RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 1528
(D. c. 8)

Research Document No. 61

ANNUAL MEETING - JUNE 1965

Size Selection and Retainment of Silver and Red Hake in Nylon Codends of Trawl Nets

by

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Three experiments were conducted by personnel of the Bureau of Commercial Fisheries' Woods Hole Laboratory during 1964 to determine the size-selectivity and relative catching efficiency of 52, 71, and 73 mm mesh (2.0, 2.8, and 2.9 inches)[1/], nylon codends for silver hake (Merluccius bilinearis) and red hake (Urophycis chuss). This information was needed to assess the effect of the larger mesh on commercial catches.

The Delaware, a research vessel of the Bureau, was used for the first experiment, in which personnel of the Exploratory Fishing and Gear Research Base at Gloucester, Massachusetts, cooperated. The object was to obtain estimates of selectivity of the 52 and 73 mm mesh codends, and to compare estimates of selectivity obtained with covered and uncovered codends. Commercial fishing vessels were used for the two subsequent experiments to estimate selectivity of a 71 mm mesh nylon codend in actual commercial operations.

A typical vessel in the Gloucester, Mass., fleet was chosen for the first of the commercial trials. This fleet currently uses a 50 mm (2.0 inches) mesh, nylon codend and lands silver hake almost exclusively for human food. Two typical vessels of the Pt. Judith, Rhode Island, fleet were used in the second commercial trial. This fleet lands silver and red hake primarily for industrial purposes (i.e., meal and animal food), and currently uses a small mesh (33 mm, 1.3 inches), nylon liner in the codend.

1/ Stretch measure of wet mesh, after use, using an ICES gauge (Westhoff, et al., 1962) at 4.4 kilograms of pressure.

Fishing areas providing a high proportion of silver hake in catches were chosen, because this species was of primary interest. Red hake were caught incidentally during the Delaware experiment, and a one-day experiment at Pt. Judith was conducted to provide additional data. Relatively small amounts of other species were caught, but are not considered herein.

This paper presents the procedures and results of the three experiments, and considers the probable effects on commercial catches of the use of the larger mesh.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the fine cooperation of William E. Ragusa, Captain of the Frances R., John Dykstra, Captain of the Nyanza, Robert D. Smith, Captain of the David D., and their crews, who enabled these experiments to be completed effectively.

Experimental Procedure and Methods of Analysis

Delaware Experiment

The experiment was conducted from 29 June through 6 August in the near-shore area of the Gulf of Maine. The trawl net was similar in construction to that used by commercial fishermen, with 64 mm (2.5 inches) mesh of No. 54 thread, cotton equivalent nylon throughout the wings and body.

Two series of 30 tows were completed. Within each series, 5 successive tows on both the port and starboard sides of the vessel were to be made with each of three types of codends: a 52 mm mesh covered with a 31 mm mesh (see Clark, 1963a for method of attachment), and a 52 and a 73 mm mesh, both without covers. The codends and vessel sides were used in random order; the tows averaged about three-quarters of an hour.

As with most experiments at sea, operational exigencies modified the procedure. Two serious tear-ups caused more tows to be made on the starboard side than the port side in the second series. The resulting array of tows was as follows:

Codend mesh (mm)	52/31*		52		73		Total
Side	Port	Stbd.	Port	Stbd.	Port	Stbd.	
Series 1	5	5	5	5	5	5	30
Series 2	2	8	5	5	4	6	30
Total	7	13	10	10	9	11	60

All fish from a representative, 2-bushel sample from each tow were measured, weighed, and counted. In occasional catches of less than two bushels, all fish were measured and counted. The total number of bushels in each tow was also counted. The total number and total weight of silver and red hake in the tow were estimated by multiplying the estimated number and weight of fish per bushel by the total number of bushels. The length-frequencies of the fish in the sample were used to estimate total numbers caught per 3 cm length interval.

Retention curves for the 52 and 73 mm mesh codends without covers were drawn by plotting for each 3 cm interval the ratios of the estimated numbers of fish retained in the larger mesh codend to that retained in the codend covered with the 31 mm mesh (including fish in the cover). The 31 mm mesh is fine enough to retain nearly all of the sizes of fish available to the trawl.

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* 52 mm covered with 31 mm.

The selection curve for the covered 52 mm mesh codend was derived by estimating the ratios of the number retained in the cover to that retained in the codend plus cover.

The average length at which 50 percent of the fish were retained was estimated from lines drawn by inspection through points of the retention ratios plotted on probability paper. The selection factor is the quotient of the 50 percent length divided by the mesh size.

Gloucester Experiment

To make the results of this experiment meaningful in relation to the silver hake commercial fishery, it was important that the experiment be conducted during normal fishing operations. This was accomplished by placing a Bureau observer aboard a cooperating Gloucester vessel, the Frances R., a wooden dragger of 57 gross tons, during two regular one-day trips. The vessel used the experimental, 71 mm mesh codend on the first day (30 September) and the standard, 50 mm mesh codend on the second day (2 October). No changes were made in the net itself, and no covers were used. The vessel fished in an area near "The Dumping Grounds", about 12 miles south-southeast of Gloucester. Eight tows of two hours each were made with each codend.

The procedure for sampling the catch was the same as that followed aboard the Delaware except that two-bushel samples of silver hake only were measured and counted on all tows; the catches were all large, and almost 95 percent silver hake. The mean weight per fish in each sample was estimated by using a length-weight relation obtained from a special sample of fish. The captain's estimate of the weight of the total catch - usually a reliable estimate - was divided by the mean weight per fish to estimate the

total number of fish in the catch. This procedure was necessary because it was impractical to count and measure the entire catch.

Pt. Judith Experiment

Two typical commercial vessels, the Nyanza and David D., wooden draggers of 39 and 27 gross tons, respectively, cooperated in this experiment. Observers from the Bureau accompanied both vessels on three, one-day trips, during which the vessels fished within 1 km of each other on commercial grounds.

On the first of the silver hake trips (19 October), one vessel used the experimental, 71 mm mesh codend attached to the net normally used in fishing. The other used the standard codend, 127 mm nylon mesh lined with a 33 mm nylon mesh. On the second trip the vessels exchanged codends. In all, 21 tows of about one hour each were completed, of which 16 were sampled.

The red hake experiments were completed on a single subsequent day (22 October), during which one vessel used the large mesh and one the small mesh. Each vessel completed 4 tows of about one hour's duration.

The sampling and estimating procedures were the same as those outlined for the Gloucester experiment.

Results

Silver hake

The data on catch and selectivity for each experiment and type of codend are presented in Table 1 and Figures 1 - 4. There are several aspects of particular interest.

The selection curve for the 52 mm mesh obtained from tows with the covered codend is quite different from that obtained from alternate tows

Table 1.--Catch and selectivity of silver hake, 1964.

