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Current Mesh Selection Studies on the Scotian Shelf in Relation to Historical Selectivity Data

by

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Abstract

Mesh selection data for haddock, cod pollock, red hake, silver hake, redfish, American plaice, witch flounder, alewife and mackerel, collected during joint Canada-Cuba and Canada-USSR cruises on the Scotian Shelf in 1977, are compared with general selection patterns for these species based on historical selectivity data. Most of the 50% retention lengths for the various groundfish species sampled fit the historical selection patterns reasonably well. Since a certain amount of variability is generally inherent in mesh selection studies, such a selection pattern for a species could be considedred as a "commercial average" and utilized in analyzing the effects of mesh regulations. This raises the question of the necessity for further mesh selection studies on species for which much data already exist.

Introduction

The results of mesh selection studies for various groundfish species (cod, haddock, redfish, pollock, red hake, silver hake, American plaice, witch flounder, alewife and mackerel) presented in this paper are based on data collected in the summer and autumn of 1977 during joint Canada-Cuba and Canada-USSR cruises. Although these cruises were originated to study the mesh selection of silver hake, *Merluccius bilinearis*, a valuable offshoot has been information on the selection of other species. There is a lack of information on small mesh kapron codend selectivity of the Scotian Shelf (a kapron is a polyamide synthetic material of trawls used extensively by the Cuban and USSR fishing fleets.

Measures agreed upon for the silver hake fishery on the Scotian Shelf limit the codend mesh size of mid-water trawls to a minimum of 60 mm (ICNAF, 1977a). An area restriction for bottom trawls limits the codend mesh size to 60 mm seaward of the "small mesh gear line" (ICNAF, 1977b) (Fig. l). The aims of these regulations were to increase the maximum sustainable yield of the silver hake fishery and, possibly, to reduce the undesirable by-catch of juveniles of other commercially important species. The purpose of the two joint mesh selection studies undertaken in 1977 was to quantify the effects of these new measures upon the silver hake fishery. The results of the studies pertaining to silver hake have been documented by Clay (MS 1978).

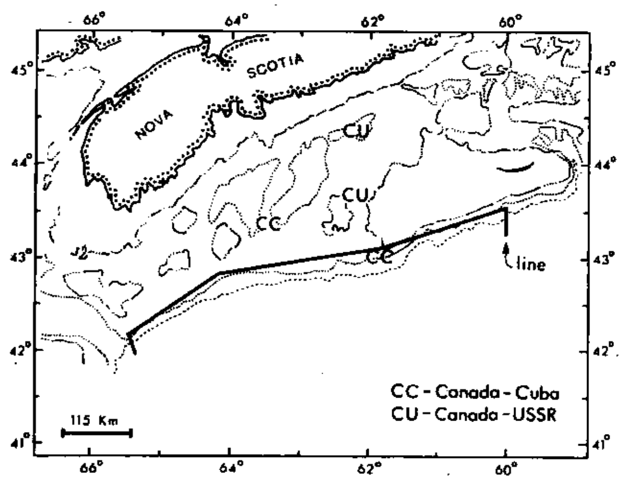

Fig. 1. Map showing the "small mesh gear line" and the approximate locations of the joint Canada-Cuba and Canada-USSR mesh selection studies in 1977.

Methods

The specifications of the research vessels and the gears used are listed in Table 1. On the USSR R/V *Foton*, a topside cover was fitted to the codend in a manner similar to the ICES specifications (ICES, 1964). The general construction and dimensions of the cover are shown in Fig. 2. On the Cuban R/V *Isla de la Juventud*, exact details of the attachment of the cover are not available in the cruise reports, although Hare

TABLE 1. Specifications of research vessels and gears used in the joint mesh selection studies in 1977.

	Cuba	USSR
	R/V *Isla de la Juventud*	R/V *Foton*
Overall length (m)	70.3	54.6
Beam (m)	12.5	.....
Displacement — net (tons)	1,556	660
— gross (tons)	2,200	987
Engine power (HP)	2,400	800
Speed (knots)	14.5	10
Type of vessel	Stern trawler (freezer)	Side trawler
Type of trawl	Bottom trawl[a]	Bottom trawl
Footrope length (m)	57.9	31.4
Headrope length (m)	41.6	28.0
Headrope height (m).	6.0	5.0
Wing spread (m)	unknown	11.0
Length of bridles (m)	113	50
Type of doors	oval	oval steel
Weight of door (kg)	1,500	650
Area of door (m^2)	5.5	(2.75 × 1.80)
Mesh size of wings (mm)	204	200
Mesh size — square (mm)	200	
— middle (mm)	150	160
— end (mm)	123	
Mesh size of codend (mm)	(1) 40.1[b]	(1) 39.6
	(2) 66.1[b]	(2) 59.8
	(3) 90.2[b]	(3) 69.7
		(4) 124.1
Liner in codend	yes[c]	no
Cover on codend	yes	yes
Mesh size of cover (mm)	20	34.5
Chafing gear fitted	yes	no
Rollers on footrope	no	yes[d]
Codend material	kapron	kapron
Codend twine	unknown	93.5 tex × 18[e]
Cover material	kapron	kapron
Cover twine	unknown	93.5 tex × 12

[a] Spanish type.
[b] Same measurements for wet and dry codends.
[c] Liner covering the codend knot.
[d] Steel rollers, 145 mm diameter, were connected through their centers with a heavy cable, and the entire apparatus was connected to the footrope by chains 18 cm long.
[e] Twine assumed to be 93.5 tex × 12 for 124.1 mm codend.

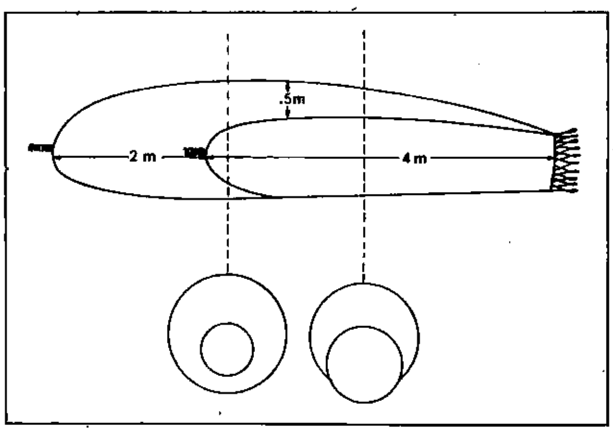

Fig. 2. Schematic diagram and dimensions of the topside covered codend used by the USSR R/V *Foton* during the joint Canada-USSR mesh selection study in 1977.

(personal communication) recalls that the cover was attached close to the codend. This would probably depress the 50% retention length and reduce the selection range (Clay, MS 1978).

TABLE 2. Results of mesh measurements of codends and covers used on Cuban and USSR reseach vessels during joint mesh selection studies on the Scotian Shelf in 1977.

