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New experiments on trawl-mesh
selection of hake on the Portuguese Coast

by

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ABSTRACT

Results on bottom trawl selectivity with three cod ends mesh sizes of nylon (32.7, 67.3 and 74.5 mm) and concerning hake, are presented. The experiments took place on the Portuguese Coast, in January 1986, on board of the R/V "NORUEGA".

Logistic equation was applied to estimate selectivity parameters, using two methods: simple logit linear regression and the method described by Paloheimo and Cadima (1964).

The selection factors estimated increased with the mesh size, from 3.3 to 5.3. The selection range obtained was wider with the weighted method than with the simple linear regression.

RESUME

Dans cette communication sont présentés les résultats des expériences de selectivité du chalut de fond, effectuées avec des poches de maillages moyennes de 32.7, 67.3 et 74.5mm. La méthode utilisée était celle de la double poche. Les essais ont été faits dans la côte portugaise, en Janvier 1986, et avec le navire de recherche "NORUEGA". Les courbes de selectivité ont été ajustées grâce à l'équation logistique, en utilisant deux méthodes: la regression linéaire simple et la méthode décrite par Paloheimo et Cadima (1964).

Les facteurs de selection ont augmenté avec les tailles des maillages, de 3.3 à 5.3. Les écarts de selection obtenus avec la méthode ponderée sont plus grands que ceux résultant avec l'autre méthode.

1. INTRODUCTION

During January 1986 (eight days) was conducted on board of the Portuguese R/V "NORUEGA" a special cruise for trawl selectivity, on the Portuguese Coast.

The main objectives of the cruise were to estimate and review selectivity parameters for three cod ends mesh sizes (40, 60 and 80 mm). The target species were hake and horse-mackerel.

The last Portuguese study about bottom trawl selectivity (CARDADOR and BORGES, 1982) concerns cod end mesh sizes of 40 and 60 mm. The aim of the present paper is to review that study, in what refers to hake, and to add selectivity information to 80 mm mesh size, using the covered cod end method.

2. MATERIAL AND METHODS

2.1. Vessel and gear

The specifications of the Portuguese R/V "NORUEGA" and the gear used are presented on Table 1.

Three cod ends mesh sizes were applied, with approximately 40, 60 and 80 mm, in nylon material (16 braided netting twines). The cod end mesh sizes were measured wet, in the end of each haul, with an ICES gauge at 4 kg pressure. Those measurements were taken (diagonally) from randomly longitudinal lines along the cod end. The results are presented on Table 2.

The covered cod end was in nylon material (3 twisted netting twines), with mean mesh size of 20.6 mm ($s = 0.58$). The cover was attached two meters beyond the end of the cod end of the selected bottom trawl nets.

2.2. Geographical areas

The geographical areas where were carried out the selectivity experiments were selected according three criteria:

- ship time
- biggest abundance of hake and horse-mackerel and

- widest length range of the two species .

The latter two factors were evaluated taking into consideration the data from the two 1985 bottom trawl surveys.

The areas covered were the Southwest and South coast of Portugal, between 20 and 500 meters depth.

2.3. Characteristics of the hauls

The hauls were carried out during day-light and with 3.5 knots of towing speed.

The total number of hauls was thirty (30):

- 10 with cod end mesh size around 40 mm
- 8*with cod end mesh size around 60 mm
- 12*with cod end mesh size around 80 mm

The tow duration had the following ranges:

- 25 - 120 minutes (cod end \approx 40 mm)
- 60 - 120 minutes (cod end \approx 60 mm)
- 60 - 120 minutes (cod end \approx 80 mm)

2.4. Fish measurements

The total length of the hake caught was measured to the centimeter below. To the estimation of the relationship between maximum girth and total length, the fish selected was measured to the millimeter in both cases. These data were collected under the responsibility of Hélia Dinis.

2.5. Fitting the selectivity curves

Two methods were applied to fit the selection curves and to estimate the selectivity parameters.

