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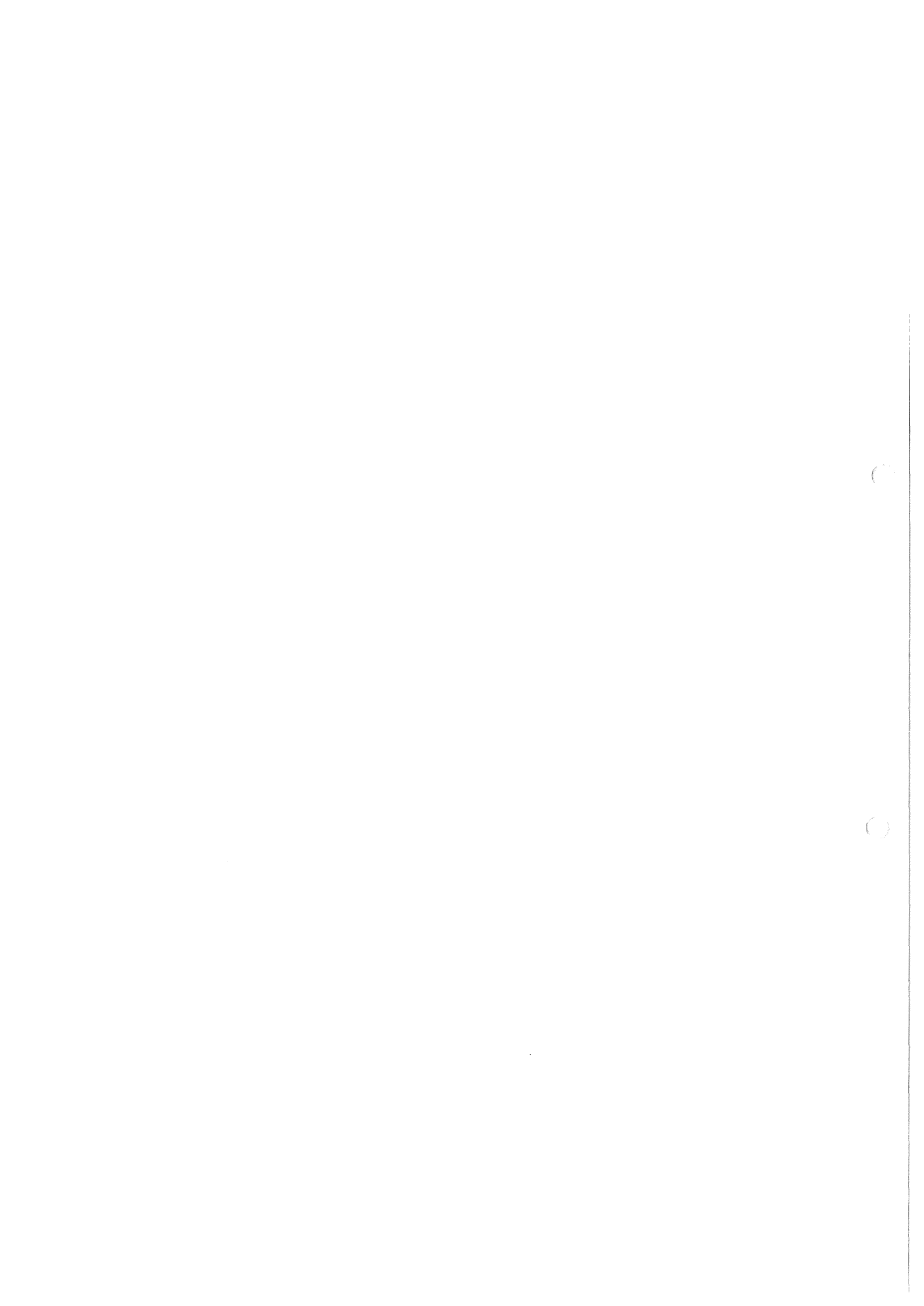
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**INTERNATIONAL COUNCIL FOR  
THE EXPLORATION OF THE SEA**

C.M. 1989/B:42  
Fish Capture Committee

**REPORT OF THE WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR.**

General Secretary  
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FISH BEHAVIOUR**

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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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IJmuiden, The Netherlands;

Rapporteur: R. Fonteyne, Fisheries Research Station, Ostend, Belgium.

Meeting Place: DUBLIN, Ireland.

Dates: 24th and 25th April 1988.

## INTRODUCTION.

In accordance with ICES Resolution C.Res.1988/2:5 the working group met in Dublin on 24th and 25th April 1989 convened by Mr. B. van Marlen and considered in particular:

- a) **the size and species selectivity of fishing gears used to sample fish populations,**
- b) **methodology for evaluating the survival rate of fish that come into contact with fishing gears but are not captured,**
- c) **engineering aspects of working practices onboard fishing vessels.**

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## **AGENDA.**

### **1. PRESENTATION AND DISCUSSION OF PAPERS ON SPECIAL TOPICS.**

#### **a) The size and species selectivity of fishing gears used to sample fish populations.**

1. Are past mesh selection data and methods of investigations valid for today's fisheries?  
S. Olsen.
2. How does a roundfish experience a given "scientific meshsize"?  
B. Isaksen, S. Olsen and J.W. Valdemarsen.
3. Change in length composition of different species with the doors and sweeps on and off the bottom.  
W. Dickson and A. Engås.
4. Effect of tow duration on length composition of trawl catches.  
O.R. Godø, M. Pennington and J.H. Völstad.
5. Escapement of fish underneath the footgear of a Canadian groundfish survey trawl.  
S.J. Walsh.
6. Size selection of plaice by square and diamond mesh codends.  
S.J. Walsh, C.G. Cooper and W. Hickey.
7. Codend design; selectivity and legal definitions.  
P.A.M. Stewart and R.D. Galbraith.
8. A divided trawl for codend selection experiments.  
J.H.B. Robertson.

#### **b) Methodology for evaluating the survival rate of fish that come into contact with fishing gear but are not captured.**

9. Fish escapement from longlines and methods to study escapement and survival.  
Å. Bjordal and O. Cruickshank.
10. A method of recapturing fish which have escaped from Danish seine and trawl codends at the surface.  
B. Isaksen, A. Engås and R. Larsen.
11. Is unaccounted fishing mortality a problem in purse seining?  
A.K. Beltestad and O.A. Misund.
12. Simulated net injuries on saithe.  
A.V. Soldal, A. Engås and B. Isaksen.
13. Aberdeen fish survival studies and the interpretation of results.  
R.S.T. Ferro.

**c). Engineering aspects of working practices onboard fishing vessels.**

14. Safety aspects in redesigning medium sized beamtrawlers.  
F.A. Veenstra.
15. Survey on location and maintenance of survival suits onboard Norwegian fishing vessels.  
E. Kjerstad.
16. A preliminary study on the landing capacity of stern freezer trawlers.  
B. van Marlen.

**2. PRESENTATION AND DISCUSSION OF PAPERS ON VARIOUS GEAR DESIGN AND ENGINEERING TOPICS.**

17. Further data on flow in trawls and codends.  
R.S.T. Ferro.
18. Full scale testing of Nephrops trawl codends in the flume tank.  
D.A. Wileman.
19. Otterboard data from Seafish flume tank and its practical application.  
N. Ward.
20. Hydrodynamic characteristics of netting panels at low angles of attack.  
Lu Chi.
21. Testing mesh shrinkage due to the penetration of bottom sediments.  
R. Fonteyne.
22. Engineering trials on supermesh trawls GM3 (4320 meshes circumference) made of polyamide and GM6 (5640 meshes circumference) with a front part of Dyneema SK-60.  
Dai T. and B. van Marlen.
23. A conservation orientated fishing vessel.  
Å Bjordal.

**3. PRESENTATION AND DISCUSSION OF PAPERS ON OBSERVATION TECHNIQUES AND BEHAVIOUR.**

24. Update of square/diamond mesh studies including plans for current year.  
C.G. Cooper.
25. Underwater observations of swimming patterns of Baltic herring approaching and swimming through the funnel of a herring pound net.  
P. Suuronen.
26. Underwater TV-observations of cod, ling and tusk in fishing trials with different types of baited traps.  
D.M. Furevik.
27. Separating Nephrops and whiting in trawls with reduced separator panel.  
J.P. Hillis.



28. Preliminary results from fishing trials with a new shrimp sorting device.  
L. Karlsen.
29. An assessment of the efficiency of trammel nets constructed of different materials  
J.E. Tumilty.
30. FOCUS, a new towed underwater vehicle for trawl observations  
U.J. Hansen.

**4. OTHER MATTERS.**

**5. SHORT PRESENTATION AND DISCUSSION OF NATIONAL PROGRESS REPORTS.**

**6. RECOMMENDATIONS.**

## 1. PRESENTATION AND DISCUSSION OF PAPERS ON SPECIAL TOPICS

### a) The size and species selectivity of fishing gears used to sample fish populations.

#### 1. Are past mesh selection data and methods of investigation valid for today's fisheries? (S. Olsen)

It was stated that regulations based upon selectivity data gathered in the past according to ICES-prescriptions cannot prevent undersized fish of being captured. The covered codend method seems to be no longer adequate to study the selectivity of modern trawls due to the masking effect that occurs with this method. Although this method is considered as the standardized ICES-method, it is believed that other methods should be authorised in order to obtain more reliable results. An international cooperative research programme was suggested to investigate all aspects of the problems raised.

#### 2. How does a roundfish experience a given "scientific meshsize"? (B. Isaksen, S. Olsen, and J.W. Valdemarsen - presented by K. Olsen)

The influence of the codend twine diameter upon the mesh opening of codends was discussed. The mesh size as measured by the ICES-gauge or the flat wedge-shaped gauge does not truly represent the escape opening of a mesh. The mesh opening measured with a cone gauge with an elliptical transsection is smaller compared to the results obtained with a flat wedge-shaped gauge when the yarn diameter is increased. Consequently the selection factor will be smaller too. Thicker yarns have stiffer bars and bigger knots and these may adversely effect the escapement of young fish, thus reducing the selection factor even more.

