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The Effect of Codend Separator Grates on Silver Hake Otter Trawl Catch Rate

by

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Introduction

The concept of using rigid separator grates in otter trawls to improve codend selectivity originated in Norway in 1989 (Isaksen *et al.*, 1992; Larsen and Isaksen, 1993). Grates are inserted in the codend of trawl nets (Fig. 1) and function by diverting unwanted parts of the catch to an escape opening while retaining the target size groups or species. They are size selection mechanisms, the sizes at which fish are sorted depending on the spacing between the bars of the grates. The extent to which they separate species is a function of the disparities in the size, and possibly the differences in behaviour, of the species involved. The efficiency of sorting depends on various aspects of grate design and installation.

The first testing of separator grates or grids in the Canadian zone was performed by the Department of Fisheries and Oceans (DFO) in 1990 resulting in their adoption by the Scotian Shelf shrimp otter trawl fleet in 1991 to reduce bycatches of groundfish species (Cooper *et al.*, MS 1991). In 1992, National Sea Products Ltd., a Canadian fishing company, approached DFO to perform an experiment to separate out pollock when fishing for silver hake. It was agreed to test a separator grate system similar to the shrimp grate system except with wider bar spacing. The expectation was that the small-bodied silver hake would pass through the bars of the grate whereas bycatch species, which are normally larger-bodied than silver hake, would be diverted by the bars to the escape opening on top of the net. The experiment aboard the National Sea Products trawler *Cape Verde* gave such encouraging results using a grate with vertical bars with 40 mm spacing that this was the only grate tested. Shortly thereafter representatives of the Cuban fleet agreed to test a grate under commercial fishing conditions, and trials were conducted aboard the trawler *Rio Moa* in 1992 and 1993. In addition, DFO conducted an experiment with different grate designs and installations aboard the DFO research vessel *Alfred Needler* in 1993. This experiment examined the effects of differences in bar orientation (vertical or horizontal), bar spacing, grate angle, and the location of the guiding mechanism , on the separation of bycatch species from silver hake in a directed silver hake fishery. This paper provides estimates of the release percentages, and of size selection, for the directed species, silver hake, for various grate configurations.

Material and Methods

A description of the vessels used and their trawls is provided in Table 1. The characteristics of the grates used, and the anterior funnels or panels used to guide fish to the bottom of the grates, are given in Table 2. A second (top) codend (Table 1) was attached over the escape opening above the grate to retain the "escapees". The mesh sizes of the top and bottom codends were identical on the *Cape Verde* and *Alfred Needler* experiments and closely similar in the *Rio Moa* experiment (Table 1). Thus the differences between size compositions of catches in

the two codends in the first cases can be attributed entirely to grate selection, whereas for the *Rio Moa* there was also a mesh size effect. The installation of the guiding funnel in the *Alfred Needler* net was identical to that in the *Cape Verde* net except that the bottom edge of the funnel was attached directly to the bottom of the codend, rather than to a tether which retained it about 30 cm above the codend bottom. Initial trials with a funnel on the *Rio Moa* net proved unsatisfactory and it was replaced by a panel. A Cuban innovation was adopted which allowed the rear end of the panel to be attached to a retaining bar set 60 cm forward of the grate and welded to the bottom of the grate frame (Fig. 2). This provided a vertical opening between bar and netting of 40-45 cm through which fish were directed to the bottom of the grate.

A remote underwater camera vehicle (Cooper, MS 1987) was deployed at the beginning of the first experiment (on the *Cape Verde*) to ensure that the grate, funnel and overall codend configuration corresponded to expectation when the net was fished.

The weights of each species caught in the top and bottom codends were recorded separately. Aboard the commercial vessels, weights recorded were based on visual estimates by experienced personnel associated with the Canadian Fisheries Observer Program, although on *Rio Moa* it was possible to obtain actual weights for small catches, and to confirm estimates of larger catches by monitoring factory production weights. On the research vessel, *Alfred Needler*, all catches were weighed except for the largest silver hake catches, for which the average weight of a basket of fish was multiplied by the total number of baskets caught. Length-frequencies of silver hake were obtained from both codends from most commercial vessel catches and from virtually all research vessel catches. Small catches were measured in total, whereas random subsamples were measured from large catches. Subsamples were weighted up to total catch based on the ratio of catch weight to sample weight to obtain length-frequencies of total catch in each tow.

Estimates of "escapement" were calculated as the weight or number of fish in the top codend compared to the totals caught in top and bottom codends. "Overall" estimates were calculated by summing over tows for each codend separately before calculating escapement, thus giving each tow a weighting based on the size of its catch. When only catch weights were available for a tow, the length frequency of the catch in that tow was assumed to be the same as that of the aggregate of sampled tows. The mean and median of tow by tow estimates of percentage escapement are also presented as alternative estimates and, as the estimates tend to be skewed, the range is provided as an indicator of tow by tow variation. As the precision of recorded weights was 1 kg, three tows with catches of less than 100 kg of silver hake (in top and bottom codends combined) were excluded from the calculation of tow by tow estimates, to allow a precision in calculation of escapement to the nearest integer or better.

Escapement expected to result from utilization of separator grates in the commercial fishery was calculated by applying escapement-at-length data from the three experiments combined to 1989-93 commercial catch length compositions. Although use of separator grate when fishing for silver hake was made mandatory in August 1993, the fishery was essentially over for the year by that date. Thus, the data for 1989-93 represent size compositions in the fishery immediately prior to grate introduction. Length-frequency of commercial catches was based on Canadian observer programme samples. Length-weight relationships for the same years, necessary for calculation of escapements by weight, were obtained from DFO July research vessel surveys in Div. 4W.

Results

Cape Verde

The grate used on the *Cape Verde* experiment was set at an angle of 45-50° and had vertical bars set 40 mm apart. Fishing was conducted south of the Small Mesh Gear Line (SMGL - as defined in 1992) and in Emerald and LaHave basins to the north of the SMGL. Total catches per tow were fairly low south of the SMGL (median = 0.6 mt, range = 0.3-1.7 mt) but were high in Emerald Basin (median = 2.6 mt, range = 0.9-4.8 mt) and LaHave Basin (median = 4.2 mt, range = 2.7-8.0 mt). The number of valid tows (these conducted without technical problems or gear damage), their average duration, and the catch rate (kg/hr) in top and bottom codends,

are summarized by area in Table 3. Three of the five tows in LaHave Basin, including the two with high escapements of silver hake, were not sampled for size composition, which limits the analysis for that area.

Silver hake catches mirrored total catches, being low south of the SMGL (median = 0.2 mt, range = 1 kg - 0.9 mt) but progressively higher in Emerald (median = 2.2 mt, range = 0.5-4.5 mt) and LaHave (median = 3.3 mt, range = 1.1-6.8 mt) basins. The overall escapement of silver hake, in each area was also highest in LaHave Basin, 10.3% by weight, compared to 6.5% and 5.0% in the other areas (Table 3). The range of percentage escapements on a tow by tow basis was 1.6 to 15.1, but median escapements were similar in all three areas, ranging between 5.2 and 5.8 (Table 4). The median for all tows combined was 5.4%. This compares to a mean of tow by tow escapements of 6.1% (Table 4) and an overall estimate, which is more heavily influenced by the large silver hake catches in LaHave Basin, of 6.8%.

