Canadian Technical Report of Fisheries

and Aquatic Sciences No. 1016

April 1981

EFFECTS OF MESH SIZE ON ROE YIELD FROM HERRING GILLNET CATCHES

by

J. F. Schweigert, A. S. Hourston, and L. A. Webb[1]

Department of Fisheries and Oceans

Resource Services Branch

Pacific Biological Station

Nanaimo, British Columbia V9R 5K6

[1]Address: Department of Fisheries and Oceans

Field Services Branch

Fisheries Development Division

1090 West Pender Street

Vancouver, British Columbia V6E 1P2

Cat. No. 97-6/1016 ISSN 0706-6457

ABSTRACT

Schweigert, J. F., A. S. Hourston, and L. A. Webb. 1981. Effects of mesh size on roe yield from herring gillnet catches. Can. Tech. Rep. Fish. Aquat. Sci. 1016: 23 p.

The selectivity curves of gillnets for roe herring were estimated by two independent methods. A model was developed to estimate relative roe yield for a range of mesh sizes which indicated that the greatest relative roe yield would be obtained by 2 1/8 in mesh if the selectivity curve does not increase with mesh size. However, empirical evidence demonstrated that the height, and probably the variance of the selectivity curve for 2 1/4 in mesh exceeded that for 2 1/8 in mesh. Catch per unit time was greater for the larger mesh size and it yielded a more favourable roe size. Hence, we recommend the retention of 2 1/4 in mesh gillnets as the preferred minimum size for management purposes.

Key words: *Clupea harengus pallasi*, gillnets, selectivity curves, roe yield.

RÉSUMÉ

Schweigert, J. F., A. S. Hourston, and L. A. Webb. 1981. Effects of mesh size on roe yield from herring gillnet catches. Can. Tech. Rep. Fish. Aquat. Sci. 1016: 23 p.

Les courbes de sélectivité des filets maillants pour le hareng plein ont été estimées à l'aide de deux méthodes distinctes. On a élaboré un modèle pour évaluer la production d'oeufs de hareng en fonction de divers maillages, lequel a indiqué qu'on obtiendrait la plus grande production avec un maillage de 2 1/8 si la courbe de sélectivité n'augment pas avec le maillage. Toutefois, des observations empiriques ont démontré que la hauteur, et probablement la variance de la courbe de sélectivité pour un maillage de 2 1/4 dépassaient celles pour un maillage de 2 1/8. Les prises par unité de temps étaient supérieures pour le maillage le plus grand et on obtenait des oeufs de taille plus itéressante. Par conséquent, nous recommandons de maintenir de préférence à 2 1/4 le maillage minimal pour les filets maillants aux fins de la gestion.

Mots clés: *Clupea harengus pallasi*, filets maillants, courbes de sélectivité, production d'oeufs.

INTRODUCTION

One objective of fisheries management is to determine the most efficient gear to be employed in the capture of various fish species. It is clear that fishing two gears side by side will demonstrate which one is preferable under these circumstances but this procedure provides only limited predictive capability for other situations. In order to make a more general statement about the relative efficiencies of several fishing gears, it is useful to develop a model which can incorporate various factors that may potentially or actually affect their efficiency under a variety of conditions.

The most obvious factors affecting the capture efficiency of a gear are its physical dimensions and the size frequency distribution of the fish population available to the gear. Since it is virtually impossible to know the size distribution of the fish available to the gear because of a range of poorly understood behavioural factors that determine distribution and movement, most research has gone into determining the effects of the physical dimensions of the gear on its capture efficiency.

In this regard by far the most information is available on gillnet selectivity to various sizes of fish (Hamley 1975). To determine these selectivity curves gillnet catches are often compared to those of another gear which is assumed to be unselective with respect to the population at large. Otherwise, a range of mesh sizes is fished simultaneously and the relative catches of fish of similar size by each pair of them is utilized to estimate individual selectivity curves.

The roe fishery for the Pacific herring (*Clupea harengus pallasi*) is presently undertaken by both gillnet and seine fishermen. The former are restricted to a minimum mesh size of 2 1/4-in stretched measure net (1 1/8 in per side) but there have been conjectures that a smaller mesh size may be more efficient for the capture of roe herring. This study was undertaken during the 1976 herring roe fishery to evaluate the relative efficiency of 2 1/8- and 2 1/4-in gillnets for the capture of spawning herring and to determine their relative roe yields.

MATERIALS AND METHODS

The study was undertaken in 1976 in Statistical Area 24, in the Yellow Bank area of Clayoquot Sound (Fig. 1). The gillnet and seine fisheries here occur in close proximity to each other, both spatially and temporally, making it possible to compare their relative selectivities of the available size range of spawning herring.

Two gillnet fishermen set 75-fm panels of 8 mil 2 1/8-in extension measure nets simultaneously with their regular panels of 8 mil 2 1/4-in commercial mesh during regular openings and collected samples from both mesh sizes when they were retrieved. Subsamples of 100 fish were measured, weighed, sexed, aged, and the state of maturity was determined (Hourston and Miller 1980). The 1976 roe fishery in Area 24 lasted for four days and samples were taken each day from March 7–10. There were 14 gillnet and 3 seine samples taken during this period, the latter as part of the regular biological sampling program (Table 1). In addition, the percentage roe yield was determined for each sample and the catch rates by each mesh size were recorded for each set.