#### 3. Change in length composition of different species with the doors and sweeps on and off the bottom. (W. Dickson and A. Engås - presented by W. Dickson)

The length distribution of catches obtained with a Norwegian sampling trawl with the doors and sweeps on and off the seabed were compared. Small cod are less herded by the doors and sweeps than large cod and the herding effect is distinctly less important at night with very little or no herding of small cod. Haddock shows the same trend but there is less difference between day and night catches and the daytime trend is flatter. Considerations on the effective pathwidth of both gears led to the assumption of a residual sweep herding effect in the otterboard off bottom operation. Though not flat, the effective spread of the otterboards off bottom rig is more constant with increasing fish length, resulting in a less biased sample of the fish distribution.

#### 4. Effect of tow duration on length composition of trawl catches. (O.R. Godø, M. Pennington and J.H. Völstad - presented by O.R. Godø)

Three fishing experiments were carried out to determine the influence of tow duration on the length composition of catches in trawl surveys. No significant differences could be established and it was stated that precision and survey efficiency could be increased by using short duration tows. Fish behaviour related to tow duration and the precision of the notion 'towing time' were discussed.

#### 5. Escapement of fish underneath the footgear of a Canadian groundfish survey trawl. (S.J. Walsh)

Three bags were attached underneath a multi-species survey trawl to estimate the escapement of fish underneath the footgear. The net efficiency seemed to be lower for small cod, plaice, yellowtail and thorny skate. The catchability of the trawl was much higher for plaice than for the other three species. Vulnerability to the fishing gear was size dependent for all species but thorny skate. Escapement also depended on trawling speed and escape area under the footrope. Roundfish behaved differently to the fishing gear than flatfish.

6. Size selection of plaice by square and diamond mesh codends. (S.J. Walsh, C.G. Cooper and W. Hickey - presented by S.J. Walsh)

A trouser trawl was used to measure the selectivity for plaice with 140 mm and 155 mm codends. The diamond mesh codends were more selective, yielding higher 50 % retention lengths and hence higher selection factors. The selection range of the diamond mesh codend was also higher. This finding is opposite to results obtained for roundfish. Escapement of plaice is related to its breath rather than to its girth so that diamond meshes present a larger escape area. The selection curves were drawn by eye as well as by application of the maximum likelihood analysis. In general good consistency was achieved between both methods.

7. Codend design, selectivity and legal definitions. (P.A.M. Stewart and R.D. Galbraith - presented by P.A.M. Stewart)

Although it is known that several parameters affect the size selectivity of fishing gear, mesh size is the only parameter legally restricted. Nevertheless this measure seems not to be sufficient to limit discarding. Changes in fishing gear design may alter gear selectivity as well. It was shown that the selectivity of a codend can also be improved by reducing the extension length and the number of meshes on the codend circumference, attaching longitudinal ropes and the use of square meshes. To ensure better escape of small fish not only minimum mesh sizes should be imposed but also other dimensions of the net and codend should be restricted or alternative means of rigging the codend should be adopted. The conditions for an effective regulation were discussed and draft definitions of codends and extensions were given.

8. A divided trawl for codend selection experiments. (J.H.B. Robertson, verbal + video)

The use of a trawl completely divided by a vertical separator panel was proposed as an alternative to the covered codend method in selectivity experiments. The divided trawl was equipped with two codends, one small mesh codend and one test codend. Tests performed with the divided trawl have shown no significant differences between the starboard and port catches of cod, haddock and whiting although some individual hauls may be biased. For flatfish a 50/50 split seemed more difficult to obtain.

**b. Methodology for evaluating the survival rate of fish that come into contact with fishing gear but are not captured.**

9. Fish escapement from longlines and methods to study escapement and survival. (Å. Bjordal and O. Cruickshank - presented by Å. Bjordal)

Hydroacoustic observations were used to observe the escapement of fish from longlines during hauling. Small plastic floats were attached to the mainline in order to simplify identification of the line when hauling through the beam of the ship's echosounder. Most parts of the gear could be identified as well as hooked fish when releasing swim bladder gas. Escaping fish could be seen as traces on the echogramme changing from an upward slope to a downward slope. Quantifying survival rate should be possible with the use of a proposed modified transducer.

10. A method of recapturing fish which have escaped from Danish seine and trawl codends at the surface (B. Isaksen, A. Engås and R. Larsen - presented by A. Engås)

A method of recapturing fish escaped at the surface from the codend of a Danish seine was tested. While hauling the codend fish was released from the Danish seine and kept under control by a skiff. Meanwhile a purse seine was set around the skiff with the codend to recapture escaping fish. These fish can then be transported to pens to study the survival rate. The authors also pay attention to the fact that the fish will be stressed again when being recaptured. This could bias the survival rate of the escaped fish.

11. Is unaccounted fishing mortality a problem in purse seining? (A.K. Beltestad and O.A. Misund - presented by O.A. Misund)

The unaccounted fishing mortality in the Norwegian spring-spawning herring fishery has been estimated at 150.000 tons. Net bursts in purse seining are regarded as one of the causes for this fishing mortality. These net bursts occur mostly during daytime when the largest catches are made. Based on purse seining fishing statistics estimates were made of the amount of fish involved in net bursts. Fish behaviour and fishing mortality related to net burst were discussed. A project has been planned to verify and quantify the net burst problem.

12. Simulated net injuries on saithe (A.V. Soldal, A. Engås and B. Isaksen - presented by A.V. Soldal)

Net injuries were simulated on saithe to evaluate the mortality due to skin damage. Injuries were induced either by forcing fish through the meshes of a piece of netting or by removing scales and mucus. Blood parameters showed that no significant differences between the control and treated groups which indicate the absence of imbalance in osmoregulation. A majority of the fish with induced damage however developed secondary infections in the damaged skin region. This group of fishes also showed a significant higher total mortality at the end of the 14 days observation period.

13. Aberdeen fish survival studies and the interpretation of results. (R.S.T. Ferro - verbal + video)

Fish escaped from the codend were recaptured by a large soft and porous nylon cover and transferred at depth to cages. The survival rates of haddock that escaped from a 90 mm square and a diamond mesh codend were compared (90 % vs 70%). The relation between the mesh opening and the girth of the fish was discussed. It was shown that increasing the mesh size without changing the number of meshes at the circumference of the codend has no effect on the mesh opening and hardly improves the escape rate. The tension on the mesh bars is regarded as an important factor relative to injuries. Death of escaped fish seems to be caused by secondary infection of the wounds.

**c. Engineering aspects of working practices onboard fishing vessels.**

14. Safety-aspects in redesigning medium sized beamtrawlers. (F.A. Veenstra)

Technical and personal safety aspects onboard Dutch beamtrawlers were discussed. Technical safety aspects such as stability, construction and equipment are subject to regulations, whereas personal safety aspects are still a matter of free interest. Safety design aspects with respect to the bridge layout, the deck layout and the noise control were considered. Special attention was paid to the location of bridge instruments, vision from the bridge, deck equipment, vertical and lateral accelerations and noise levels. Research activities in this field were explained and a design method for a safety integrated beamtrawler was presented. The idea of a new lay-out with the trawl winch placed in the forcastle was given.

15. Survey on location and maintenance of survival suits onboard Norwegian fishing vessels. (E. Kjerstad)

In order to work out recommendations for the onboard location of survival suits, information on the storage of these suits and their maintenance was gathered. Survival suits are often stored in places with limited access. Measures to improve the safety of work, emergency exercises and maintenance of survival suits are often neglected. A better attention to these suits should be enforced.

16. A preliminary study on the landing capacity of stern freezer trawlers. (B. van Marlen)

Several deterministic models for the calculation of the yearly attainable landings of stern freezer trawlers were presented. A yearly scenario of trips of equal duration was chosen with a restrip at the end. The effect of several technical and operational factors was analyzed by varying these over a range of values. The freezing capacity and continuity of the freezing process are the most significant variables followed by the volume of the fishholds and the filling coefficient of these holds. Further extension of these models with stochastic descriptions are underway. The aim is to come to a Decision Support System for the design and operation of this type of fishing vessel.

**2. PRESENTATION AND DISCUSSION OF PAPERS ON VARIOUS GEAR DESIGN AND ENGINEERING TOPICS**

17. Further data on flow in trawls and codends. (R.S.T. Ferro - verbal)

Measurements were made on the flow in trawls and codends at different locations and for different arrangements. A significant drop in flow speed was measured in the aft part of the codend. Simulating a catch in the codend or using a cover both reduced the flow speed. The towing speed did nearly not affect the flowing characteristics, even at low values. The existence of a flow component through the tubular surface of the codend could be shown. The flow in the codend can be affected by changing some parameters (eg mesh size) in the net sections in front. The implications of these findings on selectivity were discussed.

18. Full scale testing of Nephrops trawl codends in the flume tank (D.A. Wileman)

Full scale tests were performed in a flume tank in order to examine the effects of belly and codend designs of Nephrops trawls on the belly/codend geometry and hence upon selectivity. The effects of increasing catch, inserting a lengthening piece or changing the belly and codend parameters were considered. It was shown that the mesh opening in the codend is reduced by increasing the number of meshes round the codend, reducing the number of meshes at the end of the belly, increasing the length of the belly or inserting an extension piece between the belly and the codend. These parameters affected also the codend opening, the entrance becoming very narrow when using a lengthening piece. Increasing the mesh size resulted in an increased mesh opening, but to a lesser extent than the increase in mesh size.

19. Otterboard data from Seafish flume tank and its practical application. (N. Ward)

Performance results of several types of 1:4 scale model doors were given in  $C_L$  and  $C_L/C_D$  form. From the flume tank data the size of a cambered vee door and of a three slot Bison door were calculated to give the same spread as a standard vee door. These doors were tested at sea to verify that the performance curves obtained in the flume tank were correct. The spreading force characteristics found in the flume tank model door trials were also found in the full scale trials at sea, proving that the calculation of the relative door size based on the flume tank trials enables the prediction of the size of an alternative door type which will give equal spread to a trawl.

20. Hydrodynamic characteristics of netting panels at low angles of attack. (Lu Chi - verbal)

The drag of netting panels at angles of attack varying from  $0^\circ$  to  $15^\circ$  was measured in a flume tank. The influence of Reynolds number, yarn type and mesh size and type (diamond and square) on the drag coefficient was examined. It was shown that the drag coefficient increases with the netting setting angle, but is not influenced by the solidity of the netting, the mesh type and the yarn material. Vertical velocity profiles revealed that the effect of the netting setting angle on the velocity distribution is quite large, whereas the effect of solidity is very small.

