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Trawl Selectivity and Girth-Length Relationships for Cod in ICNAF Subarea 2

by

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Abstract

In 1962 and 1963 selection experiments on cod were carried out in Subarea 2, using both the covered-codend and the alternate-haul methods. From 5 series of covered-codend hauls, with 50/4 double manila codends of mesh sizes between 98 and 130 mm as measured with a 4 kg gauge, selection factors of 3.39 to 3.57 were obtained, the average being 3.47. An unusually high value of 3.96 was obtained for one series with a 120 mm codend. From 3 series of experiments by the alternate-haul method selection factors of 3.26 to 3.47 were obtained for codend mesh sizes of 95 to 113 mm. The 25-75% selection spans averaged 10.4 cm for the covered-codend series and 9.5 cm for the alternate hauls. The similarity of the selectivity results from the covered-codend series and the alternate hauls indicate that perhaps the much greater effort involved in obtaining adequate results by the alternate-haul method is not worthwhile.

For 2 of the 6 series of covered-codend hauls, codends were reversed about half-way through each series with the result that the 50% retention lengths decreased correspondingly to the decrease in the average size of the meshes in the after part of the codend, thus indicating that most codend escapement probably occurs through the larger meshes normally present aft of the splitting strap.

The relationships between fish length and maximum and opercular girths are described by linear equations. Seasonal differences in maximum girth were greater than in opercular girth, but the differences are not reflected in the selectivity results. Thus selectivity may be more dependent on opercular girth than on maximum girth, since the maximum girth is probably affected by expansion of the air bladder.

Introduction

Since the establishment of the International Commission for the Northwest Atlantic Fisheries much concern has been expressed for the conservation of fish stocks and much study devoted to methods of controlling the devastation of small fish, particularly by trawlers. An accepted method of controlling to some degree the fishing mortality of small fish is by adjusting the size of mesh in the nets so that fish below a certain size may be permitted to escape.

Much experimental work has been carried out in the North Atlantic (both east and west) on the selection of various species of fish by trawls in order to provide adequate bases for the regulation of mesh sizes. An extensive series of experiments (Clark, 1963) with several species of fish and nets of various materials and mesh sizes was carried out in ICNAF Subarea 5 by the Woods Hole Laboratory, U.S. Fish and Wildlife Service. Similar but less extensive experiments have been reported by McCracken (1963) for Subarea 4 and by Templeman (1963) for Subarea 3, but no work of this nature has been reported for Subarea 2. It is the purpose of this report to present the results of selection experiments, as well as girth-length relationships, obtained on 2 recent cruises to the Hamilton Inlet Bank area of Subarea 2. The experiments were carried out by the research trawler A.T. Cameron in August, 1962 and in October, 1963.

Materials and Methods

The Gear Used

The gear consisted basically of the No. 41-5 Yankee trawl. On both cruises a number of covered-codend hauls were made using codends of 3 different mesh sizes in each case, and on the first cruise 3 large-mesh trawls were tested against a standard small-mesh trawl by the method of alternate hauls. All hauls were of 1-hour duration dragging on bottom.

For the covered-codend hauls the trawl consisted of manila twine ranging from single 100/3 (3 ply running at 100 yards per pound) in the wings, square and forward belly section to single 75/4 in the after belly and the lengthening piece (28 feet in length). The mesh size ranged from about 110 mm in the forward parts to about 65-70 mm in the lengthening piece.

The codends used consisted of double 50/4 manila twine. The bottom section of each codend was lined with small-mesh (30 mm) nylon netting and the top section covered with 50 mm courlene netting, the width of which was more than twice the width of the codend. The cover was constructed in such a way that the posterior portion formed a bag or cover "codend" which extended 7-8 feet posteriorly beyond the end of the main codend. The method of attachment provided the greatest ease of handling in that the cover could be emptied independently of the codend.

For the alternate hauls the procedure was to alternate most of the trawl (codend, lengthening piece and about 2/3 of the belly) rather than just the codend as is usual in covered-codend hauls. Except for differences in mesh size the 4 trawls used were of the same general dimensions and for convenience are labelled A, B, C and D. The average mesh sizes (internal, wet) of the various sections of each large-mesh trawl were as follows:

Section	B	C	D
Codend, 50/4 double manila	95	106	113
Length. piece, 50/4 single manila	101	111	118
Belly*, 75/4 single manila	106	112	116
Wings and square 100/3 single manila	110	110	118

* After section of the two belly sections

Fish Measurement and Sampling

Fish lengths were measured from the snout to the mid-fork of the caudal fin (fork length). The measurements were recorded to the nearest centimetre on a measuring board, the first space of which was 1.5 cm and subsequent spaces of 1-cm intervals.

In nearly all cases length measurements were taken from the entire catches of both codend and cover. Actually on 2 occasions only was it necessary to sample the catches and in both cases one-half or more of the catches were measured.

