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The Selectivity of Halibut Gill Nets

by

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Introduction

In 1936 gill nets were introduced in the Norwegian halibut fisheries, and in a short time a successful gill-net fishery for large pre-spawning and spawning halibut developed in all major spawning areas.

Previously, the nets were made of hemp, but in recent years a change to polyamide fibres has taken place. Until now the mesh size has been regulated by law not to be less than 2o.88 cm between the knots (about 16" mesh size), but in June this year this regulation was changed to prohibit the use of mesh sizes less than about 18".

The fishing is carried out in the winter and the nets are set in long fleets at the bottom in 24o to 3oo fathoms depth.

Material and Methods

During the years 1957 to 196o experimental fishing with nets of different mesh sizes and different materials were conducted in January-February in one particular area 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 kilos the mesh sizes averaged 42.8 cm, 49.6 cm and 61.9 cm respectively, for the three different types of nylon nets.

The nets were spread in groups of two to five nets of each type throughout the fleet, and with changing positions of the groups during the season. The type of nets for each individual fish was recorded and the total length was measured. In 1959 and 196o girth measurements were also taken.

The data collected in 1957 and 1958 showed that observations on methods of attachment were needed and for the two last years' experiments records of such observations were provided. For this reason only the material collected in 1959 and 196o has been used in this treatment.

In analysing the data the methods of attachment were grouped in 1) meshing by the operculum and point of greatest girth, and 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 1 below gives the numbers caught as per type of net and attachment method.

Table 1. Numbers of halibut caught in 1959 and 196o specified by 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

Calculation of selection curves

For the meshed fish (attachment group 1) selection curves for the three different mesh sizes of nylon nets were calculated following 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 2 (page 4) gives the length distribution and log. ratios when adjusted for differences in effort (no. of nets fished), and in Figure 1 the log. ratios are plotted against length and lines fitted by the method of least squares are drawn.

From the lines of best fit values for K, l_m and σ^2 were computed:-

$$K = \frac{2\,b}{a\,({}_A\theta + {}_B\theta)}$$

$${}_A l_m = K \cdot {}_A\theta \qquad {}_B l_m = K \cdot {}_B\theta$$

$$\text{and} \quad \sigma^2 = \frac{2}{a}\,({}_B l_m - {}_A l_m)$$

where K is the ratio between mean selection length, l_m and mesh size, θ, and a and b are coefficients of the equation $y = al + b$ describing the line of best fit for the log. ratios.

The following values for K were found:-

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

The indices A, B and C refer to the mesh sizes 16", 19" and 23" respectively.

The arithmetic mean of these, $\bar{K} = 3.2o4$ gives:

${}_A l_m = 136.96$ cm, ${}_B l_m = 158.72$ cm, ${}_C l_m = 198.o8$ cm, and the

variance $\sigma^2 = 2886$.

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

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 (Figure 2). This shows that other 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.

To find the selection curve for the 16" hemp net the length distribution of the meshed fish taken by this type of net was compared by that of the 16" nylon net as adjusted for the effect of mesh selection. Thereafter the total selection curve was found in the same way as for the nylon nets.

Discussion

From Figure 1 it appears that the plots of the log. ratios deviate considerably from linearity, as would be expected because of the heterogeneity with regard to attachment method and the relatively small number of observations considering the very great size range. Nevertheless, there is no great difference between the three independent values of K, and they compare fairly well with the ratio of half the girth to the total length, which was found to equal 3.o4.

To further 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 size 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 $\bar{K} = 3.2o4$.

The total selection curves for the four different types of nets used are shown in Figure 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 5o% or more, as referred to that of the mean selection length, over a range of about 1o4 cm, 11o cm and 11o cm for the 16", 19" and 23" mesh size respectively.

The selection curve for the hemp net is more peaked and the 5o% selection range equals about 83 cm, which is 2o% less than that of the 19" nylon net.

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

Summary

Mesh selection data collected by experimental fishing with halibut gill nets of different mesh sizes were analysed by the method described by Holt (1957). The ratio between the mean selection length for meshed fish and the mesh size was found to be fairly low, viz. K = 3.2o4.

A method for finding an empirical selection curve describing both the selection by meshing and all other kinds of attachment was developed and applied to the data. The resulting total selection curve for halibut gill nets was found to be relatively flat-topped, but less pronounced in nets made of hemp than of nylon. It is suggested that this difference in selection range accounts for at least part of the difference in efficiency generally found between gill nets made of natural fibres and polyamide nets.

References

Holt, S. J. 1957 "A method of determining gear selectivity and its application". Paper No. S.15, Joint Sci. Meeting ICNAF/ICES/FAO, Lisbon, 1957. (Mimeographed).

