International Commission for the Northwest Atlantic Fisheries

Serial No. 5228
(D.c. 9)

ICNAF Res.Doc. 78/VI/60

ANNUAL MEETING - JUNE 1978

The Selection of Silver Hake (*Merluccius bilinearis*) on the Scotian Shelf
(A Final Report on Two Joint Cruises in 1977)

by

D. Clay
Department of Environment
Fisheries and Marine Service
Marine Fish Division
Bedford Institute of Oceanography
Dartmouth, N.S., Canada

Publ. in ICNAF Res. Bull. No. 14: 51-66

Introduction

Studies of the life history of Silver hake (*Merluccius bilinearis*) show that it grows rapidly during the first year of life (Hunt, 1977; Anon, 1976a). Spawning occurs between April/May and October/November with the peak occurring in June/July (Sauskan, 1964; Sarnitts and Sauskan, 1966). The larvae hatch from pelagic eggs and do not move to the bottom until they are approximately 4 cm in length (Nichy, 1967). Approximately, 10% of the male population is mature in the first year (20 cm) and 98% in the second year (Doubleday and Hunt, 1976) while the females are 3% and 80% mature in their first and second years respectively.

During the period March to October a heavy hake fishery, made up primarily of Soviet stern trawlers (1800+ tons), fishes the Scotian Shelf. In the last few years Cuban vessels have also entered the commercial hake fishery, and in addition, some exploratory fishing by Canadian companies has been carried out. Historically the Soviet fishing fleet used 40 mm mesh codends (Anon, 1976c). The modal length of the commercial catch of Silver hake, according to Soviet statistics taken from the ICNAF Sampling Yearbooks, is 28-30 cm (ICNAF, 1962-1972). This modal length group represents fish of approximately 2 years of age. The small mesh nets (40 mm) used prior to 1977 would have retained most fish over 15 cm (1+ years). Because the numbers of 2 and 3 year olds are greater than the numbers of 1 year olds (Hunt and Doubleday, 1976) there must be some selection in the fishery as a result of availability of juveniles.

Legislation of December, 1976 (Anon, 1976b) set a minimum cod-end mesh size of 60 mm for silver hake fishing. The aim of the regulation was to increase the maximum sustainable yield of the silver hake fishery, and reduce, if possible, any undesirable by-catch of juveniles of other commercially important species.

The regulation was based on experimental data from Subarea 5 using net materials different from those currently used in the Subarea 4 silver hake fishery, creating uncertainties as to whether the regulation mesh size was the most appropriate to achieve the objectives. Canada and Cuba and Canada and the USSR undertook mesh selection studies in 1977 to establish the selection characteristics of Kapron, a polyamide synthetic material used extensively by Soviet and Cuban fishing fleets, and hence the primary material used to fish silver hake Subarea 4.

Methods

A summary of the vessels and gears used is presented in Tables 1 and 2. Table 3 gives a comparison of the theoretical (commercial) mesh size and the average measured mesh sizes for both the cover and codends used in the Canada-Russia study while Table 2 gives what measurements were taken on the Canada-Cuba study. Throughout this report the measurements used will be the commercial size measurement.

All lengths taken during both the Canada-Cuba study and the Canada-USSR study were total lengths, measured to the closest 1 cm. All weights are expressed in kilograms to the nearest 0.1 kg. The data collected during these series of covered codend mesh selection trials were analysed according to Pope et al. (1964). More recent reviews of analysis of selection data by Pope et al. (1975) and Holden (1971) have also been consulted. The above reports conclude that fitting the selection ogive by maximum likelihood to be the most accurate method of deriving the curve. The tedious calculations associated with this method are not often warranted, and it has been found that fitting the curve by eye gives unbiased estimates (Pope et al. 1975) which are very close (often within 1%) to that obtained by the maximum likelihood method (Holden, 1971). The 50% retention level was calculated by a moving average of 3 points. This gives unbiased estimates of the 50% point but should not be used for other points (Pope et al. 1964). The 50% retention point was also found by a linear regression (by method of least squares) carried out on data between the 25% and 75% retention levels as a comparison of technique.

In order to obtain a "commercial average" the satisfactory hauls from one area and one codend mesh size were combined to produce a single selection ogive. To estimate the variability of the data, the 50% retention point of each satisfactory haul was calculated and the mean and standard deviation of these hauls were calculated (ICES, 1964).

On the Soviet vessel, R/V Foton, the topside cover was fitted to the codend in a manner similiar to ICES specification (ICES, 1964). The general construction and dimensions of this gear are shown in Figure 2. On the Cuban vessel, R/V Isla de la Juventud, exact details of the attachment of the cover are not available in the cruise reports although the cover may have been attached very closely to the codend. More discussion on this problem will be found in the Results and Discussion section of this paper.

The sizes of the codend meshes were measured with an ICNAF gauge at 4 kg pressure. During the Canada-USSR study three series of measurements were taken on 10 random meshes for each mesh size. During the Canada-Cuba study fewer measurements were taken. All of these data are presented in Tables 2 and 3.

To act as a check on the calculated selection, a series of 93 length - girth measurements were taken. These were collected from a stratified sample of fish between the lengths of 15 and 57 cm. The unconstricted maximum girth was measured by a loop of synthetic twine.

The areas of study for the Canada-Cuba survey were determined by a searching program to find silver hake concentration. In this study the percent make up of silver hake ranged from 9% in two parts of the study to 67% in the third part. To enable more fishing time and less steaming time for the Canada-Russia study , the author picked 6 likely areas of silver hake concentrations. Three of these were over 150 m and could not be fished. It was agreed fishing would continue, whatever the species make up, in order to provide as large a number of individual hauls. The percent make up of silver hake using this method ranged from over 60% in area 4 to 30% in area 2. Soviet scientists wished to carry out a feeding survey on Sable Island Bank and thus one additional area was studied. Although the percentage of hake was very low (9%) the number of tows and thus time spent was not high.

Results and Discussion

The major purpose of these cruises was to obtain selectivity data on the silver hake. Therefore, length and girth measurements were collected from a stratified sample of fish between the lengths 15-57 cm. The resulting relationship was:-

$$\text{Girth (cm)} = .48\ (\text{TLcm}) - 1.99,\ (r^2 = .97,\ n = 93)$$

which is shown in Figure 3 and is nearly identical to the one calculated by Hennemuth (1964) for Silver hake in ICNAF area 5. Margetts (1954, 1957) showed how girth measurements can provide a preliminary estimate of selectivity and a means of validating the selectivity results found in such studies.

i) Canada-Cuba Study

A detailed analysis of the data collected during this study was presented in an earlier report (Clay, 1977) and will only be summarized here. Figure 4 shows the selection ogives for the three studied mesh sizes and Table 4 gives pertinent results. Due to an acute lack of data from this study, no attempt was made to calculate variation in the data or any effect on the 50% retention point caused by different sizes of catch. Both Cuban and Canadian scientific participants in the cruise consider that there was a masking effect of the cover, the present analysis made no attempt to study such an estimate. Pope et al. (1975) reported that between haul variation was normally very large and it was thus advisable to make as many hauls as possible in the experimental area. Gulland (1964) in a detailed study of such variation, found the variation was mainly due to "a real difference between sets of hauls", caused either by the fish (e.g. feeding) or by the gear (e.g. towing speed).