During the process of measuring each catch 20-30 cod were usually taken (not necessarily at random but such that the selection range was adequately covered) for girth measurements. Both opercular and maximum girths were measured to the nearest millimetre using a plastic-coated cloth tape put completely around the fish, firmly, but without constricting the body. For the opercular girth measurement the anterior edge of the tape covered the extreme posterior edge of the operculum. The maximum girths were taken somewhat more posteriorly, the tape usually covering the posterior tips of the pectoral fins.

Mesh Measurements

All mesh measurements obtained on the first selection cruise to the area in 1962 were made with the Westhoff (1959 model) longitudinal pressure gauge, while those in 1963 were made with the new ICES gauge. The gauges were used on both cruises at a spring pressure of about 4 kg, but on the first cruise the row of meshes was also measured with a pressure of 12 pounds (5.5 kg) for comparison. All mesh measurements are internal wet measurements.

For the alternate haul data mesh measurements were taken in a longitudinal row along the upper surface of the trawl (several meshes from the side lacings) from codend to belly (every consecutive mesh in the codend, every third mesh in the lengthening piece and every second mesh in the belly). Periodically a few meshes in the wings and square were also measured. For the covered-codend hauls mesh measurements were taken in a longitudinal row of consecutive meshes along the top side of the codend only. All mesh measurements were recorded in millimetres and each set of codend measurements were taken along a different row of meshes, except for those involved in the 4 kg and 5.5 kg comparisons.

Except where noted otherwise, all selection factors are computed from the codend mesh measurements made at a pressure of 4 kg.

Analysis of the Data

The covered-codend catch frequencies were combined and analyzed in the usual way by taking the ratio of the number in the codend to total number at each centimetre length group. To facilitate the drawing of the selection curves the ratios were smoothed by moving average of threes. The 25, 50 and 75% retention lengths were estimated from the fitted-by-eye curves.

For the alternate haul data the catch length frequencies were combined, and for each codend tested the ratio of the number in the large-mesh to the number in the standard small-mesh trawl was computed for each fish length interval. These ratios were also smoothed by threes and plotted on graph paper. The upper asymptotes of these curves were obtained by inspection and the 50% retention lengths taken as one-half the vertical height of the selection ogives.

The selection factors were obtained by taking the ratio of the 50% retention length to the size of mesh involved, both values expressed in millimetres.

The girth measurements were averaged after grouping into 1-cm fish length intervals and straight lines were fitted by the method of least squares.

Results

Size Selection from Covered-Codend Hauls

Codends of 3 different mesh sizes were used on each of the 1962 and 1963 cruises. Data pertaining to the mesh sizes, catches and selectivity are given in Table 1 and illustrated in Fig. 1. All curves approximate symmetrical sigmoids, except for some slight skewness in the part of each curve below the 25% retention length. This has been found by most workers in selectivity studies and is probably due to differential behaviour in the net or to the decreased ability of small fish to escape through the meshes (Clark, 1963). For 5 of the 6 series of covered-codend experiments with

(Take in Fig. 1 and Table 1 here)

codends ranging in mesh size from 98 to 130 mm selection factors of 3.39 to 3.57 were obtained, the average being 3.47. For Series III, however, a somewhat higher selection factor of 3.96 was obtained with the 120 mm codend.

The size compositions of the cod catches for the 6 series of tests are shown in Fig. 2. During the 1962 cruise most of the cod caught were between 22 and 55 cm, and the upper part of the selection curves extended well beyond the second mode of the catch frequencies. During the 1963 cruise the catches consisted of considerably larger cod, and the upper asymptote of the selection curves coincided approximately with the second mode of the size distributions. Despite the great difference in size composition between the 1962 and 1963 series of experiments, the selection factors for the 1962 series (except the one value of 3.96) are essentially the same as those for the 1963 series. Although the lowest selection factor of 3.39 was obtained from the data of Series II, which had relatively more small fish in the first modal group, this argument cannot be used to explain the high selection factor of 3.96 for Series III.

(Take in Fig. 2 here)

The 25-75% selection spans (unadjusted) are indicated in Fig. 1 and given in the last columns of Table 1. The similarity of these values for all 6 series of experiments is remarkable. The average selection span is 10.4 cm. Clark, McCracken and Templeman (1958) in their summary of gear selection information for the ICNAF Area observe that the selection span for data available to them was quite variable (6 to 12 cm from 18 experiments with manila codends), and they considered a value of 10 cm as most representative.

All of the results given above are based on the average mesh size of the whole codend, that is, the average mesh size of a single longitudinal row of meshes taken periodically throughout each series of hauls. However, during the 1963 cruise (Series IV-VI) it was noted from the first drag or two with each codend that the meshes in the after part, especially aft of the splitting strap, were somewhat larger than those farther forward. About half-way through each of Series V and VI the codends were reversed so that the end which was previously forward now formed the bag posteriorly. The results of the experiments are given in Table 2 and the curves plotted in Fig. 3.