Olsen, Steinar 1959 "Mesh selection in herring gill nets". J.Fish.Res. Bd. Canada, 16(3), 1959.

Sætersdal, G. 1957 "On the fishing power of nylon gill nets". Paper No. E.7, Joint Sci. Meeting ICNAF/ICES/FAO, Lisbon, 1957 (Mimeographed).

Table 2. Halibut meshed by operculum and point of greatest girth. Length distribution and log.ratios when adjusted for differences in effort.

Range in cm		A Nylon 16" 171 nets fished	B Nylon 19" 117 nets fished		C Nylon 23" 1o6 nets fished		$\log_e B/A$	$\log_e C/B$	$\log_e C/A$
		n_1	n_1	adj. for diff. in effort	n_1	adj. for diff. in effort			
7o-89	79.5	5	4	5 84	-	-	-	-	-
9o-1o9	99.5	13	5	7.3o	2	3.22	-o.5771	-	-1.3956
11o-129	119.5	44	11	16.o6	6	9.66	-1.oo79	-o.5o84	-1.5162
13o-149	139.5	34	24	35.o4	5	8.o5	o.o296	-1.47o8	-1.44o7
15o-169	159.5	24	21	3o.66	7	11.27	o.245o	-1.ooo9	-o.7559
17o-189	179.5	14	11	16.o6	18	28.98	o.1371	o.59o2	o.7275
19o-2o9	199.5	5	8	11.68	19	3o.59	o.8475	o.9628	1.8112
21o-229	219.5	4	7	1o.22	12	19.32	o.9381	o.6369	1.5748
23o-249	239.5	2	1	1.46	7	11.27	-	-	-
≥ 25o	-	-	-	-	2	5.22	-	-	-

APPENDIX

Method to find an empirical total selection curve describing all means of attachment.

If the selection curve for one method of attachment (i.e. meshing at the maxillae, operculum, point of maximum girth etc.) is known, an empirical selection curve describing all kinds of attachment can be found, although no simple mathematical expression for this curve may be established.

Let y_l be the ordinate of the known selection curve at length l, 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,

$$n_l = N_l \cdot P \cdot y_l \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

and

$$n_l' = N_l \cdot P \cdot y_l' \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

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

We have now

$$\frac{n_l}{n_l'} = \frac{y_l}{y_l'} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (3)$$

and

$$y_l' = y_l \cdot \frac{n_l'}{n_l} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (4)$$

and the ordinate for the total selection curve

$$Y_l' = y_l + y_l' = y_l \left(1 + \frac{n_l'}{n_l}\right) \qquad \ldots\ldots\ldots\ldots \qquad (5)$$

or, if we chose Y_{lm} as unity = 1.

$$\underline{Y_l = \frac{y_l}{Y_{lm}'} \left(1 + \frac{n_l'}{n_l}\right)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (6)$$

