1969

Investigation of potential for expansion of the industrial fishery of the Mid-Atlantic Bight : completion report of project Virginia 3-5-D

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Recommended Citation

Davis, J., & et al. (1969) Investigation of potential for expansion of the industrial fishery of the Mid-Atlantic Bight : completion report of project Virginia 3-5-D. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.25773/jj26-q787

COMMERCIAL FISHERIES RESEARCH AND DEVELOPMENT ACT

COMPLETION REPORT

OF

PROJECT VIRGINIA 3-5-D

INVESTIGATION OF POTENTIAL FOR EXPANSION OF THE INDUSTRIAL FISHERY OF THE MID-ATLANTIC BIGHT

1968-1969.

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PHASE 1

DETERMINATION OF DIEL AVAILABILITY OF SEAROBINS

Northern and striped searobins were caught both in the day and at night as was the case in winter. Northern searobins were caught in 65% of the daylight tows and 71% of the night tows. Striped searobins were caught in 35% of the daylight tows and 29% of the night tows.

That northern searobin do, on occasion, rise from the bottom was indicated by our work of May 23. Between 1430 and 1600 two tows near 37° 10' N, 75° 40' W yielded 1475 pounds and 1000 pounds. We returned to the area after dark and caught only 150 pounds in the first tow and 8 in the second. The echo-sounder indicated appreciable quantities of fish above the bottom at night. During the day some fish had been above the bottom, but the major concentration was available to a trawl.

PHASE 2

INTERVIEW AND OBSERVATION

Information concerning the distribution of fish and the quantities available was obtained throughout the winter and spring seasons in 42 interviews with 13 captains. Additional information was obtained by three project personnel who spent a total of 50 days at sea on commercial trawlers. They obtained data on 173 tows. During the winter months the fleet worked predominately in the southern quarter of the project area. In April the fleet moved north out of our area of study. Sea robins were reported as readily available in offshore waters (30-50 fm) during the winter months and from inshore waters (6-10 fm) during the spring and summer months. Spiny dogfish were reported as unusually abundant this winter with one observer reporting a catch of 70,000 lbs in 1 day.

Since there is virtually no fishing effort by trawlers south of Chesapeake Bay during the summer months, there is a paucity of information concerning distribution and abundance of fish in this area.

PHASE 3

DESIGN OF SAMPLING PLAN AND PROCUREMENT OF CHARTER VESSEL

The sampling program was designed to devote the first year to describing the distribution of fishes and the second year to assessing their availability. The distribution of sampling stations was based on information obtained in Phase 2 and on a survey of the literature. The number of stations was largely determined by the amount of vessel time and by weather conditions. The sampling scheme for the second year was based on the data collected in the first year. Details of the sampling patterns, including position of each station, kind of gear used, hydrographic and biological data, are presented under the appropriate phase reports which follow.

We made inquiries about the charter of more than 10 vessels. Prices asked for a month's charter ranged from $20,000 to $6,000. Some of the vessels were too small or inadequately equipped. We contracted with the Wilton Trawling Corporation for the 92 foot trawler SEA BREEZE on a trial basis for the first survey. The vessel proved satisfactory and was subsequently chartered for the remaining work.

PHASE 4

WINTER DISTRIBUTION OF FISHES

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WINTER DISTRIBUTION OF FISHES

The portion of the continental shelf under investigation extends from the region of Cape May-Wilmington Canyon to Cape Hatteras, an area of approximately 10,600 square miles. In the winter of 1966 the quantities of spiny dogfish and northern searobin in the southern portion of the area were encouraging from the standpoint of developing a bottom trawl fishery. Squirrel hake, spotted hake, and silver hake were less abundant than dogfish and searobin, but probably could contribute significant quantities to a fishery based on some other species. These conclusions are based on data from only one cruise, and therefore are subject to revision. We trawled at 52 stations and each trawl tow covered one millionth of the project area (about 31,000 square yards). Depths sampled were from 10 to 100 fathoms but more samples were obtained from the 30-50 fathom range than from other depths. Surface and bottom temperatures and salinities were routinely collected before commencement of the trawling operation on each of the 52 stations.

We did not sample the midwaters, but the echo sounder was used to detect presence or absence of fish above the bottom. Such traces were arbitrarily rated as none, slight, moderate, and heavy. Of the 52 stations, 17% had no indication of midwater fish, 54% had slight indications, 13% had moderate indications, and 4% had heavy indications. Collections of species in the midwaters for identification was not feasible with our gear, but we assume that silver hake, Atlantic mackerel, and various species of *Alosa* were among the species accounting for the traces on the echo sounder.

Sampling gear used was a semiballoon trawl having a headrope 45 feet long and footrope 56 feet long. The net was composed of nylon netting of the following mesh and thread sizes: body, 1-3/4" stretch mesh #15 thd.; intermediate, 1-1/2" stretch mesh #18 thd.; codend, 1-9/16" stretch mesh #30 thd.; codend interliner, 1/2" stretch mesh #126 thd. The trawl was fished on a bridle in an attempt to reduce change in net configuration resulting from change in ratio of water depth to length of towing warp. A swivel at the end of the warp was necessary to prevent twisting of the bridle. Tows were of 30 minutes duration. We have not yet attempted to relate catches in these short tows with a small net to the production of larger commercial-scale gear.

In this report we present a summary of the results of our first winter cruise. We have not incorporated information available from other sources nor have we attempted to compare our data with those of others. At this point in the investigation we feel that conclusions concerning the potential of the various species would be premature. Distribution of most of the species changes seasonally. Some kinds that were common in winter will be scarce in other seasons, and conversely, some species taken only rarely in winter will be common in other seasons. Summarized below are data concerning distribution and abundance of fishes. The order in which the species are discussed is not intended to imply potential commercial status except that the four species of greatest importance in the winter trawl fishery of the Mid-Atlantic Bight are listed last. Table 1 summarizes frequency of occurrence, depth range, temperature range, and largest catch for the more abundant species. Of the 50 species caught, the 24 occurring in 5 or fewer samples are listed in Table 2 and will not be further discussed in this report.

SPINY DOGFISH

The most frequently caught fish, the spiny dogfish, Squalus acanthias, occurred in 42 samples and in all depth and temperature ranges. However, the major concentration was in the southern sector of the sampling area. South of 36° N latitude the average catch of adults in 6 tows was 139 (445 pounds). Between 36° N and 37° N the average catch in 15 tows was 13 adults (42 pounds). Between 37° N and 38° N the average of 18 tows was 9 (29 pounds) and north of 38° N the average was 4 (13 pounds) in 11 tows. Although dogfish were caught throughout the range of depths and temperatures samples, they were most abundant shoreward of the 50 fathom curve and in the 6° to 8° C (43° - 46° F) temperature range. The largest catch in a tow was 2000 pounds; In 8 tows the catch was 100 pounds or more. Distribution of young overlapped that of adults considerably, but young were scarce in water shallower than 30 fathoms.

NORTHERN SEAROBIN

Northern searobin, Prionotus carolinus, occurred in 38 samples from depths ranging from 12 to 100 fathoms and temperatures ranging from 5° to 9° C (41°-48° F). However, all catches of 25 pounds or more per tow were made at temperatures of 6 or 7° C and depths between 20 and 50 fathoms. The largest catch in a tow was 2550 pounds. Three catches were between 1000 and 2000 pounds and 5 catches were between 100 and 1000 pounds. Two concentrations of northern searobins were indicated by the distribution of catches of 100 pounds or more per tow. One of these concentrations occurred at depths of 38 to 50 fathoms between 37° 27' N and 37° 55' N. The other concentration was at 20 to 50 fathoms between 35° 59' N and 36° 29' N. The northern searobin was found in small numbers over the entire sampling area. Young were taken in 7 tows, all in water shoaler than 50 fathoms. The distribution of the young extensively overlapped that of the adults.

STRIPED SEAROBIN

The striped searobin, *Prionotus evolans*, was less abundant than the northern searobin and not so generally distributed. The striped form occurred in 11 samples taken from depths ranging from 18 to 61 fathoms. Temperature range was 6° to 8° C (43° - 46° F). The largest catch was 34 adults and 2 juveniles. The northernmost station of occurrence was 61 fathoms at 38° 02' N and the southernmost was 18 fathoms at 35° 39' N. Young occurred in but 3 tows, all on bottoms shoaler than 40 fathoms.

SILVER HAKE

Also known as whiting, the silver hake, *Merluccius bilinearis*, was caught at 32 stations through a depth range of from 11 to 100 fathoms and a temperature range of 4° to 12° C (39° - 54° F). Silver hake were somewhat more abundant in the northern sector of the sampling area, all catches of 10 or more per tow (10 tows) being made north of 37° N latitude. In 5 tows the catch was 25 or more individuals and the maximum catch in a tow was 325 pounds. Young occurred most frequently in water shoaler than 25 fathoms, whereas adults occurred mostly in deeper water.

SQUIRREL HAKE

The squirrel hake, *Urophycis chuss*, is commonly called red hake and ling. It occurred in 33 samples encompassing a depth range of from 13 to 100 fathoms and a temperature range of 4° to 8° C (39° - 46° F). The maximum catch in a tow was 100 pounds. All catches of 10 or more adults per tow were north of 37° N latitude and young were taken only north of that parallel. Distributions of young and adults overlapped considerably, but young were not caught in water deeper than 40 fathoms. Adults were more abundant at depths greater than 30 fathoms than in shoaler waters.

SPOTTED HAKE

The spotted hake, or ling, *Urophycis regius*, was caught in 26 tows spanning a depth range of 12 to 98 fathoms and a temperature range of 4° to 12° C (39° - 54° F). The largest catch in a tow was 28 pounds. This species was rarely caught north of 37° N latitude and seems to replace the squirrel hake in the southern portion of the project area. Young were not caught deeper than 30 fathoms, but adults seemed to occur rather generally through the range of depths sampled.

ALEWIFE

The alewife, *Alosa pseudoharengus*, one of the river herrings, was caught in 8 tows ranging in depth from 11 to 50 fathoms and in temperature from 4° to 7° C (39° - 45° F). Probably our otter trawl catches are inadequate to indicate the distribution of the pelagic alewife. Young were taken in depths to 26 fathoms and adults were most abundant in the same range. Sampling with a midwater trawl will be necessary to ascertain the distribution and abundance of this species.

BLUEBACK

Also known as glut herring, *Alosa aestivalis*, is similar to the alewife. Probably our samples are not representative of occurrence of this pelagic species. Juvenile blueback were taken in 6 tows in depths ranging from 11 to 30 fathoms from 38° 17' N to 36° 18' N. Temperature range was 4° to 7° C (39° - 45°F). Adults were taken in only one sample.

ATLANTIC HERRING

The Atlantic herring, *Clupea harengus*, like the river herrings, is primarily a pelagic fish and was inadequately sampled with our otter trawl. Nevertheless, the species was represented in 14 catches. The maximum catch in a tow was 115 pounds. Distribution was general inside the 50 fathom contour from the northern limit of the project area to 36° N latitude. Temperature ranged from 4° to 7° C (39°-45° F). Only two juveniles were caught.

ATLANTIC MACKEREL

The 15 samples containing mackerel, *Scomber scombrus*, were obtained at 50 fathoms or less south of 37° 30' N. The temperature range was 6° to 12° C (43°-54° F). Greatest abundance was in about 20 fathoms at 7° C. The largest catch was 55 fish. Young were taken at 3 stations at depths of 30, 40, and 50 fathoms. Midwater trawling will be necessary to assess the true distribution and abundance of this species.

WINTER FLOUNDER

More generally known as blackback, *Pseudopleuronectes americanus*, occurred in 7 catches shoaler than 35 fathoms north of 36° 45' N. Temperature range was 4° to 6° C (39°-43° F). The largest number in a tow was 15 weighing less than 10 pounds. Young were not caught.

YELLOWTAIL FLOUNDER

The yellowtail, *Limanda ferruginea*, occurred in 6 of 12 samples north of 38° N latitude. Depth range was 19 to 44 fathoms; temperature range, 5° to 8° C (41°-46° F). Both young and adults were caught, but the largest catch was only 4 individuals.

WINDOWPANE

The windowpane, or daylight flounder, *Scophthalmus aquosus*, occurred in water shoaler than 25 fathoms south of 38° N latitude. Temperature range was 4° to 7° C (39°-45° F). The largest catch was 21 fish weighing less than 10 pounds. Young were not caught.

CLEARNOSE SKATE

The clearnose skate, *Raja eglanteria*, occurred in 8 samples, all taken south of 37° 32' N. The depth range was 12 to 52 fathoms, and the temperature range 5° to 7° C (41°-45° F). The largest catch was 8 adults. Young were not caught.

LITTLE SKATE

The little skate, *Raja erinacea*, occurred from the northern edge of the sampling area south to 36° 31' N latitude but was not abundant. The largest catch was 3 adults and 10 young, and only 9 samples included this species. Depth range was 12 to 47 fathoms and temperature range was 4° to 7° C (39°-45° F). Distribution of young and adults overlapped.

OCEAN POUT

The ocean pout, *Macrozoarces americanus*, occurred in 8 samples distributed from the northern edge of the sampling area south to 36° 11' N latitude. Depth range was 26 to 50 fathoms and temperature range was 6° to 8° C (43°-46° F). The largest catch was 19 adults and 4 young. Young were caught twice and were associated with adults on both occasions.

FAWN CUSK-EEL

The fawn cusk-eel, *Lepophidium cervinum*, was caught at 7 stations all north of 37° N latitude. The largest catch was 23 adults but since this species is small, the total weight was less than two pounds.

FOURSPOT FLOUNDER

This small flounder, *Paralichthys oblongus*, occurred rather generally north of 36° N latitude between 20 and 100 fathoms, but all catches of 10 or more per tow were made between 40 and 60 fathoms. Temperature range of the 27 samples containing this species was 6° to 9° C (43°-48° F). The largest catch was 70 adults having a total weight of approximately 20 pounds.

GOOSEFISH

The goosefish, or angler, *Lophius americanus*, occurred in 18 samples encompassing the entire range of depths and temperatures encountered. Although generally distributed throughout the area, the goosefish was not numerous. The largest catch was 9 adults having a total weight of approximately 35 pounds.

GULFSTREAM FLOUNDER

Since the length of the Gulfstream flounder, *Citharichthys arctifrons*, is only about 6 inches, this fish has little commercial potential. This species occurred in 15 samples taken in depths ranging from 20 to 98 fathoms and from the northern extent of our coverage south to 36° 19' N latitude. Temperature range was 6° to 8° C (43°-46° F).

SCUP

The scup, or porgy, *Stenotomus chrysops*, was caught in 12 tows, only 3 of which were north of 37° N latitude. Depth range was 13 to 61 fathoms and temperature range 6° to 9° C (43°-48° F). Distribution of young and adults overlapped rather widely. The largest catch in a tow was 98.

BLACK SEABASS

Adult black seabass, Centropristes striatus were caught mostly along the 50 fathom contour from 37° 32' N to the southern limit of the sampling area. Temperatures were 6° to 9° C (43°-48° F). Young were caught in depths of 12 to 40 fathoms from 36° N latitude to the northern limit of the sampling area. Temperatures ranged from 5° to 7° C (41° to 45° F). The largest catch of young was 7 fish while the largest catch of adults was 176 fish weighing 100 pounds.

SUMMER FLOUNDER

The summer flounder or fluke, Paralichthys dentatus, was caught at 32 stations in depths ranging from 12 to 100 fathoms. It was distributed throughout the sampling area at depths of 50 fathoms and less, but was caught at only one deeper station. The largest catch was 14 adults. Young were not caught.

BUTTERFISH

The butterfish, Poronotus triacanthus, occurred in 23 samples generally distributed throughout the area in all depths and temperatures. The largest catch was 450 pounds, but in only 4 other samples did the catch of adults number 10 or more. Distribution of young did not differ from that of adults.

TABLE 1

DISTRIBUTIONAL DATA FOR MORE ABUNDANT SPECIES, WINTER 1966

SPECIES	FREQUENCY OF OCCURRENCE (%)	DEPTH RANGE (FATHOMS)	TEMP. RANGE (°C)	MAXIMUM CATCH NO. ADULT	NO. LBS.
Squalus acanthias	80.7	12-100	4-12	606	2,000
Prionotus carolinus	73.1	12-100	5-9	-	2,550
Prionotus evolans	21.2	18-61	6-8	36	-
Merluccius bilinearis	61.5	11-100	4-12	-	325
Urophycis chuss	63.5	13-100	4-8	-	100
Urophycis regius	50.0	12-98	4-12	-	28
Alosa pseudoharengus	15.4	11-50	4-7	26	-
Alosa aestivalis	11.5	11-30	4-7	1	-
Clupea harengus	26.9	11-49	4-7	188	115
Scomber scombrus	23.8	12-50	6-12	55	-
Pseudopleuronectes americanus	13.5	11-33	4-6	-	<10
Limanda ferruginea	11.5	19-44	5-8	4	-
Scophthalmus aquosus	15.4	12-22	4-7	21	-
Raja eglanteria	15.4	12-52	5-7	8	-
Raja erinacea	17.3	12-47	4-7	3	-
Macrozoarces americanus	15.4	26-50	6-8	19	-
Lepophidium cervinum	13.5	20-100	4-6	23	-
Paralichthys oblongus	51.9	20-100	6-9	70	20
Lophius americanus	34.6	20-100	4-12	9	35
Citharichthys arctifrons	28.8	20-98	6-8	17	-
Stenotomus chrysops	23.1	13-61	6-9	98	-
Centropristes striatus	28.8	12-100	5-9	176	100
Paralichthys dentatus	61.5	12-100	4-12	14	-
Poronotus triacanthus	44.2	12-100	4-12	450	-

PHASE 4

TABLE 2

SPECIES OCCURRING RARELY IN OTTER TRAWL CATCHES IN THE SOUTHERN MID-ATLANTIC BIGHT IN WINTER, 1966

COMMON NAME	SCIENTIFIC NAME
Gray seatrout	*Cynoscion regalis*
Atlantic cod	*Gadus morhua*
White hake	*Urophycis tenuis*
American shad	*Alosa sapidissima*
Atlantic menhaden	*Brevoortia tyrannus*
Haddock	*Melanogrammus aeglefinus*
Myxine	*Myxine glutinosus*
Bay anchovy	*Anchoa mitchilli*
Atlantic silverside	*Menidia menidia*
Chain dogfish	*Scyliorhinus retifer*
Atlantic angel shark	*Squatina dumerili*
Winter skate	*Raja ocellata*
Rosette skate	*Raja garmani*
Skates	*Raja* sp.
Atlantic torpedo	*Torpedo nobiliana*
Conger eel	*Conger oceanicus*
Blackbelly rosefish	*Helicolenus dactylopterus*
Armored searobin	*Peristedion miniatum*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Smallmouth flounder	*Etropus microstomus*
Seasnail	*Liparis atlanticus*
Sea raven	*Hemitripterus americanus*
Snake eel	*Cnochelys cruentifer*
	Chlorophthalmus chalybeius

PHASE 5

SPRING DISTRIBUTION OF FISHES

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PHASE 5

SPRING DISTRIBUTION OF FISHES

During the period from May 6 through May 24, 1966 we sampled 71 stations on the continental shelf between the region of Cape May - Wilmington Canyon and Oregon Inlet. Gear and procedure were as indicated in the progress report for the winter quarter. Depths sampled ranged from 6 to 100 fathoms with most stations being inshore of the 40 fathom curve. Tables 1 and 2 list the stations sampled in spring and winter respectively. Species caught numbered 46 of which the 21 listed in Table 3 comprised a relatively insignificant proportion of the catch and will not be discussed in this report. For the remaining 25 species, distribution with regard to depth, latitude, and temperature is summarized in the following paragraphs and magnitude of catch is usually indicated. The order in which the species are discussed is not intended to imply potential commercial status except that the four species of greatest importance in the winter trawl fishery of the Mid-Atlantic Bight are listed last. Relationship between catch in our small trawl and catch to be expected in full scale gear is not known.

Collection of samples from the midwaters was not feasible with our gear, but the echo-sounder indicated presence or absence of fish above the bottom. Indications of fish in the midwaters were arbitrarily rated as none, light, moderate, or heavy at each station. Of the 71 stations, 7% were rated none, 59% were rated light, 31% moderate, and 3% heavy.

In spring the area north of 37° N lat. and shoreward of the 30 fathom contour appeared to offer the greatest promise for a fishery as a result of concentrations of northern searobin and lesser numbers of several other species. Generally distributed through the survey area were several species having apparent commercial potential, but we found no appreciable concentrations.

Table 1. Station list, spring 1966

Station no.	Date	Latitude	Longitude	Depth (fathoms)	Temperature at bottom C	Salinity at bottom	Time of day	Midwater fish*	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)
T311	06MAY66	3641N	7542W	[illegible]	13C	32S	06.4	LT	3	16	10	66	30
T312	06MAY66	3623N	7544W	010	12C	32S	09.4	MD	1	2	11	240	29
T313	06MAY66	3611N	7532W	016	12C	33S	12.4	LT	1	20	10	100	29
T314	06MAY66	3602N	7532W	010	14C	32S	15.2	LT	1		10	58	29
T315	06MAY66	3551N	7527W	010	14C	31S	18.0	LT	2	6	10	312	30
T316	07MAY66	3556N	7517W	015	12C	33S	02.1	MD	4	2	9	40	30
T317	07MAY66	3551N	7507W	020	15C	34S	04.2	LT	1	2	9	154	30
T318	07MAY66	3550N	7456W	040	11C	34S	06.2	LT	2	4	7	112	30
T319	07MAY66	3607N	7456W	030	08C	33S	09.5	MD	1	2	7	36	30
T320	07MAY66	3612N	7508W	020	11C	33S	11.9	NO	1		6	4	30
T321	07MAY66	3632N	7508W	016	11C	33S	15.2	NO	3	2	6	52	29
T322	07MAY66	3627N	7456W	020	09C	33S	17.3	LT	1	2	8	94	30
T323	07MAY66	3626N	7449W	049	12C	34S	19.3	MD	2	104	14	84	30
T324	07MAY66	3635N	7457W	022	10C	33S	21.2	MD	2	6	9	62	30
T325	08MAY66	3642N	7443W	050	12C	35S	04.8	LT	2	17	12	33	30
T326	08MAY66	3643N	7448W	030	12C	35S	06.6	MD	2	6	9	70	30
T327	08MAY66	3647N	7505W	018	12C	33S	09.0	LT	2	10	7	64	30
T328	08MAY66	3703N	7451W	030	11C	34S	12.2	LT	1	2	9	140	30
T329	08MAY66	3710N	7441W	050	12C	34S	14.5	MD	1	8	7	32	30
T330	08MAY66	3719N	7431W	070	12C	35S	17.3	LT	2	4	10	82	30
T331	08MAY66	3733N	7419W	100	14C	35S	20.8	NO	1	4	11	200	30
T332	08MAY66	3730N	7431W	040	10C	34S	23.5	LT	2	10	10	262	30
T333	09MAY66	3719N	7444W	020	09C	34S	05.4	MD	2	2	7	54	29
T334	09MAY66	3702N	7508W	022	09C	33S	09.5	LT	3	8	6	56	30
T335	09MAY66	3707N	7520W	016	11C	33S	11.5	LT					30
T336	09MAY66	3652N	7530W	015	13C	32S	14.9	LT	3	22	8	54	29
T337	09MAY66	3648N	7540W	013	13C	32S	16.3	LT	3	2	5	6	30
T338	09MAY66	3645N	7551W	010	14C	32S	17.8	LT	2	2	2	4	29

Table 1. (Continued)

T339	12MAY66	3708N	7541W	008	15C	31S	16.8	LT	3	6	8	296	30
T340	12MAY66	3722N	7533W	008	14C	32S	19.2	LT	3	6	7	126	30
T341	12MAY66	3732N	7524W	010	14C	32S	21.5	MD	3	8	9	172	30
T342	12MAY66	3739N	7520W	009	14C	32S	22.9	MD	2	8	10	262	30
T343	13MAY66	3754N	7514W	008	14C	31S	05.9	LT	3	22	12	236	30
T344	13MAY66	3801N	7507W	010	13C	31S	07.8	LT	4	26	11	316	30
T345	13MAY66	3812N	7506W	016	14C	31S	09.6	MD	2		12	304	29
T346	13MAY66	3828N	7454W	017	14C	31S	13.0	HV	4	38	11	175	29
T347	13MAY66	[illegible]	7447W	010	13C	31S	15.6	MD	2	4	8	120	30
T348	13MAY66	[illegible]	7437W	016	12C	32S	17.5	MD	1	2	10	244	30
T349	13MAY66	3833N	7430W	[illegible]	11C	[illegible]	19.5	LT			14	516	31
T350	13MAY66	3826N	7437W	015	11C	32S	21.3	HV	2	6	14	176	30
T351	13MAY66	3817N	7436W	020	10C	33S	23.6	MD			1	2	29
T352	14MAY66	3812N	7444W	012	11C	32S	06.2	MD	2	6	6	150	30
T353	17MAY66	3738N	7437W	030	10C	33S	07.2	LT	1	2	5	14	30
T354	17MAY66	3752N	7415W	050	10C	33S	10.8	NO	1		6	20	29
T355	17MAY66	3801N	7401W	060	11C	33S	13.7	NO					30
T356	17MAY66	3814N	7355W	040	11C	34S	16.5	LT			7	10	30
T357	17MAY66	3822N	7407W	[illegible]	10C	33S	18.9	MD			8	238	30
T358	17MAY66	3806N	7415W	030	10C	33S	21.5	LT			7	18	30
T359	17MAY66	3759N	7423W	031	09C	33S	23.5	LT					30
T360	18MAY66	3757N	7436W	021	11C	32S	06.6	LT	1	4	9	64	29
T361	18MAY66	3754N	7452W	017	11C	32S	09.2	LT	2	2	7	94	30
T362	18MAY66	3744N	7448W	020	12C	33S	10.9	LT			9	56	30
T363	18MAY66	3737N	7456W	016	12C	32S	12.9	LT			1		30
T364	18MAY66	3727N	7454W	018	13C	33S	14.7	LT	1	2	5	68	31
T365	18MAY66	3712N	7458W	020	12C	33S	17.7	LT			2	4	29
T366	18MAY66	3721N	7505W	015	13C	32S	19.7	LT	2	4	12	74	29
T367	19MAY66	3703N	7535W	010	14C	32S	10.1	LT	4	2	7	182	30
T368	19MAY66	3702N	7547W	006	14C	31S	12.1	LT			1		30
T369	23MAY66	3708N	7540W	007	14C	31S	14.6	MD	1		5	3054	29
T370	23MAY66	3710N	7538W	007	14C	31S	15.4	LT	2	20	5	2104	29
T371	23MAY66	3710N	7539W	007	14C	31S	16.0	LT			1	50	30
T372	23MAY66	3707N	7543W	008	14C	31S	18.0	MD	2		5	582	30
T373	23MAY66	3709N	7440W	007	14C	31S	20.1	MD					30
T374	23MAY66	3711N	7538W	007	14C	31S	21.0	MD	2	8	11	384	28
T375	23MAY66	3719N	7533W	009	13C	32S	22.8	LT	1		1	16	30
T376	24MAY66	3725N	7527W	007	14C	31S	07.0	LT	3	74	9	98	27
T377	24MAY66	3741N	7526W	008	13C	31S	08.1	LT	2	4	1	4	30
T378	24MAY66	3747N	[illegible]	010	13C	31S	10.5	HV			1		30
T379	24MAY66	3743N	7512W	011	13C	31S	11.9	MD					30
T380	24MAY66	3724N	7517W	012	12C	32S	14.3	MD					30
T381	24MAY66	3729N	7512W	017	11C	32S	16.2	LT	2	6	6	216	30

* NO = none   MD = moderate
LT = light   HV = heavy

PHASE 5

Table 2. Station list, winter 1966

Station no.	Date	Latitude	Longitude	Depth (fathoms)	Temperature at bottom C	Salinity at bottom	Time of day	Midwater fish*	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)
T200	16FEB66	3647N	7542W	011	04C	32S	17.7	LT	1		9	124	30
T201	17FEB66	3722N	7526W	013	04C	32S	14.0	NO			5		30
T202	17FEB66	3742N	7501W	015	04C	33S	19.0	MD			11		30
T203	17FEB66	3801N	7439W	019	05C	33S	22.9	LT			10		30
T204	18FEB66	3817N	7418W	026	06C	33S	03.0	HV	1		16		30
T205	18FEB66	3822N	7406W	033	06C	33S	05.2	LT	1		13		30
T206	18FEB66	3822N	7406W	032	06C	33S	10.0	MD			8	244	30
T207	18FEB66	3833N	7333W	044	08C	34S	12.0	MD	2	10	8	72	30
T208	18FEB66	3826N	7334W	050	07C	34S	13.6	LT	2		8	24	30
T209	18FEB66	3821N	7336W	078	08C	34S	16.0	NO	1		11	148	30
T210	18FEB66	3821N	7349W	042	07C	34S	18.1	MD					30
T211	18FEB66	3818N	7351W	047	07C	34S	19.7	LT	2	36	12	206	30
T212	18FEB66	3809N	7401W	041	07C	34S	22.6	MD	3		9	140	30
T213	19FEB66	3802N	7401W	061	08C	34S	01.3	LT	2		10		30
T214	19FEB66	3759N	7358W	098	08C	34S	03.4	NO			10	114	30
T215	24FEB66	3706N	7446W	048	06C	33S	03.9	MD			6	50	30
T216	24FEB66	3650N	7448W	029	06C	33S	07.4	MD	4	12	5	152	31
T217	24FEB66	3652N	7446W	039	06C	33S	09.6	LT	1	28	6	72	30
T218	24FEB66	3643N	7442W	[illegible]	07C	34S	12.0	LT	3	6	4	90	30
T219	24FEB66	3638N	7447W	034	06C	33S	13.8	MD	2	18	7	50	30
T220	24FEB66	3629N	7449W	040	06C	33S	15.8	LT	1		3	1950	30
T221	24FEB66	3625N	7450W	050	06C	33S	17.7	MD	4	116	15	636	30
T222	24FEB66	3631N	7500W	020	05C	33S	20.7	MD	2		11		30
T223	02MAR66	3625N	7531W	012	06C	33S	14.8	LT	2		10		30
T224	02MAR66	3602N	7523W	013	07C	33S	19.9	HV	2		14		30
T225	02MAR66	3539N	7508W	018	07C	34S	23.5	MD	3	900	9		30

Table 2. (Continued)

T226	03MAR66	3521N	7454W	030	12C	34S	09.1	MD	3		8		30
T227	03MAR66	3526N	7454W	049	08C	34S	10.5	NO	4		4	4000	30
T228	03MAR66	3533N	7451W	042	08C	33S	12.0	LT					31
T229	03MAR66	3547N	7452W	049	09C	33S	14.6	LT	4		5		30
T230	03MAR66	3553N	7454W	040	07C	34S	16.1	LT	2		5		30
T231	03MAR66	3559N	7507W	020	07C	33S	18.0	LT	3		6	2500	30
T232	03MAR66	3601N	7457W	030	06C	33S	19.5	MD			1	100	30
T233	03MAR66	3705N	7449W	050	08C	33S	20.9	NO			4		30
T234	03MAR66	3611N	7452W	040	08C	34S	22.3	HV	2		9	400	30
T235	03MAR66	3616N	7455W	030	07C	33S	23.5	HV	1		8	5100	30
T236	04MAR66	3619N	7509W	020	07C	32S	02.2	LT	1		7	150	30
T237	04MAR66	3649N	7455W	020	06C	33S	07.0	LT	1		1		30
T238	11MAR66	3710N	7446W	041	06C	33S	22.0	LT	2		11	60	30
T239	11MAR66	3719N	7434W	050	07C	34S	4	NO	3	24	11	10	30
T240	11MAR66	3732N	7427W	032	07C	33S	02.9	LT	4	106	12	170	30
T241	11MAR66	3732N	7420W	100	07C	34S	04.7	NO	2	12	12	1004	30
T242	11MAR66	3728N	7424W	038	06C	34S	07.0	MD	1		5	2750	30
T243	11MAR66	3747N	7415W	050	07C	34S	09.6	LT			2	1000	30
T244	11MAR66	3755N	7414W	041	07C	34S	10.9	LT	1		5	3600	30
T245	11MAR66	3803N	7416W	032	06C	33S	12.8	LT			9	100	30
T246	11MAR66	3749N	7429W	030	06C	33S	16.0	NO	1		2		30
T247	11MAR66	3732N	7439W	030	06C	33S	19.4	MD			9		30
T248	11MAR66	3727N	7434W	039	07C	33S	21.3	HV	3		10	176	30
T249	11MAR66	3717N	7445W	030	06C	33S	23.7	LT	2		9		30
T250	12MAR66	3714N	7457W	020	06C	33S	01.5	LT	1		10		30
T251	12MAR66	3703N	7505W	022	06C	33S	04.0	MD	1		11		30

* NO = none MD = moderate
LT = light HV = heavy

TABLE 3

Species occurring rarely in otter trawl catches in the southern mid-Atlantic Bight in spring 1966.

COMMON NAME	SCIENTIFIC NAME
American shad	Alosa sapidissima
Armored searobin	Peristedion miniatum
Atlantic angel shark	Squatina dumerili
Atlantic cod	Gadus morhua
Atlantic mackerel	Scomber scombrus
Atlantic torpedo	Torpedo nobiliana
Blackbelly rosefish	Helicolenus dactylopterus
Chain dogfish	Scyliorhinus retifer
Fawn cusk-eel	Lepophidium cervinum
Gray seatrout	Cynoscion regalis
Longhorn sculpin	Myoxocephalus octodecemspinosus
Atlantic hagfish	Myxine glutinosa
Sea herring	Clupea harengus
Sea raven	Hemitripterus americanus
Smallmouth flounder	Etropus microstomus
Snake eel	Omochelys cruentifer
Striped anchovy	Anchoa hepsetus
Striped cusk eel	Rissola marginata
White hake	Urophycis tenuis
Winter skate	Raja ocellata
Witch flounder (Gray sole)	Glyptocephalus cynoglossus

NORTHERN SEAROBIN

The northern searobin Prionotus carolinus was caught in larger quantity than any other species. It occurred through a depth range of 6 to 30 fathoms and temperature range of 8 to 15° C (46-59°F) but all catches of 100 pounds or more were in 10 fathoms or less and temperatures of 13° or higher north of 37° N lat. The largest catch was 1475 pounds, one other catch was 1000 pounds, 6 catches were between 100 and 300 pounds, and 11 catches were between 25 and 100 pounds. Half of the 46 catches containing this species were of 10 pounds or more. Young occurred in only 2 samples.

STRIPED SEAROBIN

Striped searobin Prionotus evolans were caught at 24 stations spanning a depth range of 6 to 50 fathoms, and a temperature range of 12 to 15° C (54-59° F). It occurred throughout the north-south extent of the area. The largest catch was 120 individuals weighing 50 pounds. Eight of 24 catches exceeded 10 pounds. All catches of 10 pounds or more were made in water no deeper than 10 fathoms and north of 37° N. lat.

SPOTTED HAKE

The spotted hake Urophycis regius was caught in 39 samples from all depths throughout the area. Temperature range was 8 to 15°C (46-59°F). Juveniles occurred most abundantly from 9 to 18 fathoms south of 36° 45' N, whereas adults were most plentiful from 17 to 70 fathoms and were distributed throughout the area. The largest catch of adults was 33 fish weighing 32 pounds. Nine other catches contained 10 or more adults.

SQUIRREL HAKE

Urophysis chuss (red hake) was most abundant at 15 to 30 fathoms north of 38° N lat. This species was caught in 33 tows spanning a depth range of 9 to 100 fathoms and a temperature range of 9 to 14° C (48-57° F). The southern limit of occurrence was 36° 10' N. Juveniles and adults occurred together in shoaler waters, but young were not taken in waters deeper than 30 fathoms. The largest catch in a tow was 75 pounds. Four additional catches were between 10 and 36 pounds.

SILVER HAKE

Also known as whiting, *Merluccius bilinearis* was caught at 51 stations through a depth range of 6 to 100 fathoms and from the northern to the southern edge of the survey area. Adults were most abundant north of 36° 40' N and seaward of the 20 fathom contour. Distribution of young and adults was somewhat complementary, the young being more abundant shoreward of the 20 fathom contour, whereas the adults were more numerous seaward. However, the separation was incomplete. Adults were scarce south of 36° 40' N. The largest catch of adults was 300 individuals weighing 75 pounds. In 17 tows the catch was 10 or more adults.

GOOSEFISH

The goosefish or angler, *Lophius americanus*, occurred through the range of depths, latitudes, and temperatures sampled. Even though the largest number of fish caught in a tow was 4, the large size of the individuals made them an important part of the catch. The average catch in the 30 tows containing adults was 16 pounds. The largest catch was 47 pounds. Young were caught at 4 stations of 30 to 50 fathoms depth.

SMOOTH DOGFISH

The smooth dogfish, *Mustelus canis* was caught at 9 stations in water from 6 to 15 fathoms deep from the southern portion of the survey area to the northern edge. Temperatures were 13 to 14° C (55-57°F). The largest catch was 8 adults weighing 19 pounds. Young were not caught.

SPINY DOGFISH

Spiny dogfish *Squalus acanthias* were caught in 18 tows, a notable reduction in frequency of occurrence since winter. They were taken throughout the range of depths sampled and also from northern to southern extremes of the survey area. The largest catch was 8 adults weighing 29 pounds. Young were associated with adults.

CLEARNOSE SKATE

The clearnose skate *Raja eglanteria* occurred in 9 samples, mostly from waters shoaler than 20 fathoms south of 37° N lat. Temperature range was 11 to 15° C (52-59°F). The largest catch was 22 skates weighing 38 pounds.

LITTLE SKATE

Raja erinacea, the little skate, was caught at 12 stations ranging from 6 to 40 fathoms and mostly north of 37° N lat. Temperature range was 9 to 14° C (48-57°F). Young and adults occurred in the same area. The largest catch was only one individual weighing 2 pounds.

ROSETTE SKATE

The rosette skate *Raja garmani*, like the clearnose occurred mostly south of 37° N lat. However, it was caught in only 6 tows and the largest catch was 5 adults weighing 8 pounds. Depth range was 20 to 70 fathoms, temperature range 8 to 12° C (46-54°F). Young and adults were caught.

YELLOWTAIL FLOUNDER

The yellowtail Limanda ferruginea occurred in only 7 samples, all taken north of 37° 20' N at depths of 15 to 30 fathoms. Temperature range was 10 to 13° C (50-55°F). Juveniles and adults were taken in the same tows.

WINTER FLOUNDER

Pseudopleuronectes americanus, also called blackback, occurred in 29 samples from 36° 40' N lat. to the northern edge of the survey area. Depth range was 7 to 30 fathoms and temperature range 9 to 15°C (48-59°F). The largest catch in a tow was 138 fish weighing 100 pounds. Seven other catches were of 10 to 25 pounds.

WINDOWPANE FLOUNDER

The windowpane or daylight flounder Scophthalmus aquosus occurred in 26 samples from a depth range of 6 to 18 fathoms throughout the north-south extent of the area. Temperature range was 11 to 15° C (52-59°F). The largest catch was 12 adults weighing 7 pounds. Juveniles were caught only twice, at 15 and 16 fathoms.

FOURSPOT FLOUNDER

The fourspot flounder, Paralichthys oblongus occurred in 23 samples obtained from a depth range of 15 to 100 fathoms. The largest catch was 24 adults weighing 7 pounds. Temperature range was 8 to 15° C (46-59°F). The fourspot was generally distributed from north to south. Young were caught in water of 30 fathoms or less.

GULFSTREAM FLOUNDER

The gulfstream flounder Citharichthys arctifrons, occurred generally throughout the area, but because of its small size it has little commercial potential.

NORTHERN PUFFER

The northern puffer Sphaeroides maculatus, also called swellfish and blow toad, occurred in 10 samples from depths of 6 to 15 fathoms throughout the north-south extent of the area. The temperature range was 12 to 15° C (54-59°F). The largest catch was 31 individuals weighing 7 pounds.

ALEWIFE

The alewife, Alosa pseudoharengus was taken at 11 stations, all north of 37° 10' N lat. and ranging in depth from 6 to 17 fathoms. Temperature range was 11 to 14° C (52-57°F). Because the alewife is a pelagic fish, probably our samples are inadequate to determine its distribution accurately.

NORTHERN KINGFISH

Menticirrhus saxatilis, the northern kingfish was caught in 8 tows in water of 7 to 10 fathoms from 35° 50' N to 37° 35' N. Temperature range was 13 to 14° C (55-57°F). The largest catch was about 5 pounds.

HADDOCK

Juvenile haddock Melanogrammus aeglefinus were caught in 8 tows at depths ranging from 16 to 50 fathoms from 36° 40' N to the northern edge of the area. Temperature range was 9 to 12° C (48-54°F). The largest catch was 7 juveniles weighing 3 pounds. Adults were not caught.

OCEAN POUT

The ocean pout Macrozoarces americanus was caught in only 7 samples. The largest catch, 33 fish weighing 39 pounds, was made near a group of scallopers. The ocean pouts had been feeding on offal discarded from the scallop vessels. Another catch of 17 pounds was made under similar circumstances. Ocean pout were caught at depths of 15 to 40 fathoms from 37° 19' N to the northern boundary of the survey area. Temperature range was 9 to 12°C (48-54°F).

SCUP

Juvenile *Stenotomus chrysops* were distributed through the entire sampling area inshore from the 20 fathom curve. Temperature range was 11 to 15°C (52-59°F). Only 11 adults were caught and they were taken from the area inhabited by juveniles. In winter adults were taken primarily south of 37° N. In May adults were taken only north of that parallel and in much smaller numbers.

BLACK SEABASS

Centropristes striatus was generally distributed throughout all depths sampled and from north to south in the survey area. Temperature range was 8 to 14°C (46-57°F). Juveniles occurred in but 6 samples and were associated with adults. The largest catch was 16 fish weighing 3 pounds.

SUMMER FLOUNDER

The fluke, *Paralichthys dentatus* occurred in 21 samples throughout the survey area seaward to the 30 fathom curve. Temperature range was 9 to 15°C (48-59°F). Young were not caught. The average catch of the 21 tows containing this species was 2 individuals. The largest catch in a tow was 7.

BUTTERFISH

Adult *Poronotus triacanthus* were generally distributed throughout the north-south extent of the survey area at all depths sampled, but juveniles occurred only in water shoaler than 16 fathoms. Temperature range was 9 to 15°C (48-59°F). The largest catch was 50 pounds. Only 2 other catches were 10 or more pounds.

PHASE 6

COLLECTION OF MATERIALS AND DATA FOR AGE-GROWTH ANALYSIS

Part 1

AGE AND GROWTH OF THE STRIPED SEAROBIN

By

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Part 2

AGE AND GROWTH OF THE NORTHERN SEAROBIN

By

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Part 3

AGE AND GROWTH OF THE SPOTTED HAKE

By

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Part 1

AGE AND GROWTH OF THE STRIPED SEAROBIN

By

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Age and Growth of the Striped Searobin

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Made in United States of America
Reprinted from Transactions of the American Fisheries Society
Vol. 99, No. 2, April 1970
pp. 343–352

Age and Growth of the Striped Searobin[1]

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ABSTRACT

Age, rate of growth, spawning, and weight-length relationship of the striped searobin, *Prionotus evolans*, were studied. The fish were collected from Chesapeake Bight and Chesapeake Bay during 1966 and 1967. Age was determined from otoliths which had been cross-sectioned, polished, and heated. Age groups 0 to VII were represented in the sample of 803 specimens. Males and females had the same growth rate and weight-length relationship. Growth in length was rapid until the fish reached maturity at age II. Age group II averaged 221 mm fork length. The fish accomplished most annual growth between May and September. Spawning occurred from May through the first part of July.

INTRODUCTION

The striped searobin, *Prionotus evolans* (Linnaeus), is a benthic fish occurring on the continental shelf from Cape Cod to South Carolina (Bigelow and Schroeder, 1953) and straying to the lower Bay of Fundy (Leim and Day, 1959) and the northeastern coast of Florida (Bullis and Thompson, 1965).

This study describes a technique for determining the age of the striped searobin, and reports the rate of growth, age at sexual maturity, spawning time, and weight-length relationship of the species in Chesapeake Bight.

MATERIAL

In 1966 and 1967, a total of 1600 striped searobins was collected from the continental shelf, inlets, and estuaries. The fish were collected during all four seasons of 1966 and during the first three seasons of 1967. The bulk of specimens came from the continental shelf between Cape Henlopen, Delaware and Cape Hatteras, North Carolina, at depths of 5 to 100 fathoms. The samples were collected aboard the trawler "Sea Breeze," under charter to the Virginia Institute of Marine Science. The collecting gear was a semi-balloon trawl with a 0.5-inch stretch mesh inner liner in 1966 and summer 1967, and an Atlantic western trawl with a 2-inch stretch mesh cod end in the remainder of 1967.

Estuarine samples, taken from Chesapeake Bay, comprised only 4% of the collection. They were obtained from a pound net on the James River in 1966 and from a pound net on the York River in 1967.

Less than 0.4% of the specimens were caught in inlets on the seaside of the Eastern Shore of Virginia during the spring and summer of 1966 and 1967. These samples were collected by a trawl with a 0.75-inch stretch mesh cod end.

All fish were weighed in grams and measured to the nearest millimeter of fork length. Fish of each sex were classified as: immature, gravid, running ripe or spent, by macroscopically examining their gonads.

A subsample of 803 fish, representing all of the sampling periods, was used for age determination by analysis of hard parts. In 1966, scales, opercula, and otoliths were removed from the selected fish. In 1967, only otoliths were collected as scales and opercula proved to be unsuitable for age determination. The otoliths were stored in vials containing corn syrup and several drops of phenol.

AGE AND GROWTH

Otolith method

Age was determined by counting annuli in sectioned and heated otoliths. Determination of age from otoliths is based on the theory that fish in temperate regions undergo annual fluctuations in growth rate and that these fluctuations are reflected in the composition of the otoliths. Otoliths are composed of calcium carbonate crystals entwined in proteinaceous fibers (Hickling, 1931). Most of the calcium carbonate is deposited on the otolith during the warm period of the year when the fish are growing rapidly, while most

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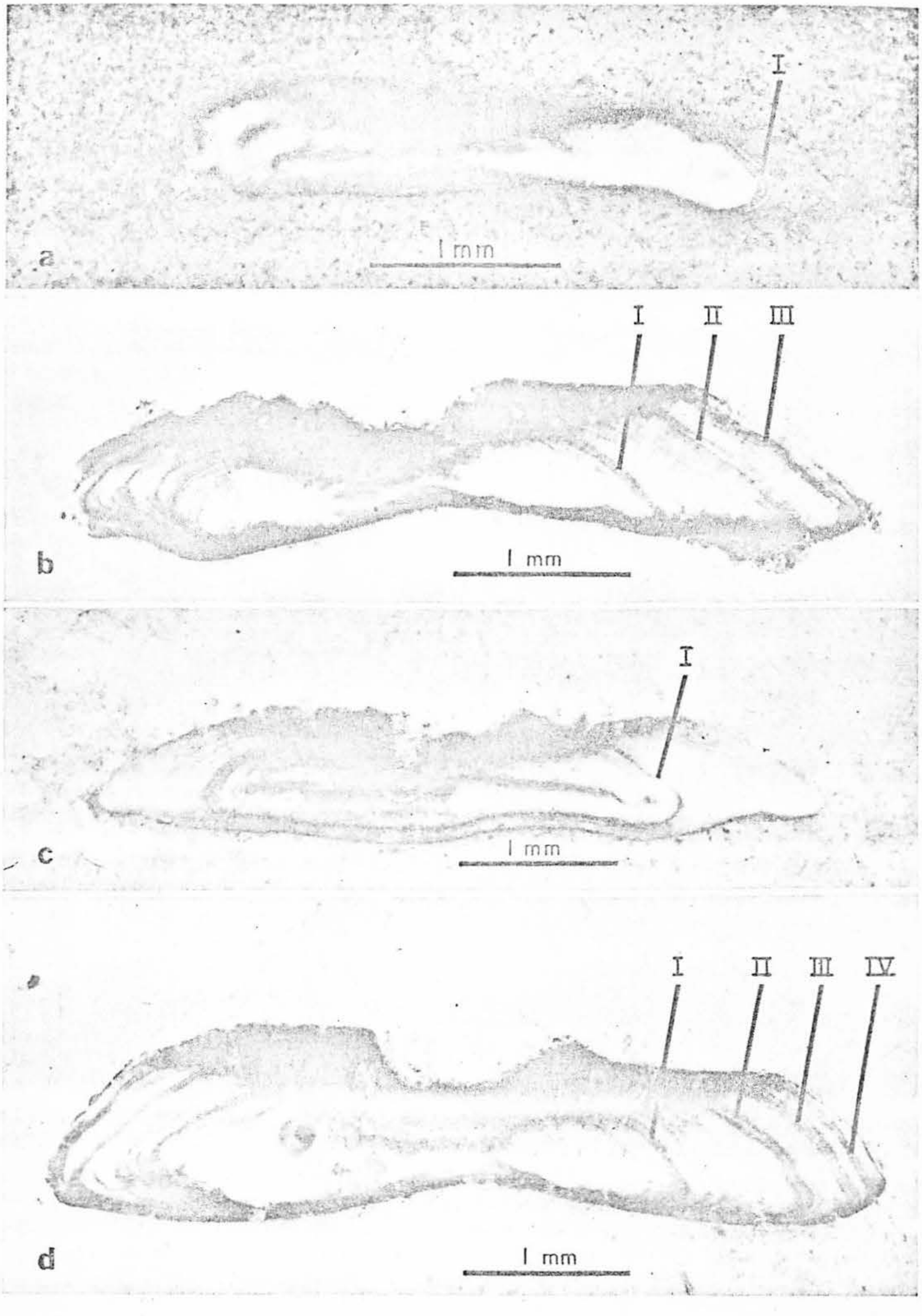
[1] Contribution No. 319, Virginia Institute of Marine Science, Gloucester Point, Virginia 23062.


I
a
I mm
I
II
III
b
I mm
I
c
I mm
I
II
III
IV
d
I mm

of the protein is deposited during the cold season when fish grow slowly (Irie, 1957 and 1960). Thus a year's growth consists of a wide inorganic band and a narrow proteinaceous band. The latter, considered to be the annulus, can be charred by heating and thus differentiated from the crystalline band (Lawler and McRae, 1961; Christensen, 1964; Poinsard and Troadec, 1966).

Otoliths of the striped searobin were imbedded in a heat-resistant plaster (Vel Mix Stone). First, wet plaster was poured into cylindrical paper molds and then slightly over one-half of the otolith was inserted on a plane perpendicular to its long axis. The protruding section of the otolith was ground off on a whet stone. The otolith was further ground with #320 alundum to expose the nucleus and polished with #400 and #600 alundum. The polished otoliths were placed in an oven and gradually heated to 530 C in 20 minutes. The otoliths were allowed to cool and examined with a dissecting microscope at 14×. The banded nature of the otolith became distinct after several drops of glycerin were placed on its surface. Rings were crowded along the ventral radius of the otolith but were well separated along the dorsal radius (Figure 1); therefore, age was determined by counting annuli along the dorsal radius.

Only one proteinaceous band was formed each year, therefore the number of dark bands is a valid indicator of age. The annulus formed in autumn and remained on the margin of the otolith until growth resumed the following spring (Figure 2). About one-fourth of the yearlings captured in February and March had a narrow inorganic band outside the annulus (Figure 1a). In May, after gonadal development was nearly complete, crystalline margins first appeared on the otoliths of older fish (Figure 1b). The percentage of crystalline margins increased through July. Annulus formation began in August and the percentage of otoliths with protein margins increased through December. Yearlings and older fish formed annuli at the same time (Figures 1c and 1d).

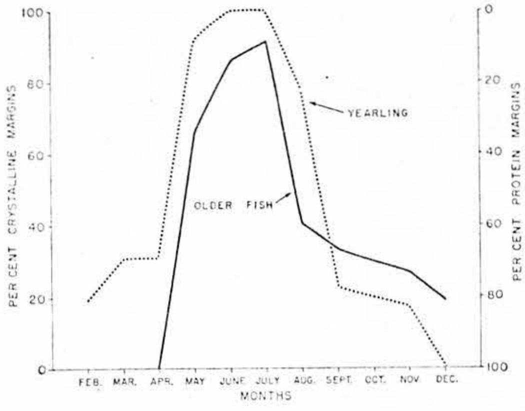


FIGURE 2.—Seasonal change in the margin of the otolith of the striped searobin.

Reduction of growth with time and irregularities in growth of some of the otoliths made age determination uncertain after age seven. Accessory rings, thinner and less distinct than the two encompassing rings, occasionally occurred (Figure 3a). In a few fish double annuli were formed. These could not be interpreted accurately when they occurred near the margin of otoliths of older fish because, with reduction of growth, spaces between annuli could not be distinguished from spaces between the two rings comprising a double annulus (Figure 3b). Reorientation of growth on the dorsal margin was observed in some of the larger otoliths. Greater growth medial to the dorsal radius after age IV or V caused the annuli to be closely spaced and made age determination uncertain (Figure 3c).

The mean lengths of the age groups in 1966 and 1967 prior to the new year's growth are shown in Figure 4. Mean lengths of age group I were obtained from the samples collected during February and March, 1966 and March, 1967. Mean lengths of older age

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FIGURE 1.—Otoliths of the striped searobin. Dorsal radius is to the right. a) An otolith from a yearling captured in March. A thin crystalline band is located outside the annulus (I). b) An otolith from a three-year-old fish captured in May. A thin crystalline band is located outside the last annulus (III). c) An otolith from a yearling captured in November. A wide crystalline band is located outside the annulus (I). d) An otolith from a four-year-old fish captured in November. A wide crystalline band is located outside of the last annulus (IV).

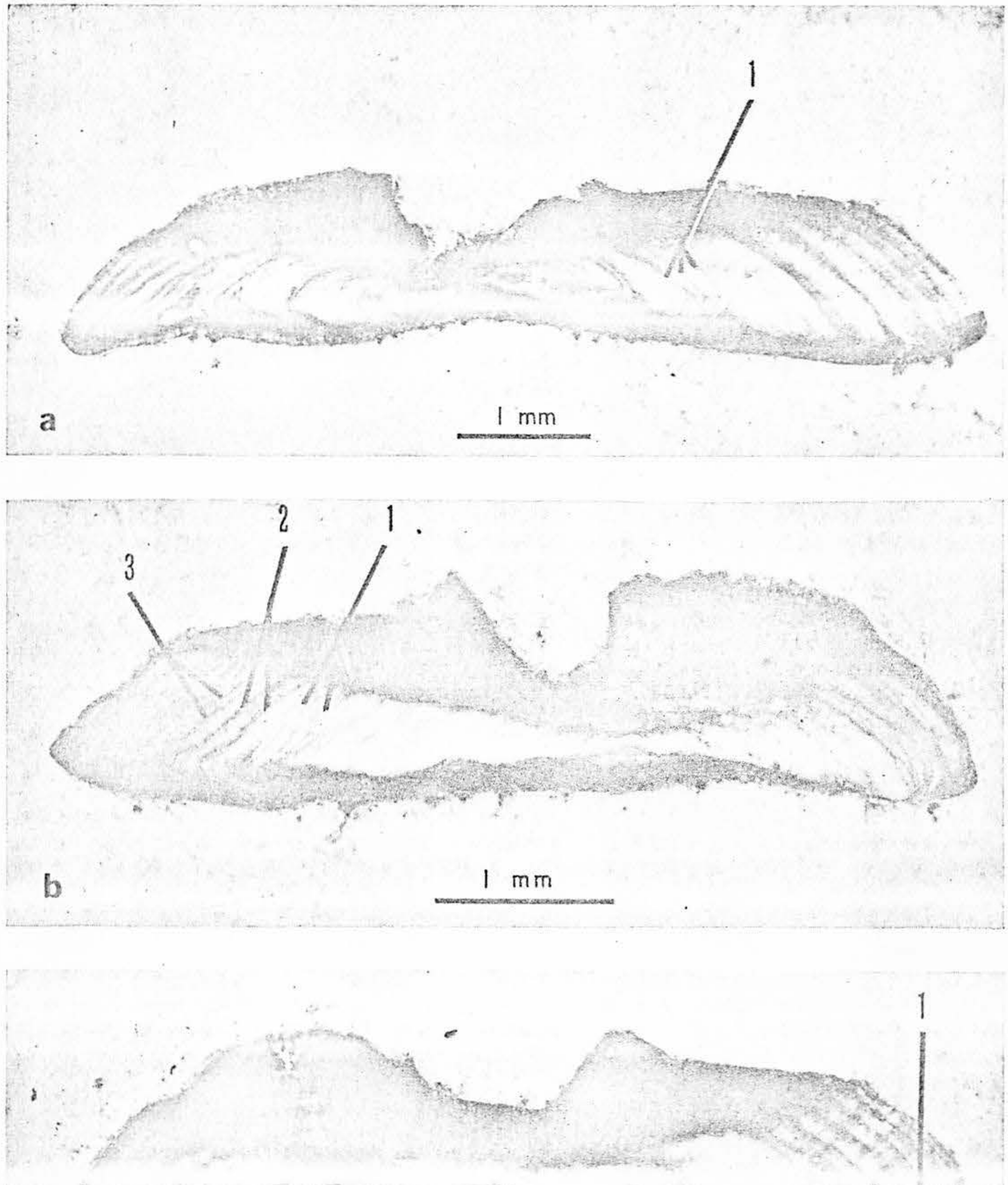

FIGURE 3.—Irregularities in growth of the otolith of the striped searobin. a) False annuli (1) in an otolith from a seven-year-old fish. b) Three double annuli (1, 2, 3) in an otolith from a seven or eight-year-old fish. c) Reorientation of growth after the fourth year (1) in an otolith from a seven-year-old fish.

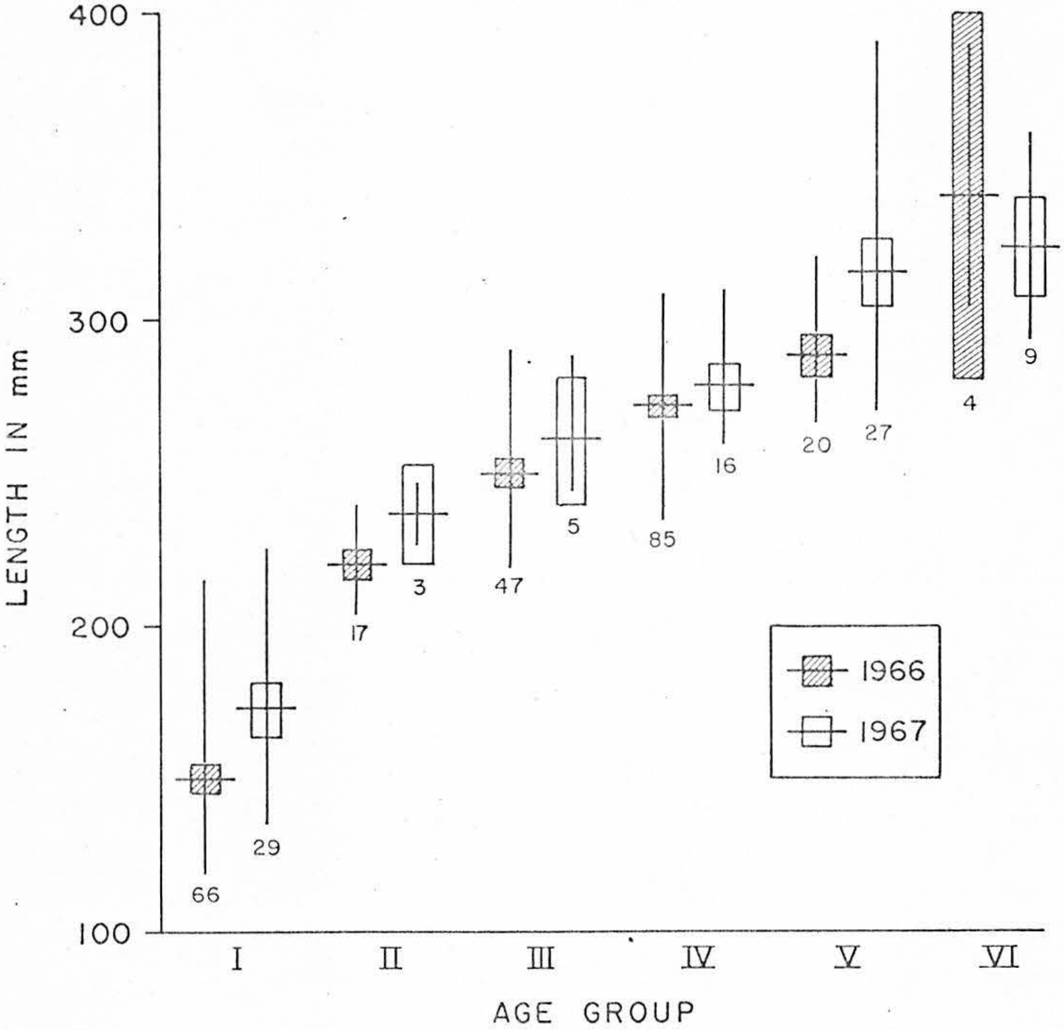

FIGURE 4.—Mean lengths and confidence interval of the means for age groups of striped searobins prior to growth in 1966. and 1967.

groups were obtained from the samples taken in May, 1966 and May, 1967 because only yearlings were captured in the winter of 1966 and the older fish grew little prior to May. Age groups I and II were significantly longer (5% level) in 1967 than in 1966 according to the "students" *t* test (Snedecor, 1956). In 1966 age groups I and II averaged 151 mm and 221 mm, whereas in 1967 they averaged 173 mm and 237 mm, respectively. The differences probably indicate that many of these young fish were not caught by the larger-meshed trawl used in 1967. (The change in sampling gear was dictated by goals of an investigation different from the age-growth study here reported.) There was no significant difference in lengths of age groups III and IV between the two years. Age group III averaged 249 mm and 261 mm and age group IV averaged 272 mm and 278 mm, respectively, in the two years. Age group V averaged 288 mm in 1966 and 315 mm in 1967. The difference, significant at the 5% level, may have resulted from inadequate sample sizes. There was no difference between lengths of the six-year-olds; they averaged 341 mm in 1966 and 323 in 1967. The largest fish was 415 mm and was seven years old.

TABLE 1.—*Fork lengths and sample sizes of age groups 0–III obtained by present study and those obtained by Marshall (1946)*

Age group	0	I	II	III
Fork lengths				
Present study	<124 (5)	134–242 (84)	208–276 (33)	219–301 (93)
Marshall (1946)	<123 (10)	154–283 (41)	209–326 (21)	271–344 (5)

Yearly growth for each of the age groups was obtained by subtracting the mean length at the beginning of the growing season from that at the end of the growing season. Since males and females had the same rate of growth, data from both sexes were combined to determine growth increments. During 1966 the yearlings grew about 80 mm, the two-year-olds grew 27 mm, the three and four-year-olds grew 22 mm, and the five-year-olds grew 30 mm. Fish of older age groups were not taken in sufficient numbers to determine yearly growth. Growth estimates for the young-of-the-year were undependable because otoliths were obtained from only nine specimens. They averaged 119 mm in the August-September sample and 169 mm in the November-December sample.

Striped searobins accomplished more than one-half of their linear growth during their first two years of life. Reduction of linear growth after the second year coincided with attainment of sexual maturity which occurred in both sexes during their third year.

Growth in length occurred during the period when crystalline material was found on the margin of the otolith. The largest growth increment occurred between May and September. As inferred from the otoliths, the yearlings had a longer growing season than the older fish, beginning linear growth in February or March and continuing until November or December. The growing season of older fish extended from May to November or December.

Marshall (1946) examined striped searobin scales and found growth more variable and more rapid than was indicated by analysis based on heated otoliths (Table 1). Comparison of Marshall's findings with ours was effected by converting standard lengths used by him to fork lengths (SL × 1.23 = FL) and then combining our samples taken in spring and summer of 1966 so that we would be considering nearly the same time span that Marshall did. Marshall could determine age from scales for only the first three years and he discarded 44% of the fish longer than 314 mm FL because of obscurity of annuli. However, from processed otoliths, age could be determined up to seven years and only 20% of the fish longer than 314 mm were discarded because of irregularities in otoliths.

Length-frequency method

At best only the first and second age groups could be discerned on length-frequency histograms (Figure 5). Age group 0 first appeared in summer 1966 and by autumn ranged from 148 mm to 187 mm. The winter, 1966 sample was unimodal and consisted of yearlings (as determined from the otoliths). By spring yearlings ranged from 118 mm to 197 mm. Their modal length was 220 mm in summer and 240 mm in autumn. Older age groups could not be individually discerned on length-frequency distributions.

During 1967 the yearlings showed a modal increase from 165 mm to 188 mm between March and May (Figure 6). The second mode

TABLE 2.—*Mean lengths of yearlings as determined by length-frequency method and by the otolith method*

	Winter 1966	Spring 1966	Summer 1966	Fall 1966	Winter 1967	Spring 1967
$\bar{x}$ length frequency method	149	155	203	228	171	182
$\bar{x}$ otolith method	151 (66)	172 (38)	211 (46)	230 (22)	173 (29)	185 (18)

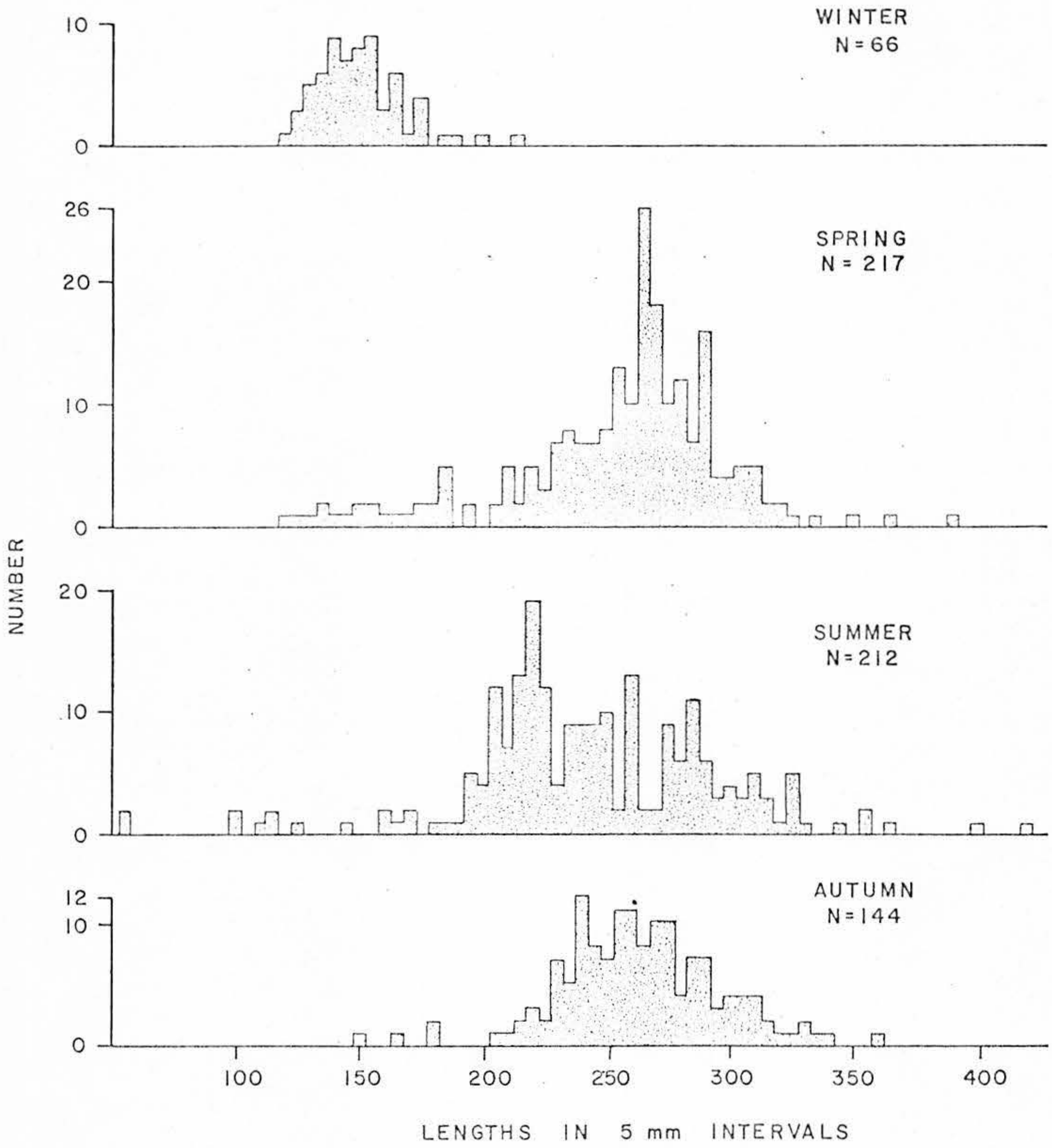

FIGURE 5.—Length-frequency histograms of striped searobins during each season of 1966.

in each of these samples consisted of older age groups which could not be individually discerned.

Mean length of yearlings determined by the length-frequency method was very close to that determined by the otolith method (Table 2).

The estimate of growth of age groups 0 and I may have been biased by unavailability or by escapement of smaller fish. Size of age groups 0 and I was based on specimens from the continental shelf, and these fish were considerably larger than fish of the same age group taken at the same time in the inlets and estuaries (Table 3). This disparity may have been due to the difference in collecting gear used in the two areas or due to the tendency of smaller fish to remain inshore of the larger

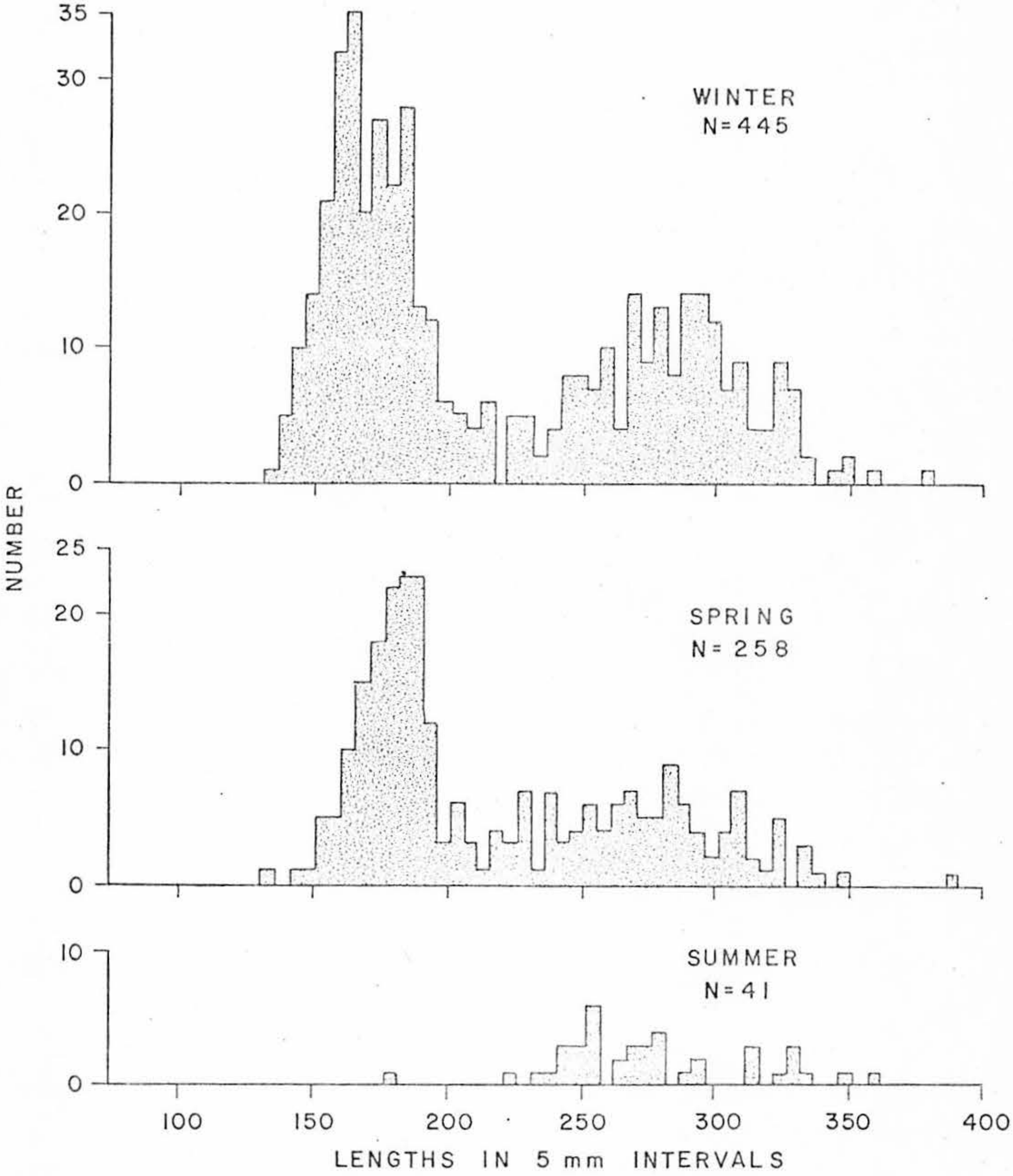

FIGURE 6.—Length frequency histograms of striped searobins during three seasons of 1967.

fish. Earlier studies also suggest that our estimates of lengths of age groups 0 and I were too large. Smith (1898) stated that striped searobins reach about four inches (102 mm) by their first autumn. Nichols and Breder (1927) took young fish averaging 55 mm SL [68 mm FL] in August and 70 mm SL [86 mm FL] in October. Warfel and Merriman (1944) collected fish averaging 36 mm SL [44 mm FL] in early August, 46 mm SL [57 mm FL] in late August, one fish 89 mm SL [109 mm FL] in early September and fish ranging from 54 mm SL [66 mm FL] to 88 mm SL [108 mm FL] in mid-September.

GONAD DEVELOPMENT, MATURITY, AND SPAWNING

Maturation of the gonads of both sexes began during the second spring or summer, one year before the first spawning. Prior to development, the gonads consisted of transparent tubules about 1 mm in diameter. During development, the tubules increased in size and became opaque; the testes became white and the ovaries yellow-orange. Small eggs were visible under a magnification of 14× shortly after the start of gonadal enlargement. Maturation began in April and by November all yearlings had enlarged gonads. Gonadal development was apparently related to size of the fish. Yearlings that began maturation early were considerably larger than the mean length for their age group. Yearlings with enlarged gonads in April were longer than 200 mm, and the majority of those which had not begun development by May were less than 185 mm.

During March and April the gonads of fish two years old and older enlarged until they occupied a major portion of the abdominal cavity. Gonads were running ripe from May through early July, with the highest incidence of ripe fish in mid-June. Males and females ripened at about the same time. Fish obtained in August were either spent or recovering from the spent condition, indicating that spawning was completed. Spent gonads were greatly reduced in volume, as were recovering gonads, the anterior section of which contained immature sex products. Segments of the striped searobin population had slightly different spawning times. The estuarine samples obtained during April 1966 and May 1967 had higher incidences of gravid and ripe fish than did the samples taken from the continental shelf at the same time.

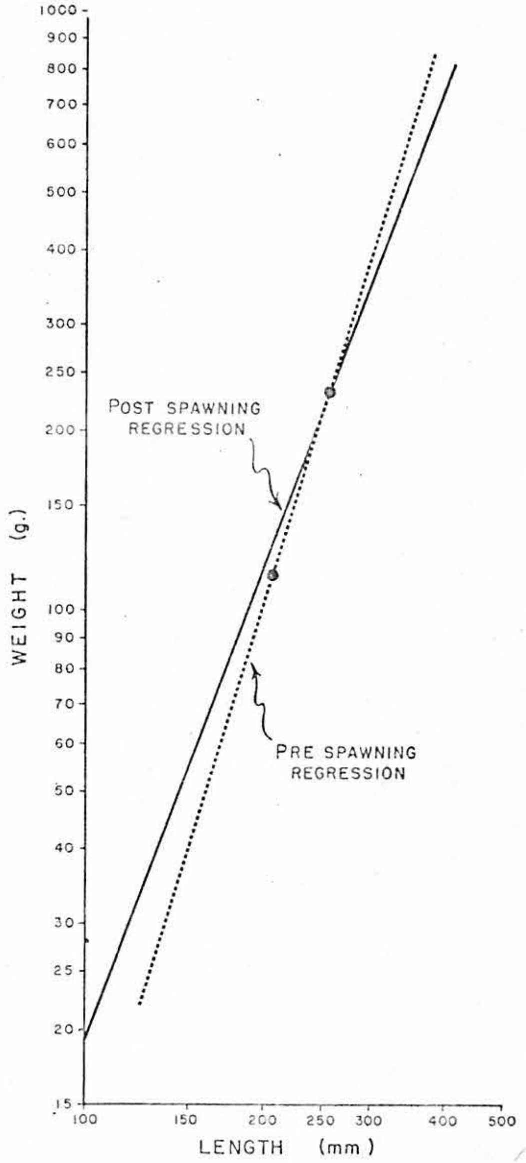

FIGURE 7.—Weight-length relationships for striped searobins in pre-spawning condition and in post-spawning condition.

TABLE 3.—*Number and fork lengths (mm) of striped searobins obtained from inlets and estuaries during 1966–67*

	May	June	July	August	September	October
Young-of-the-year						
Number				3	3	2
Length range				54–73	57–104	57–62
Mean length				65	87	60
Yearlings						
Number	11	8	1	2		
Length range	61–156	154–200	195	150–190		
Mean length	115	177	195	170		

Marshall (1946) reported striped searobins spawning from June to early August off New England and noted that yearlings, about 223 mm fork length, produced ripe eggs. However, the present study indicates that 223 mm is closer to the mean length of age group II than to that of age group I. Age group II averaged 221 mm prior to spawning while age group I averaged 172 mm and it is likely that the mature fish in Marshall's study were two years old rather than one.

WEIGHT-LENGTH RELATIONSHIP

Linear plots of weights on lengths showed that weight increased exponentially with length, fitting the formula: $\text{Log } W = \text{Log } a + b \text{ Log } L$. Log plots revealed no difference between the sexes in the weight-length relationship. Covariance tests (Mottley, 1941) indicated that all data taken prior to and during spawning could be pooled into one regression and all data taken after spawning could be pooled into a second regression. The former regression, representing 1095 fish, was: $\text{Log } W = -5.337 + 3.19 \text{ Log } L$ and had a correlation coefficient of 0.9943. The latter regression, representing 288 fish, was: $\text{Log } W = -4.175 + 2.72 \text{ Log } L$ and had a correlation coefficient of 0.9768. The slopes of these regressions were significantly different at the 5% level (Figure 7), showing that the condition of the gonads had a significant effect on the weight-length relationship.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to Edwin B. Joseph, John J. Norcross, and John A. Musick for their counsel and criticism of the manuscript. William Allen helped to develop the technique for processing the otoliths. Jane Davis and Kay Brown drew the illustrations. Fred Biggs and Linda Sweat photographed the otoliths.

This study was a part of Project 3-5-D, a joint program of the Bureau of Commercial Fisheries and the Virginia Institute of Marine Science under provision of the Commercial Fisheries Research and Development Act of 1965 (PL 88-309).

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Part 2

AGE AND GROWTH OF THE NORTHERN SEAROBIN[1]

By

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[1] From a MA Thesis, Age and Growth of the Northern Searobin, etc.

INTRODUCTION

The present study was made to determine the age and rate of growth of the northern searobin, Prionotus carolinus (Linnaeus).

The northern searobin is abundant in the coastal waters of eastern North America from southern New England to North Carolina and its range extends from the Bay of Fundy to South Carolina (Bigelow and Schroeder, 1953). These fish move inshore during the summer and offshore during the winter; they have been caught in both shallow brackish waters and in waters 186 m deep (Bigelow and Schroeder 1953). According to the above authors, northern searobins prefer sandy bottoms and when disturbed, they bury themselves in the sand, leaving the top of their head and eyes protruding. They also emit a grunting noise when alarmed as opposed to a staccato call believed to be related to breeding behavior (Moulton, 1956). They feed primarily on copepods, mysids, amphipods and decapods (Marshall, 1946; Richards, 1963). The spawning season occurs in the summer and eggs develop in a manner typical of pelagic teleostean eggs (Kuntz and Radcliffe, 1918). Incubation period is about 60 hours at 22°C, and newly hatched larvae are approximately 2.8 mm long. When the fish attain a length of 25 to 30 mm, most of the adult features have been acquired. Characteristics and taxonomic features of this triglid fish were reviewed by Jordan and Hughes (1887) and Ginsburg (1950). The life history has been investigated by Marshall (1946).

METHODS AND MATERIALS

This study was based on data obtained from 3634 fish, most of which were caught on the continental shelf of Chesapeake Bight between November 1965 and May 1967 (Fig. 1). Samples of small fish were obtained from the Chesapeake Bay and the York River. The data in Table 1 are arranged in chronological order showing the date, locality, number of fish, depth and bottom temperature for each sample.

Chesapeake Bight was sampled from the trawler, Sea Breeze, chartered by the Virginia Institute of Marine Science. A 45-foot semi-balloon otter trawl having a small mesh liner ($^{1}/4$ inch) in the cod end was used in catching the fish. The small mesh was intended to reduce escapement of small fish. At each station the trawl was towed for 30 minutes at a speed of approximately 3 knots. Fish were preserved in ice and brought back to the laboratory for examination and analysis. The Chesapeake Bay and York River collections were made from the R/V Pathfinder using a 30-foot semi-balloon otter trawl with a $^{1}/2$ inch mesh in the cod end. Fish were preserved in formalin. Samples collected in 1955 and 1956 were preserved in alcohol.

Fork length of fish was measured in mm from the tip of the snout to the center of the fork of the caudal fin. All lengths in this paper are fork lengths unless otherwise stated. Weights were

Figure 1. Area (shaded) in which *Prionotus carolinus* were caught.

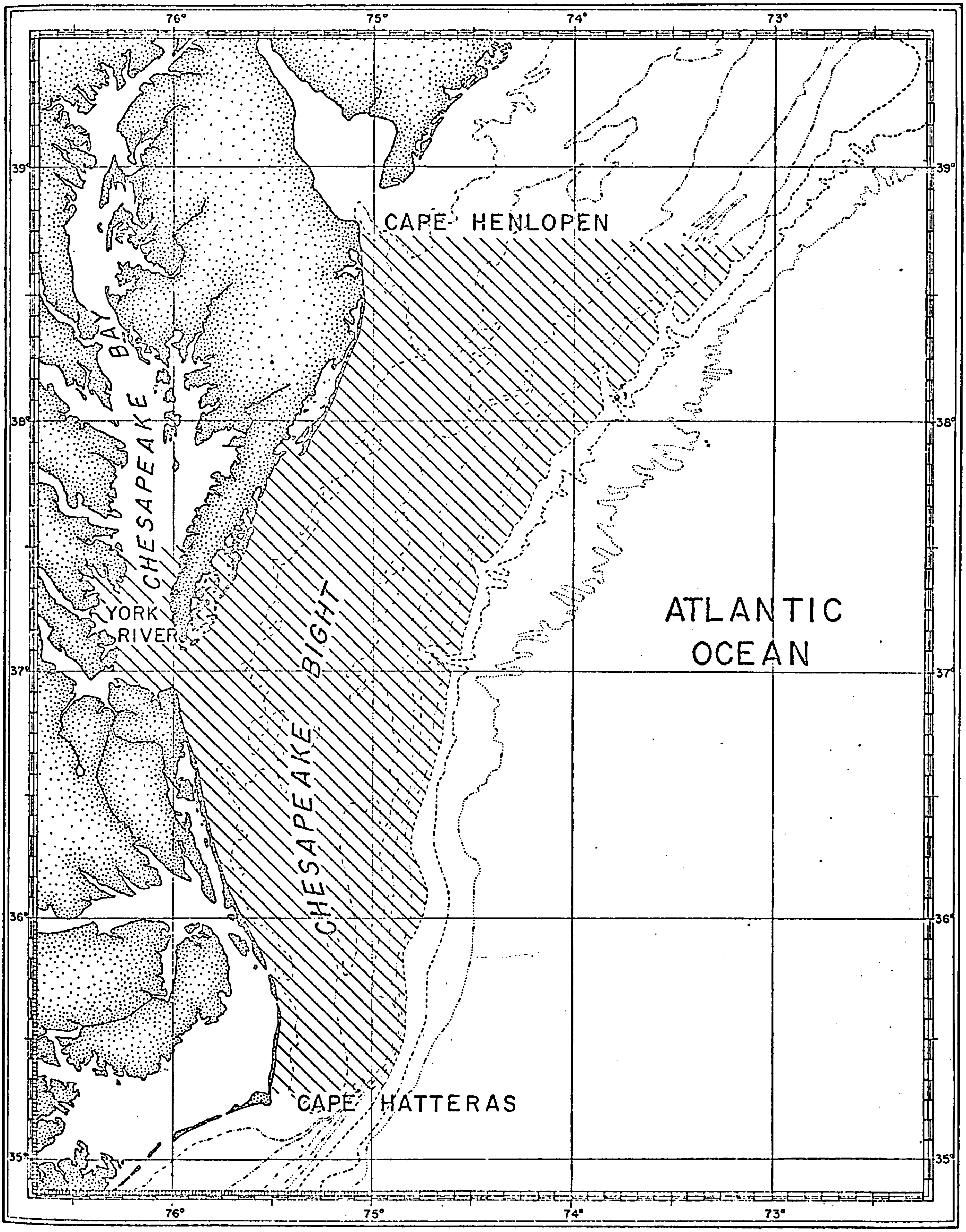

76°
75°
74°
73°
39°
38°
37°
36°
35°
CAPE HENLOPEN
CHESAPEAKE BAY
YORK RIVER
CHESAPEAKE BIGHT
ATLANTIC OCEAN
CAPE HATTERAS

TABLE 1

Data for each sample of *Prionotus carolinus*: date, locality, sample size, bottom temperature and depth.

Date	Location	Sample	Bottom	Depth
	Lat. Long.	Size (N)	Temp. (C)	(m)
April 1955	Chesapeake Bay	96	--	--
April 1956	York River Mouth	99	--	--
7 XII 1964	Chesapeake Bight	51	--	60
30 VI 1965	Chesapeake Bight	50	--	--
15 XI 1965	36°52'N 75°30'W	99	--	26
18 II 1966	38°18'N 73°51'W	65	7	86
24 II 1966	37°06'N 74°46'W	70	6	88
24 II 1966	36°50'N 74°48'W	50	6	53
24 II 1966	36°38'N 74°47'W	50	6	62
24 II 1966	36°29'N 74°49'W	175	6	73
24 II 1966	36°25'N 74°50'W	99	6	92
24 II 1966	36°31'N 75°00'W	50	5	37
3 III 1966	35°59'N 75°07'W	99	7	37
3 III 1966	36°18'N 74°55'W	99	7	55
11 III 1966	37°38'N 74°24'W	99	6	70
11 III 1966	37°47'N 74°15'W	99	7	92
13 IV 1966	35°42'N 75°02'W	99	--	48
6 V 1966	36°41'N 75°42'W	30	13	16

TABLE 1 (Continued)

Date	Location		Sample	Bottom	Depth
	Lat.	Long.	Size (N)	Temp. (C)	(m)
6 V 1966	36°28'N	75°44'W	50	13	18
9 V 1966	37°02'N	75°08'W	99	9	40
13 V 1966	38°01'N	75°07'W	70	13	18
13 V 1966	38°28'N	74°54'W	60	14	13
13 V 1966	38°38'N	74°37'W	99	12	29
13 V 1966	38°28'N	74°37'W	80	11	27
14 V 1966	38°12'N	74°44'W	99	11	22
19 V 1966	37°03'N	75°35'W	75	--	18
23 V 1966	37°01'N	75°38'W	99	14	13
26 VII 1966	37°04'N	76°05'W	95	--	26
4 VIII 1966	Chesapeake Bay		30	--	--
25 VIII 1966	37°08'N	75°41'W	150	17	15
25 VIII 1966	37°14'N	75°29'W	99	16	24
26 VIII 1966	37°46'N	74°55'W	99	11	29
27 VIII 1966	38°51'N	74°35'W	99	12	20
28 VIII 1966	38°36'N	74°53'W	40	11	22
28 VIII 1966	37°40'N	75°22'W	99	16	15
29 VIII 1966	37°03'N	75°47'W	40	16	9
1 XI 1966	37°04'N	75°26'W	30	16	27
16 XI 1966	37°47'N	74°47'W	60	12	38
25 XI 1966	36°51'N	75°19'W	33	13	26

TABLE 1 (Continued)

Date	Location		Sample	Bottom	Depth
	Lat.	Long.	Size (N)	Temp. (C)	(m)
25 XI 1966	36°36'N	75°19'W	30	12	31
26 XI 1966	36°49'N	74°45'W	250	11	73
30 III 1967	36°22'N	74°49'W	140	9	109
1 V 1967	36°54'N	75°33'W	50	8	20

accurate to ± 3 g; fish preserved in alcohol and formalin were not weighed.

Sex and gonadal condition were determined by gross examination.

Data were entered on IBM cards and computations were done with calculator and computer (IBM 360 Model 50).

CONVERSION FACTORS FOR LENGTHS OF FISH

The conversion factors for standard, fork and total lengths were derived from 175 fish having a range in length from 160 to 289 mm (Table 2). The standard and fork lengths were 76.9 and 94.2 per cent of the total length, respectively. Fish were measured according to the method of Hile (1945).

TABLE 2

Conversion factors for standard (S. L.), fork (F. L.) and total (T. L.) lengths of northern searobin.

F. L. = 0.942 x T. L.

S. L. = 0.769 x T. L.

S. L. = 0.816 x F. L.

DETERMINATION OF AGE

Cleithra, opercles, otoliths, scales and vertebrae were examined in a preliminary study to determine the skeletal structure most suitable for determining age and growth of Prionotus carolinus. All of these structures showed growth marks, but I could not determine the nature of the annulus. Scales and otoliths stored in corn syrup could be used for determining age of fish from age-groups 0 and I but were inadequate for older fish.

The technique of burning or scorching otoliths (Christensen 1964)was used to reveal zones for estimating age and growth. This method is based on the seasonally varying chemical composition of the otolith. The hyaline zone is primarily organic material (conchiolin) formed during the cold months; the opaque zone is primarily inorganic material (calcium carbonate) formed during the warm months (Dannevig, 1956; Irie, 1958). Normally, the opaque zone appears dark in transmitted light and whitish in reflected light, but the hyaline zone appears white in transmitted light and dark in reflected light. However, when the otolith is scorched the hyaline zone is carbonized and turns black, whereas the opaque zone remains white. When examined under low magnification, a transverse section of a scorched otolith exhibits alternating broad white zones (the opaque zones) and narrow black zones (the hyaline zones).

Techniques

The otolith was removed from the left sacculus by cutting with a stout scalpel through the bony layer forming the floor of the skull. Adhering tissues were removed from the extracted otolith. The length and width of the otolith were measured and the cleaned and dried otolith was weighed. The otolith was broken in two by applying gentle pressure with a scalpel at the middle of and perpendicular to the longer axis. The broken surfaces of the otolith were scorched in a low flame from a Bunsen burner for 5 to 20 seconds; the time of scorching depended on the size of the otolith and the temperature of the flame. During the process of scorching, the color of the hyaline zone changed from white to brown and then to black and the opaque zone changed from white to light-brown and then to white again. Some experience was necessary in order to avoid charring the surface.

After being cooled the brittle otoliths were imbedded in plasticine in slots of a wooden tray. In two to three days the plasticine hardened, affording a permanent mount. A few drops of glycerine on the surface of the otolith increased the contrast between the opaque and hyaline zones.

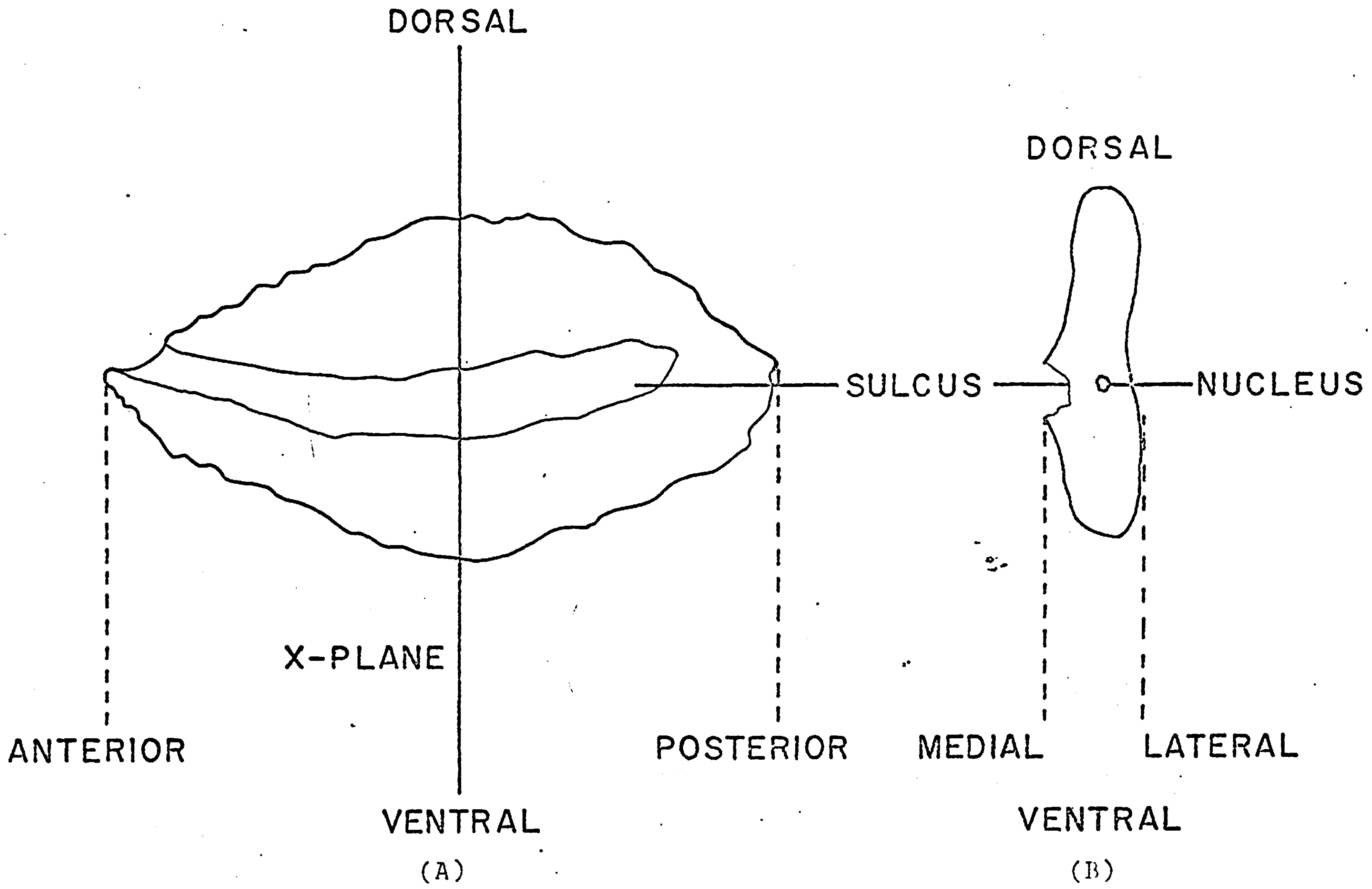
Topography and Growth of the Otolith

The otolith of the northern searobin is oval with a mildly crenated margin (Fig. 2). There is a slight concavity on the outer side and a broad but shallow sulcus on the inner side. The ventral

Figure 2. Otolith of Prionotus carolinus

(A) Side view showing the sulcus; x-plane is perpendicular to the anterior-posterior axis.

(B) Cross section of otolith (along the x-plane).


DORSAL
X-PLANE
ANTERIOR
VENTRAL
(A)
POSTERIOR
SULCUS
NUCLEUS
DORSAL
MEDIAL
LATERAL
VENTRAL
(B)

half is slightly thicker than the dorsal half and the anterior end tapers to a sharper point than the posterior end. The dorsal and ventral portions of the cross section of the otolith are not symmetrical; the nucleus is located toward the ventral portion. The maximum length and width of the otolith were approximately 9 and 5 mm, respectively, and the heaviest otolith weighed 753 mg.

Increase in length and width of the otolith was proportional to increase in length of the fish. A linear relationship was established for fish longer than 100 mm (Fig. 3). The length of fish showed a better correlation with the width of the otolith than with its length; the coefficients of correlation were 0.78 and 0.71, respectively. The weight of otolith increased logarithmically with the length of fish (Fig. 3).

Interpretation of Zones in the Otolith

In determining age, the most important features of the otolith are the alternating opaque and hyaline zones, one of each being formed at the margin of the otolith each year. The formation of these two zones has been considered by several investigators to be in response to an inherent annual rhythm (Trout, 1954; Molander, 1947; and Irie, 1960). However, such environmental variables as temperature and availability of food can determine how much organic or inorganic material is added to the otolith during each season. Generally, the opaque zones are formed in the summer and the hyaline zones in the winter.

The most common method for determining that the opaque and hyaline zones together constitute a year's growth is to examine

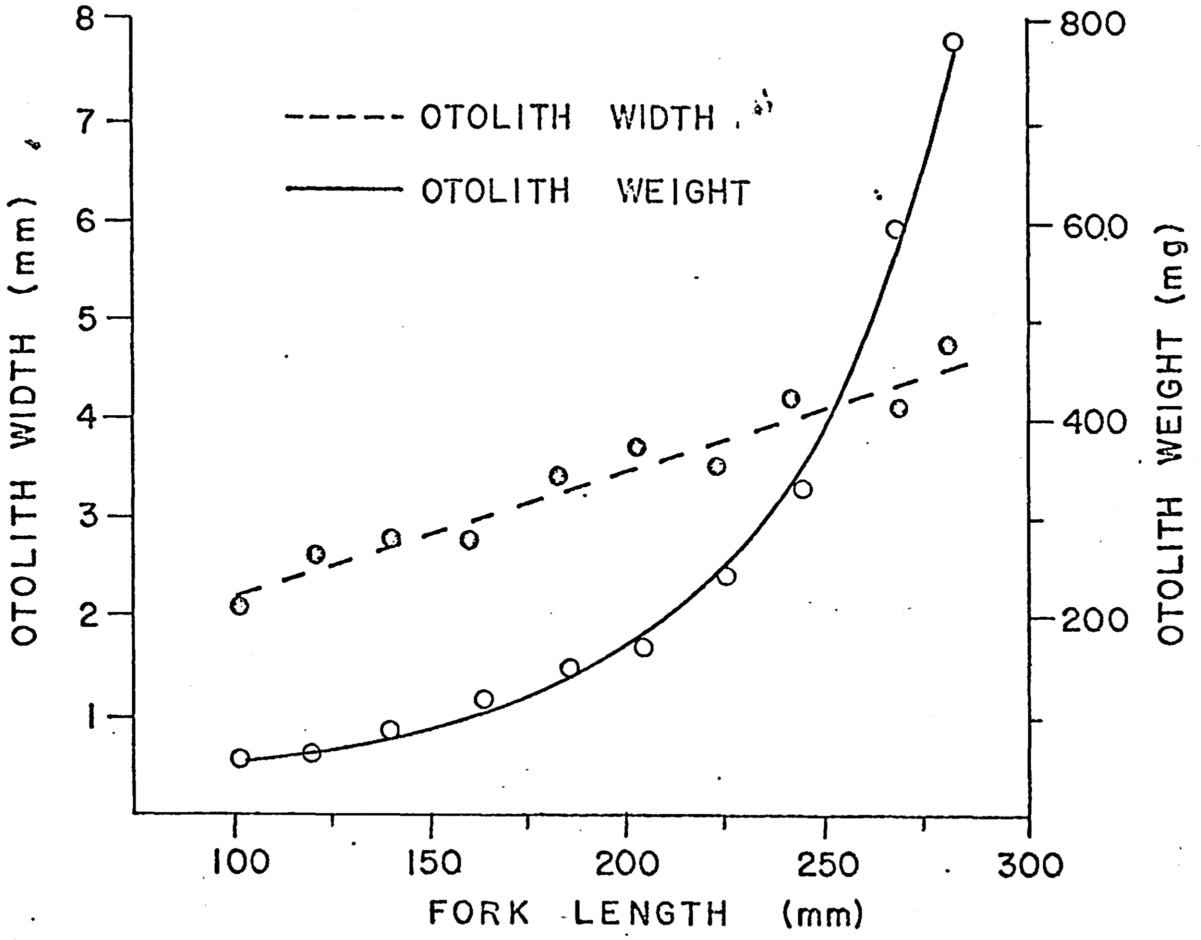


Figure 3. Regressions of otolith width and weight on length of *Prionotus carolinus*.

the marginal changes during each month of a year. In *Prionotus carolinus*, the percentage of opaque zones (with respect to both types of margins) increased from May to June, reached a maximum during August and declined thereafter. Conversely, the percentage of otoliths having hyaline margins increased during January and reached a maximum in March (Fig. 4). This definite trend of alternating opaque and hyaline zones confirmed that only one of each was formed within a year and that together they constituted a year's growth. Since no samples of otoliths were taken in October, values for October, as shown in the histogram, were taken from samples collected in early November. No fish were collected in January. The sample in June was taken in 1965. In no month was the margin restricted to one type, and the opaque zone was more prevalent than the hyaline zone in nine months of the year. I was unable to determine the nature of the margins of 10% of the otoliths for two reasons: (1) the hyaline zones were usually narrow; (2) any organic substance that was not removed from the surface of the otolith before scorching could be mistaken for a hyaline margin.

The greatest proportion of hyaline margins was observed during the coldest month, March, and the greatest percentage of opaque margins occurred in one of the warmest months, August. The bottom temperatures shown in Fig. 4 were taken in 1959 and 1960 (Joseph, Massmann and Norcross, 1961). Temperatures for 1965 and 1966 were not used because they were not measured in some months. However, a comparison of the temperatures of the Chesapeake Bight from 1959 to 1967 (personal communication from J. J. Norcross) showed that the average monthly temperatures in 1959 and 1960 were representative of an average year.