An analysis of variance of silver hake escapement by area (shelf edge, Emerald Basin, LaHave Basin) with the following as covariates: silver hake mean weight, and silver hake, dogfish and total catches, indicated no significant effects. However, a distinctive feature of LaHave Basin catches was that between 200 and 840 kg of spiny dogfish occurred in all five tows. On retrieval of one of these tows (during which escapement was 13.8%) it was noted in cruise records that the grate was "blocked off" with dogfish, and in two others partially blocked (escapement 15.1% and 5.5%). In the remaining two sets, with escapement of 3.8% and 5.8%, "a few dogfish" were noted as stuck in the grate in the first case and no note was made regarding the second. In contrast, dogfish were caught in only five of the 28 sets in the other two areas, and in none of these did the quantity of dogfish exceed 10 kg. Although, on a tow by tow basis, there was not a significant correlation between escapement and the quantity of dogfish caught, the effectiveness with which dogfish block grate openings is not necessarily a linear function of the quantities that enter the net, and the prevalence of dogfish in the LaHave Basin catches remains the most likely cause of the higher overall escapement of silver hake which occurred there.

Escapement by length could be calculated for the SMGL and for Emerald Basin, where sampling of catches was fairly comprehensive, but not for LaHave Basin where the largest catches were not sampled. Escapement at length was very similar between the SMGL and Emerald Basin and thus the data were combined to give a single set of estimates. There was a gradual increase in percentage escapement with size from about 1-3% for fish of 15-22 cm (age 1) to 3-6% for 23-33 cm fish which formed the bulk of the catch (Fig. 3). The few fish caught that exceeded 38 cm were taken mostly in the top codend, indicating high escapement above this size.

Four tows were made during the *Cape Verde* experiment with the guiding funnel either missing or improperly installed, but which were in other respects valid tows. Escapement overall of silver hake was about 36% (range 27-45) (Table 3) giving an indication of the importance of a properly installed funnel to effective selection by the grate.

Rio Moa

Initial field trials were conducted aboard the *Rio Moa* in August 1992 but, as a result of miscommunication, the grate used was too large to fit properly into the codend, and no usable data on species separation were collected. However, experimentation with a guiding panel rather than a funnel, anterior to the grate, led to an innovation where the guiding panel was attached to a metal bar welded to the front of the grate (Fig. 2). This guidance arrangement, and a grate of the proper size, was used in further trials aboard this vessel in June 1993. Vertical bars in the grate were spaced at 40 mm, as in the *Cape Verde* experiment, but the grate was mounted at an angle of 60°, rather than the 45-50° used previously. The increase in grate angle was adopted because it was thought that the angle would reduce when the codend was stretched by catches of commercial size. The vessel fished south of the SMGL.

In the five experimental tows conducted silver hake catches comprised over 90% of the total, varying from 0.8 to 14.3 mt (median = 3.0 mt). Escapement of silver hake overall was 4.8 % by weight (Table 5). The median escapement on a tow by tow basis was 4.1% (range = 2.6-5.9%). All silver hake greater than 37 cm escaped, although there were very few of this size (Fig. 4). In contrast to the *Cape Verde* results (and also those of the *Alfred Needler* - see below), there was no trend in escapement with size. This is likely attributable to the difference

in mesh size between codends, the 55 mm top codend retaining more fish in the smaller part of the length range than the 60 mm bottom codend and thus giving a rather higher estimate of grate-related escapement at these sizes than was actually the case. Clay (1979) gives a 50% selection length for silver hake of 22-23 cm for 60 mm mesh and a selection range of 13 cm.

Alfred Needler

Five grate configurations were tested on the *Alfred Needler;* the configuration of vertical bars spaced 40 mm apart was compared with a configuration of horizontal bars spaced 40 mm apart and one with vertical bars spaced 50 mm apart, all inserted at an angle of 48°. In addition, the effectiveness of the grate with vertical bars 40 mm apart was tested at a 25° angle, and at this reduced angle with the end of the funnel moved aft to 42.5 cm from the bottom of the grate, rather than the 85 cm used in the other cases. Throughout these experiments the rear end of the funnel was attached directly to the bottom of the codend, rather than being on a short tether as in the case of the *Cape Verde* experiment. All fishing was conducted south of the SMGL.

Total catches were 0.1-2.4 mt (median = 0.4 mt), rather smaller than those obtained when commercial vessels were used. However, silver hake catches were above 100 kg in all but two of the 39 valid tows (median = 283 kg, range = 11-1200 kg). Escapement of silver hake overall in tows with the "standard" grate, i.e. vertical bars spaced at 40 mm, grate angle of 48° and exit funnel 85 cm before grate, was 2.3% by weight, whereas when horizontally-oriented bars were used (at 40 mm spacing) escapement increased to 5.4% (Table 6). Increasing the spacing of the vertical bars to 50 mm reduced escapement to 0.9%. Escapement was increased substantially, to 43%, by lowering the angle of the grate, but moving the exit from the funnel closer to the grate reduced escapement to some extent (to 32.3%). Escapements summarized from tow by tow data (Table 7) agree closely with those based on global aggregations (Table 6). An analysis of variance of escapement of silver hake by grate configuration, with silver hake mean weight, and silver hake, dogfish and total catches as covariates, showed that the grate effect only was significant. Significance of the differences between mean escapements for each grate was examined using the Bonferroni test for multiple comparisons and all were significantly different from each other at the 5% level except for the vertical grates with 40 mm and 50 mm spacing.

Escapement of silver hake from the standard 40 mm vertical grate was less than 1% for fish less than 20 cm, 1-3% in the 20-30 cm range, and above 3% for fish larger than 30 cm (Fig. 5). Escapement from the grate with horizontal bars, but with the same bar spacing, also increased with fish size (Fig. 6). However, escapement was 1-2% for fish less than 20 cm, 2-6% for 20-30 cm fish, and showed steepening increments above 30 cm. The 50 mm vertical grate resulted in escapement of about 0.7% at all lengths at which substantial numbers of fish were caught (Fig. 7). When the 40 mm vertical grate was angled at 25° there was no indication of a variation in escapement with fish size, all escapements being about 40% (Fig. 8). Similarly, when the funnel was moved aft to half the distance from its exit to the bottom of the grate, there was no indication of size-dependent escapement levels, escapement being about 30% for all sizes (Fig. 9).

Projected Effects of Grate Use on Commercial Catches

Escapement estimates are dependent on the size compositions of the populations being fished, and experimental results could differ from expected escapements when using grates in the commercial fishery if the size compositions of the populations fished commercially differed from experimental ones. The separator grate introduced commercially, that with vertical bars spaced 40 mm apart, was tested in all three experiments with similar results, and thus the combined escapement-at-length data were applied to the size compositions of commercial catches in the five years prior to grate introduction to calculate the expected effects of grate use on silver hake catches.

