INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA

ICES C.M 1994/B: 2
Fish Capture Committee

REPORT OF THE WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR
MONTPELLIER, FRANCE, 25-26 APRIL 1994

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1.0 INTRODUCTION

1.1 Participants

Belgium	Ronald Fonteyne
	Hans Polet
Canada	Gerald Brothers
	Chris Cooper
	Frank Chopin
	Pingguo He
	Barry McCallum
	David Tait
	William Tait
	Stephen Walsh
Denmark	Jesper Boje
	Steen Christensen
	Nick Lowry
	Niels Madsen
	Jens Pedersen
	Rene Holst
	Thomas Moth-Poulsen
England	Geoff Arnold
Finland	Petri Suuronen
	Timo Turunen
France	Gerard Bavouzet
	Jean-Claude Brabant
	Emmanuel Charles-Dominique
	Pierre-Yves Dremiere
	Jacques Sacchi
	Patrice Woerther
	Francois Theret
	M. Mellat
Germany	Klaus Lange
Iceland	Hreinsson Einar
	Gudni Thorsteinsson

Italy	Loris Fiorentini
Japan	Takafumi Arimoto Yoshihiyo Inoue
Netherlands	Tarik Kreibel Bob van Marlen
Norway	Åsmund Bjordal Olav Rune Godø Ingvar Huse Roger Larsen Aud Vold Soldal Atle Totland
Poland	Waldemar Moderhak U. Siyiniarski
Scotland	Dick Ferro Barry O'Neill Graham Sangster Peter Stewart
Spain	Lvis Gil De Sola
Sweden	Bertil Johansson Roger Karlssen Mats Ulmestrand
United States	Arnold Carr Daniel Erickson

1.2 BACKGROUND AND TERMS OF REFERENCE

Convener: Stephen J. Walsh, Northwest Atlantic Fisheries Centre, Dept. of Fisheries and Oceans, St. John's, Newfoundland, Canada

Rapporteur: Barry R. McCallum, Northwest Atlantic Fisheries Centre, Dept. of Fisheries and Oceans, St. John's, Newfoundland, Canada

Meeting Place: Montpellier, France

Date: 25-26, April, 1994

In accordance with ICES C.Res. 1993/2:8, the Working Group on Fishing Technology and Fish Behaviour (Chairman: Mr. Stephen J. Walsh, Canada) would meet in Montpellier, France from 25-26 April, 1994 to:

a) consider and comment on the final version of the Manual on Recommended Methodology of Selectivity Experiments prepared by the Sub-Group on Selectivity Methods;

b) review available information on the characteristics of new netting and twines used in towed fishing gears which may have the property to change cod-end selectivity;

c) review the methods to measure the characteristics described in item b), particularly mesh size and make proposals for future work;

d) consider the influence of natural behaviour (diurnal migration, feeding, etc.) on sampling variability;

e) consider and develop the conclusions of the Sub-Group on Survival Experiments;

f) consider and comment on the report of the Working Group on Long-Term Management Measures;

g) consider and comment on the report of the 1993 NAFO Symposium on "Gear Selectivity/Technical Interactions in Mixed Species Fisheries".

In accordance with ICES C.Res. 1993/2:8:1, the Sub-Group on Selectivity Methods (Chairman: Mr. D.A. Wileman, Denmark) will meet in Montpellier, France from 21-23

April 1994 to prepare a final version of the Manual on Recommended Methodology of Selectivity Experiments.

In accordance with ICES C.Res. 1993/2:8:2, a Sub-Group on Methodology of Fish Survival Experiments will be established (C.Res. 1993/2:8:2) under the chairmanship of Mr. G. Sangster (UK) and will meet in Montpellier, France from 22-23 April 1994 to :

a) review and evaluate data and techniques for survival studies;

b) make proposals for the future direction of research on survival studies.

The Sub-Group will report to the Working Group on Fishing Technology and Fish Behaviour and to the ICES Working Group on Ecosystem Effects of Fishing Activities.

1.3 AGENDA AND PROCEEDINGS

The meeting was hosted by the Montpellier Science University and began at 0900 hours. A general welcome was conveyed by the vice-president of the university. R. Fonteyne, Chairman of the Fish Capture Committee replied with words of thanks. Opening remarks concerning agenda items and schedule were given by the Working Group (WG) Chairman, S.J. Walsh.

2.0 SUB-GROUP REPORTS

2.1 Report of the Sub-Group on Methodology Experiments - David Wileman (Chairman)

Mr. David Wileman, Chairman presented the Working Group with an overview of the Sub-Groups recent activities and progress. The manual has been divided in three sections, each of which has been assigned the following authors: Data Specifications - Mr. R. Fonteyne, Belgium; Techniques - Mr. R.S.T Ferro, Scotland; and Statistical Analysis - Dr. E. Pikitch, USA.

A review of the manual's status in November, 1993 showed that approximately half of the material and text had been produced for both the Data Specifications and Techniques section but a significant delay had occurred in producing material for the Statistical Analysis section. It was agreed at that time that a complete draft of all three sections would be ready for editing during the Sub-Group meeting in Montpellier, April 1994.

Completed texts for the Data Specifications Section and Techniques Section were subsequently edited during the Sub-Group meeting, 21-23 April, prior to this WG

meeting. However, little progress, to date, has been made on the Statistical Analysis Section because the lead author has stepped down due to work commitments.

The Working Group was given brief presentations by R.S.T Ferro and R. Fonteyne on their respective sections (see ICES C.M 1994/B7) and invited all Working Group members to send comments to the Sub-Group Chairman.

The Sub-Group has agreed to approach Dr. R. Millar, New Zealand, to assume the lead role and with the assistance of Dr. R. Fryer, Scotland complete the Statistical Analysis Section prior to the fall of 1994.

A revised schedule to completion will be:

Comments from FTFB members on completed sections	Aug. 31, 94
Completion of analysis section, editing of other sections	Oct. 30, 94
Completion of draft, forward to referees	Nov. 30, 94
Return of referees comments	Jan. 29, 95
Final document to FTFB members	Mar. 30, 95
Approval by FTFB	Apr., 95
Approval by Fish Capture Committee	Sept., 95

The Sub-Group recommends that it complete the manual by correspondence such that it can be submitted to the FTFB Working Group members prior to the April 1995 meeting, with a view to publish it, at a later date, as an ICES Cooperative Research Report.

