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International Council for the  
Exploration of the Sea

C.M. 1980/B:32  
Fish Capture Committee

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

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1 Meeting Place: Fisheries Association of Iceland, Ingolfstraeti 1,  
Reykjavik, Iceland

2 Date: Wednesday 7th and Thursday 8th May, 1980

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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, C.M. 1975/B:5). The third meeting in Ostend in 1975 concentrated on the effect of electric fields on fish (C.M. 1975/B:19 and B:20). The fourth meeting in Hull in 1976 as well as producing a general report (C.M. 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 (C.M. 1976/B:3).

At Hamburg in 1977 (C.M. 1977/B:4) the special subject discussed was methods of attracting fish. At Bergen Council Resolutions (C. Res. 1975/4:11 and C. Res. 1976/5:4) 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.

## 6 Agenda for the meeting at Reykjavik

- 1 Progress Reports and Programmes outlining research projects continuing in each country.
- 2 General contribution on subjects to be considered by this Working Group, (See C. Res. 1979/2:13b).
- 3 Special subject "Selectivity in fishing gears and the possibilities of species specific fishing", (C. Res. 1979/5:1b).

## 7 Progress Reports and Programmes

### Belgium

Although there are many practical fishing studies including application of electric fishing continuing in Belgium no particular work on fish reactions is in progress.

### Canada

The Federal Research and Resource Services Directorate in the Newfoundland Region reports on two selectivity experiments, one for American plaice and yellowtail on Grand Bank using alternate hauls with uncovered codend and the other concerning the 'drying twine' area on the back of cod traps. Also, a technique has been developed to reconstruct mathematically a population of Atlantic salmon fished at West Greenland using the catch in two sizes of gill-net mesh, fished concurrently with equal effort. The experimental catch is identified by comparison with the commercial catch and mortality was adjusted using rates for Pacific salmonids.

The Newfoundland Provincial Government reports on five projects. A comparative fishing trial between a Yankee 36 and Ivor Christensen star bottom trawl in the Strait of Belle Isle for 5 days in August on two 58-ft (18m) vessels of similar horsepower yielded nearly three times as much catch with the latter as with the former. A trial with bottom longlines in Harbour Breton in November-December, comparing spun nylon with monofilament gangings, yielded 47.5 fish per hundred hooks with the latter as

compared with only 19.1 for the former. Trials in Strait of Belle Isle with a rope-wing pelagic trawl in contact with the sea bed in 22 fm water for cod were not successful, even though the net sounder indicated the net was behaving properly and even though cod were being caught commercially with bottom trawls in the area. Ship sounder traces did not show in the net sounder, indicating that fish were avoiding the trawl. An original, longline, hook-baiting device has been developed and proven effective for small fishing vessels. Two Scottish vessels in the 80-85 ft (25 m) class were chartered to determine the feasibility of a Scottish seining/pair trawling operation in middle distance waters. Location of suitable grounds is a factor.

The Federal Resource Branch, Maritimes Region (St Andrews) is developing improved fish-stock survey techniques. For acoustic survey methods, target strengths of individual herring, groups of herring at high density in captivity and groups of capelin in cages have been quantified. Single pulses were recorded to study variance and confidence in measurements. A new hardware system involving microprocessors and dual beam transducers has been constructed, but scheduled trials have been frustrated by lack of fish. Techniques for photographic truthing of acoustic observations and spawn surveys from a towed, sea-bed referencing vehicle continue to be developed with promising results.

#### Faroe

No specialist programme is undertaken in fish reaction studies, but a joint programme with Norway on observing the reaction of fish to trawls has been undertaken. See report by Jakobstovu & Isaksen.

#### France

For mixed fisheries, Nephrops and hakes, a selective system was studied to separate Nephrops and other fishes. This system is based on distinct behaviour of species: Nephrops follow the lower panel of the trawl up to the codend, the fish try to escape by crossing the upper panel of the trawl. We put in the last part of a traditional Nephrops trawl a splitting panel. Good results were obtained.