21. Testing mesh shrinkage due to the penetration of bottom sediments. (R. Fonteyne)

A test method to determine the shrinkage of netting subjected to the penetration of sediments while kept under tension was presented. A first set of measurements on netting of polyester and polyethylene indicated mesh shrinkages of 2 to 5 %. Sand penetration and shrinkage decreased with increasing tension although less pronounced with monofilament yarns (PE). With these yarns grain size had little effect on mesh shrinkage whereas small particles (mud) caused a higher reduction in mesh size than coarser particles in netting made of multifilament yarns (PES).

22. Engineering trials on supermesh trawls GM3 (4320 meshes circumference) made of polyamide and GM6 (5640 meshes circumference) with a front part of Dyneema SK-60. (Dai T. and B. van Marlen - presented by Dai T.)

The mechanical performance of a new pelagic trawl with a larger mouth opening and a large mesh front part of a new thinner and stronger material was compared with a smaller big mesh trawl. Drag and net mouth dimensions were plotted against speed for different warp lengths, bridle weights and bridle lengths. Paying out more warp length, adding more bridle weight or using longer bridles resulted in an increased mouth opening and drag. The slightly higher drag of the larger trawl was fully compensated by a far bigger mouth opening. Due to the low strain of the new material, the design of such trawls should be based on three dimensional calculation methods because mistakes in the design will not be stretched out.

23. A conservation orientated fishing vessel (Å. Bjordal - verbal)

A newly designed 38 m longliner with various implementations on gear and gear handling was presented. Special attention was paid to the hull construction and shape as well as to propeller optimization. The onboard processing line featured many improvements. The new vessel is operated by a crew working in a shift arrangement.

### **3. OBSERVATION TECHNIQUES AND BEHAVIOUR.**

24. Update of square/diamond mesh studies including plans for current year (C.G. Cooper - verbal)

Selectivity experiments with square and diamond mesh codends were carried out using trouser trawls with a small mesh codend on one side and the experimental mesh codend on the other. Target species were cod, haddock and pollock, but data were also collected for flounder. The experiments supported previous results that for cod, haddock and pollock square mesh codends have higher 50 % retention lengths, higher selection factors and lower selection ranges than the equivalent diamond mesh codends. It was shown that square mesh codends perform similar as diamond mesh codends with a 10 to 15 mm larger meshsize. For flounder the diamond mesh codends yielded higher 50 % retention lengths and selection factors. A diamond/square mesh combination codend was proposed for use in mixed fisheries.

25. Underwater observations of swimming patterns of Baltic herring approaching and swimming through the funnel of a herring pound net. (P. Suuronen - verbal + video)

The behaviour of herring schools towards the funnel of a herring pound net has been observed with a low light underwater videocamera. Scattered herring schools were seen to enter the funnel mostly at night. The fish swam in an orderly manner without hesitating and at high speed through the funnel into the bagnet.

26. Underwater TV-observations of cod, ling and tusk in fishing trials with different types of baited traps. (D.M. Furevik - verbal + video)

An underwater TV-camera was used to observe the behaviour of cod, ling and tusk towards different types of traps. It was shown that the entrance of the trap is critical especially with relation to the direction of the current. Traps floating at some distance from the bottom are self orientating whereas with traps on the ground the entrance is often in the wrong direction. Ling and tusk however may not enter traps off bottom. Traps with two entrances are superior to traps with only one entrance. Positioning of the bait is also very important and contrasting accessories such as white clips should be avoided as they are often mistaken for food.

27. Separating Nephrops and whiting in trawls with reduced separator panel. (J.P. Hillis)

A series of experiments were carried out to examine the extent of separation between Nephrops and whiting to be obtained with two separate codends, but without separator panel in the net itself. Separation percentages of 97 % of Nephrops and 76-80 % whiting were obtained. The separation of the two species was superior compared to results obtained with one codend divided by a separator panel. There is some indication that the separation level can be altered by features such as floats and rope weights mounted on the codends.

28. Preliminary results from fishing trials with a new shrimp sorting device. (L. Karlsen)

A rectangular aluminum grate was used to separate shrimp from fish in shrimp trawls. The grate was installed in front of the codend while a fish release opening was cut in front of the upper edge of the grate. The preliminary experiments were very promising. The loss of shrimps is highly influenced by whether a flapper is used or not, no flapper giving the highest losses. The fish separation was near to 100 % for all fishes larger than 20 cm. The separation of the smaller fishes depended on the species (cod, haddock, redfish) and the presence of the flapper. The grate has the advantage over the widely used HH-panels that no meshing or clogging with redfish or flatfish occurs, that it is easy to install and to handle and that it can be better controlled when legally enforced.

29. An assessment of the efficiency of trammel nets constructed of different materials. (J.E. Tumilty)

A series of experiments was carried out to compare the efficiency of trammel nets made of monofilaments and/or multimonomofilaments with the conventional multifilament nylon nets. The nets with the three sheets of netting made of monofilaments proved to catch significantly more than all other combinations. They were also much easier to remove the fish and to clear.

30. FOCUS, a new towed underwater vehicle for trawl observations (U.J. Hansen, verbal + video)

A new towed underwater vehicle for trawl and fish behaviour observations was presented. The vehicle is characterized by its small dimensions and good manoeuvrability by means of a foil and flap system. The basic system consists of a power supply, a control unit, a deck winch with 800 m of fibre optic/electro-mechanical cable and the underwater housing with the multiplexer, power supply and flap control motors. The vehicle is equipped with a low light video camera system and lights but can also contain other measuring instruments. The vehicle has proven to be very handy during tests on a 17 m vessel.

#### 4. OTHER MATTERS.

##### 31. ICES Symposium on Fish Behaviour in Relation to Fishing Operations. (S. Olsen)

The symposium is planned to be held in June 1992 in Bergen and will be the first in this field since 1967. The main objectives and the scope of the symposium were presented and its organisation was discussed. A steering group will be established in which representative scientists will assist.

##### 32. Determination of the hydrodynamic coefficients of net lattice models in the region of small angles of attack. (H. Stengel)

Due to the retarded arrival of Dr Stengel this contribution was presented at the Joint Session of the FTFB and Fast Working Groups.

In order to supply data for a computer model for the calculation of fishing gear resistance, wind tunnel tests were carried out to determine the hydrodynamic coefficients of net lattice models. The influence on the lift and resistance coefficients of parameters such as angle of attack, mesh opening, twine area, twine construction and solidity was discussed.

#### 5. NATIONAL PROGRESS REPORTS.

Next to the written progress reports provided by the participating countries a **summary** of these progress reports was distributed during the meeting. Due to lack of time the progress reports could not be presented verbally, neither were they discussed at the meeting itself. Some participants regretted the limited time for this topic and suggested that more time should be made available either by extending the meeting or by limiting activities devoted to social events. At the end of this paper the full Progress Reports are given which were received prior or at the meeting (APPENDIX A).



## 6. RECOMMENDATIONS.

### 6.1 Discussion.

The working group discussed possibilities for the next meeting and its (special) topics. It was argued, that although many current research revealed some insight in these topics, further investigations are still necessary to come to more definitive statements. Some participants expressed concern about the little amount of contributions for topic c). The announcement of future regulations will however require continuous attention to the aspects of sound working conditions and safety. In order to guide the discussion at the next Statutory Meeting of the Fish Capture Committee, the various draft recommendations are given. The Working Group accepted an invitation by prof. Dr. H. Stengel to meet in Rostock in 1990. Topics for special subjects were discussed and the following recommendations to the Fish Capture Committee made:

### 6.1 Recommendations, drafted during the meeting.

1. The Working Group on Fishing Technology and Fish Behaviour (FTFB) (Convener Mr. B. van Marlen) recommends that the next meeting should be held in **Rostock, German Democratic Republic** from **23-25 April 1990** in conjunction with the Fisheries Acoustics Science and Technology Working Group (FAST) to consider in particular:

- a) A review of the current state of knowledge concerning the size and species selectivity of fishing gear with particular reference to fish stock surveys and methods of quantifying the effects of fish behaviour on gear performance.
- b) The methodology for evaluating the survival rate of fish (and other organisms) that come into contact with fishing gears but are not captured or landed.
- c) Engineering aspects of working on fishing vessels.

2. Recognizing that a large amount of presentations at the Fishing Technology and Fish Behaviour Working Group caused a limited time to remain for discussion and that many problems of common interest of both this Working Group and the Fisheries Acoustics Science and Technology Working Group exist it was recommended:

- a) To meet in conjunction with the Fisheries Acoustics Science and Technology on 25 April 1990 in Rostock, GDR, to discuss matters of common concern.
- b) The duration of the Joint Session between both groups will depend on the number of presentations and allow extension of the Fishing Technology and Fish Behaviour Working Group meeting if necessary.

3. The Working Group discussed recent experience in the demersal fisheries and the results of selectivity experiments in various member countries.

The general view has been expressed that discarding of undersized fish is a continuing problem even in towed nets with legal mesh sizes. This problem is emphasized by recent changes in the design of fishing gears and codends and in fishing gear operation.

The Group agreed that selectivity of a codend can be improved (i.e. the 50 % retention length can be raised) by the following methods:

- 1) Increasing the mesh size.
- 2) Reducing the number of meshes in the circumference.
- 3) Reducing the extension length ahead of the codend; equivalent to increasing the codend mouth diameter.
- 4) Attaching longitudinal ropes to restrict the stretching of the codend and closure of the meshes.
- 5) Using square mesh codends and/or extensions.

It was agreed that regulations aimed at improving conservation by specifying minimum mesh size alone are inadequate. To ensure that meshes in codends are sufficiently open and that codends do release small fish to a greater extent it is necessary to restrict other parameters of the codends as mentioned above in addition to the mesh size.

Problems concerning the practical application and economic consequences of those methods were recognized and discussed.

Following this discussion the Working Group added the following recommendations:

- a) Recent gear selectivity experiments show that modern towed gears have lower selectivity factors than the traditional assumed values. It is recommended that the Fish Capture Committee should review and publicize these results liaising as appropriate with the Demersal Fish Committee to ensure that the most up-to-date information on gear selectivity is taken into account in discussions about technical measures for fisheries management.
- b) It is recommended that member countries of ICES should undertake research to develop and test new techniques for gear selectivity experiments which will overcome the bias and other problems of the traditional methods such as the covered codend technique, and that the results of this work should be reported to the Fishing Technology and Fish Behaviour Working Group.