It was assumed that the selection curve has a logistic form, which is expressed by the equation:

$$p = \frac{1}{1 + e^{-(aL+b)}} \dots\dots\dots (1)$$

* one haul was not valid because the covered cod end had opened due to the high catch of blue whiting.

where p is the fraction of the fish retained in the cod end at a total length L

The equation (1) can be transformed in:

$$\ln \left(\frac{p}{1-p} \right) = a L + b \dots \dots \dots (2)$$

The simple linear regression allows to estimate the parameters a and b and from them the selectivity parameters, with the following procedures:

$$L_{50\%} = -b/a \dots \dots \dots (3)$$

$$L_{25\%} = L_{50\%} - \frac{\ln 3}{a} \dots \dots \dots (4)$$

$$L_{75\%} = L_{50\%} + \frac{\ln 3}{a} \dots \dots \dots (5)$$

$$\Delta = L_{75\%} - L_{25\%} = \frac{2 \ln 3}{a} \dots \dots \dots (6)$$

The selection factor (SF) is estimated from $L_{50\%}$ and the mean mesh size (MS), in the same units:

$$SF = L_{50\%} / MS \dots \dots \dots (7)$$

Another method used to estimate a and b of the equation (1) is the one described by PALOHEIMO and CADIMA (1964). This method is also a linear regression of the equation (2) but takes into account the total number of fish caught, for each length (cover + cod end), the fraction retained and the fraction which was not retained in the net. This weighted factor (for each length) is expressed as:

$$W_i = n_i p_i (1 - p_i) \dots \dots \dots (8)$$

Where n_i is the total number of fish caught (cover + cod end) for the length L_i .

Following this procedure, the parameters a and b of the selectivity curve can be estimated weighting each pair by its weighted factor. The others selectivity parameters will be estimated in the same way as it was referred above (equations 3, 4, 5, 6 and 7).

The homogeneous hauls for the same mesh size were grouped and the selectivity parameters were estimated following the two methods described above. Tables 3, 4 and 5 present the data base used.

3. RESULTS AND DISCUSSION

3.1. Girth - total length relationship

Biological data collected as mentioned on section 2.4, had conducted to the following relationship:

$$\begin{matrix} G & = & 0.455 & L & - & 1.169 & \dots\dots\dots & (9) \\ (\text{cm}) & & & (\text{cm}) & & & & \end{matrix}$$

$$r = 0.994$$

$$\text{total number of fish} = 561$$

$$\text{length range} = 10 - 65 \text{ cm}$$

$$\text{number of hake bigger than 50 cm} = 22$$

The relationship (9) is similar to the Spanish one of April 1979 (ROBLES, R. et al, 1980).

3.2. Selectivity parameters

Selectivity parameters and curves were estimated according to the two methods mentioned on section 2.5, to the homogeneous hauls grouped. Table 6 summarizes the results for the three cod end mesh sizes. Figures 1, 2 and 3, show the equivalent selection curves. Tables 7, 8 and 9 present for each mesh size the information and data required. It was not possible to consider all the valid hauls, because some of them had not caught hake and others were not homogeneous. This latter was mainly due to the high catch of blue whiting.

Selectivity parameters were not related with the tow duration, due to small catch of hake and its length distribution.

a) $L_{50\%}$ and selection factor (SF)

The 50% retention lengths estimated from Paloheimo and Cadima method were bigger than the ones estimated from the unweighted method, except for mesh size of 32.7 mm. On this case the $L_{50\%}$ were very similar: 10.9 cm (Pal. and Cadima) and 10.7 cm. For the mesh sizes of 67.3 and 74.5 mm the estimated values of $L_{50\%}$ were very different: 27.7 - 32.2 cm

and 31.8 - 39.4 cm.

Comparing the 50% retention lengths estimated with the maximum girth (from equation 9) corresponding and with the estimates of internal mesh perimeter, (MARGETTS, 1957), the percentages of mesh lumens occupied are:

Mesh size (mm)	Girth at $L_{50\%}$ (cm)	% of occupation
32.7	3.7 (3.8)	55 (54)
67.3	11.4 (13.5)	82 (97)
74.5	13.3 (16.8)	87 (110)

The values between () concern the $L_{50\%}$ estimated from Paloheimo and Cadima method.

