Distribution and Abundance Trends of 22 Selected Species in the Middle Atlantic Bight from Bottom Trawl Surveys During 1967 - 1979

APPENDIX: Annual Cycle of Gonad-Somatic Indices as Indicators of Spawning Times for Fifteen Species of Fish Collected from the New York Bight, June 1974 to June 1975



Final Report to the U.S. Mineral Management Service
(Contract No. AA 550-1A7-35)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

January 1985

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DISTRIBUTION AND ABUNDANCE TRENDS OF 22 SELECTED SPECIES IN THE MIDDLE ATLANTIC BIGHT FROM BOTTOM TRAWL SURVEYS DURING 1967-1979

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APPENDIX: Annual Cycle of Gonad-Somatic Indices as Indicators of Spawning Times for Fifteen Species of Fish Collected from the New York Bight, June 1974 to June 1975

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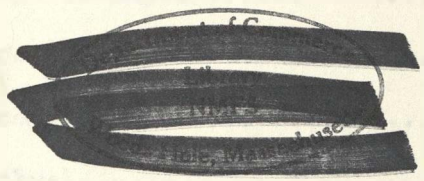

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EXECUTIVE SUMMARY

Distribution plots taken from spring and fall cruise data show that many of the more important finfish species found in the Mid-Atlantic Bight from Cape Cod to Cape Hatteras are not endemic but are seasonal migrants. Because of the absence of a discrete endemic fish fauna zoogeographers have been hesitant to recognize the Mid-Atlantic Bight as a separate faunal province (Hazel 1970, Briggs 1974). However, several species whose distributions have been summarized in this report do have their centers of abundance in the Bight (e.g., summer flounder, windowpane, fourspot flounder, scup). Most individuals in these populations do not leave the Mid-Atlantic Bight, but migrate seasonally and concentrate in narrow bands along the margins of the area. For example, summer flounder concentrate in the inshore areas in summer, but migrate offshore and concentrate on the outer-shelf in the winter. Many of the other species (e.g., bluefish, Atlantic herring, Atlantic mackerel) undergo such extensive seasonal movements that they virtually disappear from the studied area during our spring and autumn cruises.

One reason for these dramatic migratory patterns of Mid-Atlantic finfish as well as the squids and lobsters is the seasonal change in water temperature. In the inshore waters of the New York Bight apex, surface temperatures range from a maximum of 26°C in summer to a minimum of 1°C in winter. Bottom temperatures in the same inshore areas range from 21°C in summer to less than 1°C in winter (Bowman and Wunderlich 1977). This range of bottom temperature maxima and minima diminishes in a seaward direction to about 7°C (winter) and 13°C (summer) near the edge of the shelf. These large fluctuations in temperature undoubtedly play a significant role in the developed migratory patterns of many of the species discussed. With warming

temperatures in the spring there is a movement into the Mid-Atlantic from the south by some of the warm temperate species (e.g., bluefish, Atlantic croaker) and conversely, the cold temperate species (e.g., Atlantic mackerel, spiny dogfish, Atlantic herring) migrate out of the region to the north. With cooling temperatures in the autumn, the warm water species move south and offshore while the cold water species from the north return south into the region.

The Bight is considered a transition zone and serves as a migratory path for many species, but this does not diminish the biological or economic importance of the area. The area also serves as a spawning ground for many important species (Berrien 1982) and during their period of residency many of the fishes are harvested extensively by commercial and recreational fishermen.

The fishes of the Mid-Atlantic shelf are part of an extremely complex ecosystem. The natural complexities are further compounded by human impacts as the area is exploited for its resources and as a depository for wastes. Many aspects of the Mid-Atlantic fisheries and other resources are discussed or reviewed in Gross (1976), McHugh and Ginter (1978), and Grosslein and Azarovitz (1982). In order to quantitatively assess the effects of mineral exploration and recovery on the finfish or shellfish populations, more knowledge of this complex ecosystem is needed. It is evident that during any given season important finfish and shellfish species travel over or reside in virtually all areas of the shelf. It is also apparent that any major event, whether natural or man-induced, can affect the quantity or quality of these living resources.

INTRODUCTION

This report is the last in a series of documents provided to the Bureau of Land Management (BLM) summarizing the historic trawl survey catch data for the Mid-Atlantic shelf filed at the Northeast Fisheries Center (NEFC), Woods Hole Laboratory. Earlier submissions to the BLM consisted of detailed computer printouts of the trawl data base including catch records and environmental information.

The purpose of this report is to provide the reader with an understanding of the seasonal distributions of some important finfish and shellfish species found in the Mid-Atlantic Bight area. This report does not assess or predict the potential impact or effects of mineral resource exploitation on these populations. Spring and autumn catch records for 22 selected species (Table 1) are summarized and presented in coastal map plots and graphs. Cumulative distribution plots and graphs show the mean weight and number per tow, length frequencies by six geographical areas, and percentage occurrence of young-of-the-year by stratum. The report includes all cruises from the autumn of 1967 through the autumn of 1979 (Table 2).

Attached as an appendix is a report summarizing gonad-somatic indices from a special monthly study in the New York Bight.

METHODS

Data Collections

From 1963 to 1967, standard autumn NEFC bottom trawl surveys were conducted covering the Atlantic continental shelf from western Nova Scotia to just north of Hudson Canyon in depths of 28-365 meters (15-200 fathoms). In 1967 the range of the survey was expanded southward to Cape Hatteras, North Carolina. In 1968 a time series of spring surveys in the Middle Atlantic area was initiated and in autumn of 1972 the surveys were expanded inshore to include waters from the coastline out to the 28 m contour. The first inshore survey covered from Montauk Point, New York, to Charleston, South Carolina. Semiannual inshore surveys have been conducted in conjunction with the offshore surveys between Cape Hatteras and Cape Cod since 1972.

One objective of our survey effort was to obtain a statistically valid population sample that would provide reliable estimates of sampling error variance. A stratified-random sampling design was chosen for the surveys to provide a fairly uniform distribution of stations throughout all the possible ecological zones within the survey area.

Depth was used as the primary boundary criterion because of its known relationship to finfish distribution. Figures 1 and 2 depict inshore and offshore strata from Cape Hatteras to Cape Cod used in this study. The entire study area from Cape Hatteras to Cape Cod was stratified with the major stratum boundaries determined by seven depth limits: <9, 9-19, 20-28, 29-55, 56-110, 111-185, and 186-365 m.

Stations were selected randomly within each sampling stratum. Larger strata were divided into areas equivalent to 5 minutes (') latitude by 10' longitude. Each of these rectangles is considered a homogenous sampling unit

(this means only one trawl haul was necessary to characterize that unit). These units were further subdivided into 10 units, 2 ½' of latitude by 2' of longitude, and each of these smaller units in a stratum were numbered consecutively. Random numbers were generated and the stations were selected. Only one station in each of the 5' x 10' squares was selected since each of these sequences was homogeneous. This selection method also insures both the dispersion of stations and that every possible trawling site within a stratum had an equal chance of being selected. The smaller, narrower, inshore and offshore strata could not be divided into the 5' x 10' rectangles; in this case, the smaller 2 ½' by 2' rectangles were used.

The number of stations occupied within a stratum is roughly proportional to its area. Certain strata were allocated extra stations. Examples of this would be priority areas like Georges Bank and coastal locales affected by human activity or environmental extremes. Some of the very small inshore and offshore strata also were sampled disproportionately because of the requisite presence of at least two stations to permit variance computation.

About 400-450 stations were conducted in a complete survey between Cape Hatteras and Nova Scotia with approximately 190 between Cape Hatteras and Cape Cod. This survey design gives about one station for every 200 sq. nautical miles.

Substantial efforts were made to conduct the surveys at approximately the same time each year. Usually southern areas were completed first, then the ship worked northerly and easterly completing the Mid-Atlantic, southern New England, Georges Bank, and the Gulf of Maine areas in that order. An example of a cruise track for a complete groundfish survey in the Middle Atlantic Bight is attached (Figure 3).

During the study period three different sized trawls were used to collect the samples. Table 2 identifies the vessel and trawl size used during each cruise. A #36 Yankee otter trawl was used on spring and fall offshore surveys through 1972, and all subsequent fall surveys. Initially, the #36 trawl was adequate to provide spring abundance indices needed for most commercially important species. However, in the late-1960's and early-1970's the abundance of fish dropped, so a larger trawl was needed for adequate sampling. A modified, two seam, high opening #41 Yankee otter trawl was used on spring surveys from 1973 through 1981. During inshore surveys conducted from the fall of 1972 through the spring of 1975, a 3/4 size #36 trawl rigged with a chain sweep and ground cables was used. The smaller, 3/4 size #36 Yankee otter trawl was used during these early inshore surveys because the vessel used (R/V ATLANTIC TWIN) could not handle the larger, heavier trawls. Basic performance characteristics and trawl specifications for these three trawls are presented in Table 3. All the trawls were lined with 1.25 cm stretched mesh knotless webbing in the cod end and upper belly to retain small fish that would otherwise escape through the large mesh.

All trawls and otter doors used during the study period had been tested and measured during special gear mensuration cruises. During these cruises each trawl was towed in several directions relative to the surface current, at several different speeds, and at different ratios of wire out relative to depth (scope). During these tows the opening of each trawl was monitored acoustically with trawl-mounted transducers. Each trawl and set of doors had to perform within certain specifications before it was used on a survey.

Most of the surveys conducted since 1963 used the 57 m research vessel ALBATROSS IV, but recently the survey work has been shared by the 47 m R/V DELAWARE II; both are stern trawlers. The chartered R/V ATLANTIC TWIN was

used during five inshore surveys. This 27 m vessel was also rigged as a stern trawler. The data obtained with the two large vessels are considered to be interchangeable.

After arriving on a pre-selected station, a temperature profile was obtained using an expendable bathythermograph system. A surface bucket temperature was taken, and a surface water sample was collected for subsequent salinity measurement. In inshore areas some bottom salinity samples were collected along with samples for dissolved oxygen determinations. Weather, sea state, and position observations were recorded.

A standard trawl haul began when the predetermined amount of wire was let out and the winch drums were locked. The haulback process began 30 minutes later. The scope of the towing wire varied from 5:1 in the shallow nearshore areas, to 2.5:1 in depths greater than 185 m. The trawl was towed at a speed of 3.5 knots relative to the bottom. The tow direction was generally toward the next station, but this was not always the case, especially in very rough water or in areas where the bottom was steeply graded (under the latter conditions a depth contour was followed). A fathometer trace was also recorded during each tow.

The catch was dumped onto the checker table and sorted by species. All the fish and invertebrates were then weighed to the nearest 0.1 kilogram, and measured to the nearest centimeter (total length to the end of the center caudal fin ray). Large catches were sub-sampled by weight or volume for reasons of practicality and later expanded to the entire catch. After weighing and measuring had been completed, biological samples were taken including scales, otoliths, or other hard parts for age and growth studies; and stomachs were taken for food habit studies. Tissue samples were taken for pathology or contaminant studies. Gonadal conditions were noted and ovaries

removed for fecundity studies of selected species.

The initial aspects of data processing deal with the completed trawl log. After the log was coded for machine processing, all information was scanned for errors of omission, inconsistencies, or mistakes in calculations.

Machine processing involves the production of five data record types to facilitate subsequent computer analysis and auditing for gross errors. There are five different data record types: type one contains the number and weight of a particular species taken at a particular station; type two contains the corresponding length frequency data for the previous catch data record; type three contains age-length data by species which are entered into the system after age and growth samples were processed at the laboratory; type four is a summation of the total weight and number for all species combined at a station (produced by the computer by summing the type one records for a station); and type five contains detailed station data. The result is that for each species at each station, there will be a type one and a type two record in the data set. There will be only one type four and type five record for each station, and there will only be type three records if age and growth samples were taken. Record types one, two, and five were used in the production of this report.

Auditing basically consisted of cross-checking common values between record types; the totals for each species on both type one and type two records; and the observed weight and number for specified species, with the predicted weight and number after a length-weight equation has been applied. In addition, omission errors and gross latitude and longitude errors can be detected.

After audits were completed and errors corrected, the data were then stored on magnetic tape for later use.

Data Summaries and Limitations

Spring and fall distribution plots and percentage young-of-the-year plots display data for the entire geographical area. The graphs displaying catch data (weight and number per tow) and the histograms displaying length frequency data are also on a spring and fall basis, but the geographical area considered in this report was divided into six sub-areas, based on depth and latitude. This method was used to highlight any depth or north-south distributional differences that may occur with each of the studied species. Three offshore areas, and three corresponding inshore areas (separated by the 28 m contour) were established: Strata Set 1 (New York Bight Inshore) consists of inshore strata 1-23, 45 and 46; Strata Set 2 (Delaware-Chesapeake Inshore) consists of inshore strata 24-38; Strata Set 3 (North Carolina Inshore) consists of inshore strata 39-44 (Figure 1); Strata Set 4 (New York Bight Offshore) consists of offshore strata 1-8 and 73-76; Strata Set 5 (Delaware-Chesapeake Offshore) consists of offshore strata 65-72; Strata Set 6 (North Carolina Offshore) consists of offshore strata 61-64 (Figure 2).

All compilations and calculations for this report were done with the aid of a Xerox Sigma-7 computer using a Honeywell CP-V operating system. The software used were Northeast Fisheries Center in-house programs. The coastline plots were generated using the following programs: MAPRET, PREMAP, LINKSURV5, and FISHMAP. The SUR 1 package, with its subroutines, was used to analyze catch data. Subroutine LSTS produced station listings, subroutine LSTB was used to process the catch data (number and weight per tow), and subroutine LSTL was used to process length frequency data. Results of the analyses were plotted on histograms and XY graphs using the program GRAPH. Program documentation is on file with the Automated Data Processing Unit of the Northeast Fisheries Center.

The following paragraphs discuss limitations of the data used in this report and of the graphs presented in the species sections.

Because of the relatively short towing time (0.5 hour), the catches during bottom trawl surveys were low when compared to the catches of commercial vessels. Also, the randomly selected stations did not necessarily fall within areas of high population densities, whereas commercial vessels tend to concentrate in more productive areas.

The survey catches, however, are comparable from one year to the next when compared on a stratum or strata set basis. When making comparisons or interpreting data, parameters such as the dates of the survey, the trawl used, and the vessel used should be considered. Different trawls were used during spring and autumn surveys. The data from these two time series are not directly comparable without applying fishing power coefficients for the different sizes of the trawls. To date, these coefficients have been worked out for only a few species. No coefficients have been employed in this study, so care should be exercised when making comparisons, particularly since three different trawls have been used during the study period. The primary value of these data is in examining seasonal distribution as deduced from spring and fall cruises and trends over each time series. When the data are used in this manner, abundance changes or trends can be evaluated effectively.

For two of the figurative reporting formats (length-frequency histogram and the coastline figures depicting young-of-the-year distribution) percent is used in place of absolute or stratified values. This method was used to facilitate computer processing, and to put the voluminous data base in perspective. However, when interpreting the results it should be taken into account that percentages can mask the actual number of animals

represented. Also, unusually large catches tend to bias presentations based upon pooled data.

Although substantial efforts were made to conduct each survey at approximately the same time each year, differences affecting distribution did occur. These were due to: (1) unavoidable differences in calendar scheduling; (2) differences in climatic conditions; (3) the size of the stocks; and (4) the availability of food items. Since the data have been pooled, annual differences in distribution cannot be discerned from the graphics presented in this report. Also, for the same reason, anomalous distributional patterns may appear as normal when all years are plotted together. For these reasons interpretation of the distribution plots is important and has been done for each species. In some cases two spring distribution plots have been included--one with the entire series from 1968 to 1979 (Figure 4) and another with data from 1976 to 1979 (Figure 5). Several spring cruises prior to 1976 were conducted as much as four to six weeks later than the normal spring survey period. For some species this difference occurred during a critical period of their migration and the plots from the longer series reflected what appeared to be an anomalous distribution caused by this temporal bias. By deleting data prior to 1976 the temporal bias was eliminated and resulting plots can be considered a truer representation of spring distribution. Figure 6 is a plot of all trawl stations made during the autumn series 1967-79.

The results of the LSTB and LSTL analyses have been weighted to take the differing sizes of the strata into account. The area of each stratum (in square nautical miles) was used as the weighting factor.

Table 1. A list of the 22 species selected for distributional summarizations in the BLM Final Report on Historical Fisheries Data.

Common Name	Scientific Name
Smooth dogfish	*Mustelus canis*
Spiny dogfish	*Squalus acanthias*
Little skate	*Raja erinacea*
Atlantic herring	*Clupea harengus harengus*
Silver hake	*Merluccius bilinearis*
Red hake	*Urophycis chuss*
Summer flounder	*Paralichthys dentatus*
Fourspot flounder	*Paralichthys oblongus*
Windowpane	*Scophthalmus aquosus*
Atlantic mackerel	*Scomber scombrus*
Butterfish	*Peprilus triacanthus*
Bluefish	*Pomatomus saltatrix*
Atlantic croaker	*Micropogonias undulatus*
Black sea bass	*Centropristis striata*
Scup	*Stenotomus chrysops*
Weakfish	*Cynoscion regalis*
Tilefish	*Lopholatilus chamaeleonticeps*
American lobster	*Homarus americanus*
Red crab	*Geryon quinquendens*
Sea scallop	*Placopecten magellanicus*
Shortfin squid	*Illex illecebrosus*
Longfin squid	*Loligo pealei*

Table 2. A list of cruises included in the data base used for the NMFS/BIM Interagency Agreement- Historical Trawl Data Summary.

OFFSHORE CRUISES (> 28 m water depth)

SPRING

DATE*	VESSEL	TRAWL TYPE
6 Mar-29 Mar, 1968	Albatross IV	#36 Yankee
5 Mar-15 Mar, 1969	Albatross IV	#36 Yankee
19 Apr-29 Apr, 1970	Albatross IV	#36 Yankee
9 Mar-10 Apr, 1971	Albatross IV	#36 Yankee
8 Mar-27 Mar, 1972	Albatross IV	#36 Yankee
16 Mar-30 Mar, 1973	Albatross IV & Delaware II	#41 Yankee
13 Mar-30 Mar, 1974	Albatross IV	#41 Yankee
4 Mar-12 Mar, 1975	Albatross IV	#41 Yankee
4 Mar-26 Mar, 1976	Albatross IV & Delaware II	#41 Yankeel
19 Mar-16 Apr, 1977	Albatross IV & Delaware II	#41 Yankee
21 Mar-10 Apr, 1978	Albatross IV	#41 Yankee
22 Mar-18 Apr,1 1979	Albatross IV & Delaware II	#41 Yankee

AUTUMN

DATE*	VESSEL	TRAWL TYPE
18 Oct-10 Oct, 1967	Albatross IV	#36 Yankee
10 Oct-19 Oct, 1968	Albatross IV	#36 Yankee
8 Oct-18 Oct, 1969	Albatross IV	#36 Yankee
5 Sep-23 Oct, 1970	Albatross IV & Delaware II	#36 Yankee
29 Sep-13 Oct, 1971	Albatross IV	#36 Yankee
28 Sep- 9 Oct, 1972	Albatross IV	#36 Yankee
26 Sep- 8 Oct, 1973	Albatross IV	#36 Yankee
23 Sep- 9 Oct, 1974	Albatross IV	#36 Yankee
16 Oct- 7 Nov, 1975	Albatross IV & Delaware II	#36 Yankee
28 Sep-15 Oct, 1976	Albatross IV	#36 Yankee
26 Sep-27 Oct, 1977	Delaware II	#36 Yankee
7 Sep-21 Nov, 1978	Delaware II	#36 Yankee
13 Sep-19 Oct, 1979	Albatross IV & Delaware II	#36 Yankee

INSHORE CRUISES (< 28 m water depth)

SPRING

DATE*	VESSEL	TRAWL TYPE
8 May- 4 Jun, 1973	Atlantic Twin	3/4 Yankee
1 Apr-30 Apr, 1974	Atlantic Twin	3/4 Yankee
18 Mar-24 Mar, 1975	Atlantic Twin	3/4 Yankee
3 Mar-26 Mar, 1976	Delaware II	#41 Yankee
19 Mar-14 Apr, 1977	Delaware II	#41 Yankee
24 Mar-10 Apr, 1978	Albatross IV	#41 Yankee
28 Mar-17 Apr, 1979	Albatross IV & Delaware II	#41 Yankee

AUTUMN

DATE*	VESSEL	TRAWL TYPE
31 Oct- 5 Dec, 1972	Atlantic Twin	3/4 Yankee
1 Oct- 7 Nov, 1973	Atlantic Twin	3/4 Yankee
23 Sep- 4 Oct,1 1974	Albatross IV &1Delaware III	#36 Yankee
15 Oct- 7 Nov, 1975	Delaware II	#36 Yankee
28 Sep-17 Oct, 1976 1	Albatross IVl	#36 Yankee
30 Sep-10 Oct, 19771	Delaware II	#36 Yankee
11 Sep- 5 Oct, 19781	Delaware II	#36 Yankee
21 Sep-14 Oct, 1979	Delaware II	#36 Yankee

*Dates during which Mid-Atlantic stations were occupied.

Table 3. NMFS, Northeast Fisheries Center Standard Trawl Gear Specifications

	Gear Code	#36 Yankee with rollers	3/4 #36 Yankee with chain sweep	Mod. #41 Yankee with rollers
	Units	11	12	41 or 45
Opening Height of Trawls	meters	3.2	1.4	4.6
Opening Width of Trawls	meters	10.4	9.2	11.8
Overall Length of Trawls	meters	28.4	20.8	28.6
Cod End Length	meters	5.7	7.1	5.7
Foot Rope Lengths	meters	24.4	16.5	30.5
Head Rope Lengths	meters	18.3	11.9s	24.4
Opening Mesh	centimeters, stretcheds	12.7	11.4	12.7
Average Body Meshs	centimeters, stretcheds	12.7	11.4	12.7
Cod End Mesh	centimeters, stretcheds	11.4	5.1	11.4s
Cod End Liner	centimeters, stretcheds	1.3	1.3s	1.3s
Number of Floatss		36	11	53
Float Diameter	centimeters	20	20	20
Ground Cables	meters	0	16.5	0
Roller Gear		Yes	No	Yes
Length of Bridless	meters	9.1	11.6	18.3
Length of Doorss	meters	2.4	2.1	2.5
Width of Doors	meters	1.3s	1.1	1.4s
Weight of Doorss	kilograms	545	227	682
Type of Doors		BMV Oval	New England Rectangular	BMV Oval

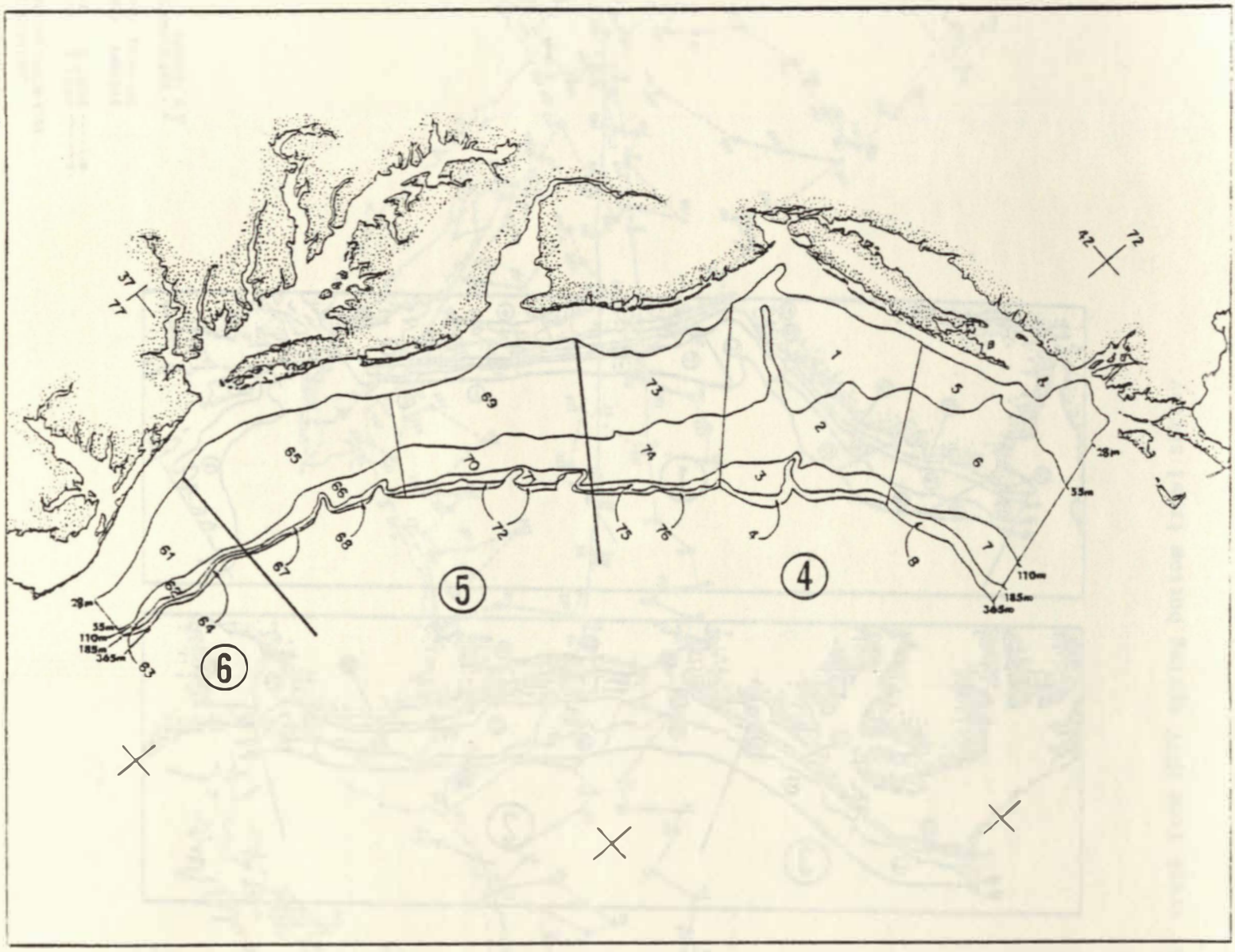


Figure 1. Standard offshore strata used by the Northeast Fisheries Center when conducting a bottom trawl survey in the Middle Atlantic Bight (Fall 1967 to date). Strata sets used in this report are separated with bold lines and identified with larger encircled numbers.

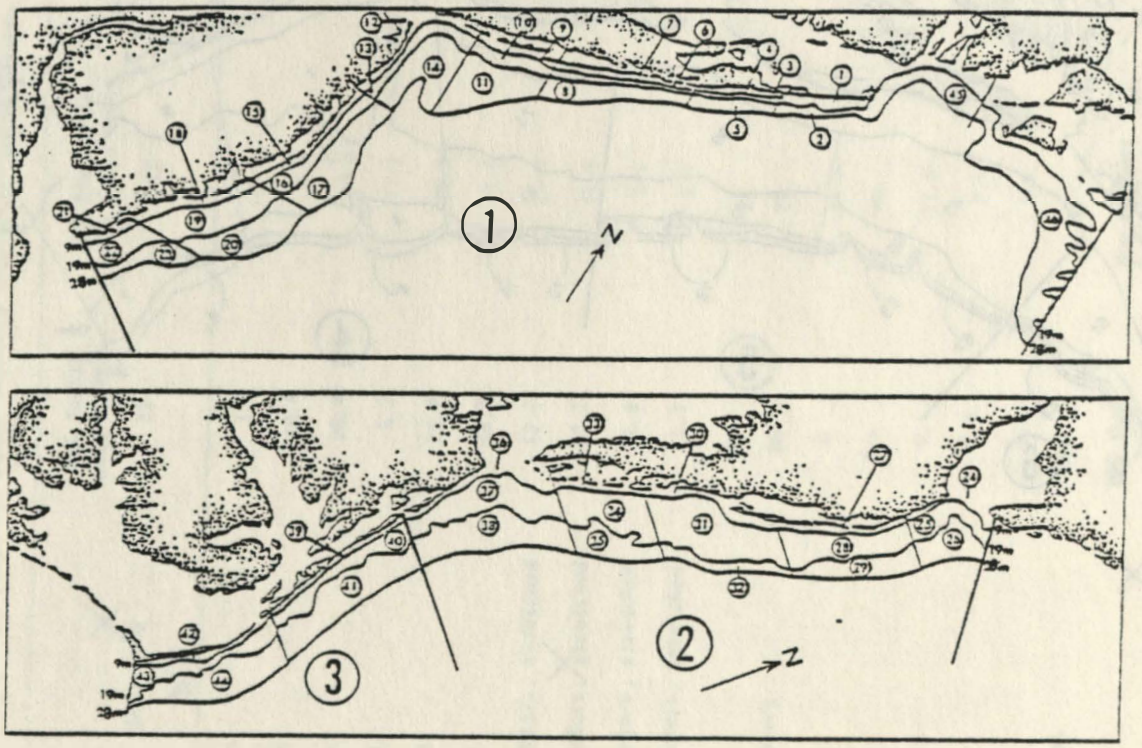


Figure 2. Standard inshore strata used by the Northeast Fisheries Center when conducting a bottom trawl survey in the Middle Atlantic Bight (Fall 1972 to date). Strata sets used in this report are separated with bold lines and identified with larger numbers.

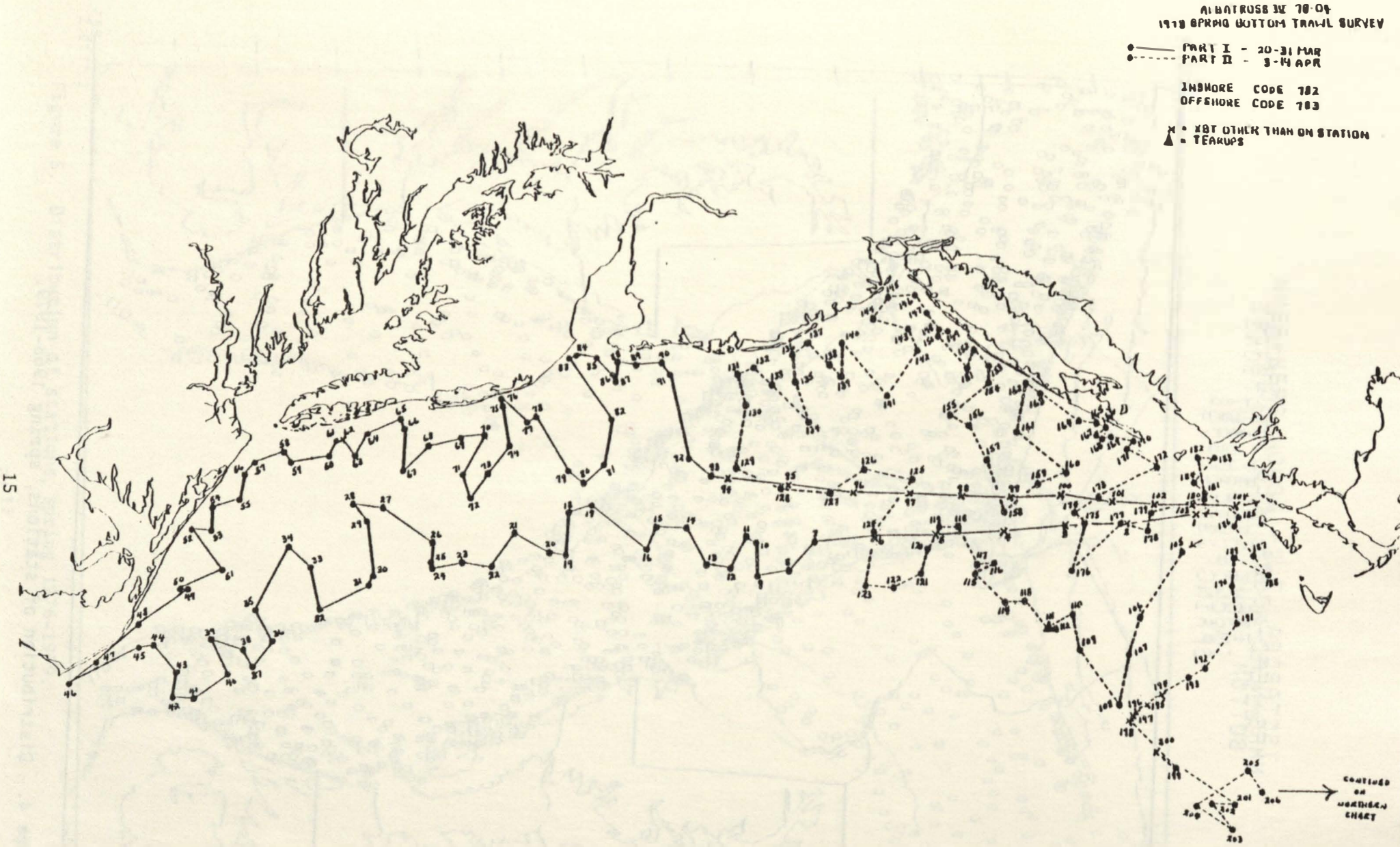


Figure 3. Typical cruise track from NEFC spring bottom trawl survey.

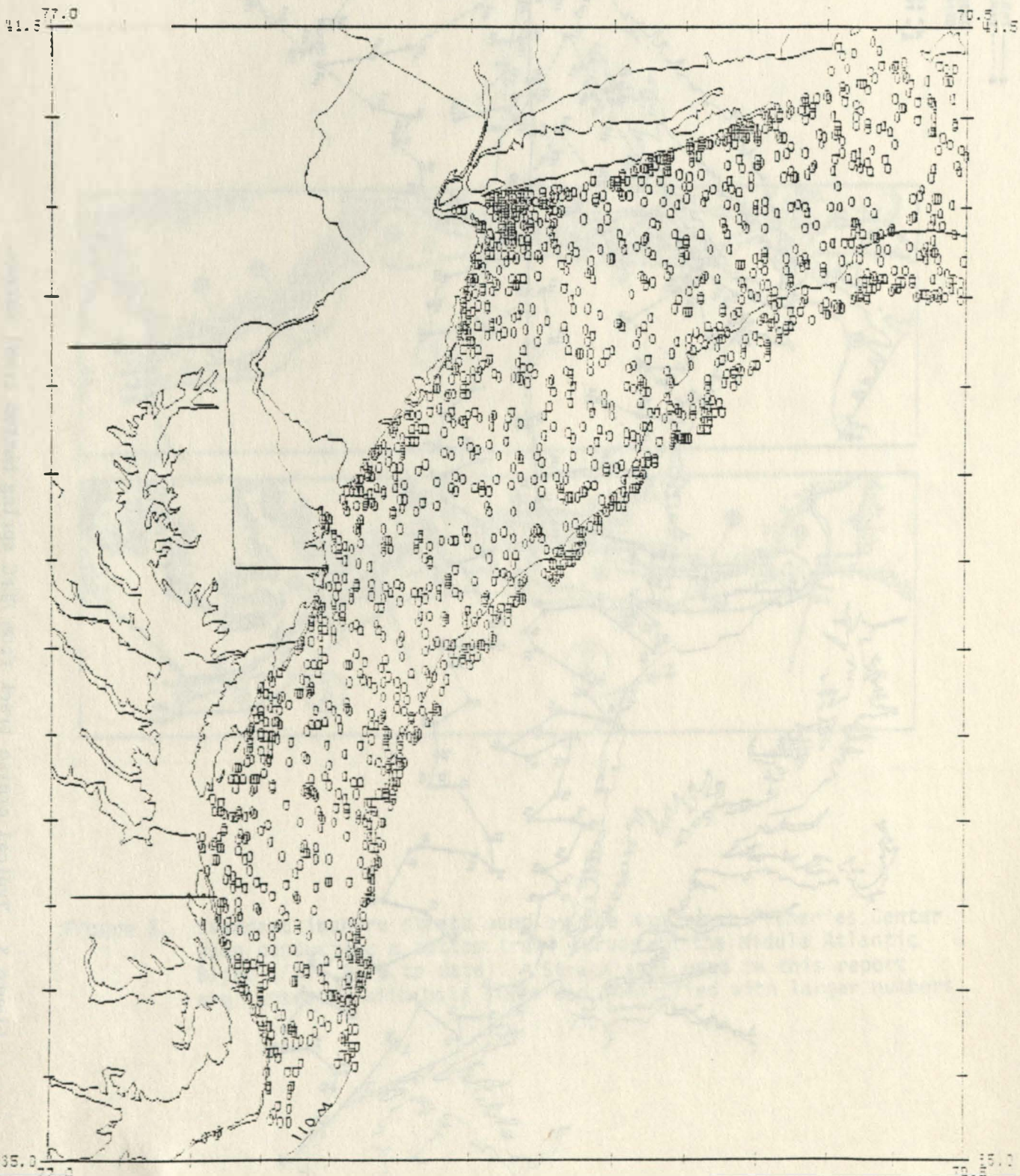


Figure 4. Distribution of stations, spring 1968-1979.

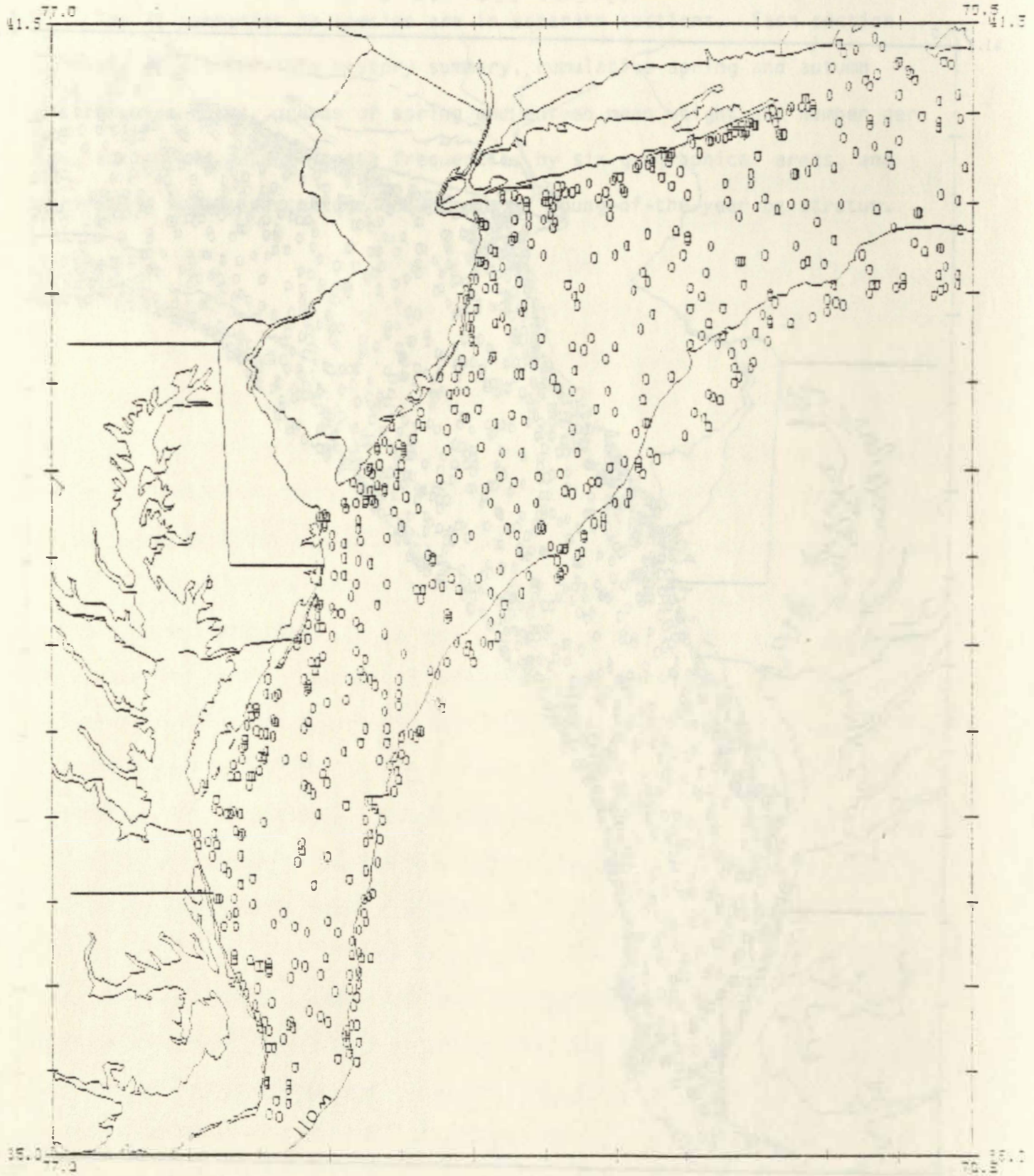


Figure 5. Distribution of stations, spring 1976-1979.

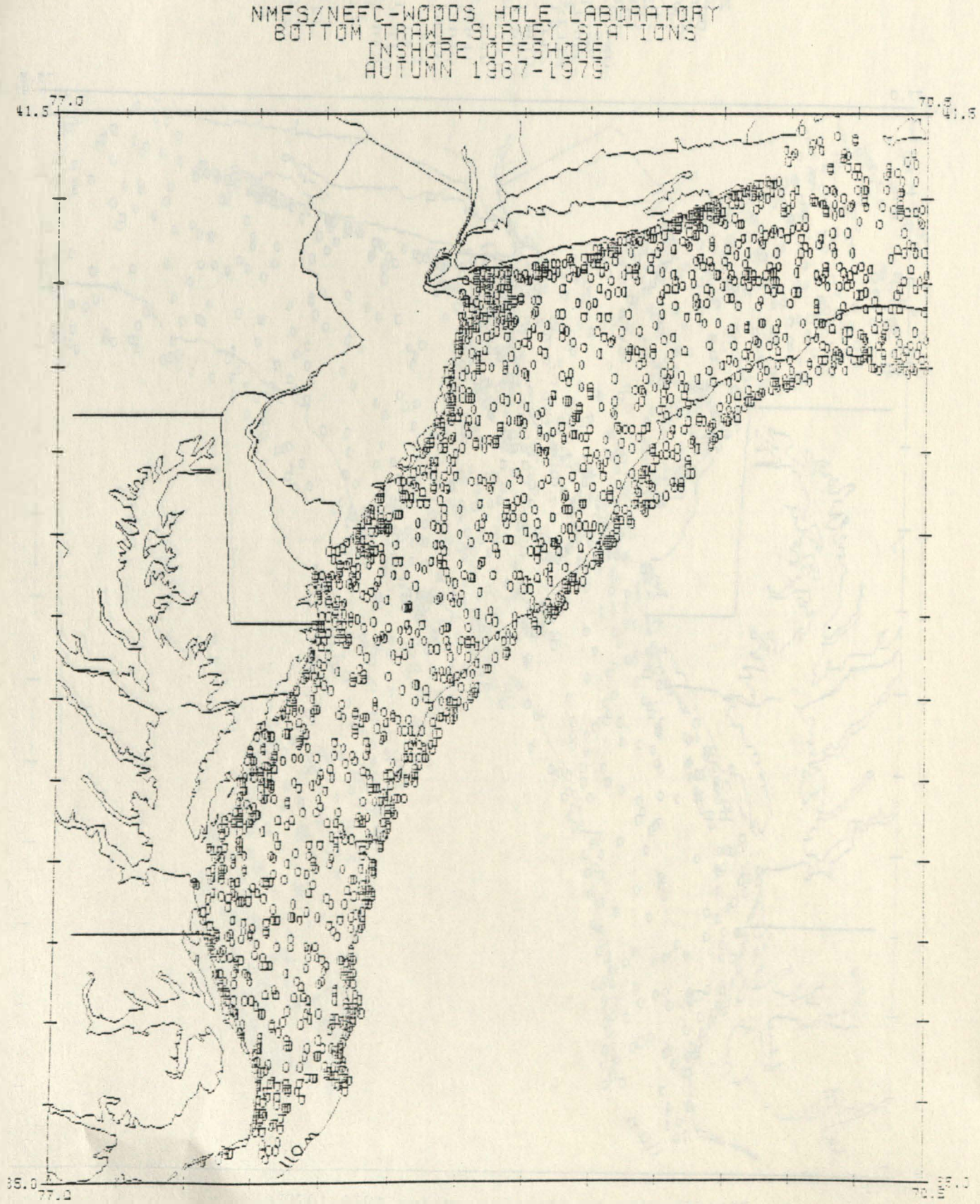


Figure 6. Distribution of stations, autumn 1967-1979.

RESULTS

The 22 summaries by species are in separate sections. Each section consists of a brief life history summary, cumulative spring and autumn distribution plots, graphs of spring and autumn mean weight and number per tow, spring and autumn length frequencies by six geographical areas, and spring and autumn percentage occurrence of young-of-the-year by stratum.

SECTION 1

Smooth Dogfish (*Mustelus canis*)

Life History Summary

The smooth dogfish inhabits the coastal waters of the western Atlantic from Cape Cod to Uruguay. In the Northwest Atlantic, it occurs most abundantly from Cape Cod to North Carolina (Bigelow and Schroeder 1953). The smooth dogfish is a bottom-dwelling shark, usually taken in less than 18 m of water, although it has been caught at depths of 165 m. The population migrates north and south seasonally in response to changing bottom water temperatures. In the summer, smooth dogfish are abundant in inshore waters from Delaware Bay to the southeastern end of Cape Cod, where they enter into bays and estuaries and occasionally freshwater reaches of the coast. Smooth dogfish have also been caught along the outer edge of the continental shelf off New York and southern New England during the summer months. Beginning in late October and November, smooth dogfish north of Chesapeake Bay withdraw from their summering grounds and migrate southward. They spend the winter inshore along the coast of North Carolina and on the offshore fishing banks off southern Virginia. Although considerable numbers of smooth dogfish may be found off the coast of North Carolina until July, most of the population has returned to its northern summering grounds by May.

The smooth dogfish is not popular as a food fish in the U.S. and is not utilized commercially or recreationally. It is considered a nuisance species because it feeds primarily on large valuable crustaceans such as lobsters and crabs, as well as on other invertebrates and small fishes, and readily takes

the bait of sport fishermen seeking other species. However, due to its abundance and anatomical distinctiveness, the smooth dogfish is commonly used by biological supply houses for dissection and study (Hildebrand and Schroeder 1928).

The smooth dogfish is a viviparous shark and bears embryos which receive nourishment from the mother by a yolk-sac placenta. Based on examinations of smooth dogfish caught in the Woods Hole area, females reach sexual maturity by the time they are 1.1m long and ovulate during the early part of July. Presumably, mating also occurs at this time, when the sharks are found on their summering grounds. The smooth dogfish has a gestation period of about 10 months, and young are therefore carried by the female during the fall migration. Dogfish are typically born in litters of 15-16 "pups" (each fish approximately 0.3 m in length) between May and mid-July, after the females have returned northward (Bigelow and Schroeder 1953).

Bottom Trawl Survey Results

The cumulative distributions over the time series are shown for the respective spring and autumn periods in Figures 1.1 and 1.2. The plots are an excellent representation of what is known of smooth dogfish distribution and movement. The spring plot (Figure 1.1) shows the shark occurring north of the Virginia capes in waters less than 37 m. This inshore, northward distribution would not be apparent if the timing of our spring cruises provided more synoptic coverage (see "Methods"). In Figure 1.3, data have been plotted from the last four spring surveys (1976-1979) only and thus produce an accurate picture of spring distribution. The inshore concentrations determined from surveys conducted during late April and May, demonstrate the rapidity of the onshore and northward movement of smooth dogfish in the spring (Figure 1.1).

The autumn plot (Figure 1.2) shows some offshore distribution to about the mid-shelf, but the population is still mainly concentrated inshore.

The graphs of mean weight and number per tow (Figures 1.4-1.7) generally reflect the importance of the inshore strata areas. The frequent occurrence of large numbers of fish in strata set 6 is the result of a combination of offshore overwintering and the first appearance of northerly-migrating smooth dogfish from south of Cape Hatteras. The extraordinarily high numbers and weights during 1974 in Figures 1.4 and 1.6 result from a few large tows.

Length frequencies from the strata sets, arranged by seasons, are shown in Figures 1.8-1.18. These frequencies suggest that, with the exception of young-of-the-year (YOY), all size ranges were represented in our survey tows. A spring plot for strata set 4 was omitted because no fish were caught in that area.

Figures 1.19 and 1.20 show the percentage occurrence by stratum of YOY. The cutoff length was 32 cm for both the spring and fall series. Very few YOY smooth dogfish were caught on NMFS surveys because they remain in very shallow water until they reach 50 cm. Because of the very light catches, no patterns are discernable in the YOY plots.

Since there is no directed fishery for smooth dogfish, and in fact fishermen try to avoid areas inhabited by significant numbers, the species has not been extensively studied. The smooth dogfish is a voracious bottom feeder and the ecological impact in areas of high density must be considered important.

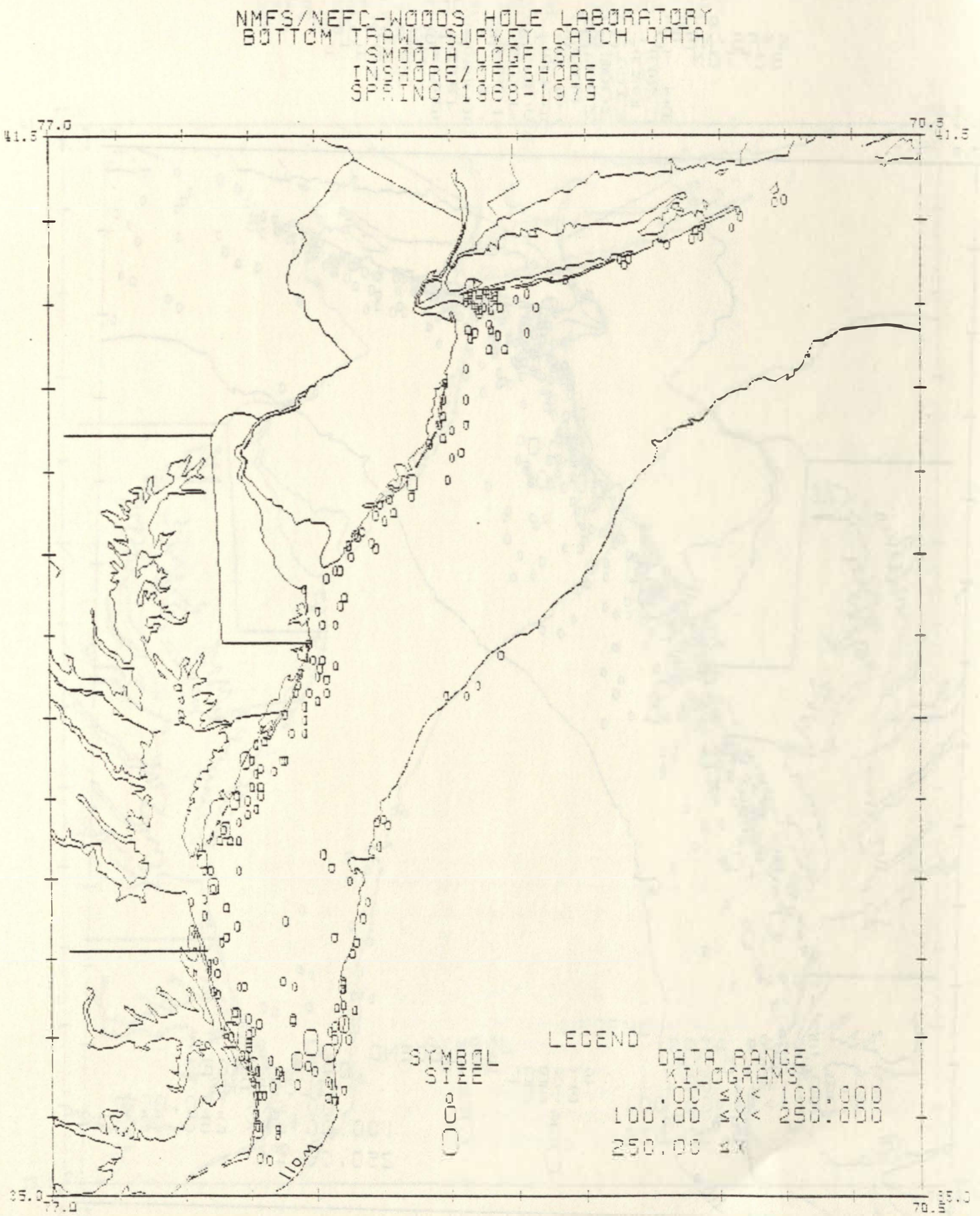


Figure 1.1. Spring distribution, 1968-1979.

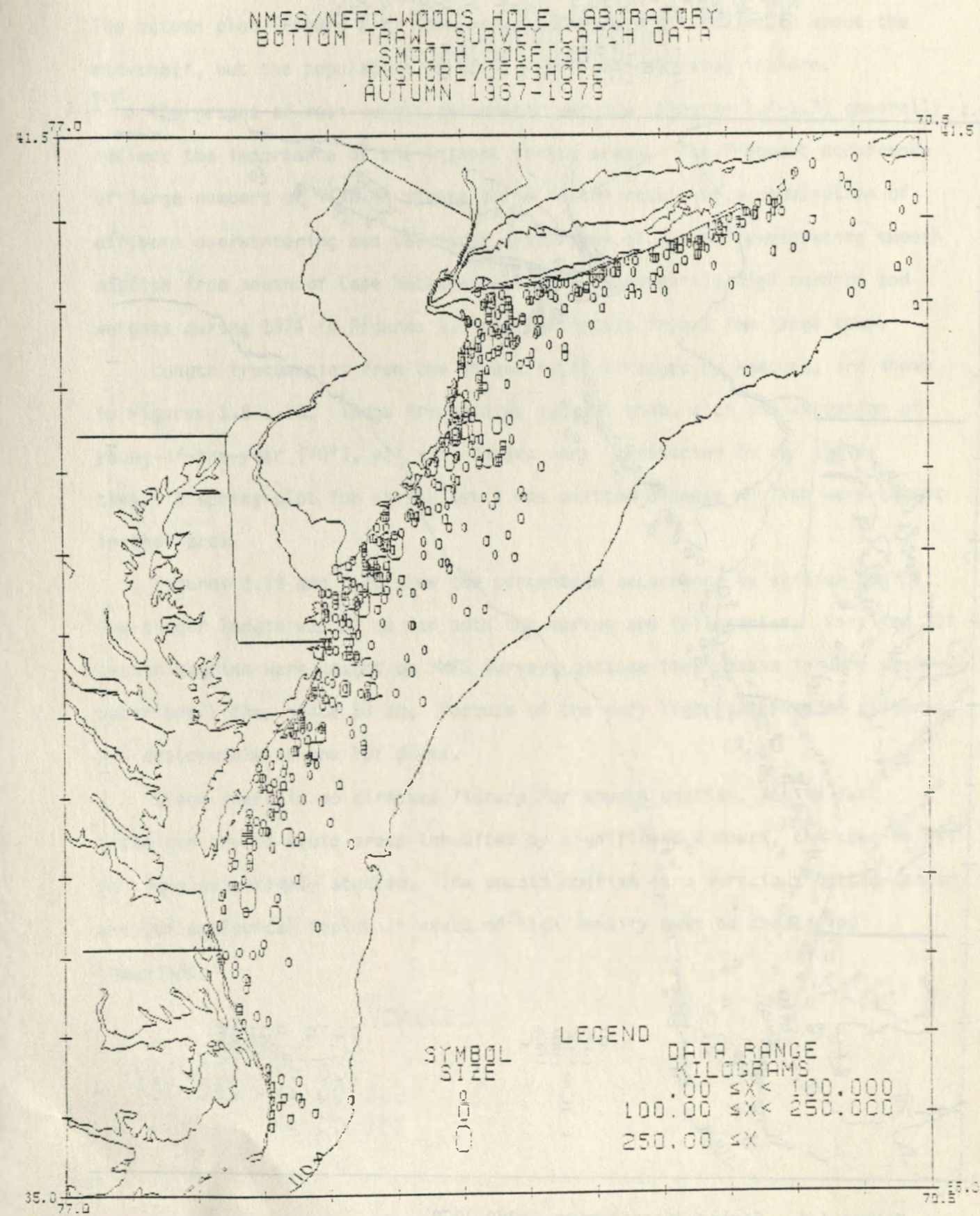


Figure 1.2. Autumn distribution, 1967-1979.

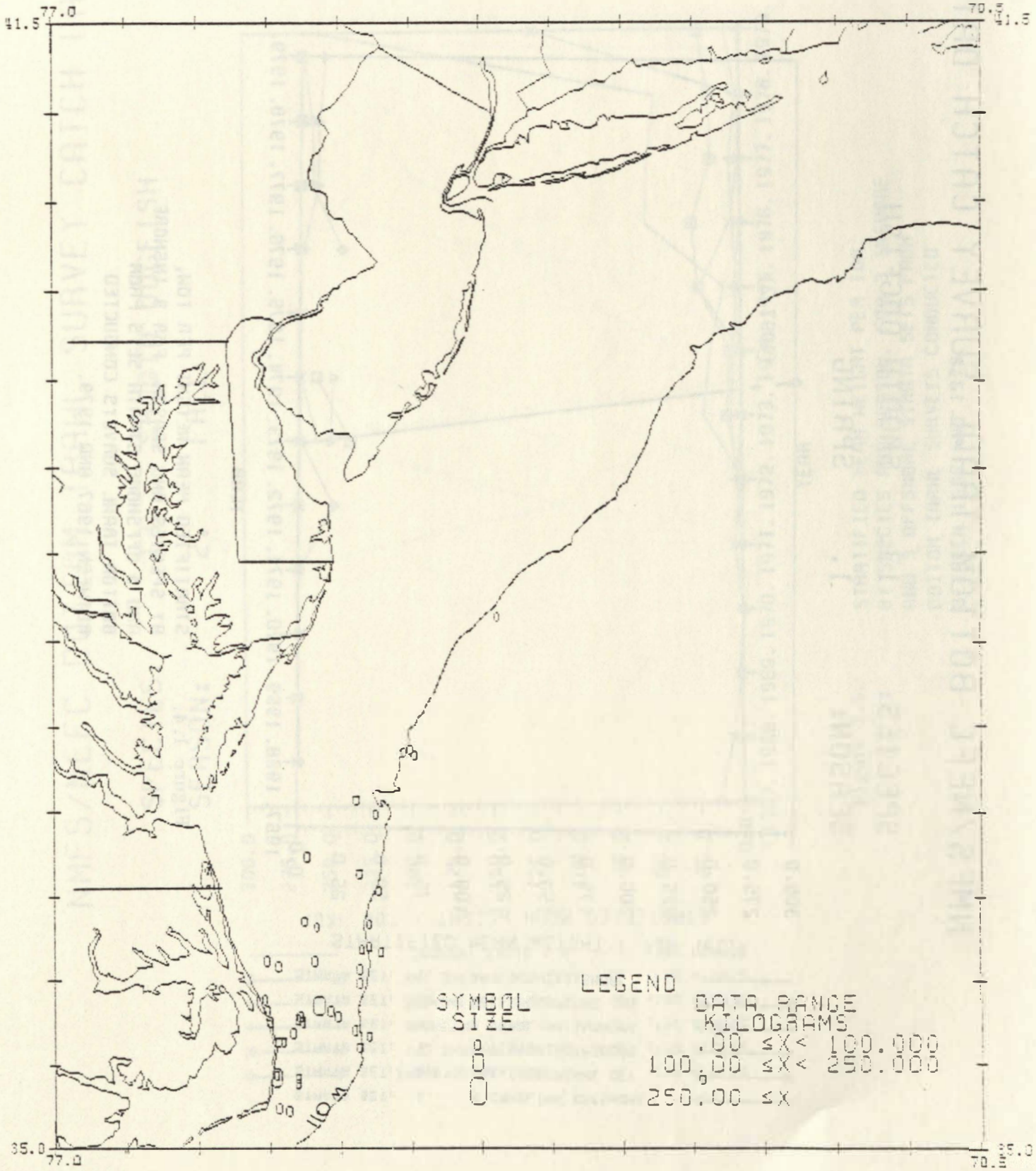


Figure 1.3. Spring distribution, 1976-1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 13. SMOOTH DOGFISH

SEASON: 1. SPRING

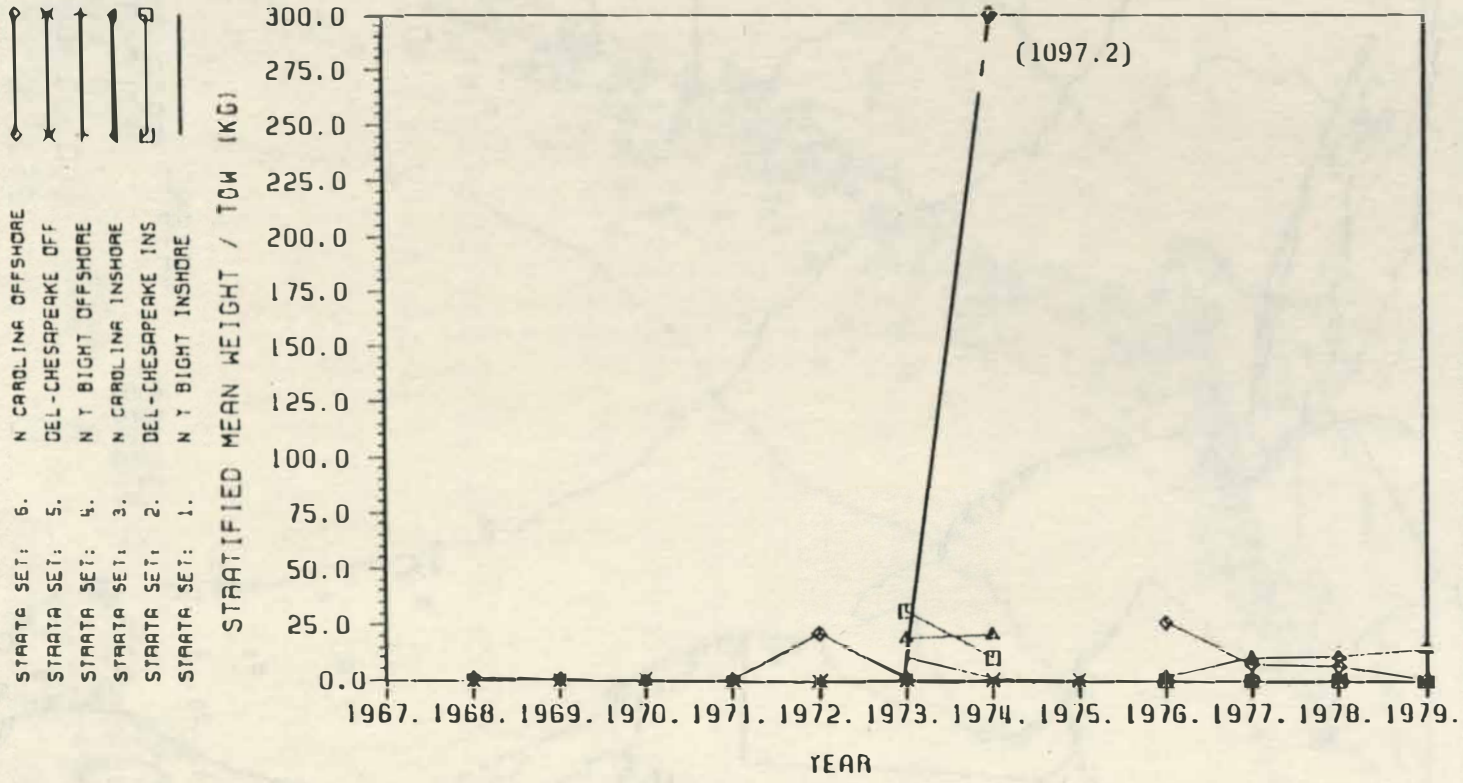


Figure 1.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

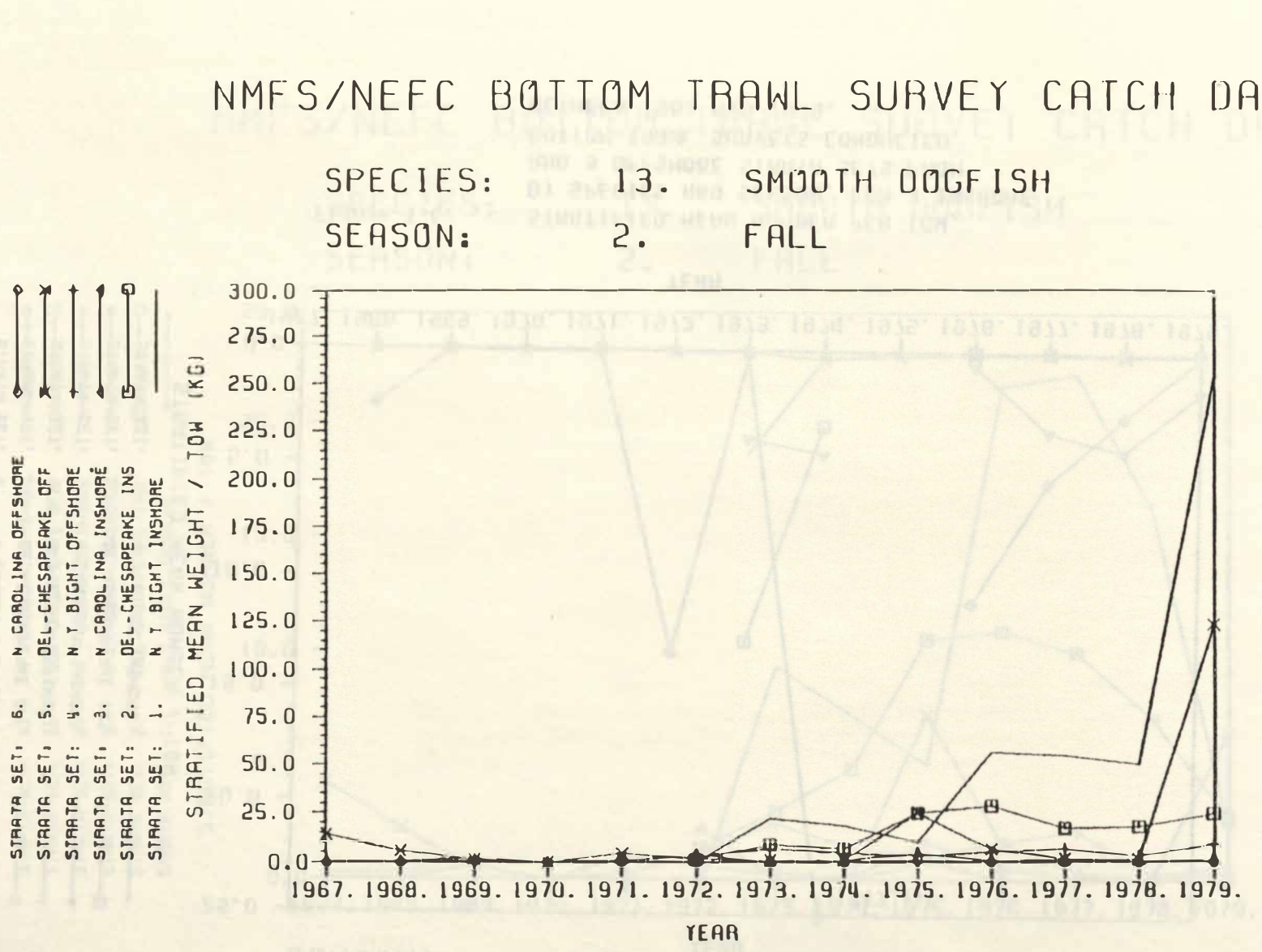


Figure 1.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

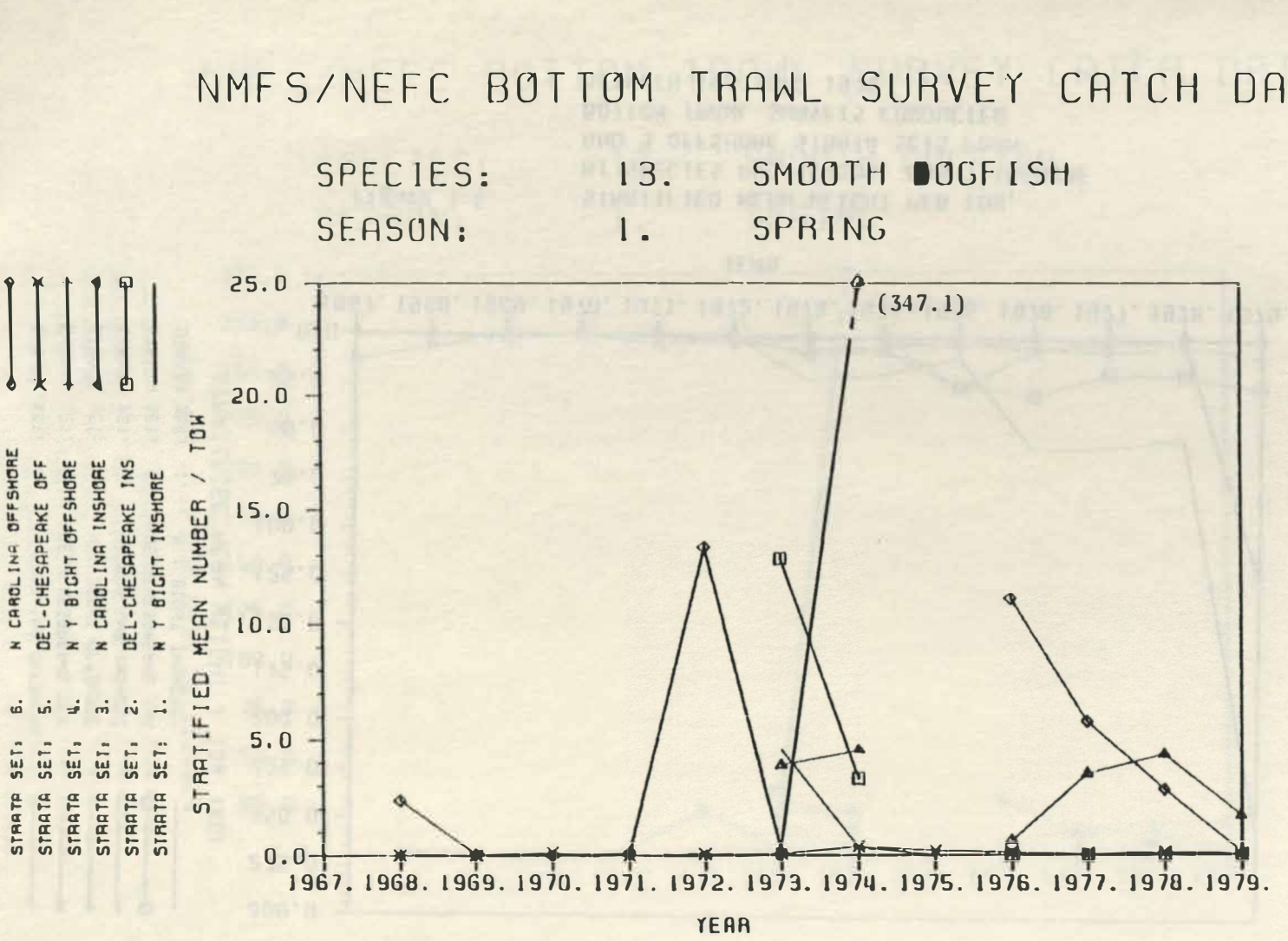


Figure 1.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

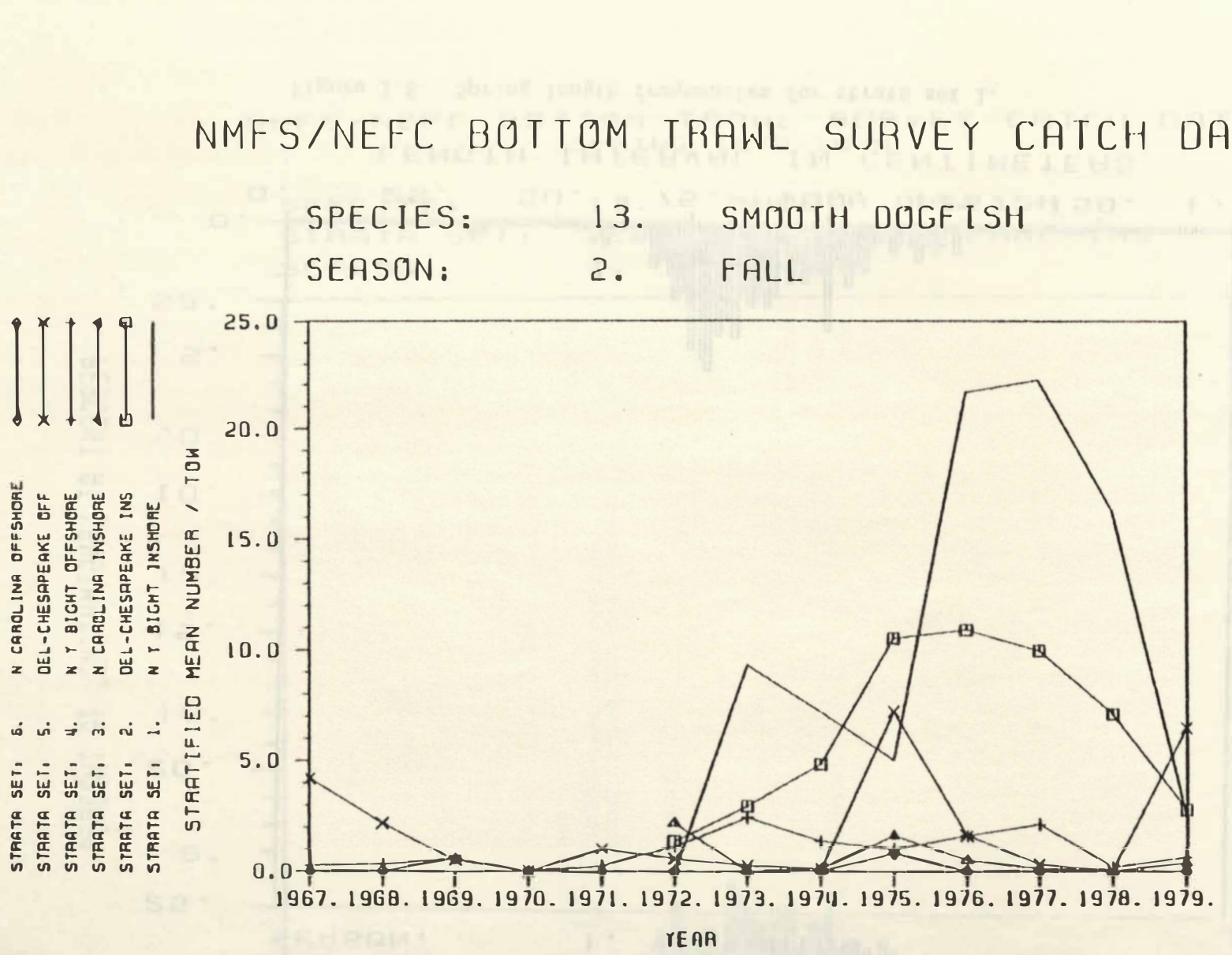


Figure 1.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

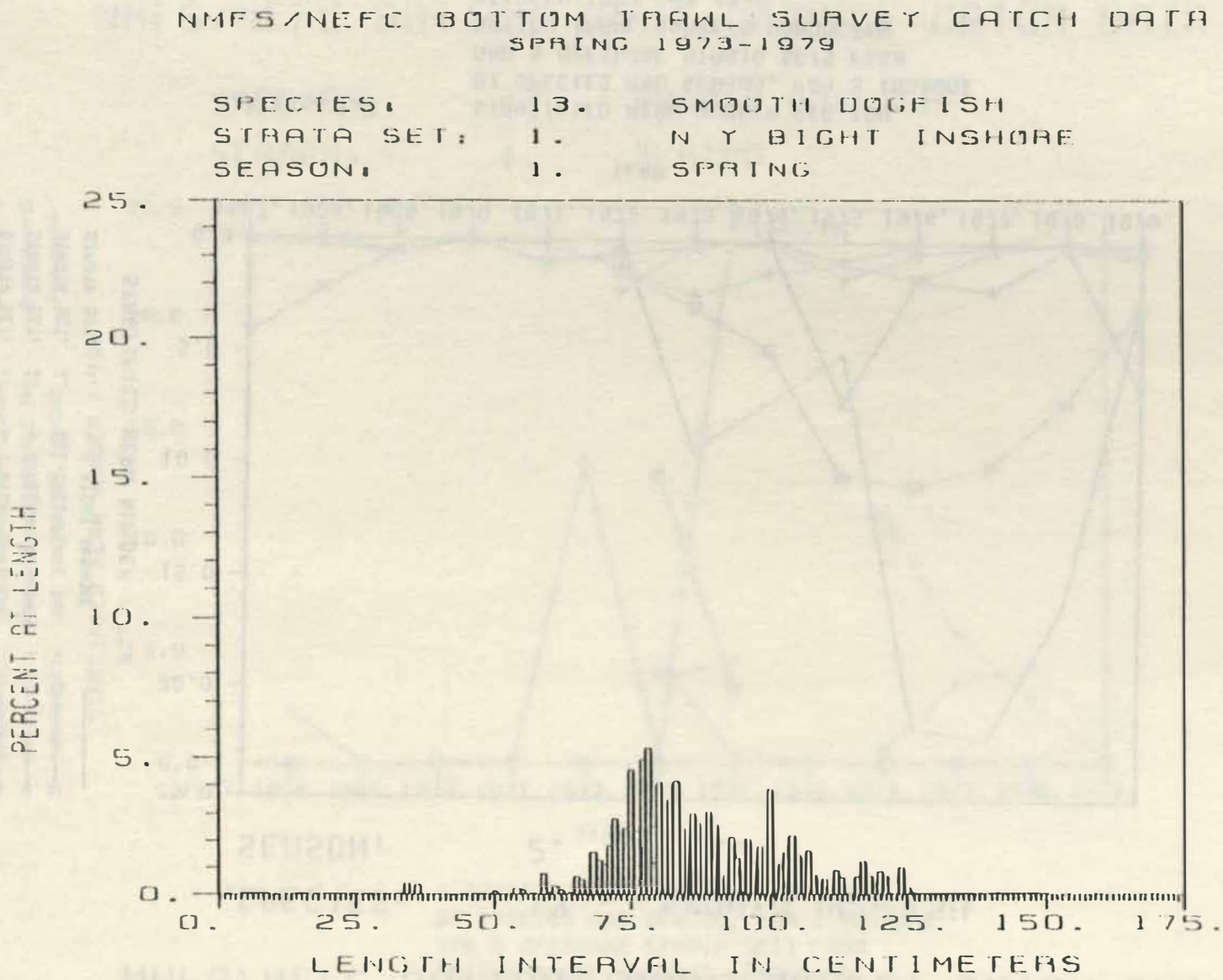


Figure 1.8. Spring length frequencies for strata set 1.

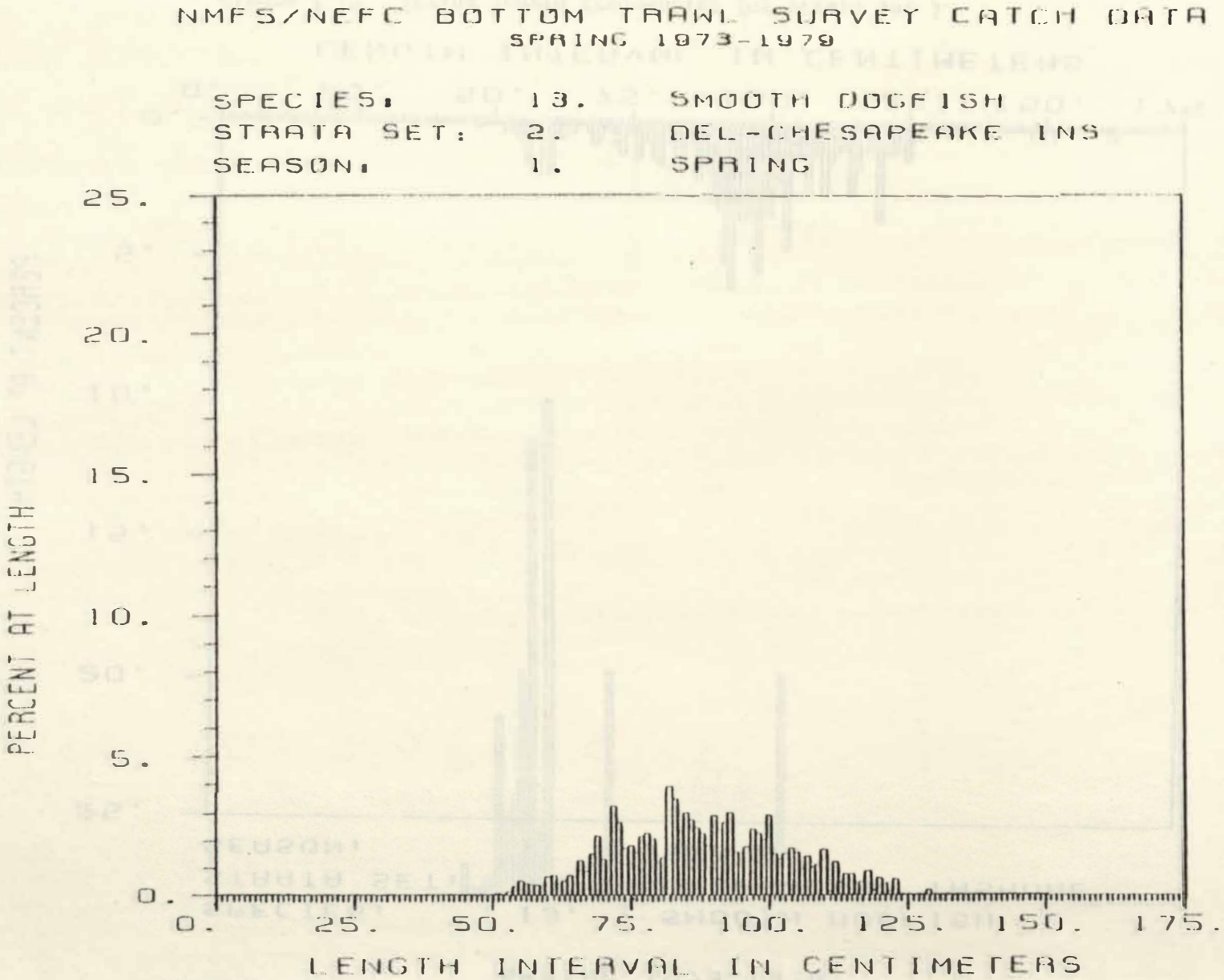


Figure 1.9. Spring length frequencies for strata set 2.

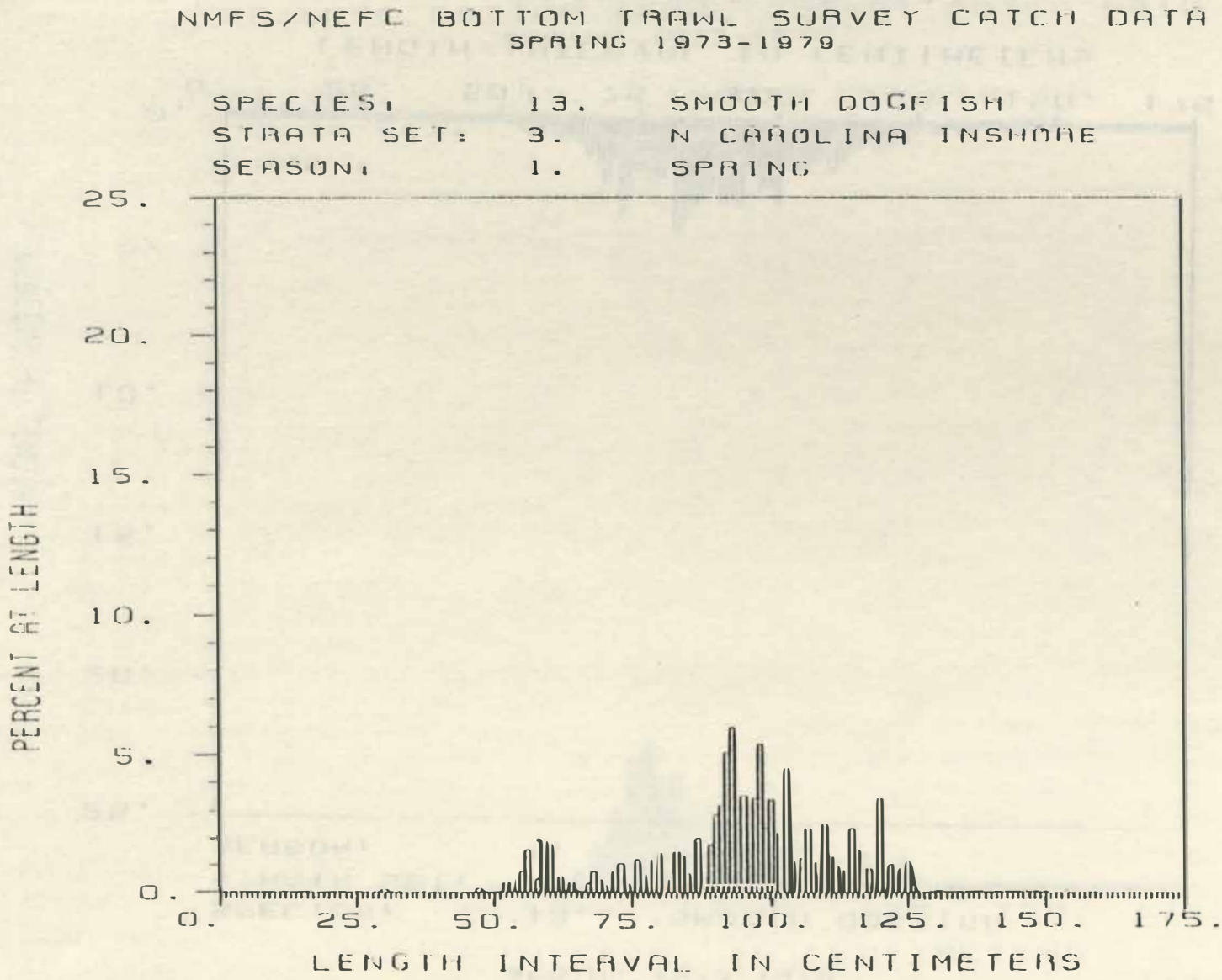


Figure 1.10. Spring length frequencies for strata set 3.

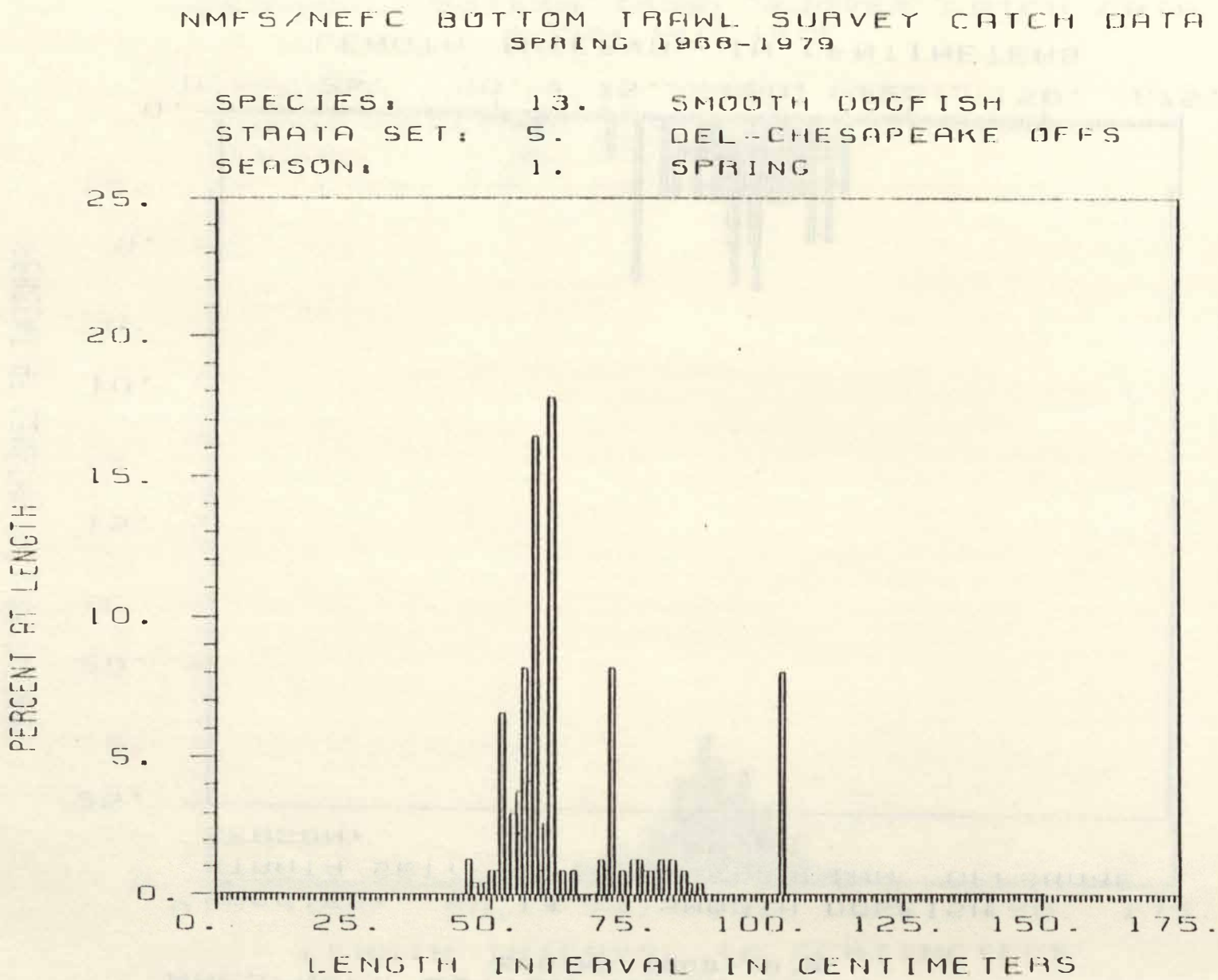


Figure 1.11. Spring length frequencies for strata set 5.

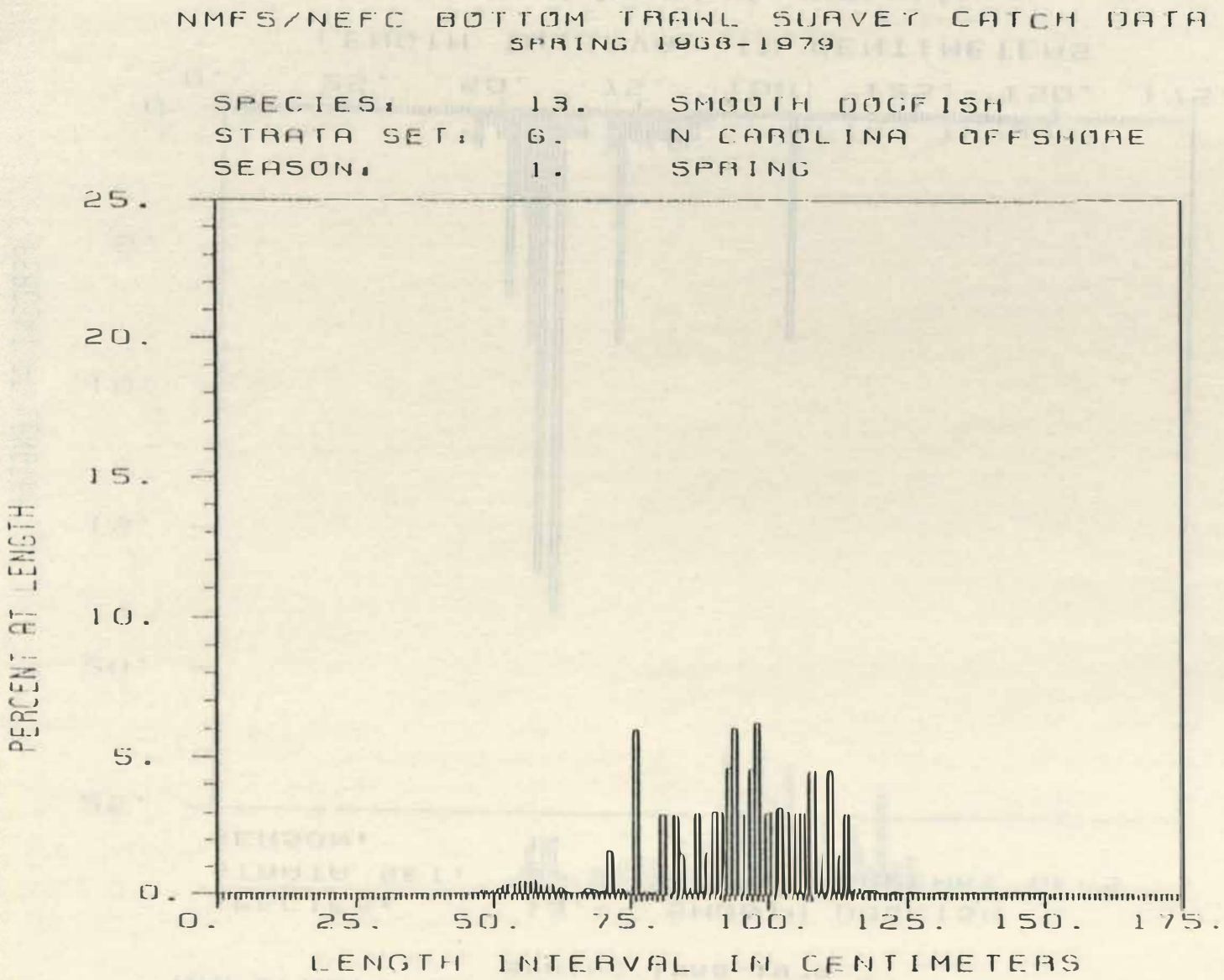


Figure 1.12. Spring length frequencies for strata set 6.

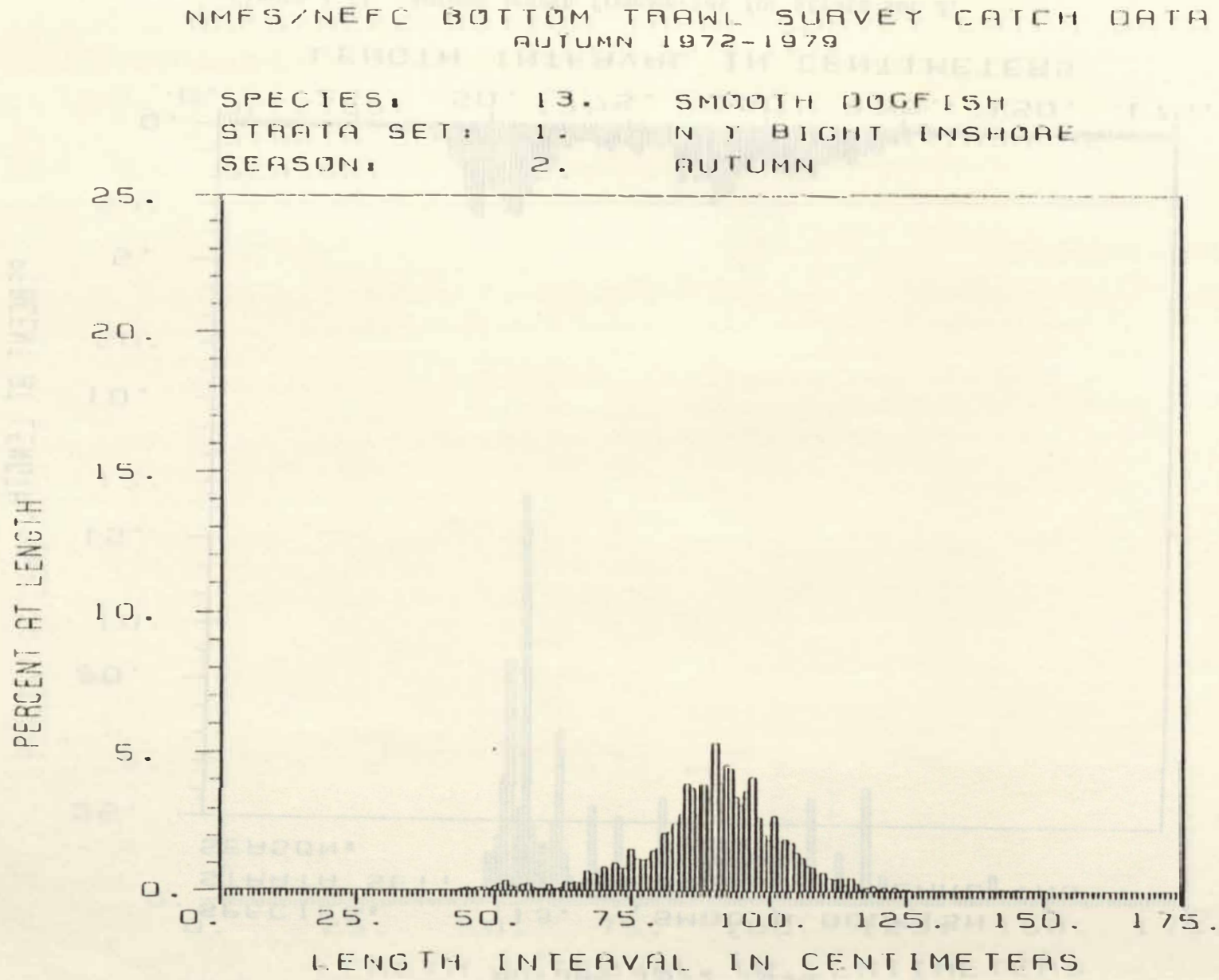


Figure 1.13. Autumn length frequencies for strata set 1.

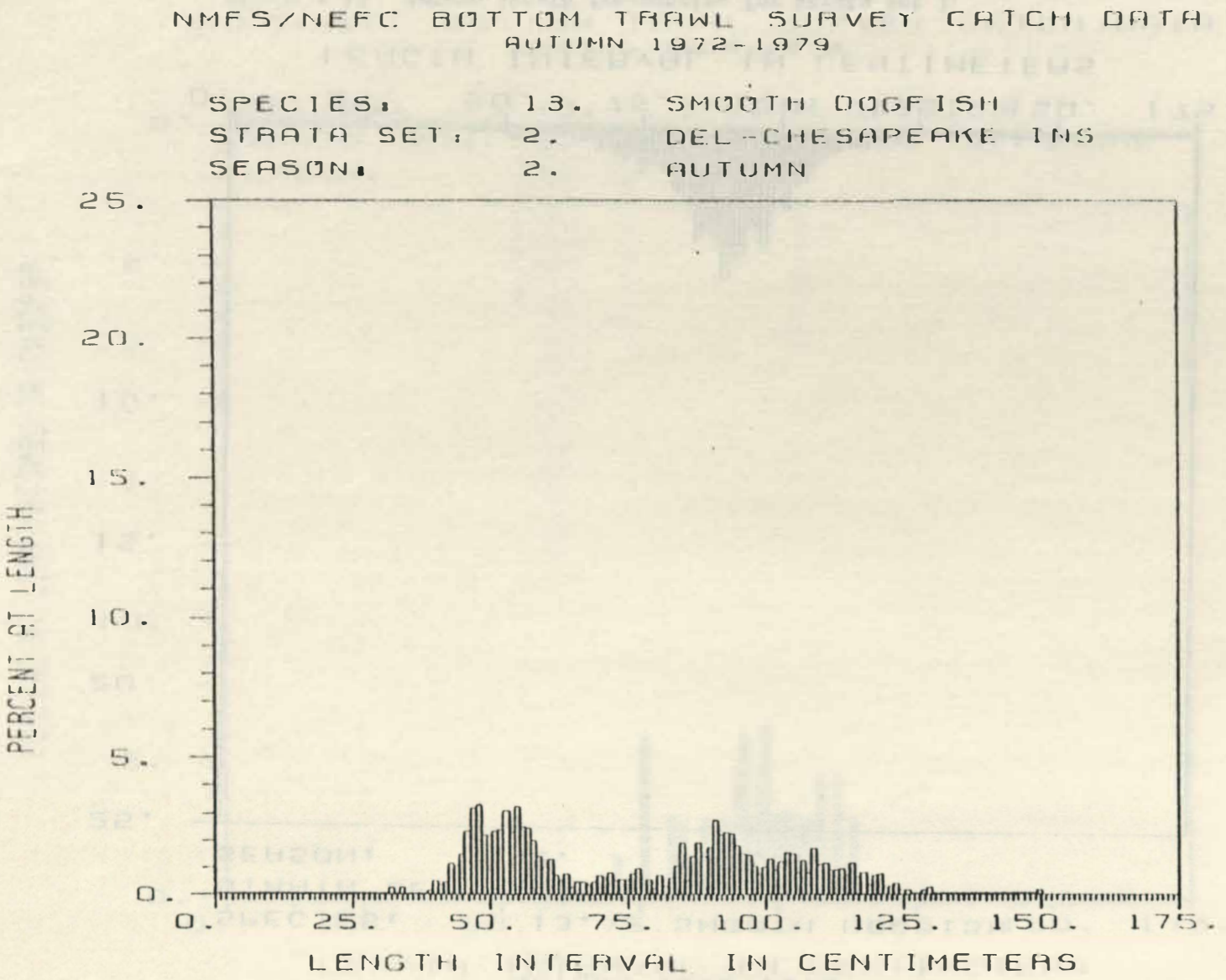


Figure 1.14. Autumn length frequencies for strata set 2.

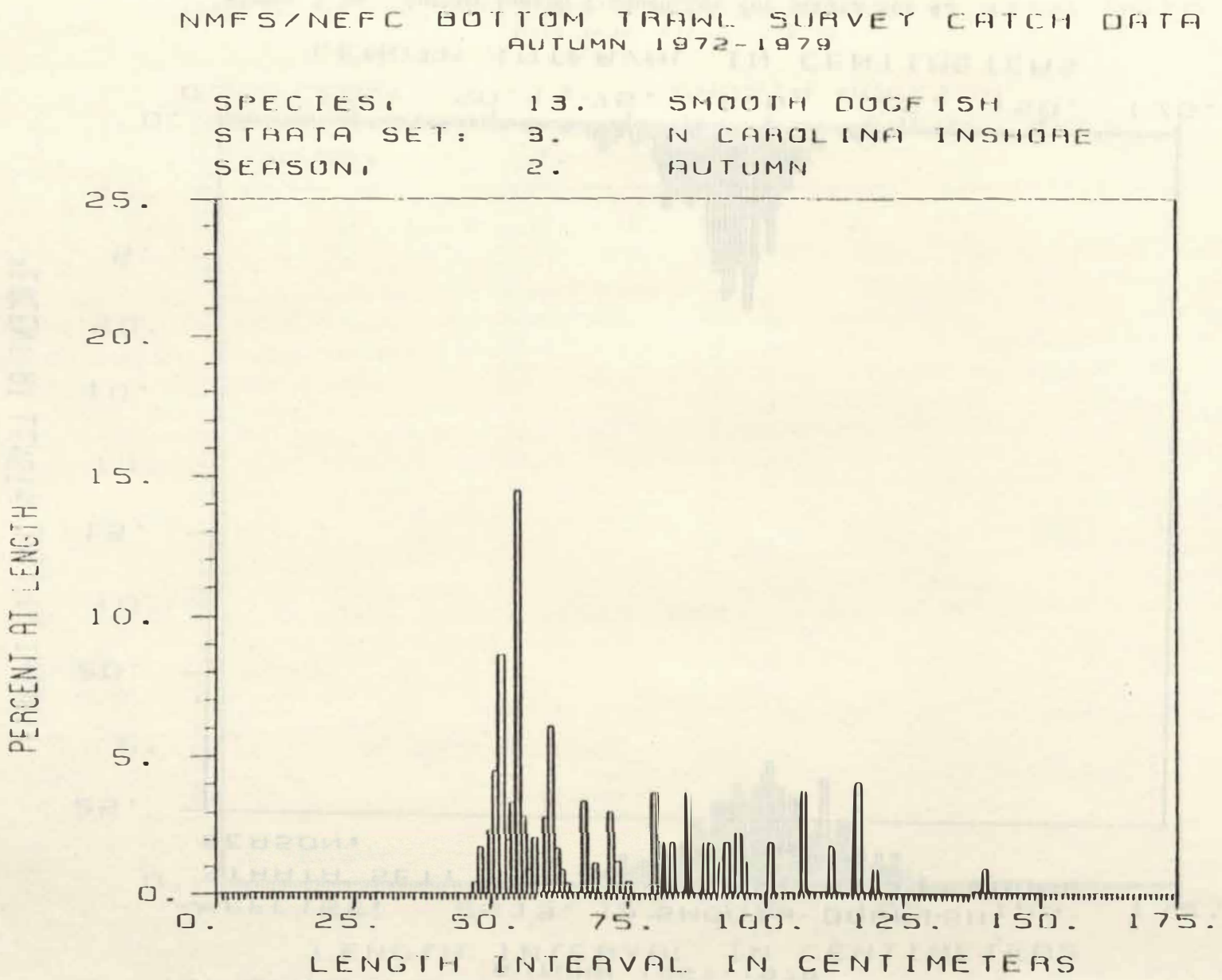


Figure 1.15. Autumn length frequencies for strata set 3.

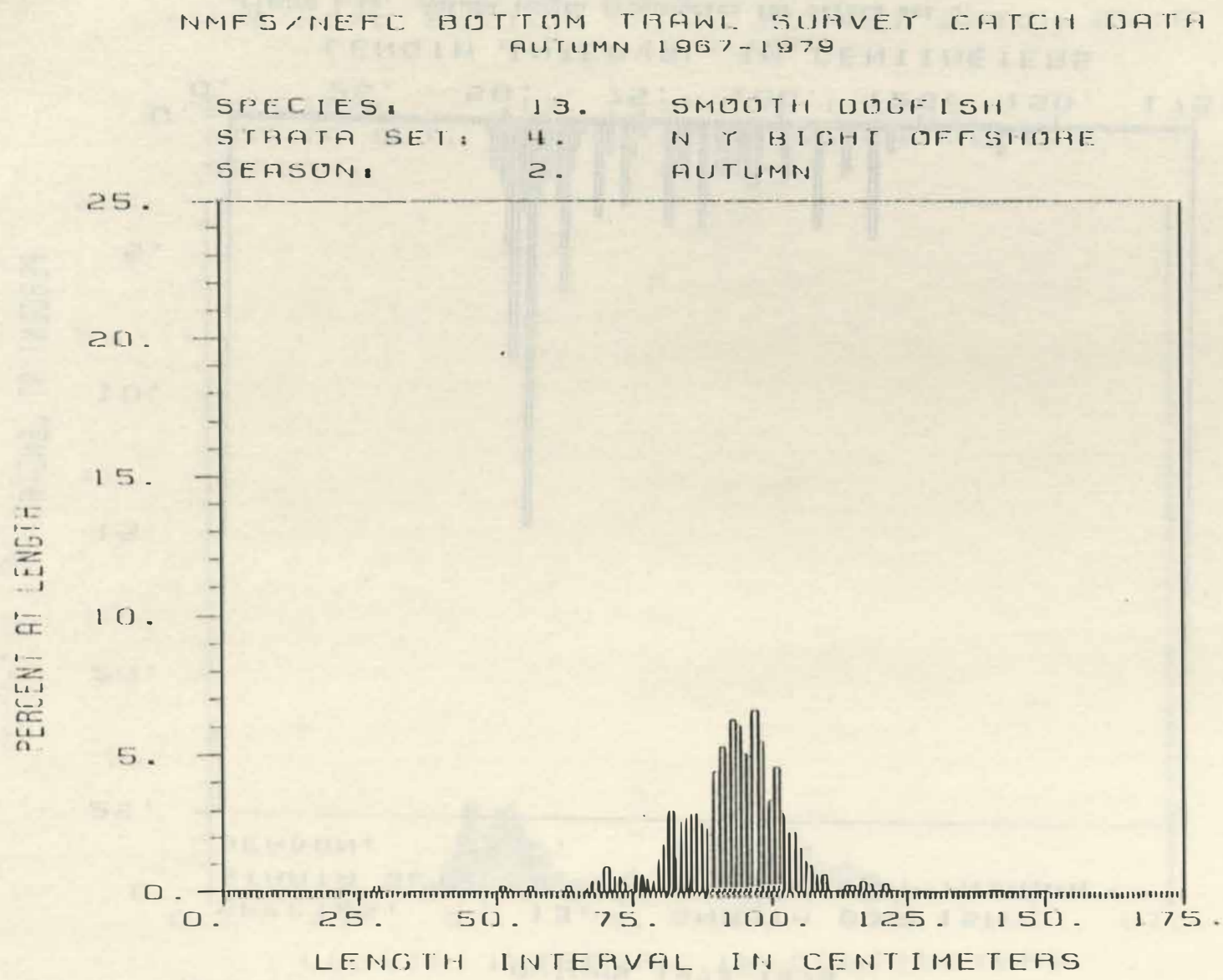


Figure 1.16. Autumn length frequencies for strata set 4.

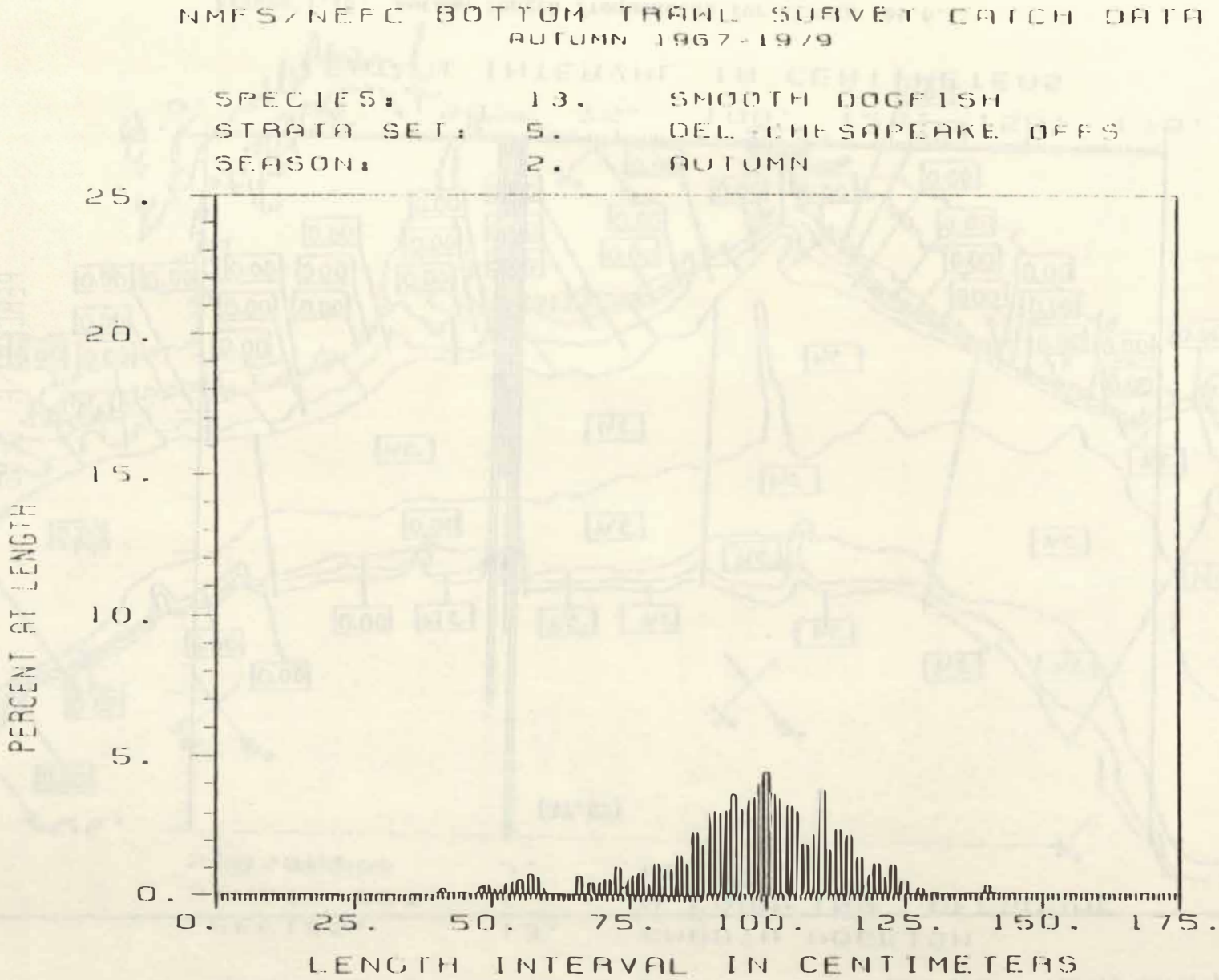


Figure 1.17. Autumn length frequencies for strata set 5.

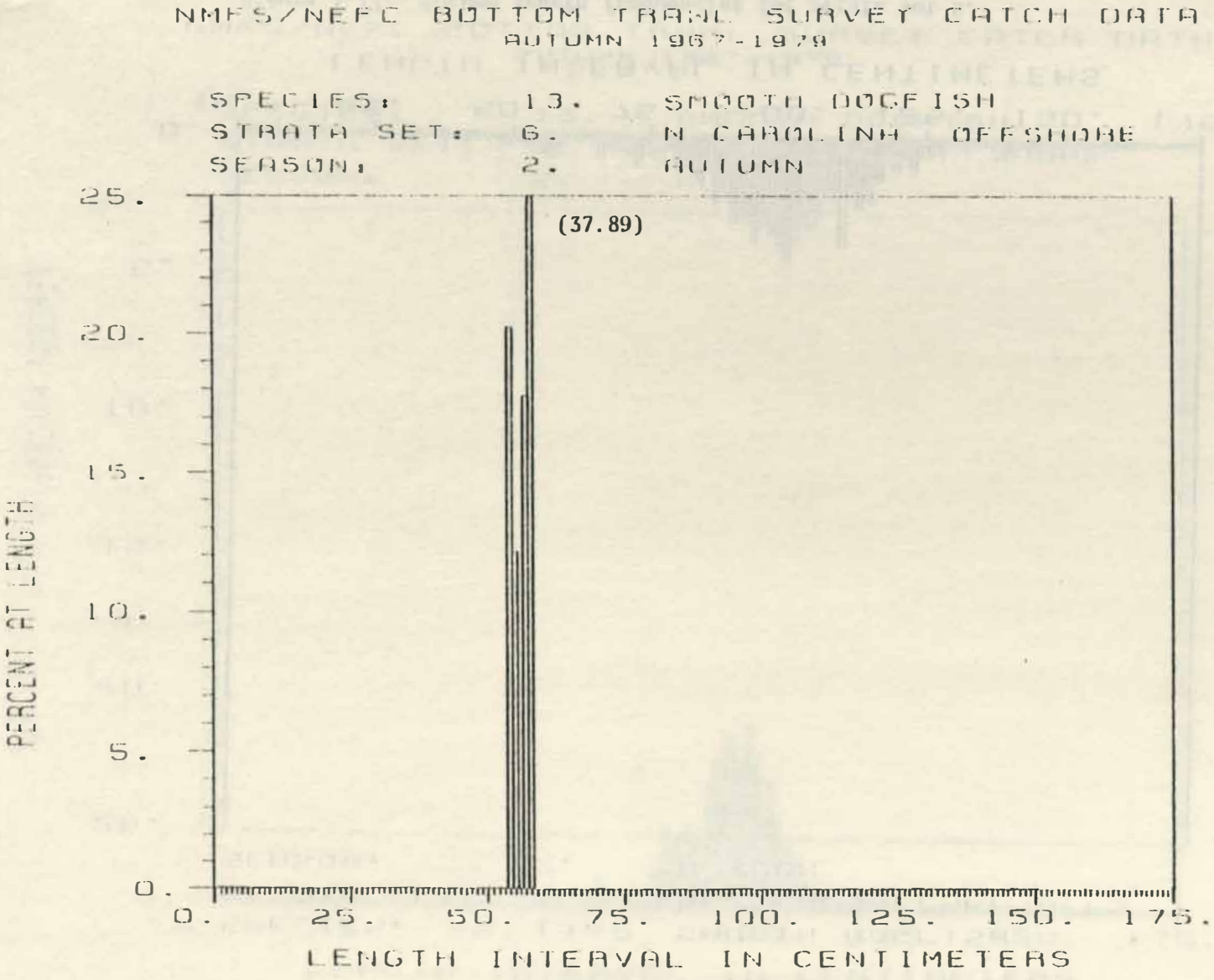


Figure 1.18. Autumn length frequencies for strata set 6.

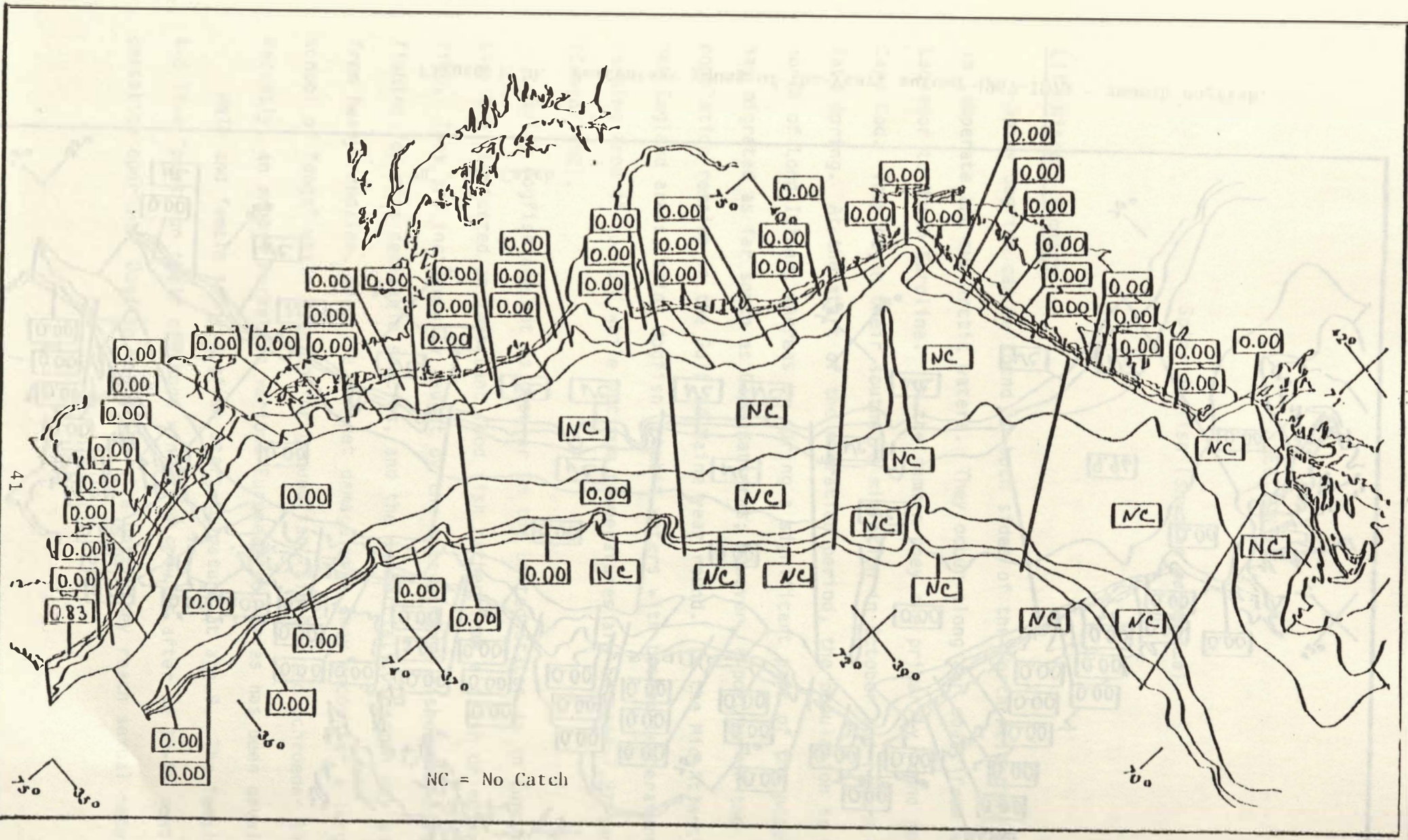


Figure 1.19. Percentage young-of-the-year, spring 1968-1979 - smooth dogfish.

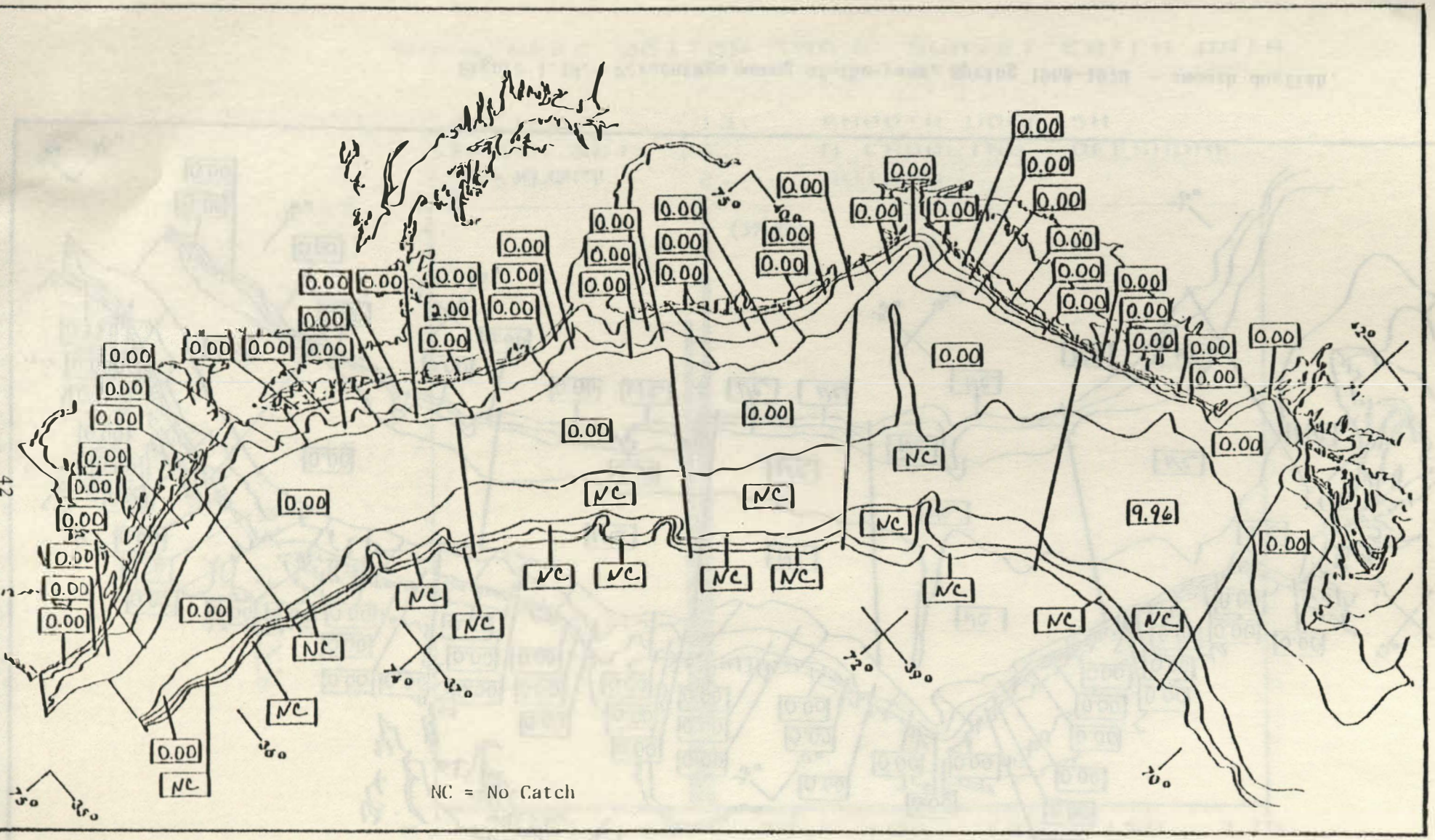


Figure 1.20. Percentage young-of-the-year, autumn 1967-1979 - smooth dogfish.

SECTION 2

Spiny dogfish (*Squalus acanthias*)

Life History Summary

Spiny dogfish can be found on both sides of the North Atlantic, chiefly in temperate and sub-arctic waters. They occur along our coast from southern Labrador to North Carolina. In the summer they are primarily found north of Cape Cod. They begin their southward migration in October and return north in late spring. At the start of the migration period, the population is centered north of Long Island, whereas by spring a significant part of the population has migrated as far south as Cape Hatteras; however, a portion of the population remains in the Gulf of Maine year round. In the Mid-Atlantic and New England areas, spiny dogfish inhabit waters with bottom temperatures ranging from 4° to 18°C while optimum temperatures are between 7.2° and 12.8°C (Cohen 1982).

Spiny dogfish are not as popular in the United States as in Europe, where they are considered an important food fish rather than a trash or nuisance fish. They are incidentally caught by the recreational fishermen while fishing for more desirable species, and the commercial fishermen may suffer from heavy handline, longline, or net damage when they encounter a large school of "dogs" while fishing for groundfish (Bigelow and Schroeder 1953). Recently, an export market to various European countries has been developed.

Male and female spiny dogfish start to mature at age 9. The females bear 4-6 live "pups" on their offshore wintering grounds after an 18-22 month gestation operiod. Dogfish school by size until they reach sexual maturity;

then they school by sex (Cohen 1982).

Spiny dogfish are well known for their voracious appetites, and will eat anything smaller than themselves, including fish, crabs, squids, worms and ctenophores (Bigelow and Schroeder 1953). They have few natural enemies, although large sharks occasionally prey on them (Cohen 1982).

The total biomass of dogfish in the New England area has been estimated to range between 150,000 and 225,000 metric tons (Cohen 1982). However, a sustained and extensive fishery would quickly deplete the resource because the spiny dogfish produces few young over a long period of time.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 2.1 and 2.2. These plots represent what is known of seasonal spiny dogfish distribution in the Middle Atlantic Bight. The spring distribution shows larger catches generally occurring offshore. The inshore concentration indicated by Figure 2.1 is partially an artifact of the different timing of the two spring cruises as discussed in the section on methods. Figure 2.3 attempts to correct this artifact by deleting all cruises prior to 1976, and is considered a more representative pattern of the spring distribution, with the dogfish inshore south of Delaware Bay but not yet as far north as coastal New Jersey or New York. The autumn distribution (Figure 2.2) indicates a southerly movement from northern summer grounds.

Graphs of mean weight and number per tow are shown in Figures 2.4-2.7. In the spring, catches are consistently larger in the offshore strata sets

(Figures 2.4 and 2.6). In the autumn, catches are higher in the northern inshore and offshore strata sets.

Length frequencies for six strata sets, arranged by season, are shown in Figures 2.8-2.19. These data show that young spiny dogfish (<32 cm) rarely occur in the inshore areas (Figures 2.8-2.10) as "pupping" (the term used when sharks give birth) is exclusively an offshore event. During the autumn, especially in the middle of the study area (Delaware-Chesapeake strata set), the offshore catch is still almost exclusively young fish (Figure 2.18), with only older larger fish inshore (Figure 2.15).

Figures 2.20 and 2.21 show the percentage occurrence by stratum of young-of-the-year (YOY), which were defined as fish under the 32 cm cutoff size. YOY virtually never move inshore. During the autumn, some of the strata in the mid- and southern areas again show a distinct distribution by size (Figure 2.21).

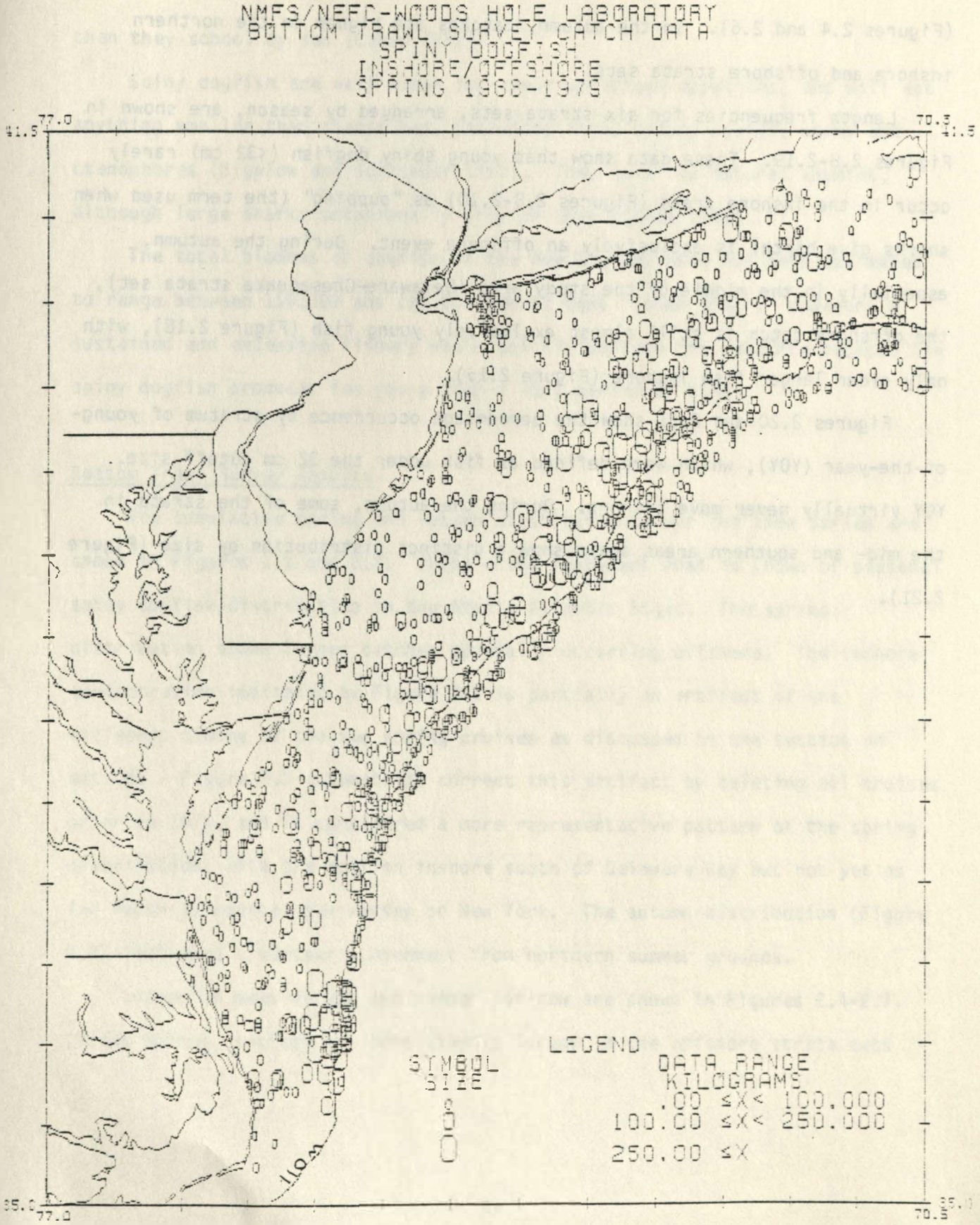


Figure 2.1. Spring distribution, 1968-1979.

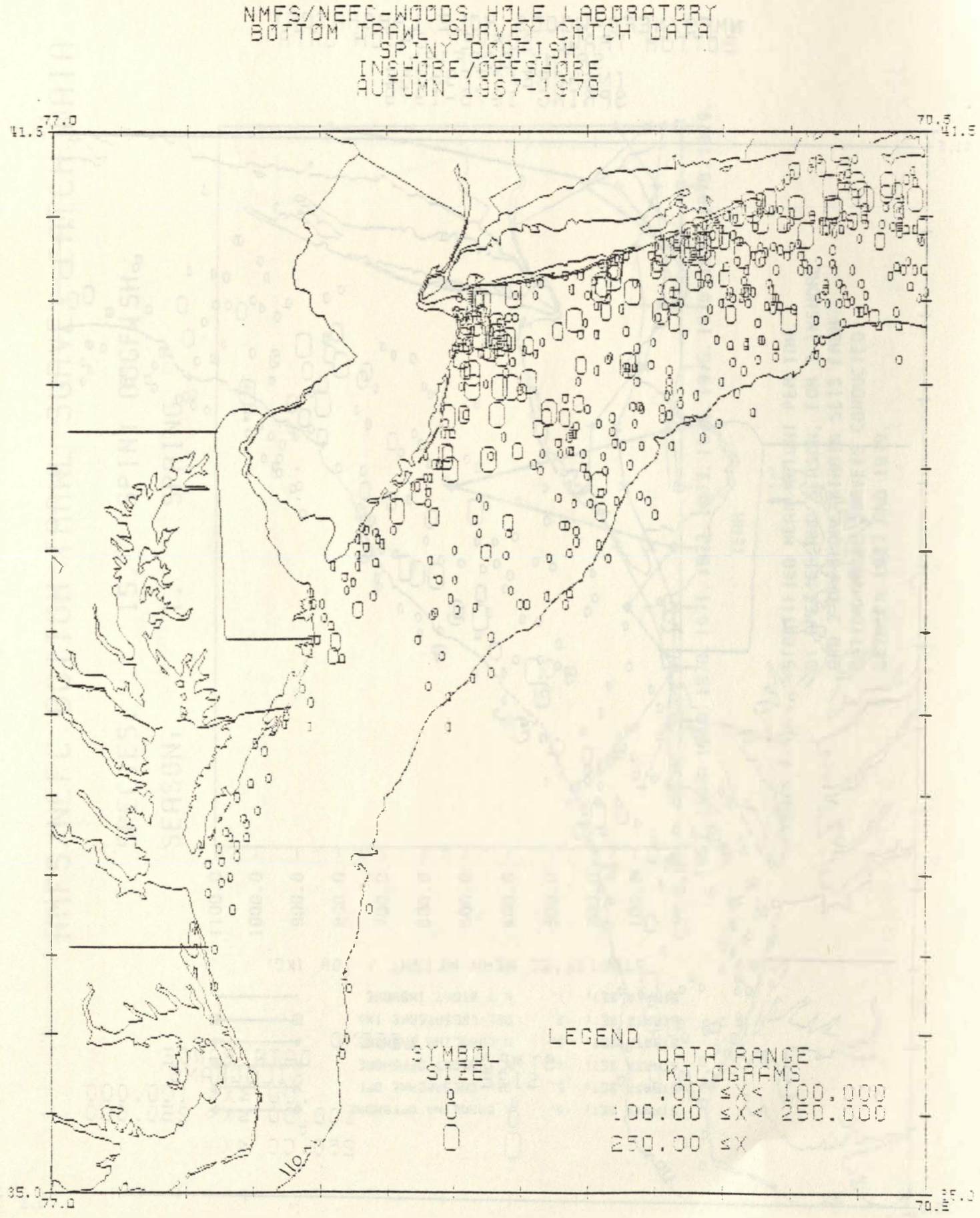


Figure 2.2. Autumn distribution, 1967-1979.

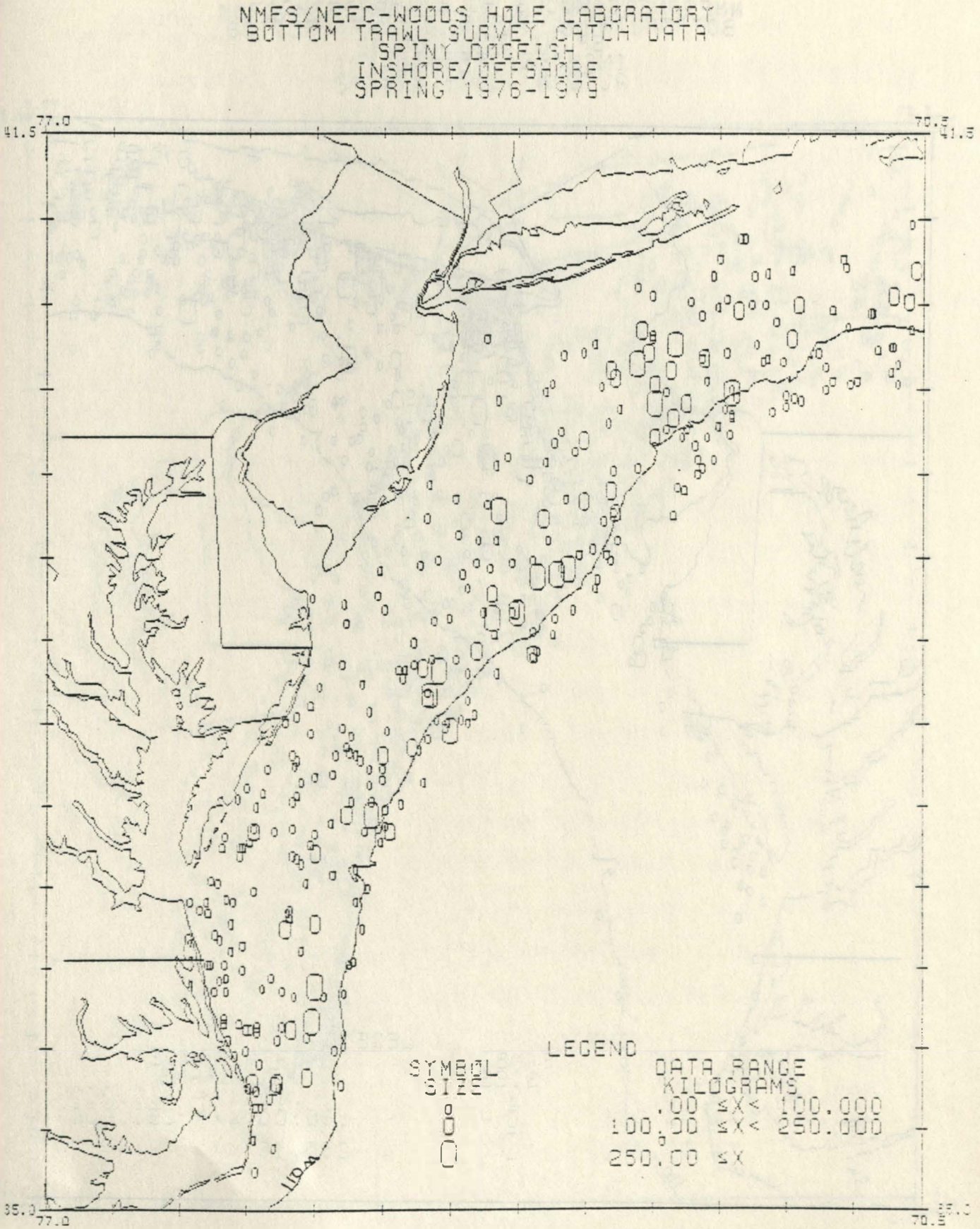


Figure 2.3. Spring distribution, 1976-1979.

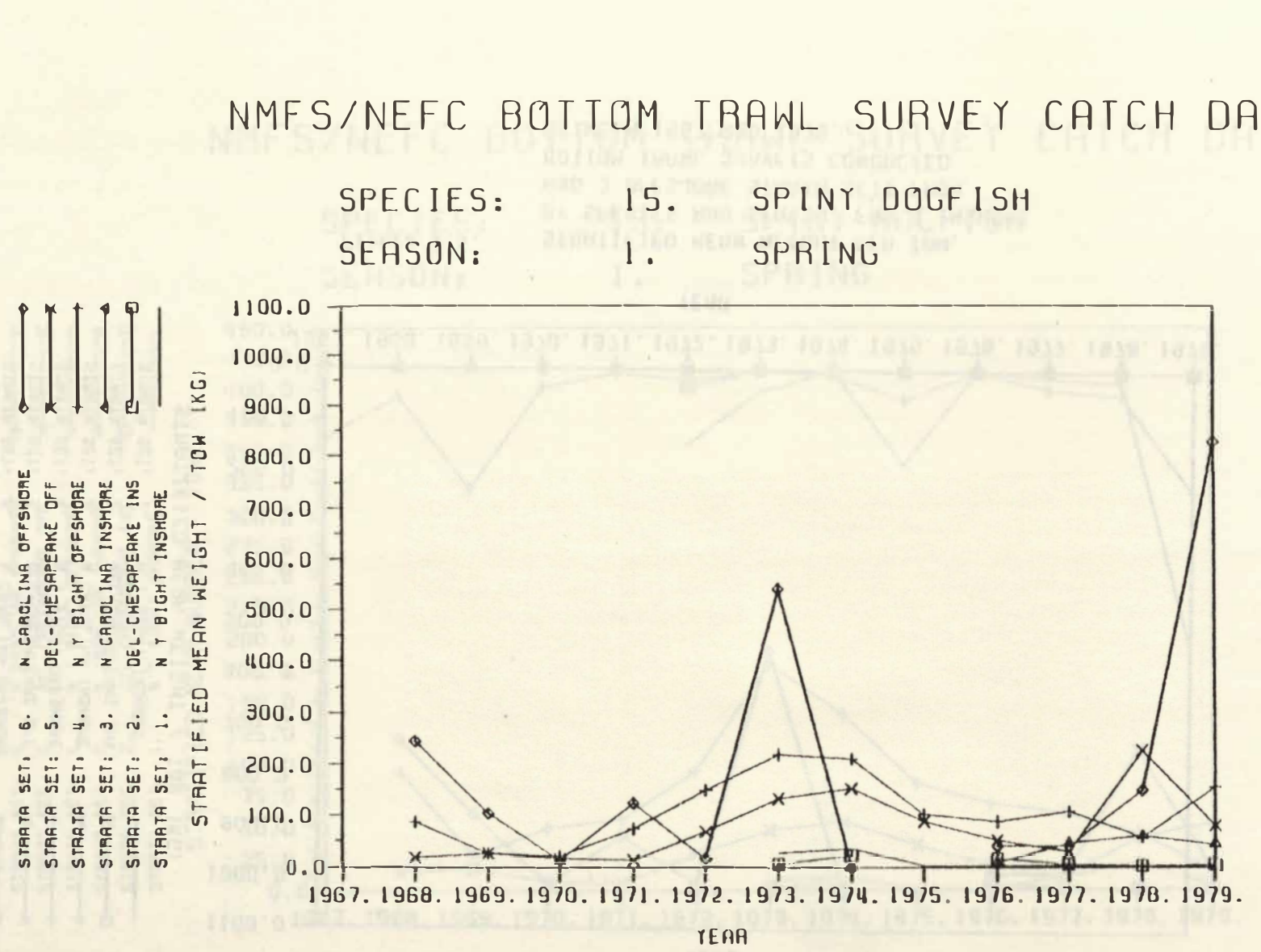


Figure 2.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 15. SPINY DOGFISH

SEASON: 2. FALL

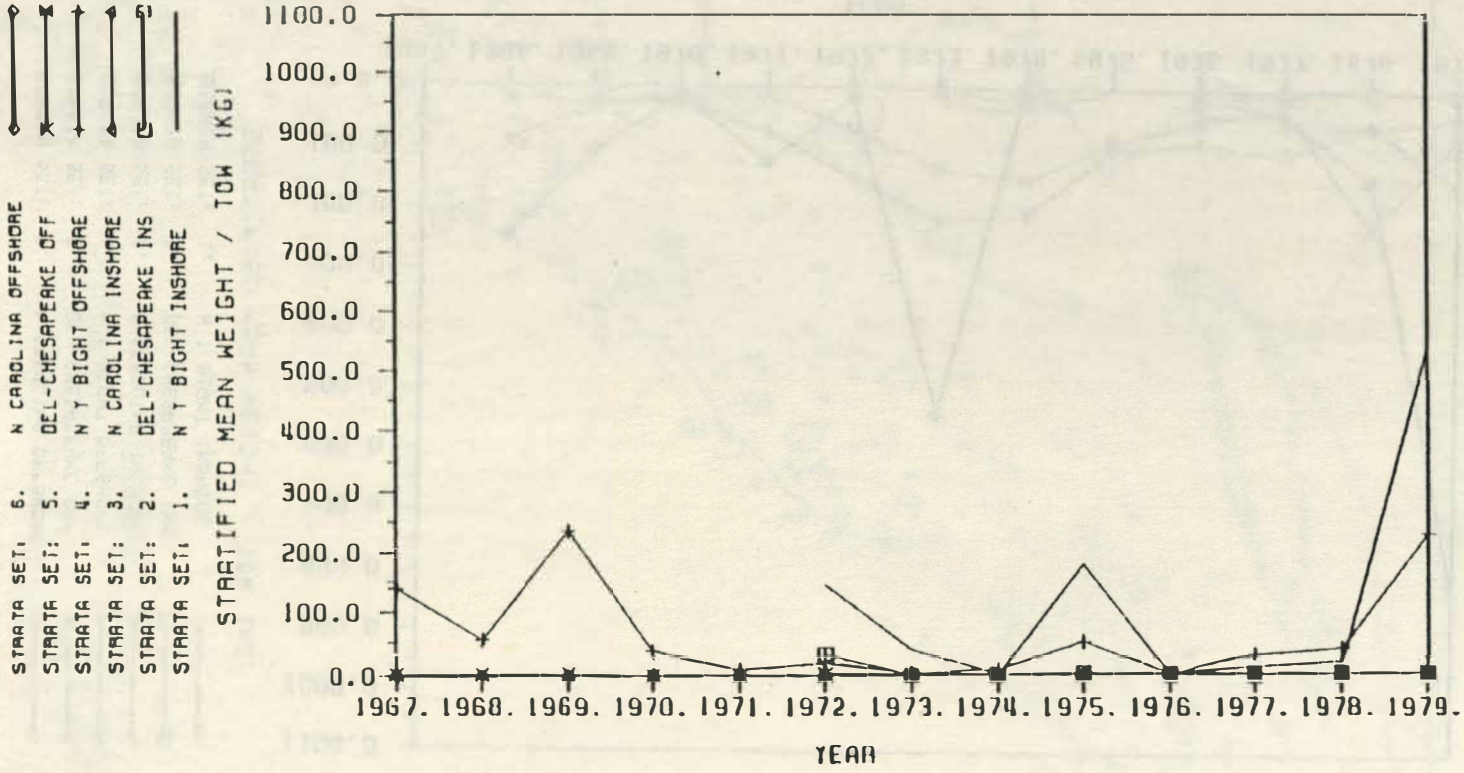


Figure 2.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

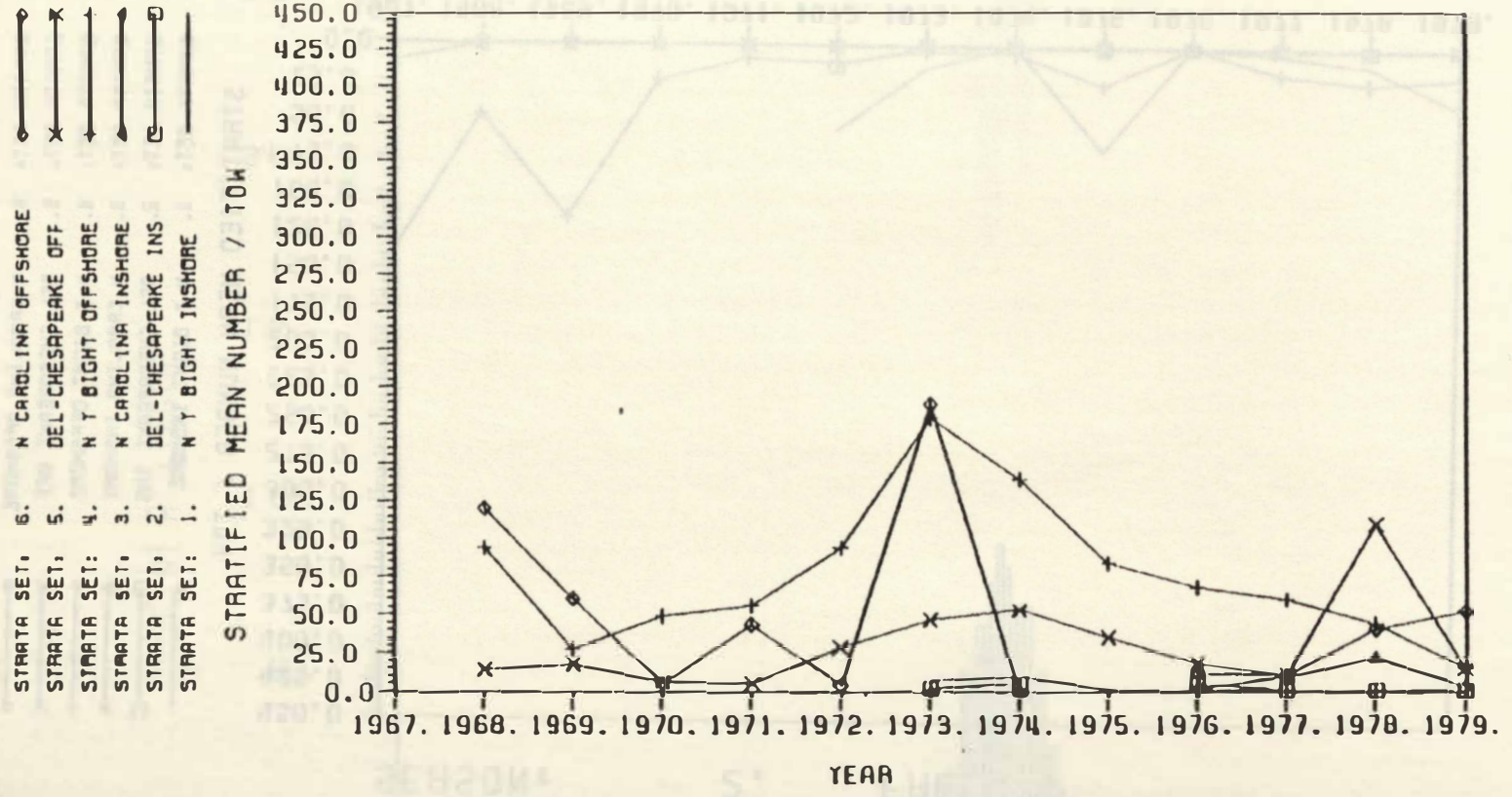


Figure 2.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 15. SPINY DOGFISH

SEASON: 2. FALL

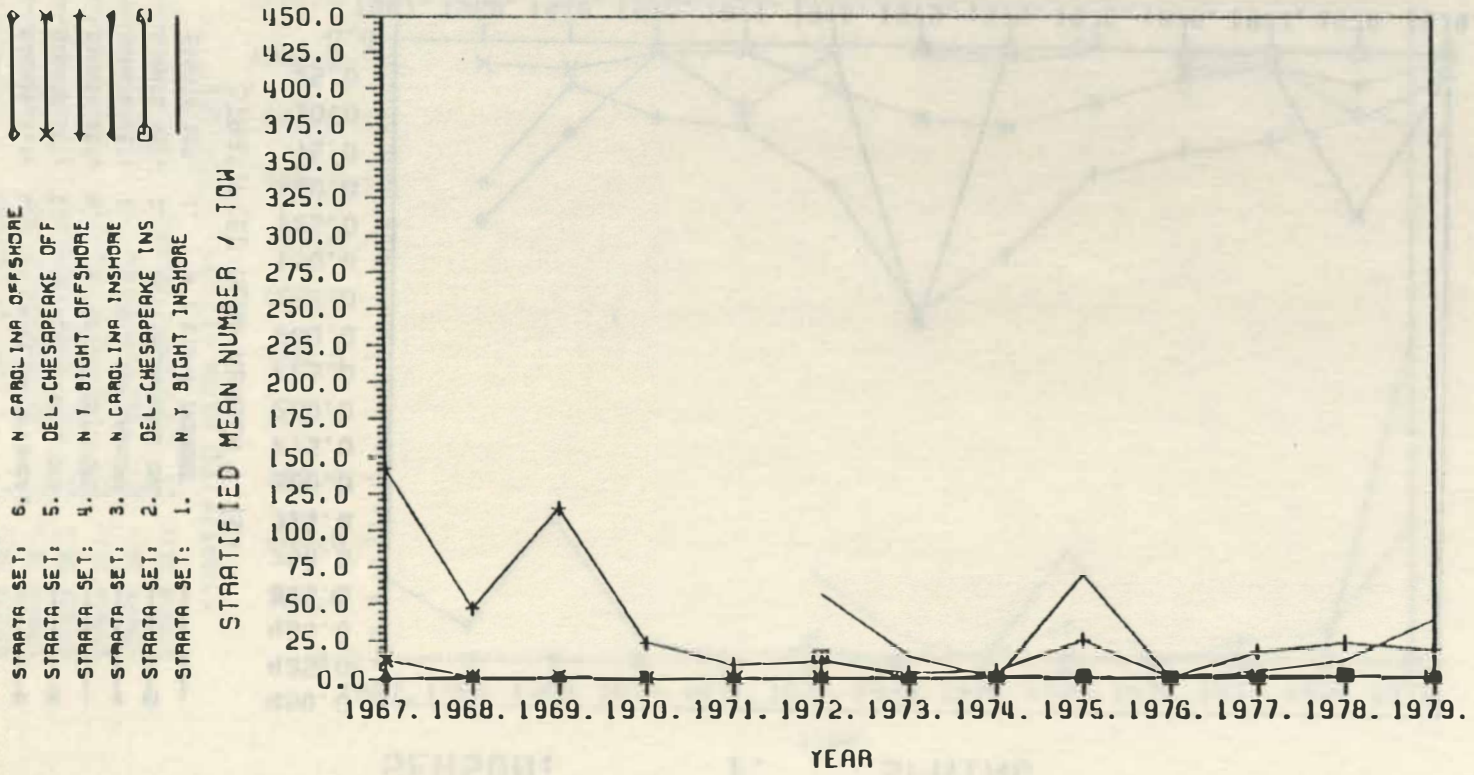


Figure 2.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

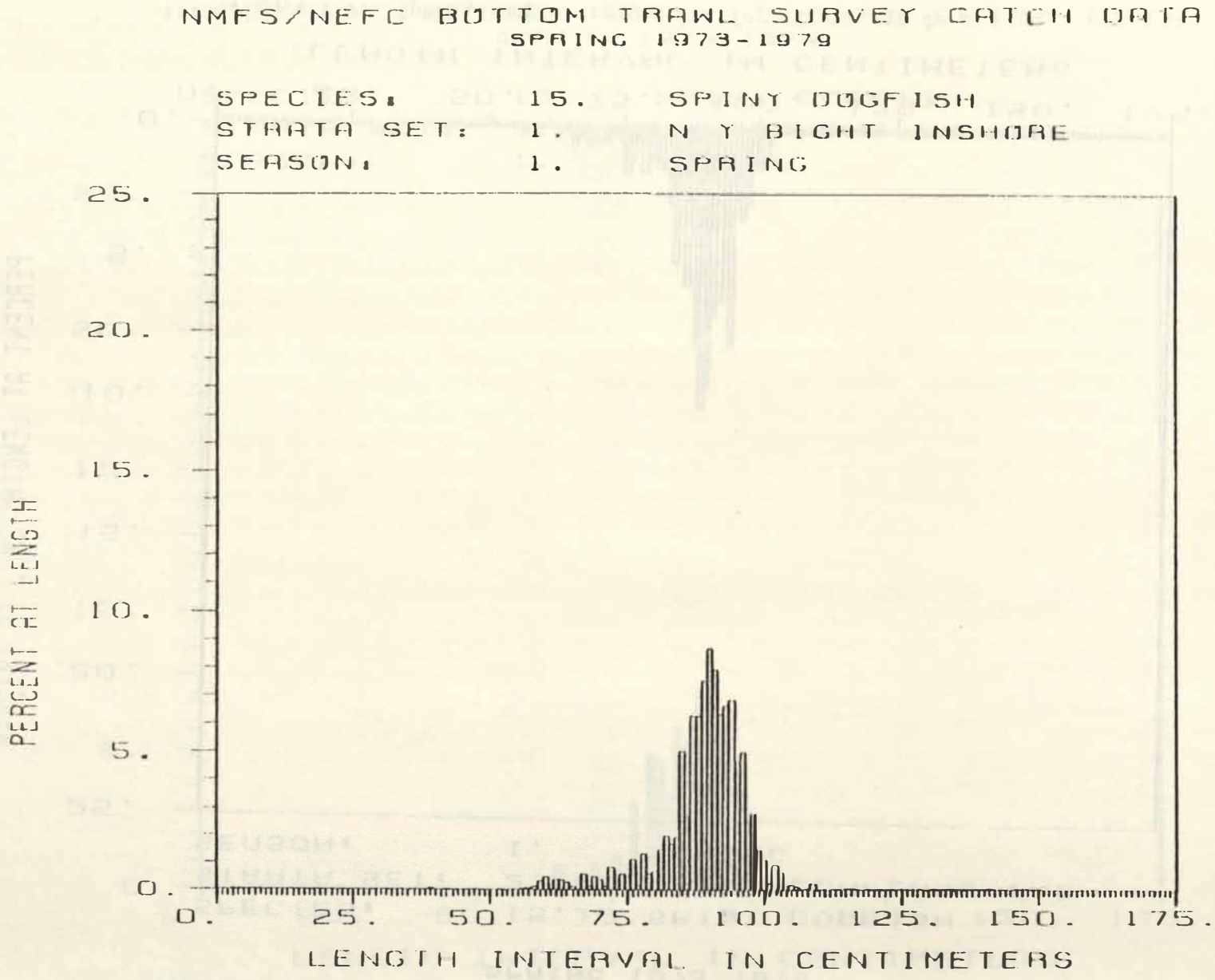


Figure 2.8. Spring length frequencies for strata set 1.

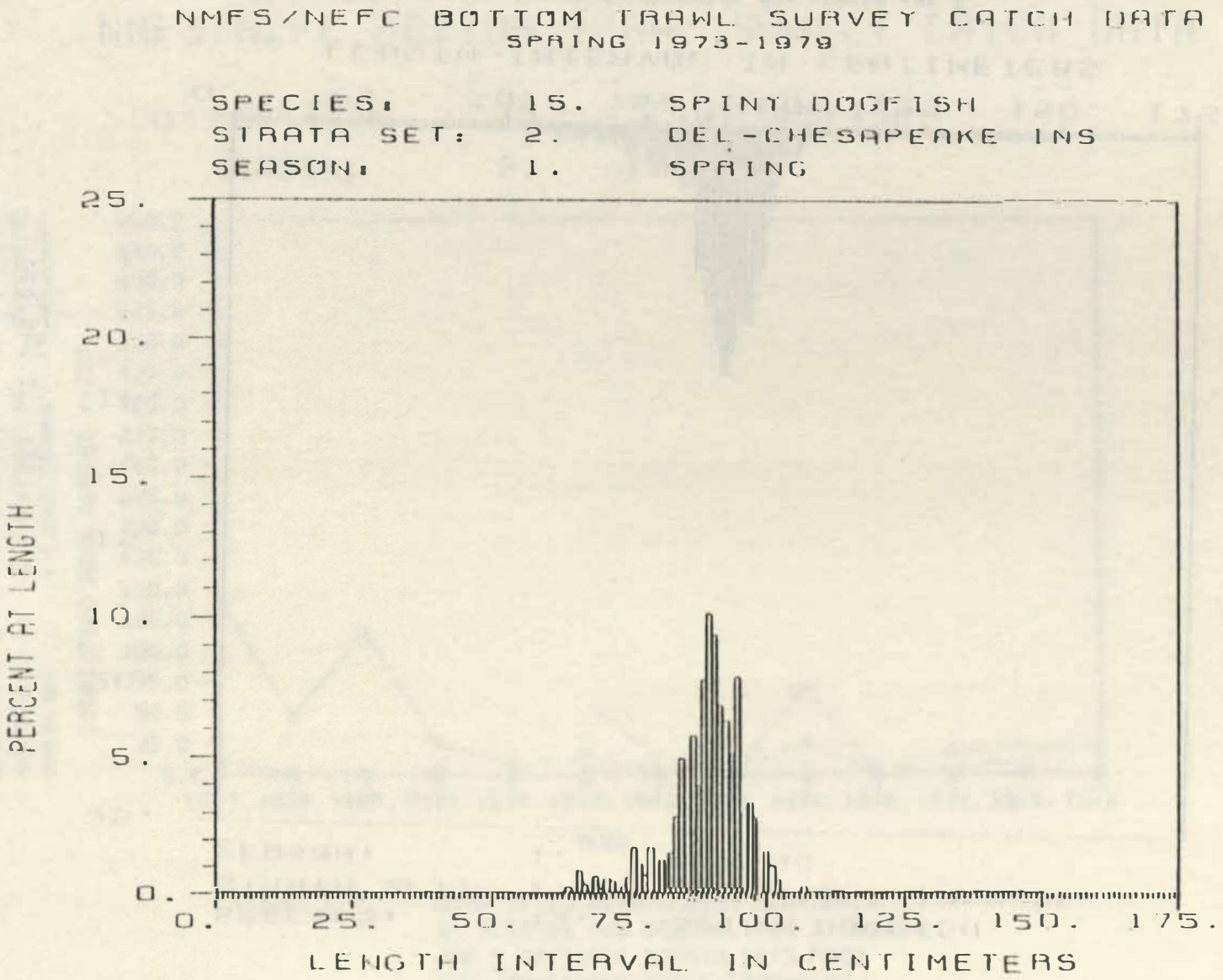


Figure 2.9. Spring length frequencies for strata set 2.

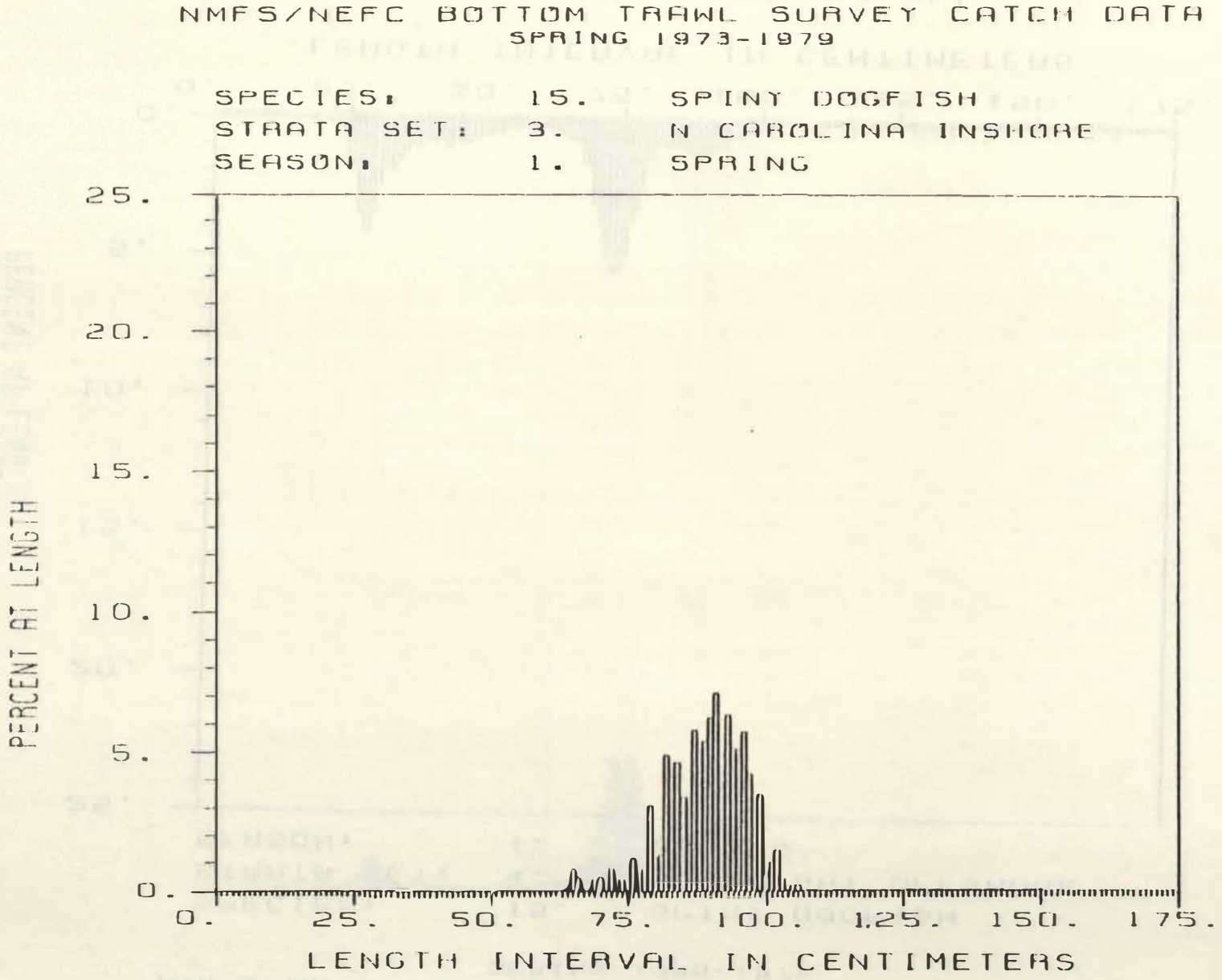


Figure 2.10. Spring length frequencies for strata set 3.

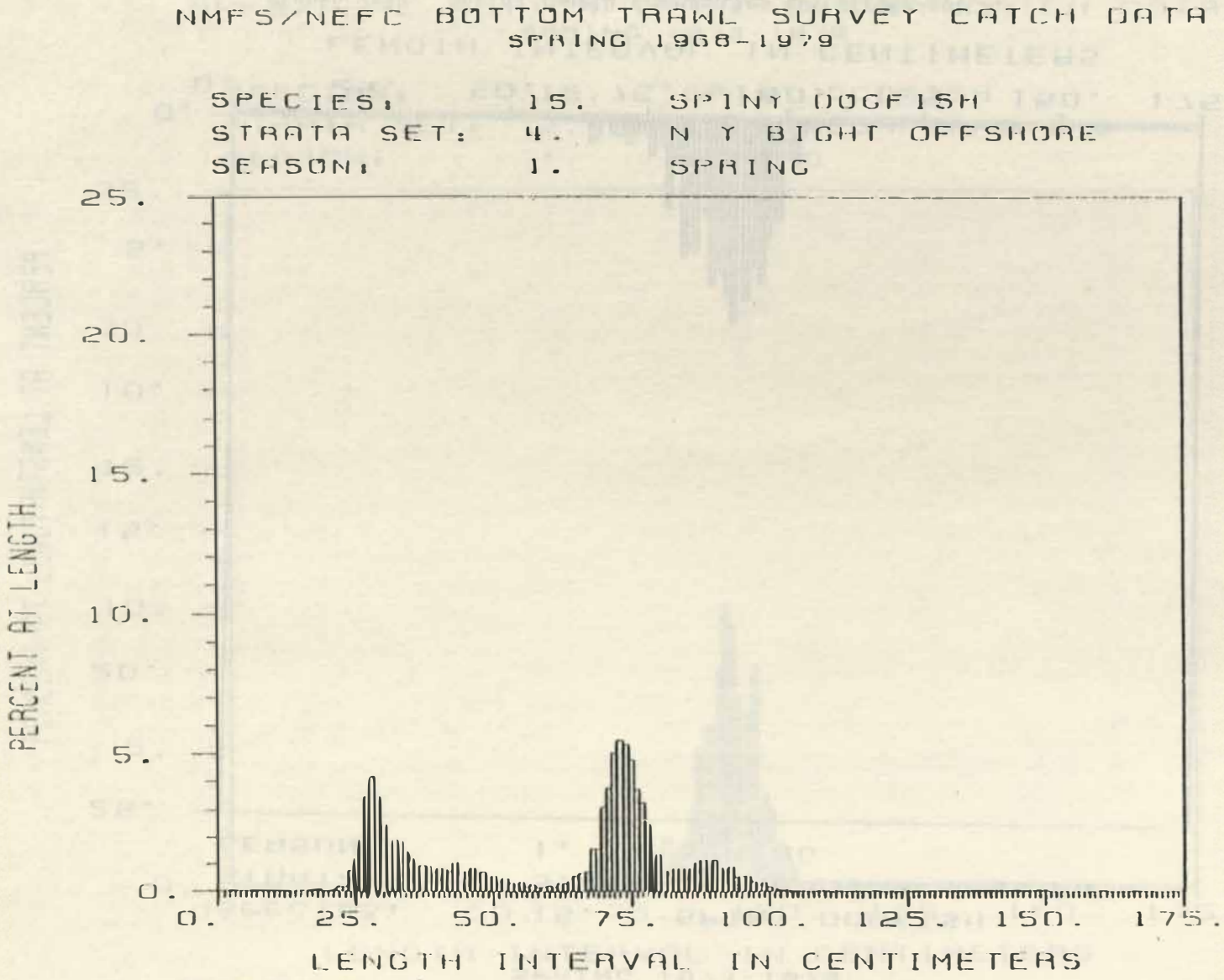


Figure 2.11. Spring length frequencies for strata set 4.

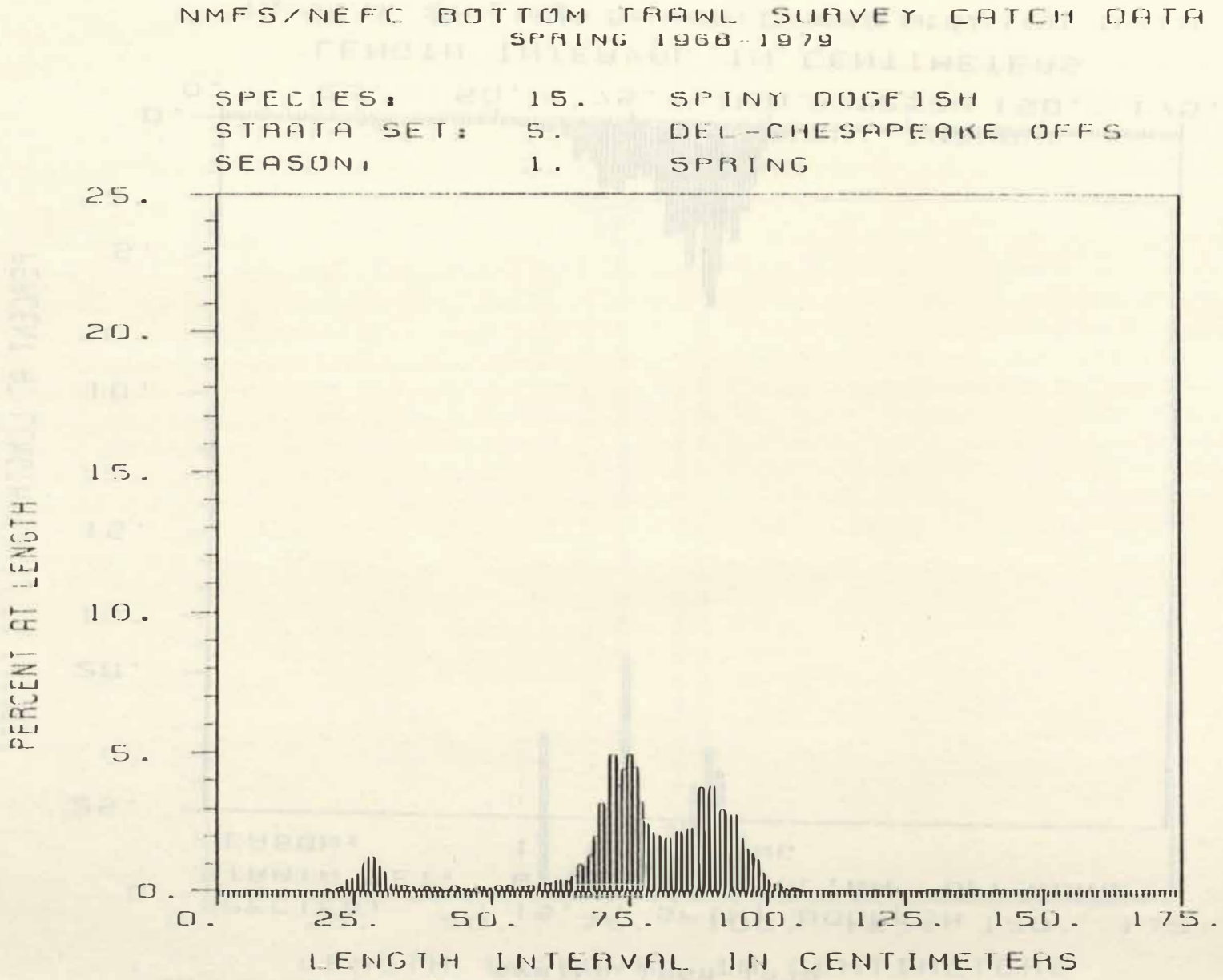


Figure 2.12. Spring length frequencies for strata set 5.

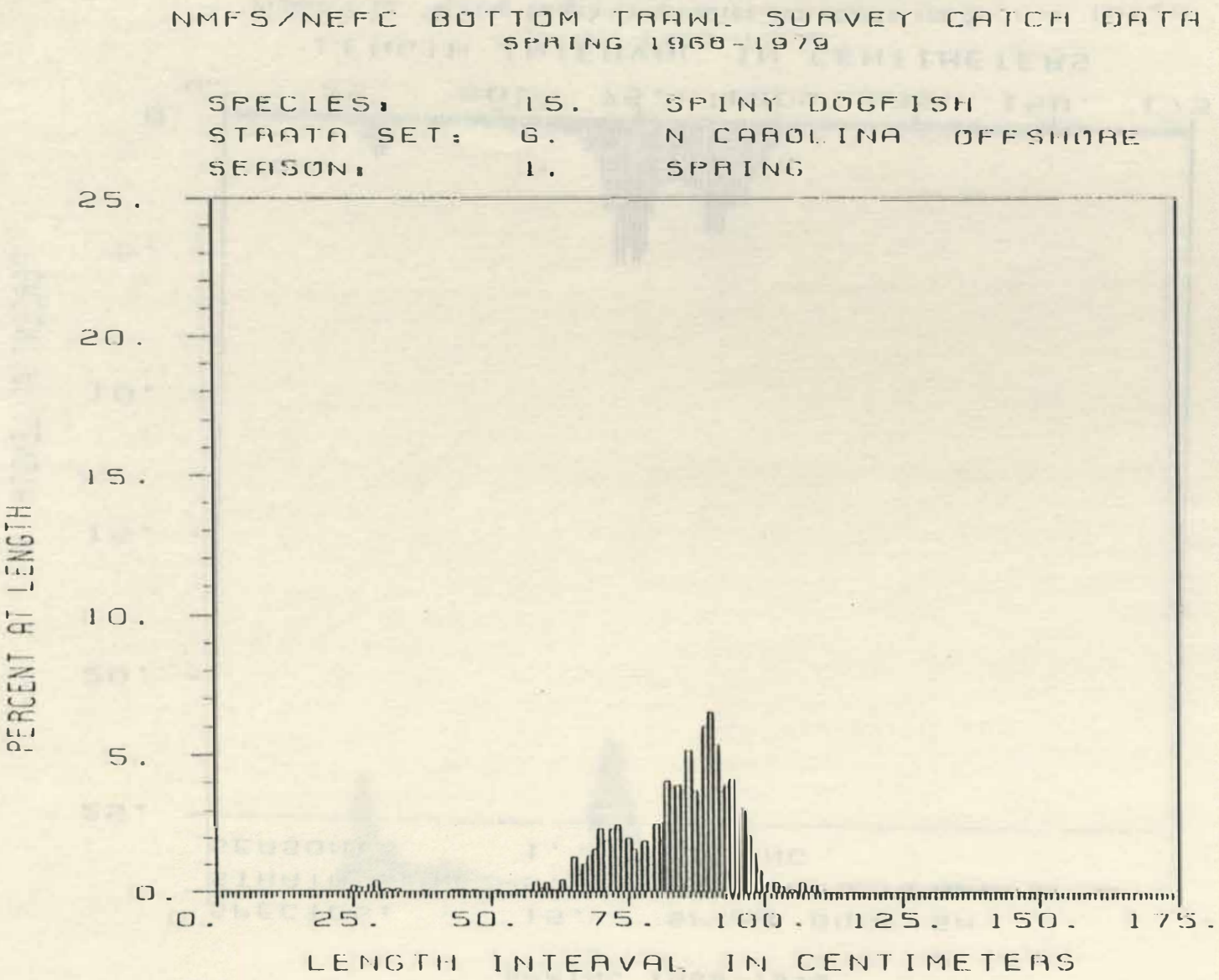


Figure 2.13. Spring length frequencies for strata set 6.

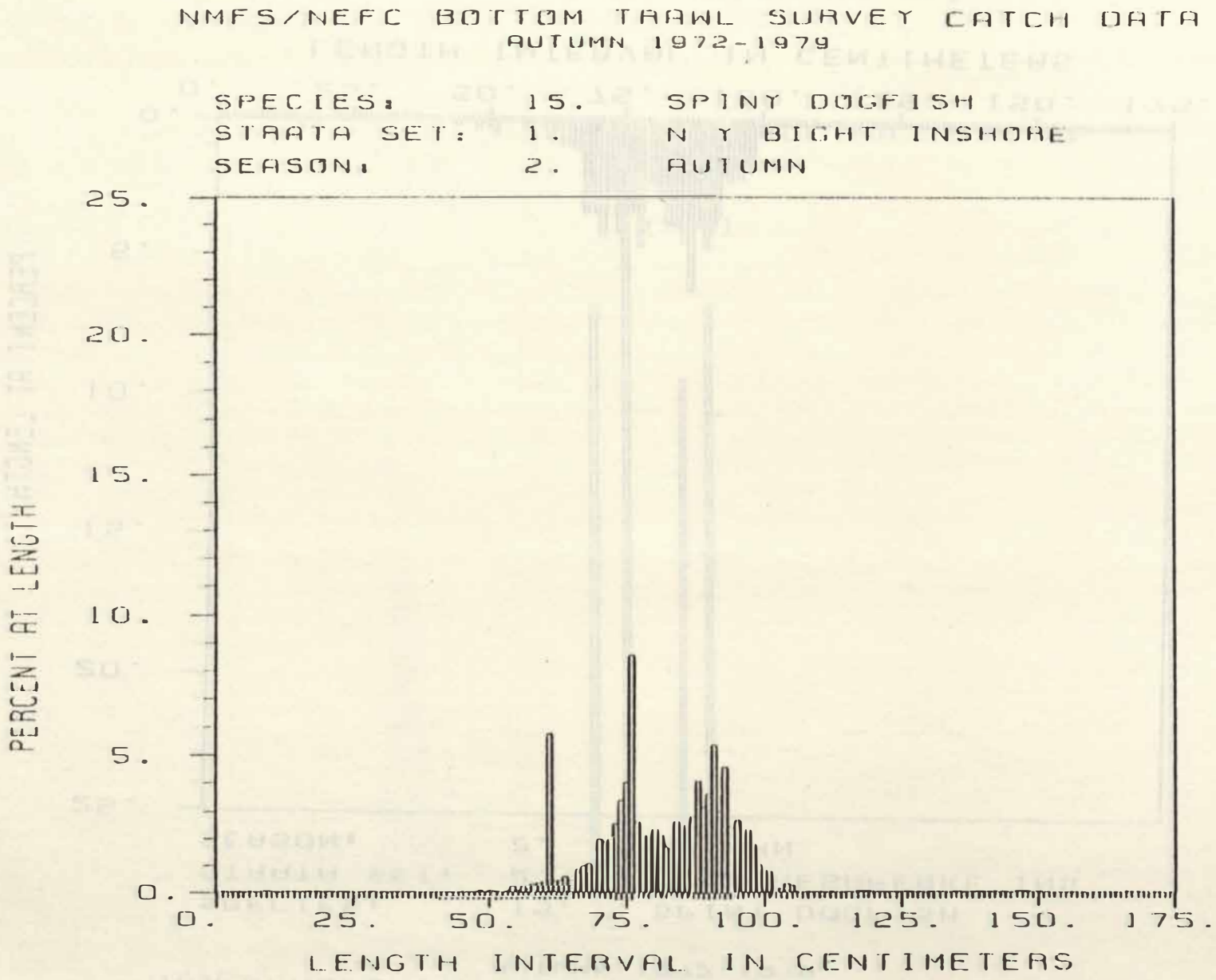


Figure 2.14. Autumn length frequencies for strata set 1.

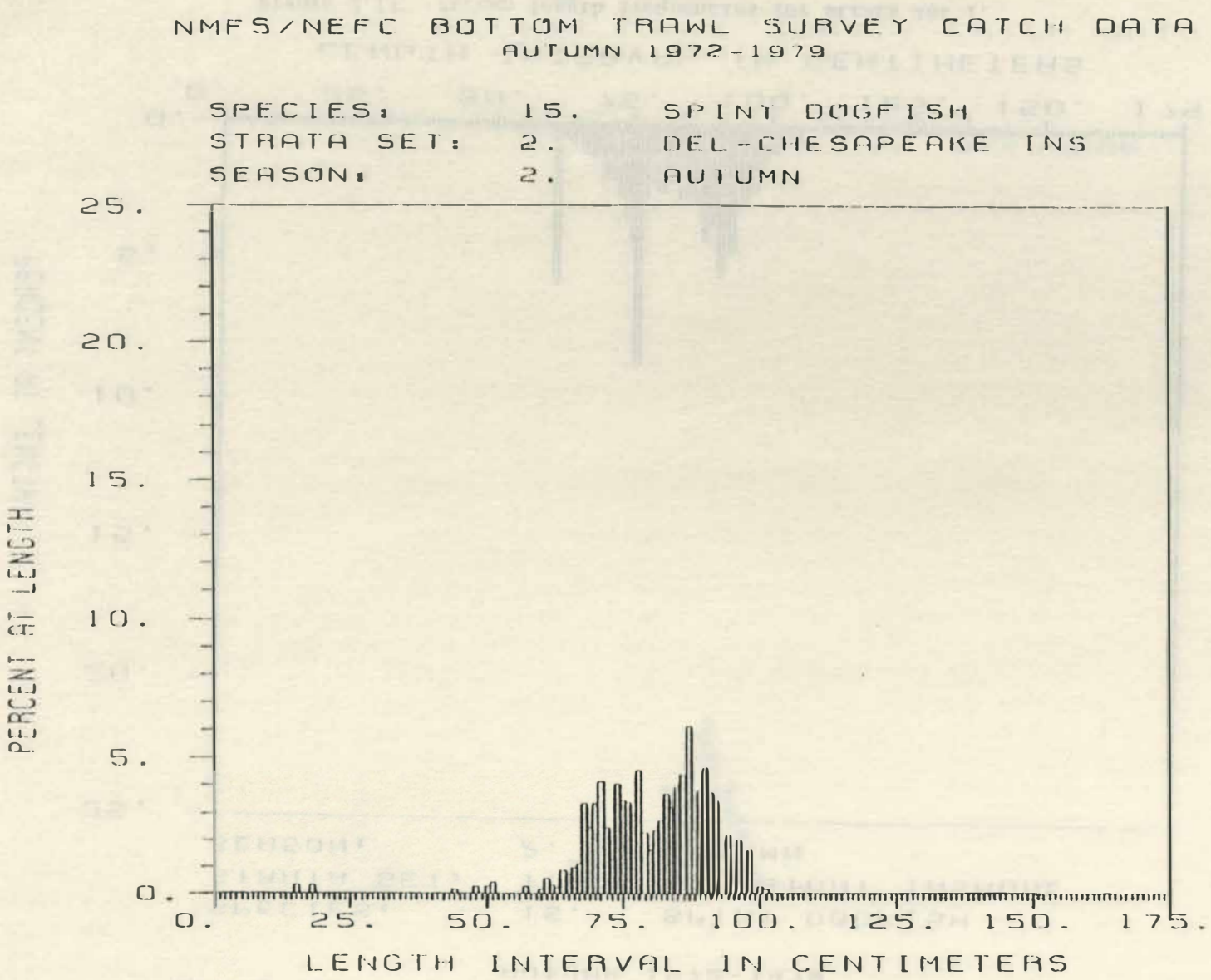


Figure 2.15. Autumn length frequencies for strata set 2.

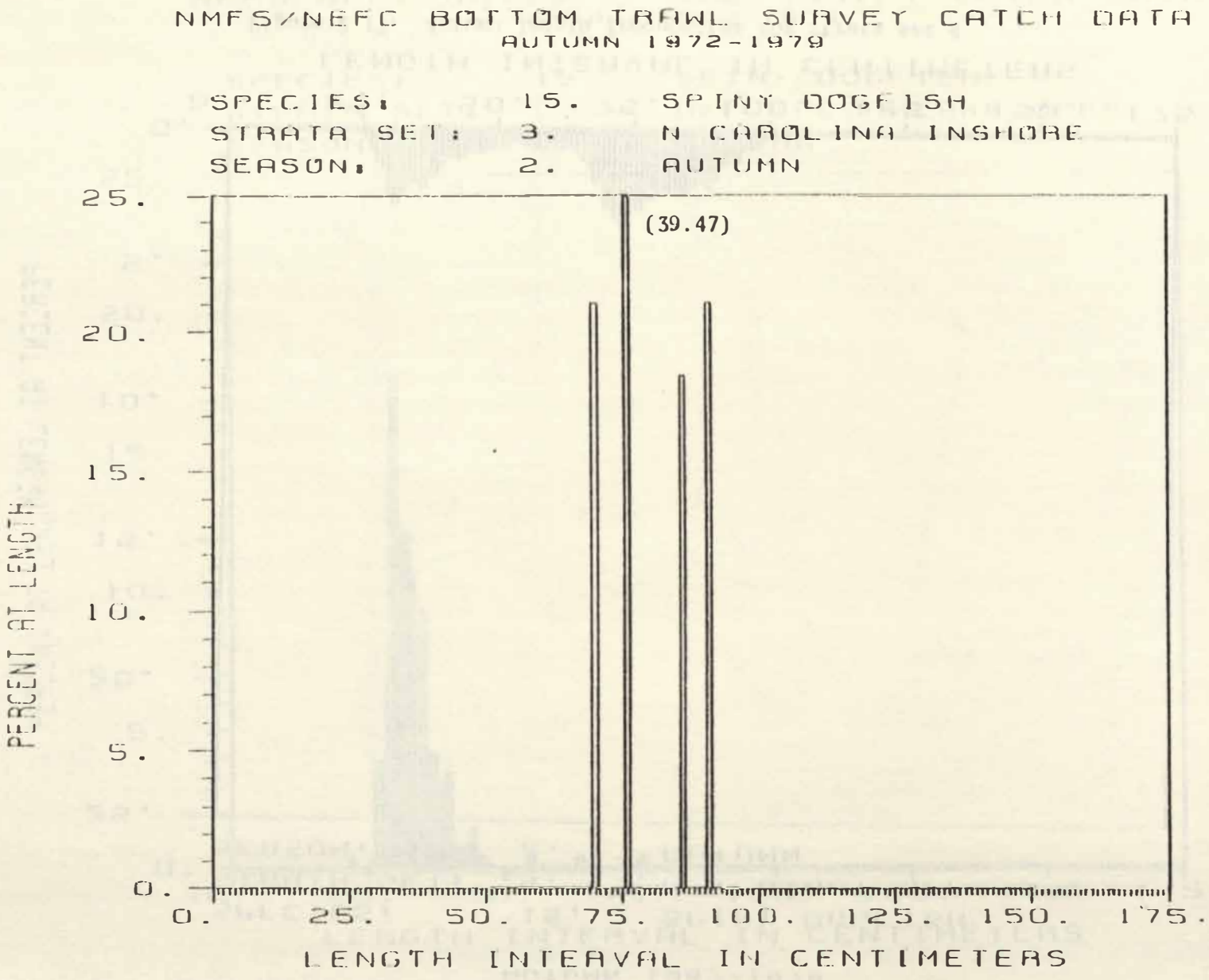


Figure 2.16. Autumn length frequencies for strata set 3.

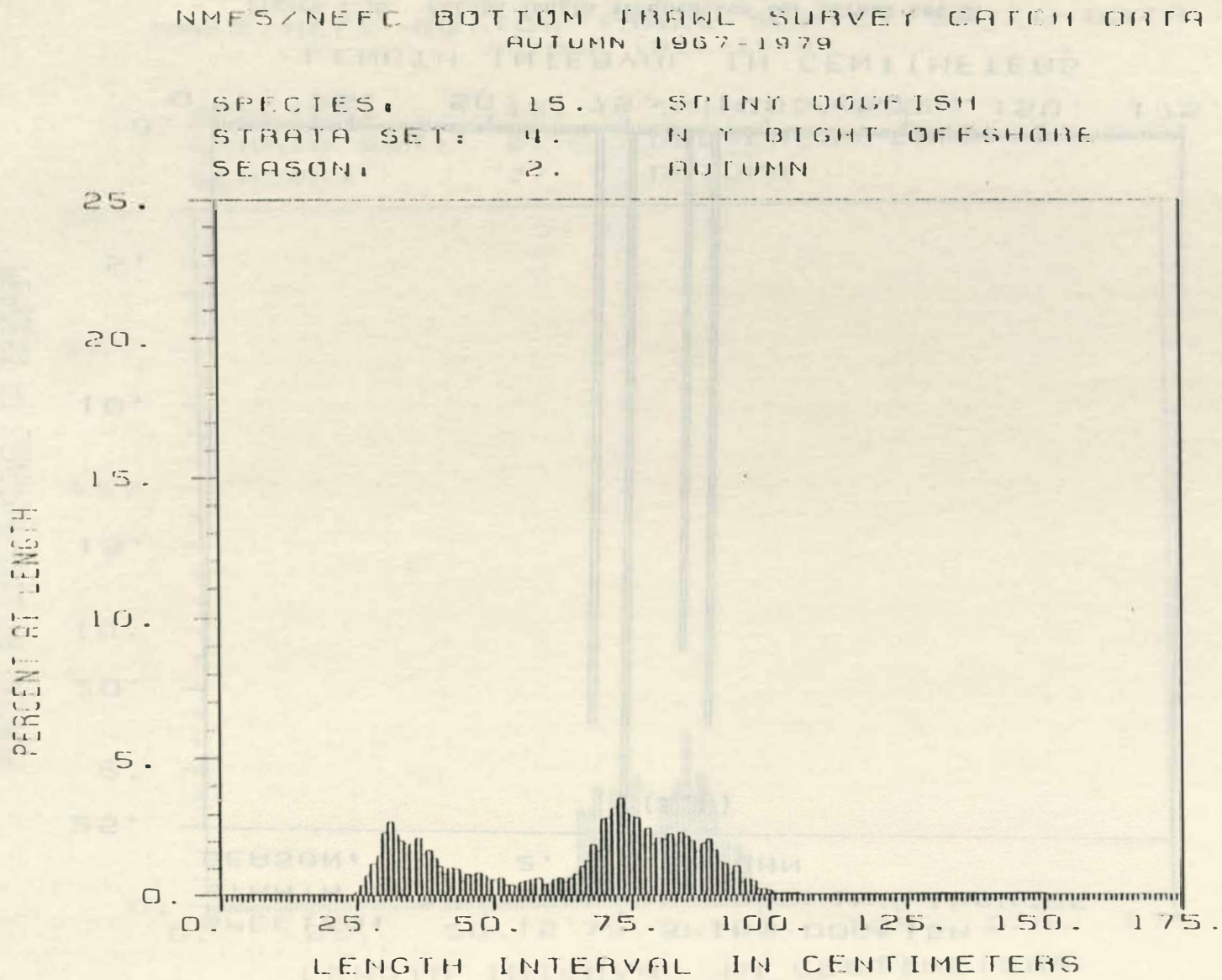


Figure 2.17. Autumn length frequencies for strata set 4.

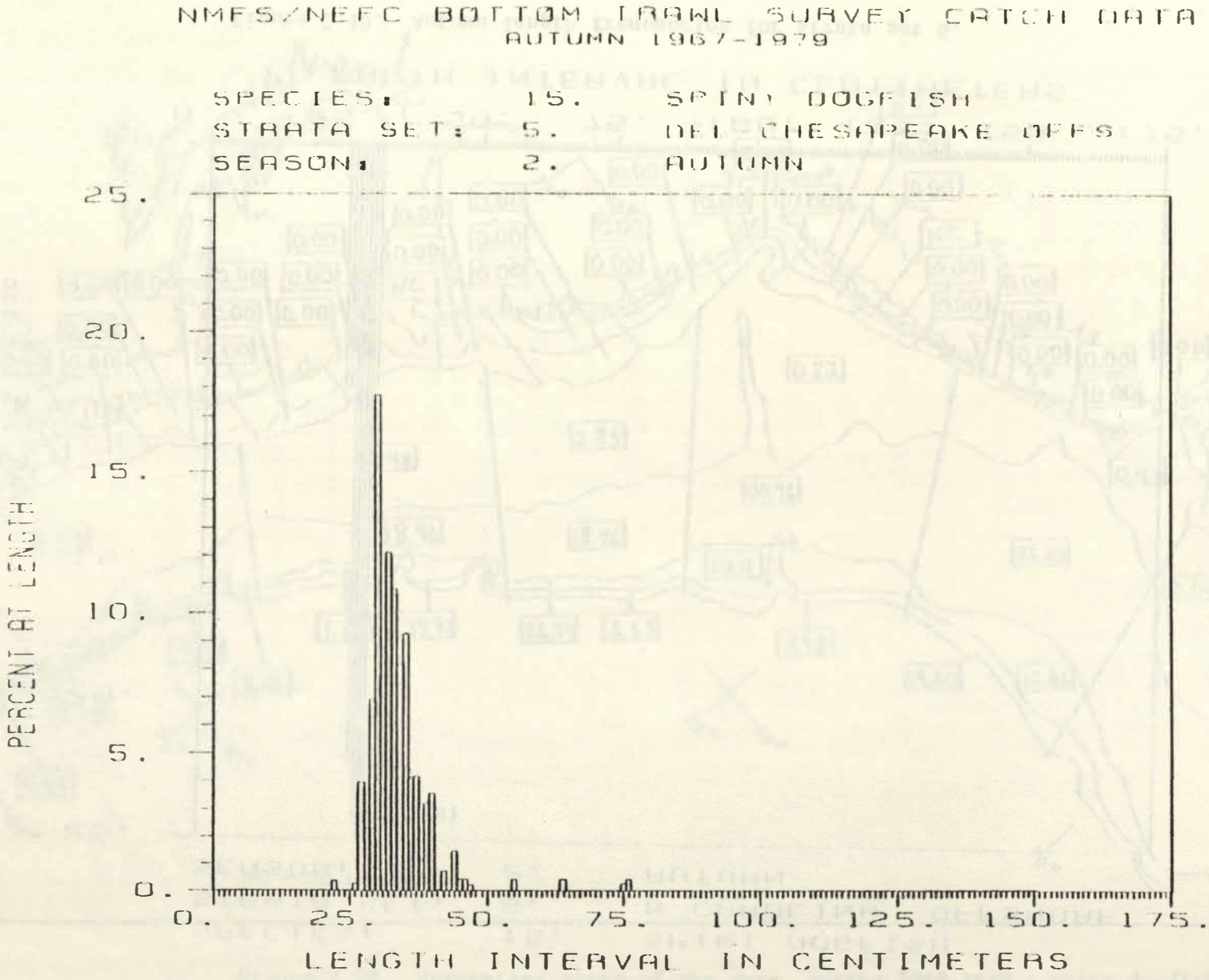


Figure 2.18. Autumn length frequencies for strata set 5.

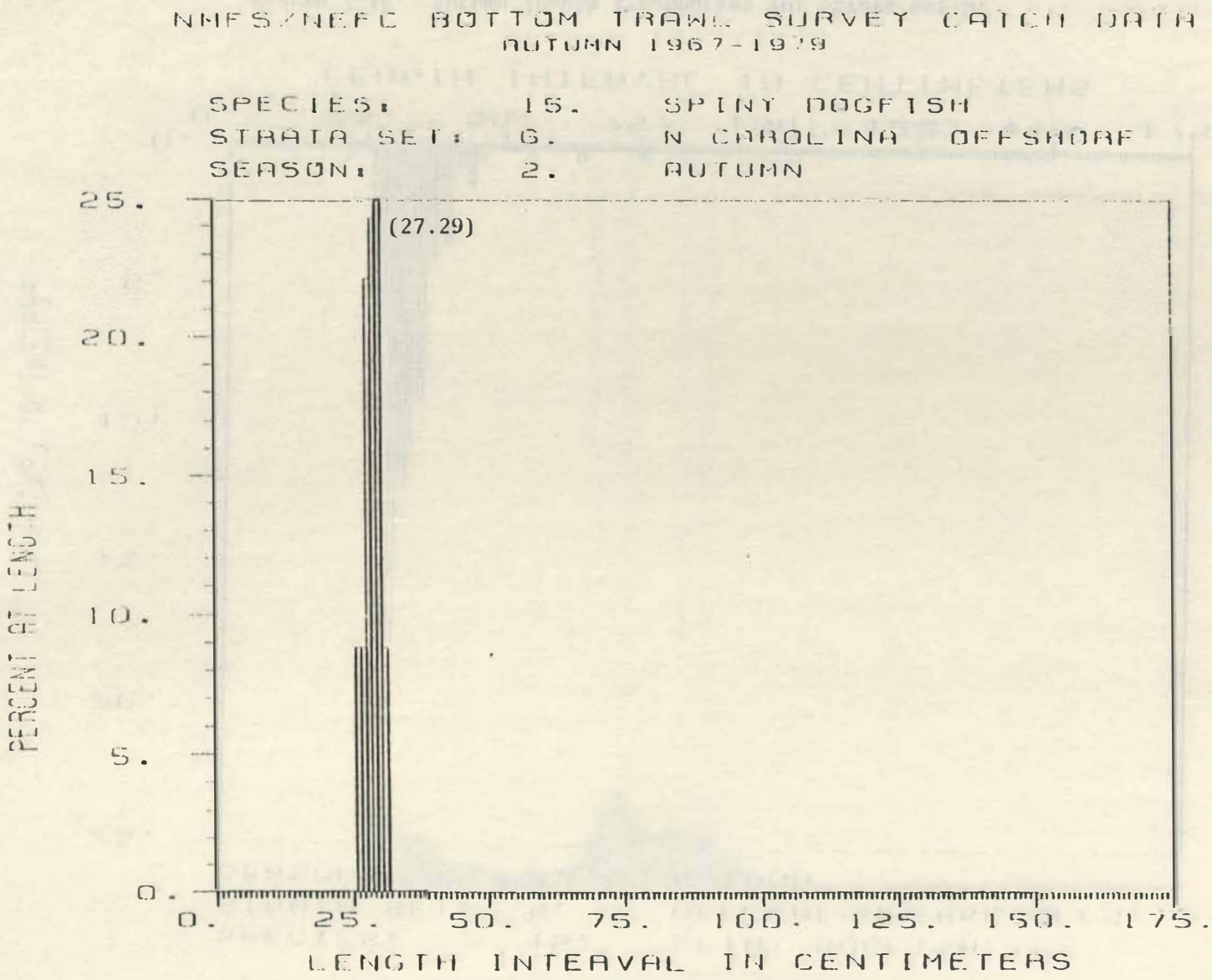


Figure 2.19. Autumn length frequencies for strata set 6.

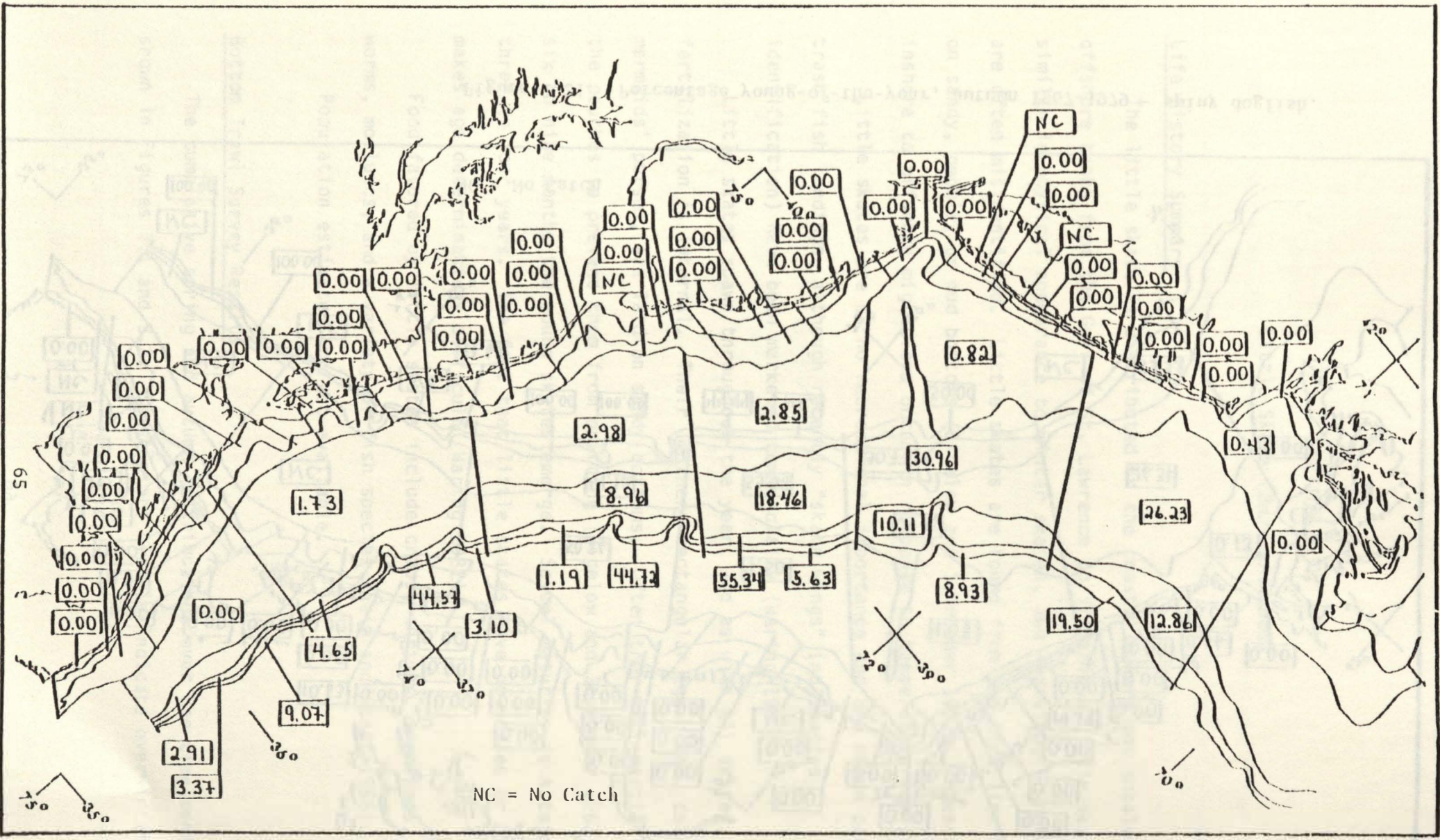
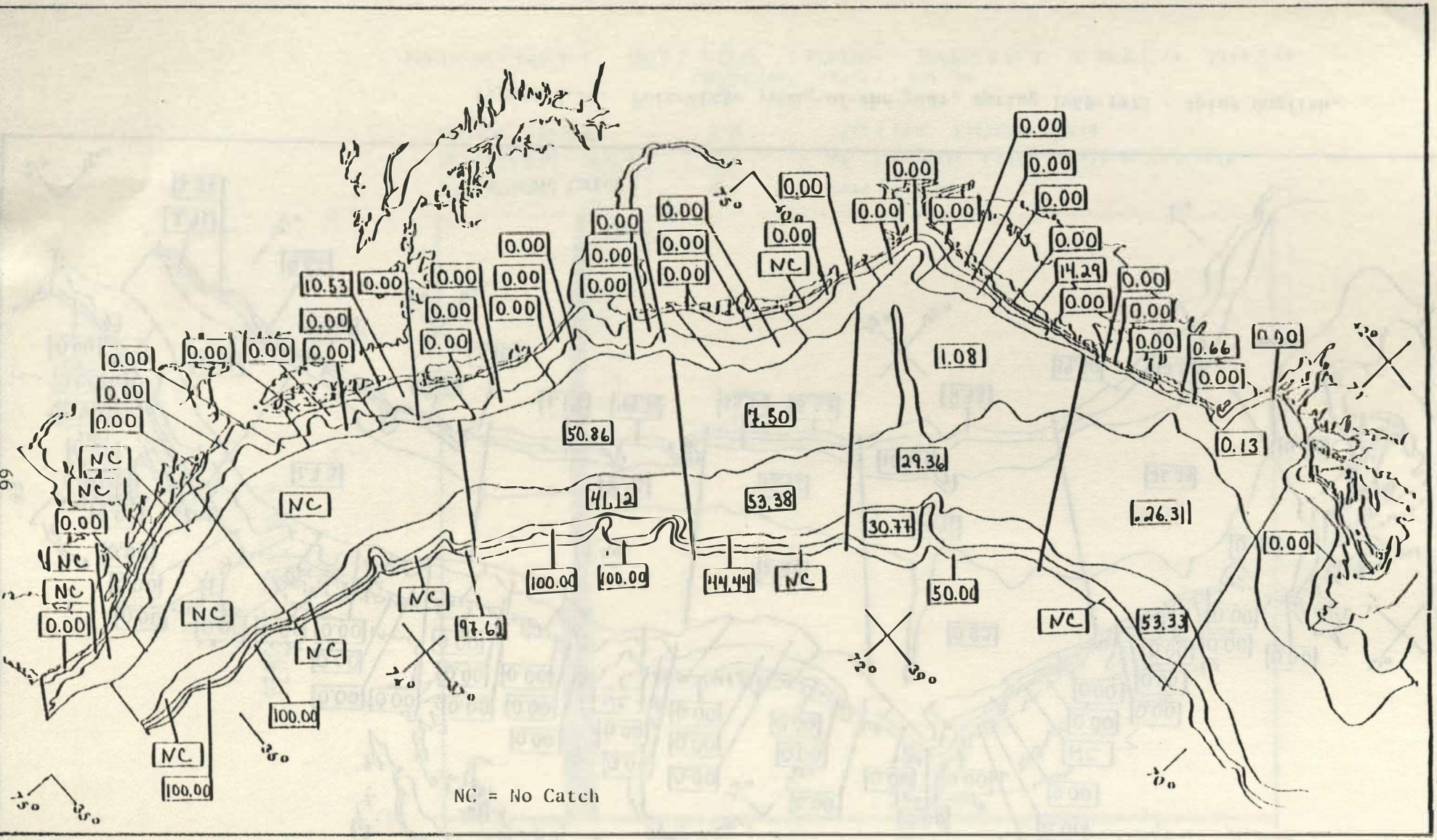


Figure 2.20. Percentage young-of-the-year, spring 1968-1979 - spiny dogfish.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SECTION 3

Little Skate (*Raja erinacea*)

Life History Summary

The little skate is distributed in the coastal waters and shoaler offshore banks from the Gulf of St. Lawrence to Virginia. Little skates are similar in physical appearance to winter skates, and individuals under 35 cm are often misidentified. Little skates are found from the tide line to 110 m on sandy, pebbly, or mud bottoms (Bigelow and Schroeder 1953). Seasonal inshore to offshore migrations occur in response to temperature variations.

Little skates are of no recreational importance and are often part of the trash fish landings, although recently "skate wings" (no species identification) have been marketed commercially (Waring 1982).

Little skates spawn throughout the year, and as with all skates, fertilization is internal. Their leathery rectangular egg cases, called mermaids' purses, are laid on sandy bottoms. Often they will partially bury the pouches to prevent them from drifting (Bigelow and Schroeder 1953). After six to nine months the young skates emerge. Sexual maturity is attained in three to four years. The fact that little skates have no scales or otoliths makes age determinations difficult (Waring 1982).

Food favored by little skates include crabs, shrimps, amphipods, annelid worms, molluscs, and a variety of fish species (Leim and Scott 1966).

Population estimates are not available.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 3.1 and 3.2. These plots clearly indicate overwintering in

the Mid-Atlantic and also northward movement during the summer months. In Figure 3.3 spring cruises in the time series prior to 1976 have been deleted (see "Methods") resulting in a changed distribution pattern.

The graphs of mean weight and number per tow (Figures 3.4-3.7) yield no conclusive information.

Length frequencies arranged by season and strata set are shown in Figures 3.8-3.17. Since there were no little skates taken in strata set 3 (North Carolina inshore), there are no length-frequency plots for this area. These graphs indicate that there are no significant changes in distribution by size. The little skate occurred more frequently in the central and northern strata sets.

Figures 3.18 and 3.19 show the percentage occurrence by stratum of young-of-the-year (YOY); the cutoff size was 16 cm for both seasons. The relative occurrence of YOY was low during both seasons, perhaps due to the low sampling efficiency of the roller rigged trawl for YOY and the possibility that YOY remain in northern areas all year.

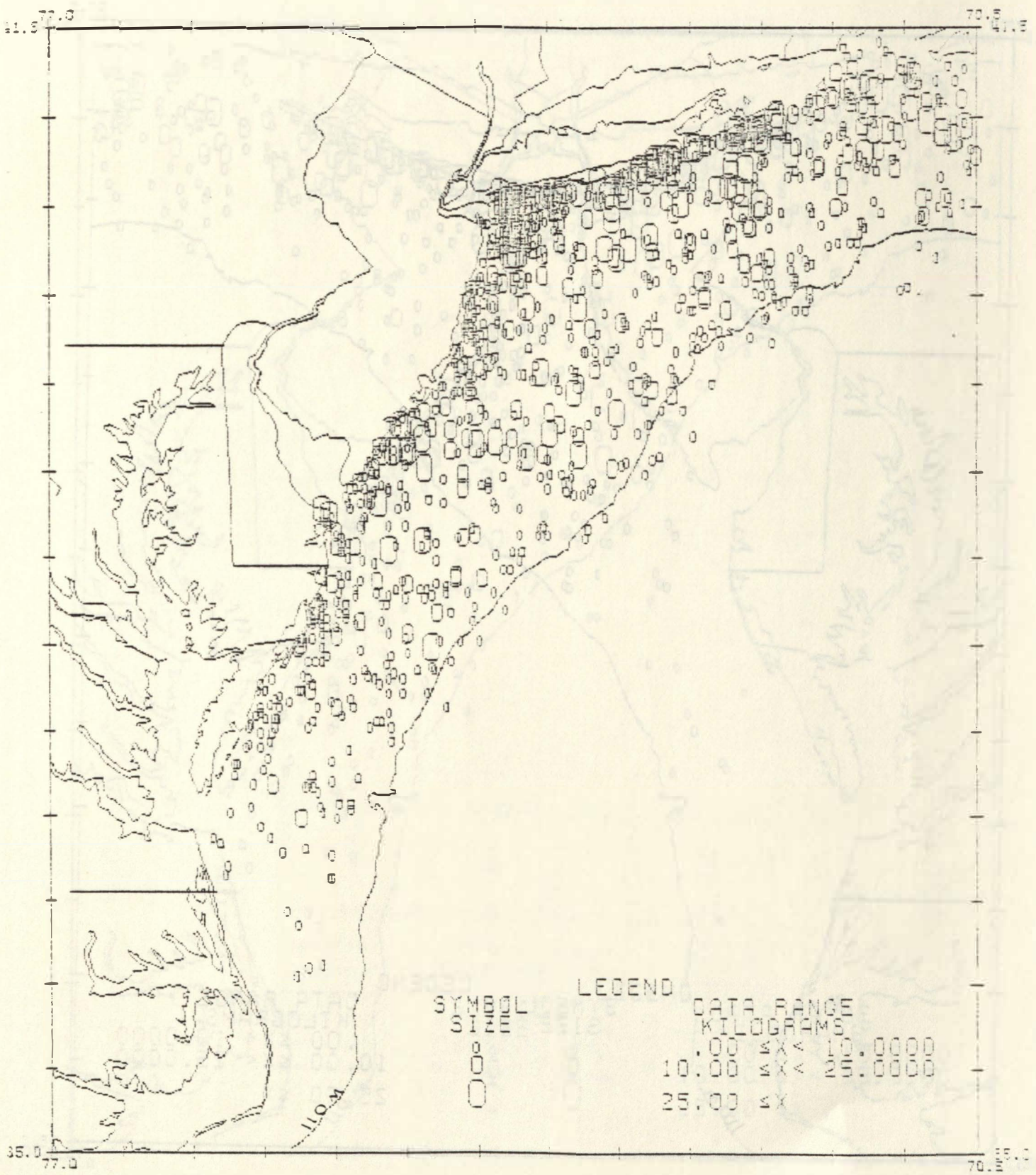


Figure 3.1. Spring distribution, 1968-1979.

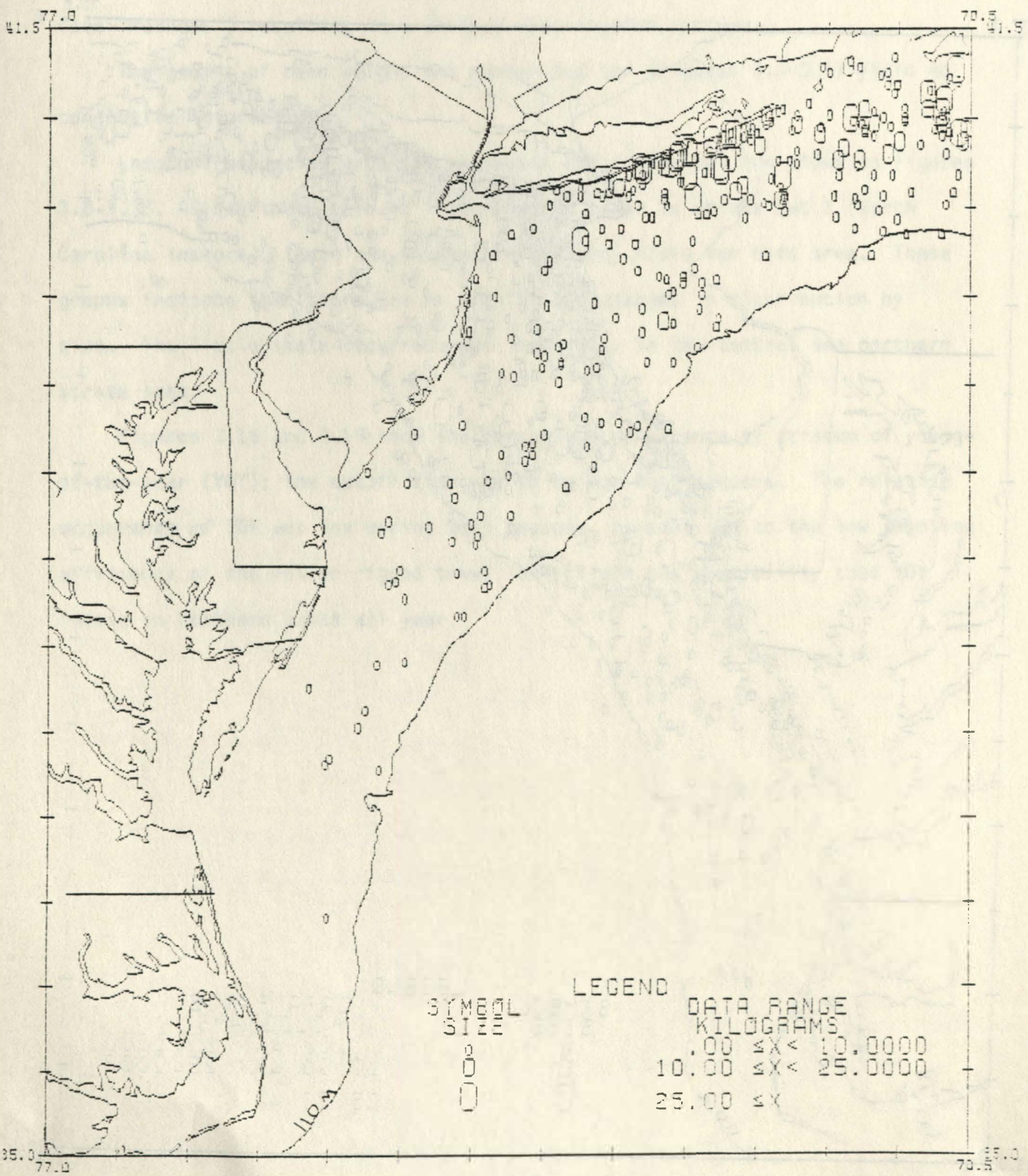


Figure 3.2. Autumn distribution, 1967-1979.

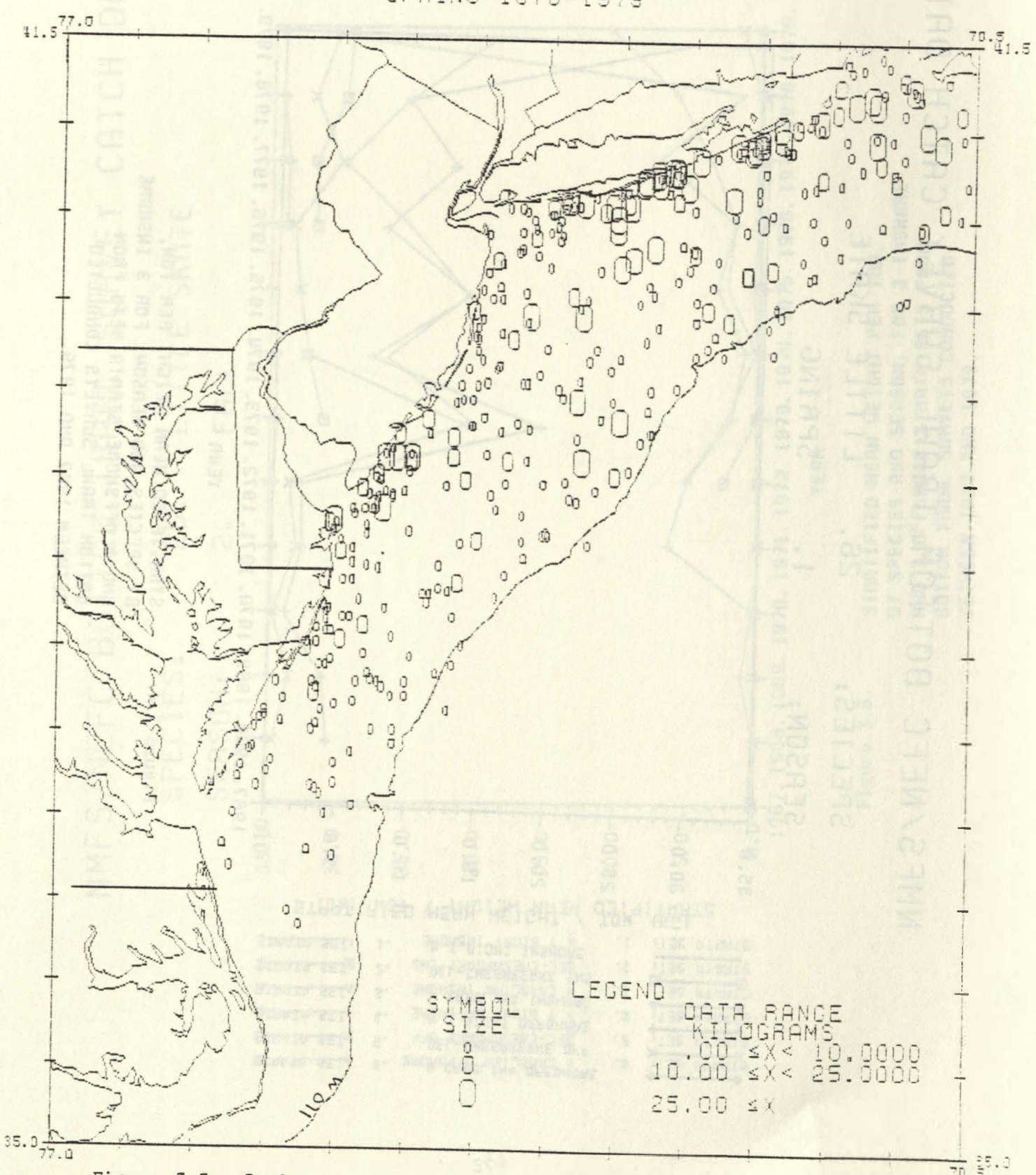


Figure 3.3. Spring distribution, 1976-1979.