**APPENDIX A: NATIONAL PROGRESS REPORTS RECEIVED AT OR PRIOR TO THE MEETING:**

1. BELGIUM.
2. CANADA.
3. DENMARK.
4. FEDERAL REPUBLIC OF GERMANY.
5. FINLAND.
6. GERMAN DEMOCRATIC REPUBLIC.
7. NETHERLANDS.
8. NORWAY.
9. PORTUGAL.
10. SWEDEN.
11. UNITED KINGDOM - ENGLAND.
12. UNITED KINGDOM - SCOTLAND.
13. UNITED STATES OF AMERICA.

**BELGIUM**

**Trawl gear**

Within the frame of energy-saving studies the influence of increasing the mesh size in beam trawls for shrimps has been investigated. Using 34 mm instead of 28 mm meshes in the front part of the net resulted in a 10% gain in resistance without any loss in catching efficiency.

The use of multiple rig trawls was studied. First experiments with twin trawls for shrimps and flatfish will start in 1989.

Several types of high opening bottom trawls for engine powers ranging from 150 to 900 hp were developed and tested on board of commercial trawlers. These trawls gain increasing popularity in the Belgian otter board fishery.

**Electrical fishing**

Work on electrical fishing was concentrated on the development of a pulse generator to be incorporated in the beam of a flatfish beam trawl. The electrical field strength between two electrodes was studied under laboratory conditions.

**Selectivity**

Several factors which may influence the selectivity of beam trawls for sole were studied. The experiments were carried out on a coastal beam trawler. The effect of the codend mesh shape (diamond versus square), the mesh size, yarn material (braided PA and PES and twisted PE) and the length of the codend were investigated. Of these only the mesh size had a significant influence on the codend selectivity for the target species.

**Netting materials**

Research on the shrinkage of meshes due to the penetration of bottom sediments was continued. A new experimental method permits to control the tension on the netting sample during testing. Netting of different materials and yarn construction are tested with sand and mud.

**Safety**

With relation to the improvement of safety on board beam trawlers, work with the new overload protection system continued. The system automatically opens the winch brakes if a preset overload occurs in one of the two warps, if a given load difference between the two warps is detected, or in the event of a sudden, well defined increase in towing resistance.

## CANADA

### Fishing Gear Selectivity

Fisheries Development Division, Department of Fisheries and Oceans (DFO) Newfoundland Region, conducted comparative fishing trials of moored monofilament longlines using "feather" hooks vs baited hooks. The feather hook and monofilament ganglion attached to the groundlines have replaced the moored baited hook in specific areas of Newfoundland. Catching efficiency was greater for feather hooks, which caught 57% of the total cod catch of 17,293 kg. A total of 46,100 hooks were fished during a Period of 42 days.

Size selectivity of 155 mm diamond and square mesh codends was determined for cod during a joint program between DFO Scotia-Fundy Fisheries Development Branch and DFO Newfoundland Science Branch. Scotia-Fundy Region also conducted selectivity experiments with 135 and 140 mm square/diamond mesh codends during the year, producing selectivity curves for cod, haddock, pollock, and American plaice. The experiments indicate that the square mesh codends have higher 50% retention lengths, higher selection factors, and lower selection ranges for cod, haddock, and pollock. In the 130 to 155 mm mesh range, a square codend appears to have the same 50% retention length as a 10 to 15 mm larger diamond mesh codend. For flatfish, the diamond mesh codends always have higher 50% retention lengths and selection factors.

Scotia-Fundy Region Fisheries Development Branch also reported the conduct of selectivity experiments with inshore scallop gear. Although large catches made selectivity analysis difficult, results did show that Digby Rakes with rubber washers require a ring size of about 3 5/8" to allow escapement equal to rakes with 3" rings having standard steel washers.

A series of tests was completed by DFO Science Branch, Pacific Region, to design and evaluate various escape mechanisms for the range of solid sided, wire mesh and web mesh covered traps employed in the British Columbia prawn trap fishery.

DFO's Biological Sciences Branch, Newfoundland Region measured escapement of capelin from a Diamond IX midwater trawl using small mesh experimental bags attached at various locations outside the trawl. Most escapement occurred near the codend and consisted of smaller capelin, Arctic cod and sand lance. Escapement underneath the footrope of the standard groundfish survey trawl (Engels 145 High Lift) was also measured. Three net bags covering the full length of the footrope were mounted beneath the trawl, behind the footgear. Net efficiency parameters indicated that the percentage of escapement is highest amongst smaller cod, yellowtail flounder, American plaice, and thorny skate. Both midwater and bottom trawl escapements were measured to determine their effect on survey abundance estimates.

### Fish Behaviour and Underwater Observations

Researchers from DFO's Central and Arctic Region in conjunction with colleagues from Quebec and Newfoundland, used acoustics to monitor the diel vertical migration of striped pink shrimp in eastern Hudson Strait. Acoustics were also used in Admiralty Inlet, Baffin Island, to examine the distribution of pelagic fish under landfast ice near an ice edge where whales, narwal and beluga, were congregating. In Barrow Strait, diel behaviour of pelagic fish beneath landfast ice was studied to determine the effects of tidal currents on the availability of food species to ringed seals.

Scotia-Fundy Fisheries Development Branch and the Department of the Environment supported a proposal by Lobsinger Associates Ltd. to develop three solid state underwater cameras. The first camera is intended as an inexpensive low-light B & W camera rated for 100 m, suitable for monitoring cod traps, herring weirs, and shallow water scallop fishing operations. The second camera is an image-intensified low-light camera rated to 300 m that will replace the Osprey camera currently used on the Mermaid vehicle. The third camera will incorporate an internal pan and tilt cradle for 180 degrees peripheral vision, for direct mounting on trawls.

Distribution and abundance of planktonic larval stages of commercial species was studied during a seismic airgun survey in Queen Charlotte Sound and Hecate Strait by DFO's Biological Sciences Branch, Pacific Region. Data will be combined with experimental work on airgun mortalities, conducted at Washington State University, to evaluate environmental impact of seismic surveys.

#### **Development of Commercial and Survey Fishing Gear.**

The Province of New Brunswick's Department of Fisheries and Aquaculture continued an active program within its Technical Services Branch. The effectiveness of a special shrimp trawl on a shrimp trawler, converted from side to stern trawling, was evaluated. The net uses kites instead of floats to obtain headline lift. A new rope counter for Scottish seining will indicate lengths of rope set or hauled in the wheelhouse, and will eliminate the need for coil counting during fishing operations. Trials were conducted on a flounder trawl, that is easily converted to a cod trawl by adding floats, and on a rough-bottom Scottish seine with light "rock hopper" footgear and combination wire seine ropes. Two vessels were fitted with monitoring equipment for a study of energy efficiency in fishing vessels. The next phase of this program will see the application of energy efficient technologies to these vessels.

A twin beam trawl for surface sampling of juvenile salmon was modified and tested by DFO, Pacific Region. The gear was developed for assessment of juvenile salmon as they migrate through inshore waters. The region also supported the development of fishing methods for flying squid. A high speed midwater trawl showed some potential and offers an alternative to the traditional high seas gillnetting method, which has unacceptably high marine mammal by-catches.

The Department of Fisheries, Province of Nova Scotia, undertook a number of projects focusing on fishing vessel design. A contract to the Technical University of Nova Scotia continued work on small boat stability, with emphasis on the traditional Cape Island style inshore fishing vessel. Another Project involved construction of an aluminum deck and hatch system which features a folding work deck for containerized unloading. Tests of an anti icing agent on a trawler fishing for northern cod were not successful. Modifications in hull form were made to a vessel equipped with a controllable pitch propeller, to decrease vibrations in the propulsion system and hull. In addition to decreasing vibrations, the modifications also increased bollard pull.

The Marine Institute in St. John's, Newfoundland, began developing a CAD package for drawing fishing gears. The routines are written using the CADKEY programming language CAD L, but may later be transferred to AutoCAD using LISP and expanded to CAM. The institute is also developing techniques for determining otterboard lift and drag coefficients, including accurate measurements of heel pitch, and angle of attack.

The Technical University of Nova Scotia has developed computer programs for calculating the forces and shapes of simple towed fishing nets. Half of the models assumed a truss analysis and half assumed a frame analysis. Modifications to the conventional finite element analysis were carried out for each. Both non-linear and linear analyses were programmed for both Cartesian and cylindrical coordinates. The computations were carried out on an IBM personal computer. The simulated results were verified experimentally by using a towing tank and by weights hanging onto a net.

## **DENMARK.**

### **Development of improved trawl designs**

Contact person: Stig Rune Yngvesson

New original trawl designs have been produced by DFTI for mixed flat and roundfish in the Kattegat and for the experimental deep water fishing for Grenadiers (*Coryphaenoides rupestris*). Both trawls utilise large meshes in the upper panels. The Kattegat trawl also incorporates knotless netting and a tickler chain system designed to be used with plastic bobbins to avoid coming fast in

soft bottoms. Both trawls were first developed using flume tank model tests and have now been successfully introduced to the commercial fleet. Model tests have been made with a new design of musseldredge which it is hoped will reduce the amount of damage to the seabed which traditional dredges are alleged to produce. These projects have been financed by the Ministry of Fisheries.

#### **Codend studies.**

Contact person : David Wileman

A study has been made for the European Economic Community in which the codend selectivity measurements made by research institutes in the North Sea have been collected into a database. A series of tests have been made in the flume tank where the mesh openings and towing resistance of different designs of nephrops trawl bellies and codends have been measured at full scale. The effects of increasing catch, lengthening the belly, extending the codend length and altering the circumference of the codend have been studied. The tests were financed by the Ministry of Fisheries.

#### **Trawl Drag Studies.**

Contact person: David Wileman and Kurt Hansen

Measurements have been taken in the flume tank of the hydrodynamic forces produced by a 4m x 2m inclined plane of sheet netting was 110mm full mesh and 2.7mm twine diameter. Angle of attack was varied from 5° to 30° and the mesh-opening from 20% to 70%. The tests are being continued in 1989 using netting of higher solidity.

