Fisheries Technology Committee

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REPORT OF THE

Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets

La Coruña, Spain
18–19 April 1998

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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1. TERMS OF REFERENCE

According to the ICES resolution (C.Res. 1997/2:17) adopted at the 1997 Annual Science Conference, the Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets (SGGRID) (Chairman: B. Isaksen, Norway) will meet in La Coruna, Spain from 18-19 April 1998 to:

a) complete the review of grid selectivity and usage and prepare a final report containing:

  i. selectivity parameters for nets with and without grids, and relevant associated data or finfish and shellfish,
  ii. estimates of the impact of actual and potential grid usage on discards levels for non-target species in different fisheries
  iii. a comprehensive bibliography on grids.

SGGRID will report to WGFTFB and to the Fisheries Technology Committee at the 1998 Annual Science Conference.

Participants at the meeting in La Coruna, Spain 18-19 April (in alphabetic order):

Boye, J.	Denmark	(Greenland Institute of Natural Resources)
Brothers, G.	Canada	(DFO, North-West Atlantic Fisheries Centre)
Dahm, E.	Germany	(Institute for Fisheries Technology)
Engås, A.	Norway	(Institute of Marine Research)
Galbraith, R. D.	United Kingdom	(FRS Marine Laboratory, Aberdeen)
Graham, N.	United Kingdom	(Marine Laboratory, Aberdeen)
Isaksen, B.	Norway	(Institute of Marine Research)
Kvalsvik, K.	Norway	(Institute of Marine Research)
Lowry, N.	USA	(University of Washington. School of Fisheries)
Marlen, B. v.	The Netherlands	(Netherlands Institute for Fisheries Research)
Polet, H.	Belgium	(Sea Fisheries Department)
Prious, D.	France	(IFREMER Fishing Gear Technology)
Puente, E.	Spain	(AZTI Fisheries and Food Technological Institute)
Revill, A.	United Kingdom	(University of Linconshire and Humberside)
Ulmestrand, M.	Sweden	(Institute of Marine Research)
West, C. W.	USA	(FRAM Div., NWFSC, NMFS)
Zachariassen, K.	Faroe Island	(Fishery Laboratory of The Faroese)

2 INTRODUCTION.

At the 1995 Annual Science Conference held in Aalborg in September 1995, a resolution to establish a Study Group on Grid (Grates) Sorting Systems in Trawls, Beam trawls and Seine was adopted (C.Res.1995/2:17).

The Study Group was given the following Terms of Reference:

a) review current research on grid (grate) sorting system 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 its findings and recommendations to the Working Group on Fishing Technology and Fish Behaviour, the Advisory Committee on the Fishery Management and the Advisory Committee on the Marine Environment.

The first session of the Study Group on Grids (Grates) was held in Woods Hole, Massachusetts on April 13 and 14, 1996 under the chairmanship of John Willy Valdemarsen.
During the two days meeting, the group of 28 participant from 13 countries discussed relevant grid (grate) research up to that date, and reported its findings to the Working Group on Fishing Technology and Fish Behaviour (WGFTFB). Both the report and recommendations from the Study Group was revised and later presented at the ICES Annual Science Conference in Reykjavik, Iceland, September 1996 (Anon 1996d, in Bibliography list).

The recommendations given by the Study Group was adopted at the 1996 Annual Science Conference with the following terms of reference (C.Res. 1996/2:20)

«The Study Group on Grid (Grate) Sorting Systems in Trawls, Beam Trawls and Seine Nets (SGGRID) (Chairman: Mr B.Isaksen, Norway) will work by correspondence in 1997 to:

a) compile selectivity parameters for nets with and without grids and relevant associated data for finfish and shellfish;
b) estimate the impact of actual and potential grid usage on discards levels for nontarget species in various fisheries;
c) compile a comprehensive bibliography on grids;
d) plan for a meeting in 1998 to complete the report.

The Study Group will report to the April 1997 meeting of the WGFTFB, and to the 1997 Annual Science Conference».

The recommendations for a last meeting in 1998 was given at the 1997 Annual Science Conference (as above).

On April 18 and 19 , 1998 the Study Group met in La Coruna to fulfil the assignments set up during the Woods Hole meeting in 1996, and later given as terms of reference. In addition to the given objectives, the Study Group spent some time to update recent research and also to update the list of grid usage around the world.

3 SELECTIVITY PARAMETERS FOR NETS WITH AND WITHOUT GRIDS, AND RELEVANT ASSOCIATED DATA FOR FINFISH AND SHELLFISH.

3.1 Introduction

The sections below give selectivity estimates for several species for both codends and for grids. *There is very little information enabling a comparison of selectivity parameters of gears with and without grids installed and much of work undertaken has investigated percentage levels of by-catch reduction rather than size selectivity parameters. Grids were originally developed for species separation and later on applied to size separation.*

Care should be taken when interpreting results since selectivity estimates with retaining bags will only consider grid selectivity. Selectivity estimates by catch comparison consider whole codend selectivity as do retaining bags and codend covers combined. Differences in selectivity may occur within codends due to effects such as catch size and composition.

3.2 Brown shrimp (*Crangon crangon* L.)

Polet, 1998 describes the retention curves for brown shrimp (*Crangon crangon* L.) in a beam trawl codend (mesh size 20mm). Table 1 shows the codend selectivity data derived on RV BELGICA for the *Crangon* trawl. Installation of the grid improved the size selection for the target species due to cleaner catches within the codend. Non target species size selectivity was shown to be poor.

Table 1: Codend and grid selectivity data, RV BELGICA

Species	Gear/Device	L50(cm)	SR(cm)
Brown Shrimp	Cod-End, No Grid	3.6	1.4
,,	Cod-End With Grid	4.4	1.6
Dab	,,	4.0	1.0
Sole	,,	8.0	1.5
Dab	Grid Only	8.6	11.6
Plaice	,,	9.4	9.7
Sole	,,	11.1	12.3
Whiting	,,	12.5	17.8
Cod	,,	12.5	17.8

No difference in fish selectivity was observed with the grid fitted. Loss of marketable shrimp was shown to be size dependent, with the smaller length classes showing the highest losses (30mm: 80% losses, 45mm (MLS): 15% loss). Approximately 10-15% of marketable shrimp were lost.

The grid used is a Nordmøre grid made of PVC tubing, and an inter-bar spacing of 14mm. It is also noted that whiting retention never reaches 100%, which would suggest a behaviour dependent escape as opposed to size dependent.

Graham, 1997 observed L50's for whiting and plaice retained in a brown shrimp trawl codend (Table 2). With the inclusion of a plastic grid with an inter bar spacing of 12mm, L50's for plaice and whiting were estimated using the Fryer between haul variation model (Fryer, 1992). Although codend selectivity data was collected for *Crangon*, no grid selectivity data for this species was observed.

Table 2: Data from Graham, 1997.

Species	Gear	L50(cm)	SR (cm)
Whiting	Cod-End	6.9	0.8
Dab	Cod-End	4.6	0.6
Whiting	Grid Only	10.5	3.6
Plaice	Grid Only	9.3	4.8

3.3 *Nephrops norvegicus*

In the Nephrops fishery in the Skagerak and North Sea Valdemarsen *et al.*, 1996 observed a range of selectivity parameters for several grid designs (table 3.), diamond mesh and square meshes (table 4.) using both a twin and a triple trawl system. The values are given below and are depend on the analysis method (cover or triple trawl) and grid position (in roof or in bottom). In the triple trawl method a grid was inserted in a small mesh codend and small mesh collecting bag placed at the outlet. The second and third trawl were fitted with experimental codends and the trawl with the grid was also used as the small mesh trawl (codend and collecting bag). In the Swedish experiment (Ulmestrand, 1996) it was shown that the L50's were significantly lower estimated with cover method compared to the same cod-end with twin trawl method, and it was also depending on the number of meshes around. L50's increased with increasing meshes around.

Table 3: Grid Selectivity data from Valdemarsen et al. 1996.

Grid Type	Bar Spacing (mm)	Position	Method	L50(cm)	SR (cm)
Metal	22.4	Top	Cover	37.2	12.8
Metal	22.4	Bottom	Cover	34.8	8.4
Metal	22.4	Bottom	Triple	40.4	11.2
Metal	22.4	Bottom	Triple	38.5	7.8
Composite	21.7	Bottom	Cover	33.7	13.9
Composite	21.7	Bottom	Cover	31.4	8.4
Composite	21.7	Bottom	Triple	36.9	14.5
Composite	21.7	Bottom	Triple	33.9	7.8

Table 4: Cod-end selectivity data from Ulmestrand, 1996.

Cod-End Type	Mesh Size (nomimal)	Mesh Round	Method	L50(cm)	SR (cm)
Square	60	100	Cover	24.6	16.9
Square	60	100	Twin	32.3	11.9
Square	60	60	Twin	40.0	14.5
Square	60	60	Triple	35.7	16.9
Square	50	70	Twin	27.4	15.4
Diamond	70	100	Cover	18.6	15.9
Diamond	70	100	Twin	19.8	13.5

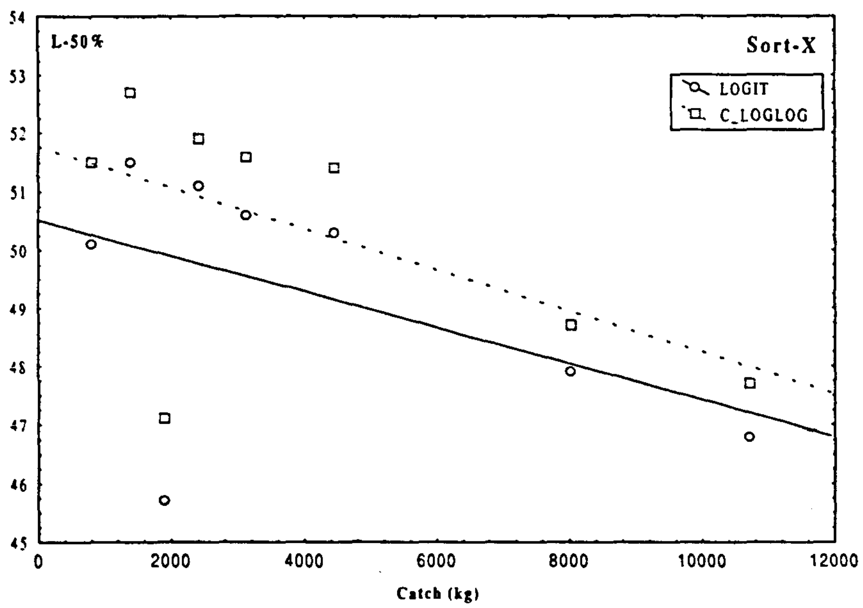
3.4 Fin-fish

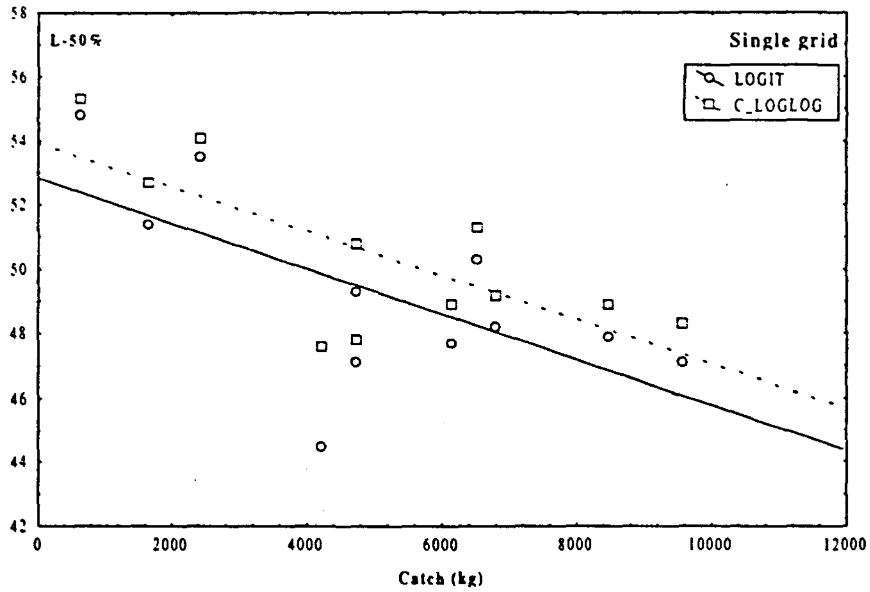
Considerable improvement in size selectivity has been recorded in the Barents Sea with the use of the Sort-X system in groundfish trawls.

During the development and testing period of the Sort-X grid system, no experiments were carried out with the direct aim of comparing selectivity parameters of nets with and without grids. The main effort was rather put on the comparison of catch (or intermixture) of fish below the minimum landing size (MLS), as fishing grounds were opened c.q. closed when the intermixture was less c.q. more than 15% in number (due to the Norwegian management regulation). The comparisons of nets with and without grids during the early development period of the Sort-X systems were therefore solely based on the data from a joint Norwegian-Russian selectivity cruise in 1989 (Isaksen, B. et. al., 1989) during which both used codends representative for their national fleets. For small catches (less than 500kg) the L50 for 135mm codend is higher than the L50 obtained with the Sort-X using 55mm bar spacing, while the selection range is about the same.