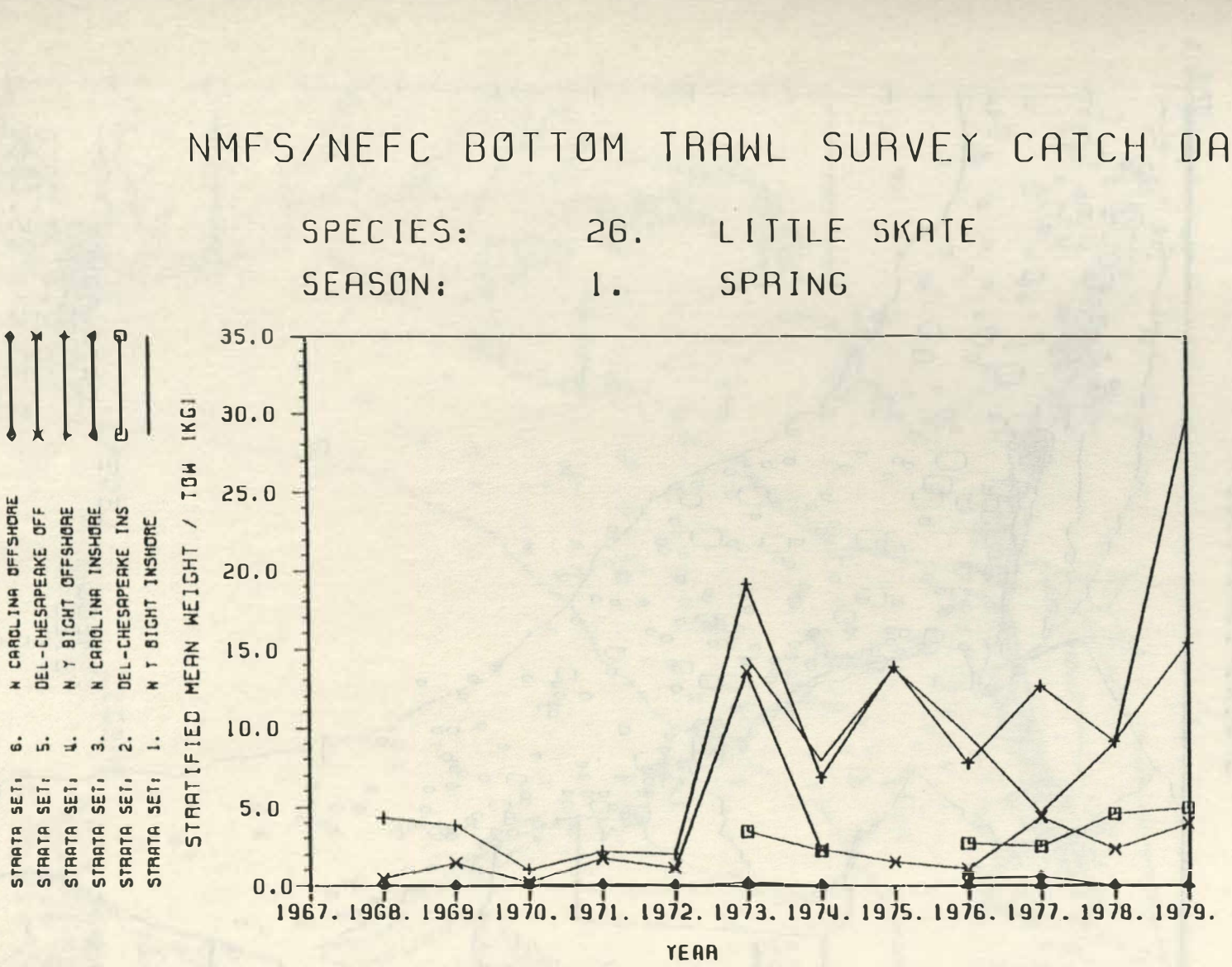


Figure 3.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

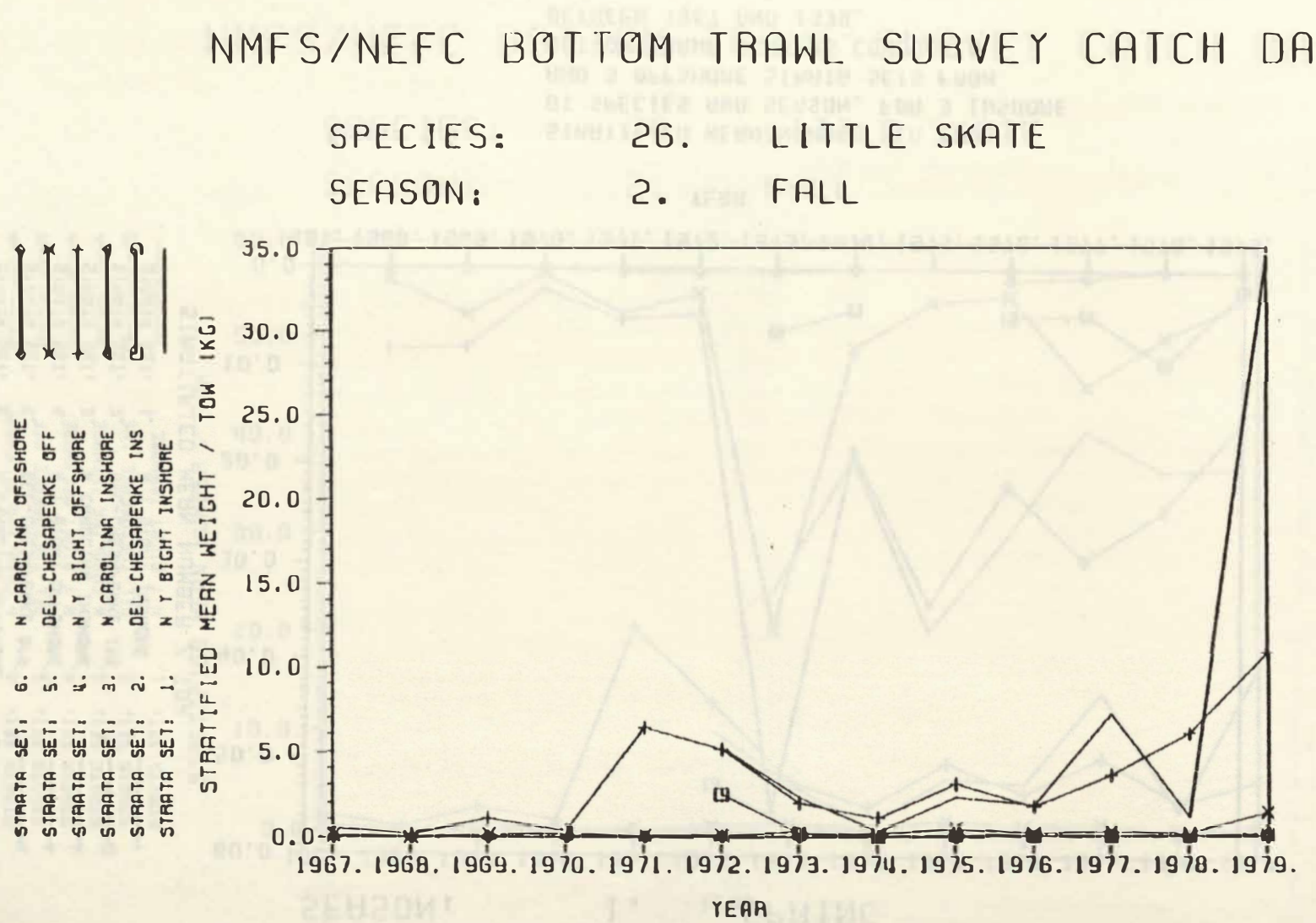


Figure 3.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 26. LITTLE SKATE

SEASON: 1. SPRING

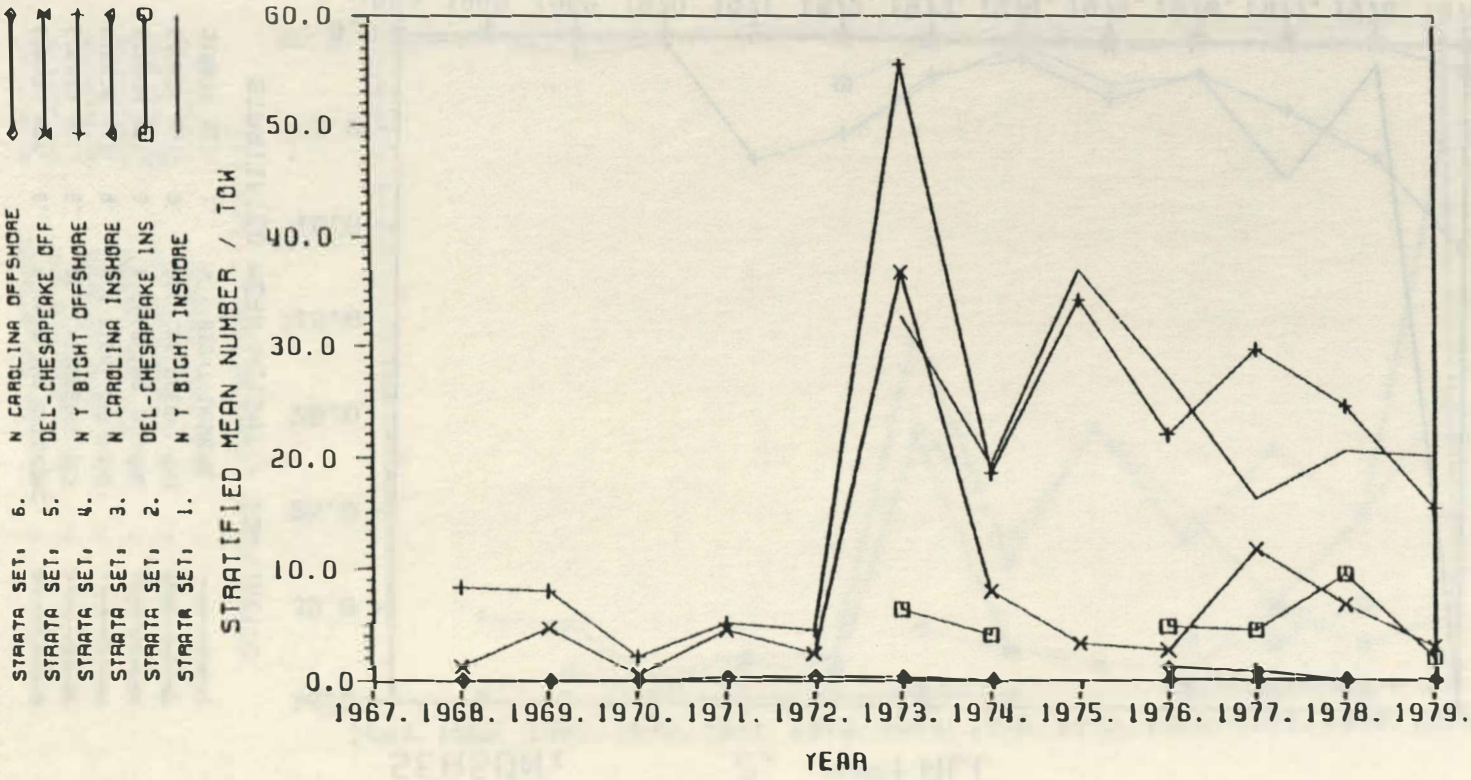


Figure 3.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

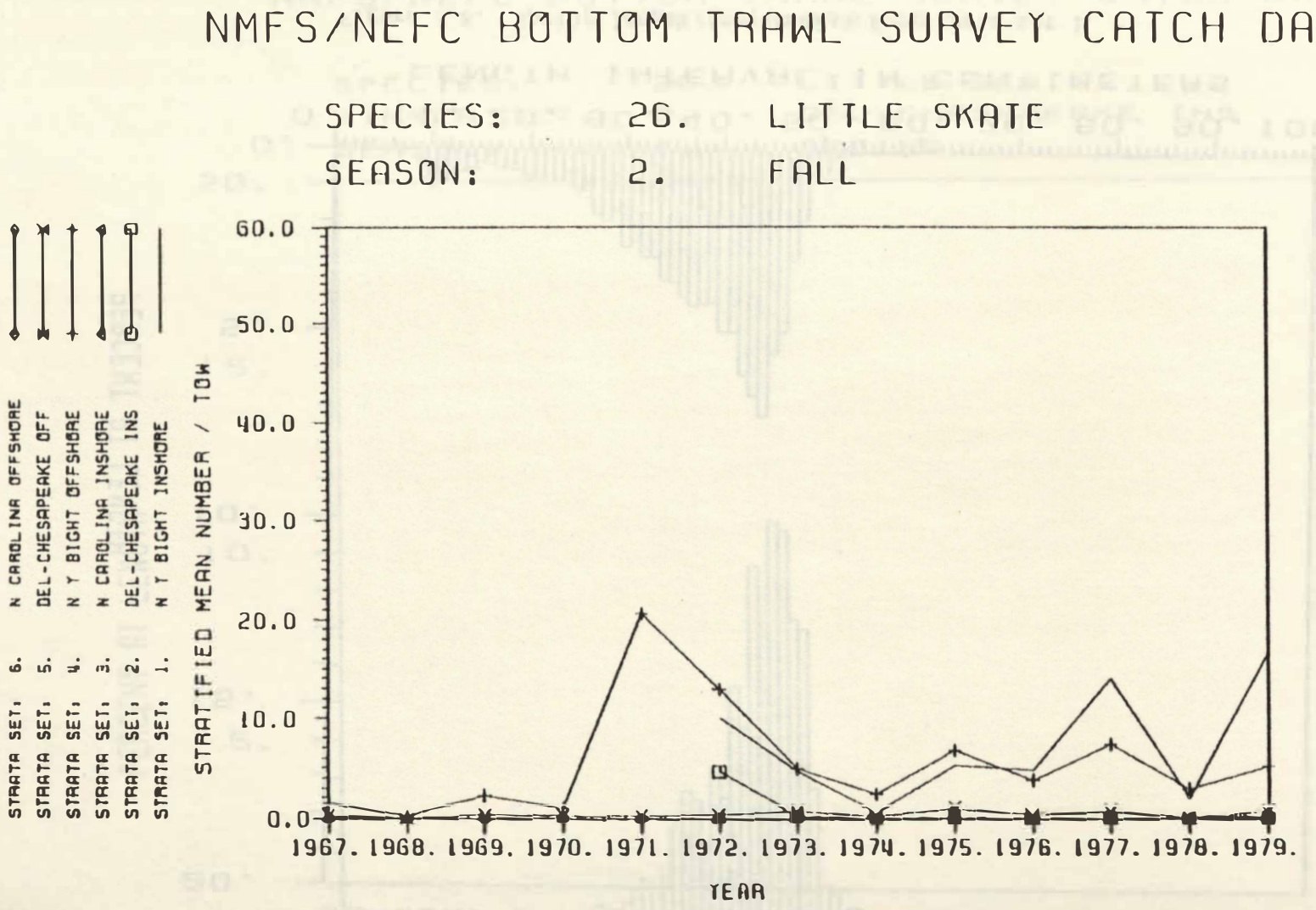


Figure 3.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

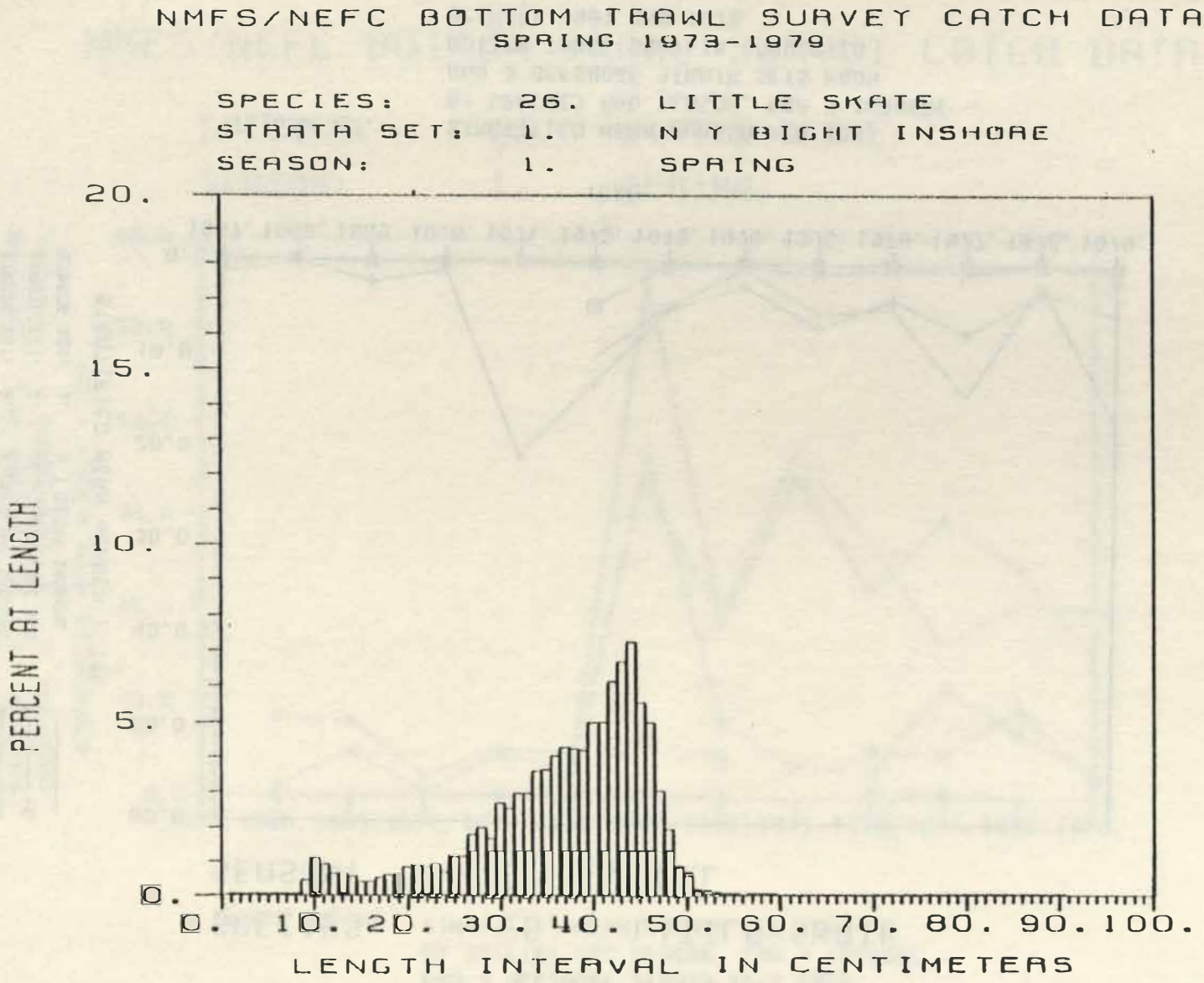


Figure 3.8. Spring length frequencies for strata set 1.

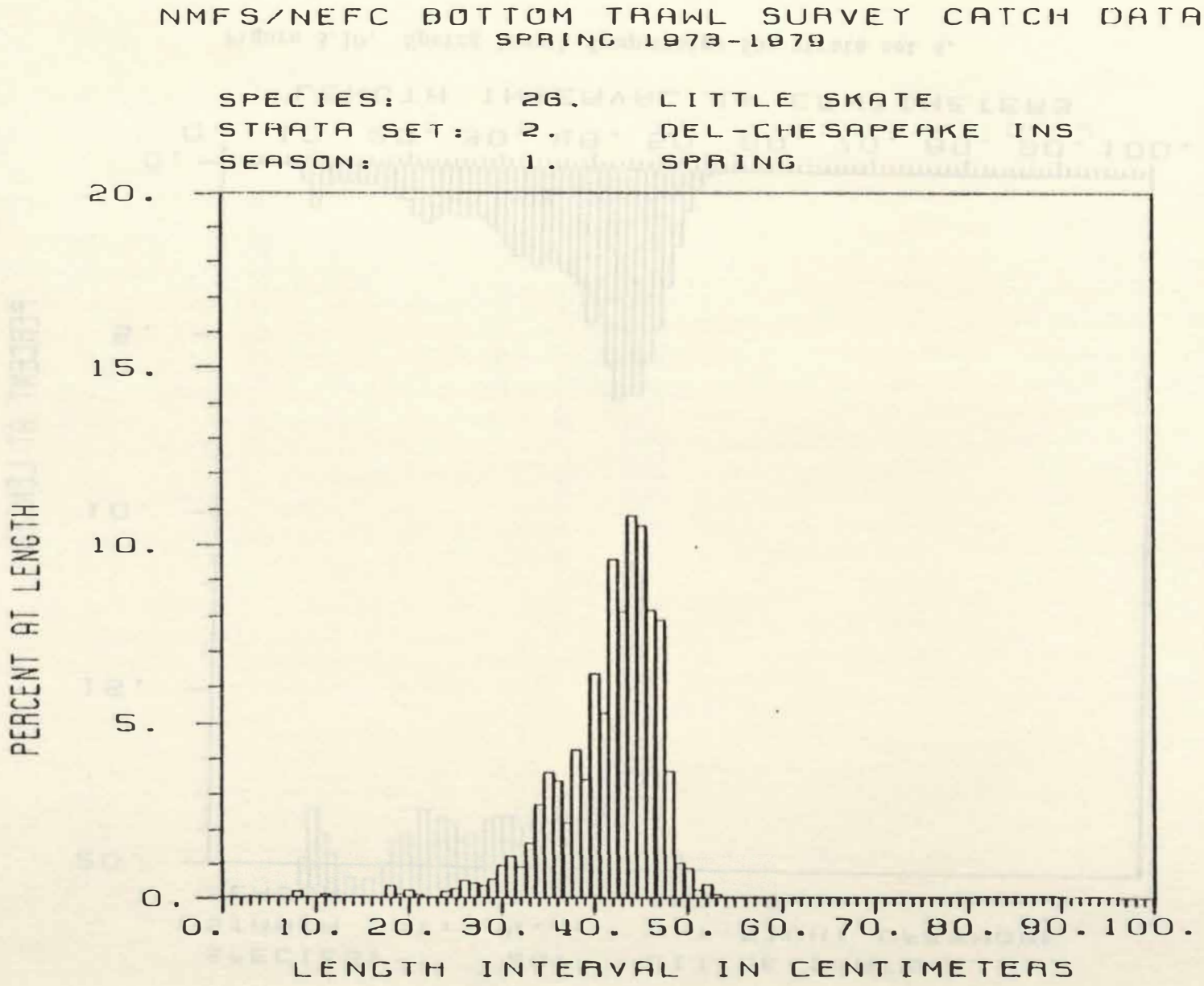


Figure 3.9. Spring length frequencies for strata set 2.

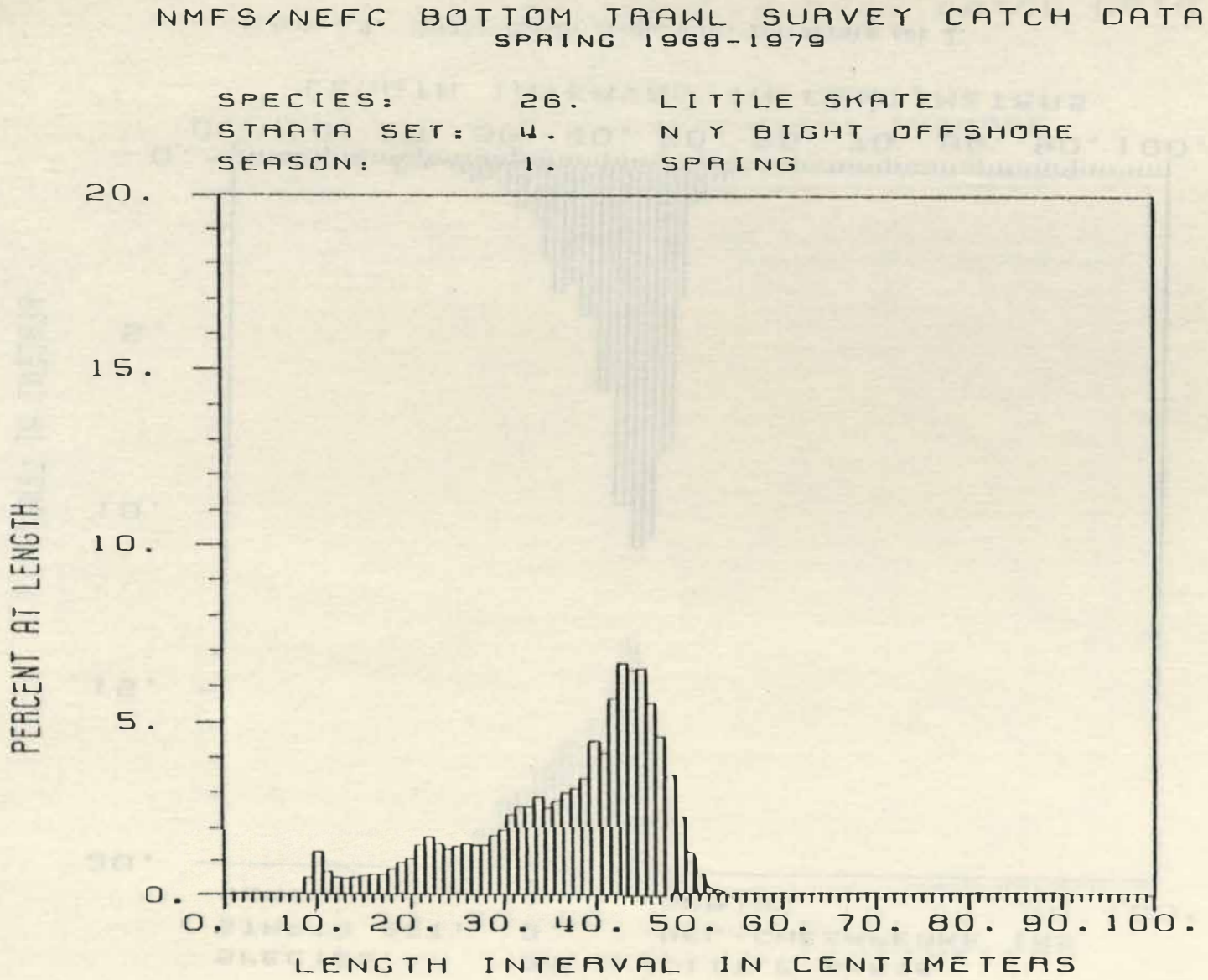


Figure 3.10. Spring length frequencies for strata set 4.

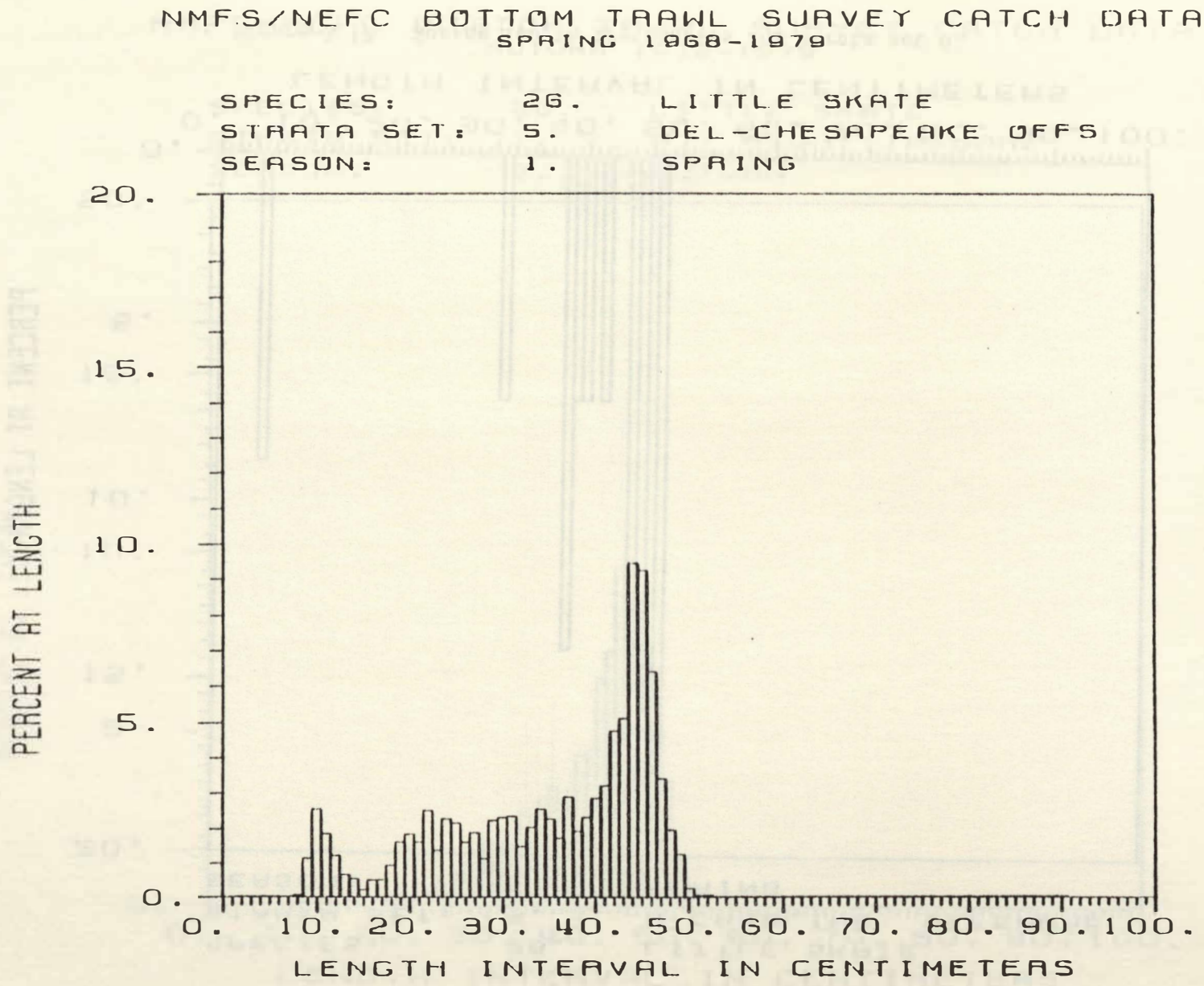


Figure 3.11. Spring length frequencies for strata set 5.

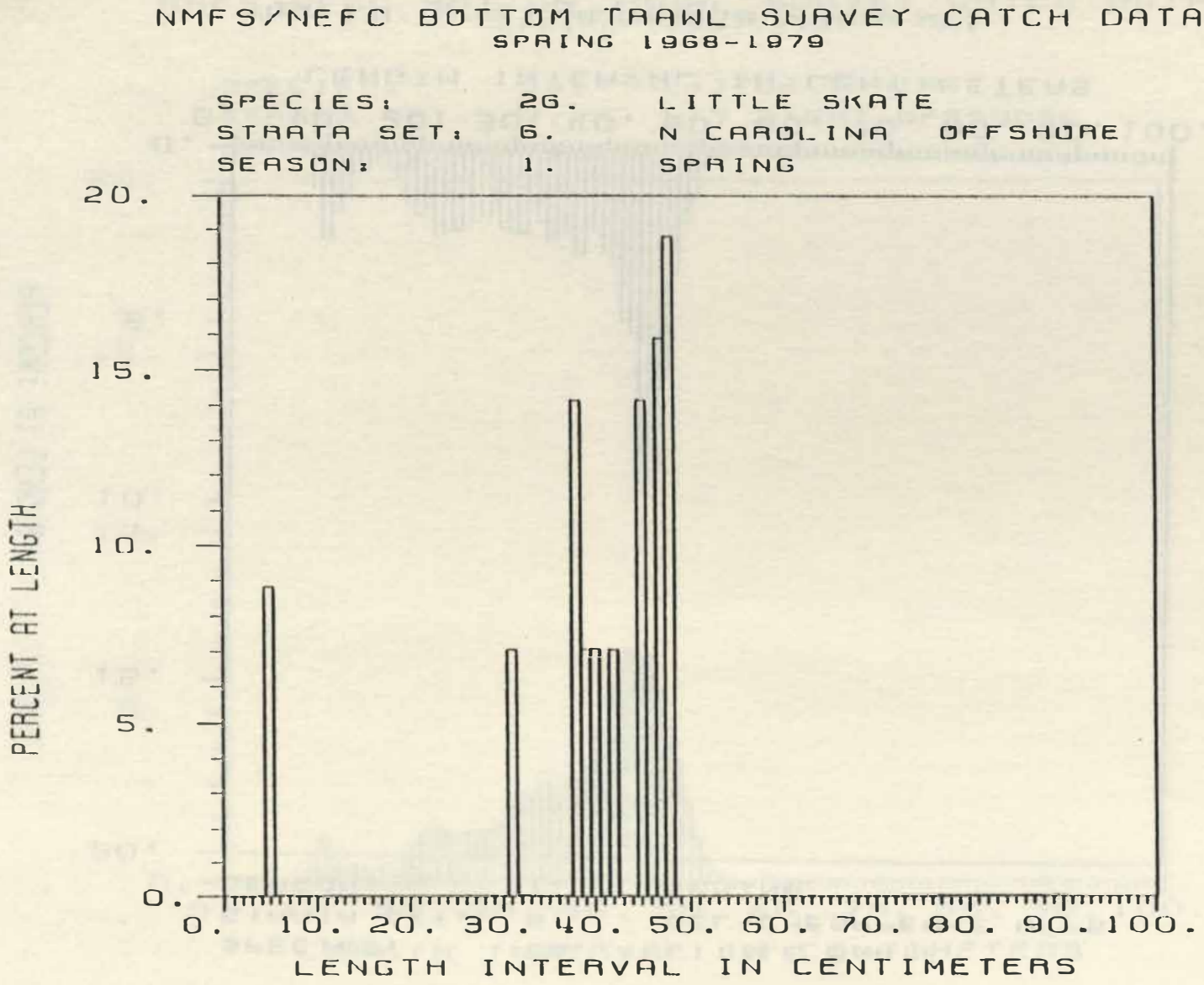


Figure 3.12. Spring length frequencies for strata set 6.

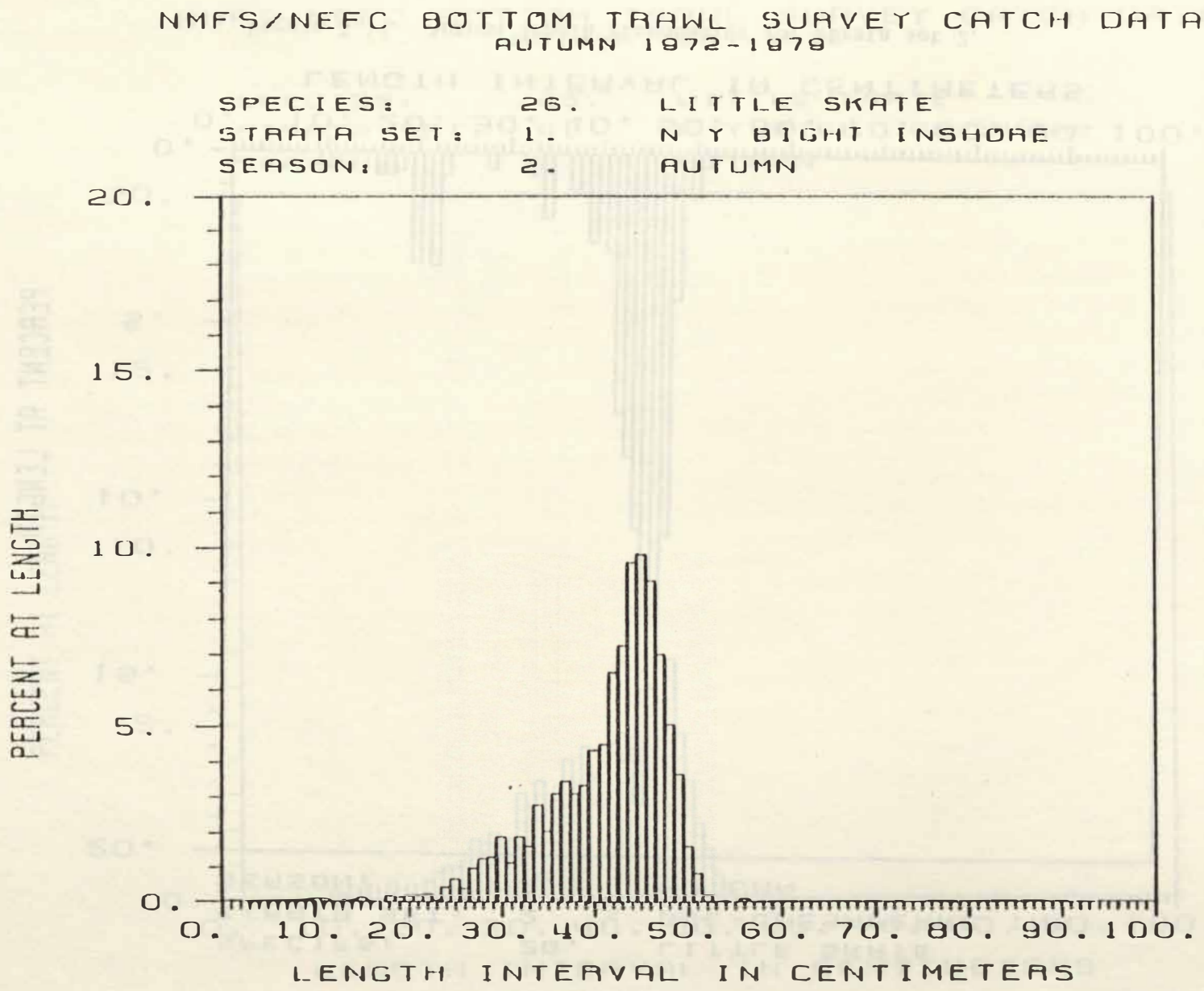


Figure 3.13. Autumn length frequencies for strata set 1.

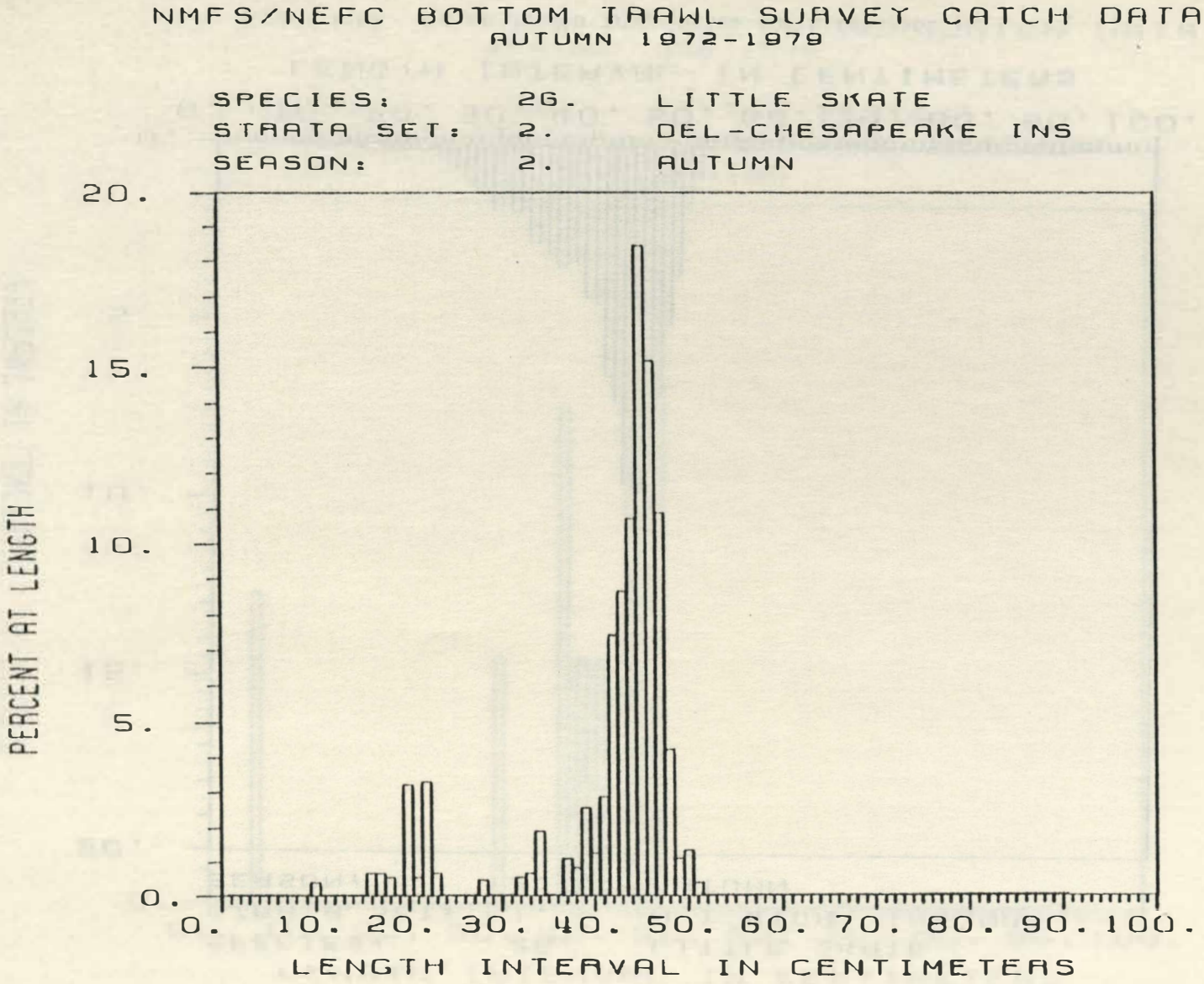


Figure 3.14. Autumn length frequencies for strata set 2.

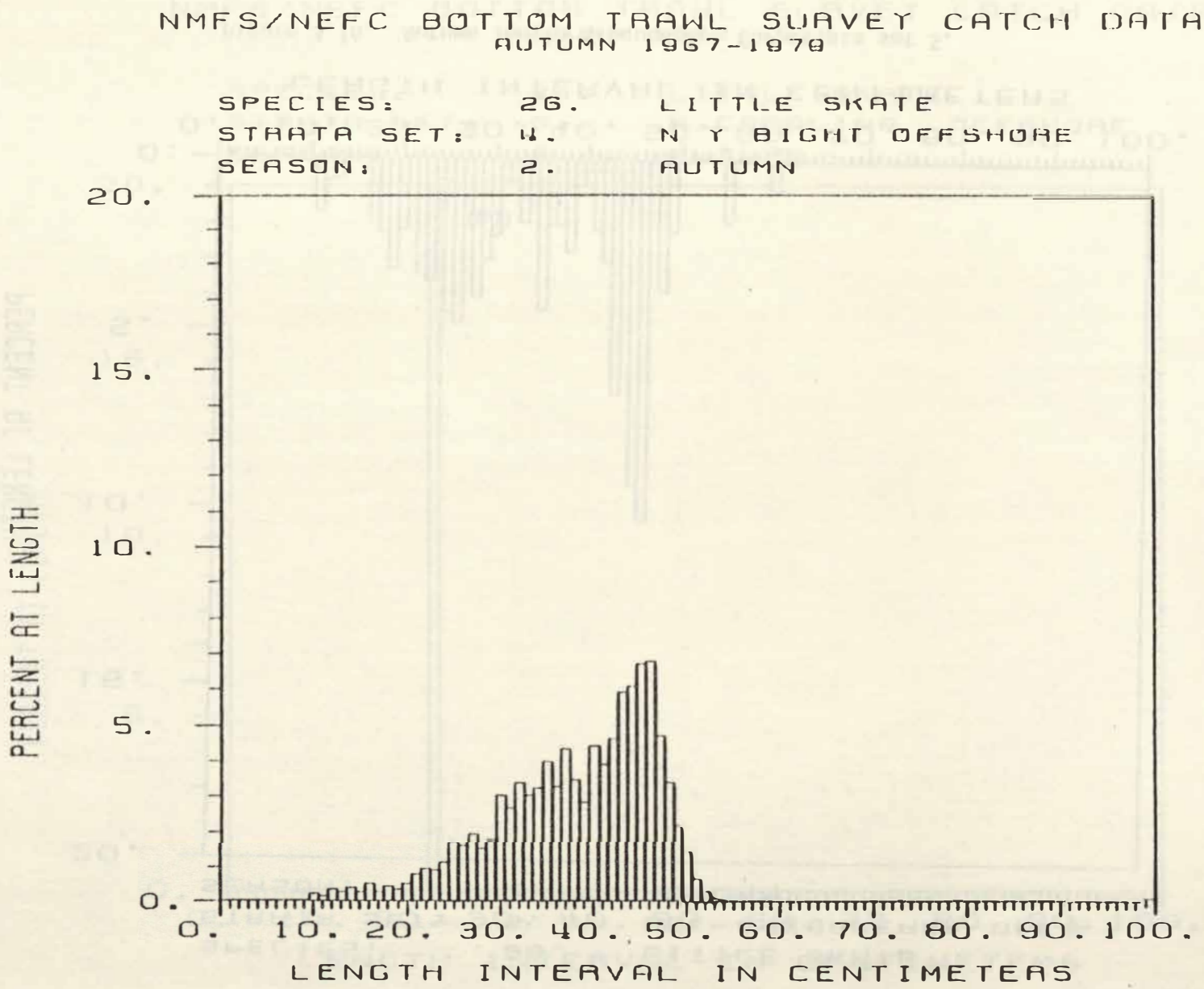


Figure 3.15. Autumn length frequencies for strata set 4.

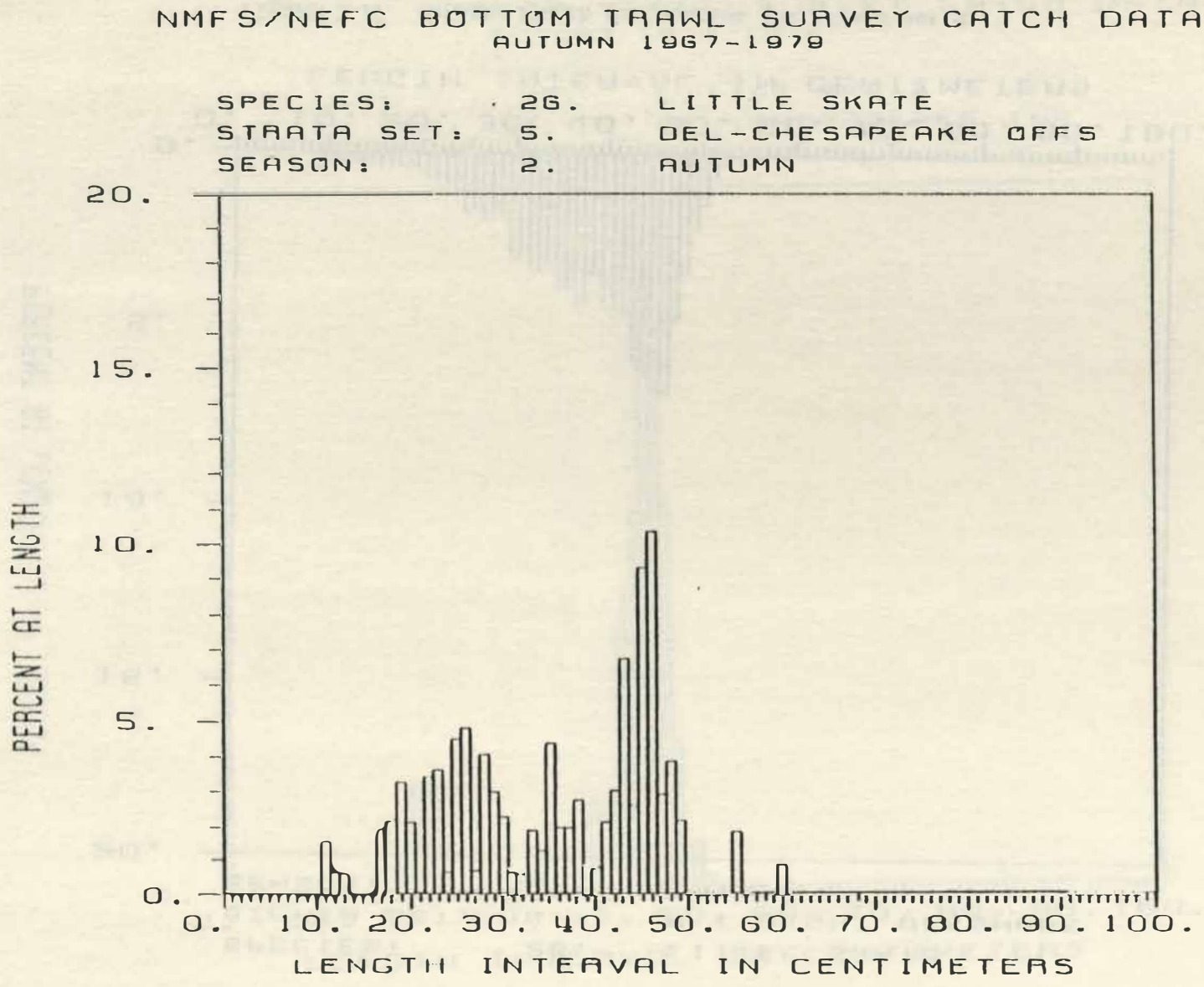


Figure 3.16. Autumn length frequencies for strata set 5.

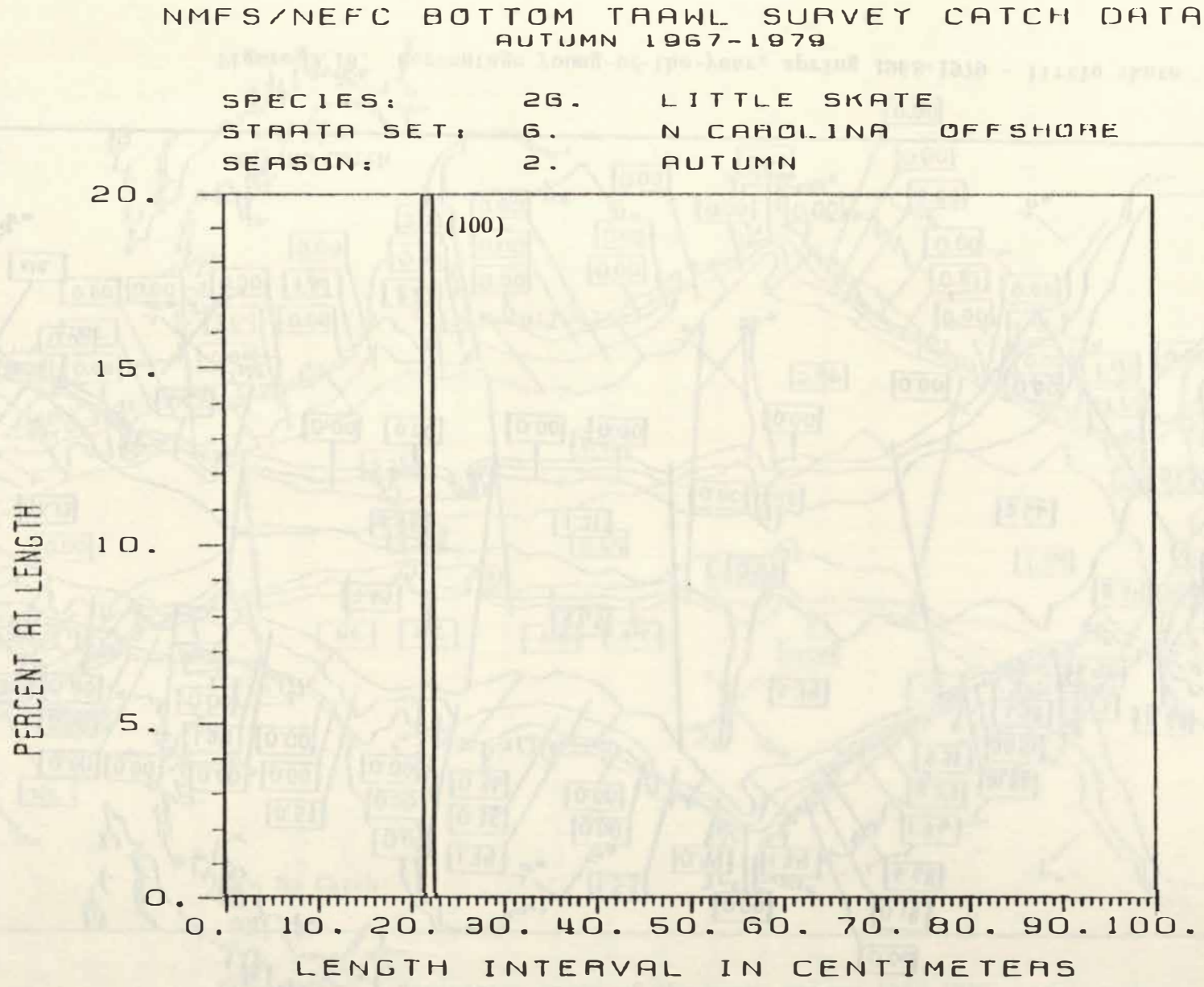


Figure 3.17. Autumn length frequencies for strata set 6.

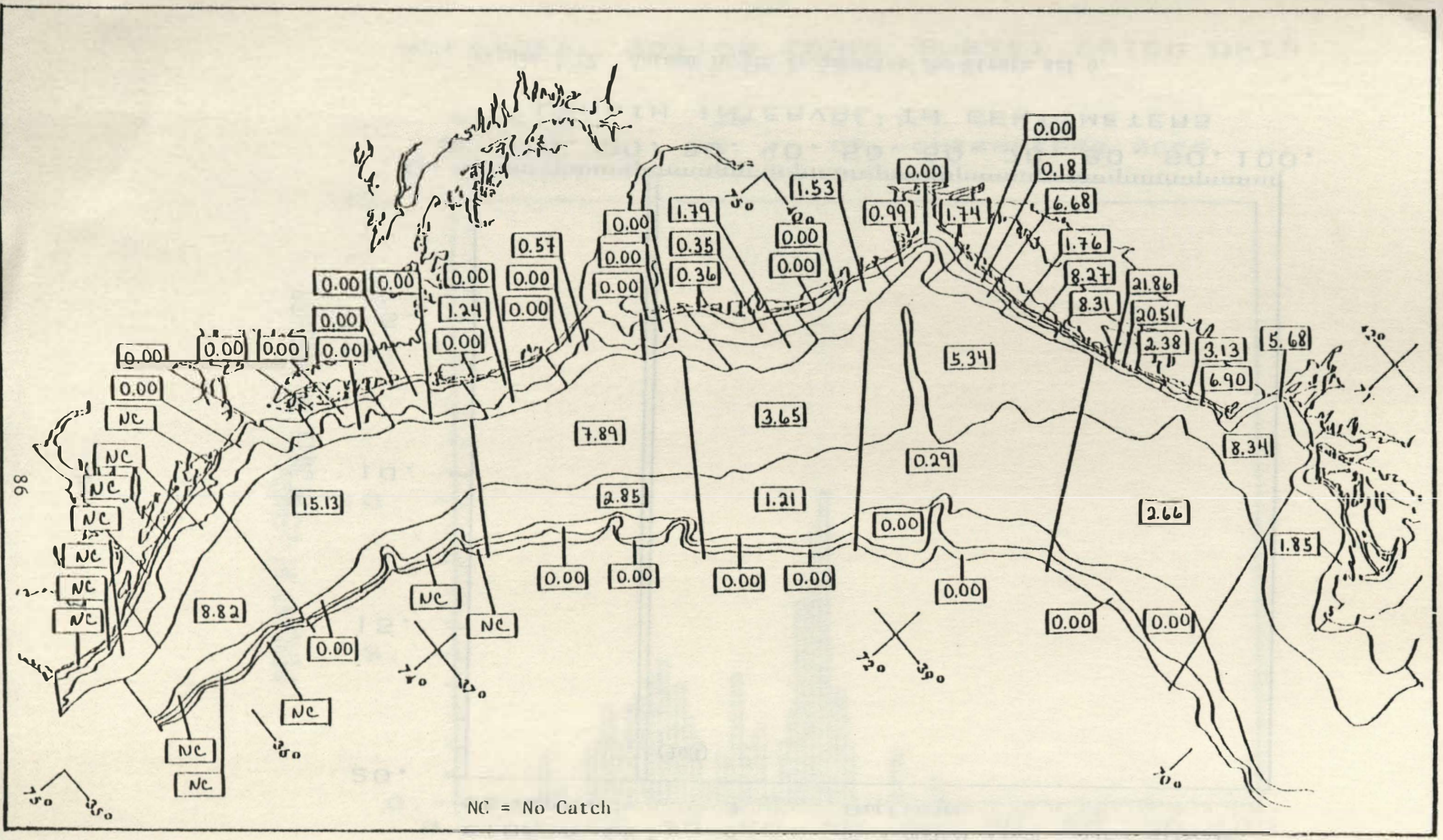
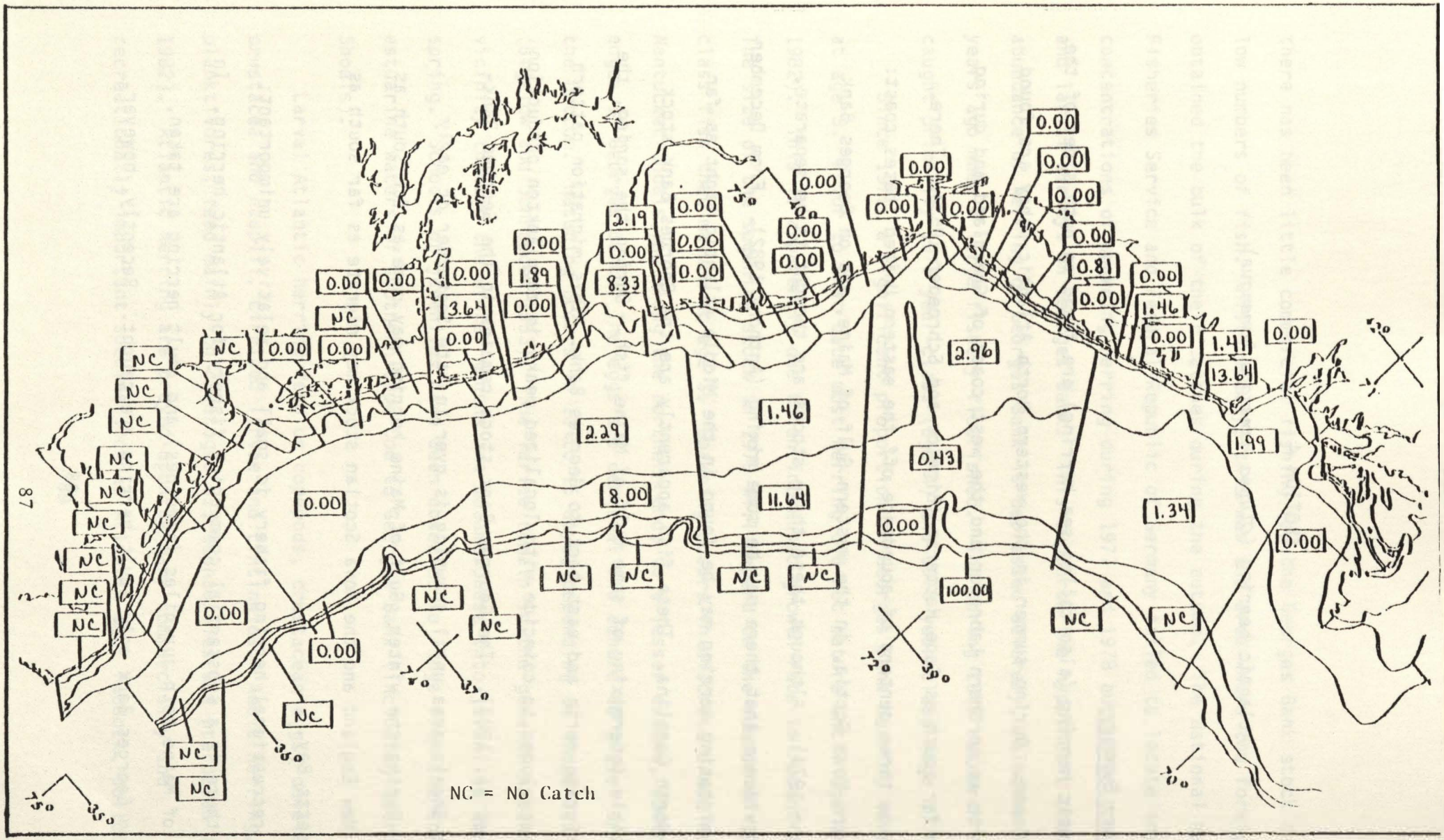


Figure 3.18. Percentage young-of-the-year, spring 1968-1979 - little skate.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SECTION 4

Atlantic herring (*Clupea harengus harengus*)

Life History Summary

Atlantic herring (also called sea herring) are found on both sides of the Atlantic Ocean. During summer in the western North Atlantic, they are found as far north as northern Labrador and the west coast of Greenland and during winter as far south as Cape Hatteras (Bigelow and Schroeder 1953). There appear to be three centers of abundance off the eastern United States coast: off southern Nova Scotia, in the western Gulf of Maine, and on Georges Bank (Sindermann 1979). Although these three stocks are thought to be separate, there is evidence that there may be some mixing (Anthony 1982). From December to April migrating herring may be found in the Middle Atlantic Bight as far south as North Carolina. These fish apparently are the Georges Bank stock with possible intermixing of some Gulf of Maine fish. During the spring, the herring migrate north and east back to Georges Bank. This migration pattern may have developed to coincide with localized peaks in zooplankton production (Sherman et al. 1983). The Georges Bank stock remains in the Georges Bank-Nantucket Shoals area until spawning is over in late September or early October. During the winter, Gulf of Maine herring may come as far south as southern New England and the Nova Scotian stock may migrate as far south as Massachusetts Bay.

The recreational herring fishery is small and relatively unimportant; however, there is a substantial commercial fishery for Atlantic herring. In the Gulf of Maine both juveniles (sardines) and adult herring are taken, whereas on Georges Bank only adult herring are caught. Recently, however,

there has been little commercial fishing for the Georges Bank stock because of low numbers of fish. Historically, this was the area where the foreign fleets obtained the bulk of their catches during the autumn. The National Marine Fisheries Service and Federal Republic of Germany failed to locate any concentrations of spawning herring during 1977 and 1978 autumn bottom trawl and larval surveys on Georges Bank. This supports the hypothesis that the abundance of herring on Georges Bank is depressed severely, relative to a few years ago when a large fishery flourished. The spring 1979 research surveys caught primarily 1975 year-class (age 4) and 1976 year-class (age 3) herring.

Since 1971, a significant proportion of Georges Bank herring have matured at age 3. Prior to that date most herring did not mature until age 4 (Anthony 1982). This is apparently due to an increased growth rate in recent years. The size of the spawning stock in 1979 will depend on the number of 1976 year-class fish that mature at age 3. Spawning occurs in discrete areas near Nantucket Shoals and along the northern and, to a lesser extent, southern edges of Georges Bank. The eggs are demersal and adhere to gravel or flora on the bottom. Hatching occurs in 10 to 15 days, depending on temperature (Bigelow and Schroeder 1953). The larvae remain in the general hatching vicinity through the winter months and metamorphose into juveniles during the spring. Schools of juveniles have been observed to range from the coastal and estuarine waters of southern Cape Cod to Georges Bank (including Georges Shoals).

Larval Atlantic herring feed on copepods, crustacean eggs, developing crustacea and nauplii, cirriped larvae and tintinnids. Adult herring, being planktivores, feed mainly on chaetognaths, euphausiids and pteropods (Anthony 1982). Atlantic herring are preyed upon by many commercially and recreationally important species such as Atlantic cod, haddock, pollock,

silver hake, Atlantic mackerel, striped bass, *Illex* squid and occasionally fin whales (Bigelow and Schroeder 1953).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 4.1 and 4.2. These plots clearly demonstrate the movements of Atlantic herring in the Mid-Atlantic. Large numbers of herring moved south and overwintered in the Mid-Atlantic after spawning in the fall. In Figure 4.3 the data from all cruises prior to 1976 has been deleted, presenting a different picture from that in Figure 4.1. The distribution difference in this case was not due so much to the timing of the earlier surveys, but to the fact that population numbers are much higher during the earlier years, resulting in a more widespread distribution. The autumn distribution plot (Figure 4.2) shows small numbers of fish in extreme northern portions of the study area.

The mean weight and number per tow summaries in Figures 4.4 through 4.7 show the increases in weight and numbers during the 1979 survey by fish from the 1976 year-class which may represent some possibilities for the recovery of the population.

Length frequencies for strata sets, arranged by seasons, are shown in Figures 4.8 through 4.16. No clear size distribution pattern is evident; mixed sizes occur in most strata sets, especially during the spring. There are no plots for inshore spring strata set 3, inshore autumn strata set 2, and offshore autumn strata set 6 because no fish were caught in those areas.

Figures 4.17 and 4.18 show the percentage occurrence by stratum of young-of-the-year (YOY); cut-off sizes were 9 cm for the spring series and 15 cm for the fall series. These figures demonstrate that very few YOY herring were caught in the Mid-Atlantic during our surveys, but substantial numbers were caught in the spring in southern New England. The catches off Chesapeake Bay in spring and autumn were not important because frequency of occurrence was very low and only a few individuals were caught.

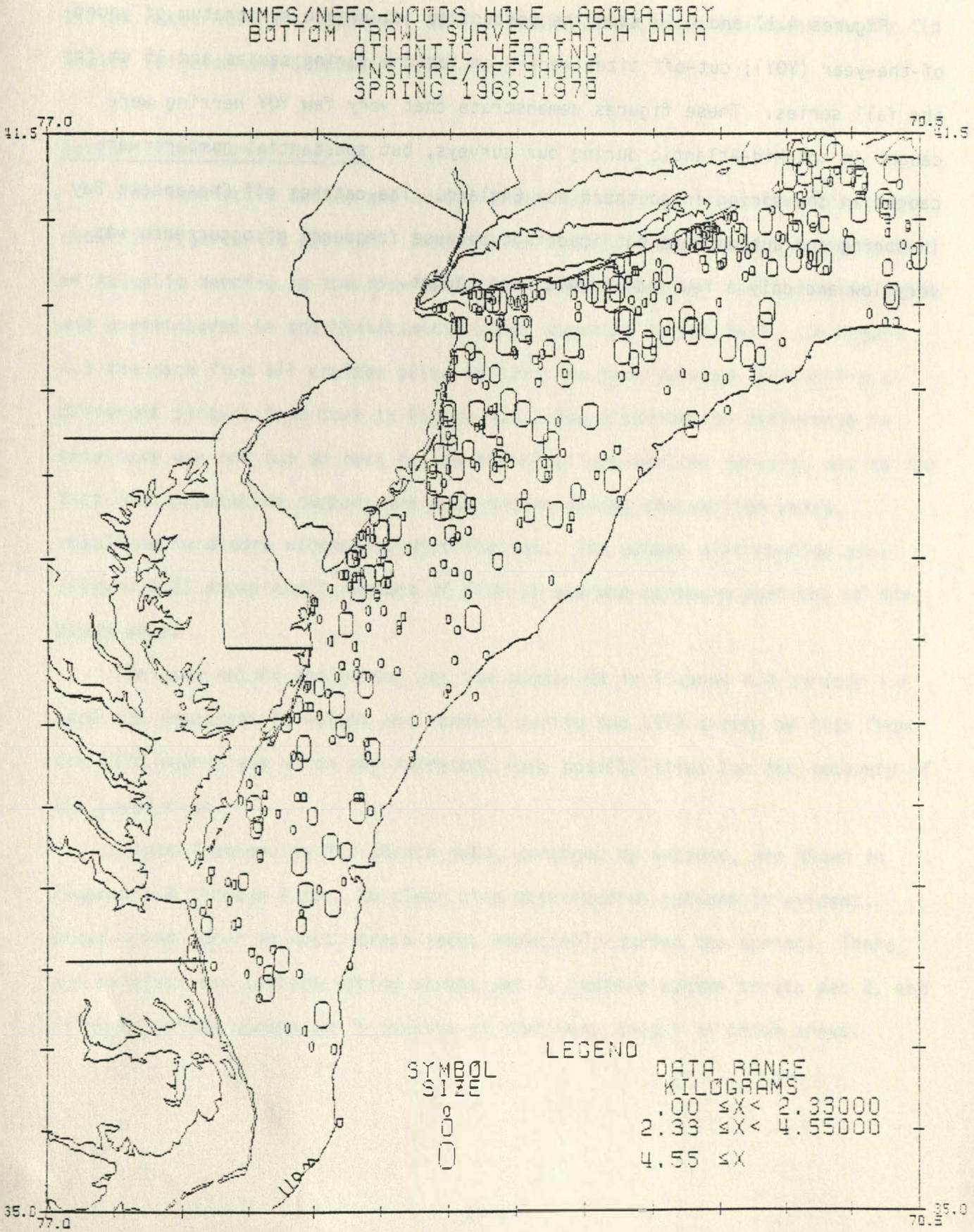


Figure 4.1. Spring distribution, 1968-1979.

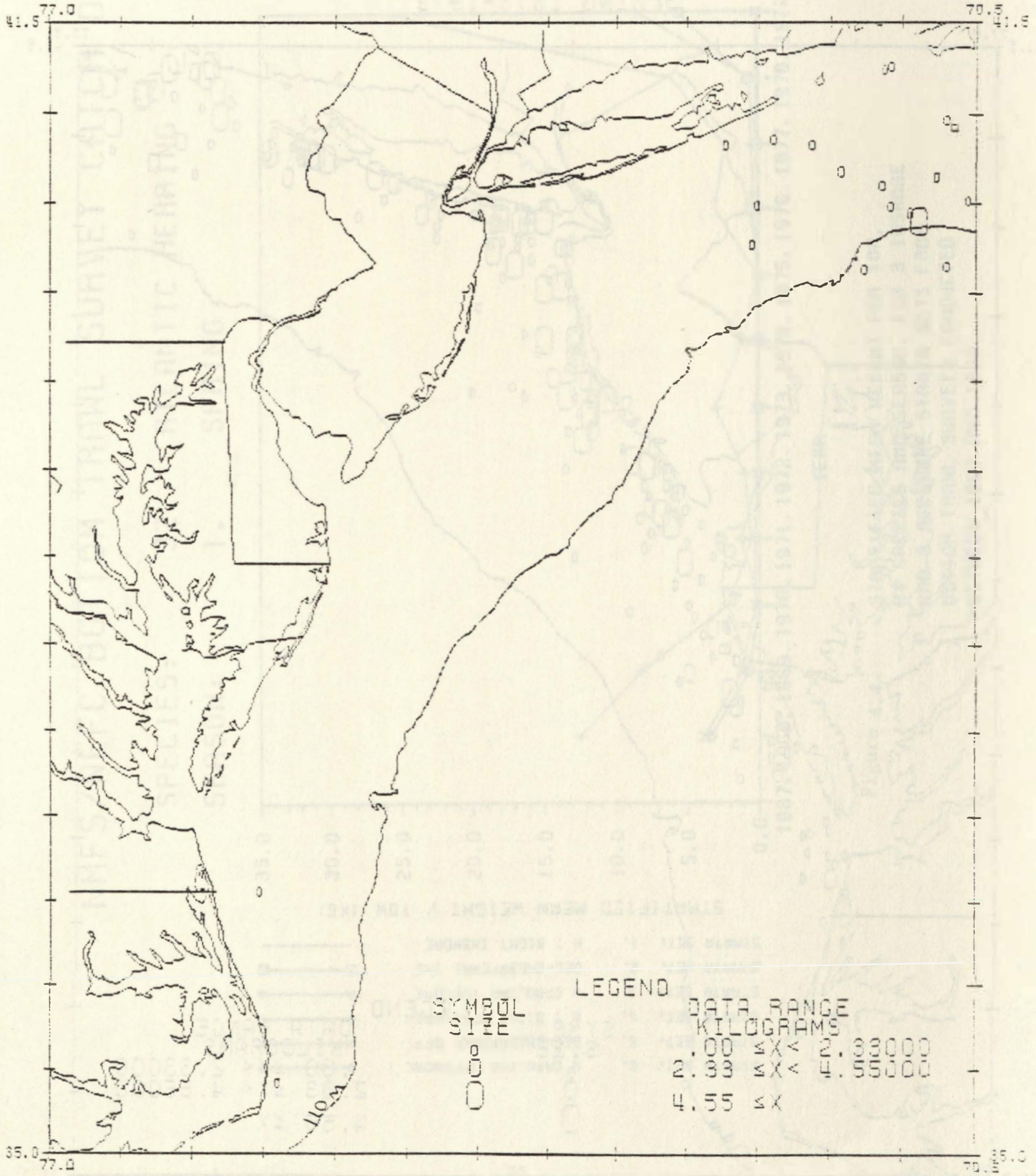


Figure 4.2. Autumn distribution, 1967-1979.

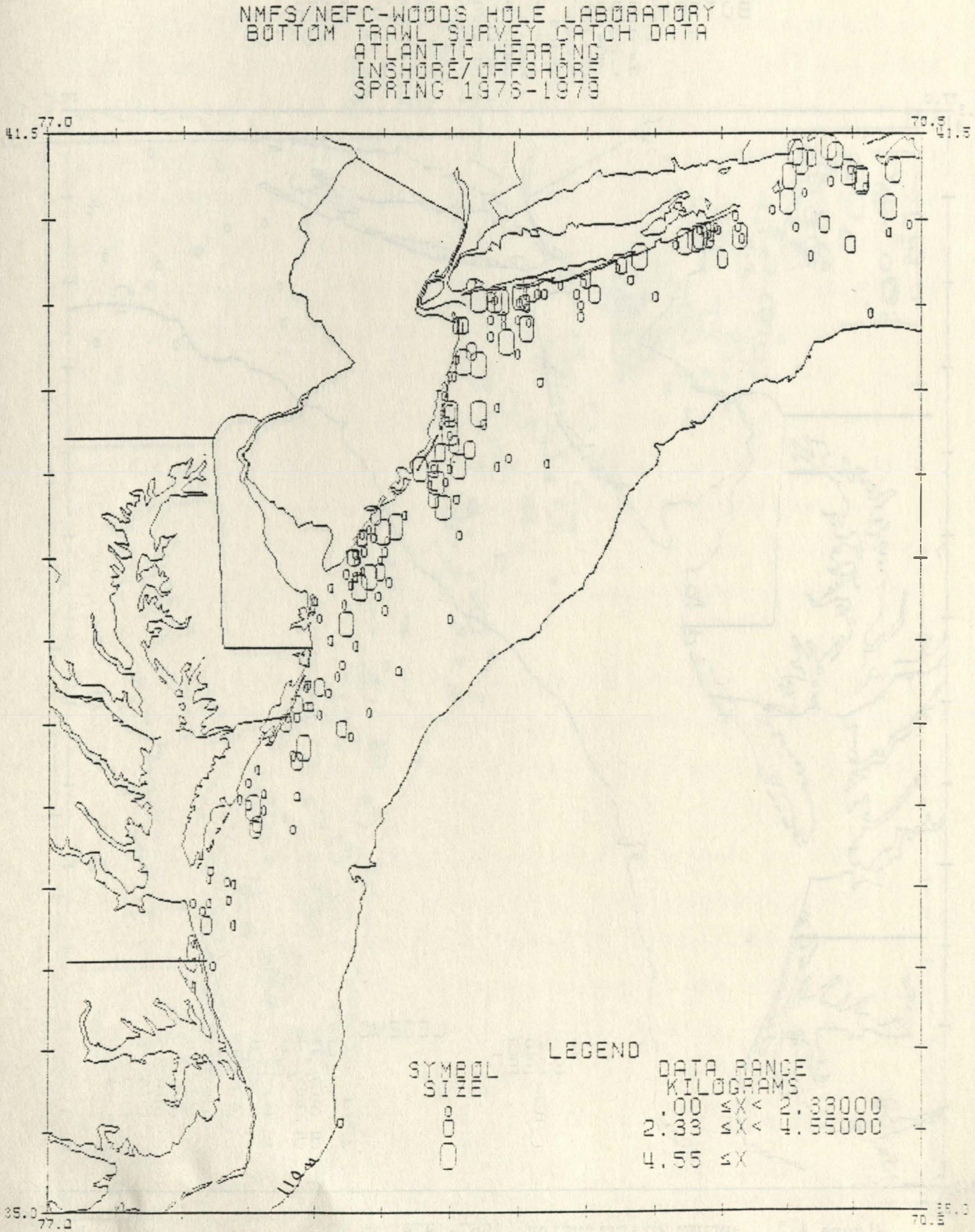


Figure 4.3. Spring distribution, 1976-1979.

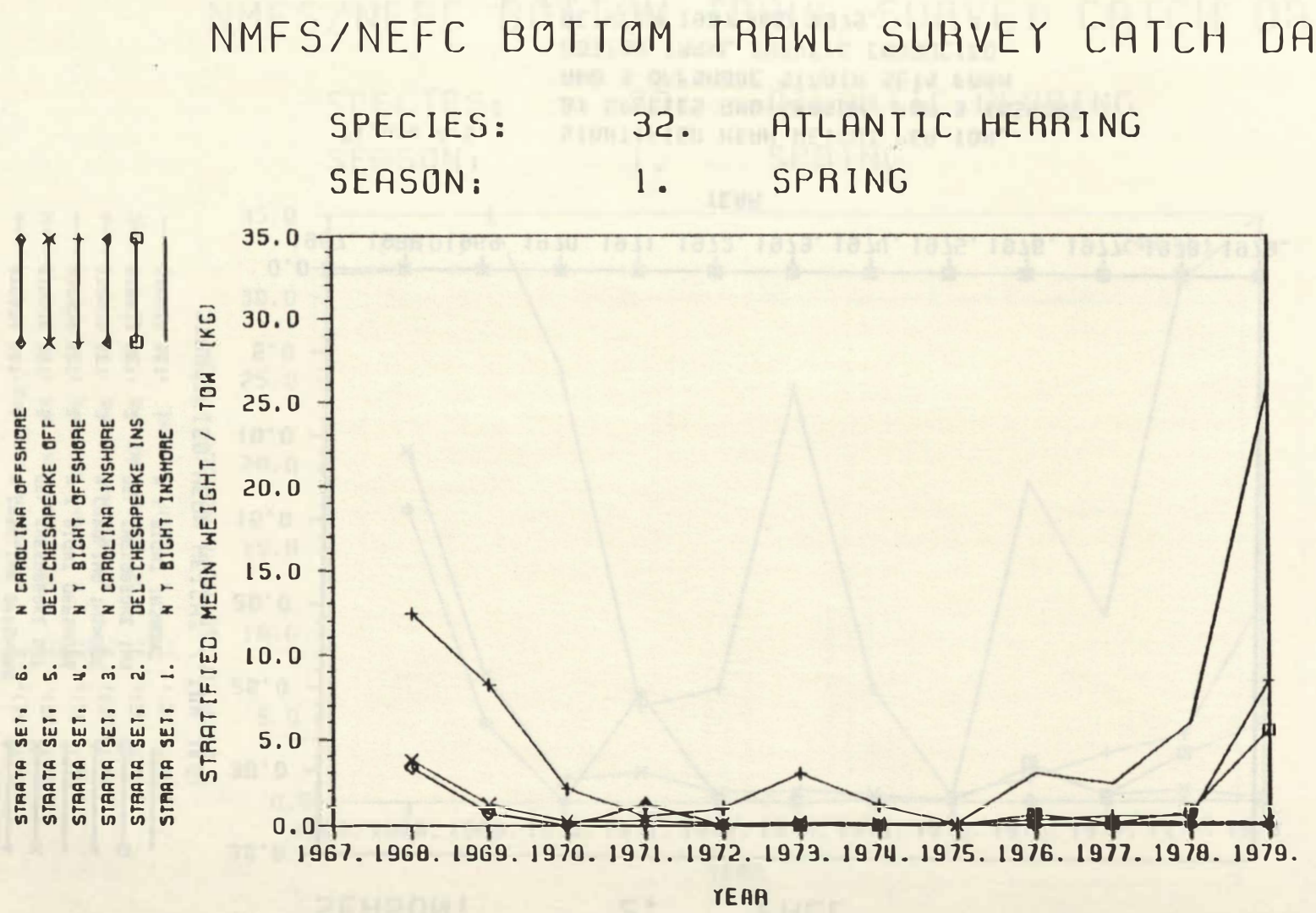


Figure 4.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

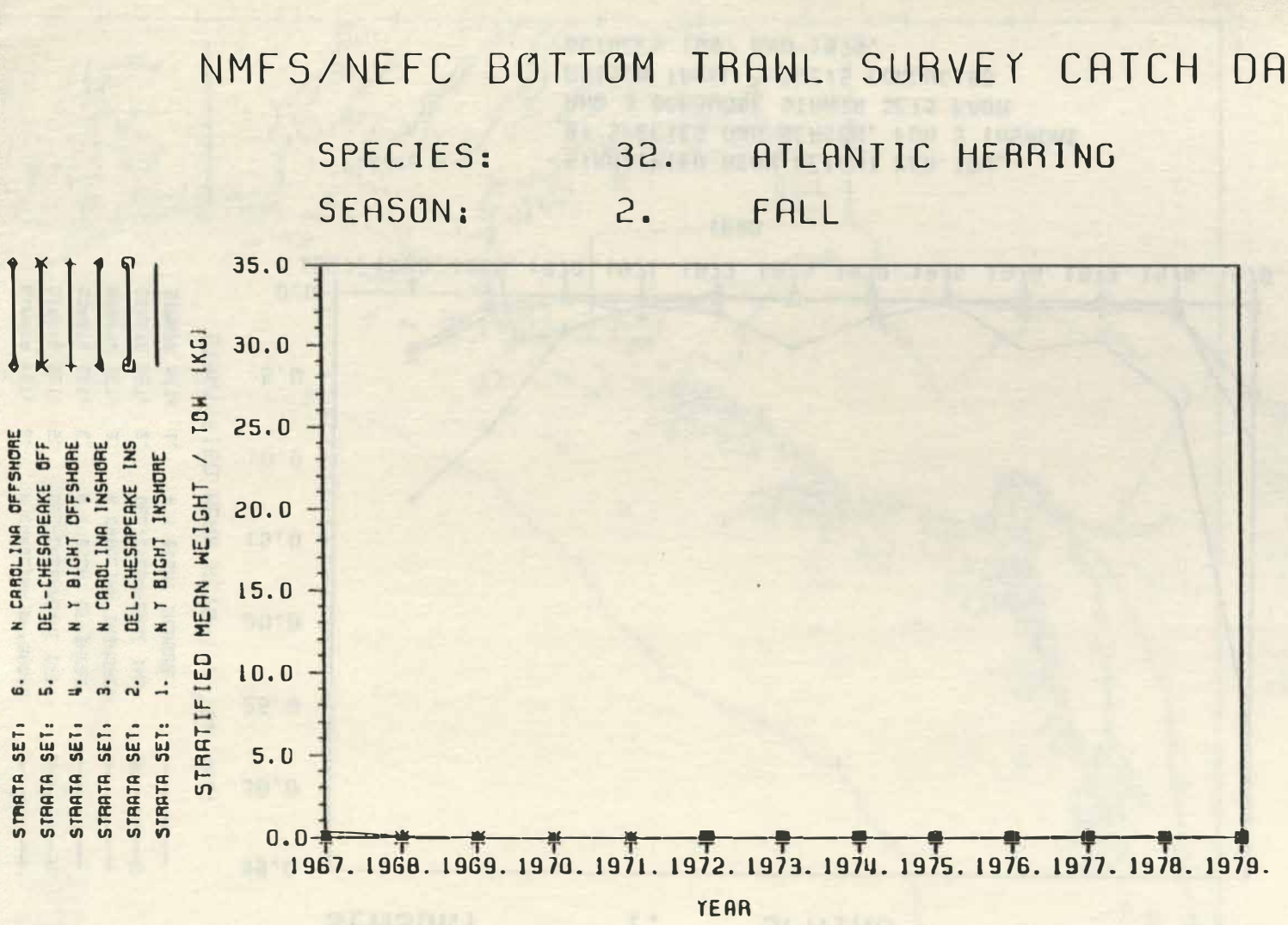


Figure 4.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

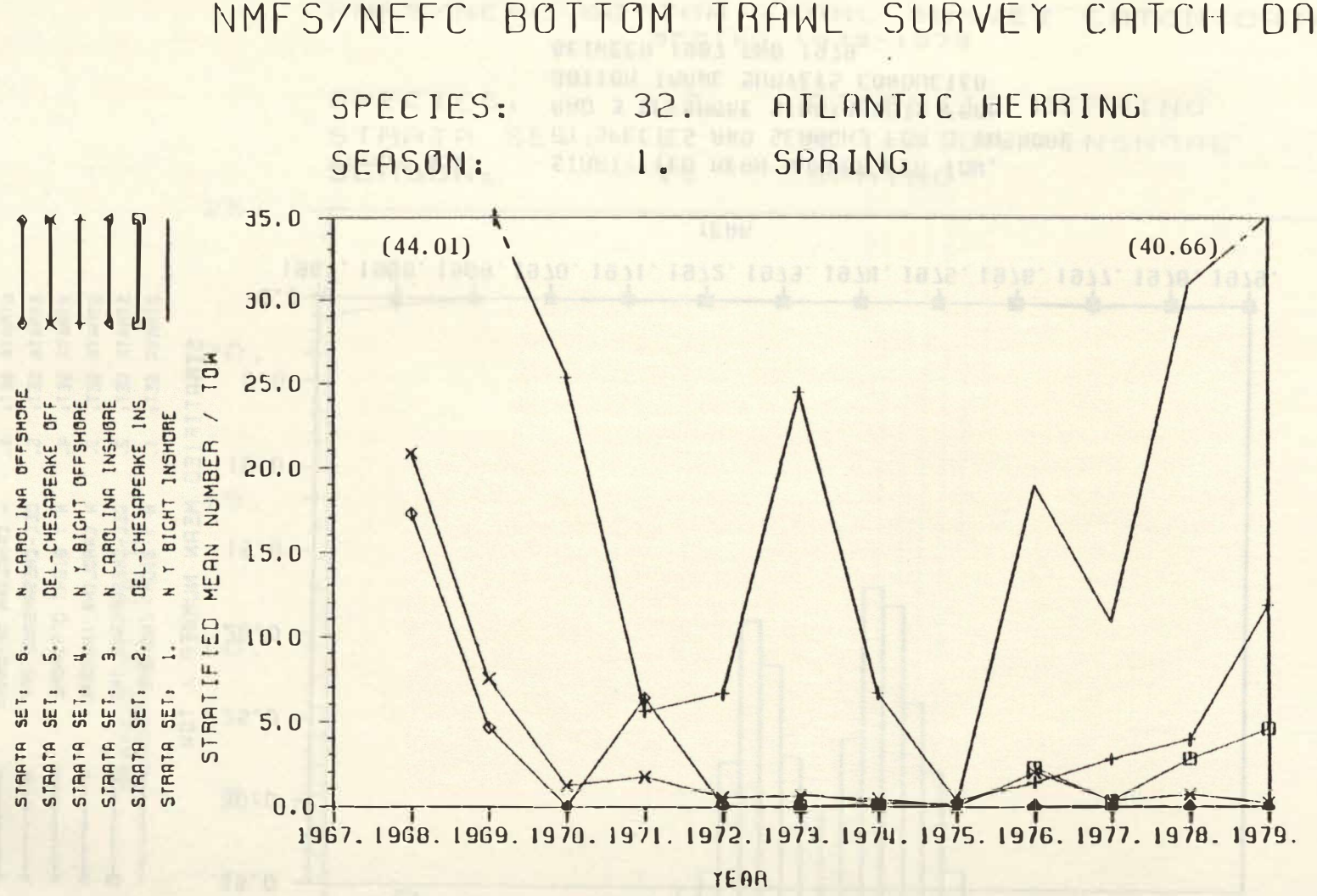


Figure 4.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

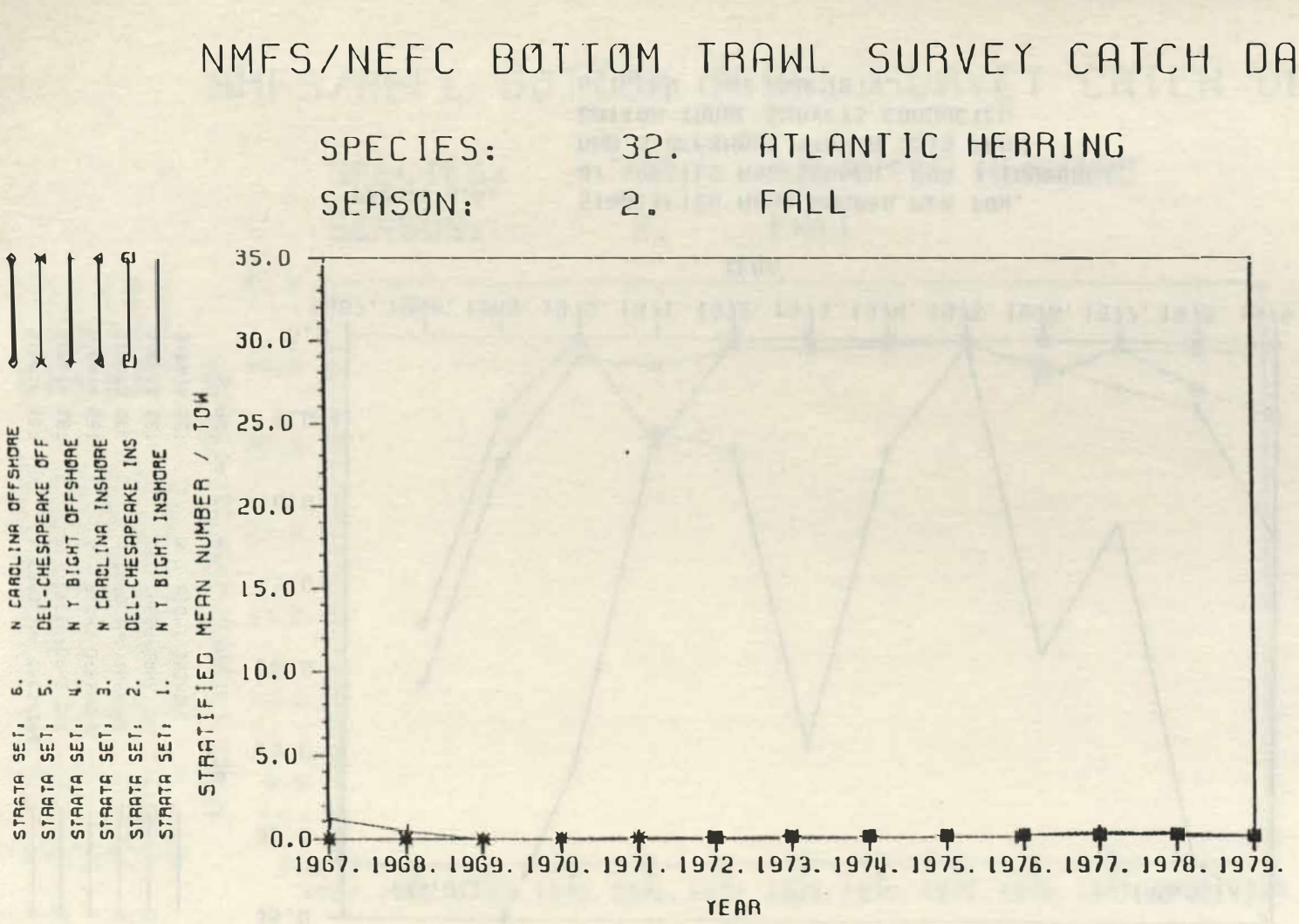


Figure 4.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

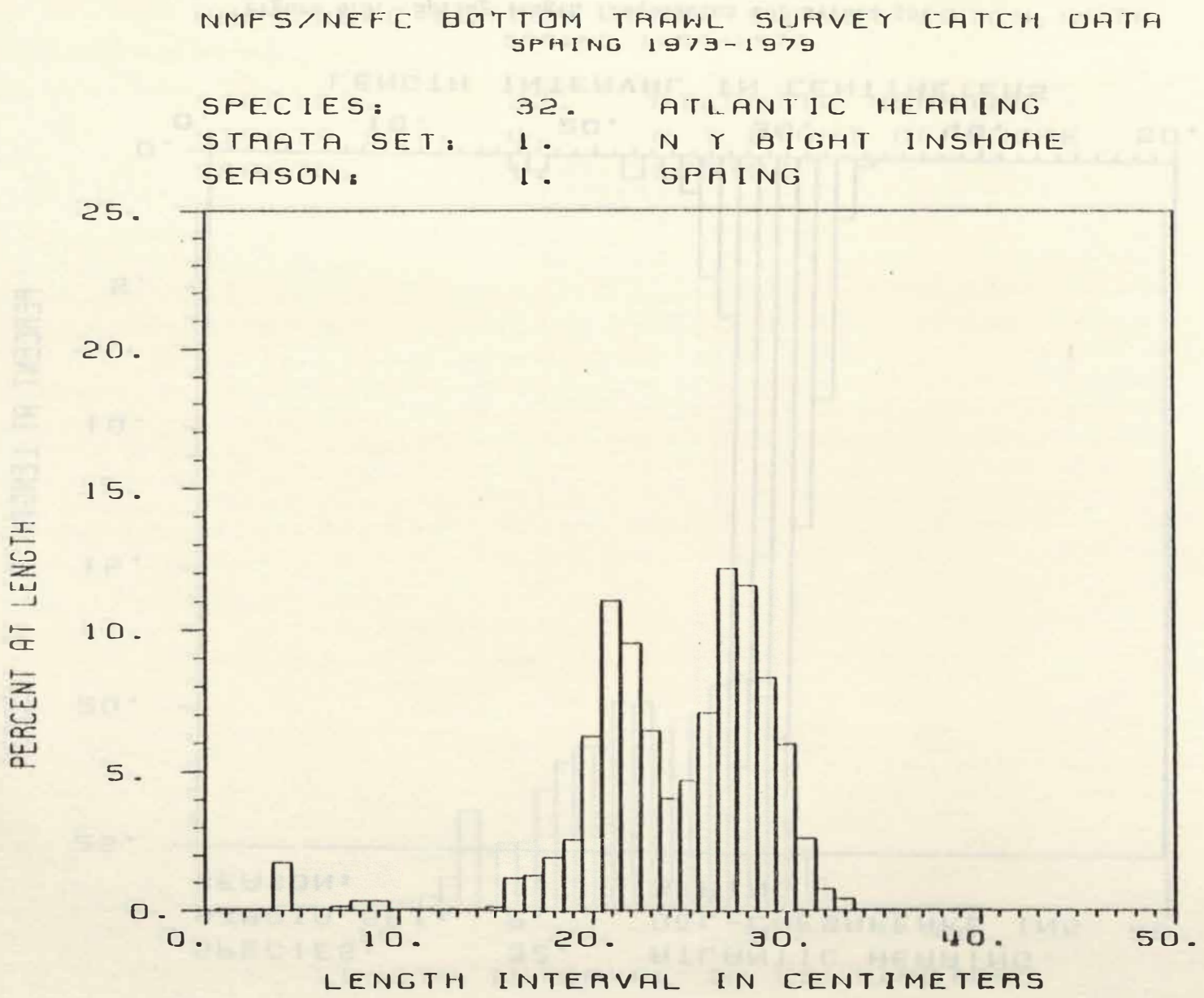


Figure 4.8. Spring length frequencies for strata set 1.

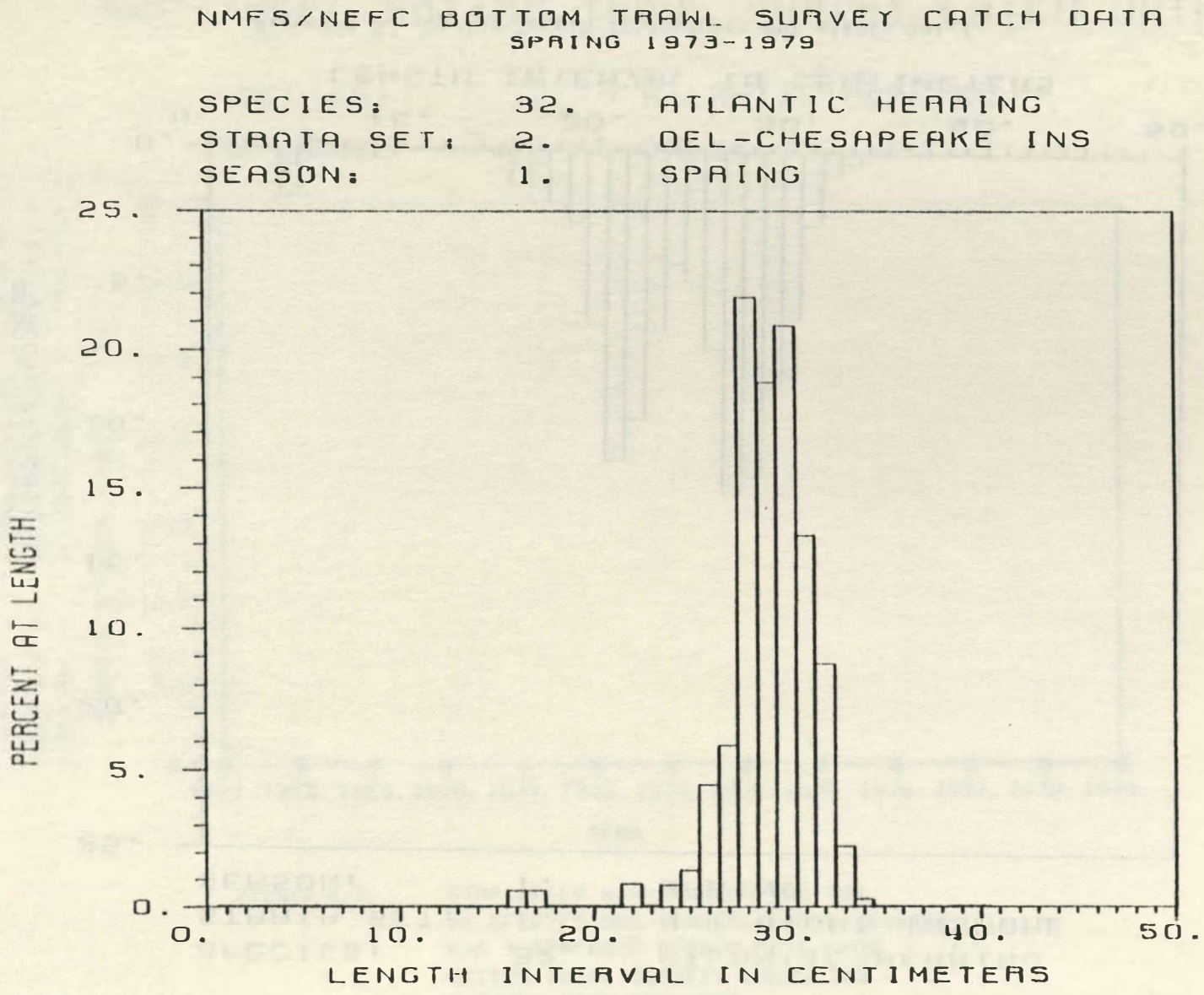


Figure 4.9. Spring length frequencies for strata set 2.

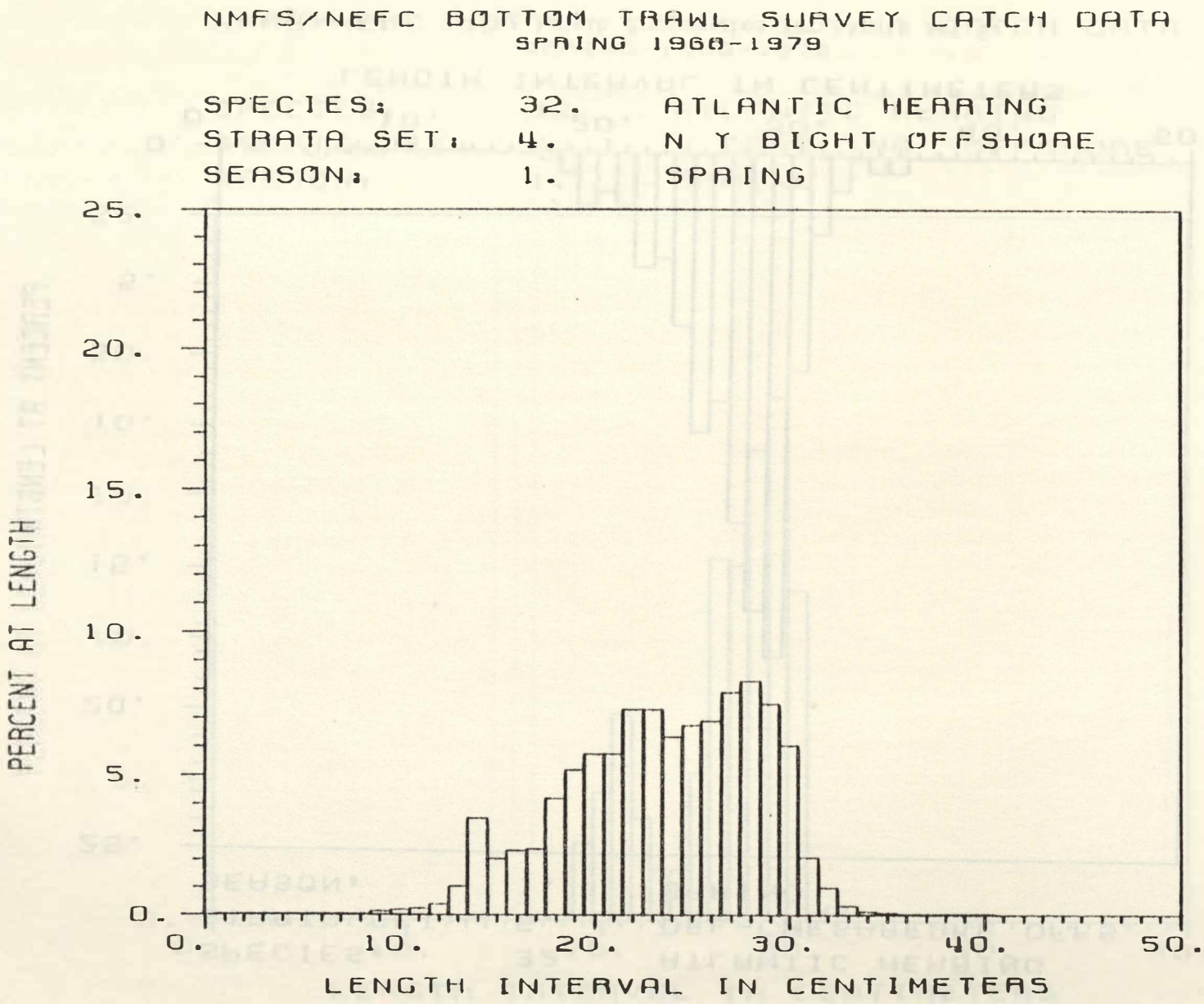


Figure 4.10. Spring length frequencies for strata set 4.

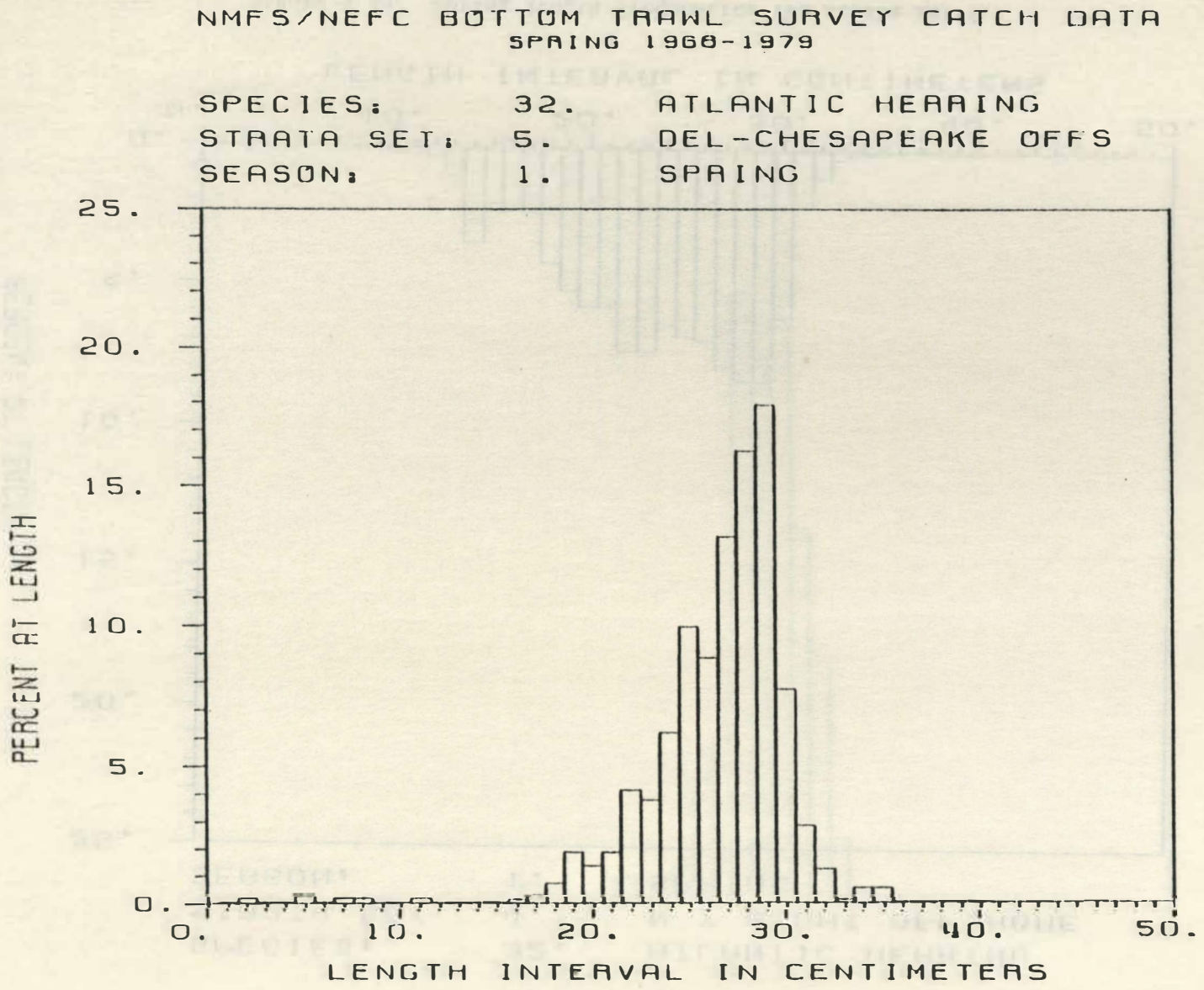


Figure 4.11. Spring length frequencies for strata set 5.

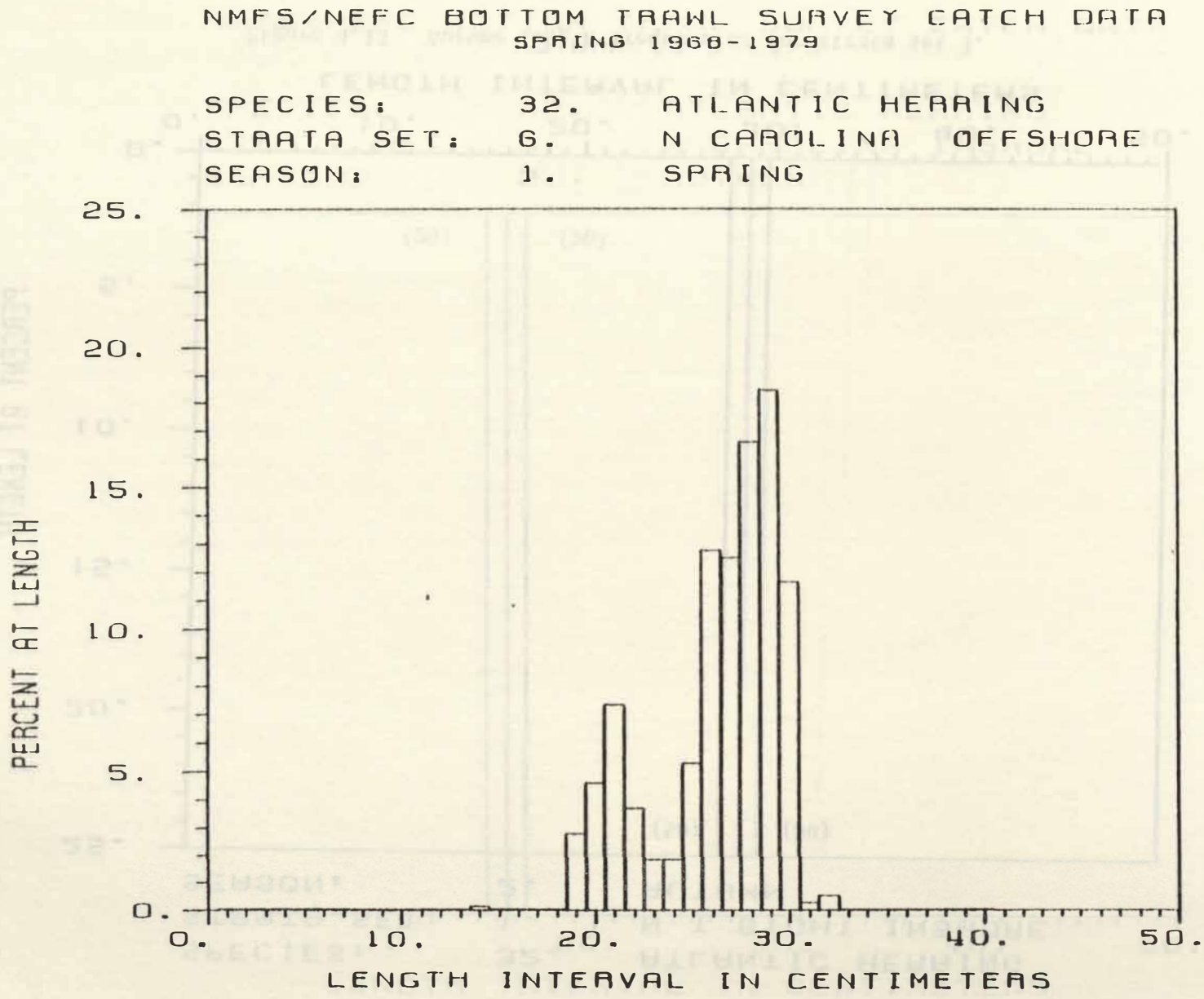


Figure 4.12. Spring length frequencies for strata set 6.

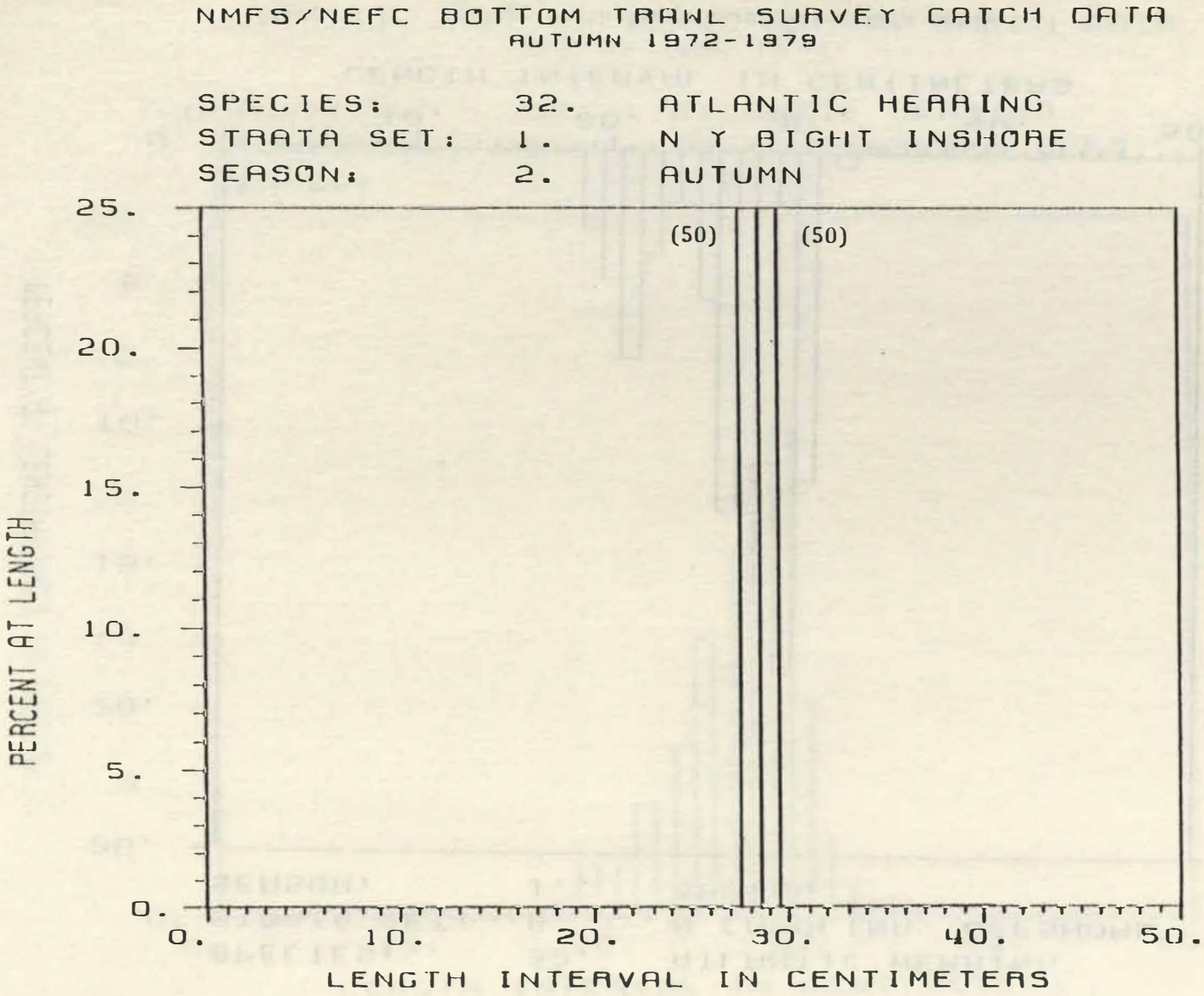


Figure 4.13. Autumn length frequencies for strata set 1.

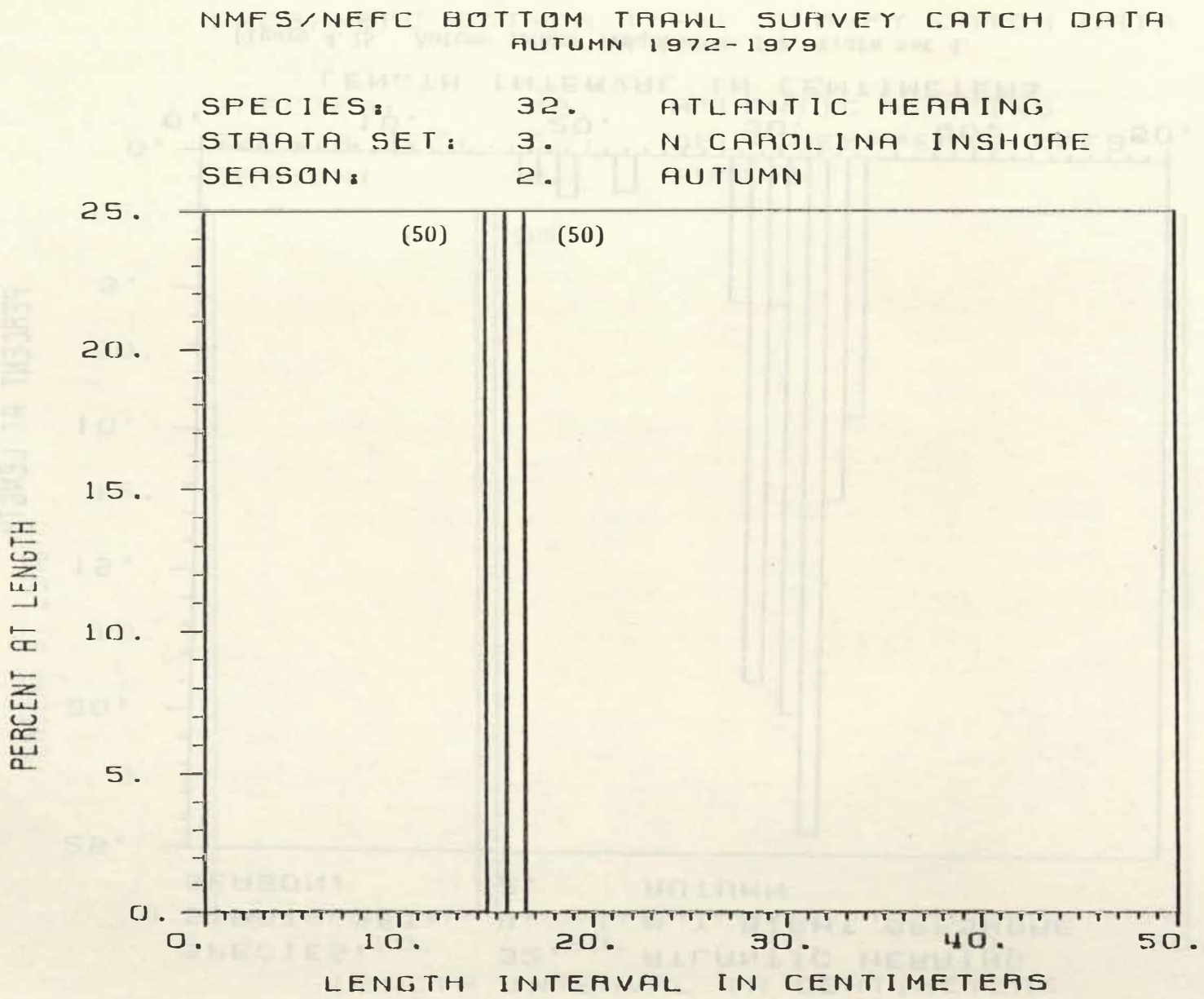


Figure 4.14. Autumn length frequencies for strata set 3.

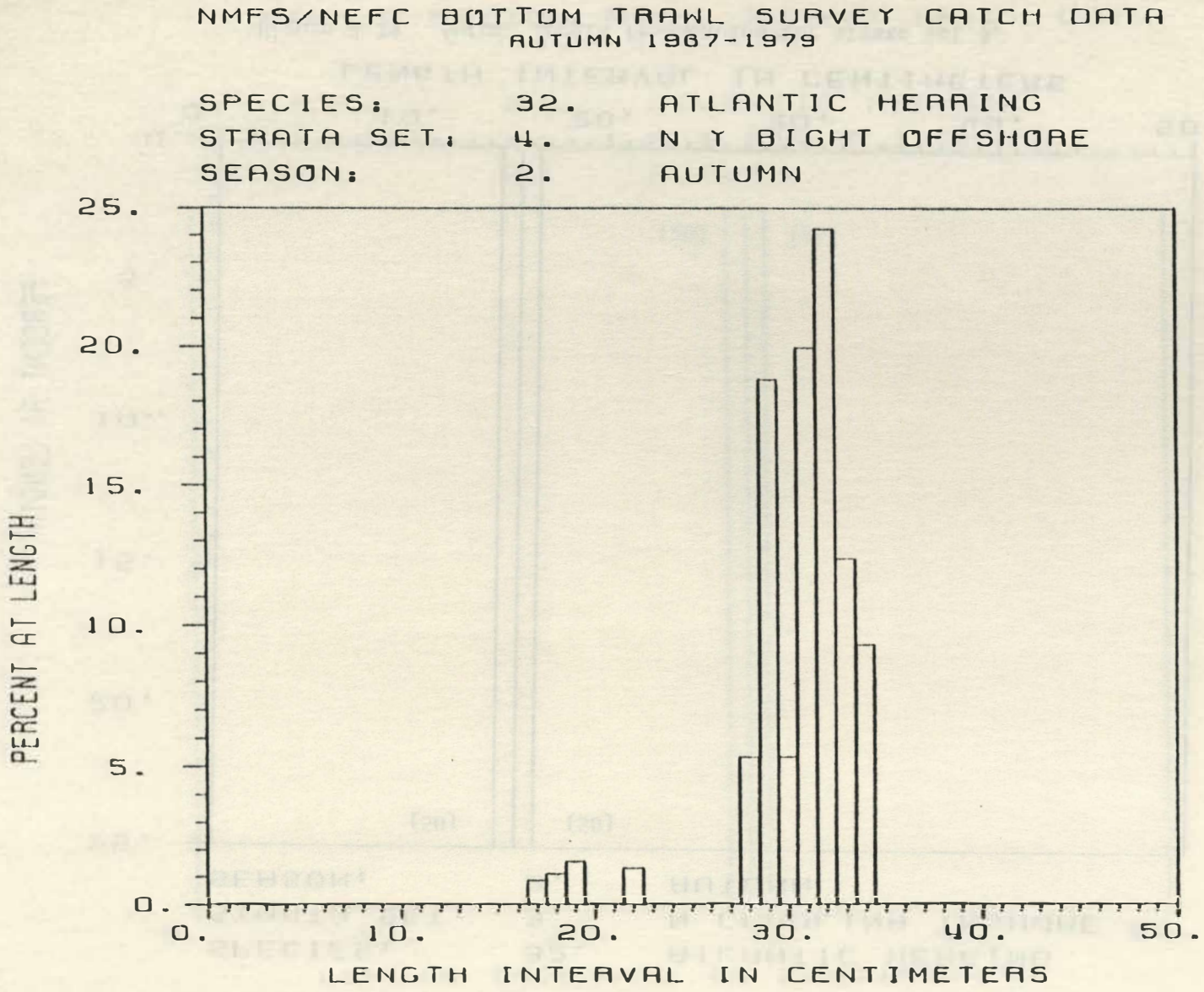


Figure 4.15. Autumn length frequencies for strata set 4.

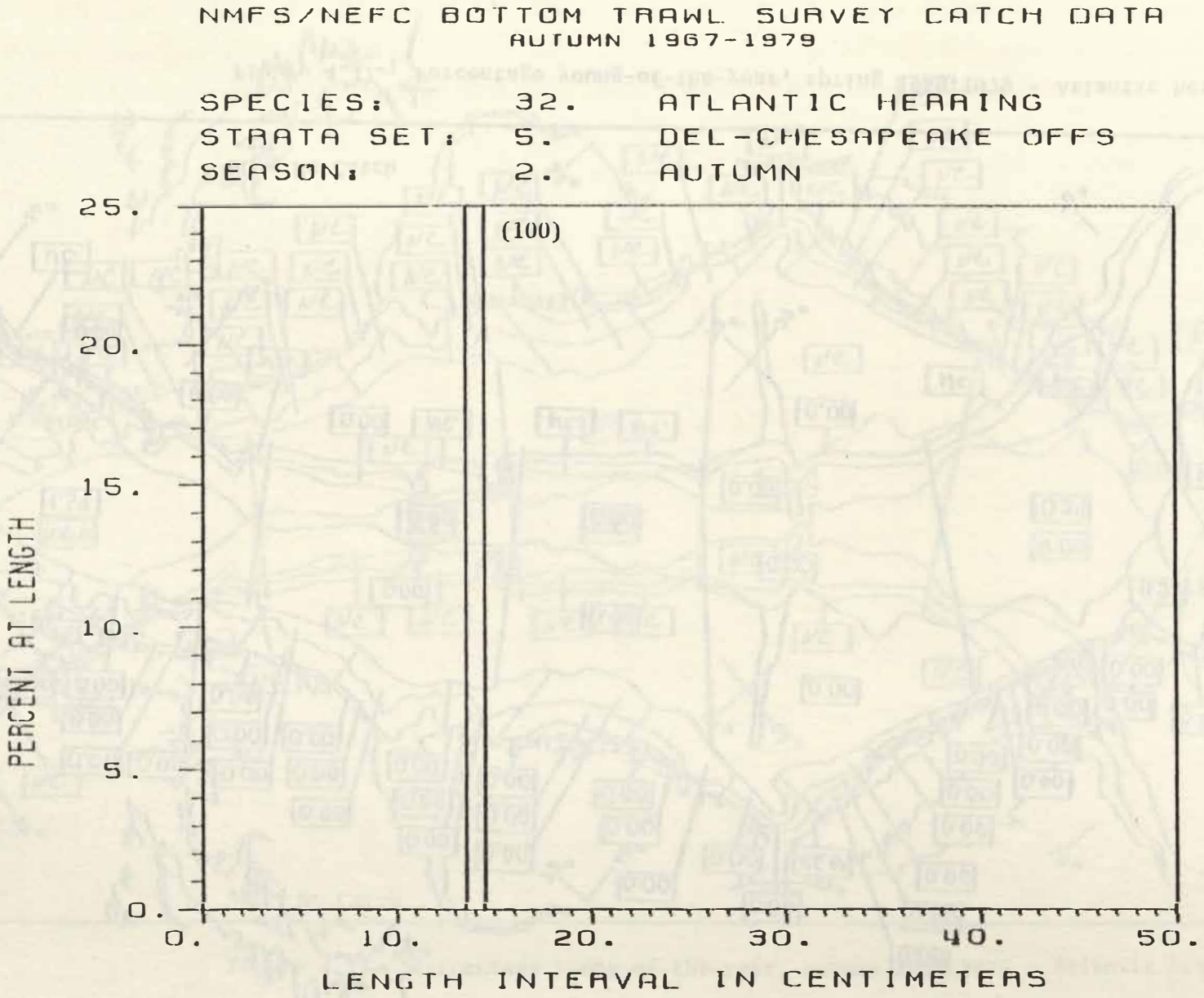


Figure 4.16. Autumn length frequencies for strata set 5.

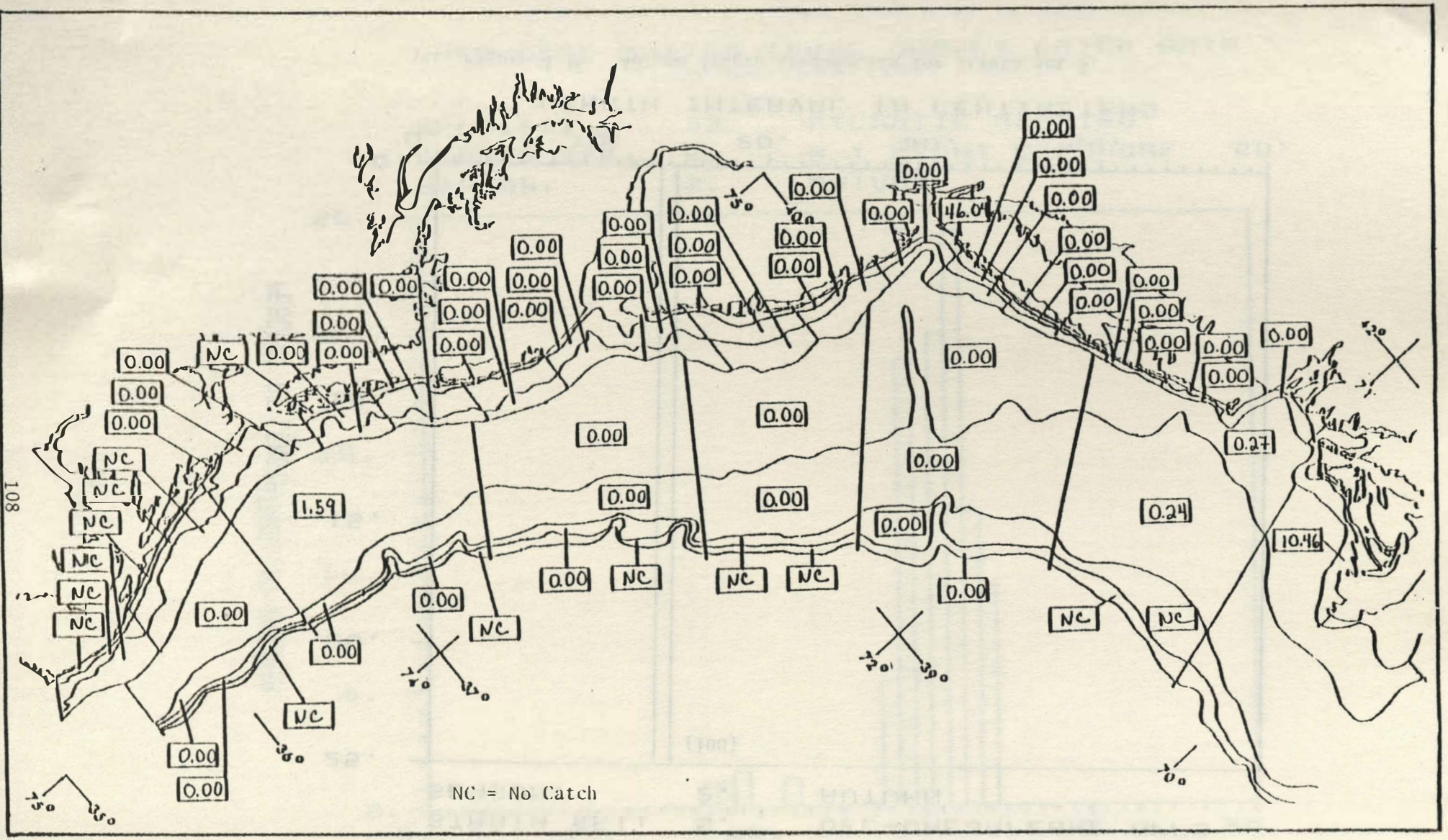


Figure 4.17. Percentage young-of-the-year, spring 1968-1979 - Atlantic herring.

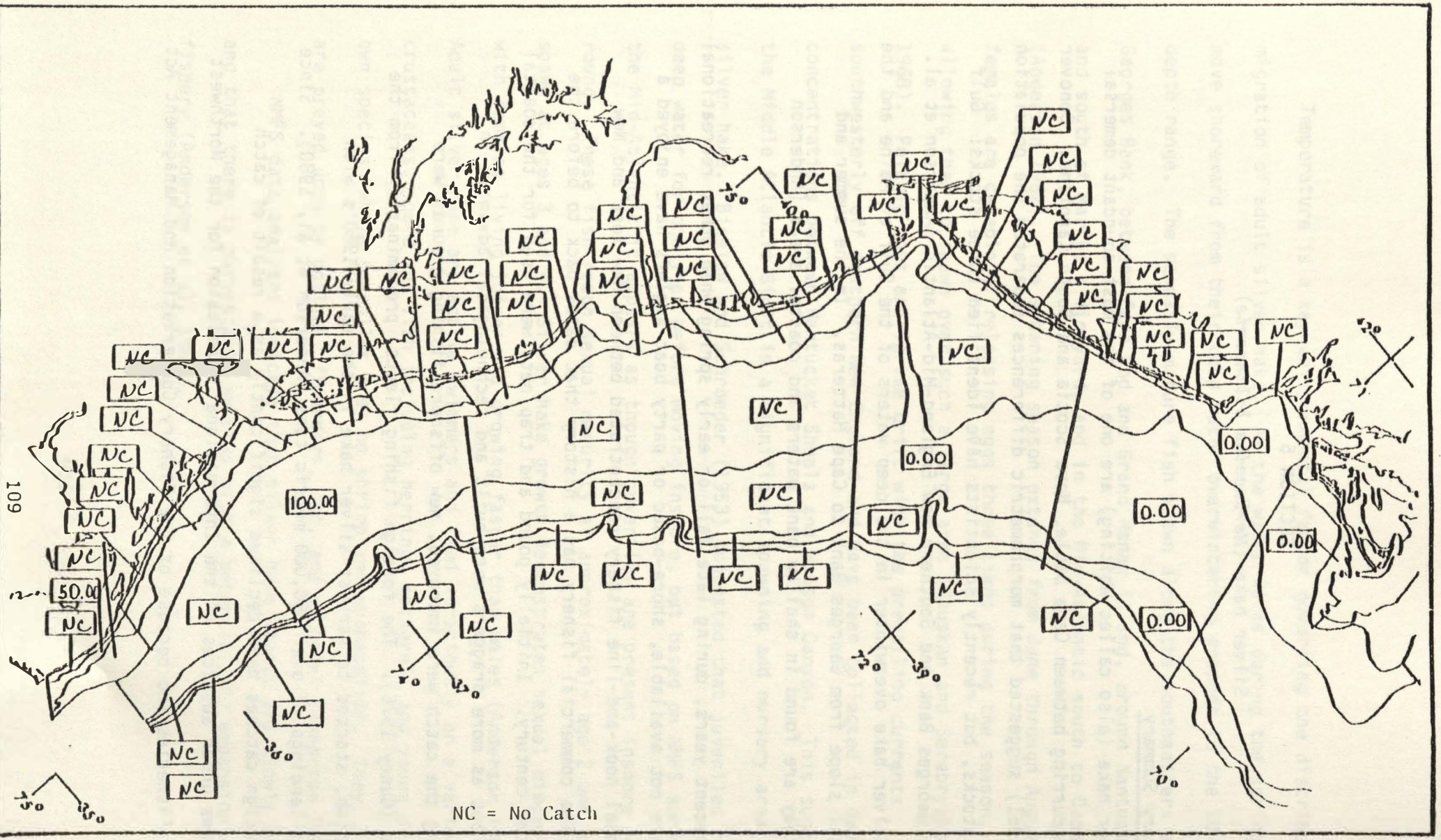


Figure 4.18. Percentage young-of-the-year, autumn 1967-1979 - Atlantic herring.

SECTION 5

Silver hake (*Merluccius bilinearis*)

Life History Summary

Silver hake (also called whiting) are one of the most abundant demersal species occurring between Cape Sable, Nova Scotia and South Carolina. Conover et al. (1961) suggested that morphometric differences separated the population into two stocks, but recently scientists have identified three stocks: Gulf of Maine, Georges Bank and Southern New England-Mid-Atlantic (Anderson et al. 1980). Silver hake overwinter in the deep waters of the Gulf of Maine and the continental slope from Georges Bank to Cape Hatteras. In the summer and autumn, they are found in shallow bank waters and coastal areas (Anderson 1974).

In recent years, during late fall or early spring when other recreational species are not available, shore-based or party boat anglers have enjoyed a recreational hook-and-line fishery concentrated between New York and New Jersey. The commercial fishery has a history that dates back to before the turn of the century. Initially pound and trap nets were used for the coastal fishery, but as more draggers were built and technological advances in processing the catch were improved, new offshore fishing grounds were exploited (Gusey 1976). The foreign fishing fleets, predominantly from the Soviet Union, started to harvest silver hake in the early 1960's with estimated landings of over 350,000 metric tons (Anderson et al. 1980). Since 1973, foreign catches have declined significantly as a result of catch limitations under auspices of the International Commission for the Northwest Atlantic Fisheries and because of the Fishery Conservation and Management Act of 1976.

Temperature is a key environmental factor governing the distribution and migration of adult silver hake. As the water warms during the spring they move shoreward from their deep water overwintering grounds to the 20-80 m depth range. The sexually mature fish spawn along the southeastern slopes of Georges Bank, between Cape Cod and Grand Manan Island, around Nantucket Shoals and south of Martha's Vineyard, and in the Mid-Atlantic south to Cape Hatteras (Anderson 1982). The spawning season extends from June through August, and females are capable of releasing eggs three times during the season, thus allowing them to spawn over such a large area (Sauskan and Serebryakov 1968). Pelagic eggs and larvae drift with the prevailing currents southwesterly off southern New England and have been collected in dense concentrations between Nantucket Shoals and Hudson Canyon. This suggests that the Middle Atlantic Bight is a significant spawning and nursery area for silver hake. Bigelow and Schroeder (1953) suggested that juveniles remain in deep water for one year before moving inshore, but based on NMFS surveys in the Mid-Atlantic it appears as though juveniles are present inshore year round. These fish reach sexual maturity at approximately age 2 and begin to spawn at ages 3 and 4. Silver hake growth demonstrates sexual dimorphism, with females living longer and growing faster than males (Anderson 1982). Adult silver hake are active swimmers and feed voraciously on a variety of crustaceans, squid and fish including herring, mackerel, and young of their own species, while juveniles prey on shrimp and euphausiids. They, in turn, are preyed upon by pollock, flounders, cod, and mackerel (Anderson 1982).

NMFS data analyses indicate that silver hake stocks are slowly rebuilding and that there is harvestable surplus with a potential for expansion of the fishery (Anderson et al. 1980).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 5.1 and 5.2. The plots show quite dramatically that silver hake were distributed over a large portion of the Mid-Atlantic shelf during each seasonal survey. The spring distribution (Figure 5.1) shows silver hake over most of the shelf, with large catches along the 100 m depth contour and north of New Jersey. In Figure 5.3 data from all cruises prior to 1976 have been deleted. This deletion frequently produces a significantly different distribution pattern because of the timing of the surveys, however, this is not evident with silver hake since the basic distribution pattern is the same in both Figures 5.1 and 5.3. The autumn distribution (Figures 5.2) shows the greatest concentration of fish in southern New England waters with some occurrences along the 100 m contour to southern portions of the area. Inshore catches were few especially south of New Jersey, indicating the southern movement from northern summering grounds had begun.

The seasonal plots of mean weight and number per tow by year are shown in Figures 5.4-5.7. The recovery of the stocks from low population levels in the late 1960's is apparent.

Plots of length frequencies by strata set and season are shown in Figures 5.8-5.19. During both seasons the adult silver hake were only rarely caught in the inshore Delaware-Chesapeake and North Carolina strata sets (Figures 5.9-5.10). Large adult fish greater than 40 cm were caught in significant numbers only in the central and northern strata sets during the spring (Figures 5.8-5.9 and 5.11-5.12).

Young-of-the-year (YOY) plots for the spring and autumn seasons are shown in Figures 5.20 and 5.21, respectively. The cutoff size for spring was <17 cm and for autumn <6 cm. The only consistent feature here was the high percentage of YOY in southern inshore areas in the spring (Figure 5.2) reflecting the lack of adults in these areas.

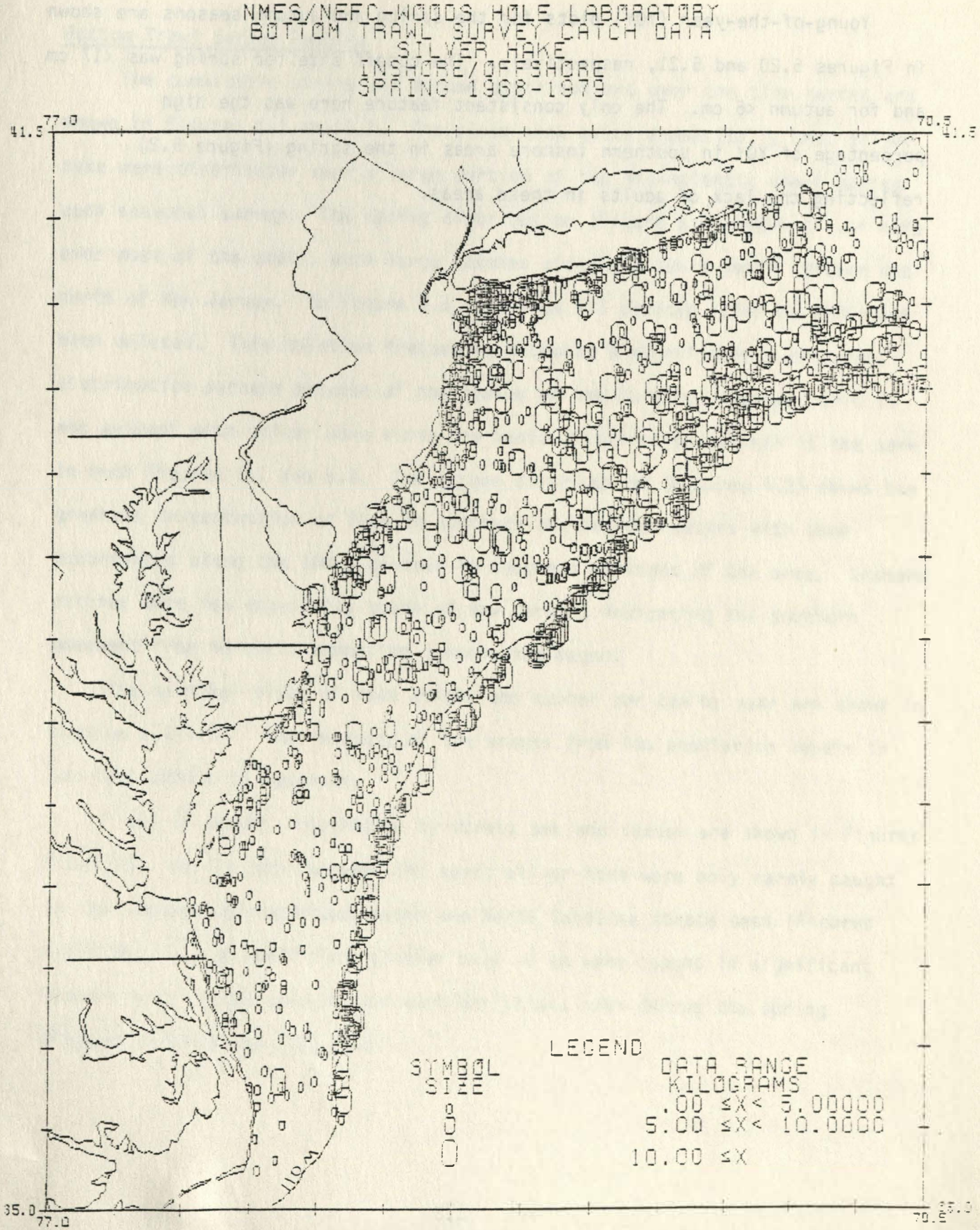


Figure 5.1. Spring distribution, 1968-1979.

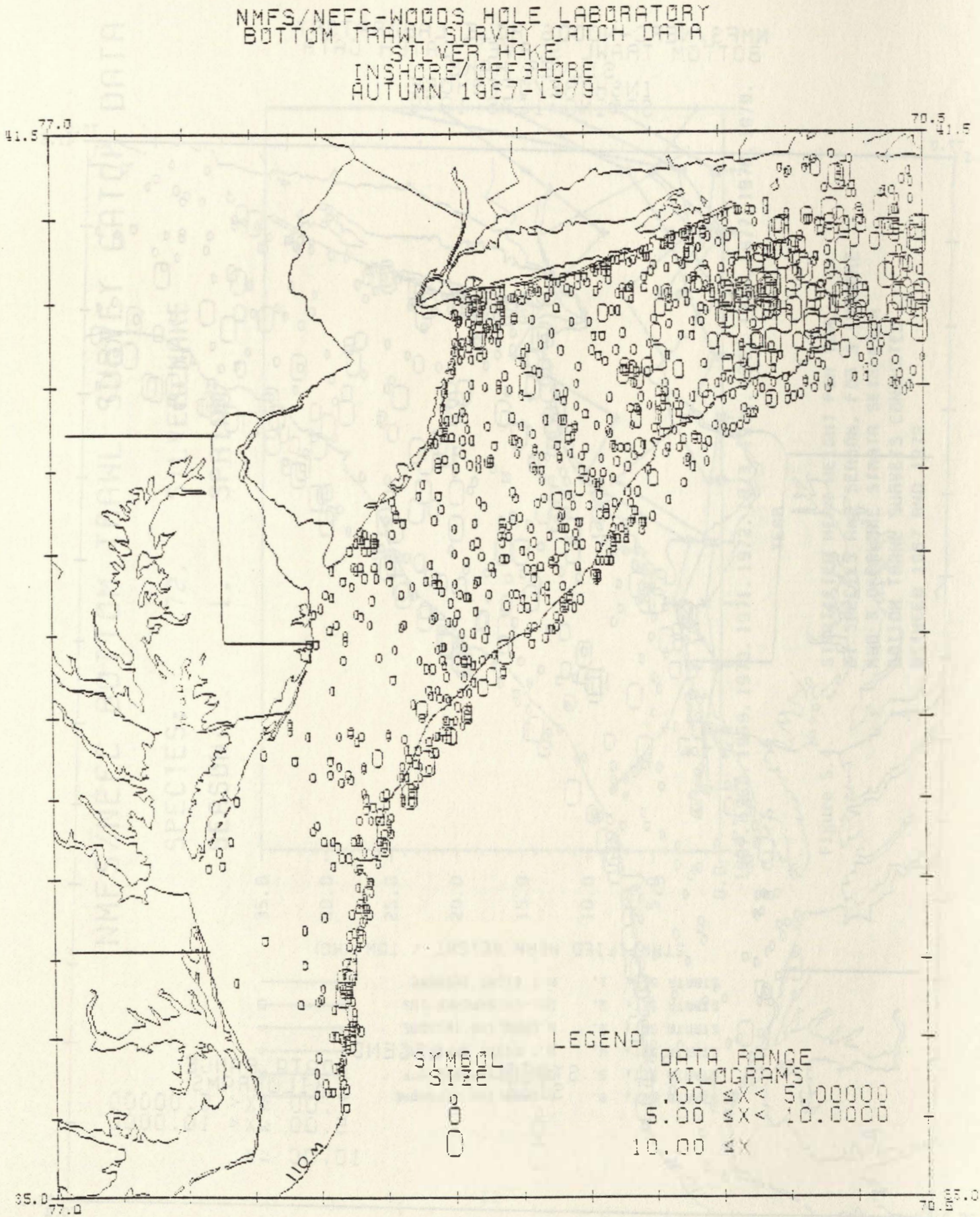


Figure 5.2. Autumn distribution, 1967-1979.

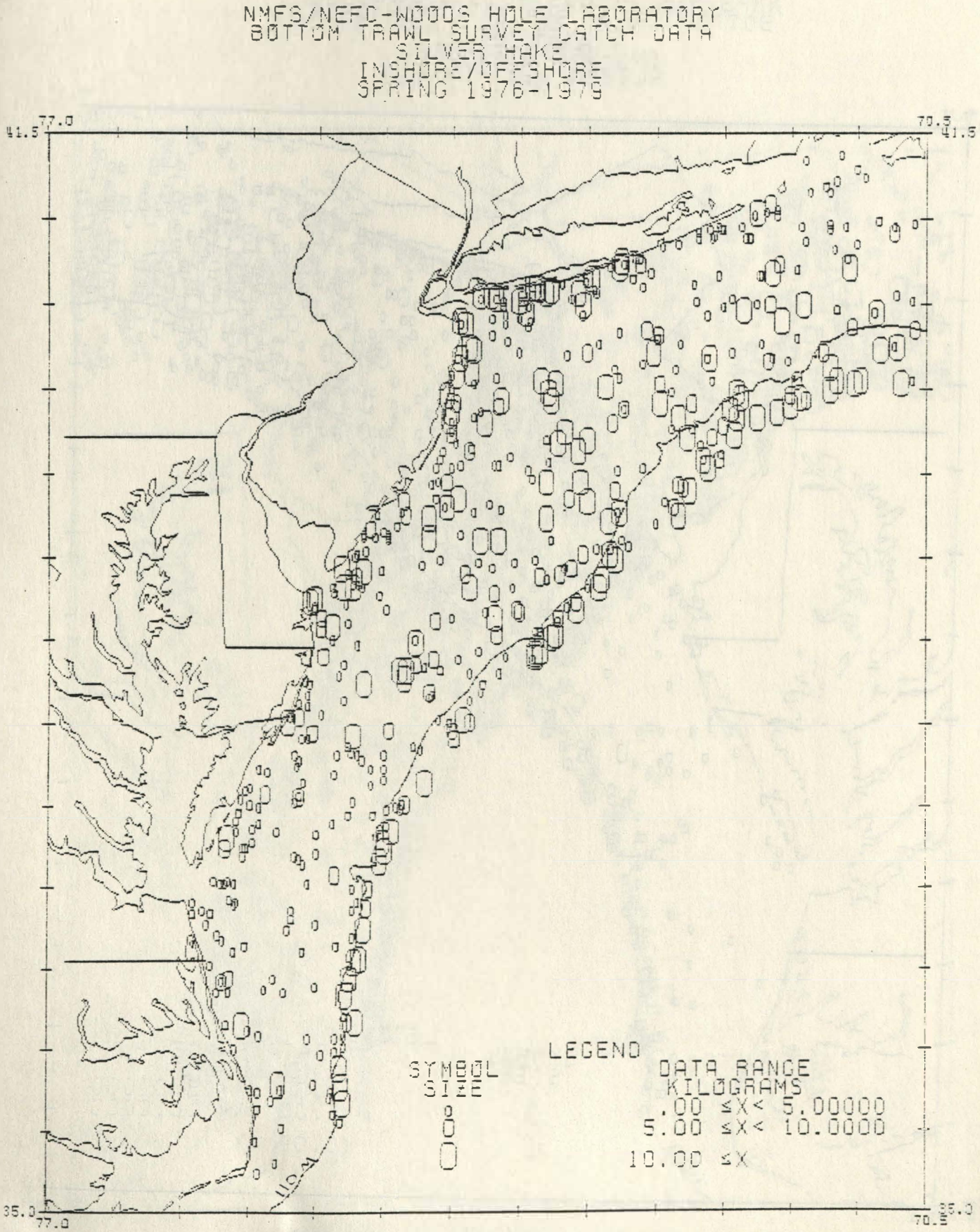


Figure 5.3. Spring distribution, 1976-1979.

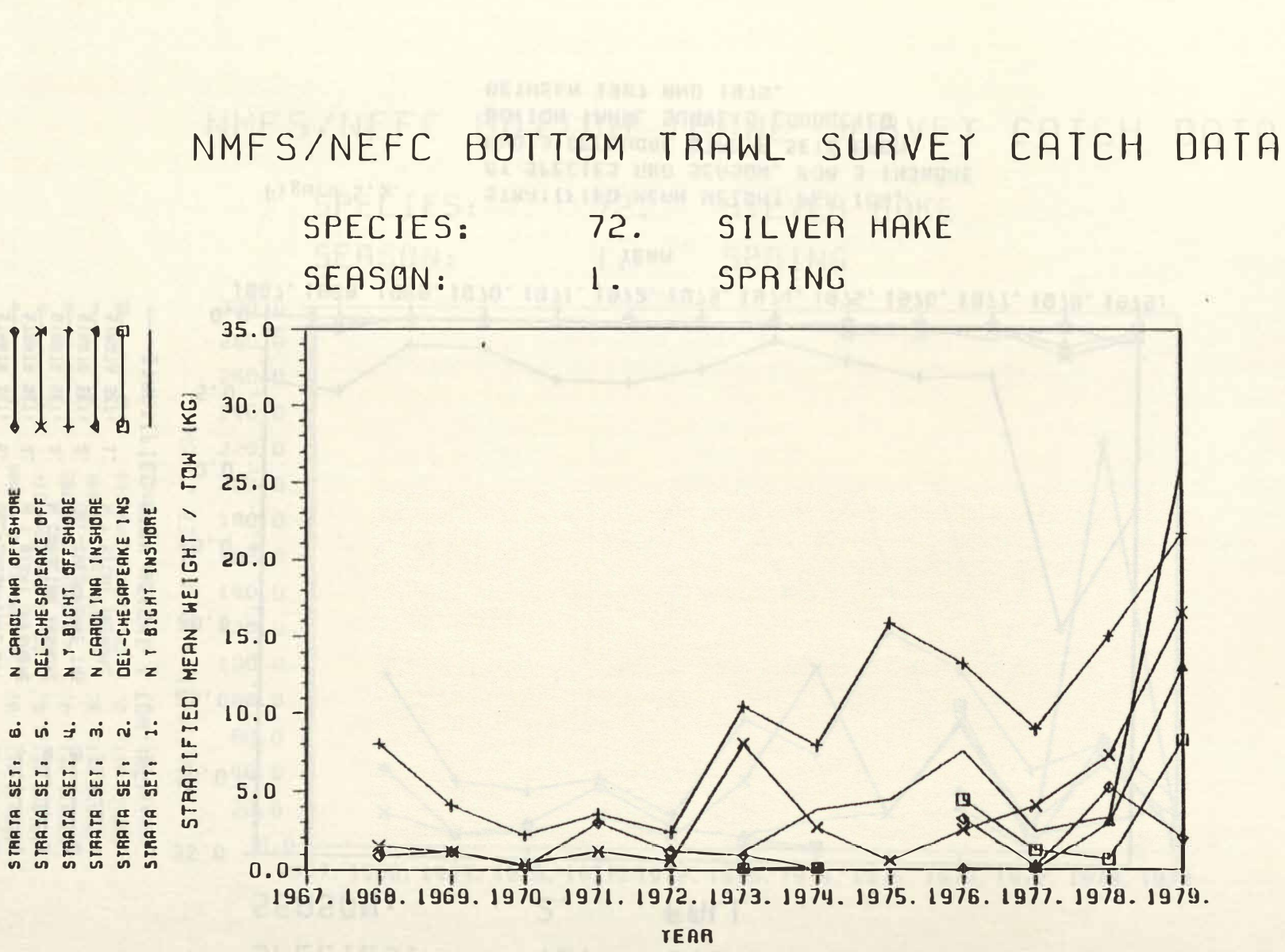


Figure 5.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

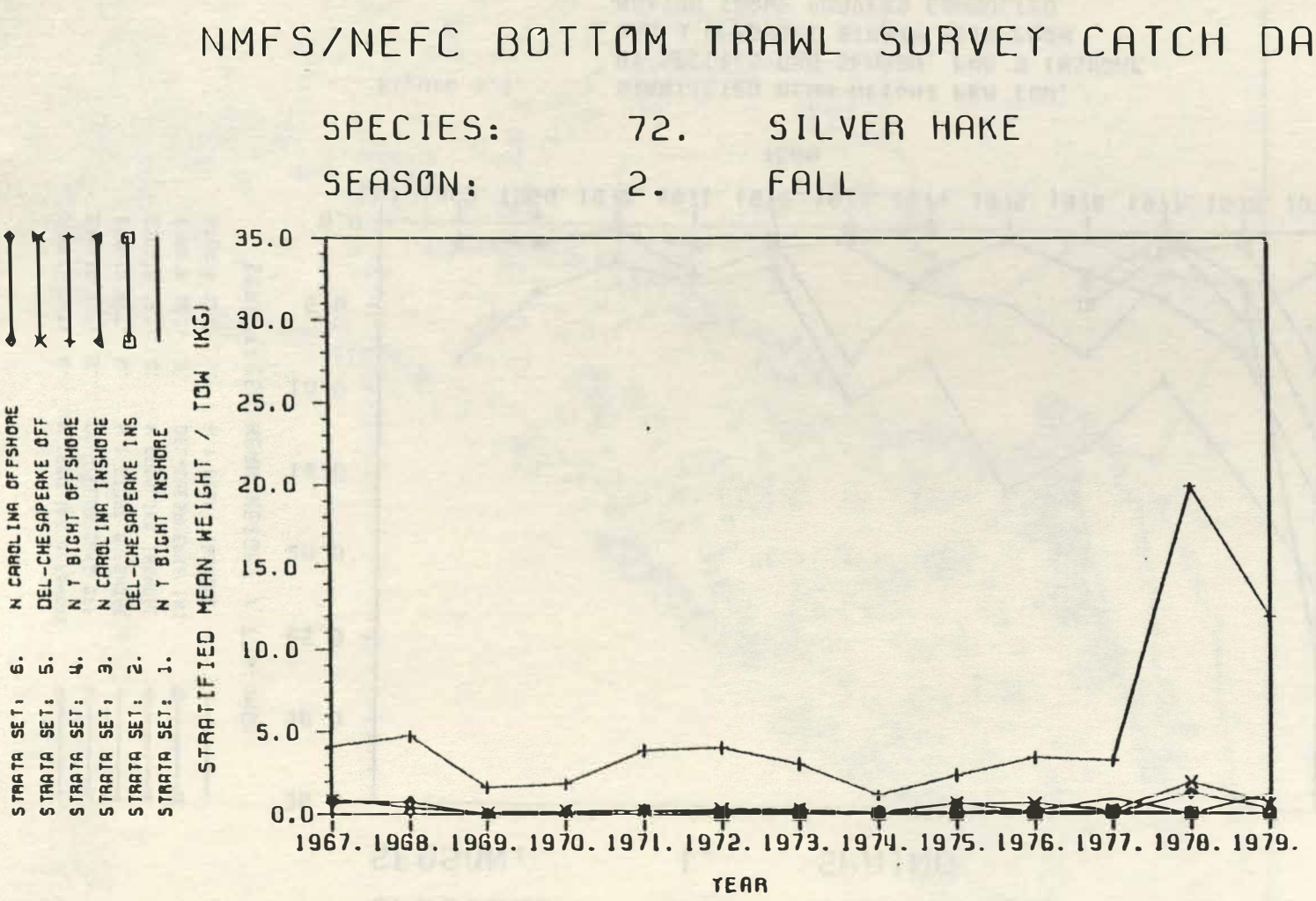


Figure 5.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

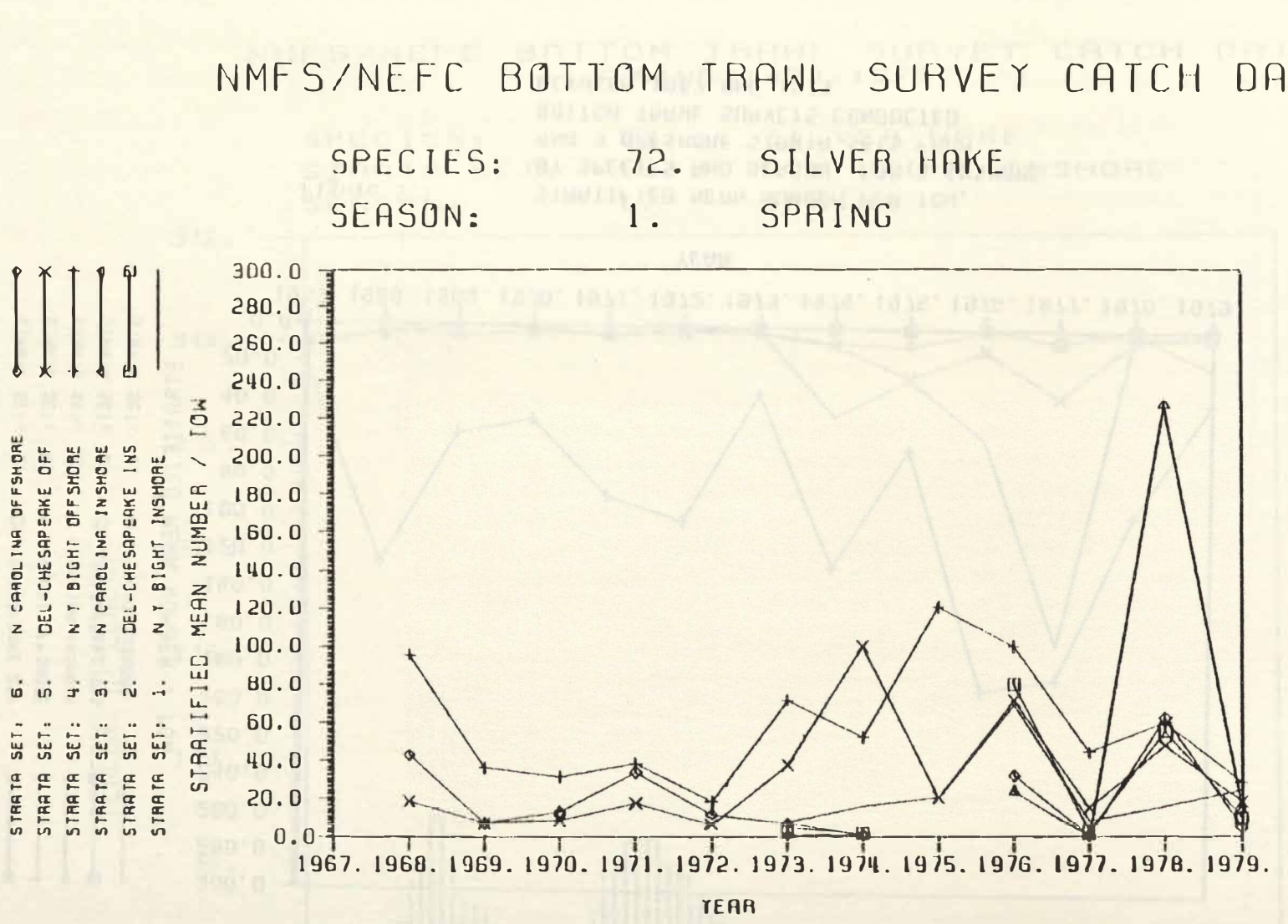


Figure 5.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 72. SILVER HAKE

SEASON: 2. FALL

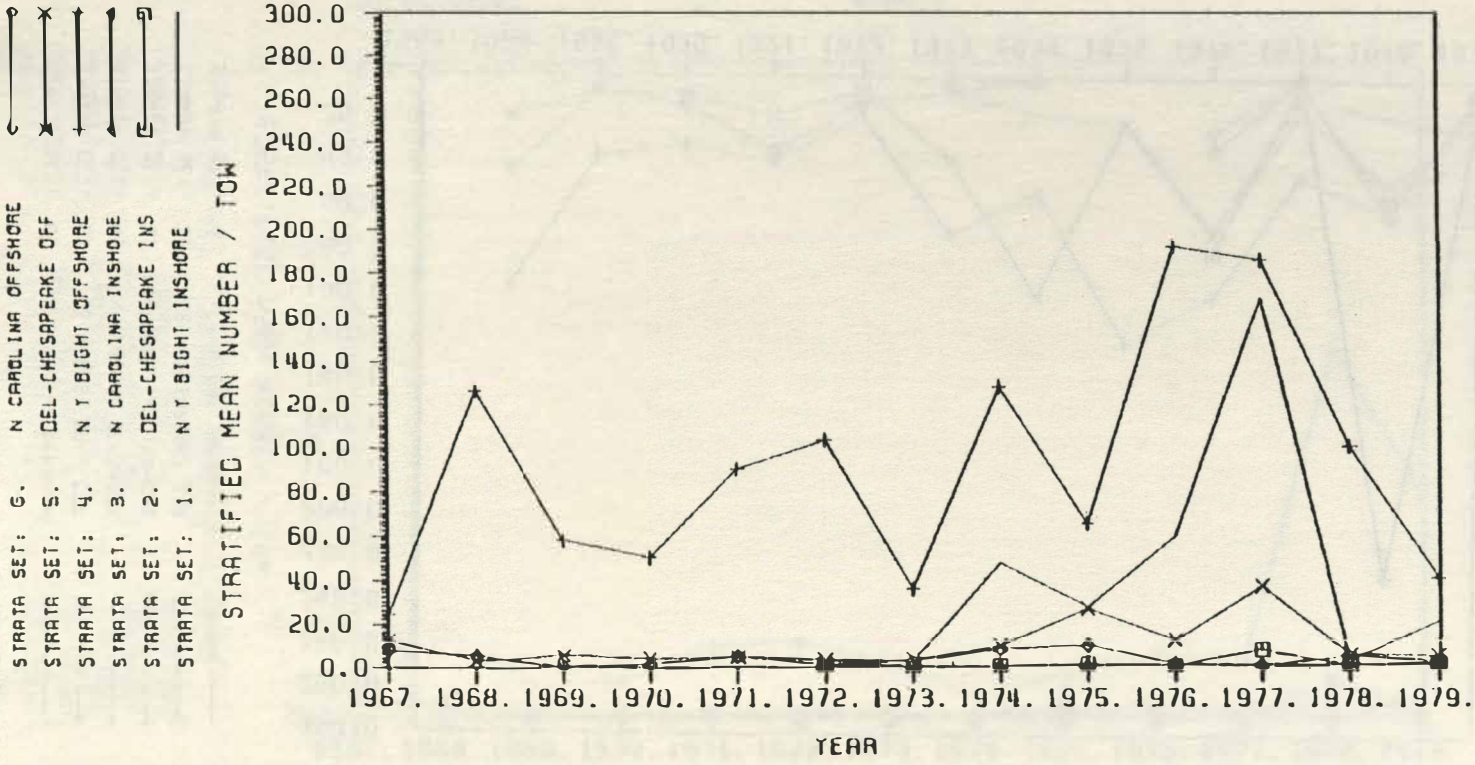


Figure 5.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

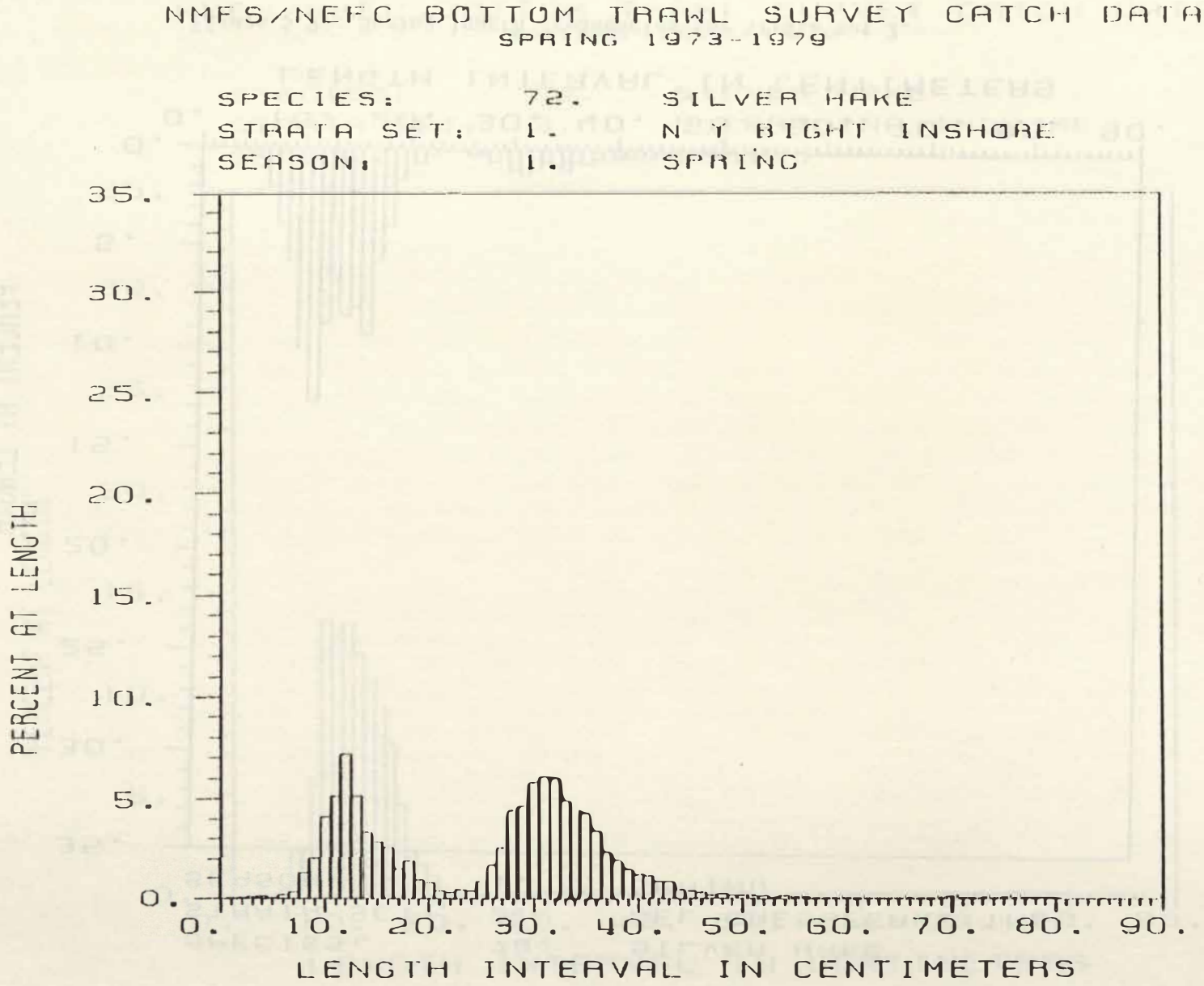


Figure 5.8. Spring length frequencies for strata set 1.

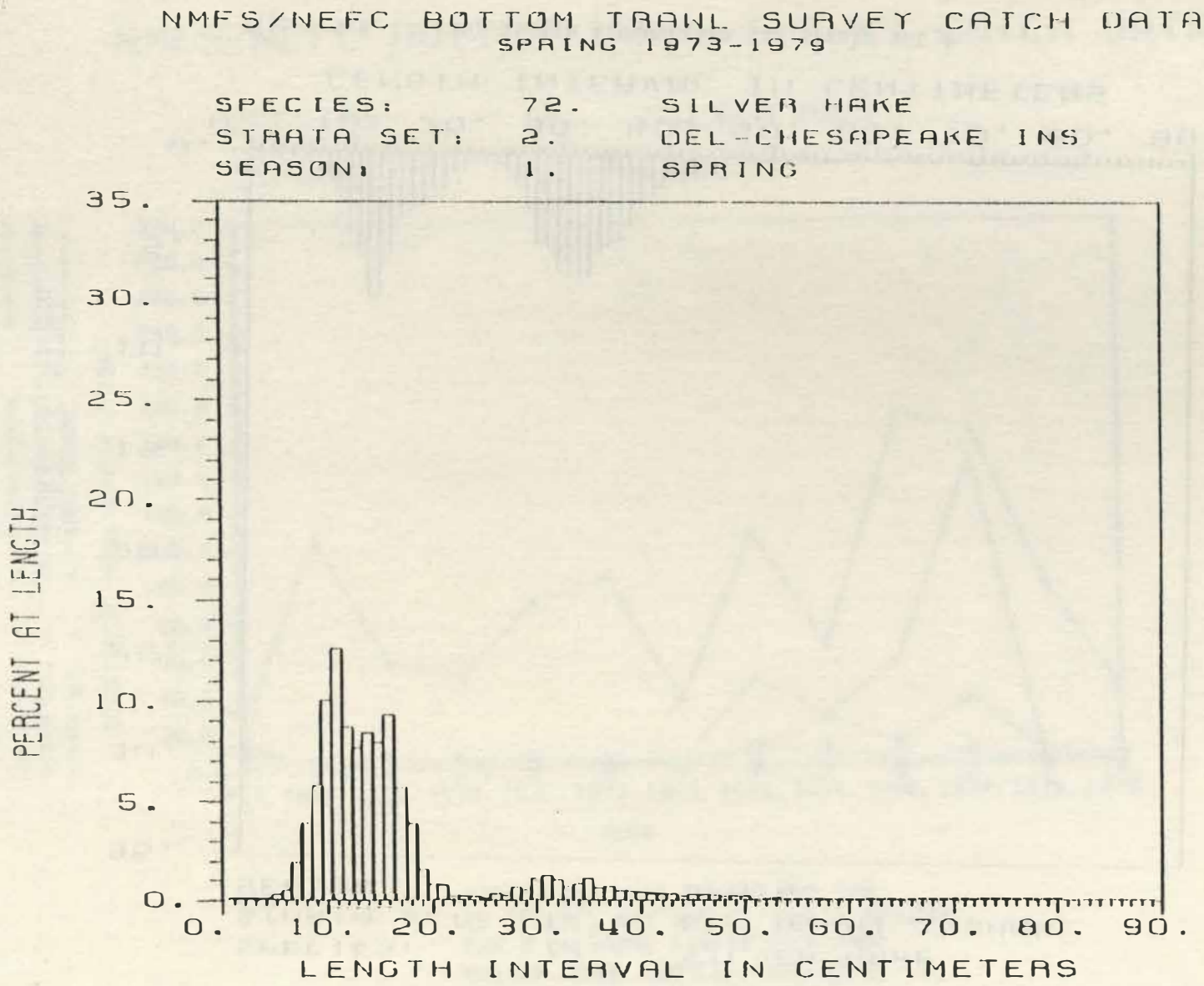


Figure 5.9. Spring length frequencies for strata set 2.

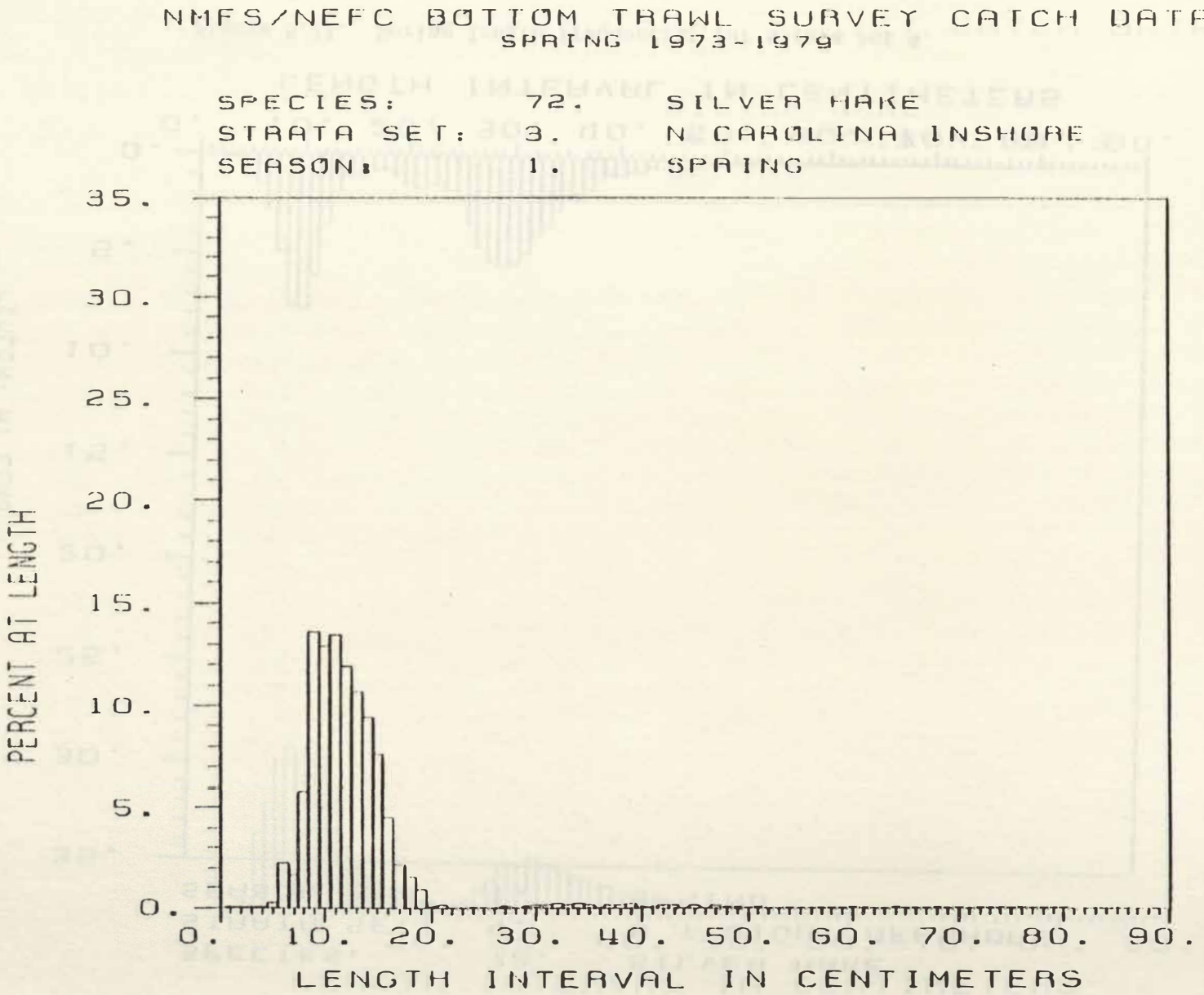


Figure 5.10. Spring length frequencies for strata set 3.

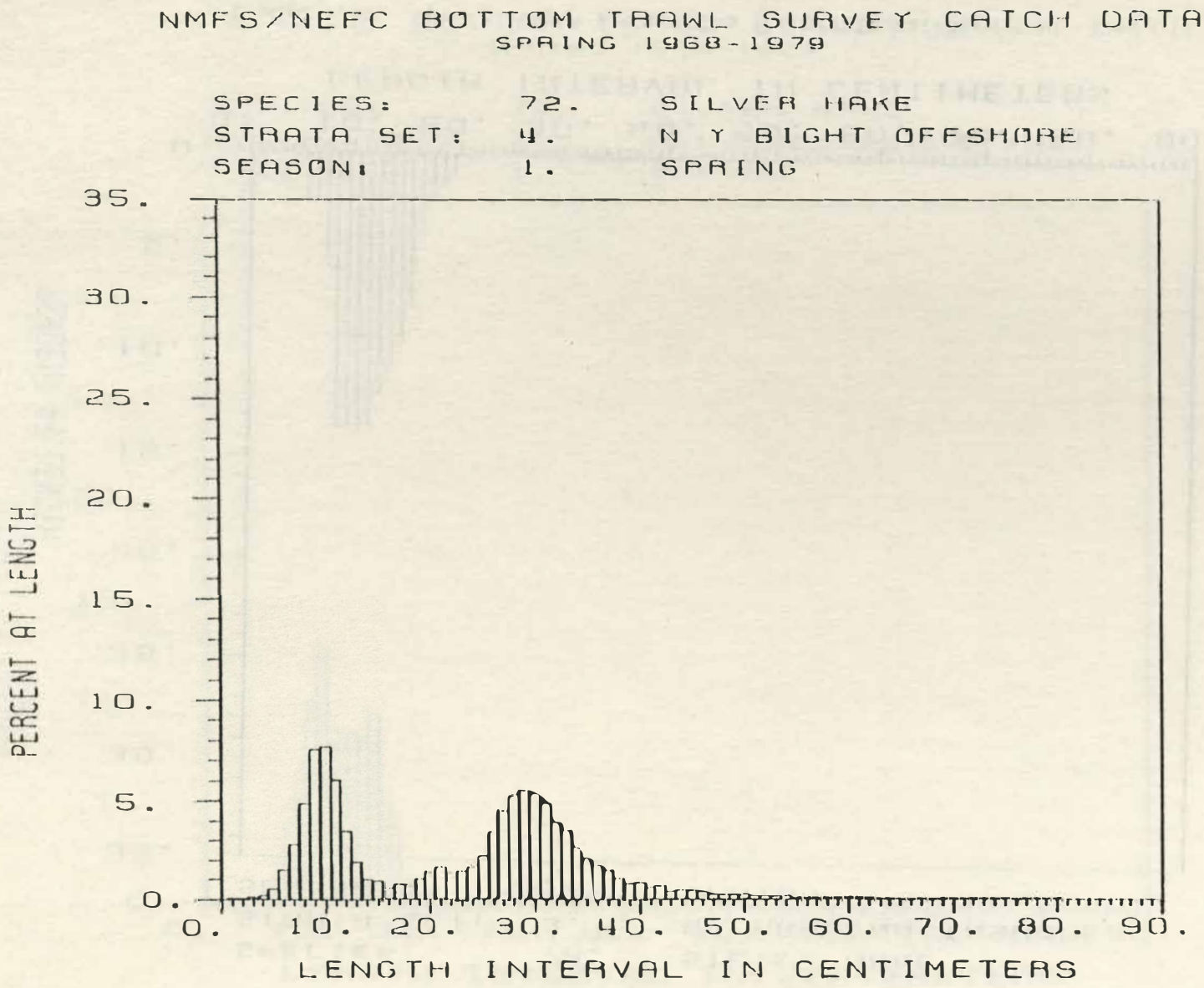


Figure 5.11. Spring length frequencies for strata set 4.

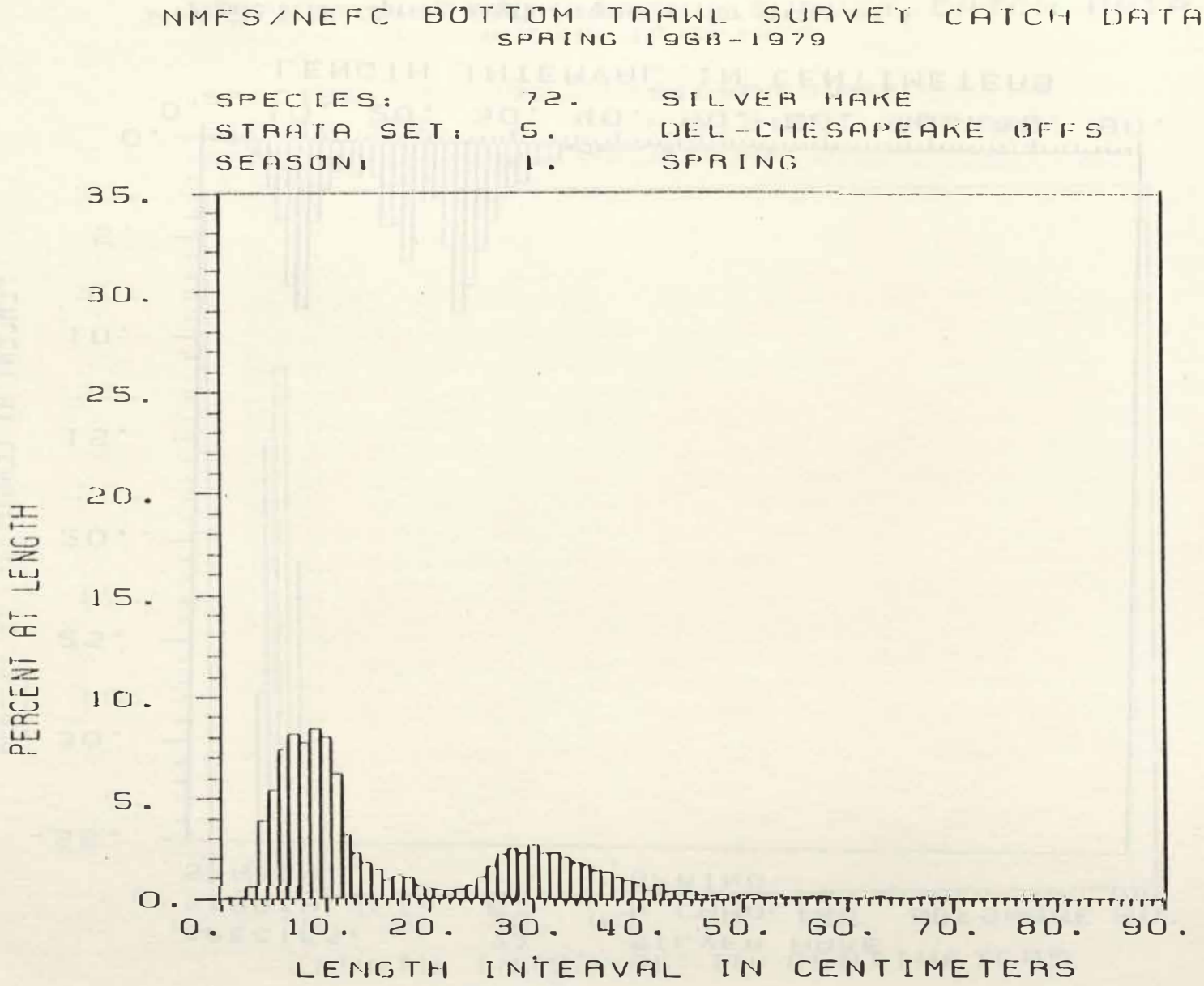


Figure 5.12. Spring length frequencies for strata set 5.

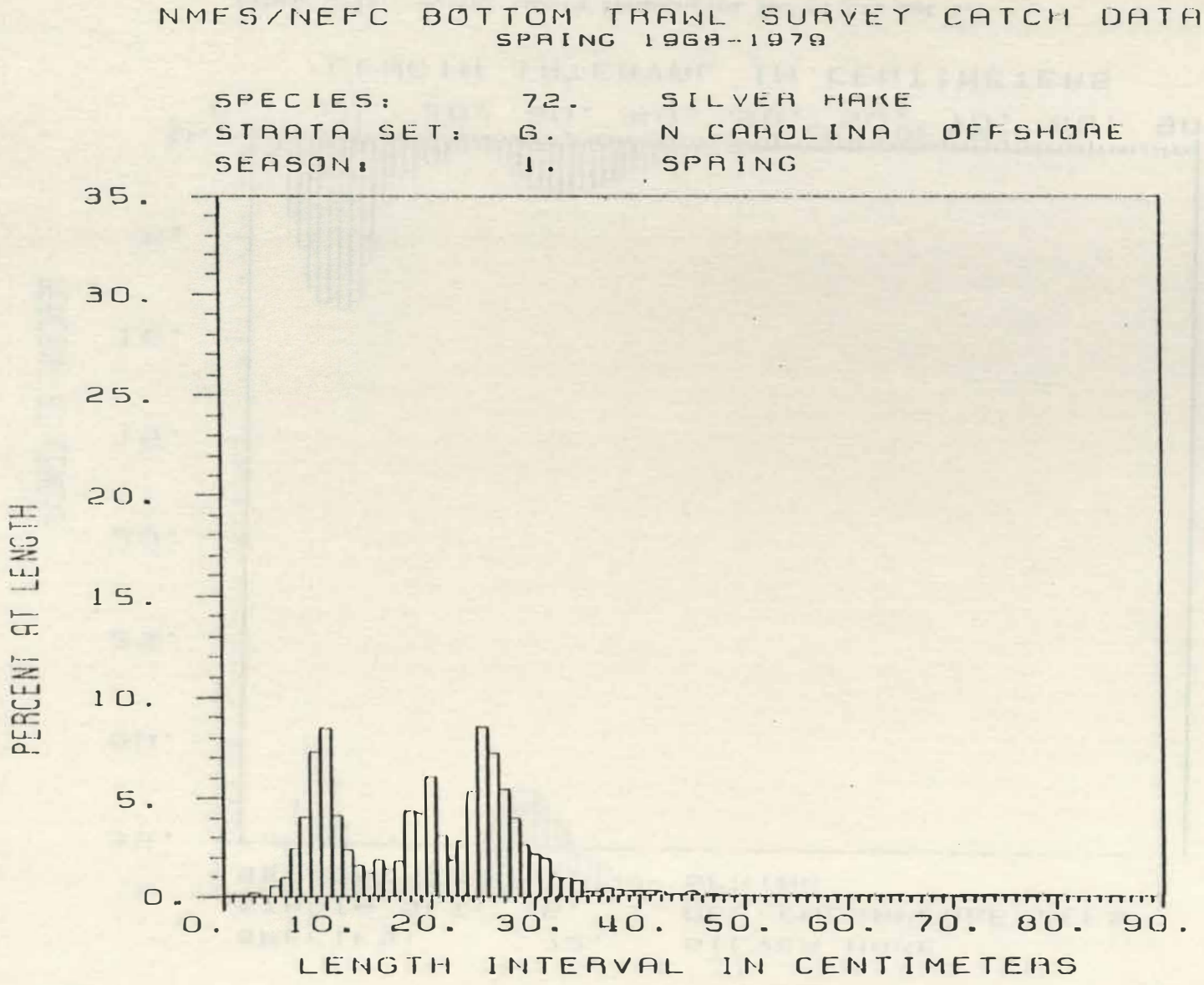


Figure 5.13. Spring length frequencies for strata set 6.

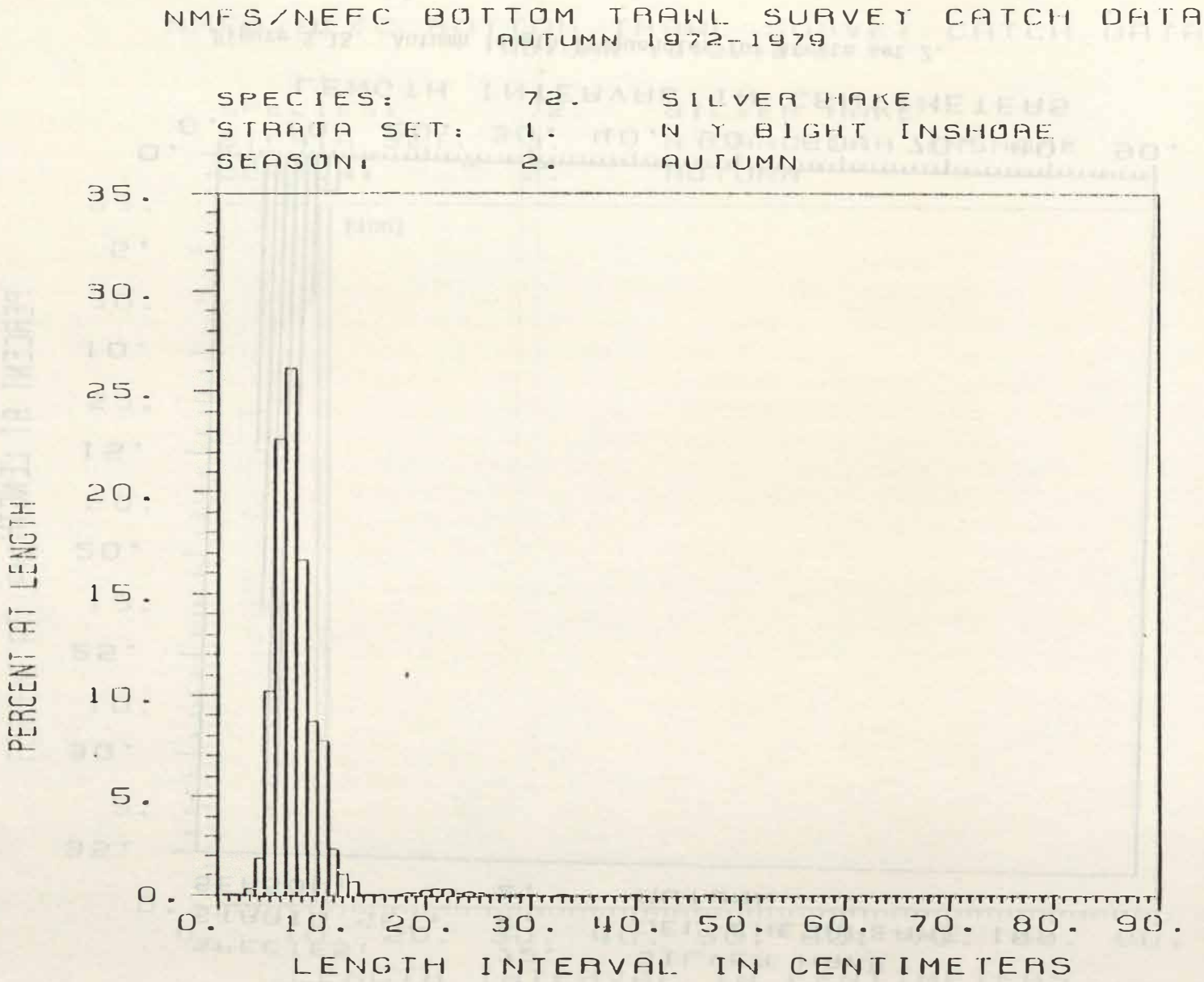


Figure 5.14. Autumn length frequencies for strata set 1.

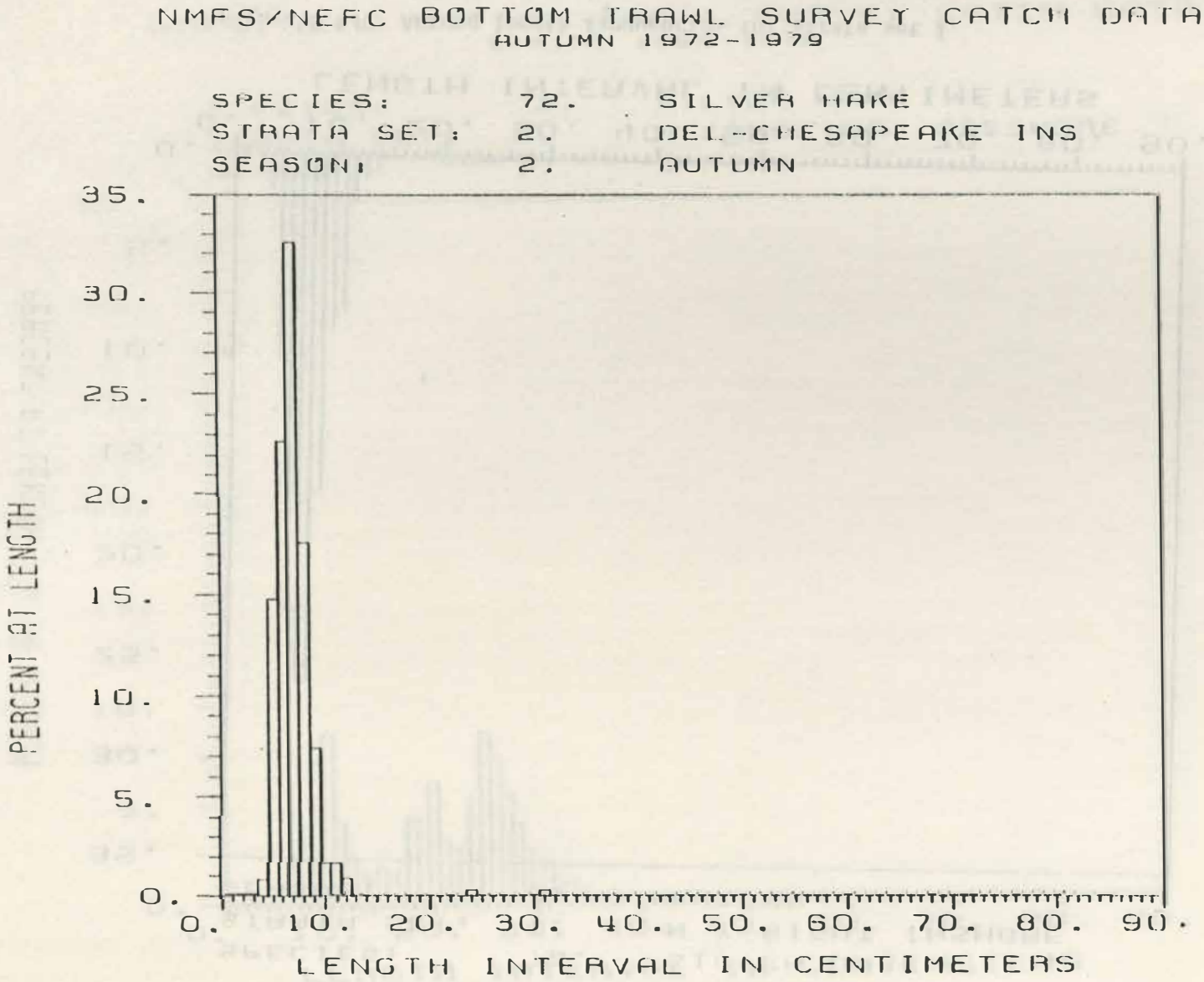


Figure 5.15. Autumn length frequencies for strata set 2.

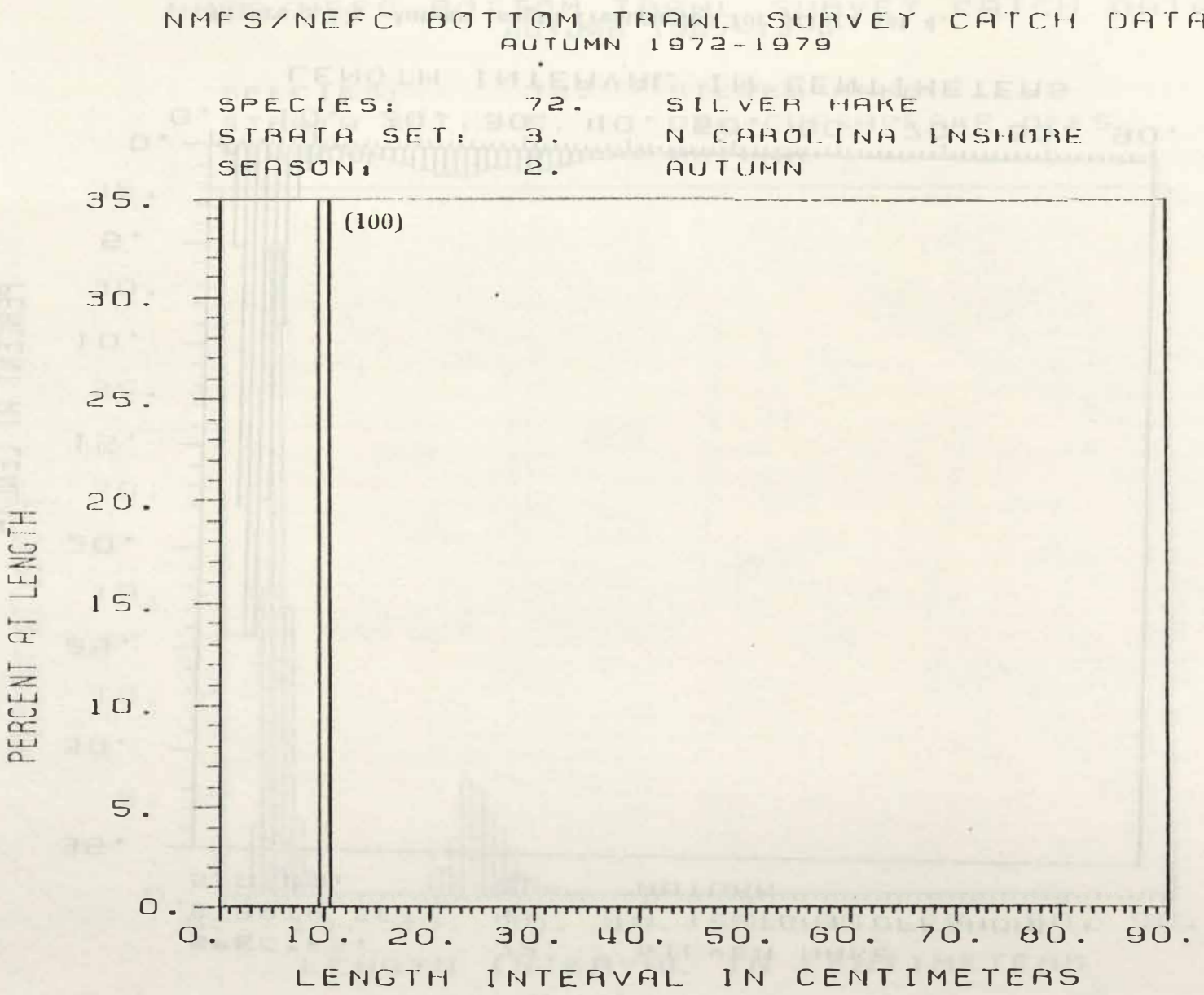


Figure 5.16. Autumn length frequencies for strata set 3.

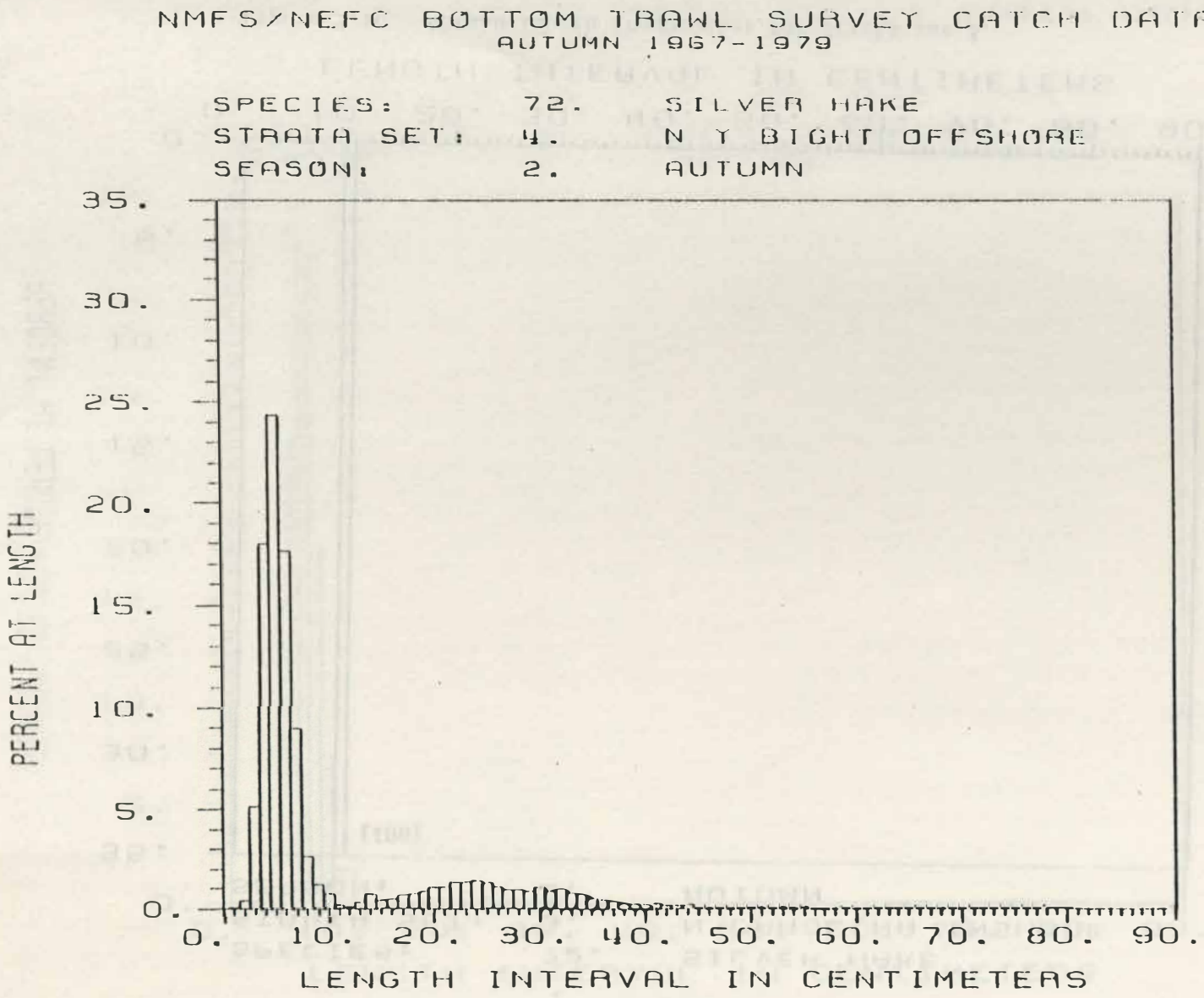


Figure 5.17. Autumn length frequencies for strata set 4.

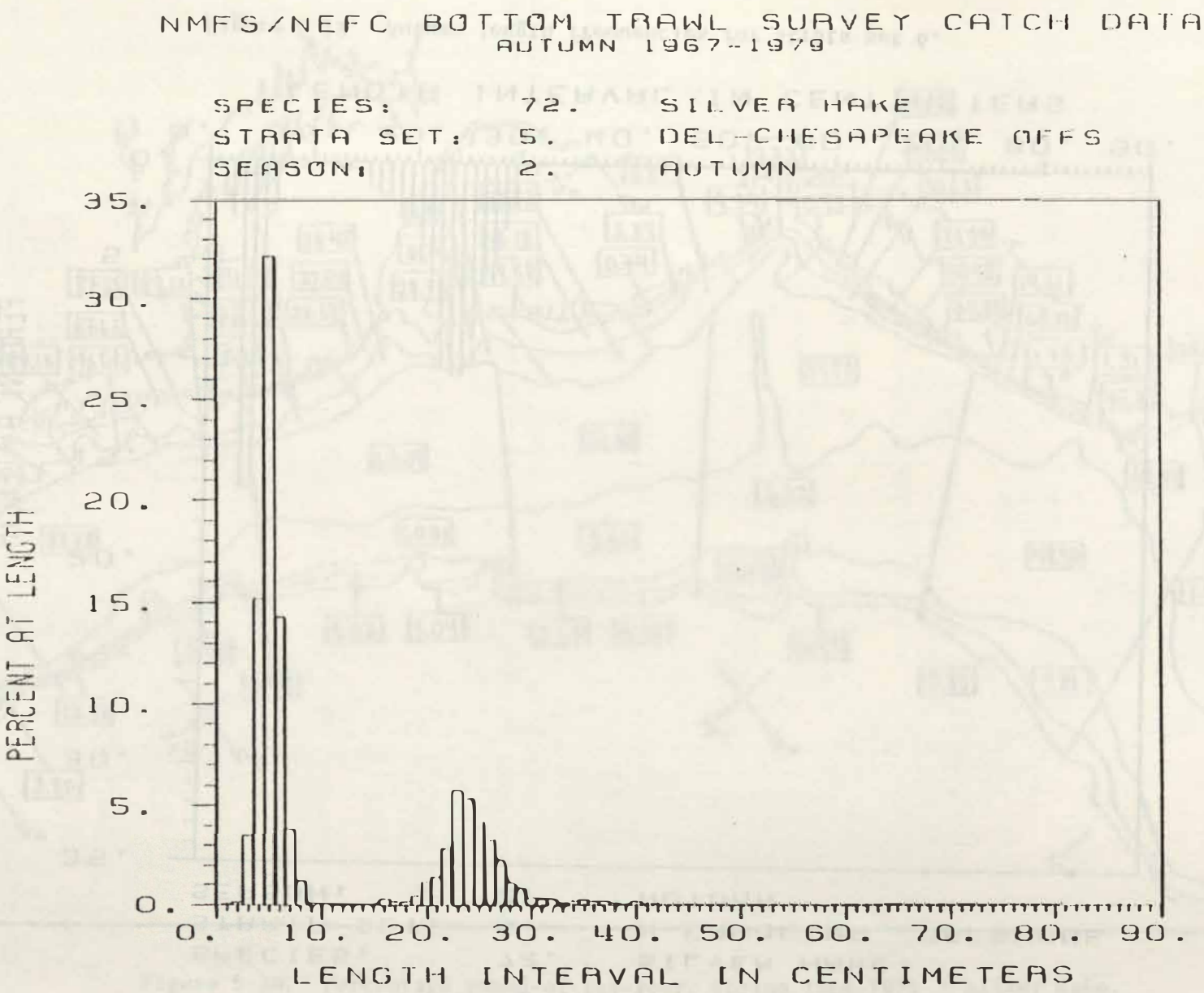


Figure 5.18. Autumn length frequencies for strata wet 5.

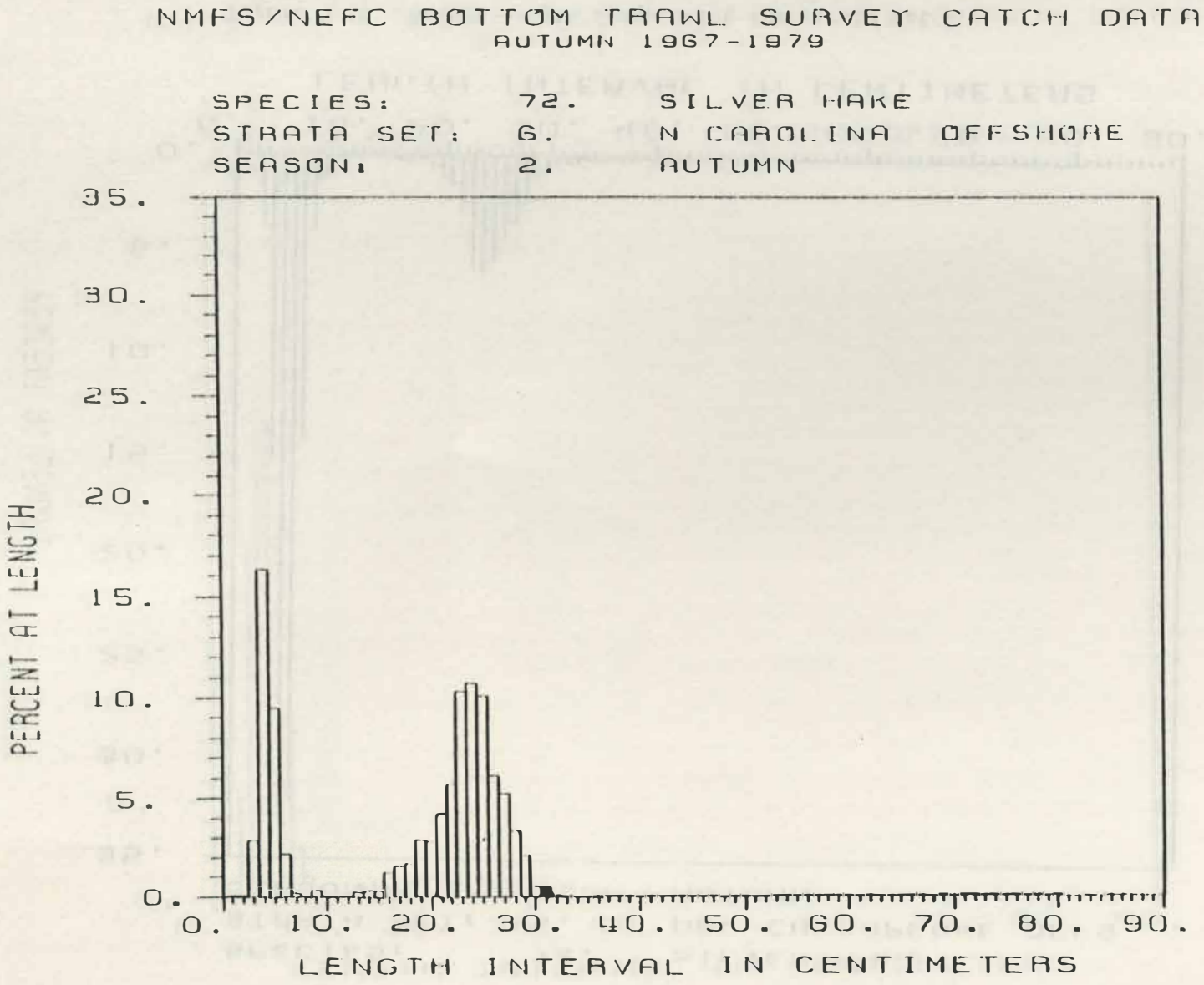


Figure 5.19. Autumn length frequencies for strata set 6.

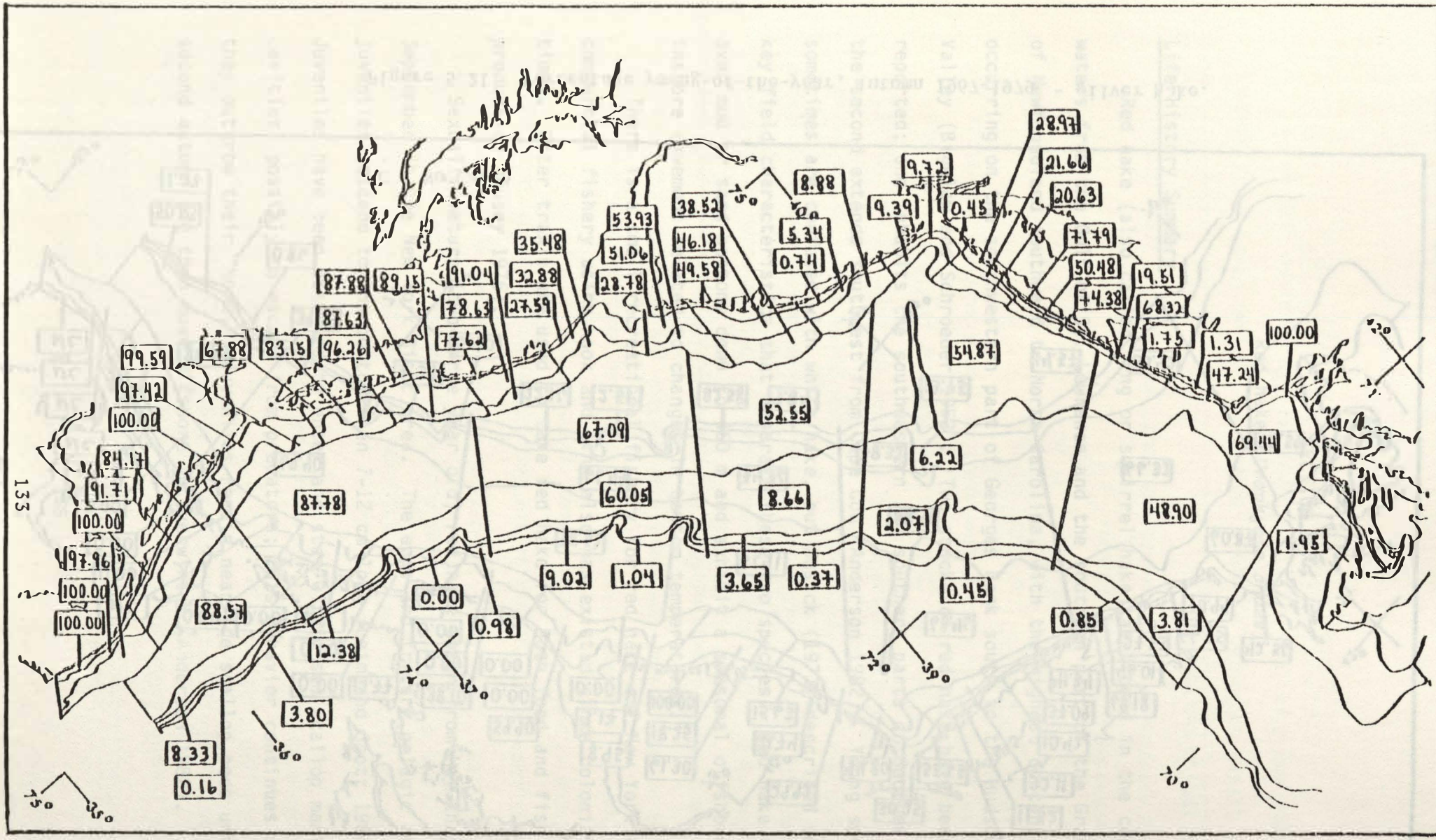


Figure 5.20. Percentage young-of-the-year, spring 1968-1979 - silver hake.

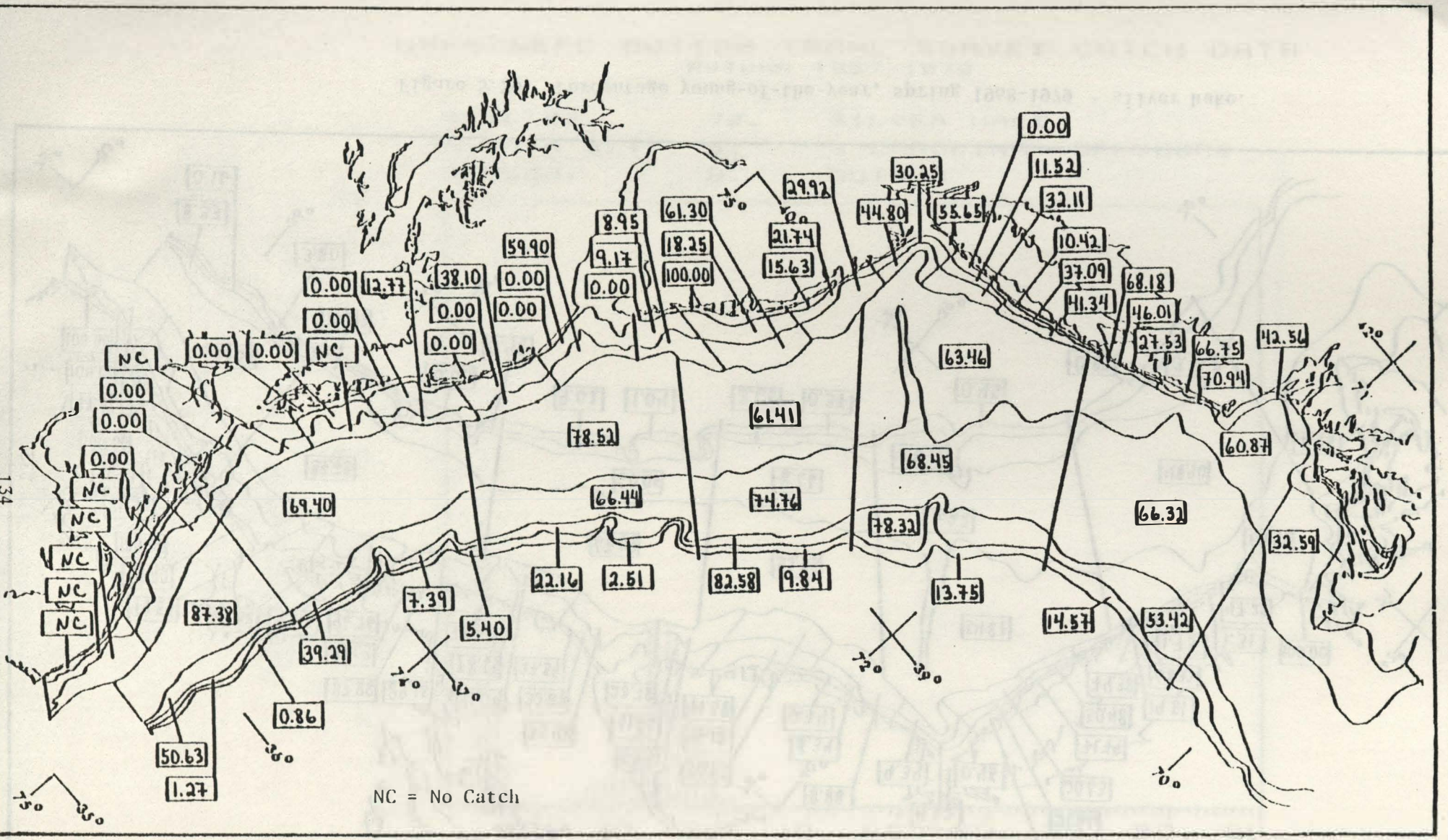


Figure 5.21. Percentage young-of-the-year, autumn 1967-1979 - silver hake.

SECTION 6

Red hake (*Urophycis chuss*)

Life History Summary

Red hake (also called ling or squirrel hake) are found in the continental waters from the Gulf of St. Lawrence and the southern part of the Grand Banks of Newfoundland southward to North Carolina, with the highest concentrations occurring on the southwestern part of Georges Bank south to the Hudson Shelf Valley (Bigelow and Schroeder 1953). Two stocks of red hake have been reported; one inhabits the southwestern and southern parts of Georges Bank and the second extends southwest from Cape Cod (Anderson 1982). Young specimens sometimes are confused with white hake, but Musick (1973) described several key field characteristics that separate these two species. Red hake are found over mud or sand bottoms down to 460 m and exhibit a seasonal offshore to inshore movement related to changes in bottom temperatures.

There is a small recreational fishery for red hake off New York and a commercial fishery using hook and line also has existed since colonial times. Otter trawls are used to take red hake for both food and fish meal production (Gusey 1976).

Sexually mature (two-three year old) red hake spawn from May through September in the New York Bight area. The eggs and fry are pelagic and the juveniles descend to the bottom when 7-12 cm long (Leim and Scott 1966). Juveniles have been observed to enter and stay within sea scallop mantle cavities, possibly to escape from predators; this behavior continues until they outgrow their "home." Juveniles remain near the scallop beds until their second autumn and then move offshore to overwinter (Anderson 1982).

Immature red hake feed mainly on amphipods, while older fish eat a variety of fishes including alewives, butterfish, silver hake, and flounders as well as squids and shrimps.

Latest assessments indicate red hake are increasing in stock size (Resource Assessment Division 1980).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 6.1 and 6.2. These plots show that red hake in the Mid-Atlantic did not migrate as extensively as other species. In the spring, large catches were common throughout most of the study area. In the autumn, some movement to the north was evident with large catches almost exclusively offshore and north. In Figure 6.3, data from all cruises prior to 1976 have been deleted, however, there was no real change in the distributional pattern.

Graphs of mean weight and number per tow for the time series are shown in Figures 6.4-6.7. Consistently higher catches have been taken in the New York Bight offshore strata during the autumn (Figure 6.7).

Length frequencies for six strata sets, arranged by season, are shown in Figures 6.8-6.19. These plots indicate consistent catches of red hake in almost all areas during both seasons with the exception of the autumn inshore set 3 (Figure 6.16). Smaller fish (<20 cm) were usually caught in the inshore strata.

Figures 6.20 and 6.21 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 13 and 5 cm, respectively, for spring and fall series. These figures show YOY were caught most frequently in the spring and in the inshore strata sets. This distribution is expected because of the previously described association of young red hake with sea scallops.

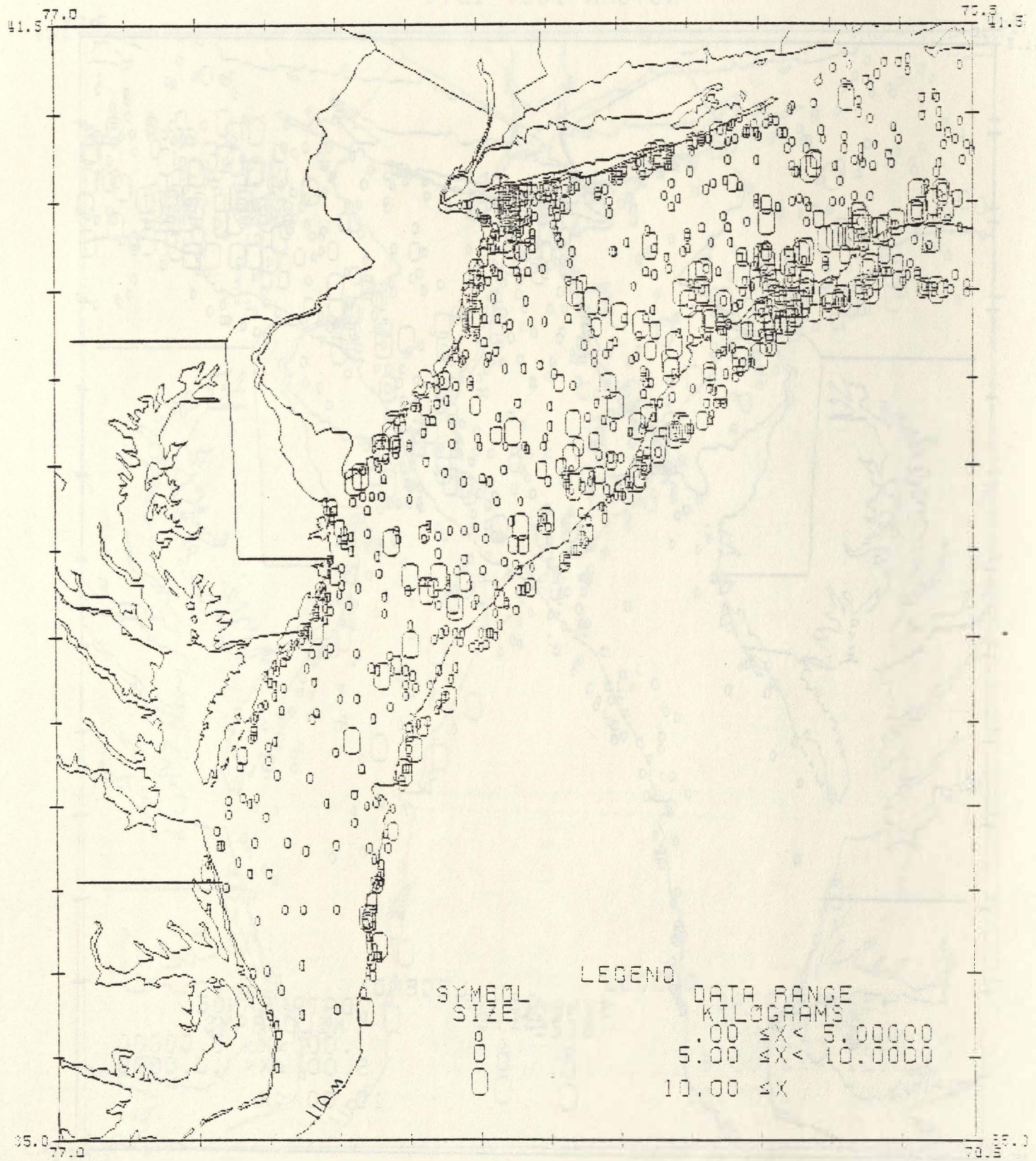


Figure 6.1. Spring distribution, 1968-1979.

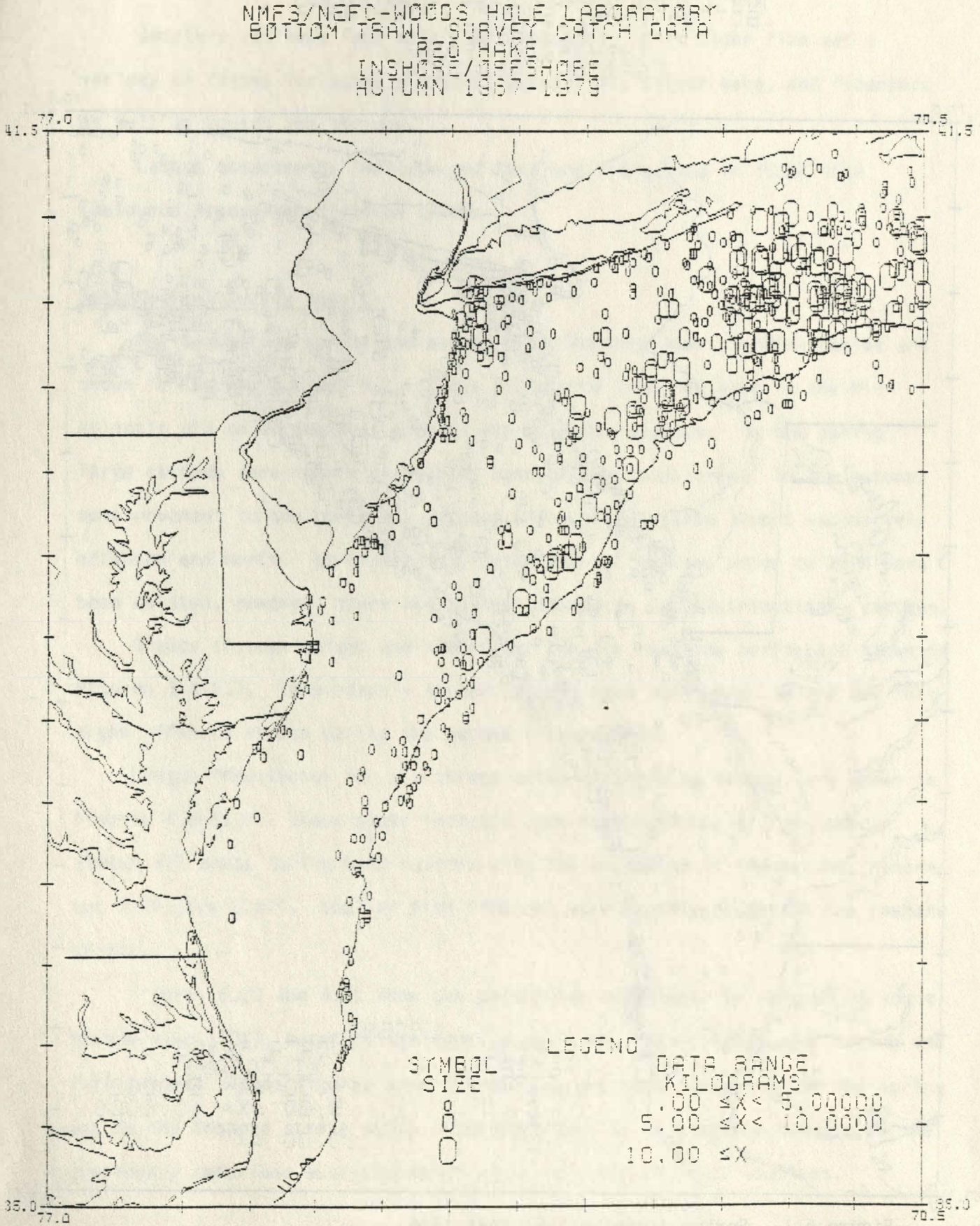


Figure 6.2. Autumn distribution, 1967-1979.