Commercial rated mesh size (mm)	Measured wet		Measured dry	
	No. of meshes	Mean ± SD (mm)	No. of meshes	Mean ± SD (mm)
R/V *Isla de la Juventud* (Cuba)				
20[a]		20.1		20.0
50		40.1		40.1
60		66.1		66.1
90		90.2		90.0
R/V *Foton* (USSR)				
30[a]	10	34.5 ± 1.5	10	32.6 ± 1.3
40	10	39.6 ± 1.5	10	33.4 ± 1.5
60	30	59.8 ± 1.5	10	56.4 ± 1.3
70	30	69.7 ± 1.7	10	65.8 ± 2.1
120	20	124.1 ± 3.1	—	— —

[a] Measurements small-meshed cover.

Codend mesh sizes (Table 2) were determined by measuring the stretched mesh with an ICNAF gauge at 4 kg pressure. The codend mesh sizes used throughout the paper refer to the designated commercial mesh sizes. The fish were measured as total length to the nearest centimeter. The locations of the study areas are indicated in Fig. I.

The data collected during these series of covered codend mesh selection experiments were analyzed according to the methods suggested by Pope *et al.* (1964, 1975) and Holden (1971). These authors indicate that fitting the selection ogive by the maximum likelihood method is the most accurate means of deriving the curve. However, the tedious calculations associated with this method are not often warranted, as it has been found that fitting the curves by eye give unbiased estimates (Pope *et al.*, 1964) which are very close (often within 1%) to those obtained by the maximum likelihood method (Holden, 1971). After comparing several methods in studying selection of silver hake (Clay, MS 1978), it was decided to estimate the 50% retention lengths from curves by eye to the present data. A "general selection pattern" was estimated for each species, for which adequate historical data were available, by calculating a geometric mean regression (Ricker, 1975) of 50% retention length against stretched mesh size, and the results of the 1977 studies were compared with the general patterns.

Results

The results of the cooperative mesh selection studies in 1977 for various groundfish species have been compared with historical data reported by Holden (1971). In most cases, the present results appear to fit within the historical patterns. For some species, past studies indicate rather high correlations between 50% retention lengths and codend mesh sizes despite great variation in trawl materials used, in the types of gauges used in mesh measuring, in the speed and duration of tow and in the size of catch. Some of these earlier studies used polyamide materials in the codends, this type of material is the closest to kapron for which comparative data are available. The actual type of material used in net construction may not be an important factor, as according to Holden (1971), it was "not possible to demonstrate any relationship between selectivity and the physical proporties of the net materials".

Haddock, *Melanogrammus aeglefinus*

Selection curves for haddock from the cooperative studies in 1977 are shown in Fig. 3. Fifty percent retention lengths of 190, 210, 230, 340 and 480 mm were estimated for covered codends hauls by trawls with codend meshes of 60, 60, 70, 90, and 120 mm respectively. These five points are indicated by triangles on the scatter diagram of historical selectivity data (Fig. 4), for which the general selection pattern was calculated to be

$$TL = 3.63\ M - 28.49 \qquad (r^2 = 0.85,\ n = 296)$$

where TL is the 50% retention length of haddock (total

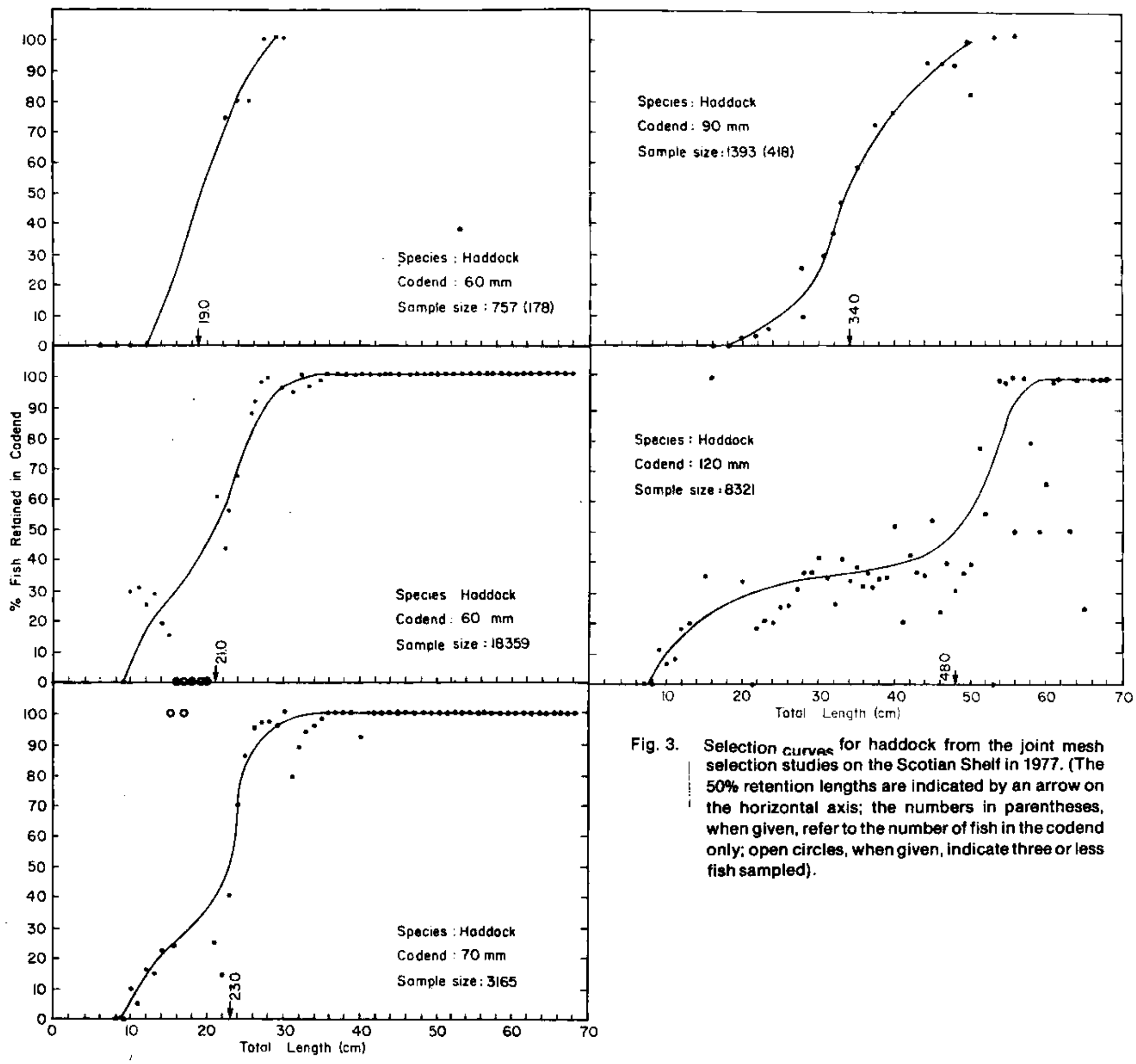

Fig. 3. Selection curves for haddock from the joint mesh selection studies on the Scotian Shelf in 1977. (The 50% retention lengths are indicated by an arrow on the horizontal axis; the numbers in parentheses, when given, refer to the number of fish in the codend only; open circles, when given, indicate three or less fish sampled).