The mean selection factor found in this experiment was 3.6. This is between the 3.1 average recorded by Clarke (1963) and the 4.1 obtained by Gulland (1956) for past studies on Silver hake using codends made of cotton, manila, and nylon. The selection range generally tends to increase as the mesh size increases (Clarke, 1954); Jensen and Hennemuth, 1966). In this study the reverse was found to hold i.e. the selection range decreased as mesh size increased. Clay (1977) suggested, at that time, that this could be due to variation in netting material. Boerema (1956) has shown great differences in selection between various materials and kapron is known to have an elongation factor almost 50% greater than nylon (Holden, 1971).

As pointed out in the Methods section of this paper, some possible problems with the attachment of the cover are suspected. If the cover is too closely attached it is conceivable that the escape of large fish (i.e. fish at or over the 50% retention length) would be inhibited. This would depress the 50% retention point with such an effect being mesh size increases, i.e. the size of ... progressively greater as the mesh size and thus the size of escaping fish increases. Figure 5 shows both the length of fish at the 50% retention point and the length of fish whose girth equals the circumference of the mesh size plotted against the mesh size. This latter measurement (i.e. girth) can be taken as a crude approximation of the 50% point for most species of fish. This figure indicates the 50% retention point found during the Canada-Cuba study was depressed by some factor throughout the experiment. The most probable factor depressing the 50% retention point and the selection range was probably the incorrect attachment of the cover to the codend.

ii) Canada-Russia Study

During the more extensive Canada-Russia study, greater amounts of data were collected than on the earlier Canada-Cuba cruise. It is assumed that these latest data will provide more realistic commercial averages for mesh selection estimates. The first analyses attempted on these data were to find the 50% retention point, selection range and selection factor for each mesh size. These results are presented in Table 4. The selection factor is within the historical bounds for hake (Gulland, 1956; Clarke, 1963) as are those derived from the Canada-Cuba study. The selection ogives are presented in Figure 6. (Appendix I gives numerical selection ogives for the hake based on total length and the 1977 selection at age values. Three methods were used to calculate the selection at age and significant differences were observed. It is felt the means of fishing a population and recording the results is the best technique.

As mentioned earlier, historical selection experiments (Clarke, 1954 and 1963; Gulland, 1956; Bohl et al. 1971) have tended to find an increasing selection range with greater codend mesh size. This was not found for the Canada-Cuba Study (Clay, 1977) but was observed for the Canada-Russia data (Table 4).

Where reliable data were collected, an attempt has been made to plot the selection factor against the weight of the total catch of individual 60 mm and 70 mm hauls. These individual 50% retention lengths and selection factors are shown in Table 5 and plots are drawn up on Figure 7. The scatter is very wide and a slight positive correction was found. This is not as expected because such species as haddock, cod (Beverton, 1964; Clarke, 1963b; Hodder and May, 1964) and the Cape hake (Bohl et al., 1971) show much better correlations that are all negative. The effect of an increase in the weight of the catch on the selection factor of the Cape hake (ibid) was a decrease of 0.18 per metric tons while in the present study it was found to increase the selection factor by over 1.0 per metric ton increase on the catch. As this is not feasible, no attempt was made to extrapolate to commercial sized catches. The decrease in selection factor for other species is reported to range from 0.05 per metric ton in the haddock to 0.3 for a change in catch from 10-15 kg in the dab and plaice (Bohl, 1964). There is no simple reason for the above discrepancy, one probable reason for this anomaly is the small range in size of catch and the large variation in the data.

An initial overview of the selection factor for Silver hake from the current studies would indicate that selection of Silver hake is different from the European or Cape hakes. However, two problems that may alter such an assumption, involved the cover material and cover mesh size. ICES (1964) suggested that the cover material should be made of a buoyant material such as polyethylene (e.g. Courlene). In both of the studies under investigation, non floating kapron covers were used. Another possible source of error was the size of cover used. ICES (ibid) again recommended the cover mesh size be no smaller than 1/3 to 1/2 of the codend mesh size. As the Canada-Cuba study used 20 mm mesh covers and the Canada-Russia study used 30 mm mesh covers through all phases of the investigations, the 90 mm and 120 mm nets of the two studies will have definite masking effects, perhaps serious ones. Masking is an effect described by Davis (1934) as an "elusive factor" of the "flow" effect of the cover. Masking tends to reduce the flow of water through the meshes and thus reduce the 50% retention point which results in a decrease in the selection factor. Table 4 indicates how the selection factor in both studies decreases as the codend mesh size increaes (e.g. 4.4 - 2.9 and 3.8 - 3.4). Thus if we take the selection factor of the codend with the least effect of masking by the cover (i.e. 40 mm for the Canada-Cuba study, and 60 mm for the Canada-Russia study) the mean selection factor is 4.1, a value that allows us to consider the fact that Silver hake will have essentially the same selection characteristics as the European and Cape hakes. Such an assumption is further borne out by the length-girth relationships for the three hakes. These are presented as an enlarged version of the Table presented by Bohl et al. (1971) - Table 6. It can be seen from this Table that the general shape (fatness) of these fish is very similiar (within 3%) and is probably the same within the bounds of variation caused by feeding and sexual maturity. The 50% retention points calculated from the Canada-Russia mesh selection study bear a reasonably close relationship to the points calculated from the length - girth measurements as described earlier (Figure 5).

The selection factor of 4.0 has been accepted as a provisional working figure for the European hake *(M. merluccius)* for cotton and hemp trawls (N.N., 1957). Bohl et al. (ibid) found similar selection factors for the Cape hake and assumed that "as the selectivities of cotton/hemp and polyamide are known to be the same" that there was no difference in escapement for Cape hake and European hake; we can now further add that the Silver hake also appears to have the same selection characteristics as other members of the genus Merluccius.

iii) Squid (Illex) fishery implications

Both the Canada-Cuba study and the Canada-Russia study had large percentages of squid in the catches, similar to current commercial catches. Thus the masking that may be caused by squid in large commercial catches will be at least partially accounted for in the present studies. The larger commercial catches will tend to depress the selection factor (reduce the % escapement); although from the current study no estimate of this can be made,we can use the results from Bohl et al. (1971) to indicate that the selection factor may drop by as much as 0.2 per metric ton increase in catch. Thus all estimates based on the current survey data will be on the low side and possibly considerably so. One factor which could depress the selection ogive even further is any "strengthening" that may be carried out on commercial sized codends (i.e. doubled twine, etc.), such alterations are common although not necessarily uniform throughout a fleet.

As much of the current Silver hake fishery by Russia and Cuba is a joint hake - squid fishery, and as the biomass of squid appears to be increasing (Scott, 1977) it would be advisable to consider the effects of a 90 mm mesh net on squid catches. Squid, due to their morphology, can not be studied as easily for selection as most fish species. The tentacles on squid lead to a heavy masking of any easily defined 50% retention point - in much the same way as teeth and spines complicate selection ogives of gill nets for many species of fish. Because of this masking problem and due to the small range of length of squid (Figure 8) at any one time on the Scotian shelf, it was decided to study the percent of the population, during different seasons, which pass through each codend mesh size, rather than trying to identify the 50% retention length. Figure 9 and Table 8 show the percent by weight of squid passing through codends of different mesh sizes. From this Figure it can be seen that 25-30% of the squid will escape a 90 mm research type trawl. These escapees will tend to be smaller squid which will increase the yield per recruit, but more importantly, the 90 mm mesh codends will allow otherwise discarded juvenile fish the chance to escape. The research studies were conducted in August and October/ November, times when the squid population had a mode or peak at 20-22 cm (Figure 8 and 10). The percent squid released by the 90 mm net (Figure 9) decreases from the August study to the October-November study - due to the growth in the population. Figure 10 gives the growth of the population which appears greatest from April to June. From June to September the growth begins to level off - fortunately this coincides with the peak in fishing effort. Because of this, a 90 mm mesh net will allow cropping of larger squid in the early months of the year and as the year progresses and the effort increases the catch per unit effort will increase significantly and a greater proportion of the population will be recruited to the fishery.