	Delaware			Gloucester		Pt. Judith	
Mesh size	31	52	73	50	71	33	71
Length int. midpoint (cm.)				Numbers caught			
12	136	---	---	---	---	97	---
15	1170	125	59	70	14	422	48
18	2183	417	79	496	82	2558	174
21	1365	313	89	936	125	6815	341
24	3496	793	463	2380	792	12553	2614
27	9084	5239	2424	19640	5842	17111	5828
30	4696	5156	2168	18410	7035	26585	14889
33	3496	5260	2484	7085	4138	11728	11054
36	1558	2380	1222	1275	725	4685	4733
39	586	730	473	192	123	1688	3043
42	229	209	118	---	37	642	1101
45	102	104	89	---	34	212	400
48	76	42	59	---	111	47	200
51	51	42	49	---	20	67	---
54	---	21	29	141	---	---	---
57	---	21	10	---	14	---	9
60	---	---	10	---	---	---	---
Total no.	28228	20852	9825	50625	19092	85210	44434
Total weight							
Kilo's	4472	4254	1975	7713	3176	20417	10662
Pounds	9856	9376	4352	17000	7000	45000	23500
No. tows	20	20	20	4	4	11	10
Hrs. towed	14.7	14.6	14.4	8.0	7.0	12.0	12.1
Wt. per hour							
Kg.	304	291	137	965	454	1702	882
lbs.	670	642	302	2125	1000	3750	1942
Ratio of wt. per hour 1/	---	0.96	0.45	---	0.47	---	0.52
Selectivity							
50% length (cm.)	15.8	26.4	30.4	---	31.8	---	29.3
Selection factor	3.2	5.08	4.16	---	4.27	---	4.13

1/--Ratio of catch of larger mesh to smallest mesh in each experiment.

without the cover (Figure 1). Both the 50 percent length and the selection factor are lower for the former (15.8 and 3.2 vs. 26.4 and 5.08, respectively); the covered codend is retaining proportionately more of the smaller fish. Escapement may be reduced by a "masking" effect of the cover; small fish may also re-enter the codend when vessel speed is reduced during haul-back. Clark (1963b) also observed this effect in similar experiments with 80 mm codends.

There is a rather sharp size-selection in the uncovered 52 mm mesh; the 25 to 100 percent retention is within a length range of 5 cm, whereas the range is about 10 cm for the 73 mm mesh, which exhibits a more gradual retention curve.

Retention ratios greater than one were observed for the 52 mm mesh in the Delaware experiments and for the 71 mm mesh in the Pt. Judith experiments (Figure 3). In alternate tow experiments, the retention ratios are the resultant of two factors -- escapement through the mesh and catch rate. Ratios greater than one imply the larger mesh is more efficient, providing both nets fished the same average population density. The retention curves for the 73 mm mesh in the Delaware tows, and the 71 mm mesh in the Gloucester tows (Figure 2) do not show this phenomenon; however, note the fish length at which ratios exceed unity is rather greater in the 71 mm mesh from the Pt. Judith experiments (36 cm) than in the 52 mm mesh (29 cm). Even if relative efficiency is an important factor, it will only be apparent when increased catch more than compensates for escapement, i.e., towards the upper limb of the curve, and this may not obtain for the larger meshes over the size range of fish observed. Regardless of the underlying causes, the retention curves from alternate tows do portray, within limits of sampling error, the expected effect in commercial application. This may not be so for the covered codend results.

Another important result is the observed effects on total catch rate. The 71 - 73 mm mesh codends caused a decrease of about 50 percent by weight compared to the 31 or 33 mm meshes. In contrast, the Delaware experiment indicated a loss of less than 5 percent with the 52 mm mesh (Table 1).

The reduction of catch is also evident in comparisons of catches made by the Frances R. using the 71 mm codend with those of vessels of similar size and horsepower fishing nearby with 50 mm codends:

Vessel	Hours towed	Catch Kg.	Catch Pounds
Frances R.	1.7	636	1400
Little Flower	1.6	909	2000
Frances R.	2.0	1137	2500
Sebastiana C.	2.0	1362	3000
Frances R.	7.0	3181	7000
Barbara C.	7.0	6820	15000

The difference in catch rate is important in application, but, of course, depend on the length-frequency of the available population, which varies in time and space. This subject will be taken up again in the subsequent section on commercial fishery application.

The retention curves obtained on the two days at Pt. Judith are very nearly coincident and the data were pooled to provide a single curve (Figure 3).

The overall uniformity of results of the several independent sets of data for the 71 and 73 mm mesh nets provides a fair measure of confidence in the results (Figure 4). The retention ratios of the 71 mm mesh obtained in the Gloucester experiment cannot be directly compared to the others because a larger base net was used (50 mm vs. 31 and 33 mm); therefore, the

retention ratios in Figure 4 have been adjusted by the retention ratios of the 52 mm mesh estimated from the Gloucester experiment to make them more comparable. The remaining small differences in mesh size between experiments (31 vs. 33 mm, 50 vs 52 mm, 71 vs. 73 mm) are of little consequence in the final results. Thus, for a mesh averaging 72 mm, the 50 percent length and selection factor may be taken as the average of those in Table 1, 29.8 cm and 4.2, respectively.

Small numbers of fish beyond about 39 cm in our catches preclude firm estimates of retention and relative catch of fish in that length category. Note also the small catches in the Delaware experiment relative to the commercial tows. This might affect the retention characteristics, although it is not apparent that it has done so.

Extensive gilling of fish sometimes is observed in meshes that permit some escapement. In all three experiments, gilling of silver hake in the 71 and 73 mm codends was of the order of 0.1 percent; certainly not of a magnitude to cause concern. Those that were gilled were 26 to 41 cm in length, with a modal length of 33 cm which is somewhat greater than the 50 percent length. More fish gilled in the forward parts of the net than in the codend, a fact which does indicate escapement through the forward parts, but is of no practical concern here. These fish measured from 27 to 39 cm, with a modal length of 33 cm.

Red hake

The catch and selectivity data for each experiment and type of codend are shown in Table 2 and Figures 5 - 8. The total number of red hake caught by the Delaware and the Pt. Judith vessels (no red hake were caught in the Gloucester experiment) was far less than the number of silver hake

Table 2.--Catch and selectivity of red hake, 1964.

Mesh size (mm.)	Delaware			Pt. Judith	
	31	52	73	33	71
Length int. midpoint (cm.)	Numbers caught 1/				
12	4	--	--	1	--
15	20	--	--	4	--
18	44	--	--	--	--
21	54	4	--	--	--
24	28	7	--	4	--
27	18	12	1	67	--
30	38	24	8	112	7
33	22	33	21	112	14
36	24	43	35	89	37
39	36	59	59	89	73
42	76	89	39	95	110
45	40	51	40	49	87
48	24	34	34	17	47
51	8	25	11	10	11
54	12	7	11	1	3
57	--	7	3	--	2
60	--	10	2	--	--
Total	448	405	264	650	391
Total weight					
Kg.	--	--	--	508	189
Pounds	--	--	--	1117	415
No. tows	10	13	18	4	4
Hours towed	6.6	8.8	13.1	4.0	5.6
Wt. per hour					
Kg.	--	--	--	127	34
Pounds	--	--	--	279	74
Ratio of weight per hour 2/	--	--	--	--	0.27
Selectivity					
50% length (cm.)	29.1	25.7	31.0	--	36.5
Selection factor	5.6	4.9	4.2	--	5.1

1/--Numbers adjusted to compensate for different fishing time.

2/--Ratio of catch of large mesh to small mesh.

caught. The Delaware fished known silver hake grounds and red hake were an incidental by-catch. The Pt. Judith vessels fished a ground that usually produces red hake but the fish were scarce the day the experiment took place. Thus, the volume of fish considered in these experiments is less than commercial quantities.