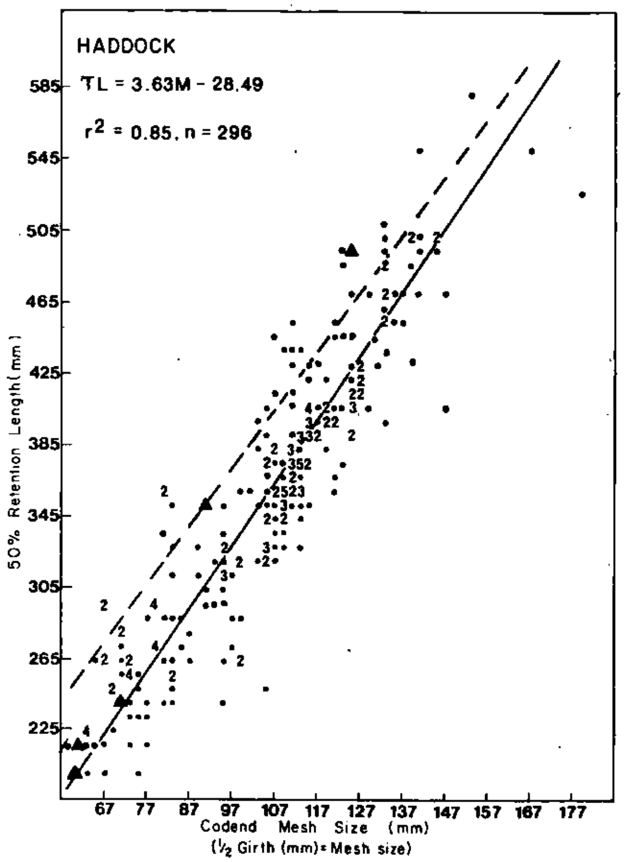

Fig. 4. General selection pattern for haddock based on historical mesh selection studies. (Each dot represents a single observation and numbers indicate points with two or more observations; triangles indicate points from the 1977 studies; the dashed line represents the length-girth relationship. The scatter graphs used throughout this paper are computer plots and as such have lower resolution than was found in the original data.)

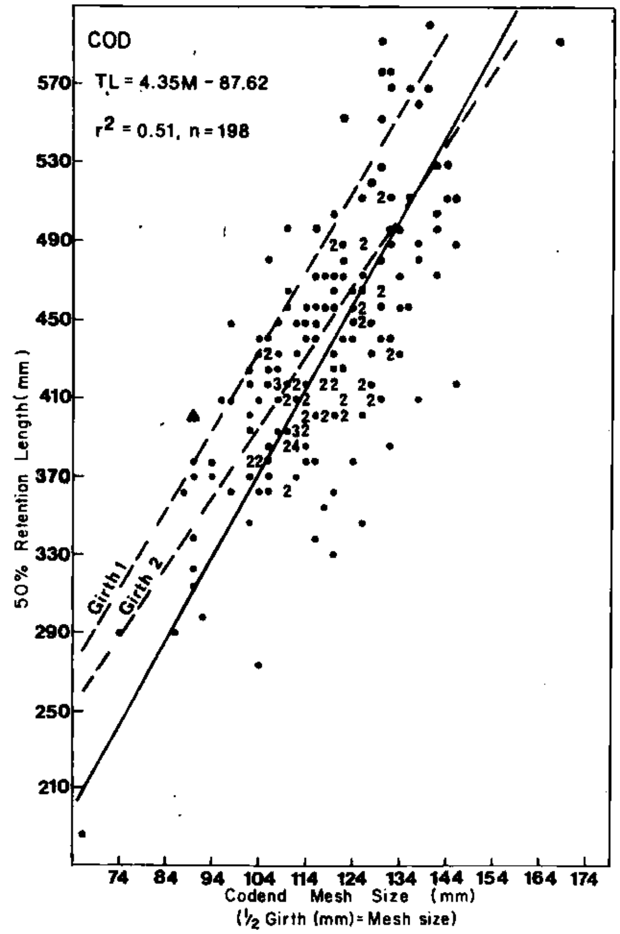

Fig. 6. General selection pattern for cod based on historical mesh selection studies. (Girths 1 and 2 lines are described in the text; other descriptors are the same as for Fig. 4.)

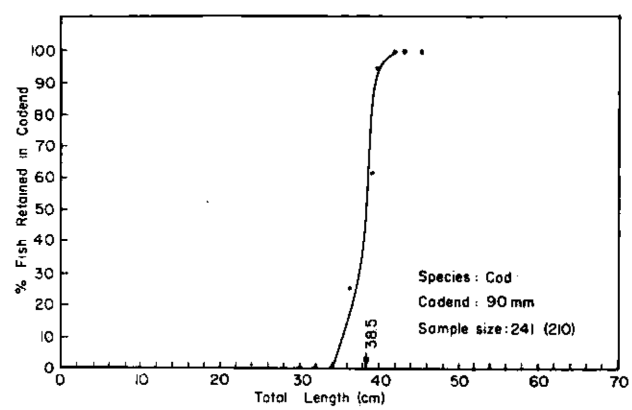

Fig. 5. Selection curve for cod from the joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

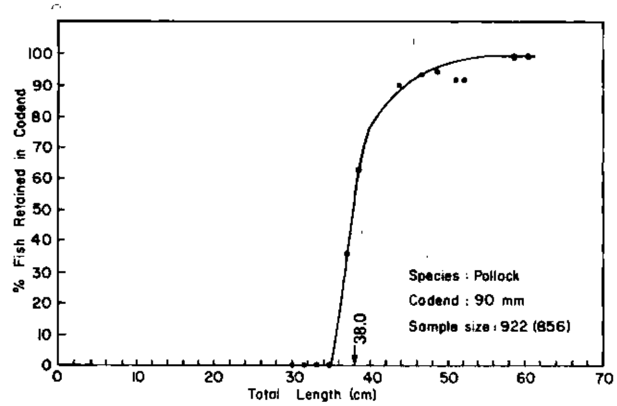

Fig. 7. Selection curve for pollock from the joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

length in mm), and M is the codend mesh size (mm). Also shown in Fig. 4 is an approximation to the length-girth relationships for haddock as reported by Wells (1969)[1] for the Newfoundland area and by Margetts (1954) for the North Sea. The relationship (dashed line) is defined by G = 0.55 TL - 1.5, where the girth (G) is expressed in centimeters. Throughout this paper the girth is assumed to be equal to twice the stretched mesh. The results from the 1977 studies for the 60 mm and 70 mm mesh codends are consistent with the historical data (Fig. 4), but the 50% retention lengths for the 90 mm and 120 mm mesh codends are above the regression line, indicating the escapement of larger fish than would be expected. However, the regression line can give a reasonably good estimate of the 50% retention length for any mesh size within the range of the experiments, and, considering the variability in the results of mesh selection studies, the estimate for a particular mesh size is probably close to the commercial average for fishing operations.