(Take in Fig. 3 and Table 2 here)

Although in each case the average mesh size of the whole codend was essentially the same before and after reversal of the codend, the 50% retention lengths decreased in each case corresponding to the decrease in mesh size of the meshes in the after part of the codend. The selection factor decreased from 3.60 to 3.43 for the Series V codend and from 3.58 to 3.34 for the codend of Series VI. If the selection factors are based on the average size of the meshes in the after $\frac{1}{4}$ of the codend only (about that part of the codend aft of the splitting strap), the selection factors for Series V are very similar, but the order of magnitude of those for Series VI is reversed. These results are consistent with similar studies reported by Clark (1963) who observes that most escapement probably takes place in the after section of the codend.

Size Selection from Alternate Hauls

During the 1962 cruise some results were obtained by alternating a small-mesh trawl with 3 other trawls of larger mesh sizes. Details of the mesh sizes, average catches and selectivity information are given in Table 3 and the curves are shown in Fig. 4. The catch frequencies of Trawl B are compared with the first 8 catches of the small-mesh trawl (A) and those of Trawl D with the last 8 catches of Trawl A. Trawl C was alternated during the entire series of drags and is compared with all the drags of Trawl A.

(Take in Fig. 4 and Table 3 here)

While equal amounts of fishing effort are involved in the large mesh/small mesh comparisons, the upper asymptotes of the curves as estimated by inspection do not coincide with a large- to small-mesh ratio of 1.0 for the larger sizes of cod. Consequently, the 50% retention lengths were estimated as one-half the vertical height of the selection curves as shown. The selection factors based on these 50% retention lengths and the average mesh sizes of the corresponding codends agree remarkably well with those obtained from the series of covered hauls. The average selection span of 9.5 cm is about 1 cm lower than the average for the covered hauls.

Mesh Size Comparison with 4 Kg and 5.5 Kg Pressures

During the August 1962 cruise the codend meshes were measured with a gauge adjusted to exert a pressure of 4 kg on the mesh. Another set of mesh measurements were taken along the same row of meshes using a gauge adjusted to exert a pressure of 12 pounds (5.5 kg), so that a conversion factor would be available to apply to the results of previous selection studies in which the mesh measurements were made with gauges exerting a pressure of 12 pounds.

As shown in Fig. 5 the results indicate that the mesh size obtained with a 5.5 kg gauge is equal to 1.04 times the mesh size obtained with a 4 kg gauge. Thus the average selection factor of 3.47 (excluding the value of 3.96 for Series III) for the covered-codend experiments based on the 4 kg gauge becomes 3.33 in terms of the 12 lb (5.5 kg) gauge.

(Take in Fig. 5 here)

Girth-Length Relationships for Cod and their Application to Mesh Selection

During the course of sampling, both opercular and maximum girths were taken from 1503 cod during the first selection cruise in August 1962 and from 589 cod during the cruise in October 1963. In view of the differences involved the results are plotted separately for the 2 cruises in Fig. 6. The greater differences between the maximum and opercular girths for the October 1963 cruise are attributed to heavy feeding on capelin, whereas in August 1962 most of the cod were feeding on ctenophores and amphipods.

Taking the mesh perimeter size as being twice the stretched mesh-size measurement, the relationships between the girth of the fish at the 50% retention length and the internal lumen perimeter of the mesh are given in Table 4. The values for girth at 50% retention length were computed from the appropriate equations given in Fig. 6. For Series I and II of the August 1962 cruise the opercular and maximum girths at the 50% retention length, expressed as a percentage of the mesh perimeter, averaged 82.3 and 86.4% respectively. For the October 1963 cruise the corresponding values are 83.1 and 90.3%. No explanation can be given for the unusually high values of Series III.

Discussion and Conclusions

From the covered-codend experiments on cod in Subarea 2 reported in the previous section selection factors, based on codend mesh sizes obtained with a gauge exerting a pressure of 4 kg, varied between 3.39 and 3.57 (excluding an unusually high value of 3.96 for one of the 6 series of experiments), the average selection factor being 3.47. In terms of a gauge exerting a pressure of 12 pounds (5.5 kg) the selection factor is 3.33. This value is the same as obtained by McCracken (1963) for Subarea 4 cod. From 8 experiments with manila codends of similar twine sizes and with mesh sizes between 109 and 129 mm his selection factors varied between 3.10 and 3.50, the average being 3.34. The average selection span (distance between the 25 and 75% retention lengths) for McCracken's data was 10.5 cm, a value similar to ours. For Grand Bank cod, using manila codends of 102 and 112 mm, Templeman (1963) obtained only slightly lower selection factors of 3.27 and 3.17 respectively. Both McCracken's and Templeman's results are based on the use of the wedge-type vertical gauge with pressures of 12-15 pounds (5.5-6.8 kg).

Some results were presented above which illustrate, at least indirectly, that the after part of the top surface is the area of greatest escapement from the codend. These results agree with Clark's (1963) observation from selection studies on haddock. Beverton (1963) carried out experiments using a compartmented cover over the codend and found that for 5 species of fish, including both demersal and pelagic species (whiting, haddock, dab, horse-mackerel, mackerel), about 90% of each species escaped through the after 1/3 of the codend. In view of this evidence, selection factors might be more meaningful if they were expressed in terms of the average mesh size of that part of the codend aft of the splitting strap, where the meshes are usually longer than those farther forward.

