Fish Capture Committee

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REPORT OF THE WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR

Woods Hole, USA

15–18 April 1996

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

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Venue: Woods Hole Oceanographic Institute, Woods Hole, Mass. USA

Date: 15-18, April 1996

In accordance with ICES C. Res. 1995/2:16, The Working Group on Fishing Technology and Fish Behaviour (Chairman: S. J. Walsh, Canada) will meet in Woods Hole, USA from 15-18 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 the reliability and precision of survey abundance indices;

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

d) review and summarize the results of the experiments and studies made so far on the selection properties of gears used in Baltic Sea fisheries for cod and on the survival rate of cod escaping through the meshes, and report to the Baltic Fisheries Assessment Working Group and the Advisory Committee on Fishery Management;

e) update the advice to the Baltic Fisheries Assessment Working Group and ACFM on appropriate mesh sizes corresponding to a L50 of 38 cm for cod in:

   i) exit windows installed in codends of cod trawls with 105 mm codends;
   ii) codends with standard diamond meshes;

f) advise the Baltic International Survey Assessment Working Group and the Baltic Fish Committee on a standard multispecies survey bottom trawl to be used for resource assessment in the Baltic Sea.

SUGGESTED WORK ITEMS FOR THE FTFB 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 ;

b) to investigate further the technical and financial feasibility of establishing an FTFB Working Group selectivity database ;

c) to monitor the FTFB E-mail server for a trial period to assess for technical and operational difficulties;

d) to consider coordinated research on mesh size measurement, and twine and netting characteristics which may affect selectivity; and

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

1.3 AGENDA AND PROCEEDINGS

The meeting was opened by the Working Group Chairman, Mr. S. J. Walsh at 0900 hrs on Monday 15th April, 1996, at the Woods Hole Oceanographic Institute. The meeting was hosted by the National Marine Fisheries Service, Northeast Science Centre (NMFS). Delegates were given a warm welcome by Dr. Emory Andersen, on behalf of the Director of NMFS.

2. STUDY GROUP AND SUB-GROUP REPORTS

2.1 Report of Baltic Cod Mesh Selection

Terms of Reference

a) To review and summarise the results of the experiments and studies made so far on the selection properties of gears used in the Baltic Sea fisheries for cod and on the survival rate of cod escaping through the meshes, and report to the Baltic Fisheries Assessment Working Group and ACFM;

b) To update the advice to the Baltic Fisheries Assessment Working Group and ACFM on appropriate mesh sizes corresponding to a L50 of 38 cm for cod in:

i)exit windows installed in cod-ends of cod trawls with 105 mm cod-ends;
ii)cod-ends with standard diamond meshes.

2.1.1 Introduction

A sub-group of the Fishing Technology and Fish Behaviour (FTFB) Working Group was formed in Autumn 1994 to report on Baltic cod mesh selection by May 1995 to the Baltic Fisheries Assessment Working Group and ACFM. The report (Section 2.3 of Anon, 1995) considered historic data collected from 1970 to 1990 and more recent data between July 1993 and March 1995.

Further selectivity data were collected between April 1995 and August 1995. The sub-group was reformed in Autumn 1995 to undertake the above terms of reference. The sub-group again worked by correspondence and then met for two days during the FTFB Working Group meeting in Woods Hole from 15-17 April 1996 to write its report which was subsequently approved by the Working Group on 17 April 1996.

2.1.2 Summary of Recent Data on Selectivity and Survival

Data on cod-end selectivity

In the previous review made at the 1995 Working Group meeting, recent data were available from only two countries, Sweden and Denmark. The test method was the same for all data sets, the covered cod-end technique with hoops supporting the cover. Materials were also the same for the main body of all cod-ends - 4 mm double polyethylene.

There are now further data sets from these countries but also data from Russia, Poland and Germany (Table 2.1.1). Measurements have been made using the alternate haul technique, unhooped cod-end covers and topside cod-end covers. The unhooped data have been included in the analyses as catch rates were low, under 400 kg per haul and it was felt that there was relatively little risk of masking of the test cod-end. Although topside covers were used because they were the only practical method on the particular vessel and gear, the data were not included as previous experiments (Anon, 1995) have shown that this technique can underestimate 50% retention lengths. A wider range of cod-end materials and twine thicknesses have been used. The ranges of the more important variables which may affect selectivity have been summarised.

<u>Summary of all trials during 1994 and 1995</u>

	Standard diamond cod-end	Danish window	Swedish window	Other windows
Number of hauls	113	61	72	22
Mesh size (mm)	102-140	102-125	97-117	90-119
Number of vessels	6	4	3	3
Vessel HP	217-1180	217-1000	898-1180	217-300
Twine type of main body of cod-end	3.1dPA 4.0sPE 4.0dPE	3.0sPA 4.0sPE 4.0dPA 6.0sPA	3.1dPA 4.0dPE	4.0sPE 3.0sPA 3.5dPA
Catch size (kg)	199-6017	169-2842	359-1267	100-234

The windows have been inserted in cod-ends of nominal 105 mm mesh sizes. The mesh sizes quoted in columns 3, 4 and 5 are those of the windows and are used to estimate the selection factors for window cod-ends throughout this report.

Mesh sizes have been converted to the equivalent of wedge gauge measurements where necessary (see section on measurement of mesh size below).

Standard Diamond Mesh Cod-ends

There are now 13 data sets (Table 2.1.1) with a total of 113 hauls. Mesh sizes range from 102 mm to 140 mm. Six different vessels have been used. Three were relatively low-powered 217-300 HP and three very large 898-1,180 HP. There are no data for medium to large powered vessels.

Danish Exit Window Cod-ends

The windows are located in the sides of the cod-end below the selvedges and are made of normal netting material turned to form a square mesh configuration. They terminate 2 to 2.5 m ahead of the codline. Most of these windows are made of double twine netting.

There are now eight sets of data (Table 2.1.1) for this design of window with mesh sizes from 102 to 125 mm inserted in cod-ends of nominally 105 mm mesh size. Sixty-one hauls were made on four different vessels, three of which were in the range 217 to 300 HP with the other being a large research vessel of 1,000 HP. Sixty-seven percent of the hauls were made on one Danish vessel.

Experiments were made to determine if escape through the window could be enhanced by altering the colour of the last 2 m of cod-end netting from green to black (such that it contrasted with the window and the rest of the cod-end). No effect was detected.

Swedish Exit Window Cod-ends

A total of seven data sets (Table 2.1.1) have now been obtained for this design of exit window where netting is made from specially treated single twine nylon netting mounted such that the meshes have some rigidity and maintain a wide opening. Like Danish windows they are mounted in cod-ends of 105 mm nominal mesh size and are located in the sides of the cod-end. Apart from the netting material of the window, a key difference between Swedish and Danish windows may be that the Swedish design terminates only 40 to 50 cm from the codline. Mesh sizes of 97 to 117 mm have been tested. Three vessels have been used; all are large - 898 to 1,180 HP. A total of 72 hauls were made, 83% of them on two Swedish vessels.

One previous set of Swedish data was deleted as the unconventional trouser trawl design is no longer in commercial use.

Other Designs of Exit Window Cod-ends

Square mesh exit windows made of normal netting material have also been inserted in the upper panel of the cod-end. In one case the whole upper panel is in square mesh. In an alternative design a central strip of square mesh netting is used (twice the width of the Danish side window) terminating 2.0 to 2.5 m from the codline. Four data sets are available (Table 2.1.1).

Window mesh sizes of 90 to 119 mm have been used. The rest of the cod-end netting is in nominal 105 mm conventional diamond mesh. Three different vessels, all relatively small 217 to 300 HP, have been used. There were 22 valid hauls.

Measurements have also been made of the selectivity of cod-ends fitted with other designs of square mesh window which are of restricted length (Table 2.1.1) and positioned either towards the forward or aft end of the cod-end. Although they too suggest improvement in selectivity there are too few data sets and numbers of hauls to allow more detailed analysis.

Comparative fishing trials

Direct comparisons have been made between the catches obtained by trawls fitted with different designs of cod-end using twin trawl systems on Danish vessels. Lowry *et al.* (1995) found that catches of cod under 50 cm were significantly reduced in a 107 mm cod-end fitted with a Danish exit window of 121 mm compared to a 123 mm standard cod-end (eight paired hauls). Moth-Poulsen *et al.* (1995) found that catches of cod under 50 cm were significantly reduced in a 107 mm mesh size cod-end if fitted with a Swedish exit window of 107 mm as opposed to a Danish exit window of 107 mm (23 paired hauls).

Lowry *et al.* (1994) compared catches in trawls fitted with standard cod-ends and made in 105 mm or 120 mm minimum mesh size throughout.

Information on the variation of the length distribution of Baltic cod catches with mesh size in gillnet fisheries can be found in Lowry *et al.* (1994) and Baranova and Shics (1995). In the first paper it was found that the fish length giving highest catches (being caught in the optimum way - enmeshed behind the gill covers) was approximately 4.3 times the mesh size for mesh sizes of 105 mm to 130 mm. In the second paper it was similarly found that catches peaked at 45-50 cm fish length for 110 mm mesh size rising to 50-60 cm at 140 mm mesh size. The gillnets used in the commercial cod fishery therefore target fish above 38 cm length.

Measurement of mesh size

In most experiments the cod-end mesh opening (inside mesh size) has been measured with the wedge gauge and 5 kg hanging weight. In some experiments the ICES gauge with 4 kg tension has been used. These ICES gauge measurements were increased by 3.9% to give an estimate of the corresponding wedge gauge measurement. This increment is derived from a regression of ICES and wedge gauge measurements for a range of mesh sizes and twine materials (Ferro and Xu, 1996).

It is considered important to relate selectivity to legally enforced mesh sizes which are, according to IBSFC Fishery Regulations, measured by the wedge gauge.

Survival Studies

Only one preliminary study exists on the mortality of Baltic cod escaping from a trawl cod-end (Suuronen *et al.*, 1995). Mortality of Baltic cod escaping from trawl cod-ends equipped with two different types of 95-mm exit windows was investigated during May-June 1994 in the southern Baltic Sea (ICES subdivision 25). Fish escaping through the end of an open cod-end extension were also studied. In total, nine valid hauls were conducted, and 261 cod (24 to 50 cm long) were held in cages for periods of 10 to 14 days. Only two escapees (34 and 36 cm) died during the experiment; both fish died during their first day in the cage. Scale loss was observed in 27% of the cod that had escaped through exit window cod-ends. The average injured area was 2.5% of the total skin area. For the open extension escapees, 35% of fish examined exhibited scale loss, and the average injured area was 2.3% of the total skin area. No clear relationship existed between the degree of skin injury and fish size. Most of the observed skin injuries were probably caused by mechanical abrasion while fish were inside the trawl.

Although based on a small number of tows and fish, these findings are encouraging and support the concept of conservation of undersized Baltic cod by allowing them to escape through cod-end meshes. Nevertheless, caution is still needed when interpreting these results for management purposes. The fish studied were not subjected to the full range of stressors and damage that may occur during commercial fishing operations. For instance, tows were substantially shorter and catches were lower than in commercial practice. Furthermore, no cod smaller than 24 cm were held in the cages. Recent Scottish and Finnish studies with species such as haddock, whiting and herring show that the smallest (youngest) fish suffer the most severe exhaustion and physical injury due to the trawl capture and escape process. Hence, it would be extremely important to assess the fate of small Baltic cod under commercial fishing conditions before making final conclusions on the overall mortality caused by capture and escape.

Finnish-Swedish experiments that will focus on estimating escapee mortality of Baltic cod at commercial catch sizes and towing durations are under way in the southern Baltic, and first results will be available in autumn 1996.

2.1.3 Analysis

The analysis methods are described in Appendix 2.

Standard diamond mesh cod-ends

The mean 50% retention lengths (L50) are plotted against mesh size (MS) for each standard diamond mesh cod-end (Fig. 2.1.1), with the number of hauls and vessel type indicated on the left and right of the plotted point. The intercept of the linear regression is not significantly different from zero. The slope of the line through the origin is significant at the 95% confidence level. This slope equals the mean selection factor (L50/MS) and is found to be 3.01.

No significant difference is apparent due to vessel type (see section on vessel size and hauling below).

Danish exit window cod-ends

These results (Fig. 2.1.2) are influenced by the data from the 25 hauls on the Ulvedal cruise in August 1995. This 290 HP vessel however, is typical of the commercial Danish fleet. See section on vessel size and hauling below for comments on catch size effect.

Again the intercept of the linear regression is not significant but there is a significant increase in L50 with mesh size. The mean selection factor is 3.06.

There is some suggestion that the L50s for side trawlers (si) are higher than those for the stern trawlers (ss) (see section on vessel size and hauling below). There may be other factors affecting the results, however. All the latter data are collected on one vessel (Ulvedal). All the other data are gathered for cod-ends either of thinner nylon material or of slightly larger mesh size both of which may increase L50.

Swedish exit window cod-ends

The data are closely grouped (Fig. 2.1.3), revealing no differences due to vessel type. The intercept of the linear regression is not significant but the slope of the line through the origin is significant at the 95% confidence level. The mean selection factor is 3.52.

Exit windows in the top panel of the cod-end

Only four data points are available (Fig. 2.1.4) and no specific advice will be given on this evidence. These results however, suggest that cod selectivity can be improved by the use of top windows as well as side windows. The mean selection factor is 3.42.

Variation of selection range

Similar regressions of selection range against mesh size, using the number of hauls as a weighting factor, were computed as for the analysis of L50 (Appendix II).

For three out of the four designs of cod-end (diamond mesh, Danish and top windows) selection range was found to have a significant linear variation through the origin with mesh size. In the other case (Swedish window) a constant selection range had a slightly higher probability. However, there was little to choose between the two models and for comparison, a linear variation through the origin was assumed for all. The slope of this variation is the selection ratio (selection range/mesh size) where window mesh size is taken for the window cod-ends. The top window cod-end selection ratio was found to be significantly different only from that of the diamond mesh cod-end and the Danish window cod-end. No other differences were significant at the 95% confidence level. Because advice on the top window cod-end is not being offered, the data for the other three cod-ends were taken together to give a linear variation of selection range (cm) with mesh size (mm). Both the intercept (5.207) and slope (0.02771) were significant and this result has been used to estimate appropriate values for selection range in the summary table of section 7.

The causes of variation of selection range are not well understood and the variation used here should be considered to be a purely statistical exercise to obtain the best estimates for selection range for these cod-ends. It is unlikely to indicate a general relationship between selection range and mesh size which will be true for other gears.

2.1.4 Unaccounted Factors in the Analysis

A number of factors representing gear design and performance, prevailing environmental conditions and vessel effects were identified in the previous report (Anon, 1995) which were considered to have a potential effect on selectivity. Particular attention has been paid to these factors in this analysis.

While it is possible to apply regression techniques to some variables such as mesh size where a wide range of values have been tested, this is not generally the case. The following sections discuss some of these key variables for which few individual values have been tested.

Vessel size and hauling method

Differences in vessel size (HP or tonnage) or vessel type (side trawler or stern trawler) may be associated with changes in selectivity of the cod-ends which they tow, even though the cod-ends may be similar. There are several factors which may cause these changes, such as the design and hence performance of the gear ahead of the cod-end, the operation of the gear (eg towing speed, hauling technique) or the interaction between vessel and gear (eg in rough weather).

As each vessel in these trials uses a different gear, the effect of gear design cannot be separated from the vessel. Similarly vessel/gear interaction is specific to each vessel.

It is possible however, to classify the different methods used to haul the gear and catch. A stern trawler with ramp (denoted by "rs" in Table 2.1.1) heaves its trawl without taking the strain off the cod-end meshes until the cod-end lies on deck. A traditional side trawler ("si" in Table 2.1.1) on the other hand stops and turns when hauling the doors and trawl. During these periods the net is under reduced or no strain. Before the cod-end is hauled aboard it floats at the side of the ship with the meshes slack and wide open. An improved selectivity for a side trawler compared to a stern trawler has often been assumed. Older compilations of available data on Baltic cod selectivity seem to support this hypothesis (Anon, 1986).

A third hauling procedure can be identified. Modern fishing ships of moderate size often have the net drum on the aft deck so that they can heave the trawl without any interruption as for a stern trawler but the cod-end with the catch is brought to the ship's side and then taken on board like a side trawler ("ss" in Table 2.1.1).

The recent data presented here contain selectivity parameters from ships using each of the three types of operation. However, differences between them are not apparent and may be masked by the effect of other factors.

There is little evidence as to which features of the operation of the gear or vessel are directly affecting selectivity. A carefully designed experiment monitoring or controlling a wider range of variables associated with operational characteristics would be necessary to clarify this point.

Season and fish condition

A significant variation of selectivity with season has been shown recently for haddock in the North Sea (Ozbilgin *et al.*, 1996). The cause may be related to fish behaviour and swimming performance rather than variation in girth alone, due eg to fish maturity or condition. Hence such effects were sought in these data. For a series of Swedish trials (lines 6, 7 and 8 of Table 2.1.1) on the same vessel using the same gear in the same area, there is a significant difference (at least 4.5 cm) in 50% retention length measured in December and June compared to that measured in March (Tschernij *et al.*, 1996). Kadilnikov *et al.* (1995 unpublished) also report small but non-significant differences in selectivity parameters between male and female cod for each of the cod-end designs. Overall when all data are considered from all vessel types, netting material and catch sizes, no consistent effect emerges.

Twine type

Recent experiments (Robertson and Lowry, 1995) have demonstrated that cod-end twine thickness can affect trawl selectivity. There are a variety of netting yarn sizes (3 to 6 mm), constructions (double and single) and materials (PE and PA) used in the recent Baltic cod selectivity trials but no experiments where the effect of twine type was specifically investigated. It is not possible to analyse the data for the effect of twine type systematically. The choice of twine type for both the cod-end and the window may affect the selectivity of that part of the gear.

Catch size effect

Except for the Danish results in 1994 (Lowry *et al.*, 1995) where the average catch for each mesh size varies from about 2 tons to 6 tons, the average catches are generally moderate (Table 2.1.1) and under 1.5 tons.

