Fish Capture Committee

ICES CM 1995/B:2

REPORT OF THE
WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR

Aberdeen, Scotland

19-21 April 1995

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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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:	Michael Breen, Scottish Office Agriculture and Fisheries Dept., Marine Laboratory, Aberdeen, Scotland, UK.
Venue:	SOAFD Marine Laboratory, Aberdeen, Scotland, UK.
Date:	19-21 April, 1995.

In accordance with ICES C.Res. 1994/2.8, the Working Group on Fishing Technology and Fish Behaviour (Chairman: Mr S J Walsh, Canada) will meet in Aberdeen, UK from 19-21 April 1995 to:

a) advise ACFM on appropriate mesh sizes corresponding to an L_{50} of 38 cm for Baltic Sea cod in

I) exit windows installed in codends of cod trawls with 105 mm codends

ii) codends with standard diamond meshes

b) evaluate recent experiments on the selectivity of Nephrops trawl and report to ACFM;

c) consider and review studies to investigate measures of fishing effort and how these vary with gear type, with the aim of improving the precision of effort data used in catch-per-unit-effort (CPUE);

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

e) consider and comment on the report of the Study Group on Unaccounted Mortality in Fisheries.

In accordance with ICES C.Res. 1994/2.8.1, a Sub-Group on Selectivity Methods (Chairman: Mr D A Wileman, Denmark) will work by correspondence in 1995, and report to the 1995 Annual Science Conference, to:

continue with the preparation of the Manual on Recommended Methodology of Selectivity Experiments. A draft will be submitted to the meeting of the Working Group on Fishing Technology and Fish Behaviour (April 1995) for their consideration.

In accordance with ICES C.Res. 1994/2.10, a Study Group on Unaccounted Mortality in Fisheries will be established under the chairmanship of Mr B. Isaksen (Norway) and will meet in Aberdeen, UK from 17-18 April 1995 to:

a) review, for major fish stocks, the relative magnitude of encounters, escapements of discards of fish from different fishing gears involved in the exploitation of these stocks;

b) review, for major fish stocks, the potential for these fish to survive;

c) make conclusions available to ACFM and ACME.

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

Suggested Items for the Working Group

1 The Working Group on Fishing Technology and Fish Behaviour recommends that a Strategic Planning Committee be set up to liaise 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.

2 Commence an investigation on the feasibility of establishing and housing a Working Group selectivity database and associated computer software.

3 Commence an investigation on the feasibility of setting up an electronic bulletin board to facilitate the movement of information on related research activities.

4 Commence a compilation of problems of data acquisition associated with measuring fishing gear performance by acoustic and other underwater observations.

1.3 AGENDA AND PROCEEDINGS

The meeting, hosted by the Scottish Office Agriculture and Fisheries Department in the Marine Laboratory, Aberdeen, was officially opened by the Chairman, Mr S. J. Walsh at 0900 on Wednesday 19th April, 1995. Prof. A. D. Hawkins, Director, extended a warm welcome to all members and observers from the Marine Laboratory. The meeting continued over the following three days and was closed at 1801 on Friday 21st April, 1995.

2 STUDY GROUP AND SUB-GROUP REPORTS

2.1 Report of the Study Group on Unaccounted Mortality

Unaccounted fishing mortality of small size target species and non target fish species is a major problem in fisheries management. These fish mainly end up as "discards", but recently several studies have also focused on unaccounted mortality caused by injuries to fish that encounter and escape the fishing gear during the catching process.

However, these studies have been limited to a few species and a few fishing methods. The role of the proposed Study-Group is to review available research from major fisheries with respect to this problem and to identify priority areas for further studies within the field of selectivity and fish survival. A Study Group on Unaccounted Mortality in Fisheries under the chairmanship of Mr B Isaksen (Norway) met in Aberdeen, UK from 17-18 April 1995 and submitted their report to the Working Group.

Fishing Mortality (F) is the sum of all fishing induced mortalities occurring directly as a result of catch or indirectly as a result of contact with or avoidance of the fishing gear and include: landed catch (F_C); illegal and mis-reported landings (F_B); discard mortality (F_D); escape mortality (F_E); drop out mortality (F_O); ghost fishing mortality (F_G); avoidance mortality (F_A); predation mortality (F_P); and habitat degradation mortality (F_H). Thus the fishery induced mortality[2] can now be written as :

$$F = F_C + F_B + F_D + F_O + F_A + F_E + F_G + F_P + F_H$$

Unaccounted fishing mortality (generally all but landed catch) has been research for only a few species and gear types, and, a large amount of research effort is necessary to quantify and priorize the other fishing induced mortalities. The relative and magnitude of all these components of fishing mortality are expected to be significantly affected by the condition of the fish prior to capture (Fig. 2.1.1). Condition indices (i.e. Fulton's K factor, HSI, etc.) can be used as a measure of the health of the fish stock, eg. Northern Gulf of St. Lawrence, and can be derived from both commercial fisheries and research vessel surveys.

The report looked at the level of research on unaccounted mortality in the eastern North Atlantic, Iceland, Norway, North Sea, and western North Atlantic. A large number of unknowns exists regarding the true magnitude of fishing mortality for many important marine fisheries throughout the Atlantic. These unknowns include illegal fishing, discards and their survival, escapement mortality after encountering the gear, predation mortality while in the gear or due to poor condition induced by stress from gear contact and habitat loss. Some of the unaccounted mortalities represented were significant in relation to some of the landed catches, ie. discard mortalities, and codend escapement mortalities, however research into identifying and quantifying the level of unaccounted mortalities for different species and gear types was extremely limited. Measurement of each component of fishing mortality would assist management decisions in directing technological research to reduce those components that were considered unacceptably high in an effort to reduce resource wastage. As well. quantifying partitioned fishing mortality for each gear would result in a more accurate measure of F for stock assessment. Some components of F are difficult to measure and may be quite low for many species and gear types. Consequently, the Study Group emphasized that initial effort should be applied to measuring and reducing discard mortality, escape mortality and ghost fishing.

The following recommendations were proposed:

(I) the Study Group reaffirms the recommendations made by the 1994 Sub Group on Methodology of Fish Survival Experiments (ICES CM 1994/B:8) (See Appendix 2.1 I);

(ii) to expand the scope and amount of unaccounted mortality research on major commercial species and in commercial fisheries in order to obtain estimates of escape mortality, discard mortality and ghost fishing mortality (gill nets and pots). (Nephrops trawl fisheries were specifically identified as a species that required further investigation);

(iii) to research the applicability of various condition indices that can be used to determine physiological condition prior to capture as an indicator of stress and injuries that fish incur during encounter and escape; and

(vi) the Study Group ask ACFM to provide guidance with respect to the most appropriate format for presenting data relating to the various F components.

2.1.1 Discussion

The Working Group noted the importance placed upon discards by the report and recognized that there has been little research on this subject in most ICES member countries. Researchers at Aberdeen Marine Laboratory are currently analysing data which demonstrate the relative magnitude of escape mortalities and survivors, discards and landed catch for haddock and whiting in an otter trawl fishery (see for example Fig. 2.1.2). Similar research is recommended for other species and different gears. This report highlighted a direct relationship between the length and survival rates of escaping fish, i.e mortality is higher in

[2] The calculation of the various components of F may involve different age classes and thus different proportions of the population, care must be taken to ensure age dependent estimates of mortality are made.

small fish when compared to larger fish escaping fishing gears. The Working Group strongly emphasized that this is counter to current thinking about reducing by-catch of juveniles through the use of various selective devices to release juvenile fish. Little evidence was available to indicate that the magnitude of habitat degradation mortality was equivalent to those of discards and misreported landings. Although it was accepted that it could be an acute problem at a localised level and it was known that Working Group on the Effects of Fishing Activities on the Ecosystem had already considered this problem.

The Working Group supported the report's recommendations to investigate the physiological conditions of fish prior to their capture and as well after encounters with the various gears. This area has been neglected in the past and efforts should be made to consider the physiological condition of a population during stock assessment. A stronger dialogue must be developed with the ACFM and ACME and other Working Groups to secure advice on how unaccounted mortality research could be best directed to aid stock assessment and the role the FTFB Working Group should play.

Note: This report, in its entirety, is printed as ICES CM 1995.B:1 Ref. Assess.

2.1.I Appendix Recommendations of the 1994 Sub-Group on Survival

Recommendations of the Sub-Group on Methodology of Fish Survival Experiments (ICES CM 1994/B:8).

The Sub-Group on fish survival recognized:

- the lack of knowledge of the unaccounted mortalities associated with the fishing processes and their impact on stock assessment and the ecosystem;
- that limited methodology and results exists for various fishing gear species ;and
- makes the following recommendations:

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[3] and mortality of fish during the capture process; and

6. Research should be aimed at identifying and correcting the damaging mechanisms of fishing gear.

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3 stress assessment is a tool that assists in determining causal factors of mortality and aids in mitigation

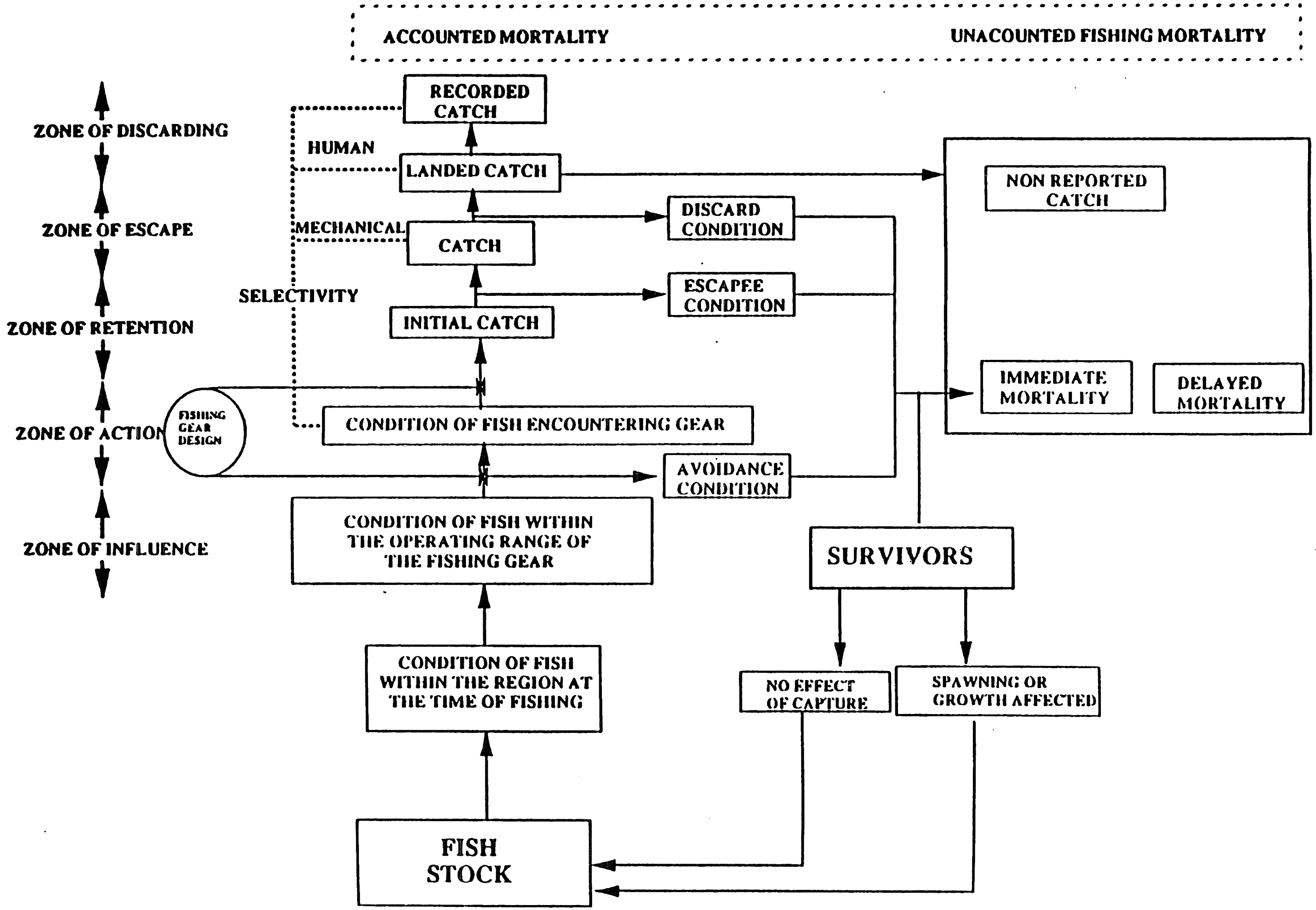
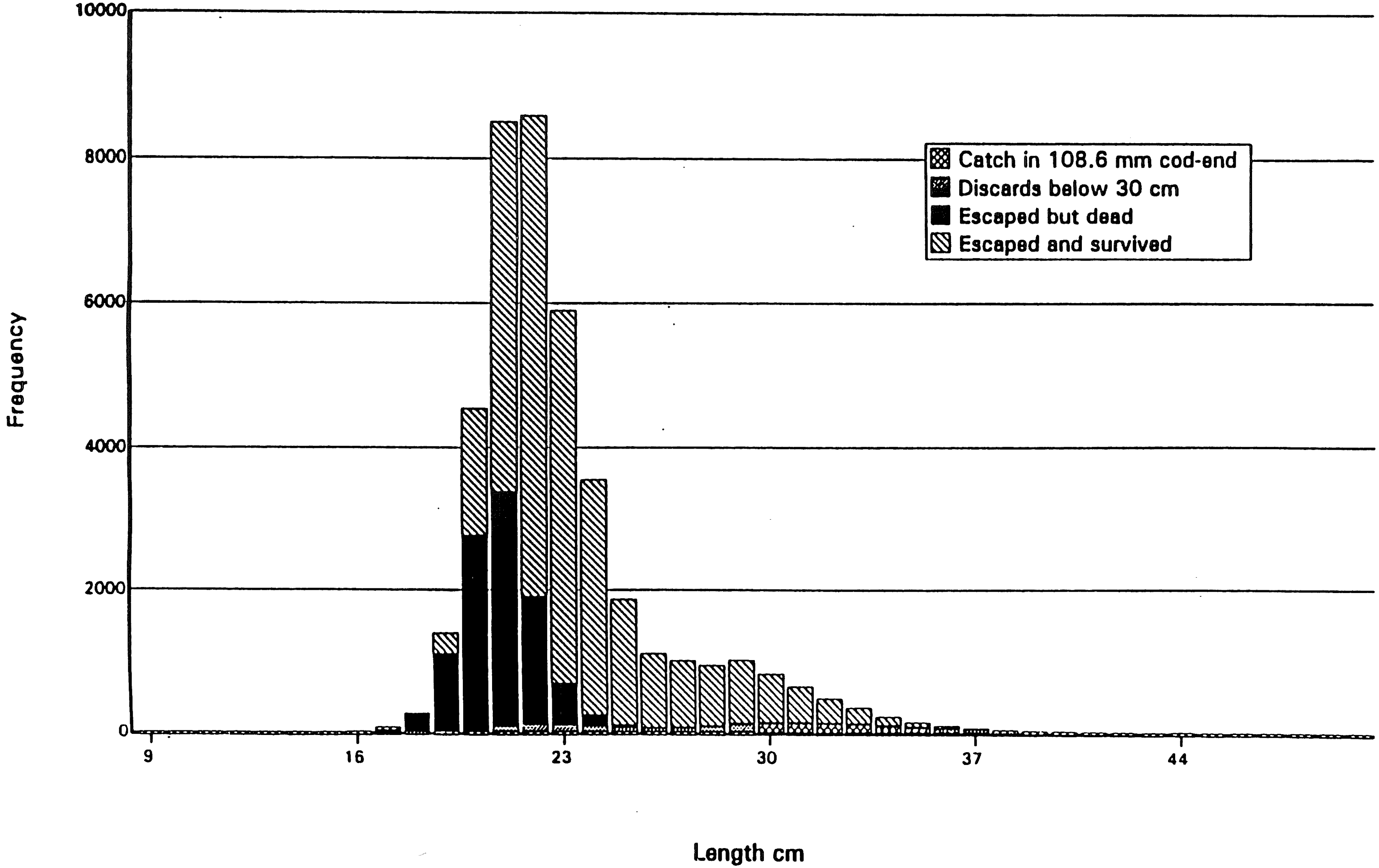


Fig. 2.2.1 The condition of fish escaping from fishing gears (Chopin, Inoue, Arimoto 1995: in press).

Fig. 2.2.2 An application of the results of survival experiments and selectivity data from the same haddock fishery which shows the relative magnitudes of mortality.



2.2 Report of the Sub-Group on Selectivity Methods

The Sub-Group, under the chairmanship of D. A. Wileman, Denmark, worked by correspondence during 1994-95, and submitted a draft of the Manual on Recommended Methodology of Selectivity Experiments prior to the Working Group meeting. The Sub-Group has recently completed a draft of this manual, after extensive work over a three year period. The only current available published manual was by Pope et al. (1975)[4] based on the work of the ICES Mesh Selection Working Group, 1959-1960. The intervening years have produced considerable improvements to the methodology used to measure selectivity of towed fishing gears, including experimental design and statistical analysis.

The Working Group endorsed the Sub-Group's decision not to propose that one standard method of measuring selectivity should be universally adopted as five different methods exist all with their own practical advantages and sources of bias. The ICES gauge should continue to be the standard instrument for measuring mesh openings in scientific trials and that calibration should also be made against the current national legally approved device and both values recorded. It was recommended that a section on the use of selectivity data in stock assessment (text by R. Cook, UK) be incorporated into the Manual's introduction, along with a section on the use of power analyses (text by R. Fryer, UK) to estimate the number of hauls required in a selectivity experiment.

With respect to the Methodologies section the Working Group recognized that there were inaccuracies and practical limitations of the various methods. In particular, experiments using trouser trawl/seine and twin trawl must assess for the split in the catch. As well, the hooped, covered codend methods creates potential problems for handling at sea, and share similar disadvantages with the traditional cover codend method, namely potential masking and its effect on escape behaviour. Here the Manual's text should not appear to assume this to be the recommended "standard method". Advice on the practical application of different methods to different fishing gears should be presented in a tabular form, with symbols for "suitable, possible and not suitable".The use of research vessels for selectivity trials should be discouraged , as their size is not representative of the many small horse power vessels in most fleets.
It was recommended that the revised draft of the Manual be submitted directly to independent referees in July 1995, and the reviews should be edited as necessary by the chief editors D. A. Wileman, R. S. T. Ferro, R. Fonteyne and R. Millar before presentation to the Fish Capture Committee at the 1995 ICES Annual Science Conference.

[4] Pope, J. A., A. R. Margetts, J. H. Hamley and E. F. Akyüz 1975. Manual of methods for fish stock assessment: Part III - Selectivity of fishing gear. FAO Fish. Tech. Rpt. 41:65.

2.3 Report on Baltic Cod Mesh Selection

Terms of Reference

To advise ACFM on appropriate mesh sizes corresponding to an L_{50} of 38 cm for cod in: i) exit windows installed in 105 mm mesh cod-ends of cod trawls; and ii) cod-ends with standard diamond meshes.

2.3.1 Introduction

A sub-group of the Fishing Technology and Fish Behaviour (FTFB) Working Group was formed in Autumn 1994 to undertake the above terms of reference. The members are listed in Appendix 2.3.I The sub-group worked by correspondence and then met for two days during the FTFB Working Group meeting in Aberdeen from 19-20 April, 1995 to write its report. This report was extensively reviewed and adopted by the Working Group.

2.3.2 Factors Causing Variance in Data

It is important to take account of the many factors influencing the selective properties of a cod-end. The main factors introducing variability in the results reported are likely to be:

a) Gear design - key parameters are mesh size, number of meshes round the cod-end circumference (Reeves et al 1992) and twine characteristics (Ferro and O"Neill 1994; Lowry and Robertson 1994). Exit windows also improve selectivity and the precise design may affect the extent of this improvement.

b) Mesh measurement method - ICES and wedge gauges of varying designs have been used. In the most recent trials (1993 onwards) mesh sizes have been standardised to the legal measurement method (wedge gauge) specified in the IBSFC Fishery Rules, to ensure comparability as far as possible. An ICES gauge generally gives a smaller mesh size.

c) Environment (wind and sea state, light level).

d) Vessel factors (size, type, power, towing speed, shooting and hauling operation).

e) Fish and fish catch (fish condition, behaviour, shape and density and catch size). The variation of the length/girth relationship may be significant (see Appendix 2.3.II).

f) Factors related to methodology (cover design, mixing and measurement of catch volume, sub-sampling).

Some of the above factors have been controlled or at least recorded during the experiments reported here; others have not. There is significant between-cruise variation in the data sets. Because of this variation, selection parameters obtained from only a few trials may not be representative of those of the commercial fleet.

2.3.3 Data Sets

Historic data 1970-1990: conventional cod-ends.
These are summarised in Table 2.3.1. Two different types of cod-end cover (both without hoops) were used: full cover and topside cover. The topside cover was found to give reduced selection factors (Fig. 2.3.1) compared to the full cover (Fig. 2.3.2). Neither type of cover would be recommended now because of the risk of masking. Measurements were taken on both research and commercial vessels. Most cod-ends were made of single nylon twine. Most data were obtained in the period 1970-1981 and since then, gear designs used in many European fisheries have changed significantly. The Baltic cod stock has also changed in terms of biomass distribution and size composition. It was decided to formulate the required advice using only post-1993 data obtained from commercial vessels using the best available methodology on current commercial gears.

Recent data on conventional and window cod-ends
All conventional and window cod-ends were made in nominal 4 mm diameter double polyethylene twine and no chafers were used. The effect of chafers on the selectivity of exit windows is not known. The data for conventional cod-ends are summarised in Table 2.3.2. Measurements (Fig. 2.3.5) have been made in Sweden (two commercial vessels) and Denmark (one vessel), using the hooped cover method. Mesh sizes in the range 107 mm to 136 mm have been tested.

The main purpose of the exit window is to give a simple cheap method of increasing a trawl's selectivity without replacing all sections made in a previous legal minimum mesh size. The results are also summarised in Table 2.3.2 Danish and Swedish designs of exit window (Figs 2.3.3 and 2.3.4 from Anon 1994) have been tested. The Swedish windows were made from artificially stiffened diamond meshes fixed in their most open form and inserted into the opened lastridges whereas the Danish windows were made from square mesh netting and inserted into the lower panel just below the lastridge. The windows were inserted in 107 mm diamond mesh cod-ends. Measurements have been made on one Danish vessel and three Swedish vessels. The trend of increasing L_{50} with mesh size shown by all the points together (Fig. 2.3.6) may not represent the true variation between these quantities. On the Danish vessel (*Ulvedal*) and the Swedish vessel (*Emilia*) where three different window mesh sizes were tested it can be seen that 50% retention length increases with window mesh size at a greater rate.

Limited tests have been made in Sweden with the whole of the upper part of the cod-end in square meshes and with wide strips of square meshes in both upper and lower halves of the cod-end. These cases are included in Table 2.3.2, but were not analysed further as only one mesh size has been tested.

Specific limitations of recent data sets
The Danish data were collected during a short period in July-August 1994, in a limited area to the west of Bornholm. During this period the fishery was closed. The weather was good during the cruise which may affect fish and gear behaviour and change catchability. Rougher weather has been found to improve selectivity (Polet and Redant 1994). Only two mesh sizes of conventional cod-ends and three window mesh sizes were tested. Catch rates were very high during the cruise and masking may have occurred, even with the hooped cover method. Selection range was significantly higher for the 120 mm diamond mesh cod-end than for the other cod-ends tested.

Each of the Swedish data sets was collected during a short time period on only one fishing ground. Some of the cruises were conducted during the summer period under good weather conditions whereas during the autumn and winter poor weather may have affected the measured selectivity. Cruises conducted during heavy commercial fishing showed much larger variation of catch size than on those cruises conducted during the closed season.

2.3.4 Advice on mesh sizes for diamond mesh cod-ends.

Data were obtained on three commercial vessels with the hooped cover method in seven data sets for a total of 54 hauls (Fig. 2.3.5). The mesh sizes tested range from 107 to 136 mm. The selection factor was calculated for each of these data sets using the between-haul analysis method (Fryer 1991). Using a weighting factor inversely proportional to the variance for each set of hauls, the slope of a linear regression of selection factor on mesh size was found to be not significant at the 95% level. A mean selection factor, using the same weighting procedure, was therefore calculated and found to be 3.03 (95% confidence interval 2.88-3.19). In drawing conclusions based on this selection factor, the limited range of vessels and mesh sizes used should be borne in mind.

a) A mesh size of 125 mm (95% confidence interval 119-132 mm) is required to achieve an L_{50} of 38 cm for a conventional diamond mesh cod-end.

b) The currently recommended diamond mesh size of 120 mm has an L_{50} of 36 cm (95% confidence interval 35-38 cm).

c) The currently used diamond mesh size of 105 mm has an L_{50} of 32 cm (95% confidence interval 30-33 cm).

2.3.5 Advice on mesh sizes for the Danish design of window cod-ends

Only a single set of tests was carried out, on only one vessel. Three window mesh sizes were tested during a total of 16 hauls (Fig. 2.3.7). A regression line ($r^2 = 0.48$), obtained by weighting each haul equally, is superimposed with 95% confidence limits. The predicted mesh sizes and confidence intervals are taken from this graph.

In view of the large scatter of data expected due to between-vessel and between-trip variation, (such as found with the conventional diamond mesh cod-end for which data were available from several vessel trips) it seems unlikely that this single test will be representative of the whole fleet.

With this proviso however, it is predicted that:

a) a window mesh size of 121 mm (95% confidence interval 117-135 mm) in a 107 mm diamond mesh cod-end will generate an L_{50} of 38 cm.

b) a window mesh size of 116 mm (95% confidence interval 111-122 mm) in a 107 mm diamond mesh cod-end will generate an L_{50} equivalent to that of a 120 mm conventional diamond mesh cod-end.

2.3.6 Advice on mesh sizes for Swedish design of window cod-end

The Swedish experiments undertaken so far (Fig. 2.3.6) have not included mesh sizes which give L_{50}'s higher than 35.9 cm. The Swedish data sets contain results from several vessels. Only with one vessel however, have windows with more than one mesh size been tested. In this case, the window mesh sizes ranged from 93 to 99 mm and a regression was obtained of L_{50} on mesh size, as with the Danish data (also plotted for comparison). It is unwise to use this regression based on so few data to extrapolate to L_{50}'s higher than 36 cm. Another experiment (Kungsö) with a 105 mm window mesh size gave a L_{50} of 34.4 cm. No specific advice is given, except that a window mesh size larger than 105 mm is likely to be needed to achieve an L_{50} of 38 cm.

2.3.7 Requirements for further data

a) Because of the limited number and types of vessel used, it is not clear how representative the existing data on diamond mesh cod-ends are of current commercial gears. Emphasis in future investigations should be put on the collection of further data from smaller commercial vessels which comprise a significant proportion of the Baltic cod fishing fleet.

b) Neither the Swedish nor Danish data collected on lateral exit windows give a reliable value for the mesh size required to reach an L_{50} of 38 cm. Therefore, more data are needed on both designs on a range of vessels from different countries, with a greater range of mesh sizes, before a mesh size to achieve a particular selectivity can be specified with confidence.

c) There are a number of further constructional modifications which could be considered because of their proven ability to improve the cod-end selectivity effectively. Among them are cod-ends with square mesh windows across the full width of the upper panel but of limited length. Alternatively a long window of similar design to the Swedish and Danish types but placed in the middle of the upper panel may have potential.

Attachment of longitudinal ropes to the cod-ends, of a length shorter than the stretched netting length is also known to improve selectivity. Last but not least, grids of metal or plastic bars may offer the prospect of better size selectivity.

d) It should be noted that further experiments are being done by Germany, Poland, Russia and Sweden in 1995, although the data are not yet available.

2.3.8 Discussion

Data on mesh selection studies in Baltic Sea cod dates back to the 1970's and the Working group agreed that there was considerable variability within the data. Both stock size (catch size) and composition has likely changed since the earlier studies were performed, and such changes could produce a significant difference between the L_{50}'s obtained from the historic and more recent studies. There has also been a number of changes in gear design since the first experiments, and these earlier experiments were likely to be more prone to masking from non-hooped covers. It was agreed by the Working Group that the early historic data (1970-81) should be excluded from the report as changes in stock size and composition, gear design, catch size and effects from masking are likely to have had a profound effect upon the data.

2.3.9 Conclusions

a) **Danish design of window cod-end**
A very limited data set suggests that, in a 107 mm diamond mesh cod-end, a window mesh size of 121 mm (95% confidence interval 117-135 mm) is required to achieve an L_{50} of 38 cm.

b) **Swedish design of window cod-end**
No specific advice is given on the mesh size required in a Swedish design of window fitted in a 107 mm diamond mesh cod-end in order to achieve an L_{50} of 38 cm. It is likely that the required window mesh size will be greater than 105 mm.

c) **Conventional diamond mesh cod-end**
A limited data set suggests that a mesh size of 125 mm (95% confidence interval 119-132 mm) is required to achieve an L_{50} of 38 cm in a diamond mesh cod-end.

Note: *A final draft of this report was sent to ACFM, prior to their May 16th meeting, for consideration.*

2.3.10 References

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Table 2.3.1

List of older data sets 1970-1981

Ref No	Date	Origin	Vessel name	Vessel power (hp)	Test method	Gauge type	Number of hauls	Cod-end mesh (mm)	50% length (cm)	Selection factor	Selection range (cm)	Average catch per haul (kg)	Twine type and size
8	4.72	Germany	*A Dohrn*	850si	top cover	I	3	89.30	28.60	3.20	5.90	420	PA 4895
8	4.72	Germany	*A Dohrn*	850si	top cover	I	13	104.60	35.90	3.43	9.00	630	PA 4895
15	2.72	Poland	*Dr Lubecki*	240si	full cover	I		116.10	35.30	3.04	6.80		PA 6339
15	2.72	Poland	*Dr Lubecki*	240si	full cover	I		117.90	39.00	3.31	12.40		PA 8075
15	2.72	Poland	*Dr Lubecki*	240si	full cover	I		102.00	30.60	3.00	6.40		PA 6362
15	3.73	Poland	*Dr Lubecki*	240si	full cover	I		114.10	36.00	3.23	8.90		PA 6339
15	3.73	Poland	*Dr Lubecki*	240si	full cover	I		116.00	37.30	3.22	10.70		PA 8075
15	3.73	Poland	*Dr Lubecki*	240si	full cover	I		98.80	32.10	3.25	5.90		PA 6484
16	1.72	Russia	?	3-400?	full cover	I N2	7	82.00	31.40	3.83	4.00		PA 93.5*12
16	5.72	Russia	?	3-400?	full cover	I N2	9	82.00	33.20	4.05	4.50		PA 93.5*12
16	10.72	Russia	?	3-400?	full cover	I N2	11	82.00	32.70	3.99	4.70		PA 93.5*12
16	3.74	Russia	?	3-400?	full cover	I N2	10	82.00	30.00	3.66	4.00		PA 93.5*12
16	4.75	Russia	?	3-400?	full cover	I N2	10	82.00	31.20	3.81	8.00		PA 93.5*12
16	4.75	Russia	?	3-400?	full cover	I N2	11	82.00	31.90	3.89	9.00		PA 93.5*12
16	5.72	Russia	?	3-400?	full cover	I N2	11	81.00	31.20	3.85	6.20		PA 93.5*24
16	9.73	Russia	?	3-400?	full cover	I N2	7	92.00	34.20	3.72	4.80		PA 93.5*24
16	3.74	Russia	?	3-400?	full cover	I N2	10	92.00	32.00	3.48	5.00		PA 93.5*24
16	5.75	Russia	?	3-400?	full cover	I N2	9	92.00	33.50	3.64	6.00		PA 93.5*24
16	5.75	Russia	?	3-400?	full cover	I N2	10	90.00	32.60	3.62	6.00		PA 3.1
9	9.74	Germany	*Solea*	870st	top cover	I	8	102.60	30.30	2.96	7.30	116	PA 4895
9	9.74	Germany	*Solea*	870st	top cover	I	16	91.70	25.90	2.82	6.90	163	PA 4895
9	9.74	Germany	*Solea*	870st	top cover	I	5	90.30	27.60	3.06	6.90	252	PA 4895
5	11.75	Germany	*Solea*	870st	top cover	I	17	109.80	25.30	2.30	13.20	565	PA 4895
4	3.74	Denmark	*Havfisken*	118si	full cover	I	15	99.60	34.70	3.48	7.70	43 - 84	PA 5358
4	5.74	Denmark	*Havfisken*	118si	full cover	I	5	106.00	42.10	3.97	4.50	173 - 227	PA 5358
4	11.74	Denmark	*Havfisken*	118si	full cover	I	8	88.00	31.10	3.53	7.00	9 - 56	PA 5358

continues....