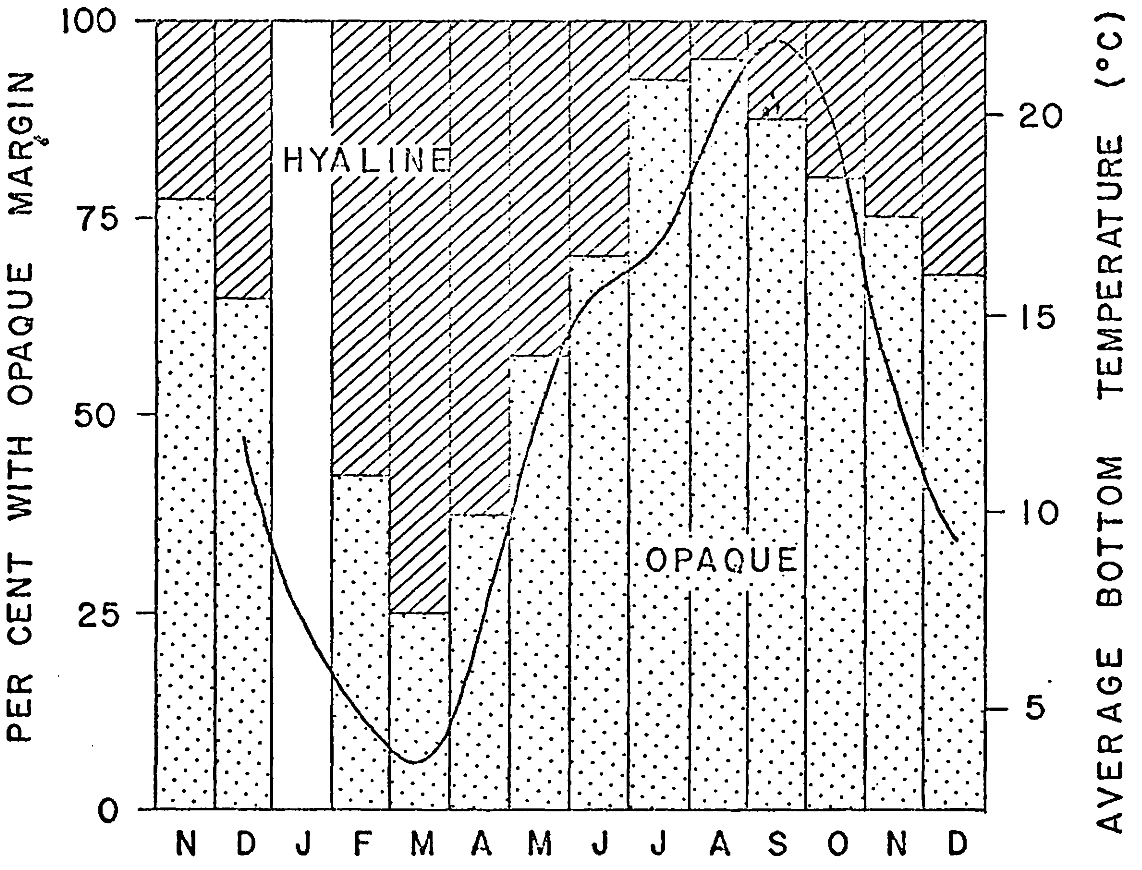


Figure 4. Percentage of opaque margins in otoliths during 1966; the curve represents average monthly temperatures of 1959 to 1960.

The nucleus of the otolith consisted of hyaline material (Fig. 5A). Outside of this was a broad opaque zone in which were several narrow and incomplete hyaline zones. The opaque zone was bounded by a clearly marked hyaline zone interpreted as the first annulus (Fig. 5B). The first annulus was surrounded by a broad opaque zone which in turn was surrounded by a hyaline zone (second annulus). The opaque zone between the first and second annuli was greater than that between any other two adjacent annuli. From the second annulus outward, the spacing was regular, with the alternating opaque zones becoming narrower toward the periphery (Fig. 5E). The transverse section of the dorsal portion of the otolith was the most desirable field for age determination because the zones were regularly spaced and could be followed around the dorsal edge.

In some otoliths, faint and incomplete hyaline zones similar to those in the first opaque zone were present between the more definite hyaline zones or annuli. These incomplete zones were considered adventitious marks. Frequently the zones appeared as double structures (Fig. 6A). These double zones differed from two separate annuli; the opaque zone between them was comparatively narrow and one of the hyaline zones united with the other after curving around the dorsal edge of the otolith. These double zones were interpreted as one annulus. Gambell and Messotorff (1964) found similar double zones in *Merlangius merlangus* and Walford and Mosher (1943) described adventitious marks as lines that meet an annulus at some point. Such accessory marks were perhaps similar to the "checks" found often in fish scales. Therefore, an annulus may be described as a distinct hyaline zone that can usually be

Figure 5. Cross-sections of otoliths of *Prionotus carolinus*. Roman numerals designate annuli. Pictures taken at different magnifications.

(A) Young-of-the-year fish 98 mm long.

(B) Age-group II fish 205 mm long, opaque margin.

(C) Age-group III fish 215 mm long.

(D) Age-group IV fish 223 mm long.

(E) Age-group V fish 248 mm long, with fifth annulus at the margin.

(F) Age-group VI fish 268 mm long, with sixth annulus at the hyaline margin.

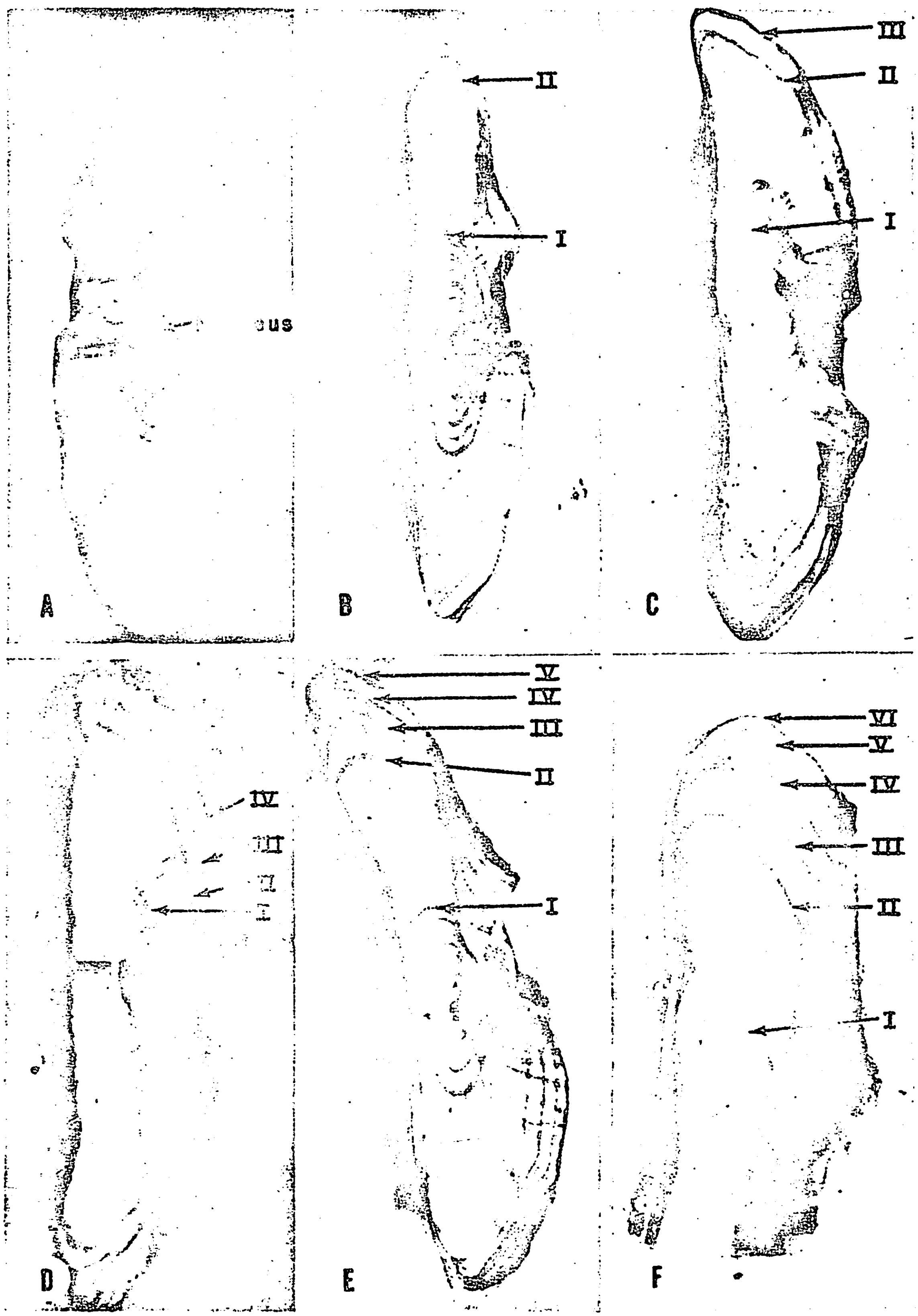
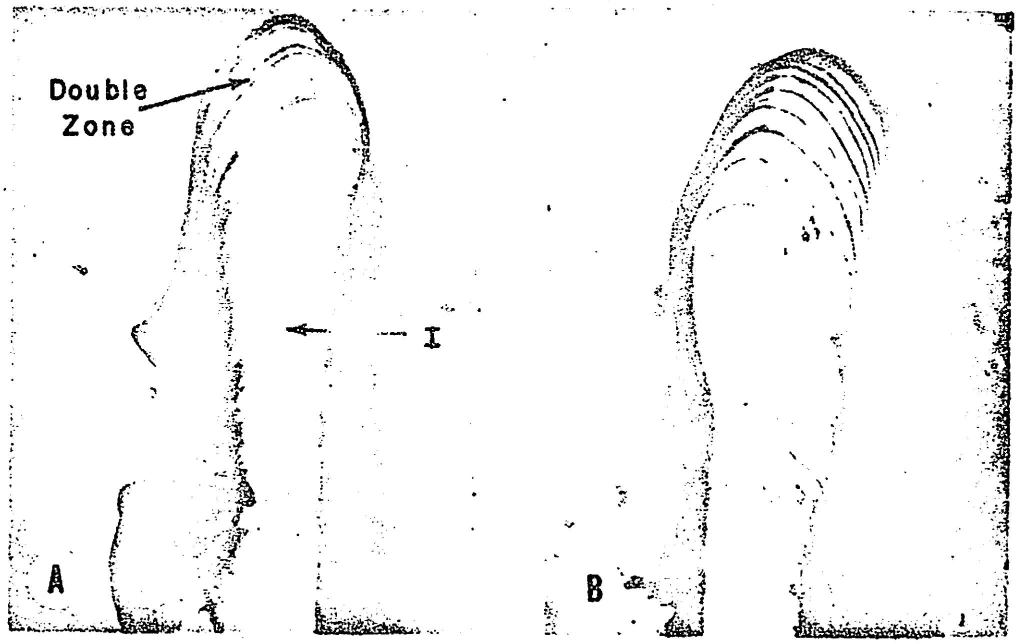

us
A
II
I
B
III
II
I
C
IV
III
II
I
D
V
IV
III
II
I
E
VI
V
IV
III
II
I
F

Figure 6. Otoliths of _Prionotus carolinus_

(A) Double zones after the first annulus.

(B) Crowding of zones near the periphery of an otolith from a fish 263 mm long.


Double Zone
I
A
B

discerned around the dorsal portion of the transverse section of the otolith. The opaque zone between annuli is of regular width in relation to other opaque zones. In contrast false annuli are usually indistinct and incomplete and tend to merge into true annuli after curving around the dorsal edge. The opaque zones between the false and true annuli are narrower than the adjacent opaque zones. The zones in the otoliths of older fish were crowded at the periphery; Fig. 6B shows the otolith of a relatively old fish with numerous marks close to the periphery. To compound the picture double zones became prevalent in older fish. Thus, I could determine the age of fish up to age-group V with confidence.

Except for one sample of age-group I fish that was used to back-calculate the lengths of fish at the formation of the first annulus, lengths of fish were not back-calculated. There are several variables in the back-calculation of lengths of fish that render results inaccurate. In this study, a variable that should be mentioned was the manner in which the otolith was cut; in order for lengths to be back-calculated accurately, the otoliths must be cut in the center of the nucleus and perpendicular to the anterior-posterior axis. Such a procedure was not followed.

Validity of the Hyaline Zone as an Annulus

The use of otoliths to determine the age and growth of Prionotus carolinus is validated as follows:

(1) One hyaline zone is formed each year.

(2) A proportional relationship exists between the growth of the fish and its otolith.

(3) There is good correlation between the increase in size of fish and the increase in number of annuli in the otolith, indicating that occurrence of the zones is not random.

(4) Age determination from examination of otoliths agrees with the result obtained from the analysis of length frequency distribution.

Analysis of Age and Growth

The average length and weight of each age-group based on the examination of otoliths are given in Table 3 and illustrated in Figs. 7 and 8. The values for length and weight of each age-group are averages of monthly means. As mentioned earlier, age determination became increasingly confusing after age-group V. Therefore, results presented for the older fish should be interpreted with caution. The oldest fish was an 11-year-old female measuring 298 mm in length and 326 g in weight. The heaviest fish weighed 386 g and was 305 mm long. Few fish exceeded 300 mm in length.

For the first five age-groups, growth of females was not significantly different from that of males. Very few males exceeded 280 mm in length. The sex ratio was approximately 1 : 1.

The average length at the formation of the first annulus, 62 mm, was derived by back-calculation of a sample of 100 age-group I fish collected in August, 1966.

The annual growth in length was greatest during the second year of life when the fish attained a length of 155 mm (average of monthly means). Growth decreased to 45 mm during the third year (Fig. 9), 21 mm during the fourth year, 21 mm during the fifth year and 8 mm during the sixth year.

TABLE 3

Results of age and growth determinations based on examination of otoliths. Average length and weight, range, sample size, $S_{\bar{x}}t_{.05}$ and 1 standard deviation for each age-group.

	LENGTH					WEIGHT				
	Range (mm)	Average (mm)	$S_{\bar{x}}t_{.05}$	Sample Size (N)	1 Standard Deviation	Range (g)	Average (g)	$S_{\bar{x}}t_{.05}$	Sample Size (N)	1 Standard Deviation
I	72-213	155	2.78	301	24.6	10-105	41	1.71	286	14.8
II	168-232	200	2.39	137	14.3	37-148	85	3.16	123	17.9
III	193-255	221	2.61	108	13.7	80-170	117	4.66	100	23.5
IV	222-274	242	2.79	83	12.8	115-260	157	6.79	64	27.2
V	204-305	250	2.81	110	14.9	125-265	181	8.81	88	41.6
VI	236-290	259	3.32	62	13.1	135-267	204	8.59	56	32.1
VII	240-287	265	3.14	54	11.5	172-297	221	10.83	43	35.2

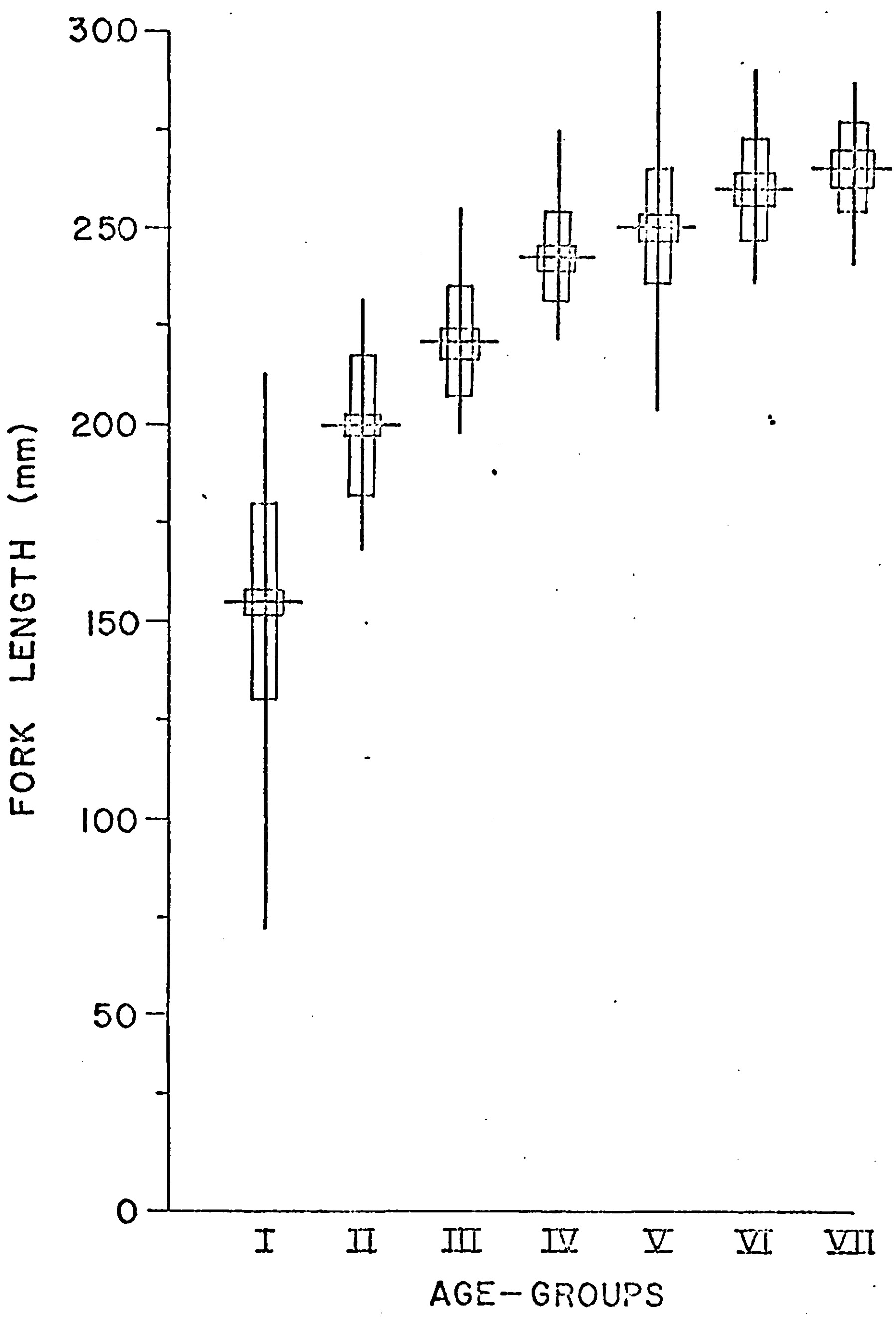


Figure 7. Average length, range and $S_{\bar{x}}t_{.05}$ of *Prionotus carolinus* at different ages.

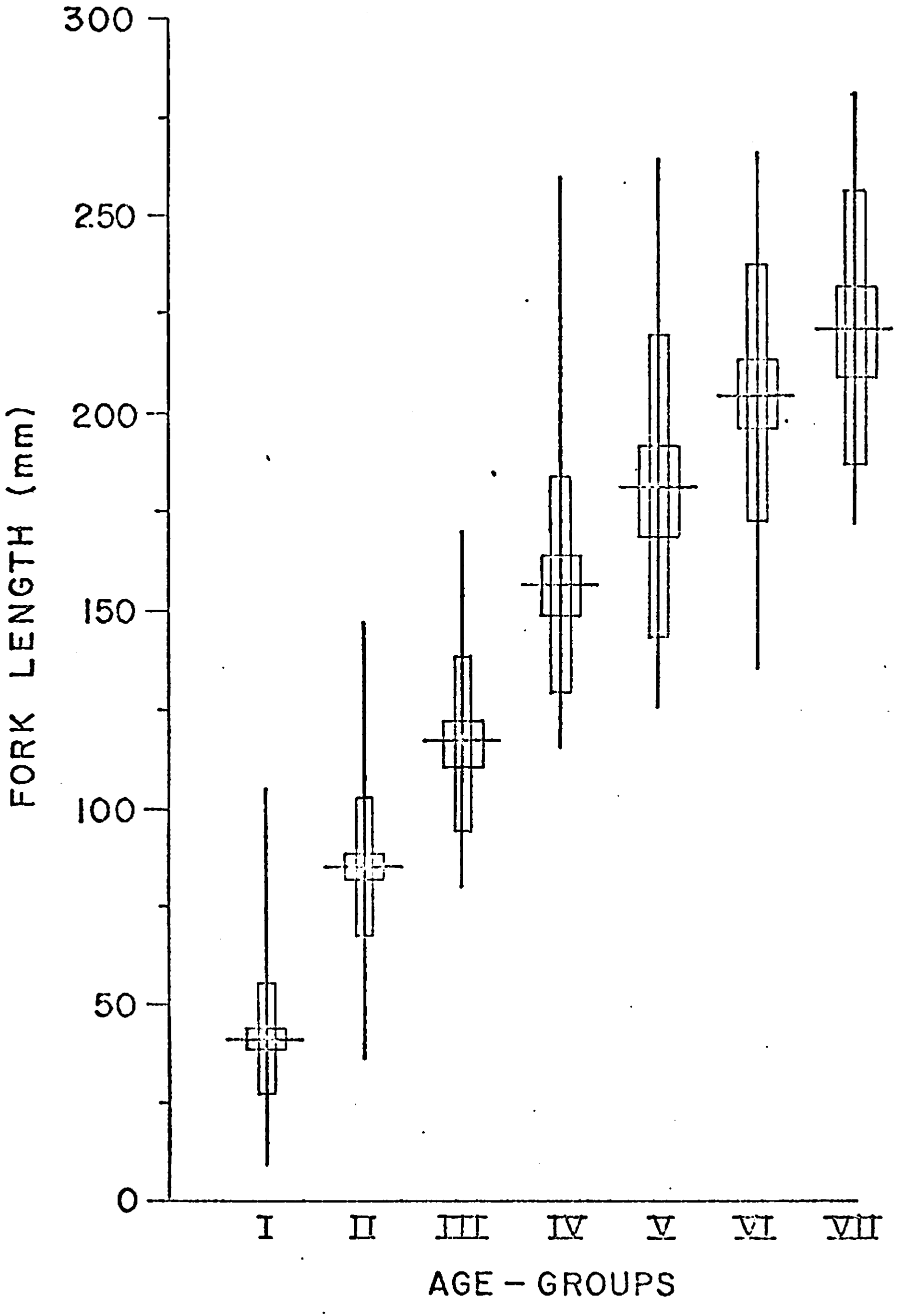


Figure 8. Average weight, range and $S_{\bar{x}}t_{.05}$ of *Prionotus carolinus* at different ages.

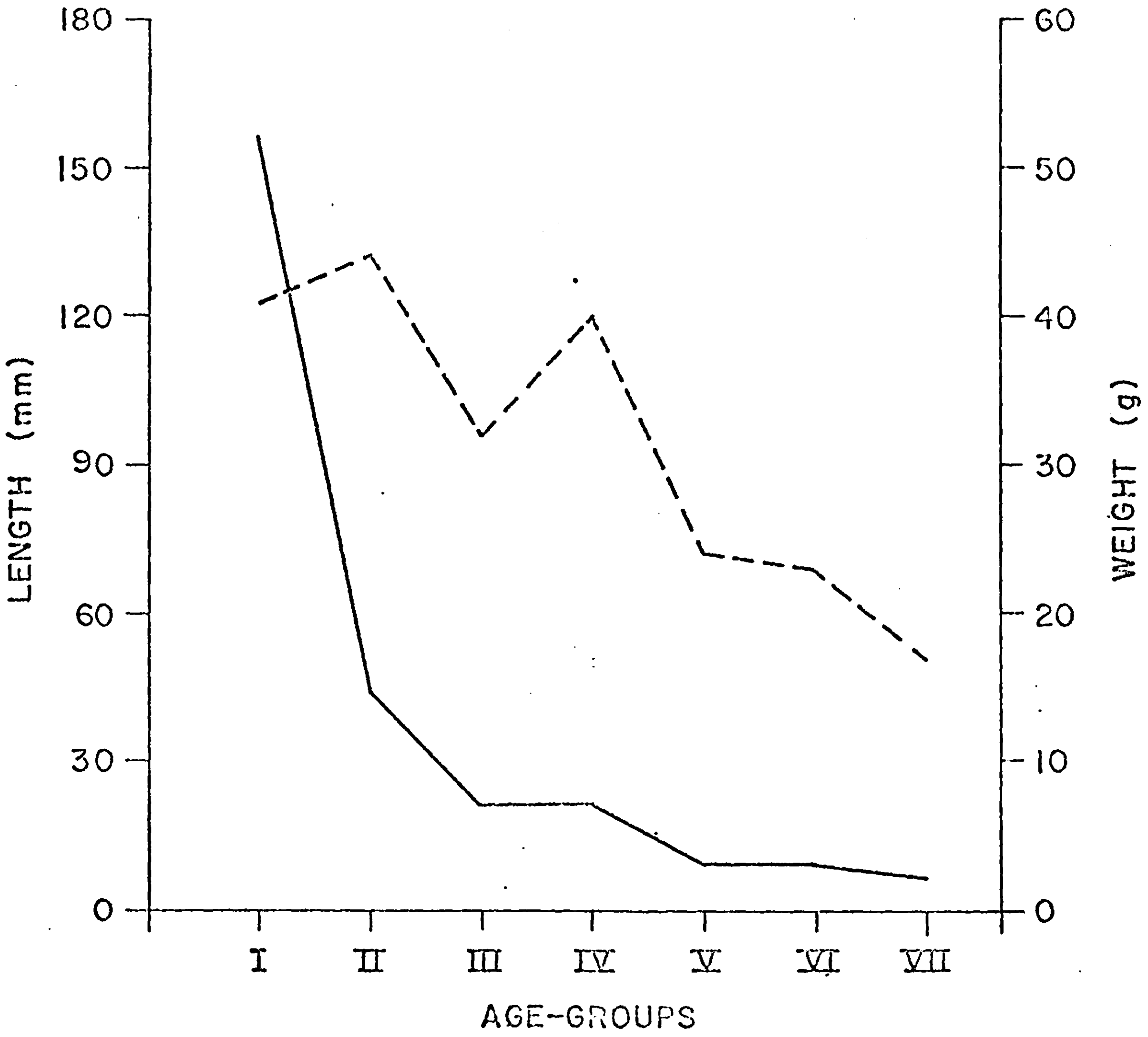


Figure 9. Annual increments of length and weight of the northern searobin.

Annual increment in weight (Fig. 9) was relatively constant from age-group I to IV and declined thereafter. Fish weighed 41 g as 1 year-olds. Increments were 44 g for the second year, 32 g for the third year, 40 g for the fourth year and 24 g for the fifth year.

From this study, it can be deduced that Prionotus carolinus is a slow growing species with a long life span.

Marshall (1946) found that marks on otoliths were too variable for age determination; however, he did not heat the otoliths. Using scales he was able to determine the first two age-groups. His results showed that fish attained a length of 153 to 214 mm (average 172 mm) and a weight of 42 to 57 g during the second summer (age-group I); and a length of 233 to 260 mm and a weight of 113 g or more during the third summer (age-group II). Scales from fish over 260 mm long were practically worthless for age determination because of illegibility and conflicting interpretations; over 30% of the readings were discarded. The heaviest fish recorded weighed 780 g and was 347 mm long.

Fish belonging to age-group I of this study measured 155 mm in length and 40 g in weight compared to 172 mm and 50 g from the study made by Marshall (1946). Further comparisons are impossible because he designated all fish over 233 mm long as age-group II or older. Some discrepancies between our results could be due to the fact that larger fish of a species are frequently distributed further north within the range of distribution. That fish from the Woods Hole area were larger than those from Chesapeake Bight was indicated by the goodly number of fish over 300 mm long in Marshall's samples. His heaviest fish was nearly twice as heavy as the largest from Chesapeake Bight.

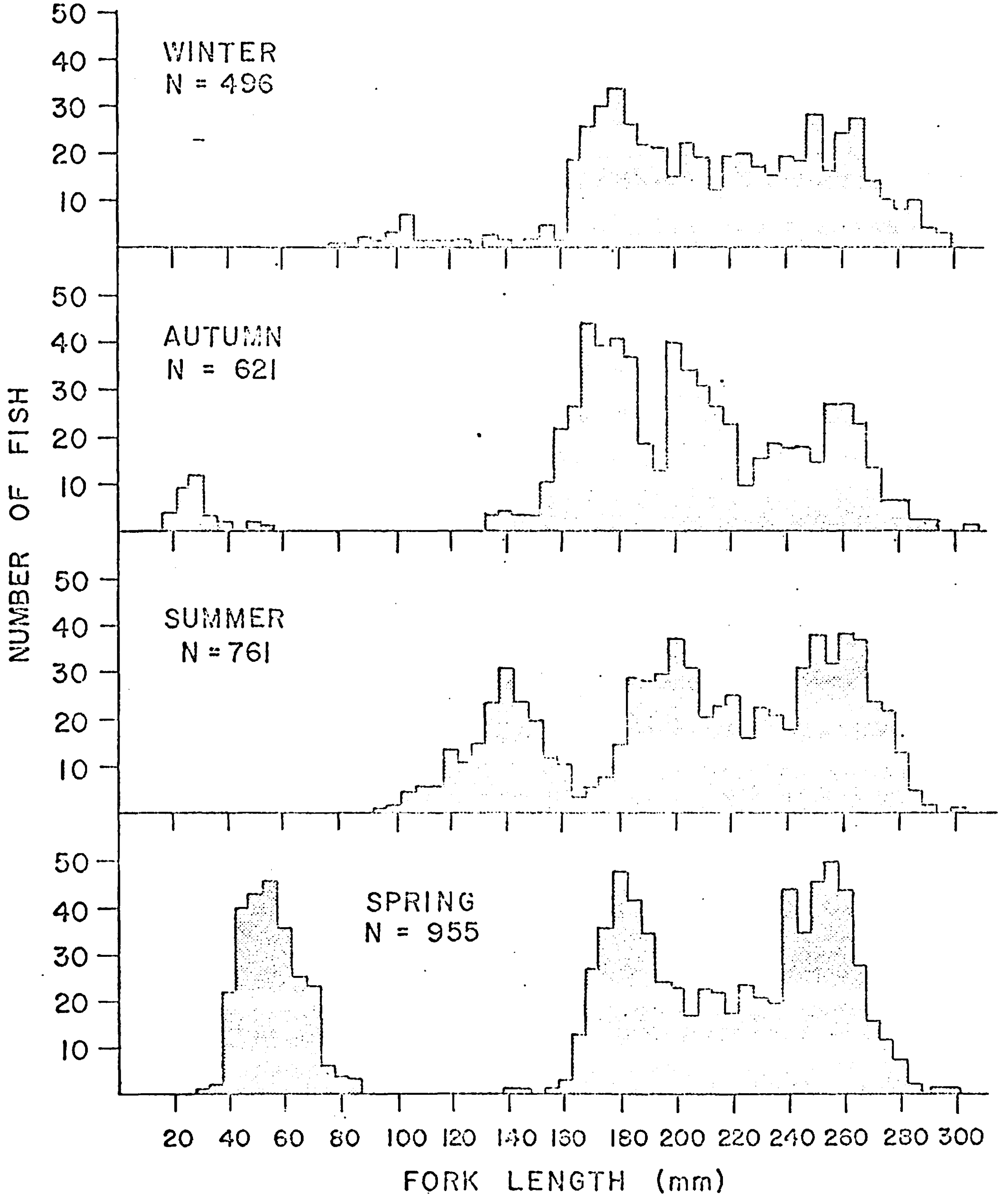
Length Frequency Distribution

A total of 2833 fish collected over a period of 12 months was included in the length frequency distribution study. Figure 10 shows the seasonal distribution of the length groups in 5 mm intervals. Three features may be noted in the length frequency histograms as follows: (1) fish below 100 mm long were poorly represented in the samples from the Chesapeake Bight (2) large fish were unusually abundant (3) there were three distinct modes in the histograms.

Most of the smaller fish were caught in the Chesapeake Bay and York River. The virtual absence of juvenile fish in the trawl samples from Chesapeake Bight could be partially attributed to escapement from the trawl between the foot rope and the cod end liner.

The length frequency distribution was unusual because of the great number of large fish. There are several possible explanations for the incongruity: (1) smaller fish were inadequately sampled (2) growth is especially slow in the older age-groups and therefore the large frequency may represent several age-groups of older fish reaching an asymptote of the growth curve (3) one or two dominant year-classes were present. Explanations (1) and (2) appeared evident from this study.

Figure 10. Length frequency histograms of *Prionotus carolinus* according to seasons.


WINTER
N = 496
AUTUMN
N = 621
SUMMER
N = 761
SPRING
N = 955
NUMBER OF FISH
10
20
30
40
50
FORK LENGTH (mm)
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

The tri-modal distribution appeared to represent the first three age-groups. However, a closer examination detected minor modes between the second and third modes. Age determination by examination of otoliths indicated that these modes represented distinct age-groups.

A sample (N=30) of small fish averaging 30 mm in length and collected in November 1966 was unmistakably the 0 age-group (Fig. 10c). In spring (April 1955 and 1956) samples of fish averaging 55 mm long were obtained; these fish had passed their first winter and therefore are designated as age-group I (Fig. 10a). Fish of that size were caught frequently but not abundantly in the James and York Rivers in Spring of 1965 and 1966. A large gap occurred between the mode at 55 mm and the following mode at 140 mm derived from the August samples (Fig. 10b). It was assumed that there were no other modes in between, and scarcity of fish between 55 and 140 mm reinforced this assumption. Thus, fish attained a modal length of 140 mm during the second summer. Through seasonal progression of modal lengths, age-groups 0 and I were established and adjacent modes in the length frequency histograms were designated as successively older age-groups.

The histogram of fish collected in spring (Fig. 10a) showed a mode at 55 mm which was designated as age-group I as explained previously. The next mode at 183 mm represented age-group I as explained previously. The next mode at 183 mm represented age-group II; age-group III was at 212 mm and age-group IV was probably at 227 mm.

In the summer collections (Fig. 10b) the distinct mode at 140 mm represented age-group I. Age-group II was at 195 mm, age-group III at 218 mm and the mode at 233 mm could be age-group IV.

The histogram of the autumn samples (Fig. 10c) showed a mode at 30 mm which represented age-group 0. The modes at 177, 208 and 235 mm represented age-groups I, II and III respectively.

In the histogram of fish caught in winter (Fig. 10d), the mode at 178 mm represented age-group I; age-group II was at 207 mm and age-group III at 225 mm. A minor mode at 105 mm was assumed to be age-group 0, although this length was large relative to age-group I in the histogram of spring.

The lengths of different age-groups during different seasons are presented in Table 4.

Marshall (1946) found three distinct modes at 49, 172 and 282 mm from the length frequency distributions and assigned them as 0, I and II or older age-groups respectively. In two of his length frequency diagrams, the third mode was replaced by two or more modes; in one, there were distinct modes at 250 and 288 mm, in the other the modes were at 245 and 300 mm with minor modes between. He did not assign two separate age-groups to the modes at 245 or 250 mm and 288 or 300 mm. Instead, he designated all fish belonging to the mode at 282 mm as age-group II or older. I am puzzled by his failure to accept modes at 245 or 250 mm and 288 or 300 mm as age-group II and III, respectively, despite the fact that most age-group II fell within the range of 233 to 257 mm and age-group III within the

TABLE 4

Modal lengths (in mm) derived from length frequency distributions during different seasons.

Age-group	Spring	Summer	Autumn	Winter
0	---	---	30	55
I	105	140	177	178
II	182	195	208	207
III	213	218	235	223
IV	227	233	---	---

range of 282 to 300 mm according to the results of age determination based on his scale method. It should be mentioned that his analysis was based on relatively few fish obtained over a period of two or three months.

Marshall (1946) also found an unusually large number of bigger fish and he attributed this phenomenon, in part at least, to the "summation of several age-groups two years or above falling close together in the expected plateau phase of their growth curve".

LENGTH-WEIGHT RELATIONSHIP AND RELATIVE CONDITION

The analysis of length-weight data has two different purposes (Le Cren, 1951). First, it describes mathematically the relationship between length and weight, so that one can be predicted from the other. Second, it measures the variation from the expected weight for length of individual fish or relevant groups of individuals as an indication of fatness, general 'well being', gonadal development and so on. The first is discussed under the term 'length-weight relationship' and the second under the term 'condition'.

The length-weight relationship of most species of fish can be described by the formula:

$$W = aL^n$$

where W = weight, L = length, "a" is a constant and "n" an exponent lying between 2.5 and 4.0 (Hile, 1936). The equation, expressed logarithmically becomes a straight line where

$$\text{Log } W = \text{Log } a + n \log L$$

and where n represents the slope of the line and Log "a" its origin.

Individual variations from the computed length-weight relationships have usually been considered more interesting than the length-weight relationship itself. The study of condition has come under the terms condition factor (Graham, 1929), coefficient of condition (Hile, 1936) and ponderal index (Kesteven, 1947) all of which measure the heaviness relative to the expected average weight at any given length. The condition factor K is based on an ideal fish whose length-weight formula follows the cubic relationship, $W = aL^3$, whereupon, $K = W/aL^3$. Martin (1949) and others have drawn attention to the fact that the cubic relationship is not obeyed generally. Le Cren (1951) proposed the relative condition factor K_n which is based on the relationship $K_n = W/aL^n$ to be determined empirically. Therefore, $K_n = W/\hat{W}$ where the observed weight is divided by the predicted weight for the observed length of fish. Values of K_n vary around 1.0; differences from 1.0 represent deviations from the regression or a measure of variability. These deviations describe all variations in weight not associated with length in a way that is not possible with the condition factor K, unless n equals 3.0, which is rarely the case (Blackburn 1960).

A scatter diagram of weights on lengths (Fig.11) indicates that the length-weight relationship of northern searobin conforms to the general exponential formula ($W = aL^n$) and that there is no significant difference between the sexes except that females predominate at lengths of 280 mm or more.

Since the weight of fish varies with feeding, spawning and other activities, the length-weight relationship was presumed to vary from season to season. Consequently, the latter relationships were calculated for each month by the least squares

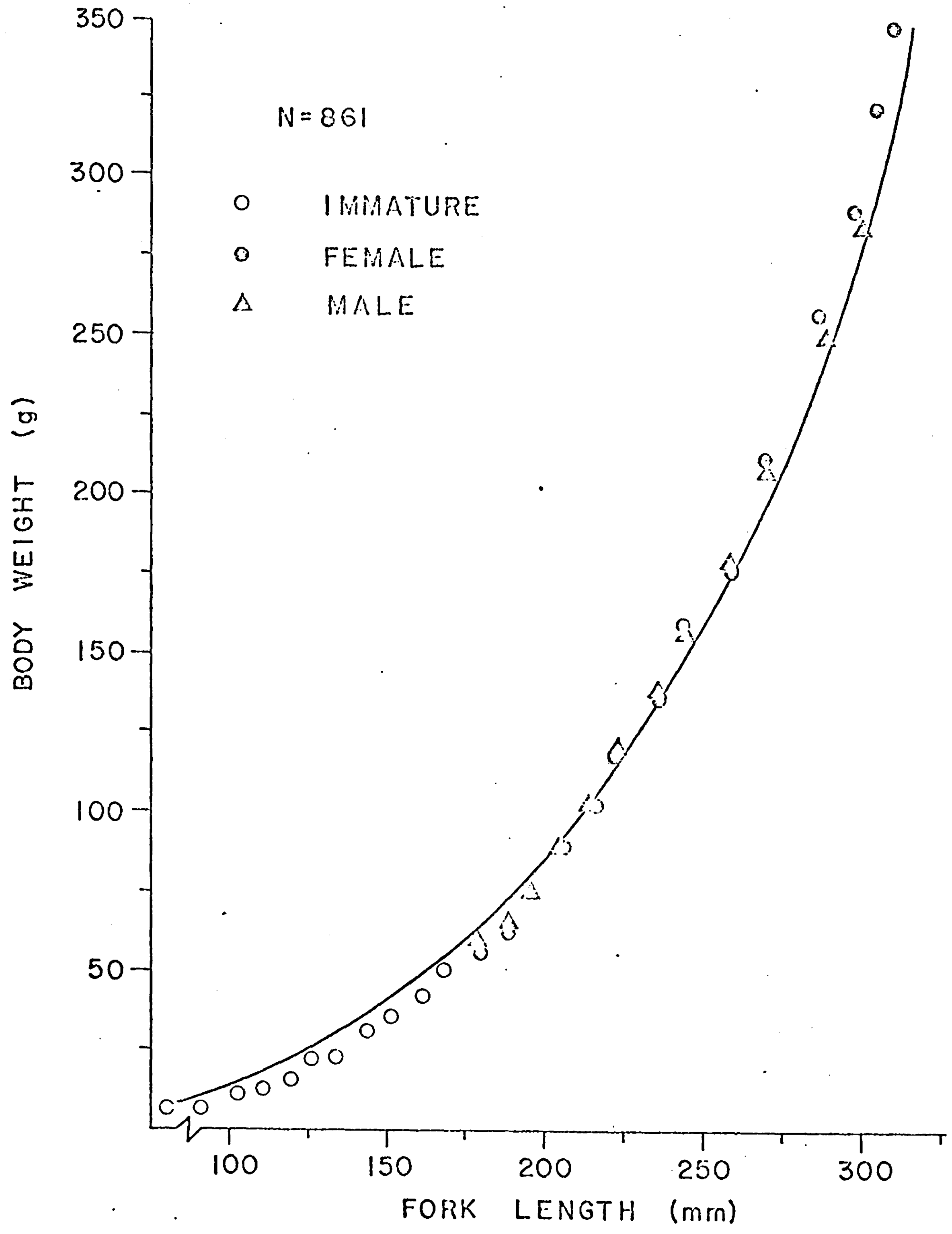


Figure 11. Annual average length-weight relationship of *Prionotus carolinus*. The curve is derived from the equation, $W = 0.000004627L^{3.1467}$.

method. The values for a and n were lowest in February and highest in June (Table 5). Analysis of covariance (Le Cren, 1951; Snedecor, 1956) demonstrated that the variance and the slope were homogeneous for March through July and in November and December. February and August were significantly different from all other months. This series of tests showed that length-weight relationships changed significantly within a year.

The average length-weight relationship of *Prionotus carolinus* was $W = 0.000004627L^{3.1467}$ or $\text{Log } W = -5.3347 + 3.1467 \text{ Log } L$ where W = weight in grams and L = length in mm.

The relative condition values were calculated for each fish and the mean values were obtained for each month's sample. No attempts were made to differentiate between the males and females or mature and immature fish. Mean relative condition, K_n, plotted against time showed a gradual increase from November 1965 to July 1966, followed by a decline from August to November 1966 (Fig. 12).

Accumulation of fat prior to gonadal maturation is observed in many fishes (Hoar, 1957). Such a trend could be inferred from the gradually increasing relative condition as indicated by the ascending curve in Fig. 12. During July and August fish were running ripe and this was indicated by the high values of K_n. Although there were no data for September and October, the low relative condition in November (in both 1965 and 1966) suggested that a decline occurred in September. This was not unexpected since most fish had completed their spawning and were spent. In his study on *Perca fluviatilis* Le Cren (1951) found

TABLE 5

Values of a and n from the length-weight formula $W = aL^n$ and mean relative condition (K_n) for each month.

Month	Sample Size (N.)	a	n	Mean K_n
December 1964	52	-5.1729	3.0806	1.012
June 1965	50	-5.9141	3.3557	0.836
November 1965	120	-5.1117	3.0401	0.956
February 1966	599	-4.8039	2.9231	1.014
March 1966	395	-5.4668	3.2085	1.034
April 1966	100	-5.6665	3.2924	1.048
May 1966	562	-5.3808	3.1593	0.968
July 1966	92	-5.4651	3.2315	1.125
August 1966	164	-5.0308	3.0298	1.107
November 1966	189	-3.1314	3.0723	0.907

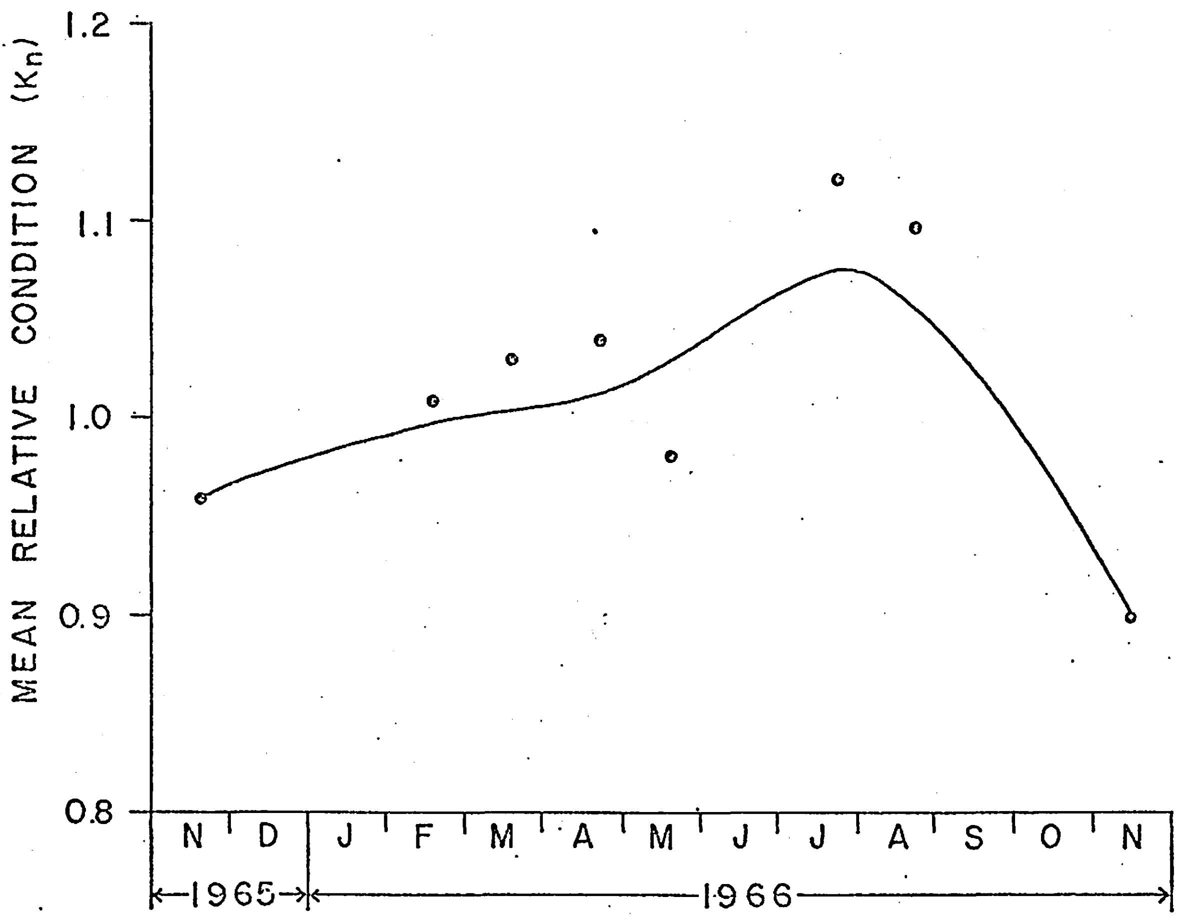
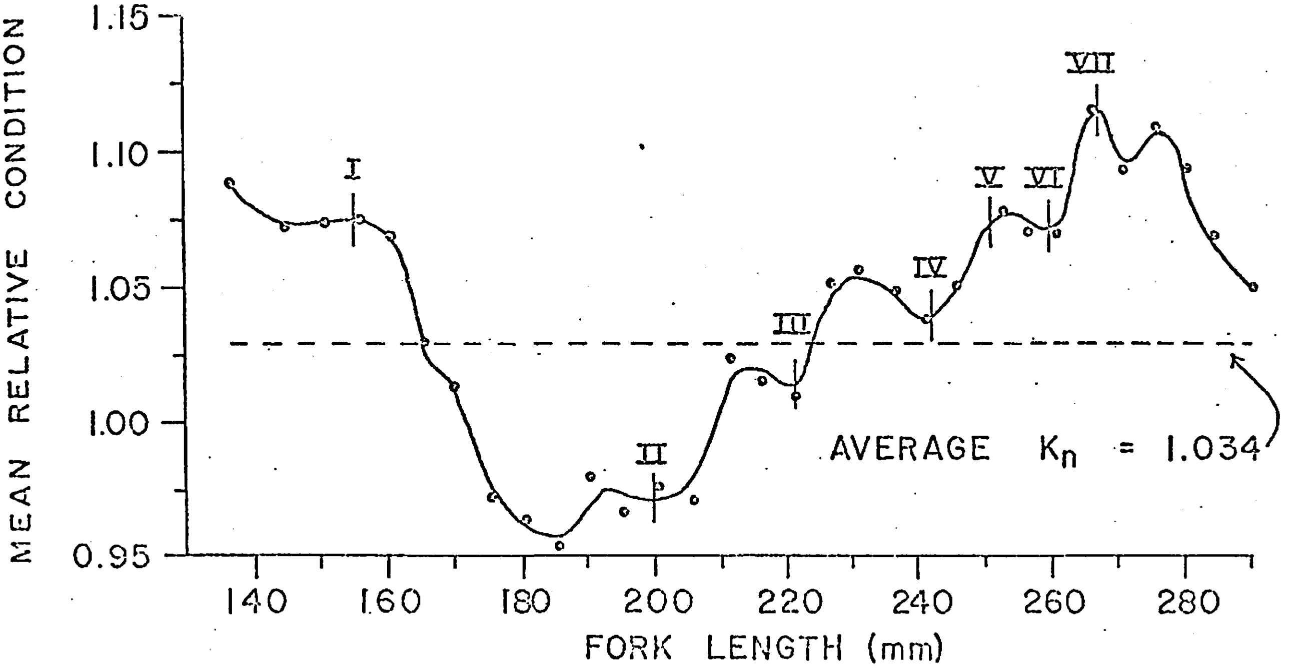


Figure 12. Mean relative conditions (K_n) of Prionotus carolinus for months of 1965 and 1966.

that seasonal changes in the weight of gonads, especially the ovaries, influenced the relative condition curve substantially. For example, when the ovaries of the perch were ripe, they averaged about 20% of the body weight and in the freshly spent fish ovaries were about 3% of the body weight. Therefore, the relative condition corresponded closely to the spawning cycle in spite of the fact that data were lacking in a few months.

Relative condition values were plotted against the length of fish for the month of March (Fig. 13). The K_n values were high for fish below 160 mm in length. Between 170 and 220 mm, relative condition was at its lowest, being less than the average for the month. Relative condition began to rise after 185 mm, reached a peak at 265 mm, and declined after 275 mm. There were several depressions between 210 and 275 mm. In other months the pattern was similar.

Relative condition was high in both the small and large fish; the former could be due to the high rate of growth before the onset of sexual maturation and the latter due to the fact that as fish increased in age, weight increased much faster than length. The decline after 275 mm was probably caused by senility. The most plausible explanation for the low relative condition between 170 and 220 mm was attributed to the demands on metabolic processes during sexual maturation (Pantulu, 1963). Fish within this length range were undergoing sexual maturation.


MEAN RELATIVE CONDITION
0.95
1.00
1.05
1.10
1.15
140
160
180
200
220
240
260
280
FORK LENGTH (mm)
I
II
III
IV
V
VI
VII
AVERAGE Kn = 1.034

SPAWNING PERIOD AND AGE AT SEXUAL MATURITY

Gonads of sexually mature fish began to increase in size in March. By May, some fish were gravid, and in July the running ripe condition was observed. Running ripe fish were prevalent in August and early September. Most fish were spent by November, except for a few males. The gonads of fish caught in February appeared little different from those found in November. The incomplete data (there were no samples in January, April, June, October and December 1966) indicated that spawning season in 1966 in the Chesapeake Bight was July, August and at least part of September.

Table 6 shows the spawning periods of *Prionotus carolinus* in various regions according to several authors. Except for Smith (1907) the other investigators reported that northern searobin spawned in the summer. However, there is doubt that *P. carolinus* spawns earlier than July in areas north of Chesapeake Bight. Wheatland (1956) differentiated the eggs of *P. carolinus* and *P. evolans* by the distribution of oil globules in the eggs --- dispersed in the former and clumped in the latter. Recent studies at the Virginia Institute of Marine Science (personal communication from E. B. Joseph) showed that the distribution of oil globules in the eggs of both species changed ontogenetically. The oil globules in the eggs were clumped in early stages and dispersed in later stages in both species. Therefore, the early

TABLE 6

The spawning periods of *Prionotus carolinus* in various regions as reported in the literature.

Spawning Period	Locality	Reference
Spring	Beaufort, N.C.	Smith, 1907
June, July and perhaps later	Woods Hole	Sumner, Osburn and Cole, 1913
June, July and early August	Woods Hole	Kuntz and Radcliffe, 1918
June, July and August	Southern New England; N. Y.	Nichols and Breder, 1927
August 19 to 25	Atlantic City, N. J.	Hildebrand and Schroeder, 1928
May through August	Long Island	Perlmutter, 1939
Mid-June to early August	Southern New England	Marshall, 1946
June to September	Woods Hole	Bigelow and Schroeder, 1953
June through August	Long Island Sound	Wheatland, 1956

spawning reported in the northern range could be due to errors in the study of embryology of *P. carolinus* and *P. evolans*. The latter species was found to spawn earlier in Chesapeake Bight.

Fish around 200 mm long were ready to spawn even though the gonads were small. Therefore, *P. carolinus* attained sexual maturity at age II or III.

SUMMARY

1. The first five age-groups of the northern searobin could be determined on the basis of growth zones observed in transverse sections of scorched otoliths.
2. The first three age-groups could be inferred from length frequency histograms despite unusually large numbers of bigger fish.
3. The northern searobin has a slow growth rate and a long life span.
4. Statistical tests showed significant seasonal differences in the length-weight relationship. The annual average length-weight formula was $W = 0.000004627\ L^{3.1467}$.
5. The lowest values of relative condition occurred during the period of sexual maturation.
6. *Prionotus carolinus* spawned in July, August and part of September in the Chesapeake Bight.
7. *Prionotus carolinus* mature sexually when 2 or 3 years old and at a length of about 200 mm.

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Part 3

AGE AND GROWTH OF THE SPOTTED HAKE[2]

By

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[2] From a MA Thesis, Distribution, Growth and Behavior of the Spotted Hake in the Chesapeake Bight. School of Marine Science, College of William and Mary in Virginia.

AGE AND GROWTH

AGE DETERMINATION

Scale samples were taken from 225 hake collected in August, 1967 and October, 1968; scales from 193 fish were readable. The relationship between scale radius and body length was not calculated because scales, taken from several locations on the fish, differed in shape.

Several facts support the validity of scale marks as annuli. The average lengths of hake of given age groups were similar to modes in length-frequencies. The number of scale marks increased with the length of the fish and was usually 1 less than the number of rings in cleared otoliths from fish of similar lengths.

An annulus is characterized by a sharp change in direction (toward the scale edge) and closer spacing of many circuli (Figs. 13 and 14). The closely spaced circuli appear as concentric rings about the focus. In several scales newly formed circuli cut across older circuli at the annulus. Most scales were difficult to interpret.

The annulus probably is formed during late February or early March. During these months the bottom waters of the northern Chesapeake Bight are the coldest (Bigelow, 1933). The absence of annuli at the edge of scales from hake caught in October indicates that hake were in or at the end of a growing period.

The majority of scales lacked annuli representing the first winter, which occurs only several months after most hake are spawned. Scales without an annulus were from hake approximately 1 year old; these hake were considered age group I. Scales with one annulus represented hake of

Figure 13. Scale of female spotted hake (TL=355mm). Arrows mark annuli.

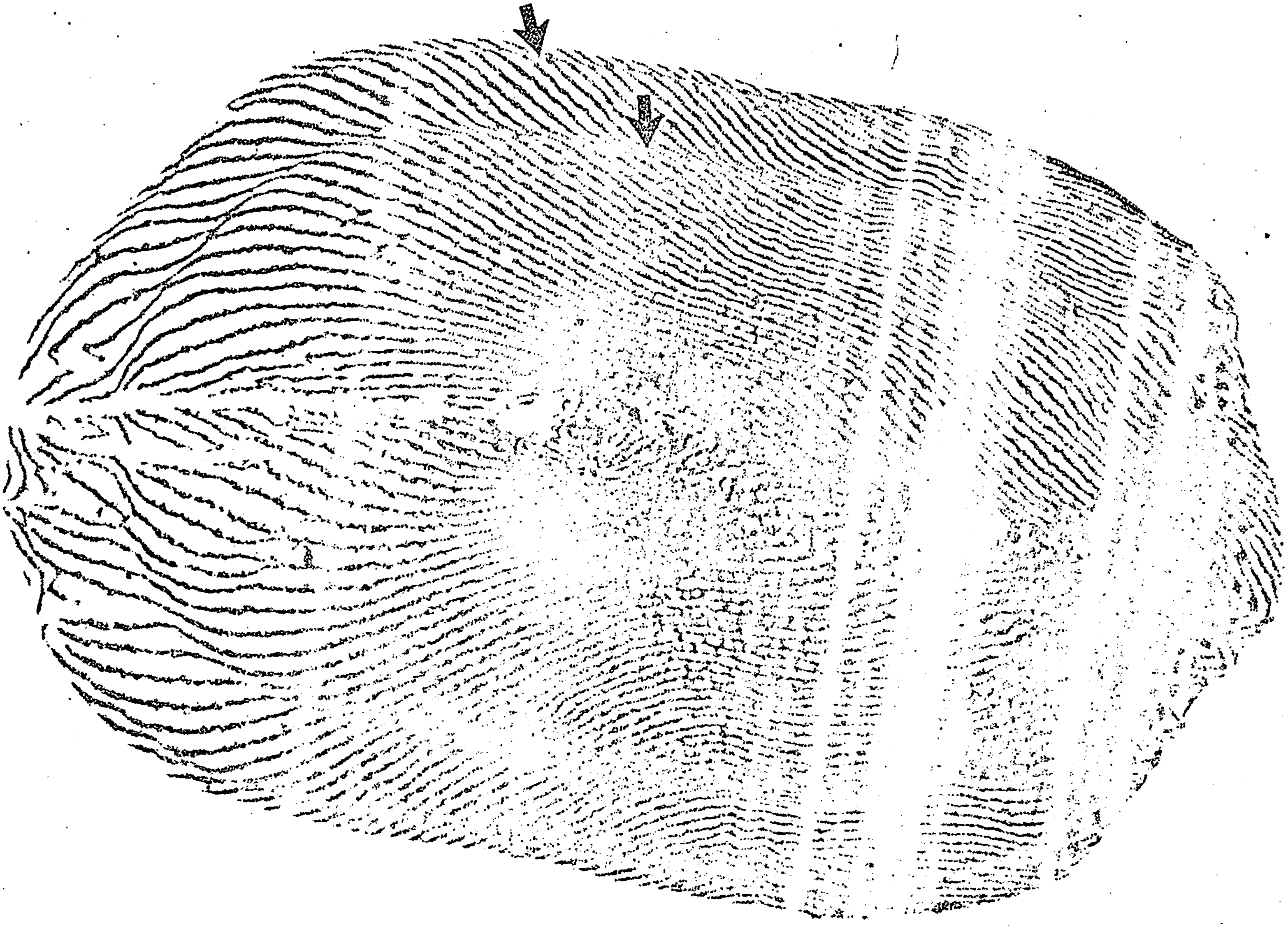
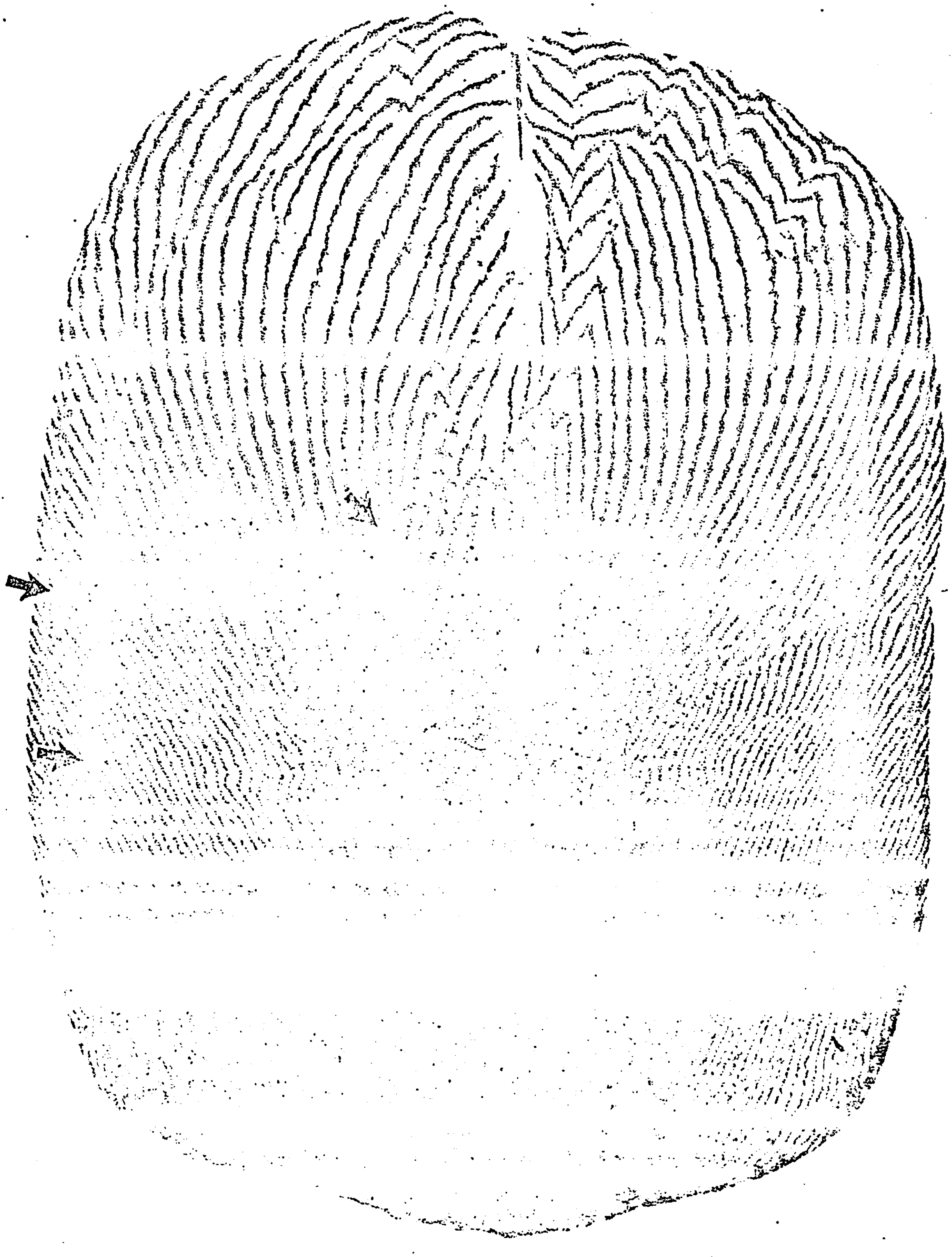


Figure 14. Scale of female spotted hake (TL=312mm). Arrows mark seldom formed inner annulus (inside), second annulus and false annulus (outside).



age group II. Otoliths had a first winter annulus, therefore the number of annuli in otoliths was one greater than in scales of the same fish.

The results of age determinations from scales (Tables 1, 2 and 3) are consistent with results from length-frequency analysis (p. 33). The mean lengths of fish of each age group are reported in cm, although lengths of fish caught in October were recorded in mm. There is little overlap in length ranges of fish between age groups. The largest female (362 mm) was 3 years old and the largest male (261 mm), 2 years old.

GROWTH ANALYSIS

Analysis of information derived from scales indicates that spotted hake grow rapidly. The mean lengths of age group I males (17.3 cm) and females (20.2 cm) from south of 37° N were considered to represent the average first years growth (p. 37). Although length at the end of the first year is comparable to that reported by Bigelow and Schroeder (1953) for *U. chuss* (200 mm), this length represents a greater proportion of the spotted hake's maximum length. Female spotted hake reach approximately half of their maximum length during the first year; males reach more than half of their maximum length during the first year.

Females grow faster and live longer than males. In October, the difference between mean lengths of age group I males and females was 4.2 cm in hake collected north of 37° N and 2.9 cm in hake collected south of 37° N. The difference between mean lengths of age group II males and females was 6.1 in the north; the sample of hake from south of 37° N contained only one age group II female (28 cm). No age group III males or females were collected south of 37° N.

Hake of both sexes appear to grow more rapidly in northern than in southern latitudes. Age group I males from north of 37° N averaged 3.9 cm longer than males from south of 37° N. The difference between age

TABLE 1

Mean lengths (cm) of spotted hake by age group and sex. Hake were collected north of 37^{o}N in August, 1967.

	FEMALES			MALES	
Age group	I	II	III	I	II
Number of fish	10	17	2	39	8
Mean length	22.3	31.3	35.2	19.9	25.0
Range in length	19-24	27-34	35-36	18-24	24-26
Standard deviation	13.35	6.36	2.24	13.29	7.71
Standard error	4.22	3.97	1.59	2.13	2.72
Yearly increment	22.3	9.0	3.9	19.9	5.1

TABLE 2

Mean lengths (cm) of spotted hake by age group and sex. Hake were collected north of 37^{o}N in October, 1968.

	FEMALES			MALES	
Age group	I	II	III	I	II
Number of fish	18	14	2	49	10
Mean length	25.4	31.1	36.0	21.2	25.0
Range in length	21-28	29-34	36	18-24	23-27
Standard deviation	1.76	1.80		1.25	1.15
Standard error	0.42	0.48		0.18	0.36
Yearly increment	25.4	5.7	4.9	21.2	3.8

TABLE 3

Mean lengths (cm) of spotted hake by age group and sex. Hake were collected south of 37^{o}N in October, 1968.

	FEMALES		MALES
Age group	I	II	I
Number of fish	19	1	4
Mean length	20.2	28.0	17.3
Range in length	18-23	28	16-18
Standard deviation	1.58		1.00
Standard error	0.36		0.50
Yearly increment	20.2	7.8	17.3

group I females from the north and those from the south was 5.2 cm. The large individuals of age group I in the north had little effect on the mean length of that year class, as is shown later, because of the great numbers of smaller individuals in the south.

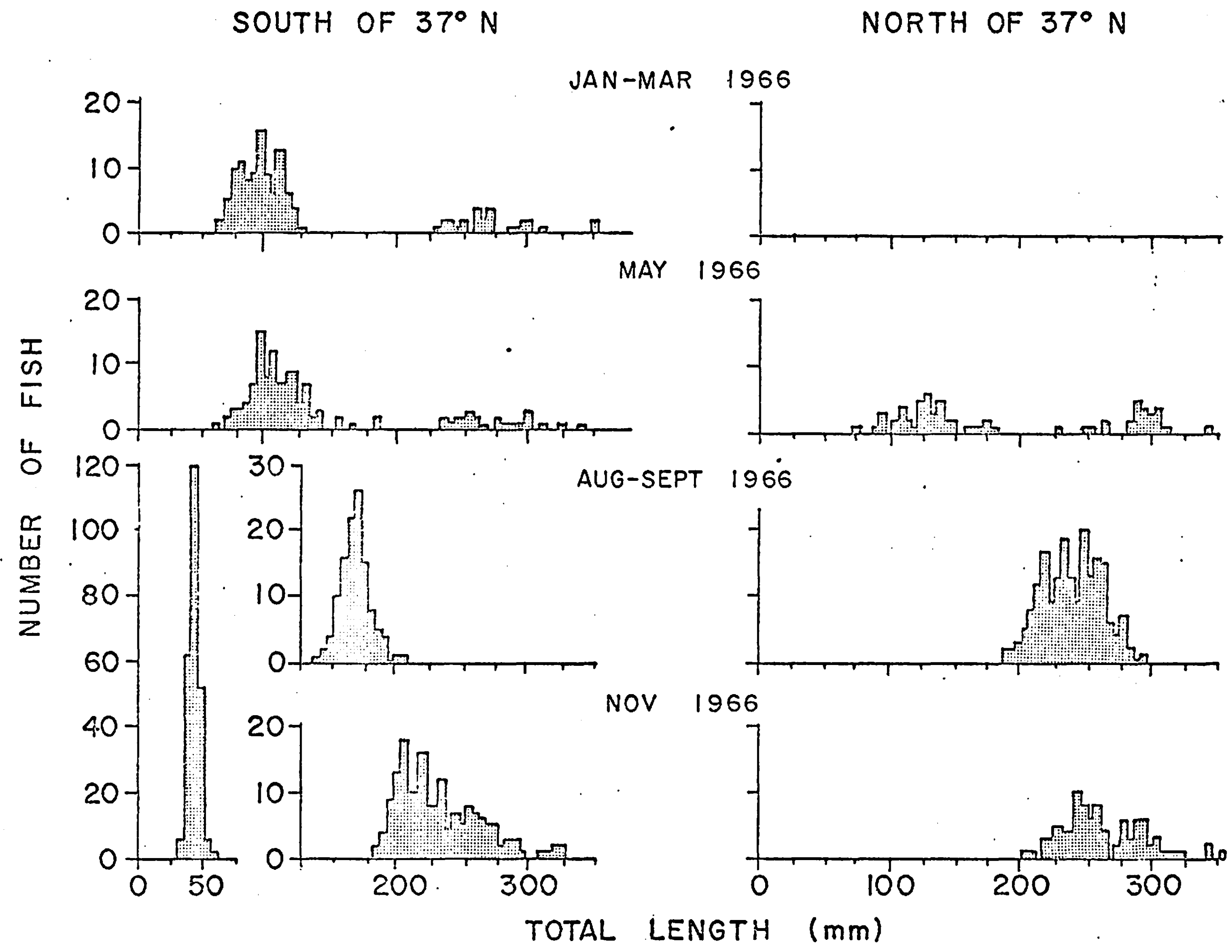
It is possible that hake (210-250 mm) from north of 37° N were not of the same age group as the smaller (200 mm) individuals from the south. A great difference in growth pattern must exist between hake spawned in fall and those spawned in winter or early spring. In fall optimum growth conditions probably exist in the surface waters of the Chesapeake Bight. During winter and early spring, plankton populations in the surface waters are probably quite poor. Although the larger northern hake may represent age group II, no intermediate age group was recognized in length-frequency analyses.

LENGTH-FREQUENCY ANALYSIS

The length-frequency distributions of hake in the York River estuary (Fig. 4) suggest that hake were all of age group I. In April, the modal lengths of fish entering the estuary ranged from 100 to 135 mm. The modal lengths of hake in June ranged from 185 to 200 mm. Estimates of growth during residency are confused by recruitment of smaller fish during April and May. Growth increments were calculated from the mean lengths of fish in monthly catches. The greatest increase in mean length was 76 mm during the April-June residency in 1968. The smallest increase was 62 mm during March-June, 1966.

Seasonal length-frequency distributions of fish from the Chesapeake Bight are presented in Figure 15. During the winter (January through March) 1966, the first mode of hake caught south of 37° N was at 95 mm. This mode represents larger individuals of age group I, which was not completely available to the sampling gear. The following season (May),

Figure 15. Seasonal length-frequency distributions of spotted hake in the Chesapeake Bight north and south of 37°N latitude.

SOUTH OF 37° N
NORTH OF 37° N
JAN-MAR 1966
MAY 1966
AUG-SEPT 1966
NOV 1966
NUMBER OF FISH
TOTAL LENGTH (mm)
0
10
20
30
40
60
80
100
120
50
200
300

the first mode was at 105 mm; in August and September, there was a well defined first mode at 170 mm. By November this mode, representing fish just over one year old, was at 205 mm and for the first time a mode occurred at 45 mm. This mode represented only the largest individuals of the new year class. The progressive change in modal length suggests a mean growth increment of approximately 200 mm during the first year. The period of most rapid growth was between May and November. These estimates are based on the assumption that the shift with time in the first mode in a series of length-frequency distributions from a single population of fish represents a progressive increase in mean length of the age group.

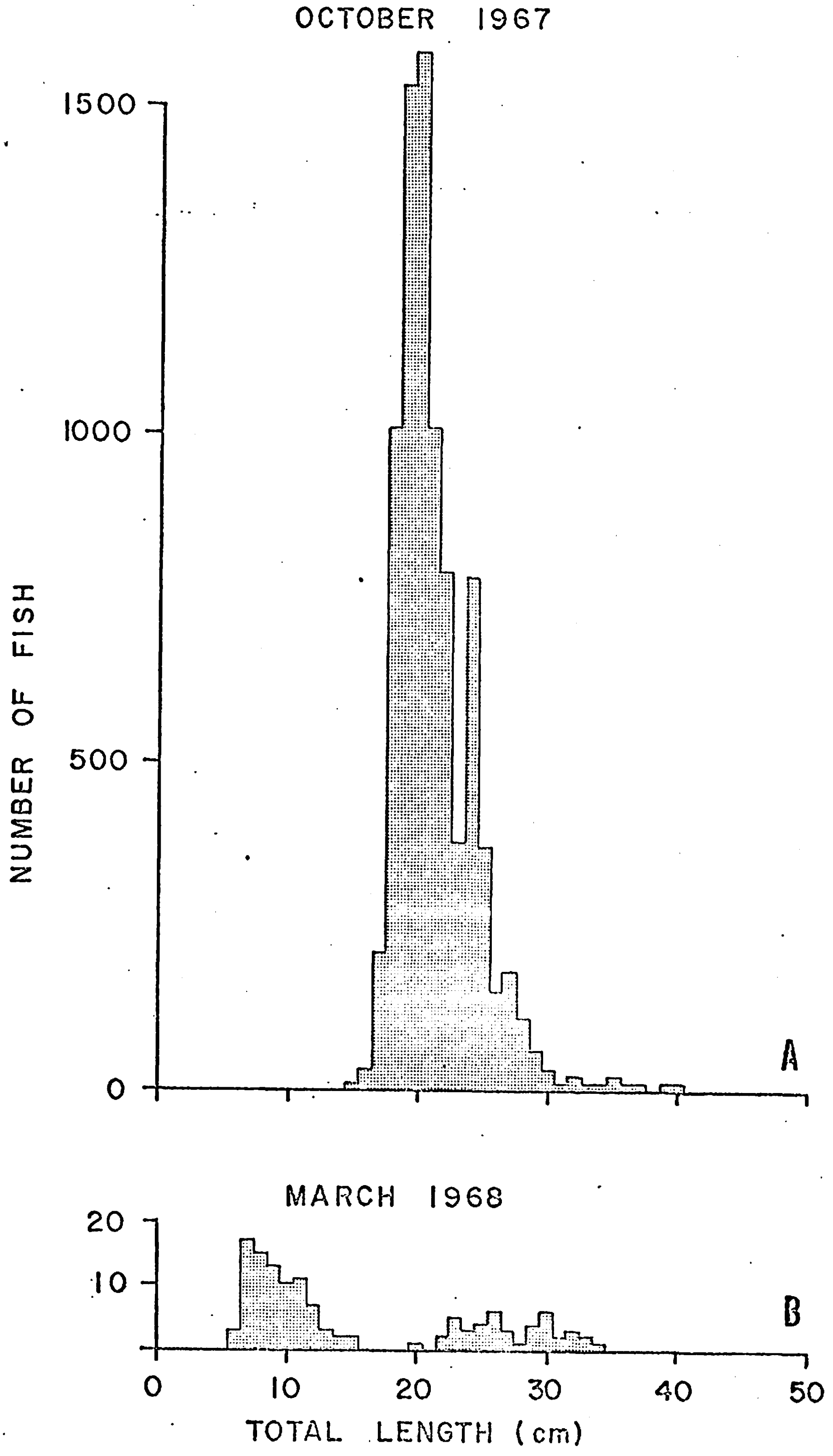
The first mode in the length-frequency distribution of hake caught in October, 1967 (similar to the 1966 mode) represents age group I, because no hake less than 15 cm in length were caught at any station in the Mid-Atlantic Bight, Chesapeake Bay or York River system in October. All areas were sampled with gear that had collected much smaller individuals during other periods of the year. The peak in length-frequencies at 20 cm represents mean growth of the spotted hake in their first year.

The other modes of the seasonal length distributions are not easily interpreted. The amount of overlap and the differential rate of growth between sexes makes following them through successive seasons impossible. Growth of preceding year classes can be estimated by analyzing one large sample that adequately represents the population. The October, 1967 length-frequency distribution (Fig. 16,a) represents 8532 hake collected throughout the Mid-Atlantic Bight. The modes at approximately 32, 35 and 40 cm probably represent additional age groups. The modes at 24 and 27 cm may be a product of sampling error and overlap in lengths of age group II males and large age group I females. In the March distribution (Fig. 16,b)

Figure 16. Length-frequency distributions of spotted hake collected between Cape Cod and Cape Hatteras.

a) 8532 hake from October, 1967.

b) 126 hake from March, 1968.

OCTOBER 1967
1500
1000
500
0
NUMBER OF FISH
A
MARCH 1968
20
10
B
0
10
20
30
40
50
TOTAL LENGTH (cm)

the skewed shape of the first curve, with a mode at 7 cm, indicates that the trawl was catching only larger individuals of age group I.

North of 37° N, hake of age group I were larger at the end of each season than those in the south. At the end of the first year of growth the mean length was slightly less than 250 mm in the north and approximately 200 mm in the south. Hake south of 37° N were considered more representative of the population, because they were more numerous during all seasons. In October, 84.4% of the sample from the Mid-Atlantic Bight was caught south of 37° N. In March, 1968, 79.4% of the total catch and all the hake less than 23 cm in length was caught south of 37° N.

There was a difference between the total number of hake caught in fall and spring. In October, 1967, the total catch by the Albatross IV in the Mid-Atlantic Bight was 1449 spotted hake; the total catch in March, 1968, was 126, 11.5% of the October catch. Surveys used the same gear and made approximately the same number of trawl stations.

A series of monthly length-frequencies (May-November, 1967) showed that females grow faster than males. Similar results were gained from the scale based age-growth analysis. The divergence of the modal lengths of females and of males occurred at a length of about 180 mm in June. In September (approximately one year after the year class was spawned), there was a 50 mm separation between the modal lengths of males and females collected in the north and 25 mm between those from the south. Although samples from August and November contained large females of other age groups, the first peaks in their length distributions clearly show the differences between modal lengths of males and females of age group I.

LENGTH-WEIGHT RELATIONSHIP

Length-weight relationships are based on 683 male, 910 female and 133 spotted hake of undetermined sex caught in the Mid-Atlantic Bight and York

River estuary between May, 1967, and February, 1968. Measurements were made to the nearest mm and g. The length-weight relationships were calculated by an IBM 1130 computer using the least squares method, where both variables were converted to common logarithms.

Data from males and females were analyzed separately because of the large difference in maximum lengths. There was no difference between modal lengths of males and females smaller than 180 mm (p. 37). The fish of undetermined sex ranged in length from 60 to 145 mm, so these lengths were added to the data of both males and females before analysis. The length-weight relationships were expressed by the equations:

$$\text{males:} \quad \log W = -5.225 + \log L \; 3.066$$

$$\text{females:} \quad \log W = -5.208 + \log L \; 3.063,$$

where W is the weight in grams and L is the total length in millimeters. Although there was a significant difference at the 5% level between the two regressions, the graphs appear to coincide (Fig. 17).

GROWTH EQUATIONS

Equations which described growth were obtained with an analog computer. A growth curve was graphically fitted to ages and average lengths that had been determined from scales (Ricker, 1958). Maximum lengths were estimated from the literature (Bigelow and Welsh, 1925; Hildebrand and Schroeder, 1928).

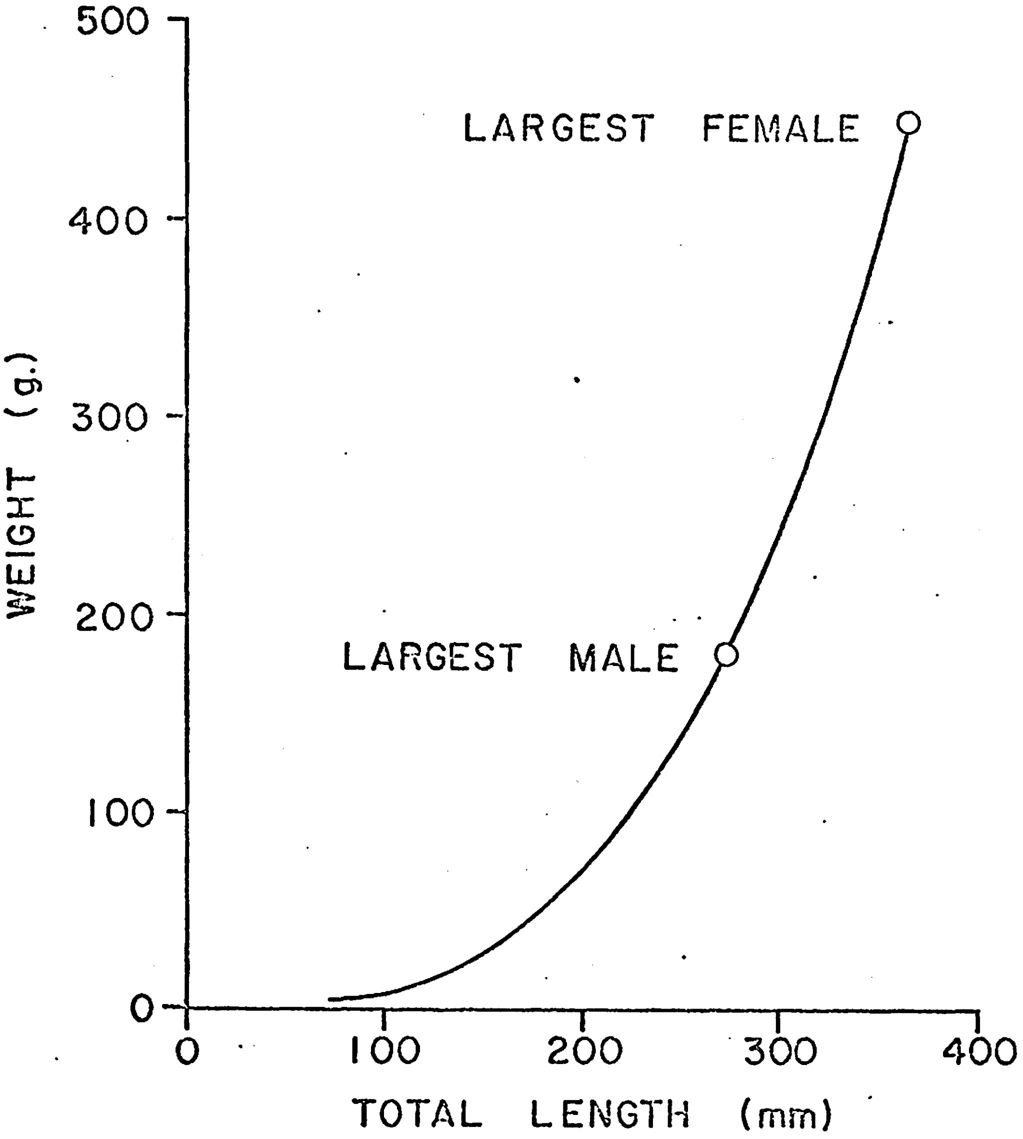
The growth curves (Fig. 18) which best fitted available length data were represented by the equations:

$$\text{males:} \quad L_t = 300\ (1 - e^{-0.96t})$$

$$\text{females:} \quad L_t = 407\ (1 - e^{-0.72t}),$$

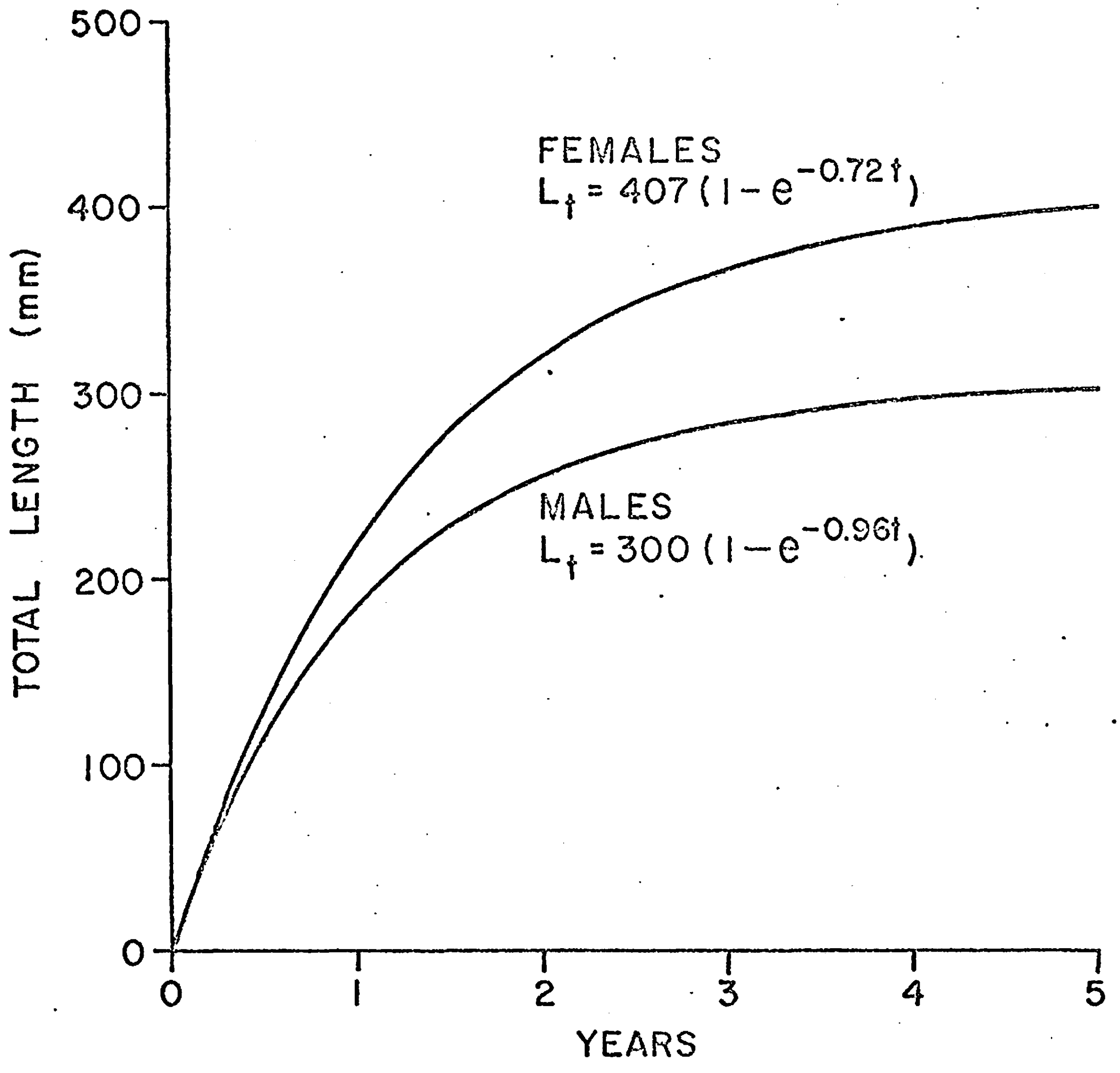
where L is total length in millimeters and t is time in years. The equations which best represented growth in weight were:

Figure 17. The relationship between length and weight of male and female spotted hake from the Chesapeake Bight.



LARGEST FEMALE
LARGEST MALE
500
400
300
200
100
0
WEIGHT (g.)
0
100
200
300
400
TOTAL LENGTH (mm)

Figure 18. Growth curves of male and female spotted hake.



FEMALES
$L_t = 407(1 - e^{-0.72t})$
MALES
$L_t = 300(1 - e^{-0.96t})$
TOTAL LENGTH (mm)
500
400
300
200
100
0
0
1
2
3
4
5
YEARS

$$\text{males:} \quad W_t = 229\ (1 - e^{-0.96t})$$

$$\text{females:} \quad W_t = 526\ (1 - e^{-0.73t}),$$

where W is weight in grams and t is time in years.

PHASE 7

SUMMER DISTRIBUTION OF FISHES

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SUMMER DISTRIBUTION OF FISHES

During the period from August 18 through September 15, 1966, we sampled 98 stations on the continental shelf of the Chesapeake Bight (Cape Hatteras to Cape May). At each station a 45-foot trawl was towed for 30 minutes and temperature and salinity of the bottom waters was measured. A more detailed description of gear and procedure was given in the progress report for winter, 1966. Depths sampled ranged from 5 to 100 fathoms. The number of stations in each 10 fathom interval is shown in Table 1. Table 1 also indicates that the most productive zone was inshore of the 25 fathom contour.

Species caught numbered 75 of which 51 occurred at fewer than 10 stations. The less abundant species are listed in Table 2 and will not be discussed in this report. For the remaining 24 species distribution with regard to depth and latitude is summarized. Because of difficulties with gear during part of the cruise, some temperature measurements were inaccurate. Therefore, distribution with regard to temperature is not summarized in this report.

The sequence in which the species are discussed below is not intended to indicate commercial potential except that important foodfish are listed last.

NORTHERN SEAROBIN

As was the case in spring, the northern searobin (*Prionotus carolinus*) was the most abundant fish. The total catch in the 39 tows containing this species was 13,000 adults weighing 3600 pounds. The largest catch was 375 pounds. In 2 other tows the catch was 300

TABLE 1

AVERAGE CATCH (IN POUNDS) OF TRASH FISH PER HOUR OF TOW, IN EACH LATITUDE AND DEPTH RANGE, SUMMER 1966

Depth	35°	36°	37°	38°	39°	No. Sta.
5-14	102	199	268	379	98	37
15-24	505	17	110	39	-	26
25-34	8	13	9	24	-	8
35-44	-	9	24	8	-	6
45-54	84	23	1	11	-	8
55-64	-	26	7	0	-	4
65-74	-	-	26	-	-	3
75-84	-	42	-	-	-	2
85-94	-	-	-	1	-	2
95-105	-	-	76	50	-	2

PHASE 7

TABLE 2

SPECIES OCCURRING IN FEWER THAN 10% OF THE SAMPLES, SUMMER 1966

AMERICAN JOHN DORY	ZENOPSIS OCELLATA
ARMORED SEAROBIN	PERISTEDION MINIATUM
ATLANTIC ANGEL SHARK	SQUATINA DUMERILI
ATLANTIC CUTLASSFISH	TRICHIURUS LEPTURUS
ATLANTIC MACKEREL	SCOMBER SCOMBRUS
ATLANTIC MOONFISH	VOMER SETAPINNIS
BAY ANCHOVY	ANCHOA MITCHILLI
BIGHEAD SEAROBIN	PRIONOTUS TRIBULUS
BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
BLACKCHEEK TONGUEFISH	SYMPHURUS PLAGIUSA
BLACK DRUM	POGONIAS CROMIS
BLUEFISH	POMATOMUS SALTATRIX
BLUE RUNNER	CARANX CRYSOS
BLUNTNOSE STINGRAY	DASYATIS SAYI
CHAIN DOGFISH	SCYLIORHINUS RETIFER
CONGER EEL	CONGER OCEANICUS
COWNOSE RAY	RHINOPTERA BONASUS
CUNNER	TAUTOGOLABRUS ADSPERSUS
FAWN CUSK-EEL	LEPOPHIDIUM CERVINUM
GRAY SEATROUT	CYNOSCION REGALIS
HADDOCK	MELANOGRAMMUS AEGLEFINUS
HOGCHOKER	TRINECTES MACULATUS
INSHORE LIZARDFISH	SYNODUS FOETENS
LANTERN FISHES	MYCTOPHIDAE
LONGHORN SCULPIN	MYOXOCEPHALUS OCTODECEMSPINOSUS
LONGSPINE SNIPEFISH	MACRORHAMPHOSUS SCOLOPAX
MYXINE	MYXINE GLUTINOSA
NORTHERN KINGFISH	MENTICIRRHUS SAXATILIS
NORTHERN SENNET	SPHYRAENA BOREALIS
OCEAN POUT	MACROZOARCES AMERICANUS
ORANGE FILEFISH	ALUTERA SCHOEPFI
PIGFISH	ORTHOPRISTIS CHRYSOPTERUS
PLANEHEAD FILEFISH	MONACANTHUS HISPIDUS
POLKA-DOT CUSK-EEL	OTOPHIDIUM OMOSTIGMUM
RED GOATFISH	MULLUS AURATUS
ROSETTE SKATE	RAJA GARMANI
ROUGHTAIL STINGRAY	DASYATIS CENTROURA
SEA HERRING	CLUPEA HARENGUS
SHORTNOSE GREENEYE	CHLOROPTHALMUS AGASSIZI
SILVER PERCH	BAIRDIELLA CHRYSURA
SMOOTH DOGFISH	MUSTELUS CANIS
SMOOTH PUFFER	LAGOCEPHALUS LAEVIGATUS
SOUTHERN KINGFISH	MENTICIRRHUS AMERICANUS
SOUTHERN STINGRAY	DASYATIS AMERICANA
SPANISH MACKEREL	SCOMBEROMORUS MACULATUS
STINGRAYS	DASYATIS SP.
STRIPED BURRFISH	CHILOMYCTERUS SCHOEPFI
THORNY SKATE	RAJA RADIATA
WITCH FLOUNDER (GRAY SOLE)	GLYPTOCEPHALUS CYNOGLOSSUS
YELLOWTAIL FLOUNDER (DAB)	LIMANDA FERRUGINEA

pounds or more. In 18 tows the catch exceeded 100 pounds. This species was caught in water of 20 fathoms or less north of 36° 50' N. Juveniles were caught in only 6 tows, all south of 37° 30' N.

STRIPED SEAROBIN

Far less abundant than the northern searobin was the striped searobin (*Prionotus evolans*). Only 214 adults were caught and the species occurred in but 26 samples from a depth range of 5 to 15 fathoms and a latitudinal range of from 35° 45' to 38° 43' N. The largest catch was 114 fish weighing 40 pounds. One additional catch exceeded 10 pounds.

SPOTTED HAKE

Occurring in 75% of the samples, the spotted hake (*Urophycis regius*) was the most frequently caught species. It occurred in depths of from 7 to 100 fathoms and at all latitudes. Four catches were about 40 pounds; 14 others were between 10 and 25 pounds. Young were caught at only 3 stations.

SILVER HAKE

Silver hake or whiting (*Merluccius bilinearis*) occurred in slightly more than half of the samples (53). Although young were taken only in depths of 20 to 60 fathoms, adults were generally distributed through all depths. The largest catch of 50 pounds was in 10 fathoms; the next largest catch of 35 pounds was in 100 fathoms. At 6 stations the catch exceeded 10 pounds. This species occurred throughout the area but was most abundant north of 37° 30' N.

SQUIRREL HAKE

Also known as red hake, the squirrel hake (*Urophycis chuss*) was caught in 29 tows in a depth range of 10 to 75 fathoms from

36° N to 39° N. Young were taken in 4 samples in the depth range of 20 to 26 fathoms. Adults were most abundant north of 37° 50'. The largest catch was 50 fish weighing 14 pounds; 5 catches were of 5 pounds or more.

WINTER FLOUNDER

At 18 stations from 12 to 42 fathoms winter flounder or blackback (Pseudopleuronectes americanus) were caught. This species occurred only north of 37° N and was not abundant. The largest catch was 30 adults weighing 20 pounds. Other catches were of 5 pounds or less. Young were not caught.

NORTHERN PUFFER

The northern puffer or swellfish (Sphaeroides maculatus) occurred in 24 samples from depths of 5 to 13 fathoms. Young occurred only south of 37° 30' N, but adults were distributed from the northern limit of the area to the southern most station. The largest catch was 33 pounds. Ten catches were of 5 pounds or more.

WINDOWPANE FLOUNDER

The windowpane or daylight flounder (Scophthalmus aquosus) occurred in 23 samples from a depth range of 5 to 20 fathoms throughout the north-south extent of the area, but was not abundant. The largest catch was 6 adults weighing 3 pounds.

ROUND HERRING

At 12 stations spanning a depth range of 5 to 40 fathoms round herring (Etrumeus sadina) were caught. Because this species is pelagic, our catches on the bottom are unlikely to give an accurate indication of its distribution and abundance. Round herring were caught throughout the north-south extent of the survey area. North of 37° N the fish were about 6 inches long. South of that parallel most of the round herring were about 4 inches long. Near 36° 20' N, 75° 00' W the echo sounder indicated a school of midwater fish, probably *Etrumeus*, that was at least 12 miles across.

STRIPED ANCHOVY

The latitudinal distribution of the striped anchovy (*Anchoa hepsetus*) was south of 37° 30' N and it was caught only in shallow water (5 to 11 fathoms). The largest of the 12 catches containing this species was 14 pounds.

SPINY DOGFISH

Although the spiny dogfish *Squalus acanthias* is very abundant in winter, in summer only 74 juveniles and one adult were caught. Juveniles were most abundant in water shoaler than 20 fathoms, but one was caught at 100 fathoms. The 10 stations at which spiny dogfish were caught were north of 36° N. The largest catch was 48 juveniles weighing 21 pounds.

CLEARNOSE SKATE

The clearnose skate (*Raja eglanteria*) was caught at 24 stations spanning a depth range of 5 to 22 fathoms and a latitudinal range of the entire survey area. The largest catch was 28 individuals weighing 56 pounds. Eight catches exceeded 10 pounds. Juveniles were caught in 4 tows.

LITTLE SKATE

Occurring at only 11 stations, the little skate (*Raja erinacea*) was less abundant than the clearnose. Latitudinal distribution of the little skate was north from 36° 30' N and the depth range was 12 to 60 fathoms. The largest catch was 3 adults weighing 4 pounds. Both adults and juveniles were caught.

SMALLMOUTH FLOUNDER

The smallmouth flounder (Etropus microstomus) occurred at 14 stations inside the 20 fathom curve and north of 36° N. The largest catch was 10 adults weighing less than 0.5 pound.

GULFSTREAM FLOUNDER

The Gulfstream flounder (Citharichthys arctifrons), like the smallmouth is too small to be of commercial significance. It occurred in 38 samples from 19 to 100 fathoms and from the southern to northern extent of the area. The largest catch was 25 adults weighing less than 0.5 pound.

FOURSPOT FLOUNDER

Twenty-three samples north of 36° N and spanning a depth range of 14 to 75 fathoms contained the fourspot flounder (Paralichthys oblongus). Young were caught at 3 stations shoaler than 25 fathoms. The largest catch was 10 adults weighing 3 pounds.

GOOSEFISH

The goosefish, or angler (Lophius americanus) was represented primarily by juveniles. Adults were caught at only 2 stations whereas young occurred at 22. This species occurred through the entire latitudinal range and through a depth range of 14 to 85 fathoms.

SNAKE EEL

Because of its small size the snake eel (Omochelys cruentifer) has insignificant commercial potential. It occurred in 15 samples spanning the entire latitudinal range and a depth range of 22 to 100 fathoms.

SCUP

The scup or porgy (*Stenotomus chrysops*) occurred in 23 samples from the 16 fathom curve shoreward and throughout the north-south extent of the area. The catch was predominantly juveniles.

BLACK SEABASS

Black seabass (*Centropristes striatus*) was caught in 23 tows inside of the 20 fathom contour and from the northern to the southern limit of the area. Both young and adults were caught. The largest catch was 5 pounds.

SUMMER FLOUNDER

At 18 stations the summer flounder or fluke (*Paralichthys dentatus*) was caught. The largest catch of 11 fish weighing 16 pounds was made in Blackfish Slough. Young were not caught. Summer flounder occurred throughout the area in water shoaler than 16 fathoms.

BUTTERFISH

Large numbers of juvenile butterfish (*Poronotus triacanthus*) were caught inside the 20 fathom curve. Adults occurred in water as deep as 70 fathoms, but the largest catches were in waters less than 20 fathoms deep. The largest catch was 30 pounds of small adults. Butterfish were caught at 48 stations and occurred from the northern to the southern limit of the area.

CROAKER

Juveniles and small adult croaker (Micropogon undulatus) occurred in 13 samples from water of 16 fathoms or less south of 38° N. The largest catch was 900 individuals weighing 150 pounds.

SPOT

Spot (Leiostomus xanthurus) occurred on 15 stations in water of 12 fathoms or less south of 38° N. Nearly all fish caught were young of the year. The largest catch was 665 pounds. Three other catches were between 100 and 200 pounds and 8 catches were between 10 and 100 pounds.

PHASE 8

FALL DISTRIBUTION OF FISHES

By
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PRELIMINARY CRUISE SUMMARY
DISTRIBUTION OF FISHES CAPE MAY TO CAPE HATTERAS
FALL 1966

By

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and

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FEBRUARY 20, 1967

AN INTERIM REPORT OF PROGRESS ON PROJECT
3-5-D UNDER PL 88-309

Fall Distribution of Fishes

In fall 1966 (1-27 Nov) we sampled 75 stations on the continental shelf of Chesapeake Bight. At each station a 45-foot trawl was towed for 30 minutes and temperature and salinity of the bottom water were measured. A more detailed description of gear and procedure was given in the progress report for winter, 1966. Work was conducted from the chartered trawler SEA BREEZE. Depths sampled ranged from 7 to 100 fathoms. The number of stations in each 10 fathom interval is shown in Table 1. Table 1 also indicates that trash fish were rather generally distributed out to the 50 fathom curve north of 36° N lat. Only one catch south of 36° contained a significant quantity of trash, a large catch of puffers made in 7 fathoms near Oregon Inlet.

Indications of midwater organisms by the echo-sounder were again recorded. At no station were heavy indications noted. Moderate indications were recorded at 8%, light at 46%, and none at 46%.

Of the 64 species caught, 36 occurred in fewer than 10% of the samples. These rare species are listed in Table 2 and will not be discussed in this report. A summary of the distribution of the 28 species occurring in 10% or more of the samples is given below.

Northern Searobin

As was the case in spring and summer, the northern searobin (*Prionotus carolinus*) was the most abundant fish in our samples. It occurred at 33 stations, all in 40 fathoms or less. Young were caught only from the 20 fathom contour inshore. Adults were caught primarily between the 20 and 40 fathom curves. Temperature range was 7 to 16° C

Table 1

Average catch (in pounds) of trash fish per hour of tow, in each latitude and depth range, fall 1966.