#### **Computer Aided Trawl Design.**

Contact person: Kurt Hansen

The institute has started a project financed by the Ministry for Energy aimed at developing a computer Aided Engineering system for helping evaluate midwater otterboard designs. Measurements have been taken in the flume tank of the hydrodynamic lift and drag forces produced by simple plates of different aspect ratio and camber. These are to be compared with numerical predictions of the forces produced by plates in the pre and after stall conditions. Routines have been produced for the prediction of the required towing chain/bracket arrangement in order to produce specified door forces.

#### **Measurement of the performance of fishing gear at sea.**

Contact person. Thorkil Berg

The institute participated in a joint research project with the Dutch research institute RIVO in which a Danish two trawl system for North Sea pink shrimps *Pandulus Borealis* was tested on board TRIDENS and observed using their Towed Underwater Vehicle. The institutes own Towed Underwater Vehicle was delivered in February 1989.

The principle dimensions are:

Working depth	0-200 m
Horizontal manoeuvring	± 100 m from center line
Towing cable	750 m x 9.6 mm diameter
Overall dimensions	1.3 m x 1.265 m x 1.415 m
Weight	150 kg in air. Buoyant in water
Instrumentation	Videocamera (B/W) Photometer Depth sensor Height above seabed sensor Pinger

### **Netting material studies.**

Contact person : Thorkil Berg

The project studying the properties of combined / blended braidmaterials was completed. Polyamides, polyethylene, polypropylene, polyesters were studied together with new high strength materials Kevlar and Dyneema. Several different combinations of sleeves and cores were tested and measurements taken of linear breaking load, wet knotted breaking load, diameter and runnage. The project was funded by the Ministry of Industry and carried out jointly with the Danish Textile Institute and two commercial manufactures of sheet netting.

### **FEDERAL REPUBLIC OF GERMANY.**

#### **Major subjects were in 1988:**

- energy saving methods in fisheries
- effects of rigging on the performance of stock assessment fishing gear and effects of beam trawls on the seabed,
- Improvements on components of commercial fishing gear and evaluation of new possible methods,
- basic principles of selection in fishing gear,
- applications of Personal Computers in fisheries research,
- weathering resistance of different netting material,
- utilization of artificial reefs.

#### **Energy saving methods in fisheries.**

Investigations on energy saving fishing gear - especially gill nets and trammel nets - were continued. Fishing for sole in the German Bight with gill nets proved to be much more efficient than using the traditional beam trawls.

There was a considerable number of small inshore fishing vessels from the North Sea and from the Baltic starting gill netting for soles during the last season.

Due to declining cod stocks in the Baltic, the herring fishery with gill nets may become more important. The Investigations of the Institute for Fishing Technology concentrated on the influence of netting yarn structure and colour on catch rates. The best results were obtained from nets made of monofilament and multifilament twine. Catches increased with decreasing twine diameter.

#### **Effects of rigging on the performance of stock assessment fishing gear and effects of beam trawls on the sea-bed.**

The methodological work on stock assessment gear was continued. This year one of the main objectives was the measurement of the effect of depth on the spread of the trawl when maintaining the same rig. With two trawls it was found that the spread increases with the depth e.g. at 75m the same trawl shows 60% more spread than at 25m. This cannot be attributed to the bigger towing warp length only, because an increase of the latter from 300 to 350m at the same water depth did not result in an appreciable change in spread.

Heavy bottom trawls e.g. beam trawls as used in the sole fishery are rather detrimental to the bottom fauna. This was demonstrated after repeated towing along the same track with a heavy beam trawl. Bottom grab samples and underwater TV observations showed that a great number of bottom dwellers had been excavated and destroyed. Parts of them were found in the stomachs of fish caught during these tows, whereas during the first tow the average stomach content revealed a completely different composition. However, the longterm effects of a repeated fishery on the same fishing place which could possibly lead to a complete devastation of the seabed, as well as the period necessary for recovery have still to be investigated in a joint research project of gear technologists and marine benthologists.

### **Improvements of components of commercial fishing gear and evaluation of new possible methods.**

The activities in trawl research, using an underwater TV camera mounted on a remote controlled towed vehicle (RCTV) were extended to big bottom trawls with heavy bobbin ground ropes as used by German distant water trawlers.

A system of flexible sail kites combined with pressure resistant hydrostatic floats was developed to give sufficient lift to the headline of trawls.

Based on the results of model tests with cambered V-doors in the windtunnel of the Institute of Naval Architecture, Hamburg, full scale tests with 4.5sqm otterboards of the same type were performed in 1988. Compared to flat V-doors, a considerable increase in the spread of the upper wing tips of a bottom trawl for inshore trawlers was obtained. Observing the performance of both types of otterboards on rough bottom by means of the underwater TV camera, no disadvantage with the cambered V-doors compared to the flat ones could be found. First trials were performed with two three warp twin trawls to investigate the problems which occur when using this type of gear on a fishing vessel with traditional deck arrangement (two warp drum winch).

### **Basic principles of selection in fishing gear.**

Underwater TV-equipment has been used to study the process of selection in towed trawls. Video tape recordings made in the summer on board of FRV "Solea" show that almost all species caught at these occasions (haddock, whiting, mackerel, horse mackerel, spiny dogfish and skate) concentrated their escape attempts at the rearmost part of the codend. A different behavioural pattern was only found for sandeels which escaped from the trawl already in the belly section.

### **Applications of Personal Computers in Fishing Gear Research.**

PC's are very useful tools for many aspects of fishing gear research. This has already been demonstrated by many applications. The Institute for Fishing Technology used PC's for the generation of two data bases containing :

- a) the catch data of all experimental gill net catches made by the institute during the last 8 years.
- b) the video-scenes collected in its videotape library.

A PC is also part of the electronic measuring board system originating and recently improved by the Institute for Fishing Technology.

### **Weathering resistance of different netting materials.**

Netting yarns of different material and construction were exposed for two years to natural sunlight and seawater in a joint exercise of the Finnish Game and Fisheries Research Institute and the Institute for Fishing Technology, Hamburg. The tests were completed and evaluated at the end of 1988.

### **Utilization of artificial reefs.**

The concentration of fish at wrecks or similar underwater obstacles causes fishing in their vicinity to be highly efficient. The construction of artificial reefs and other fish attracting devices (FAD's) in many parts of the world has been the consequence of this effect.

In cooperation with a local fisheries Research Institute, the Institute for Fishing Technology commenced research in this field in the Lake of Constance. A steel construction of about 150 cubic metres was placed in the lake at a water depth of 10 m. Observation of possible future fish aggregations at the construction will be started in the summer of 1989 by means of underwater TV.

## **FINLAND**

Bottom and midwater trawling trials were conducted in October in the northern Baltic Proper, in order to find out the vertical size distribution and the abundance of Baltic herring during daytime. The results showed that in autumn the larger herring usually swim in deeper water layers than the smaller herring and that they can be very difficult to catch, especially when they are swimming



near the bottom, because of the roughness of the sea bed. The reaction of herring in the trawl mouth were studied by use of a scanning sonar mounted on the headline.

Echo-sounding observations of midwater trawling for Baltic herring were made in May-September on commercial fishing grounds off the southwestern coast of Finland, the trawl being allowed to pass beneath the stationary echo-sounder. The objective was to find out whether and to what extent Baltic herring avoid and escape from midwater trawls. Several kinds of avoidance and escape reactions were recorded.

Underwater observations with a low light (S.I.T.) video-camera were made of the behaviour and swimming patterns of Baltic herring schools approaching the funnel of a herring poundnet. Scattered herring schools were seen to enter the funnel, mostly in the darkness at 00-03 hours. The fish usually swam in a very orderly manner and without hesitating through the funnel into the bagnet.

A preliminary study on the reaction of Baltic herring to underwater light stimuli showed that layers of more or less scattered herring schools can be concentrated and guided by the use of an underwater lamp (daylight light).

Trials on the effect of bait size on the salmon long-line catch were started in the Gulf of Finland. The baits compared were Baltic herring with lengths of 12-13 cm and 15-16 cm. Larger baitsize compared with smaller reduced the abundance of small salmon in the catch and gave a higher total catch weight.

Testing of the durability of the different kinds of netting materials used in herring trapnets was continued in collaboration with the Institute of Fishing Technology (GFR).

## **GERMAN DEMOCRATIC REPUBLIC.**

### **Deep Sea Fishing**

A midwater trawl model with a new type of wings was tested in a wind tunnel. The aim of the investigations was to achieve a headline height of 100 meter for this net. The results of the trials were used to adjust the trawl development project. Full scale trawls were tested under fishing conditions.

The designed headline height could be obtained with a main engine power of 3500 hp at a trawling speed of 5 knots.

The catching efficiency proved to be excellent for Blue Whiting in the North-East Atlantic and for Horse Mackerel in the South-East Atlantic.

Investigations of fish behaviour in midwater trawls were continued using an underwater television camera. The observations were recorded on video cassettes. These tapes supplied valuable information for current midwater trawl projects. From investigations of midwater trawls with large meshed netting made from different kind of materials it was found that the choice for the material can have a distinct influence on the catching efficiency of such nets. Braided ropes caused a considerable decrease in catchability compared to twisted ropes for knotted large meshed trawls used in the Redfish fishery in the Irminger Sea using the same trawl rigging parameters. An explanation for this phenomena has not yet been found. Further experiments will be conducted in 1989.

### **Sea and Coastal Fishery.**

Essential topics of research and development with regard to sea and coastal fishery were problems of mechanisation of fixed gillnet fishery and longline fishery as well as re-introduction of bottom seine fishery.

The following preliminary results were obtained:

The level of mechanisation in the fixed gillnet fishery could be increased substantially with a net

lifting device, designed and made in the GDR.  
New foamed floats met the special demands of mechanisation.

Preliminary fishing and technological trials with a laboratory design of a fully automatic longline system onboard of small vessels were conducted successfully. These tests were carried out on demersal fish.  
New warp elements were used successfully during pair seining investigations.

#### **Fundamental Research Topics.**

With regard to fundamental studies, the method of discretised towing systems was successfully applied for solving problems concerning the dynamics of floating fish cage constructions, subjected to regular waves.

