1950

International Commission
for the
Northwest Atlantic Fisheries

1970

RESTRICTED

Serial No. 2427
(D.c. 3)

ICNAF Res.Doc.70/79

ANNUAL MEETING - JUNE 1970

DISTRIBUTION AND RELATIVE ABUNDANCE OF DEMERSAL FISH FROM OTTER TRAWL SURVEYS IN ICNAF DIVISIONS 4X, 5, AND 6A

by

F. E. Lux and M. D. Grosslein

INTRODUCTION

Surveys have long been used to gather information on distribution, abundance, and life histories of fishes. Otter trawl surveys for sampling demersal fishes on fishing grounds off New England have been conducted since 1948 by the U.S.A. Bureau of Commercial Fisheries. The earliest of these, in 1948-50, were principally in the Georges Bank area (Figure 1) and were directed toward haddock studies (Taylor, 1953; Colton, 1955). Sampling was random within each of three depth strata. Surveys in 1951-62 were expanded to more effectively cover the Gulf of Maine and southern New England areas in addition to Georges Bank and to sample the entire demersal fish population (Fritz, 1965). The sampling technique in this series varied, but it usually was on a grid pattern.

A new survey series was begun in 1963, with the fishery research vessel Albatross IV, covering the area from western Nova Scotia to Long Island from the 15 fm (27 m) isobath to about the 200 fm (366 m) isobath. This spans western subarea 4, subarea 5 except for the deepest water, and northern statistical area 6. The aim of this survey series also was to sample the total population of demersal fish. Sampling, for most surveys in the series, followed a stratified random plan. In 1963-66 nine surveys were made, three each in summer, fall, and winter. Catch data of finfish from these nine surveys and relation of catches to area, season, and bottom temperature are given in this document.

MATERIALS AND METHODS

The survey area of about 60,000 square nautical miles was divided into four depth zones using information on fish distribution (Grosslein, 1968; 1969). These were 15-30 fm (27-55 m), 31-60 fm (56-110 m), 61-100 fm (111-183 m), and over 100 fm (183 m). The deepest depth sampled was 200 fm (366 m). The depth zones were divided into 42 sampling strata (Figure 2). This division was based principally upon statistical considerations, but information on fish distribution and water temperature also was used.

Sampling stations within a stratum were selected from all possible stations with a table of random numbers.[1/] A minimum of two stations and a maximum of up to ten were selected for each stratum. This stratified random sampling scheme permitted computation of abundance estimates for individual strata or for many strata combined into a set. The total number of stations sampled in a single survey varied from 179 to 193.

The station locations for a survey were plotted on a navigation chart and, ignoring stratum boundries, a cruise track that minimized distance was laid out between them (Figure 3). A sample consisted of a 30-minute otter trawl haul at each station at a towing speed of 3.5 k. Bathythermograms were obtained at each station and at selected points between some stations.

The net used was a No. 36 New England groundfish trawl with a 20.6 m headrope and a 24.4 m footrope. The codend and upper belly were lined with 13 mm mesh twine in order to retain 0-group and other small fish. The gear was relatively efficient only for truly demersal fish. For each haul the weight and length frequency of each species caught was recorded on a trawl log, along with time, position, and other pertinent data.

A survey occupied about 28 days of sea time, depending on weather, and it was divided into a northern and southern part, each of about 14 days. The survey, therefore, usually was completed within the span of a month (Table 1). The stations and survey track for the fall survey in 1965 in Figure 3 shows the general distribution of stations for a survey and the order in which they were sampled.

Table 1.--Inclusive dates for nine Albatross IV otter trawl surveys in 1963-66.

Year	Season	Dates
1963	Summer	July 18 - Aug. 19
"	Fall	Nov. 13 - Dec. 16
1964	Winter	Jan. 16 - Feb. 15
"	Summer	July 27 - Aug. 22
"	Fall	Oct. 22 - Nov. 25
1965	Winter	Feb. 1-15; Feb. 26 - Mar. 2; Mar. 30 - April 8
"	Summer	July 7 - Aug. 10
"	Fall	Oct. 6 - Nov. 9
1966	Winter	Jan. 18 - Feb. 23

1/ Sampling was essentially stratified systematic prior to the summer 1964 survey, but strata (and sampling within strata) were not well defined. From summer 1964 on the sampling was stratified random.

Following the survey, the data on trawl logs were checked for errors and key-punched on automatic data processing cards. Further checking for errors then was done through computer audit runs. After final correction the data were ready for computer summarization.

The survey area encompasses at least four faunal zones, each characterized by somewhat distinct hydrographic conditions and animal populations. These are the southern New England zone, Georges Bank, the Gulf of Maine, and western Nova Scotia (Ackerman, 1941; Bigelow and Schroeder, 1953; Colton, 1964; Fritz, 1965). For analysis we divided the strata into sets which correspond rather closely with these zones (Figure 4). The southern New England zone comprises strata 1-12; Georges Bank, strata 13-23 and 25; the Gulf of Maine, strata 24, 26-30, and 36-40; and western Nova Scotia, strata 31-34 and 41-42.

Differences in catchability coefficients among different species, and possible variations in availability and trawl efficiency due, for example, to time of day, depth, and season have not been considered here. The abundance indices given, therefore, reflect only catches and in their unadjusted form are imprecise measures of relative biomass.

GEOGRAPHIC DISTRIBUTION AND RELATIVE ABUNDANCE

The species caught and their seasonal occurrence by faunal zone for the three summer, fall, and winter surveys are given in Table 2. About 110 species were recorded. More species occurred in the southern New England zone (a total of 90 for all seasons combined) than farther to the north and east on Georges Bank (68 species) and the Gulf of Maine (67 species). There also were fewer species in the western Nova Scotia zone (a total of 48), although here the number of hauls was markedly less (Table 2). While greater species diversity is expected in more southern climates (Williams, 1964), the data of Table 2 suggest that the species distribution pattern in the survey area stemmed also from the failure of many species from both north and south to move past the Cape Cod-Nantucket Shoals area. This area, which forms the northern and eastern borders of the southern New England zone, is considered to be a principal ecological barrier in this region (Parr, 1933; Bigelow and Schroeder, 1953). For example, of the species that were caught in some numbers, smoothtail skate, cusk, wolf fish, halibut, hookear sculpin, lumpfish, and shanny were caught north and east of this barrier, but not south and west of it (Table 2). Spotted hake, smooth dogfish, chain dogfish, conger eel, John Dory, sea bass, tilefish, filefish, and three species of sea robins were caught south and west of the barrier, but not to the north or east of it.

Table 2.--List of fishes caught and their seasonal and geographic occurrence in nine surveys, 1963-66. (x denotes occurrence.)