	Latitude				
Depth	35°	36°	37°	38°	No. Sta.
5-14	1040	58	111	176	17
15-24	4	852	386	277	25
25-34	0	480	337	229	9
35-44	74	304	239	86	8
45-54	8	2	128	148	6
55-64	-	0	34	36	4
65-74	-	-	36	34	2
75-84	0	-	98	-	2
85-94	-	-	-	-	-
95-105	-	360	-	48	2

TABLE 2

Species occurring in fewer than 10% of the samples, fall 1966

ATLANTIC ANGEL SHARK	SQUATINA DUMERILI
ATLANTIC MACKEREL	SCOMBER SCOMBRUS
ATLANTIC MENHADEN	BREVOORTIA TYRANNUS
ATLANTIC MOONFISH	VOMER SETAPINNIS
ATLANTIC SAURY	SCOMBERESOX SAURUS
AMERICAN JOHN DORY	ZENOPSIS OCELLATA
ARMORED SEAROBIN	PERISTEDION MINIATUM
	BRYCIDAE
BIGEYE SCAD	SELAR CRUMENOPHTHALMUS
BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
BLACK DRUM	POGONIAS CROMIS
BLUEFISH	POMATOMUS SALTATRIX
BLUNTNOSE STINGRAY	DASYATIS SAYI
BULLNOSE RAY	MYLIOBATIS FREMINVILLEI
CONGER EEL	CONGER OCEANICUS
CORNETFISH	FISTULARIA TABACARIA
FAWN CUSK-EEL	LEPOPHIDIUM CERVINUM
FOURBEARD ROCKLING	ENCHELYOPUS CIMBRIUS
GREATER AMBERJACK	SERIOLA DUMERILI
HOGCHOKER	TRINECTES MACULATUS
LANTERN FISHES	MYCTOPHIDAE
LONGHORN SCULPIN	MYOXOCEPHALUS OCTODECEMSPINOSUS
NORTHERN STARGAZER	ASTROSCOPUS GUTTATUS
PIGFISH	ORTHOPRISTIS CHRYSOPTERUS
POLKA-DOT CUSK-EEL	OTOPHIDIUM OMOSTIGMUM
RED GOATFISH	MULLUS AURATUS
ROSETTE SKATE	RAJA GARMANI
ROUND HERRING	ETRUMEUS SADINA
SANDBAR SHARK	CARCHARHINUS MILBERTI
SAND SHARK	CARCHARIAS TAURUS
SILVER PERCH	BAIRDIELLA CHRYSURA
SPOT	LEIOSTOMUS XANTHURUS
STRIPED ANCHOVY	ANCHOA HEPSETUS
STRIPED CUSK-EEL	RISSOLA MARGINATA
WINTER SKATE	RAJA OCELLATA
YELLOWTAIL FLOUNDER (0-1)	LIMANDA FERRUGINEA

(45-61°F), with the largest catches in the range of 11 to 14°C (52-57°F). The largest catch in a 30-minute tow was 400 pounds. Five tows yielded 100 pounds or more; 13 had catches between 10 and 100 pounds.

In August and September searobins were in water shoaler than 20 fathoms. As fall progressed the fish moved steadily offshore. In October trawlermen reported concentrations at 20 to 25 fathoms. By the end of November we found significant quantities at 40 fathoms.

Striped Searobin

Striped searobins (Prionotus evolans) were again scarce. They were caught at only 18 stations. Their depth range was 7 to 40 fathoms, and their temperature range was 10 to 16° C (50-61°F).

Silver Hake

Silver hake, or whiting, (Merluccius bilinearis) occurred in 33 samples north of 36° N lat. in depths ranging from 8 to 100 fathoms. Young were caught only in water of 23 fathoms or less with a temperature of 11 to 13° C (52-55° F). Adults seemed to show no strong temperature preference. They were caught at temperatures ranging from 7 to 14° C (45-57° F). Adults were most numerous north of 37° N lat. and in depths of 30 fathoms or more. The largest catch in a 30-minute tow was 41 pounds. Five catches contained 10 pounds or more.

Spotted Hake

Occurring through all depths and latitudes sampled, the spotted hake (Urophycis regius) was the most widely distributed fish in Chesapeake Bight. Also it occurred in more samples (50) than any other species. Temperature range was 7 to 16° C (45-61°F). Young were caught inside of the 25 fathom curve and south of 38° N latitude. Although spotted hake were ubiquitous, they were not notably abundant. Our largest catch was 100 pounds. Only 6 stations produced more than 10 pounds

Squirrel Hake

North of 36° N lat. the squirrel hake, or red hake, (*Urophycis chuss*) occurred in 24 samples generally distributed across the shelf from 8 to 95 fathoms and through a temperature range of 7 to 14°C (45-57°F). Young were caught in 6 tows, all in water of 30 fathoms or less. Adults were more numerous from the 30 fathom curve seaward. The largest catch was 420 individuals weighing 125 pounds. Six catches were in excess of 12 pounds

Chain Dogfish

An inhabitant of deep waters, the chain dogfish (*Scyliorhinus retifer*) occurred at 7 stations, only one of which was shoaler than 48 fathoms. A total of 9 individuals weighing 7 pounds was caught. Temperatures were 11 to 16° C (52-61°F).

Smooth Dogfish

The smooth dogfish (*Mustelus canis*) was caught at 20 stations, all except one being in 26 fathoms or less. The exception was at 60 fathoms. Temperature range was 10 to 16°C (50-61°F). The largest catch was 8 fish weighing 40 pounds. Seven catches contained 10 pounds or more.

Spiny Dogfish

Spiny dogfish (*Squalus acanthias*) were caught in 42 tows north of 36° N lat. Young were north of 37° N lat. and outside of the 25 fathom curve. Adults occurred through the depth range of 8 to 60 fathoms and through the temperature range of 7 to 14° C (45-57° F). The largest catch was 356 adults weighing 1800 pounds. Eight catches exceeded 300 pounds, six were between 50 and 300 pounds, and 13 were between 10 and 50 pounds. Spiny dogfish were caught in greater quantity than any other species.

Clearnose Skate

The clearnose skate (*Raja eglanteria*) was represented in 25 samples from all depth and latitudinal ranges. Temperature range was 11 to 16° C (52-61°F). The largest catch was 11 adults weighing 28 pounds. Only one other catch exceeded 10 pounds.

Little Skate

The little skate (*Raja erinacea*) occurred in waters from 8 to 51 fathoms deep north of 36° 30' N. It was caught in 18 tows, and was not abundant, the largest catch being 11 adults weighing 15 pounds. Temperature range was 7 to 15° C (45-59°F).

Goosefish

The goosefish (*Lophius americanus*) was generally distributed throughout the depths and latitudes sampled. Temperature range was 7 to 14° C (45-57°F). Although they were not caught in large number, the large size of goosefish makes them of interest. At 4 stations the catch was between 10 and 20 pounds. Young and adults occurred with equal frequency throughout the area.

Winter Flounder

The winter flounder, or blackback (*Pseudopleuronectes americanus*) occurred in 16 samples north of 36° 30' N lat. and between 9 and 32 fathoms in depth. Temperature range was 7 to 14° C (45-57°F). Our largest catch was 85 fish weighing 35 pounds. Seven catches were of 10 pounds or more.

Windowpane Flounder

The windowpane flounder or daylight (*Scophthalmus aquosus*) occurred out to the 30 fathom curve throughout the area, but was not caught in quantity. The largest catch was 18 adults weighing 8 pounds. Temperature range was 8 to 16° C (46-61° F).

Fourspot Flounder

The fourspot flounder (Paralichthys oblongus) was represented in 31 samples. Adults occurred only in depths of 20 fathoms or more, but young were caught in the range of 8 to 50 fathoms. Temperature range was 7 to 16° C (45-61°F). The largest catch was 50 adults weighing 17 pounds. All other catches were 5 pounds or less.

Northern Kingfish

The northern kingfish (Menticirrhus saxatilis) was caught in 9 tows, all in 10 fathoms or less. Temperature range was 12 to 16° C (54-61° F). The largest catch was 24 fish weighing 7 pounds.

Northern Puffer

The northern puffer, or swellfish, (Sphaeroides maculatus) was caught at 21 stations throughout the area from north to south. Although young occurred in water as deep as 20 fathoms, adults were plentiful only inside of the 10 fathom contour. The largest catch contained 576 pounds of young and 400 pounds of adults. Temperature range was 12 to 19° C (54-66° F).

Planehead Filefish

A total of 9 planehead filefish (Monacanthus hispidus) occurred in 7 samples taken from waters of 26 fathoms or less. Temperature range was 12 to 14° C (54-57° F). This species is unlikely to be of commercial significance.

Round Scad

At 10 stations of 20 fathoms or less south of 37° 30' N round scad (*Decapterus punctatus*) were caught. Most of the fish in our samples were juveniles. The largest catch was 18 fish weighing less than 0.5 pound. This species is not likely to contribute significantly to an industrial fishery.

Rough Scad

The rough scad (*Trachurus lathami*), like the round scad is unlikely to be of significance to an otter trawl fishery. It occurred at 7 stations of 21 fathoms or less spanning a temperature range of 13 to 16° C (55-61°F).

Ocean Pout

The ocean pout (*Macrozoarces americanus*) occurred at 7 stations between 9 and 40 fathoms north of 37° 40' N lat. Temperature range was 7 to 13° C (45-55°F). The largest catch was 39 adults weighing 13 pounds.

Smallmouth flounder

Being a very small fish, the small mouth flounder (*Etropus microstomus*) is of little potential economic significance. It occurred in 10 samples from water of 23 fathoms or shoaler. Temperature range was 11 to 16° C (52-61°F).

Gulfstream Flounder

Like the related smallmouth flounder, the small Gulfstream flounder (*Citharichthys arctifrons*) is unlikely to be of commercial significance. It was caught at 13 stations ranging in depth from 19 to 95 fathoms throughout the area. Temperature range was 8 to 13° C (46-55° F).

Snake Eel

The snake eel (*Omochelys cruentifer*) is another species whose small size and scarcity make it of no commercial significance. It was caught at 11 stations ranging in depth from 20 to 95 fathoms and in temperature from 9 to 14° C (48-57° F).

Scup

The scup (*Stenotomus chrysops*) occurred in 32 samples ranging in depth from 8 to 40 fathoms. Both adults and young were caught throughout the sampling area. Temperature range was 7 to 17° C (45-63° F). The largest catch of adults was 17 weighing 10 pounds.

Black Seabass

The black seabass (*Centropristes striatus*) was caught at 24 stations throughout the area inshore from the 50 fathom contour. Young occurred only in water of 20 fathoms or less. Temperature range of the adults was 8 to 16° C (46-61° F). Young were caught only at temperatures between 12 and 16° C (54-61° F). The largest catch was 37 adults weighing 15 pounds.

Summer Flounder

Occurring throughout the sampling area at all depths out to 80 fathoms the summer flounder or fluke (*Paralichthys dentatus*) was represented in 33 samples. Young were caught at only two stations. Temperature range was 11 to 16° C (52-61°F). The largest catch was 14 adults weighing 21 pounds.

Butterfish

Butterfish (*Poronotus triacanthus*) were taken at 33 stations ranging in depth from 7 to 70 fathoms. Young were taken abundantly in waters shoaler than 25 fathoms. Temperature range was 7 to 17° C (45 - 63° F).

Weakfish

Weakfish, or gray trout, (Cynoscion regalis) were caught at 9 stations, the deepest being only 11 fathoms. Water temperatures ranged from 12 to 16° C (54-61° F). The largest catch of adults was 200 weighing 74 pounds. Five catches were of 15 pounds or more. Young were caught in significant quantities at 3 stations.

Table 1. Station list, fall 1966

Station No.	Date	Latitude	Longitude	Depth (fathoms)	Temp. at bottom C	Salinity at bottom	Time of day	Midwater fish	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)
T503	01NOV66	3708N	7542W	[illegible]	16C	32S	07.5	LT	2	12	10	168	30
T504	01NOV66	[illegible]	7526W	[illegible]	16C	32S	11.0	NO	5	132	10	54	30
T505	01NOV66	3716N	7517W	[illegible]	[illegible]	32S	13.7	LT	4	12	4	26	30
T506	01NOV66	3721N	[illegible]	[illegible]	14C	33S	16.0	LT	3	6	4	6	30
T507	01NOV66	3717N	7453W	[illegible]	14C	33S	19.0	LT	4	48	11	170	30
T508	01NOV66	3724N	7445W	[illegible]	12C	33S	21.3	LT	3	60	9	782	20
T509	01NOV66	3721N	7440W	[illegible]	12C	33S	22.8	LT	1	34	13	392	30
T510	02NOV66	3741N	[illegible]		9C	33S	03.7	LT	1		9	107	30
T511	02NOV66	3757N	7425W	[illegible]	3C	33S	12.0	LT			9	68	30
T512	02NOV66	[illegible]	7417W	[illegible]	8C	33S	14.8	LT			11	92	30
T513	02NOV66	[illegible]	7412W	[illegible]	17C	33S	17.0	NO			9	406	30
T514	04NOV66	[illegible]	7457W	[illegible]	14C	32S	16.8	MD	1	14	14	140	30
T515	04NOV66	[illegible]	7452W	[illegible]	13C	32S	18.4	MD	1	6	20	293	30
T516	04NOV66	[illegible]	7451W	[illegible]	12C	32S	20.5	LT	2	46	10	149	30
T517	05NOV66	[illegible]	7446W	018	14C	32S	07.1	LT	1		8	229	30
T518	05NOV66	[illegible]	[illegible]	[illegible]	11C	33S	10.0	LT	1		6	76	30
T519	05NOV66	[illegible]	7426W	[illegible]	09C	33S	12.4	LT			4	250	30
T520	05NOV66	[illegible]	7426W	021	10C	33S	13.7	NO	2	2	9	154	30
T521	05NOV66	[illegible]	7429W	021	11C	33S	15.5	LT	2	6	9	831	30
T522	05NOV66	[illegible]	7428W	[illegible]	12C	33S	18.1	LT	3	10	10	132	30
T523	05NOV66	[illegible]	7417W	021	8C	33S	20.5	NO	1	2	13	266	30
T524	06NOV66	[illegible]	7457W	[illegible]	14C	32S	16.7	LT	3	42	6	122	30
T525	06NOV66	3753N	7518W	[illegible]	14C	32S	18.8	LT	4	66	13	184	30
T526	06NOV66	3741N	7519W	[illegible]	14C	32S	20.9	LT	3	22	9	96	30
T527	07NOV66	[illegible]	7521W	[illegible]	15C	32S	06.4	LT	4	20	11	182	30
T528	07NOV66	[illegible]	[illegible]	[illegible]	14C	32S	08.5	LT	3	10	7	28	30
T529	[illegible]	[illegible]	7534W	[illegible]	[illegible]	32S	07.6	NO	1		1		30
T530	[illegible]	[illegible]	[illegible]		[illegible]	32S	10.1	NO	1		2	18	30
T531	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32S	12.7	NO	5	12	7	86	30
T532	[illegible]	[illegible]	7544W		16C	32S	13.7	NO	4	146	11	160	30
[illegible]	[illegible]	[illegible]	[illegible]		16C	32S	20.6	MD	2	6	10	2022	30

PHASE 8

PHASE 8

[illegible]	11NOV66	[illegible]	7531W	[illegible]	[illegible]	33S	[illegible]	NO	3	4	6	16	30
[illegible]	11NOV66	[illegible]	[illegible]	[illegible]	[illegible]	35S	10.5	NO			4		30
T537	11NOV66	[illegible]	[illegible]	[illegible]	[illegible]	35S	12.4	LT					30
T538	11NOV66	[illegible]	[illegible]	[illegible]	[illegible]	35S	14.5	LT			1		30
T539	11NOV66	[illegible]	7456W	[illegible]	[illegible]	34S	16.0	NO			1		30
T540	11NOV66	[illegible]	7455W	[illegible]	11C	34S	17.1	ND			4	74	30
T541	11NOV66	[illegible]	7452W	[illegible]	[illegible]	35S	20.4	NO	1		7	8	30
T542	11NOV66	[illegible]	7447W	[illegible]	12C	35S	21.9	NO			3		30
T543	12NOV66	[illegible]	7449W	[illegible]	11C	35S	07.4	LT			2	2	30
T544	12NOV66	[illegible]	7452W	[illegible]	[illegible]	34S	08.8	LT					30
T545	12NOV66	3617N	7453W	[illegible]	[illegible]	34S	10.2	LT			6	4	30
T546	12NOV66	3625N	7457W	[illegible]	13C	34S	14.7	LT			1		30
T547	12NOV66	3630N	7448W	040	[illegible]	35S	17.3	NO			5		30
T548	12NOV66	3632N	7545W	[illegible]	12C	35S	19.9	NO			13	360	30
T549	16NOV66	3721N	7457W	021	13C	33S	15.6	LT	2	12	2	648	30
T550	16NOV66	3727N	7452W	028	12C	33S	18.6	ND	3	134	13	924	30
T551	16NOV66	3717N	7447W	021	12C	33S	20.7	LT	3	42	8	422	30
T552	17NOV66	[illegible]	7413W	[illegible]	[illegible]	33S	06.6	LT	2		6	74	30
T553	17NOV66	[illegible]	[illegible]	[illegible]	11C	34S	09.2	NO	1	2	6	148	30
T554	17NOV66	[illegible]	7347W	[illegible]	[illegible]	35S	11.6	NO			4	34	30
T555	17NOV66	[illegible]	7338W	[illegible]	[illegible]	36S	14.1	NO			4	48	30
T556	17NOV66	3422N	7348W	[illegible]	11C	33S	16.6	LT			6	86	30
T557	17NOV66	[illegible]	7357W	[illegible]	11C	35S	19.2	NO			8	36	30
T558	17NOV66	[illegible]	7414W	048	11C	34S	22.7	NO	1	10	9	68	30
T559	18NOV66	3747N	7412W	[illegible]	12C	34S	06.6	NO	1	2	3	6	30
T560	25NOV66	3651N	7519W	014	13C	33S	17.5	NO	3	4	11	26	30
T561	25NOV66	3626N	7519W	017	12C	33S	20.1	NO	4		14	90	30
T562	25NOV66	3626N	7522W	016	14C	33S	22.2	NO	4	4	8	158	30
T563	26NOV66	3611N	7526W	016	12C	33S	8	LT	3	6	4	244	30
T564	26NOV66	[illegible]	7507W	021	[illegible]	33S	07.9	NO	3	2	3	654	30
T565	26NOV66	3625N	7507W	021	13C	33S	10.7	LT	3	6	4	3638	30
T566	26NOV66	3624N	7502W	015	12C	33S	12.9	NO	2	2	4	880	30
T567	26NOV66	3639N	7454W	021	12C	33S	14.8	LT	1	10	2	1152	30
T568	26NOV66	3641N	7448W	031	14C	33S	16.2	NO	4	42	4	956	30
T569	26NOV66	3642N	7442W	062	11C	35S	17.8	NO					30
T570	26NOV66	3649N	7446W	[illegible]	11C	34S	20.1	NO	4	38	9	912	30
T571	26NOV66	[illegible]	7445W	[illegible]	[illegible]	34S	22.7	LT	3	28	8	448	30
T572	27NOV66	[illegible]	7445W	[illegible]	14C	34S	07.9	ND	2	44	9	206	30
T573	27NOV66	3714N	7424W	[illegible]	[illegible]	35S	10.7	NO	1		8	62	30
T574	27NOV66	3724N	7422W	[illegible]	14C	34S	13.2	LT	1	18	8	110	30
T575	27NOV66	3731N	7421W	[illegible]	[illegible]	35S	15.7	NO	1	6	4	98	30
T576	27NOV66	3739N	7417W	[illegible]	12C	35S	17.7	NO	1	12	8	36	30
T577	27NOV66	3725N	7427W	[illegible]	[illegible]	33S	20.1	NO	4	16	6	196	30

PHASE 9

ASSESSMENT OF AVAILABILITY

By

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The winter cruise of 1967 was the beginning of a new phase of the program. Through 1966 our goal was to describe the distribution of fishes on the continental shelf. In 1967 we are seeking to learn the availability of the various species to commercial-scale trawls. The average catch of trash fish in 54 tows was 2,600 pounds per hour. The greatest catch rate was 42,000 pounds per hour, and the least was 88. Trash fish occurred rather spottily over the area from Cape May to Cape Hatteras with no particular latitude being especially productive. The most productive depth range was 30 to 50 fathoms. Unusually bad weather disrupted the work schedule and we were unable to sample as extensively as we had intended to.

The gear chosen for the 1967 program is an Atlantic western trawl with 78-foot footrope, 54-foot headrope, and 6-inch stretch mesh throughout. This kind of net was selected because experiments conducted by the BCF Exploratory Fishing and Gear Research Base, Gloucester, Massachusetts, indicated that it is somewhat more efficient than the #36 and #41 Yankee trawls in general use by the local fishing fleet. The headrope of the Atlantic western fishes as much as three fathoms above the bottom versus the approximately one fathom of a #41 Yankee trawl of similar size. The large vertical opening probably results in an increased catch of those species that occur slightly above the bottom.

Sampling procedure was to subdivide the Chesapeake Bight and adjacent waters by a system of grids 15 minutes on a side. In each grid we searched with a fish-finder until we found a significant concentration of fish, or until an hour elapsed. We then towed the trawl for up to an hour in order to identify the fish comprising the concentration, or in the absence of a concentration, to ascertain the quantity of fish present. This sampling procedure produces two somewhat related indices of abundance of ground fish: the duration of search before finding a significant concentration of fish, and the catch rate of fish in the trawl. Thus either a short search time or a high catch rate indicates an abundance of fish.

Paucity of significant concentrations is indicated by the fact that the search was stopped before expiration of an hour in only 7 grids.

The average catch rate in those 7 grids was 8,059 lb./hr. (range 228 to 42,460) whereas the average in grids in which the search lasted an hour was 1,767 lb./hr. (range 88 to 24,000). Figure 1 indicates the catch rates of trash fish at the various stations. Table 1 lists the stations in order of decreasing catch of trash fish and also gives hydrographic data and the position for each station.

Table 2 indicates the catch in each depth interval in each degree of latitude. Whereas in the winter of 1966 the area south of 37° seemed to be the most productive of trash fish, such was not the case in 1967. Fish were roughly equally distributed latitudinally.

Indications of fish or other organisms in the midwaters were noted from the echo-sounder record. At 28% of the stations no midwater forms were detected; 44% had light indications, 24% moderate, and 4% heavy. Our catches suggested that some of the schools of midwater fish were alewife, mackerel, herring, and butterfish. In most cases we have no indication of the identity of the schools that occur above the 2 to 3 fathoms adjacent to the bottom.

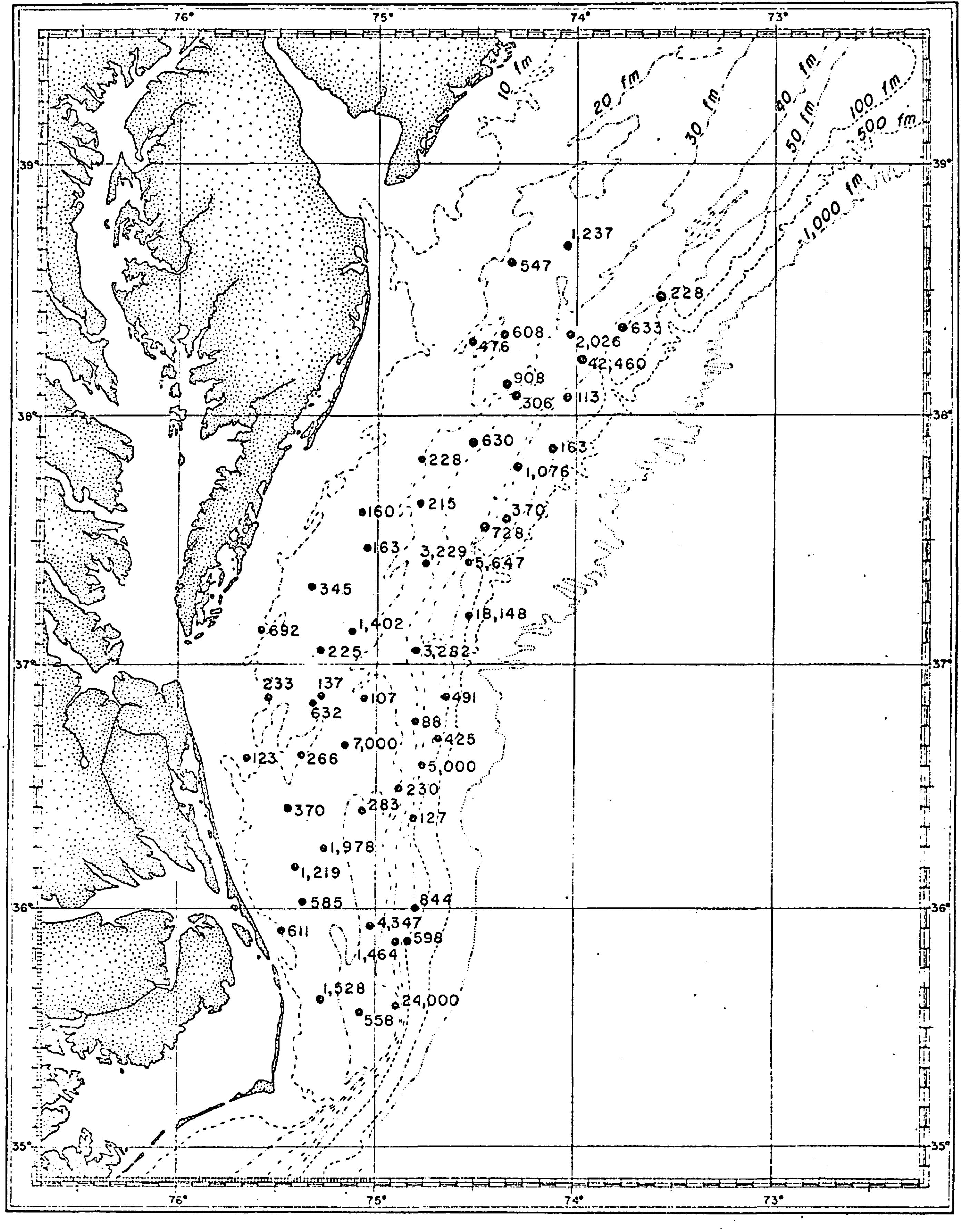

Fig. 1. Catch of trash fish per hour of trawling, winter 1967.

TABLE 1

STATION LIST, WINTER 1967

Station No.	Date	Latitude	Longitude	Depth (fathoms)	Temp. at bottom C	Salinity at bottom	Time of Day	Midwater fish	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)	Duration of Search
T026	11MAR67	3814N	7359W	037	08C	35S	10.8	MD			2	42460	60	010
T010	15MAR67	3536N	7455W	035	10C	35S	13.1	NO			1	24000	60	060
T007	14MAR67	3712N	7433W	095	12C	35S	20.6	NO			10	18148	60	060
T001	20FEB67	3640N	751[illegible]W	015	08C	34S	07.9	HV			1	7000	60	015
T004	04MAR67	3725N	7433W	046	10C	36S	07.3	MD	4	366	11	5647	60	060
T047	30MAR67	3655N	7447W	042	08C	33S	15.9	LT	2		3	5000	60	060
T049	31MAR67	3556N	7502W	020	07C	34S	06.8	LT	3	7	4	4347	60	060
T020	09MAR67	3709N	7448W	031	09C	34S	22.6	LT	4	110	11	3282	60	060
T021	10MAR67	3725N	7445W	027	08C	34S	07.6	LT	2	26	14	3229	60	060
T025	11MAR67	3623N	7403W	034	08C	33S	08.4	MD	1	2	12	2026	60	060
T050	31MAR67	3614N	7517W	017	07C	33S	09.8	LT	2	9	4	1978	60	060
T012	[illegible]MAR67	3536N	7517W	014	09C	33S	19.3	MD	1	2	6	1523	60	060
T053	05APR67	3552N	7452W	080	09C	34S	11.2	NO	4	81	11	1464	60	060
T019	09MAR67	3737N	7508W	020	08C	34S	19.8	MD	2	19	10	1402	60	060
T044	29MAR67	3841N	7403W	029	07C	34S	10.9	HV	2	5	18	1237	60	060
T015	06MAR67	3610N	7525W	015	07C	33S	12.5	NO	3	332	8	1219	60	060
T022	10MAR67	3747N	7418W	047	10C	35S	13.4	NO	3	138	13	1076	60	060
T030	12MAR67	3807N	7421W	021	08C	34S	11.5	MD	1	12	7	908	60	060
T008	05MAR67	3600N	7448W	055	12C	36S	07.7	NO	2	24	8	844	60	060
T005	04MAR67	3733N	7428W	035	10C	35S	10.5	LT	4	270	9	728	60	060
T031	22MAR67	3708N	7536W	009	05C	31S	19.2	MD			8	692	60	060
T027	11MAR67	3821N	7347W	043	10C	34S	13.6	LT	3	28	13	633	60	060
T035	27MAR67	3651N	7519W	014	06C	33S	18.8	MD			6	632	60	060
T040	28MAR67	3753N	7432W	027	06C	33S	17.2	MD	2	4	18	630	60	060
T013	06MAR67	3555N	7528W	011	07C	32S	08.5	LT	3	26	6	611	60	060
T029	12MAR67	3519N	7422W	021	07C	34S	09.2	MD	2	4	11	608	60	060
T009	05MAR67	3552N	7452W	046	11C	35S	10.0	LT	2	84	8	598	60	060
T014	06MAR67	3631N	7523W	012	07C	33S	10.5	LT	2	54	7	585	60	008
T011	05MAR67	3534N	7505W	021	13C	35S	15.8	NO	3	48	9	558	60	060

TABLE 1 (CONTINUED)

T043	29MAR67	3836N	7420W	023	05C	33S	08.1	LT	2	50	14	547	60	060
T045	30MAR67	3651N	7440W	062	10C	35S	07.4	LT	3	1126	18	491	60	060
T042	28MAR67	3817N	7432W	020	05C	33S	23.0	LT	1	1	14	476	60	060
T002	20FEB67	3641N	7442W	053	11C	35S	13.5	NO	4	123	11	425	60	
T006	04MAR67	3735N	7420W	035	11C	35S	15.1	LT	1	35	9	370	60	060
T016	06MAR67	3625N	7527W	015	07C	33S	15.1	LT	4	52	9	370	60	060
T032	23MAR67	3719N	7520W	016	05C	33S	08.5	MD	1	2	10	345	60	
T041	28MAR67	3805N	7419W	023	05C	33S	20.3	LT	1	2	19	206	60	060
T051	31MAR67	3624N	7505W	018	07C	33S	12.9	NO	2	3	7	283	60	060
T052	31MAR67	3637N	7524W	011	07C	33S	16.1	LT	1	3	9	266	60	044
T034	27MAR67	3652N	7533W	010	05C	32S	15.4	LT			8	233	60	060
T054	05APR67	3629N	7454W	019	06C	33S	13.9	LT	2	1	6	230	60	030
T028	11MAR67	3828N	7335W	051	11C	35S	16.5	NO	3	50	9	228	60	060
T039	28MAR67	3749N	7448W	020	05C	33S	13.7	NO	1	9	14	228	60	030
T018	09MAR67	3703N	7517W	017	06C	33S	17.0	LT	2	6	12	225	60	060
T038	28MAR67	3739N	7447W	024	05C	33S	11.1	LT			15	215	60	060
T023	10MAR67	3752N	7408W	069	10C	35S	16.3	NO	1	6	11	163	60	060
T033	23MAR67	3728N	7504W	015	05C	33S	11.2	LT	3	3	9	163	60	060
T037	28MAR67	3736N	7505W	015	04C	32S	08.1	LT			8	160	60	060
T003	27FEB67	3652N	7518W	013	07C	34S	17.0	MD	1	1	9	137	60	060
T017	06MAR67	3637N	7540W	008	05C	31S	18.7	NO	1	5	8	132	60	060
T048	30MAR67	3622N	7449W	064	09C	34S	18.8	NO	4	178	11	127	60	060
T024	10MAR67	3905N	7403W	041	10C	34S	19.9	NO	3	40	11	113	60	060
T036	27MAR67	3652N	7505W	017	06C	33S	21.0	LT	1	1	8	107	60	060
T046	30MAR67	3646N	7448W	033	08C	34S	13.7	MD	4	18	6	88	60	060
		N	W		C	S			103	3377	514	139498	3240	

TABLE 2

AVERAGE CATCH (IN POUNDS) OF TRASH FISH PER HOUR OF TOW IN EACH LATITUDE AND DEPTH RANGE
WINTER 1967

Depth (fm)	35°	36°	37°	38°
0-9	-	132	692	-
10-19	1,070	1,087	223	-
20-29	2,453	-	1,141	680
30-39	24,000	88	2,005	22,243
40-49	598	5,000	3,362	373
50-59	-	635	370	228
60-69	-	309	163	-
70-79	-	-	-	-
80-89	1,464	-	-	-
90-99	-	-	18,148	-

A summary of the distribution of the species occurring in 10% or more of the samples is given below. Trash fish are discussed first, followed by the four species sought by the Hampton Roads trawler fleet. Species of insignificant commercial potential are listed in Table 3 and are not discussed in this report.

Northern Searobin

The northern searobin was spottily distributed throughout the area from north to south and from 11 to 62 fathoms. Only 17 samples contained this species, but 3 were significant catches. At 38° 14' N, 73° 59' W (37 fathoms) we caught searobins at the rate of 42,000 pounds per hour. At 36° 35' N, 74° 47' W (43 fm.) the catch rate was 5,000 pounds per hour, and at 37° 25' N, 74° 45' W (27 fm.) it was 425 pounds per hour. At 3 other stations the catch was between 25 and 130 pounds. Searobins seemed less plentiful than in winter of 1966. Temperature range was 6 to 13° C (43-55° F).

Striped Searobin

The striped searobin occurred in 9 samples from 14 to 62 fathoms and throughout the area from north to south. The largest catch was 50 pounds. All other catches were of 10 pounds or less. Temperature range was 6 to 13° C (43-55° F).

Silver Hake

Although no large concentrations of silver hake (whiting) were located, the species was caught at 37 stations distributed throughout the area at all depths. Catches larger than 10 pounds

TABLE 3

SPECIES OCCURRING RARELY IN CHESAPEAKE BIGHT IN WINTER 1967

AMERICAN JOHN DORY	ZENOPSIS OCELLATA
AMERICAN SHAD	ALOSA SAPIDISSIMA
ARMORED SEAROBIN	PERISTEDION MINIATUM
ATLANTIC ANGEL SHARK	SQUATINA DUMERILI
ATLANTIC COD	GADUS MORHUA
ATLANTIC TORPEDO	TORPEDO NOBILIANA
BARNDOOR SKATE	RAJA LAEVIS
BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
CONGER EEL	CONGER OCEANICUS
FAWN CUSK-EEL	LEPOPHIDIUM CERVINUM
GULF STREAM FLOUNDER	CITHARICHTHYS ARCTIFRONS
HADDOCK	MELANOGRAMMUS AEGLEFINUS
ROCKGUNNEL	PHOLIS GUNNELLUS
SEA RAVEN	HEMITRIPTERUS AMERICANUS
SOUTHERN STINGRAY	DASYATIS AMERICANA
WHITE HAKE	UROPHYCIS TENUIS

per hour were made only outside of the 25 fathom curve and at temperatures of 6 to 12° C (43-54° F). The largest catch was only 65 pounds per hour.

Spotted Hake

From the southern edge of the area north to 38° 30' spotted hake (ling) occurred in 30 samples. Depth range was 12 to 80 fathoms, but all catches of 10 pounds or more were made in water of 20 fathoms or deeper. Temperature range was 4 to 13° C (39-55° F). The largest catch was 85 pounds. Ten other catches contained from 10 to 30 pounds.

Squirrel Hake

Squirrel hake (red hake) were caught in significant quantity only north of 36° 50' N latitude in waters deeper than 25 fathoms. Temperature range was 5 to 12° C (41-54° F). At two stations the catch rate exceeded 100 pounds per hour. The catch exceeded 15 pounds per hour at about half of the 22 stations where squirrel hake were caught.

Chain Dogfish

Chain dogfish were caught in 7 tows outside the 45 fathom curve. Catch rates ranged from 1 to 6 pounds per hour. Temperature range was 9 to 12° C (48-54° F).

Smooth Dogfish

Although the smooth dogfish occurred in only 6 samples, all south of 36° N latitude, one catch contained 24,000 pounds. Depth range was 21 to 80 fathoms; temperature range, 9 to 13° C (48-55° F).

Spiny Dogfish

Spiny dogfish were the most generally distributed and most abundant fish in the sampling area. Only 2 of our 54 samples lacked this species. The largest catch was 18,000 pounds. Eleven catches were between 1000 and 10,000 pounds, and 9 catches were between 500 and 1000 pounds. Abundance was not seemingly related to depth or latitude.

Clearnose Skate

Clearnose skate occurred throughout the area at all depths sampled but were most numerous in waters shoaler than 50 fathoms, where nearly half of the catches were between 25 and 100 pounds. This species was caught in 26 tows through a temperature range of 5 to 13° C (41-55°F).

Little Skate

The little skate was caught at 30 stations spanning a depth range of 9 to 62 fathoms from 36° N to the northern edge of the area, but became increasingly abundant toward the north. Three catches ranged between 100 and 150 pounds per hour and at 7 stations the catch was between 25 and 100 pounds. Temperature range was 4 to 11° C (39-52° F).

Winter Skate

The winter skate, a species not caught in 1966, occurred in 9 samples from inside the 30 fathom curve. Temperature ranged from 4 to 8° C (39-46° F). Although the largest catch was only 6 individuals, the large size of these fish makes them of some potential importance. The largest catch was 42 pounds and all except 2 catches exceeded 10 pounds.

Rosette Skate

The rosette skate occurred in 9 samples, all but one from 45 fathoms or deeper. Temperature range was 6 to 12° C (43-54° F). The largest catch was 60 pounds. Four catches ranged between 10 and 50 pounds.

Goosefish

The goosefish (angler, allmouth) was caught at 41 stations throughout the range of depths, latitudes, and temperatures sampled. The largest catch was 350 pounds; 3 catches ranged between 250 and 150 pounds, and 23 of the catches were between 100 and 25 pounds. Although goosefish were not plentiful, their average size of about 10 pounds makes them of potential significance.

Winter Flounder

Winter flounder (blackback) were caught at 15 stations ranging in depth from 8 to 27 fathoms and from 36° 30' to the northern edge of the area. Temperature range was 4 to 8° C (39-46° F). The largest catch was 25 pounds. All other catches were less than 10 pounds.

Windowpane Flounder

Windowpane (daylight) flounder occurred throughout the area from north to south inside of the 30 fathom curve. Temperature range was 4 to 9° C (39-48° F). Of the 27 catches containing windowpane flounder 3 were between 25 and 50 pounds, and 2 were between 10 and 25 pounds. All others were less than 10 pounds.

Fourspot Flounder

Primarily a resident of the outer half of the shelf, the fourspot flounder was caught in 26 tows ranging north from 36°. The largest catch was 50 pounds. Seven catches ranged between 20 and 50 pounds. Temperature range was 4 to 10° C (39-50° F).

Yellowtail Flounder

Yellowtail flounder occurred in 14 samples from a depth range of 15 to 62 fathoms. A few were caught as far south as 36° 30', but yellowtails were present in substantial quantity only north of 37° 40'. Two catches were about 250 pounds, and 3 additional catches exceeded 40 pounds per hour. Temperature range was 4 to 10° C (39-50° F).

Witch Flounder

The witch flounder (gray sole) was caught at 22 stations north of 37° N at depths from 16 to 69 fathoms. Temperature range was 5 to 11° C (41-52° F). All catches of 10 pounds per hour or larger were made at depths in excess of 25 fathoms. Two catches exceeded 20 pounds per hour, 4 others were in excess of 10 pounds.

Alewife

At 20 stations inside the 30 fathom curve alewife were caught. The alewife was rather generally distributed northward from 36° N. Temperature range at the bottom was 5 to 9° C (41-48° F). The catch exceeded 20 pounds per hour at 7 stations. The largest catch was 100 pounds.

Blueback Herring

Blueback (glut) herring occurred in only 9 catches, all inside the 30 fathom curve. Although the blueback enters fresh water to spawn about a month later than does the alewife, the blueback already occurred north to 38° 30' by the end of March. However, blueback were not as abundant as alewife, the largest catch being 12 pounds. Perhaps blueback are more abundant on the shelf later in the season.

Atlantic Herring

The distribution of Atlantic herring closely approximated that of the alewife and blueback. Depth range was 10 to 33 fathoms, with the exception of one fish caught in 64 fathoms. Temperature range was 5 to 9° C (41-48° F).

Atlantic Mackerel

Atlantic mackerel were caught at 13 stations shoaler than 35 fathoms and from 36° N to the northern edge of the sampling area. Range of bottom temperature was 5 to 8° C (41-46° F). Probably the distribution of mackerel and the other pelagic species such as alewife, blueback, and herring is not accurately indicated by a survey using a bottom trawl. At 3 stations the catch exceeded 20 pounds. Other catches were 1 to 5 pounds.

Ocean Pout

The ocean pout occurred in 13 samples spanning a depth range of 15 to 62 fathoms and a temperature range of 4 to 10° C (39-50° F). The southern limit of occurrence was 37° N, and the largest catch (150 pounds) was the northernmost one. Six catches ranged from 15 to 90 pounds. All others were less than 10 pounds.

Longhorn Sculpin

The longhorn sculpin was caught in 12 tows inside the 30 fathom curve north of 37° N. The largest catch was 60 pounds. Three additional catches were from 12 to 25 pounds. Temperature range was 5 to 7° C (41-45° F).

Black Seabass

Although in only 13 samples, black seabass were generally distributed from north to south. Their depth range was 30 to 80 fathoms and temperature range 8 to 12° C (46-54° F). The largest catch was 705 pounds.

Scup

Scup (porgies) were scarce in our sampling area, occurring in only 14 catches scattered through the area from north to south. Trawlers were, however, catching scup off New Jersey during this time. Depth range was 17 to 80 fathoms, temperature range, 7 to 13° C (45-55° F). The largest catch was 420 pounds.

Butterfish

Butterfish occurred at 20 stations throughout the area from 11 to 80 fathoms. The largest catches were made between 10 and 20 fathoms and at 80 fathoms (temperatures of 7 and 9° respectively). Temperature range was 7 to 13° C (45-55° F).

Summer Flounder

Summer flounder (fluke) were caught at 40 stations spanning a depth range of 8 to 80 fathoms and a temperature range of 5 to 13° C (41-55° F). The greatest concentration was in depths greater than 20 fathoms and temperatures of 8° or higher. Flounders were generally distributed latitudinally.

PHASE - 9

PRELIMINARY CRUISE SUMMARY
AVAILABILITY AND DISTRIBUTION OF BENTHIC FISHES OF CHESAPEAKE BIGHT
SPRING 1967

By

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OCTOBER 13, 1967

AN INTERIM REPORT OF PROGRESS
ON PROJECT 3-5-D UNDER
PL 88-309

In spring 1967 the average catch of trash fish at 69 stations was 475 pounds per hour, a significant decline from the average catch rate of 2,600 pounds per hour experienced in winter. The area north of 37° N latitude and shoaler than 25 fathoms was the most consistently productive (Fig. 1 and Table 1), though a few good catches of trash fish were made elsewhere. On the edge of Washington Canyon and near Baltimore Canyon 3,000 pounds of young spiny dogfish were caught in each of two tows. Catch rates ranged between 5,000 pounds per hour and 10 pounds per hour. Departure of most of the adult spiny dogfish from the area was a major factor in the decline in quantity of trash fish.

The sampling procedure followed in spring was the same as was outlined in the previous report on the winter cruise. Briefly, it consisted of a search, using a fishscope, for up to 60 minutes followed by a trawl tow of 60 minutes in each 15 minute grid in the sampling area. In only two grids were seemingly significant quantities of fish detected on the fishscope before the expiration of 60 minutes. In one case 2,300 pounds of trash fish were caught. In the other the catch was 2,000 pounds of small scup. Table 2 lists the stations in order of decreasing catch of trash fish and also gives hydrographic data and the position for each station.

Indications of fish or other organisms in the midwaters were noted from the echo-sounder record. At 73% of the stations no midwater forms were detected; at 26% light midwater traces were noted, and at 1% moderate traces were noted. No station had indications of heavy concentrations.

A summary of the distribution of species occurring in 10% or more of the samples is given below. Trash fish are discussed first, followed by the four species sought by the Hampton Roads trawler fleet. Species of

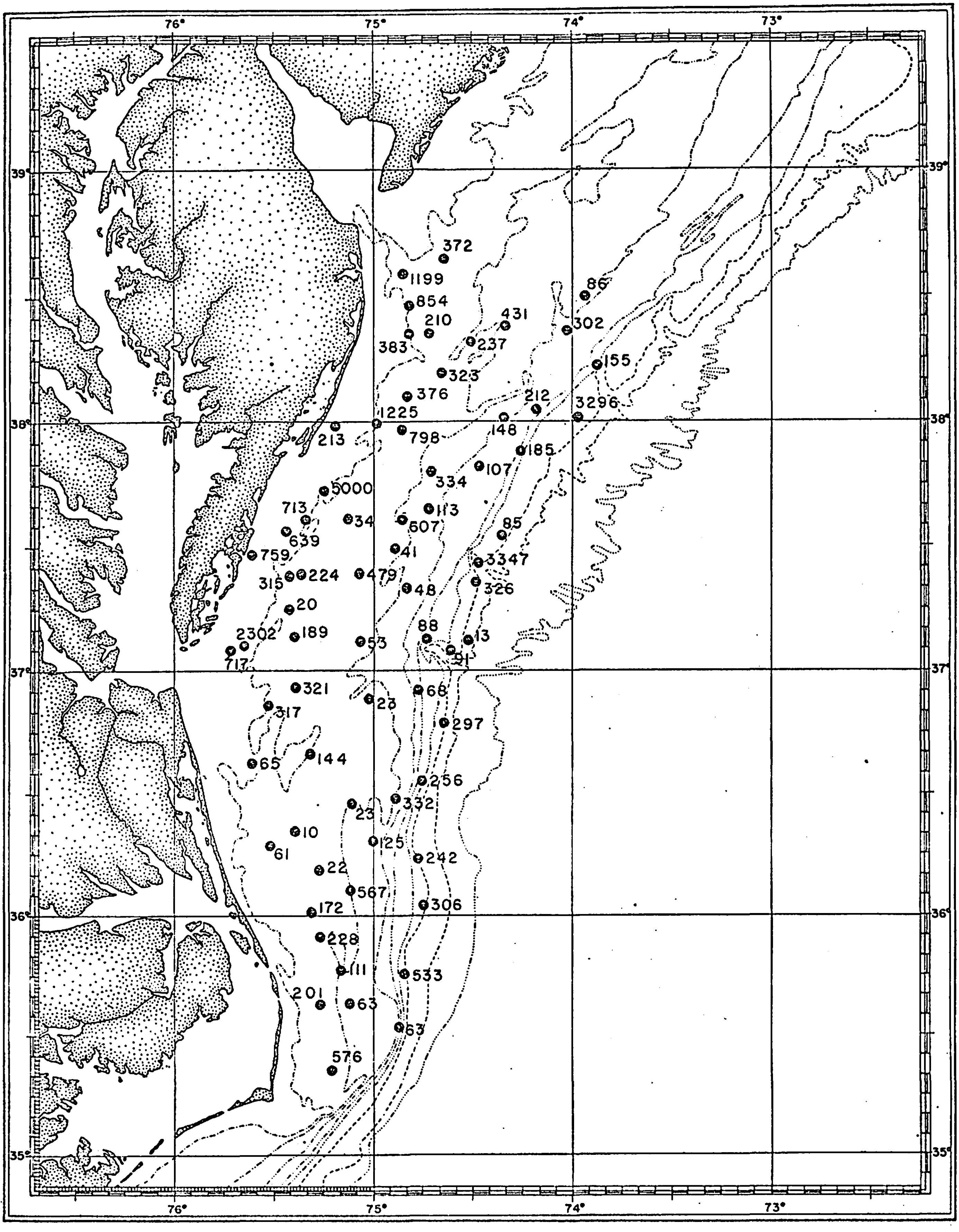

Fig. 1. Catch of trash fish per hour of trawling, spring 1967

TABLE 1

AVERAGE CATCH (IN POUNDS) OF TRASH FISH PER HOUR OF TOW IN EACH LATITUDE AND DEPTH RANGE
SPRING 1967

Depth (fm)	35°	36°	37°	38°
0-9	-	65	824	854
10-19	236	165	758	508
20-29	-	160	276	330
30-39	63	68	107	221
40-49	-	-	88	-
50-59	533	-	185	155
60-69	-	256	-	3,296
70-79	-	302	1,252	-
80-89	-	-	91	-
90-99	-	-	-	86
100-109	-	242	-	-
110-119	-	-	-	-
120-129	-	-	13	-

TABLE 2

STATION LIST, SPRING 1967

Station No.	Date	Latitude	Longitude	Depth (fathoms)	Temp. at bottom C	Salinity at bottom	Time of day	Midwater fish	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per of tow	Duration of tow (minutes)	Duration of Search
T120	13JUN67	3746N	7515W	011	11C	32S	07.9	NO	4		3	5000	60	060
T111	07JUN67	3725N	7430W	072	10C	S	14.8	NO	1	70	6	3347	60	
T095	01JUN67	3803N	7358W	065	12C	35S	07.5	NO	1	175	11	3296	60	060
T075	10MAY67	3707N	7540W	009	11C	31S	13.2	NO	1	3	6	2302	60	030
T083	30MAY67	3759N	7459W	014	10C	31S	07.7	NO	4	155	11	1225	60	060
T089	31MAY67	3837N	7452W	013	10C	31S	07.7	LT	4	117	15	1199	60	060
T088	30MAY67	3826N	7450W	009	11C	31S	20.5	MD	4	134	11	854	60	060
T084	30MAY67	3758N	7453W	015	10C	32S	10.4	LT	3	86	17	798	60	060
T117	08JUN67	3730N	7536W	005	C	S	19.8	NO	4	14	9	759	60	
T119	12JUN67	3707N	7541W	007	12C	32S	18.8	NO	2	75	8	717	60	060
T077	10MAY67	3737N	7517W	013	09C	32S	20.3	LT	4	37	14	713	60	060
T116	08JUN67	3734N	7526W	008	11C	32S	17.5	LT	3	8	10	639	60	
T079	11MAY67	3737N	7450W	022	07C	33S	09.4	NO	3	46	10	607	60	060
T068	03MAY67	3522N	7511W	015	20C	35S	22.1	NO	3	2	9	576	60	060
T073	04MAY67	3608N	7507W	017	08C	33S	18.7	LT	3	24	8	567	60	060
T066	03MAY67	3552N	7453W	057	09C	34S	15.4	NO	2	275	10	533	60	060
T082	29MAY67	3723N	7504W	015	09C	32S	20.8	LT	2	65	11	479	60	060
T122	13JUN67	3822N	7451W	011	11C	32S	15.0	NO	4	21	11	383	60	060
T091	31MAY67	3823N	7416W	027	07C	33S	14.6	NO			13	431	60	060
T085	30MAY67	3807N	7450W	013	09C	32S	12.9	NO			9	376	60	060
T090	31MAY67	3840N	7434W	016	08C	32S	10.7	LT	3	24	14	372	60	060
T100	01JUN67	3748N	7440W	026	08C	33S	19.8	NO	1		16	334	60	060
T061	02MAY67	3633N	7457W	020	07C	33S	18.0	NO	4	1110	5	332	60	060
T110	07JUN67	3723N	7428W	075	12C	35S	13.4	NO	1	4	11	326	60	060
T086	30MAY67	3813N	7435W	021	08C	32S	15.5	NO			14	323	60	060
T056	01MAY67	3657N	7523W	017	08C	32S	20.7	LT	3	21	10	321	60	060
T055	01MAY67	3654N	7533W	011	08C	32S	18.0	NO	5	70	13	317	60	060
T076	10MAY67	3724N	7532W	009	10C	32S	16.9	NO	3	4	9	315	60	060
T065	03MAY67	3604N	7445W	075	10C	35S	12.2	NO	4	186	10	306	60	060
T092	31MAY67	3822N	7402W	035	05C	33S	17.3	NO	1	1	10	302	60	060
T059	02MAY67	3652N	7440W	077	10C	34S	12.0	NO	3	330	14	297	60	060
T060	02MAY67	3637N	7444W	065	10C	34S	15.2	LT	4	346	15	256	60	060

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T060  02MAY67  3637N 7444W  065  10C  34S  15.2  LT     4    346   15    256   60  060
T064  03MAY67  3619N 7449W  100  11C  35S  09.4  NO     4    265   18    242   60  060
T123  13JUN67  3819N 7430W  021  06C  33S  18.2  NO     1      3    9    237   60  060
T072  04MAY67  3557N 7519W  013  09C  32S  15.6  NO     4      7    7    228   60  060
T081  29MAY67  3723N 7520W  014  10C  32S  18.5  NO     4    252   10    224   60  060
T121  13JUN67  3759N 7512W  005  12C  32S  10.6  LT     3     17   11    213   60  060
T096  01JUN67  3804N 7411W  030  07C  33S  10.0  LT                12    212   60  060
T087  30MAY67  3821N 7442W  014  08C  32S  17.9  LT     2     10   10    210   60  060
T069  04MAY67  3540N 7514W  015  09C  32S  07.7  NO     3      4    6    201   60  060
T080  29MAY67  3708N 7523W  015  09C  32S  15.5  NO     4     90   12    189   60  060
T098  01JUN67  3755N 7413W  050  11C  35S  14.8  NO     3     13   11    185   60  060
T103  05JUN67  3601N 7521W  014  11C  32S  21.3  NO     5      3    8    172   60  060
T093  31MAY67  3816N 7350W  051  09C  34S  19.8  NO     2     10   13    155   60  060
T097  01JUN67  3801N 7417W  035  07C  33S  12.3  NO                12    148   60  060
T074  04MAY67  3642N 7519W  014  08C  33S  23.7  LT     5     78   10    144   60  060
T063  03MAY67  3621N 7501W  021  07C  33S  06.7  NO     5    105   18    125   60  060
T113  08JUN67  3740N 7444W  026  06C  33S  06.9  NO     2      2    8    113   60  060
T071  04MAY67  3552N 7510W  019  08C  33S  12.8  NO     3      2    5    111   60  060
T099  01JUN67  3750N 7426W  031  07C  33S  17.4  LT     2      1   13    107   60  060
T109  07JUN67  3705N 7435W  082  11C    S  07.7  NO                12     91   60
T107  06JUN67  3708N 7445W  046  07C  33S  20.2  NO     2      4    6     88   60  060
T094  31MAY67  3831N 7356W  097  12C  35S  22.6  NO                10     86   60  060
T112  07JUN67  3734N 7420W  072  12C  35S  19.9  NO     1      3    8     85   60  060
T058  02MAY67  3657N 7450W  033  07C  33S  09.2  NO     3     64   10     68   60  060
T101  05JUN67  3638N 7537W  008  12C  32S  14.8  LT     4      2    8     65   60  060
T070  04MAY67  3543N 7505W  019  09C  33S  10.5  NO     2      2    5     63   60  060
T067  03MAY67  3536N 7456W  030  10C  34S  18.6  NO     2      2    3     63   60  060
T102  05JUN67  3621N 7534W  014  11C  32S  18.2  LT     4     39    7     61   60  060
T106  06JUN67  3708N 7504W  019  09C  32S  16.9  NO     2      3    6     53   60  060
T115  08JUN67  3720N 7449W  025  08C  33S  12.3  NO     1           8     48   60  060
T114  08JUN67  3732N 7454W  017  08C  33S  09.6  NO     1           6     41   60  060
T078  11MAY67  3737N 7507W  014  07C  32S  06.7  LT     2   2004    3     34   60  056
T062  02MAY67  3634N 7508W  014  08C  33S  21.3  NO     4      3    5     23   60  060
T057  02MAY67  3655N 7502W  021  07C  33S  06.7  NO     4     58    5     23   60  060
T104  06JUN67  3614N 7519W  016  11C  32S  07.0  NO     1     35    4     22   60  060
T118  09JUN67  3715N 7527W  013    C    S  07.0  LT     3    125    9     20   60
T108  07JUN67  3707N 7433W  125  10C  35S  06.3  NO                 5     13   60  060
T105  06JUN67  3623N 7521W  013  11C  32S  09.6  NO     1     20    5     10   60  060
                   N     W         C    S             173   6629  661  32775 4140
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TABLE 3

SPECIES OCCURRING RARELY IN CHESAPEAKE BIGHT IN SPRING 1967

AMERICAN SHAD	ALOSA SAPIDISSIMA
AMERICAN JOHN DORY	ZENOPSIS OCELLATA
ARMORED SEAROBIN	PERISTEDION MINIATUM
ATLANTIC COD	GADUS MORHUA
BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
CHAIN DOGFISH	SCYLIORHINUS RETIFER
CONGER EEL	CONGER OCEANICUS
CUNNER	TAUTOGOLABRUS ADSPERSUS
GRAY SEATROUT	CYNOSCION REGALIS
GULF STREAM FLOUNDER	CITHARICHTHYS ARCTIFRONS
LONGSPINE SNIPEFISH	MACRORHAMPHOSUS SCOLOPAX
LONGHORN SCULPIN	MYOXOCEPHALUS OCTODECEMSPINOSUS
NORTHERN KINGFISH	MENTICIRRHUS SAXATILIS
NORTHERN PUFFER (SWELLFISH)	SPHAEROIDES MACULATUS
NORTHERN STARGAZER	ASTROSCOPUS GUTTATUS
PIGFISH	ORTHOPRISTIS CHRYSOPTERUS
POLKA-DOT CUSK-EEL	OTOPHIDIUM OMOSTIGMUM
SAND SHARK	CARCHARIAS TAURUS
SANDBAR SHARK	CARCHARHINUS MILBERTI
SEA RAVEN	HEMITRIPTERUS AMERICANUS
SMOOTH BUTTERFLY RAY	GYMNURA MICRURA
SOUTHERN STINGRAY	DASYATIS AMERICANA
SPINY BUTTERFLY RAY	GYMNURA ALTAVELA
SPOTTED WHIFF	CITHARICHTHYS MACROPS
TAUTOG	TAUTOGA ONITIS
WHITE HAKE	UROPHYCIS TENUIS

insignificant commercial potential are listed in Table 3 and are not discussed in this report.

NORTHERN SEAROBIN

The most frequently caught fish as well as the most abundant was the northern searobin. It occurred in 51 samples from throughout the area. Significant catches were from the area between 7 and 25 fathoms north of 36°. The largest catch was 5,000 pounds. One catch was 1,800 pounds, 5 were between 500 and 1,000 pounds per hour. Temperature range was 5 to 20° C (41-68°F).

STRIPED SEAROBIN

Striped searobins, occurring in 33 catches, were again much less abundant than the northern robin. Depth range was 5 to 100 fathoms, but only 3 stations deeper than 30 fathoms yielded striped robins. Latitudinal distribution was throughout the area. Temperature range was 7 to 20°C (45-68°F). The largest catch was 200 pounds per hour. Four additional catches were in excess of 25 pounds.

SILVER HAKE

Silver hake or whiting occurred in 47 samples from all depths and latitudes, but were nowhere plentiful. The largest catch was 155 pounds, one catch was 75 pounds, and all others were less than 50 pounds. Young were inside the 35 fathom curve, whereas adults were caught at all depths. Temperature range was 5 to 12° C (41-54° F).

SPOTTED HAKE

Spotted hake (ling) were caught at about half (38) of the stations. Depth range was 5 to 100 fathoms, but catches exceeding 20 pounds were from depths of 50 fathoms or more where temperatures were 9 to 12° C (48-54° F). Spotted hake were generally distributed latitudinally. The largest catch was 270 pounds. Three other catches exceeded 100 pounds. Half of the stations deeper than 50 fathoms yielded catches in excess of 30 pounds per hour.

SQUIRREL HAKE

Squirrel hake or red hake were caught at 36 stations outside of the 10 fathom curve and north of 36°. Temperature range was 5 to 12° C (41-54°F). The largest catch was 140 pounds. One other catch exceeded 100 pounds, 2 were between 50 and 100 and 6 were between 25 and 50 pounds.

SPINY DOGFISH

Whereas in winter the spiny dogfish occurred at all stations except two, in spring it was caught at only one-half of the stations and the largest catch of adults was only 225 pounds. About 3,000 pounds of juveniles were caught at each of two stations, one on the edge of Washington Canyon and one on the edge of Baltimore Canyon. Adults were most abundant in waters shoaler than 25 fathoms, whereas juveniles were more plentiful in deep water.

SMOOTH DOGFISH

The smooth dogfish was caught at 20 stations ranging in depth from 7 to 100 fathoms, but it occurred more frequently inside the 30 fathom contour. Temperature range was 8 to 12° C (46-54°F). At 3 stations the catch was between 100 and 200 pounds per hour.

ATLANTIC ANGEL SHARK

Angel sharks were caught in 9 tows from all depths and ranging from the southern edge of the area north to 37° 30'. The largest catch was 143 pounds. Temperature range was 7 to 20° C (45-68° F).

CLEARNOSE SKATE

The clearnose skate occurred in 13 samples all from water shoaler than 20 fathoms. In three of these the catch was between 100 and 200 pounds per hour. Temperature range was 8 to 12° C (46-54°F). All catches of more than 10 pounds week at 11 or 12° C.

LITTLE SKATE

The little skate occurred in 49 samples north of 36° and having a depth range of 6 to 97 fathoms, though it occurred rarely in water deeper than 30 fathoms. Temperature range was 5 to 12° C (41-54° F). The largest catch was 450 pounds per hour. One catch contained 150 pounds and 9 ranged between 25 and 50 pounds.

WINTER SKATE

A larger fish than the clearnose, which shares its shallow water habitat, the 51 winter skate caught in 12 tows weighed a total of 509 pounds. The largest catch was 210 pounds. One half of the catches were between 25 and 75 pounds per hour. Depth range was 9 to 21 fathoms and the winter skate occurred only north of 36° 50'. Temperature range was 7 to 11° C (45-52° F).

ROSETTE SKATE

Occurring only outside the 50 fathom contour, the rosette skate was represented in only 9 samples. These covered the area from north to south and had a temperature range of 9 to 12° C (48-54° F). The largest catch of this small skate was 45 pounds. Three other catches exceeded 10 pounds per hour.

GOOSEFISH

Also called angler and allmouth, the goosefish occurred throughout the area. Three catches contained between 100 and 200 pounds. The average catch of this species in 41 samples was 42 pounds.

WINTER FLOUNDER

Winter flounder seem to be increasing in abundance in Chesapeake Bight. A total of 2,500 pounds were caught in 27 tows from depths of 9 to

31 fathoms north of 36° 30'. Temperature range was 6 to 12° C (43-54°F). The largest catch was 450 pounds. Two additional catches exceeded 300 pounds and 6 catches were between 100 and 300 pounds.

WINDOWPANE FLOUNDER

Windowpane flounder (daylight) occurred in 33 samples from 9 to 26 fathoms. Temperature range was 6 to 12° C (43-54°F), and latitudinal range was through the entire area but with greatest numbers being north of 37° 30'. The largest catch was 45 pounds. Ten catches contained 10 pounds or more.

FOURSPOT FLOUNDER

Fourspot flounder were generally distributed through all depths and latitudes sampled but were nowhere abundant, the largest catch being 47 pounds.

YELLOWTAIL FLOUNDER

Yellowtail were caught in 11 tows at depths of 16 to 35 fathoms north of 37° 30'. Temperature range was 5 to 9° C (41-48°F). The largest was 70 pounds. One other catch contained as much as 10 pounds.

WITCH FLOUNDER

The witch flounder or gray sole was caught in 19 tows all north of 36° and predominantly in water deeper than 25 fathoms. This species is of little significance, the largest catch being 19 pounds. All other catches were less than 10 pounds.

ALEWIFE

Alewife occurred in 12 samples north of 36° 30' N. Depth range was 5 to 77 fathoms, temperature range 7 to 12° C (45-54°F). The largest catch was 8 pounds.

BLUEBACK HERRING

The blueback herring, or glut herring, also was caught at 12 stations but was somewhat more plentiful than the alewife. The largest catch was 25 pounds. Depth range was 8 to 100 fathoms, temperature range 7 to 11° C (45-52°F).

ATLANTIC HERRING

Atlantic herring occurred in 7 catches, the largest of which was 5 pounds. Depth range was 15 to 65 fathoms and temperature range 7 to 11° C (45-52°F).

ATLANTIC MACKEREL

Atlantic mackerel occurred in 11 samples ranging in depth from 11 to 100 fathoms. Temperature range was 7 to 12° C (45-54° F). The largest catch was 75 pounds. Mackerel and the three kinds of herring, being pelagic fish, probably are inadequately sampled by a bottom trawl.

OCEAN POUT

The ocean pout occurred at 13 stations north of 37° 30' and through a depth range of 16 to 73 fathoms. Temperature range was 5 to 12° C (41-54° F). The largest catch was 53 pounds.

BLACK SEABASS

Black seabass, like scup, were found throughout the area at all depths. The best catches (100-300 pounds per hour) were mostly outside the 50 fathom curve in water of 10 to 11° C (50-52° F).

SCUP

Scup were taken in 35 samples from 6 to 100 fathoms throughout the area. Small fish were common inside the 20 fathom curve but were not caught in deeper water. Temperature range was 7 to 20° C (45-68° F).

BUTTERFISH

Butterfish were caught at 49 stations throughout the range of depths and latitudes sampled. Temperature range was 6 to 12° C (43-54° F). Deep water was more productive than shallow. Of the 5 catches exceeding 100 pounds per hour, all except one were in water deeper than 50 fathoms. The exception was at 14 fathoms.

SUMMER FLOUNDER

Summer flounder occurred in about one-half of the catches (32) but were nowhere numerous. The largest catches were about 25 pounds per hour and were made in waters of 13 to 16 fathoms north of 36° 30' N. Temperature range was 7 to 20° C (45-68° F) but the best catches were in the range of 8 to 10° C.

PRELIMINARY CRUISE SUMMARY
AVAILABILITY AND DISTRIBUTION OF BENTHIC FISHES OF CHESAPEAKE BIGHT
SUMMER 1967

By

JACKSON DAVIS

VIRGINIA INSTITUTE OF MARINE SCIENCE

GLOUCESTER POINT, VIRGINIA

JANUARY 31, 1968

AN INTERIM REPORT OF PROGRESS
ON PROJECT 3-5-D UNDER
PL 88-309

The summer cruise of 1967 was conducted during August and September. The average catch of trash fish at 83 stations was 378 pounds per hour. The most productive area was north of 36° 30' and inshore of the 20 fathom curve (Fig. 1 and Table 1). Catch rates ranged between 2700 pounds per hour and 3 pounds per hour.

Sampling procedure was to trawl for one hour in each 15 minute grid between Cape Hatteras and Cape May. An Atlantic western trawl was used. Mesh sizes were: 4" in body, 3" in extension, 2" in cod end. In previous sampling periods we searched with an echo sounder for an hour before setting the net. In summer, we discontinued searching. Even in the area of maximum catches, no significant schools were detected by the fish-finder.

Table 2 lists the stations in order of decreasing catch of trash fish and also gives temperature and salinity of the bottom water and the position of each station. The echo sounder indicated a scarcity of midwater organisms.

A summary of the distribution of species occurring in 10% or more of the samples is given below. Trash fish are discussed first, followed by the species sought by the Hampton Roads trawler fleet. Species of insignificant commercial potential in the summer are listed in Table 3 and are not discussed in this report.

NORTHERN SEAROBIN

The northern searobin was again the most numerous fish in our samples despite the fact that it occurred only inside the 20 fathom curve and north of 36° 30' N. Temperature range was 8 to 26° C (46 to 79°F). The average catch of northern searobins at 39 stations

Table 1. Average catch (in pounds) of trash fish per hour of tow in each latitude and depth range - summer 1967.

Depth	35°	36°	37°	38°
0- 9	--	503	817	773
10-19	129	623	694	404
20-29	13	40	248	331
30-39	11	35	47	155
40-49	322	181	--	42
50-59	--	--	66	--
60-69	--	882	--	104
70-79	--	--	63	--
80-89	--	--	--	--
90-99	--	--	--	--
100-109	--	--	--	3

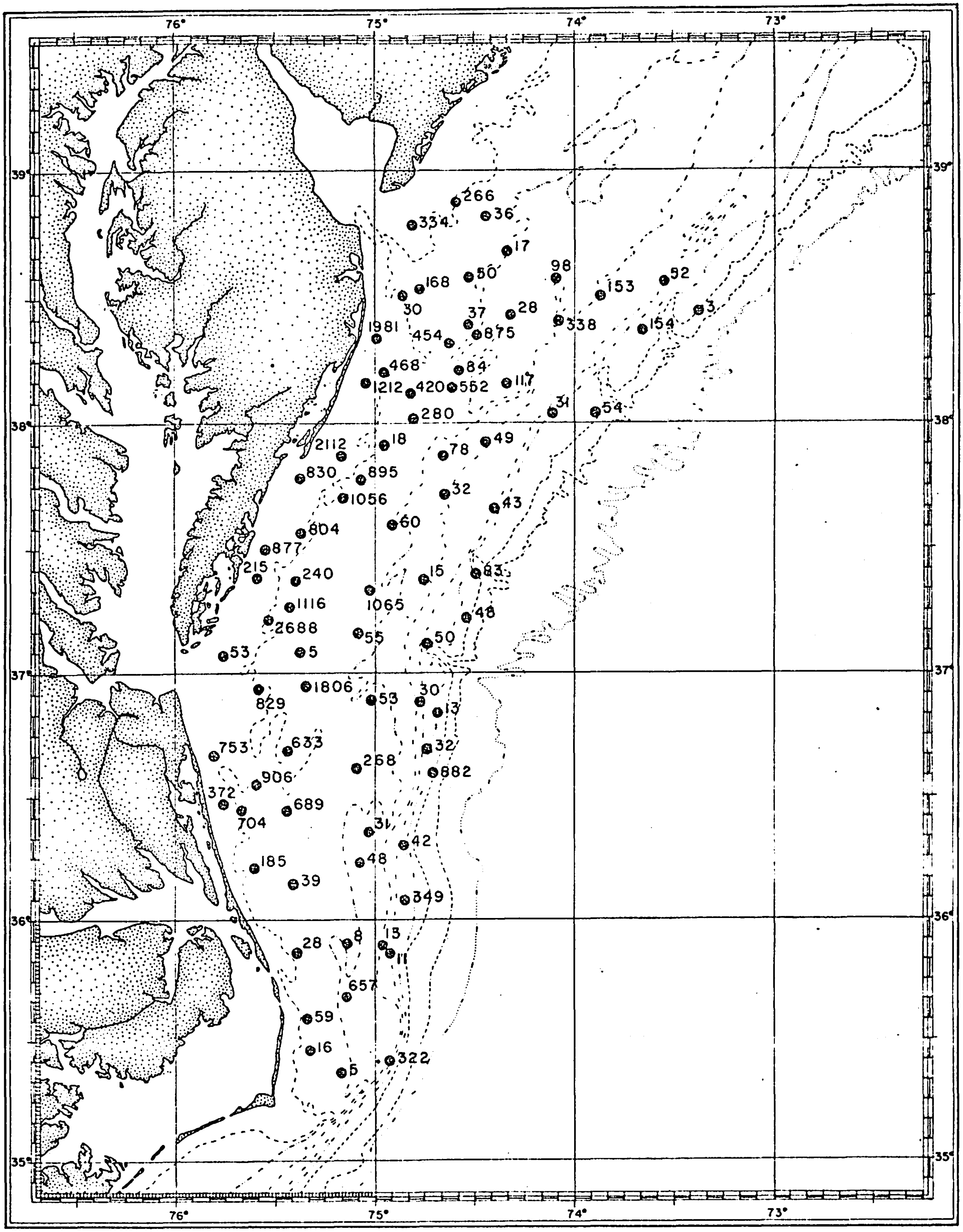

Figure 1. Catch of trash fish per hour of trawling, summer 1967.

TABLE 2

STATION LIST, SUMMER 1967

Station No.	Date	Latitude	Longitude	Depth (fathoms)	Temp. at bottom C	Salinity at bottom	Time of Day	Midwater fish	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)
T137	08AUG67	3713N	7533W	011	11C	32S	7.1	LT	1	413	4	2668	60
T142	08AUG67	3756N	7511W	009	C	32S	20.0	LT	1	3	7	2112	60
T146	09AUG67	3820N	7500W	011	15C	31S	13.6	NO	3	4	10	1981	60
T209	08SEP67	3656N	7522W	013	20C	32S	13.7		3	17	7	1806	60
T145	09AUG67	3809N	7503W	008	12C	32S	10.6	NO	4	19	9	1212	60
T158	23AUG67	3716N	7527W	014	10C	32S	20.0	NO	1	5	6	1116	60
T176	27AUG67	3720N	7503W	020	11C	31S	9.5	NO	0	0	7	1065	60
T218	21SEP67	3742N	7514W	013	18C	31S	14.1		6	111	11	1056	60
T192	05SEP67	3632N	7535W	011	21C	31S	21.5		4	356	8	906	60
T211	20SEP67	3747N	7506W	012	19C	31S	7.3		6	60	17	895	120
T182	30AUG67	3636N	7444W	062	12C	31S	12.0		0	0	11	882	60
T138	08AUG67	3730N	7533W	006	14C	32S	12.0	NO	3	17	7	877	60
T215	20SEP67	3822N	7430W	020	14C	32S	19.5		3	17	9	875	60
T141	08AUG67	3746N	7524W	008	14C	32S	16.9	HV	2	4	6	830	60
T210	08SEP67	3656N	7534W	012	20C	31S	20.7		4	92	7	829	60
T140	08AUG67	3733N	7524W	011	11C	32S	14.3	HV	3	137	5	804	60
T191	05SEP67	3640N	7548W	010	21C	31S	13.7		7	314	12	753	60
T206	08SEP67	3627N	7538W	011	21C	31S	19.6		4	63	8	704	60
T205	07SEP67	3526N	7527W	013	21C	32S	7.5		2	16	8	689	60
T217	21SEP67	3802N	7446W	016	15C	32S	9.5		3	28	9	669	60
T199	07SEP67	3542N	7509W	018	26C	35S	7.0		4	2	6	657	60
T208	08SEP67	3641N	7527W	009	20C	31S	15.8		2	6	5	633	60
T216	21SEP67	3807N	7438W	020	11C	33S	6.2		4	19	13	552	60
T202	07SEP67	3558N	7532W	009	21C	31S	14.9		3	5	7	97	60
T213	20SEP67	3611N	7458W	010	19C	31S	14.2		7	213	16	469	60
T214	20SEP67	3918N	7439W	018	14C	32S	17.3		5	58	10	454	60
T212	20SEP67	3807N	7451W	015	17C	31S	12.1		6	16	13	420	60

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TABLE 2 (Cont'd)

T207	08SEP67	3628N	7544W	009	210	315	11.7		3	21	10	372	60
T199	31AUG67	3605N	7452W	044	130	335	14.7		1	3	7	349	60
T164	25AUG67	3822N	7405W	034	050	325	7.1	0.0	1	25	10	338	60
T149	20AUG67	3847N	7449W	009	120	325	19.0	0.0	2	2	9	334	60
T195	06SEP67	3525N	7455W	040	C	365	11.6		3	10	14	322	60
T144	09AUG67	3801N	7452W	015	090	325	8.2	0.0	1	1	6	280	60
T184	31AUG67	3636N	7506W	015	080	325	6.4		1	5	9	265	60
T143	10AUG67	3862N	7436W	017	100	325	5.5	0.0	1	2	7	258	60
T219	21SEP67	3722N	7527W	011	180	315	15.4		1	2	5	240	60
T138	08AUG67	3723N	7535W	007	130	325	9.9	0.0	4	5	10	215	60
T204	07SEP67	3611N	7537W	011	210	315	20.0		7	275	11	185	60
T147	07AUG67	3832N	7449W	015	090	325	16.5	0.0	1	17	11	165	60
T169	25AUG67	3821N	7340W	069	120	355	19.1	0.0	0	0	11	154	60
T163	24AUG67	3830N	7355W	030	050	315	19.3	0.0	1	60	10	153	60
T162	24AUG67	3809N	7422W	025	060	325	9.7	0.0	1	4	11	117	60
T167	24AUG67	3834N	7407W	030	060	325	16.0	0.0	1	95	13	99	60
T154	10AUG67	3812N	7439W	020	070	325	15.9	0.0	0	0	10	84	60
T178	27AUG67	3722N	7430W	051	120	335	15.6	0.0	1	1024	7	83	60
T173	26AUG67	3752N	7440W	024	070	325	19.0	0.0	1	5	14	78	60
T171	26AUG67	3751N	7408W	074	120	355	12.5	0.0	0	0	8	63	60
T175	27AUG67	3725N	7466W	017	090	325	6.4	0.0	2	775	9	60	60
T199	06SEP67	3536N	7521W	017	240	335	19.2		8	270	14	59	60
T255	11AUG67	3709N	7507W	017	070	325	5.9	0.0	1	120	7	55	60
T263	26AUG67	3603N	7355W	063	120	355	7.1	0.0	0	0	8	54	60
T157	11AUG67	3703N	7547W	004	140	325	11.9	0.0	1	1	5	53	60
T185	30AUG67	3653N	7501W	014	080	325	20.1		1	1	9	53	60
T166	25AUG67	3834N	7339W	040	090	335	15.7	0.0	1	1	11	52	60

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TABLE 2 (Cont'd)

T152	10AUG67	3834N	7433W	018	06C	32S	13.1	NO	0	0	9	50	60
T190	30AUG67	3707N	7445W	039	08C	32S	5.6		0	0	7	50	60
T159	24AUG67	3755N	7428W	029	06C	32S	6.7	NO	1	14	12	49	60
T179	27AUG67	3713N	7434W	053	11C	34S	19.2	NO	0	0	4	49	60
T192	31AUG67	3613N	7505W	021	08C	32S	18.1		2	1	8	49	60
T172	26AUG67	3739N	7424W	037	09C	32S	15.9	NO	1	2	9	43	60
T189	31AUG67	3619N	7452W	037	07C	33S	12.1		0	0	5	42	60
T203	07SEP67	3608N	7525W	013	19C	32S	15.0		4	179	6	39	60
T153	10AUG67	3823N	7433W	019	07C	32S	16.2	NO	1	0	9	37	60
T157	10AUG67	3849N	7427W	019	08C	32S	7.9	NO	2	27	9	36	60
T174	26AUG67	3743N	7438W	029	07C	32S	21.2	NO	1	3	10	32	60
T183	30AUG67	3642N	7445W	039	11C	34S	14.7		1	12	5	32	60
T170	26AUG67	3802N	7409W	041	09C	32S	9.9	NO	0	0	7	31	60
T187	31AUG67	3621N	7502W	021	06C	33S	9.8		2	1	5	31	60
T165	25AUG67	3830N	7458W	031	06C	33S	9.9	NO	1	17	9	30	60
T184	30AUG67	3653N	7447W	031	06C	33S	17.3		1	0	7	30	60
T161	24AUG67	3825N	7420W	022	06C	32S	12.9	NO	2	15	9	28	60
T201	07SEP67	3552N	7524W	011	21C	32S	12.7		4	49	8	28	60
T143	09AUG67	3753N	7459W	014	10C	32S	6.0	NO	1	1	5	18	60
T151	10AUG67	3841N	7422W	017	06C	32S	10.5	NO	1	1	7	17	60
T197	06SEP67	3528N	7519W	012	26C	36S	17.4		9	79	9	16	60
T177	27AUG67	3722N	7447W	027	07C	32S	12.6	NO	1	7	8	15	60
T181	30AUG67	3651N	7441W	048	11C	33S	8.9		1	0	5	13	60
T194	06SEP67	3535N	7459W	024	17C	35S	9.0		3	4	6	13	60
T193	06SEP67	3552N	7457W	032	12C	34S	6.1		1	4	4	11	60
T200	07SEP67	3554N	7509W	016	17C	32S	9.8		1	0	4	8	60
T156	11AUG67	3705N	7524W	016	08C	32S	8.3	NO	0	0	5	5	60
T196	06SEP67	3522N	7511W	010	26C	35S	14.7		3	1	5	5	60
T167	25AUG67	3827N	7323W	104	13C	34S	15.5	NO	0	0	4	3	60
									180	5143	686	31391	5040

TABLE 3

SPECIES OCCURRING RARELY IN CHESAPEAKE BIGHT IN SUMMER 1967

AMERICAN JOHN DORY	ZENOPSIS OCELLATA
ARMORED SEAROBIN	PERISTEDION MINIATUM
BARNDOOR SKATE	RAJA LAEVIS
BIGEYE SCAD	SELAR CRUMENOPTHALMUS
BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
BLACK DRUM	POGONIAS CROMIS
BLUEFISH	POMATOMUS SALTATRIX
BLUNTNOSE STINGRAY	DASYATIS SAYI
CHAIN DOGFISH	SCYLIORHINUS RETIFER
CONGER EEL	CONGER OCEANICUS
COWNOSE RAY	RHINOPTERA BONASUS
CUNNER	TAUTOGOLABRUS ADSPERSUS
DUSKY SHARK	CARCHARHINUS OBSCURUS
FAWN CUSK-EEL	LEPOPHIDIUM CERVINUM
GRAY SEATROUT	CYNOSCION REGALIS
GREEN GOBY	MICROGOBIUS THALASSINUS
GULF STREAM FLOUNDER	CITHARICHTHYS ARCTIFRONS
HADDOCK	MELANOGRAMMUS AEGLEFINUS
LONGHORN SCULPIN	MYOXOCEPHALUS OCTODECEMSPINOSUS
NORTHERN KINGFISH	MENTICIRRHUS SAXATILIS
NORTHERN STARGAZER	ASTROSCOPUS GUTTATUS
ORANGE FILEFISH	ALUTERA SCHOEPFI
PIGFISH	ORTHOPRISTIS CHRYSOPTERUS
PLANEHEAD FILEFISH	MONACANTHUS HISPIDUS
ROCK SEA BASS	CENTROPRISTES PHILADELPHICUS
ROUGH SCAD	TRACHURUS LATHAMI
ROUND SCAD	DECAPTERUS PUNCTATUS
SANDBAR SHARK	CARCHARHINUS MILBERTI
SAND SHARK	CARCHARIAS TAURUS
SEA RAVEN	HEMITRIPTERUS AMERICANUS
SMALLMOUTH FLOUNDER	ETROPUS MICROSTOMUS
SMOOTH PUFFER	LAGOCEPHALUS LAEVIGATUS
SOUTHERN KINGFISH	MENTICIRRHUS AMERICANUS
SOUTHERN STINGRAY	DASYATIS AMERICANA
SPANISH MACKEREL	SCOMBEROMORUS MACULATUS
SPINY BUTTERFLY RAY	GYMNURA ALTAVELA
SPINY SEAROBIN	PRIONOTUS ALATUS
SPOT	LEIOSTOMUS XANTHURUS
STRIPED BURRFISH	CHILOMYCTERUS SCHOEPFI
TAUTOG	TAUTOGA ONITIS
WENCHMAN	PRISTIPOMOIDES ANDERSONI
WHITE HAKE	UROPHYCIS TENUIS
WINTER SKATE	RAJA OCELLATA
WITCH FLOUNDER GRAY SOLE	GLYPTOCEPHALUS CYNOGLOSSUS

was 446 pounds per hour. The largest catch was 2600 pounds, 5 catches were between 1000 and 2000 pounds, and 6 were between 500 and 1000 pounds.

STRIPED SEAROBIN

The striped searobin had approximately the same distribution as the northern searobin, but was much less abundant. The average catch in 39 tows was 8 pounds and the largest catch was 140 pounds.

SILVER HAKE

Silver hake (whiting) occurred throughout the sampling area but no significant concentrations were found. The largest catch was 20 pounds. Temperature range was 5 to 21° C (41 to 70°F).

SPOTTED HAKE

Occurring at 60 stations through a depth range of 6 to 73 fathoms, the spotted hake was the most frequently caught species. About 25% of the catches were of 10 pounds or more. The largest catch was 63 pounds. Temperature range was 6 to 21°C (43 to 70° F).

SQUIRREL HAKE

Squirrel hake (red hake) occurred in 27 samples from depths of 15 to 70 fathoms north of 36° N. This species prefers cool water and rarely is caught where the temperature exceeds 12° C (54°F). The largest catch was 38 pounds; seven catches exceeded 10 pounds.

SPINY DOGFISH

Young spiny dogfish occurred in 24 samples from a depth range of 9 to 73 fathoms and a temperature range of 5 to 15° C (41 to 59° F). None were caught south of 37° N. The largest catch was 304 pounds but most were only 1 to 3 pounds. Although adults are abundant in the winter, they do not occur in the sampling area in summer.

SMOOTH DOGFISH

Smooth dogfish were caught at 8 stations north from 36° 40' and between 9 and 20 fathoms. The largest catch was 180 pounds. Temperature range was 11 to 21° C (52 to 70°F).

ATLANTIC ANGEL SHARK

The angel shark was caught in 18 samples. Adults were north of 36° N, but young were caught at the southern edge of our sampling area. Depth range was 8 to 41 fathoms and temperature range was 10 to 26° C (50 to 79° F). The largest catch was 90 pounds.

CLEARNOSE SKATE

In 38 samples from depths of 6 to 41 fathoms clearnose skates were caught. Temperature range was 8 to 26° C (46 - 79° F). The largest quantities were caught between 36° N and 37° 30' N in temperatures of 19 to 21° C (66 - 70° F) and depths of 9 to 11 fathoms. The largest catch was 400 pounds. At 5 stations the catch was between 100 and 400 pounds. The average catch of this species in the 38 samples containing it was 70 pounds.

LITTLE SKATE

The little skate was represented in 36 samples from a depth range of 9 to 41 fathoms and a temperature range of 5 to 19° C (41 - 66° F). The largest catch was 69 pounds; the average catch was 11 pounds.

ROSETTE SKATE

The rosette skate inhabits deeper and cooler water than the preceding two species. It was caught in 17 tows from depths of 18 to 73 fathoms and temperatures of 6 to 17° C (43 - 63° F). The largest catch was 69 pounds and the average catch was 10 pounds.

BULLNOSE RAY

An average of 100 pounds of bullnose rays was caught at 8 stations. Depth range was 8 to 19 fathoms and the temperature range was 12 to 20° C (54 - 68° F). The largest catch was 300 pounds. This species was not caught south of 36° 30'.

ROUGHTAIL STINGRAY

Although only 56 roughtail stingrays were caught at 14 stations, their large size made the catch significant. The average catch was 255 pounds and the largest catch was 1000 pounds. Depth range was 9 to 41 fathoms; temperature range 6 to 21° C (43 - 70° F).

GOOSEFISH

In winter goosefish comprised a significant portion of the catch, but in summer only young were caught. The largest catch of the 37 containing this species was 33 pounds. Depth range was 15 to 73 fathoms and temperature range 5 to 14° C (41 - 57° F). Goosefish were caught only north of 36° N latitude.

WINTER FLOUNDER

Winter flounder (blackback) occurred in depths of 12 to 37 fathoms as far south as 36° 20'. However, all catches of 10 pounds or more were in depths greater than 20 fathoms and north of 37° 50' where temperatures were 5 to 6° C (41 - 43° F). The largest catch was 95 pounds.

FOURSPOT FLOUNDER

Although it occurred in about half of the samples, the fourspot was never abundant. The largest catch was 22 pounds. Depth range was 12 to 73 fathoms, and temperature range was 5 to 14° C (41 - 57° F).

YELLOWTAIL FLOUNDER

The distribution of the yellowtail was similar to that of the winter flounder. Yellowtails were taken at 12 stations north of 37° 20' in depths of 17 to 34 fathoms. Temperature range was 5 to 7° C (41 - 45° F). The largest catch was 36 pounds.

WINDOWPANE FLOUNDER

The windowpane flounder (daylight) was caught at nearly every station shoaler than 30 fathoms, but it was never caught in quantity. The largest catch was 42 pounds and 6 catches were of 10 pounds or more.

OCEAN POUT

The ocean pout was scarce and occurred only north from 37° 55'. The depth range was 15 to 40 fathoms and the temperature range was 5 to 14° C (41 - 57° F). The largest catch was 4 pounds.

NORTHERN PUFFER

The northern puffer (swellfish) was caught at 21 stations through a depth range of 6 to 41 fathoms and a temperature range of 12 to 26° C (54 - 79° F). The largest catch was 129 lbs.

BLACK SEABASS

Although black seabass were caught at 34 stations they were not abundant. The largest catch was 17 pounds. Only one was caught in water deeper than 25 fathoms. Temperature range was 8 to 26° C (46 - 79° F) and latitudinal range was throughout the sampling area.

SCUP

Small scup were caught at 23 stations, all but 2 shoaler than 20 fathoms, but adults were scarce. Temperature range was 12 to 26° C (54 - 79° F).

BUTTERFISH

North from 37° N in water shoaler than 20 fathoms young butterfish were numerous. With the exception of two catches (1024 pounds and 775 pounds) adults were scarce. Depth range of the 46 catches containing butterfish was 6 to 73 fathoms. Temperature range was 6 to 26° C (43 - 79° F).

SUMMER FLOUNDER

Summer flounder (fluke) were caught at 32 stations out to the 20 fathom curve. Although a few were caught in the southernmost portion of the area, all catches of 10 pounds or more were north of 36° 30'. The largest catch was 45 pounds per hour. Temperature range was 8 to 26° C (46-79° F).

ATLANTIC CROAKER

Croaker occurred only in relatively warm water (17-24° C, 63 - 75° F) of 15 fathoms or less. The largest catch was 47 pounds. Half of the 12 catches containing croaker were of 10 pounds or more.

PRELIMINARY CRUISE SUMMARY
AVAILABILITY AND DISTRIBUTION OF BENTHIC FISHES OF CHESAPEAKE BIGHT
FALL 1967

By

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APRIL 4, 1968

AN INTERIM REPORT OF PROGRESS
OF PROJECT 3-5-D UNDER
PL 88-309

The fall cruise of 1967 extended from mid-November to mid-December. The average catch rate of trash fish at 65 stations was 1930 pounds per hour. The most productive area was from 20 or 25 fathoms out to the 100 fathom curve (Table 1). Figure 1 indicates the catch at each station. Gear and sampling procedure also were the same as in previous cruises,as was the area covered.

Table 2 lists the stations in order of decreasing catch of trash fish and also gives the temperature and salinity of the bottom water and the position and depth of each station.

A summary of the distribution of each species of potential commercial importance is presented below. Species of insignificant commercial potential in fall are listed in Table 3 and are not discussed in this report.

NORTHERN SEAROBIN

The second most abundant fish during fall was the northern searobin. The average catch in 39 tows was about 330 pounds. The greatest concentration was north of 36° 30' between the depths of 20 and 55 fathoms. The largest catch was 3762 pounds. Three catches were between 1000 and 2000 pounds and 4 were between 500 and 1000 pounds. Temperature range was 9 to 19°C (48° - 66° F).

STRIPED SEAROBIN

The striped searobin occurred in nearly as many samples as did the northern searobin, but was not as abundant. The largest catch was 118 pounds. All others were 30 pounds or less. Depth range was 6 to 53 fathoms and temperature range 9 to 19° C (48° - 66° F).

Table 1. Average catch (in pounds) of trash fish per hour of tow in each latitude and depth range - fall 1967.

Depth	35°	36°	37°	38°
0-9	-	798	746	724
10-19	1,158	960	576	2,601
20-29	4,298	-	2,284	1,997
30-39	11,075	-	1,558	2,771
40-49	-	1,731	540	2,721
50-59	-	731	664	-
60-69	-	-	-	1,140
70-79	-	-	1,984	-
80-89	14,910	374	-	-
90-99	-	365	-	1,997
100-109	-	-	812	877

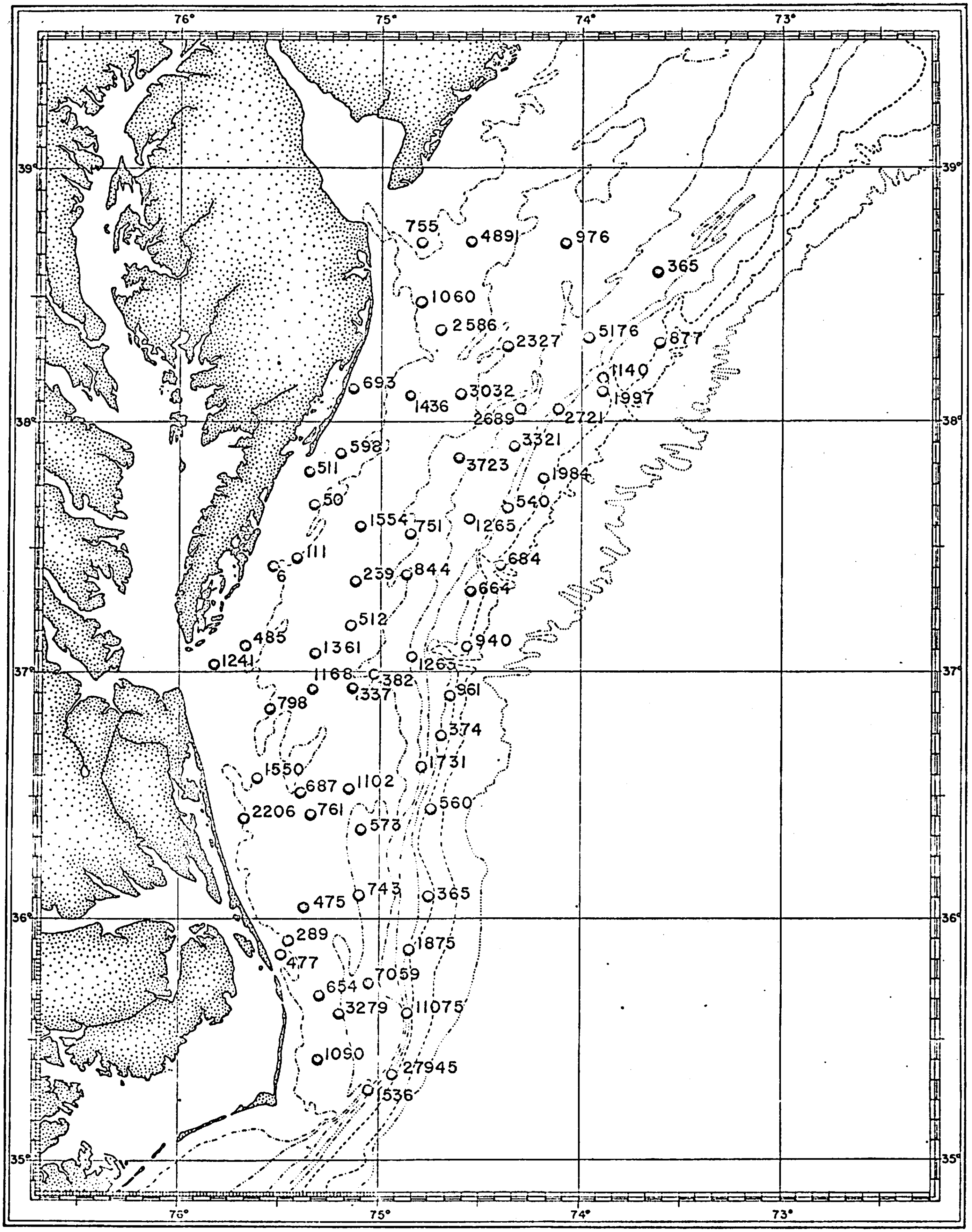

Fig. 1. Catch of trash fish per hour of trawling, fall 1967.

TABLE 2

STATION LIST, FALL 1967

Station No.	Date	Latitude	Longitude	Depth (fathoms)	Temp. at bottom C	Salinity at bottom	Time of Day	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)
T243	06DEC67	3522N	7455W	085	C	S	9.1	1	981.	4	27945.	60
T244	06DEC67	3538N	7453W	038	12C	33S	11.7	2	18.	7	11075.	60
T245	06DEC67	3545N	7502W	026	13C	34S	14.3	4	57.	10	7059.	60
T277	17DEC67	3820N	7359W	036	09C	34S	19.7	5	135.	10	5176.	60
T224	16NOV67	3843N	7434W	014	11C	32S	22.8	4	83.	17	4891.	60
T284	18DEC67	3752N	7437W	024	09C	33S	19.5	5	32.	10	3723.	60
T283	18DEC67	3755N	7421W	032	10C	34S	16.3	4	155.	8	3321.	60
T240	05DEC67	3537N	7511W	018	12C	32S	14.7	3	305.	8	3279.	60
T275	16DEC67	3808N	7436W	019	09C	33S	18.2	1	16.	18	3032.	60
T231	18DEC67	3804N	7407W	041	12C	34S	11.8	4	1092.	7	2721.	60
T282	18DEC67	3804N	7419W	026	09C	33S	14.1	3	67.	12	2689.	60
T228	20NOV67	3821N	7444W	014	12C	32S	12.5	4	394.	12	2586.	60
T276	17DEC67	3818N	7423W	023	09C	33S	16.5	2	47.	16	2327.	60
T253	07DEC67	3626N	7541W	010	10C	33S	18.5	4	3.	9	2206.	60
T280	18DEC67	3808N	7353W	092	11C	35S	8.7	2	4.	12	1997.	60
T270	14DEC67	3747N	7412W	078	12C	35S	22.1	2	58.	9	1984.	60
T246	06DEC67	3552N	7452W	098	16C	36S	16.8	3	25.	13	1875.	60
T234	02DEC67	3637N	7446W	041	16C	36S	18.5	4	117.	9	1731.	60
T256	08DEC67	3735N	7507W	016	10C	33S	7.0	3	5.	14	1554.	60
T254	07DEC67	3635N	7537W	010	11C	33S	21.0	3	5.	11	1550.	60
T242	05DEC67	3517N	7503W	027	19C	35S	20.3	5	40.	18	1536.	60
T274	16DEC67	3806N	7451W	015	09C	32S	15.6	1	10.	13	1436.	60
T261	08DEC67	3705N	7519W	014	11C	33S	19.2	3	13.	8	1361.	60
T268	14DEC67	3737N	7433W	034	11C	34S	17.1	5	121.	17	1265.	60
T264	14DEC67	3704N	7452W	031	10C	33S	5.6	4	111.	17	1263.	60
T262	13DEC67	3702N	7550W	006	10C	32S	18.6	2	4.	13	1241.	60
T229	02DEC67	3656N	7523W	014	10C	33S	6.2	4	54.	9	1168.	60

TABLE 2 (Cont'd)

T279	18DEC67	3810N	7353W	064	12C	34S	7.0	4	120.	10	1140.	60
T250	07DEC67	3632N	7510W	018	12C	34S	11.6	5	89.	12	1102.	60
T241	05DEC67	3525N	7518W	013	12C	32S	17.3	4	26.	13	1090.	60
T227	20NOV67	3829N	7447W	012	10C	32S	10.3	3	153.	12	1060.	60
T225	17NOV67	3843N	7405W	026	11C	33S	7.8	4	136.	12	976.	60
T232	02DEC67	3655N	7440W	051	14C	35S	13.9	3	35.	10	961.	60
T265	14DEC67	3706N	7435W	106	12C	36S	8.5	0	0.	15	940.	60
T278	17DEC67	3819N	7336W	105	11C	35S	23.1	0	0.	12	877.	60
T258	08DEC67	3724N	7454W	023	10C	33S	11.8	4	86.	13	844.	60
T255	08DEC67	3652N	7534W	009	11C	33S	0.5	4	5.	9	798.	60
T251	07DEC67	3627N	7520W	014	12C	34S	13.8	3	119.	9	761.	60
T223	16NOV67	3843N	7449W	008	11C	32S	20.4	2	56.	10	755.	60
T257	08DEC67	3733N	7453W	017	10C	33S	9.7	3	108.	9	751.	60
T248	07DEC67	3605N	7506W	019	13C	34S	6.2	4	95.	7	743.	60
T273	16DEC67	3808N	7508W	006	07C	30S	13.0	3	5.	14	693.	60
T252	07DEC67	3631N	7524W	012	12C	34S	15.5	3	39.	5	687.	60
T267	14DEC67	3726N	7425W	107	12C	35S	14.2	3	3.	18	684.	60
T266	14DEC67	3720N	7433W	053	12C	34S	11.7	4	404.	15	664.	60
T239	05DEC67	3541N	7518W	012	11C	32S	12.6	3	14.	7	654.	60
T272	16DEC67	3753N	7512W	010	08C	32S	9.9	2	5.	14	598.	60
T249	07DEC67	3621N	7506W	019	13C	34S	9.4	3	97.	8	573.	60
T235	02DEC67	3628N	7445W	055	15C	36S	21.1	3	170.	10	560.	60
T269	14DEC67	3740N	7422W	045	12C	34S	19.4	4	215.	12	540.	60
T260	08DEC67	3711N	7510W	015	11C	33S	16.7	4	40.	14	512.	60
T271	16DEC67	3748N	7521W	006	08C	32S	7.2	1	5.	16	511.	60
T263	13DEC67	3707N	7541W	008	10C	32S	20.8	3	9.	16	485.	60
T238	05DEC67	3551N	7530W	010	11C	31S	9.9	2	20.	11	477.	60
T236	05DEC67	3604N	7523W	011	11C	32S	6.3	3	21.	6	475.	60
T231	02DEC67	3700N	7502W	030	12C	34S	11.6	4	482.	10	382.	60
T233	02DEC67	3645N	7441W	083	13C	36S	16.2	0	0.	11	374.	60
T247	06DEC67	3605N	7445W	093	14C	36S	20.3	0	0.	9	365.	60
T226	17NOV67	3836N	7337W	036	10C	34S	11.8	4	7.	9	365.	60
T230	02DEC67	3656N	7509W	019	11C	34S	8.9	4	145.	9	337.	60
T237	05DEC67	3555N	7529W	011	11C	32S	8.3	3	4.	5	289.	32
T259	08DEC67	3721N	7509W	012	11C	33S	14.4	2	4.	10	239.	60
T221	14NOV67	3728N	7525W	014	13C	32S	17.2	3	74.	12	111.	60
T222	14NOV67	3741N	7520W	010	13C	32S	20.0	3	68.	10	50.	60
T220	14NOV67	3725N	7534W	010	14C	32S	14.9	4	298.	7	6.	60
								198.	7159.	722.	125420.	3872.