With increasing catch rates the codend shows tendencies of decreasing L50 and increasing selection range, a phenomenon not normally found for the Sort-X system, at least for catch rates up to 5 tons/hour (Figure 1).

Figure 1: L50 for Sort-X and Single grid as function of catch rate (Derived from Isaksen et. al. 1998)





There is, however, some evidence that the Sort-X suffers some capacity problems at extremely high catch rates (more than 10 tons/hour).

To assess the selectivity of a square mesh codend fitted with a selection grid, Canadian experiments (Tait and Tait, 1996) with a divided trawl have shown no significant improvement in selectivity for winter flounder with increased bar spacing. Cod showed a significant improvement in selectivity with an increase in bar spacing. However, the selection range was shown to be variable (Table 5).

Table 5: Data Tait, 1996

Species	Gear device	L-50 cm	SR cm
Cod	135mm square, 65mm grid	54.1	5.31
Cod	135mm square, 85mm grid	62.56	10.23

3.5 Conclusions

Apparently few selectivity data sets exist from which a direct comparison can be made between the same gear with and without a grid. It should also be noted that selectivity estimates are either for the grid system alone (i.e. measured with a retaining bag attached to the escape hole), or for the complete codend system, where the selectivity of the grid and codend is estimated as one entity (i.e. measured with the parallel haul or twin trawl technique). It is possible that codend selection parameters change when a grid is added. This may be due to a decrease in the total catch weight in the codend or to changes in the composition of the catch. However, it should be concluded that any benefit in terms of selectivity can only be determined when the selectivity parameters of the original gear are also known, and a direct comparison can thus be made. In most experiments with new selection devices such data are not derived.

4 THE IMPACTS OF CURRENT SORTING GRID USAGE

4.1 Introduction

The phenomenon of by-catch has long been recognised in fisheries. In many instances the by-catches are unwanted and discarded. The reasons for discarding can often be attributed to one or more of the following factors:

Lack of market value,
Quota restrictions,
Below minimum landing size etc.

It has been estimated that up to 30% of the total weight of fish caught globally are currently discarded. The small meshed shrimp fisheries around the world contribute significantly to this global discarding.

4.2 *Pandalus* spp

There are demersal otter trawl fisheries for *Pandalus* species in many countries including: Greenland, Iceland, Canada, Faroe Islands, Norway, Sweden, Russia, Spain, Latvia, Lithuania, St Vincent, Denmark and the USA.

It is estimated that an unwanted by-catch of around 15% (by weight) was common in the *Pandalus* fisheries before the introduction of the Nordmøre grid. Around 125 different species, notably including gadoids, redfish, turbot, sharks, Greenland halibut and capelin are discarded.

4.2.1 The use of sorting grids / grates in the *Pandalus* fisheries
The Flemish Cap

To date, the Flemish Cap (NAFO Division 3M) *Pandalus* fishery has been exploited by around 50 vessels from Canada, Denmark, Faroe Islands, Spain, Greenland, Iceland, Norway, Russia, Latvia, Lithuania and St Vincent. Landings of *Pandalus* were reported to be between 24,000 – 35,000 tonnes per year (1993-1995). Since 1995 NAFO have made it mandatory that a Nordmøre sorting grate (max. bar spacing 22mm) be used in this fishery.

4.2.2 Canadian East coast

Nordmøre sorting grids/grates are mandatory within the Canadian East Coast pandalus fisheries (within the 200 mile EEZ). Bar spacing varies between 25mm and 28mm depending upon the area.

4.2.3 Barents Sea and Spitzbergen

Nordmøre grid/grates has been mandatory in the Norwegian and Russian EEC since 1991. The bar spacing used in the *Pandalus* fishery of the Barents Sea and around Spitzbergen is 19 mm.

4.2.4 Iceland

Nordmøre grids/grates have been mandatoring in the Icelandic EEC since 1995. Thr bar spacing used in the offshore *Dandalus* fishery is 22 mm.

4.2.5 Case Study: The Impact of the Nordmøre Grate on the Atlantic Canadian *Pandalus* Fishery

Otter trawl fishery for northern shrimp (*Pandalus borealis*) began in Atlantic Canada in 1965. The small codend mesh (minimum 40-mm size is used) often resulted in high by-catches of many other species. In 1990 there was a total catch of 60,000 metric tonnes of shrimp with approximately 15% by-catch (by weight). The Nordmøre grate was tested in the early 1990's and became mandatory in 1994.

In 1997 there were approximately 100,00 metric tons of shrimp harvested off Canada's east coast with only a 2% by-catch (by weight), a reduction of 85 %. The grate has resulted in between 10,000 and 15,000 metric tonnes of by-catch (mostly juvenile fish) remaining uncaught in these waters each year since its adoption by the industry in 1994. (For further information see Appendix II .)

4.3 *Crangon crangon*

The fishery for North Sea *Crangon crangon* occurs in shallow coastal waters off Denmark, The Netherlands, U.K., France, Belgium and Germany. The vessels are almost all twin beam trawlers under 300 H.P. (minimum mesh size 20mm).

It was estimated that in 1996 these vessels discarded over **920 million juvenile plaice.** Similarly high numbers of dab, sole, whiting, cod and other species were also discarded. In the U.K. only around **15 million juvenile plaice** were discarded. However the impact of the U.K. discard data has been modelled and it is estimated that if a Nordmøre grate or other similar by-catch reduction measure (veil net / seive net) were to be used in the U.K. it would yield around 440 tonnes in additional white fish landings every year. Modelling of the total European *Crangon* related discard data is ongoing with results expected early in 1999.

These calculations assume a good functioning grid. The technology, however, is still not advanced enough to allow for a commercial introduction. Extensive research will most probably improve the existing technology.

At present, no vessels within this fishery use any type of grid / grate system, but veil nets are used in several fleets.

4.4 Fin-fishes

The various fisheries for finfish species are globally very diverse, however unwanted by-catches and discarding are common to many. In some fisheries the mandatory use of selection grids have been introduced. Details are as follows:

4.4.1 Case Study: Grid usage in the Faeroese lemon sole and plaice fishery.

Grids were made mandatory in 1997 for the Faeroese inshore fishery inside the 12-mile limit. These vessels target lemon sole, plaice and monkfish. They are allowed to land by-catches of 25% cod and 10% haddock. The system developed by the Faeroese fisheries laboratory uses a grid with bar spacing of 40mm. Fish passing through the grid enter a cod-end of 120-mm mesh; those deflected by the grid enter a large mesh codend (200-mm). The aim of this system is to catch all the sole and small plaice in the lower cod-end, whilst all other fish enter the upper cod-end and are selected by the 200 mm mesh. Use of this system results in a reduction of the catch of cod from 44% of the total catch to 22%, and exclusion of almost all of the haddock (27% of the total catch). All of the large plaice and monkfish are retained in the upper cod-end.

14 vessels participate in the fishery annually, catching approximately 1500 tons total catch. Using the grid system will avoid by-catches of approximately 330 tons of cod and 350 tons of haddock.

4.4.2 Case Study: Barents Sea

Up to the early 1980's the main management of the trawl fisheries in the Barents Sea was based on mesh size regulations and the obligation not to land fish below the minimum legal size. The fishery took place everywhere outside the 4 -12 nm zone and no restrictions were given with respect to the amount of by-catch brought on board and discarded. This led to an unavoidable discard level of both undersized fish of target species and non-target species.

New regulations introduced during the 1980's stated that as a starting point it was illegal to catch fish below the minimum legal size and a surveillance program established during 1983-84 quickly showed that substantial areas needed to be closed for short or longer periods due to high proportions of undersized cod and haddock in the catch.

Areas of particular interest were feeding grounds for young gadoids, such as Bear Island and parts of the south-eastern Barents sea. Typical catches in these areas could contain 30-50% juveniles of target species (by number). The closure of fishing grounds where the catch contained 15% or more fish under MLS by number led to a less efficient fishery as the fleet had to search for other areas. The need for an efficient selective device was evident.

With the development of grid systems for bottom trawling, the intermixture of undersized fish was reduced substantially. Normally these grid systems (e.g. the multi-grid system "Sort-X" and single grid "Sort-V") would reduce the catch of undersized fish by 50-70% compared to the standard trawl without a grid.

Due to the management rules applied to the Norwegian EEZ, the introduction of the grid system has not necessarily reduced the overall by-catch. However it has significantly improved the performance and economics of the fishery since a much greater area can remain open for substantial parts of the year.

4.5 *Penaeid* shrimps

There are various turtle exclusion devices (TEDs) and sorting grids / grates in use in this diverse group of fisheries.

In the United States, grids have been used by all prawn fishermen in the South-eastern U.S. from North Carolina on the East coast to Texas on the Golf coast. Grids have been required by law since 1982 and compliance exceeds 97%. There has been no detectable impact on prawn production or economic return from the fishery with the use of grids, although some vessels left the fishery when the grid regulation were implemented.

Due to the United States Public Law 101-162 (section 609) it is a requirement that nations that will export wild-caught shrimp to the U.S., do protect sea turtle populations from incidental mortality in shrimp trawl operations. The law prohibits the importation of shrimp harvested in ways harmful to the sea turtle unless the Department of State certifies that the harvesting nation either has a sea turtle protection program comparable to the U.S., or has a fishing environment that does not pose a threat to sea turtles. The chief component of the U.S sea turtle conservation program is a requirement that commercial shrimp boats use sea Turtle Excluder devices (TEDs) to prevent the accidental drowning of sea turtle in shrimp trawls. Currently the following sixteen nations meet this standard: Mexico, Guatemala, Belize, Honduras, Nicaragua, El Salvador, Costa Rica, Panama, Columbia, Ecuador Guyana, Suriname, Trinidad and Tobago, Indonesia, China and Thailand. Due to the import restriction in U.S., several other nations are currently evaluating TEDs for use in their shrimp fishery.

4.6 Industrial fishing

The Canadian industrial fishery for silver hake has in the past had a by-catch of miscellaneous gadoids of up to 30% by weight. The mandatory use of a rigid sorting grate with 40 mm bar spacing since 1994 has reduced these by-catches to less than 10%. Landings of silver hake in the fishery exceed of 50,000 metric tonnes per year.

4.7 Update estimate of Grid / grate usage.

Informal estimate by the 1996 study Group came up with a total of over one thousands commercial vessel world-wide that presently are using grids/grates. New estimates give a substantial higher number. By the end of 1998 more than one thousands vessel will use the Nordmøre grid/grate in the *Pandalus* trawl fishery alone, and in addition several hundreds using different grid /grate systems in finfish/industrial trawl fishery in the Northern Hemisphere.

Looking on the general use of grid to get rid of bycatch/prevent incidental catch of unwanted/protected species, the use of grid/grate in the *Penneaid* trawl fishery is by no doubt the main bulk of grid usage today, and this fleet may consist of several of thousands vessels. Many of the countries meeting the standards of the US Turtle Excluder program are not included in the table, due to lack of numbers of boats using grids.

Table 6: Update estimates of grid usage.

Country	No. of shrimp vessels using grids	No. of finfish vessels using grids	No. of vessels using grids in industrial fisheries	No. of vessels using grids for other species (e.g. sea turtles)
Argentina	75			
Australia	≅ 100			
Canada	171 (up to 100 more in 1998)		50	
Faeroe Islands	9 distant water	8 distant water		
		14 domestic		
Greenland	5 to 10	2 or 3		
Iceland	100	60		
Norway	450	112		
Russia	>100	350		
Spain		18		
Sweden	13 (voluntary)			
Thailand				3000
United States of America	150			36.000

N.B. A new technical regulation promulgated by the European Union will require the use of sieve nets or grids in the *Crangon* fishery by the year 2000.

5 POTENTIAL IMPACT OF GRID USE

5.1 Shrimp trawl

Although grids are extensively used to exclude large animals such as turtles in Gulf of Mexico penneaid shrimp fishery, their potential to reduce by-catch of fish has not yet been fully assessed. The problem is often that the range of sizes of by-catch species of fish overlaps that of the range of the large penneaids. Purely mechanical sorting will not give good separation without risking excessive loss of target catch. Efficient separation will have to rely on behavioural differences between fish and shrimp in these fisheries. It is not known if these are sufficiently distinct to permit this.

In other, less industrialised, fisheries world-wide, much of the fish taken incidentally by vessels targeting shrimp is landed and consumed. This provides a substantial part of the income of many fisheries. Grids may have potential for separation of shrimp and fish into different cod-ends with the aim of improving quality rather than reduction of by-catch.
Up to this date - grids have and will have their best potential of reducing by-catch in the pink shrimp fishery.

5.2 Industrial trawl fishery

Both a Faeroese and a Norwegian grid system developed for use in the mixed industrial fishery have shown that it is possible to reduce bycatch of haddock and whiting substantially. The Faeroes experiments in 1996 in their local waters, and west of Scotland in 1997 gave both a reduction in consumption fish below minimum landing size (MLS) of 80% using a grid with a bar distance of 25 mm. The Norwegian experiment in the Norwegian Trench carried out with a bar distance of 22 mm gave a reduction of fish below MLS of well above 90%, but on the expense of a slightly higher loss of target fish.

5.3 Monk trawl fishery

Both in the French and Namibian monk trawl fishery, the catches contain small low value fish/fish below minimum landing size. Grid experiments performed by IFREMER have given positive results, with a substantial reduction of small monk and other benthic fish species.