Attendee's of the Sub-Group meeting 21-23, April, 1994, who contributed as reviewers:

Bob van Marlen	RIVO-DLO	NL
Tarik Kreibel	RIVO-DLO	NL
Klaus Lange	BFA-Fischerei	G
David Wileman	DIFTA	DK (Chairman)
Francois Theret	IFREMER	FR
Dan Erickson	Univ. of Washington	USA
Chris Cooper	DFO, Scotia Fundy	CAN
Roger Karlsson	Lindholmen	S
Dick Ferro	Marine Lab	Scotland
Ronald Fonteyne	Fisheries Res. Stn.	B
Graham Sangster	Marine Lab	Scotland
Roger Larsen	Univ. of Tromsø	N
Petri Suuronen	F.F.R.I	FIN

2.1.2 Plenary Discussion

The WG Chairman stressed the importance of receiving feedback on the draft of the manual from WG members. It was noted that due to the size of the task, the scope of the manual has been restricted to small mesh towed fishing gear only, ie. "classical" selectivity experiments. Also, other methods such as catch comparison and comparative fishing have not been addressed.

2.2 Report of the Sub-Group on Survival Experiments - Graham Sangster (Chairman)

2.2.1 Mr. Graham Sangster gave a overview of the Sub-Groups meeting on April 22 and 23 and its draft report. Participants were divided into three groups and asked to focus on: general fishing mortality and how it may be defined; unaccounted mortality in the fish capture process; and, the methodology of survival studies. Brief presentations on the review were given by Frank Chopin - the mortality of fish escaping fishing gears; Åsmund Bjordal - the effects of the fish capture process on mortality; Petri Suuronen - field studies and lab experiments; Arnold Carr - lab simulation studies; and, Pinggho He - a literature review .

Aud Vold Soldal presented the following recommendations to the WG:

The Sub-Group on Fish Survival recognizes:

- the lack of knowledge of the unaccounted mortalities associated with the fishing process and their impact on stock assessment and the ecosystem.

- that limited methodologies and results exist for the various fishing gears and species.

The Sub-Group recommends that:

1. The fate of fish that encounter each phase of the fish capture process must be understood.
2. Impacts of unaccounted mortality be investigated based on biological and economic consequences.
3. Selectivity studies require a complimentary understanding of survival.
4. Efforts be made on the development of methodologies to obtain results for fisheries of commercial importance.
5. More research is needed to identify the factors causing stress* and mortality of fish during the capture process.
6. Research should be aimed at identifying and correcting the damaging mechanisms of fishing gear.

* stress assessment is a tool in determining causal factors of mortality and aids in mitigation.

Attendees of the Sub-Group meeting:

T. Arimoto	Japan
A. Bjordal	Norway
A. Carr	USA
F. Chopin	Canada
J. DeAlteris	USA
D.L. Erickson	USA
K Lehman	Denmark
P. He	Canada
E. Hreinsson	Iceland
Y Inoue	Japan
J. A. Jacobsen	Faroe Islands
G. I. Sangster	UK
A. V. Soldal	Norway
P. Suuronen	Finland
G. Thorsteinsson	Iceland
M. Ulmestrand	Sweden

2.2.2 Plenary Discussion

The Sub-Group Chairman requested that FTFB members review the report and send comments in writing to him. From these comments a second draft will be produced and presented at the September, 1994, ICES Statutory Meeting in St. John's (see ICES C.M 1994/B:8). Some members suggested that a manual on fish survival experiments should be the logical output of this group. In response to questioning Mr. Sangster stated that it is not within the Sub-Groups mandate to produce a manual, but possibly to recommend that one be written. It was suggested that this report will have relevance and applicability beyond the WG and that consideration should be given to expanding its target audience. The WG Chairman commented that the report was an enormous effort and thanked all Sub-Group members.

3.0 SPECIAL TOPICS

3.1 Characteristics of Netting and Twine (R.S.T Ferro/N. Lowry - Rapporteurs)

3.1.1 **Keynote Address** "An Overview of the Characteristics of Twines and netting that may change Cod-End Selectivity - R.S.T Ferro and F.B O'Neill (presented by R.S.T Ferro)

Factors considered to be important in determining cod-end selectivity are; water flow within the cod-end, behaviour of fish within the cod-end, and mesh opening. In considering the characteristics of netting and twine that influence cod-end selectivity we must consider how they alter the hydrodynamics of the flow, modify the behavioral response of the fish, and affect the mechanics of mesh opening. While it is difficult at this point to make statements on the effect of flow on selectivity experiments, it has been shown that the behavioral response of fish to twines and netting depends on the contrast with the background and hence on twine thickness, orientation and colour. The selectivity of a cod-end is most directly affected by the openings of individual meshes which is dictated by the flexural rigidity and elongation of the twine.

The netting and twine characteristics which influence selectivity through changes in cod-end hydrodynamics, fish behaviour and the mechanics of mesh opening

	Hydrodynamics	Behaviour	Mechanics
Twine thickness	**	**	**
Flexural rigidity			**
Elongation			*
Twine surface roughness	*		
Twine construction	*		*
Twine colour		**	
Twine torsional rigidity			*
Knot type	*	*	*
Mesh shape	**	**	**
Mesh size	**	**	**
Solidity	**	**	

*indicates less significance
**indicates more significance

3.1.2 Characteristics of High Strength Knotted and Knotless Netting in Comparison to Traditional Ones - L. Fiorentini and K. Hansen (presented by L. Fiorentini)

Laboratory tests of the newer high strength twines with the aim of developing more fuel efficient demersal trawls has shown that knotted Dyneema may be a suitable alternative to the more conventional polyamide and polyethylene twines. Polyamide knotless netting of 110 and 60 mm full mesh and polyethylene netting of 110 mm was comparatively tested with knotted Dyneema R1/R2 of 110 mm full mesh and knotless Dyneema SK60 of 110 and 60 mm full mesh.

3.1.3 The Effect of Twine Thickness on Cod-End Selectivity of Trawls for Haddock in the North Sea - N. Lowry and J.H.B Robertson (presented by N. Lowry)

The covered cod-end method was used in an experiment on the Moray Firth to evaluate the haddock selectivity of 100 mm stretched mesh cod-ends constructed of thin twine (3.5 mm nominal dia.) and thick twine (6.0 mm nominal dia.). It was concluded that mesh opening, twine flexural rigidity, fish behaviour and flow rate may have contributed to a decrease in the 50% retention length in the cod-end constructed of the larger diameter material. This can be said to be the equivalent of a 10 mm decrease in mesh size. The recent trend towards using thicker twine in the Scottish whitefish industry will tend to reduce the effect of mesh size regulations and maintain the high rate of discarding small fish.