PHASE 9

Table 3. Species occurring rarely in Chesapeake Bight in fall 1967.

256	ALOSA SP.
026ALEWIFE	ALOSA PSEUDOHARENGUS
060AMERICAN EEL	ANGUILLA ROSTRATA
244AMERICAN JOHN DORY	ZENOPSIS OCELLATA
030AMERICAN SHAD	ALOSA SAPIDISSIMA
221ARMORED SEAROBIN	PERISTEDION MINIATUM
168ATLANTIC ANGEL SHARK	SQUATINA DUMERILI
043ATLANTIC MACKEREL	SCOMBER SCOMBRUS
037ATLANTIC MENHADEN	BREVOORTIA TYRANNUS
008ATLANTIC COD	GADUS MORHUA
187BARNDOOR SKATE	RAJA LAEVIS
264BEARDFISH	POLYMIXIA NOBILIS
078BIGHEAD SEAROBIN	PRIONOTUS TRIBULUS
220BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
152BLACKCHEEK TONGUEFISH	SYMPHURUS PLAGIUSA
034BLACK DRUM	POGONIAS CROMIS
027BLUEBACK HERRING GLUT	ALOSA AESTIVALIS
009BLUEFISH	POMATOMUS SALTATRIX
186BULLNOSE RAY	MYLIOBATIS FREMINVILLEI
190CONGER EEL	CONGER OCEANICUS
262DEEPSEA HAKE	MERLUCCIUS ALBIDUS
263GULF SEAROBIN	PRIONOTUS PARALATUS
247GULF STREAM FLOUNDER	CITHARICHTHYS ARCTIFRONS
151HOGCHOKER	TRINECTES MACULATUS
222LONGHORN SCULPIN	MYOXOCEPHALUS OCTODECEMSPINOSUS
056NORTHERN KINGFISH	MENTICIRRHUS SAXATILIS
050NORTHERN PUFFER SWELLFISH	SPHAEROIDES MACULATUS
225NORTHERN STARGAZER	ASTROSCOPUS GUTTATUS
059PIGFISH	ORTHOPRISTIS CHRYSOPTERUS
240PLANEHEAD FILEFISH	STEPHANOLEPIS HISPIDUS
201PRIACANTHID	COOKEOLUS BOOPS
210ROUGH SCAD	TRACHURUS LATHAMI
175ROUGHTAIL STINGRAY	DASYATIS CENTROURA
162SANDBAR SHARK	CARCHARHINUS MILBERTI
029SEA HERRING	CLUPEA HARENGUS
248SEA RAVEN	HEMITRIPTERUS AMERICANUS
257SHORT NOSE STURGEON	ACIPENSER BREVIROSTRUM
213SILVER PERCH	BAIRDIELLA CHRYSURA
236SMALLMOUTH FLOUNDER	ETROPUS MICROSTOMUS
079SMOOTH PUFFER	LAGOCEPHALUS LAEVIGATUS
057SOUTHERN KINGFISH	MENTICIRRHUS AMERICANUS
179SPINY BUTTERFLY RAY	GYMNURA ALTAVELA
058SPOTTED SEATROUT	CYNOSCION NEBULOSUS
215STAR DRUM	STELLIFER LANCEOLATUS
031STRIPED BASS	ROCCUS SAXATILIS
025STURGEON	ACIPENSER SP.
055TAUTOG	TAUTOGA ONITIS
258WENCHMAN	PRISTIPOMOIDES ANDERSONI
024WITCH FLOUNDER GRAY SOLE	GLYPTOCEPHALUS CYNOGLOSSUS

SILVER HAKE

Silver hake (whiting) were generally distributed throughout the sampling area without apparent relationship to depth, temperature, or latitude. This species was caught at 48 stations through a temperature range of 7 to 19° C (45° - 66° F). The largest catch was 176 pounds per hour.

SPOTTED HAKE

Occurring at 56 stations, the spotted hake was the most frequently caught species but not the most abundant. The largest catch was 819 pounds, but all others were less than 100 pounds. Hake were caught at all depths but were more abundant in deeper waters than near shore. Temperature range was 7 to 19° C (45° - 66° F).

SQUIRREL HAKE

The squirrel hake was caught at 27 stations in depths of from 6 to 107 fathoms, but was more abundant in deep water. The five catches exceeding 100 pounds were in water deeper than 60 fathoms. The largest catch was 703 pounds. Temperature range was 7 to 14° C (45° - 57° F). This species was scarce south of 36° N.

WHITE HAKE

The white hake is a northern species that occurs in the sampling area in small numbers. It was present in 13 samples north of 37° N and spanning the entire depth range. Temperature range was 9 to 12° C (48° - 54° F). The largest catch was 40 pounds.

SPINY DOGFISH

Spiny dogfish, which spend the summer north of Chesapeake Bight, return in considerable numbers by fall. The average catch at the 49 stations where adults occurred was 1228 pounds. Adults were not caught in water deeper than 55 fathoms, but young occurred only outside of that depth. Temperature range was 7 to 14° C (45° - 57° F). The largest catch was 11,000 pounds. About 30% of the catches were in the range of 1000 to 7000 pounds.

SMOOTH DOGFISH

The smooth dogfish was caught at 23 stations and was most abundant in water deeper than 25 fathoms south of 37°. The largest catch was 637 pounds. Three additional catches exceeded 100 pounds.

CHAIN DOGFISH

A species of minor significance, the chain dogfish occurs in deep water and is not abundant. All except one of our 10 captures of this species were outside of the 50 fathom curve. The largest catch was 14 pounds. Temperature range was 10 to 16° C (50° - 61° F).

CLEARNOSE SKATE

Although the clearnose skate was caught throughout the area to a depth of 88 fathoms, it was more abundant inside of the 50 fathom curve and south of 37° 30'. The largest catch was 302 pounds. Four of 36 catches contained between 100 and 200 pounds and 6 catches contained between 50 and 100 pounds. Temperature range was 9 to 19° C (48° - 66° F).

LITTLE SKATE

The little skate was taken at 34 stations ranging in depth from 8 to 41 fathoms. The largest catch was 340 pounds. All of the 7 catches exceeding 100 pounds were from the depth range of 14 to 36 fathoms and north of 37° N. The temperature range was 8 to 16° C (46° - 61° F).

ROSETTE SKATE

The rosette skate occurred in 12 samples from water of 30 fathoms or deeper. The largest catch was 40 pounds. Temperature range was 11 to 16° C (52° - 61° F).

WINTER SKATE

The winter skate was caught at 13 stations north of 36° 30' and shoaler than 35 fathoms. The largest catch was 54 pounds. Temperature range was 7 to 12° C (45° - 54° F).

WINTER FLOUNDER

The winter flounder (blackback) was caught at 16 stations inside the 25 fathom curve and north of 37° N. Temperature range was 7 to 14° C (45° - 57° F). The largest catch was 94 pounds. Three other catches exceeded 50 pounds.

FOURSPOT FLOUNDER

Although the fourspot flounder was caught in water as shallow as 10 fathoms, its greatest concentration was at depths of more than 30 fathoms. The largest catch was 240 pounds. Three of 34 catches were between 100 and 200 pounds. Temperature range was 8 to 19° C (46° - 66° F).

YELLOWTAIL FLOUNDER

A fish of northern affinities, the yellowtail was caught only north of 37° N and was most abundant north of 38° Temperature range was 8 to 12° C (46° - 54° F) and depth range 6 to 30 fathoms. The largest catch was 400 pounds.

WINDOWPANE FLOUNDER

The windowpane flounder (daylight) occurred at most stations of 25 fathoms or less. The largest catch was 160 pounds. Eight of

36 catches were of 50 pounds or more. Temperature range was 7 to 14° C (45° - 57° F).

OCEAN POUT

The ocean pout was caught at 8 stations across the northern edge of the sampling area (north of 37° 40'). The largest catch was 18 pounds. Temperature range was 9 to 12° C (48° - 54° F).

GOOSEFISH

The goosefish was caught at 38 stations. Adults were distributed between the depths of 6 and 55 fathoms and were more abundant north of 37° than in the southern portion of Chesapeake Bight. Young occurred only outside of the 30 fathom curve and north of 37°. The largest catch was 646 pounds. Six catches were between 100 and 500 pounds. Temperature range was 7 to 14° C (45° - 57° F).

BLACK SEABASS

Black seabass occurred in 32 samples throughout the area. Temperature range was 9 to 19° C (48° - 66° F). The largest catch was 217 pounds. All others were less than 50 pounds. Young were caught at only 9 stations.

SCUP

Scup were caught at 36 stations throughout the range of depths and latitudes sampled but were most abundant north of 38° N latitude Temperature range was 9 to 19° C (48° - 66° F). Young and adults were caught in equal numbers. The largest catch was 235 pounds.

BUTTERFISH

Occurring in [illegible] samples, the butterfish was the most generally distributed of the food fishes. Depth range was 6 to 107 fathoms and temperature range was 7 to 19° C (45° - 66° F). The largest catch was 980 pounds. Eight additional catches exceeded 100 pounds. Distribution was not apparently correlated with temperature, depth, or latitude.

SUMMER FLOUNDER

The summer flounder (fluke) was widely distributed, occurring in 51 samples at all depths and latitudes sampled. It was more abundant north of 37° and in water deeper than 15 fathoms. The largest catch was 117 pounds, 7 samples contained between 50 and 100 pounds, and 10 contained 25 to 50 pounds. Temperature range was 9 to 19° C (48° - 66° F).

GRAY SEATROUT

The gray seatrout (weakfish) was caught at 15 stations shoaler than 40 fathoms. Temperature range was 10 to 19° C (50° - 66° F). The largest catch was 24 pounds. All other catches were less than 10 pounds.

PRELIMINARY CRUISE SUMMARY
AVAILABILITY AND DISTRIBUTION OF BENTHIC FISHES OF CHESAPEAKE BIGHT
WINTER 1968

By.

JACKSON DAVIS

VIRGINIA INSTITUTE OF MARINE SCIENCE

GLOUCESTER POINT, VA.

APRIL 23, 1968

AN INTERIM REPORT OF PROGRESS
ON PROJECT 3-5-D UNDER
PL 88-309

The winter cruise of 1968 consisted of 76 stations and extended from mid January through the end of February. The average catch rate of trash fish was 2300 pounds per hour, not appreciably different from the rate of 2600 pounds per hour in winter 1967. In the southern half of Chesapeake Bight fish were distributed across the shelf from 10 fathoms to 110 fathoms (Table 1). In the northern half the most productive depth range was 20 to 60 fathoms. Figure 1 indicates the catch at each station. Sampling gear was an Atlantic Western trawl with 78-foot footrope and 54-foot headrope and 8 inch stretch mesh, the same type of net as was used during 1967. Sampling procedure was also the same as in 1967.

Table 2 lists the stations.in order of decreasing catch of trash fish and also gives the temperature and salinity of the bottom water and the position and depth of each station. Temperature range of bottom waters was 2 to 11° C with the exception of one southern station where the temperature was 18°. All catches greater than 2000 pounds were at temperatures of 6° or higher.

The charter of the trawler SEA BREEZE was terminated at the end of February because no further cruises are planned during the fiscal year ending June 30, 1968.

A summary of the distribution of each species of potential commercial importance is presented below. Species of insignificant commercial potential in winter are listed in Table 3 and are not discussed in this report.

Noteworthy was the occurrence of small menhaden in water shoaler than 25 fathoms throughout Chesapeake Bight. Two groups were represented, one of fish about 9 cm (3.5 inches) long and one of fish

Table 1. Average catch (in pounds) of trash fish per hour of tow in each latitude and depth range - winter 1968.

Depth	35°	36°	37°	38°
0-9	713	91	116	159
10-19	4,147	2,181	193	518
20-29	2,057	15,627	2,098	2,349
30-39	312	771	5,309	6,228
40-49	816	1,104	2,048	2,477
50-59	4,182	6,377	146	196
60-69	-	-	936	-
70-79	-	3,256	323	-
80-89	-	-	-	-
90-99	-	-	-	701
100-109	5,268	6,498	828	801
110-119	-	-	-	-
120-129	-	-	-	-
130-139	-	-	-	-
140-149	-	-	-	-
150-159	-	-	2,098	-

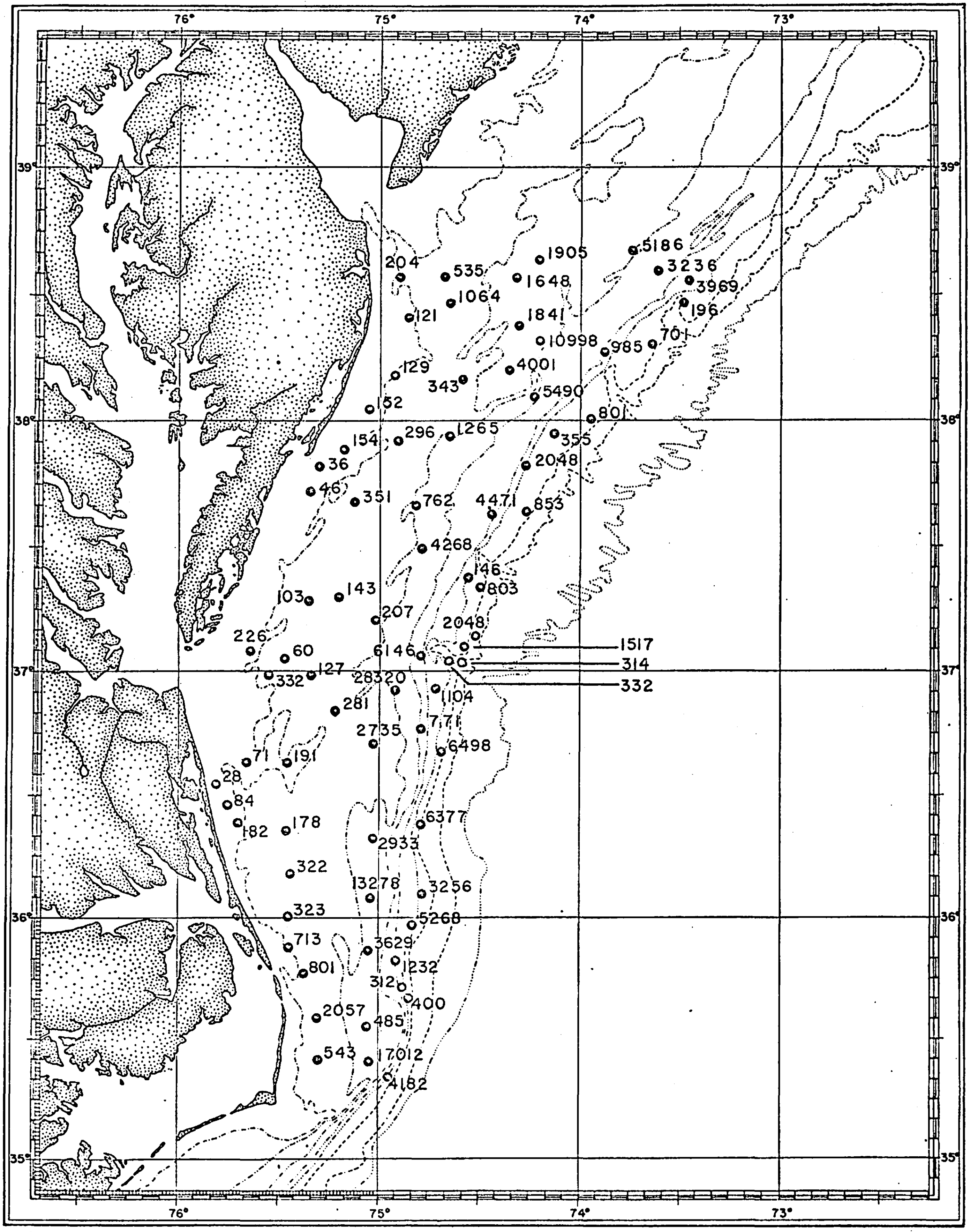

Fig. 1. Catch of trash fish per hour of trawling, winter 1968.

TABLE 2

STATION LIST, WINTER 1968

Station No.	Date	Latitude	Longitude	Depth (fathoms)	Temp. at bottom C	Salinity at bottom	Time of Day	No. species food fish	Pounds food fish per hour of tow	No. species trash fish	Pounds trash fish per hour of tow	Duration of tow (minutes)
T061	19FEB68	3655N	7455W	021	08C	34S	20.5	0	0.	3	28320.	60
T041	02FEB68	3524N	7502W	019	07C	33S	11.4	1	30.	2	17012.	60
T066	27FEB68	3604N	7504W	019	09C	35S	8.6	4	302.	5	13278.	60
T011	19JAN68	3818N	7411W	033	08C	33S	17.1	2	45.	12	10998.	60
T073	28FEB68	3640N	7443W	102	10C	35S	9.7	0	0.	14	6498.	60
T072	28FEB68	3623N	7449W	055	10C	35S	6.2	4	539.	13	6377.	60
T036	28JAN68	3703N	7448W	033	08C	34S	11.9	4	116.	13	6146.	60
T013	20JAN68	3805N	7413W	036	08C	33S	6.1	4	31.	14	5490.	60
T070	27FEB68	3558N	7451W	100	09C	35S	19.7	1	133.	17	5268.	60
T007	19JAN68	3840N	7344W	030	07C	33S	6.3	2	22.	16	5186.	60
T017	20JAN68	3737N	7426W	036	08C	34S	16.5	5	94.	10	4471.	60
T033	27JAN68	3729N	7448W	028	07C	33S	21.0	3	5.	15	4268.	60
T053	04FEB68	3521N	7458W	055	18C	36S	7.9	3	38.	11	4182.	60
T012	19JAN68	3811N	7421W	023	06C	33S	19.9	1	4.	12	4001.	60
T005	18JAN68	3833N	7329W	043	10C	35S	17.5	4	81.	10	3969.	60
T067	27FEB68	3551N	7504W	023	11C	35S	10.9	5	38.	11	3629.	60
T071	27FEB68	3605N	7448W	072	09C	35S	21.9	2	236.	11	3256.	60
T006	18JAN68	3835N	7336W	035	09C	34S	20.1	3	10.	13	3236.	60
T065	27FEB68	3618N	7502W	021	09C	34S	6.0	3	150.	8	2933.	60
T064	22FEB68	3642N	7502W	014	06C	33S	15.7	3	5.	5	2735.	60
T035	28JAN68	3708N	7431W	150	11C	34S	8.7	2	7.	15	2098.	60
T042	02FEB68	3535N	7519W	015	06C	32S	14.9	4	5.	14	2057.	60
T015	20JAN68	3749N	7415W	047	11C	34S	11.0	4	431.	15	2048.	60
T008	19JAN68	3837N	7412W	025	08C	33S	10.4	3	4.	18	1905.	60
T010	19JAN68	3822N	7418W	026	06C	33S	15.1	3	5.	19	1841.	60
T009	19JAN68	3834N	7419W	022	05C	33S	12.6	1	0.	17	1648.	60
T076	28FEB68	3705N	7435W	062	11C	35S	16.6	3	296.	8	1517.	60
T021	23JAN68	3756N	7439W	021	03C	33S	13.2	2	20.	13	1265.	60
T069	27FEB68	3549N	7455W	046	11C	35S	15.6	4	260.	10	1232.	60

TABLE 2 (Cont'd)

T[illegible]2	20FEB68	3655N	7444W	042	10C	35S	8.6	3	249.	10	1104.	[illegible]
T023	23JAN68	3827N	7439W	018	06C	32S	20.9	0	0.	15	1064.	60
T002	18JAN68	3816N	7352W	044	10C	35S	10.0	4	381.	11	985.	60
T016	20JAN68	3738N	7416W	102	11C	35S	13.6	0	0.	15	853.	60
T018	20JAN68	3720N	7430W	100	10C	35S	19.4	0	0.	16	803.	60
T043	02FEB68	3546N	7524W	010	04C	32S	17.4	1	1.	11	801.	60
T001	18JAN68	3800N	7356W	100	09C	35S	6.4	0	0.	15	801.	60
T063	20FEB68	3645N	7447W	033	11C	35S	12.2	3	95.	11	771.	60
T032	27JAN68	3739N	7450W	023	05C	33S	18.8	2	2.	20	762.	60
T044	02FEB68	3552N	7528W	009	05C	32S	19.6	2	13.	8	713.	60
T003	18JAN68	3817N	7338W	098	10C	35S	12.9	0	0.	9	701.	60
T040	02FEB68	3525N	7519W	014	05C	32S	8.2	1	0.	7	543.	60
T024	26JAN68	3834N	7440W	010	04C	32S	16.2	0	0.	12	535.	60
T054	04FEB68	3533N	7503W	023	06C	33S	12.8	2	94.	5	485.	60
T055	04FEB68	3540N	7453W	042	07C	33S	16.9	0	0.	1	400.	60
T014	20JAN68	3757N	7406W	066	11C	35S	8.6	3	99.	13	355.	60
T031	27JAN68	3740N	7508W	014	04C	32S	16.0	1	0.	14	351.	60
T022	23JAN68	3809N	7435W	019	06C	33S	15.9	2	22.	15	343.	60
T057	15FEB68	3659N	7534W	011	04C	32S	16.7	0	0.	5	332.	60
T074	28FEB68	3701N	7439W	070	09C	35S	13.4	4	358.	13	332.	60
T045	02FEB68	3560N	7529W	010	06C	32S	21.7	1	0.	10	323.	60
T046	03FEB68	3610N	7528W	014	05C	32S	7.2	1	3.	8	322.	60
T075	28FEB68	3701N	7438W	072	09C	35S	14.3	3	186.	11	314.	60
T069	27FEB68	3542N	7454W	037	11C	35S	13.3	4	544.	9	312.	60
T020	23JAN68	3755N	7454W	013	07C	32S	10.3	0	0.	14	296.	60
T060	19FEB68	3650N	7514W	018	05C	33S	17.6	1	7.	11	281.	60
T056	15FEB68	3703N	7539W	008	03C	32S	14.9	1	0.	6	226.	60
T037	28JAN68	3712N	7501W	018	06C	33S	15.4	3	11.	11	207.	60
T025	26JAN68	3834N	7454W	009	02C	32S	19.1	0	0.	12	204.	60
T004	18JAN68	3827N	7329W	058	10C	35S	15.6	1	3.	8	196.	60
T052	03FEB68	3637N	7528W	010	05C	32S	20.6	0	0.	9	191.	60
T048	03FEB68	3623N	7544W	009	05C	32S	12.3	1	0.	7	182.	60
T047	03FEB68	3620N	7529W	014	05C	32S	9.4	1	3.	6	178.	60
T019	23JAN68	3753N	7510W	009	04C	32S	7.4	1	0.	8	154.	60
T028	27JAN68	3802N	7502W	008	02C	31S	8.1	0	0.	7	152.	60
T034	28JAN68	3722N	7434W	052	07C	35S	5.9	5	112.	13	146.	60
T038	28JAN68	3717N	7512W	013	05C	33S	17.4	1	0.	10	143.	60
T027	27JAN68	3810N	7455W	010	04C	32S	5.7	0	0.	11	129.	60
T059	15FEB68	3659N	7520W	016	05C	32S	20.5	2	4.	9	127.	60
T026	26JAN68	3824N	7451W	008	02C	32S	21.1	0	0.	9	121.	60
T039	28JAN68	3716N	7521W	013	04C	32S	19.5	1	1.	10	103.	60
T049	03FEB68	3627N	7546W	009	05C	31S	14.2	0	0.	7	84.	60
T051	03FEB68	3637N	7540W	008	05C	32S	18.3	0	0.	9	71.	60
T058	15FEB68	3702N	7529W	014	05C	32S	18.6	3	0.	11	60.	60
T030	27JAN68	3743N	7521W	009	03C	31S	13.4	0	0.	9	46.	60
T029	27JAN68	3749N	7517W	007	02C	31S	11.4	0	0.	7	36.	60
T050	03FEB68	3631N	7550W	005	05C	31S	15.8	3	3.	7	28.	60
								141.	5148.	819.	174530.	4560.

Table 3. Species occurring rarely in Chesapeake Bight in winter 1968.

AMERICAN JOHN DORY	ZENOPSIS OCELLATA
AMERICAN SAND LANCE	AMMODYTES AMERICANUS
AMERICAN SHAD	ALOSA SAPIDISSIMA
ARMORED SEAROBIN	PERISTEDION MINIATUM
ATLANTIC ANGEL SHARK	SQUATINA DUMERILI
ATLANTIC CUTLASSFISH	TRICHIURUS LEPTURUS
ATLANTIC GUITARFISH	RHINOBATOS LENTIGINOSUS
ATLANTIC MENHADEN	BREVOORTIA TYRANNUS
ATLANTIC TORPEDO	TORPEDO NOBILIANA
BARNDOOR SKATE	RAJA LAEVIS
BEARDFISH	POLYMIXIA NOBILIS
BLACKBELLY ROSEFISH	HELICOLENUS DACTYLOPTERUS
BLACKCHEEK TONGUEFISH	SYMPHURUS PLAGIUSA
BLUEFISH	POMATOMUS SALTATRIX
BRIAR SHARK	ECHINORHINUS BRUCUS
CONGER EEL	CONGER OCEANICUS
CRIMSON BASS	ANTHIAS ASPERILINGUIS
CUNNER	TAUTOGOLABRUS ADSPERSUS
DEEPSEA HAKE	MERLUCCIUS ALBIDUS
FAWN CUSK-EEL	LEPOPHIDIUM CERVINUM
GRAY SEATROUT	CYNOSCION REGALIS
GULF STREAM FLOUNDER	CITHARICHTHYS ARCTIFRONS
NORTHERN PIPEFISH	SYNGNATHUS FUSCUS
POLLOCK	POLLACHIUS VIRENS
ROUGH SCAD	TRACHURUS LATHAMI
ROUGHTAIL STINGRAY	DASYATIS CENTROURA
SEA RAVEN	HEMITRIPTERUS AMERICANUS
SHORT NOSE STURGEON	ACIPENSER BREVIROSTRUM
SMALLMOUTH FLOUNDER	ETROPUS MICROSTOMUS
SMOOTH DOGFISH	MUSTELUS CANIS
SPINY BUTTERFLY RAY	GYMNURA ALTAVELA
STRIPED BASS	ROCCUS SAXATILIS
TAUTOG	TAUTOGA ONITIS
	MALACOCEPHALUS OCCIDENTALIS
	CERATOSCOPELUS MADERENSIS

about 17 cm (6.7 inches) long. Cod were feeding on the menhaden and many of our specimens were obtained from the stomachs of cod. We collected 263 specimens from 12 stations. Temperatures ranged from 3 to 11° C. Menhaden were not caught in the winter of 1967.

NORTHERN SEAROBIN

At 20 stations the northern searobin occurred. Depth range was 14 to 66 fathoms but catches in excess of 100 pounds were in the range of 20 to 50 fathoms and at temperatures of 8 to 11° C (46 - 52° F) north of 36° 50'. The largest catch was 2800 pounds; one other catch exceeded 1000 pounds, and 4 catches ranged between 100 and 1000 pounds.

STRIPED SEAROBIN

Striped searobin occurring at 15 stations were, as usual, less abundant than the northern robin. Depth range was 19 to 62 fathoms and temperature range 6 to 18° C (43 - 64° F). The largest catch was 1300 pounds; one was 400, and the remainder were insignificant.

SILVER HAKE

Young silver hake occurred in water shoaler than 30 fathoms but adults were caught in appreciable quantities only in water deeper than 30 fathoms, with the greatest concentrations being between 70 and 100 fathoms at temperatures of 9 to 10° C (48 - 50° F). The largest catch was 570 pounds. Five of 45 catches exceeded 100 pounds.

SPOTTED HAKE

The spotted hake occurred throughout the range of depths and latitudes sampled but became more abundant with increasing depth. The largest catch of 200 pounds was at 100 fathoms. One other catch exceeded 100 pounds and 6 were between 50 and 100 pounds. Temperature range of the 37 stations containing spotted hake was 3 to 11° C (37 - 52° F).

RED HAKE

Occurring in 51 samples, the red hake (squirrel hake) was the second most widely distributed fish. It was caught at all depths and latitudes but all catches of 25 pounds or more were in water deeper than 25 fathoms and north of 36° 20' in temperatures of 6 to 11° C (43° - 52°F). The largest catch was 1056 pounds. Five additional catches exceeded 100 pounds.

WHITE HAKE

Although the white hake is a northern species, a few were caught as far south as 35° 20' N. Depth range was 15 to 150 fathoms and the temperature range 6 to 18° C (43 - 64° F). The largest of the 24 catches of this species was 24 pounds.

CHAIN DOGFISH

A deep water species of little importance, the chain dogfish was caught at 10 stations of 55 to 150 fathoms and at temperatures of 8 to 11° C (46 - 52° F). The largest catch was 12 pounds.

SPINY DOGFISH

The most abundant fish was again the spiny dogfish. It was caught at all stations except 6 and comprised 77% by weight of the total catch. Although spiny dogfish occurred throughout the sampling area, they were somewhat more abundant south of 37° than elsewhere. Depth range of greatest concentration was 15 to 40 fathoms, and the temperature range 6 to 11° C (43 - 52° F). The average catch was 1970 pounds. The largest catch was 28,000 pounds. Four catches were between 10,000 and 20,000 pounds and 3 were between 5,000 and 10,000.

CLEARNOSE SKATE

Clearnose skate were caught at 22 stations ranging in depth from 14 to 66 fathoms. The largest catch was 200 pounds. One catch exceeded 150 pounds, and all others were less than 100 pounds. Temperature range was 5 to 18° C (41 - 64° F).

LITTLE SKATE

The little skate was caught in 33 samples in the depth range of 8 to 47 fathoms north of 36° 15' N. The largest catch was 270 pounds. Four catches were between 100 and 250 pounds. The average catch was about 50 pounds. Temperature range was 2 to 11° C (36 - 52° F), but catches exceeding 100 pounds were at 6° or warmer.

WINTER SKATE

The winter skate occurred in 20 samples from the cold shallow water. Depth range was 7 to 36 fathoms, and temperature range was 2 to 8° C (36 - 46° F). The largest catch was 55 pounds. The average was 22.

ROSETTE SKATE

A species of deep water, the rosette skate was caught at 14 stations ranging in depth from 37 to 102 fathoms at temperatures of 8 to 11° C (46 - 52° F). The largest catch was 18 pounds.

GOOSEFISH

Although they were scarce in other seasons, large goosefish occurred throughout the sampling area in winter. The average catch of this species at 54 stations was 90 pounds. The largest catch was 550 pounds. At 9 stations the catch exceeded 100 pounds. Depth range was 8 to 150 fathoms and temperature range 2 to 11° C. (36 - 52° F).

WINTER FLOUNDER

The winter flounder (blackback) occurred at 21 stations north of 36° 30' but the largest catch was only 16 pounds. Depth range was 5 to 26 fathoms and temperature range 2 to 8° C (36 - 46° F).

WINDOWPANE FLOUNDER

Although generally distributed in water shoaler than 35 fathoms, the windowpane (daylight) flounder was nowhere abundant. The largest catch of the 42 containing this species was 124 pounds. Only one other catch exceeded 50 pounds. Temperature range was 2 to 9° C (36 - 48° F).

FOURSPOT FLOUNDER

Although distributed throughout the sampling area in deep water the fourspot has limited potential because it occurs in minor quantity. The average catch was near 30 pounds and the largest was 190 pounds. Depth range was 19 to 102 fathoms. Temperature range was 6 to 18° C (43 - 64° F). The greatest quantities occurred north of 38° N and at depths greater than 40 fathoms.

YELLOWTAIL FLOUNDER

Yellowtail flounder occurred in greater quantity in 1968 than in 1967. The largest catch was 700 pounds and 8 catches ranged between 100 and 600 pounds. Depth range was 8 to 36 fathoms. All catches exceeding 100 pounds were at depths of 18 to 33 fathoms north of 37° 30' N in temperatures of 3 to 8° C (37 - 46° F).

WITCH FLOUNDER

The witch flounder was caught at 20 stations south to 36° N. The largest catch was 117 pounds. Two other catches exceeded 50 pounds. Depth range was 13 to 150 fathoms but the species was rare in water shoaler than 40 fathoms. Temperature range was 5 to 11° C (41 - 52°F).

ALEWIFE

Since it is a pelagic fish, the alewife probably is not adequately sampled by a bottom trawl. Alewife were caught at 33 stations in a depth range of 5 to 26 fathoms. Temperature range was 2 to 9° C (36 - 48° F). Four catches were between 50 and 100 pounds.

BLUEBACK

The blueback, migrates northward somewhat later than the closely related alewife and was caught at only 11 stations, all shoaler than 30 fathoms. The largest catch was 178 pounds. All others contained fewer than 15 fish. Temperature range was 4 to 11° C (39 - 52° F).

ATLANTIC MACKEREL

Another pelagic fish, the mackerel, was caught at 22 stations from throughout the range of depths and latitudes sampled. The fish were mostly small and were in greatest abundance south of 37° N in depths of 15 to 30 fathoms. Temperature range was 3 to 11° C (37 - 52°F). The largest catch was 121 pounds.

ATLANTIC HERRING

Herring were caught at 32 stations throughout the portion of Chesapeake Bight shoaler than 30 fathoms. Temperature range was 2 to 9° C (36 - 48° F). The largest catch was 279 pounds. Probably our trawl samples do not reflect the true distribution of this pelagic species.

OCEAN POUT

A northern species extending south only to 37°, the ocean pout was caught in 23 tows, all but one inshore of the 40 fathom curve. Temperature range was 2 to 10° C (36 - 50° F). The largest catch was 102 pounds.

LONGHORN SCULPIN

North of 37° longhorn sculpin were caught at 23 stations, all shoaler than 30 fathoms. The largest catch was 64 pounds. Temperature range was 2 to 9° C (36 - 48° F).

BLACK SEABASS

Seemingly somewhat more abundant than in 1967, black seabass were caught at 22 stations. The depth range was 14 to 150 fathoms, but the greatest concentrations were in depths of 50 to 70 fathoms. The largest catch was 537 pounds. Nearly 25% of the catches of this species exceeded 100 pounds. Young were rarely taken. Temperature range was 6 to 18° C (43 - 64°F).

SCUP

Scup were scarce, occurring in only 13 samples. Depth range was 19 to 62 fathoms; temperature range was 7 to 18° C (45 - 64° F). The largest catch of adults was 54 pounds. Scup were more abundant in the winter of 1967.

BUTTERFISH

Butterfish were generally distributed outside of the 15 fathom curve but were not caught in quantity. The largest catch was 170 pounds. Temperature range was 3 to 18° C (36 - 64° F).

SUMMER FLOUNDER

Summer flounder (fluke) were caught at 37 stations spanning a depth range of 5 to 150 fathoms and a temperature range of 4 to 11°C (39 - 52° F); however, their greatest abundance was at 30 to 60 fathoms where temperatures were 7 to 11° C (45 - 52° F). The largest catch was 255 pounds.

COD

Inside of the 30 fathom curve and south to 35° 45' N cod were caught in small numbers at 21 stations. The average catch was

3 fish weighing about 10 pounds each. Temperature range was 2 to 9° C (36 - 48° F). The largest catch was 93 pounds. Cod were more abundant and extended further south than in 1967. The economic potential of cod in Chesapeake Bight is small.

PHASE 10

COMPILATION OF RESULTS

Part 1

SEASONAL DISTRIBUTION OF FISHES OF POTENTIAL INDUSTRIAL USE IN CHESAPEAKE BIGHT

By

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PHASE 10

In 1966 we sampled the fish population of Chesapeake Bight in each of the four seasons to ascertain changes in distribution of species that might be used as a source of fish meal or FPC. Information was obtained incidentally on several other species. The program in the first year has been aimed at ascertaining distribution rather than abundance. The second year's work will be devoted to measuring abundance.

Sampling gear was a 45 foot semi-balloon trawl with 1-1/2" stretch mesh and a 1/2" stretch mesh codend liner. The work was conducted from the 94' trawler Sea Breeze chartered from Wilton Trawler Corp.

Station patterns for each of the four sampling periods are illustrated in Figures 1-4. In winter (February-March) we sampled 52 stations, in spring (May) 71 stations, summer (August - September) 98 stations, and fall (November) 75.

Temperature of the bottom water was measured at each station. Thermal pattern of the bottom water in winter is indicated in Fig. 5. The isotherms are approximations of conditions during the month; they are not synoptic. Conditions in summer are indicated in Fig. 6.

Discussed in the following paragraphs are distributions of several species that appear to be of some potential importance as an industrial fishery resource.

In general, summer and winter were seasons of stability of the fish populations, whereas in spring and fall the fish were moving between their summer and winter ranges. Therefore only the stable seasons are illustrated in this report. Distribution in spring and fall was intermediate.

Most species were characterized by either north-south migration or inshore-offshore migrations. Two species appeared to be non-migratory.

PHASE 10

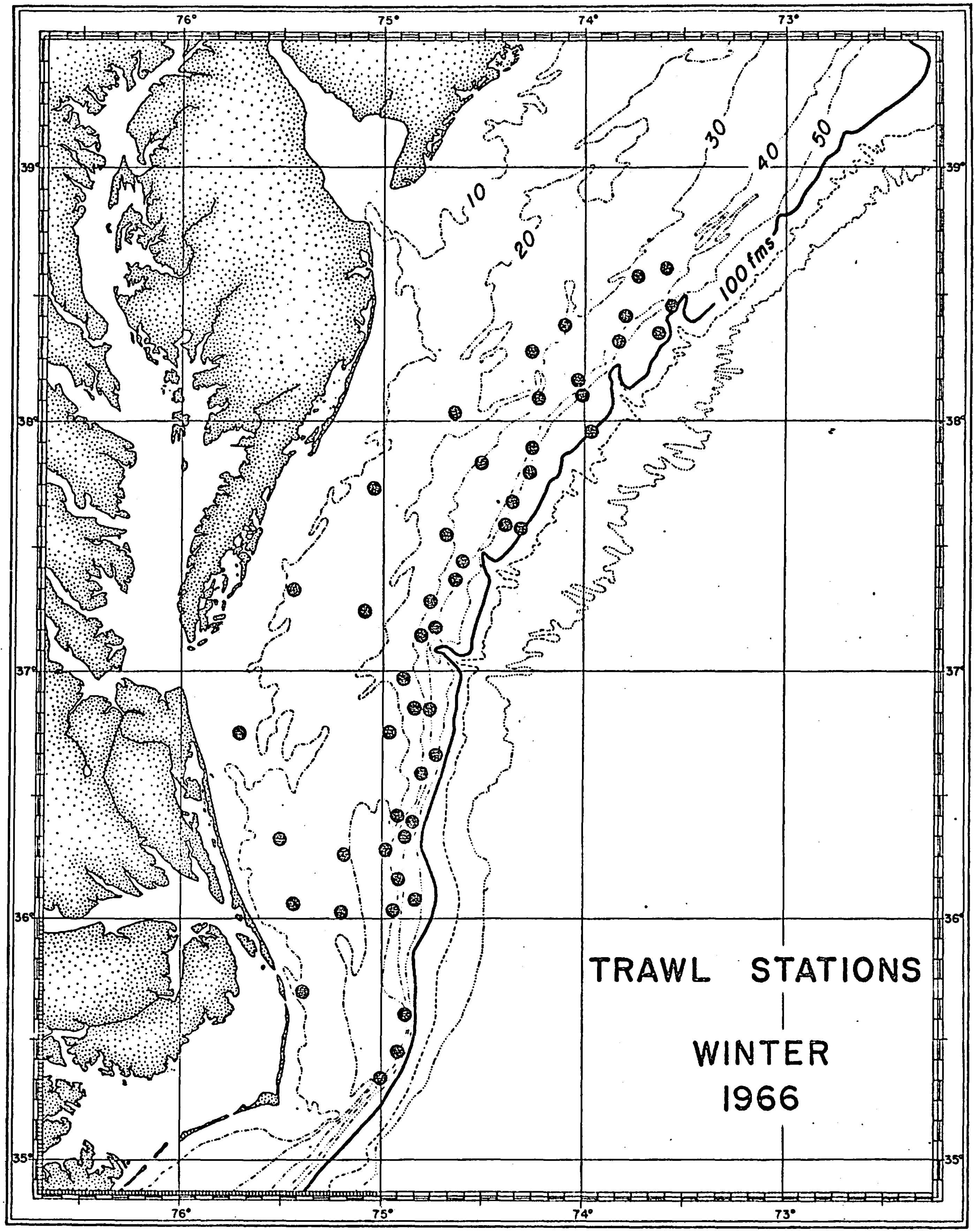


Fig. 1. Sampling pattern in winter 1966.

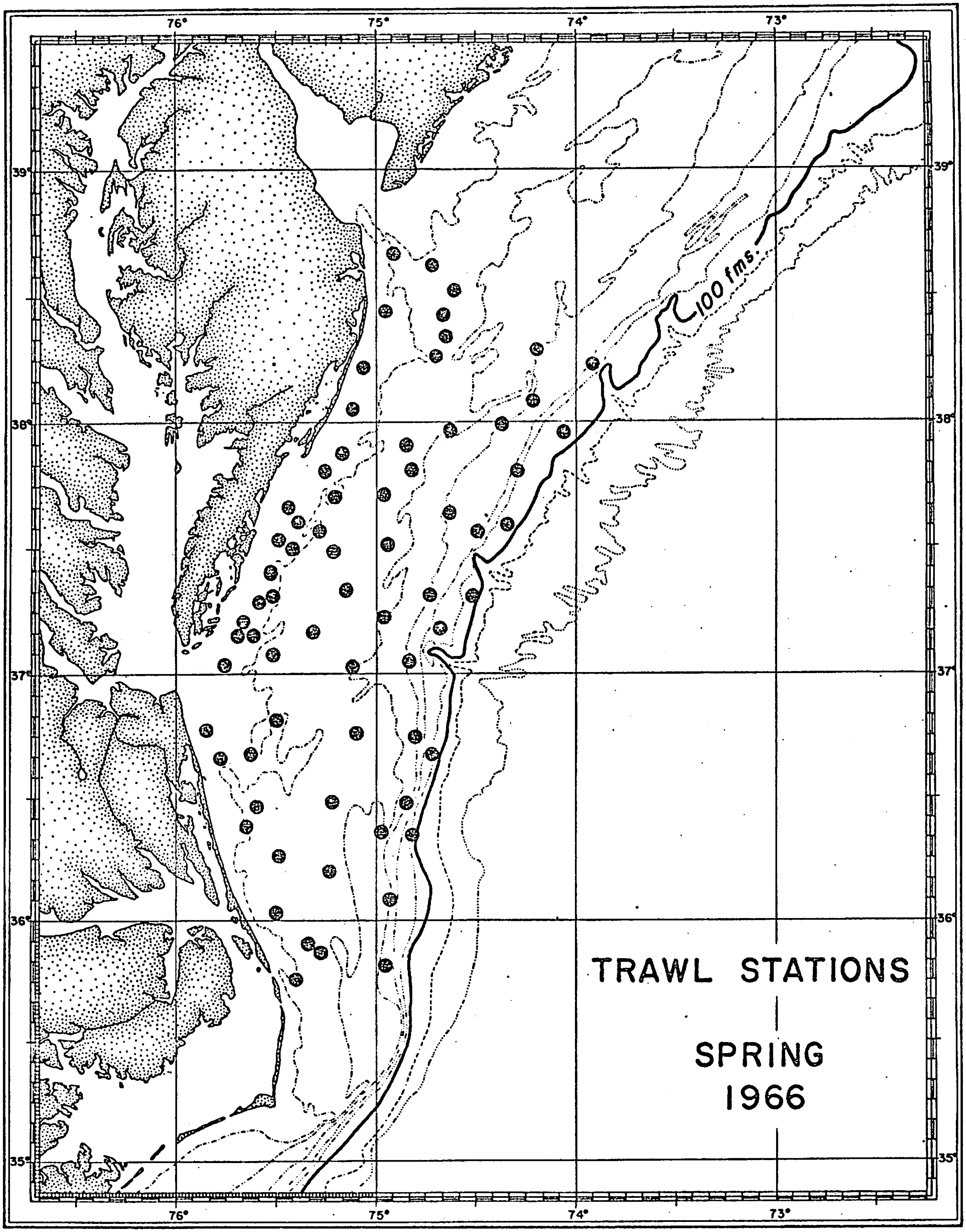


Fig. 2. Sampling pattern in spring 1966.

PHASE 10

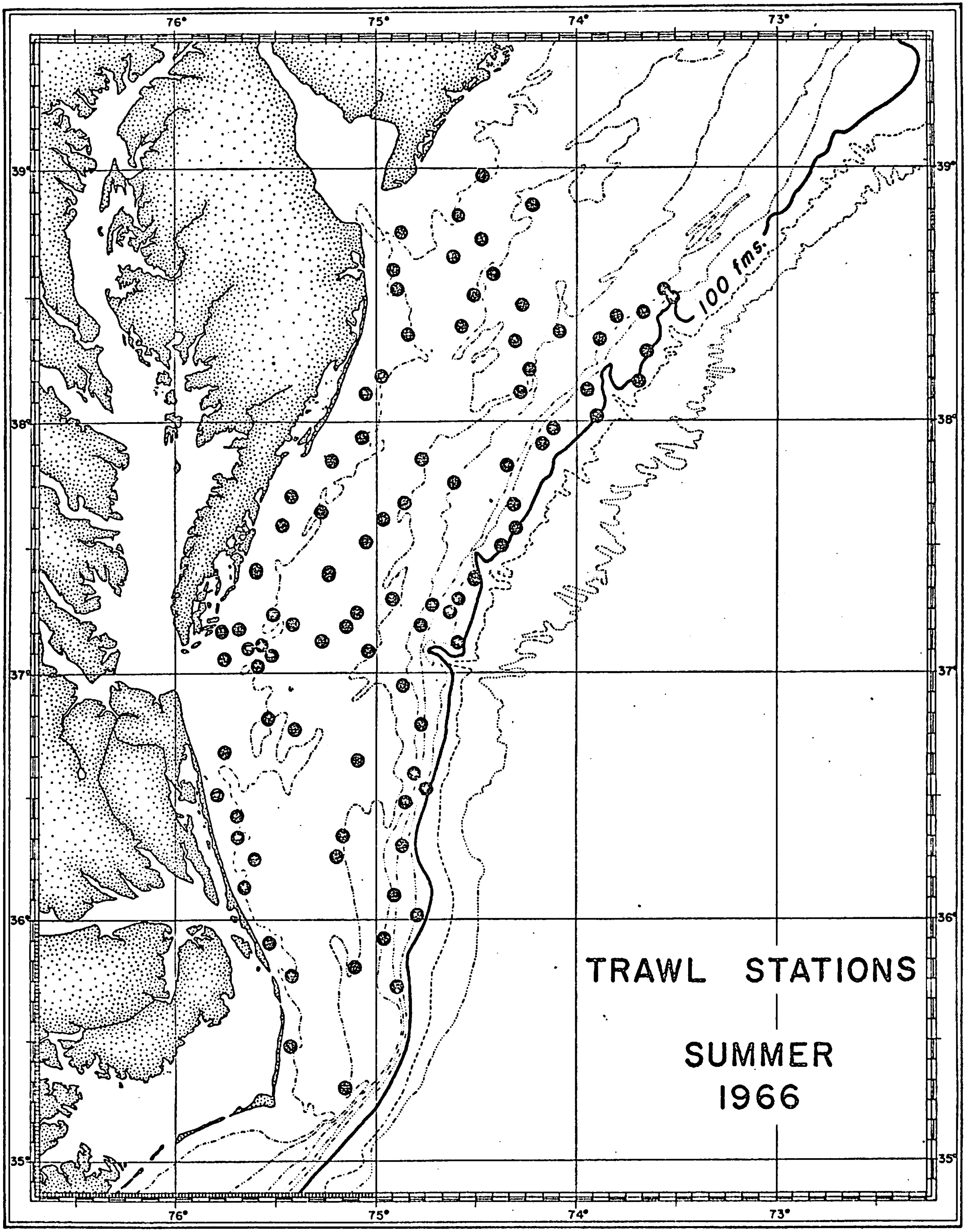


Fig. 3. Sampling pattern in summer 1966.

PHASE 10

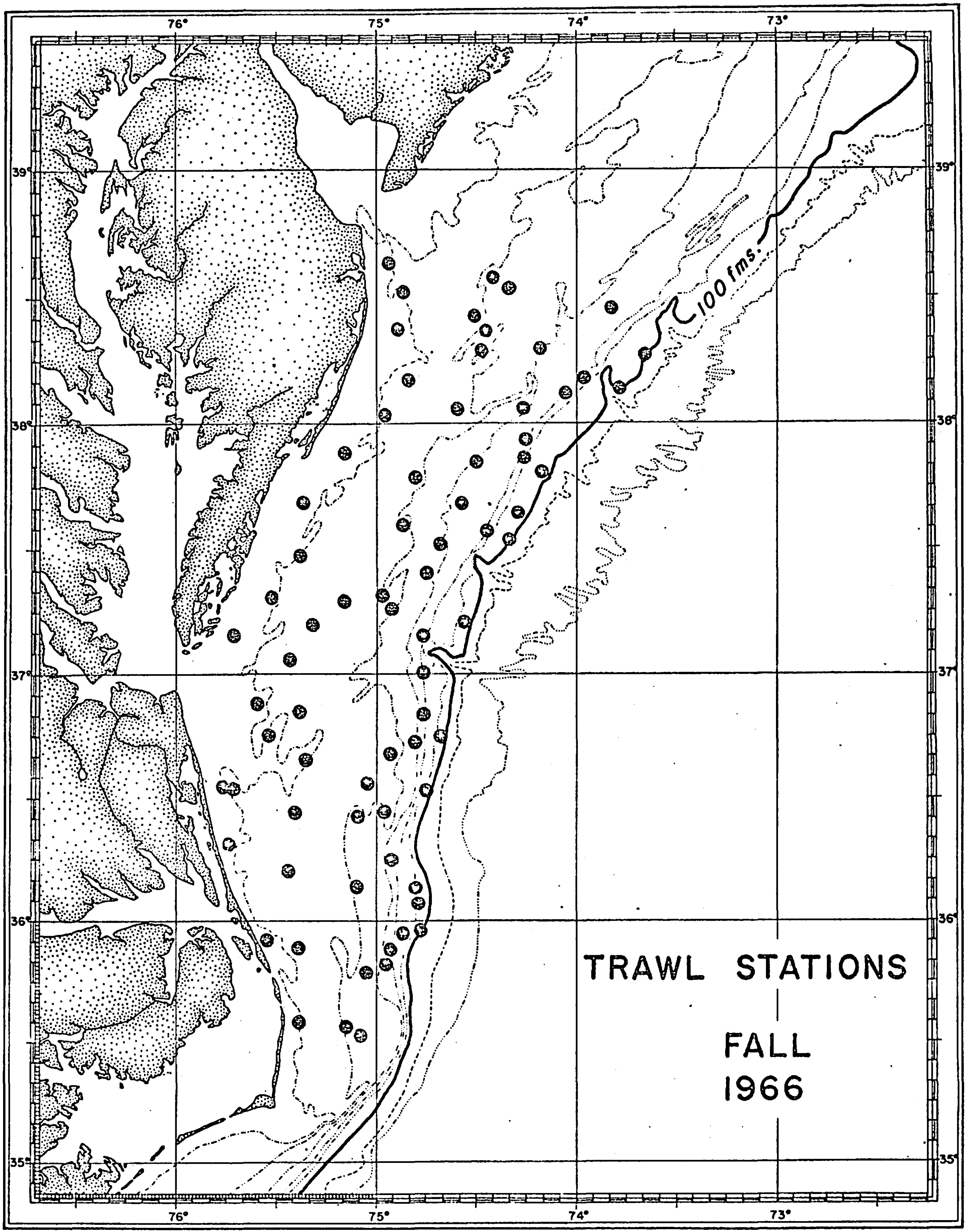


Fig. 4. Sampling pattern in fall 1966.

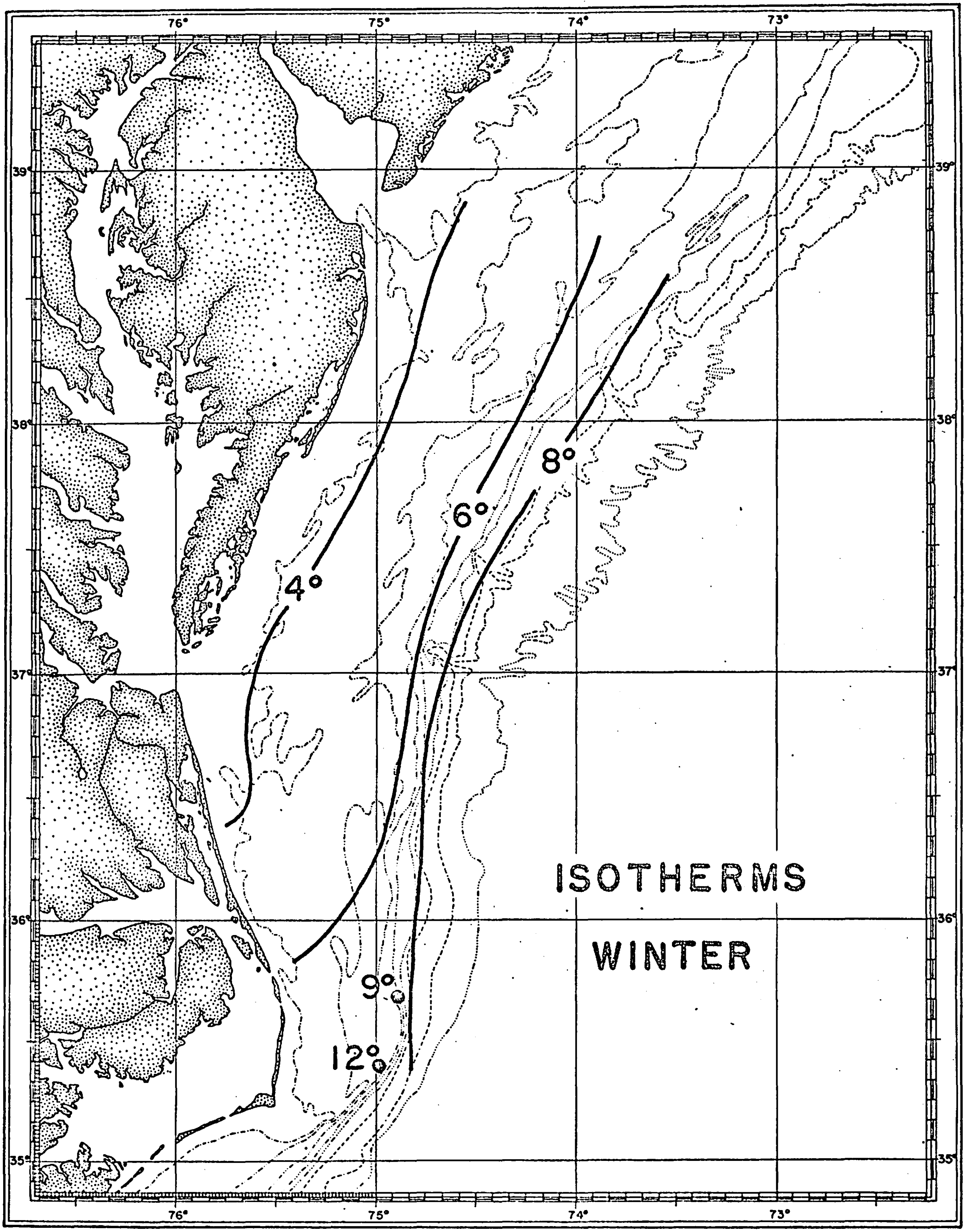


Fig. 5. Thermal pattern of bottom water in winter 1966.

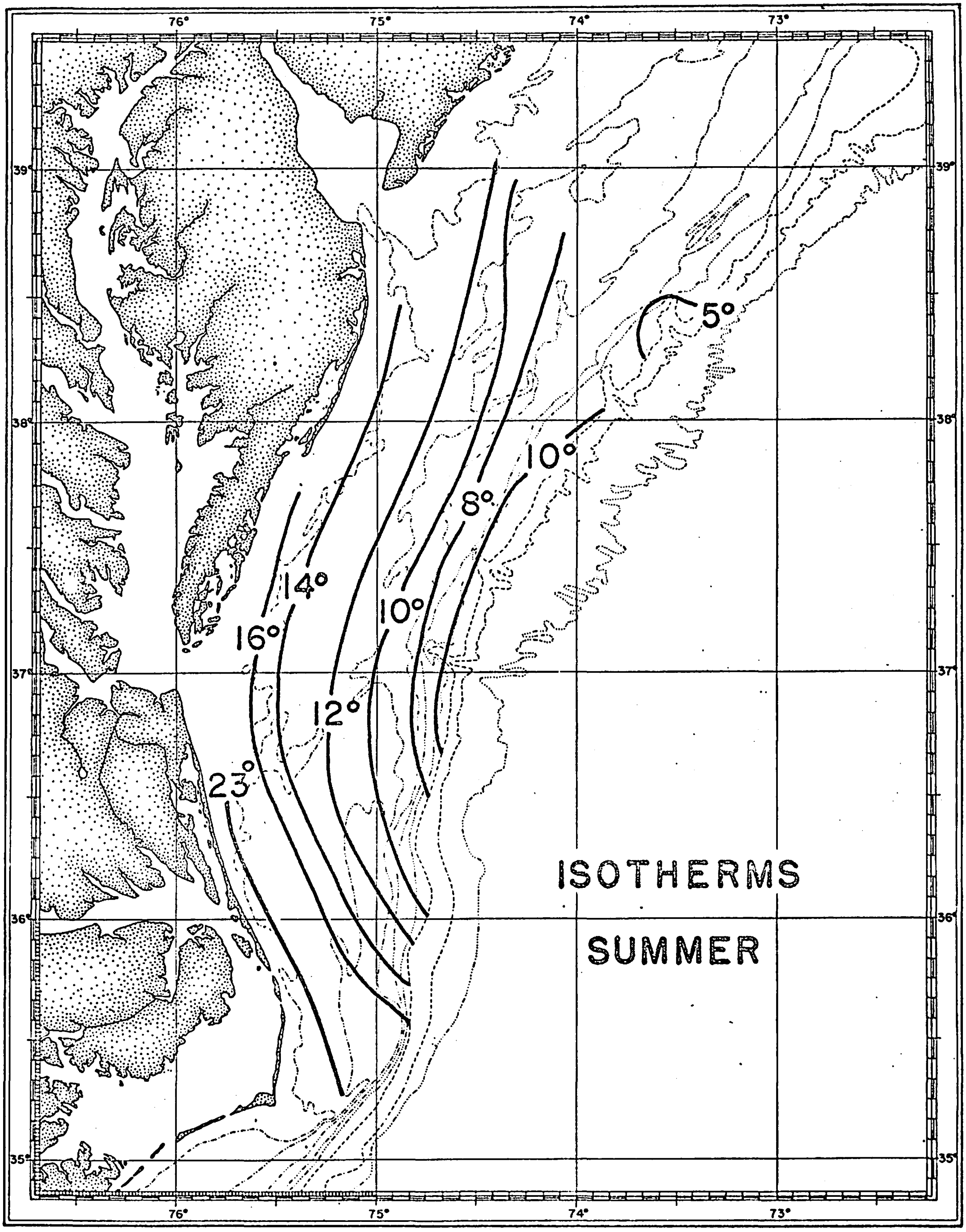


Fig. 6. Thermal pattern of bottom water in summer 1966.

North-South Migrations

The northern puffer or swellfish (*Sphaeroides maculatus*) occurred in Chesapeake Bight only in summer, and moved to the south in winter (Fig. 7). It occupied the water shoaler than 15 fathoms.

The spiny dogfish (*Squalus acanthias*) occurred in considerable numbers over the entire shelf in winter (Fig. 8) but was somewhat more abundant in the southern portion of the area. Adults moved north in the spring and by summer only a few young remained in the deepest water.

Another shark, the smooth dogfish (*Mustelus canis*) apparently wintered primarily to the south of Chesapeake Bight and summered mostly to the north (Fig. 9). During spring and fall migration it occupied the area inside the 20 fathom curve.

The goosefish (*Lophius americanus*), also called allmouth toad and angler, was a winter resident of Chesapeake Bight in waters deeper than 20 fathoms (Fig. 10). By summer all adults had moved out of the area although juveniles remained.

Two pelagic fishes, the herring (*Clupea harengus*) and the mackerel (*Scomber scombrus*), occurred in Chesapeake Bight in winter and moved to the north in the summer. Herring (Fig. 11) occupied the entire area out to the 50 fathom curve, but mackerel (Fig. 12) occurred primarily in the southern portion. Otter trawls probably do not sample the populations adequately and the distributions of these two species may have been broader than is indicated.

Inshore-Offshore Migrations

Distributions of the two species of sea robins were similar (Fig. 13 and 14) except that the northern searobin (*Prionotus carolinus*)

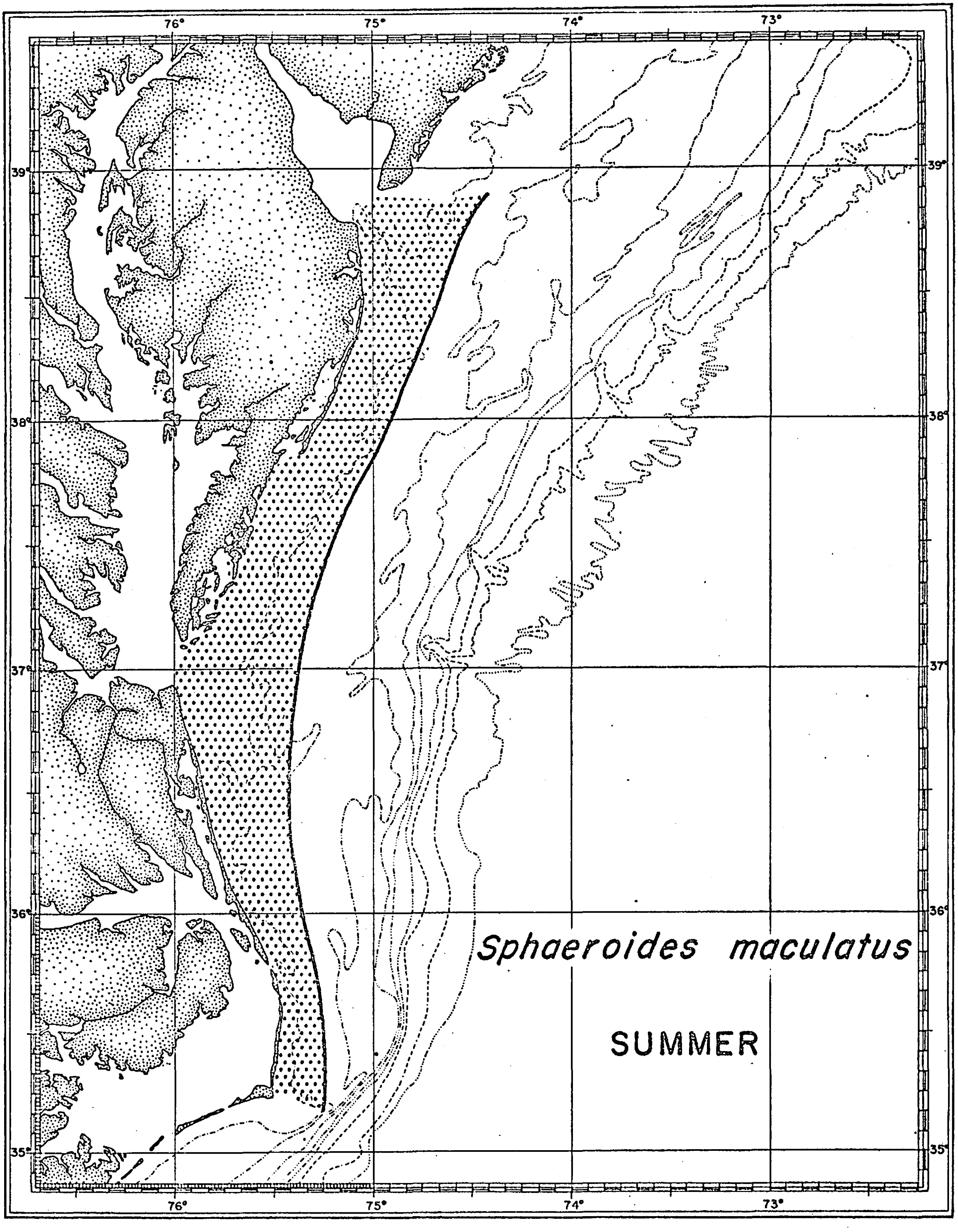


Fig. 7. Distribution of the northern puffer.

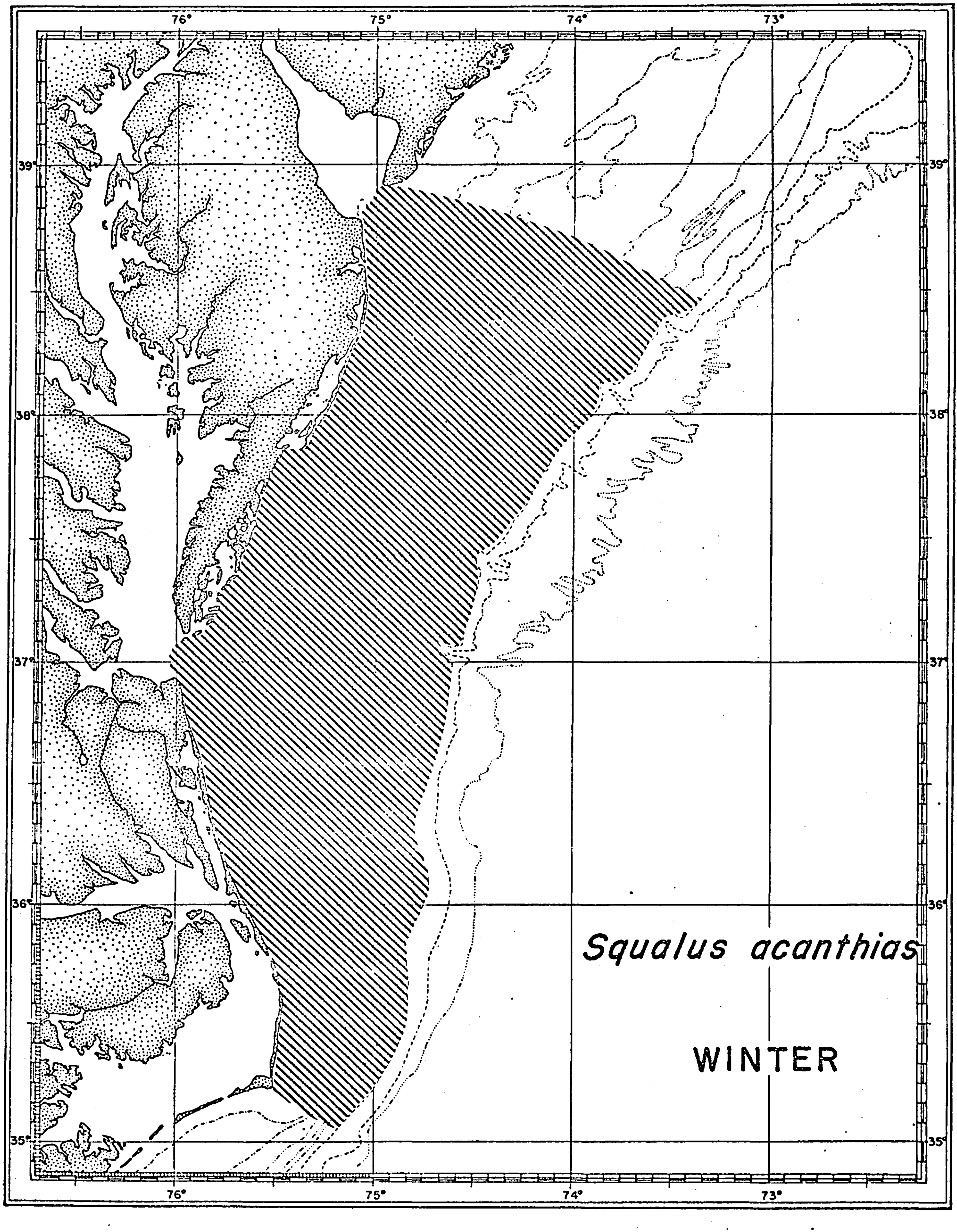


Fig. 8. Distribution of the spiny dogfish.

PHASE 10

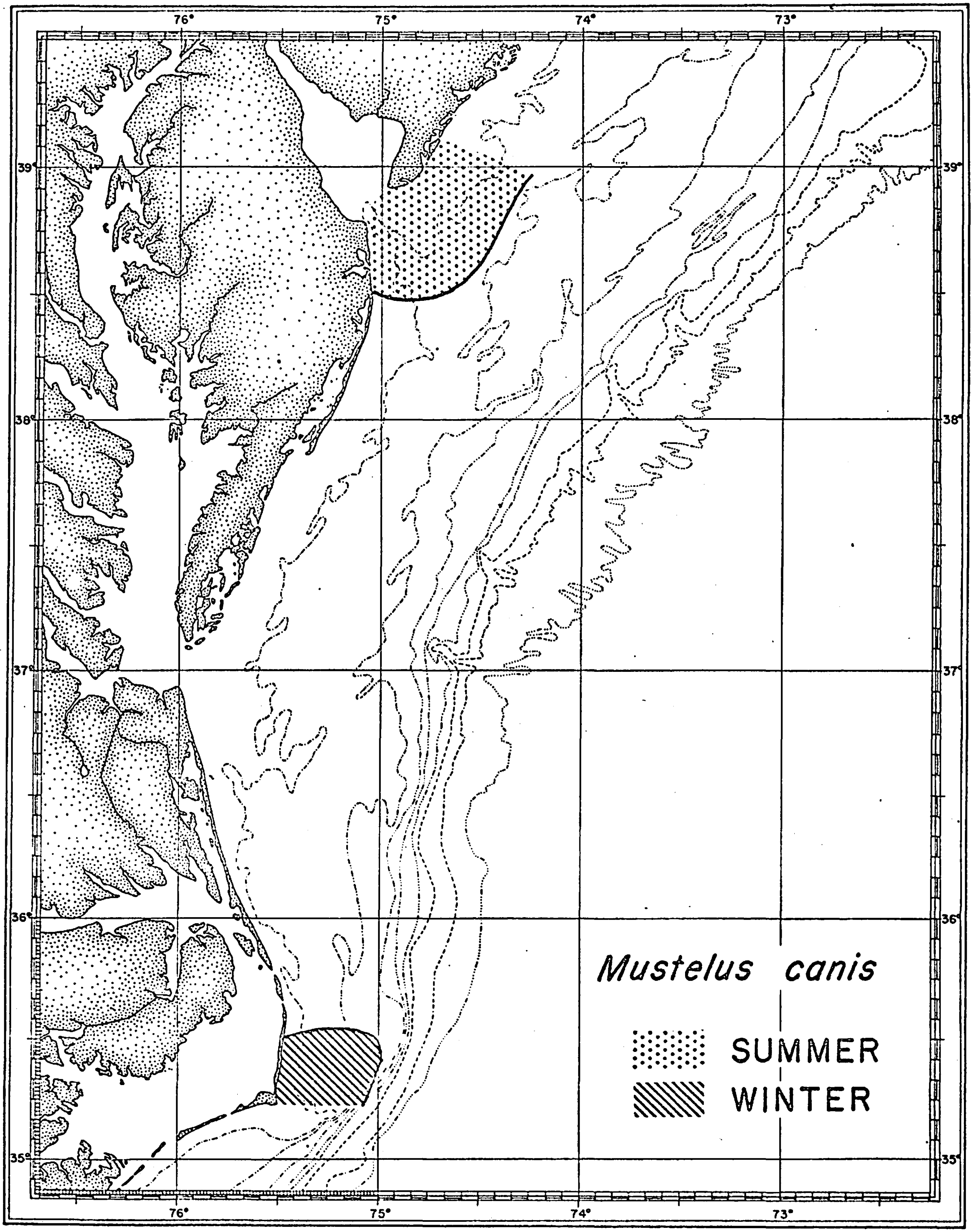


Fig. 9. Distribution of the smooth dogfish.

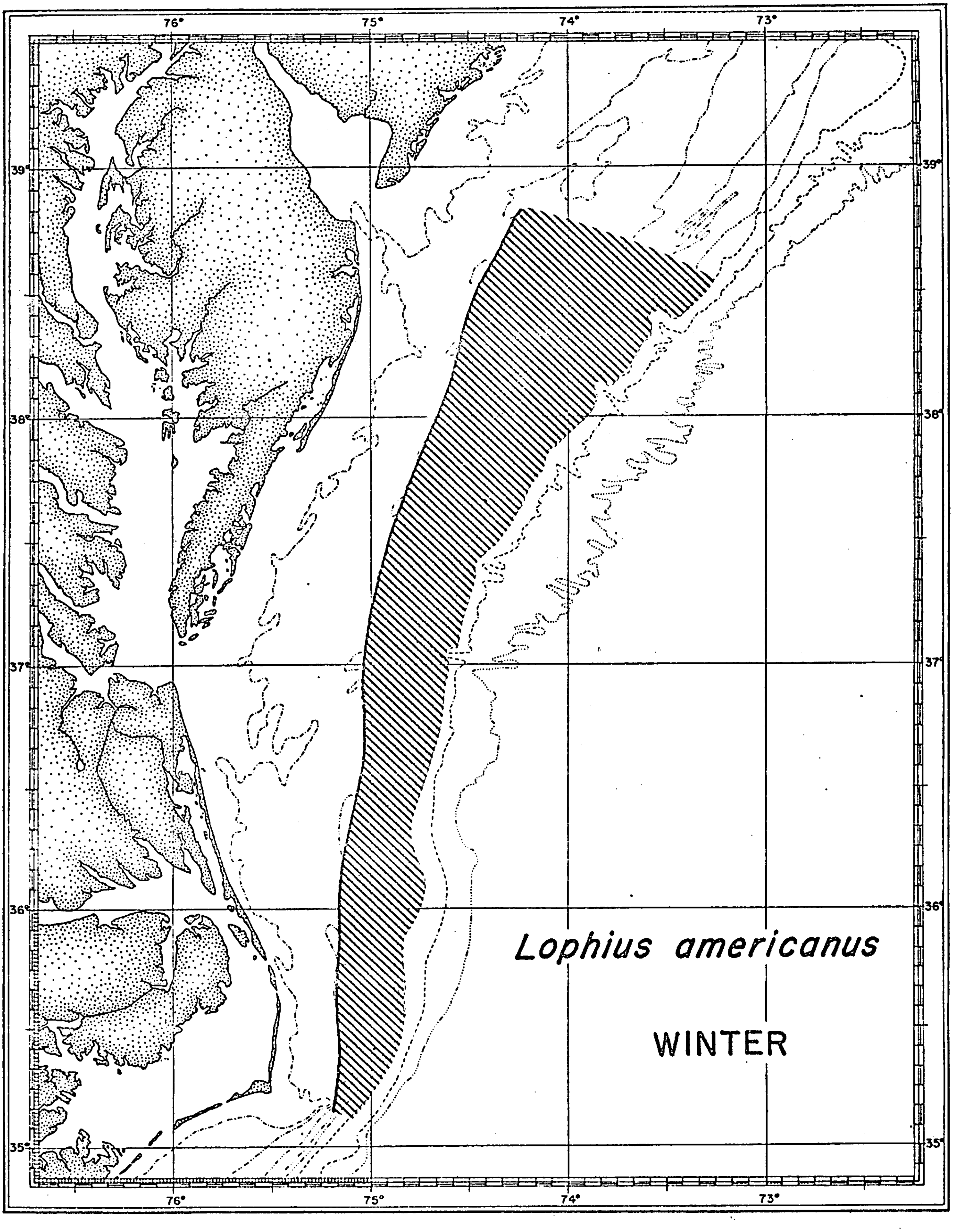


Fig. 10. Distribution of the goosefish.

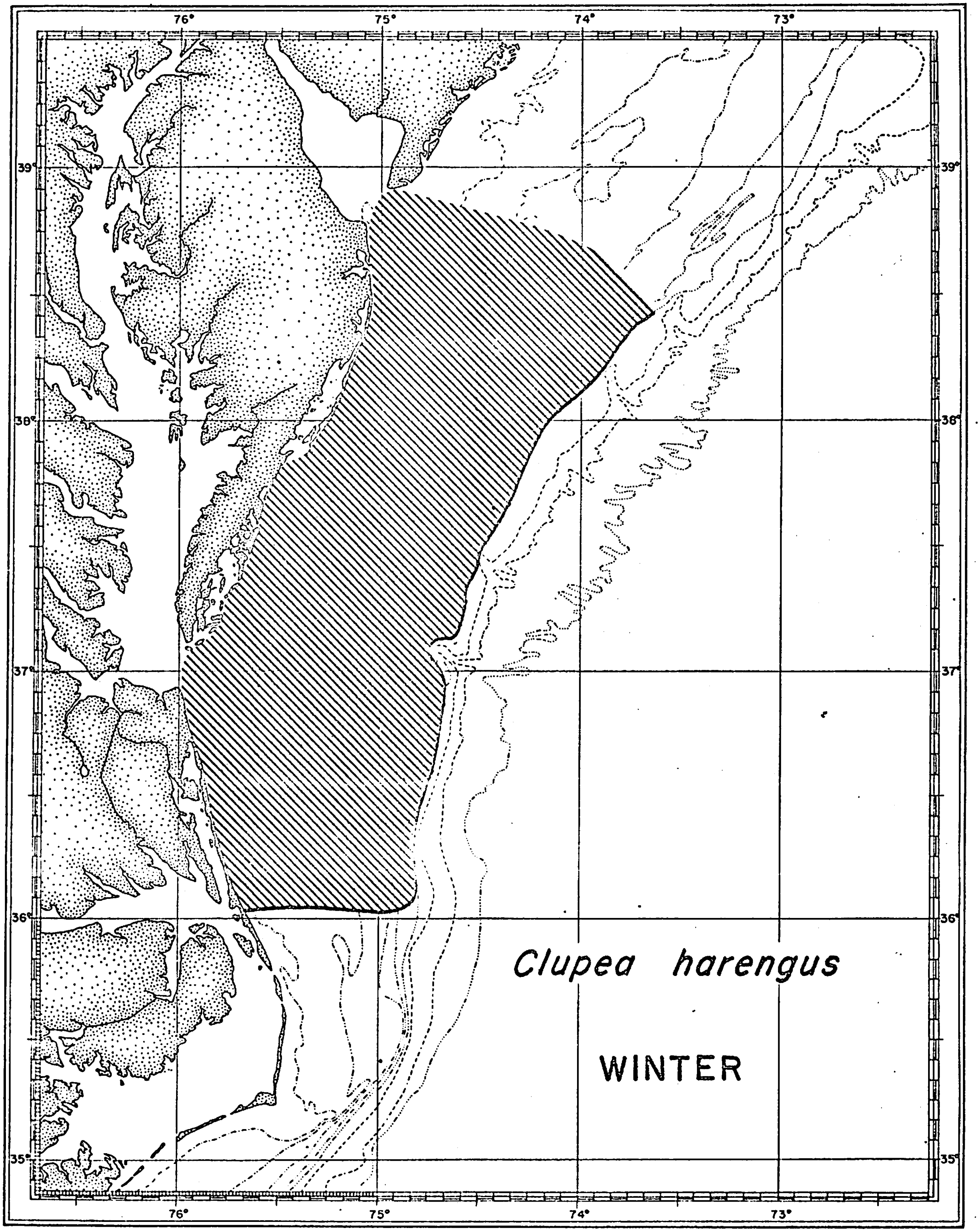


Fig. 11. Distribution of the herring.

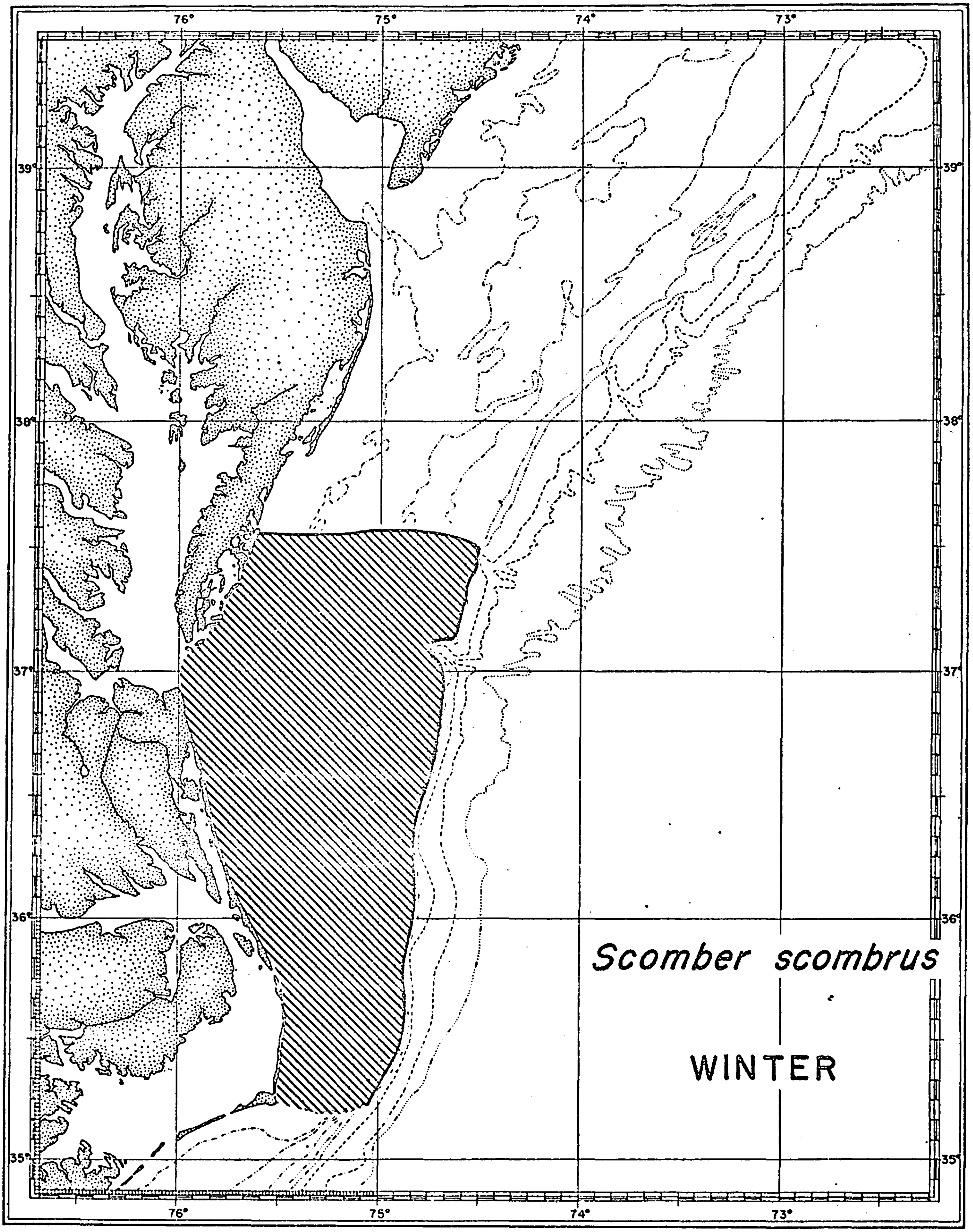


Fig. 12. Distribution of the mackerel.

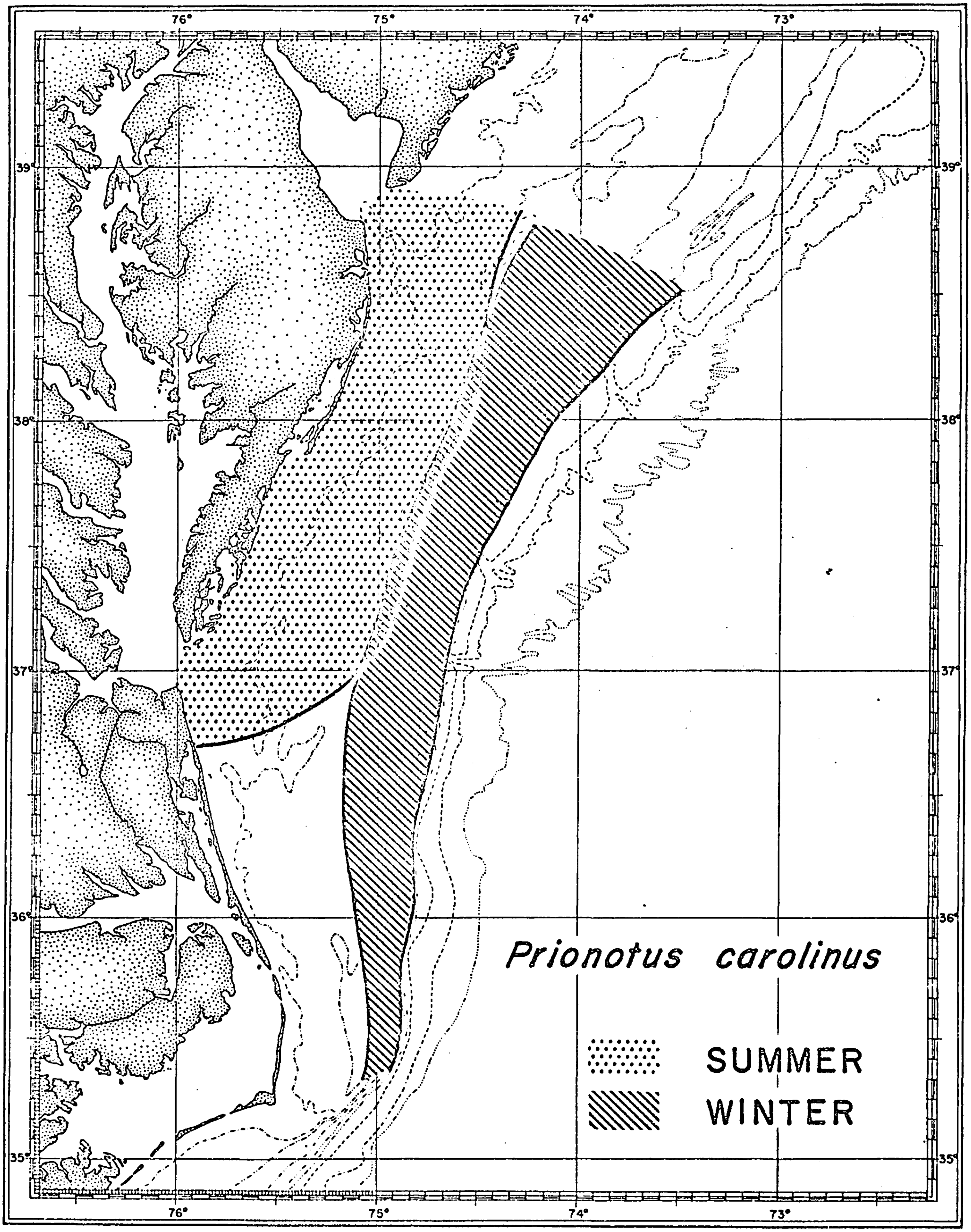


Fig. 13. Distribution of the northern searobin.

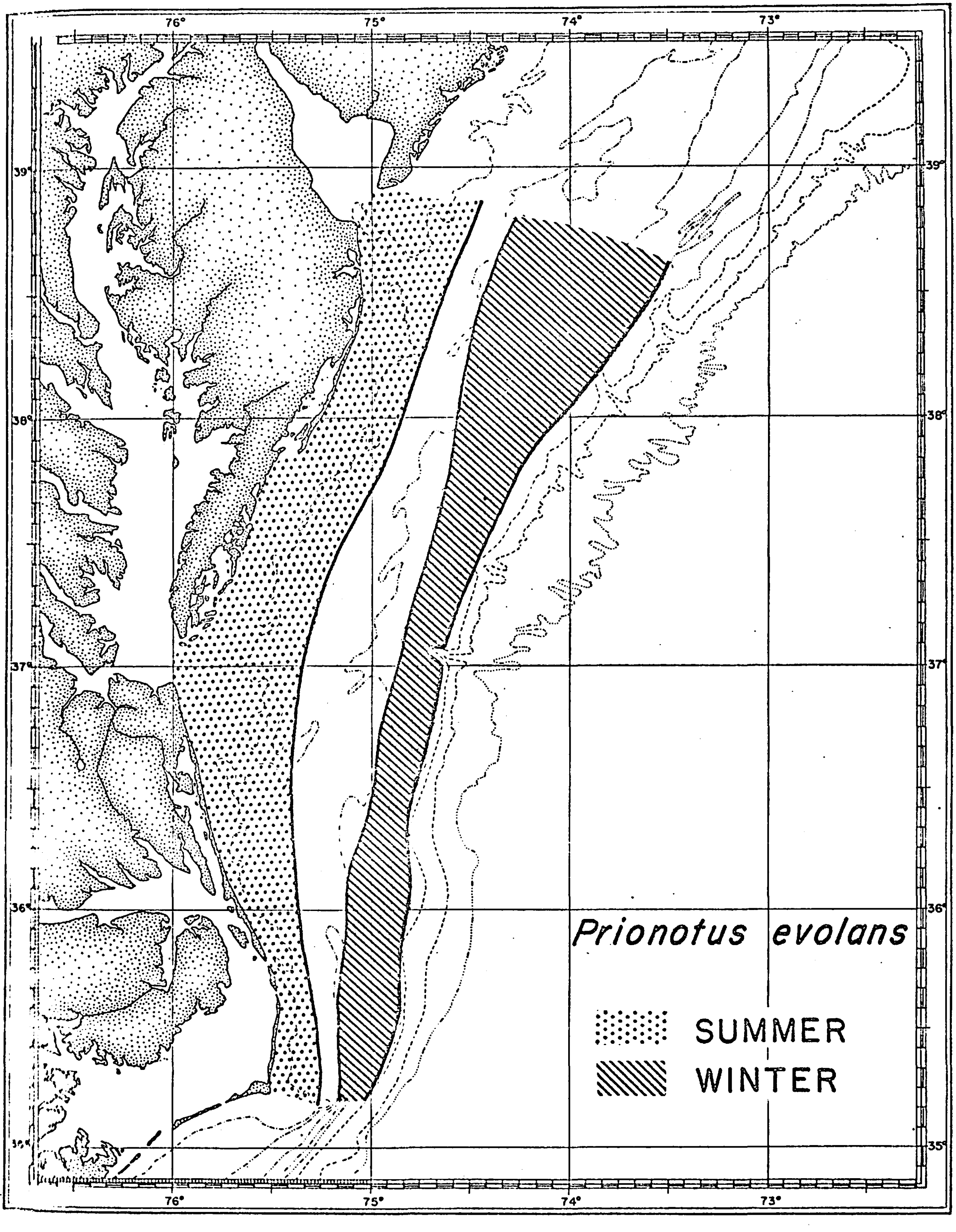


Fig. 14. Distribution of the striped searobin.

did not occur south of Chesapeake Bay in summer. In general both species were in water shoaler than 15 fathoms in summer and in winter occupied depths of 20 to 60 fathoms in a band from north to south through Chesapeake Bight. Migration of both species appears to be primarily inshore in spring and offshore in fall, with some north-south movement.

The silver hake or whiting (*Merluccius bilinearis*) occurred in summer over the entire shelf north of Cape Charles but only in water of 40 fathoms or more to the south (Fig. 15). In winter the hake withdrew from shoal water and was caught regularly only outside of the 20 fathom curve. Young occupied the inner half of the shelf in winter and were scarce in summer.

The distribution of the squirrel hake or red hake (*Urophycis chuss*) was similar to that of the silver hake (Fig. 16).

The spotted hake (*Urophycis regius*) was common throughout Chesapeake Bight in summer, but in winter it retreated to water deeper than 20 fathoms and was more abundant south of Chesapeake Bay (Fig. 17).

Non-Migratory Species

The windowpane flounder or daylight (*Scophthalmus aquosus*) occurred from the shoreline out to the 25 fathom curve in both summer and winter (Fig. 18).

Another flatfish, the fourspot flounder (*Paralichthys oblongus*) is primarily an inhabitant of deep waters (Fig. 19), although a few individuals were caught in water as shallow as 15 to 20 fathoms.

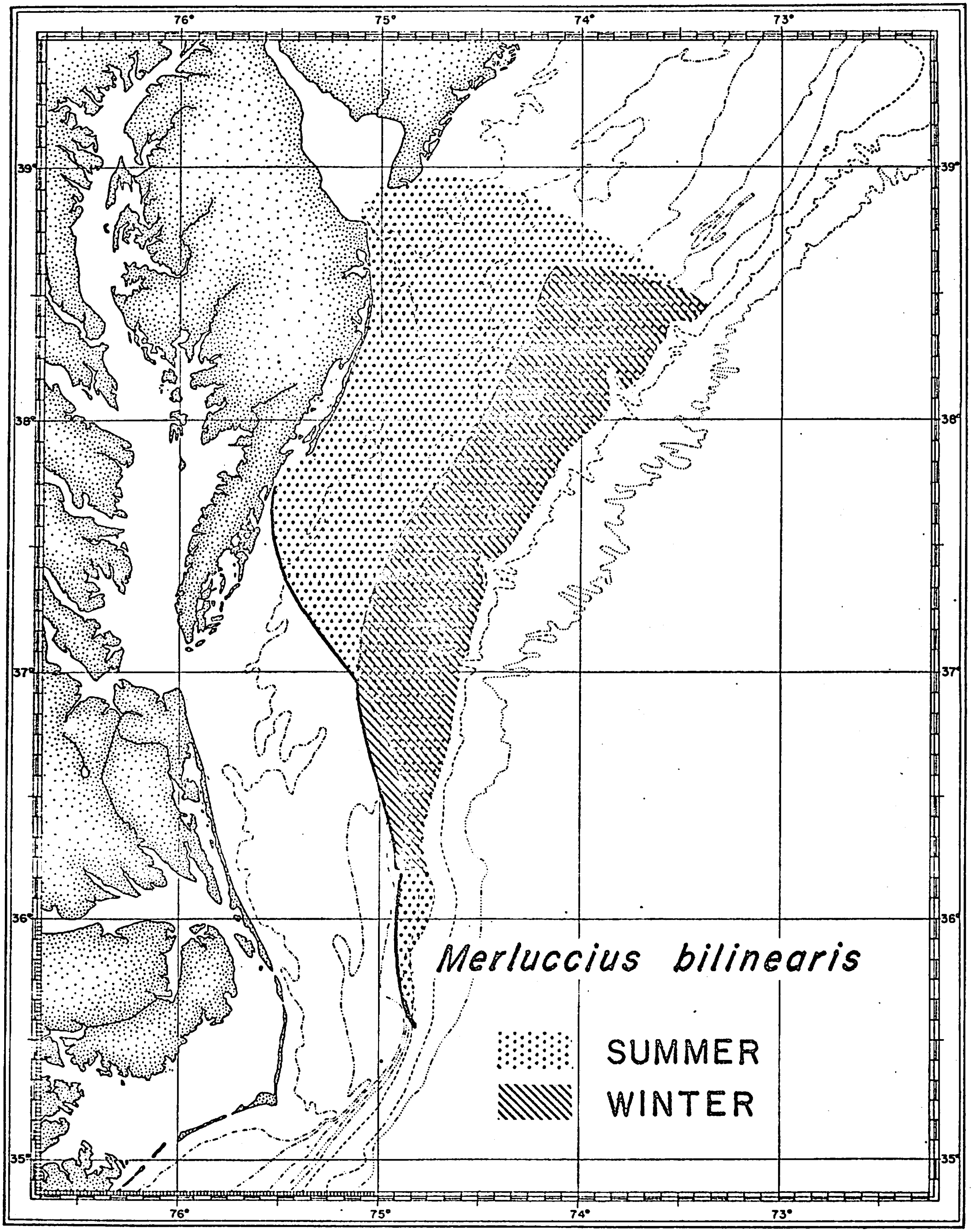


Fig. 15. Distribution of the silver hake.

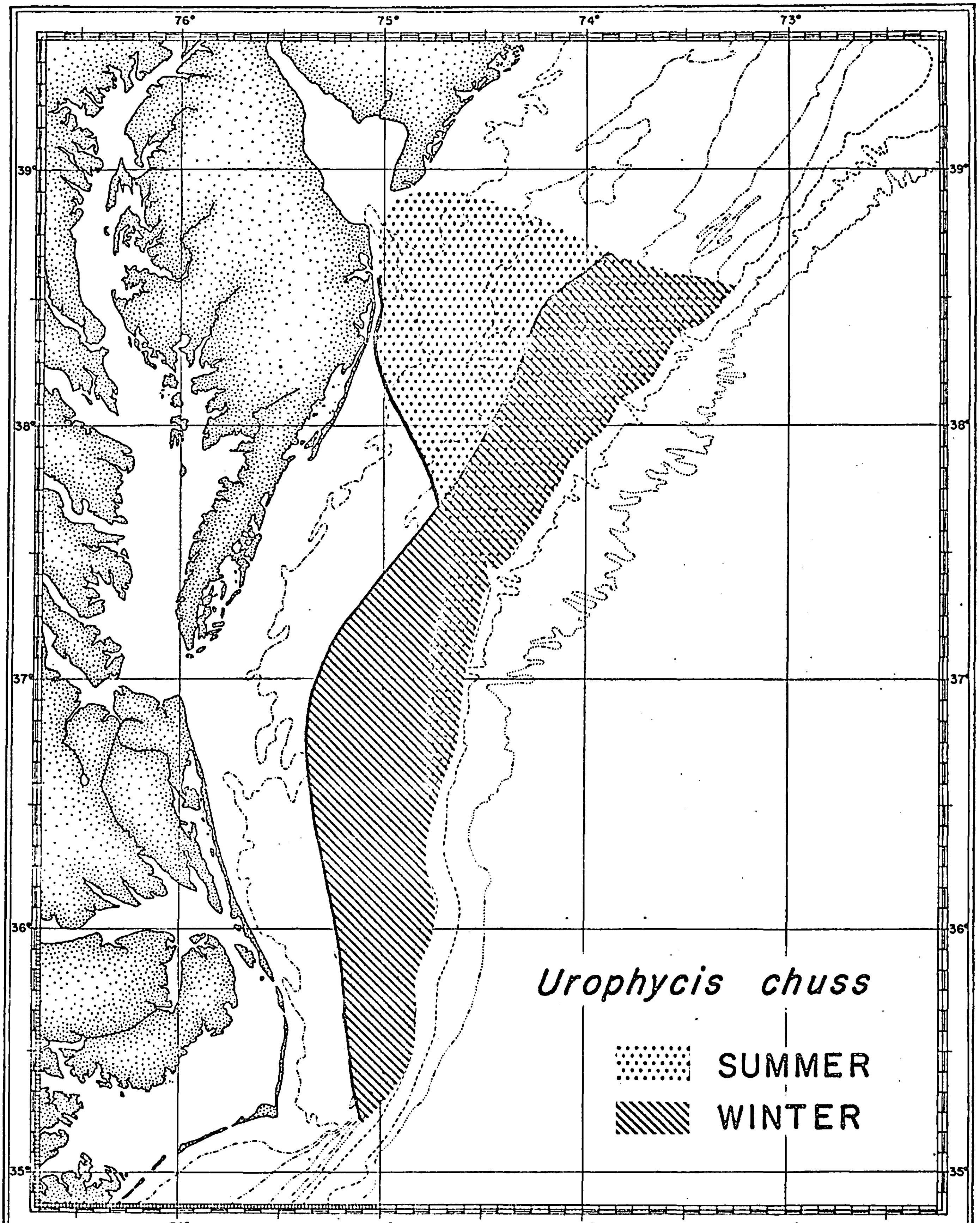


Fig: 16. Distribution of the red hake.

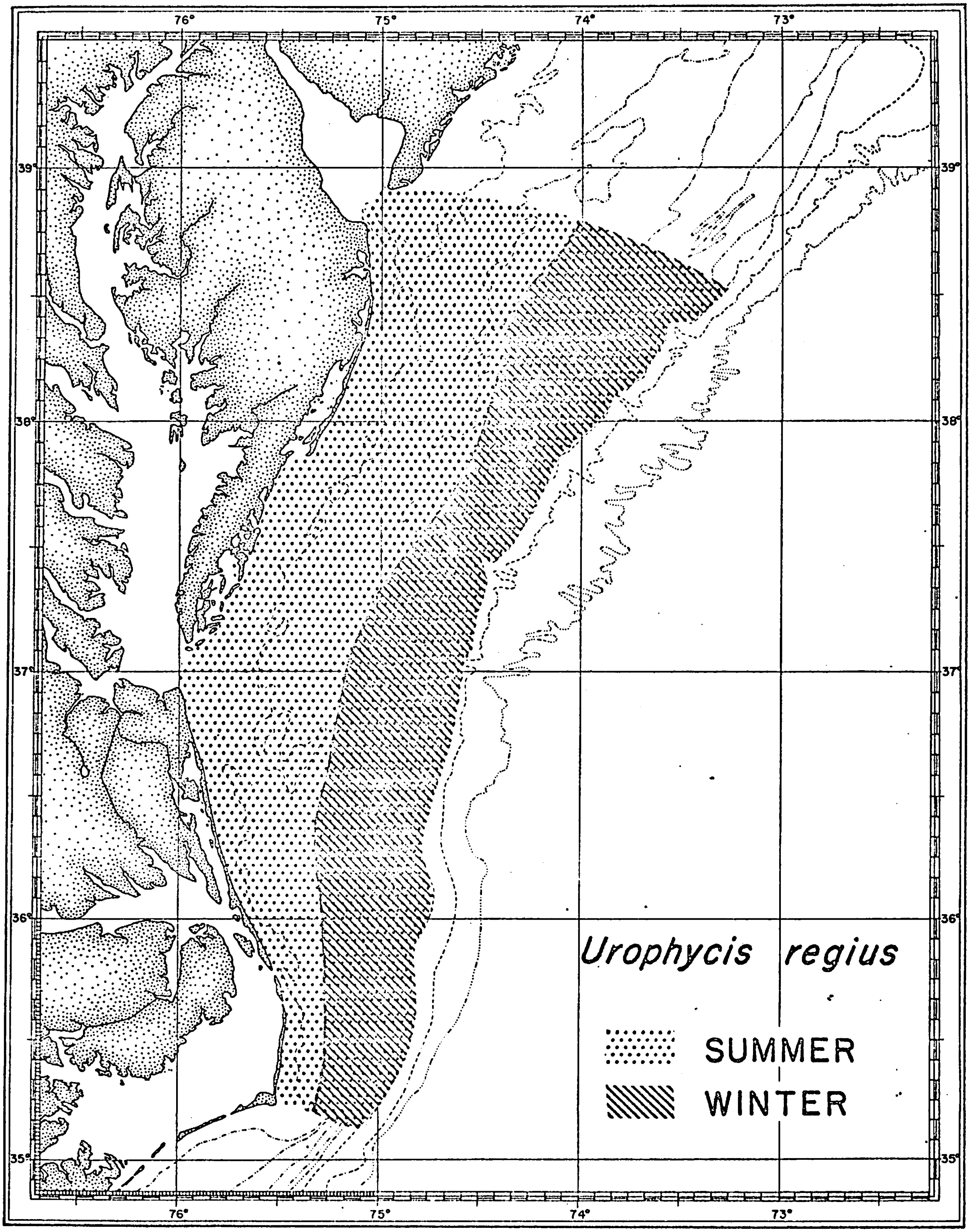


Fig. 17. Distribution of the spotted hake.

