Asian Fisheries Science 2(1988): 71-82.
Asian Fisheries Society, Manila, Philippines.

https://doi.org/10.33997/j.afs.1988.2.1.007

Gill-net Selectivity for *Amblygaster* (= *Sardinella*) *sirm*

P. DAYARATNE

National Aquatic Resources Agency
Crow Island, Colombo 15
Sri Lanka

Abstract

Gill-net selectivity for *Amblygaster* (= *Sardinella*) *sirm* was studied using material collected from commercial fishing operations on the west coast of Sri Lanka during the period January-October 1985. Selectivity estimates were made by comparing fish caught by nets of different mesh sizes ranging from 2.5 cm to 3.8 cm and by using the fish length/girth relationship. The means of the selectivity factors estimated by the two methods were 5.53 and 5.48. These values are comparable with those obtained elsewhere for similar species. The optimal lengths and the selection factors estimated for different mesh sizes tended to increase with the mesh size. Also the large mesh size caught a greater size range of fish than the small meshes. The gill-net fishery effectively caught fish within the range 12.9-23.3 cm. The selection by all mesh sizes in general is towards the lower end of the selection range.

Introduction

In Sri Lanka, the gill-net fishery for small pelagics contributes about 90% of small pelagic fish production. Gill nets are operated by traditional mechanized and nonmechanized crafts and by mechanized fiberglass boats (5-7 m). On the west coast, *Amblygaster sirm* dominates the catches of the small-meshed gill-net fishery and contributes 70-80% of the production by this gear.

On the west coast of Sri Lanka a wide range of mesh sizes, from 1.2 cm to 3.8 cm, is used in commercial small-meshed gill-net fisheries (Dayaratne 1984). The smaller meshes are used mainly for anchovies (*Stolephorus* spp.) while the sardines (*Amblygaster sirm*) are caught by the 2.5-3.8 cm mesh range. As in many other tropical fish species, stock assessment studies on *A. sirm* may be based on length-frequency data collected from commercial fishing operations. Since the gill net is a highly selective gear, the sample length-frequency distribution does not resemble that of the stock. The length distribution of the catches must be corrected for selection before unbiased growth and mortality parameters can be estimated.

Although *A. sirm* is an important species in the gill-net fishery in Sri Lanka, no attempts had been made so far to study the effects of selectivity on this species. The present paper attempts to estimate the selectivity factors for *A. sirm* by using the catch ratio method as described by Holt (1963) as well as by using the inference from girth measurements described by Hamley (1975).

Materials and Methods

The material for the present study was collected from commercial fishing operations carried out by 5-m FRP boats in Negombo on the west coast of Sri Lanka during the period January-October 1985.

Selectivity Estimates by the Catch Ratio Method

Length measurements of 2,505 fish (Table 1) were taken at the landing site while the fish were in fresh condition. The total length from the tip of the snout to the edge of the longest caudal fin was measured to the nearest millimeter. Analysis of data was based on the assumption that the mean selection length is linearly proportional to the mesh size and that the selectivity curve for normally meshed fish is symmetrical around the mean selection length and approximates the shape of a normal distribution (Baranov 1914). Holt (1963) showed that when catches are available for two gill nets with slightly different mesh sizes the logarithm of ratios of the catches by the two nets should be linearly related to fish length according to the relationship

$$Y = a + b\,L \qquad \ldots 1)$$

where Y = logarithm (natural) of ratios of catch (in number by two different meshes for length class L'; L = the class midpoint of length class L'; and a and b are constants.

Table 1. Length-frequency distribution of *Amblygaster sirm* caught by nets of different mesh size.

