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OBSERVATIONS ON DRIFT GILLNET SELECTIVITY FOR ALBACORE INFERRED FROM VARIOUS SURVEYS

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INTRODUCTION

High seas drift gill net (DGN) fisheries, both directed and indirect for albacore on an industrial scale, exist in the north and south Pacific Ocean. These fisheries, some of which had their beginnings decades ago, expanded in the early 1980's. These fisheries exert a substantial, but as yet unknown mortality on the Pacific albacore populations. Knowledge of the selectivity of DGN's is essential for determining the relative fishing mortality on the population. Documentation of the selectivity on DGN's for albacore is lacking from the western literature.

Several DGN surveys and experiments have been conducted in the north and south Pacific Ocean which have produced data on albacore. The Southwest Fisheries Center of the National Marine Fisheries Service (NMFS) in 1984 and 1985 undertook an experiment to quantify DGN mesh size selectivity for albacore. The experiment produced useful data for a single mesh size used in the US DGN commercial fishery, 184 mm (all mesh sizes referred to are stretch mesh measurements), off the US west coast. Other surveys were conducted and data published by JAMARC (Japan Marine Fishery Resource Center) which produced data useful for comparisons. The JAMARC 1980 survey for albacore across the north Pacific (JAMARC, 1983) was a year-long survey using mesh sizes ranging from 130 mm to 250 mm mesh. In 1982 JAMARC surveyed the south Pacific waters northeast, east and southeast outside of New Zealand's 200 mi EEZ (JAMARC, 1985) producing useful data on 180 mm mesh size. In 1983, JAMARC again surveyed the south Pacific area generally east and northeast of New Zealand (170° w to 140° w and 42° s to 20° s). The reported data (JAMARC, 1986) has useful information on 118 mm mesh.

NET AND SURVEY DETAILS

The various surveys were done independently at different times and in different areas. Consequently, some confounding of analyses is inevitable and comparisons between data sets require assumptions. However, enough information is available to make useful observations. Table 1 shows net characteristics for the gear used in the surveys. In general, all of the nets considered here have similar mesh hanging ratios and twine-to-mesh size ratios, and multifilament construction. These are the most important factors which can change the selectivity curve for a given mesh size (Hamley, 1975).

Detailed descriptions for the JAMARC surveys, including set locations, timing, mesh size placement, etc, are in the JAMARC references. In brief, the JAMARC north Pacific survey was a year long survey beginning in the spring of 1980 and extending into the spring of 1981 (Figure 1A). The JAMARC 1982 survey in the south Pacific was conducted in the area shown in Figure 1B. The JAMARC 1983 survey was conducted in the south Pacific area shown in Figure 1C. All of these surveys were designed to sample albacore as well as other similar fishes.

In the US experiment, a total of 29 night sets were made; 12 sets in waters south of Point Concepcion and within 300 miles of shore; 7 sets in the vicinity of the Guide Seamount south of the Farallon Islands; and 8 sets approximately 1000 miles west of Oregon near 142° W Long. and 45° N Lat (Figure 1D).

DATA COLLECTED

Data reported from JAMARC is limited to fork length frequencies by mesh size by set. The US data includes fork length frequencies, maximum and opercular girths for each fish, and notation on mode of capture for each fish tangled, wedged or gilled. Length frequencies for US troll-caught fish are available for comparison. Table 2 shows the sample sizes by mesh size and survey.

SELECTIVITY ANALYSIS

<u>JAMARC 1980 data</u>

Because no information on the actual size structure of the north Pacific albacore population is available, only an indirect estimate of selectivity can be calculated (Type B). This requires data from several mesh sizes fished simultaneously and suitable assumptions about the nature of the selectivity curves (Hamley 1975). The JAMARC 1980 survey is unique in that it is the only data set published which was designed to produce this information. Figure 2 shows the length frequencies obtained in the 1980 survey for mesh sizes 130, 150, 160, 170, 180 and 200 mm. Note that all meshes captured fish in the modes at 53 cm, 63 cm and 78 cm.

As described by Hamley (1975), two options are available for calculating an indirect (Type B) selectivity curve: 1. Fitting a pre-determined distribution function to data such as Ishida's method (Ishida, 1962), or 2. Estimating the selectivity of different mesh sizes to one size class (mode) of fish and its extension to all sizes (Regier and Robson, 1966). Because of the lack of an objective mathematical function in determining the shape of the selectivity curve in Ishida's method, and the subsequent need for fitting the selectivity curve "by eye", a combination approach was employed which provided an objective function.

As described by Regier and Robson (1966), a basic assumption of gillnet selectivity analysis is that selectivities are the same for those combinations of length interval L(i) and mesh size M(j) where the ratio of L(i)/M(j) are equal. This assumption was applied by dividing all lengths by the appropriate mesh size and multiplying by the appropriate observed frequency. This (the beginning of Ishida's method) produces "generic" size frequencies by mesh size. Each resulting size frequency, by mesh size, was normalized to the largest value within the frequency. The resulting frequencies, one for each mesh size, are now scaled to an assumed 100% efficiency at the peak frequency sampled (the mid-60 cm mode), thus differential sample sizes by mesh are accounted for. At this point, if all nets have the exact same selectivity curve, and no sampling variance, they would all overlay on one another.

Rather than following Ishida's method to map a common selectivity curve (Regier and Robson, 1966), the "generic" shape of the selectivity curve was determined by estimating the selectivity of the different mesh sizes for the largest and smallest modes captured by all mesh sizes - the modes at 53 cm and at 78 cm. Done independently, the curve obtained for the 53 cm mode will describe the left hand or ascending limb of the selectivity curve, and the curve for the 78 cm mode will describe the right hand or descending limb. Fork lengths between these two limbs are assumed to be sampled at 100%. This includes some lengths with very low percent frequencies (ie., few fish available) as well as the size mode near 62 cm. There is no assumption that the left and right limbs have the same shape.

For the 78 cm mode, the cumulative percent frequency of capture versus fork length of fish caught for all mesh sizes are shown in Figure 3. When plotted on normal probability scales, these cumulative percent frequencies form straight lines with virtually the same slopes. An average cumulative percent frequency (subtracted from 100) provides the shape of the right hand limb, Figure 4 (termed the variance constant method of estimation by Hamley, 1975). The same procedure provides the left hand limb of the selectivity curve which rises more steeply (Figure 5).

These two limbs must now be placed appropriately on the X axis for each mesh size. This is accomplished separately for each limb by mesh size. The sampling efficiency at 53.5 cm for each mesh size was estimated by linear regression. The observed maximum % efficiency of sampling at the 53 cm peak was regressed against mesh size for all mesh sizes. The estimated percent sampling efficiency at 53.5 cm for each mesh size is shown in Table 3. Using the same method, the percent sampling efficiency was estimated at 78 cm for each mesh size (Table 3).

The family of selectivity curves by mesh size is shown in Figure 6. These were arrived at by shifting the generic selectivity curve limbs to the left or right as needed so that the sampling efficiencies at 53.5 and 78 cm matched the values in Table 3 for each mesh size. Fork lengths between the two limbs were assumed to be sampled with 100 percent efficiency.

US 1985 experiment

The 1985 US experiment produced data for a mesh size of 184 mm. The length frequency obtained is shown in Figure 7. The estimated selectivity curve based on the 1980 JAMARC data is shown in Figure 8 and as expected is almost identical to the 180 mm mesh selectivity curve. For comparison, the 1985 US jig length frequency taken during the US experiment is shown in Figure 9 and superimposed in Figure 10. As predicted by the selectivity curve (Figure 8), few fish less than 50 cm fork length were sampled by the 184 mm mesh DGN even though the fish were available to the net as shown by the sizes of fish caught by the jig gear.

JAMARC 1982 survey

The 1982 JAMARC South Pacific survey produced data for a mesh size of 180 mm. The length-frequency obtained is shown in Figure 11. The estimated selectivity curve for this mesh is the same as shown for the 180 mm mesh in Figure 6. From inspection of the length frequencies for 180 mm and 184 mm mesh sizes from the north Pacific, it is obvious that the south Pacific survey sampled a much different size structure. The survey results show a much higher proportion of fish in the 70 cm to 80 cm range than was obtained in the north Pacific survey.

JAMARC 1983 survey

The 1983 JAMARC South Pacific survey produced usable data for a mesh size of 118 mm. The length frequency measured is shown in Figure 12. The selectivity relationships developed using the north Pacific data cannot be used to accurately predict the expected selectivity curve for the 118 mm mesh, owing to small sample sizes and an observed peak size mode well below the range of capture of the nets used in the north Pacific surveys. It also appears that tangling of larger fish may be more of a problem with small mesh sizes than with large mesh sizes.

