INTERNATIONAL COUNCIL FOR THE
EXPLORATION OF THE SEA

CM 1981/B:23
Fish Capture Committee

# REPORT OF THE WORKING GROUP ON REACTIONS OF FISH TO FISHING OPERATIONS

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.

Chairman: Dr C S Wardle

1. Meeting Place: Institut Scientifique et Technique des Pêches Maritimes,
Rue d l'Ile d'Yeu
BP 1049
44037 Nantes Cedex

2. Date: Monday 25 May and Tuesday 26 May 1981

3. Participants:

| | |
|---|---|
| Belgium | |
| G Vanden Broucke | Station de Peche Maritime<br>Ankerstraat, 1<br>8400 Ostende |
| Canada | |
| J Carrothers | Biological Station<br>St Andrews New Brunswick |
| P Fontaine | Direction de la Recherche Scientifique and Technique<br>DGPM - MAPAQ<br>Complex Scientifique<br>2700 Einstein Ste Foy G1P 3WB<br>P Quebec |
| Denmark | |
| J M Christensen | Danish Institute for Fisheries and Marine Research<br>Charlottenlund |

France

| | |
|---|---|
| M Portier and J C Brabant | ISTPM<br>150 Quai Gambetta<br>62200 Boulogne Sur Mer |
| J Prado | ISTPM<br>8 Rue Francois Toullec<br>56100 Lorient |
| G Kurc and N Diner | ISTPM<br>BP 1049<br>Rue de l'Ile d'Yeu<br>44037 Nantes Cedex |
| P Y Dremiere | ISTPM<br>1 Rue Jean Vilar<br>34200 Sete |

Faroe Islands

| | |
|---|---|
| H Jakupsstovu | Fiskirannsoknarstovan<br>Debessartrød<br>Torshavn DK 3800 |
| J Hansen | Orkuradid |

Germany, Federal Republic of

| | |
|---|---|
| K Lange and G Freytag | Institut fur Fangtechnik<br>Palmaille 9<br>2000 Hamburg 50 |

Iceland

| | |
|---|---|
| G Thorsteinsson | Hafronnsoknastofnunin<br>Marine Research Institute<br>Skulagata 4<br>Reykjavik |
| S Bjornsson | Engineering Research Institute<br>The University<br>Hjardahagi 2 - 6<br>Reykjavik 101 |

Netherlands

| | |
|---|---|
| E J de Boer<br>B von Marlen and T Lantau | Netherlands Institute for Fishery Investigations<br>PO Box 68<br>Haringkade 1<br>IJmuiden |
| A Schuijf | Laboratory of Comparative Physiology<br>Jan van Galenstraat 40<br>3572 LA<br>Utrecht |

| | |
|---|---|
| **Norway** | |
| L Karlsen and K Olsen | Institute of Fisheries<br>University of Tromso<br>Tromso |
| P Solemdal and S Tilseth | Institute of Marine Research<br>PO Box 2906<br>Nordnesparken 2<br>5011 Bergen-Nordnes |
| S Olsen, A Bjordal,<br>K Valdermarsen and<br>K K Angelsen | Institute of Fishery Technology Research<br>C Sundtsgate 57<br>PO Box 1964<br>5011 Bergen-Nordnes |
| A Ferno | Institute of Fisheries Biology<br>University of Bergen<br>5000 Bergen |
| **Sweden** | |
| O Hagstrom | Institute of Marine Research<br>PO Box 5<br>S-Y 5300 Lysekil |
| **United Kingdom** | |
| D MacLennan, P A M Stewart<br>and C S Wardle | DAFS Marine Laboratory<br>PO Box 101<br>Aberdeen AB9 8DB |
| **USSR** | |
| E Sabourenkov | Ministry of Fisheries of the USSR<br>Rozhdestvensky Boulevard 12<br>103045 - Moscow |
| T Valeriy | Polar Fishery Directorate Sevzhyloa<br>Sophia Perovskaya Street<br>183038 Murmansk |
| **Observer** | |
| M Ben-Yami | FAO<br>Fisheries Department<br>Via delle Terme di Caracalla<br>00100 Rome |
| Zhou Yinqi from Shanghai<br>China | Present Address<br>Marine Laboratory<br>PO Box 101<br>Aberdeen UK |