It has been shown recently in selectivity experiments in other areas that catch size has a significant influence on selectivity parameters (Madsen and Moth-Poulsen, 1994; O'Neill and Kynoch, 1996). Catch size effect was not investigated in any of the reports of the experiments described here.

The effect of catch size upon selectivity should be analysed haul by haul but the disaggregated data were not available for several experiments at the meeting and consequently this analysis has not been done.

Compared to the Danish experiment conducted in 1994 (Lowry *et al.*, 1995) a very low selection factor was estimated in the new Danish experiment conducted in August 1995 (Table 2.1.1) using exactly the same cod-end and vessel (but different trawl) A possible explanation is that when catches are very high as in the August 1994 experiment (Table 2.1.1) the zone without a window in the backward part of the cod-end is quickly filled up with fish and most of the cod entering will remain in the window area. In the 1995 experiment catches were relatively moderate in which circumstances fish will move quickly to, and remain in the area behind the window.

Sea state effect

Sea state can have an effect upon cod-end selectivity (Polet and Redant, 1994). The effect of sea state was analysed in one of the Danish experiments. Estimated wave height varied from 10 cm to 125 cm only and was not found to have any significant effect. Haul by haul sea state measurements were generally not available for most data sets and no other new analyses were therefore made during the meeting.

2.1.5 Advice on Mesh Sizes for Various Gear Designs

Advice is offered on standard diamond mesh cod-ends and cod-ends with Danish and Swedish exit windows. The commercial fishing fleet in the Baltic is dominated by vessels in the engine power range up to 400 HP. The basis on which the advice is given (in terms of available data and limitations of the data sets) are discussed more fully in section 2.1.2.

Advice on mesh sizes for diamond mesh cod-ends

No data from vessels in the power range from 301 to 897 HP are available.

a) A mesh size of 126 mm (95% confidence interval 120-134 mm) is required to achieve an L50 of 38 cm for a standard diamond mesh cod-end.

b) A cod-end with the current minimum mesh size of 120 mm has an L50 of 36 cm (95% confidence interval 34-38 cm).

c) A cod-end with the previous minimum diamond mesh size of 105 mm has an L50 of 32 cm (95% confidence interval of 30-33 cm).

Advice on mesh sizes for Danish exit window cod-ends

Data were available from three low powered vessels (up to 300 HP) and one high powered research vessel (1000 HP).

a) A window mesh size of 124 mm (95% confidence interval 116-134 mm) is required in a nominal 105 mm diamond mesh cod-end to achieve an L50 of 38 cm.

b) A window mesh size of 118 mm (95% confidence interval 110-128 mm) in a nominal 105 mm diamond mesh cod-end will generate an L50 equivalent to that of a 120 mm standard diamond mesh cod-end.

Advice on mesh sizes for Swedish exit window cod-ends

All the data on Swedish windows were gathered on vessels of 898 to 1180 HP.

a) A window mesh size of 108 mm (95% confidence interval 104-112 mm) is required in a nominal 105 mm diamond mesh cod-end to achieve an L50 of 38 cm.

b) A window mesh size of 103 mm (95% confidence interval 99-106 mm) in a nominal 105 mm diamond mesh cod-end will generate an L50 equivalent to that of a 120 mm standard diamond mesh cod-end.

Advice on mesh sizes for top exit window cod-ends

No advice is offered for these designs since only four data sets are available. They do however, demonstrate that other window designs may have potential for improving the selectivity of cod-ends. The selectivity of this design is slightly lower than that of the Swedish exit window design but significantly above that of the Danish design.

2.1.6 Requirements for Future Research

The experiments considered in this report were not designed to an overall plan but conducted independently in individual countries. There are many uncontrolled variables and there is therefore little opportunity to investigate the effect of specific factors on selectivity. The results however, do cover a range of different fishing conditions which may be met in the commercial fishery and therefore they may give a reasonable representation of the fleet selectivity. To improve this representation, data for Swedish exit windows should be collected on vessels with a wider range of horsepower (ie lower horsepowers of around 300 HP). Furthermore although there may be practical difficulties, more selectivity measurements at commercial catch rates are needed.

As regards to the effect of specific factors, it has been possible to study only the effect of window design and mesh size. More data for standard diamond mesh cod-ends of mesh sizes between 125 and 140 mm would have been an advantage. Because different countries tend to use different materials, it is also important to determine the specific effect of material and twine types. The role of fishing operation and vessel design is unclear and needs study but it may be difficult to design an experiment to determine those factors which directly alter selectivity. Differences in selectivity due to fish behavioural or morphological effects may be important and the underlying factors may be environmental (eg water temperature) or biological (fish condition).

With regard to exit windows, trials using both Swedish and Danish designs on the same vessel are required, to confirm the differences between them without the added variability due to vessel and gear operation. There are few data on optimum window design and position which, if available, might help to improve their efficiency. Such experiments should take account of fish behavioural observations on these gears. The limited results for top windows suggest that side windows may not be the only solution.

Technical means to improve the selectivity of fishing gear are only justified if they increase the numbers of escaping fish which survive. Very little is known about the behavioural reactions of cod inside a cod-end and the effects on survival of their passage through meshes. This applies especially with respect to the effect on survival of alternative constructions such as different types of exit window. Research aiming at the determination of survival after escape should therefore be given a particularly high priority.

2.1.7 Conclusions

a) **Standard diamond mesh cod-ends**

A mesh size of 126 mm (95% confidence interval 120-134 mm) is required to achieve an L50 of 38 cm for a standard diamond mesh cod-end.

b) **Danish exit window cod-ends**

A window mesh size of 124 mm (95% confidence interval 116-134 mm) is required in a nominal 105 mm diamond mesh cod-end to achieve an L50 of 38 cm.

c) **Swedish exit window cod-ends**

A window mesh size of 108 mm (95% confidence interval 104-112 mm) is required in a nominal 105 mm diamond mesh cod-end to achieve an L50 of 38 cm.

d) **Selection range**

A slight variation of selection range with mesh size is indicated by these data, given by:

selection range (cm) = 5.2 + 0.02771 mesh size (mm)

The following summary table gives mean values and 95% confidence intervals (in brackets). The window mesh sizes have been quoted for the window cases and used to determine their selection factors.

	Diamond mesh cod-ends	Danish exit window cod-ends	Swedish exit window cod-ends
Mesh size to give L50 of 38 cm	126 (120-134)	124 (116-134)	108 (104-112)
Mean selection factor	3.01 (3.17-2.85)	3.06 (3.29-2.83)	3.52 (3.64-3.40)
Mean selection range	8.7	8.6	8.2
Mesh size to give L50 as for 120 mm diamond cod-end	120	118 (110-128)	103 (99-106)

Note: *A draft of this report was reviewed by ACFM at their May 1996 meeting.*

APPENDIX I

Membership of Sub-Group
Attended sub-group meeting in Woods Hole:

Member Representing	Institute
R. Ferro (Chairman)	Scotland SOAEFD Marine Laboratory, Aberdeen
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V. Tschernij	Finland Karlskrona Research Station, Sweden

APPENDIX II

Analysis Method

Each data point represents the mean selectivity of a cod-end tested on one cruise for a number of hauls. The initial analysis to produce this mean selectivity for a group of hauls was done in all cases under the direction of the institute undertaking the trials. The analysis method varied depending on the type of data obtained.

Denmark	Logistic curve taking account of between haul variation
Sweden	Non-parametric representation of selection curve taking account of between-haul variation
Russia	Pooled data, logistic curve
Poland	Dependent on whether alternate or covered cod-end technique used
Germany	Logistic curve taking account of between haul variation.

A selectivity curve is characterised by the 50% retention length (L50) and selection range (SR). The L50 indicates the position of the curve and the selection range indicates its slope. Significant variation of these selectivity parameters with other explanatory variables is sought.

Selectivity can vary from haul to haul but it also varies from cruise to cruise. The variance from each is of the same order and therefore it is considered appropriate to take account of the haul-to-haul variation implicit in each data point. In order not to give too much weight to cod-ends which were tested for few hauls, a weighting procedure has been adopted where the weighting factor on both the response variable (eg L50) and explanatory variable (eg mesh size) is equal to the square root of the number of hauls for which that cod-end was tested. Linear regressions are appropriate in all relationships considered in this analysis. To obtain a mean relation between selectivity parameters and other variables, initially a general weighted linear regression is computed. If the intercept is found to be not significant a linear weighted regression through the origin has been used. The variance of the slope of the regression is used to compute the 95% confidence interval for the mean line (not the prediction interval for an individual value).

APPENDIX III

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Table 2.1.1

List of 1994 and 1995 data sets

Date	Origin	Vessel name	Vessel power hp	Selection method	No of hauls	Cod-end mesh (mm)	Cod-end twine (mm)	Window mesh (mm)	Window type	Window twine	50% length (cm)	Selection factor window	Selection factor cod-end	Selection range (cm)	Average catch per haul (kg)	Average wind speed (m per s)
4.95	Russia	*Monocrstl*	1000 rs	Cover	17	102	3.1dPA	0	-	-	34.40	-	3.38	8.2	199	4
7.94	Sweden	*Emilia*	1180 si	Hoop cover	7	107	4.0dPE	0	-	-	26.86	-	2.51	6.77	494	3
8.94	Denmark	*Ulvedal*	290 ss	Hoop cover	3	107	4.0dPE	0	-	-	31.80	-	2.97	7.70	6017	4
8.95	Germany	*Weisswal*	300 si	Hoop cover	4	109	4.0sPE	0	-	-	36.40	-	3.34	6.6	265	1
5.95	Poland	*Wla 151*	217 si	Alt haul	3+3	112	4.0dPE	0	-	-	35.00	-	3.13	7.4	530	6
3.95	Sweden	*Kungso*	898 ss	Hoop cover	9	123	4.0dPE	0	-	-	30.49	-	2.48	8.34	763	9
12.94	Sweden	*Kungso*	898 ss	Hoop cover	11	123	4.0dPE	0	-	-	35.12	-	2.86	8.51	1011	6
6.95	Sweden	*Kungso*	898 ss	Hoop cover	6	123	4.0dPE	0	-	-	35.20	-	2.86	7.3	1483	4
6.95	Sweden	*Emilia*	1180 si	Hoop cover	18	123	4.0dPE	0	-	-	36.10	-	2.93	9.9	622	4
12.94	Sweden	*Emilia*	1180 si	Hoop cover	11	123	4.0dPE	0	-	-	37.22	-	3.03	12.12	902	7
8.94	Denmark	*Ulvedal*	290 ss	Hoop cover	6	123	4.0dPE	0	-	-	37.50	-	3.05	9.90	2093	5
4.95	Russia	*Monocrstl*	1000 rs	Cover	11	128	3.1dPA	0	-	-	41.60	-	3.26	6.6	381	4
3.95	Sweden	*Kungso*	898 ss	Hoop cover	10	140	4.0dPE	0	-	-	45.03	-	3.22	11.69	965	8
4.95	Russia	*Monocrstl*	1000 rs	Cover	12	102	3.1dPA	102	dsw	3.1dPA	34.80	3.42	3.42	7.3	239	4
8.94	Denmark	*Ulvedal*	290 ss	Hoop cover	4	107	4.0dPE	107	dsw	4.0dPE	32.70	3.06	3.06	8.00	2842	3
5.95	Poland	*Wla 151*	217 si	Alt haul	3+3	111	4.0dPE	112	dsw	4dPE	38.00	3.39	3.42	11.0	600	5
8.95	Denmark	*Ulvedal*	290 ss	Hoop cover	25	107	4.0dPE	115	dsw	4.0dPE	32.10	2.79	3.00	6.1	434	7
5.95	Poland	*Wla 151*	217 si	Alt haul	2+2	109	3.0sPA	115	dsw	4sPA	36.80	3.20	3.38	6.0	1430	5
8.94	Denmark	*Ulvedal*	290 ss	Hoop cover	6	107	4.0dPE	116	dsw	4.0dPE	36.10	3.11	3.37	8.30	2522	3
8.94	Denmark	*Ulvedal*	290 ss	Hoop cover	6	107	4.0dPE	121	dsw	4.0dPE	38.20	3.16	3.57	8.50	1919	4
8.95	Germany	*Weisswal*	300 si	Hoop cover	3	109	4.0sPE	125	dsw	4.0sPE	42.60	3.41	3.91	11.8	169	9

Table 2.1.1 (cont'd)

Date	Origin	Vessel name	Vessel power hp	Selection method	No of hauls	Cod-end mesh (mm)	Cod-end twine (mm)	Window mesh (mm)	Window type	Window twine	50% length (cm)	Selection factor window	Selection factor cod-end	Selection range (cm)	Average catch per haul (kg)	Average wind speed (m per s)
7.94	Sweden	*Emilia*	1180 si	Hoop cover	10	107	4.0dPE	97	ssw	6.0sPA	34.25	3.53	3.20	7.22	541	3
4.95	Russia	*Monocrstl*	1000 rs	Cover	12	102	3.1dPA	102	ssw	4.5sPA	35.20	3.44	3.46	5.5	359	4
12.94	Sweden	*Kungso*	898 ss	Hoop cover	11	107	4.0dPE	103	ssw	6.0sPA	34.22	3.32	3.20	7.92	1077	6
6.95	Sweden	*Kungso*	898 ss	Hoop cover	12	107	4.0dPE	103	ssw	6.0sPA	36.70	3.56	3.43	5.8	412	5
6.95	Sweden	*Emilia*	1180 si	Hoop cover	13	107	4.0dPE	103	ssw	6.0sPA	37.20	3.61	3.48	5.4	937	3
6.95	Sweden	*Emilia*	1180 si	Hoop cover	8	107	4.0dPE	117	ssw	6.0sPA	39.80	3.40	3.72	7.8	1267	5
6.95	Sweden	*Kungso*	898 ss	Hoop cover	10	107	4.0dPE	117	ssw	6.0sPA	43.30	3.70	4.05	5.8	431	6
7.94	Sweden	*Falken*	264 ss	Hoop cover	13	107	4.0dPE	90	uc	480 ply	32.52	3.61	3.04	4.47	234	6
8.95	Germany	*Weisswal*	300 si	Hoop cover	6	109	4.0sPE	114	top	4.0sPE	37.50	3.29	3.44	6.2	153	4
5.95	Poland	*Wla 151*	217 si	Alt haul	1+1	109	3.0sPA	117	top	4sPA	39.00	3.33	3.58	4.8	100	5
8.95	Germany	*Weisswal*	300 si	Hoop cover	5	109	4.0sPE	119	top	4.0sPE	39.40	3.31	3.61	6.2	182	2
5.95	Poland	*Wla 254*	306 si	Top cover	16	129	3.5sPA	0	-	-	34.00	-	2.64	12.5	400	2
4.95	Poland	*Wla 254*	306 si	Top cover	2	109	3.0sPA	110	aft	3.5dPA	34.00	3.09	3.12	4.5	100	8
8.95	Germany	*Weisswal*	300 si	Hoop cover	3	109	4.0sPE	119	aft	4.0sPE	36.20	3.04	3.32	8.5	143	10
2.95	Poland	*Baltica*	1400 rs	Top cover	6	109	3.0sPA	109	aft	3.0sPA	31.50	2.89	2.89	6.0	200	6
8.95	Germany	*Weisswal*	300 si	Hoop cover	1	109	4.0sPE	119	fwd	4.0sPE	38.40	3.23	3.52	9	375	10

Vessel type: rs=ramp stern trawler
ss=stern trawler taking codend over side
si=traditional side trawler
NB *Monocristall* and *Baltica* are research vessels
All mesh measurements are converted to wedge gauge equivalent
A window mesh size of 0 indicates a standard diamond mesh cod-end

dsw indicates the Danish design of side window
ssw indicates the Swedish design of side window
top indicates long square mesh window in top panel
aft indicates square mesh window between lestridges in aft position
fwd indicates square mesh window between lestridges in forward position
uc indicates the Swedish whole top panel design in ultra cross square mesh

Twine type: The number indicates nominal twine thickness
d or s indicates double or single twine
PA or PE indicates polyamide or polyethylene