REFERENCES

Anon. (1976a). Report of the Silver Hake Ageing Workshop, Dartmouth, Canada, 1-3 April 1976. Ann. Meeting June 1976. ICNAF Summ. Doc. 76/VI/21. pp. 6. (Mimeo).

Anon. (1976b). Ninth Special Commission Meeting - December 1976: Proceedings Number 6. ICNAF. Ser. No. 4076 (B.E. 76) Appendix I. pp. 2. (Mimeo).

Anon. (1976c). Canadian Proposal for the Regulation of Fishing Iear Used in the Directed Silver Hake Fishery in ICNAF Subarea 4. ICNAF Comm. Doc. 76/VI/25. pp. 1 (Mimeo)

Beverton, R.J.H. (1964). The Selectivity of a flap-type topside chafter. Int. Comm. N.W. Atlant. Fish. Redbook 1964, (III): 132-139.

Boerema, L.K. (1956). Some Experiments on Facotrs Influencing Mesh Selection in Trawls. J. du. Conseil. Explor. Mer. XXI(5): 175-191.

Bohl, M. (1964). (Selektionsdaten fur Kliesche und Scholle aus Schleppnetz experimenten in Seegebiet von Helgoland.) Protok. Fisch Tech., 8: 304-356. (not seen in original).

Bohl, M., Botha, L. and van Eck, T.M. (1971). Selection of the Cape Hake (Merluccius merluccius capensis Castelnan and Merluccius merluccius paradoxus Franca) by Bottom Trawl Codends. J. Conseil. Int. Explor. Mer. 33(3): 438-471.

Clarke, J.R. (1954). Preliminary Report on the Escape of Silver Hake through Trawl Meshes. Int. Comm. Northw. Atlant. Fish. Serial No. 343. (Appendix No. 3), pp. 10 (Mimeo).

Clarke, J.R. (1963). Size Selection of Fish by Otter Trawls. Results of Recent Experiments in the Northwest Atlantic Int. Comm. Northw. Atlantic Fish. Spec. Pub. No. 5: 24-96.

Clarke, J.R. (1963b). Escapement of Haddock Through Codends Meshes. Spec. Publs. Int. Comm. N.W. Atlant. Fish., (5): 63-80.

Clay, D. (1977). Selection of Silver Hake (Merluccius bilinearis) in Kapron Codends (A Preliminary Report). CAFSAC Res. Doc. 77(20). pp. 45 (Mimeo).

Clay, D. (1978a). Report on the Joint Cruise of the USSR Research Vessel "Foton" (October-November, 1977) (Preliminar Analysis and Data Documentation with Particular Reference to Silver Hake). CAFSAC Work. Paper 78/7 pp. (Mimeo).

Davis, F.M. (1934). Mesh Experiments with Trawls 1928-1933. Fish. Invest. Lond. Series II. XIV(1). pp. 56.

Gulland, J.A. (1956). On the Selection of Hake and Whiting gy Mesh of Trawls. J. du Conseil. Explor. Mer. 21(3): 296-309.

Gulland, J.A. (1964). Variations in Selection Factors and Mesh Differentials. J. Conseil. Explor. Mer. 29(2): 158-165.

Hennemuth, R.G. (1964). Estimated Relationship of Lengths Girth for Red and Silver Hake Collected from Subarea 5 in 1963. ICNAF Res. Doc. 47. pp. 2. (Mimeo).

Hodder, V.M. and A.W. May. (1964). The Effect of Catch Size on the Selectivity of Otter Trawls. Res. Bull. Int. Comm. N.W. Atlant. Fish., (1): 28-35.

Holdlen, M.J. (Ed.) (1971). Report of the ICES/ICNAF Working Iroups on Selectivity Analysis. Int. Conseil. Expl. Mer. Coop. Res. Rep. Series A. No. 25. pp. 144.

Hunt, J.J. (1977). Age, Growth and Distribution of Silver Hake (Merluccius bilinearis) on the Scotian Shelf from Modal Analysis of Length Frequencies. ICNAF Res. Doc. 76/XII/164. (Mimeo).

ICES, Part IV. (1964). General Considerations on Trawl and Seine Mesh Selection and Its Measurement. IN: Cooperative Research Report No. 2. Int. Conseil, Explor. Mer. (May 1964): J38-156.

ICNAF. (1962-1972). ICNAF Sampling Yearbooks Vol. 7-Vol. 17.

Jensen, A.C. and R.G. Hennemuth. (1966). Size Selection and Retainment of Silver and Red Hake in Nylon Codends of Trawl Nets. Int. Comm. Northw. Atlant. Fish. Res. Bull. 3:86-102.

Margetts, A.R. (1954). The Length-Girth Relationships of Haddock and Whiting and Their Application to Mesh Selection. J. Conseil Int. Explor. Mer. 20(1): 56-61.

Margetts, A.R. (1957). The Length-Girth Relationships of Whiting and Cod and Their Application to Mesh Selection. J. Conseil. Int. Explor. Mer. 23(1): 64-71.

Nichy, F.E. (1967). Growth Patterns on Otoliths From Young Silver Hake, Merluccius bilinearis. ICNAF Res. Doc. 67/109. pp. 15 (Mimeo)

N.N., (1957). "International Fisheries Convention 1946: Report of the Ad Hoc Committee Established at the Fourth Meeting of the Permanent Commission, Sept., 1955: J. Cons. Int. Explor. Mer. V3: 1-37.

Pope, J.A., M. Roessingh and A. von Brandt. (1964). Part I. The 1958 International Comparative Fishing Experiment. In: Cooperative Research Report No. 2. Int. Conseil. Explor. Mer. (May 1964): 7-29.

Pope, J.A., S. Margetts, J.M. Hamley, and E.F. Akyuz. (1975). Manual of Methods for Fish Stock Assessment. Part III: Selectivity of Fishing Gear. FAO of UN Fish. Tech. Pap. No. 41. pp. 65.

Sarnits, A.A. and V.A. Sauskan. (1966). Hydrographic Conditions and Distribution of Silver Hake (Merluccius bilinearis Mitchell) on Georges Bank and off Nova Scotia in 1964. ICNAF Res. Doc. 66/51. pp. 8 (Mimeo).

Sauskan, V.A. (1964). Results of Soviet Observations on the Distribution of Silver Hake in the Areas of Georges Bank (5X) and Nova Scotia (4W) in 1962-63. ICNAF Res. Doc. 61: pp. 8. (Mimeo).

Scott, J. (1977). Distribution of Squid (Illex illecebrosus) on the Scotian Shelf 1970-1976. CAFSAC Res. Doc. 77/19. pp. 5. (Mimeo).

Table 1. Research vessel gear specifications for mesh selection studies.

Technical Data - Isla de la Juventud

Length over all:	70.3 m
Beam:	12.5 m
Displacement:	
Net:	1,556 tons
Gross:	2,200 tons
Power:	2,400 hp
Speed:	14.5 knots
Type of Ship:	Stern Trawler/Freezer

Technical Data - FOTON

Length over all:	54.6 m.
Beam:	
Displacement:	
Net:	660 tons
Gross:	987 tons
Power:	800 hp
Speed:	10 knots
Type of ship:	Side Trawler

Table 2. Gear specifications for the bottom trawl nets used on the Cuban R/V *Isla de la Juventud*.