Length Class (cm)	Stretched mesh size (cm) 2.5	2.8	3.0	3.2	3.8
11.5-11.9	6				
12.0-12.4	9				
12.5-12.9	48	3			
13.0-13.4	51	21			
13.5-13.9	66	36			
14.0-14.4	45	81	3		
14.5-14.9	21	117	30		
15.0-15.4	12	132	36		
15.5-15.9		81	93	15	
16.0-16.4		36	75	6	6
16.5-16.9		9	69	12	3
17.0-17.4		3	63	27	45
17.5-17.9		3	21	45	33
18.0-18.4			30	69	36
18.5-18.9			24	93	27
19.0-19.4			24	87	36
19.5-19.9			21	72	62
20.0-20.4			27	45	72
20.5-20.9			9	18	72
21.0-21.4				12	87
21.5-21.9				12	84
22.0-22.4				18	72
22.5-22.9				6	24
23.0-23.4					3

The intercept and slope of this regression can then be used to estimate the optimum length as follows (Pauly 1984):

$$L_A = -2a \cdot A \cdot (b\,(A + B))^{-1} \quad \text{... 2)}$$

$$L_B = -2a \cdot B \cdot (b\,(A + B))^{-1} \quad \text{... 3)}$$

where L_A and L_B are the optimum lengths corresponding to mesh sizes A and B, respectively.

The standard deviation of both selection curves is estimated from

$$S.D. = (2a \cdot (A-B) \cdot (b^2 \cdot (A + B))^{-1})^{0.5} \quad \text{... 4)}$$

Once, L_A, L_B and s.d. have been estimated, the probability of capture (P) at a given length (L) is given for mesh A by

$$P_A = \exp(-(L-L_A)^2 \cdot (2\ S.D.^2)^{-1}) \quad \ldots 5)$$

and for mesh B by

$$P_B = \exp(-(L-L_B)^2 \cdot (2\ S.D.^2)^{-1}) \quad \ldots 6)$$

The selection factor (SF) which is the ratio of the optimal length to stretched mesh size was then calculated (Holt 1963) from

$$SF = L_o \cdot m^{-1} \quad \ldots 7)$$

where L_o = optimum length corresponding to the stretched mesh size m.

Selectivity Estimates by Using Girth Measurements

A total of 239 fish with a length range of 11.6 to 23.2 cm was measured for maximum girth and total length.

A plot of fish length (L) versus maximum girth (G_{max}) indicated a linear relation. Therefore a linear regression was fitted by the least square method (Fig. 1). Modes of the selectivity curves were estimated following Hamley (1975). The girth of the most efficiently caught fish G_{max} is taken as proportional to mesh size (Hamley 1975) by the relationship

$$G_{max} = K \cdot M \quad \ldots 8)$$

where G_{max} = the maximum girth (cm); M = mesh perimeter setting to twice the size of stretched mesh (cm); and K = a constant.

The value of K for *A. sirm* was obtained by plotting the mean values of the maximum girth of fish caught by different mesh sizes against the mesh perimeter. The maximum girth of the fish caught by each mesh size was then calculated. The fish length/girth relationship was then used to obtain the optimum length (L_o) for different mesh sizes. Having determined the optimal lengths the selection factors were estimated using equation (7).