Experimental investigations were also done on the dynamics and stability of trawl boards and on the determination of the hydrodynamical coefficients of net lattice models at small angles of attack in the range of  $-4^{\circ}$  to  $+15^{\circ}$ .

Studies were also done in the field of Computer Aided Design (CAD) of trawls.

### **NETHERLANDS.**

#### **General**

Much attention has been given to stimulate contract-research projects, raising funds and establishing co-operation with sister-institutes abroad, either bilateral or by means of cooperative EC-research projects. A cooperative research programme has been established between RIVO and the "Institut für Hochseefischerei und Fischverarbeitung" of Rostock, G.D.R.

In addition to contributions on the yearly ICES-FTFB working group, technical fishery research activities were advertised on two symposia, a symposium, organised by RIVO on the occasion of the centennial of fishery research in the Netherlands (April 1988, Beverwijk) and the World Symposium on Fishing Gear and Fishing Vessel Design (Nov. 1988, St. John's, Newfoundland Canada).

Technical support has been given to the Ministry in pre- and detailed design of a new fishery research vessel, to be built on the Merwede shipyard in 1989, to replace the 20 year old FRV "Tridens".

#### **Projects in developing countries.**

By order of FMO (Netherlands Development Finance Company), the construction of 4 Senegalese shrimptrawlers on a Dutch shipyard has been accompanied, including extensive sea trials and a trainings programme for 4 Senegalese skippers and engineers in Holland. In addition, a skipper of RIVO accompanied the maiden fishing trips for about 6 weeks at the local fishing grounds.

A desk study "Design requirements and economic aspects of a Dutch Euro-beamtrawler, also suitable for Senegalese waters" was finished. The project was partly granted by CMO (National Foundation for the Coordination of Maritime Research) and was a cooperation between shipyard Visser (Den Helder), RIVO and Technical University Delft (Subdepartment Naval Architecture). For average fishing trips it is more economical to refit an existing vessel, than to build a multipurpose trawler.

Organisational and technical aspects concerning the establishment of joint-ventures between Dutch companies with companies of countries outside EC-waters were inventoried. By order of DGIS (Directorate General for International Co-operation) a three week mission was made to India and reported in "Deepsea fisheries in India, to ascertain the potential for deepsea fishing". This joint mission between RIVO, LEI and FISHIP led to the recommendation to build or export so-called "resources-specific-trawlers" (sterntrawling and/or longlining or purseseining) to India, instead of shrimptrawlers due to existing overcapacity in the shrimp trawling fleet.

### **Safety and working conditions.**

Handpeeling of Dutch shrimps will be forbidden from 1 July 1990.

In order to anticipate to this new rule, IVP-TNO will test and develop at least three different mechanical peeling machines, so that commercial ones will be available to the industry. For the time being, the promising RIVO tests of 1987/88 with a pressure/vacuum system (bulkpeeling) had been cancelled due to lack of funds and support from the Ministry and fishery industries. A new project was set up called "Safety in the beamtrawler fisheries", a cooperation between RIVO and the Technical University Delft, Subdepartment Safety and granted by the Directorate General of Labour.

By means of a systematic approach of the fishhandling process and analysing (near) accidents, unsafe working conditions can be categorised. In the next phase proposals will be made to improve the safety and working conditions on deck of trawlers.

In spite of interest of the Dutch fisheries for the cooperative project "Containerization" (RIVO, IVP-TNO, LEI, fresh fish landing) no national funds could be raised. However, a joint EC proposal (Denmark, Netherlands, England) have been partly adopted; and will start in 1989.

To develop requirements for the layout of wheelhouses based on ergonomic insights, the possibility of application of cognitive model technics was studied. (RIVO, TU Delft, TU Leiden), proceeding from the actual situation on modern, representative beamtrawlers and by means of human error theories.

The increase of the number of fishing vessels involved in collisions in North Sea necessitates applied research in this field. A proposal called "Ergonomic bridge layout" (participants : RIVO, IZF-TNO, TU Delft) has not been approved yet by CMO.

### **Energy Costs Reduction.**

The fuel catalyser tests done in 1987 onboard a beamtrawler have been reported. The cleansing degree increased with ca 30%, with a fuel saving of ca 4%. Sensors to be installed in motors (project "Diesel engines under partial load") are so expensive, that participation of engine manufactures and funding by third parties are inevitable. Two reports were published concerning shaft power measurements, onboard a beamtrawler with a controllable pitch propeller and a shrimptrawler. Although the data-sampling and analyzing worked properly, the sensors appeared to be vulnerable leading to data from which it was hard to draw reliable conclusions. Regarding MCR-diesel engines in newbuilding fishing vessels (max. 1500 Kw (2000 hp)), many technical advises were given to the Ministry.

### **Design of fishing vessels.**

The results of research in ship acoustics (Phase 1, funded by CMO) have been completed with the final report "Economical noise control onboard Dutch beamtrawlers". The state of the art concerning noise levels, and regulations together with appropriate noise control measures and costs is known. The next Phase will be the implementation of the results onboard a limited number of new beamtrawlers (1500 Kw, 2000 hp). This is necessary to obtain clarity about about the noise control and attainable noise levels onboard such fishing vessels. These levels can be reduced with 5-10 dB(B)\(65-70 dB(A)) with an additional investment of 1-2% of the principal sum for a new beamtrawler. Further reduction implies changes in the original beamer design. Awaiting participation of two Dutch skippers with newbuilding plans, CMO postponed the Phase 2 proposal (RIVO/TPD-TNO) for the time being. Within the scope of hullform optimization of fishing vessels the final report and first version of FISPOW programme have been finished; a cooperative contract research Project between RIVO, MARIN and shipyards, granted by CMO. With FISPOW a Personal Computer Prediction model have been programmed for the Dutch vessel designer, for optimization of the resistance and propulsion of fishing vessels in the length range of 30-70m in the pre-design phase. The model is userfriendly with appendages, bulbous bow and a fixed or controllable pitch propeller for the steaming and/or fishing condition. A planned follow-up of FISPOW in the form of model tank tests has been cancelled for the time being (CMO-proposal phase 2). An ICES contribution titled "Why few Dutch beam trawlers use a controllable pitch propeller" was presented at the FTFB-WG meeting. The pros and cons of fixed pitch vs controllable pitch propeller are explained (ICES C.M. 1988/ B: 15).

### **Techno-economic research.**

For the optimization of the design of new fishing vessels with all the present constraints involved, a techno-economic design approach is inevitable. The most important criteria and calculation methods have been given in ICES CM 1988/B:16: "A note on the investment appraisal of new fishing techniques".

Work on a digital simulation model of freezer trawler operations has been continued with emphasis on the input of the process. A substantial number of catch data of hauls of several stern trawlers were stored in a ORACLE data-base.

### **Direct observation of fishing gear.**

Further innovation on the ROV has been carried out with the aim of increasing the scope of the instrument.

Features of the new system are: hydraulic power pack, telemetry system, autodepth control and positive buoyancy of the aluminium frame. Further developments will incorporate a self-propelling mode.

### **Development of new fishing gear.**

A new fibre for netting yarns has been tried in big mesh trawls of type GM3 in March. The material is based on poly-ethylene with a very large breaking strength, but low elongation properties. It is denoted as twine SK-60, made by Dyneema BV (subsidiary of D.S.M.-Netherlands). The ropes are braided by Gleistein & Sons of W-Germany, and the nets were constructed by Maritiem BV of Scheveningen, Netherlands.

Based on twine surface area, a drag difference of 7% was expected, but the initial trials were not conclusive, due to large scatter in the data. Therefore, performance measurements were repeated towards the end of the year in Portuguese waters on net GM3 (4320 meshes circumference) and a new design GM6 (5600 meshes). The results will be analysed in 1989, but for the big trawl a tentative conclusion is, that the relatively small Power of F.R.V. "Tridens" (1800 hp) was adequate to tow this gear at speeds of 5.0 knots.

A further development of nets with the new twine material will be undertaken in 1989, subsidised by the European Community.

In co-operation with the Marine Laboratory of Aberdeen two small midwater sampling trawls PT-154 and PT-160 have also been measured thoroughly in Portuguese waters, enabling a comprehensive set of instruments to be used during the experiments.

Low aspect ratio midwater trawl doors bought from DANGREN A/S of Denmark were tried with success. Their design enables a multitude of warp and backstop settings.

These doors will be tried further on experiments on deep-water trawling in 1989.

Data acquisition has improved substantially with the aid of a Fluke data-logger, Scanmar sensors and a PC-based acquisition programme based on LABVIEW™ running on an Apple Macintosh™-SE computer. This equipment will also be used on a cooperative research trip on F.R.V. "Ernst Haeckel" in the fall of 1989.

The electro-fishing project was rounded off with a final report. Unfortunately, the implementation of this technology, which have been forwarded and postponed many years, has seriously been hampered by the prohibition from the Ministry of Agriculture and Fisheries. The reason given was fear for a further increase of trawling capacity with the new technique.

Preliminary trials with acoustic fish stimulation as a replacement of tickler chains have been conducted. Aims of this programme are to reduce gear drag, to improve its selectivity and to decrease the possibility of damage to the seabed fauna, an issue of growing concern. An EC-project proposal on the development of low drag, high selective beamtrawl did unfortunately not receive support in 1988. A design of a 7440 meshes circumference supermesh trawl, denoted as GM7 has been made for a private trawling company in the Netherlands. The trawl is projected to open 140m by 60m at the wing-ends.

A project proposal on the Relationship between Model and Full Scale Fishing Gear did not win financial support from the EC so-far, although 7 institutes expressed interest in the matter.

### **Informatics**

During the year some extra computing power and storage was implemented. For age-reading on otoliths a microdensitometer system was interfaced to a personal computer. Also interfaces were implemented for other measuring equipment like weighingscales and a CTD. Various computer programs were written, adapted and improved for clients in or outside the department.

### **NORWAY**

- 1) Institute of Fishery Technology Research (FTFI)/ Fishing Gear and Methods Division, Bergen
- 2) Institute of Fishery Technology Research (FTFI)/Vessel and Marine Engineering Division, Trondheim
- 3) Institute of Marine Research, Bergen
- 4) The Norwegian College of Fisheries Science/University of Tromsø
- 5) The Norwegian Institute of Technology, Trondheim

(Numbers in parentheses indicate institution(s) involved in different activities in the text below.