Type of trawl:	Spanish bottom trawl
Foot rope length:	57.9 m
Head rope length:	41.6 m
Head rope height:	6 m
Wing spread:	unknown
Length bridles:	113 m
Type of doors:	Oval
Door weight:	1500 Kg
Door area:	5.5 m^2
Mesh size in wings:	Dry - 204 mm; Wet - 204 mm
Mesh size in body - square:	Dry - 200 mm; Wet - 200 mm
- middle:	Dry - 150 mm; Wet - 150 mm
- end:	Dry - 123 mm; Wet - 123 mm

Mesh size in codend:

40 mm		60 mm		90 mm	
Dry	Wet	Dry	Wet	Dry	Wet
40.1 mm	40.1 mm	66.1 mm	66.1 mm	90.0 mm	90.0 mm
			66.2 mm		90.2 mm
			66.1 mm		90.2 mm
			66.1 mm		90.2 mm

Liner in codend:	Yes (covering the codend knot)
Mesh size in cover:	Dry - 20 mm; Wet - 20. 1 mm
Chafing gear fitted:	Yes
Rollers on footrope:	No

Table 2. (Continued) Gear specifications for the bottom trawl nets used on the USSR R/V *Fonton*. (Fishing Licence # 214-197)

	Gear No. 1	2	3	4
TYPE OF TRAWL	:	....	bottom trawl	....
FOOT ROPE LENGTH	:	....	31.4 m	....
HEAD ROPE LENGTH	:	....	28.0 m	....
HEAD ROPE HEIGHT	:	....	5.0 m	....
WING SPREAD	:	....	11.0 m	....
LENGTH OF BRIDLES	:	....	50.0 m	....
TYPE OF DOORS	:	....	oval steel	....
DOOR WEIGHT	:	....	650 kg	....
DOOR DIMENSION	:	....	(2.75x1.80)m	....
MESH SIZE (WINGS)	:	....	200 mm	....
MESH SIZE (BODY)	:	....	160 mm	....
MESH SIZE (CODEND)	: 59.6 mm	70.8mm	126.5 mm	39.6 mm
LINER IN CODEND	:	....	No	....
COVER ON CODEND	:	....	Yes	....
MESH SIZE (COVER)	:	....	34.5 mm	....
CHAFING GEAR FITTED	:	....	No	....
ROLLERS ON FOOTROPE	:	....	Yes*	....
CODEND MATERIAL	:	....	kapron	....
CODEND TWINE	: 93.5 tex x 18	93.5 tex x 18	93.5 tex x 12	93.5 tex x 12 1)
COVER MATERIAL	:	....	kapron	....
COVER TWINE	:	....	93.5 tex x 12	....

* Rollers were 145 mm diameter steel weights connected through the center to a heavy rope. The entire apparatus was connected by 18 cm chains to the footrope.

1) assumed although not checked.

Table 3. Results of Measurements of Codend and Cover Mesh Sizes of Kapron Codends from the Vessel "Foton"

Set Number	2	7	8	13	29	50	59	71	96	103	BEFORE FISHING				
"Size"[1] (mm)	40	60	30[2]	70	120	120	60	70	70	60	40	60	70	120	30[2]
Measurements	(wet)	(wet)	(wet)	(wet)	(wet)	(wet)	(wet)	(wet)	(wet)	(wet)	(dry)	(dry)	(dry)	(dry)	(dry)
1	40	59	34	72	127	124	59	69	69	61	33	58	67	No Data Collected	33
2	38	60	33	72	128	126	63	70	68	59	30	55	65		31
3	41	61	37	70	126	120	62	68	72	59	33	56	70		33
4	40	60	34	70	128	121	60	68	68	60	34	57	64		32
5	39	60	34	70	125	120	60	67	72	56	34	56	65		33
6	39	59	35	72	127	120	58	70	69	60	33	56	64		30
7	39	59	32	71	127	120	61	72	70	60	36	57	64		33
8	37	57	35	71	123	125	59	70	71	62	34	54	67		34
9	42	61	36	70	125	122	60	68	67	59	34	57	64		34
10	41	60	35	70	129	120	59	66	70	61	33	58	68		33
Mean	39.6	59.6	34.5	70.8	126.5	121.8	60.1	68.8	69.6	59.7	33.4	56.4	65.8	nil	32.6
± SD	±1.5	±1.2	±1.4	±0.9	± 1.8	± 2.4	±1.5	±1.8	±1.7	±1.6	±1.5	±1.3	±2.1		±1.3

1) Commercially rated size (used throughout study to denote different gear types).

2) Cover

Table 4. The selection factor, selection range and 50% retention point for kapron codends.

Mesh Size[1] (mm)	50% Retention Point (mm)		Selection Range (25-75%)	Selection Factor
CC 40	175*	177	6.3 cm	4.4
60 CR	225*	229	13.2 cm	3.8
CC 60	216*	216	1.7 cm	3.6
70 CR	205*	219	15.4 cm	2.9
CC 90	260*	259	1.9 cm	2.9
120 CR	411*	402	17.9 cm	3.4

1) CC = Canada-Cuba study; CR = Canada-Russia study.

Note: 50% Retention point or 50% Escapement point calculated by eye (*) and by moving average of 3 points. The 50% retention points were also calculated by linear regression for the Canada-Russia study and they were found to be closer to the results of the curve fitted by eye than the values found by the moving average method. (60 mm = 224 mm; 70 mm = 200; 120 mm = 417).

Table 5. The 50% retention length (cm) and selection factor for sets where data from catch were adequate to provide a unique result.

Set Number	Codend Catch	Mesh Size (mm) 60	70
5	1839	20.16/3.4	
8	762	19.62/3.3	
9	872	20.27/3.4	
10	1047		28.43/4.1
11	1610		28.93/4.1
13	1833		30.31/4.3
23	3083		27.26/3.9
24	329		18.26/2.6
26	248	18.42/3.1	
27	93	21.75/3.6	
32	200	18.51/3.1	
34	805	23.57/3.9	
37	590	19.73/3.3	
38	306	22.85/3.8	
42	394		14.95/2.1
43	215		22.18/3.2
44	183		23.47/3.4
45	244		21.61/3.1
47	623		21.77/3.1
48	580		21.94/3.1
88	421	25.76/4.3	
89	409	23.84/4.0	
90	1161	25.55/4.3	
91	1577	26.04/4.3	
93	574		22.59/3.2
94	569		24.33/3.5
95	305		23.40/3.3
96	364		25.61/3.7
97	605		25.10/3.6
98	533		24.75/3.5
101	419	27.07/4.5	
102	761	27.70/4.6	
mean 50%		22.72±3.19	23.82±3.82
mean S.F.		3.76± .53	3.40± .55

Table 6. Comparison of girth/length relationship for European hake, silver hake and cape hake. (Modified after Bohl et al., 1971)

SPECIES AND AUTHOR	RELATIONSHIP	RELATIVE GIRTH AS % OF GIRTH OF SILVER HAKE	
Silver Hake (Hennemuth, 1964)	G=0.44 (FLcm) - 0.31	30 cm = 100	50 cm = 100
Silver Hake (Present Study)	G=0.48 (TLcm) - 1.99	= 94.7	= 99.5
European Hake (Gulland, 1956)	G=0.47 (TLcm) - 1.10	= 99.2	= 101.2
Cape Hake			
- Cape grounds	G=0.49 (TLcm) - 2.44	= 93.5	= 99.7
- Luderitz grounds	G=0.46 (TLcm) - 1.45	= 94.2	= 97.4
(Bohl et al, 1971)			

Table 7. Percentage by weight of squid passing through the codend of various mesh sizes of kapron codends.