DISCUSSION

The selectivity curves derived from the JAMARC 1980 survey data appear reasonable in shape and length range of capture per mesh. The asymmetry, of each selectivity curve, steeper on the left limb and flatter on the right limb is expected (Hamley,1975). This is because, for albacore measured in the US experiment, the relationship between maximum girth and opercular girth is not a constant. The range between these two girths increases with fork length (Figure 13). This indicates that for a particular girth to mesh-size ratio which may be taken by a net, longer fish provide a wider range of available girths. This phenomena is particularly troublesome when symmetrical selectivity curves or pre-determined curves are fitted to the data. The present method of fitting the limbs separately minimizes this problem. The assumption that the peak sampling efficiency value for each mesh size is the same, and thus all selectivity curves can be scaled to 100%, cannot be tested without catch-per-effort values for each mesh size fished.

Results reported for similar shaped fishes such as slender tuna (JAMARC, 1987), mackerel and sardine (Shimazaki et al, 1984), and various salmon species (Hamley 1975) shows similar shapes and skewedness.

The assumption allowing the extension of the selectivity curves to similar nets such as the NMFS 184 mm mesh and the JAMARC 1982 180 mm mesh appears acceptable from the data available. The principal factor limiting the application of these selectivity curves to other albacore populations is the girth to length relations shown in Figure 13. Significant changes in these relationships will change the steepness of the selectivity curve limbs as well as the skewness. It appears that it will be difficult to apply this generic selectivity curve to meshes considerably smaller than the series used to derive the curve. The small sample size for the 118 mm mesh and the apparent tangling of larger fish suggests that the selectivity curves for meshes smaller than 130 may become more skewed because of tangled fish. Tangled fish did not appear to be a problem in the NMFS or JAMARC 1980 data sets presumably because all the mesh sizes gilled or wedged fish in the largest mode, and not many larger fish were available in the survey areas.

From these results, it appears that any of the mesh sizes in the 130 mm to 200 mm range sample from 50 cm to 90 cm long fish, which encompasses most of the modes seen in the surface fisheries. The best mesh sizes to sample this size range appear to be the 170 to 184 mm mesh sizes because they tend to sample both tails of the length frequency curves better than larger or smaller mesh sizes. Using the relationships derived, a series of nets may be constructed which will sample the population in a quantitative manner. Further, it appears that information on the population size structure may be derived from net catches using the selectivity curves.

ACKNOWLEDGEMENTS

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Table 1. Characteristics of drift gillnets used in surveys.

Survey	Mesh Size	Twine Size (Dinier/ Strand)	Net Material	Hang-in-Ratio (% stretch mesh distance per hanging)
JAMARC 1980 (North Pacific)	150	210/24	Nylon	56.1
	160	210/27	Nylon	56.1
	170	210/30	Nylon	55.5
	180	210/33	Nylon	56.1
	200	210/36	Nylon	56.1
	250	210/42	Nylon	56.1
JAMARC 1982 (South Pacific)	180	210/30	Nylon	55.3
JAMARC 1983 (South Pacific)	118	210/10	Nylon	-
NMFS 1985 (North Pacific)	184	210/18	Polyester	50.0

Table 2. Sample sizes, by mesh size, for experimental drift gillnet surveys for albacore.

Survey	Mesh Size (mm)	Sample Size (No. of fish)
JAMARC 1980 (North Pacific)	130	438
	150	595
	160	672
	170	1951
	180	1123
	200	498
JAMARC 1982 (South Pacific)	180	1288
JAMARC 1983 (South Pacific)	118	87
NMFS 1985 (North Pacific)	184 mm	892

Table 3. Estimated percent sampling efficiency for albacore at lengths of 53.5 cm and 78 cm for various mesh sizes.

Mesh Size (mm)	Fork length (cm) 53.5	78
130	53.3	21.7
150	42.3	31.2
160	36.8	35.9
170	31.3	40.7
180	25.7	45.4
184	23.5	47.3
200	14.7	54.8

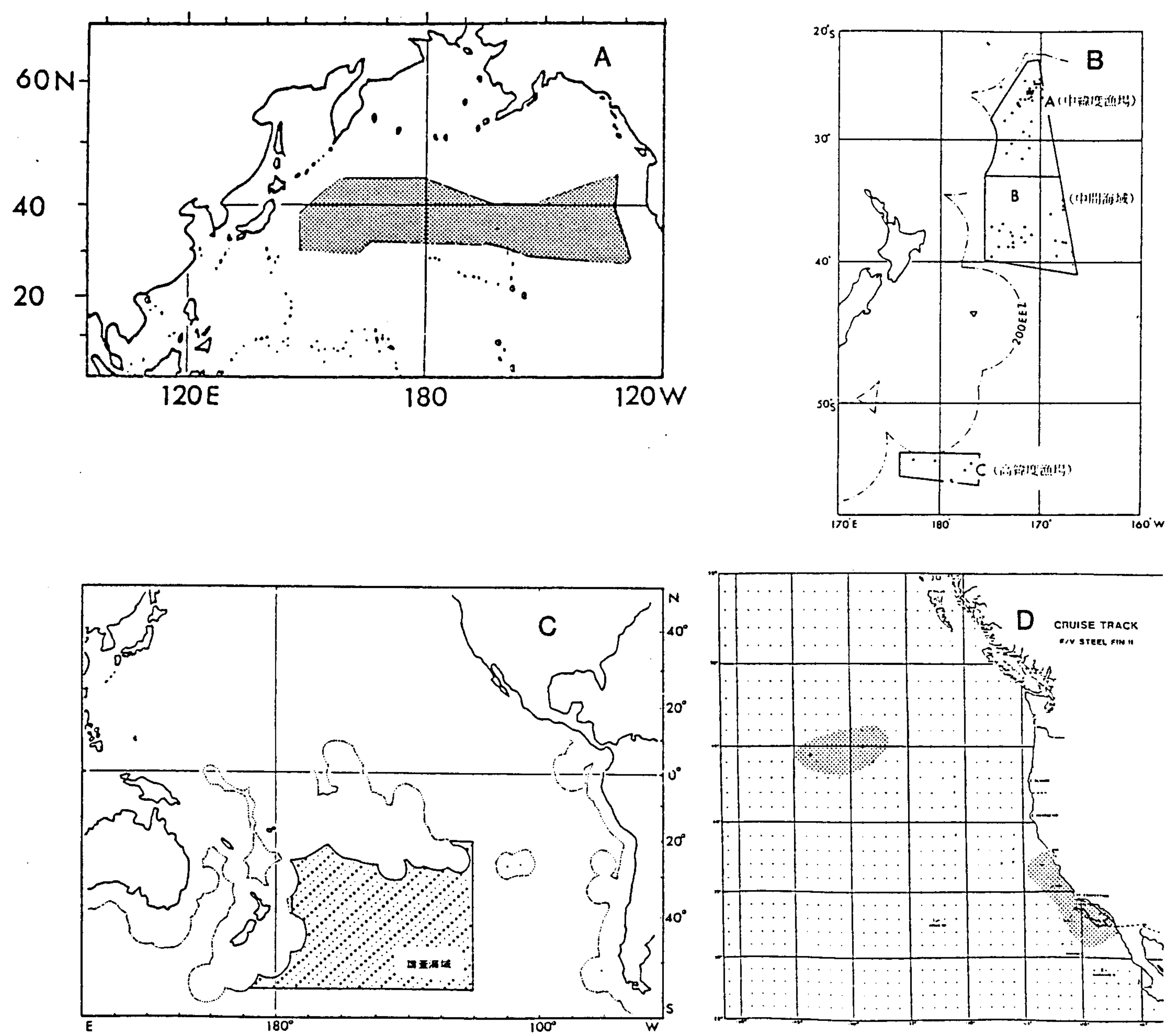
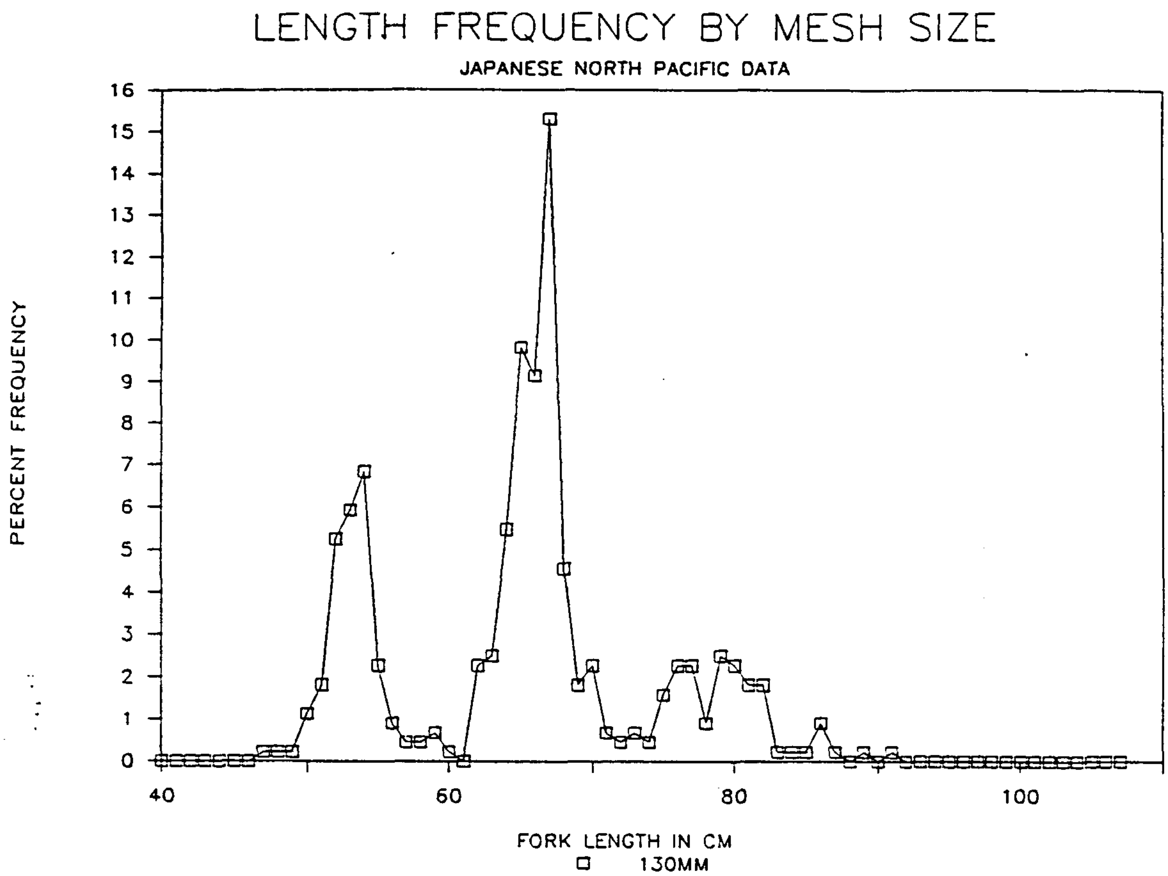