Silver hake escapement in the three experiments was low except for sizes above 38 cm (Figs. 3-5), but the selection curve above 38 cm is not adequately described even by the combined data (Fig. 10). Application of a 722 median smoother provides a smooth curve. This can be considered no more than a hypothesis as to the shape of the selection curve at these larger sizes. It transpires, however, that very few fish as large as this occurred in commercial catches and thus the shape of the selection curve above 38 cm has no important influence on estimates

of escapement. Experimental and commercial catch length frequencies were similar except that experimental catches contained higher proportions of 15-20 cm fish (Fig. 10). Estimates of escapement from commercial data were slightly over 5% by weight (4.5% by number), close to the combined estimate from experimental data of 4.8% by weight (4.1% by number) (Table 8).

Conclusions

A grate set in the codend at 45-60°, and equipped with vertical bars spaced 40 mm apart, allowed escapement of only 5% of the target species, silver hake, in the experiments. If the size compositions of the populations being fished subsequent to commercial usage of this grate were similar to those in 1989-93, escapement in the commercial fishery would have been similar to experimental results.

Escapement of silver hake when the 50 mm vertical grate was tested on the *Alfred Needler* was about half that with the 40 mm vertical grate, but the results were not significantly different. A horizontal orientation of bars, spaced 40 mm apart, increased silver hake escapement in comparison with the 40 mm vertical bar configuration. Presence, and proper installation of, a guiding funnel or panel proved necessary for effective selection of silver hake by the grate. Angle of grate installation was also important, a reduced angle greatly increasing escapement of silver hake. There was no indication that escapement was related to catch tonnage, escapement being similar in the large *Rio Moa* catches and the small catches of the *Cape Verde* and *Alfred Needler* when fishing south of the SMGL. There was evidence, however, that masking by species which stick between or lie against the grate bars could be problematic on occasion. The high escapements recorded during some of the *Cape Verde* tows in LaHave Basin are attributed to grate blockage by dogfish. However, anecdotal information from the commercial fishery indicates that grate blockage by skates is a more common problem than blockage by dogfish (M. Showell, Marine Fish Division, Bedford Institute of Oceanogr.; pers comm.) but there are no quantitative data on frequency of blockage.

Acknowledgments

These experiments were made possible by the cooperation of the owners, captains and crews of the commercial vessels *Cape Verde* and *Rio Moa*. D. Waldron and M. Showell (Marine Fish Division, Bedford Institute of Oceanogr.) collaborated in the planning and execution of the *Alfred Needler* experiment. G. Greencorn and D. Flynn (Beothuk Data Services, Seawatch Division, Halifax) conducted much of the at-sea sampling, and Greencorn the initial data editing. M. Showell provided commercial catch length compositions from the 1989-93 silver hake fishery and R. Branton (Marine Fish Division, Bedford Institute of Oceanogr.) the length-weight regressions from DFO research vessel surveys. W. Farrell prepared the typescript.

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Table 1. Statistics describing the vessels and their trawls used in separator grate experiments for silver hake in 1992-93.

Item	Vessel		
	Cape Verde	*Rio Moa*	*Alfred Needler*
Vessel type	Commercial wetfish stern trawler	Commercial factory freezer trawler	Research stern trawler
Length (m)	51.8	105	50.3
GRT	891	2579	925
BHP	2000	4000	2000
Gear type	Silver hake trawl	Silver hake trawl, 4-panel codend	1034 2-bridle Nordsea silver hake trawl
Footrope length (m)	52	44	39
Headrope length (m)	38	24	31
Vertical opening (m)	7	5	---
Door type	oval	oval	oval
Door weight (kg)	1500	1750	950
Mesh size in wings (mm)	184	80	60
Mesh size in body (mm)	90	60	60
Mesh size in codend (mm)	45	60	45
Centre roller height (mm)	610	400	306
Second codend			
Mesh size (mm)	45	55	45
Length (m)	---	13.6	9.1
Cruise dates	June 1992	June 1993	May 1993

Table 2. Statistics describing the grates and guiding funnels or panels used in each experiment.

Item	Vessel		
	Cape Verde	*Rio Moa*	*Alfred Needler*
Grate			
Width (m)	1.37	1.16	0.8
Height (m)	2.29	1.80	1.82
Bar type	vertical	vertical	vertical, horizontal
Bar spacing (mm)[1]	40	40	40, 50
Grate angle[2]	45-50^0	60^0	25^0, 48^0
Guiding Device			
Type	funnel	panel	funnel
Distance anterior (m)	0.85	0.60	0.425, 0.85
Opening (m)[3]	0.80	0.40-0.45	0.87
Tether length (m)	0.30	-	zero

1 Bar spacing means the gap between adjacent bars, i.e. the space available for a fish to pass through.

2 Grate angle is measured from the horizontal, i.e. at 90^0 the grate would be vertical.

3 Diameter of circular rear opening in case of funnel, height of retaining bar above bottom of codend in case of panel.

Table 3. *Cape Verde:* average catch per hour and percentage catch distribution, by weight and number, in top (T) and bottom (B) codends, in three fishing areas and when using no, or an improperly installed, funnel.

Area or grate configuration	No. of tows	Ave. dur. (hrs)	Silver hake		Other species	
			T	B	T	B
			Average catch per hour (kg)			
SMGL	11	3.2	6	88	93	19
Emerald Basin	17	2.4	45	850	103	47
LaHave Basin	5	2.9	133	1161	345	73
No funnel	4	2.5	861	1536	619	264
			Percentage by weight			
SMGL	-	-	6.5	93.5	83.0	17.0
Emerald Basin	-	-	5.0	95.0	93.6	6.4
LaHave Basin	-	-	10.3	89.7	82.5	17.5
No funnel	-	-	35.9	64.1	70.1	29.9
			Percentage by number			
SMGL	-	-	5.8	94.2	---	---
Emerald Basin	-	-	4.0	96.0	---	---
LaHave Basin	-	-	---	---	---	---
No funnel	-	-	---	---	---	---

Table 4. *Cape Verde*: mean, median and range of percentage escapement, and mean fish weight, by area for silver hake. (Number of tows in each area varies from Table 3 as a result of missing data.)

Area	No. of tows	Percentage escapement			Mean wt (g)
		Mean	Median	Range	
SMGL	10	5.9	5.2	1.6-11.9	135
Emerald Basin	17	5.5	5.3	2.2-14.7	153
LaHave Basin	5	8.8	5.8	3.8-15.1	(173)
Combined	32	6.1	5.4	1.6-15.1	-

Table 5. *Rio Moa:* average catch per hour and percentage catch distribution, by weight and number, in top (T) and bottom (B) codends.

