing and acoustic stock size estimates of cod and other groundfish have been made experimentally.

Netherlands

Studies on the electrical stimulation of flatfish continue, and it is expected that an electrical beam trawl system capable of the same catches as a trawl with ticklers will be a reality this year. Research at Utrecht on the hearing of fish are ongoing with current emphasis on the mechanism for localisation of low frequency sound.

Norway

Current research activities on fisheries acoustics include surveys for monitoring or assessment of fish stocks and research projects for developing methods and instrumentation for underwater acoustics. Echo integration is done during most of the Norwegian fisheries research surveys. Some of the problems still to be overcome are: instrument problems, poor coverage, uncertainty of species composition and target strength and the orientation distribution of fish beneath the research vessel.

Ongoing research projects on acoustic methods and instrumentation include: "Fish Behaviour and Acoustic Abundance Estimation", "Krill as Food for Cod", and "Acoustic Counting of Fish in Fish Farming", all being carried out at the University of Tromsø. In addition projects on "Sound Scattering from Fish", "Improved Calibration Method of Echo Sounders and Integrators using Standard Targets", "Observation of Resonance Echoes from Fish", "An Instrumentation System for Correcting Echo Integrator Values", "Acoustic Observation of Plankton", "Development of the Acoustic Tagging Methodology", and "Sonar - Doppler Observations of Fish Behaviour" are being conducted at the Institute of Marine Research, Bergen.

A national mini-symposium in Norway last February considered the bait attraction of long-lines and traps. One result is a project to determine the critical stimuli for the attraction and acceptance of cod. Experiments to find the effect of internal and external acoustic tags on the swimming performance and feeding behaviour of fish continue. Projects on the seaward migration of salmon and the vertical migration of saithe are also ongoing. Studies on the behaviour related additional mortality in herring nets and the influence of behaviour on selectivity mentioned last year are continuing. An underwater television study of herring behaviour on the spawning grounds has been started and automatic photographic equipment for recording what is in the field of a transducer has been developed. A project on the negative phototaxis of polar cod has again indicated the need for more study on whether light noise or both are the major influence on the behaviour of fish in the path of a research vessel.

Sweden

A study of the behaviour of lobster and crab in traps and their escapement is being conducted. Acoustic surveys of the herring and sprat stocks east and west of Sweden have been carried out, and joint surveys with other countries were conducted in the Skagerrak and the Baltic Sea. Another project is looking at the statistical problems related to acoustic survey data. Plans are being made to start using acoustics to survey bottom species which are off-bottom at certain times due to environmental conditions.

UK

At the Fisheries Laboratory, Lowestoft, acoustic surveys are concentrated on North Sea herring and sprat and research is directed to techniques of system calibration and estimation of fish target strength. Calibrations using reciprocity and tungsten carbide spheres have been performed. Agreement between the techniques appears to lie within the measurement precisions, $\pm 5\%$. Measurements were made at sheltered calibration sites and attempts are being made to determine, the long-term stability of acoustic calibration constants. Transducer equivalent beam angles have been calculated from two axis measurements of beam patterns. An investigation into transducers with more predictable beam patterns which can be easily measured is in progress. Target strength research is aimed at evaluating the published algorithms for in-situ target strength measurement using a single beam transducer.

At the Aberdeen laboratory, acoustic surveys have been conducted on herring, sprat, and mackerel. Mackerel has proved the most difficult because of its low target strength. In efforts to improve survey techniques, a 38.1mm tungsten carbide sphere is used for echo sounder calibration, and the procedure is considered accurate to $\pm 5\%$. Target strength measurements have been made on caged herring, sprat, and mackerel. Herring target strength has been found to be dependent on fish size. A stereo TV system is being used to investigate the tilt angle distribution of caged fish but the question of whether fish behaviour is the same in the cage and the open sea still remains. In-situ target strength data has been collected from blue whiting concentrations using a dual beam echo sounder. These indicate a high target strength similar to the target strength found in caged gadoids, but higher than expected from other in-situ experiments. Equivalent beam angles of several transducers have been measured. They are generally smaller than the theoretical value and there is a significant variation between nominally identical transducers. A sonar is being developed which will have a nearly constant sensitivity and beam angle over the frequency range of 27-54 Hz. A spherical cap transducer having 217 elements has been constructed.