Figure 1. General areas sampled for albacore by drift gillnets. A. JAMARC 1980 survey. B. JAMARC 1982 survey. C. JAMARC 1983 survey. D. NMFS 1985 experiment.



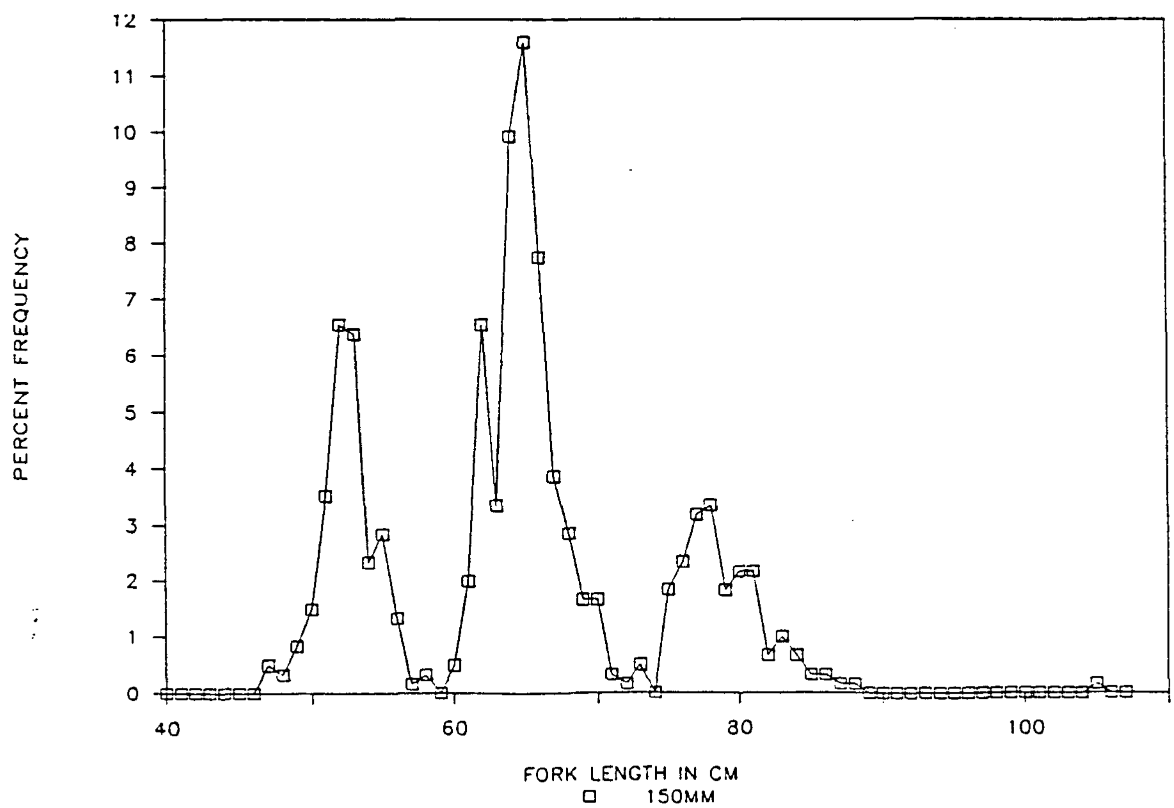
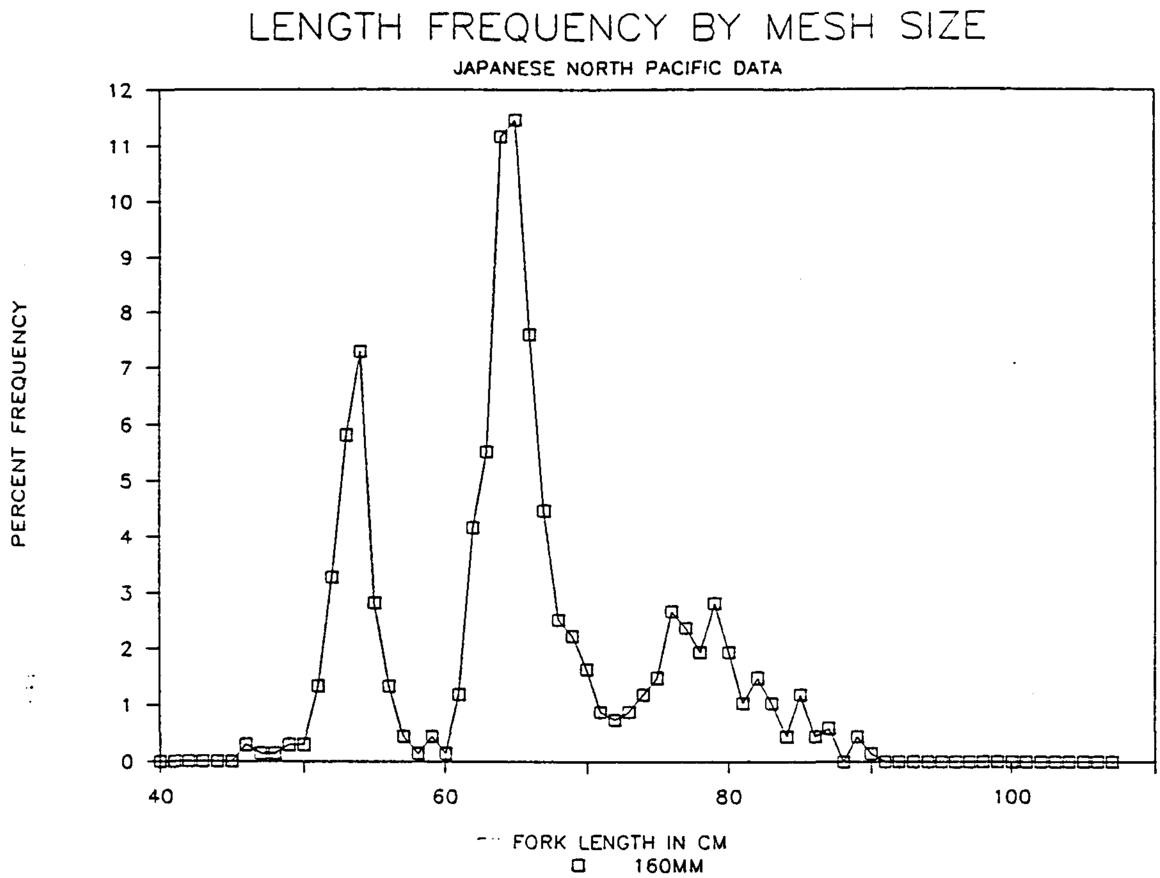
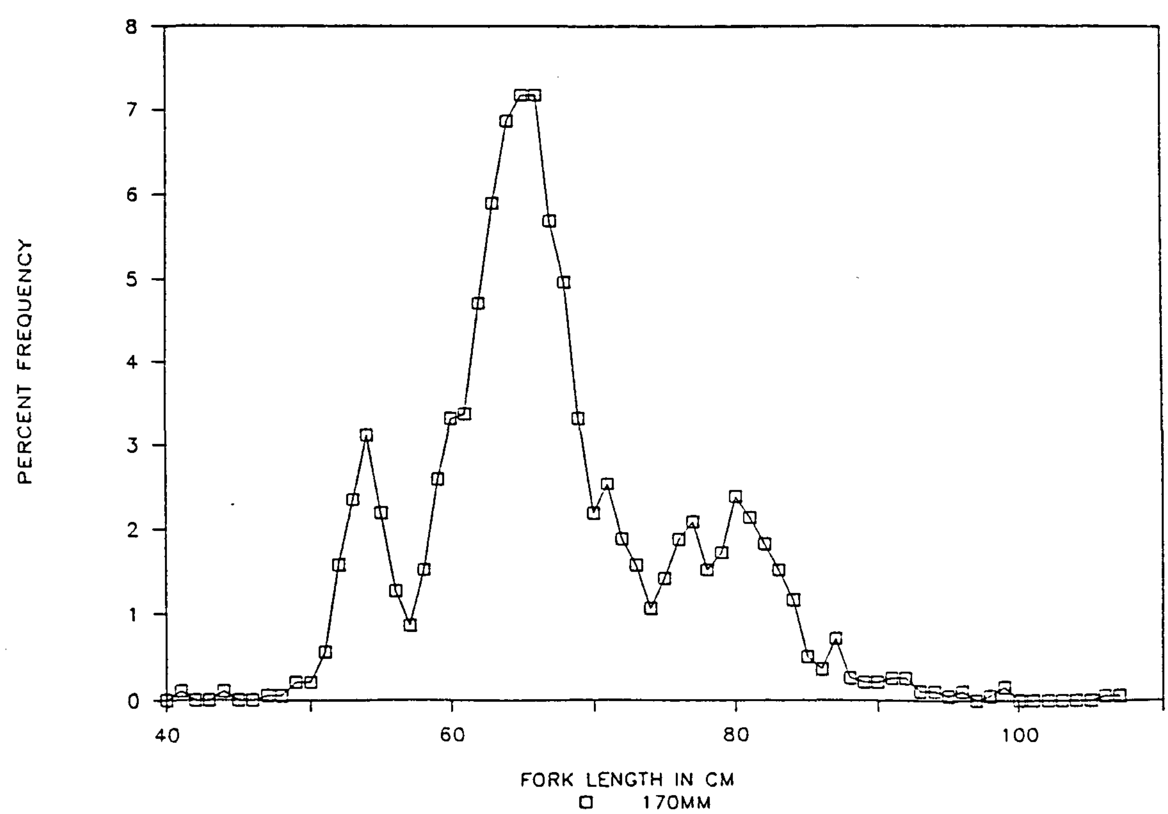