The percentage of occupation 110, which corresponds to $L_{50\%}$ of 39.4cm, can suggest that $L_{50\%}$ and therefore the selection factor (5.3) is too high.

The values of the selection factors (SF) had increased with the increase of the mesh size:

Mesh size (mm)	Selection factor	
	Unweighted method	Weighted method
32.7	3.3	3.3
67.3	4.1	4.8
74.5	4.3	5.3

This range of the selection factors (3.3 - 5.3) is in the same range of the values obtained by other authors and published on ROBLES, R. et al (1980), for nylon (polyamide) material.

b) Selection range ($L_{75\%} - L_{25\%}$)

In general terms, the selection range estimated from the two methods of fitting the selection curves, tends to increase as the mesh size increases. This conclusion was also referred by DARDIGNAC and de

VERDELHAN (1978).

This selectivity parameter, (Δ), was wider when Paloheimo and Cadima method was applied. The values estimated on this case were the following ones:

MS 32.7 mm	-	Δ	= 4.4 cm
MS 67.3 mm	-	Δ	= 20.0 cm
MS 74.5 mm	-	Δ	= 26.2 cm

The selection ranges estimated from simple linear regression were: 3.0 cm (32.7 mm), 15.0 cm (67.3 mm) and 13.6 cm (74.5 mm).

c) Effects of reducing the length range of fitting

An essay with the two methods, was tried to estimate the effects of reducing the length range of fitting the selection curve.

The test was applied to data base referred to 74.5 mm mesh size (table 5).

The length classe range 20 - 40 cm was adopted. In this range the fractions retained in the cod end are theoretically more adjusted to the fitting. The regression coefficients estimated were 0.989 and 0.982, instead of 0.898 and 0.666 (see table 6).

The selectivity parameters obtained were as follows:

	$L_{50\%}$	Δ	SF
<u>Method</u>	(cm)	(cm)	
Unweighted	32.3	8.2	4.27
Weighted	32.5	8.9	4.36

Comparing these results with the ones presented on table 6, one can conclude that for the first method of fitting, the $L_{50\%}$ and therefore the selection factor are similar ($L_{50\%} = 31.8$ cm and $SF = 4.27$). The selection range on table 6 ($\Delta = 13.6$ cm) is bigger than the value obtained with this essay ($\Delta = 8.2$ cm).

The Paloheimo and Cadima method gave, on this essay, a smaller $L_{50\%}$, Δ and SF.

This test clearly indicates that the length range of fitting had a strong influence on the selectivity parameters estimates.

4. SOME CONCLUSIONS

Comparing the selectivity parameters estimated on this study with those obtained for the same net material nylon (polyamide), experimental method and mesh sizes, (which summary are published on ROBLES, R. et al (1980)), one can achieve to some conclusions :

- Concerning the smallest mesh size of this study, 32.7 mm LARRAÑETA et al (1969) had obtained for mesh size of 34 mm, selection factor = 3.5, $L_{50\%}$ = 11.9 cm and selection range = 2.9 cm. These values are very close to the ones presented on this study, using the unweighted method.
- For the mesh size of 67.3 mm, DARDIGNAC and de VERDELHAN (1978) estimated $L_{50\%}$ around 27 cm and selection factor around 4. These selectivity parameters are also similar to the ones estimated on the present paper with the simple linear logit regression.
- The results estimated for 74.5 mm mesh size can be compared with those obtained by the Spanish scientists (ROBLES, R. et al, 1980). The $L_{50\%}$ estimated for mesh size of 74 mm were 34.7 cm and 35.9 cm (depending on the method of estimation) while on this study were 31.8 - 39.4 cm. The selection factors estimated (4.7 - 4.9) are between the ones on table 6 (4.3 - 5.3). The selection ranges estimated by the Spanish were 13.5 - 15.4 cm. The results presented on this study are 13.6 - 26.2 cm. As it was mentioned on section 3.2 - a) the 50% Length retention estimated of 39.4 cm, seems to be too high, according to percentage of mesh lumen occupied. Reducing the length range of adjustment the values estimated with the weighted method were smaller than with the wider length range.