Namibia is currently one of the major exporters of monk-tails. Up to this date there have been few regulation on size, resulting in landings of very small fish. Namibia is currently planning grid experiments to reduce the catch of small low-value monk.

5.4 Hake trawl fishery

Experiments with grid sorting systems in the Argentinean and Namibian hake trawl fishery have shown that grids are superior to square mesh windows, with respect to reducing by-catch of small and juvenile hake. Underwater observations of hake inside trawl codends has revealed an almost total lack of escape response of this species. Improved selectivity will have to rely on passive filtration.

Both Argentina and Namibia are currently working on the possibilities of introducing grids in their respective hake trawl fisheries on a mandatory basis.

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Appendix I.

Minutes of the Study Group Meeting, 18 & 19 April, 1998, La Coruña, Spain

April 18, 1998

Chairman: Björnar Isaksen
Rapporteur: Bill West

1. Opening remarks and appointment of Rapporteur – Chairman Björnar Isaksen
2. General arrangements – Sr. Pablo Carrera
3. Introduction of Study Group participants
4. Review of Study Group's prior activities and Terms of Reference
5. New Terms of Reference for this meeting

   Complete the review of grid selectivity and usage and prepare a final report containing:

   i. selectivity parameters for nets with and without grids, and relevant associated data for finfish and shellfish;

   ii. estimates of the impact of actual and potential grid usage on discard levels for non-target species in various fisheries;

   iii. and a comprehensive bibliography on grids.

6. Contributions on general issues

   Gerald Brothers, Canada – Brief update on efforts in eastern Canada (paper)

   Kurt Kvalsvik, Norway – Size selection experiment using sorting grid in pelagic mackerel trawl (paper).

   A high exploitation rate makes it necessary to use size-selective fishing gear to maximise the growth potential of the resource. There is also a strong price differential according to fish size that also favours the selective harvest of larger fish, especially fish weighing 600 gm or more. Experiments were carried out on the west coast of Norway with a single grid installed in a pelagic trawl. The grid was 3 m long by 2 m wide with an aluminium frame and GRP bars spaced 42 mm apart. A guiding ramp was installed in front of the grid, which was held at a 30-degree angle within the extension piece. The grid was attached at its leading edge to the top of the extension and sloped down and aft, with a gap between its bottom edge and the floor of the extension allowing passage of retained fish into the codend. Towing speeds were around 4.5 knots, and flows through the grid were about the same except when there were large fish concentrations in the grid section. The first trials yielded 48% selection, with smaller fish escaping through the grid into a collection bag. In the second trial 40% of the fish were selected out, again with reasonable size selection. The L50's in both trials were about 37 cm, with a wider selection range on the first trial where more small fish were encountered. It appears that reductions in the bar spacing may be needed in order to optimise selectivity. A Scanmar grid sensor proved useful for detecting when fish were passing through the grid and indicated when fish were schooling too heavily in front of it. No escapee survival studies were carried out, but results from tests on survival of mackerel escaping from a purse seine through a grid suggest that survival should be high.

The grid was large relative to the deck space typically available on this class of vessel, causing some handling problems. A new version has been developed, articulated in four sections to roll up on the net drum and employing 38-mm bar spacing, but no trials have been carried out yet.

Unlike other studies with similar gear and species, no cases were observed with very large pulses of fish accumulating in front of the grid and blowing out the trawl before they could pass through the grid. There are no plans at the present time for focused escapee survival studies, but video observations during upcoming experiments should indicate likelihood of injury rates. High catch rates in this fishery are problematic for present survival research methodologies.

Björnar Isaksen, Norway – Development and introduction of grid sorting systems for bottom trawl – "Sort-X" (paper)

Grid use became mandatory in 1997 in the Barents Sea groundfish bottom trawl fisheries. The "Sort-X" grid (see paper for description) was specified for Norwegian and EU trawlers, while a simpler, smaller, and cheaper design employing a single grid was certified for use by Russian vessels.

Prior to the mandate, many Norwegian vessels used Sort-X grids on a voluntary basis, employing very large bar spacings in order to high-grade the fish. After grid use became mandatory complaints were made about risk factors during bad weather, resulting in a dispensation from the Norwegian Fisheries Directorate, leading in turn to abuses by some vessels. There also were complaints that the use of Sort-X grids increased the wear & tear on the extension piece & codend. Apparently the fabric guiding panel behind the grid acted as a rudder, guiding the codend and extension against the bottom. Finally, there were complaints that these grids were too expensive.

Initial trials with the Russian single-panel grid gave poor results in two-panel trawls as used by Norwegian vessels, but further work with a lifting panel to direct the fish against the top front of the grid gave better results. Recent results have yielded comparable L50 values for the Sort-X and the single grid systems, but the selection range and variability were greater for the single grid. Upcoming efforts will test the use of supporting ropes or chains to stabilise the single grid's angle of attack to see if it can be made to perform as well as the Sort-X. If these are successful, the Directorate will allow its use as an option but will also take away the bad-weather dispensation. Single grid systems are also being considered for use in Namibian fisheries.

Daniel Priour, France – Tests of a grid for monkfish in the Bay of Biscay (paper)

Estimates of discards in the Celtic Sea and the Bay of Biscay indicate that about 60 million individuals of benthic species (monkfish, megrim, rays, etc.) are discarded annually by European Community fishing vessels. Most of these fish do not survive.

An experiment was carried out on a 15-day cruise on a French trawler using twin trawls to test a system for separating undersized fish from marketable fish. One of the trawls was fitted with a rigid grid with vertical bars spaced 110 mm apart and horizontal bars 50 mm apart. Small fish passing through the grid went out of the trawl while larger fish were directed up into a collection bag. The other trawl remained unchanged for comparison.

No short-term losses of commercial fish were observed during the survey, while 60% of the undersized fish escaped through the grid. If all the international fleets targeting these benthic species were to adopt the selective grid, a long term gain ranging between 20% and 30% in weight should be observed. Recent tests have been made with a flexible articulated grid, with springs between the sections and designed to wrap up onto a net drum. Selectivity results were similar and the practical results were very positive.

Mats Ulmestrand, Sweden – The use of Nordmøre grid for species selection in the Swedish inshore shrimp trawl fishery (paper)

There are concerns in Sweden regarding the impact of shrimp trawling on the benthic community as well as target finfish and shellfish stocks. Trials were conducted with the Nordmøre grid with the intent of reducing by-catch of small fish. Tests were conducted in a marine preserve area that was closed to trawling in 1989 and set aside as a test area. There was no significant loss of shrimp, but 85% of the finfish were sorted out. The principal finfish by-catch species was Norway pout, which was considerably reduced by use of the grid, while by-catches of commercial species were reduced even more. Only the very smallest cod failed to escape when the grid was used. These results show that grid use can be very effective and regulations are being prepared to require their use. Some voluntary use is already taking place. Angle of attack was not measured since the design is the same as used in Norway, which has been well documented. Some problems were seen when towing along steep contours. It was important to ensure that the angle of attack was neither too high nor too low.

Craig Rose, USA – Initial tests of a flexible grate for size selection of trawl caught fish (paper)

To take advantage of the fish selection features of grate devices for trawls, while avoiding handling problems, a grate was designed for installation in a trawl intermediate that was flexible enough to bend around a net reel, but rigid enough to maintain consistent, long, rectangular openings for fish size selection during trawling. This grate was tested for size selection of walleye pollock (*Theragra chalcogramma*) in the Bering Sea. A grate with 44-mm spacing had an L50 of 37 cm and a selection range estimated at 10 cm. Very few fish longer than 44 cm escaped. This length corresponded to a pollock with a head width equal to the 44-mm bar spacing. The grate was easily deployed and retrieved from a net reel, without any special procedures.

Ruben Ercoli, Argentina –

There are problems with by-catch of hake in the Argentinean red shrimp fishery. Recent efforts have gone into a local refinement of the Nordmøre grid, the Disela II, which uses two grids in tandem to carry out two-stage fish sorting. There is a guiding funnel in front of the first grid directing all organisms to its lower edge. This first grid with its large bar spacing excludes large fish, while reduced water flows in front of the second, more closely-spaced grid facilitate the escape of small fish. 75 double-rigged shrimp trawlers are now using this design on a mandatory basis, with good results. The "Dejupa" single-grid system is used to reduce juvenile fish by-catch in hake fisheries. It is similar to systems tested in Norway.

Derek Galbraith, Scotland – Grids have been tested for size-sorting whiting, haddock and flatfish. but results were highly variable and not very promising with the 40-mm spacing tested. A cylindrical grid with 20 mm bar spacing was tested for *Nephrops*, and it showed that about two thirds of the undersized *Nephrops* were sorted out but losses of marketable animals were unacceptably high.

Erdmann Dahm, Germany – Experiments have been conducted to use grids to reduce juvenile finfish by-catch in the brown shrimp (*Crangon*) fishery. Similar in concept to the Nordmøre grid, the grids were made of stainless steel and were mounted within a metal cage to maintain a constant angle of attack. Towing speeds were around 2.5 kn. Bar spacings of 18, 20, 22, 26 mm bar spacing were evaluated. Results are still being analysed, but finfish by-catches were reduced 34 to 56% at different spacings. Shrimp loss rates were 10% or more, which is unacceptably high for the commercial fishery. New trials are underway employing 30-mm bar spacing, and tests or 34-mm grids are being considered. Sieve nets still show superior performance compared to grids.

Hans Polet, Belgium – Nordmøre-type grids with 14-mm bar spacing were tested for the brown shrimp beam trawl fishery. On the research vessel, good results were obtained in terms of excluding undersized and non-commercial finfish, with about 10-15% reduction of shrimp, especially small shrimp. Similar trials on a commercial vessel were not so successful due to heavy clogging with starfish. Coming efforts will focus on pre-sorting starfish. There is much interest in the inconsistent results obtained in Germany, the UK, and Belgium, since all three countries efforts examined similar gear types in pursuit of the same species. Perhaps different conditions and features relating to such factors as grid position, gear design details, water flow regimes, or debris could explain these differing results.

Kristian Zachariassen, Faeroe Islands – Results from industry indicate key importance of understanding & managing water flow in and around the grids. Excessively fast or turbulent flows impede small fish escape efforts. In their research they have observed *Nephrops* clogging the grids (22-mm bar spacing) used in the pout fishery, but this may be explained by the grid angle of 55 degrees, which is so high that the *Nephrops* cannot slide along it.

7. Discussion of new efforts to estimate selectivity parameters - No comments on this topic were offered.

8. Presentations & discussion of impacts of grid usage

   Gerald Brothers, Canada – Estimates of the impact of actual and potential grid usage on discard levels for non-target species in various fisheries in Canada (paper).

Grids are mandatory in silver hake and shrimp fisheries taking place in Canadian waters, for both Canadian and foreign-registered vessels. The shrimp resource off Newfoundland is growing although cod stocks are not yet coming back. In the Gulf of St. Lawrence there are 131 shrimp vessels. Most shrimp are caught by vessels < 20 m. Shrimp must be landed within 72 hours of being caught.

Tests in 1991 with Nordmøre grids showed 2% shrimp loss with 97% finfish sorting. Since 1994 the fleet has switched almost exclusively to plastic grids. Several grid spacings have been tried in the commercial fishery but efforts are underway to rationalise on a single spacing of 22 mm. Observers on commercial vessels found an overall finfish by-catch rate of less than 4% over a shrimp catch of over 18,000 tons.

The northern shrimp stock which includes the Davis Strates, of the coast of Labrador, the north-east coast of New Foundland and the Flemish Cap was harvested by factory freezer trawlers up to 1997. Prior to grid usage this fishery had around 16% finfish by-catch. Grids became mandatory in 1994 on a contingent basis dependent on by-catch, fully mandatory in 1997. Now finfish by-catch rates are down to 2.4%. Turbot by-catch, especially for relatively small fish, is still a bit too high in some areas so efforts continue to reduce this by-catch. Comparison of 22-mm vs. 28-mm grates showed negligible differences in shrimp catch but a big reduction in turbot by-catch with the smaller grid spacing. Over 270 vessels are expected to fish shrimp in 1998, an increase of around 100 vessels over 1997.

Work has been done to develop a size-sorting grate for shrimp. Larger-mesh and square mesh codends have had marginal success. Premium prices are paid for large shrimp (> 6 gr.) while the smallest (< 2 gr.) have no commercial value but are still counted against the quota. They have tested a tandem system, with the front grate excluding fish and a second grate used to size-sort the shrimp. Water flows at the second grate are severely retarded, and sorting success has been poor. Tests were carried out aboard a vessel towing twin trawls. Testing continues.

The silver hake fishery requires use of a 40-mm grate to exclude cod, haddock and pollock. Many of the excluded cod and haddock are small enough to pass through the grate with the hake, but do not because of behavioural differences. Grate use has been very successful with no complaints from industry.

Another effort has been directed towards separating roundfish from flatfish. A single grid with vertical bars at 127-mm spacing and 65 degree angle of attack was nearly 90% effective at excluding cod with little flatfish loss.

Tests were conducted with the Sort-X grid but at high catch rates small cod were not able to escape, also the selection range was unacceptably broad. Recent efforts with the Sort-V single grid have been more promising, especially with 55-mm bar spacing vs. 60-mm. By-catch performance is monitored by fisheries observers, with about 10% coverage.