Fig. 2.1.1 Diamond mesh codends

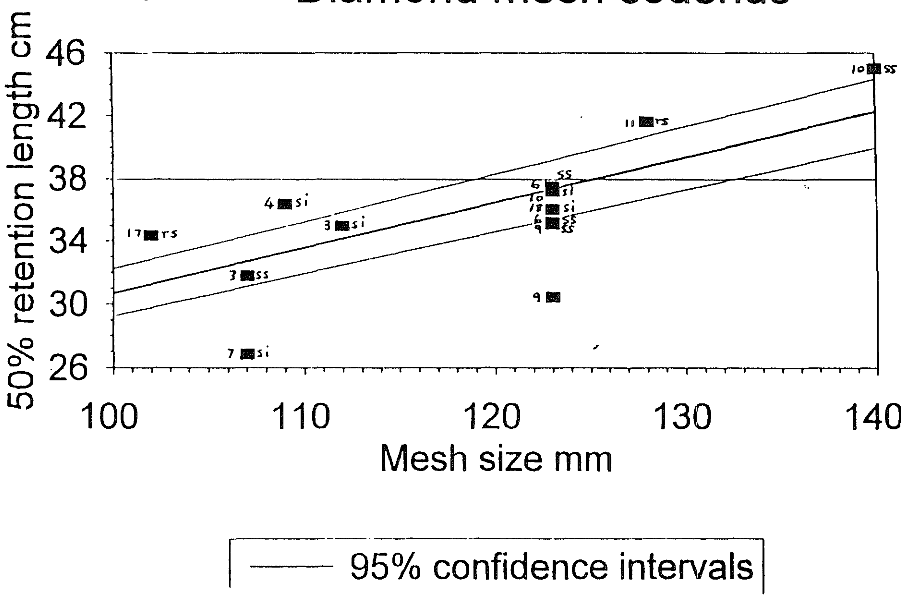


Fig. 2.1.2 Danish exit windows

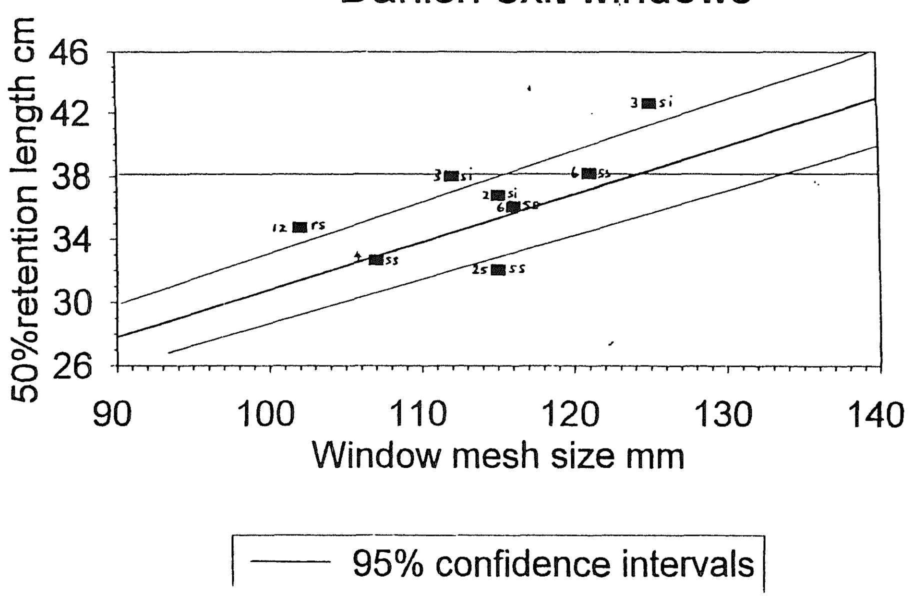


Fig. 2.1.3 Swedish exit windows

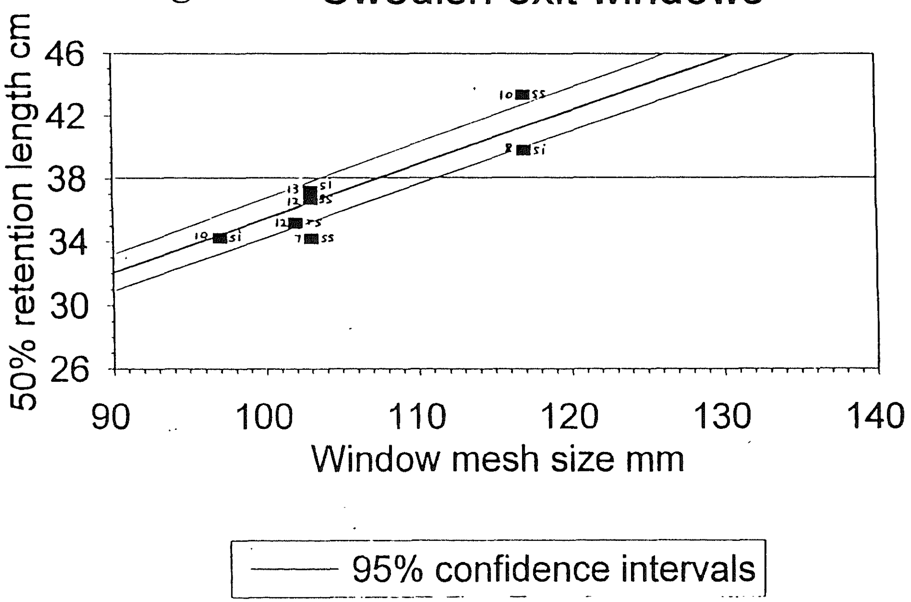
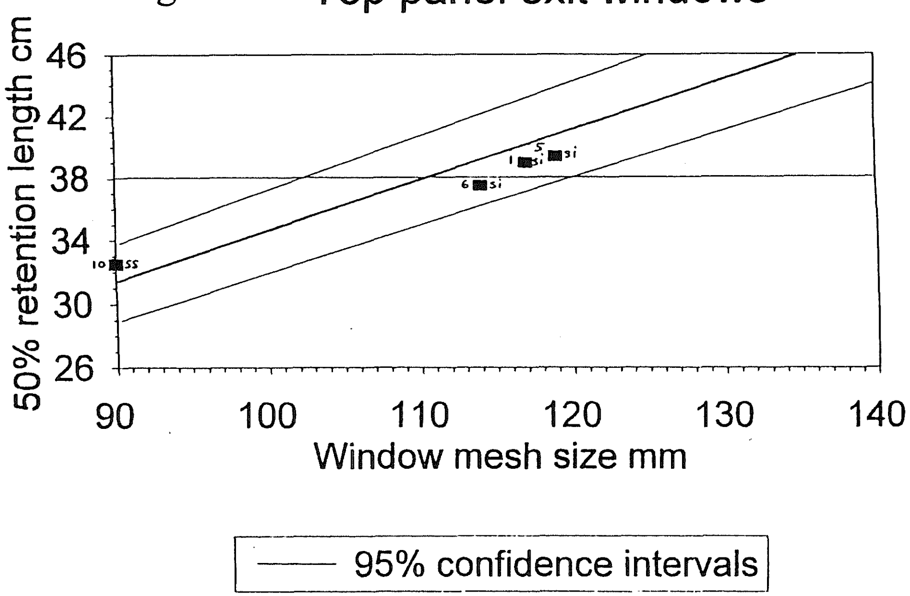


Fig. 2.1.4 Top panel exit windows



2.2 Report on the Selection of a Demersal Sampling Trawl for the Baltic Sea. T. Moth-Poulsen, Denmark

Terms of reference:

Advise the Baltic International Survey Assessment Working Group and the Baltic Fish Committee on a standard multi species survey bottom trawl to be used for resource assessment in the Baltic Sea.

2.2.1 Introduction

This is a request from the Baltic Fish Committee to the Fish Capture Committee. At present various standard trawls fitted to national research vessels are in use for resource assessment in the Baltic Sea. Two problems can be identified in relation to the use of a single standard gear. Firstly, national research vessels differ in size, engine, rigging, etc. Secondly, the variations in bottom topography and depth of the Baltic Sea restrict the use of presently employed trawls to specific parts of the Baltic. In their 1995 report the Study Group on Assessment-Related Research Activities Relevant to the Baltic Fish Resources concluded that measures to introduce new standard trawls should include expert advice on gear design and asked an appropriate Group under the Fish Capture Committee to advise on the selection of a standard trawl for use in the Baltic International Trawl Surveys. The first step in approaching this problem was to appoint a Sub-Group leader to form a Baltic survey trawl group consisting of experts from the Baltic countries.

2.2.2 Methodology

The following Working Plan was outlined to the FTFB Working Group on behalf of the Sub-Group leader: Ulrik Jes Hansen, Denmark:

1) review the survey trawl designs presently used for surveys of the Baltic Sea;
2) seek clarification on the requirements from assessment biologists at the Helsinki meeting of Baltic International Survey Assessment Working Group in May 96;
3) decide on a survey trawl that can meet these requirements;
4) develop a trawl rigging manual; and, if possible;
5) coordinate a training workshop at the flume tank in Hirtshals for biologists, captains and trawl masters.

2.2.3 Discussion

The Working Group chairman noted the delay in the start of activity by this Sub-group due to resignation of initial project leader. Both chairmen of the Baltic Fish Committee and the Baltic International Survey Assessment Working Group were notified in January that the requested advice would not be ready for the May meeting of ACFM and the Baltic International Survey Assessment Working Group. The target date for delivery was tentatively set for the Annual Science Conference in September, 1996.

The Working Group recommended that members of the Sub-group should attend the May meeting of the Baltic International Survey Assessment Working Group to discuss whether assessment biologists want a survey trawl that gives comparable findings to commercial fleets or whether the emphasis is on estimating pre-recruits or some combination of both.

The Working Group noted that this survey trawl will be used by multiple vessels and that item #1 addresses the problem of determining the types and powers of vessels involved in order to select a new survey gear that can be used by all vessels. This will make the selection a bit more difficult because the current range of horsepower in research vessels is from 150 to 1000 HP.

The Working Group suggested that the proposed flume tank training would be also beneficial if a sea trial on a research vessel was added. It is expected that all countries will build the survey trawl according to the specifications, similar to the GOV survey trawl used in the North Sea groundfish surveys.

Regarding the proposed time schedule for delivery of advice, the Working Group noted that the time frame may be too short given the complexity of selecting a survey trawl and commented that the FTFB Working Group's work on the GOV manual took a year to complete.

2.3 Report on Status of the Manual on Recommended Methodology of Selectivity Experiments prepared by the Sub-Group on Selectivity Methods. Chairman: Dave Wileman, Denmark.

This Sub-group is sun setting in 1996. The chairman reported that the final draft of the manual is at ICES Headquarters and should be published by October at the latest. Price for the manual is expected to will be around 200 kroner or $ 35 US dollars. The manual was highly praised by the Working Group.

2.4 Report of Study Group on Unaccounted Mortality in Fisheries. Chairman: Alain Fréchet, Canada.

The Study Group chairman commented that his group was working by correspondence in 1996. The group is reviewing all new work in this field and its priority will be to develop recommendations for the 1997 meeting.

2.5 Report of the Study Group on Grid (Grate) Sorting Systems in Trawls, Bean Trawls and Seine Nets. John Willy Valdermarsen, Norway.

In accordance with ICES C. Res. 1995/2:17, a Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets will be established under the chairmanship of J. W. Valdemarsen (Norway) and will meet in Woods Hole, USA from 13 - 14 April, 1996 to:

a) review current research on grid (grate) sorting systems for different fisheries;

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

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

d) report their findings and recommendations to the FTFB, ACFM and ACME.

Twenty-six scientists from 13 countries participated in the two day meeting, 13-14 April, 1996 in Woods Hole. The Study Group reviewed the research from countries participating and made the following recommendations:

a) compile grid and non-grid selectivity parameters and relevant associated data for finfish and shellfish;
b) estimate the number of vessels worldwide that are using grids;
c) estimate impact of actual and potential grid usage on discard levels for target species in various fisheries concerned; and
d) compile a comprehensive bibliography on grids.

The Study group will work on the above items by correspondence and meet again in two years

Discussions
The Working Group suggested that the summary table mentioned in recommendation 'a' should be expanded to include additional parameters such as dates of experimental periods and other parameters affecting selectivity such as towing speed, tow weight and light intensity. The Working Group noted that there are reliable techniques for estimating selection of grates and these techniques may be better than several techniques used in codend selectivity studies.

In addition, consideration should be given to measurements of survival of fish encountering the grates and this could be mentioned in the Study Group's final report. It was noted that some survival studies have been done in Norway and survival was very high. The Working Group suggested that the Study Group chairman should exchange information with the Study Group on Unaccounted Mortality in Fisheries.

The Working Group also suggested that the Study Group report should have clear definitions in its recommendations to remove any vagueness. It would be helpful to those reading the report to include justifications for recommendations made.

3. SPECIAL TOPIC: EFFICIENCY OF SURVEY GEARS

3.1 INTRODUCTION

The topic of "Efficiency of Survey Gears" was considered as theme for the Working Group 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 prevail whether the effective fishing width of bottom trawls, used in swept area modes, should be door spread or wing spread. Regardless of which one 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, however, relative abundance estimates are still used because the shortcomings of survey designs and sampling gears have not been addressed.

The purpose of the Special Topic is to review the recent progress made in estimating survey trawl efficiency and discuss further requirements for research.

3.2 **Guest Seminar:** Trends in the fishery and new tasks for research. Prof. Alexander Fridman, United States.

With the decline in traditional groundfish species the fisheries of the next century will switch emphasis to pelagics. Presently many of these small pelagics, such as sardines, anchovies etc, are converted into fish meal and oil. These fish should be used as a base for new-value fish products and the abundant mesopelagics, such as myctophids, could be used for fish meal. It may now be time for groups like FTFB to direct their focus towards pelagic fisheries.

In our current methods of assessing fish resources models dealing with sampling trawl and commercial fishery data suffer from inaccurate measurements of fishing effort and catchability. In order to relate both series of data it is necessary to establish correlations between catchabilities of both survey gears and commercial gears. Closely related to this is calculation of net selectivity and evaluation of changes in yield and stock size as a result in changes in mesh regulations. Theoretical approaches necessary to provide insight into resolving some of these problems have been dealt with in Russian literature but, are not widely known in western literature. A review of this information could help FTFB Working Group plan its future strategies.

3.3 **Keynote Speaker:** The role of trawl surveys in stock assessment. Ralph Mayo, United States

Survey catchability, i.e. the difference between what you get and what is really there, is a function of availability, vulnerability and selectivity. The first two factors are influenced mainly by fish behaviour and the later by gear performance. Time series estimates of survey abundance are used to tune fishery dependent models such as VPA, which rely heavily on exact catch at age data. Although the interactions of mulispecies can affect catchability it is not considered in VPA calculations.

The NMFS/NOAA bottom trawl survey program is the longest known standardized time series for demersal species and survey data is used to tune VPA estimates of several commercial species. There have been some changes in trawl doors used in the time series and vessels conversion factors have been derived and used to adjust survey estimates.

Recently survey data has been used to model the effects of changes in spatial distribution of the stock and its effect on estimates of the stock size in assessments. No acoustic work is currently in use by the NEFSC in addition to the trawl survey, but should the resources become available it would be a welcome addition.

3.4 **Estimating efficiency of sampling trawls to derive survey abundance indices: A review of problems and progress. S. J. Walsh, Canada**

This review presents information on some of the current methods that can be used to investigate and improve survey efficiency and outlines some of the problems related to evolution of single species surveys into multi-species surveys. First and foremost, a scientist must know how his or her sampling tool is operating and secondly the overall efficiency of the trawl should be determined. The fish capture process is a complex interaction between fish behaviour and trawl behaviour (see Fig. 3.1.1). A survey is designed to minimize the effects of catchability and hence fish behaviour and, as this synthesis emphasizes, fish behaviour can confound interpretation of data and affect reliability in the time series unless accounted for either in the design or analysis.

To understand these variations in catchability and behaviour of fishes to the trawl, more information is required on factors which may influence these processes, in particular, biological data on migration, condition, maturation, spawning, endogenous rhythms, and feeding, as well as physical data on water transparency, light levels, temperature and salinity. The development of acoustics and/or other underwater techniques to measure the bottom layer could answer many questions about fish behaviour. Mathematical modelling may provide the way forward to estimate absolute abundances and requires more studies of fish behaviour-trawl interactions to understand the fish capture process.

3.5 Chronology of Experimental Research to Standardize and Estimate Trawl Efficiency and Selectivity of Bottom Survey Trawls at NWAFC During The Past Decade. S. J. Walsh and B. R. McCallum, Canada (Handout).

Since 1990 several projects have been initiated to measure survey trawl performance, trawl standardization, trawl efficiency and fish behaviour at the Northwest Atlantic Fisheries Centre in Newfoundland.. These include the 1) effect of tow duration on catch and size composition; 2) fish behaviour reactions in the trawl mouth between the wingends and the bosum of the footgear; 3) comparison of the trawl efficiency and selectivity of the new bottom survey trawl with the two standard survey trawls; 4) investigating the effect of density on escapement of commercial species underneath the survey trawl; 5) evaluation of restricting trawl door spread on trawl geometry and catchability of the survey trawl; 6) development of scope ratios for the new survey trawl for use at depths of 40-1500 m; 7) deriving conversion factors for all commercial groundfish species to convert the old standard gear time series to the new standard survey gear; and 8) studying the effect of temperature and light on catchability of cod and American plaice by otter trawls using a combination of acoustic tags/underwater video and lab studies of swimming speed and swimming endurance.

3.6 Overview of recent activities and further research on Norwegian sampling trawls. A. Engås, Norway.

In Norway, there has been continuing research on survey trawl efficiency and methods of incorporating this information in calculation of swept area estimates. Of primary interest is the calculation of tow duration and bottom contact. The Institute of Marine Research (IMR) is working with SCANMAR A/S to develop a new acoustic trawl net sensor to monitor bottom contact. The quantification of escapement of cod and other species underneath the survey trawl has been under investigation during the last three years. During this time period, the study of natural and trawl induced fish behaviour has begun using acoustic tags. Fish behaviour ahead of trawl doors and above the trawl headline will be estimated using a tow body acoustic sounder ahead of the trawl doors, a sounder attached to a ROV and underwater video/still photography. Research continues into survey pelagic trawling and sampling.

Discussion

The Working Group noted the increase in emphasis in studies of natural and trawl-induced behaviour using acoustic tags. Concerns were raised about interpreting vessel avoidance reactions in cod which were noted to react up to depths of 300 m . There was not always a reaction of the acoustically tagged fish to the test vessel, which led to great difficulty in deciding how to quantify the behavior of those that did react. IMR has a graduate student now examining the acoustic tag behaviour database and further work is continuing with the development of stationary buoys with echosounders for studying vessel-induced reactions of demersal and pelagic fish.

3.7 Sampling gear efficiency: the Lowestoft approach. G. P. Arnold, United Kingdom.

The Lowestoft fish behaviour programme is currently concerned with migration and vertical movement and thus the *availability* and *accessibility* of fish to sampling gear. Historically, it also included the *vulnerability* of flatfish to the Granton otter trawl, at the time the most important demersal gear in the English fisheries. Gear efficiency was estimated directly using plaice marked with 300 kHz transponding acoustic tags. Fish were tracked by one research vessel using high-resolution electronic sector-scanning sonar; a second ship attempted to catch them. Fish reactions were described to various parts of the trawl - mainly the doors and wing ends - and the overall efficiency of the gear was estimated at 44%. For fish in the path of the net efficiency was 60% but for fish encountering the bridles it was only 20%. When a door-to-door tickler chain was fitted (standard in commercial fishing) the efficiency of the gear increased to 67% overall and 79% for fish in the direct path of the net. Most of this increase arose from doubling (to 48%) the efficiency for fish encountering the bridles but the average distance at which the fish first reacted to the trawl doors also doubled from 4.5 to 9 m.