The selection curve of the 52 mm mesh derived from the covered codend tows is not very different from the retention curves of the same size mesh fished without the cover, at least up to the 100 percent point (Figure 5). The 50 percent lengths differ by about 3 cm and the selection factors differ by 0.7. In each case the covered codend values are lower.

Size selection is rather sharp for the 73 mm mesh. The 25 to 100 percent retention lengths are within 3 cm, whereas the same span for the 52 mm covered and 52 mm uncovered codends are 10 cm and 7.5 cm, respectively. Also, the retention curve for the 73 mm mesh is displaced to the right of the curve for the 52 mm mesh by only about 4 cm. All of these results are in sharp contrast to those observed for silver hake.

The retention curve for the 71 mm codend used in the Pt. Judith experiments indicates again a rather sharp selection (Figure 6). We also note a proportionately greater release of smaller fish compared to the 73 mm mesh in the Delaware experiments; the 50 percent points are 37 and 31 cm, respectively.

In all retention curves based on uncovered codends, ratios exceeding unity were observed, and perhaps indicate a higher catching efficiency. However, the ratios from the Delaware experiment are quite erratic for lengths greater than about 39 cm, and, therefore, do not provide clear-cut results.

The data points for the Pt. Judith experiment are somewhat better in this regard, and indicate the same trends as observed for the silver hake.

The total catch per hour for all species in the Pt. Judith experiment was 1931 kg (4250 pounds) for the 33 mm mesh codend and 503 kg (1107 pounds) for the 71 mm mesh codend. This is a rather drastic reduction; however, it is mostly due to the reduction in catch of species other than red hake -- silver hake, flounders, butterfish, and skates. The catch of red hake in the 71 mm mesh codend was estimated to be 8 percent less than the catch in the 33 mm codend. The average length of red hake in the 1964 industrial landings was less than that observed during our experiments. Thus, in actual practice the losses would be somewhat greater.

There was no opportunity to exchange codends between the two Pt. Judith vessels to average out differences in catch rate. Therefore, we must consider the results as provisional.

We have no observations of gilled red hake in the Delaware experiment but we made some measurements in the Pt. Judith experiment. The fish gilled only in the 71 mm codend. At the end of a 1.3 hour tow, 62 red hake were gilled in the meshes. The gilled fish ranged from 33 to 46 cm in length with the mode at 42 cm. The codend catch for that tow consisted of 454 kg (1000 pounds) of silver hake, flounders, miscellaneous fishes, and 113 red hake from 33 to 56 cm long.

Conclusions

Silver hake

Silver hake is the most important single species in the industrial catches, and is the basis of an important food-fish fishery at Gloucester, Massachusetts (Fritz, 1960; Edwards, 1958; Edwards and Lux, 1958; Edwards and Lawday, 1960).

The results of the experiments make it readily apparent that the 71 and 73 mm meshes release a large proportion of the fish in the 25 - 35 cm range -- the size group which forms the bulk of fish available to commercial trawl nets. The larger meshes do not release very many more of the fish less than 25 cm in length than does the 52 mm mesh.

We do not know the magnitude of long-term benefits -- the gross gain in weight less natural mortality -- which might be obtained by postponing capture with the use of 71 or 73 mm (2.8 - 2.9 inches) mesh codends. However, judging from preliminary estimates the growth rate of fish above 25 cm is rather slow and mortality is not low; therefore, it would be rather optimistic to expect the benefits to compensate for the large immediate loss of about 50 percent.

It is of interest, however, to consider the use of 52 mm (2.0 inch) mesh in place of the 33 mm (1.8 inch) mesh. The Pt. Judith fishery is particularly concerned, and we have calculated the immediate effects for such a change by applying the retention ratios for the 52 mm mesh estimated from the Delaware experiments to the average length-frequencies of the Pt. Judith catches in 1964 (Figure 8). The weight units are in terms of lengths cubed, and do not represent absolute catches, but are assumed to be proportional thereto.

A gain of about 8 percent by weight is estimated for the larger mesh. This is brought about by the apparent increase in catching efficiency, expressed in the retention ratios greater than one which coincide with the peak length frequencies. Almost all fish below 25 cm would be released, but they do not contribute much to the weight of catch.

Red hake

Red hake contribute about 20 percent of the annual landings from the inshore grounds at Pt. Judith (Edwards, 1958; Edwards and Lawday, 1960). They make up about one-third of the landings in May, June, and July. Therefore, the expected immediate loss with the 71 mm codend would be an important loss to the industrial fishery. Our data for the 71 and 73 mm mesh codends show considerable loss of red hake less than about 30 to 35 cm, but little loss with the 52 mm codend.

To estimate the effect of a 52 mm mesh on the catch of red hake by the industrial fleet at Pt. Judith, we applied the retention ratios estimated from the 52 mm mesh aboard the Delaware to the average length-frequencies of the 1964 Pt. Judith red hake landings. The weight units are in terms of lengths cubed and are assumed to be proportional to the absolute catches (Figure 9).

The immediate effect of the larger mesh is a loss estimated to be about 8 percent. A large proportion of the fish below 24 cm would be released and enough of the sizes smaller than 33 cm to offset the gain in catch of fish between 33 cm and 42 cm.

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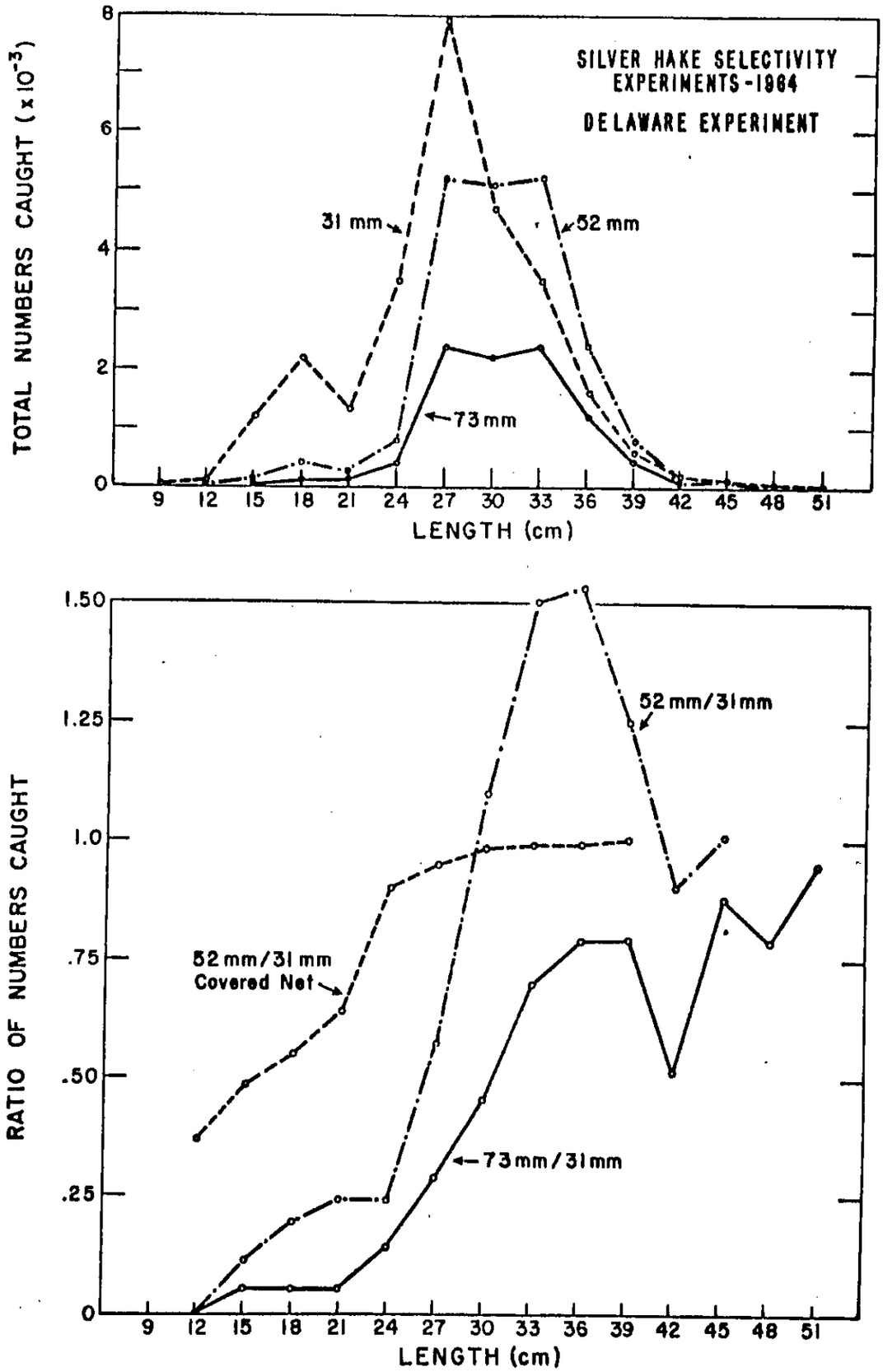