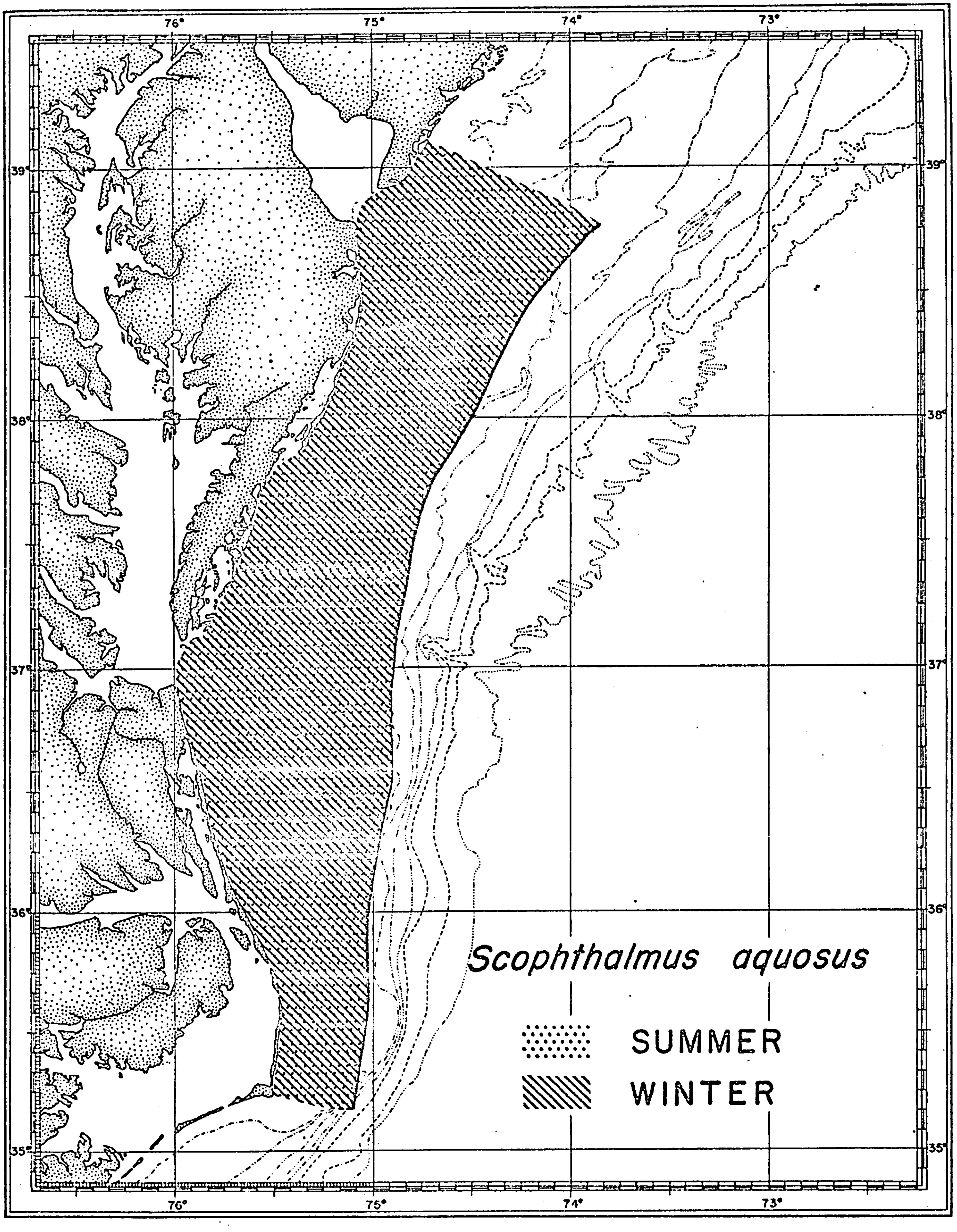


Fig. 18. Distribution of the windowpane flounder.

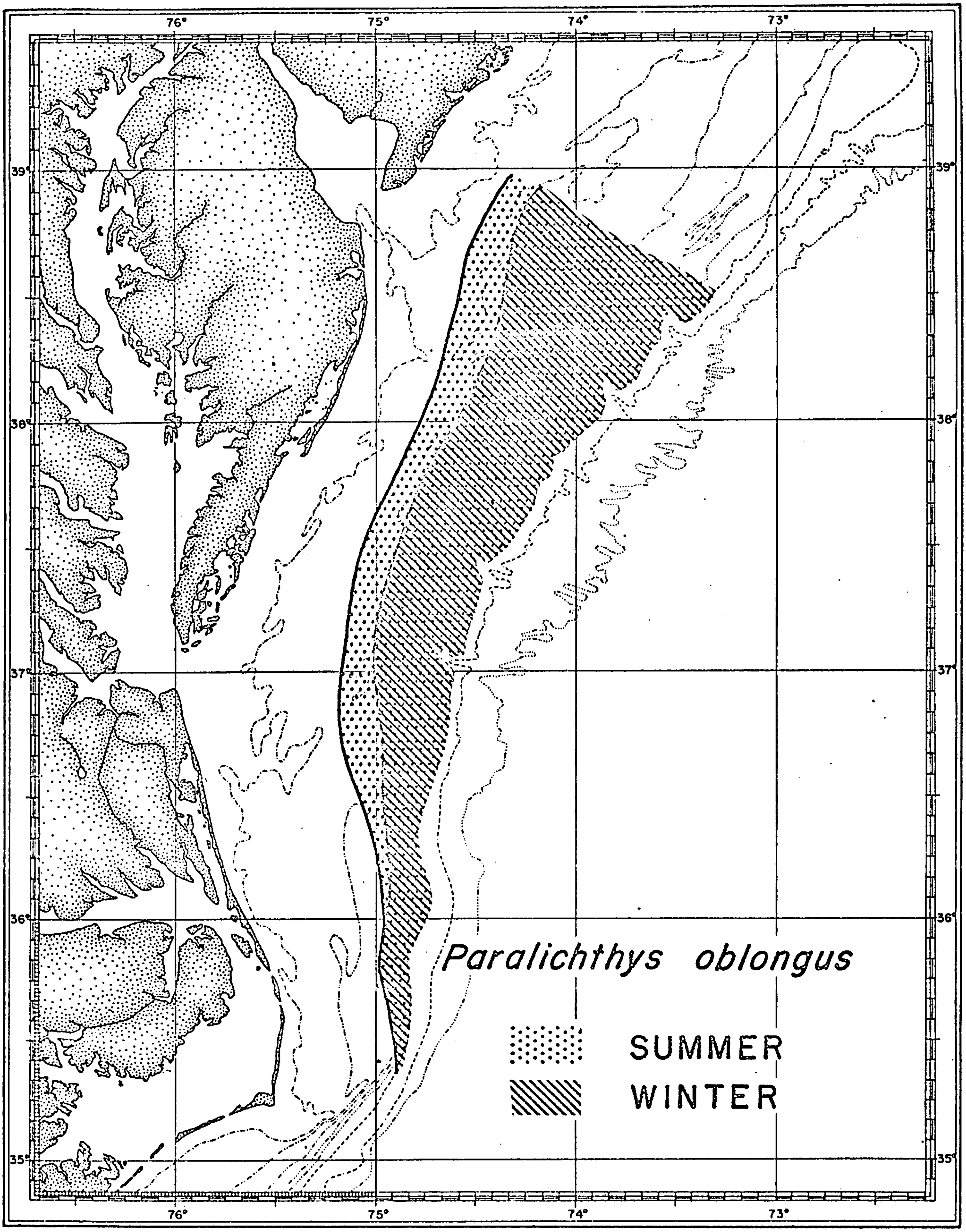


Fig. 19. Distribution of the fourspot flounder.

PART 2

AVAILABILITY AND DISTRIBUTION OF BENTHIC FISHES OF CHESAPEAKE BIGHT

By

JACKSON DAVIS

VIRGINIA INSTITUTE OF MARINE SCIENCE
GLOUCESTER POINT, VIRGINIA

Having devoted the first year of our survey of bottom fish resources of Chesapeake Bight to investigating seasonal distribution, we undertook in the second year an inventory of the quantity available in each season. Winter proved to have the greatest potential for fish for industrial uses. Autumn was nearly as good. Populations in spring and summer were comparatively small but well concentrated. Half of the total quantity available in fall and winter was spiny dogfish. Searobins were the predominant species in summer.

Sampling procedure was to trawl at least once in each 15 minute grid. That is, we divided Chesapeake Bight into rectangles measuring 15 minutes of longitude by 15 minutes of latitude and trawled at least once in each rectangle. Sampling gear was an Atlantic western trawl having 4-inch bar mesh in the body and 2-inch bar mesh in the codend. Headrope of the trawl was 54 feet long and the footrope 78 feet. Each tow of an hour's duration was estimated to cover about 0.03 square mile of bottom. The catch in 0.03 square mile was considered to be typical of the 180 square miles of that grid. Although the population indexes thus derived are fairly crude, nevertheless, they give an indication of the magnitude of the trash fish supply. We have designed a computer program which will help in arriving at better estimates of the fish population and will elucidate influences of temperature and depth on the distribution of the various species. Preliminary descriptions of distribution and abundance have been reported previously in a series of progress reports.

In the winter of 1967 samples at 54 stations, as indicated by the dots in Fig. 1, yielded a population index of 803 million pounds and a catch rate of 2600 pounds per hour of trash fish averaged over the entire area. Nearly half of the catch was spiny dogfish. If they are substracted, the average catch rate is 1460 pounds per hour. The waters from the 30 fathom curve out to the edge of the shelf were more productive than shoaler waters. On the outer portion of the shelf the average catch, excluding dogfish, was 2660 pounds per hours, and for the approximately 2700 square miles of best area the population index was 292 million pounds, again exclusive of dogfish.

Because bad weather forced curtailment of our sampling program in the winter of 1967, we examined the area again in the winter of 1968. Results were similar in the two years. In 1968 the average catch rate at 76 stations was 2300 pounds per hour. The population index was 991 million pounds in about 12,000 square miles in contrast to 803 million pounds in about 10,000 square miles in 1967. Temperature pattern of the bottom waters in winter 1968 is shown in Fig. 2.

In spring the catch rate declines to 475 pounds per hour averaged over the entire shelf. Part of the decline resulted from departure of spiny dogfish from the area. Although the average catch was poor, some searobins had returned to their summer range, and the area between 5 and 15 fathoms north of 37° yielded catches of up to 5000 pounds per hour (Fig. 3).

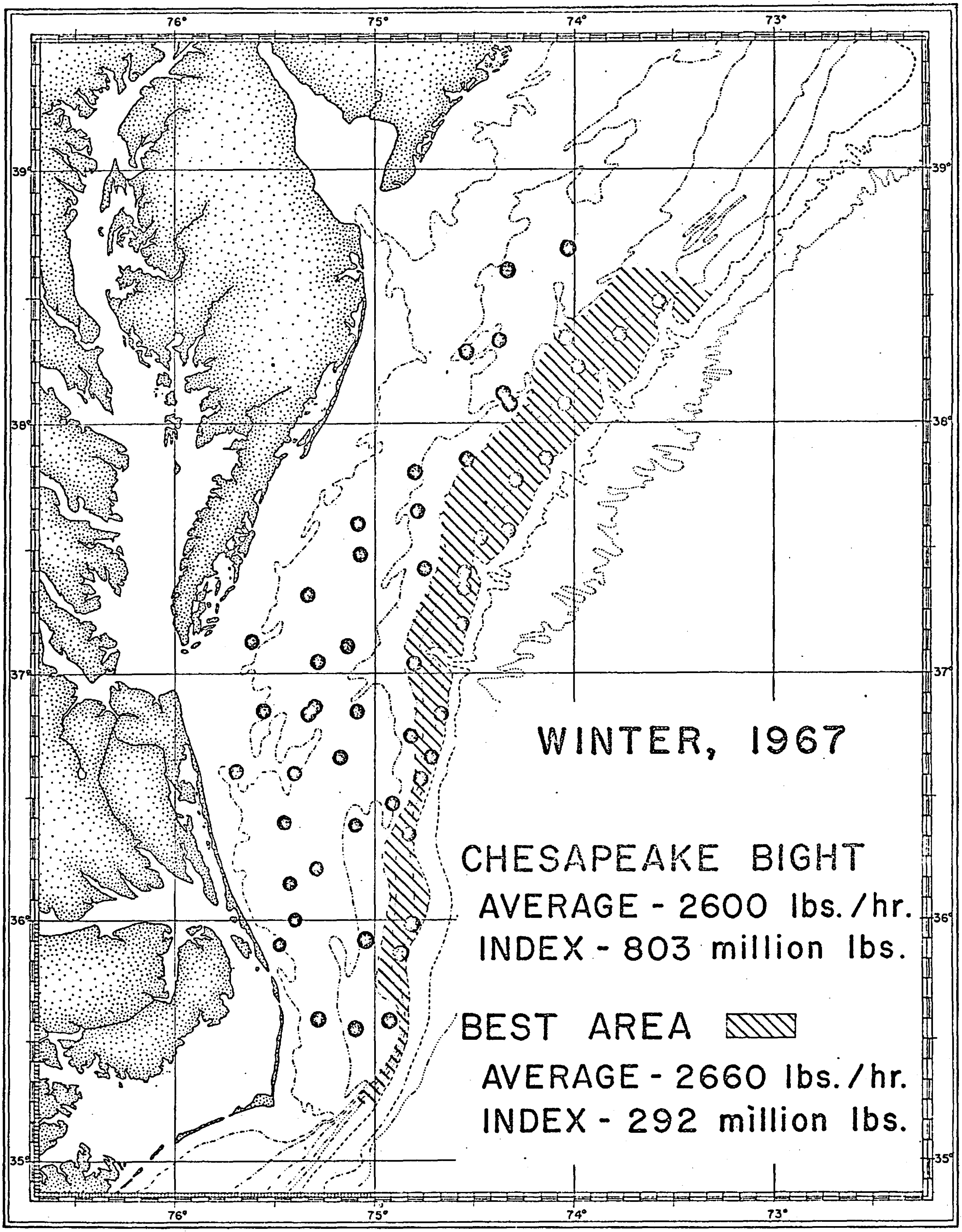

76°
75°
74°
73°
39°
38°
37°
36°
35°
WINTER, 1967
CHESAPEAKE BIGHT
AVERAGE - 2600 lbs./hr.
INDEX - 803 million lbs.
BEST AREA ▨
AVERAGE - 2660 lbs./hr.
INDEX - 292 million lbs.

Fig. 1.

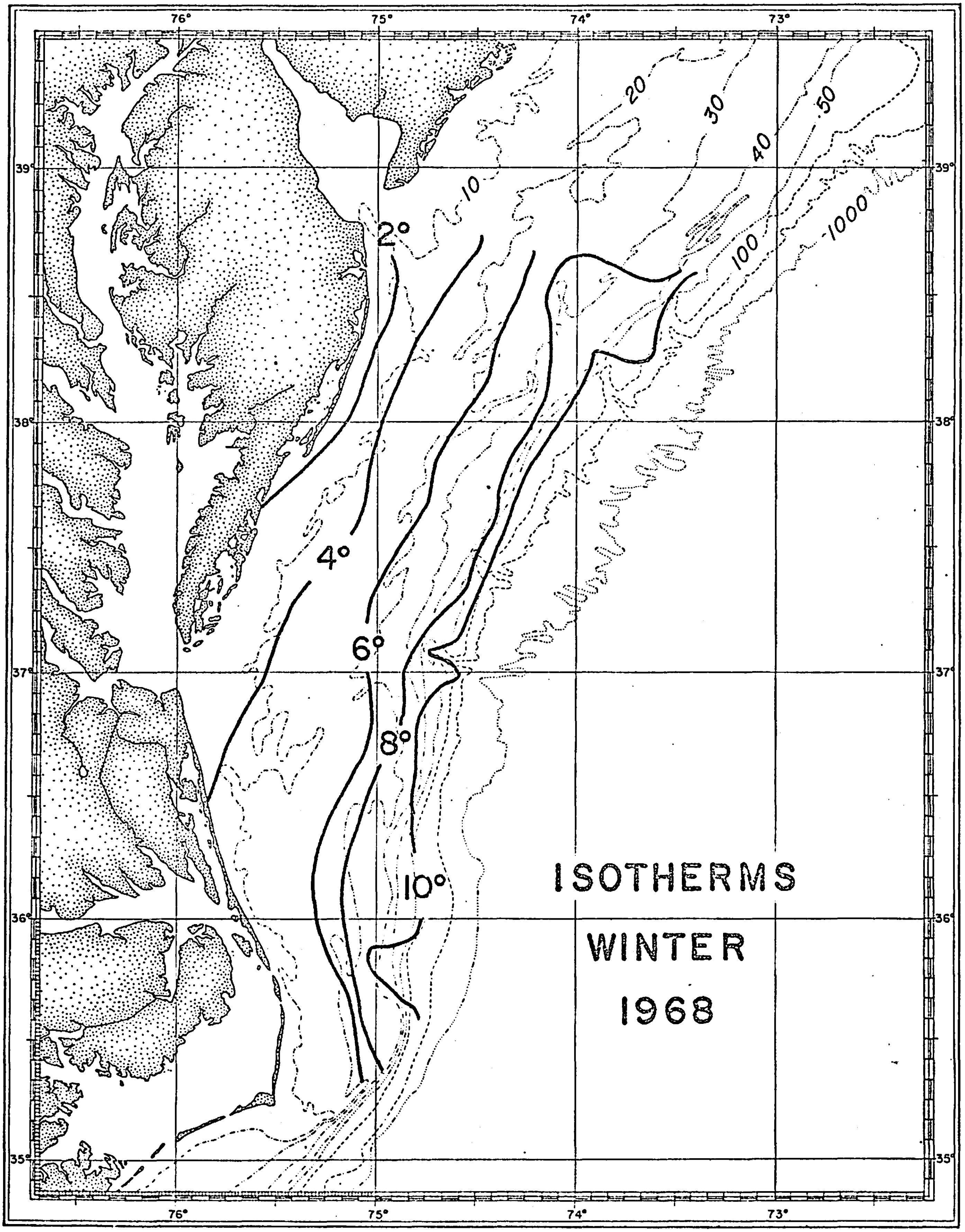

ISOTHERMS
WINTER
1968
2°
4°
6°
8°
10°
10
20
30
40
50
100
1000
76°
75°
74°
73°
39°
38°
37°
36°
35°

Fig. 2

In the 1600 square miles of best area the population index was 47 million pounds and the average catch per hour was near 900 pounds, and consisted mostly of searobins, with some skates and other kinds. The population index for the entire area was 129 million pounds. Temperature pattern is shown in Fig. 4.

In summer the catch rate declined further to 380 pounds per hour. However, as was the case in spring, the stretch of shallow water off Virginia and Maryland contained a dense population of searobins and lesser quantities of other fish. The greatest concentration was inside the 15 fathom curve between 36° 30' and 38° 30' (Fig. 5). In this area of about 2800 square miles the average catch rate was 950 pounds per hour and the population index was 102 million pounds. Catches ranged up to 2000 pounds per hour. Outside the 15 fathom curve, catch rates were, with a few exceptions, less than 100 pounds per hour. The population index was 157 million pounds for the entire area, good and poor. Fig. 6 illustrates the temperature pattern of bottom waters.

By autumn spiny dogfish had started their southward migration and again comprised a significant portion of the catch, about 900 pounds of the 1900 pounds per hour average for the area. Dogfish occurred inside the 60 fathom curve. Searobins had started moving offshore, the major concentration having shifted to between 20 and 50 fathoms. The population index was 724 million pounds of which some 340 million was spiny dogfish. The best catches of trash fish other than spiny dogfish were from the 20 fathom curve to the edge of the shelf, an area of

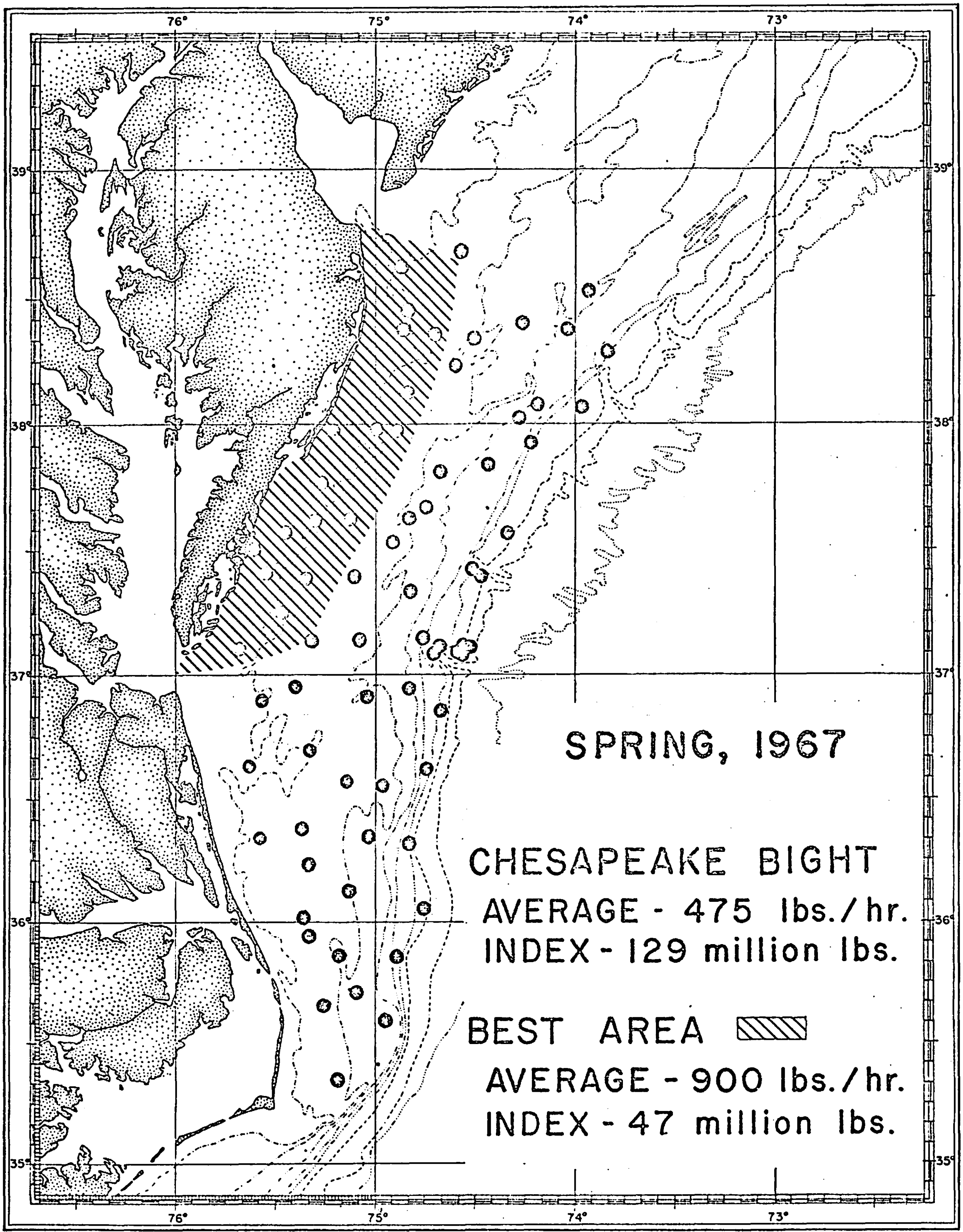

SPRING, 1967
CHESAPEAKE BIGHT
AVERAGE - 475 lbs./hr.
INDEX - 129 million lbs.
BEST AREA ▨
AVERAGE - 900 lbs./hr.
INDEX - 47 million lbs.
76°
75°
74°
73°
39°
38°
37°
36°
35°

Fig. 3.

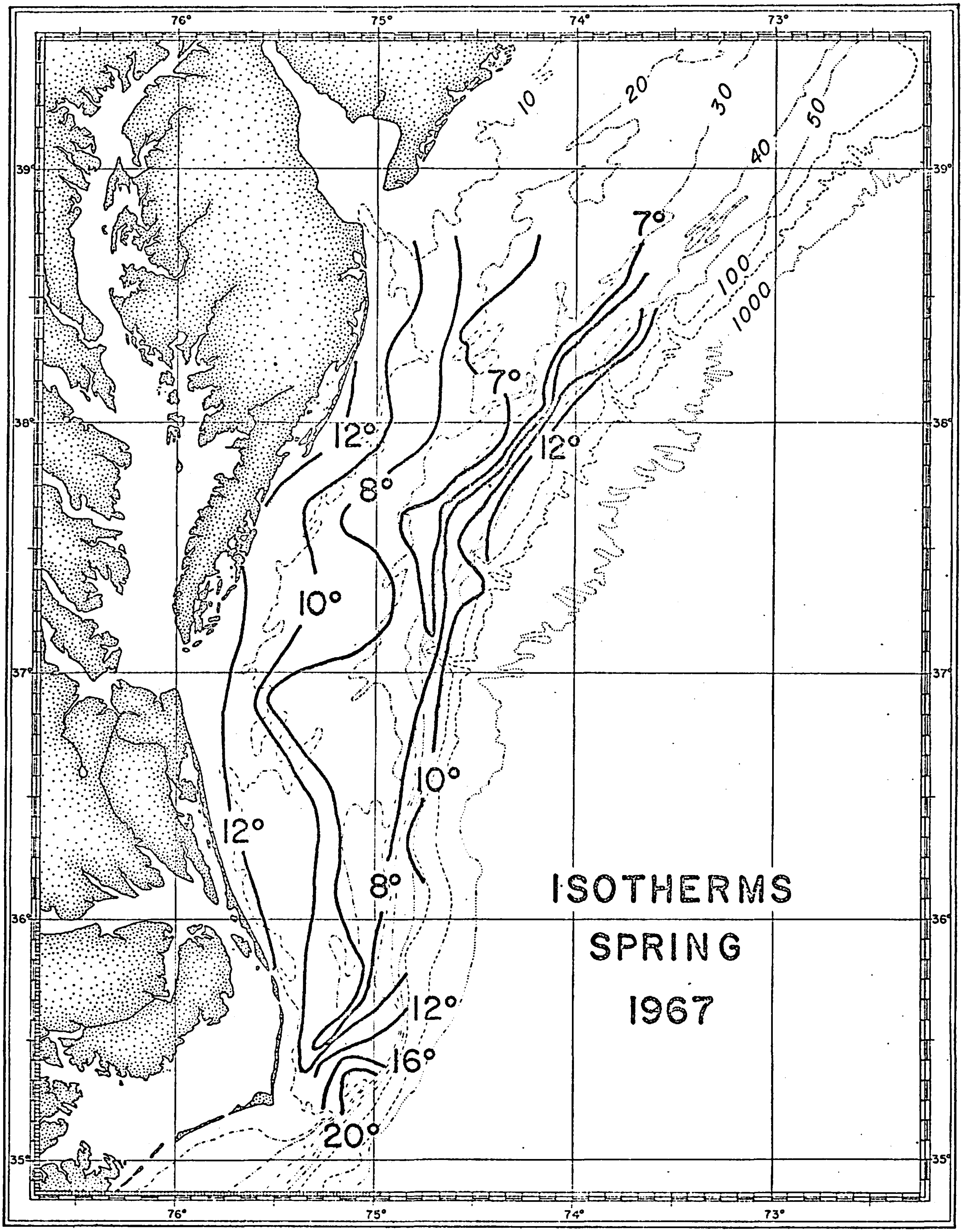

ISOTHERMS
SPRING
1967
76°
75°
74°
73°
39°
38°
37°
36°
35°
7°
7°
8°
8°
10°
10°
12°
12°
12°
12°
16°
20°
10
20
30
40
50
100
1000

Fig. 4.

some 4000 square miles (Fig. 7). The average catch (exclusive of dogfish) in this area was 2010 pounds per hour and the population index was 160 million pounds exclusive of dogfish. Fig. 8 depicts the temperature pattern of bottom waters in autumn.

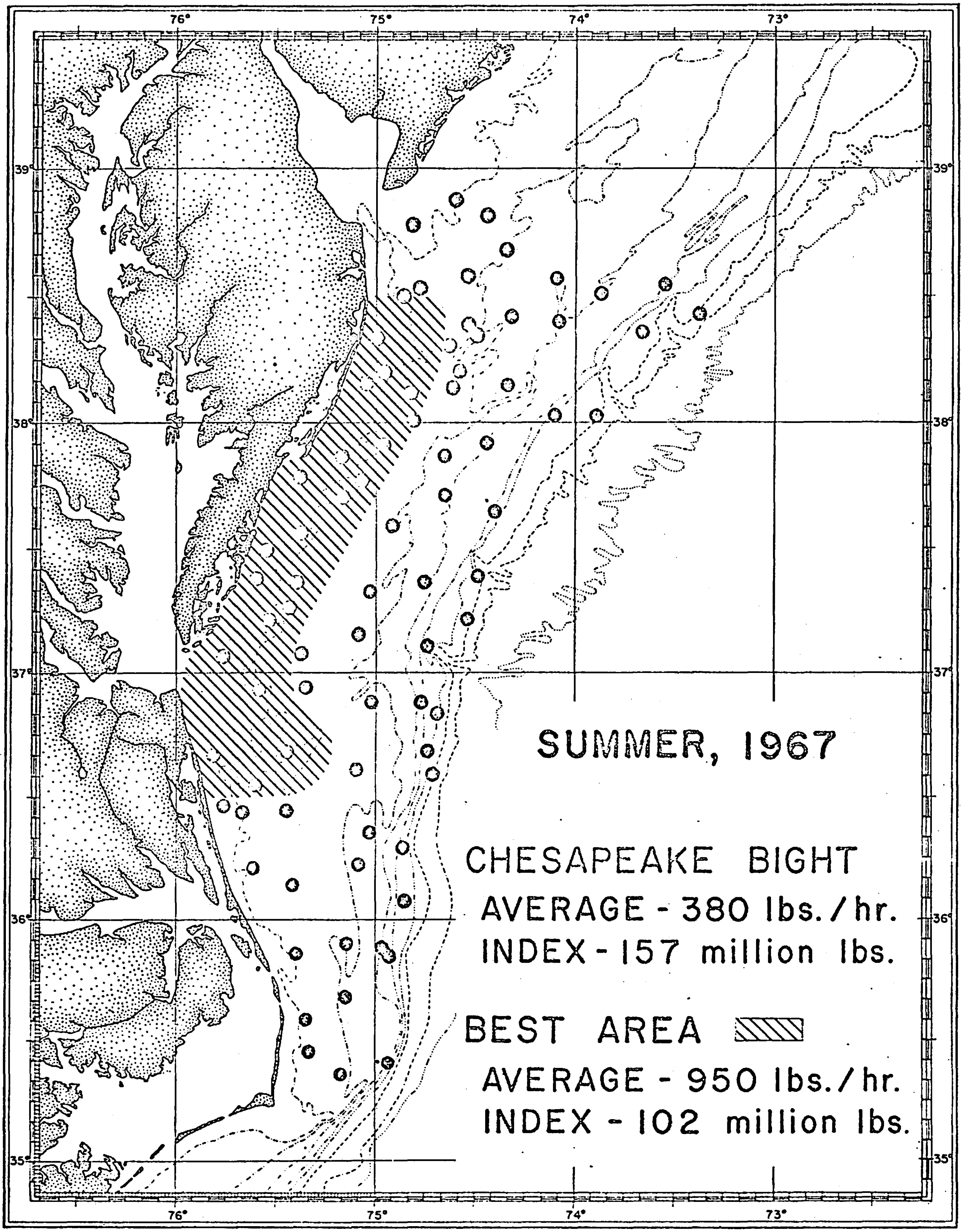
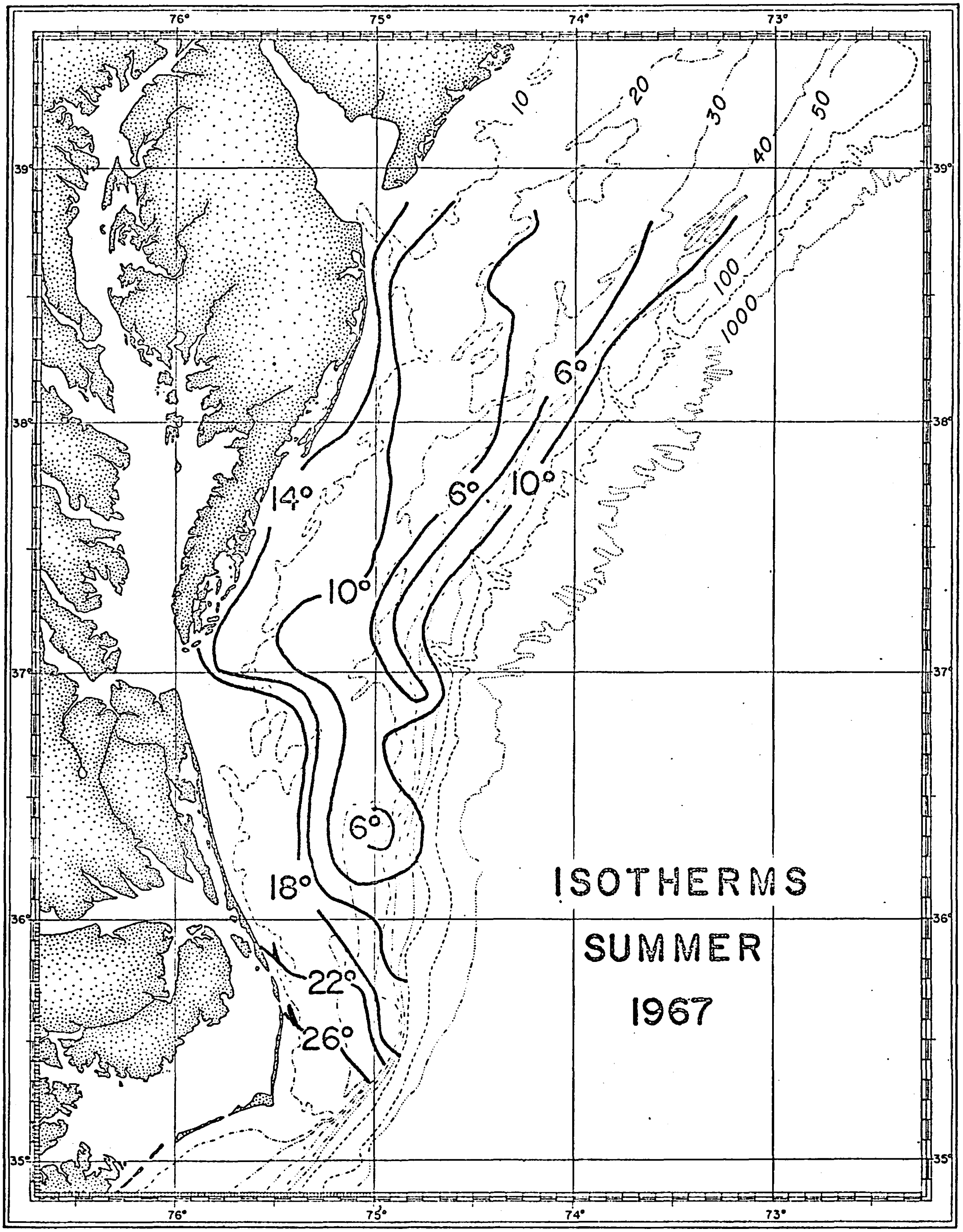

76°
75°
74°
73°
39°
38°
37°
36°
35°
SUMMER, 1967
CHESAPEAKE BIGHT
AVERAGE - 380 lbs./hr.
INDEX - 157 million lbs.
BEST AREA ▨
AVERAGE - 950 lbs./hr.
INDEX - 102 million lbs.

Fig. 5.


ISOTHERMS
SUMMER
1967
76°
75°
74°
73°
39°
38°
37°
36°
35°
10
20
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100
1000
14°
10°
6°
6°
10°
10°
6°
18°
22°
26°

Fig. 6.

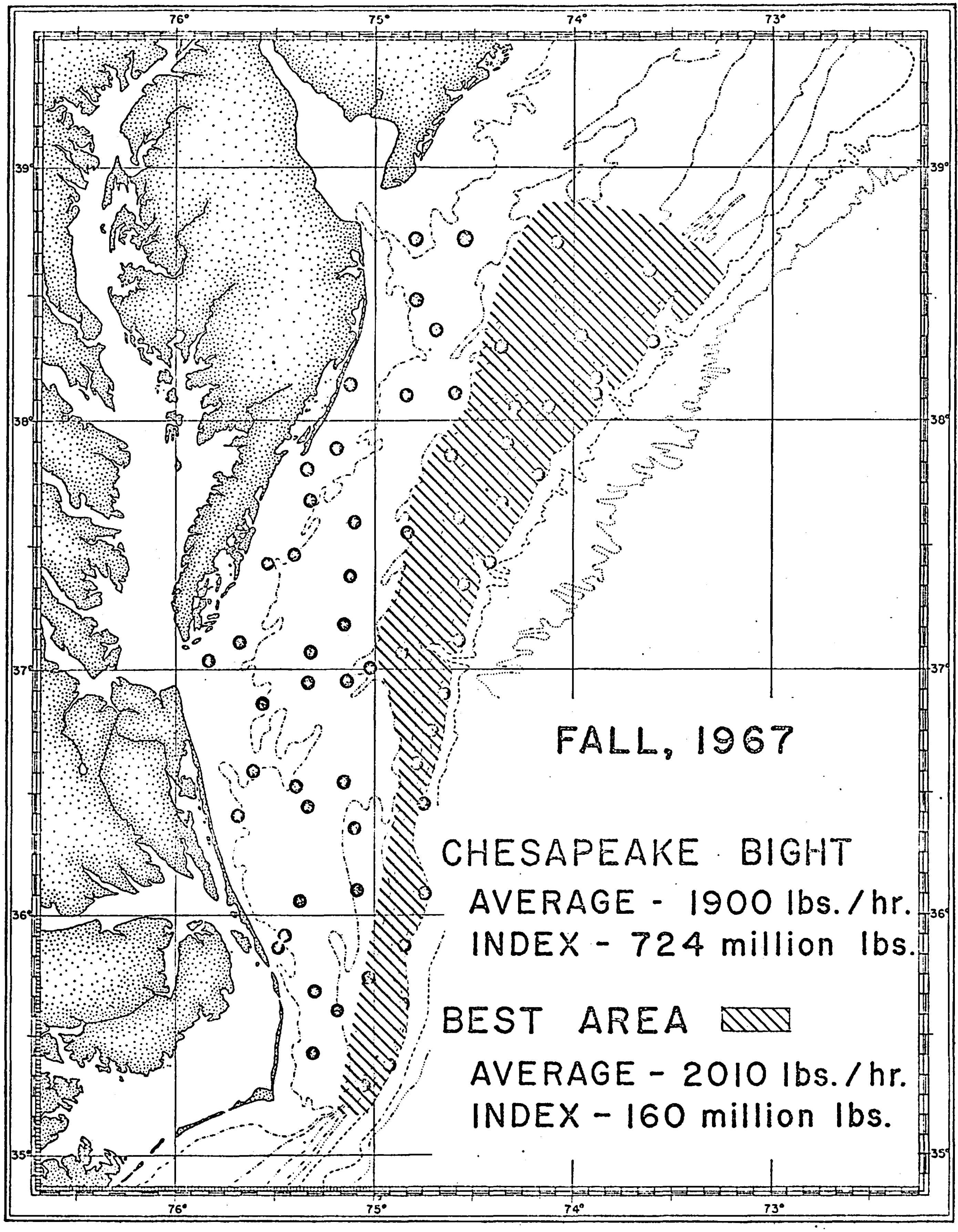
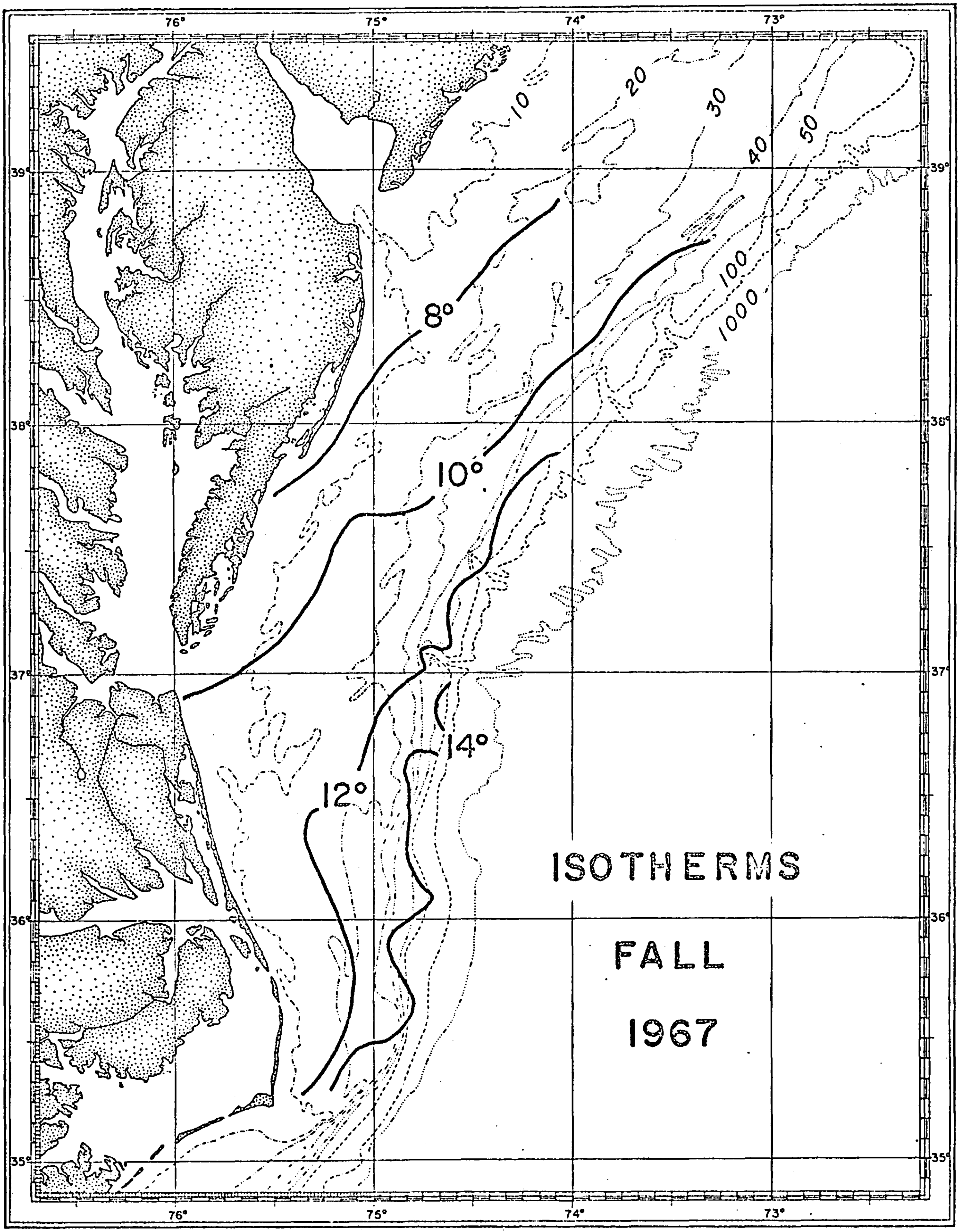

76°
75°
74°
73°
39°
38°
37°
36°
35°
FALL, 1967
CHESAPEAKE BIGHT
AVERAGE - 1900 lbs./hr.
INDEX - 724 million lbs.
BEST AREA ▨
AVERAGE - 2010 lbs./hr.
INDEX - 160 million lbs.

Fig. 7


ISOTHERMS
FALL
1967
8°
10°
12°
14°
10
20
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100
1000
76°
75°
74°
73°
39°
38°
37°
36°
35°

Fig. 8.

PHASE II

ANALYSIS OF DISTRIBUTION AND ABUNDANCE OF BENTHIC FISHES

By

JACKSON DAVIS, J. A. MUSICK, AND E. B. JOSEPH

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In considering the potential for expanding the Middle Atlantic fishery, we estimated the availability of benthic fishes on the 15,000 square miles of the continental shelf between Cape Hatteras and Cape May during 1967. Availability, as used here, is in terms of the quantity of fishes that could be caught by a specific trawl. We used an Atlantic Western Model IV trawl, which is a four-seam net having a headrope of 54 feet and footrope of 78 feet. Stretched mesh sizes were 8 inches in the body, 6 inches in the extension, and 4 inches in the codend. The net was fished from the SEA BREEZE, an 88 gross ton side trawler of 340 h.p. which we chartered.

To estimate the quantity of fish available to the Atlantic Western trawl, we converted our catch in each one-hour tow to pounds per nautical mile, and finally to pounds (or tons) in the area covered by each of the several depth strata shown in Figure 1. Measurements of an Atlantic Western trawl by the BCF Exploratory Fishing and Gear Research Base at Gloucester, Massachusetts indicated that the headrope was 9 to 11 feet above the bottom and that the mouth opening was 34 to 37 feet wide when fished as we fished it. In estimating the quantity of fish available to this trawl we have assumed a lateral mouth opening of 35 feet, thus neglecting any herding effect of the bridles and groundwires. We stress the point that our estimate is of quantity of fish available to a certain type net. Had we used a different net the estimates would be somewhat different. Nevertheless, the estimates are useful as order-of-magnitude indicators of standing crop.

As a matter of convenience for considering the economic potential of the resources, we have grouped the species into 3 categories: food fish, spiny dogfish and trash fish. The category food fish consists of those few species now caught by trawlers and marketed for human food and which are likely to be caught in sufficient quantity to make worthwhile the task of separating them from the unsalable portion of the catch. Included are:

scup	*Stenotomus chrysops*
black seabass	*Centropristes striatus*
summer flounder	*Paralichthys dentatus*
butterfish	*Peprilus triacanthus*
Atlantic croaker	*Micropogon undulatus*
spot	*Leiostomus xanthurus*

Spiny dogfish *Squalus acanthias* is considered a separate category because it is a major proportion of the fish biomass and therefore is a potential fishery resource. At present it is a nuisance species which is avoided by fishermen.

All other species are lumped in the category, trash, the composition of which changes somewhat seasonally. In winter the greatest bulk consists of:

goosefish	*Lophius americanus*
spotted hake	*Urophycis regius*
red hake	*U. chuss*
silver hake	*Merluccius bilinearis*
northern searobin	*Prionotus carolinus*
rosette skate	*Raja garmani*
little skate	*R. erinacea*
winter skate	*R. ocellata*
clearnose skate	*R. eglanteria*

fourspot flounder	*Paralichthys oblongus*
windowpane flounder	*Scophthalmus aquosus*

In summer several species move northward. Remaining as important components of the trash are:

spotted hake	*Urophycis regius*
northern searobin	*Prionotus carolinus*
rosette skate	*Raja garmani*
clearnose skate	*R. eglanteria*

In deep water the fourspot flounder remains and in shallow water the large roughtail stingray *Dasyatis centroura* becomes important, not so much in numbers, but in weight.

Thermal patterns of the bottom waters as illustrated in Figure 2 indicate that temperature changes little from summer to winter on the outer shelf. Nearshore waters are warm in summer and cold in winter. Eddies from the Gulf Stream produce an irregularly changing thermal pattern in the section from Cape Hatteras to about 36°N latitude.

In the winter (February and March) of 1967 an estimated 234,000 metric tons were available to our trawl. Figure 3 indicates a greater quantity of fish of all categories in the northern sector than in the southern and shows the overwhelming abundance of spiny dogfish, which comprised 70% to 80% of the available biomass. Figure 4, a plot of catch-rates in pounds/mile, indicates that the most productive fishing for food fish, trash fish, or dogfish was in the deepest stratum in the north. The shoal water yielded trash fish and dogfish but lacked food fish. In the south, dogfish were most concentrated in depths of 11 to 20 fathoms, trash fish in 21 to 40 fathoms, and food fish were most abundant deeper than 40 fathoms.

Because rough seas restricted our sampling in winter 1967, we sampled again in 1968 (Figure 5). Total available biomass, 340,000 tons, was much greater than in the previous winter, but other features were only slightly different.. The greatest quantity of fish was in the northern sector. Spiny dogfish were distributed as in 1967 in the south, but in the north were most abundant in mid-depths rather than in deep water. Similarly, in catch rates (Figure 6) the major change was a shift in the spiny dogfish in the north. Food fish were most abundant near the edge of the shelf.

In spring (Figure 7) the northward migration of spiny dogfish was apparent. Only 500 tons remained in the southern sector and about 4,000 in the northern. The total quantity of trash species declined somewhat in both sectors. Food fish became more abundant, especially in the south but were mostly small. Some inshore movement of both trash fish and food fish was apparent (Figure 7, 8).

By summer (Figure 9) the spiny dogfish had virtually deserted the area, there being none in the southern sector, and only 400 tons in the northern. Other species from the outer shelf had also gone north. Both the greatest quantity and the greatest concentration (Figure 10) were in the shoalest stratum.

Fall (late November and December) saw the return of the spiny dogfish (Figure 11) and other northern species and the offshore movement of the species that had been in shoal waters in summer. The deepest waters again contained the densest concentration of food fish (Figure 12).

PHASE

PROSPECTS FOR EXPLOITATION

The fishing industry can be broadly separated into three parts, the recreational sector, the food sector, and the industrial sector. The first is only slightly involved here. The second produces and marke fish for direct human consumption. The last produces fish meal, oil, and associated products which are used in animal feeds and in a varie of industrial activities. The popular food fishes which exist in Chesapeake Bight are now being harvested at the maximum level, or perha beyond. The trash fish and spiny dogfish are used in very minor quantity.

The industrial fishery is badly in need of additional resources. Less than 25% of the fish meal consumed in this country is produced her The question of whether or not the trash fish and spiny dogfish of Chesapeake Bight can be used by the industrial fishery cannot be answe unequivocally at present. The spiny dogfish, the species comprising 70 to 80% of the biomass in winter, is without a domestic market eithe as food or as an industrial fish. It is a desirable food-fish in Eu markets, but export is not economically feasible /Holmsen, Andreas A. 1968. Harvesting and processing dogfish (Squalus acanthias), Universit Rhode Island Dept. Food & Resource Economics, Occasional Paper 68-275_7 At least two problems must be solved before dogfish can be used exte in an industrial fishery. A method must be developed to handle them efficiently in large quantities. Their large size and tough, rough sk are not compatible with the machinery now in use. Also, urea, a consti uent of the blood, is undesirable in poultry feed where fish meal is no used. Either the urea must be removed or a new market must be developed. Perhaps shark meal could be used in cattle feed, since ruminants metabolize urea. Several technological laboratories are now attempting to solve problems that restrict the use of dogfish.

Although the population of spiny dogfish is large, the reproductive potential of the species is not great, and the sustainable annual yield from this stock will be smaller than from a more fecund species. Probably the population could be fished down to a low level in a brief period of time. Perhaps drastic reduction of the population would be desirable since the species is a nuisance to the existing fisheries. Certainly the reduction of a predator and competitor of such overwhelming dominance would provide an interesting opportunity to observe the responses of prey species and competing predatory species.

Trash fish appear to be sufficiently abundant to sustain a fishery and can be handled by existing machinery. The major problems seem to be to reduce the cost of catching the fish and to produce meal of constant composition. In winter an additional problem is the rather general occurrence of spiny dogfish along with trash fish. Culling them from the catch is expensive. Increased use of benthic fishes in Chesapeake Bight is feasible but spiny dogfish will be an impediment.

The manufacture of fish protein concentrate possibly offers a future market for both the trash species and dogfish. Regarding dogfish the same problems exist. In any case, the market for FPC is very small and is unlikely to change quickly unless the world economic picture changes and the Food and Drug Administration broadens its rulings concerning FPC.

SUMMARY

The fish biomass available to the Atlantic Western trawl IV was 340,000 tons in winter 1968 consisting of 61,000 tons of trash fish, 273,000 tons of spiny dogfish, and 6,000 tons of food fish (Table 1). In the winter of 1967 the quantity was less, 234,000 tons, but the proportions were about the same: trash fish, 43,000 tons, spiny dogfish, 186,000 tons, food fish, 4,000 tons. In spring 1967 the total of 60,000 tons was comprised of 46,000 tons of trash fish, 4,000 tons of spiny dogfish, and 10,000 tons of food fish. In summer the total was 58,000 tons of which 52,000 was trash fish and 6,000 was food fish. Spiny dogfish were absent. In fall the total of 356,000 tons was composed of 77,000 tons of trash fish, 257,000 tons of spiny dogfish, and 22,000 tons of food fish. These estimates exclude pelagic fish such as herring, river herring, mackerel, and round herring which occur in some quantity, at least seasonally.

TABLE I. AVAILABLE FISH BIOMASS IN CHESAPEAKE BIGHT (METRIC TONS)

SEASON	NORTH	SOUTH	TOTAL
WINTER 1968	204,960	134,922	339,882
WINTER 1967	161,112	72,971	234,083
SPRING 1967	36,843	23,271	60,114
SUMMER 1967	28,327	29,564	57,891
FALL 1967	173,404	182,120	355,524

PHASE II

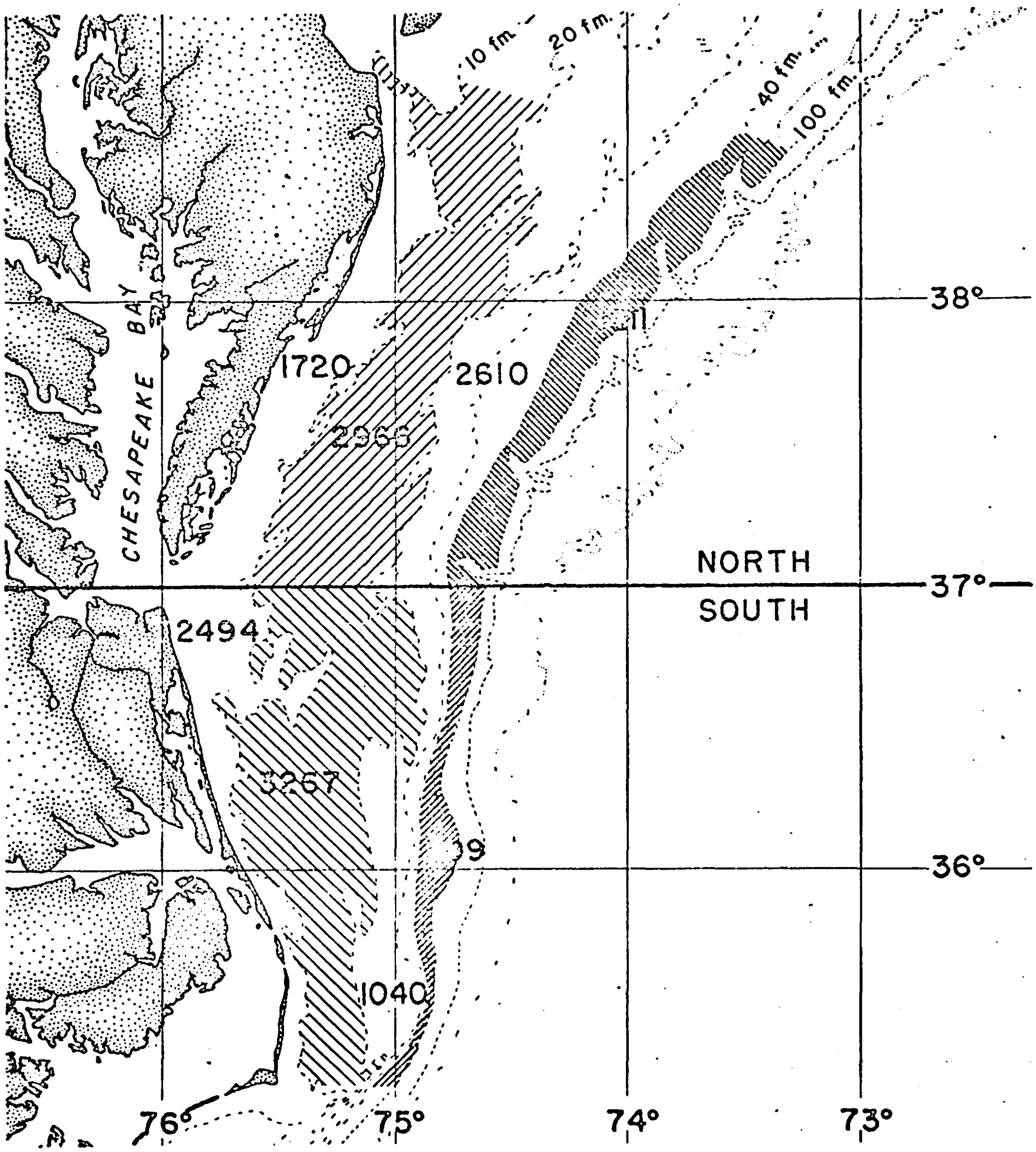

Figure 1. Area, in square nautical miles, of the depth strata used in estimating the availability of benthic fishes in Chesapeake Bight.

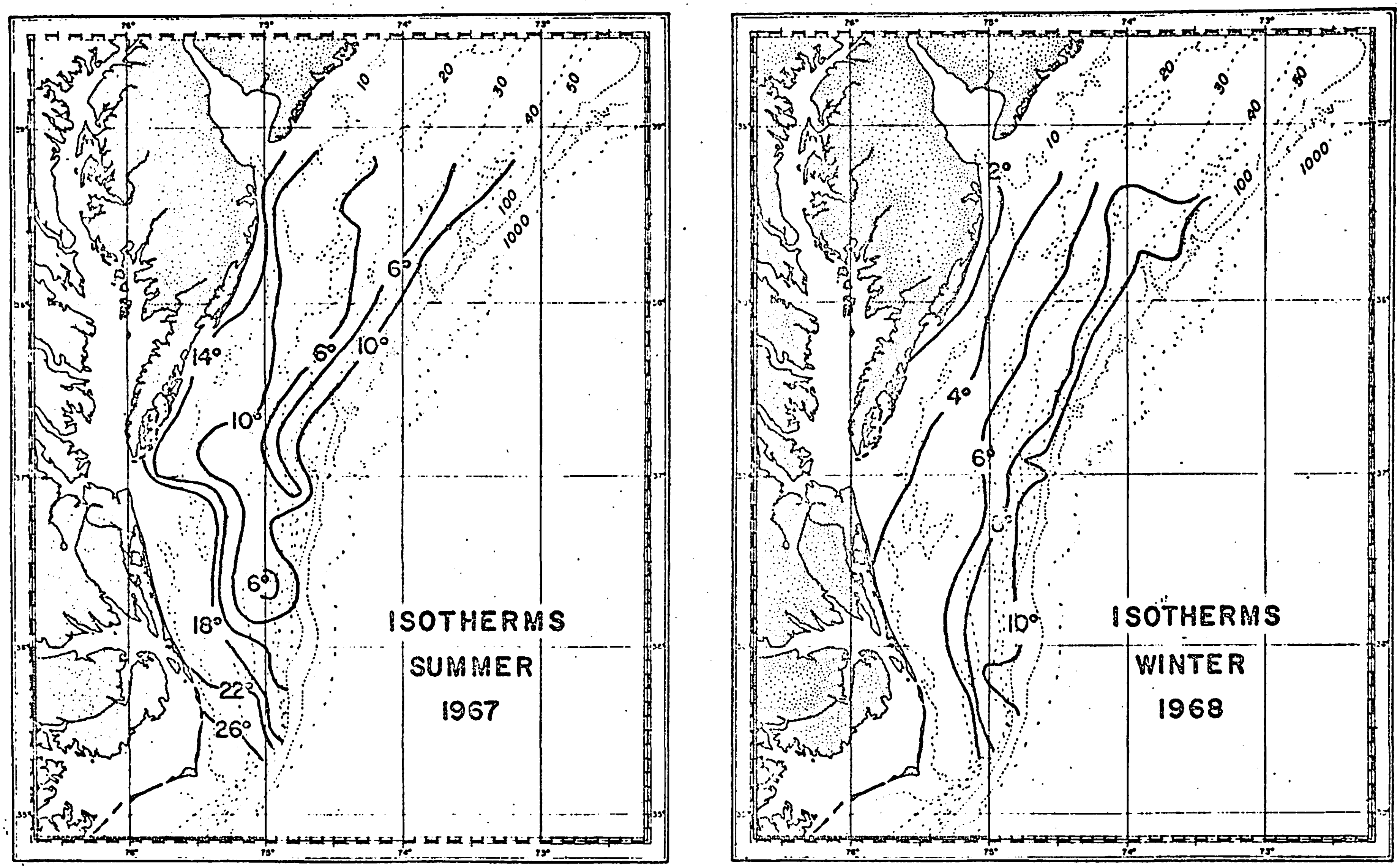

Figure 2. Thermal pattern of the bottom waters of Chesapeake Bight.

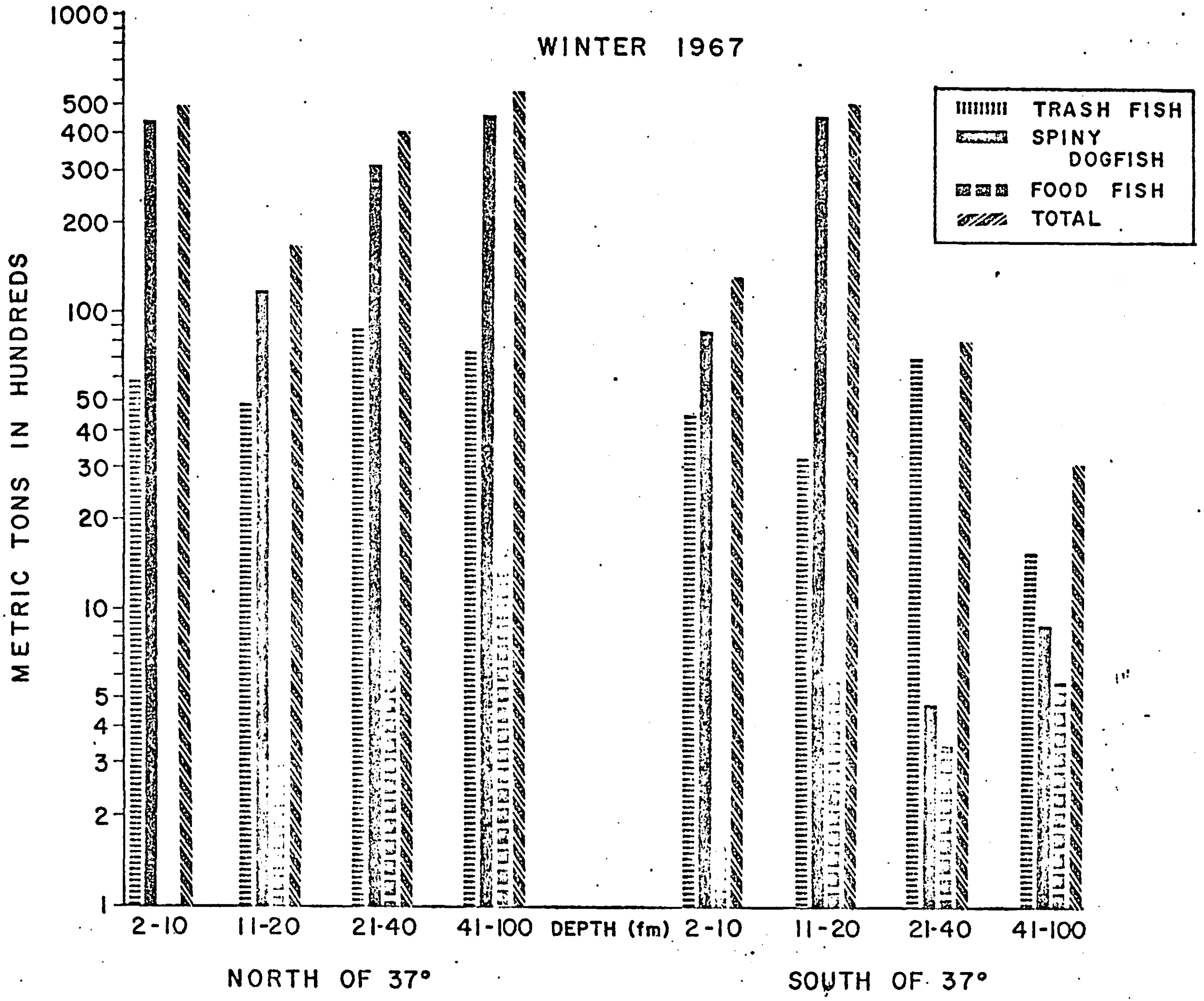

Figure 3. Distribution of benthic fishes of Chesapeake Bight in winter 1967.

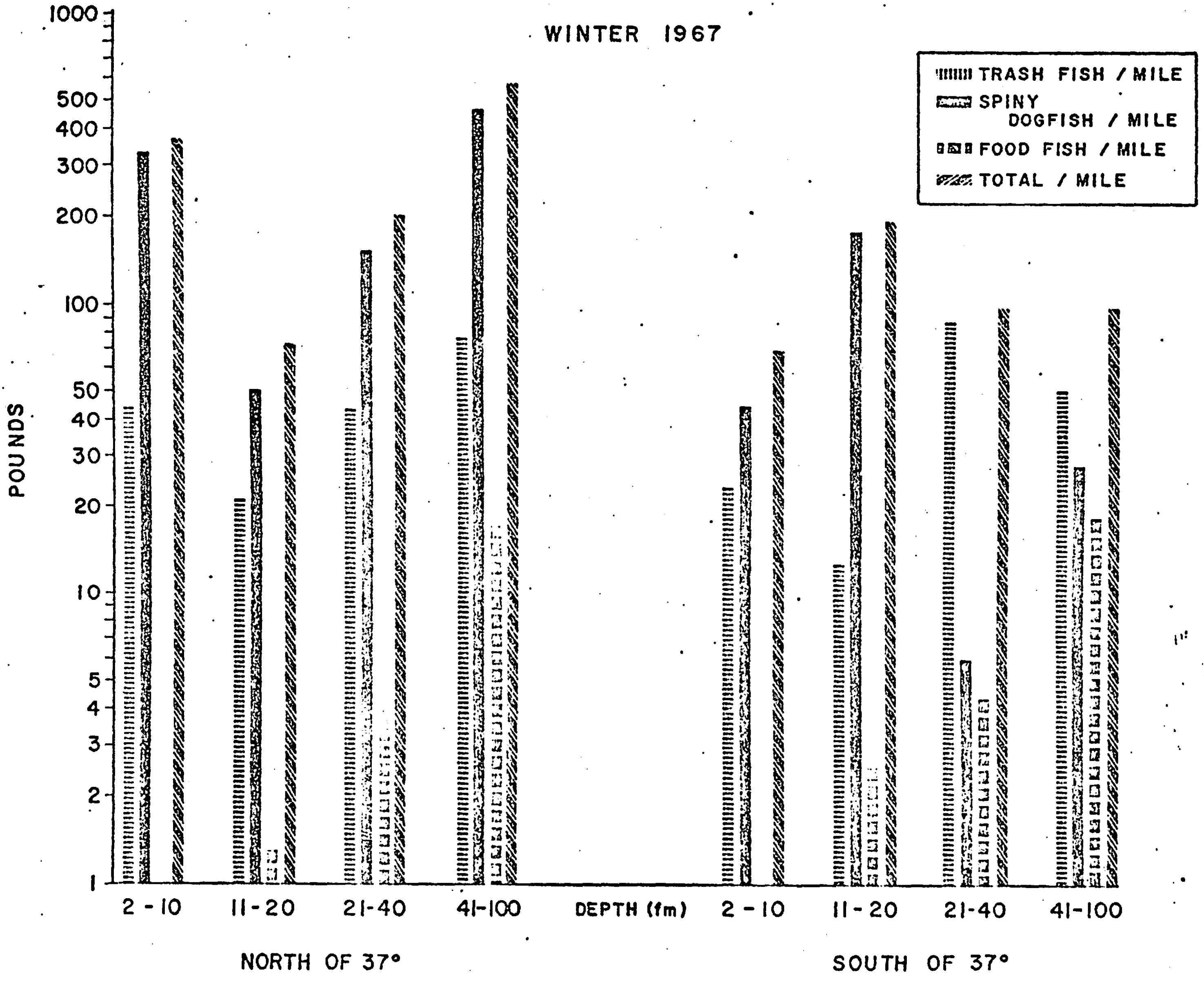

Figure 4. Catch rate of benthic fishes in Chesapeake Bight in winter 1967.

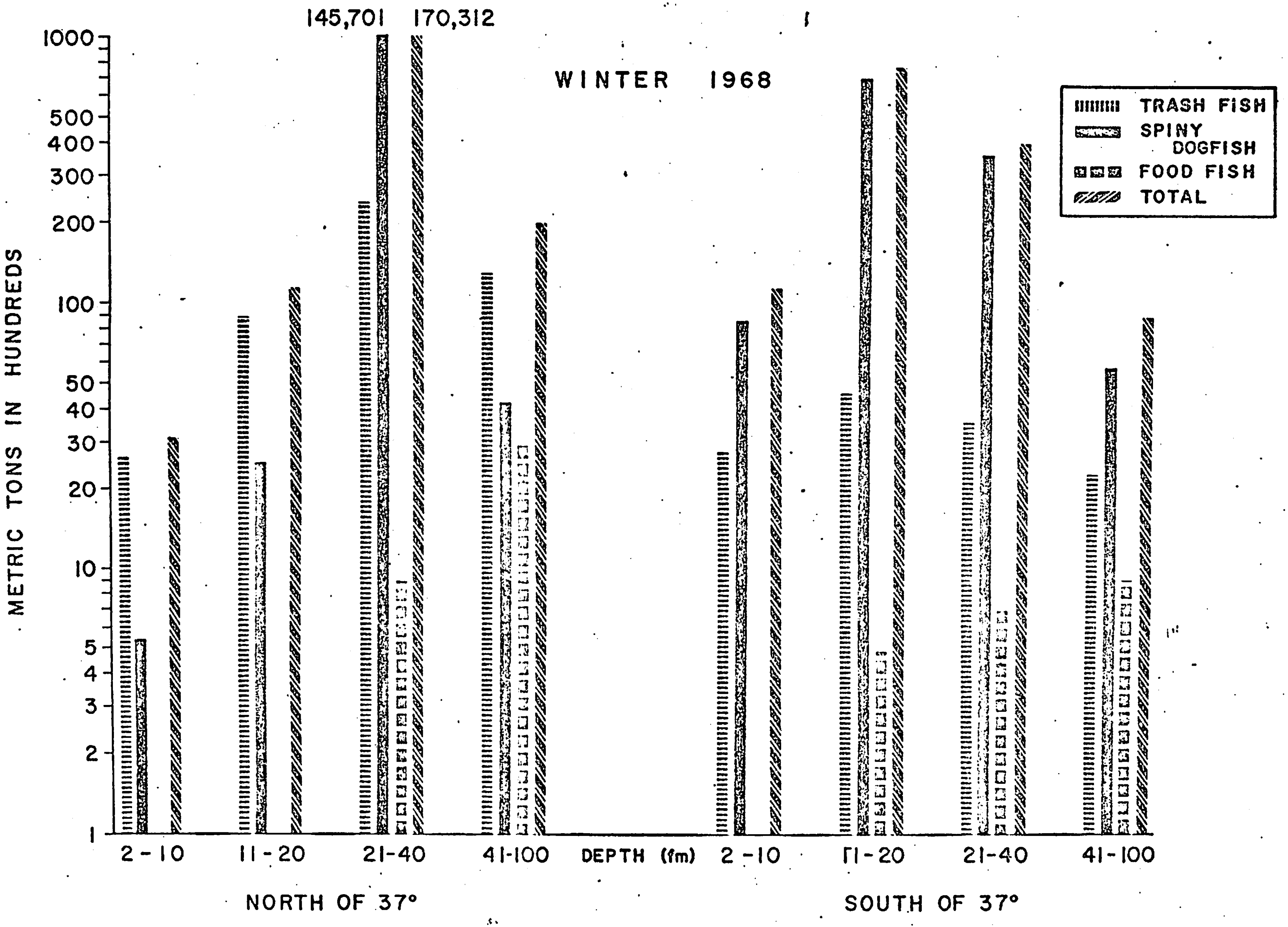

Figure 5. Distribution of benthic fishes of Chesapeake Bight in winter 1968.

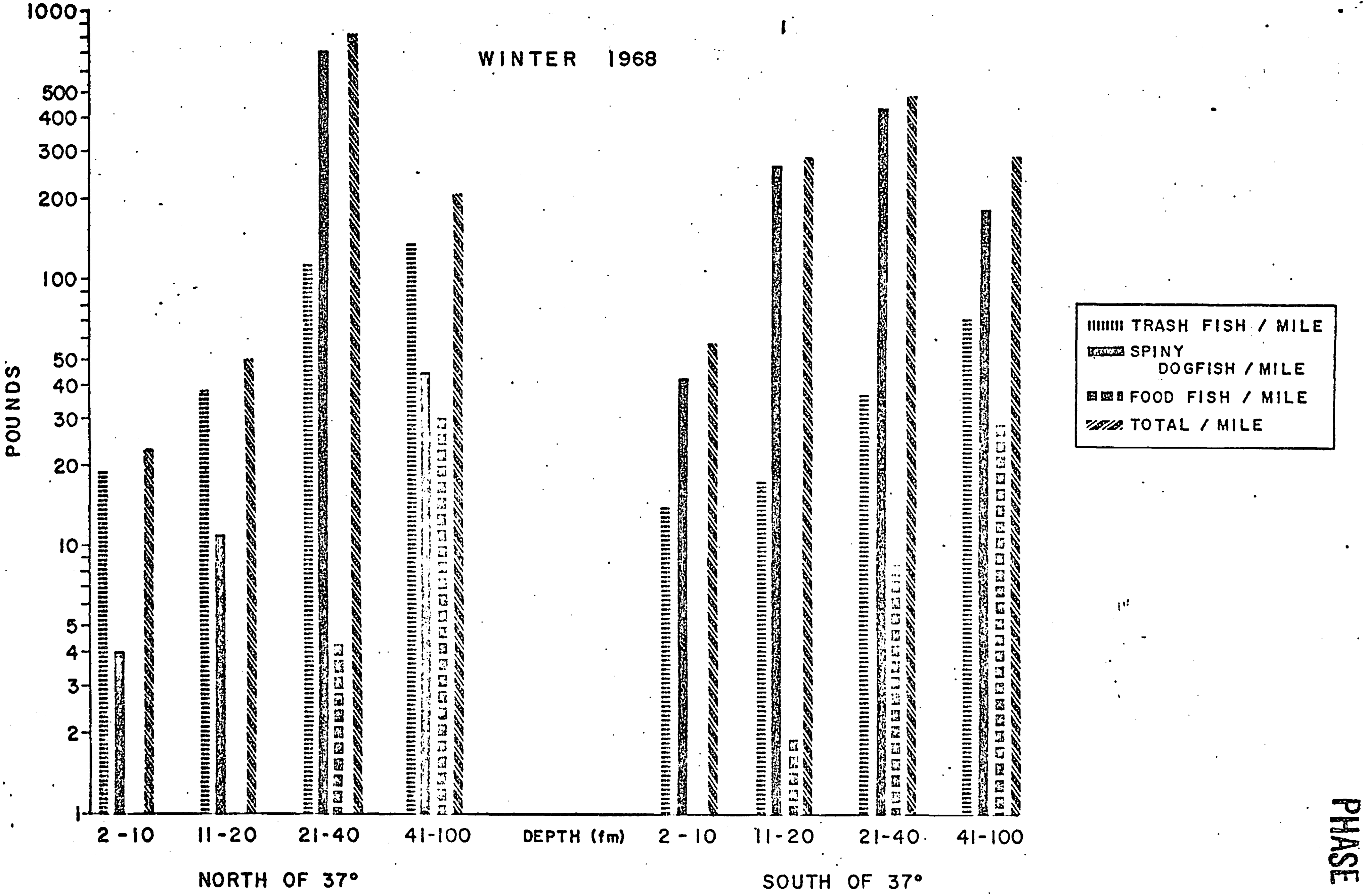

Figure 6. Catch rate of benthic fishes in Chesapeake Bight in winter 1968.

PHASE II

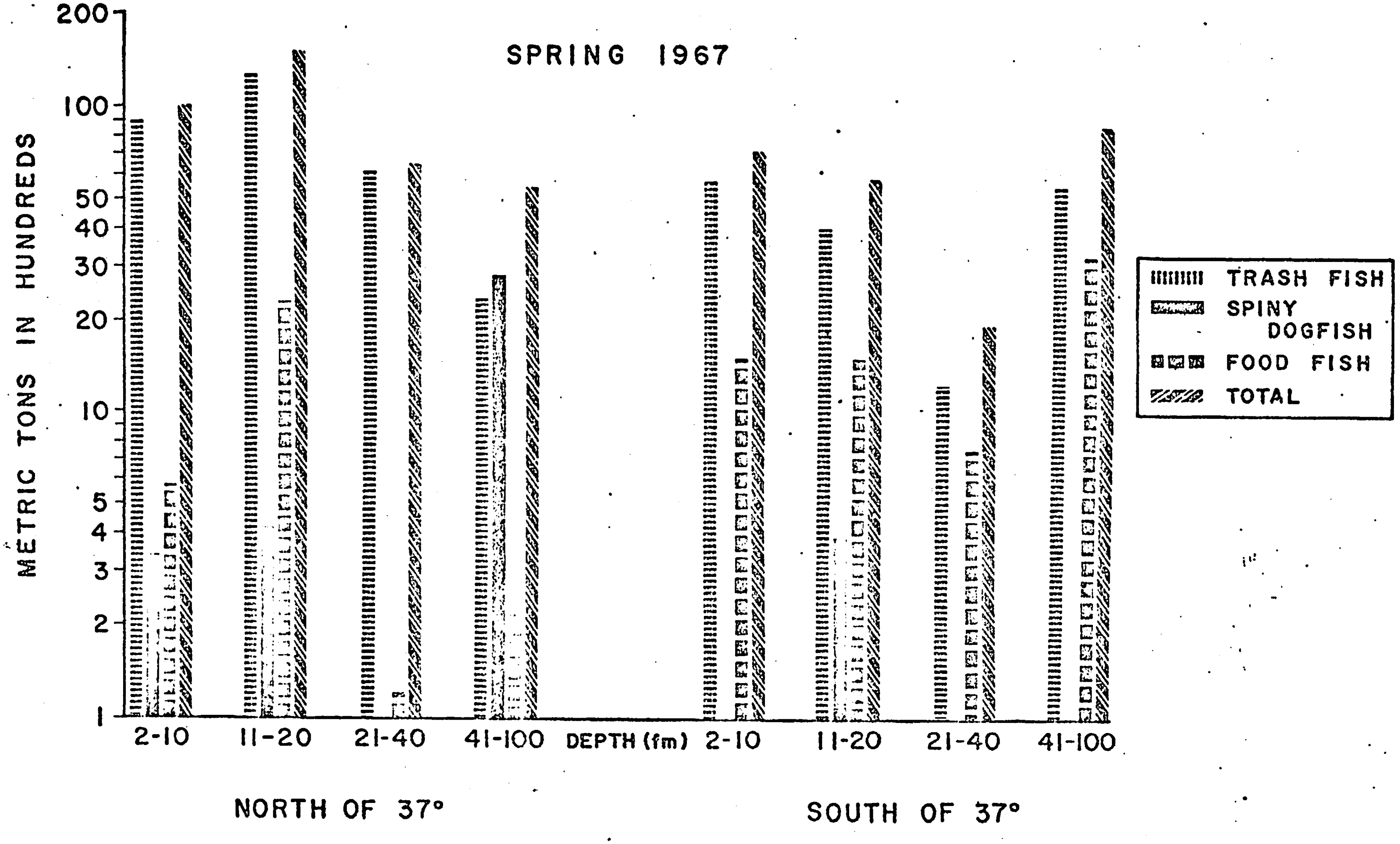

Figure 7. Distribution of benthic fishes of Chesapeake Bight in spring 1967.

PHASE II

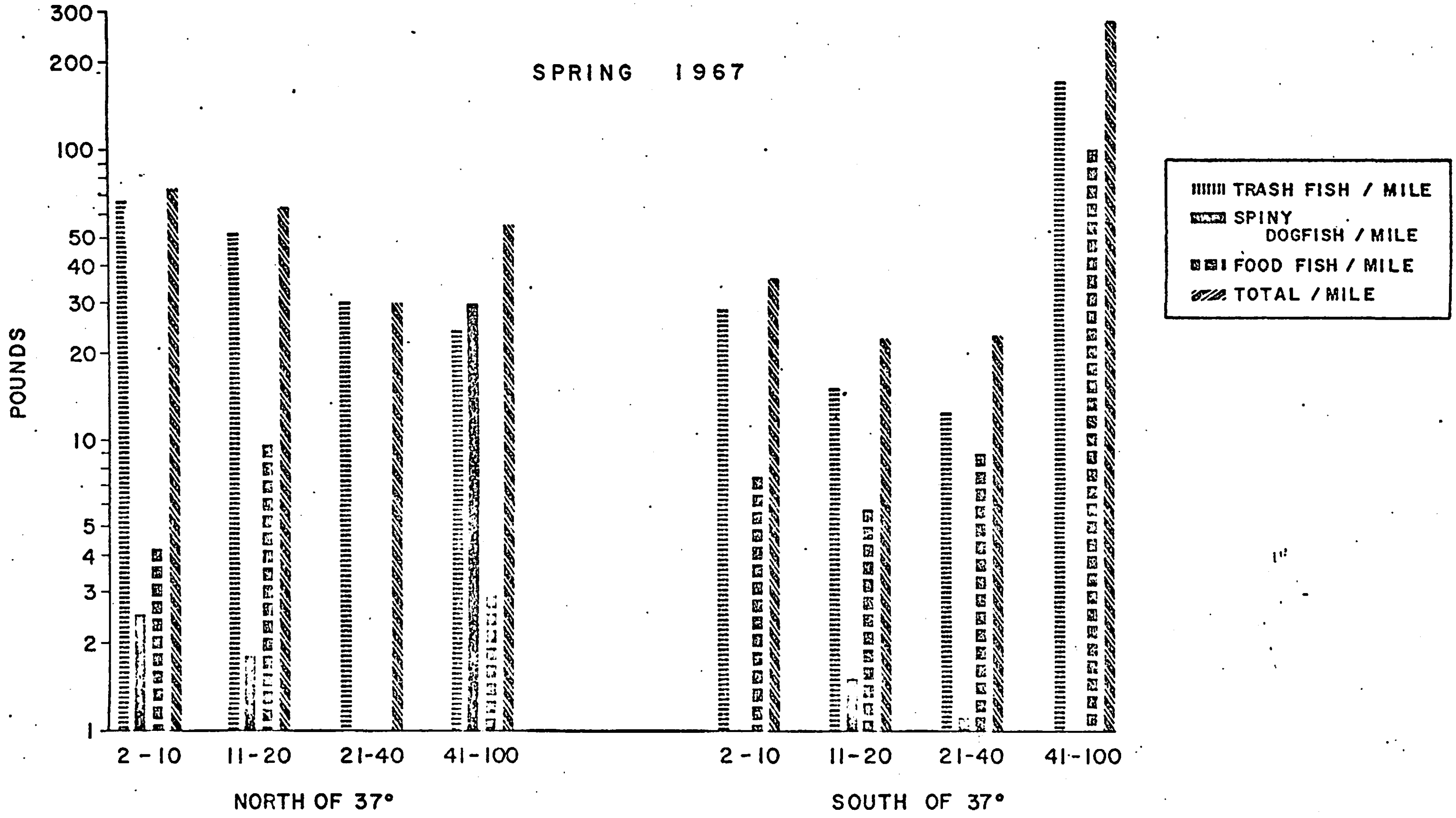

Figure 8. Catch rate of benthic fishes in Chesapeake Bight in spring 1967.

PHASE II

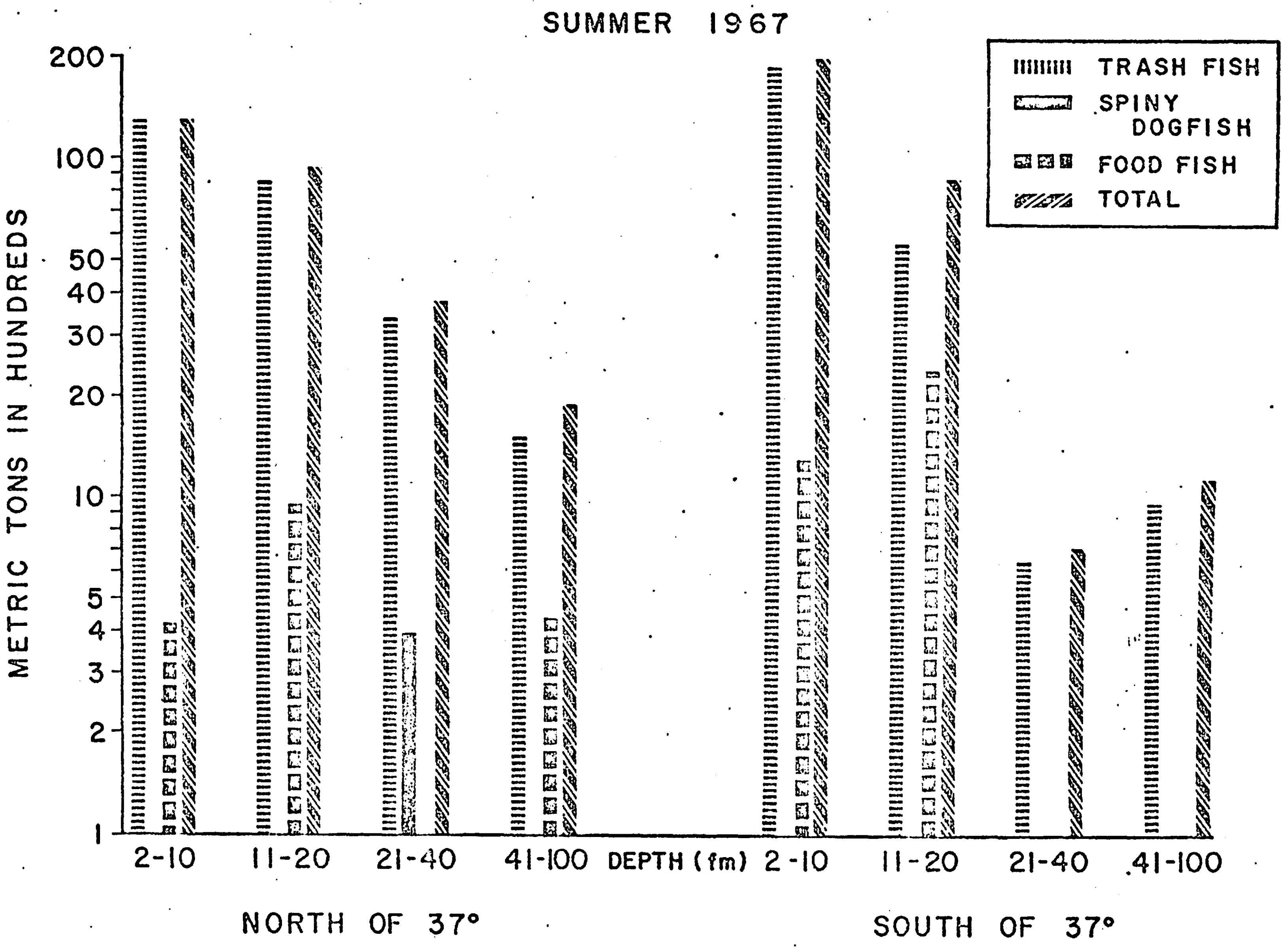

Figure 9. Distribution of benthic fishes of Chesapeake Bight in summer 1967.

PHASE II

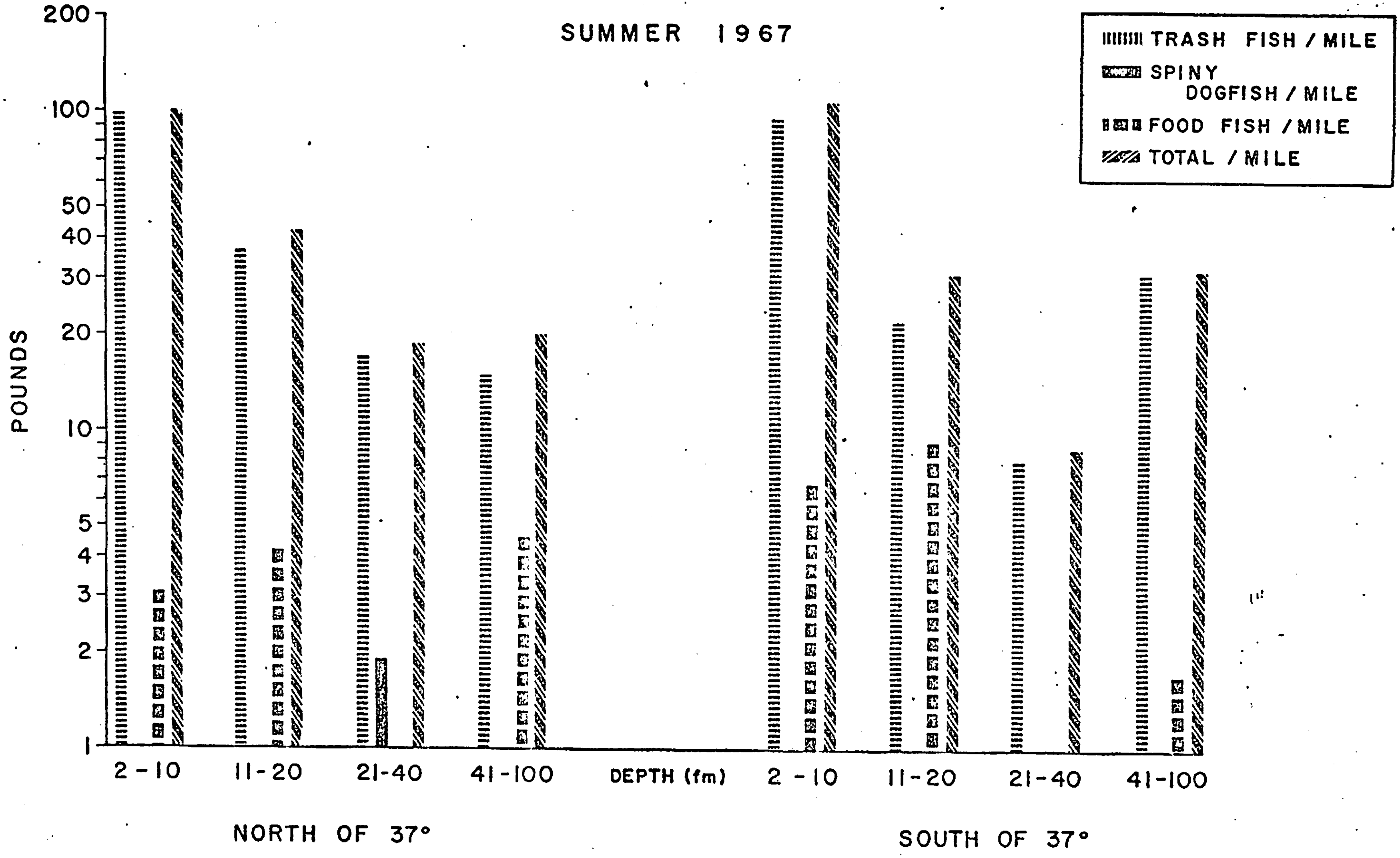

Figure 10. Catch rate of benthic fishes in Chesapeake Bight in summer 1967.

PHASE 11

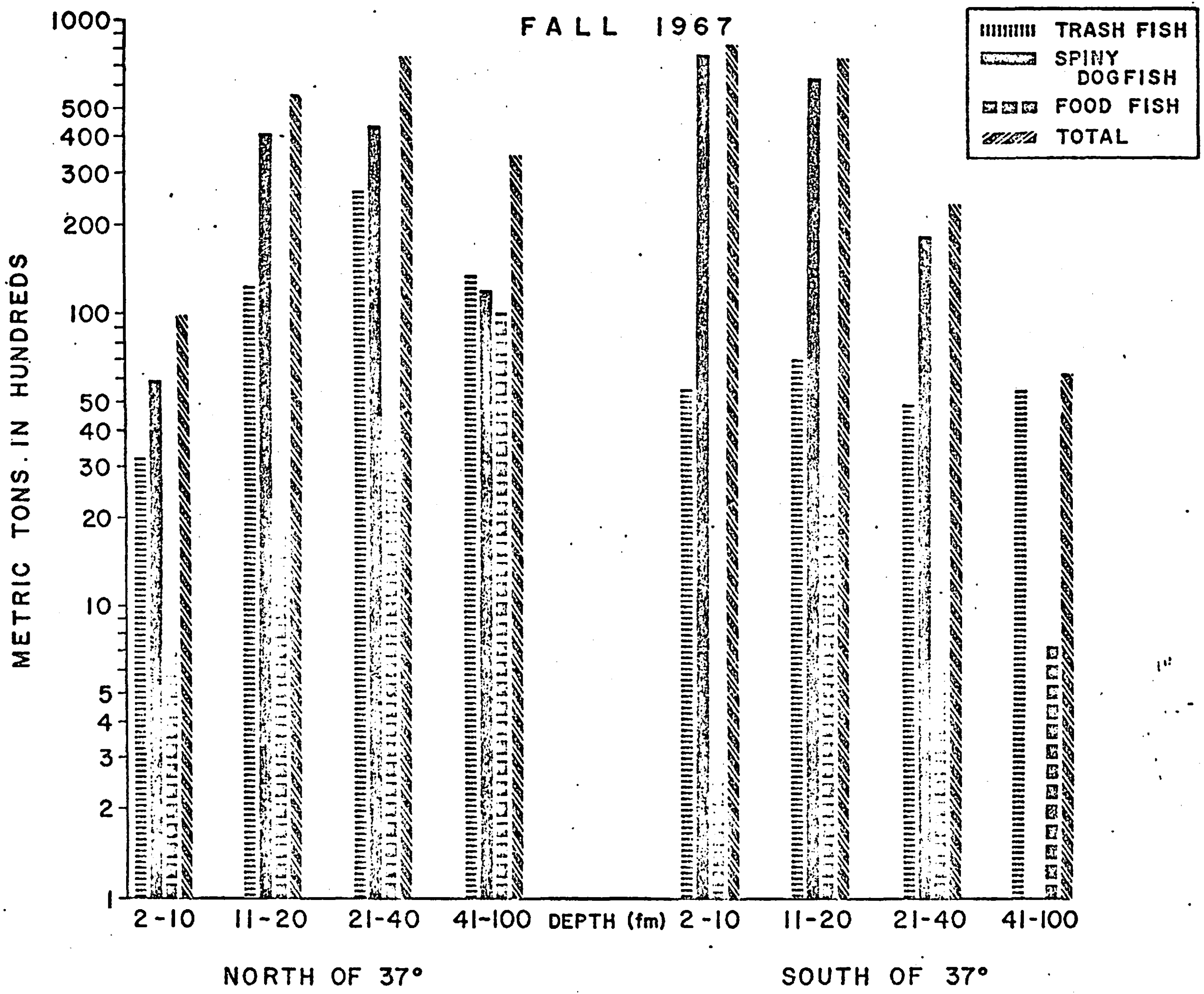

Figure 11. Distribution of benthic fishes of Chesapeake Bight in fall 1967.

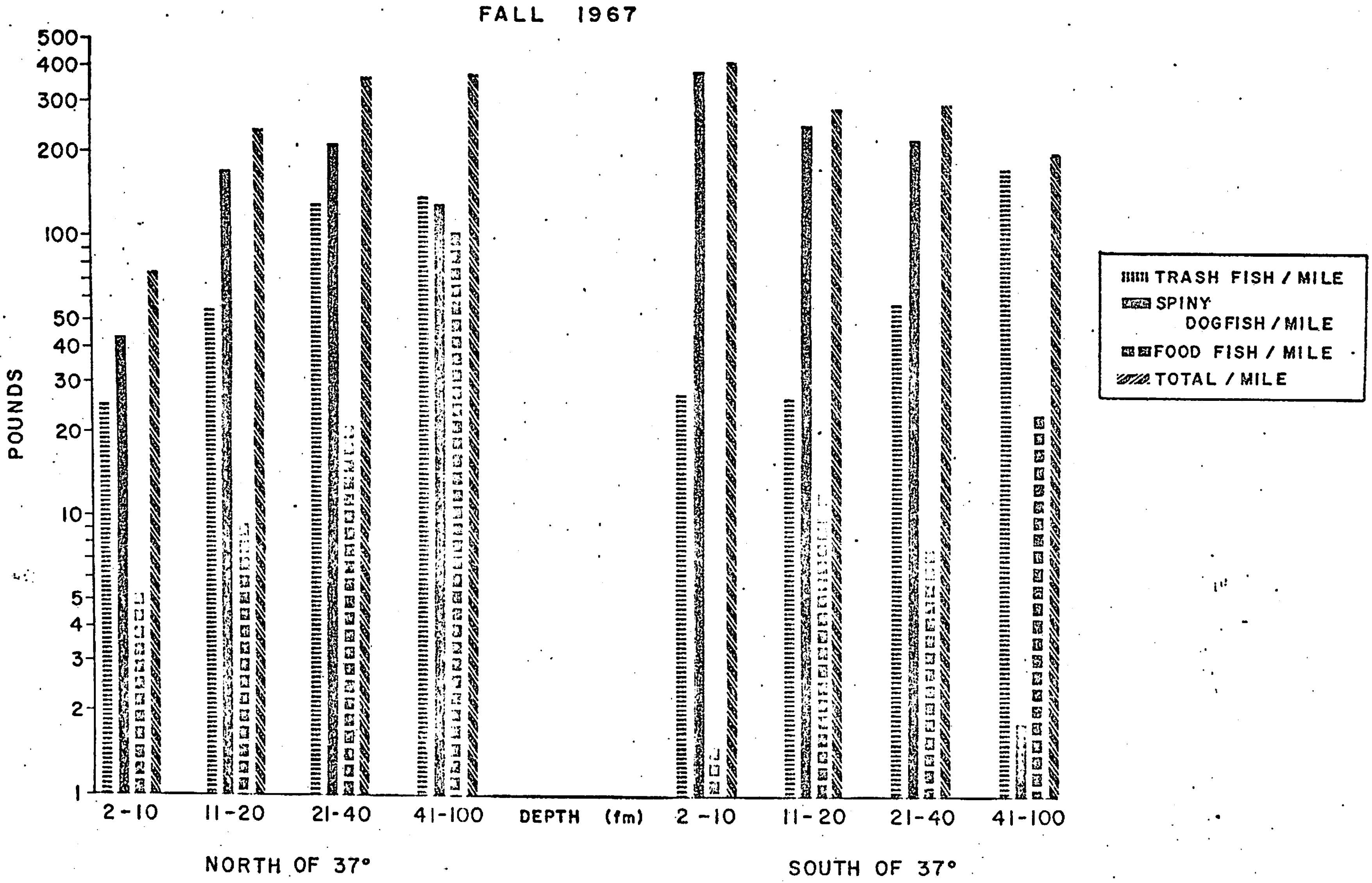

Figure 12. Catch rate of benthic fishes in Chesapeake Bight in fall 1967.

PHASE 11

SEASONAL DISTRIBUTION OF MAJOR SPECIES OF DEMERSAL FISHES IN CHESAPEAKE BIGHT

by

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INTRODUCTION

The major species of demersal fishes which occur in Chesapeake Bight may be divided into two rather loosely-margined groups. One group has southern affinities, is found inshore during the summer and migrates offshore or to the south or both during the winter. The other group has northern affinities and occurs inshore during the winter or spring and late autumn and migrates offshore or to the north or both during the summer. The following analyses examine the seasonal distribution of 11 species of demersal fishes in the Chesapeake Bight with respect to depth and temperature.

METHODS

Methods of collection have been outlined in detail in earlier phases of this report.

Analyses of distribution.

Catch data for each of the five seasonal cruises were separated geographically into two groups, one north and the other south of 37°N latitude. Each geographical group was then stratified according to depth. The following depth strata measured in fathoms were designated: 1-10, 11-20, 21-40, 41-60, 61-90, 91-150. The number of each species captured at each station was transformed by the equation: $y = \log (x + 1)$ (x = number captured). This transformation tends to normalize the catch data, which are contagiously distributed and removes the correlation between mean and variance common to such statistical distributions. Mean transformed values were computed for all stations in each stratum and these have been plotted as an index of abundance for each species in Figs. 1-5 and 16-20. The data from each geographical zone were also stratified by temperature intervals of 1 C and the same methods of transformation and computation were used (Figs. 6-15 and 21-30). A few depth and temperature strata were insufficiently sampled to arrive at reliable abundance values. We realize, of course, that the index of abundance here is one of *apparent*, not actual, abundance and merely reflects the availability of each species to our trawl. Availability may depend on many factors which influence the behavior of each species. The estimation of "catchability" and other such variables are beyond the scope of this paper and we leave this chore to others whose crystal ball may be a bit shinier than ours.

RESULTS AND DISCUSSION

Fishes with southern affinities.

Of those species examined six had southern affinities: *Prionotus carolinus*, *Urophycis regius*, *Peprilus triacanthus*, *Paralichthys dentatus*, *Centropristes striatus* and *Stenotomus chrysops*.