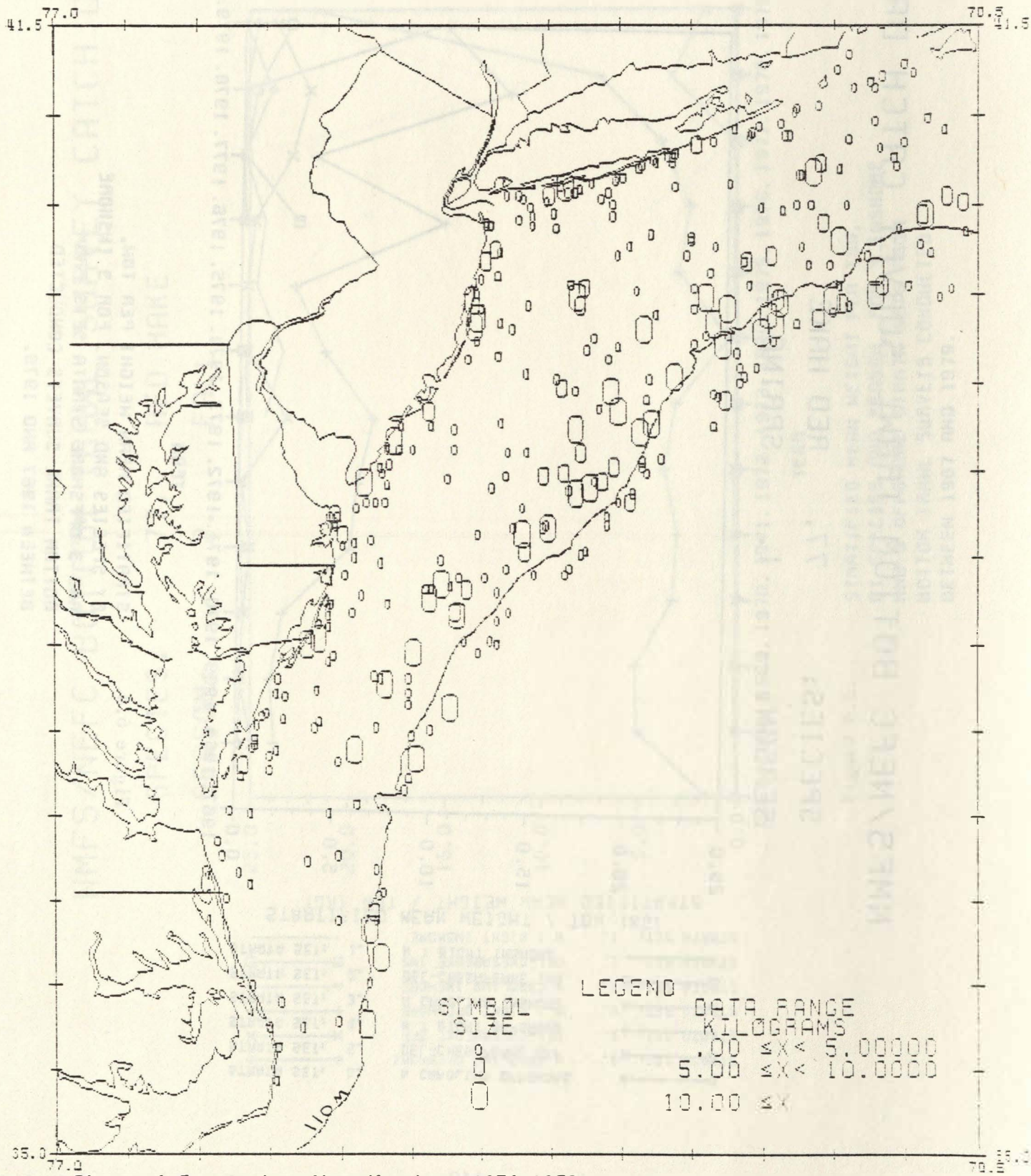


Figure 6.3. Spring distribution, 1976-1979.

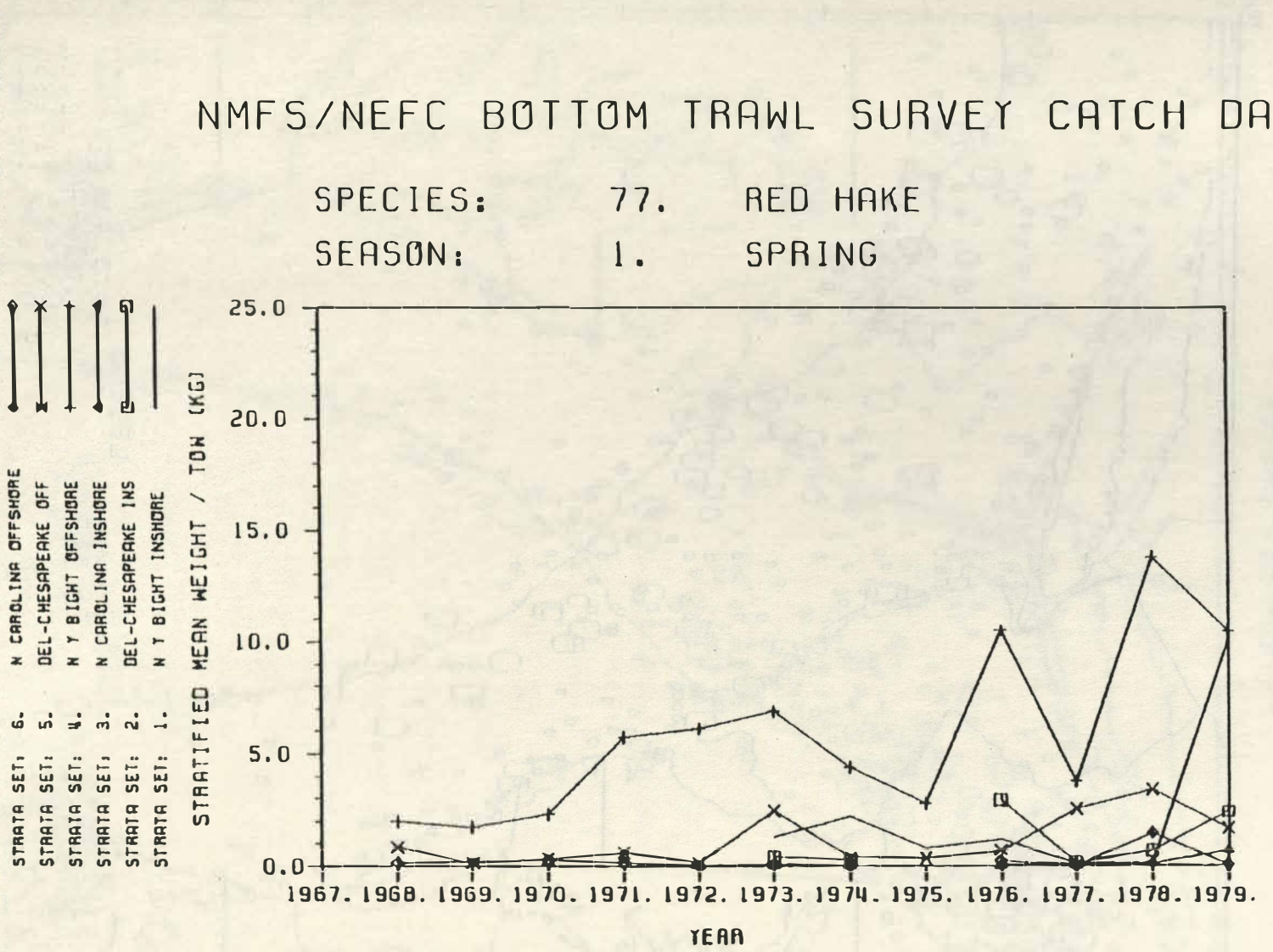


Figure 6.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

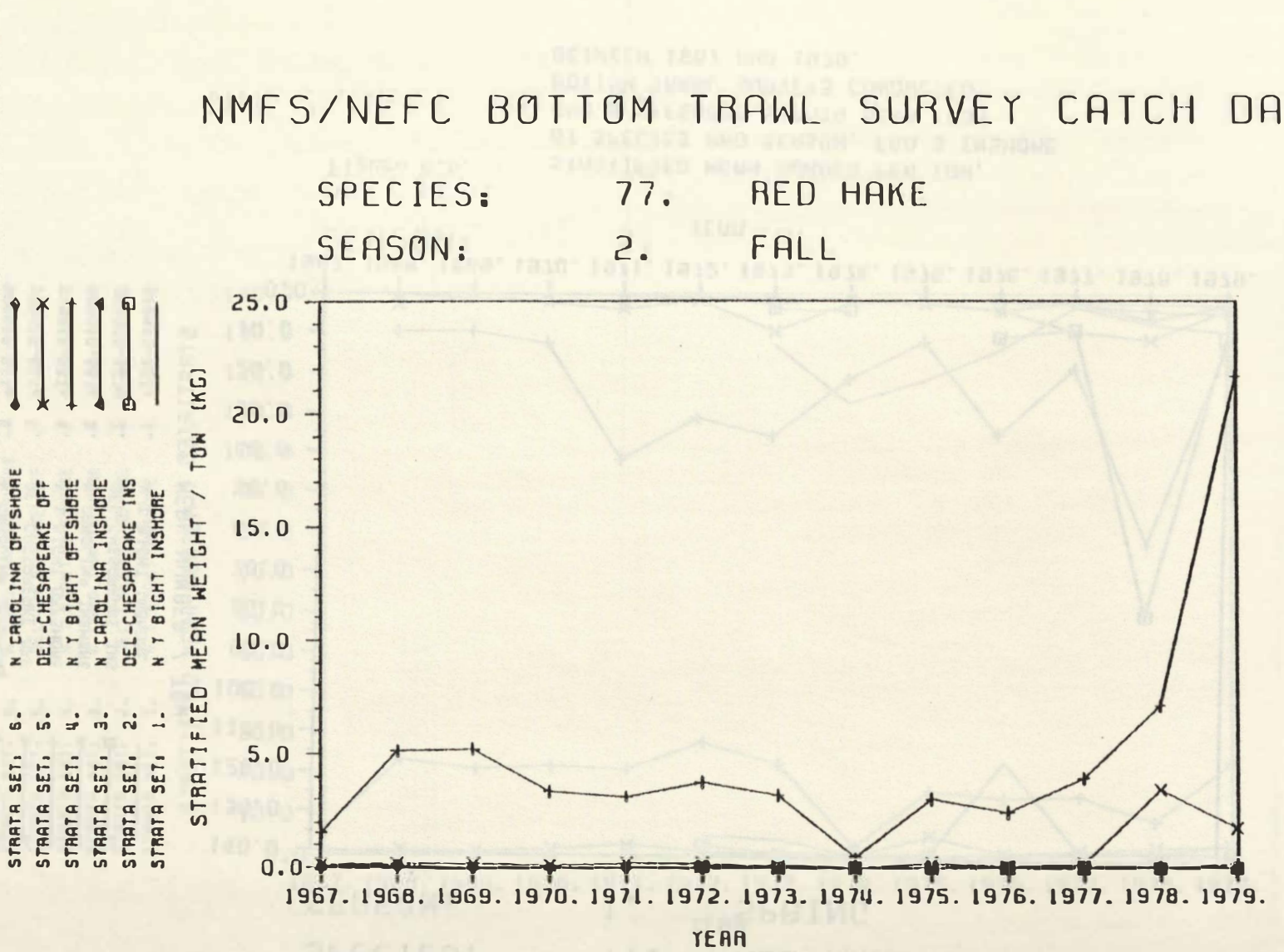


Figure 6.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

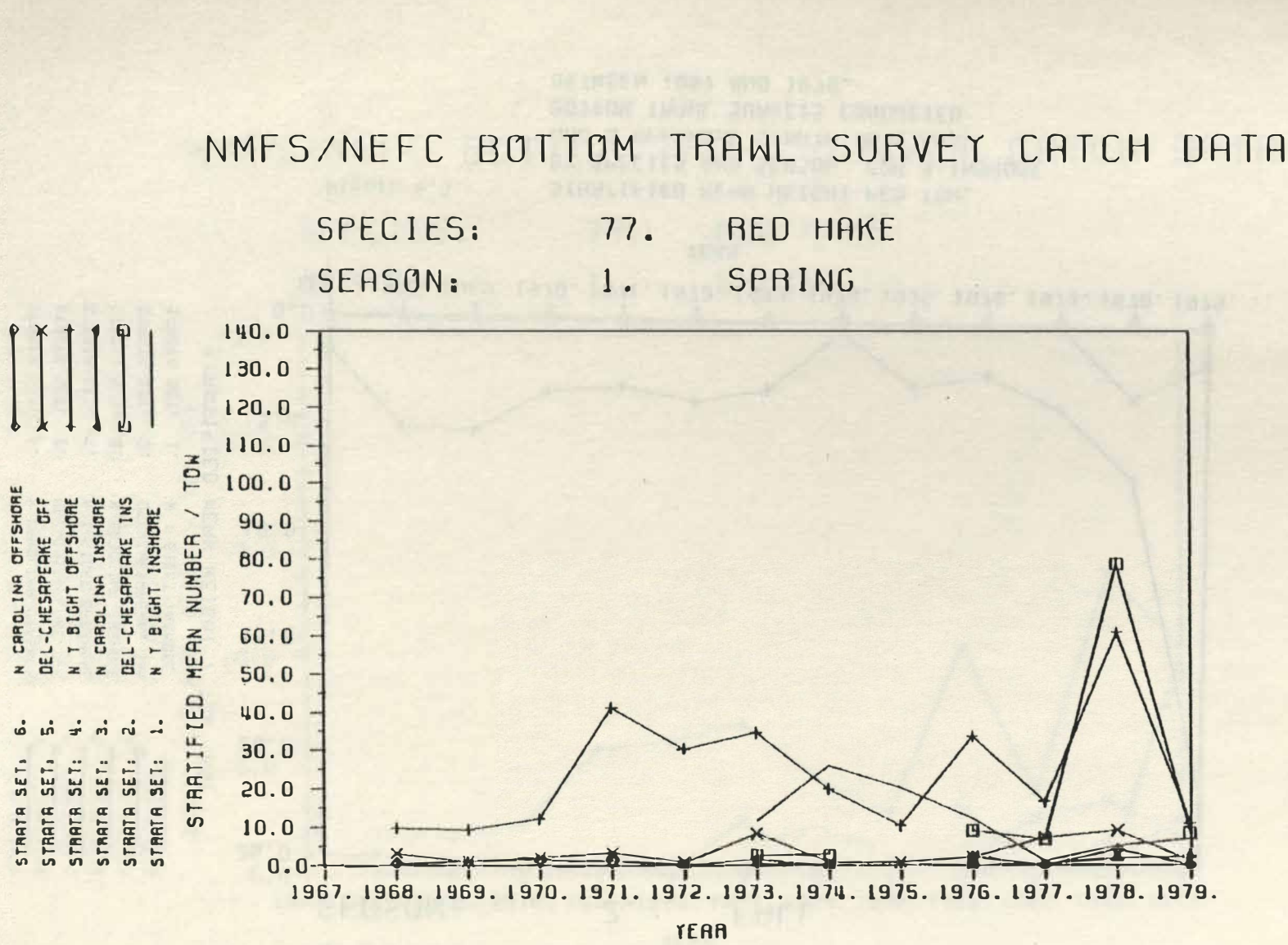


Figure 6.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

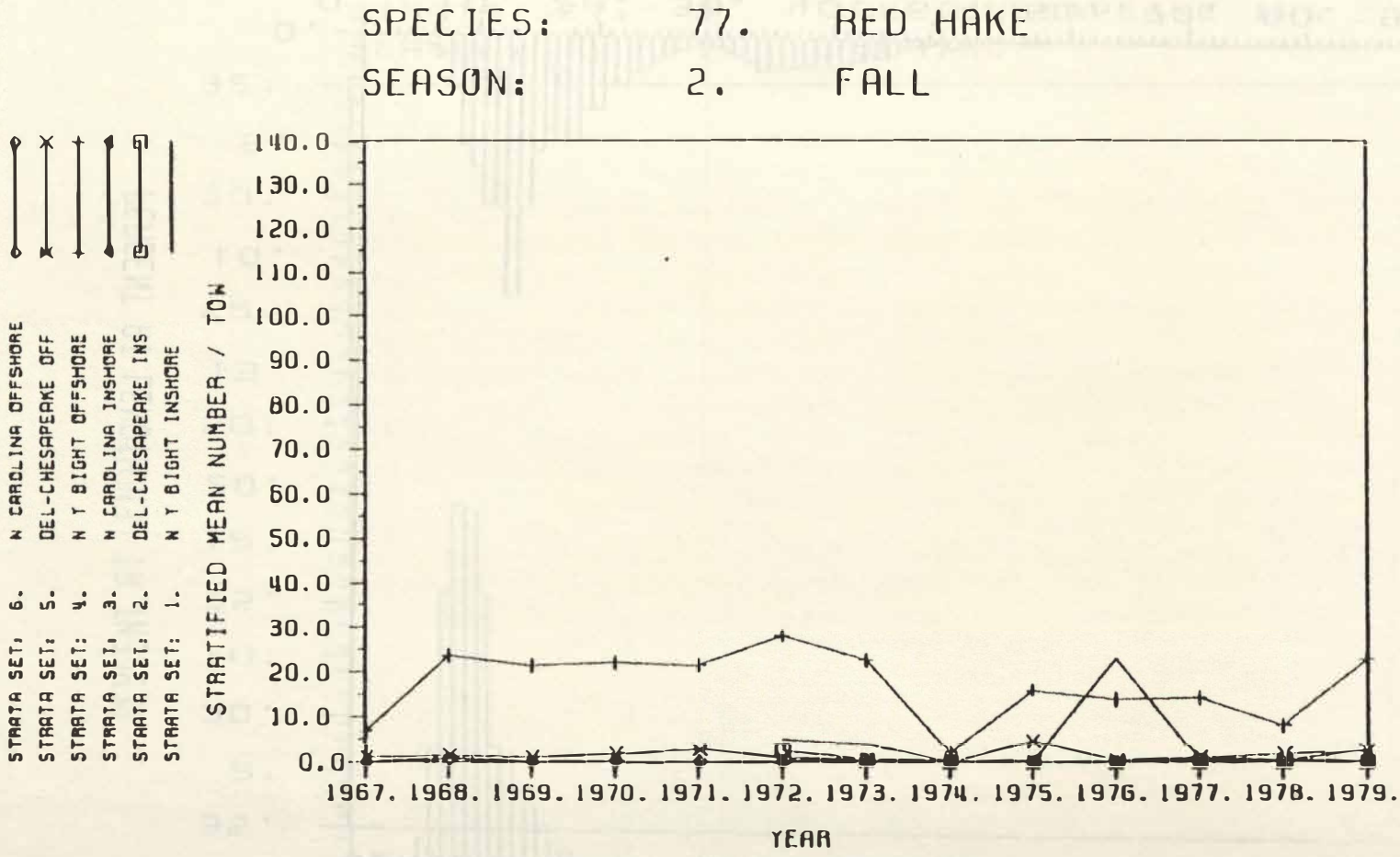


Figure 6.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

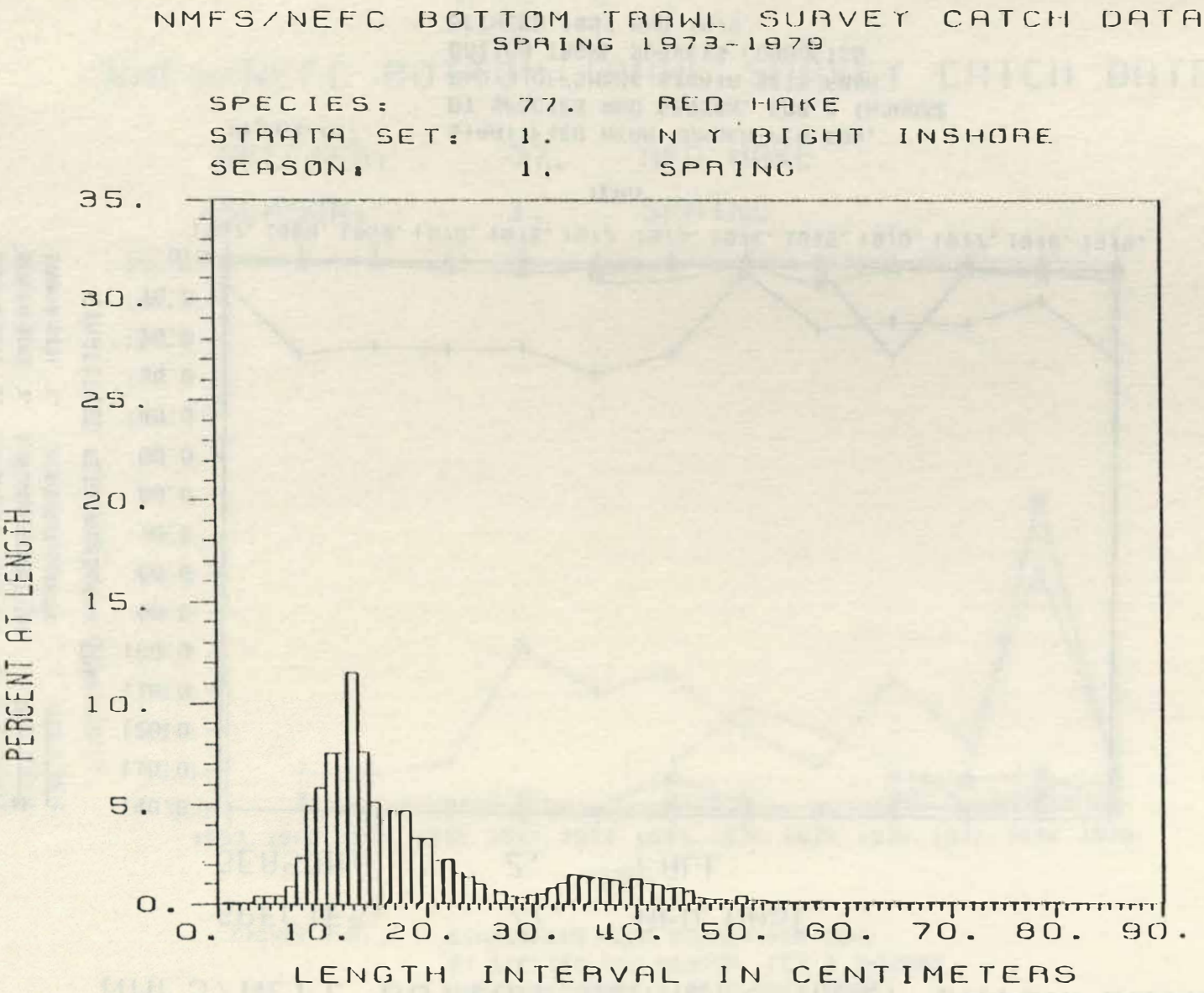


Figure 6.8. Spring length frequencies for strata set 1.

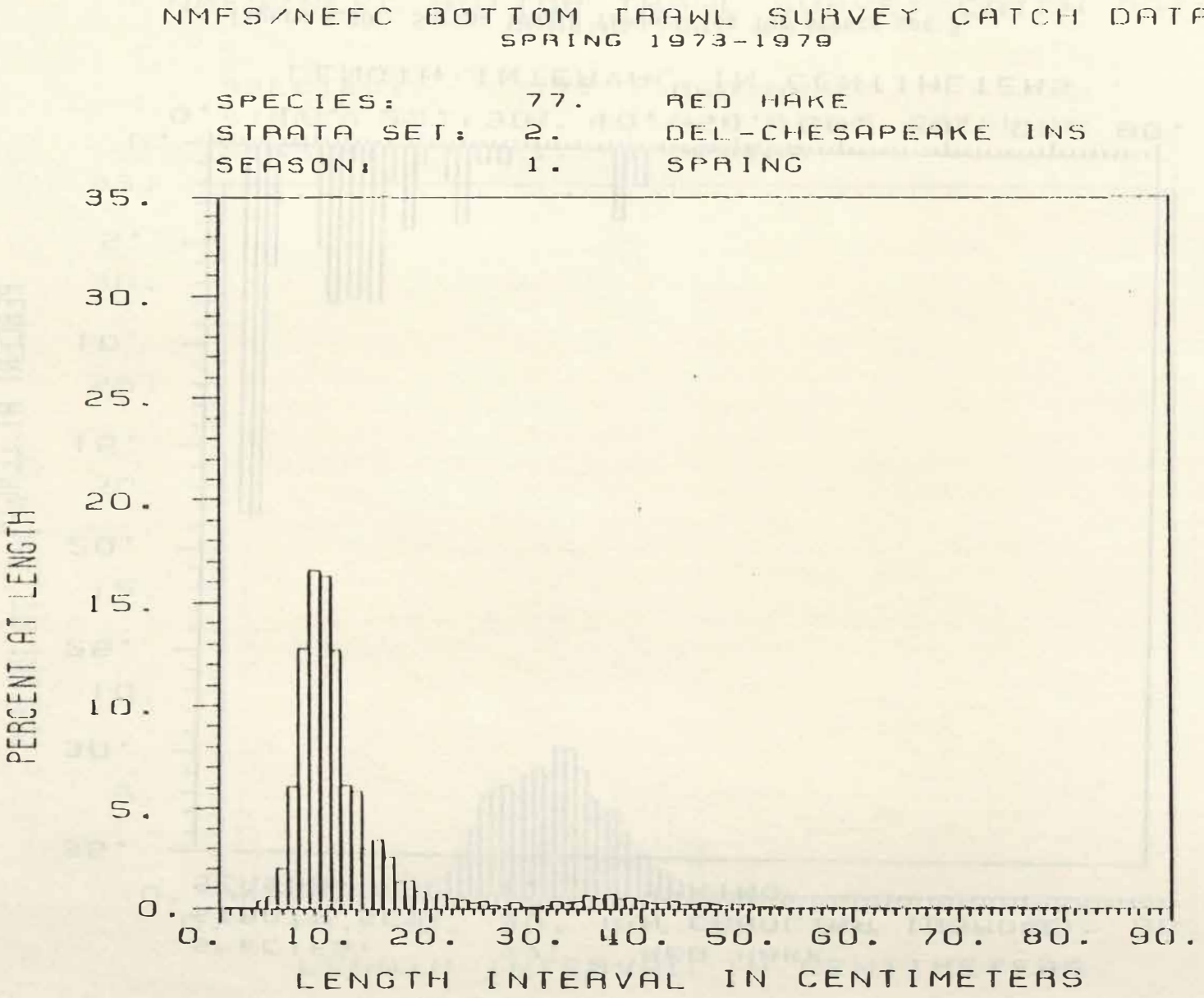


Figure 6.9. Spring length frequencies for strata set 2.

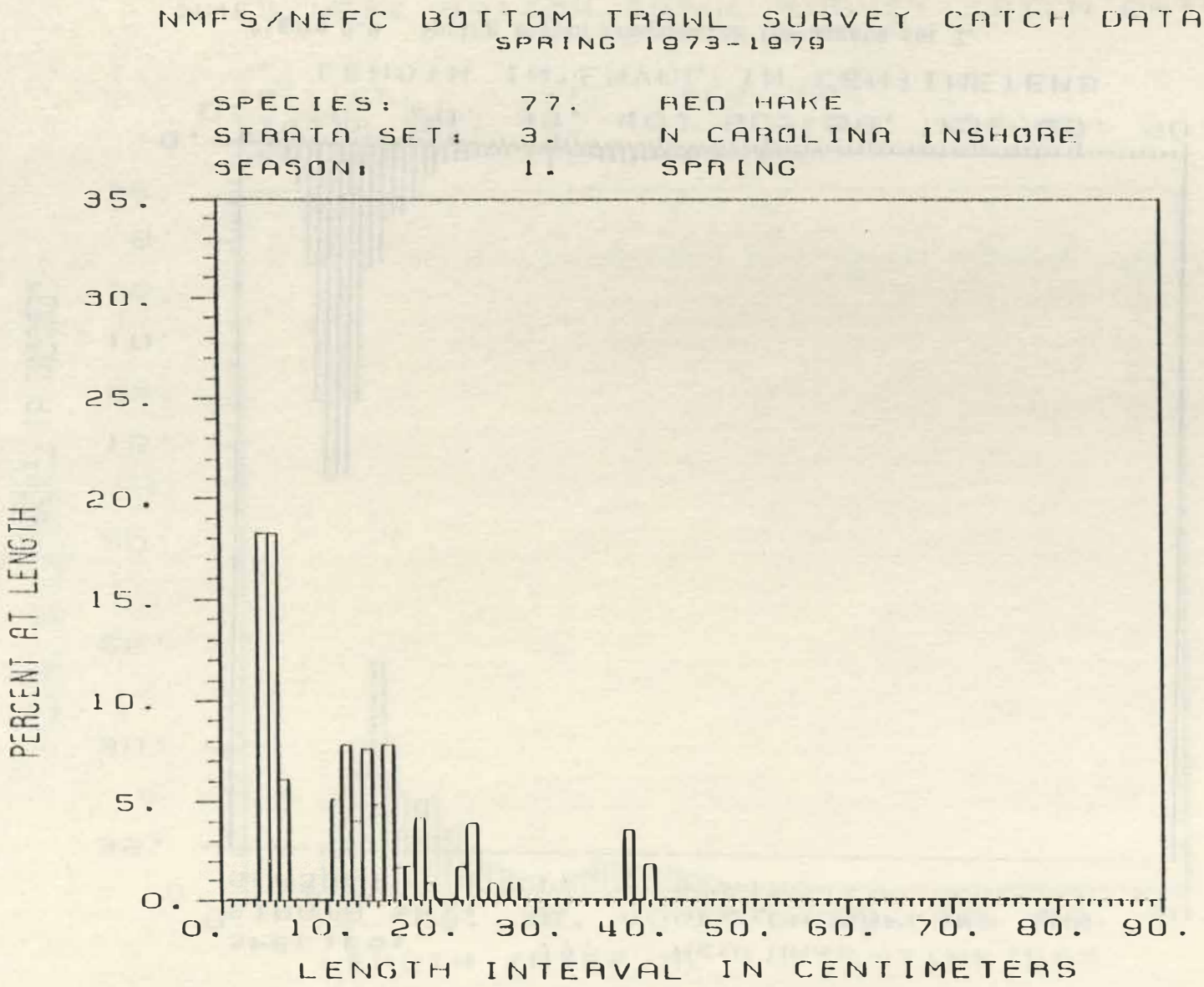


Figure 6.10. Spring length frequencies for strata set 3.

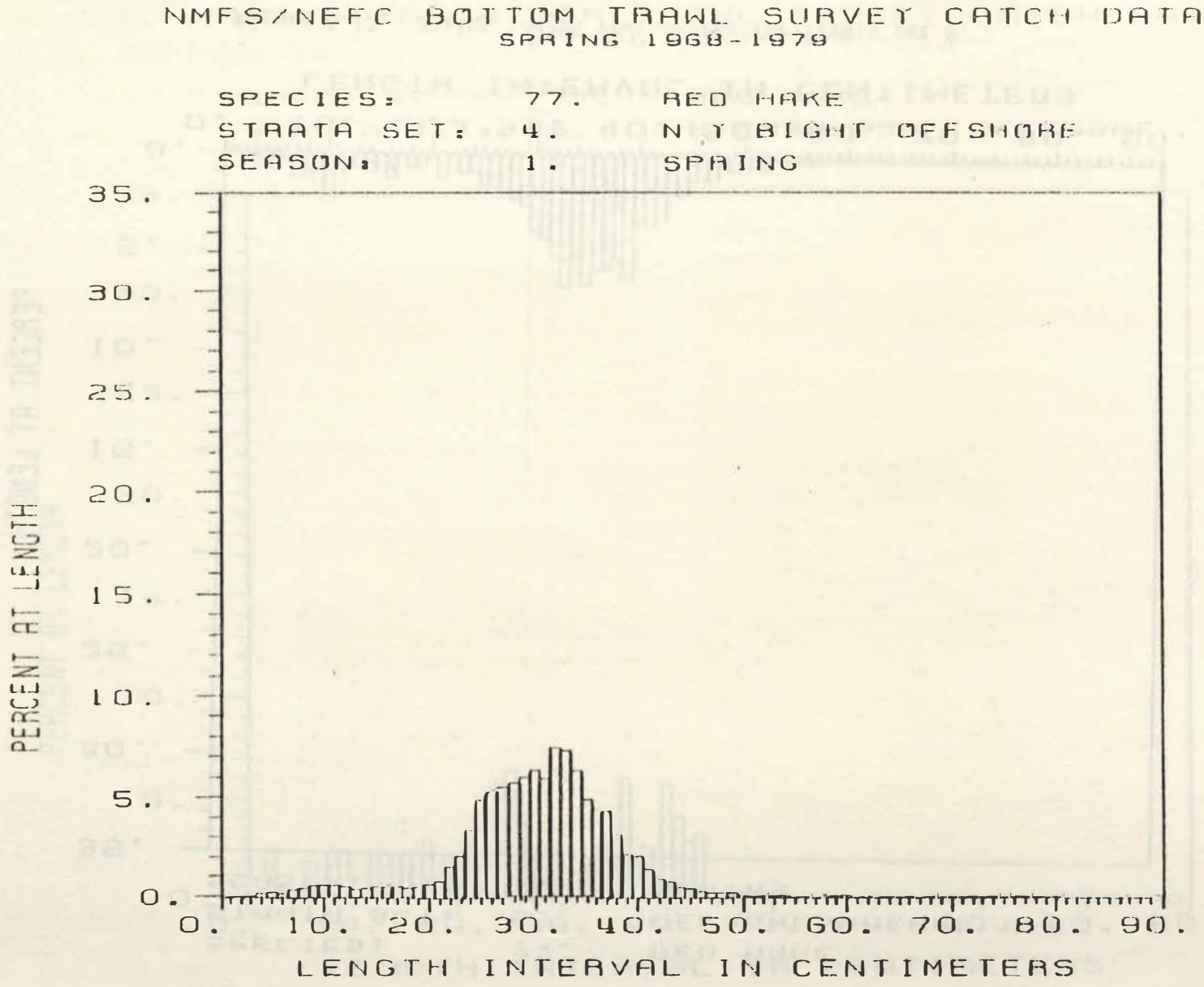


Figure 6.11. Spring length frequencies for strata set 4.

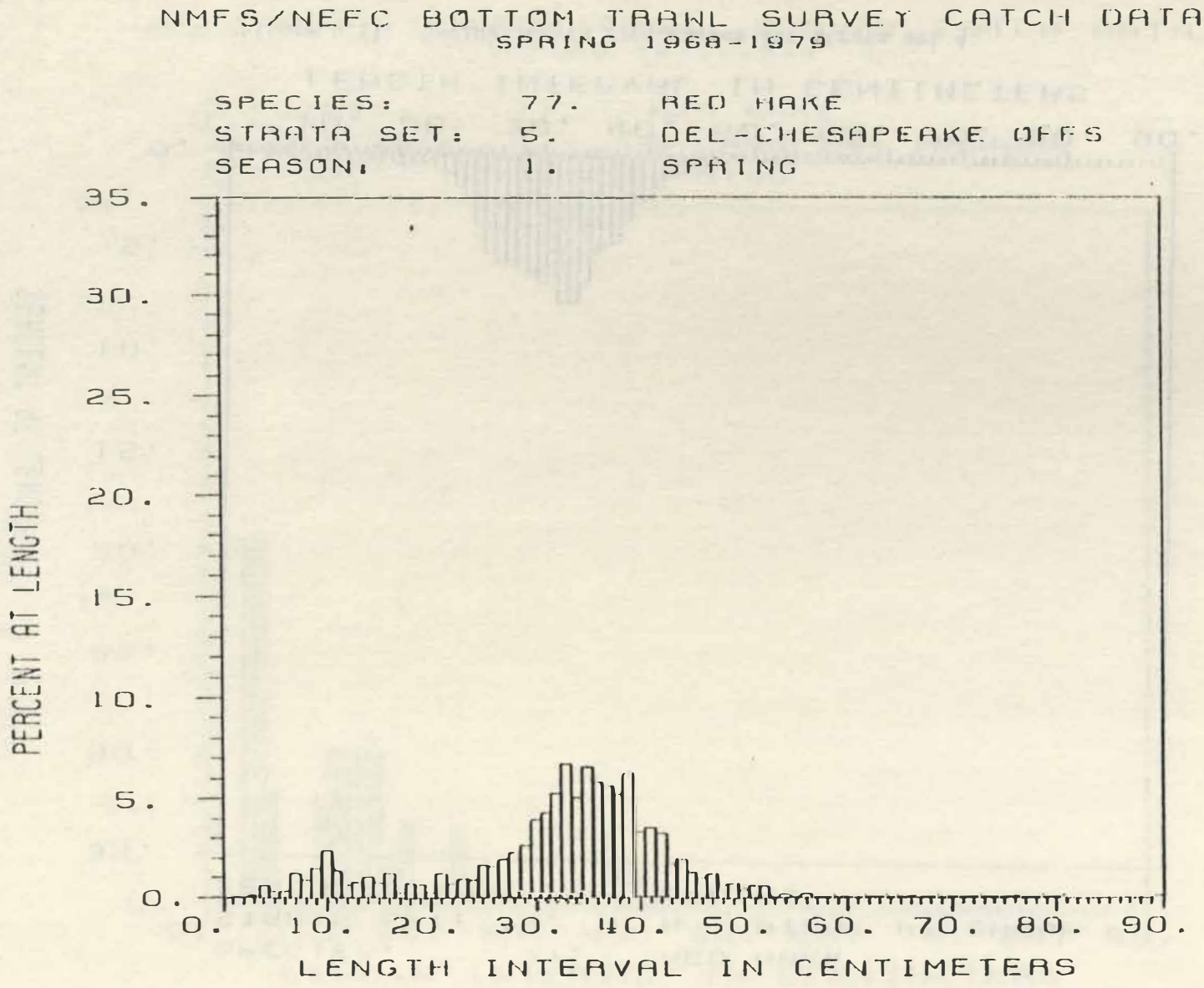


Figure 6.12. Spring length frequencies for strata set 5.

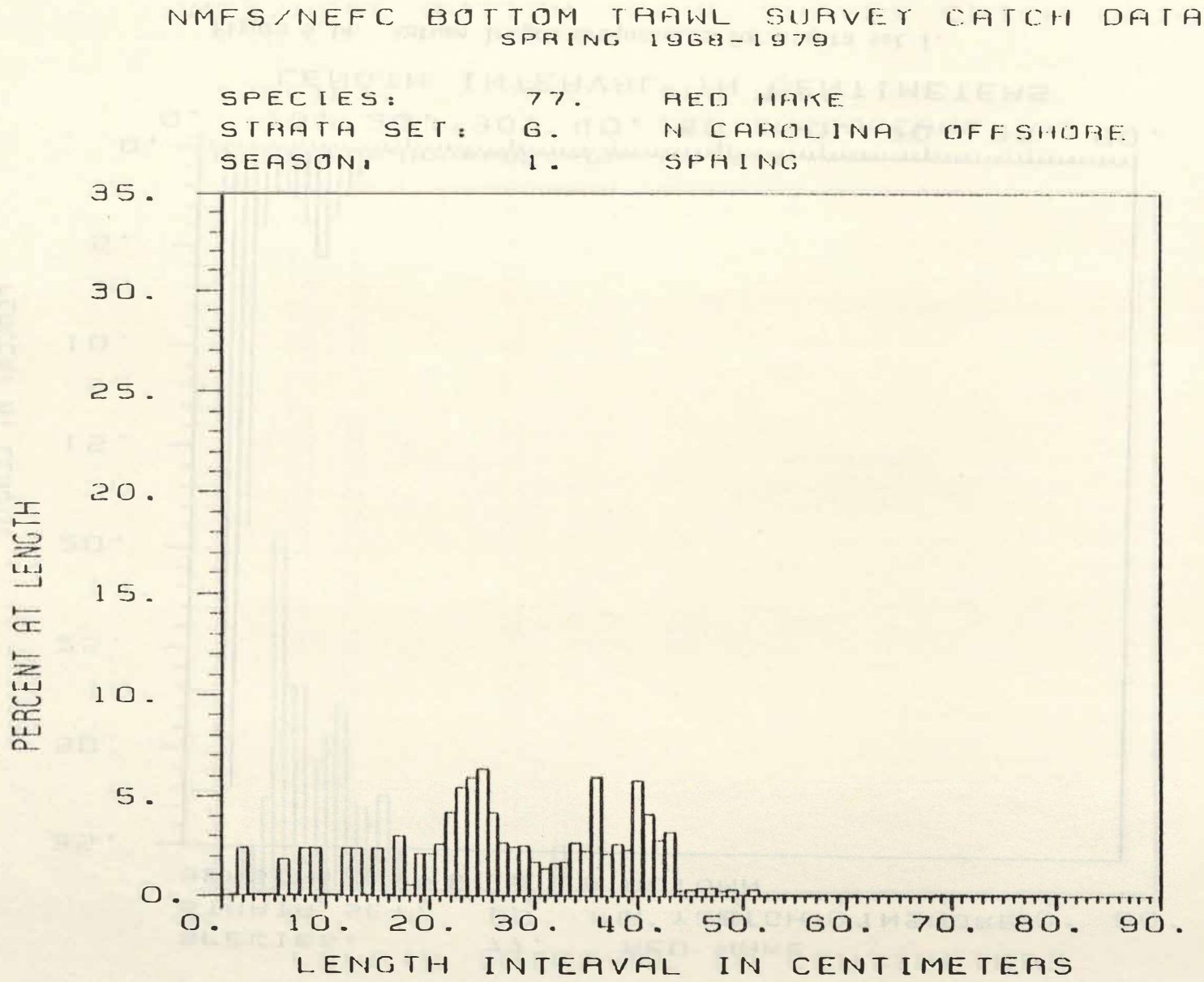


Figure 6.13. Spring length frequencies for strata set 6.

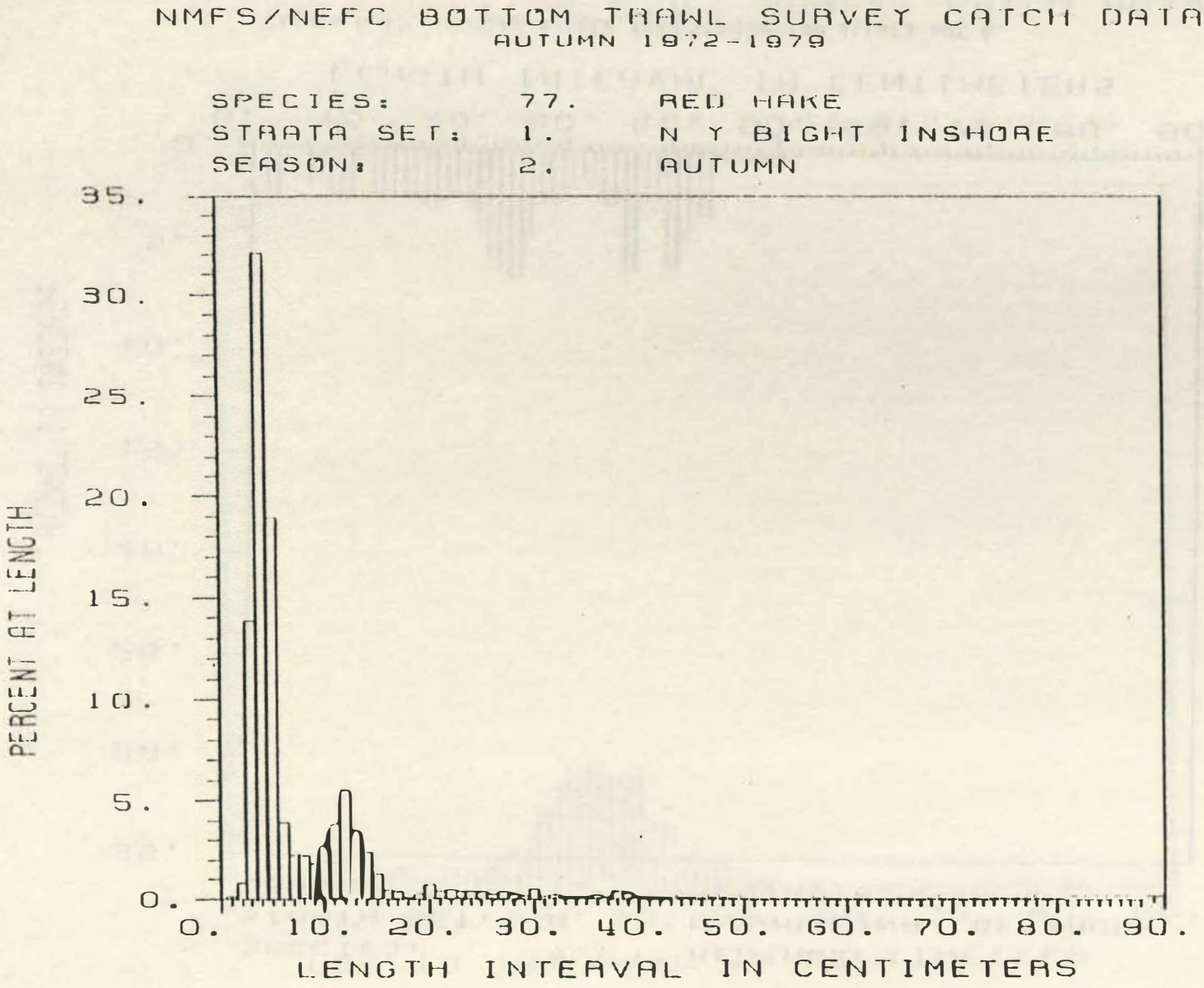


Figure 6.14. Autumn length frequencies for strata set 1.

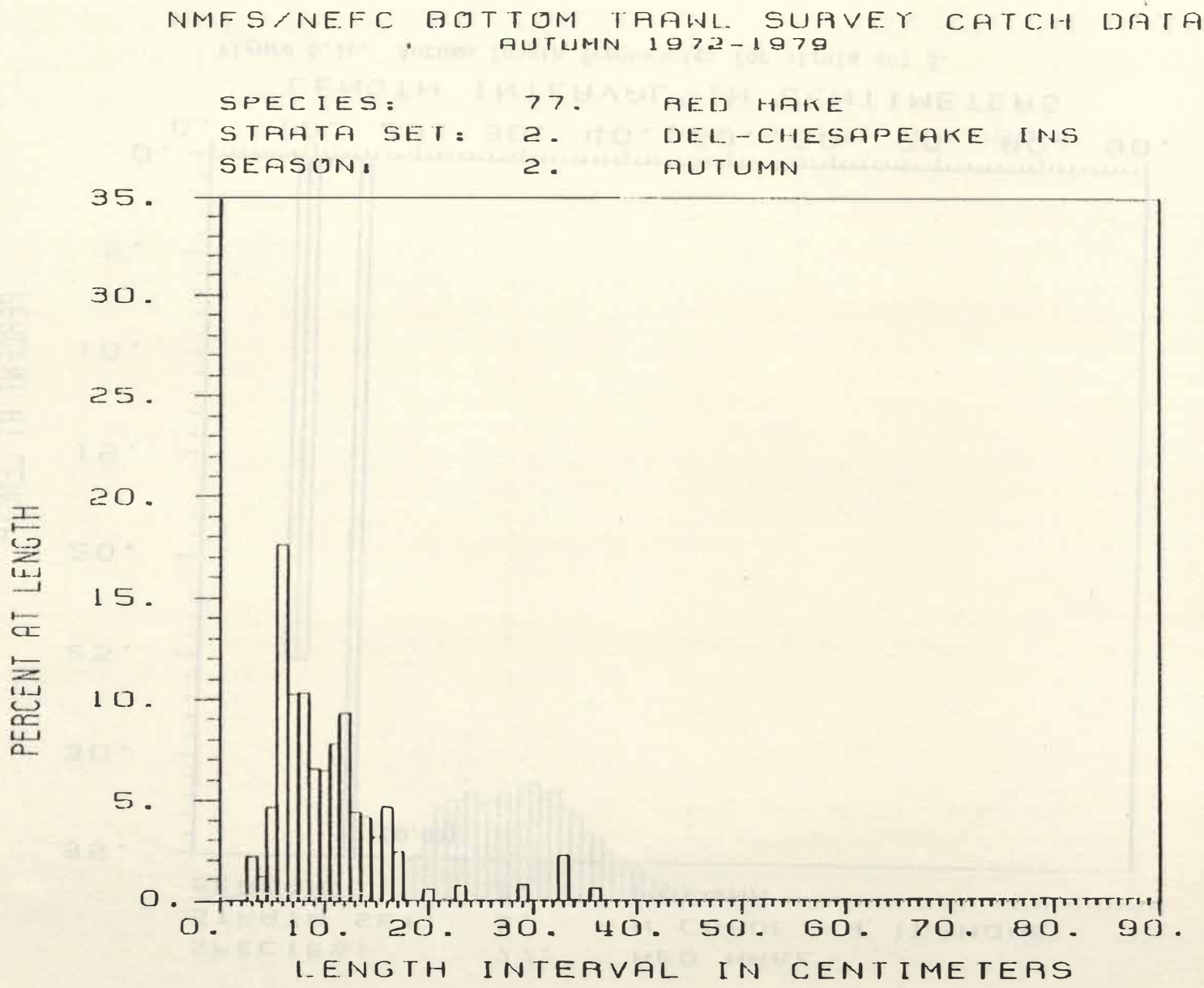


Figure 6.15. Autumn length frequencies for strata set 2.

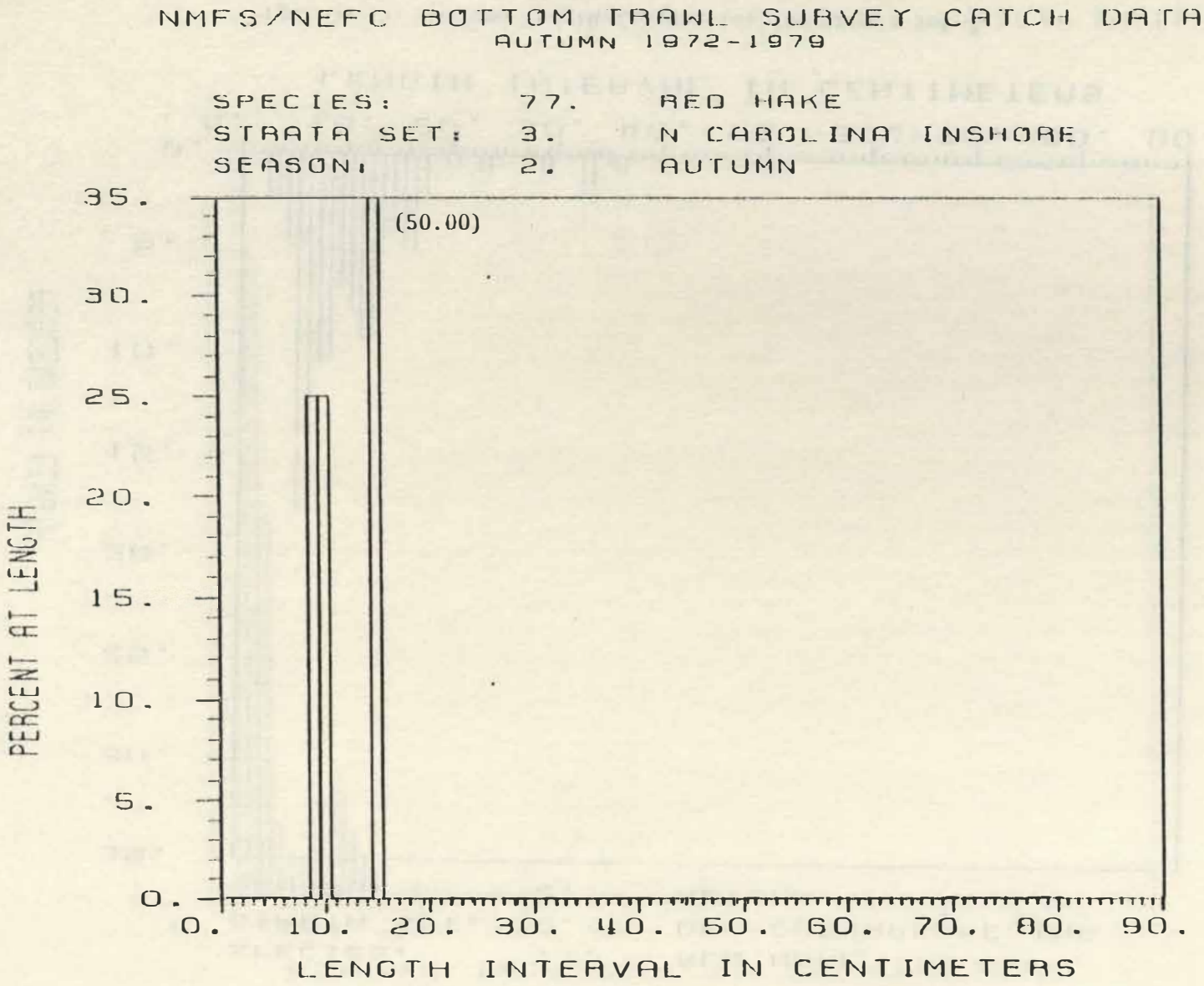


Figure 6.16. Autumn length frequencies for strata set 3.

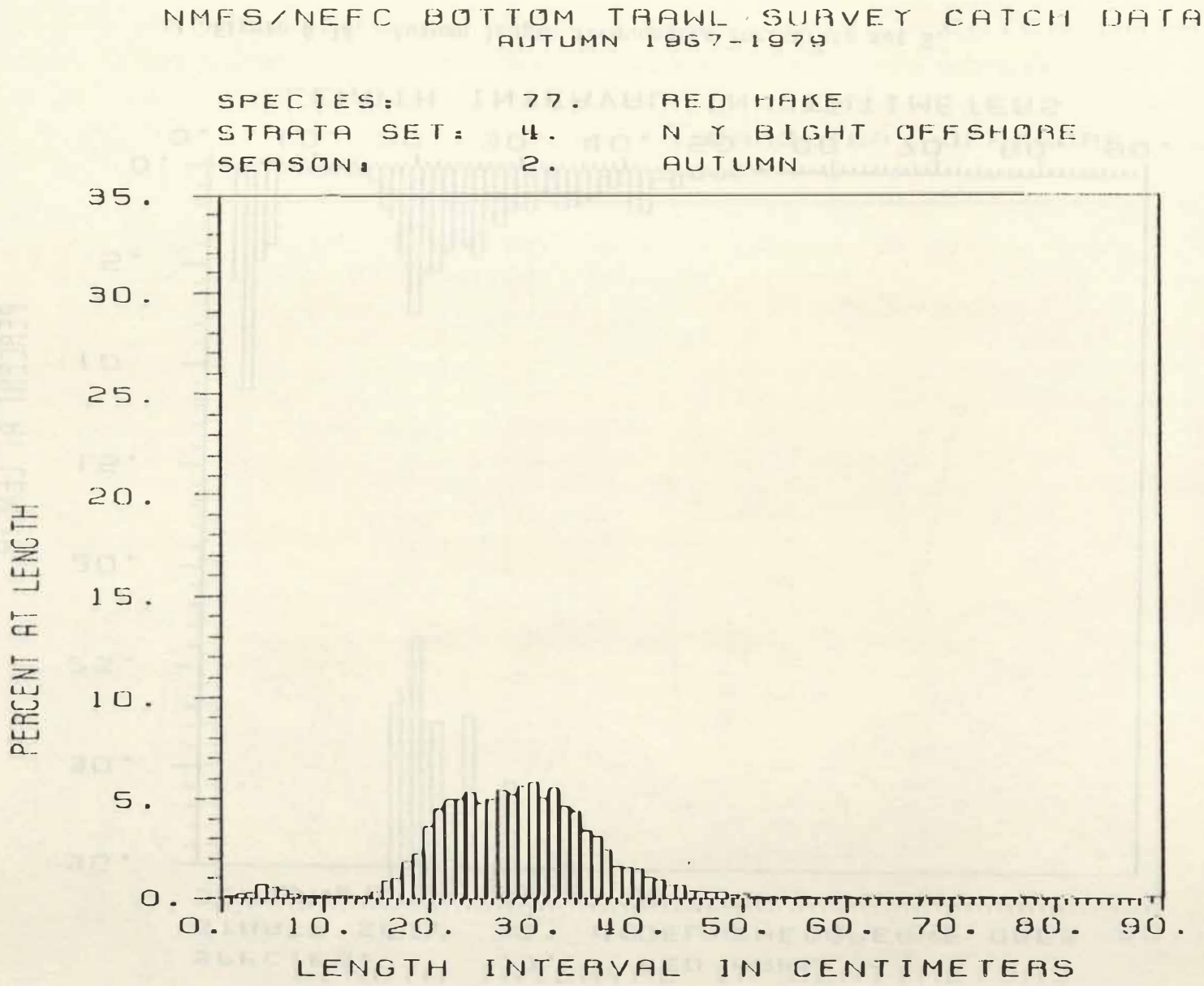


Figure 6.17. Autumn length frequencies for strata set 4.

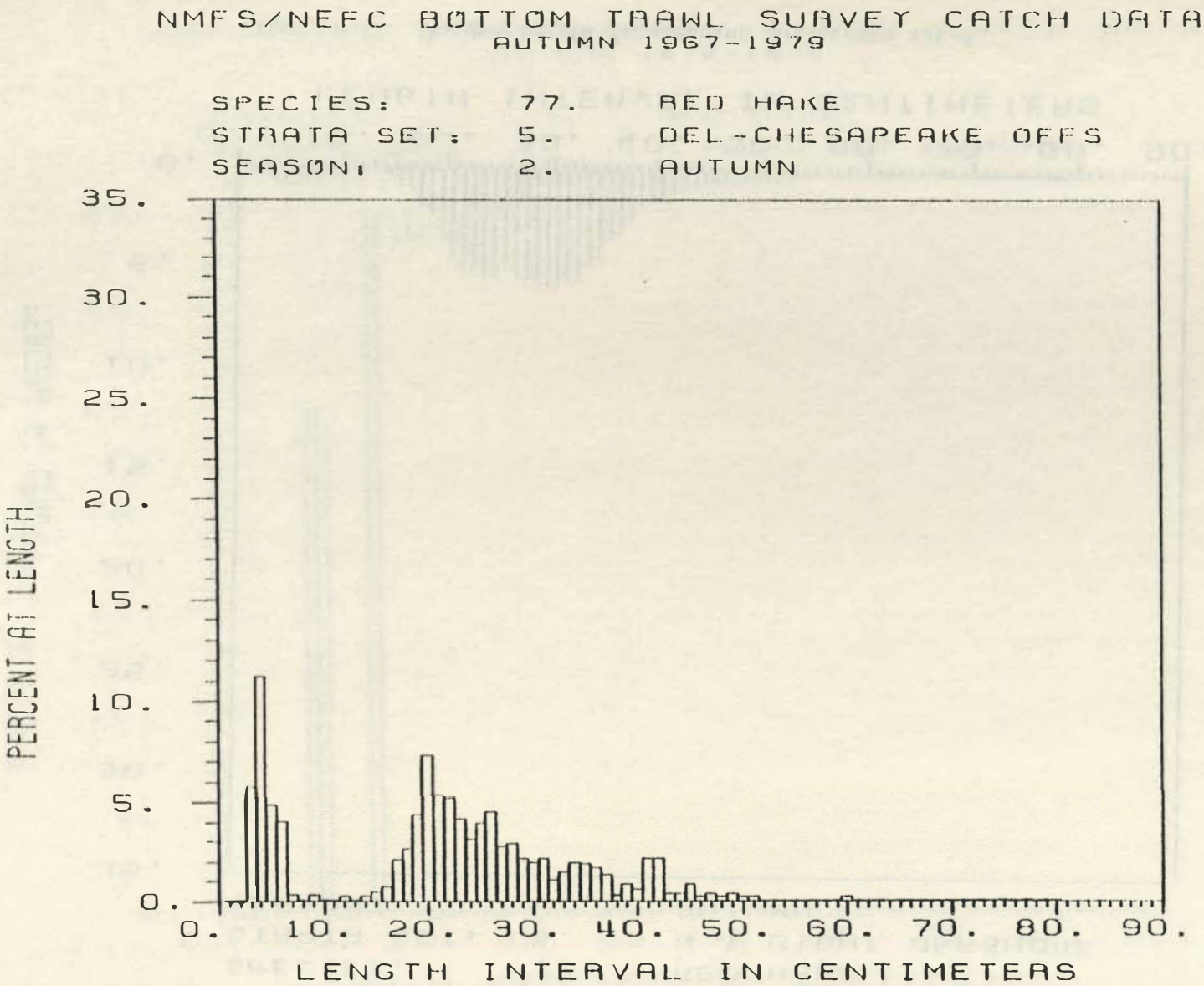


Figure 6.18. Autumn length frequencies for strata set 5.

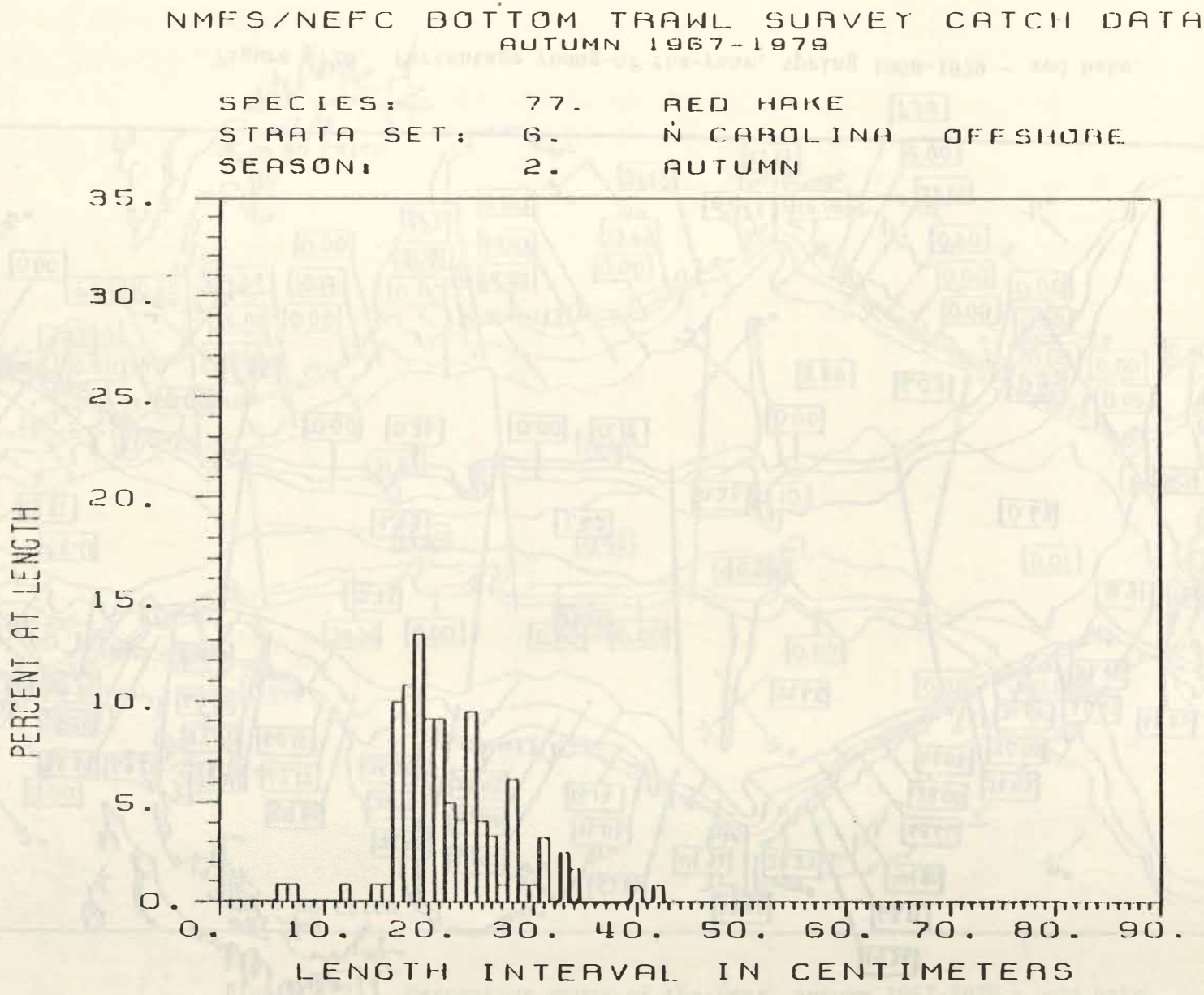


Figure 6.19. Autumn length frequencies for strata set 6.

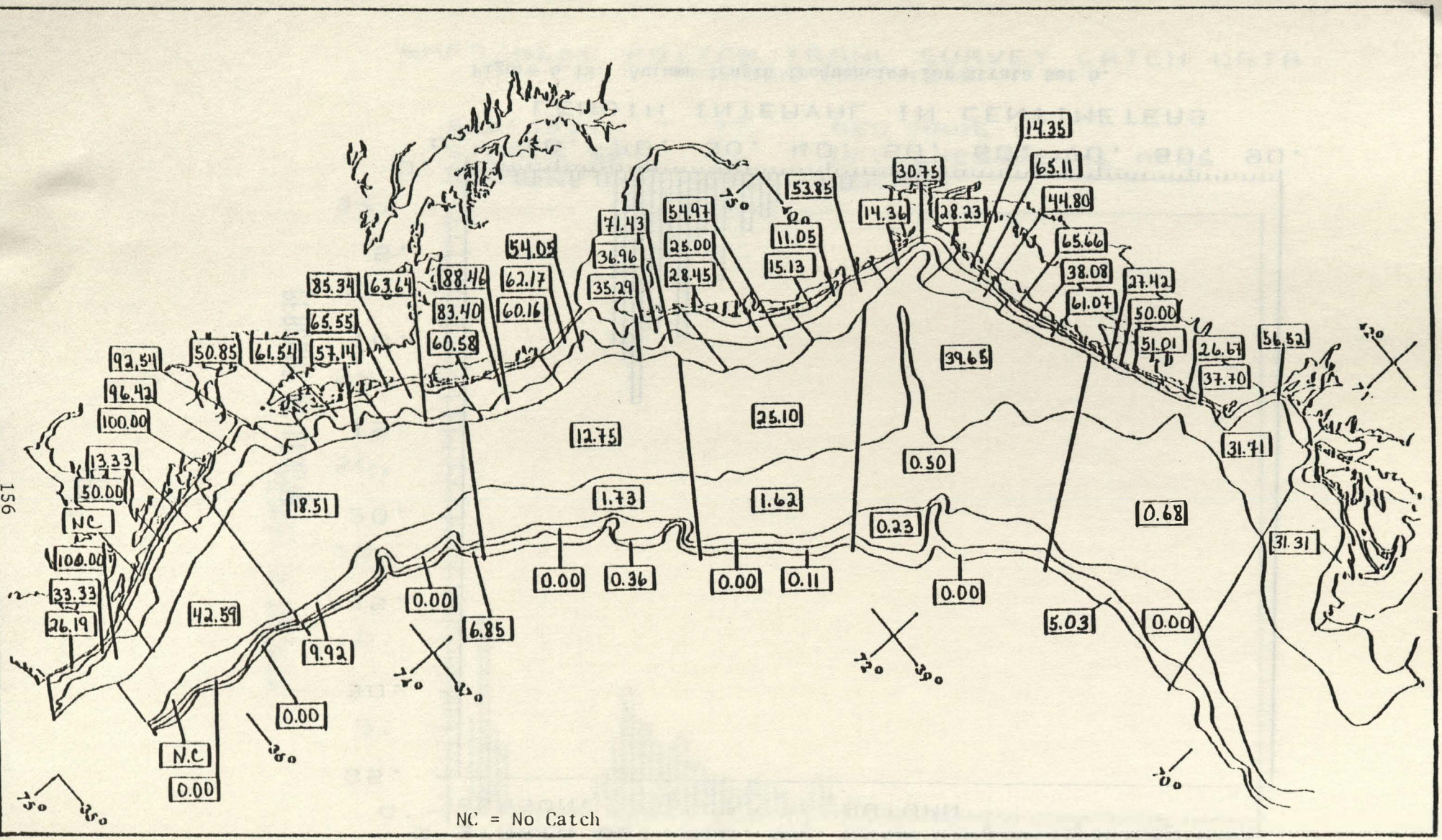


Figure 6.20. Percentage young-of-the-year, spring 1968-1979 - red hake.

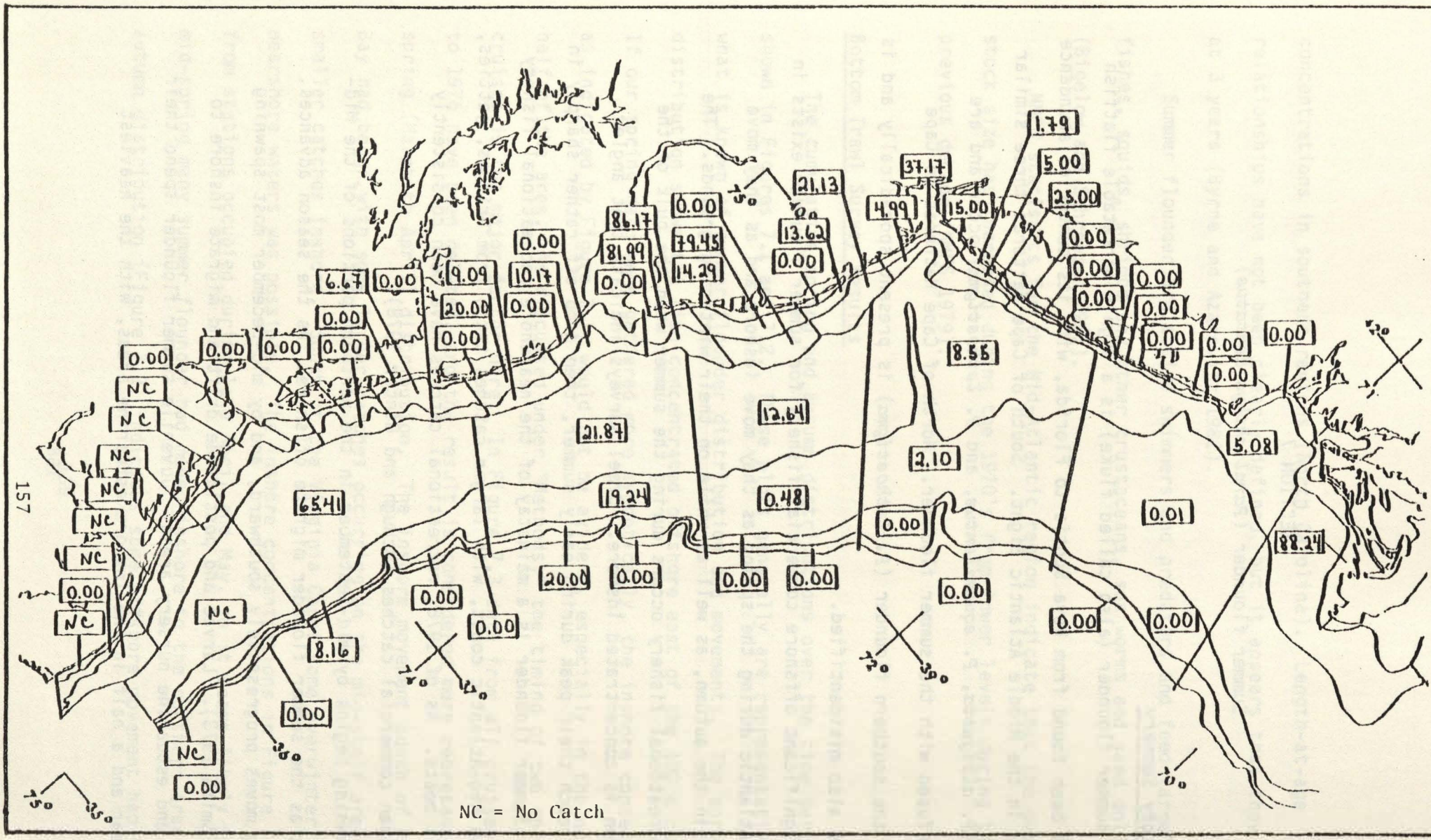


Figure 6.21. Percentage young-of-the-year, autumn 1967-1979 - red hake.

SECTION 7

Summer flounder (*Paralichthys dentatus*)

Life History Summary

The summer flounder (also called fluke) is a highly marketable flatfish which has been found from Nova Scotia to Florida, with its center of abundance generally in the Middle Atlantic Bight. South of Cape Hatteras three similar species (*P. albigutta*, *P. squamilentus*, and *P. lethostigma*) occur and are often confused with the summer flounder. North of Cape Hatteras to Cape Charles, the southern flounder (*P. lethostigma*) is present sporadically and is sometimes also misidentified.

A significant offshore commercial fishery for summer flounder exists in the Mid-Atlantic during the spring as they move inshore and as they move offshore in the autumn, as well as while on their wintering grounds. The major recreational fishery occurs during the summer when the bulk of the population is concentrated inshore. Creel surveys indicate that angler catches reach their peak during early summer, then drop off rather sharply in August. Summer flounder is a mainstay of the nearshore recreational fishery along the Mid-Atlantic coast, with larger catches taken from bridges, jetties, and small boats. As of 1978, recreational catches have been consistently higher than commercial catches (McHugh and Ginter 1978).

Spawning begins by mid-September in the northern portions of the Mid-Atlantic as the summer flounder migrate offshore. As the season advances, spawning moves progressively southward, and by mid-December most spawning ceases (Smith 1973). Larvae and postlarvae drift and migrate inshore to coastal and estuarine nursery areas. Juvenile summer flounder spend their first year and a half in the inshore estuarine areas, with the heaviest

concentrations in southern regions (North Carolina). Length-at-age relationships have not been clearly defined, but it appears that they mature at 3 years (Byrne and Azarovitz 1982).

Summer flounder are active swimmers and predators and feed largely on fishes, squids, shrimps and other crustaceans, sea worms and sand dollars (Bigelow and Schroeder 1953).

NMFS statistics for the Mid-Atlantic region indicate that the overall stock size has increased during the 1970's from lower levels during the previous decade (NMFS 1979).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 7.1 and 7.2. These plots generally are representative of what is known of summer flounder distribution and movements. The spring distribution shows the fish concentrated offshore east of the 100 m contour. If our spring data were gathered more synoptically, the inshore concentration, as indicated by Figure 7.1, would not be evident, especially in the northern half of the area. As discussed under "Methods," the timing of two spring cruises is the major factor here. In Figure 7.3 data from all cruises prior to 1976 have been deleted, and the result is considered more representative of spring (March to April) distribution. The inshore movement south of Delaware Bay had begun with some larger catches occurring on the mid-shelf area and smaller catches inshore. South of the Virginia Capes some overwintering in nearshore waters was possible. The inshore concentrations in Figure 7.1 were from stations occupied during late April and May, so it seems likely that by mid-spring many summer flounder had moved inshore in the northern area. The autumn distribution (Figure 7.2) indicates some offshore movement had begun.

If data from a similar time series in summer were available the distributions would have been concentrated closer to the coast. This demonstrates the summer flounder's availability to coastal recreational fishermen.

The decline of the summer flounder population in the Mid-Atlantic from the mid-1960's to 1970 and the increase after 1970 are substantiated by the graphs of mean weight and number per tow (Figures 7.4-7.7). The lateness of the spring 1973 survey, and the resulting high inshore catches in northern inshore strata also are reflected. As expected, consistently higher numbers and weights were obtained in the inshore areas during fall cruises as well as in inshore southern areas during spring cruises.

Length frequencies for six strata sets, arranged by season, are shown in Figures 7.8-7.19. These plots indicate the importance of the Delaware-Chesapeake area (Figures 7.9 and 7.15). Not only were consistent catches made in this area, but also the largest incidence of summer flounder of less than 20 cm occurred here. Larger and probably older fish occur more frequently in the northern inshore and offshore strata sets.

Figures 7.20 and 7.21 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 17 and 27 cm, respectively, for spring and fall series. The importance of the Chesapeake Bight to the species is demonstrated by the fact that almost all of the YOY caught during the spring series (Figure 7.20) were from this area. Some appeared in the other areas during autumn (Figure 7.21), but the percentage was very high in the Chesapeake Bight.

A report prepared by Sissenwine et al. (1979) using these data analyzed distribution based on depth and water temperature in addition to the parameters considered in this report. They found that during spring, summer flounder occurred in depths from 9 to 360 m; during summer and autumn they

were found primarily in depths less than 100 m, and during winter in depths greater than 70 m. Spring bottom temperatures for the species range between 8° and 16°C and in autumn between 12° and 28°C.

From a historical perspective, the survey time series occurs during a period of generally low abundance of summer flounder; that is, low during the 1960's and recovering during the 1970's. It is important to note that during periods of high or "normal" abundance the distribution of the species could be different. One major difference might be the occurrence of more YOY in northern areas. Regardless of stock conditions. the general inshore-offshore migratory pattern should remain the same. It is obvious that any large-scale disruption, on virtually any section of the Mid-Atlantic shelf, could have a pronounced impact on several phases of this species' life cycle.

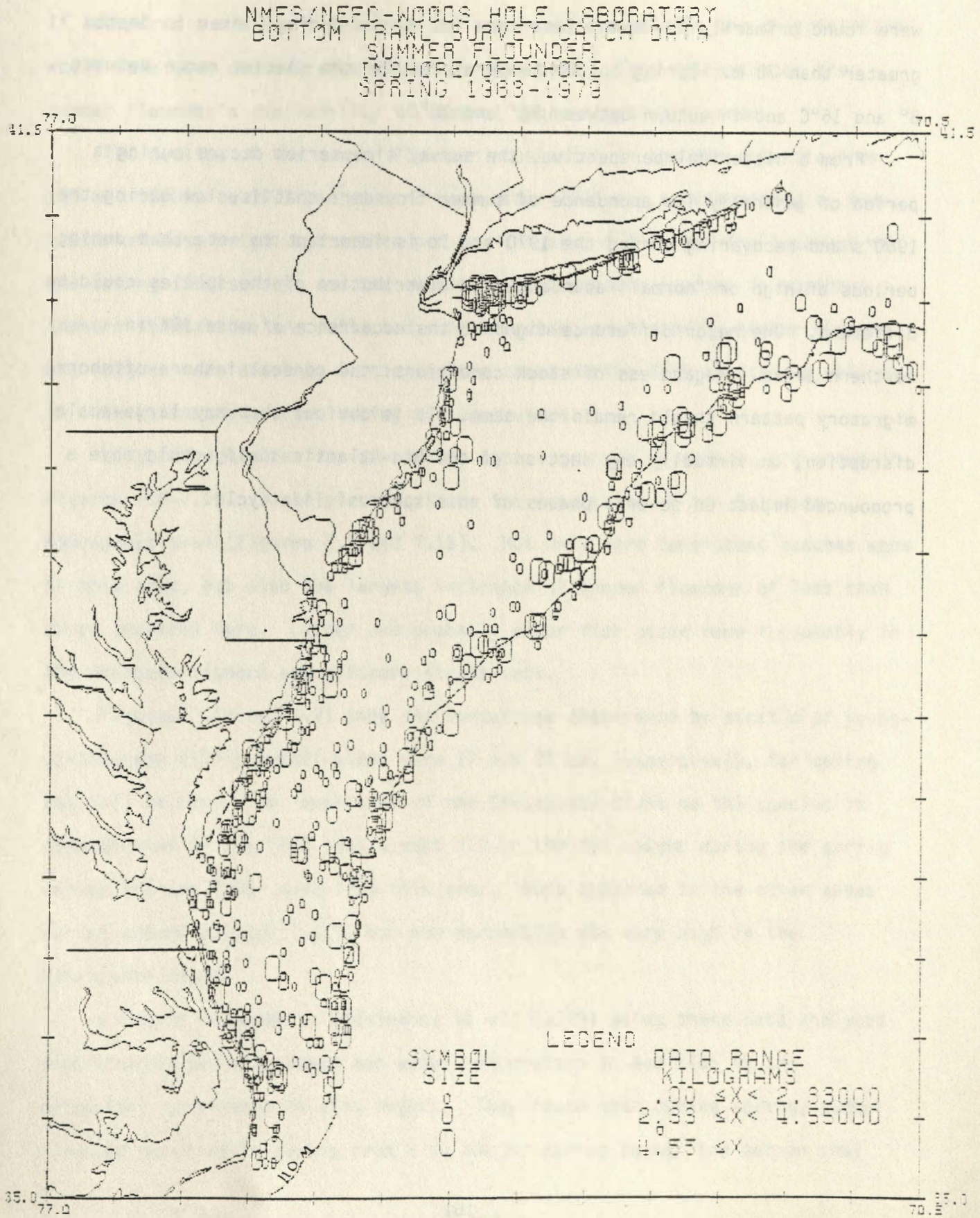


Figure 7.1. Spring distribution, 1968-1979.

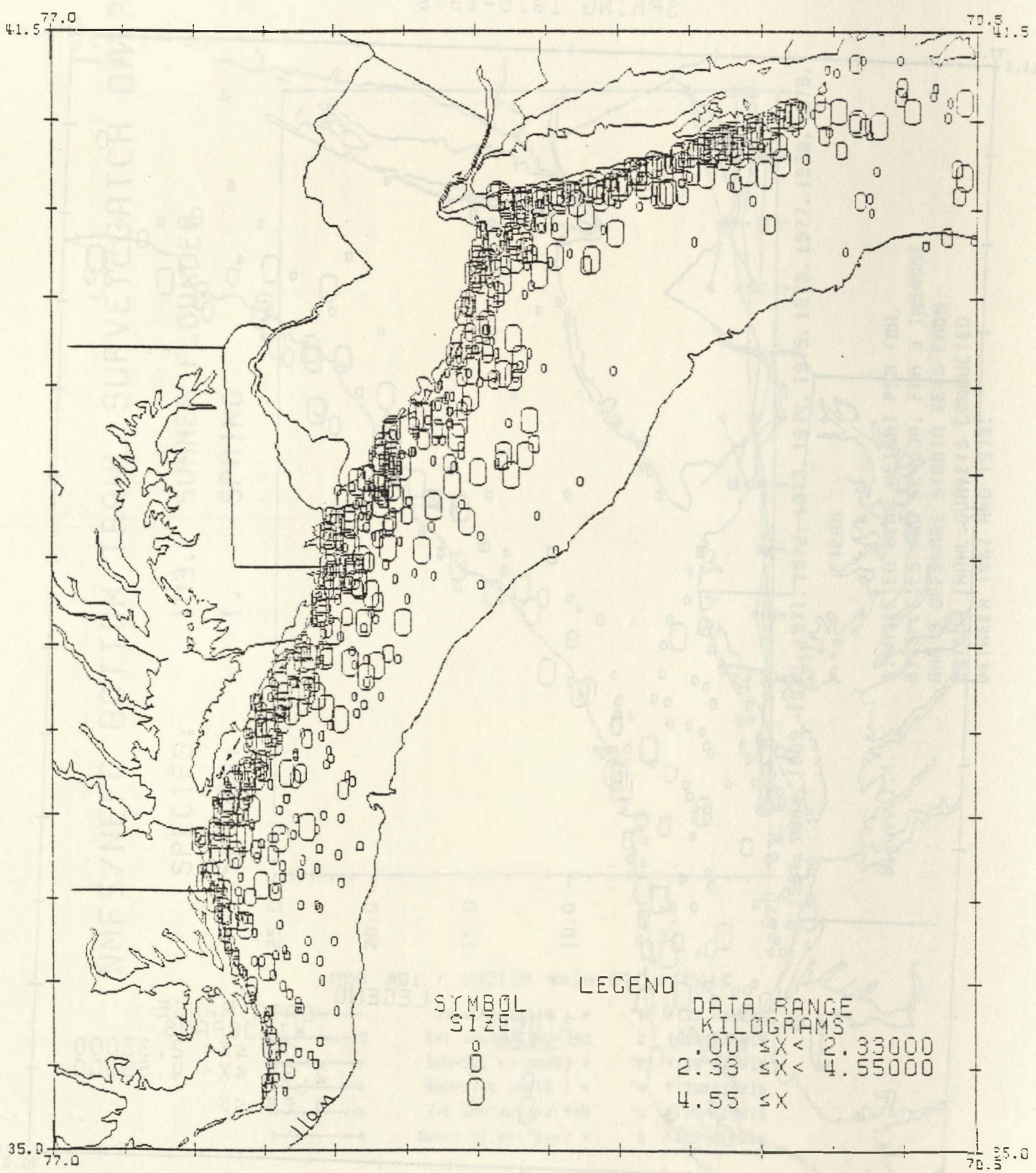


Figure 7.2. Autumn distribution, 1967-1979.

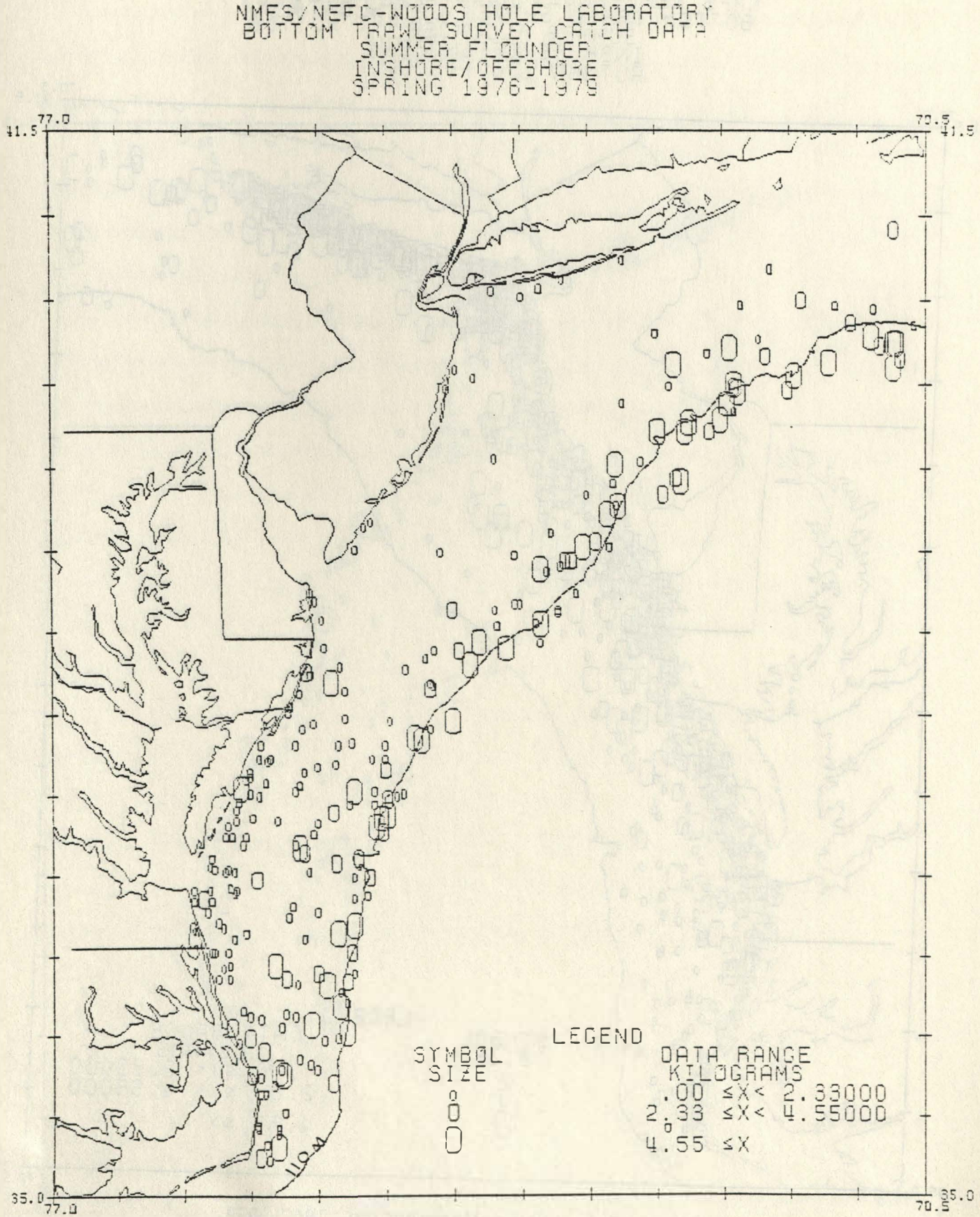


Figure 7.3. Spring distribution, 1976-1979.

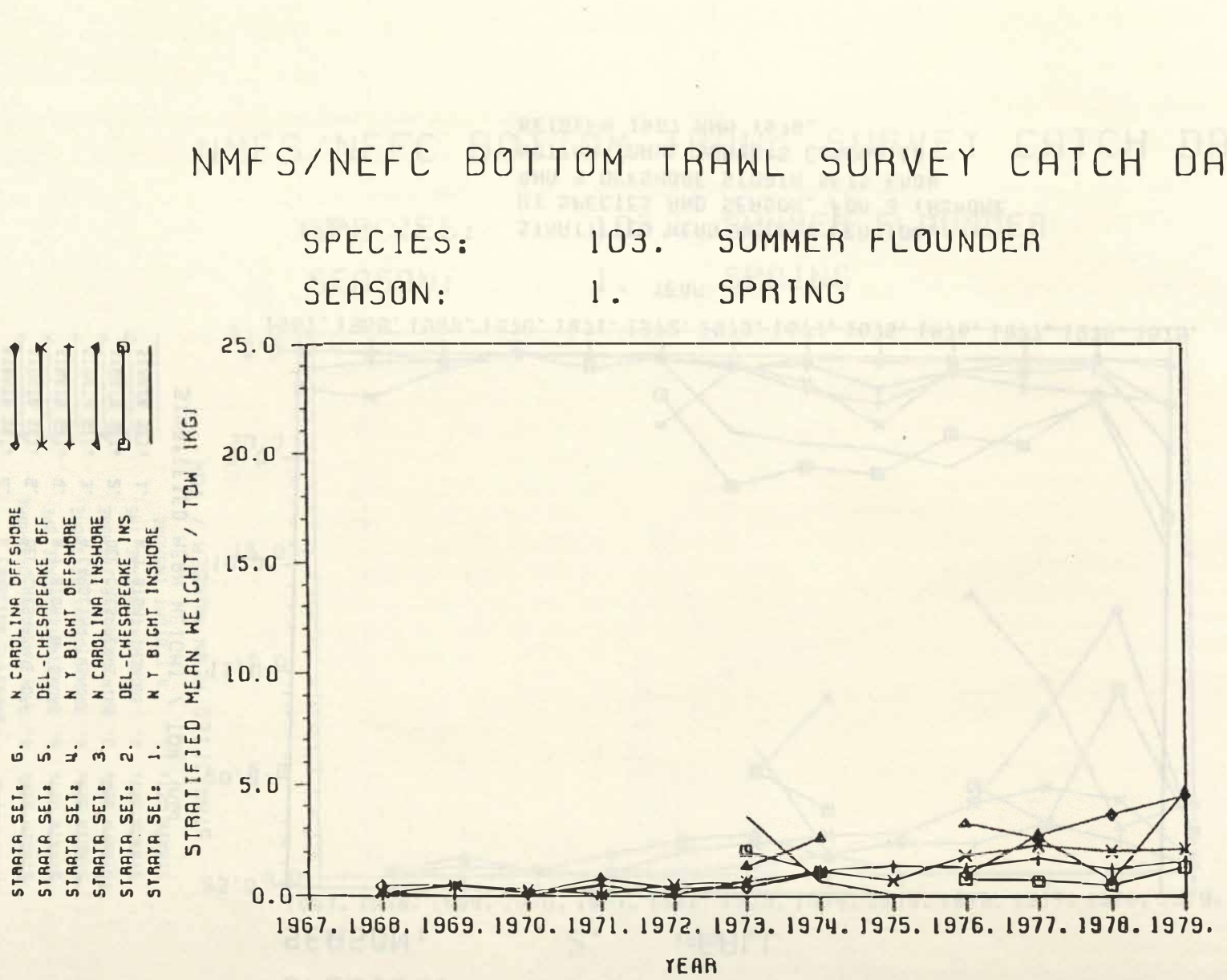


Figure 7.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 103. SUMMER FLOUNDER

SEASON: 2. FALL

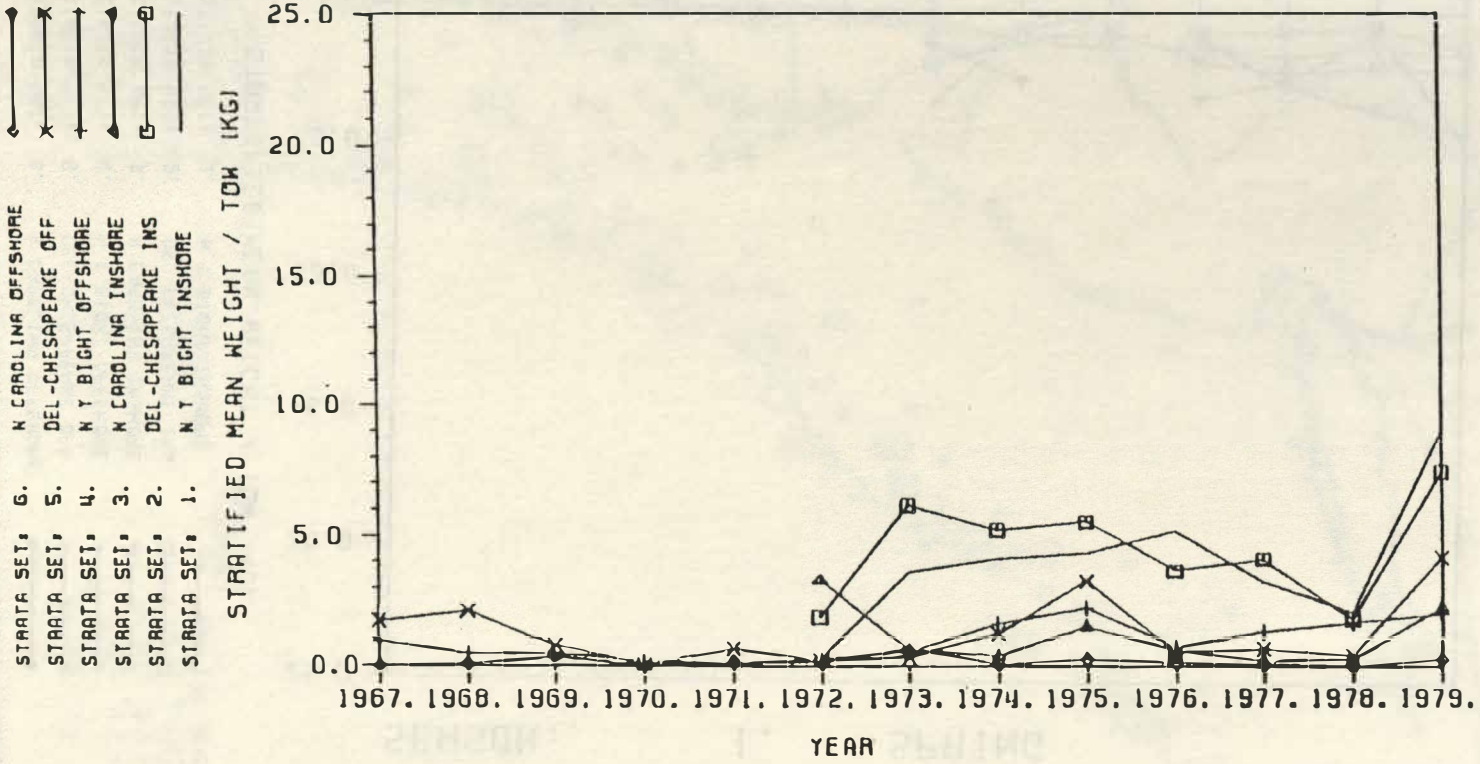


Figure 7.5. STRATIFIED MEAN WEIGHT PER TOW. BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

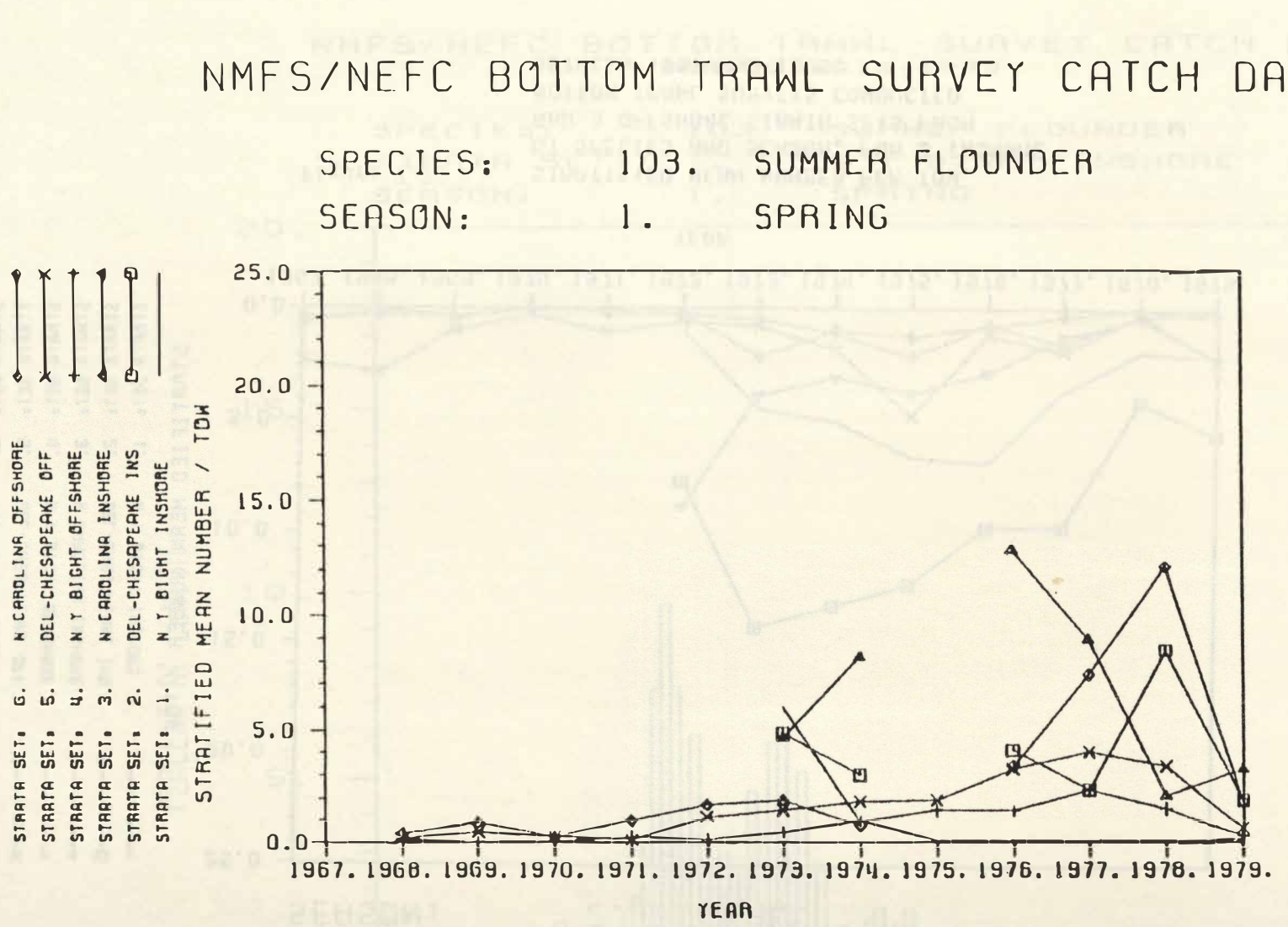


Figure 7.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

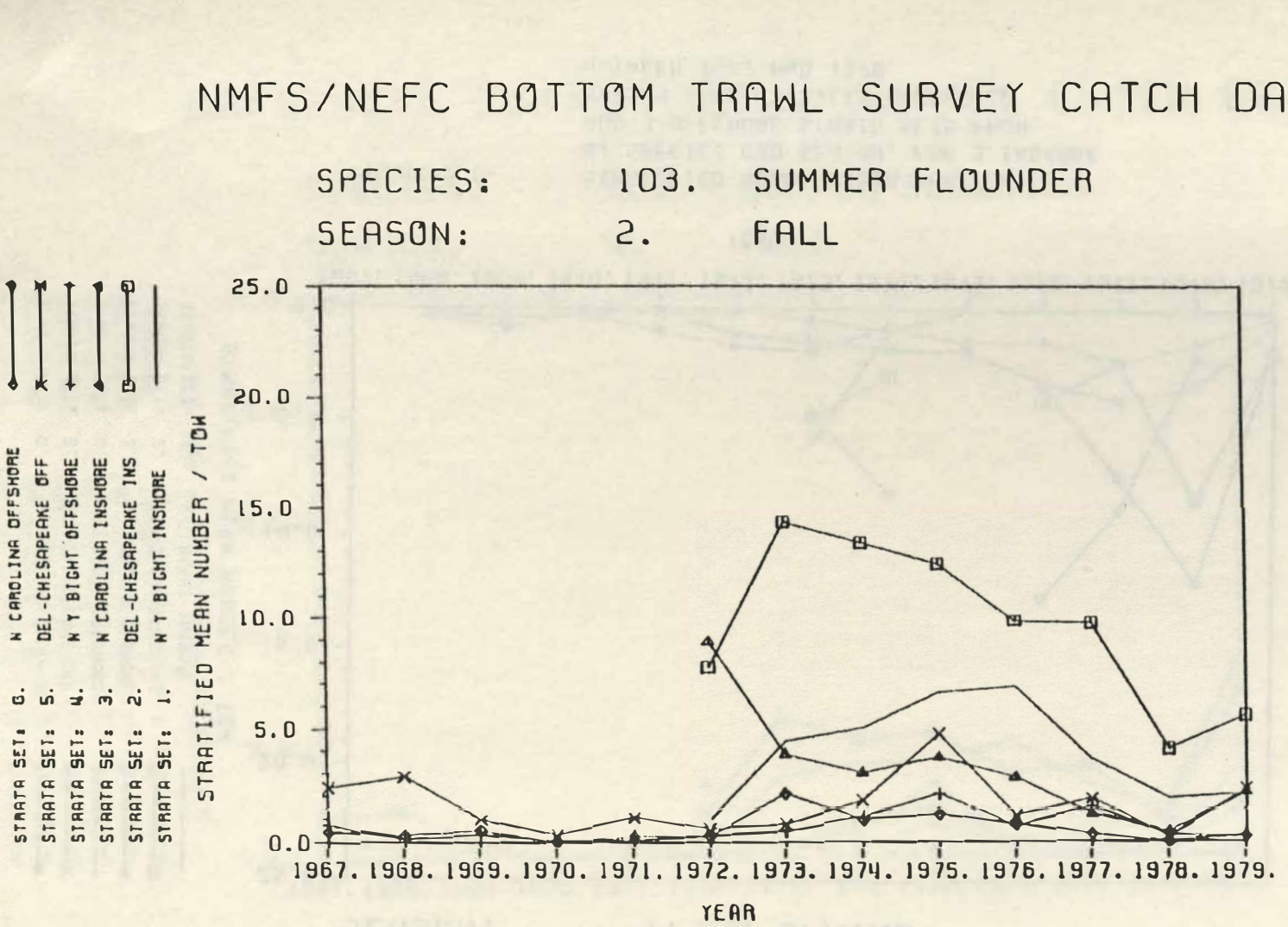


Figure 7.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

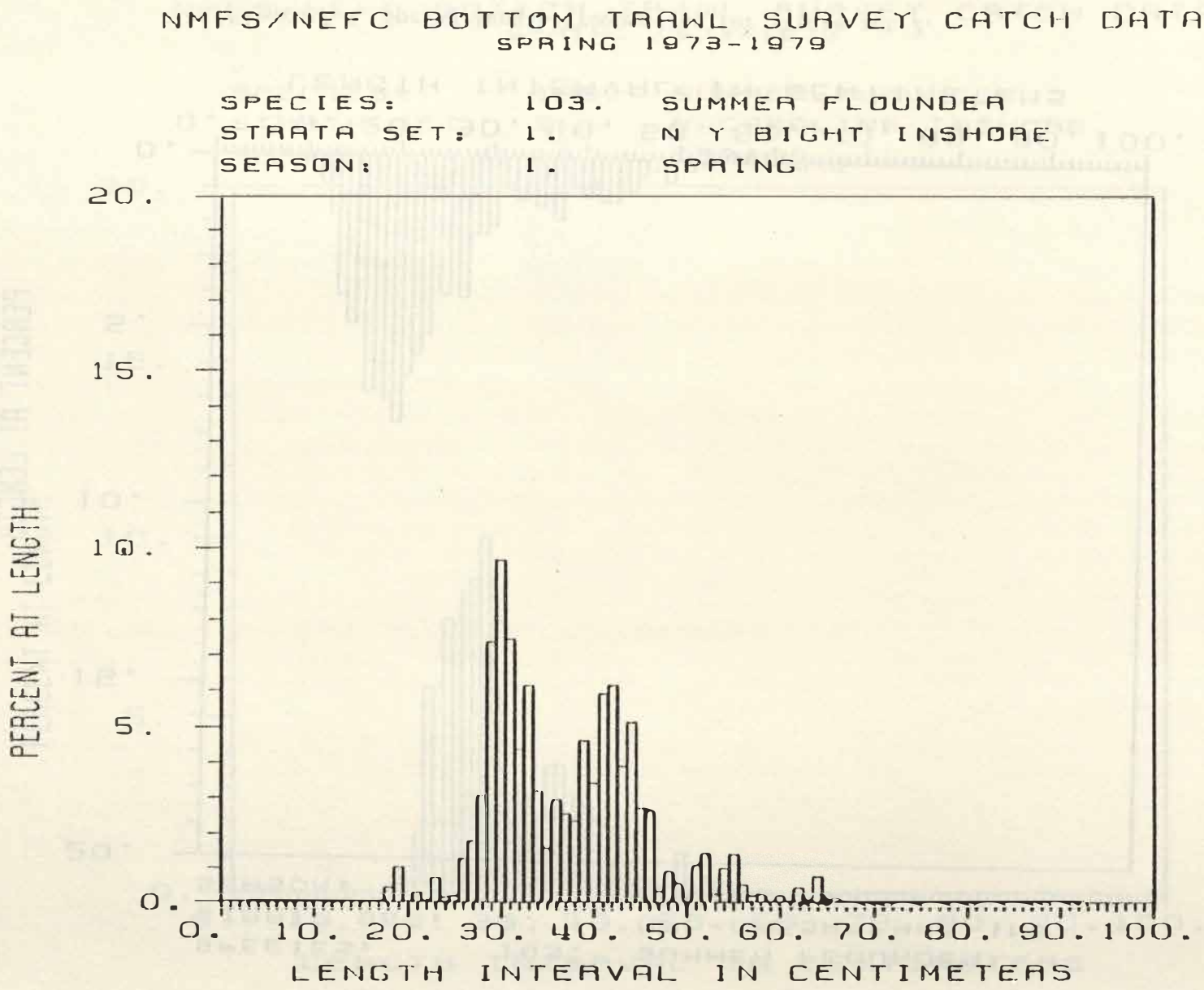


Figure 7.8. Spring length frequencies for strata set 1.

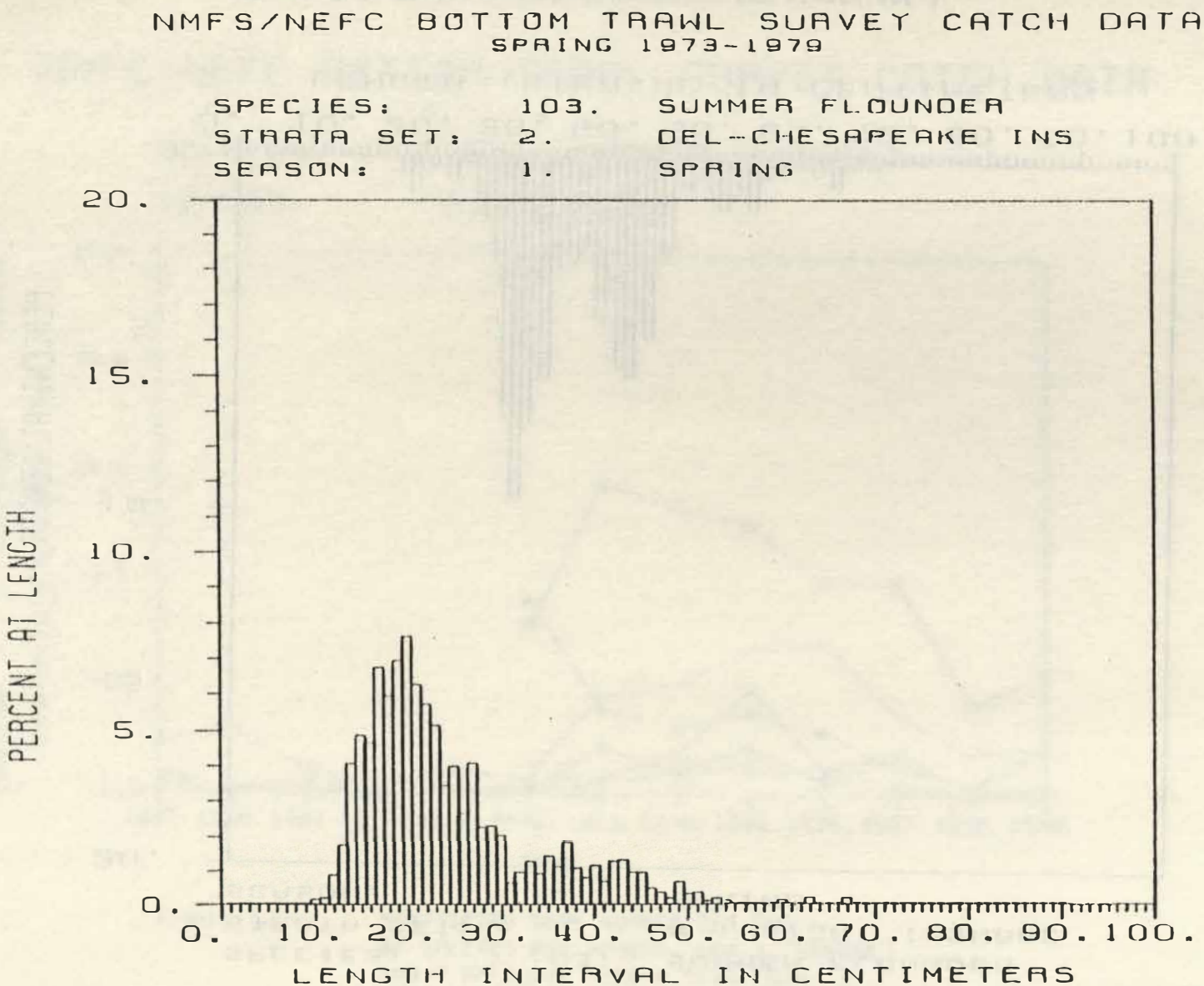


Figure 7.9. Spring length frequencies for strata set 2.

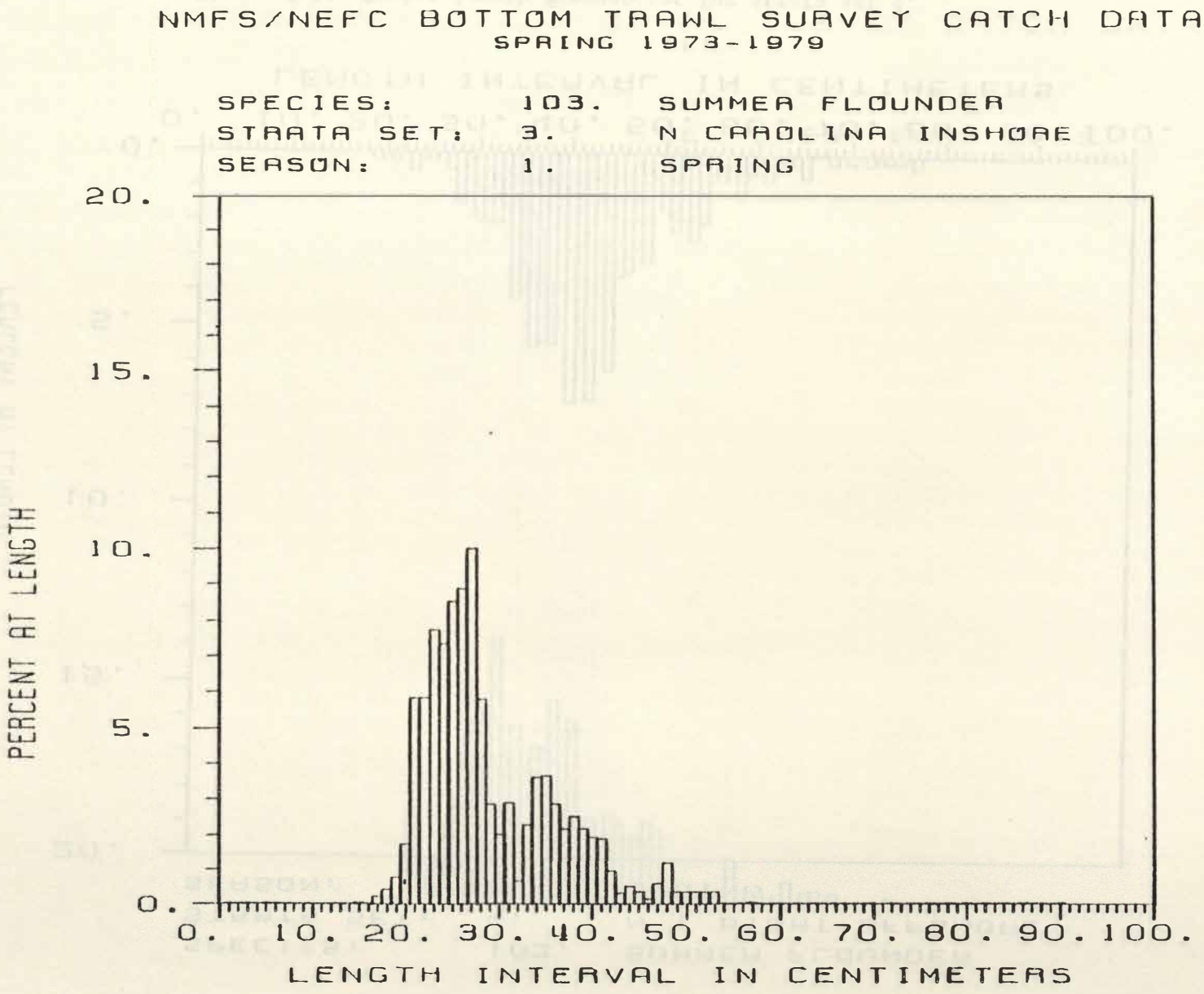


Figure 7.10. Spring length frequencies for strata set 3.

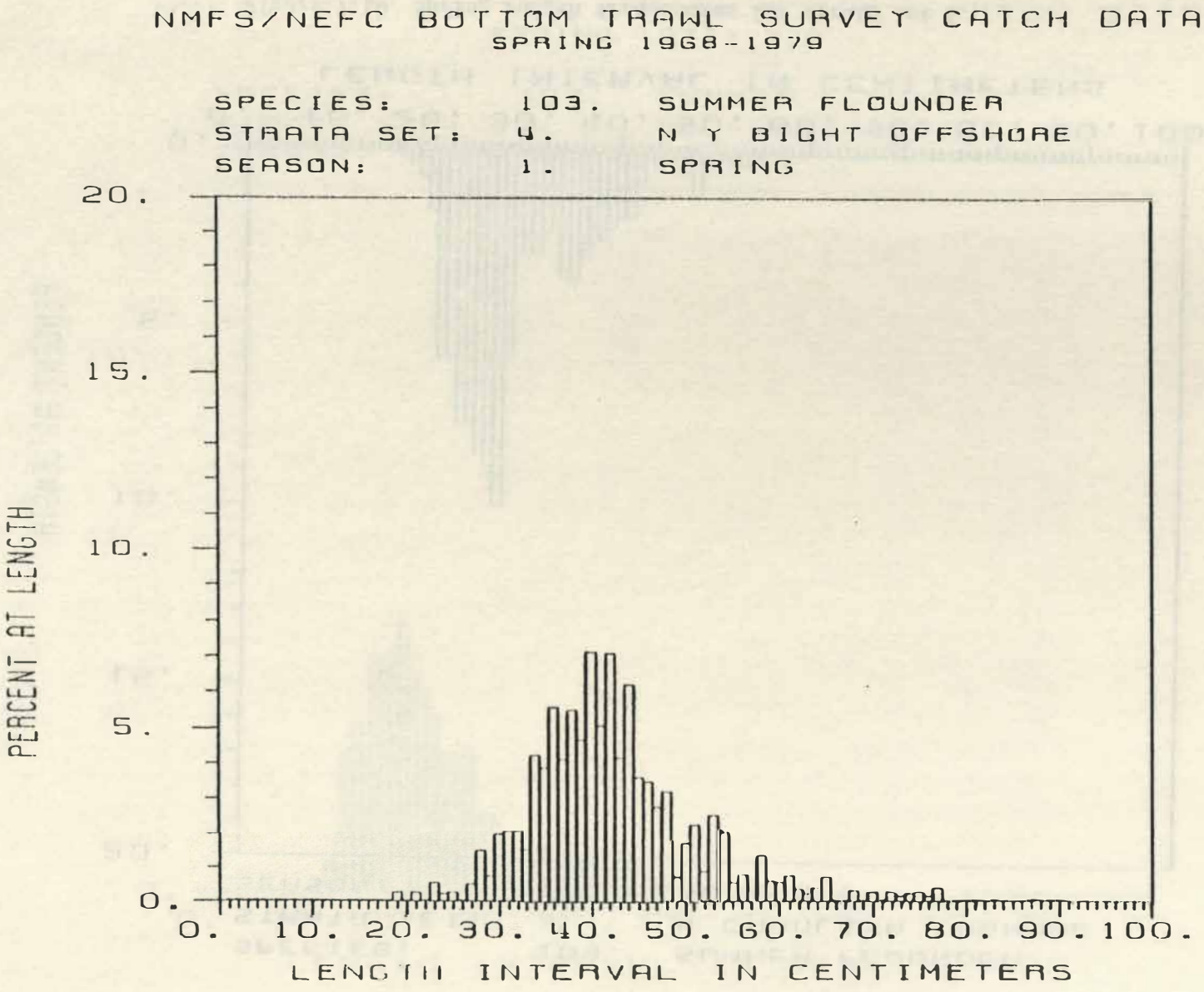


Figure 7.11. Spring length frequencies for strata set 4.

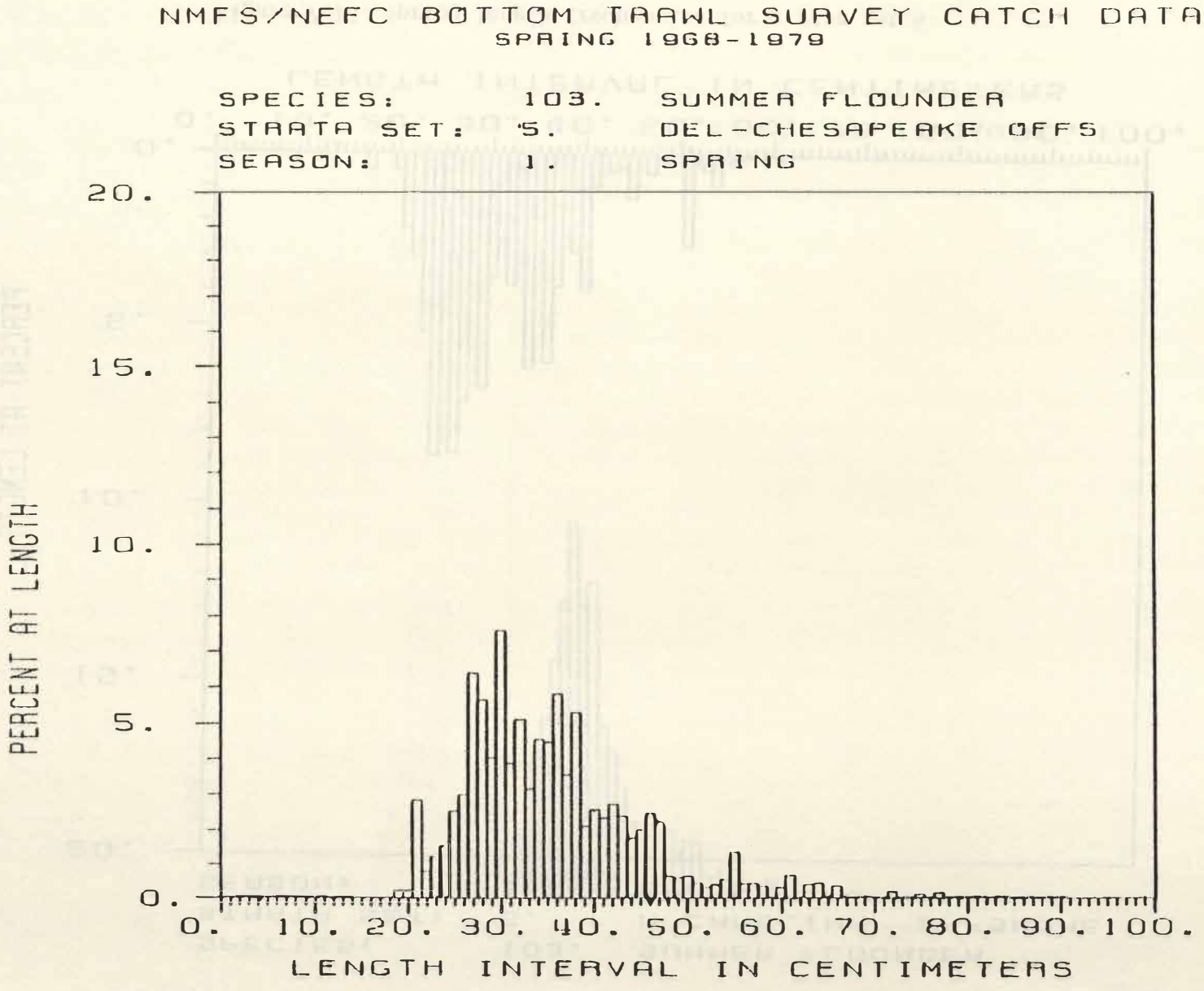


Figure 7.12. Spring length frequencies for strata set 5.

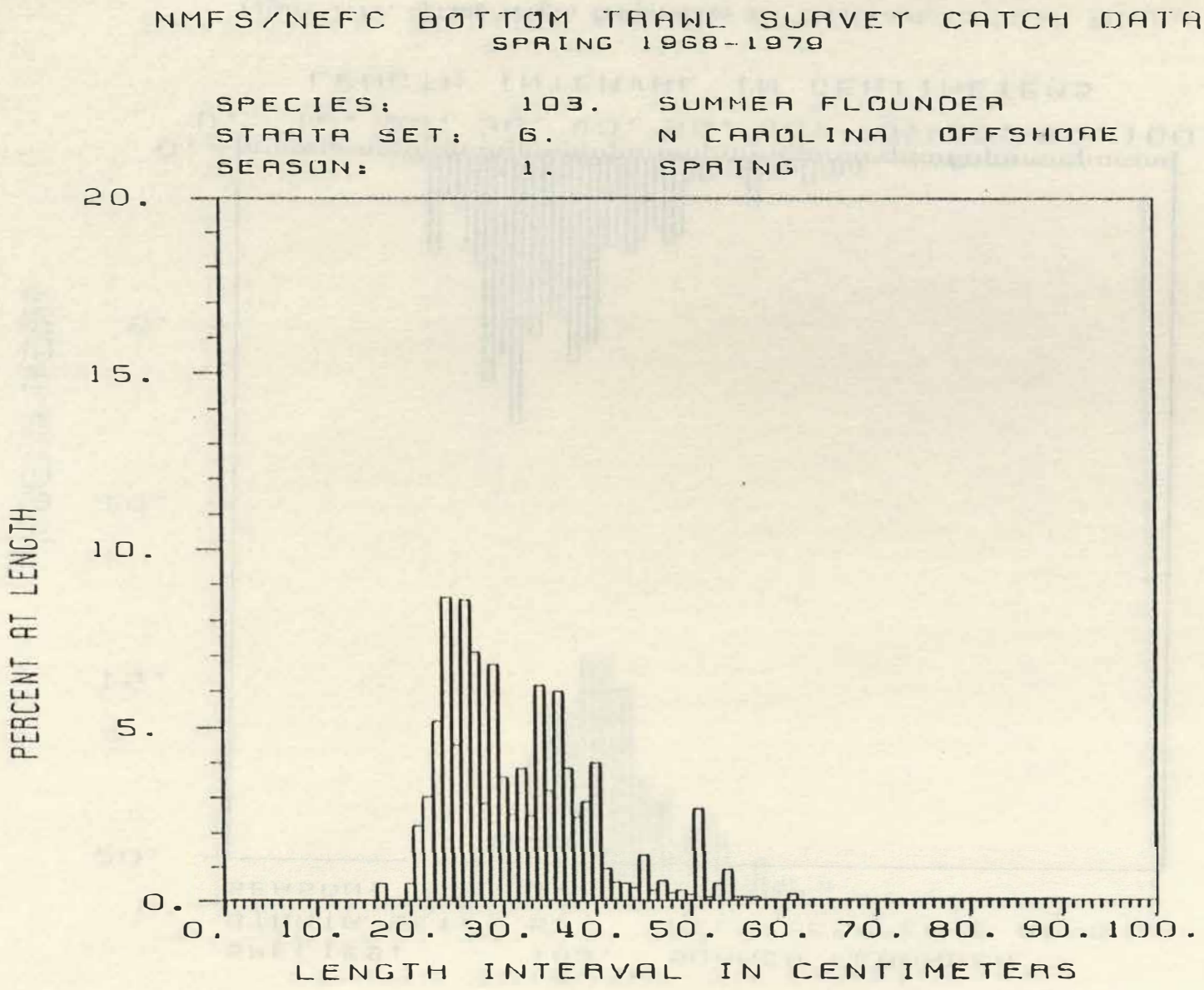


Figure 7.13. Spring length frequencies for strata set 6.

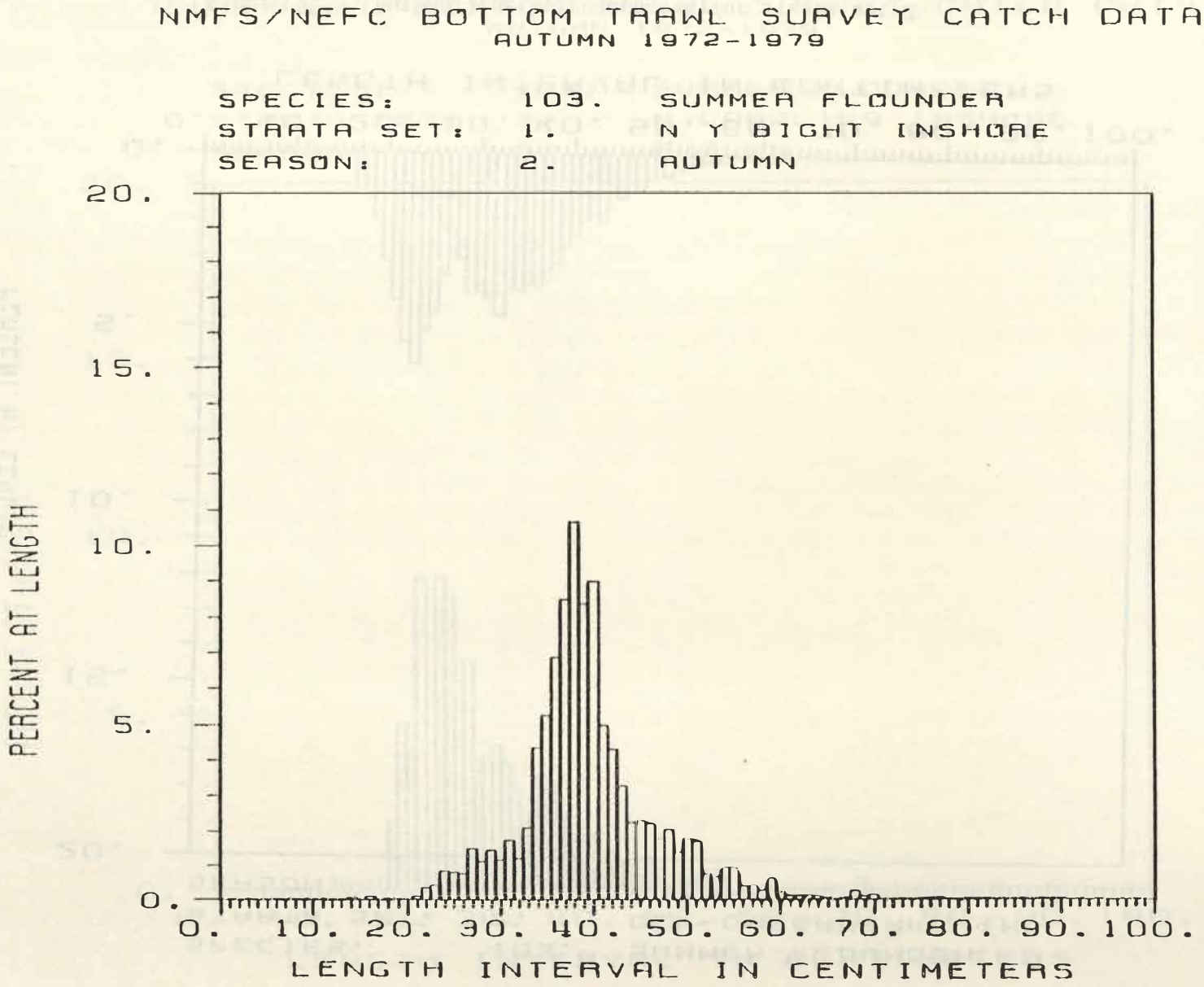


Figure 7.14. Autumn length frequencies for strata set 1.

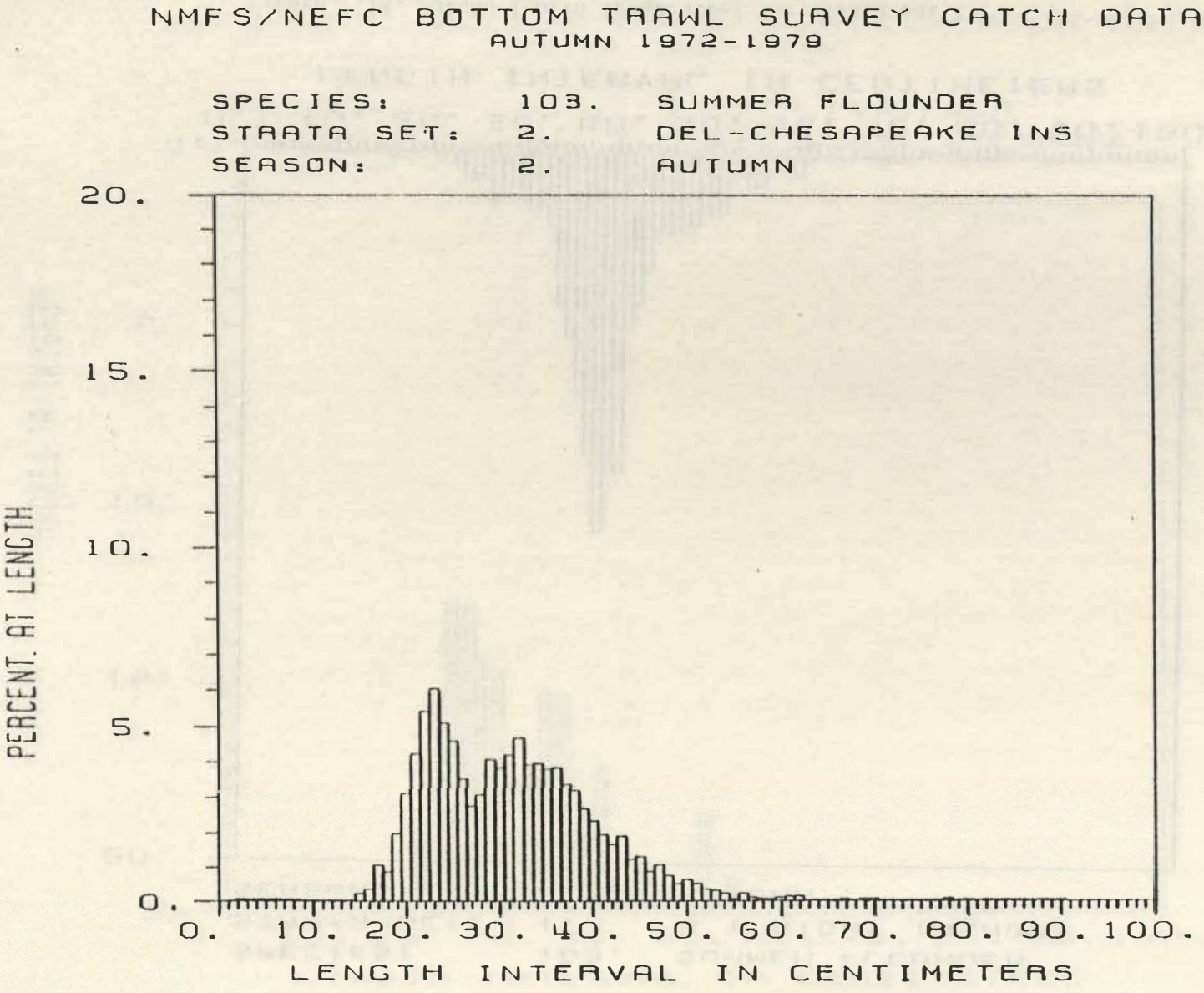


Figure 7.15. Autumn length frequencies for strata set 2.

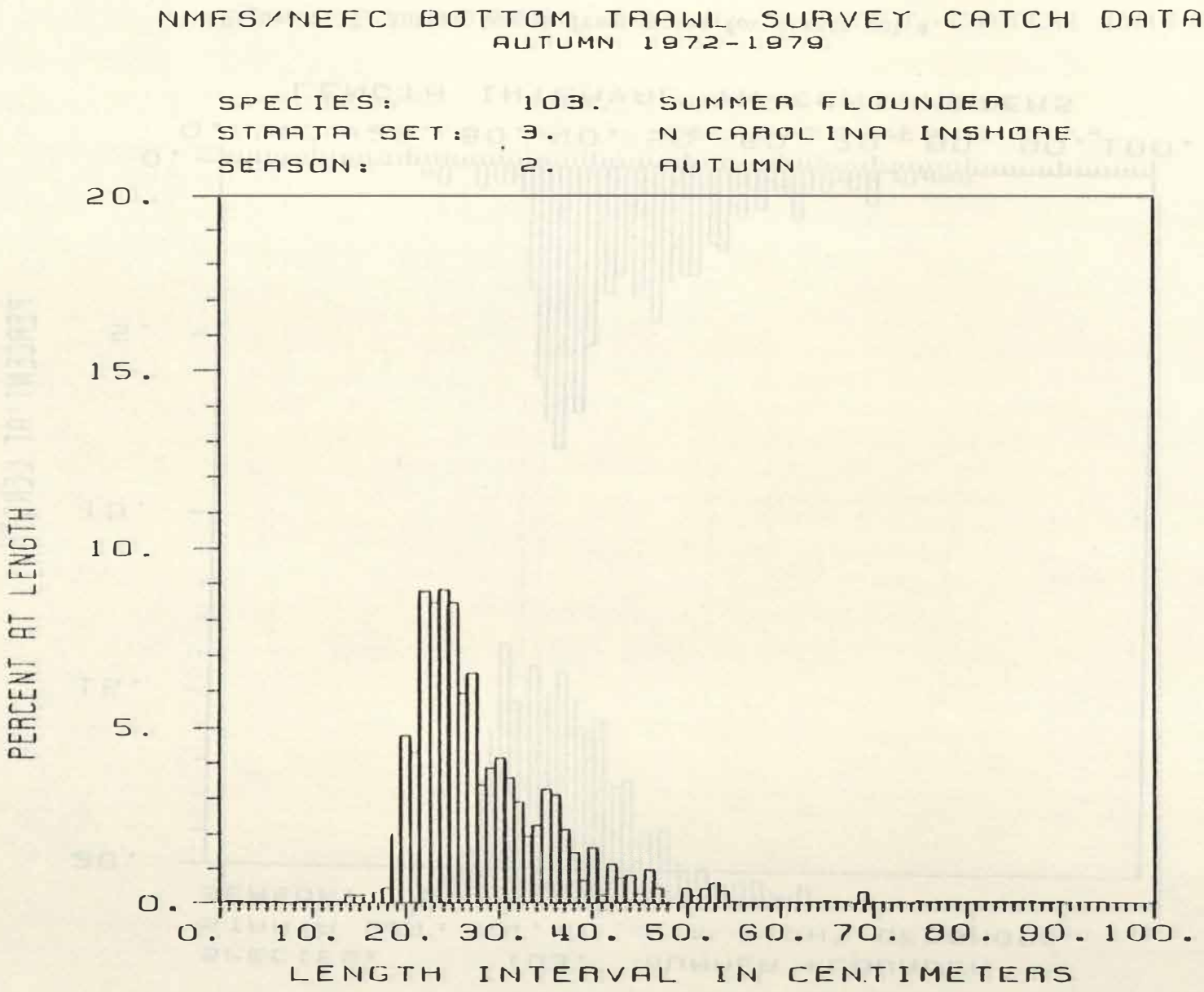


Figure 7.16. Autumn length frequencies for strata set 3.

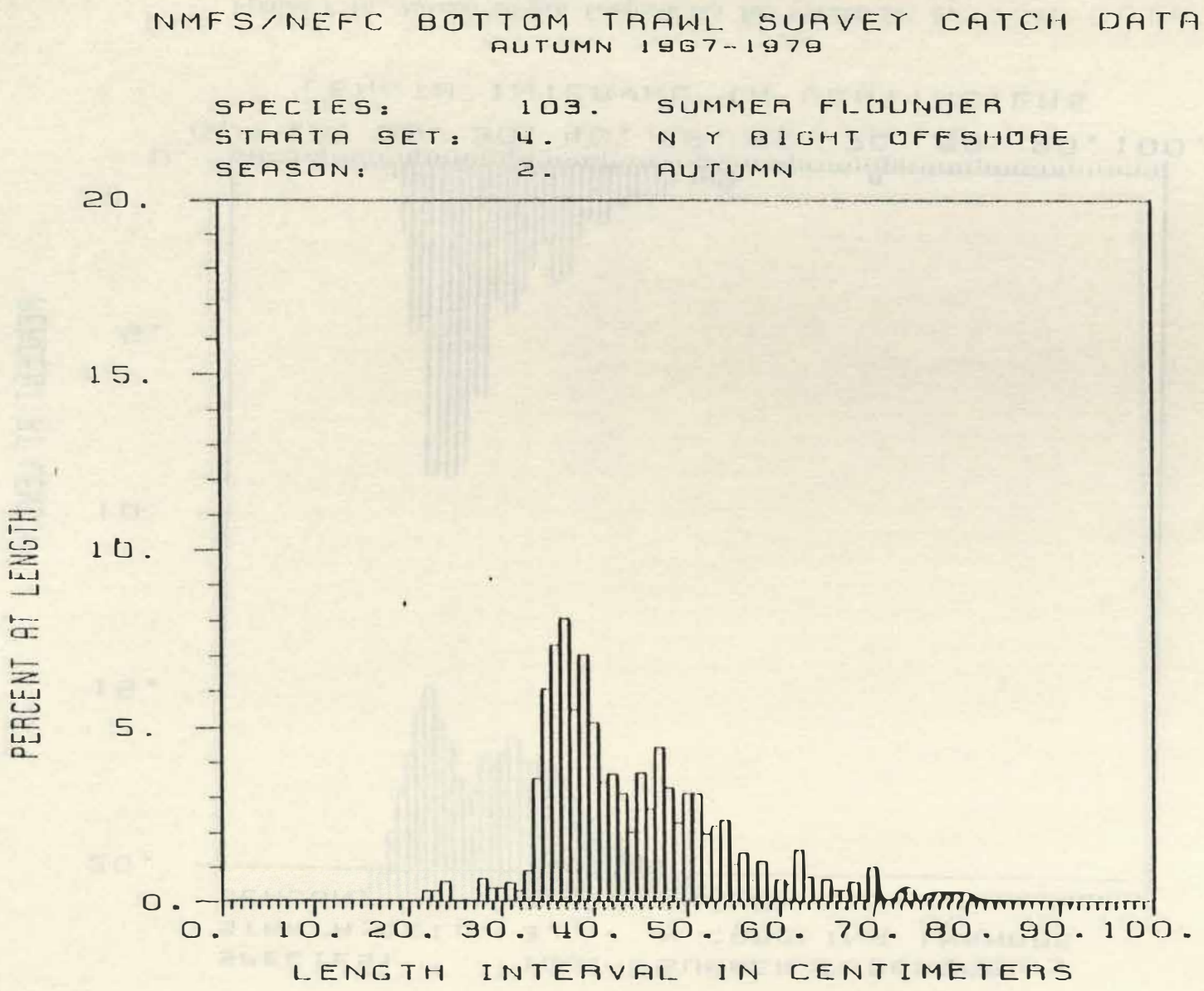


Figure 7.17. Autumn length frequencies for strata set 4.

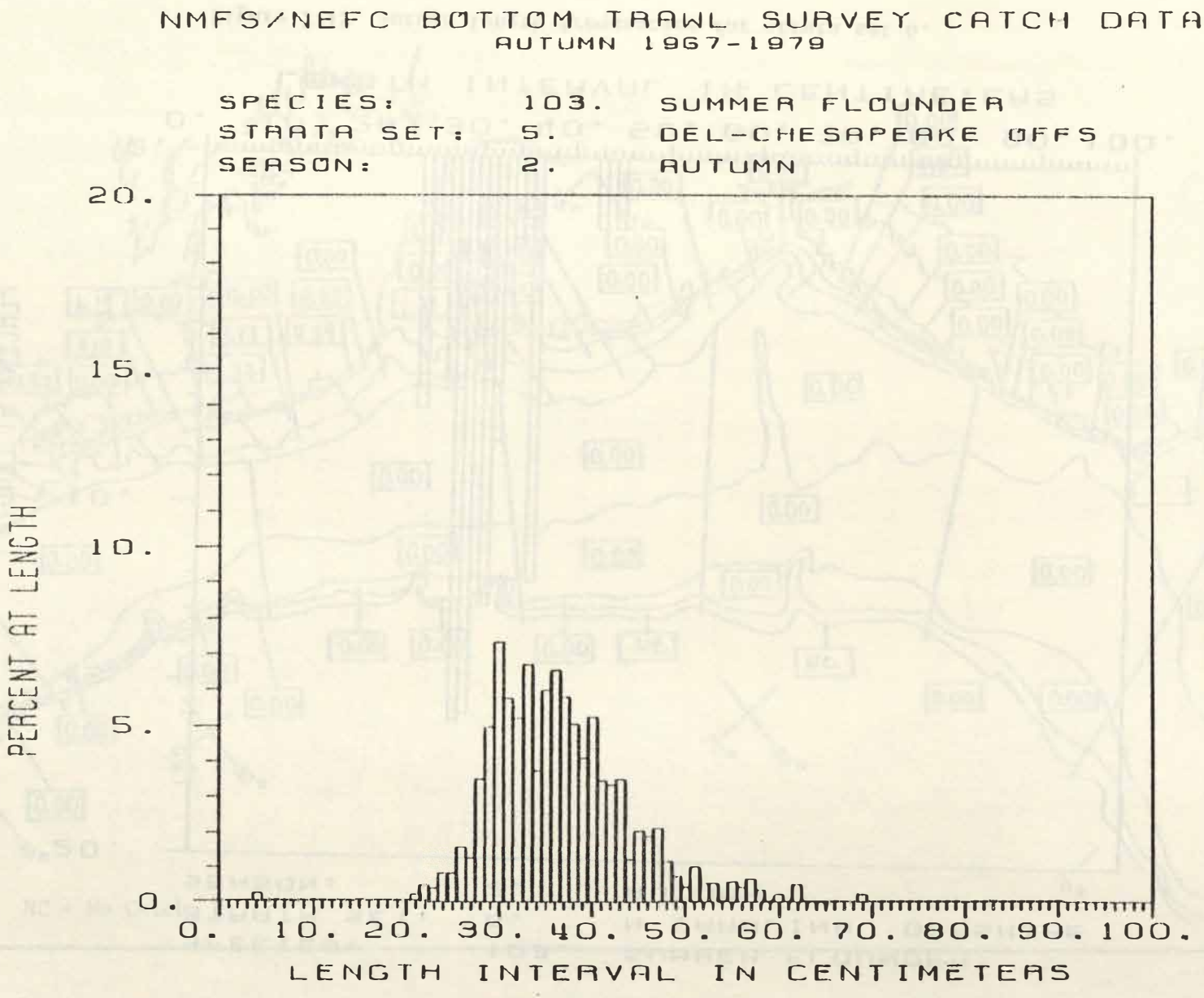


Figure 7.18. Autumn length frequencies for strata set 5.

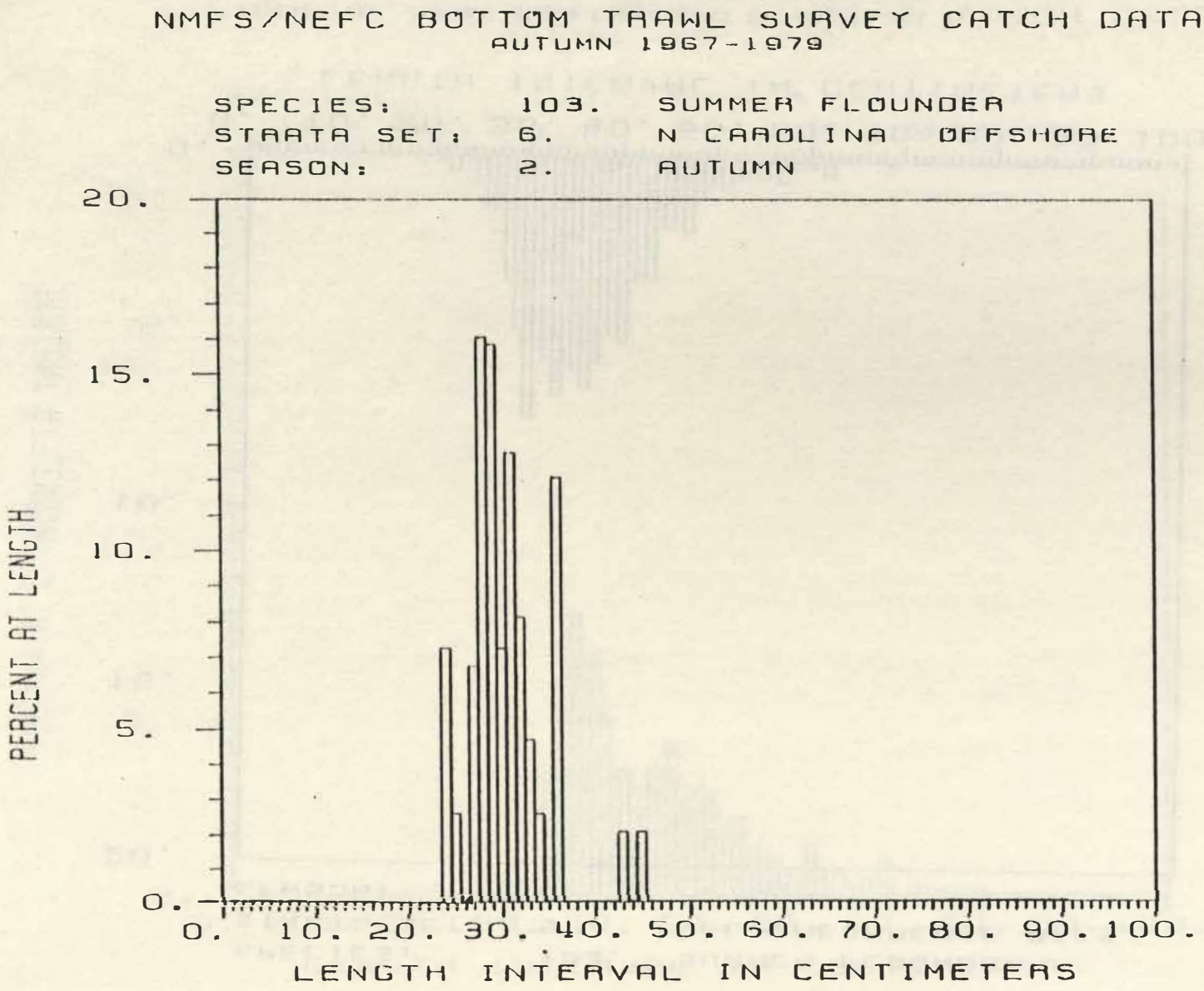


Figure 7.19. Autumn length frequencies for strata set 6.

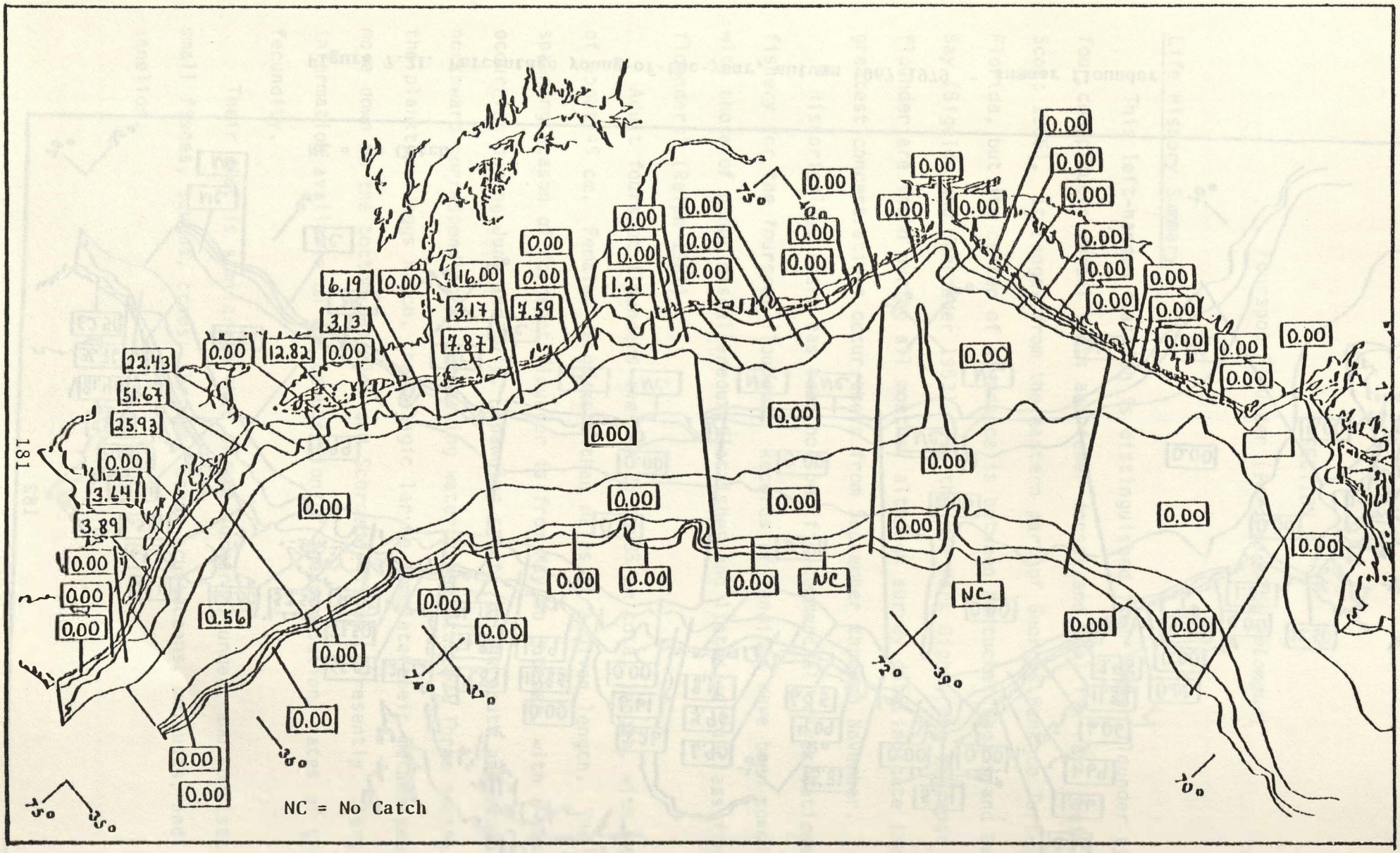


Figure 7.20. Percentage young-of-the-year, spring 1968-1979 - summer flounder.

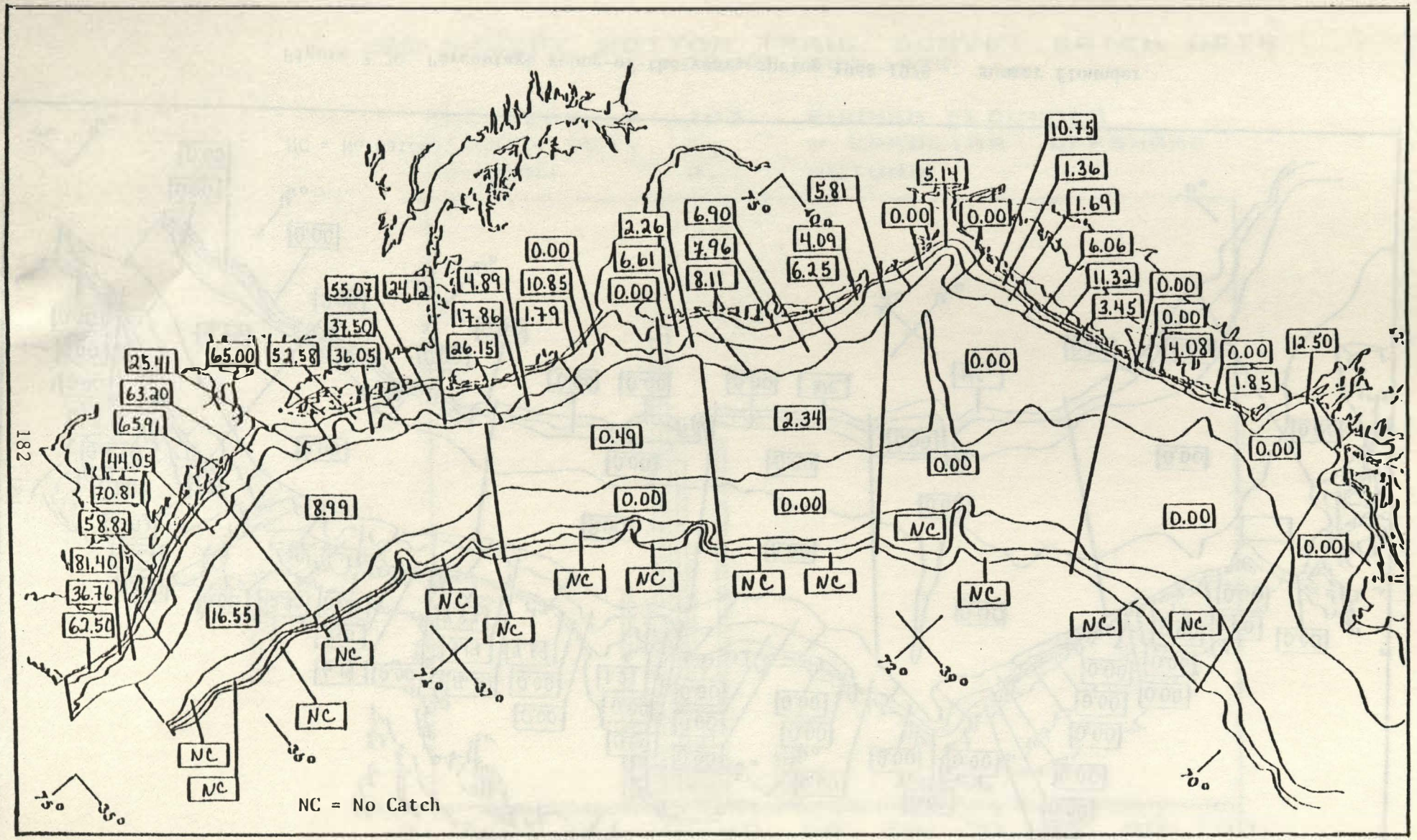


Figure 7.21. Percentage young-of-the-year, autumn 1967-1979 - summer flounder.

SECTION 8

Fourspot Flounder (*Paralichthys oblongus*)

Life History Summary

This left-handed flatfish is distinguished from summer flounder by its four conspicuous dorsal spots and fewer dorsal and anal fin rays (Leim and Scott 1966). It ranges from the eastern part of Georges Bank to Tortuga, Florida, but its center of abundance is between Nantucket Shoals and Delaware Bay (Bigelow and Schroeder 1953). In the New York Bight, the fourspot flounder are found during all months, although survey data indicate the greatest concentrations occur there from September through November.

Historically, there has been no specific commercial or recreational fishery for the fourspot flounder. Records of landings have been combined with those of other miscellaneous flatfishes and listed as "unclassified flounders" (Ralph 1982).

Adult fourspot flounders average 25 to 35 cm total length, with a maximum of about 45 cm. Females weigh more than males at a given length. The spawning season of fourspot flounder is from May to October, with a peak occurring during June and July. Spawning starts in the south and advances northward corresponding to increasing water temperatures. Three months after the planktonic eggs hatch, the pelagic larvae complete their metamorphosis and move down to the bottom (Bigelow and Schroeder 1953). Presently, there is no information available on age composition of the population, rates of growth or fecundity.

Their diet is similar to that of the summer flounder, and consists of small fishes, squids, crabs, shrimps, other crustaceans, molluscs, and annelids.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 8.1 and 8.2. The distribution patterns during the two seasons reflect some inshore-offshore movement, but no significant migration. The spring distribution plot shows the fish were concentrated offshore along the 100 m contour. The distribution pattern did not change when the pre-1976 cruises were deleted (Figure 8.3). The autumn series showed that the fish had moved inside the 100 m contour to the mid-shelf area.

The graphs of mean weight and number per tow (Figures 8.4-8.7) do not reflect any dramatic change other than some increases after 1977, especially in the New York Bight offshore strata set.

Length frequencies for six strata sets, arranged by season, are shown in Figures 8.8-8.19. The consistency of the catches is again an indication that as an adult this animal is a resident of the mid and outer shelf. It is of interest that smaller fourspot flounder (<20 cm) were strongly represented in the inshore strata during the autumn (Figures 8.14-8.15).

Figures 8.20 and 8.21 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 6 cm for both seasons. YOY were not caught in great quantities on our surveys but the inshore autumn strata sets were the most consistent producers (Figures 8.14-8.15).

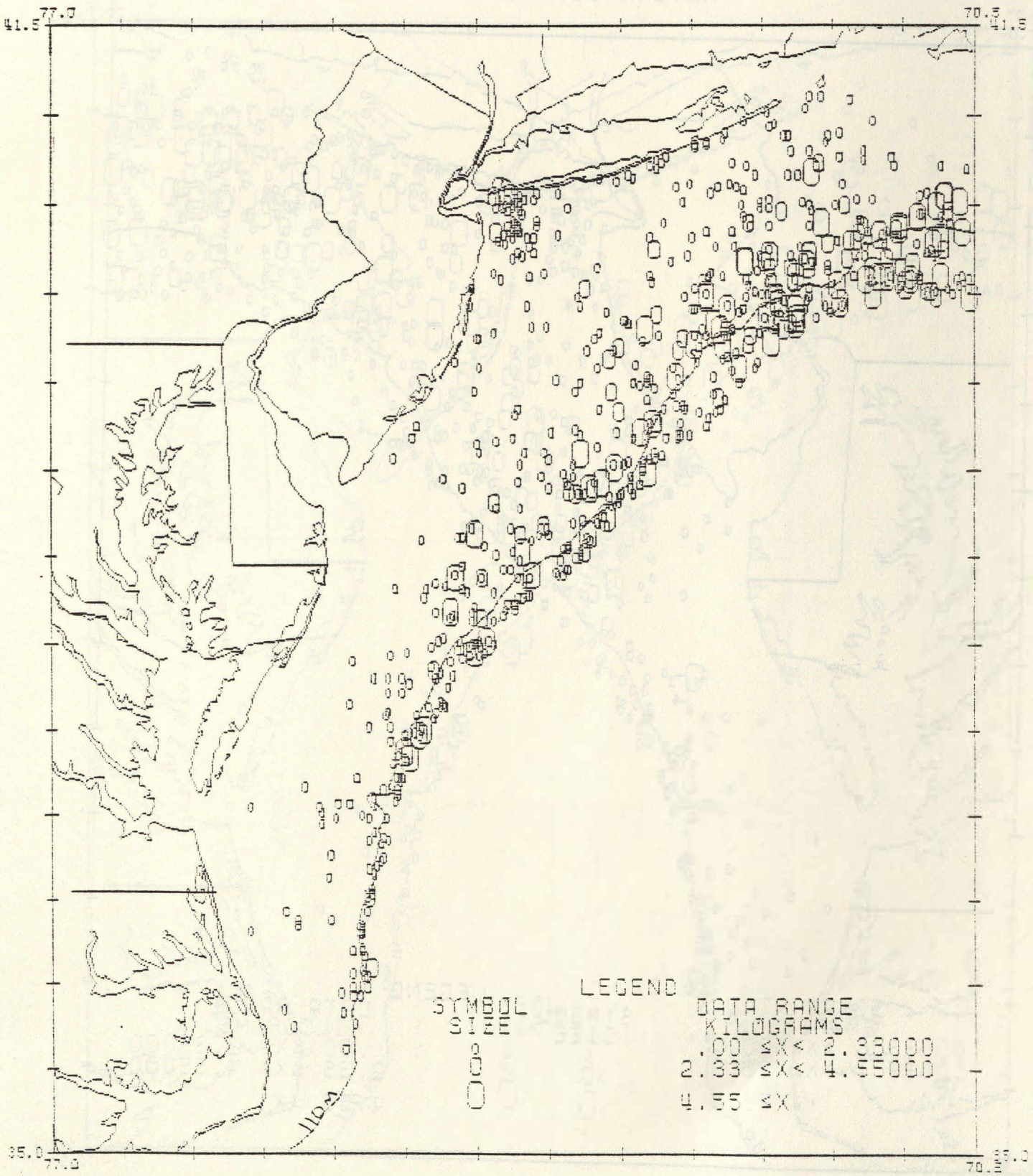


Figure 8.1. Spring distribution, 1968-1979.

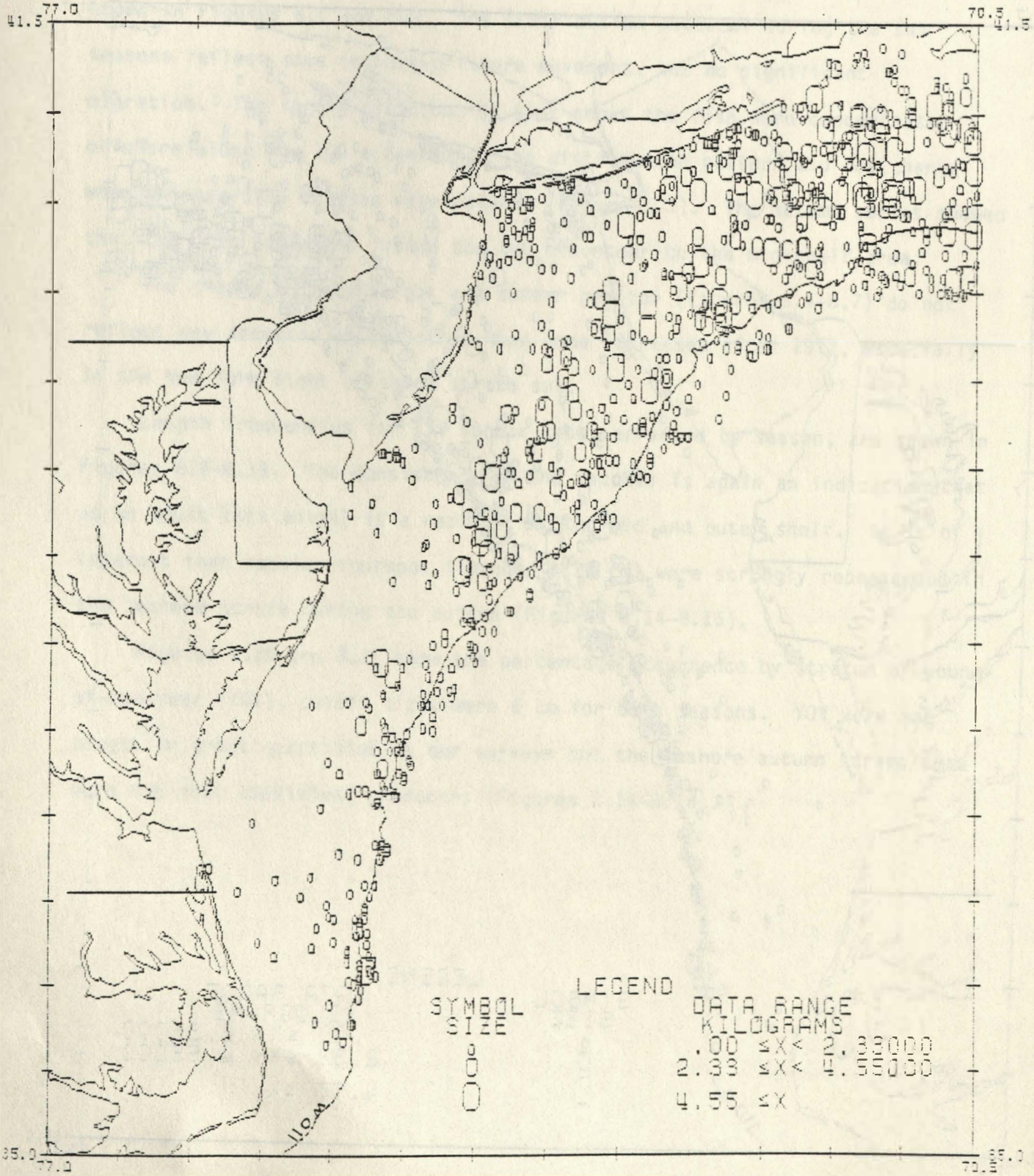


Figure 8.2. Autumn distribution, 1967-1979.

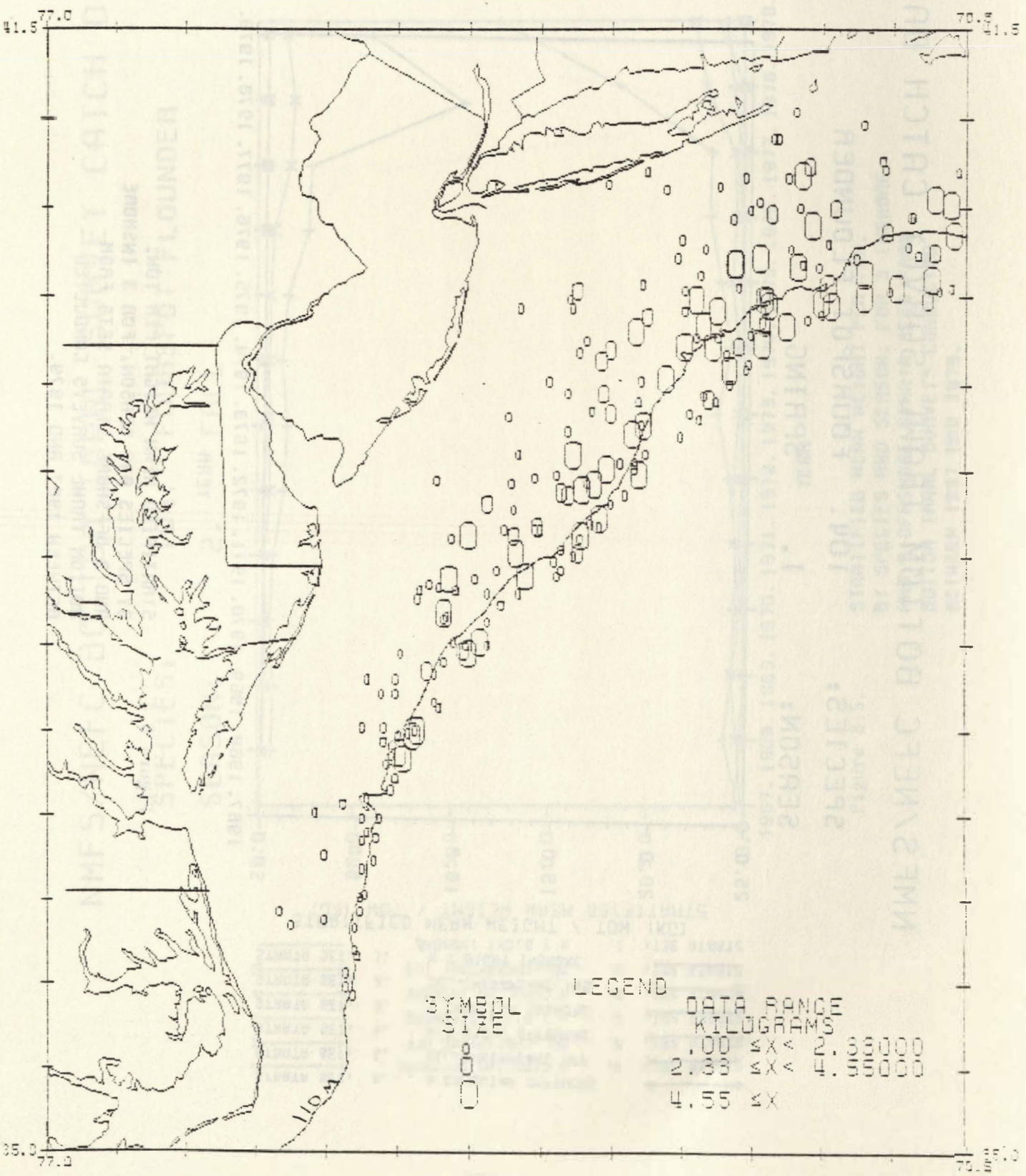


Figure 8.3. Spring distribution, 1976-1979.

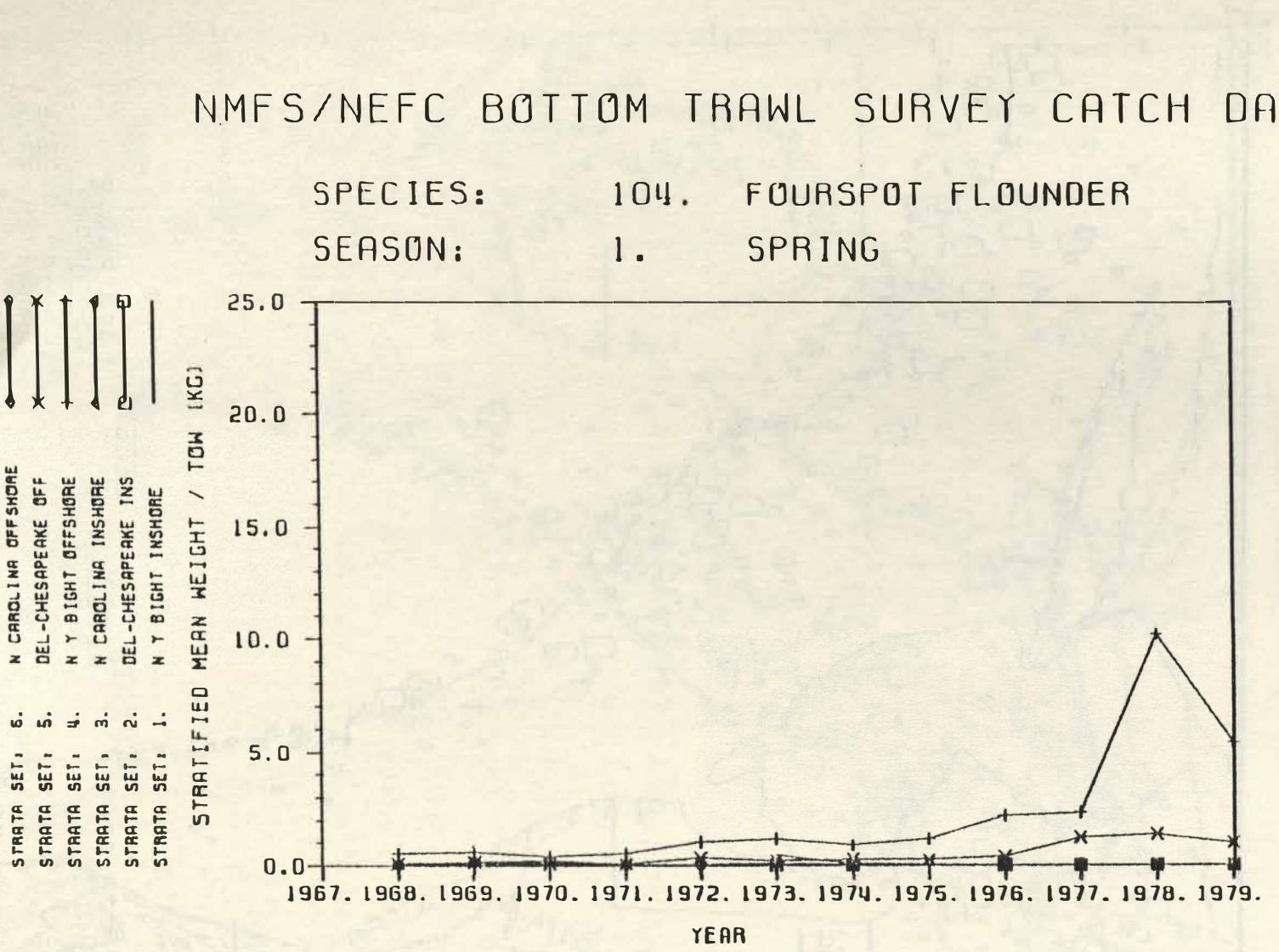


Figure 8.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

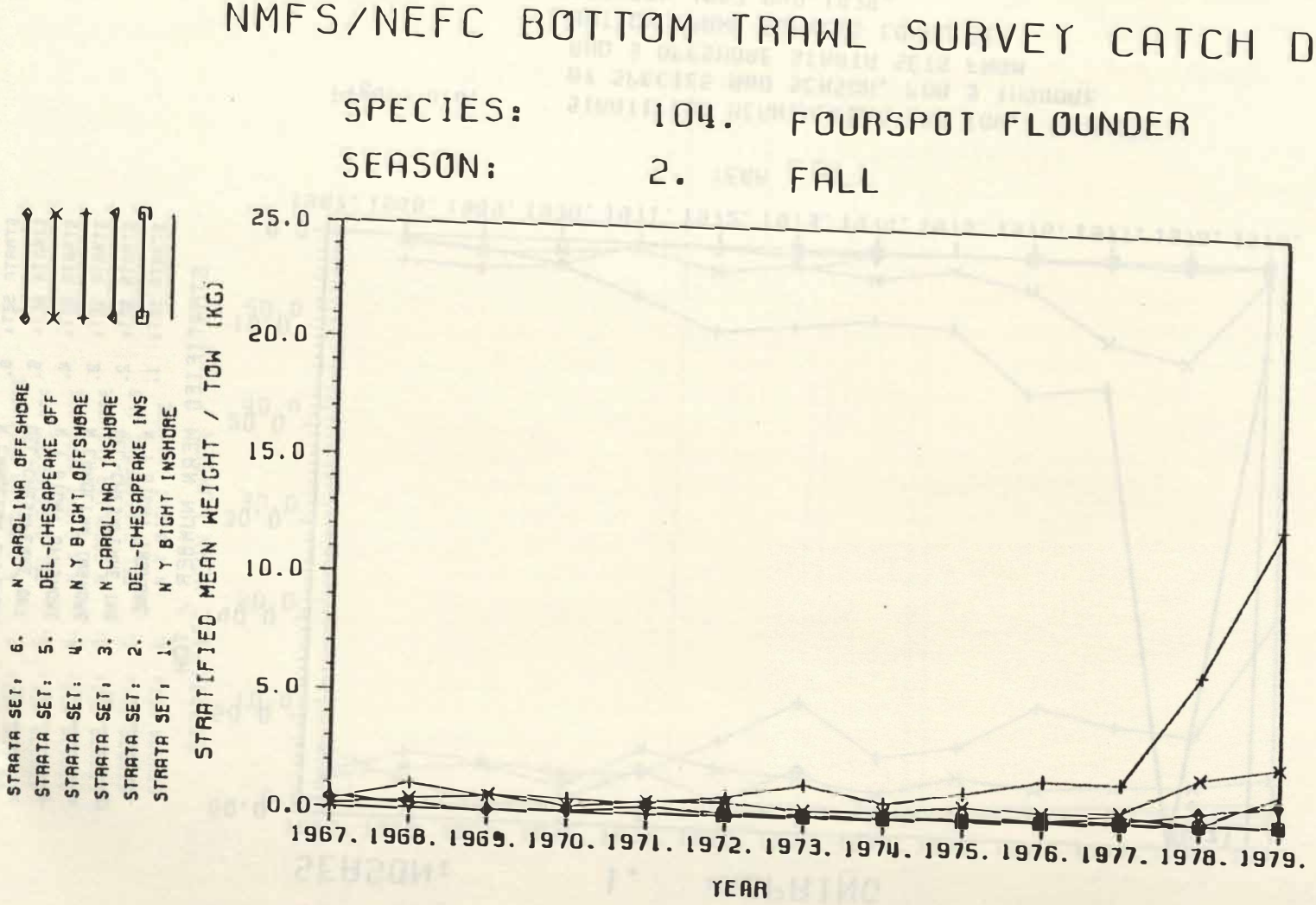


Figure 8.5. STRATIFIED MEAN WEIGHT PER TOW. BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

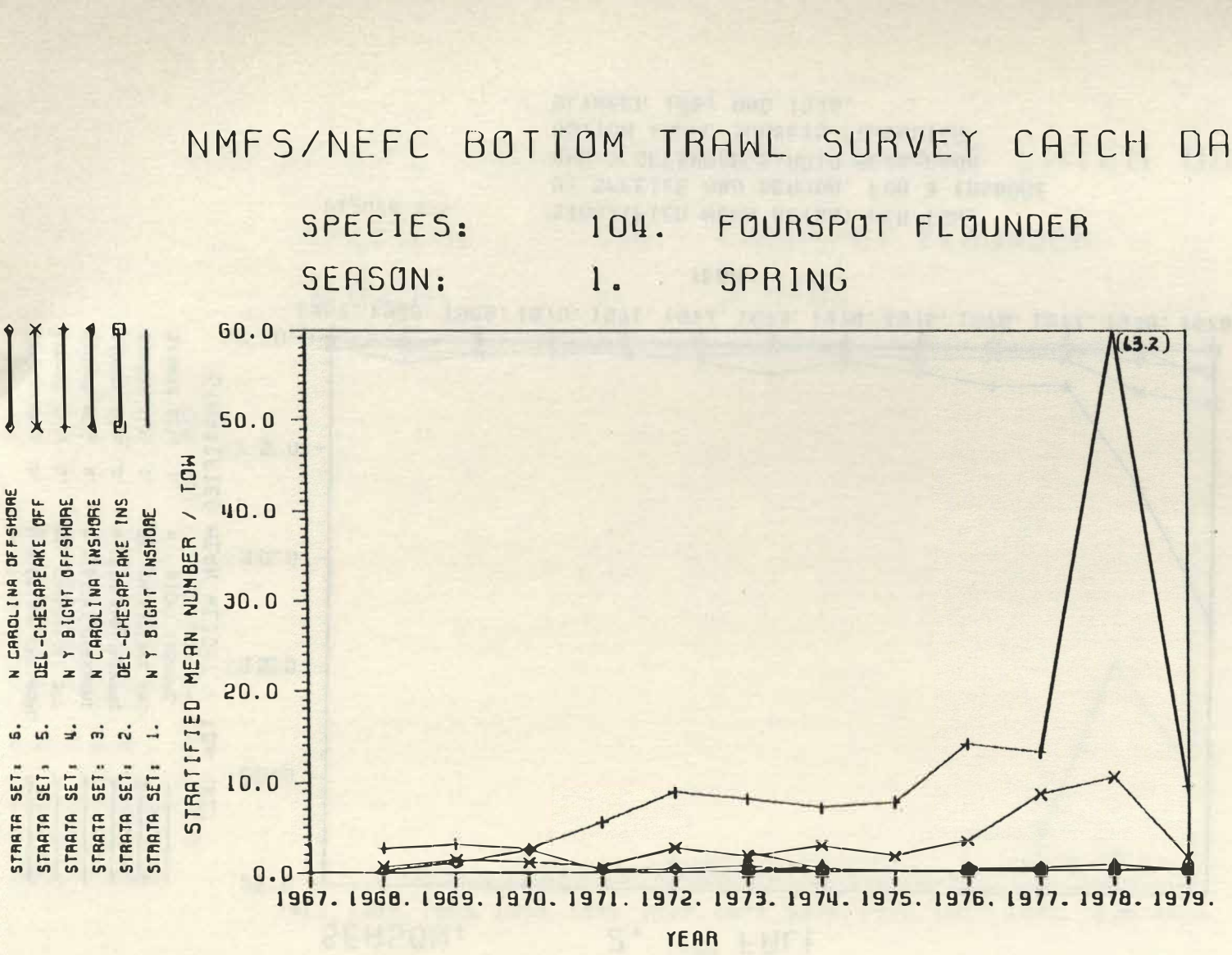


Figure 8.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

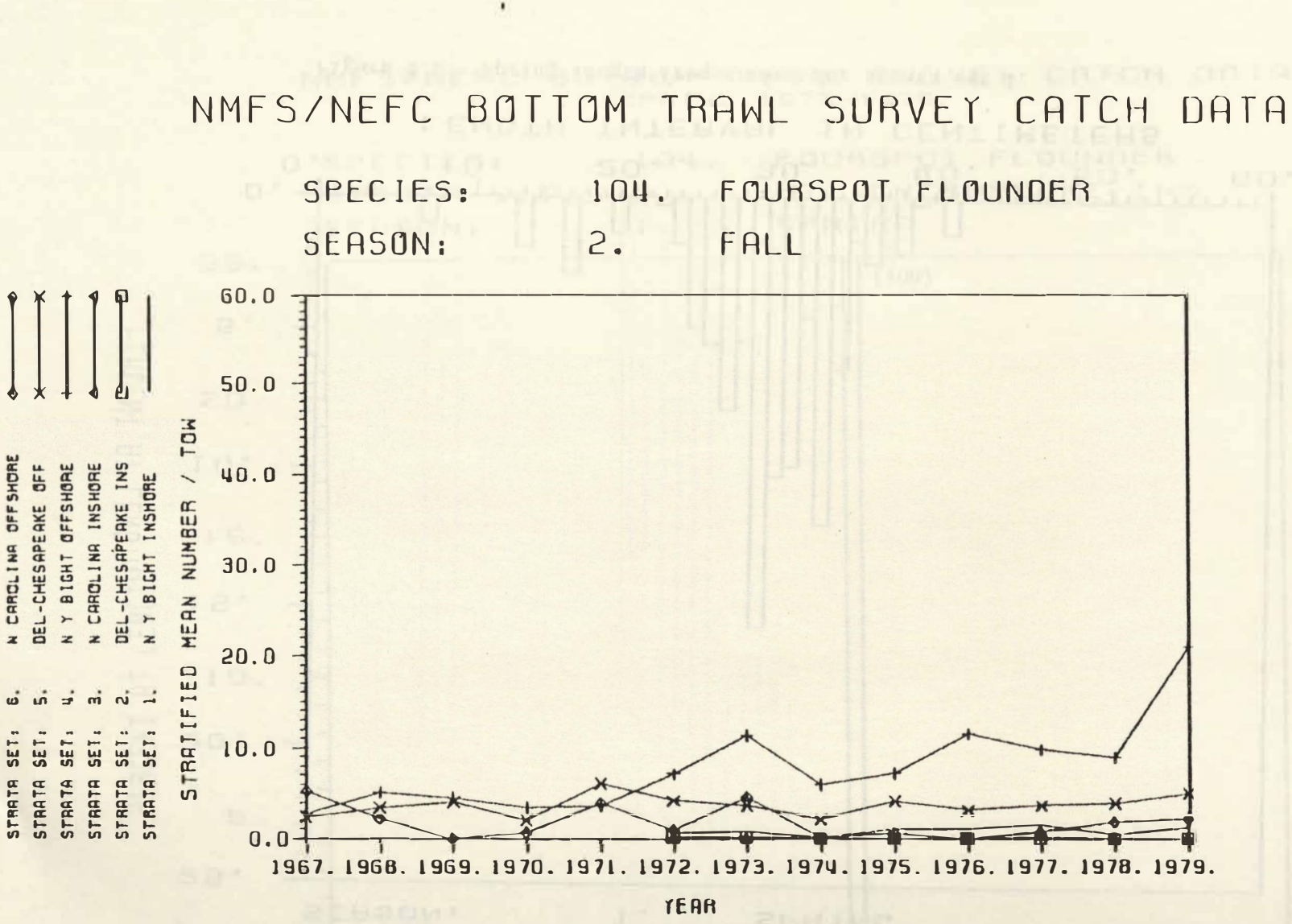


Figure 8.7. STRATIFIED MEAN NUMBER PER TOW. BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

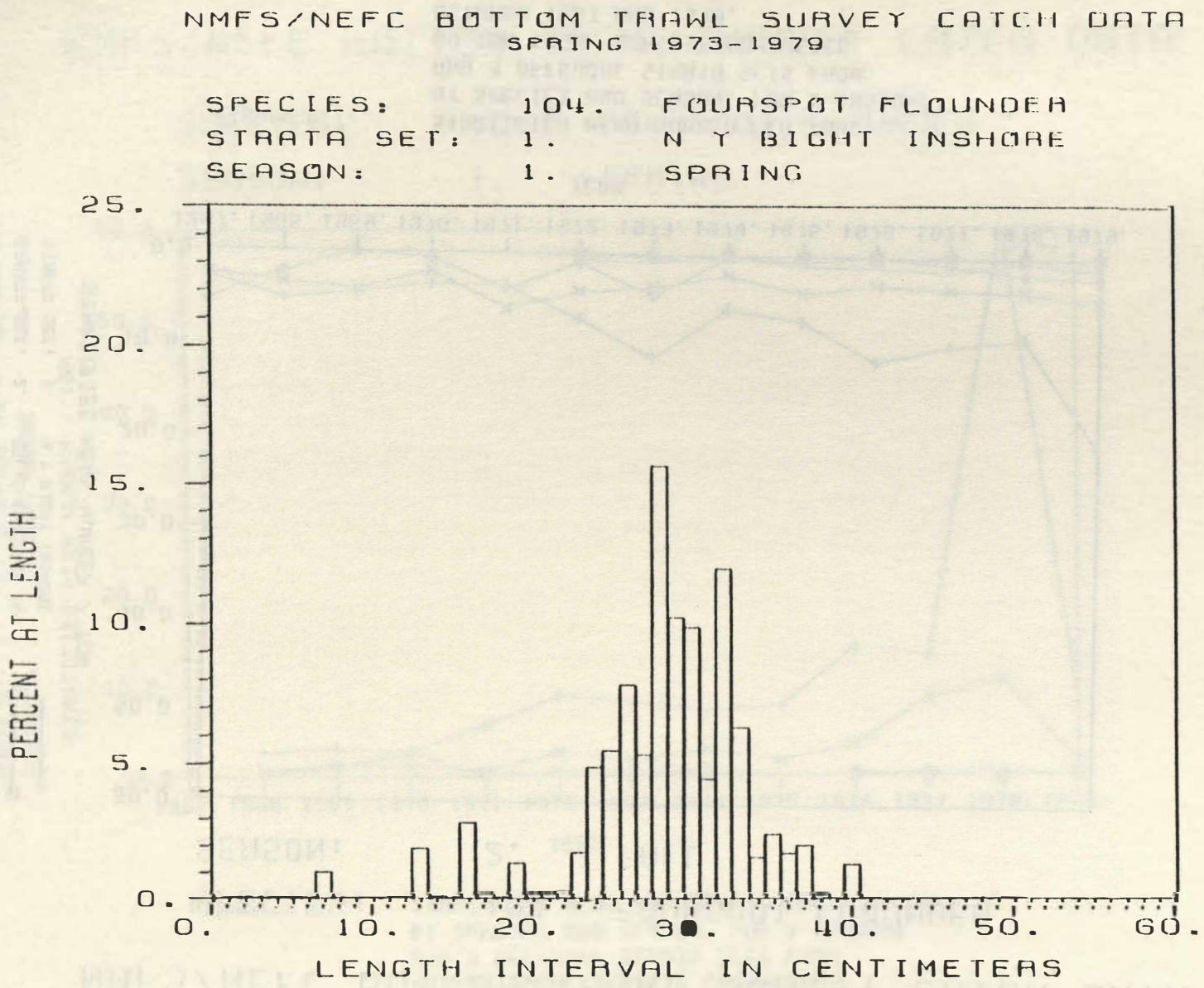


Figure 8.8. Spring length frequencies for strata set 1.

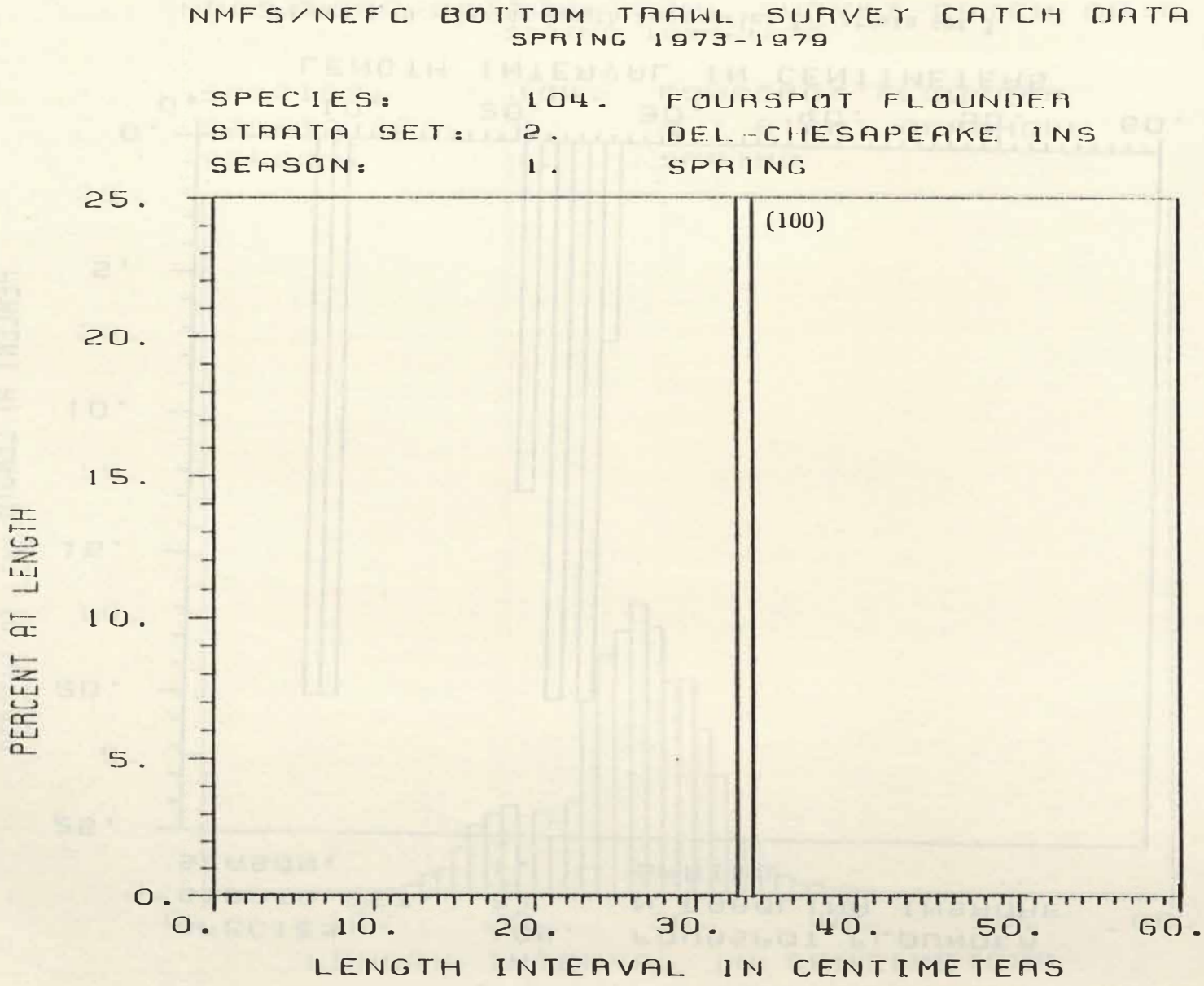


Figure 8.9. Spring length frequencies for strata set 2.

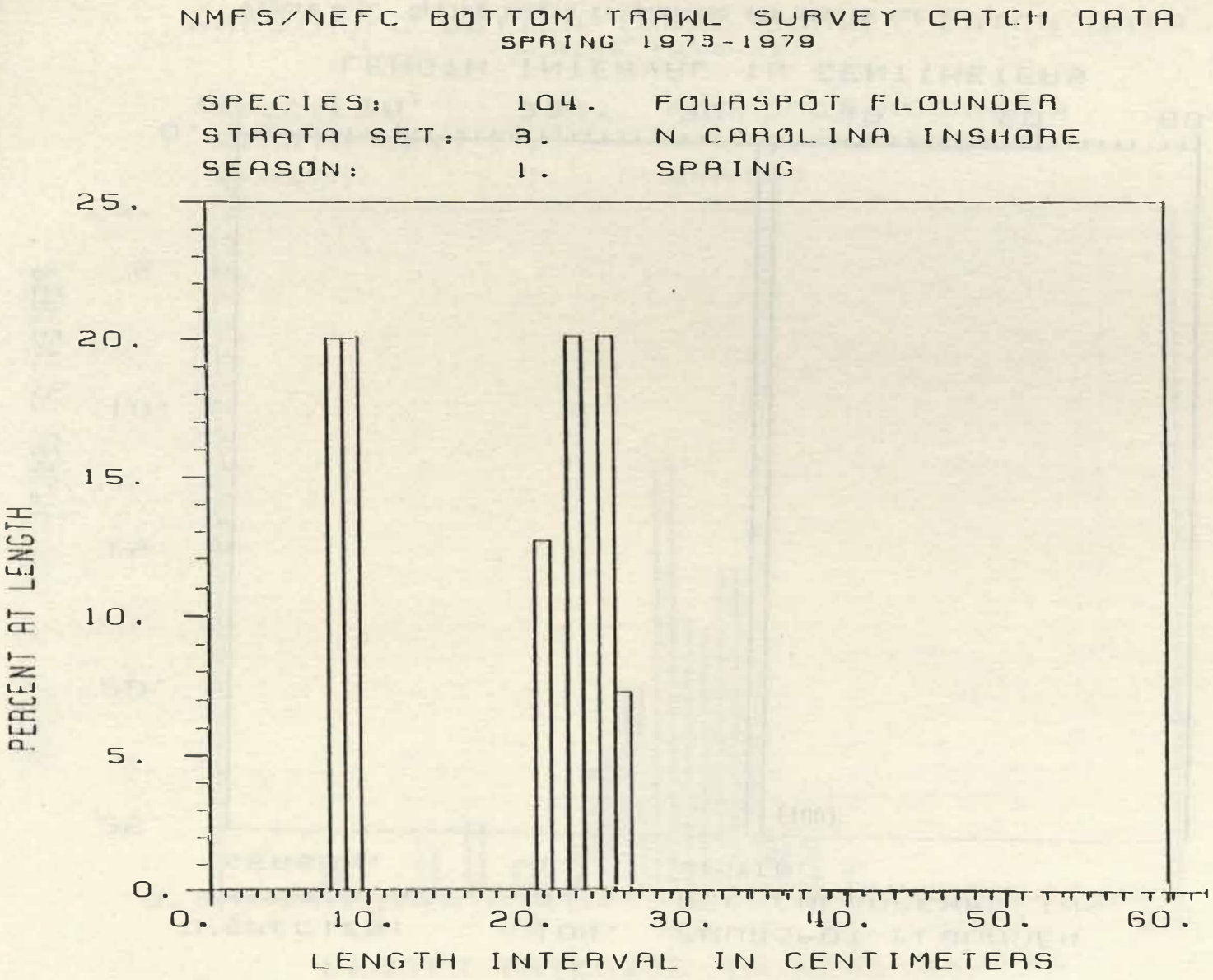


Figure 8.10. Spring length frequencies for strata set 3.

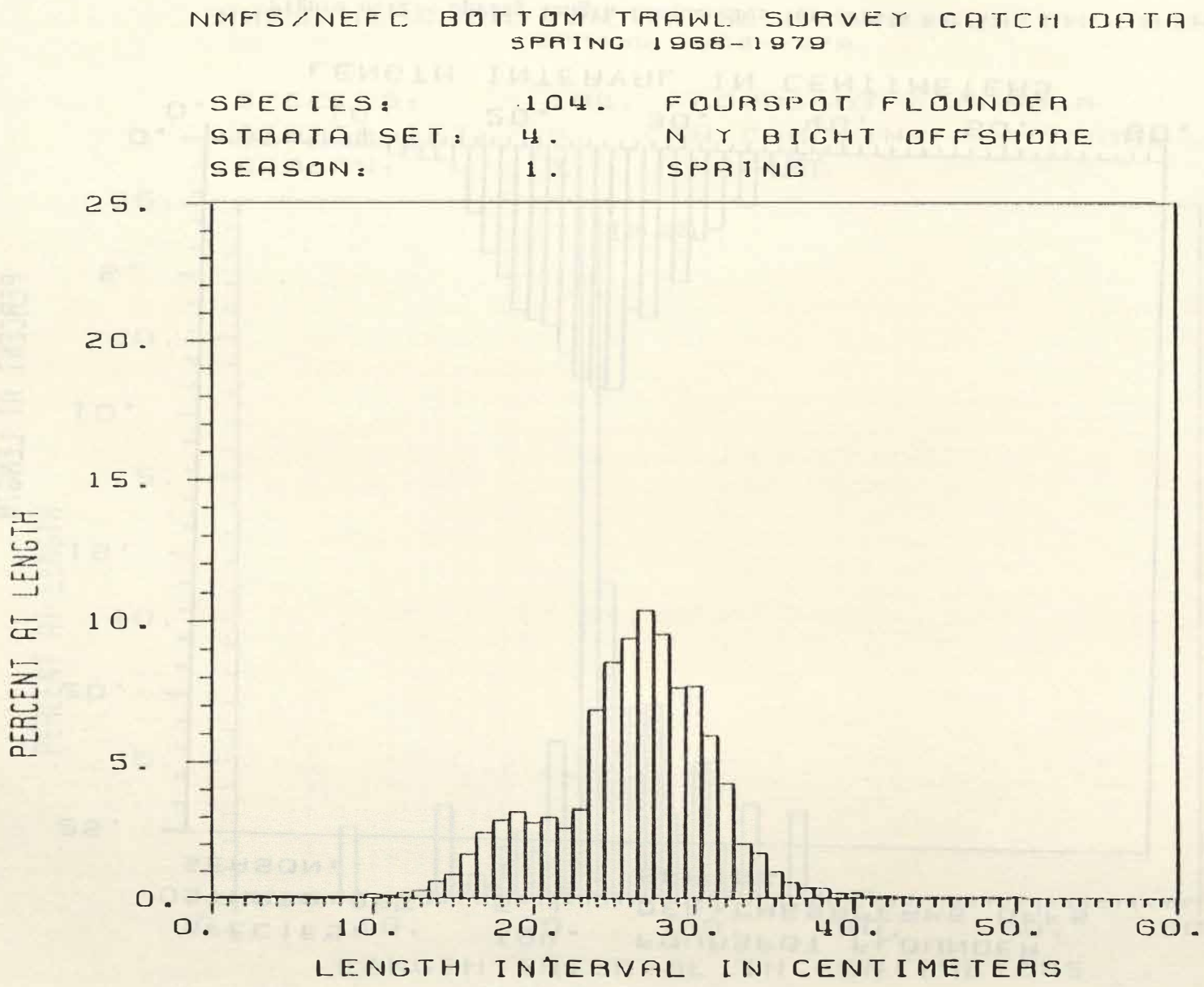


Figure 8.11. Spring length frequencies for strata set 4.

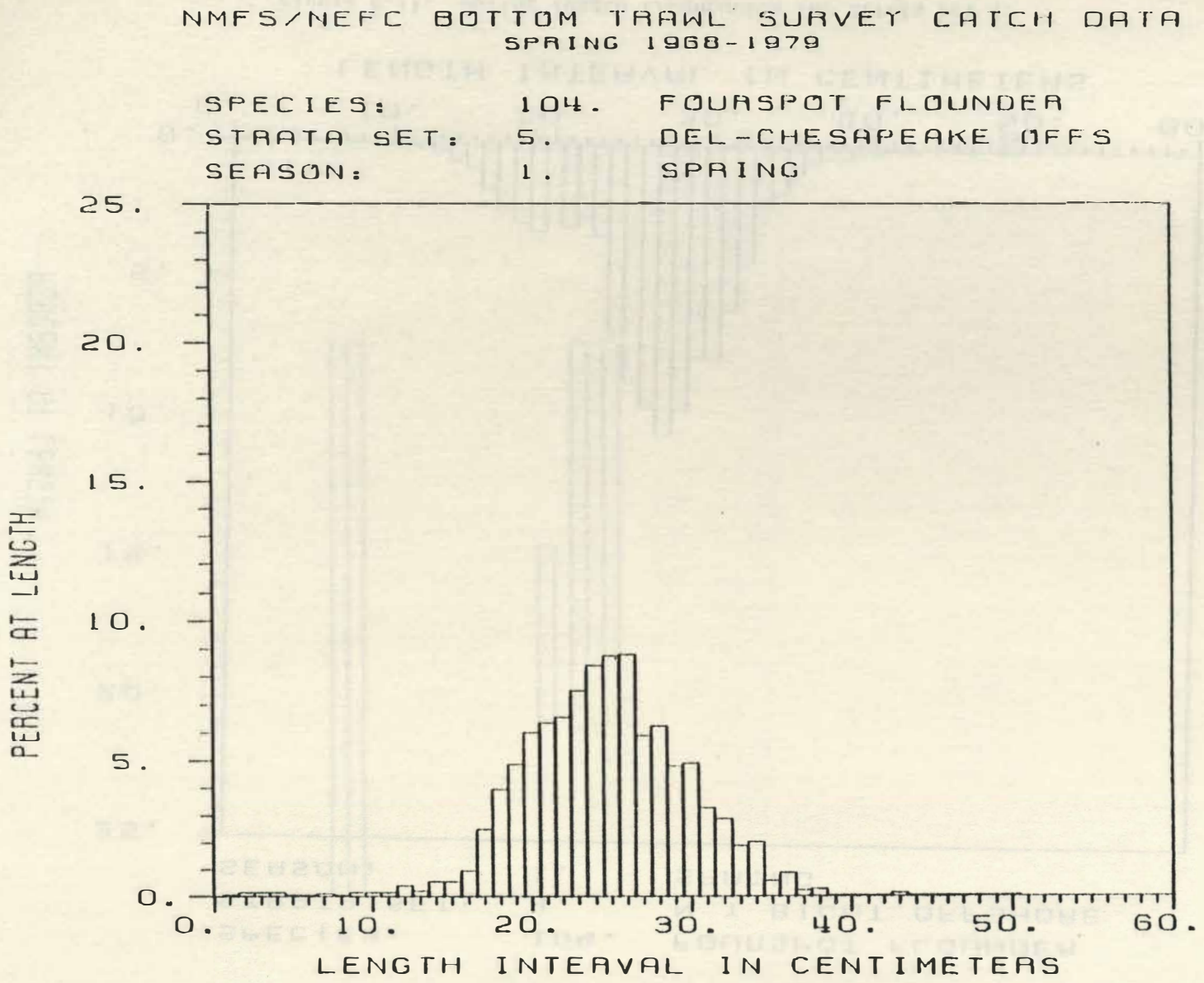


Figure 8.12. Spring length frequencies for strata set 5.

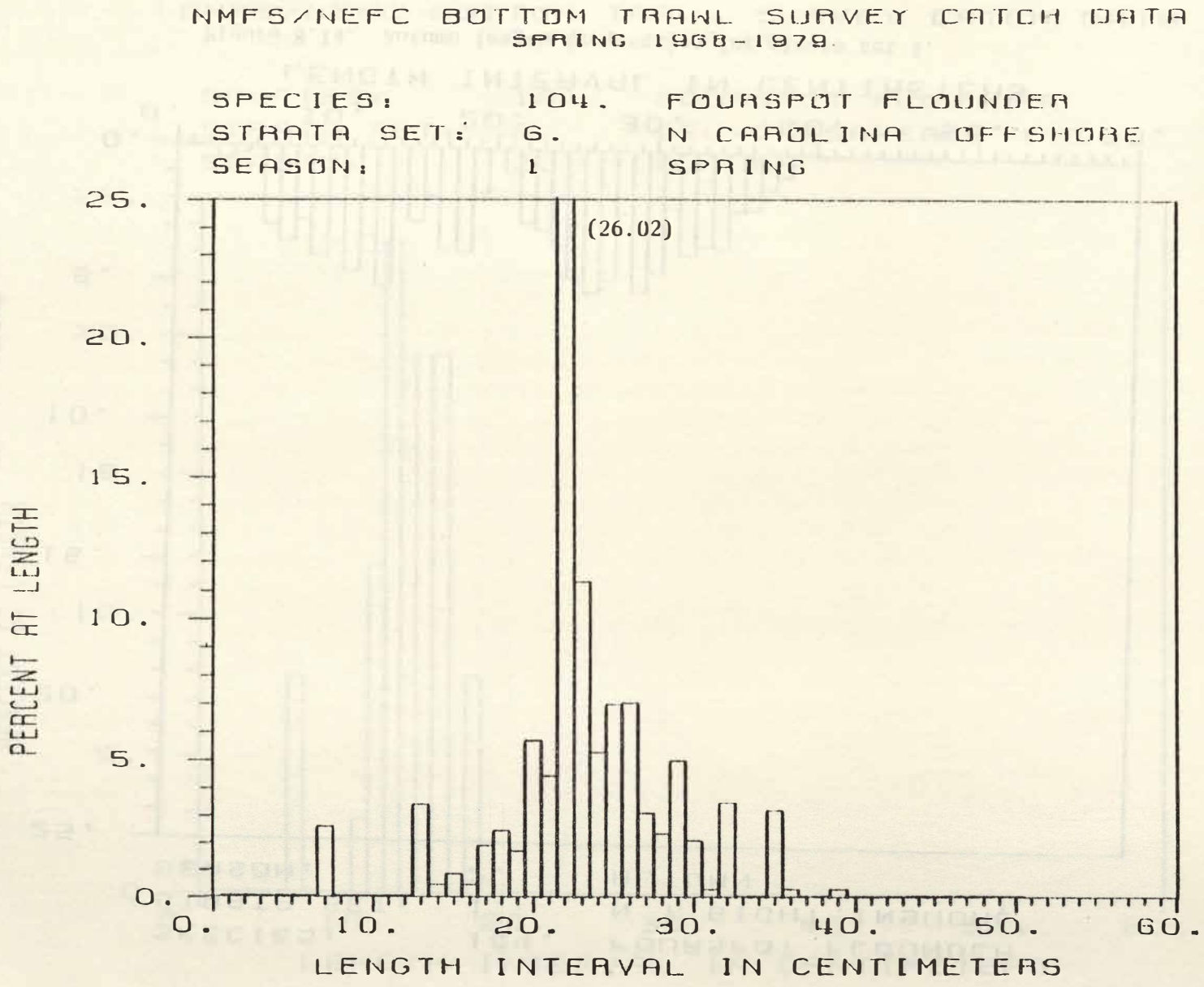


Figure 8.13. Spring length frequencies for strata set 6.

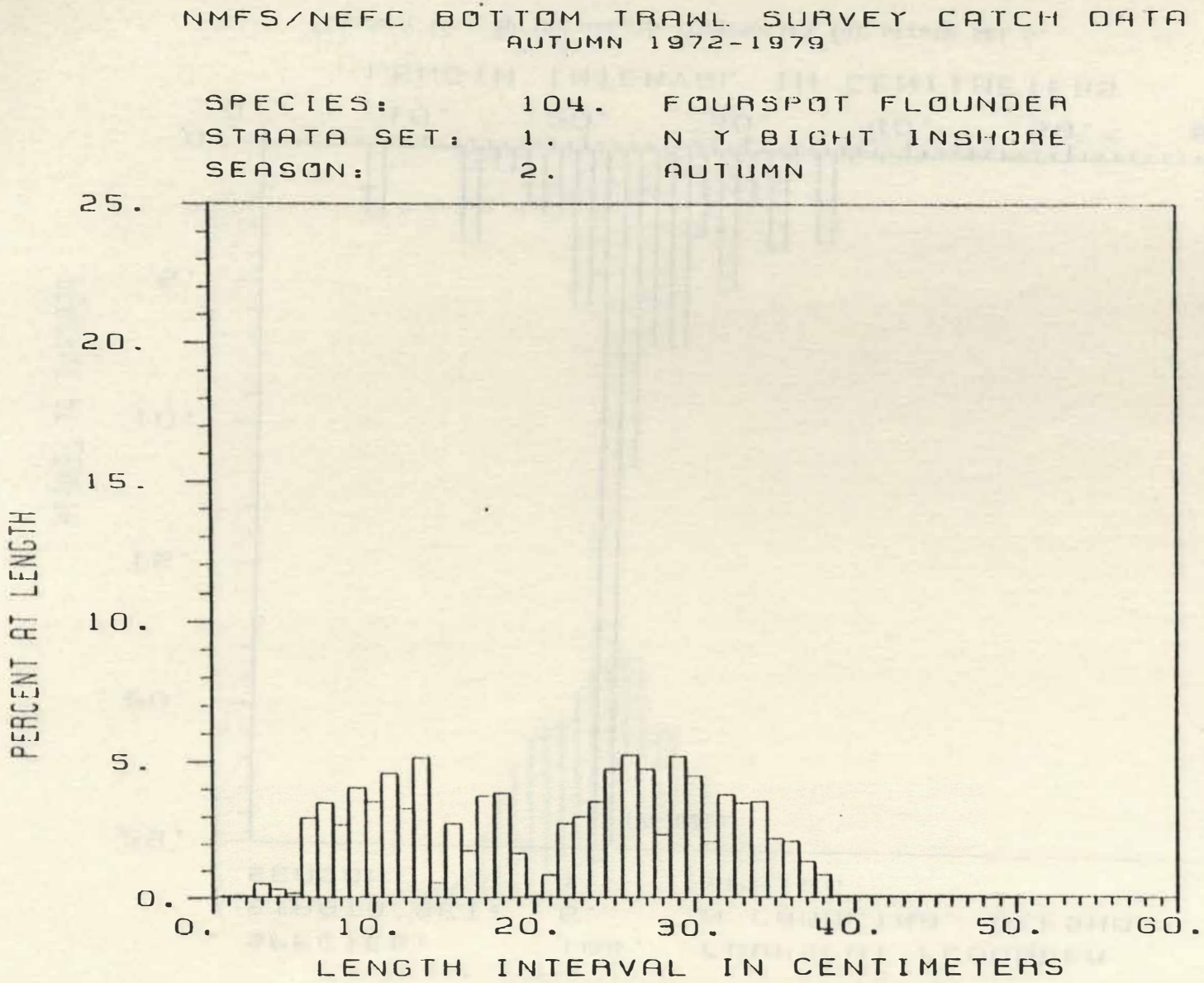


Figure 8.14. Autumn length frequencies for strata set 1.

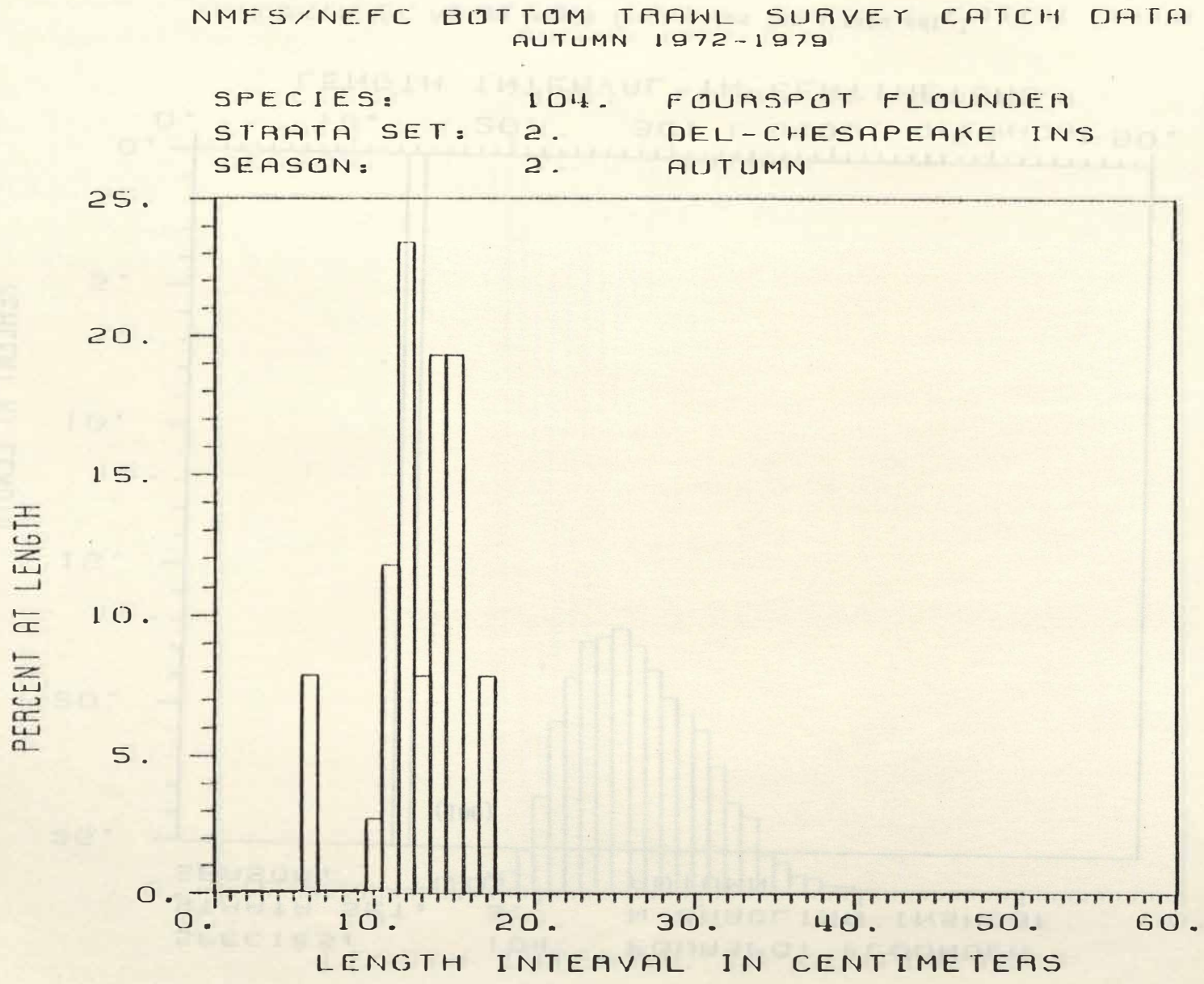


Figure 8.15. Autumn length frequencies for strata set 2.

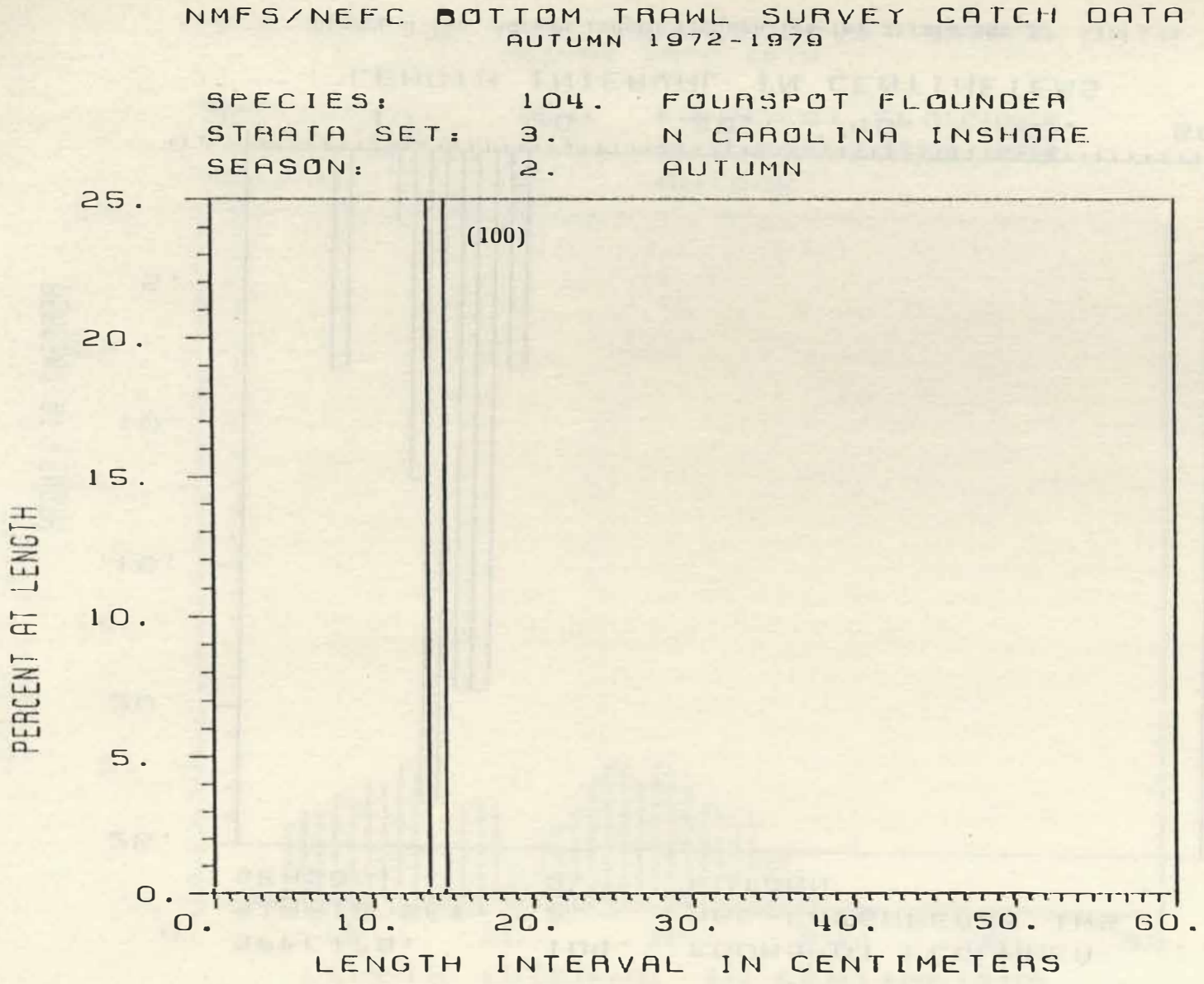


Figure 8.16. Autumn length frequencies for strata set 3.

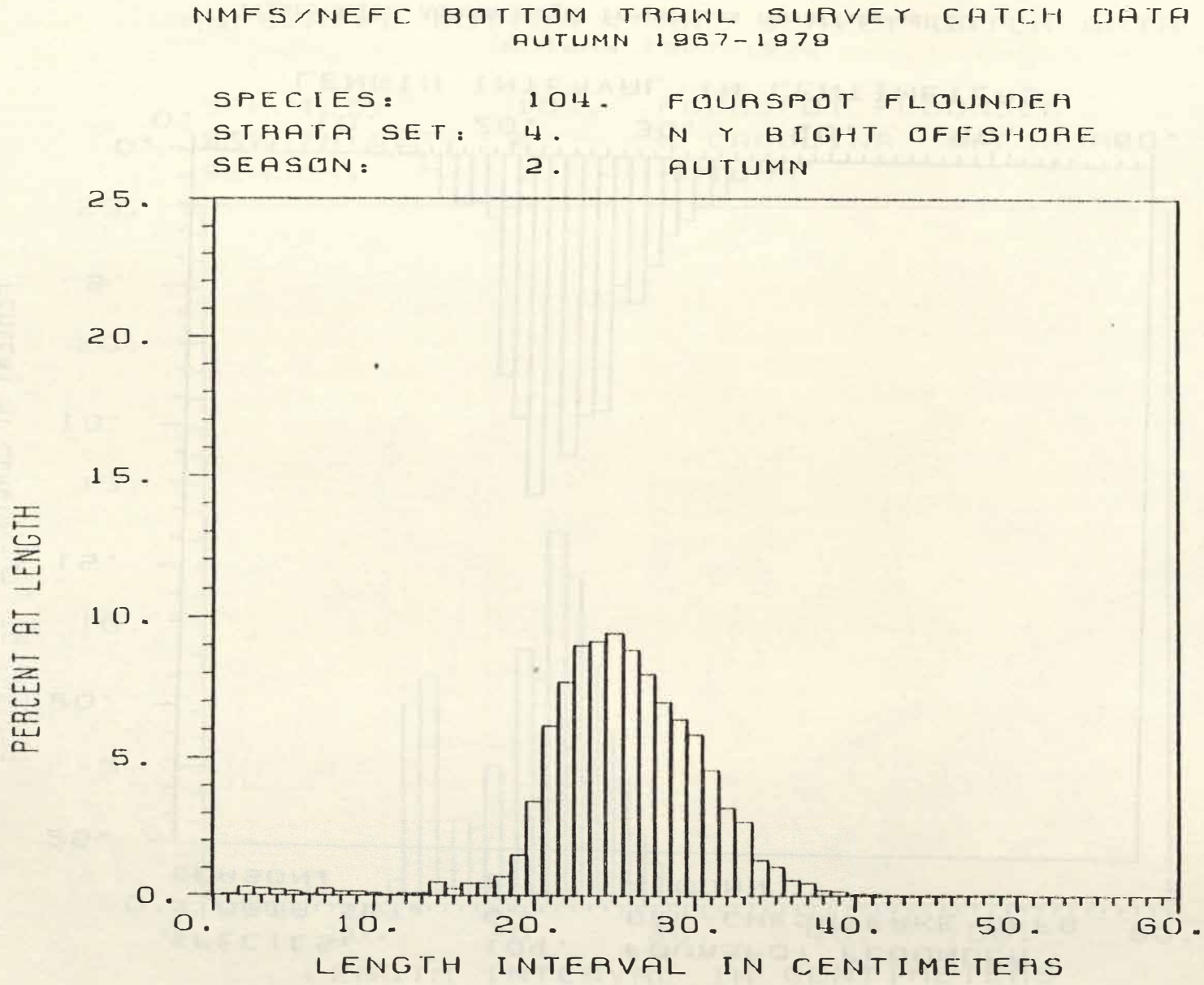


Figure 8.17. Autumn length frequencies for strata set 4.