Item	No. of tows	Average duration (hrs)	Silver hake		Other species	
			T	B	T	B
Kg/hr	5	2.2	114	2255	156	59
% by weight	-	-	4.8	95.2	72.6	27.4
% by number	-	-	4.5	95.5	...	...

Table 6. *Alfred Needler*: average catch per hour and percentage catch distribution, by weight and number, in top (T) and bottom (B) codends for five different grate configurations. (Configuration given is bar spacing (mm) and orientation (V-vertical, H-horizontal), grate angle in degrees, and distance rear end of funnel is from base of grate (cm).)

Grate configuration (Bars/Angle/Funnel)	No. of tows	Ave. dur. (hrs)	Silver hake		Other species	
			T	B	T	B
			Average catch per hour (kg)			
40V/48/85	12	1.2	6	256	224	59
40 H/48/85	11	1.0	18	303	33	36
50V/48/85	10	1.0	3	369	139	213
40V/25/85	3	1.0	225	299	53	12
40V/25/42.5	3	1.0	85	177	44	20
			Percentage by weight			
40V/48/85	-	-	2.3	97.7	79.2	20.8
40 H/48/85	-	-	5.4	94.6	47.8	52.2
50V/48/85	-	-	0.9	99.1	39.5	60.5
40V/25/85	-	-	43.0	57.0	81.5	18.5
40V/25/42.5	-	-	32.3	67.7	68.8	31.2
			Percentage by number			
40V/48/85	-	-	1.6	98.4	...	...
40 H/48/85	-	-	3.5	96.5	...	...
50V/48/85	-	-	0.8	99.2	...	...
40V/25/85	-	-	40.7	59.3	...	...
40V/25/42.5	-	-	31.7	68.3	...	...

Table 7. *Alfred Needler*: mean, median and range of percentage escapement, and mean fish weight, by grate configuration for silver hake. (Number of tows by grate configuration varies from Table 6 as a result of missing data.)

Grate configuration (Bars/Angle/ Funnel)	No. of tows	Percentage escapement			Mean wt (g)
		Mean	Median	Range	
40V/48/85	10	2.0	1.9	0-4.3	94
40 H/48/85	11	5.9	5.3	2.7-10.3	91
50V/48/85	10	1.0	0.7	0.3-3.3	111
40V/25/85	3	42.6	43.0	39.1-45.6	134
40V/25/42.5	3	30.8	31.1	23.2-38.2	159

Table 8. Percentage escapement of silver hake when standard 40 mm vertical grate configuration used, by experiment and for experiments combined, and calculated escapement in the commercial silver hake fishery in 1989-93 had this grate been in use.

Experiment	Percentage Escapement	
	weight	number
Cape Verde[1]	5.1	4.2
Rio Moa	4.8	4.5
Alfred Needler	2.3	1.6
Combined[2]	4.8	4.1
Commercial 1989-93		
Observed selection	5.3	4.5
Adjusted selection	5.2	4.5

[1] SMGL and Emerald Basin combined.

[2] Includes two tows in LaHave Basin during *Cape Verde* experiment.

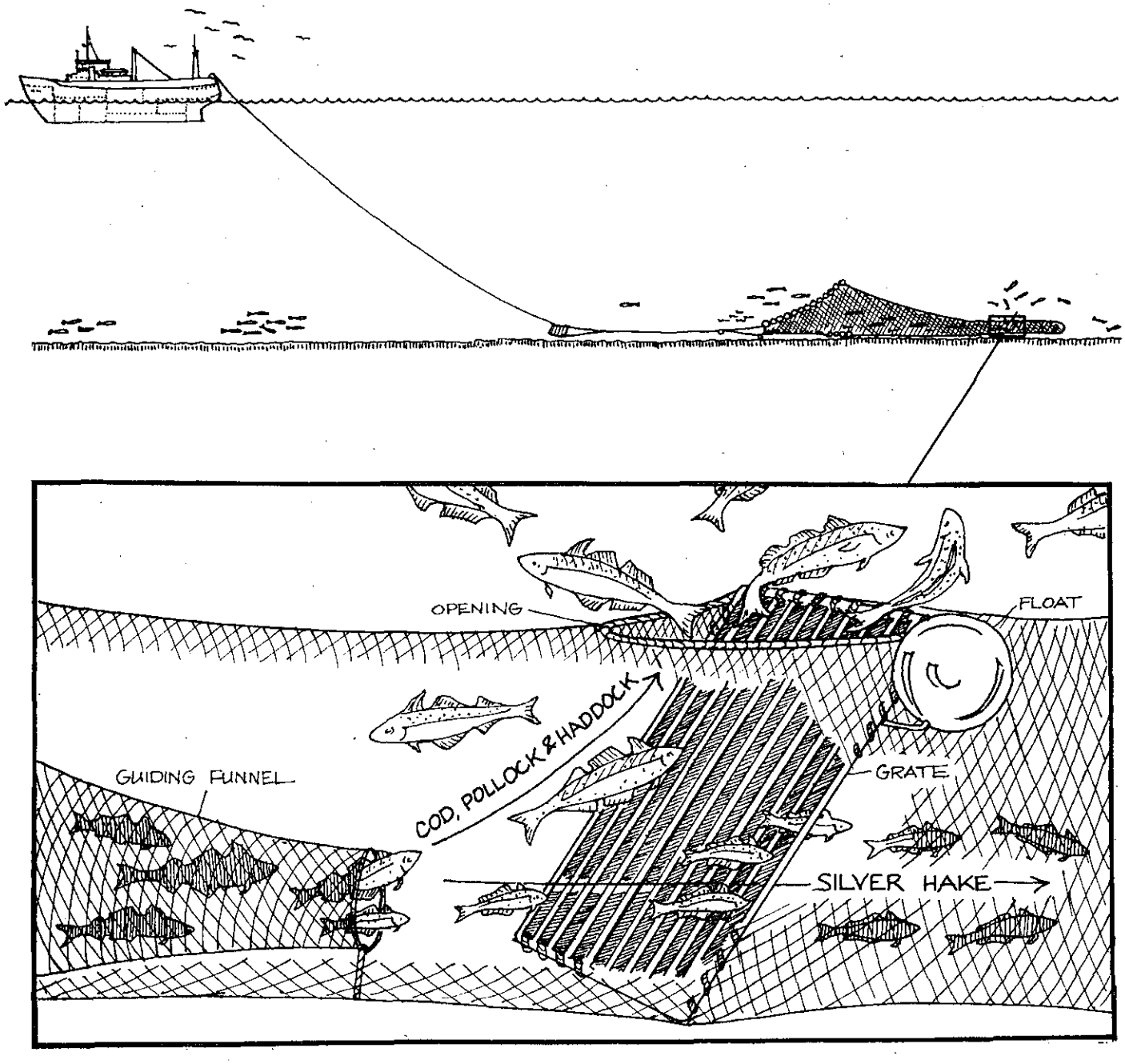

Fig. 1. Diagram illustrating the installation and operation of an otter trawl codend separator grate.