In trap fishing for cuttlefish, attraction mechanisms were studied; attraction is a sexual one based on the different colour of male and female but many variations exist our purpose is to prepare an artificial attraction system a kind of lure.

In longlining, length of snoods and space between them were studied to get the highest catching efficiency on different species; the space between snoods depends on the specific distribution of fish on the bottom (for example the shoaling behaviour of dogfish requires short spacing, on the other hand for skate it is not useful to put so many snoods on the line); many species (of shark and sea bream for example) seems to react adversely to visible lines in many cases efficiency of catching was higher by using finer monofilament line.

In the plan of an international project on listao, acoustically tagged tuna are prepared. The tuna will swallow the tags, it will be necessary to make sure that they don't regurgitate the tag.

#### Germany, Federal Republic of

There is considerable interest in the reaction of fish particularly to the new rope trawls. Studies of interest include krill behaviour during 1978-79 still to be reported and the use of fixed gill nets and other passive fishing methods that conserve energy.

#### Iceland

Gill nets are being examined. If well on the bottom cod are caught but with poor sea bed contact a greater proportion of saithe are trapped. A study was made up the behaviour of blue whiting in rope and big mesh trawls.

A part of the blue whiting stock migrates from the Faroebanks to the waters east of Iceland where some midwater trawling (and on one occasion purse seining) has taken place in July-August in the last 3 years. In summer 1979 big meshed midwater trawls were tested for the first time on these grounds. A rope trawl was tested for short periods in 1978 and 1979.

In 1979 some different designs could be tested and compared. One trawl with 16 m meshes of conventional shape, one trawl with hexagonal meshes of up to 30 m meshes, one Engel rope trawl, one trawl of 3.2 m meshes and some trawls with "small meshes" 0.8-1.0 m.

Due to very unusual low sea temperature off east Iceland in summer 1979 the majority of the blue whiting migrated northward more easterly than in previous years. Consequently the blue whiting quantity off east Iceland was less than in previous years. These factors surely have influenced the behaviour of the fish.

The advantage of the big meshed trawls and the rope trawl was the big opening height of 22-25 fathoms as compared to 15-17 fathoms of the conventional trawls. Because of the big net opening the fish was easier to catch when it was in midwater 60-80 fathoms off the bottom. With the standard trawls it very seldom succeeded to get fish which was staying more than 50 fathoms from the bottom and then usually only a small part of the school chased.

On the other hand fish concentrations close to the bottom were more difficult to catch with the big meshed trawls and a rope trawl, simply because the fish escaped more easily through the big meshes (ropes) than in case of the "small meshes". All skippers concerned agreed about this. Apparently the 0.8 m meshes could however be too small since the boat using the 3.2 m meshes caught effectively in every depth. It must be mentioned however that this boat was the biggest and the most powerful one. Then the unusual conditions mentioned before could have been in favour of the big meshes trawls. Thus a general statement of the catch ability of the different designs cannot be made.

The behaviour of the fish has already been mentioned to some extent. It can be added that the fish was most difficult to catch in the time from 22 to 2. In this time the fish was very hard to get into the trawl opening. Also in the cases where the fish was recorded in the trawl mouth the catches were much poorer than expected. The fish therefore must escape through the front part of the trawl even in case of 0.8 m mesh size. Echo sounder traces were presented which demonstrates this further fish seen in the trawl mouth amounted to some 60 tons of catch. This was in the evening before 22 o'clock. The fish does not show a great tendency to swim downwards through the front part of the netting. Just after midnight the reaction of the fish to the groundrope was much less and the traces shown resulted in only some 10 tons of catch. In both cases the echograph traces were similar.

In general the blue whiting was rather difficult to catch in 1979. The schools were frequently very scattered or very close to the bottom. Such behaviour patterns sometimes could be observed in a relatively short period of time. For example, the echograph showed the fish close to the bottom at about 20.00 hours and the fish was hard to get into the trawl mouth. After returning to the same place again at 21.30 hours the schools were well above the bottom and very easy to catch. These traces shown on that figure resulted in some 100 tons of catch. About 3 hours later the schools had dispersed and appeared as thin traces. The boats which started fishing on these schools about midnight only got small catches.