The first two of these are potentially valuable as industrial fishes and the last four presently are the most important commercial food fishes in the Bight. The last three species also contribute heavily to the inshore summer sport fishery.

Prionotus carolinus: The northern searobin was moderately abundant between 21 and 60 fms during winter 1967 (Fig. 1), and became very abundant during the spring when it moved inshore and northward (Fig. 2). In summer it was very abundant shoaler than 20 fms (Fig. 3) and in the fall the species moved offshore and to the south between 21 and 60 fms (Fig. 4). In winter 1968 the species again was most abundant between 21 and 60 fms (Fig. 5).

Urophycis regius: The spotted hake was most abundant between 41 and 90 fms during winter 1967 (Fig. 1). In spring there was some movement inshore and a great increase in abundance between 61 and 90 fms south of 37°N (Fig. 2). During the summer the species was widely distributed from the shoalest depths sampled to 90 fms and was most abundant in the deeper strata (Fig. 3). In the fall the species appeared to disperse and was abundant in all strata (Fig. 4). In winter 1968 the species was virtually absent at depths shoaler than 20 fms and was most abundant to the south between 61 and 90 fms (Fig. 5).

Peprilus triacanthus: The butterfish was most abundant offshore between 61 and 90 fms during winter 1967 (Fig. 1) and moved inshore during spring (Fig. 2). The apparent abundance of the species increased tremendously south of 37°N between 21 and 150 fms at that season. In summer the species moved to the north (Fig. 3) and in fall was widely distributed over the entire Bight (Fig. 4). During winter 1968 butterfish were most abundant between 41 and 90 fms (Fig. 5).

Paralichthys dentatus: The summer flounder was virtually absent inshore during winter 1967 and most abundant between 41 and 60 fms (Fig. 1). In spring the abundance of this species dropped as it moved inshore where it is known to enter estuaries (Fig. 2). The species remained inshore during the summer (Fig. 3). In fall the species dispersed and was abundant over a wide range of depth strata, particularly offshore to the north (Fig. 4). This pattern suggests a movement into the Bight of fish from northern summering areas. In winter 1968 the species again was most abundant between 41 and 60 fms (Fig. 5).

Centropristes striatus: The black seabass was most abundant south of 37°N between 41 and 90 fms in winter 1967 (Fig. 1). In summer the abundance of seabass dropped and it was found mostly at depths less than 20 fms (Fig. 3). In fall an offshore movement occurred and the species was most abundant between 21 and 60 fms (Fig. 4). In winter 1968 the species moved even farther offshore to 41 and 90 fms (Fig. 5).

Stenotomus chrysops: The scup was most abundant south of 37°N between 41 and 60 fms in winter 1967 (Fig. 1). During spring the species moved inshore and to the north (Fig. 2). In summer the species was most abundant inshore (Fig. 3) and during the fall it moved offshore both north and south of 37°N but was most abundant between 41 and 60 fms north of 37°N (Fig. 4). In winter 1968 the species was most abundant between 41 and 60 fms (Fig. 5).

Patterns of abundance: During the winter, the northern searobin, summer flounder and scup were most abundant between 41 and 60 fms where they often occurred with the spotted hake, butterfish, and seabass. However, these last three were also abundant down to 90 fms. During the spring all of the species with southern affinities showed evidence of movement inshore and to the north. But, seabass, butterfish, spotted hake, and scup also increased or maintained their abundance south of 37°N in the deeper strata. This pattern suggests an influx of these four species into the Bight from south of Cape Hatteras.

During the summer the apparent abundance of all species except spotted hake was low because parts of their populations migrated out of the Bight to the north and others entered estuaries or inhabited the vicinity of wrecks and other rough bottom and were unavailable to our trawl. Spotted hake remained abundant over the entire Bight, particularly between 61 and 90 fms to the south suggesting that the influx of this species from south of Cape Hatteras may continue into the summer.

During the fall all species were widely dispersed over the Bight. Most showed evidence of movement offshore and to the south. Scup and summer flounder were most abundant offshore north of 37°N, suggesting an influx of these species from northern summering areas.

All members of this southern group were captured in abundance at temperatures greater than 20 C and none were abundant at temperatures less than 7 or 8 C (Figs. 6-15).

Fishes with northern affinities.

Five of the species examined had northern affinities: *Squalus acanthias*, *Urophycis chuss*, *Hippoglossina oblonga*, *Lophius americanus* and *Merluccius bilinearis*.

The first of these is a major nuisance to trawlermen in Chesapeake Bight during the winter (see Phase). In Europe the species is used for food and it is potentially valuable on a short-term basis as an industrial fish. The next three species are potentially valuable as industrial fishes and the last, *M. bilinearis*, has been landed as both a food and industrial fish in New England.

Squalus acanthias: The spiny dogfish was extremely abundant in all strata sampled in winter 1967 (Fig. 16). During spring this species migrated to the north and was abundant in the Bight between 61 and 90 fms north of 37°N (Fig. 17). During the summer spiny dogfish were nearly absent except in small but persistent numbers between 21 and 40 fms north of 37°N (Fig. 18). In the fall the species migrated into the area from the north and was extremely abundant in all but the three deepest southern strata (Fig. 19). During winter of 1968 the species was extremely abundant in all strata (Fig. 20).

Urophycis chuss: During the winter of 1967 (Fig. 16) this species was abundant to the north between 21 and 150 fms and to the south between 61 and 90 fms. In the spring (Fig. 17) the species persisted in abundance in the two deepest southern strata and moved closer to shore in the north. In the summer (Fig. 18) the abundance of *U. chuss* dropped except in the strata between 21 and 40 fms in the north and 61-90 fms in the south. In the fall (Fig. 19) abundance increased greatly. Red hake were very abundant in the deepest northern stratum suggesting a movement from the north into the Bight. During winter 1968 the species was most abundant between 91 and 150 fms in the south and between 21 and 150 fms in the north (Fig. 20).

Hippoglossina oblonga: The four-spot flounder was most abundant between 41 and 90 fms in winter 1967 (Fig. 16). In spring the abundance of the species dropped in the Bight but the highest concentrations remained between 41 and 90 fms (Fig. 17). There was no apparent change during the summer (Fig. 18) but in fall the abundance in the area rose drastically and the species was most abundant between 41 and 60 fms (Fig. 19) in the north and 41 and 150 fms in the south. The pattern in winter 1968 was similar to that in 1967 (Fig. 20).

Lophius americanus: The goosefish was widely distributed in the Bight in winter 1967 and most abundant between 21 and 90 fms (Fig. 16). In spring the species was most abundant between 21 and 60 fms (Fig. 17). During the summer the goosefish moved to the north and was most abundant north of 37°N between 21 and 90 fms (Fig. 18). In fall the species remained north of 37°N but its abundance rose particularly in the two deepest strata probably because of an influx of fish from the north (Fig. 19). In winter the species spread over the Bight even south of 37°N. But there it was abundant only in the two deepest strata (Fig. 20).

Merluccius bilinearis: The silver hake was captured in all strata sampled in winter 1967, but was most abundant between 61 and 90 fms (Fig. 16). In the spring the species moved inshore north of 37°N, but remained offshore to the south (Fig. 17). During the summer the species was most abundant between 21 and 40 fms north of 37°N between 61 and 90 fms south of 37°N (Fig. 18). In the fall there was a general movement inshore over the entire

Bight. However this movement progressed into shoaler water north of 37°N than south and also abundance increased in the deepest northern stratum (Fig. 19). In winter 1968 the silver hake was most abundant between 61 and 150 fms (Fig. 20).

Patterns of abundance: During the winter the spiny dogfish is the most obvious element of the fish fauna in the Chesapeake Bight. Its overwhelming abundance in winter is sharply in contrast to that in the summer when the species virtually deserts the Bight for more northern climes. None of the other species with northern affinities undertakes so massive a migration. Although all may be mobile none attains the size of the dogfish except the goosefish which is a sluggish species apparently ill-suited for sustained swimming.

The silver and red hakes, four-spot flounder, and goosefish were abundant in the Bight during the winter in 21 fms and deeper. These species tended to occur deeper south of 37°N than north. In the spring all species showed a general northward movement and abundance dropped as parts of the populations moved out of the Bight. Unlike the spiny dogfish these other four northern species did not desert the Bight completely in the summer. Goosefish (mostly juveniles) occurred commonly north of 37°N but were rare to the south. Red and silver hake and four-spot flounder persisted in abundance at 21 to 90 fms in the north and 61-90 fms in the south, where a relatively cool tongue of bottom water persists during the summer because of thermal stratification in the upper layers of the water column (Fig. 31). In the fall as inshore waters north of 37°N cooled off first the northern species moved inshore. Concurrently abundance of these northern species increased in the strata between 61 and 150 fms as summering populations from the north migrated into the Bight.

All members of the northern group were abundant from temperatures of 5 C or lower to 12 C but none were abundant at temperatures higher than 16 C (Figs. 21-30).

The temperature preferences or tolerances of the northern group of species may prevent them from occurring inshore during the summer. The converse is probably true of the southern species. Both groups may find acceptable temperatures over much of the Bight during the fall and to a lesser extent during the spring. Both groups probably can find acceptable temperatures at any time of the year along the edge of the continental shelf where bottom temperatures are stable and moderate, 8-14 C, a range within which species of both groups have been captured in abundance.

FIGURES

Fig. 1. Bathymetric distribution of six species of demersal fishes during winter 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 2. Bathymetric distribution of six species of demersal fishes during spring 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 3. Bathymetric distribution of six species of demersal fishes during summer 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 4. Bathymetric distribution of six species of demersal fishes during fall 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 5. Bathymetric distribution of six species of demersal fishes during winter 1968. The index of abundance is mean transformed catch for each depth stratum.

Fig. 6. Distribution by temperature of three species of demersal fishes during winter 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 7. Distribution by temperature of three species of demersal fishes during winter 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 8. Distribution by temperature of three species of demersal fishes during spring 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 9. Distribution by temperature of three species of demersal fishes during spring 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 10. Distribution by temperature of three species of demersal fishes during summer 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 11. Distribution by temperature of three species of demersal fishes during summer 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 12. Distribution by temperature of three species of demersal fishes during fall 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 13. Distribution by temperature of three species of demersal fishes during fall 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 14. Distribution by temperature of three species of demersal fishes during winter 1968. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 15. Distribution by temperature of three species of demersal fishes during winter 1968. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 16. Bathymetric distribution of five species of demersal fishes during winter 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 17. Bathymetric distribution of five species of demersal fishes during spring 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 18. Bathymetric distribution of five species of demersal fishes during summer 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 19. Bathymetric distribution of five species of demersal fishes during fall 1967. The index of abundance is mean transformed catch for each depth stratum.

Fig. 20. Bathymetric distribution of five species of demersal fishes during winter 1968. The index of abundance is mean transformed catch for each depth stratum.

Fig. 21. Distribution by temperature of three species of demersal fishes during winter 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 22. Distribution by temperature of two species of demersal fishes during winter 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 23. Distribution by temperature of three species of demersal fishes during spring 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 24. Distribution by temperature of two species of demersal fishes during spring 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 25. Distribution by temperature of three species of demersal fishes during summer 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 26. Distribution by temperature of two species of demersal fishes during summer 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 27. Distribution by temperature of three species of demersal fishes during fall 1967. The index of abundance is mean transformed catch for each temperature stratum.

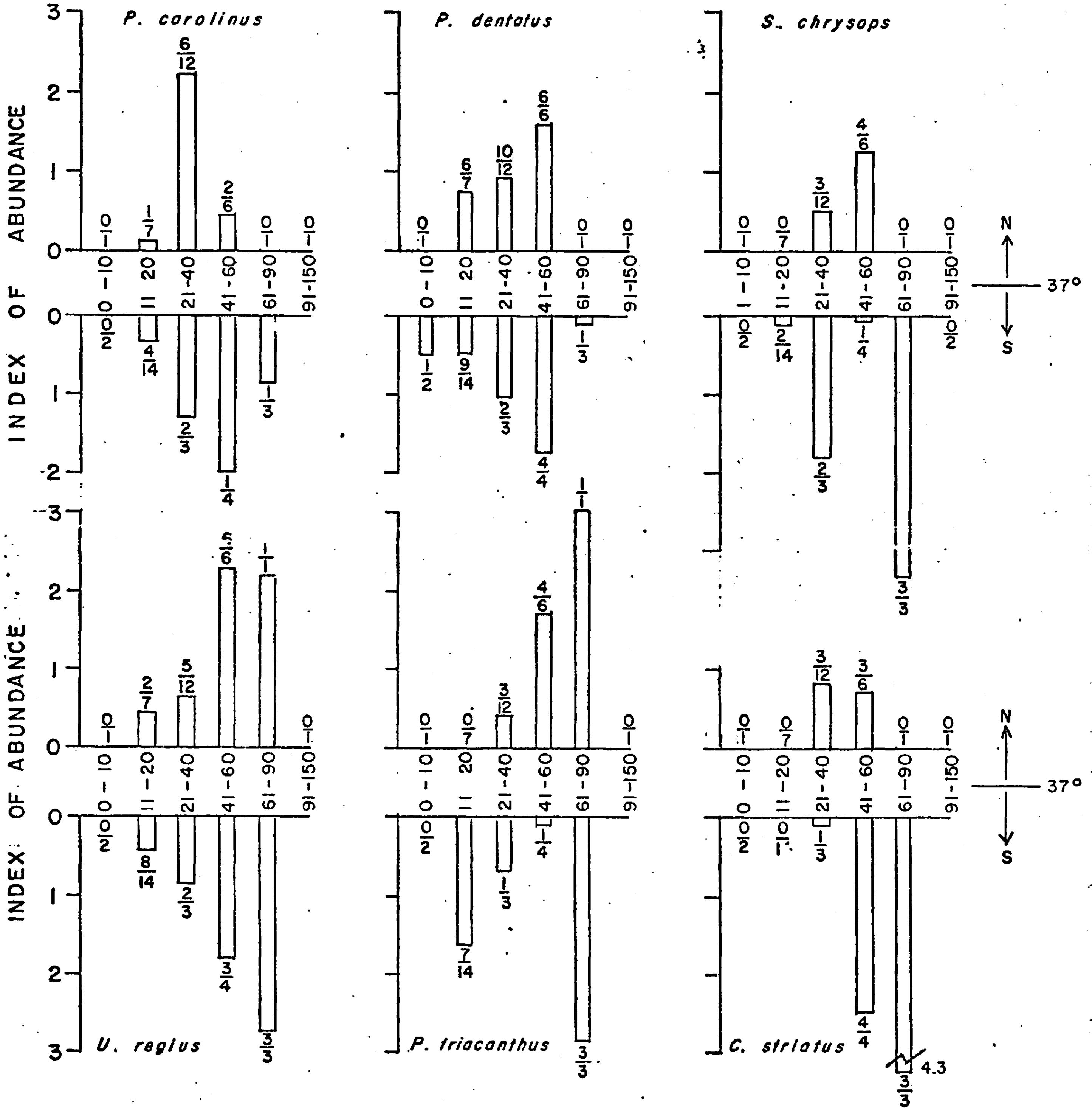
Fig. 28. Distribution by temperature of two species of demersal fishes during fall 1967. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 29. Distribution by temperature of three species of demersal fishes during winter 1968. The index of abundance is mean transformed catch for each temperature stratum.

Fig. 30. Distribution by temperature of two species of demersal fishes during winter 1968. The index of abundance is mean transformed catch for each temperature stratum.

Fig 1

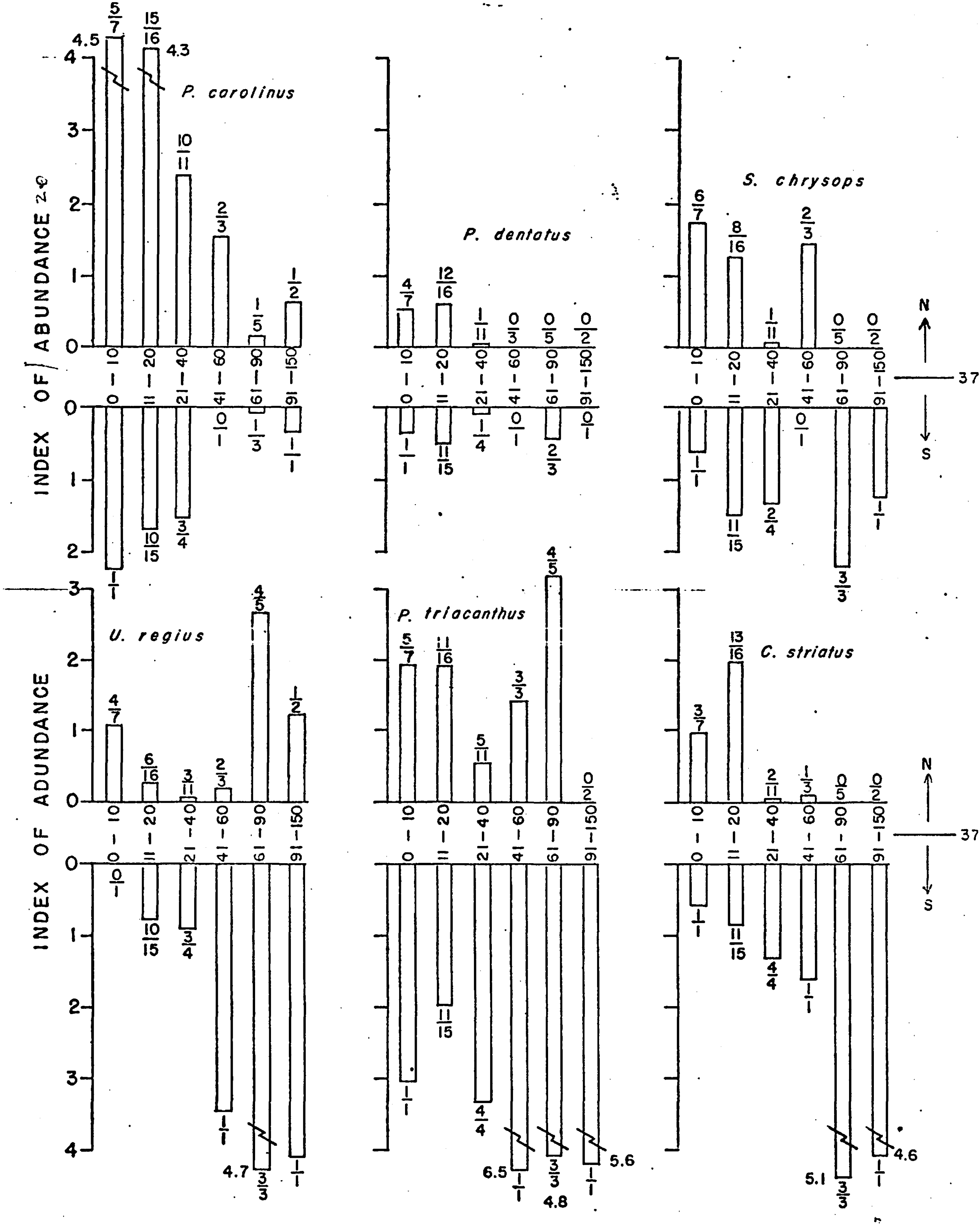
Fig 1



Winter 1967

2

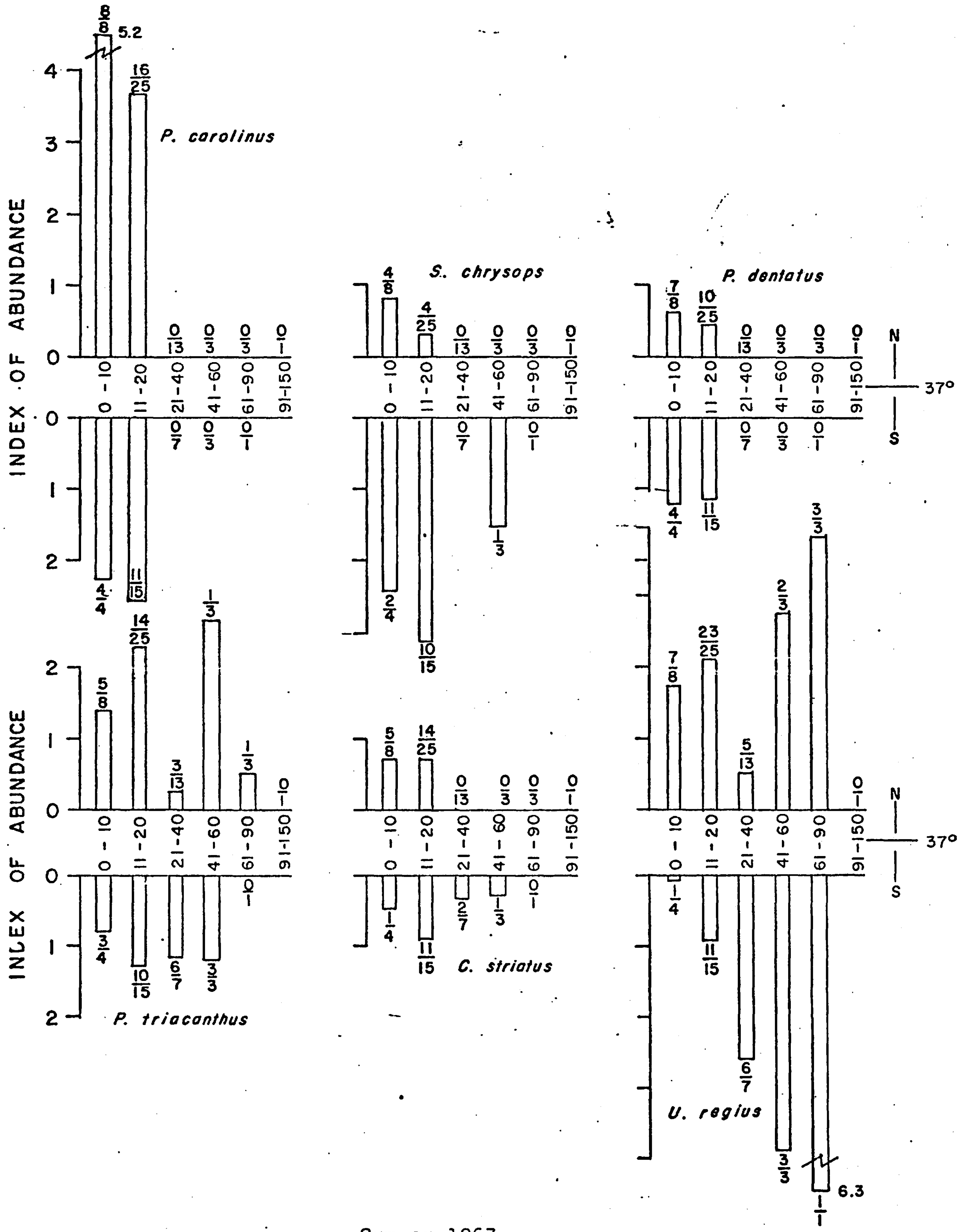
Fig 2



Spring 1967

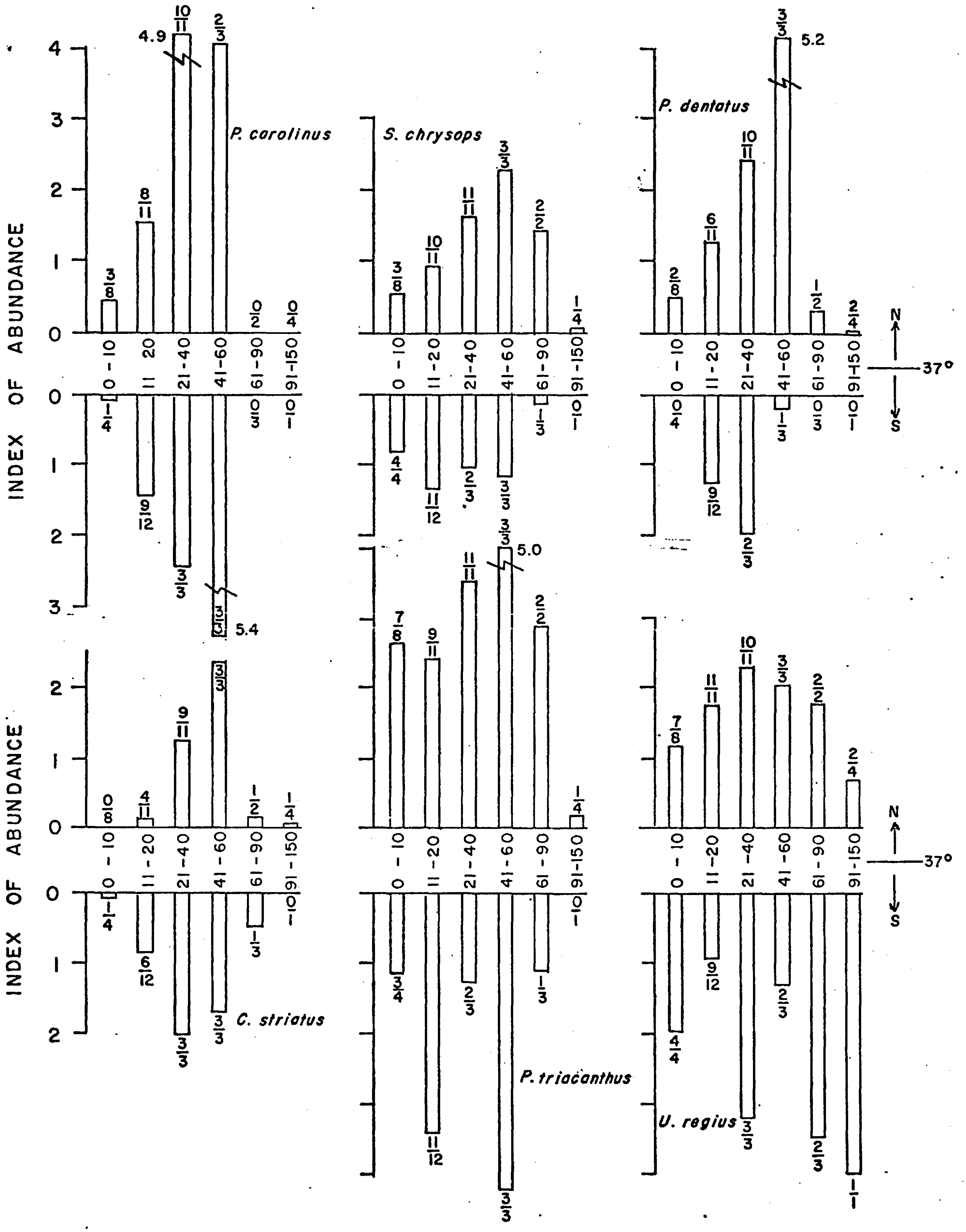
3

Fig 3



Summer 1967

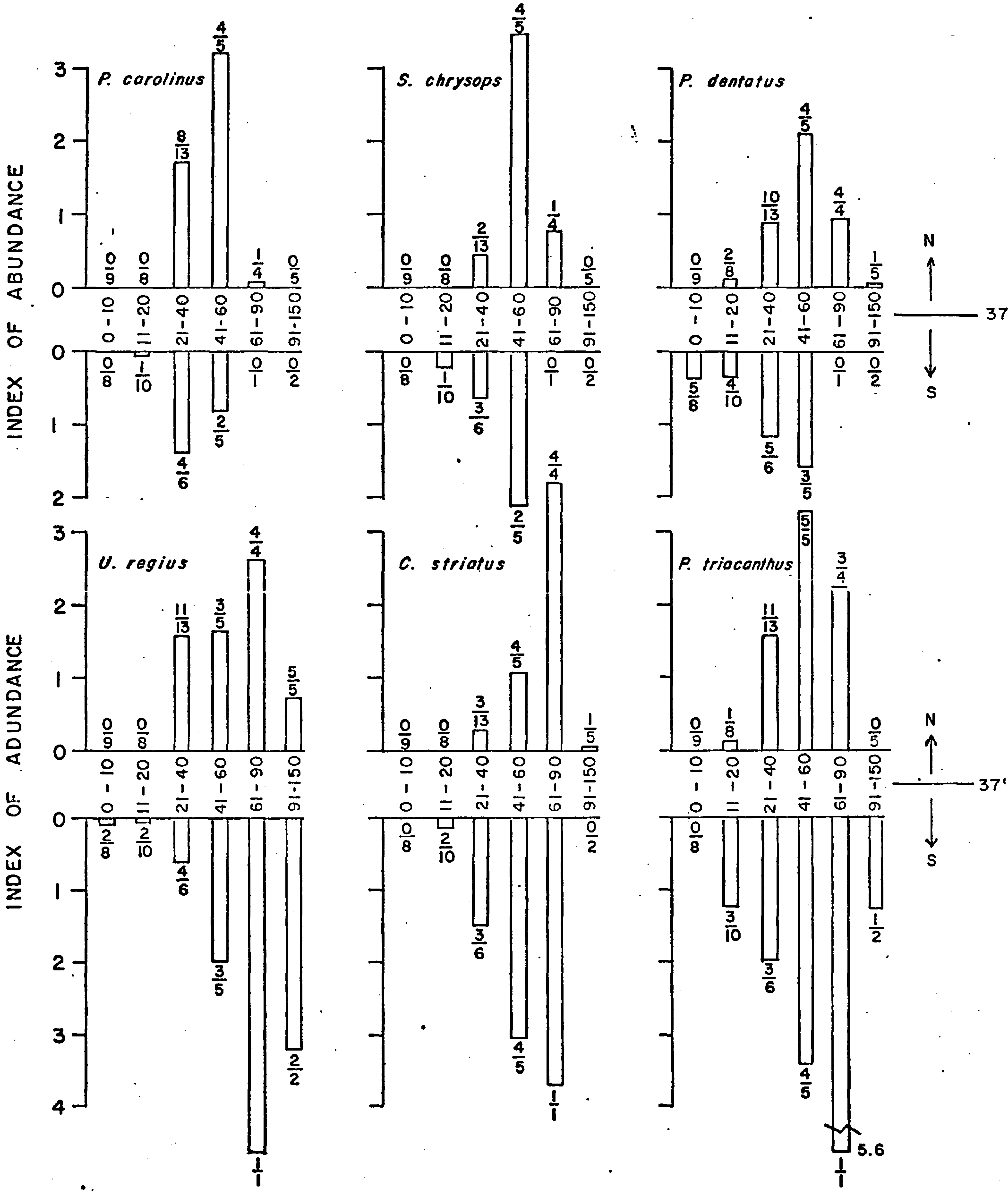
Fig 4



Autumn 1967

Fig 5. 1

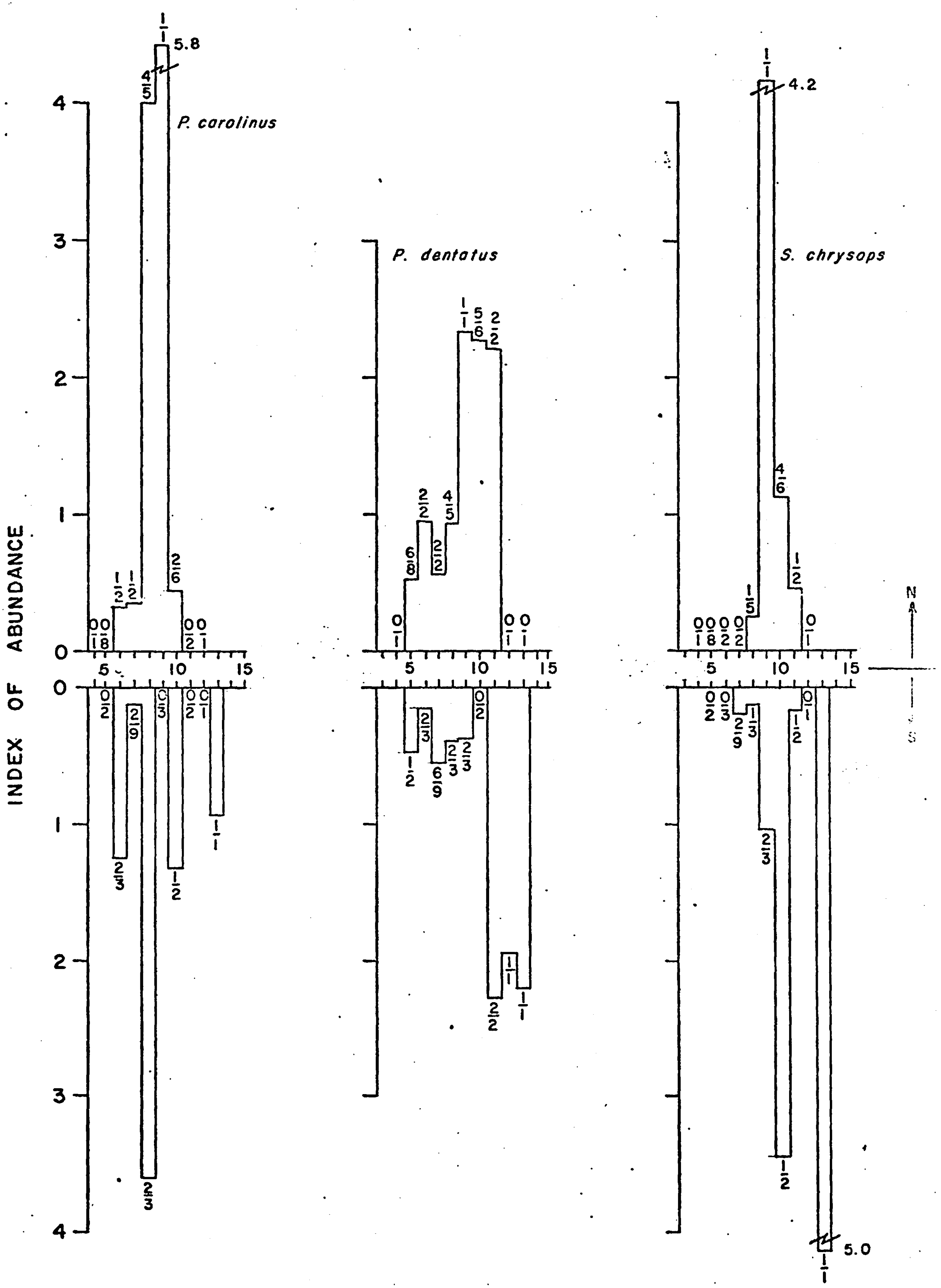
Fig 5



Winter 1968

SI Fig

Fig 6



INDEX OF ABUNDANCE
0
1
2
3
4
5
10
15
P. carolinus
P. dentatus
S. chrysops
5.8
4.2
5.0
N
S
0/1
0/8
1/3
1/2
4/5
1/1
2/6
0/2
0/1
0/2
2/3
2/9
2/3
0/3
0/2
1/2
0/1
1/1
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6/8
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4/5
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1/5
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Winter 1967 Fig 7

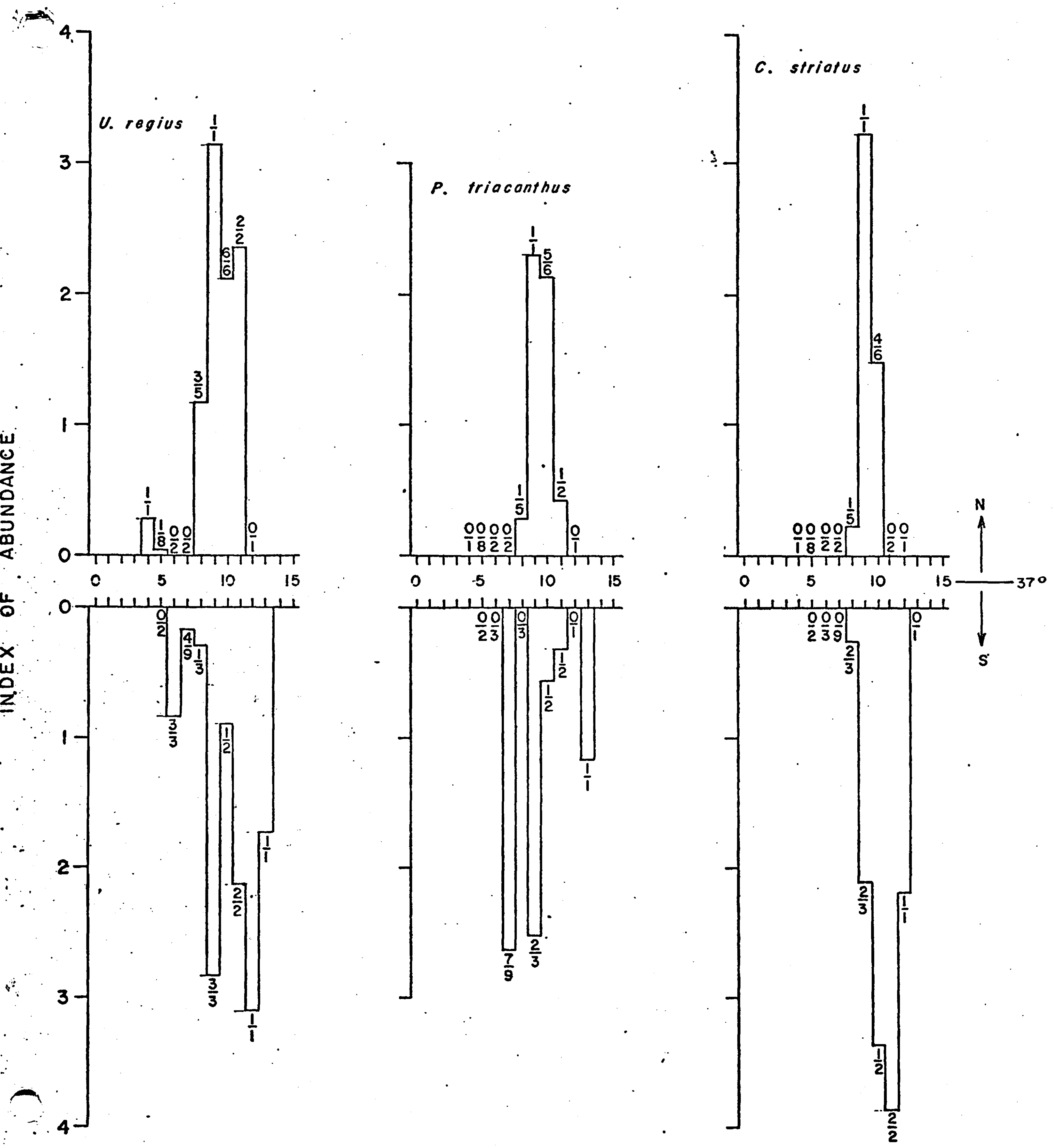
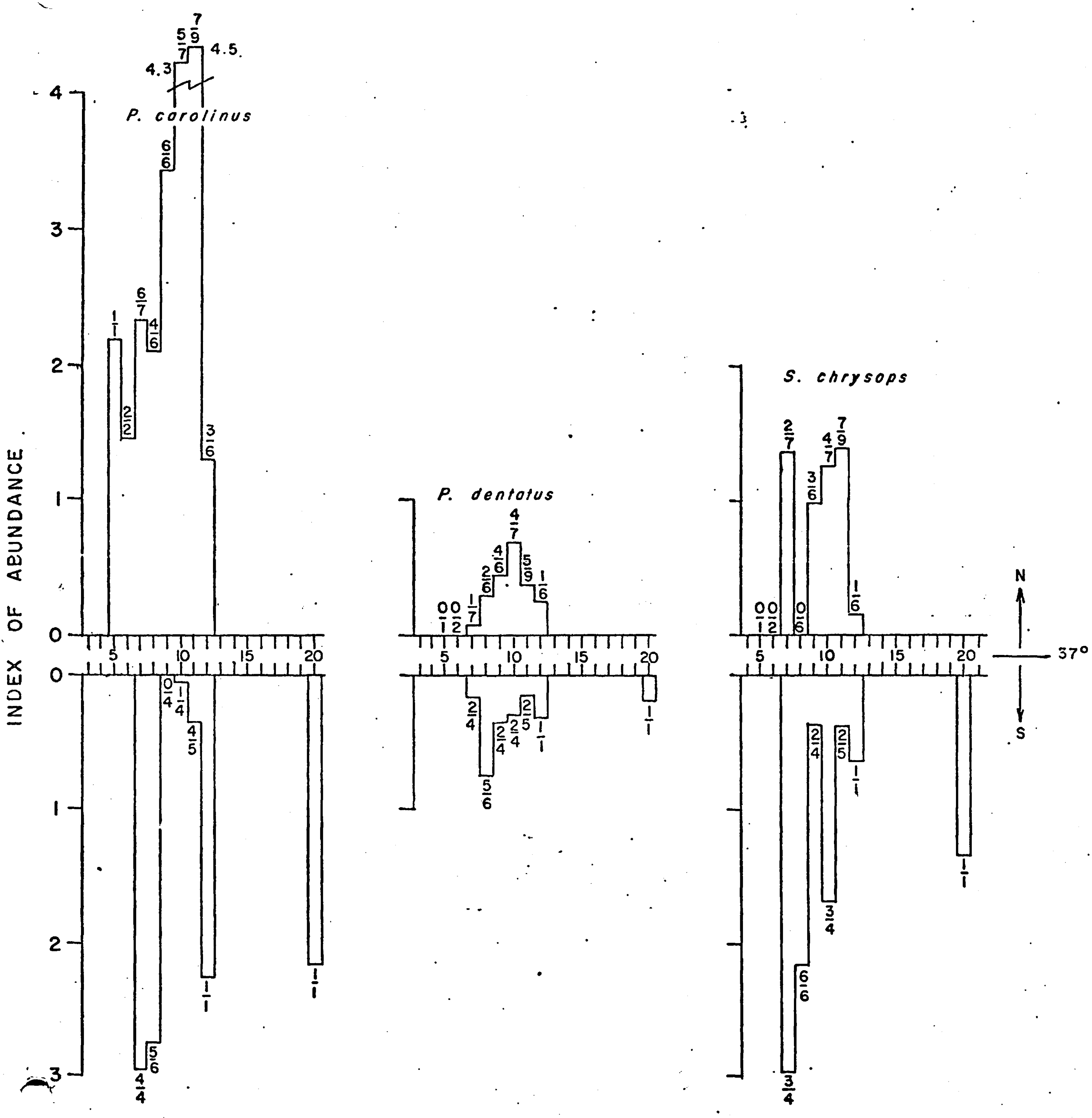


Fig. 7 Winter 1967 SII

Fig. 8

Spring 1967



Spring 1967

Fig. 4

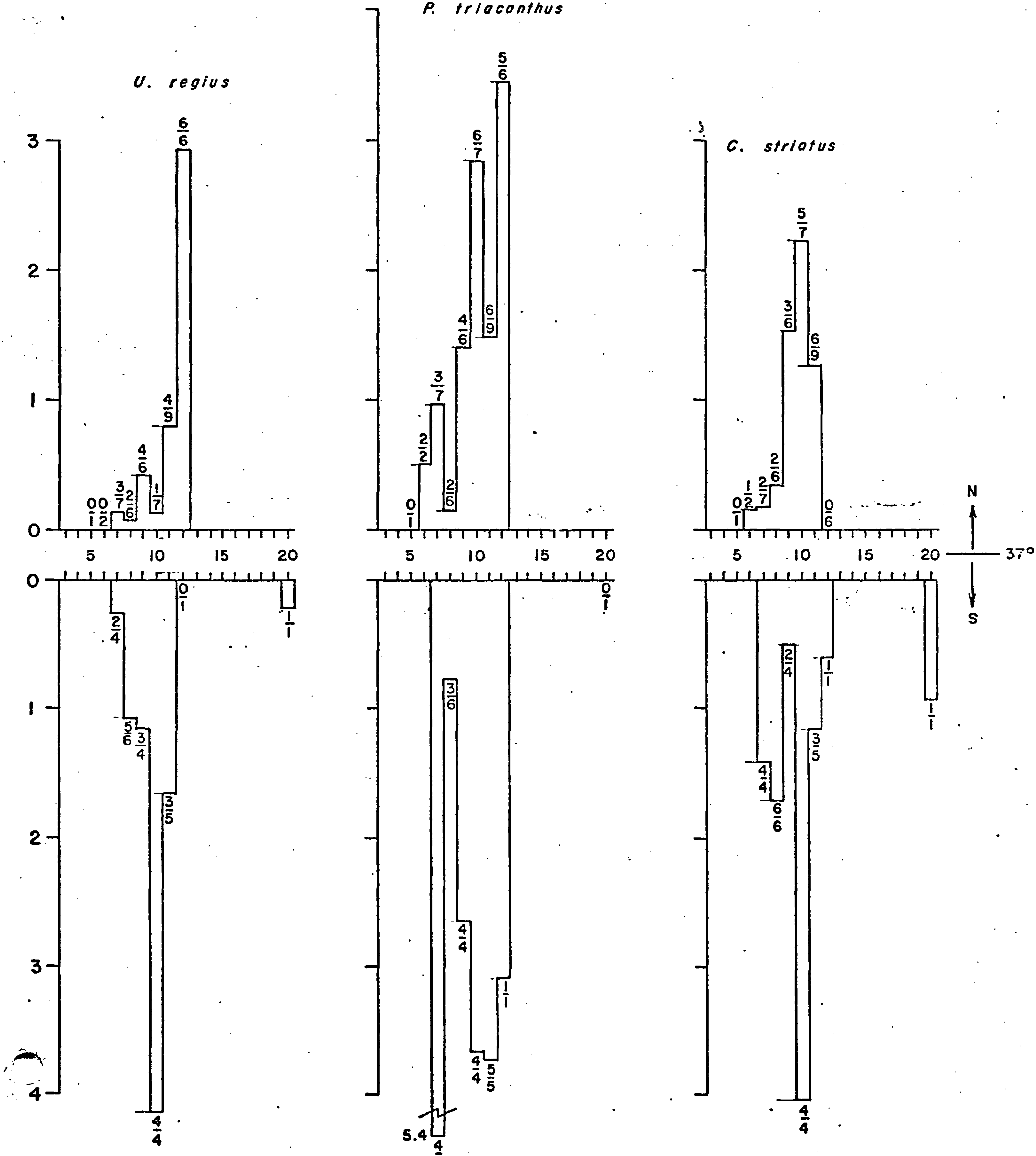
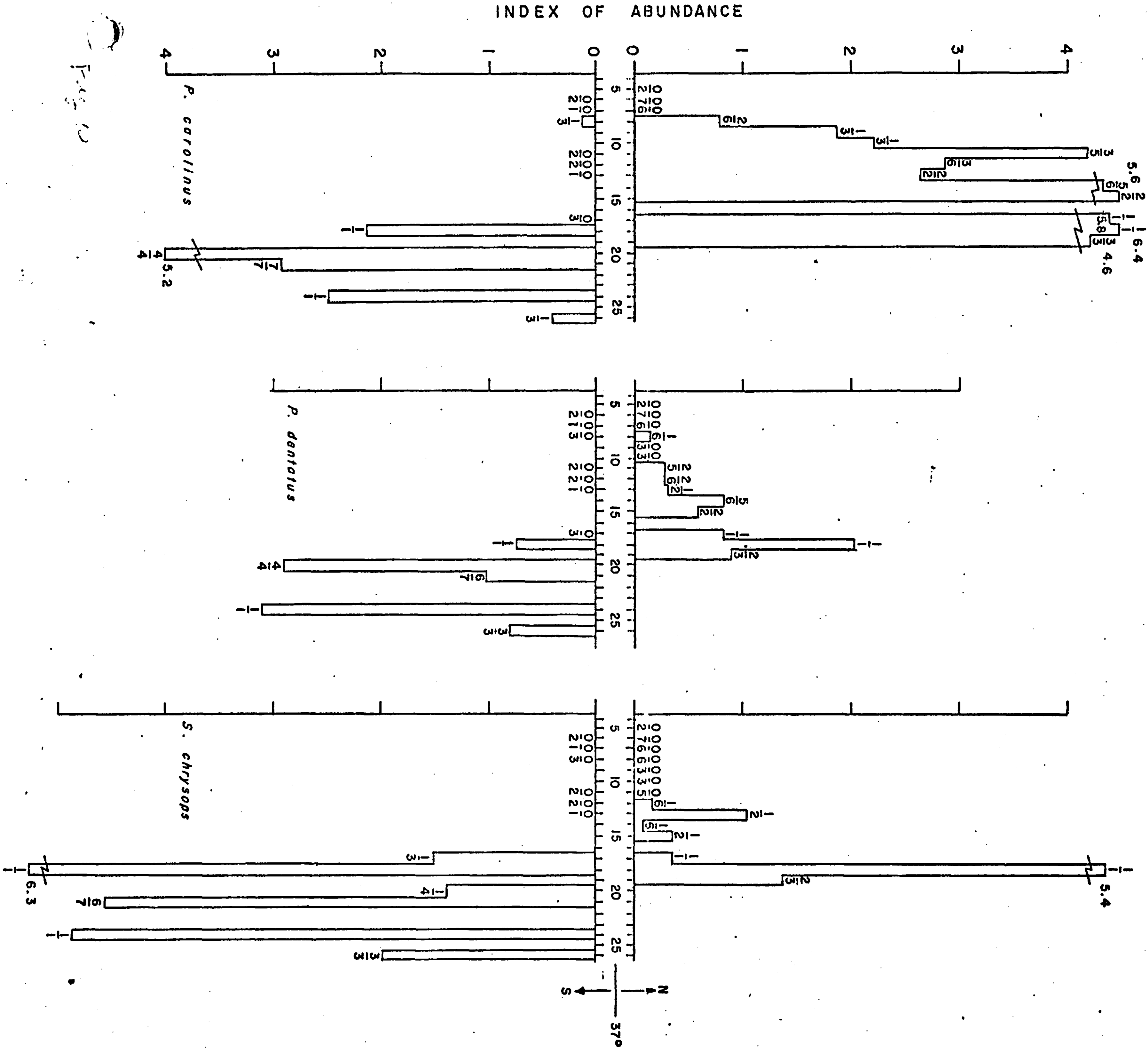


Fig. 7

Fig 10



Simmons 1967

Fig 10

Fig 11

Summer 1967

II

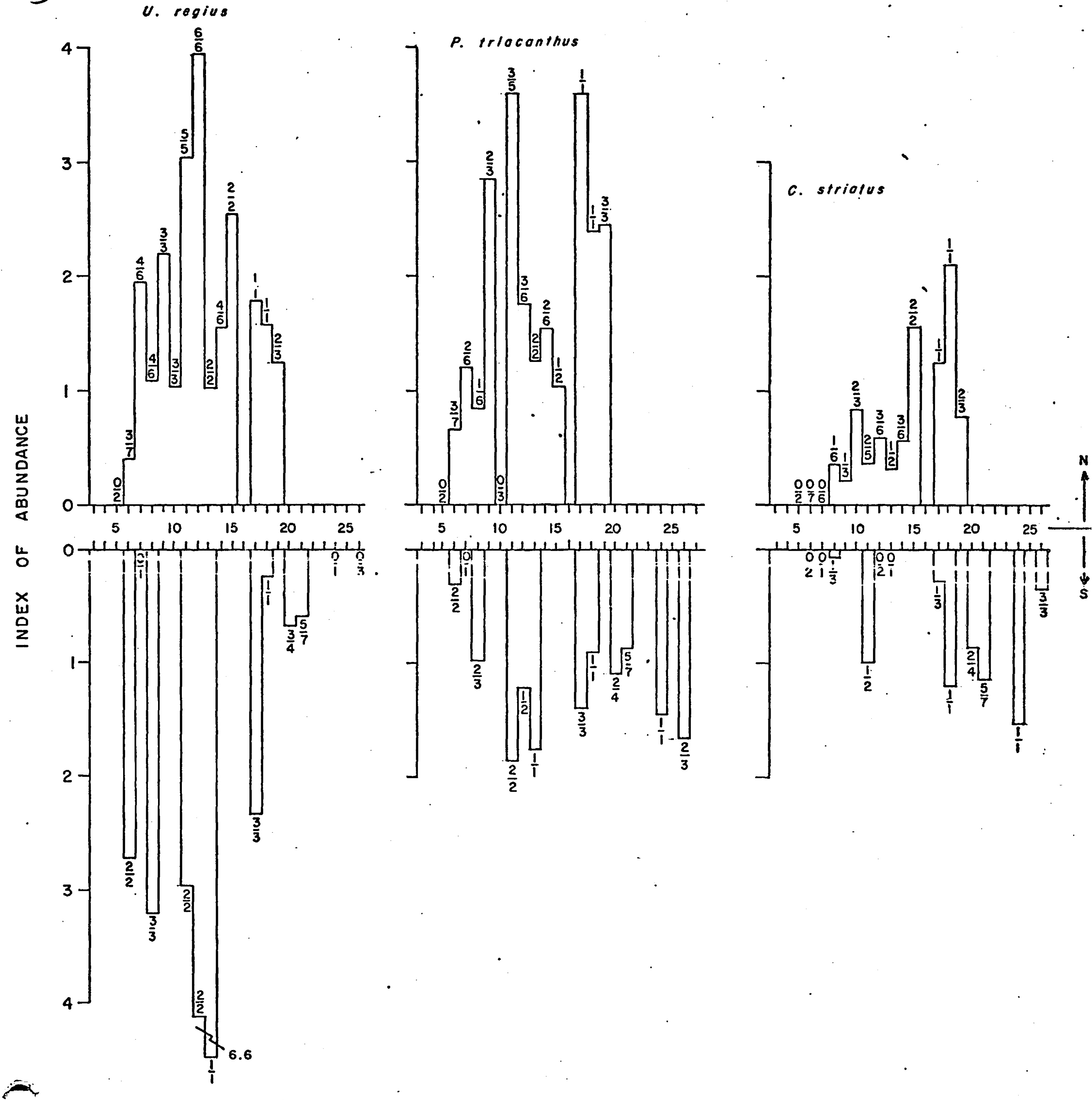
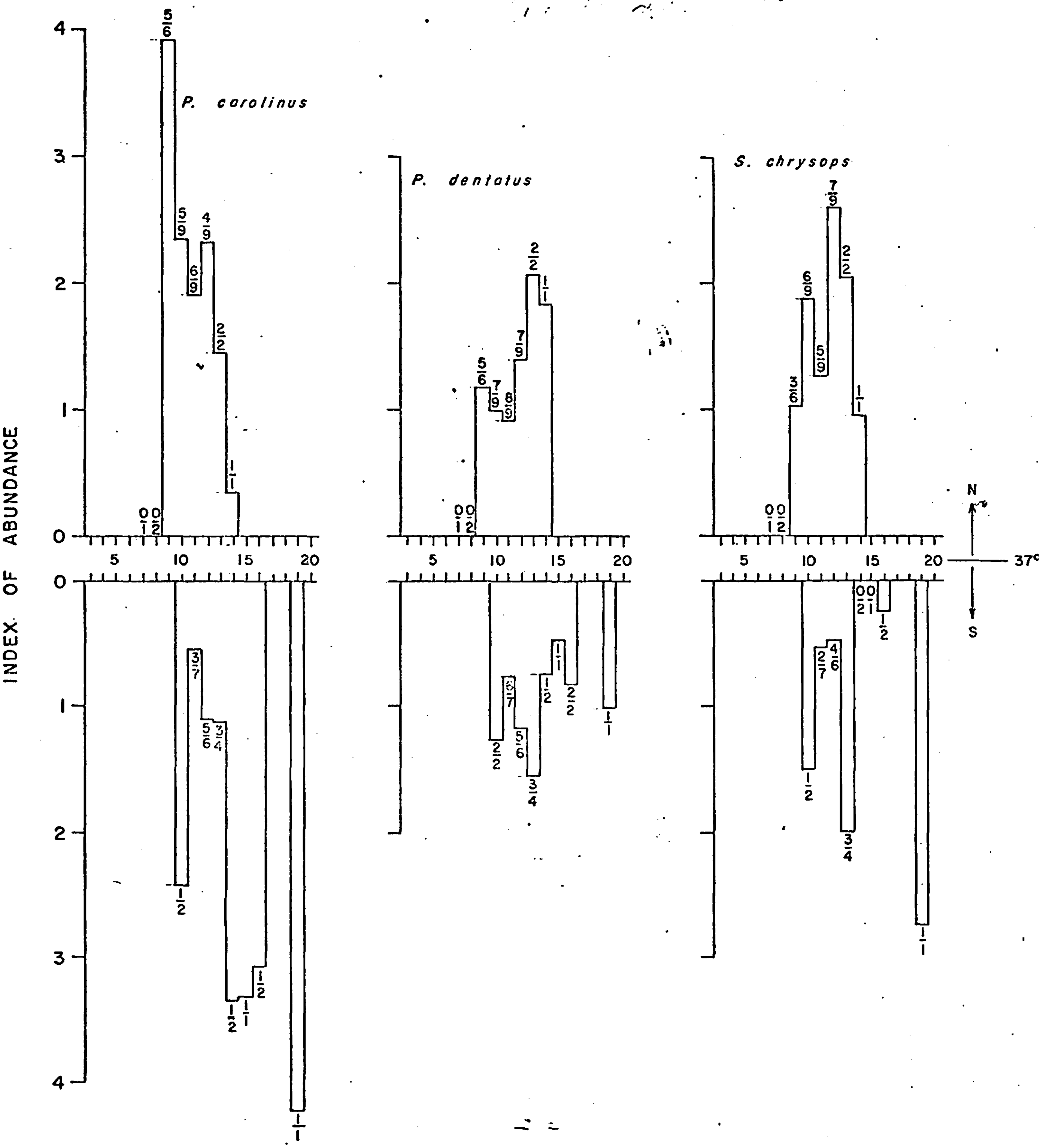


Fig 12

19.7



INDEX OF ABUNDANCE
0
1
2
3
4
P. carolinus
P. dentatus
S. chrysops
5
10
15
20
N
S
37°
0/1
0/2
5/6
5/9
6/9
4/9
2/2
1/1
7/9
8/9
3/6
1/2
3/7
5/6
3/4
2/7
4/6
0/2
0/1

Fig 13

II

Autumn 1967

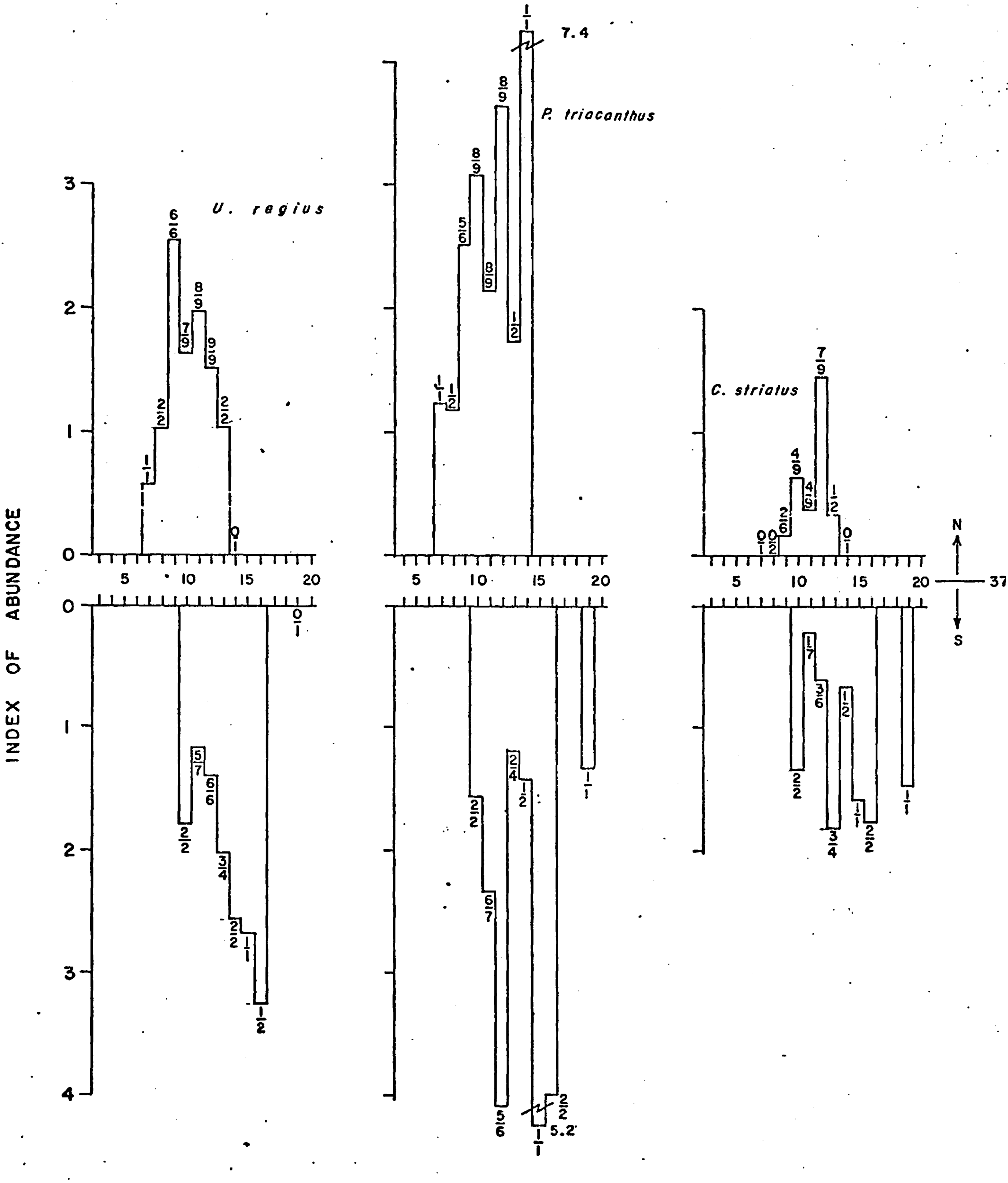
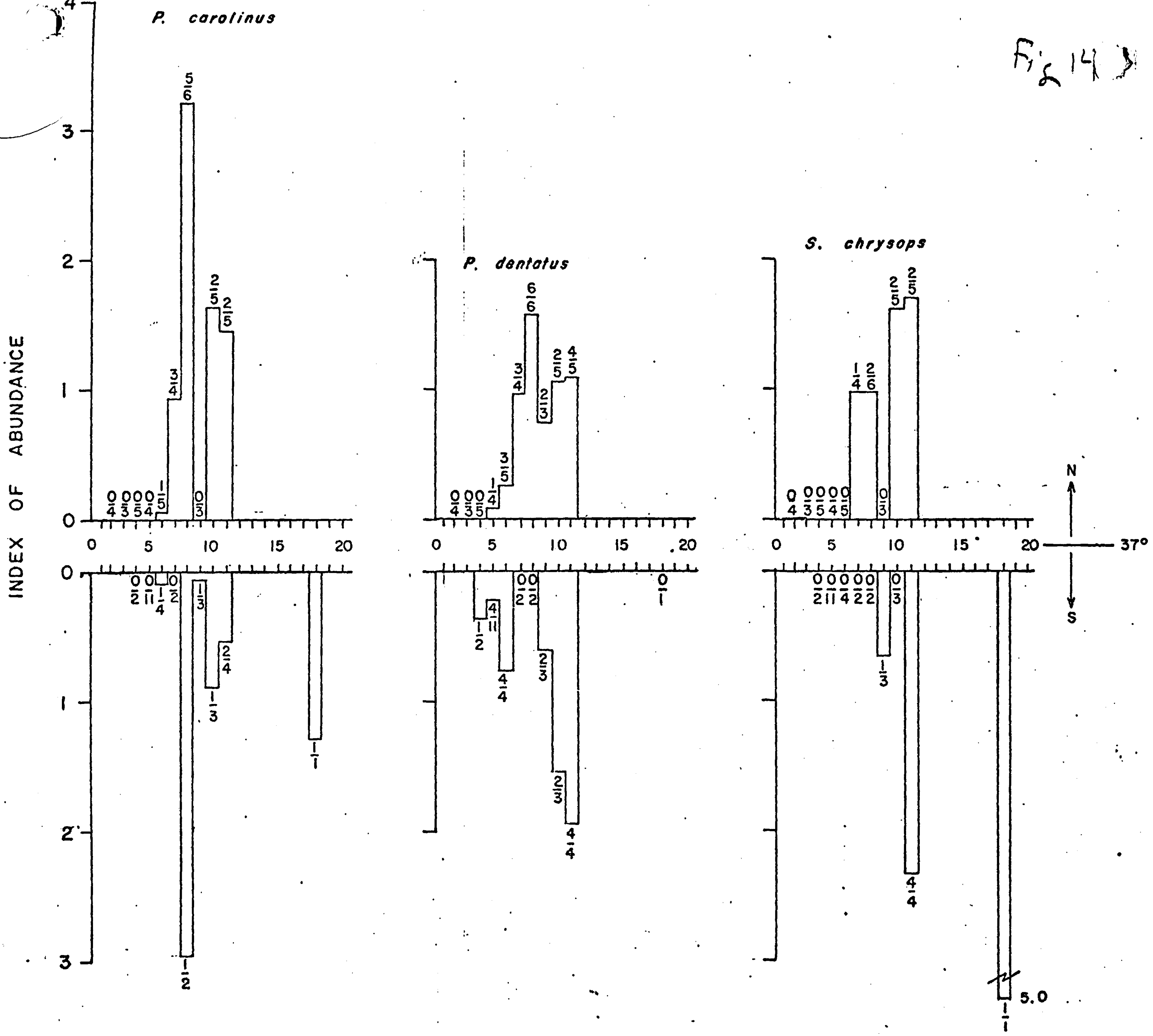


Fig 14)

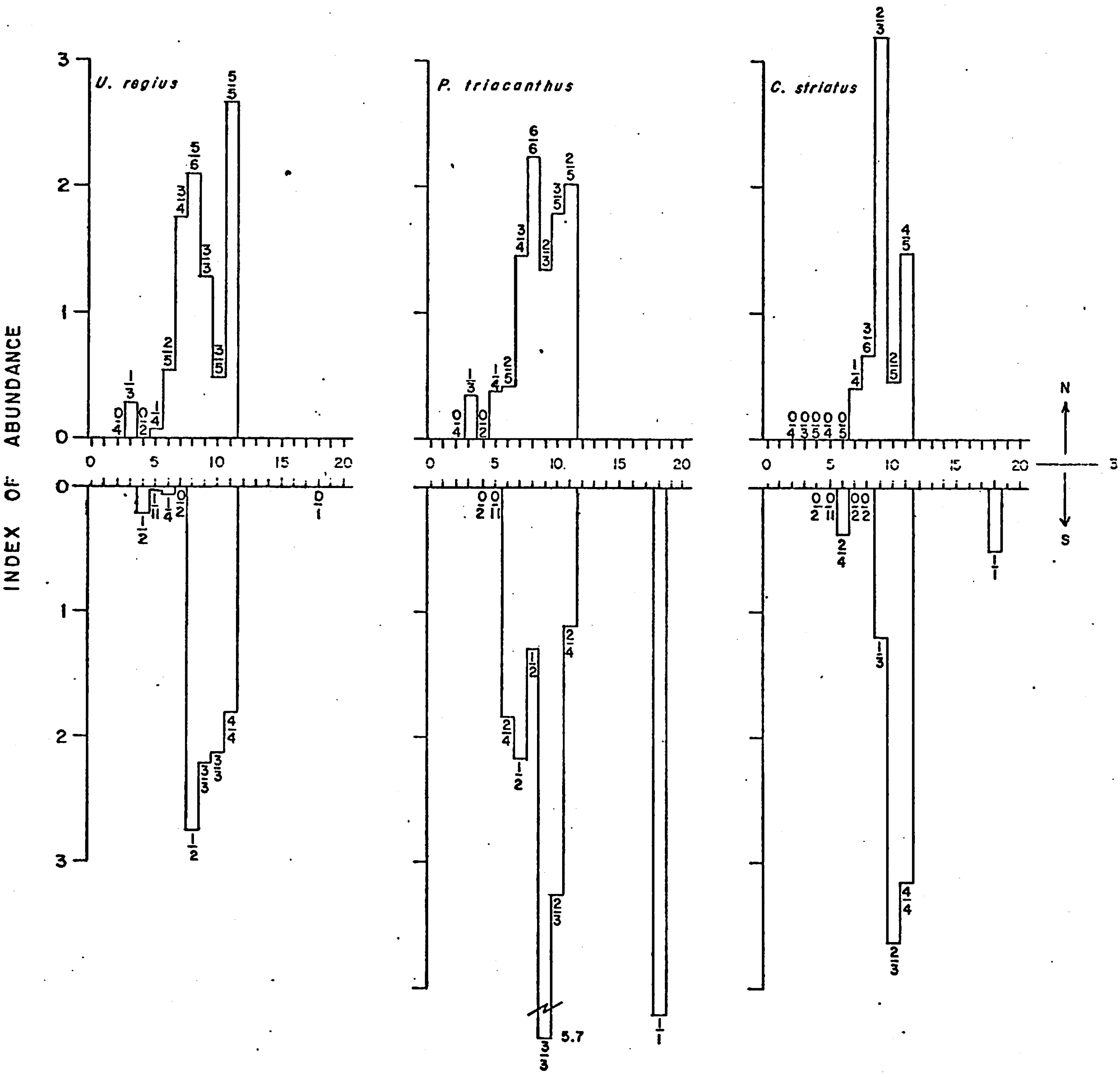


INDEX OF ABUNDANCE
P. carolinus
P. dentatus
S. chrysops
0
1
2
3
4
0
5
10
15
20
N
S
37°
5.0
0/4 0/3 0/5 0/4 1/5 3/4 5/6 0/3 2/5 2/5
0/2 0/11 1/4 0/2 1/2 1/3 1/3 2/4 1/1
0/4 0/3 0/5 1/4 3/5 3/4 6/6 2/3 2/5 4/5
1/2 4/11 4/4 0/2 0/2 2/3 2/3 4/4 0/1
0/4 0/3 0/5 0/4 0/5 1/4 2/6 0/3 2/5 2/5
0/2 0/11 0/4 0/2 0/2 1/3 0/3 4/4 1/1

Fig 14

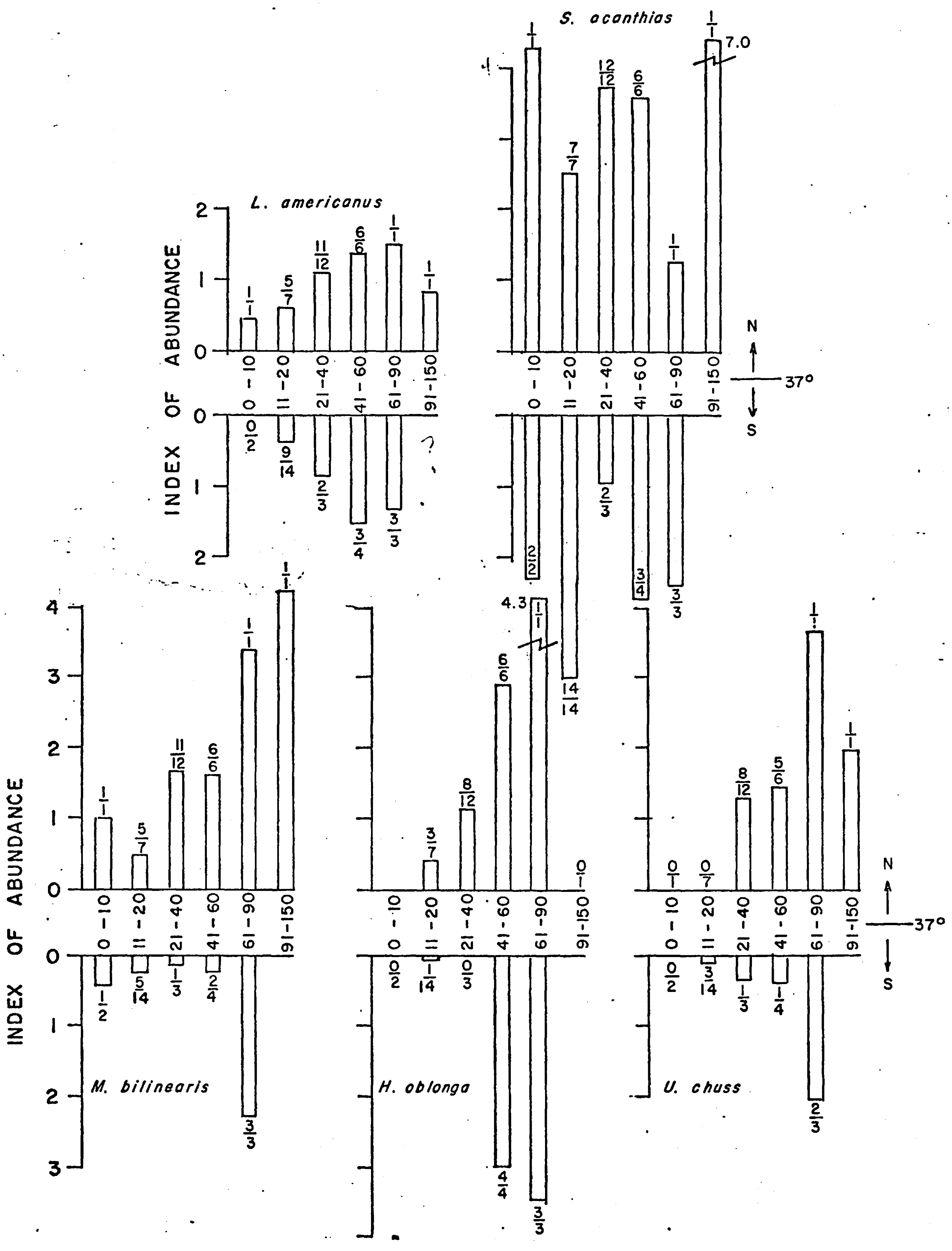
Fig 15

Winter 1968



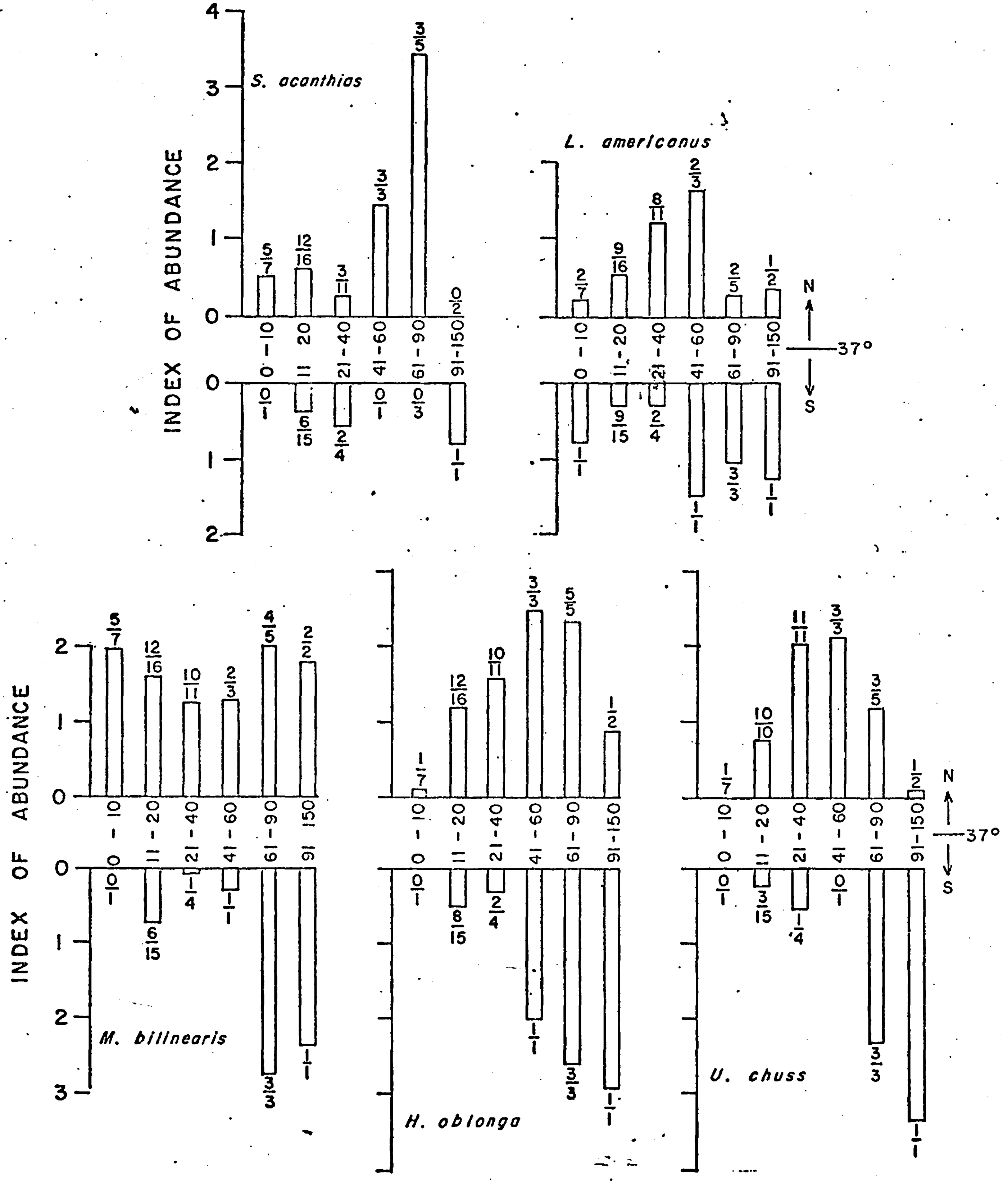
Northern Depth.

Fig 14

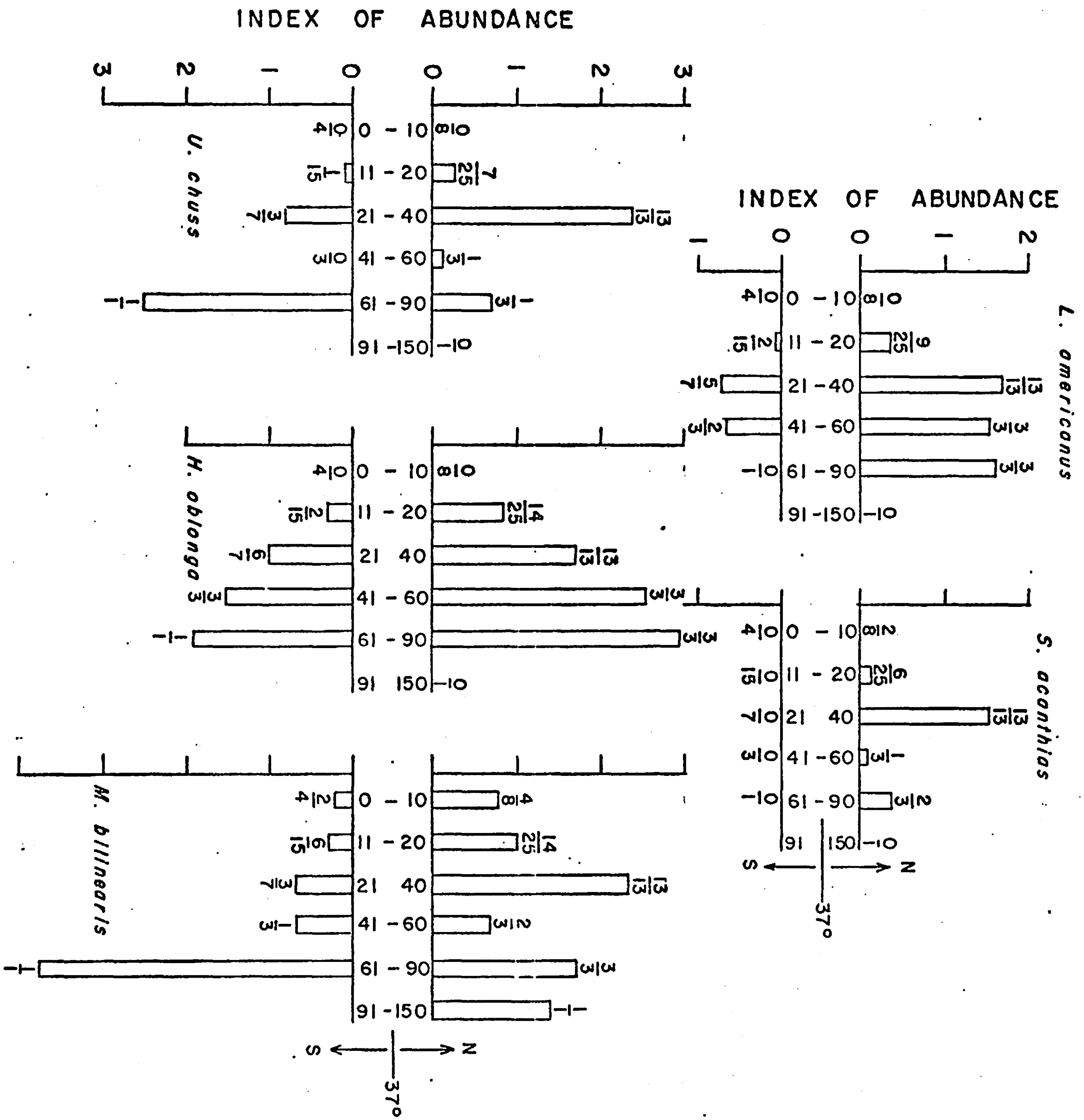


Winter 1967

Fig 17



Spring 1967



Summer 1967

Fig 18

Autumn 1967

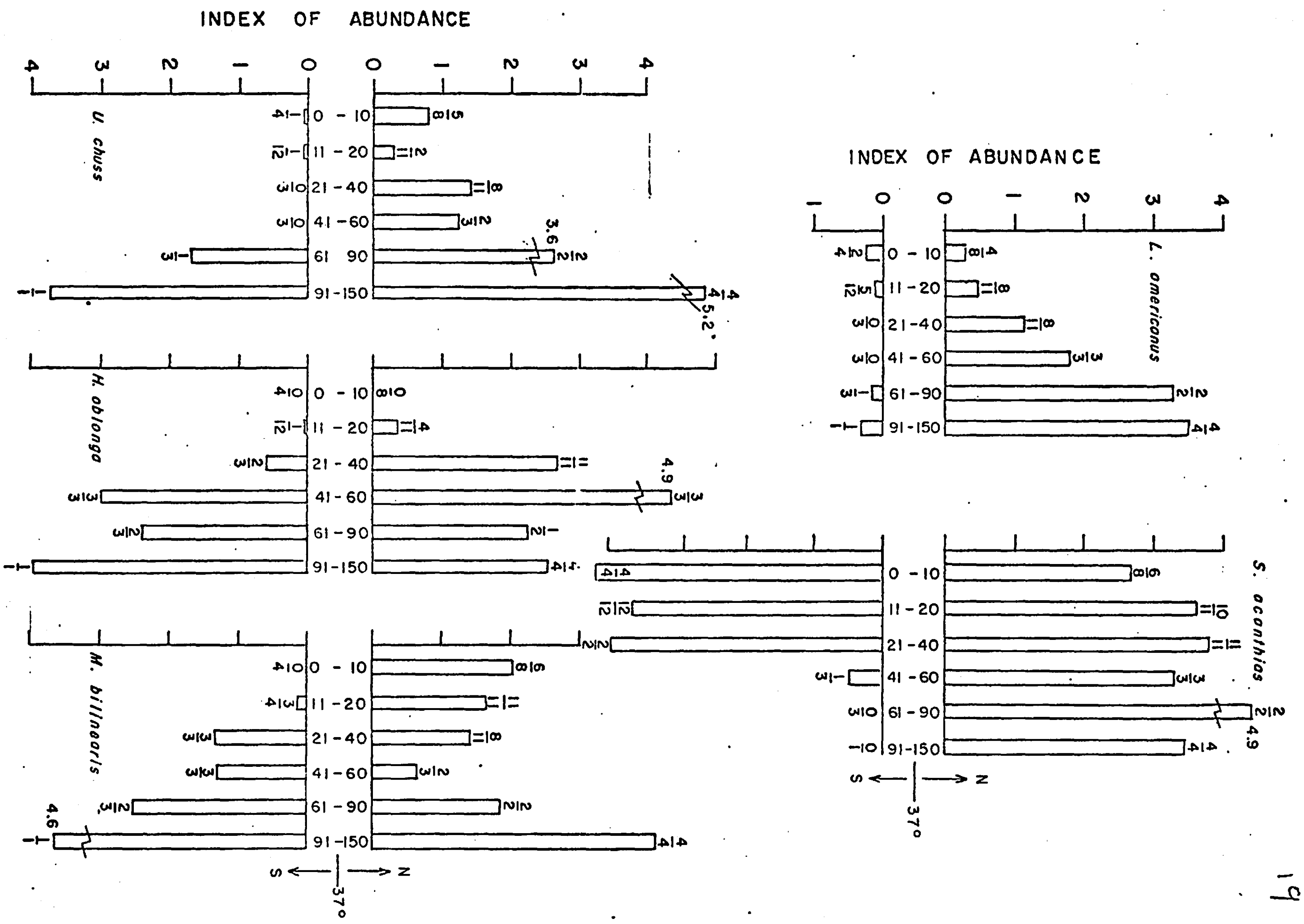


Fig 19

Winter 1968

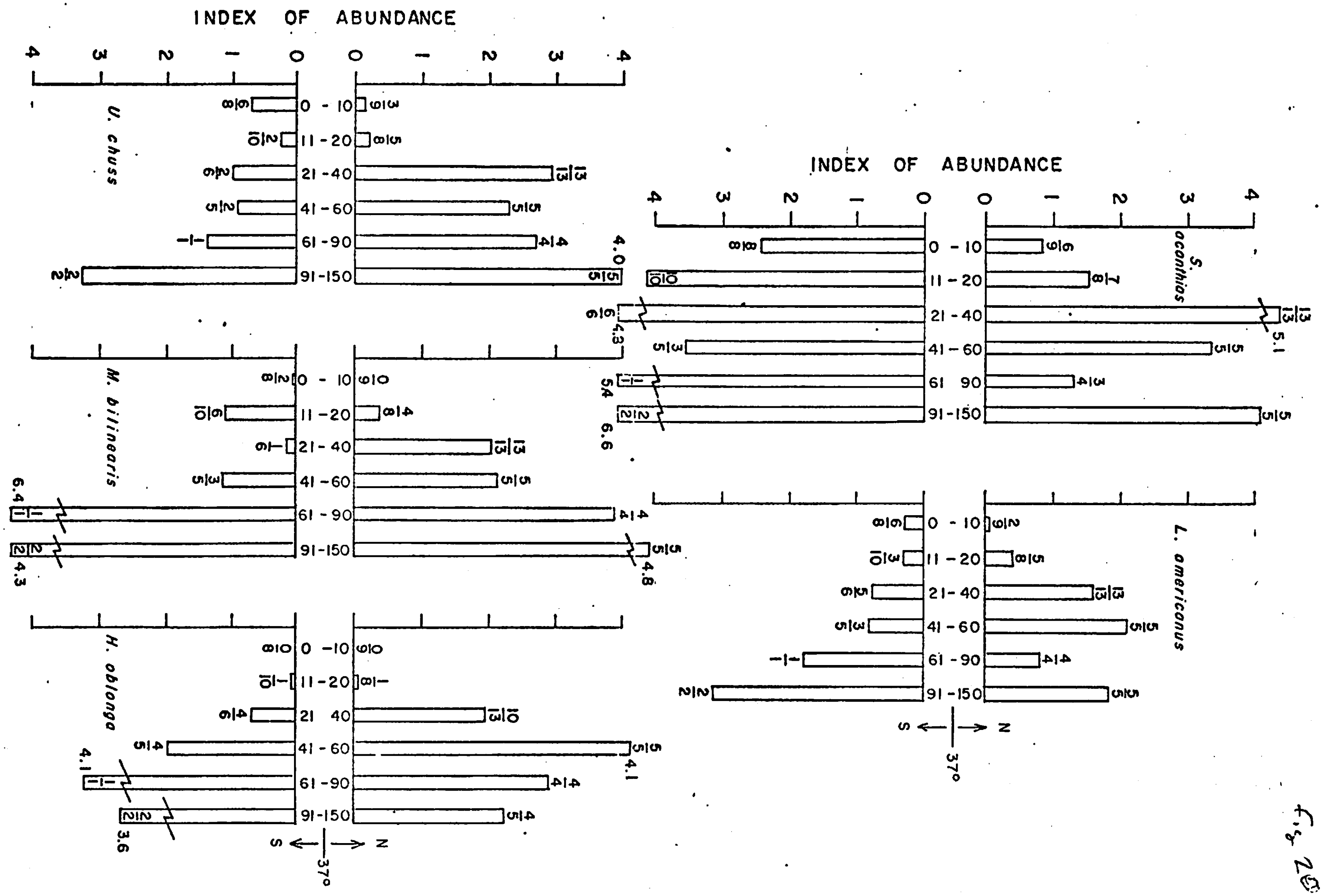


Fig 20

number 67 Fig21

Switch

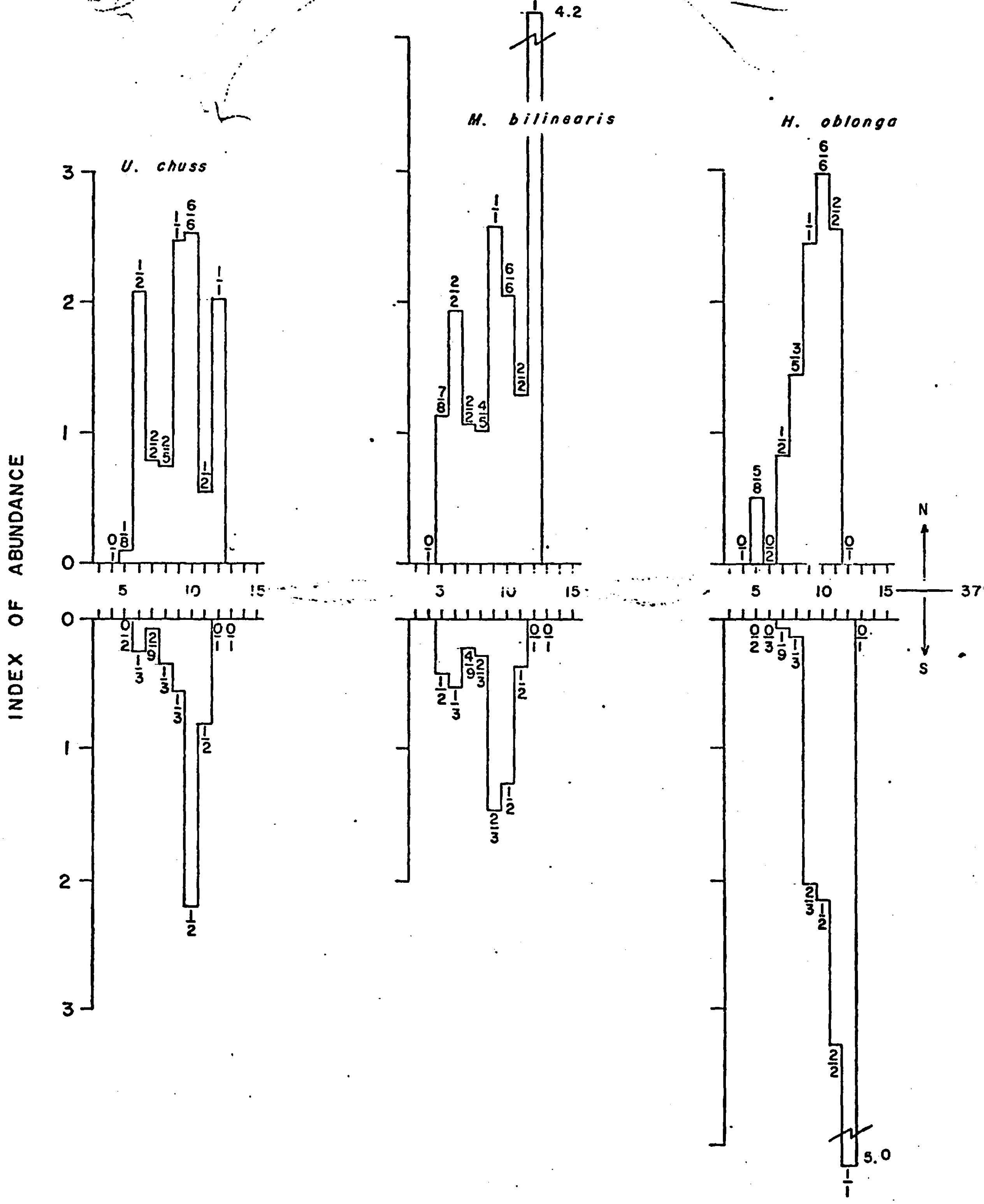


Fig 22

winter 1967
NE

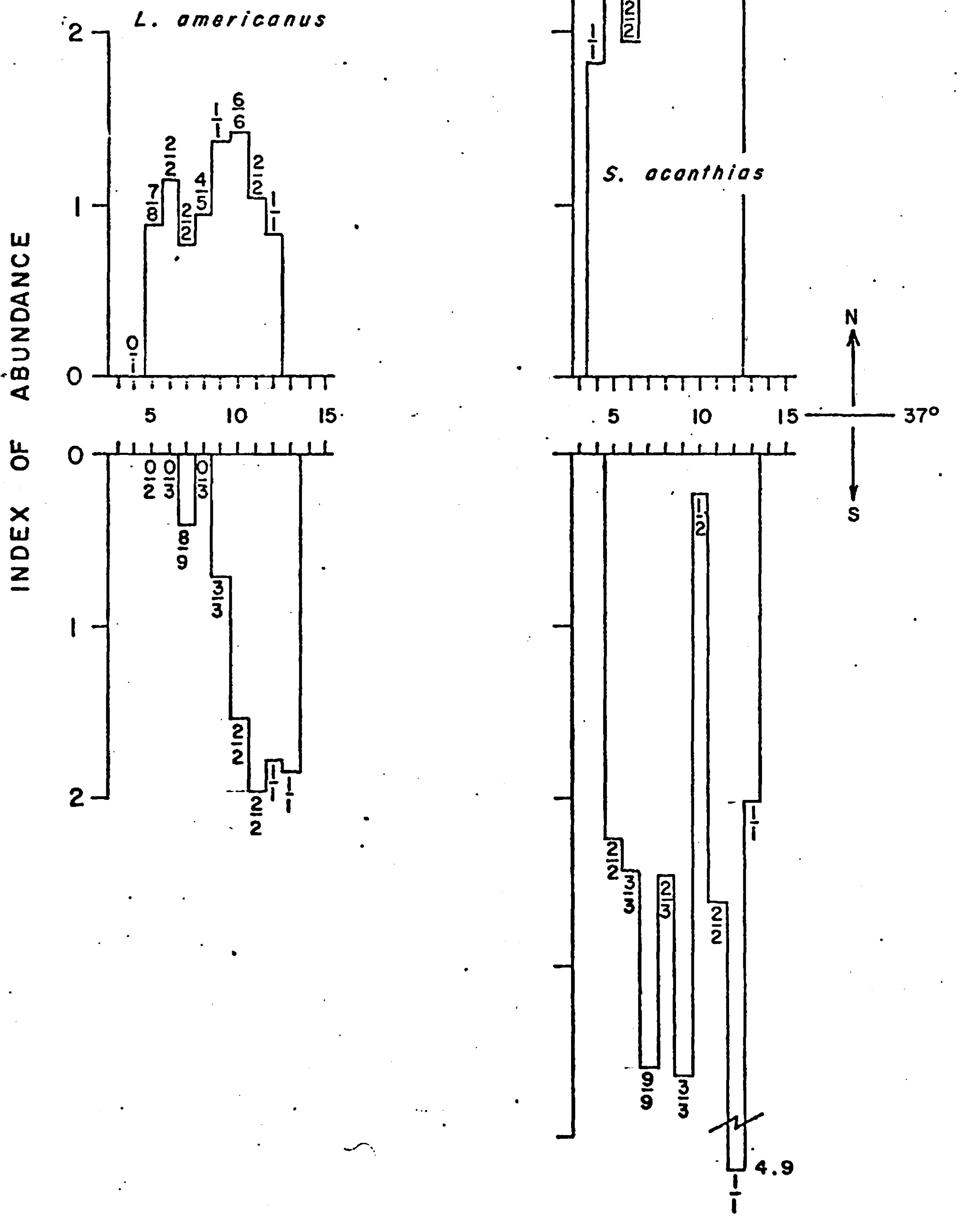


Fig 23

Spring 1967
N I

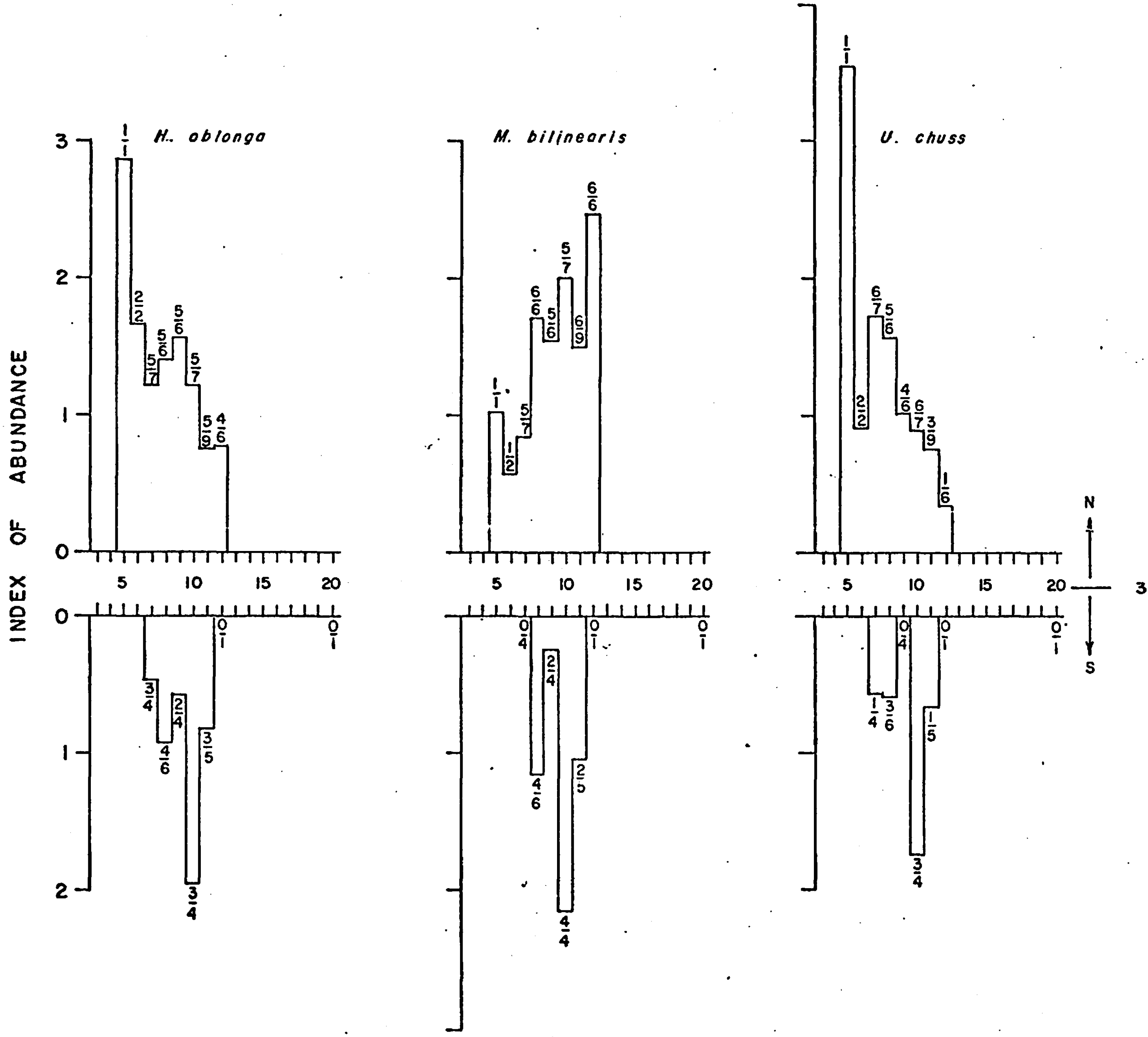
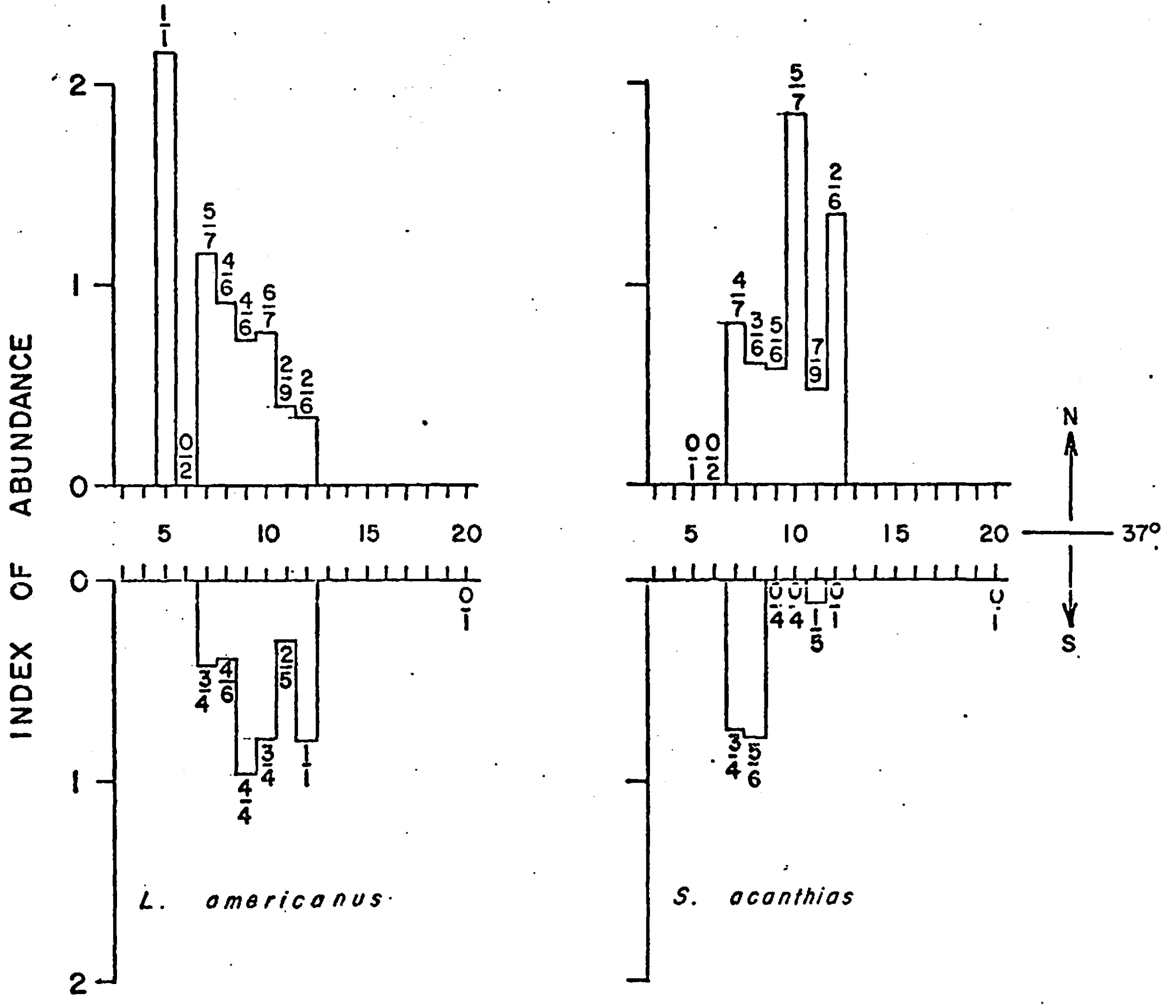