A model of roe yield requires two types of information: the selectivity curves for various mesh sizes, and some estimate of the size distribution of the herring population. Hamley (1975) discusses two independent methods for the estimation of gillnet selectivity curves. The first method for the analysis of gillnet selectivities is based on Holt's (1963) model which assumes that the selectivity curves are normal in shape with equal heights and variances for all mesh sizes. Then, if both mesh sizes are fished with the same effort and the modes of the selectivity curves are assumed to be proportional to the mesh sizes:

$$L_{io} = Km_i \qquad (1)$$

where L_{io} = mode of selectivity curve for mesh size i
m_i = mesh size (one bar)
K = constant, equal to the reciprocal of the selectivity factor (Hamley 1975)

and

$$\log_e \left[\frac{C_{1j}}{C_{2j}}\right] = \frac{L_{2o}^2 - L_{1o}^2}{2\sigma^2} + \frac{L_{1o} - L_{2o}}{\sigma^2} \cdot L_j$$

where C_{1j} = catch by mesh 1 of fish of size group j
L_j = median length of size group j
L_{1o} = modal length for mesh 1

Now the regression of log (C_{1j}/C_{2j}) against length, Lj, produces estimates of $\hat{K}$ in equation (1) and σ^2 in equation (2):

$$\hat{K} = \frac{-2\hat{a}}{\hat{b}(m_1+m_2)} \qquad (3)$$

$$\sigma^2 = \frac{2\hat{a}(m_2-m_1)}{\hat{b}^2(m_1+m_2)} \qquad (4)$$

where $\hat{a}$ = y intercept estimated by regression equation (2)
$\hat{b}$ = slope estimated by regression equation (2)
m_i = mesh sizes of nets

The geometric mean regression was calculated for each pair of samples for both males and females (Ricker 1973), and the values of σ^2 and $\hat{K}$

were determined; the mean of the five values was taken as the best estimate of K and σ^2. Now K could be used to calculate the modal length, L_o, for any mesh size m_i and utilized in the following equation to describe the selectivity curve for that mesh size:

$$S_{ij} = \frac{1}{\sigma\sqrt{2\pi}} \exp - \frac{(L_j - L_{io})^2}{2\sigma^2} \qquad (5)$$

where S_{ij} = proportion of length j fish captured by mesh i
^{2} = variance calculated in (4)
L_j = length j
L_{io} = modal length for mesh i

We also calculated the mean length and standard deviation of fish captured by the two mesh sizes and used these values in equation (5) to derive selectivity curves. These in turn, were used in equation (7) to estimate relative roe yield for comparison with values based on Holt's model of selectivity (constant variance). The latter comparison was only made for 2 1/8 and 2 1/4-in mesh where empirical data was available.

A second estimate of selectivity is available from the seine samples if one assumes that this gear is unselective and representative of the stock at large (Hamley 1975). Then the selectivity at length is given by:

$$S_{ij} = C_{ij}/X_i N_j \qquad (6)$$

where S_{ij} = selectivity of mesh i to size class j
C_{ij} = number of fish of size class j caught by mesh i
X_i = fishing effort with mesh i
N_j = number of fish of size class j in the population from seine samples

Selectivity was calculated for males and females for all ten samples relative to the combined seine samples adjusted to a sample size of one hundred. The resulting selectivities were then averaged for each sex for each mesh size and scaled relative to the largest value, which was assigned a value of one, for comparison with the normal curves calculated from equation (5) above.

The other factor required for our model is the size frequency distribution of the population available to the gear. We approximated this distribution by determining the mean length at age for both sexes from Area 24 commercial seine fishery samples and on the whole coast during 1976. We also determined the coastwide average age composition for the roe fishery for 1971-1979.

The functional relationship between total length and roe weight (Ricker 1973) was determined from two samples collected on the spawning ground in the Yellow Bank area on March 13, 1980 in connection with a tagging study. This equation was used to estimate the roe weight at age for female herring.

The model of relative roe yield combined Holt's model of selectivity and information on the size distribution of the population. From equation (1) it was possible to determine the modal selection length for a range of mesh sizes: 1 1/2, 2, 2 1/8, 2 1/4, 2 1/2, and 3 in. Since Holt assumed constant variance the modal lengths could be used in equation (5) to calculate selectivity curves for each of these mesh sizes. Combining this with our information on the roe weight for a female of age i where age group i constitutes a certain proportion of the total population and where age i females are subject to a certain selectivity by mesh j, the relative roe yield for each mesh can be determined by:

$$R_{ij} = S_i W_i P_i \qquad (7)$$

where R_{ij} = relative roe yield at age i by mesh j
S_i = proportion of females selected at age i
W_i = weight of gonad at age i
P_i = proportion of population at age i

The overall relative roe yield by each mesh size was then estimated by summing across ages. We then used our model to examine the effects of various age compositions and lengths at age on relative roe yield for a range of mesh sizes.