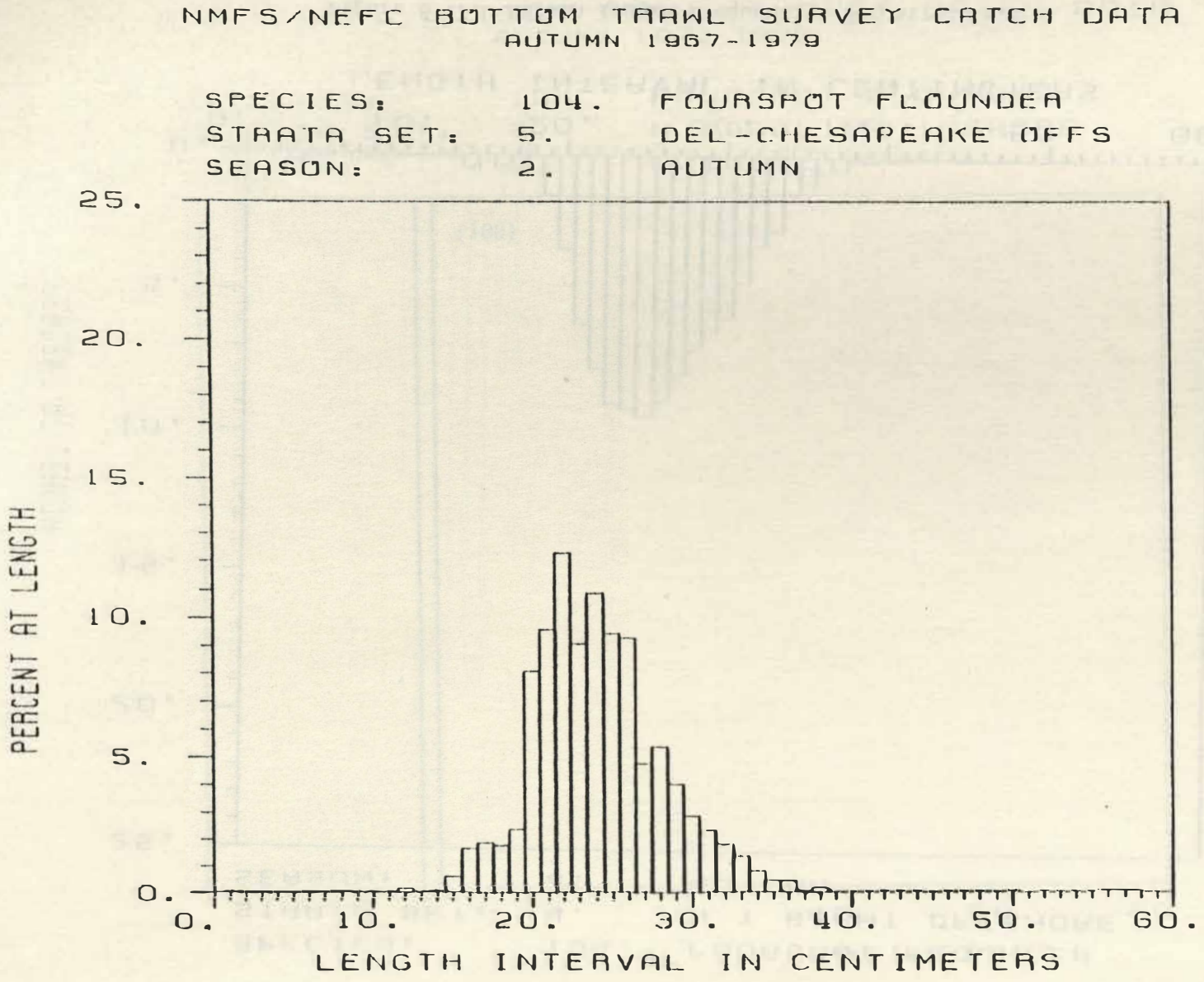


Figure 8.18. Autumn length frequencies for strata set 5.

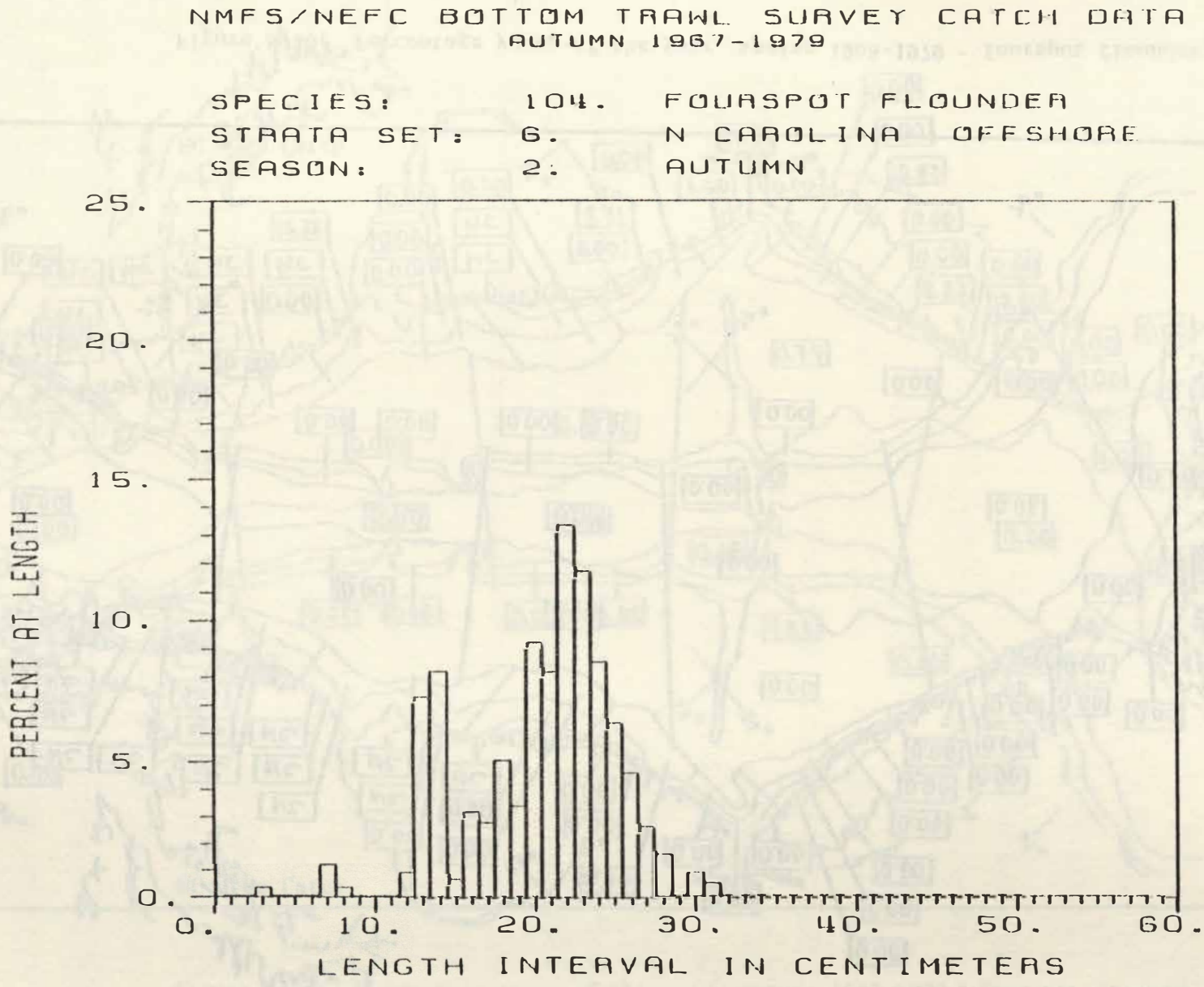


Figure 8.19. Autumn length frequencies for strata set 6.

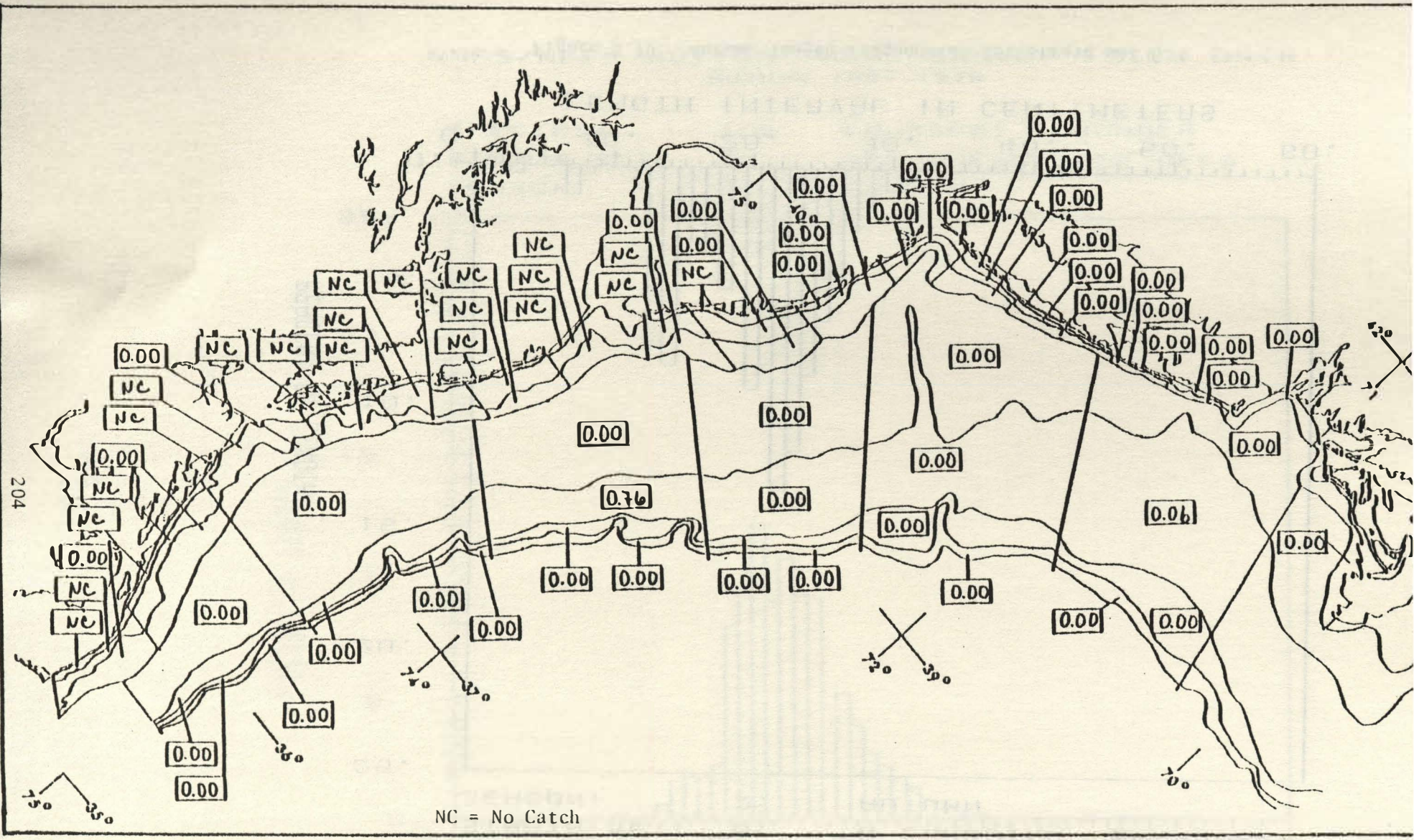


Figure 8.20. Percentage young-of-the-year, spring 1968-1979 - fourspot flounder.

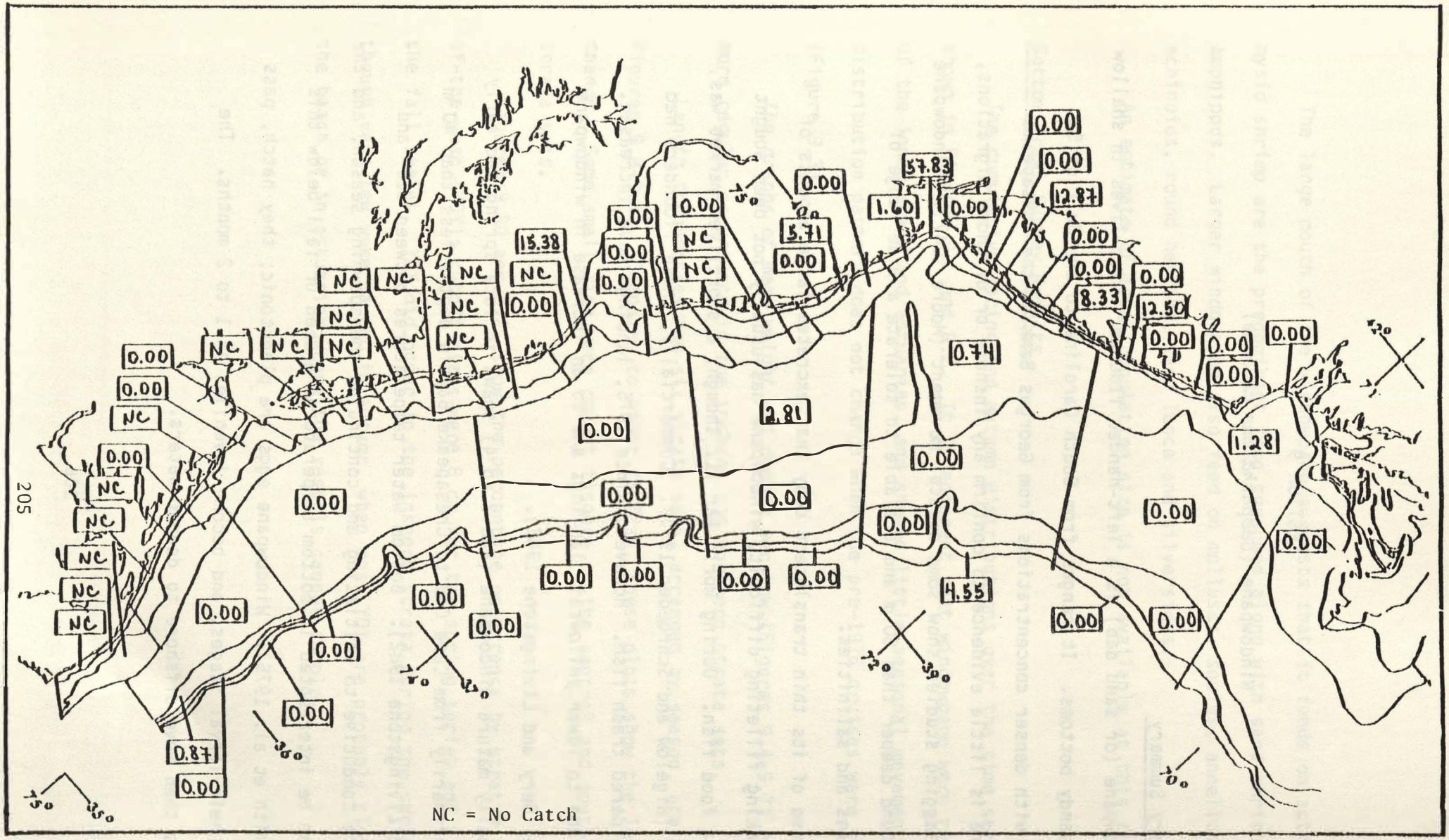


Figure 8.21. Percentage young-of-the-year, autumn 1967-1979 - fourspot flounder.

SECTION 9

Windowpane (*Scophthalmus aquosus*)

Life History Summary

Windowpane (or sand dab) is a left-handed flounder which lives in shallow water on sandy bottoms. It ranges from South Carolina to the Gulf of St. Lawrence, with denser concentrations from Georges Bank to the Chesapeake Bay. There is little evidence to confirm any inshore or offshore migrations, although tagging studies show some coastal movement (Moore 1947). Windowpane are not found deeper than 80 m and are able to tolerate a wide range of temperatures and salinities.

Because of its thin translucent body that excretes large amounts of mucous, making filleting difficult, windowpane has usually not been sought after as a food fish. During World War II, though, a shortlived market was developed (Bigelow and Schroeder 1953). Commercially, these flounders had been considered trash fish. However, since 1975, landings have increased, probably due to lower yellowtail landings and to an increase in windowpane abundance (Dery and Livingstone 1982).

Sexually mature windowpane (age 2 to 4) spawn in late spring and early summer, primarily from Cape Cod to Chesapeake Bay in depths less than 40 m (Dery and Livingstone 1982). Bottom water temperatures between 8.5° and 13.5°C are conducive to initiating and continuing the spawning season, and the season can be interrupted if bottom temperatures exceed or fall below this range (Smith et al. 1975). Windowpane eggs are planktonic; they hatch, pass through their larval stages, and become juveniles in 1 to 2 months. The juveniles then move offshore to deeper waters.

The large mouth of the windowpane suggests that it feeds on active prey; mysid shrimp are the predominant food consumed along with sand shrimp and amphipods. Larger windowpane also feed on molluscs, squids, annelids, echinoids, round herring, sand lance and silversides.

An estimate of total population size is not available at this time.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 9.1 and 9.2. It is apparent that windowpane were residents of the inner shelf and estuaries, and showed little seasonal movement. The distribution pattern does not change when the pre-1976 cruises were deleted (Figure 9.3).

The graphs of mean weight and number per tow (Figures 9.4-9.7) reflect a more regular occurrence in the inshore and northern strata sets.

Length frequencies for six strata sets, arranged by season, are shown in Figures 9.8-9.19. Compared to other finfish, these plots show the least change. Some small fish were caught inshore in the central and southern strata sets.

Figures 9.20 and 9.21 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 8 cm for the spring series and 5 cm for the fall series. YOY did occur in the inshore strata during the spring, though very few were caught in autumn, when most YOY are probably close the the beach or in estuaries where the vessels cannot sample.

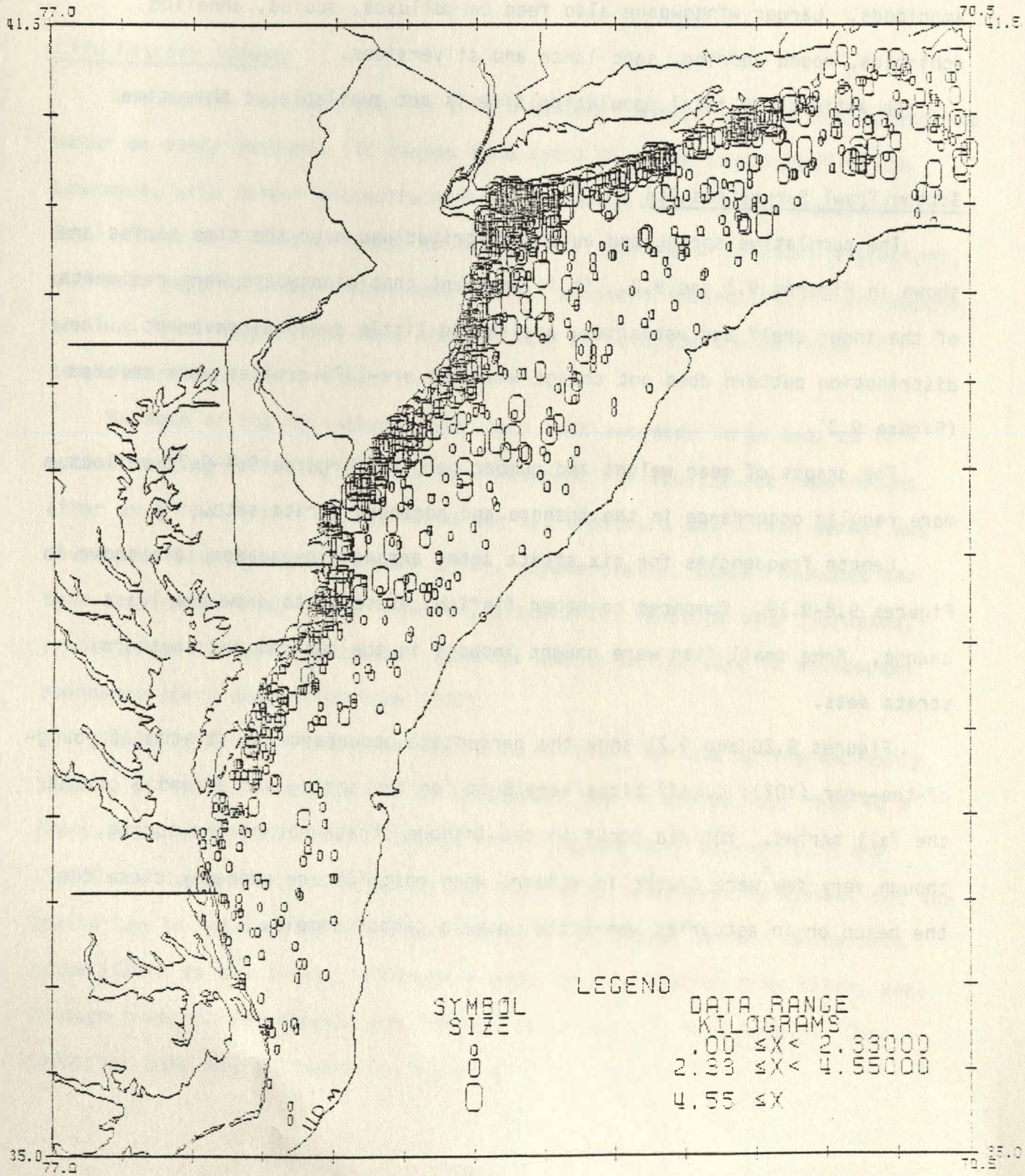


Figure 9.1. Spring distribution, 1968-1979.

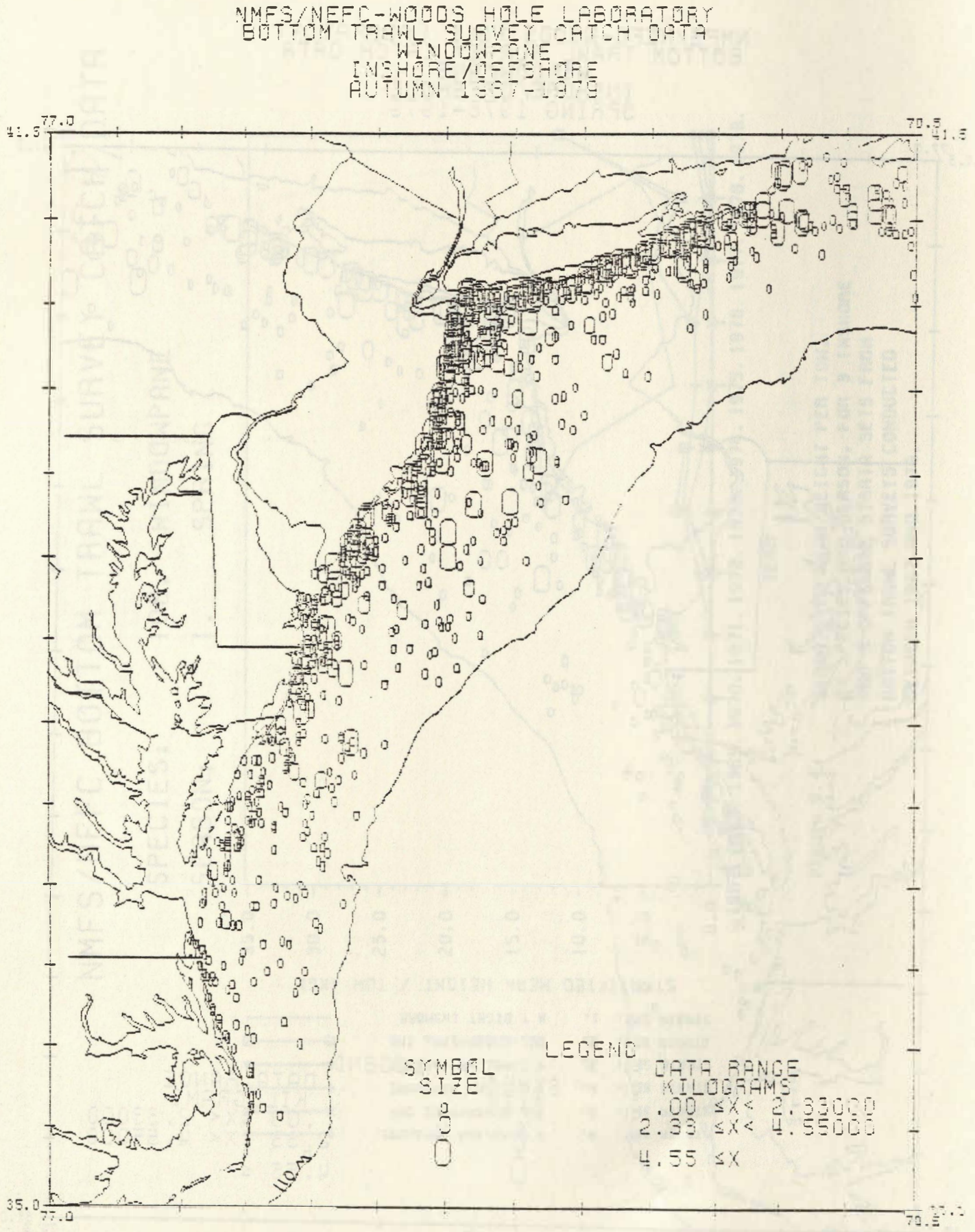


Figure 9.2. Autumn distribution, 1967-1979.

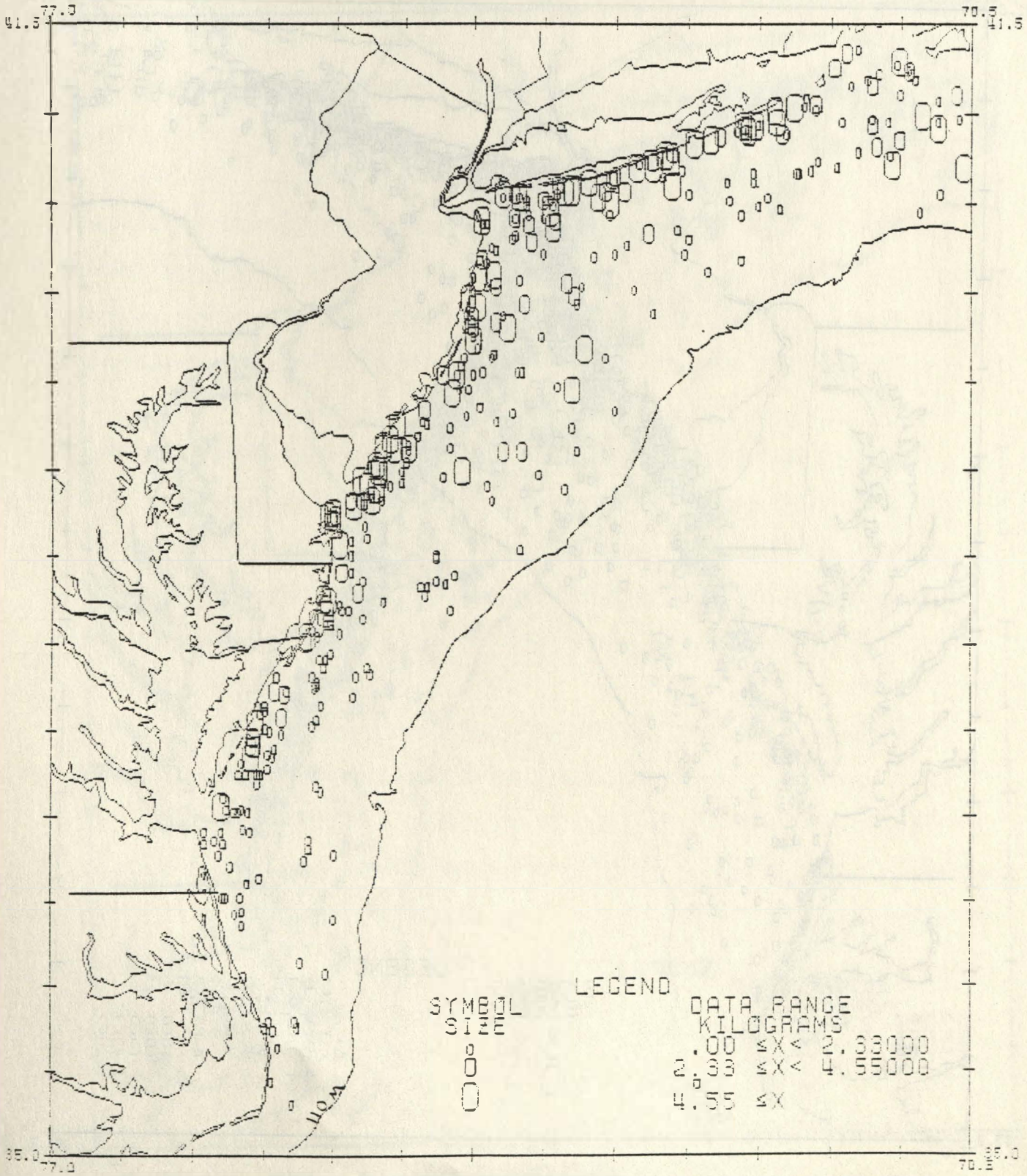


Figure 9.3. Spring distribution, 1976-1979.

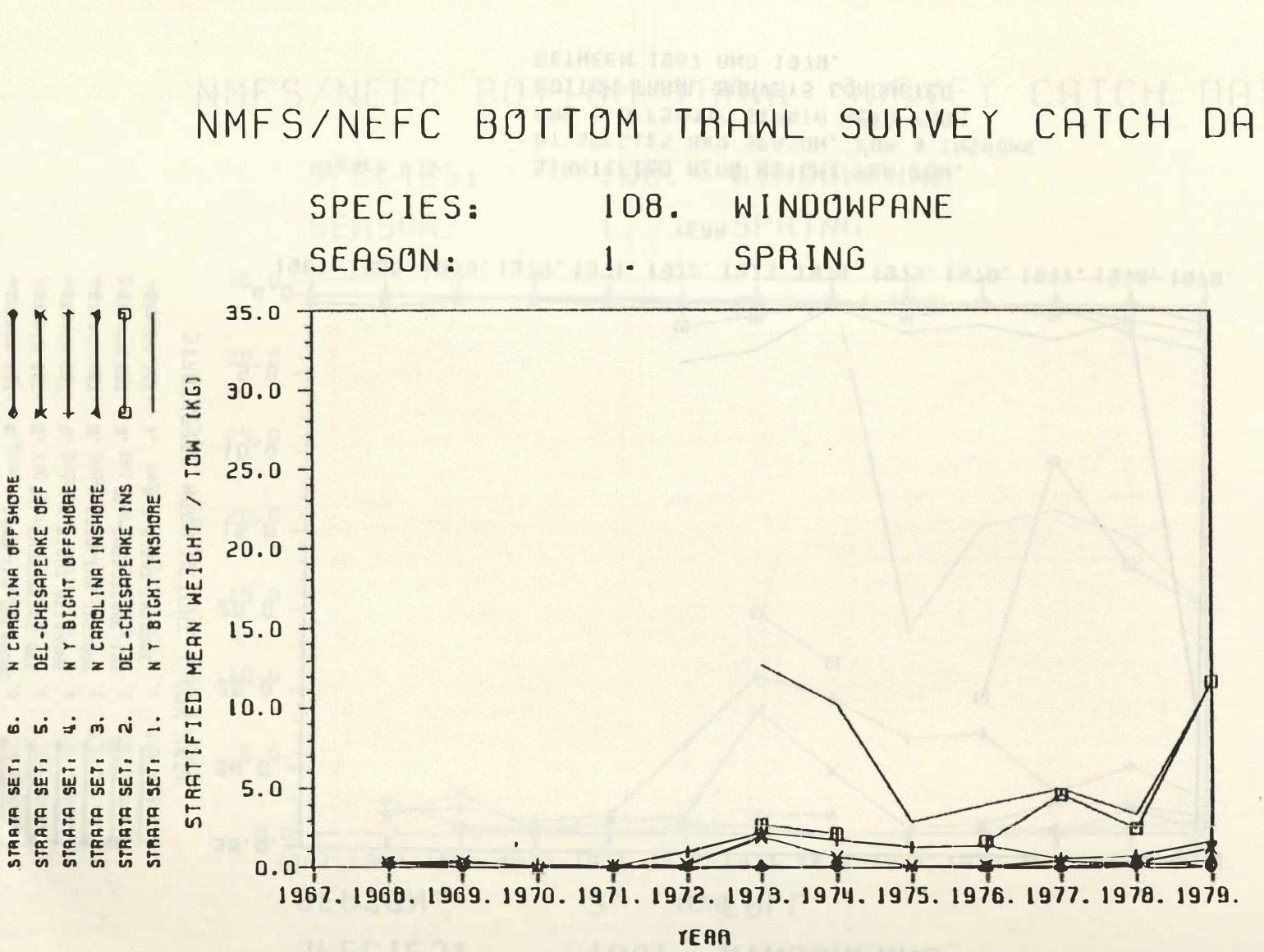


Figure 9.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 108. WINDOWPANE

SEASON: 2. FALL

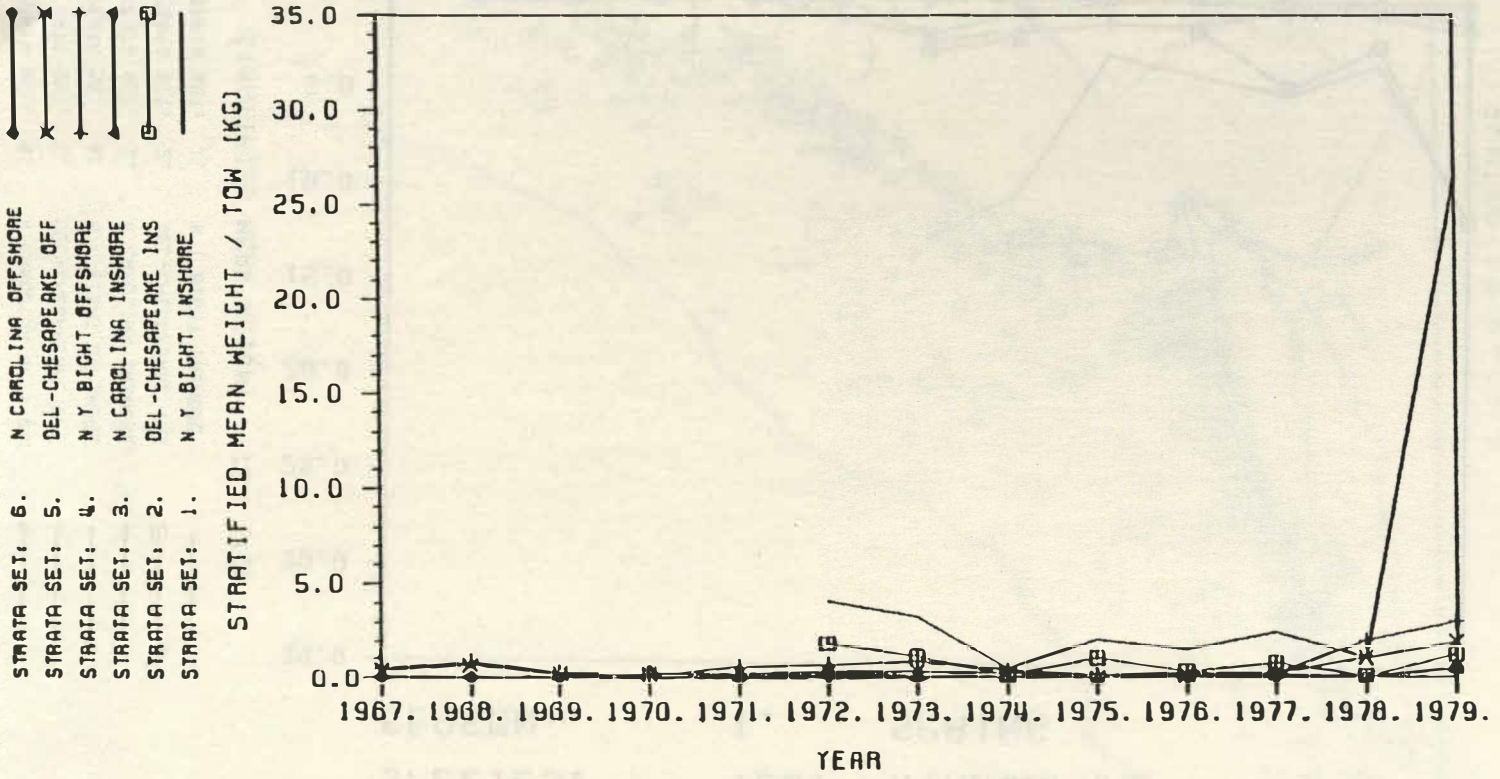


Figure 9.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

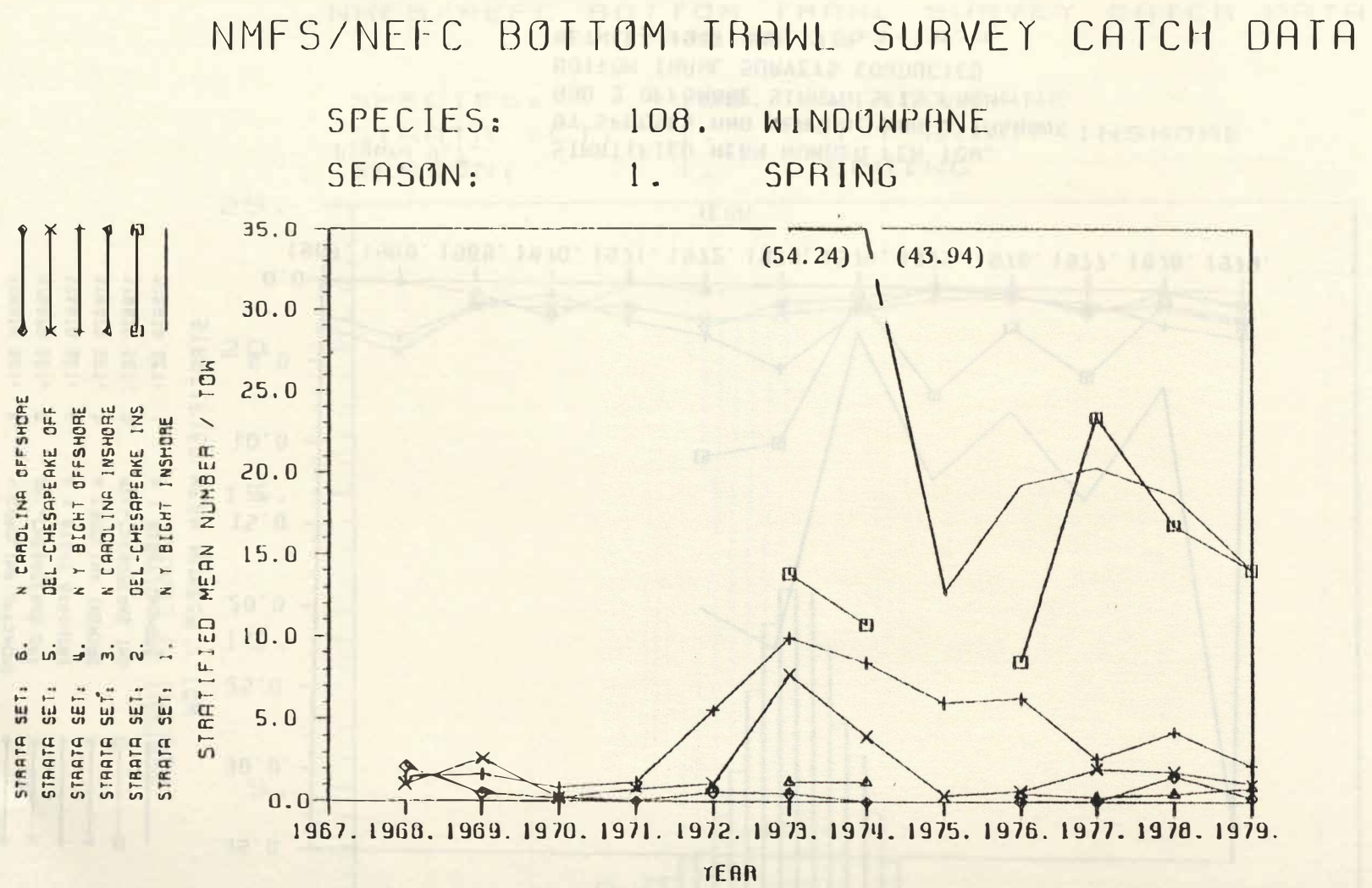


Figure 9.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

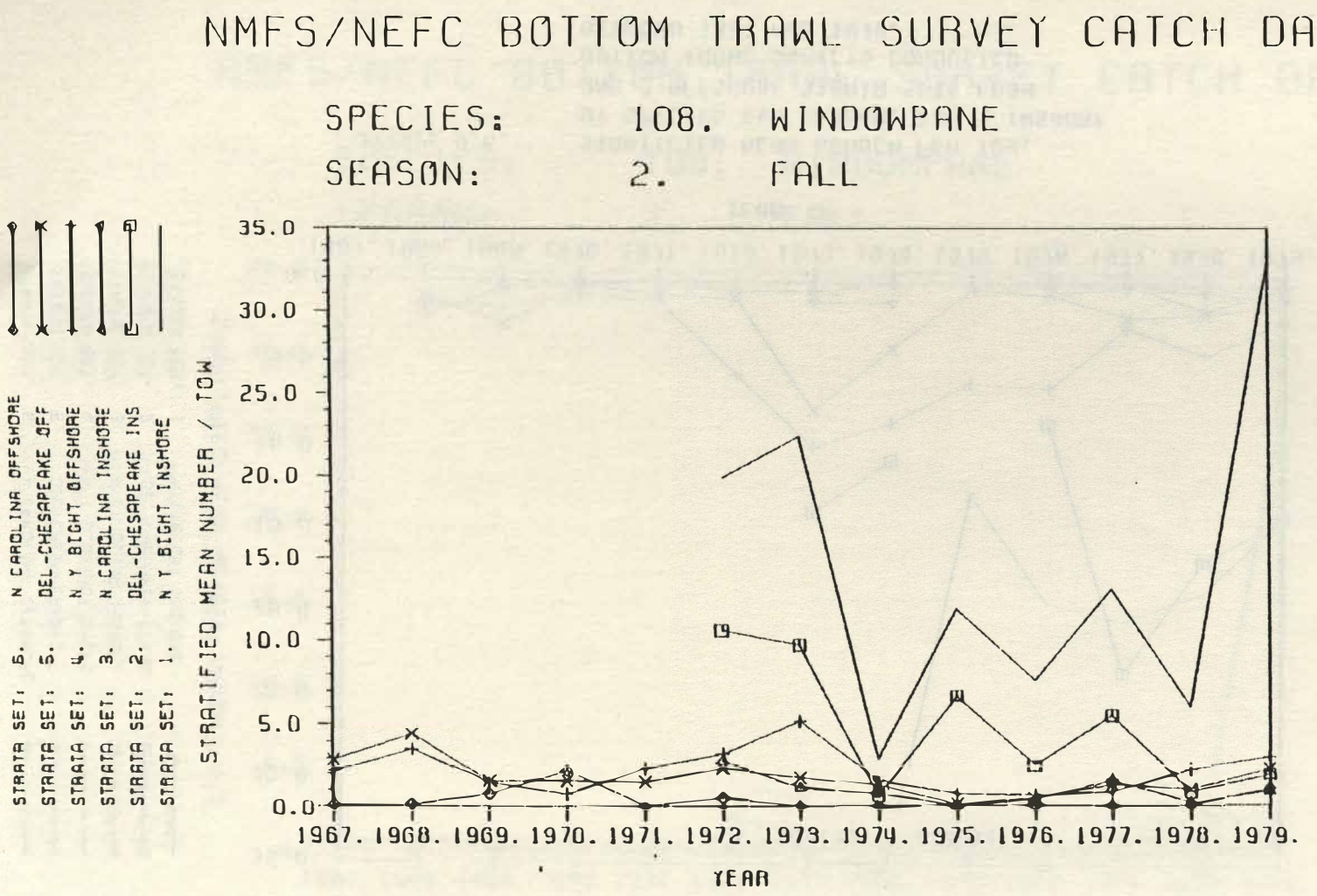


Figure 9.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

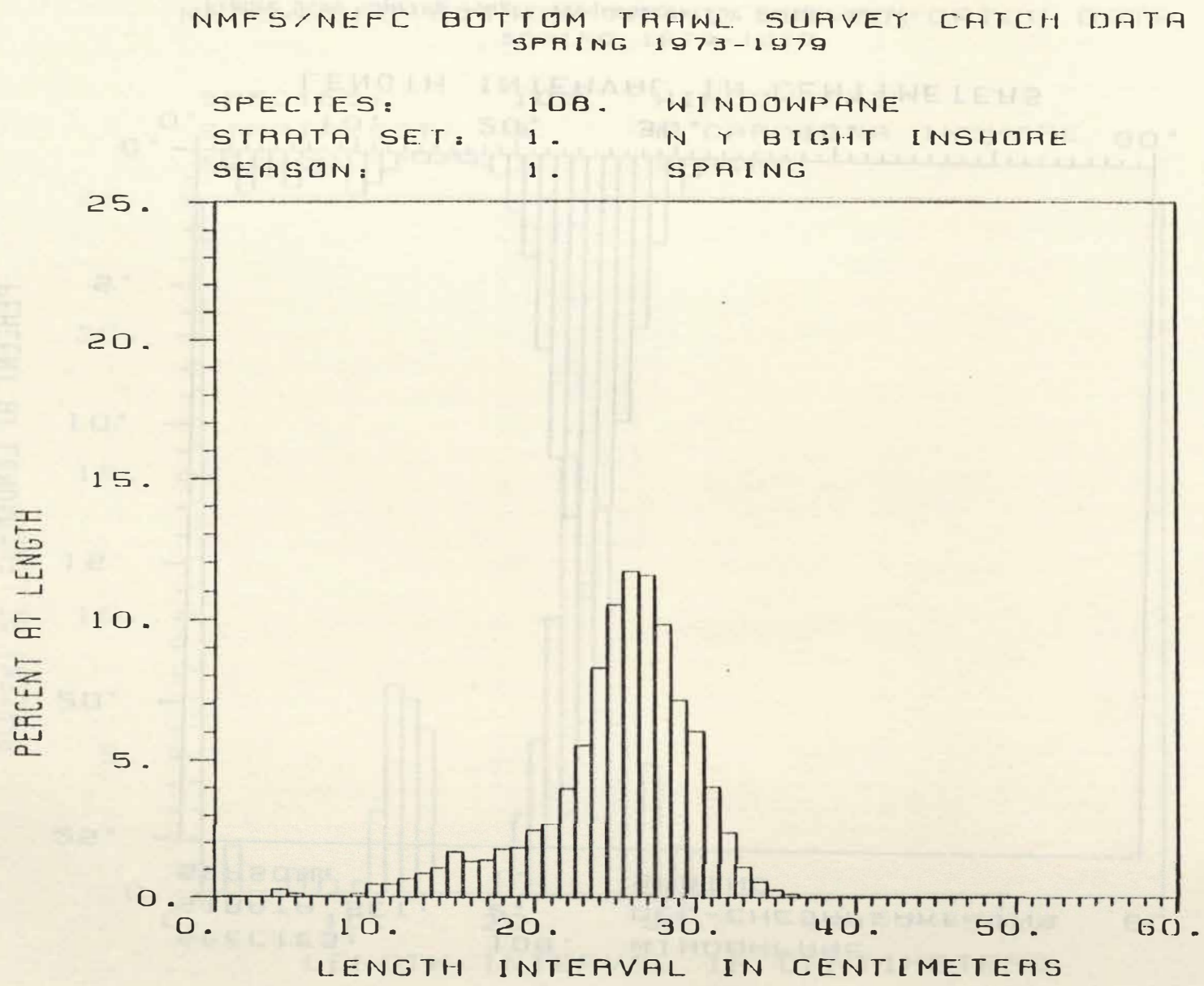


Figure 9.8. Spring length frequencies for strata set 1.

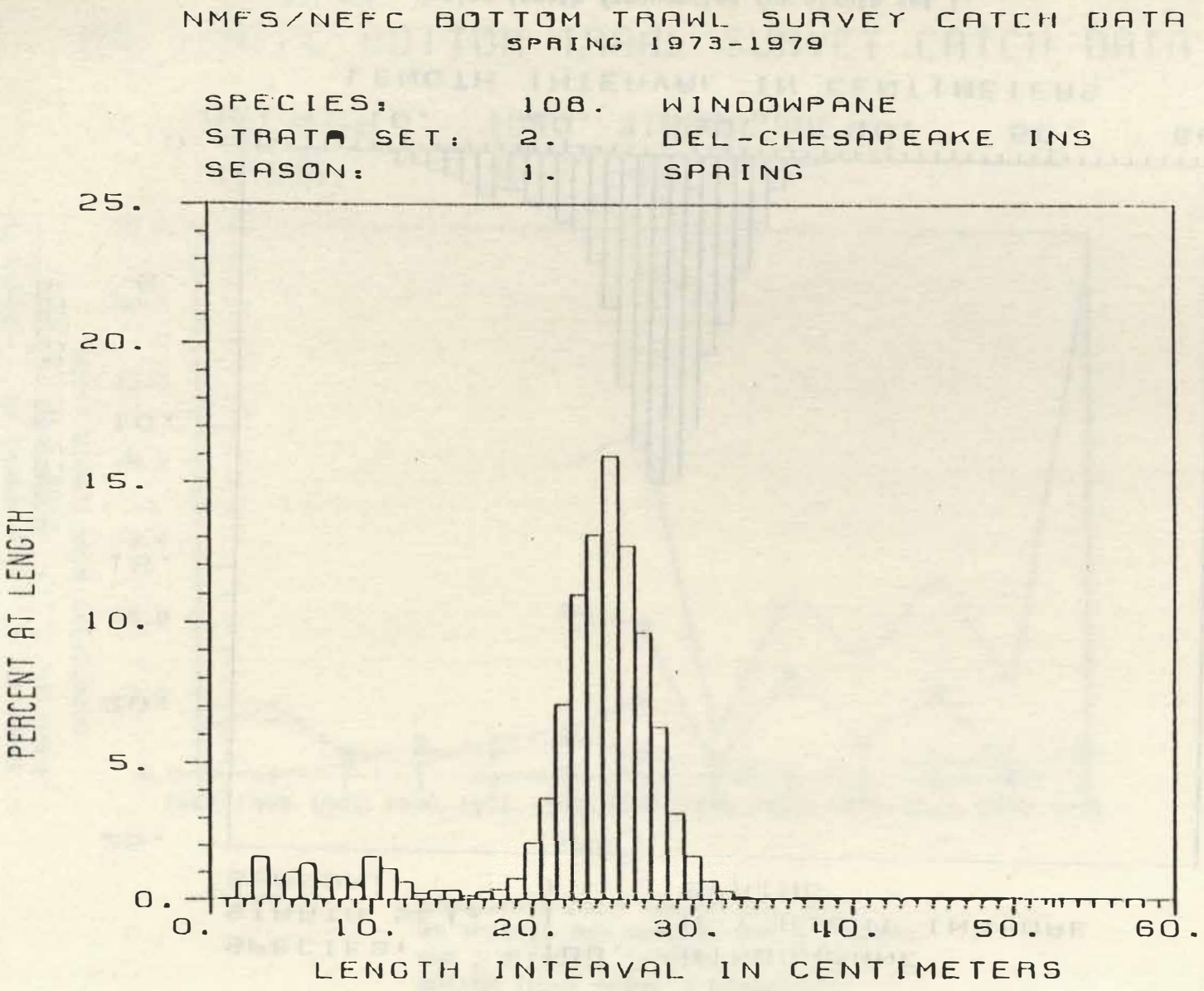


Figure 9.9. Spring length frequencies for strata set 2.

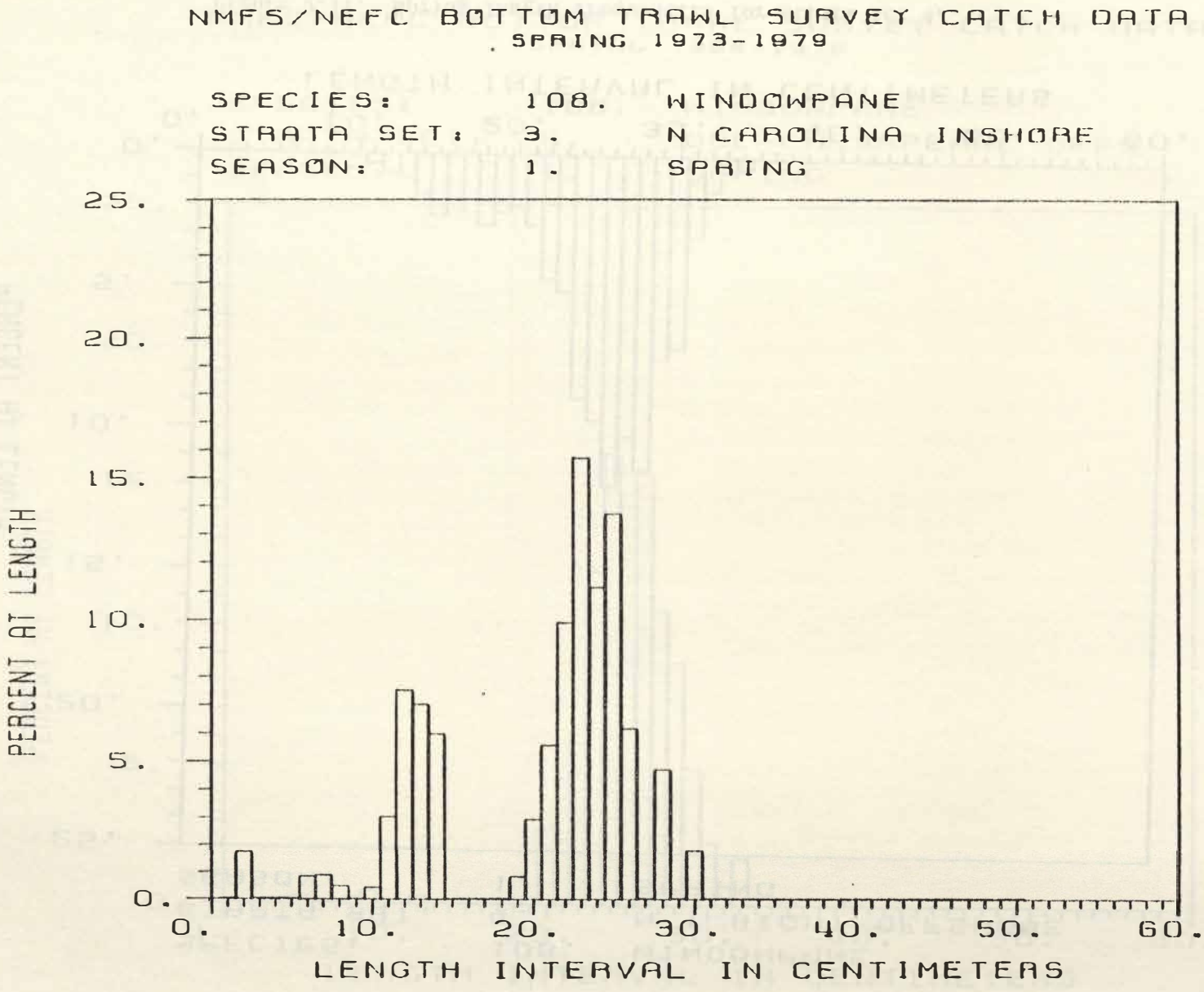


Figure 9.10. Spring length frequencies for strata set 3.

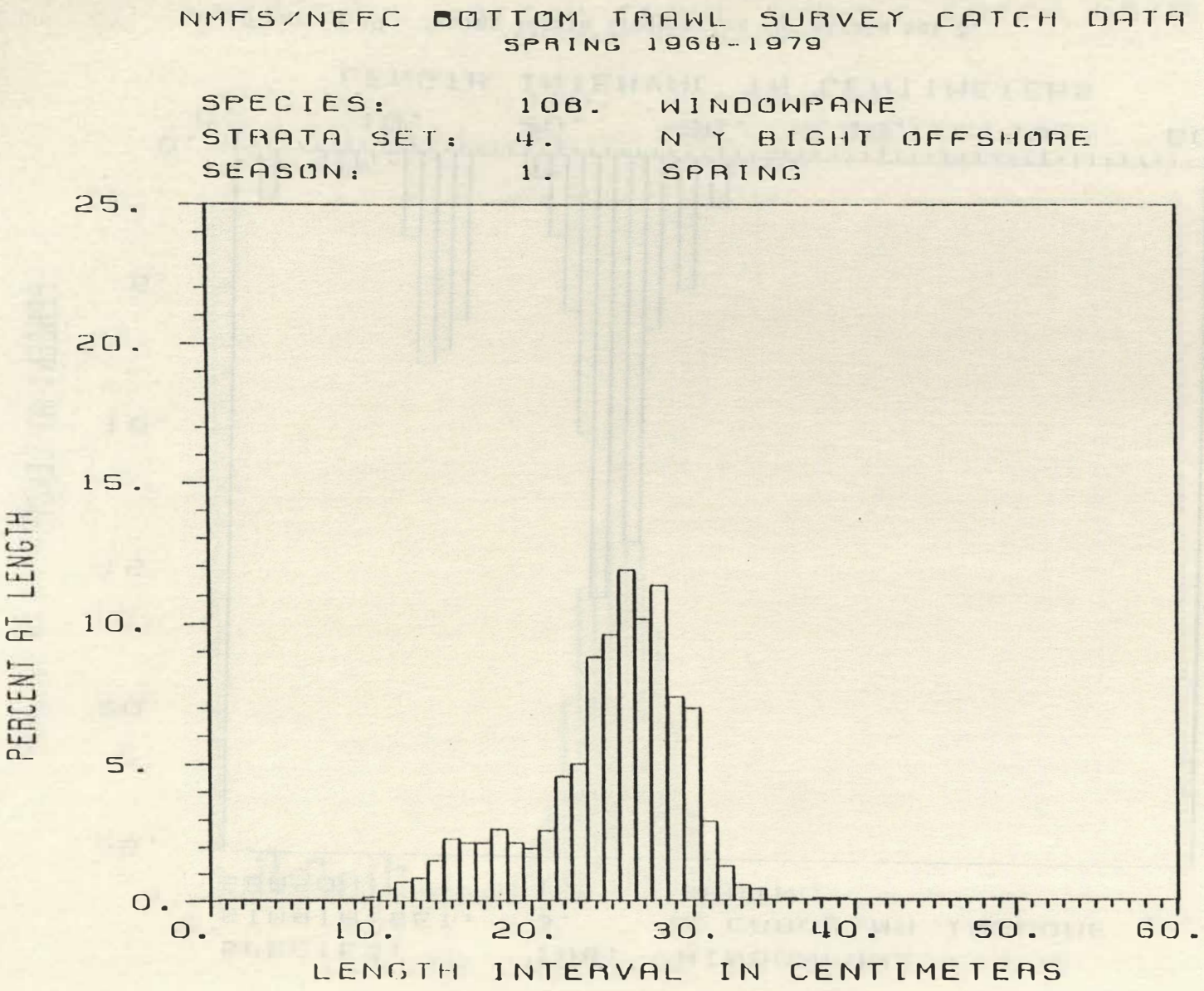


Figure 9.11. Spring length frequencies for strata set 4.

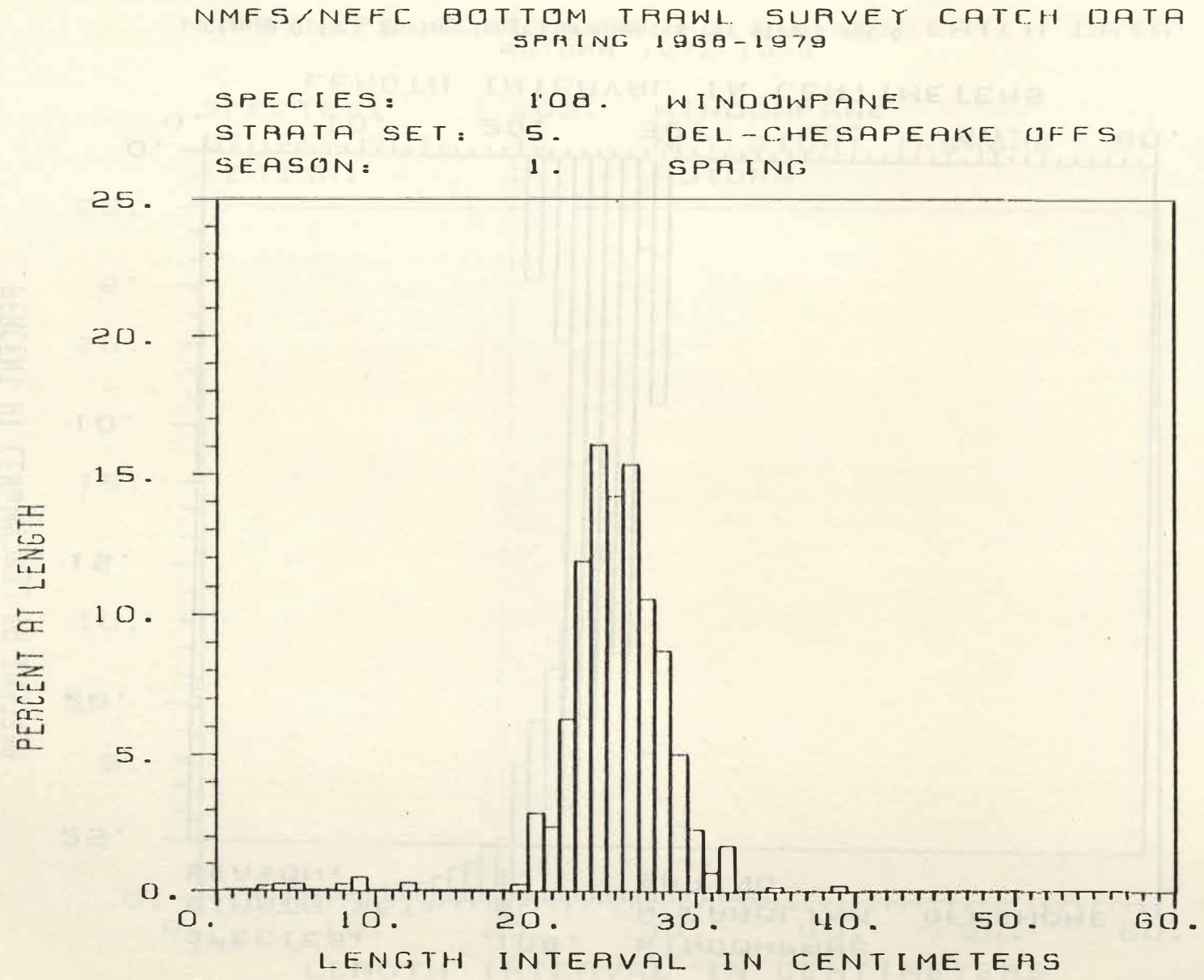


Figure 9.12. Spring length frequencies for strata set 5.

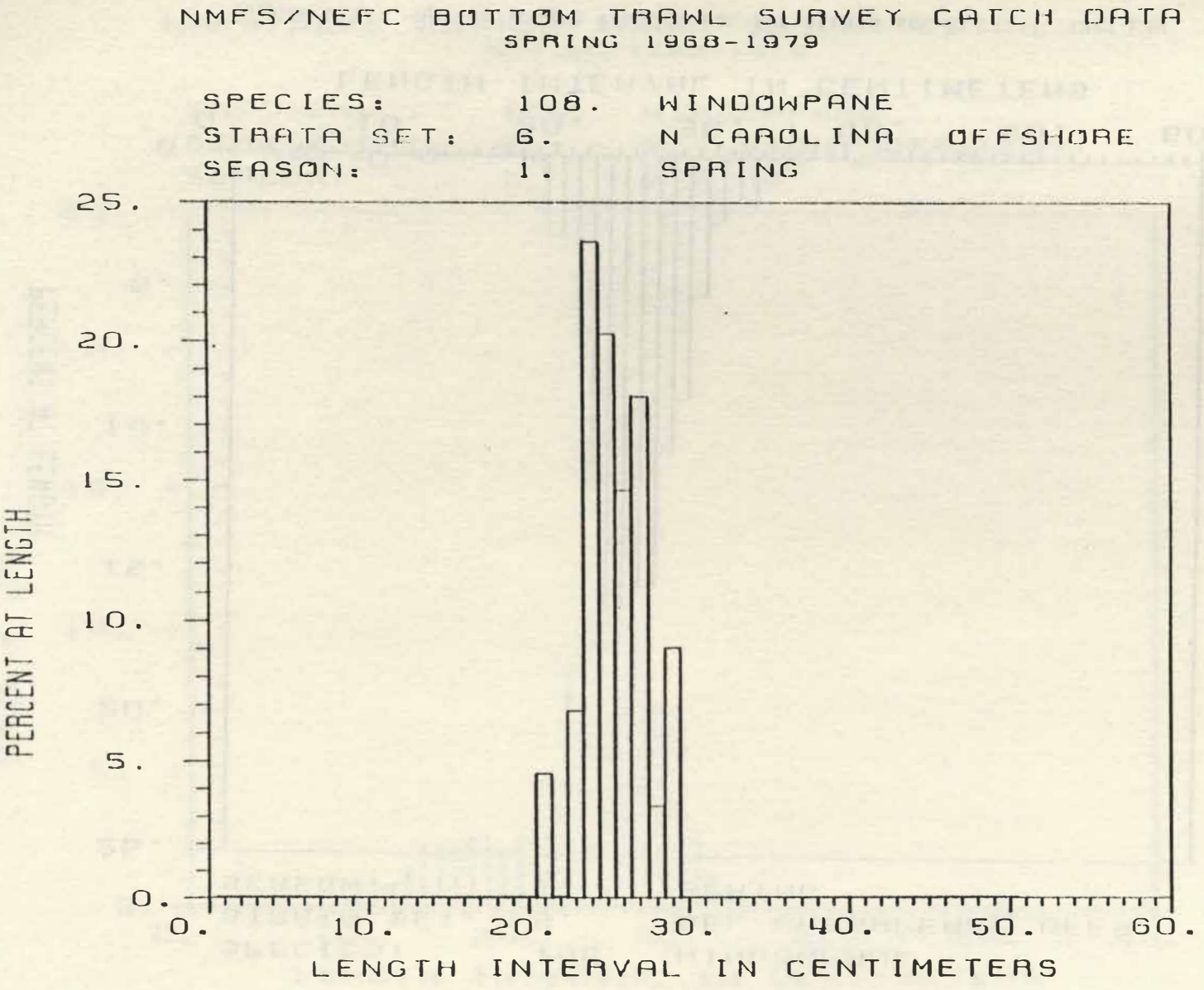


Figure 9.13. Spring length frequences for strata set 6.

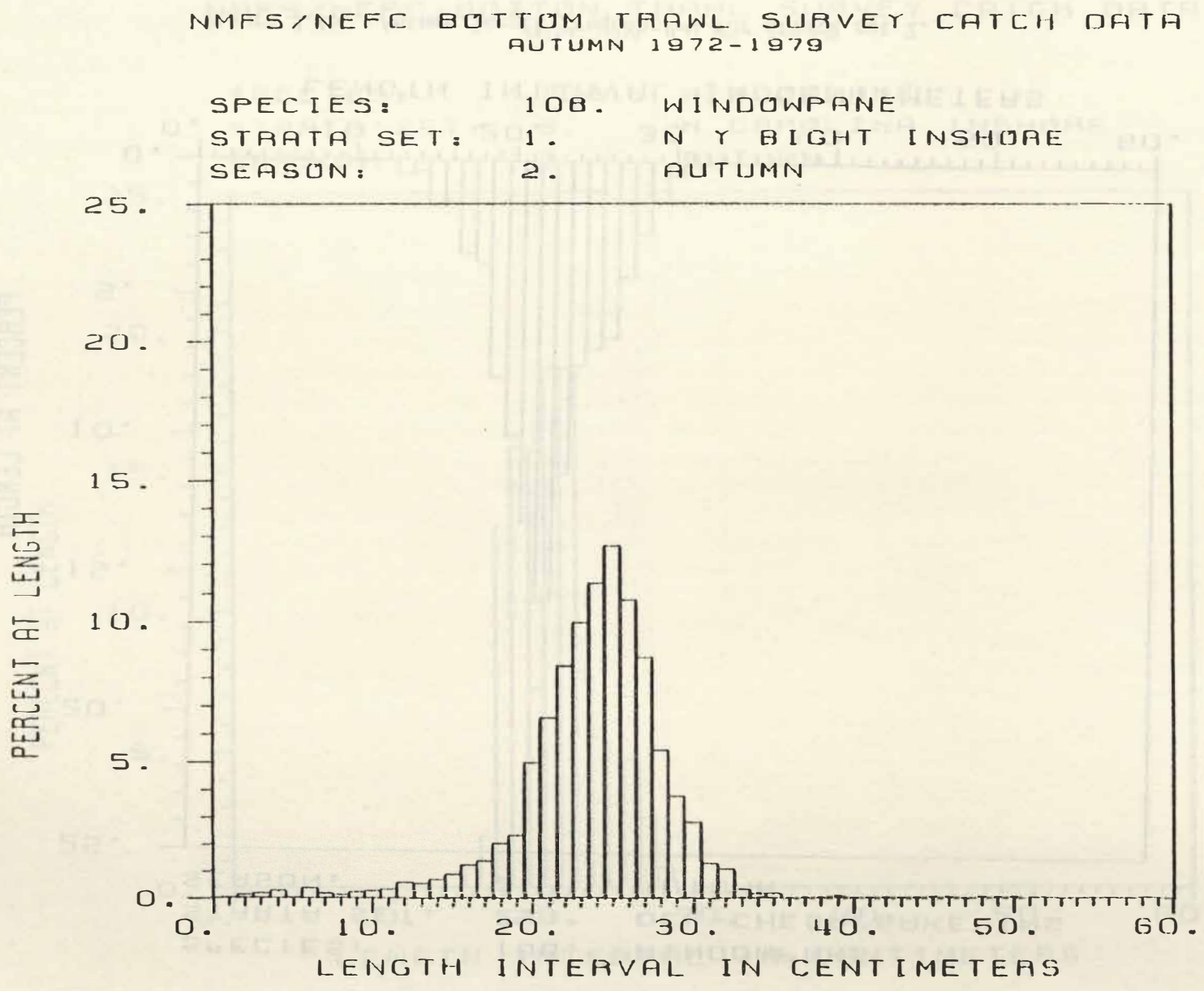


Figure 9.14. Autumn length frequencies for strata set 1.

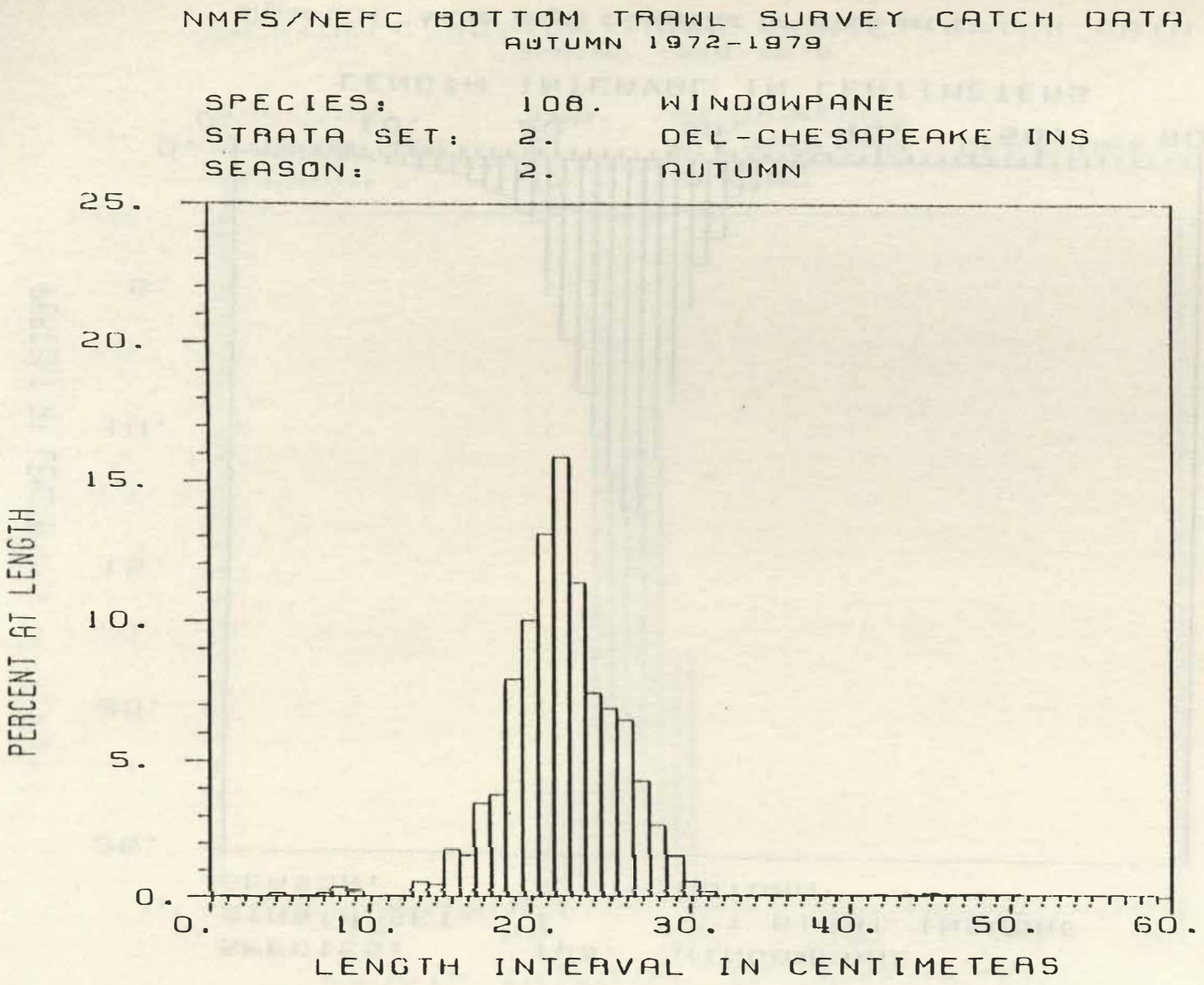


Figure 9.15. Autumn length frequencies for strata set 2.

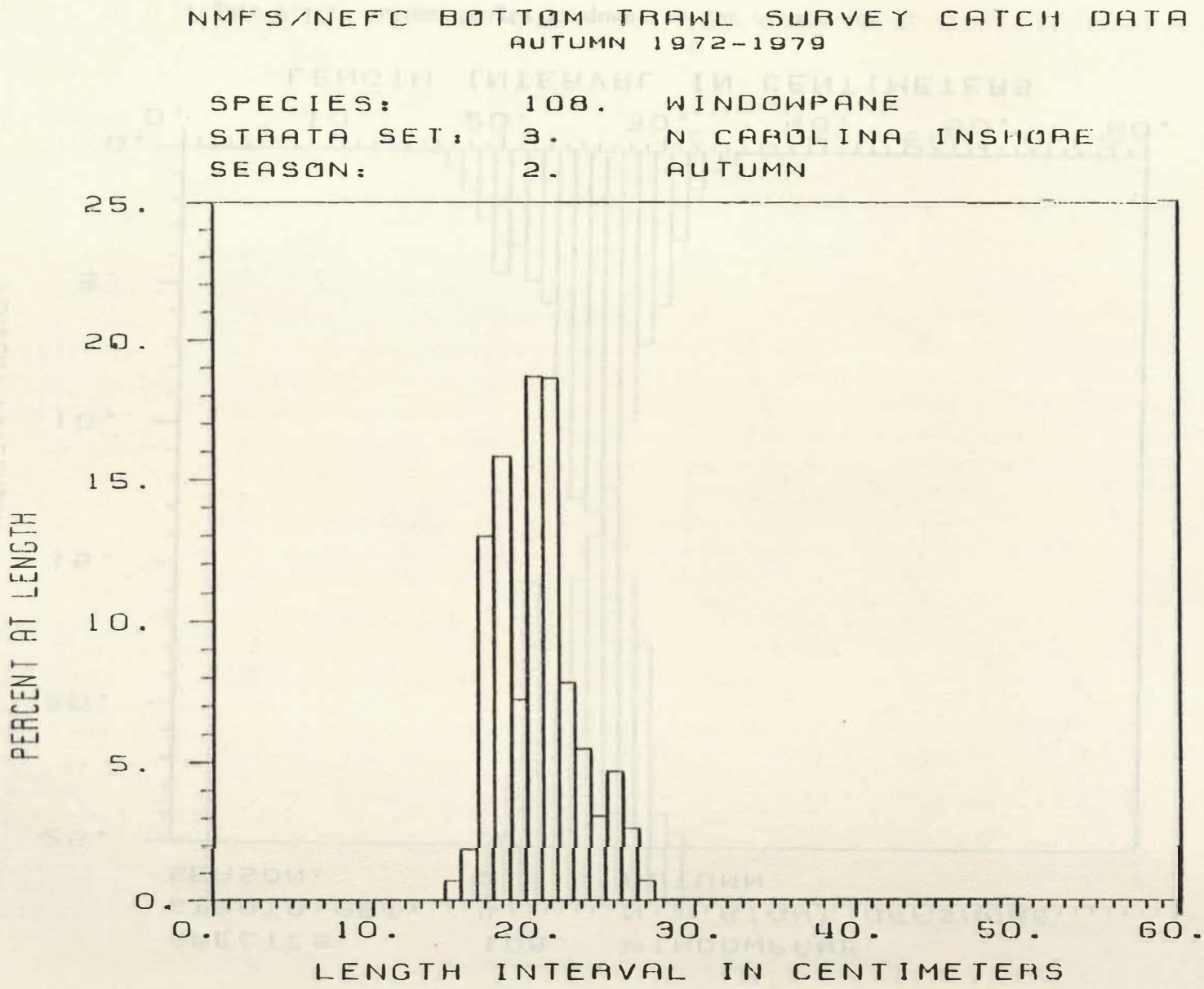


Figure 9.16. Autumn length frequencies for strata set 3.

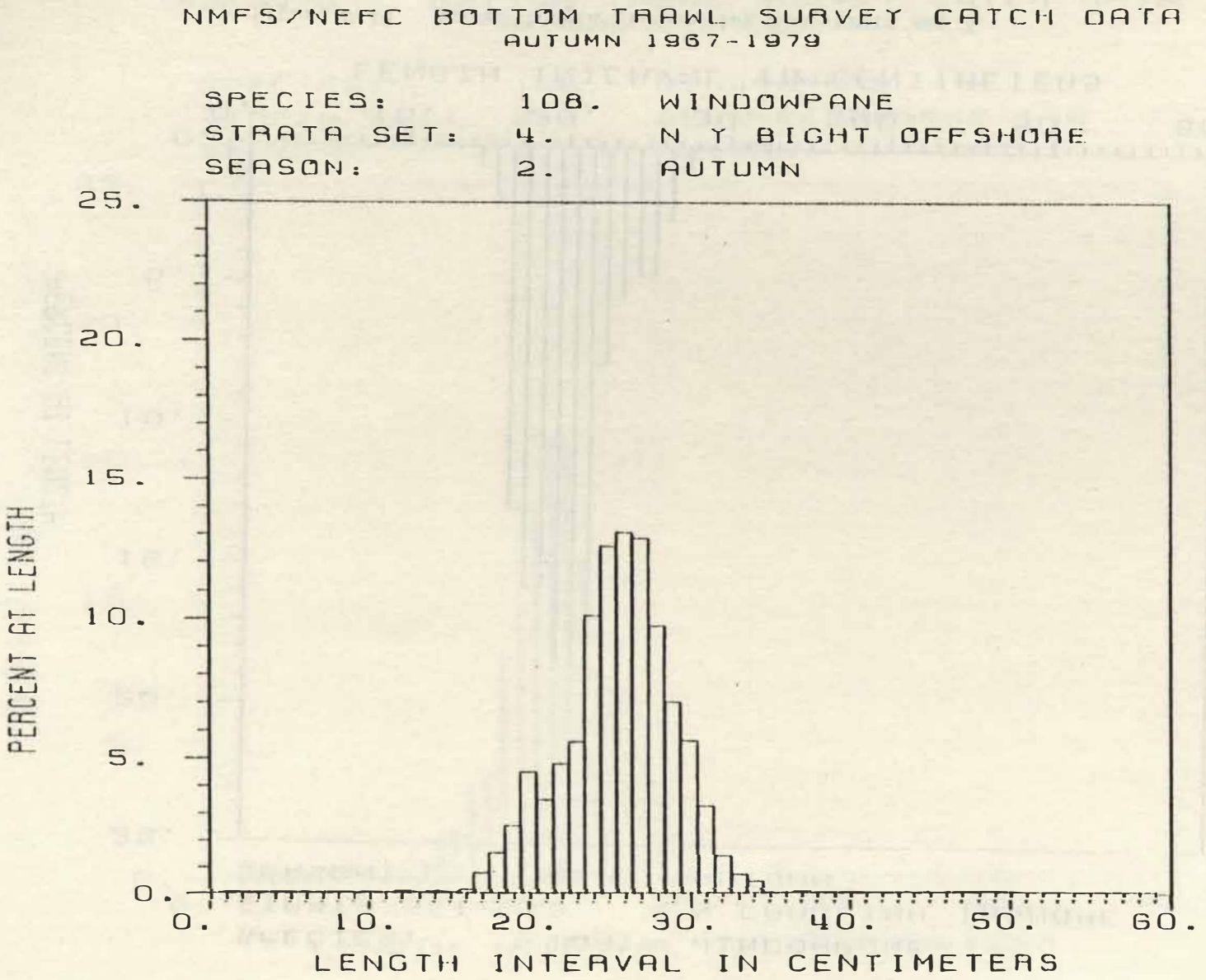


Figure 9.17. Autumn length frequencies for strata set 4.

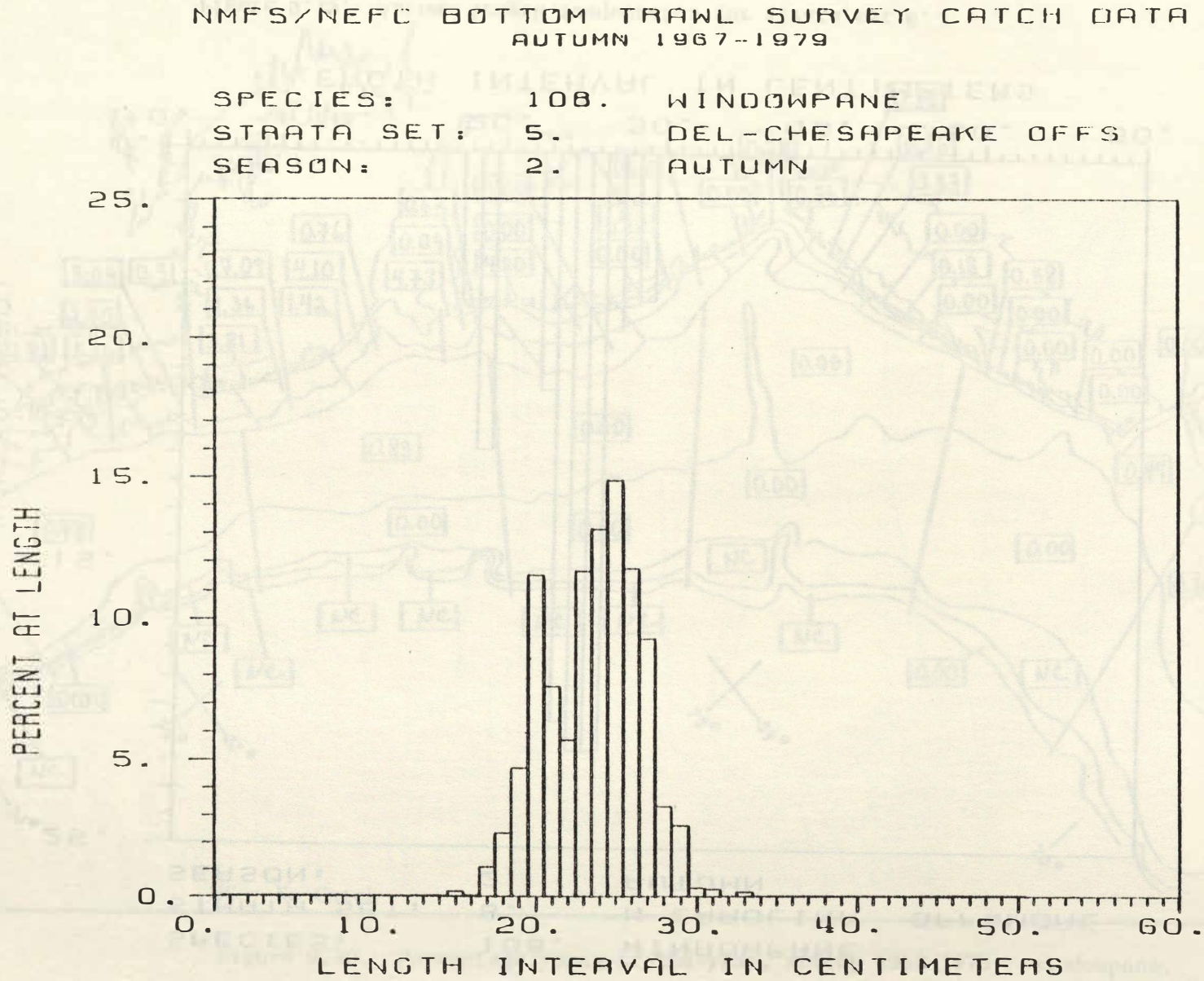


Figure 9.18. Autumn length frequencies for strata set 5.

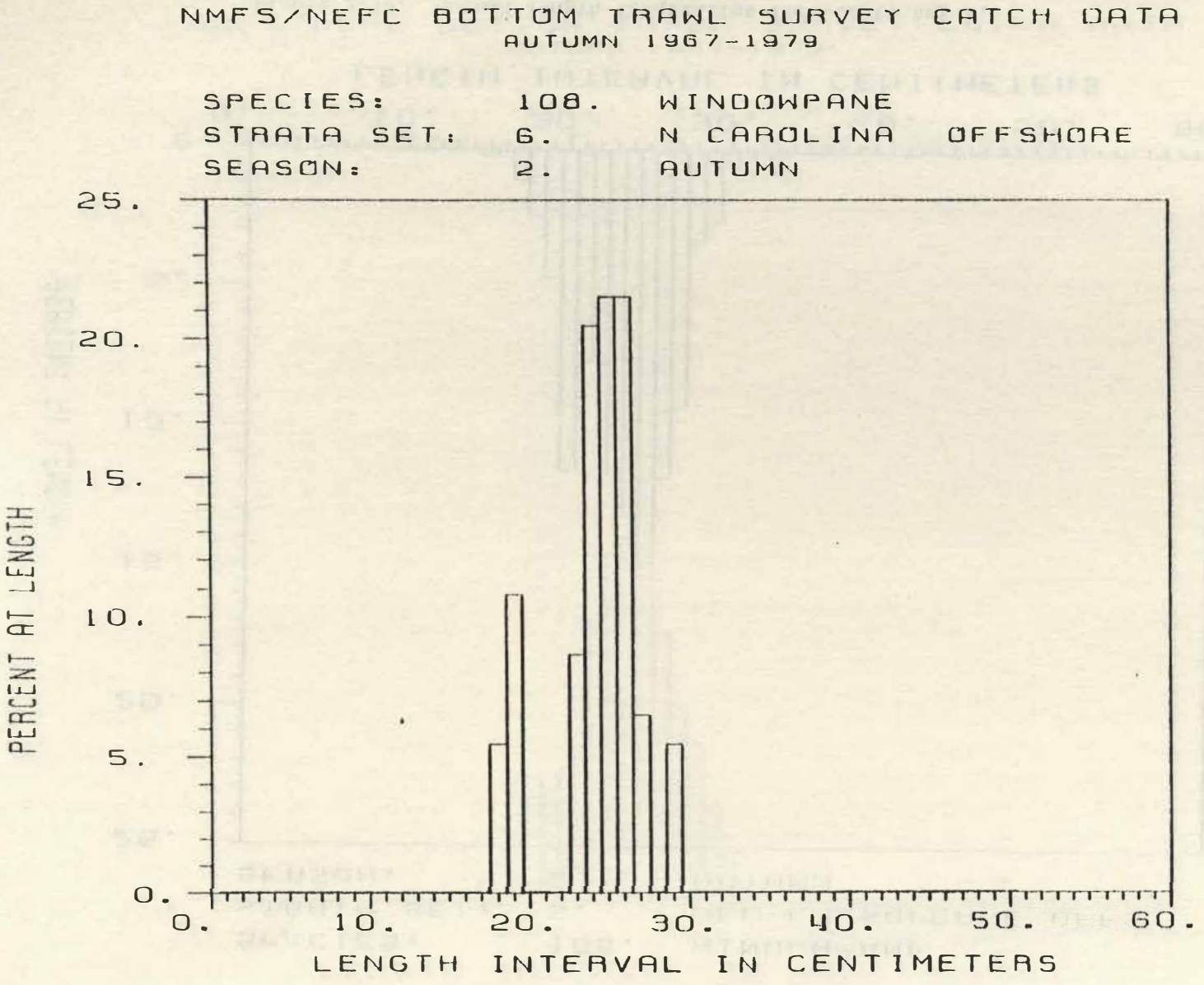


Figure 9.19. Autumn length frequencies for strata set 6.

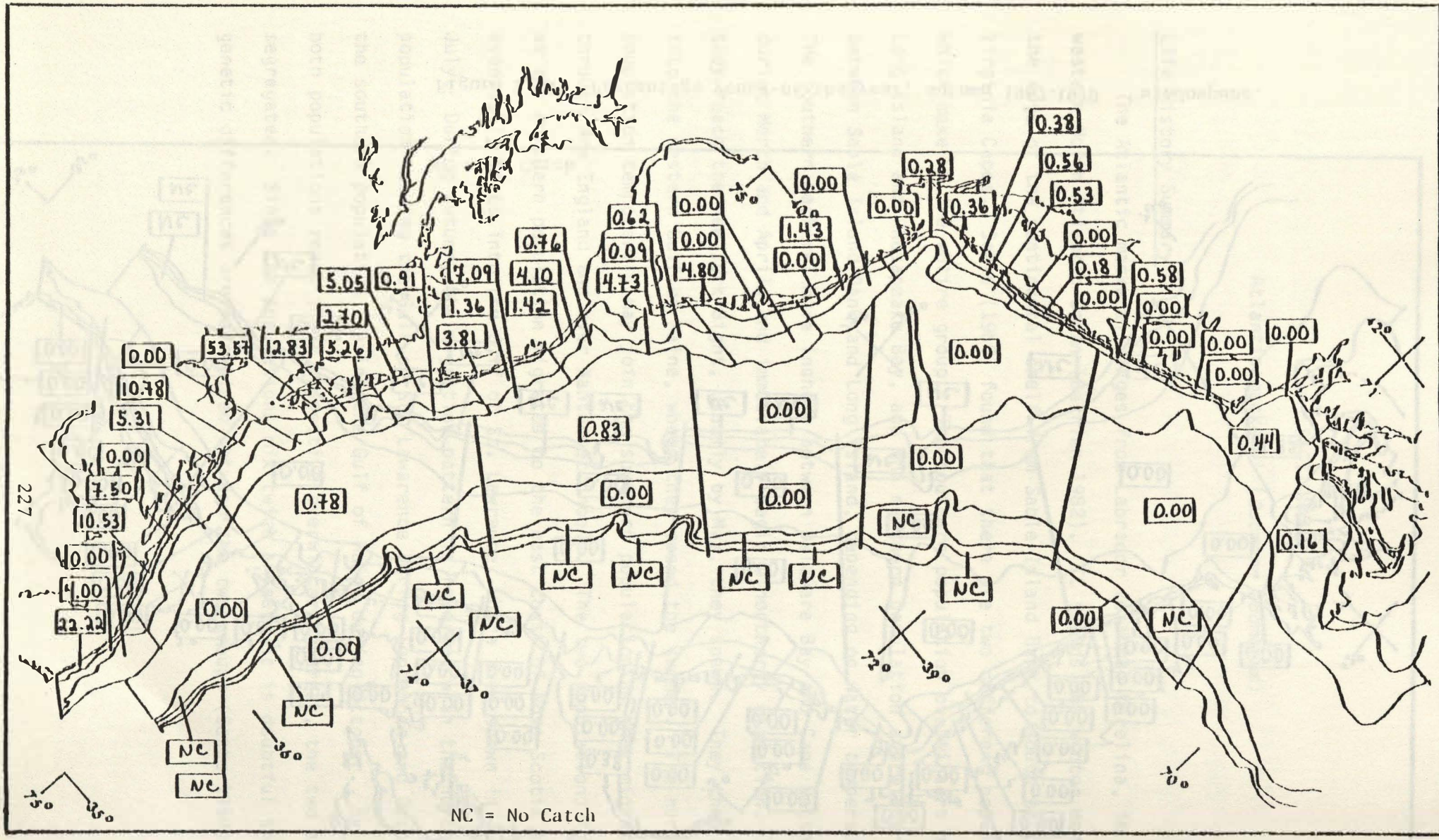


Figure 9.20. Percentage young-of-the-year, spring 1968-1979 - windowpane.

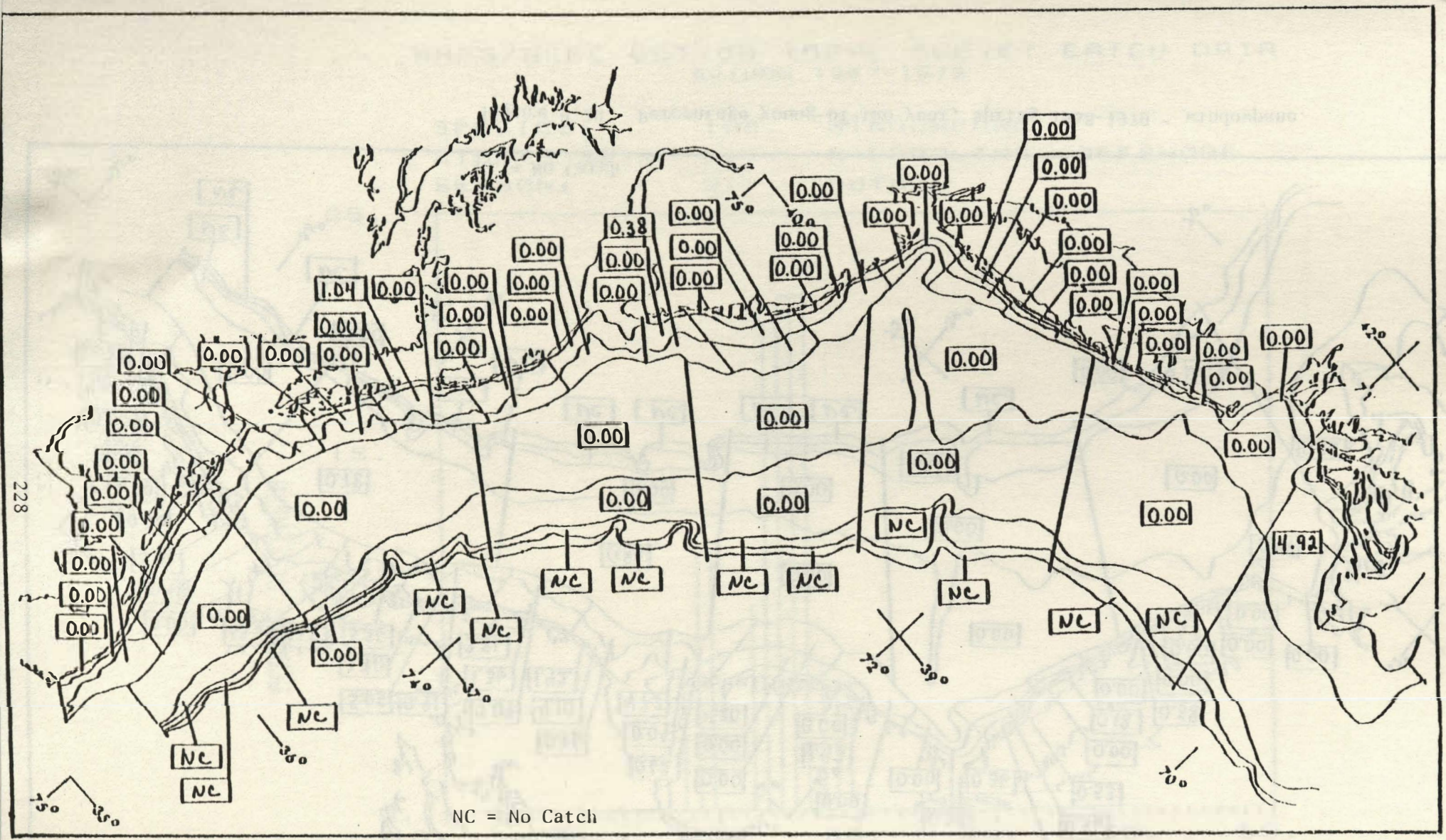


Figure 9.21. Percentage young-of-the-year, autumn 1967-1979 - windowpane.

SECTION 10

Atlantic mackerel (*Scomber scombrus*)

Life History Summary

The Atlantic mackerel ranges from Labrador to North Carolina, in the western North Atlantic Ocean (Berrien 1982). It spends the winter months near the edge of the continental shelf from Sable Island Bank to south of the Virginia Capes. Sette (1950) found that there are two different populations which make up the entire group. The southern population overwinters between Long Island and Chesapeake Bay, and the northern population overwinters between Sable Island Bank and Long Island, depending on water temperatures. The southern mackerel move inshore between Delaware Bay and Cape Hatteras during March and April, and immediately begin a northerly migration. When they reach the New York Bight, usually by May, they spawn. They then continue into the western Gulf of Maine, where they spend the summer. The northern population temporarily may join the southern population as they migrate through New England and over Nantucket Shoals. The two populations then split as the northern population migrates to the east coast of Nova Scotia and eventually moves into the Gulf of St. Lawrence, where they spawn in June and July. During autumn, the migration pattern is reversed with the northern population leaving the Gulf of St. Lawarence during September and October, and the southern population leaving the Gulf of Maine during October. By the time both populations reach their respective overwintering areas, the two are again segregated. Since the populations mix twice a year, it is doubtful that genetic differences are maintained between the two groups (Sette 1950).

There are both recreational and commercial components to the Atlantic mackerel fishery; the domestic recreational catch historically exceeds the commercial catch. Until 1978, the combined domestic recreational and commercial catch was dwarfed by that of foreign commercial fishermen. For example, during 1976, the US commercial fishermen landed 2,700 metric tons (MT); US recreational fishermen landed 4,200 MT; Canadian commercial fishermen landed 15,700 MT; and commercial fishermen from other countries landed 223,300 MT for a total of 245,900 MT (Anderson 1984). Of the commercial total approximately 57% was taken in waters west of 70° longitude (Middle Atlantic Bight and western Gulf of Maine). However, since 1977, regulation of foreign fishing has reduced the proportion of foreign catch to approximately 10% of the annual total allowable catch (Anderson 1984).

Essentially all mackerel are mature by their fifth year, although at least half of them have reached maturity by their third year. The eggs are planktonic, staying above the seasonal thermocline in the upper 15 m. The incubation period is temperature-dependent, and takes about 4 days at 16°C. Juveniles are thought to move inshore, while the larger fish stay further offshore in deeper waters (Bigelow and Schroeder 1953).

Atlantic mackerel are opportunistic feeders. They feed both on zooplankton and are active predators on larger organisms as well.

NMFS stock assessments indicated that the total stock biomass (ages 1 and older) declined from an estimated 2,515,000 MT in 1969 to 485,000 MT in 1977, then began rebuilding to about 631,000 MT at the beginning of 1979 (Anderson 1980).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 10.1 and 10.2. These plots accurately and dramatically depict the seasonal extremes of mackerel migration. If the spring data were gathered synoptically, the northern and inshore occurrences would not be seen. In Figure 10.3, data from all cruises prior to 1976 have been deleted, and a more representative picture of spring (March to April) distribution results. Once mackerel begin moving onto the shelf in the spring, the rapidity of their movement is evident (compare Figures 10.1 and 10.3). The autumn distribution plot shows some occurrences in northern portions of the area; these are all young-of-the-year (YOY) which frequently inhabit these waters during the summer. The autumn catches near the North Carolina-Virginia border were probably chub mackerel (*Scomber japonicus*), a smaller species that frequents warmer southern areas and is often confused with Atlantic mackerel.

The graphs of mean weight and number per tow (Figures 10.4-10.7) do not present a very definitive picture. However, the declining population size during the mid-70's and the beginning of a recovery during 1978 and 1979 are apparent.

Length frequencies for six strata sets, arranged by season, are shown in Figures 10.8-10.18. These graphs support the earlier description concerning the occurrence of YOY during autumn. There is no plot for autumn offshore strata set 6 because no fish were caught in that area.

Figures 10.19 and 10.20 show the percentage occurrence by stratum of YOY; cutoff sizes were 17 and 18 cm, respectively, for spring and fall series. Once again it is apparent that the autumn catches consisted mostly of YOY.

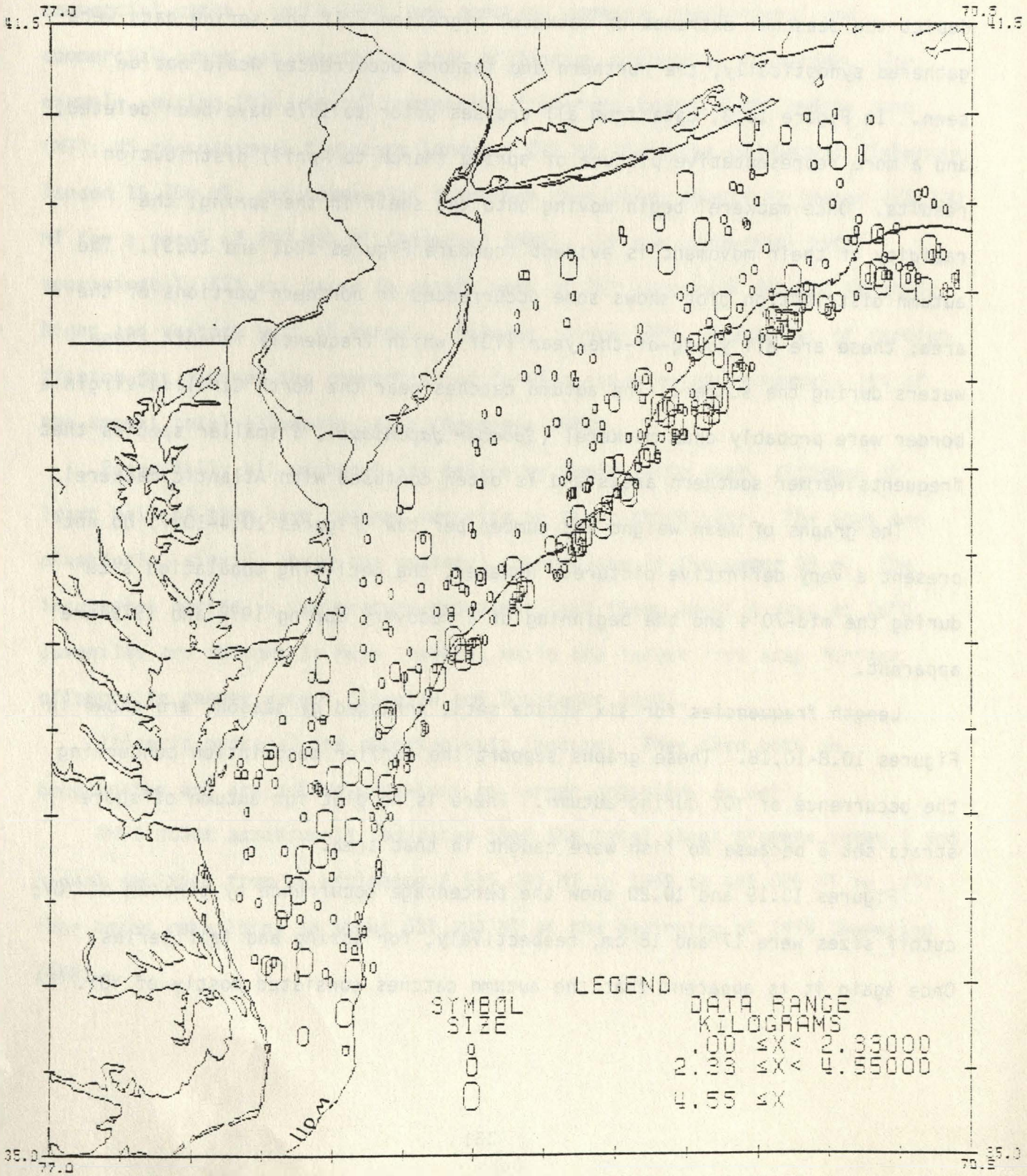


Figure 10.1. Spring distribution, 1968-1979.

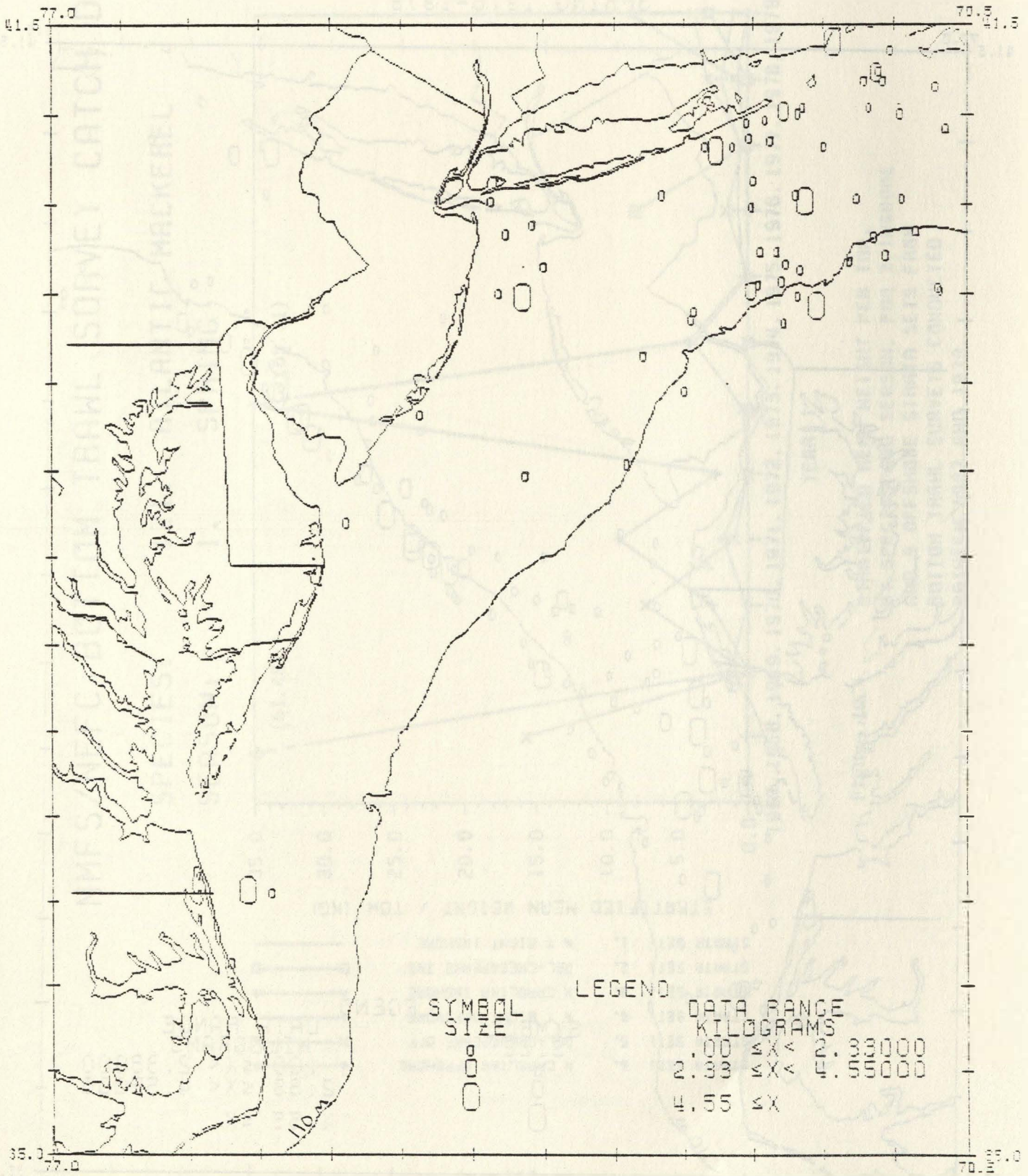


Figure 10.2. Autumn distribution, 1967-1979.

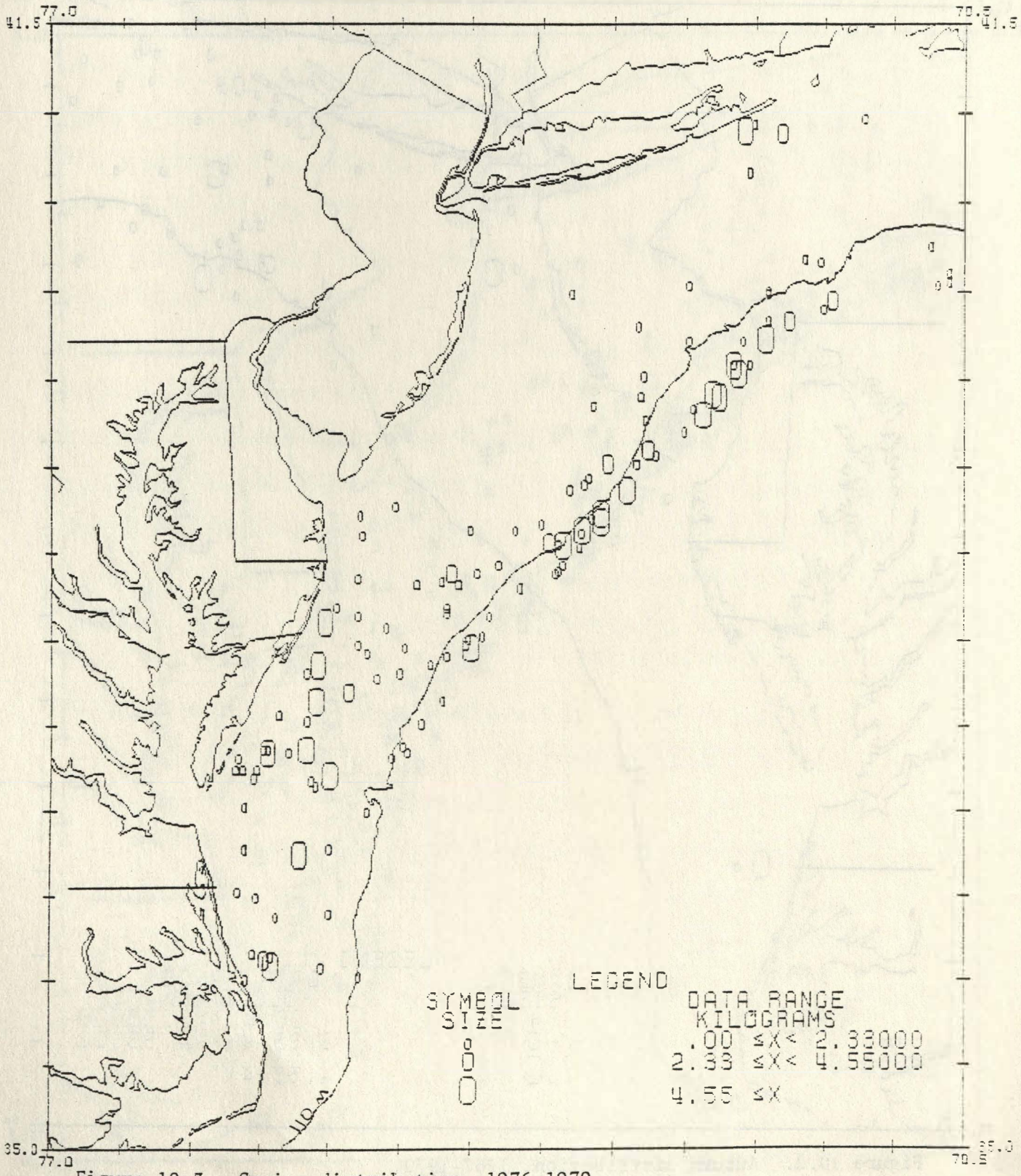


Figure 10.3. Spring distribution, 1976-1979.

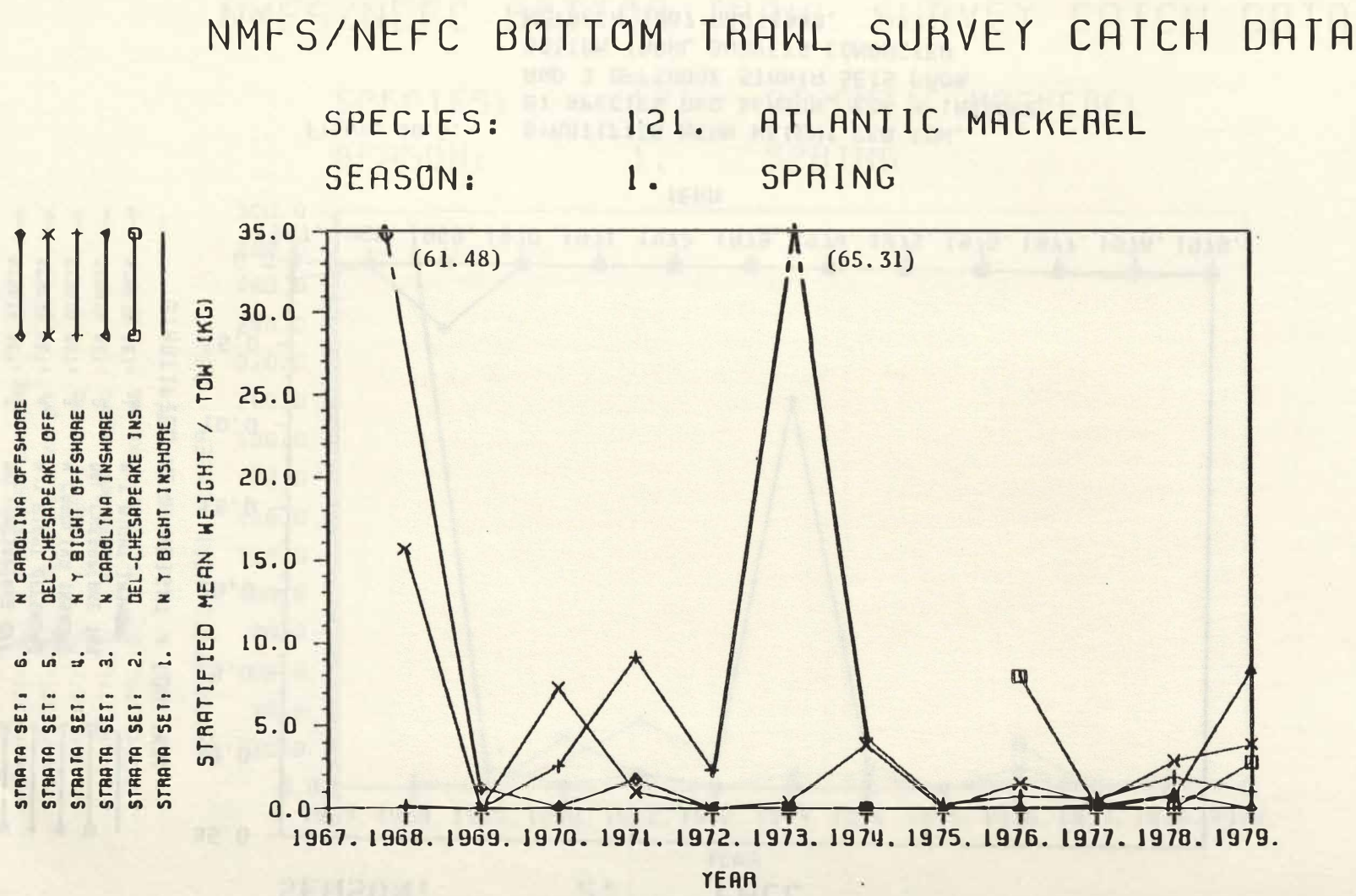


Figure 10.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

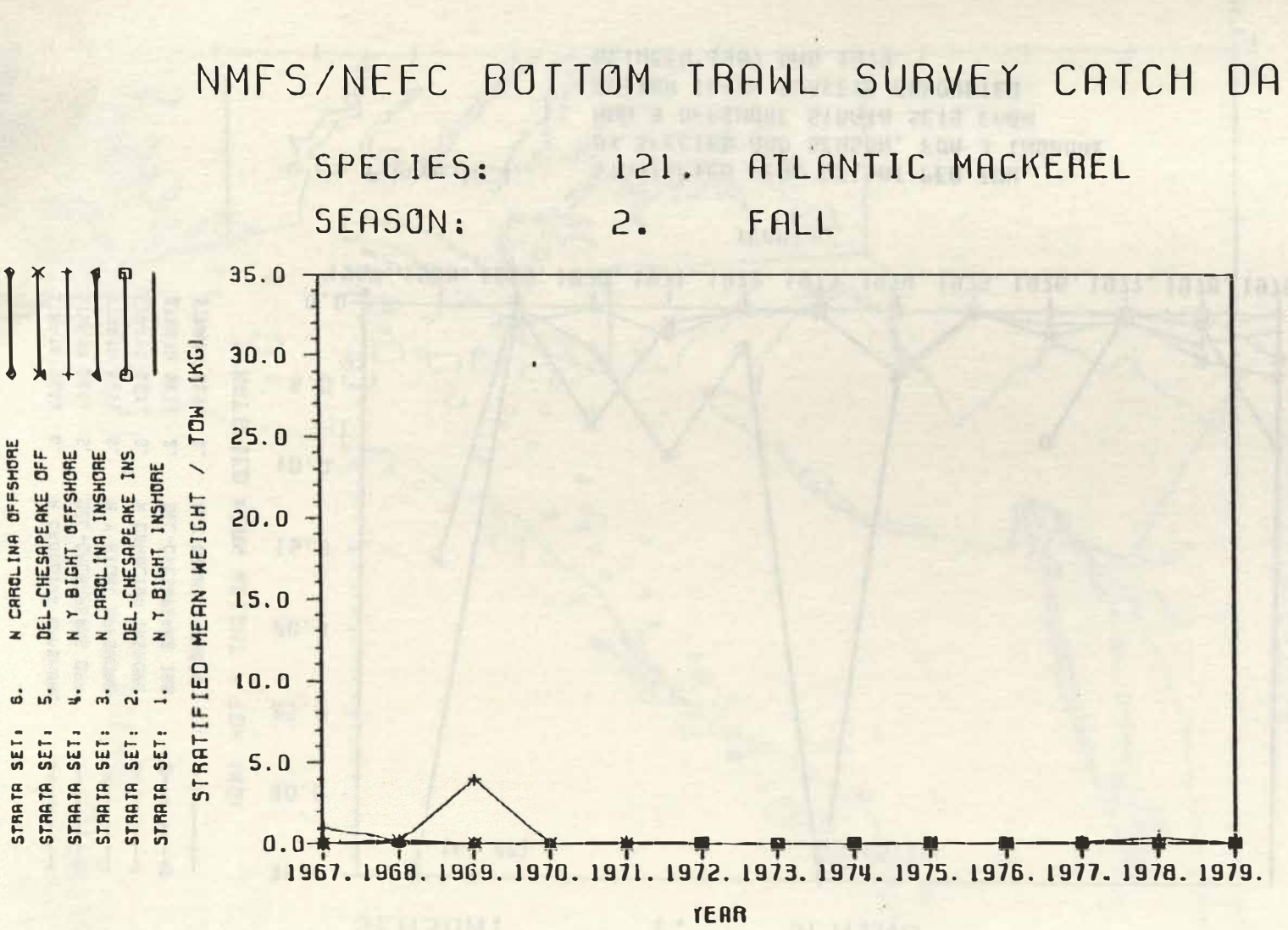


Figure 10.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

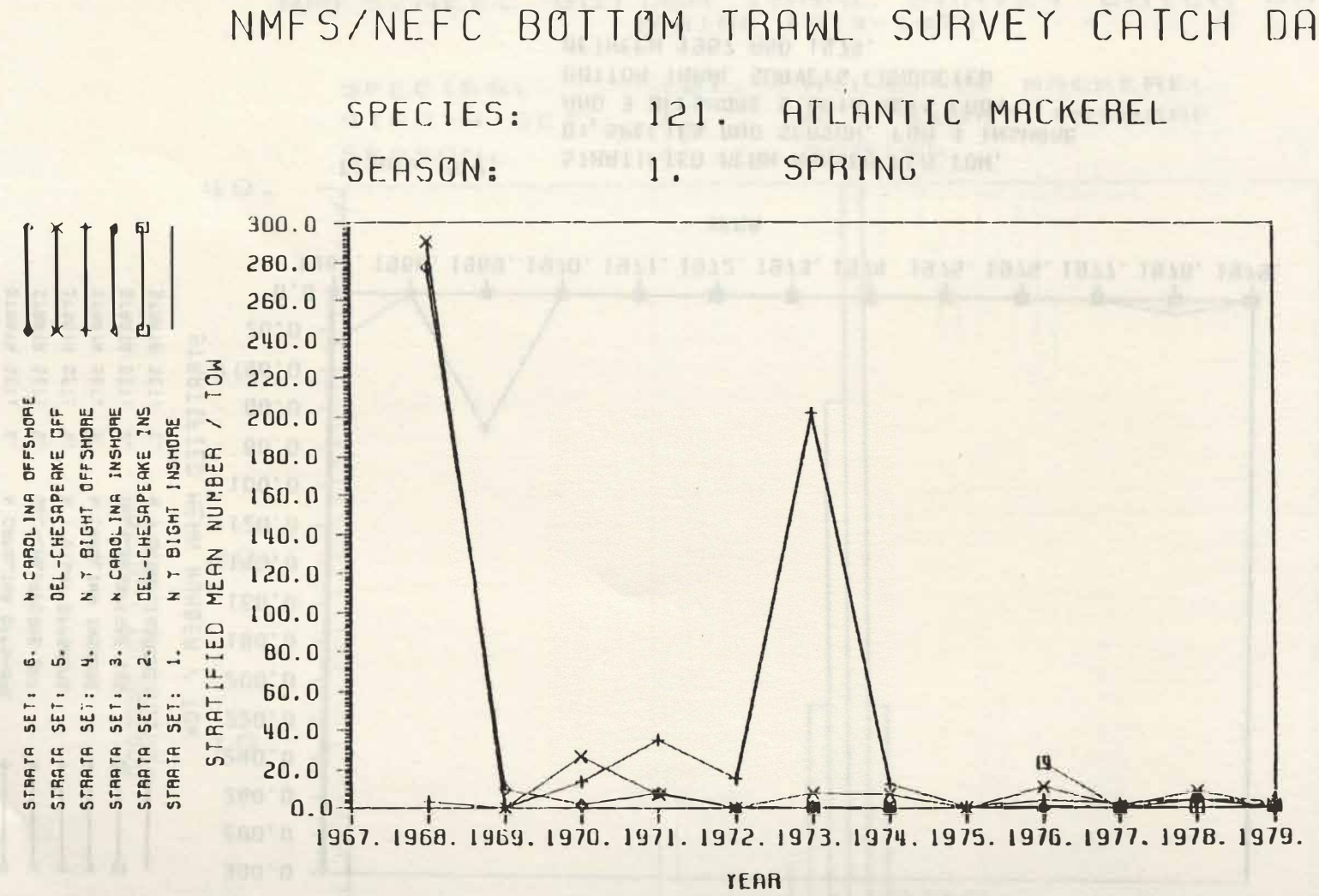


Figure 10.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

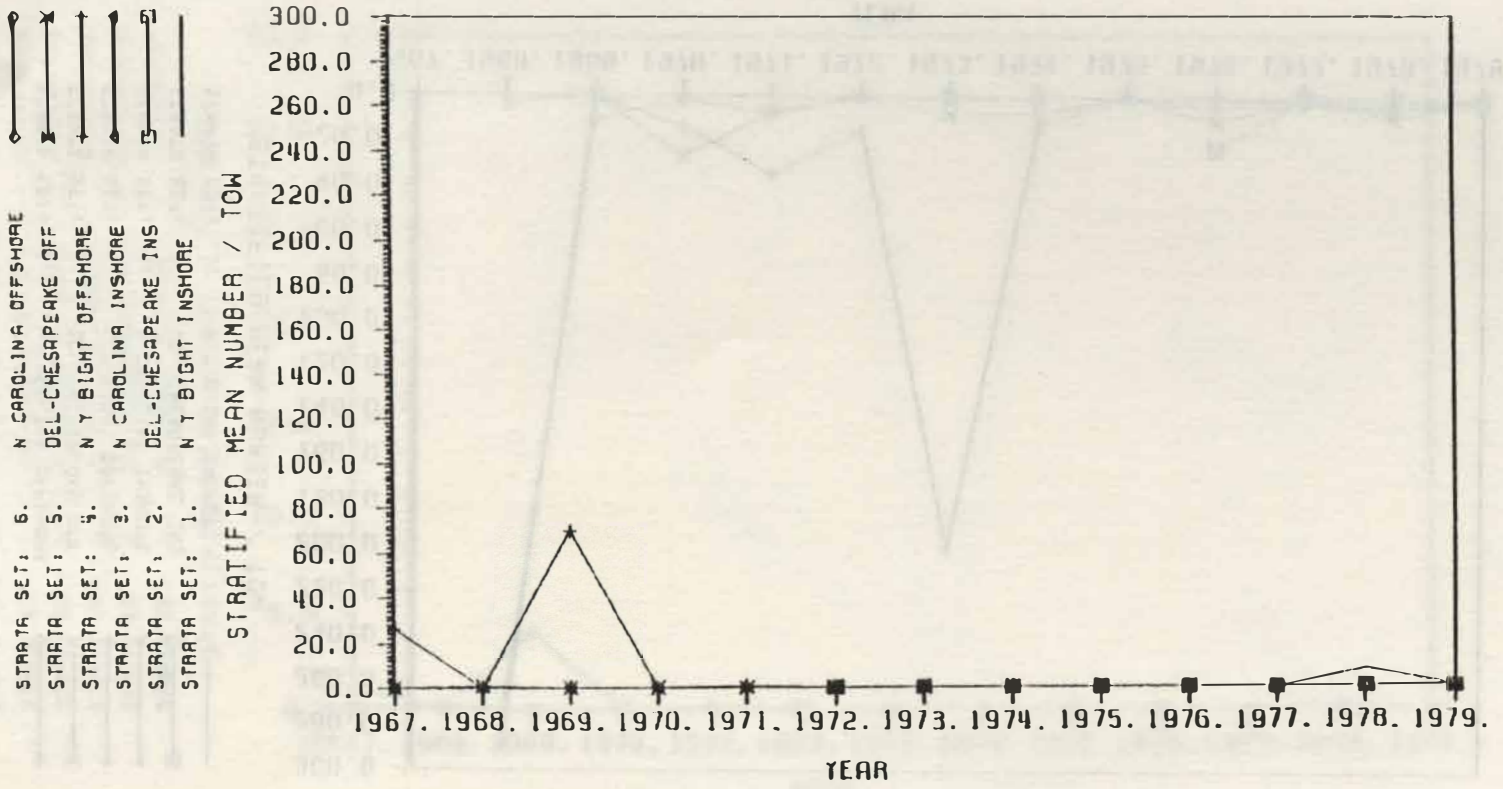


Figure 10.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

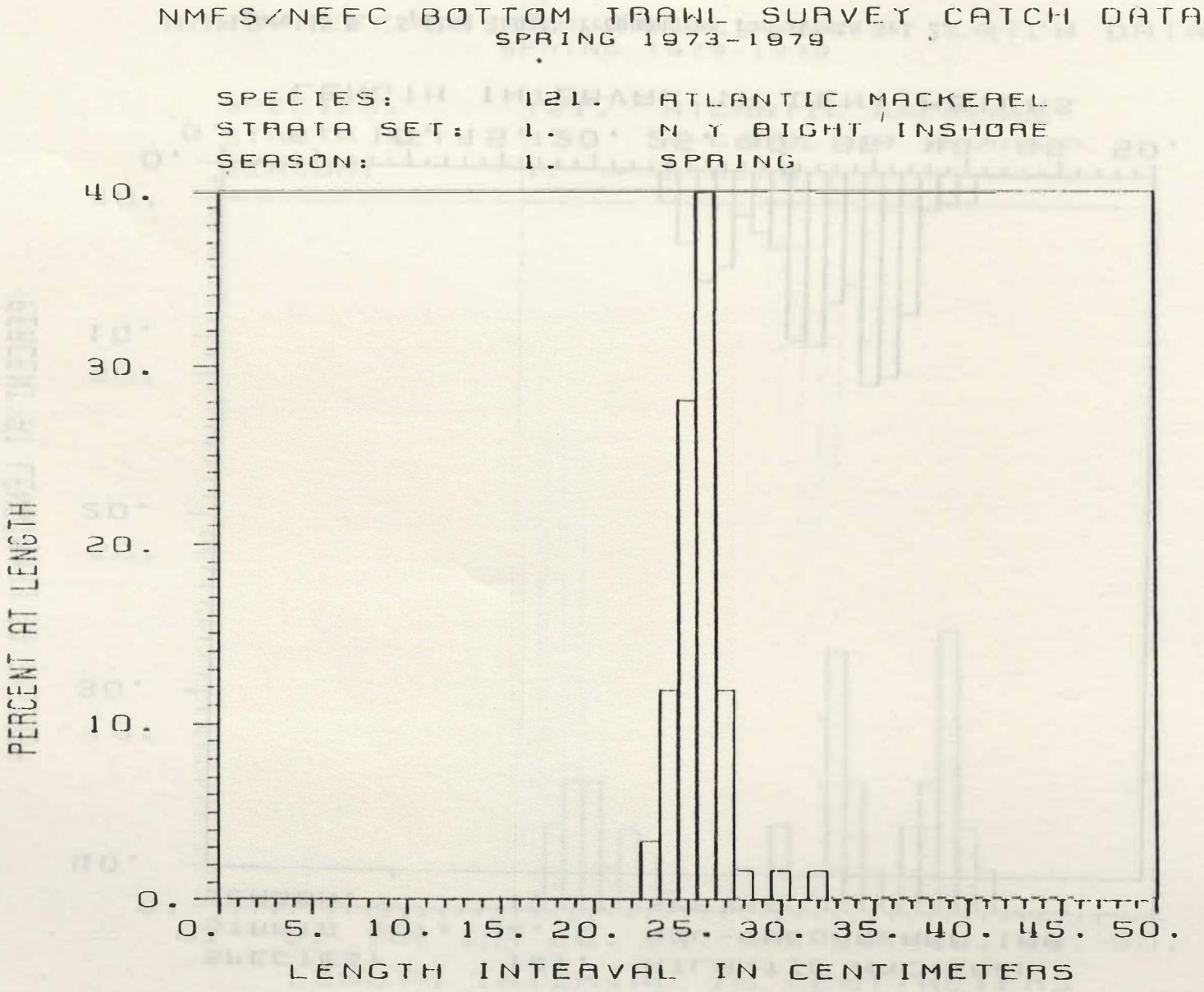


Figure 10.8. Spring length frequencies for strata set 1.

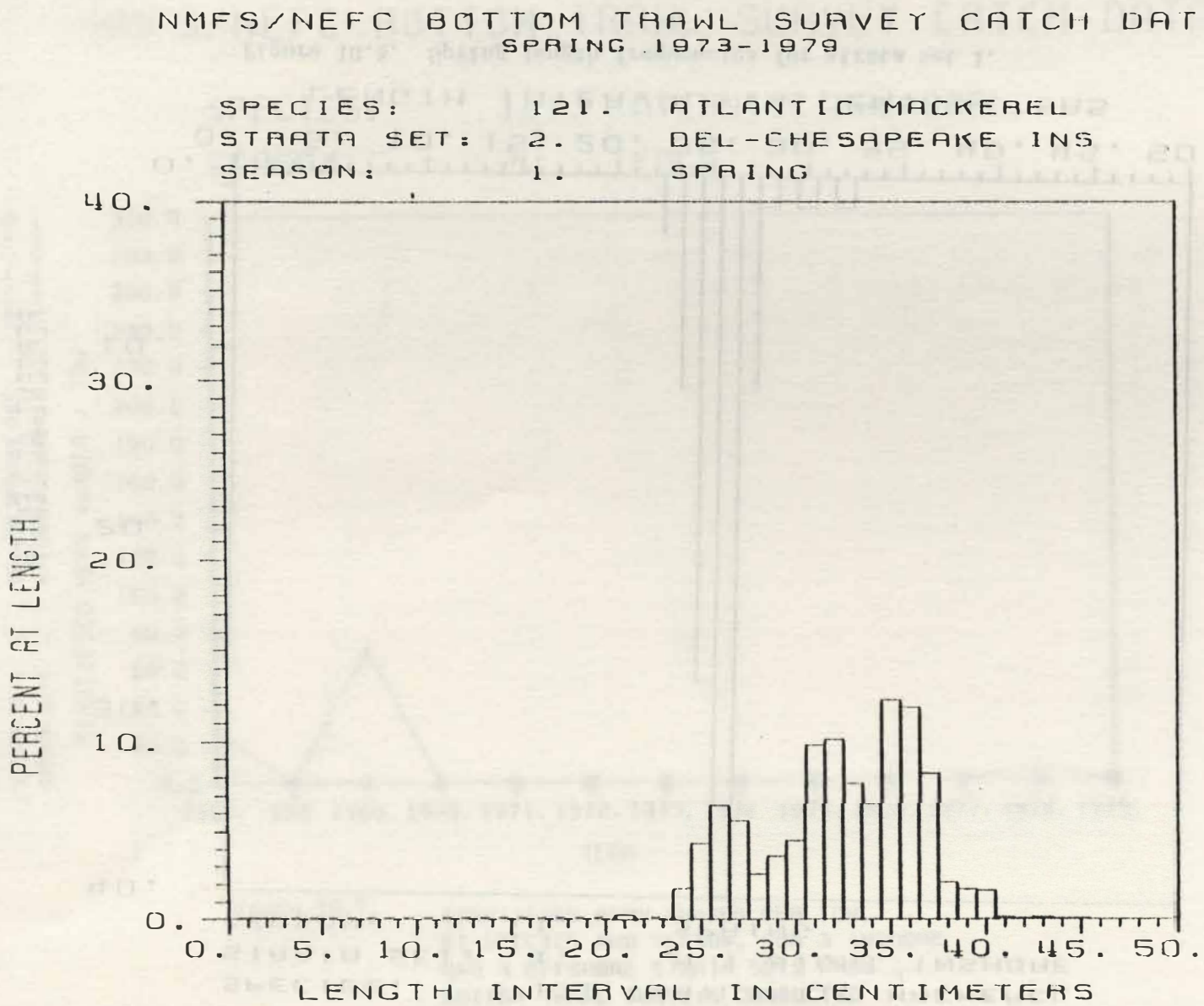


Figure 10.9. Spring length frequencies for strata set 2.

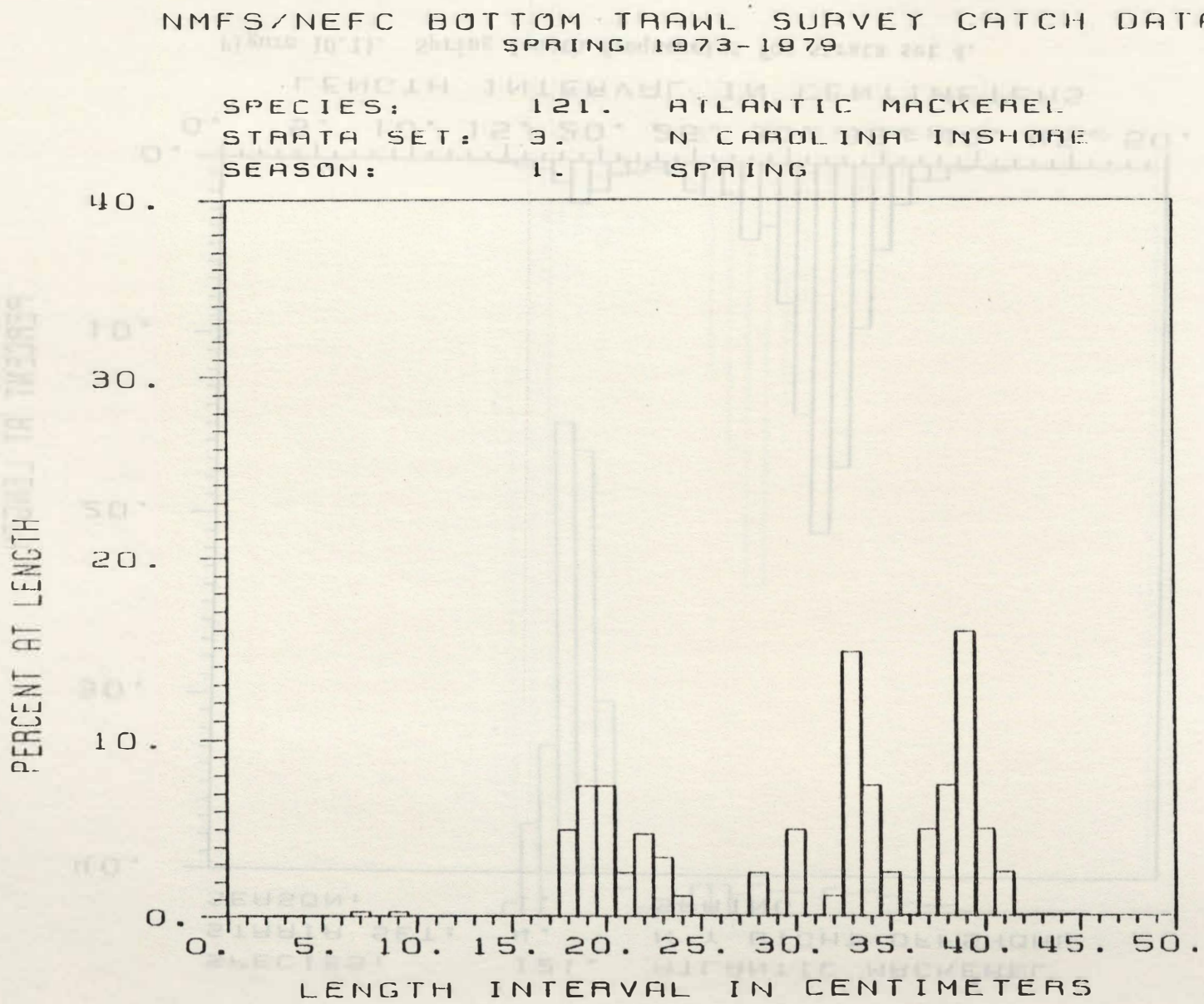


Figure 10.10. Spring length frequencies for strata set 3.

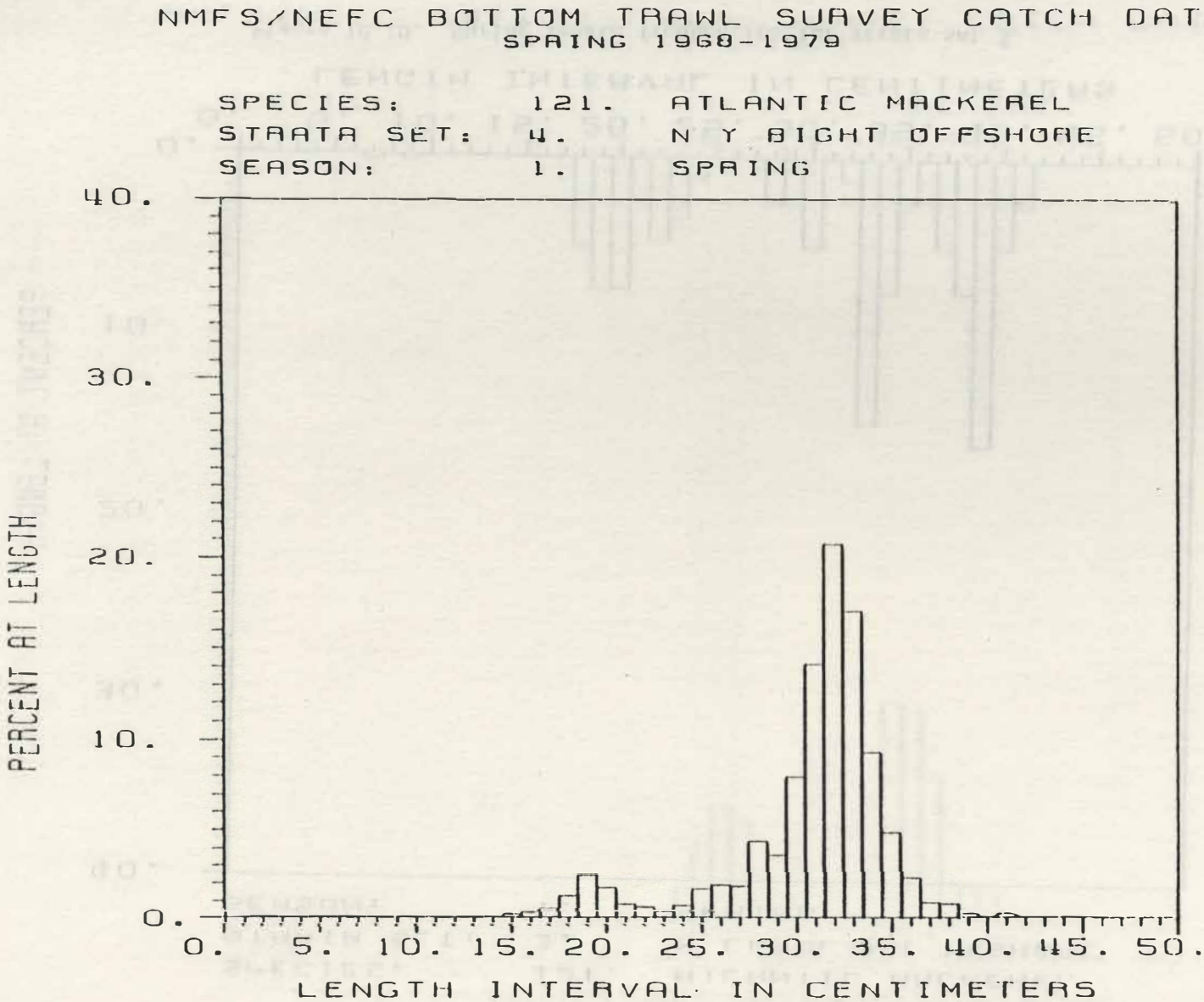


Figure 10.11. Spring length frequencies for strata set 4.

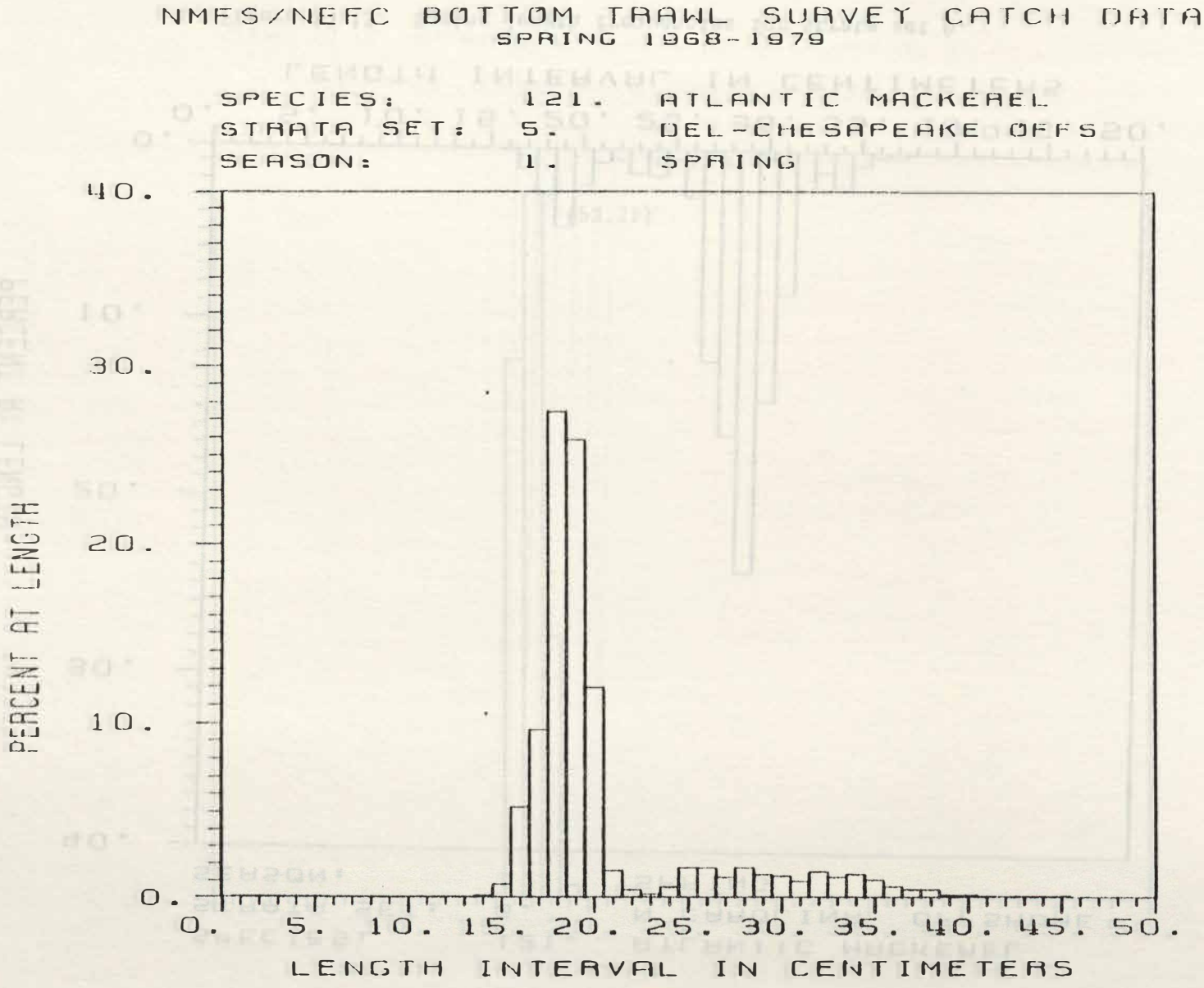


Figure 10.12. Spring length frequencies for strata set 5.

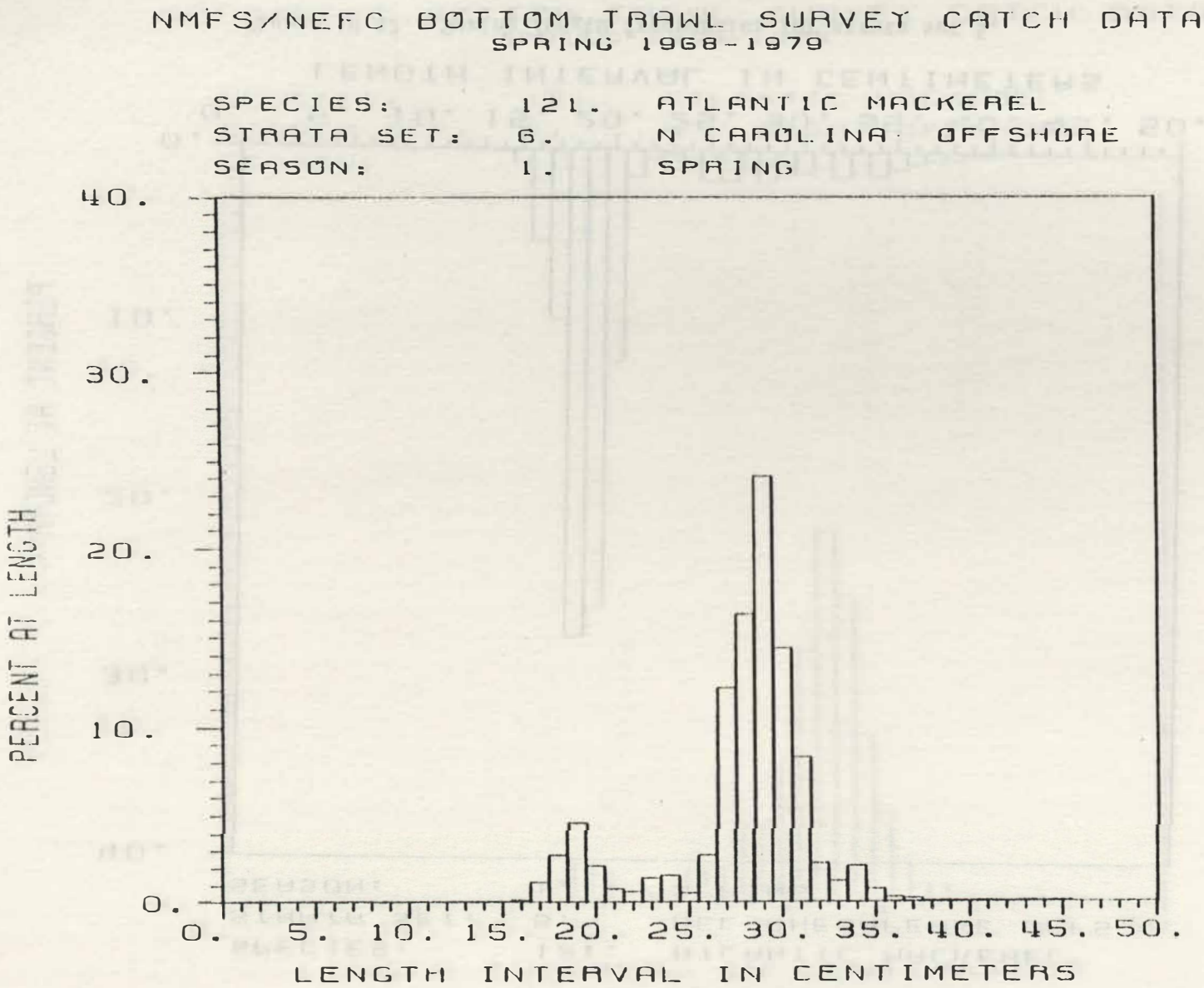


Figure 10.13. Spring length frequencies for strata set 6.

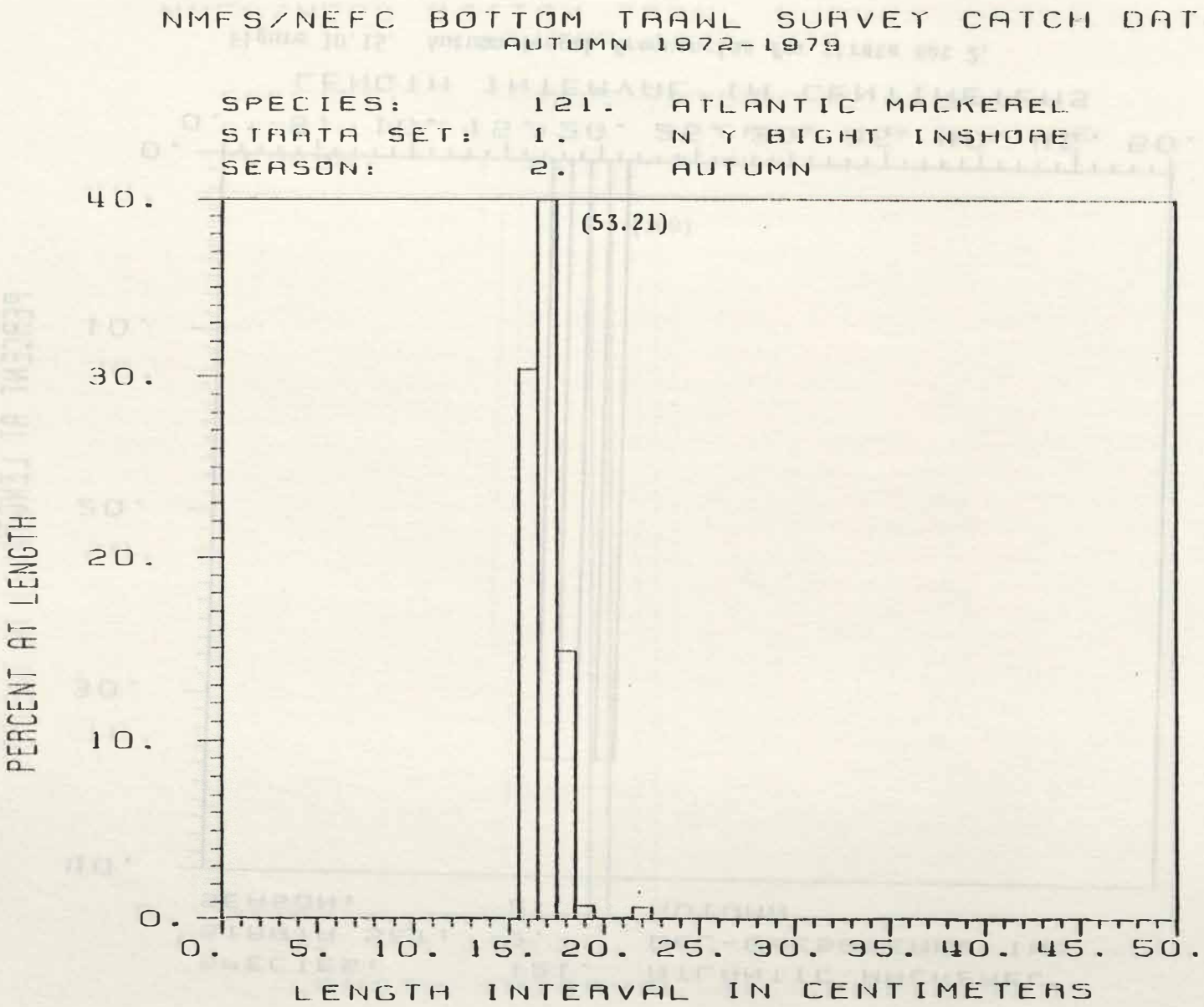


Figure 10.14. Autumn length frequencies for strata set 1.

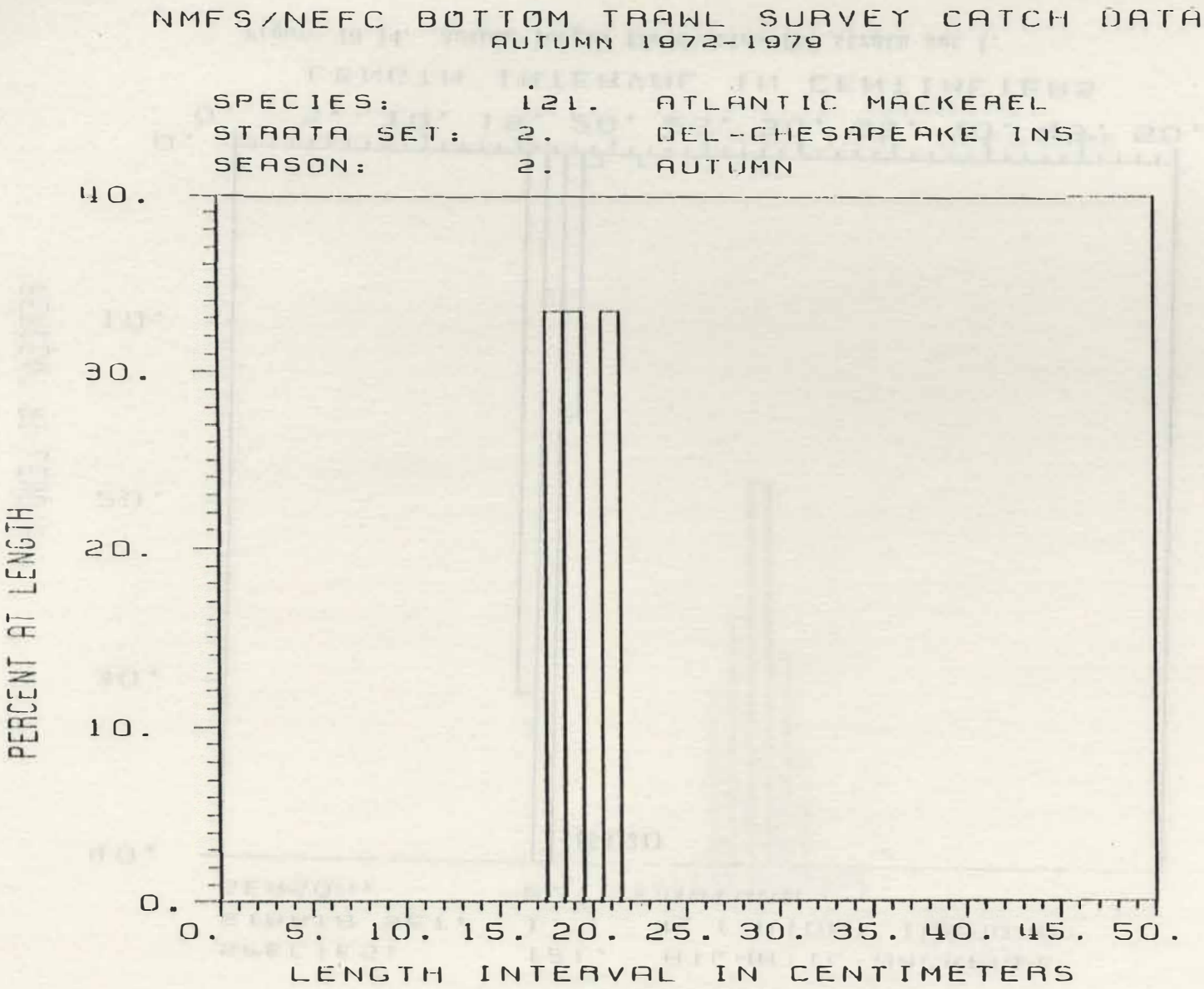


Figure 10.15. Autumn length frequencies for strata set 2.

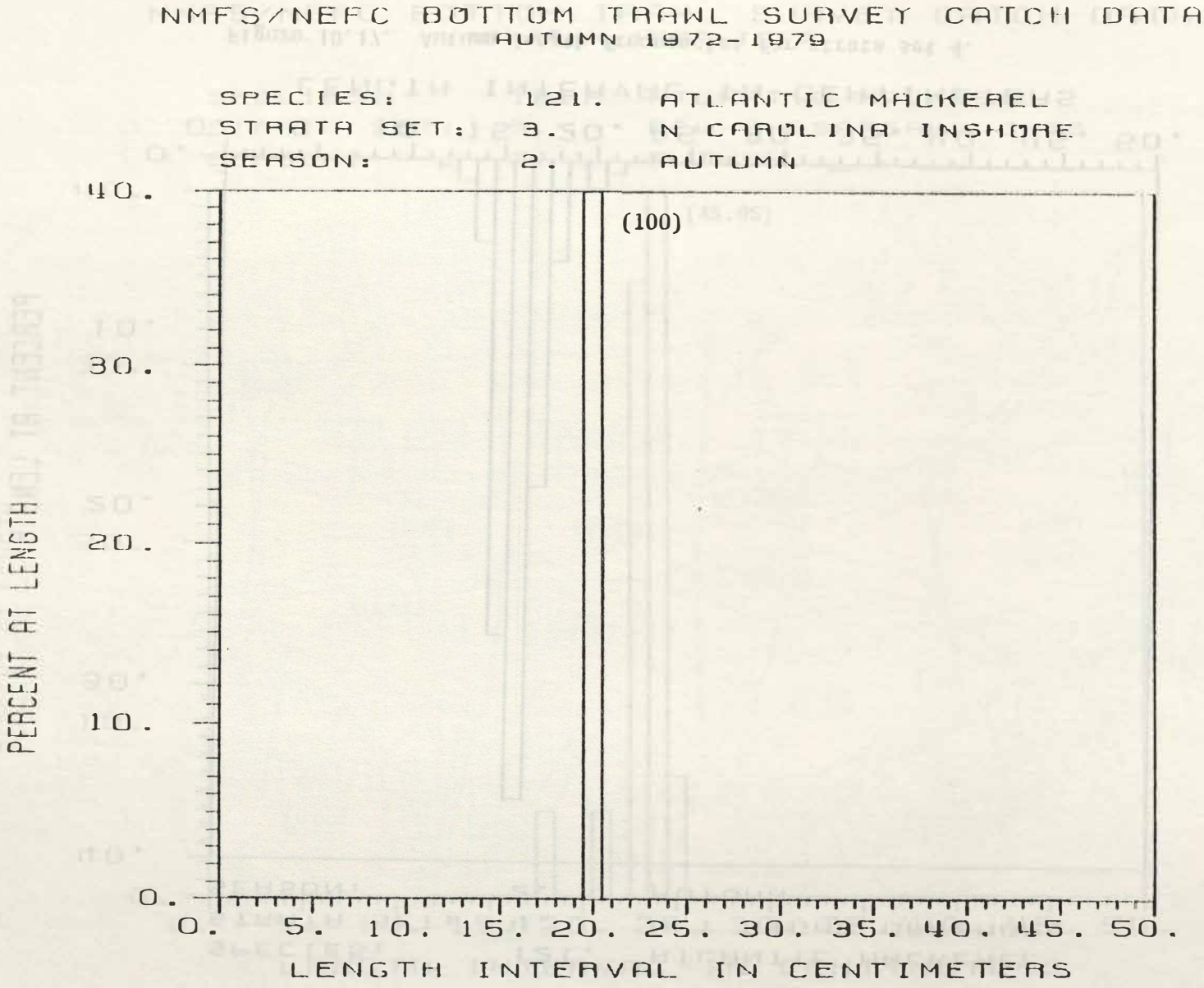


Figure 10.16. Autumn length frequencies for strata set 3.

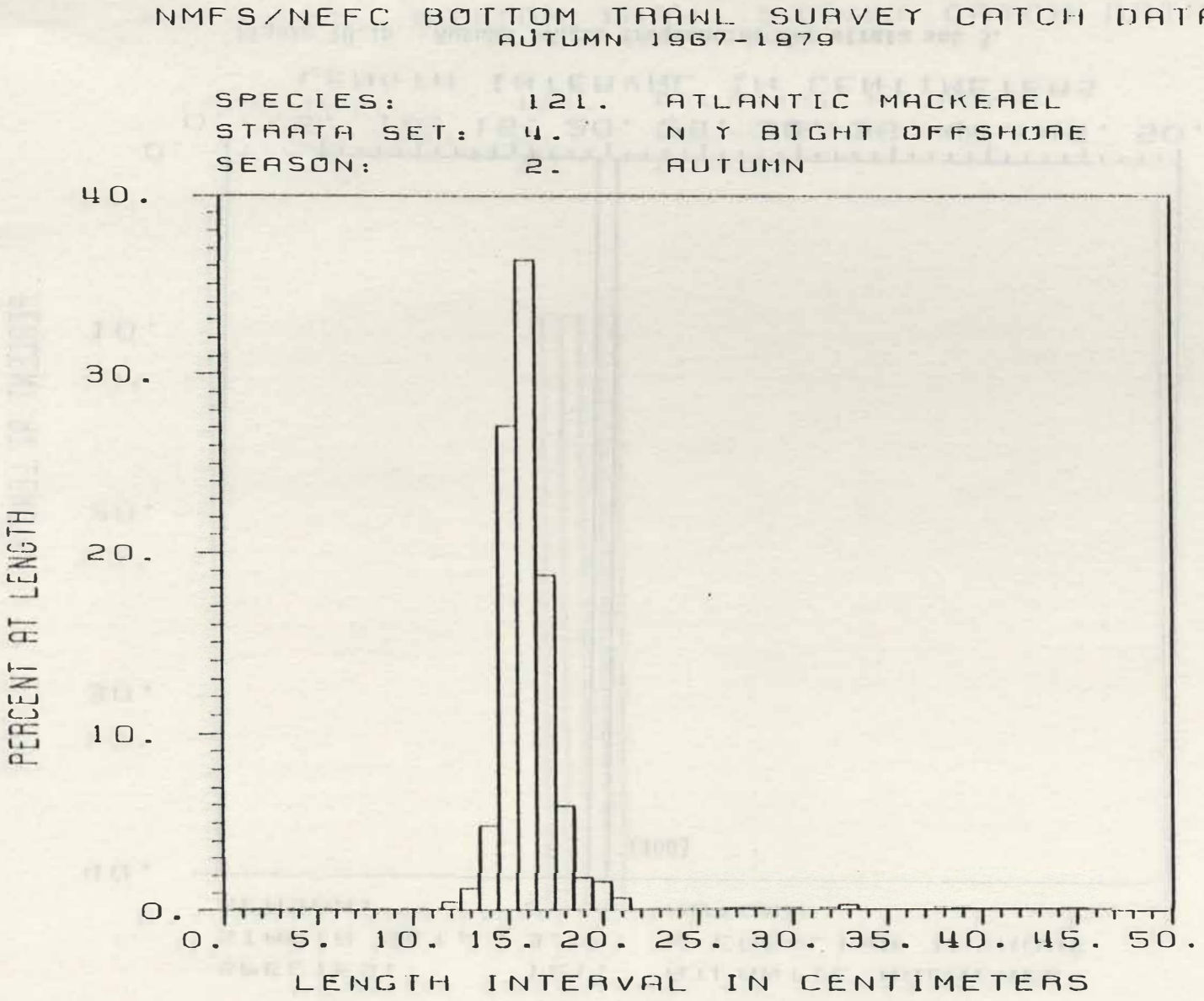


Figure 10.17. Autumn length frequencies for strata set 4.

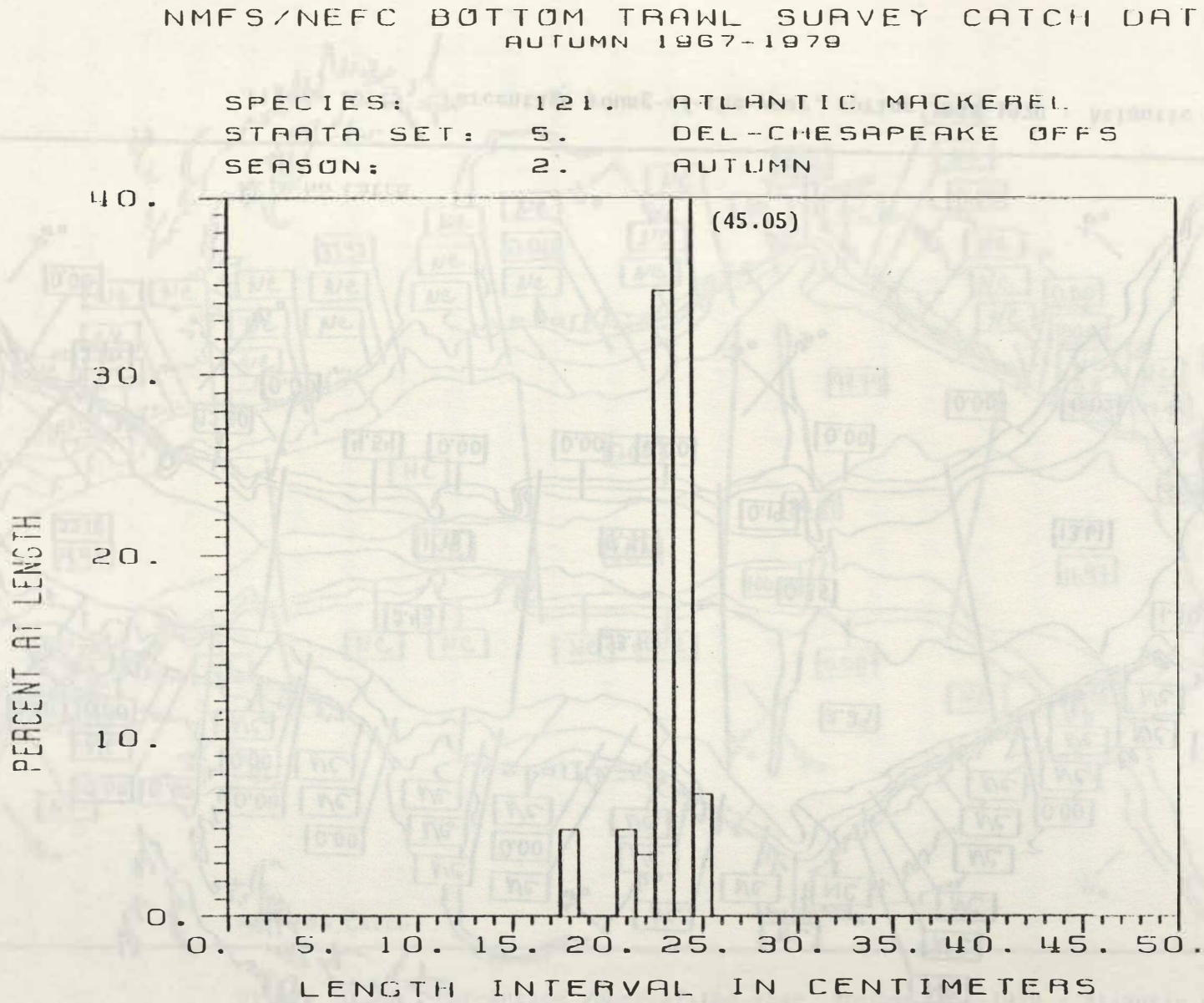


Figure 10.18. Autumn length frequencies for strata set 5.

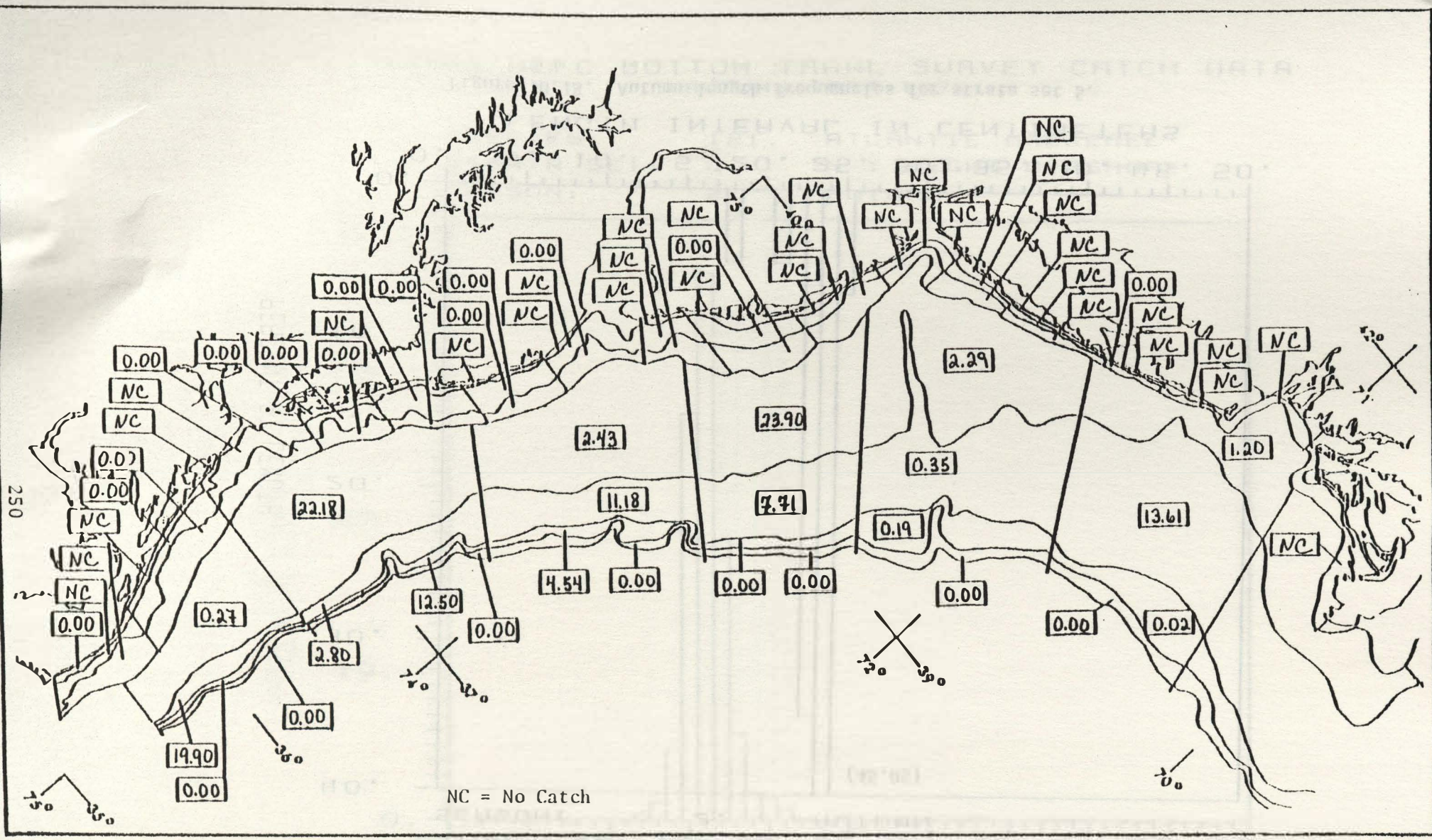


Figure 10.19. Percentage young-of-the-year, spring 1968-1979 - Atlantic mackerel.

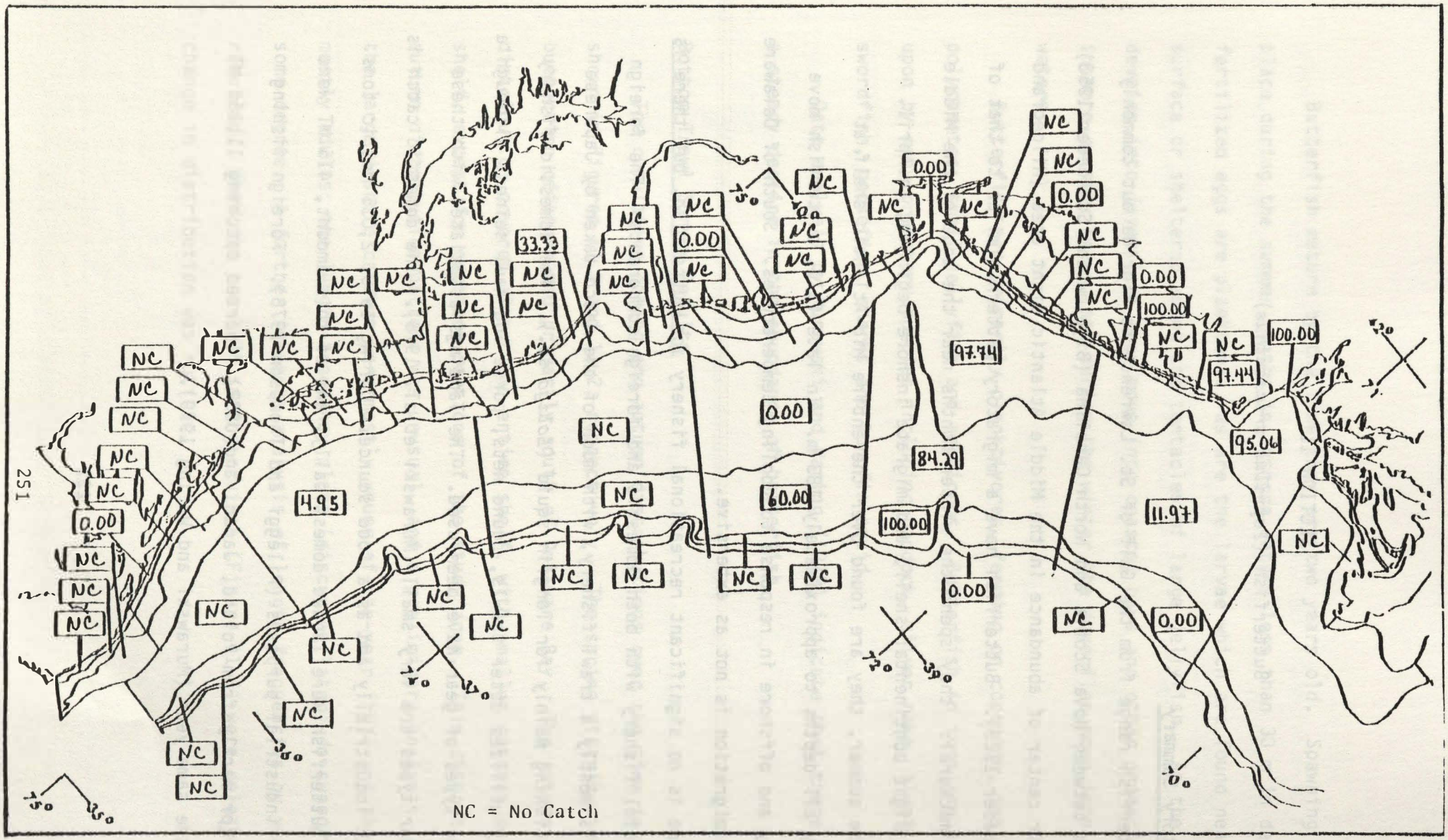


Figure 10.20. Percentage young-of-the-year, autumn 1967-1979 - Atlantic mackerel.

SECTION 11

Butterfish (*Peprilus triacanthus*)

Life History Summary

Butterfish range from the Gulf of St. Lawrence to Florida but commonly are found between Nova Scotia and North Carolina (Bigelow and Schroeder 1953) with their center of abundance in the Middle Atlantic Bight area (Hildebrand and Schroeder 1928). Butterfish have a migratory pattern similar to that of Atlantic mackerel: they spend the winter months near the edge of the Middle Atlantic Bight continental shelf, and migrate inshore beginning in April. During the summer, they are found over the entire Mid-Atlantic shelf at virtually all depths to approximately 183 m. In late fall, butterfish move southerly and offshore in response to cooling temperatures. South of Delaware Bay, the migration is not as extensive.

There is no significant recreational fishery for butterfish, but there is a commercial fishery with both domestic and foreign components. The foreign fishery is mostly a trawl fishery, with much of the catch taken by Japanese vessels fishing mainly for longfin squid (*Loligo* sp.). The domestic fishery primarily utilizes otter trawls, pound nets, purse and haul seines, although a few other types of gear have been used. The landings associated with these other gear types are very small (Murawski et al. 1978). The domestic catch is used both industrially and as a food source. During 1975, 2,035 metric tons (MT) of butterfish were landed domestically, and of this amount, 416 MT were used for industrial purposes (Pileggi and Thompson 1978). Foreign fishing vessels (primarily from Poland, Japan, and USSR) reported catching 11,166 MT during the same year (Murawski and Waring 1979).

Butterfish mature by the time they are two years old. Spawning takes place during the summer months in inshore waters less than 30 m in depth. The fertilized eggs are planktonic, as are the larvae which are found near the surface or sheltered among the tentacles of large jellyfish. As the larvae develop into juveniles, they move into coastal bays and other protected inshore nursery areas, and during the winter the juveniles move into deeper waters.

Butterfish are primarily planktivores, feeding on copepods, small fishes, polychaetes, small jellyfish and amphipods. Butterfish in turn are preyed upon by many predatory species including haddock, silver hake, bluefish, swordfish, goosefish, sharks and longfin squid.

Data analysis by Murawski and Waring (1979) indicate that there has been a steady decline in the abundance of butterfish.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 11.1 and 11.2, respectively. The spring distribution shows butterfish offshore and primarily south of Delaware Bay. The autumn distribution covered almost the entire shelf, with smaller catches on the mid-shelf, except for northern portions of the study area. This discontinuous autumn distribution pattern was unusual, and a preliminary analysis indicates the large inshore catches were mostly young-of-the-year (YOY) and the offshore mostly adults; the length-frequency plots (discussed later) do support this to some degree. A further in-depth analysis of length frequencies by year is required. When the pre-1976 spring cruises (Figure 11.3) were deleted, little change in distribution was noticed.

Graphs of mean weight and number per tow (Figures 11.4-11.7) show a sharp increase during autumn 1978 and 1979 surveys. These increases may indicate a rebuilding of the Mid-Atlantic population.

Length frequencies for six strata sets, arranged by season, are shown in Figures 11.8-11.9. Smaller YOY and one-year-old fish dominated the inshore catches in the north in autumn (Figure 11.14); this is the only area where this pattern occurred. The lack of offshore YOY catches in southern areas during the autumn (Figures 11.18-11.19), may have been because the small fish were still in shallow coastal waters or the estuaries. The very small butterfish in inshore areas during the spring (Figures 11.9-11.10) may have been spawned early and were caught in the same season.

Figures 11.20 and 11.21 show the percentage occurrence by stratum of YOY; cutoff size was 13 cm. Two size groups of YOY can be seen in these figures. In the spring (Figure 11.20) the northern areas contained YOY from last summer's spawning, these fish were approaching 13 cm; in the south the fish were around 5 cm and were products of a late winter-early spring spawn which were captured during the same year.

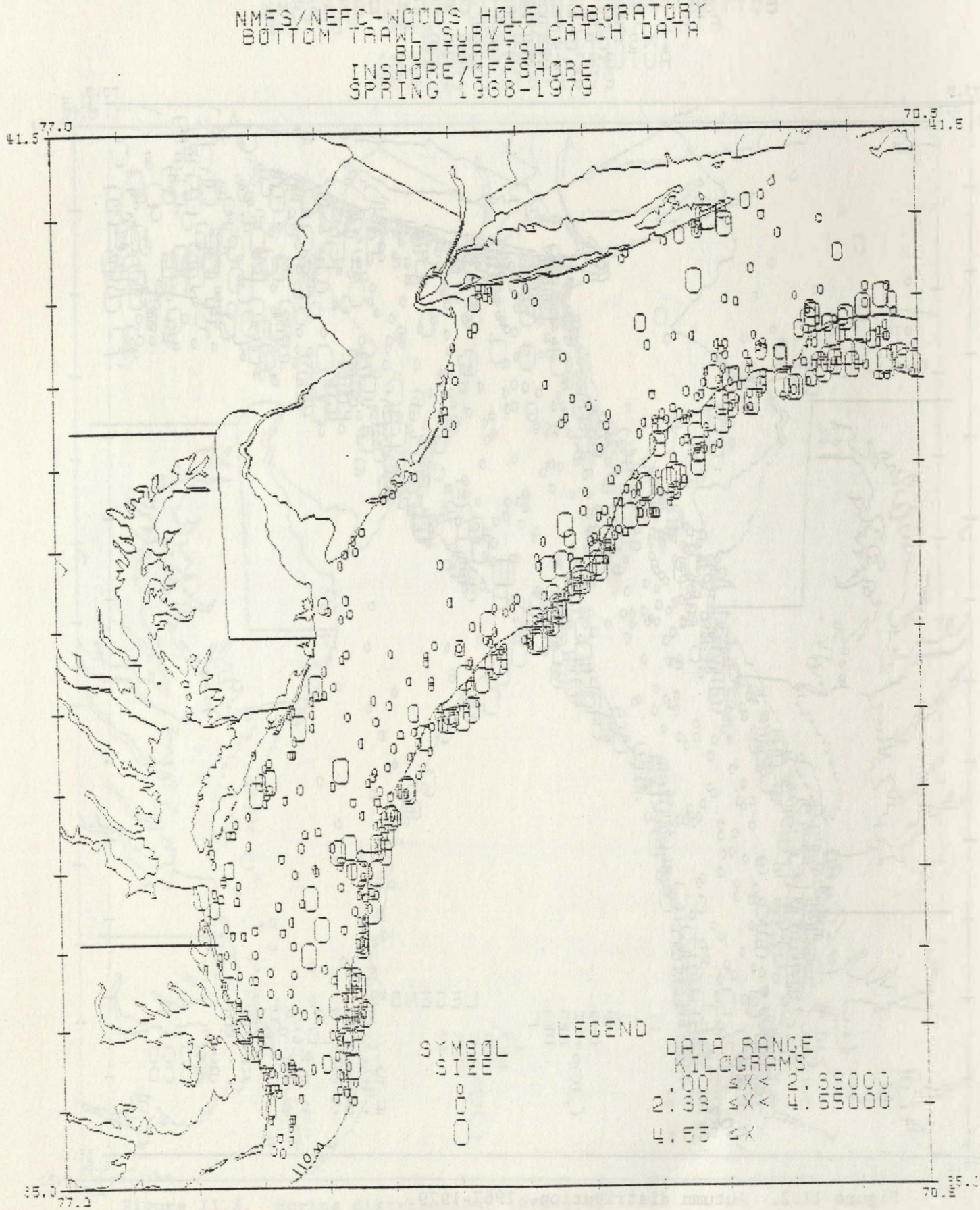


Figure 11.1. Spring distribution, 1968-1979.

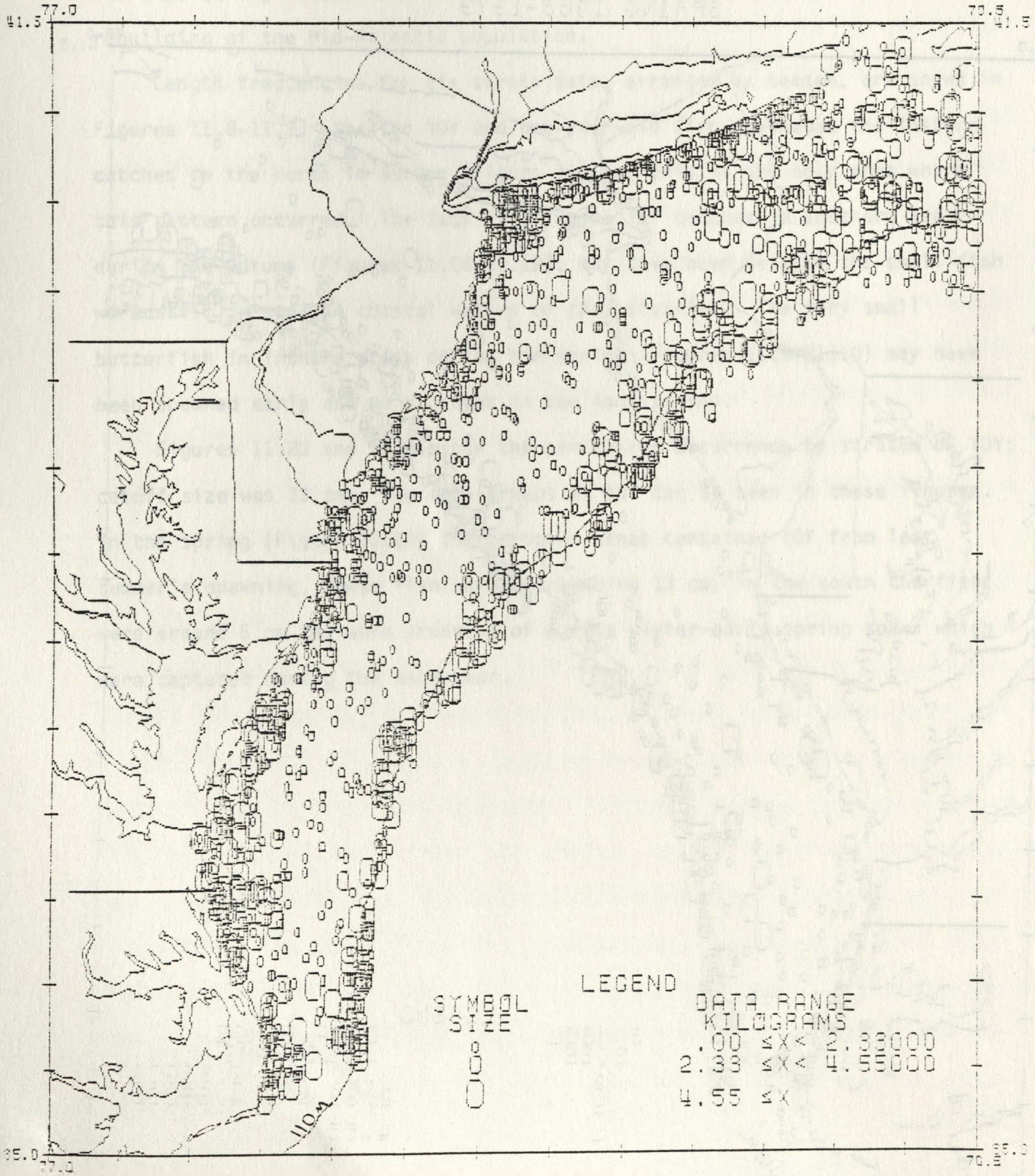


Figure 11.2. Autumn distribution, 1967-1979.

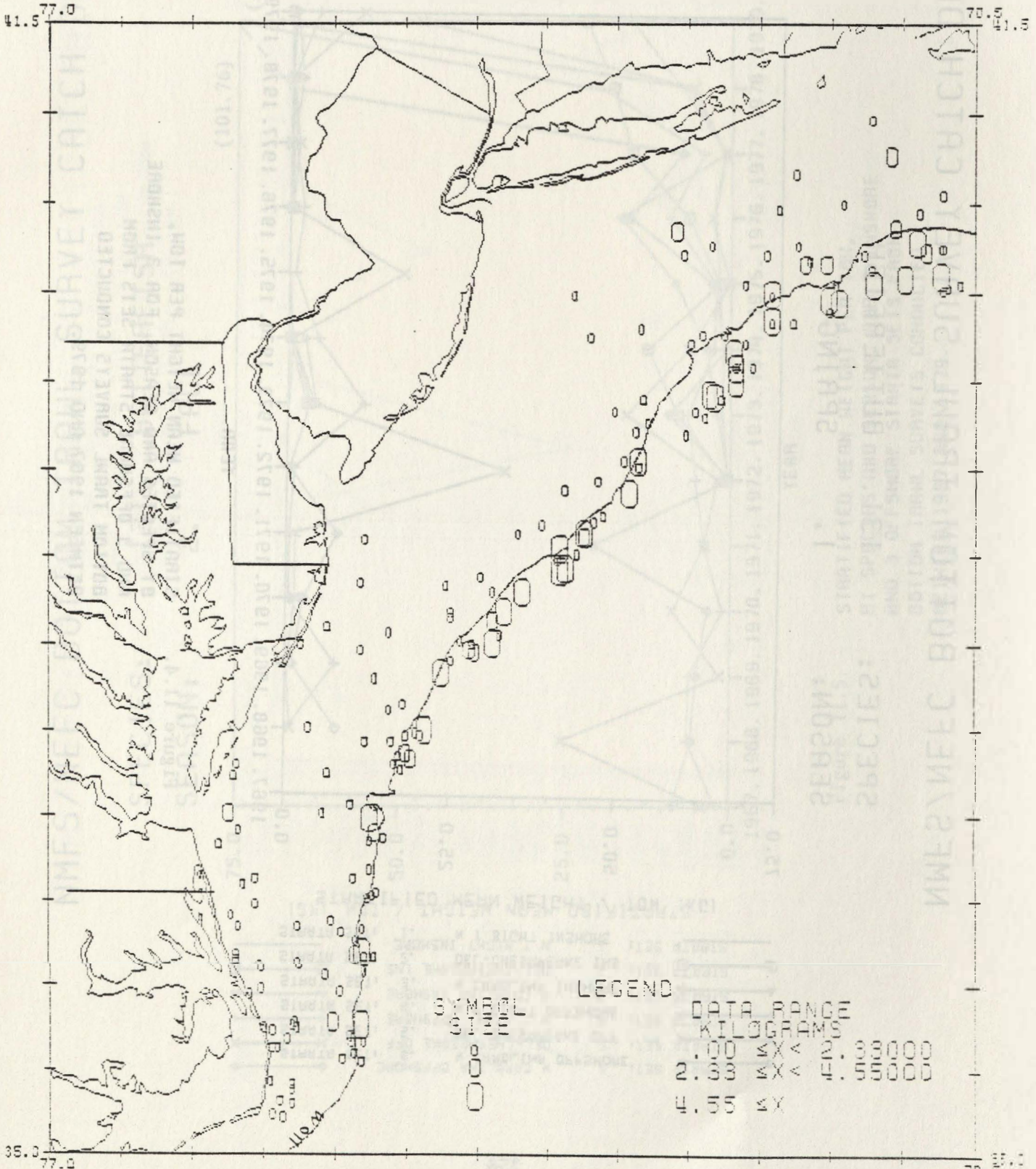


Figure 11.3. Spring distribution, 1976-1979.

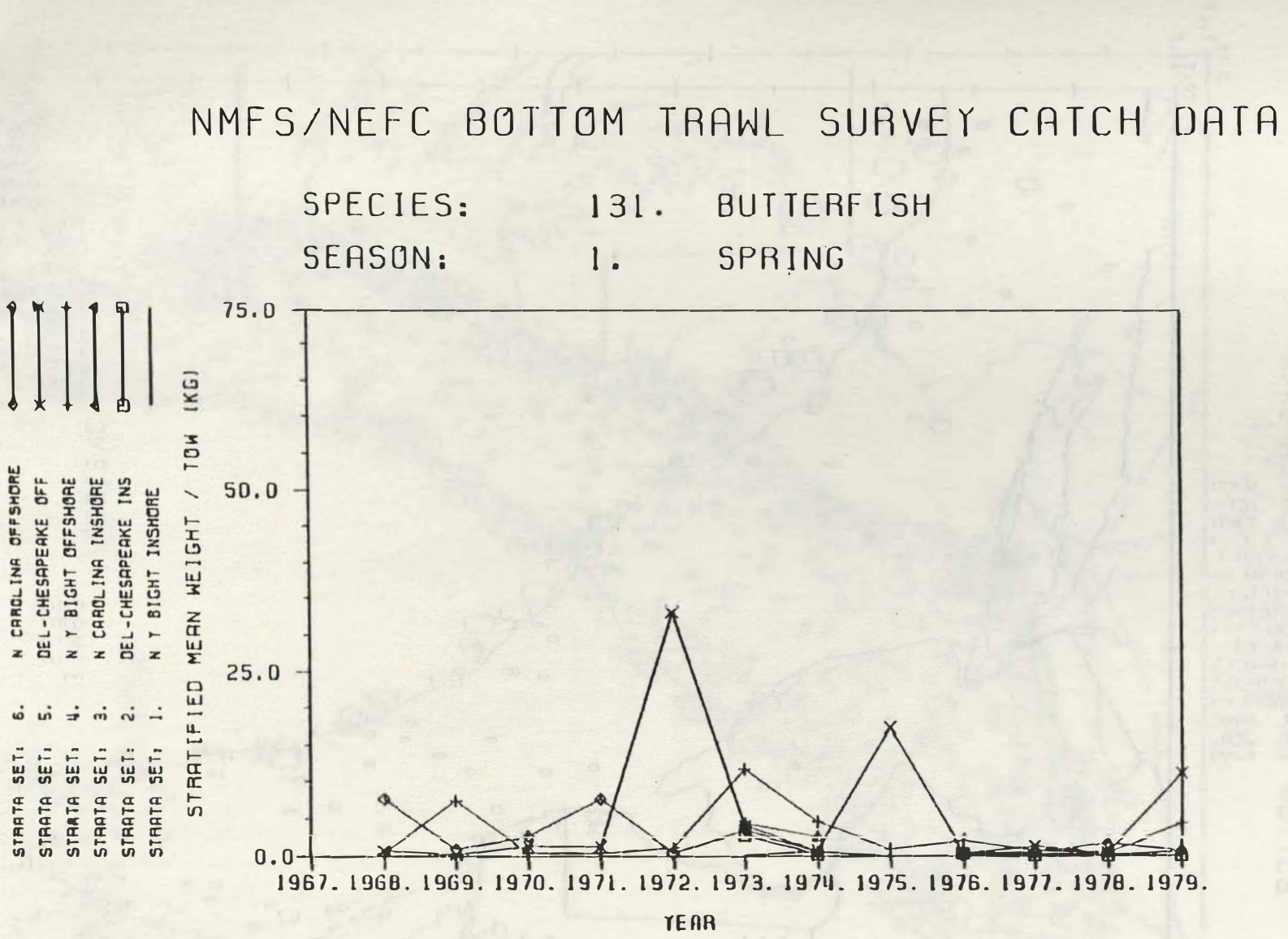


Figure 11.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

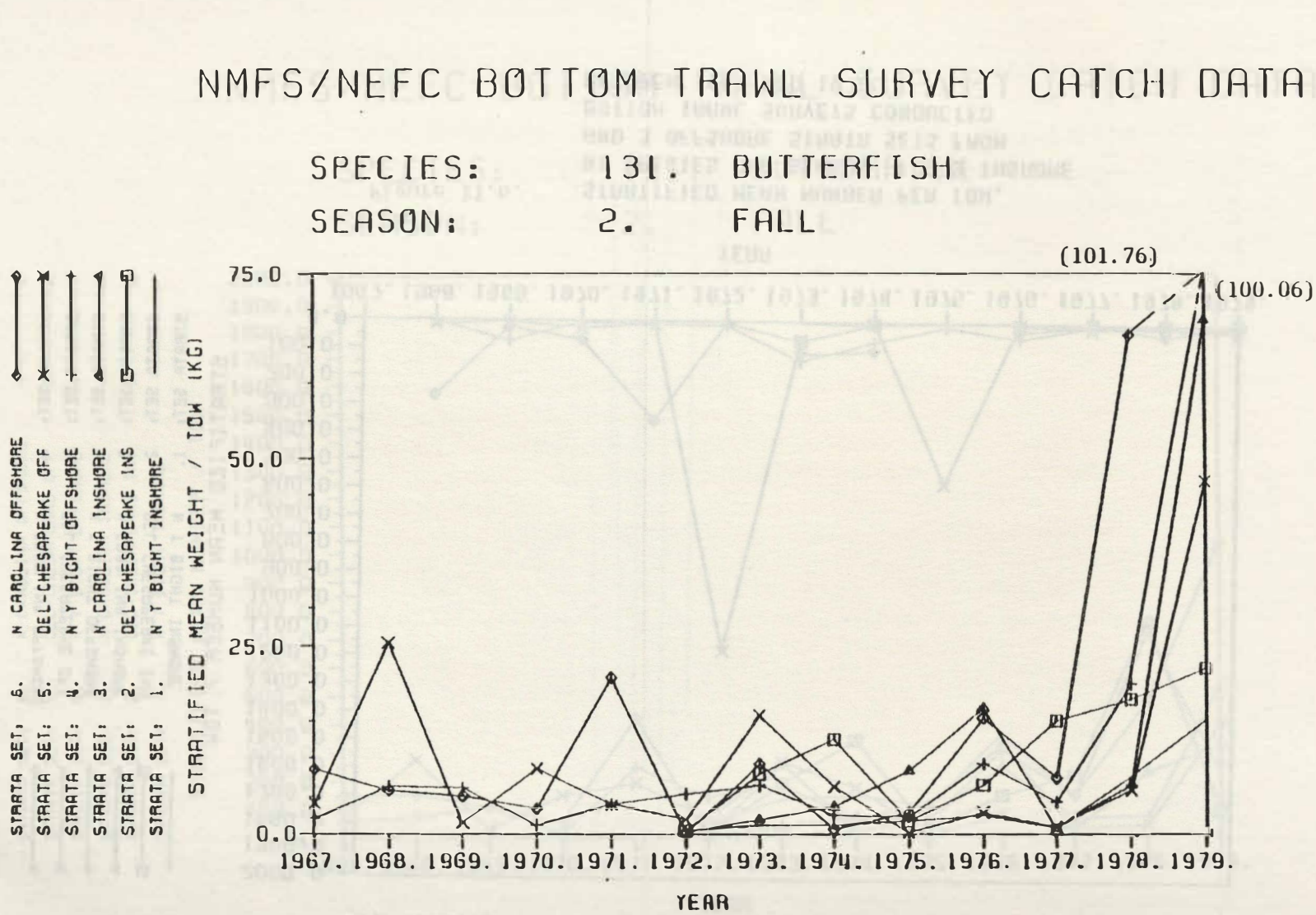


Figure 11.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

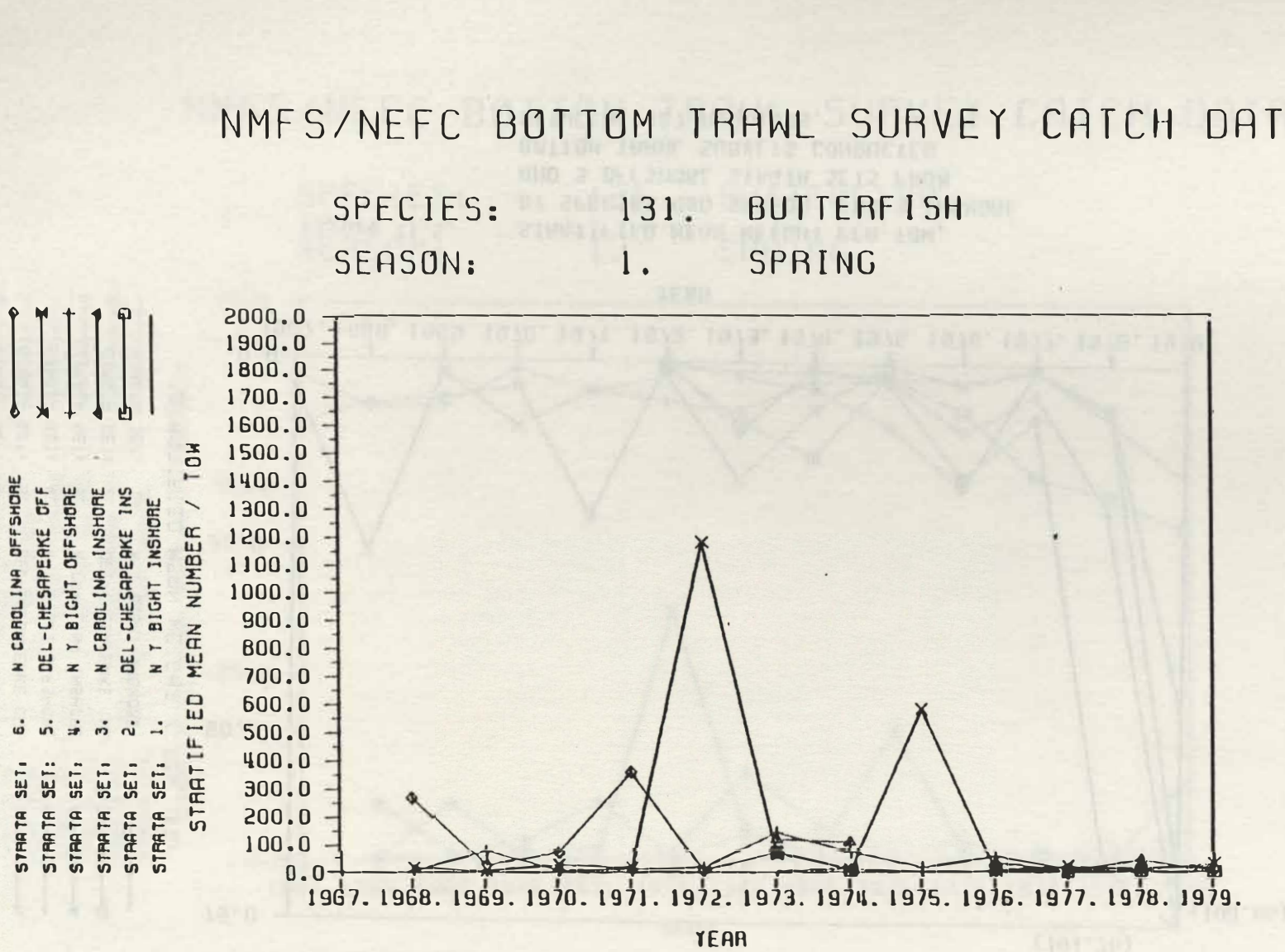


Figure 11.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

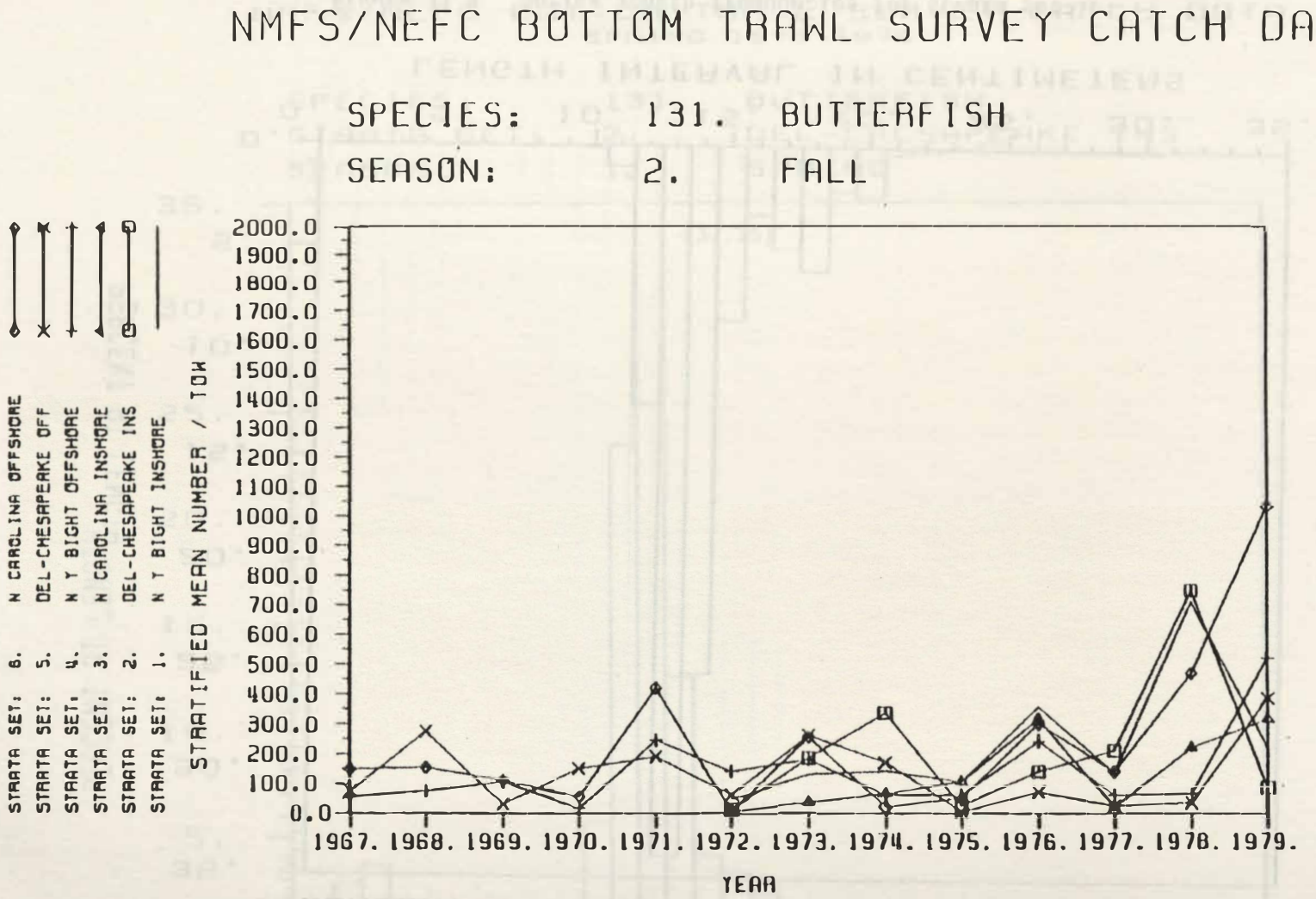


Figure 11.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

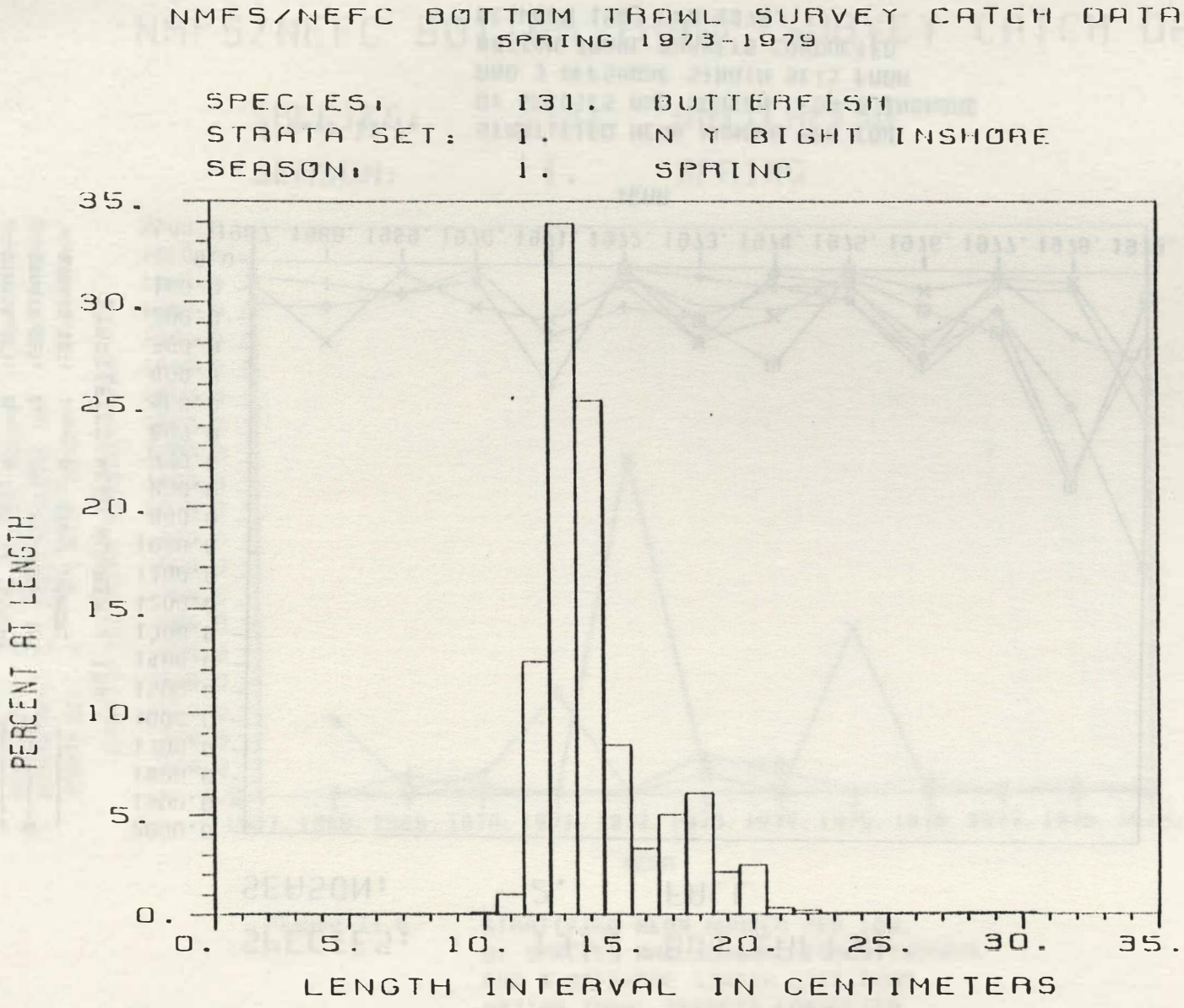


Figure 11.8. Spring length frequencies for strata set 1.

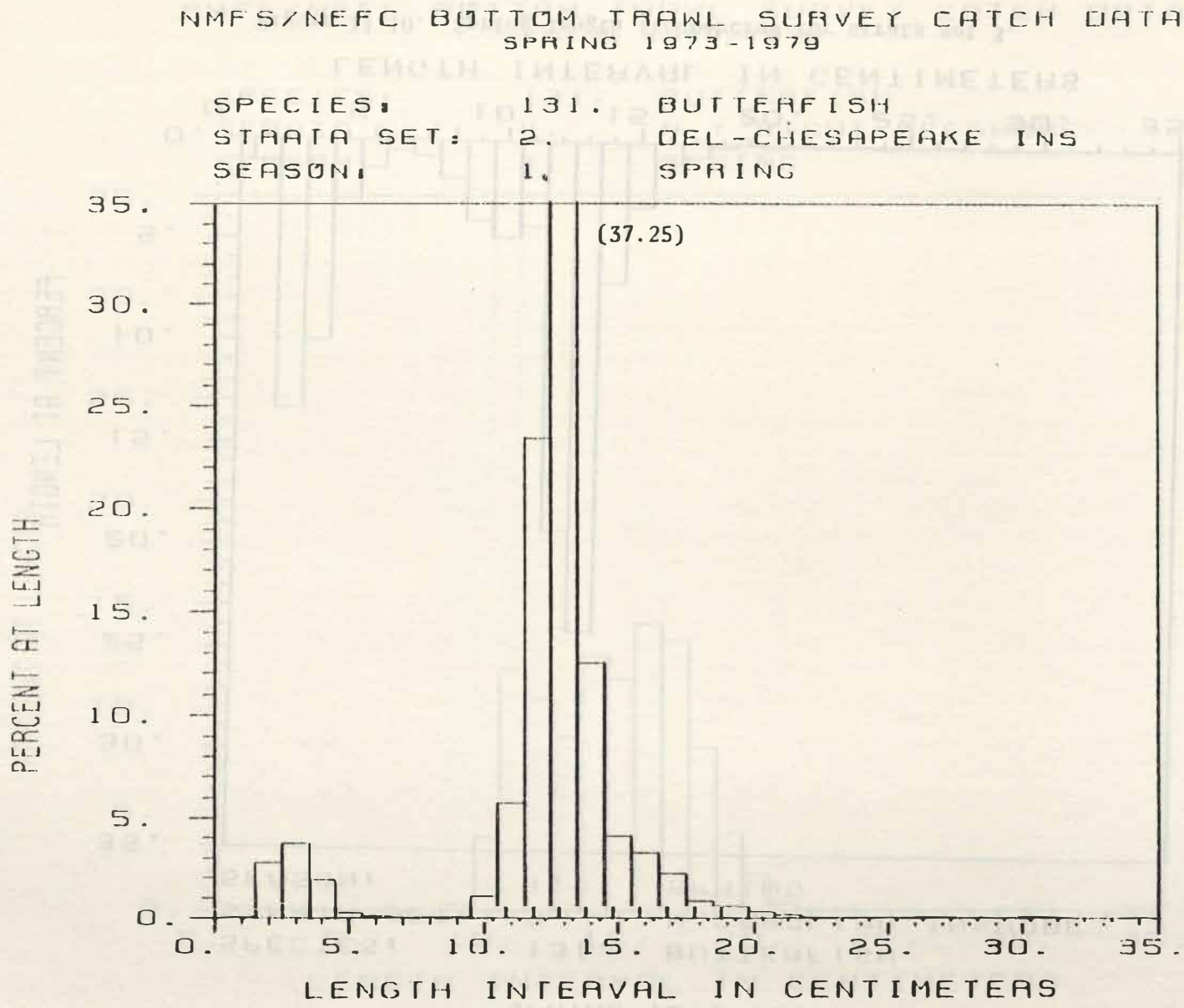


Figure 11.9. Spring length frequencies for strata set 2.

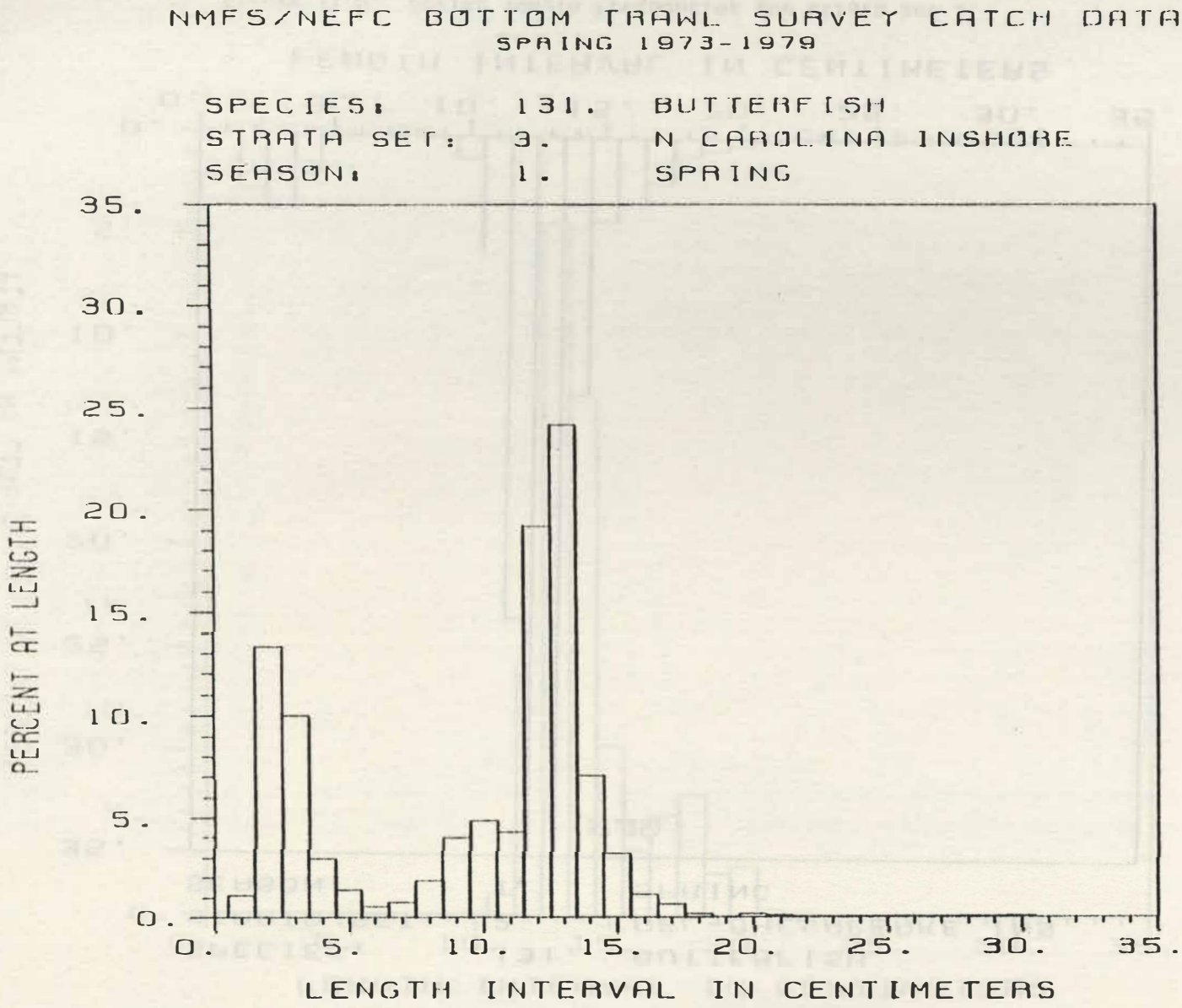


Figure 11.10. Spring length frequencies for strata set 3.

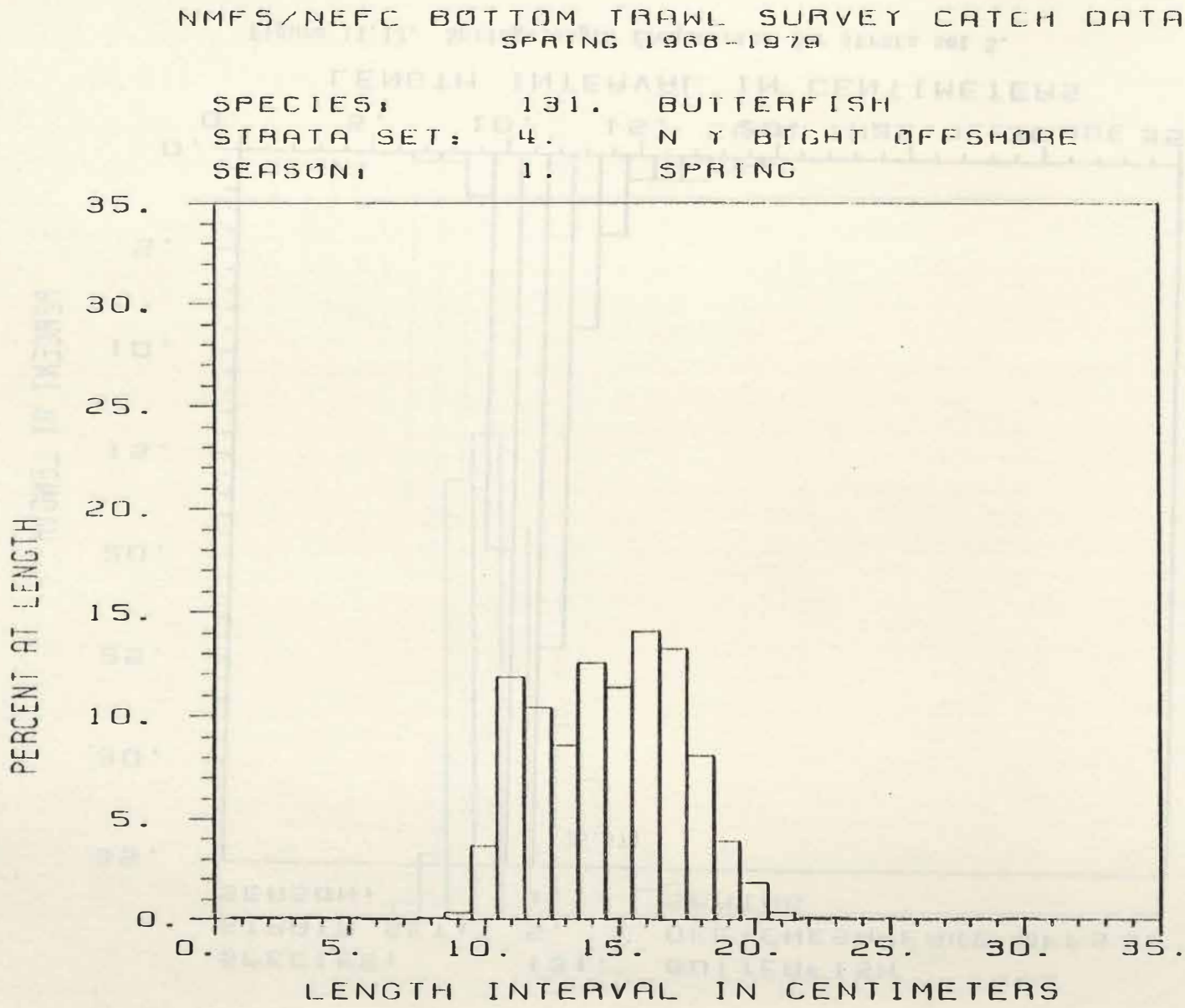


Figure 11.11. Spring length frequencies for strata set 4.