Species	Southern New England			Georges Bank			Gulf of Maine			Western Nova Scotia		
	Summer	Fall	Winter	Summer	Fall	Winter	Summer	Fall	Winter	Summer	Fall	Winter
Spiny dogfish, Squalus acanthias	x	x	x	x	x	x	x	x	x	x	x	x
Barndoor skate, Raja laevis	x	x	x	x	x	x	x	x	x	x	x	x
Big skate, R. ocellata	x	x	x	x	x	x	x	x	x	x	x	x
Little skate, R. erinacea	x	x	x	x	x	x	x	x	x	x	x	x
Smoothtail skate, R. senta	-	-	-	x	x	x	x	x	x	x	x	x
Thorny skate, R. radiata	x	-	x	x	x	x	x	x	x	x	x	x
Sea herring, Clupea harengus	x	x	x	x	x	x	x	x	x	x	x	x
Alewife, Alosa pseudoharengus	x	x	x	x	x	x	x	x	x	x	x	x
Argentine, Argentina silus	x	x	x	x	x	x	x	x	x	x	x	x
Offshore hake, Merluccius albidus	x	x	x	x	x	x	-	-	-	-	-	-
Silver hake, M. bilinearis	x	x	x	x	x	x	x	x	x	x	x	x
Cod, Gadus morhua	x	x	x	x	x	x	x	x	x	x	x	x
Haddock, Melanogrammus aeglefinus	x	x	x	x	x	x	x	x	x	x	x	x
Pollock, Pollachius virens	x	x	x	x	x	x	x	x	x	x	x	x
White hake, Urophycis tenuis	x	x	x	x	x	x	x	x	x	x	x	x
Red hake, U. chuss	x	x	x	x	x	x	x	x	x	x	x	x
Spotted hake, U. regius	x	x	x	-	-	-	-	-	-	-	-	-
Cusk, Brosme brosme	-	-	-	x	x	x	x	x	x	x	x	x
Sand flounder, Scophthalmus aquosus	x	x	x	x	x	x	-	x	x	-	-	-
Summer fldr., Paralichthys dentatus	x	x	x	x	-	x	-	-	-	-	-	-
Fourspot fldr., P. oblongus	x	x	x	x	x	x	-	x	x	-	x	-
Yellowtail fldr., Limanda ferruginea	x	x	x	x	x	x	x	x	x	x	x	x
Winter fldr., Pseudopleuronectes americanus	x	x	x	x	x	x	x	x	x	x	x	x
Graysole, Glyptocephalus cynoglossus	x	x	x	x	x	x	x	x	x	x	x	x
Am. plaice, Hippoglossoides platessoides	x	x	x	x	x	x	x	x	x	x	x	x
Butterfish, Poronotus triacanthus	x	x	x	x	x	-	x	x	-	-	-	-
Scup, Stenotomus chrysops	-	x	x	-	x	-	-	x	-	-	-	-
Redfish, Sebastes marinus	x	-	-	x	x	x	x	x	x	x	-	x
L.h. sculpin, Myoxocephalus octodecemspinosus	x	x	x	x	x	x	x	x	x	x	x	x
Sea raven, Hemitripterus americanus	x	x	x	x	x	x	x	x	x	x	x	x
Wolf fish, Anarhichas lupus	-	-	-	x	x	x	x	x	x	x	x	x
Eelpout, Macrozoarces americanus	x	x	x	x	x	x	x	x	x	x	x	x
Am. goosefish, Lophius americanus	x	x	x	x	x	x	x	x	x	x	x	x
Hagfish, Myxine glutinosa	x	x	x	x	x	x	x	x	x	x	x	x
Sea lamprey, Petromyzon marinus	-	-	-	-	-	x	-	x	x	-	x	x
Smooth dogfish, Mustelus canis	x	x	x	-	-	-	-	-	-	-	-	-
Chain dogfish, Scyliorhinus retifer	x	x	x	-	-	-	-	-	-	-	-	-
Torpedo, Torpedo nobiliana	-	x	x	x	-	-	-	-	-	-	-	-
Brier skate, Raja eglanteria	-	-	x	-	x	x	-	-	x	-	-	x
Leopard skate, R. garmani	x	x	x	-	-	x	-	x	x	-	x	-
Round herring, Etrumeus sadina	-	x	-	-	-	-	-	x	-	-	-	-
Blueback, Alosa aestivalis	x	x	x	x	x	x	x	x	x	-	-	x
Am. Shad, A. sapidissima	x	x	x	x	x	-	x	x	-	x	x	-
Hickory shad, A. mediocris	-	-	x	-	-	-	-	-	-	-	-	-
Menhaden, Brevoortia tyrannus	-	x	-	-	-	-	-	-	-	-	-	-
Striped anchovy, Anchoa hepsetus	-	x	-	-	-	-	-	-	-	-	-	-
Capelin, Mallotus villosus	-	-	-	-	-	-	-	-	-	-	-	x
Smelt, Osmerus mordax	-	-	-	-	-	-	-	x	x	x	-	x
Chlorophthalmus chalybeius	x	-	x	x	x	-	-	-	x	-	-	-
Paralepis borealis	-	x	-	-	-	-	-	x	-	-	-	-
Lanternfish (several species)	x	x	-	x	x	x	x	x	x	-	-	x
Pearlsides, Maurolicus pennanti	x	x	-	x	-	-	-	x	x	x	-	-
Viperfish, Chauliodus sloani	-	-	-	-	-	-	-	x	-	-	-	-
Hatchetfish, Argyropelecus aculeatus	-	x	-	-	-	-	-	-	-	-	-	-
Conger eel, Conger oceanicus	x	x	x	-	-	-	-	-	-	-	-	-
Slime-eel, Simenchelys parasiticus	x	-	-	-	-	-	-	-	x	-	-	-
Snake-eel, Ophichthys cruentifer	x	x	x	-	x	-	-	-	-	-	-	-
Snipe-eel, Nemichthys scolopaceus	x	-	-	-	-	-	-	-	-	-	-	-
Garfish, Ablennes hians	x	-	-	-	-	-	-	-	-	-	-	-
Needlefish, Scomberesox saurus	-	x	-	-	x	-	-	-	-	-	-	-
Halfbeak, Hyporhamphus unifasciatus	-	-	-	-	x	-	-	-	-	-	-	-
Threebeard rockling, Gaidropsarus ensis	-	-	-	-	-	-	-	-	-	-	x	-
Fourbeard rockling, Enchelyopus cimbrius	x	x	-	x	x	x	x	x	x	-	x	x
Longfin hake, Urophycis chesteri	x	x	x	x	x	x	x	x	x	-	-	-
Blue hake, Antimora rostrata	x	-	-	x	-	-	-	-	-	-	-	-
Common grenadier, Macrourus bairdii	x	x	x	x	x	x	x	x	x	-	-	-
Longnose grenadier, Coelorhynchus carminatus	x	-	-	-	-	-	-	-	-	-	-	-
Gulfstream flr., Citharichthys arctifrons	x	x	x	x	x	x	-	-	-	-	-	-
Halibut, Hippoglossus hippoglossus	-	-	-	x	x	x	x	x	x	x	x	x
Tonguefish, Symphurus sp.	-	x	-	-	-	-	-	-	-	-	-	-
John Dory, Zenopsis ocellata	x	x	x	-	-	-	-	-	-	-	-	-
Snipefish, Macrorhamphosus scolopax	x	-	-	-	-	-	-	-	-	-	-	-
Silverside, Menidia menidia	-	-	x	-	-	-	-	-	x	-	-	-
3-sp. stickleback, Gasterosteus aculeatus	-	-	x	-	-	-	-	-	-	-	-	-
Pipefish, Syngnathus fuscus	-	-	-	-	-	-	-	-	x	-	-	-
Mackerel, Scomber scombrus	x	x	x	x	x	-	-	x	-	-	-	-
Barrelfish, Palinurichthys perciformis	x	-	-	-	-	-	-	-	-	-	-	-
Mackerel scad, Decapterus macarellus	x	x	-	-	-	-	-	-	-	-	-	-
Bigeye scad, Selar crumenopthalmus	-	x	-	-	-	-	-	-	-	-	-	-
Saurel, Trachurus trachurus	-	x	-	-	-	-	-	-	-	-	-	-
Bluefish, Pomatomus saltatrix	x	x	-	-	-	-	-	-	-	-	-	-
Seabass, Centropristes striatus	x	x	x	-	-	-	-	-	-	-	-	-
Weakfish, Cynoscion regalis	-	x	-	-	-	-	-	-	-	-	-	-
Tilefish, Lopholatilus chamaeleonticeps	x	x	x	-	-	-	-	-	-	-	-	-
Scorpionfish, Pontinus longispinis	-	x	-	-	-	-	-	-	-	-	-	-
Bl. belly redfish, Helicolenus dactylopterus	x	x	x	x	x	x	x	x	x	-	-	-
Hookear sculpin, Artediellus uncinatus	-	-	-	x	x	x	x	x	x	x	x	x
Mailed sculpin, Triglops ommatistius	-	-	x	x	x	x	x	x	x	x	x	x
Little sculpin, Myoxocephalus aeneus	-	-	-	-	x	-	-	-	-	-	-	-
Shorthorn sculpin, M. scorpius	-	-	-	x	-	-	-	x	-	-	-	-
Alligatorfish, Aspidophoroides monopterygius	-	x	-	x	x	x	x	x	x	x	x	x
Lumpfish, Cyclopterus lumpus	-	-	-	x	x	x	x	x	x	x	x	x
Seasnail, Neoliparis atlanticus	x	x	x	x	-	x	-	x	x	x	x	x
Careproctus ranulus	-	-	-	-	-	-	-	x	x	-	-	-
Northern searobin, Prionotus carolinus	x	x	x	-	-	-	-	-	-	-	-	-
Striped searobin, P. evolans	x	x	-	-	-	-	-	-	-	-	-	-
Armored searobin, Peristedion miniatum	x	x	x	-	-	-	-	-	-	-	-	-
Cunner, Tautogolabrus adspersus	x	x	x	x	x	x	x	x	x	-	-	-
Tautog, Tautoga onitis	-	x	-	-	-	-	-	-	-	-	-	-
Sand launce, Ammodytes americanus	x	-	x	x	x	x	-	x	-	x	x	x
Rock gunnel, Pholis gunnellus	-	-	-	-	-	x	-	-	-	-	-	-
Snake blenny, Lumpenus lumpretaeformis	-	-	-	x	x	-	x	x	x	-	-	-
Shanny, Leptoclinus maculatus	-	-	-	-	x	x	x	x	x	x	x	x
Radiated shanny, Ulvaria subbifurcata	-	-	-	x	-	x	-	x	-	-	-	x
Wrymouth, Cryptacanthodes maculatus	-	-	x	-	-	-	x	x	x	-	-	-
Arctic eelpout, Lycodes reticulatus	-	x	-	-	-	-	-	-	-	-	-	-
Wolf-eel, Lycenchelys verrillii	-	-	-	-	-	-	x	x	x	x	-	x
Cusk-eel, Lepophidium cervinum	x	x	x	x	x	x	-	x	x	-	-	-
Planehead filefish, [illegible]nacanthus hispidus	x	x	-	-	-	-	-	-	-	-	-	-
Northern puffer, Sph[illegible]oides maculatus	-	x	-	-	-	-	-	-	-	-	-	-
Batfish, Ogcocephalu[illegible]pertilio	-	-	-	-	x	-	-	-	-	-	-	-
Frogfish, Dibranchus [illegible]atlanticus	x	-	-	-	-	-	-	-	-	-	-	-
Number of species	67	72	59	57	58	53	45	62	57	39	40	44
Number of hauls	140	143	147	162	163	171	165	175	171	80	77	76

The first 33 species in Table 2, through American goosefish, comprised from 94 to 97 percent of the catches, by weight. These include the species of current economic interest (haddock, cod, flounders, hakes, etc.) and those of potential interest (dogfish, skates). The distribution and abundance, by faunal zone, of these 33 species is discussed below.

In the southern New England zone the spiny dogfish made up a far greater portion of the catch than any other species (Table 3, Figure 5). Large catches of this species in the fall surveys were responsible for much of this. Other species of high relative importance were yellowtail and red hake (present in some numbers in all seasons), silver hake (summer and fall), little skate (fall and winter), and eelpout (winter only). Of these species, the yellowtail and silver hake are of greatest economic importance here.

In the Georges Bank zone the catches of haddock led those of other species in all seasons (Table 4, Figure 5). Other species of importance were cod, yellowtail, big skate, and little skate, all of which were present in some abundance in all seasons, and eelpout, which were relatively available in winter only. The haddock, cod, and yellowtail are the bottom fish of greatest economic importance in this area.

In the Gulf of Maine zone redfish were first in abundance followed by haddock, spiny dogfish, thorny skate, cod, silver hake, pollock, and American plaice (Table 5, Figure 5). All of these were present in some amounts during all seasons sampled. Redfish, haddock, and silver hake are principal species of economic importance.

In the western Nova Scotia zone the principal species was haddock (Table 6, Figure 5). Other species of some abundance were cod (summer, fall, winter); pollock (summer, winter); and spiny dogfish (summer only). Haddock and cod are the species of greatest economic importance, and most are caught in the vicinity of Browns Bank.

Total fish catch per haul within faunal zones varied rather widely from season to season (Tables 3-6). The average catch per haul in all seasons combined, however, was relatively uniform from zone to zone. It was highest on Georges Bank at 336 lb (152 kg) followed by Gulf of Maine, 283 lb (128 kg); southern New England, 278 lb (126 kg); and western Nova Scotia, 269 lb (122 kg).

The bottom temperature regimes in summer, fall, and winter (Figure 6), estimated from about 800 bathythermograms per season, indicated that bottom temperature generally was highest in the fall. In addition, there was a much greater seasonal variation in temperature in the southern New England and Georges Bank

Table 3.--Abundance of 33 selected species and all species combined of fishes caught in three summer, three fall, and three winter surveys in the southern New England faunal zone in 1963-66, expressed as average numbers and pounds per haul and percentage total number and total weight per haul. (The symbol t indicates a trace catch of less than 0.1.).