Figure 1. --Retention of silver hake in 52 mm and 73 mm nylon codends, Delaware.

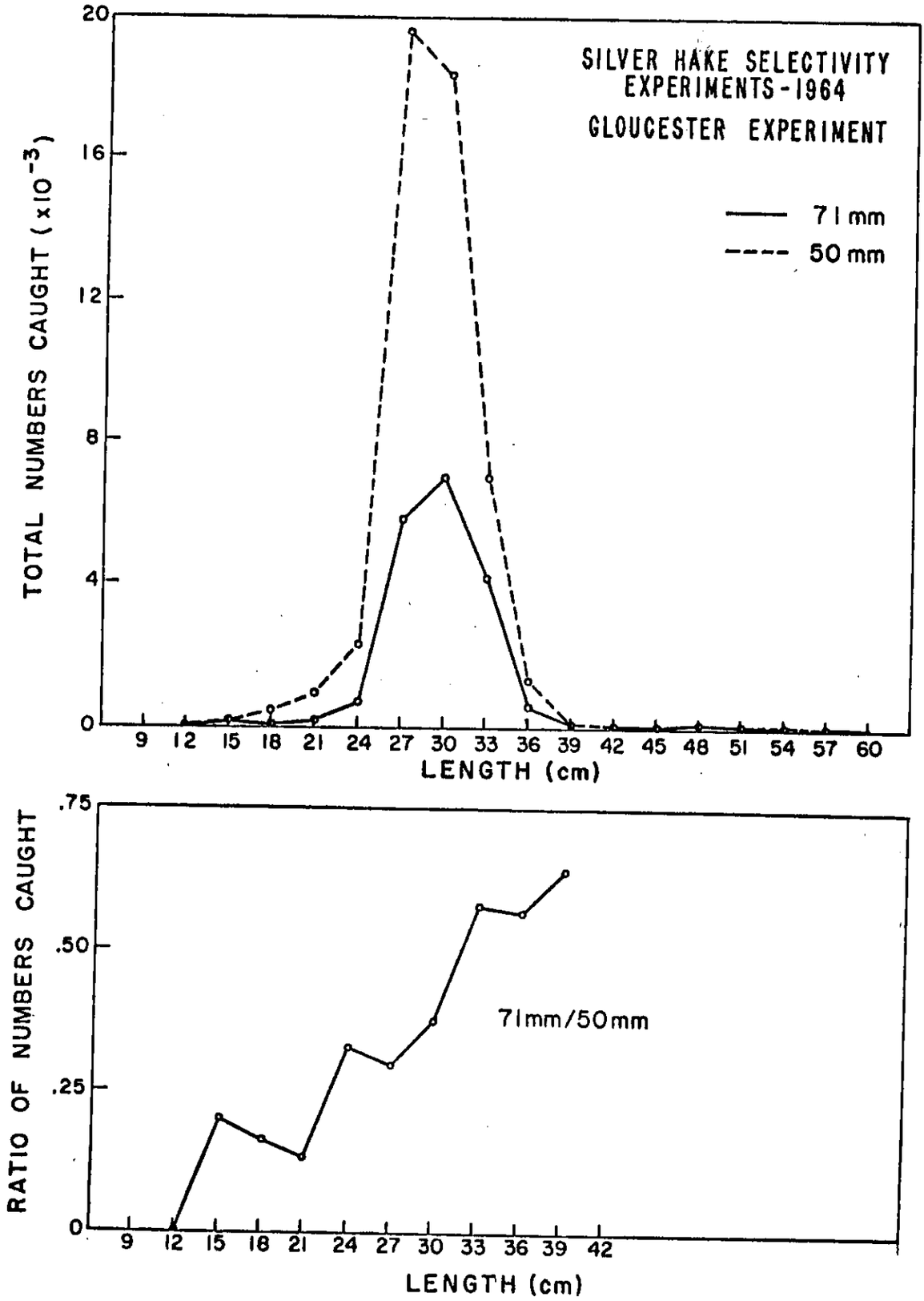
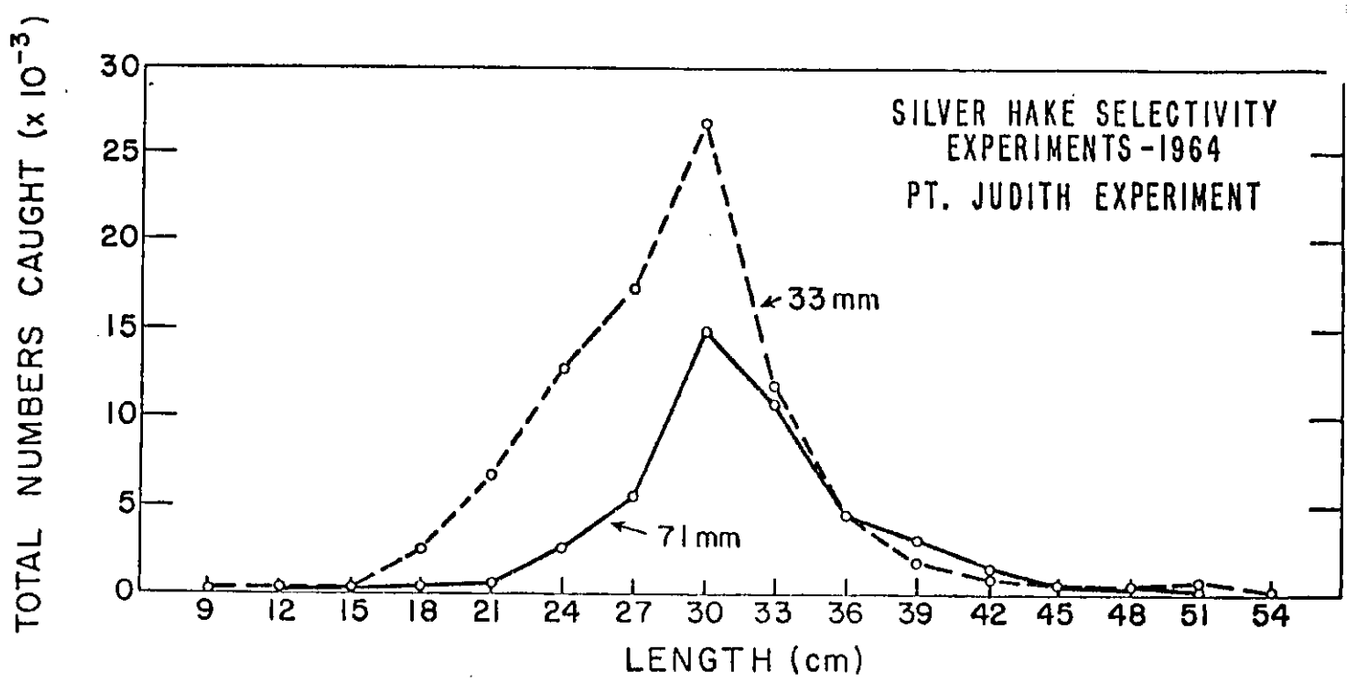