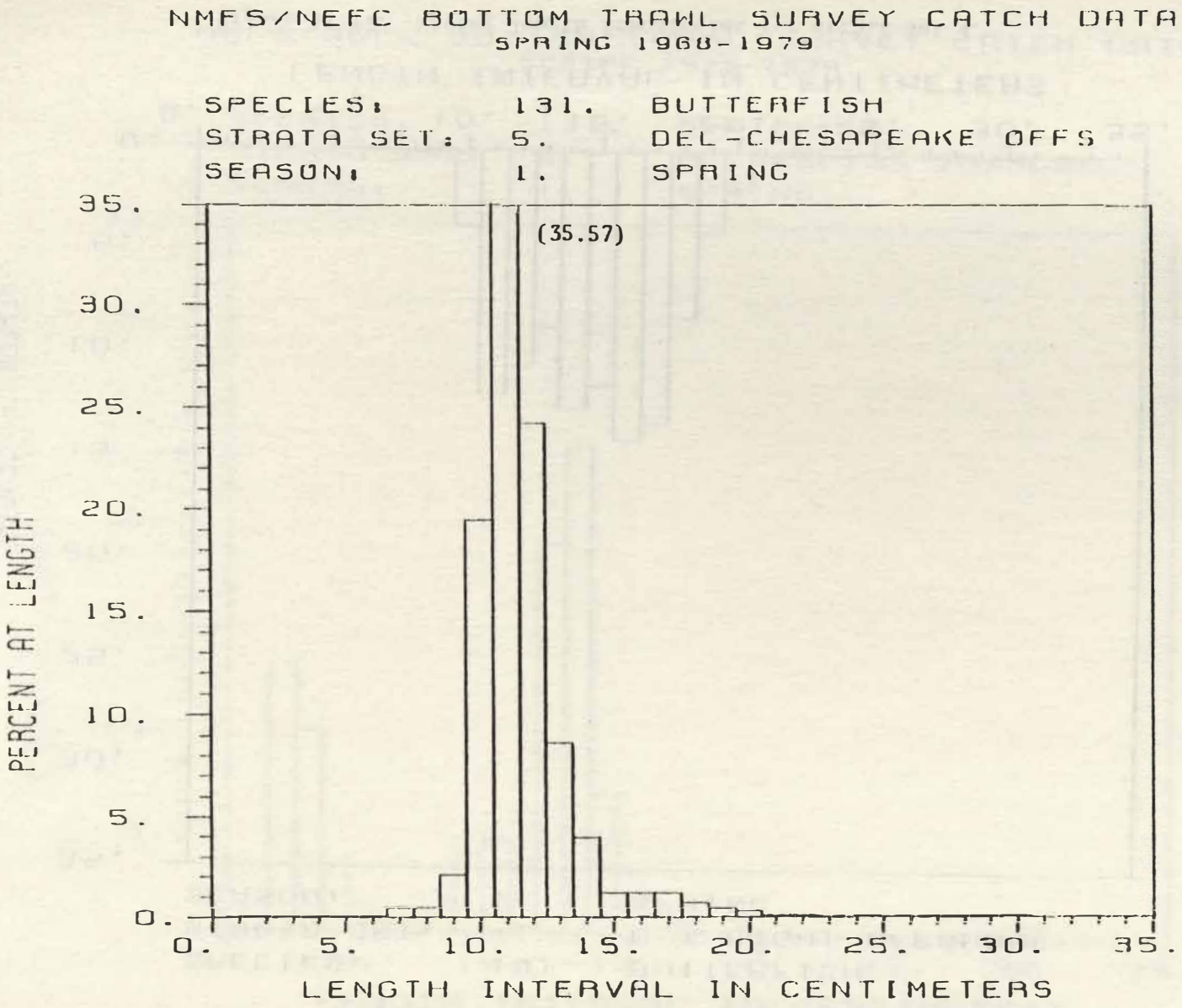


Figure 11.12. Spring length frequencies for strata set 5.

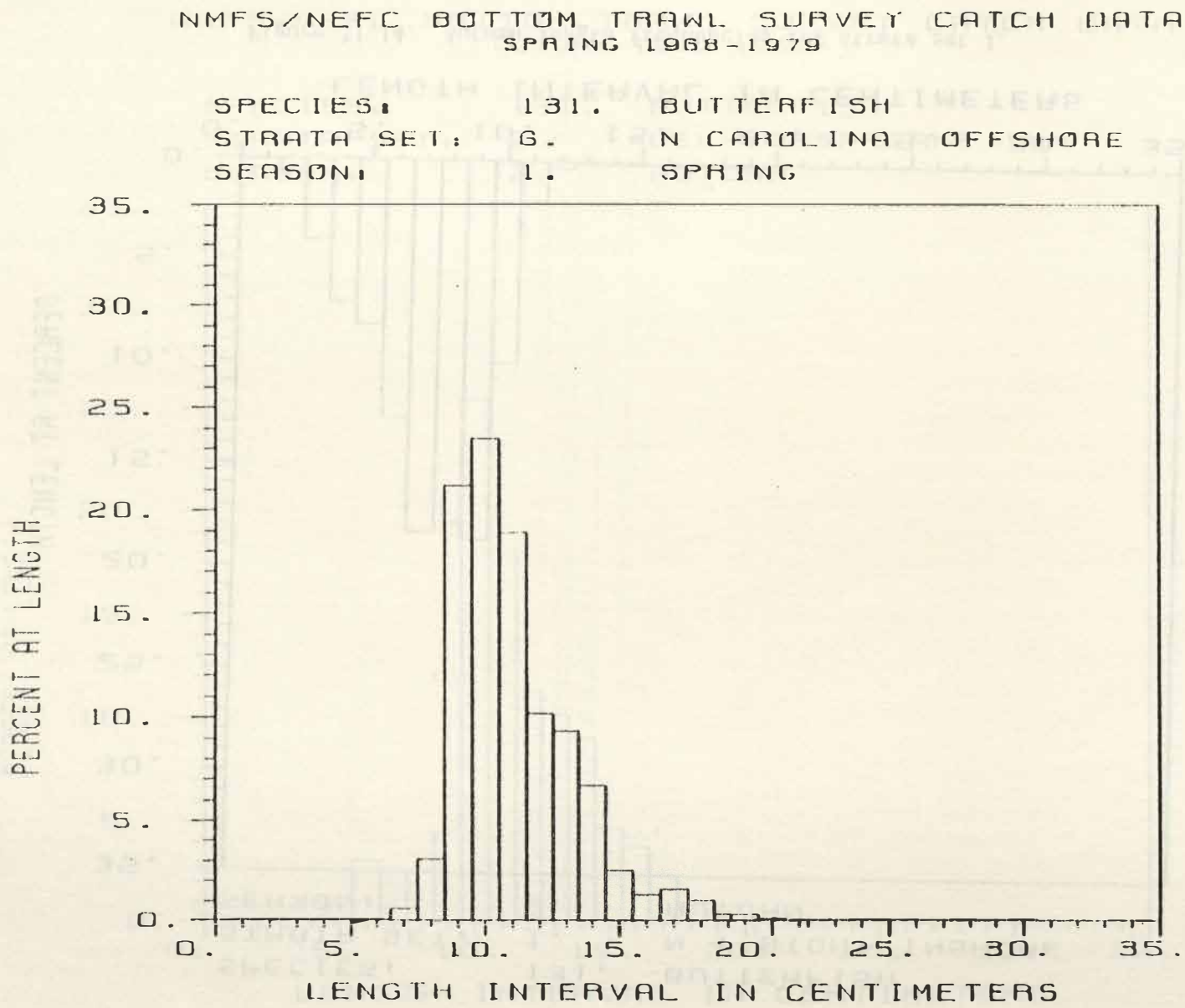


Figure 11.13. Spring length frequencies for strata set 6.

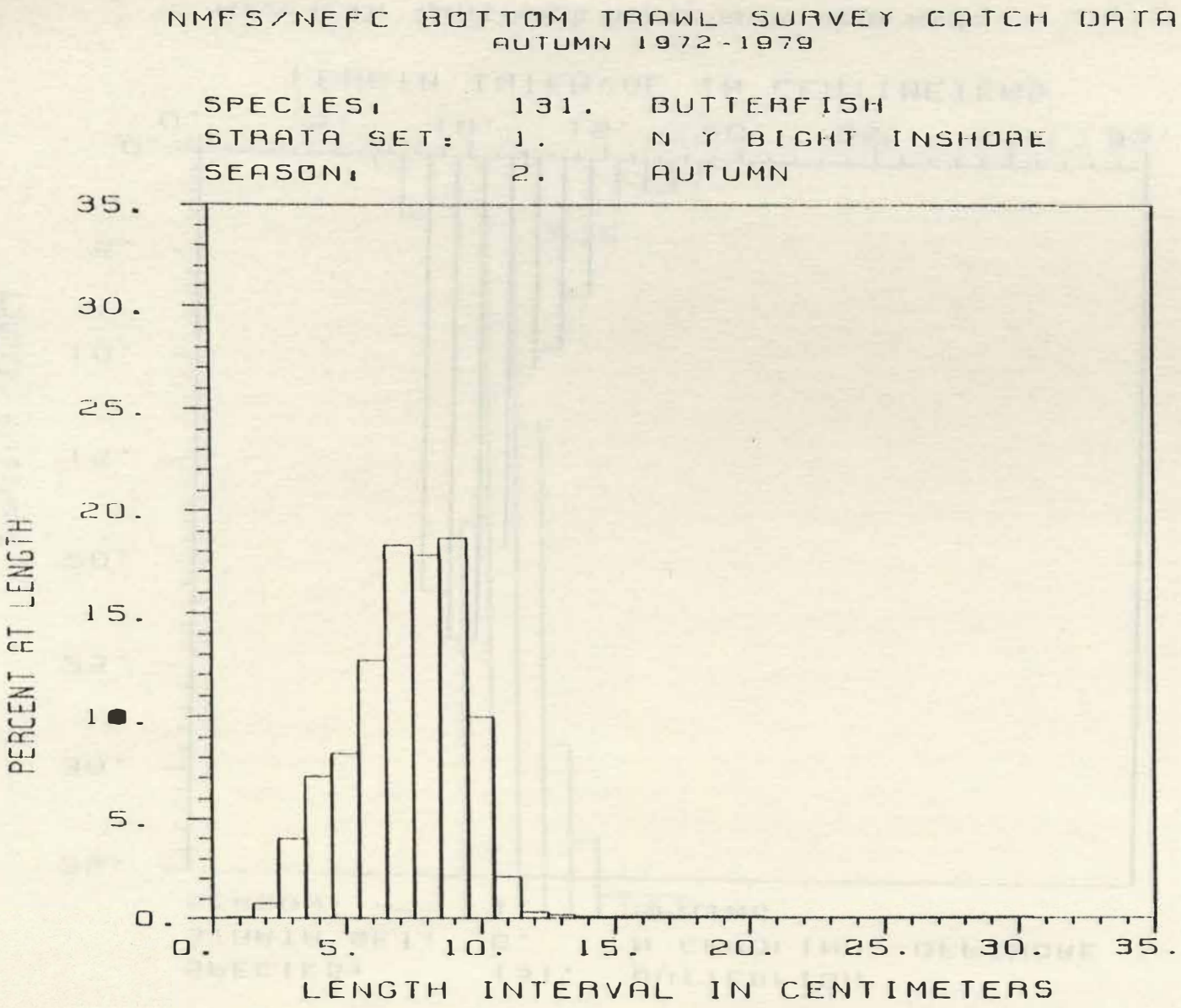


Figure 11.14. Autumn length frequencies for strata set 1.

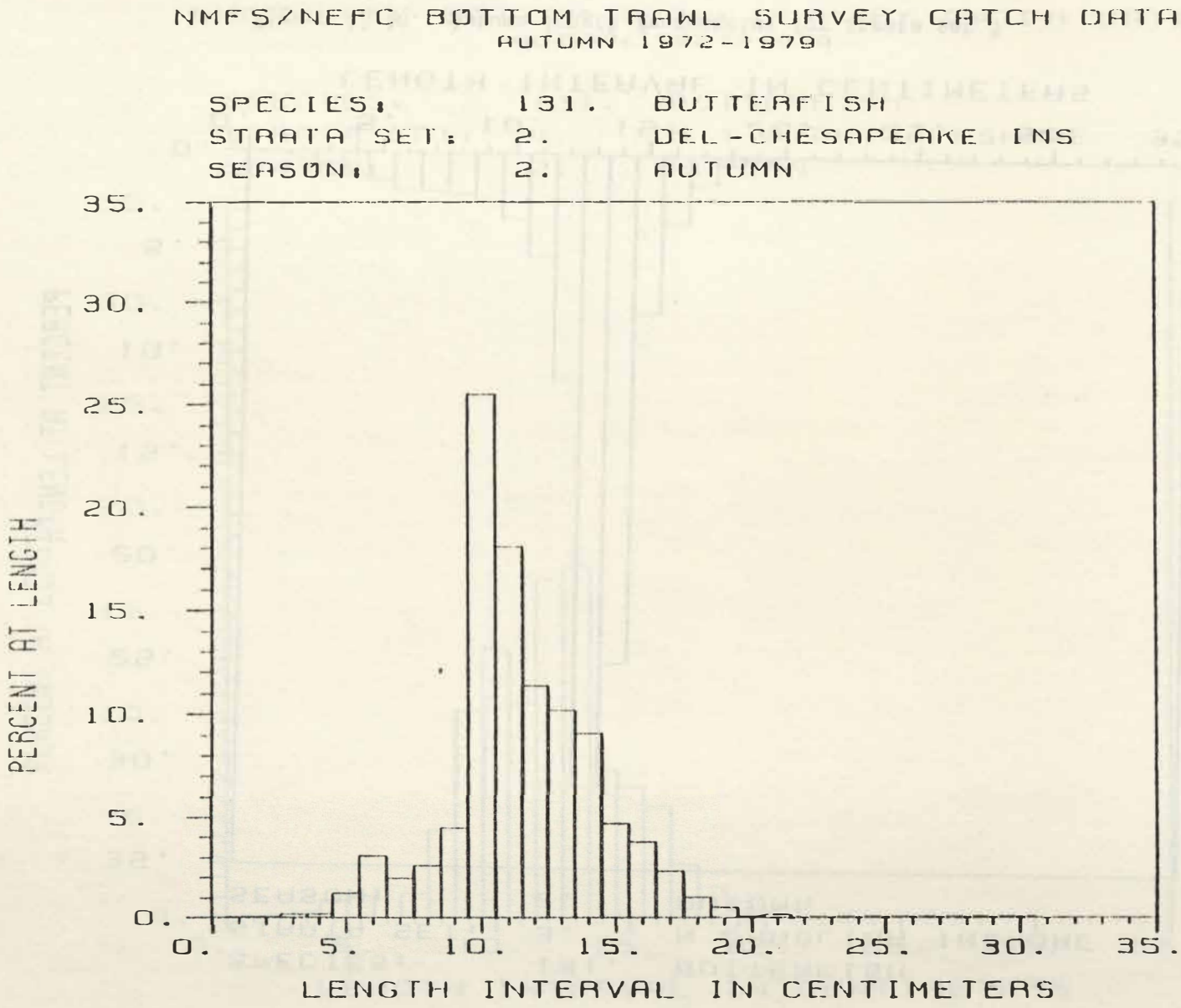


Figure 11.15. Autumn length frequencies for strata set 2.

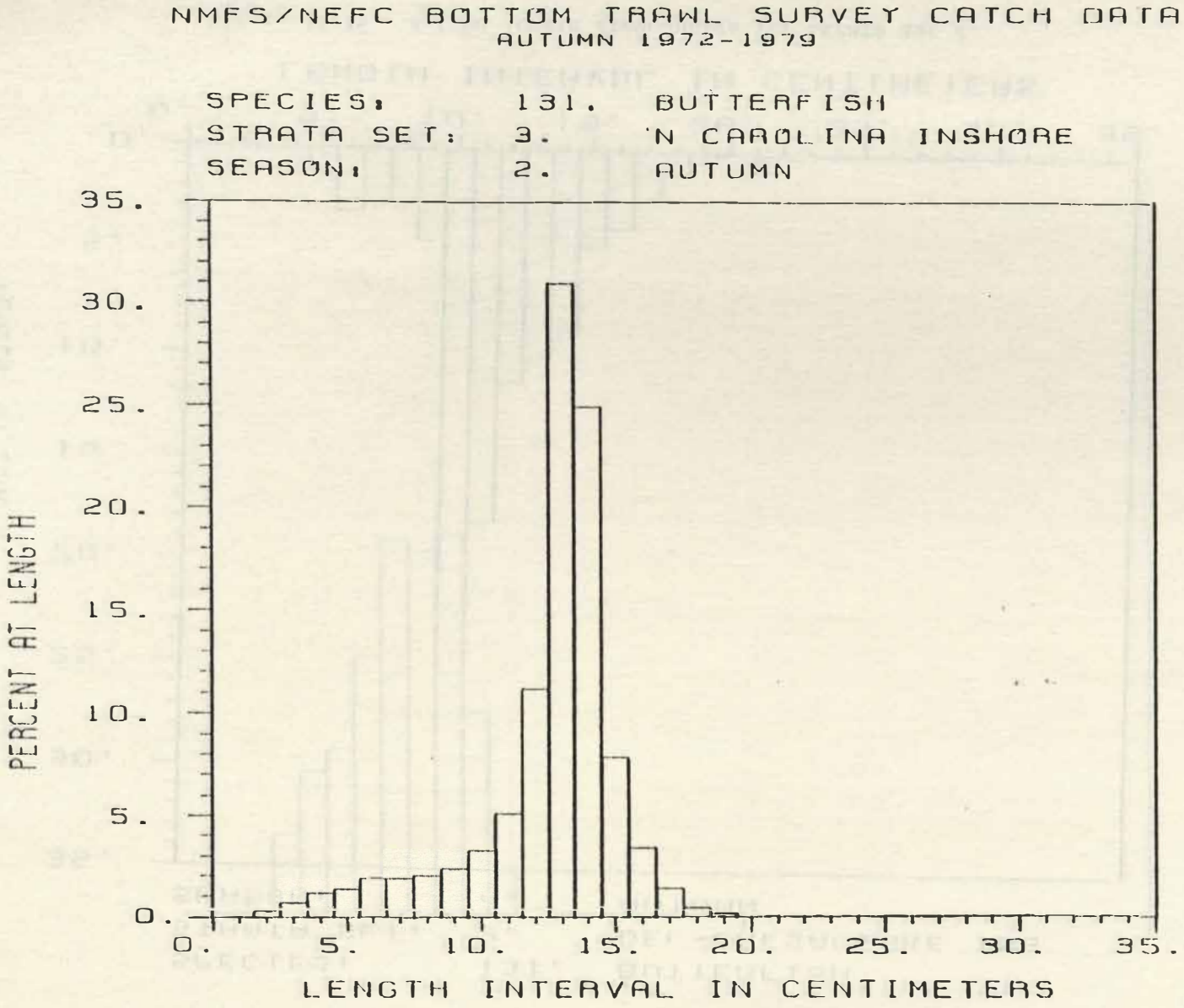


Figure 11.16. Autumn length frequencies for strata set 3.

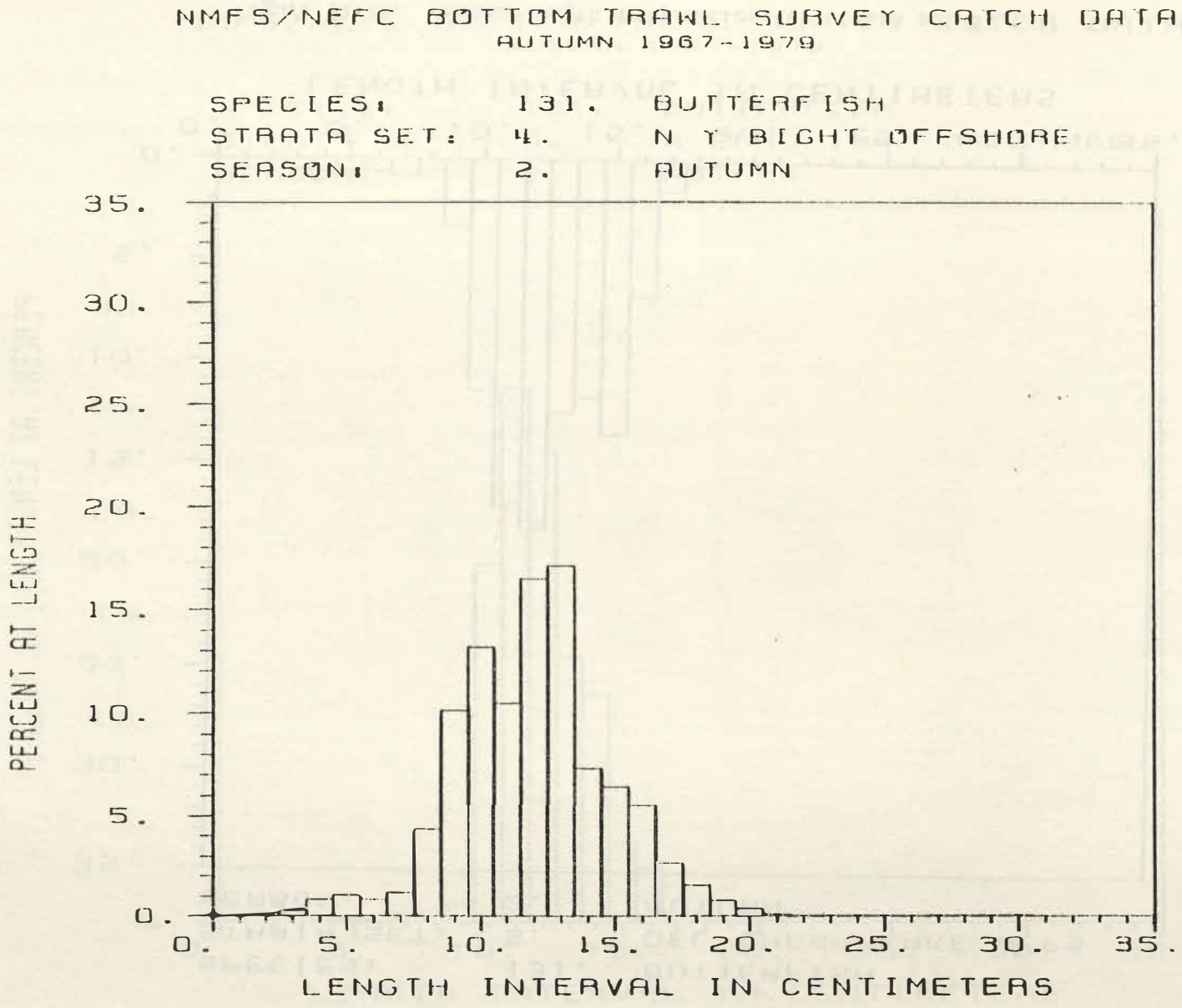


Figure 11.17. Autumn length frequencies for strata set 4.

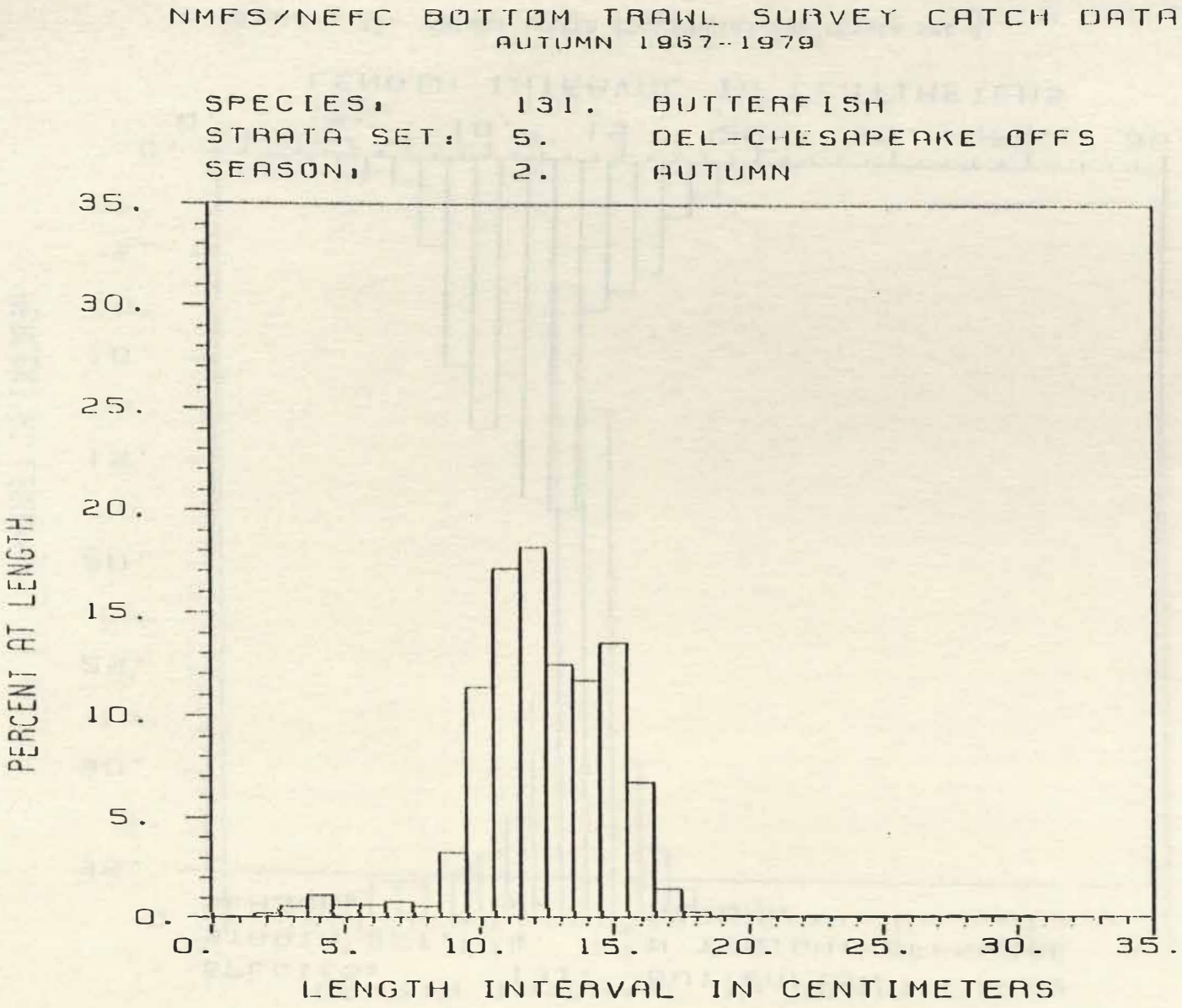


Figure 11.18. Autumn length frequencies for strata set 5.

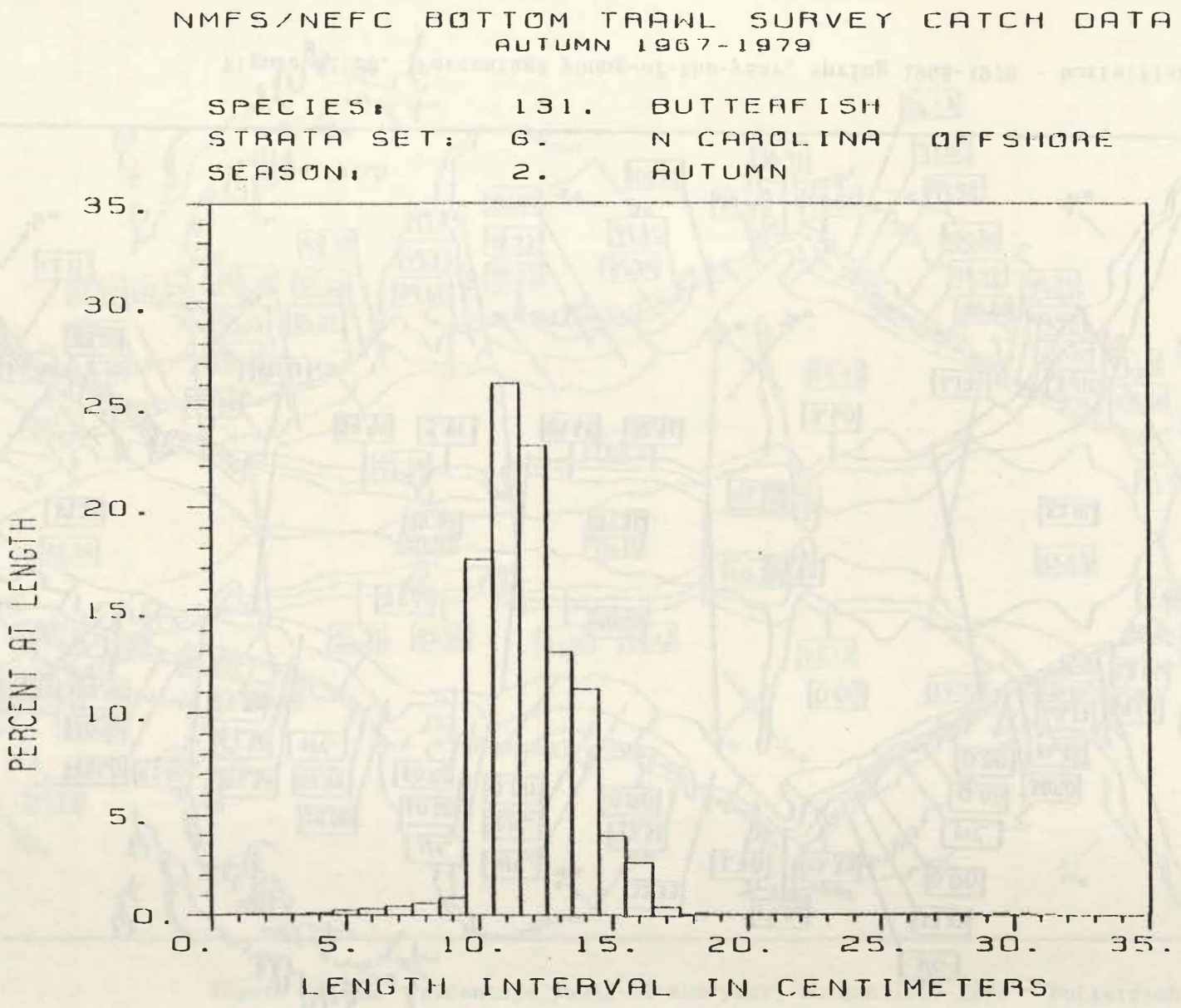


Figure 11.19. Autumn length frequencies for strata set 6.

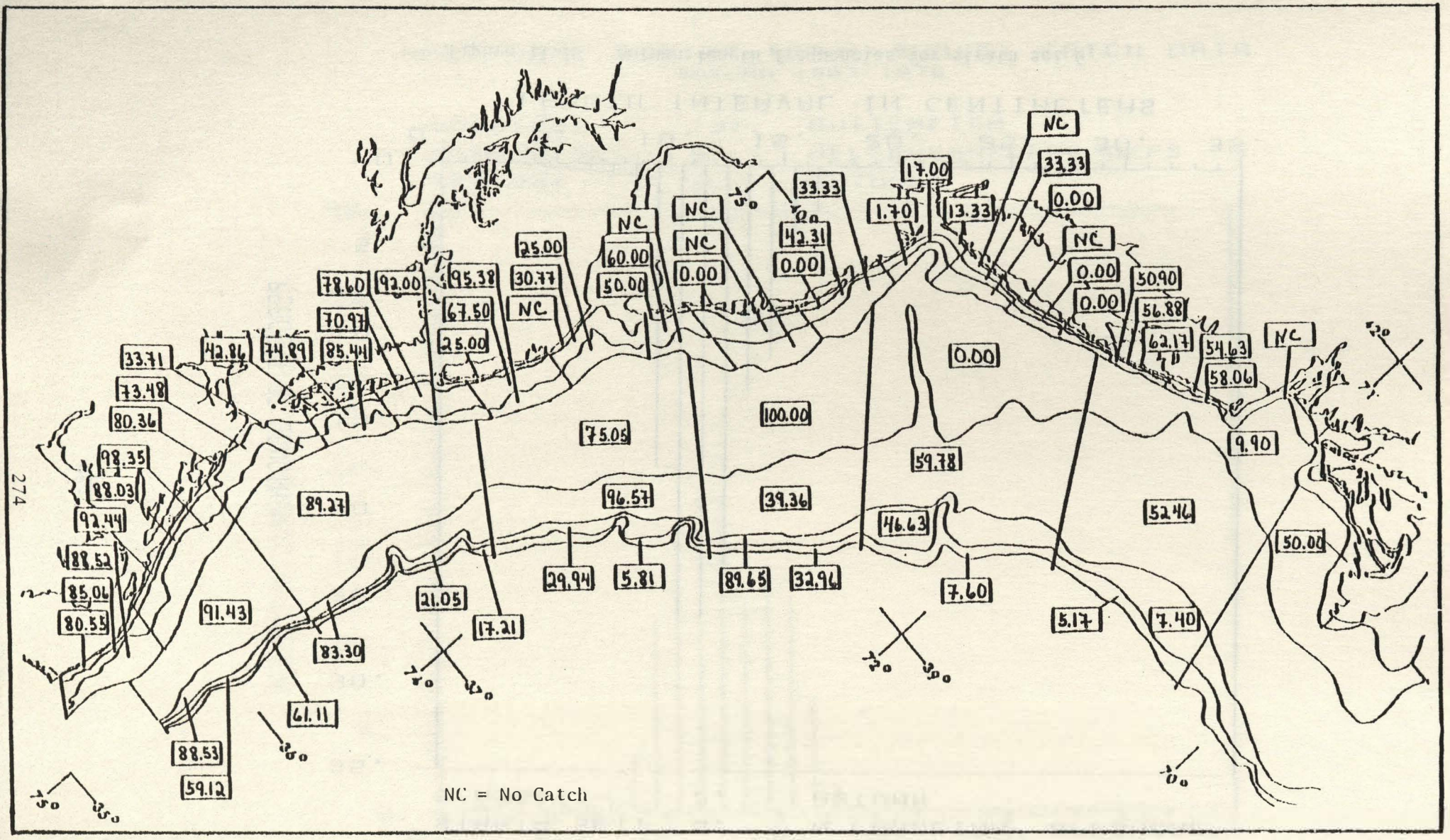


Figure 11.20. Percentage young-of-the-year, spring 1968-1979 - butterfish.

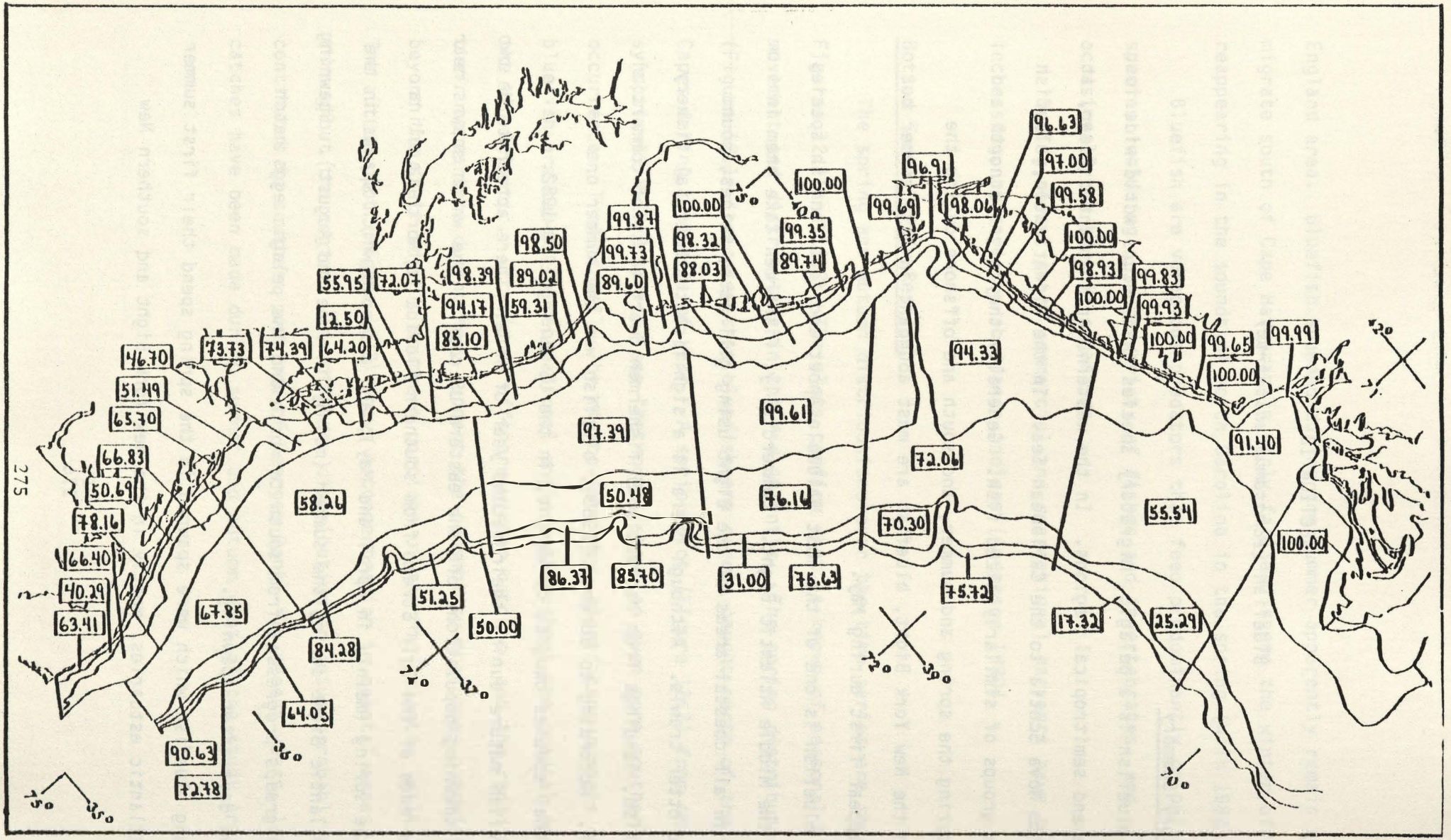


Figure 11.21. Percentage young-of-the-year, autumn 1967-1979 - butterfish.

SECTION 12

Bluefish (*Pomatomus saltatrix*)

Life History Summary

The bluefish is a pelagic, migratory species that occurs world-wide in temperate and semitropical regions. In the western North Atlantic Ocean, it ranges from Nova Scotia to the Caribbean Sea. In the Mid-Atlantic, bluefish travel in groups of similarly sized fish. Generally they migrate north and inshore during the spring and summer, and south and offshore during the fall. In the New York Bight, bluefish are most abundant in late summer but usually appear first during May.

The bluefish is one of the most valuable sport and food finfish species found in the Middle Atlantic Bight. Commercially, fishermen take them in quantity in all coastal areas of the Bight using gill nets, seines, pound nets, and otter trawls. Although there is a significant commercial fishery for bluefish, landings from recreational fishermen dwarf those of commercial fishermen. According to Boreman (1983), bluefish was the number one recreational species caught, by weight, in the US during 1970-1982.

Bluefish mature during their second year of life. There appear to be two discrete spawning populations off the eastern US coast: one which spawns near the inner edge of the Gulf Stream from southern Florida to North Carolina during the spring (mainly in April and May); and a second which spawns in the Middle Atlantic Bight during the summer (mainly in June and August). Spawning for both groups progresses from south to north and the pelagic eggs hatch about two days after spawning.

Young bluefish which were spawned in the spring spend their first summer in Mid-Atlantic estuaries, mostly in the New York Bight and southern New

England area. Bluefish spawned during the summer apparently remain at sea and migrate south of Cape Hatteras in early fall and spend the winter offshore, reappearing in the sounds of North Carolina in the spring (Wilk 1982).

Bluefish are voracious predators that feed predominantly on pelagic species including a large variety of fishes and invertebrates, and occasionally on benthic organisms.

During recent years commercial and recreational harvests have been increasing, as have the abundance indices (Anderson 1980).

Bottom Trawl Survey Results

The spring and autumn distributions over the time series are shown in Figures 12.1 and 12.2. The plots confirm what is known of seasonal bluefish movement and distribution in the Mid-Atlantic. The spring distribution plot (Figure 12.1) indicates that bluefish are rarely caught north of the Virginia Capes during that time of year. A spring plot (Figure 12.3) from the more synoptic 1976-1979 series (see "Methods") shows an even more southerly occurrence. Traditionally, by mid-to-late May, significant numbers of bluefish are caught by recreational anglers throughout the coastal regions of the Mid-Atlantic. Occasional offshore winter catches, and the rapidity of their appearance during May, support the possiblity that they overwinter beyond the shelf edge in southern portions of the Mid-Atlantic (Wilk 1977). The autumn plot (Figure 12.2) shows a concentration in coastal areas throughout the region. The offshore distribution in autumn probably would be continuous to southern portions of Georges Bank. In recent years, large catches have been made during summer and autumn east of the study area on

Georges Bank, possibly as a result of recent high population levels and a resulting range expansion.

The mean weight and number per tow summaries in Figures 12.4-12.7 reflect the recent trends in increased abundance. It must be kept in mind that bluefish were caught mostly inshore during the surveys, and coverage inside of 28 m did not begin until autumn 1972. Therefore, the low catches indicated by Figures 12.4-12.7 prior to 1972 can be misleading.

The seasonal length frequencies for six strata sets (Figures 12.8-12.17), and the percentage young-of-the-year (YOY) plots (Figures 12.18 and 12.19) show clearly the large numbers of young fish caught during surveys. This predominance of young fish in survey catches (especially in the autumn) was a result of the great numbers of young bluefish and their vulnerability to capture by the trawl compared to the more pelagic and faster swimming adults. No bluefish were caught in strata sets 1 and 4 during the spring time series.

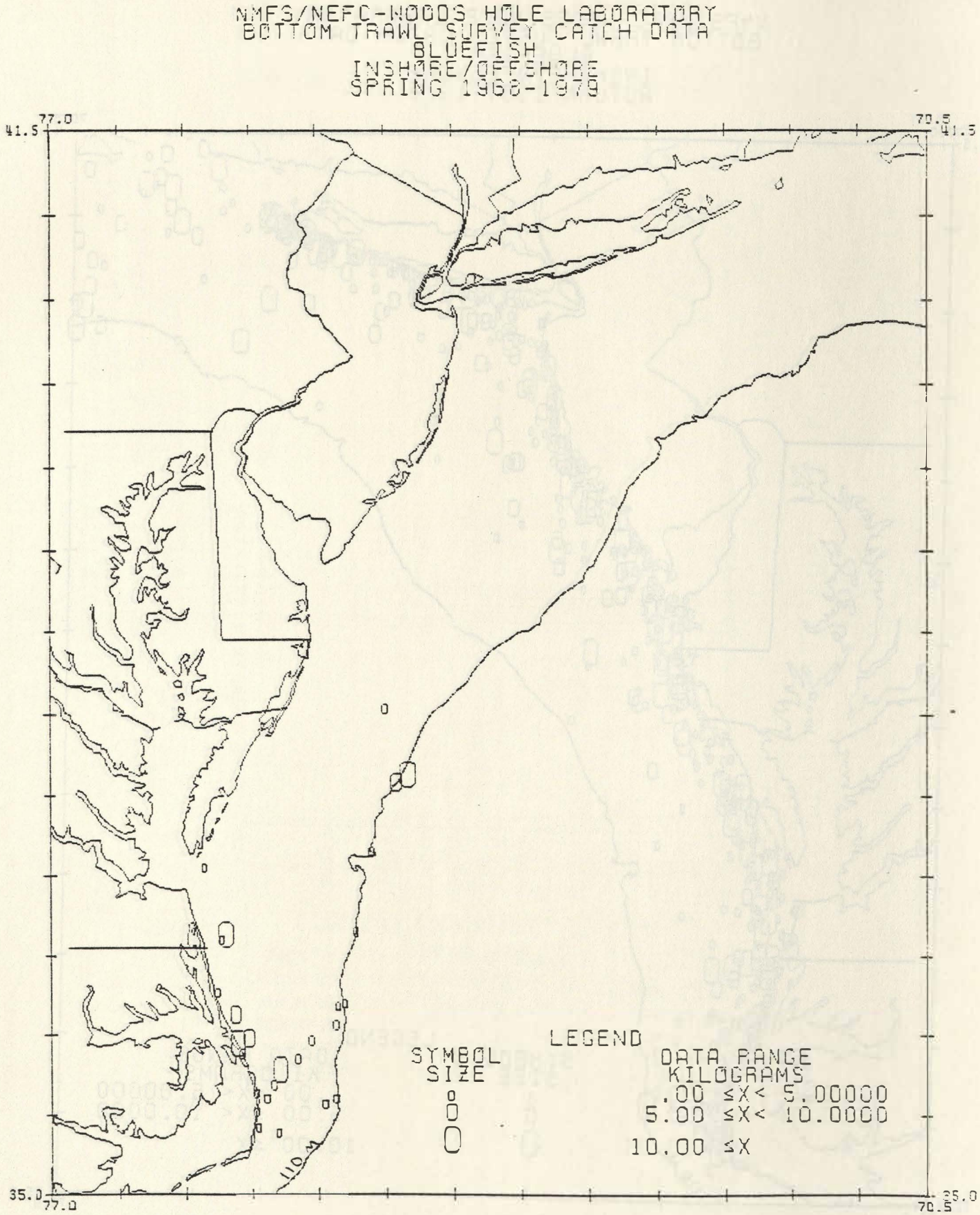


Figure 12.1. Spring distribution, 1968-1979.

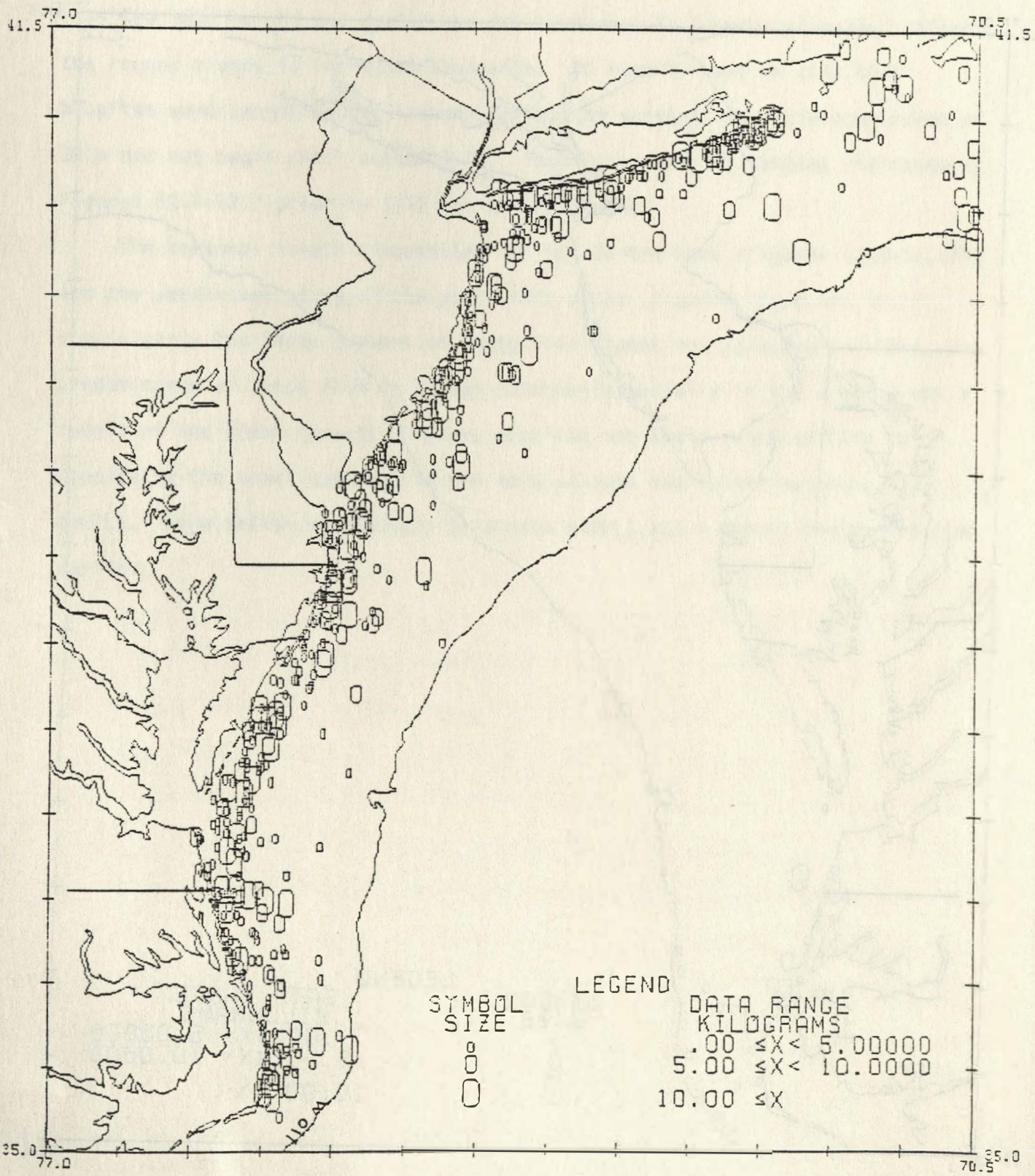


Figure 12.2. Autumn distribution, 1967-1979.

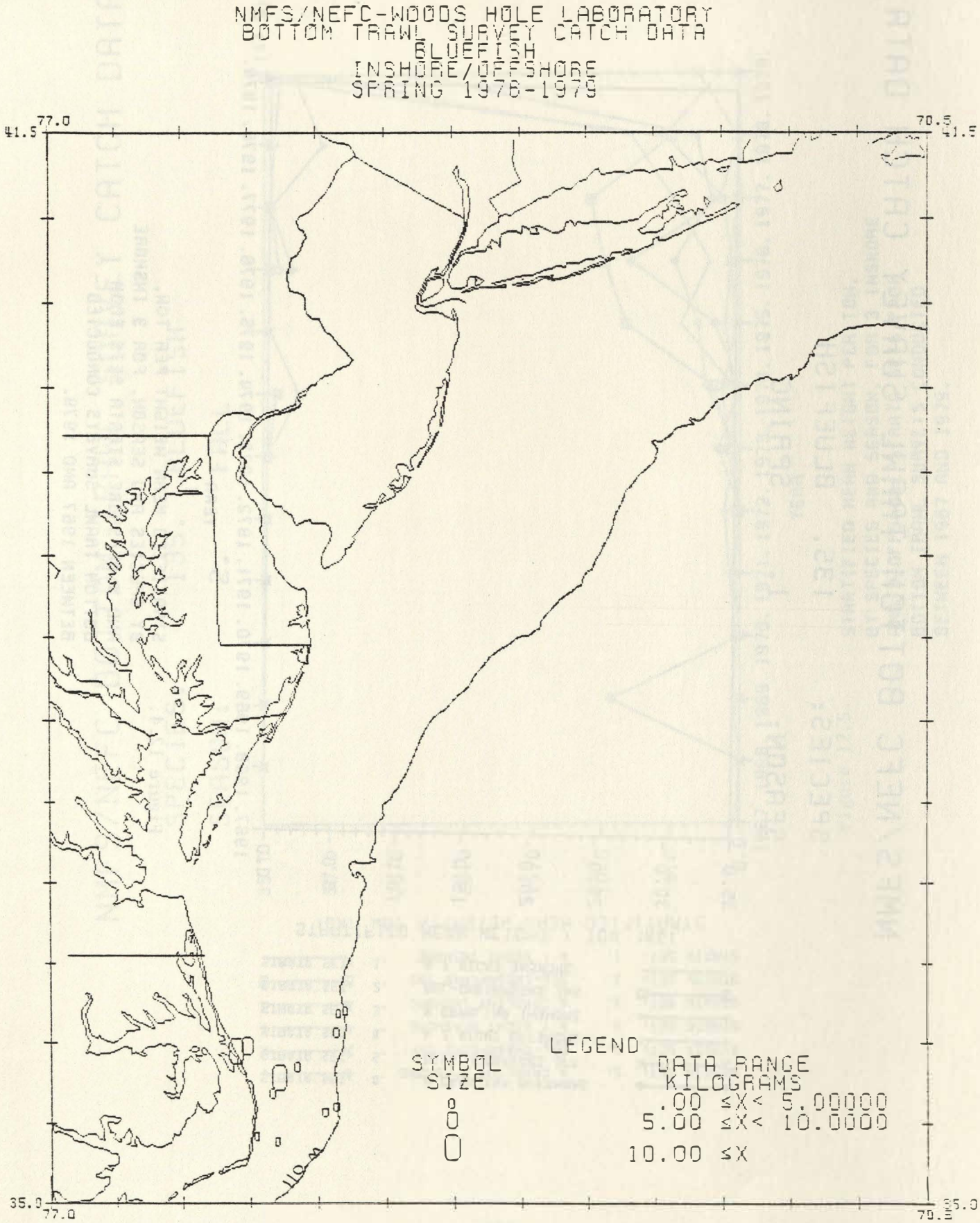


Figure 12.3. Spring distribution, 1976-1979.

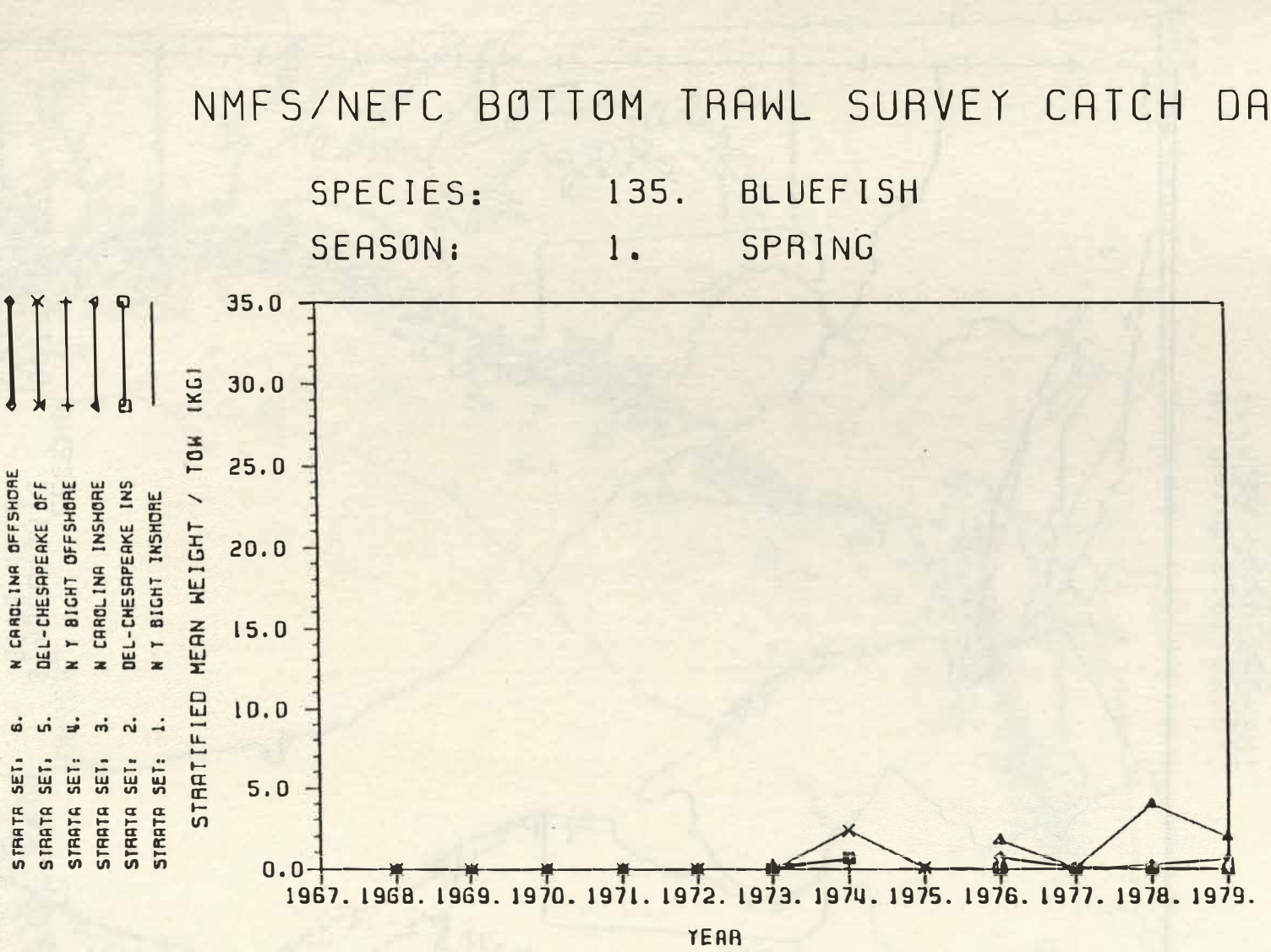


Figure 12.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

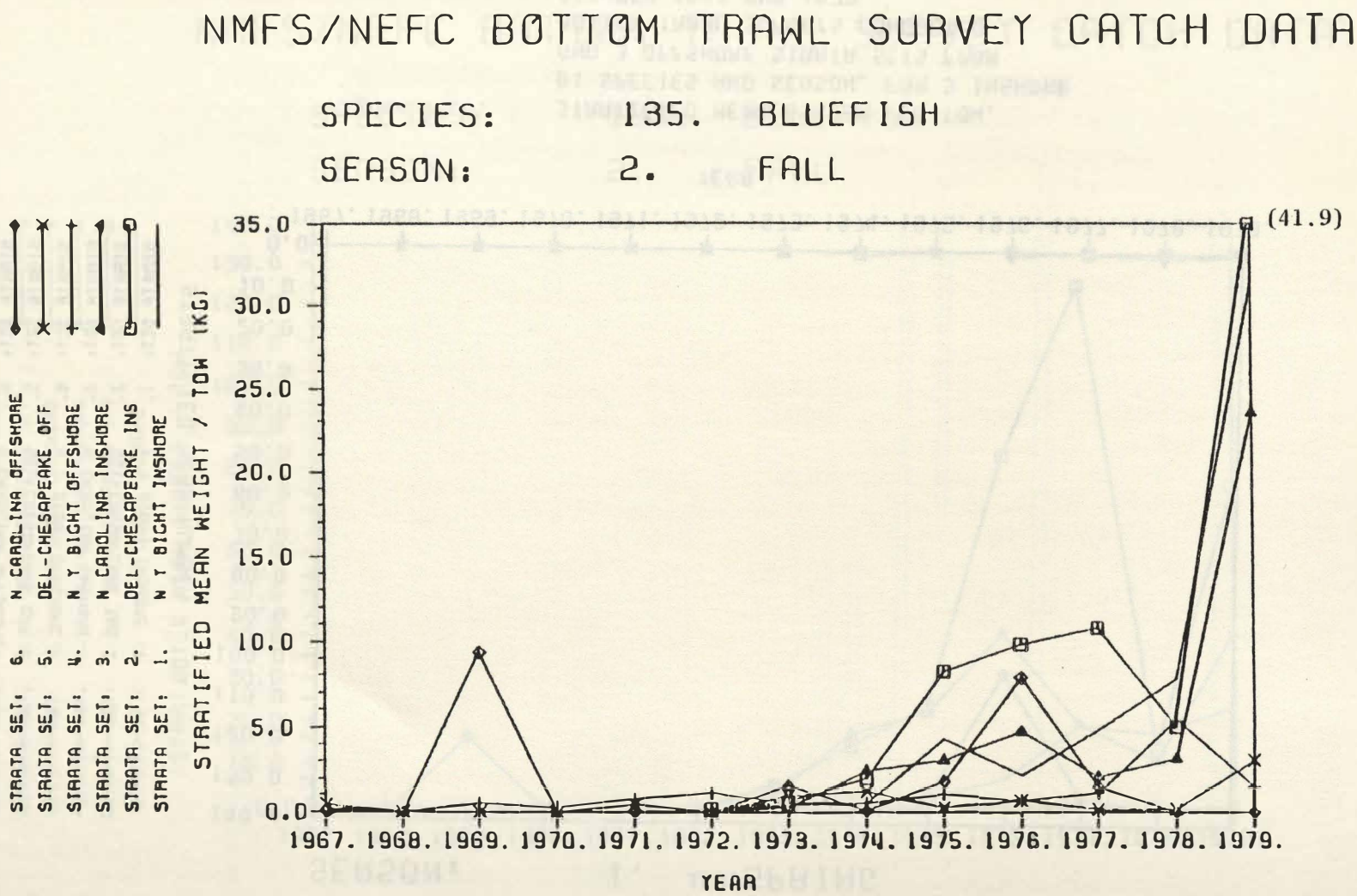


Figure 12.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

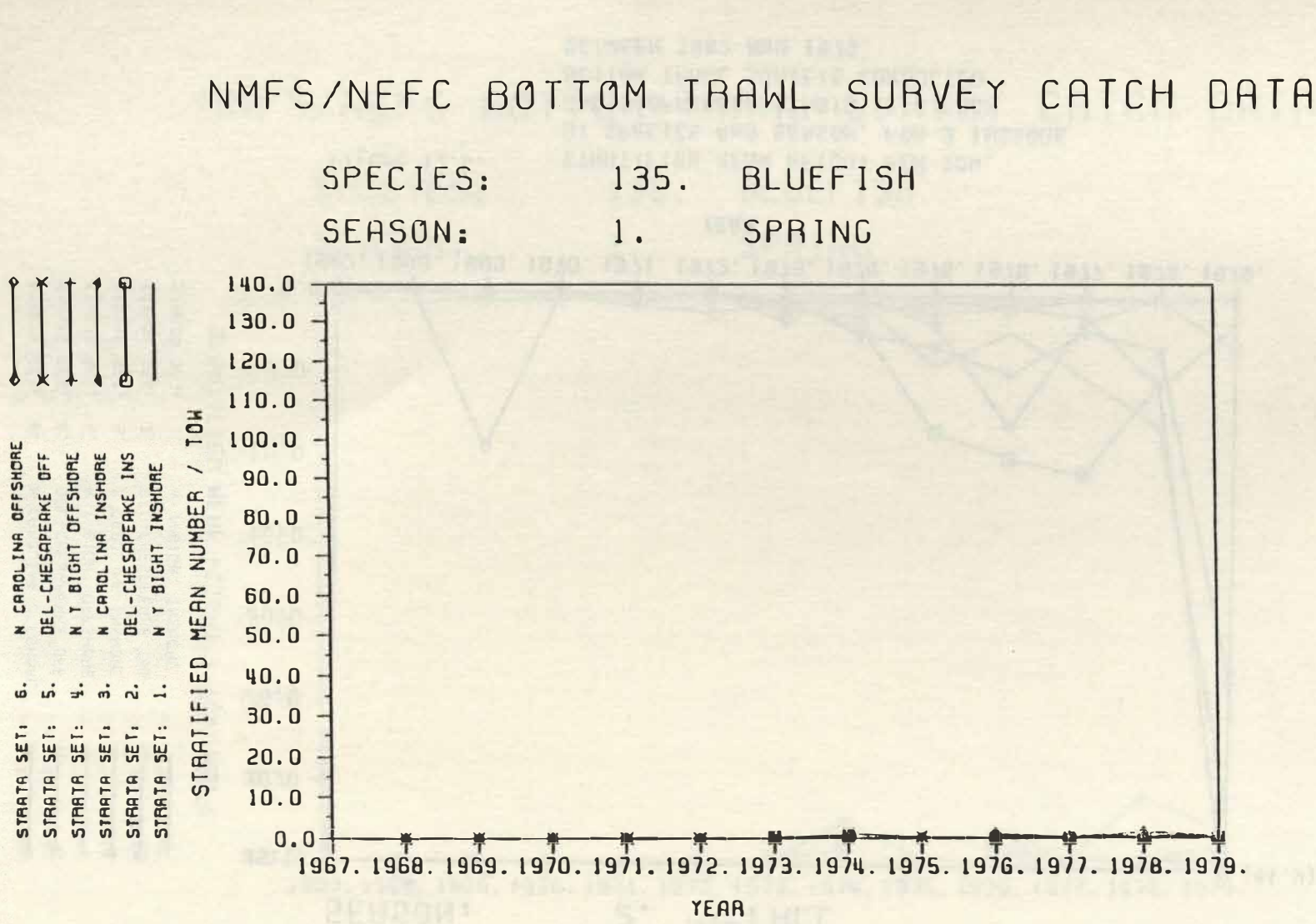


Figure 12.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

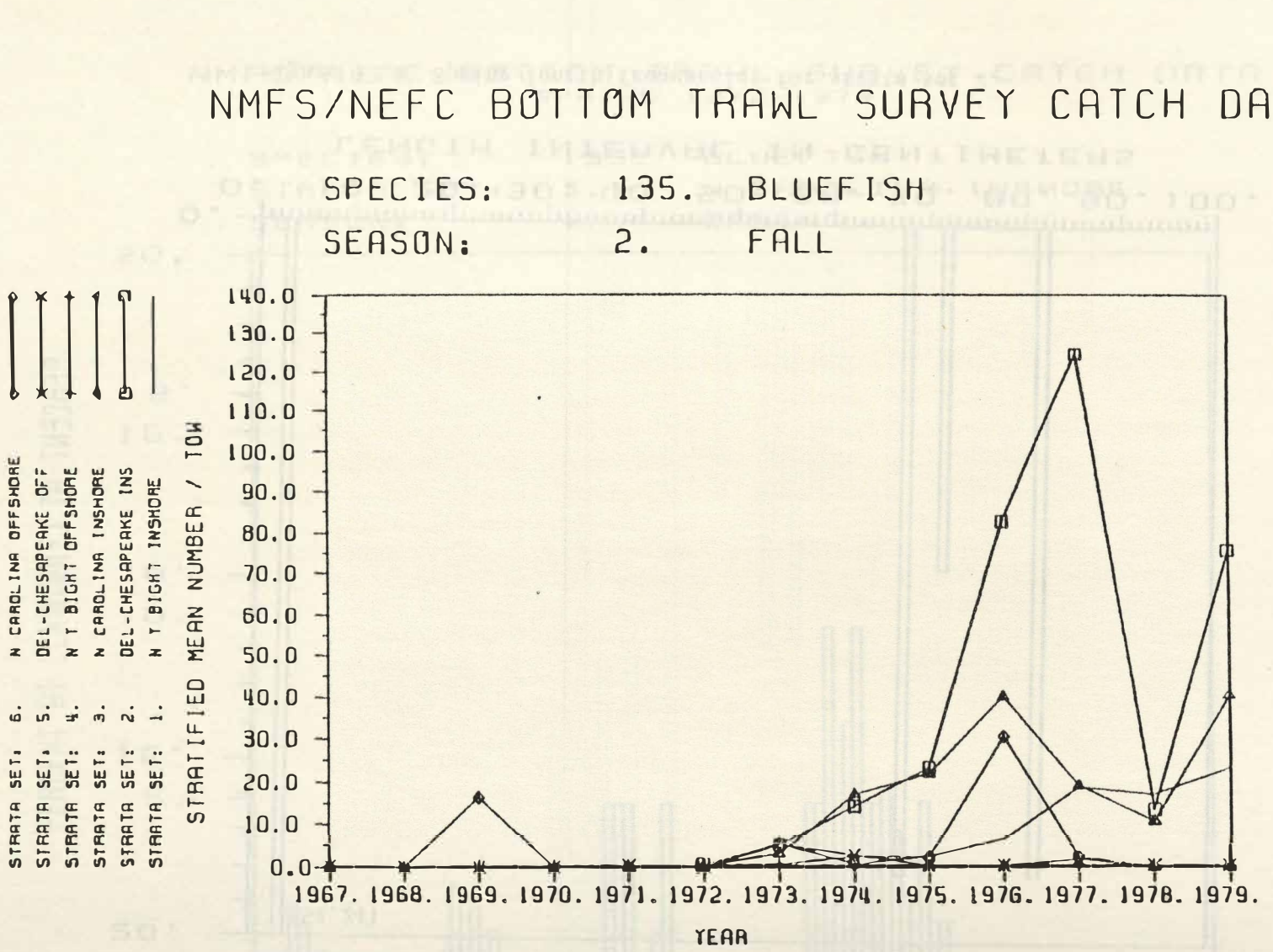


Figure 12.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

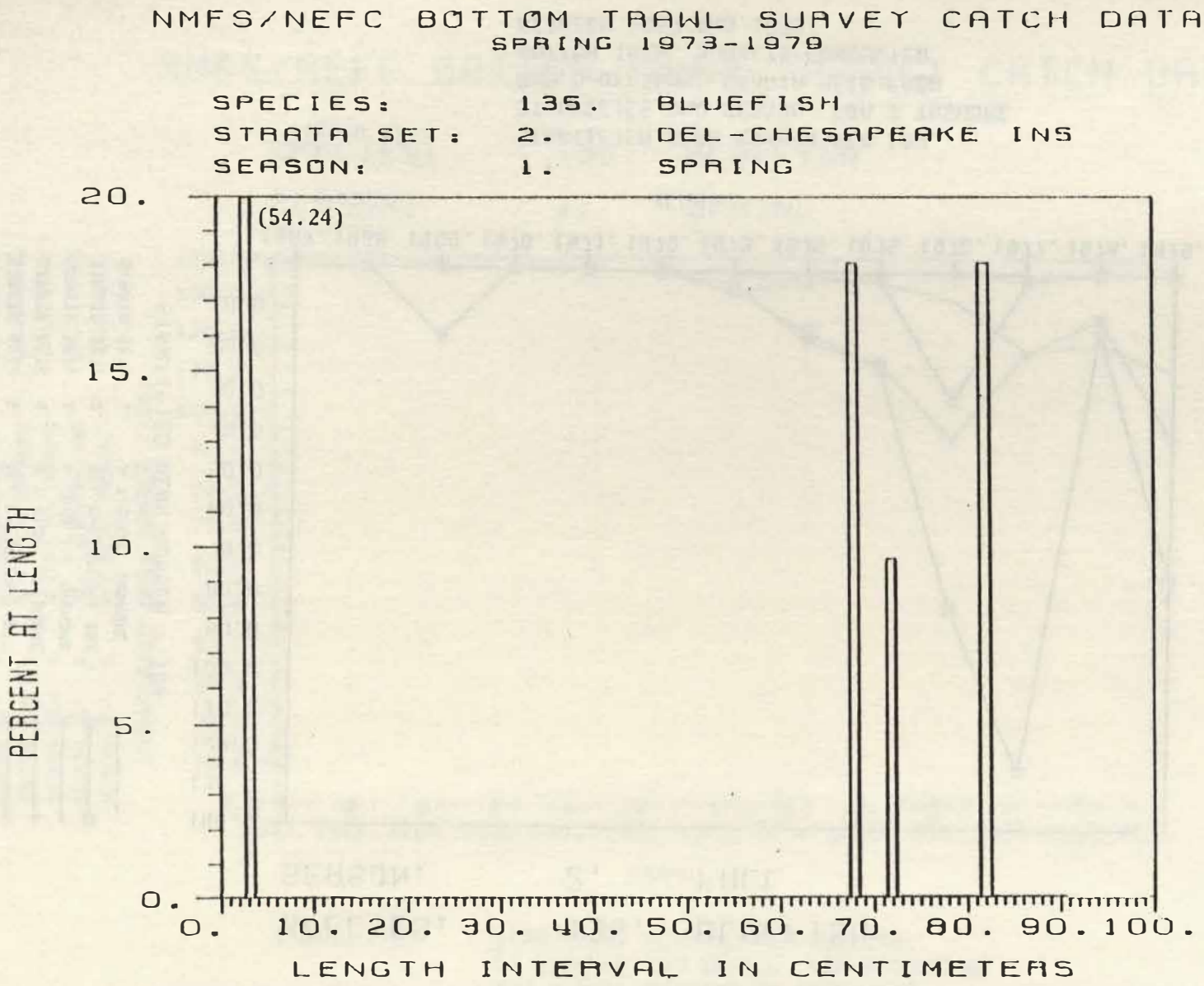


Figure 12.8. Spring length frequencies for strata set 2.

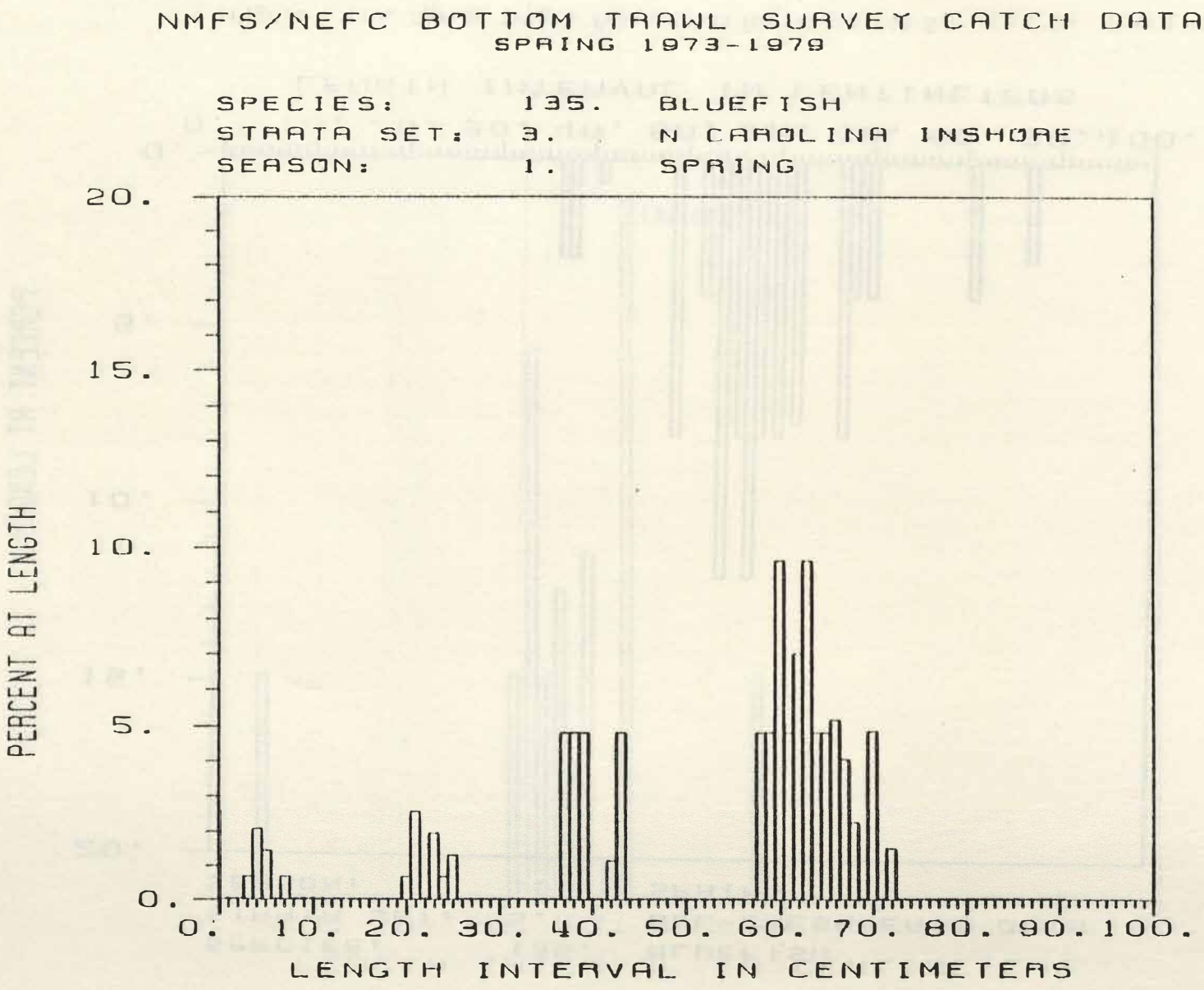


Figure 12.9. Spring length frequencies for strata set 3.

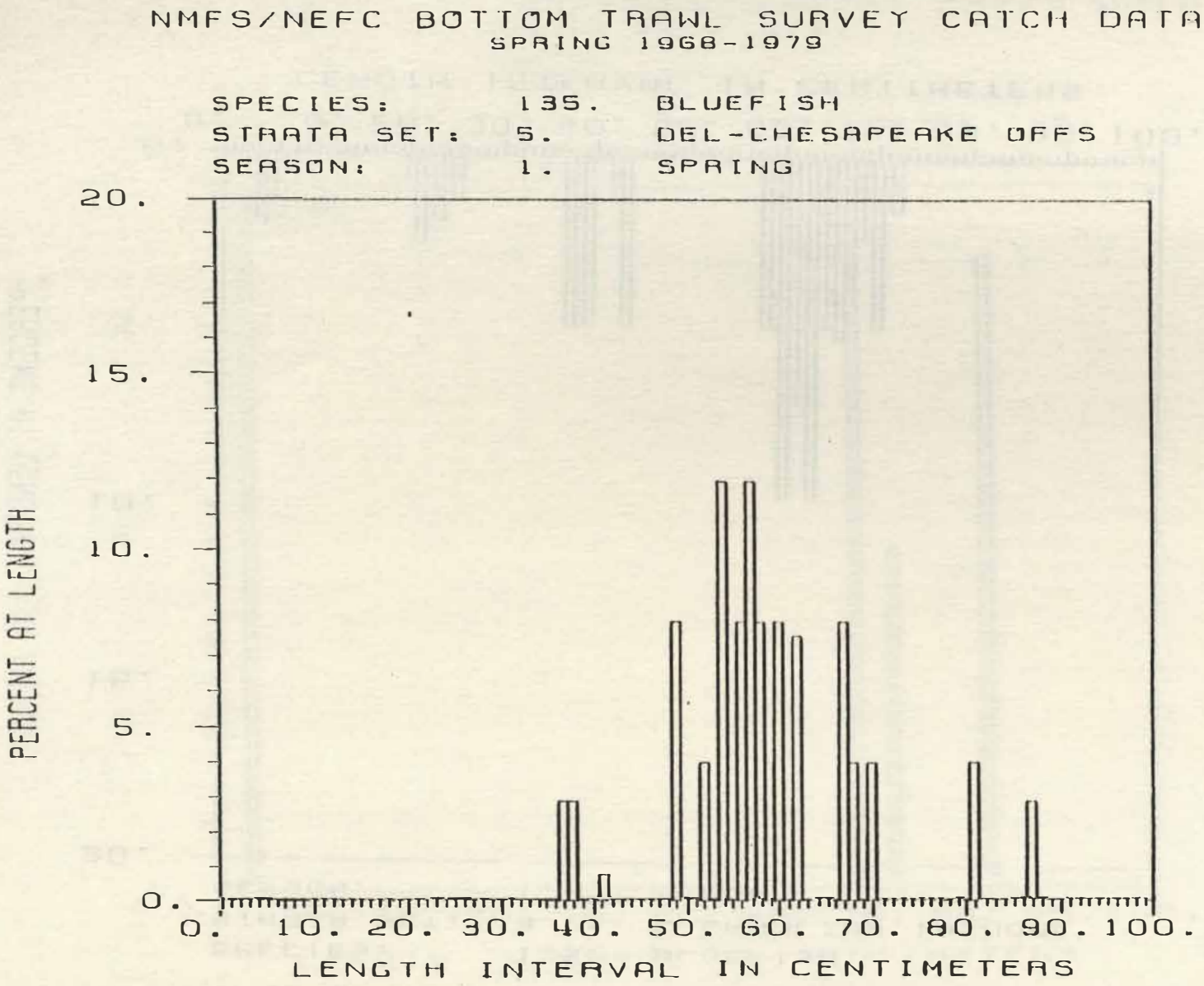


Figure 12.10. Spring length frequencies for strata set 5.

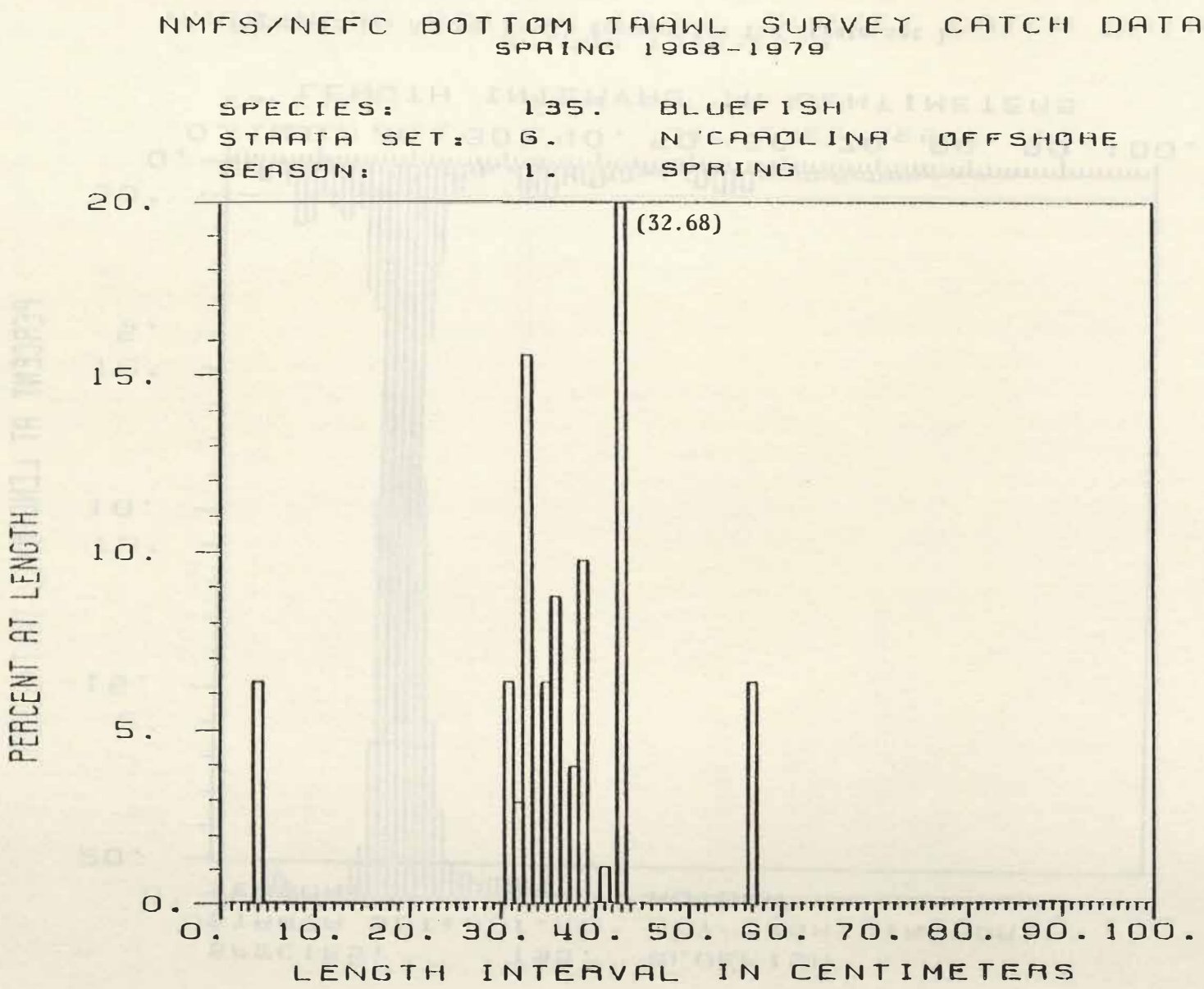


Figure 12.11. Spring length frequencies for strata set 6.

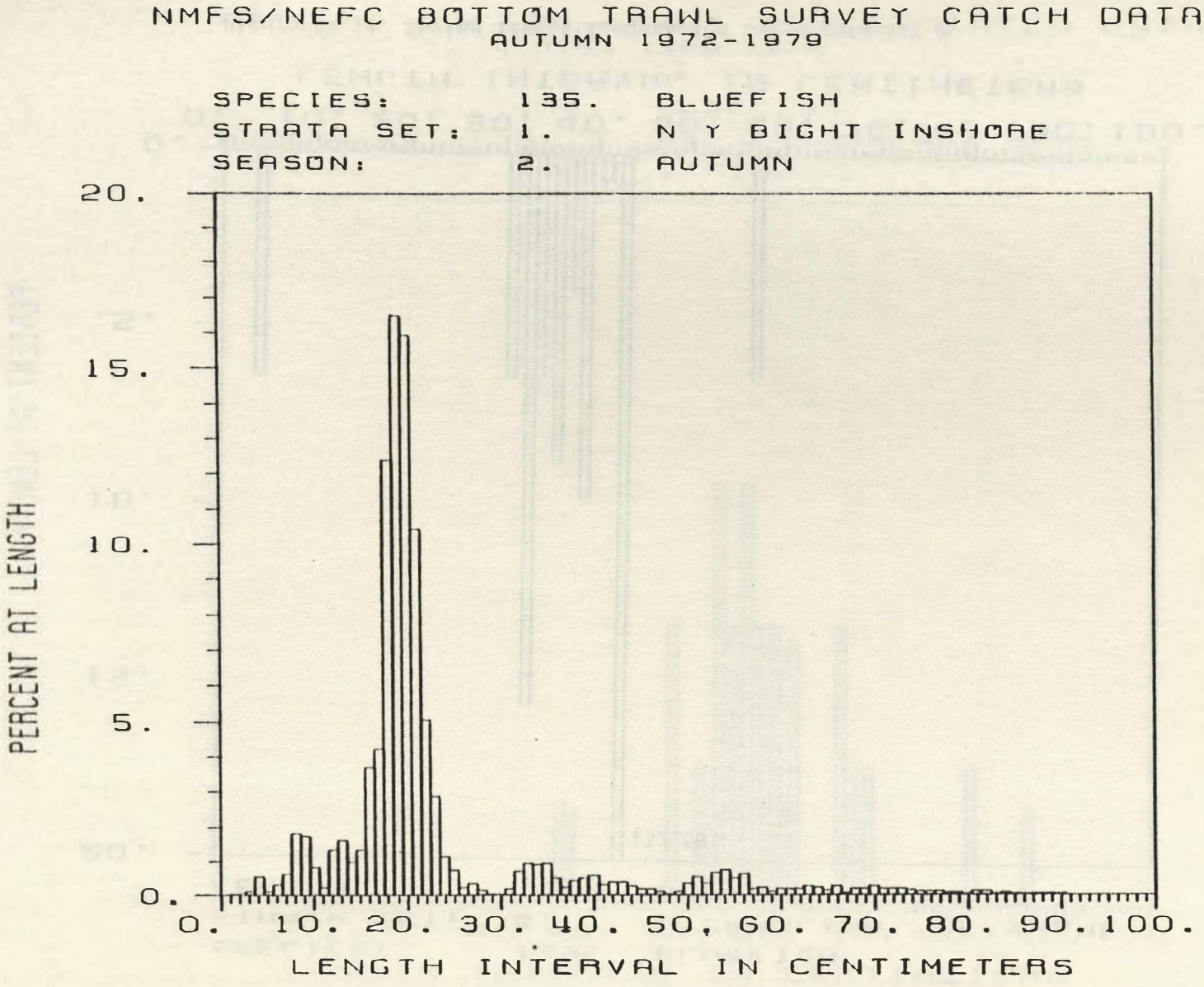


Figure 12.12. Autumn length frequencies for strata set 1.

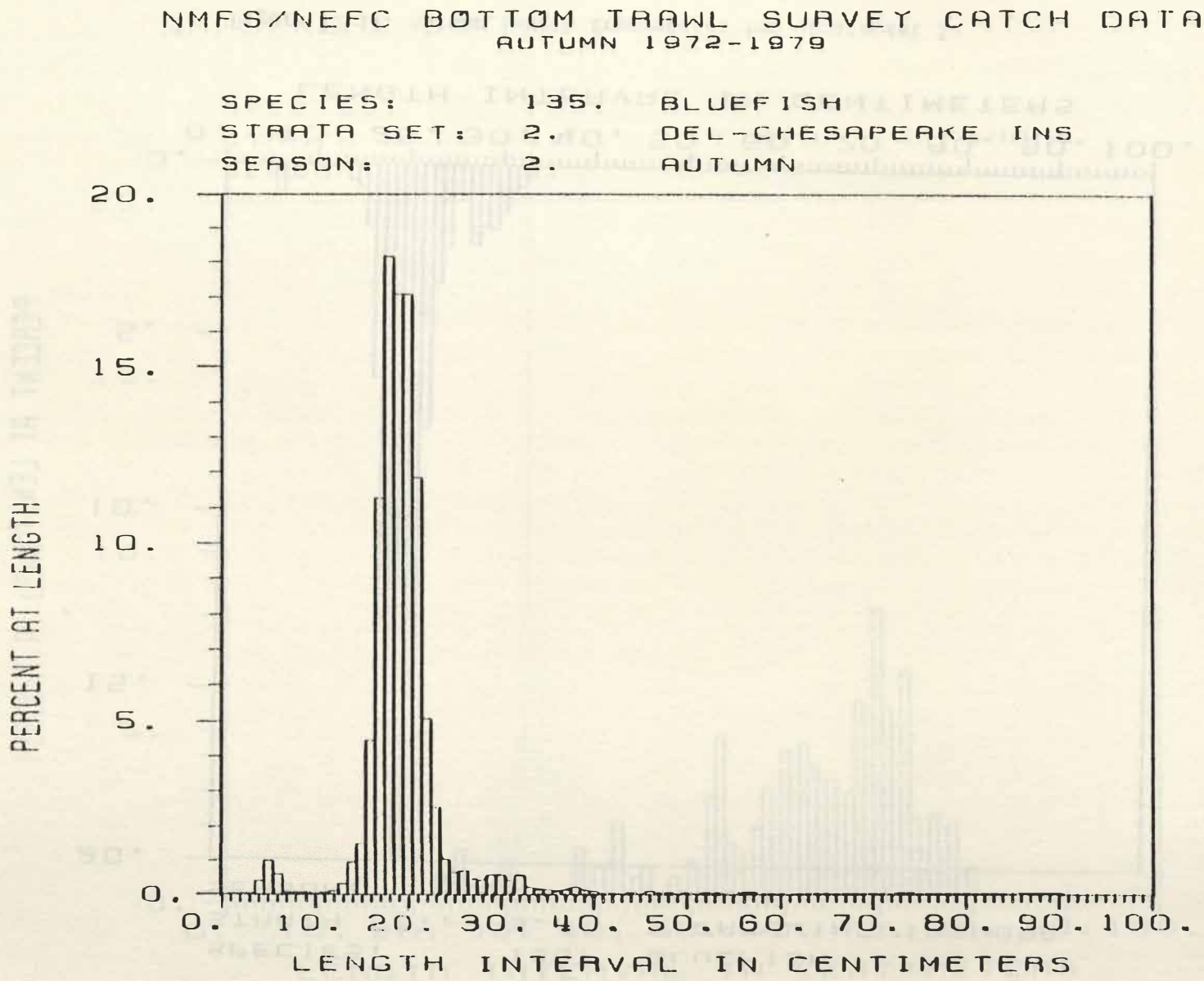


Figure 12.13. Autumn length frequencies for strata set 2.

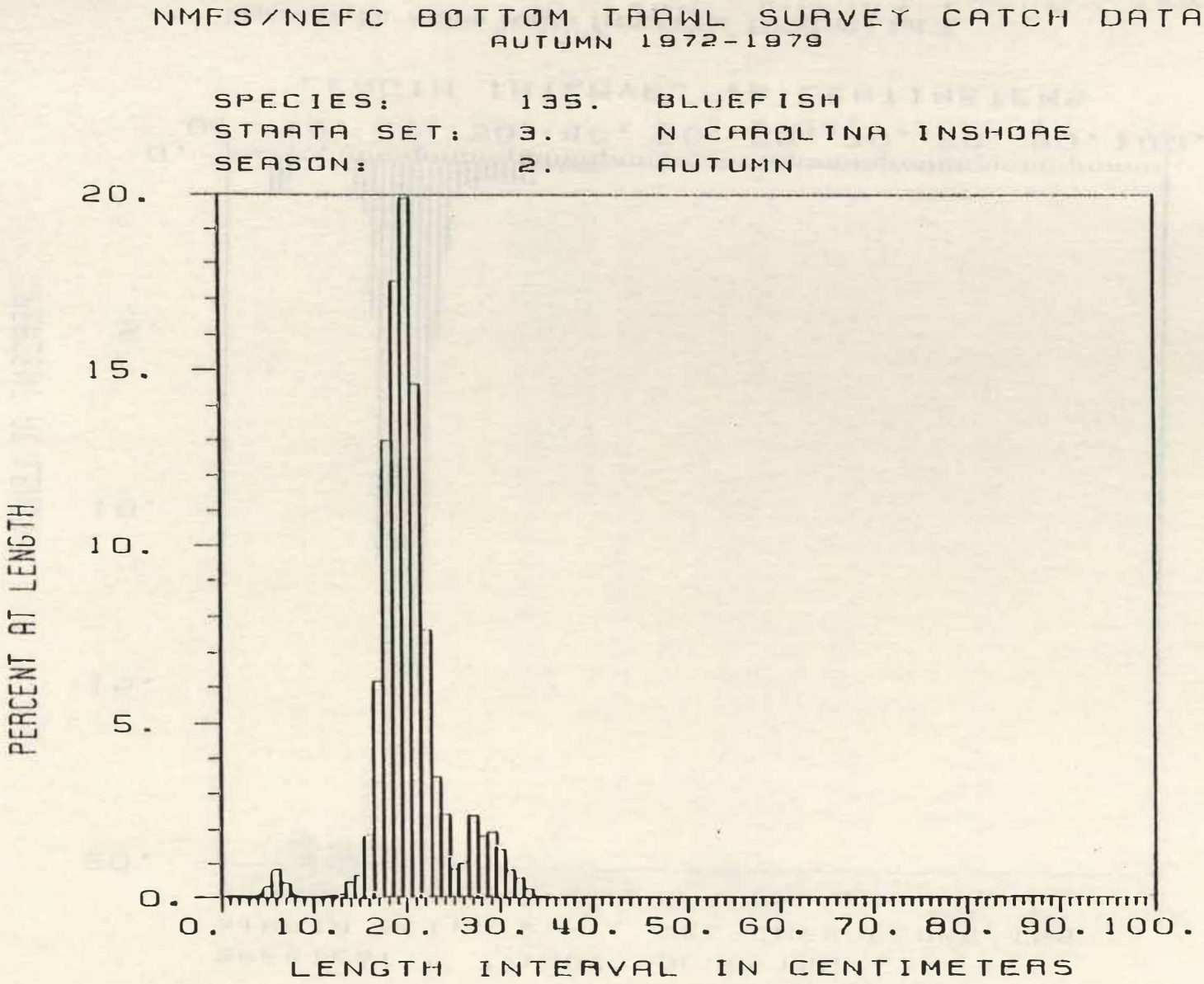


Figure 12.14. Autumn length frequencies for strata set 3.

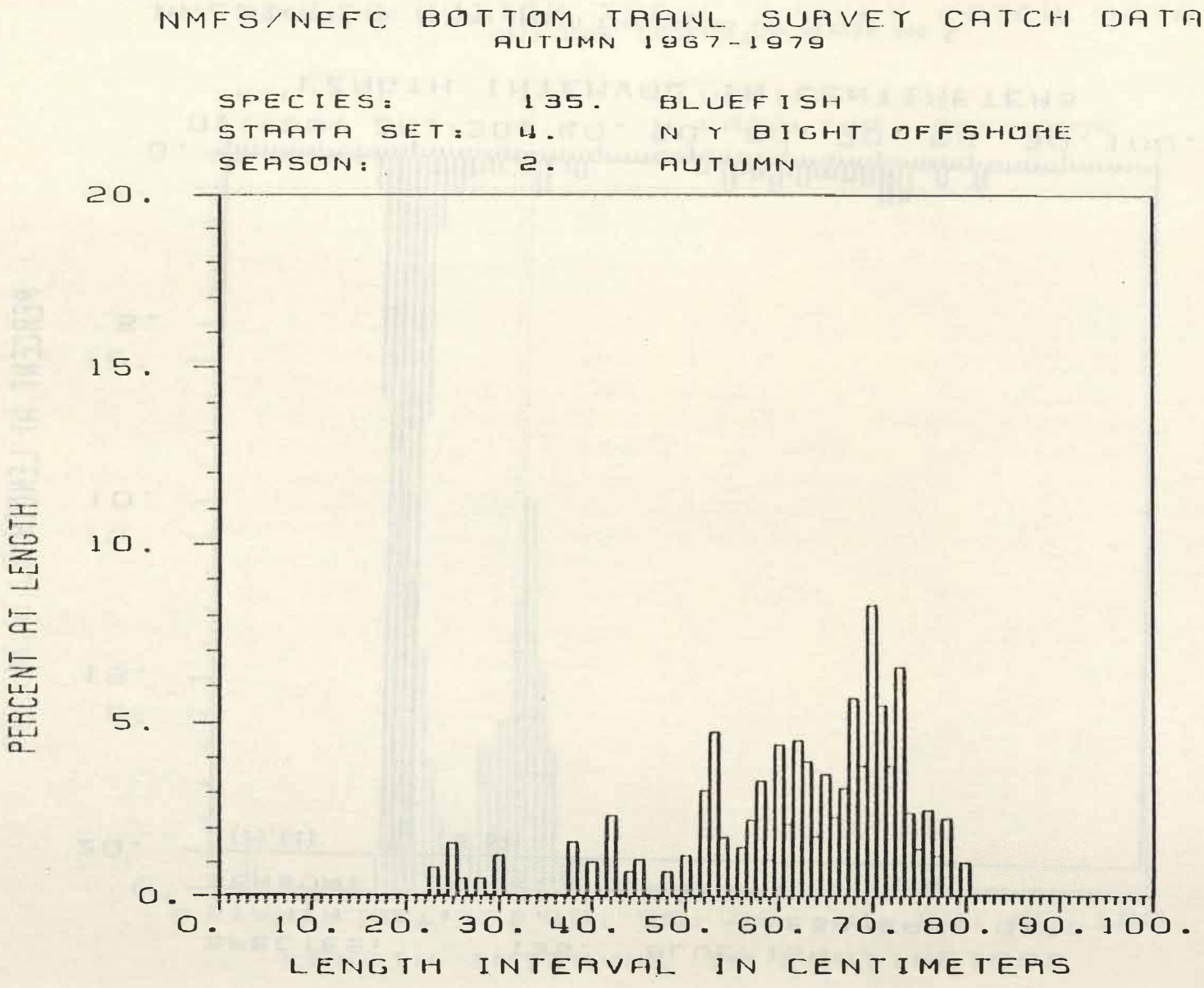


Figure 12.15. Autumn length frequencies for strata set 4.

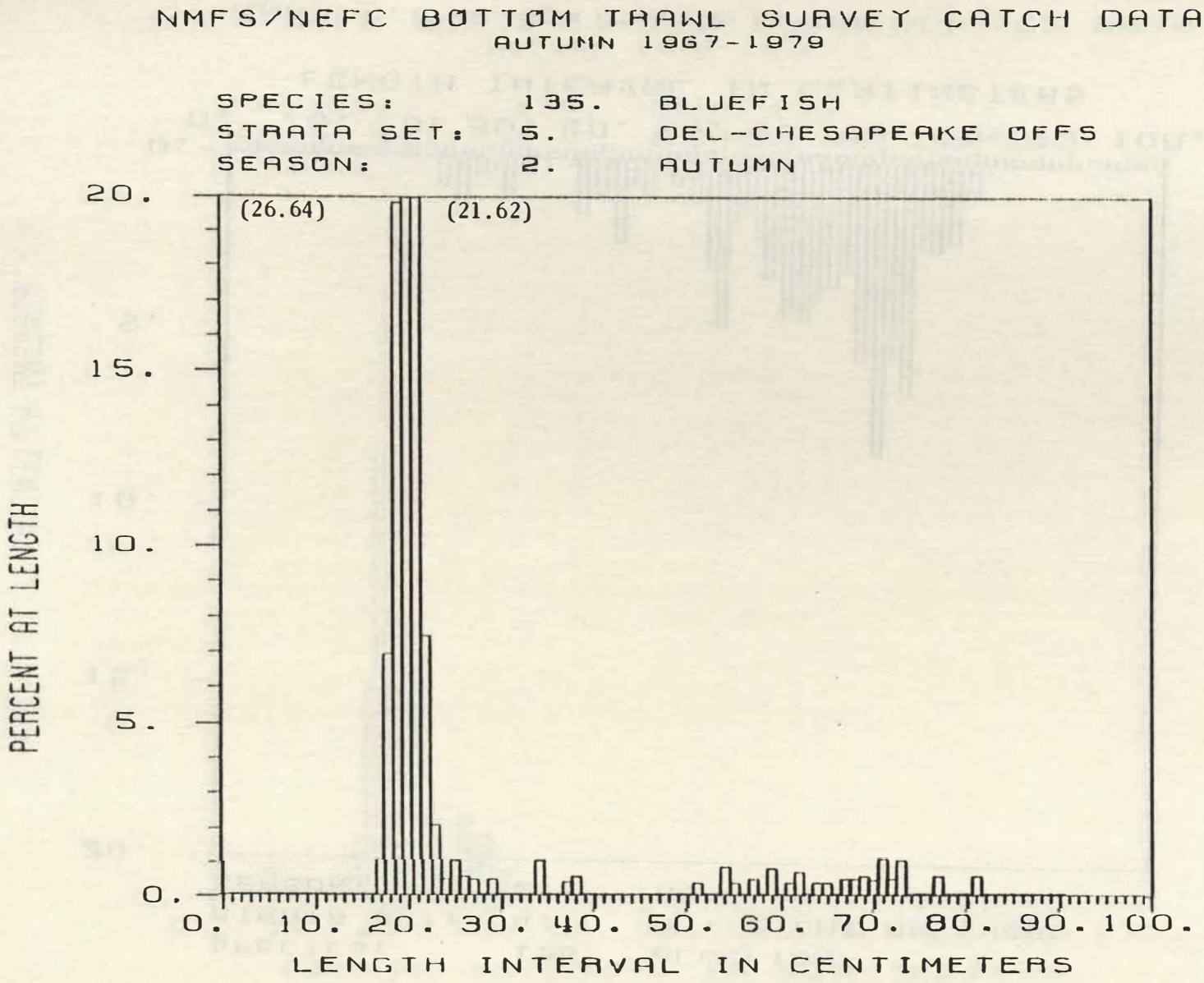


Figure 12.16. Autumn length frequencies for strata set 5.

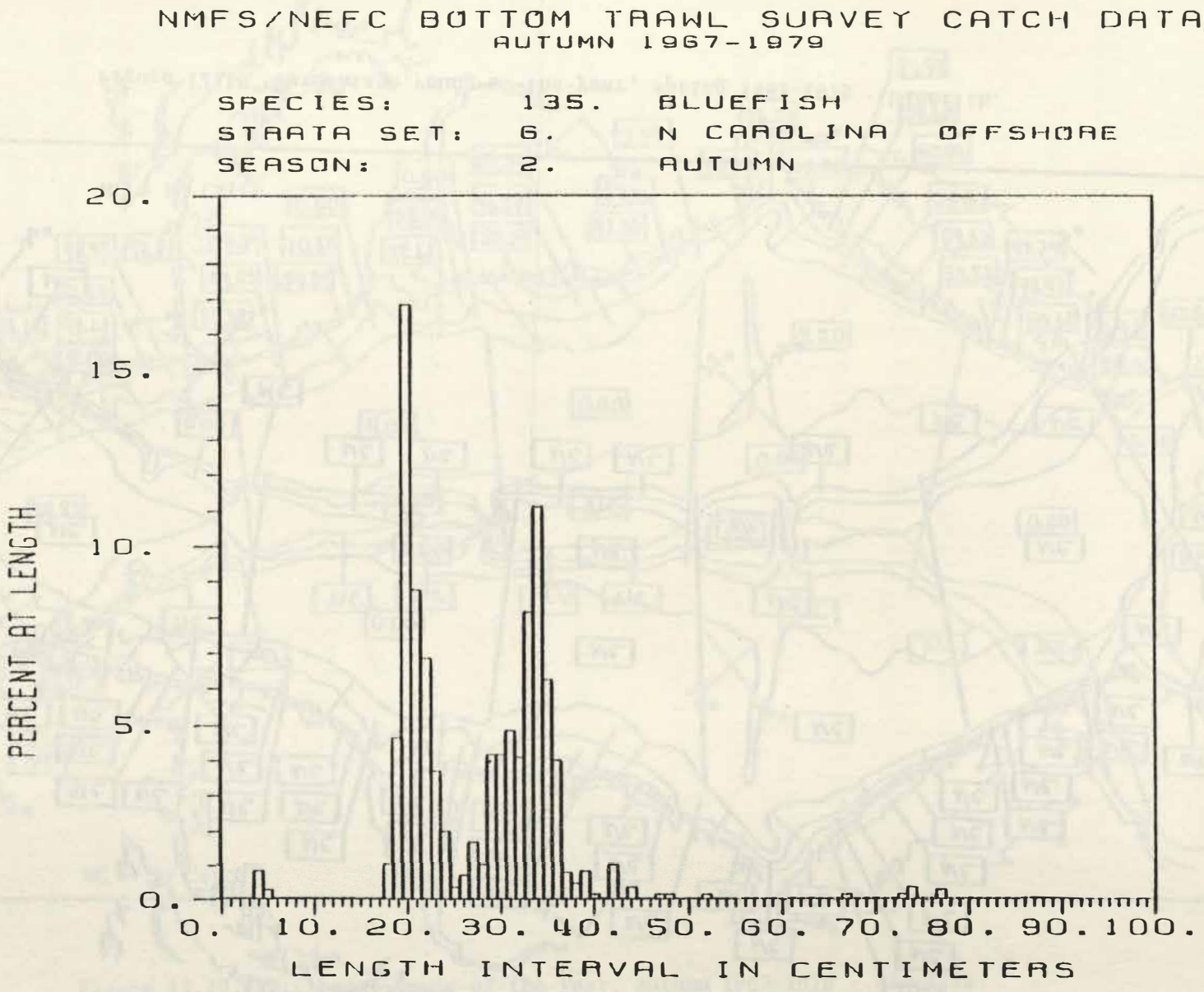


Figure 12.17. Autumn length frequencies for strata set 6.

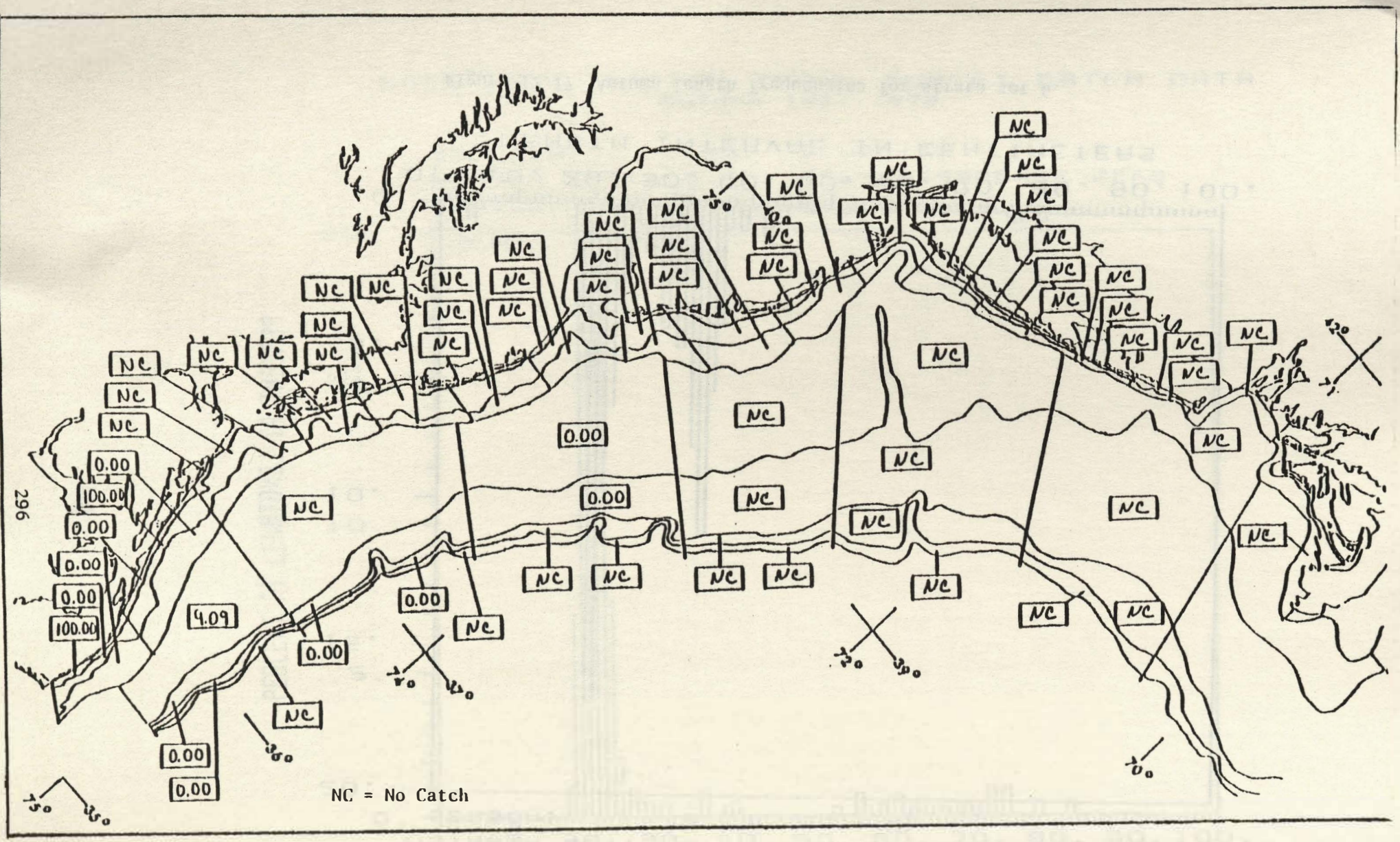


Figure 12.18. Percentage young-of-the-year, spring 1968-1979 - bluefish.

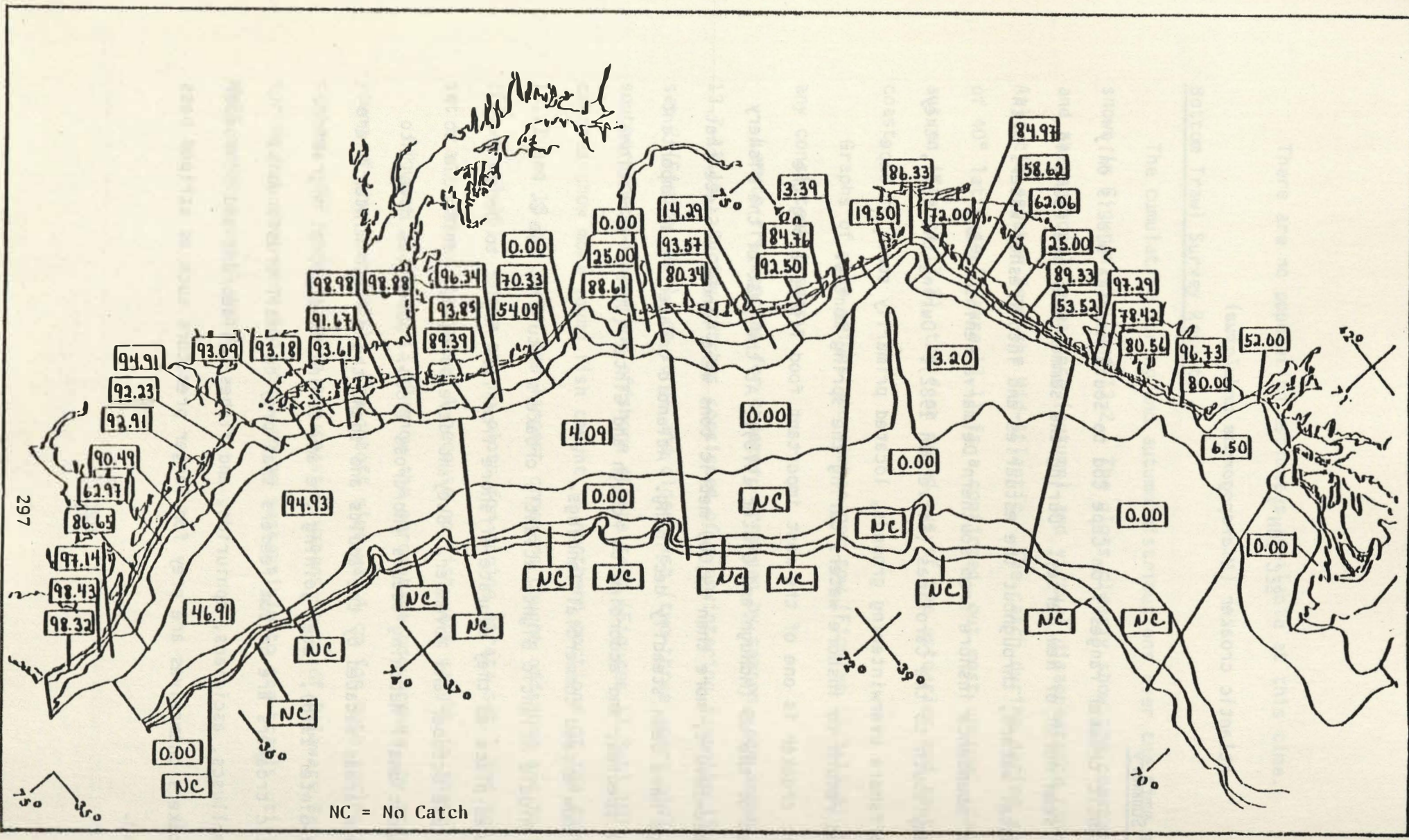


Figure 12.19. Percentage young-of-the-year, autumn 1967-1979 - bluefish.

SECTION 13

Atlantic croaker (*Micropogonias undulatus*)

Life History Summary

The Atlantic croaker ranges from Cape Cod to South America but is only occasionally seen north of New Jersey. During the summer they are found in and near coastal waters, throughout the estuaries and into fresher waters with the center of abundance inshore from southern Delmarva Peninsula and Chesapeake Bay south to the Carolinas (Silverman 1982). During the fall, they migrate to offshore overwintering grounds, located primarily south of Cape Hatteras, and return to inshore waters during the spring months.

Atlantic croaker is one of the most important food fishes along the eastern coast of the US (McHugh and Ginter 1978). At the peak of the fishery during the mid-1940's, more than 29,000 metric tons were landed. Since that time landings have been steadily declining. Atlantic croaker is an important recreational species, and according to McHugh and Ginter (1978) recreational catches may now exceed commercial landings.

In the Middle Atlantic Bight, Atlantic croakers mature at age 2. Spawning takes place as they migrate offshore from late August to December, peaking in late October and November. Buoyant developing eggs drift due to Ekman transport until hatching occurs (Norcross 1983). Juveniles move into the shallower areas vacated by the adults and spend their first winter there (McHugh and Ginter 1978), later joining the adults in the seasonal migration.

Atlantic croakers are bottom feeders that prey on small crustaceans, annelids, molluscs, ascidians, ophiurids, and fishes (Hildebrand and Schroeder 1928). Croakers themselves are prey for larger predators such as striped bass and bluefish.

There are no population estimates available at this time.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 13.1 and 13.2. The plots clearly show the coastal dependence and the seasonal appearance (autumn) and virtual disappearance (spring) of Atlantic croaker from the Mid-Atlantic. The catch during spring surveys north of 40° latitude (Figure 13.1) is a confirmed, but most unusual, catch. In the autumn (Figure 13.2), the fish moved out of the estuaries and south along the coast.

Graphs of mean weight and number per tow (Figures 13.3-13.6) did not show any consistent trends.

Length frequencies for croaker, arranged by season, are shown in Figures 13.7-13.15. Spring catches consisted of overwintering juvenile fish in strata set 2 (Figure 13.7), or large and older fish (two-three years old) in the southernmost inshore and offshore strata sets (Figures 13.8-13.10). Autumn catches show more young fish caught in northern portions of the range (Figures 13.11 and 13.12), with the largest croakers caught offshore and to the south (Figure 13.14). There are no plots for spring strata set 1 and spring strata set 5 and autumn strata set 4 because no fish were caught in these areas.

Figures 13.16 and 13.17 show the percentage occurrence, by stratum, of young-of-the-year (YOY). The cutoff size was 4 cm for both spring and autumn series. YOY were found in the coastal waters south of Delaware Bay in the spring but they were too small to be susceptible to the trawls utilized during NMFS surveys until autumn.

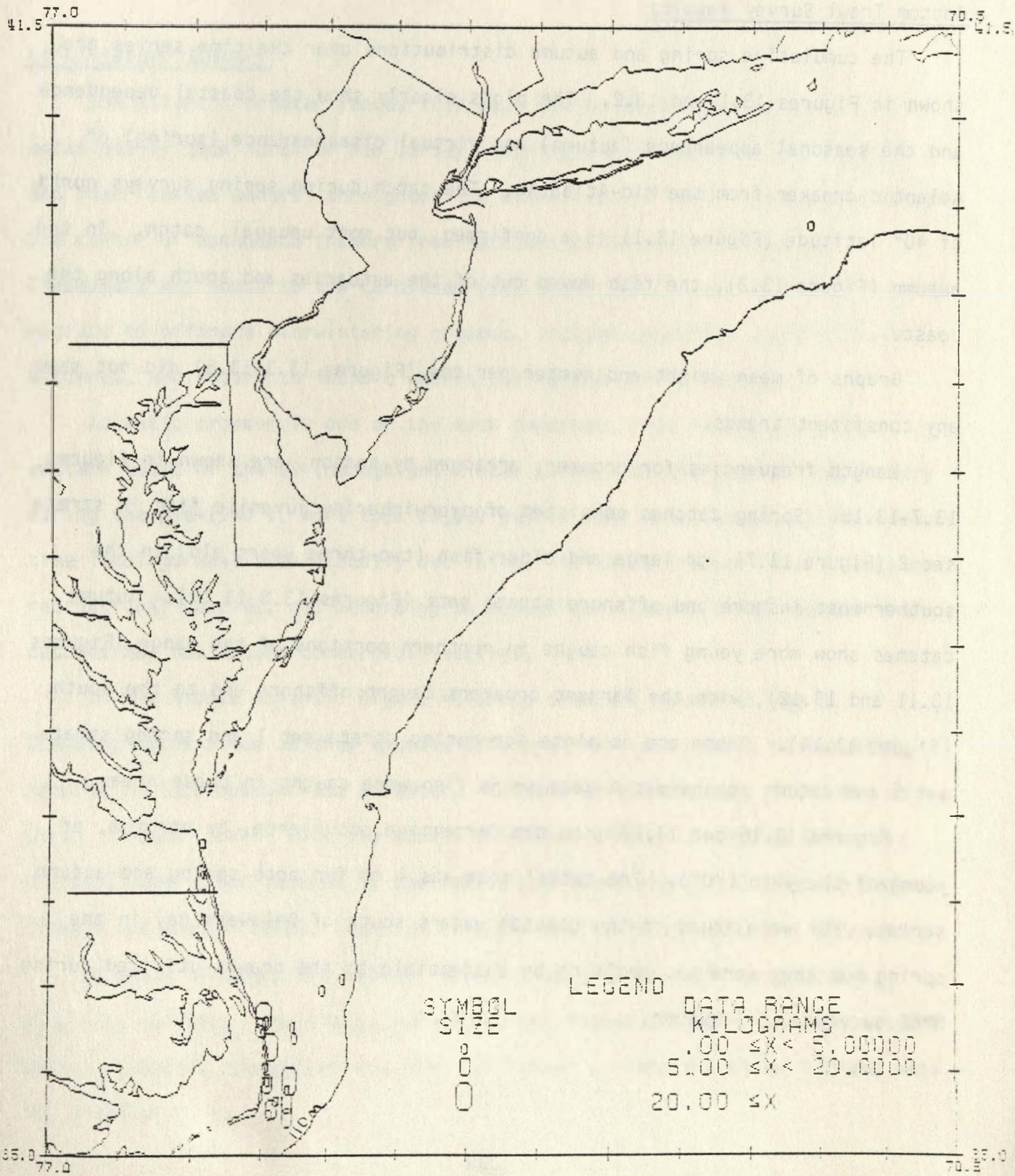


Figure 13.1. Spring distribution, 1968-1979.

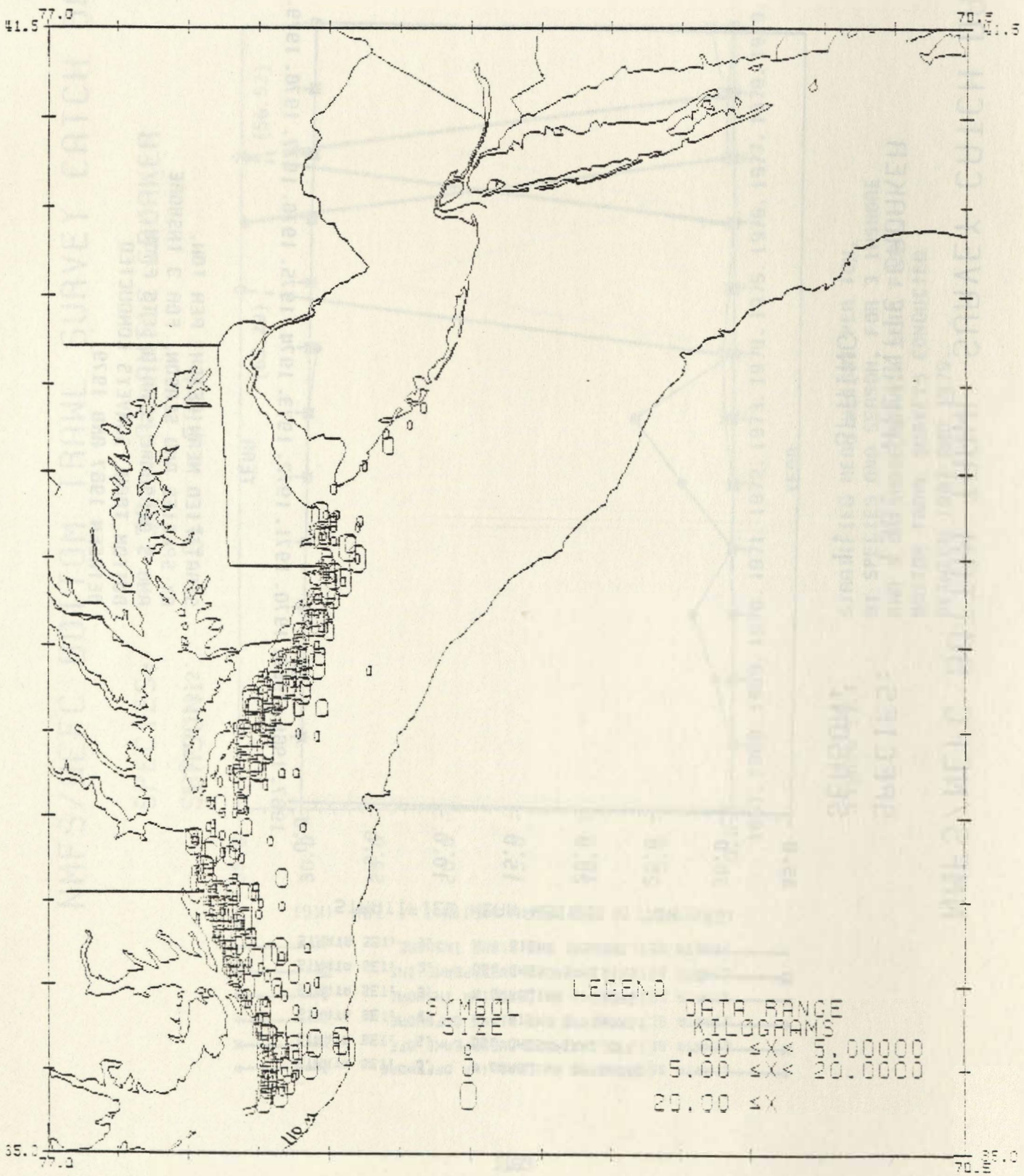


Figure 13.2. Autumn distribution, 1967-1979.

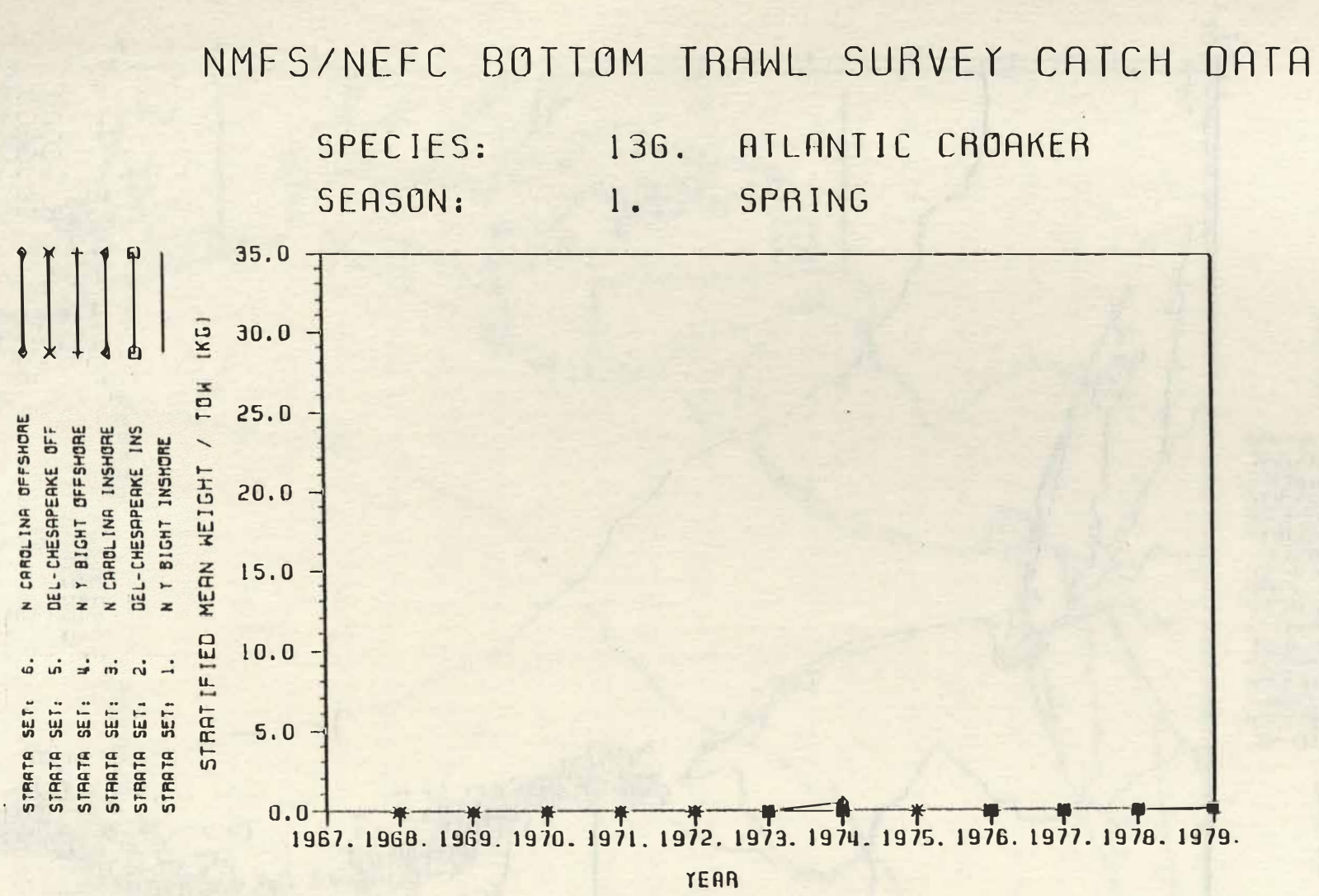


Figure 13.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

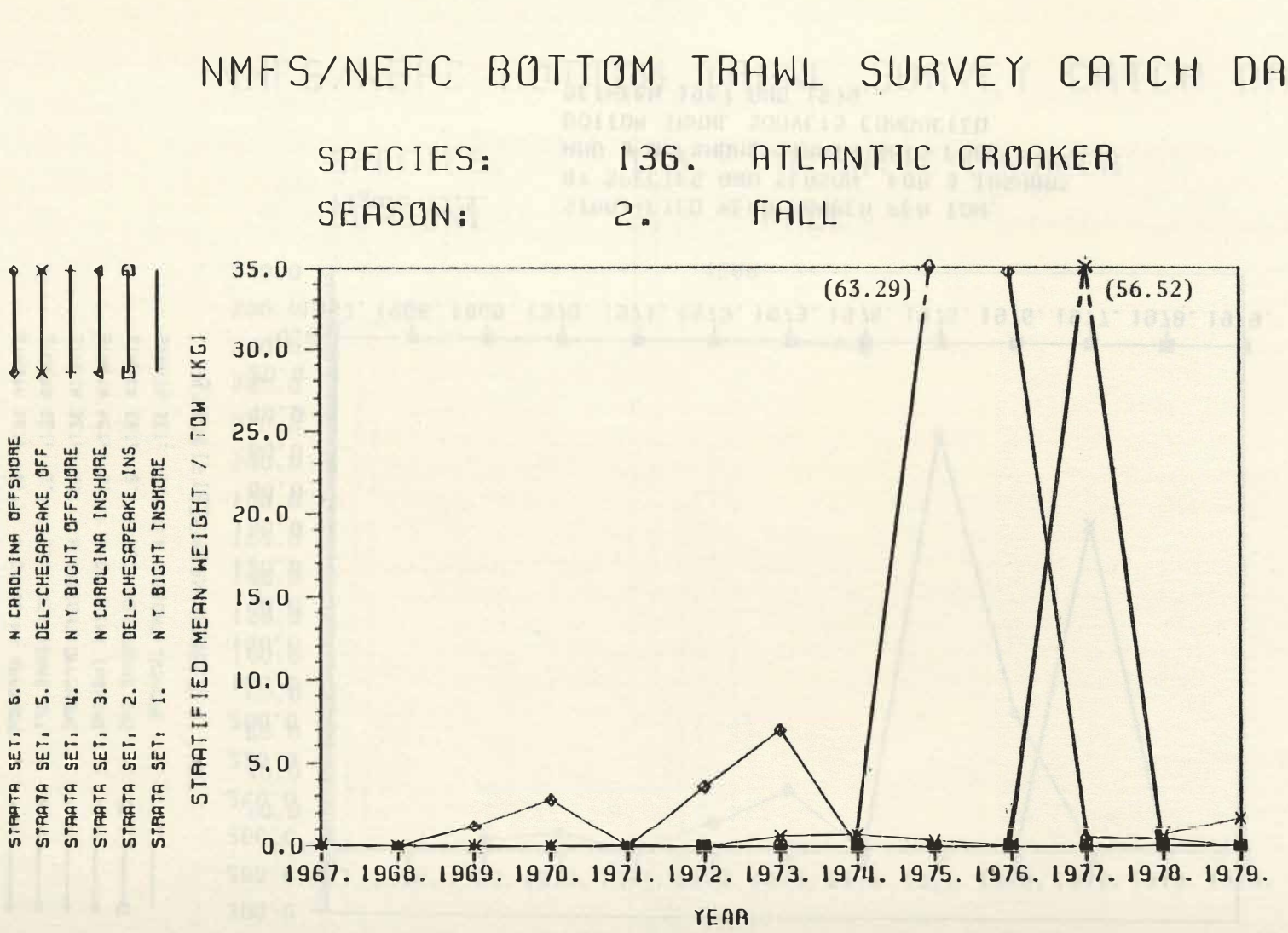


Figure 13.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

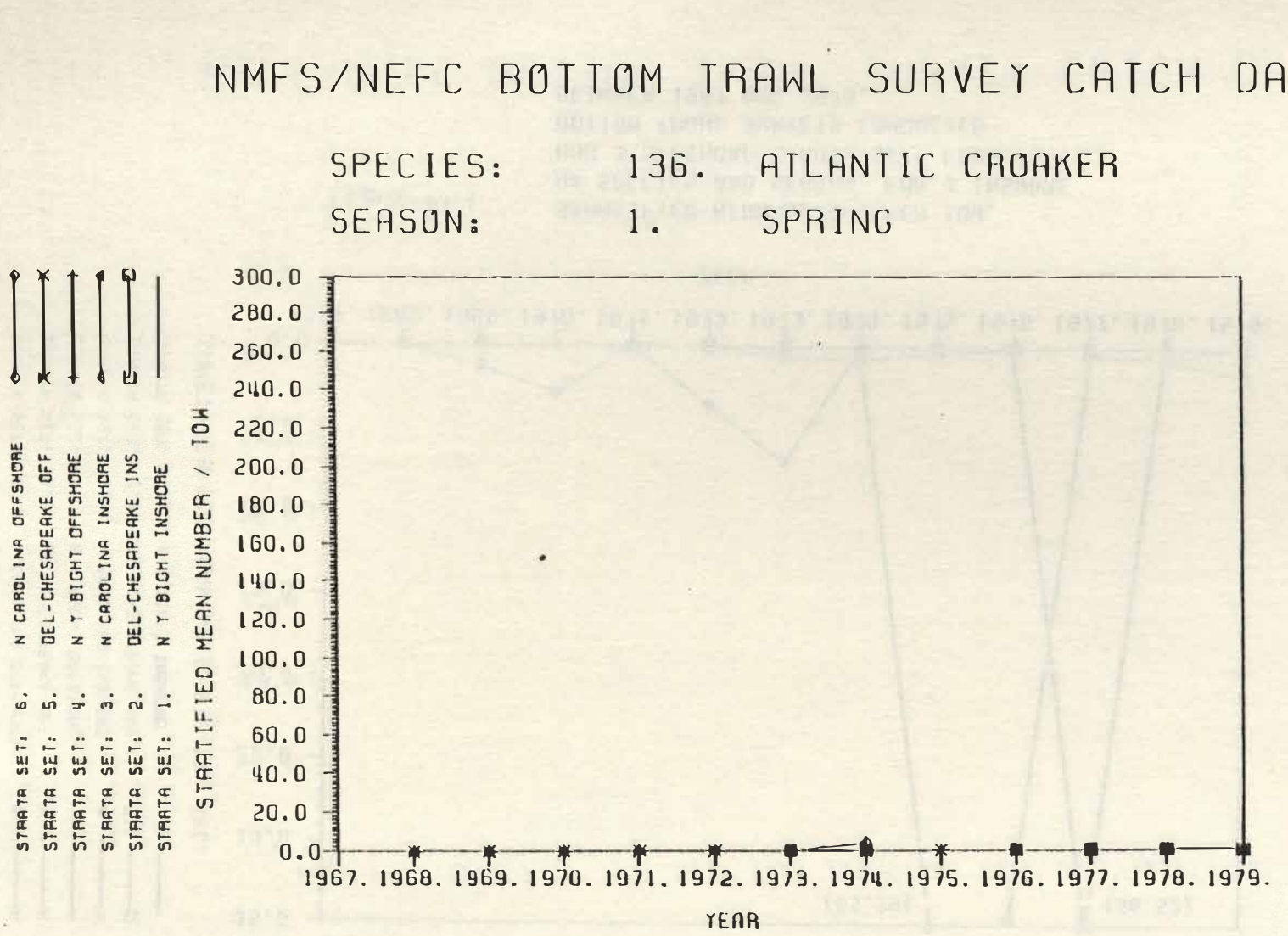


Figure 13.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

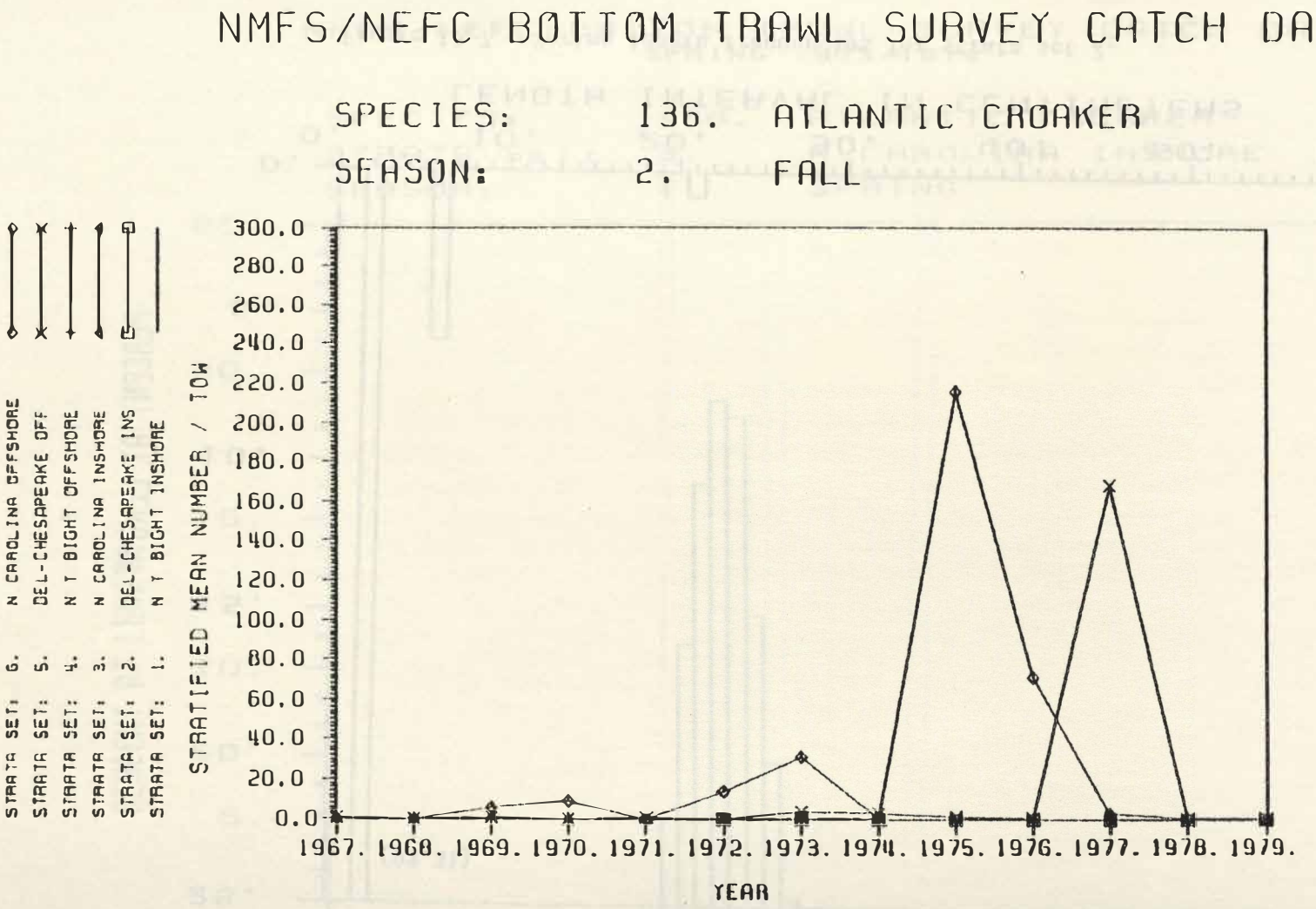


Figure 13.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

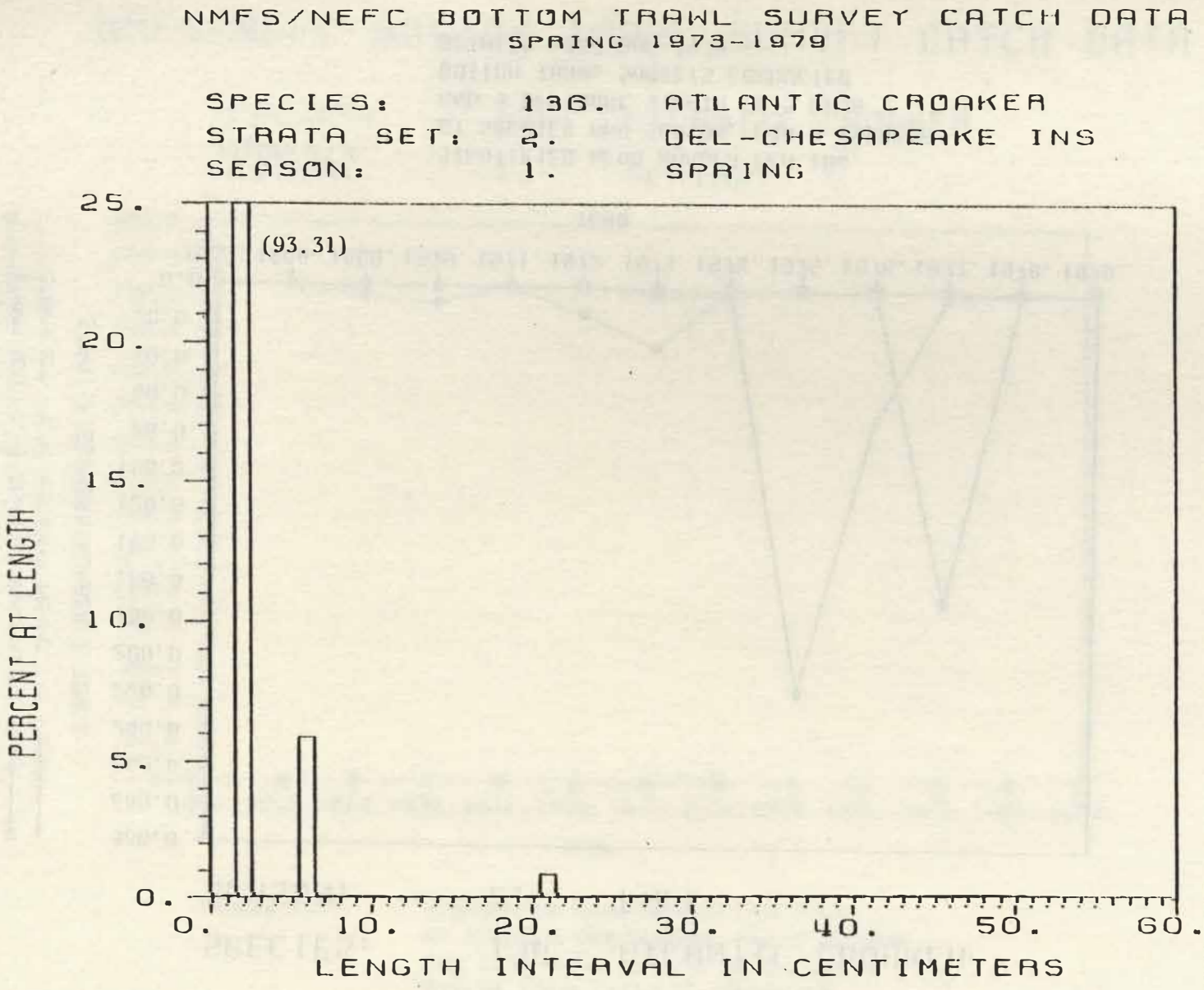


Figure 13.7. Spring length frequencies for strata set 2.

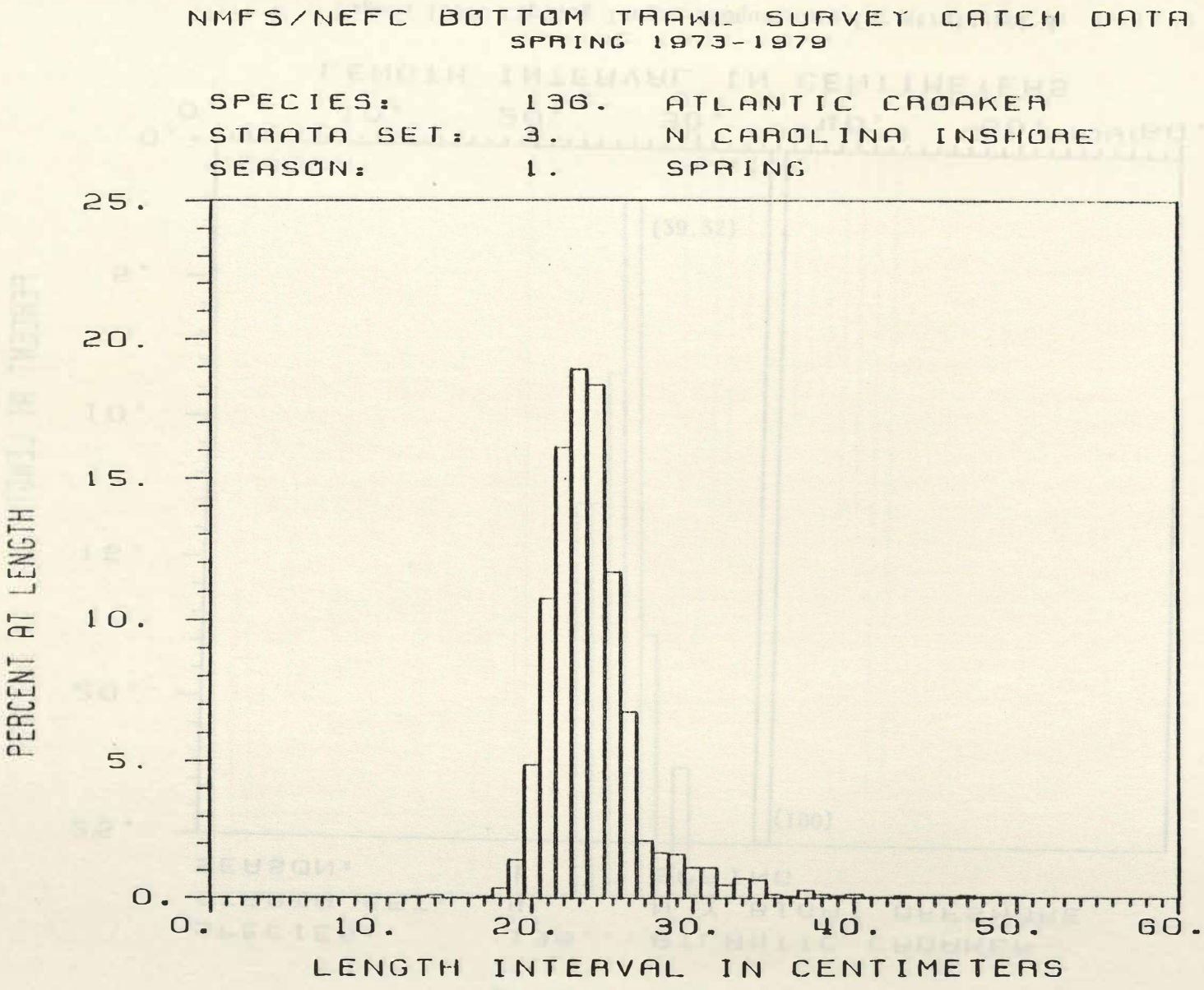


Figure 13.8. Spring length frequencies for strata set 3.

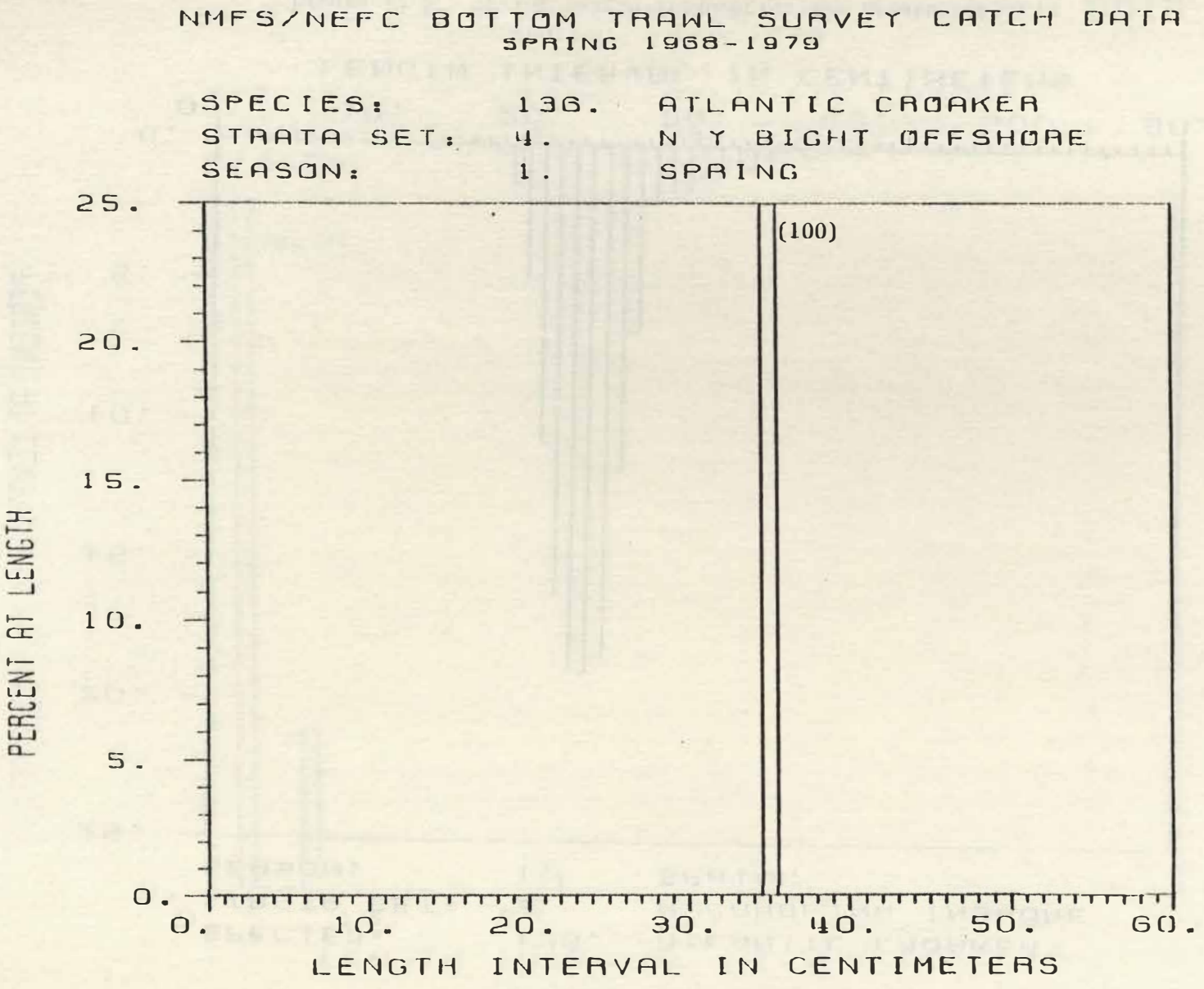


Figure 13.9. Spring length frequencies for strata set 4.

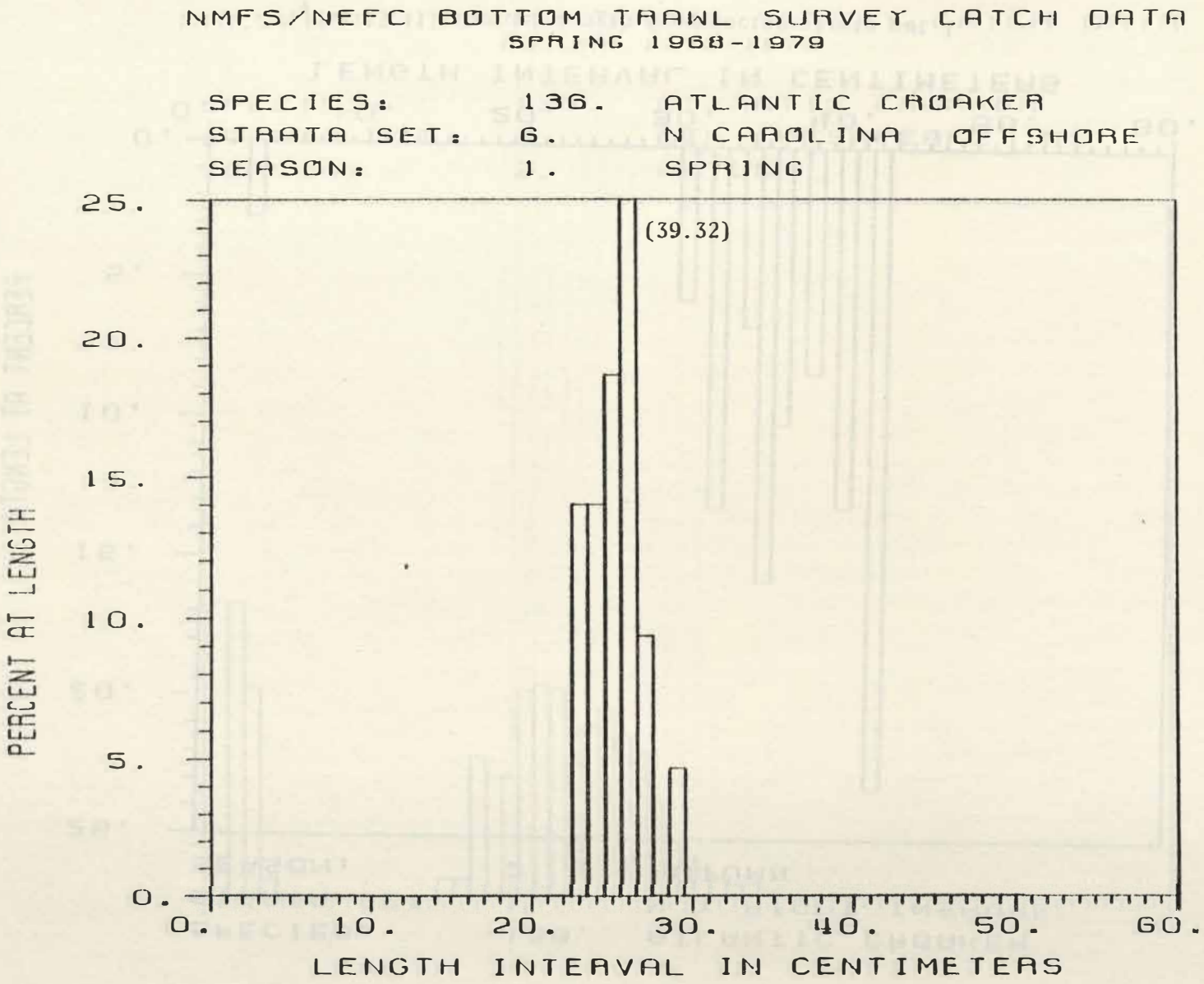


Figure 13.10. Spring length frequencies for strata set 6.

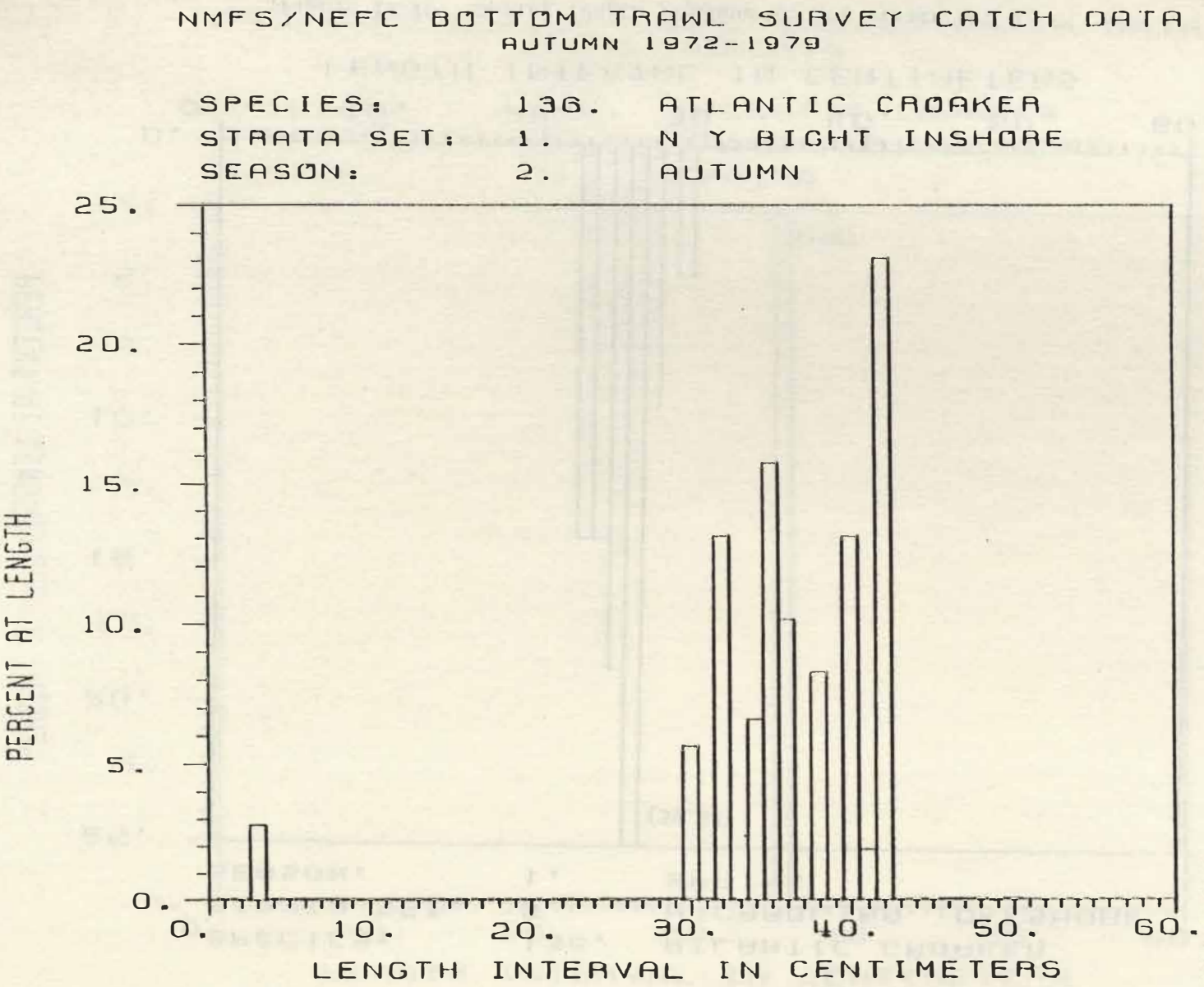


Figure 13.11. Autumn length frequencies strata set 1.

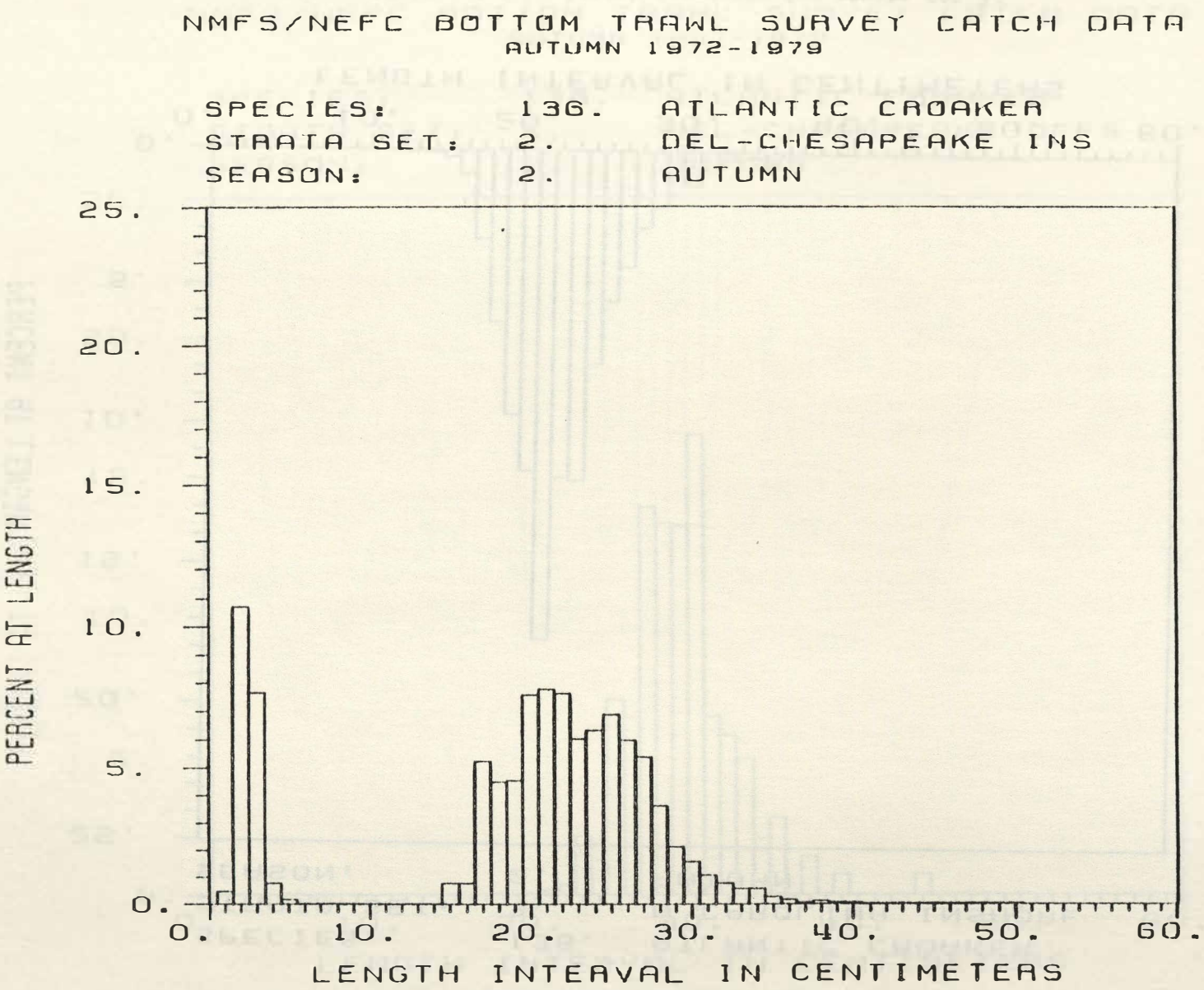


Figure 13.12. Autumn length frequencies for strata set 2.

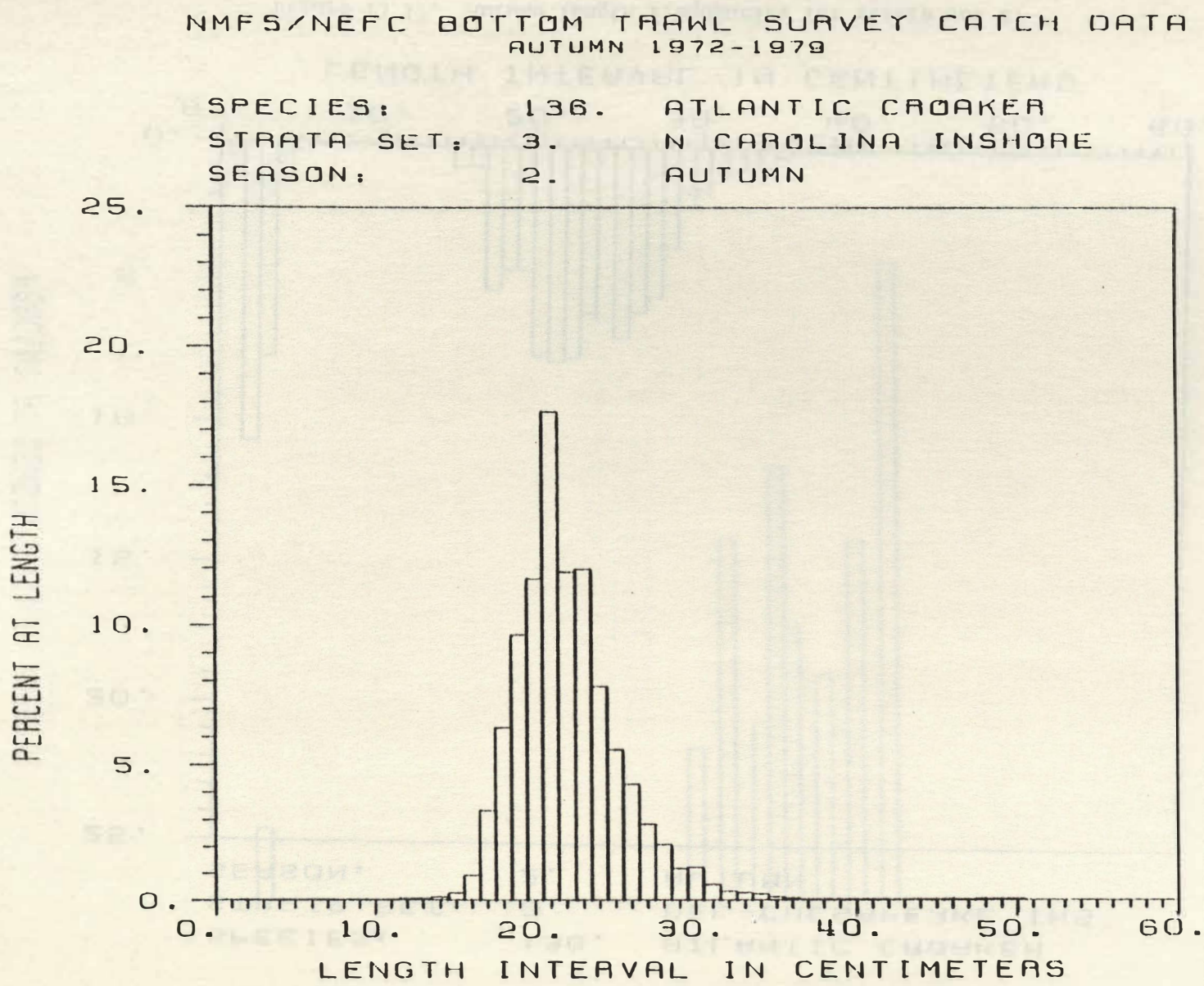


Figure 13.13. Autumn length frequency for strata set 3.

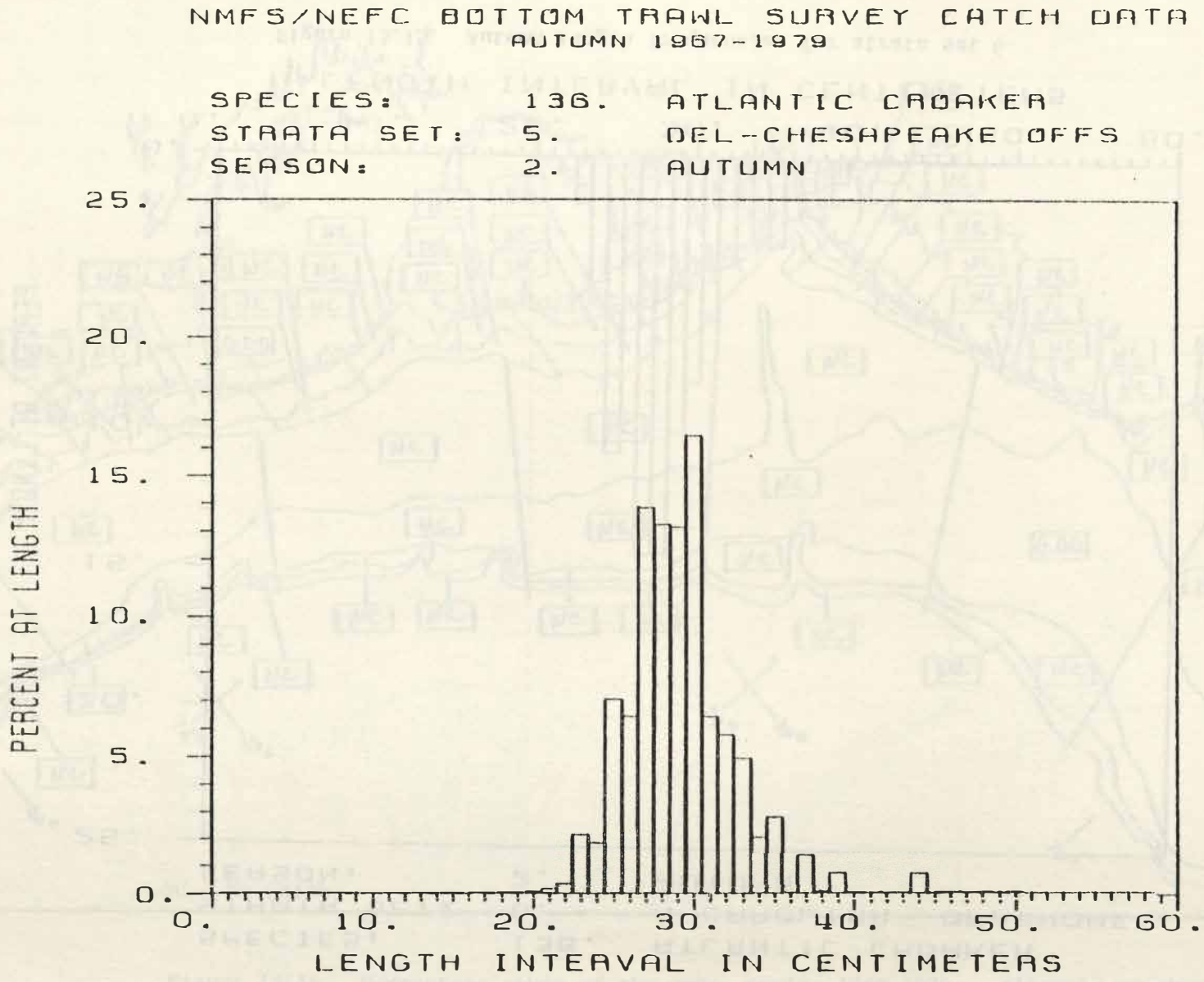


Figure 13.14. Autumn length frequencies for strata set 5.

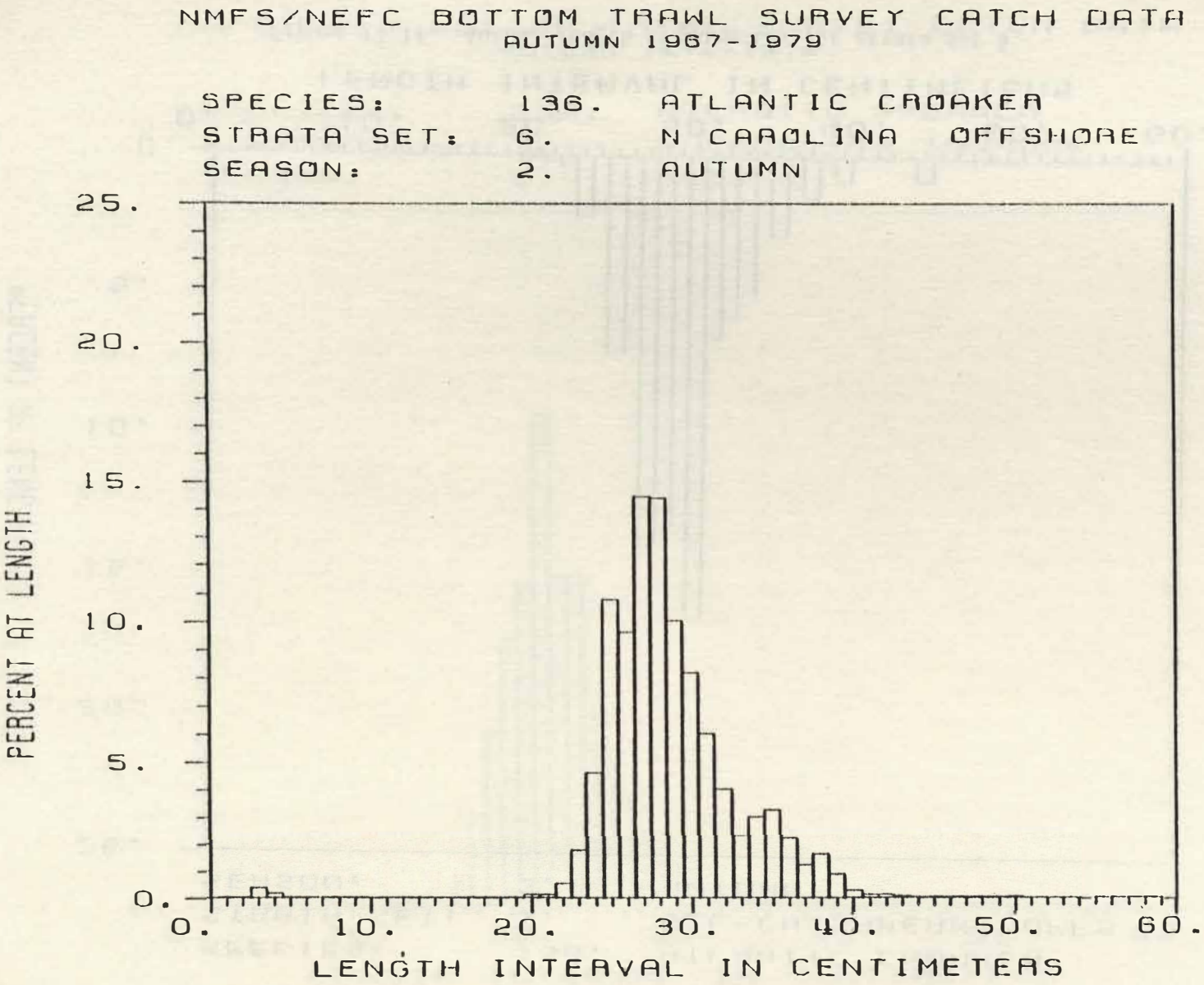


Figure 13.15. Autumn length frequencies for strata set 6.

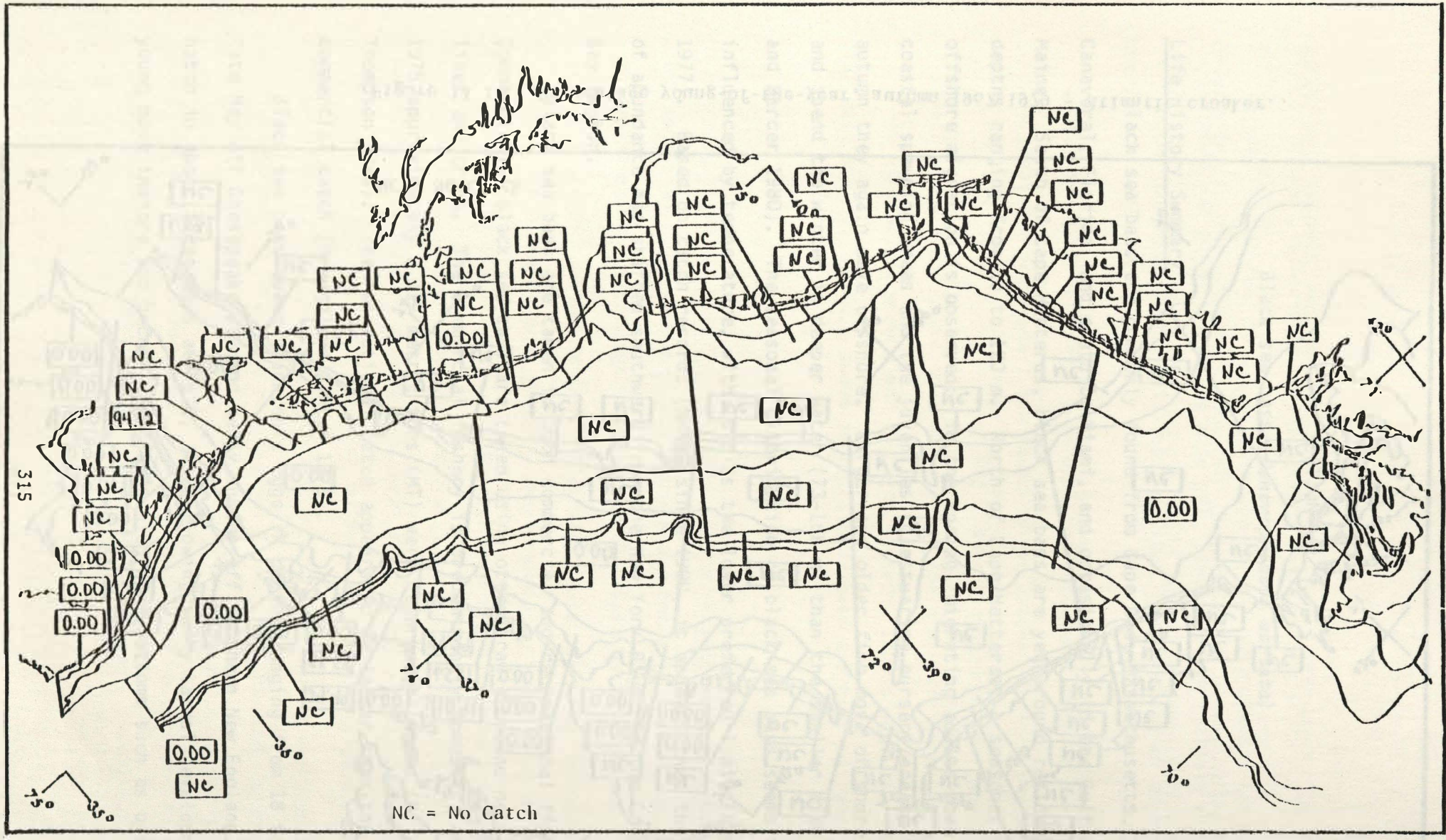


Figure 13.16. Percentage young-of-the year, spring 1968-1979 - Atlantic croaker.

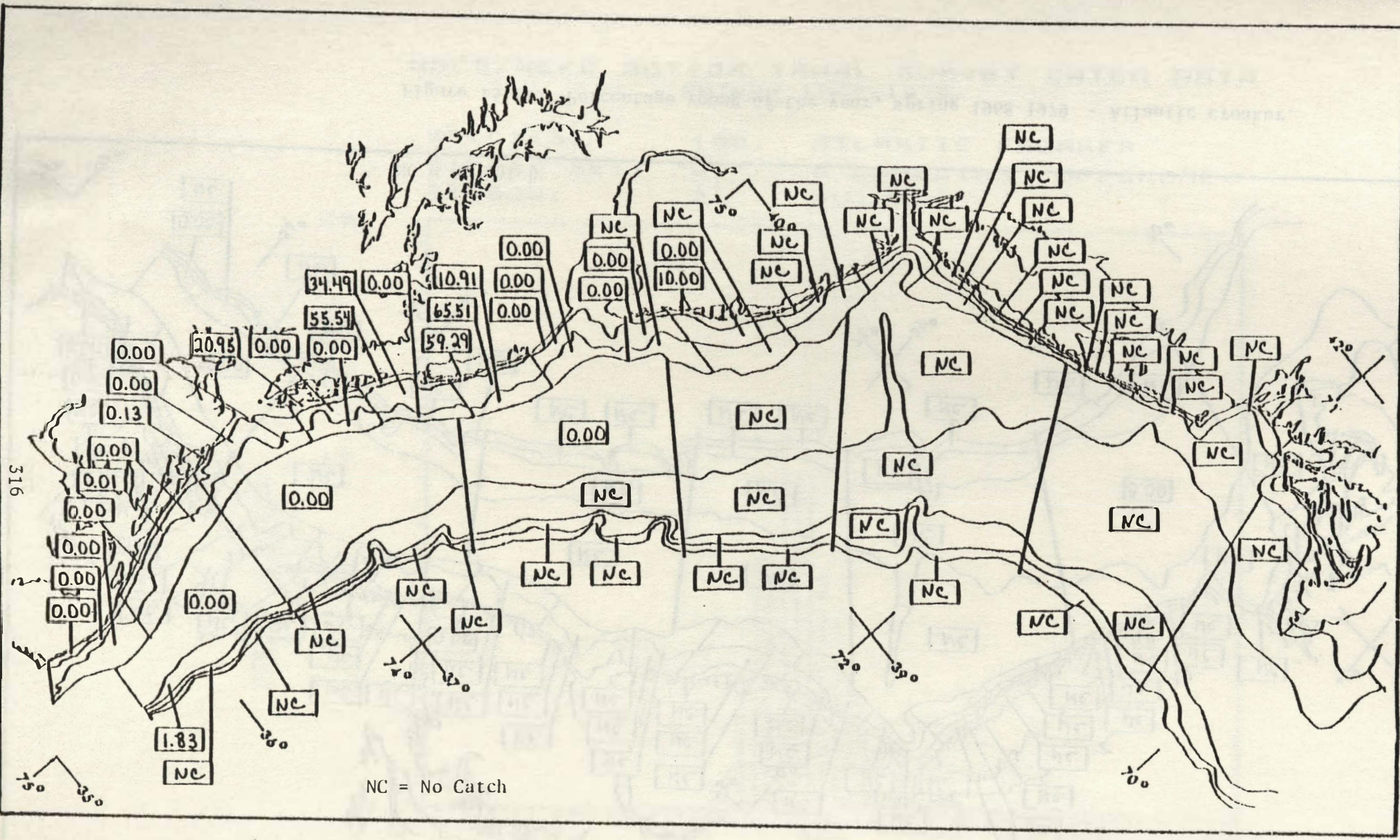


Figure 13.17. Percentage young-of-the-year, autumn 1967-1979 - Atlantic croaker.

SECTION 14

Black sea bass (*Centropristis striata*)

Life History Summary

Black sea bass are commonly found from Cape Cod, Massachusetts, to Cape Canaveral, Florida, and south to Miami, and occasionally in the Gulf of Maine. South of Cape Hatteras, black sea bass are year-round residents in depths ranging from 10 to 120 m. North of Cape Hatteras, a seasonal inshore-offshore migration is observed: in the spring, migrating adults move to their coastal spawning areas and the juveniles to estuarine nursery areas; in late autumn they again move offshore. Larger and older fish move offshore sooner and spend the winter in deeper water (73-165 m) than the smaller fish (Kendall and Mercer 1980). The seasonal distribution of black sea bass seems to be influenced by temperature, with 10°C as the lower preferred limit (Kendall 1977). Based on catch records (NMFS) since 1900, it appears that their center of abundance has shifted southward from the New York Bight to the Chesapeake Bay region.

Black sea bass are taken in both commercial and recreational fisheries. Commercially, black sea bass are taken using otter trawls, pound nets, hand lines and traps. The commercial fishery is predominantly domestic, and during 1975 approximately 2,319 metric tons (MT) were reportedly landed (Pileggi and Thompson 1978). The recreational catch appears to be larger than the commercial catch (McHugh and Ginter 1978).

Black sea bass spawn planktonic eggs in depths ranging from 18 to 45 m in late May off Chesapeake Bay and early summer off southern New England. Eggs hatch in about three days at 16°C, and following early larval development, the young move inshore and become associated with hard bottoms such as oyster beds

(Kendall 1977). Black sea bass are protogynous hermaphrodites, beginning life as females and transforming into males, but the sex of individuals remains functionally distinct at all times. The size and age at which sex reversal takes place is variable, but it usually takes place after spawning in the autumn.

Black sea bass are omnivores and feed on a variety of fish, molluscs, echinoderms and plants. Adults prefer crabs and fish, while the young eat shrimp, isopods and amphipods (Kendall 1977).

Based on commercial landings between 1962 and 1972, there was a steady decrease in the population. However, by 1975 there were indications of recovery, and the landings have stabilized at about 2,000 MT for the last half of the decade.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 14.1 and 14.2. These plots are generally representative of what is known of black sea bass distribution and movements. The spring distribution shows the fish concentrated offshore along the 100 m contour. If the spring data were gathered more synoptically, the inshore concentration, as indicated in Figure 14.1, would not be nearly so pronounced. In Figure 14.3, data from all cruises prior to 1976 have been deleted and what is considered a more representative spring distribution pattern is evident.

The recovery of sea bass populations since the mid-1970's, indicated in the commercial records, also can be seen in the graphs of mean weight and number per tow (Figures 14.4-14.7).

Length frequencies for six strata sets, arranged by season, are shown in Figures 14.8-14.19. Young black sea bass (<10 cm) were found in all sets

during both seasons, and apparently were distributed over much of the shelf during the winter. Adult fish were caught infrequently inshore in the spring (Figure 14.8), and offshore in the fall (Figure 14.17) in the northern areas. The larger fish caught inshore in the spring (Figure 14.8) were from the late pre-1976 surveys.

Figures 14.20 and 14.21 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were, respectively, 13 and 9 cm for spring and fall series. The high numbers of YOY caught in northern strata during the autumn are an indication of the importance of the northern portions of the Mid-Atlantic to the successful propagation of year-classes.

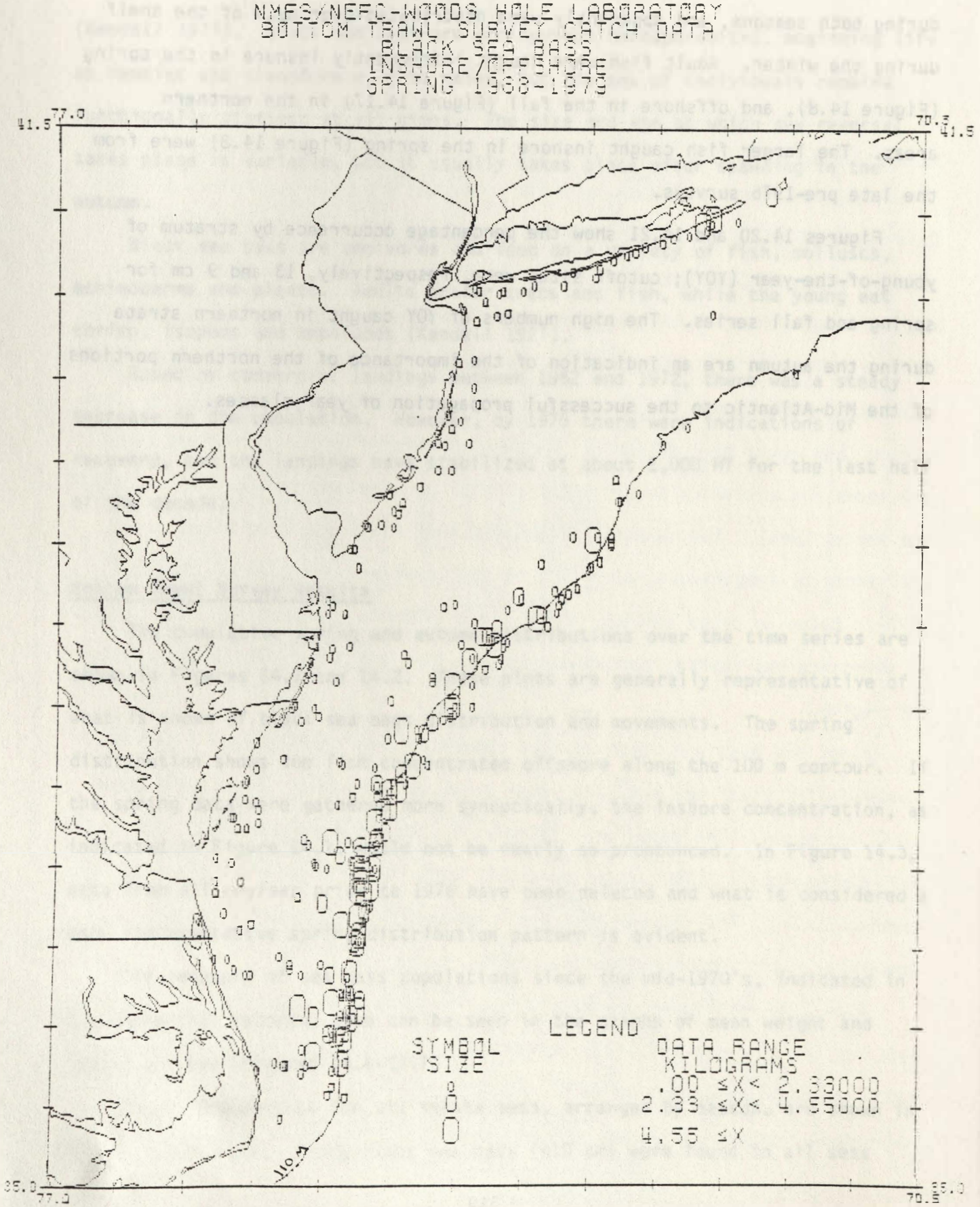


Figure 14.1. Spring distribution, 1968-1979.

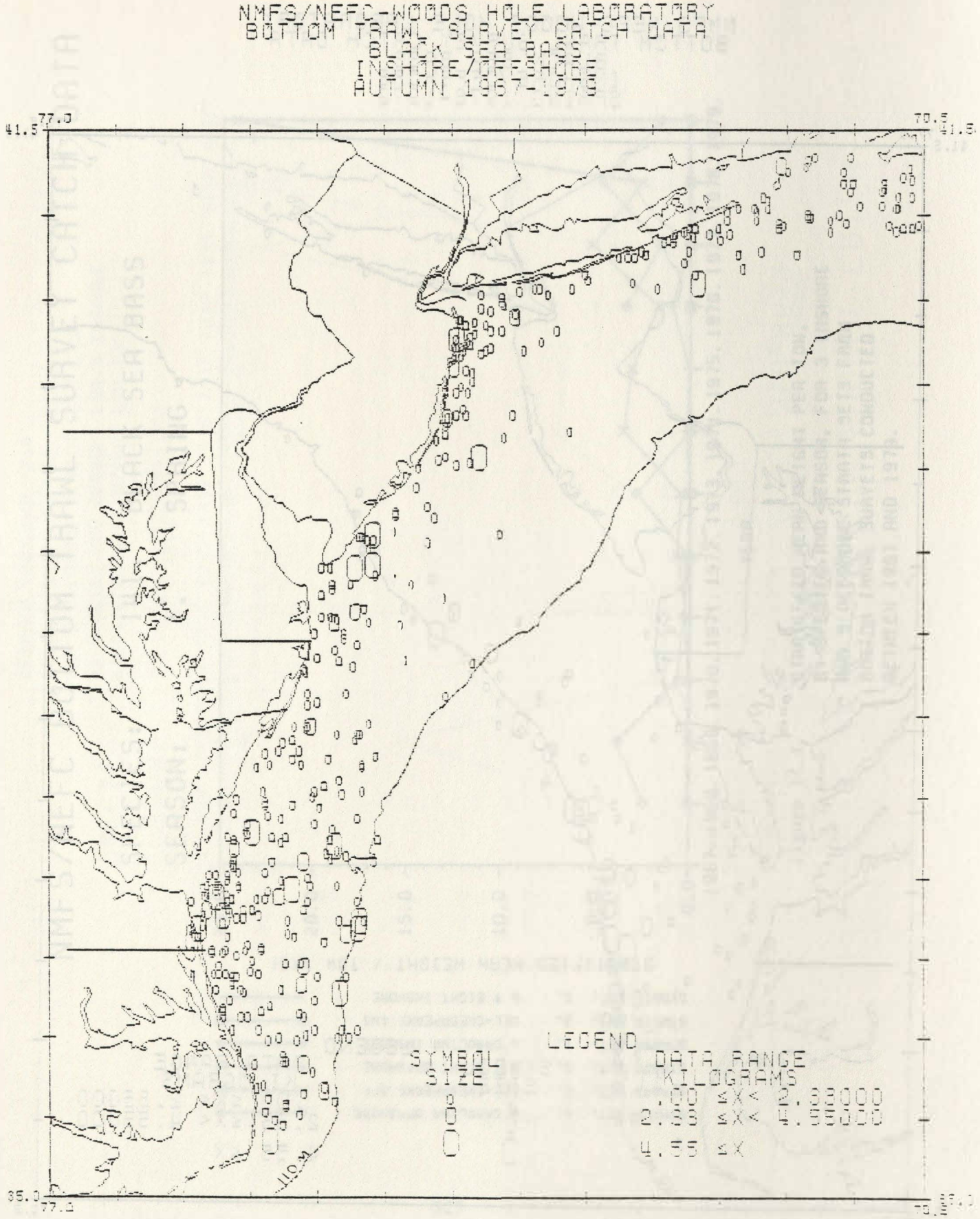


Figure 14.2. Autumn distribution, 1967-1979.

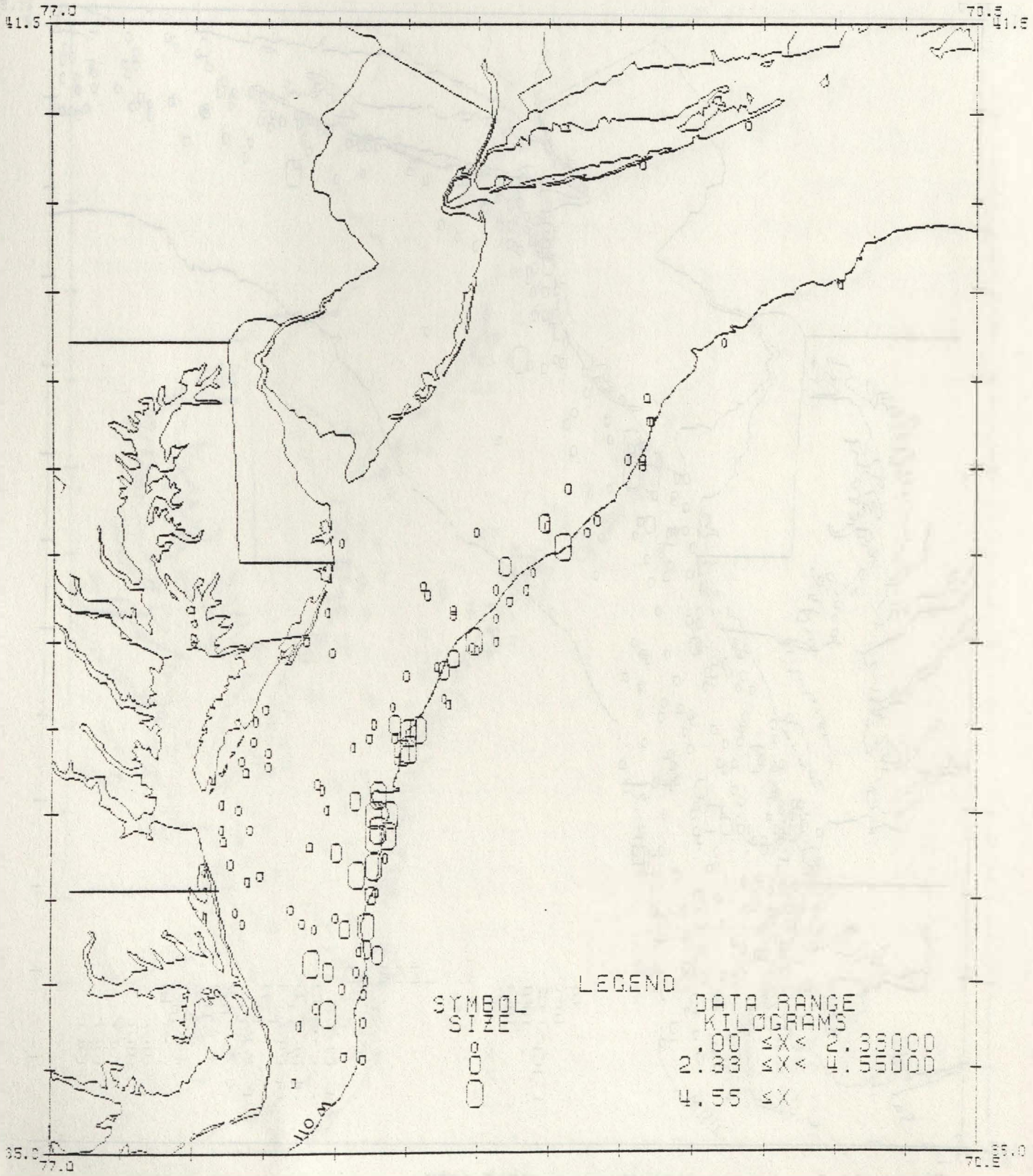


Figure 14.3. Spring distribution, 1976-1979.

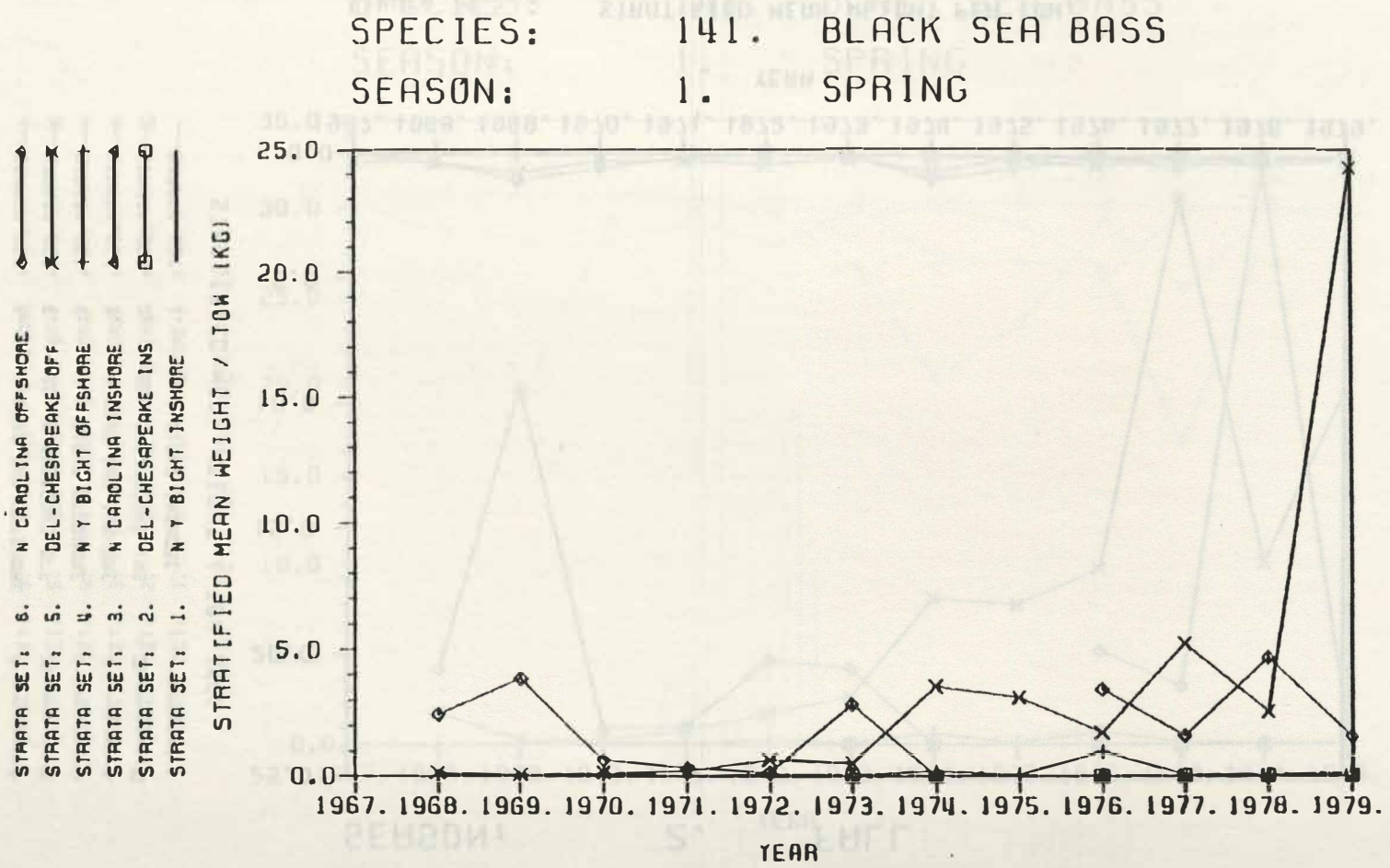


Figure 14.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

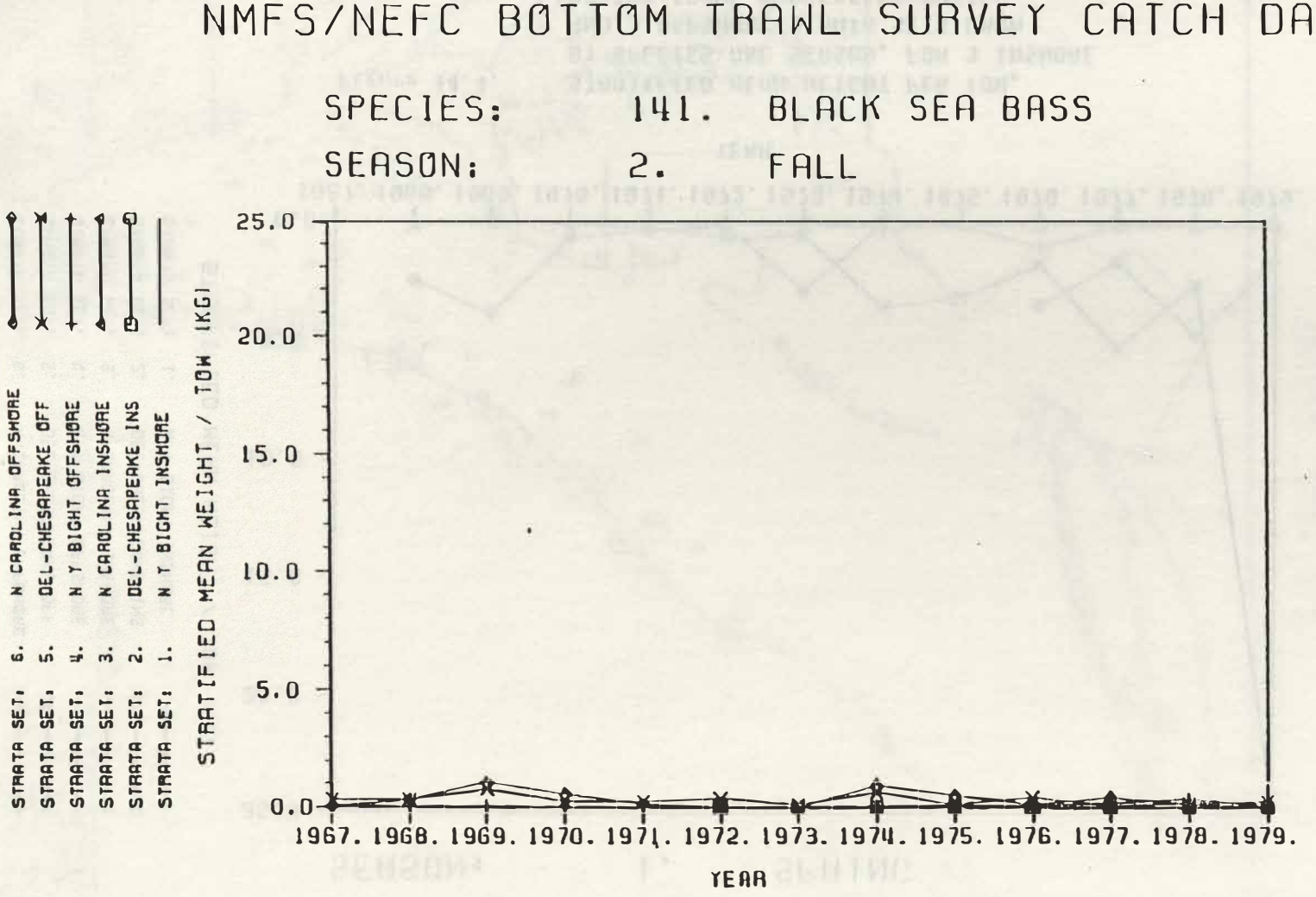


Figure 14.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

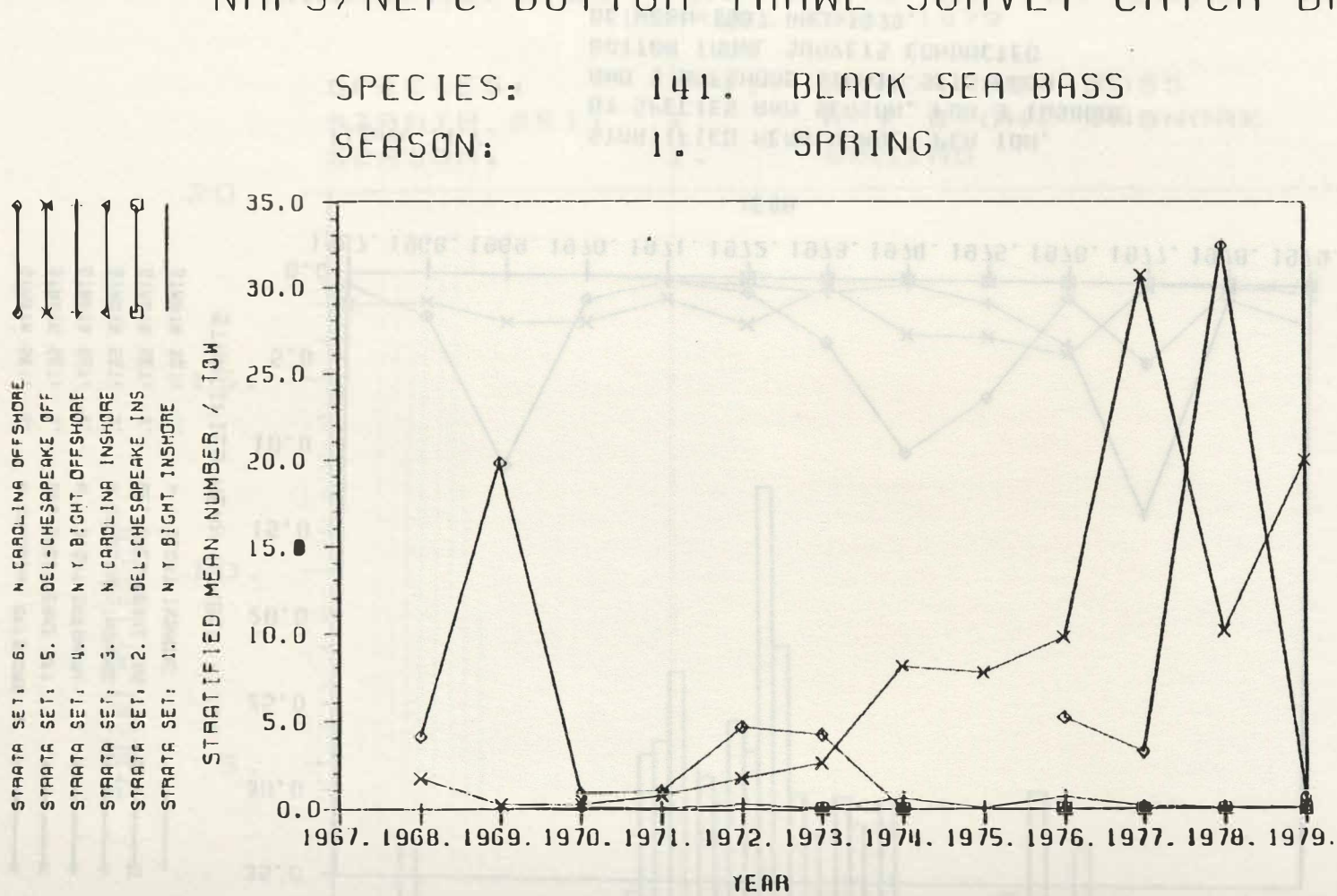


Figure 14.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

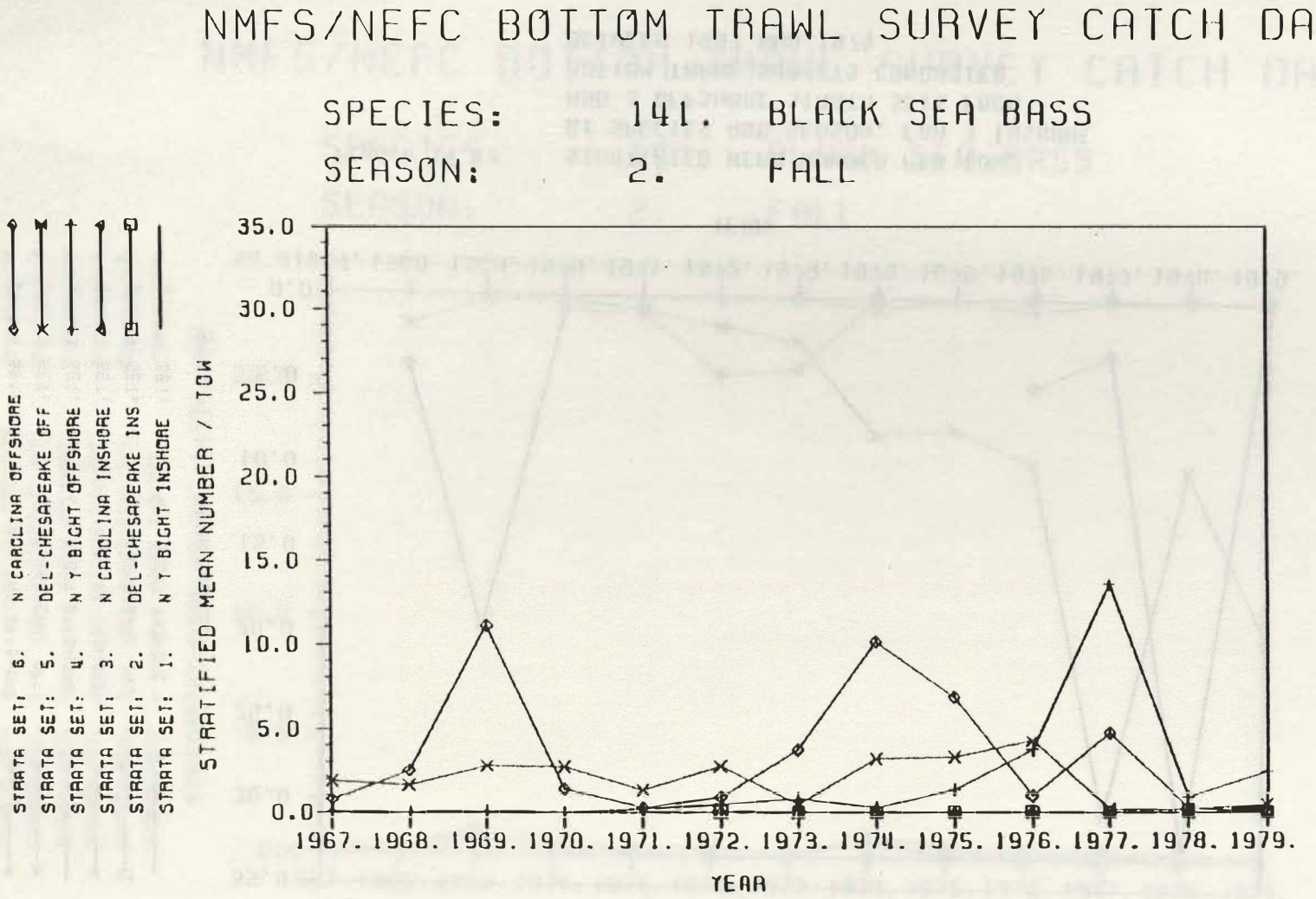


Figure 14.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

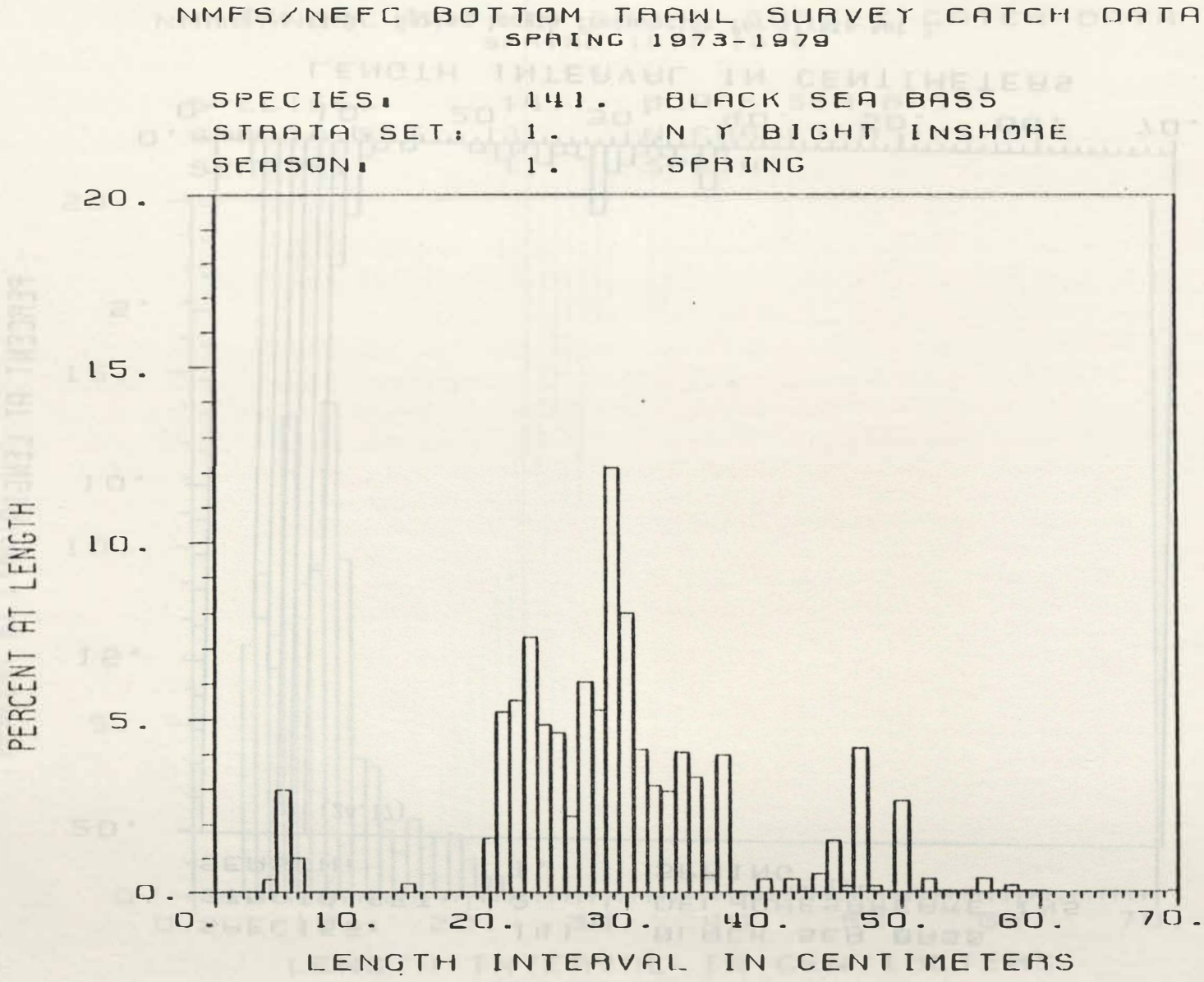


Figure 14.8. Spring length frequencies for strata set 1.

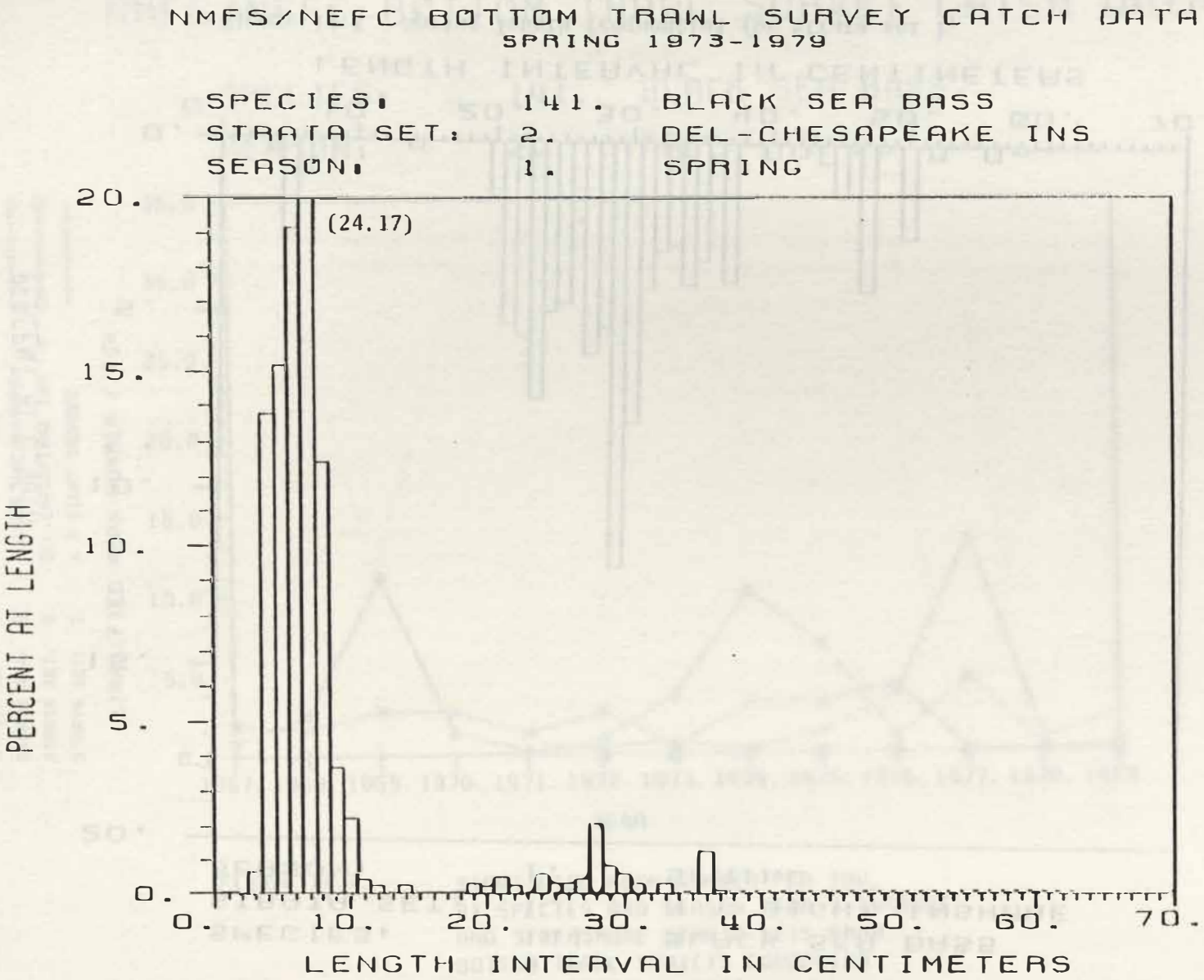


Figure 14.9. Spring length frequencies for strata set 2.

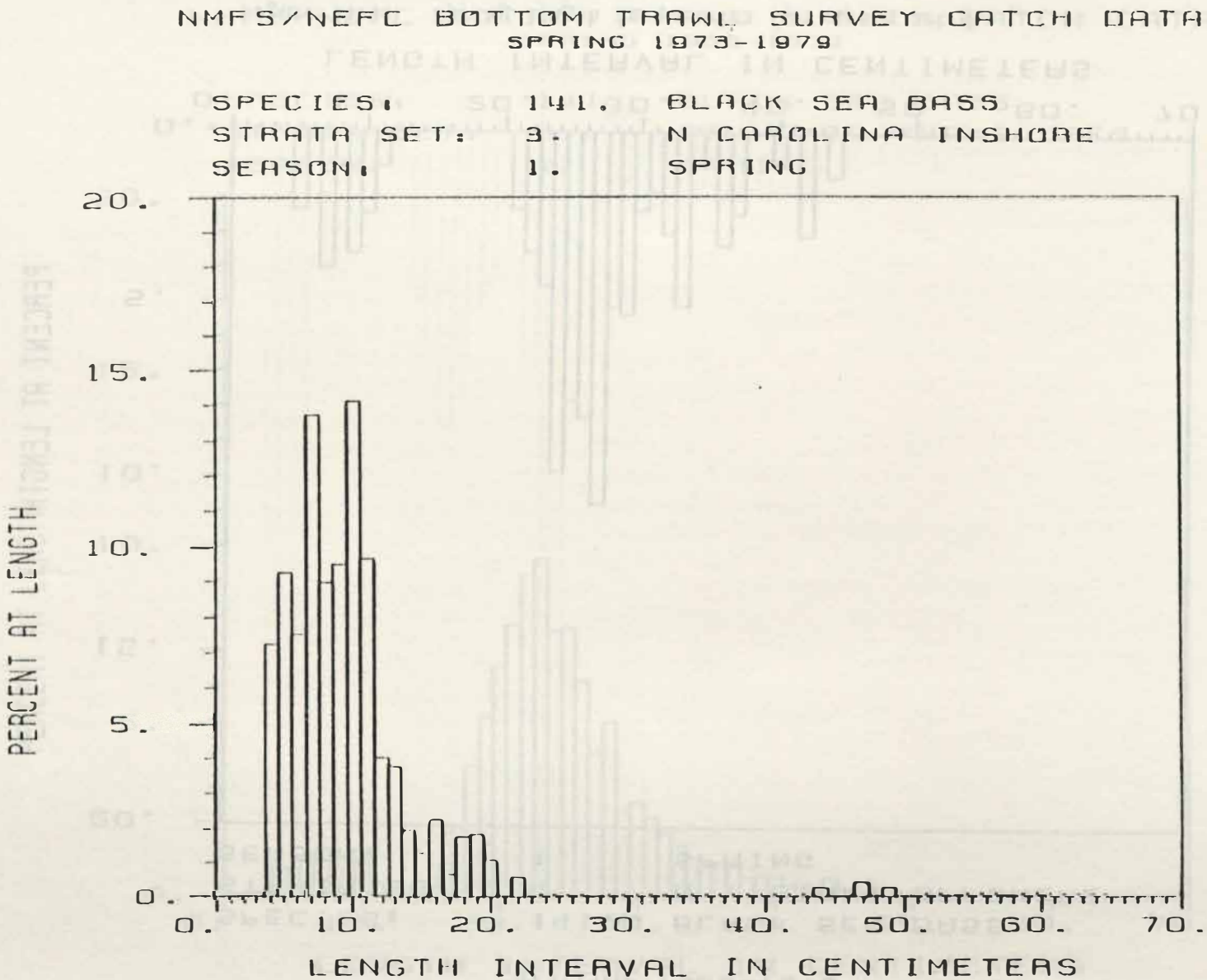


Figure 14.10. Spring length frequencies for strata set 3.

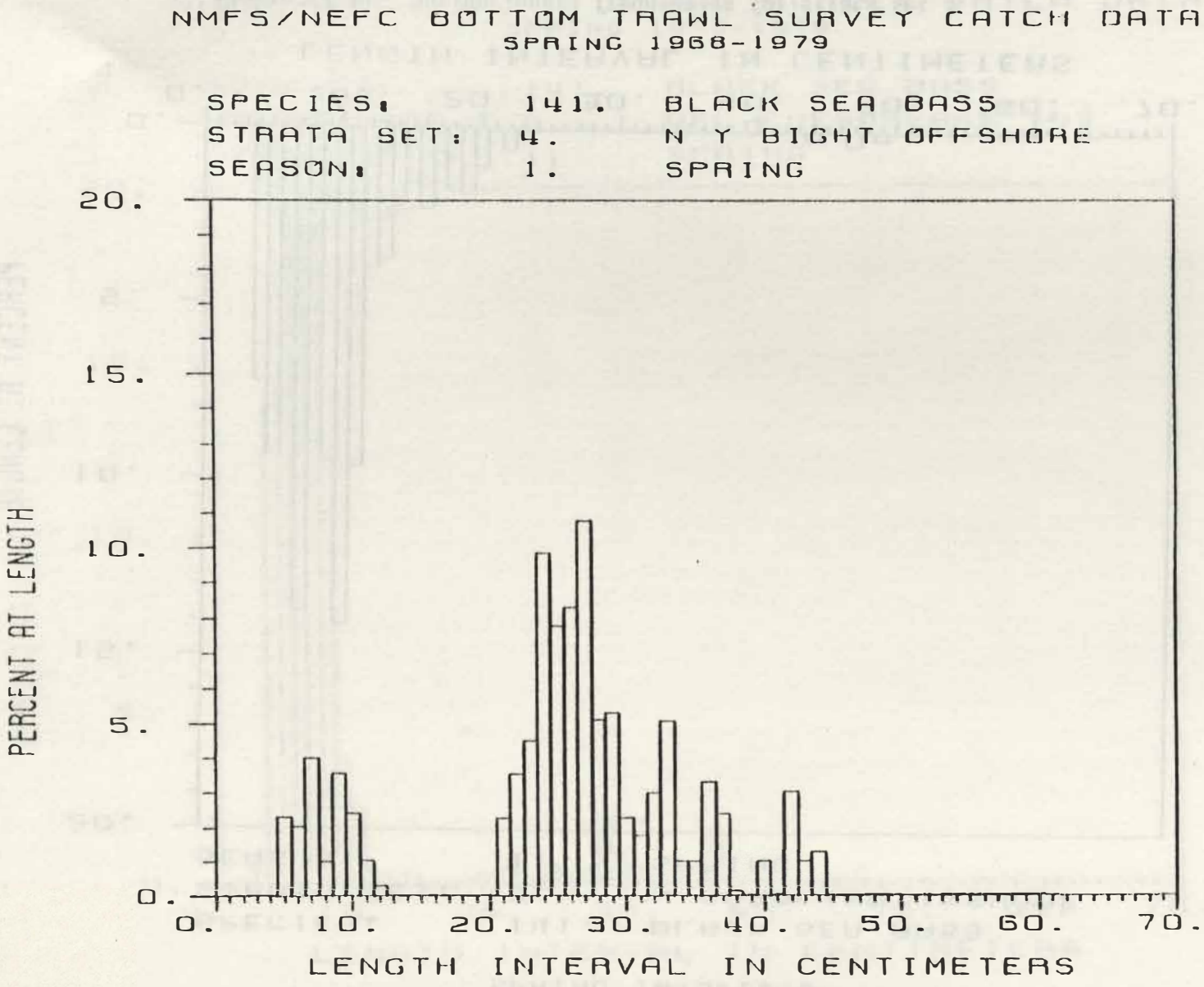


Figure 14.11. Spring length frequencies for strata set 4.