In 1980 some fishing trials with a high opening bottom trawl is planned.

#### Netherlands

There are a number of university groups working on aspects of fish behaviour but none particularly dealing with fishing gear reactions. There is a great deal of interest in the reactions of fish to gear at the IJmuiden laboratory but, no specialists. Cooperative programmes with other institutes, including Aberdeen Marine Laboratory, have helped to examine the behaviour of fish in gear.

#### Norway

A programme has been developed where members of the Universities, the Marine Institutes and the Fishery Technology Institute co-operate on a number of projects.

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.

Other studies include: The use of sound signals to recall salmon to feeding points is being developed for fish farming purposes. Acoustic heart beat tag studies and behaviour of fish and Nephrops during trapping.

Salmon smolt migration is being investigated by acoustic tag.

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

#### Poland

No specialist work in the field of fish reaction but some important studies have been made of the use of nylon tape instead of twine to form the meshes in the codend and the effect of this on codend selectivity has been examined. Studies on the ways of catching new species include Ice fish in S. Georgia. Jig fishing studies in NE Canada area Patagonia and Argentina using Japanese equipment for squid.

#### 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.

There is a growing collection of video tapes which now includes a large number of fish reactions to gears made by a diver piloted wet vehicle and a towed vehicle which carries the TV to all parts of the gear without divers in attendance. TV observations are practical to 100 m using natural daylight.

A collected version of these video film 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 captive process and also the function of rising and constricting panels.

A careful study of the geometry of the sand cloud generated by different trawl boards was made using the diver operated observation vehicle a detailed report will be published.

Other studies continuing include the flow about the components of 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 colour in relation to the water background at different depths.



It is planned to use the remote towed TV observation vehicle 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.

Mr Hatfield, WFA, mentioned strong evidence that blue whiting dives below advancing pelagic trawls; the smaller (10-15 fathom opening) trawls could not fish successfully, in spite of seeing large quantities of fish on the netsonde, unless they fished close to the sea bed. Also some work had shown dog fish schooling while feeding, ie close spacing of snoods was very successful when long lining for dogs.

#### USA

Gear research and gear related fish behaviour studies in the United States are carried on by the National Marine Fisheries Service, state agencies, universities, and individuals. The emphasis in much of this work is on conservation as we have a recognised need to develop gear that is size and species selective. Another significant area of study is in the development of sampling gear to assess the resource. On a smaller scale, studies are done to improve safety and comfort at sea and to improve the efficiency of the gear.

As a supplement to the detailed list of projects still continuing and presented in last year's report. The turtle tracking and porpoise tracking projects are continuing. A loggerhead turtle was fitted with two transmitters, one for satellite reception and another for reception by an airplane mounted receiver. The turtle has been successfully tracked by both systems since October 1979. The porpoise satellite transmitter has not worked quite as well, and analysis of the problem is continuing. It may be that the weight of the transmitter is making the porpoise stay underwater more than usual, thus making the antenna ineffective.

Herring tagging and migration studies are continuing, with the major emphasis on population assessment.

Porpoise behaviour in tuna seines is still being studied to reduce mortality. At present a computer model of the seine is being developed to evaluate proposed gear changes.

Scallop gear studies will be looking at the selectivity of a new dredge this year.

#### USSR

As was described in the Administrative report of the USSR to the ICES fish capture committee during 1979

- the works on determining survival rate of young flounder released from trawl catches into the sea were initiated. Since this work has just started there is not sufficient data to draw conclusions.

Report on the results will be forwarded upon accumulating materials and their processing.

- The program for computer analysis of the influence of fishing on the state of fish stocks continues to be improved.

Besides the works indicated in the Administrative report investigation on bottom trawl selectivity in relation to the Barents Sea shrimp Pandalus borealis was carried out. On the basis of the results of that investigation the USSR introduced 35mm mesh size in the trawls for shrimp fisheries since January 1, 1980.