Discussion
The Working Group noted that the Lowestoff research is one of the few direct measurements of trawl efficiency for demersal finfish. Fish were seen escaping beneath the ground gear, near the wing ends. Positions of the fish were estimated with models of tidal stream simulations along with assuming certain paths and swimming speeds and inputs of observed vertical migrations. Having the tickler chain on the net does not decrease door spread. It was emphasized that the results are not universal to all trawls and could be improved upon through today's digital technology, eg. DGPS, which allows faster positioning fixing, although resolution is not much better. Any such exercise is inherently expensive, as the operation requires two vessels.

3.8 Survey Gear Specification. R.D. Galbraith, United Kingdom

The implementation of the recommendations contained in the report compiled by the FTFB contained subgroup (ICES C.M. 1992/B:39) which evaluated the sources of variability in the fishing power of the GOV trawl was discussed. New groundgear arrangements scheduled for inclusion in the manual for International Bottom Trawl Surveys currently being revised by the IBTS Working Group were presented. Problems in devising a suitable gear for deep water surveys were examined and gear specifications invited from countries currently involved in deep water commercial fisheries.

Discussion
The Working Group noted that the new manual will be coming out by the Assessment team and will be revision 5. A constant ground speed was chosen in order to calculate area swept. Speed through the water was recommended but was overturned in favor of speed over the ground. The Working Group also expressed dismay over rejection of using the recommended fishing checklist critical in the standardizing protocols of the GOV. It was noted that deepwater fishing, i.e. > 500 m is being conducted by many countries such as Canada, Iceland, New Zealand and Spain. Deep water surveys up to 1500 m using a shrimp trawl are being conducted by Newfoundland. It was emphasized that the impacts of using large mesh or small mesh in a standardized trawl on net geometry, bottom tending and fish size selection should be investigated.

3.9 New facts on the efficiency or total gear selectivity of German survey bottom trawls: Possible effects on stock assessment and stock protection. E. Dahm and H. Weinbeck, Germany

German sampling trawls such as the GOV demonstrated losses of catchable fishes beneath the groundrope irrespective of the roller gear used, Species specific behaviourial differences determine if fish species are caught by the sampling trawl or not (Fig. 3.1.2). The amount of losses of one particular species is caused by the type of the roller gear used and by the length composition of the fished stock. In the same length class the proportional losses at different fishing grounds are deviating for unknown reasons. Measures to reduce the effects mentioned are demonstrated. The most promising was the attachment of an apron behind and spanning the full footgear.

These results lead to considerations on the accuracy of present survey stock estimates and also to the possible application of such effects in stock management.

Discussion
Observations of the bags under the trawl were made and found not to affect geometry, however, it could not be determined through these observations if these bags were catching fish on haul back, though it is probably unlikely. Underwater observations were difficult due to reduced visibility form the sand clouds. It would be valuable to assess the differential escapement under the ground gear on different bottom types, but this may be difficult because of the fragility of the bags.

The Working Group noted that this experimental method to measure trawl (capture) efficiency have been used in Norway, Canada, Germany and the United States. All of these experiments point to a size and species dependent catchability in survey trawls

3.10 Changes in groundfish trawl catchability due to differences in operating width and measures to reduce width variation. C. S. Rose & E.P. Nunnallee, United States.

To test for an effect of trawl width variation on the ability of a survey trawl to capture groundfish, catch rates were compared between paired tows with and without a constraint line that reduced the operating width of the trawl (Fig. 3.1.3). The vertical distribution of fish near and above the sea floor was recorded with a scientific echosounder to test for fish diving into the path of the trawl.

Arrowtooth flounder (Atheresthes stomias), flathead sole (Hippoglossoides elassodon) and walleye pollock (Theragara chalcogramma) were captured at higher rates (fish per area swept) by a survey trawl fished in a narrow configuration. The size composition of the catches with both configurations were identical (Fig. 3.1.4). The difference was consistent across size groups within the species. The greatest difference occurred with the pollock. Correlations detected between catch rates of pollock and echo integration values well above the trawl height indicated that some of these fish were diving from midwater into the path of the trawl. Differences between the correlation patterns with and without constraint lines indicate that the diving behavior may be affected by the presence of the line.

Discussion

Differences in catching efficiency related to size was not seen, which may have been caused by a lack of fish in the size ranges smaller than 20 cm. This experiment was conducted at depths greater than 200 meters, where small fish were not as likely to occur. A similar experiment could be conducted in a shallow water environment where small fish are present to test for a size related difference in catches with and without a constraint line.

With respect to the difference in bridle angle of attack it was calculated that fish would have to swim 50% faster to stay ahead of the bridles with the constraint rope. There was a blind spot on the acoustic dead zone and it is not known what was in the area, however approaching this zone abundances had been decreasing. The constraint rope reduced variation around mean door width however door spreads for both net configurations were very consistent within 3 m.

3.11 Preliminary analysis of the effect of restricting door spread on bottom trawl geometry and catchability of groundfish. S. J. Walsh and B.R. McCallum, Canada

Experiments were carried out to investigate the use of a restrictor (constraint) rope to physically control door spread of a bottom survey trawl. The alternate haul method was used to compare differences in trawl performance and geometry at the same station, with the doors unrestricted and restricted and to evaluate the effect on catchability of groundfish species. The restrictor rope technique was effective in minimizing trawl width variation at bottom depths ranging from 43 to 1244 meters (see Table 3.1.1) and had no obvious effect on the magnitude of catches and size composition.

Discussion

The analysis is still preliminary and a power analysis has not yet been carried out to test differences in magnitude of catches. It was noted that the lack of differences in size composition was similar to results obtained in the US experiments. The depth of the tows and the incidence of zero catches of certain species due to tows outside their depth ranges will be accounted for in the design and analysis. The positioning of the depth sensor on the restrictor rope was adopted from Norwegian work.

The Working Group noted that research on the use of restrictor rope technology to minimize depth dependent trawl width variation is being carried out in Norway, United States and Canada and the success of these experiments show that this is a promising technique for minimizing trawl width variation in trawl surveys. Norway is now using the constraint rope on every second haul during their Barents Sea demersal surveys to collect data needed to develop conversion factors for unrestrained data.

3.12 Inter-vessel Calibration with Scanmar Technology. A. Fréchet, Canada

The use of multiple vessels to perform a stratified random groundfish survey presents a difficulty that the trawls may not have the same geometry. The geometry of a standard otter trawl may vary from one boat to another because of unique properties of each boat. We have tried to reduce this inter-boat variability by forcing the use of a single type of otter trawl. In order to verify the geometry of the trawls in a fishing situation, some acoustic trials were done using SCANMAR acoustic trawl geometry monitoring sensors.

We found that the wing spread varied from one boat to another, the range could reach 20% (Fig 3.1.5). Coefficients were derived in order to compare the fishing power from each boat. The average catches are thus calculated with a standard of 19 meters for the whole fleet. It was recommended to proceed with analysis aimed to control gear geometry with the use of a restraining cable instead of modifying the catch with the parameters derived for the wings because in fact, it is the whole gear that changes it's catchability with changes in wing spread.

Discussion
Scanmar data of trawl geometry were not edited further than the normal Scanmar software editing. Utilizing nine boats enabled many out of work fishermen to work and also creates a snap shot of the fishery when the 300 tows in nine days are examined. There are currently no commercial data due to fisheries moratoria. Experiments using fixed gear did not provide reasonable size distributions, although they did provide interesting data on feeding and condition relative to size. Fishermen were employed and not allowed to keep or sell any of the catch. The fishermen involved in the fishery were given set protocols to adhere to in terms of operation of the gear. Fishermen were requested to use a consistent type of door.

The Working Group noted the unique approach involved in the use of commercial vessels to achieve an estimate of stock size in the sentinel fishery and look forward to additional work on standardization of trawl geometry.

3.13 Some aspects of the effectiveness of the Campelen trawl for estimates of abundance and distribution of deep-water shrimp (Pandalus borealis) in the Barents Sea and Spitzbergen areas. M. T. Hafsteinsson Norway

The effectiveness of the Norwegian Campelen trawl used for shrimp surveys was investigated by making comparable tows with the trawl and a shrimp sampler. The shrimp sampler is a 3 m wide steel frame, with an array of fine meshed bags placed at different heights. Two variants were used, one of 2.3 m height, and another of 8 m height. Where the lower version of the shrimps sampler was used, tows were made after each other, with the shrimp sampler and the trawl respectively on different trawl stations in the Eastern Barents Sea. Using the 8 m height shrimp sampler 20 tows were made on the same location (West of Spitzbergen) covering a period of 3 days. Afterwards 8 hauls were made with the Campelen trawl on the same location over 24 hours. Samples were examined and density and length distributions of shrimp calculated.

Comparison of the catches in the shrimp sampler and the trawl indicates low efficiency of the survey trawl. Shrimp density estimated with the trawl gave on average much lower density compared with the shrimp sampler. Shrimp size distributions in the trawl showed to be highly biased compared with the shrimp sampler. The smallest shrimp showed to be almost non existant when trawl samples were used, while they were found in numbers when the shrimp sampler was used.

Discussion
The separation of different lengths of shrimp by depth may be explained by larger shrimp being better swimmers and may also have a tendency to rise up in the water column. Work is planned to examine further the differences in catch between day and night.

The Working Group noted that this was probably the first attempt at estimating trawl efficiency for shrimp and was encouraged by the results.

3.14 Estimating the herding coefficient for a bottom trawl. D. Somerton and P. Munro, United States

To quantitatively estimate the herding coefficient, H, or the proportion of fish between the wingtips and doors that are herded into the path of a trawl, we experimentally manipulated the area exposed to herding by varying the length of the bridles. Since flatfish are herded by the lower bridles, while roundfish are herded by the doors and mud clouds, the area exposed to herding is smaller for flatfish than it is for roundfish. We attempted to measure the area exposed to direct contact of the bridles by determining the point along the lower bridle where it leaves the bottom. This was done by viewing the lower bridle at various points along its length with underwater video. A model of the herding process was fit to catch per swept area and relative swept area data. For most flatfish examined, H varied between 0.2 and 0.3. Neither Pacific cod nor snow crab were herded (Table 3.1.2).

Discussion
Using longer bridles results in lower wing spread, causing better footgear contact and thus greater probability of catching fish which typically dive

down when entering a trawl. Cameras were not mounted when conducting these experiments, however it may be possible to mount cameras on the bridles and estimate herding from the camera observations alone. Pacific cod observed in this study occur in very high densities in the Bering sea and were probably not subject to vertical herding. Gaps between the sand cloud generated by the door and the bridles may be larger with longer bridles. Such gaps may indicate that net is overspread. In the commercial fishery the longer the bridles, the more cod you catch. Marteshevskii and Korotkov tried to regulate the relative positions of the bridles and the sand cloud and found that the optimal position for herding was to have the sand cloud superimposed over the bridles. The net was not altered to try to change the position or configuration of the sand clouds, as the aim of the study was to examine how the sampling net was fishing.

The Working Group noted that the experimental approach to model herding parameters was unique. It stressed that quantifying catchability of survey trawls should consider the trawl path defined by the doors and not by the wings as is typically used in swept area estimates.

3.15 Can Commercial CPUE be used in conjunction with or supplemental to bottom trawl survey CPUE? J. Alvsvåg and O. R. Godø, Norway

A commercial CPUE was compared with VPA data and bottom trawl survey data to test the feasibility of using commercial trawl catches data to monitor the adult cod population throughout the year. Data from commercial catches in the period 1980 to 1994 where cod made up more than 50% of the haul, are presented in this paper. The VPA and survey data variation in CPUE from year to year, time series analyses were applied. Regression between CPUE and VPA and between CPUE and bottom trawl survey data both show a good relationship (r^2=0.91 and r^2=0.69, respectively) between commercial catch data and population size.

Discussion
The Working Group noted that as data on commercial CPUE has been accumulated over years, it has been seen that the commercial CPUE can remain constant as stocks decline, due to increased technology and trawlers ability to fish on concentrations. Perhaps fixed gear is a better estimate than trawls. Fixed gear landings correlate well with stock size, but it is often hard to determine accurately the amount of effort that is associated with the landings.

In the AFSC (Alaska Fisheries Science Center) Bayesian assessments are popular and are using joint estimators, using commercial CPUE as initial estimates which are compared to fishery independent information and where the two diverge, less weight is placed on the commercial CPUE. When both indices are used, the VPA is very sensitive to the number of data points in each component.

3.16 Estimating net efficiency for snow crabs using depletion experiments. D Somerton, United States

No Abstract Available

Discussion
The Working Group noted that Leslie depletion experiments are well suited to model trawl efficiency in most shellfish. There is size differential behavior of crabs in that females tend to be buried and males tend to be on the surface of bottom. Strong northeast winds created problems with reduced catchability as fish rose off the bottom to avoid the strong surge. The location and performance of the net can be estimated through acoustic gear, mathematically, or using vessel speed and Scanmar to determine bottom contact.

3.17 GENERAL DISCUSSION

A total of 14 papers and 2 keynote addresses were presented on the Special Topic from scientists representing 10 institutes in 5 countries. The Working Group noted that since the 1980 Canadian Workshop on Bottom Trawl Surveys (Doubleday and Rivard 1981; Can, Spec. Publ. Fish. Aquat. Sci. Vol 58), much effort has gone into standardization of survey operations to reduce variability in trawl geometry and performance to reduce measurement error and bring bias to an acceptable level. Work during the early years was directed at developing standardizing protocols onboard to fine tune the performance of the nets and this has evolved to looking more at variation in area swept. There has been a significant amount of research conducted on quantifying trawl variability by estimating escapement under trawl, width of trawl etc, at many international fisheries institutes. The Working Group concluded that we have come to a point where we agree that if we could standardize trawl width we could reduce the variation and bias in survey estimates used in stock assessment. It must be emphasized that researchers need to continue to look at natural fish behavior as well as behavior of fish in path of fishing gear.

These experimental investigations and the availability of off the shelf instrumentation has permitted investigations into the effect of environmental conditions on catchability. Various parameters affecting the capture efficiency of a trawl at the Aberdeen Marine Laboratory have shown that light levels, temperature and net geometry strongly influence their estimates of abundance. Once the relationships between these parameters are quantified it should be possible to apply corrections to catches under the measured conditions to fine tune survey estimates for stock assessments.

The Working Group noted that very little information exists on whether the condition of the fish at the time of capture affects the degree to which a fish will attempt to escape from a trawl path. A large catch of fish in the survey time series are generally looked upon as an anonymously catch, i.e. " a year effect" in time series jargon. The interpretation of catchability during those one or two fishing hauls is confounded because we don't know if it was density effect or response to favorable/unfavorable conditions at the station. Regradless of which cause there has been an obvious change in trawl efficiency. Research in Norway and Canada have indicated that catching efficiency of the survey trawl increases with fish density, which may mean that the amount that you catch may not be indicative of the amount of fish that are in the survey area.

Are we close to estimating absolute abundance indices? Researchers from the Alaska Fisheries Science Center were asked to inform the Working Group on their use of survey trawl abundance indices. Alaska views data from their surveys in the Bering Sea as a contribution to the modeling effort and as such cannot stand alone. Catchability has to be estimated in some way. How precisely can you estimate catchability with a model or with experimentation? It takes three years for the Alaska Fisheries Science Center to complete a survey of the shelf area which does not allow for a long time series and so catchability must be assessed experimentally. It is true that an acoustic survey is carried out along with the trawl survey and the acoustic estimate of fish in water column above the trawl is added to the estimate of fish from the trawl, i.e. estimates are treated as absolute. But because the surveys are not annual, they are not used in tuning VPA.

The Working Group noted that catchability has two sides, the survey trawl efficiency and evaluation of fishing mortality by the commercial fleet. We need to know how they interconnect. We also need to find dynamic models to explain the basic parameters, and how to weight each parameter and as well as the interaction factors. Survey indices are still be used as relative indices of abundance in most institutes and in many cases little effort is made to increase their precision and accuracy through use of quantitatived data on the variability of the sampling trawl. This becomes more critical when VPA estimates cannot be used because of problems with the CPUE data or fisheries are under moratoria, as are many stocks in the Northwest Atlantic Fisheries Organization management area, and the only source of data is survey trawl estimates.

The Working Group noted that the papers presented here summarize the progress and direction taken since 1980 and felt that a more organized international effort was necessary to plan the way ahead. It strongly supported the recommendation that an ad hoc group should be formed to investigate critical areas for further research and advise FTFB on the role it should take in promoting research aimed at maximizing the use of information on survey trawl catchability to increase precision, accuracy and reliability of bottom trawl estimates of abundance in stock assessment.

Table 3.1.1 Comparison of gear geometry for unrestricted and restricted trawls. CV = coefficient of variation * 100

	Unrestricted					Restricted				
	Hauls	$\bar{x}$	CV(%)	Min.	Max.	Hauls	$\bar{x}$	CV(%)	Min.	Max.
Doorspread	41	51.9	12.9	42.6	68.3	41	45.1	6.5	37.6	50.6
Wingspread	40	15.5	7.4	13.4	17.9	41	14.3	8.8	12.2	17.9
Opening	40	4.8	12.5	3.8	6.1	41	5.0	10.6	4.2	6.5
Sweep Angle	40	21.3	15.3	16.6	27.9	40	18.0	8.6	13.6	20.7

Table 3.1.2 Values of H for the two herding experiments.