Mesh Size [1] (mm)	% by Weight of Squid in the Catch	% by Weight of Squid Released From Codend
CC 40 mm	29.5% *	0% *
60 mm CR	28 %	0.5%
CC 60 mm	83.0% *	1.8% *
70 mm CR	21%	0.5%
CC 90 mm	66.0% *	28% *
120 mm CR	26%	59.8%

1) CC = Canada-Cuba study; CR = Canada-Russia study.

Note: The Canada-Cuba study (*) covered very different locations and therefore the variation in % squid by weight of the catch cannot be linked to mesh size. The length frequency of these populations caught in August-September is less than those caught in October-November (Figure 9). The modal size of the populations would probably be the determining factor for mesh selection of squid.

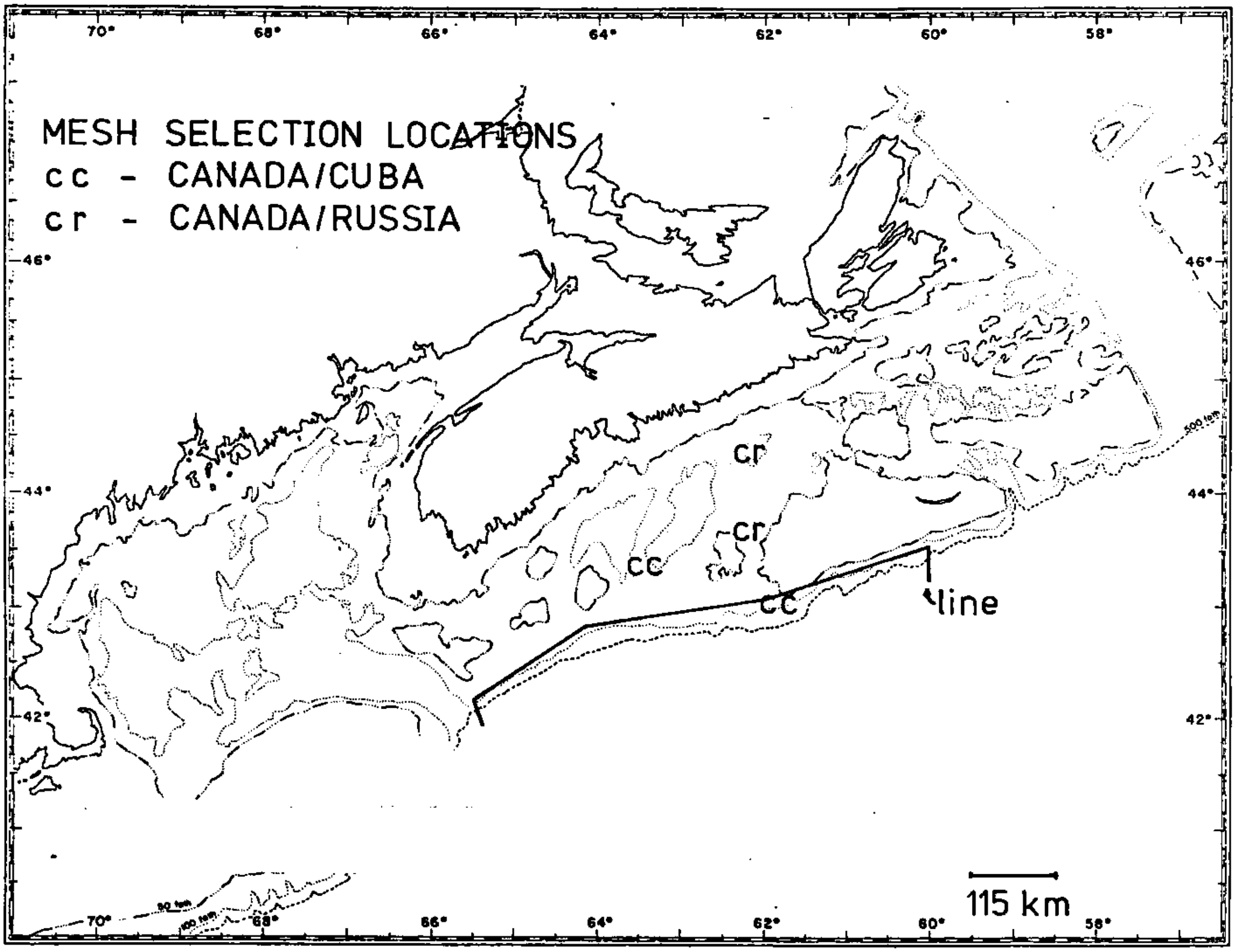

Fig. 1. Map showing small mesh gear line and approximate locations of the 1977 mesh selection studies for silver hake.

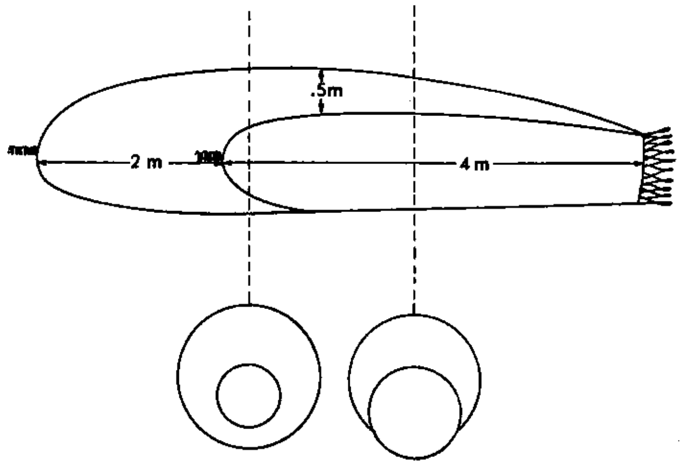

Fig. 2. Construction and general dimensions of topside covered codend used on Russian R/V *Fonton* mesh selection study in 1977.