Species	Summer				Fall				Winter			
	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.
Spiny dogfish	46.2	7.8	47.8	9.9	70.9	18.0	264.9	48.4	51.2	14.1	113.9	29.2
Barndoor skate	0.1	t	0.3	0.2	1.0	0.4	4.4	2.2	0.7	0.6	3.2	2.3
Big skate	1.2	0.2	4.2	1.0	3.6	0.8	10.2	2.6	2.0	1.0	7.1	3.0
Little skate	1.8	0.6	2.0	1.2	10.2	2.8	11.4	2.8	16.6	8.2	20.7	9.5
Smoothtail skate	-	-	-	-	-	-	-	-	-	-	-	-
Thorny skate	t	t	t	t	-	-	-	-	t	t	t	t
Sea herring	1.2	0.2	0.7	0.3	1.1	0.3	0.5	0.2	9.5	4.1	2.1	1.4
Alewife	43.6	5.0	14.6	4.4	5.5	1.4	2.1	0.6	6.4	3.8	1.8	1.3
Argentine	t	t	t	t	0.1	0.1	t	t	t	t	t	t
Offshore hake	0.1	0.2	0.1	0.4	0.1	0.1	0.1	0.3	0.2	0.2	0.3	0.3
Silver hake	50.7	23.8	15.4	17.6	61.3	21.8	13.6	7.9	32.0	15.8	5.9	3.8
Cod	0.4	0.1	1.9	0.4	0.4	0.1	4.3	1.0	0.6	0.2	4.7	2.0
Haddock	14.5	4.0	13.1	2.9	8.6	3.0	8.8	3.1	0.9	0.7	2.4	1.2
Pollock	0.1	t	0.1	t	t	t	t	t	0.1	t	0.8	0.2
White hake	0.2	0.2	1.4	1.1	0.8	0.4	1.6	1.2	0.7	0.5	1.2	0.9
Red hake	34.1	19.0	15.4	22.1	29.8	9.1	12.9	4.8	18.9	7.0	9.7	4.8
Spotted hake	0.3	0.7	0.1	0.9	0.2	0.1	0.1	0.2	t	t	t	t
Cusk	-	-	-	-	-	-	-	-	-	-	-	-
Sand flounder	1.2	0.3	0.7	0.3	11.8	2.7	2.6	0.6	3.9	2.2	2.0	0.9
Summer flounder	t	t	t	t	0.4	0.2	1.1	0.4	0.4	0.2	1.2	0.7
Fourspot flounder	7.3	5.5	3.2	6.2	8.3	3.6	3.5	1.9	7.0	4.2	3.2	2.2
Yellowtail flounder	17.6	4.7	12.3	4.9	37.4	8.5	24.5	6.2	23.6	13.7	17.8	10.4
Winter flounder	7.2	2.7	5.8	5.2	8.8	2.2	6.6	1.6	5.9	2.9	5.9	2.1
Graysole	0.1	0.1	0.1	0.1	0.5	0.3	0.8	0.4	0.7	0.5	1.3	0.9
American plaice	0.2	0.1	0.1	0.1	0.5	0.1	t	t	0.7	0.3	0.2	0.1
Butterfish	67.4	16.4	13.0	8.2	53.0	11.1	9.4	1.9	9.2	3.6	1.3	0.7
Scup	-	-	-	-	45.6	3.3	3.2	1.0	t	t	t	t
Redfish	0.1	0.3	t	t	-	-	-	-	-	-	-	-
Longhorn sculpin	3.9	1.2	1.4	0.6	7.4	2.1	2.1	0.6	25.6	6.7	14.3	3.3
Sea raven	0.2	t	0.3	0.1	0.2	0.1	0.2	0.1	0.4	0.2	0.4	0.3
Wolf fish	-	-	-	-	-	-	-	-	-	-	-	-
Eelpout	0.8	0.2	1.2	0.2	0.9	0.4	1.0	0.3	15.9	6.4	35.7	11.9
American goosefish	0.3	0.4	1.9	5.6	1.8	0.9	11.9	7.0	0.7	0.4	6.2	4.7
All other species	6.5	6.3	3.9	6.1	14.6	6.1	5.7	2.7	4.9	2.5	2.6	1.9
Total	307.3	100.0	161.0	100.0	384.8	100.0	407.5	100.0	238.7	100.0	265.9	100.0

Table 4.--Abundance of 33 selected species and all species combined of fishes caught in three summer, three fall, and three winter surveys in the Georges Bank faunal zone in 1963-66, expressed as average numbers and pounds per haul and percentage total number and total weight per haul. (The symbol t indicates a trace catch of less than 0.1.).

Species	Summer				Fall				Winter			
	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.
Spiny dogfish	4.4	0.8	13.6	2.2	2.3	0.9	8.0	2.5	0.6	0.3	2.0	0.8
Barndoor skate	0.9	0.3	5.5	1.7	1.1	0.5	7.9	3.3	1.3	0.9	7.2	3.2
Big skate	3.9	1.0	17.3	4.3	8.5	3.3	21.5	6.8	6.9	4.2	20.8	8.0
Little skate	9.1	2.1	11.2	2.7	15.1	5.9	18.2	5.5	21.4	11.1	26.2	9.3
Smoothtail skate	t	t	0.1	0.1	0.2	0.1	0.3	0.1	0.2	0.1	0.2	t
Thorny skate	0.8	0.4	4.5	1.1	1.7	0.8	6.6	1.9	1.4	1.0	6.9	2.9
Sea herring	12.5	3.5	7.4	2.5	3.1	1.5	1.3	0.6	1.6	1.2	0.4	0.2
Alewife	19.7	3.2	8.6	1.6	2.3	0.8	0.9	0.3	0.2	0.2	t	t
Argentine	0.1	t	t	t	0.1	0.1	0.1	t	t	t	t	t
Offshore hake	t	0.1	0.1	0.1	t	t	t	t	t	t	t	t
Silver hake	31.7	10.6	13.7	6.0	9.9	5.5	4.7	3.0	5.4	2.8	1.0	0.6
Cod	3.2	0.9	22.7	4.7	2.2	0.9	16.0	5.3	3.3	2.4	35.8	12.7
Haddock	268.4	51.0	244.4	50.8	135.4	48.1	147.7	45.4	100.2	35.2	118.1	31.3
Pollock	0.6	0.2	1.4	0.4	0.4	0.3	3.2	1.1	0.8	0.6	5.5	1.9
White hake	0.5	0.2	0.5	0.4	0.8	0.4	1.5	0.8	0.5	0.2	0.7	0.3
Red hake	16.8	6.7	9.8	5.4	15.3	6.1	9.2	4.3	8.9	3.5	5.1	2.8
Spotted hake	-	-	-	-	-	-	-	-	-	-	-	-
Cusk	t	t	t	t	t	t	0.2	0.1	t	t	0.2	0.1
Sand flounder	2.3	0.5	1.4	0.4	1.9	0.8	0.8	0.3	1.3	0.9	0.8	0.3
Summer flounder	t	t	0.1	t	-	-	-	-	t	t	t	t
Fourspot flounder	2.3	1.8	1.1	0.6	2.2	1.1	1.1	0.6	1.9	1.0	1.0	0.6
Yellowtail flounder	15.2	4.9	12.2	4.8	21.8	8.0	19.6	6.7	14.9	8.3	13.8	4.7
Winter flounder	1.5	0.4	3.9	0.8	1.7	0.7	5.1	1.5	2.1	1.3	5.8	2.0
Graysole	0.2	0.1	0.2	0.1	0.4	0.2	0.5	0.2	0.4	0.3	0.6	0.2
American plaice	1.7	1.0	1.4	0.7	3.1	1.3	2.6	0.7	2.8	1.9	3.2	1.1
Butterfish	13.4	3.7	3.4	1.5	10.3	2.9	2.0	0.6	-	-	-	-
Scup	-	-	-	-	0.2	0.1	0.3	0.1	-	-	-	-
Redfish	0.5	0.6	0.3	0.3	0.3	0.3	t	t	0.7	0.3	0.2	t
Longhorn sculpin	10.2	2.9	3.9	1.0	13.0	5.8	4.7	1.9	24.5	11.3	8.6	2.8
Sea raven	1.1	0.3	2.8	0.8	1.3	0.7	2.5	1.1	1.3	0.9	3.3	1.3
Wolf fish	t	t	0.6	0.1	t	t	t	t	t	t	0.8	0.3
Eelpout	1.2	0.4	4.1	1.1	1.5	0.9	3.1	1.5	7.0	5.1	30.9	10.4
American goosefish	0.3	0.1	3.9	1.5	0.6	0.2	8.4	3.0	0.4	0.2	4.7	1.5
All other species	2.1	2.3	1.5	2.3	4.1	1.8	1.5	0.8	11.0	4.8	1.5	0.7
Total	424.6	100.0	401.6	100.0	260.8	100.0	299.5	100.0	221.0	100.0	305.3	100.0

zones than farther to the north and east. This probably contributes to the apparently greater migrations of fish in these southern areas and may help to account for the somewhat greater seasonal variations in abundance and availability there (Tables 3-6).

Relative abundance by sampling stratum for five species only is presented in Figures 7-11.[2/] These data provide a finer breakdown of distribution and abundance by area than the tabled data do, and they also permit comparison of catch with bottom temperature.

Spiny dogfish were relatively abundant only in the southern New England zone and in coastal areas just to the north of Cape Cod (Figure 7). Greatest abundance was during fall surveys and in the shallowest depth zone, 15-30 fm (27-55 m). During winter surveys such concentrations as were observed were in the intermediate and deeper depths where bottom temperature was slightly higher than inshore.

Silver hake were caught in small amounts over the entire survey area; abundance was lowest in the western Nova Scotia zone (Figure 8). Distribution by depth was not clear, although the fish tended to be in deeper water during winter surveys where the temperature was slightly higher than inshore.

Haddock were most abundant in the Georges Bank and western Nova Scotia zones and in intermediate water depths (Figure 9). There was no marked difference in distribution by season.

Red hake were caught in greatest amounts in the southern part of the survey area (Figure 10). Like silver hake, the only significant concentrations were found in deep water during winter surveys, where water temperature is higher than farther inshore.

Yellowtail were found in significant amounts only in the southern New England and Georges Bank zones (Figure 11). In southern New England waters the greatest concentrations were in depths of 15-30 fm (27-55 m); on Georges Bank the concentrations were at slightly greater depths. There was little variation in abundance with season.

2/ In the western Nova Scotia zone, stratum 35 was sampled only in the last six surveys of this series, and strata 1 and 42 only in the last three surveys. Abundance estimates in these strata are therefore based on relatively few hauls.

Table 5.--Abundance of 33 selected species and all species combined of fishes caught in three summer, three fall, and three winter surveys in the Gulf of Maine faunal zone in 1963-66, expressed as average numbers and pounds per haul and percentage total number and total weight per haul. (The symbol t indicates a trace catch of less than 0.1.).