Figure 2. --Retention of silver hake in 50 mm and 71 mm nylon codends, Gloucester.



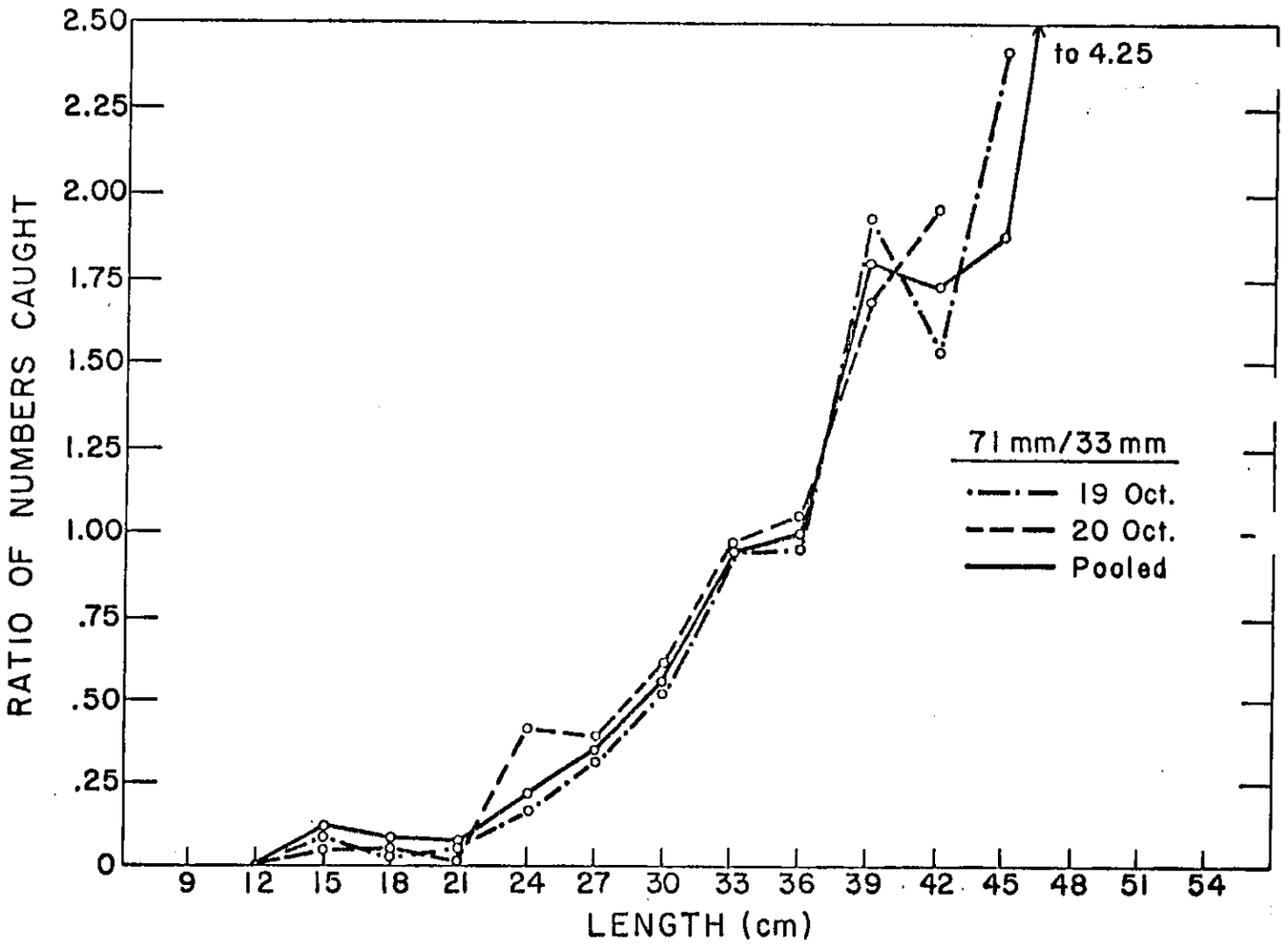


Figure 3. --Retention of silver hake in 33 mm and 71 mm nylon codends, Pt. Judith