3.1.4 Twine Flexural Rigidity and Mesh Resistance to Opening - F.G O' Neill and L. Xu (presented by F.B O'Neill)

The resistance of a mesh to opening is of considerable importance in determining the selectivity of a cod-end. It is therefore important to be able to describe and quantify the flexural rigidy of netting and twines. Non-linear Euler beam theory has been applied to the deformation of mesh bars to determine the flexural rigidity (EI) of a twine. Experimental results show that this remains valid up to the yield point of the material or as long as the stress-strain relationship is linear. The extent to which the typical forces experienced by mesh bars are in the linear range of the stress-strain curve must be ascertained for cod-end twines.

3.2 Methods to Measure Netting and Twine (R.S.T Ferro/A. Carr - Rapporteurs)

3.2.1 **Keynote Address** :A Review of Methods of Measuring Twine Characteristics and Mesh Size - R.S.T Ferro

Readings obtained with the wedge gauge operated manually show too much variance although under controlled conditions the wedge gauge can provide consistent data. The complexity of the ICES type gauge has lead to objections from the enforcement community. The spring mechanism will require calibration prior to each use. Both the wedge and ICES type gauges fail to take into account the resistance to opening of the meshes, especially stiffer twine. Furthermore, neither "mesh opening" or "mesh length" describe well the opening throught which fish escape. A more appropriate mesh characteristic may be the cross-section of an open mesh.

The most promising approach may be to improve current methods. A significant reduction in variance may be achieved by the general adoption of a recommended gauge design and a more rigorious measurement procedure, as has been done in some countries. Radical changes to the method for enforcement purposes will require more complex legal definition of the measurement method which might not gain acceptance.

Factors causing variance in each measuring device.

	Wedge	ICES	Tape	Conical
Force on Gauge	Y			Y
Time Applied	Y			Y
Netting Tension	Y	Y	Y	Y
Gauge Design	Y			
Inserting Gauge	Y	Y		
NettingCondition	Y	Y	Y	Y
Twine Material	Y	Y	Y	Y
Knot Size			Y	

3.2.2 Comparison of Mesh Size Measurements with the ICES and Wedge Gauges - R.S.T Ferro and L.X Xu (presented by R.S.T Ferro)

Experiments to determine the variance in mesh size measurements between the ICES and EC wedge gauges were carried out on typical cod-ends ranging in mesh size from 70 to 120 mm and twine diameter from 2.5 mm to 6.1 mm. The main factors affecting mesh measurement are the force applied to the mesh gauge, the tension in the netting and netting type. Under controlled and standardized conditions the coefficient of variation in mesh size measurements of both gauges is below 2%. Mesh size measurement will vary significantly with the force applied to the gauge. The ICES mesh gauge is sensitive to the tension with which the twine is held and will record a reduction in mesh size with an increase in twine tension. The legislated design of the EC gauge is vague and has resulted in different gauges for EC member countries which produce different reading for the same size mesh.

3.2.3 Possibilities of Changing Cod-End Mesh Openings by Means of Controlling Volume of Flow Intensity - W. Moderhak (presented by W. Moderhak)

By fully exploiting the laws of mechanic forces acting upon trawl bellies and the cod-end and the laws of hydrodynamic forces acting within the cod-end, it may be possible to improve the mesh opening coefficient and therefore the selectivity of the trawl. It is proposed that greater selectivity in the cod-end can be attained by increasing the flow of water through the cod-end. This can be achieved by increasing trawling speed, shortening the last belly segment to force an increase in the cod-end inlet area and/or by altering the construction of the last belly to reduce water flow through its walls. The increase in mesh size from which a cod-end is made has in itself made little impact on its selectivity as the hydrodynamic forces are too small to open the mesh. Observed increases in the selectivity of larger meshes takes place during momentary stops of the trawl when forces are relaxed and the meshes open.

3.2.4 Developing a Lastridge Ropes Measuring Device - G. Brothers, H. Delouche and Z. Kwidzinski (**Poster**)

To meet the requirement for an enforceable standard method of measuring the hanging ratio of cod-end twine to a lastridge rope, a prototype lastridge rope hanging ratio gauge has been developed. During field trials 10 measurements (5 per side) were made of a control cod-end and lastridge rope. The hanging ratios as measured by the gauge were found to within +/- 2% of the nominal value.

3.2.5 Measuring Commercial Fishing Nets: Comparative Testing of the MARFISH Gauge, Weighed Wedge Gauge and the Spring Gauge - P. G Caruso and A. Carr **(Poster)**

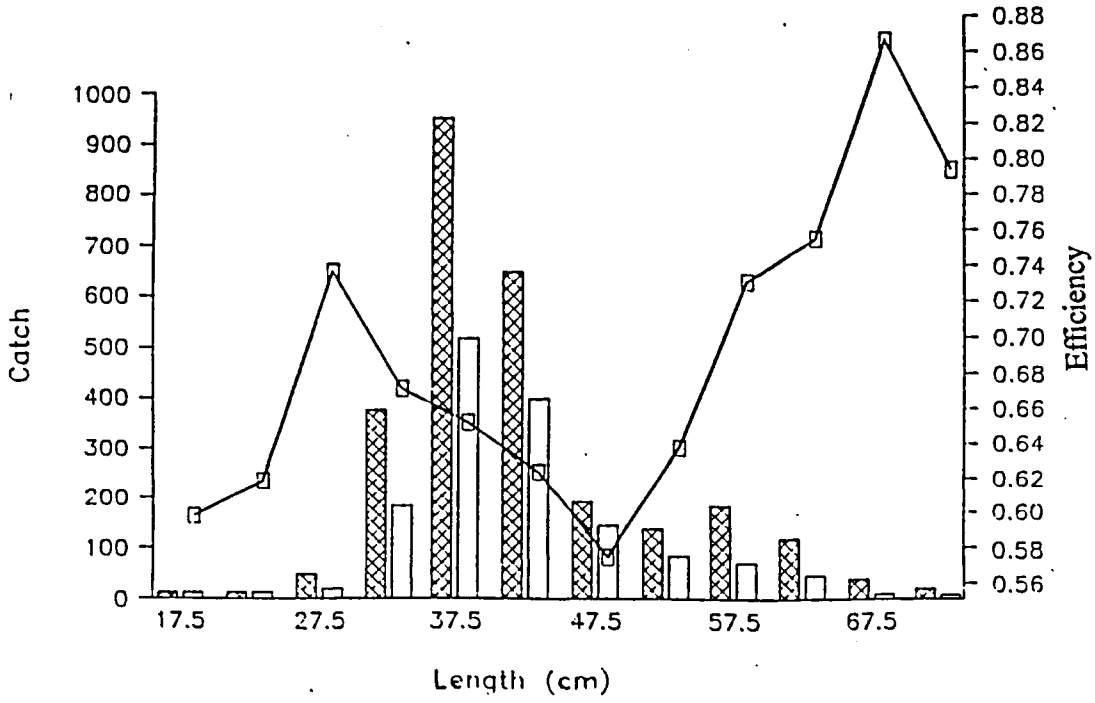
Four pressure type gauges were tested to determine comparative measuring ability, consistency in measuring and the utility of each gauge. The ICES and MARFISH gauge were found to be more precise than either the weighed wedge gauge or spring wedge gauge. With the absence of a method to control applied force the weighed wedge gauge is particularly susceptible to operator error.