In view of the similarity of the selection factors from the alternate hauls and the covered-codend hauls, one wonders whether alternate haul experiments are worth the much greater effort necessary to obtain adequate results. Hoder and May (in press) from a number of alternate-haul

experiments on Grand Bank haddock found that the selection factors obtained, even when catches were very large, were similar to those reported by Clark (1963) and McCracken (1963) for haddock in Subareas 5 and 4 respectively, ~~but~~ using the covered-codend method.

In the present data the maximum girths are shown to differ more widely than the opercular girths between the two periods, but these differences are not reflected as differences in selectivity. Consequently selectivity may be more dependent on the opercular girth than on maximum girth. Margetts (1957) carried out an analogous procedure in measuring the maximum and constricted girths, and considered constricted girths to be of greater practical value, since the maximum girth measurements were affected by expansion of the air bladders and since fish will normally exert some force in swimming through the meshes.

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Table 1. Results of covered-codend selection experiments, with codends of various mesh sizes, carried out in the Hamilton Inlet Bank region of Subarea 2.

Cruise	August 1962			October 1963			
Codend Series	I	II	III	IV	V	VI	Average
Av. mesh size of codend (mm)	98	113	120	109	120	130	
No. of 1-hour hauls	12	4	8	9	12	8	
Av. number caught - codend	362	480	210	685	447	283	
- codend + cover	580	1067	855	815	667	507	
Av. weight caught (kg) - codend	305	430	240	1075	810	475	
- codend + cover	375	620	560	1140	930	615	
50% retention length (cm)	35.0	38.3	47.6	37.2	42.2	45.0	
Selection factor	3.57	3.39	3.96	3.41	3.52	3.46	3.47
25% retention length (cm)	30.1	32.7	42.3	31.9	37.0	39.4	
75% " " (")	39.7	43.7	52.8	41.9	47.4	50.1	
Unadjusted selection span (cm)	9.6	11.0	10.5	10.0	10.4	10.7	10.4

Table 2. Results of covered-codend selection experiments in Subarea 2 with 120 mm and 130 mm codends before and after reversal.

	Codend V (120 mm)		Codend VI (130 mm)	
	Before reversing	After reversing	Before reversing	After reversing
Number of 1-hour hauls	7	5	4	4
Av. codend + cover catch - No.	839	428	493	520
- kg.	2625	1230	1250	1450
Av. mesh size for whole codend (mm)	119	121	130	130
Mesh size of last ¼ of codend only (mm)	124	119	139	123
50% retention length (cm)	42.8	41.5	46.5	43.4
Selection factor based on mesh size of whole codend	3.60	3.43	3.58	3.34
Selection factor based on last ¼ of codend meshes	3.45	3.49	3.35	3.53

Table 3. Results of selection experiments in Subarea 2 from alternate hauls with trawls of 3 different mesh sizes.

Cruise	August 1962			
Trawl	A	B	C	D
Codend mesh size (mm)	55	95	106	113
No. of 1-hour hauls	16	8	16	8
Av. number caught	761	614	367	363
Av. weight caught (kg)	520	465	345	330
Estimated 50% retention length (cm)	-	31.0	36.8	38.0
Selection factor	-	3.26	3.47	3.45
Selection span (cm)	-	10.6	8.8	9.0

Table 4. Relationship between girth and trawl selectivity for cod of Subarea 2.

Cruise		August 1962			October 1963		
Codend Series		I	II	III	IV	V	VI
Mesh size of codend (mm)		98	113	120	109	120	130
Diameter of mesh (mm)		196	226	240	218	240	260
50% retention length (cm)		35.0	38.3	47.6	37.2	42.2	45.0
Girth at 50% retention (mm)	Op.	165	181	224	177	203	217
	Max.	172	192	234	192	220	236
Percentage of mesh lumen occupied by 50% retention length fish	Op.	84.2	80.1	93.3*	81.2	84.6	83.5
	Max.	87.8	85.0	97.5*	88.1	91.7	90.8