The values of SF estimated on CARDADOR and BORGES (1982), for nylon material and for the smallest mesh sizes, were between 3.7 and 4.3, which are in the range of the ones estimated on this study.

The selectivity experiments presented on this paper showed that although the fishing areas were choosen hake catches were small. The maximum average catch per hour was 29 Kg, what becomes difficult to obtain selection curves for each haul.

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TABLE 1. Research vessel "NORUEGA" and gear specifications

1. Length over all	: 47.5 m
2. Power	: 1500 HP
3. GRT	: 495 Tons
4. Type of ship	: stern trawler
5. Type of gear	: bottom trawl
Length of ground-rope	: 33.2 m
Length of head-rope	: 39.1 m
Head rope height	: 3-4 m
Circunference at head-rope	: 1056 meshes (60 mm)
Circunference at ground-rope	: 924 meshes (60 mm)
Rollers on ground-rope	: Yes
Type of doors	: rectangular stell (Norwegian type)
Door weight	: 650 kg
Door dimension	: 2.7 x 1.4 m
Mesh size (Wings)	: 80 mm
Mesh size (body)	: 60-40 mm
Mesh size (cod end)	: \approx 40 mm (nylon)
	\approx 60 mm (nylon)
	\approx 80 mm (nylon)
Mesh size (cover)	: \approx 20 mm
Length of cod end	: 10 m (stretched mesh)

TABLE 2. Mesh measurements of cod ends (bottom trawl nets)

Material : 16 braided twines (nylon)

Mean mesh (mm)	Standard desviation (mm)	range (mm)	Number of meshes measured
32.7	1.81	28-44	458
67.3	0.53	62-74	313
74.5	0.46	68-81	479

TABLE 3. Data base used to fit selection curves for hake
 - R/V "NORUEGA" (January 1986)

Length class (cm)	Cod end (number of fish)	Cover (number of fish)	% Ret.
9-		7	0
10-	15	17	46.9
11-	100	55	64.5
12-	193	96	66.8
13-	175	34	83.7
14-	80	4	95.2
15-	12		100.0
16-	4		
17-	3		
18 < L < 59	126		
TOTAL	708	213	
Number of hauls			
8			
Mean mesh size (mm)			
32.7			

TABLE 4. Data base used to fit selection curves for hake

- R/V "NORUEGA" (January 1986)

Length class (cm)	Cod end (number of fish)	Cover (number of fish)	% Ret.
10-	3	25	10.7
12-	25	176	12.4
14-	54	364	12.9
16-	35	208	14.4
18-	21	99	17.5
20-	10	30	25.0
22-	4	13	23.5
24-	4	4	50.0
26-	3	7	30.0
28-	3	2	60.0
30-	3		100.0
32/4 L/4 58	11		
TOTAL	176	928	
Number of hauls	6		
Mean mesh size (mm)	67.3		

TABLE 5. Data base used to fit selection curves for hake
 - R/V "NORUEGA" (January 1986)

Length class (cm)	Cod end (number of fish)	Cover (number of fish)	% Ret.
8-	1	41	2.4
10-	23	250	8.4
12-	106	500	17.5
14-	56	457	10.9
16-	34	463	6.8
18-	28	358	7.3
20-	6	167	3.5
22-	18	138	11.5
24-	11	77	12.5
26-	17	71	19.3
28-	17	51	25.0
30-	18	27	40.0
32-	18	17	51.4
34-	20	8	71.4
36-	21	5	80.8
38-	19	5	79.2
40-	28	2	93.3
42-	16		100.0
44-	11		
46-	7		
48-	5		
50/L/63	8		
TOTAL	488	2637	
Number of hauls	9		
Mean mesh size (mm)	74.5		

TABLE 6. Main results of selectivity from bottom trawl nets, concerning hake - R/V "NORUEGA" (January 1986)