3.3 **Influence of Natural Behaviour (Olav Rune Godø/Geoff Arnold - Rapporteurs)**

3.3.1 **Keynote Address :** Influence of Natural Behaviour - O. R Godø

Aspects of natural behaviour, independent of the sampling gear and research vessel, that may have significant relevance to the reliability of trawl survey catches are: vertical distribution, diurnal distribution and social behaviour. The catch equation $n=qfN$ assumes that trawl efficiency is constant and that all fish or a fixed proportion are available to the trawl yet acoustic surveys for cod and haddock clearly show this is not the case. Diurnal variation in catchability will be influenced by light conditions and tidal current. It is hypothesized that abrupt changes in catchability can be

explained by the distribution pattern of fish and it is further suggested that catching efficiency will be reduced if the population is composed of individual fish scattered throughout its habitat as opposed to the population being distributed in patches.



Social effects on escapement of cod under trawl. Hatched bars are catch in numbers, open bars are numbers of escapes under the trawl. Fish belonging to the dominant size size group (25-45 cm) form and react as a school and thereby escapement is reduced compared to larger and smaller individuals.

3.3.2 Patterns of Vertical Migration in Plaice and Cod - G. Arnold (ORAL)

Imaging sonar and acoustic tags were used to observe the natural behaviour of plaice in the English Channel. The pattern of vertical migration tends to be influenced by availability, accessibility and vulnerability. Plaice show a vertical migration on the north going tide. Comparative fishing was used to check that the observed migration patterns were consistent. On their summer feeding grounds, a different pattern of behaviour was observed; plaice rose to the mid-water at night over a tight geographical range. Using a tidal model and data retrieved from acoustic storage tags it was possible to reconstruct the migration track of plaice. By exploiting tidal transport the fish are able to migrate very quickly. This study indicates a very structured life history.

3.3.3 Swimming Behaviour of Winter Flounder in the Natural Environment - P. He (ORAL)

The swimming movement of winter flounder, *Pleuronectes americanus*, is characterized by up and down caudal fin undulation, alternating periods of swimming and resting, and swimming near the seabed. The proportion of time spent moving and resting, the swimming speed while moving, and the overall rate of movement was studied. Analysis of underwater video observations have shown that winter flounder swim slower and move less at lower temperatures (-1^0 C) and that the overall rate of movement is reduced at lower temperatures. The implication of these findings is that at lower water temperatures winter flounder will be slower to react to stimuli and predators, take longer to reach migratory destinations and will be less likely to encounter stationary fishing gear.

4.0 OTHER TOPICS

4.1 Survival Experiments (Graham Sangster/Petri Suuronnen - Rapporteurs)

4.1.1 Commercial Fishing Experiments to Assess the Scale Damage and Survival of Haddock and Whiting after Escape from Four Sizes of Diamond Mesh Cod-Ends - Graham Sangster and Klaus Lehmann (presented by Graham Sangster)

The survival rate and damage to haddock and whiting as the result of escape from 70, 90, 100 and 110 mm diamond mesh cod-ends was described. Escapees were held in insitu cages for 60 days while their survival was evaluated against control fish. The survival rates for the haddock and whiting experimental groups were 48-67% and 52-60% respectively, for the 70 mm cod-end; 79-82% and 73-78% respectively, for the 90 mm cod-end; 73-83% and 67-77% respectively, for the 100 mm cod-end; and, 85-89% and 83-86% respectively, for the 110 mm cod-end. The survival rate of smaller fish was much lower than larger fish, suggesting that survival may be a complex function of fish length. Mean total percentage body damage as determined with image analysis techniques shows that damage was not dependent on mesh size.

4.1.2 Survival of Young Vendace Escaping from a Trawl Cod-End - T. Turunen, P. Suuronen and M. Kiviniemi (presented by P. Suuronen)

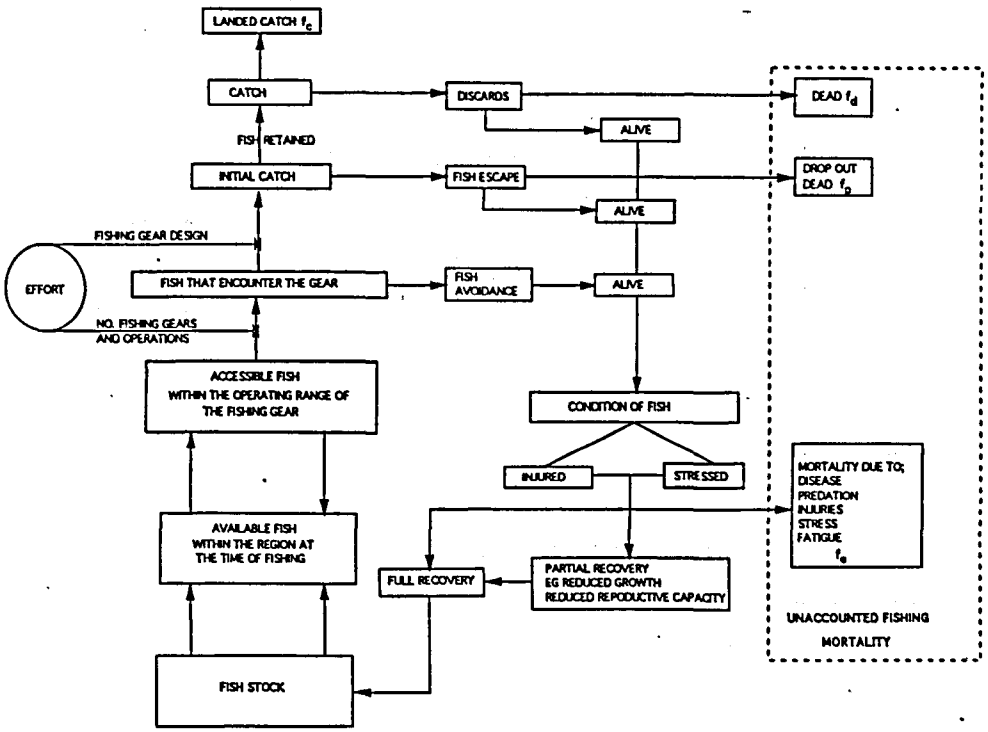
The survival of Vendace after escaping from 24 and 26 mm square mesh cod-ends constructed of knotless nylon was examined using a releasable cod-end cover cage. Escapees were held at depth and evaluated against control Vendace caught with a purse seine. Physiological indicators such as lactic acid, chloride and glycogen demonstrated that stress was highest during the first few hours after escape. Mortality was primarily attributed to the physical damage induced by the trawl and this was most pronounced in the cod-end and at night. The mortality of escapees may be reduced by redesigning the trawl and changing fishing practices.

