On Sweeping Trammel Net (Kogisasiame) Fishery along Coast of the San'in District—III.

Mesh Selectivity Curve of Sweeping Trammel Net for Branquillos

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The preceding papers^{1,2)} treated the change in the daily catch of branquillos, *Branchiotegus japonicus japonicus*, by sweeping trammel net in Wakasa Bay and Shimane offing, and gave the estimations of the gear efficiencies to branquillos for every size categories in market, such as large, middle, small and extremely small sizes. It is seen that the efficiencies of this gear vary largely from one category to another and that their variation with the change of every category is very similar to the general trends of selectivity curves for gill net. The above fact suggests that the gear has the selectivity for the species to some extent.

In order to evaluate the effect of the mesh selection, comparative fishing experiments were carried out with nets of different mesh sizes. The present paper includes a method of determining the mesh selectivity curve of the gear to the species and the discussion about the result obtained.

Data and Sources

Analysis was made with the data on the comparative fishing experiments with fourteen nets of three different mesh sizes of inner webbing, 6.06, 7.57 and 8.20 cm in stretched measure. The fishing experiments were carried out off Hamada, Shimane Prefecture, from November to December 1964. The construction and materials of the fishing gear are the same to those employed by MATUDA *et al.*³⁾ except that three different mesh sizes of inner webbing were employed and an arrangement of the nets was modified as illustrated in Fig. 1. The operation was made according to the usual fashion at Shimane Prefecture³⁾. The length of the species taken were measured separately for each mesh and then

A	A	B	A	C	A	A	A	A	B	A	C	A	A
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Fig. 1. The arrangement of net, A, B and C showing the nets of 6.06, 7.57 and 8.20 cm mesh sizes in stretched measure, respectively.

the catch number was grouped in accordance with the length at a regular interval of 1 cm. The catch amounts to 845 and their length ranges 10 to 37 cm.

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In addition, employed were the catch data for each net by commercial fleet and the research ship of Kyoto Prefectural Fisheries Experimental Station in Wakasa Bay over the period of 1961~1962. The gear used in this area are constructed from the nets of the equal mesh size. In this period, we engaged in the observation for 12 hauls aboard the commercial boat.

General Theory

Gear-selectivity is defined as the probability that a fish of given species and size is caught upon encountering a specified gear. Accordingly, gear-selectivity is dependent on various factors such as materials and construction of gear, its operational condition, species and their sizes etc. We concern ourselves in this paper only with the selection of inner mesh of sweeping trammel net toward branquillos when all other characteristics of this gear are held constant.

Up to the present time, many investigators⁴⁻⁶⁾ have been devising how to determine mesh selectivity of gill net. Here, a graphical method is derived from the modification of MCCOBIE and FRY's⁶⁾, and ISHIDA's⁷⁾ methods.

HOLT⁴⁾ and OSLEN⁵⁾ *et al.* reported that the modal length in selectivity curve of gill net was approximately proportional to mesh size. MCCOBIE and FRY showed that the range of length of fish which is liable to be captured was increased with increasing mesh size⁶⁾. On the basis of these facts we use a few simple assumptions about selectivity curve.

Suppose a fishing gear not to be saturated. Denoting the selectivity, i.e. relative efficiency, of mesh size m_i of a given gear to fish at length l_j by $S(m_i, l_j)$, then we assume that all $S(m_i, l_j)$ are approximately equal for those combination i and j for which l_j/m_i are equal in certain ranges of l and m . These assumptions lead us to the result that $S(m, l)$ is reduced to a function of l/m , as is identical with ISHIDA's expression⁷⁾,

$$S(m, l) = S(km, kl) = S(l/m), \quad (1)$$

where k is a constant. Eq. (1) may approximately hold only for a certain range of length since it can be considered that the constant k is affected by such various factors as the form and swimming thrust of fish, and the materials of the gear etc.

Suppose that the comparative fishing experiments are practiced with nets of some different mesh sizes. Then, letting population density of fish at l_j to be d_j , catch per unit effort C_{ij} of fish at l_j taken by the net with a given mesh size m_i can be given by

$$C_{ij} = S(m_i, l_j) q d_j, \quad (2)$$

in which q is catchability at the peak of selection curve. Taking logarithm for both sides of Eq. (2),

$$\log C_{ij} = \log S(m_i, l_j) + \log q d_j. \quad (3)$$

Eqs. (1) and (3) indicate that the plots of $\log C_{ij}$ against l_j/m_i for different lengths l_j show a family of vertically parallel curvilinear for a variety of l_j , and that we can superpose these curvilinear on a standard curve by means of parallel shifting up- or downwards in a certain range of m and l . $S(m, l)$ is able to be obtained from the curvilinear thus superposed. It should be noted from Eq. (3) that anti-logarithm of the distances shifted downwards represents the theoretical ratio of fish population density.