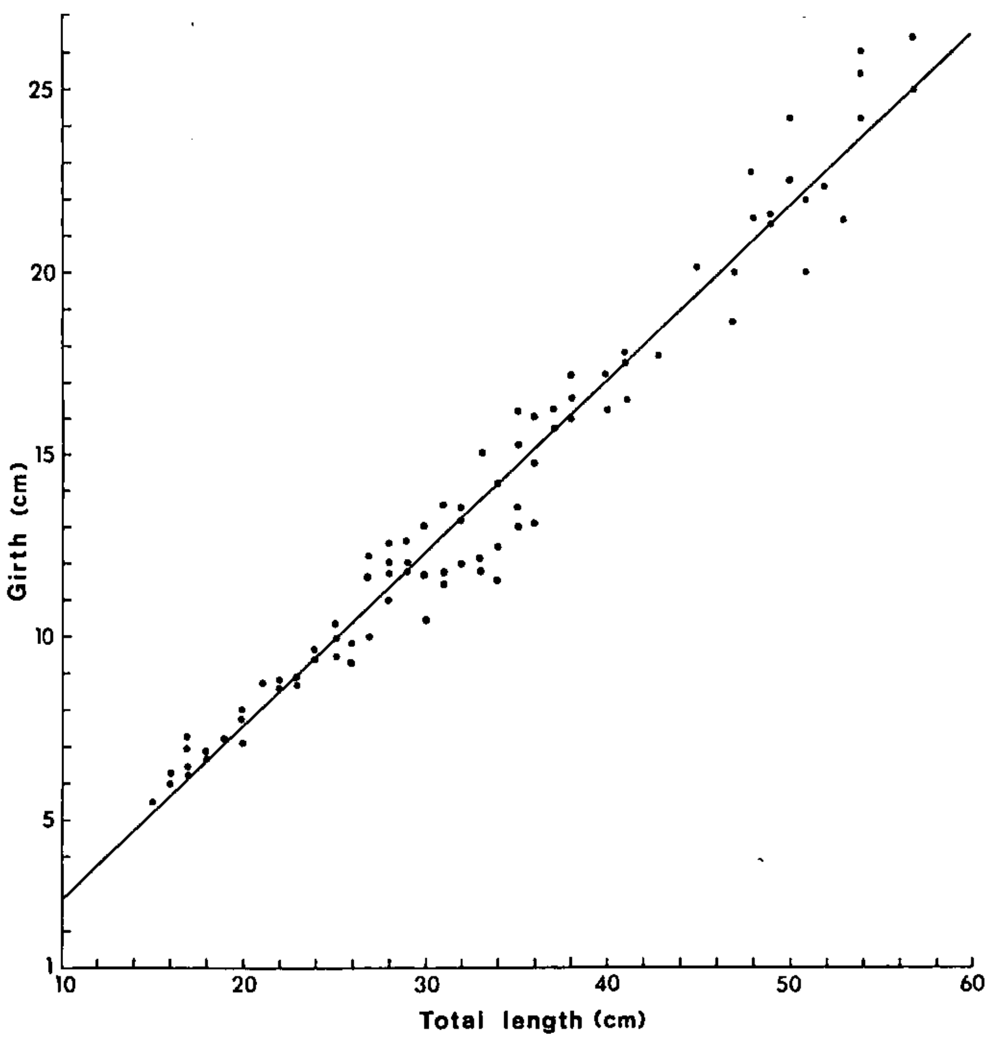

Fig. 3. Total length-girth relationship for silver hake in ICNAF Area 4W in October 1977.

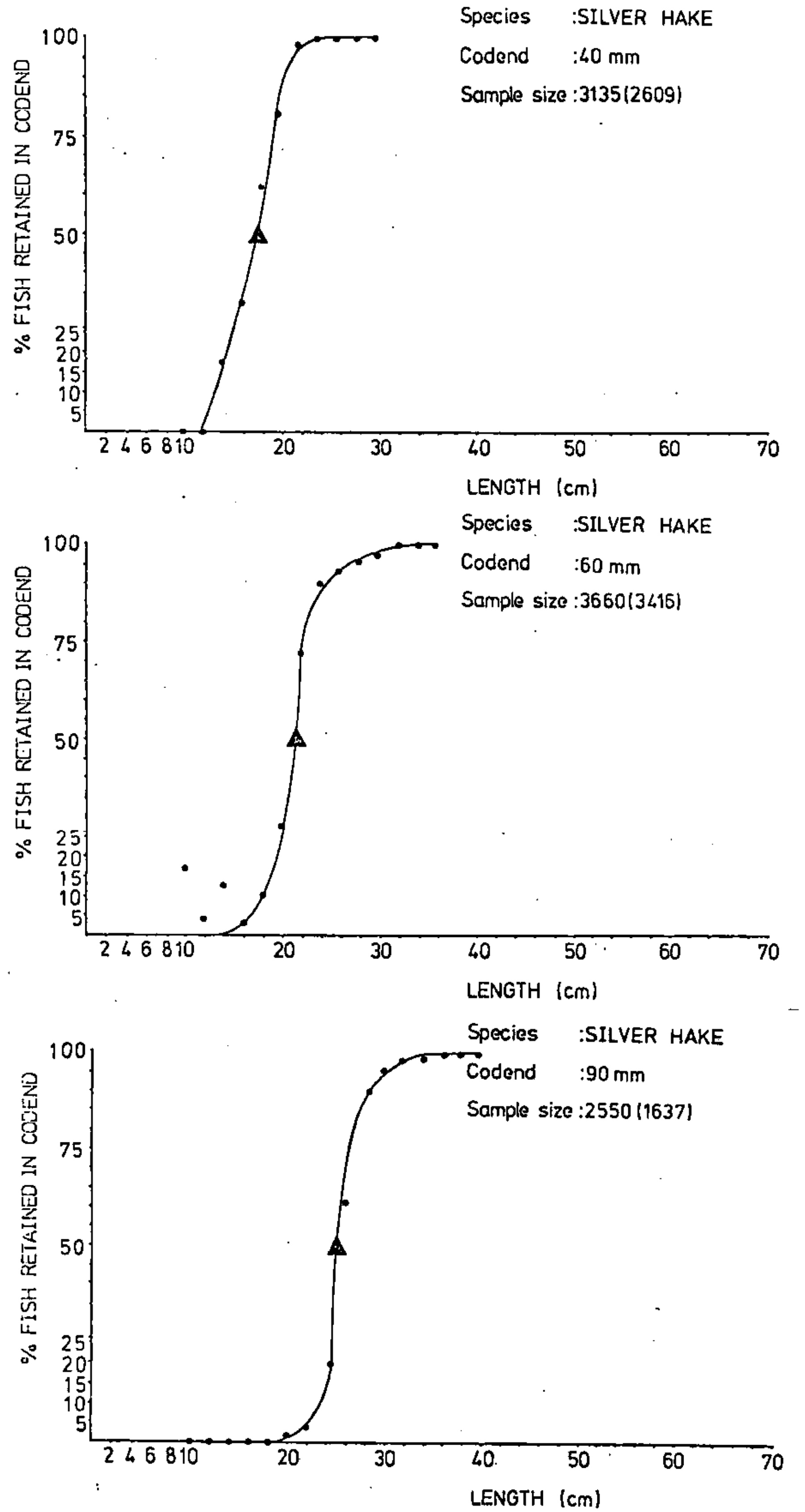

Fig. 4. Selection ogives for Silver hake from ICNAF Area 4W studied during the Canada-Cuba mesh selection study. The sample size is the number of fish measured and the number in brackets is the number of fish in the codend. The heavy triangle indicates the 50% retention point.

D 3

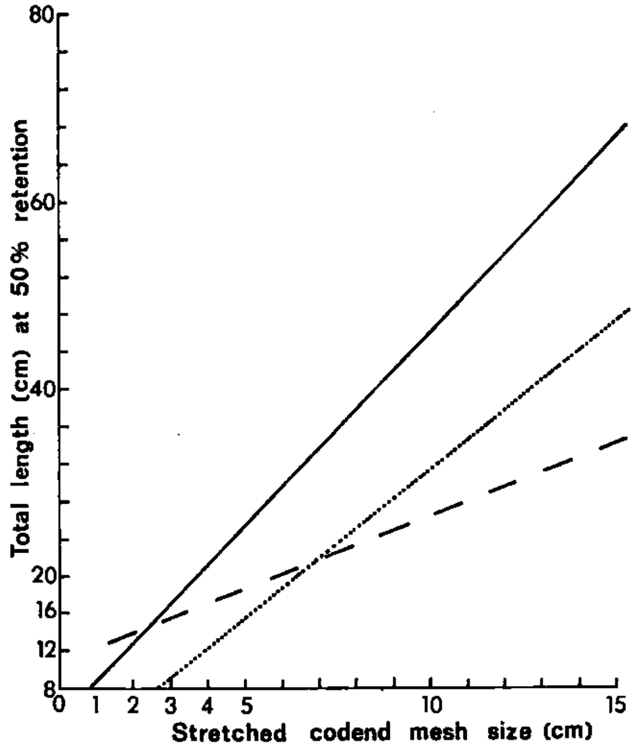

Fig. 5. The 50% retention point and the length at which the girth equals the circumference of the mesh plotted against the mesh size. Solid line represents the girth relationship while the broken line represents the Canada-Cuba mesh selection results. The dotted line represents the Canada-Russian mesh selection results.