RESULTS

The seine samples contained a much greater range of fish lengths than did gillnet samples from either mesh size (Table 2). There was a slight tendency for the 2 1/4-in net fish to be larger than those taken in 2 1/8-in nets but there were no apparent size differences between the sexes. The estimates of a and b from the regression of catch ratios against mean length of the males and females (Table 3) were consistent except for one pair of samples; the fit of the lines for samples 335 and 331 was poor, resulting in low parameter estimates and an exceedingly large variance estimate for the males. In most cases the regression parameter estimates for males and females were similar as were the estimates of $\hat{K}$ and σ^2. In general there was selection for slightly smaller females than males and the variance was usually smaller for males. However, the average variance was larger for males because of the one exceptionally large value mentioned previously. These average values were used in equation (5) to obtain the male and female selectivity curves scaled to proportions (Fig. 2).

Estimates of average (5 samples) selectivity at length derived from equation (6) were quite variable (Table 4) but roughly approximate to the normal curves derived from fitting Holt's model for selectivity (Fig. 2). Chi-square goodness of fit values for normality were all non-significant at the 5% level (Table 4), although frequencies in most classes were marginal. For both mesh sizes, the fitted curve appears to overestimate selectivity relative to empirical estimates at the smaller lengths. The point of maximum selectivity, although difficult to estimate accurately from the empirical estimates, appears to be underestimated by the fitted curve for the 2 1/8-in mesh.

The functional relationship between female length and gonad weight derived from 61 females from two seine samples collected March 13, 1980 in the Yellow Bank area was:

$$\text{Gonad weight} = -116.657 + .74557 \text{ length}; \; r = .92. \qquad (8)$$

The estimates of mean length at age for males and females indicated that fish from Area 24 seine samples were slightly larger at age than for the coast as a whole, resulting in relatively higher estimates of roe weight at age than for the coast as a whole (Table 5). The average coastwide age composition indicated that only ages 3-7 are prevalent in the spawning stocks (96.3% of the total) and since our length at age eight for Area 24 appears to be too low we considered only ages 3-7 in the subsequent calculations.

Our simple model of gillnet selection to estimate relative roe yields indicated that, for starting conditions of coastwide age composition and Area 24 length at age data, 2-, 2 1/8-, and 2 1/4-in gillnets all produce high relative roe yields but those from 2 1/8-in mesh are marginally higher than those from 2 1/4-in mesh (Table 6). Also, when estimates of the mean lengths and standard deviations of the females captured by the two mesh sizes (Table 4) were used to estimate the selectivity curves through equation (5) and these selectivities were then utilized to calculate relative roe yields (Table 7), 2 1/8-in mesh was found to have the higher roe yield.

Conversely, the selectivities from equation (6) indicated that at their highest values, the 2 1/4-in mesh captured 14% more females and 18% more males than did the 2 1/8-in net, although for females the greatest selectivities occurred at different lengths for the two meshes (Table 4). The effects of the different heights of the selectivity curves for the two mesh sizes were not incorporated into the scaled selectivities in order to compare them directly to the curves calculated by Holt's method. In fact,we have no information to indicate how the selectivities calculated by Holt's model compare to those derived from equation (6) in terms of relative height at maximal selectivity. However, it is apparent that the selectivities calculated for 2 1/4-in mesh are greater at their maximal values than for 2 1/8-in mesh and also that the variance of the larger mesh exceeds that for the smaller (Table 4, Fig. 2).

We subsequently examined the effects of changes in length at age and age composition on maximum roe yield, assuming that Holt's model of selectivity was applicable and that the fish length-gonad weight relationship would still apply for slower or faster growth rates. We found that any decrease in growth rate (length at age) would further favour the 2 1/8-in net whereas an increase of as little as one percent in length at age would result in the highest roe yield with 2 1/4-in nets (Table 6). The coastwide length at age was less than for Area 24 in 1976 favouring 2 1/8-in nets; it would require a 3% increase in length at age to produce the highest yields with 2 1/4-in nets on a coastwide basis.

Since age composition may fluctuate widely from year to year, we also examined the effects of a large number of permutations of percentages at age ranging from zero to 50 for age groups 3 through 7. The results from the model suggest that if the percentage of 3- and 4-yr-olds in the stock together exceed 50% then 2 1/8-in mesh will produce the maximum roe yield whereas if the 3- and 4-yr-olds constitute less than 50% of the fishable stock the 2 1/4-in nets will yield the most roe.

The direct observations on the relative efficiencies of the two gillnet mesh sizes indicated that the 2 1/4-in mesh samples yielded a higher percentage of mature roe (Table 8) than did either the 2 1/8-in mesh or seine samples. The 2 1/4-in mesh was also found to catch more fish per unit time than did the 2 1/8-in mesh (Table 9), suggesting that the larger mesh size should on average be expected to result in a higher roe yield. This contrasts with the predictions from the model of relative roe yield presented above.

DISCUSSION

The objectives of this study were to evaluate the relative efficiencies of 2 1/8- and 2 1/4-in mesh gillnets for the capture of roe herring. To do this, we examined roe yield and catch rates by the two meshes and developed a model to estimate relative roe yield by a range of mesh sizes. The latter relies heavily on the estimate of selectivity. We derived three estimates of gillnet selectivity.

The first, Holt's model, assumes that the height and variance of the selectivity curve does not increase with mesh size. Secondly, we calculated gillnet selectivity values relative to seine samples. The mean length and standard deviation of fish captured by the two mesh sizes was calculated and used in equation (5) to provide a third selectivity estimate that could be more readily compared with the first estimate. The selectivity curves resulting from the first and third approaches were very similar and produced similar estimates of relative roe yield. In both cases it was estimated that 2 1/8-in mesh should result in marginally higher roe yield than 2 1/4-in mesh. The second and third selectivity estimates were based on empirical estimates for 2 1/8- and 2 1/4-in mesh only, while Holt's model could be generalized to any mesh size. The second method could not be compared directly to the first method except by arbitrarily scaling the heights of the curves as in Fig. 1, since there is no obvious way to intercalibrate these two selectivity estimates.