Figure 2. Albacore percent frequency of occurrence by fork length interval for various drift gillnet mesh sizes sampled





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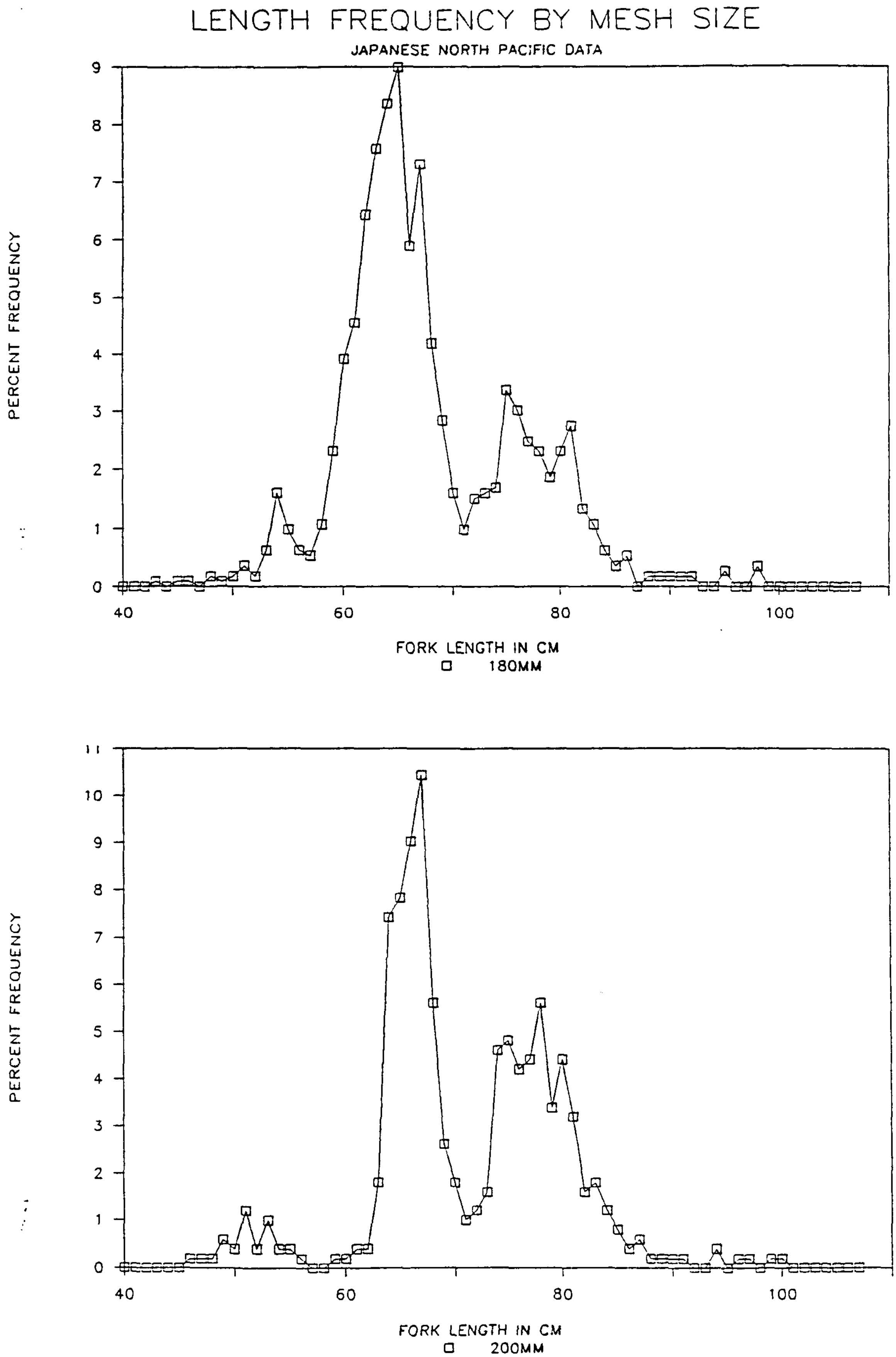

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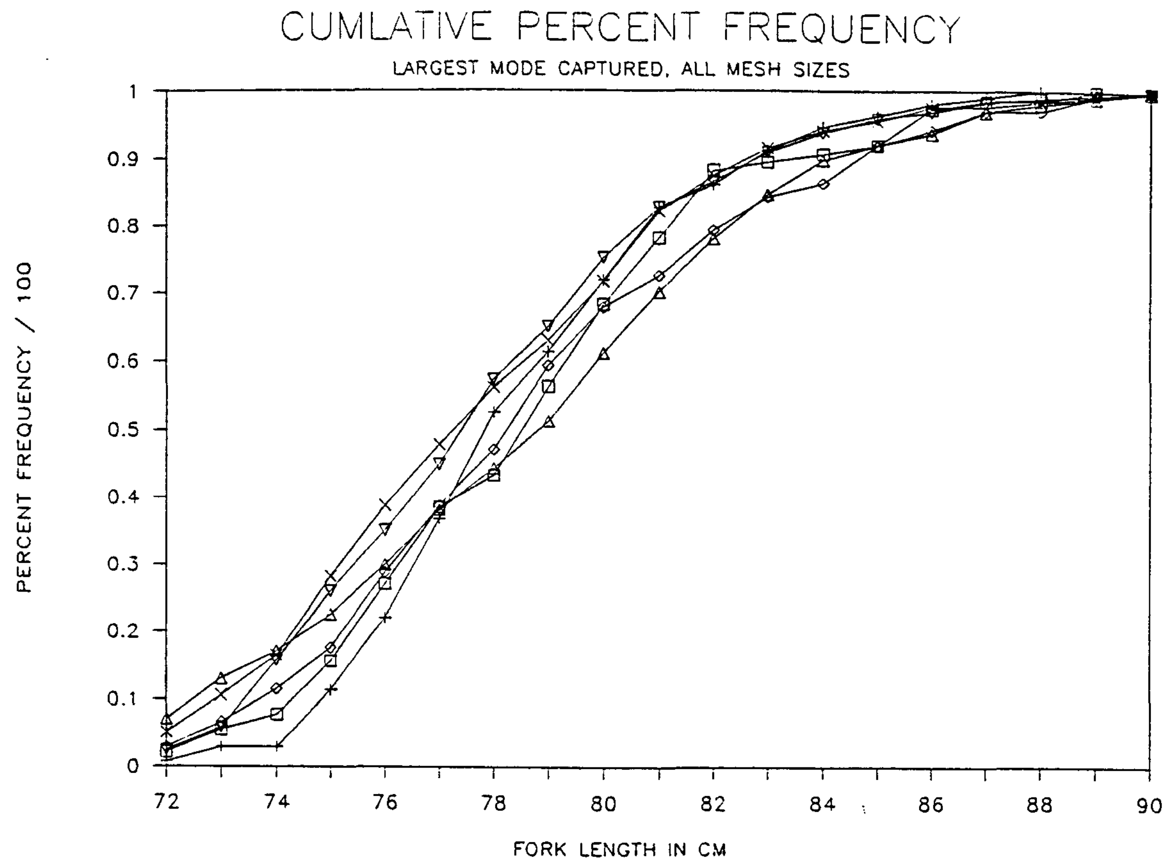

Figure 3. Cumulative percent frequency of occupance by fork length interval for 130 mm, 150 mm, 160 mm, 170 mm, 180 mm, and 200 mm mesh sizes for the 78 cm mode of albacore sampled in the 1980 JAMARC survey.