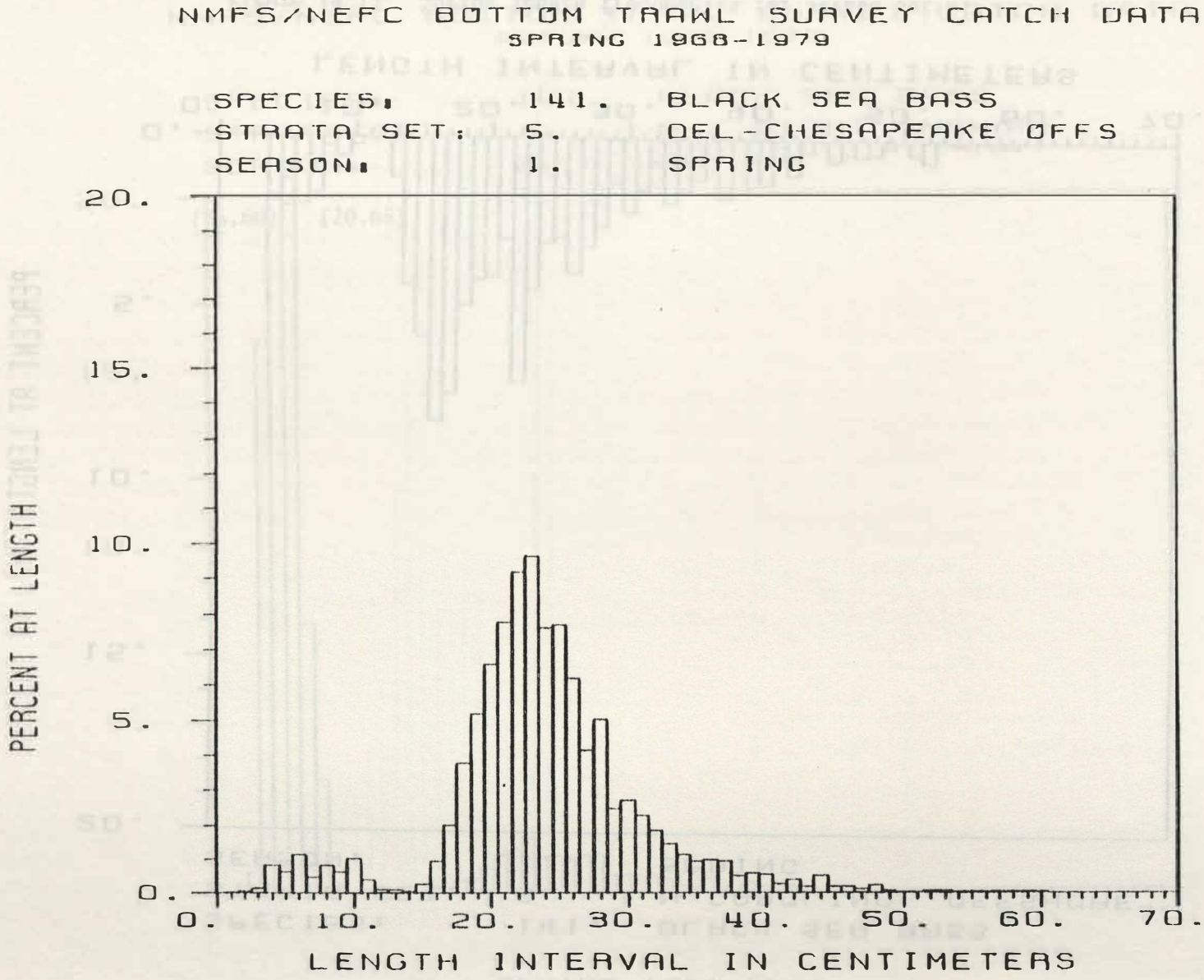


Figure 14.12. Spring length frequencies for strata set 5.

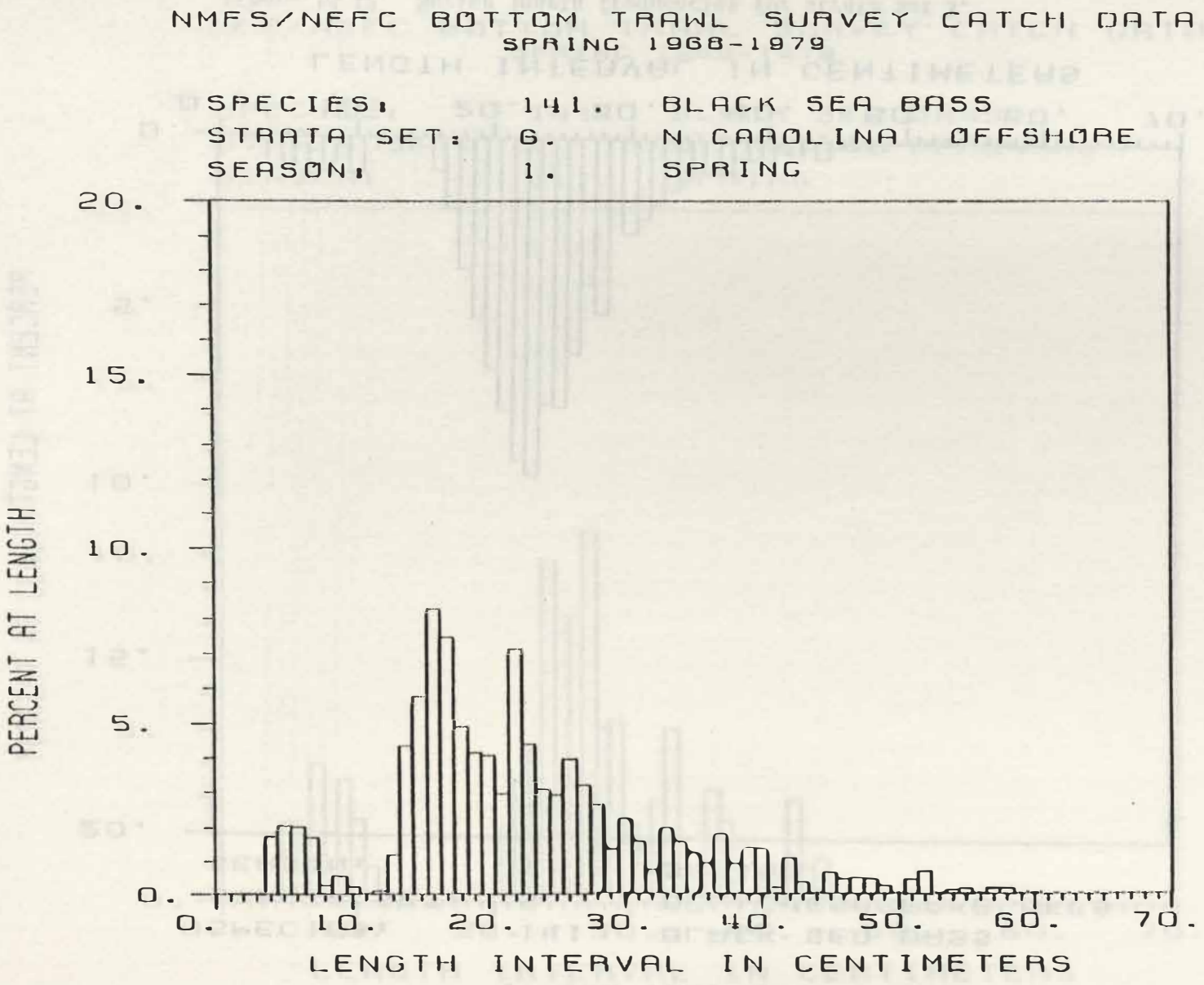


Figure 14.13. Spring length frequencies for strata set 6.

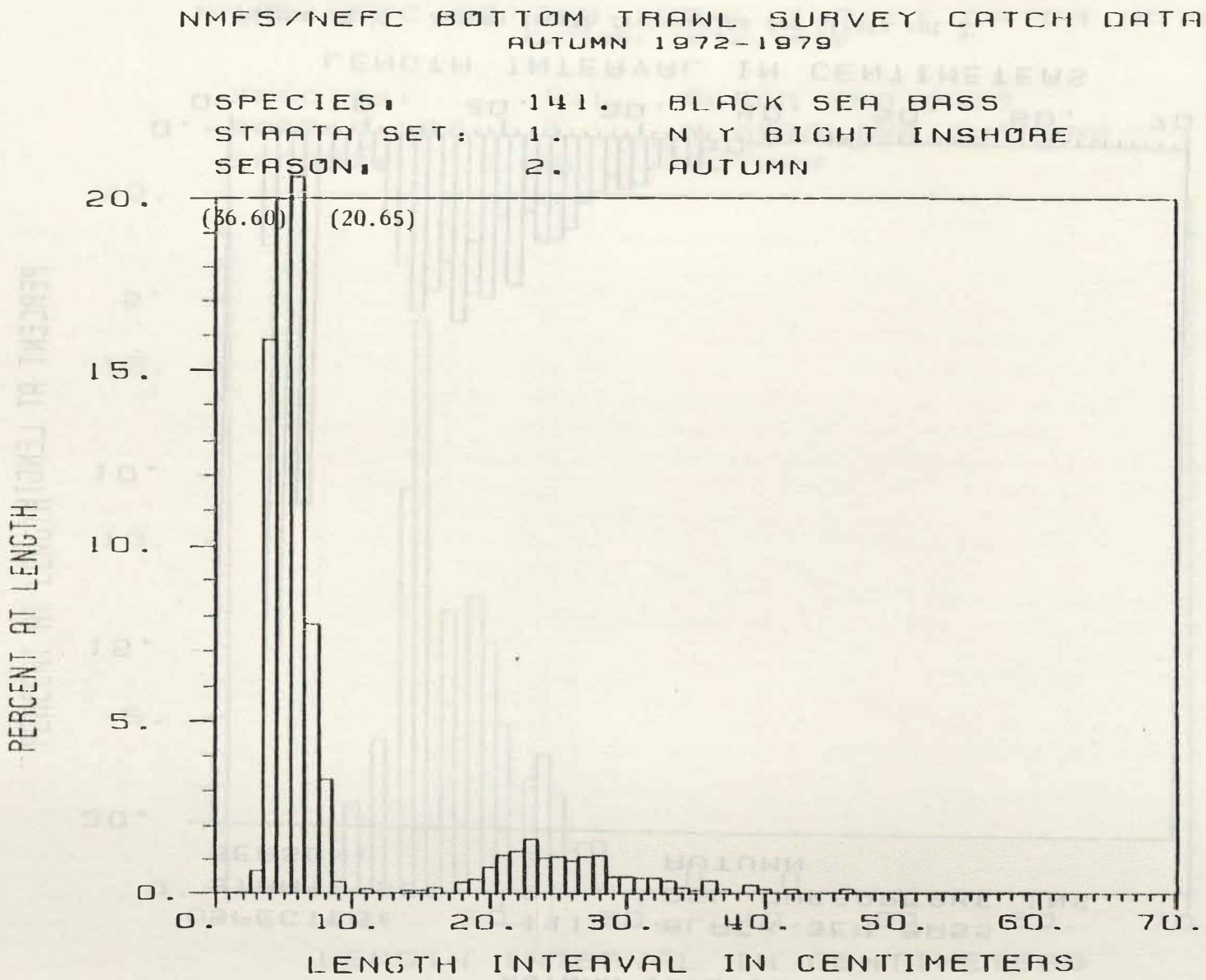


Figure 14.14. Autumn length frequencies for strata set 1.

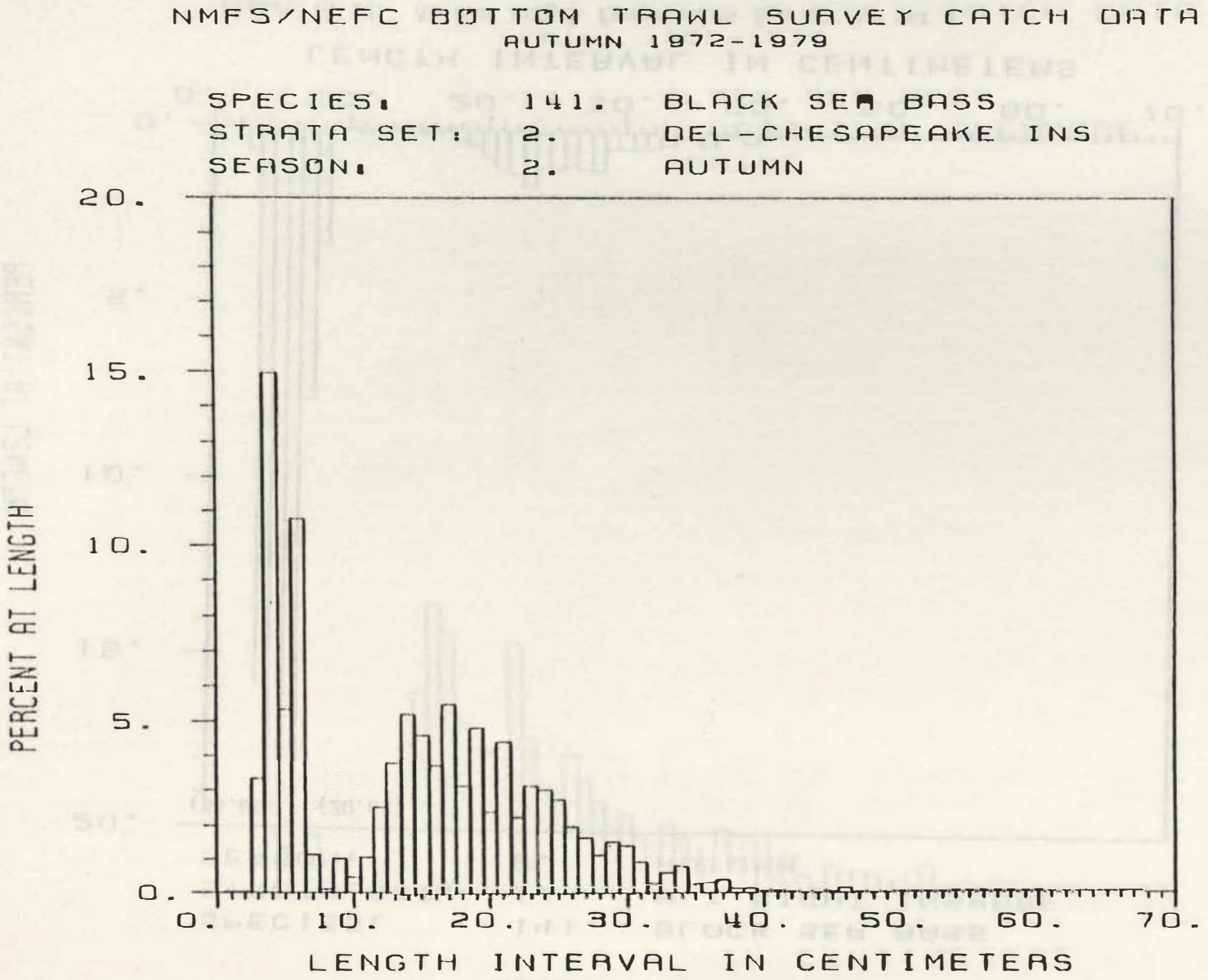


Figure 14.15. Autumn length frequencies for strata set 2.

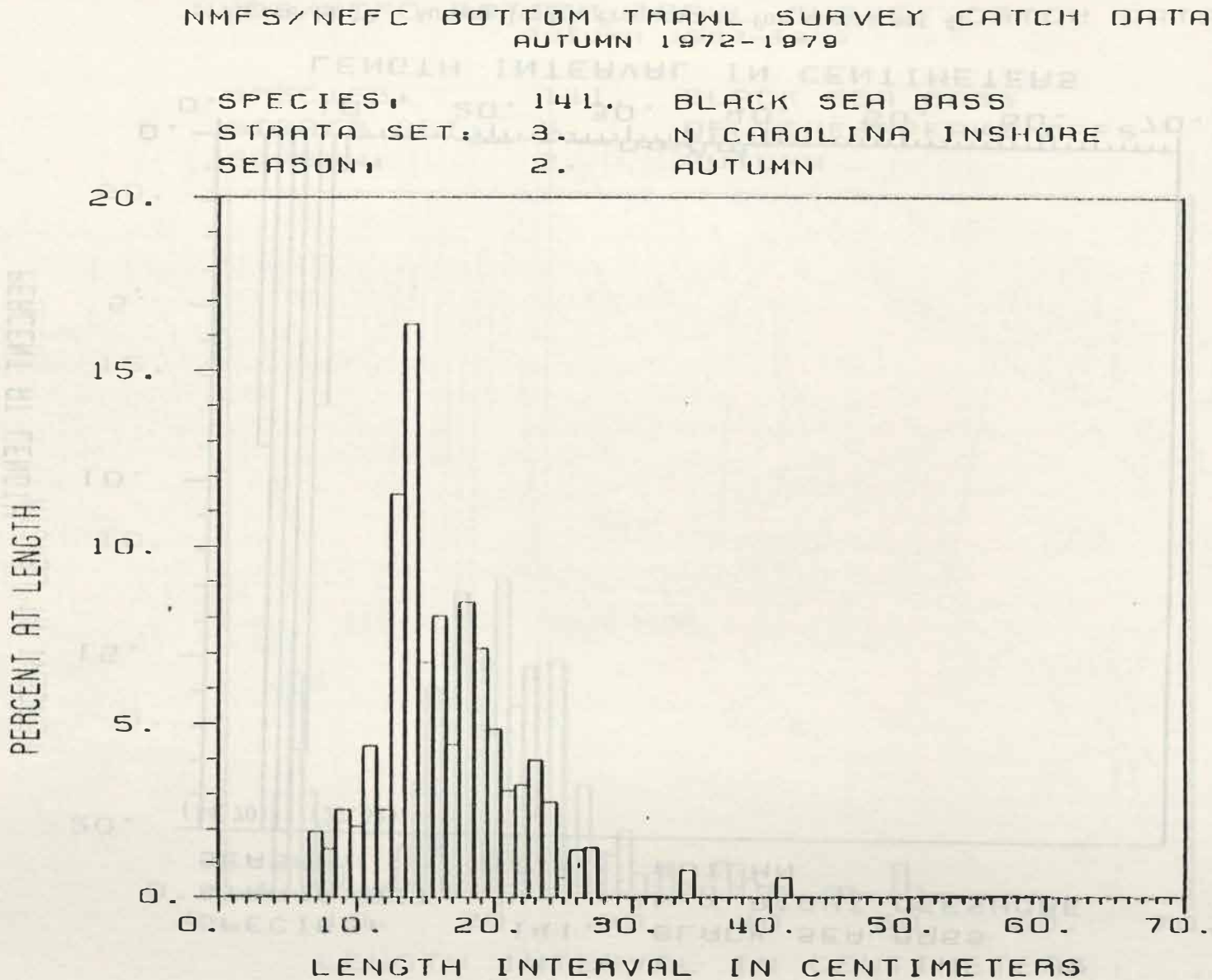


Figure 14.16. Autumn length frequencies for strata set 3.

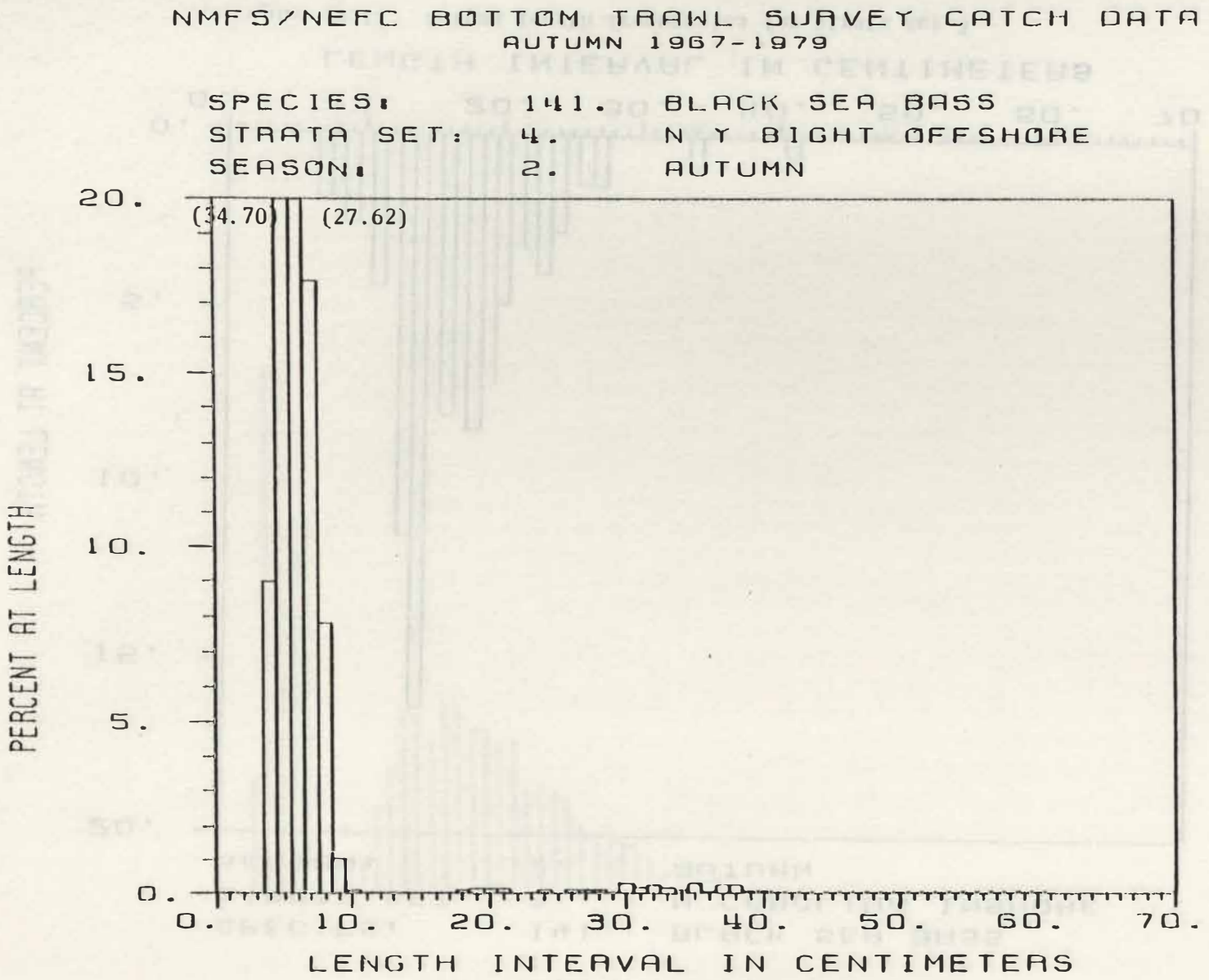


Figure 14.17. Autumn length frequencies for strata set 4.

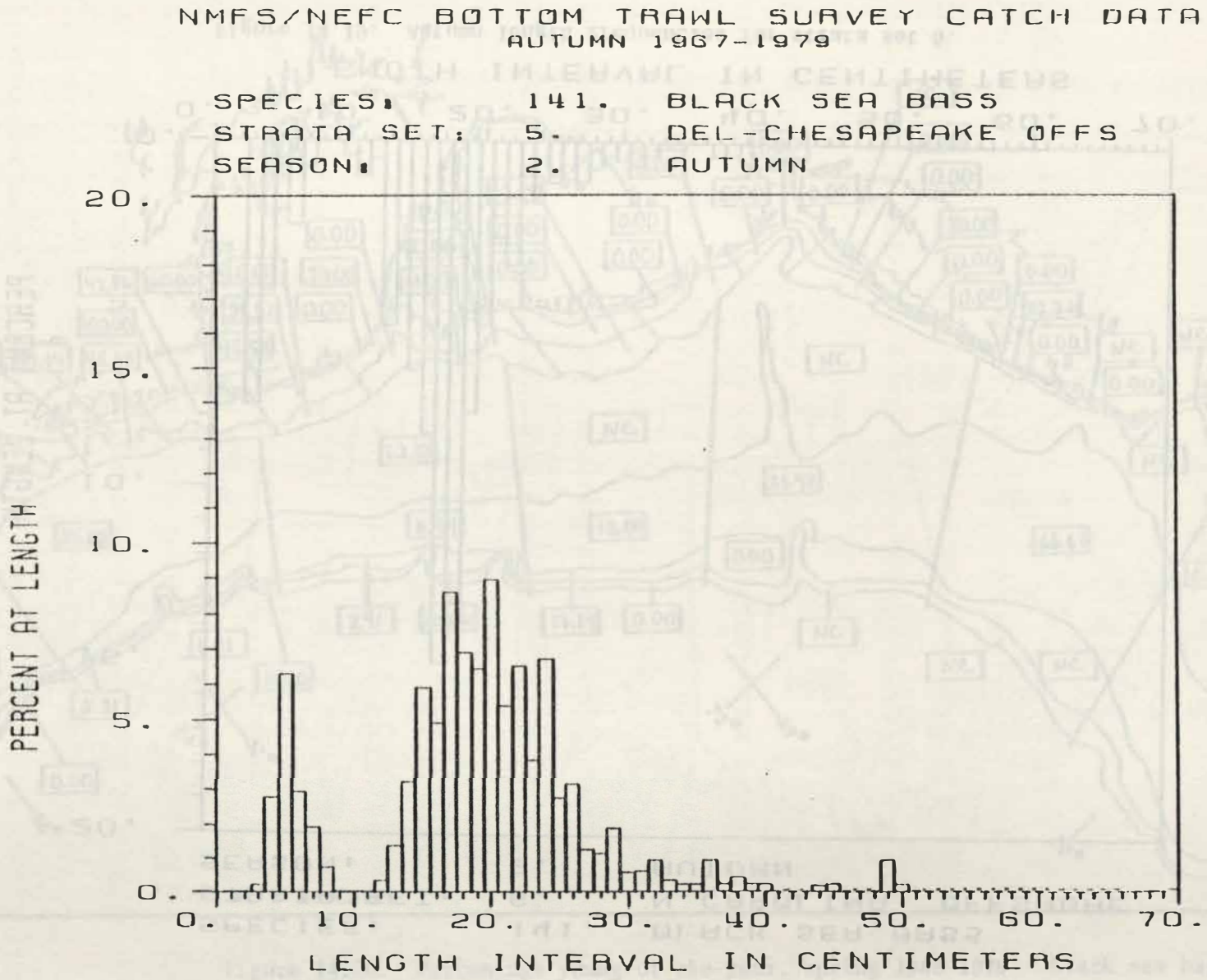


Figure 14.18. Autumn length frequencies for strata set 5.

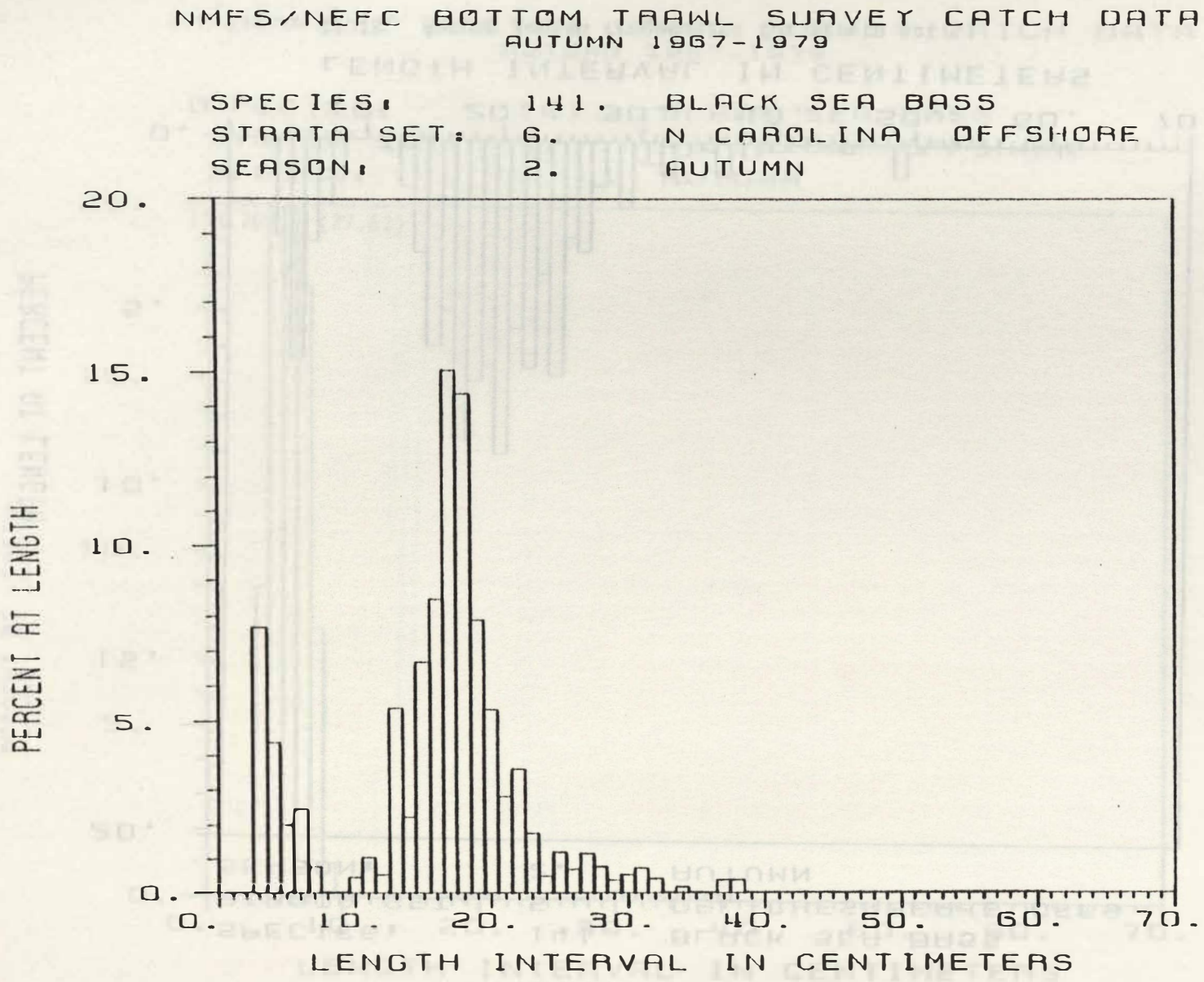


Figure 14.19. Autumn length frequencies for strata set 6.

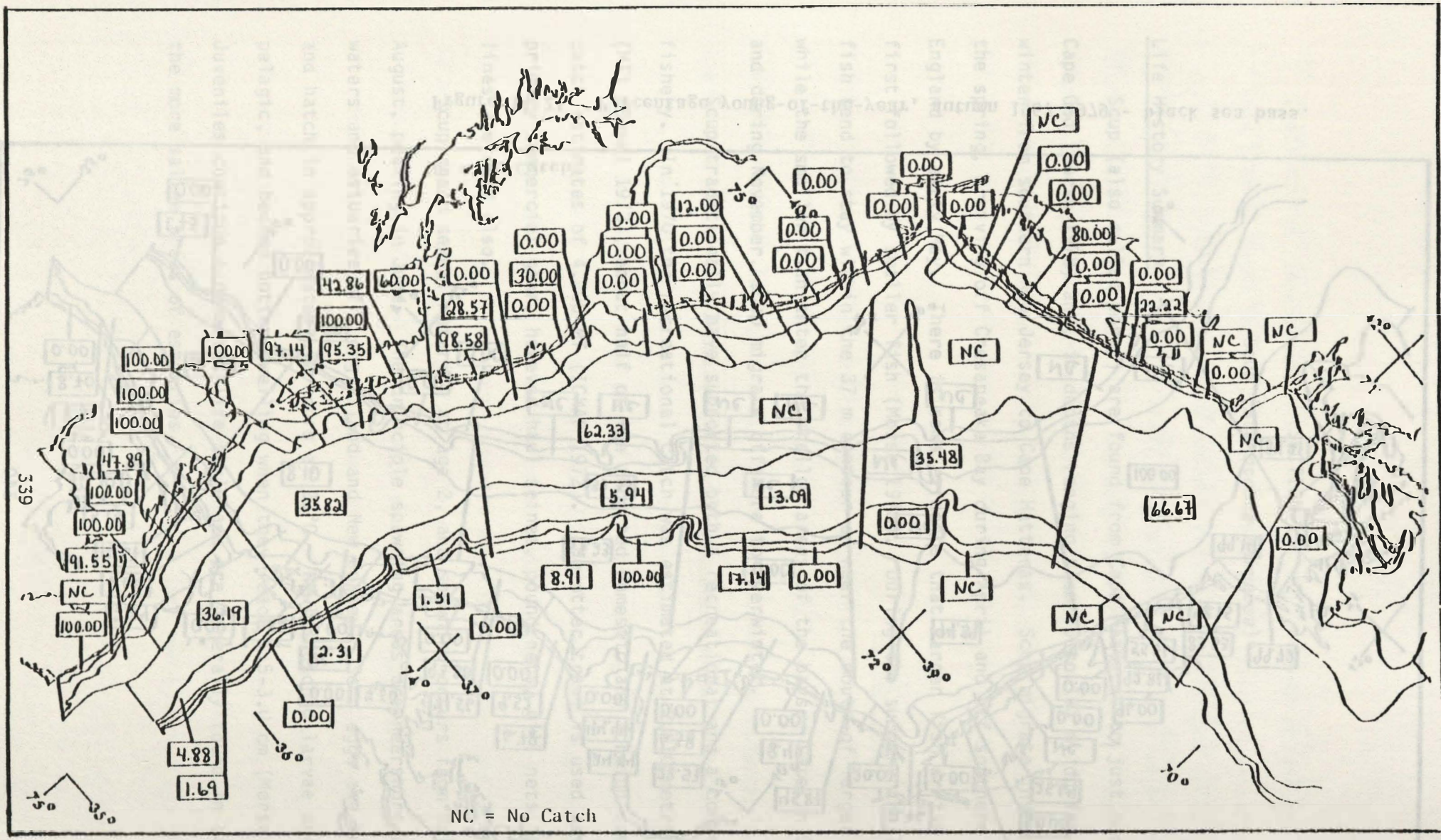


Figure 14.20. Percentage young-of-the-year, spring 1968-1979 - black sea bass.

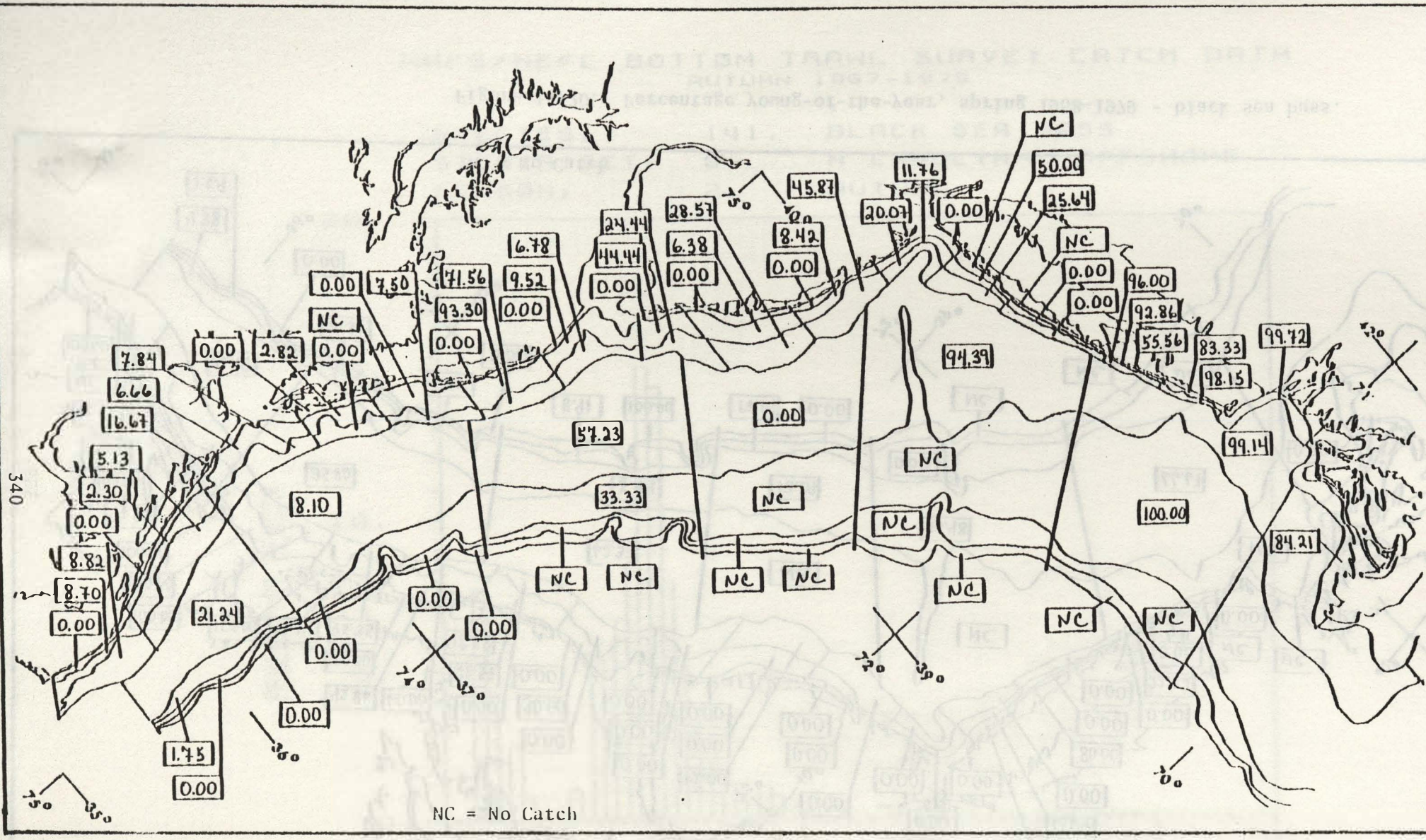


Figure 14.21. Percentage young-of-the-year, autumn 1967-1979 - black sea bass.

SECTION 15

Scup (*Stenotomus chrysops*)

Life History Summary

Scup (also called porgy) are found from Cape Hatteras to just north of Cape Cod (Morse 1978) and, in depths ranging from 73 to 183 m, during the winter from southern New Jersey to Cape Hatteras. Scup migrate inshore during the spring, arriving off Chesapeake Bay during April and off southern New England by early May. There is some evidence that larger fish arrive inshore first followed by smaller fish (Morse 1978). During the summer, the larger fish tend to stay within the 37 m contour or near the mouth of larger bays, while the smaller fish enter the shallow areas of the bays. Late in October and during November, scup migrate offshore to overwinter.

Scup traditionally have supported both a recreational and a commercial fishery. In 1970 the recreational catch was estimated at 2,010 metric tons (MT) (Deuel 1973), about half of the reported domestic and foreign commercial catch estimates of 4,700 MT (ICNAF 1972). The otter trawl is used as the primary commercial gear, however haul seines, pound nets, gill nets, and hand lines are used also.

Scup reach sexual maturity at age 2, and spawning occurs from May through August, peaking in June. The principle spawning areas are nearshore ocean waters and estuaries off Long Island and New Jersey. Scup eggs are buoyant and hatch in approximately 40 hours at 22°C. Newly-hatched larvae are pelagic, and become bottom-dwelling when they reach 1.5-3.0 cm (Morse 1982). Juveniles continue a demersal life style and are generally found in bays and the more saline areas of estuaries.

Scup are bottom feeders, preying upon small crustaceans, polychaetes, coelenterates and molluscs (Morse 1982). Adult scup are known to be a prey species of spiny dogfish and weakfish (Maurer and Bowman 1975).

Since the early 1900's, scup landings steadily increased until 1960, peaking at about 12,250 MT. Between 1960 and 1971, landings decreased sharply to a low of about 1,360 MT during 1971. Since that time landings have been increasing steadily, again probably indicating an increase of abundance (McHugh and Ginter 1978).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 15.1 and 15.2. These plots are good representations of what is known of seasonal distribution of scup. The spring distribution shows the fish concentrated offshore along the 100 m contour. If the spring data were gathered more synoptically, the inshore concentrations would not occur. In Figure 15.3, data from cruises prior to 1976 have been deleted, and a more representative spring (March to April) distribution results. The autumn plot (Figure 15.2) shows widespread dense inshore distribution throughout the Mid-Atlantic with the indication of some offshore movement.

The recovery of scup populations since 1971 is reflected in the graphs of mean weight and number per tow (Figures 15.4-15.7). In the spring, catches were almost exclusively offshore; in the autumn, catches were high in both inshore and offshore strata sets.

Length frequencies for six strata sets, arranged by season, are shown in Figures 15.8-15.19. Fish over 20 cm were caught most frequently offshore except for the northern New York Bight inshore strata set (Figure 15.8). Fish

<20 cm were caught only occasionally in either inshore or offshore southern strata sets (North Carolina) (Figures 15.13 and 15.16).

Figures 15.20 and 15.21 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 12 and 8 cm for spring and fall series, respectively. Although the inshore frequency of occurrence was low in spring, the YOY dominate the catches (Figures 15.20). In the autumn, YOY catches were restricted to northern inshore areas where the fish were spawned during the past spring and were moving out of the bays and estuaries (Figure 15.21).

Scup is one of the few species endemic to the Mid-Atlantic, and its high number and availability to both commercial and recreational gear make it one of the more important species in the region from both an ecological and fisheries point of view.

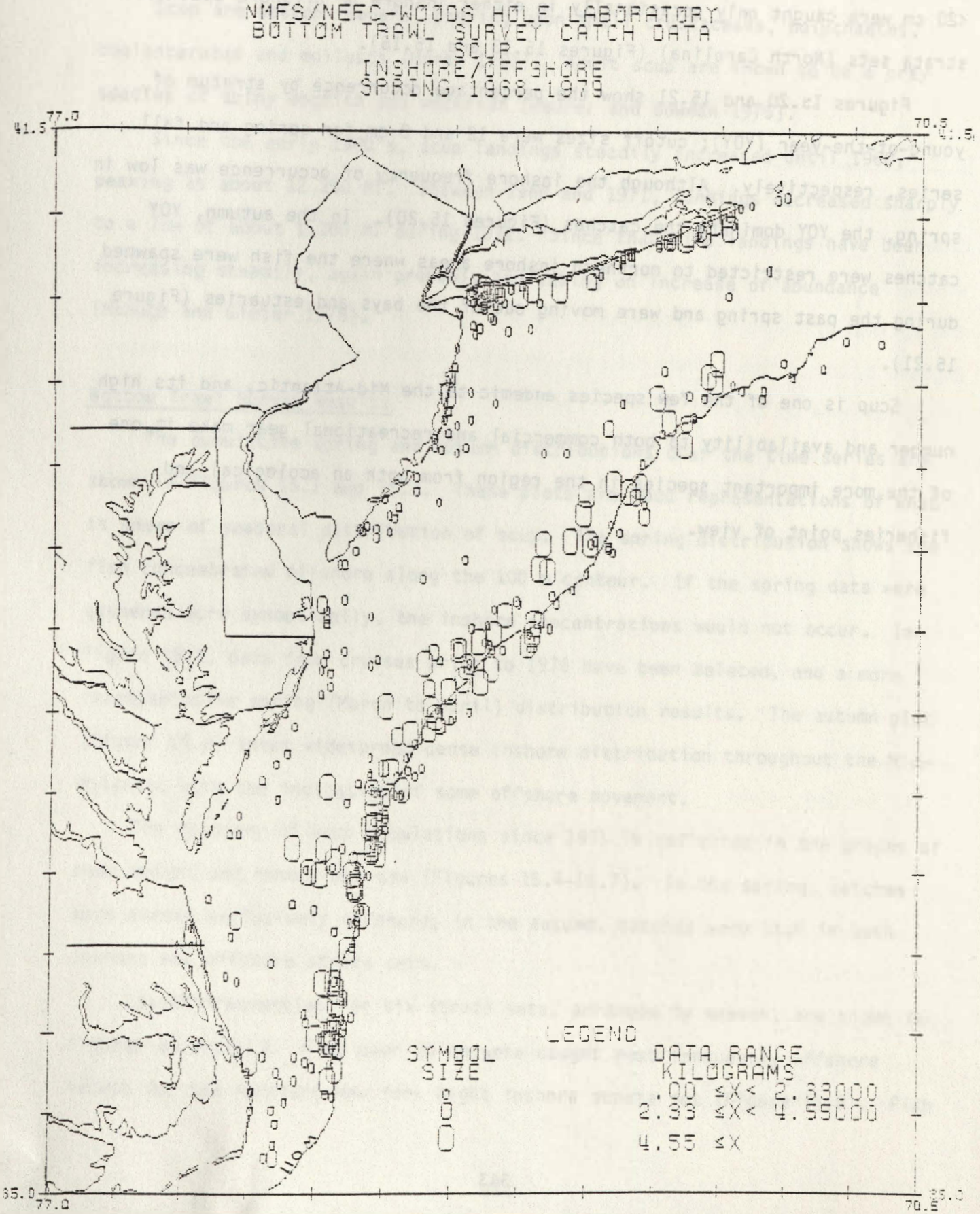


Figure 15.1. Spring distribution, 1968-1979.

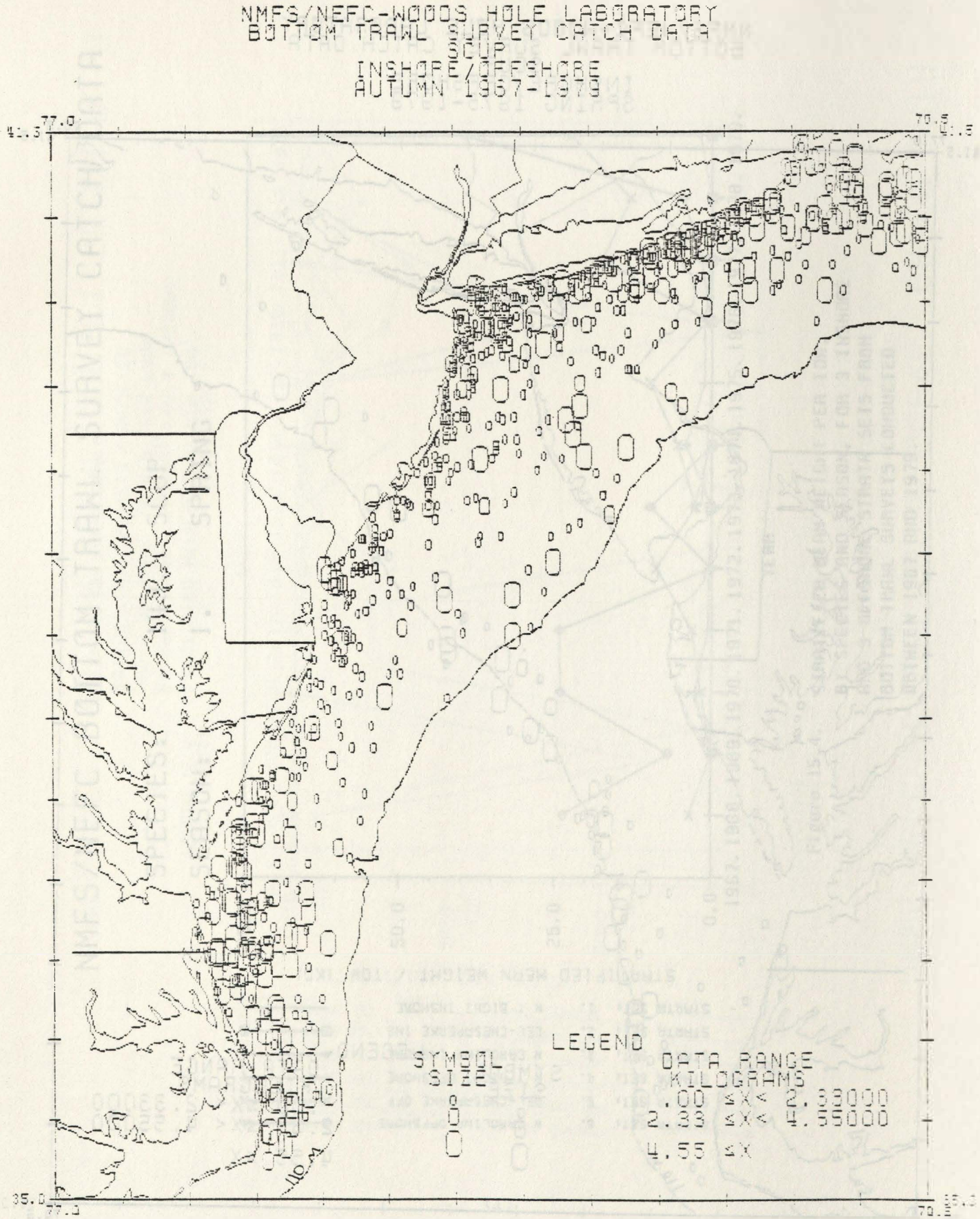


Figure 15.2. Autumn distribution, 1967-1979.

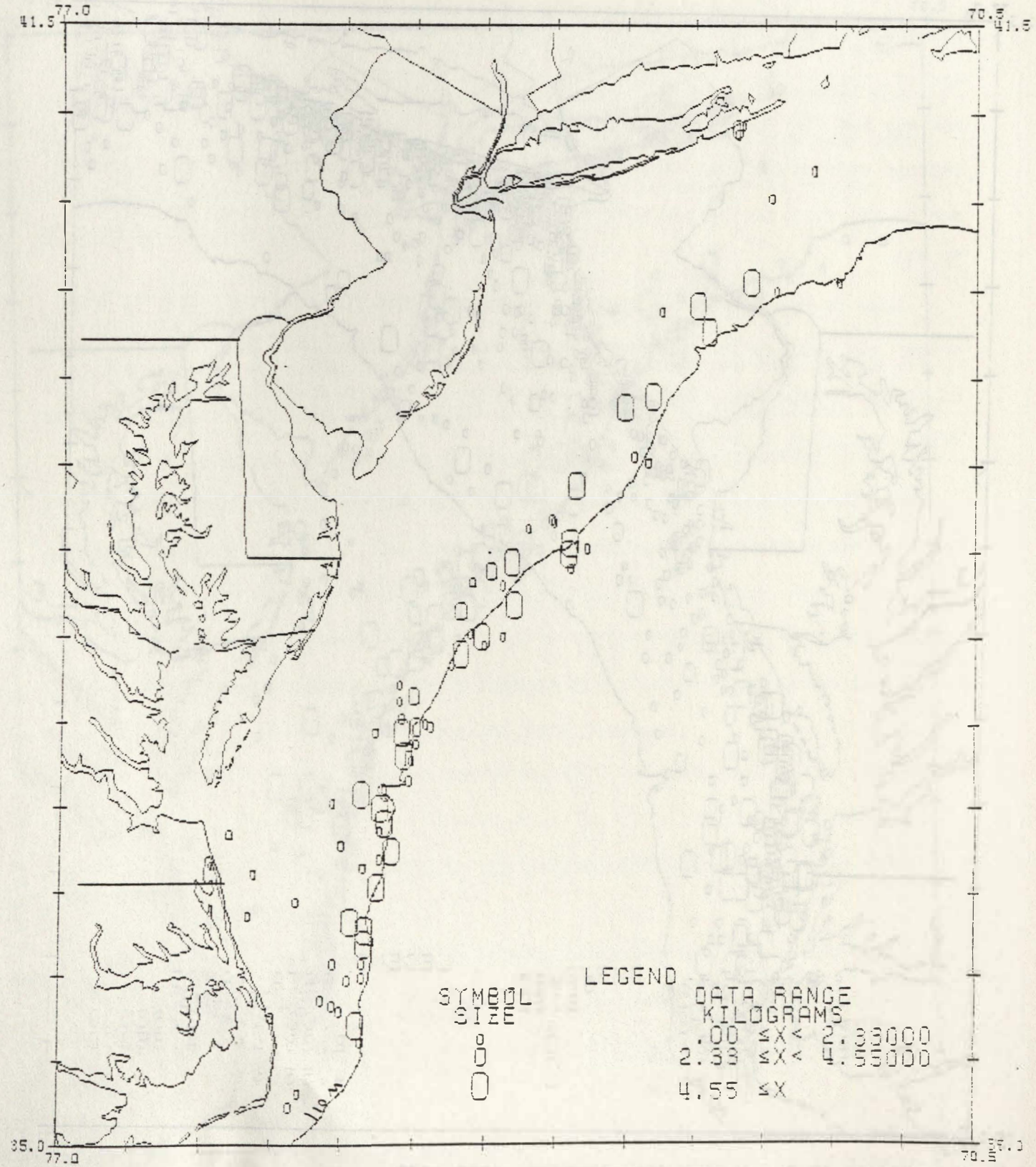


Figure 15.3. Spring distribution, 1976-1979.

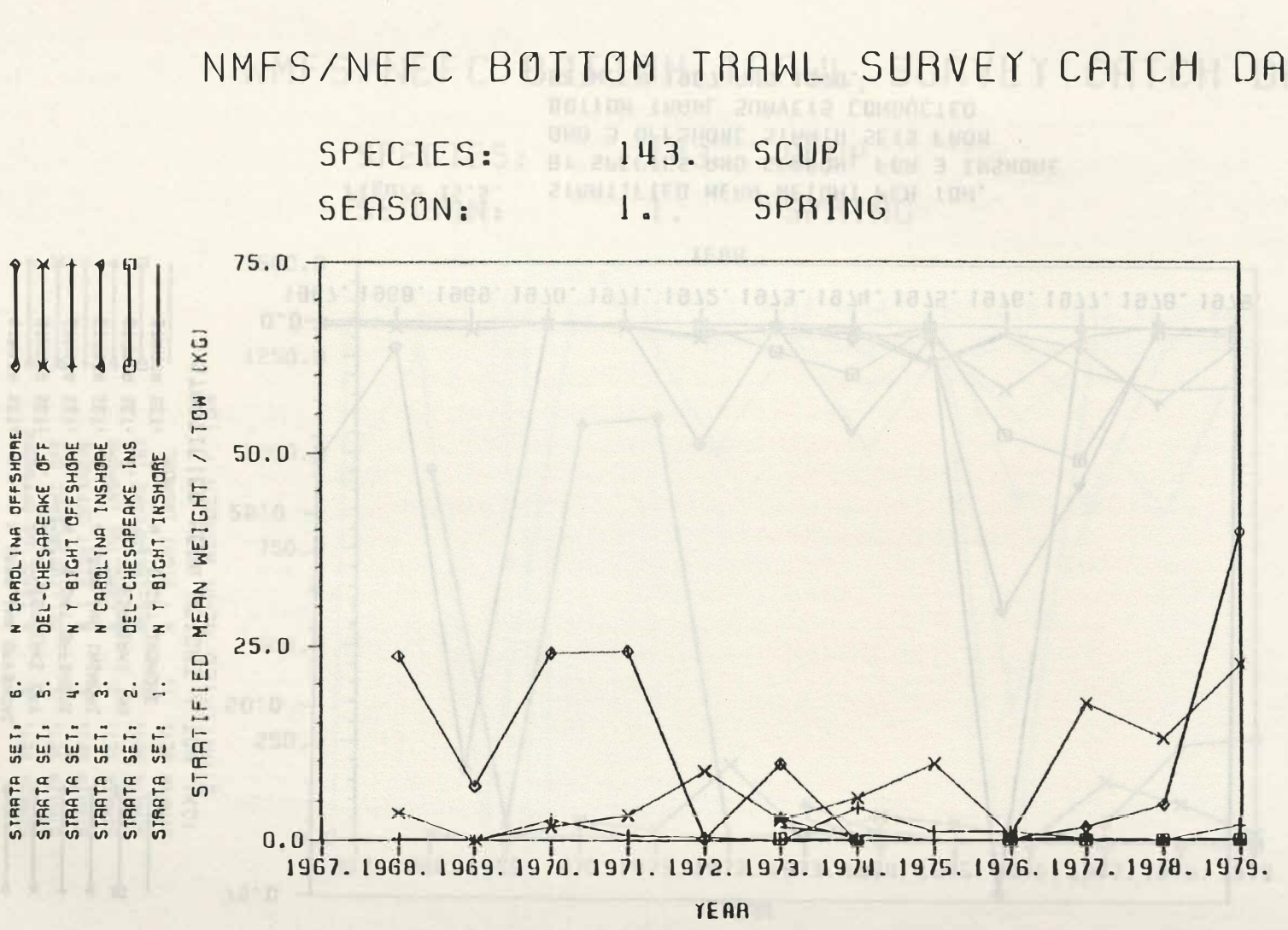


Figure 15.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

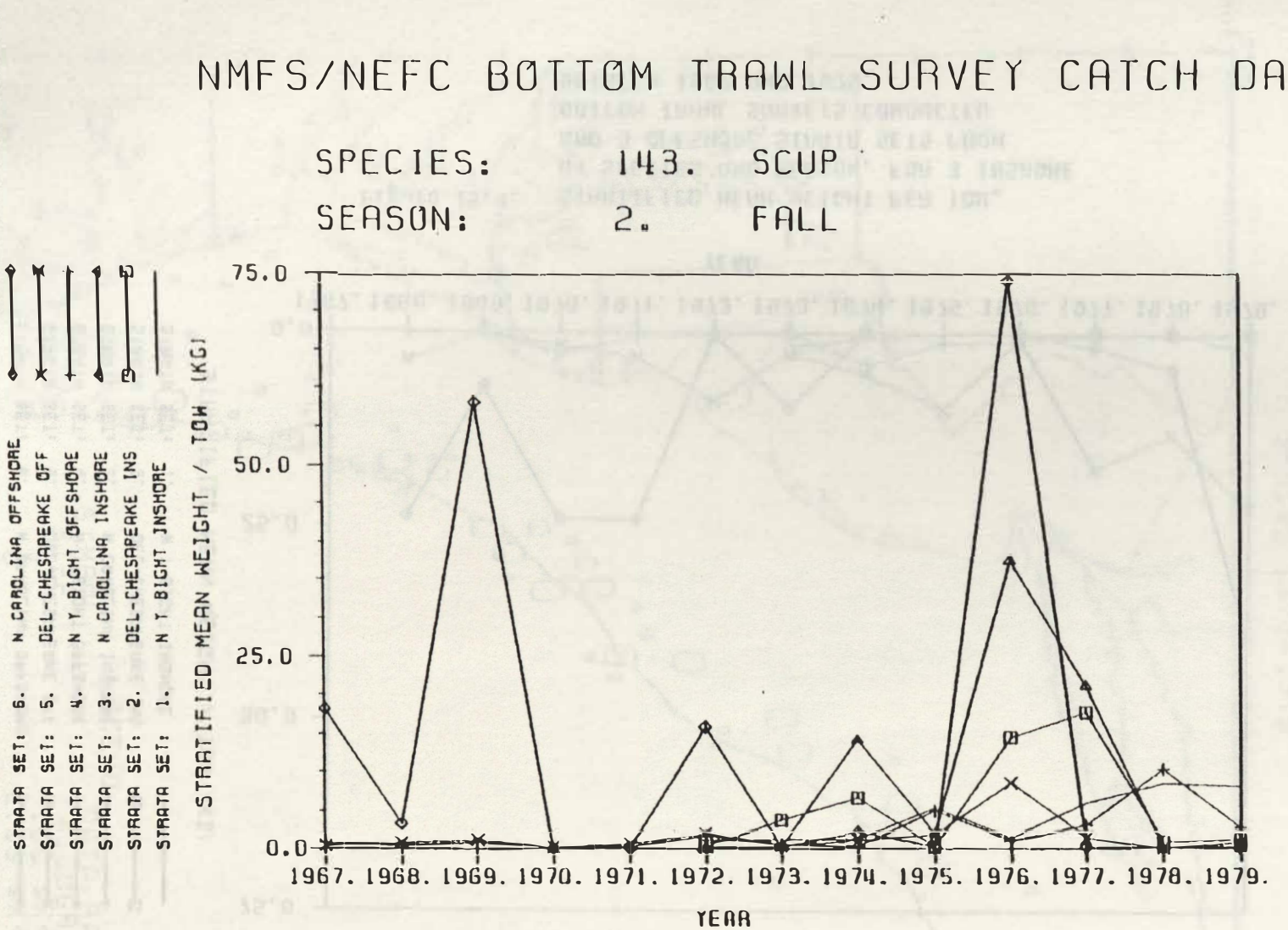


Figure 15.5. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

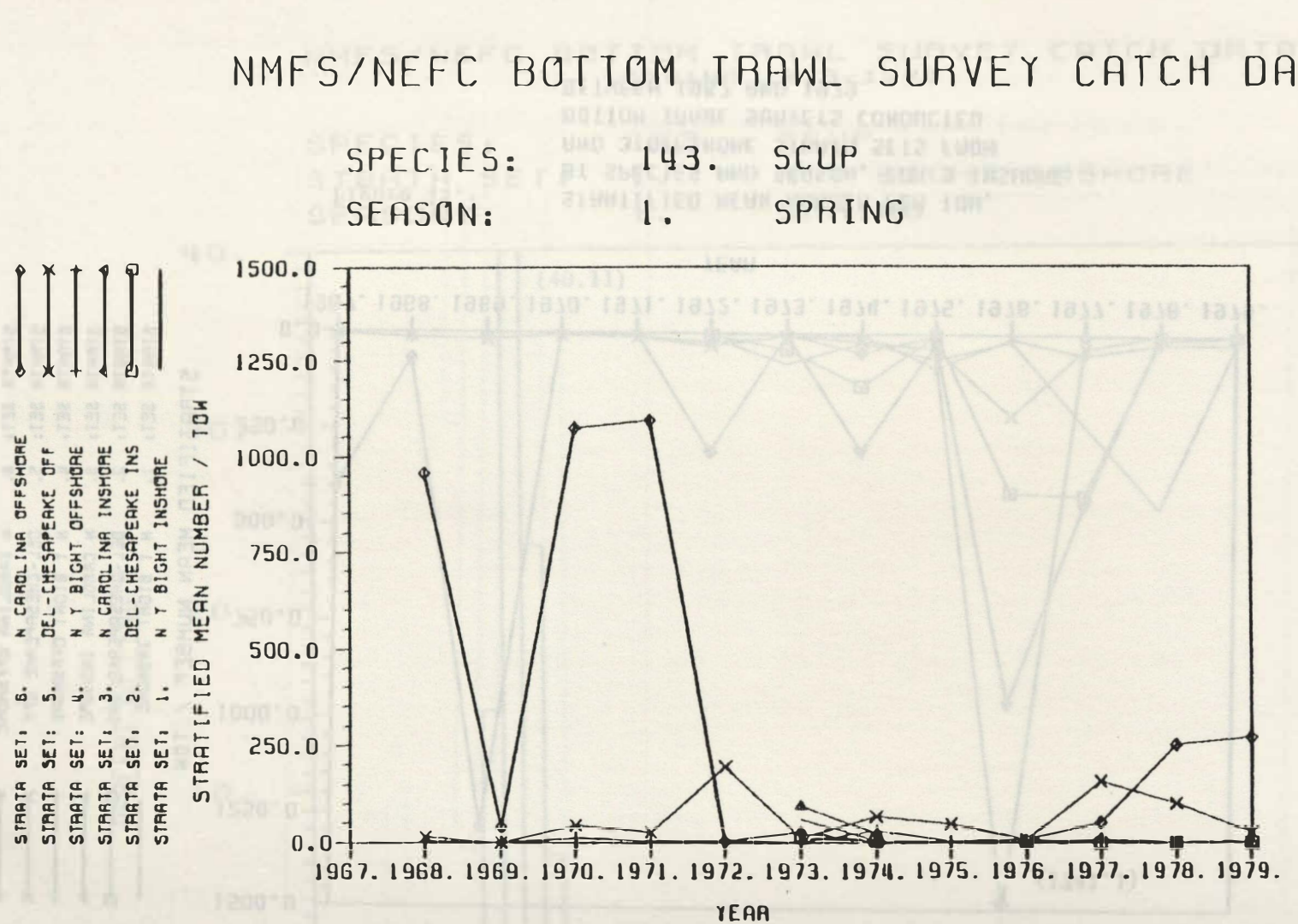


Figure 15.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

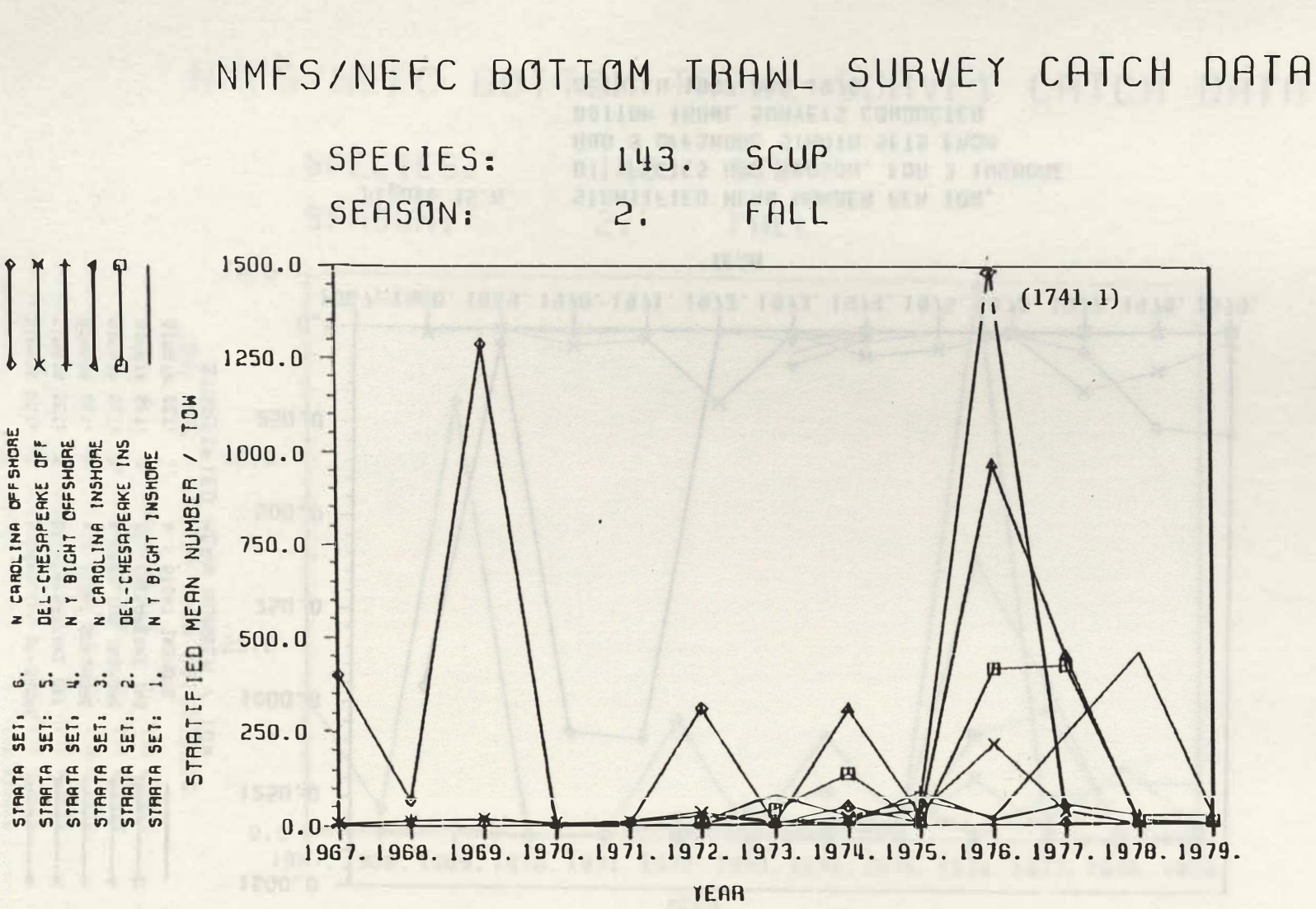


Figure 15.7. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

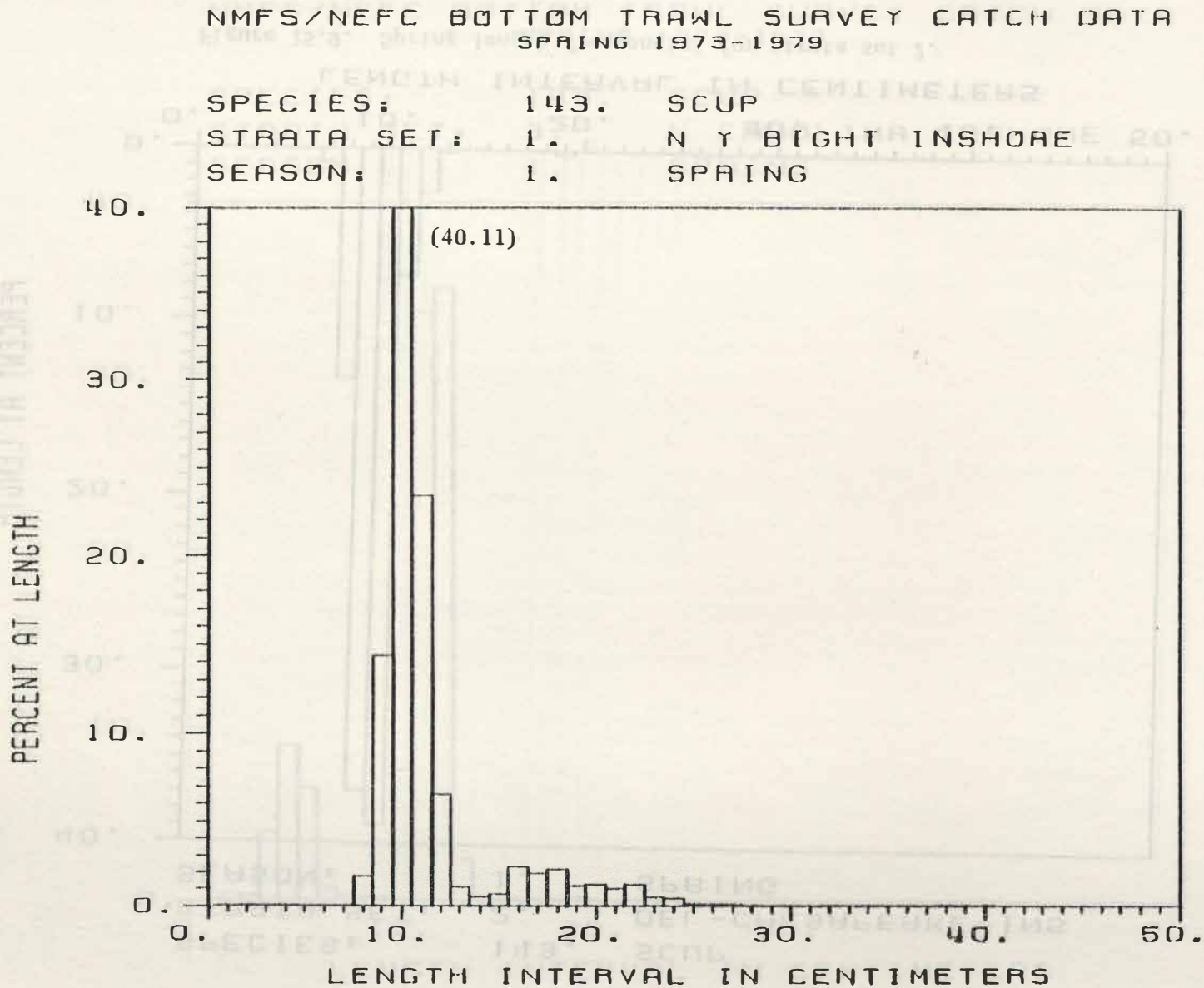


Figure 15.8. Spring length frequencies for strata set 1.

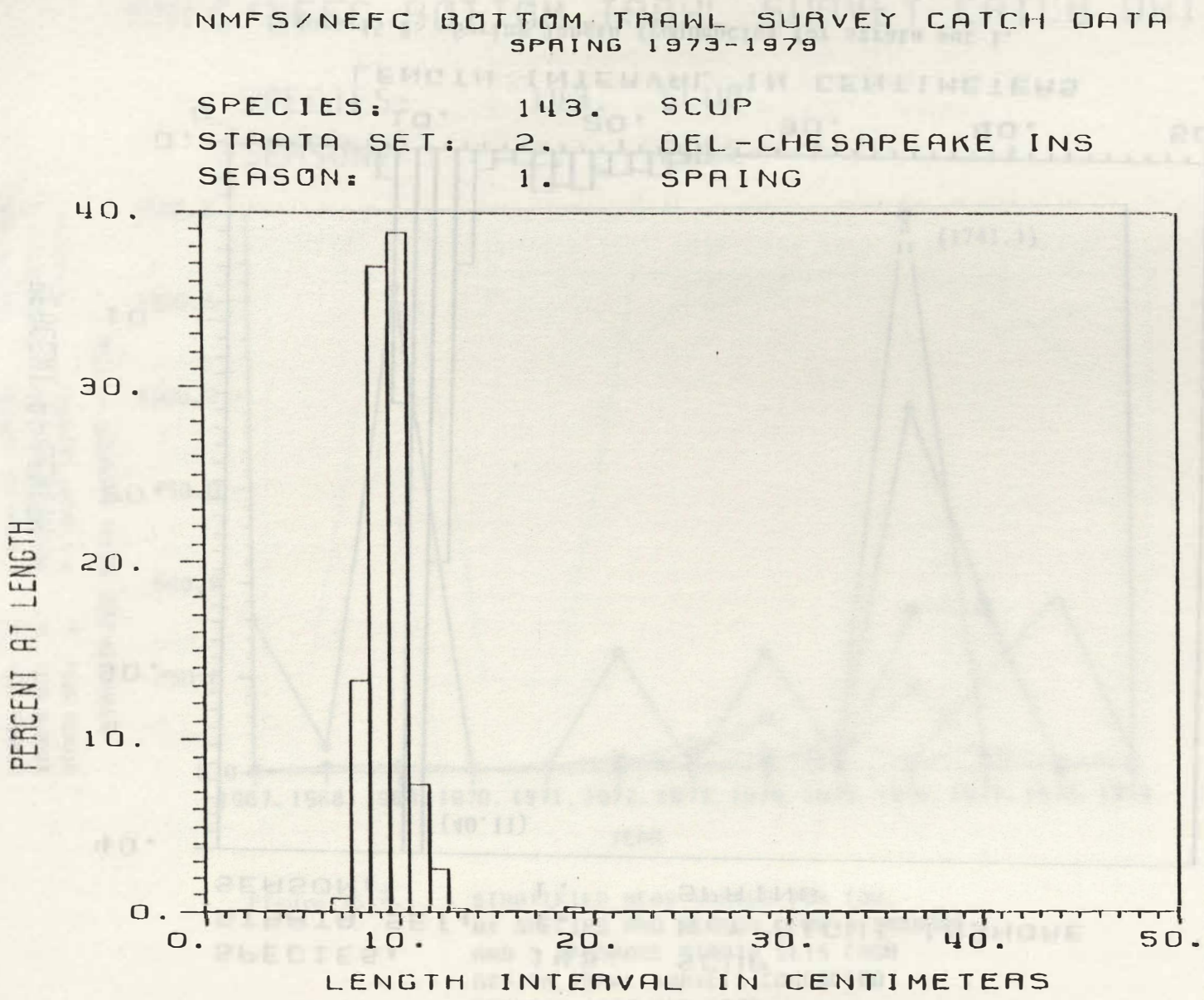


Figure 15.9. Spring length frequencies for strata set 2.

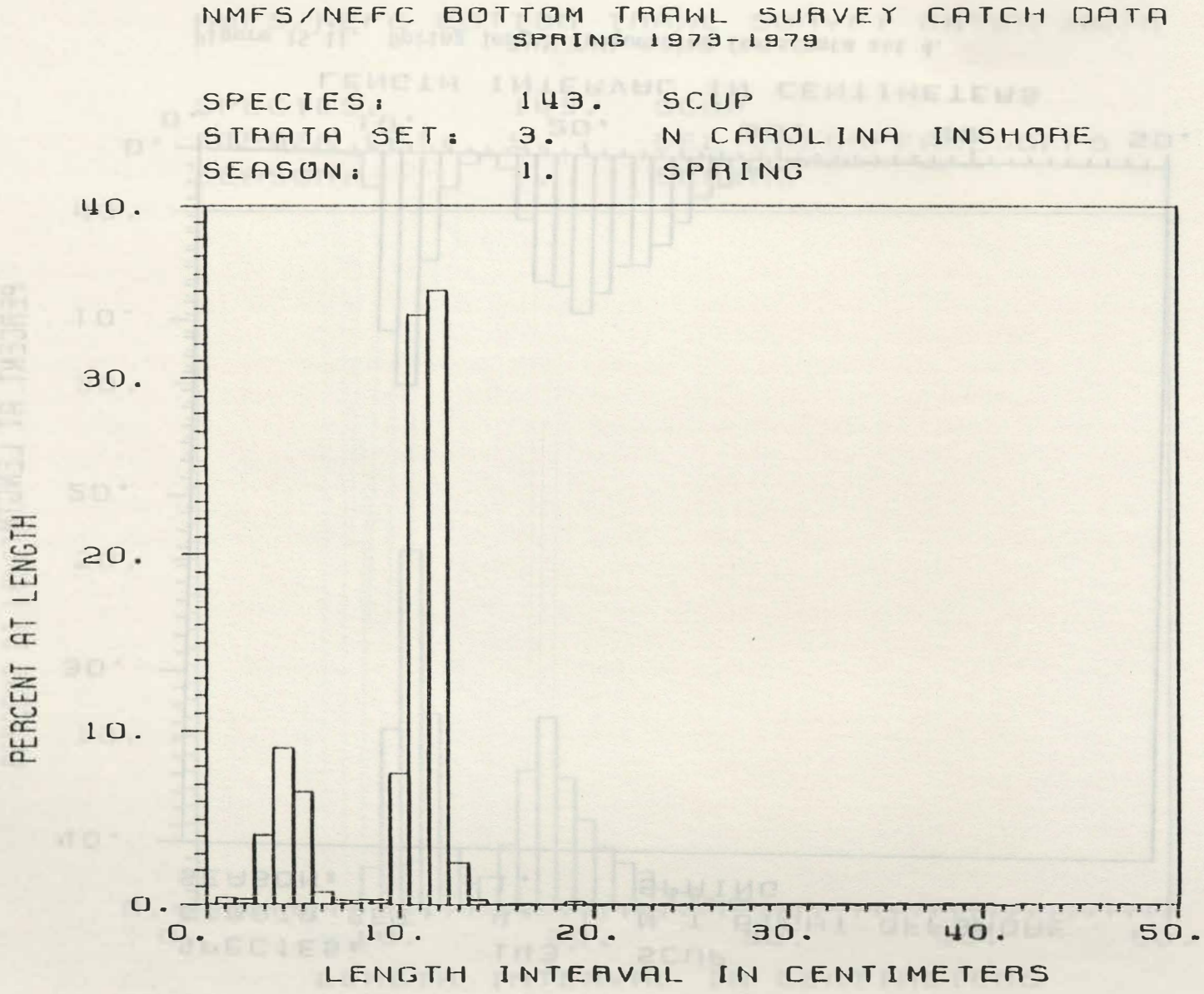


Figure 15.10. Spring length frequencies for strata set 3.

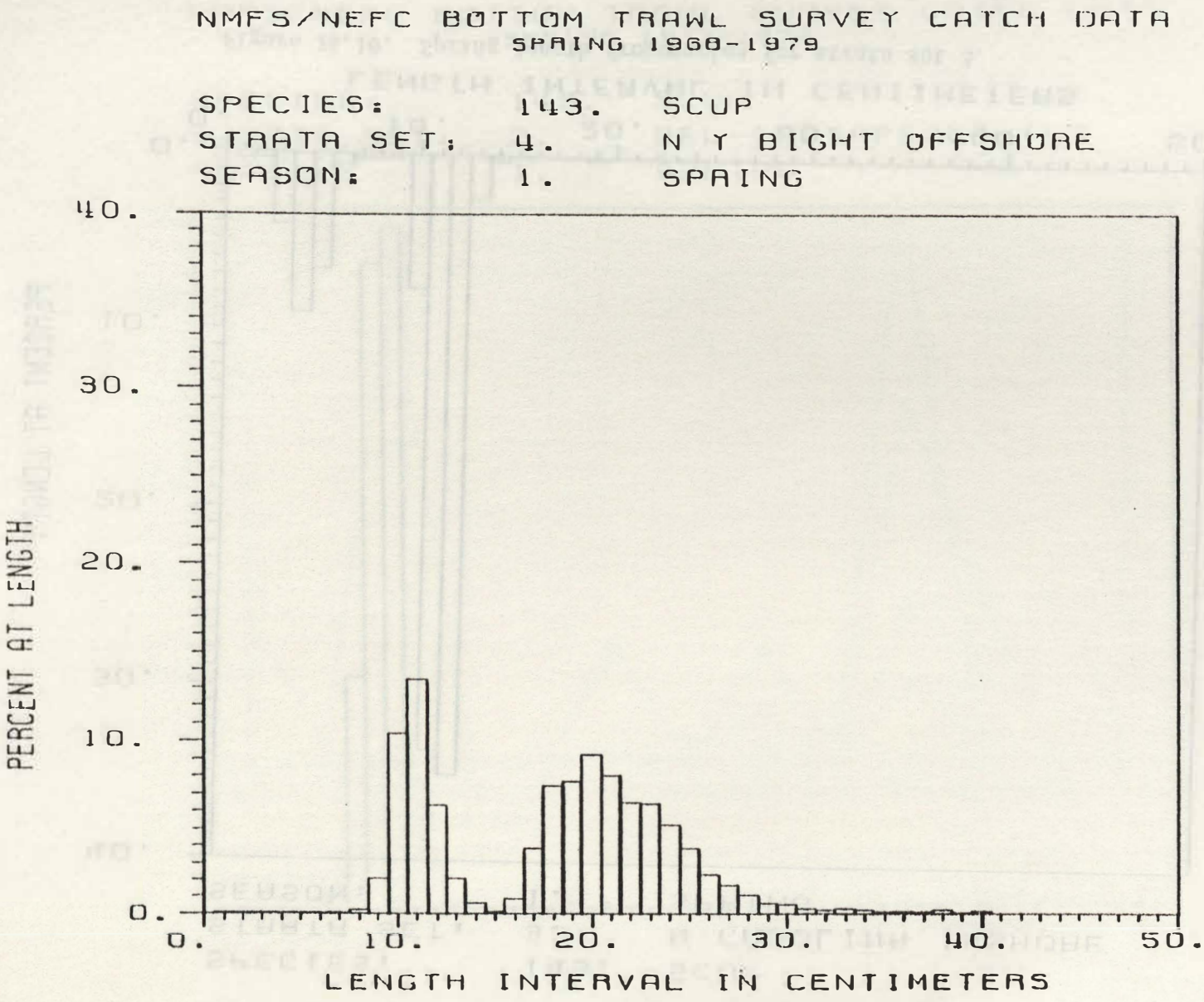


Figure 15.11. Spring length frequencies for strata set 4.

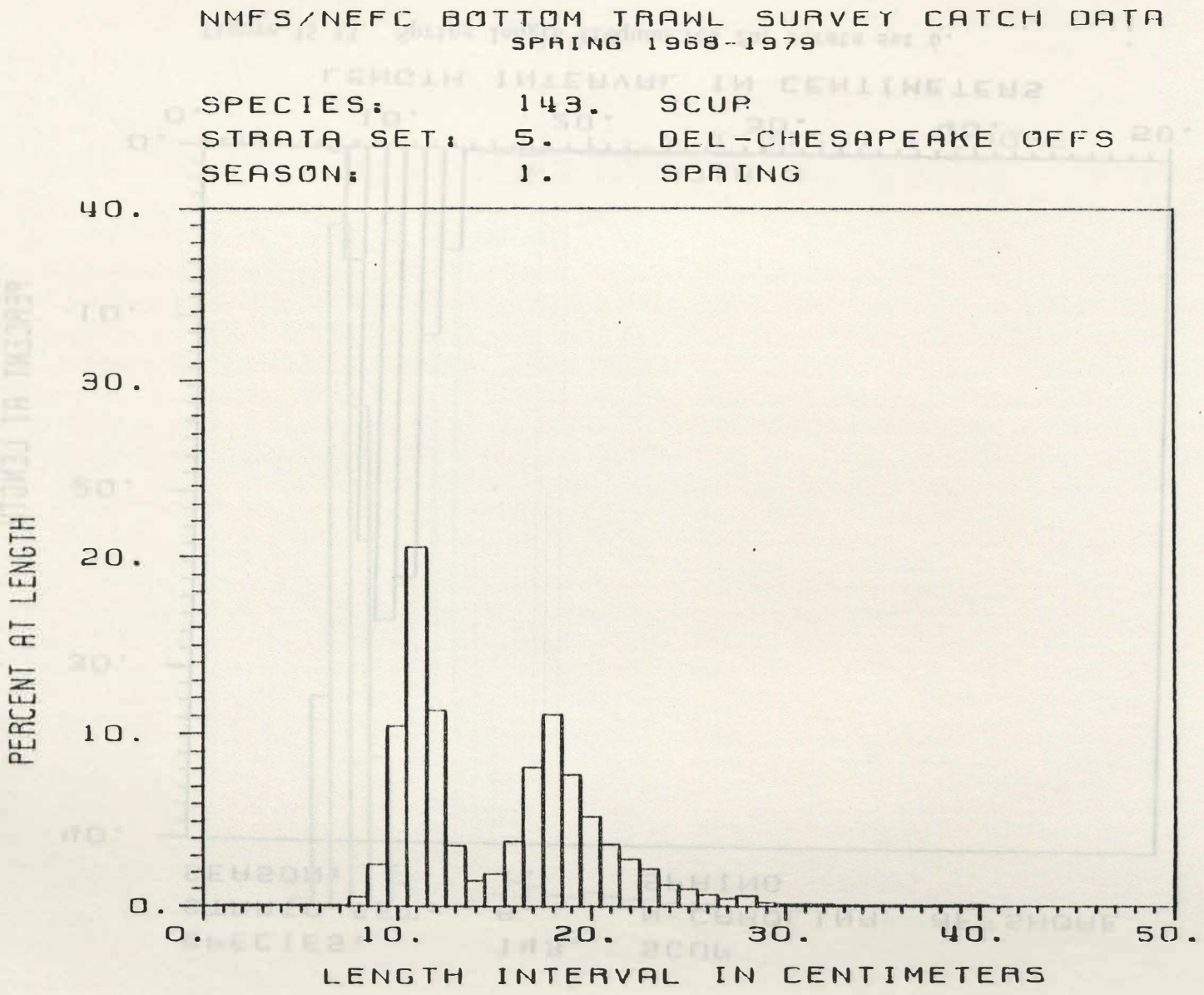


Figure 15.12. Spring length frequencies for strata set 5.

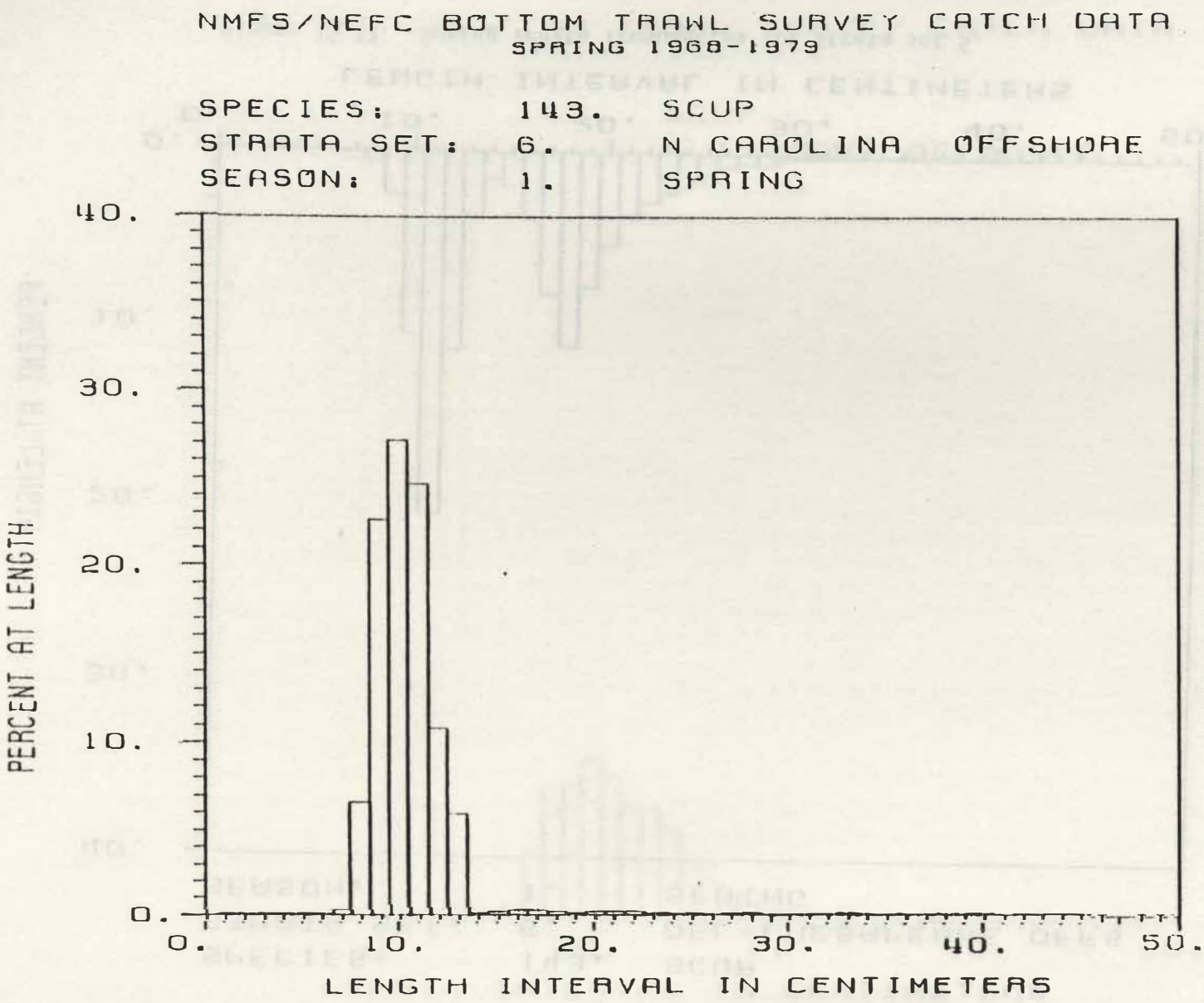


Figure 15.13. Spring length frequencies for strata set 6.

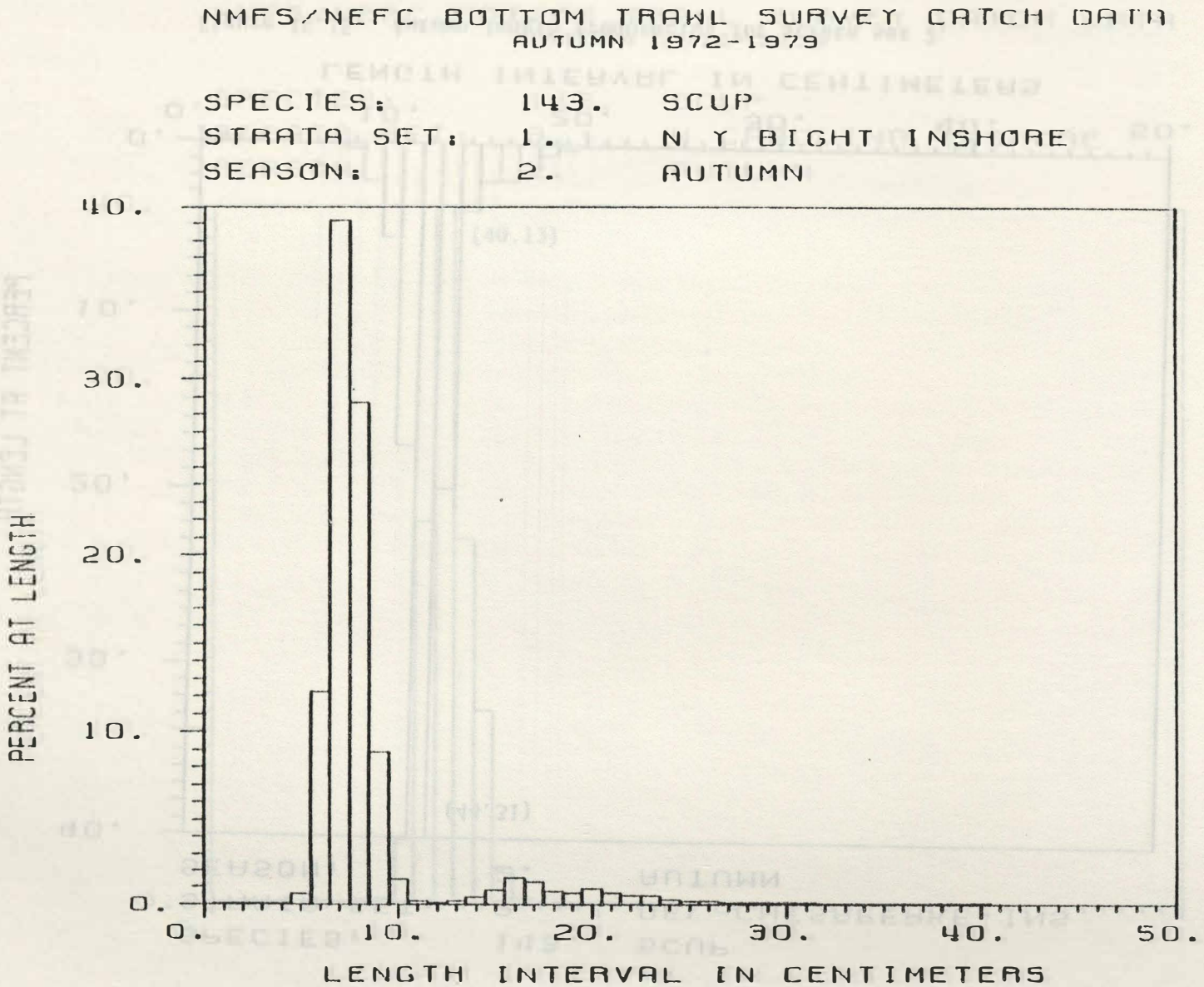


Figure 15.14. Autumn length frequencies for strata set 1.

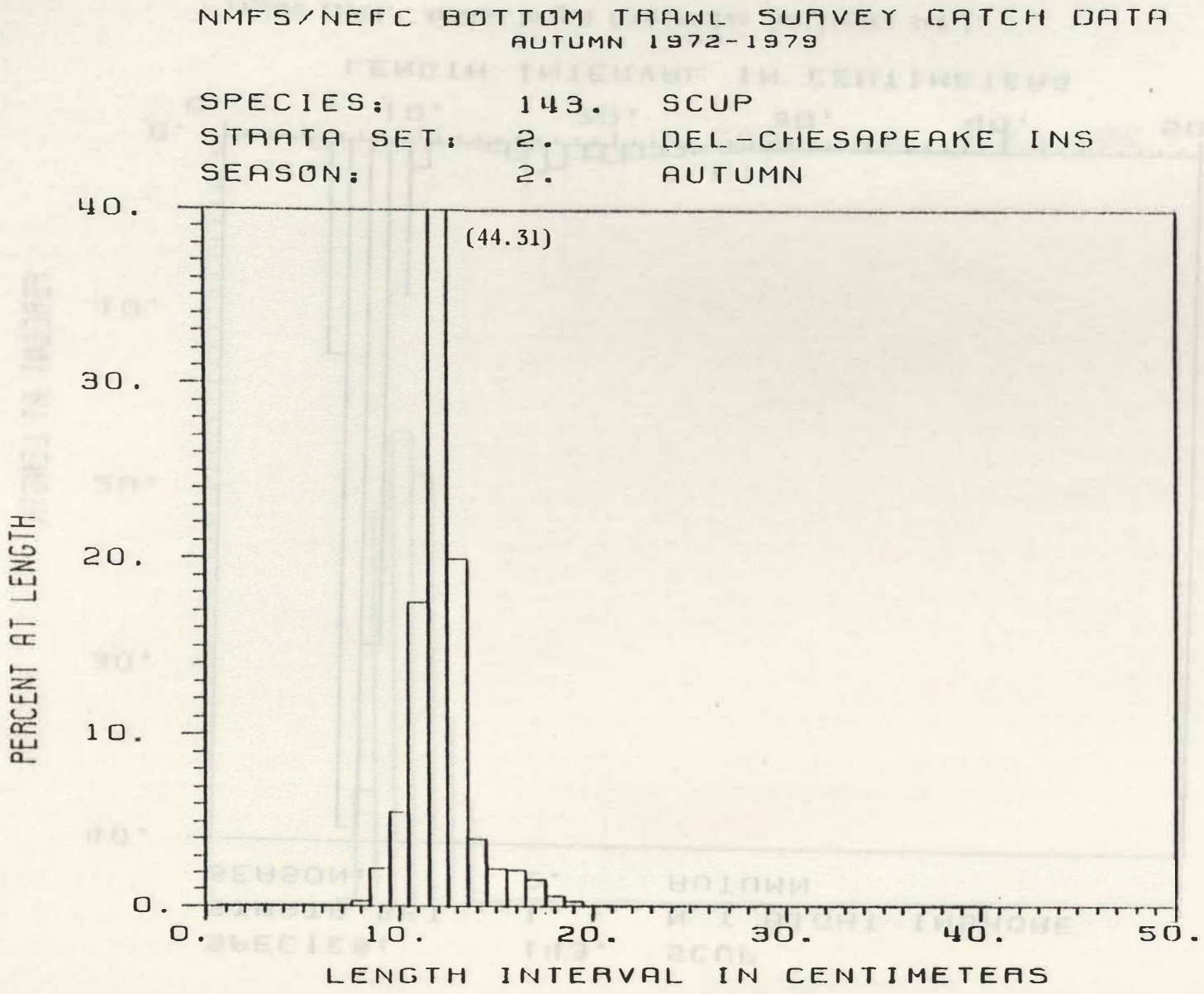


Figure 15.15. Autumn length frequencies for strata set 2.

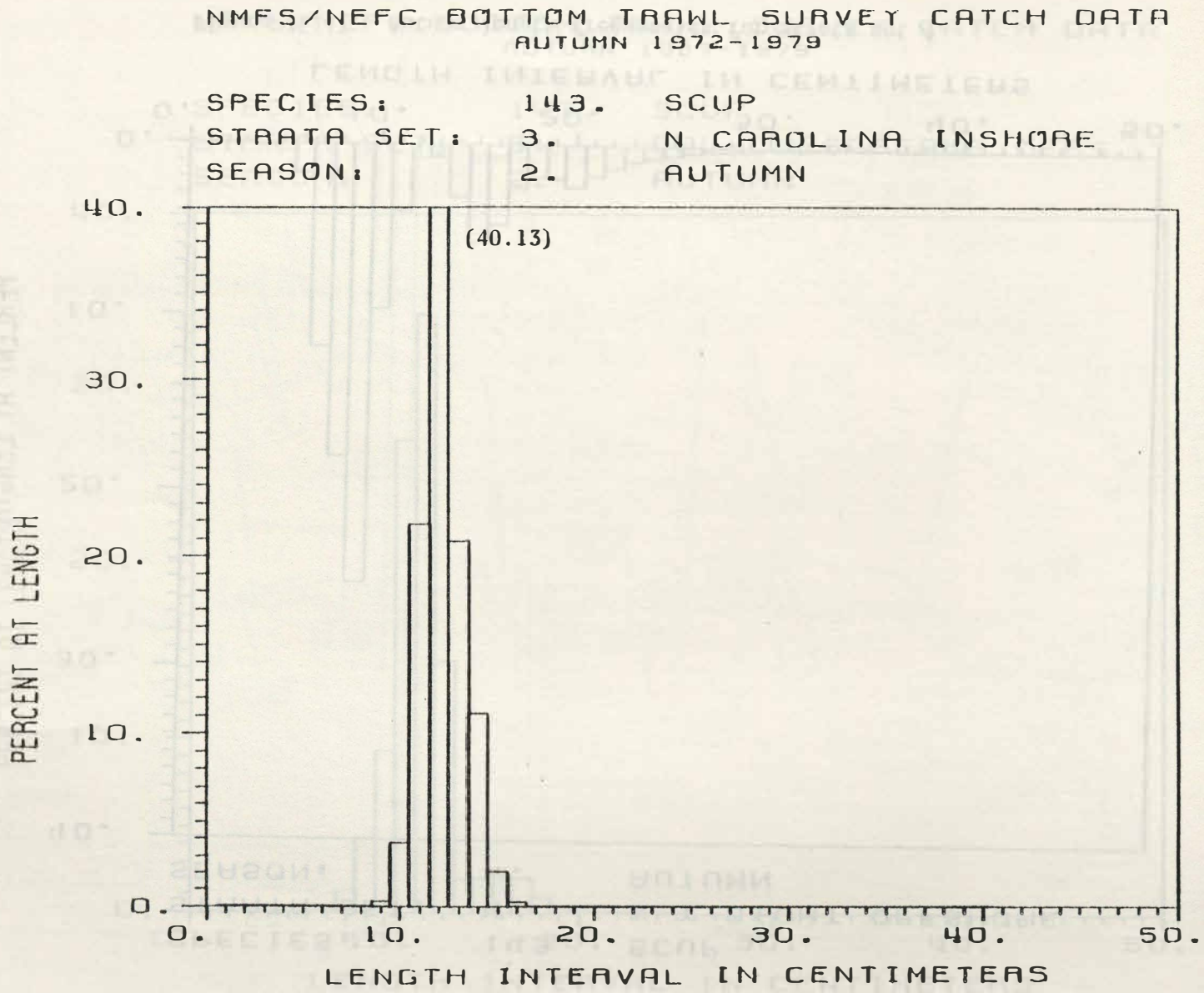


Figure 15.16. Autumn length frequencies for strata set 3.

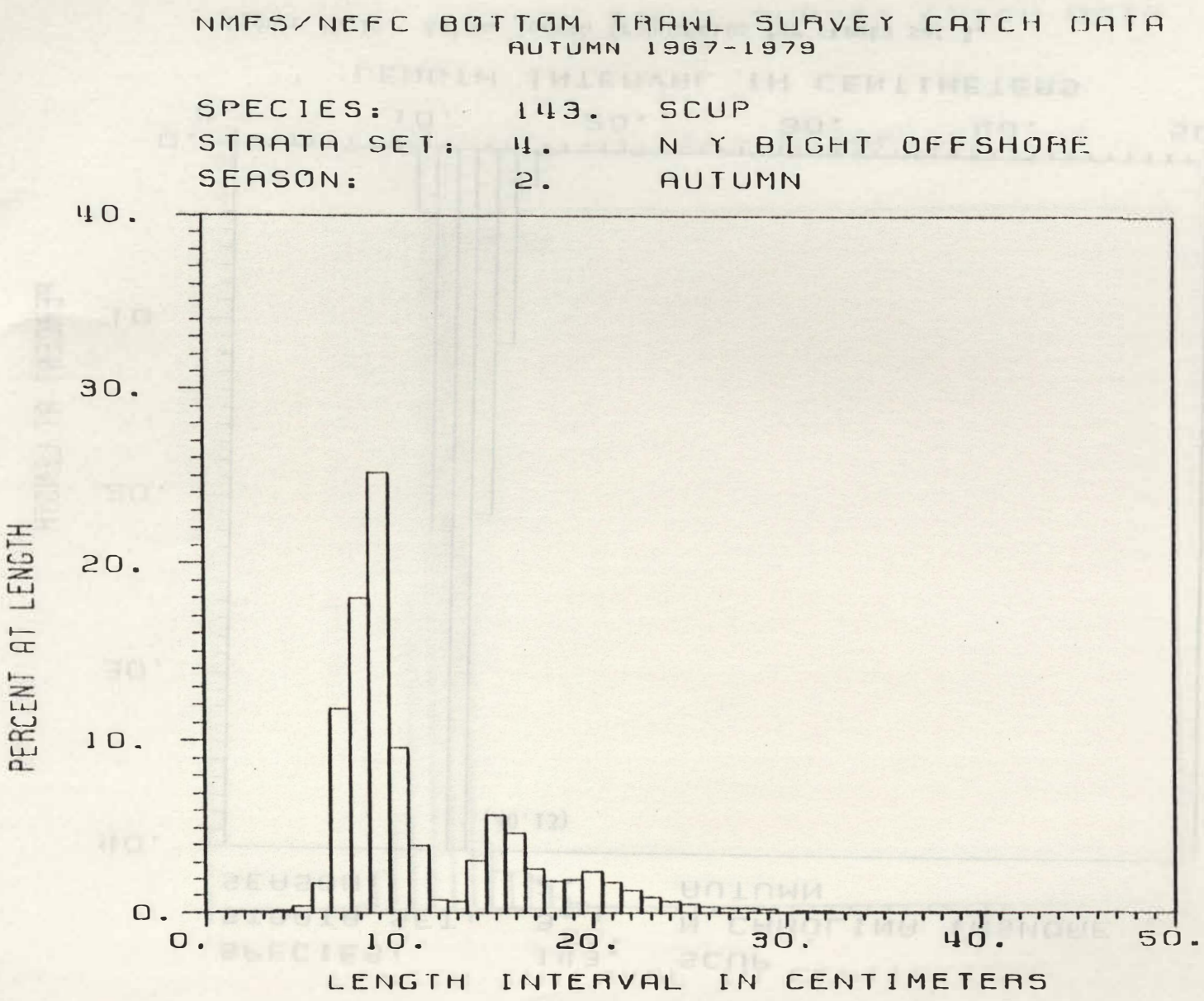


Figure 15.17. Autumn length frequencies for strata set 4.

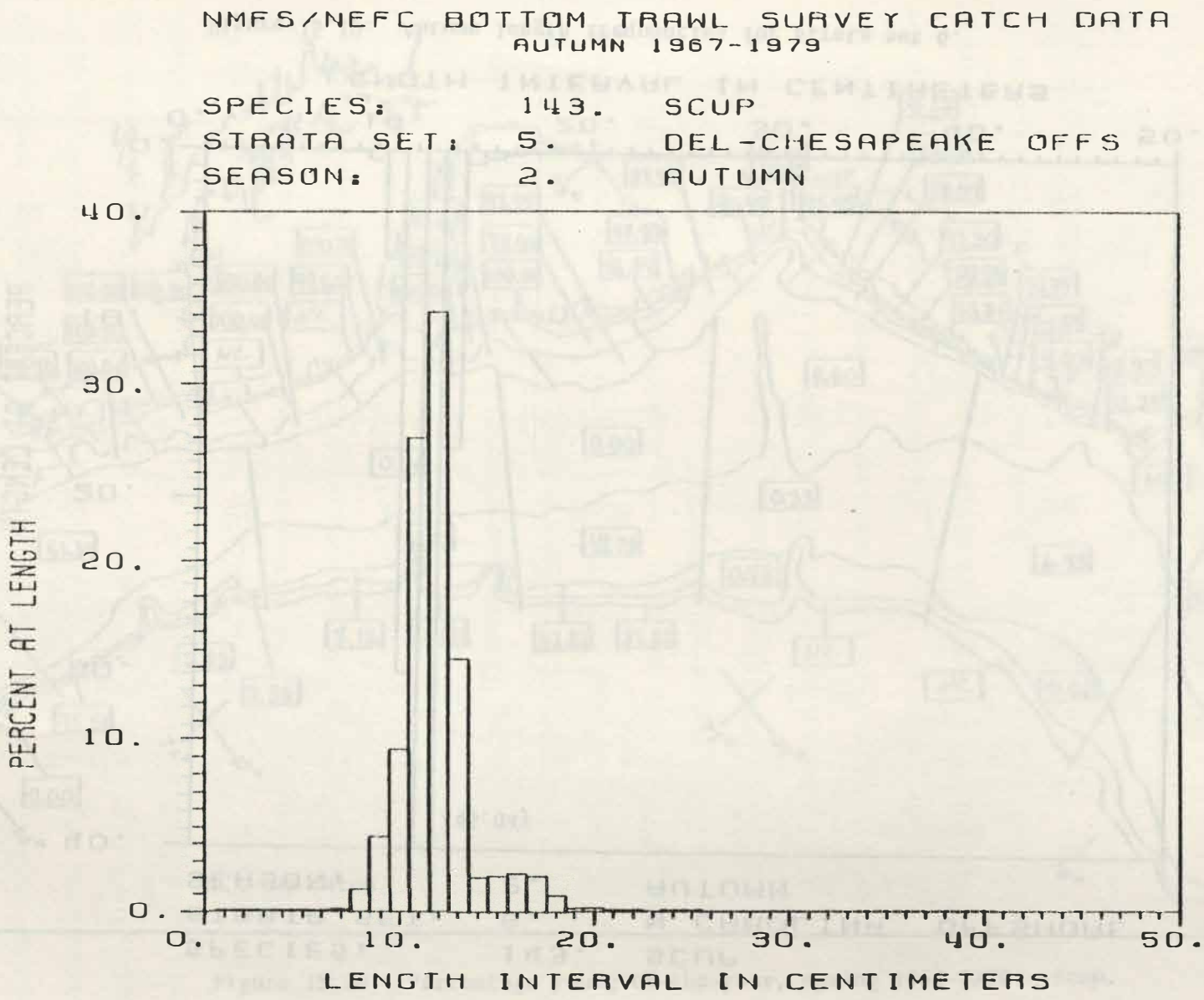


Figure 15.18. Autumn length frequencies for strata set 5.

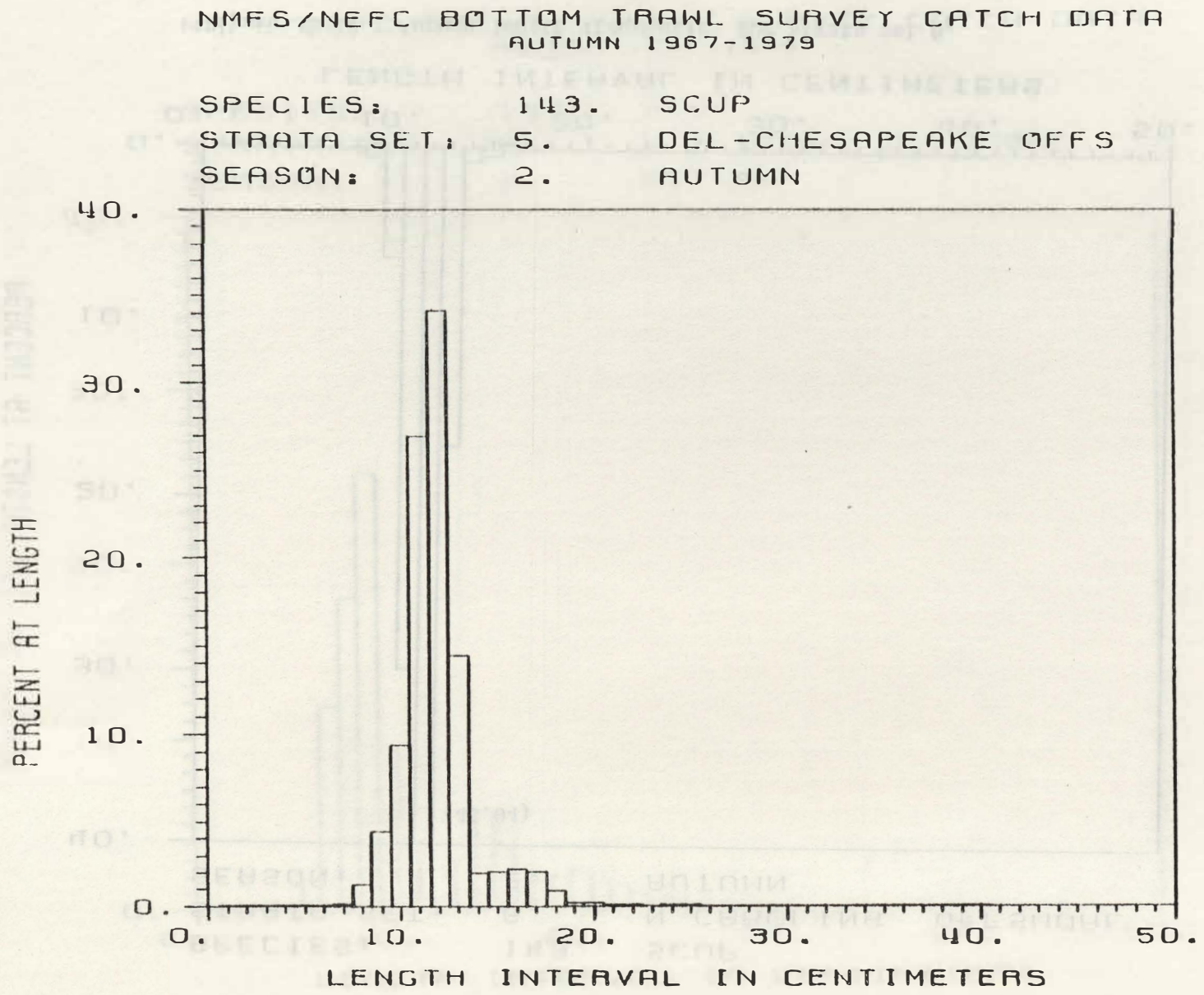


Figure 15.18. Autumn length frequencies for strata set 5.

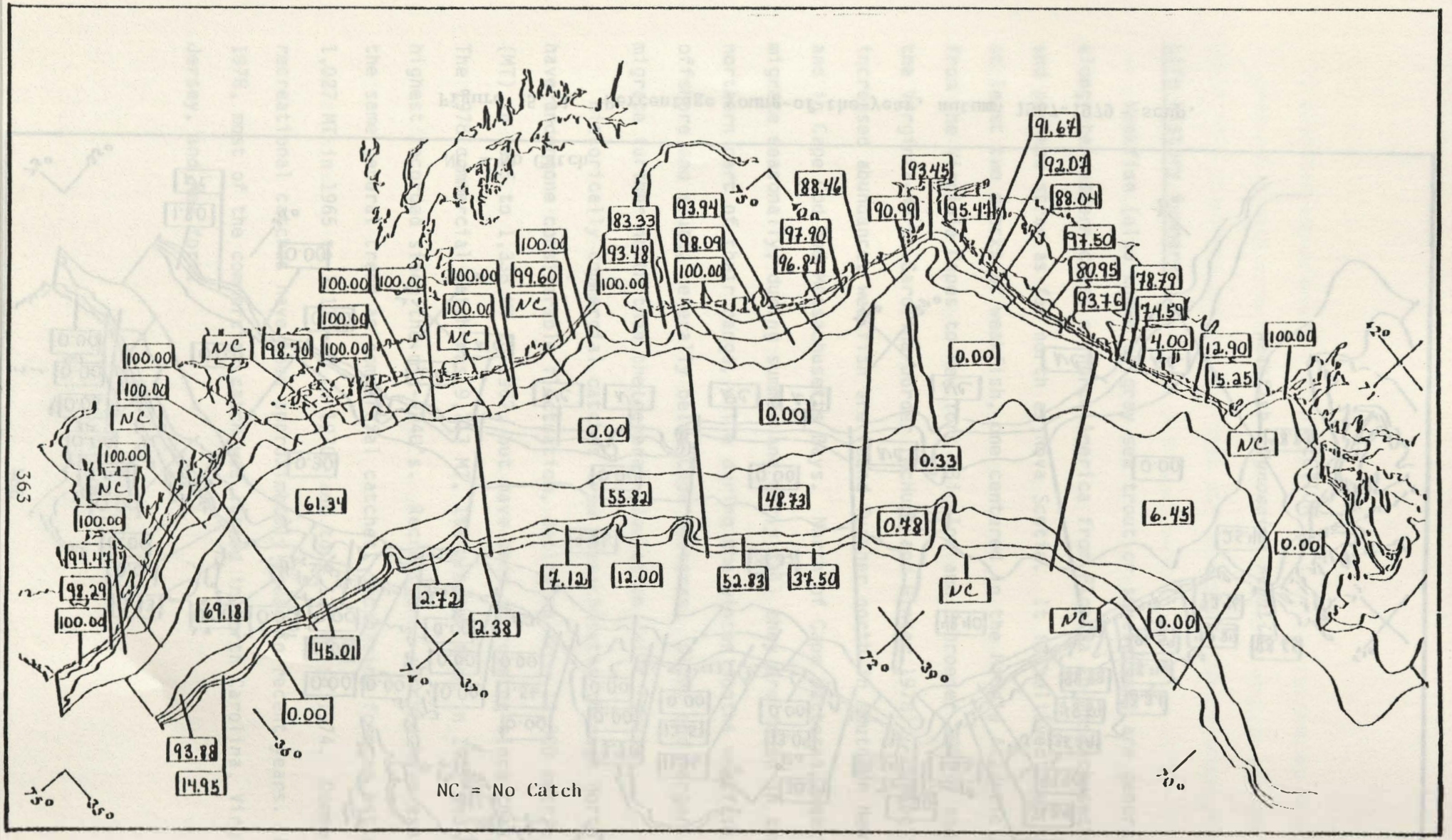
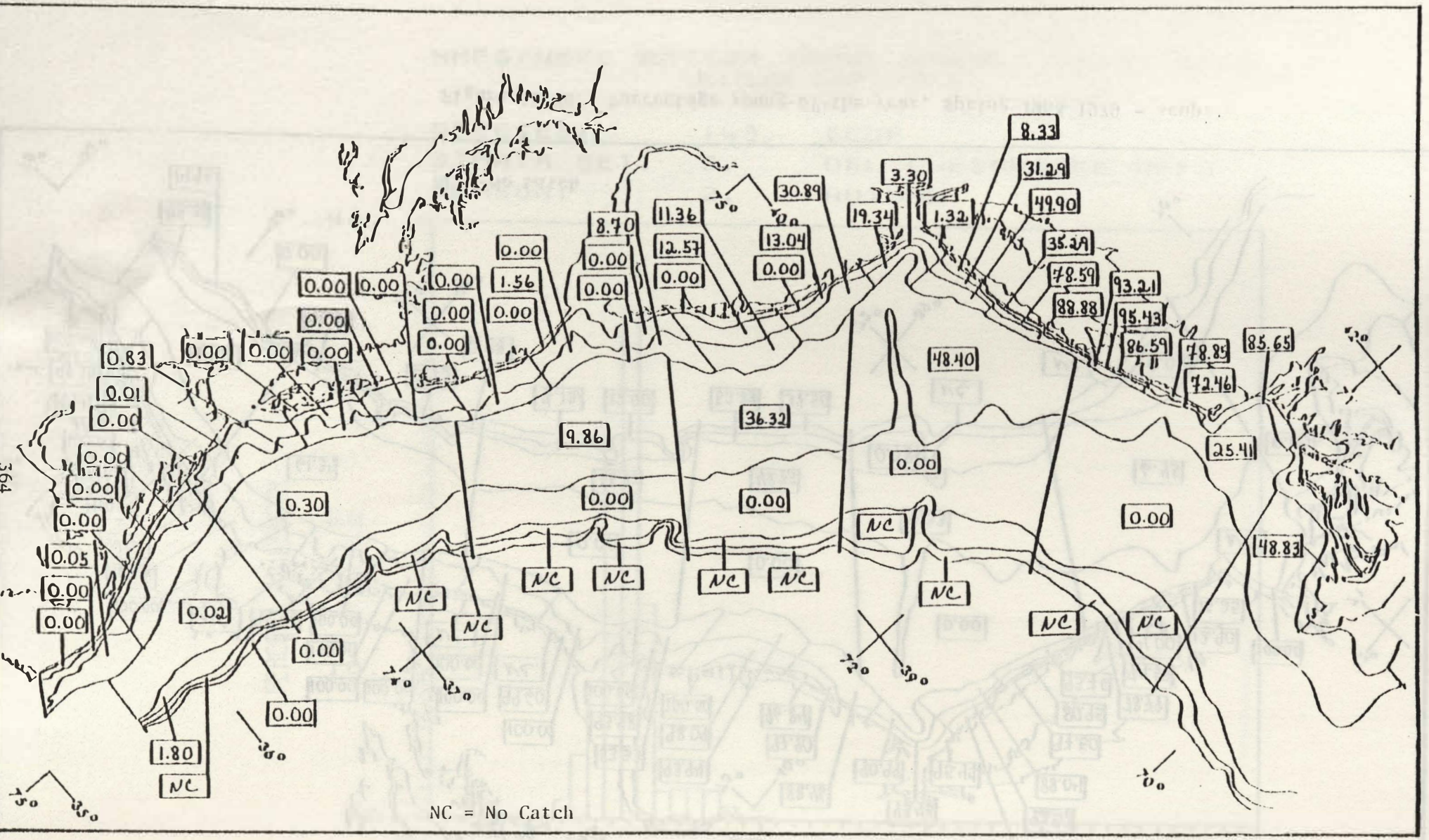


Figure 15.20. Percentage young-of-the-year, spring 1968-1979 - scup.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SECTION 16

Weakfish (*Cynoscion regalis*)

Life History Summary

Weakfish (also known as gray sea trout or squeteague) are generally found along the eastern coast of North America from Florida to Massachusetts Bay, and perhaps stray as far north as Nova Scotia. It is believed that there are at least two stocks of weakfish, one centered in the Middle Atlantic Bight from the Virginia Capes to New York (Bigelow and Schroeder 1953), and one off the Virginia-North Carolina border (McHugh and Ginter 1978). During times of increased abundance, weakfish are found further north in southern New England and in Cape Cod and Massachusetts Bays. North of Cape Hatteras, weakfish migrate seasonally; during summer and early fall they are found in the northern part of their range, while during the winter months weakfish migrate offshore and south, generally below Cape Hatteras. Older and larger fish migrate further north than the general population (Wilk 1982).

Historically commercial catches from Massachusetts through North Carolina have undergone considerable fluctuation, declining from 19,000 metric tons (MT) in 1945 to 1,338 MT in 1967, but have been increasing since that time. The 1978 commercial catch was 9,713 MT, 15% greater than in 1977 and the highest recorded since the mid-1940's. Recreational catches have exhibited the same general trend as commercial catches, increasing from an estimated 1,027 MT in 1965 to 7,113 MT in 1970, and to 9,137 MT in 1974. Commercial and recreational catches have been approximately equal in recent years. During 1978, most of the commercial catch was landed in North Carolina, Virginia, New Jersey, and New York.

Weakfish become sexually mature by age 2, with the majority maturing at age 1. Spawning occurs in coastal and estuarine areas from May to October, with peak spawning in May and June. The eggs are buoyant and hatch within two days (at 20°-21°C). Little is known regarding larval dynamics.

Feeding takes place throughout the water column. Young weakfish consume invertebrates and smaller fishes, while adults eat shrimps, squids, crabs, worms and clams.

Some weakfish are recruited to the fishery in the first year and strong year-classes, as indicated by NMFS inshore trawl survey during the mid-1970's, should continue to support catches for the next several years.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 16.1 and 16.2. The plots are an excellent representation of seasonal weakfish distribution in the Mid-Atlantic area. Weakfish were, for the most part, absent from the study area in the spring (Figure 16.1), and those that did occur were in southern or offshore areas. The offshore occurrences in the spring, although very limited, support the hypothesis of an offshore component to the winter distribution of the species. The autumn distribution (Figure 16.2) clearly shows the preference of a coastal habitat.

The mean weight and number per tow summaries in Figures 16.3-16.6 show the recent increased trends in abundance, especially in the northern strata sets of the Mid-Atlantic. The inshore strata were not occupied before the autumn of 1972.

Length frequencies for six strata sets, arranged by season, are shown in Figures 16.7-16.18. The sizeable autumn inshore catches were predominantly small fish with some larger fish; the infrequent offshore catches consisted almost entirely of larger fish.

Figures 16.19 and 16.20 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 25 and 22 cm, respectively, for spring and fall series. It is quite obvious that the large catches of the autumn time series are composed primarily of spring-spawned weakfish that had left the estuaries and begun their southern migration along the coast.

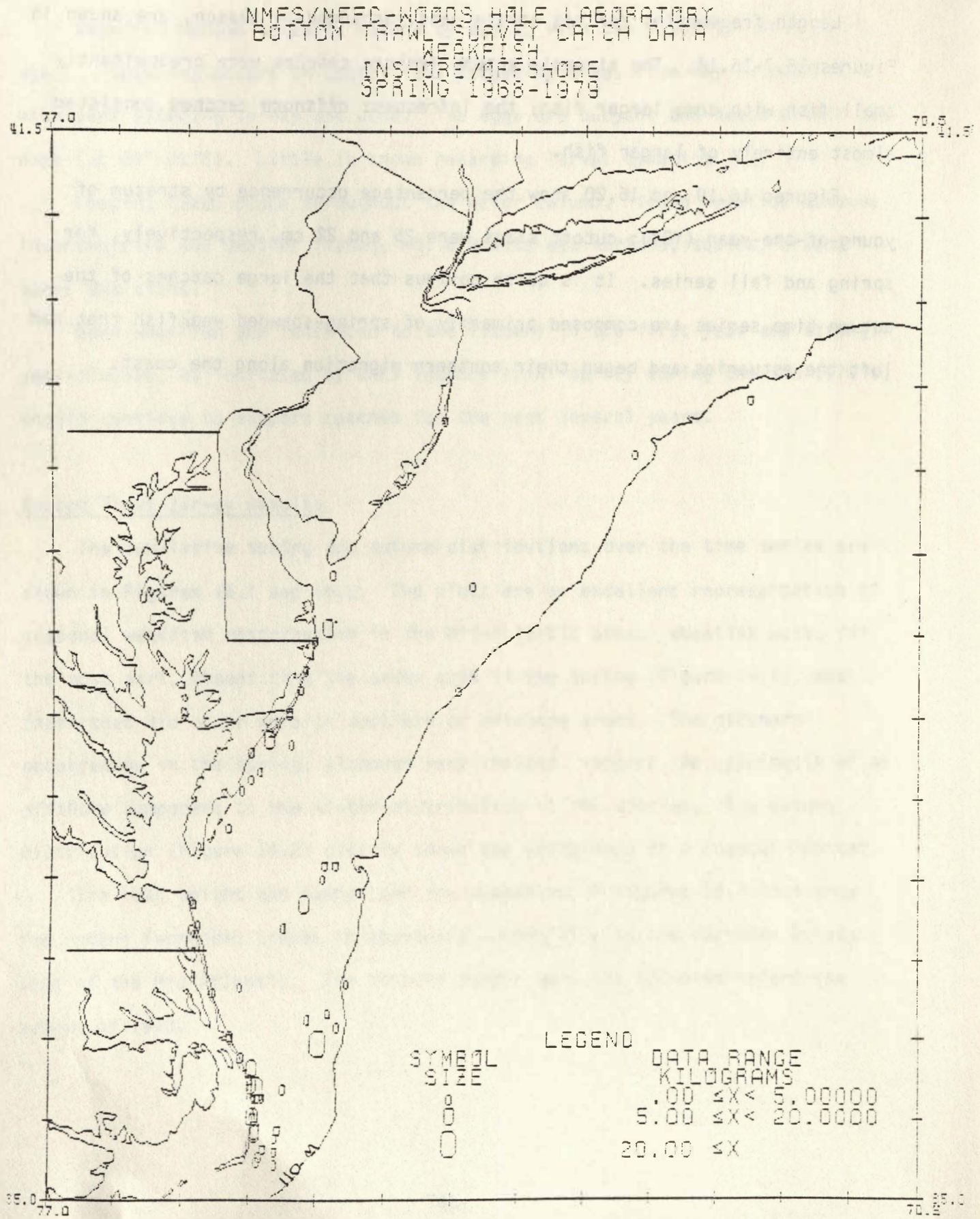

Figure 16.1. Spring distribution, 1968-1979.

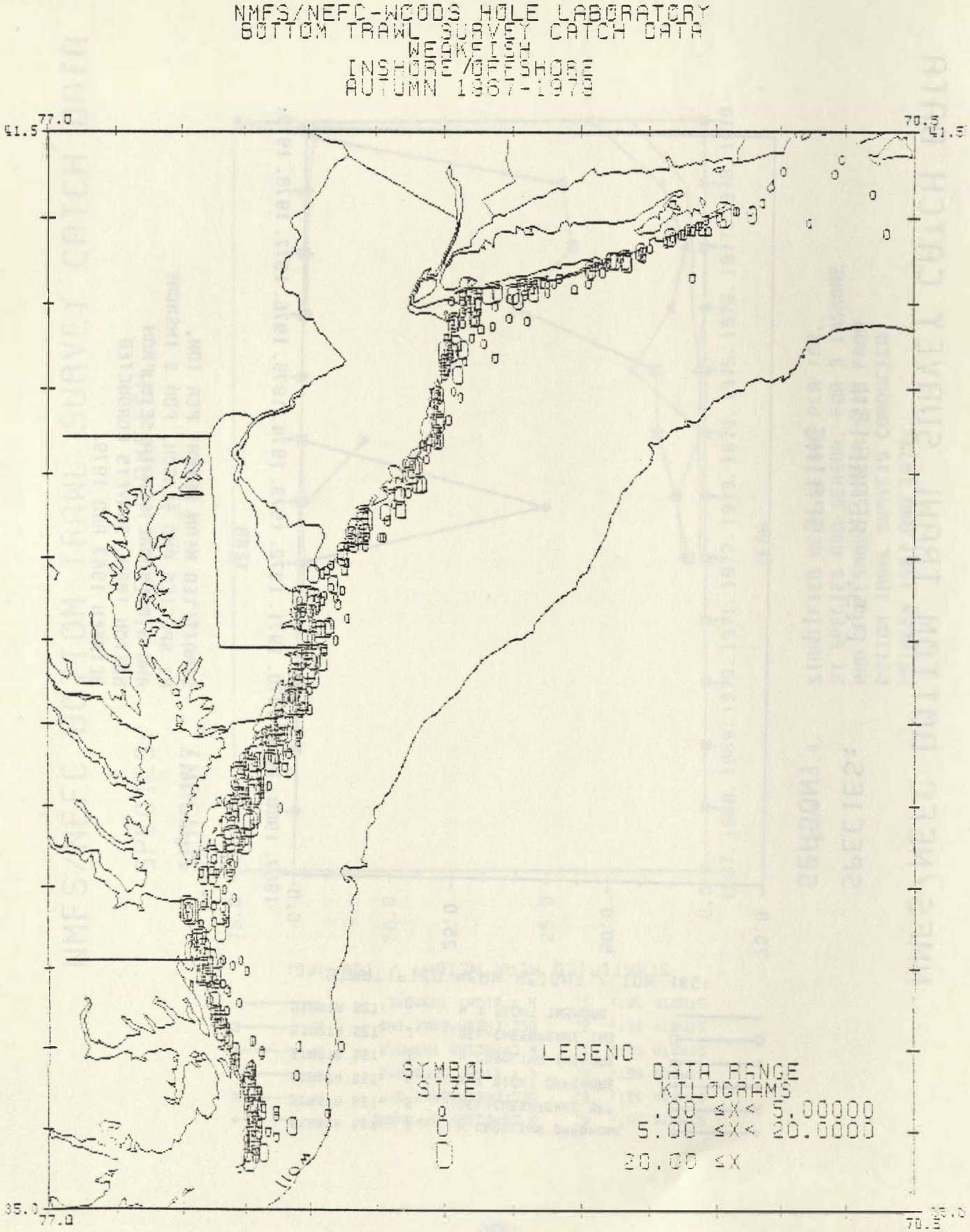

Figure 16.2. Autumn distribution, 1967-1979.

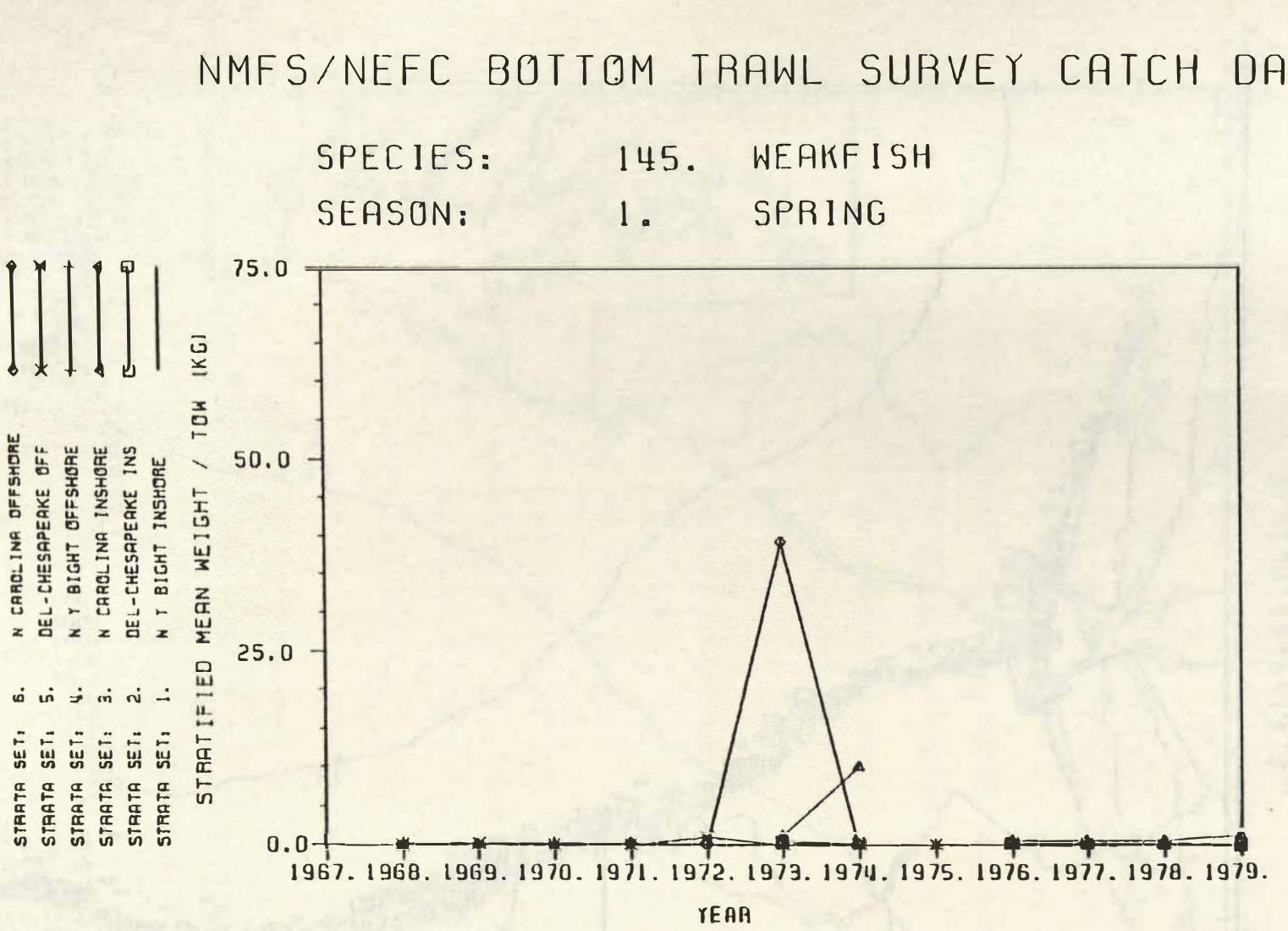

Figure 16.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

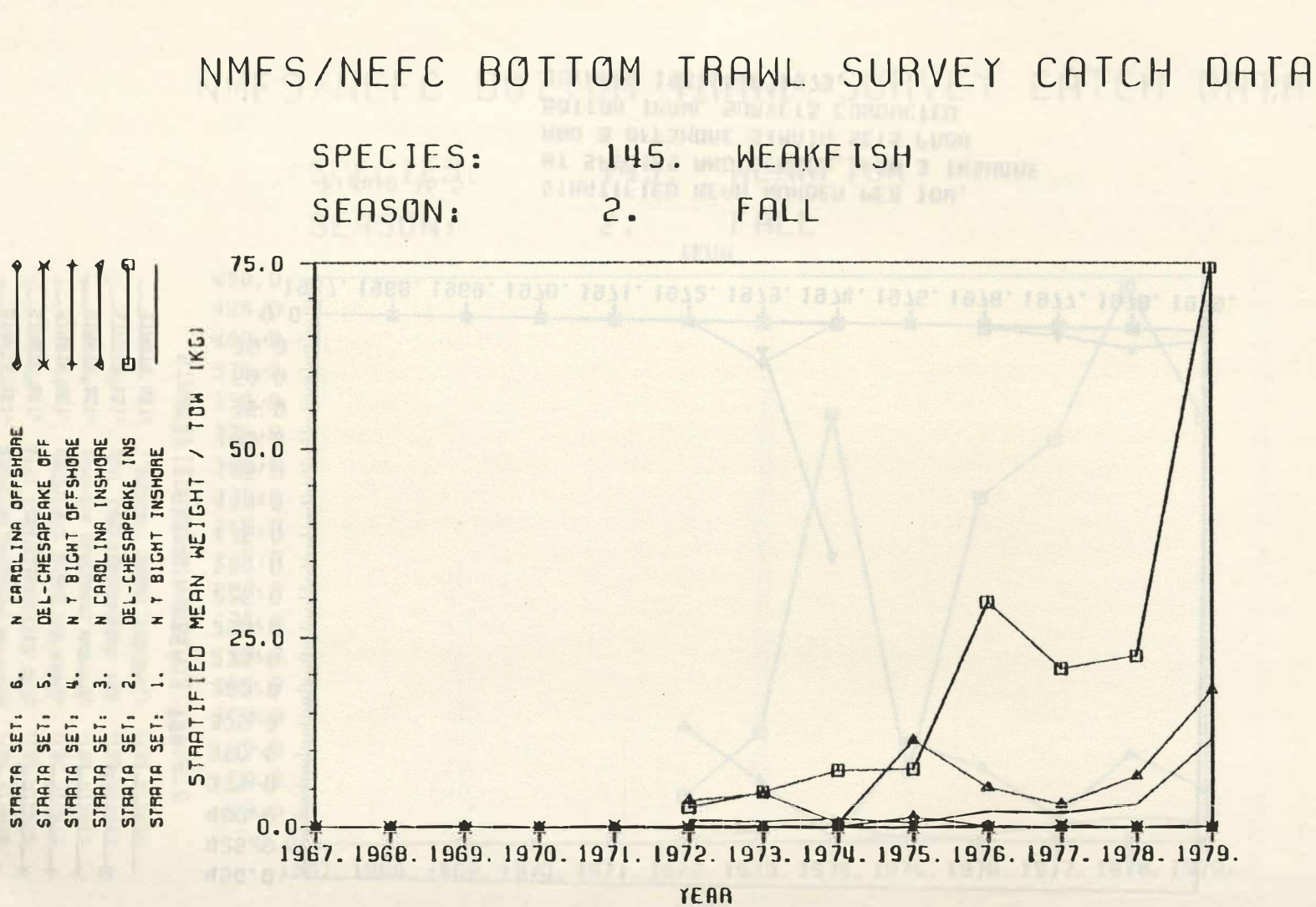

Figure 16.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

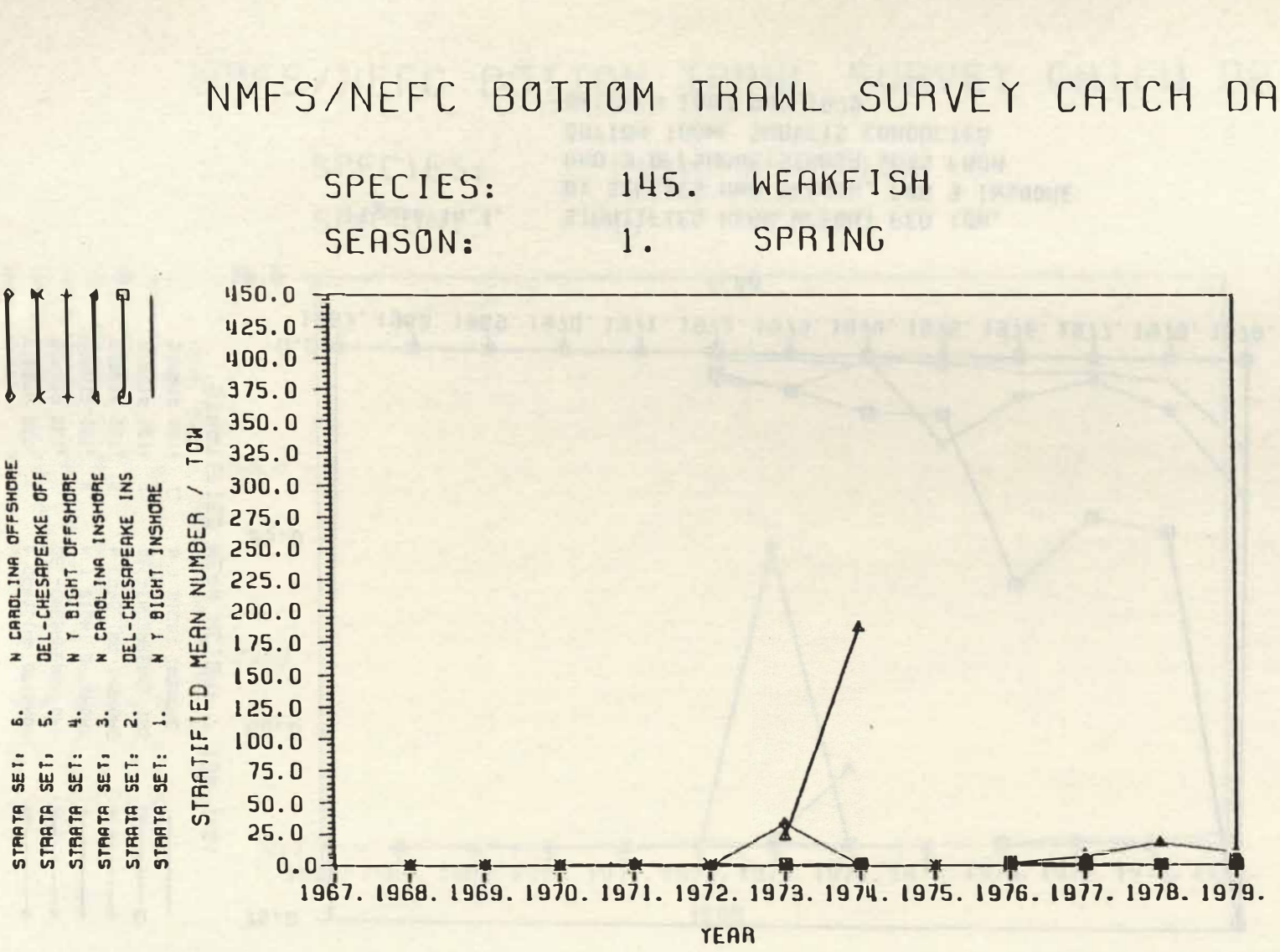

Figure 16.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

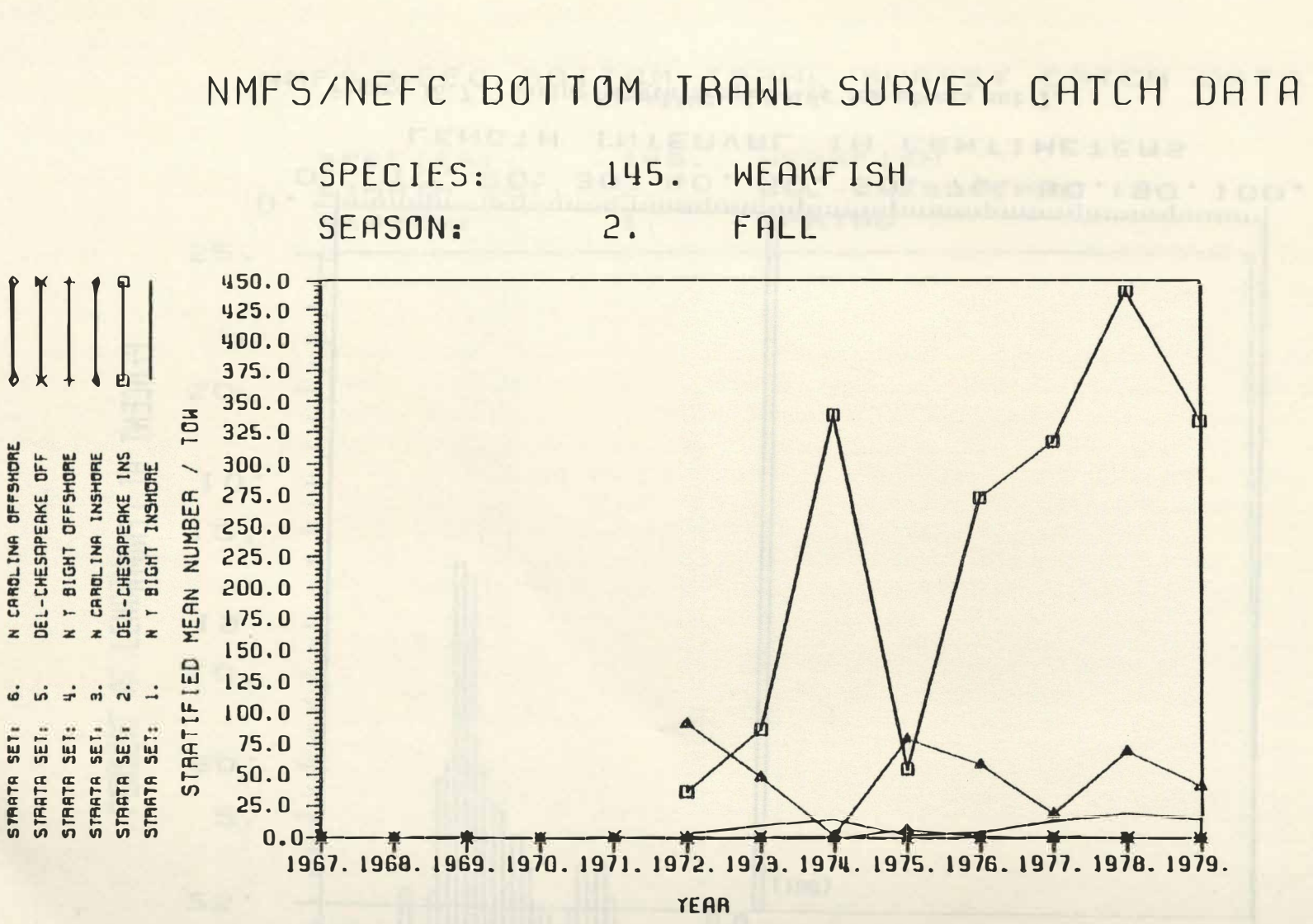

Figure 16.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

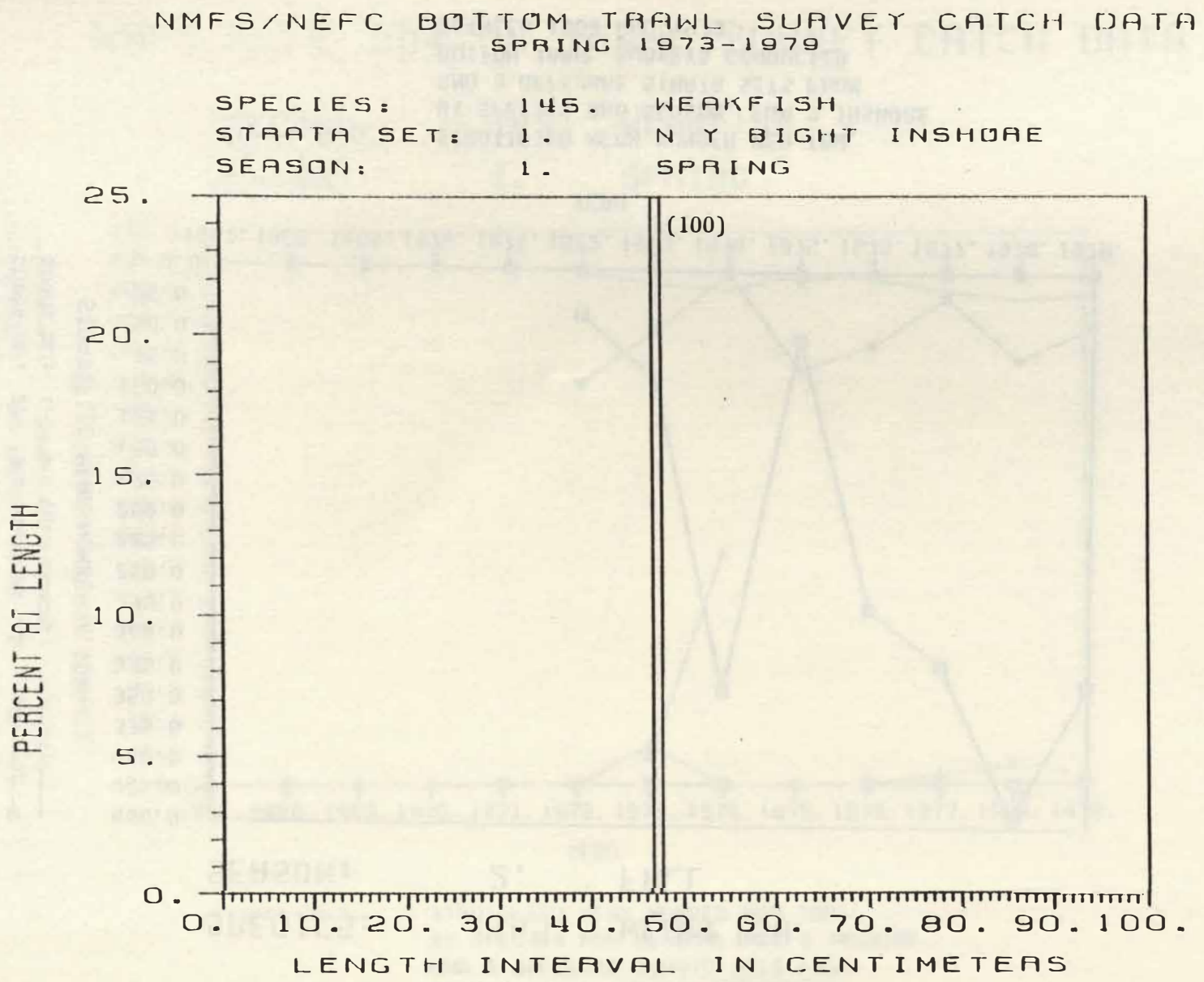

Figure 16.7. Spring length frequencies for strata set 1.

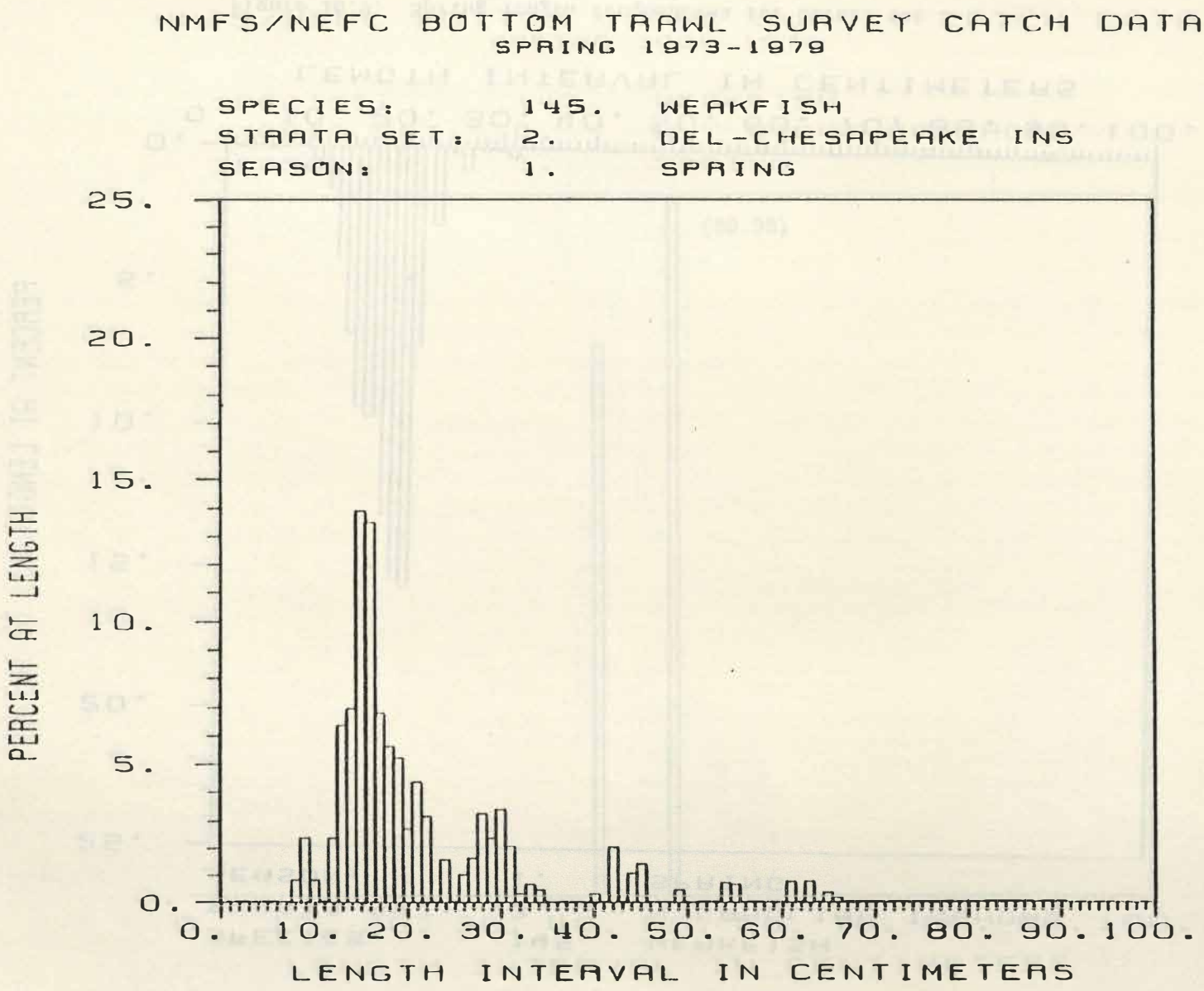

Figure 16.8. Spring length frequencies for strata set 2.

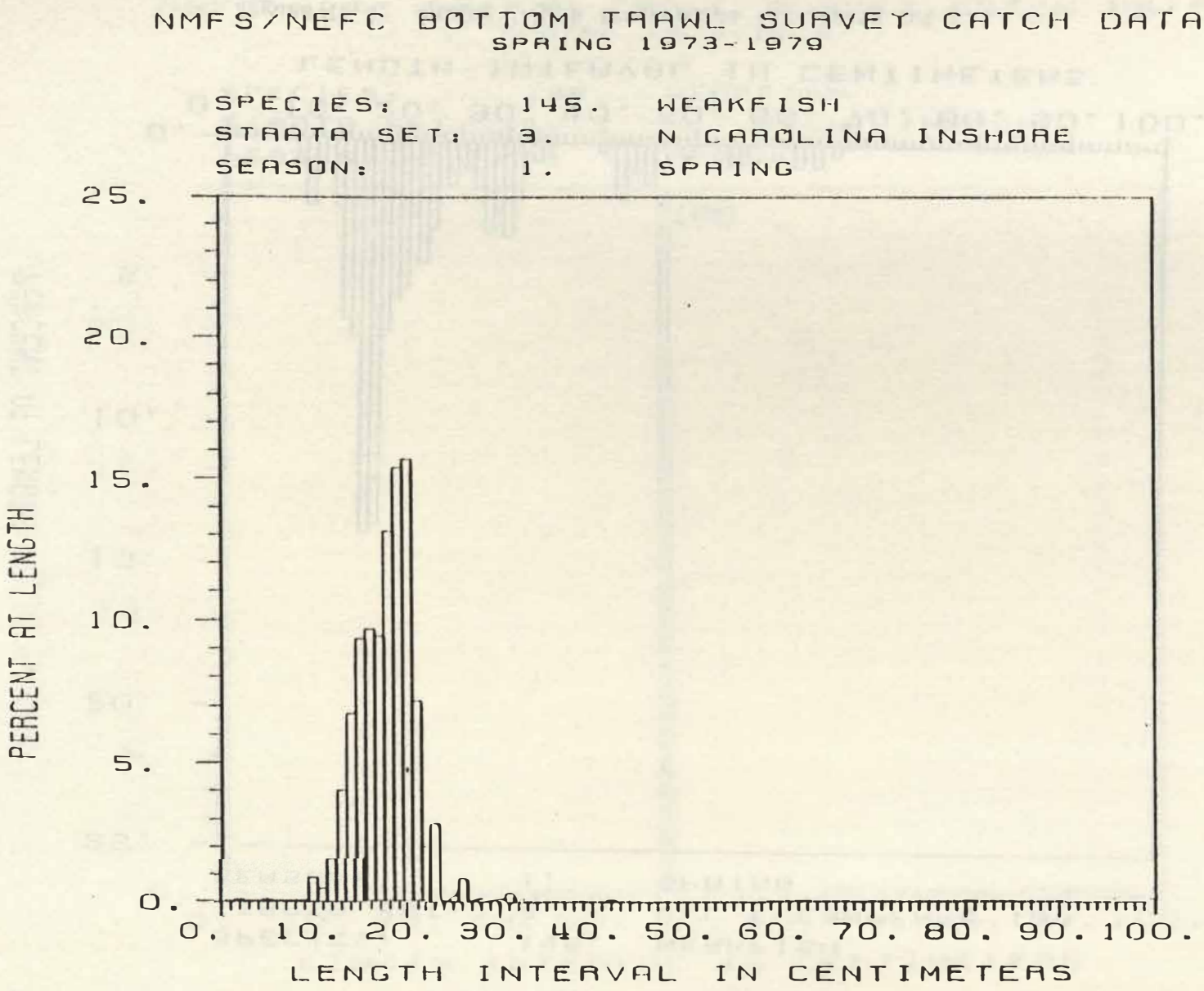

Figure 16.9. Spring length frequencies for strata set 3.

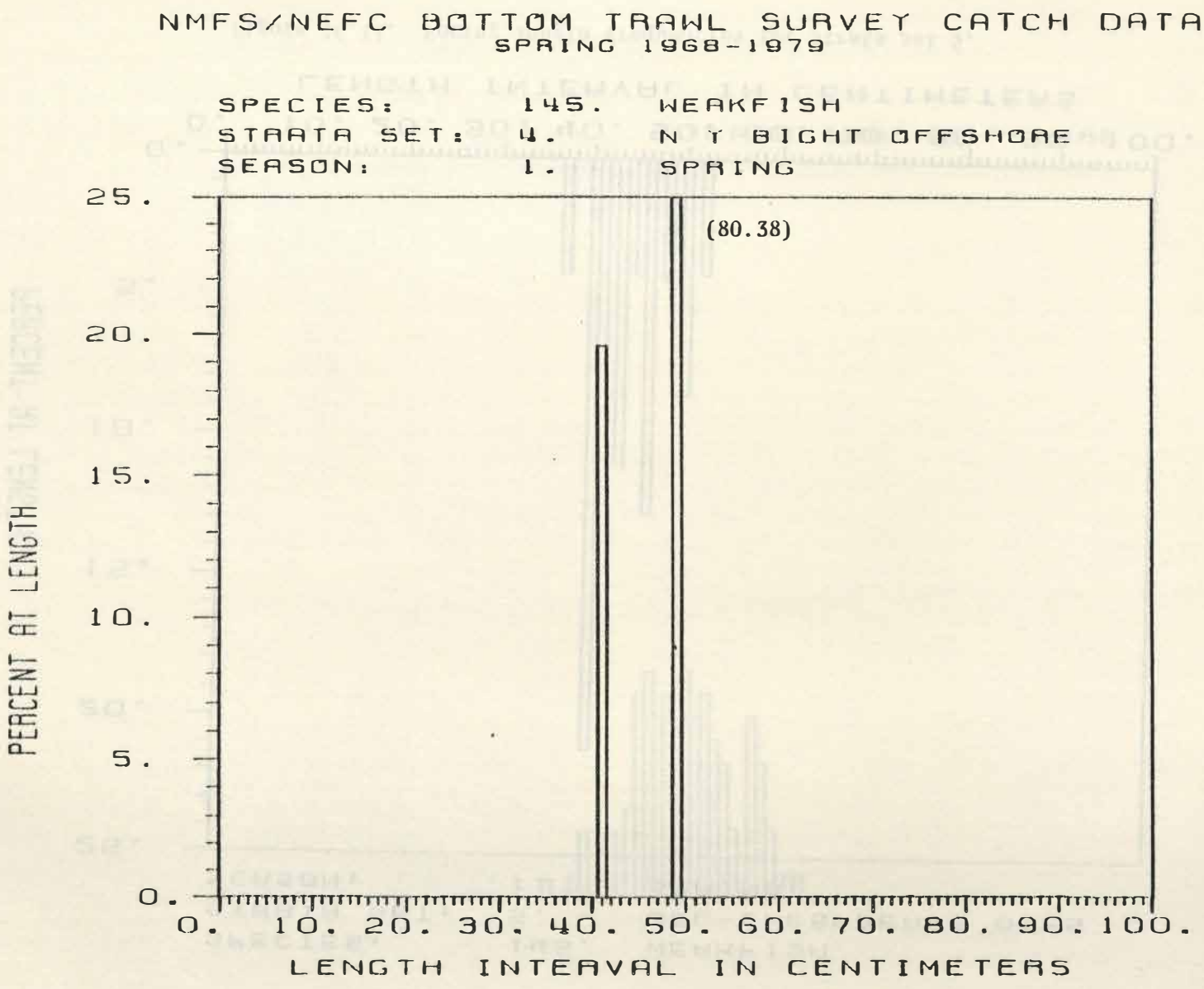

Figure 16.10. Spring length frequencies for strata set 4.

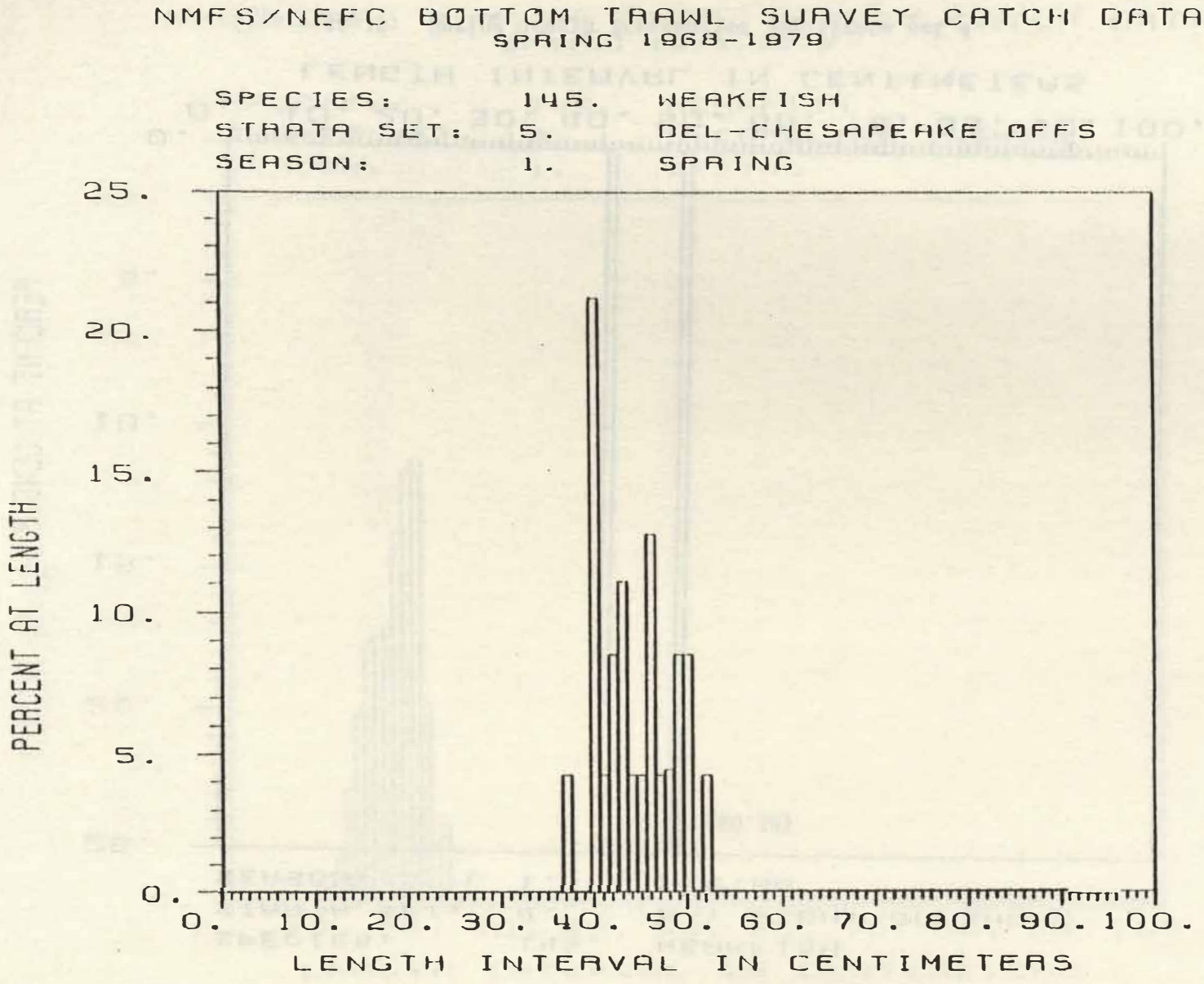

Figure 16.11. Spring length frequencies for strata set 5.

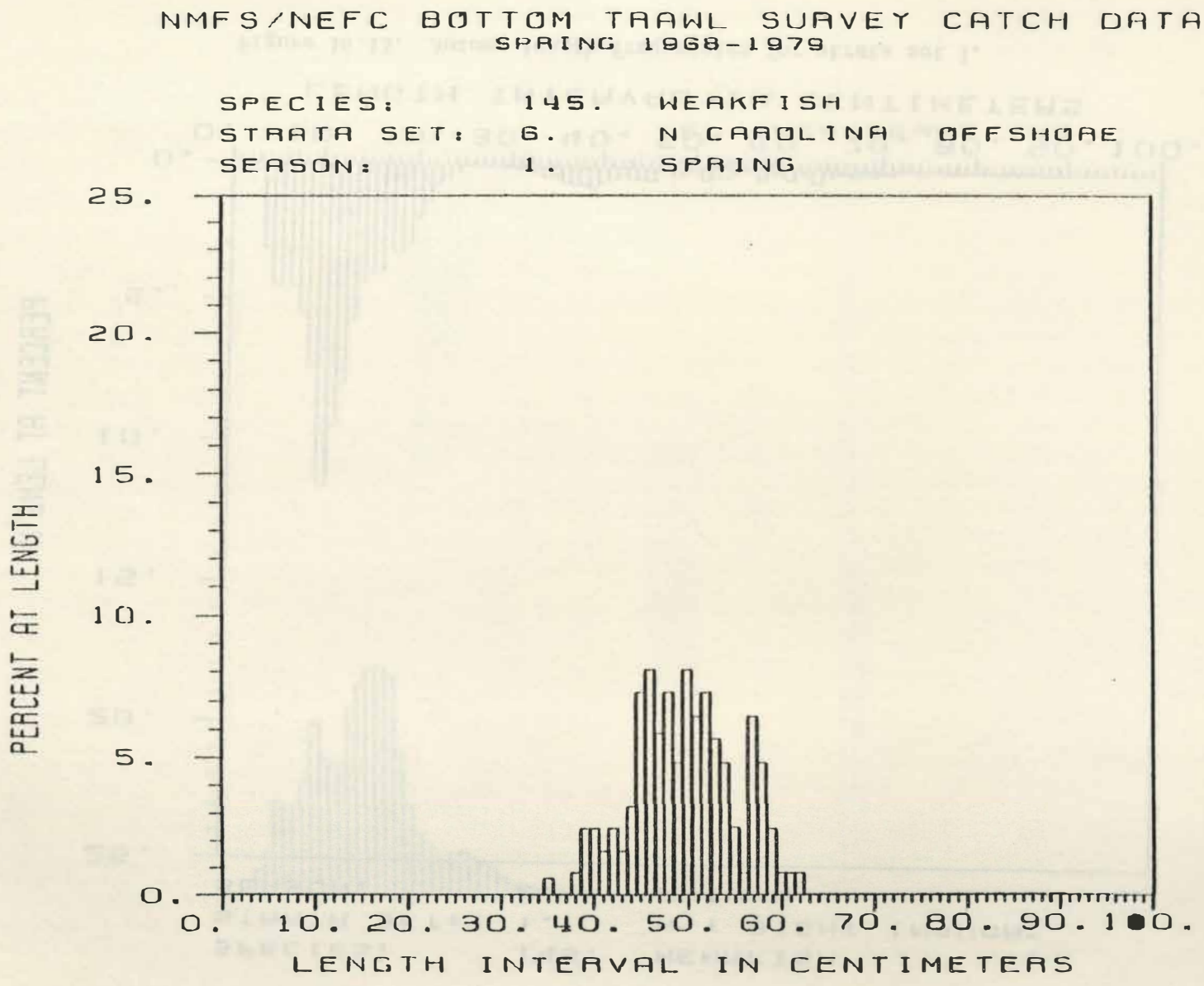

Figure 16.12. Spring length frequencies for strata set 6.

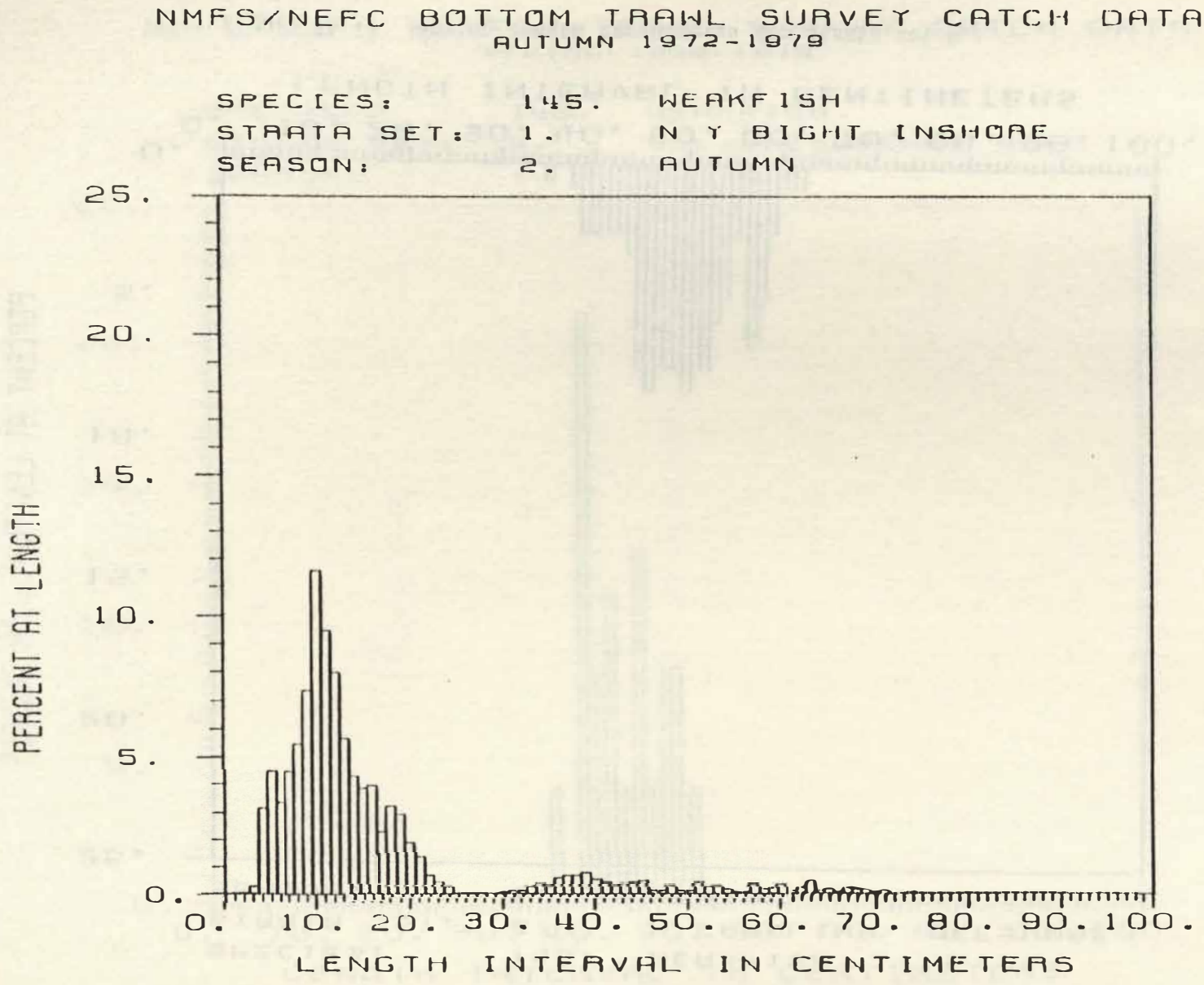

Figure 16.13. Autumn length frequencies for strata set 1.

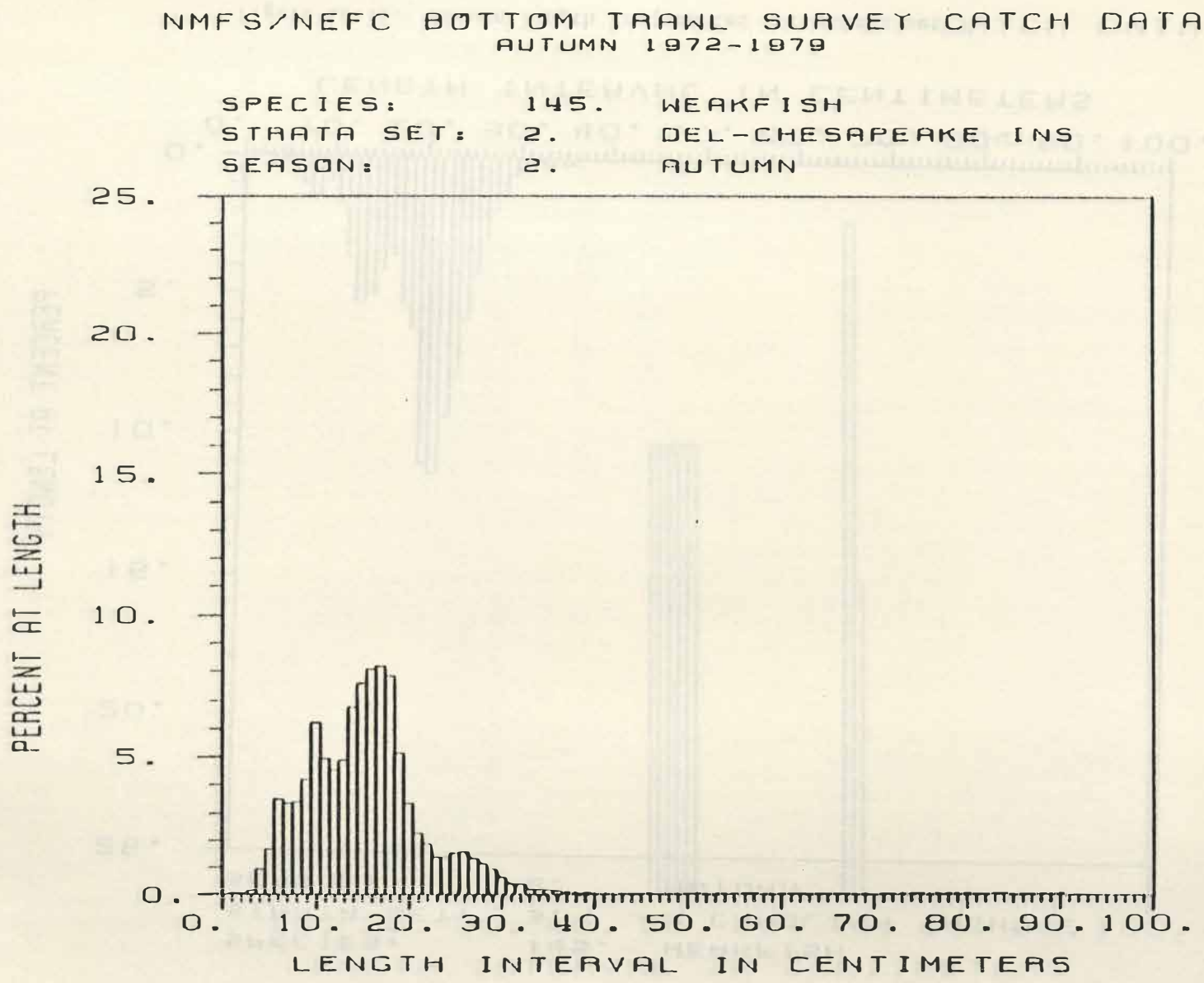

Figure 16.14. Autumn length frequencies for strata set 2.

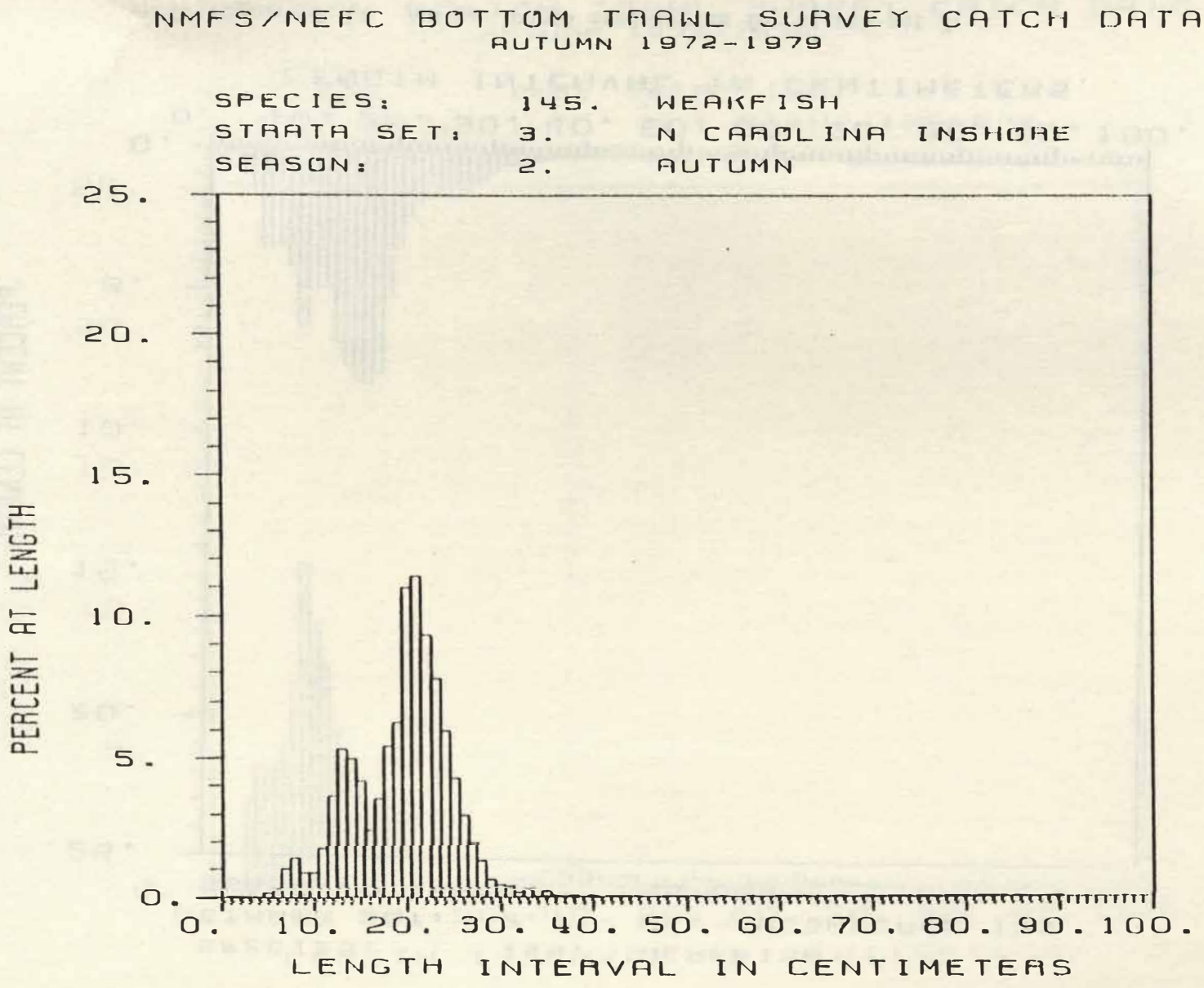

Figure 16.15. Autumn length frequencies for strata set 3.

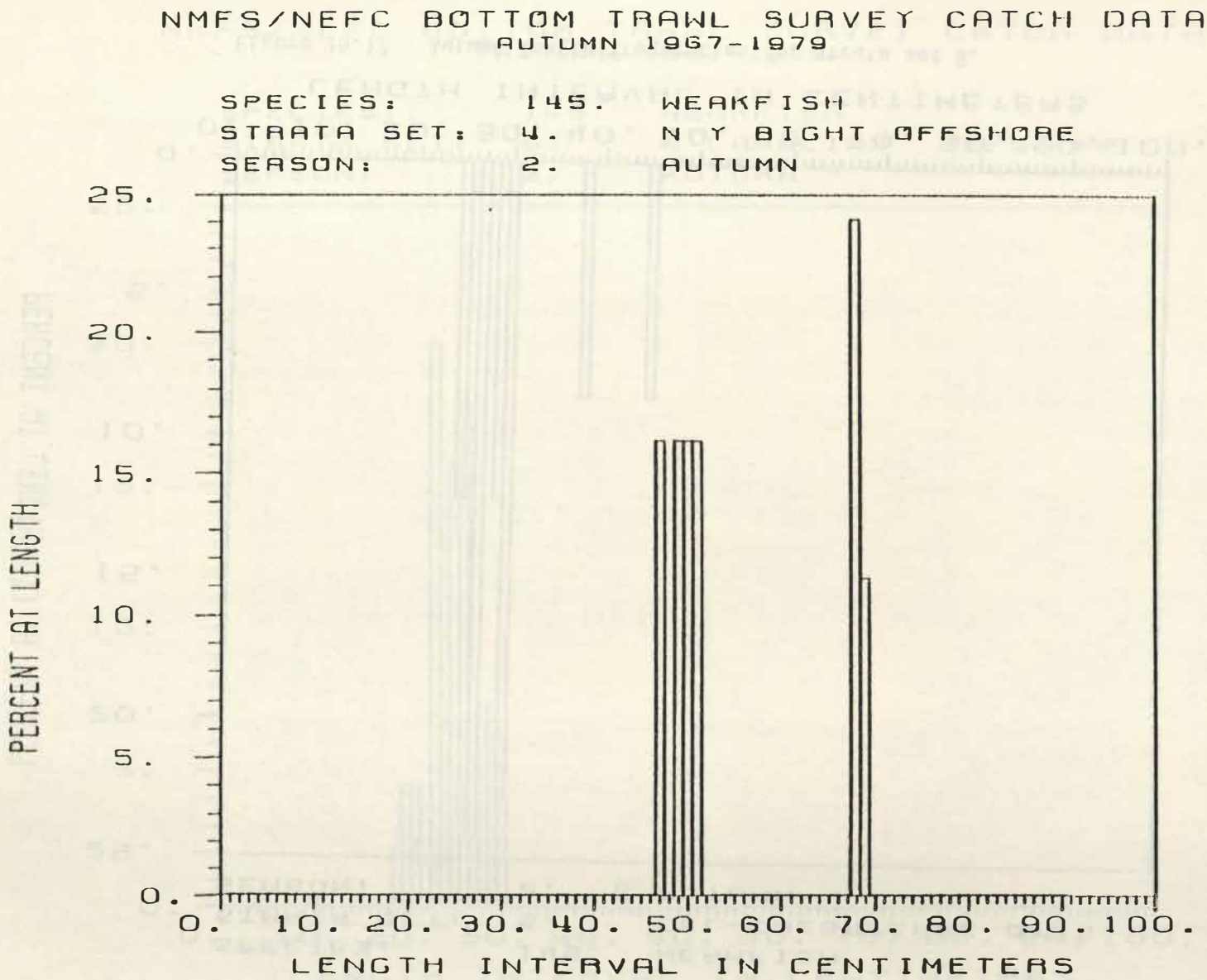

Figure 16.16. Autumn length frequencies for strata set 4.

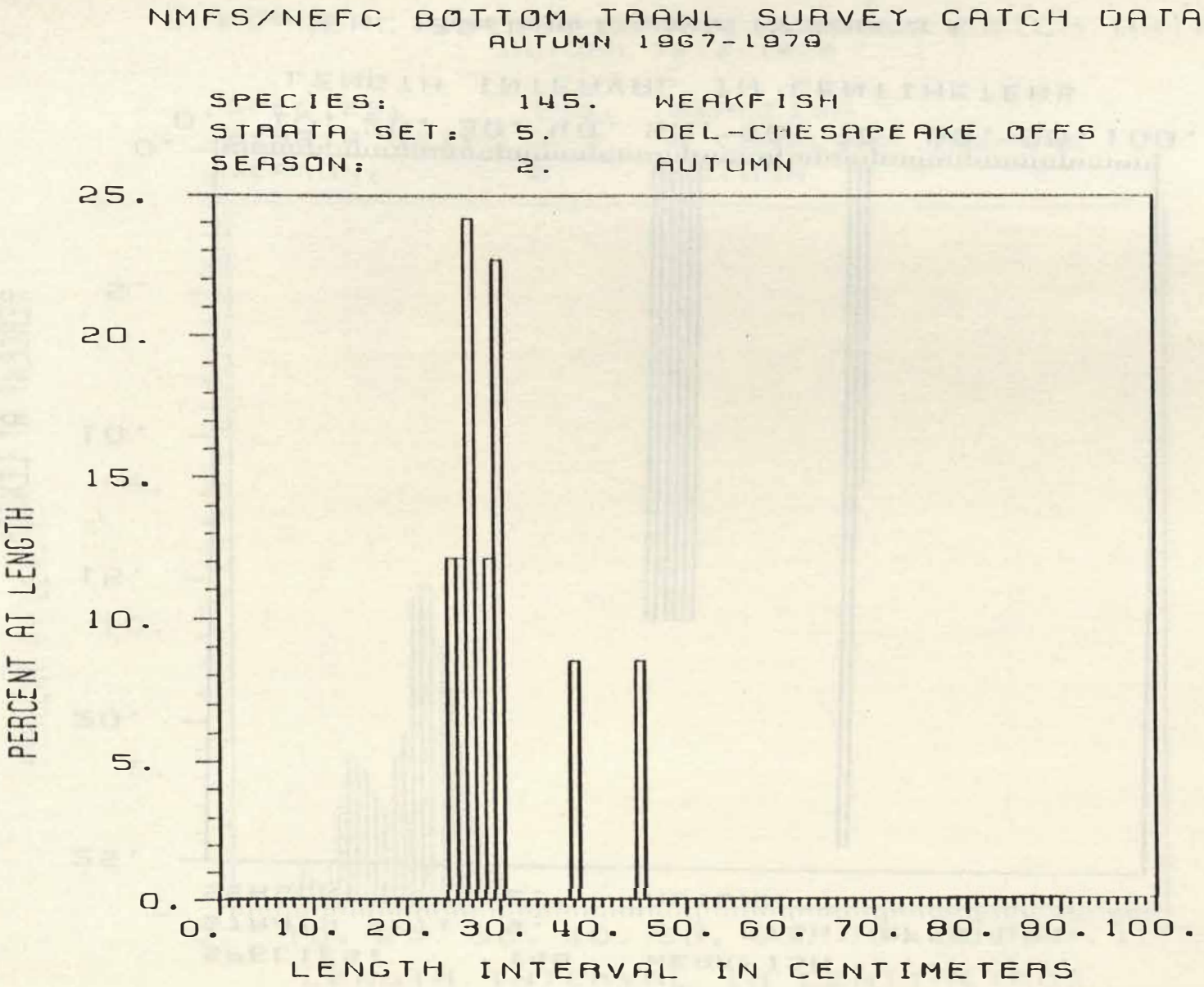

Figure 16.17. Autumn length frequencies for strata set 5.

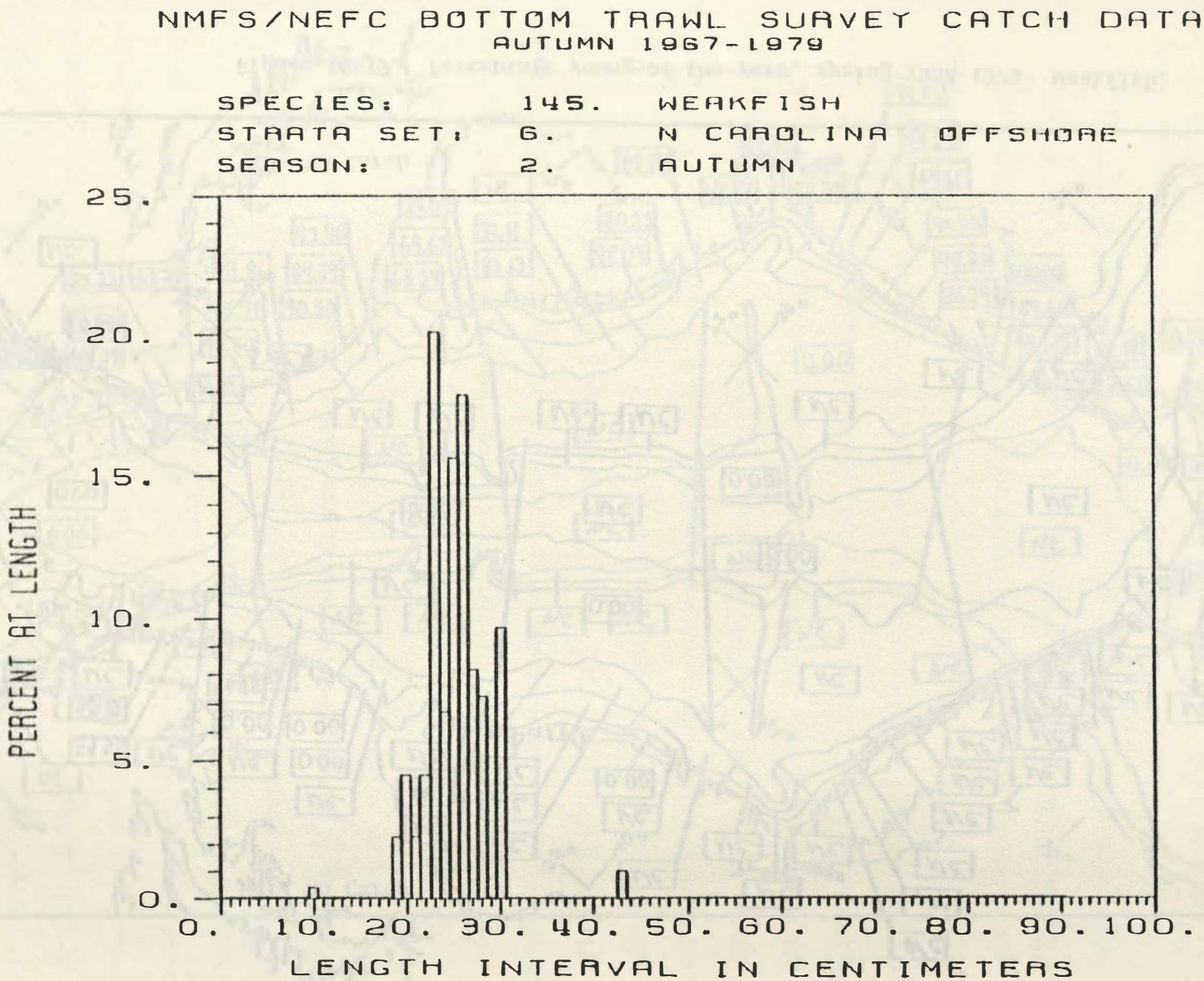

Figure 16.18. Autumn length frequencies for strata set 6.

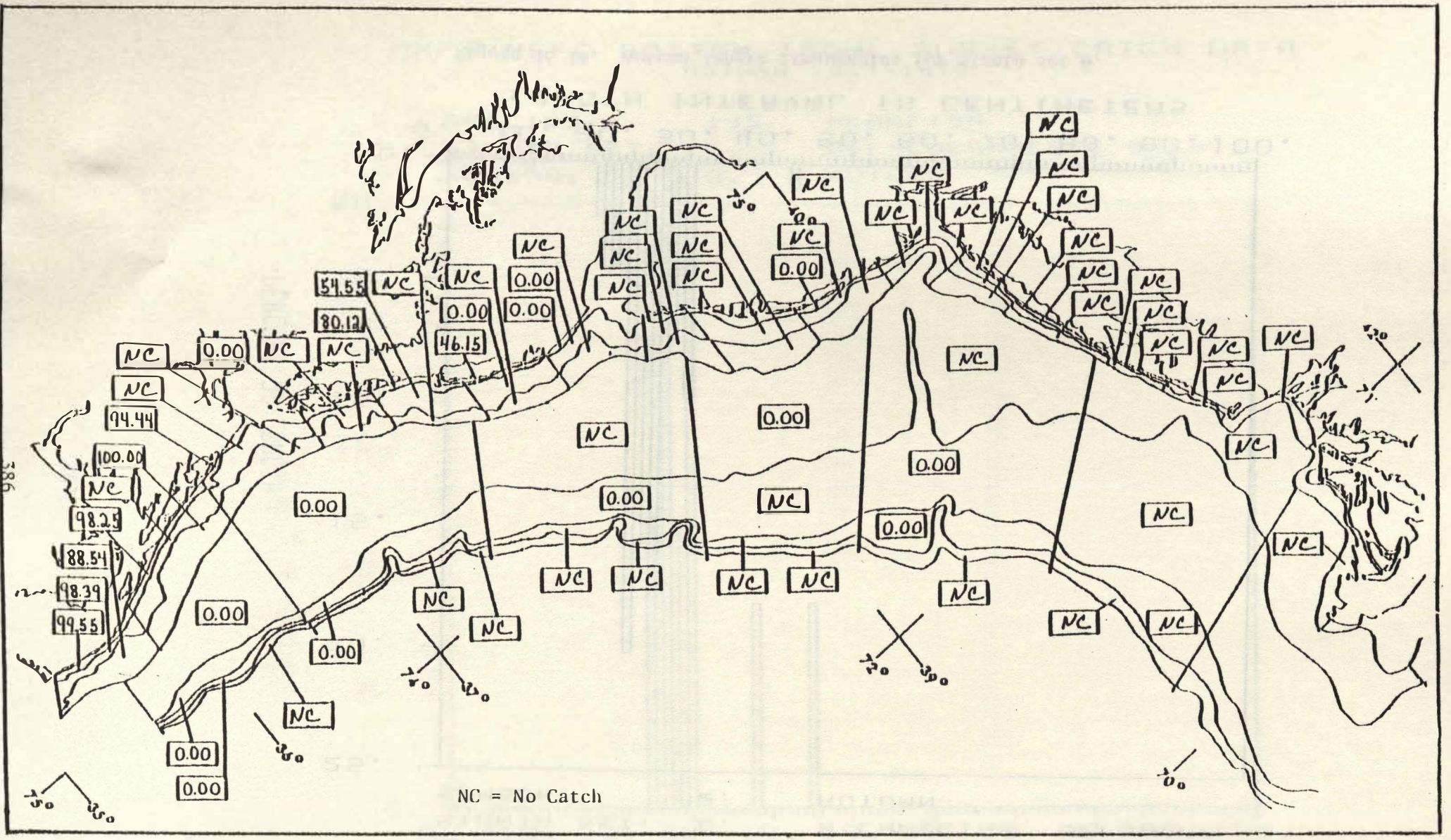

Figure 16.19. Percentage young-of-the-year, spring 1968-1979- weakfish.

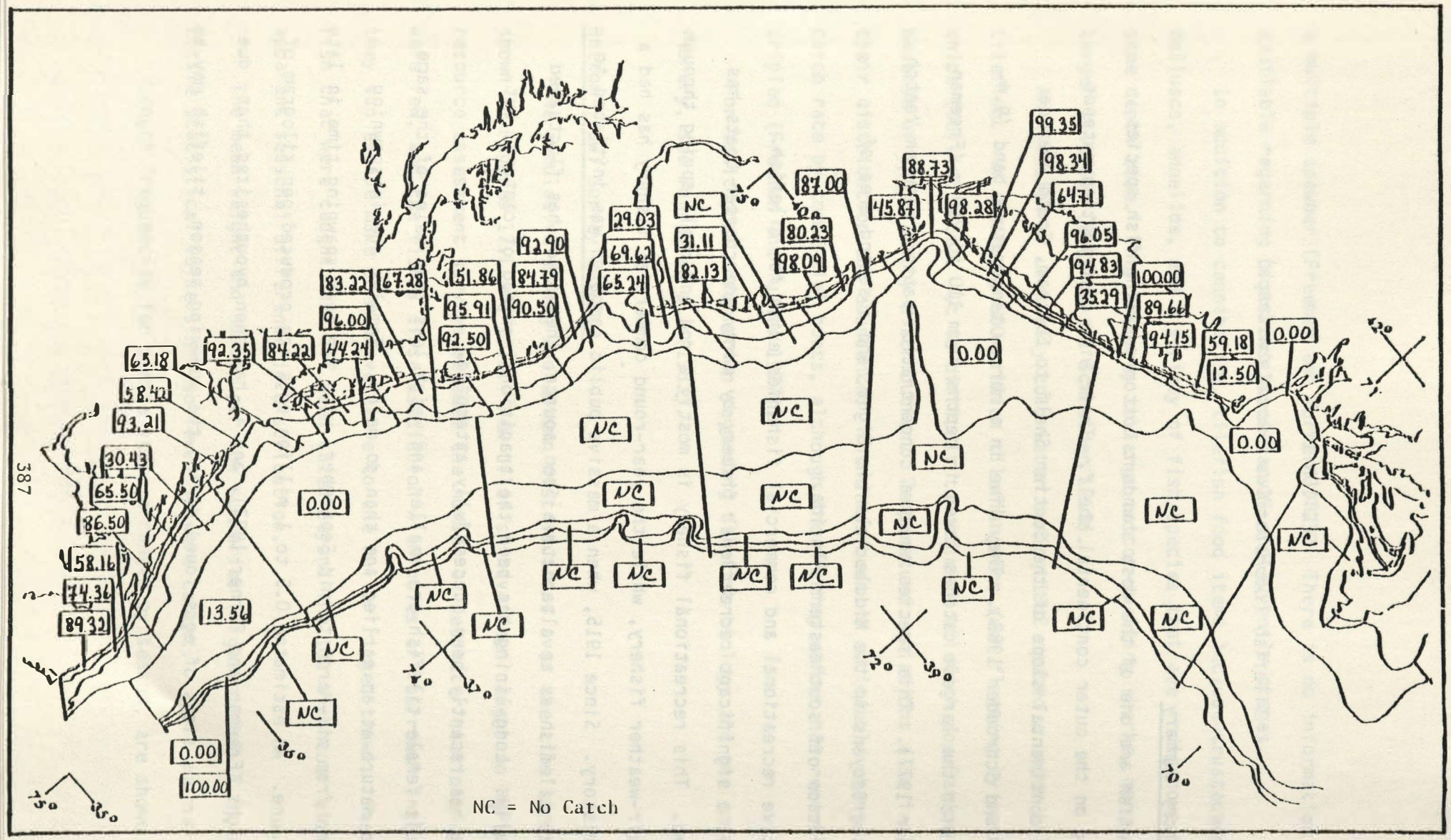

Figure 16.20. Percentage young-of-the-year, autumn 1967-1979 - weakfish.

SECTION 17

Tilefish (*Lopholatilus chamaeleonticeps*)

Life History Summary

Tilefish are one of the most abundant bottom-dwelling fish species occurring on the outer continental shelf. Their wide distribution extends from the continental slope of the Scotian Shelf to Surinam, South America (Bigelow and Schroeder 1953). They live in a narrow temperature band (9.4-14.4°C) with the largest catches taken in depths from 110 to 780 m (Freeman and Turner 1977). This species shows a concentration pattern between Veatch and Hudson Canyons in the Middle Atlantic Bight, and a second area of concentration off southeastern Florida.

Active recreational and commercial fisheries exist for tilefish. Recently, a significant recreational fishery by party and charter boats has developed. This recreational fishery is mostly a rod and reel, spring through fall, fair-weather fishery, while the year-round commercial fishery has had a longer history. Since 1915, when a massive public campaign was initiated to introduce tilefish as an alternative food source, the market has fluctuated erratically. Long-lining has been the traditional method of capture, but trawling has recently been successfully attempted.

Adult female tilefish are smaller and weigh less than males of the same age, and mature at an earlier age than do males. Females are in spawning condition from mid-March to mid-September, with the peak spawning time in late May to June. An estimated 0.5 to 1 million eggs are produced per kilogram of body weight (Freeman and Turner 1977), and it has been hypothesized that, due to the various sizes of eggs found during the spawning season, tilefish may be

a multiple spawner (Freeman and Turner 1982). There is no information available regarding distribution of larval and juvenile stages.

In addition to cannibalism, tilefish food items include crustaceans, molluscs, annelids, and a variety of fish species that are indigenous to the same depth zone. They are prey to large bottom-dwelling sharks, man, and larger tilefish (Bigelow and Schroeder 1953).

An invasion of unusually cold water during 1882 caused a major kill of tilefish. An estimated 500 million tilefish were seen floating by passing ships (Collins 1884). It is difficult to estimate tilefish population size because of their patchy distribution. Temperature variations also influence their distribution and abundance. There has been no noticeable change in catch rate by commercial boats, although the fishing effort has recently tripled (Freeman and Turner 1977).

For additional information regarding tilefish biology and the commercial fishery, see Turner et al. (1983).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 17.1 and 17.2. Few tilefish have been caught on NMFS resource assessment surveys because the number of deepwater stations occupied were few, and the fish's close asociation with holes or "burrows" into which they can escape make them unavailable to the roller rigged trawl. The few fish that were caught have all been taken beyond the 100 m contour with no apparent seasonal difference in distribution.

The mean weight and number per tow summaries (Figures 17.3-17.6) are of little statistical value since so few fish were caught.

Length frequencies for strata sets, arranged by season, are shown in

Figures 17.6-17.11. These figures also show few consistent trends except that small fish (<19 cm) were taken only during the autumn, but since catches have been so small, it is hard to attribute any real significance to that observation. No fish were caught in spring or autumn strata sets 1-3 and autumn strata set 6.

There are no plots for young-of-the-year because so few have been caught.

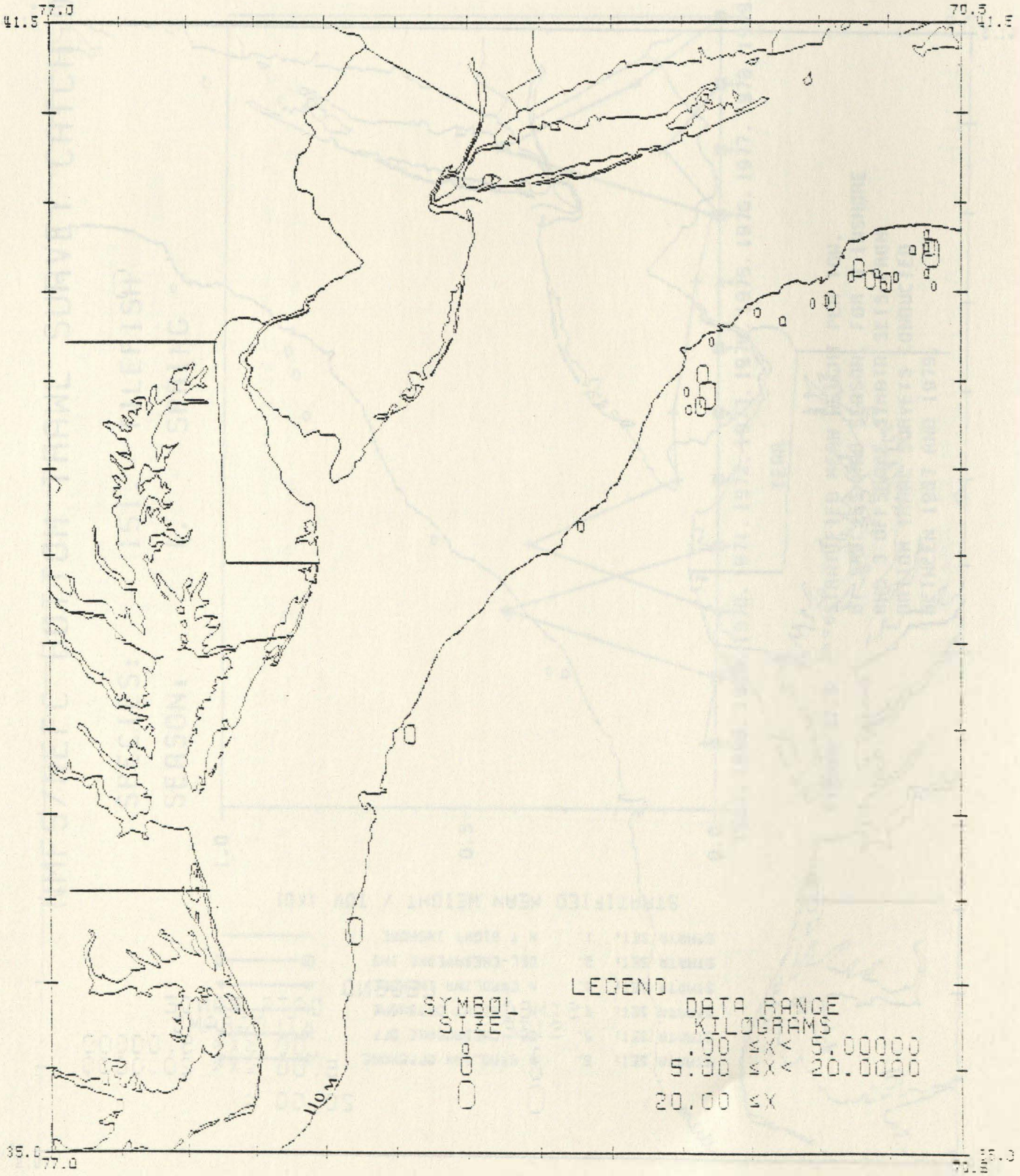

Figure 17.1. Spring distribution, 1968-1979.

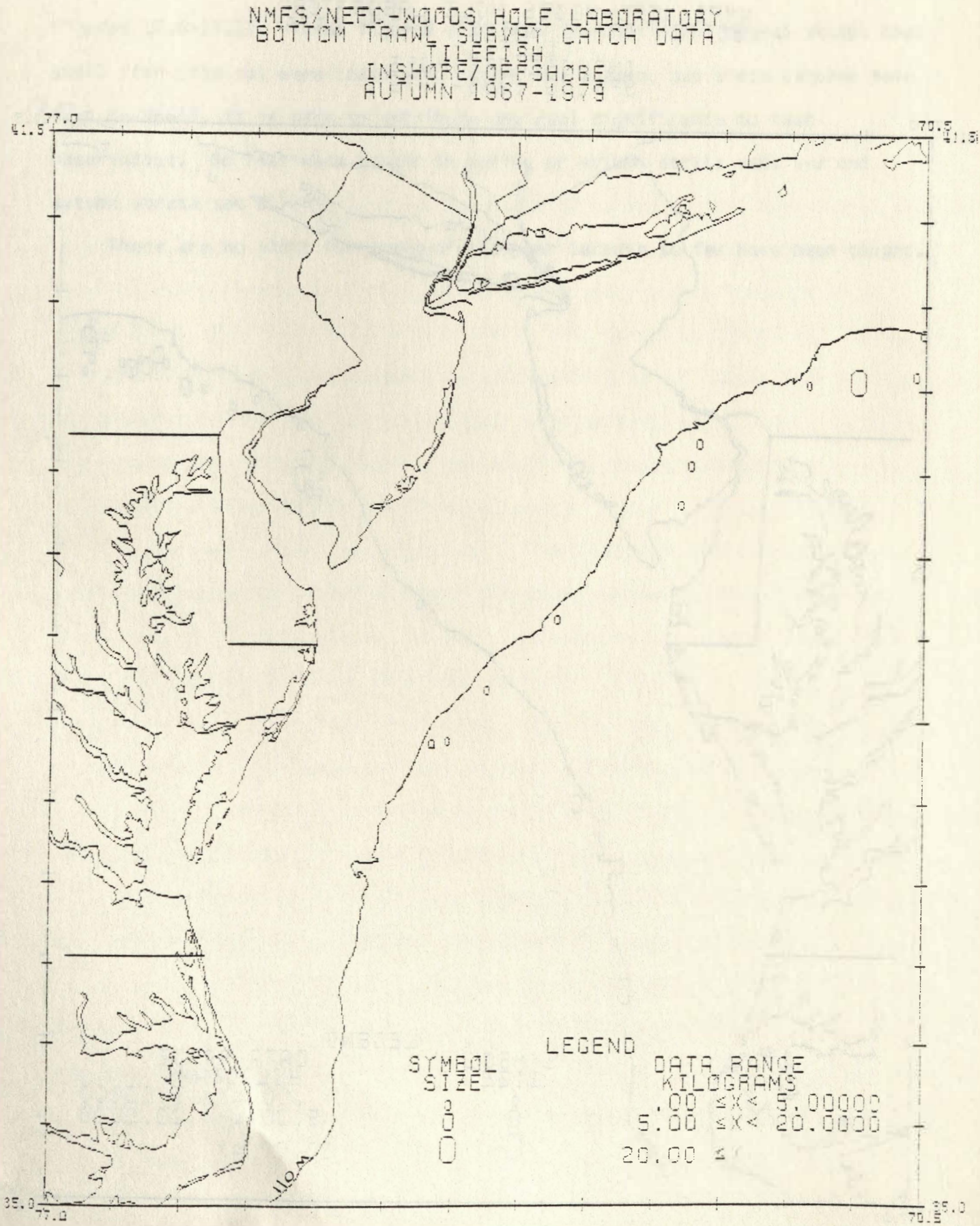

Figure 17.2. Autumn distribution, 1967-1979.

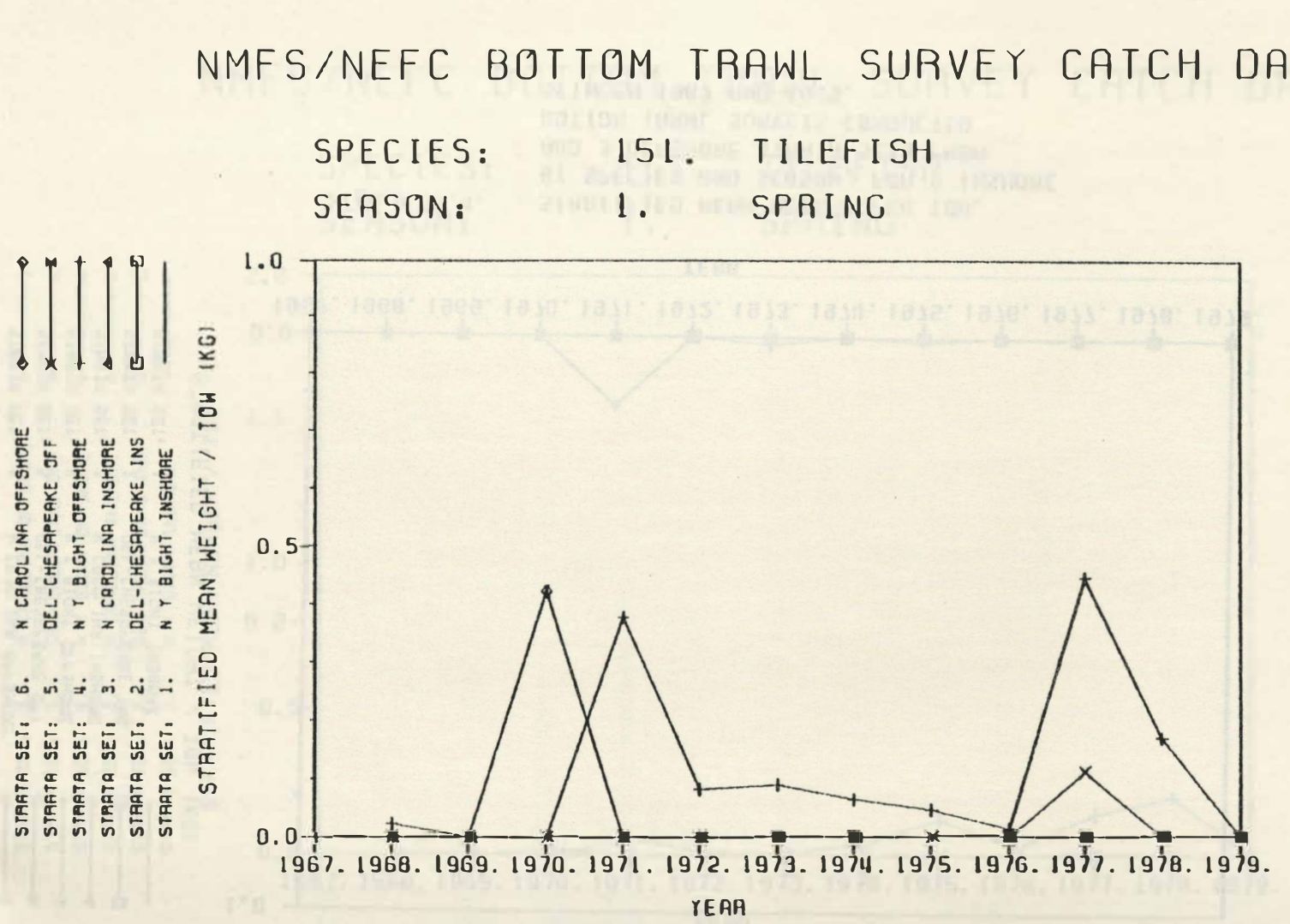

Figure 17.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

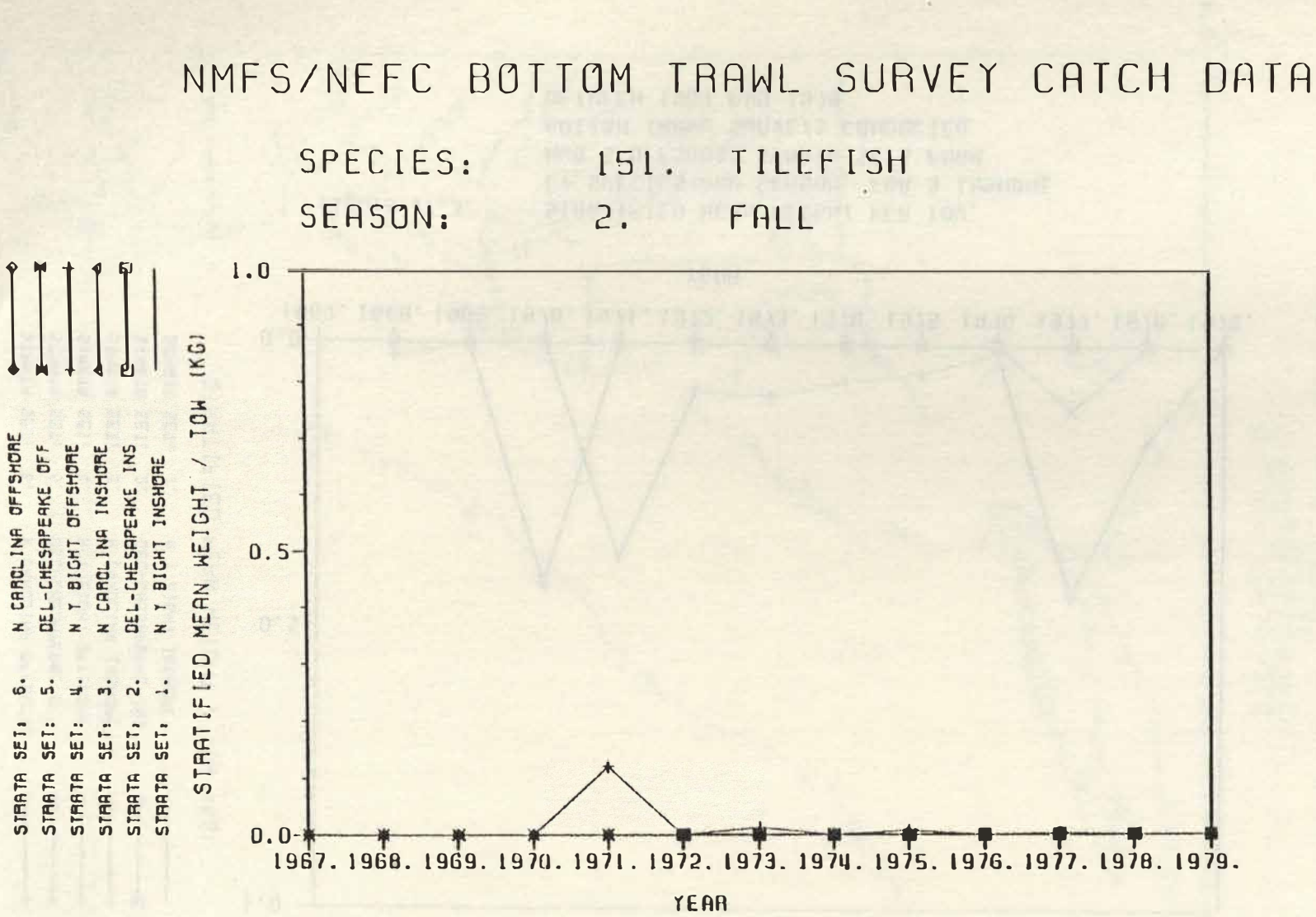

Figure 17.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 151. TILEFISH

SEASON: 1. SPRING

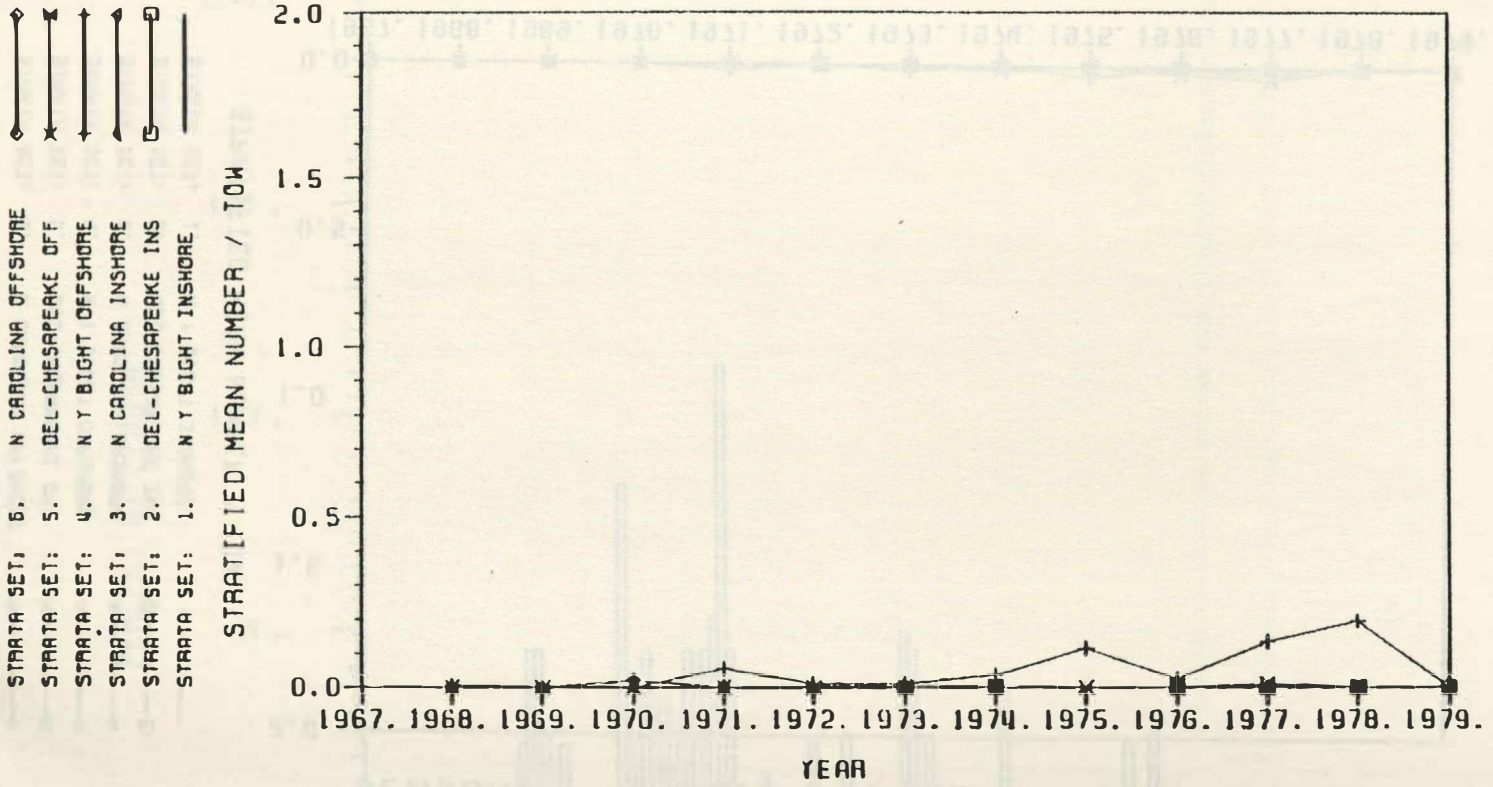

Figure 17.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

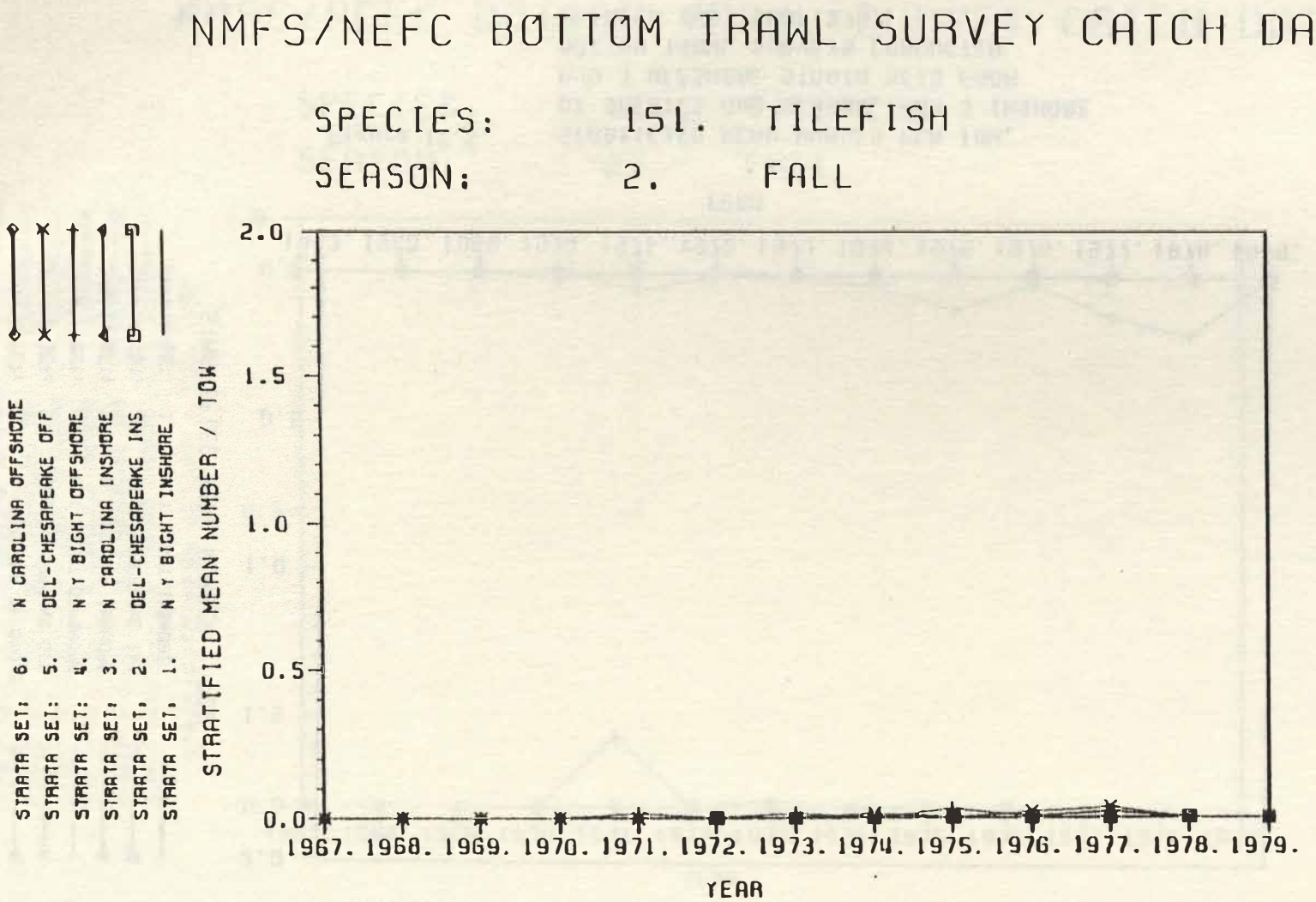

Figure 17.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

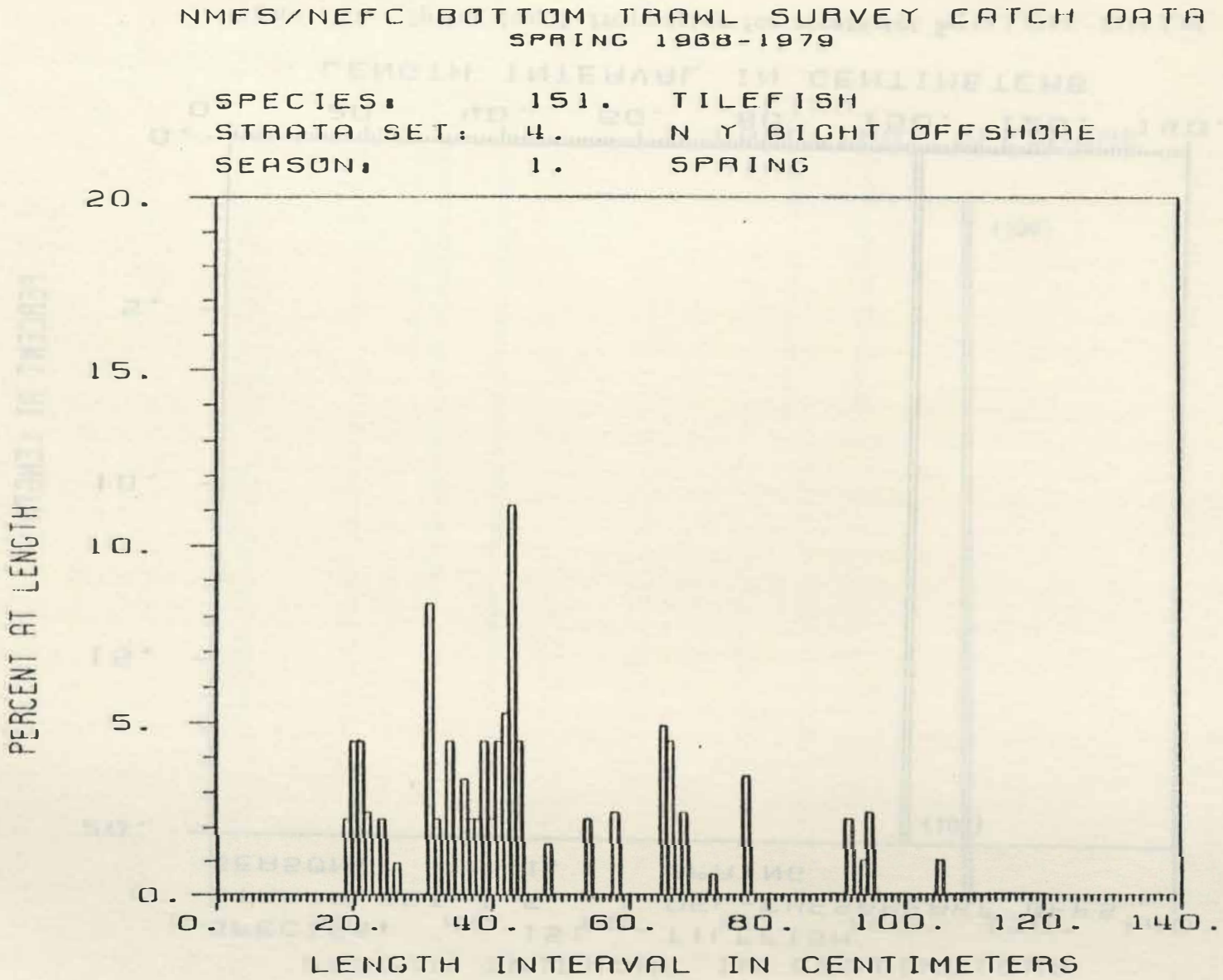

Figure 17.7. Spring length frequencies for strata set 4.