In the small-boat fleet plastic is preferred over stainless steel because it is lighter and does not require so many floats. Now about 90% of the vessels use plastic and the rest use aluminium. The situation is different with the larger factory trawlers, which almost exclusively use stainless steel.

No survival studies have been conducted on shrimp or finfish escapees, but video observations suggest that there is little mechanical contact that could lead to injury. Norwegian studies on survival of finfish escaping through a Nordmøre grid showed that escapee mortality was low. Icelandic studies on survival of shrimp escaping through codend meshes indicated high survival, with low survival for deck-sorted shrimp.

Andy Revill, England – The biological and economic impacts of discarding by the U.K. (East Coast) brown shrimp fishing fleet (paper).

Crangon grounds also are usually nursery areas for finfish. *Crangon* are mostly fished with beam trawls, with 20-mm codend mesh sizes. Juvenile finfish by-catches are quite high, commonly around 50%. Typically the vessels are small, 300 HP or less. There are many more vessels involved in this fishery in Germany and the Netherlands than in France, Denmark, and the UK. Studies showed large numbers of finfish discards, but no evaluations had been made on the biological or economic significance of these discards.

Revill applied various models to evaluate economic for the UK fleet. He estimated discard reductions attributable to grids and sieve (veil) nets, converted to reductions at age for the finfish species, then used these as input values in various biological and economic models. The models also included discards by other fleets, natural mortality, and economic value.

Results showed that for UK fleet the present level of finfish discards in the *Crangon* fleet has a value of 2 million pounds. Estimated total value of additional landings if the whole fleet used sieve nets would be nearly 1 million pounds, and this should be a bit higher if grids are used instead of sieve nets. The model shows that it is important to look at final biological and economic parameters, not just initial discard quantities. The model did not consider such economic costs of using selectivity devices as loss of target species, which seem to be around 10%. Revill also pointed out that economic benefits (e.g. increased value of plaice catches) will not necessarily fall to the *Crangon* vessels operators who incur the costs of reducing by-catch. Since these were single-species models, effects of ecosystem responses could not be evaluated.

Hans Polet, Belgium – More on the *Crangon* beam trawl fishery – Comparison of selectivity with and without grids. Wave heights and the presence or absence of hydrozooan fouling organisms, together with catch size, explained about 70% of the variability in the selectivity results when testing without grids. Grids yielded L50 values near the upper end of the range observed for nets fished without grids. Finfish selectivity was very poor with the 20-mm codends used in this fishery.

Whole-trawl selectivity for shrimp was also observed by means of collection bags attached to the trawl body. For commercial sized shrimp, about 80% remain in the codend, but for undersized shrimp much more selection occurred in the trawl body than in the codend. With the grid installed, about 1/3 of the shrimp escaped from the codend perhaps because the catches were cleaner and there was no mesh blockage.

In terms of catch composition there were 25 non-commercial species caught (and discarded) vs. one species of shrimp and 9 species of valuable fish.

The grids were made of plastic pipe and had bar spacings of 12 mm initially, then 14 mm during the remainder of the study. By-catch rates were evaluated by means of collection bags just covering the grid outlet during trials made using a research vessel, while a different collection bag surrounding the entire codend was used during trials aboard commercial vessels.

There was a strong size-selective effect with the 14-mm spacing. Small shrimp seemed to be entrained in the water flowing out the grid outlet so they were not caught at all, while around 10-15% of commercial sized shrimp were lost.

The opposite effect was seen for flatfish: small fish were not sorted out very well, but larger fish escaped. Very few whiting were retained, while cod followed a pattern similar to the flatfish. When trials were conducted on a commercial vessel, the finfish patterns were similar but overall catch rates were at a lower level. This may be due to higher waterflow through the fish outlet since these experiments were carried out without a fish outlet cover. For most benthic invertebrates around 50% were sorted out. The most troublesome species were starfish: if they were present they would stack up on the grid and not pass out, this caused deflection of the water flow and high rates of shrimp loss.

Meeting adjourned for the day.

April 19, 1998:

1. Discuss arrangements and work assignments to complete the tasks of the Study Group.

   (Suggestion: divide into 3 subgroups, each taking one of the points given in the Terms of Reference)

   Bibliography – Dahm, Kvalsvik, Puente, Boje, Galbraith, Priour.

   Impact of grid usage – Brothers, Lowry, Graham, Polet, Isaksen, Revill, Zachariassen

   Selectivity parameters – Polet, Graham, Van Marlen

2. Review and synthesize this session's accomplishments, agree on structure & content of draft report to the Working Group

3. Close meeting

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Appendix II

Gerald Brothers, 1998: Estimates of the impact of actual and potential grid usage on discarded levels for non-target species in various fisheries in Canada. La Coruña, Spain, April 18-19, 1998.

Appendix II

ICES, FTFB, STUDY GROUP ON GRID (GRATE)
SORTING SYSTEMS IN TRAWLS, BEAM TRAWLS AND SEINE NETS

LA CORUNA, SPAIN
APRIL 18-19, 1998

ESTIMATES OF THE IMPACT OF ACTUAL AND POTENTIAL GRID USAGE ON DISCARDED LEVELS FOR NON-TARGET SPECIES IN VARIOUS FISHERIES IN CANADA

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I. Introduction

Declining fish stocks in Canada and a growing concern for conservation has given rise to pro-active efforts by the fishing industry in co-operation with government agencies to develop and adopt sustainable fish harvesting technologies.

In the 1980's the fishing industry began using square mesh codends and larger diamond mesh to reduce the catch of juvenile fish. However, the by-catch of other species in the shrimp and silver hake fishery resulted in some areas being closed.

Following the development of the nordmore grate by a fisherman in northern Norway in the 1980's, Canada was quick to transfer the technology.

This paper will highlight the adopting and implementation of the nordmore grate into the Canadian shrimp fishery. It will also discuss modifications to the original grate which has been commercially used in some fisheries. Further developments to the original system are continually being tested to resolve outstanding by-catch problems.

II. Impact of the nordmore grate on the Canadian shrimp fishery

In Canada there are four separate stocks of shrimp; three on the Atlantic Coast and one on the Pacific Coast. The three stocks on Canada's east coast are: Gulf of St. Lawrence, Northern Shrimp Fishery and off Nova Scotia. Shrimp fishers on the west coast of Canada harvested 5,000 mt of shrimp in 1997. Some fishers on the Pacific Coast use nordmore grates on a voluntary basis, however, many do not.

The impact of the nordmore grate on the Canadian shrimp fishery will describe developments and adopting only on the Atlantic coast.

1. Gulf of St. Lawrence

The shrimp fishery began in the Gulf of St. Lawrence in 1965. It is being persued by fishers from Quebec, New Brunswick and Newfoundland. Catch and effort has gradually increased over the years. In 1997, 131 vessels, 35 between 20 and 30 meters and 96 < 20 meters, harvested 20,031 mt of shrimp. Between 1990 and 1996 the catches ranged as follows:

YEARS	1990	1991	1992	1993	1994	1995	1996
SHRIMP CATCH MT	15,372	16,279	12,757	15,461	16,210	16,634	18,111

While by-catch data is not available for all years, there was some data collected in 1991 (Hurtubise 1992).

SPECIES	COD	REDFISH	TURBOT	SHRIMP
CATCH (MT)	3,793	2,235	777	16,279
% DISCARDED	64	67	32	

In 1991 nordmore grate experiments were carried out on six Quebec shrimp boats. Traditional shrimp trawls were equipped with nordmore grates with 19mm bar spacings and retainer bags over the fish release opening. During 126 sets, 93 mt of shrimp were caught in the codend and only one mt in the retainer bag. The by-catch of groundfish amounted to 1.9 mt in the codend and 27 mt in the retainer bag. The nordmore grate resulted in a 96.6% reduction in groundfish by-catch, with only a 2% shrimp loss (Table 1).

Experiments with the nordmore grate resulted in the mandatory use of the grate in the Gulf of St. Lawrence in 1993.

In 1995 observers went to sea for 63 days in the northern Gulf (4R) and covered 32 different vessels. The catch observed was 123 mt of shrimp. The three main species in the by-catch were: herring 0.3%, capelin 3.4% and cod 0.2%.

During the last two years there has been increased catch rates of turbot and atlantic halibut in the Gulf of St. Lawrence. This may be attributed to the nordmore grate.

TABLE 1

NORDMORE GRATE EXPERIMENT
QUEBEC 1991

NO. OF VESSELS - 6 **TOTAL # OF SETS - 126**

CATCH	CODEND	RETAINER	% REDUCTION
SHRIMP	208,821	4,218	2.0
GROUNDFISH (BY-CATCH)	2,167	60,811	96.6
TOTAL	210,988	65,092	

2. Northern Shrimp Fishery

The northern shrimp fishing area extends from NAFO Division 3K off the northeast coast of Newfoundland in the south to NAFO Division 0 in the Davis Straits in the north (Figure 1). Following exploratory surveys in the mid 1970's which showed good catch rates, this fishery began in 1977. Until 1997 this fishery was persued by 13 factory freezer trawlers which are owned by 17 licence holders. This fleet also fishes shrimp in NAFO Division 3M when their individual shrimp quota inside Canada's 200 nm economic zone is taken. Table 2 gives a breakdown of the shrimp catch and by-catch species most commonly caught by this fleet from 1987 to 1994 (Kulka 1995). Table 3 is the same data expressed as a percentage of the total of those five species; cod, american plaice, redfish, turbot, and shrimp. The by-catch for most years averaged 14%. However, following the voluntarily use of the nordmore grate in 1993 and the mandatory use in 1994 in areas where by-catch exceeded 300 kelos per day, the by-catch dropped to less than 3%. In 1997 the grate with 28 mm bar spacings became mandatory in all northern shrimp fishing areas except outside the 200 mile limit where NAFO requires that a 22mm grate be used.

Table 4 shows the catch composition of shrimp and by-catch in the Davis Straits during one trip in 1990.

Table 5 shows the shrimp catch and by-catch of redfish, turbot and other species in northern shrimp fishing areas 1 to 6 in 1997. Over 30,000 mt of shrimp were caught with < 3% by-catch.

In 1997 there was a 57% increase in the northern shrimp fishery (Table 6) and much of that increase went to vessels < 20 meters long. This influx of 80 smaller vessels using nordmore grates with 28mm bar spacings had unacceptable by-catch of turbot in some areas (Table 7). Very few of those turbot were < 33cm (Table 8). This inspired fishers and government agencies to conduct an experiment to reduce turbot by-catch.

A < 20m shrimp twin trawler was rigged with a 22mm grate in one trawl and a 28mm grate in the second trawl. Ten sets were completed during 43 fishing hours. The by-catch of turbot and lantern fish was low during the experiment. However, the catch of turbot was 56% less and the catch of lantern fish was 30% less in the trawl with the 22mm grate. The shrimp catch and shrimp size were similar in both trawls (Table 9) (Brothers 1997).

Nordmore grates with a minimum bar spacing of 22mm will become mandatory in 1998 for vessels < 20m fishing northern shrimp.

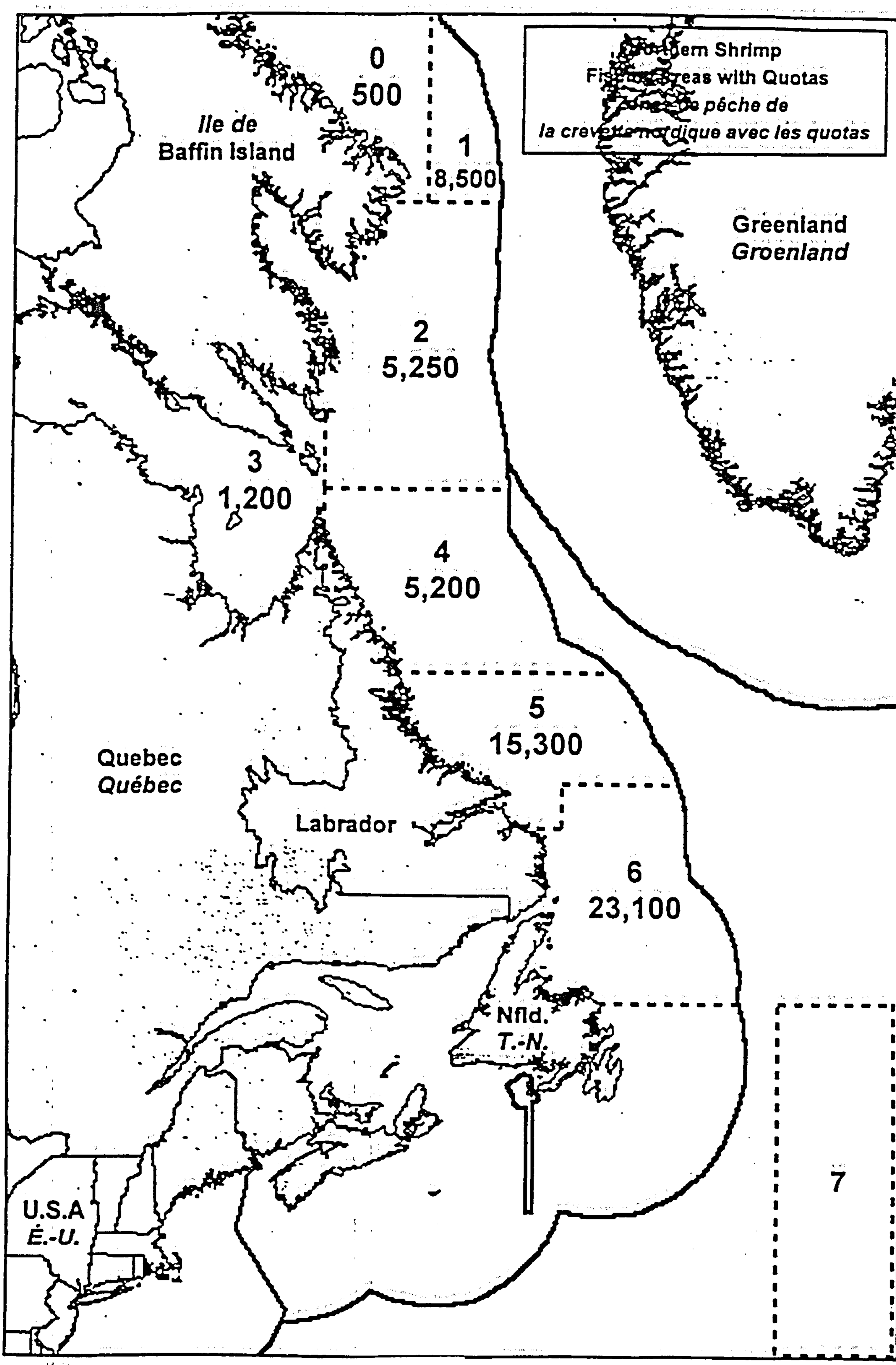


FIGURE 1:

NORTHERN SHRIMP FISHING AREAS INDICATING 1997

TABLE 2

BY-CATCH IN THE NORTHERN SHRIMP FISHERY
1987 - 1992
CATCH MT

YEAR	COD	PLAICE	REDFISH	TURBOT	SHRIMP
1987	659	194	2,542	837	25,573
1988	3,121	549	2,841	1,561	53,578
1989	1,119	531	3,848	2,028	57,667
1990	835	384	3,296	2,348	44,818
1991	1,286	444	3,988	2,572	46,038
1992	553	247	5,234	1,291	47,511
1993	111	132	2,009	867	43,878
1994	48	188	2,149	809	53,748

TABLE 3

BY-CATCH IN THE NORTHERN SHRIMP FISHERY
1987 - 1992
% OF TOTAL CATCH

YEAR	COD	PLAICE	REDFISH	TURBOT	SHRIMP
1987	2	0.6	7.7	2.7	87
1988	5.1	0.9	4.6	2.5	86.9
1989	1.7	0.8	5.9	3.1	88.5
1990	1.6	0.7	6.5	4.5	86.7
1991	2.4	0.8	7.4	4.7	84.7
1992	1.0	0.5	9.5	2.4	86.6
1993	0.2	0.3	4.3	1.8	93.4
1994	0.1	0.3	3.8	1.4	94.4

TABLE 4

CATCH COMPOSITION OF COMMERCIAL SHRIMP TRIPS FOR THE DAVIS STRAITS (CANADIAN SIDE) DURING OCTOBER AND NOVEMBER, 1990

SPECIES	CATCH (kgs)	% OF TOTAL CATCH
Shrimp	1,383,400	84.36
Redfish	105,727	6.45
Greenland Halibut	24,665	1.51
Shark	67,130	4.09
Arctic Cod	12,995	0.79
Skate	7,976	0.49
Atlantic Cod	2,272	0.14
Wolfish	1,573	0.10
Eelpouts	1,551	0.09
Sculpins	12,634	0.77
Others	19,866	1.21
TOTAL	1,639,790	100

TABLE 5

OBSERVED SHRIMP AND BY-CATCH (KG) INFORMATION BY NORTHERN SHRIMP FISHING AREAS (SFA'S) 1997

SFA'S	# SETS	SHRIMP	%	REDFISH	%	TURBOT	%	OTHERS	%
1	187	499,771	89.0	44,820	8.0	3,906	0.7	13,151	2.3
2	2,190	6,042,354	96.6	80,660	1.3	26,269	0.4	108,759	1.7
3	121	373,963	95.2	2,812	0.7	1,209	0.3	14,871	3.8
4	1,020	3,396,879	98.6	29,291	0.8	5,298	0.2	14,940	0.4
5	2,786	9,782,934	97.1	33,086	0.3	110,749	1.1	145,736	1.5
6	2,978	10,497,797	98.8	9,127	0.1	48,836	0.5	69,224	0.6
TOTAL/ AVG	9,282	30,593,698	97.6	199,796	0.6	196,267	0.6	366,681	1.2

TABLE 6

NORTHERN SHRIMP
TOTAL ALLOWABLE CATCH (TAC)

SHRIMP FISHING AREA (SFA)	TOTAL ALLOWABLE CATCH (TAC)		INCREASE IN TAC
	1996	1997	
SFA 0	500	500	0
SFA 1	8,500	8,500	0
SFA 2	3,500	5,250	1,750
SFA 3	1,200	1,200	0
SFA 4	5,200	5,200	0
SFA 5	7,650	15,300	7,650
SFA 6	11,050	23,100	12,050
TOTAL	37,600	59,050	21,450

Table 7

OBSERVED INDIVIDUAL TRIP HIGH BY-CATCH OCCURRENCES

SHRIMP FISHING AREA	3K	3K	3K	3K	4R
DAYS FISHED	4	2	3	3	1
TIME FRAME	OCT. 14-18	NOV. 1-6	OCT. 21-24	OCT. 25-28	NOV. 7
OBS. DIR. CATCH (KGS)	7,880	4,890	9,738	13,864	2,250
OBS. TURBOT BY-CATCH (KGS	2,060	340	405	835	19
% TURBOT BY-CATCH	26%	7%	4.2%	6%	0.8%
OBS. REDFISH BY-CATCH	NEG [1]	NEG	6	12	NEG
% REDFISH BY-CATCH	NEG	NEG	6	12	NEG
OBS TOTAL BY-CATCH (KGS)	2,347	560	960	948	110
% TOTAL BY-CATCH	29.8%	11.5%	9.9%	6.8%	4.9%

. TABLE 8

AVERAGE SIZE OF TURBOT RETAINED BY THE GEAR

- 15-17 CM: 25%
- 21-23 CM: 46%
- > 23 CM: 29%
- VERY FEW FISH > 33 CM RETAINED

TABLE 9

SHRIMP TWIN TRAWLING PROJECT

DIFFERENCE IN CATCH BETWEEN A SHRIMP TRAWL WITH 22MM NORDMORE GRATE AND ONE WITH A 28MM GRATE

DATE:	Nov. 8 - 14, 1997	M/V:	"Cape Mariner"
LOCATION:	2J	NO. OF SETS:	10
WATER DEPTH:	167-228 Fathoms	TOTAL FISHING TIME:	43 Hrs.

CATCH	22MM GRATE	28MM GRATE	% DIFFERENCE
TOTAL SHRIMP (lbs)	21,866	20,852	5
% SMALL SHRIMP (< 20mm - 5 gms)	15.07	19.05	21
SHRIMP COUNT PER LB.	56	55.9	0.2
TOTAL TURBOT (lbs)	89	200	56
NUMBER OF TURBOT	448	969	54
TOTAL LANTERN FISH (lbs)	194	276	30

3. Shrimp fishery off Nova Scotia

The shrimp fishery off Nova Scotia is primarily concentrated in holes with water depths greater than 200 meters. In recent years a fleet of 26 vessels from Nova Scotia, all < 20m, and 7 vessels from New Brunswick between 20m and 30m harvested approximately 3,000 mt annually.

SCOTIAN SHELF SHRIMP LANDINGS (MT)
1990 - 1997

YEARS	1990	1991	1992	1993	1994	1995	1996	1997
SHRIMP CATCH MT	50	810	1,850	2,044	3,073	3,171	3,171	3,574

Prior to 1990 little effort was given to harvesting shrimp on the eastern Scotian shelf. This was mainly because the by-catch of groundfish exceeded the maximum limit of 10%. Table 10 shows the catch composition of commercial shrimp trips off Nova Scotia between 1984 and 1990. Over 30% of the catch consisted of groundfish by-catch.

Several experiments with the nordmore grate system were carried out off Nova Scotia in 1990 on both research vessels and commercial shrimp vessels. Results showed a reduction in by-catch to < 3% with little or no loss of shrimp (Tables 11 & 12) (Cooper 1991). The grate was voluntarily used by fishers in 1991 and 1992 and mandatory in 1993.

TABLE 10

CATCH COMPOSITION OF COMMERCIAL SHRIMP TRIPS FROM THE EASTERN SCOTIAN SHELF FROM 1984 TO 1990

SPECIES	CATCH (LBS)	% OF TOTAL CATCH
Shrimp	718,022	66
Cod	119,669	11
Redfish	209,967	19.3
Flatfish	26,109	2.4
Hake	1,087	0.1
Halibut	4,352	0.4
Haddock	3,263	0.3
Pollock	5,439	0.5
TOTAL	1,087,908	100

TABLE 11

SHRIMP SEPARATOR TRAWL - LADY HAMMOND - JULY, 1990
EASTERN SCOTIAN SHELF

SPECIES CAUGHT	CODEND WITH GRATE (KGS)	CODEND WITHOUT GRATE (KGS)	REDUCTION IN CATCH WITH GRATE %
Shrimp	1949	1994	2.3
Plaice	36	380	90.5
Cod	2	341	99.4
Redfish	9	28	67.9
Haddock	0	17	100
Others	34	184	81.5

TABLE 12

SHRIMP SEPARATOR TRAWL - LEADING LADY- AUGUST, 1990
EASTERN SCOTIAN SHELF

SPECIES CAUGHT	CODEND WITH GRATE (KGS)	CODEND WITHOUT GRATE (KGS)	REDUCTION IN CATCH WITH GRATE %
Shrimp	3211	2922	(9) increase
Plaice	20	615	96.7
Cod	0	179	100
Redfish	11	202	94.6
Haddock	0	6	100
Others	23	140	83.6

III. Size Sorting Shrimp With Rigid Grates

Shrimp fishers in Canada are paid based on shrimp counts/lb on inshore vessels and counts/kg on the offshore factory freezer trawlers. Fishers can substantially increase the value of their catch by increasing the percentage of large shrimp in their catch. In 1995 shrimp fishers in 4R only received 64¢/lb. This could have been 97¢/lb for all large shrimp (Fig. 2).

To increase the value of our shrimp resource, industry and government agencies have been experimenting with in-trawl shrimp size sorting systems. Experiments have included larger diamond mesh, square mesh, modified nordmore grates, and a second size sorting grate in the trawl behind the nordmore grate.

In 1995 a nordmore grate was modified to size sort shrimp and also to reduce by-catch. This grate (Fig. 3) had 12mm bar spacings in the bottom ⅓ of the grate and 25mm bar spacings in the top ⅔ of the grate was tested in the Gulf of St. Lawrence. Shrimp and by-catch were guided to the bottom of the grate where the small shrimp passed between the 12mm bar spacings and exited the trawl. The large shrimp were guided to the top ⅔ of the grate and passed into the codend between the 25mm bar spacings. The by-catch exited the trawl through an opening in the top in front of the grate.

The by-catch blocked the grate and resulted in poor shrimp size selectivity. The experiment was cancelled after a few fishing days.

The next device tested was an in-trawl shrimp size sorting grate installed into the shrimp trawl behind the nordmore grate (Fig. 4). This system was tested with both guiding funnels and panels of netting in front of the grate to guide the shrimp to the bottom of the grate. Small shrimp would pass between the bars and exit the trawl while large shrimp were guided up the grate to a large opening in the top of the grate which led to the codend.

Between 1995 and 1997 size sorting grates have been tested on offshore factory freezer trawlers and inshore < 20 m vessels. Bar spacings from 7mm to 14mm were tested. Observations made in the flume tank at the Marine Institute, St. John's, and underwater observations with video cameras have led to many modifications.

In 1997 a 60 meter factory freezer trawler tested size sorting grates with 10mm, 11mm, 12mm, 13mm and 14mm bar spacings (Table 13) installed into the shrimp trawl behind the nordmore grate with 28mm bar spacings. The grate was installed at an angle of 30° in one leg of a trouser trawl codend. The other leg had no size sorting grate. Results showed that the 12mm grate had 8.3% less small shrimp (Brothers 1998). This vessel has been using a size sorting grate in areas with high catch of small shrimp for the past two years.

During the summer of 1997 a < 20 m shrimp twin trawler tested a 12mm bar spacing size sorting grate in one trawl and no size sorting grate in the other. Results showed that the trawl with the size sorting grate had 22% less shrimp (Table 14). The size of shrimp in both codends were large (95/kg). A smaller bar spacing may have been more effective.

Development of an effective shrimp size sorting technology will continue in Canada in 1998. Plans are to test grates with 8mm bar spacings.