Species	Summer				Fall				Winter			
	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.
Spiny dogfish	3.9	1.5	14.4	4.4	13.0	4.4	51.9	12.5	8.6	3.7	37.8	11.0
Barndoor skate	t	t	0.4	0.1	0.1	0.1	1.3	0.4	0.3	0.1	5.4	1.4
Big skate	0.1	t	1.1	0.4	0.3	0.1	2.4	0.5	0.4	0.1	2.7	0.8
Little skate	0.1	t	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.3	0.4
Smoothtail skate	0.2	0.2	0.5	0.3	0.9	0.7	1.6	0.5	0.6	0.5	1.9	0.7
Thorny skate	1.9	1.4	14.8	7.1	2.9	2.2	30.7	9.7	3.3	2.2	24.6	10.3
Sea herring	8.1	3.3	5.4	1.9	2.8	1.2	1.5	0.4	0.3	0.2	t	t
Alewife	0.4	0.1	0.1	t	0.6	0.3	0.2	0.1	1.0	0.5	0.1	t
Argentine	1.8	1.4	1.1	0.7	3.2	1.2	1.6	0.5	9.7	3.5	2.4	0.7
Offshore hake	-	-	-	-	-	-	-	-	-	-	-	-
Silver hake	37.2	16.5	12.1	5.0	92.6	30.6	28.7	8.7	47.7	14.8	12.6	3.2
Cod	2.0	0.8	12.5	5.1	3.1	1.2	24.9	7.3	2.7	1.5	19.5	7.0
Haddock	22.9	9.5	38.9	17.2	23.4	10.7	50.8	18.5	24.2	12.5	48.1	16.0
Pollock	1.5	0.6	11.9	4.1	2.0	1.1	14.2	4.4	3.1	1.9	16.5	5.0
White hake	3.3	1.6	12.4	5.1	4.0	2.4	13.9	5.8	5.8	3.4	19.9	6.8
Red hake	3.0	1.8	2.9	1.4	4.5	1.9	4.8	1.4	7.1	4.4	5.2	1.9
Spotted hake	-	-	-	-	-	-	-	-	-	-	-	-
Cusk	0.6	0.4	4.6	2.3	0.5	0.3	3.5	1.3	0.6	0.5	4.6	2.1
Sand flounder	-	-	-	-	t	t	t	t	0.2	0.1	0.1	t
Summer flounder	-	-	-	-	-	-	-	-	-	-	-	-
Fourspot flounder	-	-	-	-	t	t	t	t	t	t	t	t
Yellowtail flounder	0.2	0.1	0.2	0.1	0.9	0.3	0.7	0.2	1.1	0.3	0.6	0.3
Winter flounder	0.2	0.1	0.3	0.1	0.4	0.2	0.8	0.2	0.4	0.3	0.4	0.3
Graysole	3.7	2.0	5.1	2.3	4.4	2.5	6.1	2.4	5.6	4.7	8.0	3.6
American plaice	14.9	7.8	10.3	4.7	16.6	9.4	13.3	5.4	17.2	10.3	11.8	5.3
Butterfish	t	t	t	t	t	t	t	t	-	-	-	-
Scup	-	-	-	-	t	t	t	t	-	-	-	-
Redfish	98.4	47.8	76.8	33.2	88.9	26.8	67.5	16.7	76.7	29.1	55.4	15.6
Longhorn sculpin	0.2	0.1	0.1	t	0.4	0.3	0.2	0.1	1.3	1.1	0.4	0.4
Sea raven	0.2	0.1	0.4	0.2	0.2	0.1	0.2	0.1	0.3	0.2	0.6	0.8
Wolf fish	0.1	0.1	0.7	0.3	0.2	0.1	0.4	0.2	0.1	t	0.3	0.1
Eelpout	0.2	0.1	0.4	0.1	0.1	t	t	t	0.5	0.2	0.8	0.3
American goosefish	0.4	0.2	4.3	1.9	0.5	0.4	5.4	2.2	1.2	0.7	14.6	5.4
All other species	2.1	2.5	2.6	1.9	1.9	1.4	1.0	0.4	4.0	3.0	1.1	0.6
Total	207.6	100.0	234.4	100.0	266.6	100.0	317.8	100.0	224.2	100.0	295.7	100.0

Table 6.--Abundance of 33 selected species and all species combined of fishes caught in three summer, three fall, and three winter surveys in the western Nova Scotia faunal zone in 1963-66, expressed as average numbers and pounds per haul and percentage total number and total weight per haul. (The symbol t indicates a trace catch of less than 0.1.)

Species	Summer				Fall				Winter			
	No.	% No.	Wt.	% Wt.	No.	% No.	Wt.	% Wt.	No.	%No.	Wt.	% Wt.
Spiny dogfish	14.7	4.2	48.5	10.7	2.2	1.8	9.4	3.7	1.6	0.7	7.8	2.7
Barndoor skate	0.2	0.1	2.4	0.5	0.5	0.5	4.4	3.4	0.2	0.1	0.9	0.3
Big skate	0.3	0.1	0.3	0.1	0.2	0.2	0.3	0.2	0.2	0.1	1.1	0.4
Little skate	1.1	0.3	1.1	0.4	1.5	2.2	2.2	2.1	5.4	2.7	7.1	2.0
Smoothtail skate	0.4	0.3	1.0	0.6	0.7	0.5	0.5	0.2	0.1	0.1	0.1	t
Thorny skate	1.5	0.8	5.2	2.5	1.8	1.4	6.2	3.0	2.1	1.2	6.9	2.7
Sea herring	5.8	2.8	2.8	1.2	4.5	1.5	1.7	0.5	0.2	0.1	t	t
Alewife	0.1	t	0.1	t	0.1	t	t	t	0.1	t	t	t
Argentine	14.2	5.8	5.0	2.4	2.2	1.2	0.5	0.3	2.2	0.8	0.7	0.2
Offshore hake	-	-	-	-	-	-	-	-	-	-	-	-
Silver hake	10.0	4.6	3.8	1.8	3.6	2.5	2.0	0.8	0.2	0.1	t	t
Cod	11.1	5.7	55.9	19.0	5.5	4.4	40.6	22.2	6.8	4.5	37.7	15.7
Haddock	134.9	54.5	135.1	35.4	95.0	54.9	93.3	42.0	113.8	62.2	126.6	48.5
Pollock	3.2	1.6	24.8	9.1	1.0	0.7	7.2	3.1	14.0	7.1	39.7	12.2
White hake	1.6	1.1	4.4	1.6	1.9	1.4	5.8	2.8	0.3	0.2	0.5	0.2
Red hake	0.2	0.1	0.1	t	1.5	1.1	0.9	0.4	0.6	0.4	0.4	0.1
Spotted hake	-	-	-	-	-	-	-	-	-	-	-	-
Cusk	0.9	0.6	5.0	2.4	0.5	0.5	2.5	1.4	0.7	0.5	4.2	1.6
Sand flounder	-	-	-	-	-	-	-	-	-	-	-	-
Summer flounder	-	-	-	-	-	-	-	-	-	-	-	-
Fourspot flounder	-	-	-	-	t	t	t	t	-	-	-	-
Yellowtail flounder	1.3	0.6	0.6	0.2	2.0	1.8	0.8	0.4	1.6	0.8	0.7	0.3
Winter flounder	3.1	0.8	6.5	1.1	1.6	1.1	2.9	1.1	4.2	2.1	9.5	3.8
Graysole	0.9	0.5	1.6	0.4	1.2	1.3	1.9	1.1	0.5	0.2	0.9	0.3
American plaice	8.0	4.8	5.2	2.6	6.4	6.3	6.1	3.1	6.4	4.2	4.1	1.5
Butterfish	-	-	-	-	-	-	-	-	-	-	-	-
Scup	-	-	-	-	-	-	-	-	-	-	-	-
Redfish	13.1	7.8	11.8	5.2	14.3	7.3	12.0	4.2	5.3	3.5	4.2	1.8
Longhorn sculpin	0.6	0.2	0.2	0.1	2.4	2.0	0.7	0.3	1.9	1.4	0.5	0.2
Sea raven	0.2	0.1	0.5	0.1	0.5	0.3	1.5	0.6	0.8	0.6	2.5	1.0
Wolf fish	0.2	0.1	1.5	0.4	0.3	0.3	1.3	0.6	0.4	0.3	4.1	1.7
Eelpout	t	t	t	t	0.1	0.1	t	t	0.1	t	t	t
American goosefish	0.3	0.1	4.3	1.5	0.2	0.1	4.1	1.8	0.3	0.2	4.6	1.7
All other species	3.6	2.2	1.7	0.7	13.0	5.0	3.3	1.7	7.8	5.9	2.7	1.1
Total	231.5	100.0	329.4	100.0	164.7	100.0	210.1	100.0	177.8	100.0	267.5	100.0

LITERATURE CITED

Ackerman, E. A. 1941. New England's fishing industry. 303 p. Univ. of Chicago Press.

Bigelow, H. B., and Wm. C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Dept. Int., Fish. Bull. 53:1-577.

Colton, John B. 1955. Spring and summer distribution of haddock on Georges Bank. U.S. Dept. Int., Spec. Sci. Rept.-Fisheries No. 156, 65 p.

Colton, John B. 1964. History of oceanography in the offshore waters of the Gulf of Maine. U.S. Dept. Int., Spec. Sci. Rept.-Fisheries No. 496, 18 p.

Fritz, Raymond L. 1965. Autumn distribution of groundfish species in the Gulf of Maine and adjacent waters, 1955-1961. Am. Geograph. Soc., Serial Atlas of Marine Environment, Folio 10, 20 plates.

Grosslein, M. D. 1968. Results of joint USA-USSR groundfish studies. ICNAF Res. Doc. 68-87, 17 p.

1969. Groundfish survey program of BCF, Woods Hole. U.S. Dept. Int., Commer. Fish. Rev. 31(8-9): 22-35.

Parr, A. E. 1933. A geographic-ecological analysis of the seasonal changes in temperature conditions in shallow water along the Atlantic coast of the United States. Bull. Bingh. Oceanogr. Coll. 4(3):1-90.

Taylor, Clyde C. 1953. Nature of variability in trawl catches. U.S. Dept. Int., Fishery Bull. 54: 145-166.

Williams, C. B. 1964. Patterns in the balance of nature. 324 p. Academic Press Inc., London and New York.

