

# A method of finding an empirical total selection curve for gill nets, describing all means of attachment

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## INTRODUCTION

A symmetrical or slightly skewed selection curve probably describes the selection of a gill net fairly accurately when the range of fish size does not greatly exceed the normal selection range. In some gill net fisheries, however, significant numbers of fish outside the size range of that for normal meshing are caught by other methods of attachment, for example, meshed by the maxillae, attached by the teeth, entangled by the tail, completely embedded in the net, etc.

In such a case the total selection curve for the net may deviate significantly from one that can be adequately described by a reasonably simple mathematical expression.

The present paper discusses a method of overcoming this difficulty when data are available on the methods of attachment of the fish caught, and it gives an example of how the method has been applied to establish selection curves for halibut gill nets. A preliminary report on this topic was presented at the 1961 statutory meeting of the International Council for the Exploration of the Sea (Olsen and Tjemsland 1961).

## THEORY

We assume that the selection curve for the fish meshed in the normal way (i.e. by the operculum and point of greatest girth) closely approximates a normal curve or a slightly skewed curve which can be determined, for example, by the method described by Holt (1957).

Let  $y_l$  be the ordinate of this curve at length  $l$ , and  $n_l$  the catch in number of fish caught by this method of attachment. Similarly  $y_l'$  and  $n_l'$  refer to the selection curve and catch of all other methods of attachment.

Then, 
$$n_l = N_l \cdot P \cdot y_l \quad (1)$$

and 
$$n'_l = N_l \cdot P \cdot y'_l \quad (2)$$

where  $N_l$  is the number of fish of length  $l$  encountered by the net and  $P$  is a constant.

We have now:

$$\frac{n_l}{n'_l} = \frac{y_l}{y'_l} \quad (3)$$

and 
$$y'_l = y_l \cdot \frac{n'_l}{n_l} \quad (4)$$

and the ordinate of the total selection curve at length  $l$

$$Y'_l = y_l + y'_l = y_l \left( 1 + \frac{n'_l}{n_l} \right) \quad (5)$$

or, if we choose  $y_{lm}$  as unity = 1

$$Y'_l = \frac{y_l}{Y'_{lm}} \left( 1 + \frac{n'_l}{n_l} \right) \quad (6)$$

## APPLICATION TO DATA

### a) *Material*

The material was obtained from experimental fishing conducted during January and February in the years 1957 to 1960 in an area at the entrance to the Alta Fjord in Northern Norway. The nets used were hemp and nylon nets of about 16" mesh size and nylon nets with mesh sizes of approximately 19" and 23". Measured under a tension of 4 kg, the mesh sizes for the three different types of nylon nets averaged 42.8 cm, 49.6 cm and 61.9 cm respectively.

The nets were spread in groups of two to five of each type throughout the fleets, and the positions of the groups were changed during the season. The type of net for each individual fish was recorded and the total length measured. In 1959 and 1960 girth measurements were also taken, and for part of the material records were kept of the way each fish was attached to the net.

In analysing the data the methods of attachment were divided into group 1) meshing by the operculum and point of greatest girth, and group 2) all other methods of attachment (i.e. meshed by the maxillae, attached by the teeth, entangled by the tail, completely embedded in the net etc.). Table I gives the numbers caught according to type of net and attachment method.

Table I. Numbers of halibut caught in 1959 and 1960 according to type of net and method of attachment.

Type of net	Numbers caught	
	Attachment 1	Attachment 2
Hemp 16"	82	23
Nylon 16"	145	44
Nylon 19"	92	29
Nylon 23"	78	25

b) *Calculation of selection curves*

For the meshed fish (attachment group 1) selection curves for the three different mesh sizes of nylon nets were calculated by the method described by Holt (1957):

$$n_l \propto \exp. - (l - l_m)^2 / \sigma^2$$

where:  $n_l$  is the number of fish of length  $l$  caught,  
and  $l_m$  is the mean selection length.

Table II gives the length distribution and log ratios when adjusted for differences in effort (number of nets fished), and in Fig. 1 the log ratios are plotted against length and lines fitted by the method of least squares.

From the lines of best fit values for  $K$  (the ratio between mean selection length and mesh size),  $l_m$  and the variance  $\sigma^2$  were computed.

The values of  $K$  were estimated as

$$K_{BA} = 3.325, K_{CA} = 3.133 \text{ and } K_{CB} = 3.154,$$

where the indices A, B and C refer to the mesh sizes 16", 19" and 23" respectively. The arithmetic mean of these,  $\bar{K} = 3.204$  gives:

${}_A l_m = 136.96$  cm,  ${}_B l_m = 158.72$  cm,  ${}_C l_m = 198.08$  cm, and the variance:  $\sigma^2 = 2886$ .

The selection curves established in this way for meshing by the operculum and point of greatest girth were then used to find the total selection curves for all methods of attachment, following the procedure described previously.