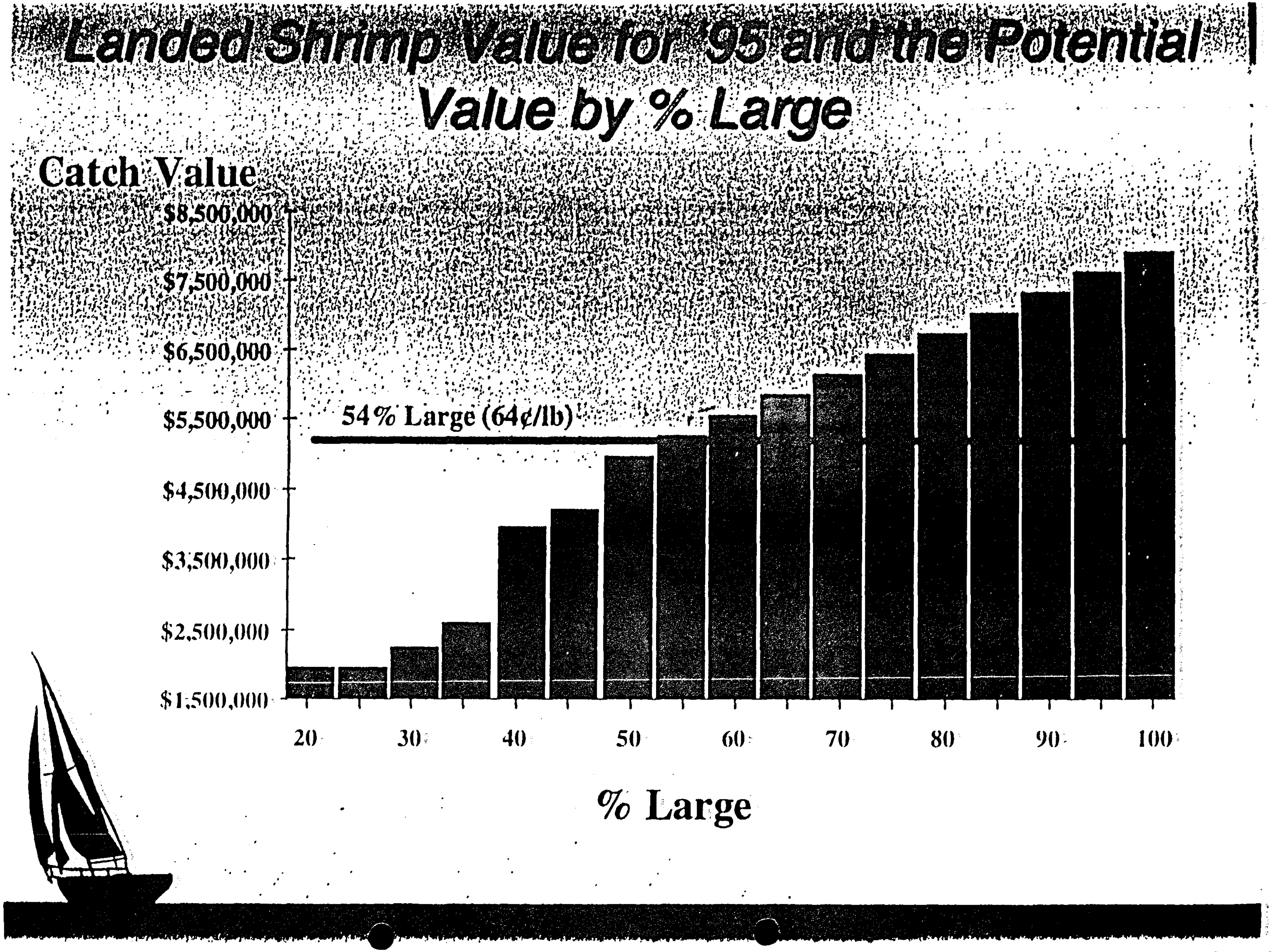

Landed Shrimp Value for '95 and the Potential Value by % Large
Catch Value
$8,500,000
$7,500,000
$6,500,000
$5,500,000
$4,500,000
$3,500,000
$2,500,000
$1,500,000
54% Large (64¢/lb)
20
30
40
50
60
70
80
90
100
% Large

FIGURE 2

EXPERIMENTAL SHRIMP SIZE SORTING GRATE

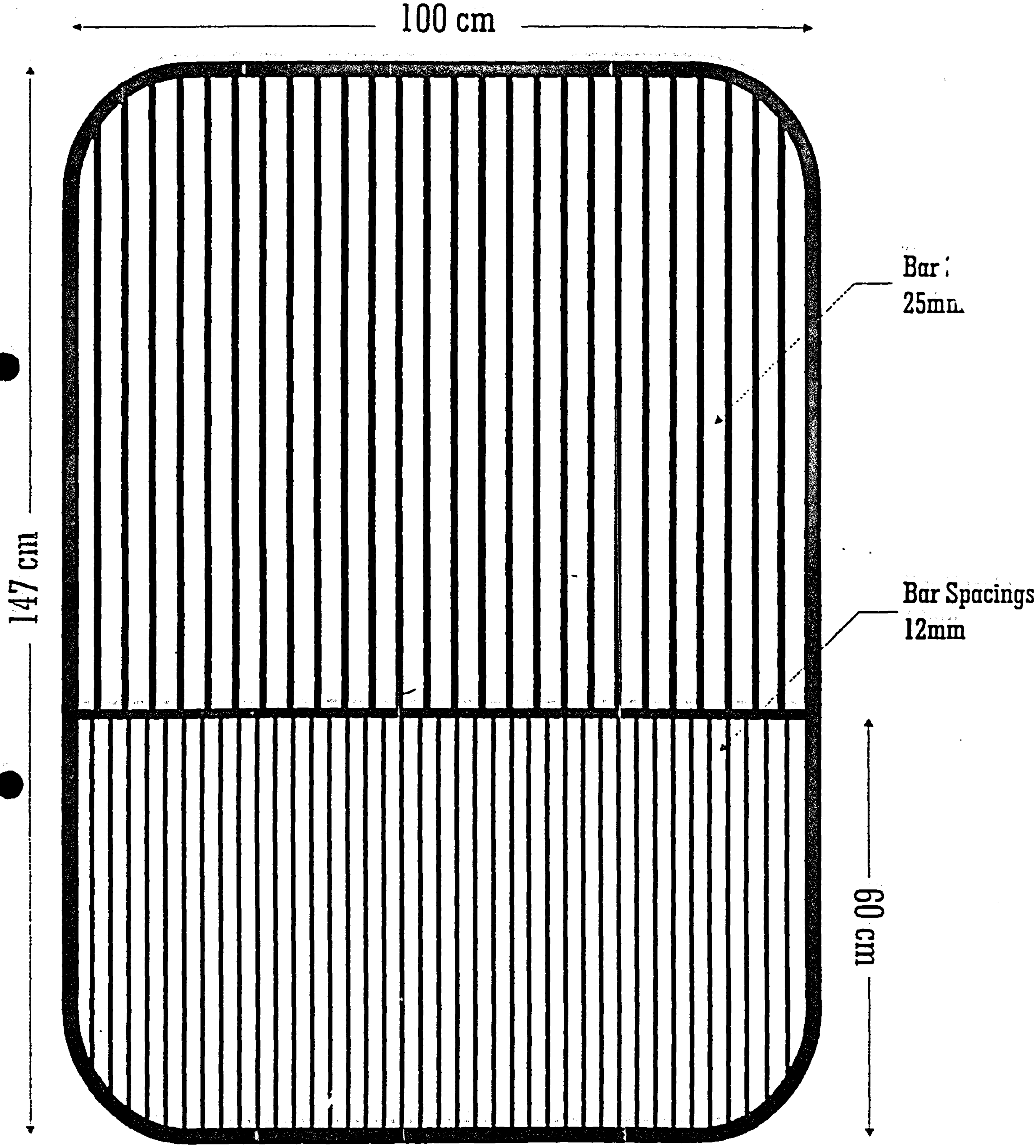


FIGURE 3 MODIFIED NORDMORE GRATE

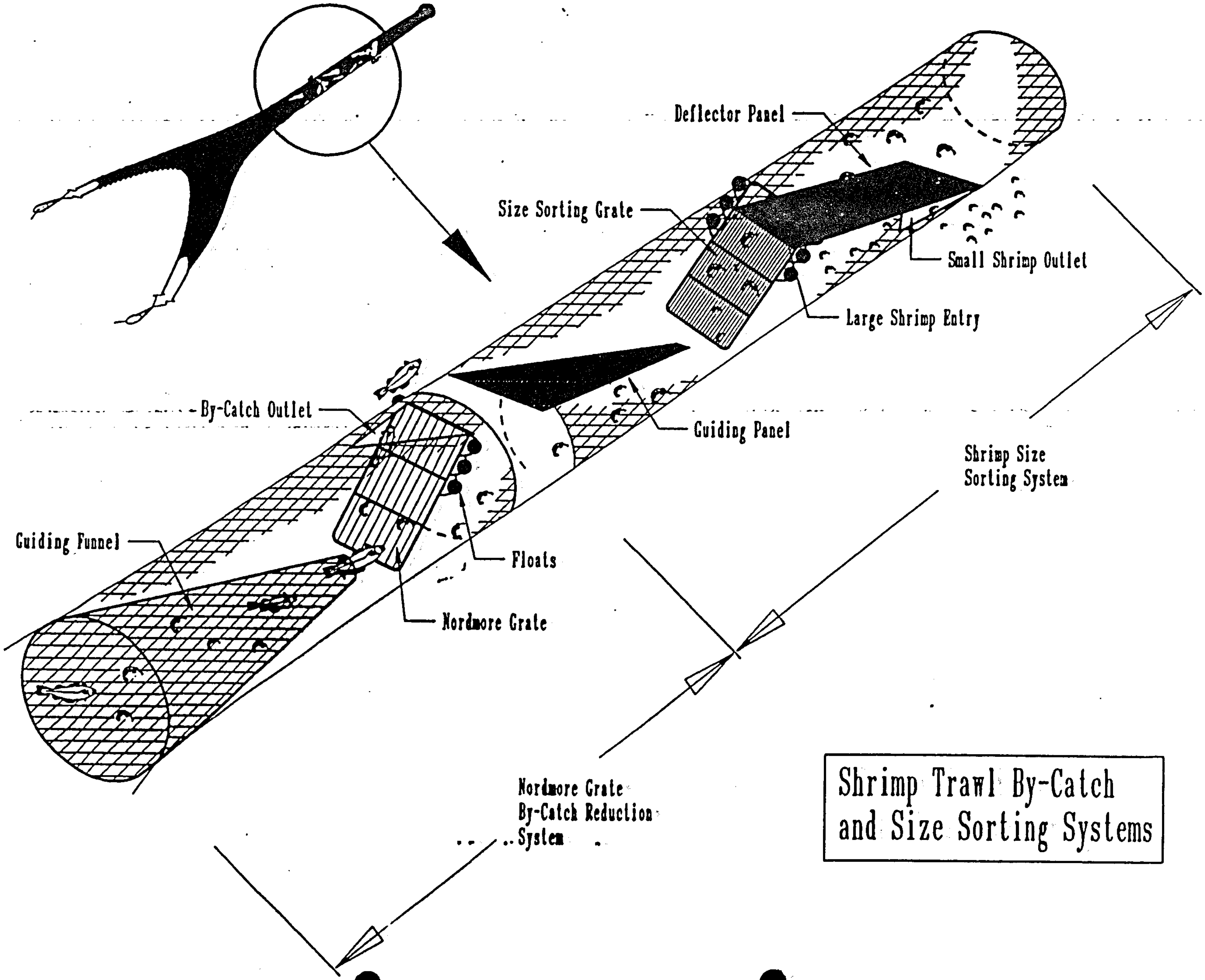

Deflector Panel
Size Sorting Grate
Small Shrimp Outlet
Large Shrimp Entry
By-Catch Outlet
Guiding Panel
Shrimp Size
Sorting System
Guiding Funnel
Floats
Nordmore Grate
Nordmore Grate
By-Catch Reduction
System
Shrimp Trawl By-Catch
and Size Sorting Systems

FIGURE 4

TABLE 13

PERCENTAGE OF SHRIMP 21MM LONG AND UNDER
(6 GRAMS AND UNDER)

GRATE BAR SPACING	% OF SHRIMP 21MM AND UNDER		
	EXPERIMENT	REGULAR	% DIFFERENCE
10MM GRATE	28.8	31.5	2.7
11MM GRATE	40.2	47.0	6.8
12MM GRATE	36.1	44.4	8.3
13MM GRATE	42.7	50.1	7.4
14MM GRATE	52.3	57.2	4.9

TABLE 14

SHRIMP TWIN TRAWLING PROJECT

DIFFERENCE IN CATCH BETWEEN A SHRIMP TRAWL WITH 40MM DIAMOND MESH CODEND AND ONE WITH A 12MM SORTING GRATE

DATE: Oct. 31- Nov. 03, 1997
LOCATION: 2J
WATER DEPTH: 171-225 Fathoms
M/V: "Cape Mariner"
NO. OF SETS: 4
TOTAL FISHING TIME: 15.3 hrs.

CATCH	40MM DIAMOND	12MM SORTING GRATE	% DIFFERENCE
TOTAL SHRIMP (lbs)	5,694	4,446	- 22
% SMALL SHRIMP (< 20mm)	0	0	0
SHRIMP COUNT PER LB.	43	42	+ 2
TOTAL TURBOT (lbs)	11	14	- 27
TOTAL LANTERN FISH (lbs)	12	7	+ 42

IV. Reducing the silver hake by-catch with rigid grates.

The by-catch of cod, haddock, and pollock in the silver hake fishery prevented this specie from being commercially harvested for many years. Silver hake range in size from 15-40cm, which is considerably smaller than other groundfish species such as haddock (35-60cm) and cod and pollock (40-110cm).

