PRELIMINARY FINDINGS OF TRAWLING ON THE CONTINENTAL SHELF OFF THE SOUTHEASTERN UNITED STATES DURING FOUR SEASONS (1973-1975)[1]

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Introduction

Previous studies of the groundfish stocks of the continental shelf along the southeastern United States have generally been limited to considerations of specific temporal or spatial aspects of fish abundance and distribution (Powell 1950) or selective exploratory fishing with a variety of noncomparable gear (Cummins et al., 1962; Struhsaker 1969a). In addition, Struhsaker (1969a) described the general continental shelf physiography, groundfish habitats and general fish species assemblages of the southeastern U. S. coast.

This report presents a brief overview of a comprehensive survey of fishery stocks based on standardized trawling gear and stations selected randomly within depth strata over the total survey area. In the southeastern Atlantic, staff of the Marine Resources Research Institute of South Carolina Wildlife and Marine Resources Department conduct Marine Resources Monitoring Assessment and Prediction (MARMAP) surveys between Cape Fear, North Carolina and Cape Canaveral, Florida in cooperation with the National Marine Fisheries Service. This introductory paper reports on the seasonal depth distribution and relative abundance of major groups of groundfish collected at depths between 10-366m during the period of 1973-1975; detailed results of the survey will be presented elsewhere. Objectives of the study were to 1) identify the fish species available to standard trawl fishing gear, 2) determine relative abundance and distributional patterns of benthic fish species, 3) identify and describe groundfish communities, and 4) document quantitative fisheries information for comparison with future resource monitoring results. These objectives are particularly important at present because of anticipated activities on the continental shelf, including increased sport and commercial fish harvest, exploration for and possibly production of hydrocarbons, and location of floating nuclear generators to produce electricity (Burrell 1975).

Methods

A total of 380 trawl stations was made on four seasonal cruises (Fall 1973, Spring 1974, Summer 1974 and Winter 1975) on the continental shelf and upper slope between Cape Fear, North Carolina and Cape Canaveral, Florida, except in spring 1974 when sampling extended to Cape Hatteras. Time between start and completion of cruises ranged from 23 days (Fall, 1973) to 85 days (Winter, 1975) during which a major vessel breakdown occurred. The sampling schemes, developed by Grosslein (1969), consisted of randomly preselected station locations with a set number in each of six depth strata (Fig. 1, 10-18 m; 19-27 m; 28-55 m; 56-110 m; 111-183 m; 184-366 m). Inshore areas within the 10 m isobath were not routinely sampled.

Collections were made using a 3/4-scale version of a "Yankee No. 36" trawl (Wilk and Silverman 1976) having a 16.5 m (54-ft.) footrope, 11.9 m (39-ft.) headrope, and 1.3 cm (1/2-in.) stretch mesh cod end-liner. All trawl tows were made from the R/V Dolphin, a 32.6 m (107-ft.) converted tug of about 354 MT (390 tons) displacement with a 1200 BHP diesel engine and fixed pitch propeller. Each trawl was of 30 minutes duration at a vessel speed of 6.5 km/h (3.5 kts), with a wire to depth ratio of 2.5-3:1 depending on water depth.

The average catch per trawl was used as an index for estimates of relative abundance, although the effects of several large catches on this index must be considered in analysis. Each species catch less than 0.45 kg arbitrarily was assigned a weight of 0.1 kg for the computerized compilations of the total weight of that species. Standard trawling gear and randomly selected stations within each depth stratum permitted comparisons of relative abundance within the area and with samples taken with a similar gear by the NMFS Northeast Fisheries Center north of Cape Hatteras.

Chemical and hydrographic measurements made at each station included a temperature profile, surface and bottom salinity, dissolved oxygen (O_2), and nutrients (PO_4, NO_3 and SiO_4). More complete sampling of the water column at standard hydrographic depths was performed at selected stations which approximated transects across the shelf.