## 4. 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 co-operative experimental work where this seems worthwhile.

## 5. Summary of Past Meetings

The first meeting, in Nantes in 1973, considered and defined these aims. 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 in 1977 (CM 1977/B:4) the special subject discussed was methods of attracting fish. At Bergen 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 Goteburg 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 was 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. The same meeting recommended that the subject 'The behavioural aspect of low energy fishing methods' should be discussed at Nantes in 1981. This was supported by the Fish Capture Committee and reinforced by C Res 1980/2:8.

## 6. Agenda for the meeting at Nantes

1. Progress Reports and Programmes outlining research projects continuing in each country.

2. General contribution on reaction of fish to fishing operations.

3. Special subject 'The behavioural aspects of low energy fishing methods' See C Res 1980/2:8.

## 7. Progress Reports and Programmes

Belgium

During the year 1980 - 1981 there was no specific work done in the field of fish reaction. It can be mentioned that a project investigating tangle nets will be started in the period 1981 - 1982 and trials in the field of electrical fishing for shrimps and flatfish are planned.

Canada

In Newfoundland there has been some experimental development of trawls as tools for research surveys of indigenous fish stocks. In particular, with a Yankee 36 shrimp trawl for juvenile flatfish, a short chain foot gear and 12.7 mm extended mesh cod-end liner was successful for witch and yellowtail flounder, 9.5 mm tickler chain was successful for 6 - 15 cm witch and rubber bobbins and floats on the footrope bosum was effective for 4 cm and larger yellowtail on rough sea bed.

The Quebec Department of Fisheries has developed a prototype instrument for measuring trawl wing spread during research surveys. An original device for measuring vertical shrimp distribution to a height of 5 m above the sea bed has produced interesting results. Plans for 1981 include a shrimp trawl with sorting panel and experiments with traps for lobster, whelk (to avoid lobster by-catch) and crab.

The Federal Industrial Development Division in Vancouver is experimting with commercial herring impoundments to assess the effect on the fish, particularly respecting roe development. Some selectivity of black cod traps in the presence of high juvenile concentrations was achieved by using two 8.5 cm rings in each trap. Cod-end mesh selectivity studies on English and rock sole in Hecate Strait with $4\frac{1}{2}$", 5 1/4" and 6" meshes indicated that one-third as many undersize discards were retained by the 6" mesh as by the $4\frac{1}{2}$" mesh. Preliminary studies are bing conducted on the effectiveness of hexagonal-mesh netting to permit escape of juvenile salmon from purse-seine bunts.

At the Biological Station in Nanaimo, BC automatic longlinging has been developed to survey rock fish on untrawlable sea bed. Coordinated tests were conducted by hydro-acoustic, swept-volume and ichthyoplankton methods for estimating the biomass of adult Pacific hake and walleye pollock. Mesh selectivity for flatfish in Hecate Strait was measured. Canadian fishing effort for Pacific Ocean perch in Queen Charlotte Sound and for Pacific cod, rock sole and English sole in Hecate Strait is being standardized, and fishing effort is being allotted to single species in a multi-species fishery in Hecate Strait.

Denmark

The Danish participant informed the Working Group about the plans for establishing a Fishing Technological Institute in Denmark. The Institute will comprise a flume-tank, a simulator for fishing operations and other facilities for technological research. The Institute is expected to be fully established in the autumn of 1982. It was further stated that projects on energy saving fishing operations are in progress at the Shipbuilding Institute in Copenhagen. Studies of reaction of fish to fishing operations are not being carried out at present.

Faroe Islands

No specialist programme is undertaken in fish reaction studies, but a number of joint programmes with Norway on observing the reaction of fish to trawls are continuing.

France

An automatic system for underwater observation has been developed. Its originality is its low cost as it is made with an ordinary camera and flash. In operation the system is hung under the vessel.

Underwater films were obtained with a TV camera fixed on a scallop dredge, the purpose was to count the number of shells to estimate the available stock.