Behaviour work at the Marine Laboratory in Aberdeen continues and has resulted in an important paper on the hearing of cod by Hawkins and Schuijf. The development of the underwater observation vehicles continues while use of the existing vehicles is becoming routine for gear observation and deep water, to 50 fathoms, operation. The Marine Laboratory videotape collection of underwater observations is being catalogued and the best information is being extracted and recorded on a collection of 13 one-hour tapes which will be available for sale. Other research previously reported continues. The most interesting is the use of the net as a stimulus to control the behaviour of the fish in it. This extends previous work on the effect of the colour and pattern of netting, floats, and bobbins which are strong stimuli. The purpose is to use contrasting material and colour to control fish behaviour through visual stimulus. In an effort to reduce reaction distance, the question of fish reaction to netting in total darkness was raised, and attempts to observe this have been made. Preliminary evidence seems to indicate that in total darkness the fish are unable to detect the netting until they touch it. Investigations into separating species by their behaviour in the net continue. Bait problems are being studied by two techniques, heart beat conditioning and direct observation of hooks. Research on fish swimming ability continues with emphasis on the limits of performance and the reaction in nets. Current projects are investigating how energy is transferred from the muscle to the tail.

USA

The underwater observation of the reaction of halibut and black cod to long-line gear and bait is continuing with more submersible trips planned. A study of tilefish long-lining on the east coast has been conducted. Divers have been observing bottom gill nets and the fish associated with them. Underwater TV observation on fish behaviour in and around gill nets is planned. Interest in shark behaviour is increasing. Tagging, and feeding studies of shark and swordfish continue.

Several ongoing efforts are concerned with acoustics. One is aimed at using colour echosounders on ships of opportunity to gather fish assessment data. Others on the west coast and in the Gulf of Mexico are using hydroacoustics for assessment of various midwater species.

USSR

Experiments are being conducted to assess the catchability of bottom trawls using stereo photo cameras installed on the trawl and a TV camera towed independently of the trawl. Data is being collected to evaluate the condition and survival of fish which escape through the meshes of a trawl. Experimental measurements of the hydroacoustic and hydraulic characteristics of bottom trawls are being made, and results will be published this year. Laboratory studies of schooling behaviour and the reaction of model schools to visual and acoustic stimuli are continuing. The models used are bream and roach because of the schooling propensity of these species. Also continuing are investigations into fish swimming ability and its relation to environmental and biological factors. This is done in a flume tank and in still water. Studies on fish reaction to electrical barriers and bubble curtains are also ongoing.

Italy

Acoustic surveys in the middle and north Adriatic have been conducted since 1975, and the results have shown that the catch and the acoustic data agree. The target species are sprat, anchovies and sardines. It is very important to discriminate the different species. This year the survey will be extended to Sicily and Mediterranean Sea. Acoustic research is aimed at

three problems. The first is direct calibration on live fish. It has been found that fish behaviour effects the calibration level. Behaviour is characterised as "quiet", "alarmed" or "wild". Calibration is also dependent on the fish pattern within the beam pattern. Underwater TV is being used to determine this. The second problem is automatic classification of species. Improved acoustic instruments are needed but the concept is to match the acoustic image of the unknown to a known image by extracting seven features. Another project is aimed at developing statistical analysis techniques for acoustic information using spectrum analysis of the low end of the spectrum.