20 May 1970

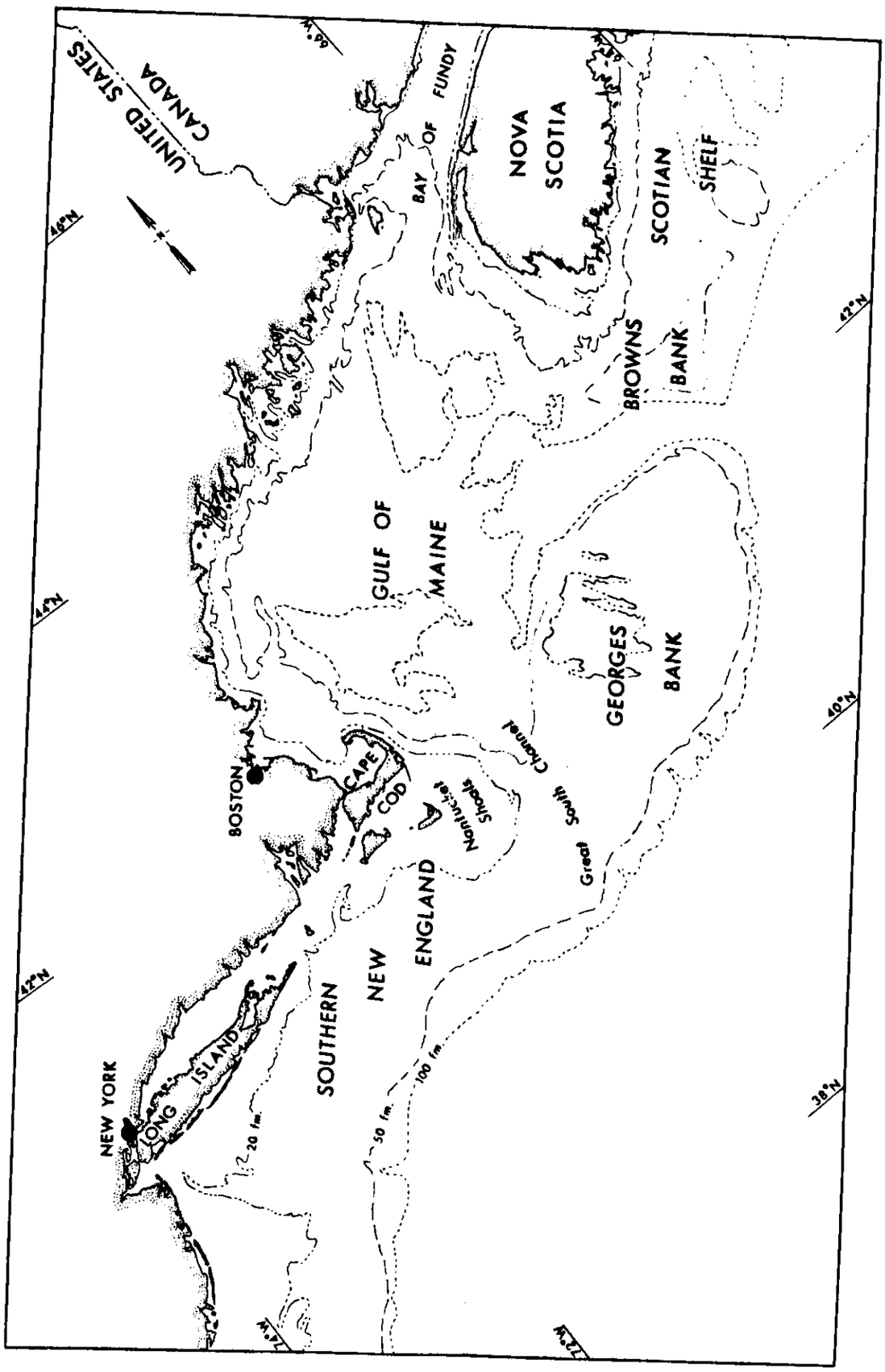

Figure 1.--Chart of fishing areas off northeastern U.S.A. and southeastern Canada.

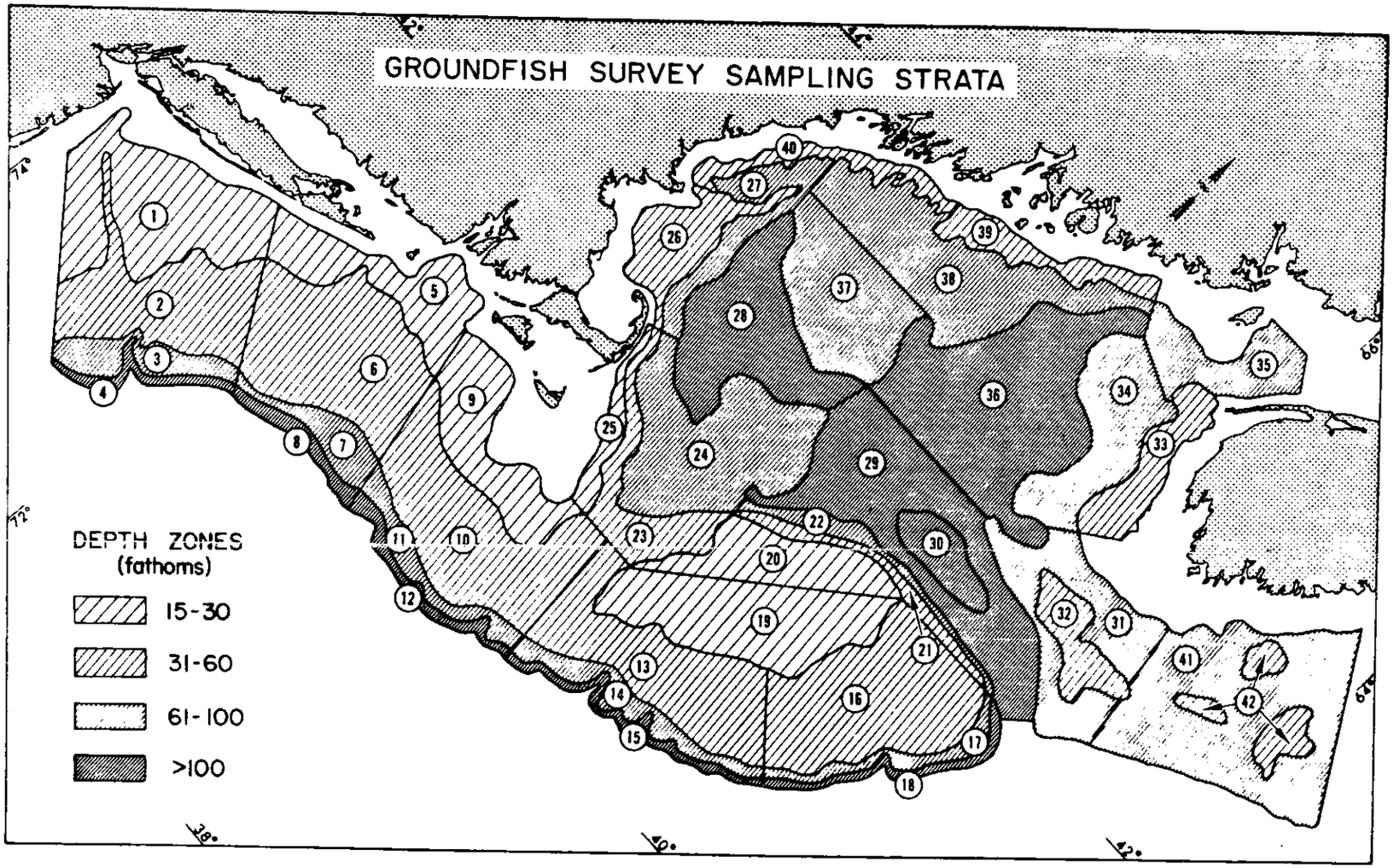

Figure 2.--Depth zones and sampling strata (numbered) in the area surveyed.

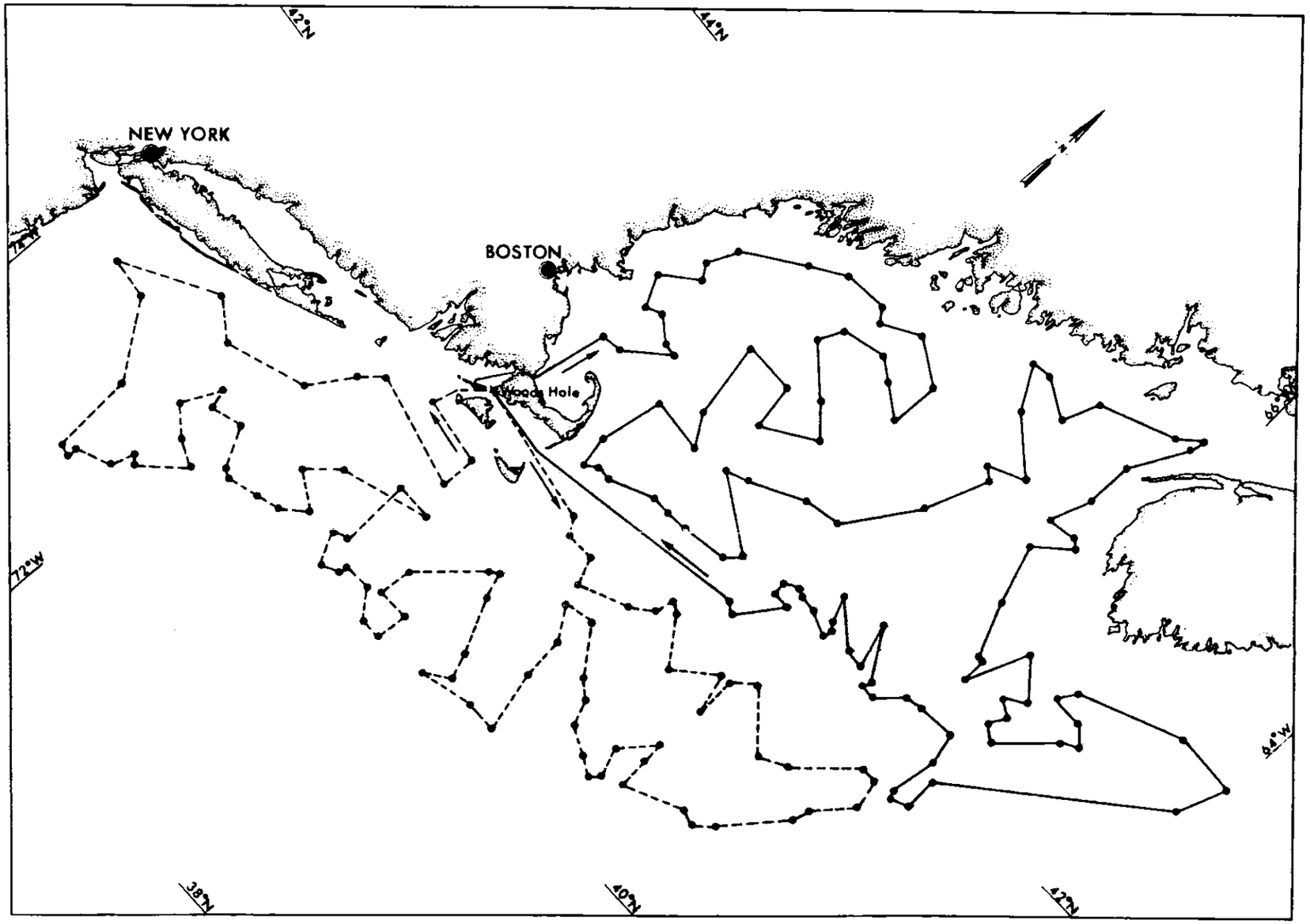

Figure 3.--Station pattern and cruise track for the otter trawl survey in fall 1965. (The solid line is the track for the first half of the survey, the dashed line for the second half.)