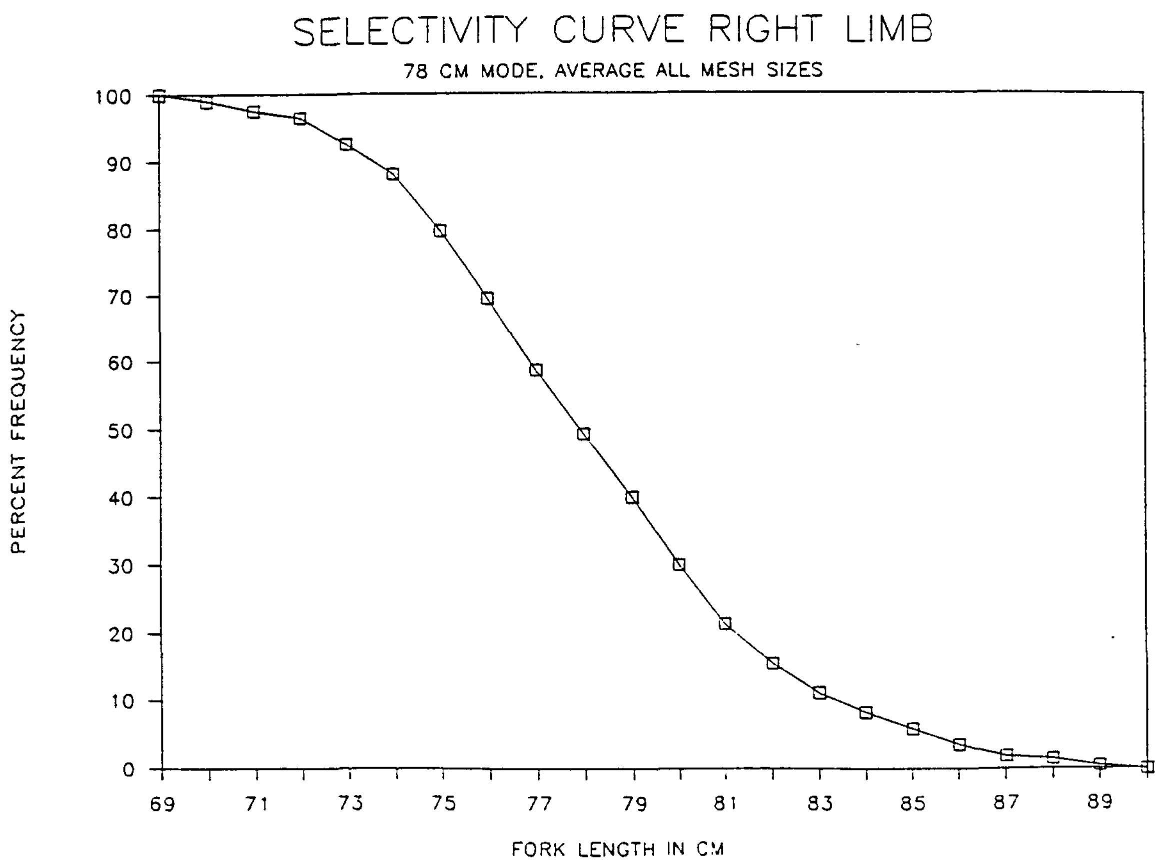

Figure 4. Generic selectivity curve right hand limb for albacore from the 78 cm mode sampled in the 1980 JAMARC survey.

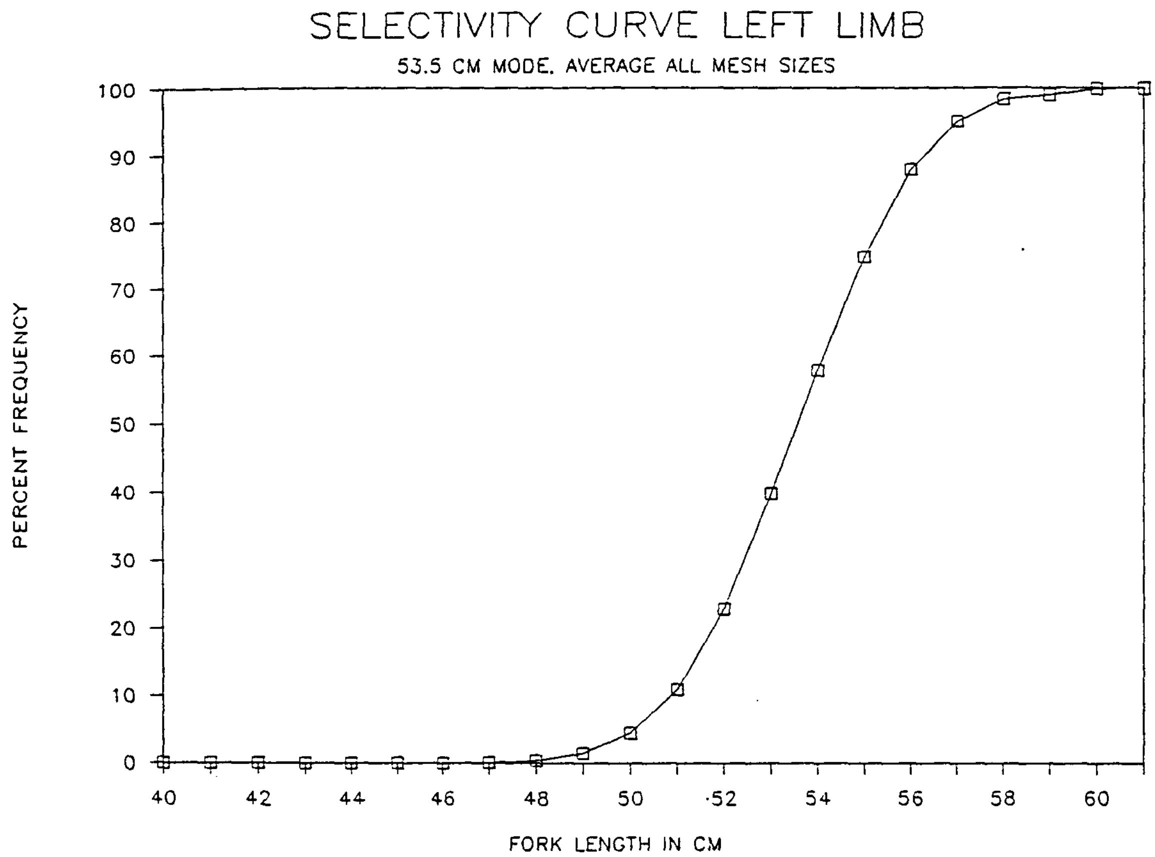

Figure 5. Generic selectivity curve left hand limb for albacore from the 53.5 cm mode sampled in the 1980 JAMARC survey.