FAO

A high opening trawl designed by FAO for small trawlers has been used successfully in India. Catches of white pomfret off the southwest coast have convinced some fishermen to switch from shrimp trawling. An ineso-pelagic rope trawl project has shown that myctophids can be herded by a large trawl towed slowly. This has raised the question of whether sardines can be caught in the same manner. "Pop" manuals are being produced on acoustics, FADs and gear measurement. An acoustic manual is being written which will instruct users in how to do acoustic surveys. Three acoustic projects are underway. The "Dr Fridtjof Nansen" is being used in cooperation with Norway to do acoustic surveys, with emphasis on the Indian Ocean this year. Another project is trying a combined sonar and echo-integrator acoustic survey in Indonesia. The last is performing as technical secretary for the acoustic groups of the ACMR and the GFCM.

General Contributions on Fish Reactions

- a) A review of the progress on the project "Electrical stimulation of Flatfish" was presented by J B Agricola. It has been shown that the chains on a beam trawl consume 30% of the propulsion power of a fishing vessel, so electrical stimulation may save energy. The generation of stronger and shorter pulses resulted in bigger catches so more powerful pulse-generators have been built each year. In 1981 catches with the electrical gear were higher than the chain gear during night. In 1982 the mean, 24 hour catch was higher, and in 1983 it is hoped the daytime catch will equal that of the chain rigged gear. If the electrical gear can catch the same as conventional gear about 20% will be saved on fuel, and the gear will be more selective due to different size fish responding differently to the electrical stimulus. The electrical gear also catches less trash so the condition of discards is better.
- b) Per Solemdal presented the results of Norwegian laboratory and field studies on the reaction of cod to smell stimuli from bait. The object was to develop an alternate bait for long-lining. The smell, preference of cod to different potential baits was investigated. Using both small and large cod and manipulating them by systematic feeding and change of food it was concluded that crustaceans especially euphausiids, elicit the most intense feeding behaviour. Krill extracts elicited the same feeding behaviour as natural krill. Various stimuli carriers were tested. A series of long-line experiments showed that the artificial bait caught only 50% of the catch of natural bait.
- c) Anders Ferno reported the results of field studies on the cod response to chemical fractions of mackerel and artificial bait. The purpose was to identify the substances most effective in attracting and eliciting bite response in cod. Enclosed cod were pumped the stimuli from a distant boat, and the behaviour of the fish was recorded using underwater television. response to 10 fractions tested was grouped as strong, medium or

low. The most effective was the total extract of mackerel. A second experiment was carried out from an oil rig without an enclosure. Results were inconclusive due to environmental variations. Additional experiments compared an artificial bait made by O Mustad & Son with mackerel. Results showed the artificial bait was not as effective as natural bait. The artificial bait seemed to lack critical stimuli involved with bait acceptance.

- d) Results from tests of a remote controlled underwater vehicle used to observe fixed fishing gear were presented by Asmund Bjordal. The vehicle was operated down to 250m and observations were made of gill nets, creels, and two types of long-lines. Fish reacted to the vehicle at a distance of about 2m, while Nephrops did not exhibit a fright reaction. It was concluded that a vehicle will be useful for observing the dynamics of the catching process, but stationary observations will still be necessary for detailed behaviour studies.
- e) Kjell Olsen presented a verbal contribution on observations of additional mortality of unharvested fish in gill nets. It has been observed that herring get caught in gill nets with the twine or a knot caught behind the maxilla or super maxilla. Many of these fish fall out of the net when it is moved and the fish turns over. The level of mortality is 25 to 60 greater when mismatching occurs between the fish size and twine size than when the fish and twine size are matched.
- f) A van den Berg presented a review of recent literature on the use of sound to influence fish behaviour. Attraction and withdrawal response of predatory fish to sound have been reported at distances from the sound source up to 4.8km. Low frequency noise band seem to be effective. A sound field set up to attract or repel fish needs to contain enough perceptible information about the sound identity and the source position at the fish position. To do this more information is needed on the abilities of fish to estimate source direction and source distance. A van den Berg has sent Dr Wardle a useful four page reference list on hearing and sound source detection by fish available from Dr Wardle.