Results and Discussion

We will try to apply the method to the data on the comparative fishing experiments which were carried out in Hamada offing to determine mesh selectivity curve of sweeping trammel net to branquillos. It is considered that the swept area, and hence the number of capture, by each net is clearly different corresponding to net arrangement. Therefore, it is necessary to correct the data about the comparative fishing experiments, taking the position of nets into account. The effect of the net position on the catch can be estimated from the data of Wakasa Bay, in which is employed the gear of equal mesh size for whole net. Now, c and $\bar{c}$ refer to the catch number in the n -th net counted from the anchored end and the mean of those

Fig. 2. $\bar{c}/\bar{c}$ plotted against n/N .

per net for each haul, respectively, and N the number of total nets. Fig. 2 shows the plot of the mean, $\bar{c}/\bar{c}$, of $c/\bar{c}$ over all observed hauls against n/N . We can obtain the correction coefficients as the reciprocal of the values of $\bar{c}/\bar{c}$ for

each net from the smoothed curve in Fig. 2. Table 1 gives catch number of branquillos thus corrected for each length class in nets of three mesh sizes. Since in the comparative fishing experiments were employed ten nets for 6.06 cm mesh size, two nets for 7.57 cm mesh size and two nets for 8.20 cm mesh size, the determination of selectivity curve is made with the catch number, in nets of 7.57 and 8.20 cm mesh sizes, multiplied by five.

Table 1. Corrected number of branquillos caught by sweeping trammel nets of three mesh sizes.

Length (cm)	Mesh size (cm)		
	6.06	7.57	8.20
≤ 19.5	63	3	2
20.5	77	2	
21.5	108	4	
22.5	143	11	5
23.5	131	11	4
24.5	91	10	5
25.5	74	14	8
26.5	58	12	15
27.5	24	2	6
28.5	13		2
29.5	13	5	2
≥ 30.5	55	5	7

Fig. 3. Log C plotted against $\log (l/m)$ for each length class.

Fig. 4. Master curve, marks showing length classes.

According to Eq. (3), the plot of $\log C$ against $\log l/m$ is made for each length class from 20.5 to 29.5 cm in Fig. 3. The logarithm of l/m is used because there appears a pronounced positive skew when both variables are plotted in arithmetic scale. The plots for each length class increase gradually with increasing of $\log l/m$ and reach a peak at about 0.58, and then decrease as $\log l/m$ increases. It is seen that the plots for each length class are nearly parallel up- or downwards to one another except a few plots for large species by large mesh sizes whose catch number is very scanty. This trend seems that Eq. (3), and hence Eq. (1), holds at least for this range of length. A master curve illustrated in Fig. 4 is obtained by means of superposing plots on that for 23.5 cm length class, which shows a smooth curve though there appear a few plots of derivation. The master curve obtained is likely to have a parabolic trend with a peak at $\log l/m = 0.58$ and it may be interpreted that the selectivity curve shows a positive skew. Making anti-logarithm of the

master curve and letting the peak be 100% of relative efficiency, we obtain the selectivity curve as a function of l/m as shown in Fig. 5.

Fig. 5. Selectivity curve plotted as function of l/m . Marks show length classes.

As seen from the determined selectivity curve, the relative efficiency increases sharply with increasing of l/m and reaches a maximum value at $l/m = 3.8$ and then decreases gradually as l/m increases. A measurement of fish sizes gives the ratio of length to maximum girth 1.7 which is slightly less than the value of $l/2m$ for maximum efficiency. That is, this gear

becomes difficult to catch fish as the perimeter of the mesh becomes larger than the maximum girth of fish, but in the case that the girth exceeds the perimeter the species is liable to be taken. The positive skewness of the selectivity curve can be supposed to be due to the elasticity of thread and the deformation of fish by tension of thread etc.^{9,10)}

Fig. 6 gives the frequencies of length corrected by selectivity curve for each mesh size. In the same figure, are shown the frequencies of length that are theoretically estimated from the distances shifted when the master curve has been obtained. They seem to be in an agreement with one another though a few plots scatter since the used data are not sufficient. The trend of selectivity curve corresponds to the change of efficiencies among size categories estimated from CPUE¹⁾. It is likely that the above findings support the selectivity curve, determined by this graphical method, of sweeping trammel net to branquillos to some extent.

The attempts were made to apply the present method to MCCOBIE and FRY's⁶⁾, and ISHIDA's⁷⁾ data, though the results of which are not shown in the present paper. In determining the selectivity curves, the master curves were treated separately according to the groups of smaller and larger length ranges. The results will be discussed in details in the other paper. It is very interest to compare this method with the computational method (the skew-normal model) by REGIER and ROBSON⁸⁾.

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Fig. 6. Length composition of branquillos in fishing experiments. The polygon is theoretically computed from shifted distances, marks showing data corrected by the selectivity curve for each mesh size.

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