Direct estimates of the mean length and variance of fish captured by the two meshes indicated that the selectivity curves for 2 1/4-in mesh were wider than those for 2 1/8 in mesh in concordance with Regier and Robson (1966). Estimates of gillnet selectivity relative to seine samples had also suggested that the heights of the curves differed. Thus, two assumptions of Holt's model of selectivity were violated and so the estimates of relative roe yield may be somewhat biased. However, since only

Holt's model of selectivity could be generalized to a range of mesh sizes, it was used to examine the effects of changes in age composition and size at age on relative roe yields by various mesh sizes. The basic model of roe yield with coastwide average age composition and Area 24 length at age then favoured 2 1/8-in mesh because Holt's model of selectivity underestimated the height and probably the variance of the 2 1/4-in mesh selectivity curve, as determined from empirical data.

On this basis the model also predicted that in Area 24 increases in growth would favour 2 1/4-in mesh while decreases would further favour 2 1/8-in mesh. Similarly, increases in length at age on a coastwide basis would also favour larger mesh sizes while decreases would favour smaller meshes. It seems unlikely that major changes in coastwide length at age would occur from year to year. On the other hand one would expect considerable annual variation in age composition (Hourston 1981). Prior to 1976 most of the 11 stocks which regularly contributed to the roe fishery (Louscoone Inlet, Skincuttle Inlet, Chatham Sound, Porcher Island, Kitasu, Milbanke Sound, Queens Sound, Nanaimo-Comox, West Barkley, South Clayoquot, and Nuchatlitz Inlet management units) were made up of over 50% 3- and 4-yr-old fish. Since then older age classes have predominated in most of these stocks. Only for the Nanaimo-Comox stock (and other minor stocks in the Strait of Georgia) was the percentage of 3- and 4-yr-olds consistently greater than 50. Therefore, the mesh size best suited for the roe fishery may vary from year to year depending on the age composition of the stocks. However, it is apparent that the predicted maximum roe yields based on our model are obtained at a very narrow range of mesh sizes that are not significantly affected by changes in the size distribution of the herring population (Fig. 3, Table 6). It is also apparent that there are only marginal differences in yields between similar mesh sizes making it difficult to clearly favour one mesh size over another.

Two further considerations in determining the best mesh size for the roe fishery need to be examined. Firstly, the efficiency of gillnets at capturing fish should be reflected by their selectivity curves. We found, however, that the size of fish most readily captured by 2 1/8-in mesh were similar to those found in the seine samples. This suggested that this mesh size should be more efficient than the 2 1/4-in mesh at capturing the available size range of fish in the population at large. Rough estimates of landings by these two mesh sizes indicated that the 2 1/4-in nets caught 74% more fish per unit time than did the 2 1/8-in nets (Table 9) which, even including the 10% weight differential in size of fish taken in the two meshes, indicated that the larger mesh was more efficient. The second consideration is the quality of the roe product. Smaller roe will not be classed as first grade and therefore brings less economic return. Our data indicated that 2 1/4-in nets yielded slightly higher percentages of mature first grade roe than did either the 2 1/8-in nets or seines (Table 8). These two considerations would appear to quantitatively outweigh the marginal superiority of the 2 1/8-in mesh suggested by our model of relative roe yield.

Taking into consideration all of the data we feel that 2 1/4-in mesh should be retained as the minimum mesh size for the British Columbia herring roe fishery.

ACKNOWLEDGMENTS

We would like to thank Walter Piatoka and John Chorney, skippers of MISS ROBYN and GALA BABE, for their assistance in obtaining the samples from the two gillnet meshes sizes and for advice in constructing the gill nets. Dick Isaacson aged the scales and Captain Ed Arnet collected the samples from the fishing grounds.

REFERENCES

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. Int. Comm. Northwest Atlantic Fish. Spec. Publ. 5: 106-115.

Hourston, A. S. 1981. Summary tables for annual assessments of the status of British Columbia herring stocks in the 1970s. Can. Data Rep. Fish Aquat. Sci. 250: 381 p.

Hourston, A. S., and D. C. Miller. 1980. Procedures for sampling herring at the Pacific Biological Station. Fish. Mar. Serv. MS. Rep. 1554: 23 p.

Ricker, W. E. 1973. Linear regressions in fishery research. J. Fish. Res. Board Can. 30: 409-434.

Regier, H. A., and D. S. Robson. 1966. Selectivity of gill nets, especially to lake whitefish. J. Fish. Res. Board Can. 23: 423-454.

Table 1. Gillnet and seine samples taken in Clayoquot Sound (Area 24), March 7-10, 1976.