Fig 24

11 -
Spring 1967



Summer 67

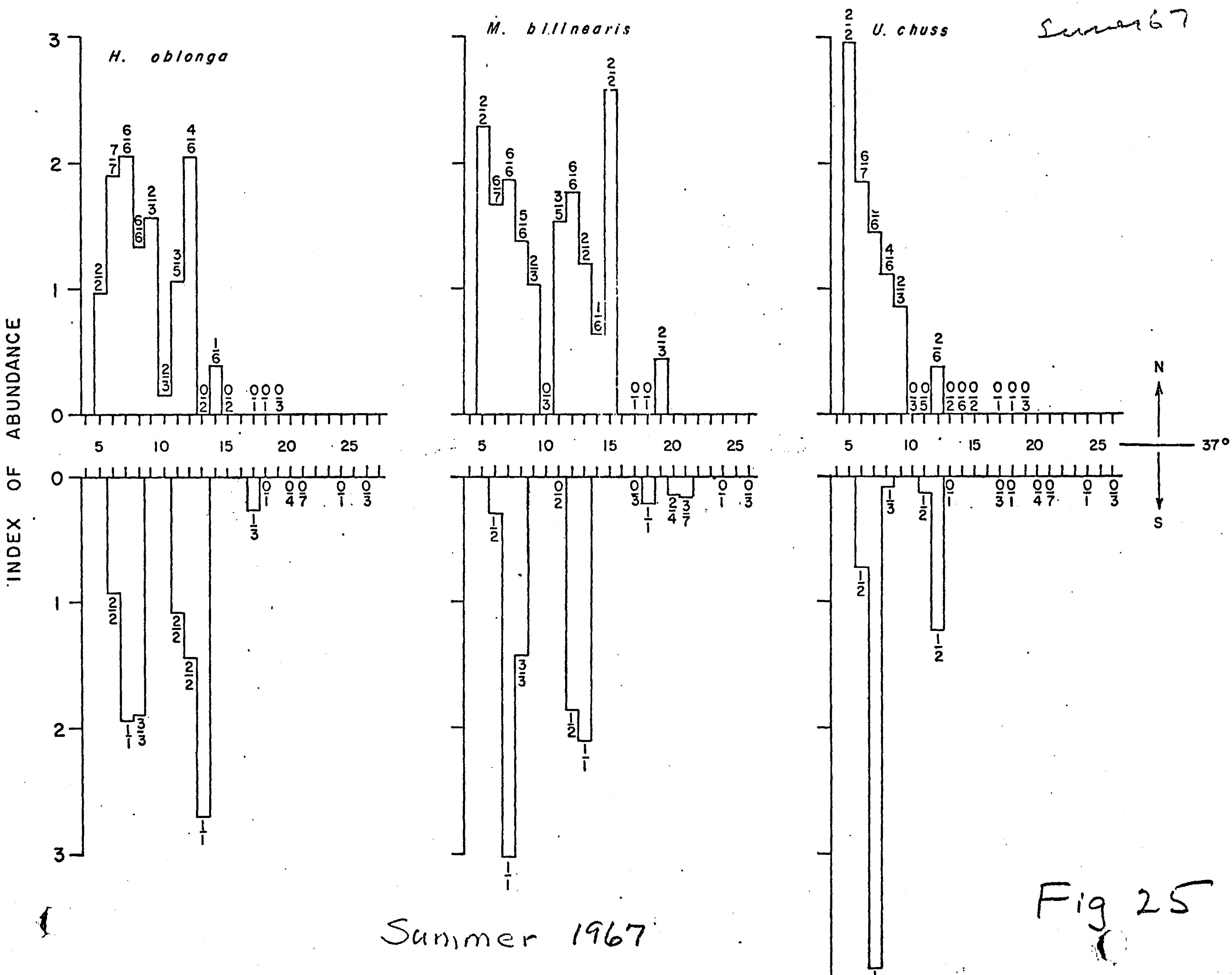


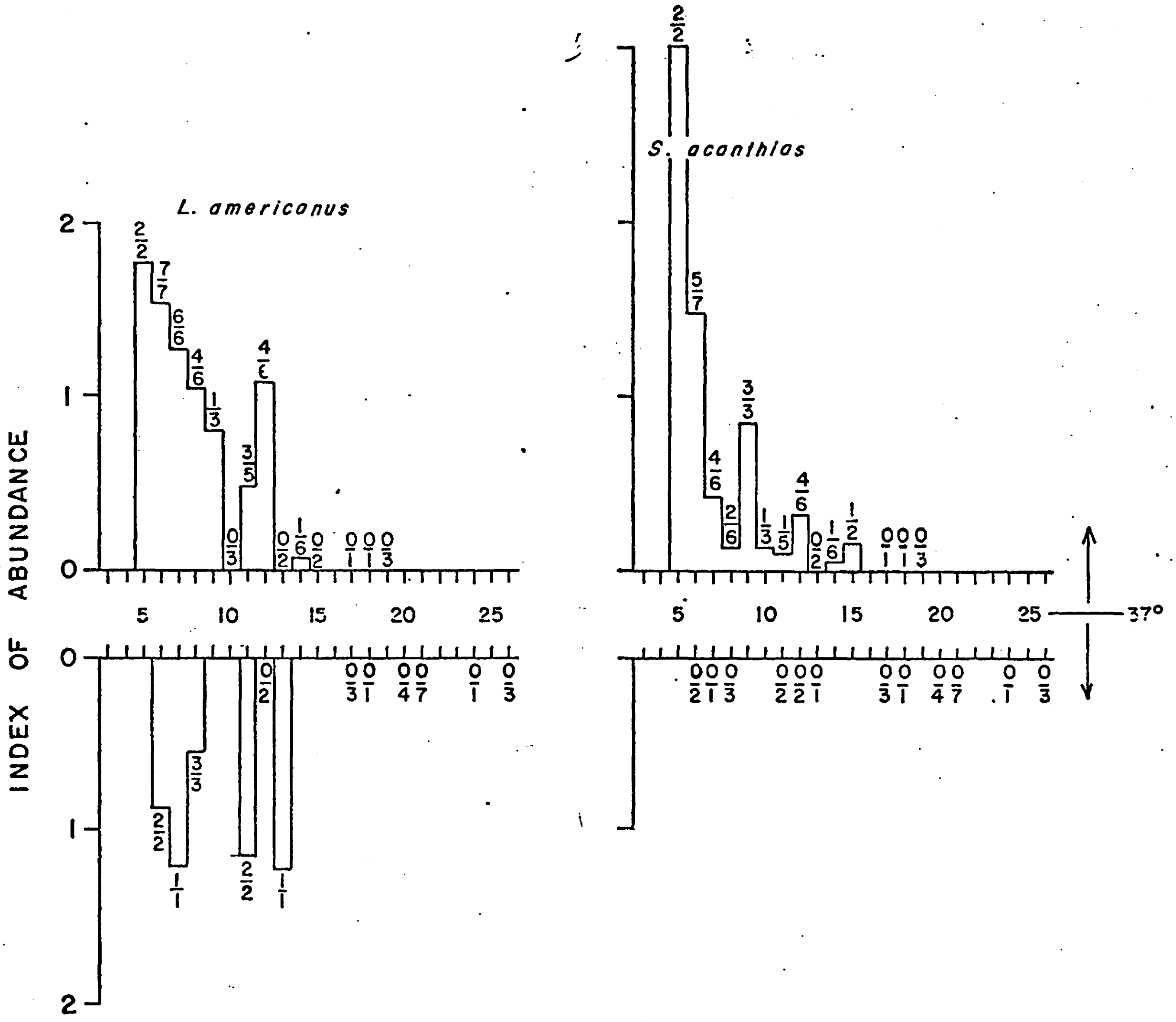
Fig 25

Summer 1967

Fig 26

Summer 1967

N II



Autumn 1967
II

Fig 27

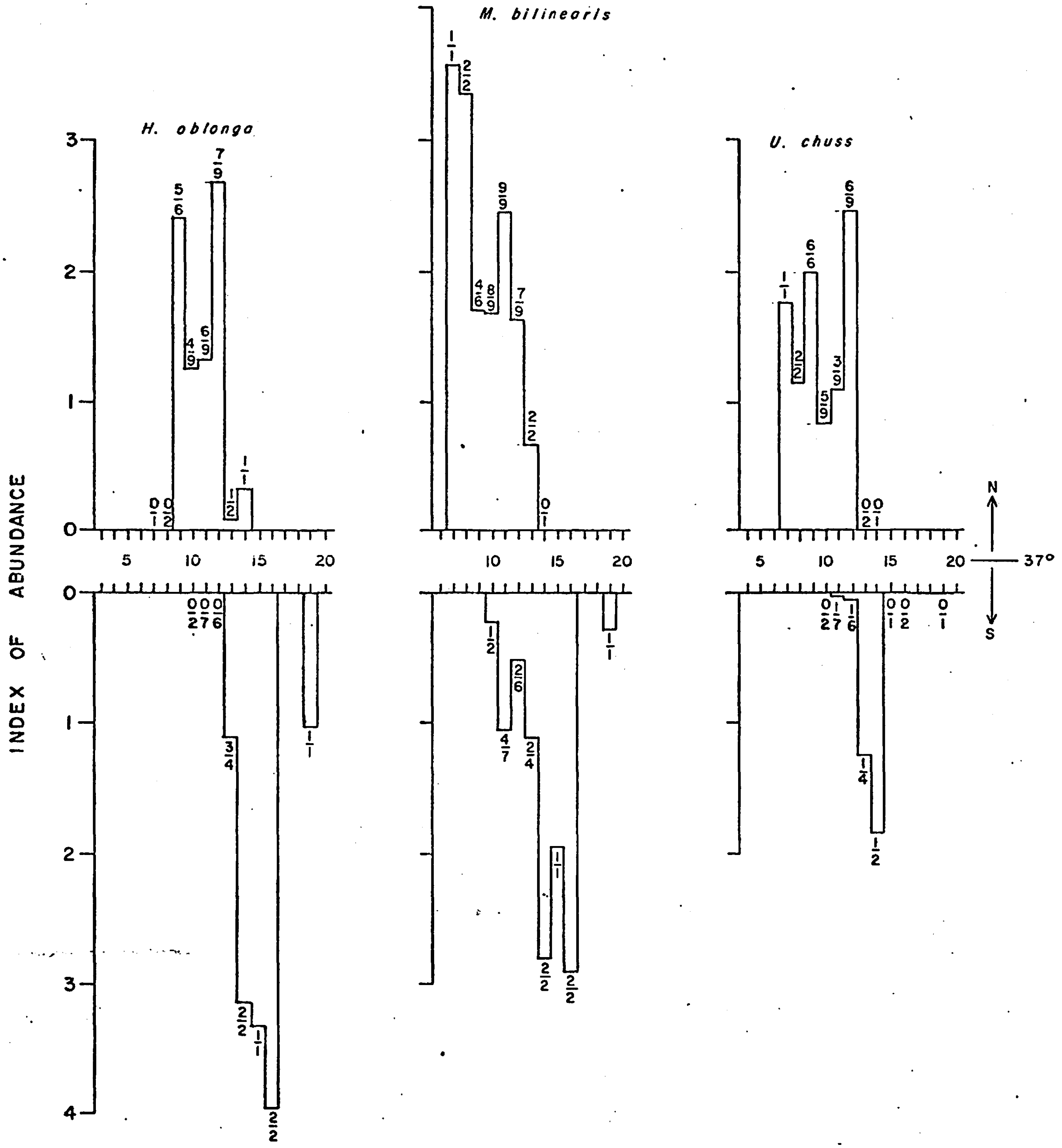
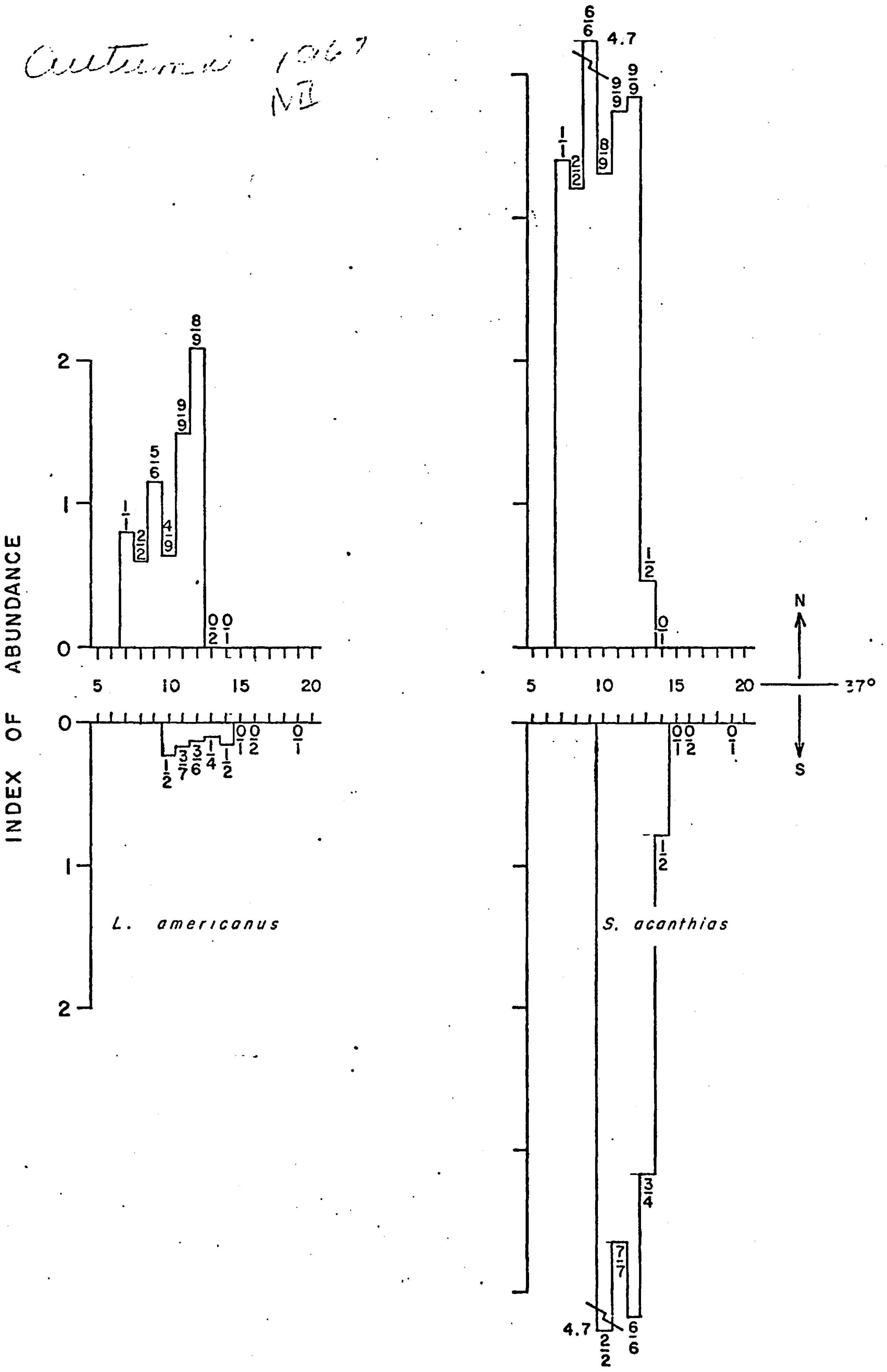
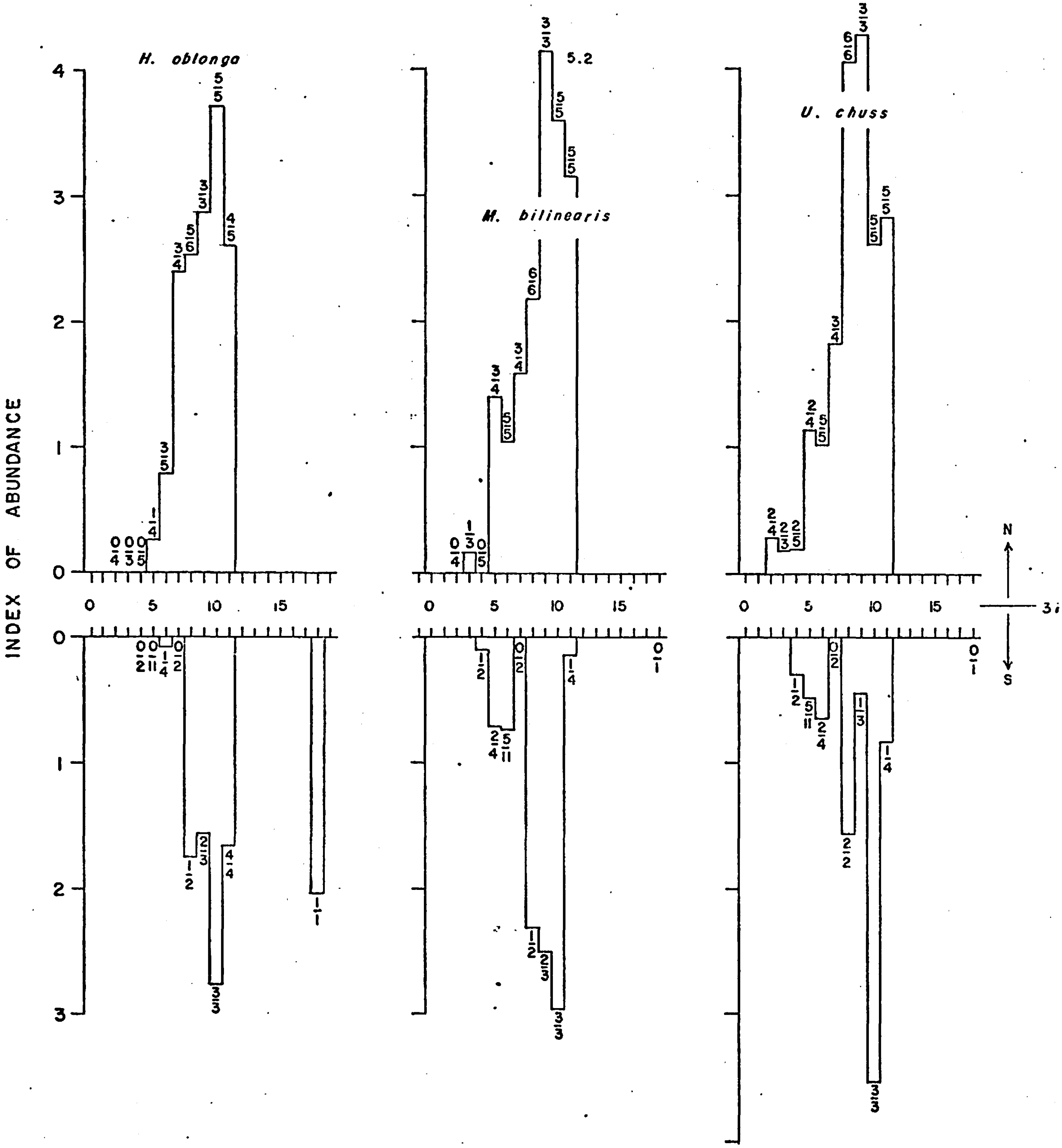


Fig 28

Autumn 1967
NII

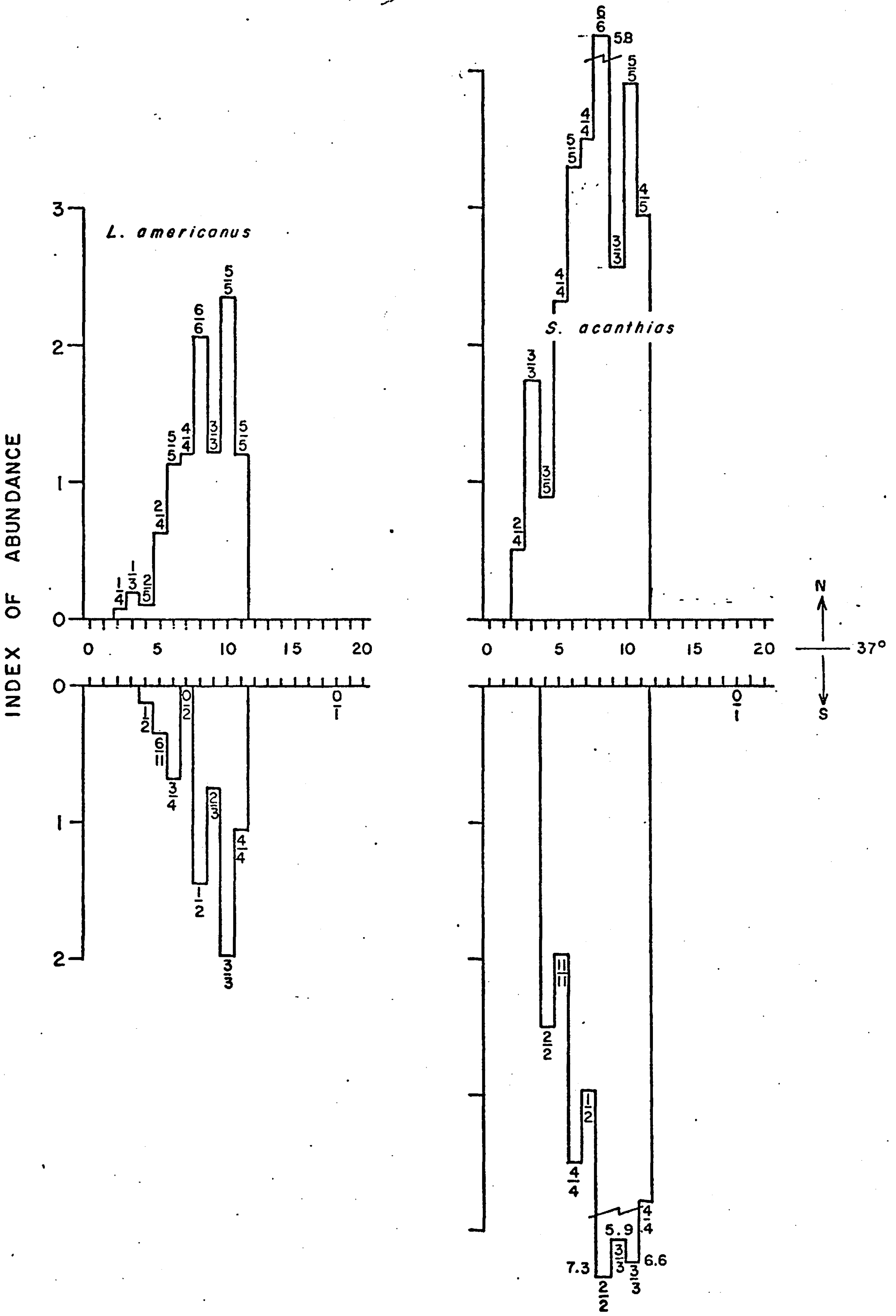


NJ Fig 29
Winter 1968



Winter 1964
N II

Fig 30



PHASE 12

ANALYSIS AND PUBLICATION OF ANCILLARY INFORMATION

By .

J. A. MUSICK AND J. D. McEACHRAN

VIRGINIA INSTITUTE OF MARINE SCIENCE
GLOUCESTER POINT, VIRGINIA

PHASE 12

Autumn and Winter Occurrence of Decapod Crustaceans in Chesapeake Bight, U.S.A.[1]

By

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Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

Chesapeake Bight includes the Continental Shelf from Cape Henlopen, Delaware (38°43'N) to Cape Hatteras, North Carolina (35°13'N). The zoogeography of this region is of particular interest because of the extreme seasonal variations in temperature and the presence of a marine faunal barrier at Cape Hatteras (Parr, 1933). The decapod fauna of this region has been treated by Williams (1965), Williams, McCloskey and Gray (1968) and Cerame-Vivas and Gray (1966). The latter authors also commented on the effectiveness of Cape Hatteras as a faunal barrier and gave evidence to support the reality of Johnson's (1934) Carolinean, Virginean and Carribean faunal provinces.

Twenty-one species of decapods were collected during an investigation of the seasonal distribution of demersal fishes in Chesapeake Bight from November, 1967 to February, 1968. Observations of the distribution, abundance, reproduction and ecdysis of these species are reported in the present paper.

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[1] V.I.M.S. Contribution No.

This work was supported in part by the United States Commercial Fisheries Research and Development Act, Project No. 3-5-D, Dr. Jackson Davis, principal investigator. We wish to thank Dr. Raymond B. Manning of the U. S. National Museum for identifying *Nephropsis aculeata* and Dr. Marvin Wass of V.I.M.S. for identifying the pagurids.

METHODS

Two series of cruises were made aboard the trawler "Sea Breeze" to coincide with seasonal hydrographic conditions. Sixty-four stations were occupied during the autumn from 14 November to 18 December, 1967 and 76 stations were occupied from 18 January to 28 February, 1968. The survey area was divided into grids (15° latitude x 12.5° longitude). We attempted to sample each grid once during each season, and to stratify stations by depth within the grids in order to adequately sample the following depth intervals: 0-18 m, 19-37 m, 38-73 m, 74-110 m, 111-165 m, 166-274 m. At each station a bathythermograph cast was made and a model IV Atlantic Western otter trawl with 50 mm stretched mesh in the cod end was towed for one hour.

The number of each species of decapod crustacean captured at each station was recorded during the winter cruises, but in the autumn such records were kept only for about half of the trawl stations. The net usually retained only specimens larger than 50 mm in diameter. Occasionally smaller specimens were collected when they became entangled in detritus or were disgorged by fishes. Representatives of all species have been deposited in the collections of the Virginia Institute of Marine Science except the specimen of *Nephropsis aculeata* which has been donated to the U. S. National Museum.

Cancer borealis, *C. irroratus*, and *Homarus americanus* were sufficiently abundant in the collections to allow statistical analyses of their distribution and abundance. The three species were contagiously distributed (fig. 1). The natural log transformation $y = \log (x + 1)$, where x represents the number of individuals of a species taken at each station, tends to "normalize" contagious distributions and substantially reduces correlation between the mean and variance (Pereya *et al.*, 1967). An index of transformed mean abundance of *C. borealis*, *C. irroratus*, and *H. americanus* captured during the winter was computed for each depth stratum. Data collected north and south of 37°N were analyzed separately (fig. 2). A similar abundance index was computed for these species after the capture data stratified into temperature intervals of one degree C (fig. 3).

Association among certain species was suggested by the data. Consequently, where applicable, two coefficients of association, C7 and C_8 (Cole, 1949; Hurlbert, 1969) were calculated to determine whether a given pair of species co-occurred more or less frequently than could be expected by chance. The coefficients, C_7 and C_8 were very similar for all comparisons and only the values of C_7 will be presented and discussed.

RESULTS

Species are listed below in phylogenetic order by season of capture. The inclusive latitudes, longitudes, depths, and bottom water temperatures within which each species was captured are followed by three values indicating respectively: total number, number of ovigerous specimens, and the number undergoing ecdysis. Data which were not recorded or were unavailable are indicated by asterisks (*). Pertinent information collected on trawling cruises other than those noted above are included for some species.

Suborder: Natantia
Crangonidae

Crangon septemspinosa Say

Winter 1968: 3 stations

26 January-15 February, 37°02'N-38°34'N, 74°54'W-75°29'W,
16-26 m, 2-5 C, 4, 1, 0.

Suborder: Reptantia
Nephropidae

Nephropsis aculeata Smith

Winter 1968: 1 station

20 January, 37°02'N, 74°30'W, 183 m, 10 C, 1, 0, 0.

Astacidae

Homarus americanus Milne-Edwards

Autumn, 1967: 18 stations

17 November-18 December, 35°52'N-38°43'N, 73°36'W-74°52'W,
44-196 m, 9-16 C, 187, *, *.

Winter 1968: 20 stations

18 January-28 February, 35°57'N-38°35'N, 73°28'W-75°10'W,
16-274 m, 4-11 C, 196, *, *.

Additional records:

4 March-5 April 1967, 35°52'N-38°05'N, 74°19'W-74°52'W,
42-174 m, 5-12 C, 74, *, *.

2 May-1 June 1967, 36°19'N-38°16'N, 73°50'W-74°59'W,
24-183 m, 9-12 C, 44, *, *.

9 August-21 September 1967, 36°36'N-38°49'N, 73°23'W-75°27'W,
15-190 m, 6-20 C, 83, *, *.

on trawling cruises other than those noted above are included for some species.

Suborder: Natantia
Crangonidae

Crangon septemspinosa Say

Winter 1968: 3 stations

26 January-15 February, 37°02'N-38°34'N, 74°54'W-75°29'W, 16-26 m, 2-5 C, 4, 1, 0.

Suborder: Reptantia
Nephropidae

Nephropsis aculeata Smith

Winter 1968: 1 station

20 January, 37°02'N, 74°30'W, 183 m, 10 C, 1, 0, 0.

Astacidae

Homarus americanus Milne-Edwards

Autumn, 1967: 18 stations

17 November-18 December, 35°52'N-38°43'N, 73°36'W-74°52'W, 44-196 m, 9-16 C, 187, *, *.

Winter 1968: 20 stations

18 January-28 February, 35°57'N-38°35'N, 73°28'W-75°10'W, 16-274 m, 4-11 C, 196, *, *.

Additional records:

4 March-5 April 1967, 35°52'N-38°05'N, 74°19'W-74°52'W, 42-174 m, 5-12 C, 74, *, *.

2 May-1 June 1967, 36°19'N-38°16'N, 73°50'W-74°59'W, 24-183 m, 9-12 C, 44, *, *.

9 August-21 September 1967, 36°36'N-38°49'N, 73°23'W-75°27'W, 15-190 m, 6-20 C, 83, *, *.

Galatheidae

Munida iris Milne-Edwards

Autumn, 1967: 1 station

14 December, 37°26'N, 74°25'W, 196 m, 12 C, 1, 0, 0.

Winter, 1968: 6 stations

18 January-28 February, 35°57'N-38°17'N, 73°38'W-74°50'W, 121-274 m, 8-11 C, 64, *, *.

Additional records:

11 August, 1969, 37°20'N, 74°29'W, 165 m, *, 4, 2, *.

8 May, 1966, 37°33'N, 74°19'W, 183 m, 13.7° C, 13, 2, *.

7 September, 1966, 36°00'N, 74°48'W, 137 m, 10° C, 8, 2, *.

Porcellanidae

Porcellana sigsbeiana Milne-Edwards

Winter, 1968: 1 station

4 February, 35°21'N, 74°53'W, 101 m, 18 C, 1, 0, 0.

Paguridae

Dardanus insignis (Saussure)

Winter, 1968: 1 station

4 February, 35°21'N, 74°53'W, 101 m, 18 C, 1, 0, 0.

Pagurus acadianus Benedict

Winter, 1968: 2 stations

19-23 January, 37°54'N-38°40'N, 73°44'W-74°54'W, 24-55 m, 5-7 C, 2, 0, 0.

Pagurus annulipes (Stimpson)

Winter, 1968: 1 station

3 February, 36°19'N, 75°29'W, 26 m, 5 C, 1, 0, 0.

Calappidae

Calappa sulcata Rathbun

Autumn, 1967: 1 station

5 December, 35°17'N, 75°03'W, 49 m, 19 C, 1, 0, 0.

Winter, 1968: 1 station

4 February, 35°21'N, 74°53'W, 101 m, 18 C, 1, 0, 0.

Portunidae

Ovalipes ocellatus (Herbst)

Autumn, 1967: 5 stations

5-16 December, 35°41'N-37°48'N, 75°21'W-75°30'W, 11-22 m, 8-11 C, 25, 0, 0.

Ovalipes guadulpensis

Autumn, 1967: 4 stations

5-7 December, 35°13'N-37°31'N, 75°03'W-75°30'W, 18-49 m, 11-19 C, 8, 0, 0.

Portunus gibbesii (Stimpson)

Autumn, 1967: 2 stations

5 December, 35°17'N-35°51'N, 75°03'W-75°30'W, 18-49 m, 11-19 C, 4, 0, 0.

Winter, 1968: 1 station

4 February, 35°23'N, 75°02'W, 42 m, 6 C, 1, 0, 0.

Portunus spinimanus Latreille

Autumn, 1967: 1 station

5 December, 35°15'N, 75°03'W, 49 m 19 C, 2, 0, 0.

Portunus spinicarpus (Stimpson)

Winter, 1968: 1 station

4 February, 35°21'N, 74°58'W, 101 m, 18 C, 10, 2, 0.

Callinectes sapidus Rathbun

Autumn, 1967: 2 stations

13 December, 37°02'N -37°07'N, 75°41'W-75°50'W, 11-15 m, 10 C, 4, 0, 0.

Bathynectes superba (Costa)

Winter, 1968: 1 station

28 January, 37°08'N, 74°21'W, 274 m, 11 C, 1, 1, 0.

Additional records:

June 7, 1967: 37°05'N, 74°35'W, 159 m, 11 C, 1, 0, 0.

October 8, 1967: 40°00'N, 70°00'W, 196 m, 10 C, 1, 0, 0.

August 1, 1969: 40°02'N, 70°50'W, 265 m, *, 1, 0, 0.

Cancridae

Cancer irroratus Say

Autumn, 1967: 12 stations

14 November-17 December, 35°41'N-38°18'N, 74°23'W-75°50'W, 11-196 m, 8-13 C, 241, *, *.

Winter, 1968: 48 stations

18 January-28 February, 35°46'N-38°40'N, 73°44'W-75°49'W, 9-274 m, 2-11 C, 472, 43, 35.

Remarks:

Ovigerous individuals were captured only within 29 m, and individuals showing evidence of recent ecdysis, were recorded only within 16 m. Abundance values, stratified by depth and latitude and temperature and latitude, are given in figures 2 and 3.

Cancer borealis Stimpson

Autumn, 1967: 6 stations

16 November-18 December, 36°05'N-38°43'N, 73°53'W-74°49'W, 15-196 m, 11-14 C, 56, *, *.

Winter, 1968: 20 stations

18 January-28 February, 36°39'N-38°33'N, 73°28'W-74°50'W, 33-274 m, 3-11 C, 227, 0, 0.

Remarks:

Abundance values stratified by depth and latitude, and temperature and latitude are given in figures 2 and 3.

Majidae

Libinia emarginata Leach

Autumn, 1967: 4 stations

14 November-7 December, 36°31'N-38°43'N, 74°35'W-75°24'W, 18-22 m, 11-13 C, 5, 0, 0.

Winter, 1968: 2 stations

27 January-2 February, 35°46'N-37°29'N, 74°48'W-75°24'W, 18-51 m, 4-7 C, 2, 0, 0.

Rochinia crassa Milne-Edwards

Autumn, 1967: 1 station

14 December, 37°06'N, 74°35'W, 194 m, 12 C, 1, 0, 0.

Goneplacidae

Geryon quinquidens Smith

Autumn, 1967: 1 station

18 December, 38°08'N, 73°53'W, 168 m, 11 C, 1, 0, 0.

DISCUSSION

Jeffries (1966) noted that in Narragansett Bay, R. I., *Cancer irroratus* and *C. borealis* very rarely occur together, the former preferring sandy substrates and the latter living on rocky bottoms with the lobster, *Homarus americanus*. *Cancer irroratus* and *C. borealis* do not appear to be mutually exclusive in Chesapeake Bight. Rather the C_7 value of -0.064 is not significant and suggests that the species are distributed randomly with respect to one another. Conversely C_7 for *Homarus americanus* and *C. borealis* (0.571) is significant at the 0.001 probability level ($t = 4.830$) and indicates that *H. americanus* and *C. borealis* are closely associated. These findings are not surprising because the bathymetric distribution of *H. americanus* (fig. 4) is similar to that of *C. borealis*, both species being most abundant along the shelf edge. *Cancer irroratus* is widespread over the continental shelf and very abundant inshore.

Bottom type, which Jeffries (1966) thought to be very important in segregating *C. irroratus* from *C. borealis* and *H. americanus* appears to be less important in the Chesapeake Bight where rocky substrates are few and occur only adjacent to submarine canyons. The shelf sediments consist mostly of sand with occasional patches of gravel and the slope sediments are mostly silt and clay (Uchupi, 1963). The bathymetric distributions of *C. irroratus*, *C. borealis* and *H. americanus* when compared to the bathymetric distribution of sediment types suggest that any of the species may be taken over any of the above sediment types, but the likelihood of finding *C. irroratus* over sandy bottoms would be greater than that of capturing it over silt, clay, or coarse canyon sediments. The converse is apparent for *C. borealis* and *H. americanus*.

The distribution of *C. borealis* and *C. irroratus* within the demersal thermal regime of the Chesapeake Bight (fig. 3) suggests that *C. borealis* may be more stenothermal than *C. irroratus*. However, the appearance of stenothermality may be no more than an artifact of the abundance of *C. borealis* along the shelf edge where slope water has a more stable temperature regime than that of coastal water on the continental shelf.

Saila and Flowers (1968, 1969) have shown that *H. americanus* from the outer shelf and upper slope comprise a population different from those found in New England inshore waters. The similarity in bathymetric distribution between *H. americanus* and *C. borealis* suggests that *C. borealis* may also be isolated into inshore and offshore populations. Conversely, the wide bathymetric distribution of *C. irroratus* suggests a continuous population from southern New England to the Chesapeake Bight.

The galatheid *Munida iris* was not captured shoaler than 121 m. C_7 for *M. iris* and *H. americanus* is 0.771, a value significant at the 0.005 level ($t = 3.29$) and C_7 for *M. iris* and *C. borealis* is 0.778, a value significant at the 0.001 level ($t = 3.44$). These three species form the nucleus of a shelf edge-upper slope decapod fauna which also includes the rarer species, *Nephropsis aculeata*, *Bathynectes superba* and *Rochinia crassa*. *Geryon quinquidens*, another deep-water form was captured once during the "Sea Breeze" cruises but we subsequently found it to be abundant at 400-1000 m (Musick and McEachran, M.S.).

During each season one station was made within the Gulf Stream and the following species were captured only there: *Porcellana sigsbeiana*, *Dardanus insignis*, *Culappa sulcata*, *Portunus spinicarpus* and *Portunus spinimanus*. The first four of these have tropical affinities (Cerame-Vivas and Grey, 1966; Williams, 1965) and the last, Carolinean. The Gulf Stream thermal front was obvious during both seasons at the edge of the shelf between Cape Hatteras and Oregon Inlet (figs. 5 and 6). Another form with southern affinities, *Portunus gibbesii*, was captured both in the Gulf Stream and elsewhere and at a temperature as low as 6 C at one station, which was located along the northwest front of the Gulf Stream. The bottom temperature was 18 C within a few miles and the specimen may have been stranded by the meanderings of the stream.

The sibling species *Ovalipes ocellatus* and *O. guadulpensis* were captured only during the autumn. In winter they may burrow into the bottom and be unavailable to a trawl. Williams (1962) suggested that adult *O. ocellatus* occurred closer to shore than *O. guadulpensis* in those areas where their ranges overlap. The habitat difference may be related to differences in temperature preferences, because we captured *O. ocellatus* from 8 to 12 C and 11 to 22 m and *O. guadulpensis* from 11 to 19 C and 18 to 49 m.

Vernberg and Vernberg (1970) pointed out that the tolerance of *O. ocellatus* to elevated temperature is similar to that of *O. guadulpensis*. However, they also found *O. ocellatus* to be tolerant of 4 C for prolonged periods of time without apparent harm. They did not give similar lower lethal limit data for *O. guadulpensis* nor did they examine temperature preferences of the two species.

The previously known range of *O. guadulpensis* extended from North Carolina to Brazil (Vernberg and Vernberg, 1970). We now extend this range north within the Chesapeake Bight to the Virginia coast. Its presence here is not surprising. Other southern forms such as *Portunus gibbesii* were also captured on the continental shelf inshore during the fall. In the winter, the inner shelf may support boreal species such as *Pagurus acadianus* and ubiquitous species, such as *Pagurus annulipes* and *Libinia emarginata*. These last three species were all captured at temperatures at least as low as 5 C.

SUMMARY

Autumn and winter collections of decapod crustaceans in Chesapeake Bight suggest that the region might be divided into three zoogeographical zones: the Gulf Stream with its attendant tropical and southern fauna; the environmentally stable outer continental shelf and upper slope where *C. irroratus*, *H. americanus* and *M. iris* are abundant; and the seasonally variable inner shelf which may support tropical or boreal species at certain seasons but where the fauna is dominated by Virginian species such as *C. irroratus* and *O. ocellatus*.

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APPENDIX

Contingency tables necessary to compute Cole's coefficient of association (C_7)

		C. borealis	
		present	absent
M. iris	present	5	1
	absent	14	56

		C. borealis	
		present	absent
H. americanus	present	13	7
	absent	6	50

		C. borealis	
		present	absent
C. irroratus	present	11	36
	absent	8	21

		H. americanus	
		present	absent
M. iris	present	5	1
	absent	15	55

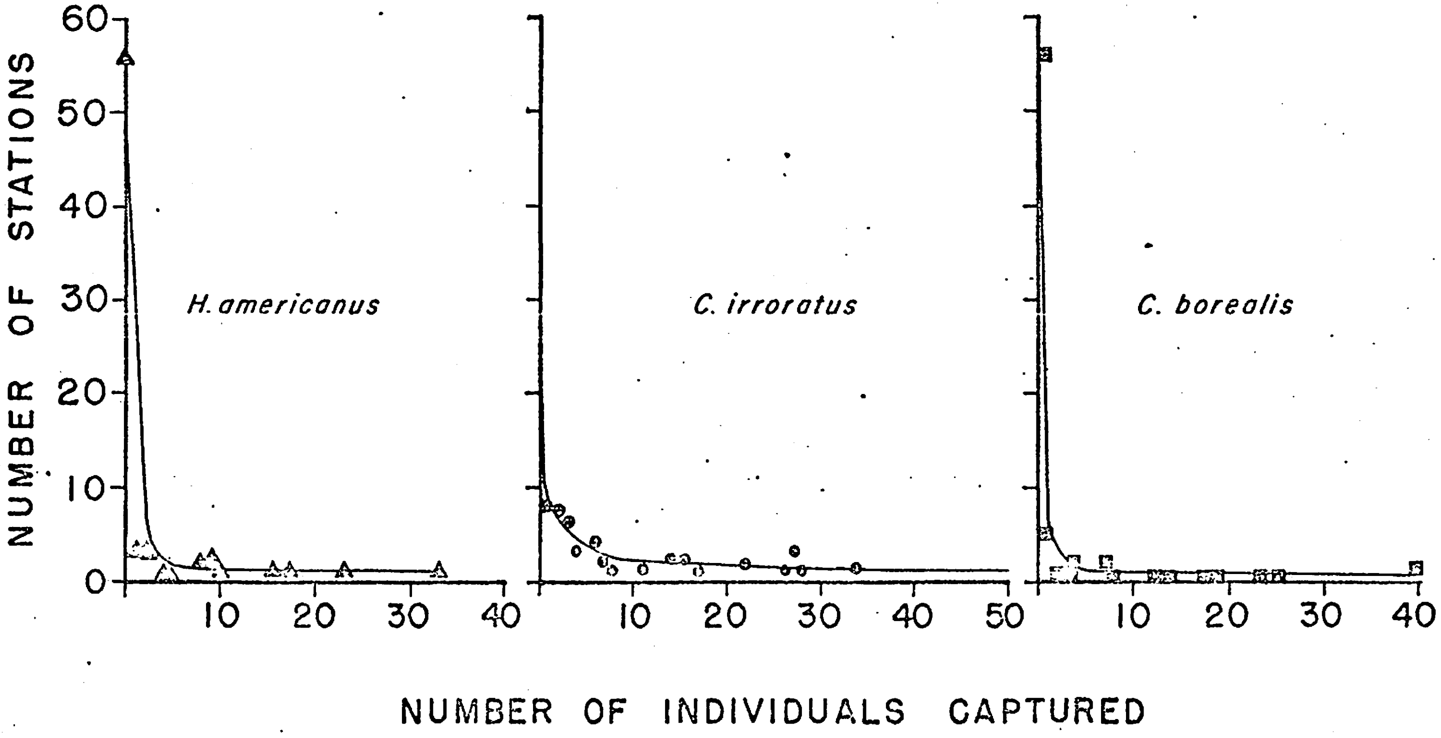

Figure 1. Statistical distribution of the number of individuals of *C. irroratus*, *C. borealis*, and *H. americanus* captured per station.

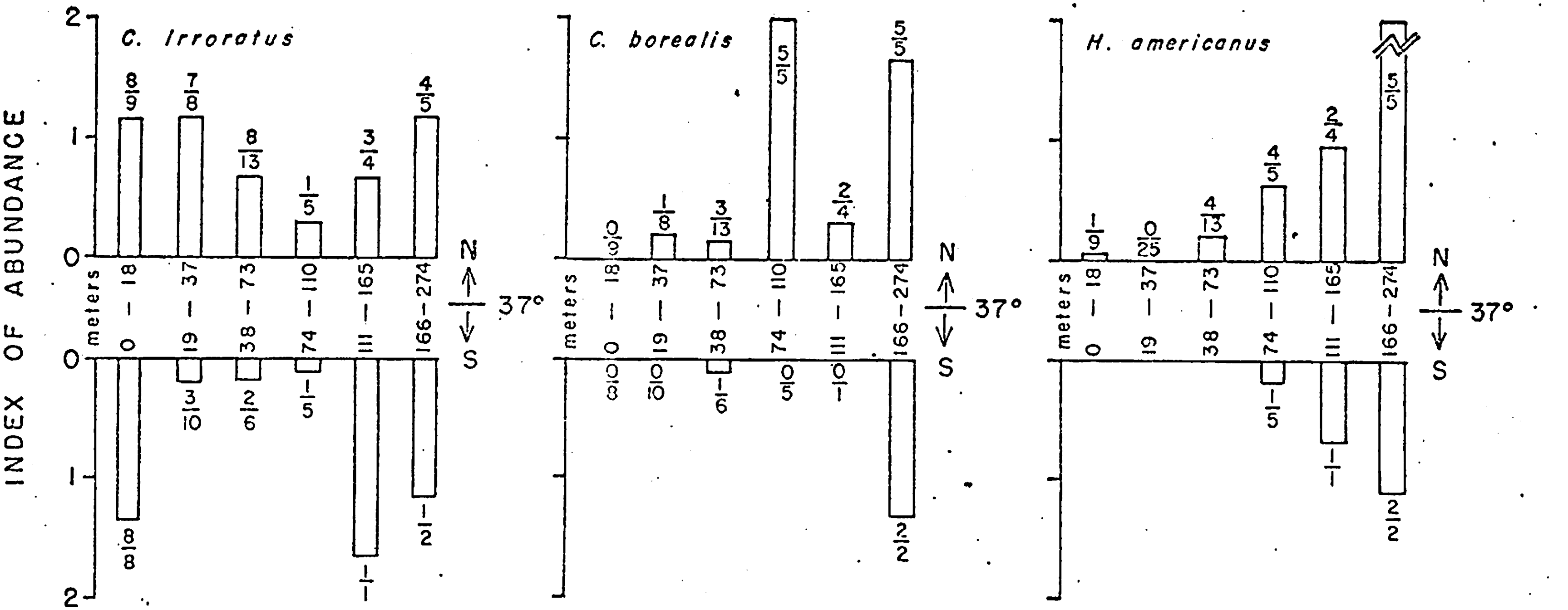

Figure 2. Index of transformed mean abundance of C. borealis, C. irroratus, and H. americanus captured during the winter within each depth stratum. Data collected north and south of 37°N were analyzed separately.

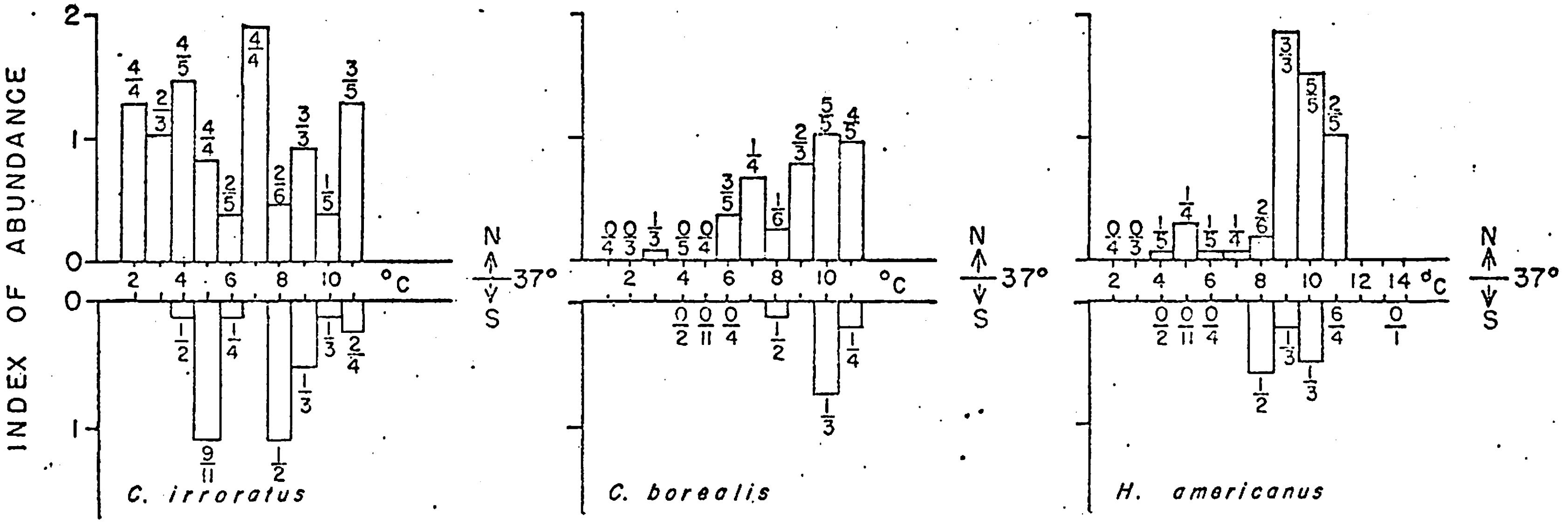

Figure 3. Index of transformed mean abundance of C. borealis, C. irroratus, and H. americanus captured during the winter at each degree C. Data collected north and south of 37°N were analyzed separately.

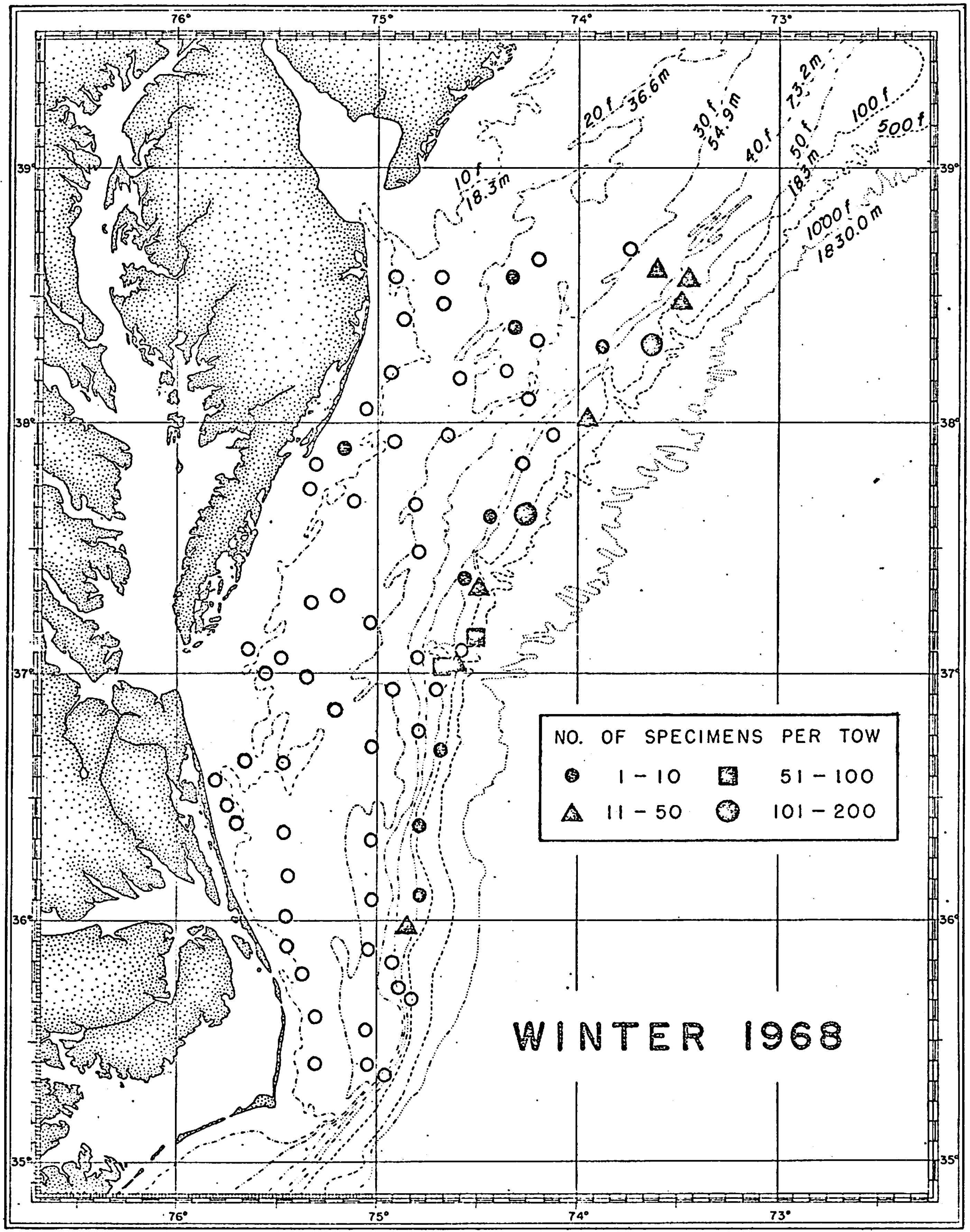

Figure 4. Bathymetric distribution of H. americanus in Chesapeake Bight during winter cruises.

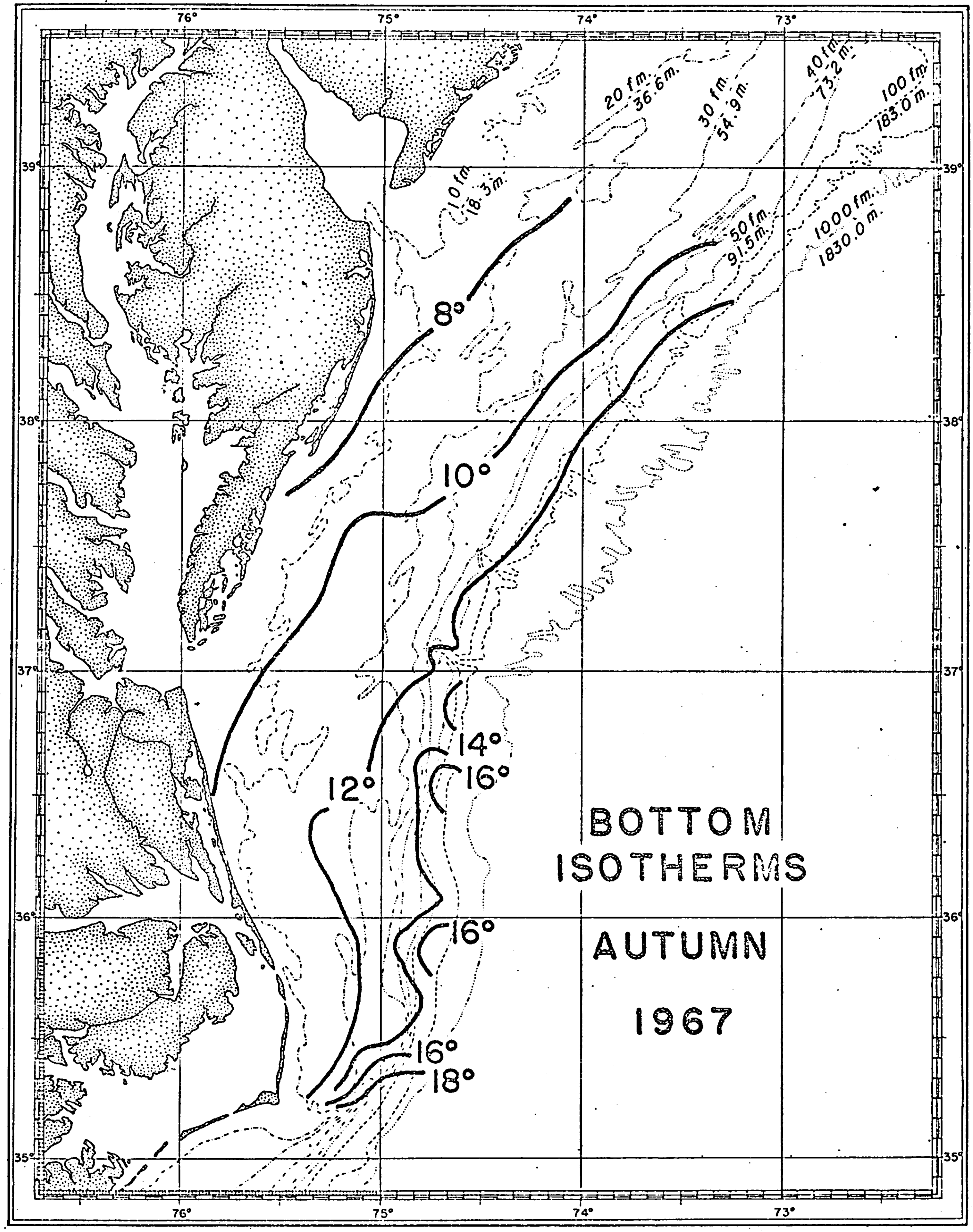

Figure 5. Distribution of bottom water temperatures in Chesapeake Bight during autumn cruises.

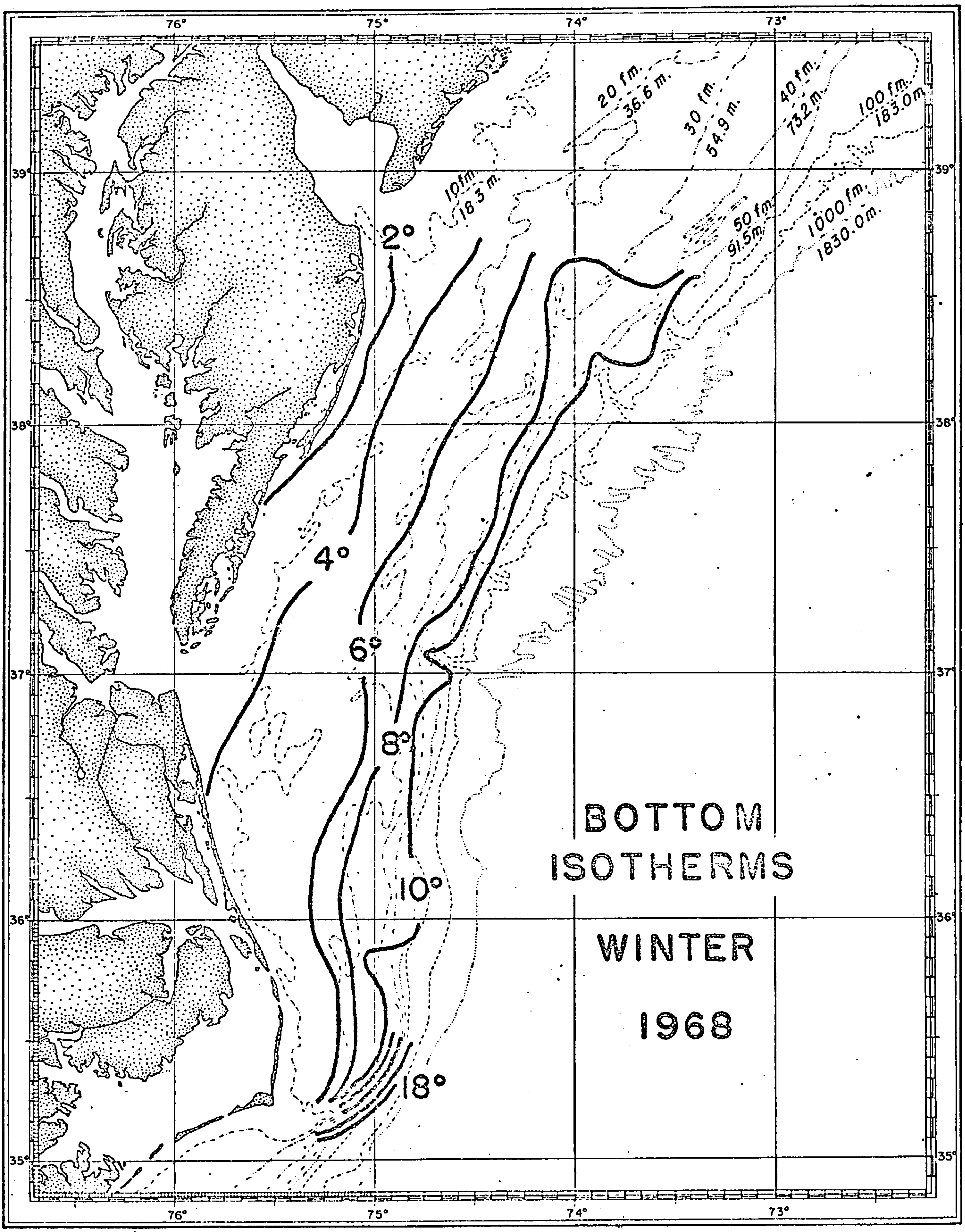

Figure 6. Distribution of bottom water temperatures in Chesapeake Bight during winter cruises.

DISTRIBUTION AND ABUNDANCE OF LOBSTERS AND SEA SCALLOPS IN CHESAPEAKE BIGHT

by

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PHASE 12

Distribution and Abundance of Lobsters and Scallops in Chesapeake Bight

Information about the abundance and distribution of lobsters and scallops was obtained during an inventory of the fishery resources of the continental shelf of the middle Atlantic Coast. The approximately 15,000 square miles between Cape Hatteras and Cape May was sampled with an Atlantic Western Model IV trawl during the four seasons of 1967 and in the winter of 1968. Although the primary objective of the series of cruises was to sample the fish population, lobsters and scallops were counted and weighed whenever they were caught. A trawl is not an efficient gear for taking scallops, therefore these data are not to be considered a definitive survey of the scallop population, but they may yield some information of value concerning this valuable resource. Rocky bottom, where lobsters are likely to be most abundant, was not sampled with the trawl.

Lobsters

Throughout the year lobsters were most abundant at depths greater than 60 fathoms and usually occurred in greater quantities north of 37°N latitude than to the south. The total weight of lobsters caught in each one-hour trawl tow in each season is shown in Figures 1-5. The index of abundance shown in these figures is based on the logarithmic transformation ($\log(x + 1) = y$) of numbers rather than on weight. Abundance is compared in six depth strata in both the northern and southern sectors.

During spring and summer small lobsters were caught in some quantity north of 37°N at intermediate depths, accounting for the relatively high abundance indices in 41 to 60 fathoms (Figs. 2 and 3). As a general rule, lobsters of desirable sizes were at depths greater than 60 fathoms during all seasons. As many as 167 pounds were caught in a one-hour tow. The largest catches were made between Norfolk Canyon and Wilmington Canyon during the fall and winter.

Lobsters were caught at bottom water temperatures of 4 to 20°C but the range of from 9° to 12° produced the best catches. The high value at 16° in Figure 6 resulted from a single unusually large catch. Bottom water temperature changes little from one season to the next in the area from the 60 fathom contour to the edge of the shelf. Lobsters apparently find in this stable thermal regime a satisfactory environment.

Scallops

The numbers of pounds of scallops caught at each station during each season are shown in Figures 7 to 11. Seasonal changes in distribution and abundance other than those attributable to the highly contagious distribution of the scallops were not apparent. Therefore, the data for all seasons were combined. A log transformation was applied to the numbers of scallops captured at each station and abundance values were calculated for six depth strata north of 37°N latitude and for six strata south of 37°N (Fig. 12).

North of 37°N scallops were caught between 21 and 52 fathoms. South of 37°N scallops were caught from 19 to 55 fathoms. Although the depth range at which scallops were captured is similar in the two areas, scallops in the southern area were more abundant deeper than 40 fathoms.

The greatest catch south of 37°N was made during the summer at 36°05'N, 74°52'W in 44 fathoms. In the northern area many catches were made along the 40 fathom isobath between Washington Canyon and Wilmington Canyon. The most productive stations were near the inshore extensions of these canyons and Baltimore Canyon (Figs. 8-12).

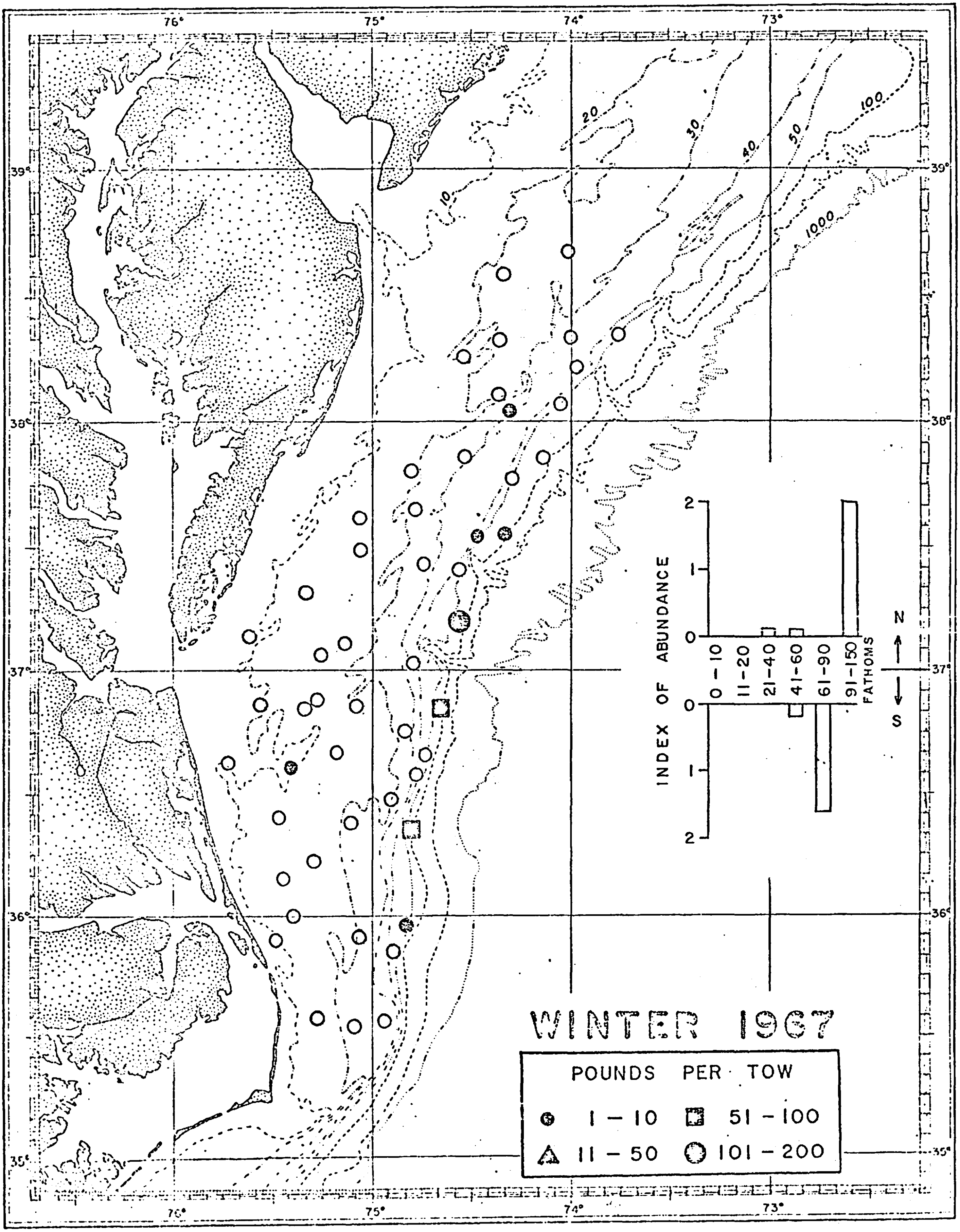

Figure 1. Distribution and abundance of lobsters in Chesapeake Bight, winter 1967.

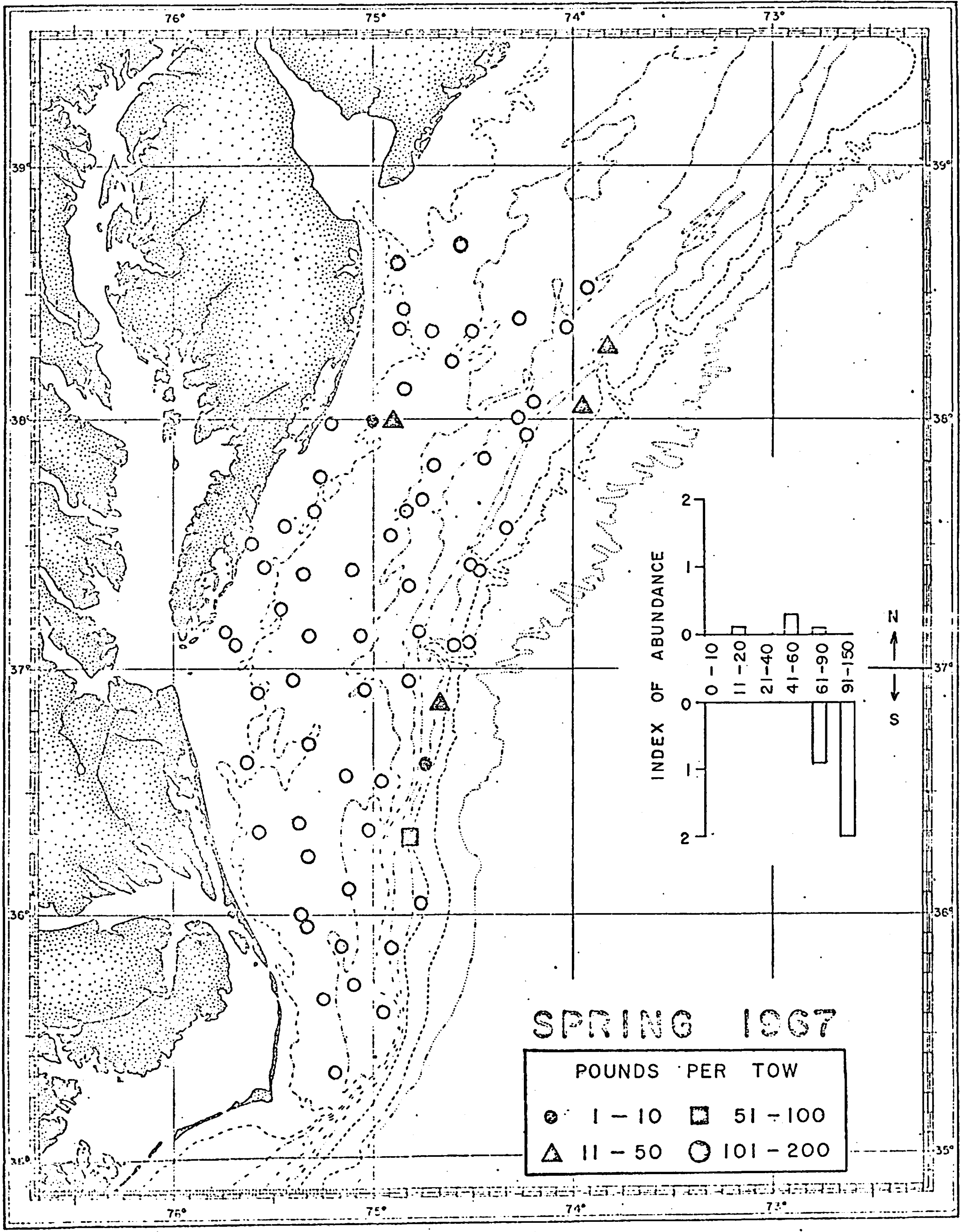

Figure 2. Distribution and abundance of lobsters in Chesapeake Bight, spring 1967.

PHASE 12

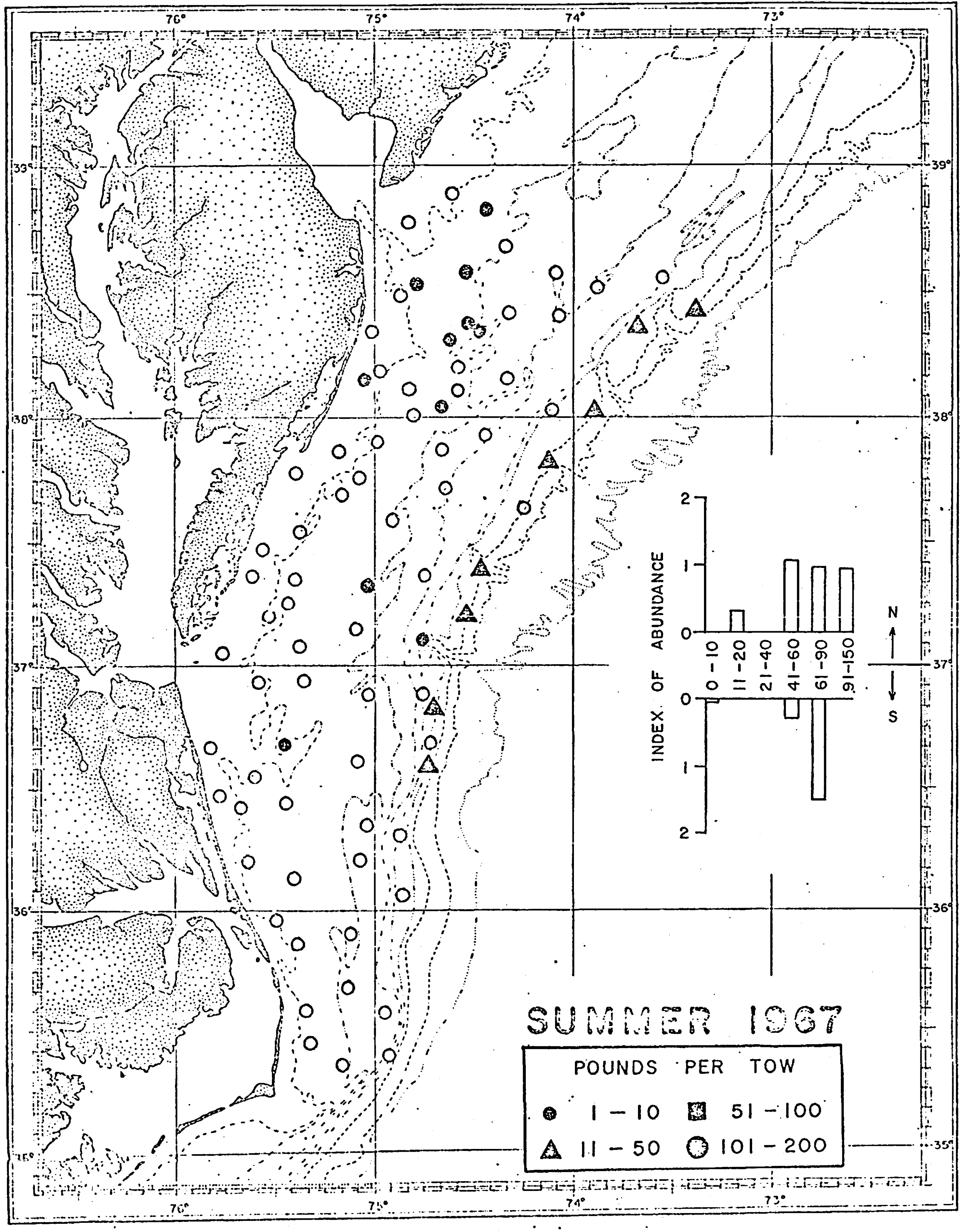

Figure 3. Distribution and abundance of lobsters in Chesapeake Bight, summer 1967.

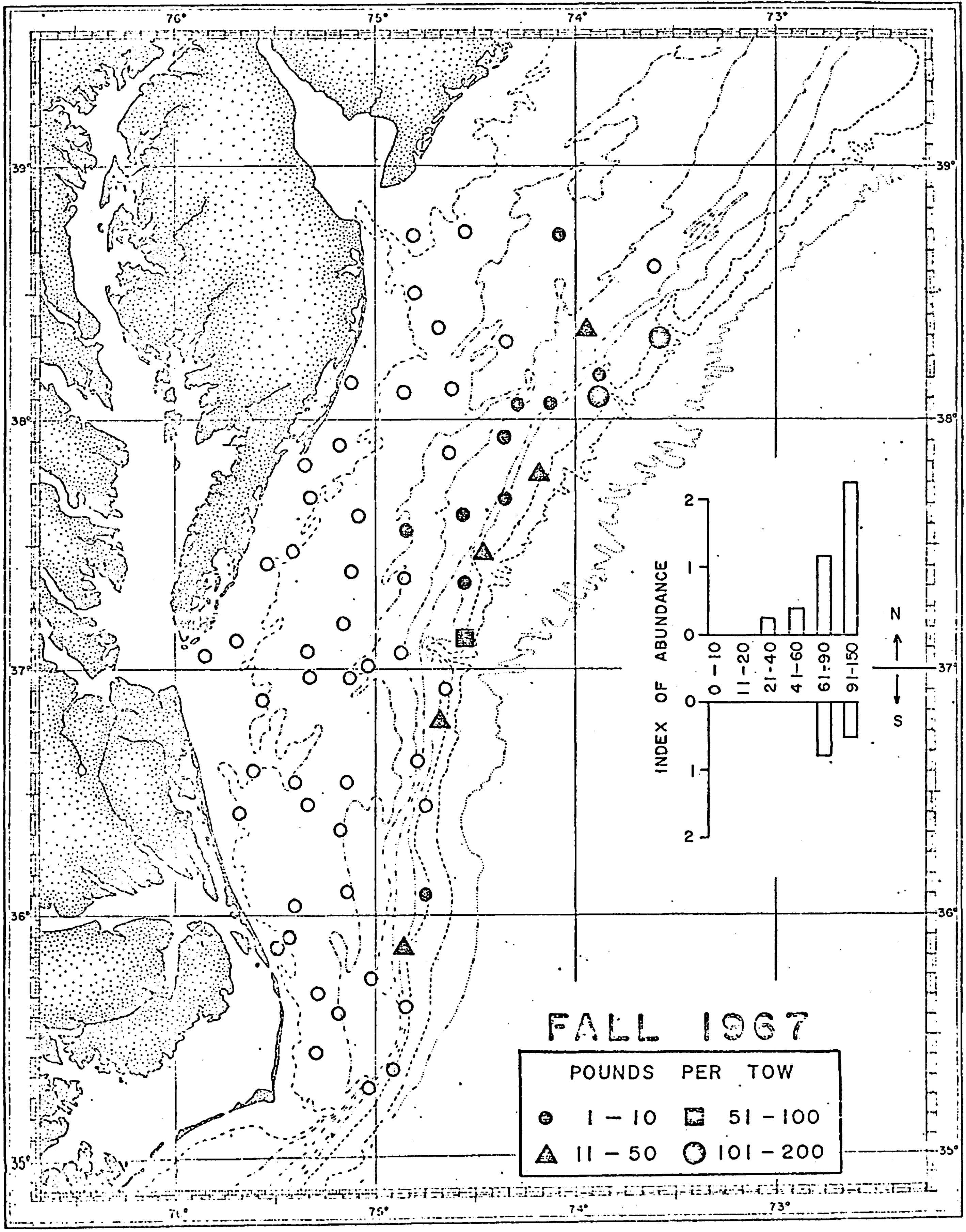

Figure 4. Distribution and abundance of lobsters in Chesapeake Bight, fall 1967.

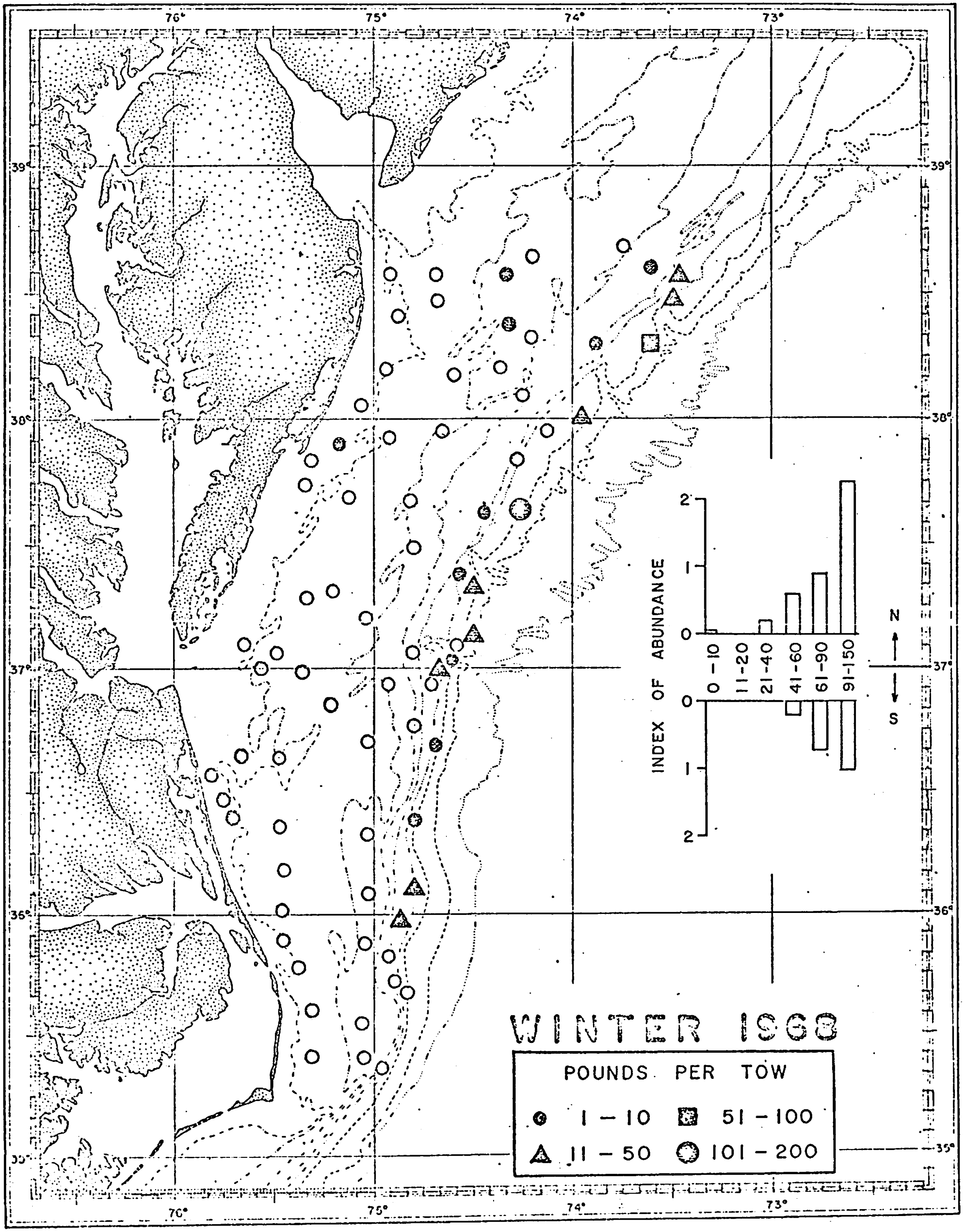

Figure 5. Distribution and abundance of lobsters in Chesapeake Bight, winter 1968.

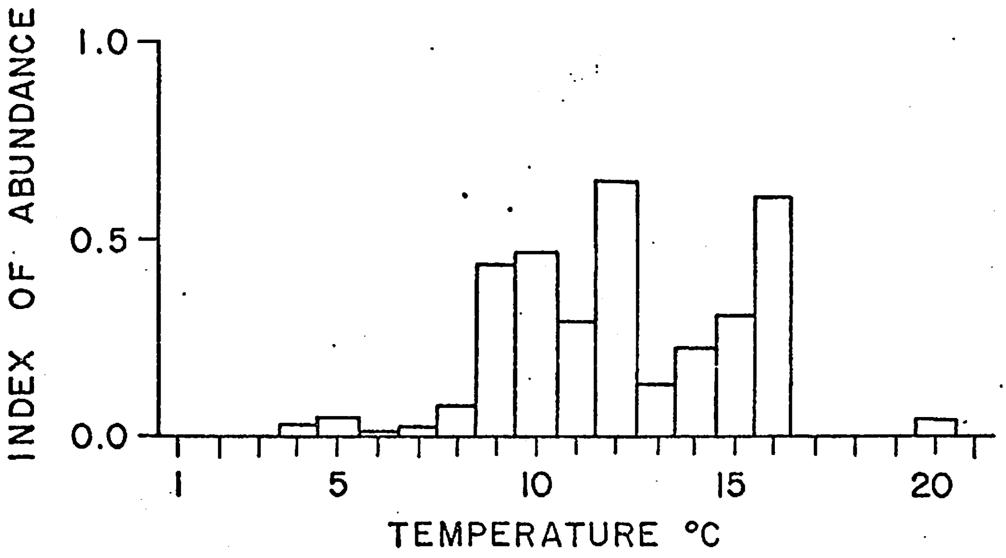

Figure 6. Distribution of lobsters in relation to temperature of the bottom water.

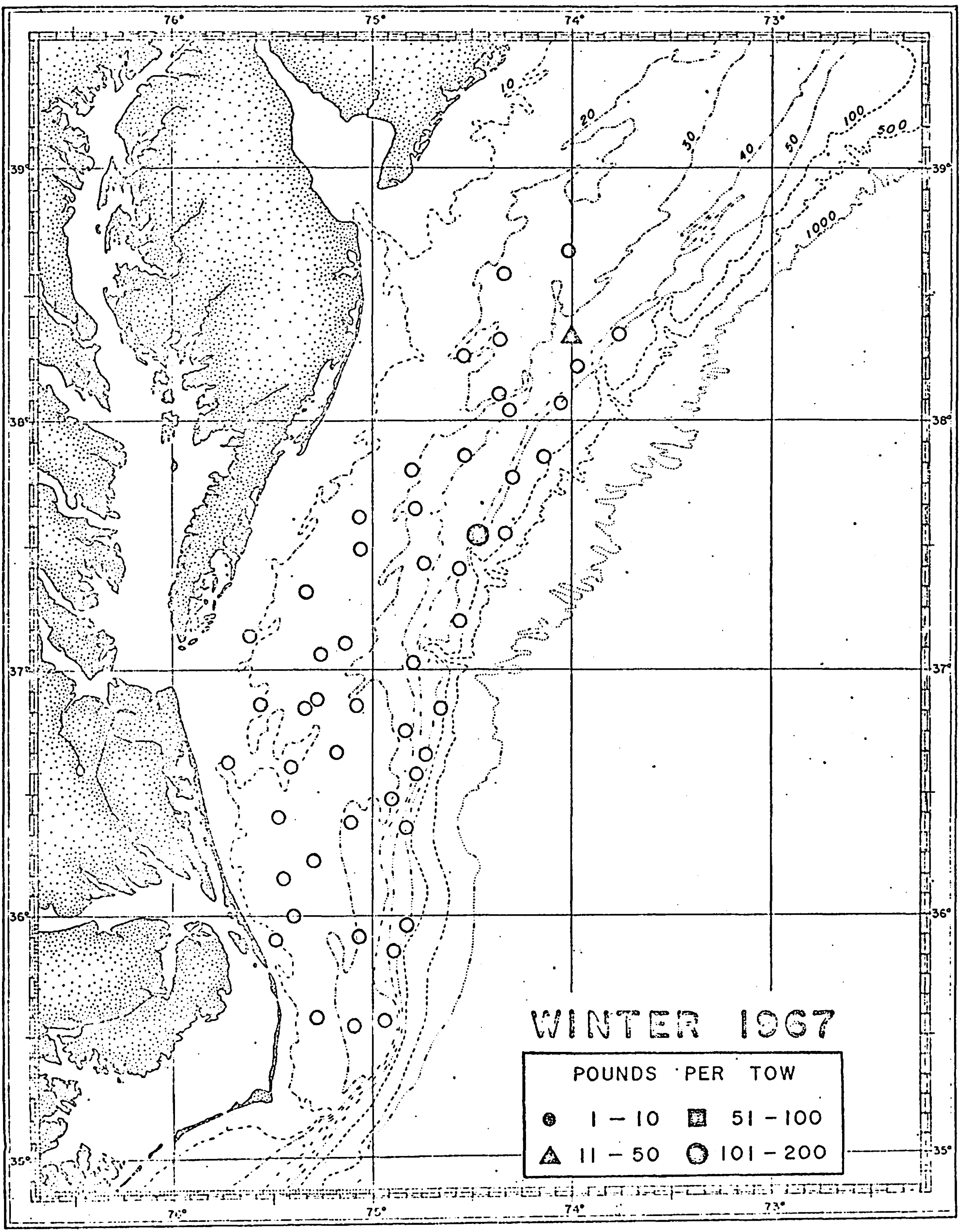

Figure 7. Distribution and abundance of sea scallops in Chesapeake Bight, winter 1967.

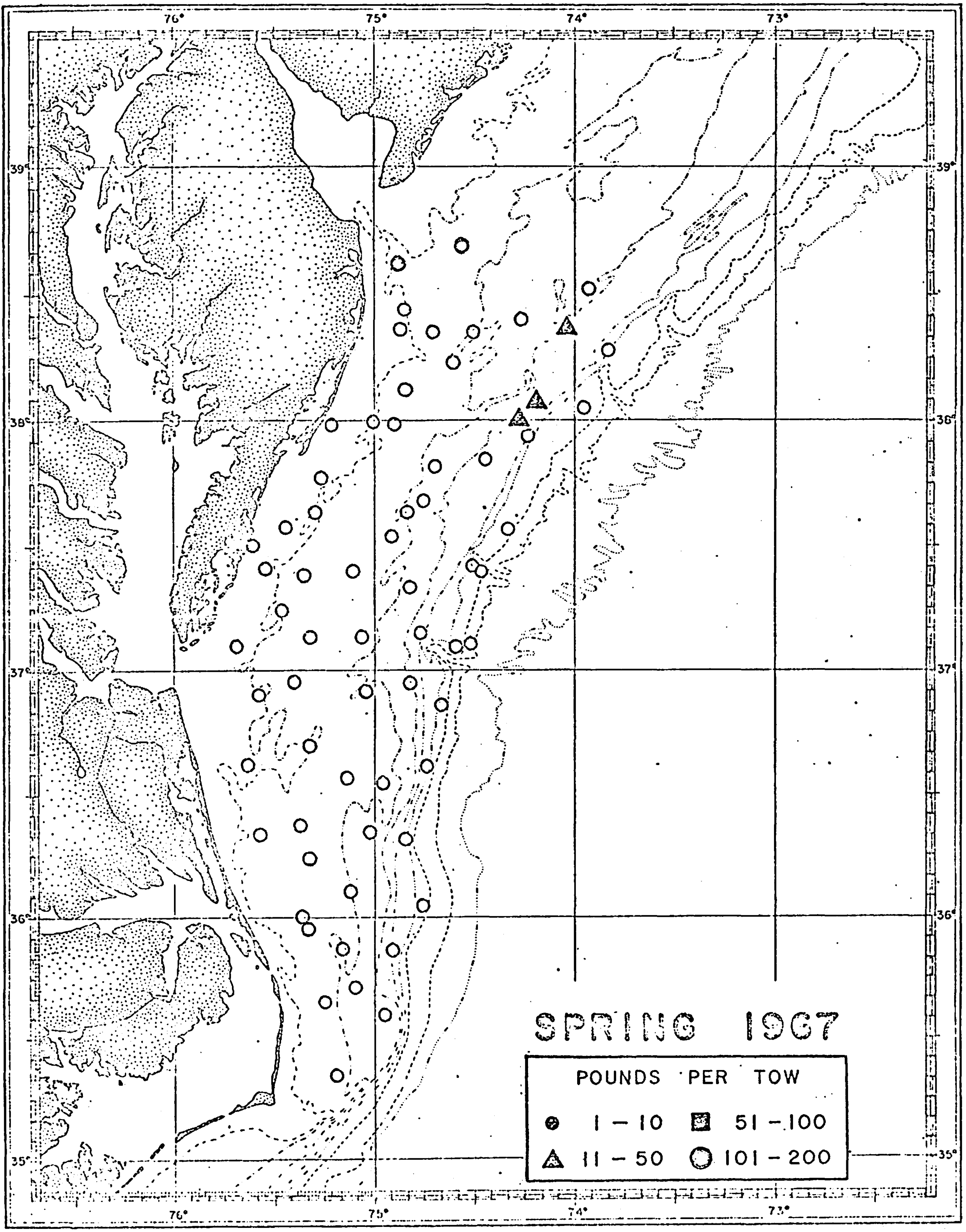

Figure 8. Distribution and abundance of sea scallops in Chesapeake Bight, spring 1967.

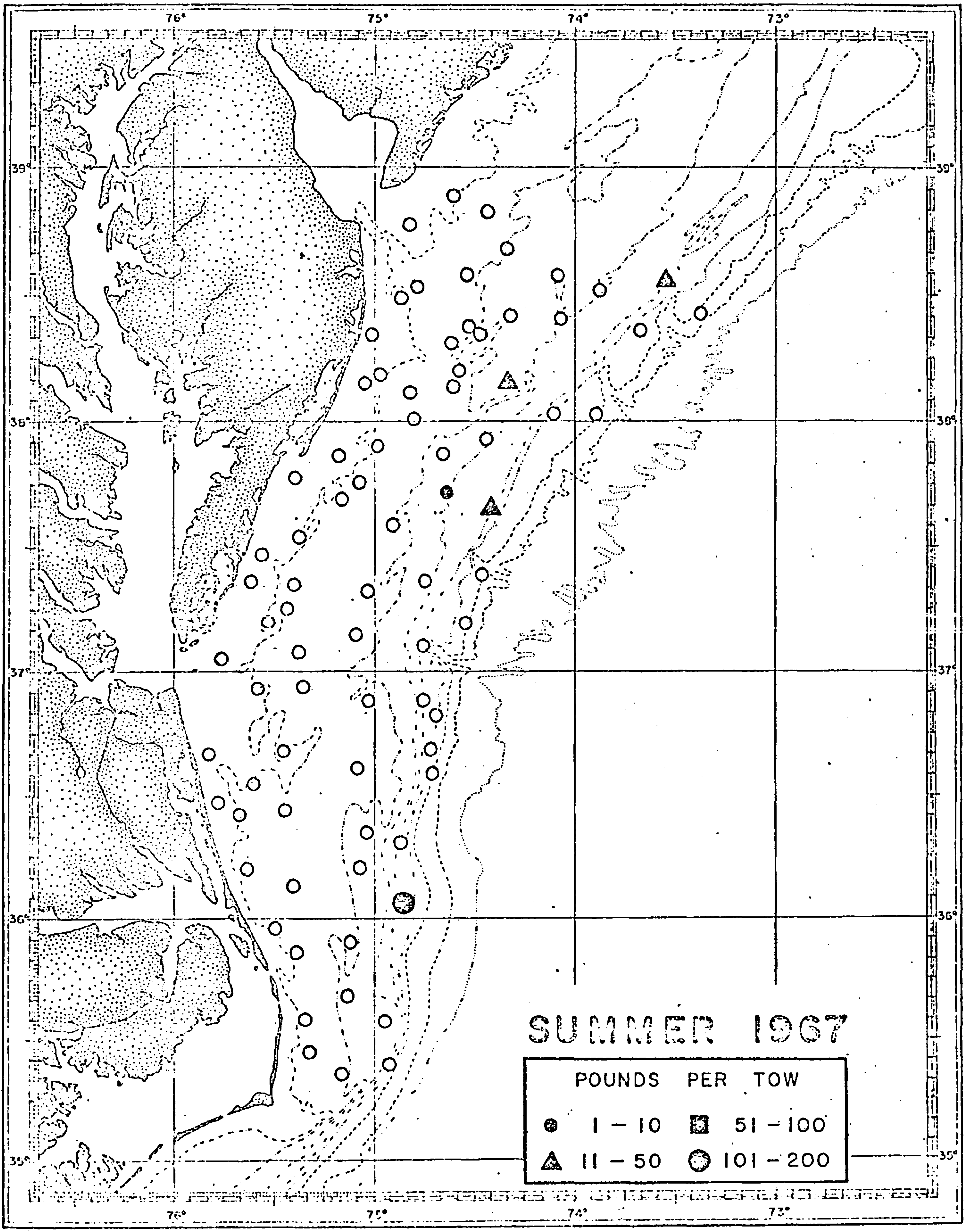

Figure 9. Distribution and abundance of sea scallops in Chesapeake Bight, summer 1967.

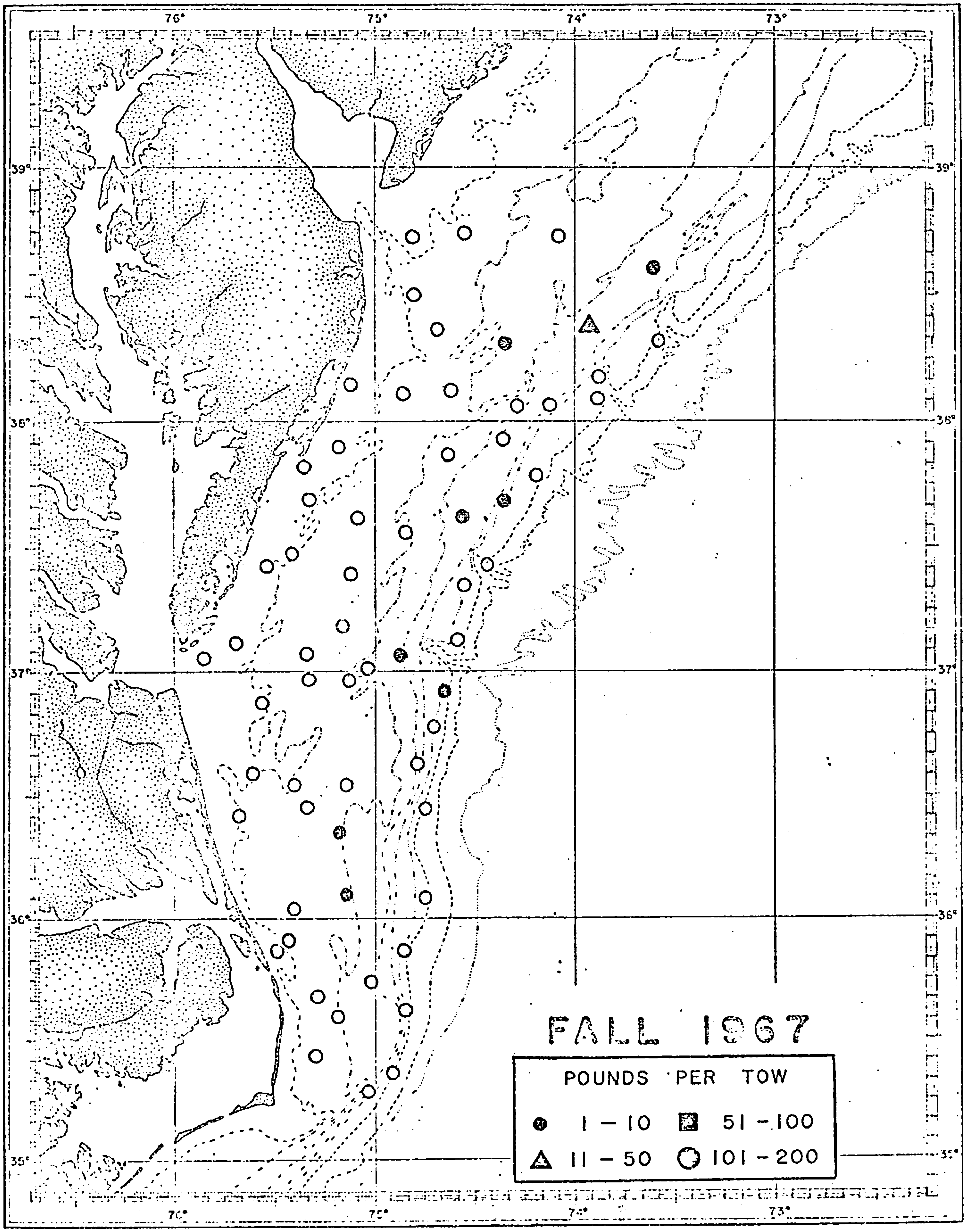

Figure 10. Distribution and abundance of sea scallops in Chesapeake Bight, fall 1967.