	M e a n m e s h s i z e (mm)					
	32.7		67.3		74.5	
	U	W	U	W	U	W
Length range of fit (cm)	10-14	10-13	10-28	10-28	8-40	8-38
Number of length classes	5	4	10	10	17	16
Slope (a)	0.7282	0.5031	0.1461	0.1098	0.1618	0.0839
s_a^2	0.0159	0.0305	0.0003	0.0003	0.0004	0.0006
Interception (b)	-7.9419	-5.3830	-4.0395	-3.5336	-5.1491	-3.3027
s_b^2	2.5125	4.6633	0.1210	0.0888	0.3012	0.2523
Regression coefficient (r)	0.9579	0.8976	0.9514	0.9100	0.8983	0.6662
$L_{50\%}$ (cm)	10.9	10.7	27.7	32.2	31.8	39.4
$L_{25\%}$ (cm)	9.4	8.5	20.2	22.2	25.0	26.3
$L_{75\%}$ (cm)	12.4	12.9	35.2	42.2	38.6	52.5
$L_{75\%}-L_{25\%}$ (cm)	3.0	4.4	15.0	20.0	13.6	26.2
Selection factor (SF)	3.33	3.27	4.12	4.78	4.27	5.28

U - Simple linear regression (Unweighted),

W - Weighted linear regression (Paloheimo and Cadima, 1964)

TABLE 7 Selectivity data for grouped hauls - R/V "NORUEGA"
(January 1986)

Hake - Merluccius merluccius

1. Material.....	nylon
2. Number of hauls.....	8
3. Average duration of tow (minutes).....	70
4. Average towing speed (knots).....	3.5
5. Average depth (meters).....	131
6. Cod end mesh size, mean (mm).....	32.7
range.....	28-44
number of measurements.....	458
7. Selection range (cm).....	9.4-12.4 (8.5-12.9)
8. Number of fish in selection range.....	483
cod end.....	308
cover.....	175
9. Total number caught.....	921
cod end.....	708
cover.....	213
10. Average weight per haul (Kg).....	6.3
cod end.....	6.0
cover.....	0.3
11. Average weight of total catch per haul (Kg).....	314
cod end.....	287
cover.....	27
12. Range of total catch per haul (Kg).....	152-492
cod end.....	151-390
cover.....	0.2-125
13. 50% Retention length (cm).....	10.9 (10.7)
14. Selection factor.....	3.33 (3.27)

() values estimated from PALOHEIMO and CADIMA (1964) method.

TABLE 8 Selectivity data for grouped hauls - R/V "NORUEGA"
(January 1986)

Hake - Merluccius merluccius

1. Material.....	nylon
2. Number of hauls.....	6
3. Average duration of tow (minutes).....	60
4. Average towing speed (knots).....	3.5
5. Average depth (meters).....	78
6. Cod end mesh size, mean (mm).....	67.3
range.....	62-74
number of measurements.....	313
7. Selection range (cm).....	20.2-35.2 (22.2-42.2)
8. Number of fish in selection range:.....	88 (51)
cod end.....	32 (25)
cover.....	56 (26)
9. Total number caught.....	1104
cod end.....	176
cover.....	928
10. Average weight per haul (Kg).....	6.9
cod end.....	2.3
cover.....	4.6
11. Average weight of total catch per haul (Kg).....	108
cod end.....	18
cover.....	90
12. Range of total catch per haul (Kg).....	45-201
cod end.....	5-47
cover.....	11-192
13. 50% Retention length (cm).....	27.7 (32.2)
14. Selection factor.....	4.12 (4.78)

() values estimated from PALOHEIMO and CADIMA (1964) method.

TABLE 9 Selectivity data for grouped hauls - R/V "NORUEGA"
(January 1986)

Hake - Merluccius merluccius

1. Material.....	nylon
2. Number of hauls.....	9
3. Average duration of tow (minutes).....	107
4. Average towing speed (knots).....	3.5
5. Average depth (meters).....	345
6. Cod end mesh size, mean (mm).....	74.5
range.....	68-81
number of measurements.....	479
7. Selection range (cm).....	25.0-38.6 (26.3-52.5)
8. Number of fish in selection range.....	402 (385)
cod end.....	141 (199)
cover.....	261 (186)
9. Total number caught.....	3125
cod end.....	488
cover.....	2637
10. Average weight per haul (Kg).....	29
cod end.....	16
cover.....	13
11. Average weight of total catch per haul (Kg).....	280
cod end.....	85
cover.....	195
12. Range of total catch per haul (Kg).....	42-767
cod end.....	13-387
cover.....	5-661
13. 50% Retention length (cm).....	31.8 (39.4)
14. Selection factor.....	4.27 (5.28)

() values estimated from PALOHEIMO and CADIMA (1964) method.