4	12.71	Denmark	*Havfisken*	118si	full cover	I	8	88.00	30.10	3.42	9.00	20 - 25	PA 5358
4	4.75	Denmark	*Dana*	1250si	full cover	I	14	88.00	29.70	3.38	6.50	17 - 299	PA 5358
6	10.78	Germany	*Solea*	870st	top	I	5	107.90	30.60	2.84	8.00	120	PA 4895
6	10.78	Germany	*Solea*	870st	top	I	9	97.90	28.50	2.91	5.60	120	PA 4895
6	10.78	Germany	*Solea*	870st	top	I	14	97.90	28.70	2.93	11.10	375	PA 4895
6	10.78	Germany	*Solea*	870st	top/bot cover	I	5	101.70	31.50	3.10	7.30	285	PA 4895
6	10.78	Germany	*Solea*	870st	full cover	I	8	101.10	32.70	3.23	7.60	200	PA 4895
12	3.77	Sweden	Commercial	630	parallel haul	I P	16	107.50	41.50	3.86		240	PA 5358
12	3.77	Sweden	Commercial	630	parallel haul	I P	16	88.50	29.50	3.33		417	PA 5358
12	3.77	Sweden	Commercial	630	parallel haul	I P	18	100.50	39.50	3.93		535	PA 5358
12	3.77	Sweden	Commercial	630	parallel haul	I P	18	88.50	33.50	3.79		658	PA 5358
12	1.78	Sweden	*Thetis*	960	full cover	I P	9	100.50	38.30	3.81	6.00	196	PA 5358
12	1.78	Sweden	*Thetis*	960	full cover	I P	9	88.50	32.70	3.69	6.00	238	PA 5358
14	9.79	Russia	Commercial	300	full cover	I N3,4	10	98.30	34.80	3.54	7.00	>350	PA 3.1
14	9.79	Russia	Commercial	300	full cover	I N3,4	10	98.30	36.10	3.67	6.00	=<350	PA 3.1
14	8.80	Russia	Commercial	300	full cover	I N3,4	15	115.60	41.30	3.58	7.00	>250	PA 3.1
14	8.80	Russia	Commercial	300	full cover	I N3,4	15	115.60	43.70	3.78	6.00	=<250	PA 3.1
11	75-81	Poland	*Dr Lubecki*	240si	full cover	I	10	92.25	27.70	3.36	6.30		PA 3.0
11	75-81	Poland	*Dr Lubecki*	240si	full cover	I	19	97.03	35.30	3.63	5.90		PA 3.0
11	75-81	Poland	*Dr Lubecki*	240si	full cover	I	19	96.03	34.20	3.56	6.70		PA 3.0
11	75-81	Poland	*Dr Lubecki*	240si	full cover	I	10	96.78	37.60	3.88	5.30		PA 3.0
11	75-81	Poland	*Dr Lubecki*	240si	full cover	I	19	97.20	34.60	3.65	7.40		PA 3.0
13	1979?	Russia			full cover		10	76.10	30.30	3.98	4.00	<200	PA10.7*12
13	1979?	Russia			full cover		10	75.90	29.75	3.92	4.50	=>200	PA10.7*12
13	1979?	Russia			full cover		9	76.00	30.50	4.00	4.50		PA10.7*12
13	1979?	Russia			full cover		11	76.00	28.90	3.80	6.00		PA10.7*24
13	1979?	Russia			full cover		9	86.00	31.20	3.63	5.40		PA10.7*24
13	1979?	Russia			full cover		10	86.00	30.20	3.51	5.40		PA 3.1
7	10.79	Germany	*Solea*	879st	top cover	I	10	95.40	27.20	2.85	13.40	332	PA 4895
7	10.79	Germany	*Solea*	879st	top cover	I	10	110.50	25.50	2.31	10.40	322	PA/PE
7	10.79	Germany	*Solea*	879st	top cover	I	8	105.30	28.70	2.73	14.10	255	PA 4895

continues....

7	10.79	Germany	*Solea*	879st	top cover	I	7	110.30	26.00	2.36		676	PA/PE
7	10.79	Germany	*Solea*	879st	top cover	I	7	105.90	30.20	2.85		485	PA 4895
7	10.80	Germany	*Solea*	879st	top cover	I	9	95.50	28.60	2.99	7.10	159	PA 4895
7	10.80	Germany	*Solea*	879st	top cover	I	6	110.20	27.90	2.53	7.30	78	PA/PE
7	10.80	Germany	*Solea*	879st	top cover	I	5	105.60	28.40	2.69	6.00	154	PA 4895
7	10.80	Germany	*Solea*	879st	full cover	I	15	98.40	29.50	3.00	6.90	138	PA 4895
7	10.79	Germany	*Solea*	879st	full cover	I	5	98.30	27.60	2.81		312	PA 4895
7	10.79	Germany	*Solea*	879st	full cover	I	4	98.60	29.80	3.02	10.50	733	PA 4895

Vessel: st=stern trawler, si=side trawler.
Gauge: The method of measuring mesh size is indicated by W or I for wedge or ICES gauge.
I P stands for ICES pressure gauge with vertical force of 4 kp as used by Sweden in 1977/8.
I N2,3,4 stands for various ICES recommended "probes" used by Russia. Not clear what these are.
Twine: PA = polyamide; PE = polyethylene. 4895 refers to Rtex. 3.1 refers to diameter in mm.
93.5*12 indicates Tex*yarns. All netting made of single twine.

Table 2.3.2

List of recent data sets 1993-1995

Ref No	Date	Origin	Vessel name	Vessel power (hp)	Test method	No of hauls	Cod-end mesh (mm)	Window mesh (mm)	Window type	50% length (cm)	Selection factor window	Selection factor cod-end	Selection range (cm)	Average catch per haul (kg)	Average wind speed (m/s)
17	7.94	Sweden	*Emilia*	1180si	Hoop cover 1	7	107W	0	-	26.93		2.52	8.23	494	3
10	8.94	Denmark	*Ulvedal*	290st	Hoop cover	3	107W	0	-	31.80		2.96	7.70	6017	4
17	7.94	Sweden	*Emilia*	1180si	Hoop cover 1	6	107W	93	ssw	32.76	3.50	3.06	5.47	908	2
17	6.94	Sweden	*Falken*	264st	Hoop cover 1	10	107W	95	uc	32.50	3.42	3.04	3.66	251	5
unpub	7.93	Sweden	*Ringenas*	887si	Trouser	15	107W	95	ssw	34.50	3.64	3.22	2.6?		4
17	7.94	Sweden	*Emilia*	1180si	Hoop cover 1	10	107W	97	ssw	33.98	3.50	3.18	6.57	541	3
17	7.94	Sweden	*Emilia*	1180si	Hoop cover 1	9	107W	99	ssw	35.85	3.62	3.35	7.15	674	
unpub	12.94	Sweden	*Kungso*	898st	Hoop cover 2	3	107W	105	stp	33.53	3.19	3.13	6.98	572	
unpub	12.94	Sweden	*Kungso*	898st	Hoop cover 2	7	107W	105	ssw	34.40	3.28	3.22	7.22	1146	
10	8.94	Denmark	*Ulvedal*	290st	Hoop cover	4	107W	107W	dsw	32.70	3.06	3.06	8.00	2842	3
10	8.94	Denmark	*Ulvedal*	290st	Hoop cover	6	107W	116W	dsw	36.10	3.12	3.37	8.30	2522	3
10	8.94	Denmark	*Ulvedal*	290st	Hoop cover	6	107W	121W	dsw	38.20	3.16	3.57	8.50	1919	4
unpub	12.94	Sweden	*Kungso*	898st	Hoop cover 2	9	120W	0	-	35.50		2.96	7.59	1011	6
unpub	12.94	Sweden	*Emilia*	1180si	Hoop cover 2	10	120W	0	-	38.06		3.17	1.27	999	7
unpub	2.95	Sweden	*Kungso*	898st	Hoop cover 2	9	120W	0	-	30.53		2.54	7.02	763	9
10	8.94	Denmark	*Ulvedal*	290st	Hoop cover	6	123W	0	-	37.50		3.05	9.90	2093	5
unpub	3.95	Sweden	*Kungso*	898st	Hoop cover 2	10	136W	0	-	44.34		3.26	9.66	965	8

Vessel type: st=stern trawler si=side trawler
All cod-ends made of 4 mm (nominal) double PE twisted twine
The method of measuring mesh size is indicated by W for wedge gauge

A window mesh size of 0 indicates a standard diamond mesh cod-end
with unpub = unpublished report

ssw indicates the Swedish design of side window
dsw indicates the Danish design of side window
stp indicates the Swedish design with a window in the top panel
uc indicates the Swedish ultra-cross square mesh cod-end
three diamond mesh strips (each 10 meshes wide)

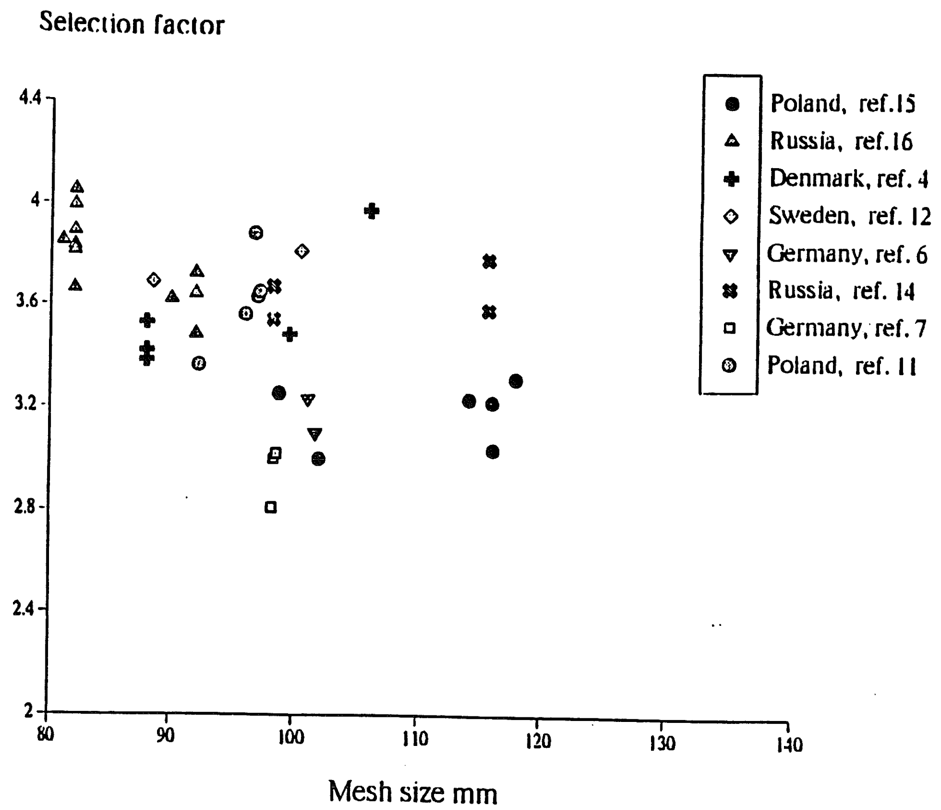

Fig. 2.3.1 Selection factors derived during from full cover codend experiments on Baltic Sea cod, 1970-81.

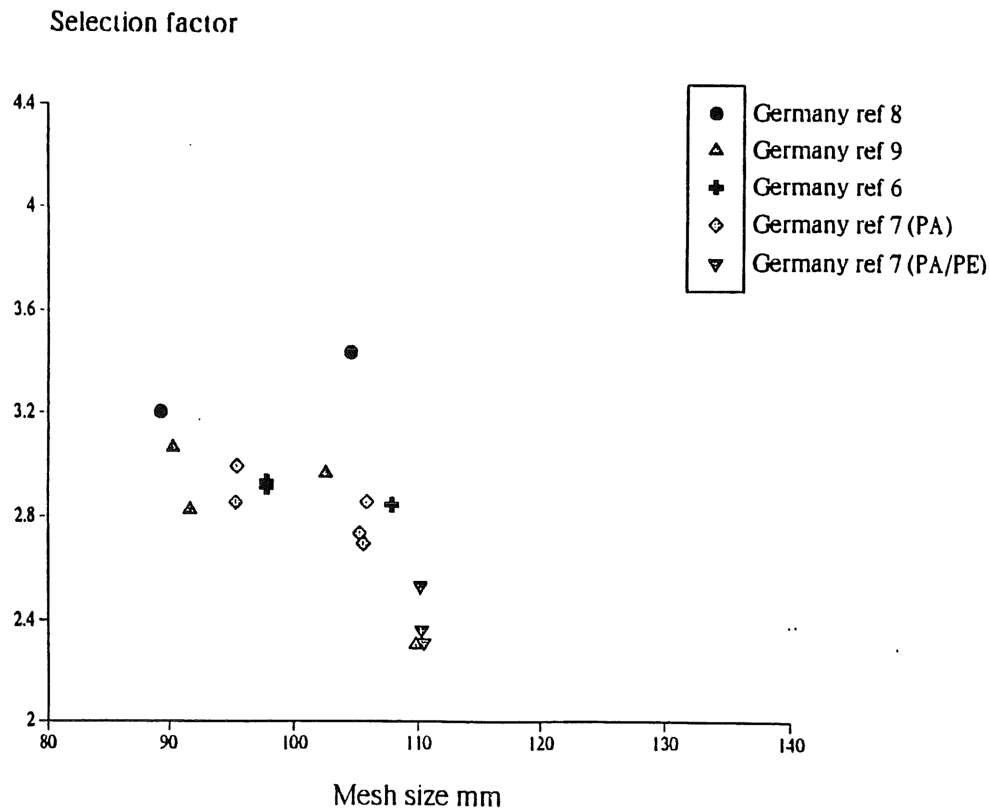

Fig. 2.3.2 Selection factors derived during from topside cover codend experiments on Baltic Sea cod, 1972-80

Diagram (Exit window model 1)

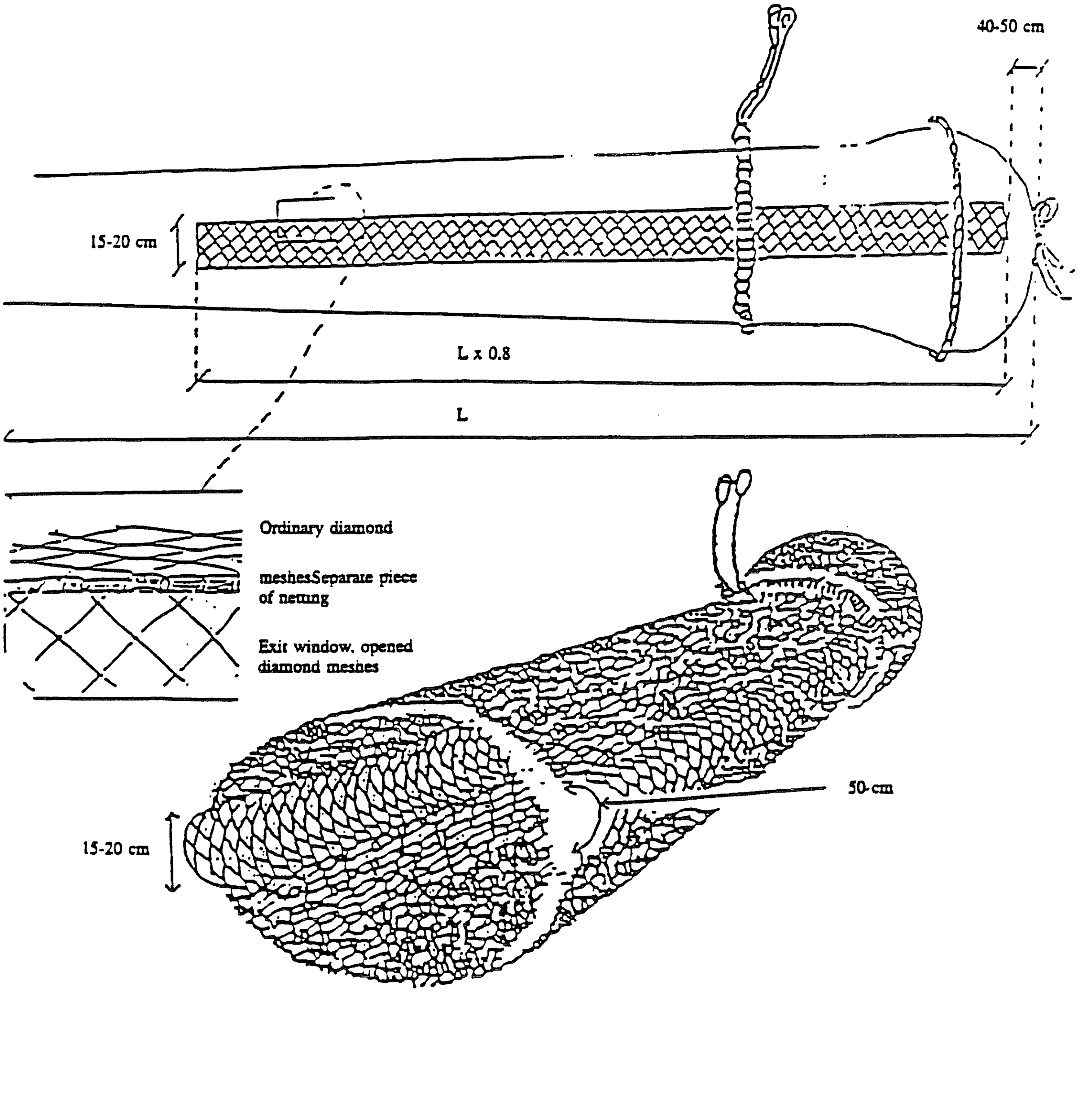

Fig 2.3.3 Swedish design of exit window.

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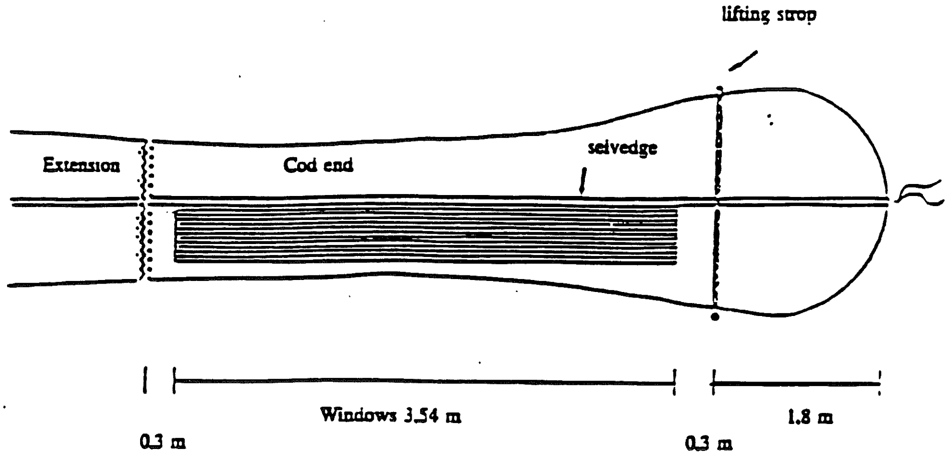
Figure 1

Position of the square mesh windows in the cod end

A suggested specification



Square mesh windows are 0.48 m high

Cod end cross-section

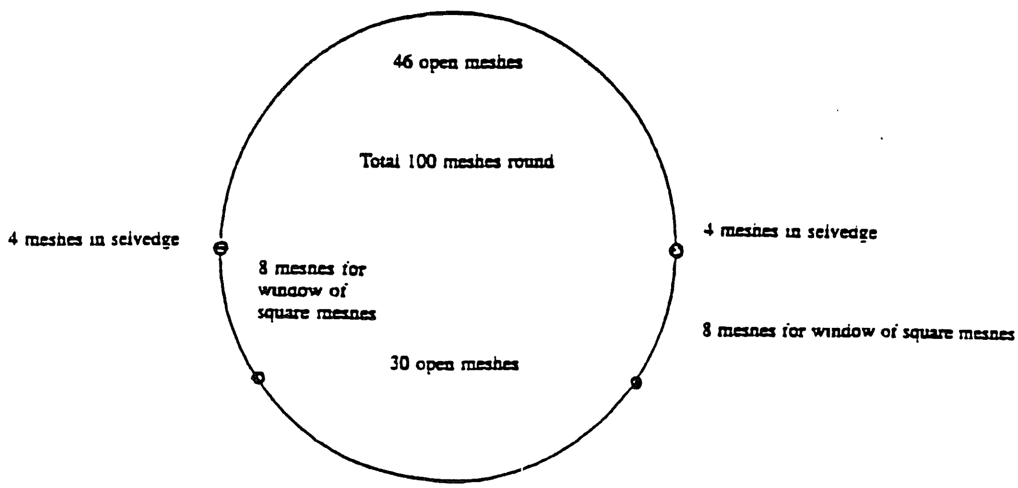


Fig. 2.3.4 Danish design of exit window.

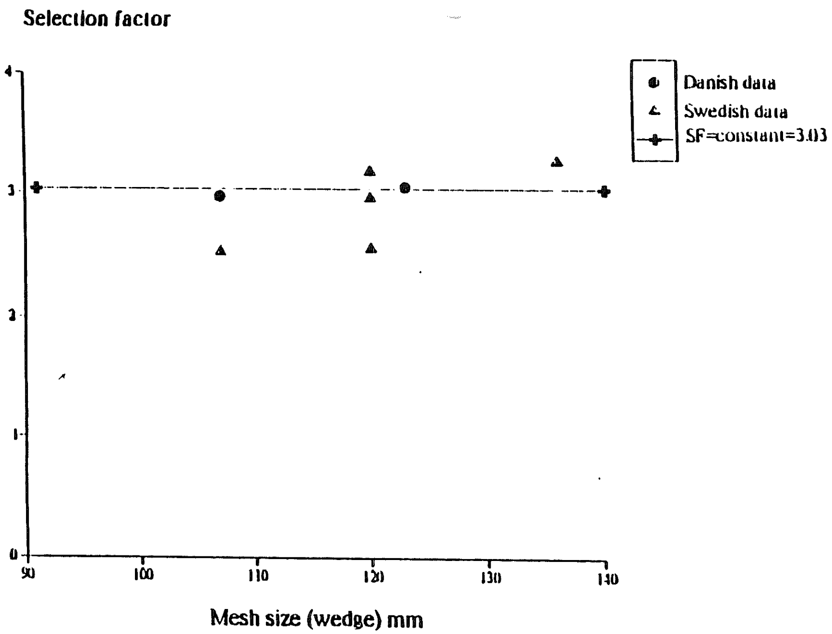


Fig. 2.3.5 Baltic Sea cod selection factors derived from conventional diamond mesh codends

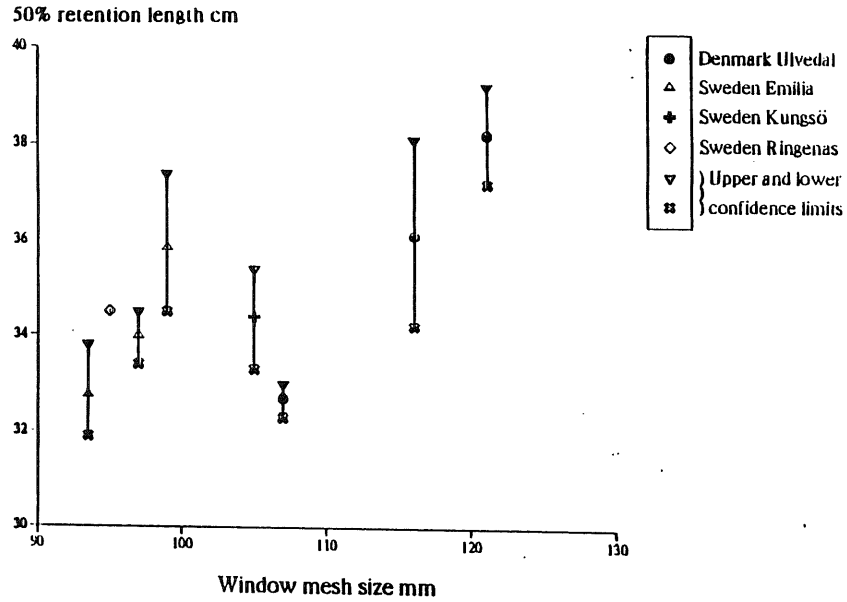


Fig. 2.3.6 Baltic Sea cod 50 % retention lengths from window codends showing 95% confidence limits

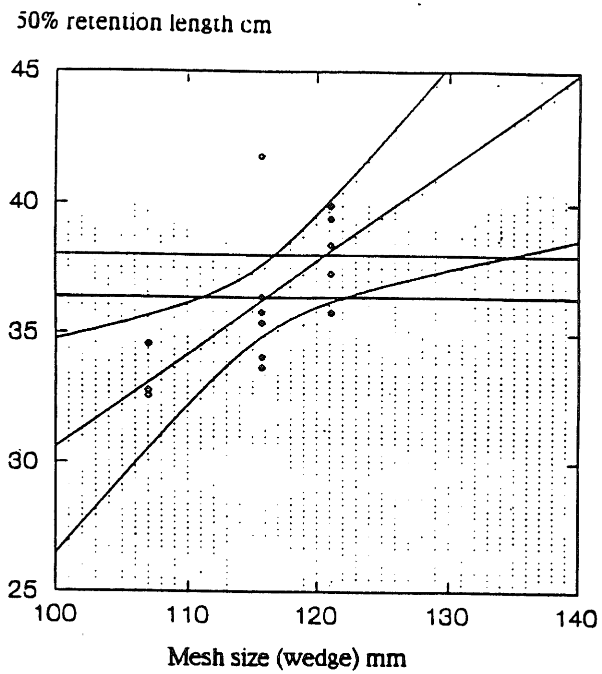


Fig. 2.3.7 Baltic Sea cod 50% retention lengths from Danish window codends showing 95% confidence intervals about the regression line through points for each haul. L_{50}'s of 38 cm and 36.4 cm (120 mm Diamond mesh codend) are shown.

2.3.I APPENDIX Membership of sub-group

Attended sub-group meeting in Aberdeen:

Member	Representing	Institute
R. Ferro (Chairman)	Scotland	SOAFD Marine Laboratory, Aberdeen
W. Czajka	Poland	Sea Fisheries Institute, Gdynia
E. Dahm	Germany	IFT, Hamburg
P-O. Larsson	Sweden	IMR, Lysekil
N. Lowry	Denmark	DIFTA, Hirtshals
V. Tschernij	Finland	Karlskrona Research Station, Sweden
D. A. Wileman	Denmark	DIFTA, Hirtshals

Participated by correspondence:

Member	Representing	Institute
A. Jarvik	Estonia	Estonian Marine Institute, Tallinn
Yu Kadilnikov	Russia	Atlantniro, Kaliningrad
M. Plikshs	Latvia	Fisheries Research Institute, Riga

2.3.II APPENDIX The Effect of Variation in Fish Body Shape on Selectivity Estimates

Selectivity is a function of maximum girth rather than length. The relation between girth and length may vary by area, season or year. To assess the consequent uncertainty in L50, a series of length/girth relations for Baltic cod have been used (refs 5-9, 15) to estimate the range of lengths which fish of a given girth may have (Table 3). The German and Polish references give empirical relations of the form Girth = a * Length + b. These were used to estimate the length of fish having a girth of 18 cm (approximately mid-range) in each case.

The length of fish having a girth of 18 cm has been calculated from empirical expressions obtained from cruises in different years, times of year and fishing area. The % change from the length obtained from October 1979 data:

Date	Area	a	b	Length (cm)	% change in length	Ref no
Feb/Mar 1972	Gdańsk Bay	0.560	0	32.1	-13	15
Apr 1972	S and E of Bornholm	0.4875	1.1009	34.7	-7	8
Mar/Apr 1973	Gdańsk Bay	0.542	0	33.2	-11	15
Sept 1974	Stolpe Bank Bornholm, Christiansö	0.512	-0.766	36.6	-1	9
Nov 1975	Fehmarn Belt	0.549	-0.444	33.6	-10	5
Sept 1978	Bornholm, Christiansö	0.491	0.016	36.6	-1	6
Sept 1978	Utklippan, Mittelbank	0.514	-0.365	35.7	-4	6
Oct 1979	Bornholm, Christiansö	0.472	0.535	37.0	0	7
Oct 1979	Utklippan, Mittelbank	0.503	-0.683	37.1	0	7
Oct 1980	Bornholm, Christiansö	0.538	-0.952	35.2	-5	7

There is no clear trend of variation with fishing area but the fish caught during September/October seem to be thin compared to those caught from November to April. This conclusion is not in agreement with the expected annual growth pattern. The main point to be made from these estimates, however, is that there is a variation of length with girth. For the same girth of 18 cm, there is a maximum difference of 13% in fish length relative to the largest length. This may account for some of the observed variation in selectivity of cod-ends of the same mesh size.

2.4 Report on Nephrops Selectivity

Terms of Reference
To evaluate recent experiments on the selectivity of Nephrops trawls and report to ACFM.

2.4.1 Introduction

A sub-group of the Fishing Technology and Fish Behaviour Working Group (FTFB) was formed in December 1994, to undertake the above terms of reference. The members are listed in Appendix 2.4.I. The sub-group worked by correspondence and then met for three days during the FTFB Working Group meeting in Aberdeen, from 18-20 April 1995 to formulate and write its report. This report was reviewed and adopted by the Working Group.

2.4.2 Evaluation of Selectivity Data

As the TOR has been to review recent experiments, only research carried out since 1990 is included in the analysis. Recent developments in gear design which have an effect on selectivity have been taken into account. Experiments carried out before 1990 are summarised in Wileman (1991).