Atlantic cod, *Gadus morhua*

Insufficient data for cod were collected during the Canada-USSR mesh selection studies to allow the construction of any selection curves and only the curve for the 90 mm mesh with a 50% retention length of 385 mm was estimated from data collected during the Canadian-Cuba studies (Fig. 5). An analysis of historical selectivity data gave the general selection pattern (Fig. 6) defined by the regression

$$TL = 4.35\ M - 87.62 \qquad (r^2 = 0.51,\ n = 198)$$

and two length-girth relationships based on data reported separately in several references. The first,

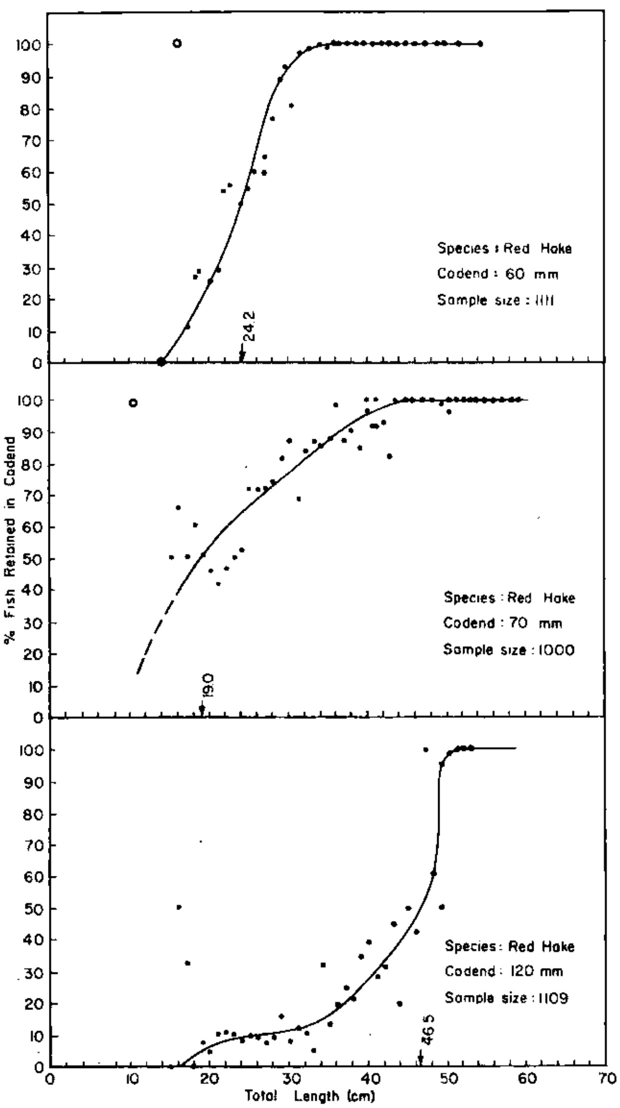

Fig. 8. Selection curves for red hake from the joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

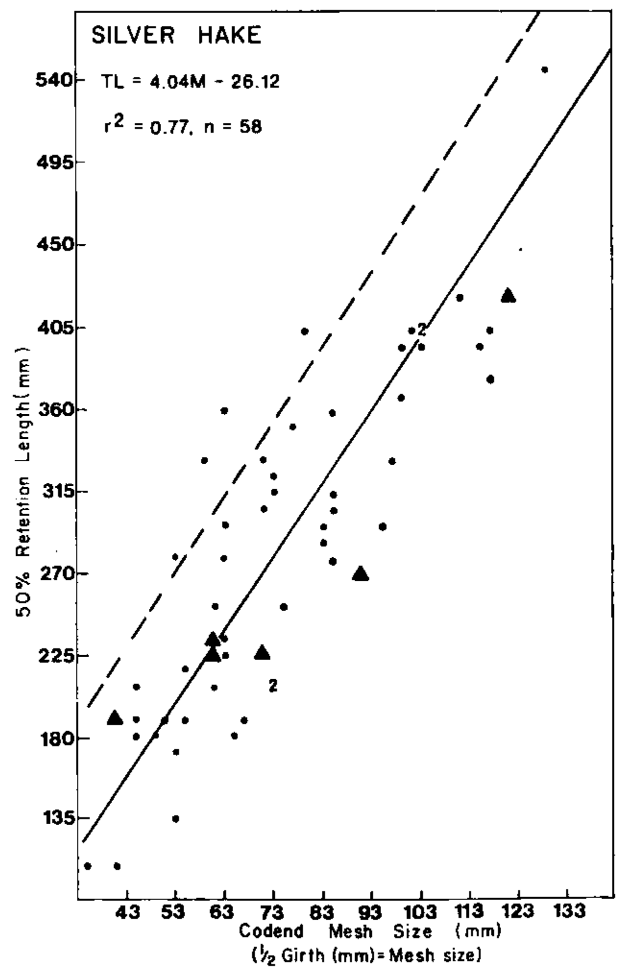

Fig. 9. General selection pattern for silver hake based on historical mesh selection studies. (Other descriptors are the same as for Fig. 4.)

labelled "Girth 1" in Fig. 6, is approximately G = 0.50 TL =0.75, based on relationships reported by Hodder and May (1965)[1], Cendrero (MS 1965)[1] and Bohl (1966a, 1967), and the second, labelled "Girth 2", is approximately G = 0.56 TL - 1.50, based on relationships reported by Hodder and May (1965)[1], Wiles and May (1968)[1], Bohl (MS 1966b) and Cendrero (MS 1965)[1]. Both length-girth relationships include data from different geographical regions of the Northwest Atlantic and for different periods of the year although no trend was noted. The 50% retention length for the 90 mm mesh from the Canada-Cuba study is well above the regression line (Fig. 6), again indicating the escapement of larger fish than would be expected.