Bering Sea		Washington	
Species	H	Species	H
rock sole	0.30	Dover sole	0.27
yellowfin sole	0.22	English sole	0.19
flathead sole	0.20	Pacific sanddab	0.10
Pacific cod	0.00	rex sole	0.23
snow crab	0.00	slender sole	0.47

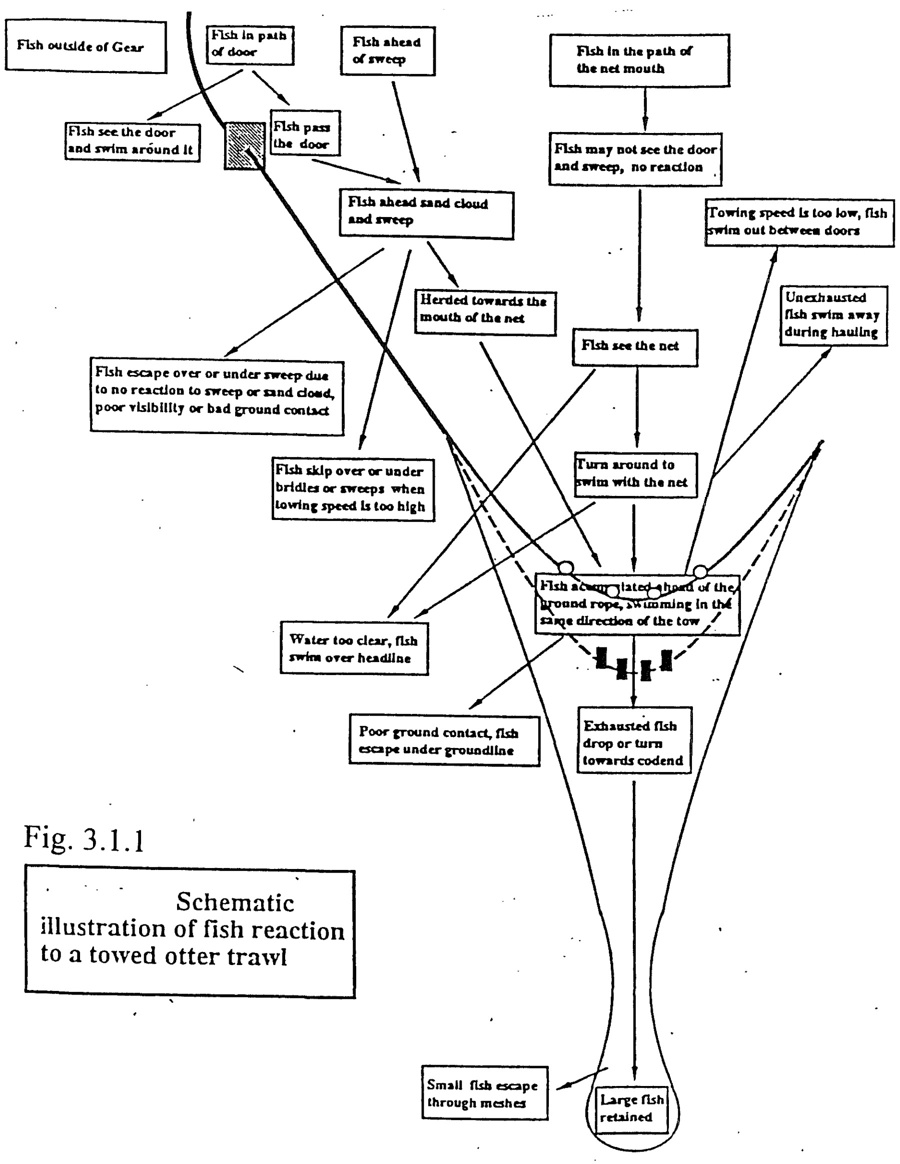
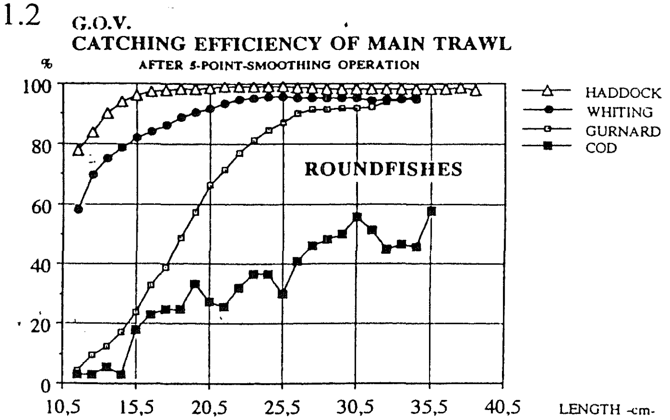
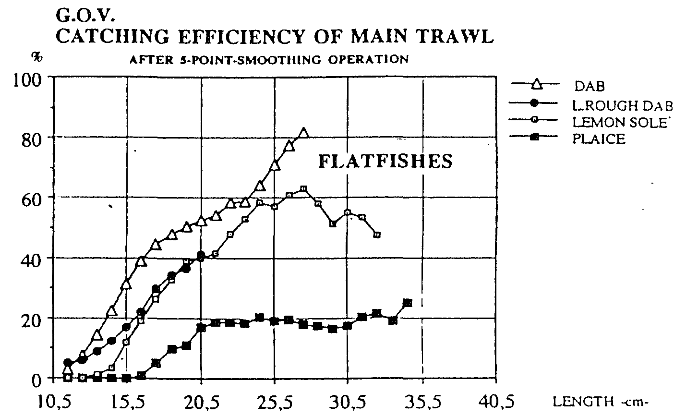


Fig. 3.1.1

Schematic illustration of fish reaction to a towed otter trawl

Fig. 3.1.2





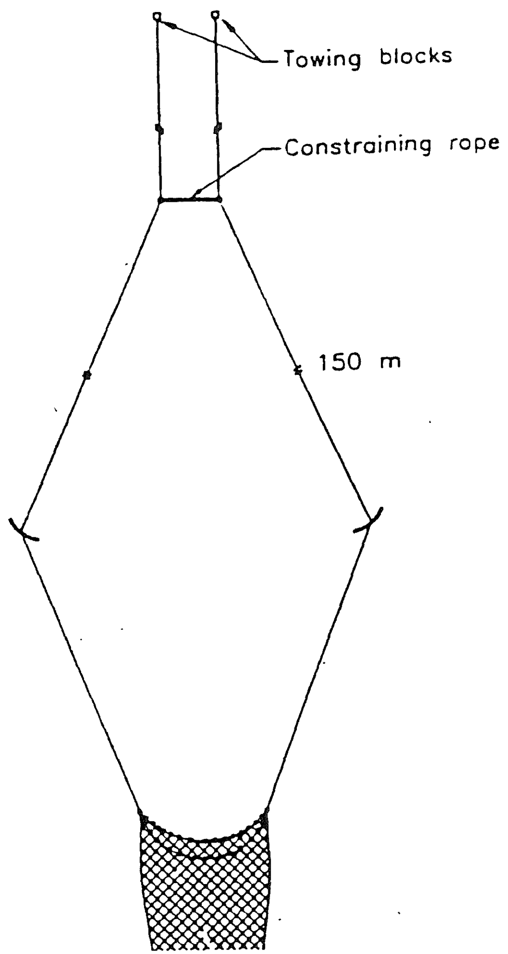


Fig. 3.1.3

Schematic outline of the constraining technique (after Engås & Ona. 1991).

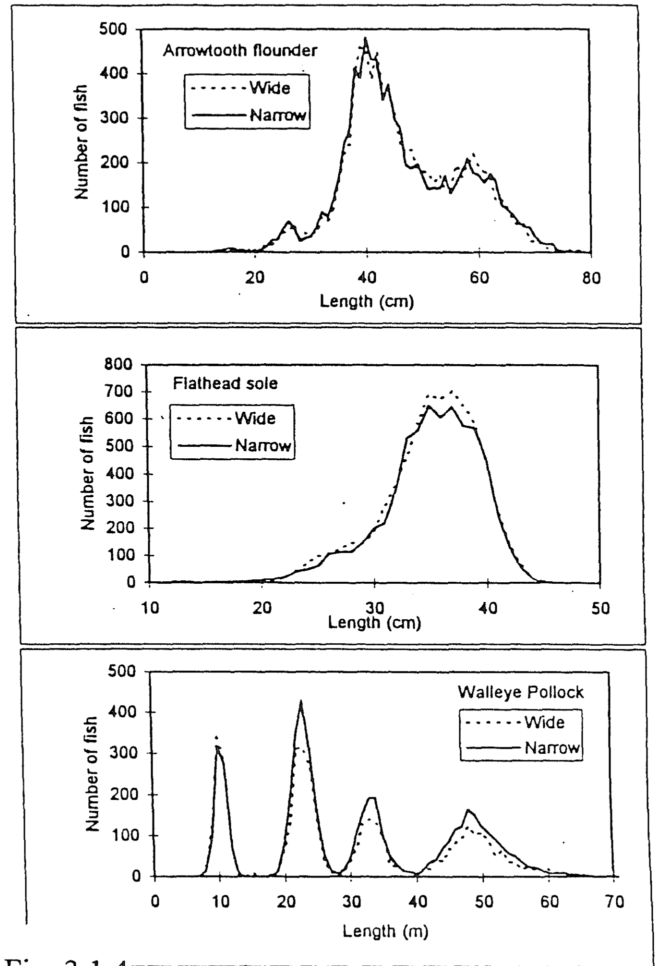


Fig. 3.1.4 Size composition of fish caught during paired tows of a groundfish survey trawl in wide and narrow (without and with constraint line) configurations.

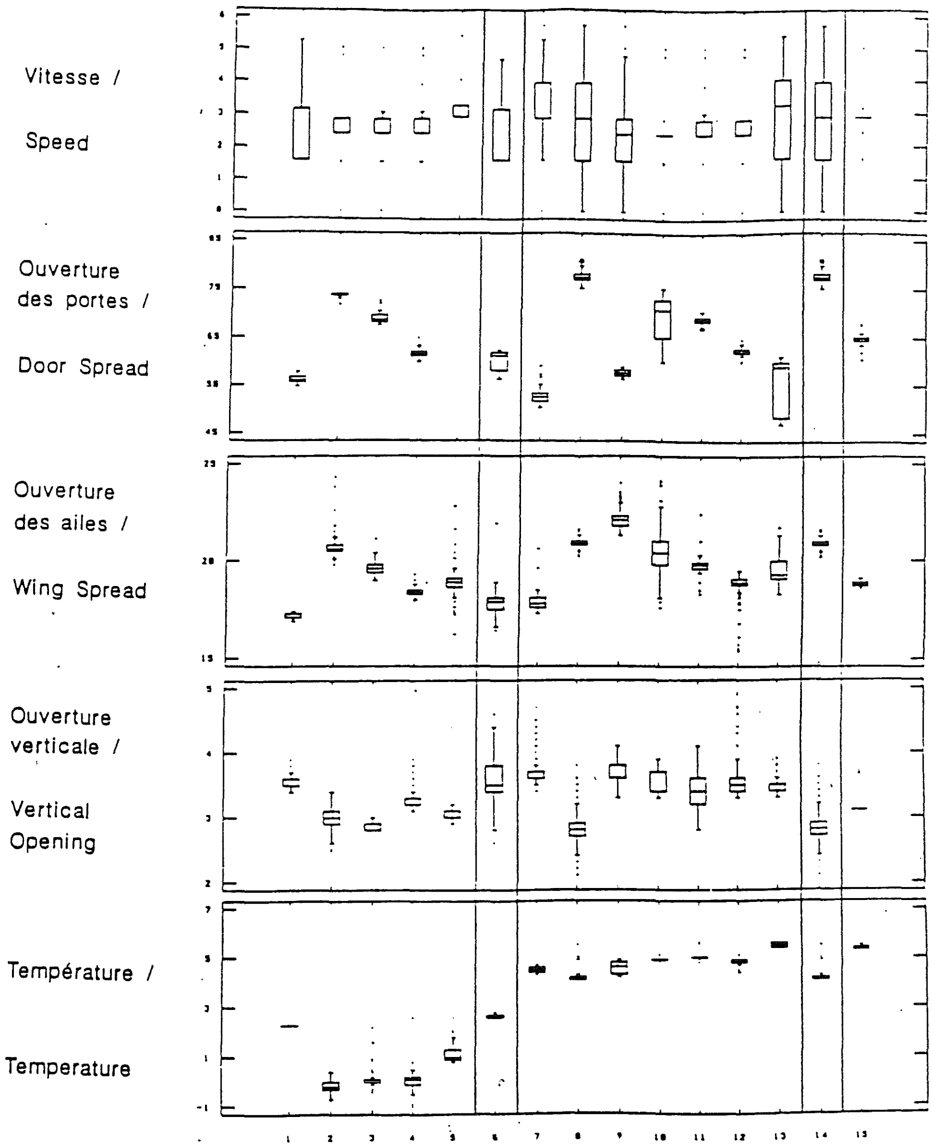


Fig. 3.1.5 Graphes boîtes et moustaches de paramètres mesurés par SCANMAR.
Box and whisker plots of parameters measured by SCANMAR.

4.0 COMMERCIAL SELECTIVITY STUDIES

4.1 INTRODUCTION

A total of 10 papers were presented on various aspects of continuing studies of estimating selectivity in commercial fishing gears were presented and discussed by the Working Group. Summaries of these presentations and discussions are below..

4.2 Effect of population structure, sampling strategy and sample size on the estimates of selectivity parameters for shrimp (Crangon crangon) trawls: preliminary results. H. Polet and F. Redant, Belgium

In selectivity experiments with shrimp trawls, very high numbers of marine animals in the catches of single hauls are a common feature, therefore, sub-sampling is inevitable. In order to find an acceptable balance between work load and accuracy in the estimation of the selectivity parameters, it is of utmost importance to have precise numbers of shrimp to be measured in each fraction of the catches (cover, discards and commercial shrimp). The present theoretical study tries to answer this question by means of computer simulations of different sampling strategies and sample sizes on catches with known size compositions.

Discussion
Hoops were used in the codend cover to avoid masking, no underwater video observations were made in the area between the codends. Shrimp were sorted first to get rid of the bycatch. Electronic calipers for measuring shrimp sped up measurement time. A similar project was conducted with whiting. All fish were measured and then data were analyzed for different proportions resulting in the conclusion it was worthwhile to conduct more tows that sample whole catches.

The Working Group noted the importance of simulation studies to examine different sampling and sub-sampling strategies before conducting field work and complimented the authors on their research.

4.3 Commercial evaluation of a separator trawl in a North Sea fishery K. Arkley and P. MacMullen, United Kingdom

This paper describes the results of comparative fishing trials, under commercial conditions, using a standard trawl and a separator trawl. The target species in the fishing area were cod, haddock, whiting, lemon sole and plaice. The separator trawl was fitted with a 120 mm lower codend; the upper codend and the standard net were 100 mm (see Fig. 4.1.1). The trials involved about 90 paired tows over a period of 10 weeks. Sample sizes were generally good with the exception of plaice. The results were very encouraging. The separator trawl showed a useful reduction in catches of sub-legal fish as well as size grades around the minimum legal size. The data obtained were consistent with those from previous and more recent trials. The fishing skippers were initially very skeptical about the concept of a separator trawl but both subsequently became enthusiastic advocates of the advantages offered by this type of net for their fishery.

Discussion
The separator panel was set at one meter high above the footrope, and was constructed of the same material as the bottom belly. There was no observation of gilling in the separator panel. The Working Group noted the benefits of cooperative projects with fisherman.

4.4 A comparison of the catch of juvenile cod (Gadus morhua) from four configurations of groundfish longlines. J. Harris and H. A. Carr, United States.

New England groundfish fisheries are continuing to experience tremendous scrutiny and restrictive management due to the depleted state of the resource. In order to discern areas of further research on the selectivity and survival of groundfish on longline gear, four configurations of longline gear were rigged and fished by commercial fishermen in the Cape Cod groundfish longline fishery. Two fishermen fished gear rigged with Mustad 11/0 circle hooks on gangions spaced at either 6' or 12' along a string. Two additional fishermen fished with gear rigged with strings of either 11/0 or 13/0 Mustad circle hooks (Fig. 4.1.2). No statistically significant differences between the two pairs of gear could be assessed. Future work will entail using 11/0 and 15/0 circle hooks, with the 15/0 hooks constructed of the same gauge wire as the 11/0 hooks. The proposed work will also be a true selectivity study utilizing an alternative gear to assess the structure of the population available to the hooks.

Discussion
All hooks were Mustad circle hooks. All hooks were baited, however there was no quantification of lost baits. There did not appear to be a problem with birds stealing the baits. The Working Group welcomed this research on static gears and noted that this area of research is becoming more prevalent. It also noted that fish survival data for static gears is also minimal and encouraged that this research should be included into selectivity investigations of static gears.

4.5 Research programme on the reduction of by-catches in the Belgian shrimp fishery. H. Polet, Belgium. (Poster)

In 1995 a comprehensive research programme was started, aiming at a reduction of by-catches in the Belgian shrimp fishery. In the current second phase of the programme, the "whole trawl selectivity" of the commercial shrimp trawls is being studied. By means of small sample nets mounted on the net, the escape of shrimps from 16 different net sections is sampled. Cod-end selectivity is determined by means of the covered cod-end technique.

It was found that the "net selectivity" is important compared to the cod-end selectivity. In most cases more shrimps escape from the net than from the cod-end. Catch rate affects cod-end but not net selectivity. Catch composition (and the presence of seaweed) affects both. It was concluded that when introducing by-catch reducing devices in the shrimp fishery it might be important to investigate the effect of the alterations on the whole trawl selectivity.

4.6 Variation in the Haddock length - girth relationship and its effect on codend retention. H. Őzbilgin, United Kingdom. (Poster)

The ability of a fish to escape through the mesh of a net during fishing depends partly on its girth in relation to the opening and configuration of the mesh. However, due to the ease with which length can be measured, it is customary to relate the mesh selection directly to the length rather than any other dimensions.

During September 1995 and February 1996, both girth and length were measured for haddock (Melanogrammus aeglefinus) in two sea trips designed to investigate the seasonal variation in cod-end selectivity. The length -girth relationship for haddock was established for each trip. Both retained and escaped fish were grouped in 1 cm and 10 mm girth classes for each haul. Owing to inadequate sample sizes in each length -girth class, six hauls in each trip were pooled regardless of between haul variation. Finally, the retention probabilities for each length -girth class were calculated. There is a tendency for retention to increase as length increases at constant girth (see Table 4.1.1). This suggests that the condition of the fish is more important than its physical shape.