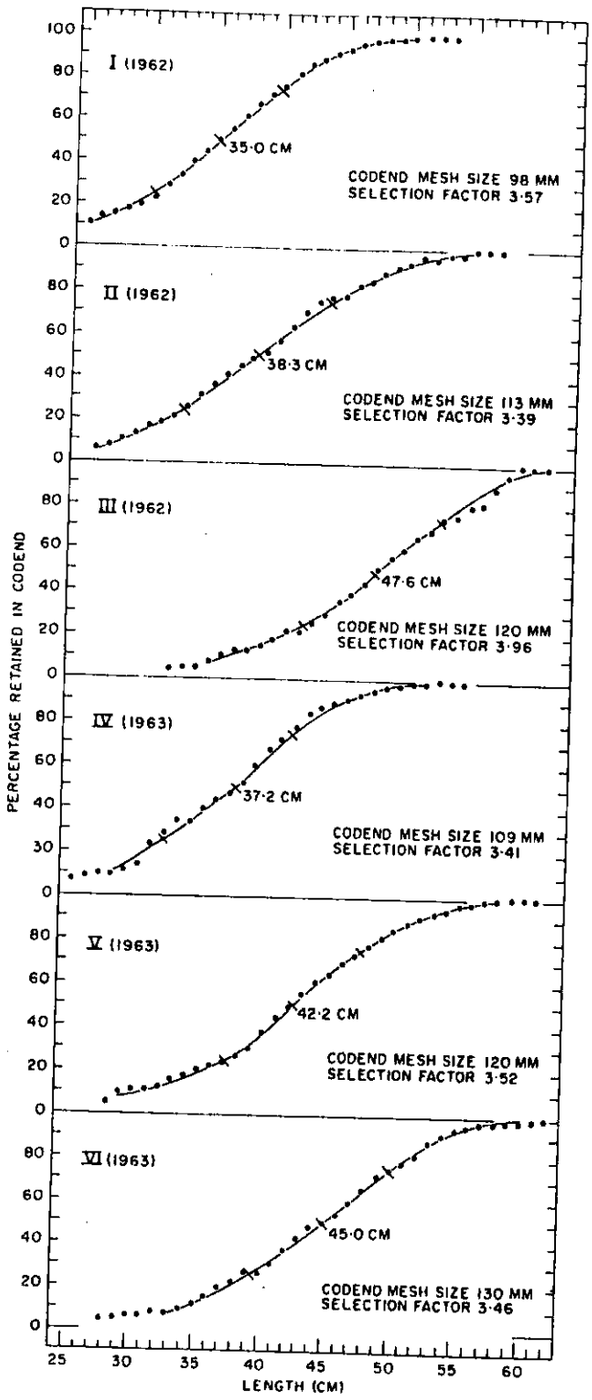

Fig. 1. Selection curves for cod of Subarea 2 from covered-haul experiments in 1962 and 1963.