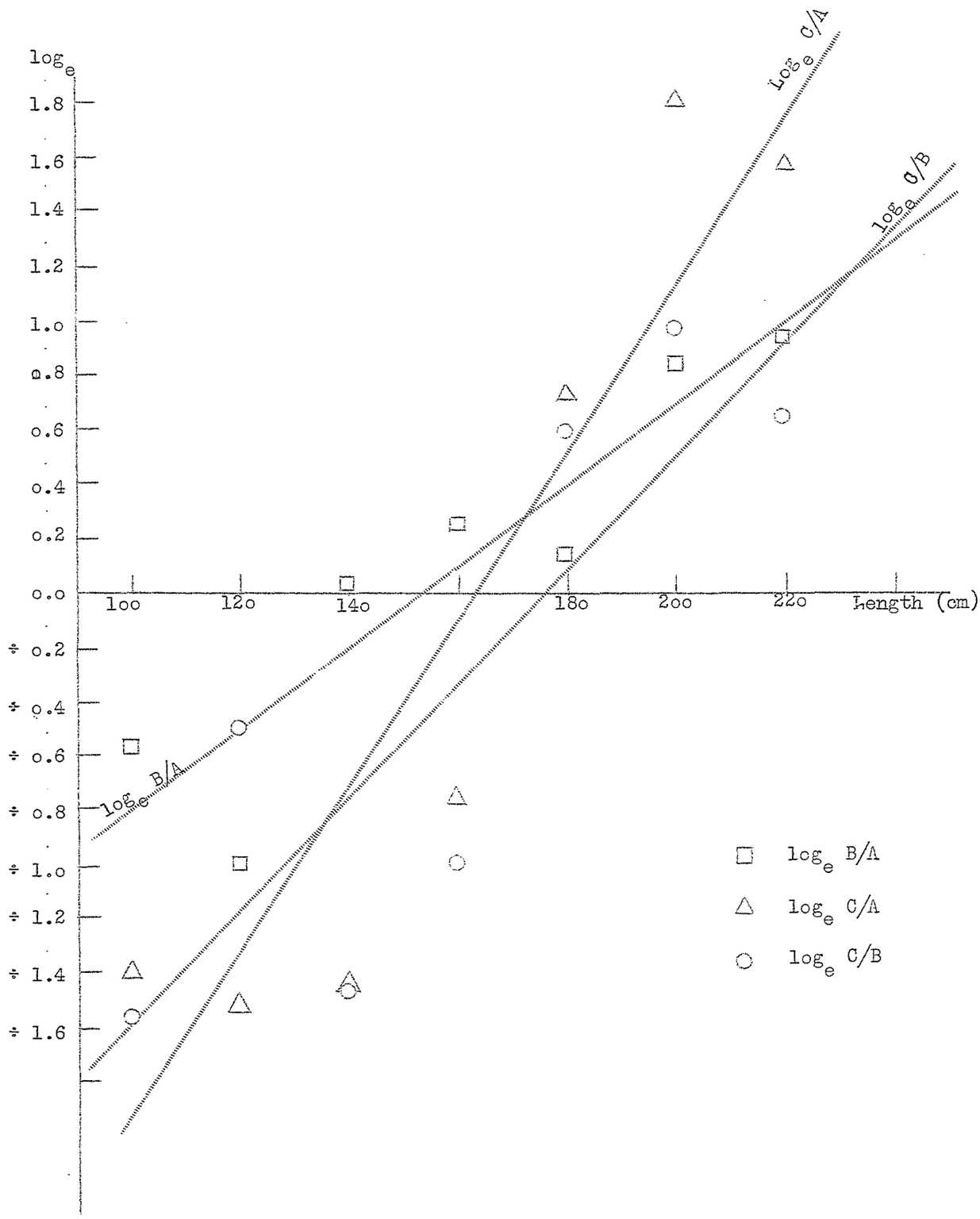

Figure 1. Plots of log. ratios against length

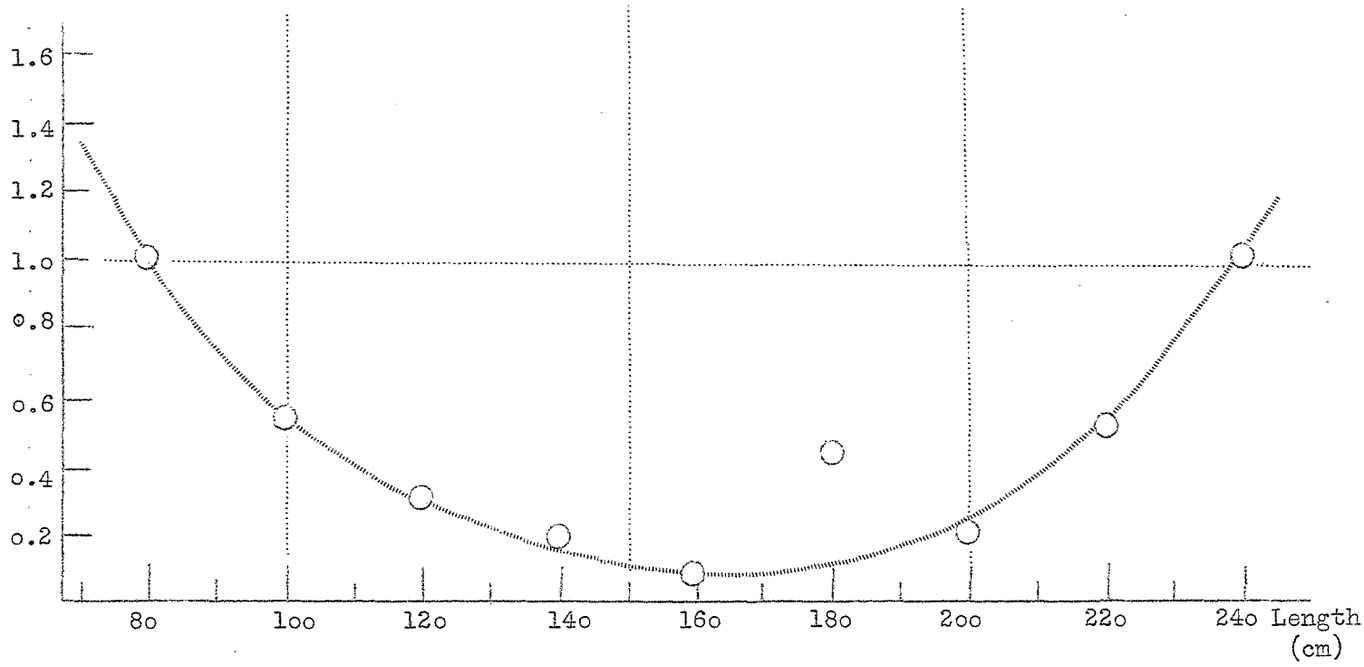

Figure 2. Ratios between numbers of fish meshed and those attached in other ways, 16" - nylon nets.