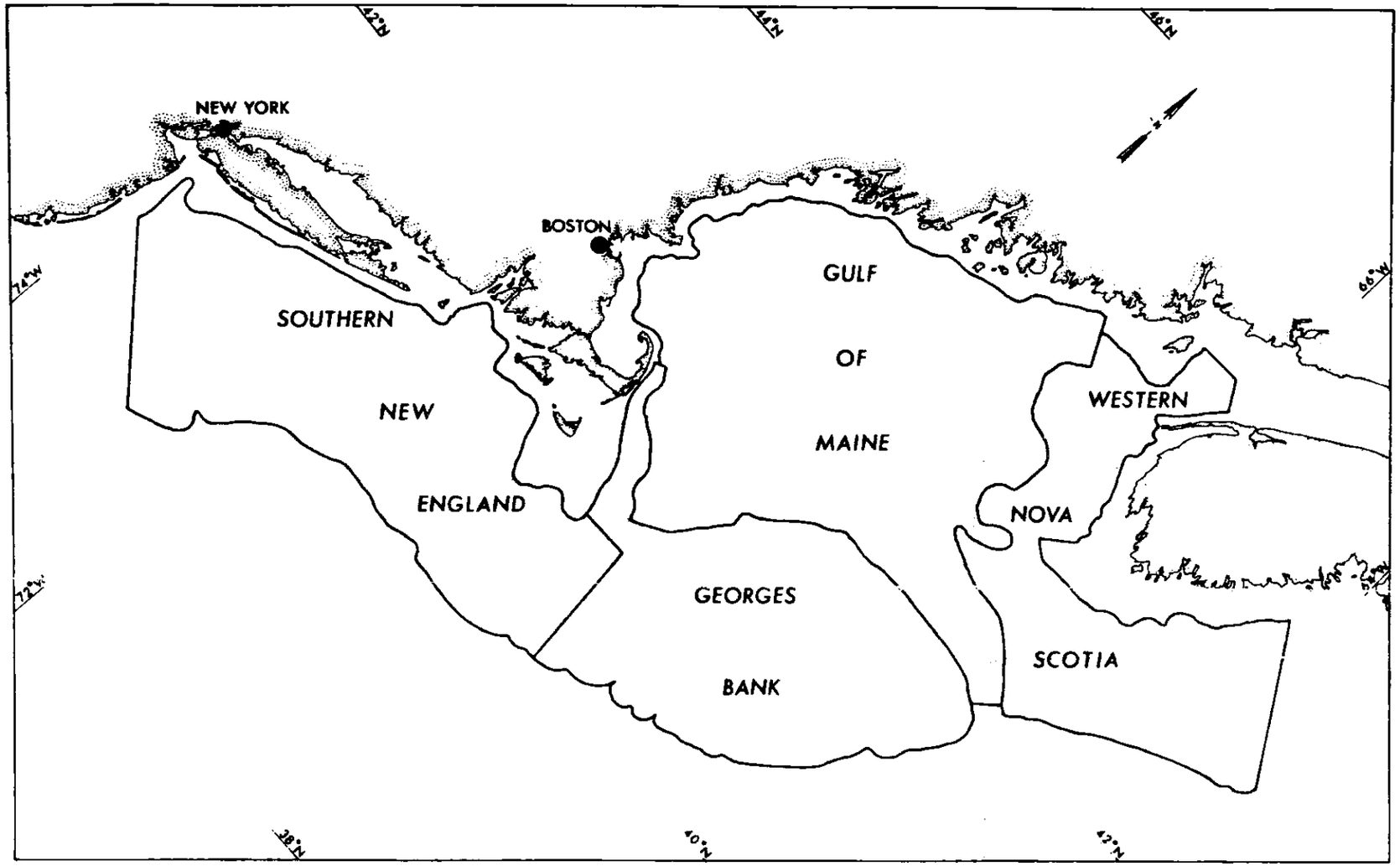

Figure 4.--Faunal zones by which catch information from surveys was summarized.

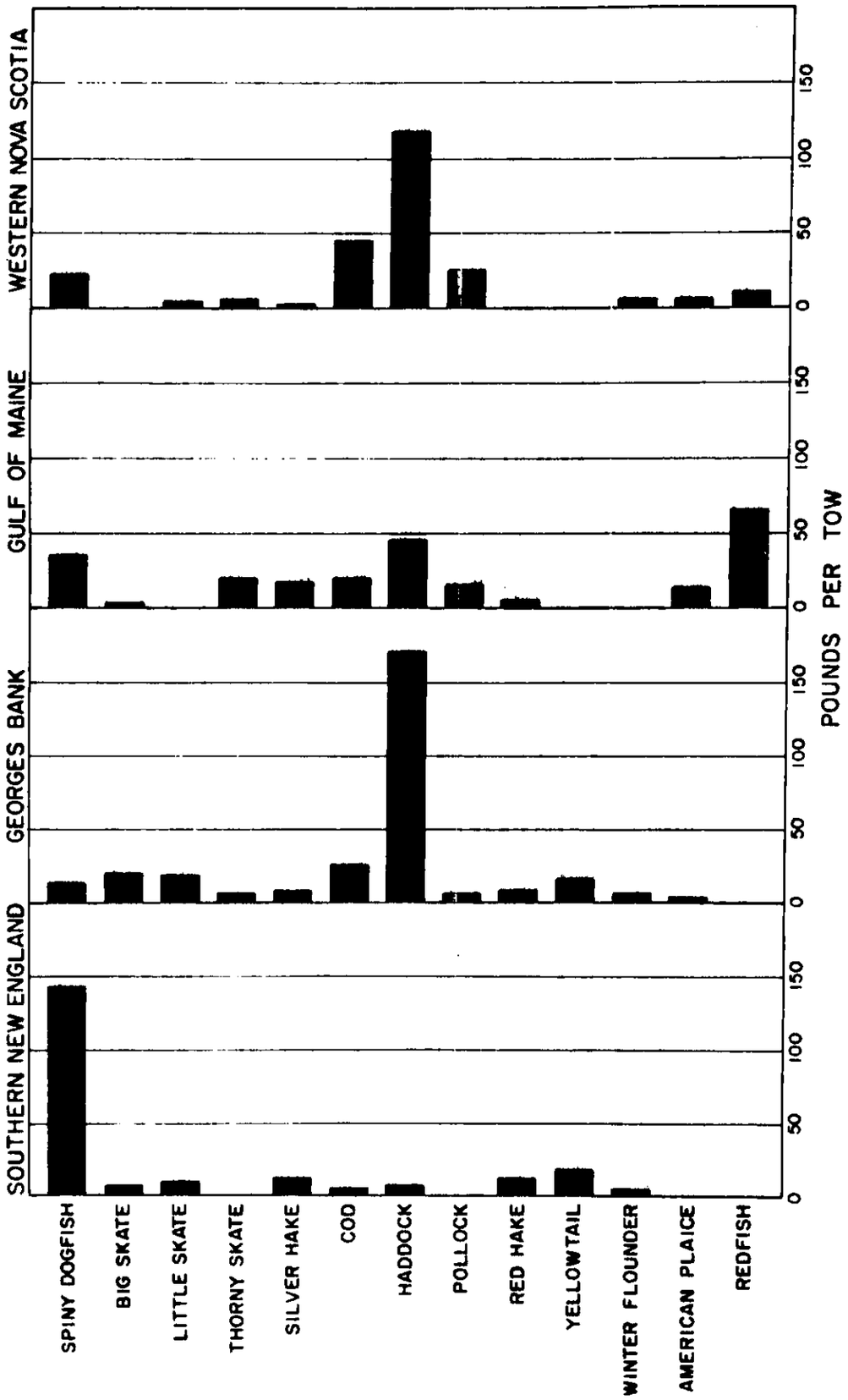

Figure 5.--Relative abundance of the principal species in the four faunal zones for nine surveys in 1963-66.

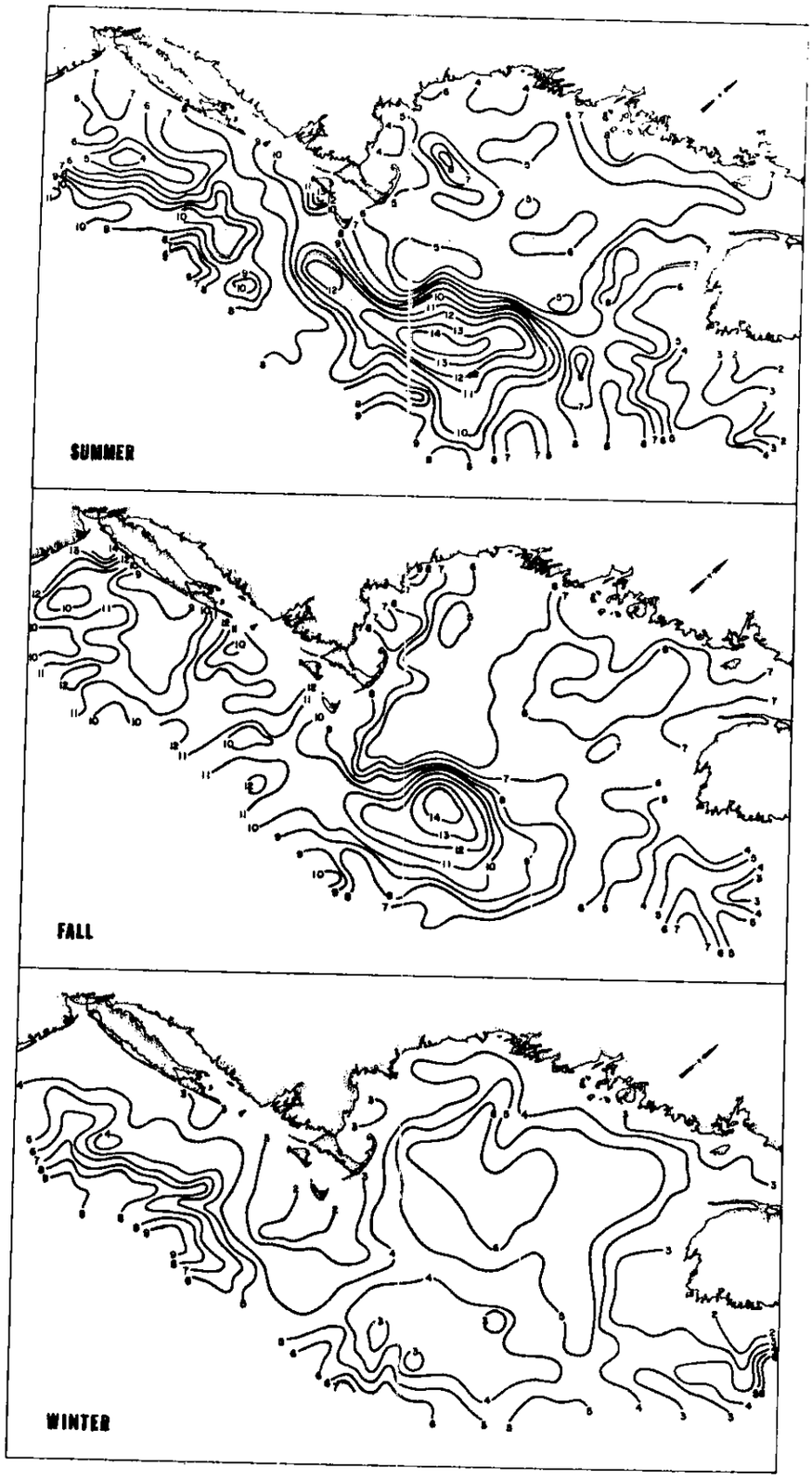

Figure 6.--Isotherms (°C) at the bottom in summer, fall, and winter estimated from bathythermograms obtained on nine otter trawl surveys in 1963-66.