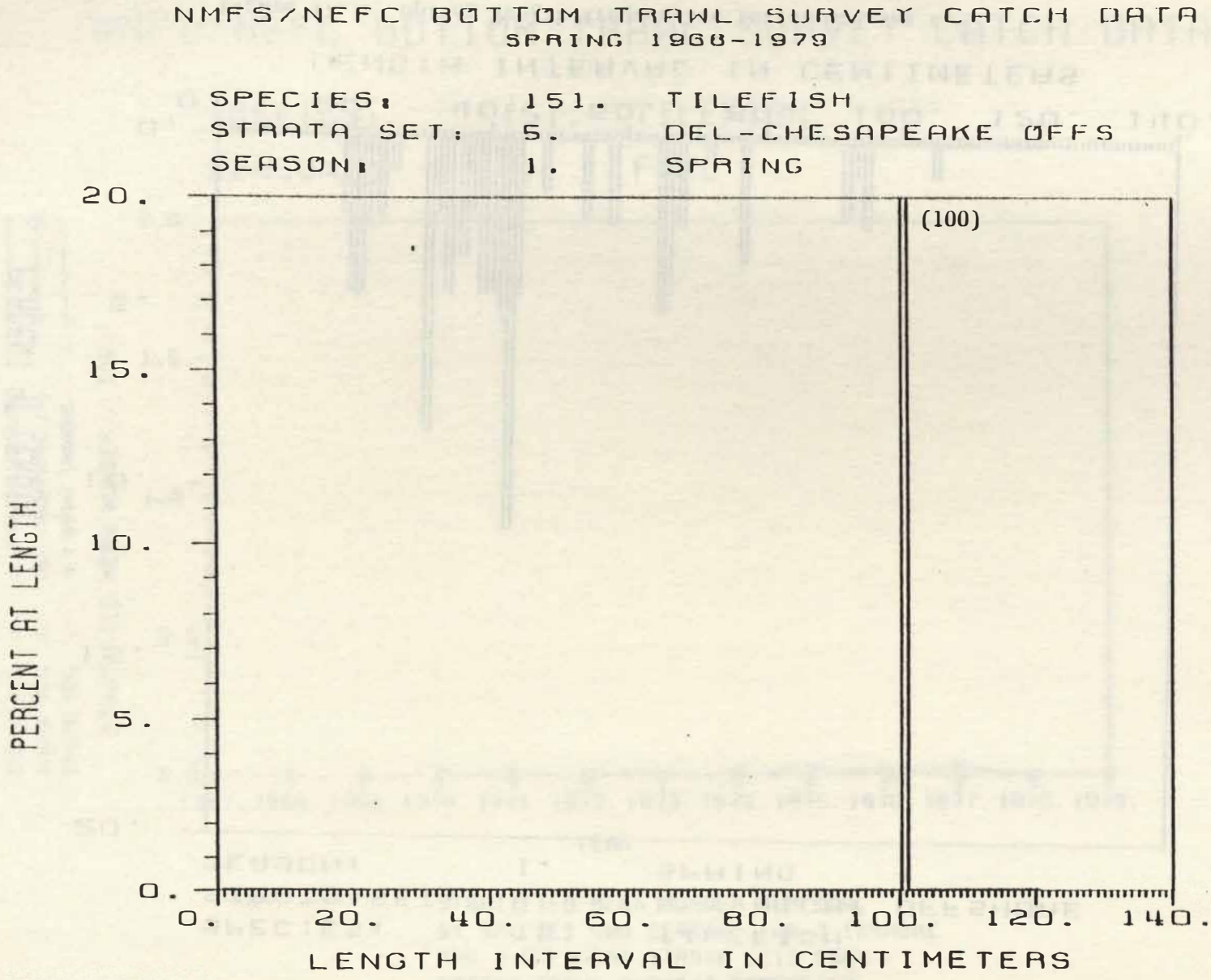

Figure 17.8. Spring length frequencies for strata set 5.

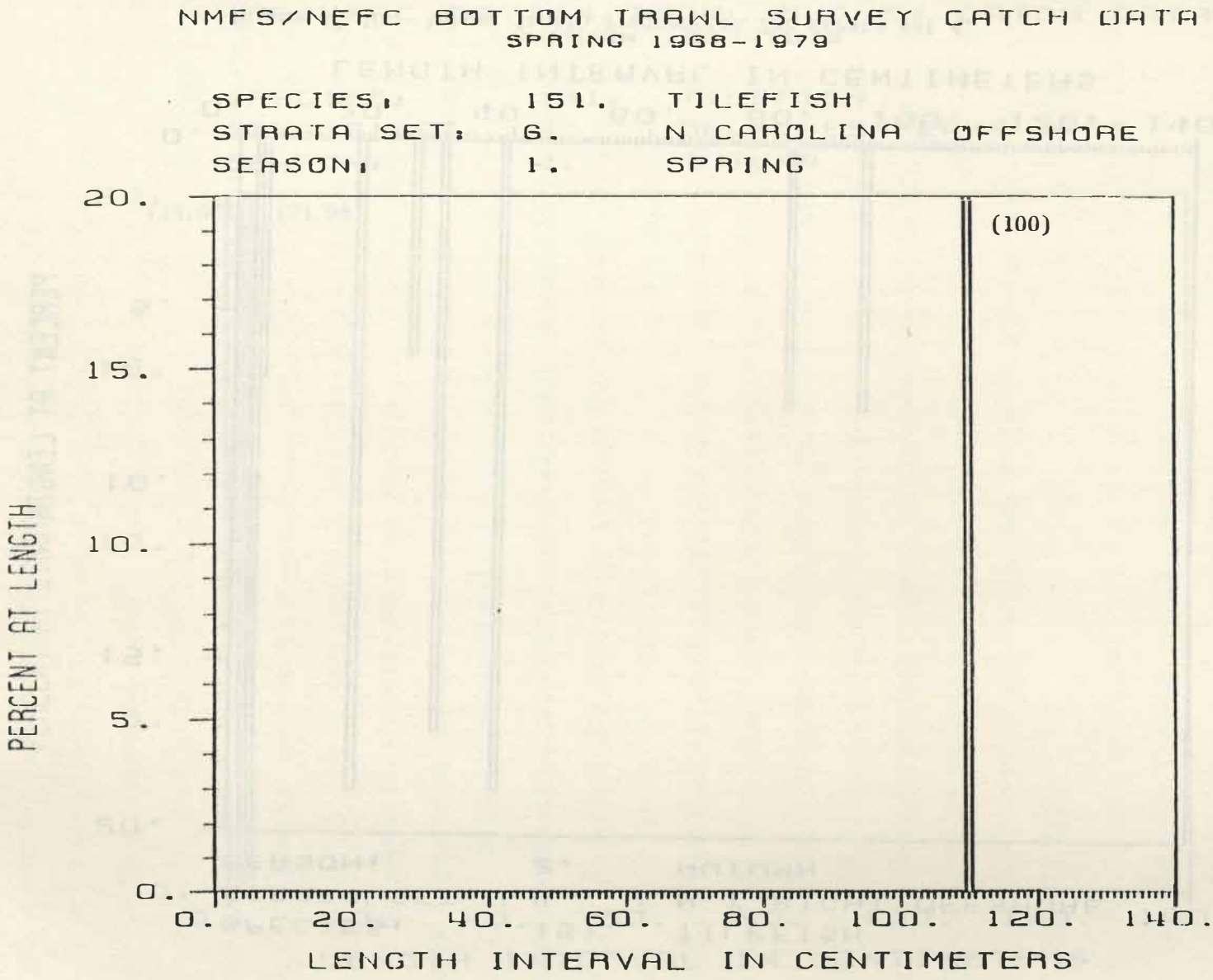

Figure 17.9. Spring length frequencies for strata set 6.

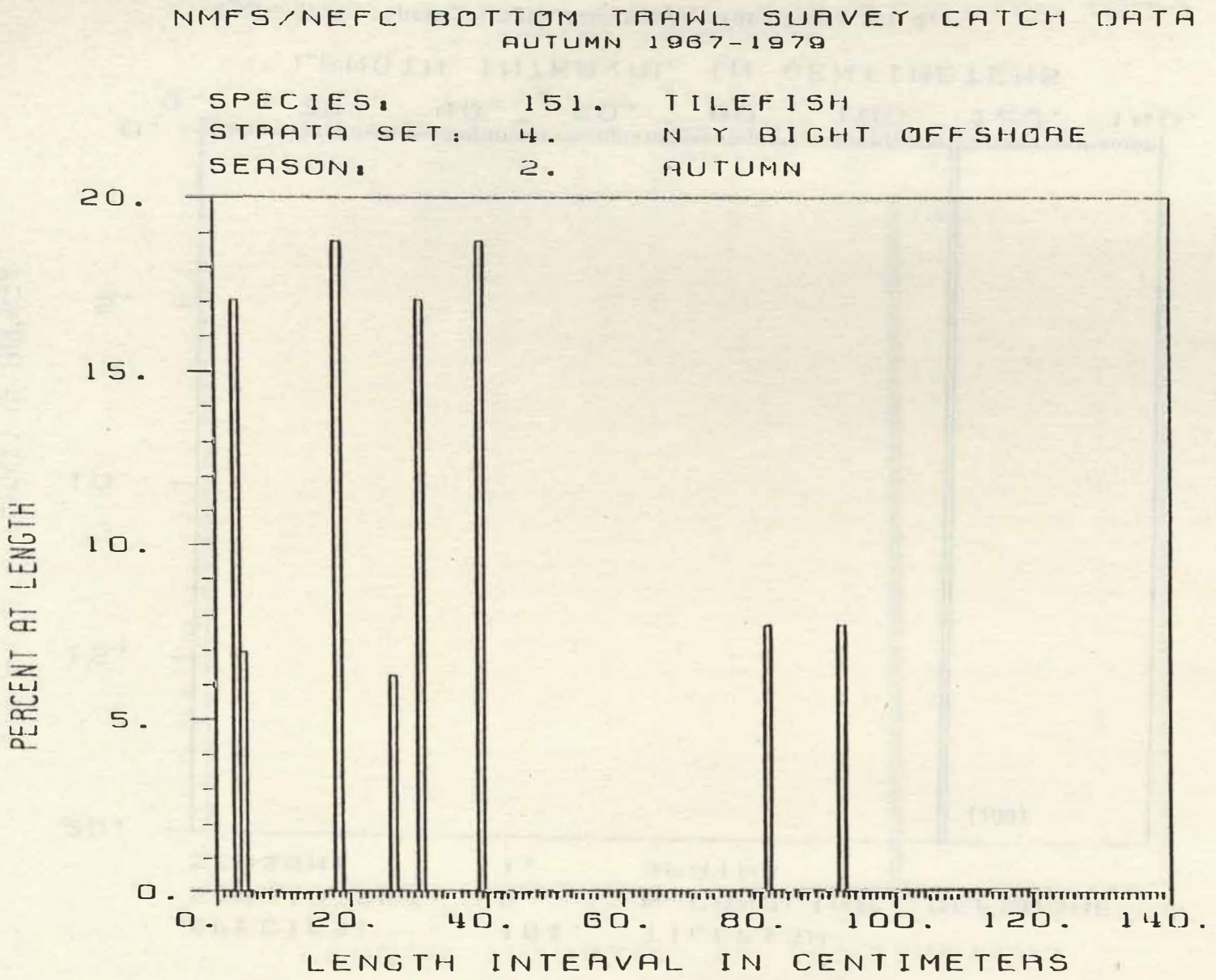

Figure 17.10. Autumn length frequencies for strata set 4.

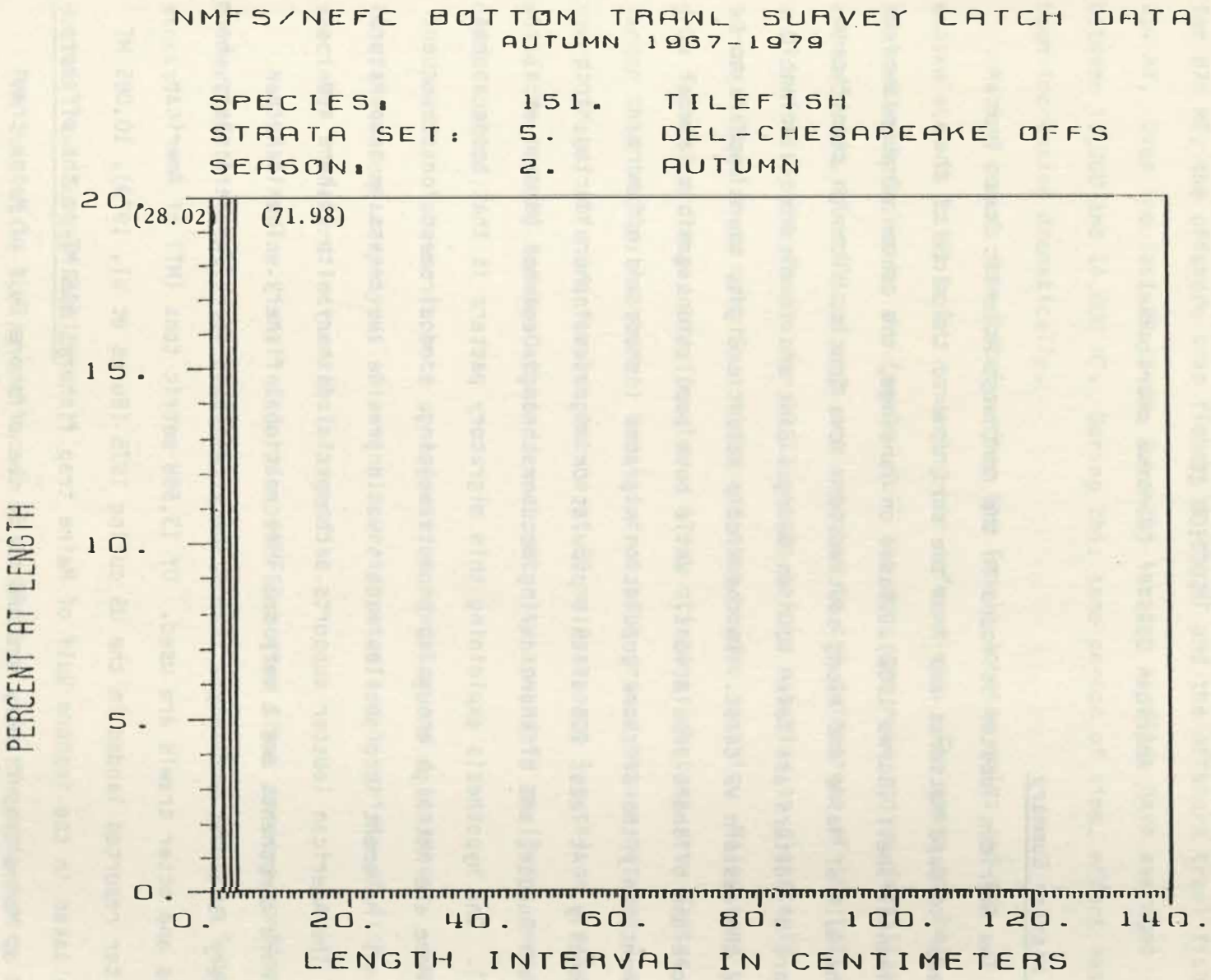

Figure 17.11. Autumn length frequencies for strata set 5.

SECTION 18

American Lobster (*Homarus americanus*)

Life History Summary

The American lobster is found in the northwest Atlantic Ocean from Labrador to Cape Hatteras and from the surf zone to the slope of the continental shelf (Burns 1982). Based on landings, the center of abundance is in the Gulf of Maine and along southwestern Nova Scotia, although significant numbers of losters are taken both on Georges Bank and in the Middle Atlantic along the eastern US coast. In the Middle Atlantic Bight, there appears to be inshore and offshore populations. While both populations exhibit lateral movement, only the offshore population migrates inshore and offshore seasonally. At least 20% of this population migrates inshore during March through August, and offshore during October through December (Uzmann et al. 1977). One hypothesis explaining this migratory pattern is that temperatures offshore are not high enough to promote molting, a requirement for subsequent mating. Movement into shallow waters would provide the necessary temperature.

The American lobster supports a commercial fishery with inshore and offshore components and a very small recreational fishery. The inshore fishery is almost entirely a trap fishery, while in the offshore fishery, both traps and otter trawls are used. Of 13,698 metric tons (MT) of American lobster reported landed in the US during 1975 (Burns et al. 1979), 10,085 MT were taken in the inshore Gulf of Maine trap fishery, 518 MT in the offshore Gulf of Maine trap fishery and 368 MT in the offshore Gulf of Maine trawl fishery, for a total of 10,971 MT. The rest, 2,727 MT, was either taken in the Middle Atlantic Bight or by other methods (diving, fish pots or dredges). In the Middle Atlantic Bight, the inshore trap fishery accounted

for 876 MT, the offshore trap fishery 1,418 MT and the offshore trawl fishery 414 MT. Over the last 20 years, American lobster landings have averaged between 13,000 and 14,000 MT. During this same period of time, effort has been increasing dramatically.

Mating occurs immediately after the female lobster molts and her exoskeleton is still soft, rendering her defenseless. The sperm are held in seminal receptacles in the female until the eggs are ready to be fertilized and extruded. Fertilized eggs are attached to the swimmerets of the tail and are carried by the female for 10-12 months before hatching as planktonic larvae. The larvae molt four times and then become benthic. Males tend to grow faster and larger than females. Also, offshore lobsters grow faster and larger than inshore lobsters. Females from both groups mature between 4 and 5 years of age; offshore females mature at 85 mm (carapace length) or greater, while the inshore females attain sexual maturity around 70 mm (Burns personal communication).

American lobster is both an aggressive predator and a scavenger. Adult lobster consume many types of marine invertebrates and a variety of fish species. Predators include most large fish.

National Marine Fisheries Service (NMFS) bottom trawl surveys confirm commercial catch analyses demonstrating a general decline in American lobster stocks.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 18.1 and 18.2. In the spring, the lobsters were concentrated offshore along and east of the 100 m contour (Figure 18.1). The autumn distribution plot (Figure 18.2) again shows lobsters concentrated near the 100

m contour, but some have moved onto mid-shelf areas, especially in the north. These lobsters were probably part of the offshore population migrating back to deeper water from inshore summering grounds.

Graphs of mean weight and number per tow (Figures 18.3-18.6) show that few lobsters are available to the trawl (see "Methods"), and those caught are normally small in size.

Length frequencies for six strata sets, arranged by season, are shown in Figures 18.7-18.8. There appears to be little seasonal shift in size between the different areas; inshore catches consisted mostly of smaller lobsters (< 10 cm carapace length), while larger lobsters were taken more frequently offshore.

Young-of-the-year lobsters were not caught in NMFS bottom trawl surveys.

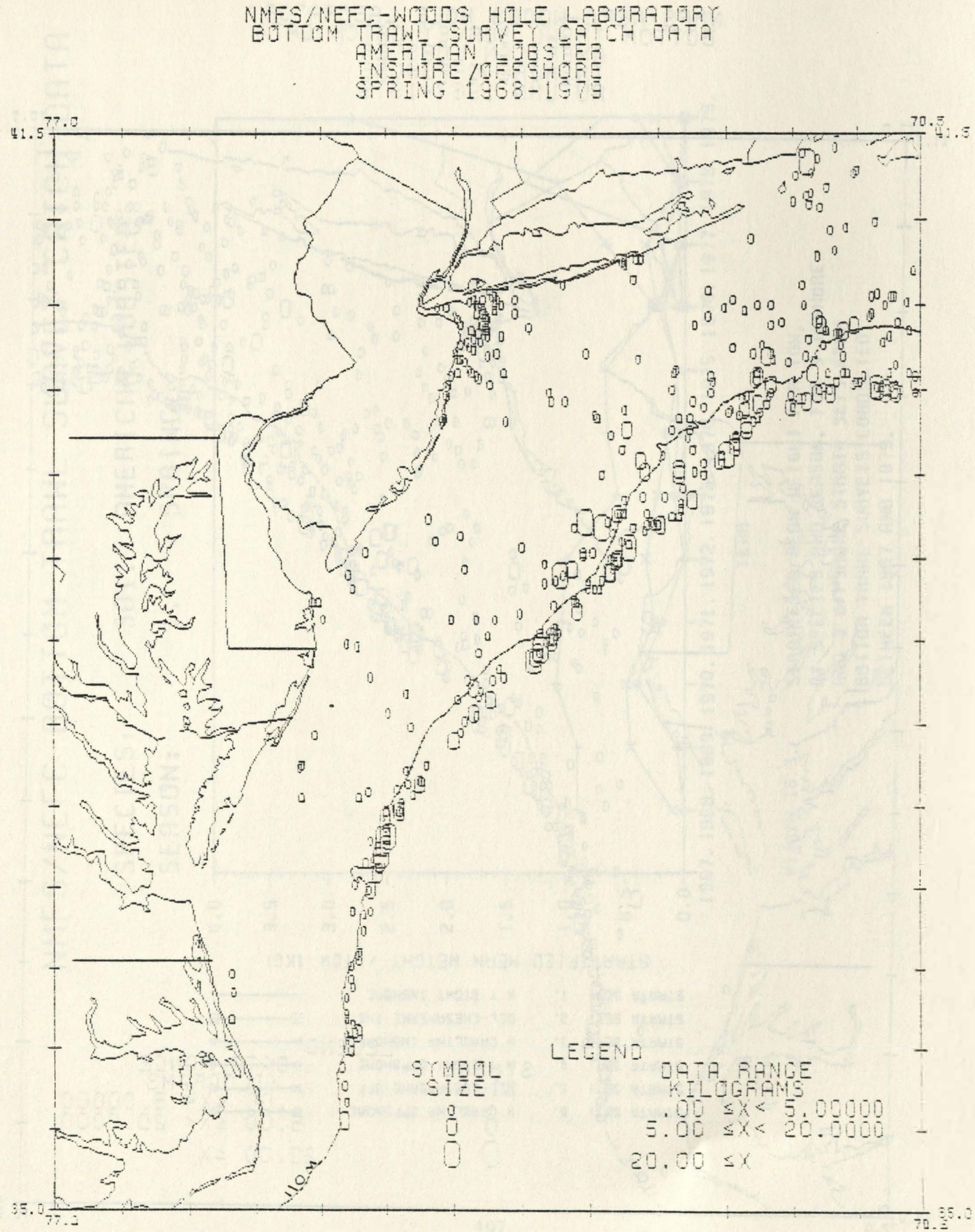

Figure 18.1. Spring distribution, 1968-1979.

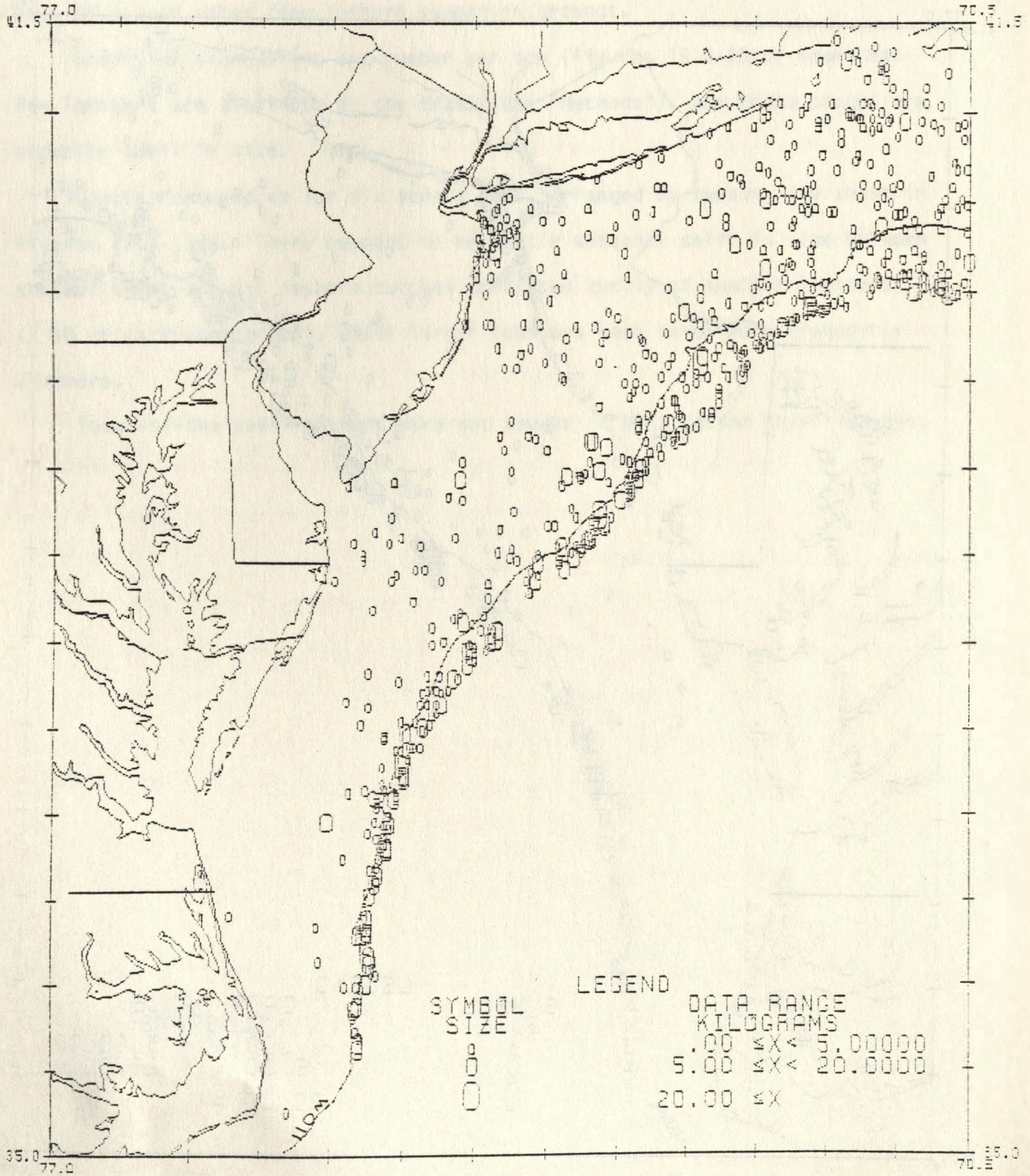

Figure 18.2. Autumn distribution, 1967-1979.

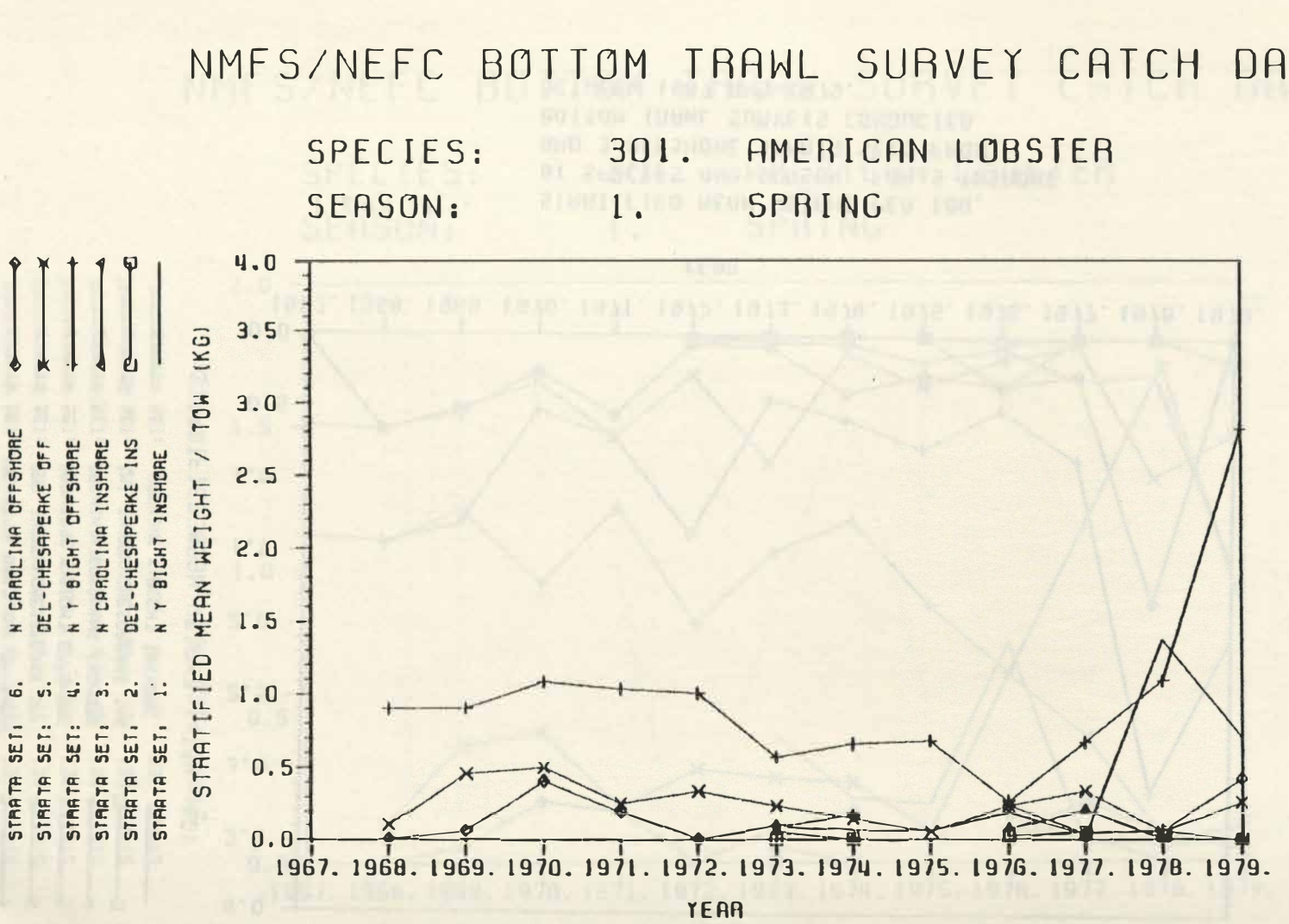

Figure 18.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

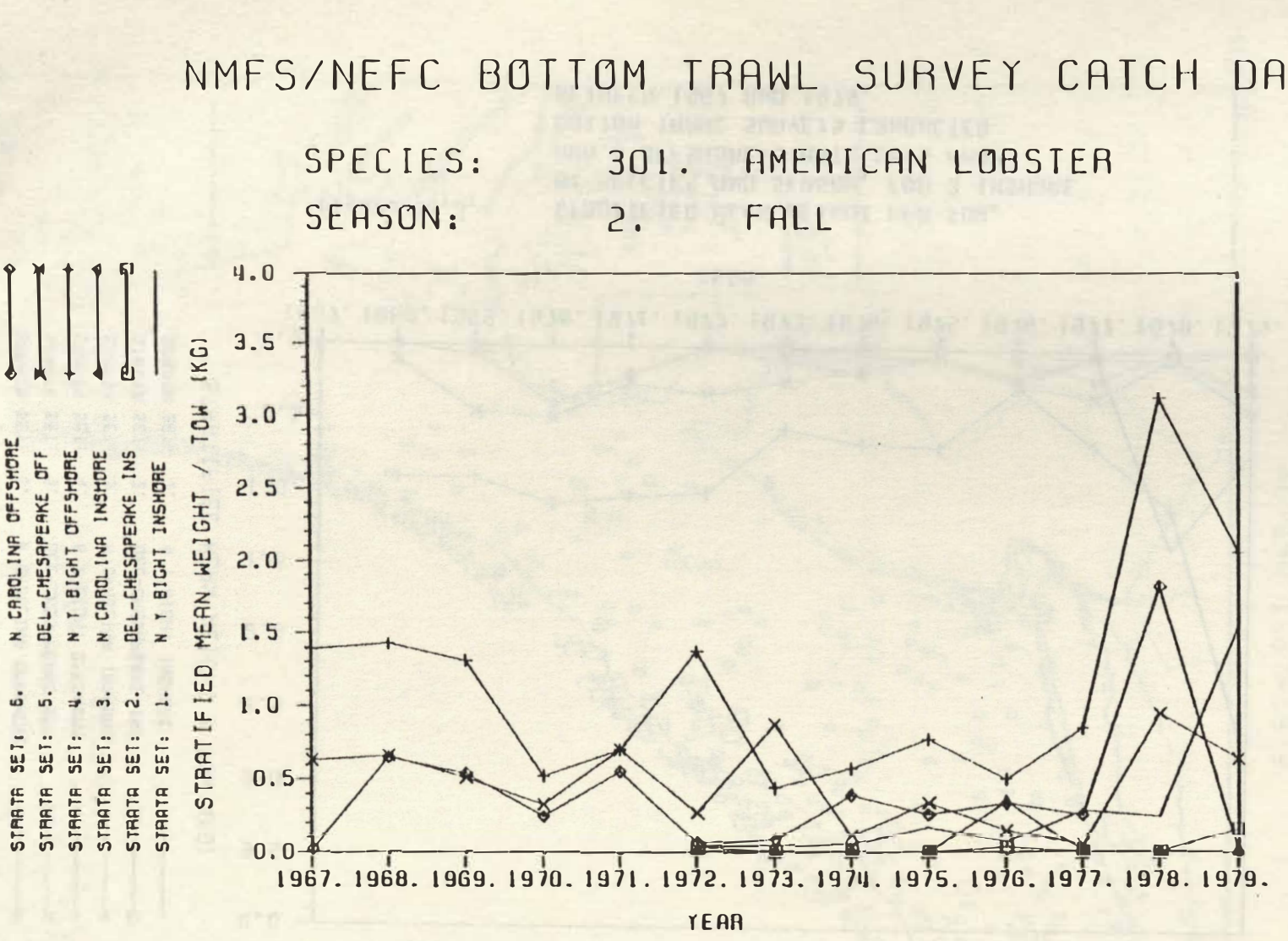

Figure 18.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

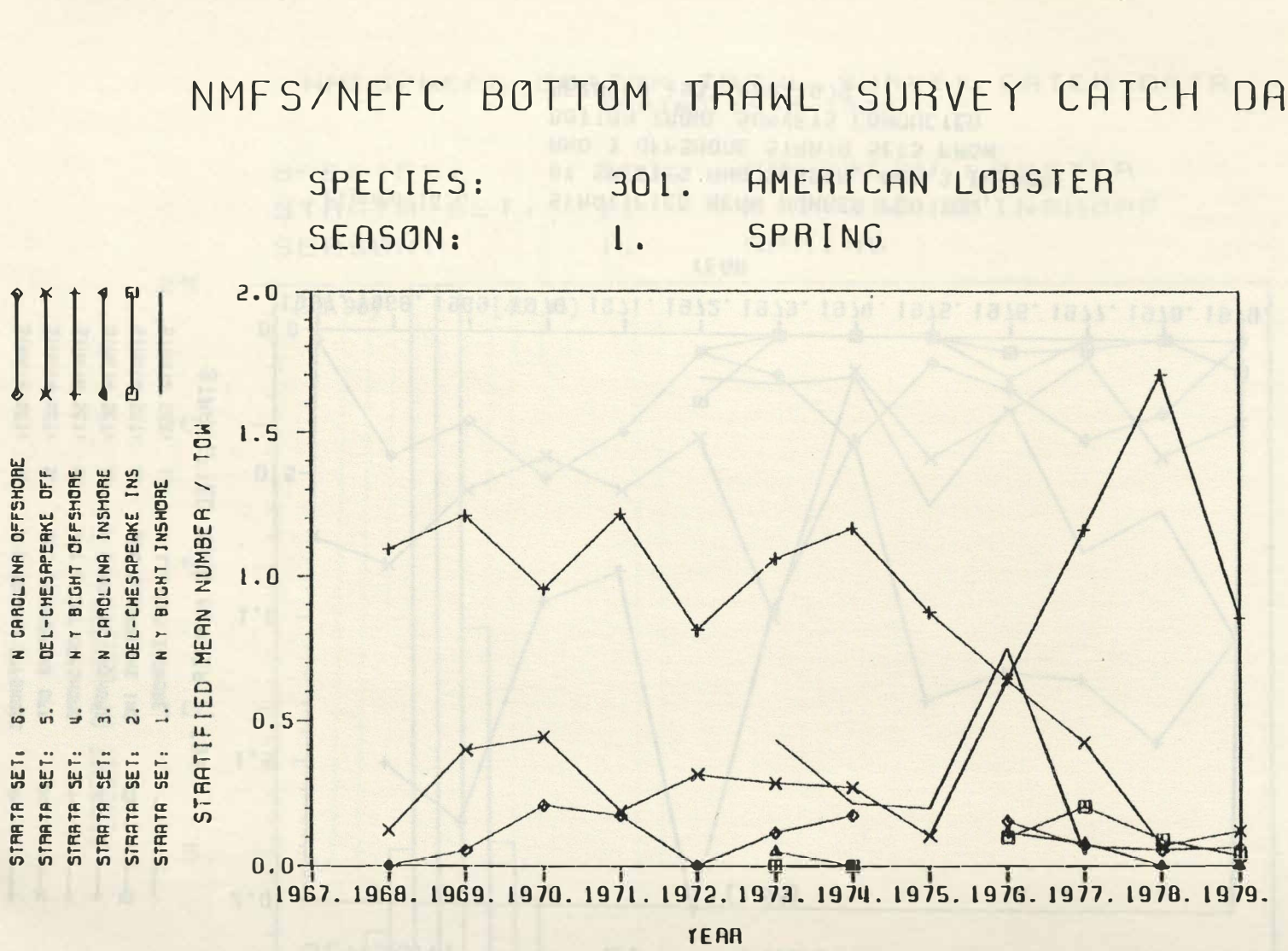

Figure 18.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

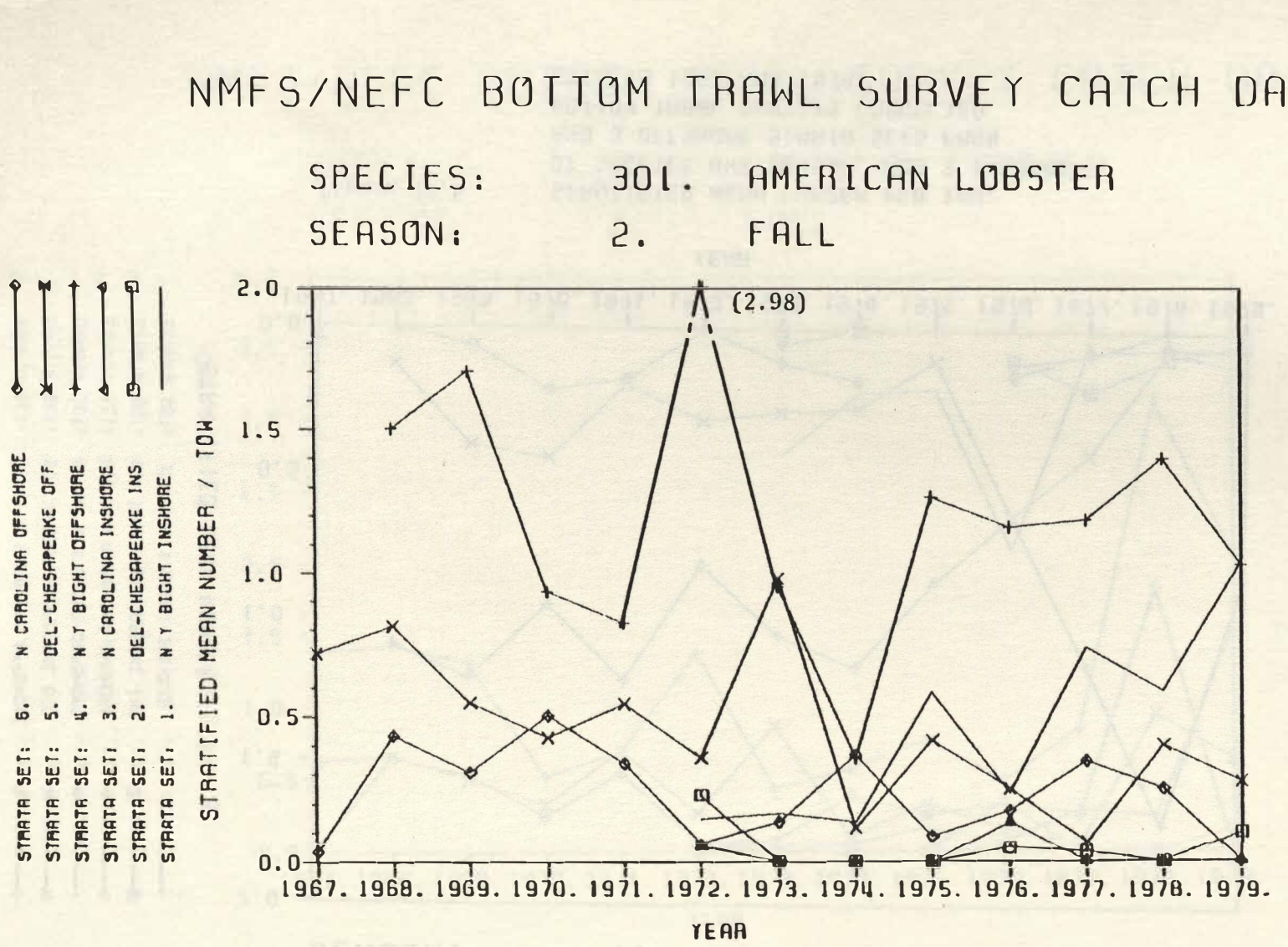

Figure 18.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

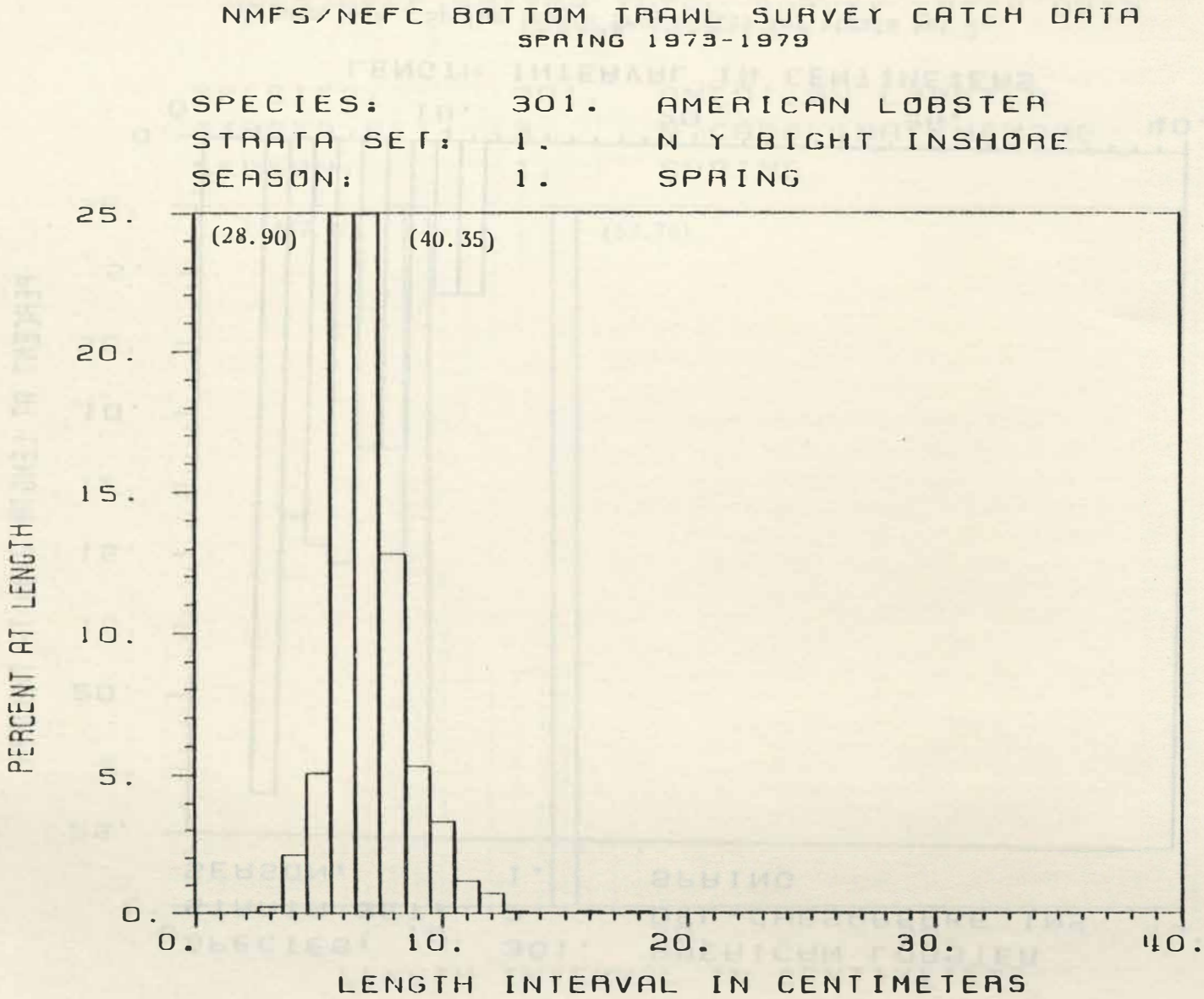

Figure 18.7. Spring length frequencies for strata set 1.

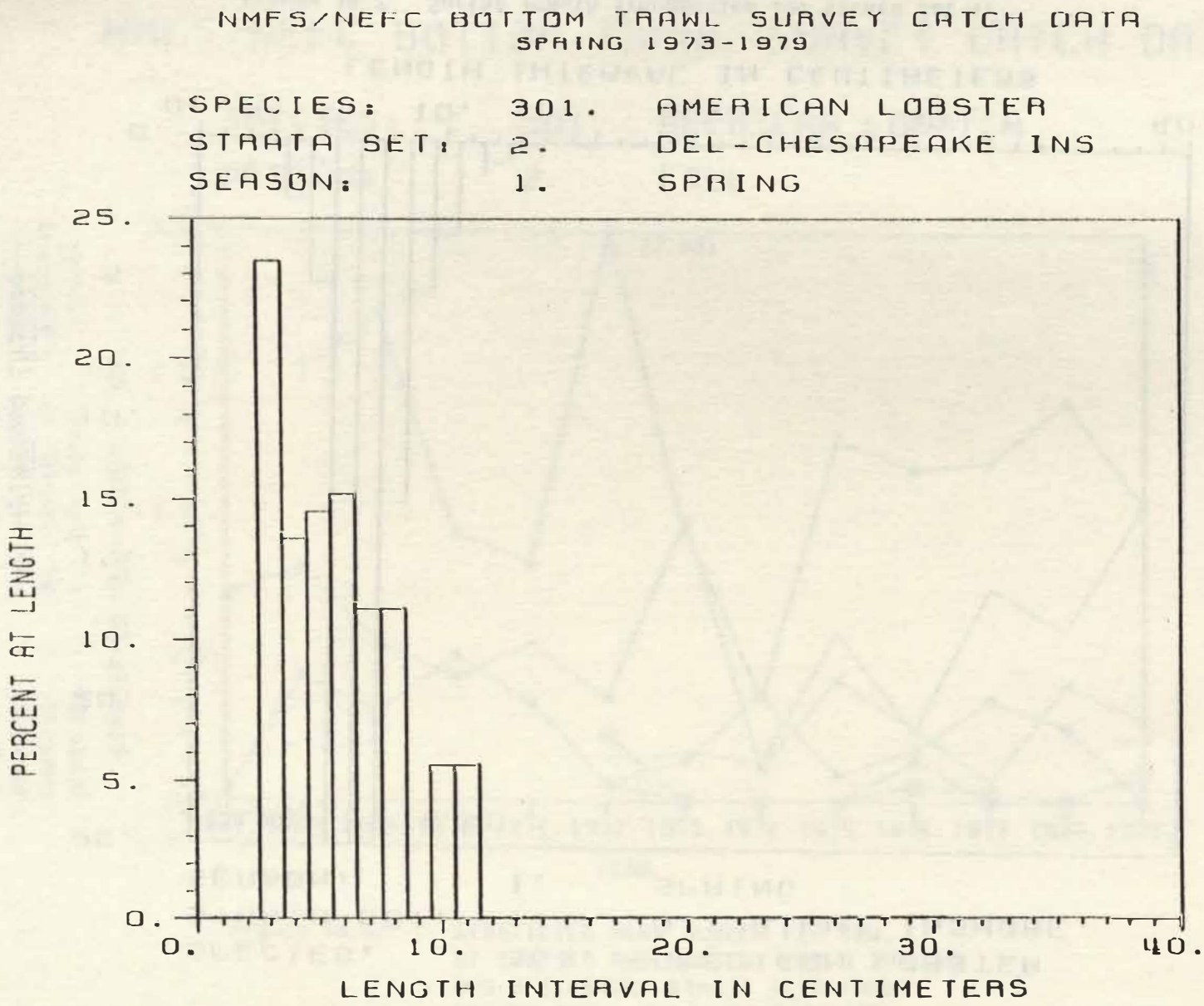

Figure 18.8. Spring length frequencies for strata set 2.

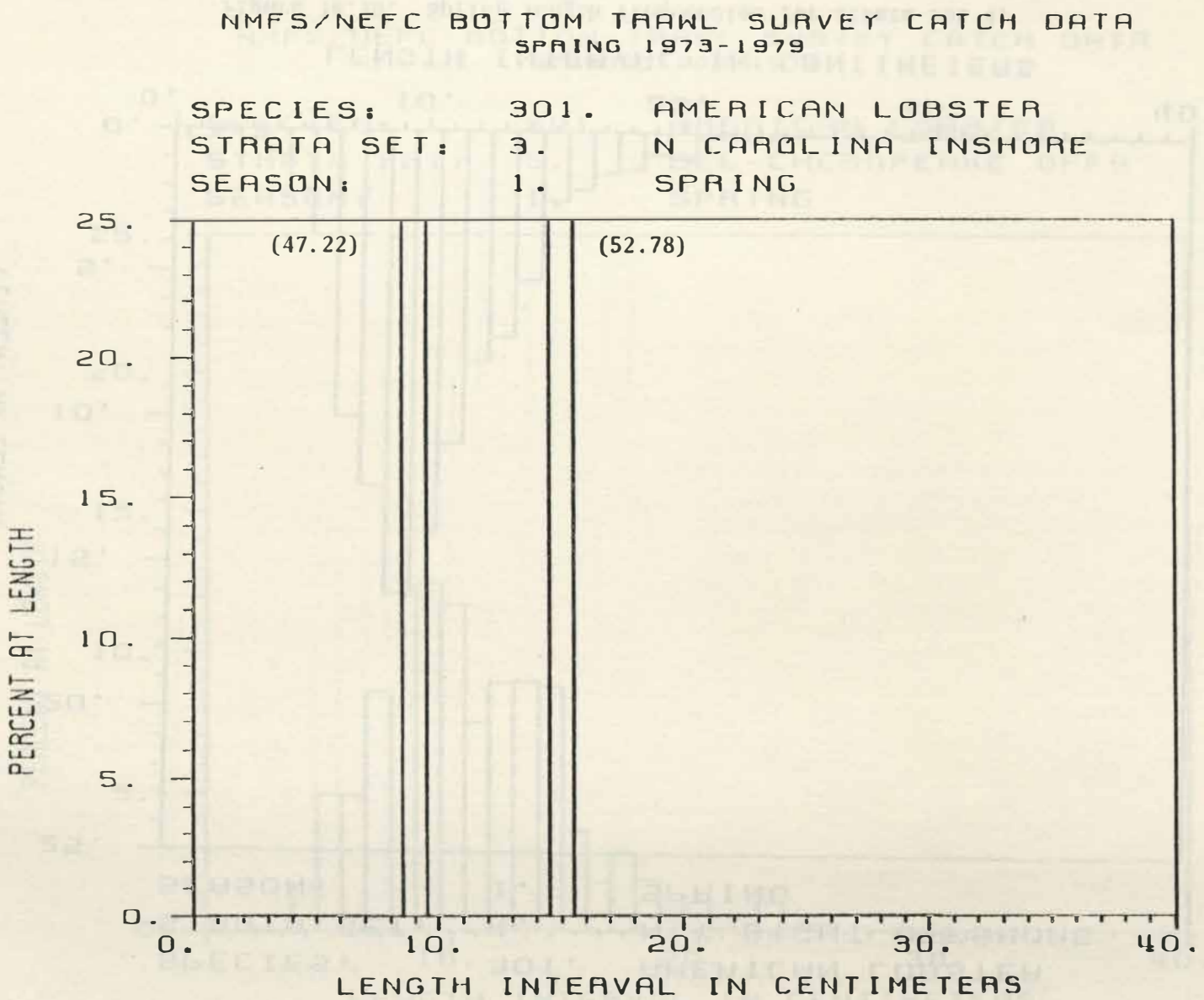

Figure 18.9. Spring length frequencies for strata set 3.

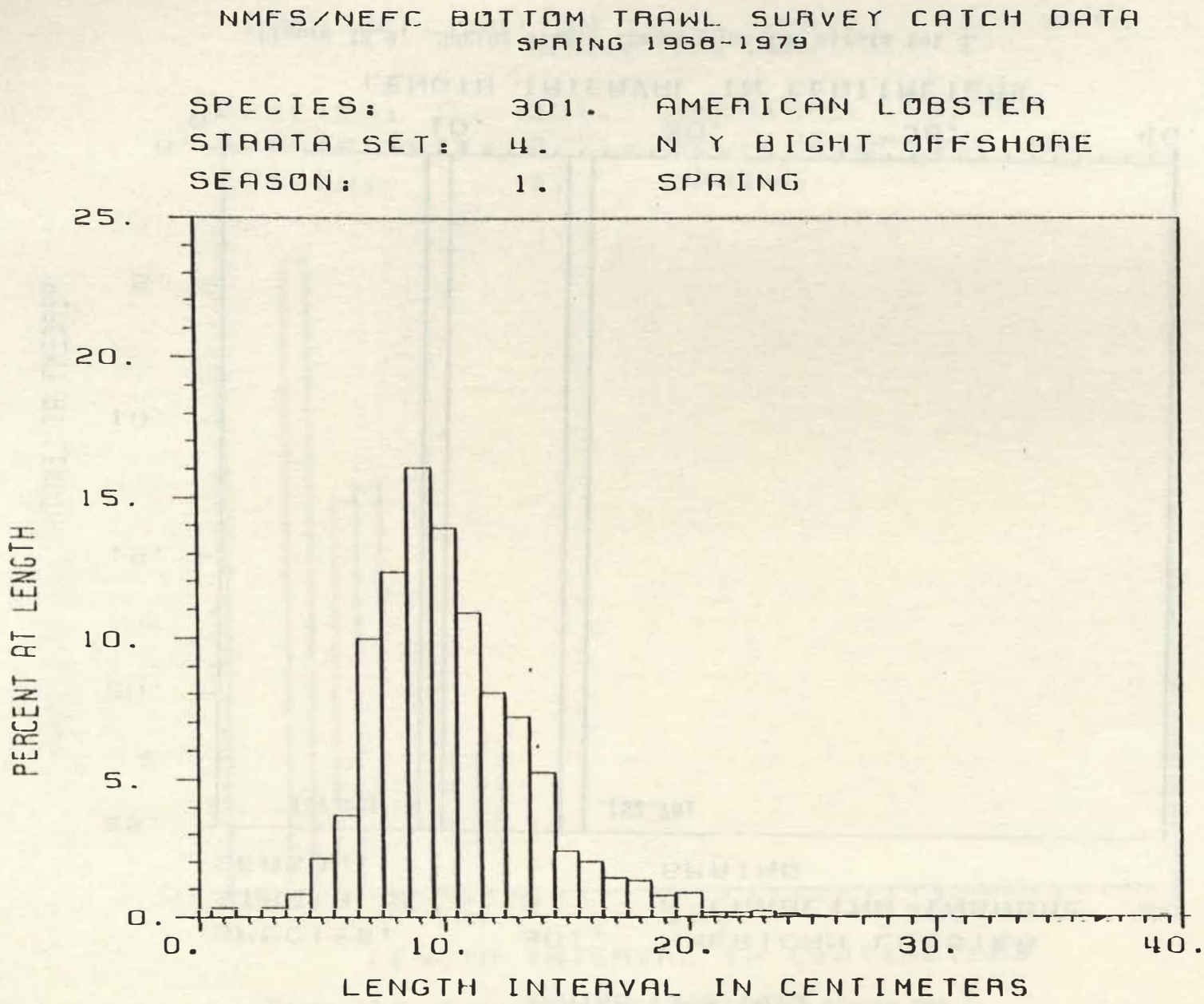

Figure 18.10. Spring length frequencies for strata set 4.

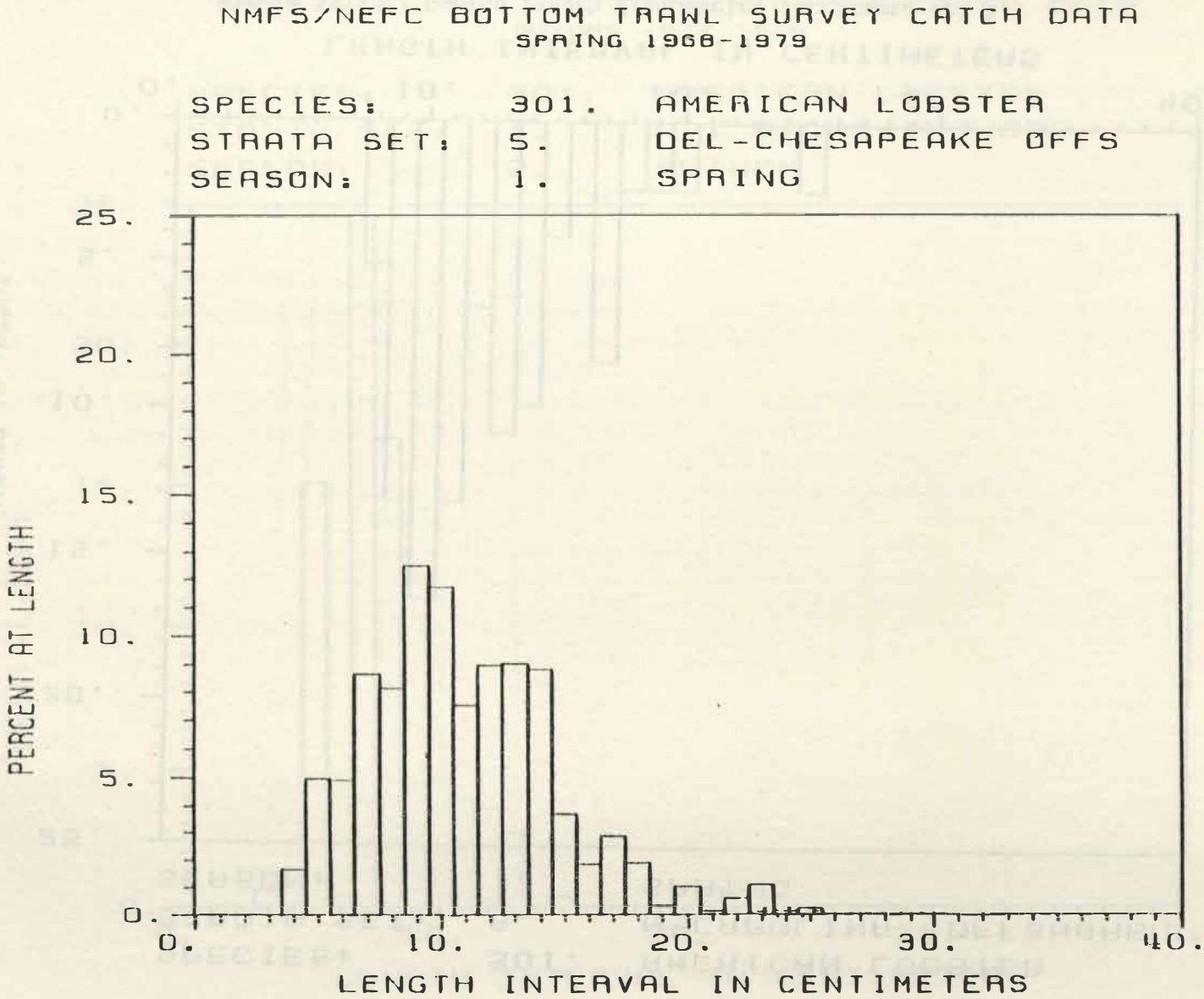

Figure 18.11. Spring length frequencies for strata set 5.

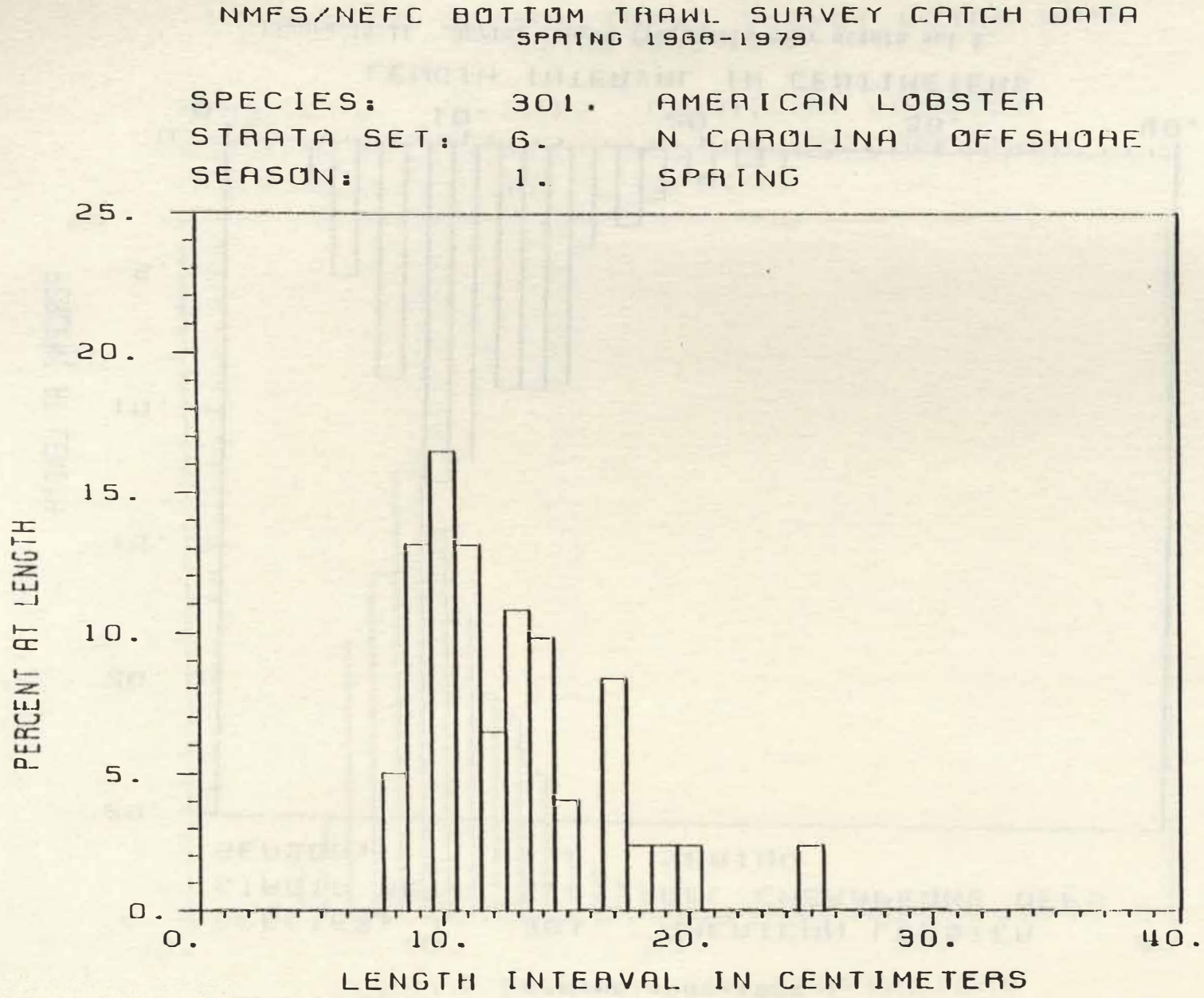

Figure 18.12. Spring length frequencies for strata set 6.

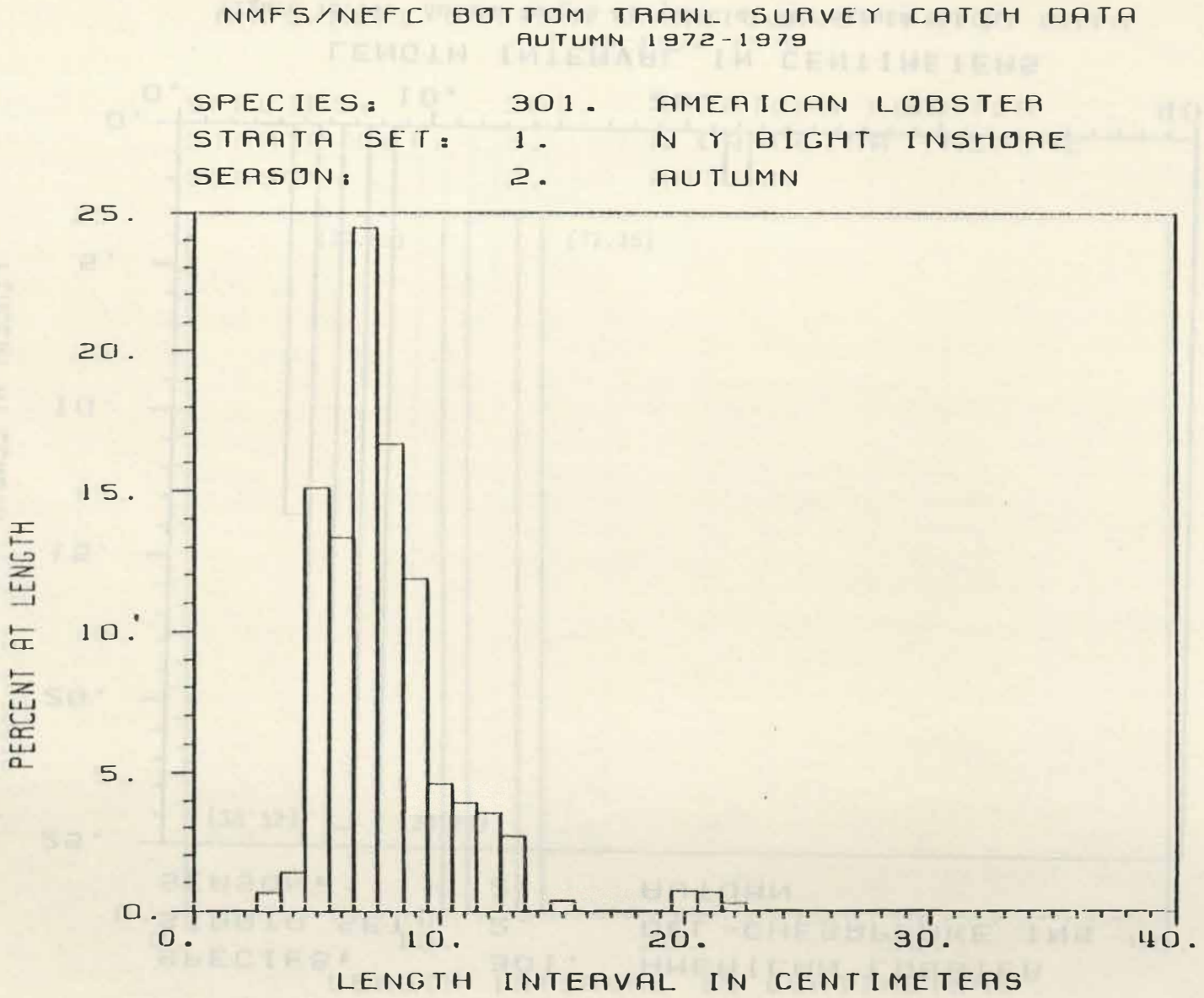

Figure 18.13. Autumn length frequencies for strata set 1.

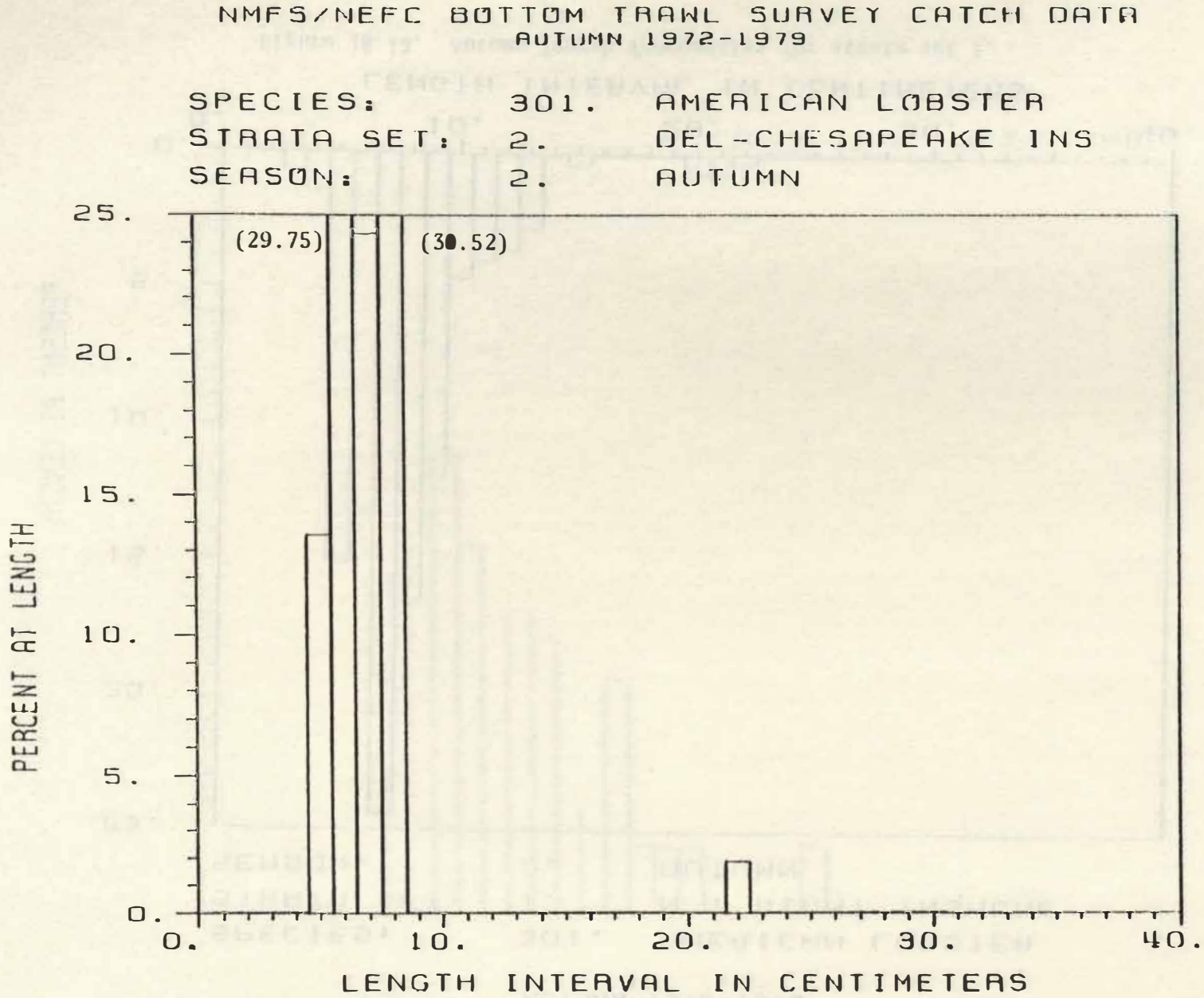

Figure 18.14. Autumn length frequencies for strata set 2.

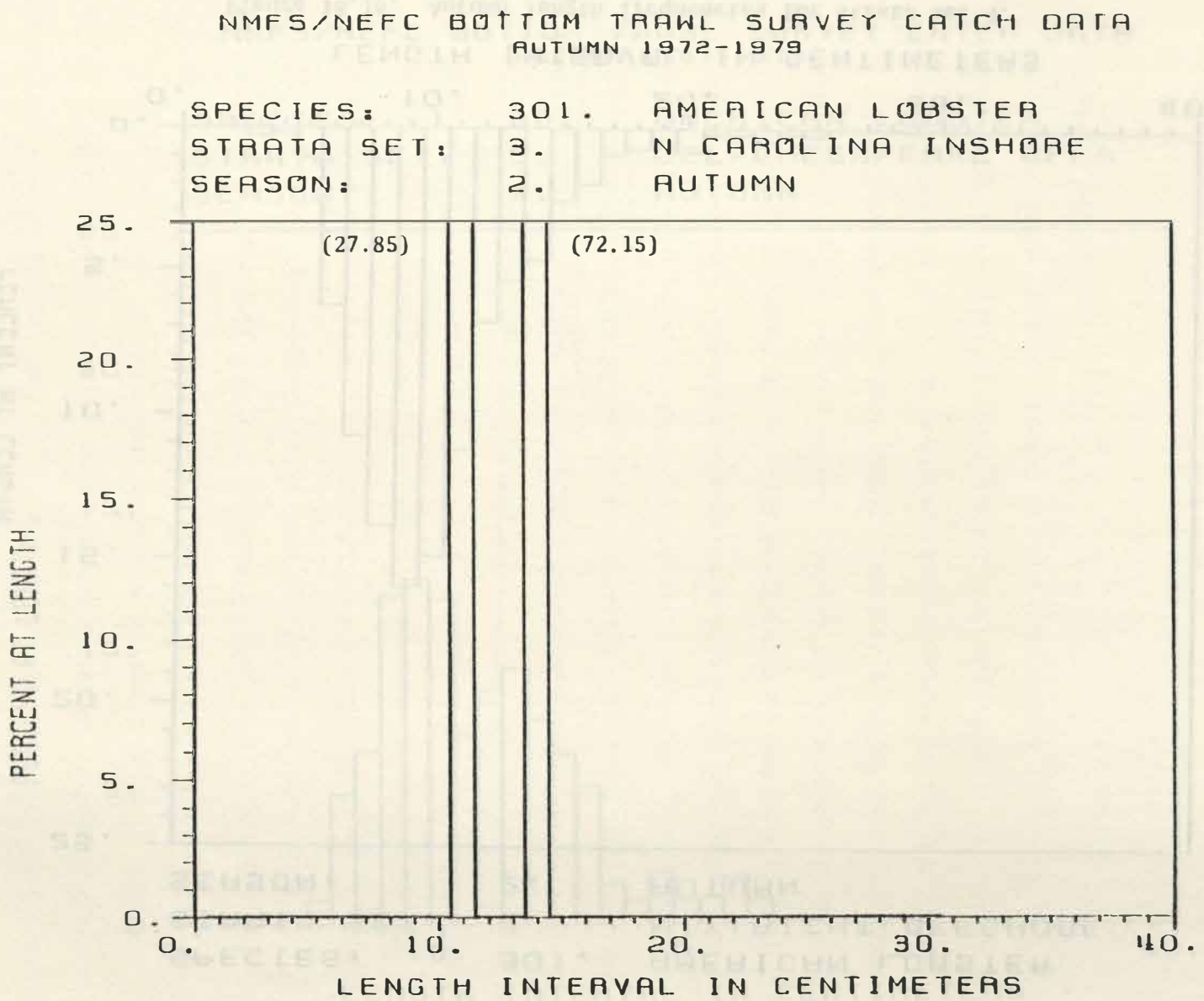

Figure 18.15. Autumn length frequencies for strata set 3.

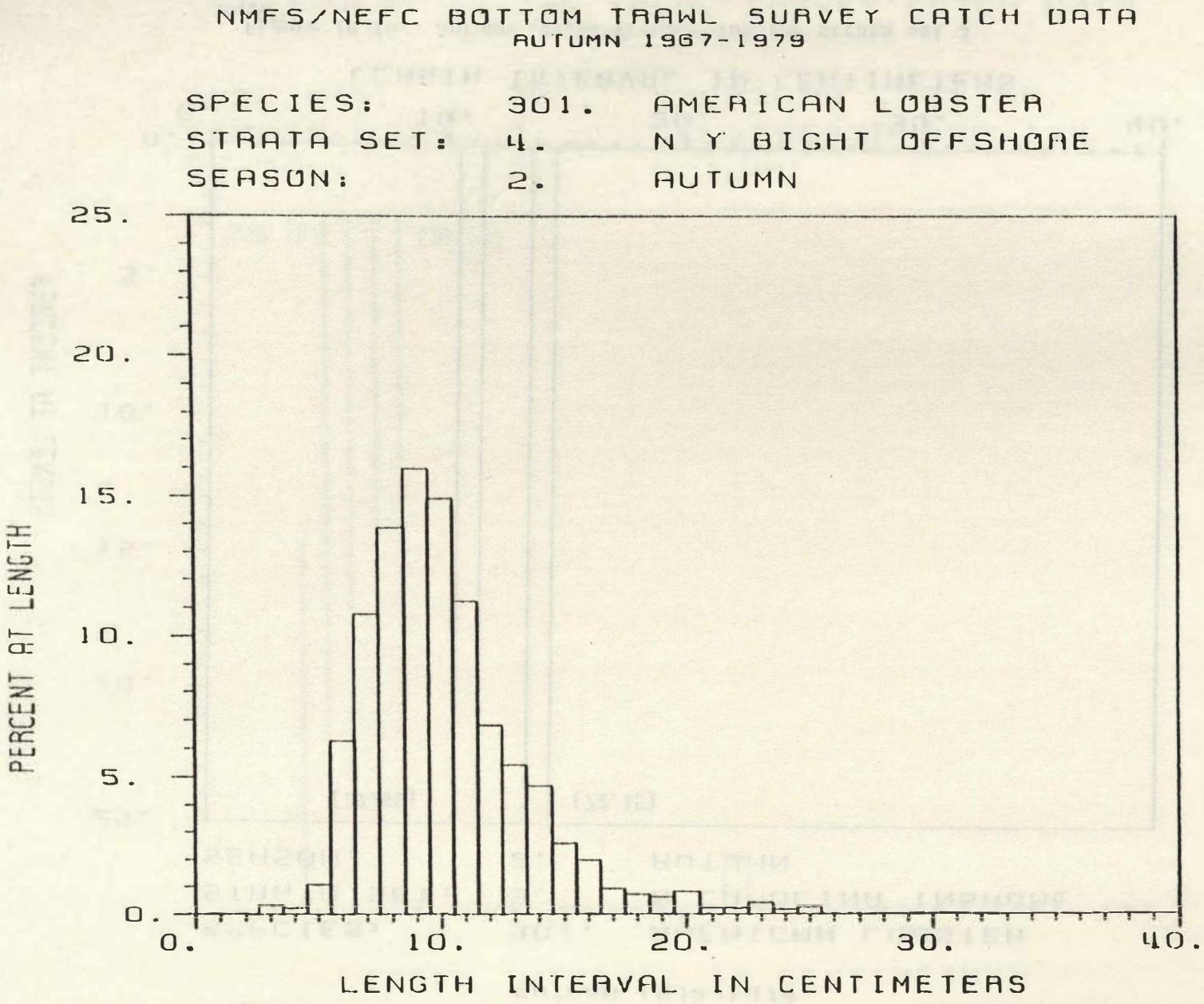

Figure 18.16. Autumn length frequencies for strata set 4.

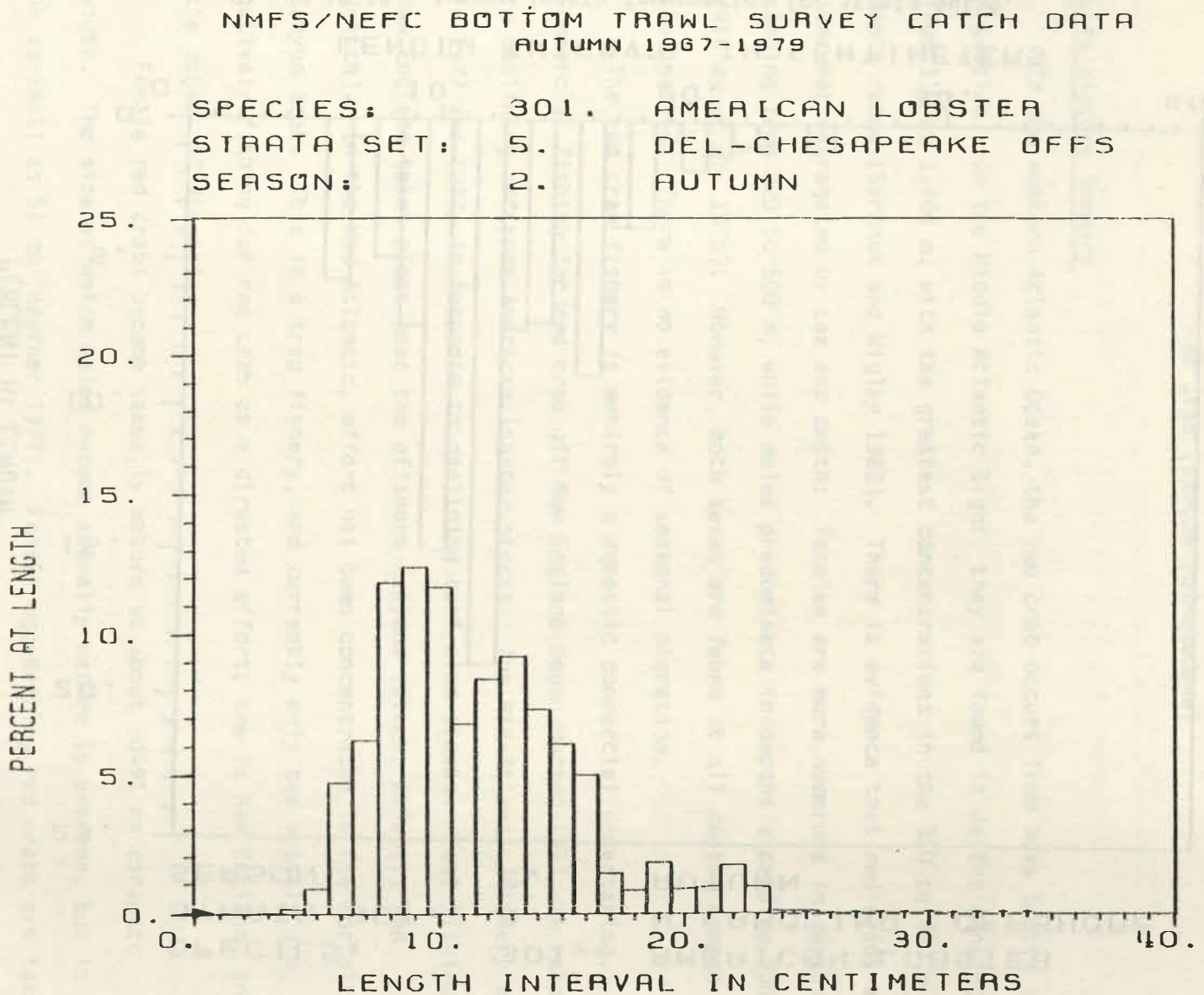

Figure 18.17. Autumn length frequencies for strata set 5.

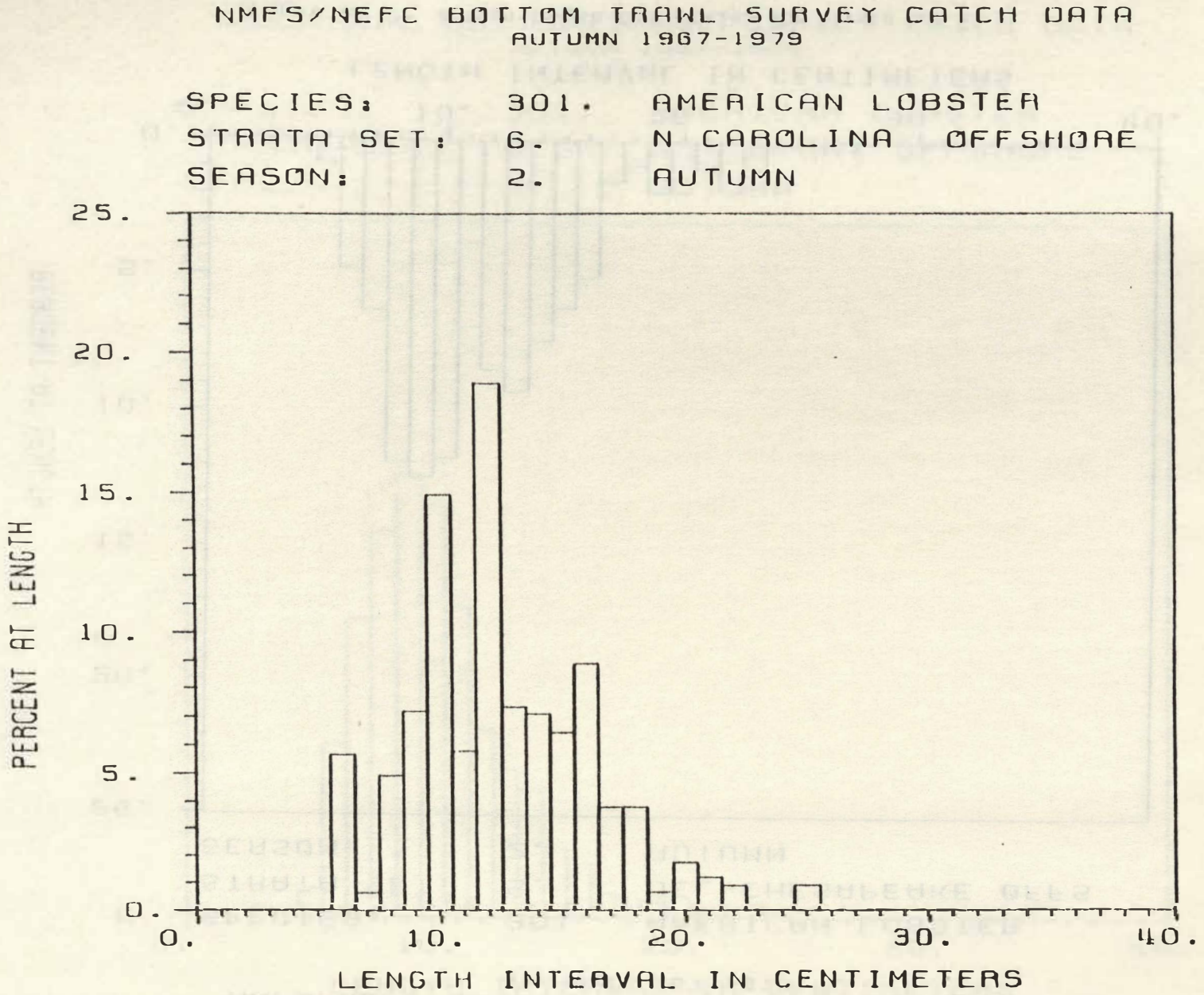

Figure 18.18. Autumn length frequencies for strata set 6.

SECTION 19

Red Crab (*Geryon quinquedens*)

Life History Summary

In the western Atlantic Ocean, the red crab occurs from Nova Scotia to Argentina. In the Middle Atlantic Bight, they are found in depths ranging from 110 to 1,460 m, with the greatest concentrations in the 320 to 550 m depth range (Serchuk and Wigley 1982). There is evidence that red crabs are somewhat segregated by sex and depth: females are more numerous in depths ranging from 320 to 500 m, while males predominate in depths exceeding 500 m (Wigley et al. 1975). However, both sexes are found at all depths common to the species. There is no evidence of seasonal migration.

The red crab fishery is entirely a domestic commercial undertaking. Commercial fishing for red crab off New England began during 1973, in response to declining offshore American lobster stocks. The Mid-Atlantic fishery began in 1977 and 1978, in response to declining surf clam stocks. Most fishing off New England takes place near the offshore canyons (Block, Atlantis and Veatch). In the Mid-Atlantic, effort has been concentrated in the Norfolk Canyon area. This is a trap fishery, and currently only two vessels are actively fishing for red crab as a directed effort; one in New England, and the other off Virginia.

Female red crabs become sexually mature at about 80-91 mm carapace width. The size at which males become sexually mature is unknown, but it may be as small as 51 mm (Haefner 1977). Female egg-bearing red crabs are taken throughout the year, however, the percentage of females carrying eggs increases during the summer and peaks in late autumn. Apparently, most hatching occurs between January and June (Haefner 1978). The preponderance of

small crabs at greater depths (> 640 m), suggests that larvae settle to the bottom in the deeper area to assume a benthic life style, and they appear to migrate upslope as they mature.

Little is known about the feeding habits of red crab; however, habitat and morphology suggest that it is both a scavenger and a predator on smaller benthic organisms. Under laboratory conditions, they have eaten molluscs, coelenterates and fishes.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 19.1 and 19.2. Due to the type of gear used (roller sweep), and limited deepwater sampling, catches of red crab were small for both seasons.

Graphs of mean weight and number per tow are shown in Figures 19.3-19.6.

Length frequencies for strata sets, arranged by season, are shown in Figures 19.7-19.11. These plots are of minimal value because of light catches. There are no plots for inshore spring and autumn strata sets, and offshore autumn strata set 6.

Young-of-the-year red crab have not been caught during bottom trawl surveys.

Haefner (1978) conducted an extensive study of red crab distribution and abundance in the Norfolk Canyon area, but differences in survey design did not allow incorporation of his data into this report.

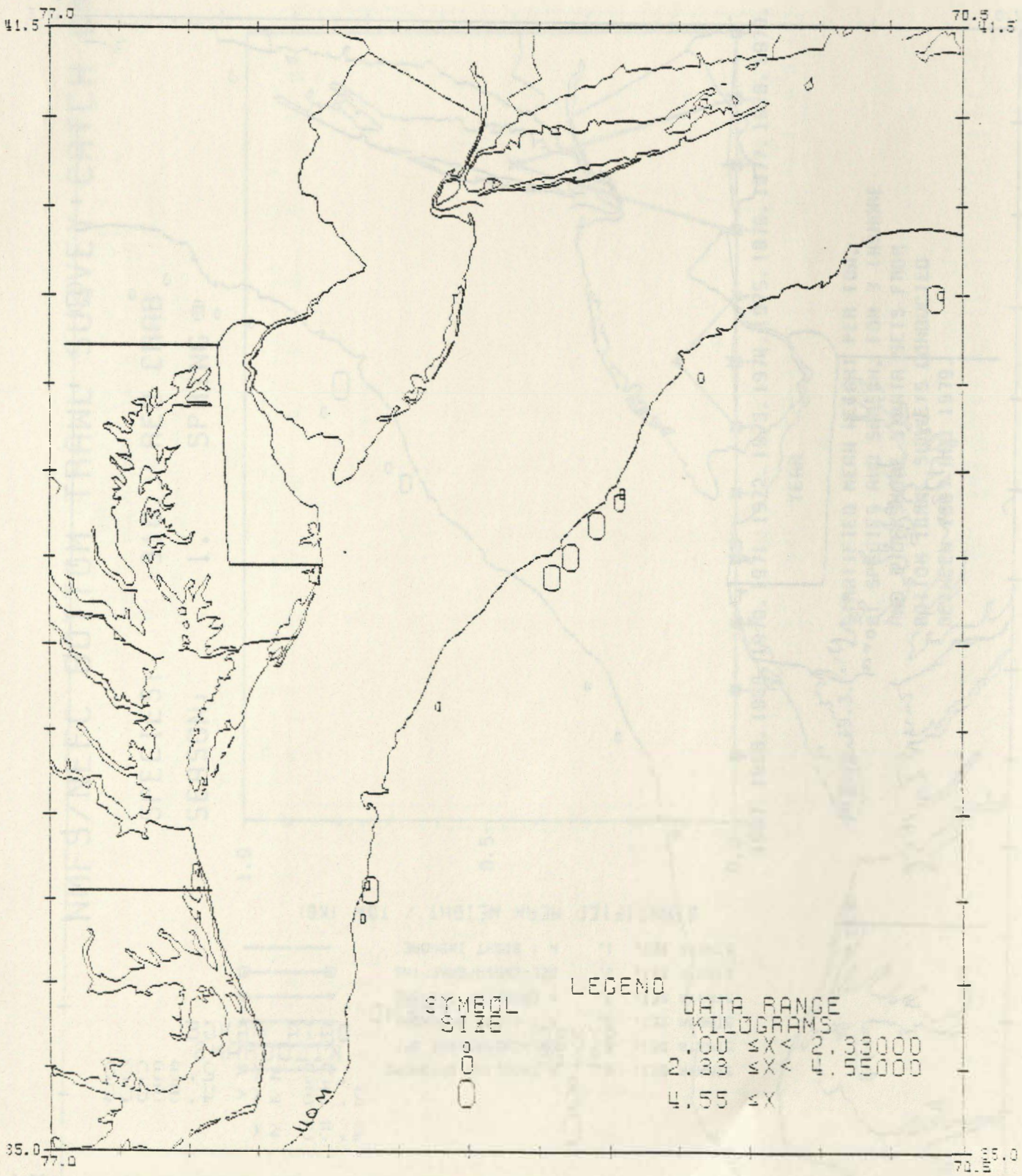

Figure 19.1. Spring distribution, 1968-1979.

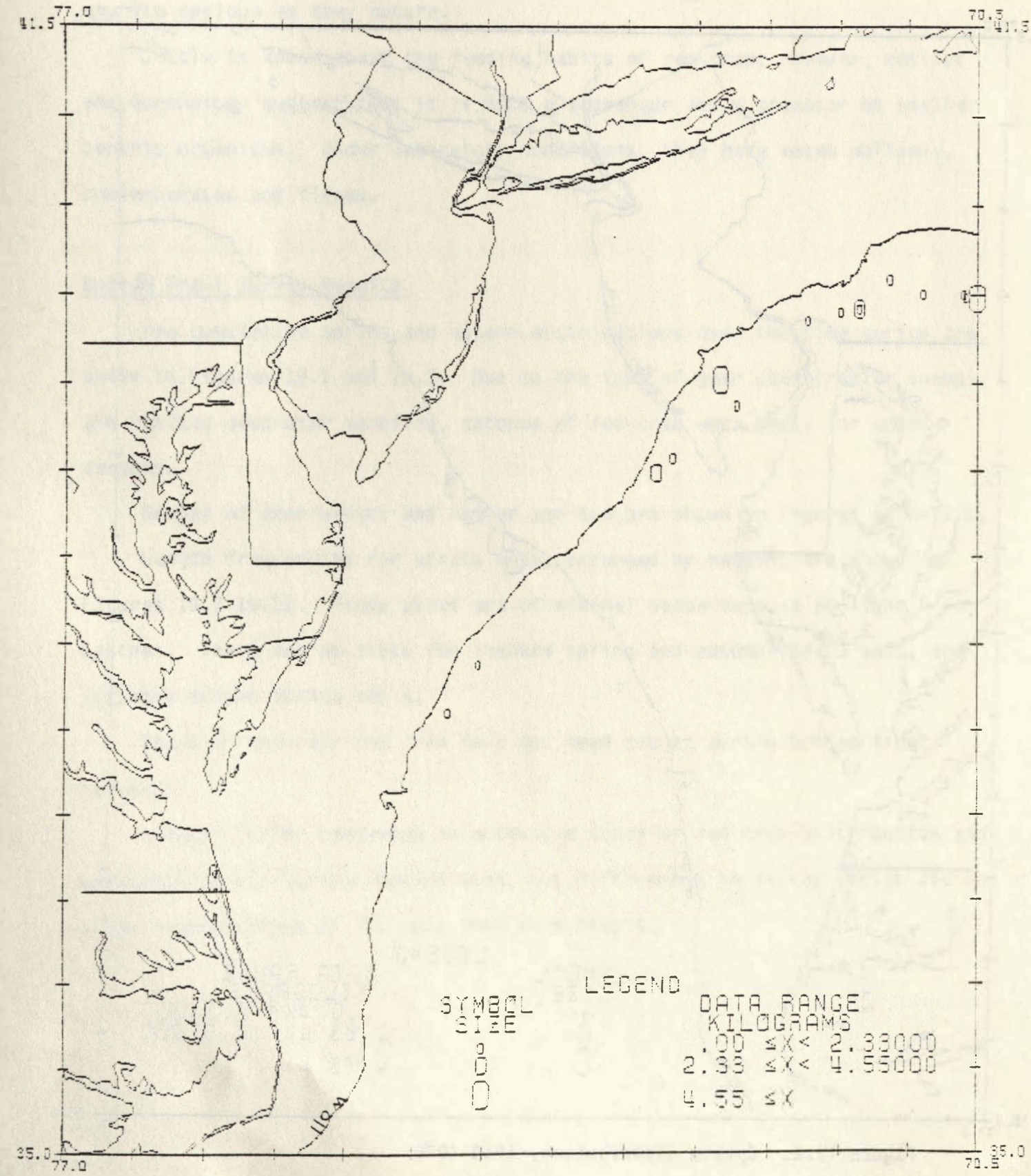

Figure 19.2. Autumn distribution, 1967-1979.

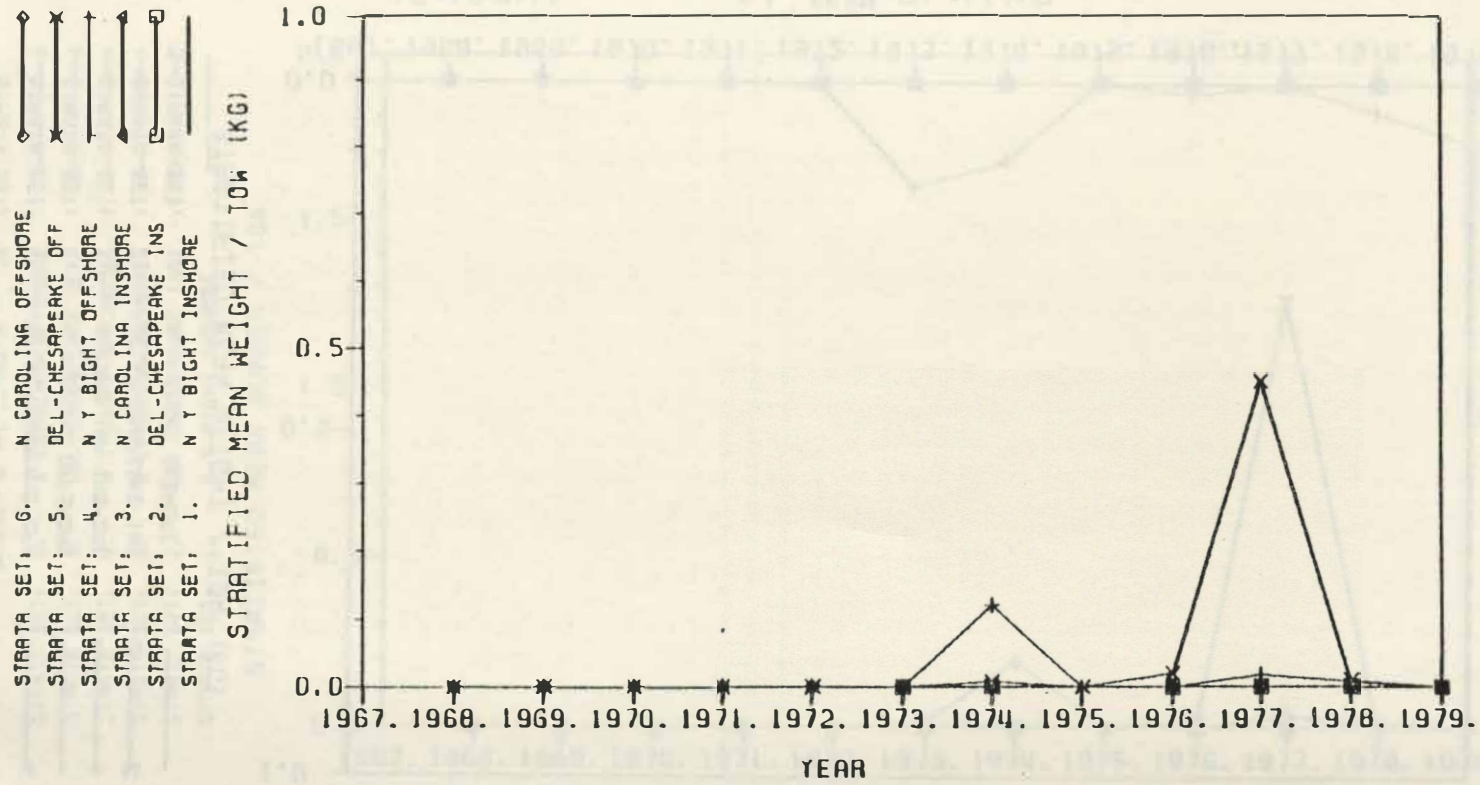

Figure 19.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 310. RED CRAB

SEASON: 2. FALL

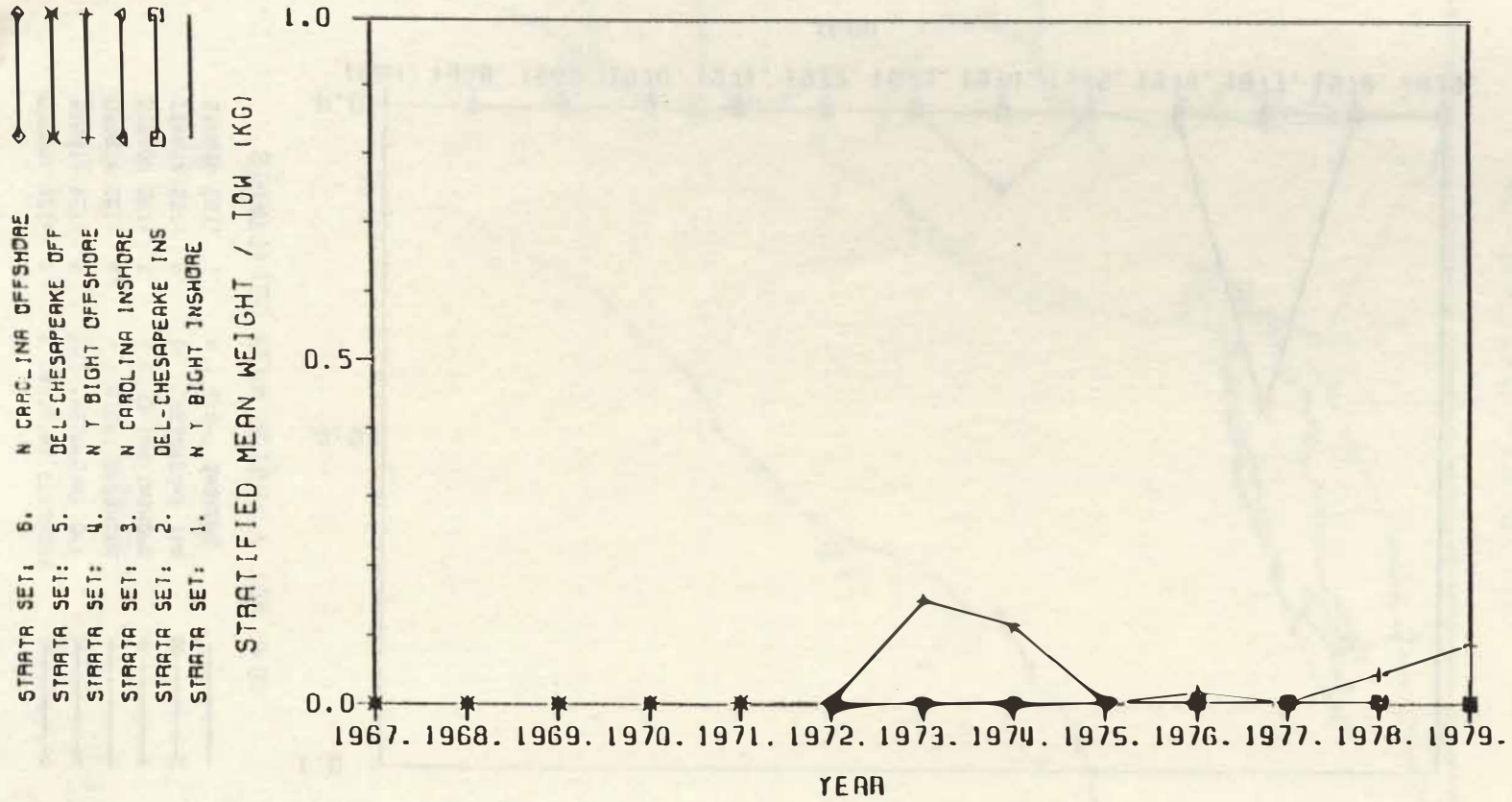

Figure 19.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

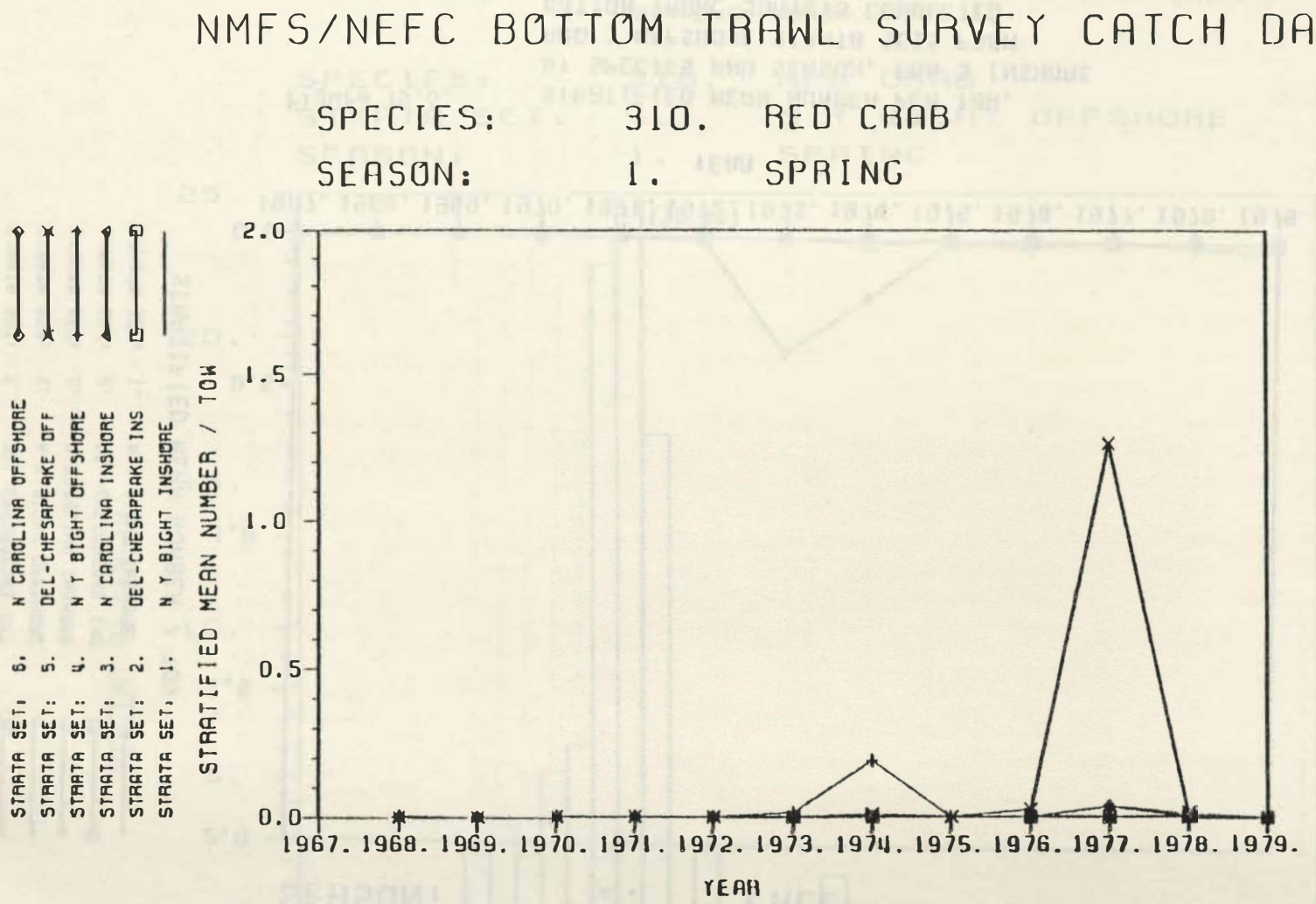

Figure 19.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

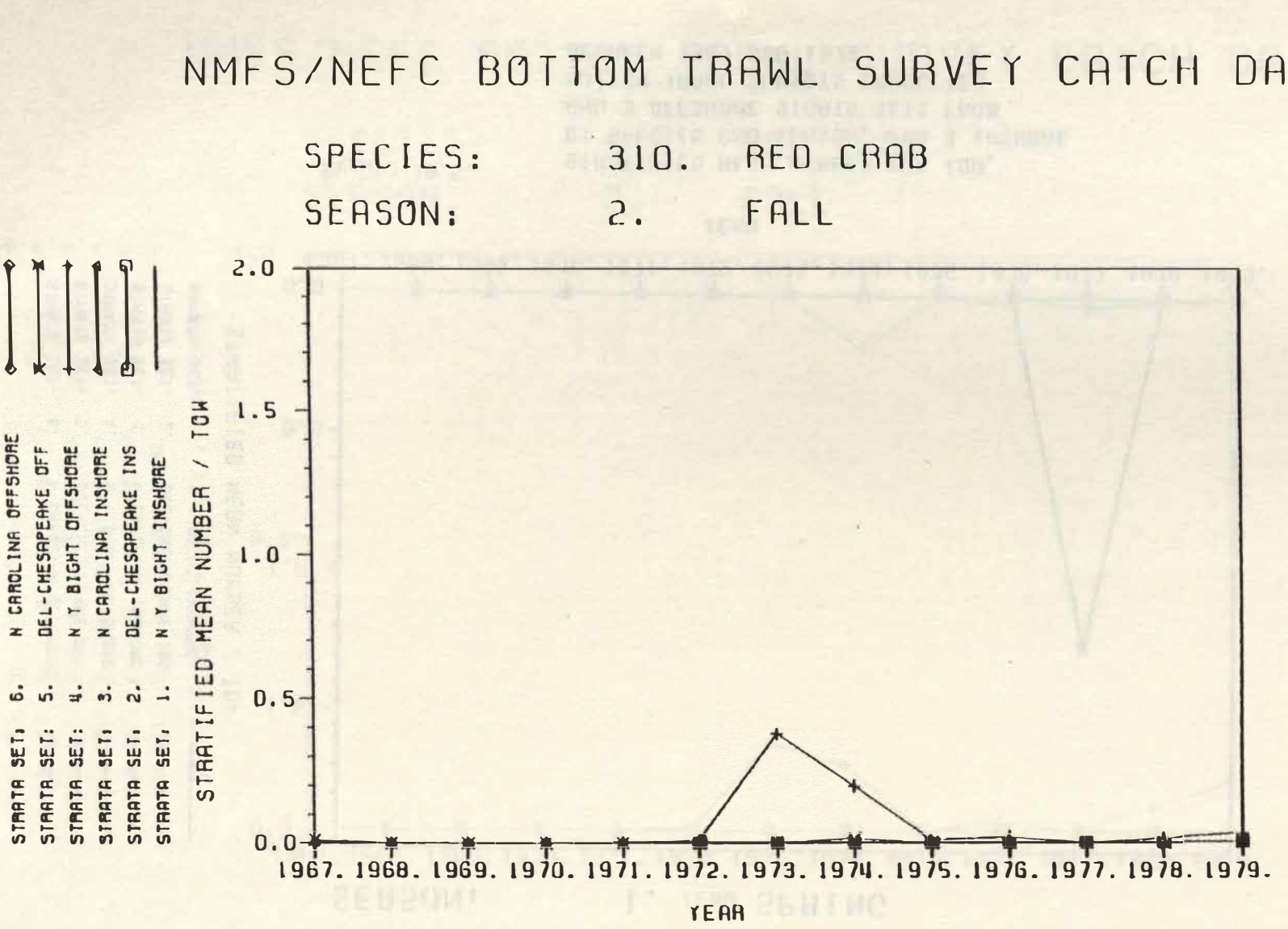

Figure 19.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

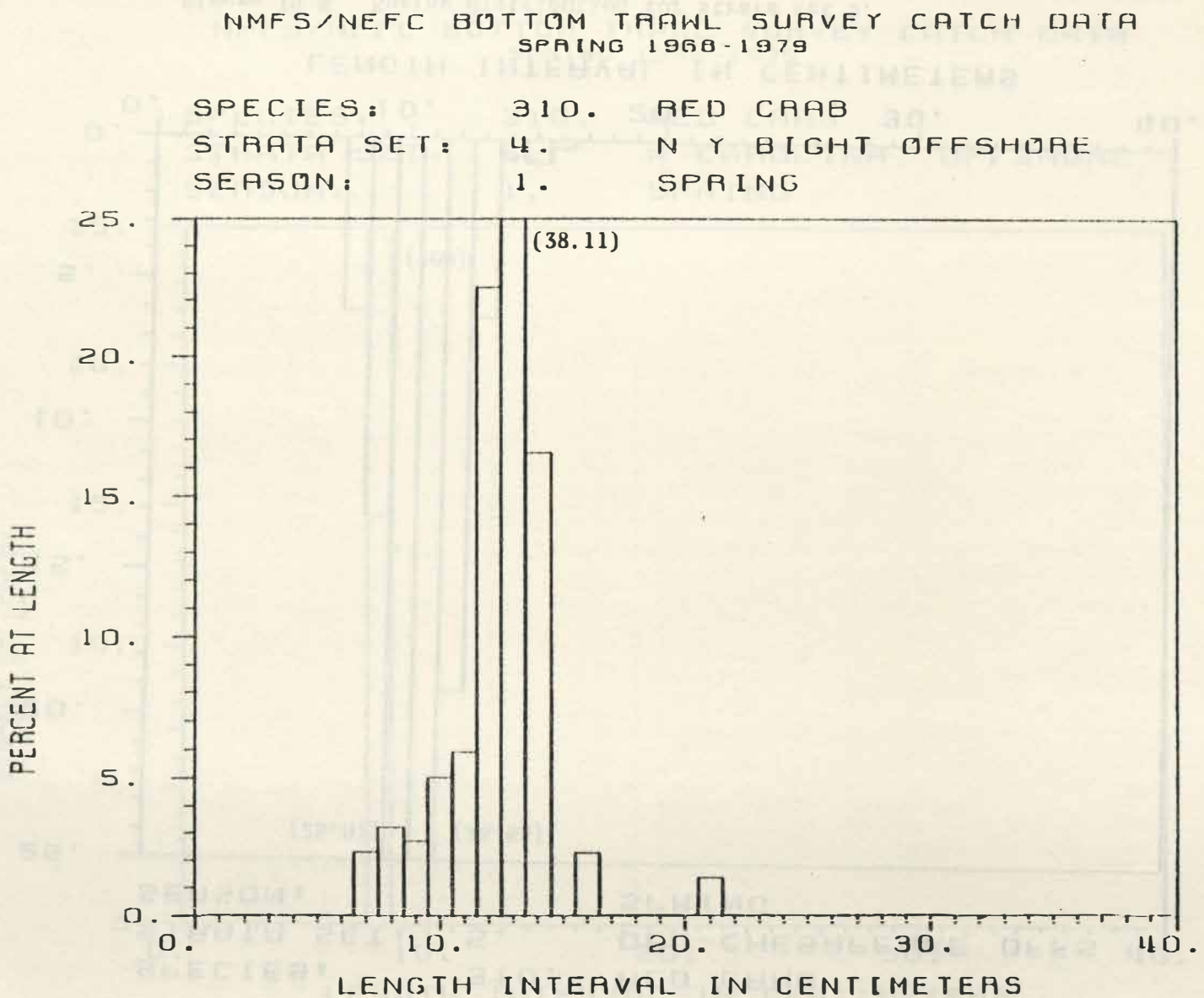

Figure 19.7. Spring length frequencies for strata set 4.

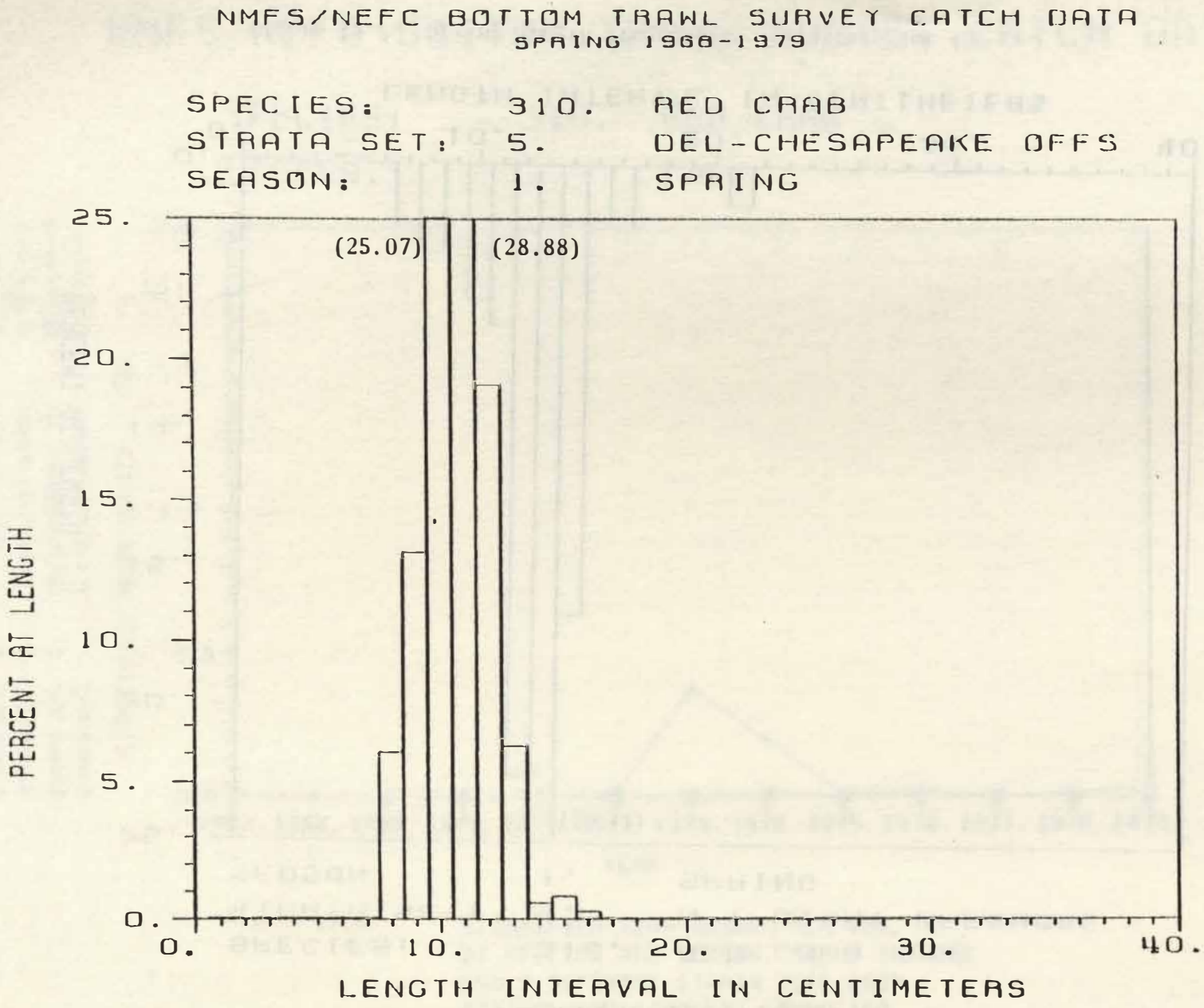

Figure 19.8. Spring distribution for strata set 5.

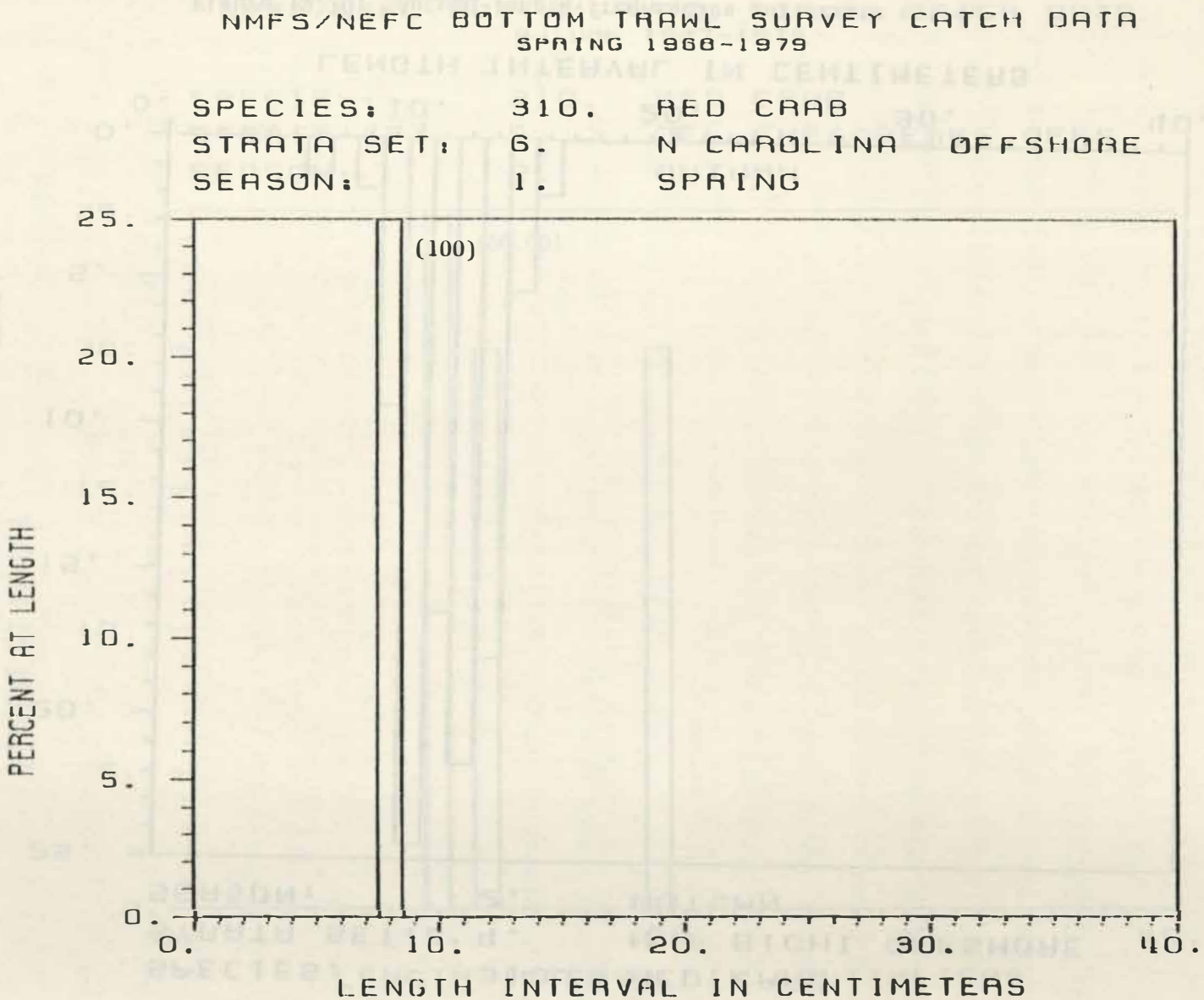

Figure 19.9. Spring length frequencies for strata set 6.

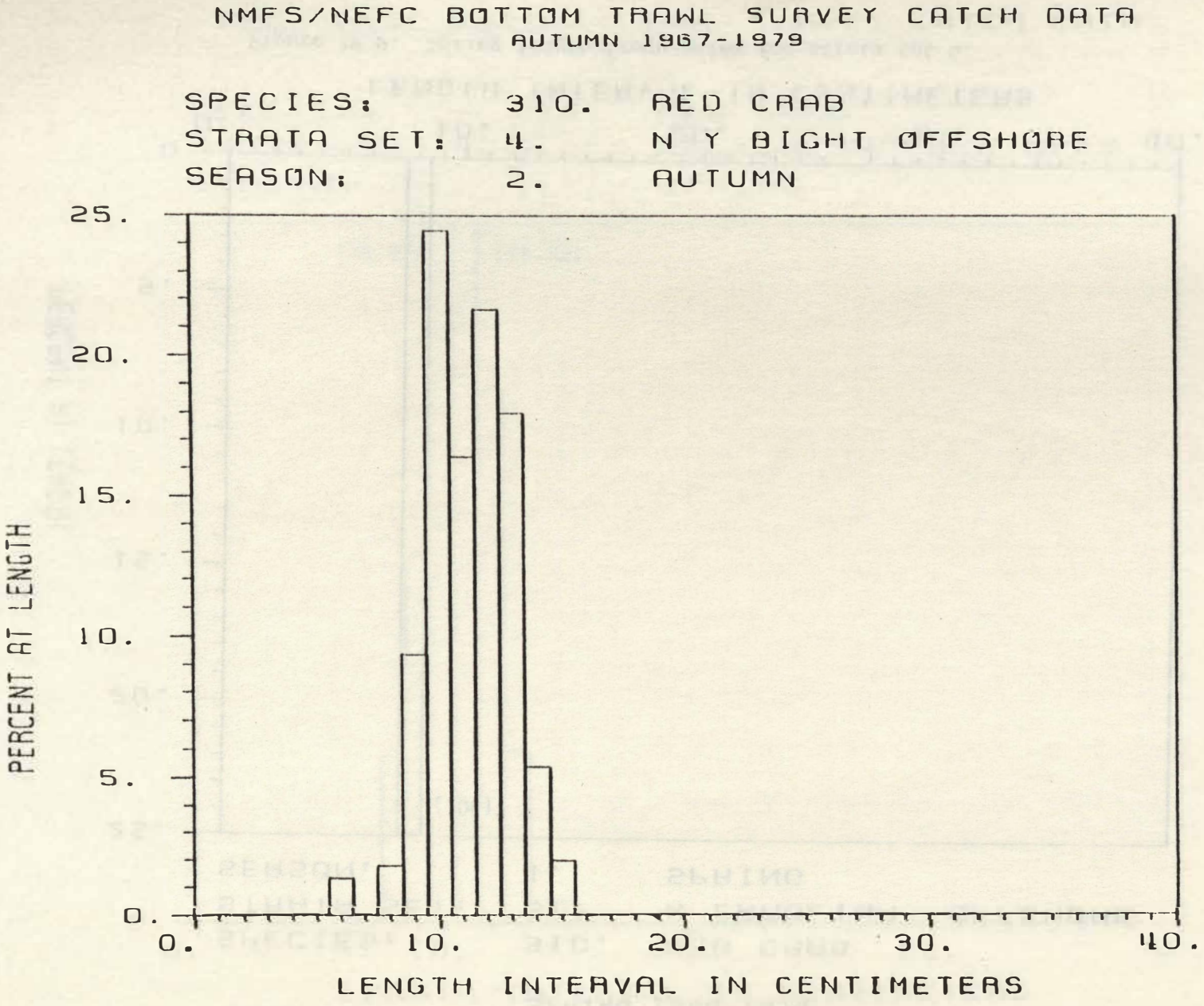

Figure 19.10. Autumn length frequencies for strata set 4.

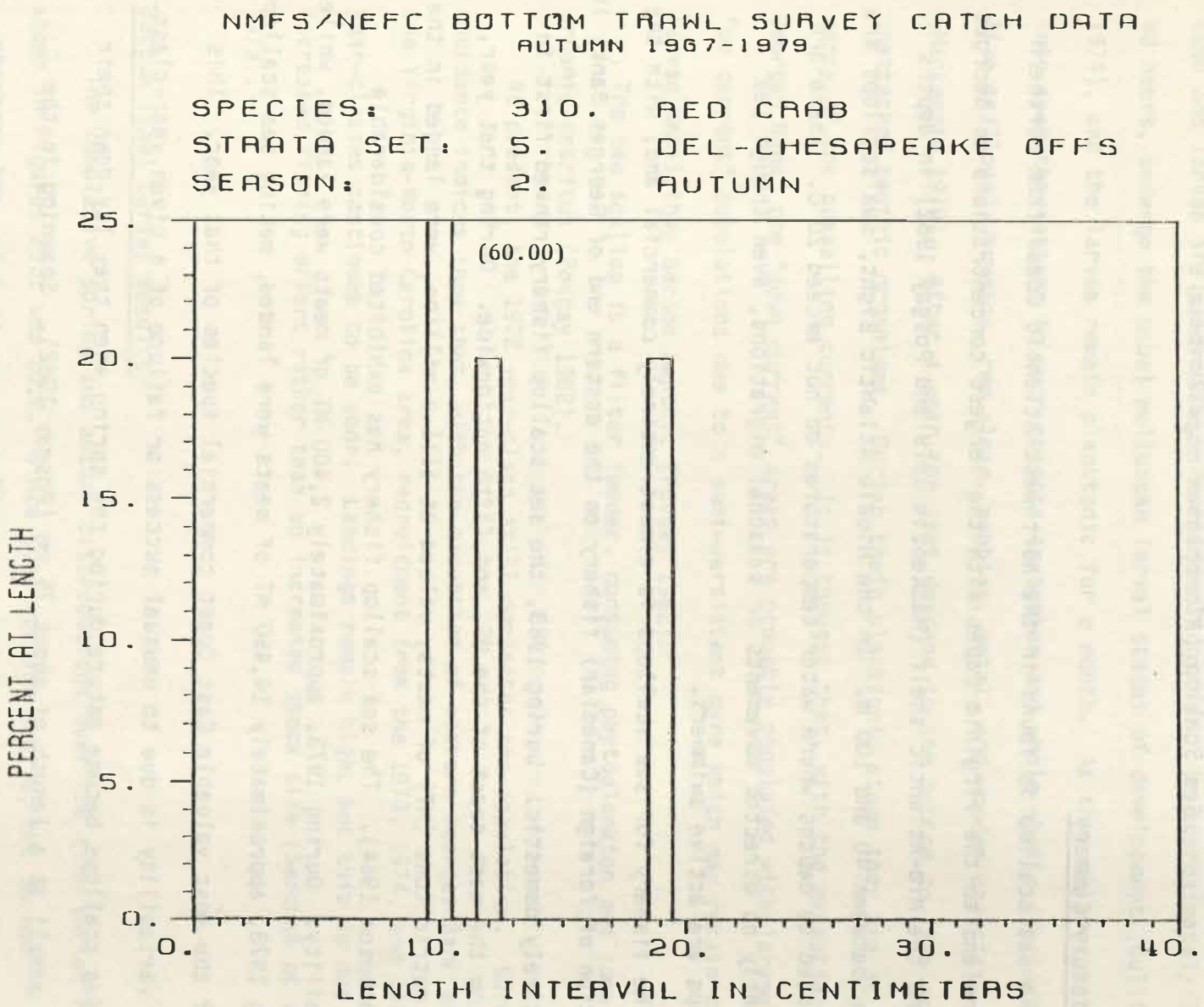

Figure 19.11. Autumn length frequencies for strata set 5.

SECTION 20

Sea Scallop (*Placopecten magellanicus*)

Life History Summary

The sea scallop is found in the Northwest Atlantic Ocean from northern Newfoundland to the Virginia Capes with the largest concentrations on Georges Bank and the Mid-Atlantic shelf (MacKenzie 1979 and Posgay 1982) in depths ranging between 40 and 100 m. In the Middle Atlantic Bight, sea scallops are restricted to depths where water temperatures do not exceed 20°C. There are apparently no directed movements or seasonal migrations, even though sea scallops are active swimmers.

The fishery for sea scallops is almost entirely commercial and, with the exception of foreign (Canadian) fishery on the eastern end of Georges Bank, it is entirely domestic. During 1983, the sea scallop fishery ranked first in value on the east coast of the US, and fifth nationwide. During that year, 9,289 metric tons (MT) of meats, valued at $111.5 million, were landed in the US (Thompson 1984). The sea scallop fishery has exhibited considerable variability. During 1973, approximately 2,400 MT of meats were landed, while during 1978, approximately 14,450 MT of meats were landed, making sea scallops one of the most valuable East Coast commercial species of that year. This catch variability is due to unusual success or failure of a given year-class.

Sea scallops become mature during the spring when they lay down their third annuli at a length of about 75 mm (Posgay 1982). Spawning in the southern part of the range of the sea scallop occurs in July, and proceeds northward, in a wave-like manner, so that spawning on Georges Bank occurs in late September and early October (MacKenzie et al. 1978). All scallops in a localized area spawn at the same time for about a week. Gametes of both sexes

are released directly into the water column where fertilization takes place. Eggs and larvae are planktonic. Fertilized eggs hatch in approximately 30 to 40 hours, undergo the usual molluscan larval stages of development (Culliney 1974), and the larvae remain planktonic for a month. As they metamorphose into spat they attach to such objects as broken and whole shells (including live scallops), bryozoa, red algae, pebbles, metal, and wooden objects (Mackenzie 1979). After a year the spat descend to the bottom to live as unattached benthic organisms. During their planktonic stage they are at the mercy of the prevailing currents. It is thought that, with the exception of Georges Bank, the "down current" areas are probably populated with larvae from "up current" populations due to a semi-persistent gyre which may retain the larvae until they become benthic (Posgay 1982).

The sea scallop is a filter feeder, consuming phytoplankton and some organic detritus (Posgay 1982).

At present, the 1972 year-class still dominates the population. Survey abundance indices show that, with the exception of eastern Georges Bank and the Virginia-North Carolina area, recruitment from the 1973, 1974, and 1975 year-classes continues to be poor. Landings remain high, but this is due to increased fishing effort rather than an increased stock size (Serchuk et al. 1979).

Bottom Trawl Survey Results

The cumulative spring and autumn distrubutions over the time series are shown in Figures 20.1 and 20.2. Since scallops are mobile, but do not migrate, the seasonal distributions are similar.

The graphs of mean weight and number per tow (Figures 20.3-20.6) indicate some seasonal sampling inconsistencies. Trawls with roller sweeps decrease

the sampling efficiency for scallops, and large or small catches probably can be related to bottom type as much as the actual distribution. Also, the overall sampling scheme was designed for finfish populations and not for shellfish.

The autumn and spring length frequencies by strata sets (Figures 20.7-20.13), are consistent from area to area; growth is too slow to show any seasonal difference with this method of presentation. There are no plots for spring strata sets 2-4 and autumn strata sets 2 and 3 as no scallops were taken in these areas.

Young-of-the-year scallops do not appear in the bottom trawl survey sampling gear.

The mid-shelf, non-migratory distribution, combined with high economic value, make scallops one of the more important species to be considered when evaluating man's activities on the shelf. Since scallops are filter feeders, they can be used as test animals for indicators of toxic elements.

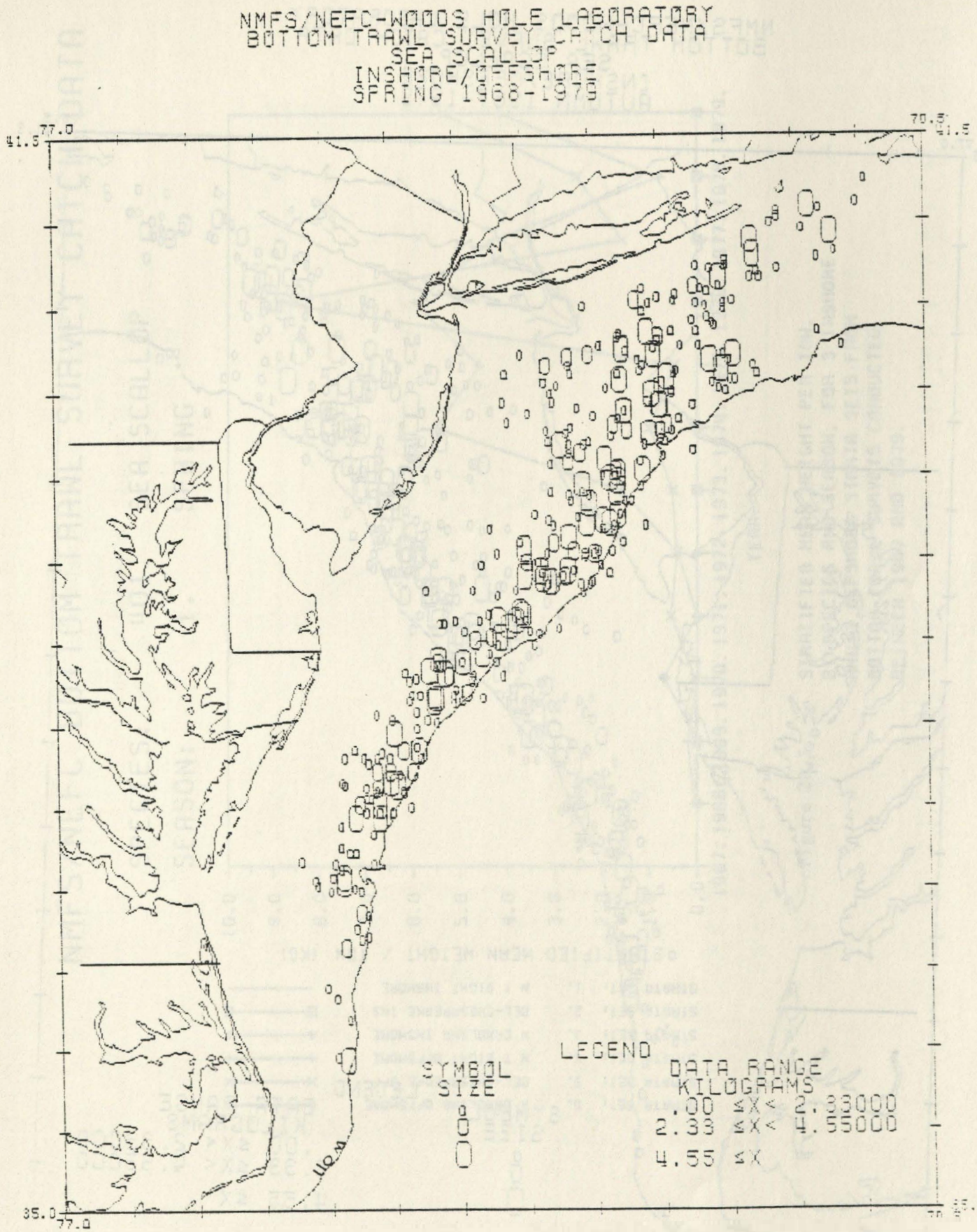

Figure 20.1. Spring distribution, 1968-1979.

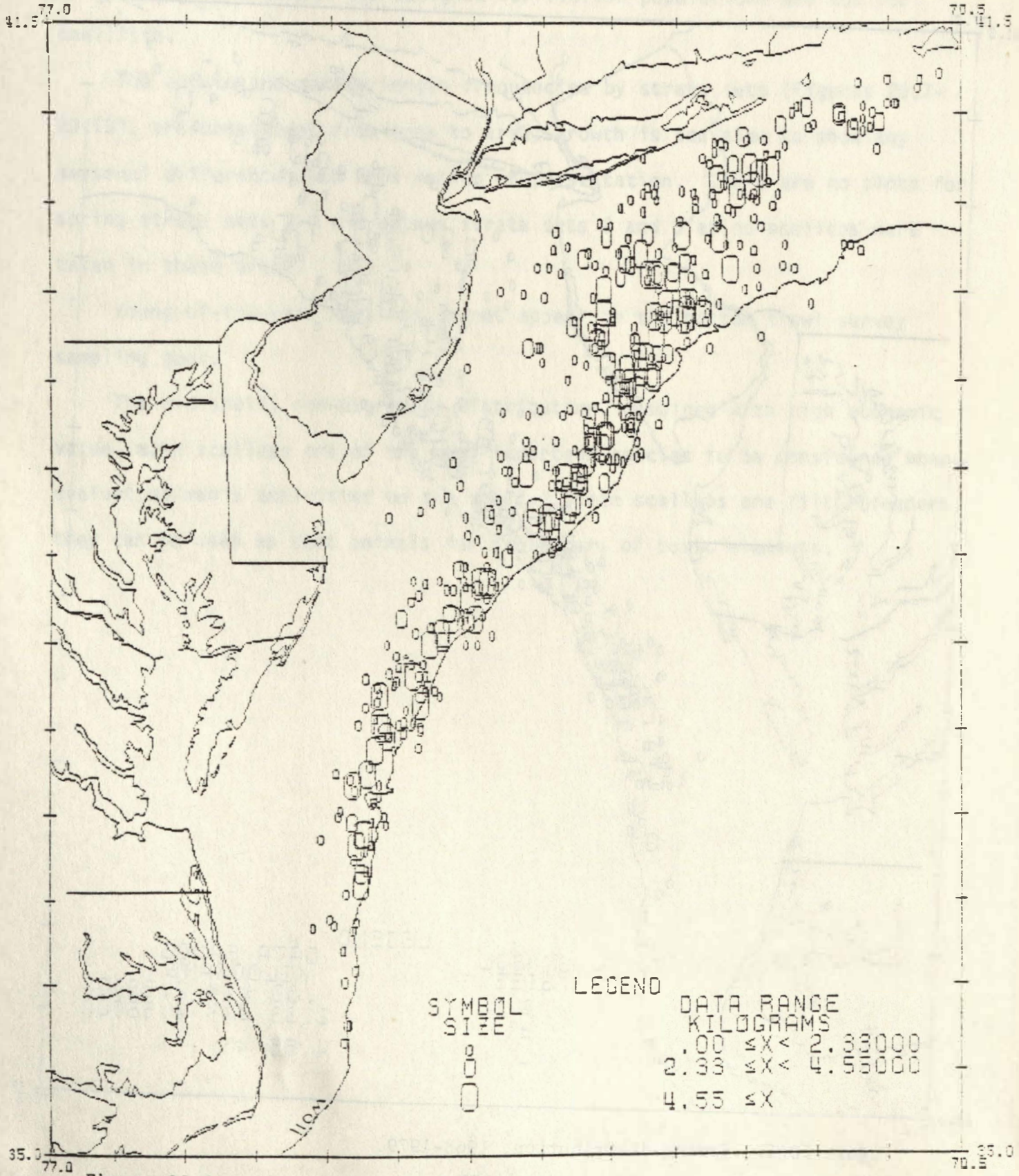

Figure 20.2. Autumn distribution, 1967-1979.

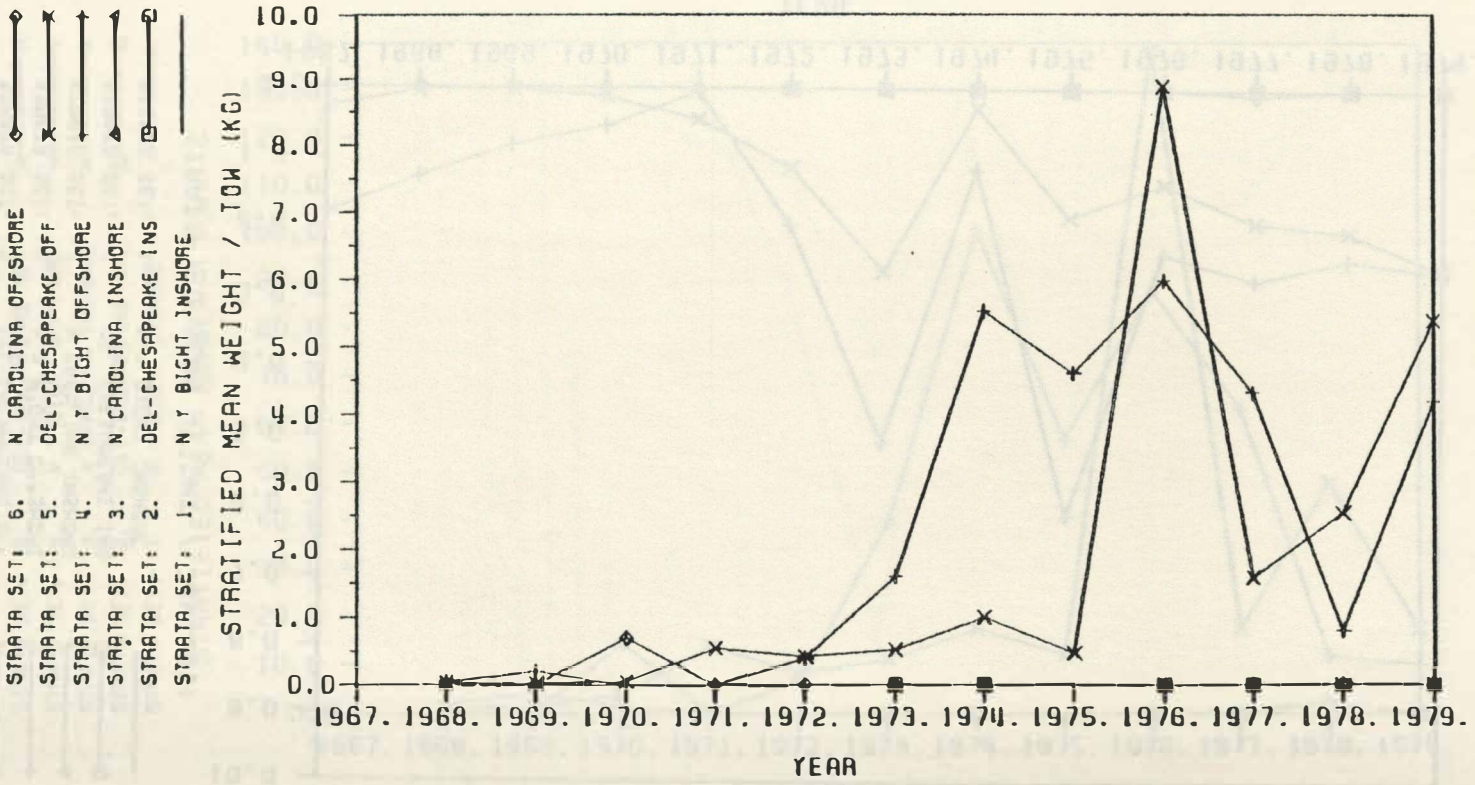

Figure 20.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 401. SEA SCALLOP

SEASON: 2. FALL

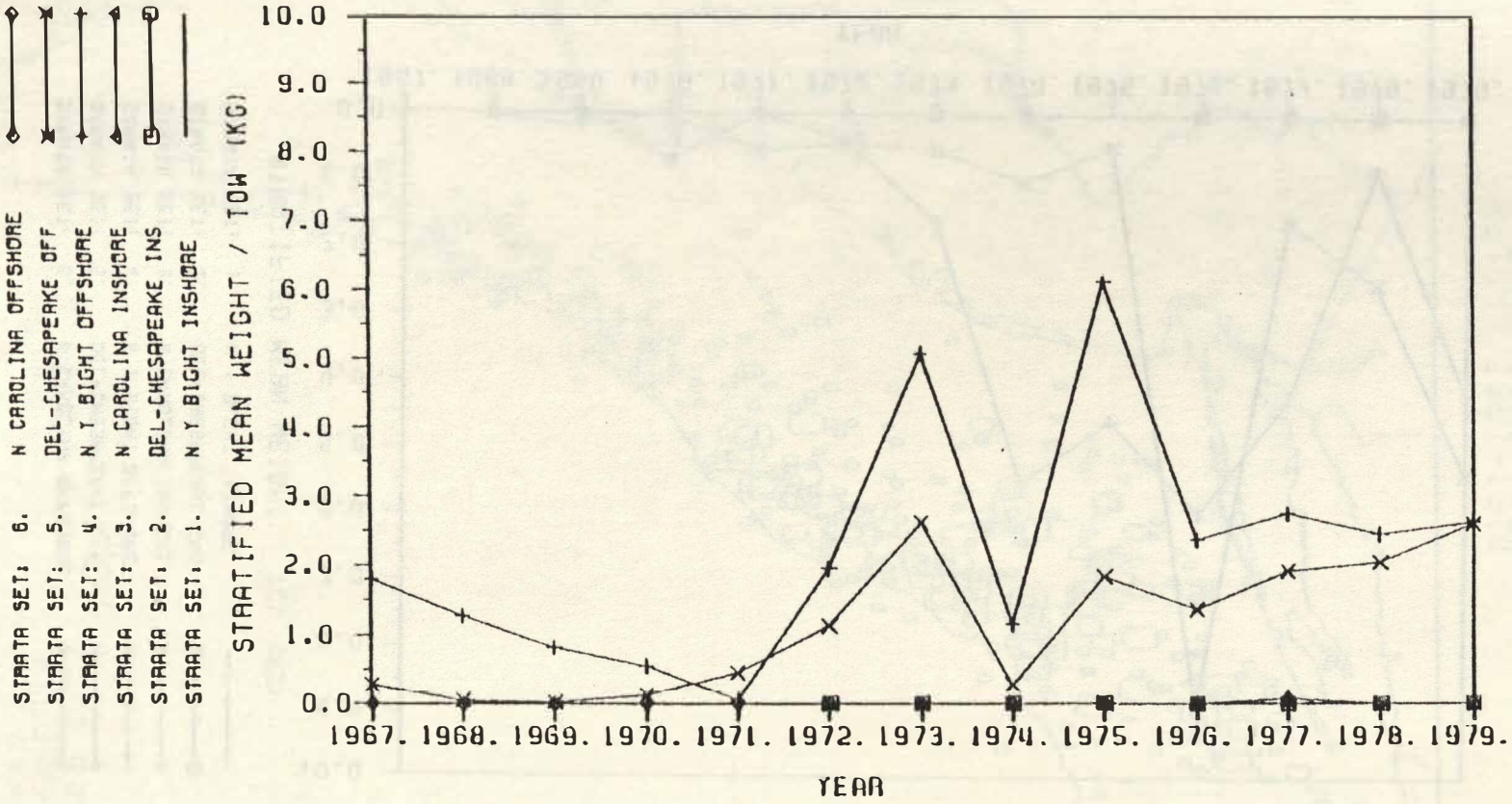

Figure 20.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

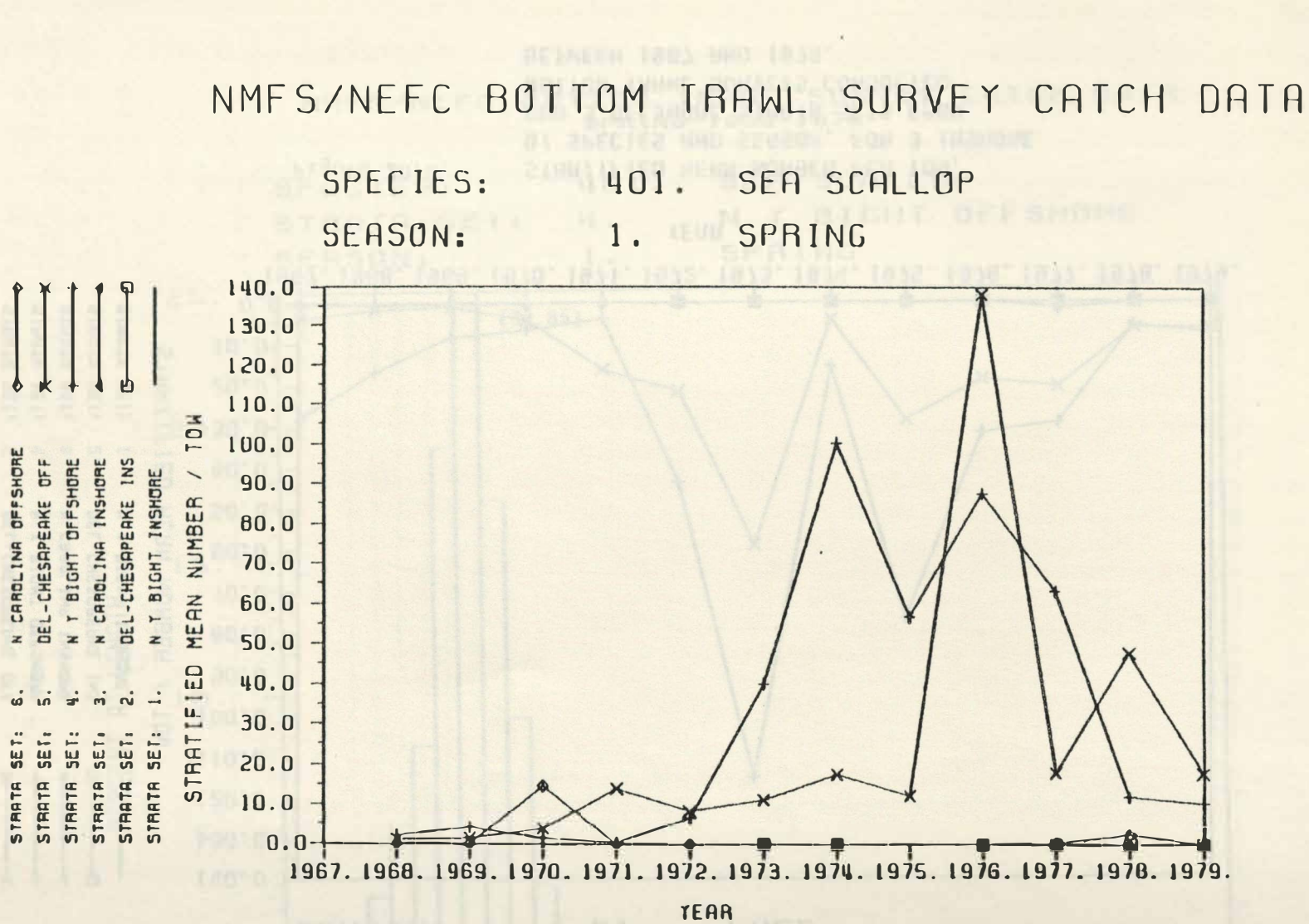

Figure 20.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

NMFS/NEFC BOTTOM TRAWL SURVEY CATCH DATA

SPECIES: 401. SEA SCALLOP

SEASON: 2. FALL

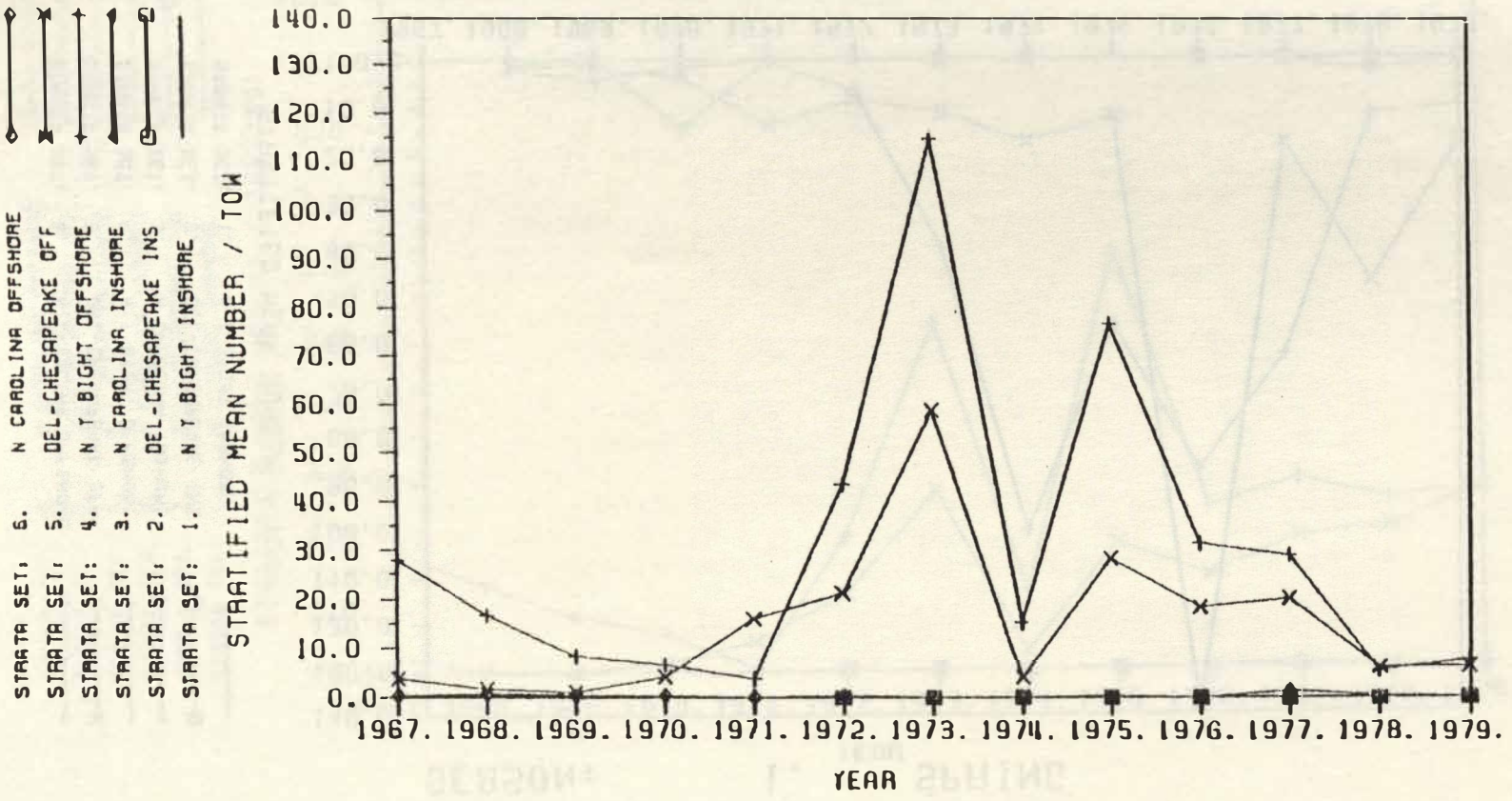

Figure 20.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

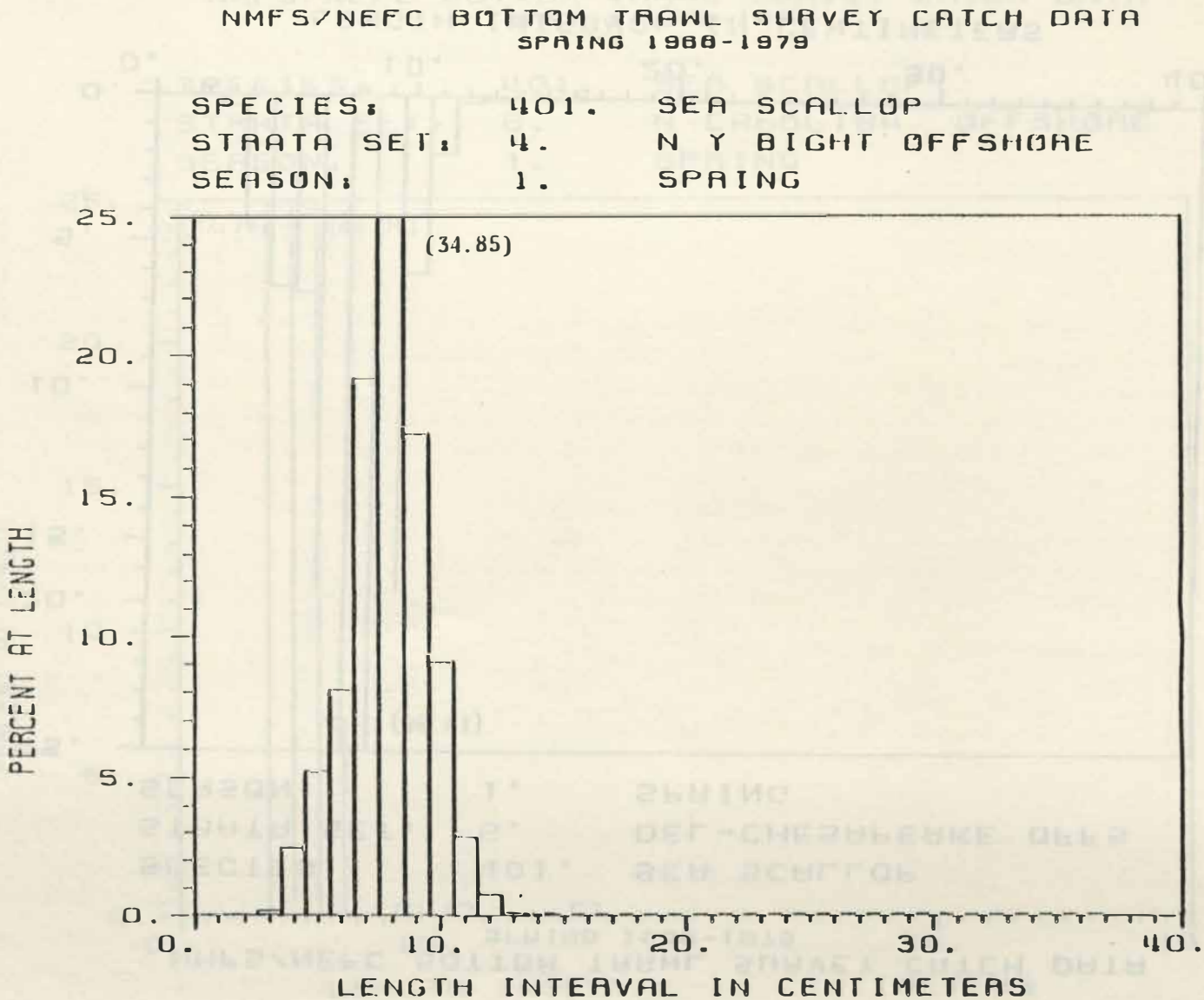

Figure 20.7. Spring length frequencies for strata set 1.

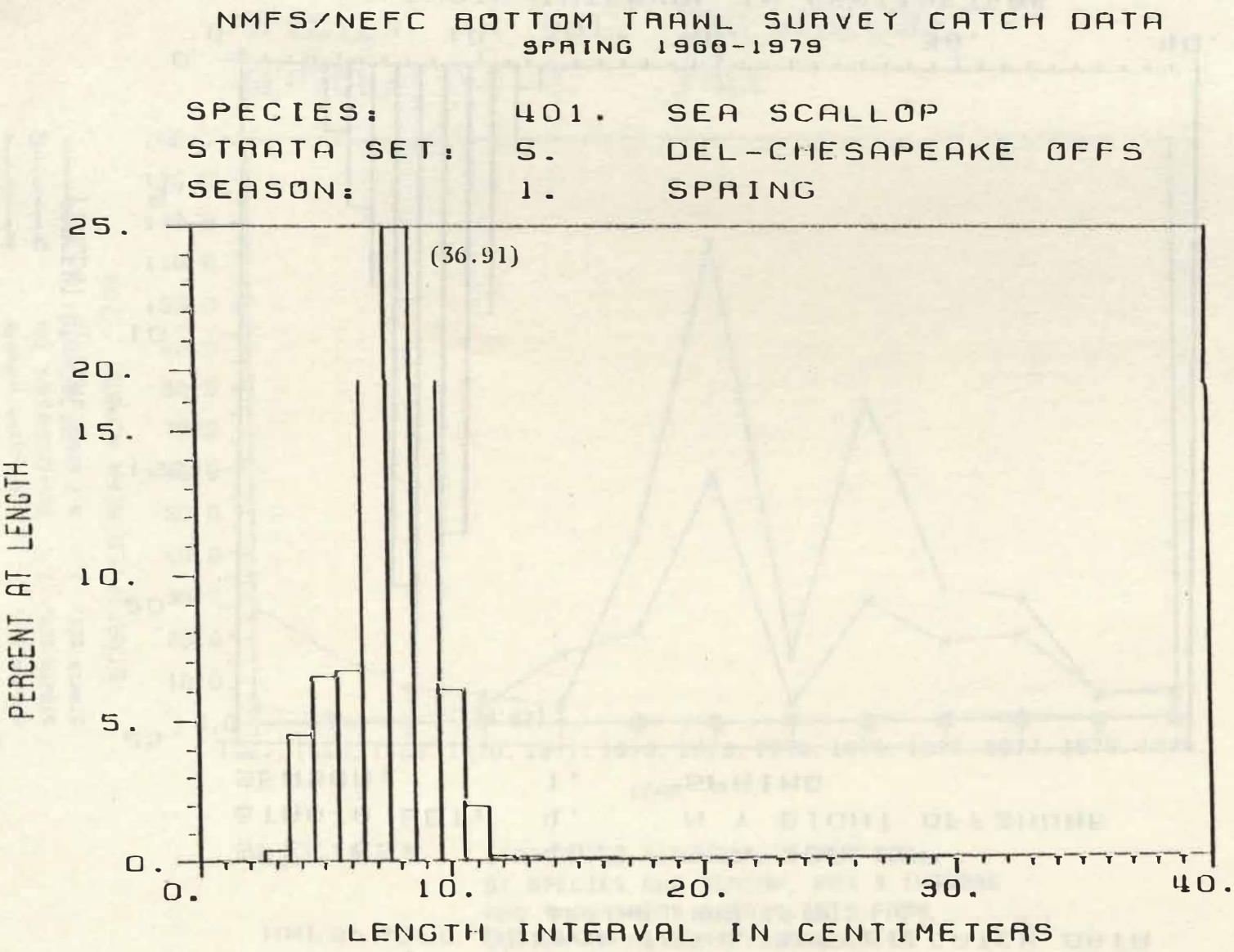

Figure 20.8. Spring length frequencies for strata set 5.

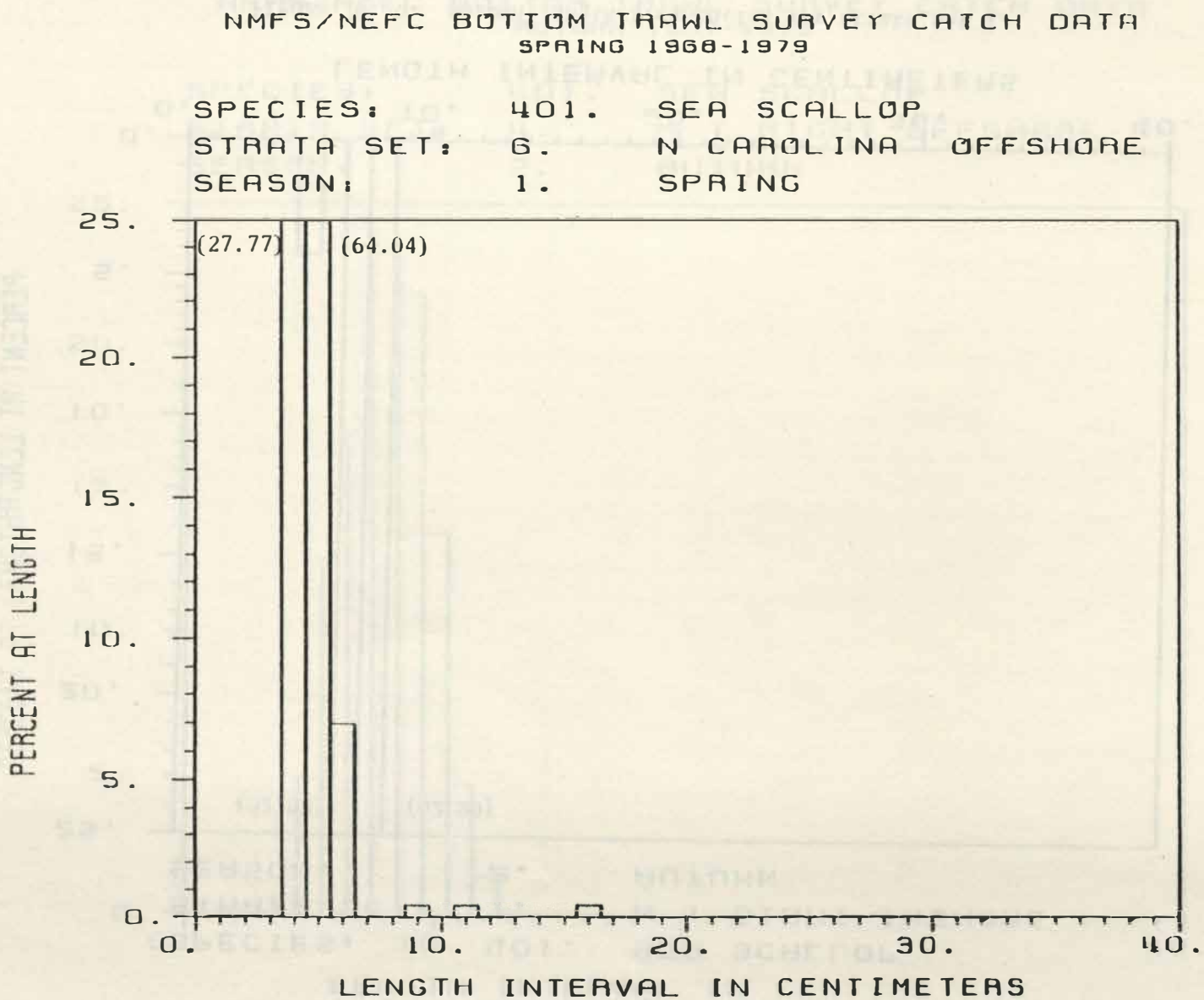

Figure 20.9. Spring length frequencies for strata set 6.

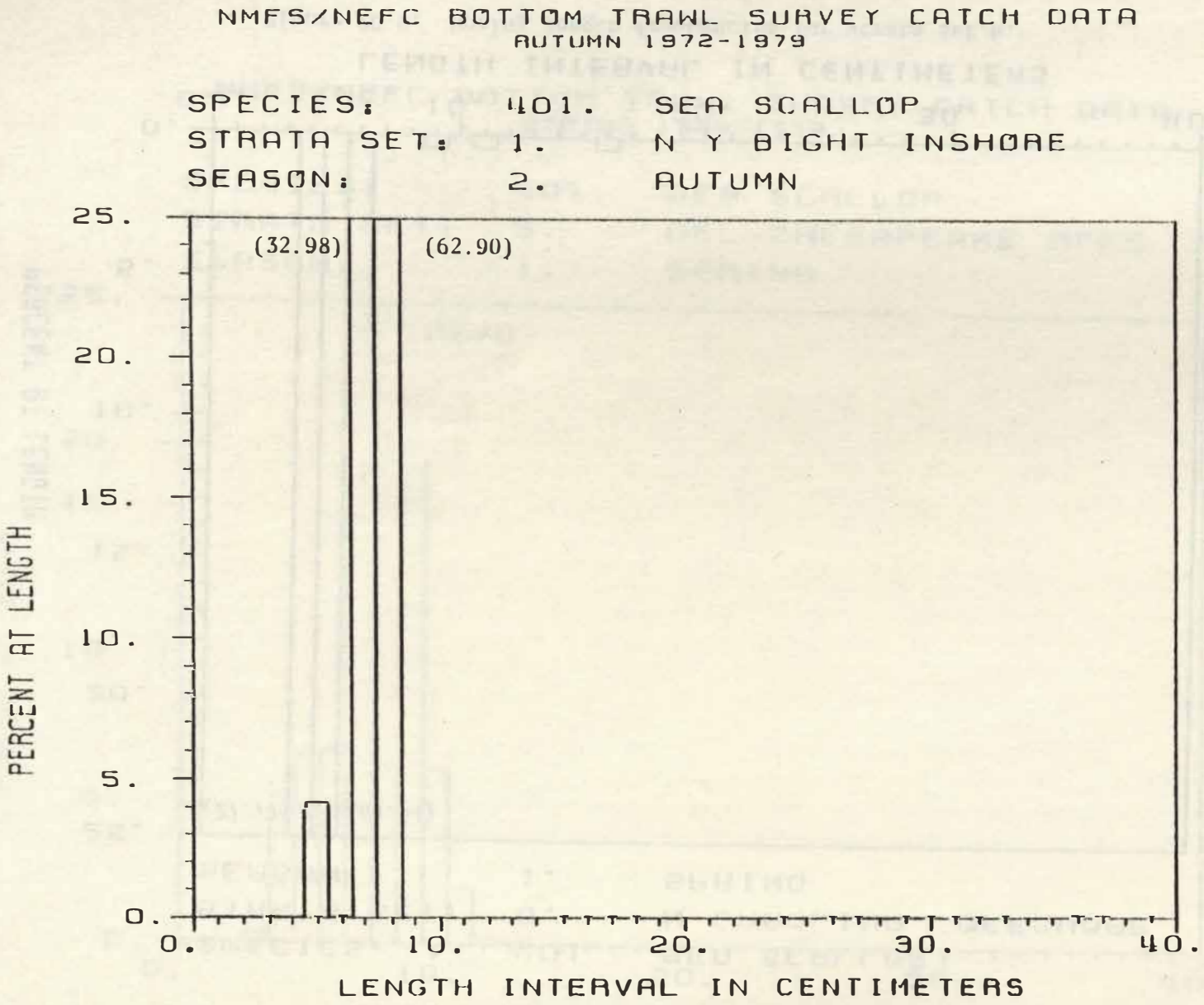

Figure 20.10. Autumn length frequencies for strata set 1.

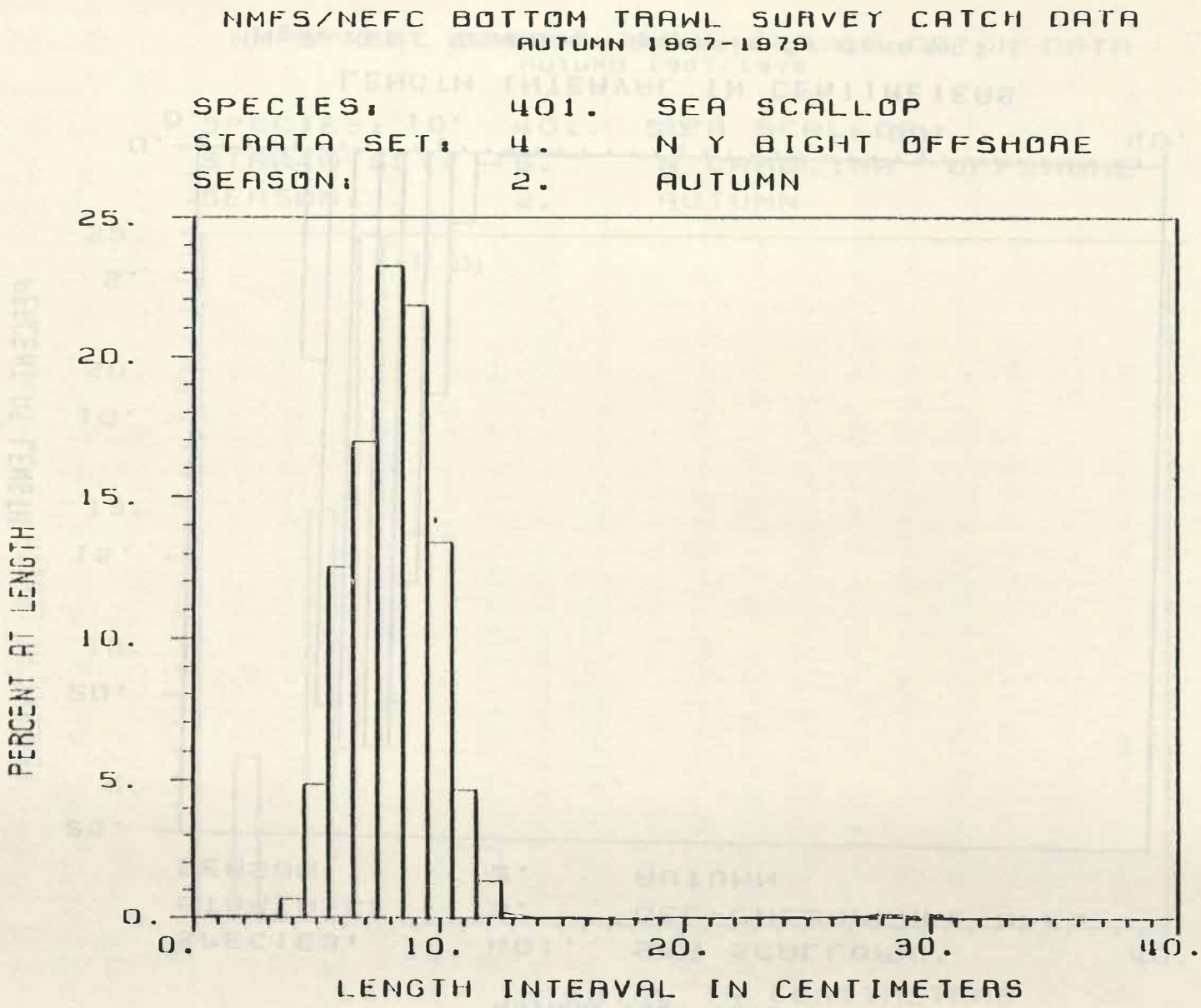

Figure 20.11. Autumn length frequencies for strata set 4.

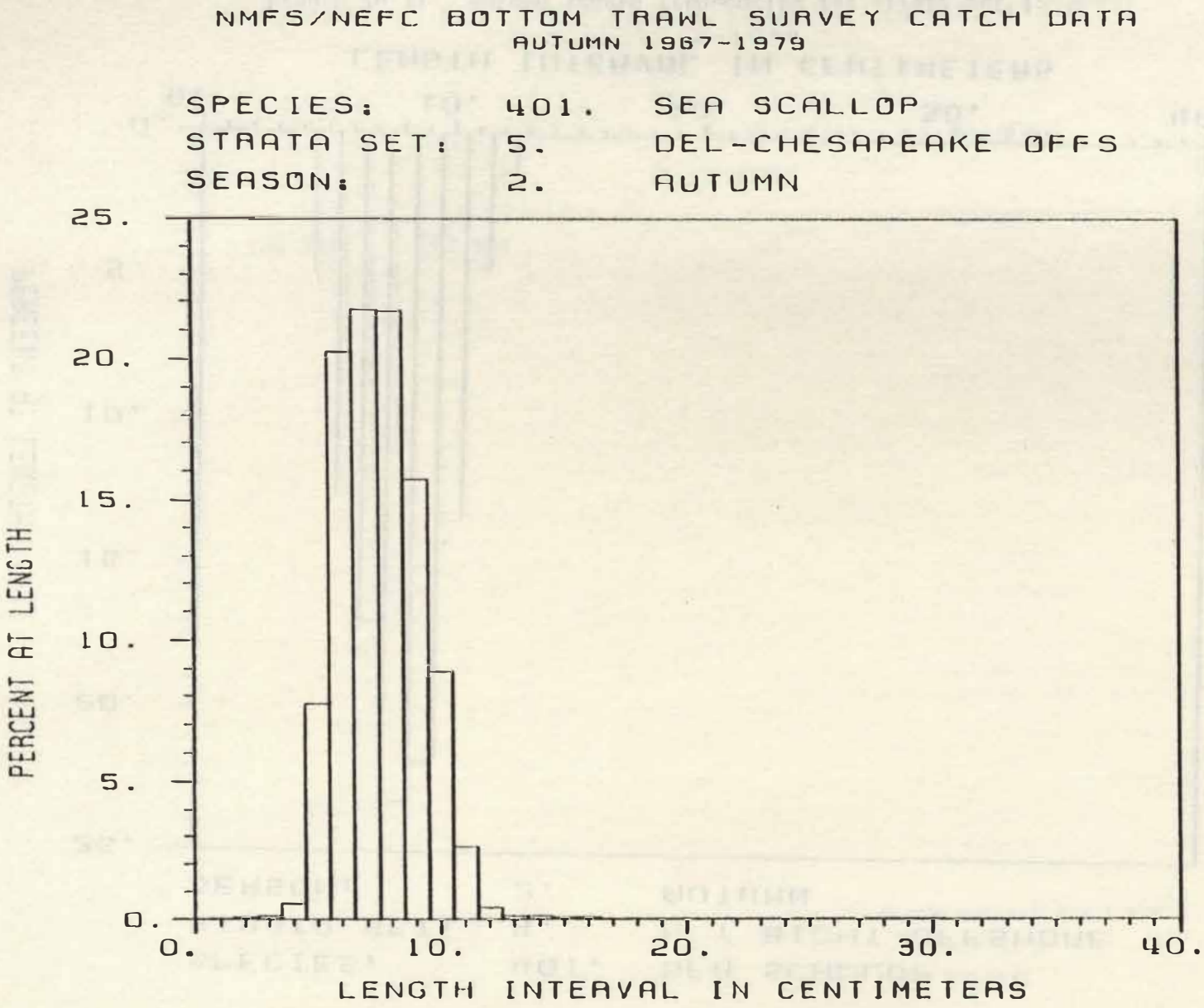

Figure 20.12. Autumn length frequencies for strata set 5.

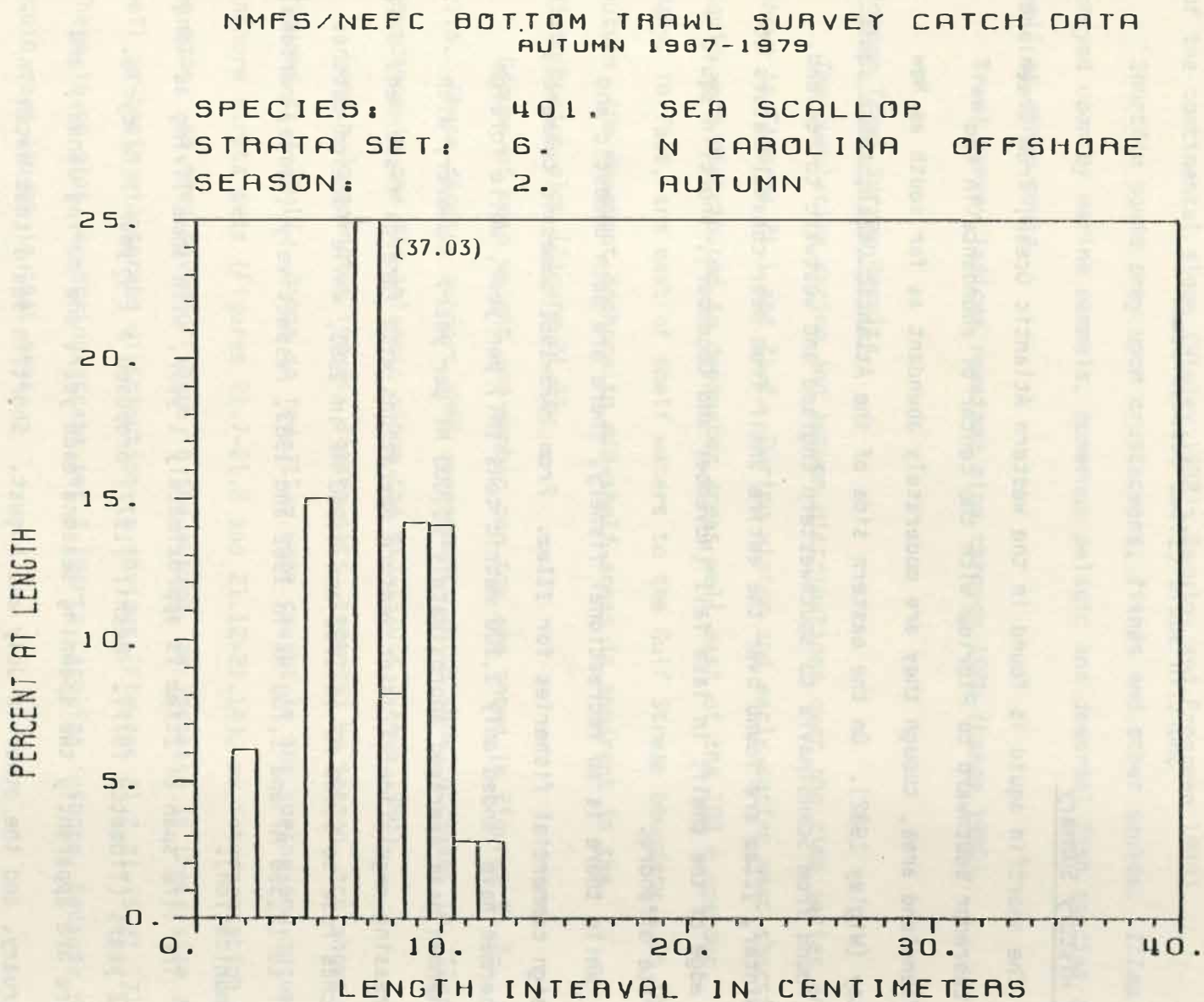

Figure 20.13. Autumn length frequencies for strata set 6.

SECTION 21

Shortfin squid (*Illex illecebrosus*)

Life History Summary

The shortfin squid is found in the western Atlantic Ocean, from Greenland and Labrador southward to Florida with the center of abundance in the Newfoundland area, though they are moderately abundant as far south as New Jersey (Wigley 1982). On the eastern side of the Atlantic Ocean, these squid are found from Scandinavia to southwestern England and westward to Iceland. In winter, *Illex* are found over the entire shelf from near coastal waters to the edge of the shelf; in late fall (November and December), shortfin squid migrate offshore.

While there is no recreational fishery, there are both domestic and foreign commercial fisheries for *Illex*. From 1975-1981 domestic commercial fishermen have landed only 1,100 metric tons (MT) per year, while foreign fishermen have averaged approximately 20,000 MT per year. However, with increasing regulation of joint venture operations with foreign fishermen, U.S. catches rose to 5,900 MT in 1982 and 9,950 MT in 1983, while foreign catches fell to 12,350 MT and 1,780 MT in 1982 and 1983, respectively (Lange, personal communication).

The life span of *Illex* is approximately 1 year, with some living as long as 2 years (Tibbetts 1977). Mesnil (1977) proposed a 1 ½ year life cycle. There are apparently two spawning seasons each year, one during January and February, and the other in July and August. Shortfin squid that hatch in January or February spawn 1 ½ years later, during the summer spawning season. Those that hatch during the summer, spawn 1 ½ years later during the winter. They are believed to die shortly after spawning, as has been observed

in other squid species. Spawning probably takes place near and off the edge of the continental slope (Wigley 1982); Fedulov and Froerman 1980).

Shortfin squid prey upon crustaceans, fishes and other squids. *Illex* are preyed upon by marine mammals, numerous pelagic and demersal fish species as well as other squid.

Trawl survey indices remained high through 1980 (Lange 1980).

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 21.1 and 21.2. During winter and early spring most shortfin squid were distributed in deepwater areas well east of the 100 m contour. Many, in fact, are east of shelf waters to the Gulf Stream boundary. In the autumn, the movement inshore to mid-shelf areas is apparent in the distribution plot (Figure 21.2).

Graphs of mean weight and number per tow are shown in Figures 21.3-21.6. These figures support NMFS assessments which show increases in *Illex* abundance in the Mid-Atlantic since the mid-1970's (Lange 1980).

Length frequencies for six strata sets, arranged by season, are shown in Figures 21.7-21.17. Since so few *Illex* were caught in the spring and autumn inshore strata sets (Figures 21.7-21.8 and 21.12-21.14), no interpretation can be made. As they moved offshore in the autumn, an increase in their size as well as their widespread distribution is obvious (Figures 21.2,21.15-21.17). There is no plot for spring strata set 3 (North Carolina inshore) because no squid were caught in that area.

Figures 21.18 and 21.19 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 15 and 18 cm for spring and autumn series, respectively. YOY predominated in all offshore strata (>55 m) during both seasons although, in the autumn, they were found up to the 28 m contour. As discussed in "Methods", the spring surveys occur prior to any major inshore movement of *Illex*. The variability in these indices may reflect differences in distribution rather than abundance.

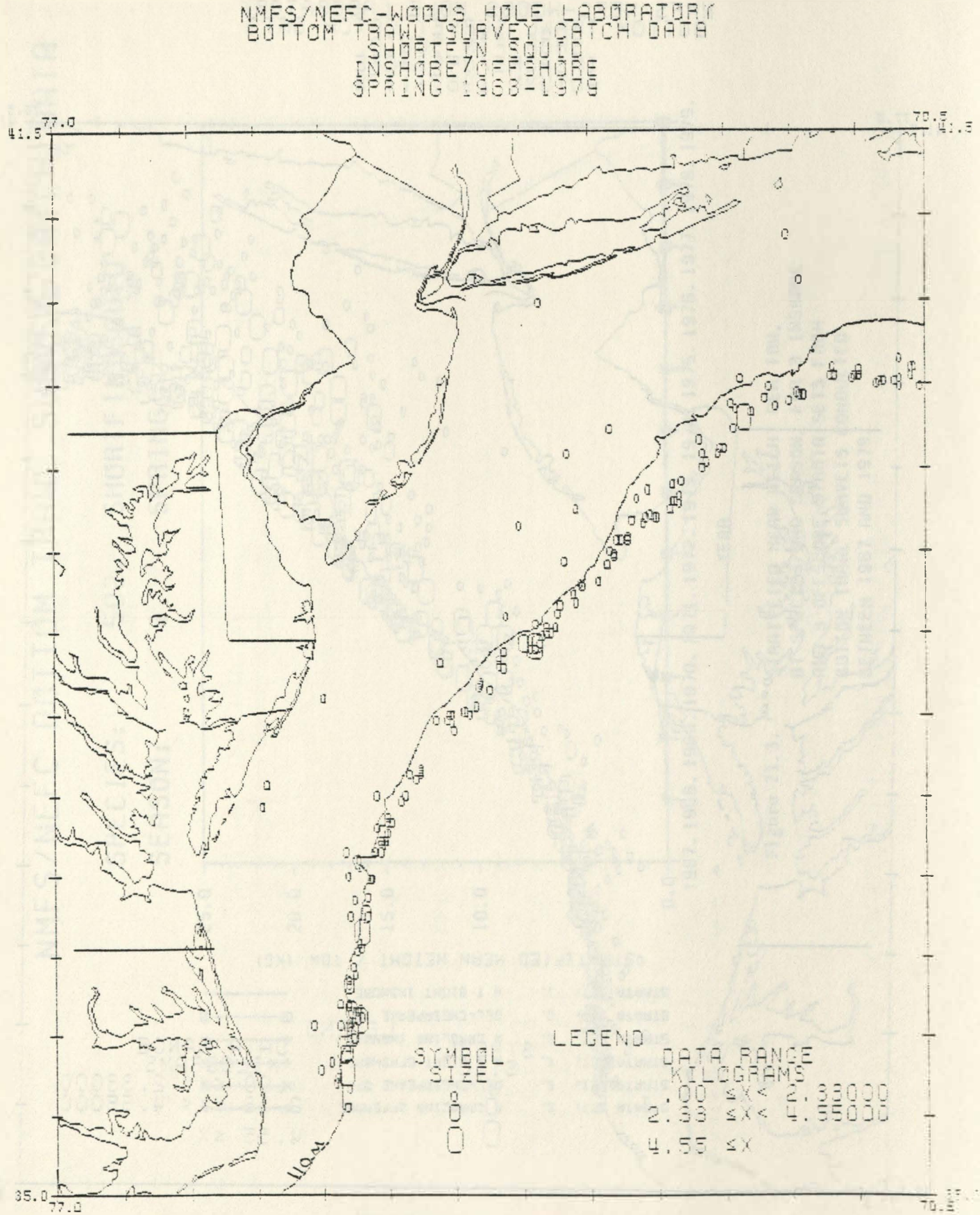

Figure 21.1. Spring distribution, 1968-1979.

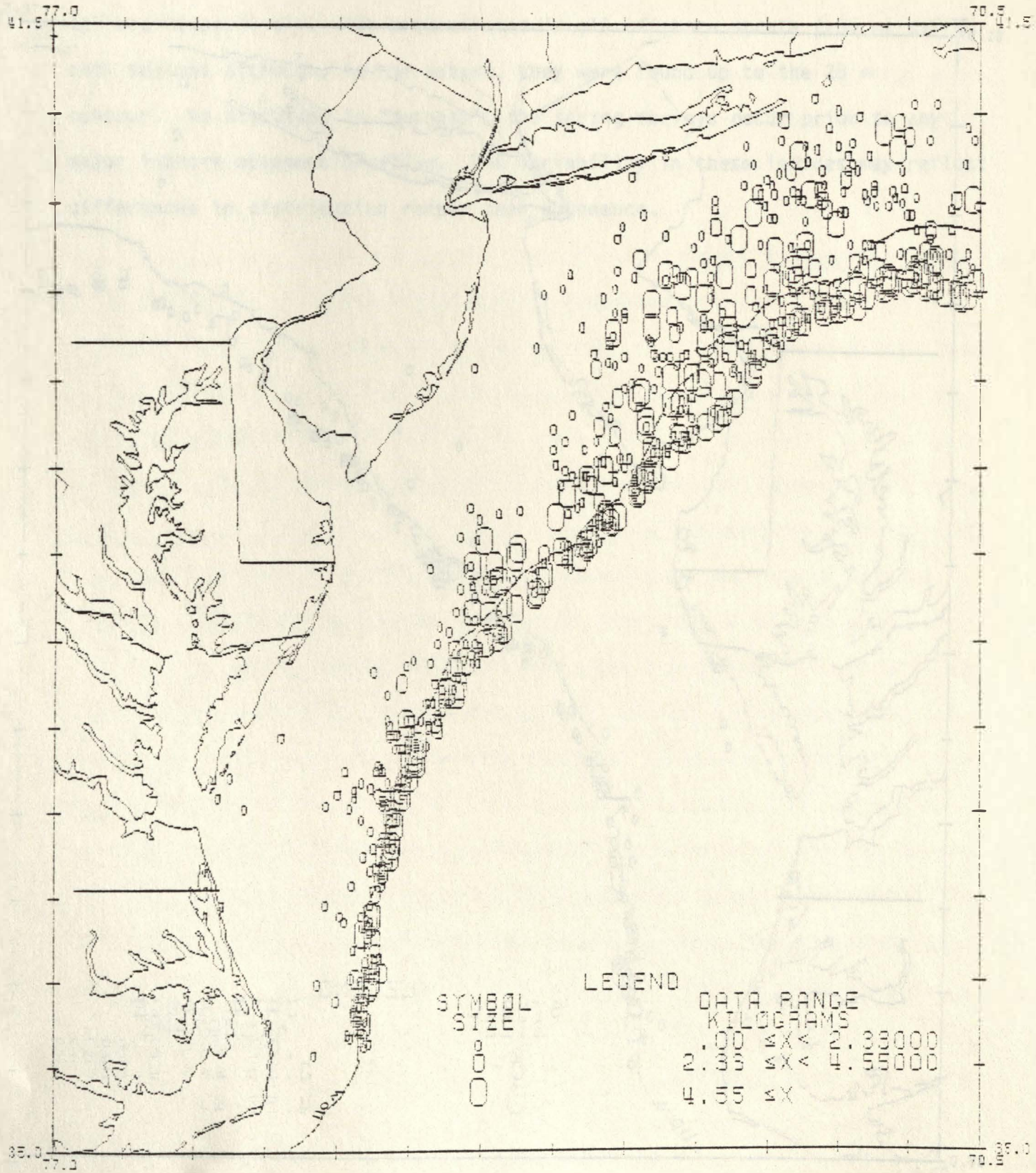

Figure 21.2. Autumn distribution, 1967-1979.

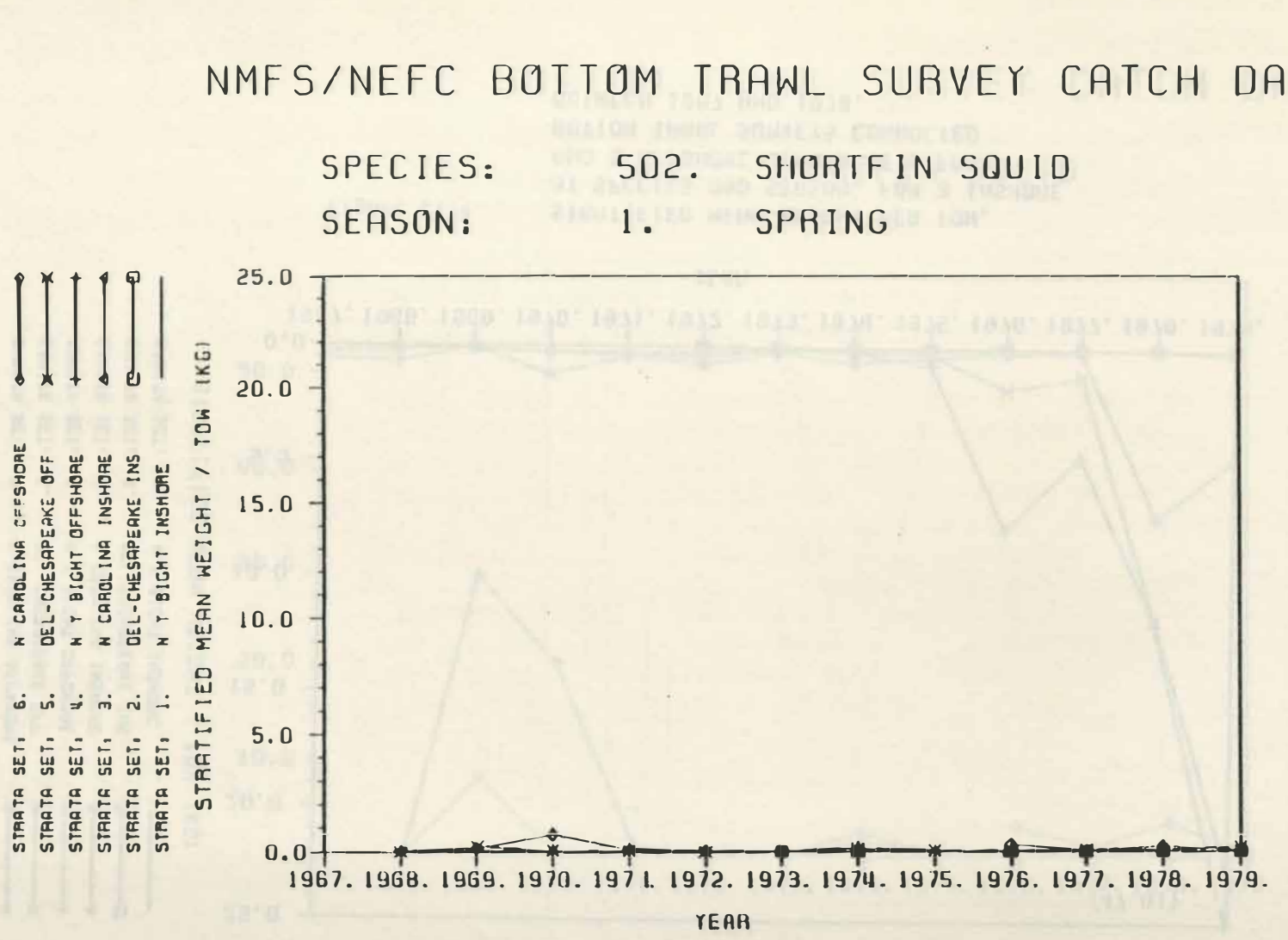

Figure 21.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

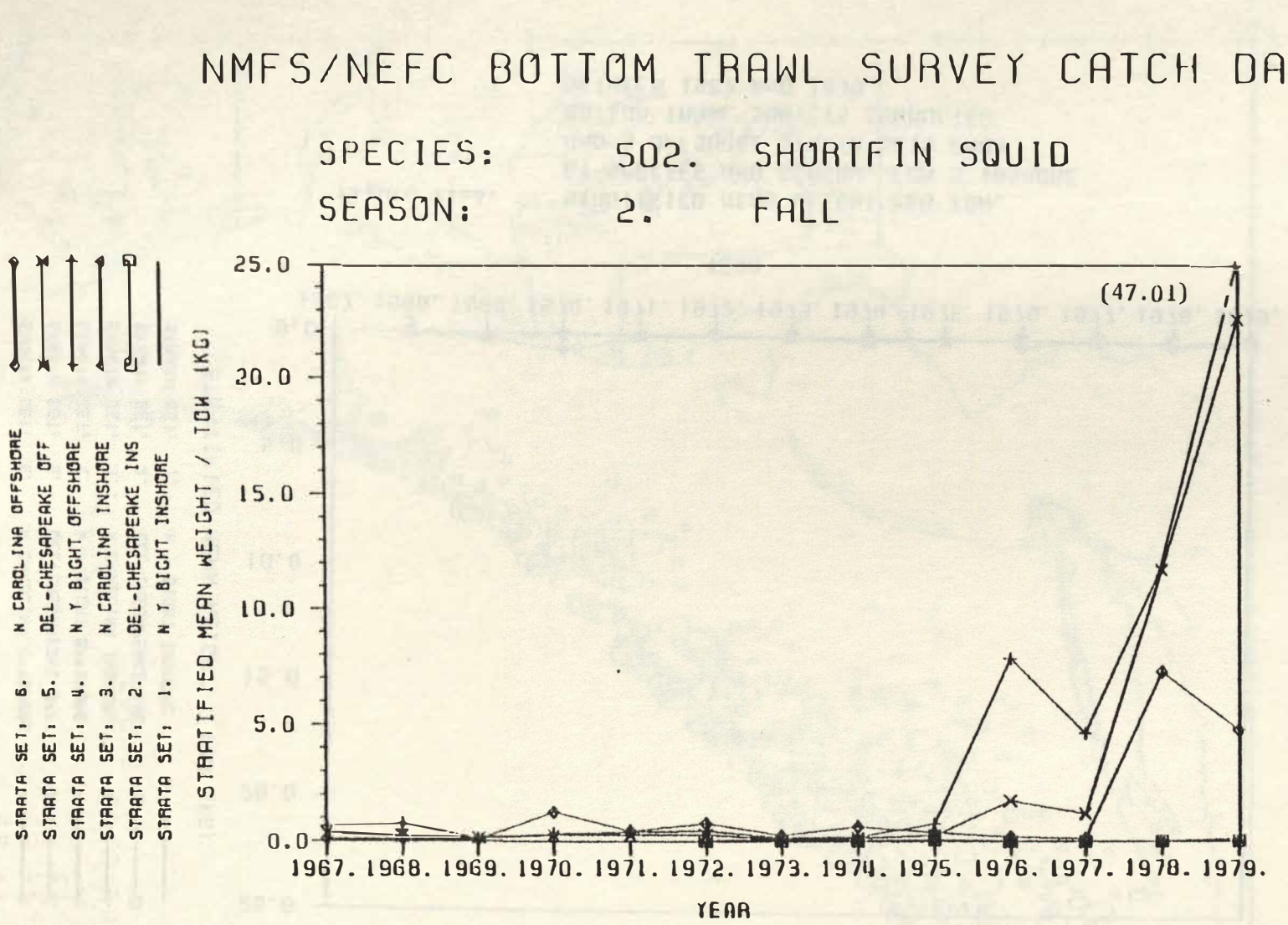

Figure 21.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

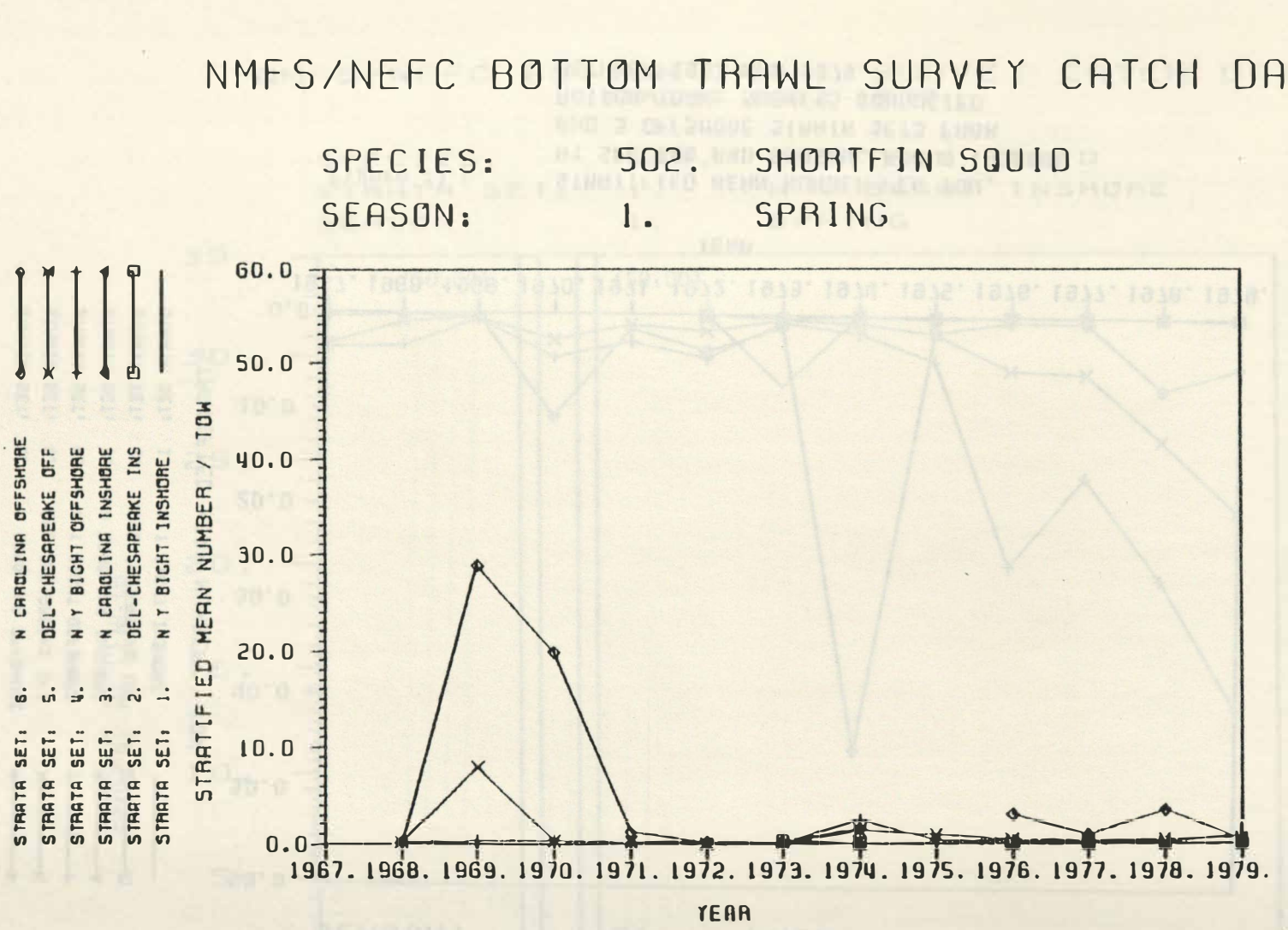

Figure 21.5. . STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

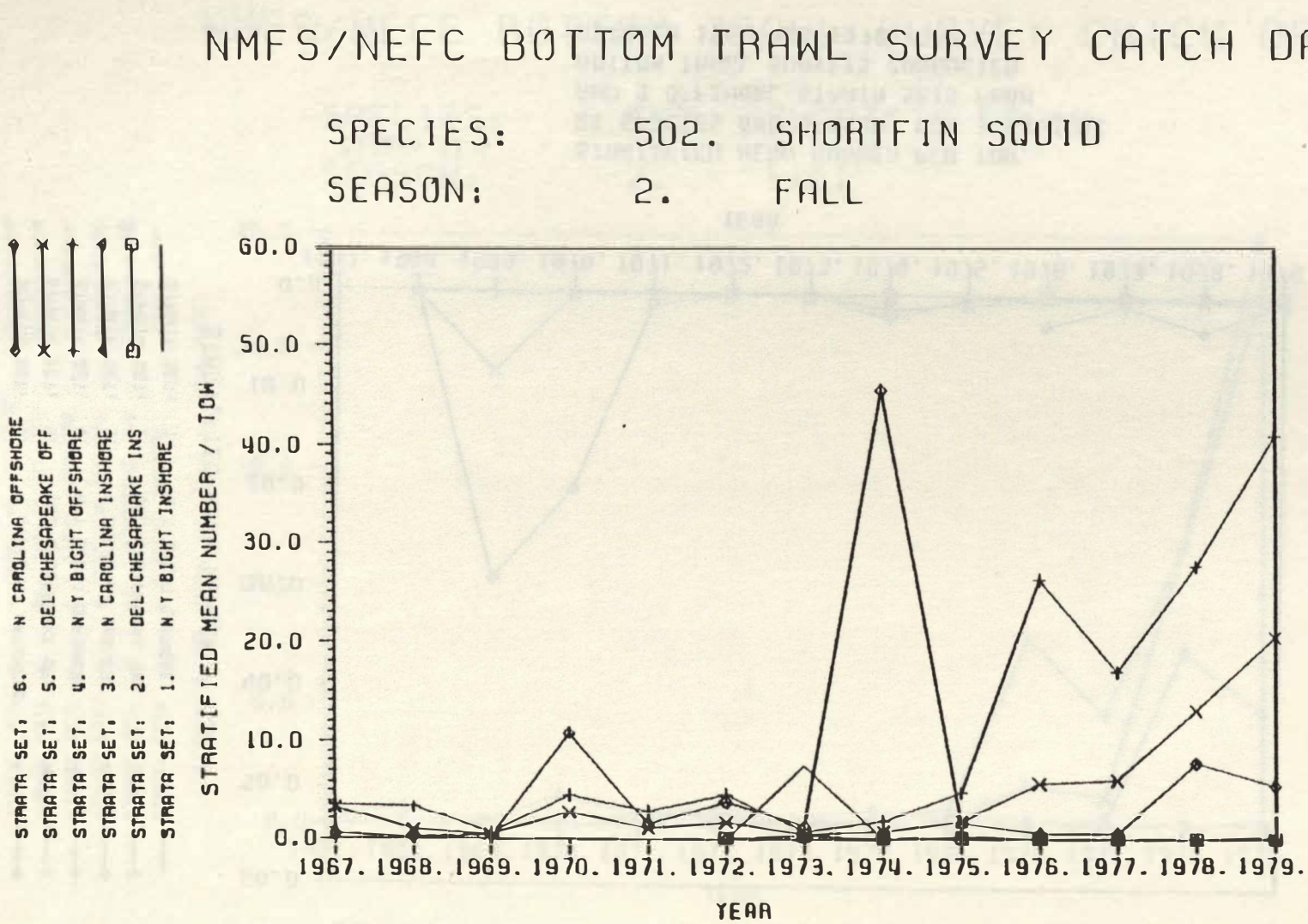

Figure 21.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

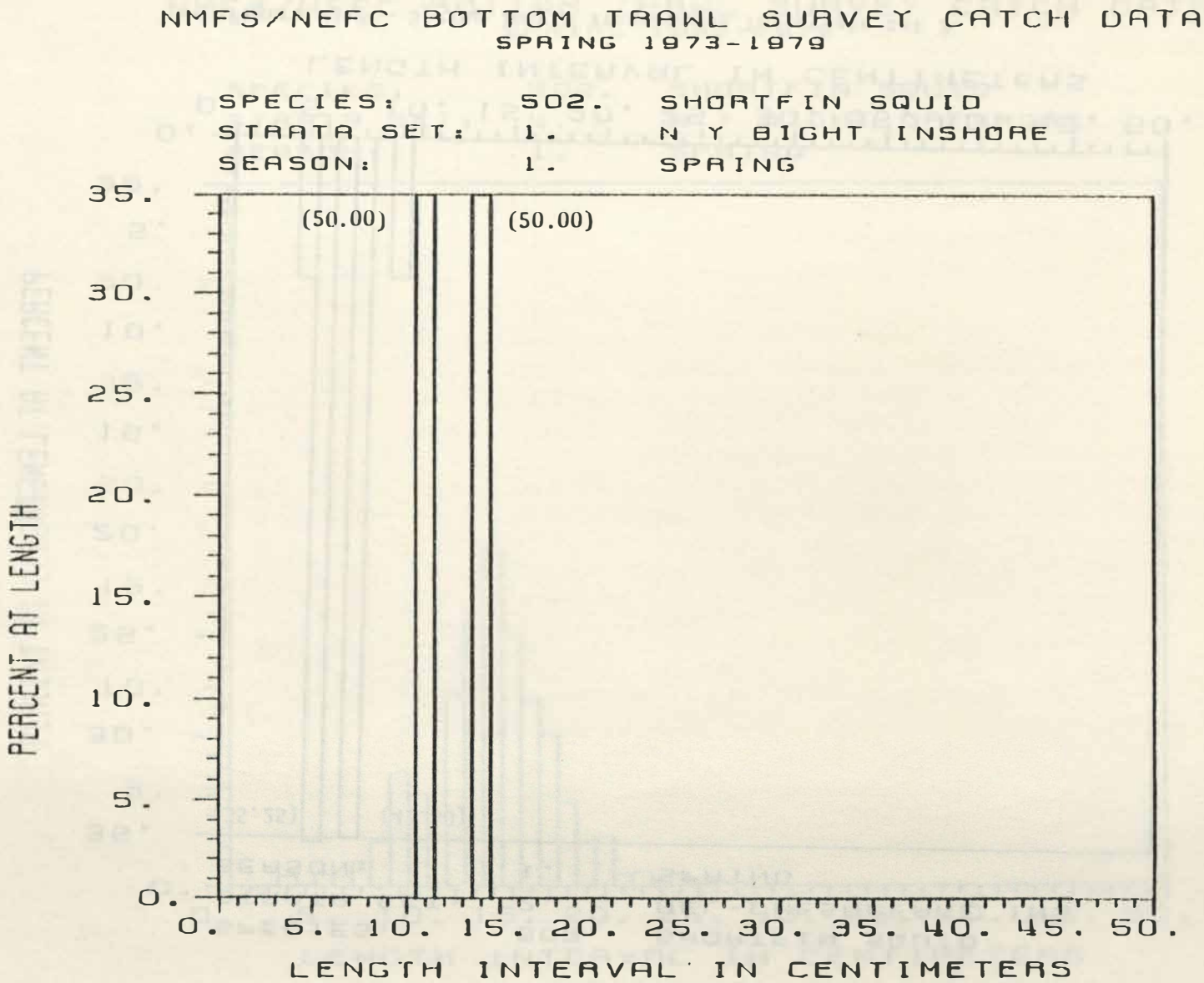

Figure 21.7. Spring length frequencies for strata set 1.

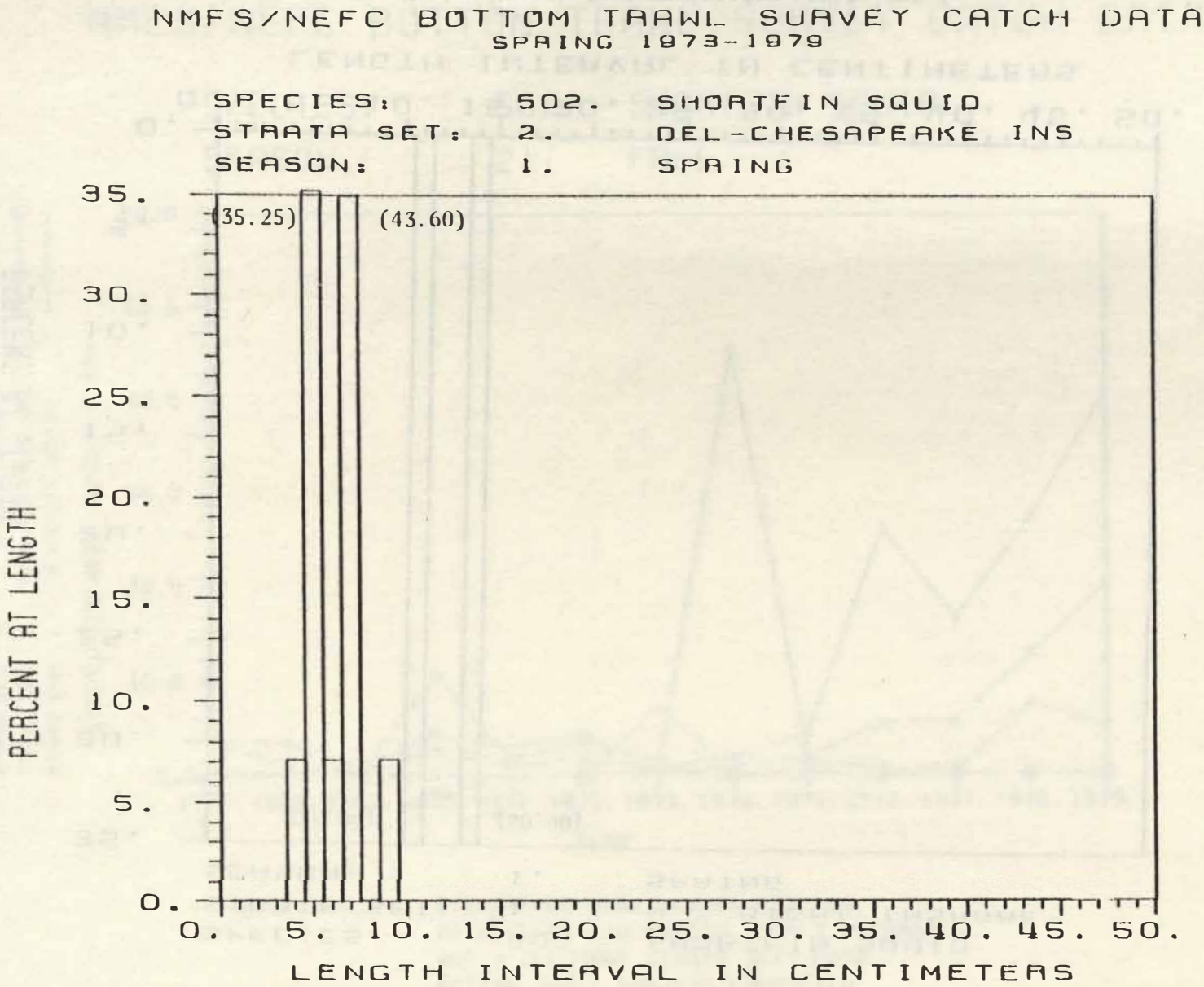

Figure 21.8. Spring length frequencies for strata set 2.