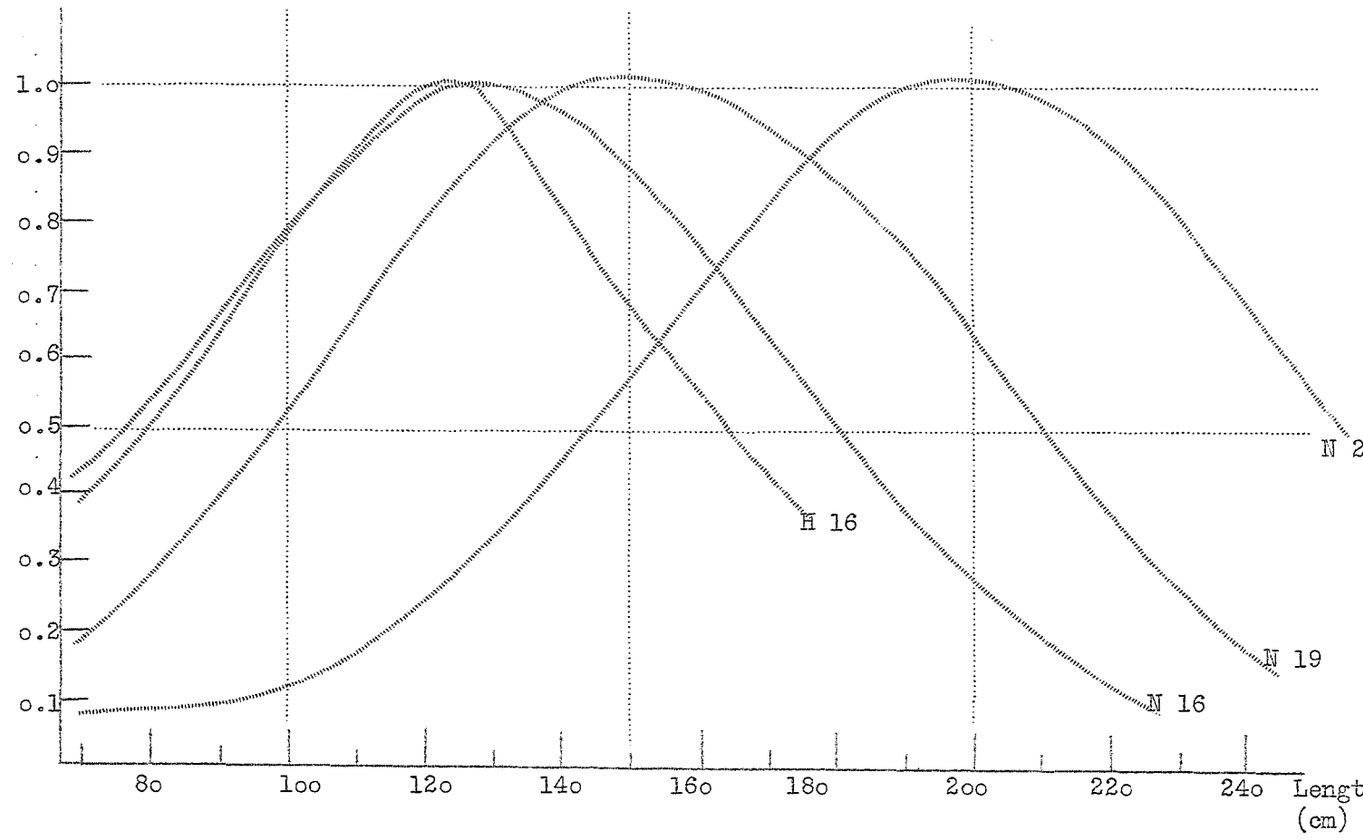

Figure 3. Relative selection curves describing all methods of attachment, H 16 - hemp 16", N 16 - nylon 16", N 19 - nylon 19", N 23 - nylon 23".