In 1992 National Sea Products, in co-operation with DFO, experimented with a rigid grate, similar to the shrimp nordmore grate, in the silver hake fishery, to reduce the groundfish by-catch. The grate measured 1.4 meters x 2.3 meters and had vertical bars spaced 40mm apart (Figure 5). It was constructed of mild steel and was installed into the silver hake trawl at a 45° angle. The trawl had a codend with 45mm mesh and a retainer bag also with 45mm mesh was attached over the opening above the grate to retain any fish that would normally escape. This allowed the personnel onboard to monitor the species and sizes of fish being sorted by the grate.

Results from the experiment clearly demonstrated that a rigid grate can effectively separate and release cod, haddock and pollock from silver hake. For the 32 valid sets made during the experiment, only 5% of the pollock and haddock, and only 1% of the cod entered the codend with the silver hake (Table 15) (Cooper 1992). Ninety-five percent of the silver hake passed between the bars and were collected in the codend. There was no difference in the size of silver hake which escaped or caught. However, it was interesting to find that 50% of the pollock and haddock which escaped were small enough to pass through the grate. This would indicate that silver hake behaves differently than pollock or haddock.

Further experiments were carried out in 1993 on grates with horizontal vrs. Vertical bars with 40 to 50mm bar spacings. However the vertical bars with 40mm spacings installed at a 45° angle proved most effective.

The rigid grate reduced the by-catch of pollock, haddock and cod from 20 to 40% to less than 10%.

In 1994 the use of a 40mm sorting grate became mandatory for all vessels fishing silver hake inside Canada's 200 mile economic zone.

The total 1997 silver hake quota for Canadian and foreign vessels on the Scotian Shelf was 50,000 mt. That was lower than previous years.

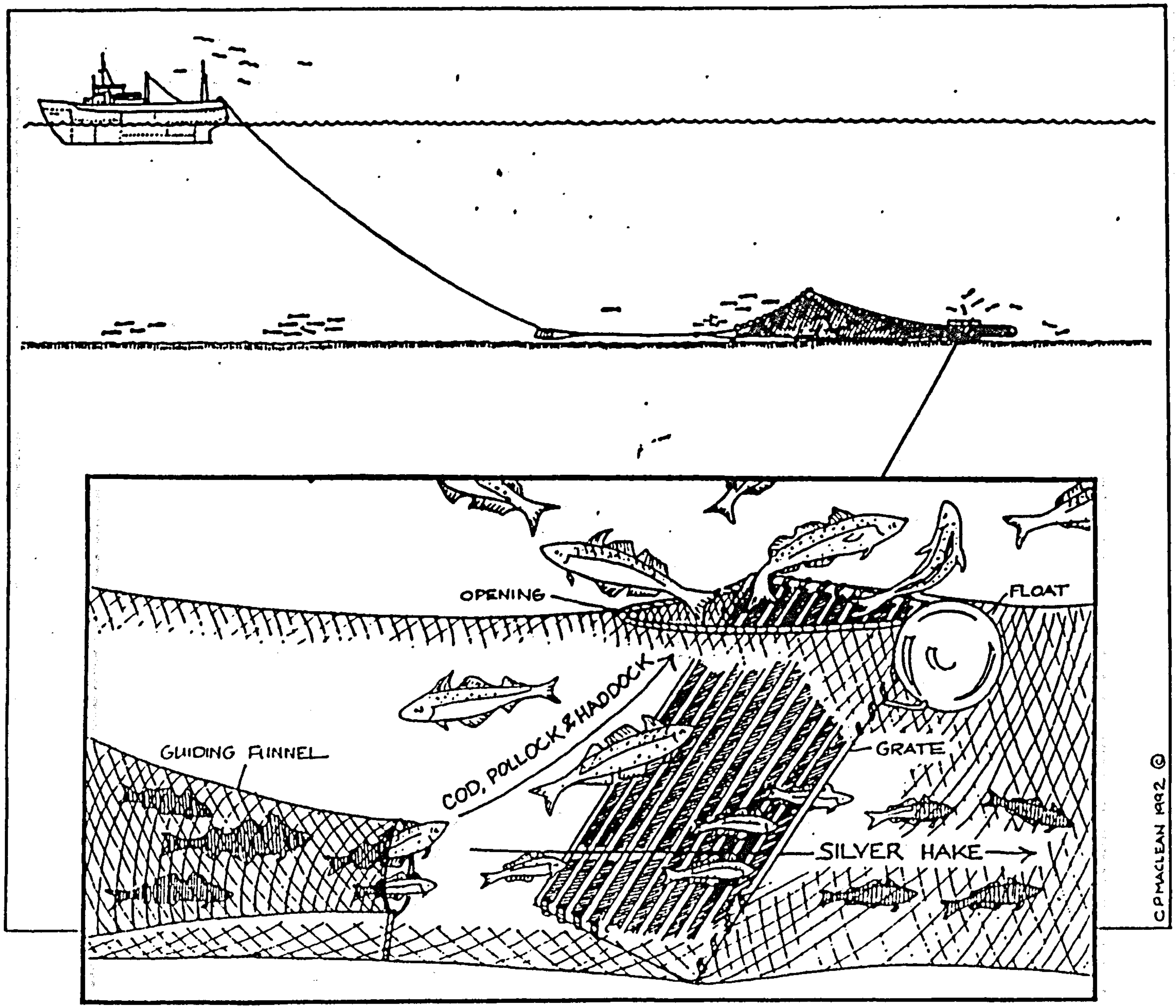

OPENING
FLOAT
COD, POLLOCK & HADDOCK
GUIDING FUNNEL
GRATE
SILVER HAKE
C.P. MACLEAN 1992 ©

FIGURE 5

TABLE 15

SILVER HAKE EXPERIMENT 1992 - NUMBER OF SETS - 32

SPECIES	TOP CODEND	BOTTOM CODEND	% IN BOTTOM CODEND
Silver Hake	2,021	37,363	95
Cod	92	8	1
Haddock	781	38	5
Pollock	3,298	166	4
Herring	608	993	62
Others	2,696	1,396	34
TOTAL	9,449	39,960	81

* All numbers - weights in kgs.

V. Using rigid grates to separate roundfish and flatfish

The low quota on atlantic cod on the Grand Banks in 1993 made it necessary for Fishery Products International, in co-operation with DFO, to develop ways to harvest flatfish species (american plaice and yellowtail) without exhausting their limited cod quotas.

A 48 meter stern trawler carried out two experimental trips to investigate the effectiveness of steel rigid grates to reduce the catch of roundfish, in particular cod, while directing for flatfish, american plaice and yellowtail (Figure 6). Prior to the experiment, the by-catch of cod was up to 70% of the catch. The objective of the study was to reduce the catch of cod to approximately 20%.

During the two 10-day trip, steel grates measuring 1.5 x 1.5 meters were tested with horizontal bars spaced 76, 102, and 150mm apart, and vertical bars spaced 127, 163, and 152mm apart. Grate angles of 50, 58 and 67° were tested. The grate was installed into the trawl similar to nordmore grates. The codend had a mesh size of 140mm mesh. A retainer bag also 140mm was attached over the grate to catch the fish which would have escaped. Each grate contained 18 floats to neutralize its weight in the water.

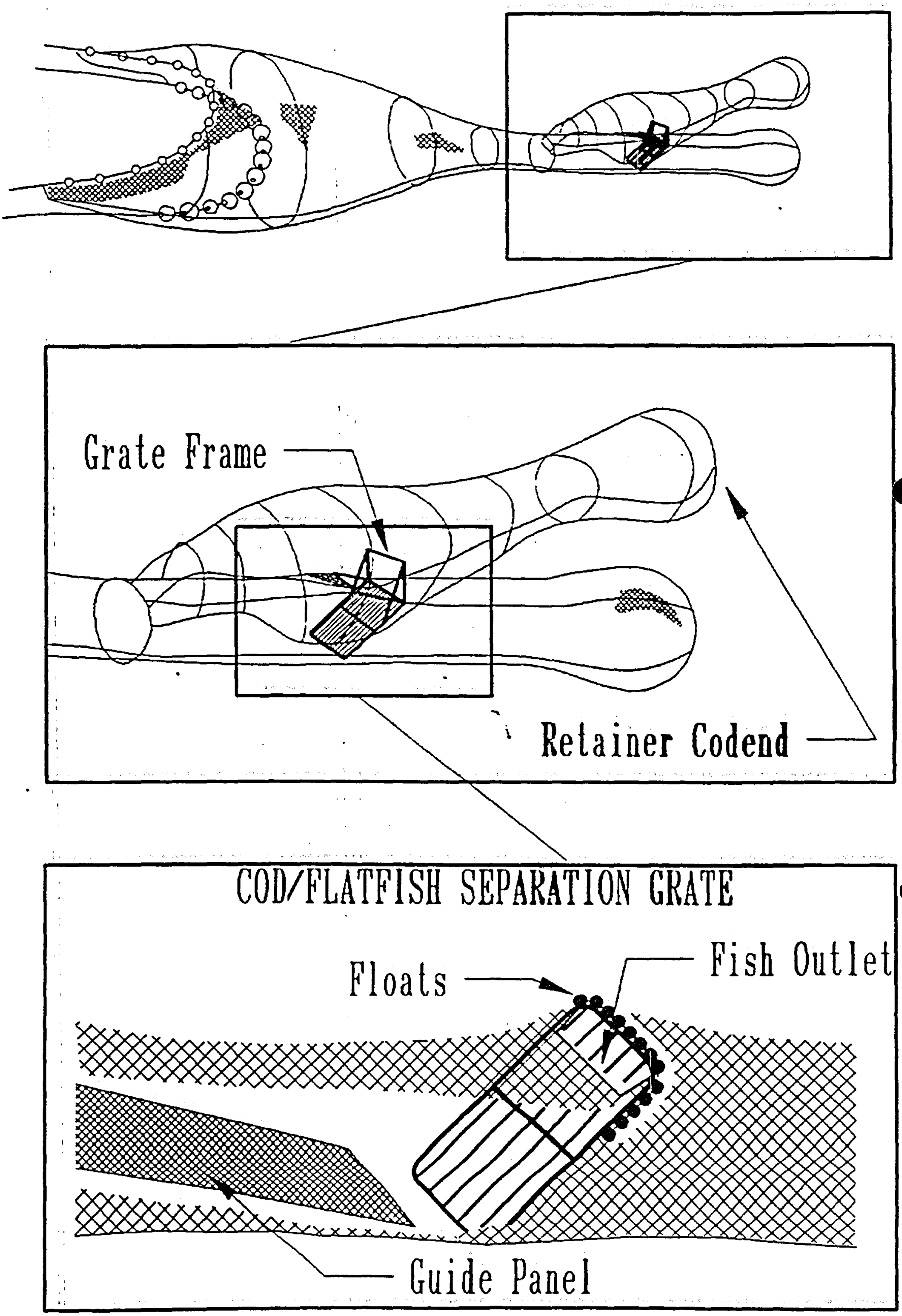
A total of 72 sets were made during the two trips. Grates with vertical bars performed much better than grates with horizontal bars. The grate with 127mm vertical bar spacings installed at a 65° angle gave the best results. It excluded 84.4% of the cod with only a 7.9% loss of plaice (Table 16) (Hickey 1995).

Following the experimental trips, FPI rigged eight of the stern trawlers with rigid grates and commercially harvested plaice

TABLE 16

FLOUNDER/COD SEPARATION EXPERIMENT
NEWFOUNDLAND REGION
1993/94

GRATE ORIENTATION		HORIZONTAL		VERTICAL	
BAR SPACING (MM)		102	76	165	127
NUMBER OF SETS		7	1	4	7
GRATE ANGLE		54°	65°	65°	65°
COD	CODEND	7	3	1057	270
	RETAINER	1125	61	1161	1994
	% EXCLUSION	99.4	95.3	52.3	88
PLAICE	CODEND	1107	363	1544	4180
	RETAINER	537	301	68	346
	% LOSS	32.7	45.3	4.2	7.6
YELLOWTAIL	CODEND	658	227	331	1709
	RETAINER	425	215	12	151
	% LOSS	39.2	48.6	3.8	8.1
WITCH	CODEND	322	165	673	1059
	RETAINER	164	121	17	65
	% LOSS	33.7	42.3	2.5	5.8


Grate Frame
Retainer Codend
COD/FLATFISH SEPARATION GRATE
Floats
Fish Outlet
Guide Panel

VI. Sort-V Grate

An experiment began in the Gulf of St. Lawrence in 1997 to test the effectiveness of the sort-v grate to reduce the catch of small cod onboard < 20 meter vessels. The objective of the experiment was to reduce the catch of cod < 43cm caught in otter trawls to below 15%. Four vessels participated in the experiment. Two used traditional trawls with 145mm diamond mesh codends. The third vessel used a trawl with a 60mm bar spacing sort-v grate, and the fourth vessel used a sort-v grate with 55mm bar spacing (Figure 7).

There was very few cod in the area during the experiment. Preliminary results showed that the percentage of cod caught < 43cm with the 60mm sort-v grate was 8.2 and the percentage caught < 43cm with the 55mm sort-v grate was 10%. One of the vessels using 145mm diamond mesh codend had 36.8% small fish, while the other vessel had 9% small fish (Table 17). Further studies using sort-v grates are planned for 1998.