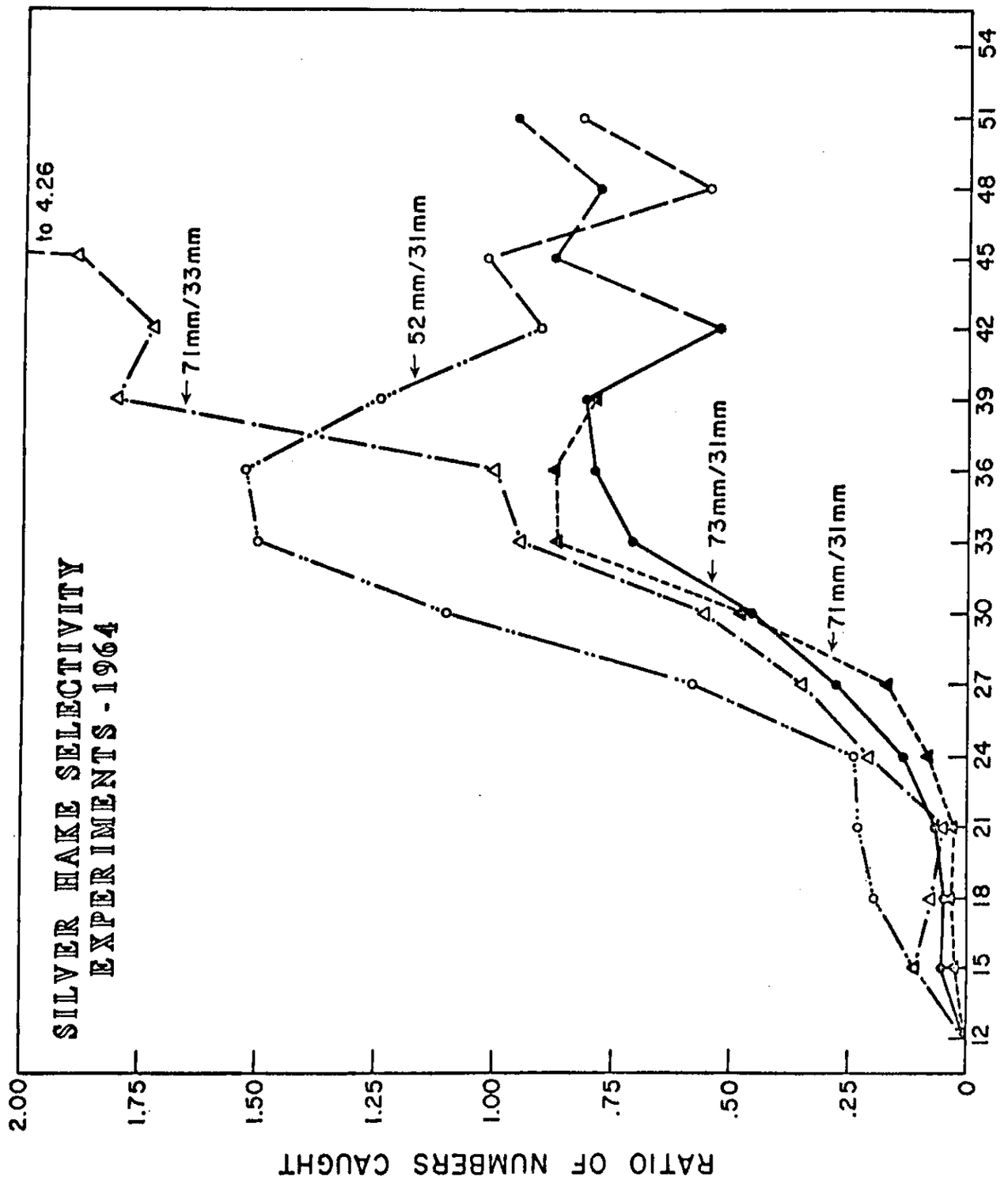


Figure 4.--Estimated retention curves for silver hake in nylon codends.

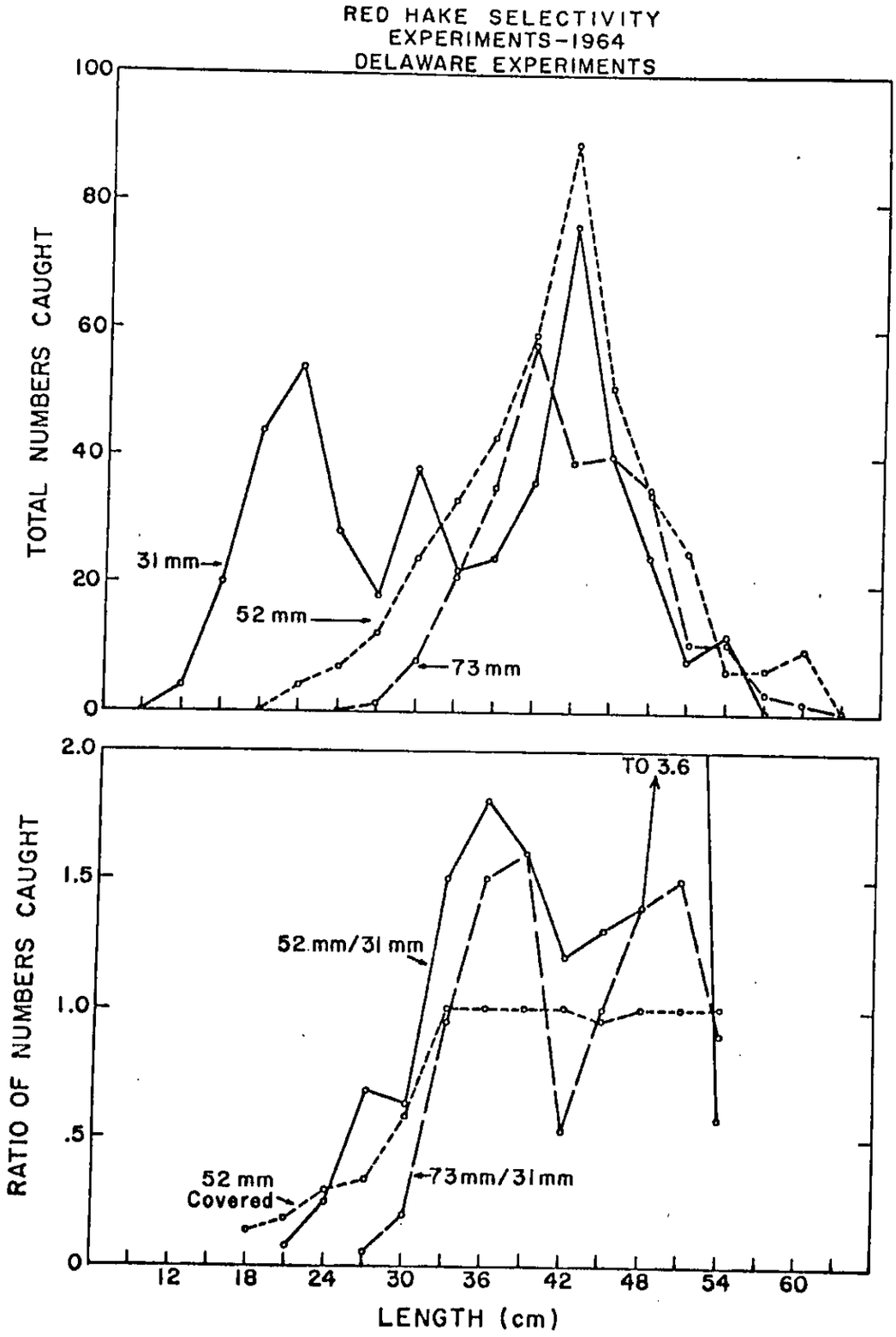


Figure 5. --Retention of red hake in 52 mm and 73 mm nylon codends, Delaware.