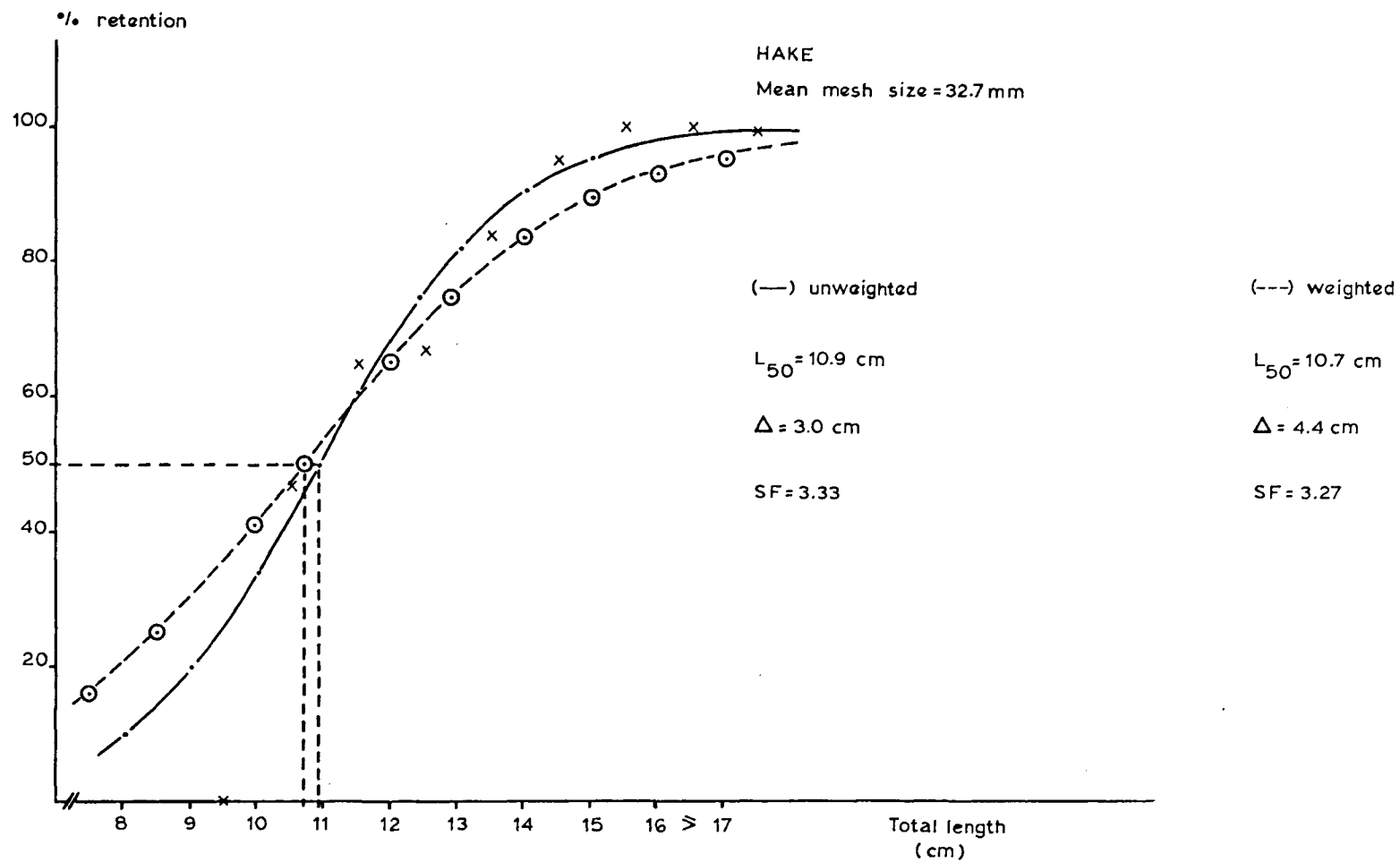


Fig. 1 - Selectivity curves for hake