Gear	Sample No.	Date	Location	Vessel
2 1/8 Gillnet	332	March 7	Yellow Bank	MISS ROBYN
	333[a]	March 7	Yellow Bank	GALA BABE
	233	March 8	Yellow Bank	GALA BABE
	335	March 8	Yellow Bank	MISS ROBYN
	231	March 9	SW Yellow Bank	GALA BABE
	336	March 9	Yellow Bank	MISS ROBYN
	-[b]	March 10	Yellow Bank	MISS ROBYN
2 1/4 Gillnet	334	March 7	Yellow Bank	MISS ROBYN
	232[a]	March 7	Yellow Bank	GALA BABE
	234	March 8	Yellow Bank	GALA BABE
	331	March 8	Yellow Bank	MISS ROBYN
	230	March 9	SW Yellow Bank	GALA BABE
	337	March 9	Yellow Bank	MISS ROBYN
	338	March 10	Yellow Bank	MISS ROBYN
Commercial seine	167	March 7	Yellow Bank	SNOW CLOUD
	170	March 9	Ritchie Bay	B.C. SAFARI
	171	March 9	Ritchie Bay	OCEAN JOYE

[a]Samples appear to be mislabelled.
[b]Sample lost in transit.

Table 2. Length distributions of gillnet and seine samples from Clayoquot Sound (Area 24).

Length group	Seine		2 1/8										2 1/4									
	Combined		332		233		335		231		336		334		234		331		230		337	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
171-175	1	1												1								
176-180		1																				
181-185	6	4																				
186-190	8	8	1																			
191-195	11	3					2				1	1		2								1
196-200	14	10		2			2		1		4	6		1							1	
201-205	21	17	12	12	5	4	2	5	6	1	14	8	5	6	1	2			3		2	2
206-210	23	15	12	8	15	3	11	9	10	8	12	8	6	7	5	3	5	3	4	4	6	2
211-215	16	25	8	7	18	12	8	11	11	6	12	10	8	8	10	3	9	5	5	9	6	6
216-220	9	9	7	5	10	8	6	12	12	9	4	2	4	7	7	8	12	10	5	5	18	2
221-225	13	7	13	3	7	5	4	3	11	5	6	3	6	6	9	7	7	11	9	4	11	4
226-230	8	13	1		4	3	6	3	4	5	4	1	4	12	5	4	10	11	7	5	12	4
231-235	11	12		1	3	1	6	2	3	3	2		3	5	7	2	6	2	6	8	8	4
236-240	6	10			2		1	2	1	2	1	1	2	3	5	8	1	3	4	7	3	3
241-245	4	9					2	3	2				1	1	2	2	3	2	3	6		2
246-250		3												1	2	1			3	1	2	
251-255	1																		1	1		
Total	152	147	54	38	64	36	50	50	61	39	60	40	39	60	53	40	53	47	50	50	69	30

Table 3. Parameter estimates for normal approximations to the selectivity curves for male and female herring (Holt's model).

Sample No.		$\hat{a}$	$\hat{b}$	r	$\hat{k}$	σ^2
332/334	M	20.062	-.092	-.653	199.55	135.68
	F	14.222	-.067	-.986	192.97	179.00
233/234	M	16.409	-.074	-.985	203.78	173.00
	F	14.370	-.065	-.705	200.83	191.86
335/331	M	8.544	-.039	-.347	201.74	325.63
	F	16.303	-.073	-.373	205.34	176.79
231/230	M	13.681	-.061	-.856	204.59	209.14
	F	15.352	-.070	-.778	201.76	181.25
336/337	M	20.595	-.095	-.871	198.27	130.48
	F	15.338	-.071	-.712	197.84	174.45
Mean	M				201.58	194.79
	F				199.75	180.67

Table 4. Estimated gillnet selectivity relative to seine catches and expected values assuming a normal distribution.

	2 1/8				2 1/4			
	Male		Female		Male		Female	
Length class	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
191-195	.1636	.2196	.2000	.2419	.0000	.0352	.6000	.1430
196-200	.3000	.5123	.4800	.5306	.0429	.1208	.0600	.3138
201-205	1.1143	.9772	1.0588	.9411	.3143	.3518	.3529	.5960
206-210	1.5652	1.5378	1.4400	1.3779	.6783	.8218	.7600	.9747
211-215	2.1375	2.0377	1.1040	1.6722	1.4250	1.5150	.7440	1.3898
216-220	2.6000	2.2310	2.4000	1.6663	3.0667	2.2544	2.1333	1.7490
221-225	1.8923	2.0436	1.6286	1.3605	1.9385	2.7133	2.7429	1.9052
226-230	1.4250	1.5462	.5539	.9221	2.8500	2.6310	1.6615	1.8278
231-235	.7636	.9853	.3500	.5153	1.6364	2.0372	1.0500	1.5135
236-240	.5000	.5181	.3000	.2327	1.5000	1.2856	1.4400	1.1043
241-245	.6000	.2227	.2000	.0861	1.3500	.6490	.8667	.7061
246-250			.0000	.0273			.6000	.3897
Mean	218.54		215.89		225.23		224.28	
S.D.	11.57		11.25		10.64		13.50	
χ^2		$.8981^{ns}$		$.9961^{ns}$		1.5239^{ns}		2.9741^{ns}

Table 5. Mean length (mm) and roe weight (g) at age and age composition for herring.