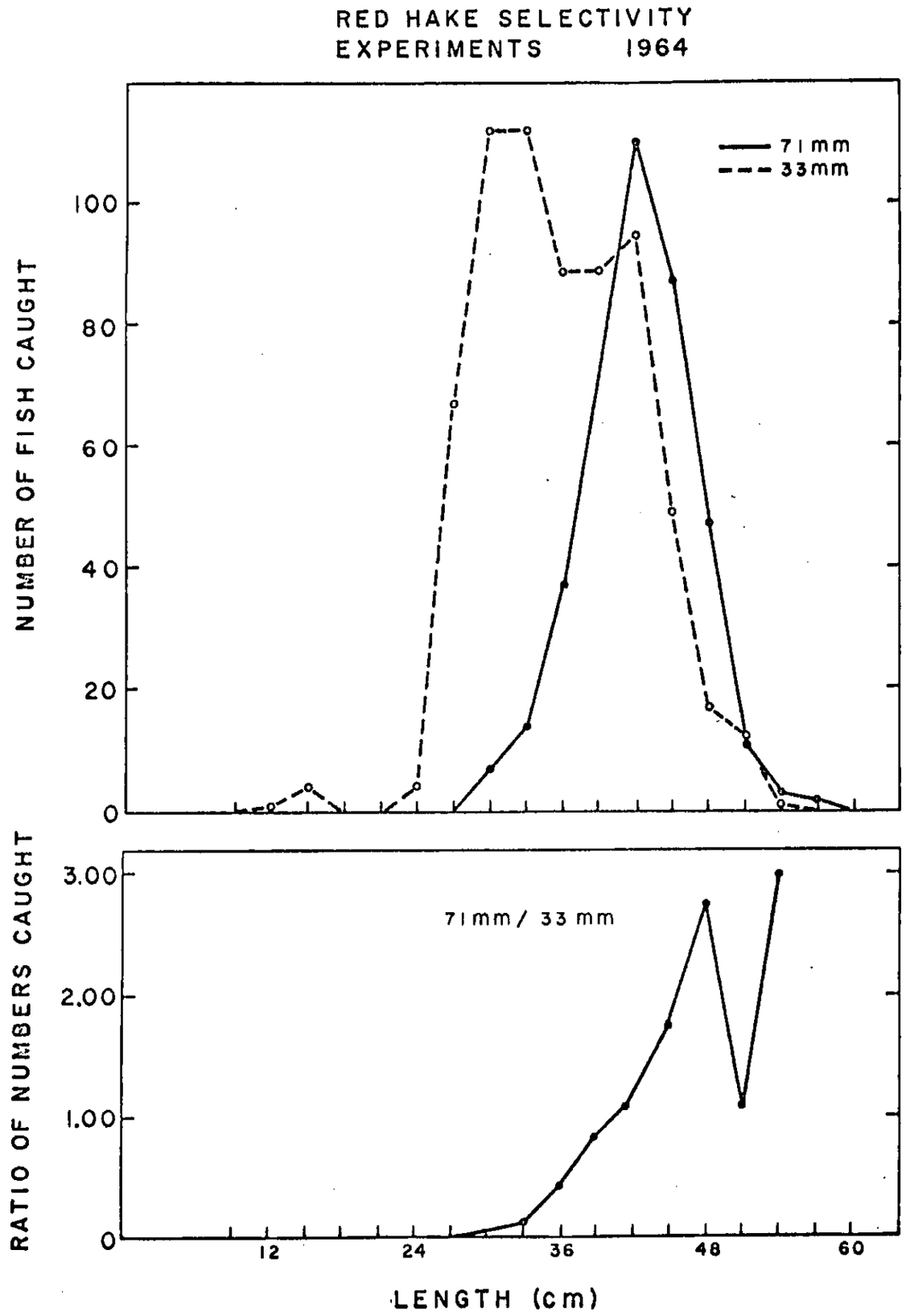


Figure 6. --Retention of red hake in 33 mm and 71 mm nylon codends, Pt. Judith.

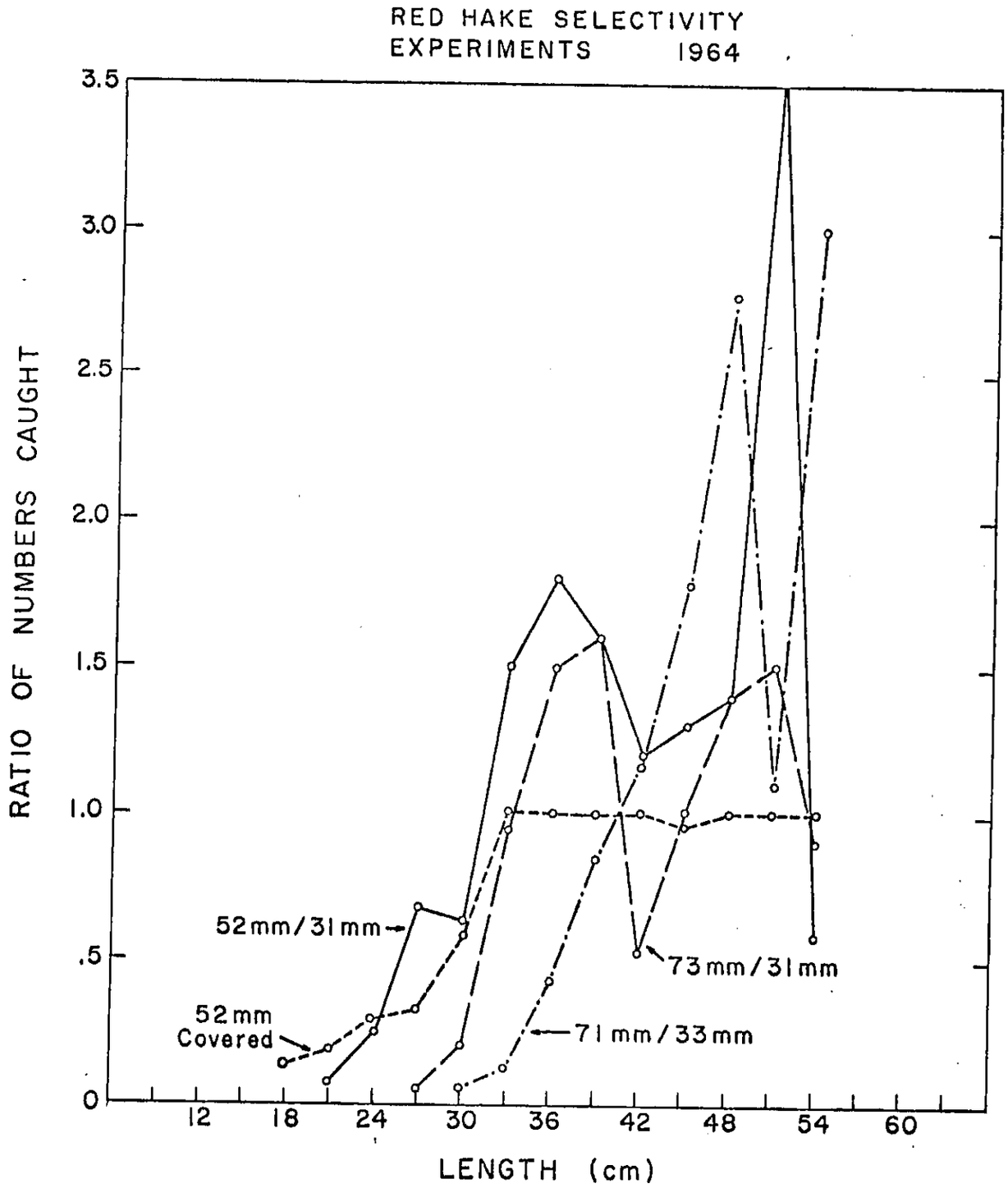


Figure 7. --Estimated retention curves for red hake in nylon codends.