As a first step a free hand curve was fitted to the ratios between the numbers of fish meshed and those attached in other ways. This curve has a parabolic shape with a minimum approximately at the length of greatest selection by meshing (Fig. 2). This shows that other

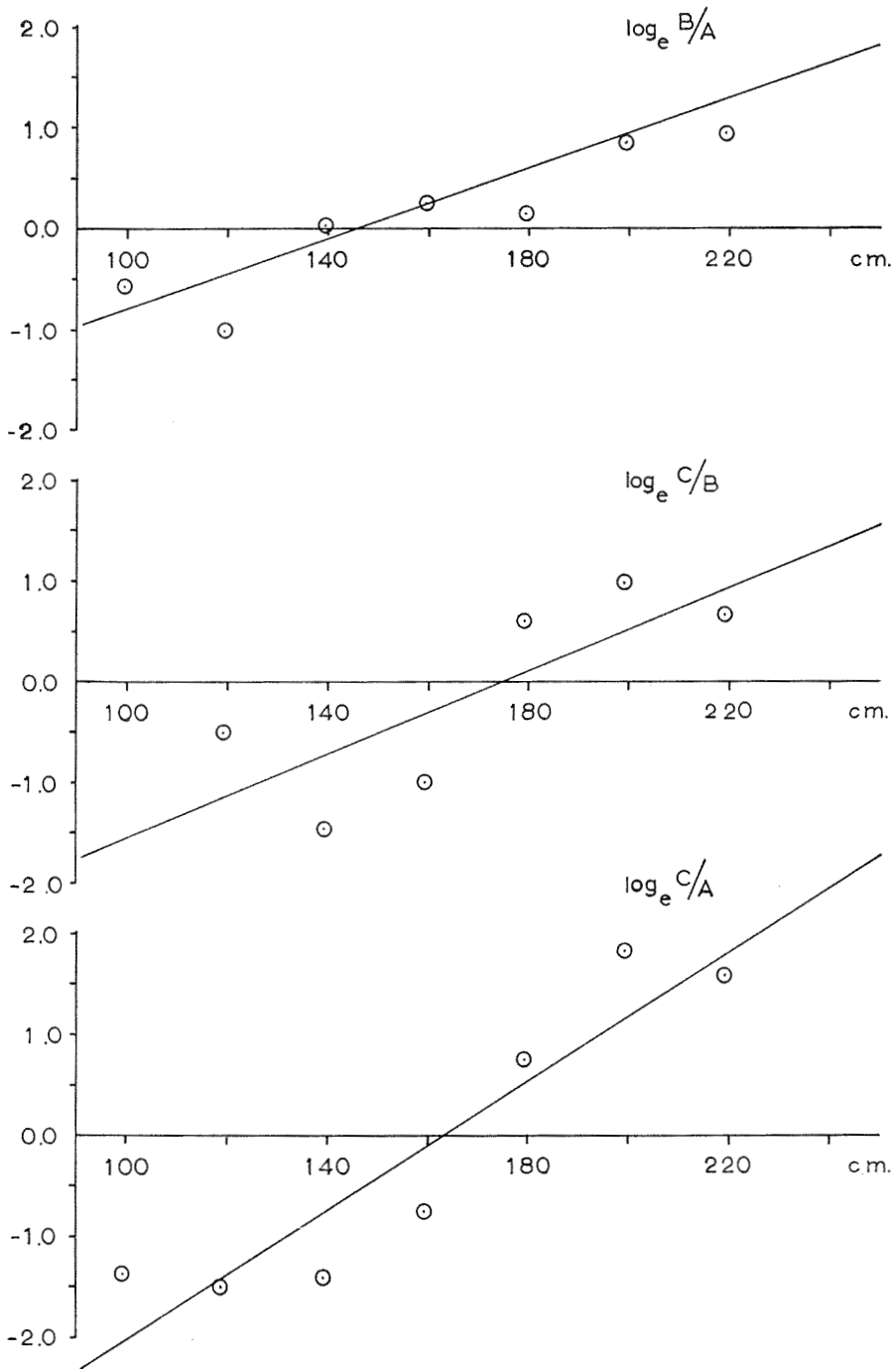


Fig. 1. Plots of log ratios against length for the data of the 16'' (A), 19'' (B) and 23'' (C) nylon nets.

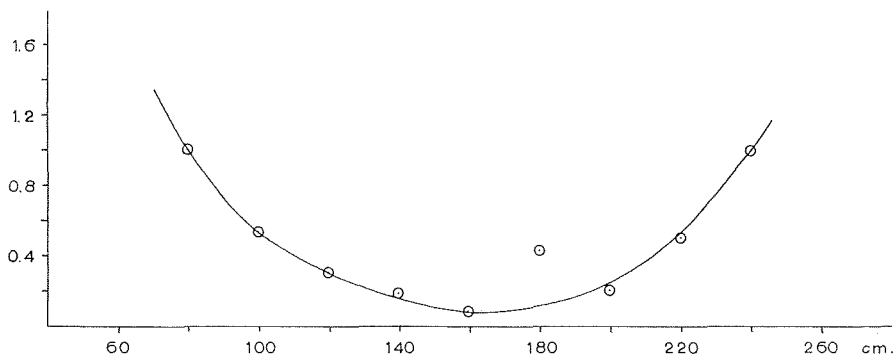


Fig. 2. Ratios between numbers of fish meshed and those attached in other ways, 16" nylon nets.

methods of attachment are of significance mainly for the small and very large fish and thus tend to increase the efficient selection range of the net; i.e. make the selection curve more flat-topped.