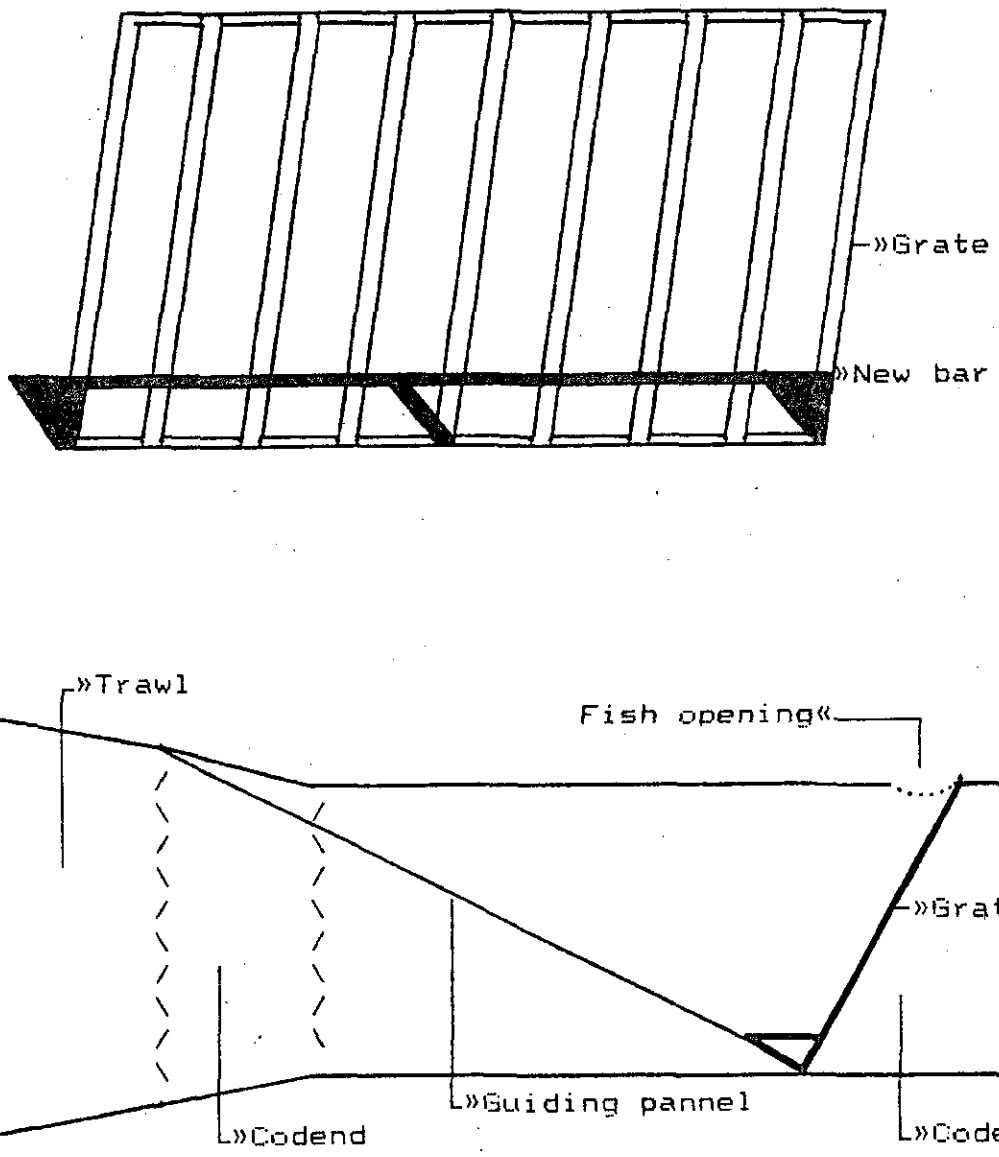

Fig. 2. Diagram illustrating the bar installed in front of the separator grate, and attachment to it of the guiding panel, used during the *Rio Moa* experiment.

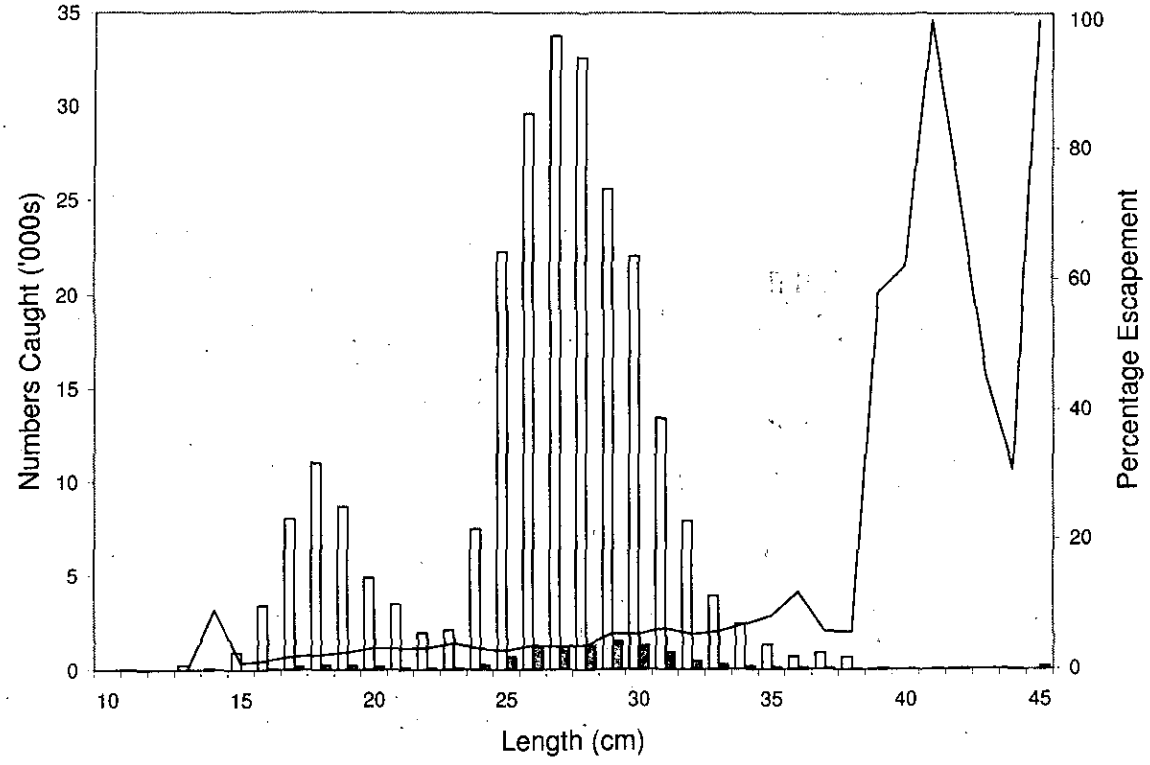

Fig. 3. *Cape Verde* (40mm vertical grate): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line).