General Contributions on Fishery Acoustics

- a) J B Suomala discussed the development of Sensor"Processor equipment to generate synoptic indices of acoustic volume backscatter from insonified fish. A prototype has been tested and the final model will be used aboard ships of opportunity - the system uses a video display, audio tape recorder, and a programmable calculator. The results suggest a high sampling rate may not be required to obtain useful indices of volume back scatter. In the future a small high-volume production mini-computer will replace the proprogrammable calculator and vessel position will be interfaced with the data output.
- b) D N MacLennan reviewed the status of the echo integration method of fish stock estimates and the accuracy of those estimates. The key problems in the use of acoustics are species identification in order to know what proportion of the signed is the species of interest; fish avoidance effect on the mean fish density and the target strength; and the statistical scaling up of the survey results. Possible sources of error are the electronic factors, acoustic factors, and the target. Assuming ideal conditions for an acoustic survey, the best an assessment can be expected to be is within a factor of two of the absolute stock size and within 30% for relative trends.

- c) A discussion of the Aberdeen transducer housing was presented by David MacLennan. This towed body has reduced the motion of the transducer. Angle measurements inside the 1½m long body has shown its performance to be acceptable at speeds above 6 knots. It has exhibited better performance than hull mounted transducers.
- d) Kjell Olsen initiated a general discussion of the problems and results researchers have experienced with caged experiments related to acoustic studies. Major problems brought up include fish behaviour, whether it imitates natural behaviour, and how it effects the acoustic results; the spacial pattern of the fish in the cage; and the packing density. How these problems relate to experimental design and what effect they have on target strength measurements were also discussed.

Special Subject - "Behavioural aspects of fish attraction to submerged and floating structures and artificial devices".

Several references on the performance of fish aggregation devices were brought to the attention of the group:

- a) "Fish aggregatation devices (FADs)" by Michel de San. SWIO Fisheries Bulletin des peches IOSO No. 2, December 1982.
- b) "Maldives utilization of anchored surface floating rafts". FAO Rome 1982. Field Document 1, July 1982, 28pp.
- c) "Fish aggregating devices or payaos" by Michel de San. FAO Working Paper, June 1982, 17pp and figs.
- d) "The Fijian experience in the utilisation of fish aggregating devices" by G Preston, South Pacific Commission, 14th Regional technical meeting on fisheries, Noumea, 2-6 August, 1982.
- e) "Fish aggregating devices" - Bay of Bengal News, FAO, December 1982, No. 8. p 16-19.
- f) "Les techniques de peche au thou utilisees aux Philippines". par J. Marcille et W. Bour, La Peche. Maritime, 20 Fevrier, 1983, p 95-97.

S Venema related the experience of FAO with fish aggregating devices. They have been introduced in Sri Lanka, Zanzibar, the Seychelles, Mozambique and in the Maldives they have worked very well although there has been a problem with thefts of the anchor ropes. FAO has two people working with FADs. In Indonesia, a rattan anchor cable is used with is 6" in diameter and 2½km long with stone anchors. Tuna are hand-lined near it and a lampara net is towed under the raft to catch smaller fish. It is still unknown what the attraction mechanism is, but FADs are very helpful to the fisherman because it is a fixed point to go to fish. It has been noted that FADs do not increase the number of fish, it only congregates them. It may be worthwhile to try FADs in places other than the tropic seas to test their effectiveness on other species of interest.

General Business

- a) In a joint session with the Engineering Working Group, it was decided to combine the functions of the Engineering and Reaction groups because the interests and problems of the two groups are so inter-twined. In addition, it was decided to recommend the formation of a new working group to be concerned with fisheries acoustics.

- b) A Bjordal of Norway suggested the formation of an ad hoc study group to examine the biology of line fishing, bait attraction and acceptance. It was decided to follow up on the suggestion by determining who would be interested in participating and what the terms of reference would be.
- c) Dr Wardle was heartily congratulated for his excellent efforts as chairman of the Reaction Working Group for the past 9 years.