4.1.3 Potential Bioeconomic Impact of Reduced Mortality of Cod-End Escapees in the Shrimp Fishery in the Davis Strait - S. Christensen (presented by S. Christensen)

A dynamic pool model applying constant fishing effort on a varying stock was used to evaluate the potential impact of reduced mortality of cod-end escapees in the Greenland shrimp fishery. The study indicates that the present level of catch and value may be increased significantly if mortality on the cod-end escapees is present and reducible. The magnitude of the potential gain is proportional to the mortality rate of the cod-end escapees and the magnitude of the reduction. Simulations show that the potential impact of an increase in mesh size may rely heavily on the present level of mortality of the cod-end escapees.

4.1.4 The Mortality of Fish Escaping From Fishing Gears: Some Notes on Unaccounted Mortality - T. Arimoto, Y. Inoue & F. Chopin (presented by F. Chopin)

Improvements in fishing gear selectivity are based on the assumption that escapees are not damaged, minimally stressed and make a full recovery. In many cases escape results in stress and damage as a result of contact with other fish, the trawl and the footgear. Where mortality is high after escapement the use of traditional selectivity measures such as a minimum mesh size may not be effective in protecting the pre-spawning biomass. Unaccounted fishing mortality can be defined in terms of discards (fd); fish escape (fe); and, avoidance and drop out (fp). Traditional models of fishing mortality reflect only the landed catch. It is suggested that where Fd +Fe + Fp can be determined for a particular fishing method, a quota penalty could be applied to account for mortalities specific to that gear type.



Fishing mortality model combining landed catch, discards, drop out, fish escape and avoidance mortality.

4.1.5 Survival Experiments of Fish Escaping from 145mm Diamond Cod-End Meshes at Faroes in 1992 and 1993 - J. A Jacobsen (read by title)

Results of survival experiments of fish escaping from 145mm diamond cod-end meshes are discussed. Escaped fish were collected in fine mesh cages (2x2x5m-aluminium frame) mounted on a cod-end cover. After 1 hr of trawling at depths of 150-250m the cages were released by means of an acoustic release system and slowed hauled-up to 40m below the surface for television observations. The cages were allowed to drift in the open sea and were located with radio tracking buoys. No mortality was observed for cod and the results indicated that saithe can withstand almost the same cod-end mesh sorting as cod with a high survival rate (96-100%). Haddock was more vulnerable with 15% mortality. The results for whiting indicated 7% mortality. *Sebastes viviparus* showed a survival rate of (94-100%).

4.2 Selectivity Studies (Ron Fonteyne/Thomas Moth-Poulson/Bob van Marlen - Rapporteurs)

4.2.1 Selectivity in Danish Conventional and Square Mesh Panel Cod-Ends during Nephrops Sea trials in the Northern North Sea - M. Madsen and T. Moth-Poulsen (presented by T. Moth-Poulsen)

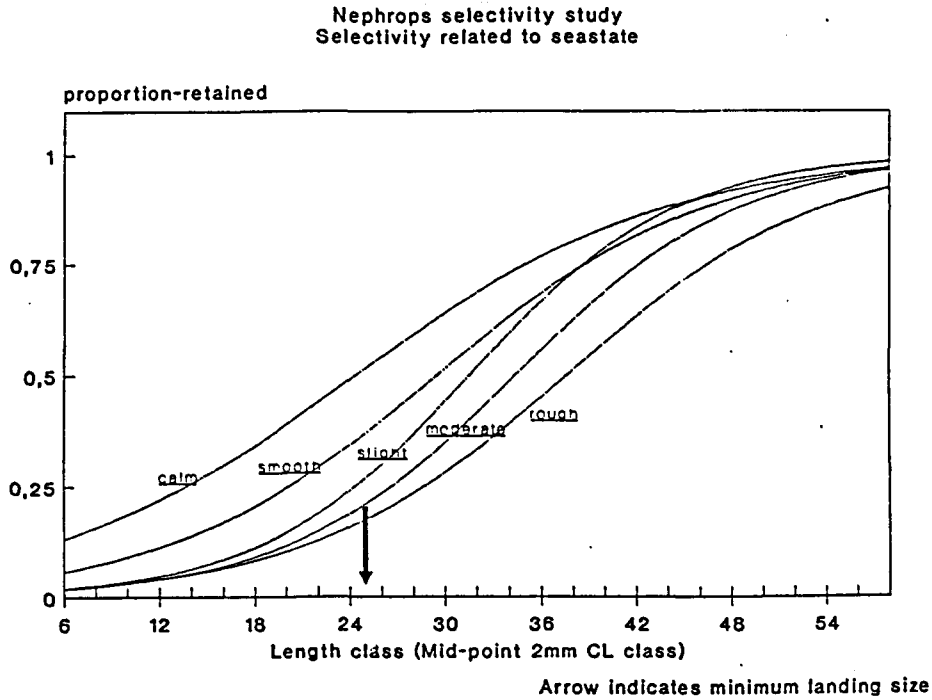
A three wire twin trawl system using 35 mm cod-end covers over 70 mm polyethylene cod-ends was used to evaluate the effectiveness of a knotless square mesh panel as a selectivity device in Danish groundfish trawls. The cod selection curves showed improved selectivity in the cod-end with the use of a square mesh panel. While there was considerable loss of marketable whiting (52%) when using the square mesh window there was no loss of haddock over the Danish minimum landing size (MLS). There was some reduction in cod (24%) and nephrops (12%) under MLS and a small loss of individuals over MLS (5%) for both.

4.2.2 Experiments with Lastridge Rope Hanging Ratios - G. Brothers and D. L Boulos (presented by G. Brothers)

The selectivity of a cod-end fitted with lastridge ropes is shown to decrease the catch of small fish. A standard commercial trawl was fitted with a vertical dividing panel of 40 mm mesh and two cod-ends (trouser trawl) . A control cod-end was evaluated against an experimental cod-end of 130 mm mesh size with lastridge ropes hung at 72, 80 and 85% ratios . The 80% hanging ratio was also evaluated against a 141 mm diamond mesh cod-end. Higher hanging ratios tended to retain smaller fish (< 41cm) ie. 1.02%, 3.03% and 3.25% for 72, 80 and 85% hanging ratios respectively. All three hanging ratios produced good selection characteristics with similar L50's and sharp selection ranges.