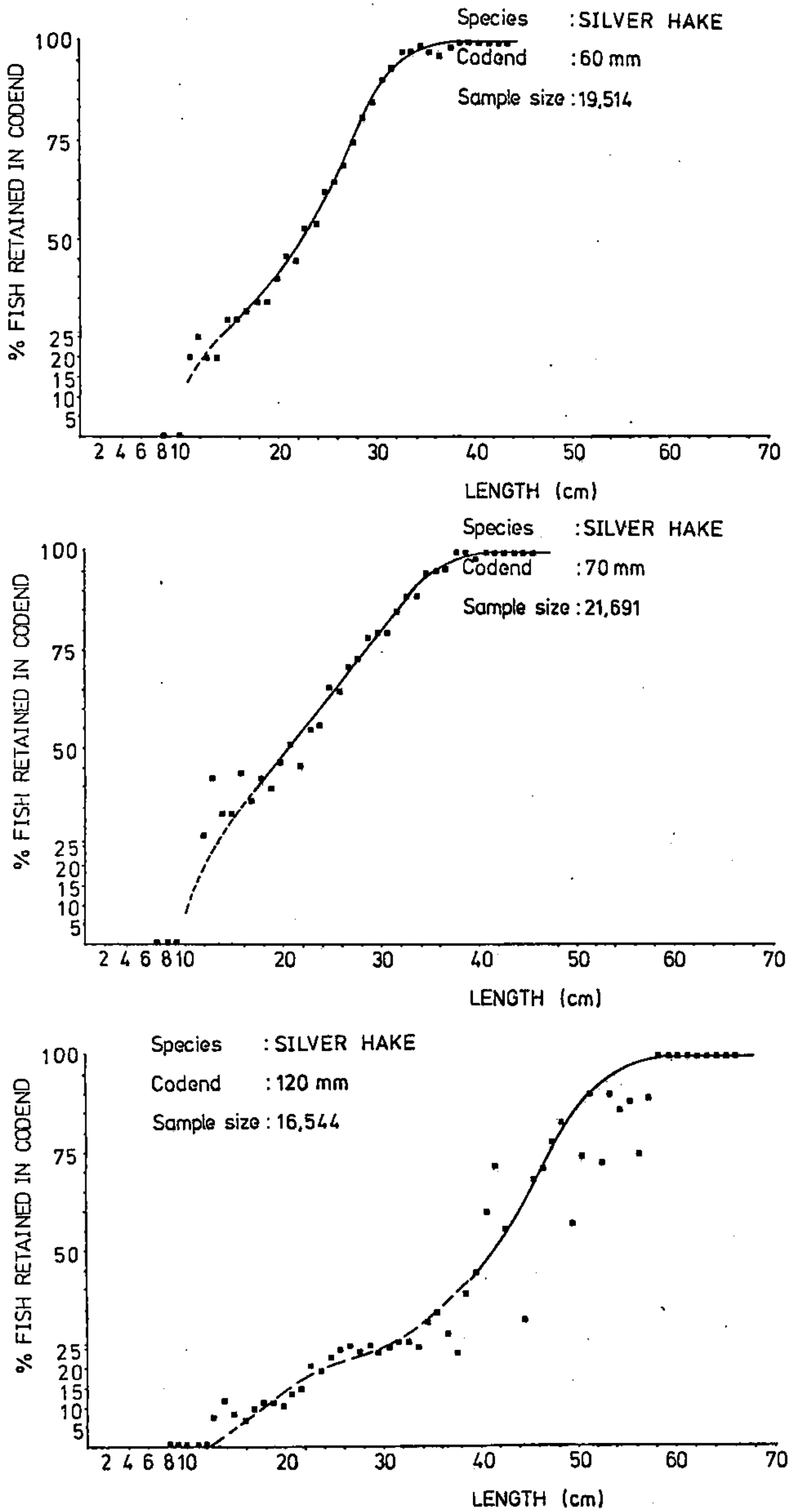

Figure 6. Selection ogives for Silver Hake from ICNAF area 4W studied during the Canada-Russian mesh selection study. The broken line indicates possible areas of controversy over exact placement of the curve.

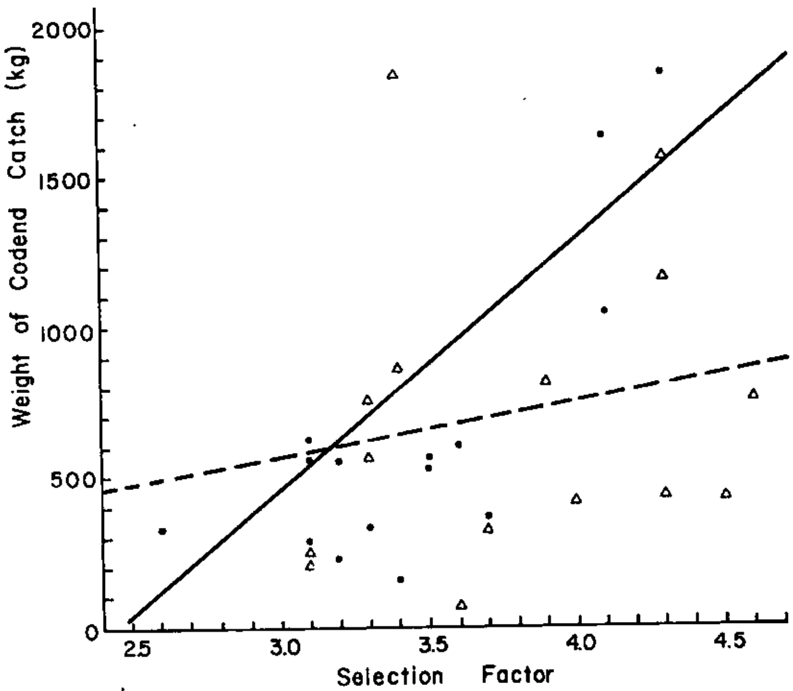

Fig. 7. The selection factor of individual tows with the 60 mm codends (broken line, circles) Y = 164.76 x + 72.53, (r^2 = .03, n = 15), and 70 mm codends (soldid line, open triangles) Y = 818.38 x - 2012.44, (r^2 = .36, n = 16) against the weight of the codend catch. One point over 2000 kg is omitted from the plot.

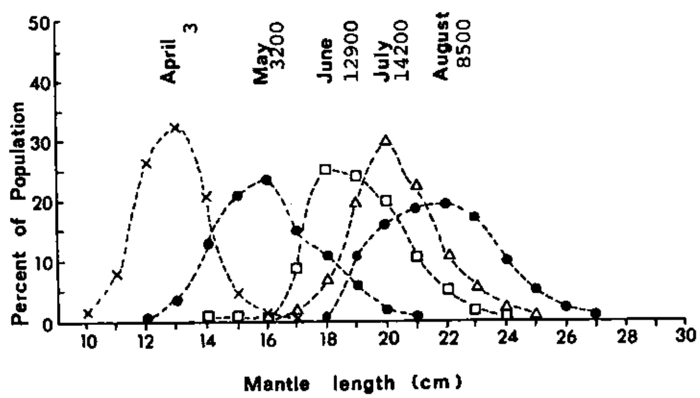

Fig. 8. Monthly length composition of the commercial squid catch from 1977. Numbers under the month are the total (approximate) catches of squid for that month.