In the COB laboratory (in Brest) tank experiments are conducted on the behaviour of norway lobsters in an electric field in order to help development of an electric trawl.

Observations on the reaction of fish in commercial fisheries were recorded in relation to two main problems; speed of trawling and maximum mesh size at the mouth of a large trawl. In coastal fisheries a very large trawl towed by less powerfull trawlers at speeds of 2.5 - 3 knots are found to be efficient with the mouth opening covering the surface to the bottom.

For demersal fishing, it has been found that it is not possible to use meshes that are too big at the mouth opening of trawl ie no larger than 200 mm for the lower panel and lower parts of the side panels.

Germany, Federal Republic of

Within the past year the Institut fur Fangtechnik has undertaken promising investigations for the introduction of so called passive gears (setnets, longlines) and certain active gears (Danish seine and electrified beam trawl. At this very beginning it was a special topic to find out which gear can be successfully used in each area and to adapt the methods to the different conditions of the fishing areas. In the tidal areas of the German Bight and especially to those of the shallow area of the Baltic. The introduction of new fishing methods required the application of mechanical auxiliary instrumentation to reduce manpower and time consumption so that behavioural aspects could not be covered in the year of reference.

Iceland

No special work on fish behaviour was carried out since the last meeting.

In Summer 1981 it is planned to make a film on Danish Seining and the behaviour of some fish species reacting within this fishing gear.

Netherlands

There is a great deal of interest in the reaction of fish to gear at the IJmuiden laboratory. In the new hexagonal mesh trawls some observations are being made by placing echo sounder transducers at various positions on the gear.

There is a special group in Holland dealing with design of barriers that prevent fish entering industrial plants.

At the Laboratory of Comparative Physiology in Utrecht some unique and very relevant work is continuing on the hearing of fish. Ingeneous new experiments are being undertaken to define the directional hearing of many species of commercial fish and also investigate their ability to measure the distance of sound sources such as fishing gear components.

Norway

A coordinated programme continues to develop where members of Fisheries Institute of the Universities of Tromso, Trondheim and Bergen and the Marine Institutes and the Fishery Technology Institute co-operate on a number of projects. Many of these studies are of interest to the reaction working group and are closely linked to development of fisheries in Norway.

In Bergen the longline behaviour investigations include how the fish takes the hook: Aspects of bait, hook shape, construction of snoods and lines, fishing technique and seasonal variations. Oslo University have a programme examining how specific olfactory components stimulate cod behaviour.

The attraction of fish to oil rigs is being studied in the Ekofisk.

The behaviour of capelin and blue whiting in a mid-water trawl using acoustic techniques to look at herding and by observing meshing of fish etc is continuing including cooperative work with Faroes.

Acoustic techniques continue to be used for a number of studies including the observation of the change in attitude and spatial distribution of fish when a vessel is approaching.

There are plans to expand interest in the behaviour of fish in relation to more selective fishing and to seek energy saving capture techniques.

Sweden

Studies are carried out on the behaviour of lobster in creels and constructing escape holes with size selection corresponding to the minimum landing size in force.

Target strength measurements are being carried out on caged herring and cod.

Field experiments with different cod end mesh sizes are conducted to study size selection on herring and shrimp.

United Kingdom

Aberdeen Marine Laboratory is continuing a programme of fish swimming performance studies and experiments where fish reaction behaviour to gear components is being recorded as opportunity arises.

There is a growing collection of video tapes which now includes a large number of fish reactions to gears made by diving scientists in a piloted wet towed vehicle and also a remote vehicle which carries the TV camera to all parts of the gear without divers in attendance. TV observations are practical to 100 m using natural daylight and have been extended to observe bioluminescence and gear in deeper waters using artificial light to 200 m.

A collected version of these video films is now available from the Marine Laboratory Aberdeen.

Some experiments investigating the behaviour of fish in a towed cubical cage with walls made from various netting materials are giving a better understanding of the optomotor reflex in the capture process and also the function of rising and constricting panels.