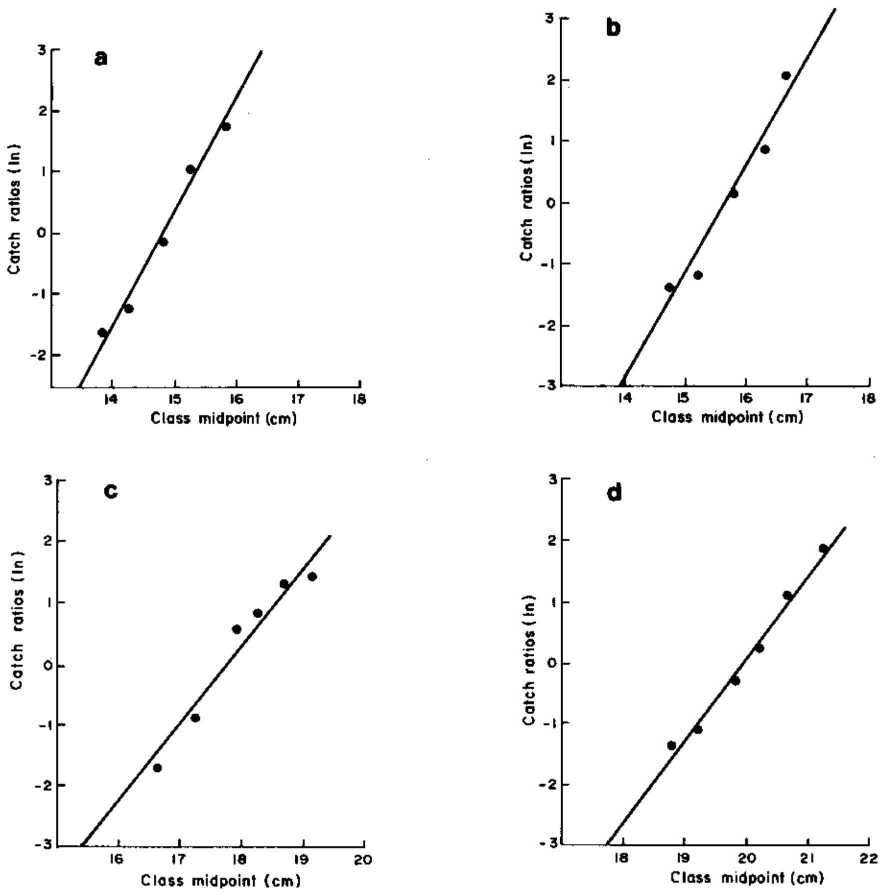

Fig. 1. Plots of logarithm of catch ratios for different mesh combinations versus length (class midpoint).

a) 2.5 cm and 2.8 cm combination
b) 2.8 cm and 3.0 cm combination
c) 3.0 cm and 3.2 cm combination
d) 3.2 cm and 3.8 cm combination

Results

In this analysis instead of the actual numbers the relative frequency in each length group was used because the fishing operations with different meshes were carried out at different times and it was not possible to sample the entire catch.

Fig. 1 shows the linear relationships that were obtained for different mesh combinations and Table 2 gives the detailed results of the linear regressions. The slopes and the intercepts of these regressions were then used to estimate the optimal lengths and the standard deviations.

More than one combination was possible for the size distribution of fish caught by 2.8 cm, 3.0 cm and 3.2 cm mesh. Therefore, the means of the two values obtained by the two different combinations were used to estimate the optimum lengths (Table 3) and standard deviation for these meshes. As expected there was an increase in the optimal length with the increase in mesh size. There was no increase in standard deviation with the increase in mesh size as expected (Table 2). Only the large mesh combination resulted in a relatively high standard deviation of 1.59. These values were then used to estimate probability of capture at each length (Table 4). The selection curves for different meshes were plotted by using these probability values (Fig. 2). To observe the selectivity effect from the combination of different mesh sizés, the selection range (one S.D. on each side of the optimal length) was plotted against the optimal length (Fig. 3).

Table 2. Details of the regression analysis of natural logarithm of catch ratios against the class midpoint and the estimated standard deviation.

Mesh combination (cm)	Coefficient of determination (r^2)	slope	intercept	Estimated standard deviation
2.5 and 2.8	0.97	-26.23	1.78	0.969
2.8 and 3.0	0.95	-27.42	1.75	0.785
3.0 and 3.8	0.92	-22.15	1.25	0.957
3.2 and 3.8	0.98	-26.75	1.34	1.590

Table 3. Selectivity estimates by the catch ratio method.

Mesh size (cm)	Optimal length (cm)	Selection factor
2.5	13.91	5.56
2.8	15.36	5.49
3.0	16.69	5.56
3.2	18.26	5.71
3.8	21.67	5.70

The estimated length/girth relationship for *Amblygaster sirm* takes the form:

$$L = 1.94\,G + 1.33$$

with the coefficient of determination r^2 as 0.99 where L = total length of fish in cm and G = maximum girth in cm.