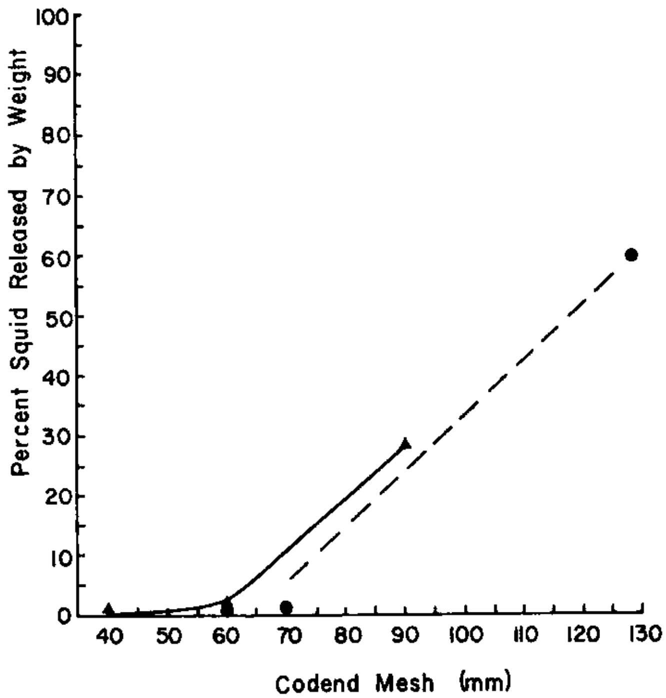

Fig. 9. Codend mesh size and the percent by weight of squid released by each mesh size. The solid line is the Canada-Cuba study and the broken line is the Canada-Russia study. The difference between the two lines is due to the growth of the squid population between August/Setpember to October/November (see Figure)9).

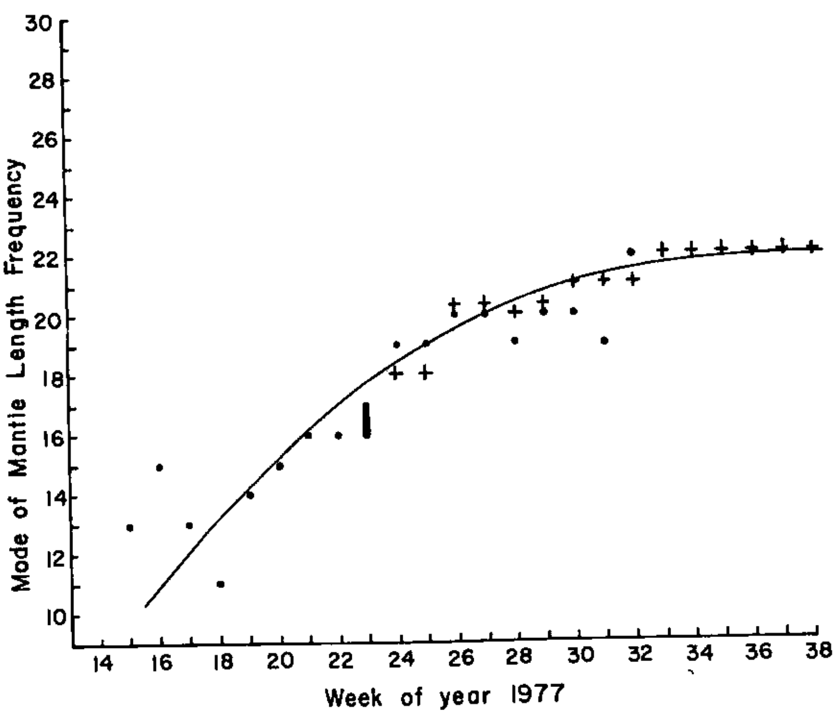

Fig. 10. Growth of squid measured by movement of modal peak on a weekly basis. Circles are samples from Cuban commercial catches while crosses are samples from Russian commercial catches. The vertical bar represents one week where mode spread over two centimeter groups.

APPENDIX I

Table 1. Selection ogives for Silver hake (*Merluccius bilinearis*) calculated from the joint Canada-Russia mesh selection study of Oct/Nov 1977. Values smoothed by a running average of 5.

TOTAL LENGTH	PERCENT RELEASED FROM CODEND MESH SIZE				
	40 mm*	60 mm	70 mm	90 mm*	127 mm
15	59%	73%	62%	77%	91%
16	56%	71%	62%	76%	90%
17	53%	68%	61%	74%	90%
18	51%	66%	58%	73%	90%
19	46%	63%	57%	71%	89%
20	41%	61%	55%	68%	88%
21	37%	57%	53%	66%	86%
22	33%	53%	49%	64%	84%
23	30%	48%	45%	62%	82%
24	27%	45%	42%	60%	80%
25	21%	40%	38%	56%	78%
26	17%	35%	34%	52%	77%
27	11%	30%	30%	48%	76%
28	8%	25%	27%	46%	76%
29	3%	20%	22%	44%	76%
30	1%	15%	18%	42%	75%
31	0%	11%	17%	40%	75%
32		8%	14%	38%	74%
33		5%	14%	37%	73%
34		4%	11%	35%	71%
35		4%	9%	33%	71%
36		4%	8%	31%	71%
37		3%	5%	30%	69%
38		3%	3%	28%	66%
39		2%	3%	27%	61%
40		1%	2%	26%	53%
41		0%	2%	25%	46%
42			2%	24%	45%
43			1%	23%	43%
44			1%	22%	40%
45			1%	20%	39%
46			1%	19%	34%
47			0%	14%	29%
48				10%	28%
49				7%	25%
50				2%	22%
51				1%	19%
52				0%	18%
53					15%
54					15%
55					15%
56					13%
57					10%
58					7%
59					2%
60					0%

* Estimated values using linear interpolation of 60-70-127 mm results and taking values of the Canada-Cuba cruise into consideration.

Table 2. Selection by age for 60 mm mesh codend by 3 methods. The first method uses sample populations and "fishes" each length frequency with the selection agove of Table 1. The other two methods use the selection values of the ogive at specified length.

Age	Sex	Sample Numbers	Modal length	Mean Length
1	M	0.41	0.37	0.38
	F	0.40	0.39	0.38
2	M	0.72	0.75	0.68
	F	0.78	0.80	0.74
3	M	0.83	0.89	0.87
		0.91	0.95	0.94
4	M	0.91	0.95	0.95
	F	0.95	0.96	0.95
5	M	0.91	0.89	0.96
	F	0.97	0.97	0.99
6	M	1.00	0.98	1.00
	F	0.99	1.00	1.00

Table 3. Mesh selection by age for Silver Hake from ICNAF area 4VWX in 1977 with sexes combined. Four commonly considered nets are shown with the results calculated by fishing sample populations.

Net Size	40 mm	60 mm	90 mm	130 mm
Age		Fraction of Fish Retained		
1	0.59	0.40	0.34	0.11
2	0.93	0.74	0.52	0.21
3	0.99	0.87	0.59	0.25
4	1.00	0.95	0.64	0.27
5	1.00	0.97	0.69	0.34
6	1.00	0.99	0.83	0.64