Age		2	3	4	5	6	7	8	9
Mean length (Whole coast, 1976)	Male	154.41	182.92	202.56	213.45	224.3	233.32	237.97	242.55
	S.D.	13.68	12.51	11.63	13.68	13.69	13.21	12.46	12.84
	N	395	1567	5484	3025	1946	700	232	38
	Female	152.81	185.01	205.38	216.35	227.85	237.06	242.82	244.46
	S.D.	13.35	11.85	11.41	14.39	13.96	12.64	12.07	11.84
	N	328	1339	5586	3095	2118	882	291	69
Est. Roe weight		-2.73	19.72	36.47	44.65	53.22	60.09	64.38	65.61
Mean length (Area 24)	Male	-	189.50	205.08	217.80	229.46	239.82	239.50	-
	S.D.	-	7.79	10.37	12.91	8.80	16.37	6.36	-
	N	-	10	79	20	13	11	2	-
	Female	-	188.0	208.12	219.68	236.55	236.80	234.00	-
	S.D.	-	7.17	9.83	9.25	6.08	7.47	1.41	-
	N	-	8	59	25	22	10	2	-
Est. Roe weight		-	23.51	38.51	47.13	59.71	59.89	57.81	-
Age composition (coast 1971-79)		.021	.267	.300	.220	.127	.049	.013	.003

Table 6. Effects of changing growth rate on relative roe yields assuming Holt's model of selectivity.

	Relative roe yields at various mesh dizes					
	1 1/2	2	2 1/8	2 1/4	2 1/2	3
Area 24 Growth	.0033	.5194	.6881	.6622	.2229	0.00
Growth +1%	.0023	.5011	.6927	.7003	.2763	0.00
Growth -1%	.0046	.5354	.6769	.6207	.1752	0.00
Whole Coast Growth	.0055	.5503	.7030	.6102	.1246	0.00
Growth +1%	.0041	.5320	.7155	.6633	.1619	0.00
Growth +2%	.0029	.5116	.7200	.7118	.2057	0.00
Growth +3%	.0020	.4901	.7168	.7545	.2558	0.00

Table 7. Comparative roe yield and maximal selectivity from Holt's model and calculated mean and standard deviation of females captured by 2 1/8- and 2 1/4-in mesh.

	Mean length	Standard deviation	Maximum selectivity	Relative roe yield
Empirical value				
2 1/8	215.89	11.25	.03546	.7488
2 1/4	224.28	13.50	.02955	.6656
Holt's model				
2 1/8	212.23	13.4	.02968	.6881
2 1/4	224.72	13.4	.02968	.6622

Table 8. Average sizes of herring taken by various gears and roe yield for samples from Clayoquot Sound (Area 24).

Gear description	Sample No.	N.	Mean weight	Mean length	Mean girth	Percent Mature Roe
2 1/8" Gillnet	231	100	136.28	218.05	116.47	12.11
	233	100	141.45	215.68	117.91	9.73
	332	92	139.82	213.18	120.42	9.93
	333	100	145.30	217.94	123.89	14.79
	335	100	146.44	216.84	122.95	13.56
	336	100	128.26	211.44	118.67	11.71
	Mean		139.59	215.52	120.05	11.97
2 1/4" Gillnet	230	100	161.28	226.68	125.22	13.85
	232	100	136.22	210.98	141.89	9.06
	234	93	154.16	224.37	124.15	13.20
	331	100	156.89	223.11	125.65	12.51
	334	99	149.68	218.08	126.99	16.41
	337	99	147.54	221.15	127.22	8.61
	338	94	157.97	225.59	130.85	13.39
	Mean		151.96	221.42	128.85	12.43
Commercial Seine	167	100	135.24	214.00	-	10.92
	170	100	133.85	213.72	-	12.84
	171	100	138.34	214.61	-	13.16
	Mean		135.81	214.11		12.31

Table 9. Catch rates calculated from logbook aboard M/V MISS ROBYN.

Mesh size	Sample No.	Hours fished	Estimated catch (lbs.)	Catch lbs./h
2 1/8"	332	6	1500	250
	335	12	1500	125
	336	18	1500	83
	-*	12	700	58
	Average	48	5200	108
2 1/4"	334	6	2000	333
	331	12	3000	250
	337	18	3000	167
	338	12	1000	83
	Average	48	9000	188