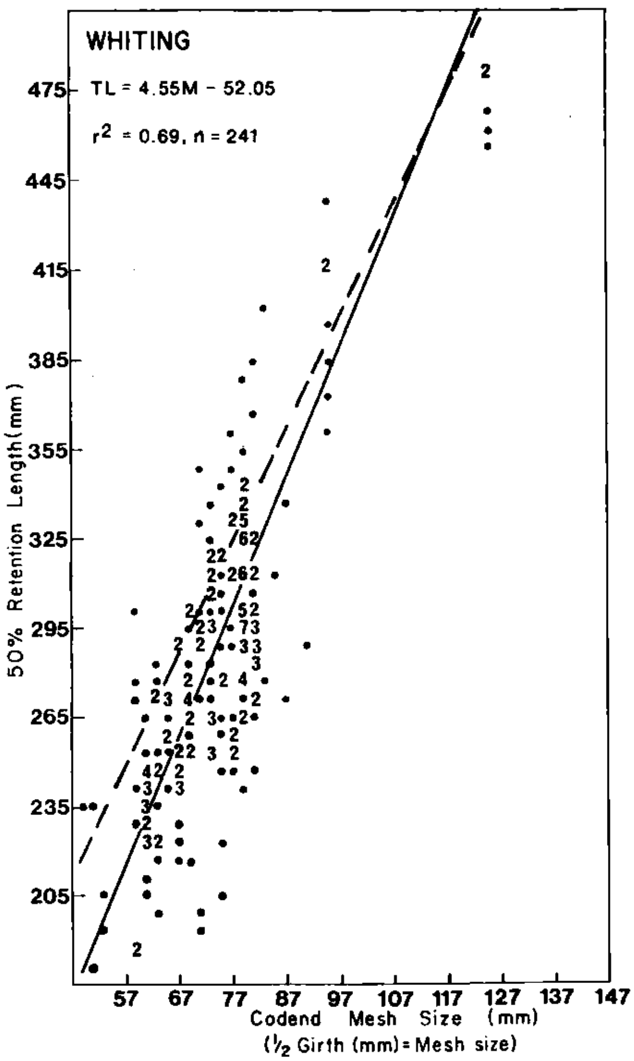

Fig. 10. General selection pattern for whiting based on historical mesh selection studies. (This species is not found in the Northwest Atlantic; other descriptors are the same as for Fig. 4.)

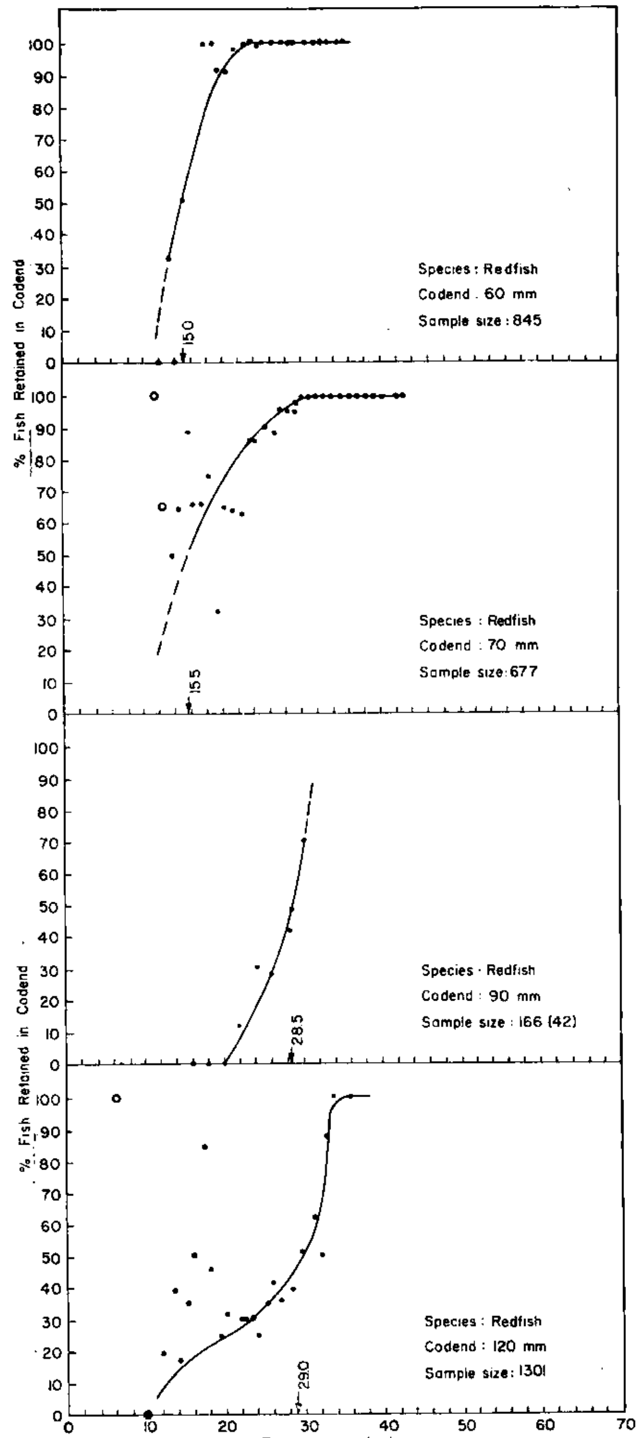

Fig. 11. Selection curves for redfish from the joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

[1] Fish lengths were expressed as fork length.

Other gadoids

Examination of available data for other gadoid species collected during the 1977 cooperative studies reveal that the 50% retention length for pollock, *Pollachius virens*, with a 90 mm mesh is 380 mm (Fig. 7), which is virtually the same as that obtained for cod (see Fig. 5). The 50% retention lengths for red hake, *Urophysis chuss*, were estimated at 242, 190 and 465 mm for codend mesh sizes of 60, 70 and 120 mm respectively (Fig. 8). These points fall completely within the bounds of the historical haddock data (Fig. 4), a gadoid with similar soft body characteristics.

Selection curves for silver hake are discussed in detail by Clay (MS 1978). The general selection pattern based on historical data is defined by the regression

$$TL = 4.04\ M - 26.12 \qquad (r^2 = 0.77,\ n = 58)$$

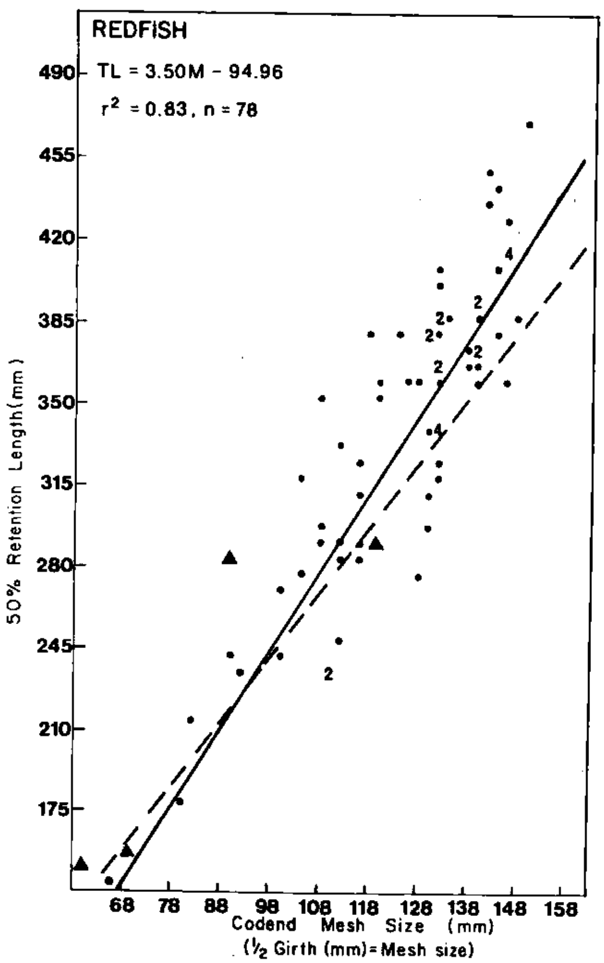

Fig. 12. General selection pattern for redfish based on historical mesh selection studies. (Other descriptors are the same as for Fig. 4.)

which is illustrated in Fig. 9, together with the length-girth relationship, $G = 0.48\ TL - 1.99$. The 50% retention lengths (triangles) show a trend in bias opposite to that observed for the gadoids noted above. This may be due to the softer, thinner body of silver hake when compared with that of cod and pollock.