### **Fish behaviour and reactions to fishing gear**

- The behaviour of fish towards different trap-designs has been studied in the field by UTV (1).
- Studies of schooling behaviour of herring, including measurements of school dimension and -density have been conducted (1).
- Further trials have confirmed the possible manipulation of herring behaviour (vertical migration) by underwater light and sound stimuli (1).
- A stationary telemetry fish tracking system has been tested with promising results. The system give the position and swimming speed and -direction of the fish with updating every 5 seconds (1).

### **Selective fishing (including sampling gear)**

#### Shrimp trawls

The work on selective shrimp trawls has been continued:

- Fishing trials with a new types of (solid) sorting device (5).
- Fishing trials with separator panels (70 mm HH-net) (4,5).
- UTV-observations of square mesh cod end in shrimp trawls (4,5).
- Studies on the effect of ground gear (rock hopper, bobbins) on shrimp trawl catch composition (size and maturity) (1,3)

#### Fish trawls

- Joint investigations with USSR have been conducted to evaluate the effect on cod end selectivity of two different cod end methods (1).
- Selectivity of cod ends with 10-20% shorter lace ropes has been compared with traditional cod end design, using the modified trouser cod end method. Improved escapement of small cod and haddock was found (1).
- A combined square-diamond mesh cod end gave improved size selectivity compared with standard cod ends (4).

- Trials have been conducted to investigate the effect of towing time on species and size selectivity of bottom trawls (1,3).
- Experiments with a (600 m circumference) pelagic trawl have been done to clarify if this could be a useful gear for representative sampling of cod and haddock (1,3).

#### Longline

- Further trials confirm earlier findings on the improved size selective properties of artificial bait (Probait) for cod (1).

### **Improvements of fishing gear and methods**

#### Fish traps

- Several coastal vessels are now successfully using fish traps for catching tusk. The traps are operated in fleets of 50, with trap spacing of 40-50m (1).

#### Longline

- The work on artificial bait (Probait) has been continued (1). More effective longline gear (swivel, EZ-hook and monofilament gangion) has now been adopted by several autoline vessels. Compared with traditional gear, the long term improvement in catch rate is at least 30% (1).

#### Gill nets

- Experiments with different twine materials in gill nets have been continued (5).

#### Purse seine

- Based on promising results with large meshes in the last part of purse seines, several purse seiners have lengthened their nets with large mesh panels (1).

#### Trawl

- Development of a new multipanel fish trawl design (1,4).
- A fish trawl designed for 3 warp drag has been tested in the flume tank. Vertical opening could be increased by 50-70% by pulling the 3rd warp, attached to a tounge of the central head line (1,4)
- An investigation on otterboards has been started (5).
- Successful results are obtained with a 4 winch/2 (standard) trawl system on a factory trawler.

### **Vessel technology and marine engineering (2)**

Within the program **Information Technology in the Fishing Fleet** main topics have been:

- Future functional requirements for instrumentation system and bridge design on fishing vessels.
- Decision Support System on fishing vessels.
- Systems for ship to shore data communication in the fishing fleet.

The project **Robotization of catch handling** has focused on the need and requirements for an automated system for loading and unloading of frozen fish in the hold of a freezer trawler.

The program **Intregrated production systems in the fishing industry** has aimed at finding the most efficient division of tasks between the fishing fleet and the shore plants in the fishing industry, and to develop the technology for such production systems.

The objective of the program **Renewal and increased efficiency in the fishing fleet** has been to analyse future requirements to Norwegian fishing vessels, and to study how alternative fisheries management regimes will affect the possibilities of meeting these requirements.

The program **Cost reduction in the fishing fleet** has focused on how to reduce running and maintenance costs, and on improving profits by means of preventive maintenance, thus reducing the probability of non-planned interruptions in fishing operations.

Among the activities outside the main areas mentioned above, the following topics of relevance to the interests of the working group have been treated:

- Predesign studies of the qualities of catamarans as fishing vessels (large deck areas, moderate motions in a seaway, etc.).
- Model tests of antipitching tank for reduction of vessel motions and resistance in a seaway.
- Evaluation of water draining systems for the working deck area of shelter decked longliners and gillnetters.
- Survey of location and maintenance of survival suits onboard Norwegian fishing vessels.
- Development of fishing vessels designed for bringing their catch alive on shore.
- Recording and reduction of vessel noise affecting fish behaviour.

#### **Other relevant activities**

- A model has been developed to simulate the sinking of a purse seine (1).
- In a project aimed at catching cod fry as seed fish for farming, about 600,000 O-group cod were caught with a small meshed Danish seine in shallow waters along the outer coastline of Finnmark, during August/September 1988. The fry were easily located with a 38 kHz echosounder. Assessment of the O-group cod stock in coastal waters of Finnmark was estimated to about 40 million individuals (1).
- Trawling across pipelines was observed by underwater TV (Ocean Rover) in the North Sea. At low angles (less than 45°) the trawl door would slide along the pipe, giving reduced door spread and a distorted trawl geometry. When crossing the pipe, minor effect was observed on the trawl (1).
- A data bank on fishing vessel economy and technology is being established (5).

#### **PORTUGAL.**

The Fishing Technology Departement (DTP) has been involved in the following activities:

##### **Full scale testing**

An observation and testing cruise will be carried out next summer. As in the last year, the performance of commercial trawls, some with new rigging, will be measured with Scanmar instrumentation aboard the R/V "Noruega". Behavioural aspects of the trawls and the possibility of improving them will be demonstrated to skippers and netmakers.

##### **Fishing technology laboratory.**

Studies have been started in order to build a fishing technology laboratory in which will be included a flume tank for fishing gear and vessel models testing.

### **Collaboration with other countries.**

#### **- Portugal-France**

Collaboration between INIP and IFREMER has been carried on in fishing technology area.

The activities planned for this year are the following:

- construction of trawl models to be tested in a flume tank, observation of tuna pelagic pair trawl fishing and bivalve capture in France.

- observation of sardina's purse seining and vertical drifting longlines on Black Scabbard (APHANOPUS CARBO) fishery in Portugal.

#### **- Portugal-Guiné Bissau**

Scientific and technical cooperation began in 1988 and will continue in the next years with a large range of activities, including collaboration on fishing gear experiments and in fishing technology.

### **Jigging machines.**

More experiments to fish squid with light attraction using jigging machines aboard R/V "NORUEGA" in portuguese waters will be made this year.

### **Long lines.**

Fishing experiments using vertical drifting longlines has been carried out during last years to detect and capture Black Scabbard fish. Observations in commercial vessels will be made during 1989.

### **Trawl gear.**

Observations aboard R/V "Noruega" related with the behaviour of a new crustacean trawl gear working on deep waters rigged for rough grounds.

### **Informatics.**

New computer equipment has been acquired and some computer programs have been written. A new computer program for fishing gear drawing will begin to be written this year.

A CAD system have been utilized for drawing hulls of fishing vessels.

### **Fishing vessels.**

Economic parameters, concerning fishing vessels exploitation and reconversion of some fishing vessels for tuna and swordfish longline captures were evaluated.

## **SWEDEN.**

### **General**

Sweden is still without an institute for research in the field of fisheries technology but at last special funds for research activities have been raised in 1988. It is believed that this funds will give better continuity in fisheries technology work and in the future will form the basis for establishing an institute.

### **Vessel design**

Full scale measurements were carried out of pull force of three fishing vessels in the size range of 23-38 m with different propeller systems including ducted propeller.

Model tests have been carried out to study stability of rebuild fishing vessels after several accidents.

Several projects have been carried out on workload and ergonomics measures in professional fishing. The findings is believed to provide a sound basis for action-orientated research and development programme focusing on reducing chronic disorders of the musculo-skeletal system. New methods and improved equipment are implemented in fishing fleet together with actions to improve living quarters onboard vessels.



### Selectivity in trawls

A comparison regarding proportion of undersized cod caught by codend with 95mm diamond and square meshes was performed onboard commercial fishing vessels in the Baltic. The result indicate a "saving effect" of about 10% with the diamond mesh. Several Swedish fishing vessels have applied square mesh in the fishery.

## U.K.- ENGLAND

### 1. TRAWL GEAR DEVELOPMENT

#### 1.1 Model/Full Scale Relations

There has been steady progress with this project throughout the year.

Flume Tank trails of a 1/10th scale model of the Marine Laboratory pelagic trawl PT-163 were carried out, and although differences were detected between the drag in full scale net and the model it was determined that such differences were not significant. It was observed however, that there were differences in mesh angles in selected panels, however this is to be further investigated later this year. Sea trials to collect full scale data on a small demersal net have also been carried out.

In conjunction with the above project significant progress has been made in improving the water flow in the Flume Tank by the introduction of a series of dual net mesh screens.

#### 1.2 Model Otter Board Tests

Further Flume Tank tests of a number of otter boards of innovative design have been carried out, namely **Nettec**, **Bison** and **Perfect** of Denmark. These were followed up by sea trials of the **Nettec** and **Bison** doors. The size and performance of the above mentioned doors were predicted from the Flume Tank trials and were proved to be sufficiently accurate for commercial purposes. Further tank and sea trials are scheduled in order to examine the effect of otter board weight on performance. As part of an improved instrumentation package for sea trials, Seafish are currently developing an angle of attack meter based on a 3 axis fluxgate sensor.

#### 1.3 Multiple Trawls

Following earlier work to introduce and develop twin trawls in U.K. fisheries, trials were successfully carried out using a **triple trawl system**. The vessel used for the trial was based on the West Coast of Scotland and had been using a twin trawling rig for some time. A third smaller net was designed and inserted between the two principal nets in an area in which it was suspected significant quantities of fish were escaping. There were a number of handling problems initially but these were quickly overcome and catch rates increased by some 15-20%.

### 2. STATIC GEAR

#### 2.1 Trails to Reduce Crab Mortalities in Trammel Nets

One of the major problems associated with the use of bottom gill and trammel nets is the often excessive time spent clearing crabs and debris from the nets. This project examined the effectiveness of various rigging configurations and the use of a number of different netting materials to improve clearing time. The trials also indicated that large mesh barrier strips along the bottom of the nets allowed the crabs to escape but still retained high value flat fish such as turbot. The catch rates during the trials, however, were relatively low and therefore there was some lack of confidence on behalf of the fisherman to accept that the experimental nets caught as much fish as his standard gear. It is intended to carry out further trials this year.