The above relationship was obtained by plotting the means of the total length against the means of the girth of the fish caught by different mesh sizes (Fig. 4).

Table 4. Estimated probability of capture of each length class of *A. sirm* for different mesh sizes.

Class midpoint (L)	Probability of capture for different mesh size				
	mesh size (cm)				
	2.5	2.8	3.0	3.2	3.8
11.7	0.08				
12.2	0.21				
12.7	0.46	0.02			
13.2	0.77	0.08			
13.7	0.98	0.21			
14.2	0.94	0.46	0.02		
14.7	0.72	0.77	0.07		
15.2	0.41	0.98	0.23	0.05	
15.7	0.26	0.95	0.52	0.12	
16.2	0.18	0.71	0.85	0.26	
16.7	0.06	0.41	1.0	0.45	
17.2		0.18	0.85	0.68	0.18
17.7		0.06	0.52	0.89	0.04
18.2			0.23	0.99	0.09
18.7			0.07	0.95	0.17
19.2			0.02	0.77	0.29
19.7				0.55	0.45
20.2				0.33	0.64
20.7				0.17	0.82
21.2				0.07	0.95
21.7					1.0
22.2					0.95
22.7					0.82
23.2					0.64
23.7					0.45
24.2					0.29
24.7					0.19
25.2					0.08
25.7					0.04

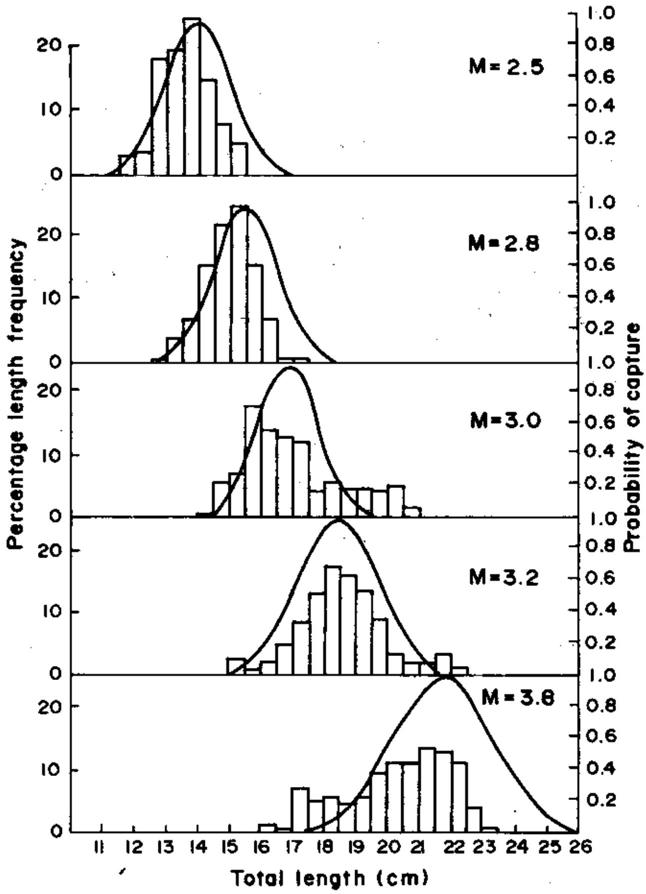

Fig. 2. Length-frequency distribution of *Amblygaster sirm* caught by 2.5-3.8 cm gill net, with the estimated selection curves.