4.7 Seasonal Variation in Cod-End Selectivity of Haddock. H. Őzbilgin, R. S .T. Ferro, J. H. B. Robertson, J. R. Hutcheon, R. J. Kynotch and G. Holtrop, United Kingdom. (Poster)

To investigate the seasonal variation in cod-end selectivity, three sea trips were carried out on board a Scottish commercial trawler. Experiments were performed on the same grounds using the same fishing gear with an improved cod-end technique. The target species was haddock (*Melanogrammus aeglefinus*). Sea trips were conducted April 1995 (post-spawning stage), September 1995 (after summer feeding) and February 1996 (pre-spawning stage). Selectivity parameters based on fish length were obtained by using probit analysis and the 50% retention lengths (L50) for each cruise was found to be significantly different. Girth measurements were obtained in September 1995 and February 1996 allowing the selectivity parameters to be estimated in terms of girth.

There were differences in the length/girth relation among the three cruises (Table 4.1.2). However, the variation in selectivity between seasons cannot be explained by the variation in girth alone. The highest L50 occurred when girths at a given length were greatest. The changes in the selectivity may be due to changes in fish condition and water temperature which may modify escape behaviour and swimming ability.

4.8 Computation of the Flow Field in the Codend V. Benoît, France (Poster)

This work takes place in a global improvement project of trawl selectivity. The selectivity of a fishing gear is its capacity to let young fish escape through the meshes. The object is to improve our knowledge about mesh geometry in codend where selectivity especially works. To be able to calculate mesh geometry we need to know water velocity in the trawl. Indeed, mesh geometry depends on hydrodynamic forces due to flow. The study is restricted to codend, where variations of water velocity are more important. We suppose the flow to be uniform in the beginning of the trawl.

Navier-Stokes equations are used to solve the problem. These equations are not solved around each twine of codend, because it is technically impossible. The codend is supposed to be an homogeneous and permeable surface. Specific equations are used to compute tangential and normal velocity components at the net's surface. We add to these equations a turbulent model. At least, we compare numerical results and a first serial of experiences made in a flume tank.

4.9 Swedish Trials To Improve Selectivity In Demersal Trawls In The Baltic Cod Fishery. V. Tschernij, R. Holst, Denmark and P-O. Larsson Sweden.

A new type of codend design with two lateral exit-windows was compared to a traditional diamond mesh codend. Experiments were conducted in 1994-1995 in Hanš Bay (ICES SD 25). The primary goal was to assess the effect of mesh size on codend selectivity, the range of seasonal variation, and the effect of vessel type on the selectivity. Some supplementary data was collected on alternative codend designs and materials. The results show that a bigger mesh size allows a higher L50 both in a traditional codend and in the side window codend. With traditional codend design the 50% selection length was 1-2 cm higher with a side trawler than with a similar size of stern trawler whereas with a window codend design no systematical difference between vessel types was found.

The selection range was 7-12 cm for diamond mesh codends and 5.5-8 cm for window codends with a slightly wider selection range with the side trawlers (Fig. 4.1.4). The sharpest selection (SR 4.5 cm), however, was obtained with a special multi-panel codend design using knotless Ultra-Cross netting. In video observations cod showed surprisingly passive swimming behaviour within the codend and during escape process. During towing, codends often were twisting and hence the lateral exit windows were occasionally top and bottom windows.

Discussion
Underwater observations have been made but have not yielded the reason for the difference. The differences in the L50 are not due to spawning differences in this case as spawning does not occur at this time, nor could it be due to temperature as cod stays below the thermocline where the temperature is constant year round. This also enables them to feed year round, although there is some variation in condition of the fish with respect to the fat content in their livers.

The lateral panel could also be used in the upper and lower panel but it is likely that this would produce same affect. The cause for the difference between side and stern trawlers is unknown and is confounded by differences in vessel power. The Working Group noted that there may be some quantification of the differences in the literature.

4.10 Experiments with sorting panels and square mesh windows in the Portuguese crustaceans fishery. A. Campos and P. Fonseca, Portugal and D. Wileman, Denmark (read by title).

Table 4.1.1

September 1995 retention probabilities (pooled data)

Girth	Length (cm) 20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5	29.5	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	Girth
85																					85
95	0																				95
105	0	0	0																		105
115	0	0	0	0	0.1																115
125			0	0	0	0	0.1														125
135					0	0.1	0.1	0.2	0.2												135
145							0.2	0.1	0.1	0.2	0.2										145
155									0.1	0.1	0.3	0.4	0.4								155
165										0.3	0.2	0.2	0.3	0.6	0.5	1					165
175												0.2	0.2	0.4	0.4	0.6	0.8				175
185														0.5	0.4	0.5	0.3	0.6			185
195																	0.5		0.6	0.7	195
205																					205

February 1996 retention probabilities (pooled data)

Girth	Length (cm) 20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.5	29.5	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	Girth
85	0																				85
95	0	0	0																		95
105		0	0	0																	105
115			0	0	0	0															115
125					0	0	0.1	0													125
135						0.1	0.1	0.1	0.2	0.2	0.3										135
145							0	0.2	0.2	0.2	0.3	0.3									145
155									0.3	0.4	0.4	0.5	0.5	0.7							155
165											0.3	0.7	0.5	0.6	0.8	0.6					165
175												0.9	0.8	0.8	0.9	0.7	0.7				175
185														0.8	0.8	1	0.9	1			185
195															1	1	1	1			195
205																	1	1	1		205

Table 4.1.2

Summary of the length selectivity parameters, water temperature and the fish condition between the seasons

	April 1995	September 1995	February 1996
50% retention length (cm)	27.7	32.9	30.9
95% confidence interval	26.7 - 29.2	32.0 - 33.7	30.5 - 31.2
Selection range (cm)	6.4	6.9	4.6
95% confidence interval	5.3 - 7.5	6.4 - 7.4	4.2 - 5.0
Selection factor	2.96	3.51	3.30
Number of hauls	8	18	12
Water temperature (°C)	-7	-12	-7
Fish condition	After spawning	After summer feeding	Pre-spawning

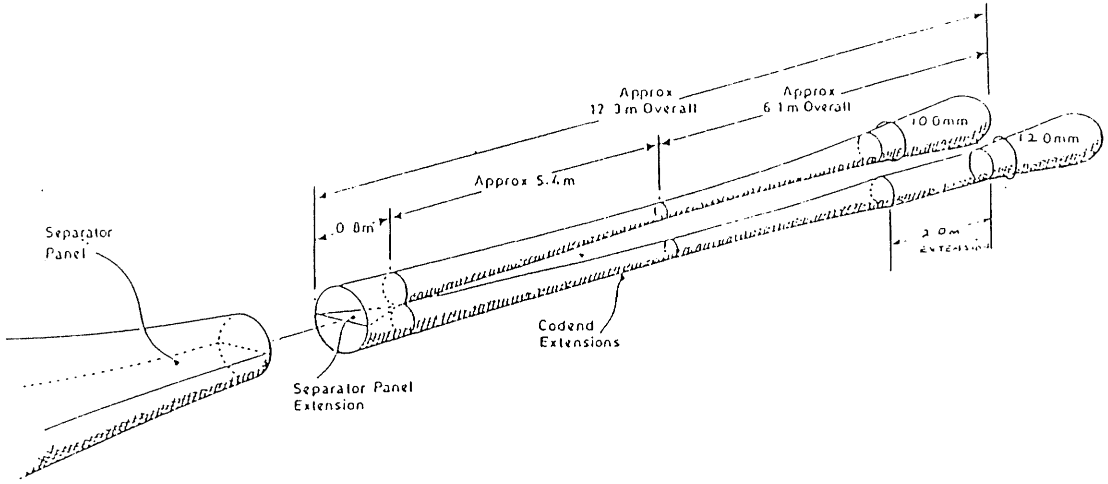


Fig. 4.1.1 Codend arrangement used in conjunction with the separator trawl

Fig. 4.1.2 Sublegal catch per hook by trip for hook size experiment.

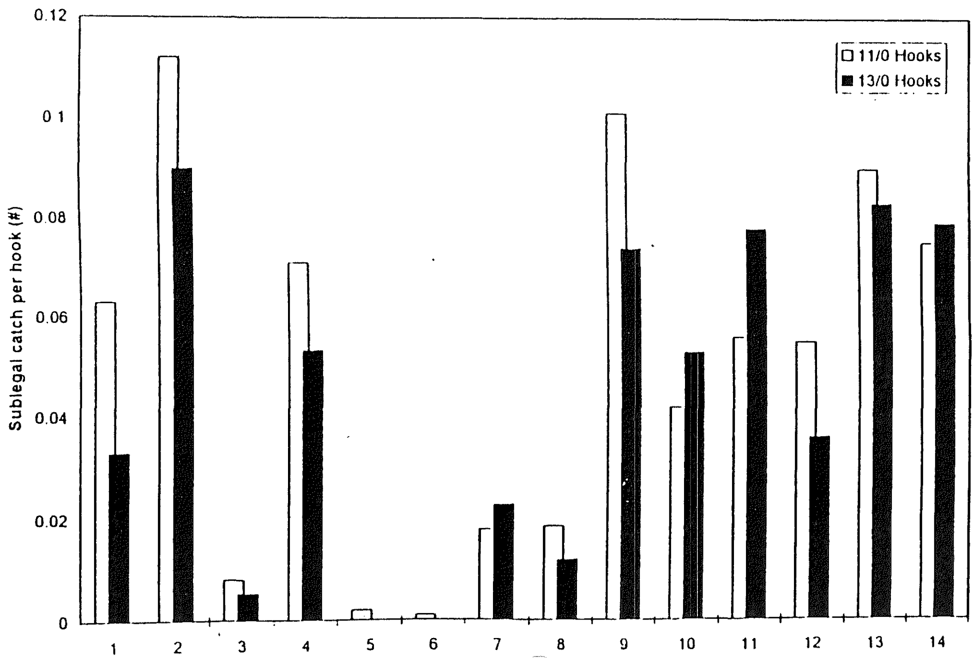
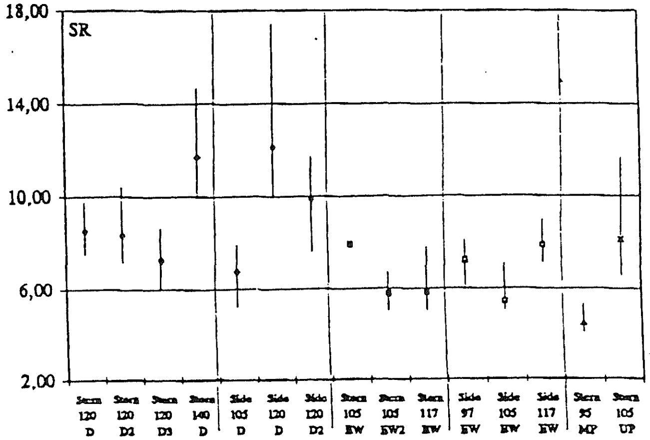


Fig. 4.1.3 Selection range (cm) in the different experiments. The number below the vessel-type refers to the nominal mesh size (mm). D=diamond mesh codend , EW=side window design, MP=multi-panel and UP=upper panel codend. The last number after codend design refers to the replicate of experiment.



5.0 GRID SELECTIVITY STUDIES

A total of 3 papers on continuing investigations of the use of grid selectivity devices in trawls were presented and discussed by the Working Group. These papers and several others were presented during the Study Group on Grid (Grate) Sorting Systems in Trawls, Bean Trawls and Seine Nets, 13-14, April 1996, Woods Hole . These papers are listed by title only and can be seen in detail in ICES. CM 1996/B:1.

5.1 Size selectivity of Norway lobster in trawls using grid devices. J. W. Valdermarsen, Norway

5.2 Size sorting shrimp with an in-trawl grid system. G. Brothers & D. Boulos, Canada

5.3 Summary of grid selection devices tested in Norway. B. Isaksen, Norway

6.0 MODELING SELECTIVITY DATA

6.1 INTRODUCTION

Two papers were presented that used mathematical and statistical models to examine various aspects of codend mesh selection.

6.2 Substantiation of the trawl escape panel use and determination of its optimal parameters. A . Fridman and H. Milliken, United States

When scientists develop large mesh panels to separate target and bycatch fish species, often they select the size of the mesh in the panel and the hanging ratios based on availability and ease without considering factors such as the fishes' swimming speed, trawl speed and morphology and the velocity of the net. When these factors are known, a series of calculations can be performed by the use of the proposed model which allow the researcher to construct a panel that can be shown to allow fish, which are charging the net, to escape. Furthermore, by modifying the mesh size and hanging coefficient of the net, the researcher may be able to construct large mesh panels that select for or against species depending on that species morphology. Without calculating the optimal mesh size for a separator panel, the researcher is making a guess as to the expected outcome of his field work. When calculations are made in advance, some time, effort and money can be saved.

Discussion

The model does assume that the fish is perpendicular to the mesh and 28 cm/s is used as a maximum burst speed. It can be used with more detailed parameters of escape and with data from actual observations for escape parameters concerning individual fish. The Working Group noted that the use of theoretical modeling may not be duplicated entirely with field data but emphasized that it was a valuable tool for providing insight into the process of escapement from codend meshes.

6.3 Non-parametric analyses of codend selectivity. R. Holst , Denmark and V. Tschernij Sweden.

Estimating selectivity curves is most often done by use of parametric techniques. An alternative non-parametric approach is presented and techniques for validating these fits are discussed. The method is applied to three data sets, each covering several hauls conducted in Swedish waters. The non-parametric fits are compared with those obtained using the SELECT model. Bootstrap methods are applied to account for between haul variation and techniques for performing tests and computing confidence intervals for the selection statistics are briefly mentioned.

Discussion

The proportions on the curve were not weighted by the number of fish making up that point, although it is an option. The Working Group noted that the higher than expected proportions retained at the lowest lengths of the curve may be due to the inability of these fish to escape from window due to lower swimming capacity and endurance.

7.0 FISH SURVIVAL STUDIES

7.1 INTRODUCTION

Two papers were presented on fish survival studies which are considered an intregal component of selectivity work (see Report of the Sub-Group on methodology of fish survival experiments ICES CM 1995/B:8)

7.2 Survival of gadoid fish escaping from the cod-end of trawls. N. Lowry, Denmark andGraham Sangster, United Kingdom.

An experiment was conducted during the summer of 1995 on the Scottish west coast to investigate the survival of haddock and whiting which escape from demersal trawls with different cod-end mesh sizes, especially in relation to length and age of the fish. In general the survival rates were high, but were shown to be dependent on size and age. Within each age class the smallest fish showed the highest mortality rate. Mesh size had little effect on survival, given that the fish escaped.

Discussion
The twine characteristics of the cages were the same, soft twine was used to minimize damage. Twine sizes could perhaps be important with respect to damage. The finding of age dependent survival was consistent across tows, although individual tows may have had few fish to support the curves. There was great care taken in moving the fish from the codend cover to the cage site to minimize stress. The transport container was closed so fish did not feel the movement of water during transport. The tow duration was one half hour, implying that some fish may be in the cover for that long. This may be a long time for a small fish to be in the cover. The Working Group noted that it would be beneficial to study this problem at commercial fishing rates. Observations were made of the cover and fish were not seen lying against the cover. There were also problems with the control group, in terms of equating treatment and in terms of numbers. Future work will involve using fish traps to collect control fish. It is important to conduct these studies at local levels in order to avoid applying data on survival to disparate fisheries.

7.3 Swimming Capabilities and Survival of Scup, *Stenotomus chrysops*, Following severe exercise. K. J. La Valley and J. DeAlteris, United States.

The behavior of a fish in the path of a mobile fishing gear is largely dependent on their ability to swim for prolonged periods at advanced speeds. Therefore, a knowledge of the swimming characteristics and the stress induced by swimming of trawled fish species may lead to more selective fishing methods.

In this study, scup *(Stenotomus chrysops*) were severely exercised by manual chasing for six minutes and the clearance of lactate over a 12 hour period was evaluated. Rested concentrations of lactate ranged from 5.2 to approximately 23.0 mg/dL lactate. Lactate peaked from 0.5 to 1.0 hour following exercise with concentrations ranging from 61.0 to 126.0 mg/dL, and returned to rested concentrations within 4 hours post-exercise. Fish were observed for ten days following exercise for delayed mortality. A 100% survival of scup was observed with no significant difference between control and experimental populations. Swimming capabilities were evaluated for 14.0 to 15.0 cm fork length scup at 12 °C, with a towed stimulus through a still-water circular swimming channel, at prolonged and burst speeds. A maximum sustainable swimming speed of 2.2 BL/s was observed. At speeds of 3.0, 3.3 and 4.4 BL/s endurance time decreased with the increase in swimming speed. This relationship was described by the lest squares regression line as; logE = 5.9191 - 0.96233 U with an R^2 value of 0.97.

Blood lactate concentrations were measured at 0.5 and 4.0 hr following exercise, and were used as an indicator of white muscle recruitment. A significant difference was not found between rested and experimental mean lactate concentrations at the maximum sustainable swimming speed of 2.2 BL/s. White muscle recruitment indicated by increases in lactic acid, was seen at speeds above the maximum sustained swimming speed, and mean blood lactate concentrations were significantly different within blood sampling times and between swimming speeds. Due to the effect of swimming path curvature, an estimated 7.3% increase in swimming speed would be obtained for fish swimming along a straight path with the same available swimming power.

Discussion
In a commercial fishery this species will be able to swim ahead of the gear for only a very short period of time. At the beginning of the work it was expected that some metabolic consequences of lactic acid and cortisol buildup such as immuno-suppression, would contribute to mortality. The Working Group emphasized that although the use of laboratory studies on stress cannot be duplicated in field studies lab studies are the generally the only available source of data on swimming endurance and speeds.