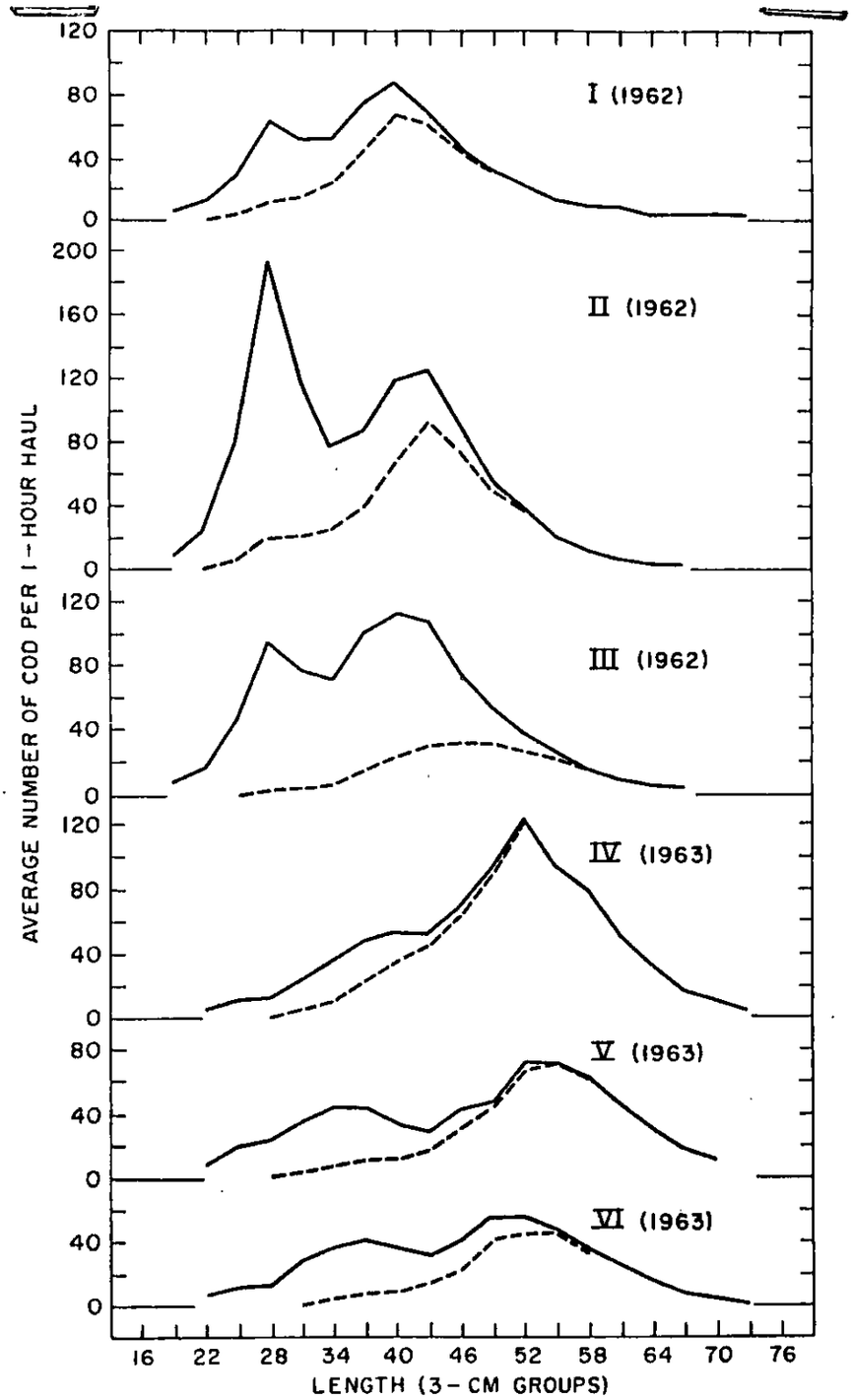

Fig. 2. Size composition of cod catches for the 6 series of selection experiments with covered codend carried out in Subarea 2 (the broken lines represent codend frequencies).

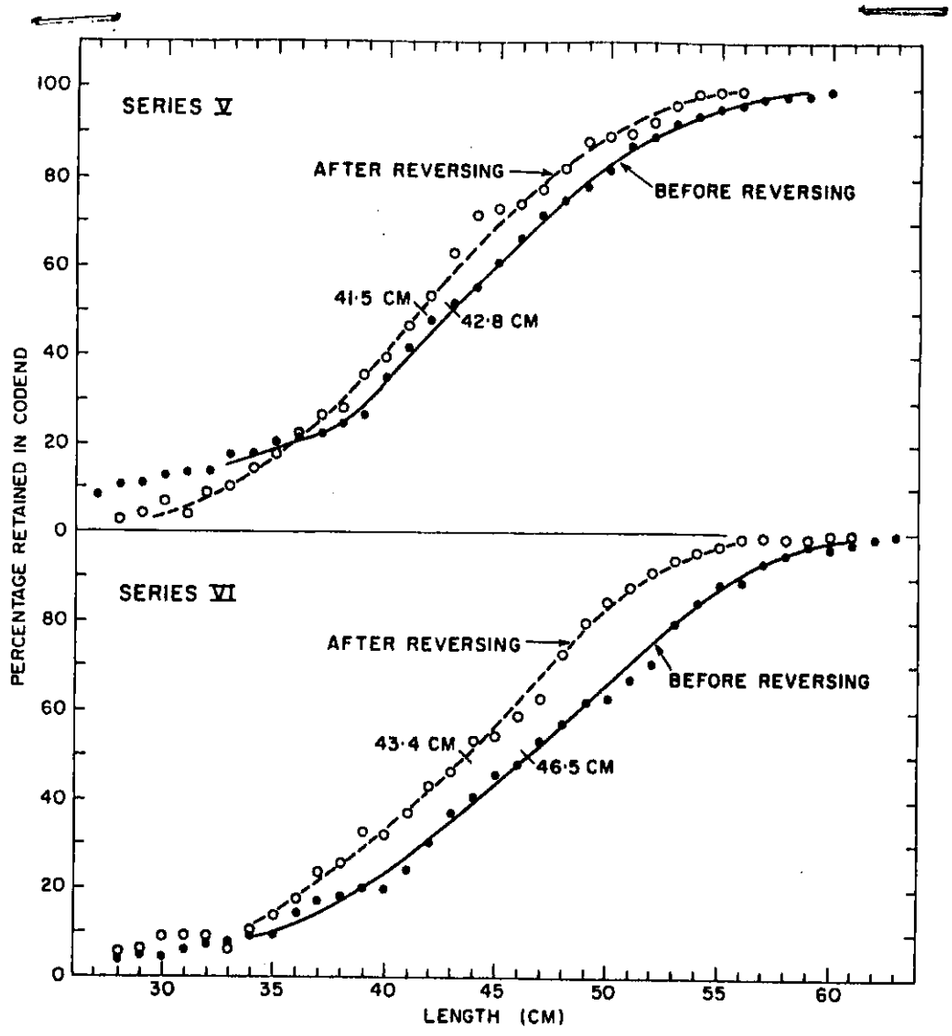

Fig. 3. Selection curves for cod before and after reversing the 120 mm (above) and 130 mm (below) codends from the covered-haul experiments in 1963.