Although not found on the Scotian Shelf, the whiting, *Merlangius merlangus*, is a gadoid for which much historical selectivity data are available from the Northeast Atlantic (Holden, 1971). The general selection pattern, defined by the regression

$$TL = 4.55\ M - 52.05 \qquad (r^2 = 0.69,\ n = 241)$$

and a length-girth relationship ($G = 0.60\ TL - 3.60$), based on data reported by Gulland (1956) and Margetts (1954), are illustrated (Fig. 10) to further test the developing patterns of mesh selection. The regression line for the general selection pattern and the length-girth relationship (dashed line) follow the established pattern for other gadoids; the 50% retention length falls slightly below the length at which the girth equals twice the codend mesh size (stretched)

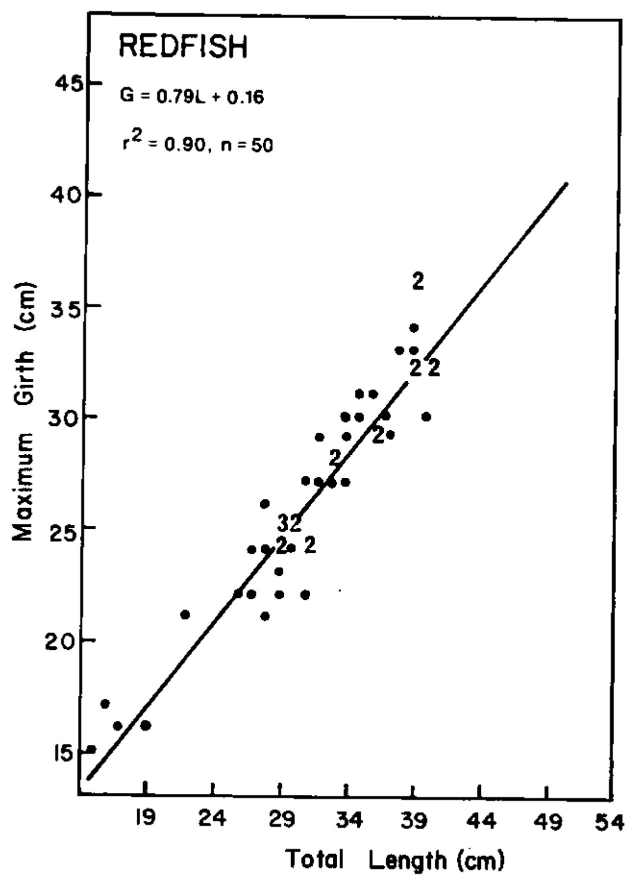

Fig. 13. Length-girth relationship for redfish from data collected by the author in a Canadian research cruise on the Scotian Shelf in 1978.

(at least over the range of codend mesh size to which most of the data apply).

Atlantic redfish, *Sebastes* spp.

Selection curves for redfish from the 1977 co-operative studies (Fig. 11) indicate 50% retention lengths of 150, 155, 285 and 290 mm for codend mesh sizes fo 60, 70, 90 and 120 mm respectively. The general selection pattern (Fig. 12) based on historical data is defined by the regression

$$TL = 3.50\ M - 94.96 \qquad (r^2 = 0.83,\ n = 78)$$

which is quite different in absolute values from those described above for gadoids. The length-girth relationship, from data collected by the author on the Scotian Shelf in 1978 (Fig. 13) and defined by the regression G = 0.79 TL + 0.16 (r^2 = 0.90, n = 50), is very similar to that reported by Templeman (1963) in Newfoundland. Of the four points representing the results of the 1977 studies (triangles in Fig. 12), that for the 90 mm mesh deviates from the general trend. This anomaly may in part be due to inadequate data. In contrast to the patterns for gadoid species, the length-girth relationship lies largely to the right and below the regression line defining the general selection pattern (Fig. 12). This indicates that the net is retaining larger fish than would theoretically be predicted from the length-girth relationship. The reason for this may be the firmer nature of the body of redfish and its numerous spines and boney protrusions of the opercula, constrast the smoother, softer bodies of gadoids.

Flatfishes

Little data were collected on selection of flatfishes during the two studies in 1977. For American plaice,

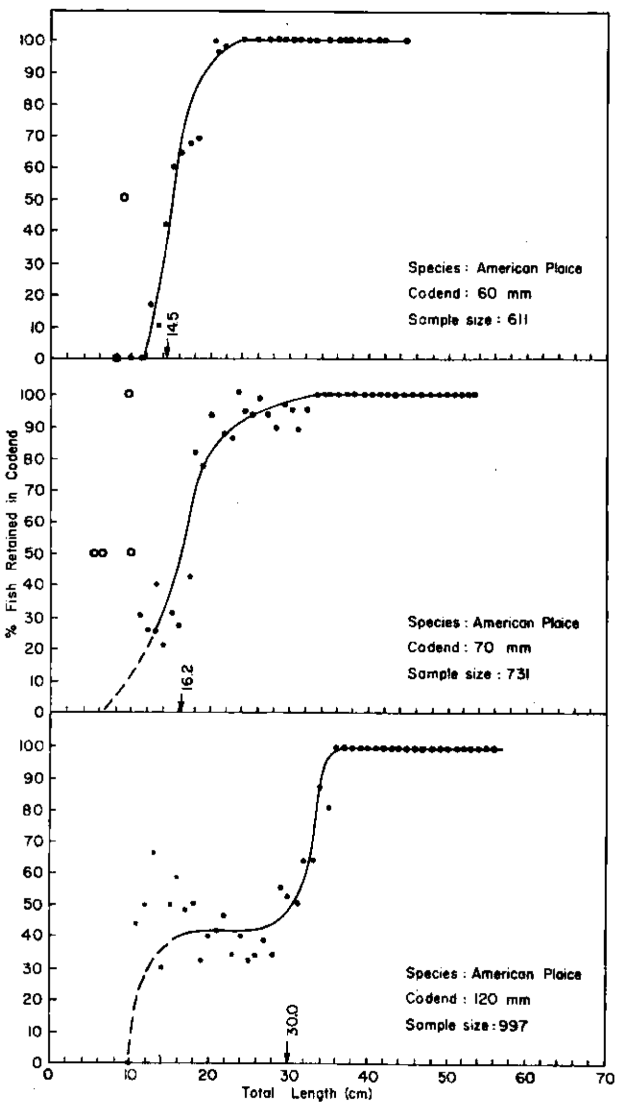

Fig. 14. Selection curves for American plaice from the joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