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#### General Contributions Reaction Observations

- (i) Report on experiments with electrified barriers and bubble curtains by P A M Stewart.
- (ii) Some notes on the behaviour of blue whiting off East Iceland in summer 1979 by Gudni Thorsteinsson.
- (iii) S Isaksen presented some aspects of a paper Preliminary report of the blue whiting fishing experiments East/South East of the Faroe Islands in Jan/March 1980 by S H Jakobstovu and B Isaksen to which he outlined a successful technique using 2 netzonds to obtain evidence of fish being herded upwards by the lower panels of the net. Here the net used was a 16 m big mesh net accepted as an excellent fishing device for blue whiting. The double netsonde system was used on the 16-m trawl and altogether 17 trawl hauls were made with the system working.

The locations of the second transducer were: at the changes of mesh size from 160 to 80 cm, 80 to 40 cm and 40 to 20 cm, respectively.

The echo recordings from the different locations showed that the distance from the fish to the panel in the lower belly changed little from fore to aft in the trawl. The recordings furthermore confirmed the earlier experience that the fish do swim along with the trawl inside the belly.

Beneath the trawl at the locations of the second netsonde transducer very few fishes were recorded. This together with the very good catch-rates clearly suggests that the big meshes in the fore part of the trawl do herd the blue whiting.

For the time being the impression consequently is that the big meshed trawls in the blue whiting fishery are here to stay.

9 General Contribution Echo Surveys

A useful experiment was reported by Kjell Olson when he presented a draft paper 'Echo Surveying and Fish Behaviour'. He showed that fish do react to the survey vessel and the reaction does cause a major change in the target strength. Following lengthy discussions, the working group encouraged the author to present his paper as a contribution to the Fish Capture Committee. The working group felt that a greater effort should be made by other member countries to carry out experimental work to evaluate the effect of fish behaviour on echo surveys. A recommendation to this effect was developed and is included as the second recommendation of the working group.

10 Selectivity in Fishing Gears and the Possibility of Species Specific Fishing

(a) The Discussions

It was made clear from the start of these discussions that the widely understood idea of mesh selection was a minor part of the whole gear selection process. Mesh selection does let selected smaller fish out of the bag of the net once they have been caught but the process of capture involves many other factors which lead to selection of certain sizes and species. The following is a brief account of the main points brought up by those present at the meeting. The first selection can be made by the fisherman taking his boat to a certain sea area at a certain time of year with the aim of locating and recognising certain expected species of a commercially useful size. These well known traditional fisheries include species like cod, mackerel, herring, sprats and blue whiting. Certain areas are known to yield pure catches for short periods. Identifying the characters of the species by echo sounder and the selection of an appropriate effective gear has evolved as the every day approach by the fishermen. His methods are not infallible and could be made more accurate to increase selection. In many cases this attack has been limited to breeding congregations of the mature adults of the species eg Lofoten Cod fishery and traditional herring fisheries. The recent trend to the use of aimed mid water trawling and purse seining has increase the effective effort on these specific stocks. The purse seine uses small mesh to avoid gill meshing of fish and for this reason can have no selective function. Purse seine are known to kill large quantities of the wrong species or size when the fishermen misjudges his target. This makes it even more important to make exact identification of species and size range of the target fish. In contrast to these specific fishing efforts are the opposite trends where the fishermen is attempting to get anything available within the path of his trawl. It was for example thought by those present that Nephrops and shrimp trawls could be made very specific to catch only Nephrops or shrimps and the other fish avoided or allowed to escape. However many fishermen extend the sweeps and headline height of those shrimp or Nephrops trawl in order to land the improved by-catch of mixed roundfish species. Together with the smaller mesh often allowed in these fisheries this seems a trend in the wrong direction. Within demersal trawling and seine netting there

have been small changes in nets to make them more effective in catching particular species simple things like good sea bed contact for flatfish or high headlines for haddock are examples. However we are only by direct observation of the fish behaviour beginning to understand how some of these gear adjustments bring about their effect and more observations are required. It was agreed that the vertical and horizontal distribution of fish varies its catch ability. Vulnerability of a fish is also effected by its size morphology and performance characters and by the exact way the species reacts to a gear. Both different species and different sizes might be separated by small details of a gear exploiting these catch ability differences. With the aim of separating species the Norwegian labs are intending to study in more detail the diurnal behaviour of species and at Aberdeen detailed observations are being collected on the reaction of each size of each species to various gear components. These sorts of detailed study could lead to more effective ways of separating the fish to be caught from those to be left in the sea undamaged.