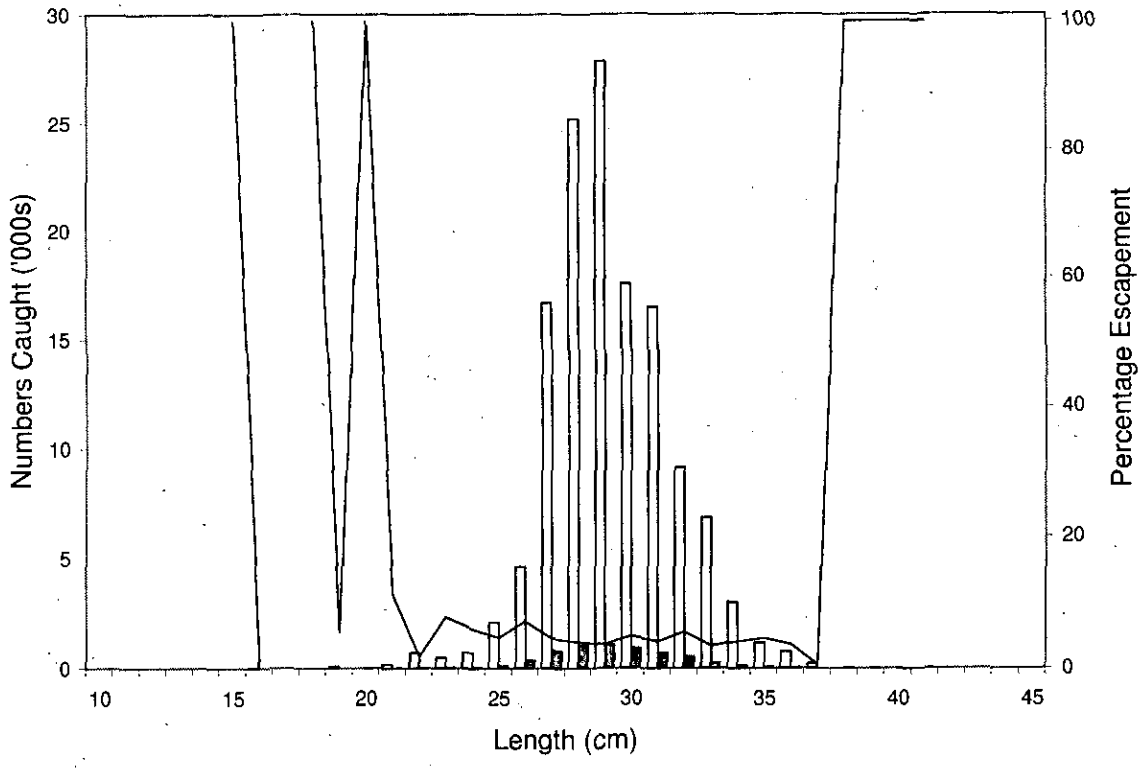

Fig. 4. *Rio Moa* (40mm vertical grate): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line).

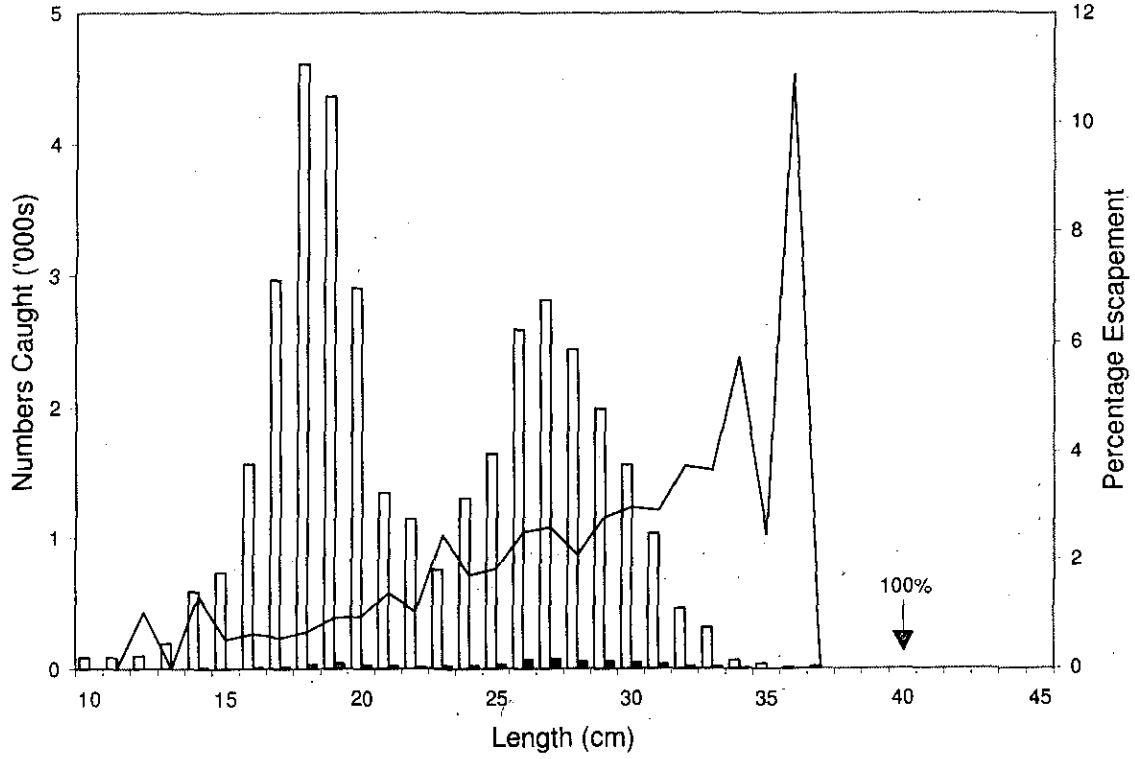

Fig. 5. *Alfred Needler* (40mm vertical grate): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line). (Note percentage escapement scale.)