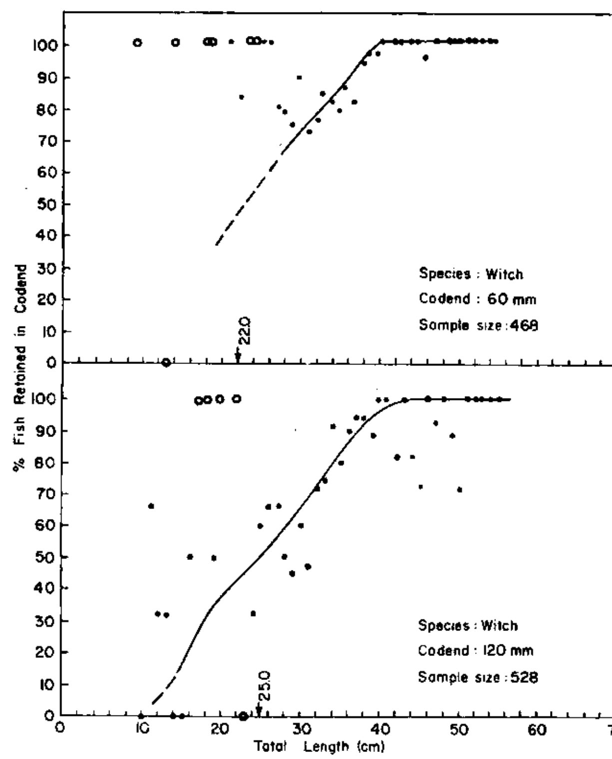

Fig. 15. Selection curves for witch flounder from the joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

Hippoglossoides platessoides, 50% retention lengths of 145, 162 and 300 mm were estimated for codend mesh sizes of 60, 70 and 120 mm respectively (Fig. 14), and the 50% retention lengths for witch flounder, *Glyptocephalus cynoglossus*, were 220 and 205 mm for 60 and 120 mm mesh codends (Fig. 15).

The general selection pattern for American plaice based on historical data is illustrated in Fig. 16, the regression line being defined by

$$TL = 2.32\ M - 3.29 \qquad (r^2 = 0.95,\ n = 25).$$

The general selection pattern for the European dab, *Limanda limanda*, is defined by $TL = 2.38\ M + 8.97$ ($r^2 = 0.46$, $n = 36$). These data, together with historical data for the yellowtail flounder, *Limanda ferruginea*, and current flatfish selection ogives, are shown in Fig. 17. The general selection pattern for these flatfishes is defined by the relationship

$$TL = 2.10\ M + 22.91 \qquad (r^2 = 0.92,\ n = 67).$$

The results of the 1977 studies for American plaice and witch flounder are indicated by the letters "A" and "W" respectively. In addition, the observations on witch flounder by Templeman (1963) are indicated by the letters "WT".

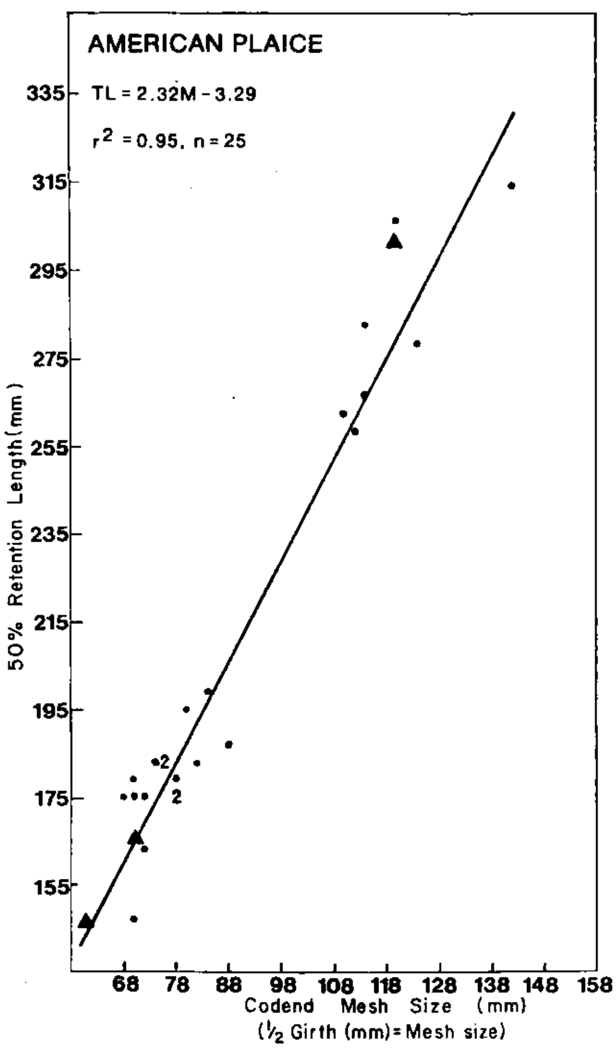

Fig. 16. General selection pattern for American plaice based on historical mesh selection studies. (Other descriptors are the same as for Fig. 4.)

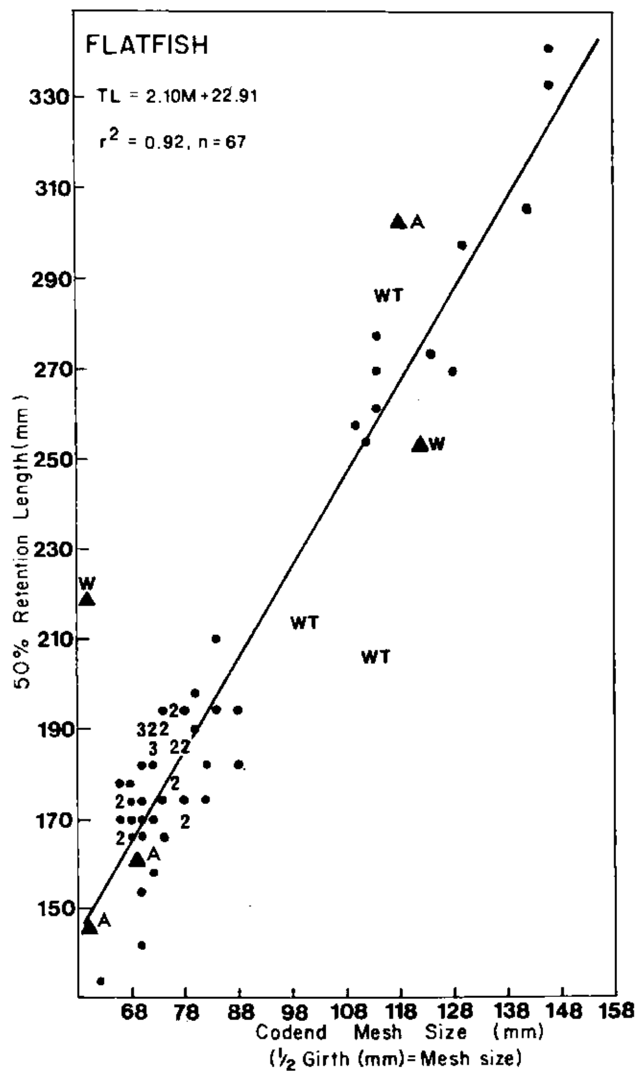

Fig. 17. General selection pattern for flatfish species based on historical mesh selection studies. (The 1977 results for American plaice and witch flounder are indicated by A and W, and Templeman's (1963) values for witch are indicated by WT; other descriptors are the same as for Fig. 4.)