New measurements of Nephrops selectivity parameters are included from Portugal, Spain (Mediterranean), Belgium, Sweden, Scotland and Denmark. Measurements of full square mesh codend selection and grid selection are included from Norway, Sweden and Portugal and on ground gear selection from Germany. These data, together with other parameters of relevance to the interpretation of results, are presented in Table 2.4.1. Abstracts of relevant papers are presented in Appendix 2.4.II.

2.4.3 Overall Selectivity Results

In Table 2.4.1, 25 data sets for standard diamond codends, 2 data sets for square mesh window codends (SQUW), 5 data sets for full square mesh codends (SQU) and two data sets for grids are presented. Most selectivity parameters have been calculated using Fryer's model of between haul variation (Fryer 1991). The two square mesh window sets were included in the regression analysis of standard diamond mesh codends as this square mesh window configuration is known not to change the selectivity for Nephrops. So were the four Scottish results as justified in the section below on Moray Firth, Firth of Fourth and Clyde Estuary. Regressions and 95% confidence limits were calculated using the statistical software package, SAS.

The data presented were divided into two regions according to differing codend designs:

North : Scotland, Denmark, Sweden, Belgium-large mesh size
South : Portugal, Spain, Belgium-small mesh size.

Weighted linear regressions of L_{50} and SR (figures 1 and 2) were fitted with respect to mesh size and this regional factor.
For the SR the regional factor showed no significance ($p>10\%$), whereas a significant difference of 4.04 mm CL was detected ($p<0.9\%$) for L_{50}. The model parameters are:

L_{50} : (R^2=99%)
North : $L_{50} = 0.4408$*mesh size - 4.04 mm
South : $L_{50} = 0.4408$*mesh size mm

SR : (R^2=90%)
SR = 0.1812*mesh size mm

These regressions are based on mesh measurements using the ICES gauge since all these investigations used this type of gauge.

2.4.4 Selectivity Results by Fishing Area

<u>Botney Gut - Silver Pit Area</u>

Selectivity parameters have been determined for this area by combining several hauls together. Since, however, weather conditions had a major impact on selection, it seemed reasonable to tune the selectivity according to the prevailing weather conditions in Silver Pit - Botney Gut grounds. Wind speed data have been based on recordings from the "Viking Alpha" platform in this area. The resulting codend selectivity parameters for the 67.3 mm mesh size (ICES gauge 4 kg - 70 mm nominal mesh) are: L_{50}= 33.8 mm; L_{25}=26.4 mm; L_{75}=41.1 mm; SF=0.50; SR=14.7 mm.

The L_{25} is very close to the MLS of 25 mm, which indicates that the selection properties would be in line with a general principle that the L_{25} should be at, or at least close to, the MLS. It should, however, be emphasized that selection by the 70 mm codend is far from being knife-edged. The selection ogive has a very gentle slope, resulting in a wide selection range. Retention rates of 100% are being reached from a size of 50 mm CL onwards only. The by-catch problem for whiting is quite small in this fishery. Almost all whiting below MLS escape through the diamond meshes of the codend. The L_{25} equals 24.2 cm and is slightly above the EU MLS of 23 cm.

Fladen Ground and East of Shetland

Two data sets exist with relatively different results for comparable data sets conducted with a nominal mesh size of 70 mm and a codend circumference around 100 open meshes (full specifications is given in table in the appendix). Lehmann (1993) estimated following selectivity parameters: L_{50} = 28.4 mm; L_{25} = 21.6 mm; SR = 13.6 mm while Madsen and Moth-Poulsen (1994) estimated selectivity parameters as follows: L_{50} = 37.1 mm; L_{25} = 29.0 mm; SR = 16.2 mm. Differences in twines used, could be possible explanations for these different findings. As 70 mm is the minimum allowed mesh size there is a poor correlation with Danish minimum landing size, which is 40 mm CL (general MLS is 25 mm CL). Consequently adjustments are needed either to the mesh size or Danish MLS if L_{25} should be close to MLS.

Lehmann (1993) found a decrease in L_{50} with increased codend circumference. The highest estimated selectivity parameters were obtained with the largest mesh size tested (100 mm) and the smallest circumference tested (70 open meshes). Selectivity parameters were as follows: L_{50} = 43.2 mm; L_{25} = 33.0 mm; SR = 20.5 mm. These results still gave a L_{25} well below the Danish national MLS.

In the commercial Nephrops fishery both 70 mm and 100 mm meshes are used, depending on the importance of the bycatch. Because of large bycatches of undersized roundfish in the 70 mm directed Nephrops fishery, this is an area where square mesh windows can be introduced with advantages for those nations who are not presently using them. Mesh sizes of the windows should be between 80 and 90 mm. Windows are compulsory for UK vessels and some Danish fishermen use these windows voluntary. When fished correctly the windows will not influence the catch of Nephrops, but will release undersized haddock and whiting. There can be a loss of marketable haddock (Madsen and Moth-Poulsen 1994). Rather large vessels participate in this fishery, but large twine diameters far beyond the mechanical requirements of the gear are frequently used.

Moray Firth, Firth of Fourth and Clyde Estuary

Two Scottish Nephrops whole trawl selection trips were conducted in 1992 and 1993. The 1992 data showed no difference in L_{50} (24.4 mm and 24.7 mm for 70 and 80 mm respectively) but a difference in selection range (9.3 mm and 5.1 mm for 70 and 80 mm respectively). The selection range change does not agree with the general trend for Nephrops of increasing selection range with increasing mesh size. There was some doubt that the data are correct because the small mesh gear may not have been catching the total population. The 1993 data showed an improvement in L_{50} between the mesh sizes (L_{50} of 30 mm and 32 mm for 70 and 80 mm respectively) but not so for selection range (7.6 mm and 8.2 mm for 70 and 80 mm respectively. The larger mesh gives a small level of improved selection. This means two data sets where the -92 data revealed a L_{25} for a 70 mm codend which was well below the MLS of 25 mm CL and the -93 data with a L_{25} above the MLS.

Because these results originates from full trawl experiments they are generally expected to have higher L_{25} and L_{50} than codend selectivity results. However the poor bottom contact of the reference trawl giving smaller values, underwater observations showing very few escapees in the wings and belly section and the fact that the values are not higher than comparable codend selectivity values from other countries, has justified a pooling of these results with the codend selectivity data

It may be appropriate to apply other gear designs in these areas. For example, catch comparisons showed a longitudinally roped codend and codends with fewer meshes on the circumference caught significantly fewer juveniles than a normal codend. It may be worth considering that vessels in one of these fisheries be given dispensation to use these gear types or be allowed to use square mesh of a smaller mesh size on an experimental basis. Robertson et al, 1986 suggests that there is no loss of marketable catch (i.e. above 25 mm carapace length) but there is a reduction of juveniles. Fishermen are therefore more likely to use the gear and careful monitoring of its use may be helpful in future determination of appropriate technical measures for these areas.

Square mesh windows are required by law to be used in Nephrops trawls in the UK and Irish fisheries. They are designed to allow juvenile haddock and whiting to escape from the gear. Trials have demonstrated conclusively that enhanced escape rates are achieved and it is recommended that such devices should be made mandatory for all Nephrops fisheries which are subject to a by-catch of juvenile haddock and whiting.

The Kattegat Skagerak Area

In the Skagerak-Kattegat area the Nephrops fishery has a minimum landing size of 40 mm carapace length and the mesh in use of is 70 mm diamond shaped. Regular measurements of the size compositions in the trawl catches shows that more than 70 % is undersized and discarded.

Preliminary results from Swedish and Norwegian estimations (Unpublished data) of the selection parameters in the 70 mm diamond mesh codend (28 hauls) gave an L_{50} at 19.8 mm (95% confidence limits; 14.4-22.5) and Selection Range at 13.5 (95% limits; 8.6-18.4). This means that the L_{50} is about the same size as the smallest individuals caught and there are obviously very few, if any, sizes that escape through the 70 mm diamond mesh codend in these experiments. The analytical assessments that have been carried out on this stock are uncertain due to lack of reliable growth and mortality parameters for this stock, but it indicates that a gain (about 20%) in long term landings is achieved by reducing effort by about 50%. On the other hand the Nephrops Assessment WG suggests that improvements in gear selectivity give higher long term gains in yield per recruit than reduction in effort (Anon, 1990). A mesh assessment with parameters from square meshes (Anon, 1994) shows that a change to 60 mm square mesh in 8 m long codends (corresponding to an L_{50} at MLS) would give a long term gain in landings by about 60% even if the effort remains at current level. The amount of selectivity data and corresponding discard and escape mortality is not sufficient to base any advice of mesh change on. Some Swedish fishers are voluntary using 80 mm square mesh windows in the upper sheet of the extension piece and four Nephrops trawlers have been granted dispensation to use 60 mm square mesh whole codends. It would be desirable to establish an experimental area with a general derogation to use 60 mm whole square mesh codends.

2.4.5 Effect of Codend Design Alterations

It is probable that an increase in mesh size will result in a higher L_{50} for Nephrops. It is, however, also probable that selection range, which is already quite high for Nephrops, will increase, which means that there will be an extra loss of marketable prawns and only limited saving of undersized ones. Most fishermen will fear high losses of marketable catch, especially in bad weather conditions. Nephrops selectivity is sensitive to technical changes in the gear.- An increase in numbers of meshes in the circumference of the gear can decrease the selectivity.- A switch from single to double braided netting, an increase of the yarn diameter and a change to stiffer netting material can have a negative effect on Nephrops selectivity. Fishermen may use these devices to offset any increase in mesh size. These factors could be misused in the commercial fishery and should also be incorporated in technical measures regulations.

2.4.6 Conclusions

Nephrops Selection Parameters

27 recent data sets from traditional gears have been collated to form general regressions, weighted by hauls, on 50% retention carapace length and selection range relative to mesh size. These are presented in Figures 2.4.1 & 2.4.2.

Although the regressions fit the data relatively well, it is important to emphasise that large between experiment variances exist. There are large differences between the regions from which the data were collected concerning vessels, gear, way of fishing and population composition of Nephrops. These regressions should only be used when valid parameters for the fishing area under study are not available.

Codend Design Parameters

Codend circumference and twine thickness should be considered when formulating mesh regulations. There should be a requirement for a maximum number of meshes around the codend circumference. This will help ensure that the codend meshes are held open during towing. Length of extension and twine material will also influence on the selection parameters.

2.4.7 Discussion

The Working Group stressed the importance of the Nephrops fishery and the complexities of its management arising from the wide distribution of the species. There are a number of different fisheries which necessitate advising on each separately. There are concerns recommending that the minimum landing size of a fishery (see Appendix 2.4.III) should be similar to the L_{25} of that fishery. Minimum landing size should be a function of the biology and spawning behaviour of the Nephrops in a fishery as opposed to the selectivity.

The FTFB Working Group recommends increased research for innovative constructions such as whole square mesh codends, grids, altered groundropes and roped codends in Nephrops trawls with the aim of improving selectivity in the Nephrops fisheries and reducing discards. New selectivity studies on Nephrops should be conducted with survival studies on codend escapees as recommended in the 1995 FTFB report of the Study Group on Unaccounted Mortality in Fisheries (ICES CM 1995/B:1 Ref. Assess.)

2.4.8 Recommendations

The Botney Gut - Silver Pit Area

The L_{25} for 70 mm mesh size is in good correspondence with the EU minimum landing size for Nephrops.

Fladen Ground and East of Shetland

The Danish minimum landing size of 40 mm CL is much higher than the L_{25} for the codends and mesh sizes used. On Fladen Ground, square mesh windows of 80 - 90 mm in 70 mm diamond mesh codends, will avoid some bycatch problems with undersized haddock and whiting.

Moray Firth, Firth of Fourth and Clyde Estuary

Derogations should be considered to allow the use of full square mesh codends of a smaller mesh size than the current legal minimum on an experimental basis.

Kattegat Skagerak Area

The minimum landing size are not in correspondence with the L_{25} of the mesh size used. A general derogation should be considered for the use of full square mesh codends with a minimum mesh size of 60 mm.

Note: *This report was sent to ACFM, as requested, prior to their May 16th meeting.*

2.4.9 References

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Abbreviations used in Table 2.4.1

item	Abbreviation	means
Type	standard	diamond mesh codend
	SQU	full square mesh codend
	SQUW	square mesh window codend
	FT	full trawl selectivity
Vessel type	R	research vessel
	C	commercial vessel
Test Method	CH	covered codend with hoops
	C	covered codend
	TW	twin trawl
Codend material	PA	nylon
	PE	poly ethylene
	PP	poly propylene
	br.	braided

Table 2.4.1. Nephrops Selectivity Data Since 1990

Type	standard	standard	standard	standard	standard	standard	standard
Author	IPIMAR	IPIMAR	IPIMAR	Lehmann	Lehmann	Lehmann	Lehmann
Source	1993	1993	1993	1993	1993	1993	1993
ICES Area	IXa	IXa	IXa	IVa	IVa	IVa	IVa
Test Date	4+8-93	4+8-93	4+8-93	06-93	06-93	06-93	06-93
Vessel Type	R	R	R	C	C	C	C
Vessel HP	1500	1500	1500	775	775	775	775
Towing Speed (kn)	2,9	2,9	3	2-3	2-3	2-3	2-3
Test Method	CH	CH	CH	CH	CH	CH	CH
Nr Hauls	13	11	10	6	5	5	2
Av.duration (min)	60	60	60				
Mesh Size (mm)	55,2	60,3	70,6	71,1	72,7	74,2	81,4
Small Mesh Codend Size	20	20	20	37	37	37	37
Codend Material	PE br.	PE br.	PE br.	PE br.	PE br.	PE br.	PE br.
Single/Double	S	S	S	S	S	S	D
Twine Code							
Twine Diam. (mm)	2,5	2,5	2,5	4	4	4	4
Meshes Round+Selv.	230	212	182	128	106	149	86
Opes Meshes	218	200	170	122	100	143	82
Length Codend (m)	6,0	6,0	6,0	6	6	6	6
Length Extension (m)	-	-	-	0	0	0	0
L50 (mm)	23,9	25,7	26,9	26,1	28,4	24,5	30,3
Selection Factor	0,43	0,43	0,38	0,37	0,39	0,33	0,37
Selection Range (mm)	9,7	10	12,4	8,4	13,6	14,7	23,9
Selection Ratio	0,18	0,17	0,18	0,12	0,19	0,20	0,29
Number in selection Range							
Codend	430	944	537	877	2224	425	7153
Cover	268	552	359	2394	7049	552	9600
Total	698	1496	896	3271	9273	977	16753
Total Number Caught							
Codend	3216	3945	1299	2082	2838	772	7697
Cover or small mesh codend	569	946	468	16385	12826	3504	12048
Total	3785	4891	1767	18467	15664	4276	19745
Av.Total Catch Weight (kg)							
Codend	7,23	10,34	4,77				
Cover or small mesh codend	0,72	1,57	0,72				
Total	7,95	11,91	5,49				

continues...

Type	standard	stamdard	standard	standard	standard	standard	standard
Author	Lehmann	Lehmann	Lehmann	Lehmann	Lehmann	Larsvik-Ulmestrand	Madsen-Moth
Source	1993	1993	1993	1993	1993	Sweden	1994
ICES Area	IVa	IVa	IVa	IVa	IVa	IIIa	IVa
Test Date	06-93	06-93	06-93	06-93	06-93	04-05-91	05+06-93
Vessel Type	C	C	C	C	C	C	C
Vessel HP	775	775	775	775	775	544	775
Towing Speed (kn)	2-3	2-3	2-3	2-3	2-3	2-3	2-3
Test Method	CH	CH	CH	CH	CH	TW	CH
Nr Hauls	3	2	5	4	3	10	10
Av.duration (min)						210	436
Mesh Size (mm)	83,2	83,5	106,8	108	108	68,6	72,8
Small Mesh Codend Size	37	37	37	37	37	38,3	37
Codend Material	PE br.	PE br.	PE br.	PE br.	PE br.	PP	PE br.
Single/Double	D	D	D	D	D	S	D
Twine Code							
Twine Diam. (mm)	4	4	4	4	4	3	2,5
Meshes Round+Selv.	104	122	89	74	104	100	100
Opes Meshes	100	118	85	70	100		94
Length Codend (m)	6	6	6	6	6	8	4
Length Extension (m)	0	0	0	0	0	0	0
L50 (mm)	28	26,4	41,3	43,2	39,7	26,5	37,1
Selection Factor	0,34	0,32	0,39	0,4	0,37	0,39	0,51
Selection Range (mm)	18,7	25,1	15,4	20,5	21,7	10,7	16,2
Selection Ratio	0,22	0,30	0,14	0,19	0,20	0,16	0,22
Number in selection Range							
Codend	2850	4070	935	588	1641	1326	7477
Cover	5033	7216	910	671	2800	2095	6985
Total	7883	11286	1845	1259	4441	3421	14462
Total Number Caught							
Codend	3436	5214	1489	814	1839	6415	9710
Cover or small mesh codend	9831	12027	1221	756	3241	7534	8475
Total	13267	17241	2710	1570	5080	13949	18185
Av.Total Catch Weight (kg)							
Codend							501
Cover or small mesh codend							995
Total							1496

continues...

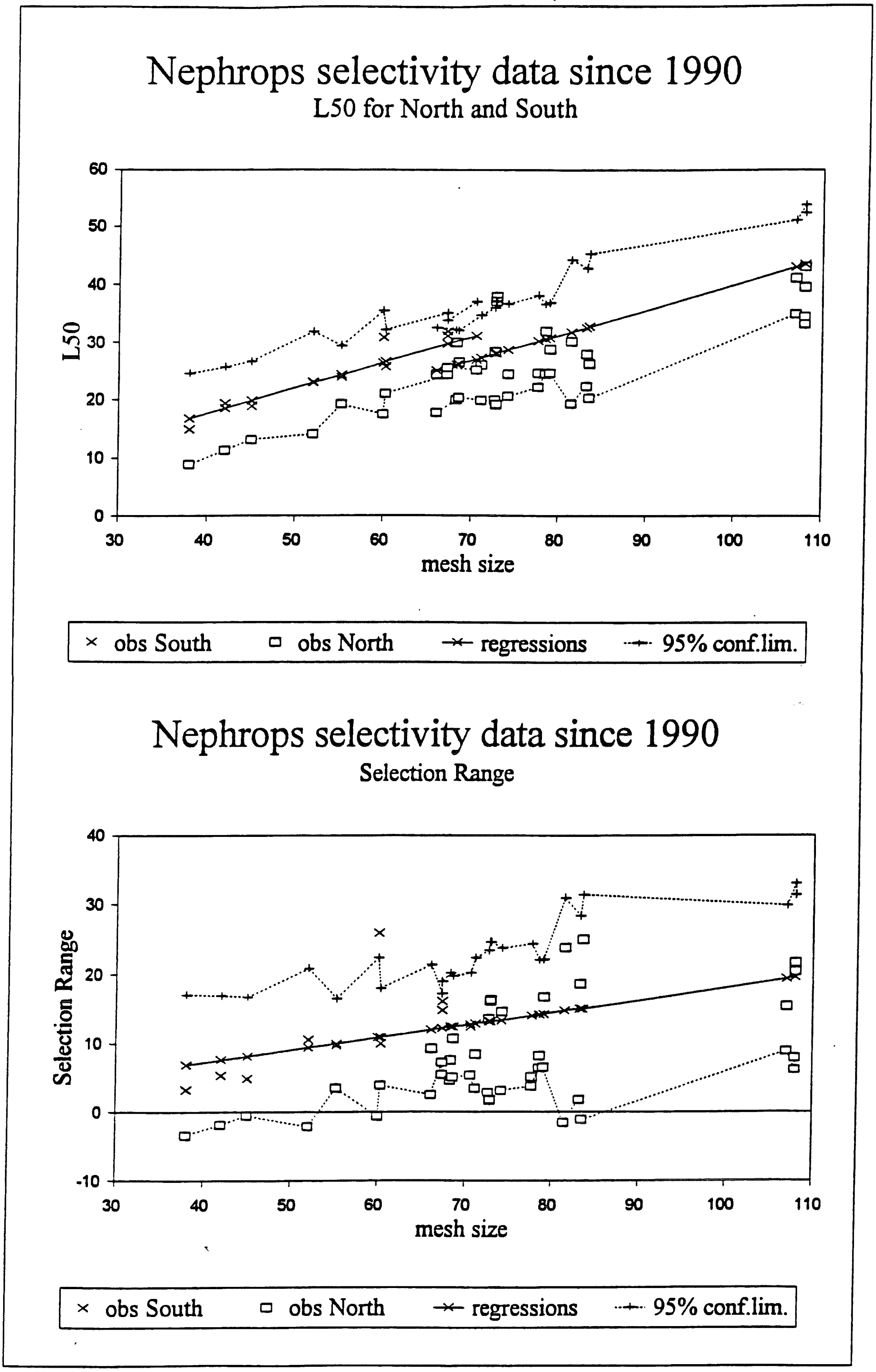
Type	standard	standard	FT	FT	FT	FT	standard
Author	Polet-Redant	Polet-Redant	Roberts. upbl	Robert. upbl	Robertson & Ferro	Robertson & Ferro	Sarda
Source	1994	1994	1993	1993	1993	1993	1993
ICES Area	IVbc	IVbc	IVa	IVa	IVa	IVa	Mediterranean
Test Date	05+06-92	05+06-92			05-92	05-92	09+11-90
Vessel Type	C	C	C	C	C	C	C
Vessel HP	360	360	550	550	550	550	700
Towing Speed (kn)	3-3.5	3-3.5			2,4	2,4	
Test Method	C	C	TW	TW	TW	TW	C
Nr Hauls	23	9	9	9	6	5	5
Av.duration (min)	210	21			234	174	120
Mesh Size (mm)	67,3	79	68,3	78,5	66,1	77,7	38
Small Mesh Codend Size	37,1	37,1			35	35	13
Codend Material	PA	PE			PE	PE	PA
Single/Double	S	D			S	S	S
Twine Code							
Twine Diam. (mm)					3,5	3,5	
Meshes Round+Selv.	100	100			120	120	
Opes Meshes	90	90			106	104	
Length Codend (m)	3,5	3,5			7	7	
Length Extension (m)	0	0			5,1	5,1	
L50 (mm)	31,9	28,9	30	32	24,4	24,7	14,9
Selection Factor	0,47	0,37	0,44	0,41	0,37	0,32	0,39
Selection Range (mm)	14,8	16,8	7,6	8,2	9,3	5,1	3,3
Selection Ratio	0,22	0,21			0,14	0,07	0,09
Number in selection Range							
Codend							
Cover							
Total							
Total Number Caught							
Codend	25356	12700					1474
Cover or small mesh codend	17640	7126					86
Total	42996	19826					
Av.Total Catch Weight (kg)							
Codend							
Cover or small mesh codend							
Total							

continues...

Type	standard	standard	standard	standard	SQUW	SQUW
Author	Sarda	Sarda	Sarda	Sarda	Madsen-Moth	Polet-Redant
Source	1993	1993	1993	1993	1994	1994
ICES Area	Mediterranean	Mediterranean	Mediterranean	Mediterranean	IVa	IVbc
Test Date	12+03-90-91	11+02-90-91	06-91	05-91	05+06-93	05+06-92
Vessel Type	C	C	C	C	C	C
Vessel HP	700	700	700	700	775	360
Towing Speed (kn)					2-3	3-3.5
Test Method	C	C	C	C	CH	C
Nr Hauls	6	7	4	4	10	12
Av.duration (min)	120	120	120	120	436	210
Mesh Size (mm)	42	45	52	60	72,9	67,3
Small Mesh Codend Size	13	13	13	13	37	37,1
Codend Material	PA	PA	PA	PA	PE br.	PA
Single/Double	S	S	S	S	D	S
Twine Code						
Twine Diam. (mm)					2,5	
Meshes Round+Selv.					100	100
Opes Meshes					94	90
Length Codend (m)					4	3,5
Length Extension (m)					0	0
L50 (mm)	19,4	18,9	23,1	30,8	37,9	31,1
Selection Factor	0,46	0,41	0,44	0,51	0,52	0,46
Selection Range (mm)	5,3	4,9	10,6	25,9	16,4	16,1
Selection Ratio	0,13	0,11	0,20	0,43	0,22	0,24
Number in selection Range						
Codend					6812	
Cover					7439	
Total					14251	
Total Number Caught						
Codend	963	3895	1846	749	8458	19222
Cover or small mesh codend	230	630	946	801	9320	15780
Total					17778	35002
Av.Total Catch Weight (kg)						
Codend					392	
Cover or small mesh codend					889	
Total					1281	

continues...

Type	GRID	GRID	SQU	SQU	SQU	SQU	SQU
Author	Unpubl.	Unpubl.	Unpubl.	Unpubl.	Larsvik-Ulmestrand	Unpublished	IPIMAR
Source	Norw.+Sw	Norw.+Sw	Sweden	Sweden	Sweden	Norw.+Sw	1993
ICES Area	IIIa	IIIa	IIIa	IIIa	IIIa	IIIa	IXa
Test Date	06-06-94	15-06-93	06-09-93	13-04-93	04-05-91	06-06-94	4+8-93
Vessel Type	R	R	C	R	C	R	R
Vessel HP	1500	1500	544	544	544	1500	1500
Towing Speed (kn)	2-3	2-3	2-3	2-3	2-3	2-3	2,9
Test Method	TR+C	TW+C	D	D	TW	TR	CH
Nr Hauls	8	10	9	7	11	6	11
Av.duration (min)	150	150	210	150	210	150	60
Mesh Size (mm)	22	22,5	49,4	49,4	61,6	61,6	55,2
Small Mesh Codend Size	25	25	31	32	38,3	25	20
Codend Material	PA	PA	PA	PA	PA	PA	PE br.
Single/Double	S	S	S	S	S	S	S
Twine Code							
Twine Diam. (mm)			1,8	1,8	2,5	2,5	2
Meshes Round+Selv.	130	130	80	80	100	100	142
Opes Meshes							130
Length Codend (m)	2*1	2*1	6,5	6,5	8	8	6,0
Length Extension (m)			0	0	0		-
L50 (mm)	33,7	37,2	26,6	33	40	35,7	35,4
Selection Factor			0,54	0,67	0,65	0,58	0,64
Selection Range (mm)	13,8	13,5	12,7	9,3	14,5	16,9	16,4
Selection Ratio	0,63	0,60	0,26	0,19	0,24	0,27	0,3
Number in selection Range							
Codend	320	2556	3701	338	3449	272	910
Cover	325	2850	5814	750	7375	530	1107
Total	645	5406	9515	1088	10824	802	2017
Total Number Caught							
Codend	380	3075	6633	489	4696	323	1152
Cover or small mesh codend	564	3249	8906	1060	10651	636	1268
Total	944	6324	15539	1549	15347	959	2420
Av.Total Catch Weight (kg)							
Codend	28	126	248			15	4,18
Cover or small mesh codend	11	-115	296			25	2,79
Total	39	11	544			40	6,96



Figs. 2.4.1 & 2.4.2 Weighted regressions of L_{50} and selection range with mesh size showing 95% confidence limits, Nephrops data since 1990.

2.4.I Appendix Membership of Sub-Group

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Niels Madsen, DIFTA, Denmark.
Hans Polet, FRS, Belgium.
Jack H.B. Robertson, Marine Laboratory, Scotland.
Mats Ulmestrand, Havsfiskelaboratoriet, Sweden
Rene Holst, ConStat, Denmark (statistical analyses)

2.4.II Appendix Abstract of Papers

Standard and Square Mesh Window Codends

Polet, H.; Redant, F. (1994)Selectivity experiments in the Belgian Norway lobster (Nephrops norvegicus) fishery. ICES C.M. 1994/B:39

ICES Area IVc: In a Belgian study, codend selectivity for Nephrops has been investigated for the Botney Gut-Silver Pit area. Three net configurations were tested: a standard Nephrops trawl with a 70 mm codend, a standard trawl with a 90 mm codend and the same trawl with a square mesh window in the top panel in front of a 70 mm codend. Codend selectivity varied widely, with most of the variability being attributable to vessel motion related to weather conditions. Rather surprisingly, the 90 mm codend was found to be less selective than the 70 mm codend, both for Nephrops and whiting; a phenomenon that could be related to the difference in netting material. This demonstrates that an increase of the minimum mesh size can miss its goal if it is not accompanied with technical measures defining netting material and other characteristics influencing selectivity.

Sarda, F.; Conan, G.Y.; Fusté, X. (1993). Selectivity of Norway lobster, Nephrops norvegicus (L.) in the Northwestern Mediterranean Sci. Mar., 57(2-3):167-174

In the Northwestern Mediterranean, 5 different codend mesh sizes were tested on their selective properties for Nephrops by means of the covered codend method (cover mesh = 13 mm). The mesh sizes were 38, 42, 45, 52 and 60 mm and the netting material was braided PA. It is clear from the data that L_{50}, but also the selection range tends to increase with mesh size. The 52 mm was the only mesh size where L_{50} was nearly the size at first maturity for the Mediterranean. The authors stress that caution should be taken when comparing the results with other data since some technical features in the overall design of the trawl, and especially the way of closing the codend may differ from other Nephrops directed fisheries. The final conclusion of the report is that fisheries management of Norway lobster catches in the considered area based on mesh size regulations may not be appropriate and should be seriously reconsidered. Considerations about selectivity in different areas

Madsen, N.; Moth-Poulsen, T. (1994). Measurements of the selectivity of Nephrops and demersal roundfish species in conventional and square mesh panel codends in the northern North Sea. ICES-CM-1994/B: 14

Lehmann, K. (1993). Analysis of whole gear and codend selectivity in Nephrops trawls.
EEC study 1992/5 DIFTA

ICES area IVa: Two Danish experiments were carried out in 1993 at the Fladen- and the East-ground in the northern North Sea. In both experiments hooped covers were used. In the experiment carried out by Lehmann three different mesh sizes and three different codend circumferences were tested giving a total of nine combinations. Selectivity parameters were analysed haul by haul and the effects of changing codend mesh size and circumference was assessed by a variance analyse model. There were large variations in selectivity parameters between hauls and not all hauls were included in the analyse of variance model. Consequently the model is then based on very few hauls for some of the combinations and the data set is to limited to make final conclusions. However the model predicted that L_{50} increased with increasing codend mesh size and decreased with increased codend circumference. The twine was changed from single to double braided during the experiment which could possibly have affected the results. In the other Danish experiment selectivity parameters (Madsen and Moth-Poulsen 1994) for a nominal 70 mm codend, with 94 open meshes in circumference, was around 0.5. This is considerable higher than the selection factor on 0.39 estimated for the same nominal mesh size for a codend with 100 open meshes in circumference, in the previously mentioned experiment. Both experiments were carried out from the same vessel, at the same fishing grounds using the same covers. A possible explanation could be that different twines (single contra double braided) and different twine diameter (2.5 contra 4) were used in the experiments (see table).

Ferreira, C.; Fonseca, P.; Campos, A.; Henriques, V.; Martins, M.M. (1993). Codend selectivity in the Portuguese bottom trawl crustacean fishery (ICES div.IXa). IPIMAR Fin.Rep. EEC Study 1992/11.