*Lost in transit

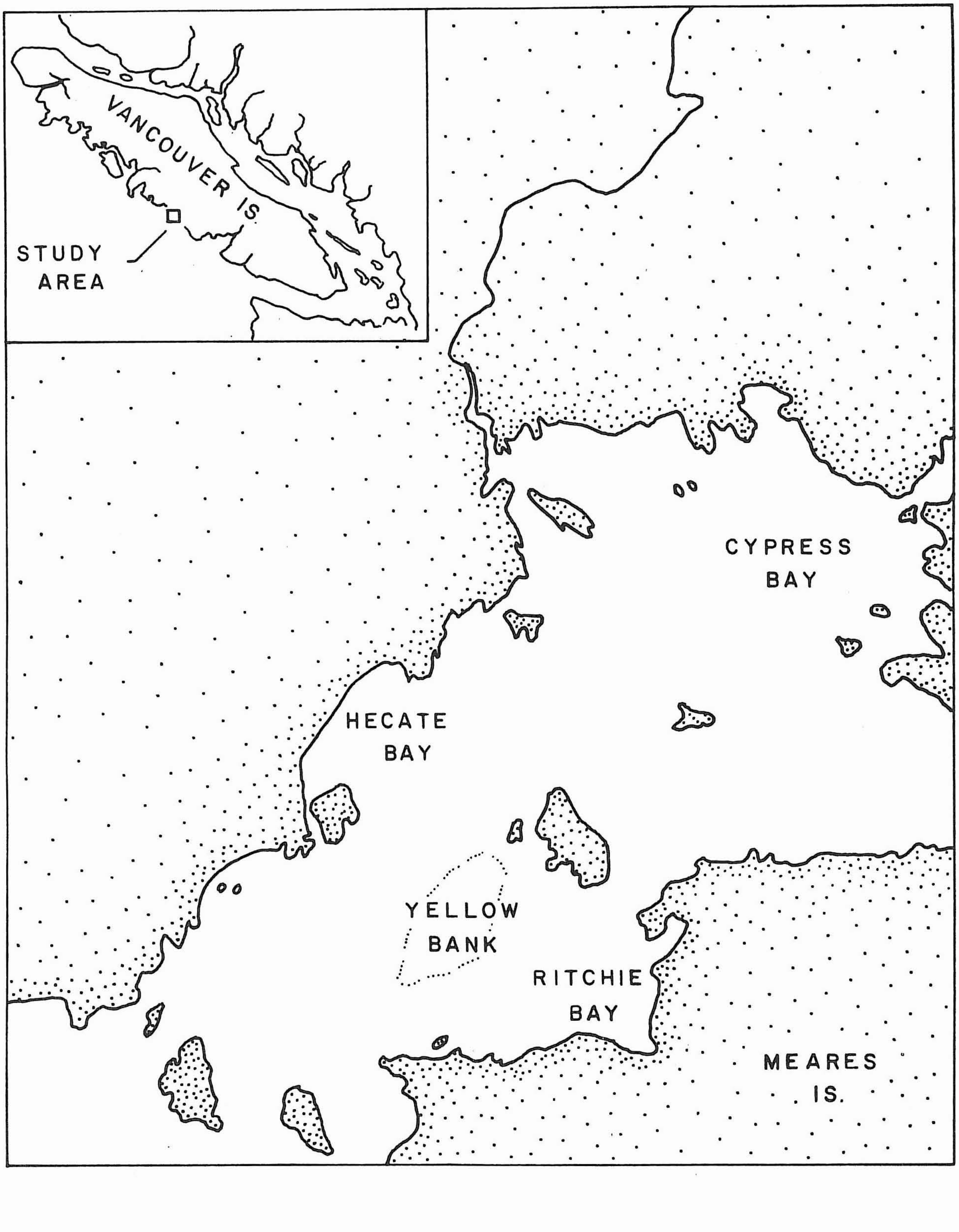

Fig. 1. Location of the 1976 herring gillnet selectivity study in Clayoquot Sound.