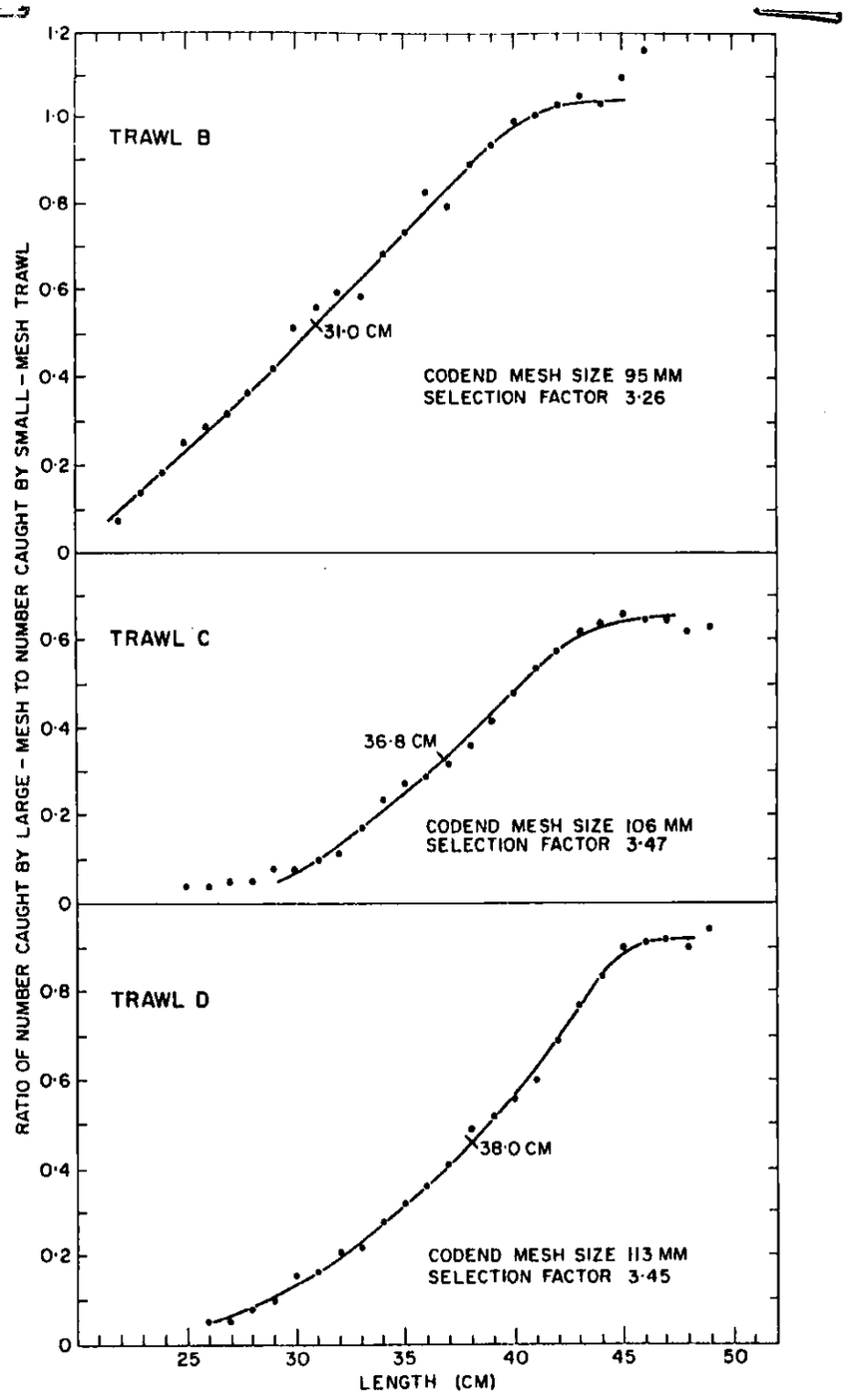

Fig. 4. Selection curves for cod of Subarea 2 from the alternate-haul experiments in 1962.