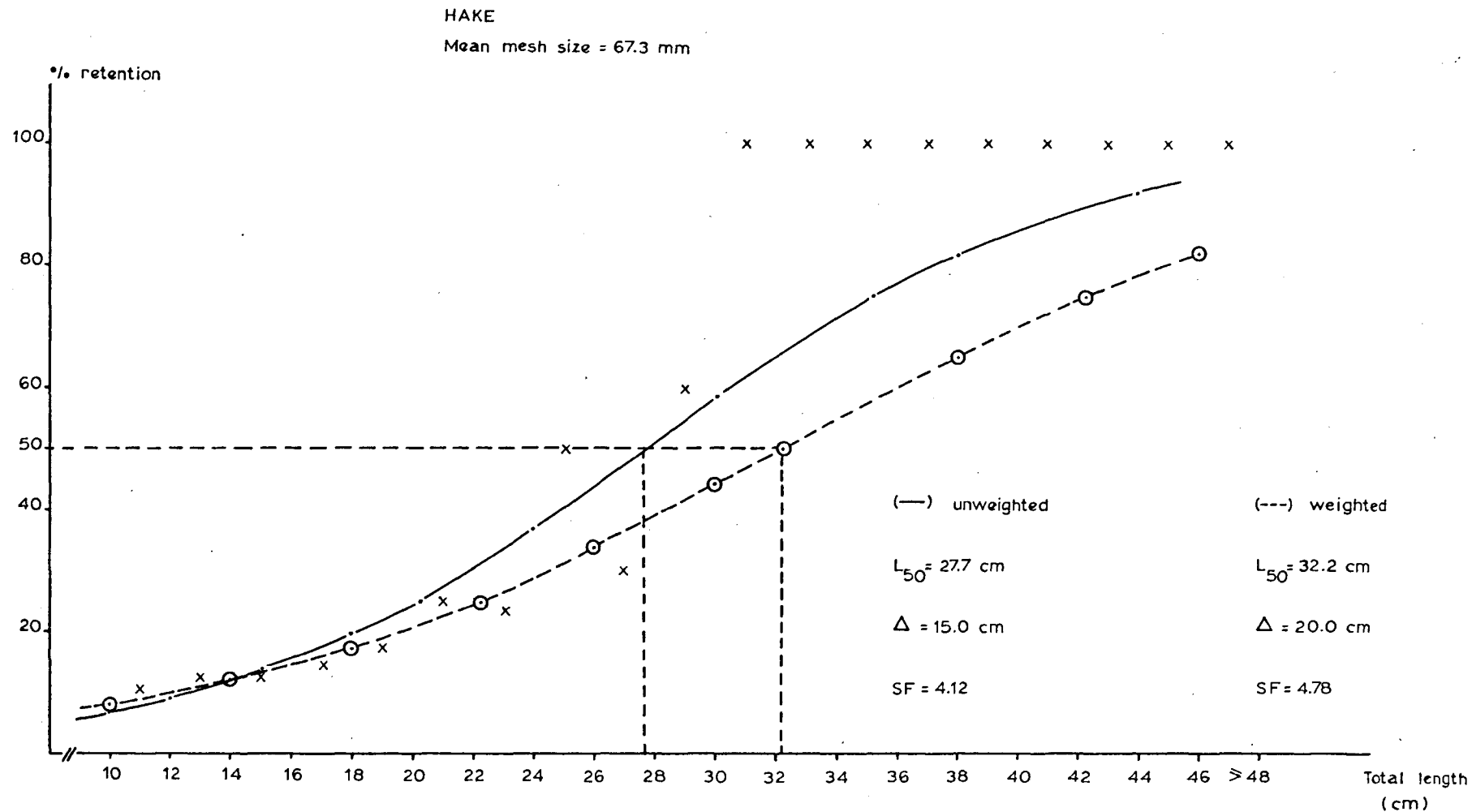


Fig. 2 - Selectivity curves for hake