ICES area IXa: Experiments were carried out at Portuguese fishing grounds at depths between 283 to 520 metres. Three different codends with conventional meshes of 55, 60 and

70 mm, made of 2.5 mm braided polyethylene were tested. In addition a nominal 55 mm full square mesh codend of 2.0 mm twine was tested. Codend selectivity was estimated by using codend covers supported by iron hoops. A total of 13 hauls were conducted with the 55 mm (measured mesh size: 55.2 mm) conventional codend and selectivity parameters were estimated as follows: L_{50} = 28.8 mm; SF = 0.43; SR = 9.7 mm. For the 60 mm codend (60.3 mm) 11 hauls were conducted and selectivity parameters estimated as follows: L_{50} = 25.7 mm; SF = 0.43; SR = 10.0 mm. For the 70 mm codend (70.6 mm) 10 hauls were conducted and selectivity parameters were: L_{50} = 33.1 mm; SF = 0.38; SR = 12.4 mm. Finally 11 hauls with the 55 mm square mesh codend were conducted and following selectivity parameters were estimated: L_{50} = 35.4 mm; SF = 0.64; SR = 16.4 mm.

Whole Square Mesh Codend Studies

(The Swedish and Norwegian square mesh and grid studies are unpublished but will be presented to Nordic Ministry Council during autumn 1995)

ICES area IIIa: Studies with 50 mm (49.4 mm) square meshes in all of the 6.5 m of codend and extension piece was carried out with trouser trawl experiments in 9 hauls with a commercial trawler and 7 hauls with a research vessel. The small mesh codend in the two studies was 31 and 32 mm diamond mesh respectively. The L_{50} was 26.6 and 33.0, the selection range was 12.7 and 9.3 respectively. When the 16 hauls with 50 mm square meshes were put together, the logit adjustment with fixed split value at 0.5 gave an L_{50} of 27.4 (variance component analysis 95% limit ; 25.8-28.6) and SR of 15.4 mm (95% limit; 11.6-19.4). 60 mm (61.6 mm) square meshes in all of the 8 m of codend and extension piece was studied in twin trawl experiments in 11 hauls with a commercial trawler and 6 haul with a triple trawl research vessel. The small mesh codend had 38.3 and 25 mm diamond mesh respectively. The L_{50} was 40.0 and 35.7, the selection range was 14.5 and 16.9 respectively. Put together, the logit adjustment with fixed split value at 0.5 gave an L_{50} of 39.7 (95% limit; 39.2-40.3) and SR of 14.5 mm (95% limit; 13.3-15.7).

Ferreira, C.; Fonseca, P.; Campos, A.; Henriques, V.; Martins, M.M. (1993). Codend selectivity in the Portuguese bottom trawl crustacean fishery (ICES div.IXa). IPIMAR Fin.Rep. EEC Study 1992/11.

ICES area IXa: Ferreira et al. investigated 55 mm (55.2 mm) square meshes in a 6 metres codend and a 20 mm codend cover with 2.2 m iron hoops. The cover was 1.5 times the codend dimensions. These Portuguese trials were carried out at depths between 283 to 520 metres, which is much deeper than the Nephrops fishery in Skagerak-Kattegat and North Sea. The results from the 11 hauls in this study gave an L_{50} of 35.4 mm and SR of 16.4 mm. The minimum landing size in the Portuguese waters is 20 mm carapace length and a shift from the mesh in use (55 mm diamond) to the 55 mm square mesh codend was estimated to give a loss by about 40 % in short term catch.

Grid Studies

(The Swedish and Norwegian square mesh and grid studies are unpublished but will be presented to Nordic Ministry Council during autumn 1995)

ICES area IIIa: A Nordic study using grids for selection of Nephrops in a twin and triple trawl with a Norwegian research vessel were carried out with the grid angled backward from the top sheet. A small mesh cover (25 mm diamond mesh) inside the codend and extension piece, and a small mesh collecting bag for the escapes were used. Two types of 2 m x 1 m grids were used, one metal grid with 22.5 mm spacings and one with 22.0 mm spaced plastic bars. Preliminary results are presented in table 1. Scottish trials with a cylindrical grid 1.2 m long by 0.6 m diameter with 20 mm longitudinal bar spacing using a hooped cover technique gave L_{50} for 3 hauls of 28.3 to 33.1 mm

Footrope Selection

Dahm, E.; Wienbeck, H. (1993). Aspekte des Kaisergranatbeifangs in der Schleppnetzfisherei. Inf.Für die Fishwirtschaft. 40 (3),1993

This German investigation tries to assess the order of magnitude of Nephrops escapes underneath the groundgear of a roundfish trawl by means of small bag nets, rigged below the belly of the trawl, behind the groundgear. With a roller gear of rubber discs, 200 mm in diameter, less than 10 % of the Nephrops end up in the codend. 91% of the undersized Nephrops never enter the trawl. It is admitted, however that this will not occur, to the same extent, in a real Nephrops trawl, where the bottom contact of the groundrope is much better. Based on these data and on the results from Hillis and Earley (1982), the author questions the value of codend mesh size regulations if a large part of the possible catch already escapes in front of the trawl and through the wing and belly meshes.

Whole Trawl Selectivity

Robertson, J.H.B.; Ferro, R.S.T. (1993). Selectivity of Nephrops trawls. MarLab. Fin. Rep. EEC Study 1991/9; Fis. Res. Serv. Rep. 1/93

ICES area IVa: A collaborative Scottish and Danish experiment was set up to investigate Nephrops whole trawl selectivity with two different mesh sizes (i.e. 70 and 80 mm) in ICES sub-area IVa. The twin trawl method was used. One trawl was constructed entirely of small 35 mm mesh and the other commercial trawl with a minimum mesh size of either 70 or 80 mm. The small mesh trawl sampled the Nephrops population over the tow. By comparing the catches between the two trawls selection curves could be drawn. Valid analysis was possible for only a few hauls. The results for Nephrops indicated little difference in L_{50} between the 70 and 80 mm configurations. The whole gear selectivity for Nephrops measured during these trials is poor compared to previous trials. Data variability causes problems with the analysis on hauls when more Nephrops were captured by the large mesh commercial trawl. This was possibly caused by escapement of Nephrops underneath the groundrope of the small mesh gear.

Robertson, J H B 1995 (unpublished)

ICES area IVa: The twin trawl method was used with a small mesh trawl on one side to capture the total population and the normal trawl on the other side. Nominal codend and trawl mesh sizes tested in each experiment were 70 and 80 mm. The data were analysed using the method of Millar and Walsh taking into account the between haul variability (Fryer 1991) giving L_{50} of 30 mm and 32 mm for 70 and 80 mm mesh respectively and selection range of 7.6 mm and 8.2 mm. The larger mesh gives a small level of improved selection.

2.4.III Appendix Minimum Mesh- and Landing Sizes

Minimum landing size (MLS) and minimum mesh size (MMS) for important Nephrops fishing areas. ICES sub-squares are indicated in brackets.

Area	MLS (mm CL)	MMS (mm)
Iceland (Va)	30	80
Skagerak-Kattegat (IIIa)	40	70
North Sea (IVa,b and c)	25	70
North Sea, Denmark (IVa,b and c)	40	70
W of Scotland (VIa)	20	70
Irish Sea (VIIa)	20	70
SE of Ireland (VIIc,b,k and J)	25	70
SW of Ireland (VIIg and H)	25	70
Bay of Biscay (VIIIa and b)	20	55
N-NE off Spain (VIIIc)	20	55
W of Portugal/Spain (IXa)	20	55

SPECIAL TOPIC

3 FISHING EFFORT

Introduction

It is recognized that fishing effort in the waters of ICES member countries is too high for sustainable exploitation of the stocks. Measures for controlling fishing effort are needed and EU member states now have to meet targets for fleet size. Decommissioning schemes are in operation and ideas like annual effort quotas are being considered. At present, fishing capacity is defined in terms of vessel size and horsepower and, effort as days at sea or hours fishing by these vessels. These measures ignore the type of fishing gear used, although it is the gear not the vessel that actually catches the fish. For example, engine size may be enlarged to enable a vessel to steam quickly to and from the fishing grounds rather than to operate a large fishing gear. The various gears in use differ in capture efficiency and more precise knowledge of the catching capacity of fleets by fishing method and gear size would assist both stock assessment and fisheries management. Effort controls unrelated to the fishing methods used can encourage a trend to use the most efficient methods, eg from single boat to pair trawling.

Several member countries of ICES are studying the relative fishing effort exerted by gear types and sizes and the FTFB Working Group is an ideal forum for analysis and discussion of findings. The current work is much more practical and has the potential of producing relative efficiency factors for gear type and size which may be used to regulate fleet catching capacity. This information can also be of value to stock assessment work by enabling fishing effort by fleet to be measured in more precise terms.

3.1 Keynote Presentation: Fishing effort: a gear technologists perspective -R. D. Galbraith and P. A. M. Stewart, UK.

Fishing effort exerted by a particular vessel may be defined as the product of the fishing power of that vessel and the appropriate measure of fishing activity or time spent fishing. Total effort expended by the fleet is the sum of these products for all the fishing units in that fleet. Both catch per unit effort (CPUE) and fishing intensity (effort per unit area) are essential information required in formulating fisheries management advice. Because fishing effort may be too high for sustainable exploitation of traditional stocks, effort control, i.e reduction in number of vessels in the fleet, restricting the number of days at sea etc., is seen as a means of reducing fishing mortality. Clearly the accuracy of estimating effort is of major importance in the subsequent estimates of changes in abundance and assessment of the resource. Here gear technologist can make some contributions to improve precision of these estimates and help better define fishing effort through estimation of effort as defined by the gear itself, in particular, towed fishing gears. For most static gears, eg. lines, pots, traps, gill-nets, days fished or duration between lifts (soak times) are the appropriate units to measure fishing activity.

Fishing power is generally standardized by tonnage, length and horsepower. In some fisheries vessels are limited by certain parameters, such as length or horsepower. Ships may have more power than is required for purposes other than towing the gear., i.e to steam long distances, and vessel size may be a function of the requirement for space to process and store fish.

For towed gears, it is generally assumed that the gear is related to vessel size and effort data has traditionally been ordered on this assumption. Since many types and sizes of gears may be used on a particular stock in a given area, and since the fishing power is known to vary with method and species then it is necessary to classify each vessel by size, fishing method and target species to calculate accurately as possible the fishing effort expended. Increase in fishing power occurs due to advances in gear design or new methods of fishing. The adoption of pair trawling, twin trawling (and multiple rigged trawling) and specialized species directed trawls, eg long- winged "scraper" trawls for monkfish and megrim, are all examples of how fishing power can be increased irrespective of any fleet effort controls that may be imposed based on vessel parameters. Modern fishing units can also change quickly from one metier to another, deploying different gears not only between trips but on a day to day or even a haul by haul basis. Clearly a measure of gear size in addition to fishing method or metier should be considered when calculating fishing power. An easily verified gear parameter could be considered as an indicator of potential, if not actual gear performance. For pelagic and high headline demersal trawls one could use the fishing circle, i.e the product of the number of circumferential meshes immediately aft of the footrope and stretched mesh size, whereas for towed demersal nets targeting groundfish, Nephrops, etc., total footrope length or some such similar ground contact parameter, may be more appropriate. Aggregate beam lengths would seem suitable for both beam trawls and scallop dredging gears.

A clear research objective is to determine empirical relationships linking vessel parameters (eg horsepower, tonnage), gear design parameters (eg fishing circle, footrope length) gear performance parameters (eg swept area, swept volume, gear drag) with yearly and quarterly catch rates of target species. A collaborative EC project between United Kingdom, Denmark, and Belgium has begun to look at establishing the empirical relationships between gear design, gear performance and fishing power.

3.2 Sampling and analysis protocol, solution to the inter-calibration problem of varying fishing power of otter trawlers and a reflection of an acceptable turnover rate of sentinel fishermen - D. Robitaille and A. Fréchet, Canada

This project, namely Sentinel Fisheries, is an association between scientists and fishermen. The idea is to put together science and practical fishing knowledge. Ten commercial trawlers have to cover, simultaneously, a fishing area using a stratified random design in order to derive an abundance index for groundfish. Those trawlers are likely to have different fishing power and thus a "vessel" effect is present. The aim is to estimate and control the "vessel" effect based on data analysis from a series of parallel tows using each vessel. Then an inter-calibration factor will be derived and applied to the catch data from each vessel.

The conversion factors for the individual fishing power will be derived using the following notation:

$$CONFACTi = \frac{AVEPOW}{RELPOWi}$$

Where $CONFACT_i$ is the conversion factor for vessel I; $RELPOW_i$ is the relative power of the vessel I; and $AVEPOW$ is the average power of the 10 vessels. The catches of each vessel is then multiplied by the conversion factor and thus the vessel effect is eliminated.

Several supplementary variables have been identified such as: vessel position in relation to current; operational procedures aboard vessel; tow duration; tow distance; tow speed; gear type; gear geometry; and, bridle and warp lengths. Several ways are proposed to manage the variability inherent to their presence. Among those, there are the use of questionnaires completed by vessels captains, the use of a restrictor rope between the warps to limit the wing spread and the realisation of experiments with acoustic instruments (SCANMAR) to study the trawl geometry of each vessel before the survey.

There are still variables which cannot be controlled directly, eg. depth, vessel, strata and time of day fishing. A method is suggested to do an indirect control, further more it will allow to compute an inter-calibration factor for the catch data.

3.3 General Discussion on Fishing Effort.

The commercial fleet can be very heterogenous, even though they are using the same nominal mesh size, due to the increasing multi-gear nature of individual vessels. Fishing gear could be included as a separate category in multiplicate models which analyse catch rates to arrive at a more precise measure of effort. What is needed for this new category are typical values for the parameters describing that gear.

It may now be feasible to describe gears by the volume of water swept method originally attempted by Treschev (1978; Coop. Res. Rep. ICES 79:54p). This work was not accepted earlier because Treschev originally tried to apply his model to all gears, this was not the best approach. With advancements in measurement techniques this method may now be more practical. For some species the catch is a function of the area of seabed swept and not the volume of water and this parameter would need to be measure where appropriate.

Clearly, the standardization of fishing power by estimating and controlling the vessel effect in the Canadian sentinel fishery illustrates the complexity of standardizing effort in research surveys. Here this fleet will be homogeneous because it will use the same fishing gear.

The Working Group endorses research to improve the precision of effort data by establishing empirical relationships between vessel and gear. The Working Group realizes that the use of a measure of fishing gear with traditional measures of effort data in stock assessment is a fairly new area and it anticipates that the EC collaborative project will provide some clear insight into its feasibility.

OTHER RELATED TOPICS

4 SELECTIVITY STUDIES

4.1 Keynote Presentation: The use of selectivity data in stock assessment - R. Cook, UK

Introduction

At present the only method allowing effective control of a fishery is manipulation of the exploitation rate. The rate of exploitation of any stock is strongly influenced by the selectivity of the gear used in that fishery. Selectivity plays a major part in the exploitation rate of fish stocks and is therefore an important tool for fishery management. This seminar concentrates on size selectivity, principally of towed gears and in particular the selectivity of codends.

Selectivity and fishing mortality rate

The fishing mortality rate of an exploited population is a measure of the proportion of fish removed by fishing over a given time (usually a year). It may also be crudely represented as a function of the product of both fishing effort and the "catchability" of the fish. However, by far the major component of "catchability" is the selectivity of the fishing gear, and in particular the codend. It is important to note that if we want to control fishing mortality then it can be done either by controlling effort or by controlling selectivity or both.

Size dependent mortality

Selectivity of a codend is dependent upon the size of fish attempting to pass through the gear and generally assumes a sigmoid shape. Since fish in a population will have a range of sizes, the modification of the codend selectivity will alter the exploitation pattern of the fishery and can lead to improvements in the expected equilibrium yield.
Managing gear selectivity is therefore an important means of fully exploiting the growth potential of fish. However, it must be emphasised that, because fishing mortality is also dependent upon on fishing effort, controlling gear selectivity alone is insufficient to manage a stock at a target exploitation rate. Fig. 4.1.1 illustrates this property. Fishing mortality rates which remain in the fully selected size range are little affected while those at the younger ages are substantially reduced. By contrast, if effort was altered the effect would be the same for all age groups. Thus, in general, selectivity properties are most useful for improving the exploitation pattern (i.e. age dependent mortality) of the fishery while effort controls are most useful for controlling the overall exploitation rate.

Properties of selectivity ogives

There are two ways to change size selectivity properties (Fig. 4.2.2). A change in location (or L_{50}) shifts the curve to the left or right but retains the same slope. Altering the slope (selection range) by changing the steepness of the curve retains the same L_{50}. A gear with a steep slope (narrow range) retains all the fish above L_{50}, but allows all fish below it to escape. A gear with a low slope (wide range) still retains a large number of fish above and below L_{50}.

It is commonly argued that it is desirable to shift selectivity ogives to the right , i.e. change of location, to protect juvenile fish. This is true in heavily exploited fish stocks where juveniles comprise a large part of the catch. However , it is possible to have a mesh size too large resulting in too many fish escaping and dying before they are caught at a larger size. It is often possible to calculate an optimum mesh size for a particular stock. Fig. 4.2.3 shows a calculation for North Sea whiting which suggests that a mesh size of about 110 mm would be an optimum.

Gears which possess a steep selectivity ogive are sometimes claimed to have "better" selectivity properties than those with a wide selection range. This is not necessary always the case. Steepening the selection curve but retaining the same L_{50} will give more protection to small fish but increases the potential mortality on larger fish which may be undesirable if the spawning stock is already depleted. In addition, steep selectivity curves will tend to exploit a smaller size (and hence age) range of fish which means the catch will be comprised of fewer year classes. This can mean that catches will show greater inter-annual variability.

Technical and biological interactions

It is important that fish stock assessment quantify the expected changes resulting from the implementation of a new gear or mesh size. This requires a knowledge of the selectivity characteristics of both the existing gear and the new gear. Altering gear selectivity can have an effect on both technical, eg. sequential competition between multiple gears exploiting the same stock (Fig. 4.1.4), and biological interactions, eg. increase mesh results in increase natural mortality in a stock due to predation, which counteracts the effect of increase mesh size.

The use of selectivity data

There is a practical question of how best to use selectivity data in stock assessments. First of all it is worth briefly considering one of the commonest methods of evaluating the effect of a mesh size change on an exploited stock. In essence all that is done is to re-calculate a mew set of age dependent fishing mortalities based on the new mesh size using the equation:

$$F_{new} = F_{old}\left(\frac{S_{new}}{S_{old}}\right)$$

where "old" and "new" refer to the old and new mesh sizes. The parameters, S are calculate directly from selectivity ogives derived from experiments. The new fishing mortalities can be used in any assessment model. It is clear that in the above equation there is an implicit that the observed fishing mortalities correspond the mesh size quantified by S. If the ratio of selectivity parameters in the above equation is not represented of the true operational selectivities in the fishery then subsequent estimates of fishing mortality and the assessment will be in error.

The main issue is how best to quantify the selectivity characteristics of a fleet. Any fishing fleet will be heterogeneous to a greater or lesser degree and even given the same nominal mesh, the selectivity of the gear is vessel dependent. It should be emphasised, that while it is necessary to conduct selectivity experiments in somewhat ideal conditions, there is a definite need to establish a link between experimental data and the effective selectivity of commercial fleets. How best to do this? Solving this problem will almost certainly need a recourse to indirect measurements of selectivity based on the passive dimensions of gears and the size range of fish retained in them. An exploratory analysis is required in order to identify the most promising way forward.

Although most selectivity experiments concentrate on commercial gears, there is an important need for selectivity data relating to sampling gears used on research vessels. There is concern about the degradation of catch data from official statistics as a result of mis-reporting. This has resulted in an increasing reliance on research vessel survey data, which need to be corrected for the effects of size specific selection by the sampling gear. Selectivity information for these gears would be a valuable contribution to the correction of potential bias.

4.1.1 Discussion.

There are differences in measured selectivity between different fleets and the Working Group stressed the importance of careful measurement of the selectivity for each fleet. Fisheries managers should appreciate that this value does vary between fleets and that while it is assumed that measured selectivity is reflective of the real values, it may in fact not be the case. Thus the differences between fleets exist but to what degree? Although there is great variation in selectivity parameters estimated for individual experiments and commercial hauls, it may be perceived to carry over these inaccuracies to the selectivity values of a fleet as a whole. However, the number of hauls taken by a fleet would average this data out, and thus allow for better predictions. Stock assessment calculations, which normally use age classes, as opposed to length, with respect to frequency distribution, would benefit if selectivity data could be calculated with respect to age class as well as length. This could improve accurate calculation of fleet selectivity values. The Working Group recognized the need for age selectivity data in assessment work and encouraged all members to take their data one step further and provide selectivity information based on age.

The Working Group noted that many selectivity experiments were being carried out by many institutes each year, and wondered how often stock assessment researchers actually reviewed these new selectivity parameters . Clearly, there must be a definite effort to use the most up to date selectivity parameters in deriving age dependent fishing mortalities in assessment models. More communication between gear and stock assessment researchers is needed and this could be achieved if the FTFB Working Group formally report to the ACFM.

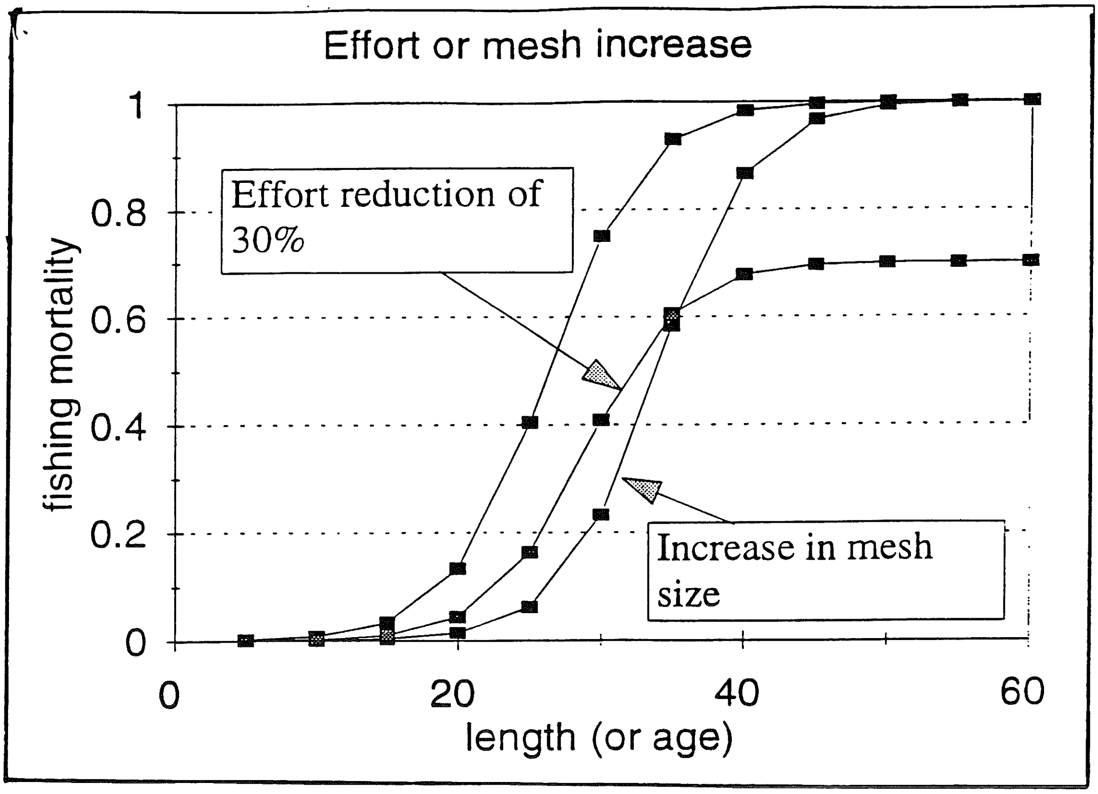


Fig. 4.1.1 The difference between increasing mesh size or reducing effort on fishing mortality rate. Increasing the mesh size reduces fishing mortality on the smaller fish but there is not change on the largest fish. Effort reduces the mortality on all size groups by the same proportion.

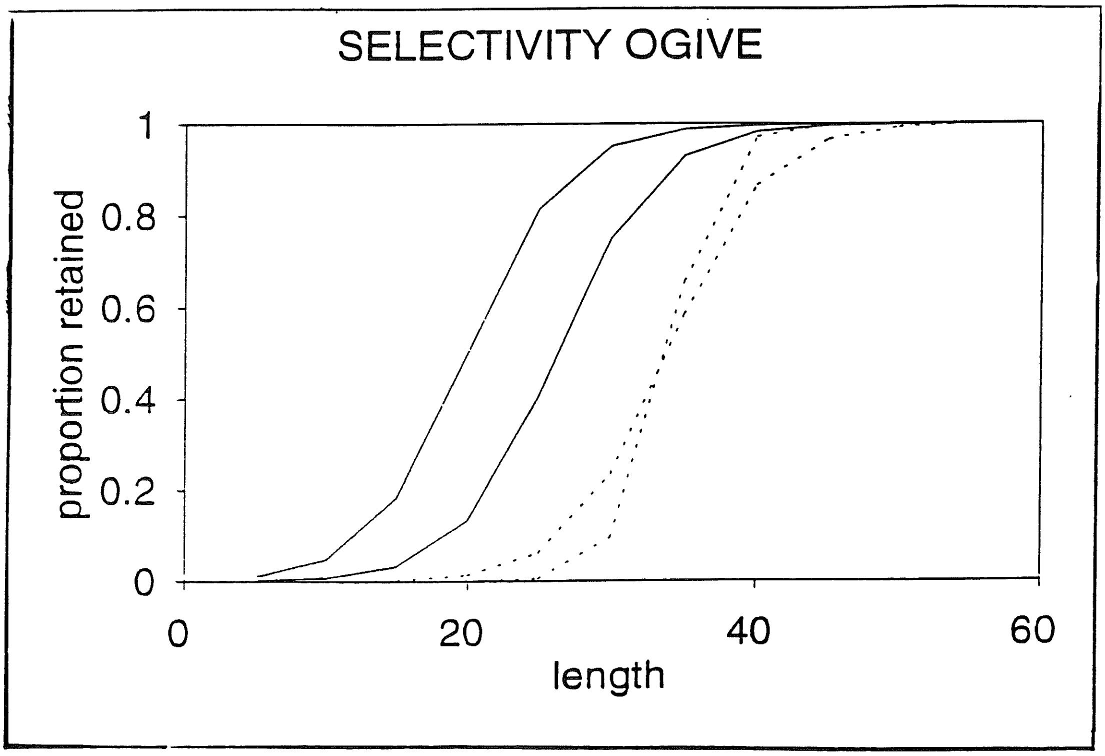


Fig. 4.1.2 The two principal ways in which size selectivity can be changed. A change of location (or L_{50}) shifts the curve while retaining the same slope. Altering the selection range or slope retains the same L_{50}. The consequences of these changes are different for the conservation of the stock.

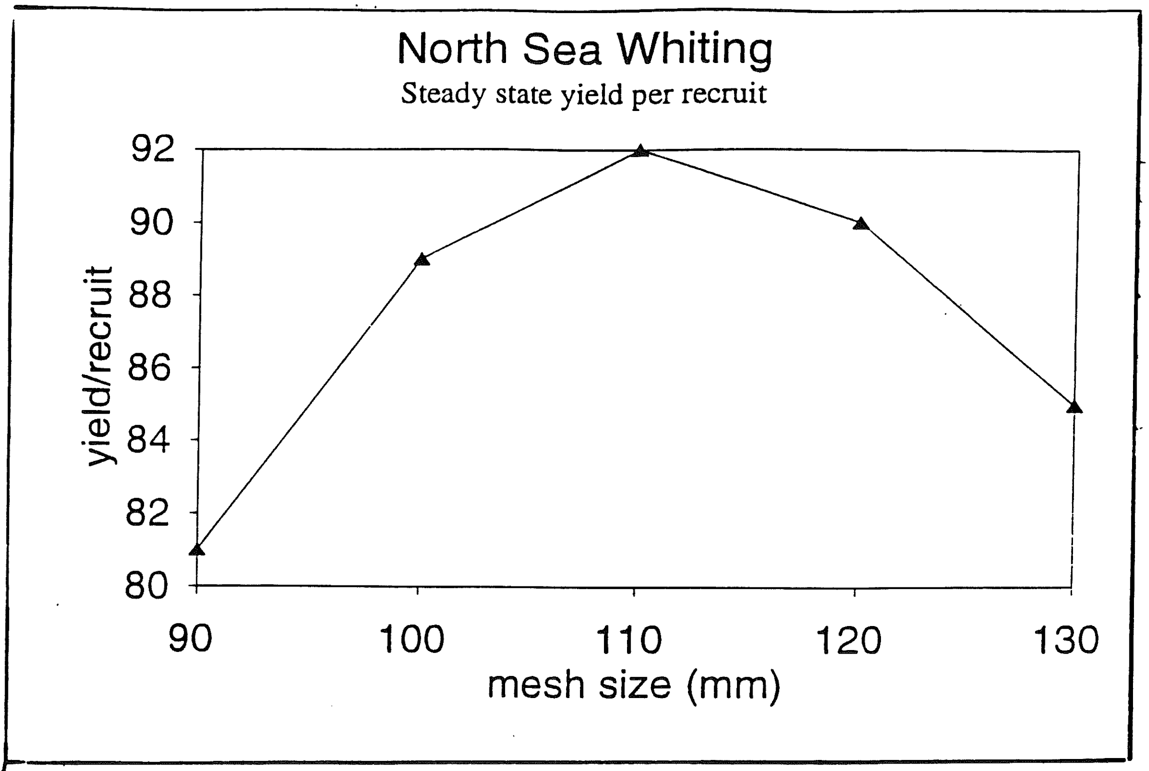


Fig. 4.1.3 The theoretical optimum mesh size for North Sea whiting assuming stationary recruitment and natural mortality rates.