4.2.3 Selectivity Experiments in the Belgian Norway Lobster (Nephrops norvegicus) Fishery - H. Polet and F. Redant (presented by H. Poulet)

Selectivity curves for 70 and 90 mm mesh cod-ends fitted with square mesh panels were developed for whiting and nephrops. The cover cod-end method was used during two experiments in the Botney Gut-Silver Pit area of the North Sea. The variability in nephrops selectivity curves was primarily attributed to weather i.e sea surface conditions. The 90 mm cod-end was found to be less selective than the 70 mm cod-end which may have been caused by differences in construction; the 90 mm cod-end being constructed of double braided polyethylene as opposed to the single braided polyamide 70 mm cod-end. The L25's for nephrops and whiting for the 70 mm cod-end were found to be only slightly above the Minimum Landing Size.



4.2.4 Development of a Species Selective Whiting Trawl - T. Moth-Poulsen (presented by T. Moth-Poulsen)

Exploiting the observation that whiting escape more readily through panels of square mesh netting than cod or haddock two design concepts using horizontal square mesh panels were used to separate cod, whiting and haddock into two vertically stacked cod-ends. Both a full trawl separator and a cod-end design was tested. Where separation of cod into the lower cod-end was complete an average of 63% and 19% of the whiting and haddock respectively were separated into the upper cod-end. When compared against a standard trawl the whiting trawl was found to increase the ratio of marketable whiting to total haddock from 0.39 to 0.88. While marketable whiting was increased by 319% so was the catch of undersize haddock by 220%.

4.2.4 Preliminary Results of Grid Studies in the French Monkfish Fishery - M. Mellat (presented by M. Mellat)

Three grid designs were evaluated in separating non-marketable monkfish from megrim, hake and rayfish in the Celtic Sea and the Bay of Biscay. Grids with vertical bars of 77.5 mm spacing, horizonal bars of 55.0 mm spacing and a combination of vertical and horizontal bars with spacing of 110 and 65 mm, respectively, were mounted in a standard monkfish trawl. A second small mesh cod-end mounted above the escape hole captured escapees. The combination grid of horizontal and vertical bars with the lower cod-end removed or its mesh size increased was suggested to be the most efficient method of releasing juvenile Monkfish with a marginal loss of marketable megrim and hake.

4.2.5 Intermediate Results in EC-project TE-3-613 " Improved Species and Size Selectivity of Mid-Water Trawls (SELMITRA)" - B. van Marlen, K. Lange, C.S. Wardle, C.W. Glass and B. Ashcroft - (presented by B. van Marlen)

In attempting to improve the selectivity of mid-water trawls used in mixed fisheries of mackerel, horse mackerel and herring many behavioral differences were investigated. Extensive tank testing lead to the conclusion that management of towing speed would be ineffective in creating species separation. Over the course of Flume Tank testing and three research cruises involving two vessels, 9 grid configurations were tested. In each case a black contrasting tunnel was installed behind the grid arrangement to create an illusory block. Sorting efficiencies were typically in the order of 10 to 25% with only 20 to 25% of the fish passing through the grids. Stronger stimuli may be required to increase selectivity. It is suggested that the towing speed of 4.5 kts may have been to high to allow small fish to escape.

4.2.6 Selectivity Experiments with Cod in the Baltic - P. O. Larsen (Poster)

The trouser trawl method was used on a modified Micro trawl to evaluate the selectivity of a square mesh window and a 107 mm mesh cod-end for cod in the Baltic. The 522 x 77cm, 95 mm mesh size escape window was coated in plastic to aid in mesh opening. The control cod-end was fitted with a small mesh liner of 36 mm. While there was no difference in selectivity between the control and 107 mm diamond mesh cod-ends the selectivity window proved very effective with a L25 at 33.2 cm and a selection range of 2.6 cm. A long term experiment involving 10 commercial vessels is planned.

4.2.7 Gill Net Selectivity in Hellenic Waters - G. Petrakis, K.I. Stergiou and C.Y. Politou **(Poster)**

The selectivity of four different mesh size (17, 19, 21 and 23 mm on the bar) gill nets used in Hellenic waters was investigated. Selection factors for the six most abundant species; *Mullus barbatus, Mullus surmuletus, Pagellus erythrinus, Pagellus acame, Diplodus annularis and Spicara flexuosa* range between 4.83 and 9.01. The smaller estimated optimum lengths for all gill nets corresponded to *D. annularis and P. erythrinus*. Based on a comparison of this data with similar data from trawls it was concluded that the nets used in the present study catch larger specimens than the bottom trawl or the beach seine.

4.2.8 Beam Trawl Selectivity Experiments with Cod-end Covers Equipped with Hoops - H. Polet (presented by H. Polet)

A comparative analysis of the hooped cod-end cover, standard cod-end cover and twin trawl method in assessing the selectivity of beam trawls is described. Severe practical problems limit the applicability of the hooped cover method which may be impossible to implement in commercial operations. The selection factor and the selection range for sole were 3.1 and 6.0 cm respectively, for the covered cod-end method; 3.4 and 3.9 cm respectively, for the covered cod-end method with hoops; and, 3.8 and 7.3 cm respectively, for the twin trawl method. For dab the selection factor and selection range were 2.5 and 6.6 cm , respectively, for the covered cod-end with floats; 2.6 and 2.6 cm, respectively, for the covered cod-end with hoops; and, 3.0 and 6.9 cm respectively, for the twin trawl method. While based on a limited number of observations the selectivity parameters indicate that the covers are impacting (masking) on the escape behaviour of fish.

4.2. 9 Selectivity in Shrimp Trawl Cod-end from an Alternate Haul Experiment - J. Boje and K.M. Lehmann (presented by J. Boje)

The selectivity parameters for a commercial shrimp trawl using a 44 mm stretched cod-end are derived using the alternate haul method. A 20 mm stretched mesh control cod-end was used. As 21 of the 30 alternate tows could not be used in the analysis results were inconclusive as to whether mesh selection takes place or not. Selectivity parameters calculated for the 9 successful tows do show considerable variation between cod-ends. It was suggested that this variation was a result of the first tow disturbing or removing a significant part of the population along the trawl track thus biasing the alternate tow.

4.2.10 Influence of Increased Cod-end Mesh Size and the Square Mesh Panels in Shrimp Trawls on Catch Rates and Size Distributions of Shrimps and By-Catch - K.M. Lehmann (presented by K.M. Lehmann)

An experiment to reduce the by-catch of juvenile fin-fish and to evaluate the effect of increased cod-end mesh size on catch rates in the Fladen Ground Shrimp fishery is described. Three combinations of experimental cod-ends were fitted and tested in a twin trawl system; a 35 mm mesh cod-end with a 90 mm square mesh window, a 40 mm mesh cod-end with a 90 mm square mesh window and a standard 40 mm cod-end. It was found that while a 90 mm mesh window decreases the by-catch of fin-fish by approx. 33% there is no loss of shrimp. This was found to be the case in both the 35 and 40 mm cod-ends. The 40 mm cod-end without a window reduces the fin-fish by-catch by 4% and the shrimp catch by 8%.