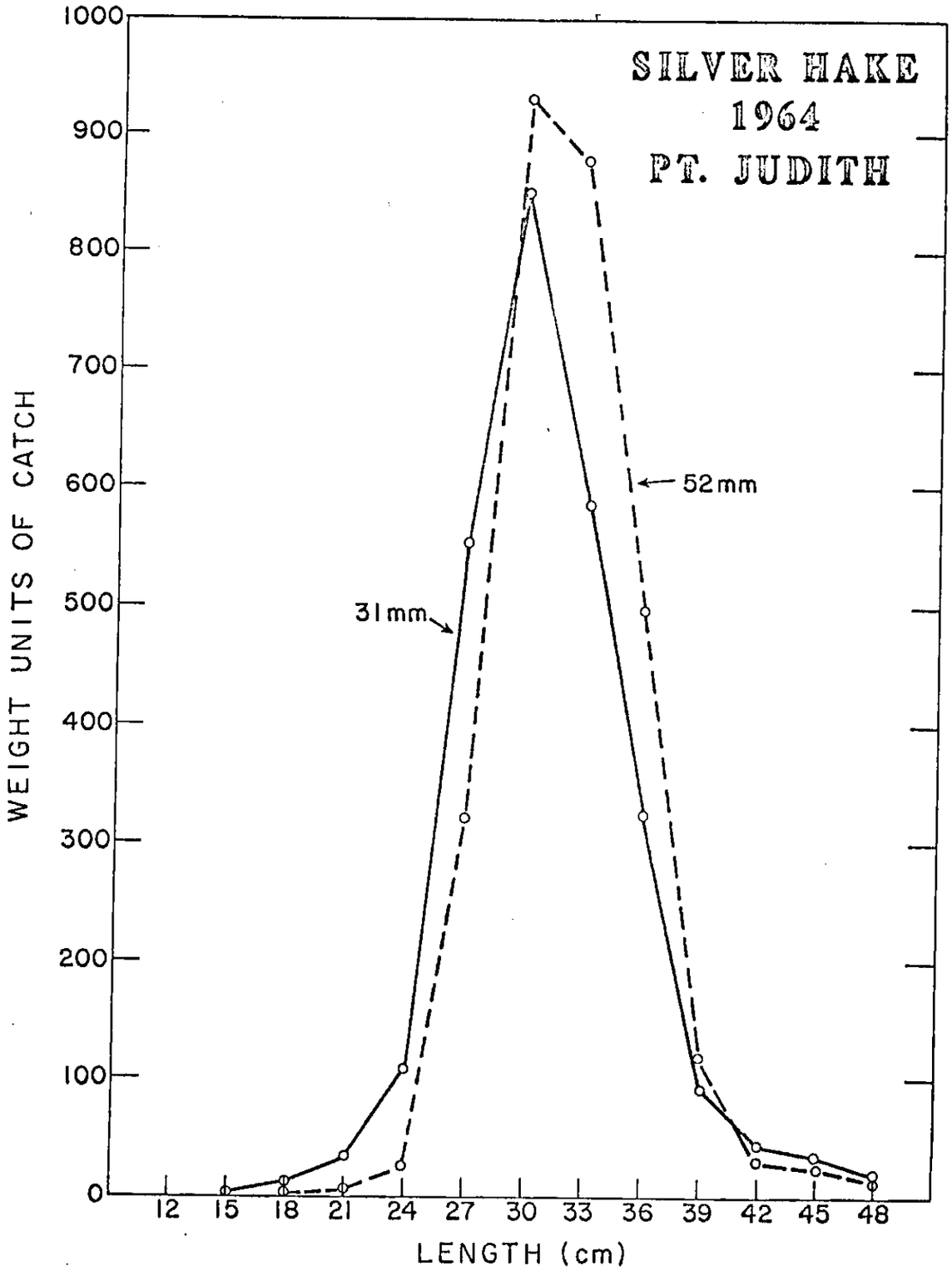


Figure 8. --Estimated weight at length in Pt. Judith catches of silver hake with 31 mm and 52 mm nylon codends.

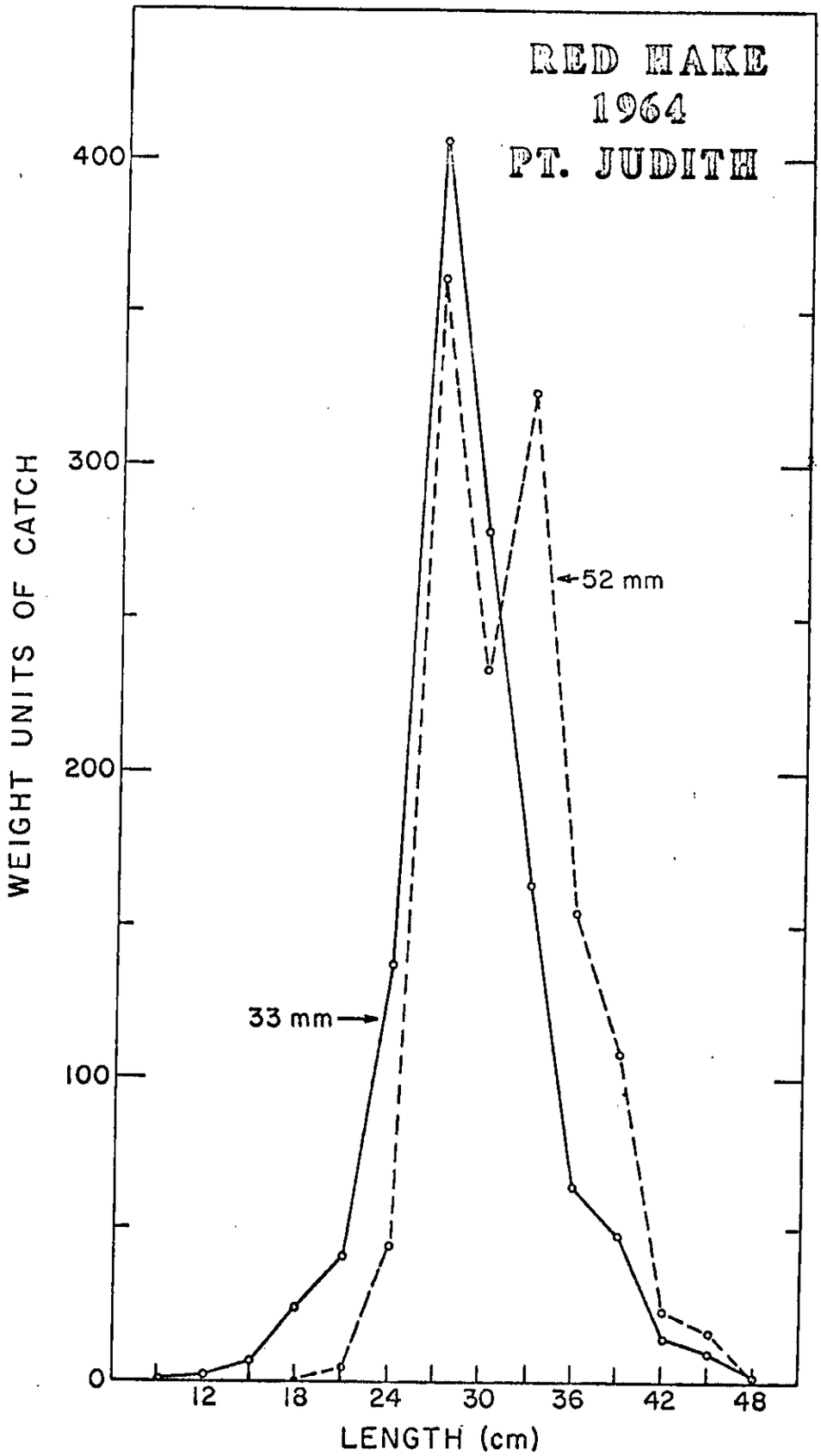


Figure 9. --Estimated weight at length in Pt. Judith catches of red hake with 31 mm and 52 mm nylon codends.