Pelagic species

From the limited amount of data collected for alewife, *Alosa pseudoharengus*, the 50% retention lengths were 180 and 240 mm in 60 and 70 mm mesh codends, and for mackerel, *Scombrus scombrus*, the 50% retention length was 160 mm in a 60 mm mesh codend (Fig. 18).

Discussion

Graham (1954) proposed that mesh selection could be predicted from girth measurements, and since then various attempts have been made to utilize this concept for selection in otter trawls (Margetts, 1954; Gulland, 1956) and gillnets (Kondo, 1966; Berst, 1961; Kawamura, 1972). From the present review, it appears that the line representing the length-girth relationship runs approximately parallel to and above the regression line representing the general selection pattern, the extent of the separation of the lines being dependent on the firmness of the body. Exceptions to this pattern are those species with bony protrusions which may inhibit escapement (e.g. redfish), and result in length-girth relationships which usually lie below the general selection pattern. In the absence of adequate mesh selection data, length-girth relationships may be used to approximate the general selection pattern over a range of mesh sizes and allow the estimation of selection factors for the species concerned.

For comparison of the general selection patterns of the various species considered in this paper, the regression lines are plotted in Fig. 19. It appears that the gadoid species investigated can be considered as having similar selection patterns. Although the lines for cod and haddock have different slopes, they are quite close over the range of codend mesh sizes applicable to management of the Scotian Shelf

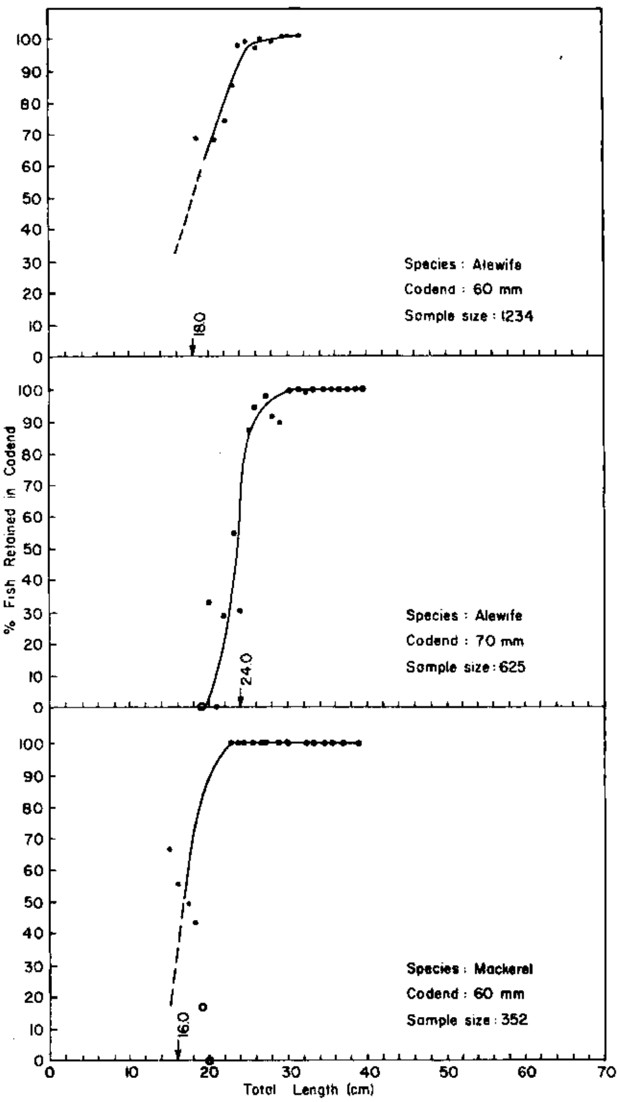

Fig. 18. Selection curves for alewife and mackerel from joint mesh selection studies on the Scotian Shelf in 1977. (Other descriptors are the same as for Fig. 3.)

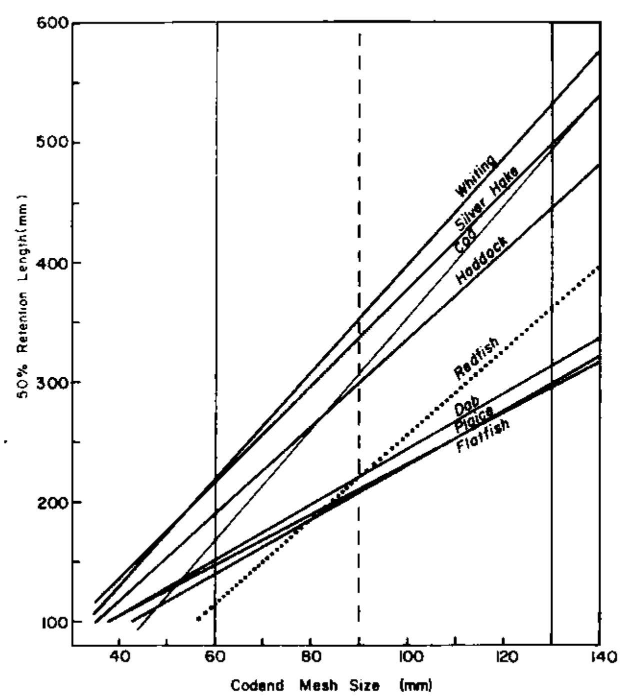

Fig. 19. General selection patterns (regression lines) for all groundfish species considered in this paper. (The vertical lines represent the curent minimum 60 mm mesh for silver hake, the minimum 130 mm mesh for other groundfish species, and the proposed minimum 90 mm mesh (Clay, 1979) to replace the 60 mm mesh size in use for silver hake on the Scotian Shelf.)

fisheries. The regression line for redfish deviates significantly from those of the gadoid species, the reason for this being the shape of the body and the boney structures of the head. The lines for the flatfishes are very different in slope from those of the gadoids and redfish.

Most of the 50% retention lengths for the various fish species sampled on the Scotian Shelf in 1977 fit the historical selection patterns reasonably well. Exceptions, such as the 50% retention length for witch flounder in the 60 mm mesh codend (Fig. 17), are probably due to small numbers of fish in the selection range. The most valuable result of this analysis is the possibility of utilizing past studies on species of interest to produce "general selection patterns" which may be useful in analyzing the effects of mesh regulations on species of fish having similar body form but for which no mesh selection data are available. Such a selection pattern for a species could be considered as a valid "commercial average". The inherent variability in mesh selection studies raises the question of the necessity and value for further studies on species for which much data already exist. In the case of species for which selection studies are not well documented, the possibility exists of estimating a "commercial average" general selection pattern from the length-girth relationship, if some assumptions are made about the shape, smoothness and firmness of the body.

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