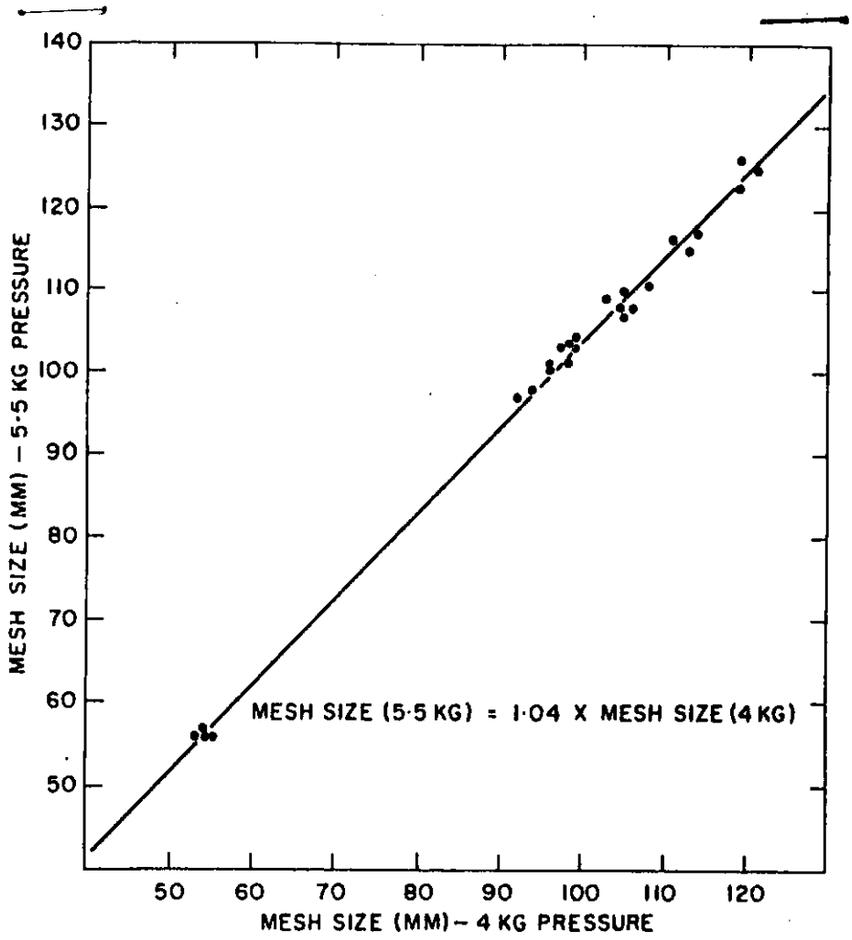

Fig. 5. Comparison of average internal mesh sizes of codends using gauges adjusted to exert pressures of 4 kg and 12 lb (5.5 kg).

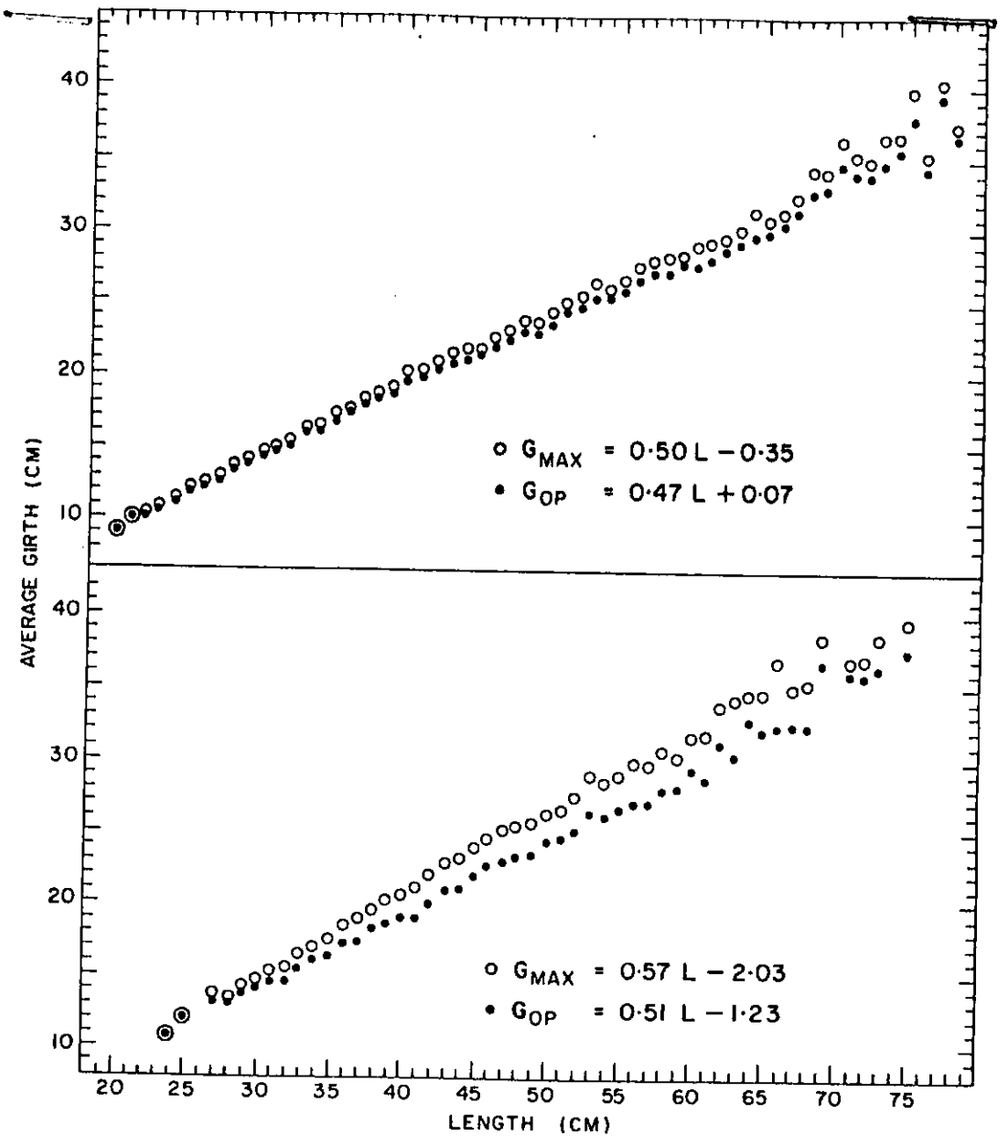

Fig. 6. Relationships between opercular and maximum girths and length of cod taken during the 1962 (above) and 1963 selection experiments in Subarea 2.