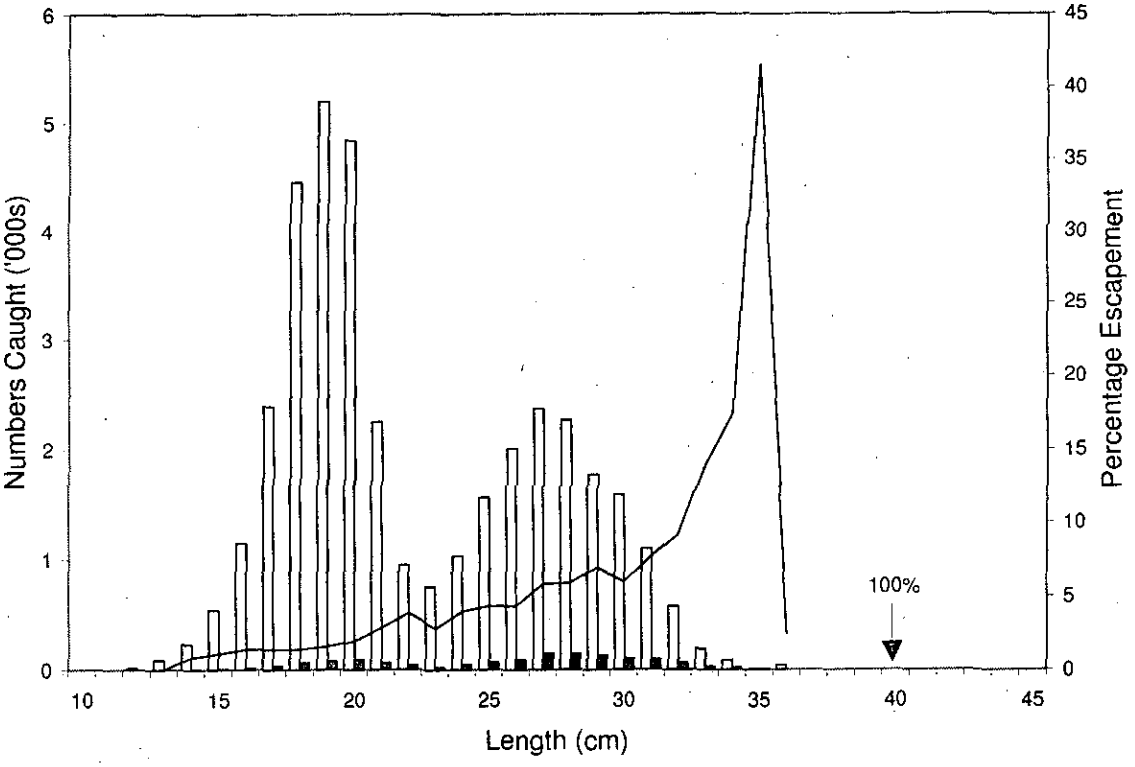

Fig. 6. *Alfred Needler* (40mm horizontal grate): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line). (Note percentage escapement scale.)

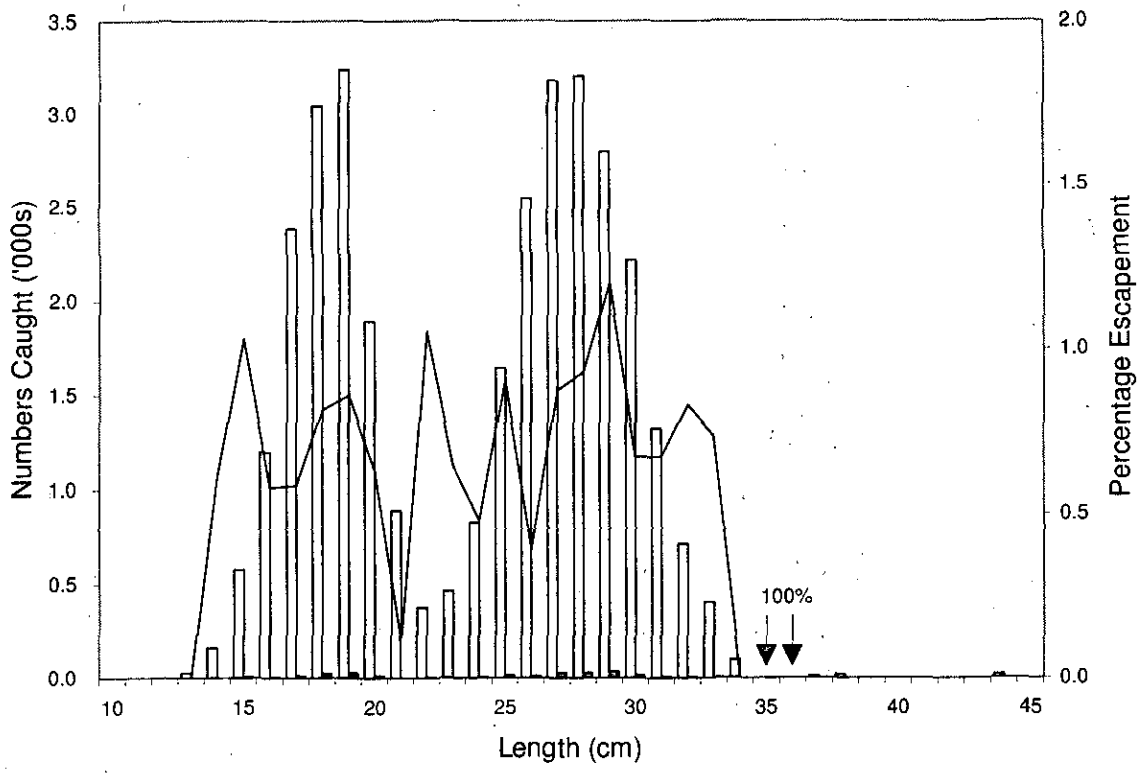

Fig. 7. *Alfred Needler* (50mm vertical grate): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line). (Note percentage escapement scale.)

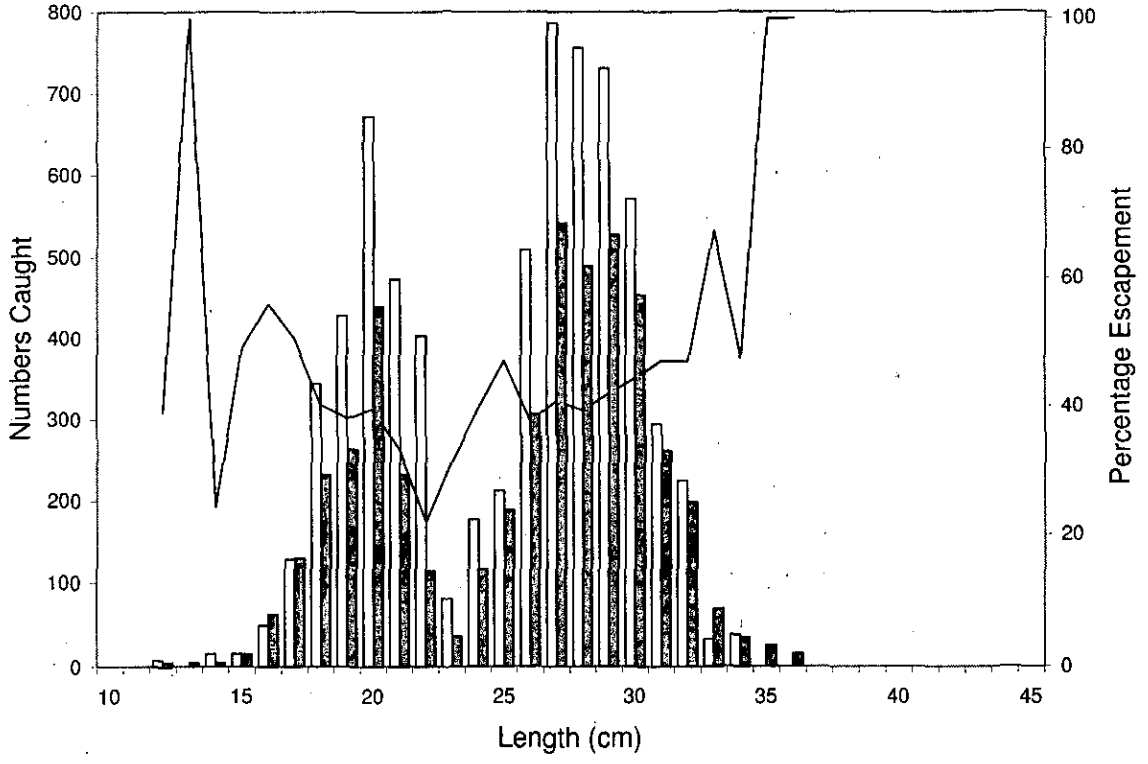

Fig. 8. *Alfred Needler* (40mm vertical grate inserted at 25 degrees): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line).