A plot of the maximum girth (G_{max}) against the mesh perimeter (M) is shown in Fig. 5. The close linear relationship observed was:

$$G_{max} = 1.54\ M - 1.43\ (r^2 = 0.99)$$

However, according to Hamley (1975) as given by equation (7), the regression should pass through the origin with zero intercept. Therefore, a regression through origin was fitted (Zar 1974):

$$G_{max} = 1.307\ M\ (r^2 = 0.99)$$

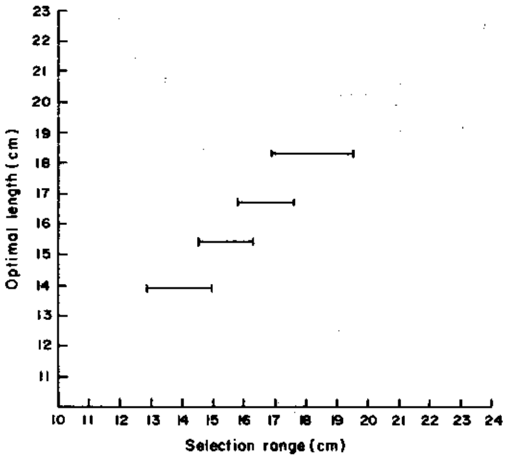

Fig. 3. A plot of selection range against optimal length.

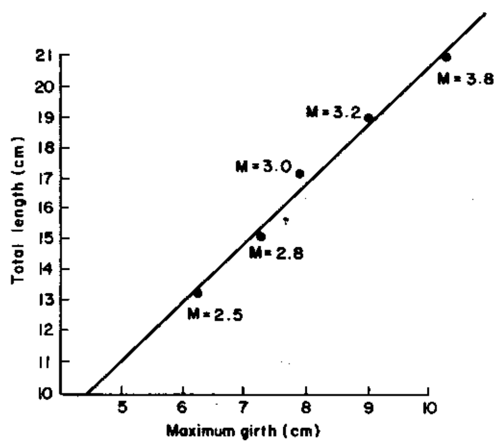

Fig. 4. Fish length/maximum girth relationship.

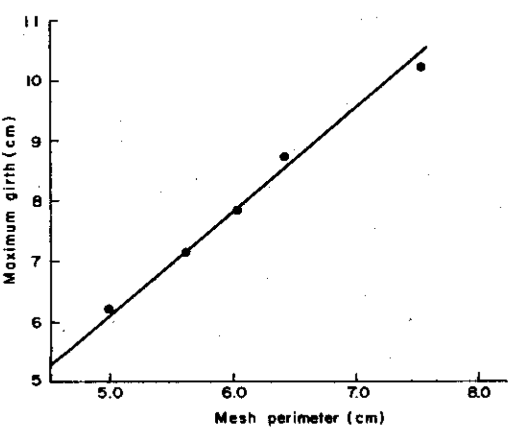

Fig. 5. Maximum girth/mesh perimeter relationship.

This relationship was used to estimate the maximum girth corresponding to each mesh size. The girth/length relationship was then used to obtain the optimal lengths for each mesh. Table 5 gives the optimal lengths estimated by this method. These lengths were used in equation (7) to estimate the selection factors (Table 5).

Table 5. Selectivity estimates using girth/length relationship.

Mesh size (cm)	Optimal length (cm)	Selection factor
2.5	13.46	5.38
2.8	15.26	5.45
3.0	16.45	5.48
3.2	17.65	5.52
3.8	21.24	5.59

Discussion

The selectivity estimates for *Amblygaster sirm* were made assuming that:

- the selectivity curve would take the form of a normal frequency distribution;
- the efficiencies of two nets with different mesh sizes would be similar for fish of the same length group;
- the standard deviations of the distribution for two different mesh sizes were equal;
- no significant bias was introduced using relative rather than absolute size frequencies.