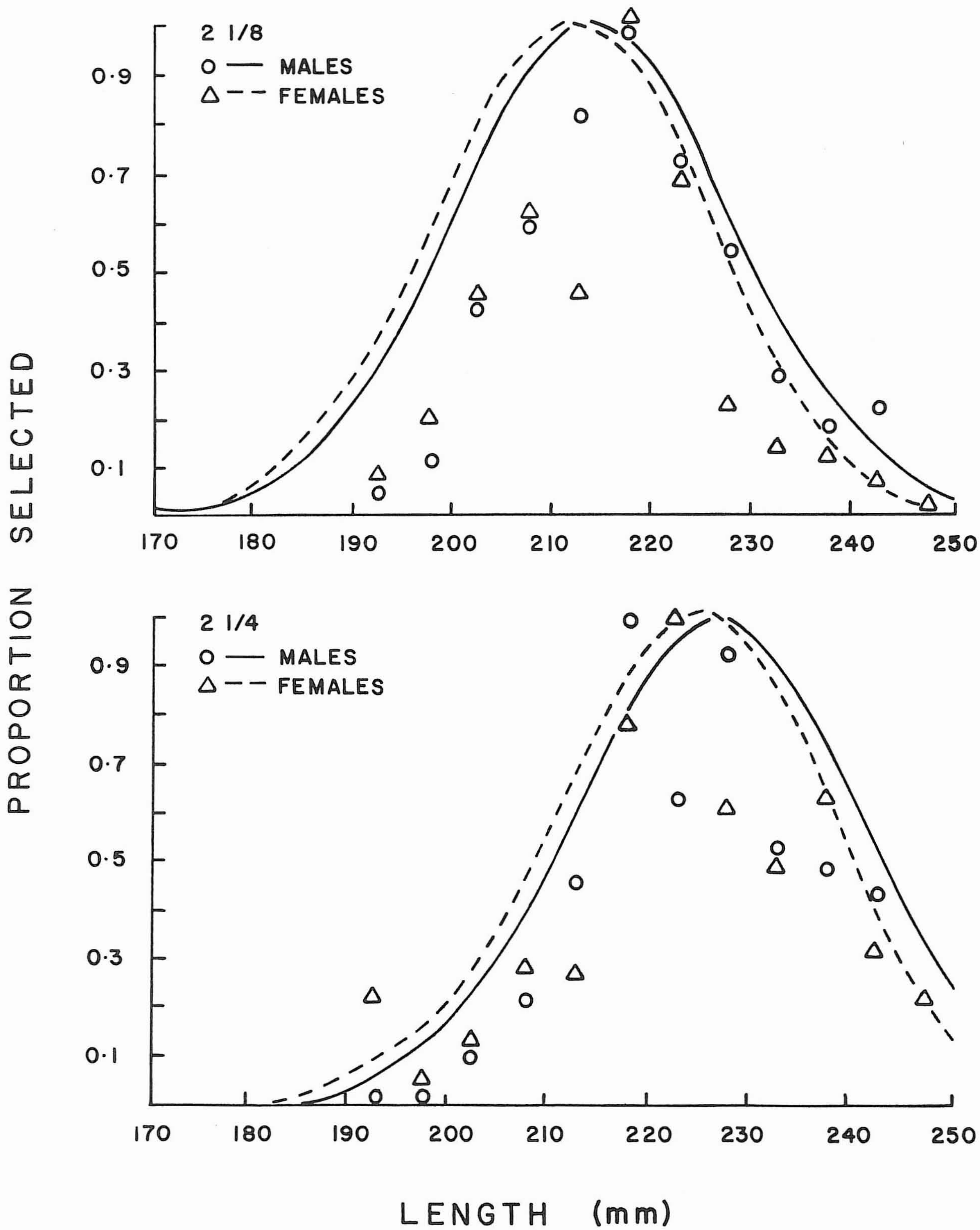

Fig. 2. Calculated selectivity curves using Holt's (1963) model and selectivity estimated directly relative to seine samples.

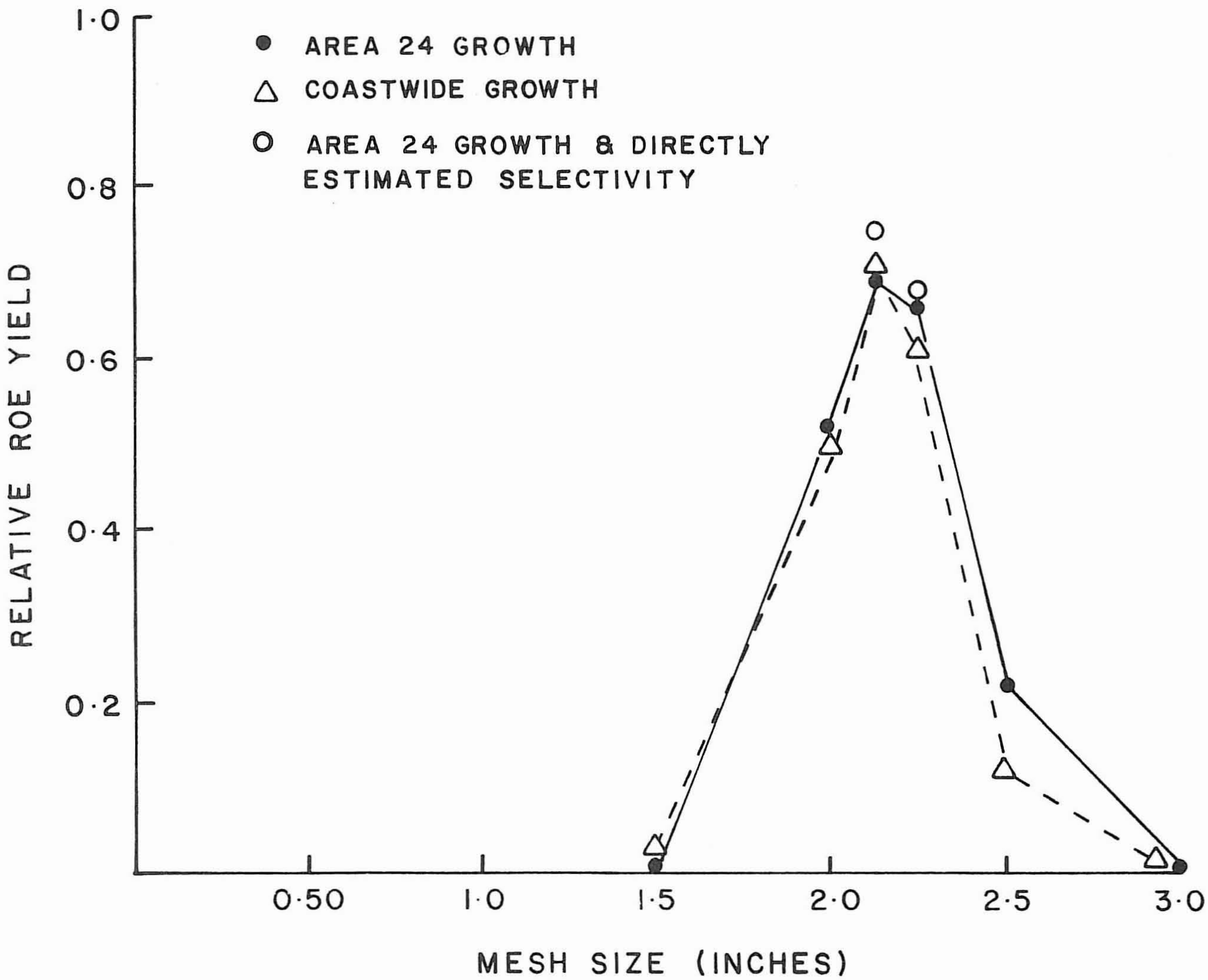

Fig. 3. Relative estimated roe yields for a range of mesh sizes using Holt's model for selectivity and a direct estimate of the mean length and variance of fish captured by the two mesh sizes.