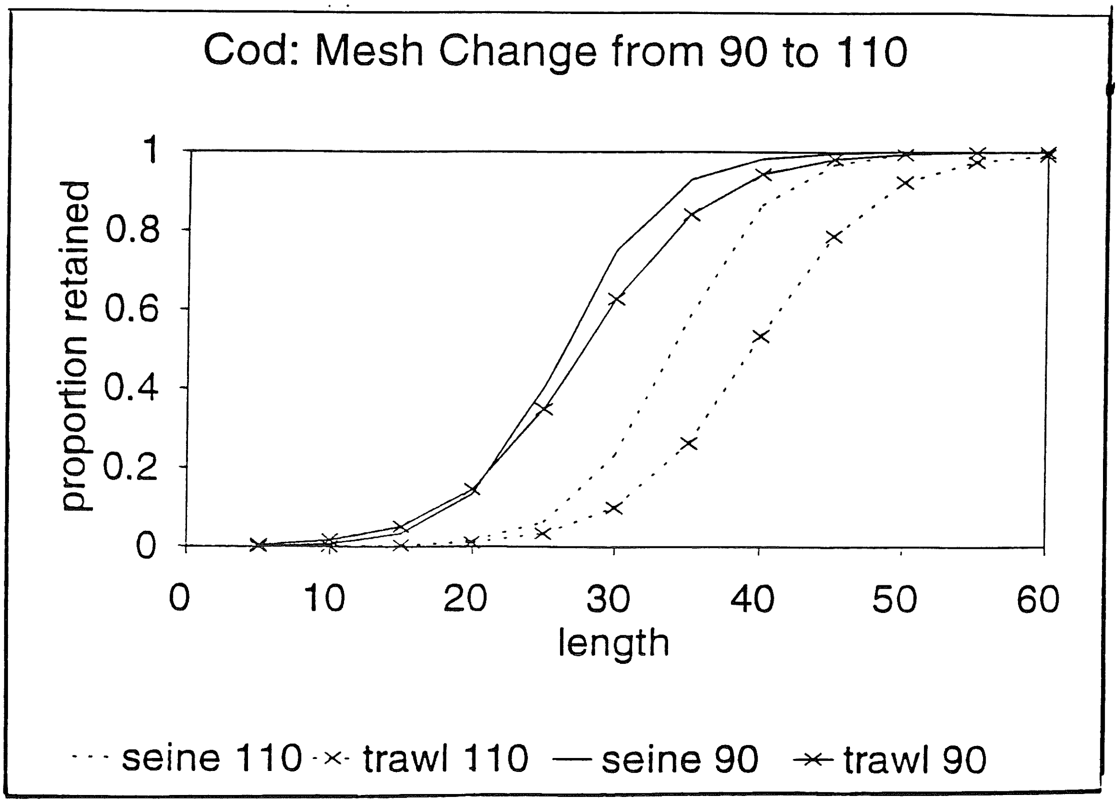


Fig. 4.1.4. Selectivity ogives for two gears, seine and trawl, for mesh sizes of 90mm and 110mm. Increasing the mesh size produces a greater separation between the gear types. Because the seine ogive lies to the left of the trawl ogive. seiners would benefit from the mesh increase at the expense of trawlers. This is an example of sequential competition.

4.2 Improvements in design of codend covers - J. Robertson, (UK) and N. Lowry, (Denmark), B. Kynoch and H. Özbilgin (UK)

The designs of codend covers used for estimating selectivity have recently been improved by the use of 2.5 m diameter external supporting hoops which hold the meshes of the cover away from the codend in order to prevent masking of the meshes. However, in some circumstances there appears to still be masking with this design. In order to further improve the cover design, a 3 m internal hoop was used and is reported here (Fig. 4.2.1). Video observations showed that this gave a significantly greater clearance around the aft part of the codend, and that this was further improved by using a smaller hoop to hold the cover clear at the front of the codend.

Handling of this cover design can be difficult, especially during poor weather conditions. The problem of reduction of flow rate within the cover and codend may be altered by the use of the cover, this problem should be further investigated before continuing to use the method.

4.3 A comparison of the twin trawl and covered codend methods of selectivity measurements - J. Robertson and R Fryer, UK

The measurement of codend selectivity is accomplished by two main methods, namely the twin or trouser trawl and the small mesh codend cover. There were nine hauls with the twin trawl and ten hauls for the covered codend technique. We compare the selection parameters for haddock from both methods and find that there is no difference.

4.3.1 Discussion.

A lower L_{50} for the cover was expected due to masking and flow effect which could affect escape behaviour, however, this was not evident in this experiment. Lack of differences in L_{50} could have been due to the low number of hauls.

4.4 Gear performance and catch comparison trials between a single trawl and a twin rigged trawl - G. I. Sangster and M. Breen, UK

During a 15 day February cruise, *Nephrops* and fish by-catch data were collected from a single trawl and a 3-wire twin rig towed by a 550 hp commercial vessel. The single net was a "scraper" type trawl suited to the size of the vessel. The two identical twin rig "scraper" nets were of a size normally fished in dual formation by that same vessel on the same grounds. Both gears used 70 mm stretched mesh cod-ends. At a normal towing speed of 2.5 knots, comparisons were made of both of the gear's catches, together with each gear's performance using remote instrumentation. Furthermore, because of the behavioural activity of *Nephrops*, catches were compared during the periods of dawn, day, dusk and night. The ship's fuel consumption wand trawl geometry as monitored during each of the 54 hauls accomplished (Table 4.4.1). It was concluded that during each haul, the vessel used an average of 19.6% litres per hour more fuel when towing the twin rig compared with the single trawl and that the average swept area (ie, the product of the board spread and the distance covered) of the twin rig was 15.3% greater. The headline heights of both gears were similar, ranging from 2.0 - 2.3 m, whereas the combined wing end spreads (55.2 m) of the twin gear was 26% greater than the spread (40.7 m) of the single net. The twin trawl significantly out-fished the single trawl for haddock, flatfish (plaice and lemon sole), *Nephrops* and bycatch (Fig. 4.4.1). Cod also showed increased catches by the twin trawl, however, this was not proved to be significantly different. The greater catch for haddock and bycatch was attributed to the greater door spread and wing-end spread of the twin trawl. Over the same swept area the twin trawl was still more effective at catching ground species (monks, flatfish and *Nephrops*). The increased catch of monks is thought to be due to the shallower bridle angle of the twin trawl (Table 4.4.2). A difference in the ground gear shape was noted between the two trawls and this could imply different fishing abilities for ground living species (*Nephrops*, plaice and lemon sole).

4.4.1 Discussion.

Bridle angles observed in this experiment could be different from those usually seen in commercial operations. However, this study was comparing two trawls as operated by a single commercial fishing, thus the bridle angle would be determined by a single set of doors. It was also noted that wing shape of the scraper trawl could have a major influence on the catch. The Working Group agreed that this work is necessary to provide much needed management information for fisheries using the twin trawl, and expressed hopes that the work would continue.

4.5 Recent developments in selective midwater trawls - B. van Marlen, The Netherlands

This project aims to improve the selectivity of midwater trawls in a mixed fishery on mackerel, horse mackerel and herring. Fish will be discarded at sea when its quota is fully fished. It was investigated whether behavioural differences exist that can be utilised to separate the species. A black tunnel was shown to be an effective scaring device in tank experiments described later in this report. Fish tended to avoid this device. Adjustment of towing speed was not found to be an effective measure to separate the species. Further model design studies on grid arrangements were done in May 1994 in the SeaFish flume tank. Further comparative fishing and observation trials were done with grid sections on RV *Solea* in September 1994, and RV *Tridens* in December 1994 (see Fig. 4.5.1). This paper describes the results of the *Tridens* trials. The ideas brought forward after the trials in 1993 were applied with more success. Not only was the grid section lengthened, but also leading grids and a flow deflector were added. In some hauls a remarkable improvement in selection between Atlantic mackerel and horse mackerel was found. More evidence is needed to confirm this finding. Additionally there is a need for a construction that can handle large catches without distorting the net too much.

4.5.1 Discussion.

The Working Group raised concerns about the acceptance of grid systems in the commercial sector, due to their complexity and problems with handling. It was noted that this work had changed to using a simpler system with flexible PVC grids. A rectangular mesh would be needed to provide the elongated escape zone required at the high operating speeds of this gear. The Working Group re-emphasised that towing speed is a major problem in selectivity research and more work is needed to clarify the effect it has on selectivity parameters.

4.6 Gillnet selectivity in plaice, exposed to different "statistical" methods. - R. Holst and T. Moth-Poulsen, Denmark

The selectivity of static gear, such as hooks, gillnets and trammel nets has been studied with various approaches and a number of methods have been developed either for estimating selectivity or for assessment purposes. For legislation purposes this area has been given renewed interest within the framework of the EU. Compared to the study of selectivity in towed gears, in most studies the lack of a "nonselective" reference causes the analysis of catch data to be less simple.

This paper is associated with an EU-funded study, which aims to investigate some of the methods that are frequently applied to the analysis of gillnet selectivity, with respect to biological as well as statistical properties. Previous papers (Regier and Robson, 1966, J. Fish. Res. Board Can. 23: 423-54; Hamley, 1975, J. Fish. Res. Board. Can. 32: 1943-1969) have been concerned with a survey on the methodology for gill net selectivity but due to more recent developments in hardware and statistics and the interest from a legislation point of view, more knowledge in this area is requested.

At this intermediary stage of the study, we concentrate on presenting the results obtained from applying six different methods to data sampled, using six different mesh sizes in the Danish trammel net fishery for plaice (Figs. 4.6.1 & 4.6.2). Some of these methods are more recent works not presented in the previous reviews. Each method is summarised, prior to the presentation of the results. Finally we give a brief discussion on the statistical properties of the methods concerned.

4.6.1 Discussion

The Working Group welcomed these developments in statistical modelling of selectivity for static gears and look forward to future developments.

4.7 Experiments with rigid grids in the *Nephrops* and whitefish trawl fisheries. - J. Robertson and A. M. Shanks, UK

We report the results from the use of three designs of rigid grid system used in the *Nephrops* and whitefish fisheries in ICES Area IVa. Grids allow increased opportunities for unimpeded escape of juveniles from trawl gear. Details are given of grid design and attachment to the trawl with details of the catch retained in the codend and the quantities and size ranges of the escapees.

4.7.1 Discussion.

The Working Group expressed concern about the effect of a large catch on the device. It was agreed that a large catch, or indeed large object such as skate and debris, can cause an obstruction preventing the catch from reaching the codend. This device was popular with the fishermen who have used it, as it is simple to handle on deck. Also, it appears to cause no distortion of the net, being neutrally buoyant, (when fitted with the correct floatation, 4 x 6 inch floats), and attached to the net with the selvedges central and the net cut on the bar.

4.8 The effect of haddock selectivity of six different diamond mesh sizes. - R. J. Kynoch and J. H. B. Robertson, UK (Poster)

Selection measurements for six separate diamond mesh codends ranging from 90 to 120 mm (full mesh size) were gathered for haddock (*Melanogrammus aeglefinus* L.), on a single boat trawl using the hooped covered codend technique. A gradual improvement in selectivity was demonstrated as mesh size was increased (Fig. 4.8.1)

4.9 The effect of cover mesh size and codend catch size on codend selectivity. - F. G. O'Neill and R. J. Kynoch, UK (Poster)

Selectivity trials were carried out to test whether an increase of the cover mesh size would have any impact on the selection parameters of the codend fished and to examine the effect of catch size on selectivity. The increase of cover mesh size from 40 mm to 60 mm had no effect on the selection parameters of the 100 mm codend tested. There was a significant increase of the 50% retention length for both haddock and whiting over the range of catch weights considered which was from 100 kg to 450 kg.

4.10 Effects of sub-sampling procedure on the accuracy of parameter estimates from selectivity experiments. - H, Özbilgin and G, Holtrop, UK (Poster)

Sampling only a proportion of the total catch is a common method of collecting selectivity data. To investigate the effects of sub-sampling on the accuracy of the selectivity data, a ten day sea trial was conducted in July 1993 on board a commercial trawler using the covered codend technique. Codends were tested under normal fishing conditions, except for the use of a cover and shorter haul duration. Data were collected for haddock which usually comprised half the catch weight. The catch was put into standard baskets and every haddock in all baskets was measured. More than 60,000 haddock were measured in 18 hauls of which 13 were accepted as valid. Two different gears were used.

The results showed that the parameter estimates definitely improved if the catch is well mixed before a sample is taken from it (Fig. 4.10.1). Variance reduces as more baskets are sampled, but this does not necessarily imply that the parameter estimates are better. This may be linked to the ratio of sampling proportions which should be in the range of 0.3 to 3 (ICES Manual on Recommended Methodology of Selectivity Experiments)

4.11 Study of the influence of lastridge ropes on redfish selectivity in a bottom trawler. - G. Brothers, W. M. Hickey and D. L. Boulos Canada (Poster)

Between October and December of 1994, redfish (*Sebastes mentella*) selectivity was examined during two 10-day commercial fishing trips to NAFO sub-division 3Ps. The MV *Atlantic Lindsey*, a 44.5 m stern trawler, was used to fish in depths of 329 to 516 m. This vessel's standard model 96 bottom trawl was modified to a trouser trawl design which accommodated codends with nominal mesh sizes of 115, 105 or 90 mm, rigged with and without lastridge ropes hung at 88%. The study's objective was to reduce, below 5%, the amount of small redfish (<23 cm) caught while optimizing the retention of commercial sizes. Comparative results showed the codends with lastridge ropes consistently catching fewer small and more commercial-sized fish than codends of similar mesh size without these ropes (Table 4.11.1). Selection ranges obtained for the codends without lastridge ropes varied from 4.6 to 6.6 cm and from 3.3 to 3.8 cm with lastridge ropes. The L50's assessed for the 115, 105 and 90 mm mesh sizes were 31.5, 28.5 and 27.2 cm when not using lastridge ropes and 32.3, 32.1 and 26.9 cm with lastridge ropes, respectively (Fig. 4.11.1). Of the codends evaluated, optimal selectivity was obtained using the 90 mm nominal mesh size with lastridge ropes. Sets with this codend caught only 1.3% small redfish and possessed a narrow 3.3 cm selection range which maximized retention of commercial sizes.

4.12 Methodology manual: Measurement of fishing gear selectivity. - J. Foster, Canada (Poster).

Measurement of fishing gear selectivity has been developed by the Canadian Department of Fisheries and Oceans in recognition of the need to apply conservation principles. The manual focuses on size and species selectivity of fixed and mobile gears operating under normal commercial fishing conditions. Written for fisheries technicians, senior fishing personnel and others involved in the practical conduct of selectivity work at sea, the manual provides the reader with the underpinning knowledge required to monitor demonstrations, collect data and validate scientific research. Mathematical and statistical examples are presented to facilitate understanding and application. Worked examples of selectivity analysis are provided for fixed gears such as gillnets, longlines, baited traps, unbaited traps and mobile gears - trawls. These examples carry the user through the steps and procedures necessary to analyse data. Pre-existing data sets and programs that can be used in the analysis are provided on diskette. Directions for using these programs are found in the appendices to the manual. Once familiar with the programs, the user can input and analyse their own data sets.

4.13 Canadian northern shrimp selectivity programme. - D. Tait, Canada (Poster)

Fish By-catch Selectivity Experiment
In the first project, the Canadian Department of Fisheries and Oceans , in conjunction with Fishery Products International (FPI), carried out an experiment between January and March, 1993, to investigate, under commercial conditions, the effectiveness of: (I)the Nordmøre grate, using three different bar spacings (22 mm, 25 mm, 28 mm) in reducing fish by-catch, and (ii) a square mesh codend in reducing the catch of industrial (small) shrimp. The grate was found to be effective in reducing the by-catch of non-target species especially groundfish and reducing sorting time for the catch. Some lost of commercial shrimp occurred. In the mesh shape experiments the 43 mm square mesh caught a lower count per kilogram than the 43 mm diamond mesh, i.e square mesh caught larger shrimp.

Industrial (Small) Shrimp By-catch Experiment
The second selectivity experiment, conducted off the northeast coast of Newfoundland and Labrador during the spring of 1993, involved sea trials of various selectivity devices to assess their performance in reducing they by-catch of industrial (small) shrimp using means other than increases in mesh size. It was hoped that these trials would greatly diminish the catch of shrimp (carapace size 21 mm or less; approximately 150 or more per kilo) with a minimum loss in overall catch. Four trials were carried out to test a variety of combinations of lastridge ropes and sorting grates. It was concluded that lastridge ropes and sorting grates clearly show promise in excluding industrial shrimp from the catch, with catch rates being higher with the lastridge ropes in comparison to grates. Further research is needed.

Mesh Size Selectivity Experiment
The third project was conducted on a pan-Atlantic basis and was designed to reduce the ratio of industrial shrimp in the catch without incurring a loss of larger shrimp. Codends constructed of mesh larger than Canada's regulation size (40 mm) have been tried elsewhere, and there was much interest in the new 55 mm codend mesh regulation introduced in April 1993 in Greenland. The objective of this experiment was to investigate, under commercial conditions, the selectivity characteristics and catch implications of codends constructed with mesh sizes of 45, 50, and 55 mm. There was little differences in the catches of shrimp (amount or size) taken by 45, 50 and 55 mm codends.

4.14 Selectivity in Baltic cod trawls with square mesh codend windows. - N. Lowry, L. H. Knudsen and D. Wileman, Denmark (Poster)

Covered cod-end experiments were made using 105 mm cod-ends with panels of square meshes of 105 mm, 115 mm and 120 mm inserted on each side below the selvedges. The use of these panels gave a significantly greater selectivity than the standard 105 mm cod-end currently used, and the resulting overall selectivity appeared to be proportional to the window mesh size (Fig. 4.14.1). A comparative fishing experiment with the same cod-end gave slightly different results to the covered cod-end experiment. The first experiment indicated that the 105 mm cod-end with a 120 mm square mesh window and a 120 mm standard diamond mesh cod-end should have similar selectivity. In fact the catch was 25% less in the window cod-end.

4.15 The effect of twine diameter on trawl codend selectivity. - N. Lowry, Denmark (Poster).

An investigation was carried out on the effect of using different twine sizes on selectivity for cod and haddock in the North Sea. Four double twine cod-ends were tested, twines ranging in size from 2.7 mm to 4.8 mm, and 3.6 mm to 5.9 mm single twines. The experiment used a twin trawl with two covered codends of different twine types. The results were equivocal, there was some indication of an effect of increased twine thickness reducing selectivity observable in individual hauls (Fig. 4.15.1) but this effect was not seen in the combined haul analysis due to a high degree of between haul variability.

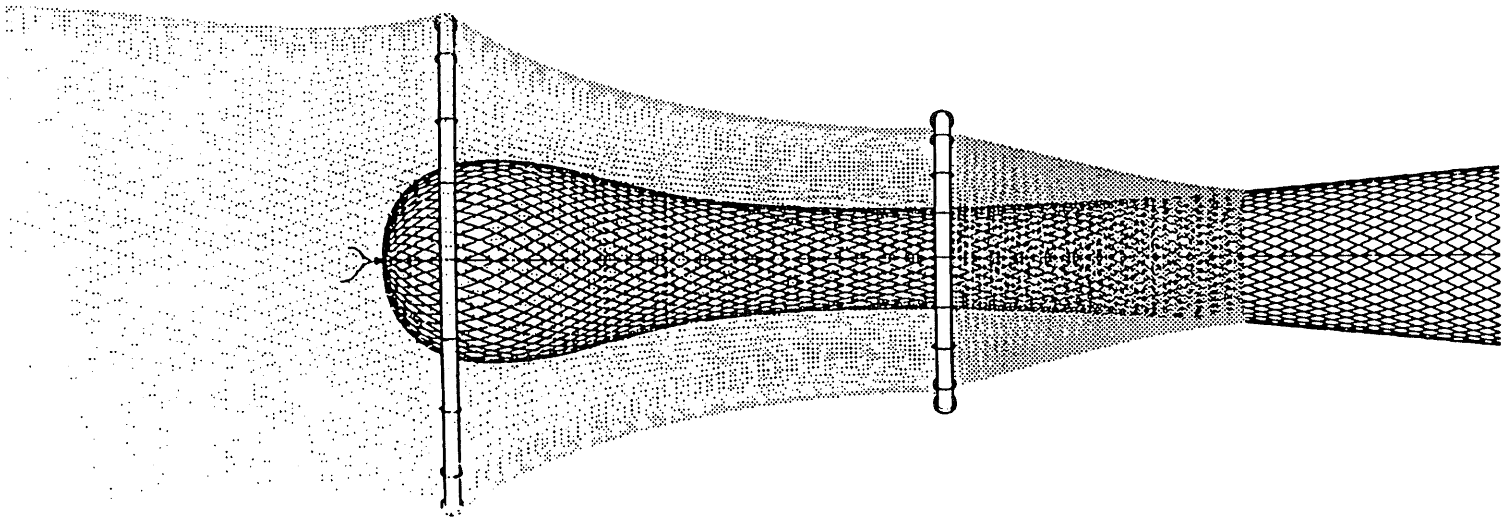


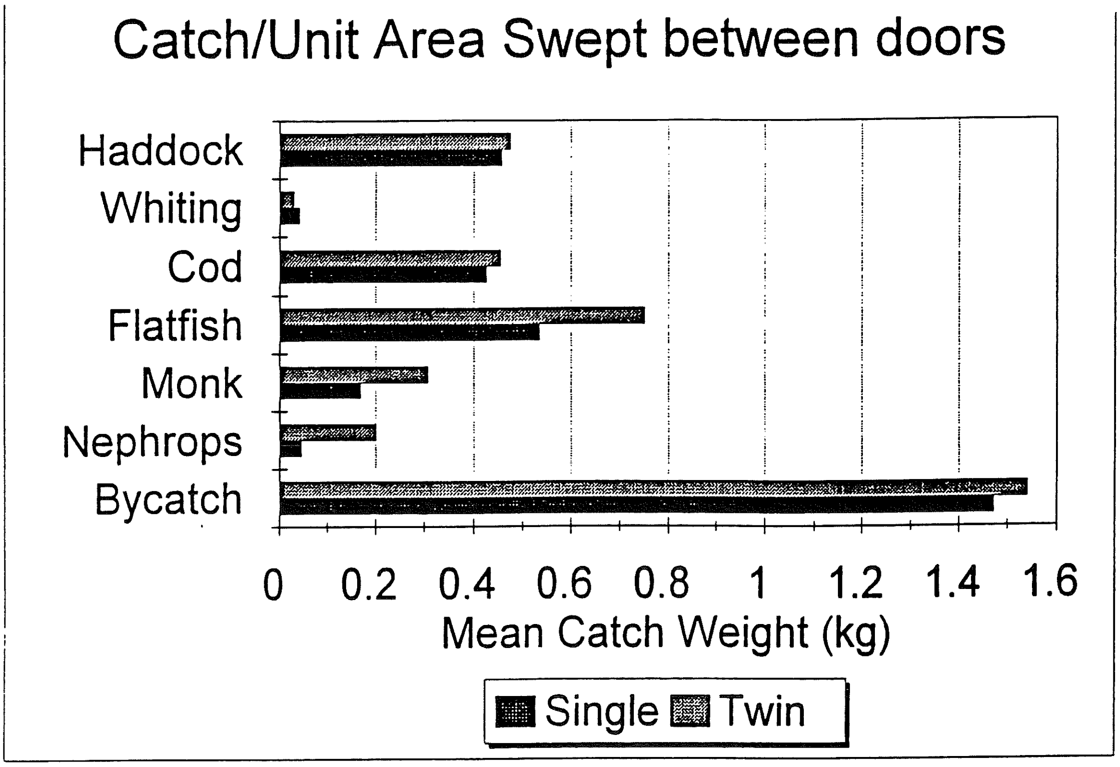
Fig. 4.2.1 The cover fitted with a 3 m diameter hoop made from 62 mm diameter alkathene tube with a 1.8 m diameter external forward hoop fitted at a position 1.6 m from the cover join

Table 4.4.1 Measurements of gear and vessel parameters from the single and the twin trawl experiments

	Single	Twin
Average board spread	83.0m	103.0m
Average wing spread	40.6m	55.2m (combined)
Average headline height	2.3m	2.1m
Average bridle angle	13.3°	6.6°
Average swept area (x 10,000)	152.9m2	180.59m2
Average fuel consumption/haul	51.0 Ltrs/hr	61.0 Ltrs/hr
Average distance between the inner wingends of twin rig.	N/A	26.7m

Table 4.4.2 Statistical analysis of the mean bridle angle per gear type using Student t-test

	Single Mean	n	Twin Mean	n	T value	T critical value	d.f.	P
Haddock*	0.929 0.093	27	0.473 0.031	25	5.20	2.014	45	0.0000
Whiting	0.0835 0.0083	27	0.0312 0.0030	25	5.95	2.037	32	0.0000
Cod	0.869 0.083	27	0.455 0.035	25	4.60	2.032	34	0.0001
Flatfish*	1.087 0.090	27	0.750 0.048	25	2.50	2.016	44	0.016
Monk	0.346 0.042	27	0.307 0.027	25	0.78	2.017	43	0.44
Nephrops	0.0923 0.015	27	0.200 0.032	25	-3.04	2.035	33	0.0046
Bycatch*	3.00 0.27	27	1.541 0.12	25	4.99	2.014	45	0.0000



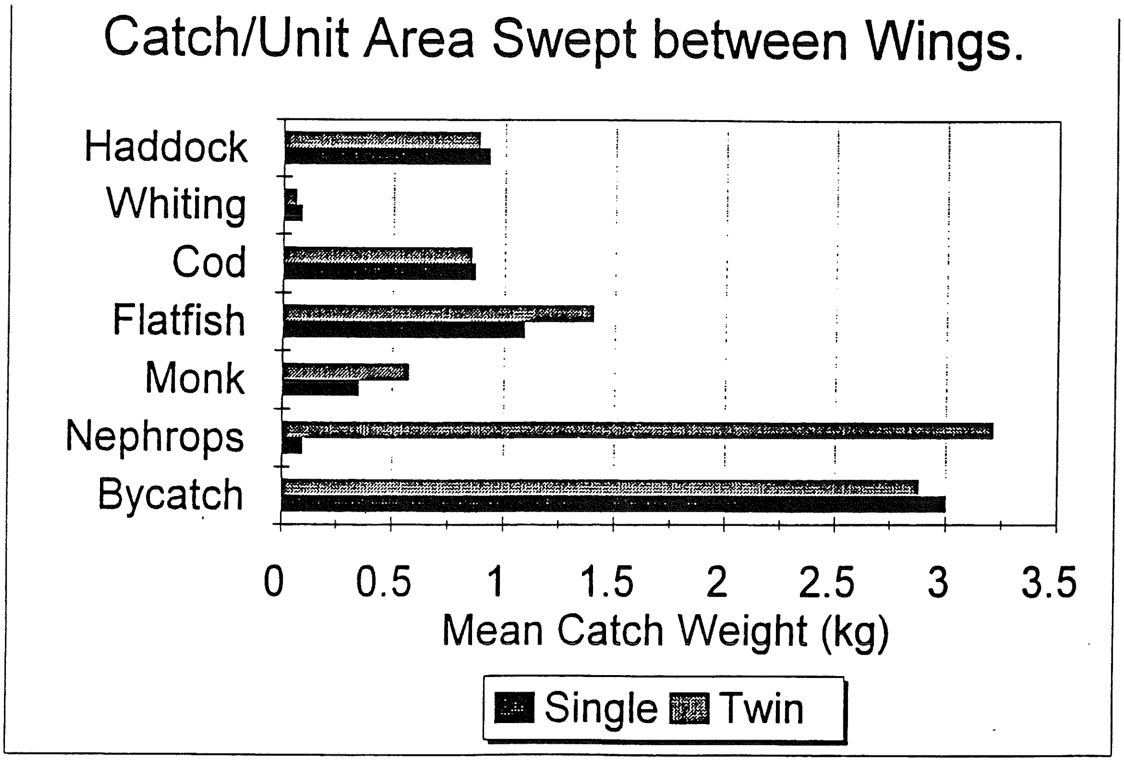
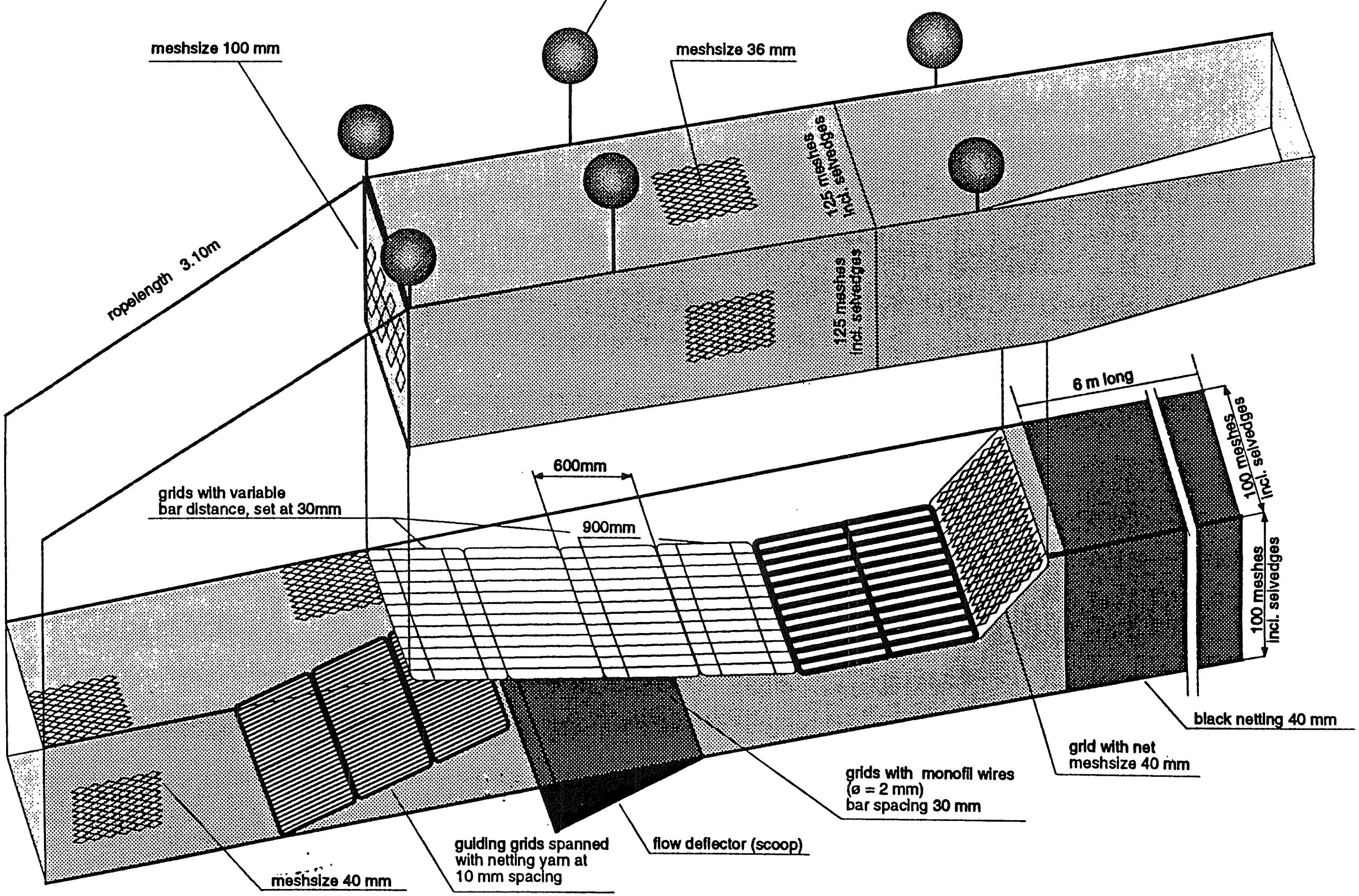


Fig. 4.4.1 Comparison of catch per unit area using door and wing spreads of the single and twin trawls.