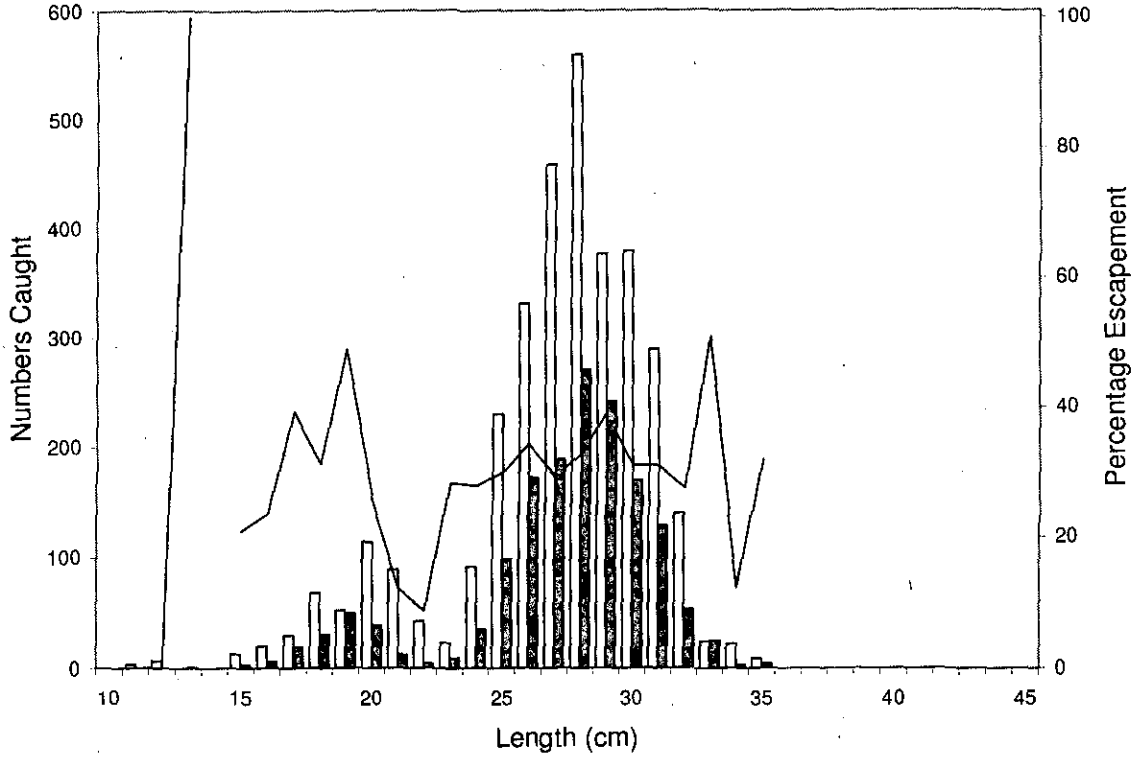

Fig. 9. *Alfred Needler* (40mm vertical grate inserted at 25 degrees and funnel 42.5cm ahead): length compositions of silver hake catches in top (black bars) and bottom (white bars) codends, and estimated escapement at length (line).

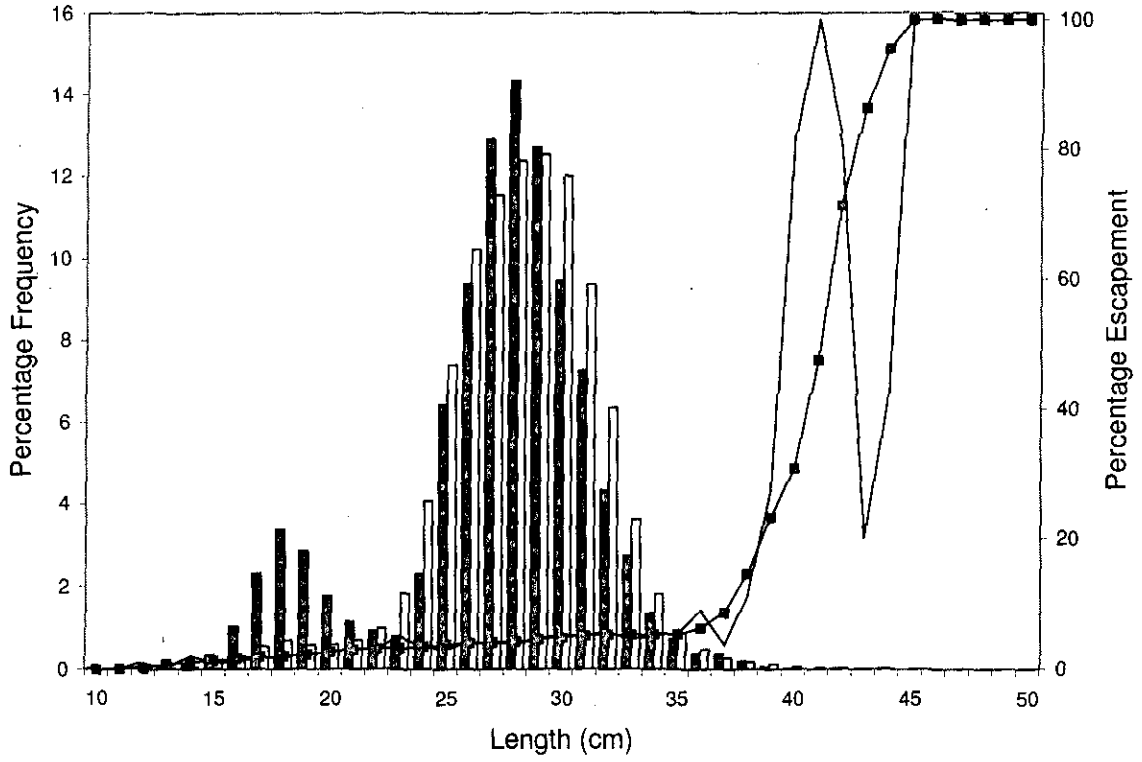

Fig. 10. S*ilver hake*: percentage length compositions of 1989-93 commercial catches (white bars), and combined experimental catches(black bars) when using the 40mm vertical grate, and estimated escapement at length (lines - squares indicate smoothed data).