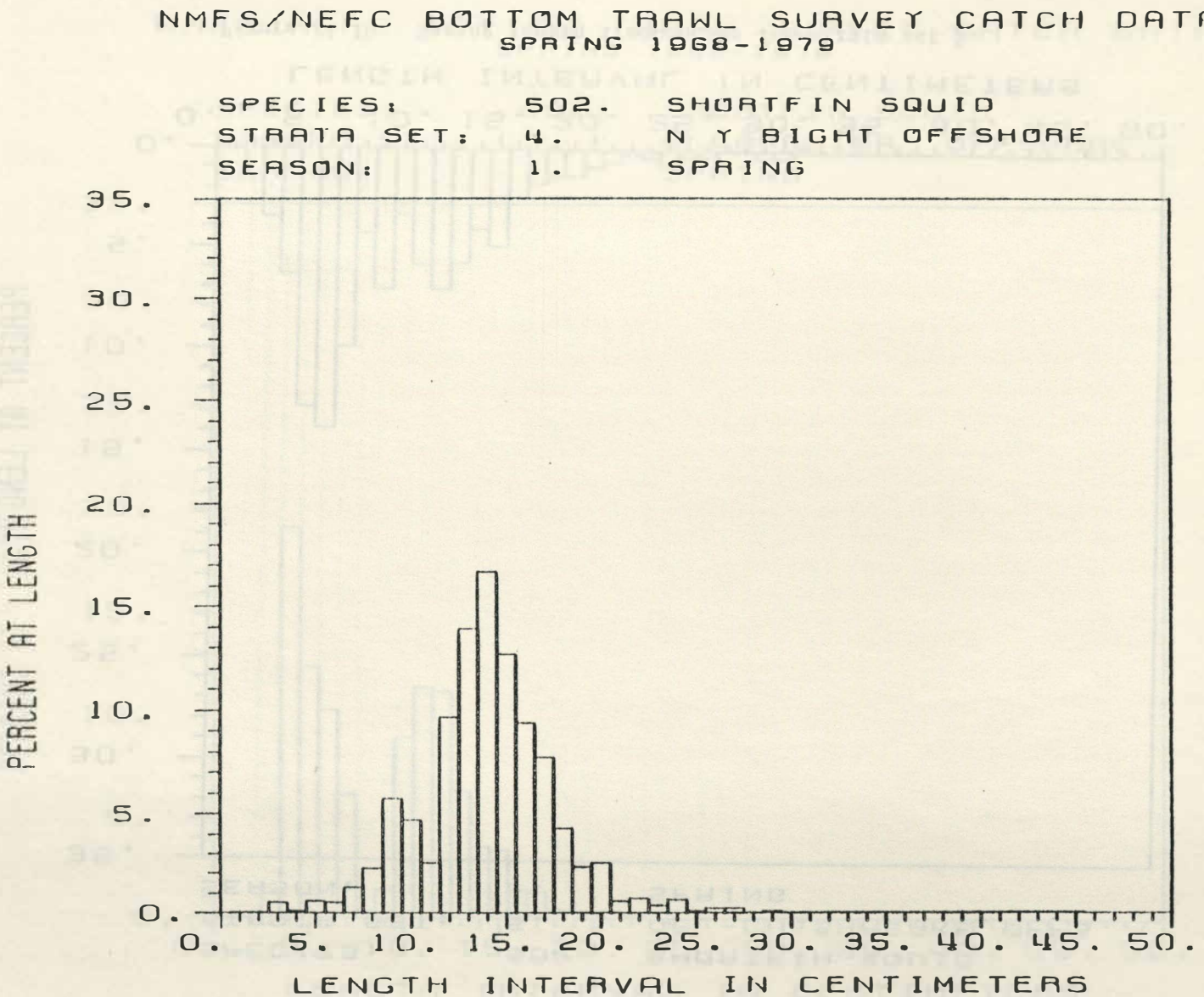

Figure 21.9. Spring length frequencies for strata set 4.

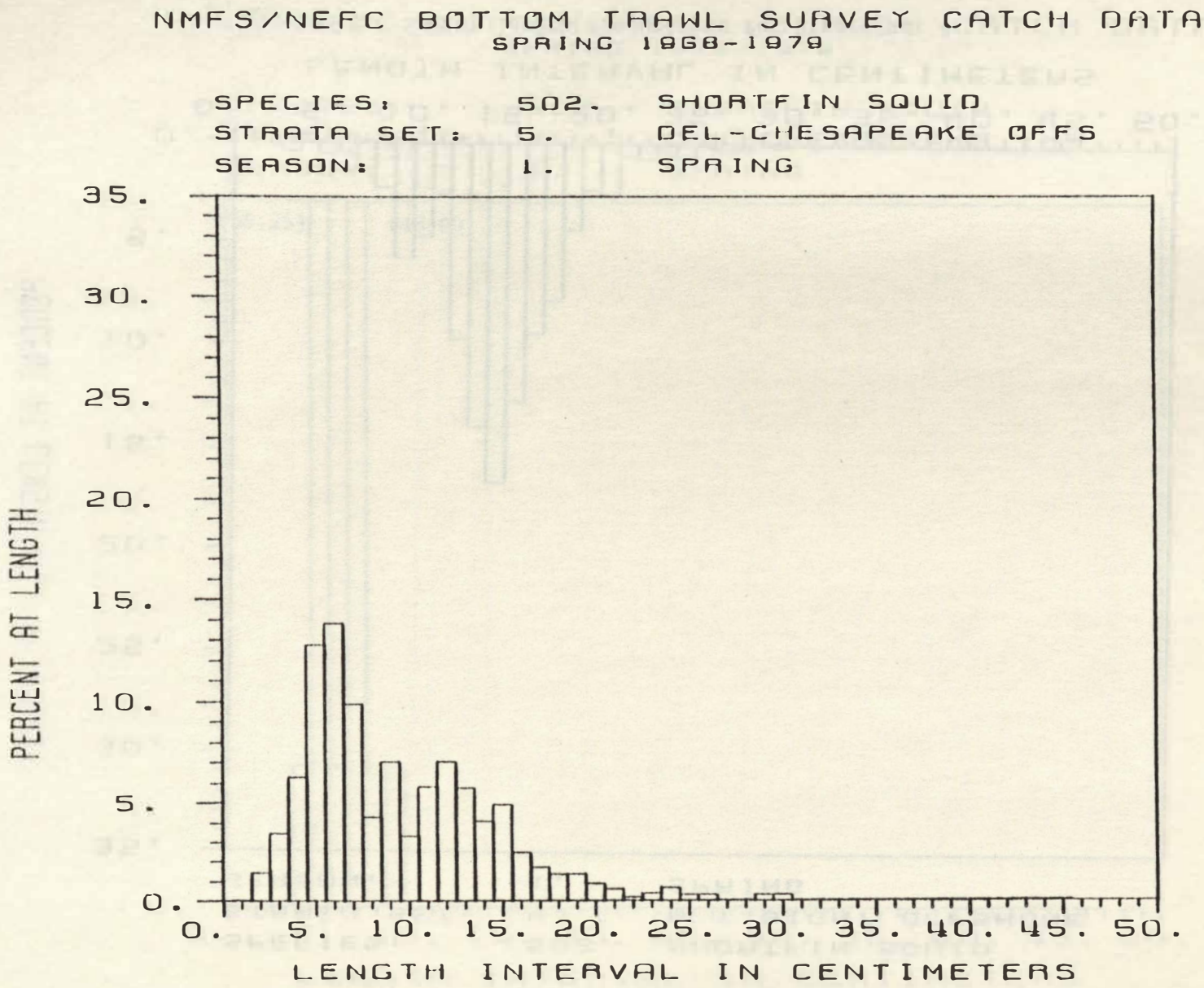

Figure 21.10. Spring length frequencies for strata set 5.

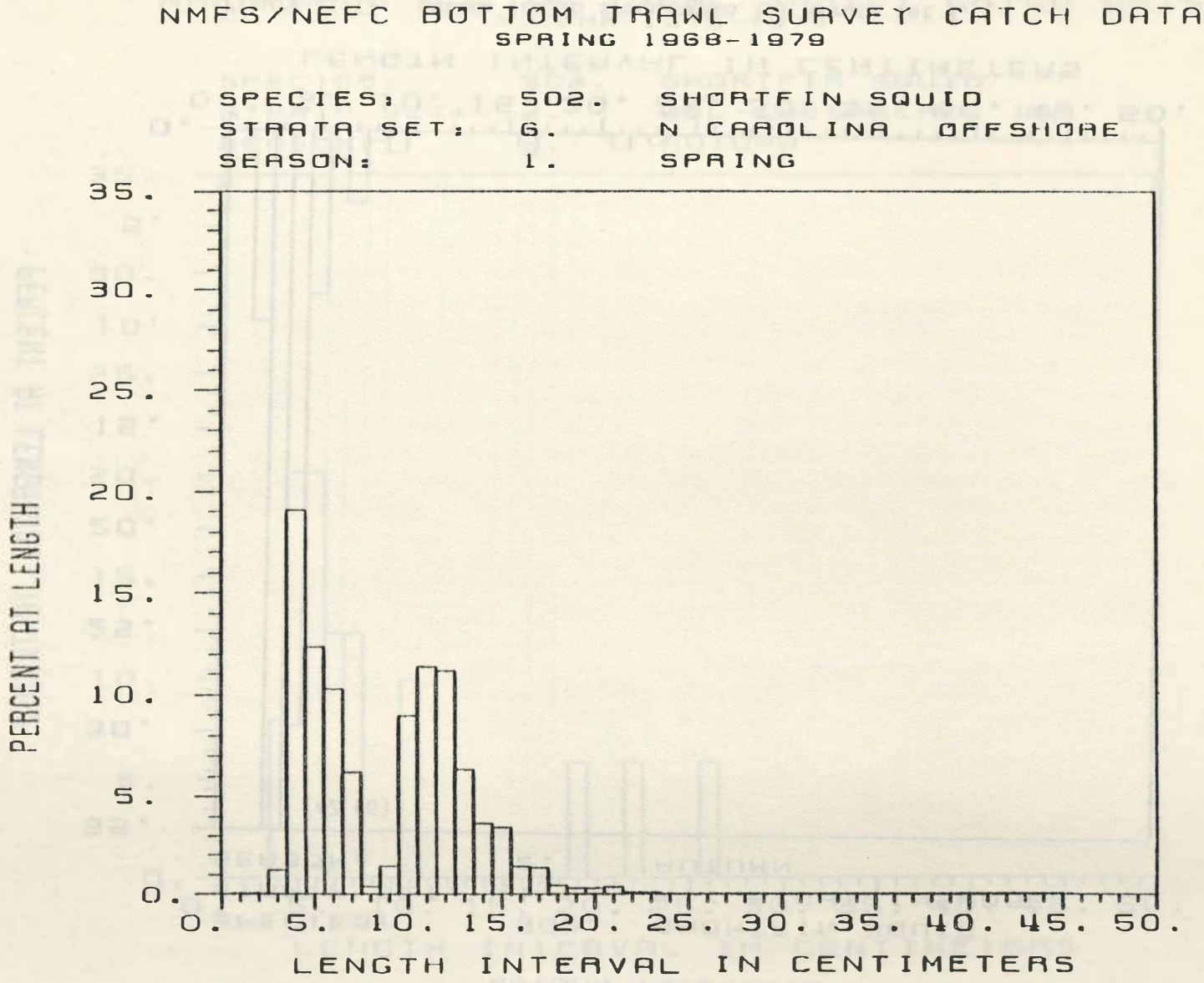

Figure 21.11. Spring length frequencies for strata set 6.

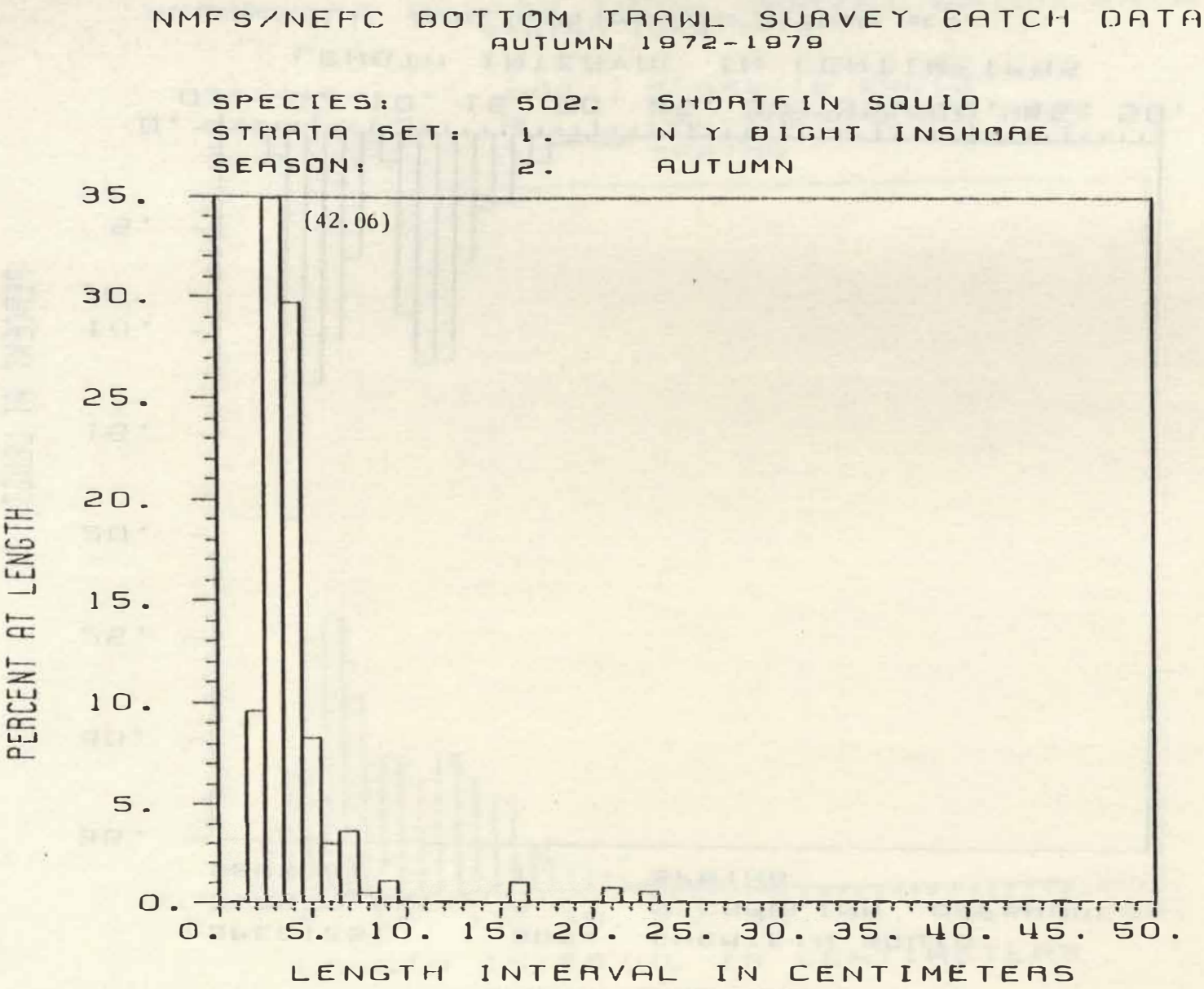

Figure 21.12. Autumn length frequencies for strata set 1.

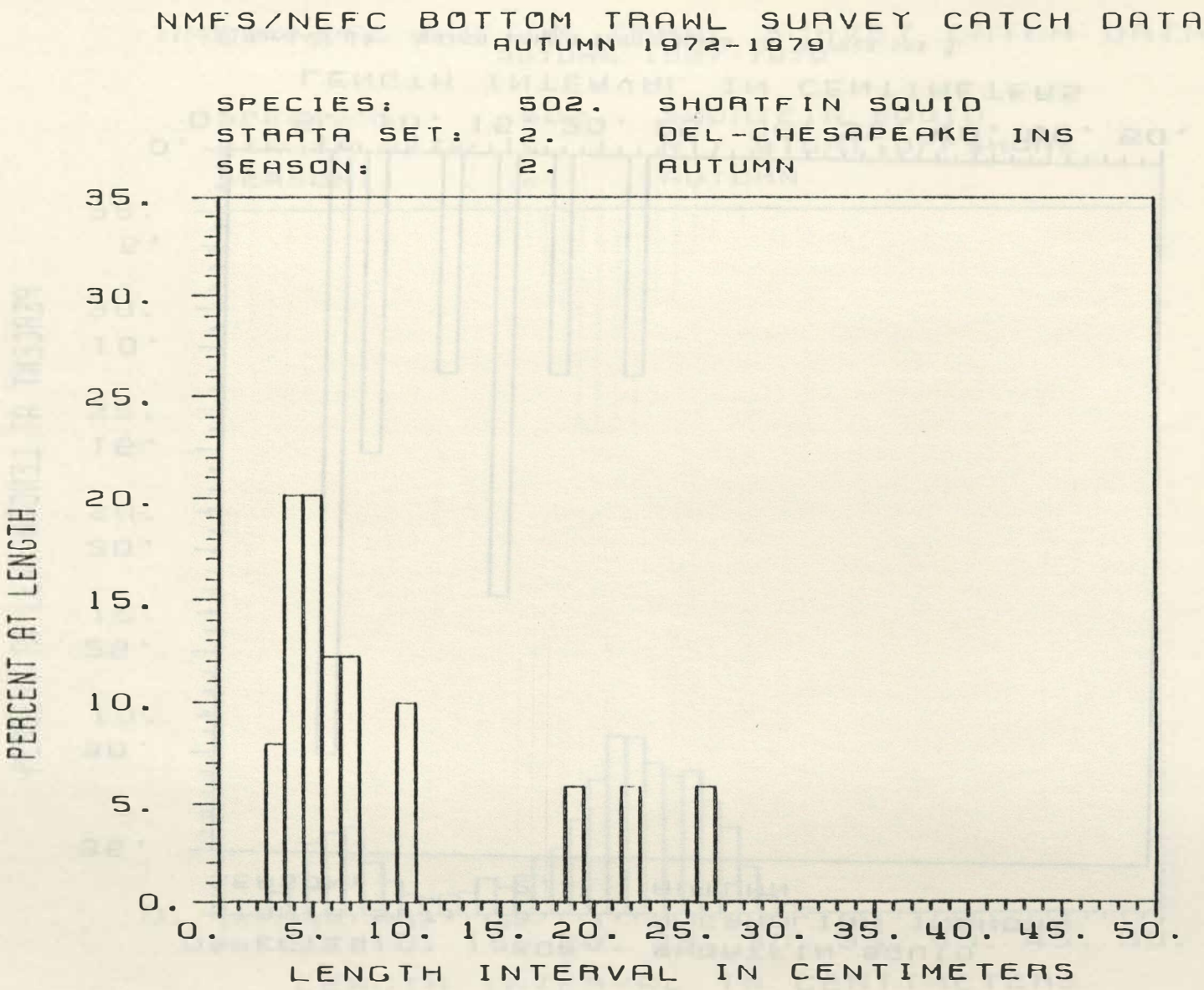

Figure 21.13. Autumn length frequencies for strata set 2.

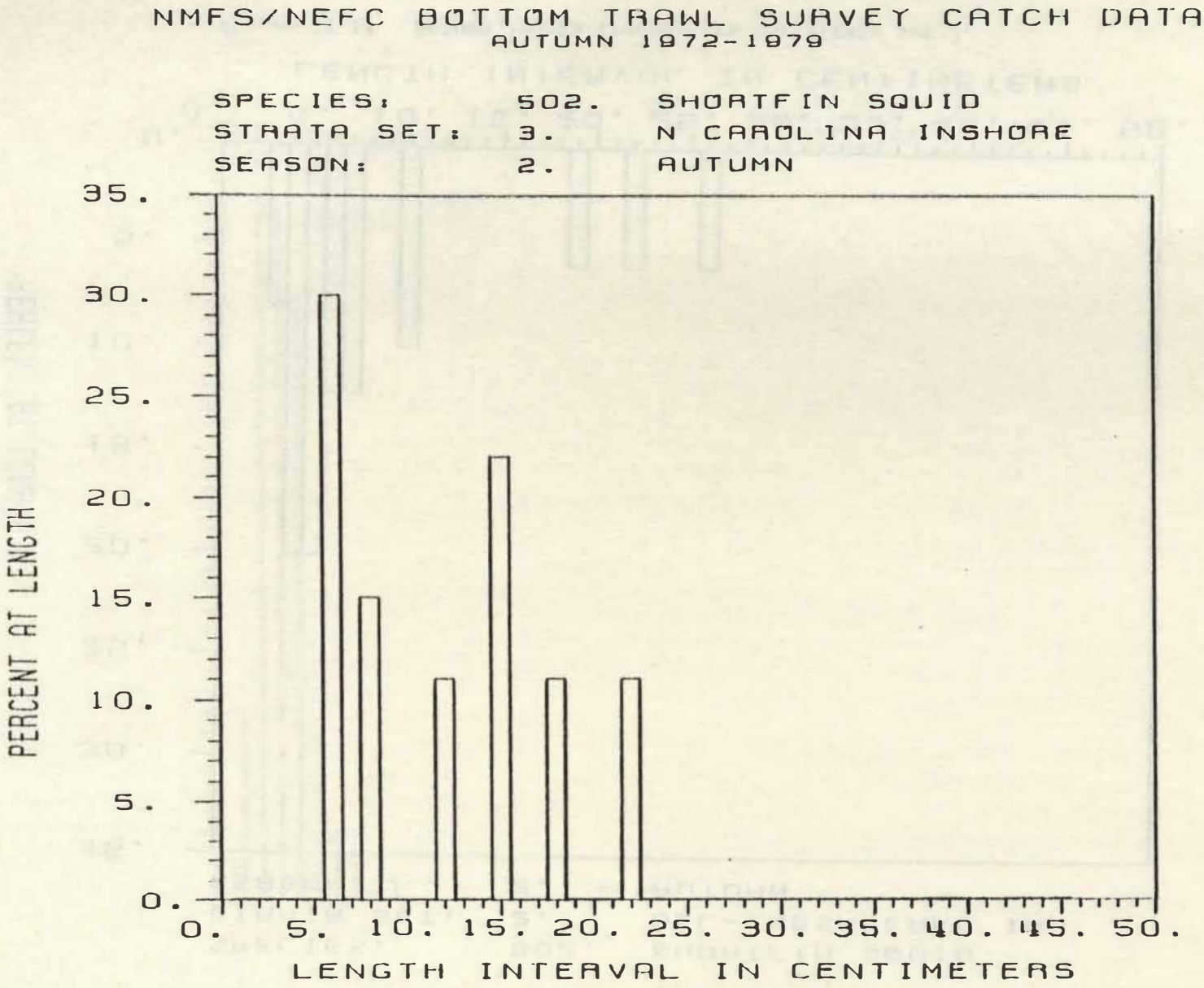

Figure 21.14. Autumn length frequencies for strata set 3.

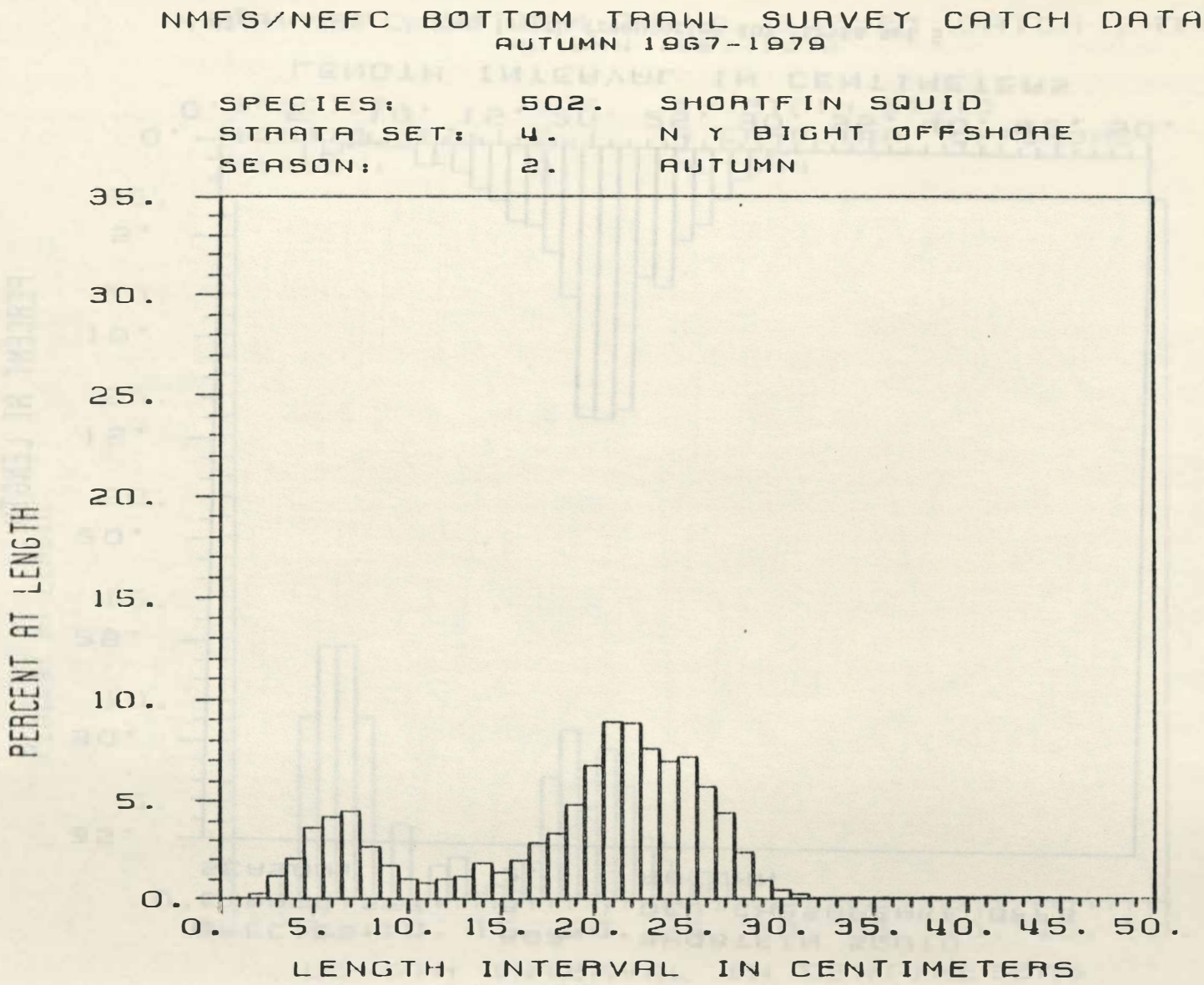

Figure 21.15. Autumn length frequencies for strata set 4.

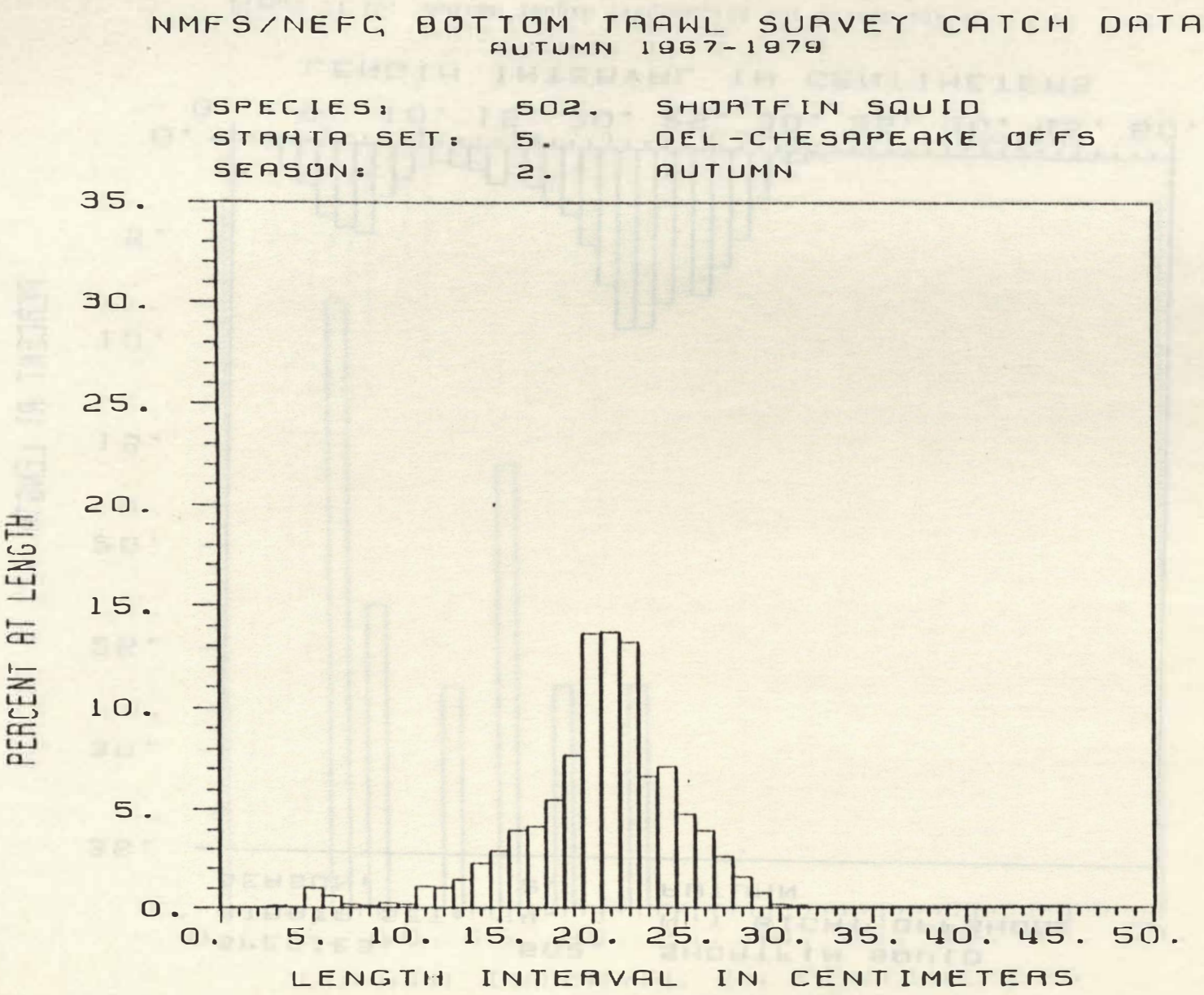

Figure 21.16. Autumn length frequencies for strata set 5.

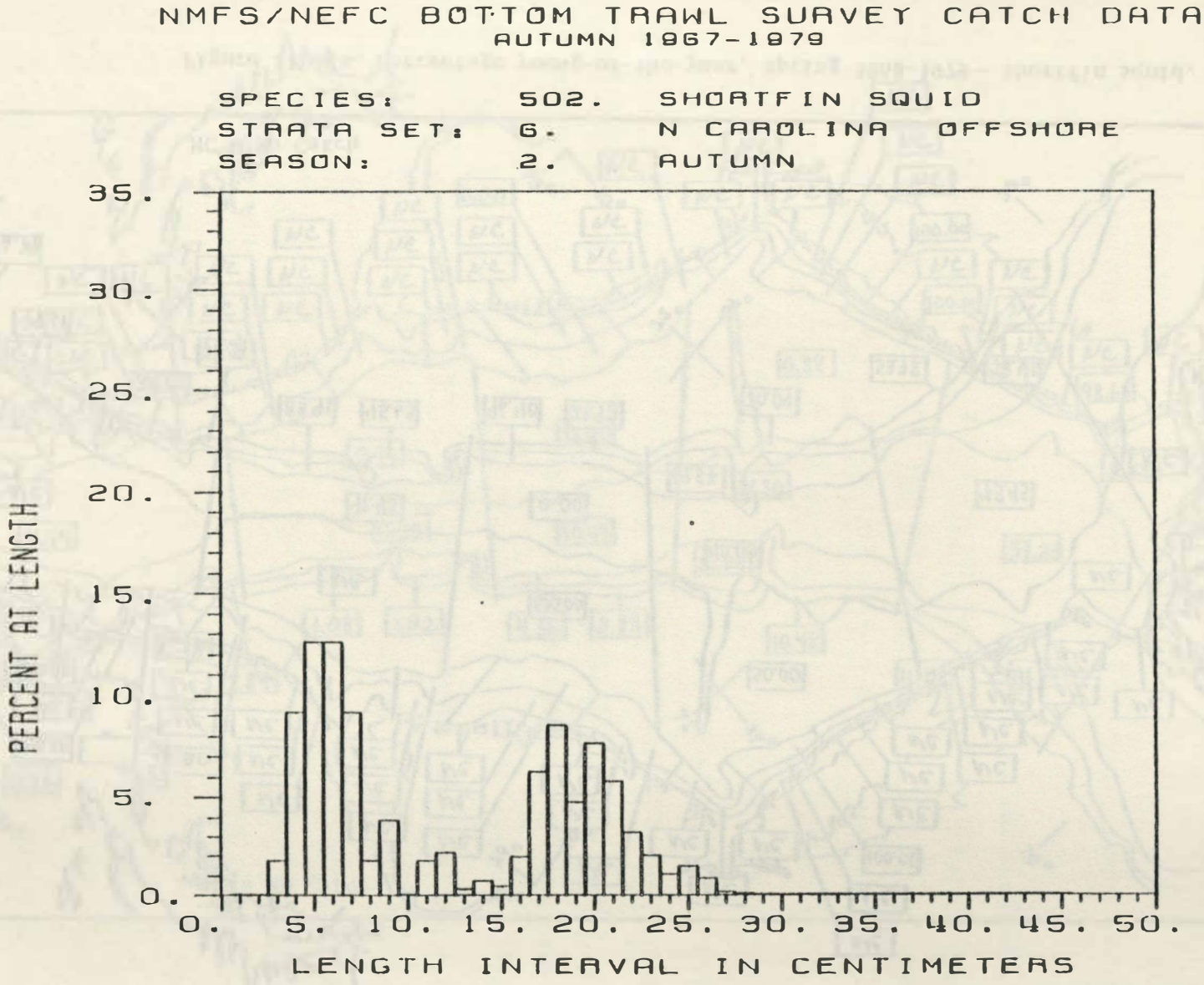

Figure 21.17. Autumn length frequencies for strata set 6.

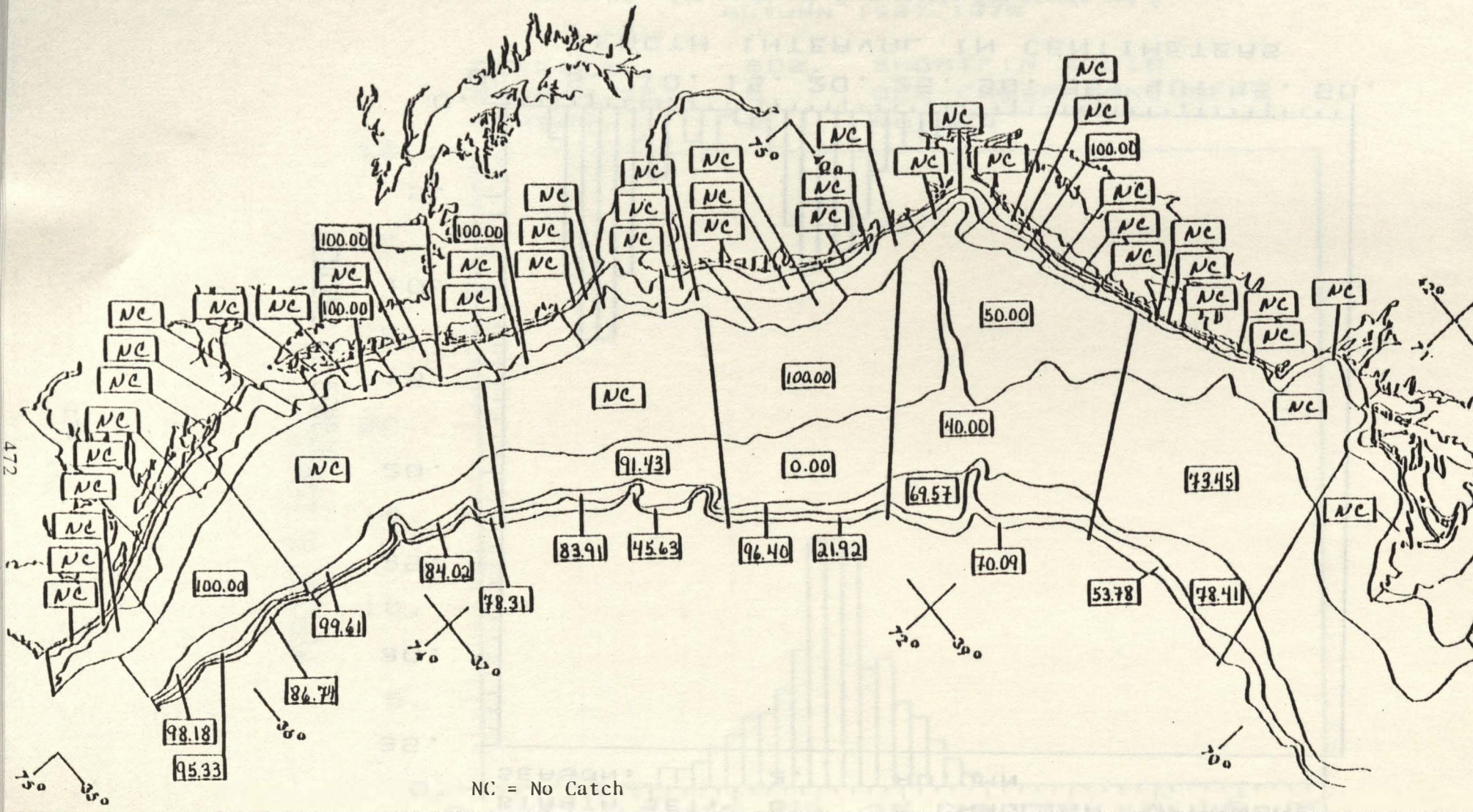

Figure 21.18. Percentage young-of-the-year, spring 1968-1979 - shortfin squid.

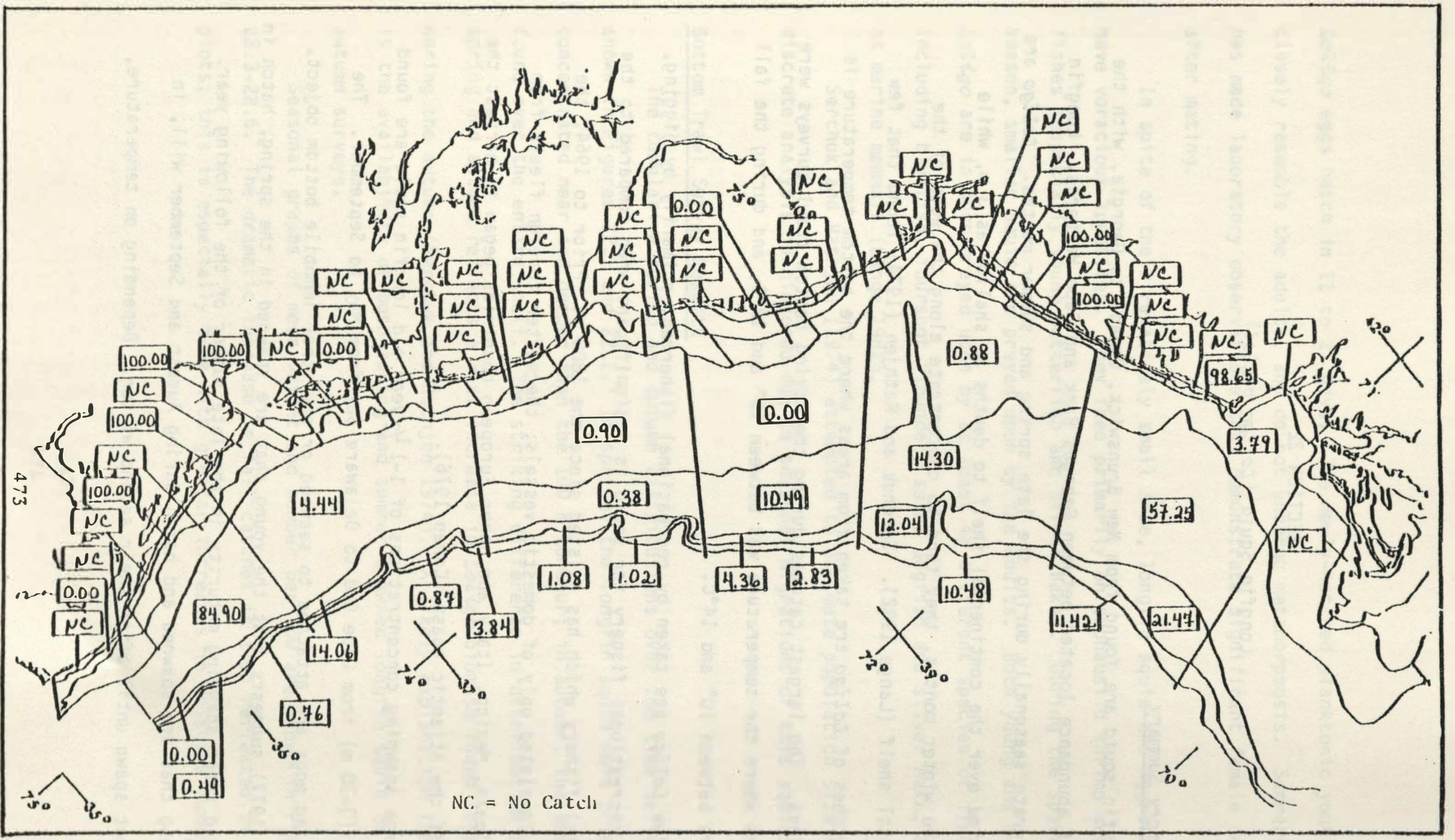

Figure 21.19. Percentage young-of-the-year, autumn 1967-1979 - shortfin squid.

SECTION 22

Longfin Squid (*Loligo pealei*)

Life History Summary

Longfin squid are found from New Brunswick, Canada to Georgia, with the center of abundance located between Georges Bank and Cape Hatteras. Longfin squid migrate seasonally during the late spring and summer months. *Loligo* are distributed over the continental shelf to depths as shallow as 3 m, while during the winter months, they tend to concentrate along the edge of the continental shelf (Lange 1982). Serchuk and Rathjen (1974) found that few large catches of *Loligo* are taken from areas where the bottom temperature is 8°C or less. The largest catches during the spring bottom trawl surveys were in waters where the temperature was between 10° and 12°C, and during the fall in waters between 10° and 14°C.

A few *Loligo* are taken by recreational fishermen, primarily by jigging, but the recreational fishery for squid is insignificant when compared to the commercial fishery which has existed since the 1800's. Prior to 1964, the fishery consisted only of domestic vessels; thereafter foreign fleets from Japan, Spain, Mexico, Italy and other European countries began to harvest the squid off the Atlantic coast (Cohen 1976).

Large spawning concentrations of 1-1 1/2 year old longfin squid are found inshore (3-30 m) from Cape Cod to Delaware Bay from May to September. The fertilized eggs are attached to seaweed or any other immobile bottom object. Mesnil (1977) suggests that the young that are spawned in the spring, hatch in June, and reach spawning maturity in the late summer of the following year. The young that are spawned and hatch during August and September will, in turn, not spawn until after their second winter. Depending on temperature,

Loligo eggs hatch in 11 to 27 days. The newly-hatched planktonic young closely resemble the adults, and do not undergo metamorphosis. Summers (1971) has made laboratory observations that demonstrate significant female mortality after mating.

In spite of their relatively small size, longfin squid are aggressive and have voracious appetites. They feed primarily on euphausiid shrimp and small fishes (especially young butterfish and silver hake). During the spawning season, smaller squid are preyed upon by the adults. Both young and adult *Loligo* are in turn preyed upon by at least 48 different species of fish, including bluefish, fourspot flounder, spiny dogfish and silver hake, as well as marine mammals (Lange 1982).

Serchuk and Rathjen (1974) attempted to estimate population size but discrete analysis is hindered due to seasonal migrations of this squid.

Bottom Trawl Survey Results

The cumulative spring and autumn distributions over the time series are shown in Figures 22.1 and 22.2. In spring, the longfin squid were primarily concentrated near and deeper than the 100 m contour; in autumn, the squid were found over the entire shelf. The striking difference in distribution between spring and autumn reflects a real increase in *Loligo* biomass found inshore during the autumn (Serchuk and Rathjen 1974). A likely explanation for this is the availability of both spring and summer spawned longfin squid to the autumn surveys.

Seasonal graphs of mean weight and number per tow are shown in Figures 22.3-22.6. The dramatic increase in fall catches is also reflected in these plots; this is especially true with greater increases in relative numbers

(Figures 22.5-22.6). This supports the previously offered explanation for larger fall catches.

Length frequencies for six strata sets, arranged by season, are shown in Figures 22.7-22.18. During the spring in the northern areas, larger adult squid were caught inshore as they moved there to spawn (Figures 22.7-22.8). Younger and smaller squid more frequently were caught offshore (Figures 22.10-22.12). In the autumn, small young squid appeared in all areas especially inshore (Figures 22.13-22.15).

Figures 22.19 and 22.20 show the percentage occurrence by stratum of young-of-the-year (YOY); cutoff sizes were 15 and 8 cm for spring and autumn series, respectively. YOY occur in all strata during both seasons. In spring they seemed to be more common offshore, and in autumn they occurred with greater frequency inshore.

The occurrence of all sizes of squid in most of the shelf areas during most of the year, combined with their importance as prey to many species of fish, indicates their great ecological importance to the Middle Atlantic Bight area.

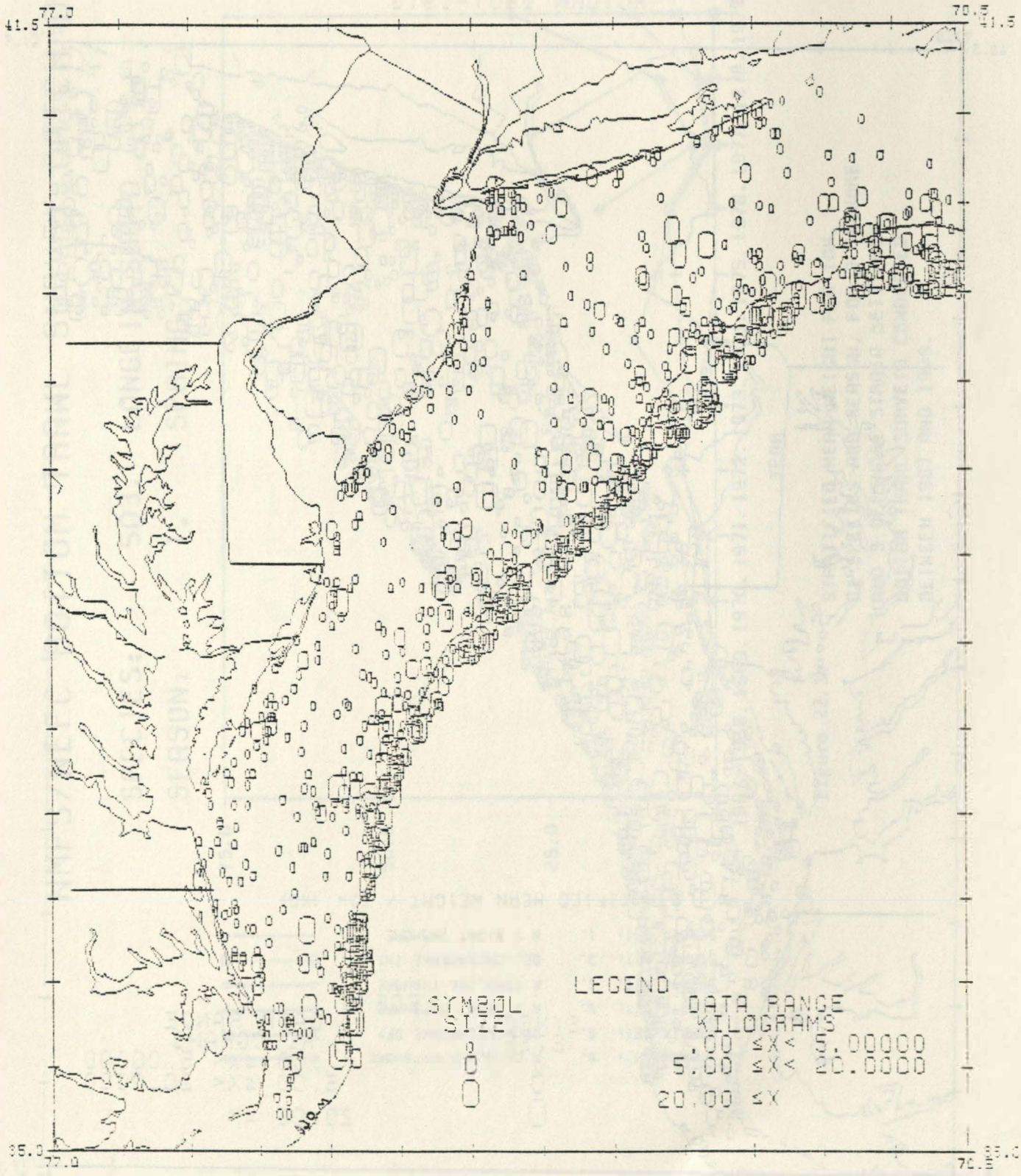

Figure 22.1. Spring distribution, 1968-1979.

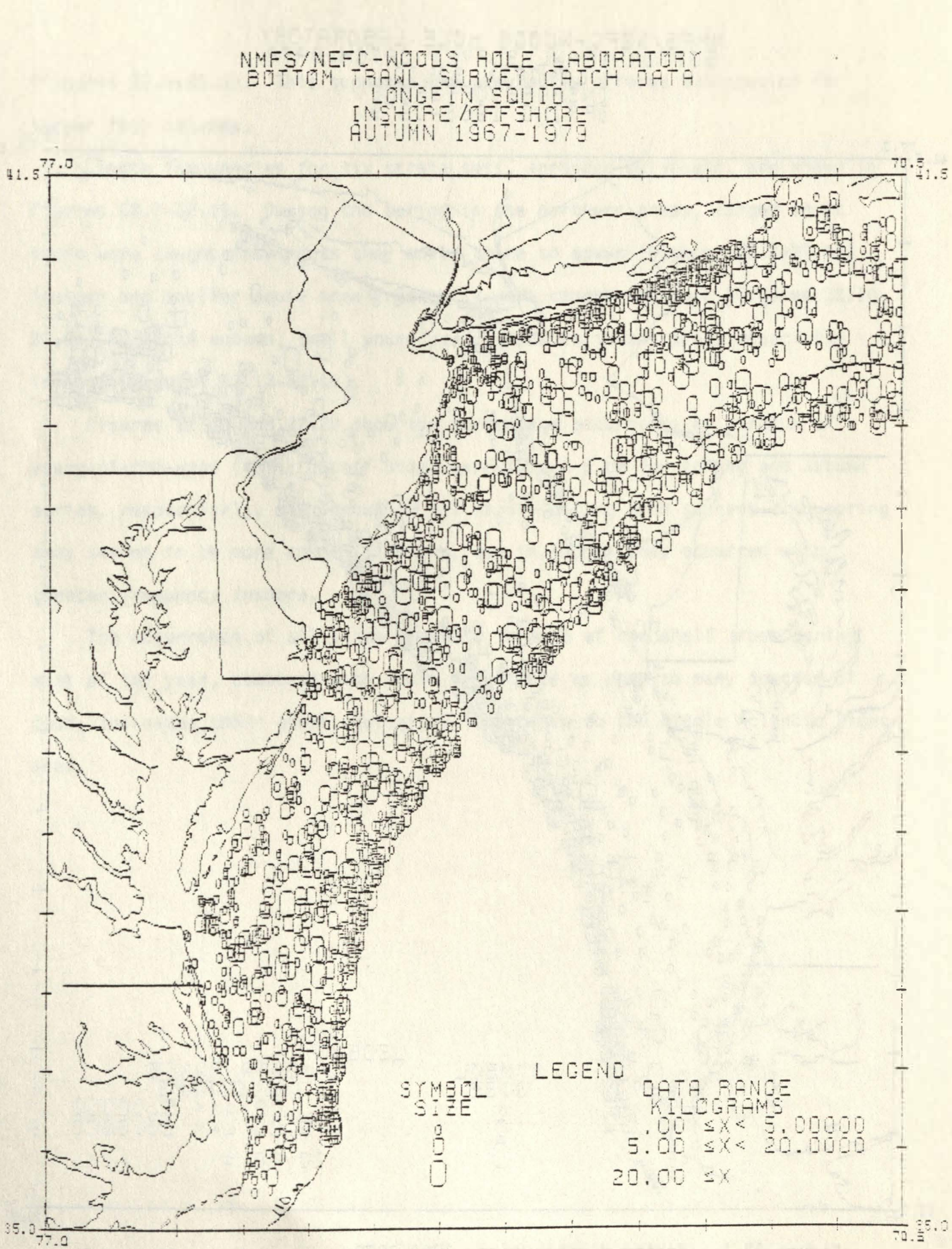

Figure 22.2. Autumn distribution, 1967-1979.

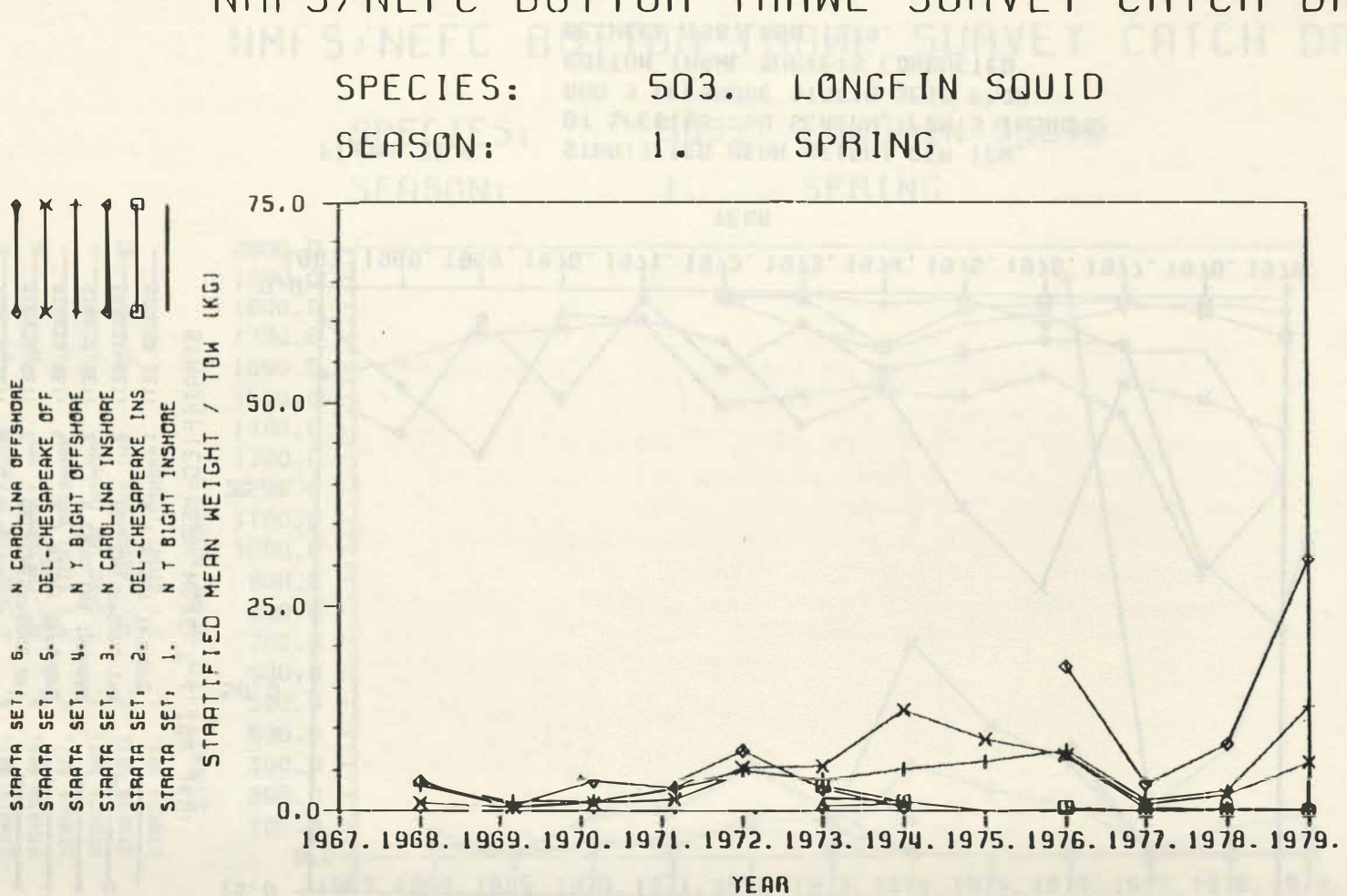

Figure 22.3. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

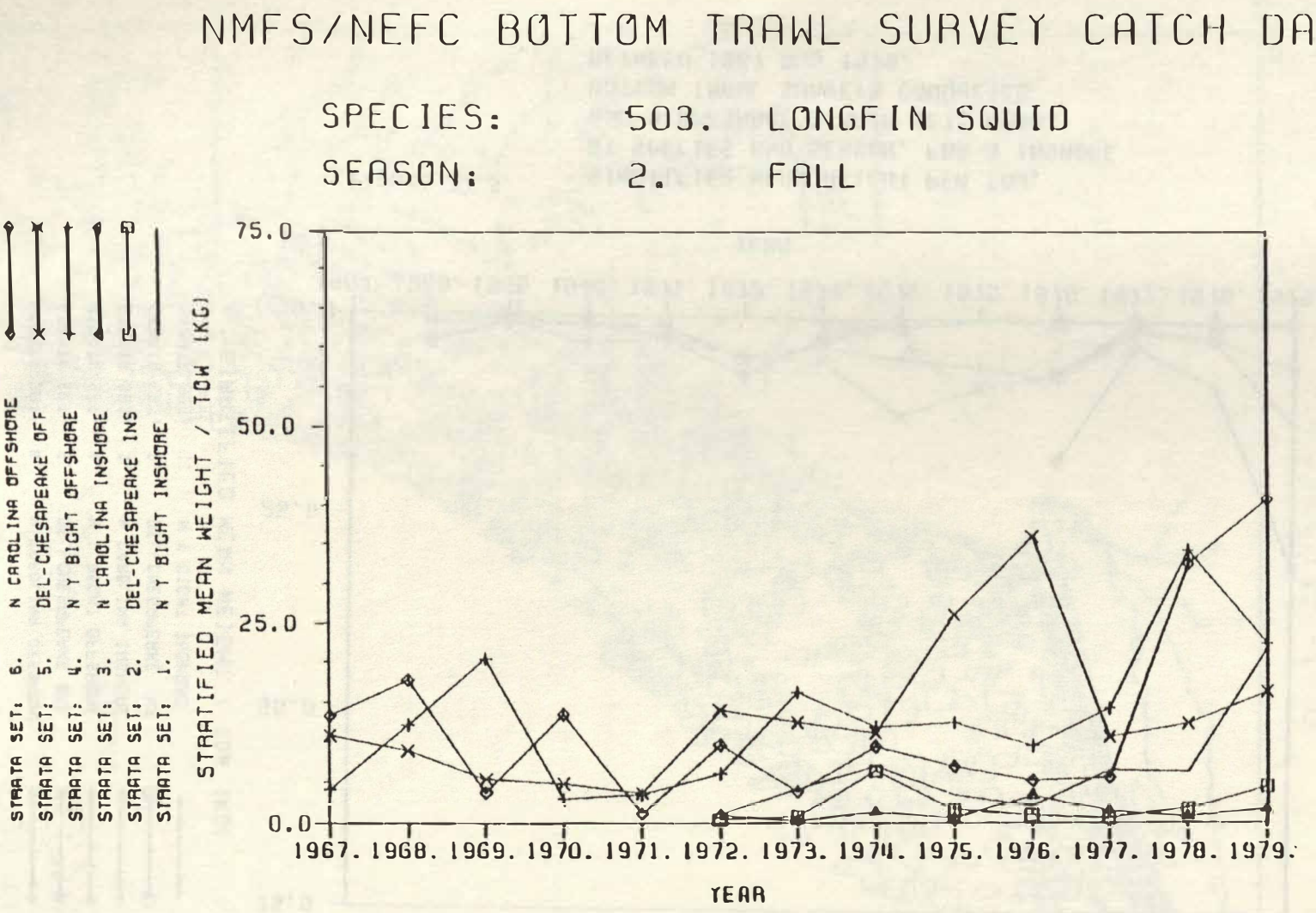

Figure 22.4. STRATIFIED MEAN WEIGHT PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

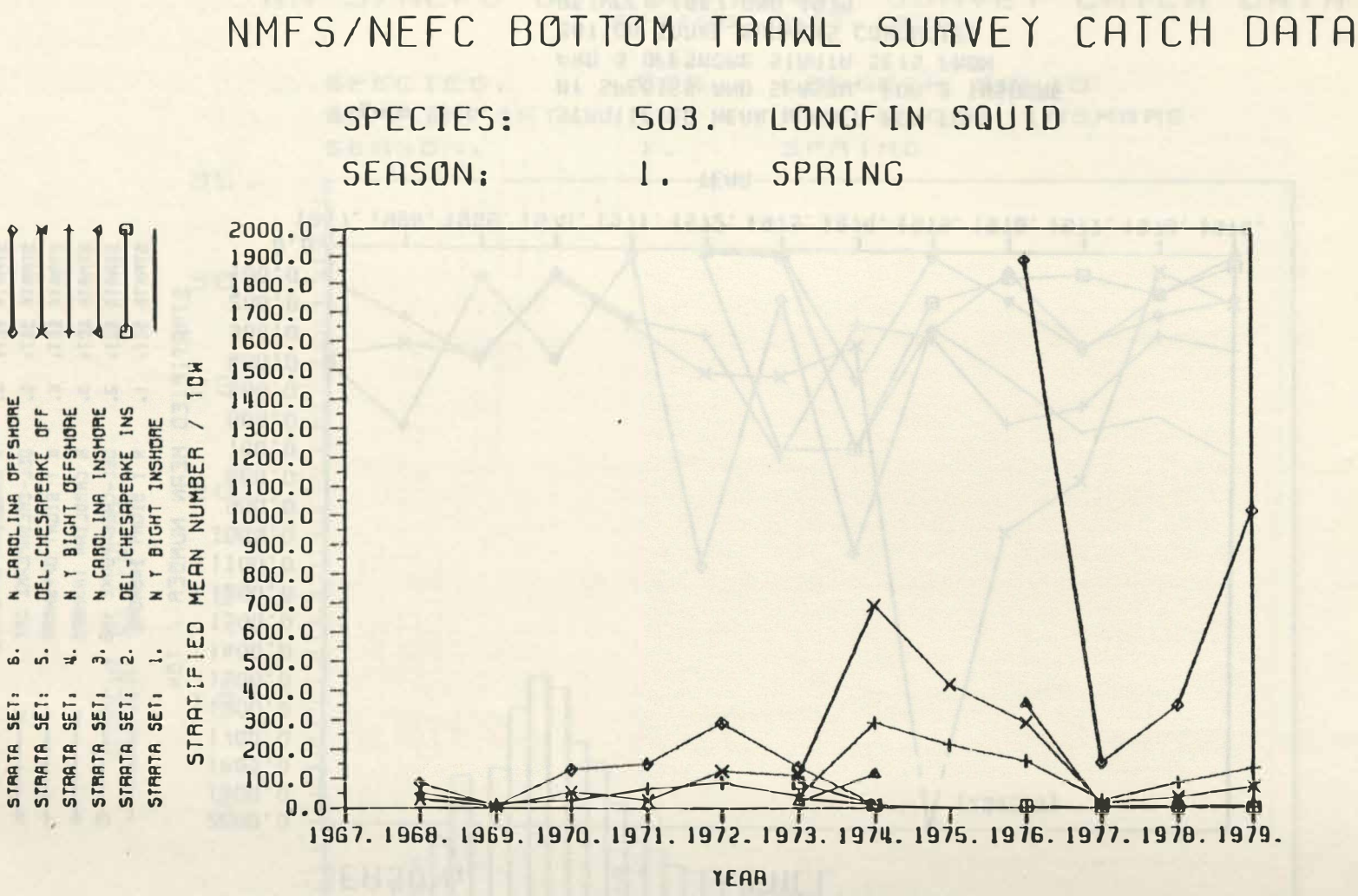

Figure 22.5. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

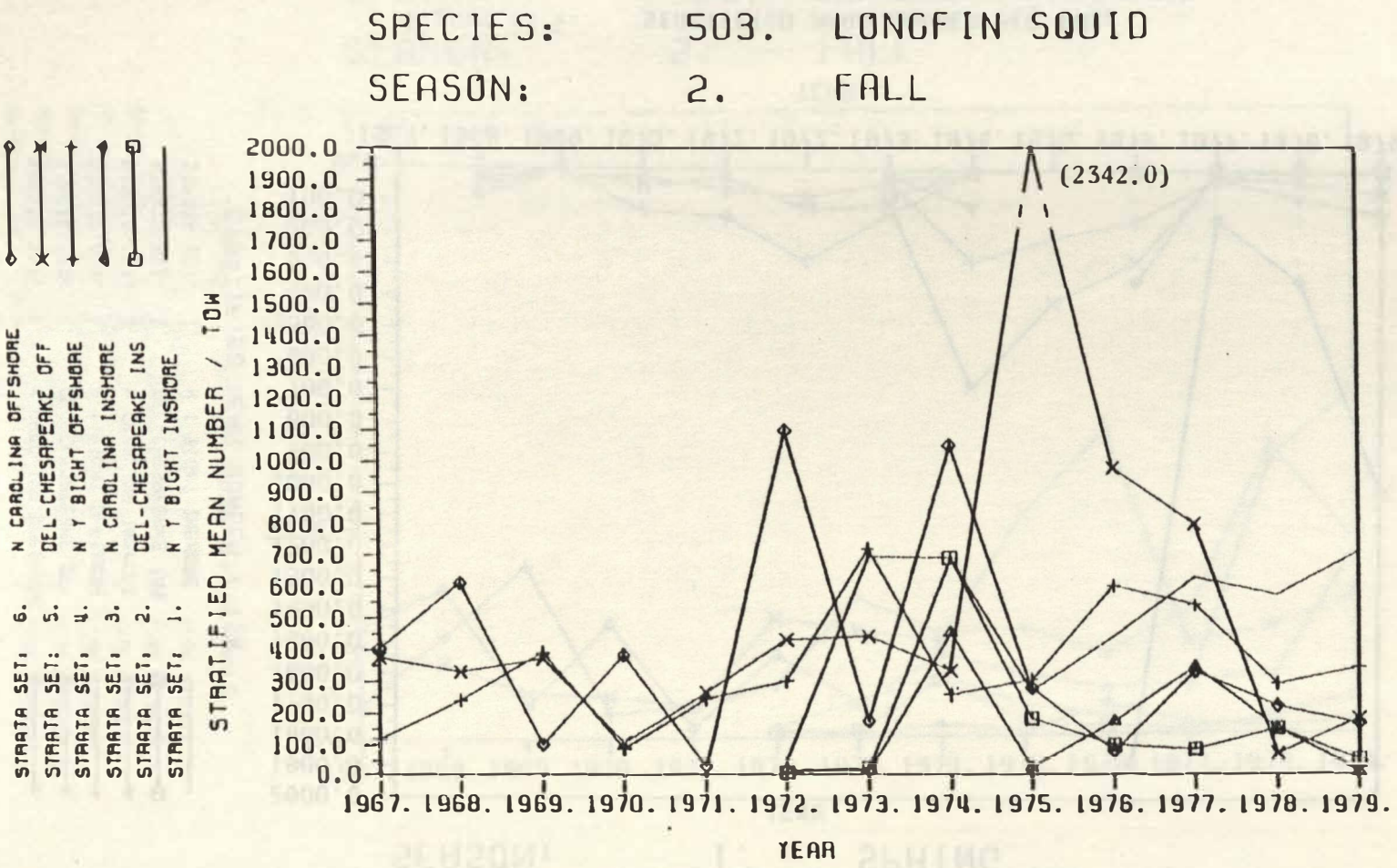

Figure 22.6. STRATIFIED MEAN NUMBER PER TOW, BY SPECIES AND SEASON, FOR 3 INSHORE AND 3 OFFSHORE STRATA SETS FROM BOTTOM TRAWL SURVEYS CONDUCTED BETWEEN 1967 AND 1979.

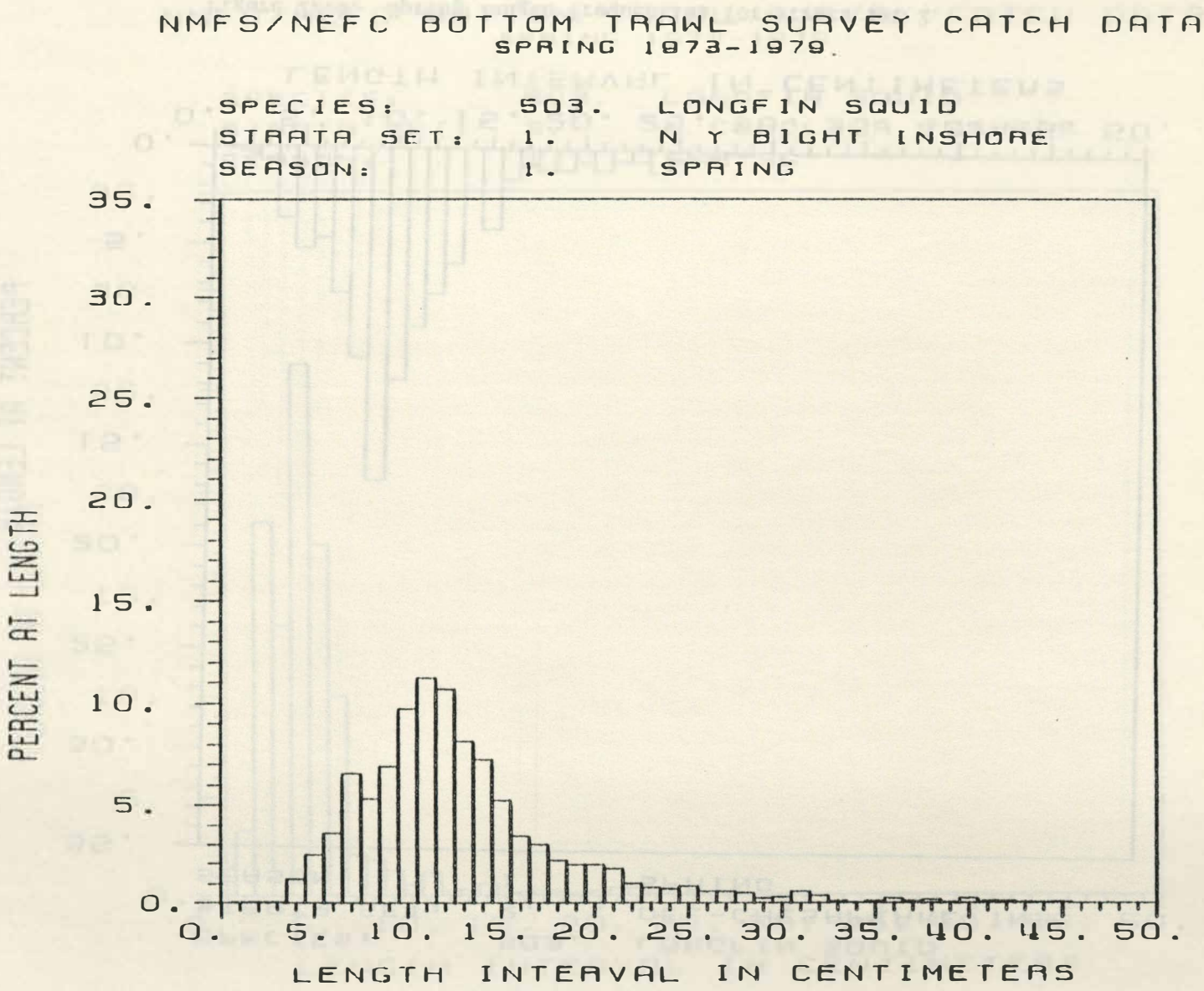

Figure 22.7. Spring length frequencies for strata set 1.

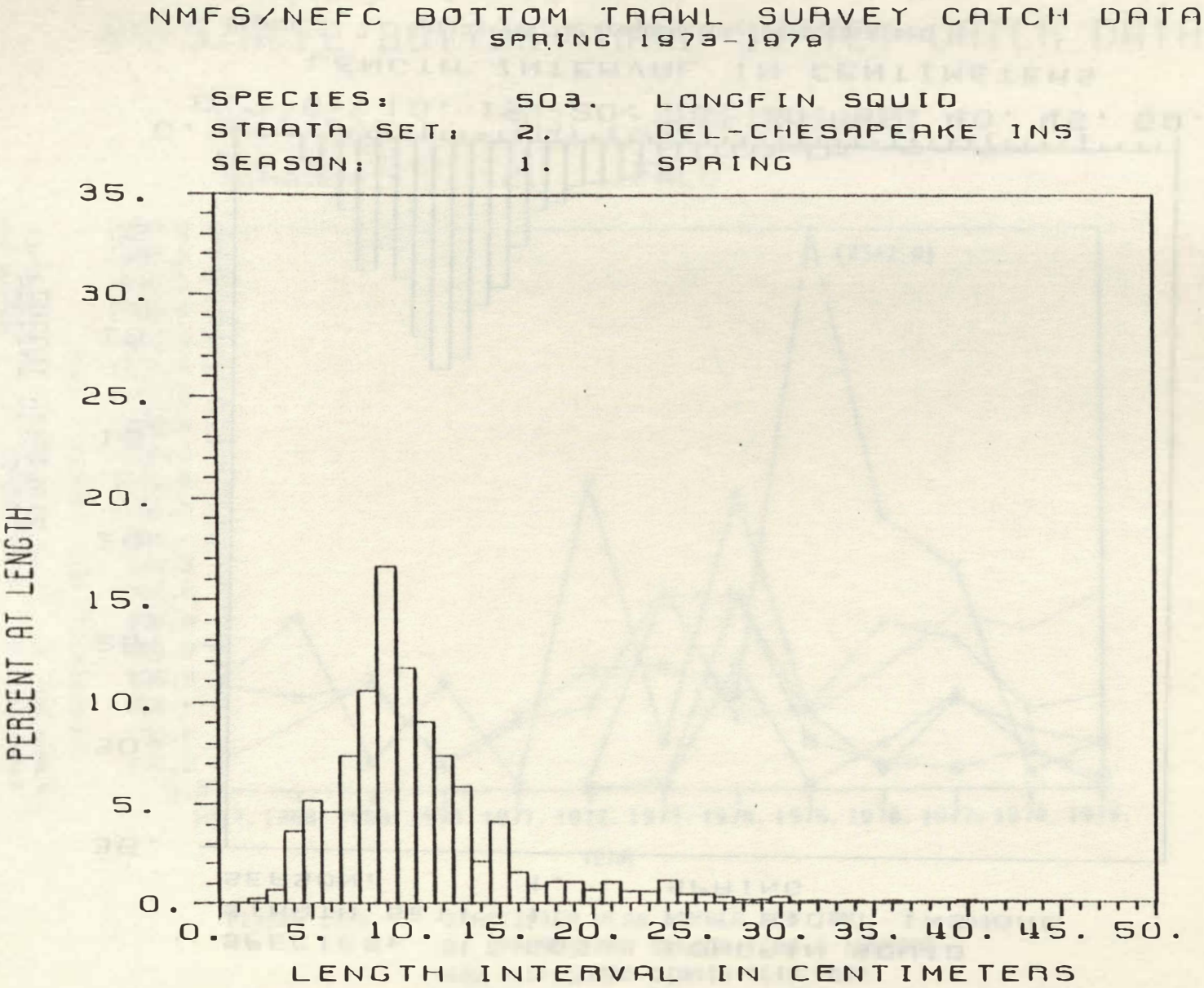

Figure 22.8. Spring length frequencies for strata set 2.

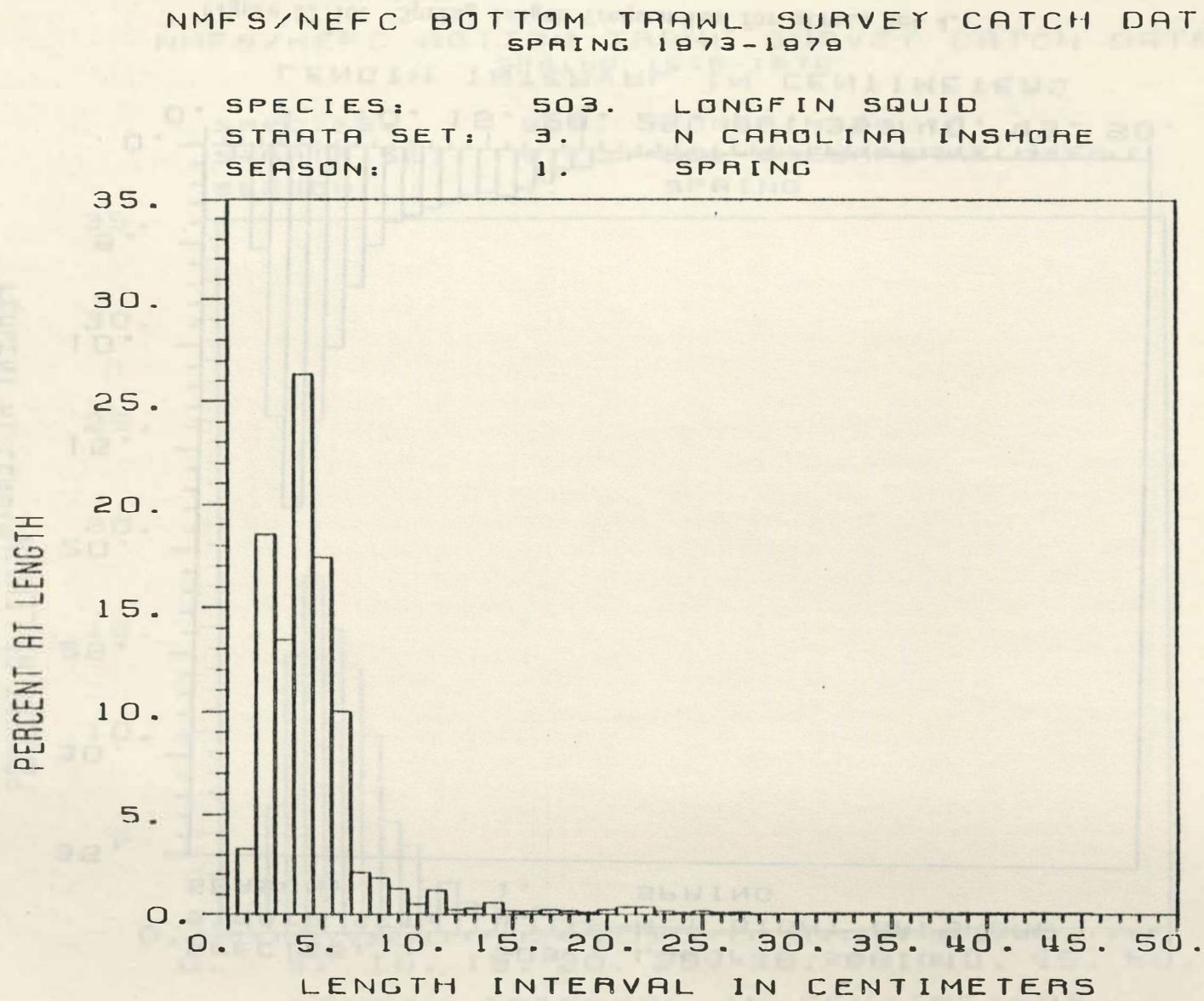

Figure 22.9. Spring length frequencies for strata set 3.

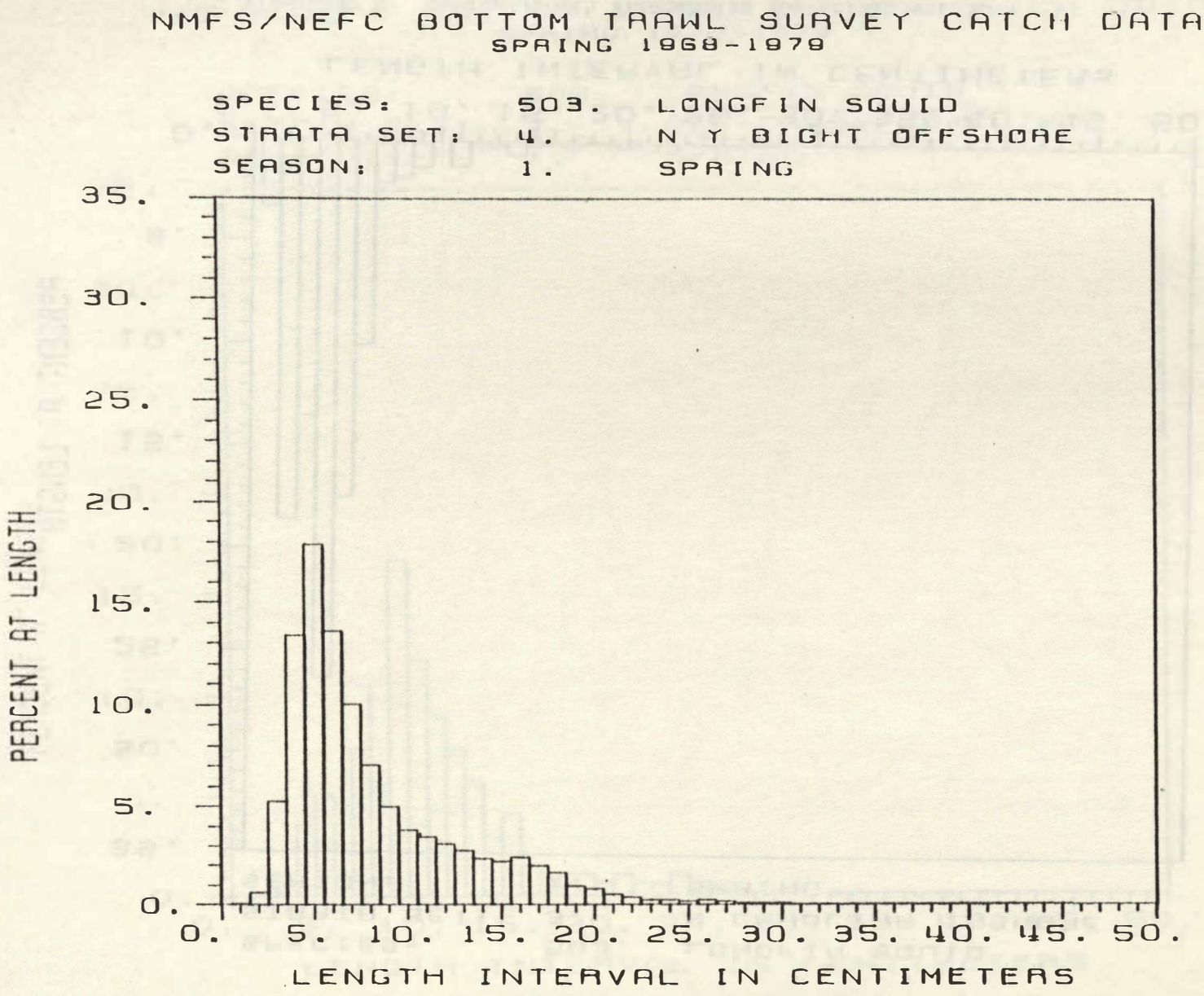

Figure 22.10. Spring length frequencies for strata set 4.

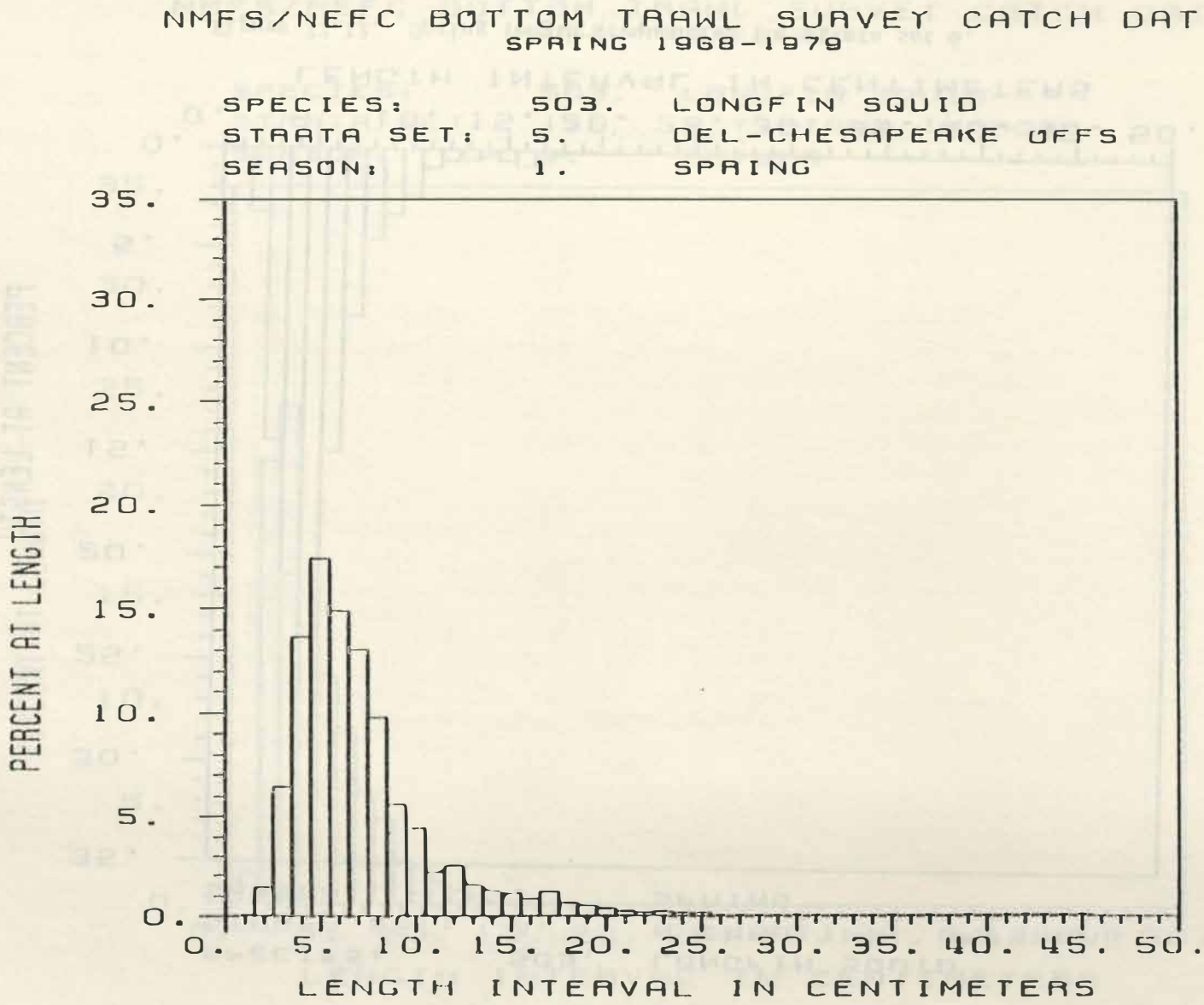

Figure 22.11. Spring length frequencies for strata set 5.

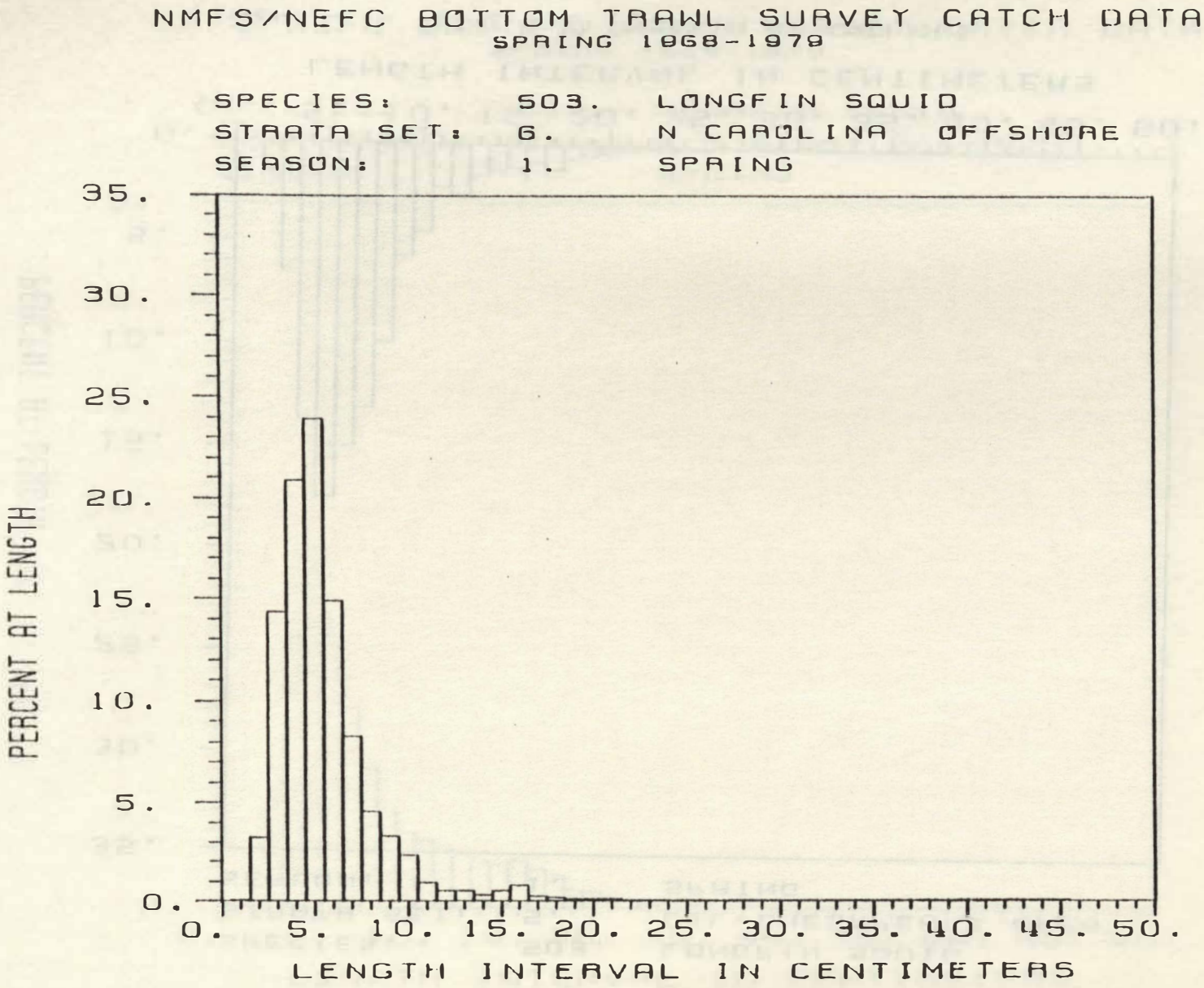

Figure 22.12. Spring length frequencies for strata set 6.

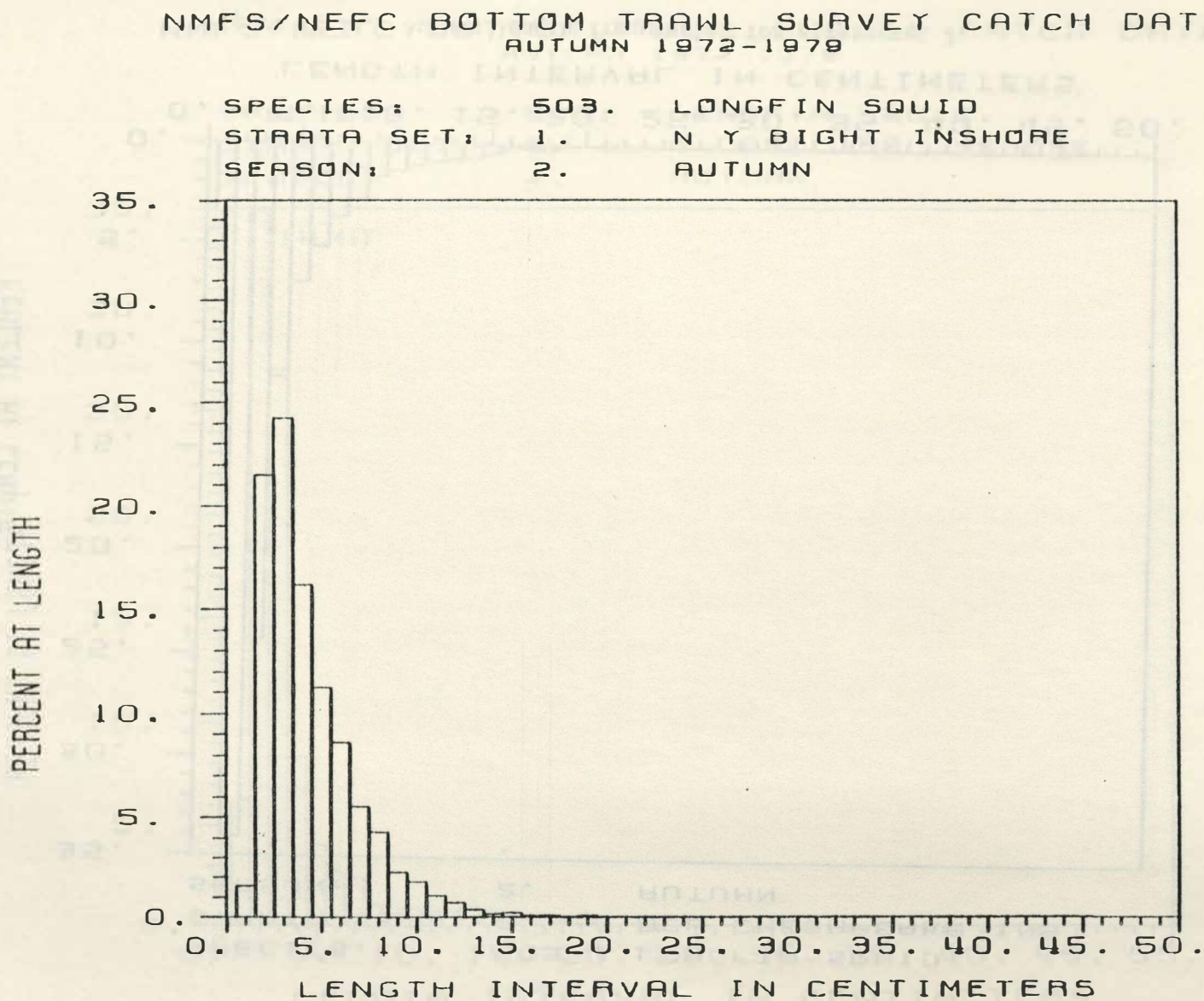

Figure 22.13. Autumn length frequencies for strata set 1.

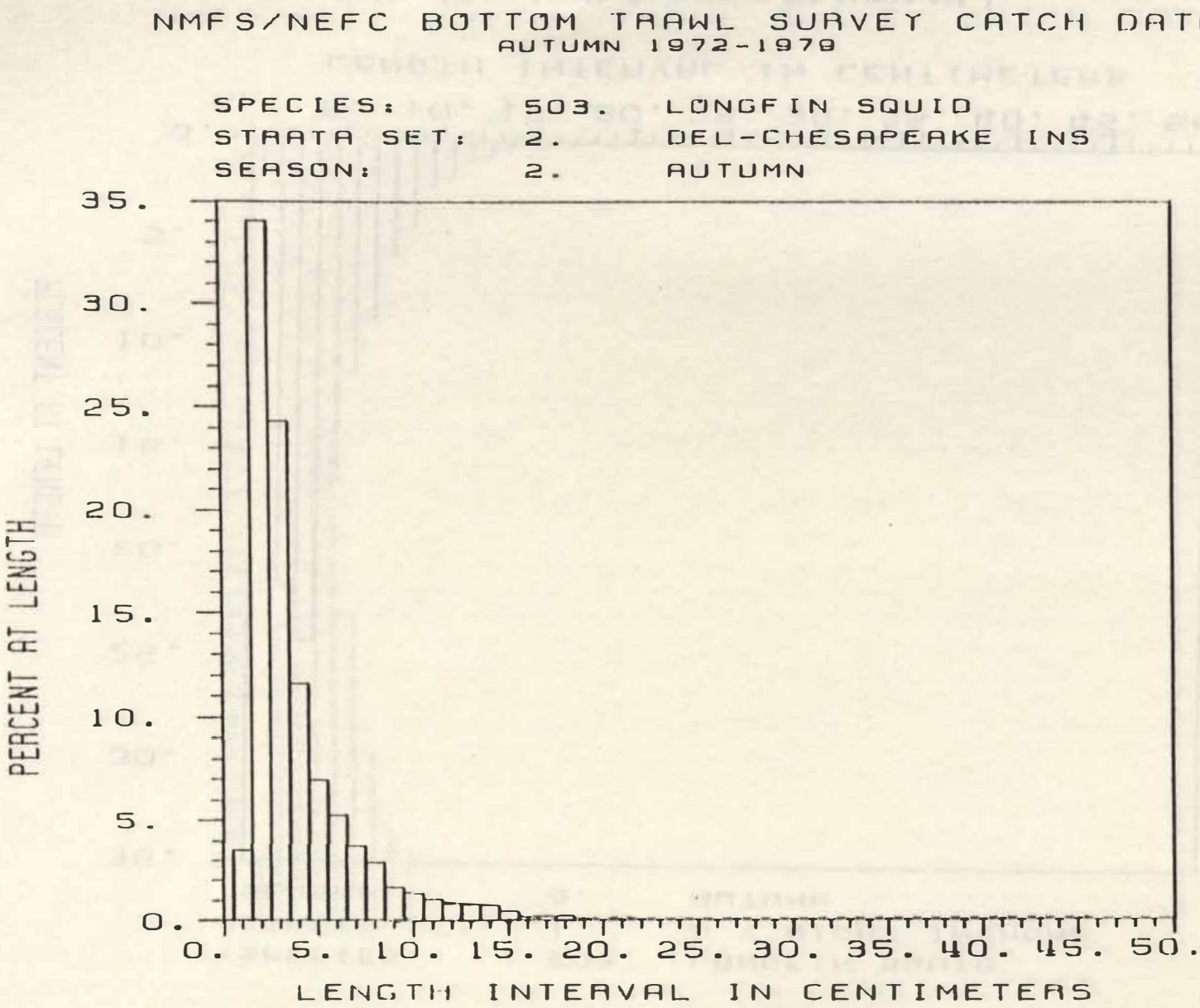

Figure 22.14. Autumn length frequencies for strata set 2.

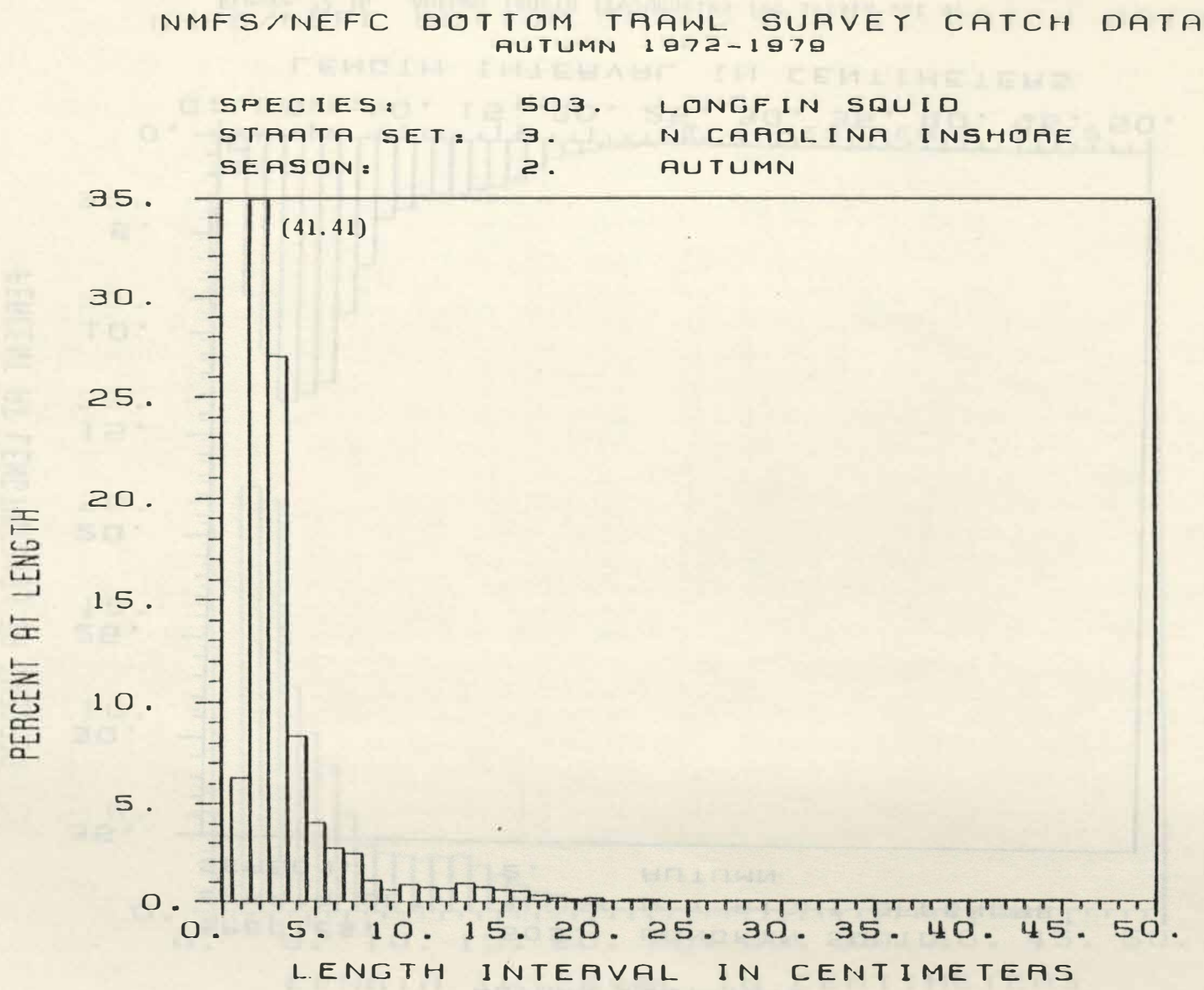

Figure 22.15. Autumn length frequencies for strata set 3.

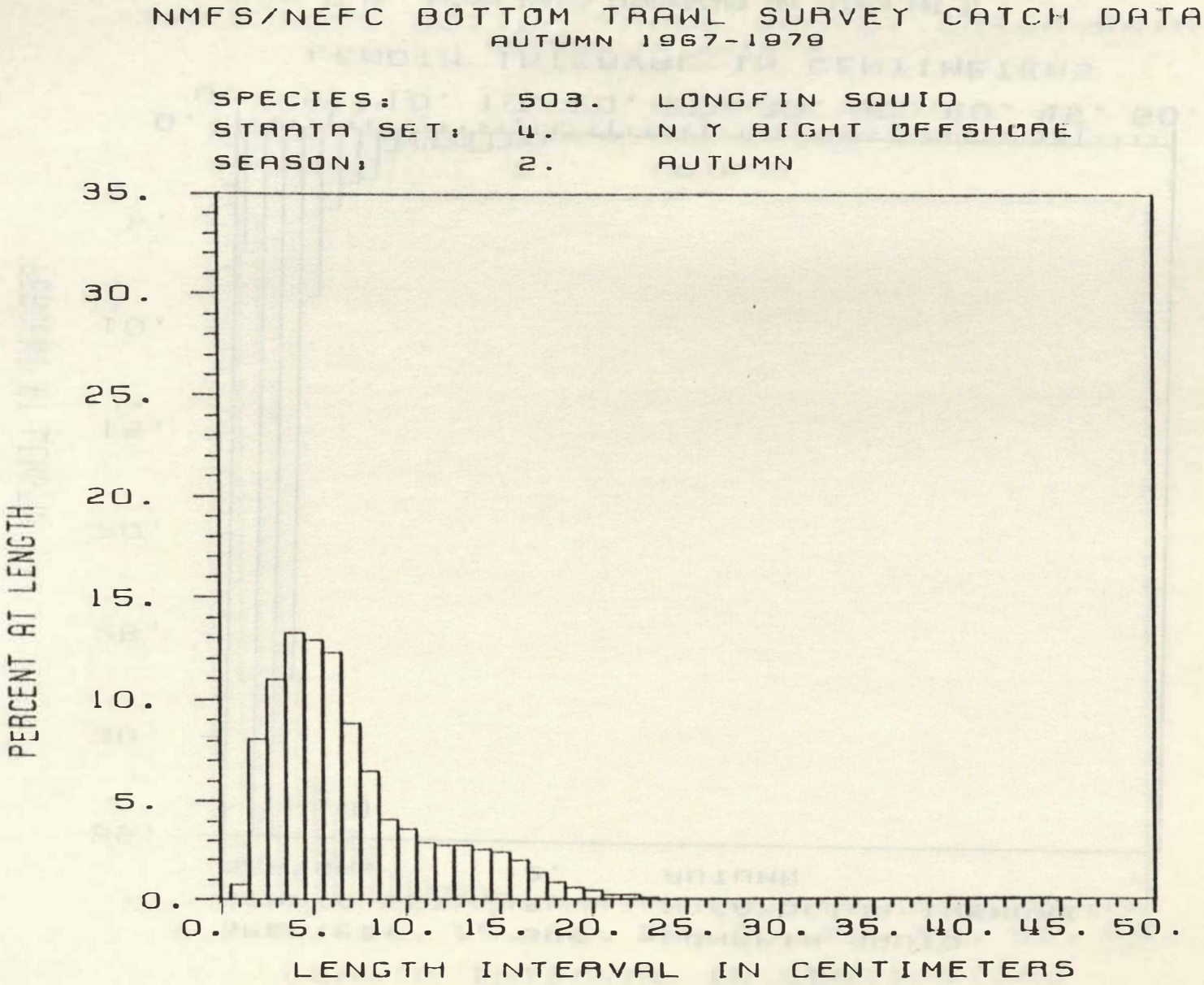

Figure 22.16. Autumn length frequencies for strata set 4.

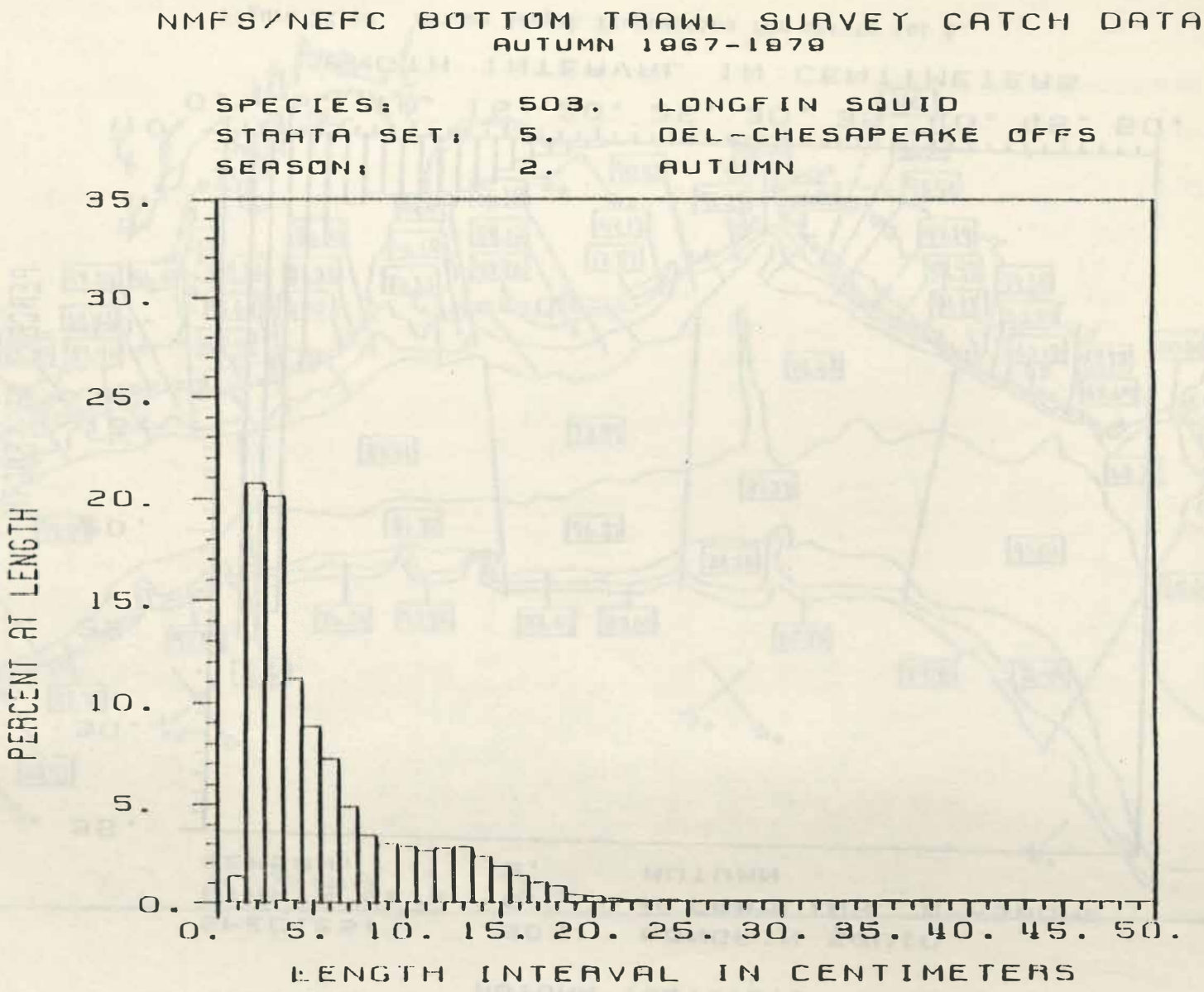

Figure 22.17. Autumn length frequencies for strata set 5.

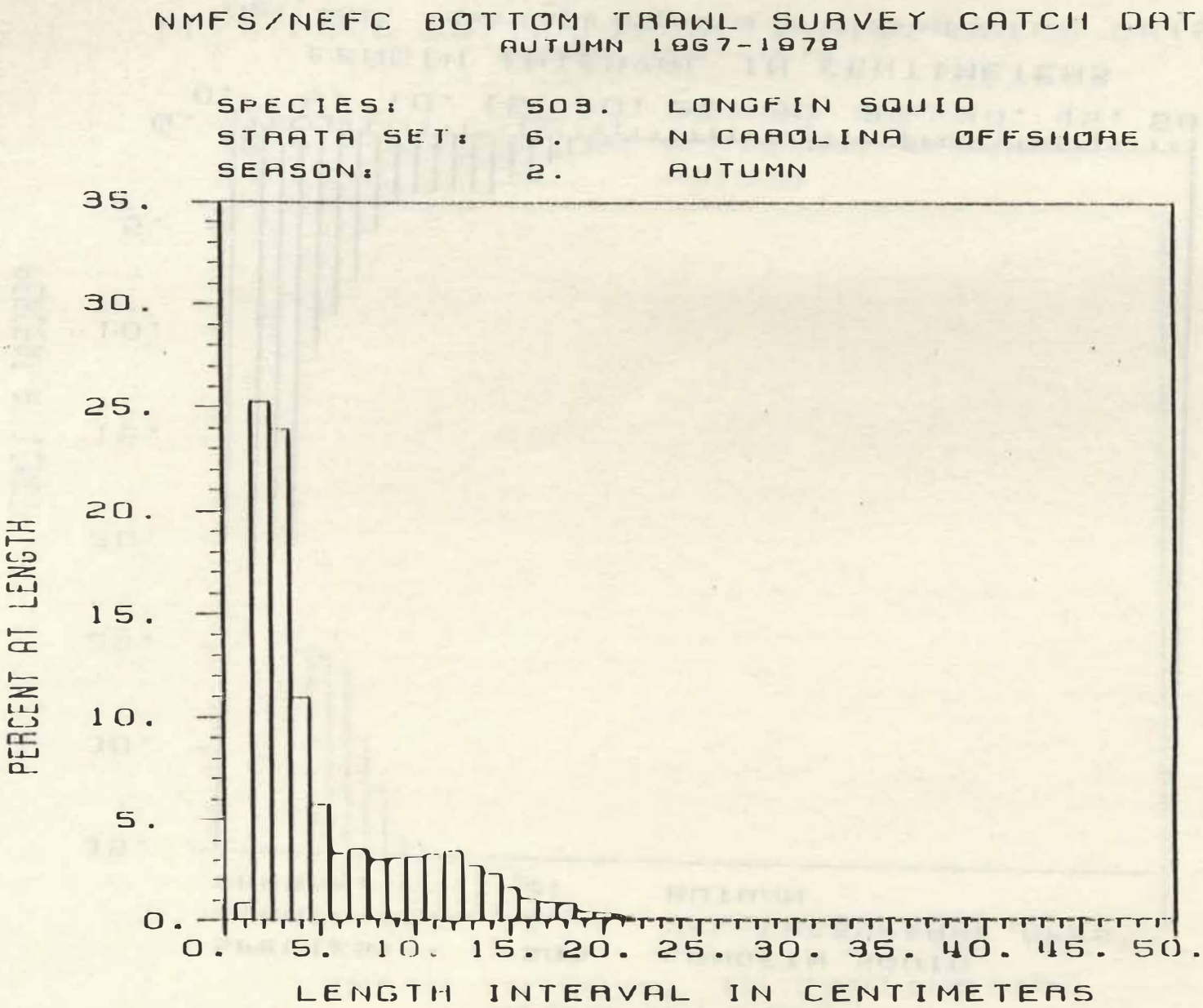

Figure 22.18. Autumn length frequencies for strata set 6.

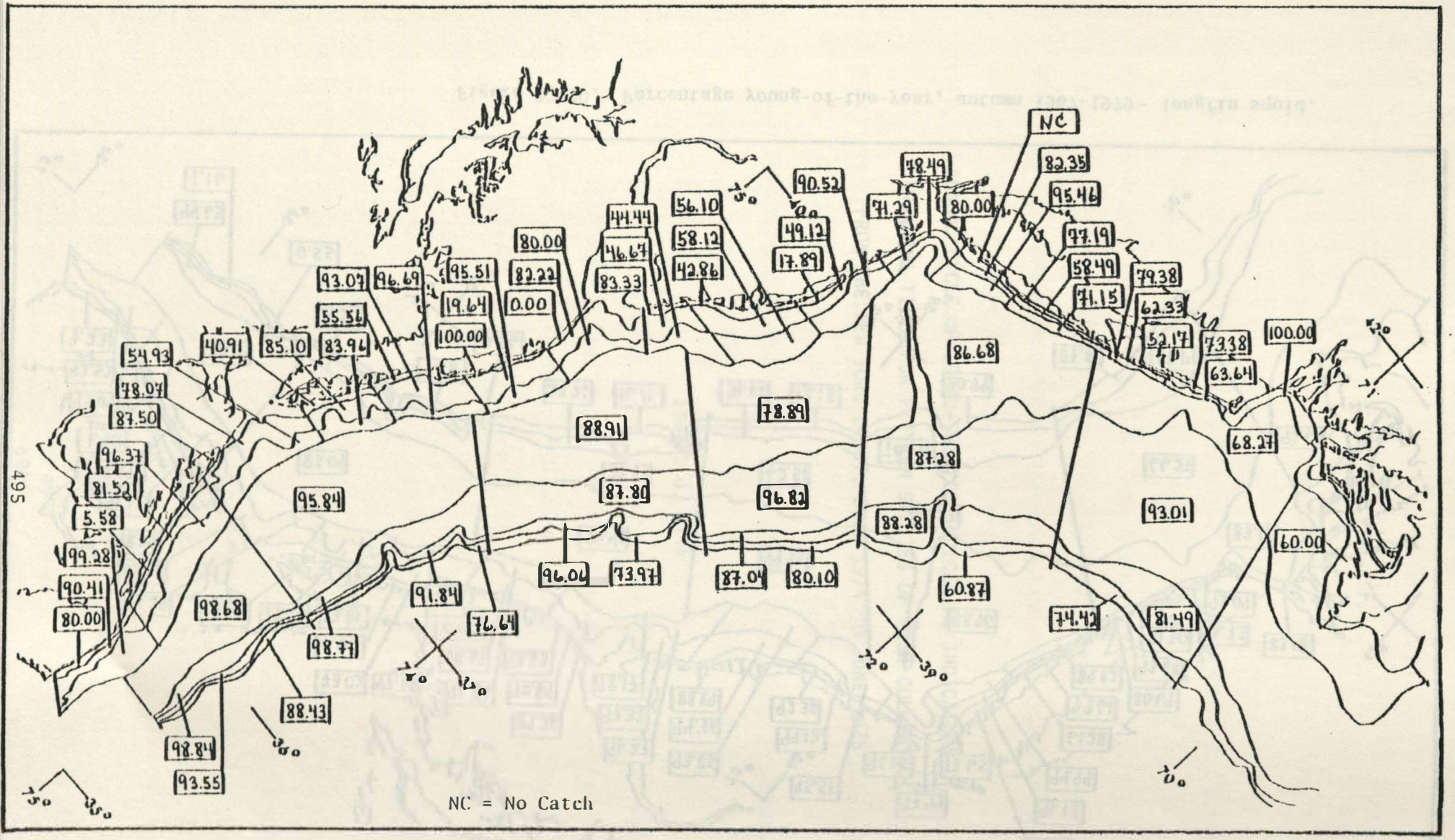

Figure 22.19. Percentage young-of-the-year, spring 1968-1979 - longfin squid.

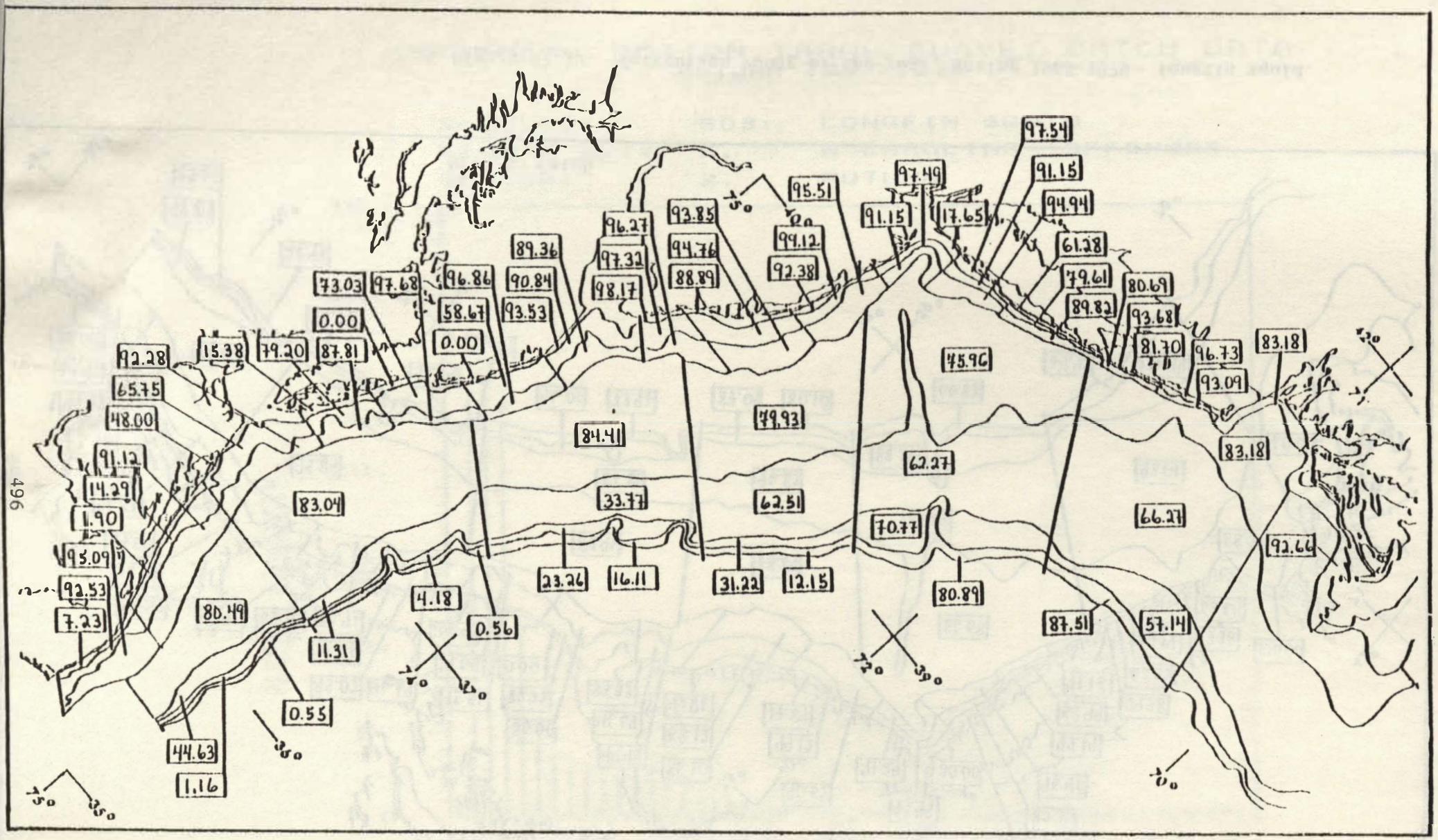

Figure 22.20. Percentage young-of-the-year, autumn 1967-1979 - longfin squid.

ANNUAL CYCLE OF GONAD-SOMATIC INDICES AS INDICATORS OF SPAWNING TIMES FOR FIFTEEN SPECIES OF FISH COLLECTED FROM THE NEW YORK BIGHT, JUNE 1974 TO JUNE 1975

Stuart J. Wilk

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INTRODUCTION

The Sandy Hook Laboratory of the National Marine Fisheries Service began a systematic survey during June 1974 of benthic fishes occurring in the New York Bight and Sandy Hook, Lower, and Raritan Bays. This study was designed to provide a comprehensive life history data base for current and anticipated research needs. This report summarizes gonad-somatic data as indicators of spawning times for the following 15 species of fish: alewife, *Alosa pseudoharengus*; offshore hake, *Merluccius albidus*; silver hake, *Merluccius bilinearis*; red hake, *Urophycis chuss*; spotted hake, *Urophycis regia*; ocean pout, *Macrozoarces americanus*; black sea bass, *Centropristis striata*; butterfish, *Peprilus triacanthus*; northern searobin, *Prionotus carolinus*; striped searobin, *Prionotus evolans*; summer flounder, *Paralichthys dentatus*; fourspot flounder, *Paralichthys oblongus*; windowpane, *Scophthalmus aquosus*; yellowtail flounder, *Limanda ferruginea*; and winter flounder, *Pseudopleuronectes americanus*. In addition, the literature pertinent to this study is reviewed to provide a basis of comparison throughout their range.

These data, when compared with similar time series, contribute ultimately to a significant portion of the material needed to detect and understand natural and man-induced changes in the reproductive cycles of fishes occurring in the New York Bight.

STUDY AREAS

The New York Bight is that portion of the Atlantic continental shelf between eastern Long Island, New York, and Cape May, New Jersey (Figure 1).

This study was conducted in the northern section of the New York Bight where the Long Island and New Jersey coastlines are nearly perpendicular.

Two study areas, ocean and bay, were designated to facilitate sampling and data handling. The ocean study area was delineated by two sets of imaginary lines and the 28- and 366-m isobaths (Figure 2). The first set of lines extends seaward from points on Long Island and New Jersey to the 28-m isobath; the second set from the 28-m isobath to the edge of the continental shelf (366 m). The bay study area included Sandy Hook, Lower, and Raritan Bays (Figure 3).

STATION SELECTION

Station locations in the ocean survey area were selected by a stratified random sampling design (Steel and Torrie 1960). Strata boundaries were determined by depth, i.e., 0-10, 11-19, 20-28, 29-55, 56-110, 111-183, and 184-366 m (Figure 2). A minimum of two stations per stratum were selected randomly for sampling during each cruise. Inshore strata (0-28 m) were sampled at a rate of approximately one station per 515 km^2 and offshore strata (29-366 m) at a rate of approximately one station per 1,030 km^2. Grosslein (1969) described additional details pertaining to this sampling method and design.

The bay survey area was divided into 103 sampling blocks. Except where interrupted by land, each block measured 1' of latitude by 1' of longtitude, i.e., 1.8 km x 1.4 km (2.5 km^2). Trawl stations for all bay cruises were selected randomly from these blocks at the beginning of the study and were retained as permanent stations throughout the study.

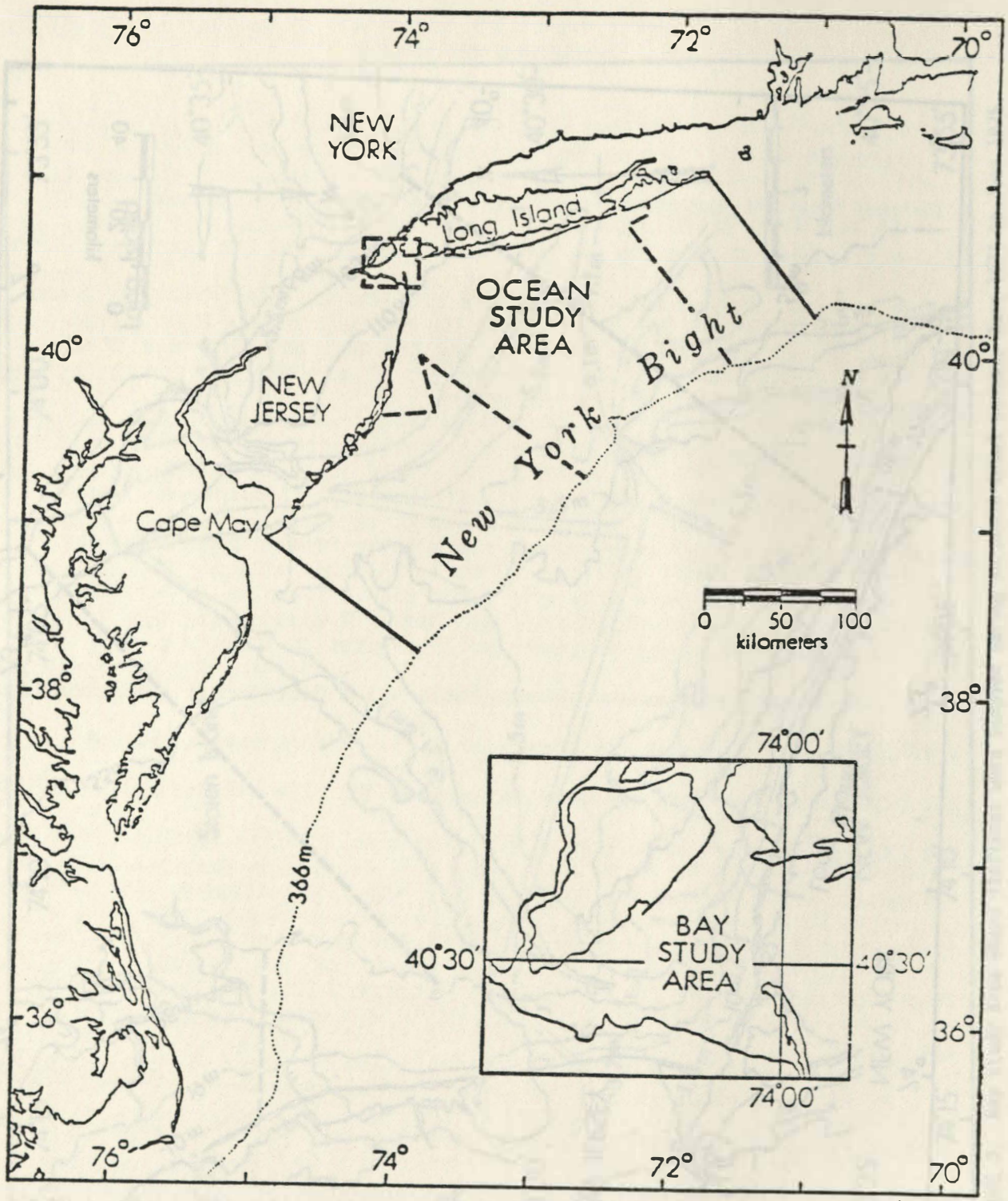

FIGURE 1. Middle Atlantic continental shelf with outlines of the New York Bight (solid lines) and the survey areas (dashed lines) within the Bight.

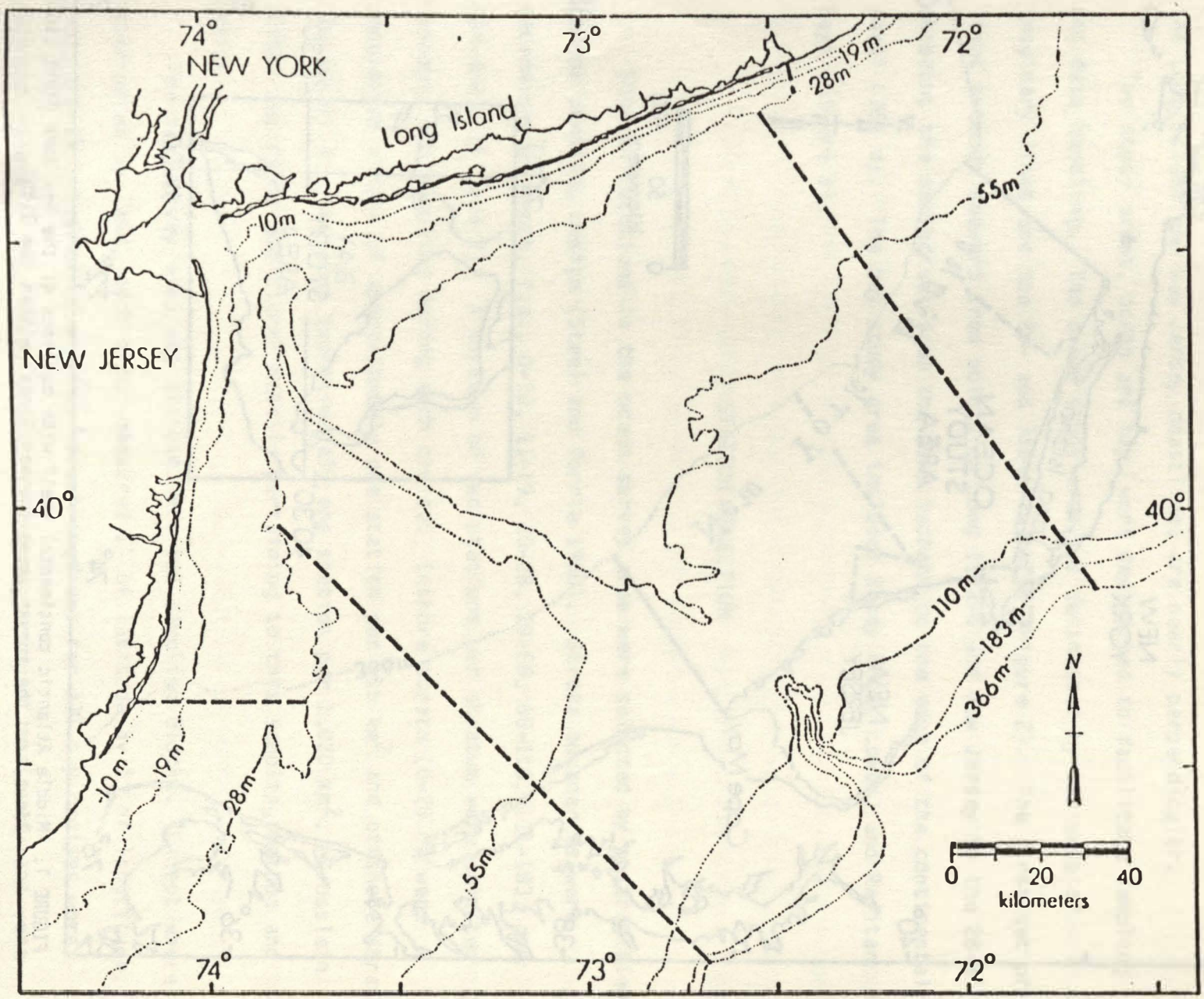

FIGURE 2. Ocean study area divided into depth strata where finfishes were sampled during an otter trawl survey, June 1974 to June 1975.

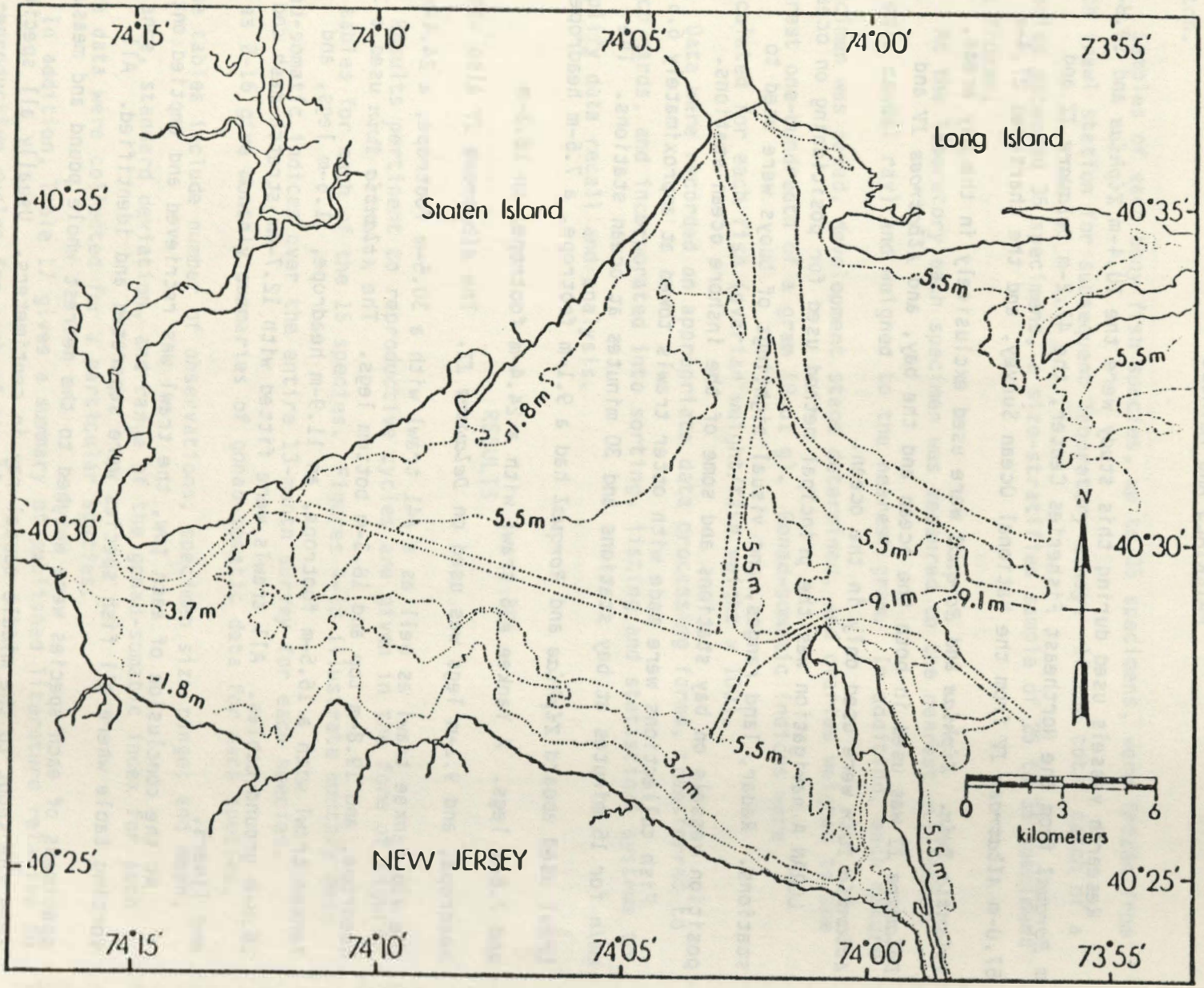

FIGURE 3. Bay study area where finfishes were sampled during an otter trawl survey, June 1974 to June 1975.

MATERIALS AND METHODS

Research vessels used during this study were the 10.4-m *Xiphias* and 19.8-m *Rorqual* from the Northeast Fisheries Center, the 47.2-m *Delaware II* and 57.0-m *Albatross IV* from the National Ocean Survey, and the chartered 27.4-m *Atlantic Twin*. *Xiphias* and *Rorqual* were used exclusively in the bay areas, *Delaware II* was used in both the ocean and the bay, and *Albatross IV* and *Atlantic Twin* were used only in the ocean.

LORAN A navigation was the principal method used for positioning on ocean stations. Radar, land ranges, and visual sightings of buoys were used to position vessels on bay stations and some of the inshore ocean stations.

Fish collections were made with otter trawls towed at approximately 6.5 km/h for 15 minutes at bay stations and 30 minutes at ocean stations. The trawl used aboard *Xiphias* and *Rorqual* had a 9.1-m footrope, a 7.6-m headrope, and 7.6-m legs. A Yankee #36 trawl with a 24.4-m footrope, an 18.3-m headrope, and 9.1-m legs was used on *Delaware II*. The *Albatross IV* also used the #36 Yankee trawl as well as a #41 trawl with a 30.5-m footrope, a 24.4-m headrope, and 19.8-m top and 18.3-m bottom legs. The *Atlantic Twin* used a 3/4 Yankee trawl with a 16.5-m footrope, an 11.9-m headrope, 11.6-m legs, and 16.5-m ground cables. All trawls were fitted with 12.7-mm stretch mesh cod end liners.

At the conclusion of each tow, the trawl was retrieved and emptied onto a sorting table where all fish species were separated and identified. All specimens of each species were weighed to the nearest whole pound and measured from the snout to the middle caudal ray in centimeters. Usually all specimens of each species were measured except when subsamples of very large catches were taken. In such cases, an expansion factor (weight of total catch/weight

of subsample) was applied to the number and length frequency of the total catch.

Samples of each bony fish species, up to 35 specimens, were frozen from each trawl station for subsequent laboratory study. If the total catch of a species exceeded 35 specimens, a size-stratified sample of 25 to 36 specimens was frozen.

At the laboratory each specimen was measured to the nearest millimeter (middle caudal ray) and weighed to the nearest gram. In addition, each mature specimen was sexed, development stage determined, and ovaries weighed to the nearest one-hundredth of a gram (0.01 g). Gonad-somatic indices were calculated for each fish (ovarian weight/fish weight x 100).

Data were recorded on appropriate data processing forms, transferred to punch cards, and incorporated into sorting, listing and statistical systems to simplify data recall and analysis.

RESULTS

Results pertinent to reproductive cycles are given in the form of figures and tables for each of the 15 species. Figures 4-18 illustrate monthly mean gonad-somatic indices over the entire 13-month survey for each species. Tables 2-16 give monthly summaries of gonad-somatic data for each species. These tables include number of observations; specimen size range; and mean, variance, standard deviation, and range of the gonad-somatic index for each month data were collected for a particular species.

In addition, Table 17 gives a summary of published literature relative to the reproductive cycles for each of the 15 species and contrasts these published results with those found during the present study.

TABLE 1. Summary of collecting intervals sampled during trawl survey of New York Bight, June 1974 to June 1975.

Date	Vessel	No. of Sta.	Gear Type	Study Area
1974				
June 3, 4, 6	*Xiphias*	15	9.1-m trawl	bay
June 3	*Delaware II*	3	#36 trawl	bay
June 3-17	*Delaware II*	43	#36 trawl	ocean
July 23-25	*Xiphias*	15	9.1-m trawl	bay
July 24	*Delaware II*	3	#36 trawl	bay
July 24-29	*Delaware II*	41	#36 trawl	ocean
August 14, 15, 21-23	*Rorqual*	16	9.1-m trawl	bay
August 16-21	*Delaware II*	45	#36 trawl	ocean
September 23-25	*Xiphias*	12	9.1-m trawl	bay
September 23	*Delaware II*	3	#36 trawl	bay
September 23-28	*Delaware II*	40	#36 trawl	ocean
October 22-24	*Xiphias*	19	9.1-m trawl	bay
October 22	*Delaware II*	3	#36 trawl	bay
October 22-28	*Delaware II*	40	#36 trawl	ocean
November 18-20	*Xiphias*	19	9.1-m trawl	bay
November 18	*Delaware II*	3	#36 trawl	bay
November 18-25	*Delaware II*	37	#36 trawl	ocean
1975				
January 3, 6, 9	*Rorqual*	14	9.1-m trawl	bay
January 31; February 3, 4	*Rorqual*	14	9.1-m trawl	bay
January 31	*Delaware II*	3	#36 trawl	bay
January 31; February 1-6	*Delaware II*	51	#36 trawl	ocean
March 6-8, 10	*Albatross IV*	19	#41 trawl	ocean
March 20-24	*Atlantic Twin*	27	3/4 Yankee trawl	ocean
April 1, 2, 7	*Rorqual*	15	9.1-m trawl	bay
April 1-3, 5-10	*Albatross IV*	48	#36 trawl	ocean
May 5, 6, 8	*Xiphias*	16	9.1-m trawl	bay
May 5	*Delaware II*	3	#36 trawl	bay
May 5-12	*Delaware II*	60	#36 trawl	ocean
June 3, 9	*Xiphias*	9	9.1-m trawl	bay
June 2-9	*Delaware II*	64	#36 trawl	ocean
TOTAL		700		

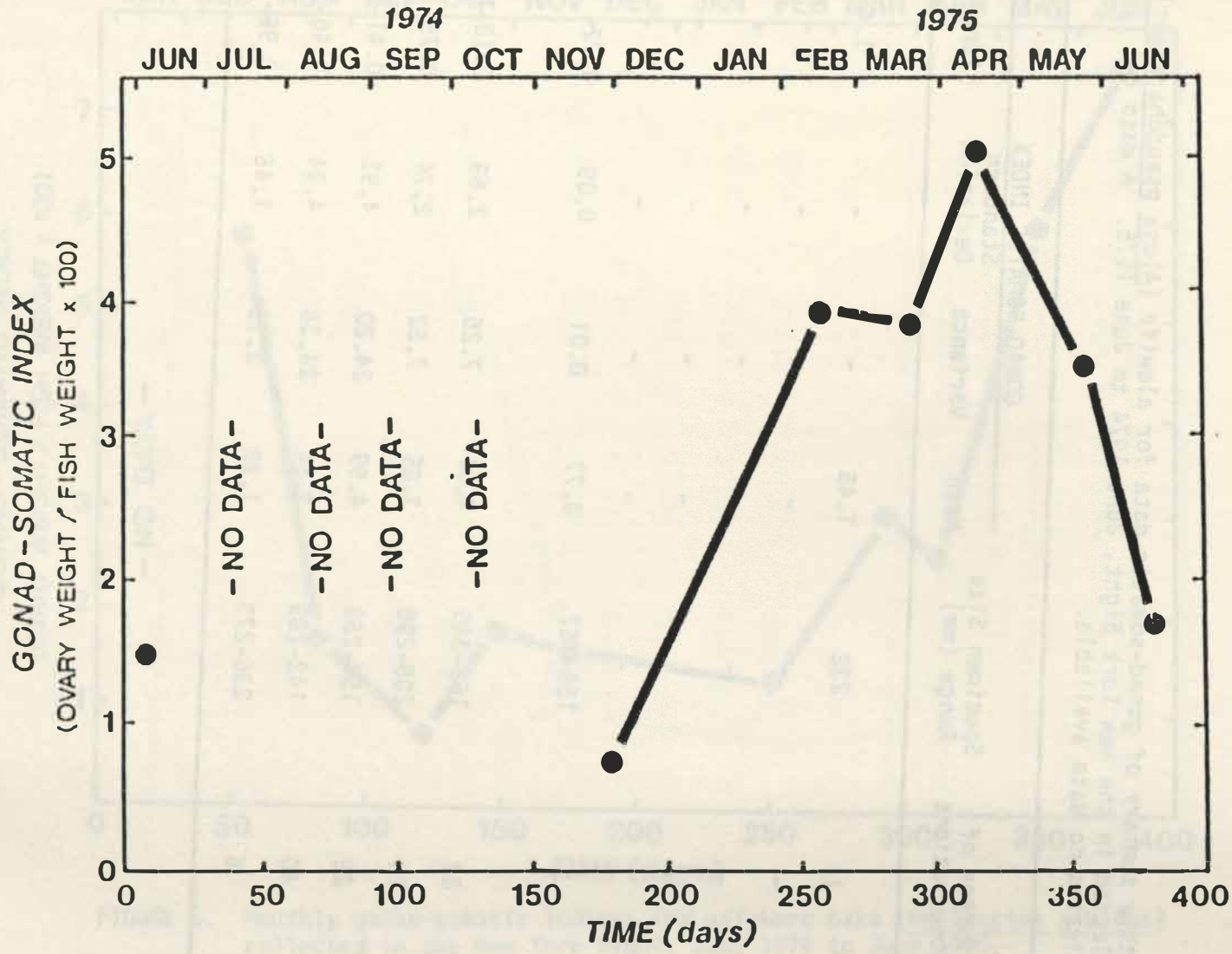

FIGURE 4. Monthly gonad-somatic indices for alewife (Alosa pseudoharengus) collected in the New York Bight, June 1974 to June 1975.

TABLE 2. Monthly summary of gonad-somatic data for alewife (Alosa pseudoharengus) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	1	232	1.45	-	-	1.45
July	-	-	-	-	-	-
August	-	-	-	-	-	-
September	-	-	-	-	-	-
October	-	-	-	-	-	-
November	3	156-167	0.77	0.01	0.09	0.72- 0.87
1975						
February	83	168-345	4.04	7.26	2.69	0.13-12.44
March	19	208-298	3.85	7.52	2.74	0.75-11.78
April	29	154-269	4.99	24.20	4.92	0.41-15.00
May	40	142-289	3.54	24.38	4.94	0.46-15.67
June	6	236-273	1.88	2.15	1.46	0.96- 4.83

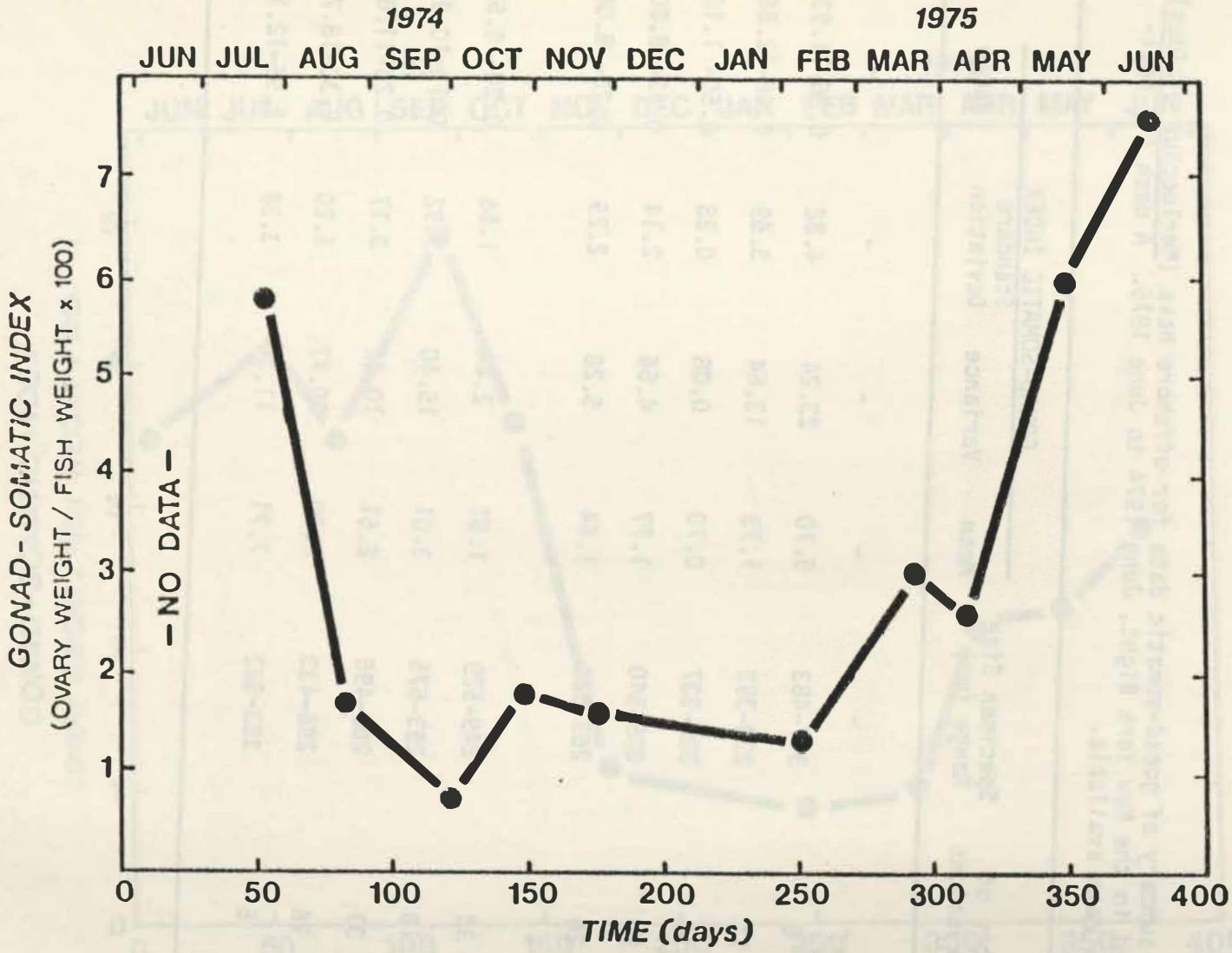

FIGURE 5. Monthly gonad-somatic indices for offshore hake (Merluccius albidus) collected in the New York Bight, June 1974 to June 1975.

TABLE 3. Monthly summary of gonad-somatic data for offshore hake (*Merluccius albidus*) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	-	-	-	-	-	-
July	6	317-483	5.70	23.24	4.82	0.36-11.93
August	11	230-393	1.73	13.64	3.69	0.46-12.86
September	6	302-337	0.70	0.08	0.28	0.50- 1.18
October	20	289-540	1.77	4.56	2.14	0.43- 8.80
November	20	269-504	1.64	5.26	2.29	0.20- 8.00
1975						
February	30	249-529	1.51	2.44	1.56	0.20- 6.53
March	10	293-575	3.01	15.40	3.92	0.17-10.94
April	31	268-495	2.61	10.02	3.17	0.25-11.82
May	16	286-433	6.00	38.47	6.20	0.30-18.72
June	6	383-522	7.71	11.39	3.38	3.95-12.15

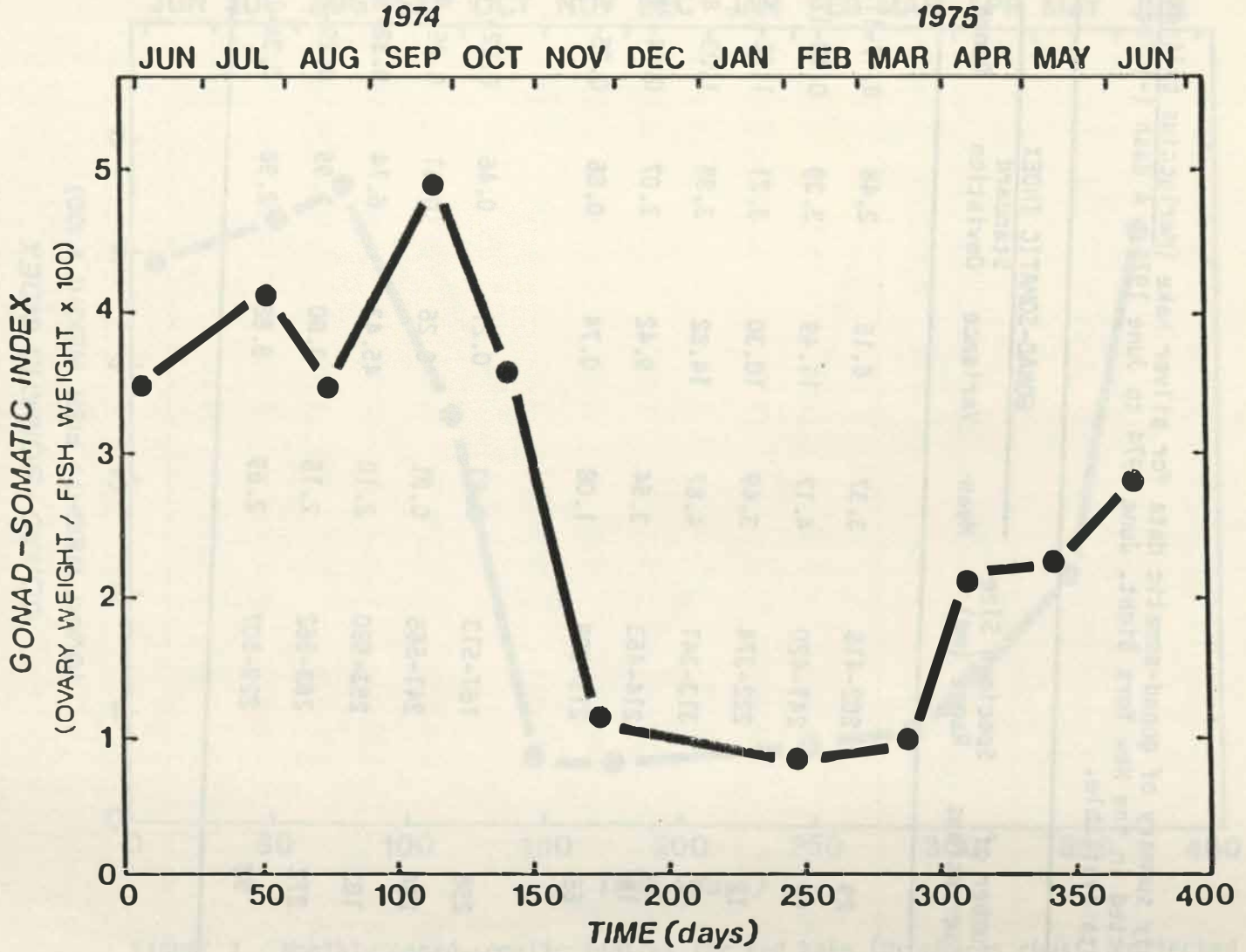

FIGURE 6. Monthly gonad-somatic indices for silver hake (Merluccius bilinearis) collected in the New York Bight, June 1974 to June 1975.

TABLE 4. Monthly summary of gonad-somatic data for silver hake (Merluccius bilinearis) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	29	202-415	3.37	6.15	2.48	0.47-11.35
July	15	241-420	4.17	11.49	3.39	0.40-11.58
August	12	222-374	3.49	10.30	3.21	1.62- 8.37
September	4	313-341	4.87	14.82	3.85	1.03- 8.72
October	19	214-463	3.54	9.42	3.07	0.44- 9.65
November	65	219-508	1.08	0.74	0.86	0.25- 6.07
1975						
February	298	167-513	0.81	0.21	0.46	0.22- 6.39
March	264	241-565	0.91	0.26	0.51	0.25- 4.43
April	183	253-590	2.10	45.43	6.74	0.32-38.38
May	272	263-562	2.15	3.80	1.95	0.29-13.35
June	98	228-507	2.69	8.88	2.98	0.36-14.37

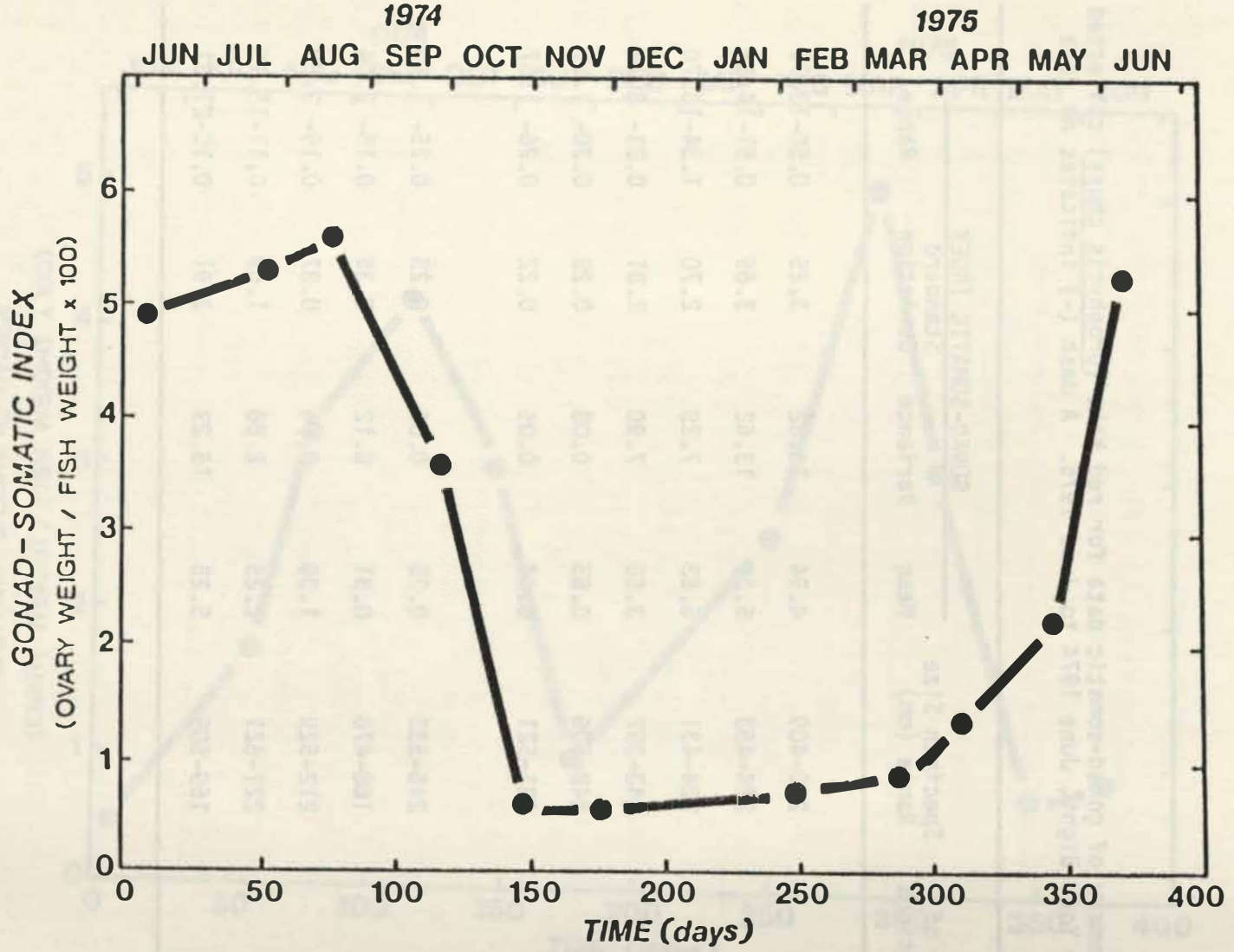

FIGURE 7. Monthly gonad-somatic indices for red hake (Urophycis chuss) collected in the New York Bight, June 1974 to June 1975.

TABLE 5. Monthly summary of gonad-somatic data for red hake (Urophycis chuss) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	18	270-409	4.94	10.82	3.29	0.50-13.77
July	31	224-453	5.36	13.62	3.69	0.81-14.86
August	46	224-431	5.63	7.29	2.70	1.34-13.70
September	19	243-397	3.58	7.90	2.81	0.23- 8.16
October	9	248-506	0.65	0.08	0.29	0.30- 1.29
November	51	231-521	0.64	0.05	0.22	0.26- 1.37
1975						
February	125	245-533	0.75	0.05	0.23	0.25- 1.59
March	123	188-476	0.91	0.12	0.35	0.15- 2.04
April	102	212-529	1.39	0.76	0.87	0.19- 2.69
May	223	221-621	2.25	2.86	1.69	0.11-15.15
June	79	169-505	5.25	15.29	3.91	0.10-21.31

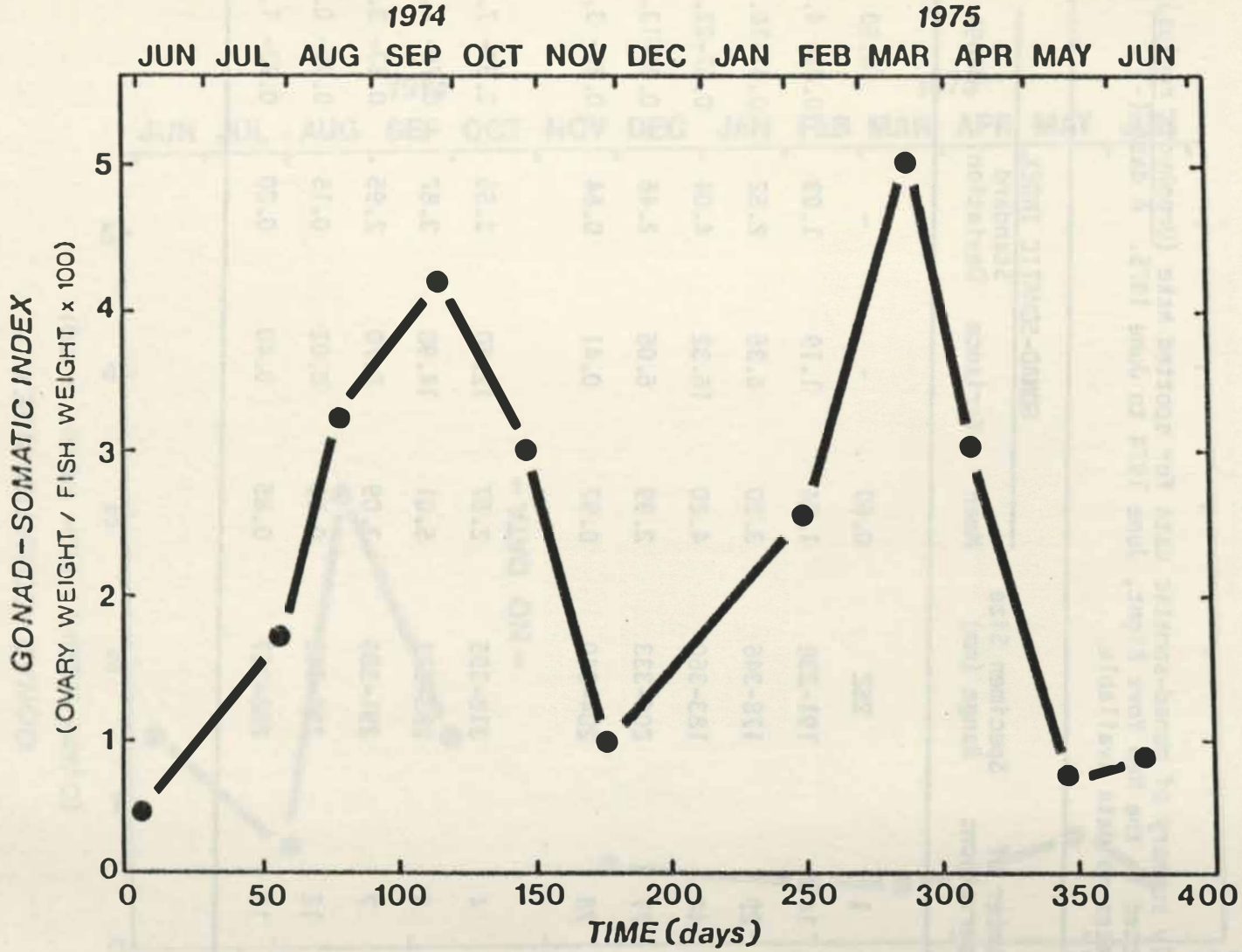

FIGURE 8. Monthly gonad-somatic indices for spotted hake (Urophycis regius) collected in the New York Bight, June 1974 to June 1975.

TABLE 6. Monthly summary of gonad-somatic data for spotted hake (Urophycis regius) collected in the New York Bight, June 1974 to June 1975. A dasn (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	1	252	0.60	-	-	0.60
July	14	191-338	1.64	1.19	1.09	0.44- 4.04
August	29	178-346	3.20	6.35	2.52	0.41-10.12
September	44	183-360	4.20	16.32	4.04	0.37-22.09
October	77	206-333	2.99	6.05	2.46	0.32-13.75
November	78	204-340	0.97	0.41	0.64	0.26- 3.60
1975						
February	4	318-355	2.57	12.60	3.55	0.57- 7.87
March	3	283-333	5.01	14.98	3.87	0.76- 8.34
April	7	291-386	3.09	8.70	2.95	0.33- 8.03
May	12	299-368	0.69	0.02	0.15	0.48- 0.99
June	13	288-367	0.85	0.40	0.20	0.73- 1.26

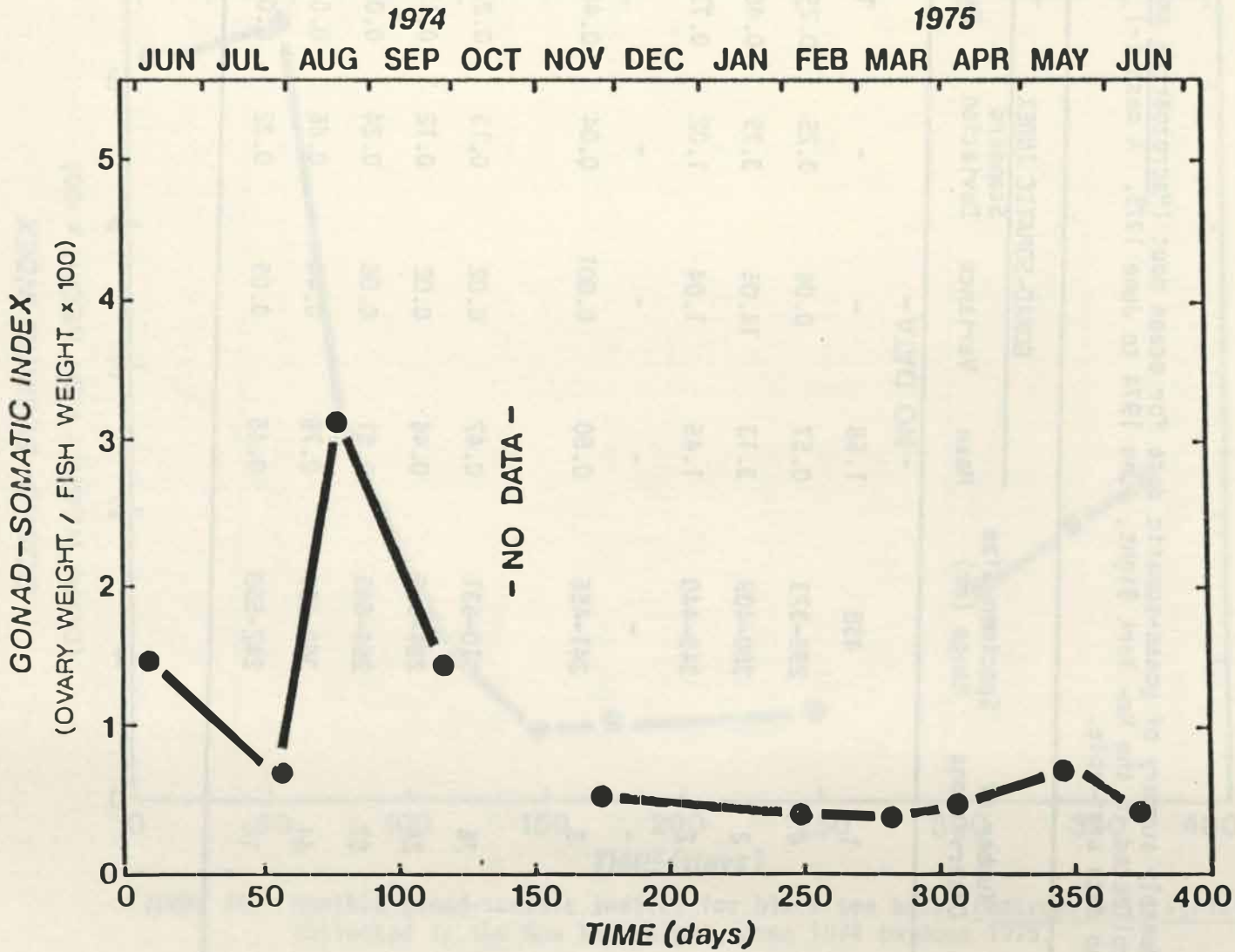

FIGURE 9. Monthly gonad-somatic indices for ocean pout (Macrozoarces americanus) collected in the New York Bight, June 1974 to June 1975.

TABLE 7. Monthly summary of gonad-somatic data for ocean pout (Macrozoarces americanus) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	1	458	1.58	-	-	1.58
July	4	299-373	0.57	0.06	0.25	0.29- 0.89
August	2	380-409	3.13	14.05	3.75	0.48- 5.78
September	2	349-440	1.45	1.04	1.02	0.73- 2.17
October	-	-	-	-	-	-
November	3	341-455	0.50	0.001	0.04	0.46- 0.53
1975						
February	76	310-631	0.47	0.02	0.13	0.29- 0.98
March	24	284-586	0.46	0.02	0.12	0.12- 0.68
April	57	269-663	0.51	0.06	0.24	0.05- 1.58
May	64	360-659	0.79	0.44	0.66	0.07- 3.43
June	14	242-558	0.45	0.05	0.22	0.05- 1.04

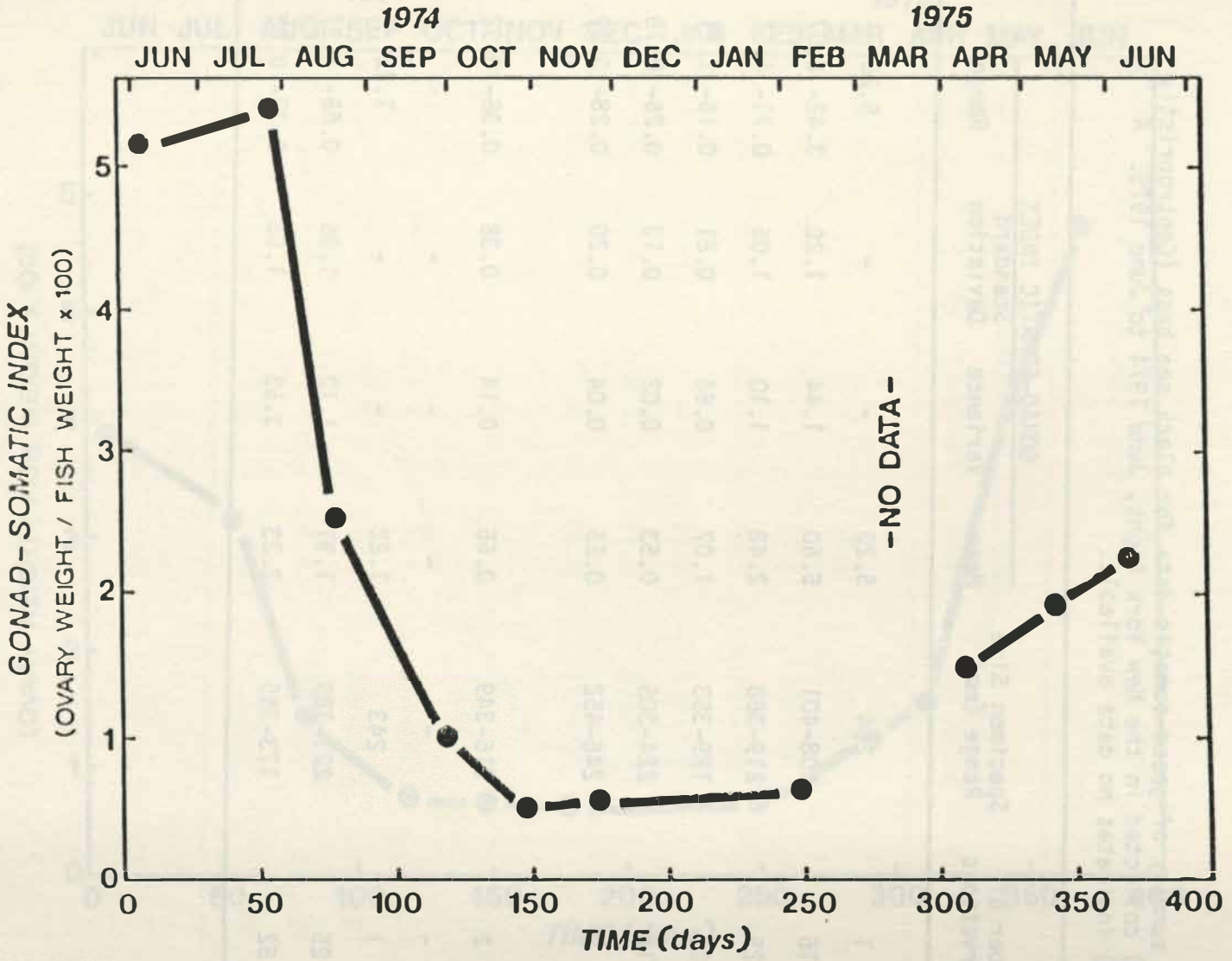

FIGURE 10. Monthly gonad-somatic indices for black sea bass (Centropristis striata) collected in the New York Bight, June 1974 to June 1975.

TABLE 8. Monthly summary of gonad-somatic data for black sea bass (Centropristis striata) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	1	264	5.20	-	-	5.20
July	16	208-401	5.60	1.44	1.20	3.42- 8.07
August	25	219-368	2.48	1.10	1.05	0.71- 4.61
September	20	189-353	1.07	0.66	0.81	0.16- 2.71
October	15	224-305	0.53	0.02	0.13	0.26- 0.78
November	8	246-452	0.55	0.04	0.20	0.28- 0.89
1975						
February	2	316-349	0.65	0.14	0.38	0.38- 0.92
March	-	-	-	-	-	-
April	1	243	1.22	-	-	1.22
May	25	221-389	1.91	1.12	1.06	0.68- 4.87
June	52	173-365	2.23	3.53	1.88	0.33- 8.05

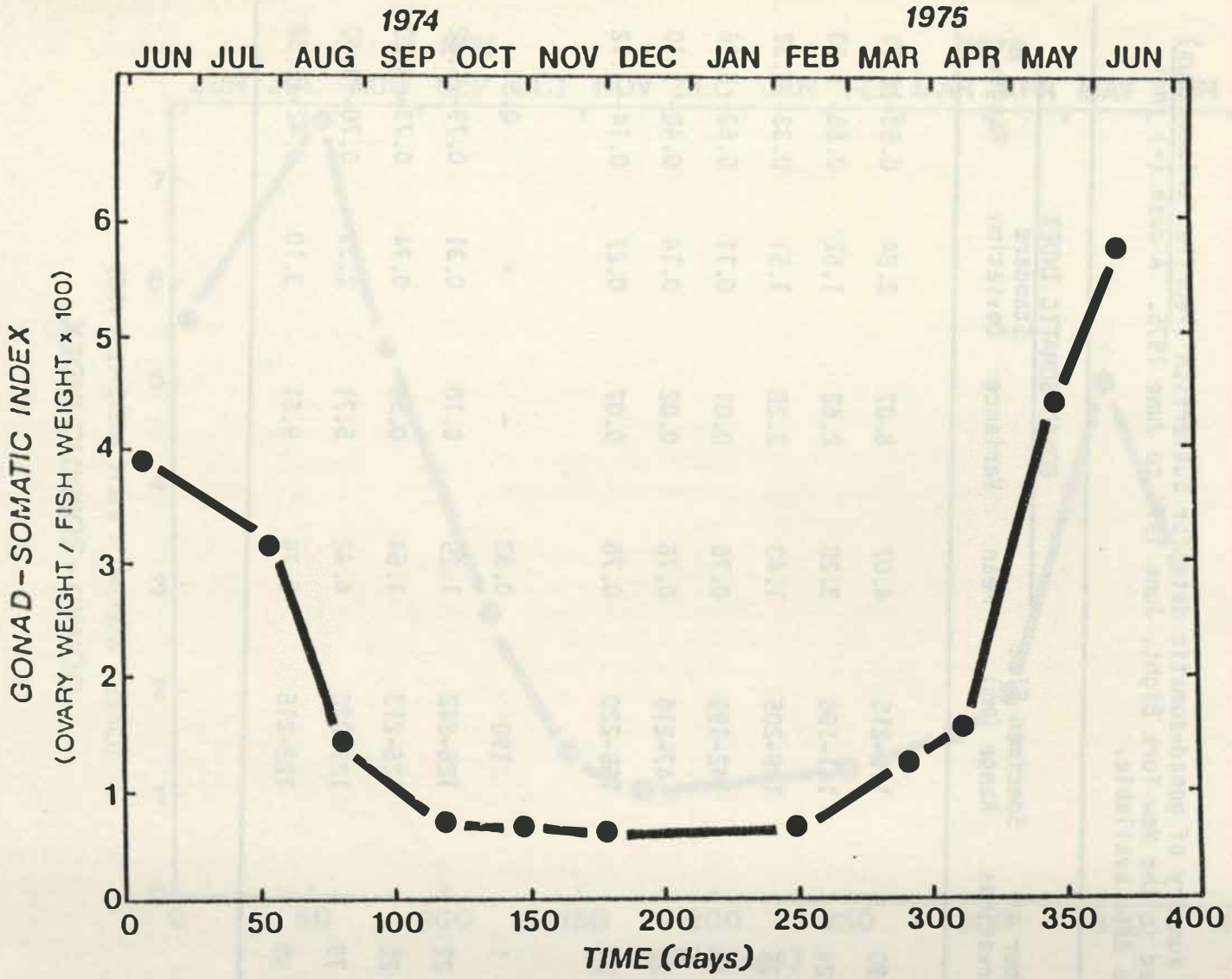

FIGURE 11. Monthly gonad-somatic indices for butterfish (Peprilus triacanthus) collected in the New York Bight, June 1974 to June 1975.

TABLE 9. Monthly summary of gonad-somatic data for butterfish (Peprilus triacanthus) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	90	119-215	4.07	8.07	2.84	0.53-12.71
July	24	141-196	3.20	2.62	1.62	0.65- 5.93
August	26	139-205	1.43	2.28	1.51	0.33- 6.32
September	16	142-199	0.76	0.01	0.11	0.63- 0.96
October	30	147-216	0.76	0.02	0.14	0.40- 1.10
November	21	155-220	0.76	0.07	0.27	0.14- 1.12
1975						
February	1	190	0.83	-	-	0.83
March	22	126-242	1.29	0.10	0.31	0.79- 1.82
April	20	126-213	1.64	0.55	0.74	0.73- 3.20
May	79	127-230	4.42	5.71	2.39	0.70-10.40
June	99	122-215	5.74	9.61	3.10	0.42-12.38

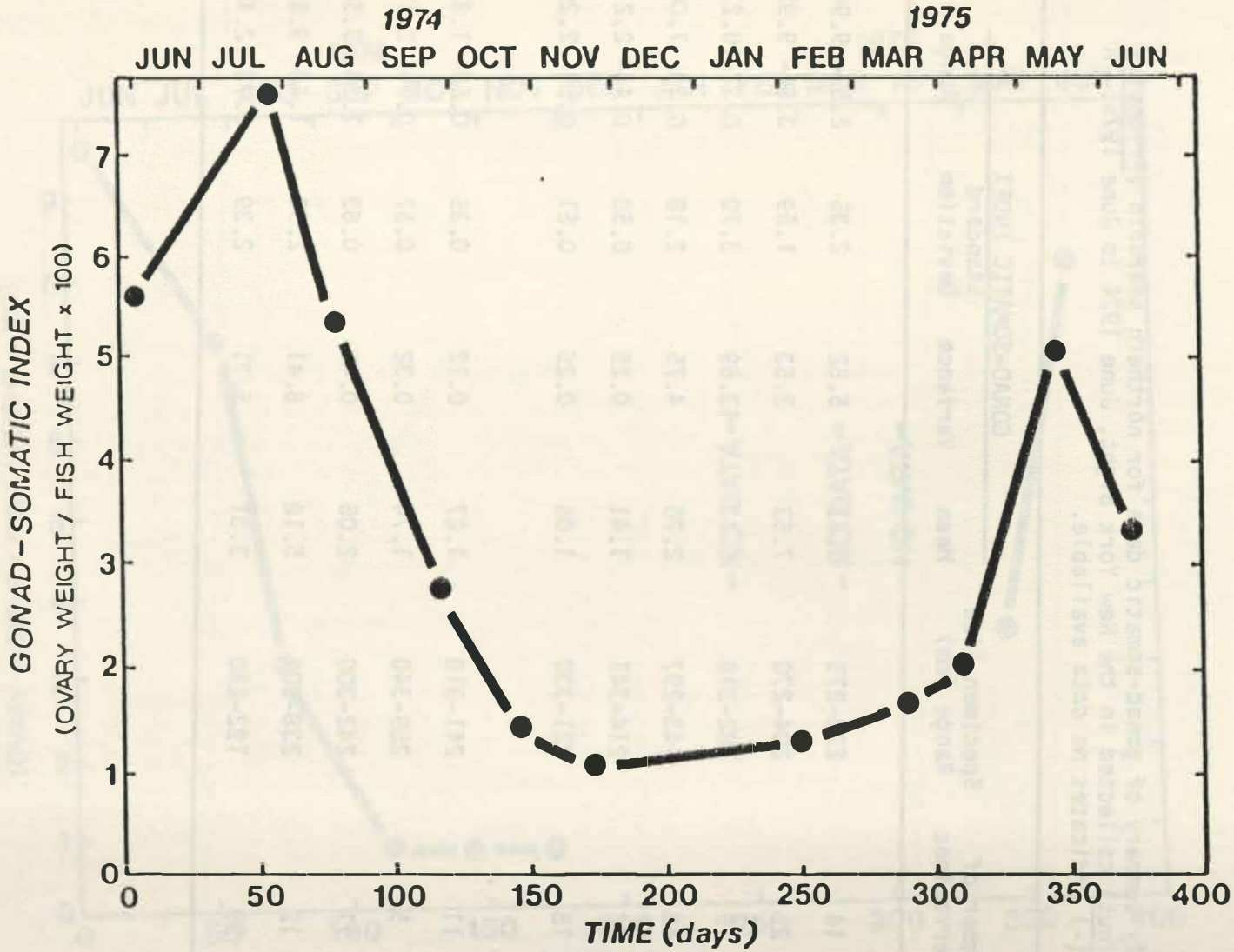

FIGURE 12. Monthly gonad-somatic indices for northern searobin (Prionotus carolinus) collected in the New York Bight, June 1974 to June 1975.

TABLE 10. Monthly summary of gonad-somatic data for northern searobin (Prionotus carolinus) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	14	228-275	5.63	5.52	2.35	2.57- 9.94
July	21	204-270	7.63	2.53	1.59	3.86- 9.92
August	19	182-318	5.43	13.69	3.70	0.32-10.23
September	48	143-297	2.76	4.75	2.18	0.33- 7.04
October	16	214-341	1.41	0.25	0.50	0.46- 2.27
November	15	221-330	1.06	0.26	0.51	0.55- 2.25
1975						
February	11	241-318	1.27	0.12	0.35	0.59- 1.83
March	5	259-340	1.74	0.32	0.57	0.74- 2.10
April	11	242-300	2.05	0.40	0.63	1.34- 3.54
May	12	238-308	5.18	8.41	2.90	1.40- 9.87
June	39	192-280	3.31	5.71	2.39	0.73-12.40

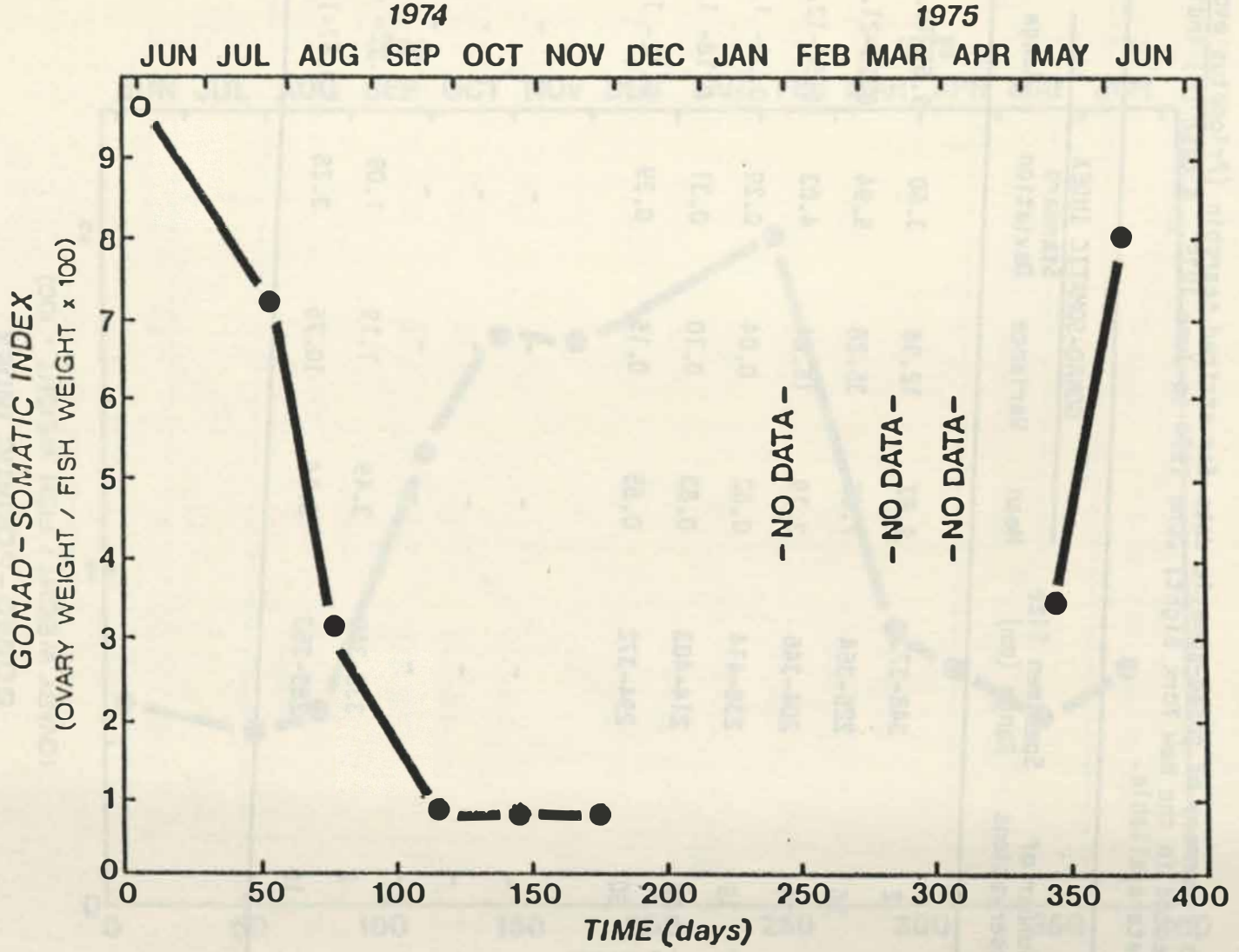

FIGURE 13. Monthly gonad-somatic indices for striped searobin (Prionotus evolans) collected in the New York Bight, June 1974 to June 1975.

TABLE 11. Monthly summary of gonad-somatic data for striped searobin (Prionotus evolans) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	2	348-373	9.87	12.96	3.60	9.61-10.12
July	16	225-364	7.35	35.28	5.94	0.23-21.32
August	11	204-346	3.19	16.24	4.03	0.50-13.35
September	19	238-414	0.82	0.04	0.29	0.33- 1.35
October	36	214-403	0.83	0.10	0.31	0.18- 1.36
November	30	294-372	0.85	0.15	0.39	0.12- 1.68
1975						
February	-	-	-	-	-	-
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	2	338-348	3.49	1.19	1.09	2.72- 4.26
June	10	289-353	8.16	10.76	3.28	3.57-13.07

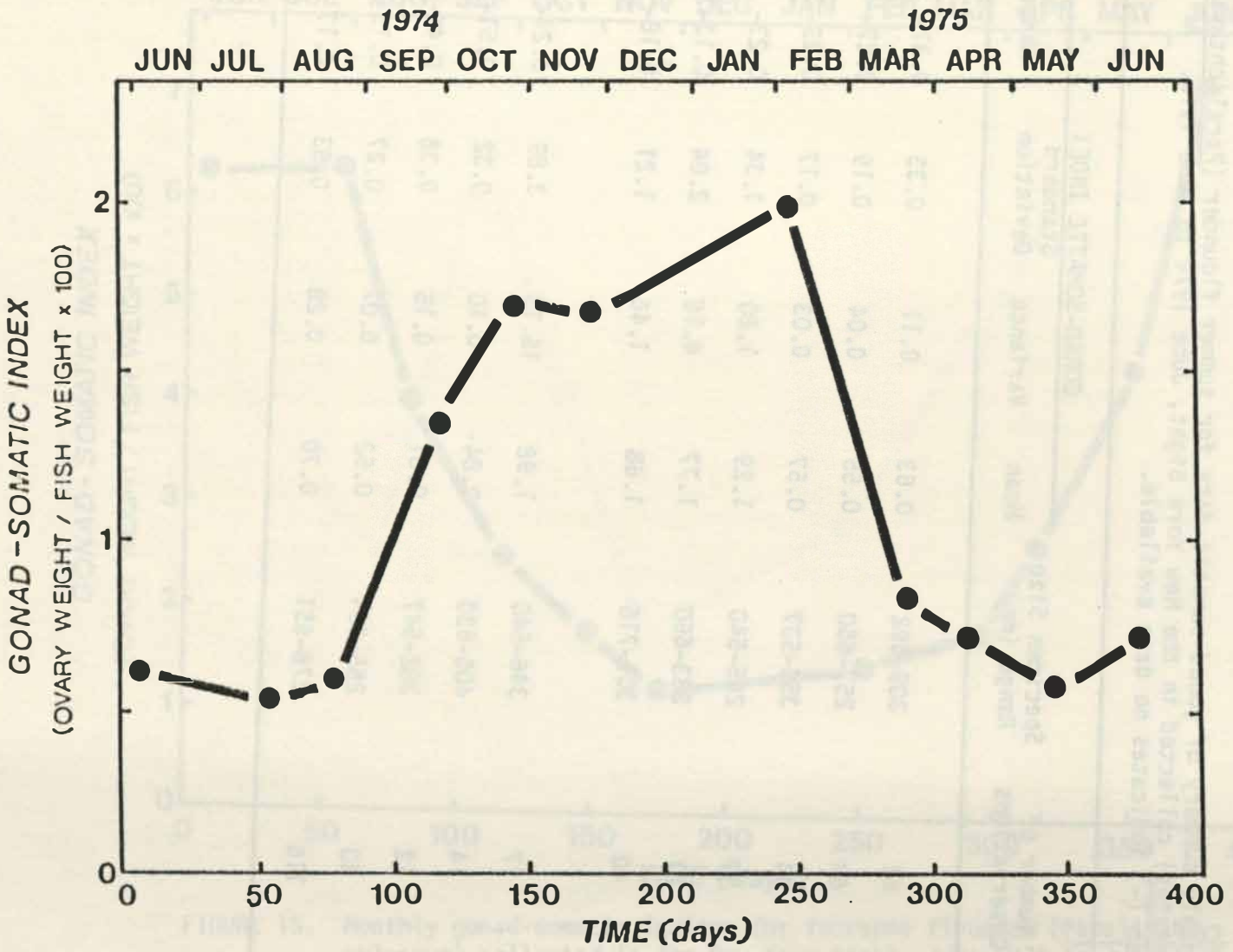

FIGURE 14. Monthly gonad-somatic indices for summer flounder (Paralichthys dentatus) collected in the New York Bight, June 1974 to June 1975.

TABLE 12. Monthly summary of gonad-somatic data for summer flounder (*Paralichthys dentatus*) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	62	309-692	0.63	0.11	0.33	0.31- 2.26
July	69	257-650	0.55	0.04	0.19	0.27- 1.27
August	44	353-537	0.57	0.03	0.17	0.29- 1.01
September	97	265-540	1.29	1.80	1.34	0.23- 5.59
October	81	283-660	1.77	4.16	2.04	0.13-11.53
November	40	301-716	1.68	1.46	1.21	0.18- 6.35
1975						
February	17	346-540	1.98	15.13	3.89	0.24-13.17
March	14	406-630	0.84	0.10	0.32	0.51- 1.78
April	12	382-547	0.81	0.15	0.38	0.46- 1.91
May	63	255-594	0.52	0.07	0.27	0.15- 1.22
June	116	276-651	0.70	0.28	0.53	0.17- 4.94

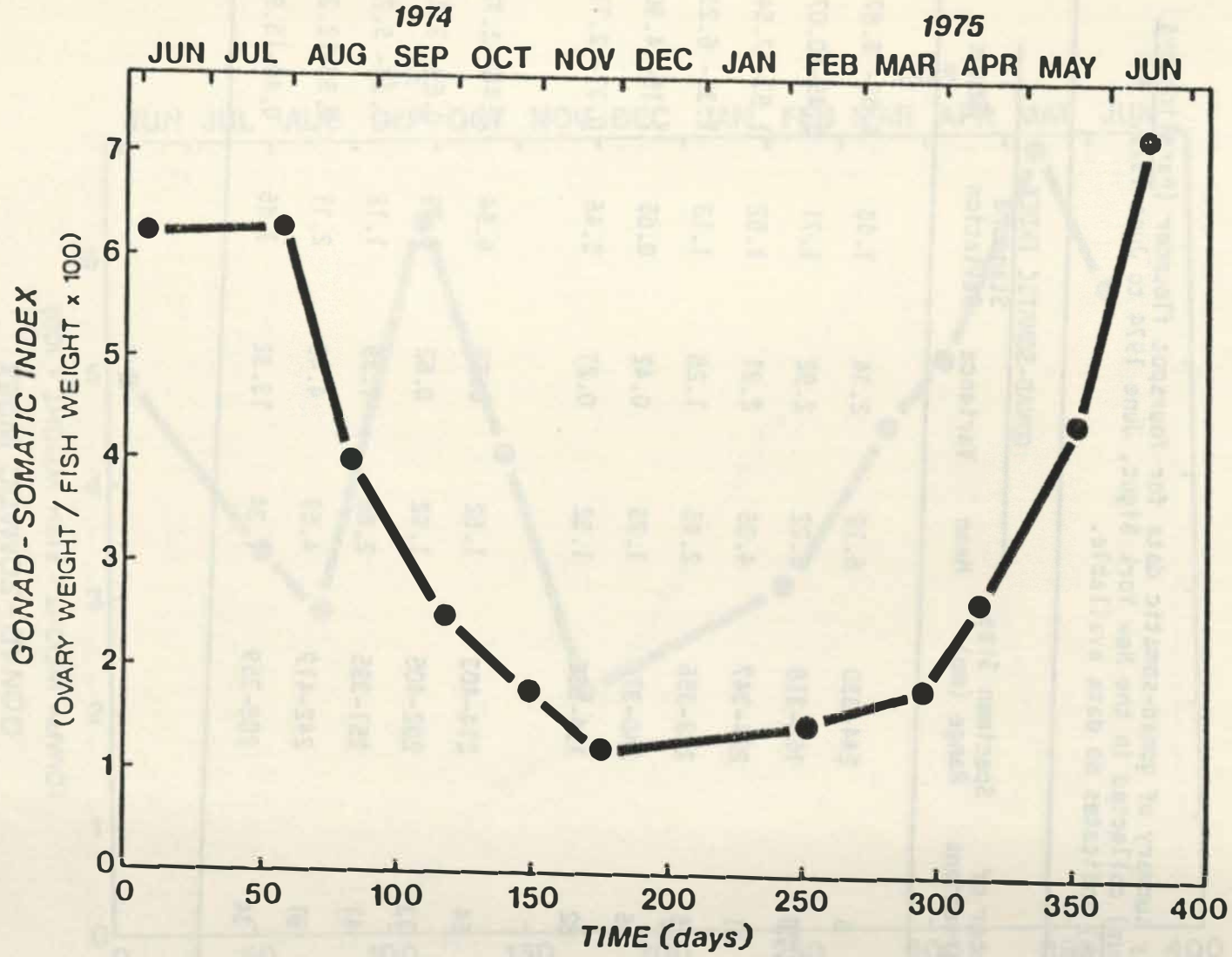

FIGURE 15. Monthly gonad-somatic indices for fourspot flounder (Paralichthys oblongus) collected in the New York Bight, June 1974 to June 1975.

TABLE 13. Monthly summary of gonad-somatic data for fourspot flounder (Paralichthys oblongus) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	6	244-330	6.19	2.34	1.53	4.63- 8.87
July	28	153-318	6.22	2.92	1.71	3.45-10.07
August	31	224-347	4.05	2.31	1.52	1.53- 7.54
September	25	233-356	2.45	1.28	1.13	1.35- 6.23
October	36	240-374	1.75	0.42	0.65	1.15- 4.90
November	82	194-386	1.32	0.21	0.46	0.37- 2.11
1975						
February	64	214-403	1.52	0.29	0.54	0.48- 2.73
March	33	202-405	1.92	0.62	0.79	0.69- 3.27
April	41	251-395	2.85	1.39	1.18	0.59- 5.72
May	81	242-419	4.59	4.45	2.11	0.53-12.38
June	34	208-359	7.34	13.32	3.65	0.40-13.98

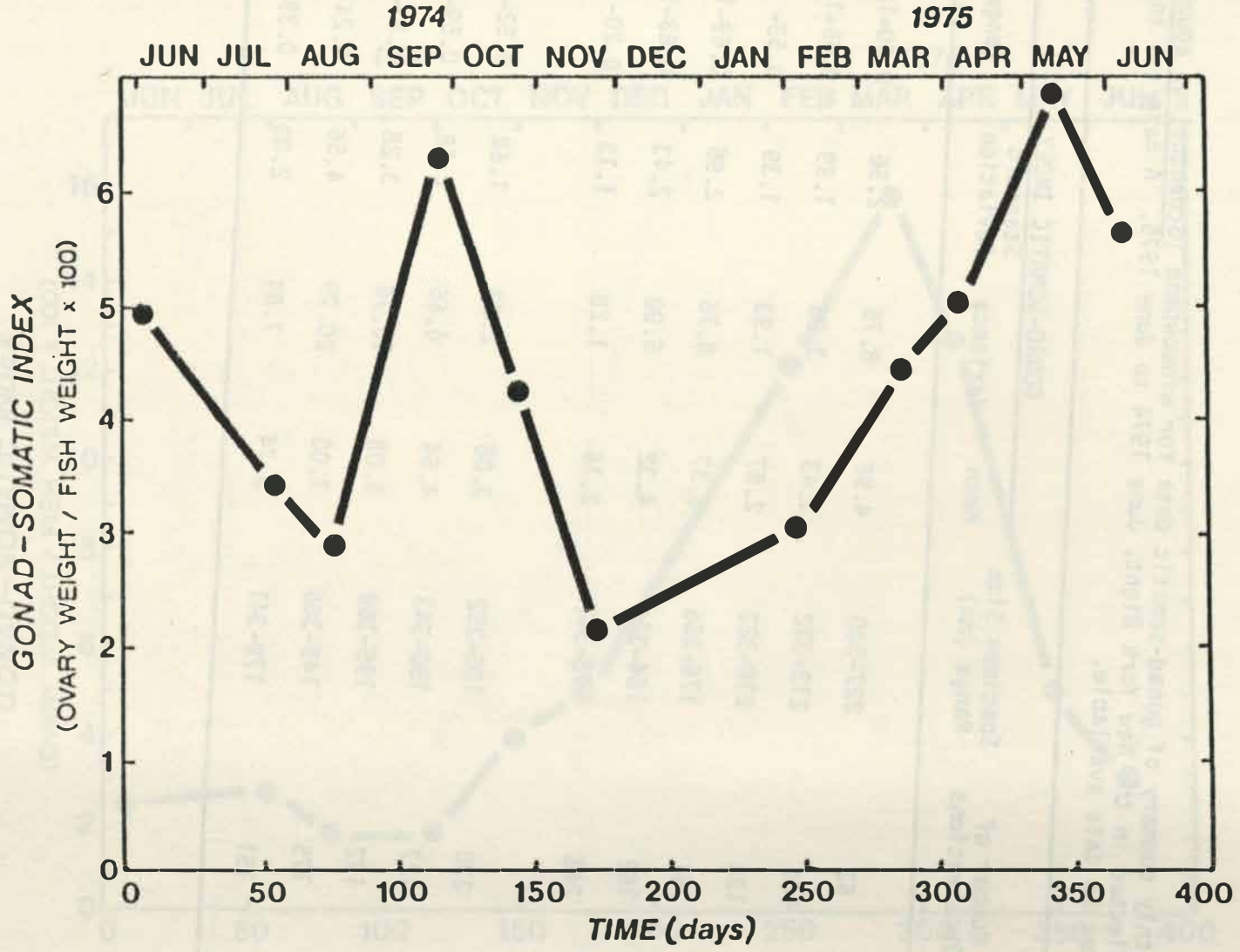

FIGURE 16. Monthly gonad-somatic indices for windowpane (Scophthalmus aquosus) collected in the New York Bight, June 1974 to June 1975.

TABLE 14. Monthly summary of gonad-somatic data for windowpane (Scophthalmus aquosus) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	63	227-330	4.98	8.76	2.96	0.90-12.73
July	106	213-332	3.43	3.96	1.99	0.55-10.14
August	133	218-323	2.87	1.93	1.39	0.53- 6.96
September	151	176-356	6.37	8.76	2.96	0.69-16.63
October	162	164-340	4.32	5.90	2.43	0.63-13.36
November	246	178-341	2.16	1.28	1.13	0.20- 5.72
1975						
February	230	186-352	3.08	2.82	1.68	0.52-10.92
March	127	180-343	4.54	6.66	2.58	0.59-11.52
April	172	195-369	5.08	10.76	3.28	0.52-18.57
May	175	149-366	7.00	20.79	4.56	0.24-16.13
June	151	179-341	5.74	7.84	2.80	0.39-12.90

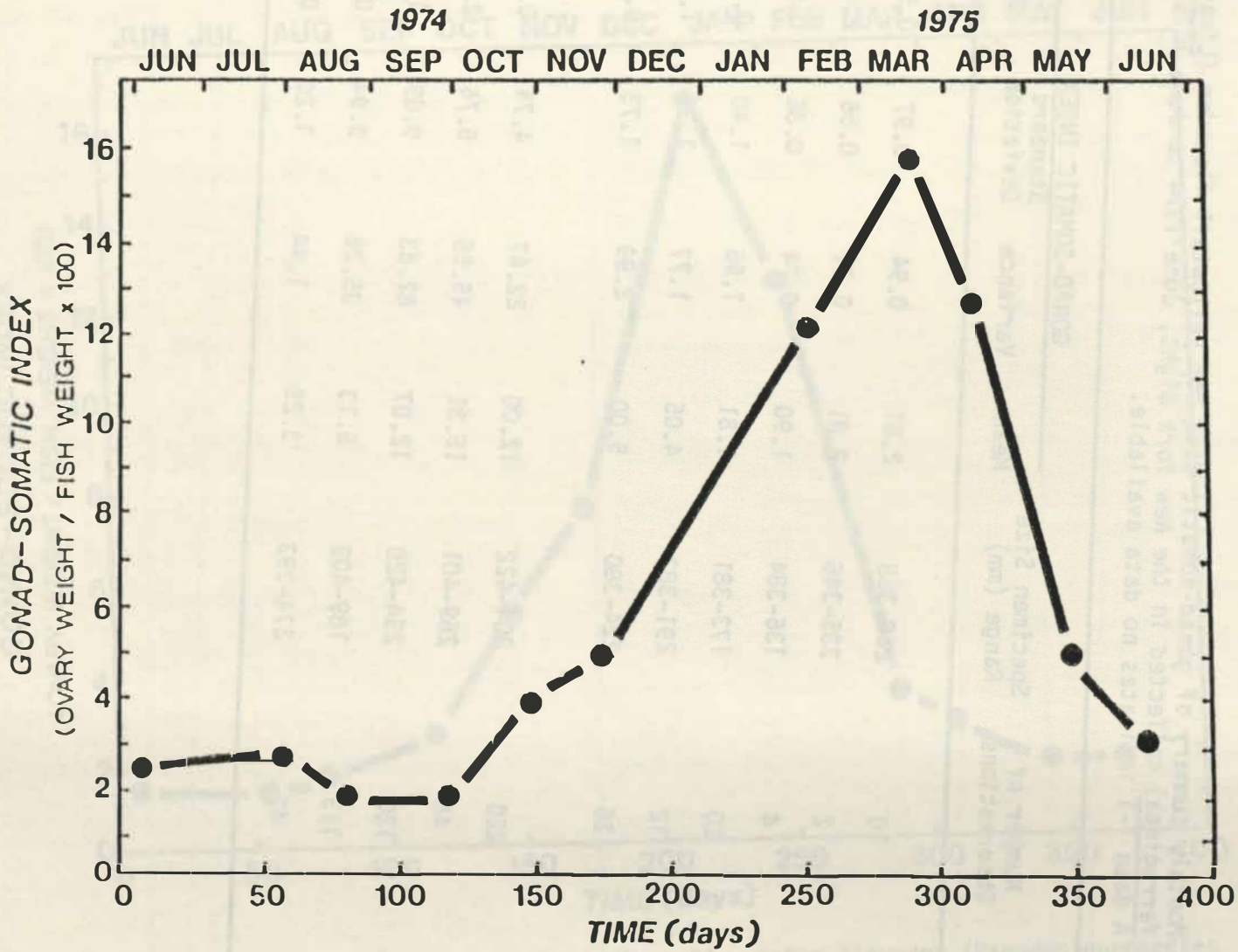

FIGURE 17. Monthly gonad-somatic indices for yellowtail flounder (Limanda ferruginea) collected in the New York Bight, June 1974 to June 1975.

TABLE 15. Monthly summary of gonad-somatic data for yellowtail flounder (*Limanda ferruginea*) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	10	268-368	2.61	0.94	0.97	0.58- 3.98
July	2	335-346	2.81	0.31	0.56	2.41- 3.21
August	4	136-384	1.90	0.74	0.86	0.96- 2.96
September	20	173-381	1.81	1.96	1.40	0.34- 3.94
October	12	291-382	4.05	1.77	1.33	1.38- 6.80
November	36	224-380	5.00	2.99	1.73	0.44- 8.21
1975						
February	220	204-422	12.00	22.47	4.74	0.39-23.85
March	48	269-401	15.81	45.56	6.75	2.25-27.09
April	120	254-420	12.87	82.63	9.09	0.47-30.23
May	113	189-409	5.13	35.28	5.94	0.26-27.04
June	47	274-393	3.28	1.44	1.20	0.39- 5.57

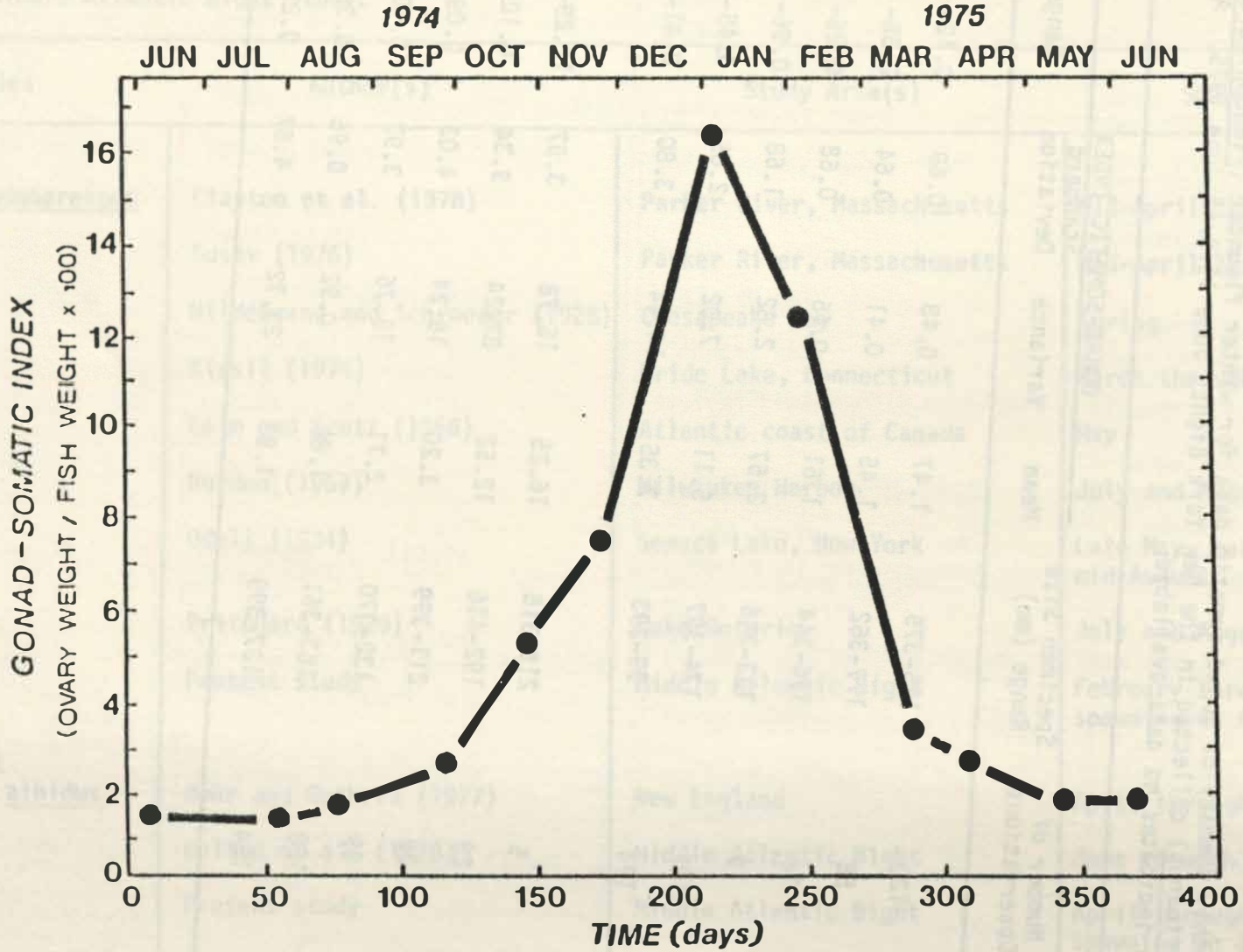

FIGURE 18. Monthly gonad-somatic indices for winter flounder (Pseudopleuronectes americanus) collected in the New York Bight, June 1974 to June 1975.

TABLE 16. Monthly summary of gonad-somatic data for winter flounder (*Pseudopleuronectes americanus*) collected in the New York Bight, June 1974 to June 1975. A dash (-) indicates no data available.

Survey Month	Number of Observations	Specimen Size Range (mm)	GONAD-SOMATIC INDEX			
			Mean	Variance	Standard Deviation	Range
1974						
June	120	175-375	1.47	0.48	0.69	0.42- 3.70
July	58	177-362	1.45	0.41	0.64	0.38- 3.06
August	16	196-344	1.61	0.46	0.68	0.26- 2.98
September	19	173-346	2.57	2.82	1.68	0.96- 6.16
October	107	174-397	5.11	7.02	2.65	0.45-12.48
November	174	99-393	7.35	14.44	3.80	0.41-17.21
1975						
January	5	218-316	16.25	15.78	3.97	12.29-21.40
February	128	192-416	12.52	87.24	9.34	0.18-28.77
March	35	211-399	3.20	16.24	4.03	0.09-21.27
April	89	132-370	2.71	15.76	3.97	0.48-20.84
May	158	163-361	1.80	0.92	0.96	0.36- 4.41
June	164	137-399	1.83	23.72	4.87	0.25- 3.91

TABLE 17. Summary of published literature relative to reproductive cycles as well as results of the 1974 to 1975 Middle Atlantic Bight study.

Species	Author(s)	Study Area(s)	Spawning Times
ALEWIFE *Alosa pseudoharengus*	Clayton et al. (1978)	Parker River, Massachusetts	Mid-April through June
	Gusey (1976)	Parker River, Massachusetts	Mid-April through June
	Hildebrand and Schroeder (1928)	Chesapeake Bay	Spring
	Kissil (1974)	Bride Lake, Connecticut	March through June
	Leim and Scott (1966)	Atlantic coast of Canada	May
	Norden (1967)	Milwaukee Harbor	July and August
	Odell (1934)	Seneca Lake, New York	Late May, early June, through mid-August
	Pritchard (1929)	Lake Ontario	July and August
	Present study	Middle Atlantic Bight	February through May; peak spawning in April
OFFSHORE HAKE *Merluccius albidus*	Rohr and Gutherz (1977)	New England	April through July
	Colton et al. (1978)	Middle Atlantic Bight	June through September
	Present study	Middle Atlantic Bight	April through August; peak spawning in June
SILVER HAKE *Merluccius bilinearis*	Bigelow (1917)	Gulf of Maine, Nova Scotia	June through September; peak spawning in July and August

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
SILVER HAKE (cont.)	Bigelow and Schroeder (1953)	1) Gulf of Maine: outer part of Nova Scotia to Sable Island	1) June through August
		2) Long Island	2) May, June and July
	Bigelow and Welsh (1925)	Gulf of Maine	June through October
	Clayton et al. (1978)	New England to Mid-Atlantic coast	Late spring and summer
	Colton et al. (1978)	1) Northeast Georges Bank and central Gulf of Maine	1) June through October; pea spawning in July and Augu
		2) Southern Georges Bank	2) May through October; peak spawning in May and June
		3) Nantucket Shoals - Virginia	3) June through December; pe spawning in June
	Colton and Temple (1961)	Georges Bank	May through July
	Fahay (1974)	Middle Atlantic shelf	May through November; peak spawning in June
	Herman (1963)	Narragansett Bay	June through September
	Hildebrand and Schroeder (1928)	New England Coast	June through October; peak spawning in July and August
	Leim and Scott (1966)	Middle Ground and Sable Island Bank, off Nova Scotia to off Cape May at the mouth of the Delaware Bay	June through September

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
SILVER HAKE (cont.)	Sarnits and Sauskan (1967)	West bar of Sable Island	June through August
	Present study	Middle Atlantic Bight	June through October; peak spawning in September
RED HAKE *Urophycis chuss*	Bigelow and Schroeder (1953)	Ipswich Bay	July
	Colton and Temple (1961)	Georges Bank	June through September
	Colton et al. (1978)	1) South Georges Bank, Nantucket Shoals	1) May through September; peak spawning in June and July
		2) Middle Atlantic Bight	2) May through October; peak spawning in June and July
	Gusey (1976)	Gulf of Saint Lawrence to North Carolina	June through September
	Hildebrand and Schroeder (1928)	1) Massachusetts Bay region	1) Early summer
		2) Southeastern Nova Scotia	2) June
	Leim and Scott (1966)	1) Southern Gulf of Saint Lawrence	1) Mid-summer
		2) Southeastern Nova Scotia	2) Early autumn
		3) Bay of Fundy	3) Winter or spring
	Musick (1969)	Northern part of Middle Atlantic Bight	May through September
	Perlmutter (1939)	Long Island waters	May through September
	Present study	Middle Atlantic Bight	June through September; peak spawning in August

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
SPOTTED HAKE *Urophycis regius*	Barans (1969)	Chesapeake Bight	October
	Barans and Barans (1972)	Mid-Atlantic Bight	Late September through Nover
	Bigelow and Schroeder (1953)	Coast of Carolinas	December
	Colton et al. (1978)	New York Bight-Cape Hatteras	January through May and Augu through December; peak spawn in October
	Present study	Middle Atlantic Bight	February through April; peal spawning in March and August through October; peak spawn in September
OCEAN POUT *Macrozoarces americanus*	Bigelow and Schroeder (1953)	Gulf of Maine	September and October
	Clayton et al. (1978)	1) Bay of Fundy	1) Mid-September through November
		2) New York-New Jersey	2) Late October through December
	Leim and Scott (1966)	Atlantic coast of Canada	Autumn
	Present study	Middle Atlantic Bight	August

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
BLACK SEA BASS *Centropristis striata*	Bean (1903)	Woods Hole area	June
	Bigelow and Schroeder (1953)	1) North Carolina coast	1) May
		2) Off New Jersey, Long Island, southern New England	2) Mid-May through June
	Hildebrand and Schroeder (1928)	1) North Carolina coast	1) May
		2) Chesapeake mouth	2) Late May
		3) New Jersey, Long Island, southern New England coasts	3) Mid-May through June
	Kendall (1977)	1) Chesapeake Bay	1) Late May
		2) Southern New England	2) Early summer
	Perlmutter (1939)	Long Island waters	Mid-May through June
	Present study	Middle Atlantic Bight	June through August
BUTTERFISH *Peprilus triacanthus*	Bigelow and Schroeder (1953)	Gulf of Maine	June through August; peak spawning in July
	Colton et al. (1978)	1) Southwest Georges Bank, Nantucket Shoals	1) May through August; peak spawning in June and July
		2) Middle Atlantic Bight	2) May through October; peak spawning in July and August

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
BUTTERFISH (cont.)	Croker (1965)	Sandy Hook Bay	July
	Herman (1963)	Narragansett Bay	May through August
	Hildebrand and Schroeder (1928)	Chesapeake Bay	June and July
	Kawhara (1978)	Gulf of Maine, Georges Bank, southern New England, Middle Atlantic Bight	April or May through August
	Leim and Scott (1966)	1) Gulf of Maine	1) June through August
		2) Saint Mary's Bay	2) July
	Murawski et al. (1978)	1) Chesapeake Bay	1) May through June
		2) Gulf of Maine	2) June through August; peak spawning in July
	Pearson (1941)	Chesapeake Bay	June and July
	Present study	Middle Atlantic Bight	May through August; peak spawning in June
NORTHERN SEAROBIN *Prionotus carolinus*	Bigelow and Schroeder (1953)	1) Woods Hole area	1) June through September; p spawning in July and Augu
		2) Off England coast	2) April and May
	Clayton et al. (1978)	Woods Hole, Massachusetts	June through September
	Colton et al. (1978)	Block Island to Cape Hatteras	May through November

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
NORTHERN SEAROBIN (cont.)	Herman (1963)	Narragansett Bay	June through August
	Hildebrand and Schroeder (1928)	1) Beaufort, North Carolina	1) Spring
		2) Woods Hole, Massachusetts	2) June through August
	Leim and Scott (1966)	Off New England	June through August
	Nichols and Breder (1926)	New York	June through August
	Roberts (1978)	1) Chesapeake Bight	1) July through September
		2) Woods Hole, Massachusetts	2) June through August
	Present study	Middle Atlantic Bight	April through August; peak spawning in July
STRIPED SEAROBIN *Prionotus evolans*	Herman (1963)	Narragansett Bay	June through August
	Perlmutter (1939)	Long Island	May through July
	Present study	Middle Atlantic Bight	May through August; peak spawning in June
SUMMER FLOUNDER *Paralichthys dentatus*	Bigelow and Schroeder (1953)	Eastern coast	Late autumn, winter, early spring
	Colton et al. (1978)	1) Nantucket Shoals - south	1) January through April and October through December
		2) Middle Atlantic Bight	2) January through April and September through December peak spawning in October

TABLE 17. (continued)

Species	Author(s)	Study Area(s)	Spawning Times
SUMMER FLOUNDER (cont.)	Gusey (1976)	Cape Cod, Massachusetts to Cape Lookout, North Carolina	September through November
	Leim and Scott (1966)	Cape Cod area	Early spring
	Smith (1973)	1) Northern part of Mid-Atlantic Bight	1) Early September through February
		2) Chesapeake Bay	2) Peak spawning in October
		3) South of Chesapeake Bay	3) Peak spawning in November
	Smith et al. (1975)	1) North of Chesapeake Bay	1) September through December
		2) South of Chesapeake Bay	2) November through February
	Present study	Middle Atlantic Bight	October through February
FOURSPOT FLOUNDER *Paralichthys oblongus*	Bigelow and Schroeder (1953)	Gulf of Maine, including Georges Bank	May through mid-July
	Colton et al. (1978)	1) Nantucket Shoals-south	1) May through July
		2) Middle Atlantic Bight	2) May through October; peak spawning in July
	Herman (1963)	Narragansett Bay	May
	Leonard (1971)	36°00' to 38°00' north latitude to 80 miles offshore, and Norfolk Canyon	June through August
	Present study	Middle Atlantic Bight	May through August; peak spawning in June

TABLE 17. (continued)

Species	Author(s)	Study Area(s)	Spawning Times
WINDOWPANE *Scophthalmus aquosus*	Bigelow and Schroeder (1953)	1) Gloucester	1) Late June
		2) Woods Hole, Massachusetts	2) May and June
		3) Long Island Sound	3) May through August
	Colton et al. (1978)	1) Georges Bank, Nantucket Shoals-south	1) May through August
		2) Middle Atlantic Bight	2) April through December; peak spawning in October
	Croker (1965)	Sandy Hook Bay	May and June
	Hildebrand and Schroeder (1928)	Gulf of Maine	Late spring and summer
	Leim and Scott (1966)	Gulf of Saint Lawrence	Late spring, early summer
	Perlmutter (1939)	Long Island waters	May through August
	Smith et al. (1975)	South of Chesapeake Bay	April through June
	Present study	Middle Atlantic Bight	Bimodal with peaks in May and September
YELLOWTAIL FLOUNDER *Limanda ferruginea*	Bigelow and Schroeder (1953)	Isles of Shoals-Boone	Mid-March through August
	Colton and Temple (1961)	Georges Bank	May through July
	Colton et al. (1978)	1) Browns Bank	1) May through July; peak spawning in June
		2) Middle Atlantic Bight	2) April through August; peak spawning in May and June

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
YELLOWTAIL FLOUNDER (cont.)	Gusey (1976)	General	Spring
	Hildebrand and Schroeder (1928)	New England coast	Summer
	Leim and Scott (1966)	1) Middle ground	1) June and early July
		2) Cape Cod	2) Mid-April through July
	Smith et al. (1975)	North Carolina to eastern tip of Long Island	March through June
	Present study	Middle Atlantic Bight	February through April; peak spawning in March
WINTER FLOUNDER *Pseudopleuronectes americanus*	Bigelow and Schroeder (1953)	1) New England	1) January through May; peak spawning in February and March
		2) Gulf of Maine-Booth Bay, Maine	2) March through May; peak spawning in March and April
	Colton et al. (1978)	Georges Bank	March through June
	Croker (1965)	Sandy Hook Bay	April through June
	Leim and Scott (1966)	1) South of Cape Cod	1) Late winter and spring; peak spawning in February and March
		2) Canadian waters	2) April and May

TABLE 17 (continued)

Species	Author(s)	Study Area(s)	Spawning Times
WINTER FLOUNDER (cont.)	Perlmutter (1939)	Long Island waters	Mid-December through May; peak spawning in January, February, and March
	Present study	Middle Atlantic Bight	November through March; peak spawning in January

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