TABLE 17

MOBILE GEAR SELECTIVITY EXPERIMENT - 1997
REDUCING THE CATCH OF SMALL COD
USING SORT-V SYSTEMS

VESSEL NAME	GEAR USED	NO. OF SETS	TOTAL CATCH (LBS)	% < 43CM
Cape Harrigan	55mm grate	7	4,300	10.04
Lady Jennifer	145mm dia grate	9	10,500	36.81
Gallant Lady	60mm grate	12	19,700	8.20
Ocean Joy	145mm dia mesh	12	7,811	9.05

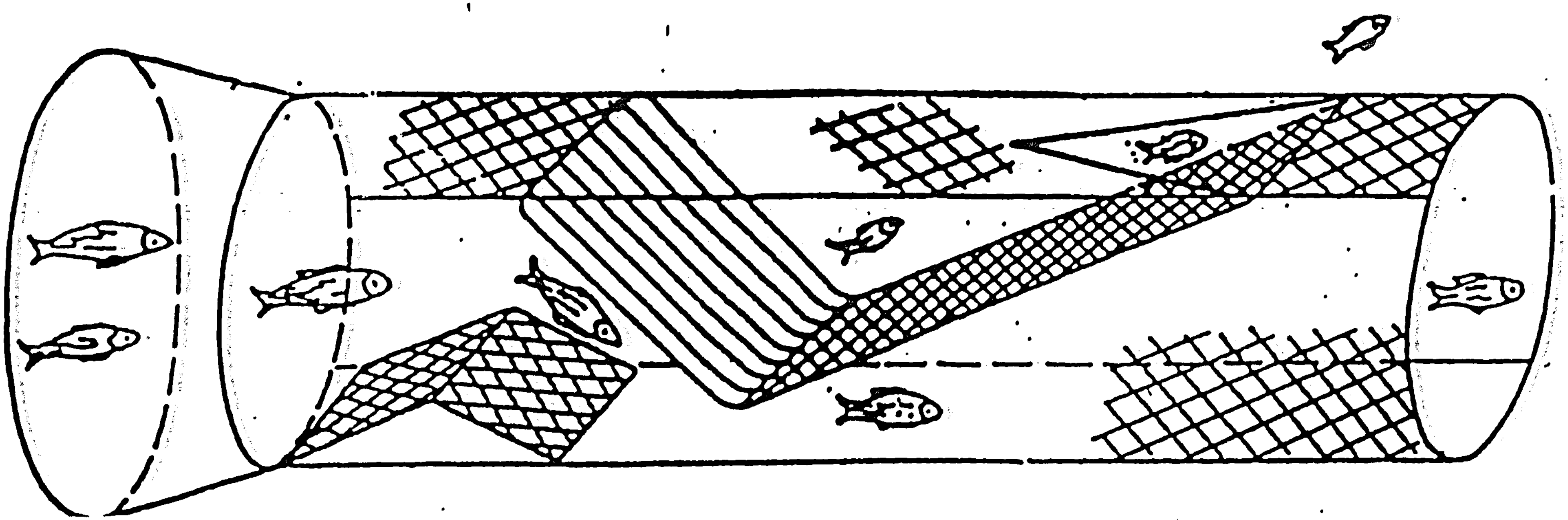


FIGURE 7

Illustration of the working principle of the single-grid system "Sort-V".

VII.Sort -X Grate

Two experimental trips were carried out onboard a 52 meter stern trawler to determine if the sort-x system could significantly reduce the capture of immature cod fish. One 10-day trip took place in 1991 and the second 10-day trip was carried out in 1993. The sort-x system tested had 50mm bar spacings and a 45mm mesh retainer bag over the grate (Figure 8). The codend in the 1991 experiment had 140mm mesh with a 45mm mesh cover. During the 1993 experiment the codend had 45mm mesh.

Ten successful sets were completed in 1991. High catch rates up to 38,500 kgs/set made it difficult for the grate to sort the catch. However, indications were that the sort-x system, with a few modifications and more testing, could be a valuable asset to the fishing industry.

In 1993, 8 successful sets were completed. The total catch was 138,964 kgs. The cod length ranged from 27 to 57cm in the retainer bag and from 31 to 75cm in the codend. The percent of fish below 43cm in the codend was 19.54, as compared to 48.57 in the retainer. The L50 varied from 36.5 to 41.5 cm for individual sets (Figure 9). The selectivity factor varied from 9.1 to 15cm (Hickey 1993). High catch rates may have influenced the selectivity of the sort-x system.

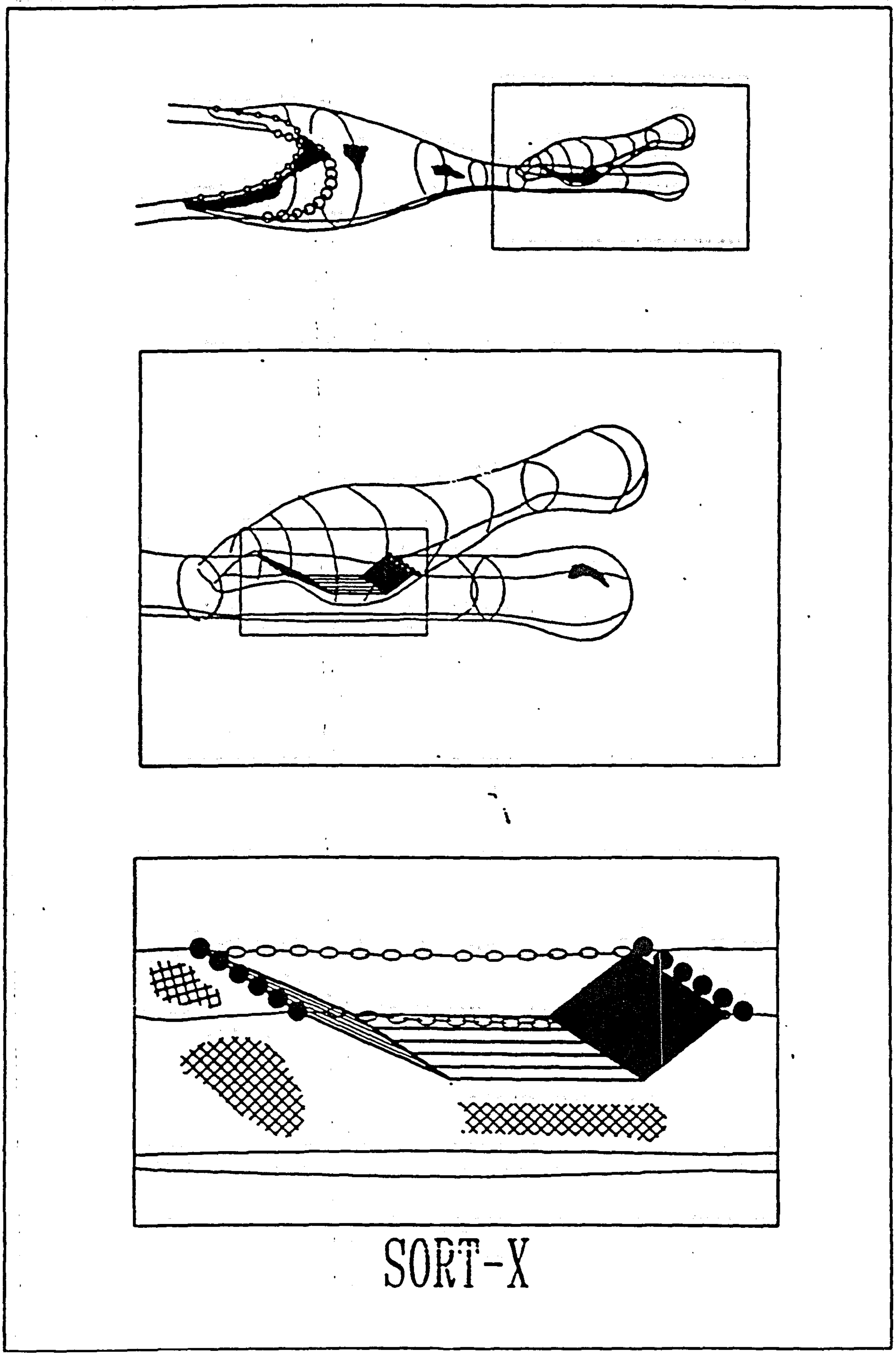
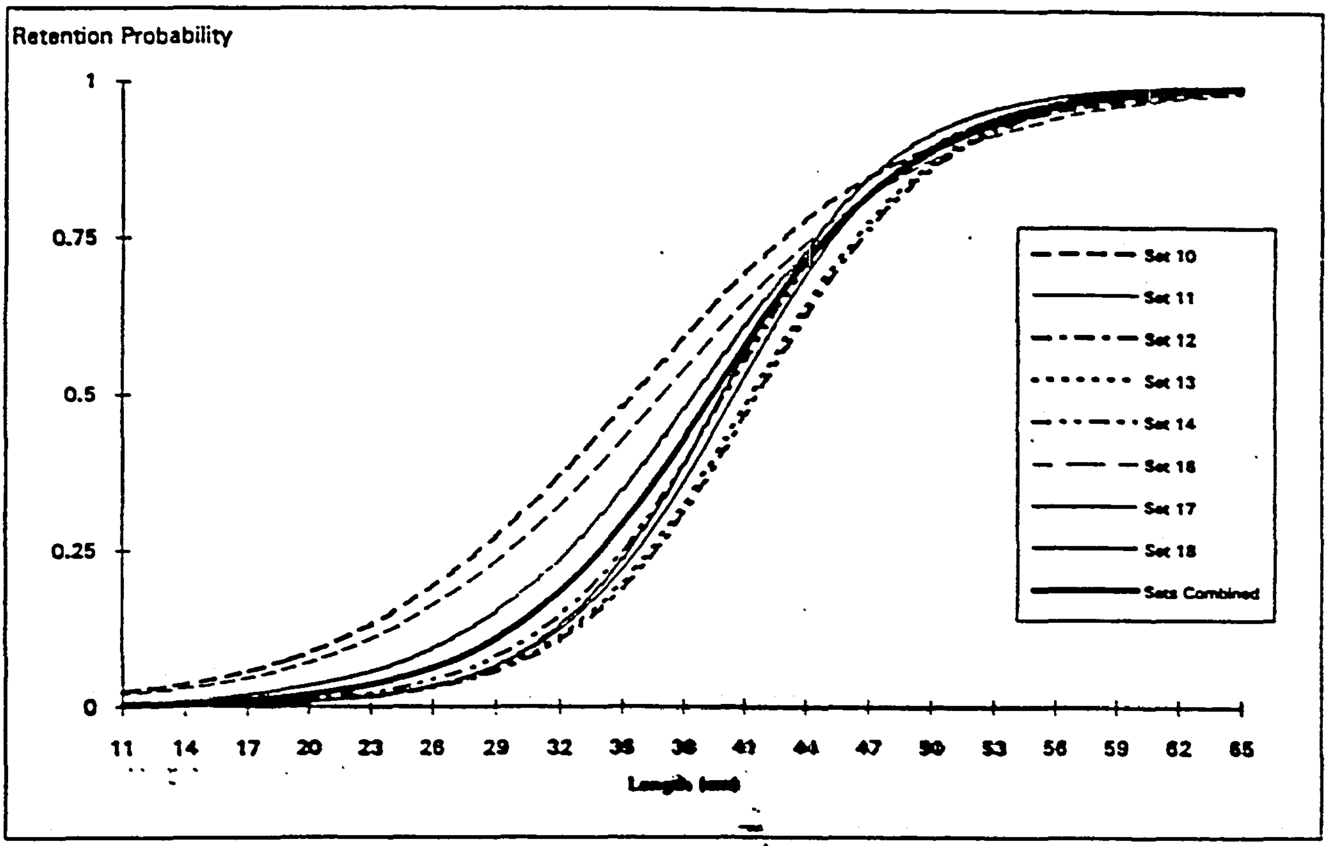


FIGURE 8

The Sort-X system with a retainer bag over the grid system.



	Sort-X System with 50mm Bar Spacings								
	Set 10	Set 11	Set 12	Set 13	Set 14	Set 16	Set 17	Set 18	Sets Combined
a	-5.33(0.16)	-9.31(0.26)	-9.15(0.34)	-9.09(0.19)	-8.08(0.16)	-5.54(0.26)	-[illegible].93(0.13)	-9.57(0.15)	-7.88(0.06)
b	0.15(0.01)	0.23(0.01)	0.22(0.01)	0.22(0.01)	0.22(0.01)	0.15(0.01)	0.1[illegible](0.01)	0.24(0.01)	0.20(0.01)
L50	36.5	40.7	41.2	41.5	40.3	37.2	3[illegible].[illegible]	39.8	39.6
L25	29.0	35.9	36.3	36.5	35.3	29.8	32.6	35.2	34.0
L75	44.0	45.5	46.2	46.5	45.4	44.6	44.9	44.3	45.1
S.R.	15.0	9.6	9.9	10.0	10.1	14.8	12.3	9.1	11.0

FIGURE 9 : Atlantic cod selectivity curves and parameter estimates for separate and combined sets using the Sort-X System with 50mm bar spacings.

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