### c) Discussion

From Fig. 1 it appears that the plots of the log. ratios deviate considerably from linearity, as would be expected considering the heterogeneity with regard to attachment method and the relatively small number of observations covering a very great size range. Nevertheless there is no great difference between the three independent values of  $K$  and they compare fairly well with a figure of 3.04 estimated for the ratio of half the girth to the total length.

In order to test the validity of the assumption that the mean selection length is proportional to the mesh size, the lengths at which the log. ratios equal zero were plotted against the sum of the mesh sizes as described by Olsen (1959). The plots fit fairly well to a straight line through the origin with a slope of 1.599. This corresponds to a value of  $K = 3.198$ , against  $\bar{K} = 3.204$ .

The total selection curves for the four different types of nets used are shown in Fig. 3. The curves are fairly flat-topped, i.e. the halibut gill nets are effective over a great range of fish size. Thus the nylon nets have an efficiency of 50 % or more, with respect to the mean selection length, over a range of about 104 cm, 110 cm and 110 cm for the 16", 19" and 23" mesh sizes respectively.

The selection curve for the hemp net is more peaked and the 50 % selection range equals about 83 cm, which is 20 % less than that of the 19" nylon net.

Table II. Halibut meshed by operculum and point of greatest girth. Length distribution and log. ratios when adjusted for differences in effort.

Range in cm	$\bar{l}$	A	B		C		$\log_e B/A$	$\log_e C/B$	$\log_e C/A$
		Nylon 16'' 171 nets fished	Nylon 19'' 117 nets fished		Nylon 23'' 106 nets fished				
		$n_l$	$n_l$	adj. for diff. in effort	$n_l$	adj. for diff. in effort			
70-89	79.5	5	4	5.84	—	—	—	—	—
90-109	99.5	13	5	7.30	2	3.22	-0.5771	—	-1.3956
110-129	119.5	44	11	16.06	6	9.66	-1.0079	-0.5084	-1.5162
130-149	139.5	34	24	35.04	5	8.05	0.0296	-1.4708	-1.4407
150-169	159.5	24	21	30.66	7	11.27	0.2450	-1.0009	-0.7559
170-189	179.5	14	11	16.06	18	28.98	0.1371	0.5902	0.7275
190-209	199.5	5	8	11.68	19	30.59	0.8475	0.9628	1.8112
210-229	219.5	4	7	10.22	12	19.32	0.9381	0.6369	1.5748
230-249	239.5	2	1	1.46	7	11.27	—	—	—
$\geq 250$	—	—	—	—	2	5.22	—	—	—

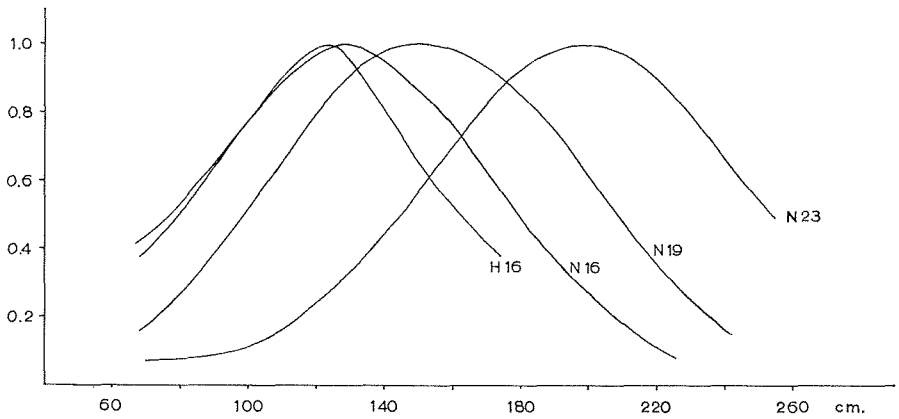


Fig. 3. Relative selection curves describing all methods of attachment. H16 — hemp 16'', N16 — nylon 16'', N19 — nylon 19'', N23 — nylon 23''.

It is a general experience in all gill net fishing that nets made of polyamide fibres are more efficient than similar nets made of natural fibres (see, for example, Sætersdal, 1957). The results of these experiments would suggest that part of this difference in fishing power is caused by the extended selection range of polyamide nets.

#### LITERATURE CITED

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