Fig. 4.5.1 **Grid-arrangement IV**
TRIDENS 94 : Haul 9-16
Project TE-3-613



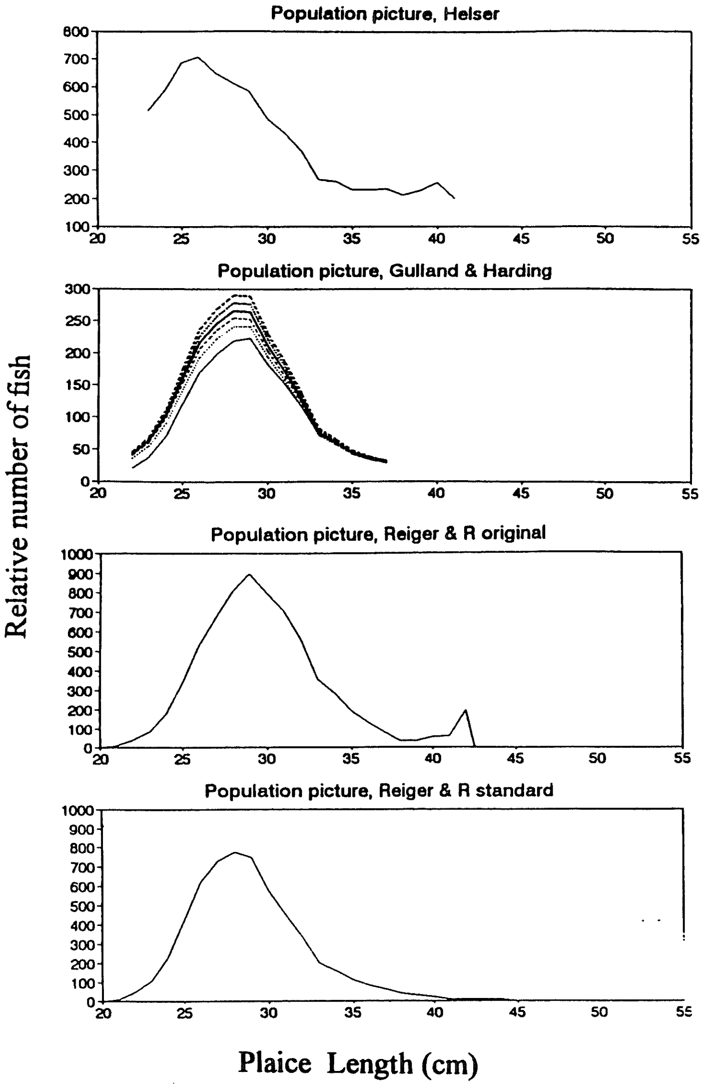


Fig. 4.6.1 Population Composition as a result of the selectivities produced by the methods of Helser, Gulland & Harding and the two variants of Reiger and Robinson. The G.H. pop. is the result of a start and 5 iterations from the bottom

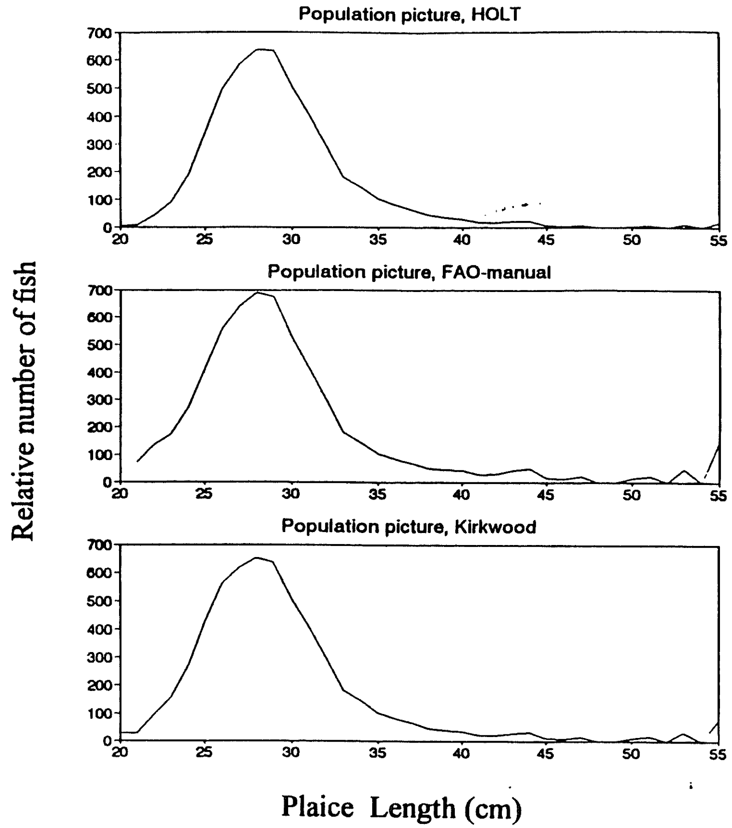


Fig. 4.6.2 Population composition as a result of the selectivities produced by the methods of Holt, FAO and Kirkwood.

Method	Reference
Holt	Holt, S.J. 1963 ICNAF/ICES/FAO Jt. Sci. Meet. Lisbon Contrib S-15:21p
FAO	FAO Manual 1995 DIFMAR (in press)
Kirkwood & Walker	Kirkwood, G.P. and T.I. Walker 1986. Aust. J. Mar. Freshw. Res 37:669-97
Helser	Helser, T.E., E. Condrey and J.P. Geaghan 1990 Can. J. Fish Aquat. Sci. 48:487-92
Gulland and Harding	Gulland, J.A. and D. Harding 1961 J. Du Cons. XXVI 92):215-22
Reiger & Robson	Reiger, H. A. And D. S. Robson 1966 J. Fish. Res. Board Can 23:423-54

Table 4.8.1 Selection parameters of haddock derived from six different diamond mesh sizes

Nominal mesh size (mm)	Actual mesh size (mm)	Combined hauls	50% length (cm)	Selection factor	Selection range * (cm)	Total numbers large mesh	Total numbers small mesh	Number in selection range large mesh	Number in selection range small mesh
90	88.2	3	29.0	3.2	4.9	2324	20044	660	1258
95	94.0	3	31.4	3.3	9.6	3526	15030	235	624
100	98.4	5	30.1	3.0	4.5	5659	25689	1595	2542
105	101.8	5	31.4	3.0	3.7	1324	24211	315	243
110	108.0	3	32.7	3.0	4.1	436	23798	150	295
120	118.0	4	39.4	3.3	5.9	350	22069	111	203

*Based on nominal mesh size

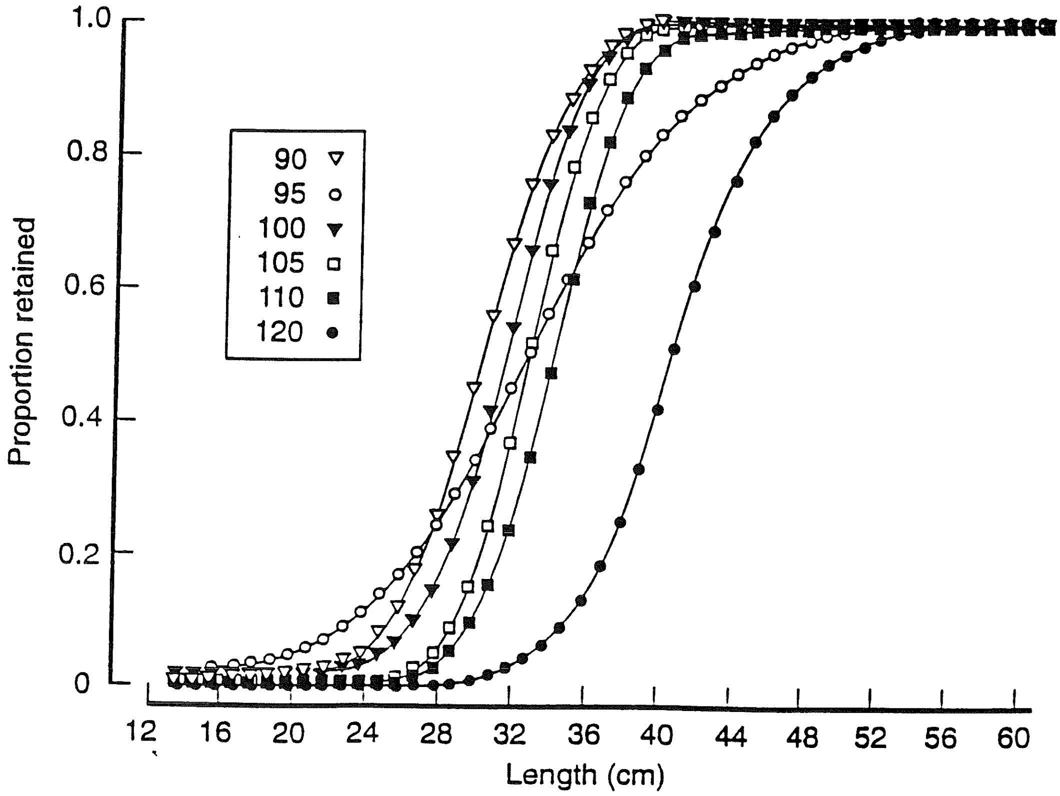
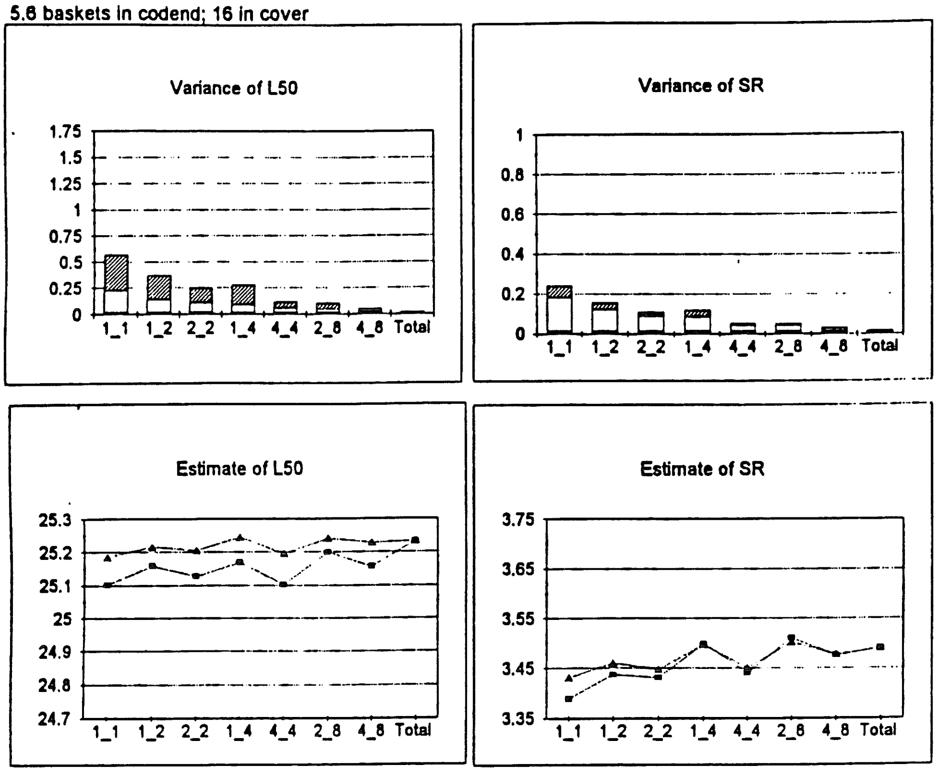


Fig. 4.8.1 Mean selection curves of haddock for six diamond mesh sizes

Fig. 4.10.1 Effects of sub-sampling on the accuracy of selection parameters for haddock
Notation: 1_4 means that 1 basket was sampled from the codend and 4 from the cover

Quite well mixed haul
5.6 baskets in codend; 16 in cover



Poorly mixed haul
5.5 baskets in codend; 28.3 in cover

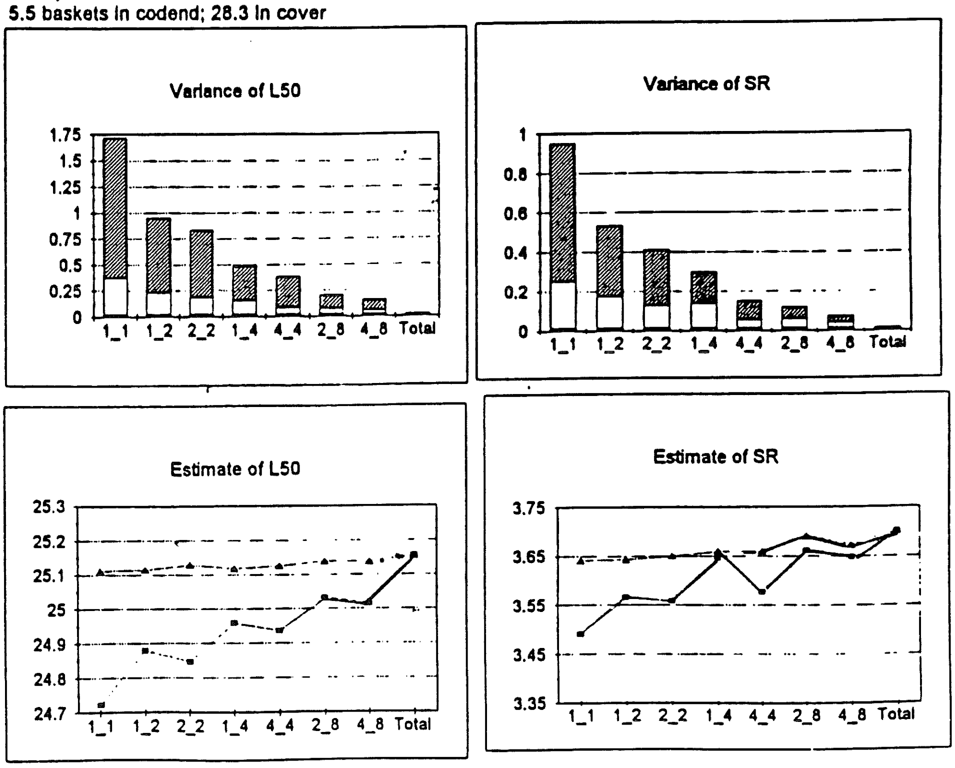


Table 4.11.1 Summary of catches for each of the redfish selectivity experiments using lastridge ropes hung at 88%

Mesh Size (mm)	Lastridge Ropes	Sets	Sampled Catch Results			*Catch (kg)
			# Sampled	Mean Length (cm)	% Under 23cm	
115	No	11	3631	31.0	2.5	34,795
114	Yes	11	3091	33.5	0.5	17,888
108	No	3	1024	26.6	10.0	6,060
107	Yes	11	3571	33.1	0.4	23,398
91	No	6	2304	30.4	10.9	14,536
86	Yes	10	3991	31.9	1.3	34,757

* These catches represent the redfish taken in both legs of the trouser trawl codends.
Note: All experiments were performed between October and December of 1994.

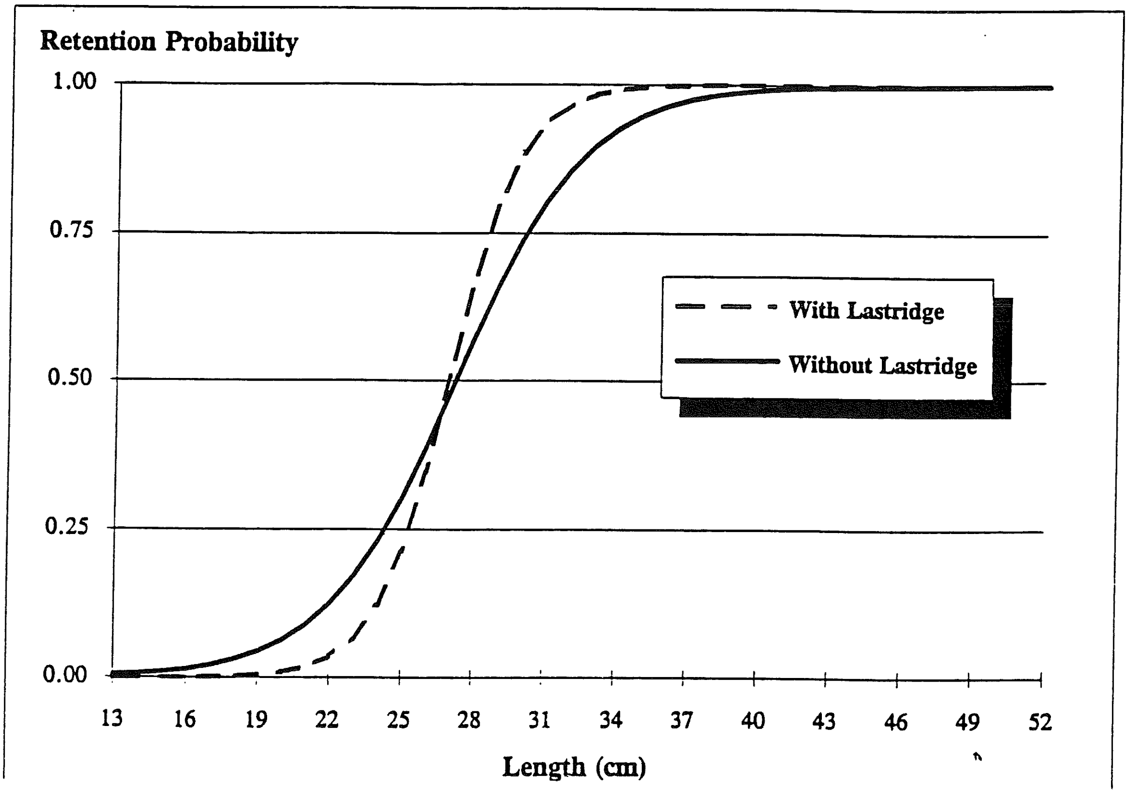
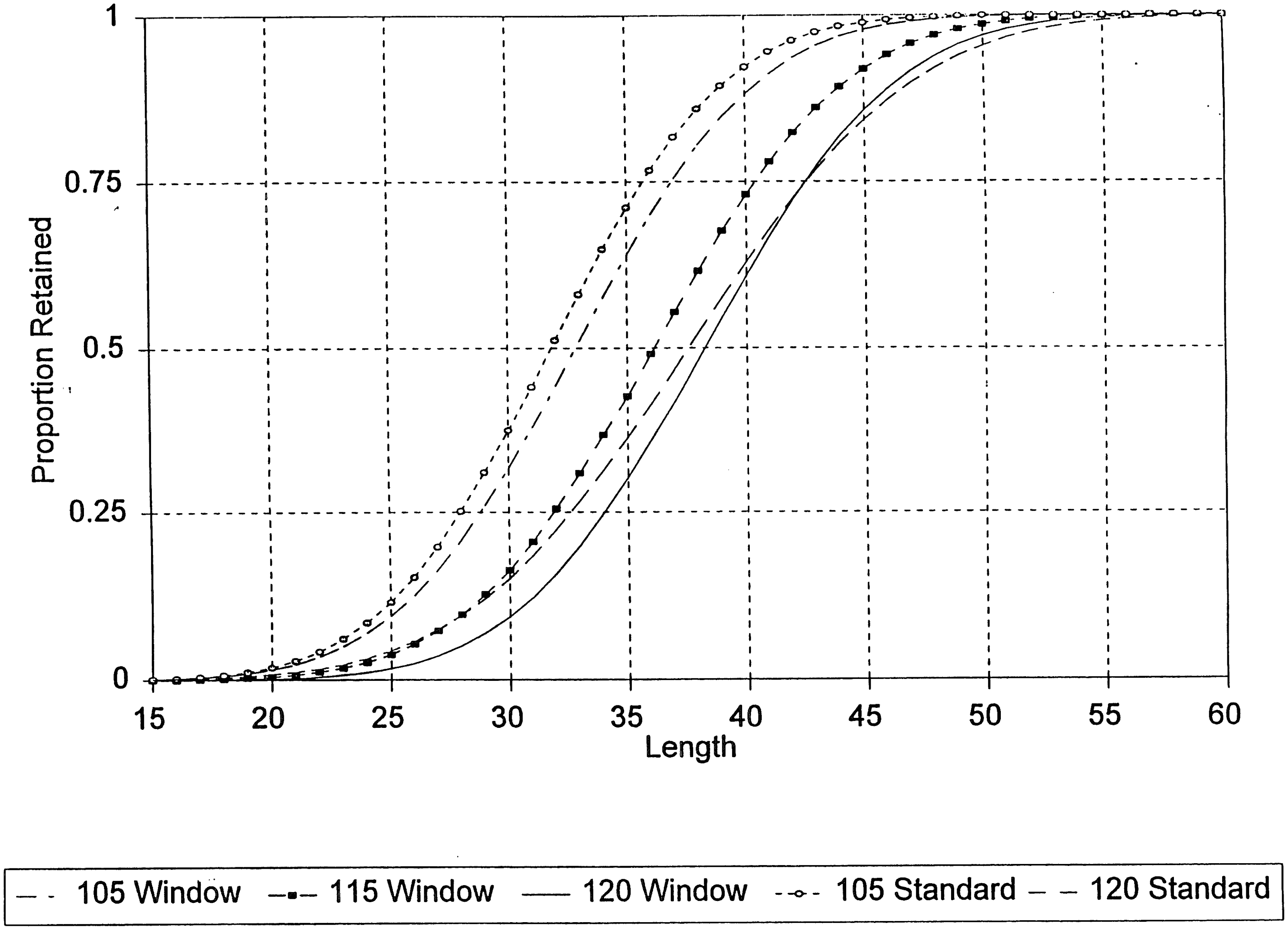


Fig. 4.11.1 Redfish selectivity using 90 mm mesh codends with and without lastridge ropes hung at 88%

Lastridge:	With	Without
a	-17.32	-10.16
b	0.64	0.37
L25 (cm)	25.3	24.3
L50 (cm)	26.9	27.2
L75 (cm)	28.6	30.2
S.R.(cm)	3.3	5.9
S.F.	3.1	3.0

Fig 4.14.1 Selection curves for Baltic Sea cod derived from various configurations



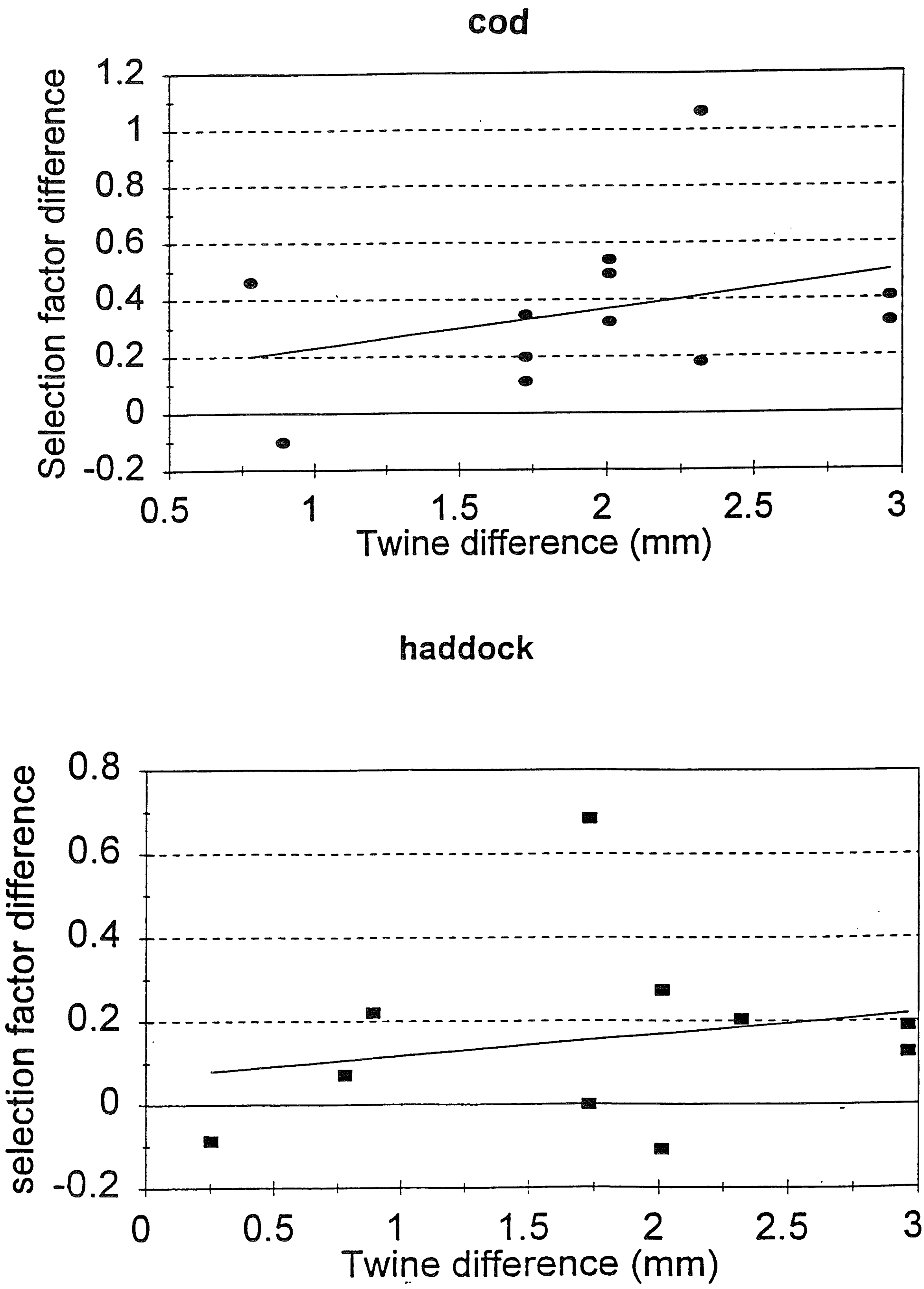


Fig. 4.15.1 Difference in selection factor regressed against twine diameter using individual hauls.

5 FISH BEHAVIOUR STUDIES

5.1 Keynote Presentation The role of fish behaviour in size and species selectivity of fishing gears. - C. S. Wardle, UK

The problem of the many variables in fishing. This seminar dealt with the threshold for active behavioural reactions based on light levels, what happens when there is no light and what effects the daily and yearly changes in light level and water visibility can have. The complications of size effects on species selection and, species effects on size selection were discussed, with examples of swimming performance differences and other factors. Those present were reminded about the additional complications due to variables, such as seasonal temperature and depth, on swimming abilities and the effects on behaviour that might be expected.

Some experimental variables are controllable. The problems in making careful studies, such as comparative fishing trials, were outlined. As was the importance of ignoring visual effects, such as colour of the materials used to construct different parts of the gear under study or use of artificial lights, where both these can cause serious changes in the subtle effects of the underwater light on the gear as a visual stimulus to the fish.

Catch and interpretation of what is going on. The catch of a fishing gear is a result reflecting the combination of many variables. Any interpretation must be based on sound basic understanding and appropriate measurement of the relevant variables. Each variable that can modify the limits to the ability of fish to behave can alter the catch composition. We are beginning to understand these variables and they should not be ignored in any gear development or comparative study.

Codends, ditch jumping, sieves and mesh selectivity. As part of a continuing effort to investigate how cod ends might be made more selective, tank experiments have been developed which investigate the mechanisms whereby fish can be encouraged to swim through the meshes of a confining funnel, modifying the natural behaviour which is to keep clear of them. The most effective cause for fish choosing to pass through the funnel meshes is a complete blockage of the funnel and this is similar to the case at the rear of the conventional codend. In all the tank experiments, an effective illusion has been found to be a tunnel made from black canvas or black meshes. Despite the clear passage along the centre of the dark tunnel, fish in experiments elect to pass laterally around the outside of the dark tunnel, even if this means passing through meshes. This arrangement has now been tried during a variety of research cruises and has continued to convince observers that it is causing large numbers of fish that normally ignore meshes or grids to pass out ahead of the black tunnel. (See Fisheries Research May 1995, vol 23, p157-174). Fish will avoid entering predatory mouth like structures. Changes in contrast can appear like a predatory mouth. In some circumstances fish desperately avoid entering the mouth. **BUT:** These findings have pointed to other problems which can be identified "DITCH JUMPING" behaviour[5]. They are problems common to all panel-windows and grid-windows as well as all gears where fish are required to dodge out through meshes. The problems are listed here:

1. Fish choose to take the clear path away from the netting walls (keep clear of the ditches).
2. The clear path must appear blocked for fish to take to the mesh walls (to ditch jump).
3. The Predatory mouth illusion blocking the clear path is a good way of stimulating ditch jumping.
4. Selection panels or grids positioned in extensions ahead of the codend involve seriously fast water flow on either side of the mesh (create deeper wider ditches).
5. Fish arriving here are already physically exhausted (reduces their ability to jump ditches).
6. Cold seasonally temperatures slows down the maximum speed swimming ability (reduces their ability to jump ditches.
7. Smaller fish have less ability than larger fish to jump ditches.
8. Low light levels reduce the stimulus and glow materials may be needed below certain low light levels to maintain ditch jumping.
9. Ditch jumping involves behavioural decision thresholds effected by 1-6.
10. Hydrodynamic help in the form of local flow modifiers could be useful (bridges!).

5.1.1 Discussion.

The Working Group were concerned if the behavioural responses of fish to fishing gear would change at different densities. There have been observed different reactions by fish in different densities but it was difficult to state that these were simply density dependent responses. As an example, observations of a shoal of saithe swimming into the cod-end of a trawl, which normally individual saithe would outswim, are presumably due to a shoaling fright

[5]**Explanatory note:** Passing through meshes is behaviourally like ditch jumping, where a ditch in human terms is a channel of water blocking the progress of a walk across a field and at some judgeable point might be jumpable, whereas at other points is judged as a barrier and will cause a diversion in the walkers progress. Ditch jumping involves a balance between the individuals ability to jump the prevailing conditions and the judgement of the problem.

reaction. It must be emphasised that when designing any selective device the designer should be aware of the way in which fish react to stimuli. That is, the leap across the "ditch" must be made as easy as possible.

5.2 Studies on the use of visual stimuli to control fish escape from codends. - C. Glass, UK.

A school of Atlantic mackerel (*Scomber scombrus*) was conditioned to circulate a large swimming pool tank, passing through a constricting funnel of netting on each circuit. The funnel comprised two panels of netting (400 mm square mesh) narrowing to a central gap (0.6 m x 0.9 m). The proportions of fish passing through the meshes of the funnel were noted in three experimental conditions. When given a clear path through the funnel almost all the fish avoided the meshes and over 92% of the fish crowded through the gap. When faced with a fine mesh (35 mm) netting panel blocking the gap, all fish passed through the meshes of the funnel itself. When a black-walled open-ended tunnel was positioned beyond the opening of the gap all the fish passed through the meshes of the netting panels and none through the gap and black tunnel. These experiments confirm that fish keep clear of netting panels and are reluctant to pass through large meshes when a clearer passage is available to them. They also show that fish will pass through meshes when the alternative route is blocked or appears in some way (black tunnel effect or visual illusion) to be a less clear route. The results are discussed in relation to the role of fish behaviour in the selective efficiency of full-scale fishing gears.