Two independent methods were used to estimate the selectivity factors of *A. sirm*. The results obtained by these two methods were similar. The mean of the selectivity factors estimated by the catch ratio method, 5.53 (S.D. = 0.13), is very close to that estimated by using the girth/length relationship, 5.48 (S.D. = 0.07). No previous estimates of selectivity for *A. sirm* are available to compare with the present values. The estimated selection factors of 5.59 and 5.49 are a little higher than those obtained for similar species: 4.83 for North Sea herring (Holt 1963) and 4.95 for Japanese sardine (Ishida 1964). The selection factors estimated for fish caught by large meshes (3.2

cm and 3.8 cm) were a little higher. This was true for estimates made by the two independent methods. This is probably due to the change in body proportions in mature fish. Maturity studies on *A. sirm* have indicated that fish larger than 18 cm are all mature (Fernando, pers. comm.). This would have resulted in a slight increase in selection factors for fish caught by large meshes. There is evidence that the selectivity factor varies between immature and ripe fish (Strzyzewski 1964).

The estimated optimum lengths for different meshes showed a clear resemblance. The estimated selection curves plotted on the observed length frequencies (Fig. 2) indicate that in general the selection is towards the lower end of the selection range. This is because *A. sirm* is a smooth bodied fish and is mostly gilled or wedged. Some entangling was however observed in large meshes (3.0-3.8 cm).

The selection ranges for different mesh sizes (Fig. 3) show that large mesh sizes catch a greater size range of fish. This also shows that the gill-net fisheries on the west coast of Sri Lanka effectively catch fish within the range 12.9-23.2 cm. Few fish below this range have been observed. The maximum recorded length by this fishery was 23.2 cm. This clearly shows the selectivity effect of these gill nets. *A. sirm* larger than this have been caught by the purse seine fishery on the southwestern coast (maximum recorded size, 24.8 cm).

The gill-net fishery for *A. sirm* on the west coast is carried out throughout the year. However, the size of the mesh or mesh combination used by the fishermen changes from time to time as the fishermen try to follow a cohort of a population and move towards the deeper waters with the large meshes. Variation of depth of operation with mesh sizes is described by Dayaratne (1984).

In the present study the estimates were based on material collected from the commercial gill-net fishery over a period of 10 months. Because the nets were operated at different times and at different depths it would have affected the selectivity estimation of *A. sirm*. A comparison of the estimated selection factors by the two methods suggest that the bias introduced in using percentage length frequencies is not great. Mesh selectivity is also affected by the thickness of material and color of the net twine, hanging ratio, etc. (Hamley 1975), but the present data are insufficient to account for these effects.

References

Baranov, F.I. 1914. The capture of fish by gillnets. Mater. Poznaniyu Russ. Rybolov. 3(6): 56-99. (Selected work on fishing gear. Vol. 1. Commercial fishing technique. Israel Program for Scientific Translations, Jerusalem. 1976.)

Dayaratne, P. 1984. Fishery and biology of some small pelagic fish species (clupeioides) from the West coast of Sri Lanka. University of Bergen, Norway. Ph.D. thesis.

Hamley, J.M. 1975. Review of gillnet selectivity. J. Fish. Res. Board Can. 32:1943-1969.

Holt, S.J. 1963. A method for determining gear selectivity and its application. ICNAF Spec. Publ. 5:196-115.

Ishida, T. 1964. Gillnet selectivity curves for sardine and herring. Bull. Hokkaido. Reg. Fish. Res. Lab. 28: 56-60. (Fish. Res. Board Can. Transl. Ser. No. 1284).

Pauly, D. 1984. Fish population dynamics in tropical waters. A manual for use with programmable calculators. ICLARM Studies and Reviews 8 325 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Strzyzewski, W. 1964. Methods of calculating the selectivity factor. Prace Morsk Inst. Ryback Ser B 12: 39-56. (U.S. Dept. Commerce, Natl. Tech. Inf. Serv. TT 66-57061. NTIS Springfield.)

Zar, J.H. 1974. Biostatistical analysis. Prentice Hall, Inc., Englewood Cliffs, N.J. 620 p.

Manuscript received 6 August 1987; accepted 6 September 1988