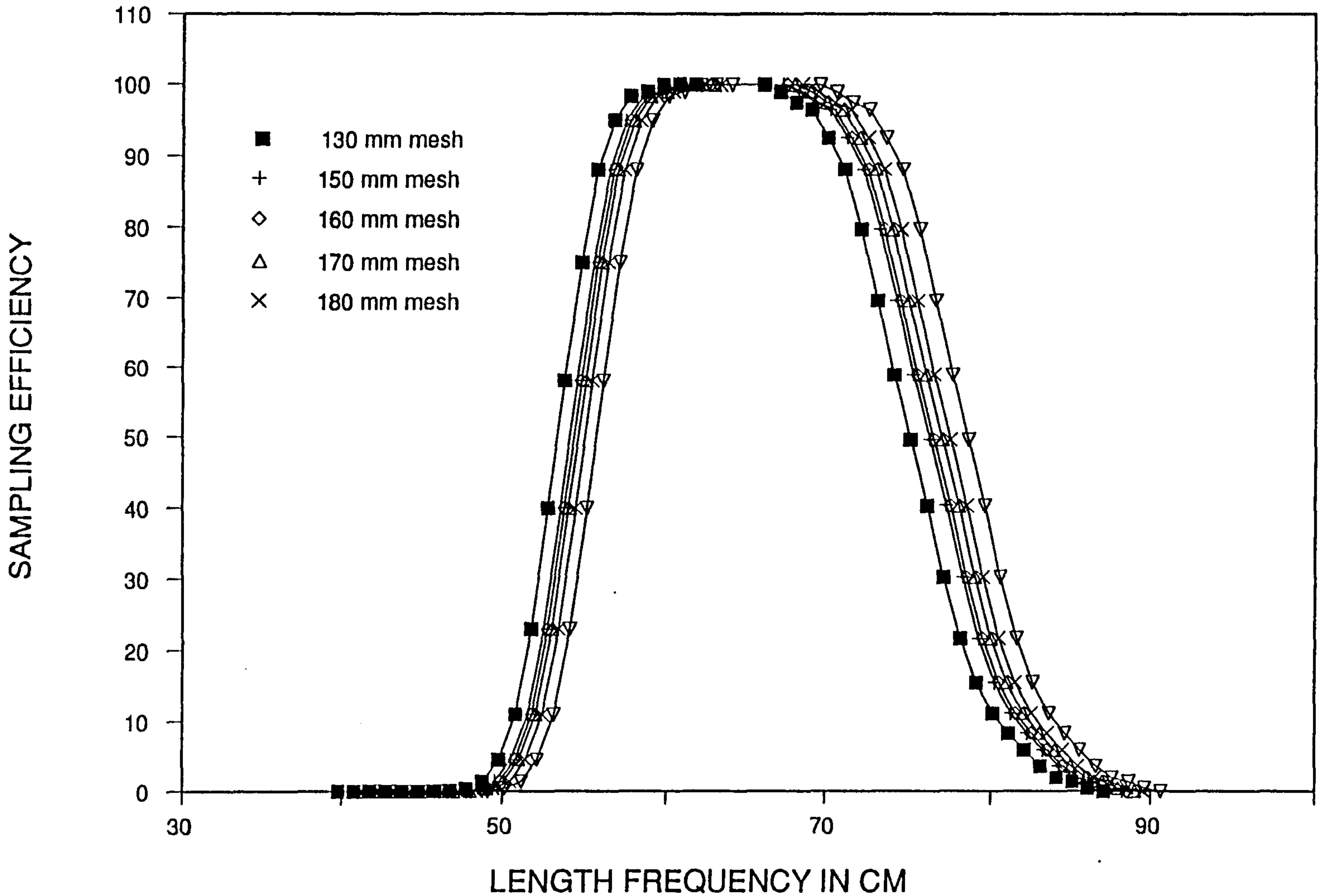

Figure 6. Selectivity curves for albacore for 130 mm, 150 mm, 160 mm, 170 mm, 180 mm, and 200 mm mesh sizes (left to right respectively on the left portion of the graph).

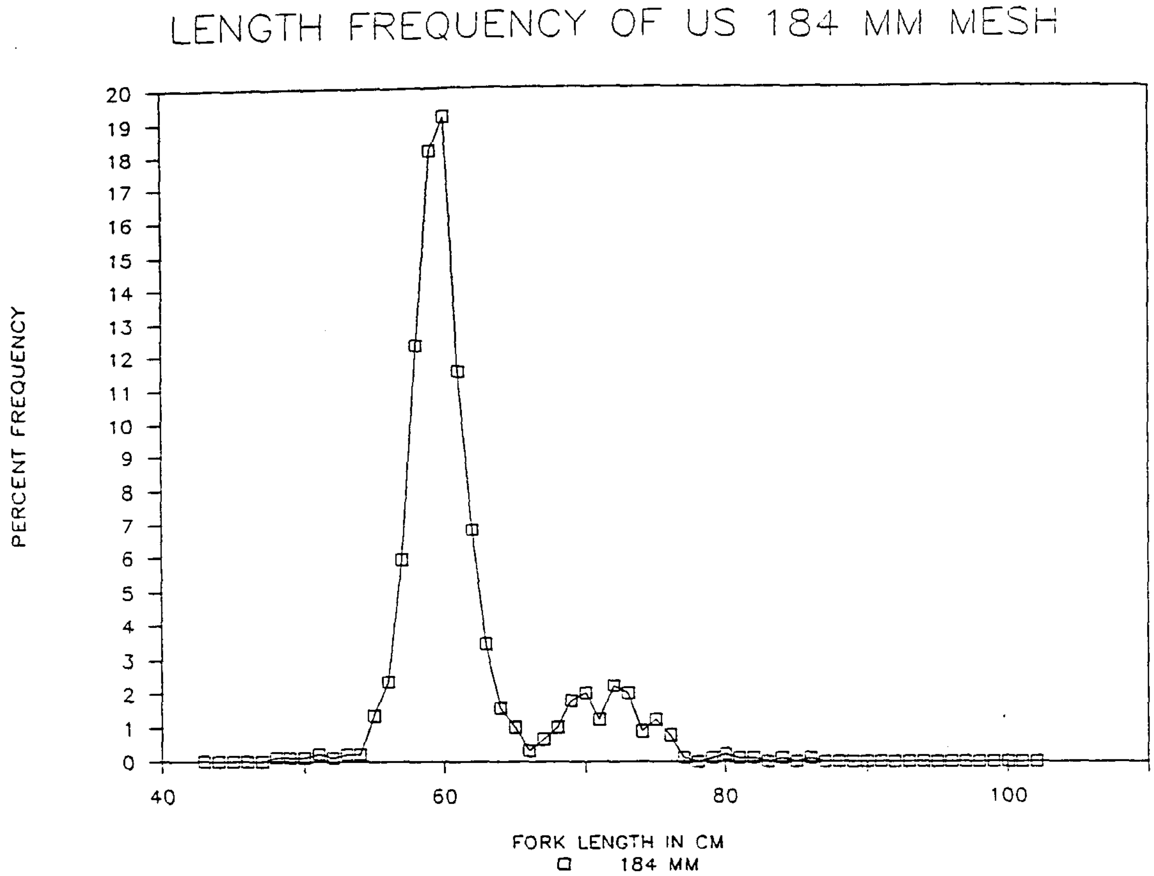

Figure 7. Albacore percent frequency of occupance by fork length interval for 184 mm mesh size sampled in the 1985 NMFS experiment.

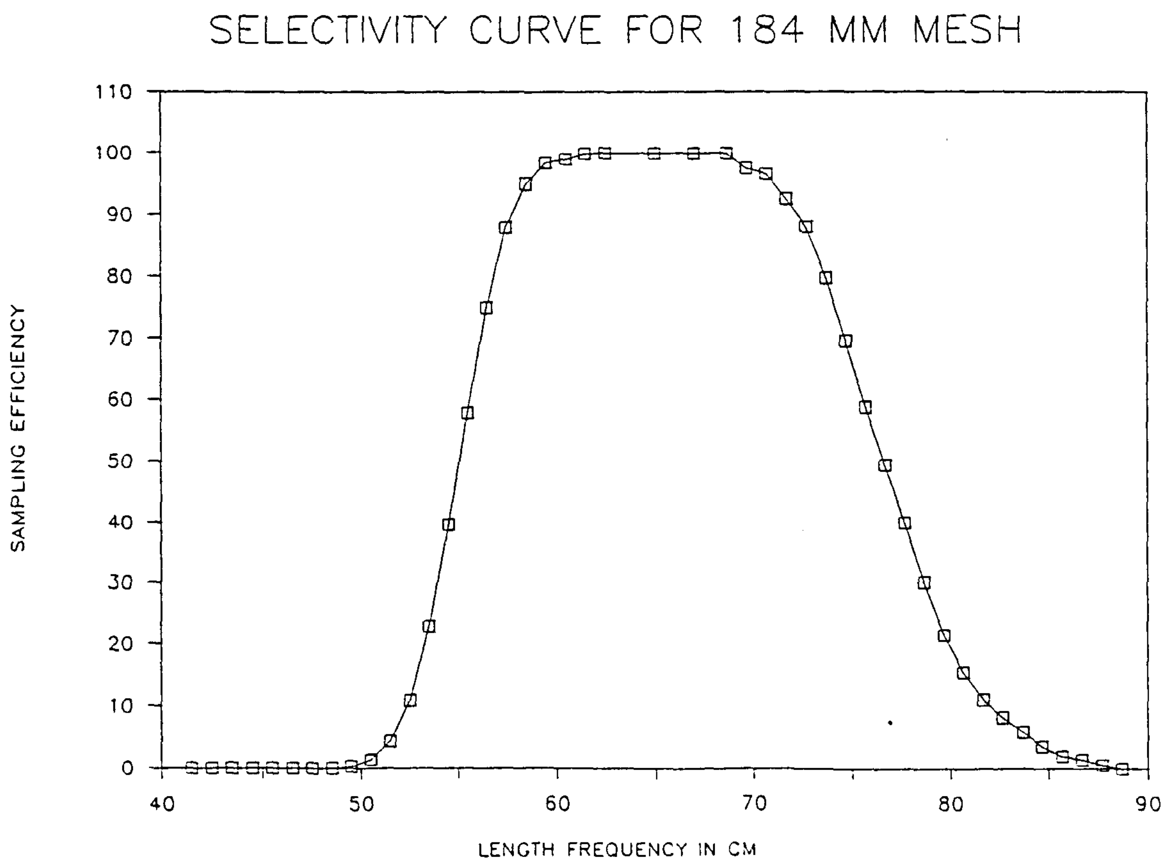

Figure 8. Selectivity curve for albacore for 184 mm mesh size.