4.3 Technical Studies (Peter Stewart/Klaus Lange - Rapporteurs)

4.3.1 Remote Control Closure of Trawl Cod-end - S. Pennec and P. Woerther (presented by P. Woerther)

The remote closure of the cod-end using a hydro-acoustic link and drag parachute was described. This system has particular application to hydro-acoustic biomass surveys where the sampling of discreet shoals of fish may be required. A hydro-acoustic signal from the ship deploys a parachute folded within a trawl mounted transducer, the drag of the parachute closes a loop around each compartment. Up to three parachutes can be deployed on one trawl separating the cod-end into three compartments

4.3.2 Optical Fish Measuring and Weighing System - P. Woerther (presented by P. Woerther)

An optically based fish weighing and measuring system has been developed specifically for research purposes at sea. Automation of these tasks is said to improve the precision and reliability of the data and increase productivity. Fish length is measured by a linear CCD camera and imaging recognition software as it moves along a belt, a second conveyor belt measures weight. The system is capable of a length precision of +/- 1.0 mm and a weight precision of +/- 2 gram up to 0.2 kg and 1% up to 2 kg.

4.3.3 CC - For Easy Analysis - R. Holst (Poster)

CC is a statistical software package designed specifically for selectivity researchers. Hauls may be analyzed with 4 different models; logit, probit, c-log-log or log-log. Options are provided for extreme points, detection and adjustment for overdispersion and convergence limit for Fishers scoring method. Multiple hauls may be analyzed by

pooling or by variance component analysis. A fitted model is evaluated with confidence bands which account for the variation in the number of fish observed in the length classes by producing binomial confidence limits for each length class.

4.3.4 Meschal Data Acquisition Software for Sea Trials - G. Bavouzet and Y. Cadiou (presented by G. Bavouzet)

Meschal is a user friendly software package designed to log multiple parameters on a PC during sea trials. Up to 16 analog or digital inputs as well as Scanmar and GPS serial inputs can be accommodated. Analog inputs can be manipulated with regression coefficients and filters, and displayed as either raw input or corrected data. Analog inputs can be sampled at up to 100 Hz whereas Scanmar and GPS may be sampling at up to 1 Hz. The output from each device can be displayed on a separate page where minimum and maximum filter values may be applied for online editing.

4.3.5 A Mathematical Model for the Determination of the Shape and the Tensions of a Trawl Placed in a Uniform Current - F. Theret (presented by F. Theret)

A computer based trawl simulation has been developed to study the influence of external forces on the shape of a trawl. The software may ultimately be used to allow skippers to adjust the trawl shape for a given set of fishing conditions. Tensions are determined by writing the equilibrium equations for each knot and resolving the system iteratively. Convergence is reached when the calculated shape remains constant from one iteration to the next. A comparison between the simulation output and results of Flume Tank testing at both Lorient and Hirtshals for the same trawl are in close agreement, less than 10%.

5.0 REPORTS

5.1 Report on the 1993 NAFO Symposium on "Gear Selectivity/Technical Interactions in Mixed Species Fisheries" (presented by Peter Stewart)

The Symposium was hosted by the Scientific Council of NAFO in Dartmouth, Nova Scotia from 13-15 September, 1993. The gathering was unique in that it brought together scientists from a number of disciplines ie. gear technologists, biologists, statisticians, economists, and presentations were of an applied nature as opposed to pure science. Presentations by Gabriel, Showell, Suuronen, Fryer, Soldal, Hassager, Christensen and Murawski were among some of the best which represented the multi-disciplinary nature of the symposium.

5.2 Report on the 1994 ICES Working Group on Long-Term Management Measures (presented by Ron Fonteyne)

Ron Fonteyne represented the WG, upon invitation, at the January, 1994 ICES Working Group on Long-Term Management Measures. The terms of reference of this WG (C.Res. 1993/2:6:15) , as it pertains to our WG, were discussed . The mandate of this WG may be summarized as "to develop advice on management strategies and other tools such as technical measures and other regulations". Future collaborations between both WGs may best work on a ad hoc basis. Their WG report is available and copies can be provided. It was commented that cross-pollination between both WGs is important and that the responsibility is with each WG to provide documents of their proceedings to the other.

6.0 Plenary Reports and Discussion of Special and General Topics by Rapporteurs

6.1 Report of the Special Topic on " Characteristics of Netting and Twine" (presented by Richard S.T Ferro)

Cod-end selectivity is most likely to be affected by the hydrodynamic, behavioral and mechanical characteristics of netting and twine. These characteristics may also affect the measured mesh size. Twine material science has evolved to the point where it is now possible to use some of the new high strength twines in knotted meshes but consideration must be given to their relatively low elasticity and stretch. Cod-end selectivity trials of haddock in the North Sea have shown an increase in the 50% retention length with a decrease in twine diameter suggesting that this parameter will influence the selection range. Beam theory may be applied to the deformation of netting twines in a attempt to objectively quantify the resistance of meshes to opening.

The three papers highlight the necessity for researchers to remain current on new material technologies and the ability of fisherman to exploit twine and netting characteristics to influence selectivity. Some aspects of netting and twine properties are not well understood. Further research is required to study these properties in the context of water flow, cod-end shape and ultimately selectivity. During the plenary session a recommendation was forwarded that the FTFB WG should hold a special session to discuss which twine and netting characteristics significantly affect selectivity and the practicality of measuring and controlling these characteristics.

6.2 Report of the Special Topic on "Methods to Measure Netting and Twine" (presented by Richard S.T Ferro)

In over-viewing methods of measuring netting and twine characteristics and mesh size it was concluded that while more decisive methods could be developed, standardization of the wedge gauge may achieve a level of accuracy acceptable to both

the scientific and enforcement communities. Laboratory testing has shown no significant difference between the ICES and WEDGE gauges in their measurement variability of mesh size.

A detailed comparative analysis of the precision and operating technique of 5 different mesh gauges on commercial fishing nets has shown that the ICES and MARFISH gauges are consistently more precise than either the weighted wedge gauge or weighted spring gauge. A Lastridge Rope Measuring Device has been developed for the measurement and regulation of Lastridge Rope hanging ratios in an attempt to reduce the catch of small fish. It has been proposed that cod-end mesh opening coefficients can be improved by increasing water flow within the cod-end, which would improve the conservation of small fish.