#### 2.2 Pilchard Drift Net Trials

Further fishing trials of nets made of various different types of synthetic material were carried out last summer and their effectiveness compared with traditional cotton nets. These trials showed that

the type of material used in the nets was less important than finding the right degree of stiffness of the netting in order to clear the nets quickly and easily on hauling. A treatment using a water based latex compound was found to be most effective. Considerable quantities of pilchards were caught during the trials but the marketing situation for this species is very difficult in the U.K.

### 3. SAFETY ENGINEERING

#### 3.1 Noise Attenuation

Work has continued this year to reduce the amount of hydraulic fluid noise, particularly on vessels with shelter decks. This has consisted of introducing attenuators into the circuits, improving the effectiveness of hydraulic pipework insulation and introducing foam cladding materials on bulkheads and deckheads. The result of this work has been a reduction of noise levels of 10dBA on a selected vessel.

Seafish are continuing to make boatyards more aware of the problems of noise on fishing vessels and to take noise measurements during sea trials. The long term objective of this work is to set sound level standards for spaces on fishing vessels both for the welfare of fishermen and efficiency of operation.

### 4. STANDARD TOWING TEST FOR TRAWLERS

The **drogue** method of standardising the towing capability of trawlers is intended to become the recognised method of rating trawlers. Further sea trials of various designs of drogues have been carried out and the results of these trials are being analysed. The trials demonstrated that two drogues may be towed simultaneously without any interaction between them, so that it will now be possible to test vessels up to 1000hp in this way.

#### U.K.- SCOTLAND.

Fish damage and survival as a result of escape from 90 mm diamond and square mesh codends were studied. Replicated experiments gave consistent results for the survival of 15-35 cm haddock in each case compared to that of the handline caught control fish.

Experiment	1	2	3
Diamond mesh escape survival	67%	74%	73%
Square mesh escape survival	92%	94%	92%
Control survival	97%	100%	100%

Survival depends on the openness of the mesh relative to the size of the fish.

A study was started of gadoid fish reactions to both diamond and square mesh codends towed in a frame. The length and girth of each fish was measured before introduction to the codend. The opening and tension of the actual mesh through which the fish escaped were also measured. Individual fish were killed at various times during the haul to collect muscle samples for lactic acid and glycogen level analysis to assess exhaustion states.

Further catch comparisons were made on prawn trawls using standard, longitudinally roped and square mesh codends. Discards of small prawns were reduced to some extent with both the roped and square mesh codends.

A vertically divided 600 hp trawl was used to compare the catches of roundfish and flatfish in different codends. A range of sizes of square mesh codend were compared with a 90 mm diamond mesh codend. The trawl was also used to measure the selectivity of 90 mm diamond and square mesh codends for comparison with the results of covered codend experiments. The results are not yet available. The variation of selection range with gear design parameters has been investigated using a large data set and no significant relationships found with codend diameter and extension length for haddock, whiting and cod. Mesh size was found to have a significant influence on the selectivity range of all three species in seines but not in trawls.

Further television observations of novel codend designs were made. Gathering meshes at intervals along the codend and around the codend circumference was found to increase the mesh opening of those meshes which were not gathered. A wire reeved through rings across the codend, instead of a normal codline, effectively maintains wide-open meshes near the aft end of a codend to allow small fish to escape.

The effect of gear and environmental factors on the catch of fish sampling gears was monitored on two stock assessment cruises on FRV "Scotia". The GOV trawl was used on both surveys.

The performance of Scottish seines was studied on a 500 hp vessel by measuring the tensions and rope geometry throughout the hauling process, using up to 14 coils (3080m) of rope per side. Long-range rope spread measurements (>300m), during the early stages of hauling, again proved difficult to obtain.

The fishing performance of a two warp twin trawl was studied on FRV "Clupea" to assess the suitability of this type of trawl for selection experiments. The catches in the two sides were similar in terms of total numbers of fish of all species. On an individual species basis only whiting were found to be more abundant in one side. The length compositions of each species indicated no significant difference in selection occurring in the two codends.

Further measurements on the flow in codends and pelagic trawls confirmed that flow is reduced by more than 10% only when netting of high solidity is used, eg open meshes of less than 30mm or closed meshes in a 90mm codend perhaps.

Preliminary tests to predict the flow in codends using computational fluid dynamics have shown encouraging results. A method of measuring codend shape using a laser and TV mounted on an underwater vehicle is being developed.

Major improvements have been made in modelling demersal and pelagic trawls by computer. Convergence techniques continue to be investigated and improved and the possibilities for integrating flow prediction in the model are being considered. The model has been used to study the variation of net geometry with codend load.

A cruise was undertaken to monitor the hydrodynamic performance of plankton and larval fish samplers using the remote controlled television vehicle. Some good videos of a multi-depth plankton sampler, the standard Methot net and the 5.2sqm area Lochness sampling device were obtained.

Further studies on the rules that determine the appearance of objects underwater have led to tests on sampling gears for small fish. The evidence suggests that larval fish are avoiding the Gulf III sampler during daylight but not after dark. Observations of the frontal appearance of the device show it to be a high contrast visual image when it is viewed horizontally from directly in front against the grey water background. Because the device is always towed horizontally concentric mirrored rings were used to make the nose cone invisible. The central hole appears black and the inside of this aperture was coated with reflex reflector material. Filmed observations have shown both treatments successful. Fishing tests comparing the treated and untreated device are to be carried out during the next larval survey season.

## U.S.A.

### **Northeast Region.**

Much of the gear-related research activities carried out in the Northeast Region of the United States focussed on trawl codend mesh selectivity properties of square-versus diamond-mesh netting, and will assess the survival rates of fish escaping from both types of codends.

Researchers at the Massachusetts Division of Marine Resources will compare the effectiveness of square- and diamond-mesh extension pieces, backed up by television observations of fish/trawl interactions. The Maine Department of Marine Resources will carry out a study on the influence of twine color on codend selectivity and will also use underwater TV to document fish behaviour. Ongoing codend mesh selectivity studies by the Connecticut Department of Environmental Conservation continued in 1988.

The Center for Fisheries Engineering Research at the Massachusetts Institute of Technology (MIT) was active in several areas of fishing gear research, and contributed substantially to the gear research activities of other workers around the country.

MIT is heavily involved in the development of a compact, low cost TV-equipment remotely operated towed vehicle that has been used for several of the fishing gear studies mentioned elsewhere in this summary. MIT also continued to refine testing equipment and techniques for model gear studies in the model ship towing basin at the U.S. Navy's David Taylor hydrodynamics research facility.

These make it possible to test models of complete trawl systems (including warps, doors, sweeps and bridles, and the trawl and its codend) at very large scales, which in turn allows the detection and measurement of effects unobservable in conventional flume tank studies.

A study underway at the University of Rhode Island is utilizing trawl instrumentation to record full size trawl performance for comparison with the results from trawl model studies.

Scallop gear selectivity and performance were the main concerns of research activities by the fisheries Engineering Group, Northeast Fisheries Center, National Marine Fisheries Service (NMFS). The selective properties of different mesh sizes and/or ring diameters in collection bags of scallop dredges were evaluated. Another study looked at the pressure fields around the depressor plate of a scallop dredge to see how this may affect selectivity.

### **Southeast Region.**

Bycatch reduction and gear selectivity were key schemes for gear research in this region as well. The North Carolina Division of Marine Fisheries carried out several studies in this area: a codend mesh selectivity study; test of fish sorting systems in shrimp trawls; further test of Turtle Excluder Devices (TED's for shrimp trawls; and evaluations of fyke nets (a form of fish trap) as an alternative to the less-selective gillnets currently used in various fisheries. Two programs at the University of Georgia also focused on selectivity issues (tests of the effectiveness of escape openings in crab traps, and TED development) while two other studies were aimed at increasing shrimp trawl efficiency (development of a more efficient door, and experiments with large-mesh panels in shrimp trawls).

The Harvesting Systems Division at the NMFS Mississippi Laboratories also worked with TED's as well as following several other lines of gear research. One major effort recently concluded was the development of a high-speed semi-pelagic trawl featuring Kevlar netting for capturing fast-swimming species. Also working with these species, which do not quickly tire in the codend, the group was compelled to develop a funnel system for holding the fish in the codend during haulback. An underwater TV camera system was developed for trawl observation featuring a self-contained camera/recorder unit that may be fastened to the net and turned on prior to shooting the gear. This greatly facilitated fish and/or gear observations compared to systems relying on divers or ROV's.

**Southwest Region.**

Relatively little information was available on gear research programs in this region, which includes the U.S. Pacific Islands.

Projects in the islands included a time-depth study in the longline fishery for sashimi-grade tuna, and evaluations of fish aggregation devices. On the mainland a project sponsored by the Coastal Fisheries Foundation examined the practicality and environmental impacts of converting small California coastal gillnet vessels to several alternative gear types including otter trawls, pair trawls, beam trawls, longlines, and traps. Work with Scottish seines will follow.

**Northwest and Alaska Region.**

The Conservation Engineering Task of NMFS' Northwest and Alaska Fisheries Center continued its research on factors affecting the physical performance of sampling trawls, and analyzing their implications for area-swept abundance estimation techniques. Factors investigated included depth (thus scope) and vessel-to-vessel differences.

The Fisheries Research Institute at the University of Washington was engaged in continuing studies of codend mesh selectivity studies for coastal fisheries of the mainland U.S. West Coast. This study, which compared square-mesh and several sizes of diamond-mesh, was entirely carried out aboard working commercial vessels in order to ensure the applicability of the results to real-world fisheries.

Other gear research efforts were undertaken by private companies providing gear to the growing U.S. fleet of factory trawlers. Major emphases included increasing the size of trawls while reducing their towing resistance, optimizing the design of codends for strength and fishing efficiency, and developing large semi-pelagic trawls for fishing in the shallow but highly productive waters of the eastern Bering Sea. Working with large scale models, much was learned about the details of the performance of high-efficiency trawl doors, pointing the way to the design of "second-generation" high-efficiency doors.

RF/BvM