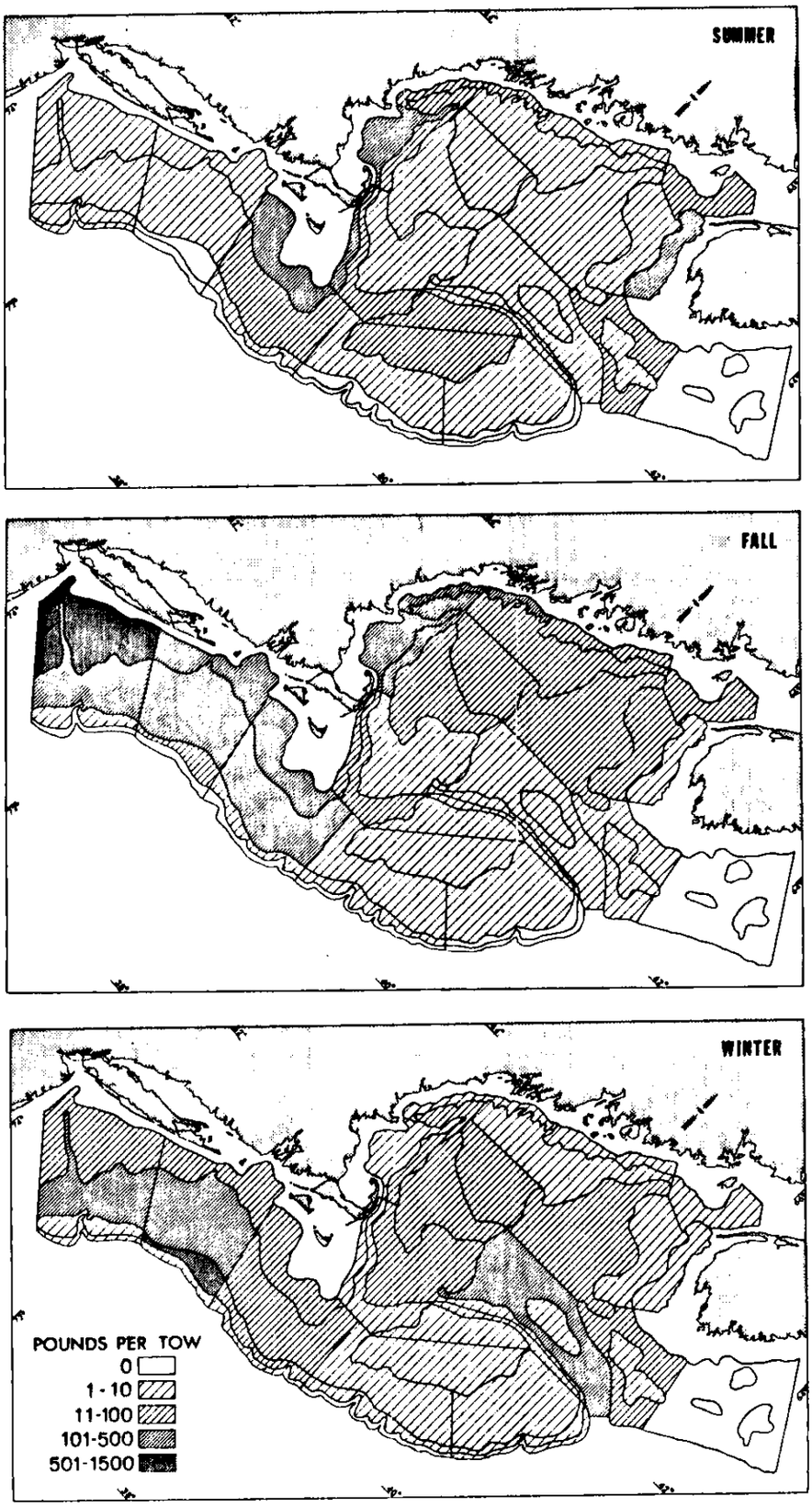

Figure 7.--Relative abundance of spiny dogfish by sampling stratum for three summer, fall, and winter otter trawl surveys in 1963-66.

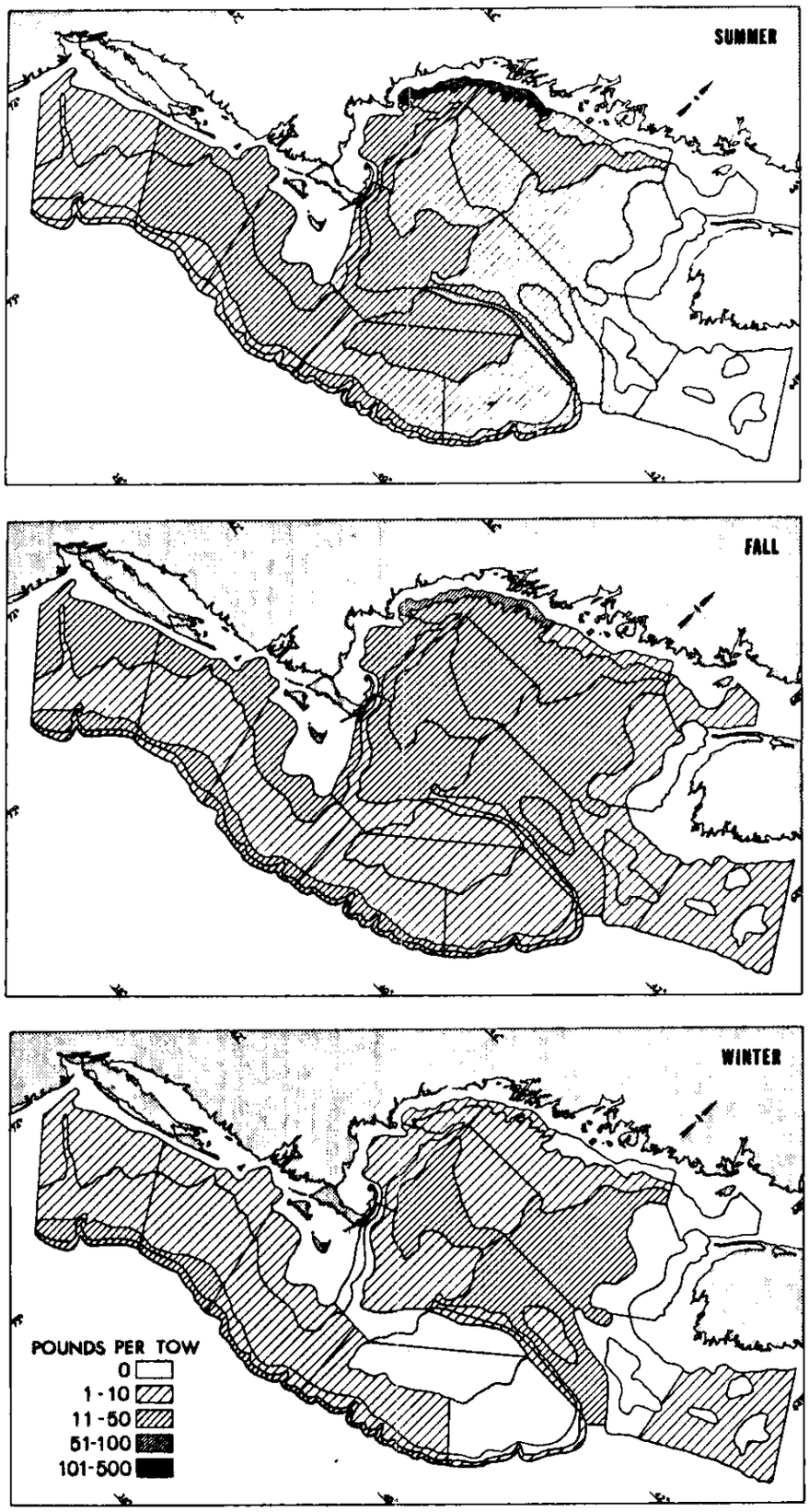

Figure 8.--Relative abundance of silver hake by sampling stratum for three summer, fall, and winter otter trawl surveys in 1963-66.