The separation of different size of fish in towed fishing gears due to the different swimming abilities related to size (work continuing at Aberdeen) was discussed. The more obvious examples are the ropes of Danish seine nets and the warps of the demersal pair trawls which sweep large areas of the sea bed. The swimming performance characters of fish are such that larger sizes are herded into the track of the nets of these gears whereas the smaller fish are left behind. The setting of the angle and spread of these herding devices splits the encountered fish into two groups around a particular size. In all the towed gears once the fish are collected in the mouth of the net the exact forward speed determines which size becomes exhausted and drops back into the net. The larger sizes and better cruising species can swim for the length of the tow in positions between the wings and swim away when the net is hauled to the surface. Of those exhausted and dropping back into the funnel of the net various details of the design and the tailoring in different areas of the net can allow loss of certain species and or sizes and retention of others.

It was realised by those present that there were many methods of fishing and each by various means could be biased in which species and which sizes it caught. However there was no way envisaged to solve some of the current problems; for example separation of Norway pout from the similar sized young of other species like haddock and whiting. The only hope in this difficult example were detection of small differences in diurnal or some other behaviour pattern. Catch quotas are causing wastage and there is a real need by fishermen to develop techniques to avoid catching particular species but still allow economical returns on other species often in mixed fisheries. These were but two of the examples mentioned that desperately needed constructive suggestions but with little hope of an effective solution without more knowledge of the reaction of each species to the net. Some work examining these details is continuing in Aberdeen by direct observation techniques. Gill net fishing by set nets or drift nets is recognised as

very selective but labour intensive. It must be admitted that if a certain size range of fish is to be caught a gill net with the appropriate mesh is very effective and predictable. Longlines are to some extent also size selective depending on bait and hook size. It was agreed that often the most selective fishing may not give the greatest immediate economic returns to the fishermen, for example, the by-catch is a valuable extra making the operations more worthwhile. There are as many incentives against efficient selection as there are for it.

It was felt that information on fish reaction and fish capture should be more easily available to fishermen it was thought that a more informed fishermen might improve the selectivity of his own gear if the facts were available. It was also felt that fishermen had evolved many tricks of the trade that do modify the specific catching efficiency of these gear and this sort of information should be collected analysed and made more widely known.

#### (b) Conclusions

The general conclusion was that there are many species specific and size specific fishing techniques. There are non-specific and very-specific fisheries. There are areas of conservation where damage to conserved stocks occurs due to the mixed nature of the fishery because there are no suitable species specific techniques which separate protected and unprotected species. There was some hope expressed by those present that the specificity of fishing can continue to improve as we understand more about the reactions of fish to the gears and apply this knowledge to fishing techniques. Mike Hatfield mentioned that his department (WFA) were intending to make a survey of all existing information on gear selectivity including particularly the pelagic trawl and that he could make his report available to the reaction working group at a future meeting.

#### 11 Recommendations

- (1) This working group should meet at Nantes in May 1981 and in addition to general reaction discussion prepare for a special examination of "The behavioural aspects of low energy fishing methods".
- (2) Following the detailed discussion of the paper by Kjell Olson "Echo surveying and fish behaviour" (paragraph 9 above) and taking into consideration previous discussions at meetings of this working group on the subject of the effect of fish reactions on stock assessment by echo sounding and C. Res. 1975/4:11, C. Res. 1976/5:4, C. Res. 1977/2:12b and Reaction Working Group report CM 1978/B3 Fishing Technology Committee. This working group, with the support of those attending the planning group for the 1982 meeting on "Fisheries Acoustics" recognises that certain aspects of fish behaviour can significantly influence the data on stock sizes collected by acoustic methods and recommends that member countries carry out experiments on the behaviour of fish in relation to acoustic stock assessment.

C S WARDLE  
19 September 1980