Observations were made at sea to quantify penetration of meshes by fish caused by addition of a black tunnel behind three different open mesh netting configurations in the extension region of an otter trawl. A Marine Laboratory "North Sea" 600 hp four-panel trawl was used throughout the study. A remotely controlled television system was positioned alongside the extension area of the net and observations of fish behaviour (mainly haddock and whiting) in natural lighting conditions were recorded on videotape for later analysis. The proportion of those fish entering the extension which escape through the meshes was determined. With the black tunnel in place the behaviour of the fish was modified and despite their exhausted state fish swimming towards the codend were seen to turn and swim ahead of the tunnel. Fish approaching the tunnel tail first was seen to speed up and attempt to hold station ahead of it. In both cases fish appeared reluctant to enter the tunnel and many were observed attempting to pass through the open meshes ahead of the leading edge of the tunnel. The proportion of fish escaping from the three net configurations without a tunnel was low but increased with addition of the black tunnel. With a square mesh extension the effect of the tunnel was to raise the proportion escaping from around 18% to 77%. With a square mesh window, numbers escaping rose from 20% to 60% and, even with diamond meshes ahead of the extension, the proportion escaping rose from 5% to 40%. The results are discussed in relation to the selective efficiency of towed fishing gears.

5.2.1 Discussion.

The Working Group expressed concerns as to whether this system would work at low light levels, especially at night. It was agreed that below the dark adaption threshold of the fish this behavioural response would not happen. In addition, while a fluorescent panel could be used to compensate for the low light levels, this was difficult to assess, as there are no visual imaging systems that will currently work in such low light conditions. The "escape" response varied according to the fishes orientation in the net. When passing into the net tail first, as the tunnel approached the fish would swim faster and hold station with the tunnel, and eventually attempt an escape. However when entering head first the fish will either turn and hold station or immediately attempt an escape. In addition, the responses seen in the work so far do not appear to vary between different species. It was noted that this behavioural response is likely to break down when a large catch is washed passed the tunnel at high speed. In addition the Working Group noted that such a gear design would be extremely difficult to legislate for, in that its use could have to be limited to particular times of the day and year The Working Group stressed how this work exemplifies the importance of measuring and using fish behaviour in selectivity studies to achieve desired results.

6 SURVIVAL STUDIES

6.1 Survival of shrimp and small fish in the inshore shrimp fishery in Iceland. - G. Thorsteinsson, Iceland

This paper is a part of a Nordic project on the survival of shrimp and small fish. The experiments were carried out by a research vessel in Ísafjarðardjúp, NW Iceland, in September 1994. Generally, the survival of shrimp which pass codend meshes was high (Table 6.1.1). However, the survival of discarded shrimp was very low, unless the shrimp was discarded immediately after being brought on deck Table 6.2.2. The survival of small fish in cages where escaping shrimp and fish were kept, was generally low. Direct observations indicated that the main reason for the mortality was captivity together with the shrimp and not the passing through the codend netting. However, the low number of 0-group gadoids prevents a significant statement.

6.2 A revised method of assessing skin damage to fish escaping from trawl codends. - M. Breen and G. Sangster, UK (Poster)

Methods for assessing the damage to skin of fish escaping from trawl codends have previously used simply visual estimates. A method is described in which the area of skin damage for two gadoid species, haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*), is assessed objectively. Damaged skin is stained and photographed, and an accurate estimate of the damaged area relative to the fish is calculated using image analysis techniques. In addition, an histological description is included of the normal skin structure of the two gadoids and the varying degrees of damage sustained by these tissues. An attempt is made to relate the varying degrees of damage sustained by skin tissue to the form of staining seen.

6.3 Trawl deck discards: Assessing the handling and survival of three groundfish species. - A. Carr, USA (Poster)

Juvenile groundfish deck discards and codend escapees were collected during normal fishing operations during the summers of 1993 and 1994. Tow durations were either one or three hours. Once landed juvenile Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*) and yellowtail flounder (*Pleuronectes ferruginea*) were placed in one of three deck treatments, wet, spray or dry bins, for a set period of time. Survival rates were determined by placing the "discarded" fish in large cages and returning them to the tow depth for a period of about 72 hours. Codend escapee survival was determined by releasing a codend cover/cage approximately 20 minutes into the tow and returning them to depth for a period of 24 or 72 hours.

Deck discarded was the only species to show differential survival according to both tow duration and deck treatment. Cod showing the highest survival (25%) were from one hour tow - dry trays. Cod showing the worst survival were from the one hour tow - wet trays (0%). Neither flatfish species showed any difference in their survival according to deck treatment. Both showed somewhat better survival from one hour tow durations than two hour tow durations. For codend escapees, during the first cruise all three species studied had high 24 hour survival (cod had 83% and both flatfish had 96% survival). After these survivors were held for an additional 72 hours, 94% of the cod survived whereas only 68% and 39% of yellowtail and American plaice survived, respectively. During the second cruise, cod and yellowtail flounder both showed high survival (96% and 90%, respectively) while American plaice had only 41% survival after a 72 hour soak in the codend cover. Survival of escaped fish of each species was substantially higher than fish handled as "discard". Blood biochemical measurements revealed that all treatment groups of cod and yellowtail were highly stressed as soon as they were landed when compared to "control" values. Control values were acquired from fish held in captivity for 14 days and from values obtained from a previous study. Conclusions made from comparisons of these values obtained from captive animals to values obtained in the field do not take into account the stress induced changes endured by control fish due to net capture or the out of water sampling of blood. The only physiological indicators that showed alterations with increased survivability in cod were glucose and haematocrit.

Table 6.1.1 Mortality estimates of shrimp passing through square and diamond mesh codends

Sta. nr.	Codend type	Towing time(min)	Mean depth(m)	Catch (kg)	Weight in cage(g) shrimp	fish	Time in sea (h)	Mortality (%)
838	diamond	21	82	77	22199	1195	233	13.8
839	no	2	83	-	33392	1323	213	8.1
841	square	15	94	223	59703	6934	47	6.9
849	diamond	5	58	191	193	1159	10	42.9
850	no	2	56	-	659	8485	24	14.9
851	square	24	60	10	3159	206	71	1.7
852	no	17	64	-	11847	5188	68	1.9
853	diamond	15	57	71	30370	44800	51	0.5
854	no	10	64	-	32300	1009	23	1.2
855	square	25	56	22	14173	1139	46	2.3
859	square	8	54	58	3144	3307	20	2.6

Table 6.1.2 Mortality estimates of discarded shrimp

Sta. nr.	Codend type	Towing time(min)	Mean depth(m)	Catch (kg)	Time on deck(min)	Time in cage(h)	Mortality %
845	square	30	84	1122	19.50	20	71.9
845	square	30	84	1122	35.05	20	94.4
849	diamond	11	58	191	4.40	10	62.1
859	square	33	54	85	1.25	23	15.1

7 SURVEY TRAWL STUDIES

7.1 The multisampler: A system for remotely opening and closing codends on a sampling trawl. A. Engås, R. Skeide, C. W. West, T. Ward and B. Foss, Norway

The Institute of Marine Research has, in cooperation with SCANMAR, developed a new multiple codend system for sampling trawls. The system has been used in a large, pelagic trawl and was controlled by a wireless hydro-acoustic link (Fig. 7.1.1). This new device enables scientists to bring up samples from discrete layers in the water column, without influence from fish and organisms in different depths. Apart from the fact that the system will give better samples and information of the fish composition in the water column, the benefit will also be the rationalising effect in having three samples in one single trawl haul.

7.1.1 Discussion.

The Working Group noted that this system could be used for a time series survey, but the authors emphasised that the trawl must be flushed out between samples to prevent cross contamination. The sampling device weighs 80 kg in air, but is neutrally buoyant in the water due to the addition of floats and its dynamic lift. It can be quickly installed on many different types of trawls and although only installed on a pelagic trawl other configurations or applications can be accommodated within the concept.

7.2 Measure of 3D geometry of trawl scale model in the IFREMER-Lorient flume tank by video picture analysis. M Meillat and D Marichal, France

In the past it was impossible to obtain the complete geometry of a trawl net model in a flume tank. With a spyglass moving along two graduated rules it was possible to determine positions of some characteristic points of our model, in a vertical plain. This spyglass was placed in front of the lateral observation window. It was also possible to measure wing spread with the observant placed above the flume-tank. This method was neither accurate nor complete. A new method was developed to obtain the complete geometry of the trawl scale model. It uses a video camera submerged in the flume-tank and placed behind the model. The video signal goes to a conversion card placed in a computer and gives a digitised image of the trawl. All the points of the trawl are illuminated by a laser lamp moving on a trolley. With this conversion card, the screen positions (in line and column) of these points are obtained. After calibration of the video picture, the real positions of each illuminated point is calculated. Thus, it is possible to reconstitute the 3D form of the trawl Fig. 7.2.1).

7.3 On the influence of the roller gear on the catch composition of *Nephrops* in a trawl. E. Dahm and H. Wienbeck, Germany (Poster)

A number of scientists working on *Nephrops* assume losses in considerable amount of the fishable biomass before the trawl. The poster presented quantifies this assumption by example of a normal groundfish trawl with a roller gear. The escaped crayfish were caught by a bag-net system running underneath and behind the ground rope. Thus, only 8.9% of the available marketable prawns got into the main codend. In the case described the roller gear showed the same selective characteristics as the meshes of a codend with an L50 of 11 cm total length and a selectivity range of 3 cm (Table 7.3.1; Fig. 7.3.1). The authors question the effect of any codend mesh size regulation protecting smaller animals if no regard is taken to the ground gear selection before the trawl and suggest a research program investigating this more closely also on commercial *Nephrops* gear.

7.4 Escapement of fish under the fishing line of the GOV trawl at different fishing places of the North Sea. H. Wienbeck, Germany (Poster)

A recent ICES paper describes a footrope for the standard GOV-trawl which ought to reduce much of the escape observed in other trawls. The poster presented shows that this assumption is far from being correct. The GOV in its present configuration shows length and species dependent escapement beneath the ground rope (Fig. 7.4.1). The situation is worsened by the fact that for unknown reasons this phenomenon shows up in differing importance at different fishing areas (Fig. 7.4.2). The results question the suitability of the GOV as a tool of a young fish survey.

7.5 Survey trawl standardisation used in groundfish surveys. B. R. McCallum and S. J. Walsh, Canada (Poster)

The variability in survey trawl efficiency is one component known to contribute to the variance in bottom trawl abundance estimates. Survey gear efficiency is dictated by a myriad of physical, environmental and human influences, some of which can be actively addressed and controlled to reduce the variability in gear performance and capture efficiency. This paper discusses aspects of survey trawl mensuration and standardization work ongoing at the Northwest Atlantic Fisheries Centre, Canadian Department of Fisheries and Oceans in Newfoundland, since 1989. Detailed, precise and unambiguous net plans, a quality control program enforcing manufacturing and construction tolerances on key dimensions of the survey gear (Table 7.5.1) and a ergonomically designed checklist for use by technicians at sea are elements designed to ensure a high level of conformity to original specifications. The training of research vessel crews, technicians and scientific staff in gear technology and survey methodology are discussed in addressing the human element of standardization. Survey trawl performance is routinely measured on groundfish surveys using SCANMAR hydroacoustic instrumentation requiring the development of specialized data collection software and edit criteria (Fig. 7.5.2). The application of hydroacoustic trawl instrumentation and trawl mensuration data to improve survey abundance estimates is discussed.

7.6 Survey trawl mensuration using acoustic trawl instrumentation. S. J. Walsh, B. R. McCallum and M. F. J. Veitch, Canada (Poster)

Bottom trawls are used in ocean environments to measure abundance, distribution and diversity of organisms which inhabit near-bottom waters. The "standard trawl" chosen by Newfoundland's fisheries institute, the Northwest Atlantic Fisheries Centre, was a common commercial trawl in use at the time: an Engel 145 High Lift Otter Trawl. It has been the primary groundfish sampling trawl for the FRV *Gadus Atlantica* since 1979 and the FRV *Wilfred Templeman* since 1983. However, in the absence of construction, repair or fishing protocols these trawls have evolved independently, to vary significantly in design, rigging and fishing operation. Measurement error related to trawl performance can contribute significantly to the variability in the precision of trawl estimates of the resource, however, this has never been investigated with these gears. Northern cod (Labrador-Newfoundland), *Gadus morhua*, indices are derived from combining estimates from both trawls; under the assumption that both trawls are identical and that there is no difference in their fishing power.

SCANMAR acoustic trawl instrumentation was used to measure and compare trawl performance of both versions of the Engel 145 trawl. For surveys using combined indices from both vessels, it has been assumed that a) the trawls and fishing protocols are identical; b) for a standard fishing tow the swept area is constant for different depths and under varying towing conditions; c) there is no difference in mesh selection; and d) there is no significant difference in trawl catchability. The validity of these assumptions is strongly questioned

The results show that the larger trawl doors (5.8 m^2) on the G. Atlantica considerably overspreads the survey trawl when compared to the trawl doors (3.8 m^2) of the W. Templeman. This would explain the large differences in doorspread and wingspread (see Fig. 7.6.1), bridle angles and hence swept area. These differences in geometry and herding efficiency (bridle angles) are expected to affect catchability of the Engel survey trawl on each vessel.

7.7 Warp calculation for bottom trawling. W. Dickson, Norway (Handout)

A computer program was developed which calculates the warp length required for any required depth. The inputs are: the weight of the otterboard in water, the proportion of otterboard weight to be eased off bottom, warp diameter, warp unit weight in water, warp drag coefficient, warp skin friction coefficient, water speed, warp tension at the bottom, depth plus the height of the towing point above the surface and minus the height of the otterboard towing point above the otterboard keel (Fig 7.7.1).

The water speed is assumed to be constant throughout the water column. The program starts with the required conditions at the bottom end of the warp adding on usually 10 m lengths until the surface is reached. The outputs are warp length required, scope, warp tension at the top and warp declination at the top. These last two being useful shipboard monitoring parameters.

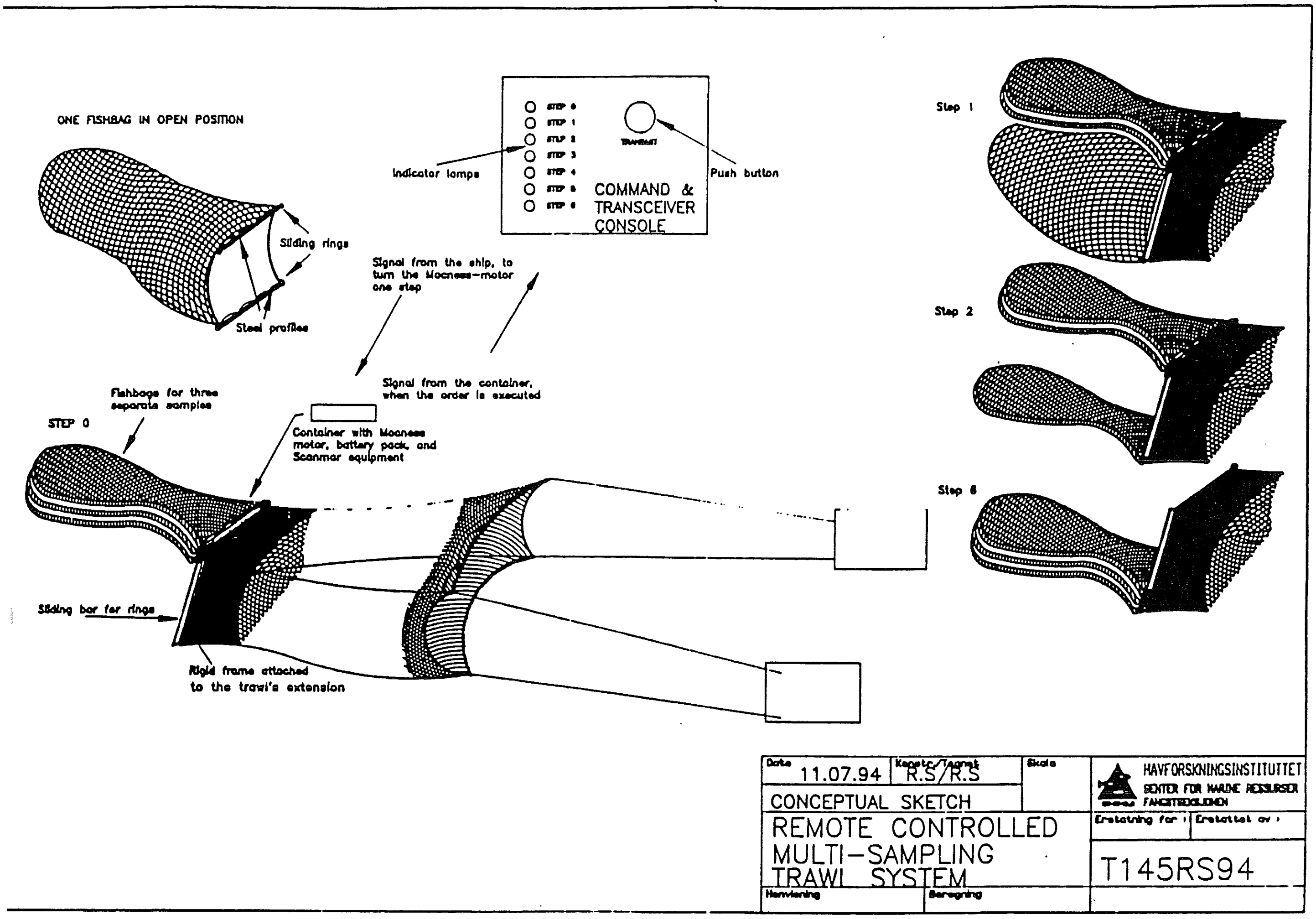


Fig. 7.1.1 Multi-Sampler: a remote controlled multi-sampling trawl system

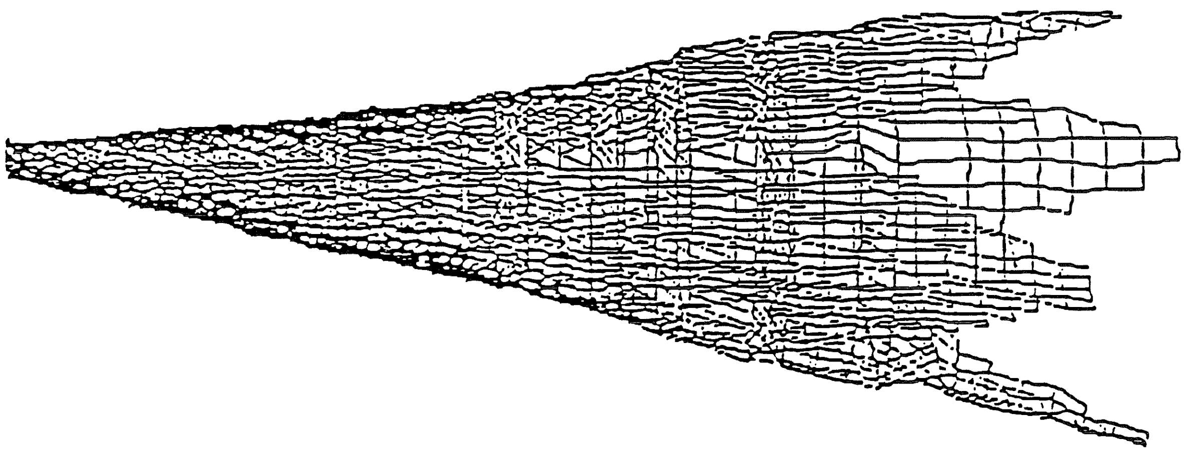


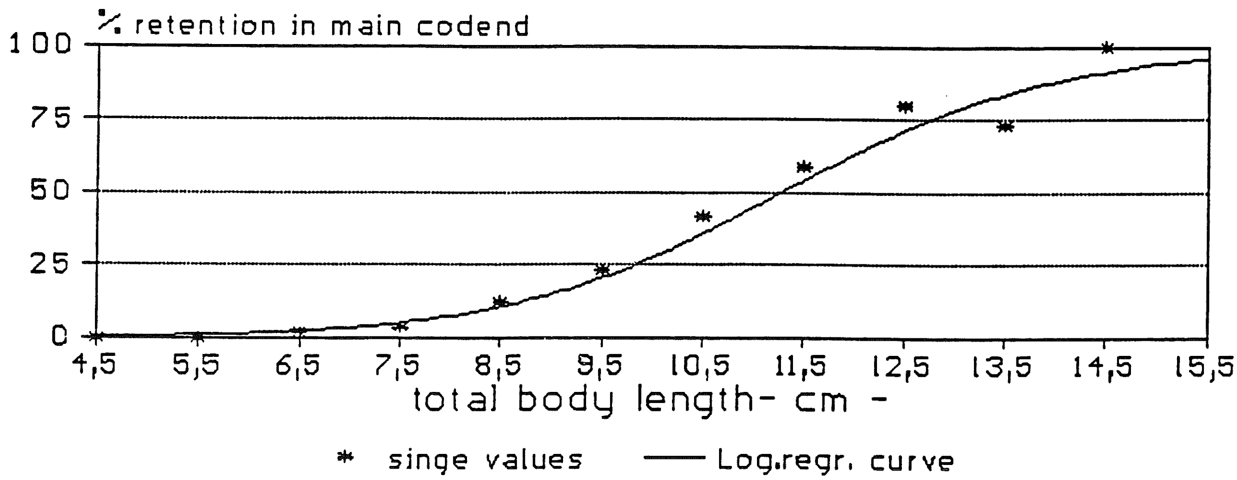
Fig. 7.2.1 Reconstructed trawl picture derived from a video image analysis system

Table 7.3.1 Length distribution of Nephrops catches in the main codend and the 3 bag nets mounted underneath the trawl taken at Farn Deeps

Length Total -mm-	catches in numbers main codend	bag net middle	bag nets wings
4.5	-	-	19
5.5	-	9	83
6.5	11	68	501
7.5	34	181	707
8.5	79	173	389
9.5	128	141	289
10.5	88	46	77
11.5	33	20	3
12.5	16	1	3
13.5	11	1	3
14.5	1	-	-

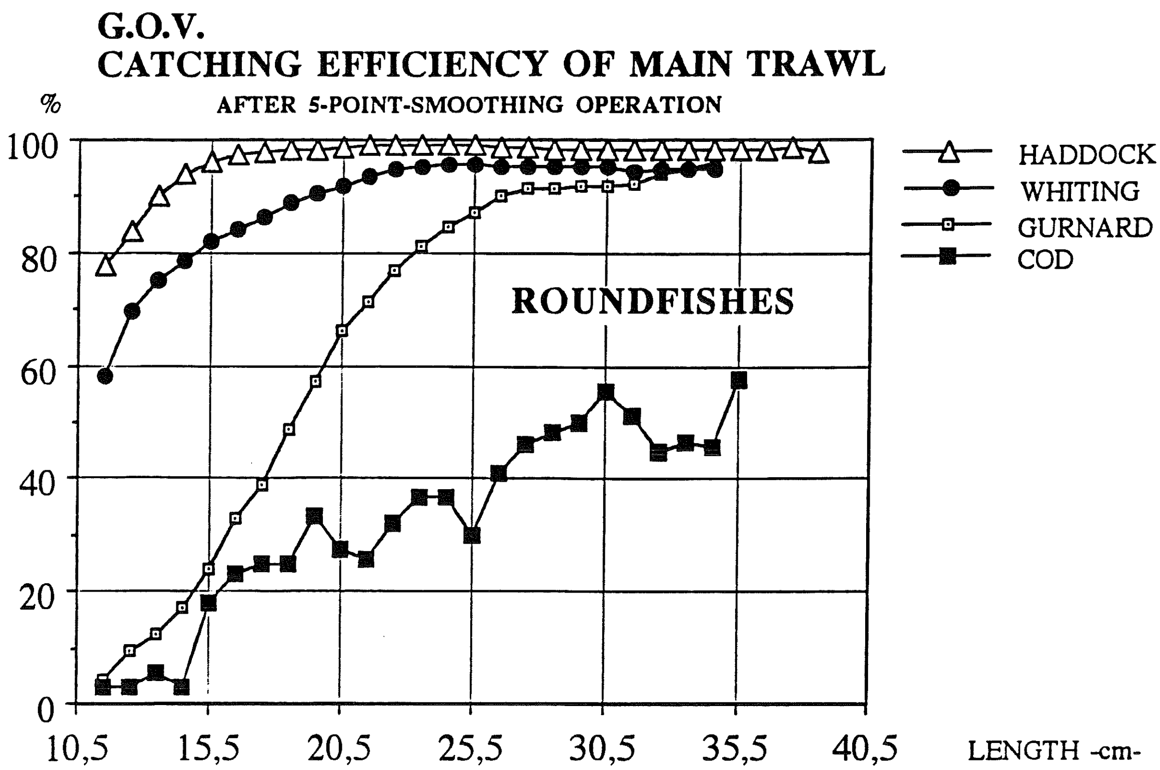
Fig. 7.3.1 Catching efficiency of codhopper for Nephrops norvegicus

Selection by the roller gear

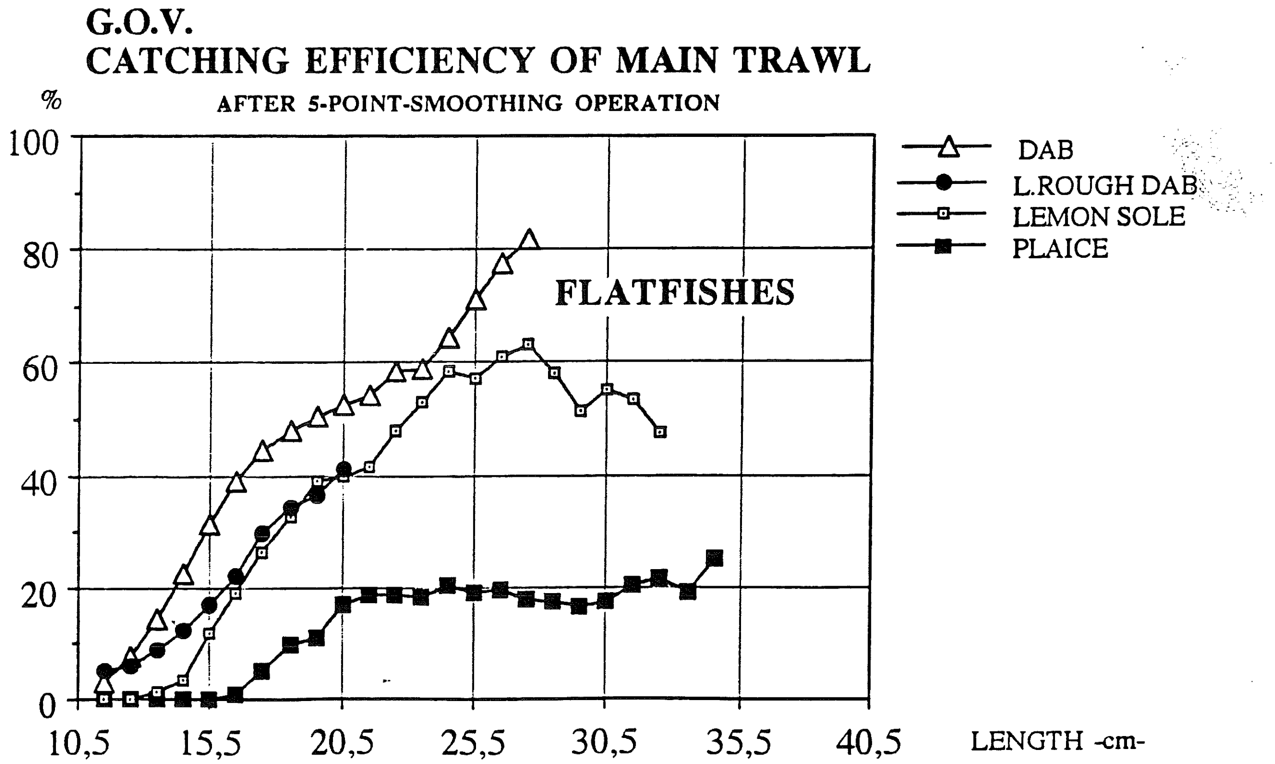


n=3115

Fig. 7.4.1



G.O.V.
CATCHING EFFICIENCY OF MAIN TRAWL
%
AFTER 5-POINT-SMOOTHING OPERATION
100
80
60
40
20
0
10,5
15,5
20,5
25,5
30,5
35,5
40,5
LENGTH -cm-
HADDOCK
WHITING
GURNARD
COD
ROUNDFISHES



G.O.V.
CATCHING EFFICIENCY OF MAIN TRAWL
%
AFTER 5-POINT-SMOOTHING OPERATION
100
80
60
40
20
0
10,5
15,5
20,5
25,5
30,5
35,5
40,5
LENGTH -cm-
DAB
L.ROUGH DAB
LEMON SOLE
PLAICE
FLATFISHES