There is a demonstrated need for further research on twine and netting characteristics to determine those properties which best describe twine and netting behaviour. Due to industry concerns over the subjectivity of current mesh measurement methods and the lack of a standardized gauge to be used by enforcement officers and scientist the FTFB WG should develop a recommendation on the subject. This may be carried out by first assessing the magnitude of variance in mesh sizes attributable to different causes from which it would be possible to further assess the effect of these variances in introducing a more rigorously designed gauge and operating procedure. This analysis may yield a recommendation for a standard specification or the investigation of an alternate design.

6.3 Report of the Special Topic on "Influence of Natural Behaviour on Sampling Variability" (presented by Olav Rune Godø)

The variability of survey trawl catches reduces the reliability of stock estimates based on catch data. This variability can be mainly attributed to changes in the natural behaviour of the fish. Variability in vertical distribution, diurnal catchability and seasonal schooling patterns must be considered and taken into account if survey estimates are to be improved. Acoustic tagging experiments have shown the influence of light and tidal currents on the behaviour of cod and plaice. Large scale observations of this behaviour have been supported by results from single fish observations. The effect of temperature on the natural behaviour of winter flounder was clearly demonstrated; swimming speed decreases with temperature, resting time increases with temperature and overall activity increases with temperature.

It is important that researchers exploit the new possibilities of investigating and accounting for the influence of natural behaviour on trawl surveys and experiments in general. Considerable attention and effort must be focused on this problem to: disseminate information, develop measuring devices and standards for observation and to develop methods and models to describe behaviour. Inter-working group co-operation will be necessary to address may of these issues ie. ICES FAST WG

(observation techniques) and ICES METHODS WG (modelling). The question may be asked; "Is the FTFB WG ready to take on the task"?

6.4 Report of the General Topic on "Survival Experiments" (presented by Graham Sangster)

Four different size diamond mesh cod-ends were used in assessing the scale damage and survival of haddock and whiting after escape. The analysis suggested that pure percentages of escaping fish are not enough and that survival can be a more complex function of fish length. The analysis further suggested no clear relationship between survival and mesh size. A study of vendace concluded that there was no evidence of size dependent mortality, but that the methods of collecting and observing the escapees can affect the mortality results. In a review of survival methodologies, gear types and associated survival data it was concluded that in the majority of cases the escaping fish had been subjected to a wide variety of stress and that survival is a global problem not just a scientific one. The potential bioeconomic impact of reduced mortality of cod-end escapees was investigated and it concluded that the magnitude of the potential gain was proportional to the mortality rate of the cod-end escapees and the magnitude of the reduction.

The papers presented a wider awareness of the implications and significance of this new science of survival studies and demonstrates a need for further research.

6.5 Report of the General Topic on " Selectivity Studies" (presented by Ron Fonteyne)

This topic generated 10 papers and 2 posters concerning the selectivity of towed gears and 1 on the selectivity of gill nets. Species selectivity studies are achieving increased status as fish stocks dwindle and should present solutions for the discard problems in mixed species fisheries. A strong relationship between sea state and cod-end selection parameters was demonstrated for the Nephrops fishery. The use of windows, grids, separators, panels and shortened lastridge ropes was discussed in light of increased species selectivity. The degree of success however varied with the gear type and species involved.

It is felt that fish behaviour is of major importance in gear selection and that further work in this field is highly recommended. Concerning the present situation in many fisheries and the potential of applying more selective gears to improve conservation of stocks the WG effort in this field must be encouraged.

6.6 Report of the General Topic on "Technical Studies" (presented by Peter Stewart)

There were two papers on improved methods of sampling: 1) a remote control closure of the cod-end in a pelagic trawl to target shoals more efficiently; and 2) automated measurement of fish length and weight. Two papers presented on user friendly

software : 1) data collection during cruises; and 2) fitting ogives to selectivity data One paper was presented on mathematical modelling of trawl shape from the first principle. These papers all highlighted valuable progress in scientific sampling and data analysis techniques.

7.0 RECOMMENDATIONS

The Working Group on Fishing Technology and Fish Behaviour recommends that the next meeting will be held in Aberdeen, Scotland (Chairman: S.J. Walsh) from April 19 to 21, 1995 to:

a) consider and review studies on the economic impact of applying more selective fishing gears at the private company and fisherman level.

b) consider and review studies relative to measures of fishing effort and how these vary with gear type with the aim of improving the precision of catch-per-unit effort (CPUE) data.

c) consider and comment on the final version of the manual on Recommended Methodology of Selectivity Experiments prepared by the Sub- Group on Selectivity Methods

The Working Group on Fishing Technology and Fish Behaviour recommends that the Sub- Group on Selectivity Methods complete its work on their manual "Recommended Methodology of Selectivity Experiments" , via correspondence, and present it to Working Group members, for consideration, at the 1995 meeting in Aberdeen.

The Working Group on Fishing Technology and Fish Behaviour recommends that a Study Group be formed to review, for major fish stocks, the relative magnitude of fishing gear encounter, fishing gear escapement and discards of fish from different fishing gears involved in the exploitation and, the potential of these fish to survive.

The Working Group on Fishing Technology and Fish Behaviour recommends that a Strategic Planning Committee be set up to liase with the Chairman of the Working Group (via correspondence) to review, evaluate and implement immediate changes in the format and direction of the Working Group based on replies and suggestions generated from the 1994 FTFB Questionnaire.

The Working Group on Fishing Technology and Fish Behaviour recommends that the 1996 Working Group Meeting be held in conjunction with the Working Group on Fisheries Acoustics Science and Technology in Woods Hole/Boston, Massachusetts, USA, April 1996

The Working Group on Fishing Technology and Fish Behaviour recommends that further research on mesh size measurements and twine and netting characteristics which may affect selectivity be conducted at various institutes, with a view to consider this field as a special topic in two years time (see Sections 5.3 & 5.4)

8.0 SUGGESTED WORK ITEMS FOR THE WORKING GROUP.

In addition to the above recommendations, the Working Group also made the following suggestions for work to be initiated prior to the next meeting:

a) investigate the feasibility of establishing and housing a Working Group selectivity database and associated computer software programs.

b) investigate the feasibility of setting up an electronic bulletin board to facilitate the movement of information on related research activities by various Working Group members and observers

c) collate information on problems of data acquisition associated with measuring fishing gear performance by acoustics and other underwater observations.

9.0 MEETING CLOSURE

The Chairman thanked all members for a tremendous effort in participating not only in the WG meeting but the Sub-Group meetings as well. Special thanks were extended to our hosts and meeting organizers. The meeting adjourned at 1945 hrs.