8.0 REPORTS ON SUGGESTED WORK ITEMS FOR THE WORKING GROUP

8.1 Report of the analysis of the FTFB questionnaire: Measuring fishing gear/ fish behaviour and problems related to data acquisition. G. Bavouzet, France and B. McCallum, Canada.

The questionnaire has been distributed but due to its lateness, all replies have not been received. We will summarize results and send to FTFB chairman for inclusion in FTFB report. The Working Group advised that the questionnaire should also be sent to the technical people who are directly working on instrumentation. This will be a discussion item at the 1997 FTFB meeting.

8.2 Report on further investigations of the technical and financial feasibility of establishing and FTFB working group selectivity database. B. Van Marlen, The Netherlands.

A group of 22 experts in fishery biology, gear technology and computer science representing most ICES countries has been formed to apply for EU funding. If funded the primary aim will be to determine the needs of users, quality and availability of the database and software, and quality controls for access. Should we receive the funding then work can begin in November.

8.3 Report on the monitoring of the FTFB E-mail server for a trial period to assess for technical and operational difficulties; N. Lowry, Denmark

At present there are 49 FTFB members listed on the FTFB server which uses an account on the ICES server and forwards all the messages it receives to all 49 addresses. Members use it primarily to query other researchers on particular problems. The Working Group agreed to investigate setting up a web page which could facilitate flow of information such as agenda, mailing lists, abstracts of papers and recommendations from FTFB meetings to the members and the world community

8.4 Report on the consideration of an international coordinated research on mesh size measurement and twine and netting characteristics which may affect selectivity. R. Ferro, United Kingdom

A recent joint EU project has looked at mesh opening/ twine thickness effect on selectivity. Since then there is little work being done without funding. Presently, fishery inspectors are not happy with the current legislated mesh gauges which are different than those used in scientific studies. North sea inspectors have initiated information requests to resolve this. Currently there is a 'Concerted Action Proposal' to look for EU funding. The aims of this proposal would be to identify problems of mesh measurements; make lists of current procedures and instruments; look at problems encountered with current procedures; conduct hearings with fishermen and net makers to receive input from industry; carry out mesh measurements on specific netting; and make some recommendations for development of more appropriate gauge. If this funding is approved the work plan will be sent to FTFB members and other interested parties.

8.5 Report on the feasibility of compiling of a complete bibliography of selectivity experiments for publication. S. Walsh, Canada

The FTFB Chairman informed the Working Group that Dr. Pingguo He of Canada would be willing to head an ad hoc group to prepare a complete bibliography of selectivity experiments for publication. Members noted that there were several topic-specific bibliographies in their position and would contribute these to a larger volume. The Working Group endorsed the utility of such a bibliography as a compliment to the soon to be released ICES COOP Selectivity Manual edited by FTFB members.

9.0 RECOMMENDATIONS FOR THE NEXT MEETING

9.1 The Working Group on Fishing Technology and Fish Behaviour recommends that the next meeting will be held in Hamburg, Germany (Chairman: Dr. S J Walsh) from 14 to 17, April 1997 to:

a) review and evaluate progress in estimating and improving catching efficiency and size and species selectivity in static fishing gears used in commercial fisheries and scientific surveys of finfish and shellfish;

b) make recommendations for future research in neglected areas; and

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

Justification

The topic of "Selectivity and Efficiency of Static Fishing Gears" will be considered as a theme for this meeting.

Static gears (gillnets, pots, traps, longlines, etc.) are commonly used in commercial fisheries of both the inshore, nearshore and offshore fisheries for finfish and shellfish. Static gears are also viewed as an alternative to mobile gears in conserving dwindling fish stocks or in the re-opening of fisheries under moratoria. Many shellfish stocks are assessed based upon surveys using static gears and in several ICES countries static gears are used in place of mobile gears to sample finfish in untrawlable areas. The FTFB Working Group would be an excellent forum to discuss and review the recent research in methods to improve both size and species selectivity of static gears used in the commercial fisheries and scientific surveys. The range of related topics will be: selectivity, efficiency, fish behaviour, survival, unaccounted mortality, statistical analysis and assessment.

9.2 The Working Group recommends that an "ad hoc group" of 3 to 5 members be setup to examine in detail the problem and mechanisms of integrating estimates of bottom survey trawl catchability more effectively into the stock assessment process.

Justification

At this meeting the Working Group reviewed the progress of current research efforts in estimating survey trawl catchability in several ICES countries, for example Canada, Norway, Germany, United Kingdom and the United States. Much effort has gone into standardization of survey operations to reduce variability in trawl geometry and performance to reduce measurement error and bring bias to an acceptable level. Work during the early years was directed at developing standardizing protocols onboard to fine tune the performance of the nets and this has evolved to looking more at variation in area swept. There has been a significant amount of research measuring survey trawl geometry, escapement of the target species under trawl and the role of fish behaviour in the fish capture process in the estimation of catchability, however, the leap forward to incorporating trawl catchability research into swept area modeling has not generally happened.

Standardizing trawl width variation through use of adaptive techniques such as physically restricting trawl door spread will result in a more accurate estimates of swept area indices which are traditionally biased by a depth dependent relationship. Recent efforts in mathematical modeling of the effects of availability and trawl efficiency on survey catchability offers a promising step forward. Once the relationships between these parameters are quantified it should be possible to apply corrections to catches under the measured conditions to fine tune survey estimates for stock assessments.

The Working Group noted that the 14 papers presented here summarize the progress and direction taken since 1980 and felt that a more organized international effort was necessary to achieve the ultimate goal of increasing precision, accuracy and reliability of bottom trawl estimates of abundance in stock assessment using trawl data. The role of this internal FTFB ad hoc group would be to investigate critical areas for further research and advise FTFB Working Group at the April 1997 on the role it should take in promoting research aimed at maximizing the use of information on survey trawl catchability.

9.3 The FTFB and FAST Working Groups recommends that they meet in joint session, 17 th April 1997 under the Chairmanship of Dr. O.R. Godø, Norway, to consider the problems to be resolved in determining the catchability of the sampling gears used to estimate the sizes and species encountered in acoustic surveys of both pelagic and demersal fish stocks.

Justification

This joint session allows both Working Groups to focus on problems related to groundtruthing acoustic signals in pelagic and demersal surveys.

9.4 SUGGESTED WORK ITEMS FOR THE WORKING GROUP

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

a) investigate the feasibility of accessing the Russian literature on theoretical and applied research on fishing effort and trawl catchability (Action: A. Fridman, United States);

b) discuss the results of the 1996 FTFB Questionnaire on the problems related to the acquisition of data from measuring fishing gear performance by acoustics and other underwater observations and advise the Working Group on a the need for any action (Action: G. Bavouzet, France);

c) investigate the feasibility of setting up of a FTFB webpage (Action: N. Lowry, Denmark);

d) report on the progress of setting up a ICES database on commercial trawl selectivity (Action: B. Van Marlen, The Netherlands); and

e) report on the feasibility of establishing a bibliography of trawl selectivity experiments (P. He, Canada).

9.5 CLOSING REMARKS

The Chairman thanked all members for their efforts and contributions. Special thanks to organizers, Arne Carr and Jessica Harris and staff. The meeting closed at 1225 hrs on April 18, 1996.

10.0 NATIONAL COUNTRY REPORTS

CANADIAN ACTICITIES REPORT.

S. J. Walsh, Northwest Atlantic Fisheries Center, Newfoundland

Nova Scotia and New Brunswick - Work has been proceeding with the Offshore Scallop Industry to identify how fish are entering the scallop drags (rakes) and ways of reducing the by catch, particularly cod and haddock. To date several experiments have been performed using square mesh ropebacks, windows in the ropebacks, and tickler chains. Experiments have been confined to simply comparing the catches from the rakes on a vessels with one rake modified and other in standard configuration. C. G. Cooper, Senior Advisor Technological Development, Maritimes Region, DFO, 1505 Barrington Street , 17 North, PO Box 550 Halifax NS B3J 2S7

Newfoundland

Department of Fisheries and Oceans, Newfoundland Region

Shrimp size selectivity: - An investigations were carried out onboard two, 20 metre vessels to reduce the catch of small shrimp using a trouser codend behind the nordmøre grate to conduct two experiments. The first experiment compared 55 mm diamond mesh to the standard 43 mm diamond mesh, while, the second compared 45 mm square mesh to the standard mesh. The second vessel investigated the effectiveness of a shrimp size sorting grate with 7 mm bar spacings installed into the trawl behind the Nordmøre grate. A follow-up shrimp size selectivity experiment was carried out using thirty, 13 to 20 metre vessels. Each vessel had a quota of 8,300 kg. of shrimp to harvest. The vessels were divided into five groups of six, and only one group operated at a time. Four of the vessels used size sorting grates with either 8 mm or 10 mm bar spacings installed into the trawl behind the Nordmore grate, while the other two vessels were operated as control vessels, and only used Nordmøre grates. An underwater camera was used to observe the behaviour of shrimp to the grate. *Salmonid by-catch in capelin traps* - Two capelin traps each 77 metres on-the-rounds, and 8 metres deep were used in an experiment to reduce salmonid by-catch. Salmon deflectors were used on one trap, while the second trap was operated normally. Each of the two deflectors was 37 metres long, and 1.8 metres deep, and extended from the trap leader, 37 metres from the doorways, to the front corners of the trap. Contact person: Gerald Brothers, Section Head, Conservation Technology, Industry Development Division, Fisheries Management Branch, Department of Fisheries and Oceans, P.O.Box 5667, St. John's, Newfoundland, Canada, A1C 5X1,Telephone +1 709 772-4438, Fax +1 709 772-2110, E-Mail gb@dfonfl01.nwafc.nf.ca.

Science Branch, Newfoundland Region

Scope Ratio Project: Development of scope ratios for Campelen 1800 survey trawl to fish depths of 40-1500 m. Method: Determine the required warp angle of incidence (WAI) to achieve optimum trawl door performance and bottom contact. Warp angle and trawl door attitude were measured using SCANMAR sensors; depth and speed modified to measure angle. New ratios were determined by targeting the required WAI on each tow at stations from 40-1500 m.

New Bottom Survey Trawl Project: Comparative fishing of Campelen 1800 (new survey trawl) with Engel 145 otter trawl (old survey trawl) to derive conversion factors for all commercial groundfish species. Method: parallel tows using two vessels with a tow duration of 30 minutes (3.5 knots) for Engel trawl and 15 minutes (3.0 knots) for Campelen trawl. Focus: cod, American plaice, redfish, yellowtail flounder, thorny skate, Greenland halibut, witch flounder. Contact person: Stephen J. Walsh, Dept. Of Fisheries and Oceans, P.O. Box 5667, St. John's Newfoundland, Canada, A1C-5X1. Tel. +1 709 772 5478, Fax +1 709 772 4188, Email walsh @ nflorc.nwafc.nf.ca

Department of Fisheries and Aquaculture, Newfoundland

Crab Selectivity Project - The purpose of this project was to reduce the by-catch of undersized crab by placing a plastic collar around the top of the crab pot to prevent undersized crab from entering the pot. *Exploratory Hagfish Trials*- Fishing trials were undertaken to determine the ability of harvesting Hagfish and their suitability for marketing. *Shrimp Pot Fishing Project* - The project was to determine the suitability of a pot design used in Maine for harvesting shrimp when used in Newfoundland. *Onboard Handling of Shrimp Project* - The purpose of the project was to determine if the quality of shrimp could be better maintained on board vessels using plastic boxes for storage rather than using the traditional method of storing them in bags. Contact person: Brian Johnson, Department of Fisheries and Aquaculture P.O. Box 8700, St. John's, Newfoundland, Canada, A1B 4J6, Telephone +1 709 729-3766, Fax +1 709 729-6082 or E-mail at BJOHNSON@fish.dffa.gov.nf.ca

FISHERIES LABORATORY, LOWESTOFT, UK CURRENT RESEARCH ACTIVITIES: 1996. G. Arnold, United Kingdom

DFR Lowestoft currently has a five year programme of research to investigate the movements and migrations of plaice and cod in the southern North Sea. The programme, which lasts until 1999, involves tracking individual acoustically-tagged fish, as well as deploying several hundred fish tagged with data storage (archival) tags. A parallel programme continues the development of the Lowestoft data storage tag with the aim of making the tag significantly smaller, as well as adding additional sensors.

The aim of the archival tagging programme is to describe patterns of behaviour over the time scales of seasonal migrations. To date the work has been restricted to plaice and 140 tags have been released in three batches between December 1993 and March 1995. Different return rates have been recorded between the three batches of tags, but in each case the return rate of fish marked with data storage tags has matched that of control fish marked with Petersen disc tags. Overall, 20 tags have been returned. Two tags failed prematurely but the remaining 18 have yielded 1500 days of pressure and temperature data recorded at 10 minute and 24 hour intervals, respectively. Three tags have been returned with full memories (225 days) after approximately a year at liberty. The pressure data have been used in conjunction with the Lowestoft tidal stream simulation model to successfully reconstruct the ground tracks of the fish. Independent checks of the veracity of these reconstructions have been obtained from the pressure and temperature data recorded by the tags, using a different tidal (hydrostatic) model and satellite measurements of sea surface temperature.

The aim of the complementary fish tracking programme is to obtain a direct estimate of the downtide swimming speed of fish migrating by selective tidal stream transport. The work is being undertaken by RV 'Corystes', using sector scanning sonar and high-frequency transponding acoustic tags. Continuous measurements of tidal stream speed and direction are made with an Acoustic Doppler Current profiler during tracking.

Engineering developments have included the construction of a batch of 20 archival tags for Norway designed to work at depths down to 1000 m. The titanium cases of these tags proved to be too large for practical application and further development of deep water tags has been postponed until completion of the Mk 3 Lowestoft data storage tag, which is scheduled for the summer of 1996. This new tag will be only half the size of the existing tag. But it will have four times as much memory and will only cost half as much a the Mk 1 hemispherical tag currently being used with large plaice. Development work on a high-resolution solid state miniature compass is also well advanced.

REPORT OF ACTIVITIES - BELGIUM. R. Fonteyne and H. Polet Fisheries Research Station (RVZ)

Selectivity - Within the framework of the EU AIR-programme the project "Optimization of a species selective beam trawl" (contract AIR2-CT93-1015) was continued. The development of species selective beam trawls aims at the reduction of roundfish discards while maintaining the flatfish catch rates. This project is performed in collaboration with RIVO (NL) and SEAFISH (UK). The coordination is held by RVZ. Comparative fishing experiments with experimental gears towed at one side of the vessel and the standard gears towed at the other side were carried out during five two-weeks sea trials with chartered commercial beam trawlers of 300 hp, 700 hp and 1200 hp. The experimental gears selected for these trials were a beam net with a partly square mesh top panel and a beam net with a reduced top panel. With these configurations the whiting and haddock catches could be reduced by 30 to 50 % for the larger vessels but the effect was less pronounced for the 300 hp beamer. The new gears are not only evaluated with regard to their selective properties but the economic impact will also be assessed.

A study has been started to develop a simulation model for the whole trawl selectivity of a shrimp beam trawl. Two experimental sea trips have been carried out with RV BELGICA to develop the methodology and to collect basic data.

In the framework of the ICES Working Group on Fishing Technology and Fish Behaviour further collaboration was given to the compilation of the Manual of Methods of Measurement of Selectivity of Towed Fishing Gears. The Manual will be published in 1996 in the ICES Cooperative Research Report series.

Ecological effects of fishing activities - In the framework of the EU-project "IMPACT II - The effects of different types of fisheries on North Sea and Irish Sea benthic ecosystems" (contract AIR2-94-1664) the studies on the impact of fishing gear on the sea bottom and the benthos populations was continued. This project runs in collaboration with fisheries research institutes and universities in the Netherlands (coordinator), Belgium, Germany, Ireland and the UK. During a campaign on RV "BELGICA" the pressure on the sea bottom exerted by a 4 m beam trawl fitted with a chain mat was measured. The changes in benthos populations and catch composition as a result of fishing activities were assessed. A similar experiment was simultaneously made by the Dutch RV "TRIDENS" fishing with 4 m and 12 m beam trawls with tickler chains. Seabed disturbance was studied by side scan sonar and RoxAnn observations of the fish tracks. A historical review concerning vessel and fishing gears used since 1900 was made up. In 1995 a new and detailed inventory of vessels and gears engaged in bottom trawling was started. This sub-project is being coordinated by RVZ.

Fishing Effort - An EU-project on the relation between the fishing effort and technical vessel and gear characteristics was completed (Investigation of the relative fishing effort exerted by towed demersal gears on selected North Sea species - contract AIR1-92-0445). The other participants in this project were the Danish Institute for Fisheries Technology and Aquaculture (coordinator), the SOAFD Marine Laboratory (UK), the SEAFISH Industry Authority (UK) and the Danish Institute for Fisheries and Marine Research. Statistical analysis of catch and effort data for the period 1989-1994 allowed the development of models describing the relationship between the catch per unit effort and vessel and gear characteristics. For different fishing gears and vessel classes the relative fishing power was determined per species and per groups of species (flat and roundfishes). It was found that between vessel differences in relative fishing power could be explained as well by vessel as by gear parameters. Vessel hp usually correlated best to relative fishing power and the addition of extra explanatory variables did not give great improvement.

Fishing gear research - In the frame of fishery projects financed by the Flemish Region Government Nephrops twin trawls and roundfish triple trawls were tested and introduced. A series of flume tank tests on models of typical Belgian trawl was completed. The tests were performed in close collaboration with the fishing industry and IFREMER in the flume tank in Boulogne.

Two EU-projects concerned "Research into the Cragnon fisheries unerring effect" (BIO 94/C 144/04), in collaboration with RIVO (NL), DIFMAR (DK), University of Humberside (UK) and Institut für Seefisherei (DE), and "Alternative stimulation in fisheries" (AIR3-94-1850) with RIVO (NL), Institute of Marine Research (NO), Finnish Game and Fisheries Research Institute (FI), SEAFISH (UK) and Institut für Seefisherei (DE).