POSITION OF THE FISHING PLACES

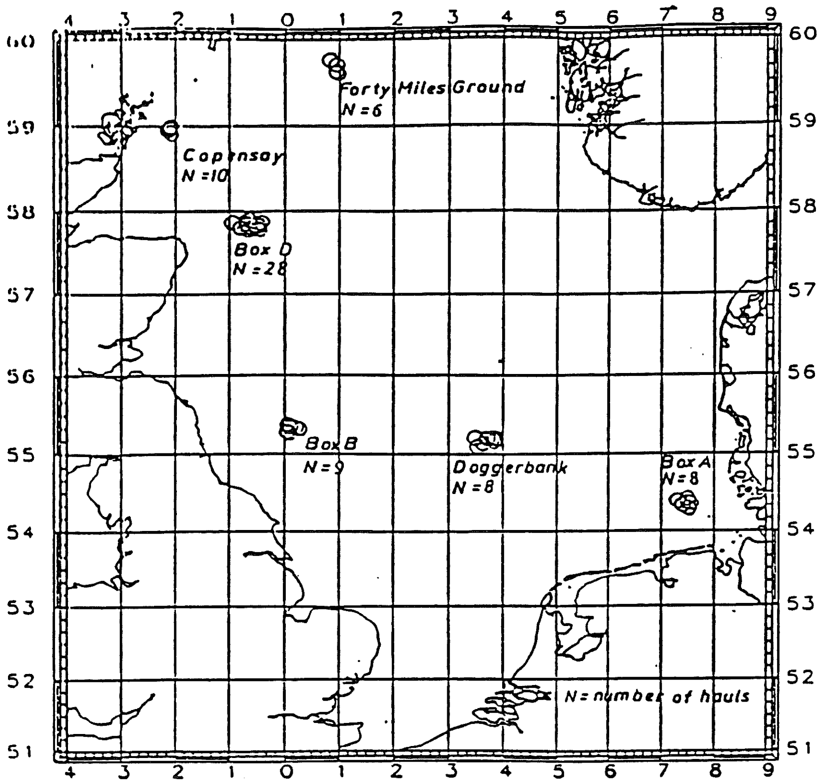


Fig. 7.4.2 CATCHING EFFICIENCY OF MAIN TRAWL AT DIFFERENT FISHING PLACES

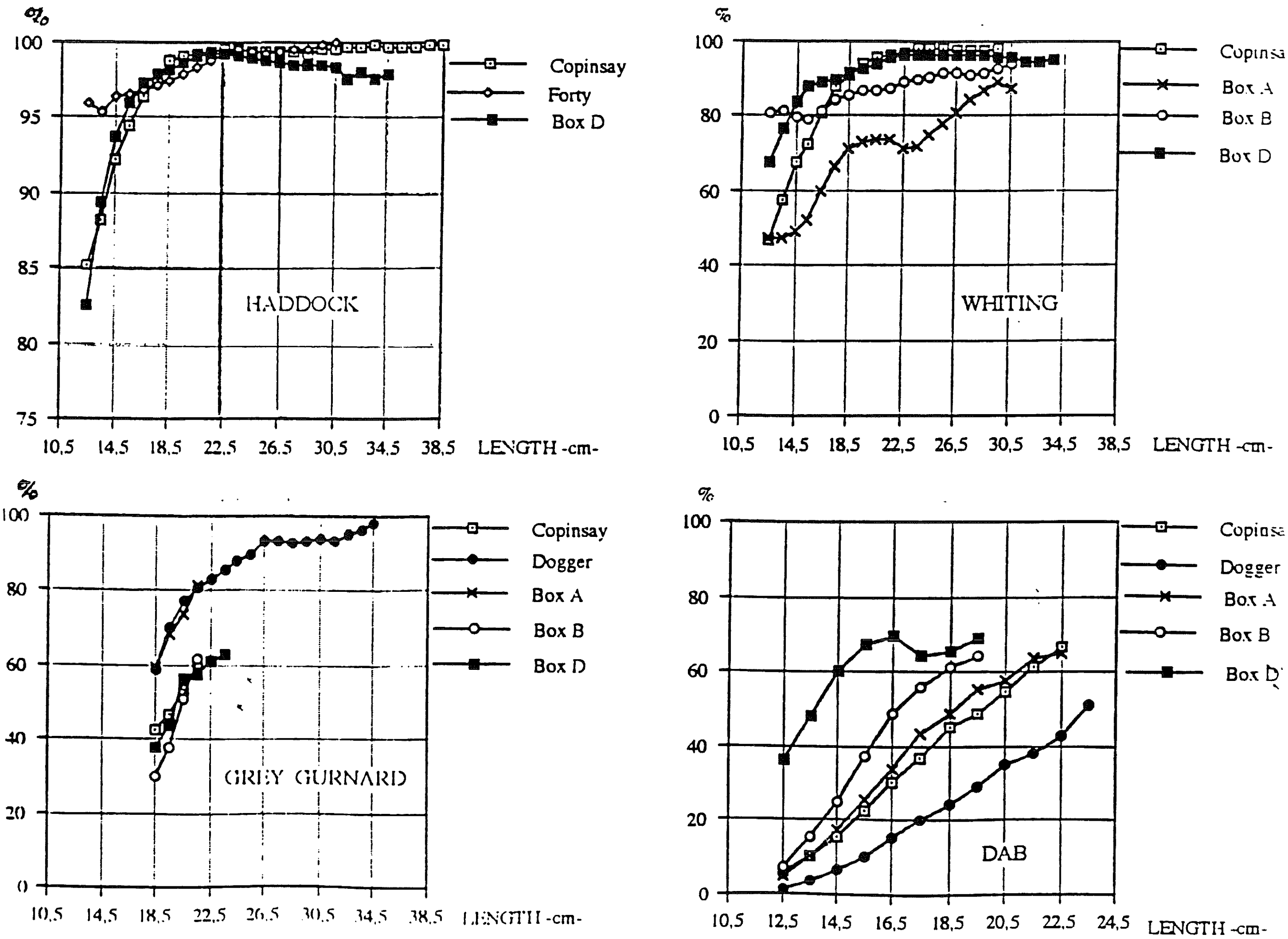
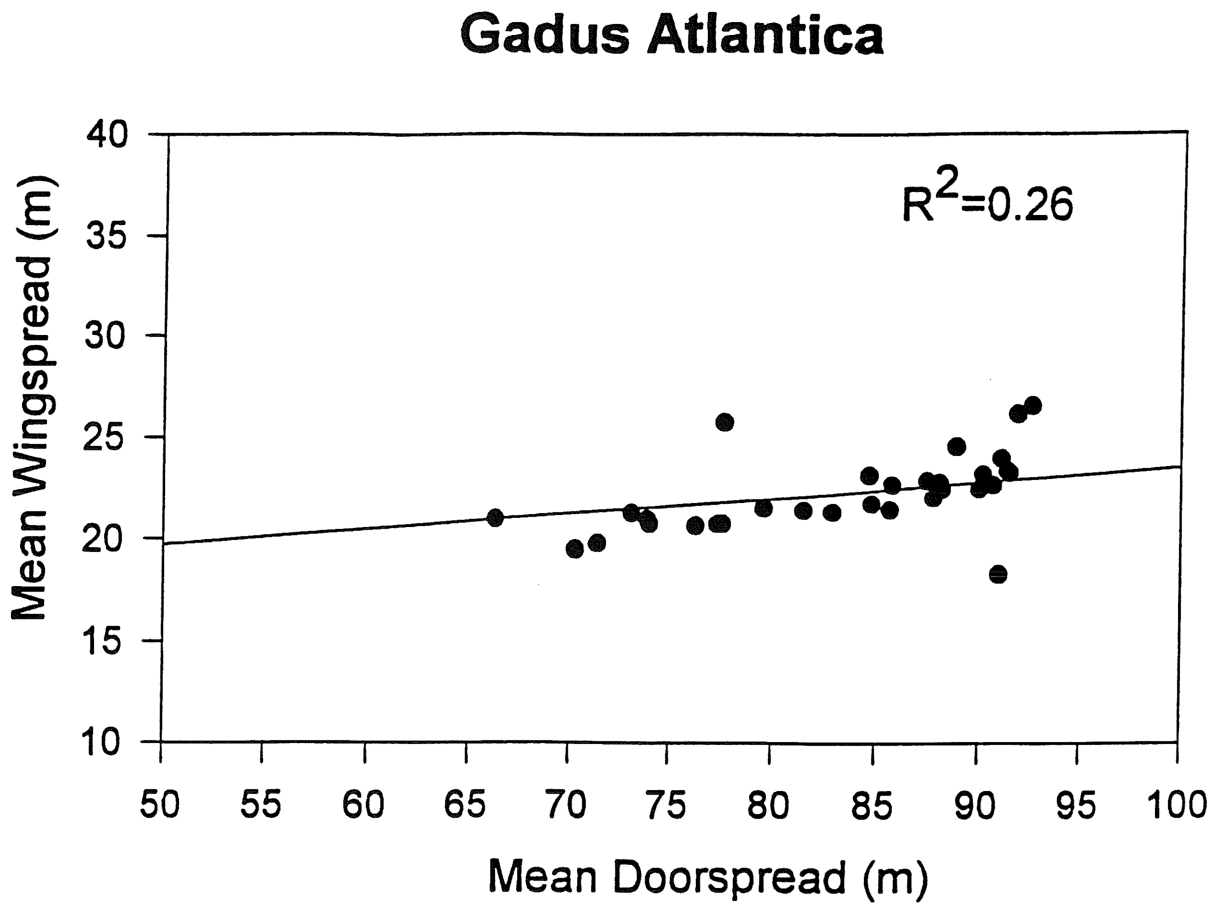


Table 7.5.1 Significant specifications and associated tolerances for the Engel 145 survey bottom trawl

Component	Specification	Tolerance	Procedure
Wire and Rope	Length	+/- 0.5%	P1
	Diameter	No substitute	Manufactures spec.
	Material	No Substitute	Observation
	Weight (U.L.)	+/- 2%, warp +/- 1%	P1
	Min. Breaking Strain	≥	Manufacture spec.
Chain	Length	+/- 0.5%	P1, nearest link
	Material	No substitute	Observation
	Weight (U.L.)	+/- 2%	P1
	Min. Breaking Strain	≥	Manufactures spec.
Floats	Buoyancy	+/- 2%	P2
	Colour	No substitute	Observation
	Depth Rating	+/- 10%	Manufactures spec.
Footrope Comp.	Length	+/- 2%	P3
	Diameter	+/- 2%	P3
	Material	No substitution	Observation
	Weight	+/- 5%	P3
Net Panels	Twine Diameter	+/- 10% Rtex	P4, CAN2-55.1-M85
	Mesh Size	+ 3%	P5, CAN2-55.1-M85
	Colour	No substitution	Observation
	Material	No substitution	Observation
	Mesh Count/Taper	No substitution	Observation

Table 7.5.2 Trawl and vessel mensuration data collected automatically by PC during a regular bottom trawl survey (except checklist which is recorded by hand).

	Parameter	Measured	Recorded
	Headline Height	Scanmar	Seatrawl
	Wing Spread	"	"
	Door Spread	"	"
Survey Trawl	Footrope Clearance	"	"
	Depth	"	"
	Trawl Speed (Fwd.)	"	"
	Trawl Speed (Cross)	"	"
	Trawl	Technician/Crew	Checklist
	Speed over Ground	GPS Navigator	Seatrawl
	Heading	Gyro Compass	"
Research Vessel	Position	GPS Navigator	"
	Speed (fwd-aft)	Doppler Log	"
	Speed (port-stbd)	"	"
	Sea State	Ships Officer	Set Details
	Wind Speed	Annometer	"
	Wind Direction	Annometer	"
	Water Depth	Doppler Log	Seatrawl
Environmental	Current Direction and Speed at		
	Depth 1	Doppler Log	"
	Depth 2	"	"
	Depth 3	"	"
	Bottom type	Seabed Classifier	Dedicated PC



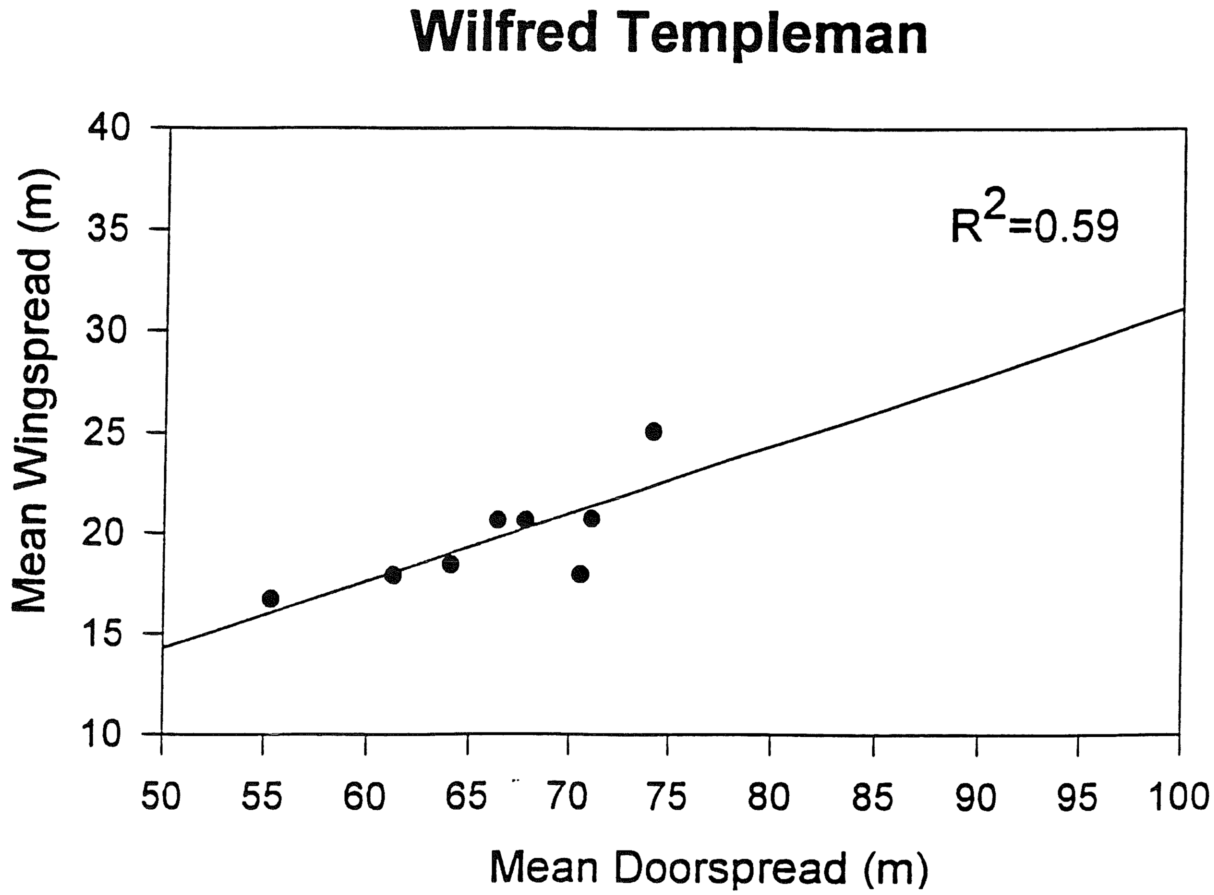


Fig. 7.6.1 A comparison of the relationship between wingspread and doorspread of the Engel 145 bottom trawl used in offshore surveys by the FRVs Gadus Atlantica and Wilfred Templeman.

Notes on nomenclature used in Figure

Standard inputs: These are also printed in the output tables.

WB	143 kg	otterboard weight in water
UPF	0.75	up pull factor required (ground reaction = WB/4)
DW	24 mm	warp diameter
WS	1.76 kg/m	unit weight of warp in water
CD	1.5	warp drag coefficient (including warp vibration factor)
CFS	0.03	skin friction coefficient based on warp diameter
VK	3 knots	water speed of warp
T2	4300 kg	warp tension at bottom end
HT	5.0 m	height of towing point above surface
HB	1.1 m	height of otterboard towing point above keel
DP	50, 75, 100, 150, 200, 300, 400, 500 and 600 m	range of depths for which warp lengths are required

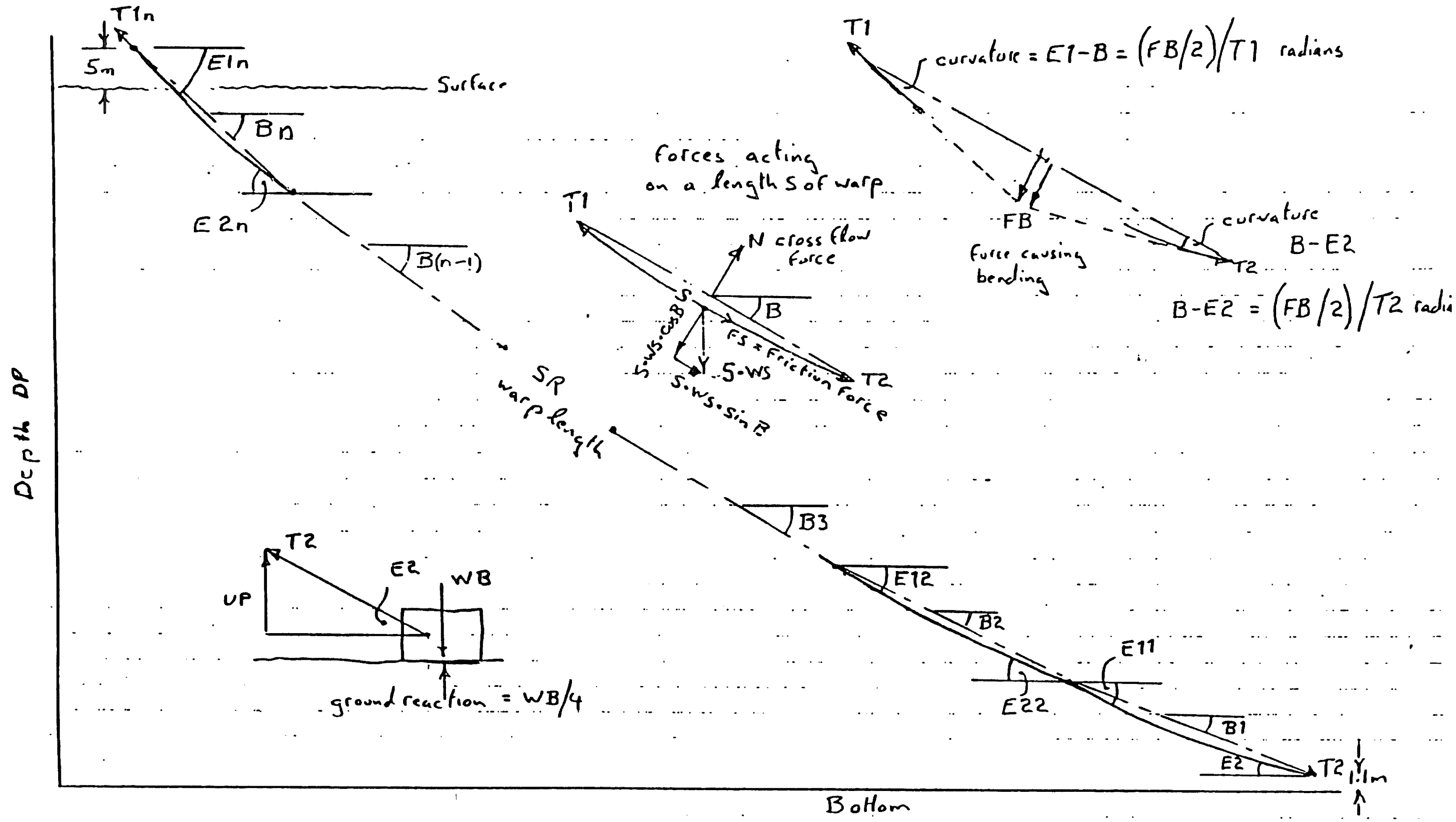


Fig. 7.7.1 Nomenclature of angles, forces and dimensions used in the computer program to calculate required trawl warp length for any depth.

8 REPORTS ON SUGGESTED WORK ITEMS

8.1 Report of the FTFB Strategic Planning Committee. - S. J. Walsh, Canada

This committee worked by correspondence during the period between April to September 1994 and met at the 1994 ICES Annual Science Conference in St. John's, Newfoundland (Sept.) to review the results of the 1994 FTFB Questionnaire. Over 50% of regular members replied to the questionnaire and there was aconsensuss on most items.

The committee concluded that the FTFB Working Group (WG) has two functions: provide advice to other WG's and be a pool of expertise for our members. Our clients are ICES and WG members. Special Topics are to be used as a first step to assess a particular subject, while a Study Group would be formed to solve particular problems of an applicable nature.

Proposed Special Topics need to be filtered by the WG, preferable in advance of the meeting and that all proposals and recommendations require justification. Review papers and Thematic seminars were seen as constructive steps to introduce new areas of research. More time is necessary for discussions of Study Group reports, Special Topics and other WG business. Time should be freed up by making use of posters for several related topic papers and these posters will be summarized in the annual FTFB WG report. The meetings needs to be longer and more focussed in its work. Effort should be made to attract more fish behaviourists and assessment biologists to our WG.

8.2 Report of the problems of data acquisition related to the measuring of fishing gear performance by acoustic and other underwater observations. G. Bavouzet, France and B. R. McCallum Canada.

Many research facilities in ICES member countries are using a wide variety of sophisticated electronic, video and engineering hardware and software to monitor trawl performance and fish behaviour. Since this is a very limited field, ie. research is not commercial, many of the institutes are using the same or similar equipment and of course it is expected that similar problems will arise with the methods of deployment, retrieval, data logging, etc.. However, these problems and their solutions are very rarely mentioned in research reports or published proceedings. FTFB Working Group members agreed that some initial investigations into this area may be warranted to determine the extent of the problem with the view that it may be a Special Topic in the future.

This work item was suggested (1994) in order to reduce costly software and hardware development time through the sharing of expertise amongst ICES member countries. The ultimate product of this work item may be a manual describing accepted operational methodologies, as well as the hardware and software used in monitoring gear performance and fish behaviour. Alternatively a more simple inventory list of researchers in ICES member countries, their area of expertise and hardware capabilities may suffice. In an effort to gauge support for this initiative and the extent to which researchers feel it merits ICES FTFB involvement Dr Bavouzet requested the delegates to complete a questionnaire. The questionnaire consisted of three sections: the first, covered general information about the individual and their institute; the second, asked for details on the institutes methods of data acquisition and what data is collected; and the third, asked for the individuals views on ICES cooperation in data acquisition.

8.2.1 Discussion

The questionnaire was reviewed and a few minor amendments made, it was suggested that an additional section be included to determine specific problems experienced by the researcher with respect to data acquisition. The usefulness of this piece of work was generally accepted by the Working Group, and it was suggested that this could set up similar to the selectivity manual or alternatively workshops could be run by the WG as a method of disseminating this information. The Working Group felt that in the future it could be expanded to include other technical areas, eg twine characteristic measurement. Finally, it was proposed that this suggested work item be carried over to next year, and will include an assessment of the data from this year's questionnaire.

8.3 Report on the feasibility of setting up an electronic bulletin board to facilitate the movement of information on related research activities. N. Lowry, Denmark.

For this purpose, a mailing list was set up for an initial trial shortly after the meeting last year. It is in fact simply an account on the server at ICES Secretariat in Copenhagen which forwards all the messages it receives to all the addresses on a list (i.e. it has a large forward file). The address of this account is: *ftfb@server.ices.inst.dk.* To be added to the list[6] the forward file needs to be edited, currently this is done by N. Lowry after he receives a request from someone to be added to the list. It would be better to have some form of list management software for this but it is not currently possible on the ICES machines. To date there are 35 names on the list, mostly of people who attended the 1994 meeting. There have been a total of about 30 messages distributed via the list, some of which have been direct questions regarding aspects of work going on or equipment, others have been administrative details. There has been little group discussion as such, but that is not really to be expected on this sort of list with this small membership, most discussion would be direct after contact is made.

Currently there are a few questions regarding the status of this facility:

1) should the list be open to all subscribers or limited to certain people, and if so, who decides?
2) does the list need a moderator?
3) should there be guidelines about what is suitable to send to the server?
4) should we set up an archive of reports, data. etc., which people can access, and what should be in this archive?

8.3.1 Discussion

After considering questions 1 to 3 the Working Group concluded that the number of members on the mailing list was currently too low to cause any problems in these areas. Thus it was decided to leave the membership open to any interested party and give the system a trial run over the next year to assess whether there will be any problems. With respect to archiving reports, it was revealed that ICES does not keep copies of reports and papers and the only way of getting copies is directly from the authors. Thus it was accepted that using the e-mail facility to archive FTFB papers and reports would be a useful mechanism. However, there is currently an ICES Working Group looking at the use of e-mail for the communication of ICES grey literature, and it was accepted to wait for the outcome of their report. Finally the management and editing of the .forward file was considered. It was recommended that if FAST WG sets up their server then both mailing lists could be combined in the future.

[6]To be added to the list, send a message to Nick Lowry <nlowry@inet.uni-c.dk> .To send mail to the list, send to FTFB@server.ices.inst.dk

8.4 Report of the feasibility of establishing and housing a Working Group selectivity database and associated computer software.
D. Wileman, Denmark

There are a number of different models for the type of data to by archived using a database:

- Model A - Selectivity parameters by test gear plus their variance;
- Model B - Selectivity parameters by haul plus their variance; and
- Model C - Complete raw data set plus selectivity results

In the case of FTFB users: Model A will allow for estimation of up to date average values of selectivity parameters and the effect of vessel/gear design parameters. Model B will further allow for the determination of the effect of haul by haul variables such as weather and catch weight. Model C will give the possibility for the recalculation of results and testing of new selectivity models.

In the case of ICES Stock Assessment Working Groups: All WG chairmen contacted supported establishment of a database. The WGs dealing with techniques and multi-species interactions would not be first hand users. The demersal fisheries WGs would definitely want access to a Model A or B type database. The pelagic fisheries WGs currently make little use of selectivity data but might in the future.

The experience from other ICES WG databases is that we would in the long term require access to the raw data , i.e. Model C.

Organisation and Finance: The database could be organised by ICES headquarters but only if there is widespread support for it and the amounts of data are low. It is unlikely that any individual institute would take on the task unless paid to do so. The CEC could possibly give financial assistance to establishing the database. A system of data quality control by a FTFB subgroup would be required. A compromise might be an ICES selectivity results database plus participating institutes holding the raw catch data in an agreed format.

Future Action:

a) Make detailed technical description of alternative models;
b) determine cost of maintenance; and

c) determine to what extent organizations such as ICES/CEC would be able to fund establishment and running costs

8.3.1 Discussion.

The Working Group generally agreed that a selectivity database would prove an valuable asset to our members and the members of some other Working Groups. It would provide a useful mechanism for storing and disseminating data of interest to all researchers in the group and thus giving them access to a greatly increased pool of the most up to date data. However, it was also recognised that the operation of such a system would require a great deal of effort to coordinate the formatting and inputting of data, not to mention the difficult task of initially setting up the system. Funding would also be necessary for the more complex databases, and it was suggested that the EC would be a possible source in the form of a grant for a concerted action or study project, although a number of problems were identified with this. It was decided that an informal group be set up to assess the technical and financial feasibility of setting up an FTFB database.

9 RECOMMENDATIONS

9.1 The Working Group on Fishing Technology and Fish Behaviour recommends that the next meeting will be held at Woods Hole, Massachusetts, USA (Chairman: Dr. S J Walsh) from 15 to 17 April, 1996 to

a) review and evaluate progress in estimating efficiency of sampling gears used to derive survey abundance indices of different life history stages of marine and fresh water species;

b) make recommendations for future research on survey gears that will improve reliability and precision of survey abundance indices;

c) consider other related research in fishing technology and fish behaviour

<u>Justification</u>

The topic "Efficiency of Survey Gears" will be considered as a Special theme for this meeting.

Survey indices are increasingly been used to calibrate fishery dependent models to increase confidence in abundance estimates and in some cases are the only source of estimates in the provision of scientific advice for fishery management. Survey indices can be more advantageous because of the rigorous standard methodology used to collect data and are generally better for predicting recruitment. Consequently, errors and unexplained variability in survey indices of population size and age composition could impact seriously on fisheries management in particular, and the economy in general.

During the mid- and late 1980's, researchers in several ICES member countries began extensive studies dedicated to quantifying trawl efficiency (catchability) of, mainly, bottom trawl survey gears used in stock assessment. Some consistent causes of inefficiency were identified, such as escapement beneath the groundgear, the influence of natural behaviour in the trawling zone, etc., and, as a result there have been recommended changes in design parameters to increase efficiency of trawls, i.e. GOV trawl, the Norwegian Campelen trawl, etc.. However, direct measurement of efficiency of sampling gears is still elusive. This applies also to other sampling gears such as Methot nets, Gulf III samplers, etc. Arguments also still prevail about whether the effective fishing width of bottom trawls, used in swept area models, should be door spread or wing spread. Regardless of which spread value is used, it must be accompanied by estimates of the overall efficiency of the gear in catching individual fish within the path of the trawl.

More selectivity information is needed to correct for potential bias in age dependent abundance estimates. The development of species interaction models/ecosystem models require absolute abundance estimates. Relative abundance estimates are still be used because the shortcomings of survey designs and sampling gears have not been addressed.

This meeting be will be held in conjunction with the Working Group on Fisheries Acoustics Science and Technology, at the same venue, on 18 and 19 April, 1996.

9.2 The Working Group on Fishing Technology and Fish Behaviour recommends that the Manual of Methods of Measuring the Selectivity of Towed Fishing Gears drawn up by the Sub-Group on Selectivity Methods be published in the ICES Cooperative Research Report series after final review by the Fish Capture Committee

Justification

The Sub-Group has recently completed this manual, after extensive work over a three year period. The only current available published manual was by Pope et al. (1975) based on the work of the ICES Mesh Selection Working Group, 1959-1960. The intervening years have produced considerable improvements to the methodology used to measure selectivity of towed fishing gears, including experimental design and statistical analysis. The FTFB Working Group has reviewed and approved this new updated manual and consider it to be a valuable document for wide use in fisheries science.

9.3 The Working Group on Fishing Technology and Fish Behaviour recommends that a Study Group be established on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets and this group should meet in Woods Hole, Massachusetts, USA from 13 to 14 April, 1996 to:

a) review current research on codend grid sorting devices for different fisheries;

b) identify opportunities for further application of grid sorting devices to improve selectivity in single and mixed fisheries;

c) assess the advantages and disadvantages of grids as selective devices in comparison with other techniques; and

d) Make their conclusions available to FTFB, ACFM and ACME.

Justification

Around 1990/91 the use of grid sorting systems, as a selective device in the codends of trawls, escalated on both sides of the North Atlantic, first of all with the Nordmøre grid (grate) for separating fish from shrimp. Since that time, several experiments, both for size and species selectivity, using different grid modifications, have been or are being carried out by several ICES member countries to reduce by-catch mortality of juveniles and non-target species. The proposed Study Group should 1) summarize both the positive and negative results of these selective devices (compared to other selective devices such as square mesh, horizontal separator panels, etc.), to improve size and species selectivity in bottom trawls, beam trawls and seine nets; and, 2) identify further applications and modifications to these grid systems to improve selectivity in single and mixed fisheries. Particular focus should be directed towards summarizing designs and solving handling problems of grid systems aboard various sizes of vessels. The Study Group should consider whether the amount of existing experimental work is sufficient enough to compile a technical users manual with the view of having it published as an ICES Cooperative Research Report at a later date.

9.4 The Working Group on Fishing Technology and Fish Behaviour recommends that a Study Group on the Use of Selectivity Measurements in Stock Assessment be established and should meet in Woods Hole, Massachusetts, USA from the 13 to 14, April, 1996 to:

a) evaluate whether selectivity parameters obtained under experimental conditions are good predictors of the selectivity of commercial fleets using the same nominal mesh size;

b) suggest ways in which experimentally obtained selectivity parameters can be translated into whole fleet selectivity estimates;

c) consider ways in which estimates of selectivity parameters obtained in different experiments on the same nominal mesh size can be used to derive a unified estimate; and

d) make their conclusions available to FTFB and ACFM.

Justification

Stock assessments, which evaluate the effect of a mesh change in a fishery, use selectivity data obtained from experiments conducted under controlled conditions. For practical reasons such experiments are limited to a few vessels in a small range of conditions. In performing the assessment, the assumption is made that experimental estimates of selectivity are representative of whole fleets operating under commercial conditions. It is unlikely that this assumption is correct and this may have a potentially severe effect on any assessment. There is a need therefore to determine the extent to which fleet selectivity differs from parameters estimated experimentally and to investigate methods which can predict fleet selectivity from such experiments. In addition, experiments examining the same nominal codend mesh size often give differing selectivity estimates. There is a need to resolve these differences to determine whether such differences are due to imprecision in the estimates or are simply inconsistent. An exploratory analysis is required in order to identify the most promising way forward.

9.5 Suggested 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) to initiate the collection of information, through the use of a Questionnaire, about the problems related to the acquisition of data from measuring fishing gear performance by acoustics and other underwater observations (Action: G. Bavouzet, France and B. McCallum, Canada);

b) to investigate further the technical and financial feasibility of establishing an FTFB Working Group selectivity database (Action: B. van Marlen, The Netherlands and N. Lowry, Denmark);

c) to run the electronic bulletin board for a trial period to assess for technical and operational difficulties (Action: N. Lowry, Denmark);

d) to consider co-ordinated research on mesh size measurement and twine and netting characteristics which may affect selectivity (Action: D. Ferro, UK); and

e) to investigate the feasibility of compiling of a complete bibliography of selectivity experiments for publication.

9.6 CLOSING REMARKS

The Chairman thanked all the members for their efforts in participating in the WG meeting, as well as the study and sub-groups. Special thanks were given to the Aberdeen hosts and organisers, in particular Anne-Marie Meconi and Peter Stewart. The meeting was closed at 1801 on 21st April 1995.

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