A creful study of the geometry of the sand cloud generated by different trawl boards was made using the diver operated observation vehicle a detailed report has been published in Fisheries Research series Publication No 20 available from the Marine Laboratory PO Box 101 Aberdeen.

Other studies continuing include the flow about the componentsof the net; the schooling behaviour of saithe, herring, mackerel and sandeels and its relation to reaction to net components; the appearance of different netting materials and colours in relation to the water background at different depths.

A programme has been started in which the remote towed TV observation vehicle is used to examine the efficiency of function of each net component for each size and species of fish to integrate a picture of net efficiency for each size and species of fish. The remote vehicle with magnus effect rotors has now been optimised by experiment to give a very effective movement about the net with 1 HP motors.

USSR

There are a number of directions in investigation of fish behaviour, including fish reactions to different natural and artificial factors. The main aim of these investigations is to increase the possibilities of incorporating the knowledge of fish behaviour into design and improvement of existing and future fishing methods and gears and to provide the basis to carry out the rational fisheries ie to obtain catches with predicted species, lengths and sex distributions.

The general directions of these investigations are the following (not in the order of their importance):

1. Mathematical modelling of fish reactions to create a model of fish behaviour in relation to different factors.

2. Methods of marine fish handling in experimental conditions.

3. Observation of fish reactions during fishing operation on fishing grounds under natural conditions.

4. Fish behaviour in relation to their acclimatization.

5. Investigation of fish orientation within a field of artificial stimulus.

6. Investigation of fish responses to stimuli such as light, electricity, magnetism, sound and chemical substances.

At present about, 38 different organizations are engaged in these investigations, so the main problem now is to coordinate these works and to encourage utilisation of results into the fishing industry

8. General Contributions:

a) Hearing in fish

The question of hearing in fish are discussed at length with Dr Arie Schuijf who presented a practical account of the careful and excellent work he is doing in Holland on the directional hearing of fish an on the question of can the fish assess the distance to the identified sound source. Dr Schuijf was pointing out the relevance in fishing context expanding a published paper (Schuijf and Buwalda 1980 in Comparative Studies of Hearing in Vertebrates. Proc. Life Sciences). The meeting was very much encouraged by Dr Schuijf's results and members expressed the need for this basic work on fish hearing to be stronly supported and expanded as it is so directly relevant to the reaction of fish in fishing gears and may help explain many of the observations of fish behaviour in nets. Careful study should be made of this work by all researchers interested in reaction of fish to gear.

b) Herring bycatch in cod gill nets!

A report by Kjell Olson demonstrated how 35 cm herring were caught and killed by conventional multifilament nylon cod nets with a 186 mm mesh. The herring were caught by snagging their great external maxilla and supramaxilla (corner of the mouth) onto the thred of the large mesh and areheld there whether the mouth is open or closed. These herring can become loosened during hauling and possibly up

to 40 - 50% of the dead fish can be lost. The conventional herring net with 57 mm mesh size caught 10 times as many herring about 300 kg per net. Some herring were also found entangled in these nets. The short written contribution was entitled 'Bycatch of herring in cod gill nets'.

c) Longline fishing

A contribution entitled 'The factors influencing the attraction and hooking of fish in longline fishing' was presented by Tilseth, Ferno and Solemdal and illustrated with video tape extracts of their observations. Their contribution described the main sequences of behaviour and the effect of time of day on the hooking of whiting in Trondheims fjord at different seasons of the year. The attraction to the hook was effected by olfactory stimulus, fish sensory threshold and size of bait. Of those fish testing the bait only some bite and texture and taste were thought to be important. In discussion the greatest effect of particularly artificial baits was in the first few minutes as the tasty substances are soon washed away from the surface of many of these baits. Following a bite the character of the hook can determine whether the fish swallows, spits out or rushes and jerks. Swallowing or rush and jerk may then lead to successful hooking. The majority of the whiting observed were hooked following a rush and efficiency was measured by considering the number of hooked fish divided by the number of rushes. The experiments allowed detailed comparisons of efficiency in different circumstances of the gear, bait, season and time. It was noted that whiting with a lower liver weight tended to swallow the hook suggesting correlation with high feeding motivation. The rush and jerk behaviour suits the so called 'rush hook' and explains its success but also indicates that basic observation studies of this type could lead to sensible developments in gear design. The effect of experience and the reactions of neighbours was discussed in relation to experimental design and comparative fishing tests. The work is continuing.