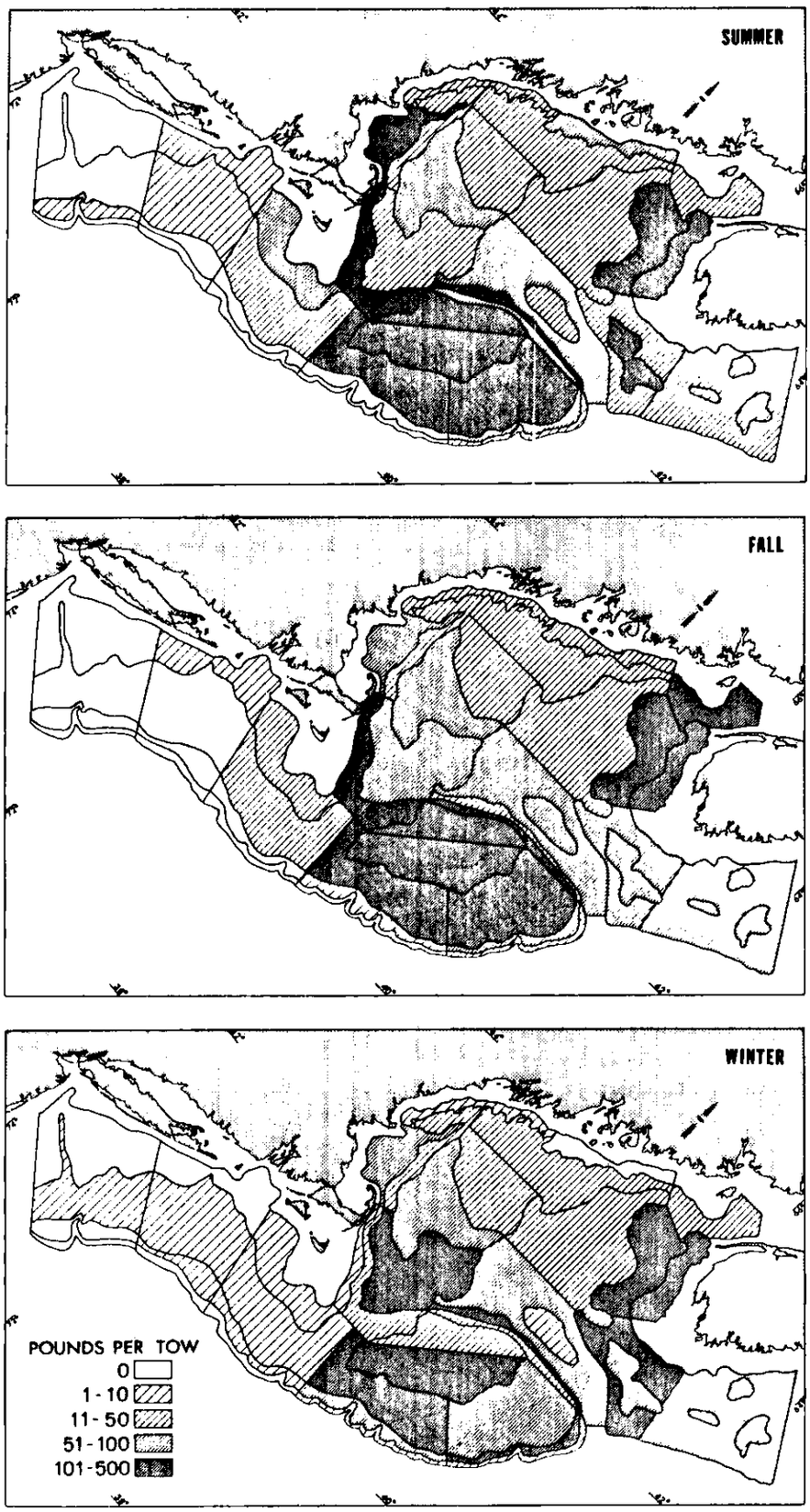

Figure 9.--Relative abundance of haddock by sampling stratum for three summer, fall, and winter otter trawl surveys in 1963-66.

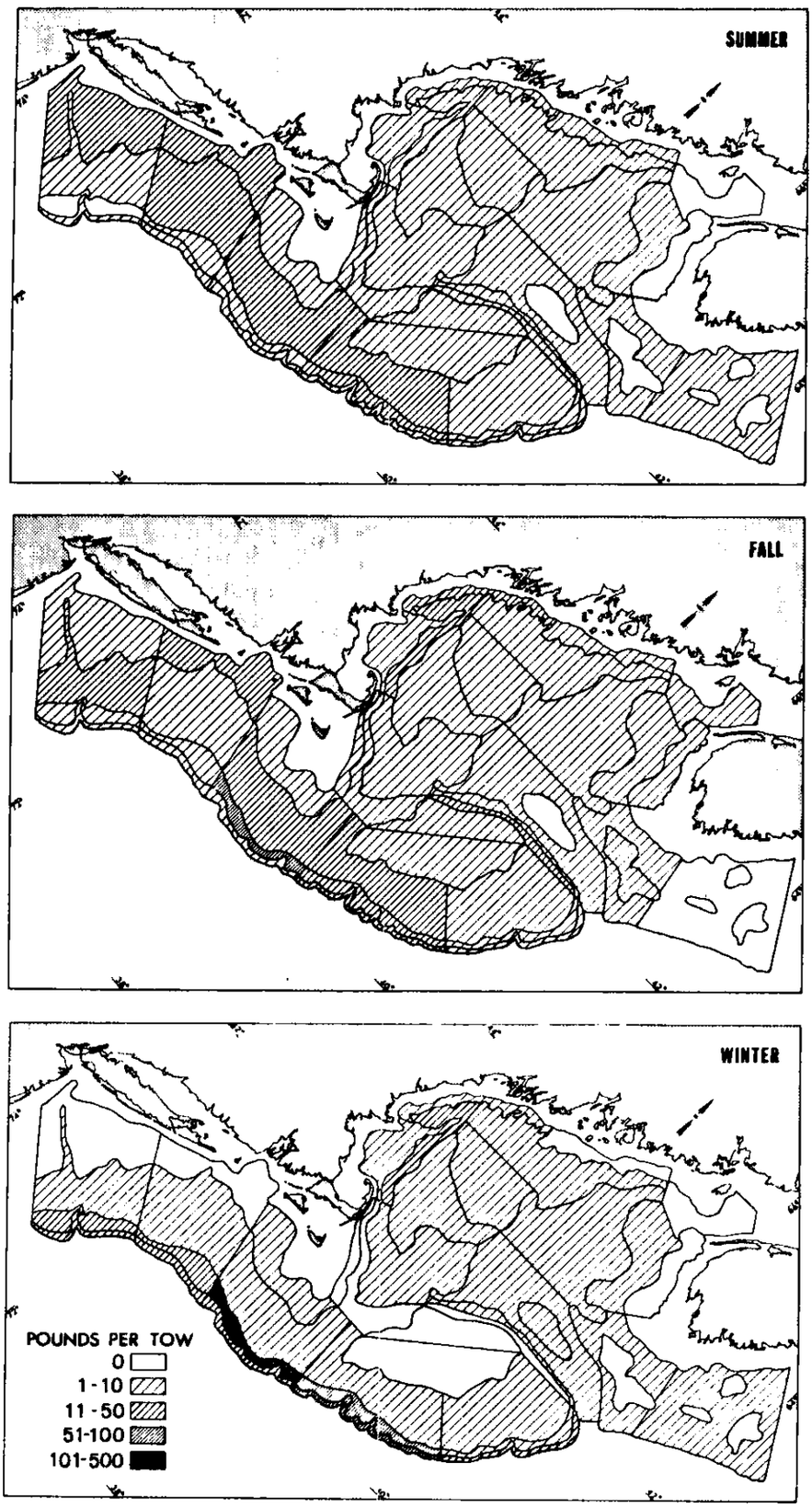

Figure 10.--Relative abundance of red hake by sampling stratum for three summer, fall, and winter otter trawl surveys in 1963-66.

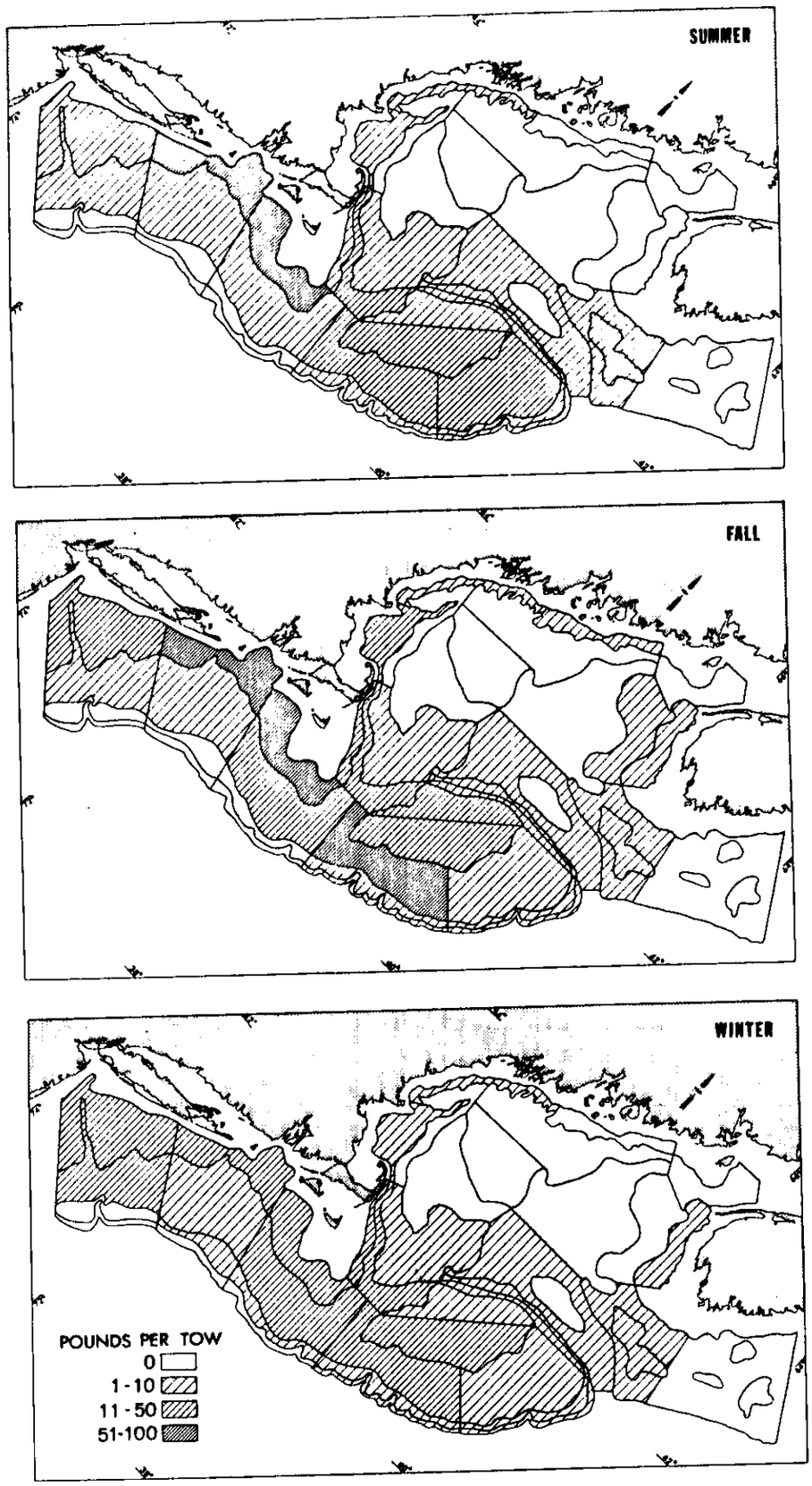

Figure 11.--Relative abundance of yellowtail by sampling stratum for three summer, fall, and winter otter trawl surveys in 1963-66.