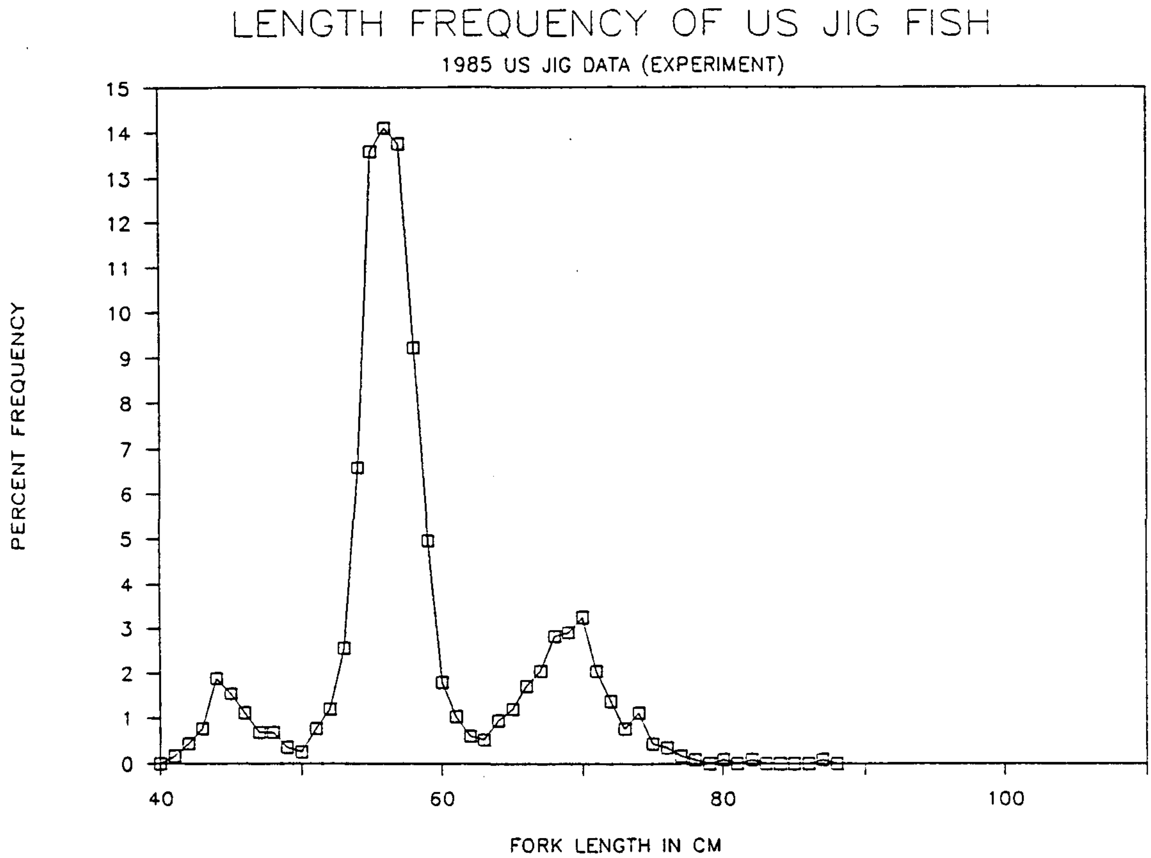

Figure 9. Albacore percent frequency of occupance by fork length interval sampled by trolling (jig) gear in the 1985 NMFS experiment.

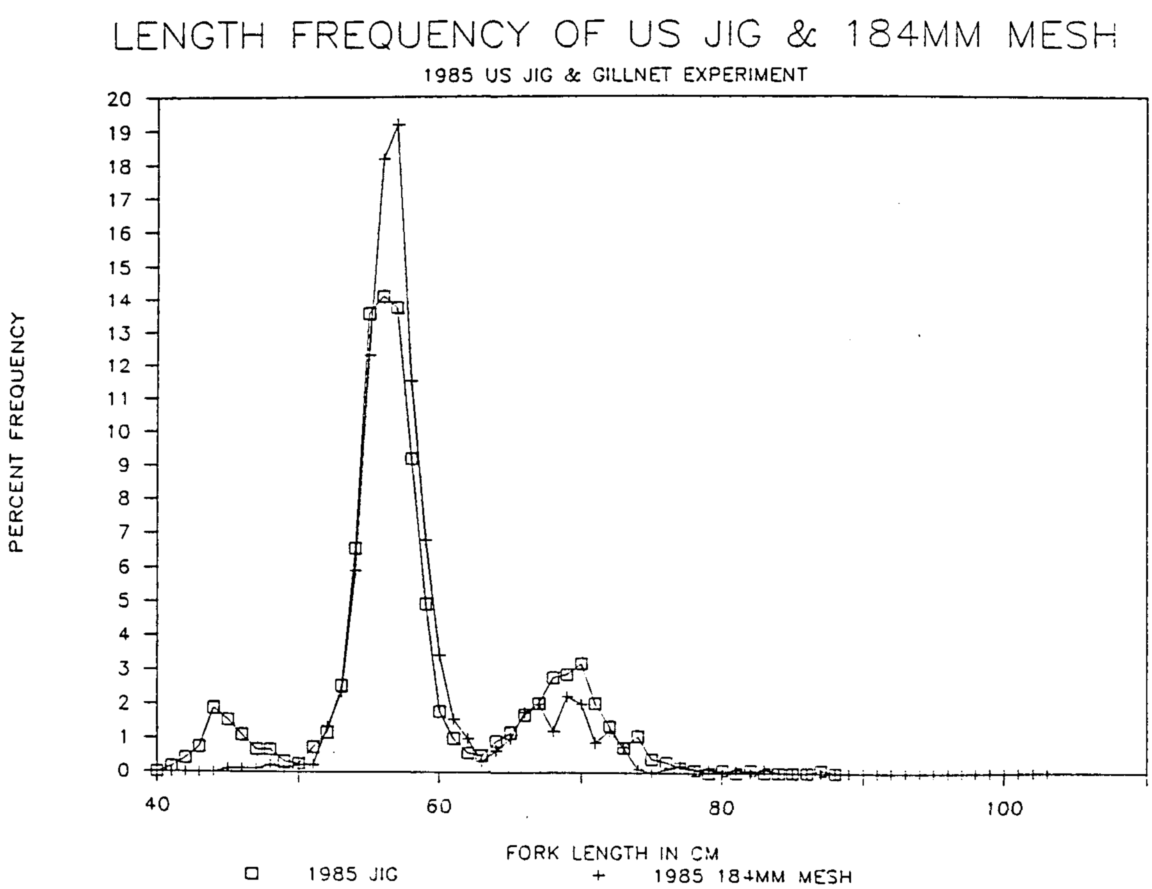

Figure 10. Comparison of albacore length frequencies for 184 mm mesh and troll (jig) gear sampled in the 1985 NMFS experiment.