PROGRESS REPORT, DIFTA, DENMARK

ICES Manual of Methods of Measuring the Selectivity of Towed Fishing Gears - The referees comments and suggested improvements were received by the end of November 1995. Subsequent editing was completed and the final document forwarded to ICES headquarters 5 March 1996. The text is currently being converted to the column format used in Cooperative Reports. It is anticipated that it will be published before October 1996.

Fishing Effort - A 3 year CEC AIR Project coordinated by DIFTA has been completed. The dependence of Relative Fishing Power upon vessel size and fishing method was investigated for vessels targeting flatfish or demersal roundfish.

Size Selectivity in Gill Nets - DIFTA is coordinating a 3 year CEC Air Project. Cod and sole selectivity in slackly hung gill nets and plaice selectivity in trammels were measured. DIFTA is also participating in a CEC Study coordinated by the

Danish company ConStat which aims to produce standard methodologies and data analysis software for measuring size selectivity in gill nets.

Size Selectivity in Trawl Codends and Fishing Mortality - DIFTA and Marine Laboratory, Aberdeen (Scotland) completed a CEC Study studying the effect of length and age upon the escape and subsequent survival rates of fish entering trawl codends. The final report is currently being produced. The main aim was to confirm that the survival rate of codend escapees increases with length and also with age. It also increased with length for fish of the same age.

Size Selectivity in Baltic Cod Trawls fitted with Exit Windows - The size selectivity of Baltic cod in 105 mm codends fitted with 115 mm square mesh windows was measured as part of a CEC Study coordinated by the Marine Laboratory, Aberdeen. It was found that replacing the green codend netting behind the windows (in the last 1.8 m of the codend) with contrasting black netting did not affect selection. A comparative fishing exercise using a twin trawl system was also carried out. The Danish design of exit window with 105 mm square meshes was compared with the Swedish design of exit window with 105 mm plastic coated netting (hung to give slack wide-open meshes).

Gear Design in Crangon Beam Trawls - A detailed survey of the gears used by Danish beam trawlers to catch Crangon shrimp was carried out as part of the CEC project coordinated by RIVO, IJmuiden entitled RESCUE. All trawls are fitted with a netting "sieve" which leads flatfish to an exit hole.

Development of Fishing Gear - In cooperation with a Danish netmaker, a series of trawls have been developed for the project "Fishing Vessel 2000". The subprojects comprise an easy-to-operate pelagic trawl, a shrimp trawl with low towing resistance and a selective whitefish trawl. For the same project a new codend design for improved fish quality has been developed and tested. Different methods of measuring and quantifying the fish quality have been tested. Moreover a new design of trawl spreading device - a trawl door - has been developed and tested in the flume tank. The device is made totally of flexible materials for safety and weight reasons.

Investigation of the Relative Fishing Effort exerted by towed demersal gears on North Sea human consumption species - The participating organisations were:

Danish Institute for Fisheries Technology and Aquaculture DENMARK (DIFTA)
The Scottish Office Agriculture, Environment and Fisheries Department, Marine Laboratory Aberdeen, UK (SOAEFD)
Seafish Industry Authority, Seafish Technology UK (SeaFish)
Rijksstation voor Zeevisserij BELGIUM (RVZ)
Danish Institute for Fisheries and Marine Research DENMARK (DIFRES)

The main objective of this project was to investigate the influence of vessel and gear parameters upon the Relative Fishing Power of Danish, Scottish, English and Belgian fishing vessels operating towed gears in ICES IVb and IVc to catch cod, haddock, whiting, plaice or sole.

National Progress Report - Germany (E. Dahm)

The activities of the Institute for Fishing Technology , Hamburg, concentrated in 1995 mainly on questions of biological-technical interactions of fishing gear and fish or the environment and on technical performance trials

<u>Selectivity of fishing gear</u>

Selectivity of trawl codends for cod in the Baltic - the replication of Danish experiments concerning the new legal mesh size in the Baltic (120 mm) and of modifications of existing codends on a small side trawler revealed remarkable differences. The codend used on this type of ship had a much better selectivity than reported from a stern trawler. A modification with one single escape window in the middle of the upper panel with ca.110 mm mesh opening proved as appropriate solution to attain the required goal to enable a L50 of 38 cm. First attempts to use sorting grids inserted into the upper panel gave encouraging results.

Factors affecting trawl codend selectivity - Germany participated at an international research project with this subject and conducted an experiment concerning the influence of trawling speed on selectivity. With cod and haddock this factor was found to be rather negligible.

Sorting grids in pelagic trawls- the results obtained in the frame of an EU- project under German participation of inserting sorting grids into the upper panel of a pelagic trawl with the aim to separate mackerel and horse mackerel were rather disappointing. Size selectivity (herring) functioned well in principle but was hampered in case of sudden catches of larger amounts of fish.

Sorting grids in brown shrimp beam trawls - positive results in trawls of experimental size encouraged to transfer such devices of the Nordmore type to commercial beam trawls. After removal of first operational difficulties the device proved to be superior to the sieve nets used so far especially I n the case of drifting weeds.

Selectivity of gillnets for cod in the Baltic - a large amount of data collected over the last 15 years enabled to define the selective properties for a range of gillnet types used in the Baltic. As a first result it could be demonstrated that the present legal mesh size of 105 mm for gill nets is totally sufficient for the protection of undersized cod. Trials with regard to species selectivity and for the determination of the gillnet efficiency are in the planning stage.

Environment related research

EU- project RESCUE - A recent EU-project under German participation investigates fishing effort and effect on unwanted species of the coastal shrimp fishery. The inventory of the existing German fleet and the determination of its present effort is nearly completed. The assessment of the total bycatch of this fleet is bound to be done in the next phase of the project.

EU-project IMPACT - In the frame of a similar project assessing the impact of towed gear on marine ecosystems of the North Sea Germany contributed with an inventory and classification of the different German fleets

Survey trawls

Synchronous comparison of two survey trawls on the same fishing place - a plaice trawl and a beam trawl with equal codend mesh size were tested in alternate hauls at several fishing places of the German Bight. On equal area fished the catch of the plaice trawl of invertebrates is significantly lower than with a beam trawl; a higher catch in numbers of fish by the plaice trawl is not matched by the species diversity caught. Of 34 species caught in total only 26 appeared in the catch of the plaice trawl. Remarkable differences were also found in the length composition of equal species in the two trawls tested.

Performance trials with a new developed trawl design - species and length compositions of targets counted in hydroacoustic stock assessments has to be verified in regular trawl catches. A trawl specially designed for this purpose was tested. Net geometry , towing resistance and behaviour in operation was found to be appropriate. A one otterboard operation of the new trawl out of the ships wake is envisaged.

Progress Report - NORWAY

Summary of recent research activities

Recent fishing technology research of interest to FTFB can be grouped into the following categories: Sampling technology, fish behaviour, selectivity and survival studies, environmental impact of fisheries, and methods or technology developments aimed at increasing the value of the fish product or reducing the cost of capture.

Sampling technology research includes further efforts to develop methods to study the absolute efficiency of a demersal sampling trawl. Studies have been conducted (using collecting bags mounted under the trawl) of the escapement of fish below a "Campelen" demersal sampling trawl equipped with Rockhopper gear. The "Multi-Sampler" remotely-controlled multiple codend system has been further developed and has been successfully used in a pelagic trawl to sample herring from various discrete depth strata. The migration and vertical distribution patterns of various sizes and sex of shrimp (*Pandalus borealis*) have been studied with a specially designed frame containing several small meshed bags. Small-meshed bags were attached in different areas of the standard sampling trawl to study if and where escapement of shrimp occurs.

Fish behaviour has been studied in natural and undisturbed settings, and when exposed to various stimuli (i.e. bait, sound, and artificial light) using acoustically tagged fish tracked with the VEMCO system. Cod and ling were found to be most active by day. The reaction distance was estimated for cod stimulated with baits on a long line. Cod actively avoided a vessel towing a trawl, plaice did not.

Selectivity and survival. In a multi-national project sponsored by the EU, factors affecting the variability of cod-end selectivity were studied. Grid technology to size-select Norway lobster in trawls has been developed and tested with encouraging results. A species-selective trawl which can separate cod, haddock and saithe using a horizontal panel of 300 mm square meshes in the belly has been developed with the following results: 90% of the haddock were caught in an upper codend while around 70% of the cod were captured in the lower codend. Improvement of size selectivity in Danish seines was achieved both with sorting grids and with square mesh codends. The size selective properties of the Norwegian "Sort-X" grid system have been further evaluated for species like saithe, cod, haddock and redfish. In a joint Norwegian-Russian experiment the selectivity properties of the "Sort-X" grid and a Russian grid sorting device were compared. The two systems gave similar selectivity results for cod and haddock and both will be mandatory in the Barents Sea starting in 1997.

The selectivity performance of a modified version of a Nordmøre grid, 2.5 m long and sloped at 25 to 30 degrees, was compared with the standard grid (1.5 m long, 45 degree slope) which is at present legislated in the Norwegian shrimp fisheries. Efforts have continued to develop grids which can improve size selectivity of shrimp but with no breakthroughs so far.

Tests have continued of grids installed in the bunt sections of purse seines to improve size selection in saithe and mackerel fisheries. Studies of the survival of fish escaping through such grids were included. The mortality of mackerel escapees was high while most saithe swimming through the grids survived. The selectivity performance for both species was convincing.

A flexible sorting grid for purse seines has been developed and successfully tested by MARINTEK in Trondheim. In addition to being as efficient and selective as rigid sorting grids in letting undersized fish escape unharmed from the seine, its flexibility also allows it to be easily handled with a net winch or power block like the rest of the seine, a significant practical advantage.

Comparative fishing experiments were recently conducted off the coast of northern Norway to study the selectivity and catching efficiency of demersal trawls, Danish seines, gillnets, and longline gear when simultaneously operated in the same area.

Environmental impact of fisheries. The environmental effects of lost gillnets were studied and methods were evaluated to both reduce such losses and to retrieve lost nets.

Increasing value of fish products and reducing harvesting costs. Keeping fish alive after capture and holding them in pens is believed to have great potential to increase the value of the catch. Development continues of techniques for live transport and storage of fish like cod and plaice. Research continues aimed at developing a "Kazanoku Kombu" fishery in Norway. The Institute of Marine Research is cooperating with industry participants to develop an alternative longline bait using low-value fish and/or processing offal as raw materials. Fish trap development continues and commercially-viable catch rates for cod have been achieved with a two-chambered trap.

In 1995 MARINTEK started up a three year research program named "HYDROFISK," which involves hydrodynamic analysis of fishing gear and fish farming structures. Among other topics the project includes non-linear finite element formulation and flow through three-dimensional net structures, and development of a computer program for 3-D analysis of otterboard balance and stability. Laboratory tests have verified that the exact balance of both pelagic and bottom otterboards can be calculated by the program. MARINTEK is also involved in ongoing studies on the effects of interactions between vessel motions and fishing gear. The analyses are mainly based on computer simulations of a trawler towing a trawl system in different sea states and at different speeds.

UK (Scotland) - Report of activities in 1995

COD-END SELECTIVITY

Mesh size and meshes round circumference - the variations of haddock, whiting and cod selectivity with cod-end mesh size (and in some cases with number of circumferential meshes) for otter trawl, pair trawl and pair seine have now been measured using the new hooped cover method. These data have allowed models of selectivity in the style of the Armstrong model to be developed and do not show significant differences between gears. In general larger differences can be demonstrated due to seasonal effects and design parameters such as twine thickness (see below) than due to gear type.

Variation in selectivity - a three year EU supported project involving Scotland, Germany, Norway and Denmark is assessing the sources of variance in otter trawl cod-end selectivity data by measuring the effects of season, twine thickness, towing speed and catch size. To date a significant change in L50 has been found between trials conducted in February, April and September. Previous Scottish trials data using two twine thicknesses showed that the thicker twine gave a decrease in L50 equivalent to a reduction in mesh size of about 10%. A similar trend has been established in this project although the results were not statistically significant due to considerable variability from haul to haul. Towing speed and catch size trials are continuing.

Square mesh windows - haddock selectivity in a 100mm otter trawl cod-end with a 95mm window was measured with separate covers over window and cod-end, thus giving an estimate of the selectivity of each. A very thick cod-end twine was used and the selectivity was extremely low (L50 ~ 18cm). The window also showed poor selection. New methods of analysis which model the different mechanisms of selection through both window and cod-end were developed. Enhancement of window selectivity by using black netting aft of the window was also studied. In all cases the window / cod-end combination showed a higher L50 than the cod-end alone. It is concluded that windows do present additional opportunities for fish to escape but that their selectivity may be influenced by changing design parameters and environmental conditions.

Lifting (strengthening) bags - Trials were carried out to examine the influence of large meshed lifting bags on cod-end selectivity. No significant effects were found when using a standard commercial bag of twice the cod-end mesh size on a 100 mm otter trawl cod-end.

Static gear selectivity - Three sizes of escape gap (24, 28 and 32mm) in creels used to catch velvet swimming crabs were compared with standard creels having no escape gaps and clear differences in selection were demonstrated. A follow-up commercial trial of one gap size (27 mm) is planned for 1996.

GEAR PERFORMANCE AND FISHING EFFORT - In 1995 the Marine Laboratory, together with SFIA, RVZ of Belgium and DIFTA and DIFMAR of Denmark, completed a joint EC supported 3 year contract to investigate the relative fishing effort of towed demersal whitefish gears used by Scottish, English, Belgian and Danish vessels in ICES sub areas IVb and IVc. Gear types studied included otter, beam and pair trawls together with anchor, flydragging and pair seines. Catch statistics for cod, haddock, whiting, sole and plaice and fishing time expended by each defined subfleet were extracted from each national database for the years 1989 to 1994 and typical gear performance parameters such as swept area, volume and towing power were measured. A detailed statistical analysis was carried out to obtain comparative values of fishing capacity for different gear types and vessel horsepowers for each target species. The results show a significant difference in fishing power between methods with horsepower the parameter most closely correlated to catch.

A study of fishing effort exerted by Scottish whitefish otter trawlers in ICES VIa commenced in 1995. Ports between Oban and Kinlochbervie were visited and details of typical gears obtained. Performance measurements were carried out with hopper, scraper and twin rig trawls. By using statistical techniques similar to those described above it is hoped that empirical relationships linking gear design or performance parameters with fishing power may be determined.

PHYSICAL MODELLING - Flume tank trials carried out at the SFIA facility in Hull led to improvements in the design of cod-end cover normally used on cod-end selectivity trials. Wind tunnel tests at Aberdeen University have led to a new understanding of the hydrodynamic forces acting on the cod-end catch. The differential equations governing cod-end geometry are being further developed to take account of twine stiffness. This work permits the investigation of the effect of cod-end design and catch size on mesh opening and will provide the basis of a predictive model of cod-end selectivity.

FISH SURVIVAL AFTER COD-END ESCAPE - A joint Scottish/Danish EC Study Contract investigated haddock and whiting escapee damage and survival from 70mm, 90mm and 110mm cod-ends. Triplicated cage experiments were used to show the variance in the results. All handline caught control fish survived. The survival rates for the haddock and whiting experimental groups were 53-64% and 78-85% (70mm cod-end), 79-85% and 78-85% (90mm cod-end) and 81-95% and 84-93% (110mm cod-end) respectively. Further analysis showed that smaller fish suffered higher mortality irrespective of mesh size and that age and length clearly affect survival. Selectivity data were collected at the same time so that, given the estimated survival probability, the fate of the population as a whole could be determined. Analysis of body damage showed that the survival of a fish escaping from a cod-end is dependent upon the nature and severity of injuries sustained in the process. Further work is planned to investigate Nephrops and fish survival where survival rates may differ markedly from the above data which were obtained from relatively "clean" catches containing minimal debris.

Current gear related research. Sweden P-O Larsson and Mats Ulmestrand

Selection of Nephrops, cod, haddock and whiting by using a square mesh codend - an investigation was performed with the covered codend and the twin trawl method on a commercial stern trawler fishing for Nephrops at the Swedish west coast during November 1995 to February 1996. The investigated codend and extension piece (8 m length, 93 meshes around) was made of 60 mm (62.2 mm, SD=2.0 mm) knotless square meshes except for the first 7 hauls when 70 mm diamond mesh in 8 m codend was tested. The first part of the square mesh experiment (5 hauls) was carried out with a single trawl and a hooped cover. In the twin trawl method, one of the two trawls had the test codend (24 hauls) and the opposite trawl had 32 mm diamond mesh. After the first 12 hauls the codends was interchanged between the trawls to eliminate any differences in catch efficiency of the trawls.

The results showed that the same 60 mm square mesh codend had a significant smaller L50 for Nephrops estimated with the cover method (L50=24.6 mm) compared to the twin trawl method (L50=32.3 mm). No significant differences were found in the catches of legal sized Nephrops, but there was a significant reduction in the proportion undersized, from 70 % (in numbers) with the 70 mm diamond mesh to 63 and 49% with square meshes and covered codend and twin trawl respectively.

The catch of cod, whiting and haddock was drastically lower than in the 32 mm diamond codend. About 48 % less cod (by weight), 94 % less haddock and 94 % less whiting was caught . The loss of commercial sizes was however small.

Selectivity of Baltic cod bottom trawls - trials have been performed with two commercial vessels, one stern trawler and one side trawler, with the hooped covered codend method. Diamond meshes, 107 - 136 mm, have been tested as well as the Swedish design of side window with mesh sizes 103 - 117 mm. One aim was to find L50 of 38 cm to meet IBSFC½s requirements. This was obtained with 107 mm mesh size (106 for stern trawler and 108 for side trawler) in June - July but the significantly lower SF in December raised the required mesh size to 114 mm (stern trawler only).

Swedish design of side window in vendace trawling - the Swedish design of side window in the codend has been tested in vendace (Coregonus albula) trawling in Lake Vènern and the northern coast of the Baltic (the Bothnian Bay). Positive effects on the selectivity have been obtained and will soon be reported. Survival experiments on escapees have started, but no results reported so far.

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