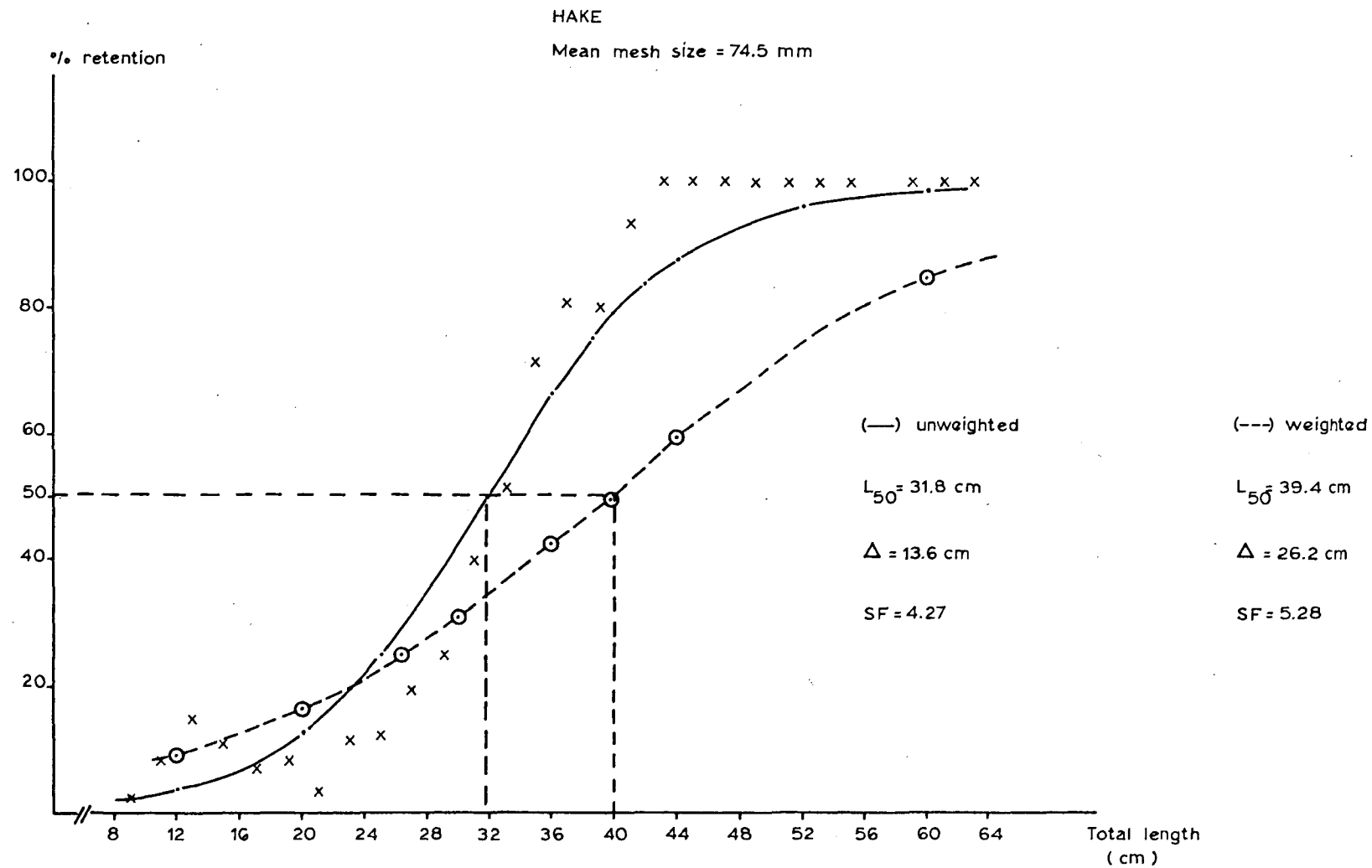


Fig. 3 - Selectivity curves for hake