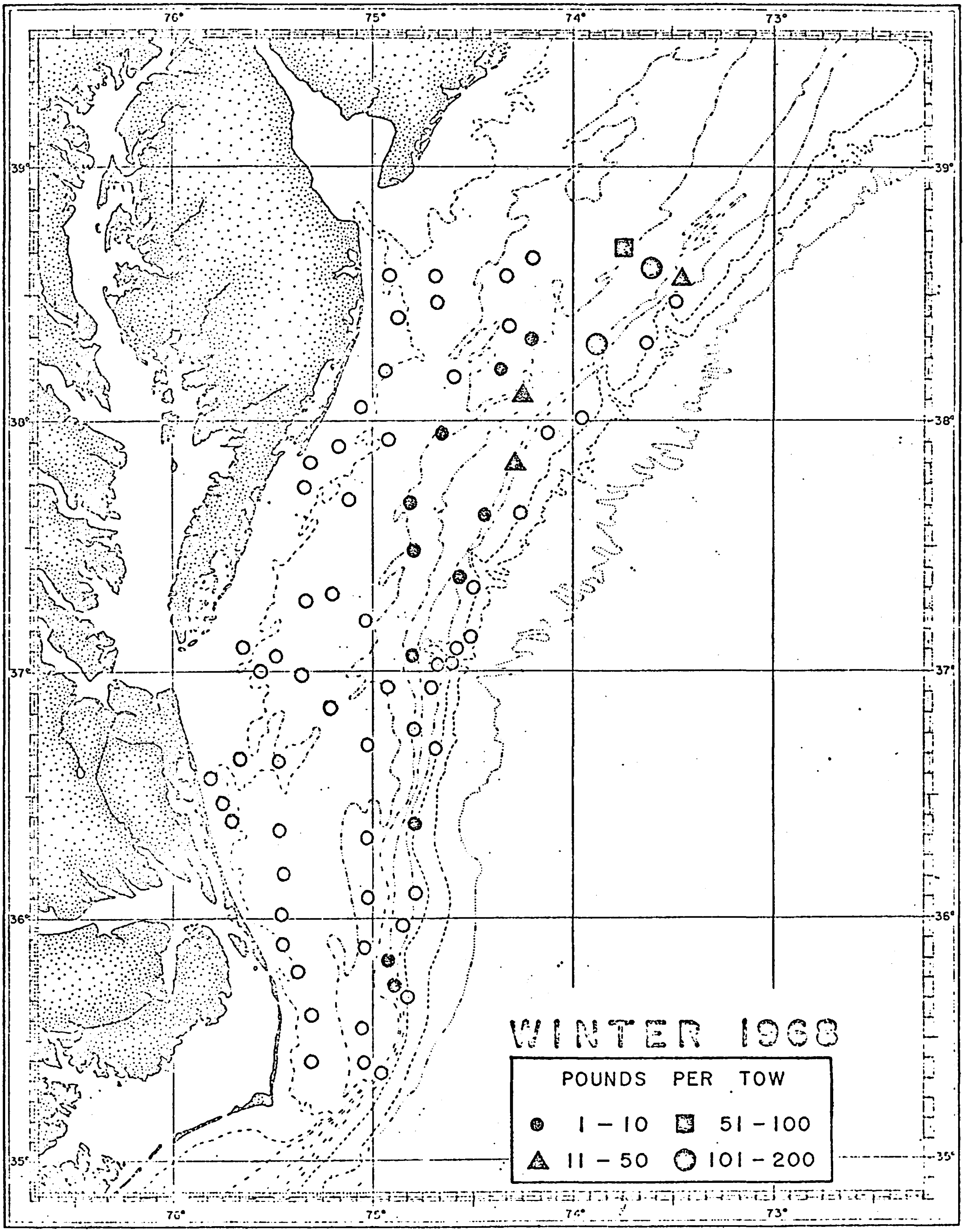

Figure 11. Distribution and abundance of sea scallops in Chesapeake Bight, winter 1968.

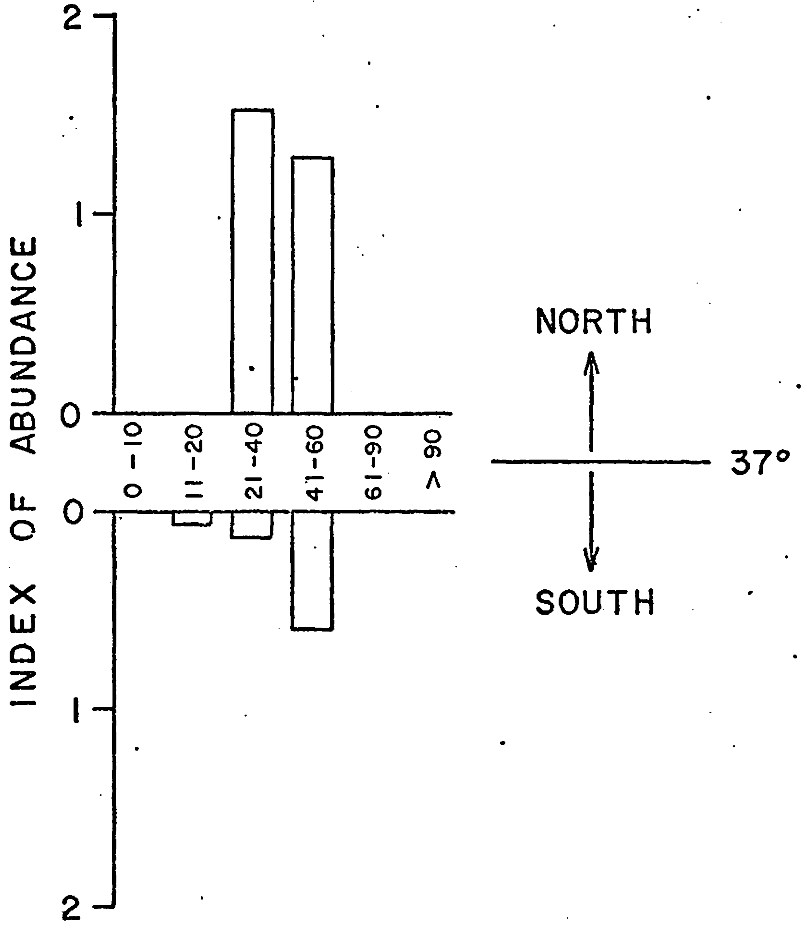

Figure 12. Index of abundance of sea scallops in relation to depth.

Information Provided to Industry and Scientific Community

Throughout the course of the investigation the industrial fishing industry was kept informed. A summary of the findings of each seasonal cruise was sent to the National Fish Meal and Oil Association for distribution to its membership. The information in the summaries has been presented in this report under Phases 4, 5, 7, 8, 9. In addition the information embodied in Phase 10 was presented in an illustrated talk to NMFOA at the annual meeting in 1968.

Information of general interest was released to the news media. Resulting newspaper articles and television news coverage generated several requests for information which were handled on an individual basis.

The fishing community was also kept informed by means of informal dockside conversations and by means of radio contact when we were working at sea.

Information was transmitted to the scientific community by presentation of papers at meetings of fisheries and oceanographic societies. At the 30th annual meeting of the American Society of Limnology and Oceanography in 1967, a paper was given entitled Seasonal Distribution of Some Benthic Fishes of Chesapeake Bight. The paper was based on Phase 10, Part 1 of this report. This paper was also presented at a joint meeting of the US and Russian scientists who took part in the first joint groundfish survey in the fall of 1967. A paper entitled, Seasonal Availability and Distribution of Benthic Fishes of Chesapeake Bight was presented at the 99th annual meeting of the American Fisheries Society in 1969. An expansion of that paper comprises Phase 11 of this report.

The echo-sounder traces of midwater fishes obtained during the course of this survey were a part of the data base which led to an exploration for schooling pelagic fishes in the Middle Atlantic Bight in 1969. (See Davis, Jackson, 1970. Exploring for schooling pelagic fishes in Middle Atlantic Bight. Commercial Fisheries Review. Vol. 32, No. 3.)

Ancillary information has also been of interest to the fishing industry. Several interests have been provided with our data about scallops and lobsters. One of these has established a lobstering venture in the Chesapeake Bight.

SEASONAL AVAILABILITY AND DISTRIBUTION
OF
BENTHIC FISHES OF CHESAPEAKE BIGHT

by

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Summary of Project 3-5-D
Commercial Fisheries Research and Development Act

In considering the potential for expanding the Middle Atlantic fishery, Virginia Institute of Marine Science estimated the seasonal distribution and availability of benthic fishes on the 15,000 square miles of continental shelf between Cape Hatteras and Cape May. The survey, which started in the winter of 1966 and continued through the winter of 1968, was conducted in two phases. The work in 1966 was devoted to determining the seasonal distribution of the various kinds of fishes, especially those which appeared to be under-utilized. For this work a 45-foot semi-balloon shrimp trawl was employed to make 295 tows which were divided among the four seasons. In the second phase, conducted in 1967 and 1968, the objective was to estimate the quantity of fish potentially available to trawlers, should a market be developed. Availability is expressed in terms of the quantity of fishes that were caught by a specific trawl. We used an otter trawl, the Atlantic Western Model IV, which is a four-seam net having a headrope of 54 feet and a footrope of 78 feet. Stretched mesh sizes were 8 inches in the body, 6 inches in the extension, and 4 inches in the codend. Nearly 350 trawl tows were made. The net was fished from the SEA BREEZE, an 88 gross ton side trawler of 340 h.p. This work was supported by the Commercial Fisheries Research and Development Act, Project No. 3-5-D.

To estimate the quantity of fish available to the Atlantic Western trawl, we converted our catch in each one-hour tow to pounds per nautical mile, and finally to pounds (or tons) in the area covered by each of the several depth strata shown in Figure 1. Measurements of an Atlantic Western trawl by the BCF Exploratory Fishing and Gear Research Base at Gloucester, Massachusetts, indicated that the headrope was 9 to 11 feet above the bottom and that the mouth opening was 34 to 37 feet wide. In estimating the quantity of fish available to this trawl we have assumed a lateral mouth opening of 35 feet, thus neglecting any herding effect of the bridles and groundwires. We stress the point that our estimate is of quantity of fish available to a certain type net. Had we used other nets the estimates would be somewhat different. Nevertheless, the estimates are useful as order-of-magnitude indicators of quantity of fish potentially available.

The economic potential of the resources were considered by grouping the species into 3 categories: food fish, spiny dogfish and trash fish. The first category consists of those few species now caught by trawlers and marketed for human food, and which are caught in sufficient quantity to justify the task of separating them from the unsalable portion of the catch. Included are:

scup	*Stenotomus chrysops*
black seabass	*Centropristes striatus*
summer flounder	*Paralichthys dentatus*

butterfish	*Peprilus triacanthus*
Atlantic croaker	*Micropogon undulatus*
spot	*Leiostomus xanthurus*

The spiny dogfish, *Squalus acanthias*, is considered separately because it constitutes the major proportion of the catch and is a potential fishery resource. For lack of market it is at present a nuisance species which is avoided by fishermen.

All other species are lumped as "trash". In using this term we have for convenience adopted the existing terminology. This group of species is a significant protein resource for which markets should be developed. The composition of the trash changes seasonally. In winter important species include:

goosefish	*Lophius americanus*
spotted hake	*Urophycis regius*
red hake	*U. chuss*
silver hake	*Merluccius bilinearis*
northern searobin	*Prionotus carolinus*
rosette skate	*Raja garmani*
little skate	*R. erinacea*
winter skate	*R. ocellata*
clearnose skate	*R. eglanteria*
fourspot flounder	*Paralichthys oblongus*
windowpane flounder	*Scophthalmus aquosus*

In summer several species move northward. Remaining as important components of the trash are:

spotted hake	*Urophycis regius*
northern searobin	*Prionotus carolinus*
rosette skate	*Raja garmani*
clearnose skate	*R. eglanteria*

In deep water the fourspot flounder remains and in shallow water the large roughtail stingray *Dasyatis centroura* becomes important, not so much in numbers as in weight.

Temperature patterns of the bottom waters (Fig. 2) indicate that temperature changes little from summer to winter on the outer shelf, but that nearshore waters are warm in summer and cold in winter. Eddies from the Gulf Stream produce an irregularly changing thermal pattern in the section from Cape Hatteras to about 36° N latitude.

Change in seasonal distribution of the fishes results from two general migratory patterns. One group of fishes migrates to higher latitudes in summer and goes south in winter. The other pattern is primarily a movement inshore in summer and offshore in winter, although some north-south movement may be involved also. Some species move little between one season and another. Migratory patterns of the more numerous under-utilized species are described below.

Spiny dogfish are strongly migratory, being the most abundant fish in the Chesapeake Bight during winter and completely deserting the area for more northern waters in the summer (Fig. 3). Goosefish (allmouth) have a similar migratory pattern (Fig. 4).

The northern searobin, probably the second most abundant bottom species in Chesapeake Bight moves inshore in summer and offshore in winter (Fig. 5). The searobin population probably has a north-south component to its migration also, but our data are not conclusive on that point. The red hake and silver hake (whiting) also move inshore in summer and offshore in winter (Figs. 6, 7). The fact that these two species are more abundant in winter than in summer indicates that they have a north-south component to their migration also. Spotted hake, on the other hand, seem to move mostly inshore and offshore with but little north-south movement (Fig. 8).

Two species of flatfish, windowpane flounder and fourspot flounder, are essentially nonmigratory (Figs. 9 and 10).

Although an otter trawl is not notably effective at catching sea herring and mackerel, especially at night, we noted the rather general occurrence of these two species throughout the Chesapeake Bight in winter. They were not caught in summer (Figs. 11, 12).

In the winter (February and March) of 1967 an estimated 234,000 metric tons were available to our trawl. A greater quantity of fish of all categories was found in the northern sector than in the southern and the overwhelming abundance of spiny dogfish, which comprised 70% to 80% of the available quantity of fishes was notable (Fig. 13). A plot of catch-rates in pounds/mile, indicates that in the north the most productive fishing for food fish, trash fish, or dogfish was in the deepest stratum (Fig. 14).

The shoal water yielded trash fish and dogfish but lacked food fish. In the south, dogfish were most concentrated in depths of 11 to 20 fathoms, trash fish in 21 to 40 fathoms, and food fish were most abundant deeper than 40 fathoms.

Because rough seas restricted our sampling in winter 1967, we sampled again in 1968 (Fig. 15). The total estimated quantity of fish, 340,000 tons, was greater than in the previous winter, but other features were similar. The greatest quantity of fish was in the northern sector. Spiny dogfish were distributed as in 1967 in the south, but in the north were most abundant in mid-depths rather than in deep water. Similarly, the major change in catch rates in the north was a shift in the spiny dogfish (Fig. 16). Food fish were most abundant near the edge of the shelf.

In spring the northward migration of spiny dogfish was apparent (Fig. 17). Only 500 tons remained in the southern sector and about 4,000 in the northern. The total quantity of trash species declined somewhat in both sectors. Food fish became more abundant, especially in the south, but were mostly small. Some inshore movement of both trash fish and food fish was apparent (Figs. 17, 18).

By summer (Fig. 19) the spiny dogfish had almost deserted the area, there being none in the southern sector, and only 400 tons in the northern. Other species from the outer shelf had also gone north. Both the greatest quantity and greatest concentration were in the shoal water (Fig. 10).

Fall (late November and December) brought the return of the spiny dogfish and other species from the north and the offshore movement of the species that had been in shoal waters in summer (Fig. 21). Again the densest concentration of food fish was near the edge of the shelf (Fig. 22).

PROSPECTS FOR EXPLOITATION

The fishing industry can be broadly separated into three parts: recreational, food, and industrial sectors. The first is only slightly involved here. The second now produces and markets fish for direct human consumption. The last produces fish meal, oil, and associated products that are used in animal feeds and in a variety of industrial activities. The popular food fishes which exist in the Chesapeake Bight are now being harvested at the maximum level, or perhaps beyond, catches of scup, sea bass and flounder having declined recently. The trash fish and spiny dogfish are used very little, but they are good sources of protein and markets should be developed.

The industrial fishery is urgently in need of additional resources. In some recent years the domestic fishing industry has been able to supply no more than 25% of the domestic demand for fish meal, with the remainder of the market being met by imports. The question of whether trash fish and spiny dogfish of the Chesapeake Bight can be used by the industrial fishery cannot be answered unequivocally at present. The spiny dogfish, the species comprising 70 to 80% of the available quantity of fish in winter, is without a domestic market either as food or as an industrial fish. It is a desirable food fish in European markets, but export is not economically feasible [Holmsen, Andreas A. 1968. Harvesting and processing dogfish (*Squalus acanthias*), University Rhode Island Dept. Food & Resource Economics, Occasional Paper 68-275]. At least two problems must be solved before dogfish can be used extensively in an industrial fishery. A method must be developed to handle them efficiently in large quantities. Their large size and tough, rough skin are not compatible with the machinery now in use. Also, urea, a constituent of the blood, is undesirable in poultry feed where fish meal is now used. Either the urea must be removed or a new market must be developed. Perhaps shark meal could be used in cattle feed, since ruminants metabolize urea. Several technological laboratories are attempting to solve problems that presently restrict the use of dogfish.

Although the population of spiny dogfish is large, the reproductive potential of the species is not great, and the sustainable annual yield from this stock might not be as great as the large population would suggest. Probably the population could be fished down to a low level in a brief period of time. Perhaps reduction of the population would be desirable since the species is a nuisance to the existing fisheries. Certainly the reduction of a predator and competitor of such overwhelming dominance would provide an interesting opportunity to observe the responses of prey species and competing predatory species.

Trash fish appear to be sufficiently abundant to sustain a fishery and can be handled by existing machinery, although some modification may be desirable. The major problems seem to be to reduce the cost of catching the fish and to produce meal of constant composition. In winter an additional problem is the rather general occurrence of spiny dogfish along with trash fish. Culling them from the catch is expensive. Increased use of benthic fishes in Chesapeake Bight is feasible but spiny dogfish will be an impediment unless they can be used profitably.

SUMMARY

The fish biomass available to the Atlantic Western trawl IV was estimated at 340,000 tons in winter 1968 consisting of 61,000 tons of trash fish, 273,000 tons of spiny dogfish, and 6,000 tons of food fish (Table 1). In the winter of 1967 the quantity was less, 234,000 tons, but the proportions were about the same: trash fish, 43,000 tons; spiny dogfish, 186,000 tons; food fish, 4,000 tons. In spring 1967 the estimate of 60,000 tons was comprised of 46,000 tons of trash fish, 4,000 tons of spiny dogfish, and 10,000 tons of food fish. In summer the estimate was 58,000 tons of which 52,000 was trash fish and 6,000 was food fish. Spiny dogfish were absent. In the fall of 1967 the estimate of 356,000 tons was composed of 77,000 tons of trash fish, 257,000 tons of spiny dogfish, and 22,000 tons of food fish. These estimates exclude pelagic fish such as herring, river herring, mackerel, and round herring which occur in some quantity, at least seasonally.

The seasonal change in both kinds and quantities of fish available results from migrations. In winter deeper waters tend to be more productive, but in summer the water shoaler than 10 fathoms has the largest quantity of under-utilized bottom fish.

Chesapeake Bight contains significant quantities of fish that are not being utilized. Most abundant are spiny dogfish, searobins, and hakes. Development of markets for these would enhance the fisheries of the area.

TABLE I. AVAILABLE FISH BIOMASS
IN CHESAPEAKE BIGHT (METRIC TONS)

SEASON	NORTH	SOUTH	TOTAL
WINTER 1968	204,960	134,922	339,882
WINTER 1967	161,112	72,971	234,083
SPRING 1967	36,843	23,271	60,114
SUMMER 1967	28,327	29,564	57,891
FALL 1967	173,404	182,120	355,524

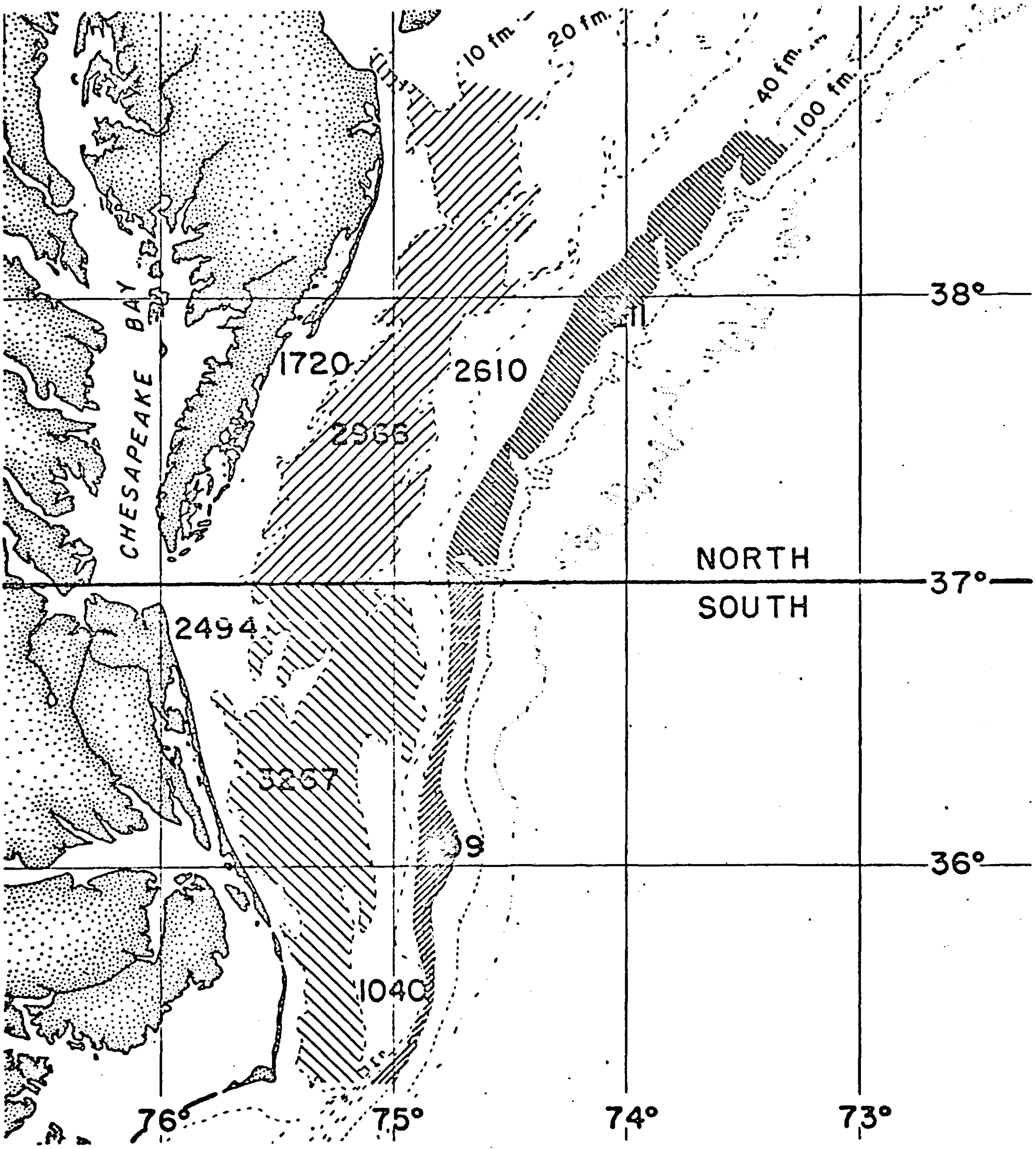

Figure 1. Area, in square nautical miles, of the depth strata used in estimating the availability of benthic fishes in Chesapeake Bight.

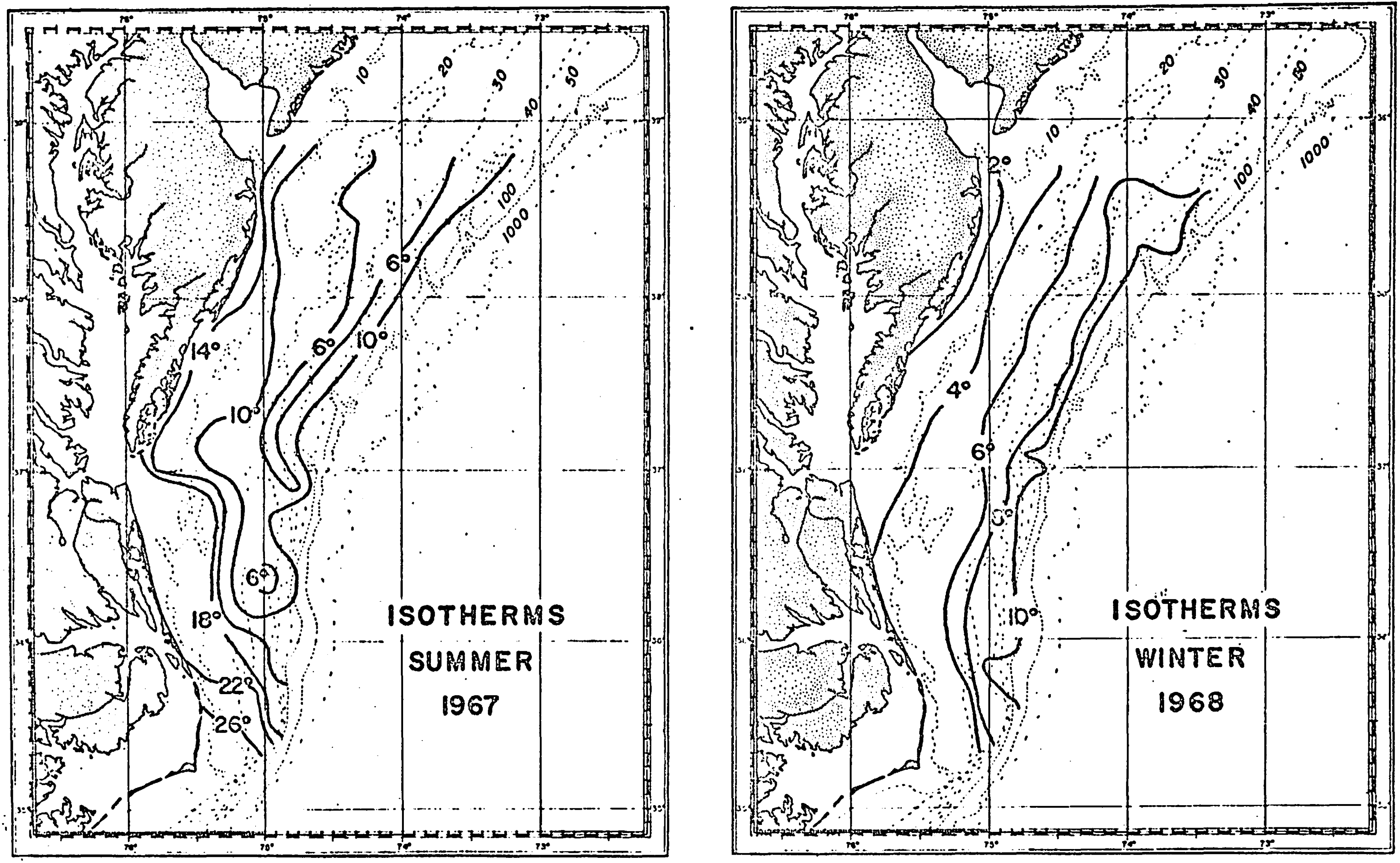

Figure 2. Thermal pattern of the bottom waters of Chesapeake Bight.

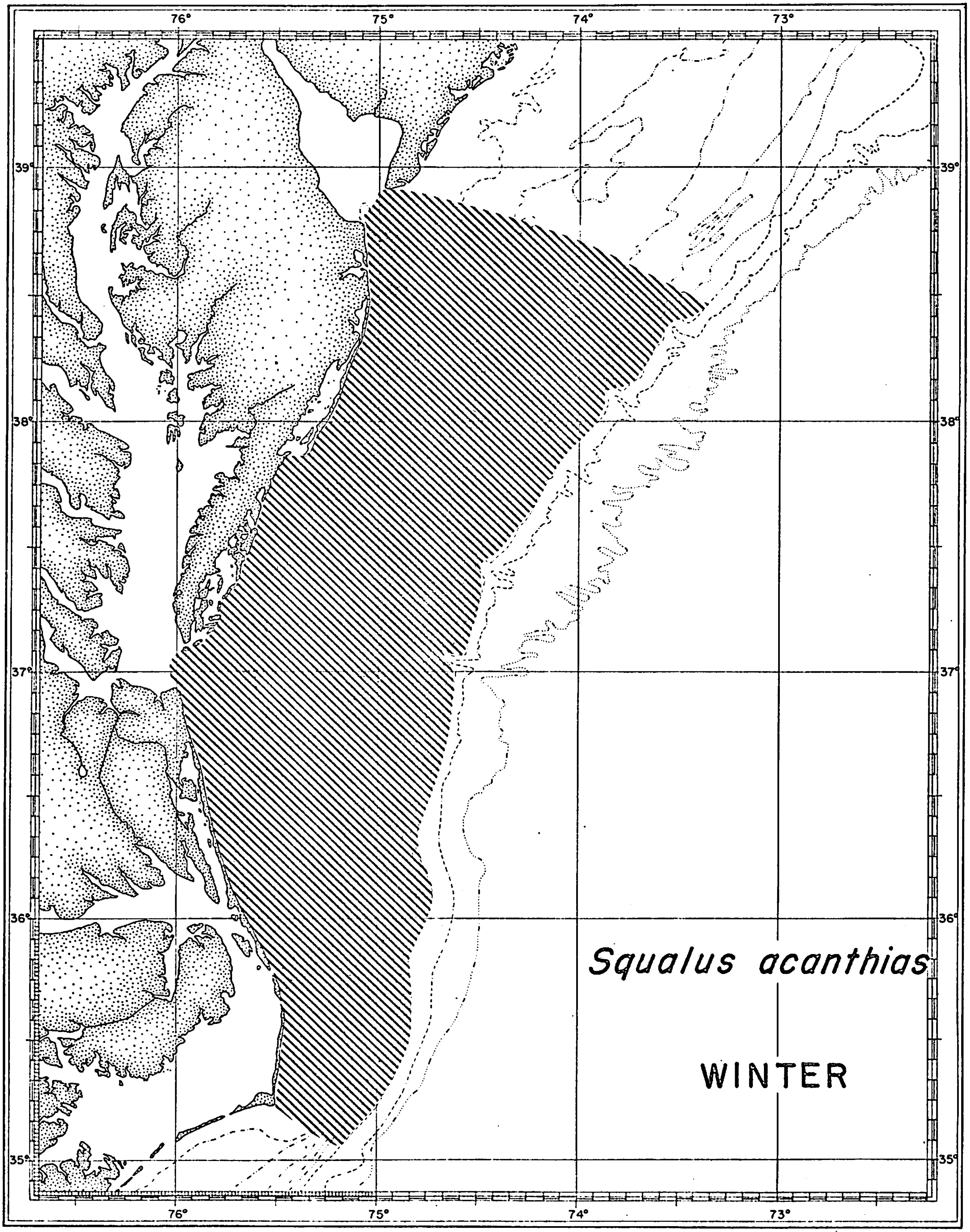

Fig. 3. Distribution of the spiny dogfish.

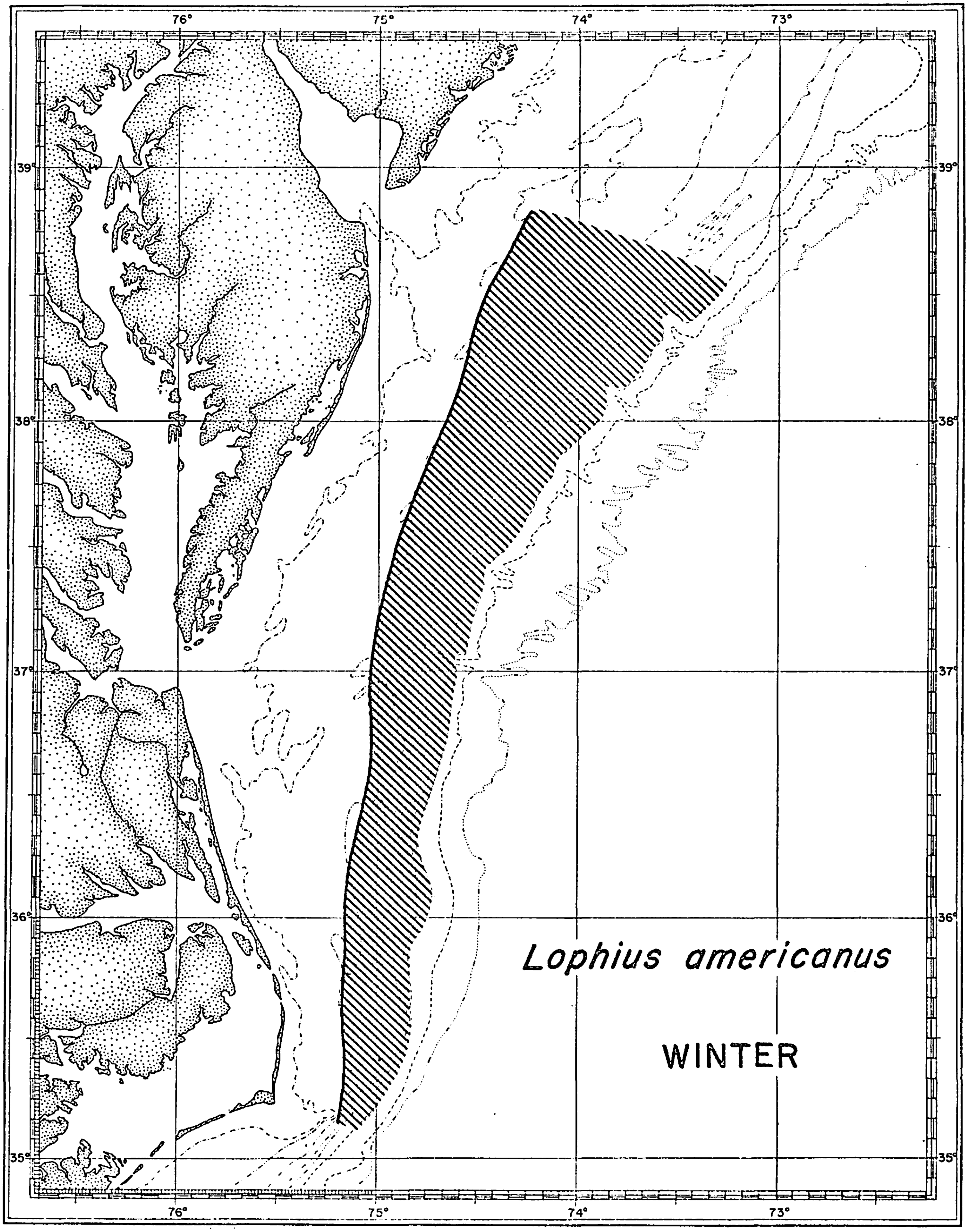

Fig. 4. Distribution of the goosefish.

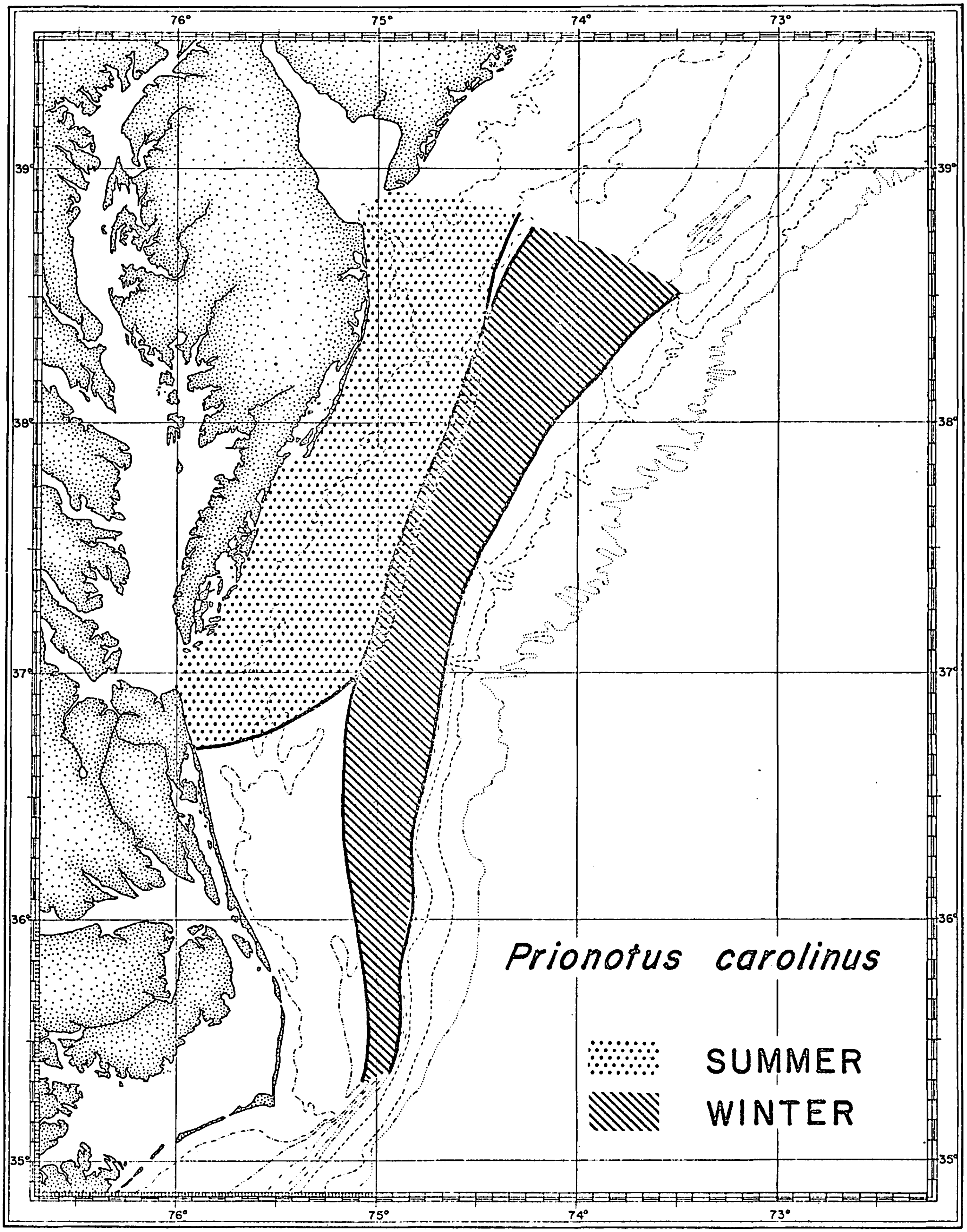

Fig. 5. Distribution of the northern searobin.

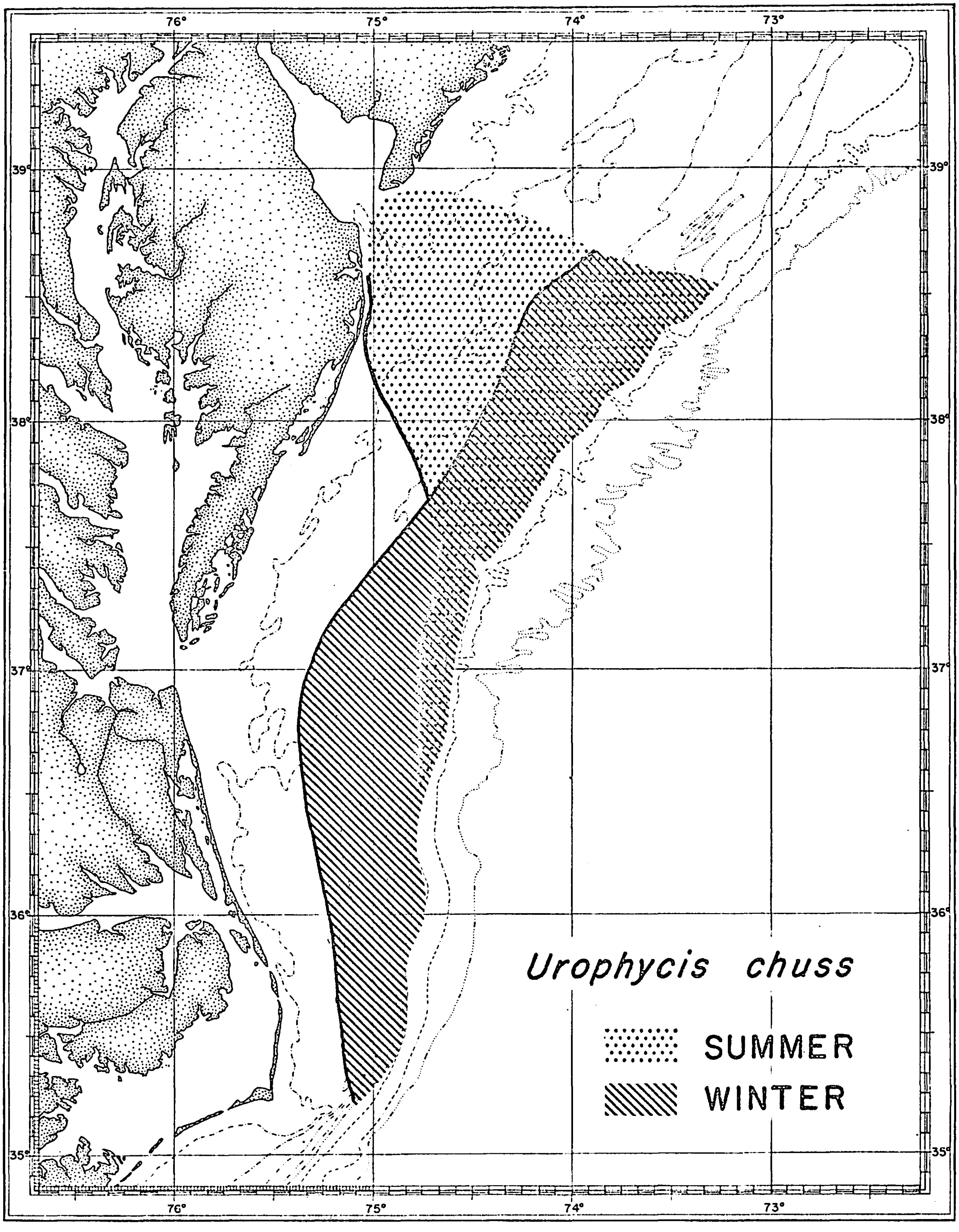

Fig. 6. Distribution of the red hake.

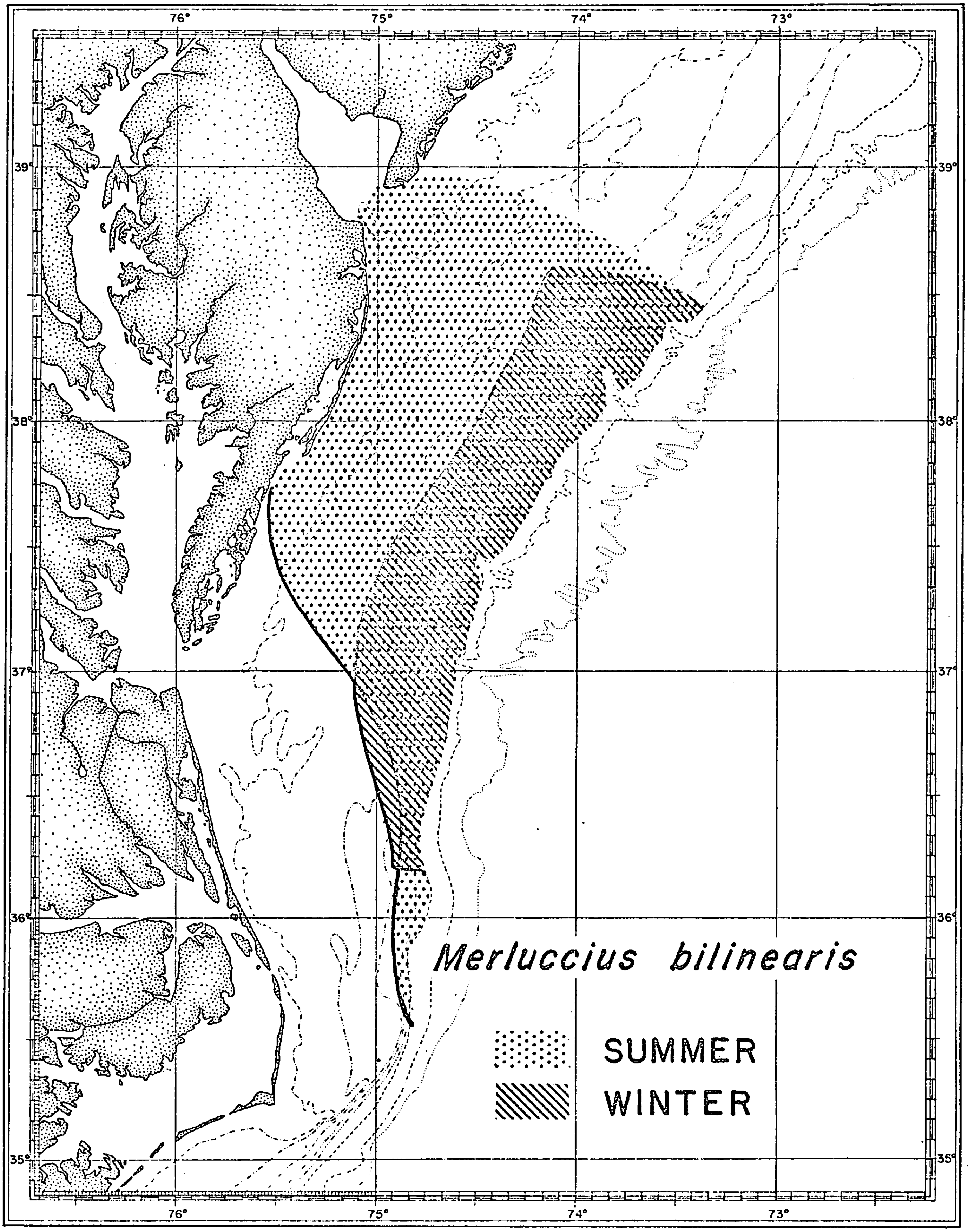

Fig. 7. Distribution of the silver hake.

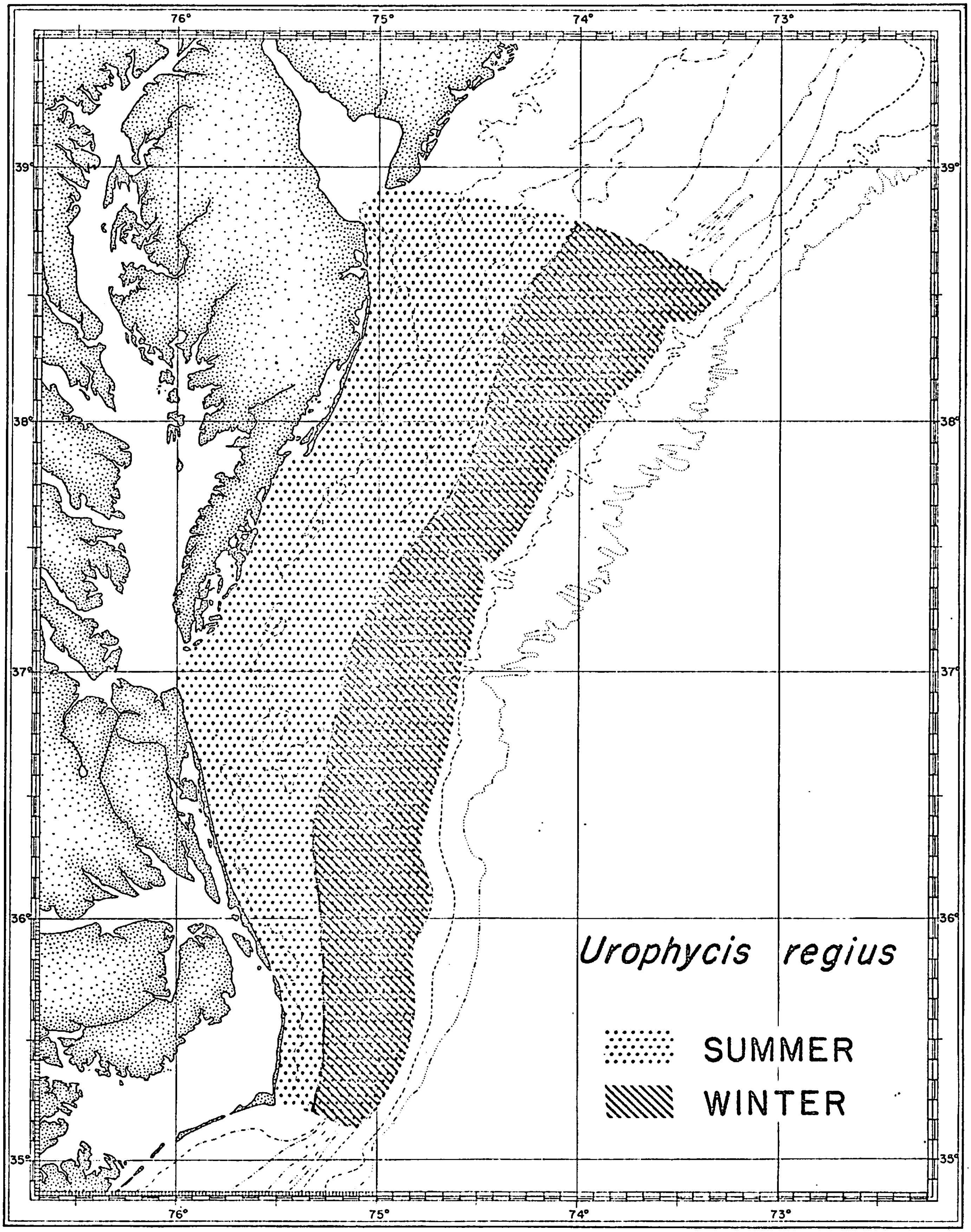

Fig. 8. Distribution of the spotted hake.

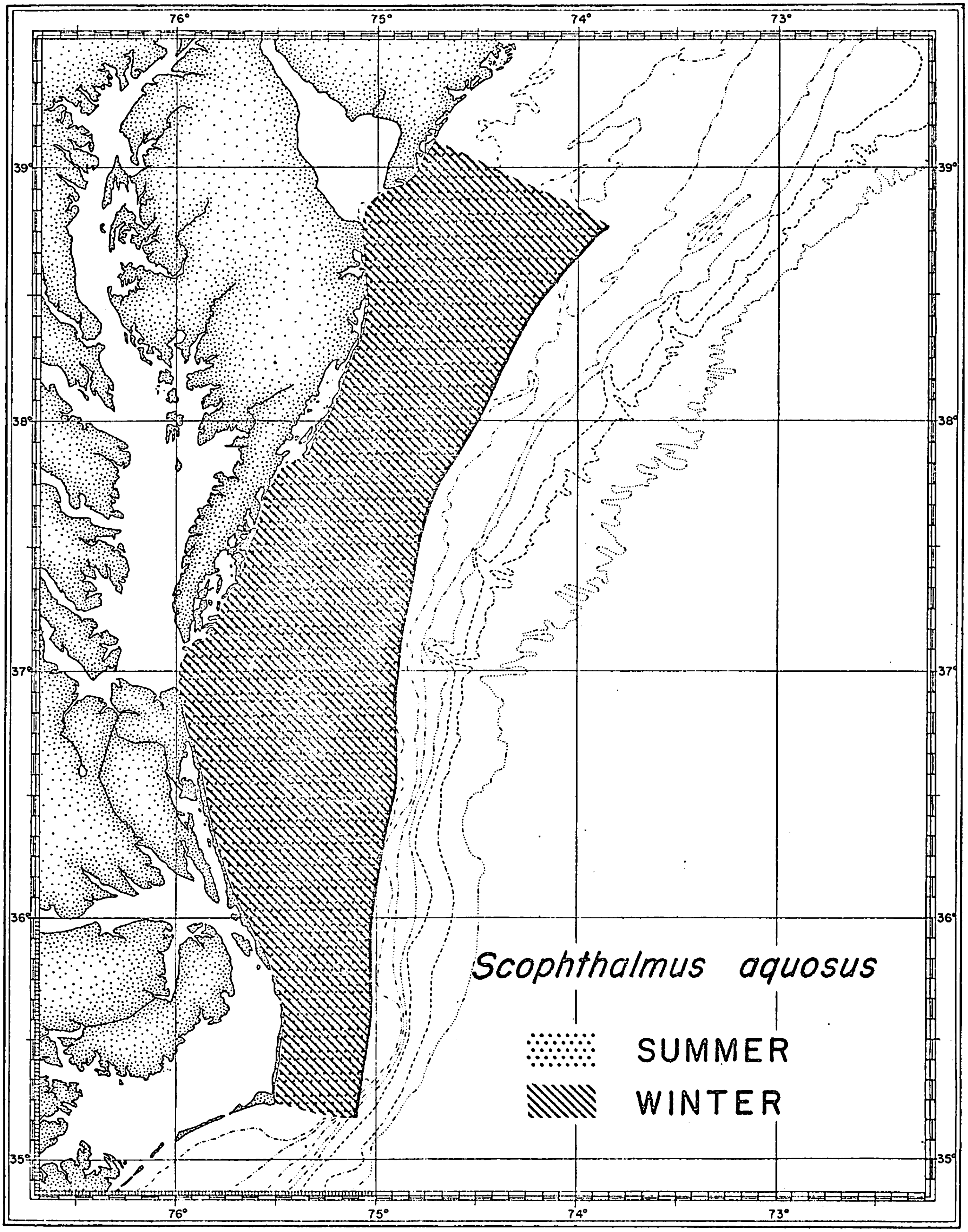

Fig. 9. Distribution of the windowpane flounder.

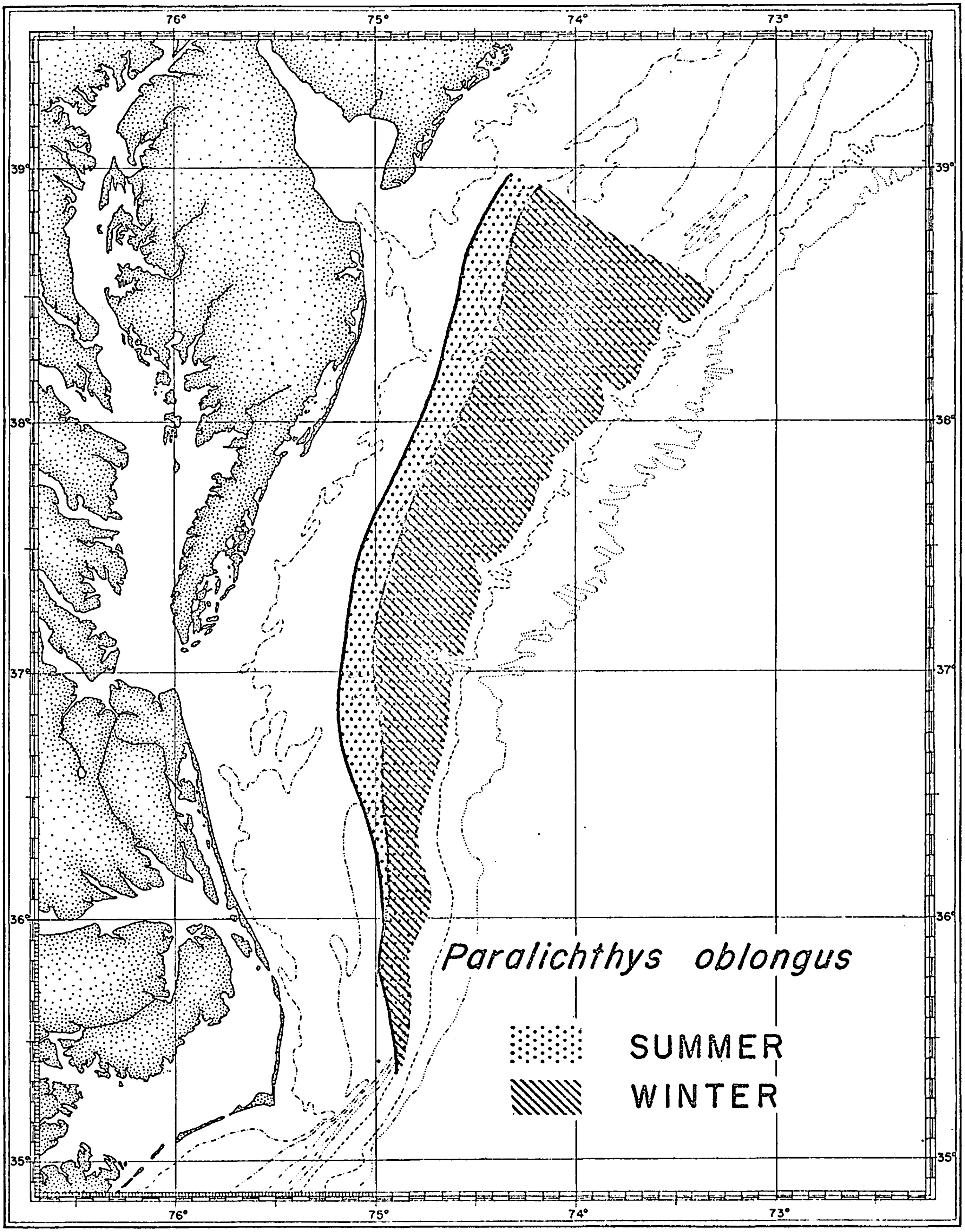

Fig. 10. Distribution of the fourspot flounder.

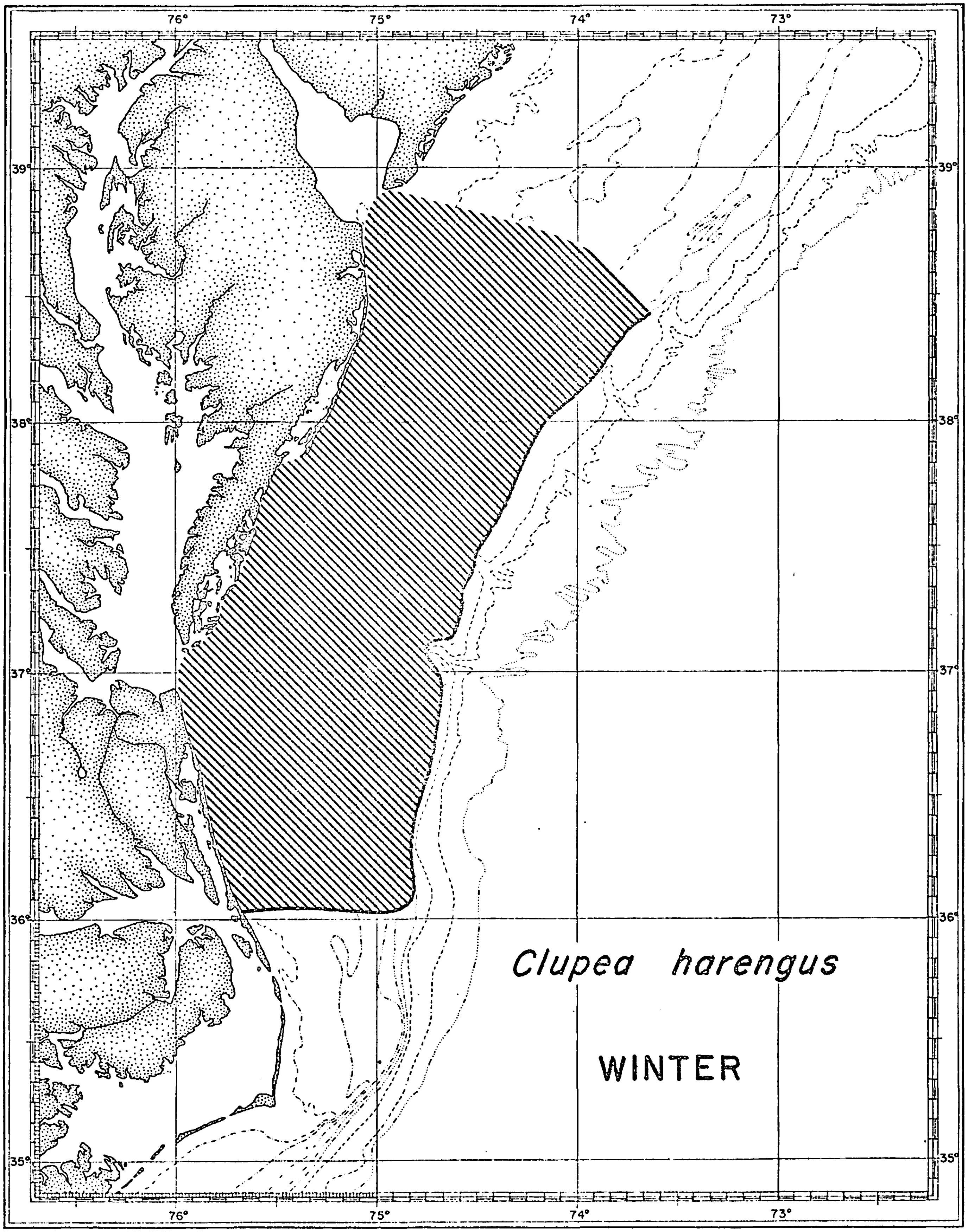

Fig. 11. Distribution of the herring.

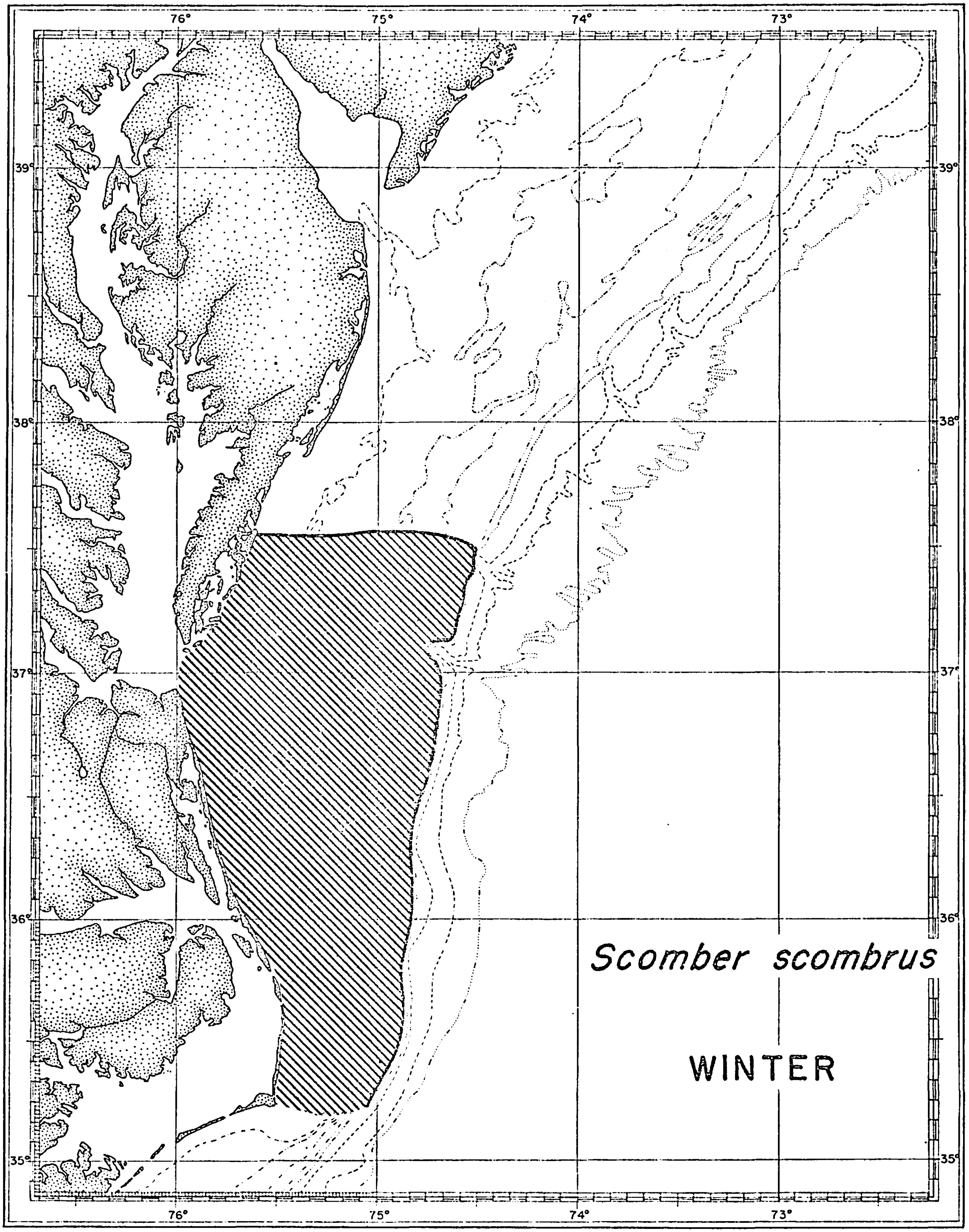

Fig. 12. Distribution of the mackerel.

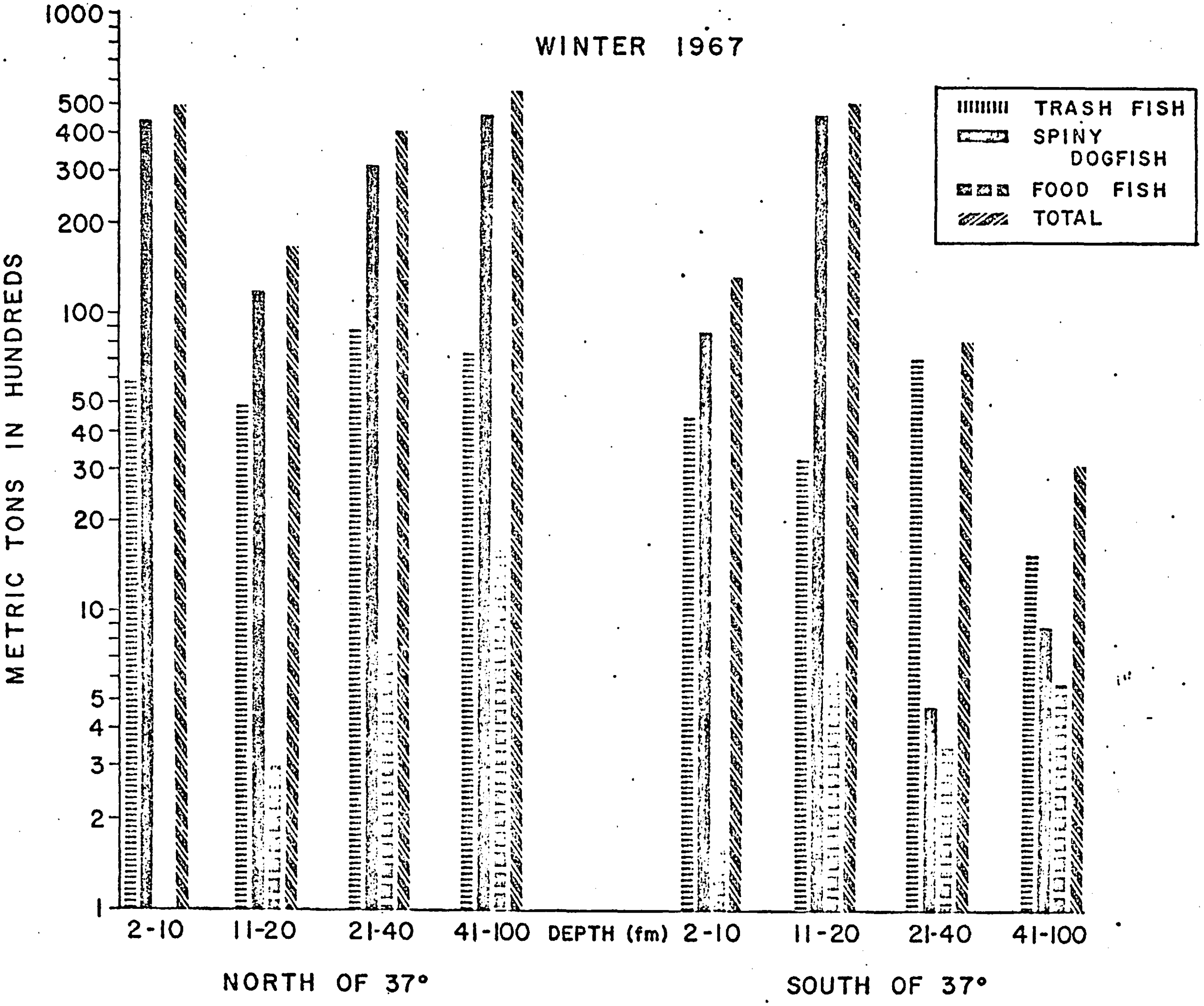

Figure 13. Distribution of benthic fishes of Chesapeake Bight in winter 1967.

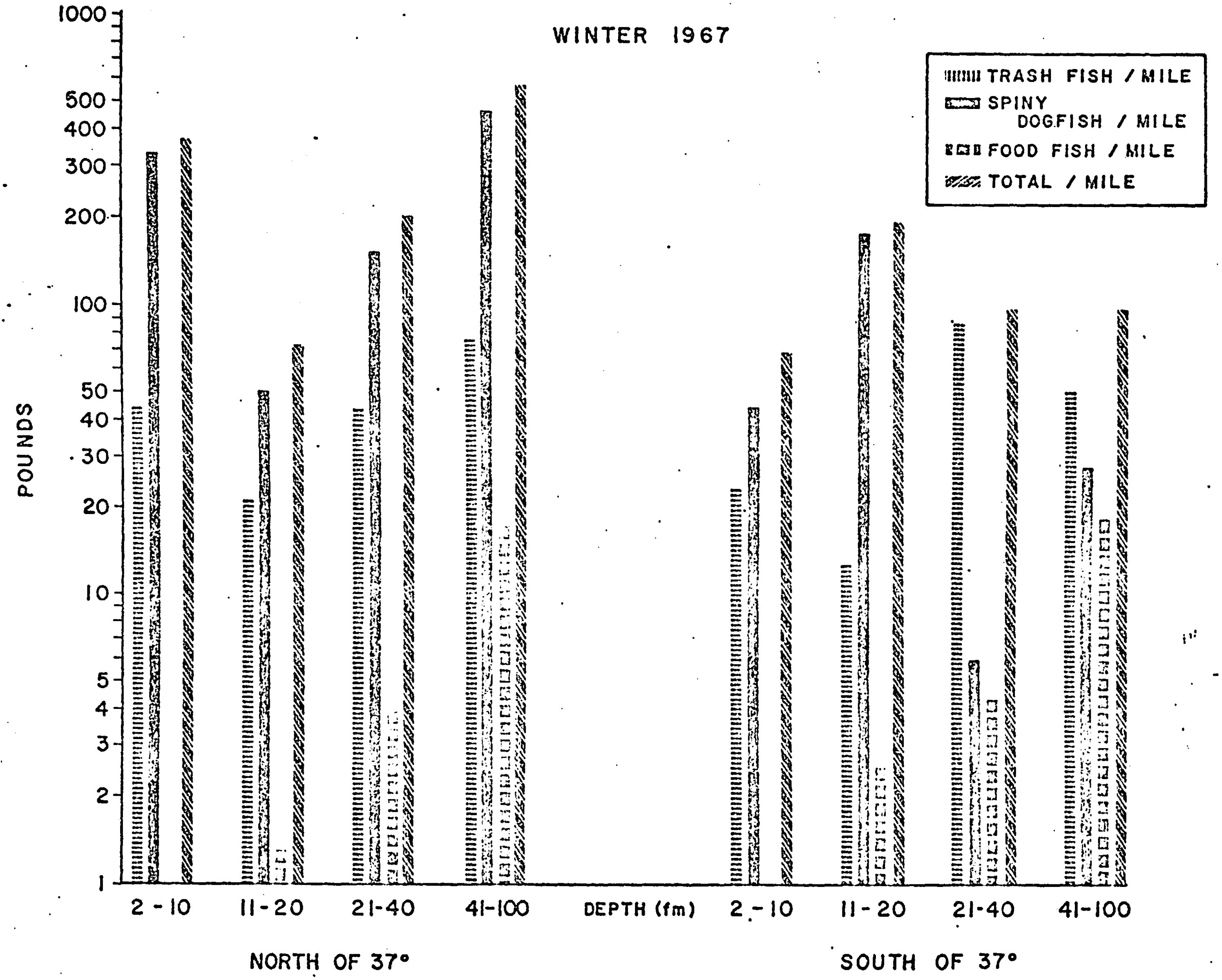

Figure 14. Catch rate of benthic fishes in Chesapeake Bight in winter 1967.

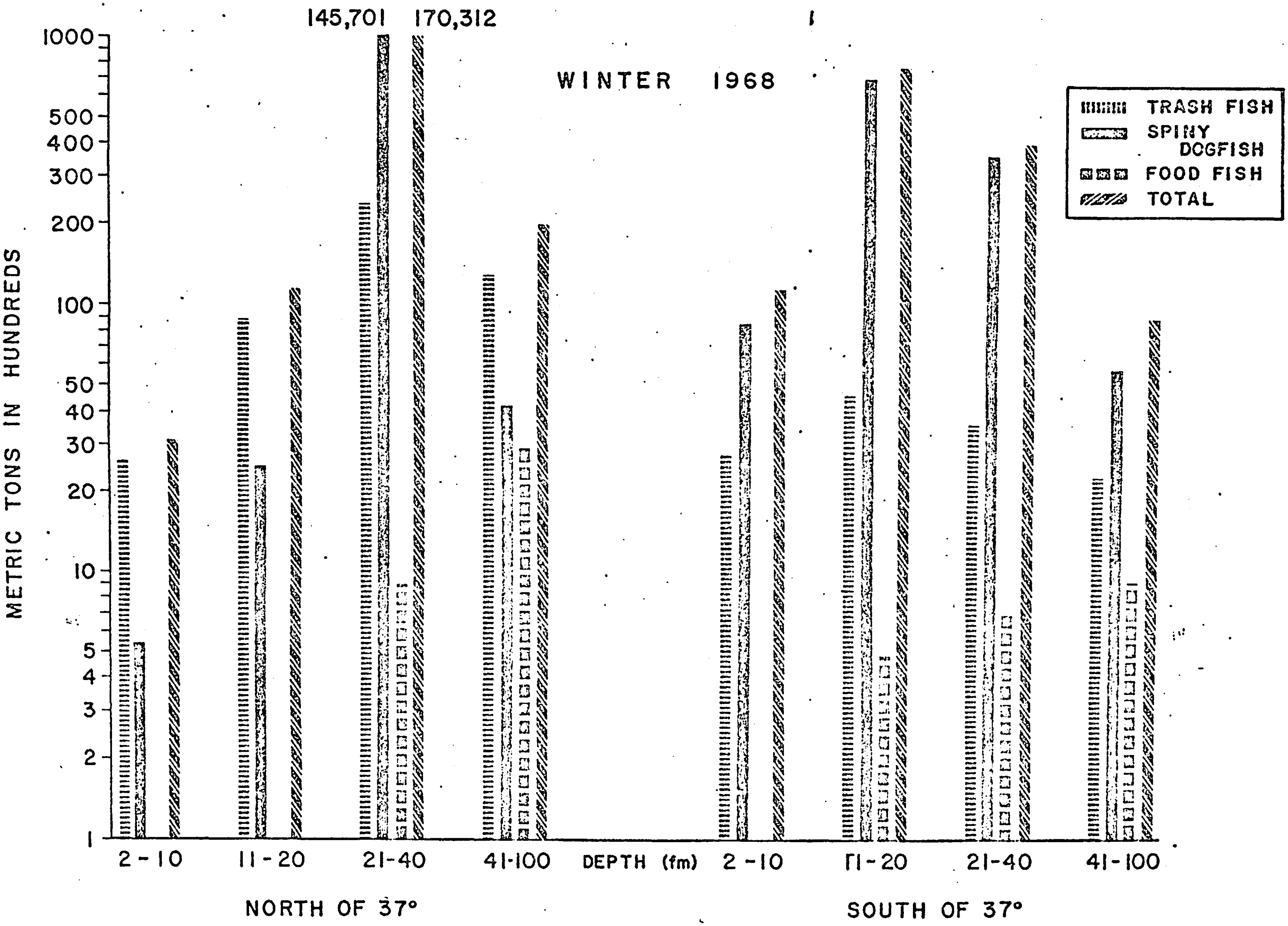

Figure 15. Distribution of benthic fishes of Chesapeake Bight in winter 1968.

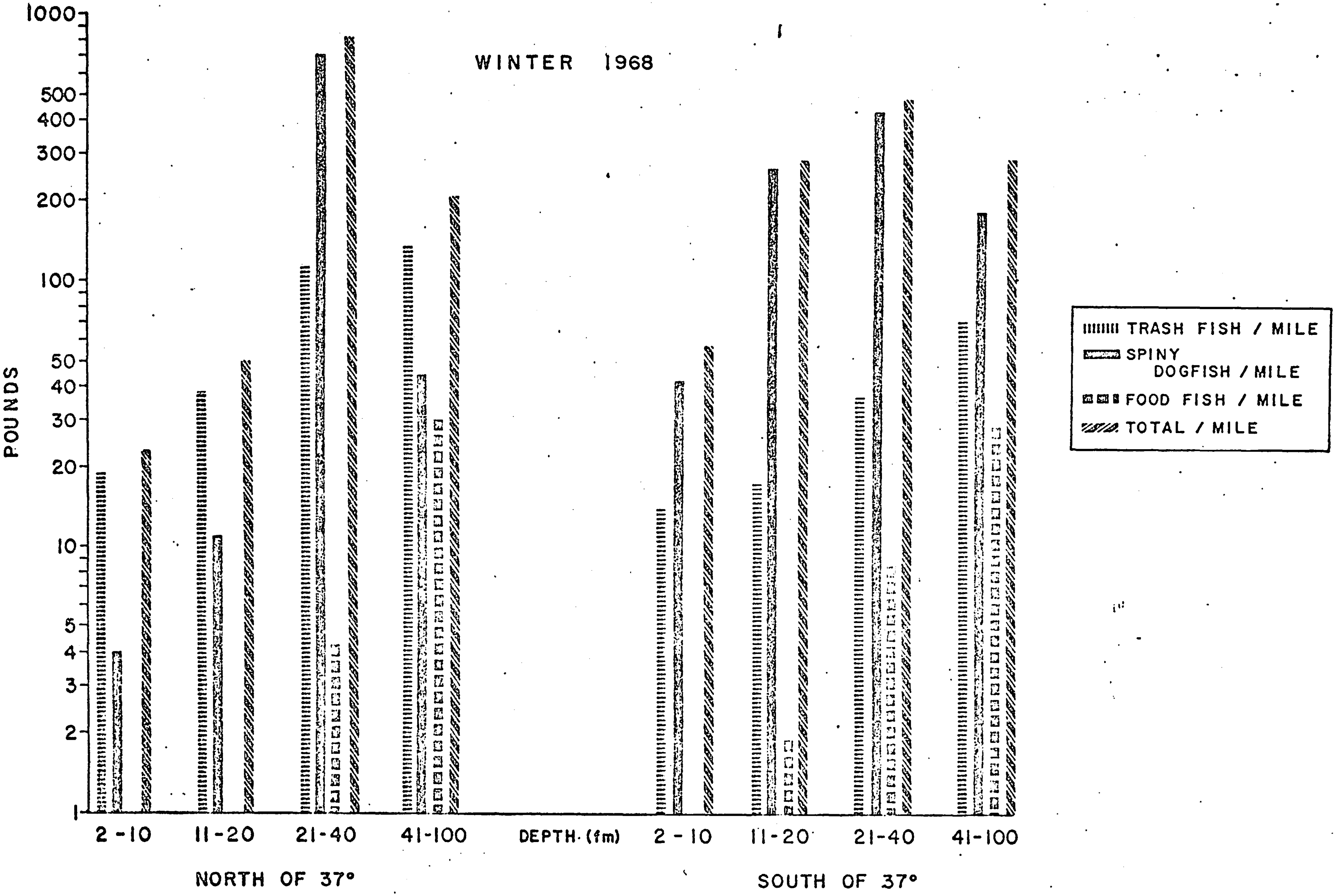

Figure 16. Catch rate of benthic fishes in Chesapeake Bight in winter 1968.

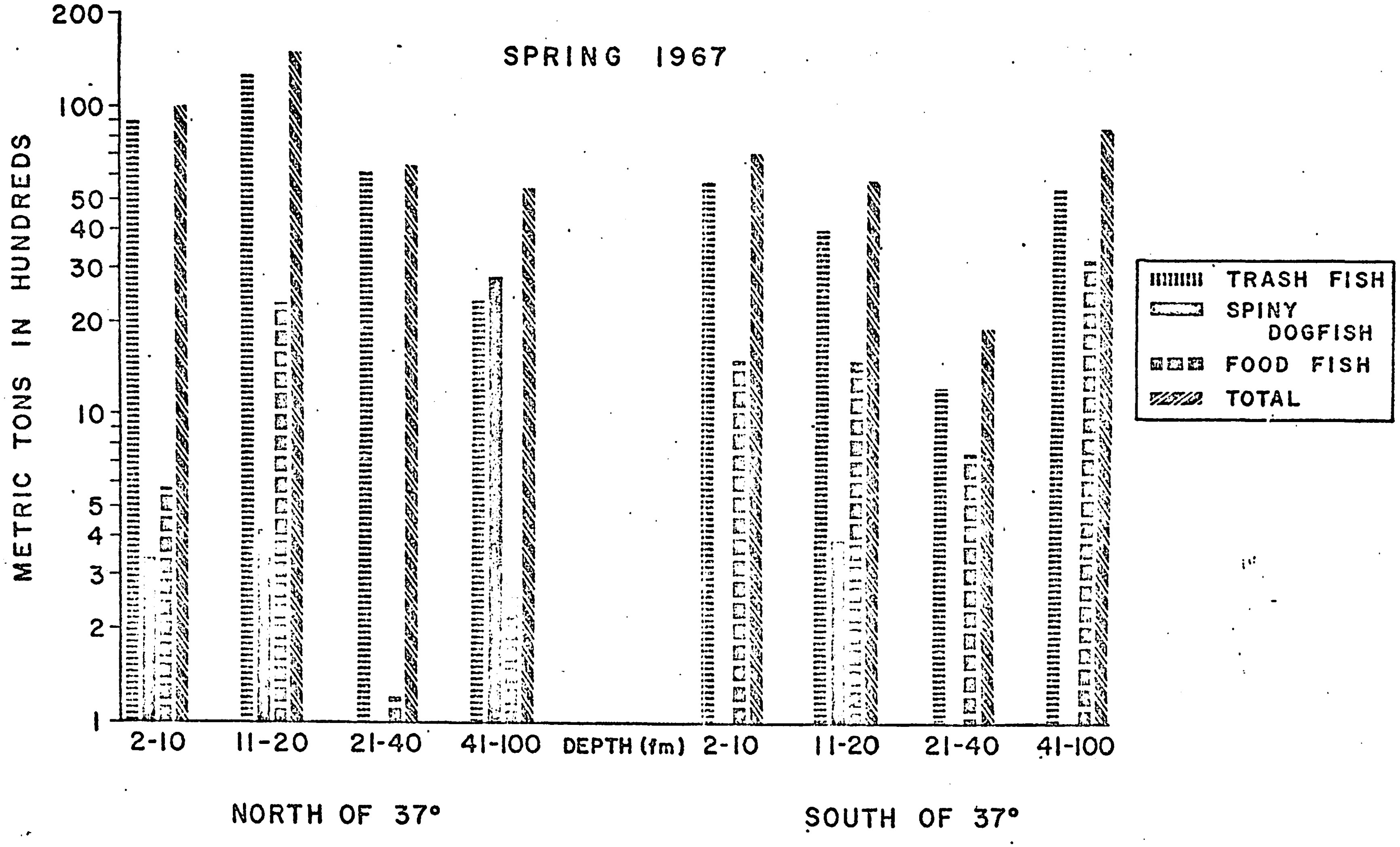

Figure 17. Distribution of benthic fishes of Chesapeake Bight in spring 1967.

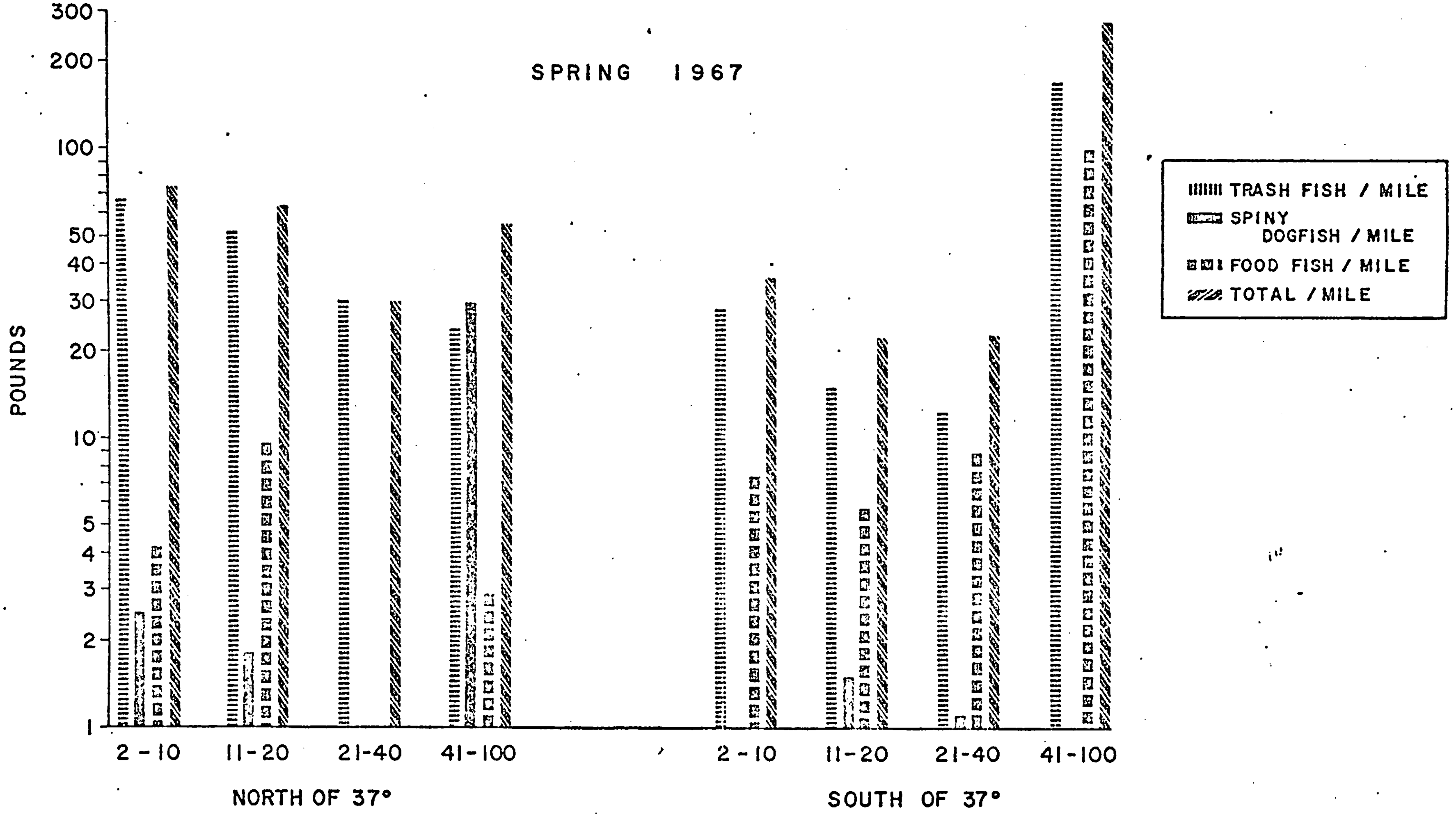

Figure 18. Catch rate of benthic fishes in Chesapeake Bight in spring 1967.

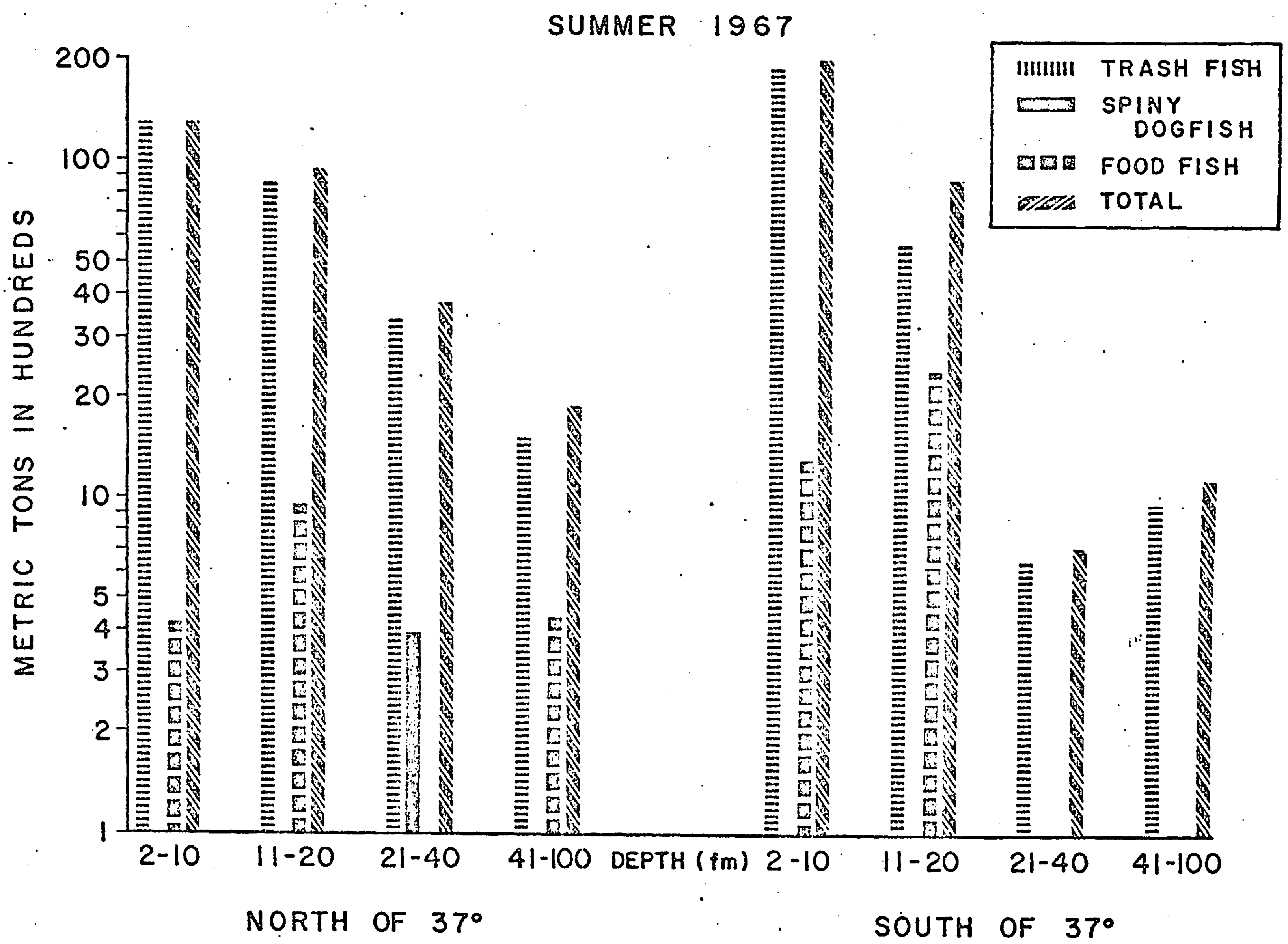

Figure 19. Distribution of benthic fishes of Chesapeake Bight in summer 1967.

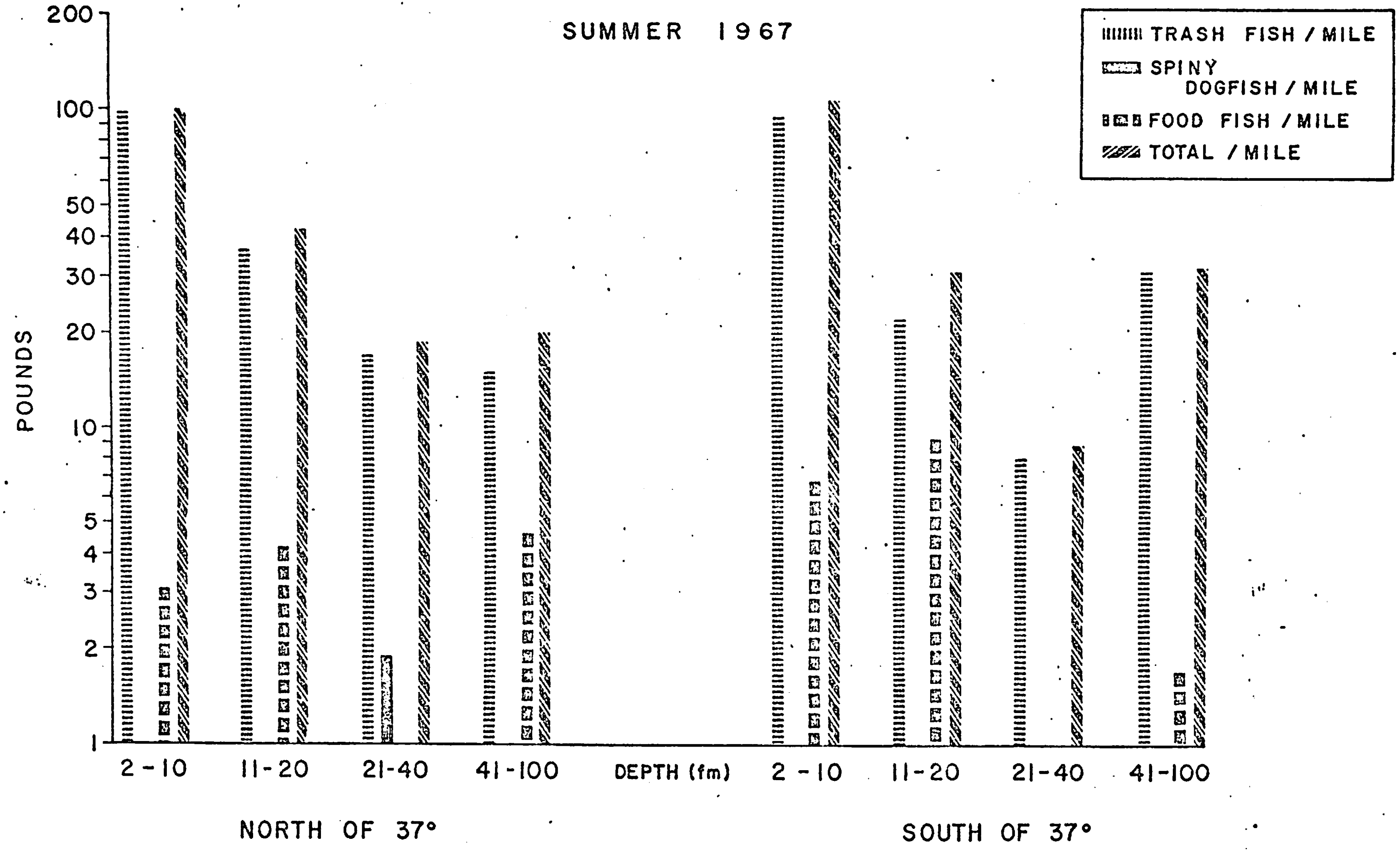

Figure 20. Catch rate of benthic fishes in Chesapeake Bight in summer 1967.

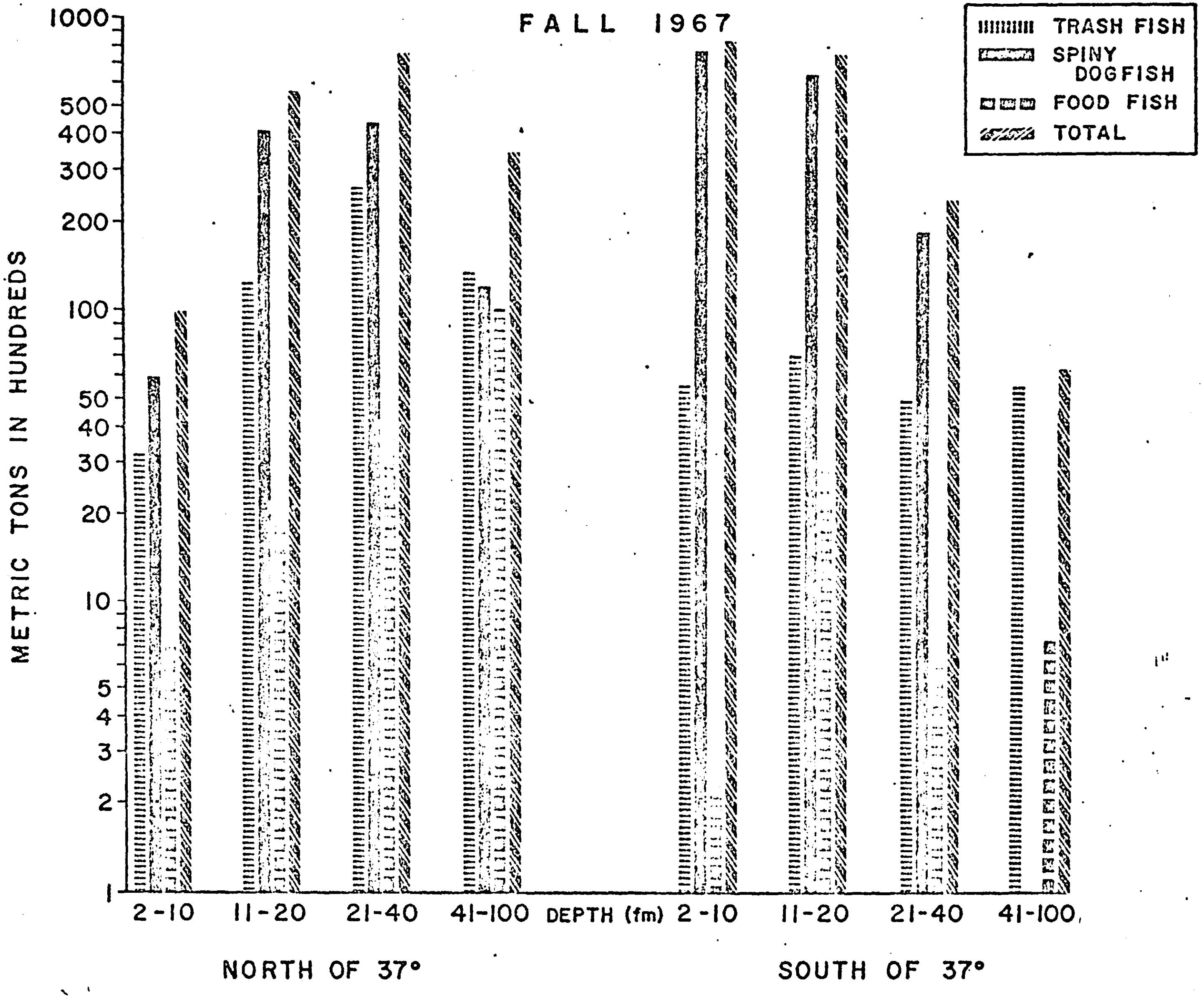

Figure 21. Distribution of benthic fishes of Chesapeake Bight in fall 1967.

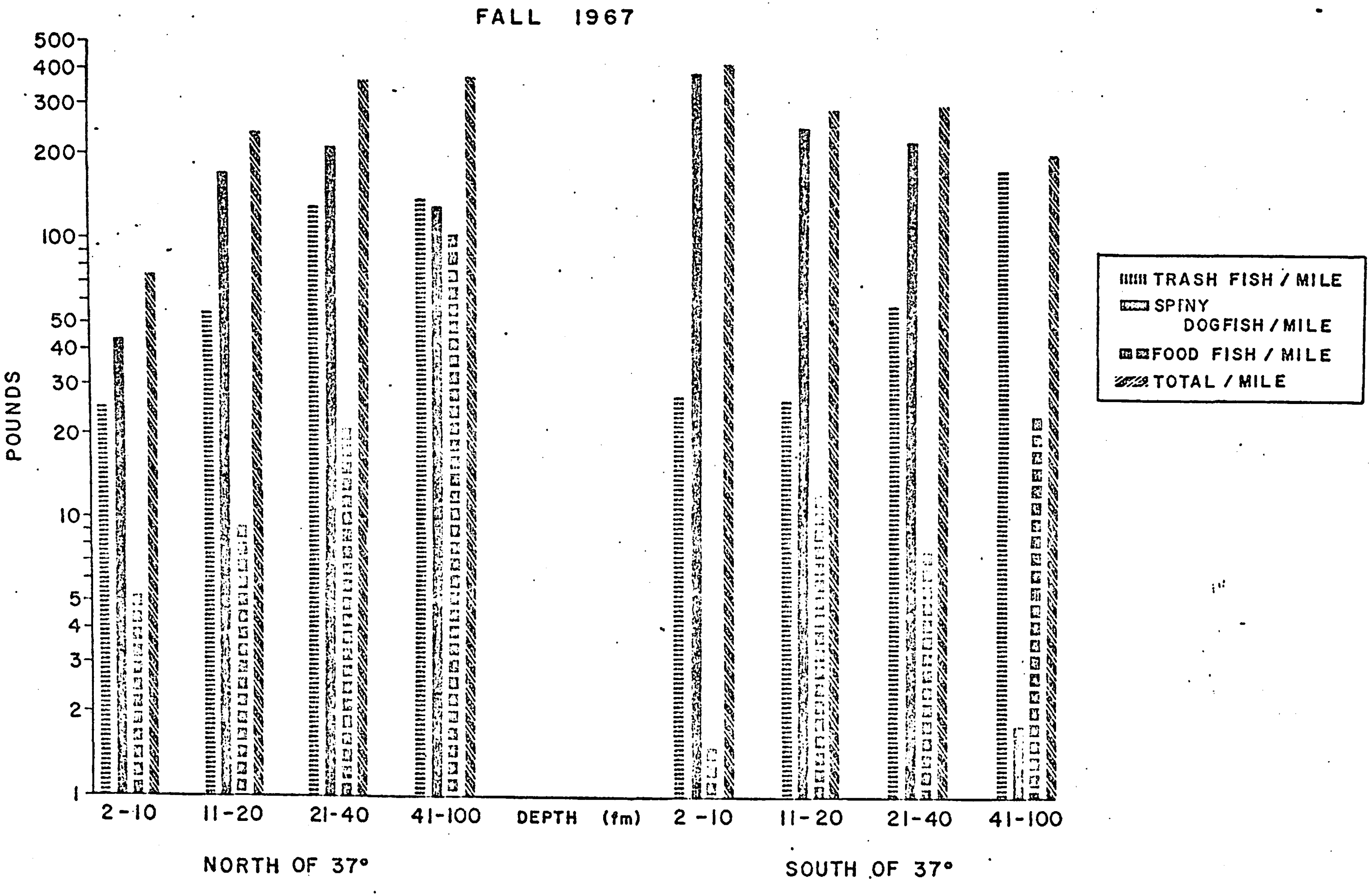

Figure 22. Catch rate of benthic fishes in Chesapeake Bight in fall 1967.