NEPHROPS

d) Nephrops selection

A contribution entitled 'Influence of gear and behaviour on selection in the Nephrops fishery' was presented by A Bjordal. The contribution discussed mainly the selection process of baited creels based on field work with underwater TV watching creels and practical fishing experiments. Bjordal agrees with Chapman et al., 1979 that Nephrops are only attracted during feeding excursions from their burrow and larger animals have longer ranging excursions and more chance of creel encounter. TV observation of the 2 m area around a creel showed 80 - 90% approached the creel up current and only 10% of these entered the creel. Entering time varied from 1 minute to 1 hour larger animals were less sensitive to disturbance during the entering period and were therefore more successful, whereas small Nephrops were nervous and easily disturbed and often gave up their effort to enter the creel. Creels caught larger Nephrops than trawls. (Chapman and Howard 1979 Mar Biol. 51(2) 157 - 165.)

e) Underwater view

This contribution showed by colour slides the appearance of various coloured netting panels and ropes at different depths of water on the Scottish west coast and was made by C S Wardle. The disappearing horizon was demonstrated in an orange netting panel where at 15 m depth the apparently greeny grey net image merges with the background when seen horizontal but appears silhouetted black when seen from slightly below and appears bright against a dark background when seen from above. The gradation from light above to dark below in the background appearance causes this change in relative contrast. The use of white and black in ropes and netting panels was demonstrated in slides. The means of making panels and ropes more or less visible was discussed and illustrated using various combinations of black and white cwt. This work is continuing. Some of the latest videotapes of fish reaction in gear made in Aberdeen were shown.

fuel consumption possible that the subtilitiesof fish behaviour that are becoming known to us by experiment and observation of the various gears are hardly relevant to the energy argument. Such ideas as towing trawls at lower and more appropriate speeds (if these exist) were thought not to make very noticeable economy when related to these other fuel using manouvres. It was thought that the more the behaviour of the fish was understood by the fishermen the more efficient he may become in finding, selecting and catching larger numbers of fish for each fuel unit used, so that knowledge of fish behaviour seems to become part of the fishermans potential knowledge, training, experience and skill. It does appear therefore important that knowledge acquired by the scientists studying each type of fishing gear becomes available to fisherman as soon as possible. For example, in 8c above the potential increase in hook efficiency was pointed out as a result of research observations. The fisherman can possibly increase his yield per fuel unit by applying the new knowledge of fish behaviour, or by adding a second technique to his repertoire. When fuel becomes such a major part of the fishing cost one may assume that the fisherman is constantly on the look out for ways of bettering his return. However factors such as depreciation, subsidies, insentives, escalating price of manpower and market price of fish all upset the balance of this delicate economy. An example put forward was the four panel trawl designed at the Marine Laboratory Aberdeen which was taken up by many fisherman in several countries because it was not damaged on rough ground. The design however incorporated many detailed features resulting from fish behaviour studies which maintained an effective fishing mode of the carefully tailored net. The result was the net was equally effective in catching fish as earlier nets, but suffered less damage and the consequent mending and replacement costs became noticeably less.

c) Conclusions

One sensed at the meeting that the discussions of the behavioural aspects of low energy fishing methods was disappointing unless we realised that nearly all the research and developments and observation and understanding of the reaction of fish in fishing gears is already directed towards making practical fishing gears 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.

10. Recommendations:

1. This Working Group should meet at Aberdeen in May 1982 and in addition to further discussion of research programmes andcurrent topics of interest to the working group should prepare for a special discussion of the 'Biology of escaping fish' or what happens to those species including undersized fish that interact with but escape from all types of commercial fishing gears.

2. This working group should prepare for a joint discussion with the Engineering Working Group of the fish capture committee on 'the trawl as an instrument for the assessment of pelagic fish stocks'.

C S Wardle
17 August 1981