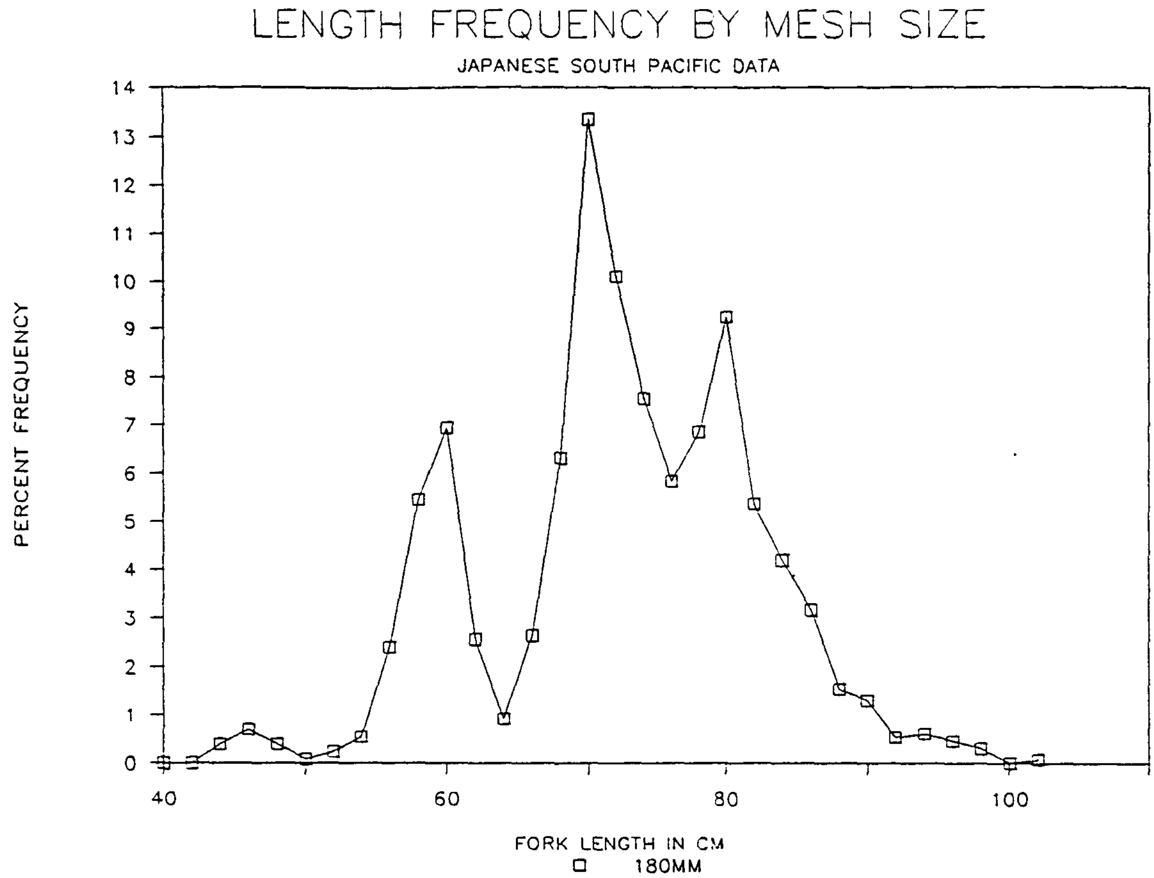

Figure 11. Albacore percent frequency of occurrence by fork length interval for 180 mm mesh sampled by the 1982 JAMARC survey.

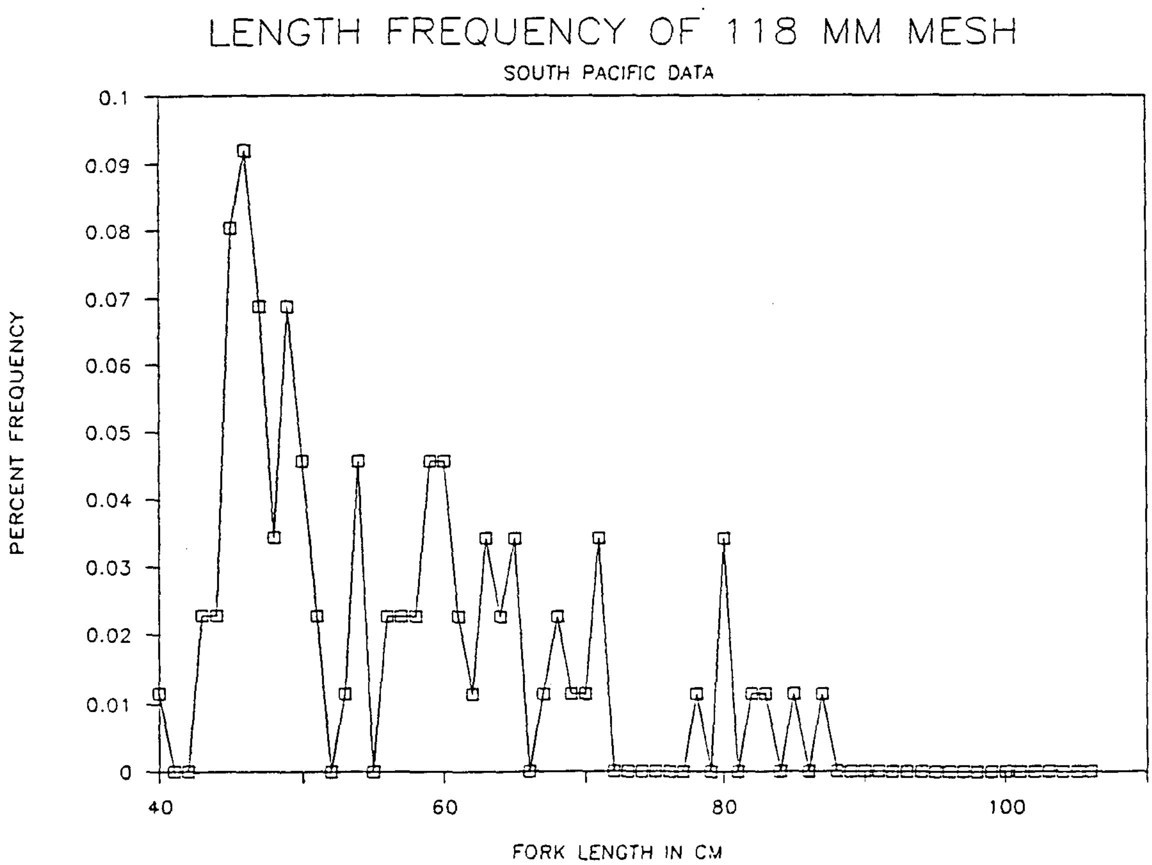

Figure 12. Albacore percent frequency of occurrence by fork length interval for 118 mm mesh sampled by the 1983 JAMARC survey.

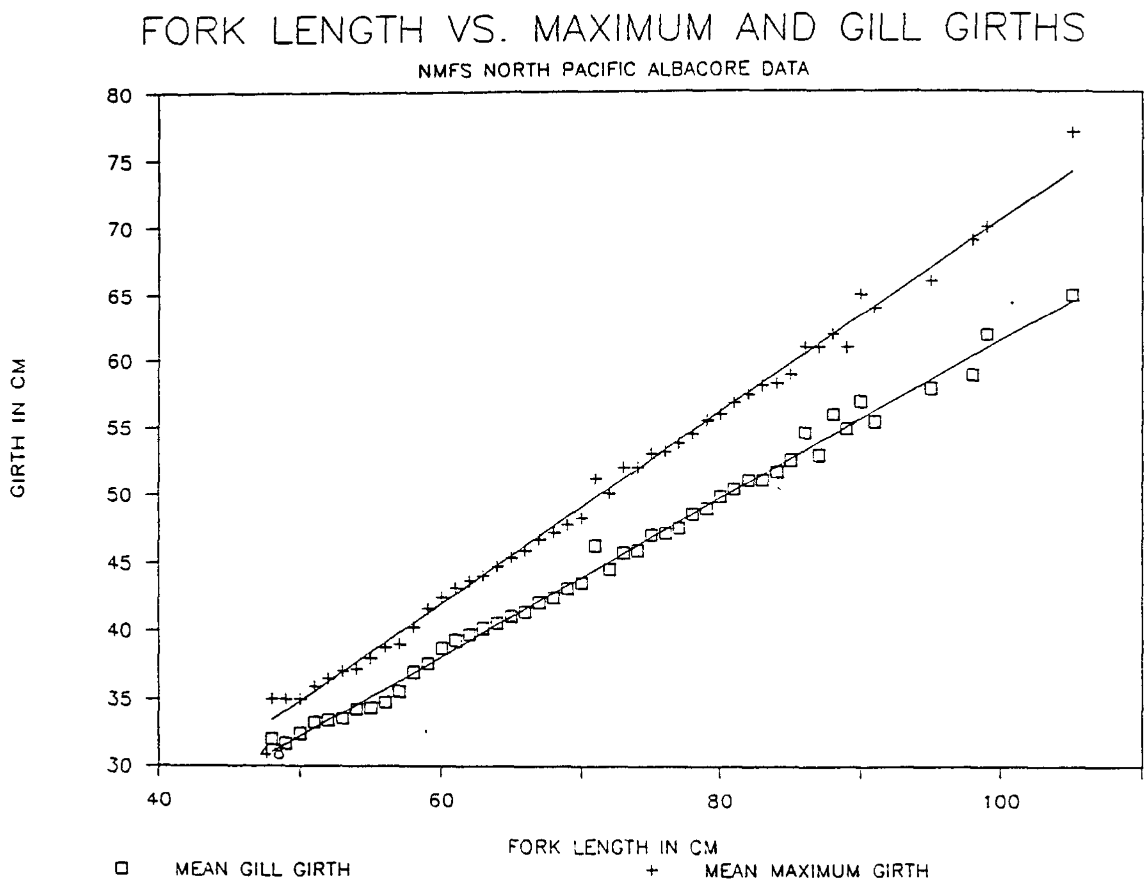

Figure 13. Relationship of albacore maximum and opercular girths to fork length for 1144 fish sampled by the 1985 NMFS experiment.