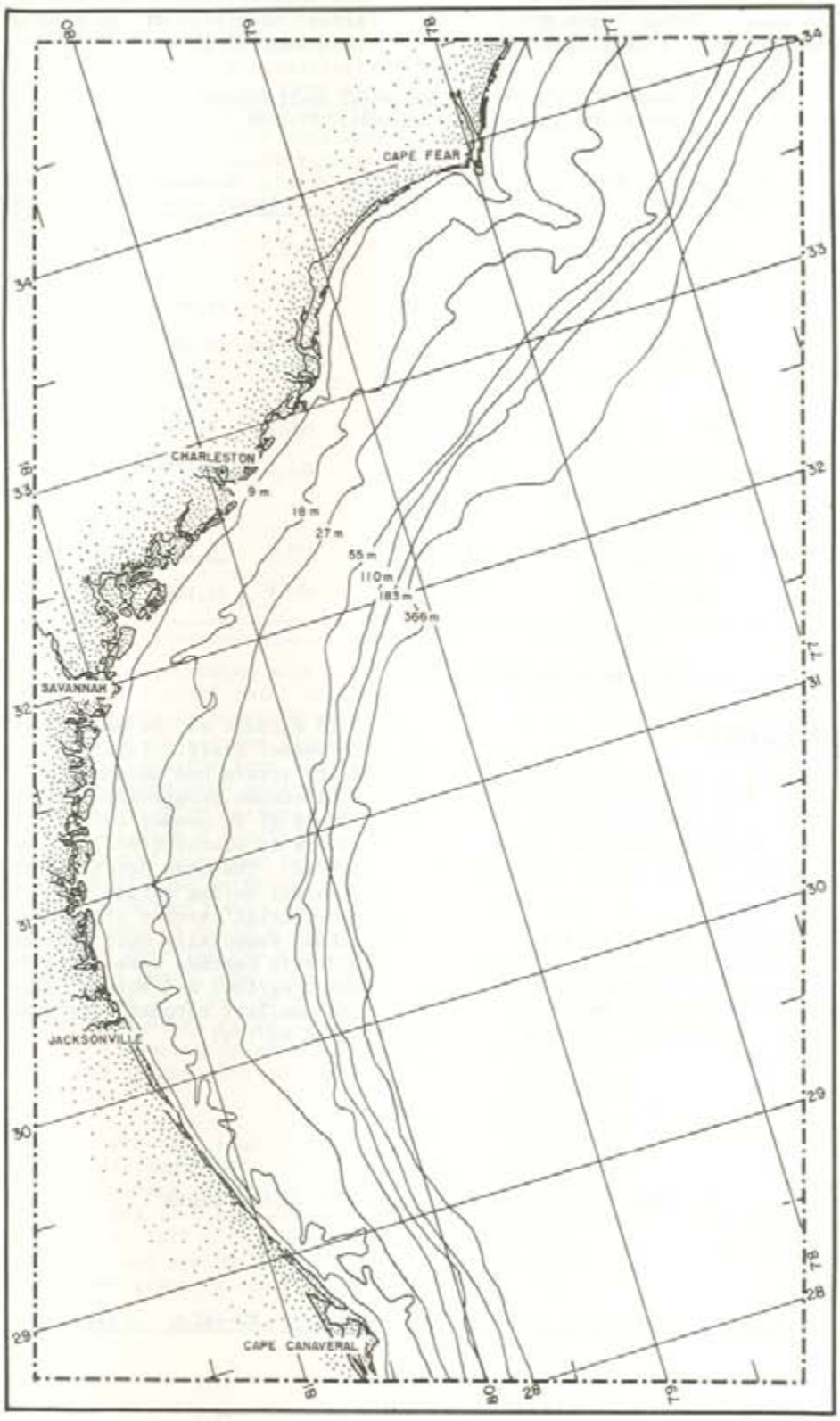

Figure 1. Depth strata over the continental shelf and upper continental slope of the South Atlantic Bight.

Catch information was grouped by depth strata for analysis. The depth strata closely correspond to the continental shelf physiography and groundfish habitats described by Struhsaker (1969a). "Open shelf" sand bottom makes up the largest single habitat in the area (Table 1). Live or hard bottoms, features described by Struhsaker (1969a) and Bearden and McKenzie (1971), are interspersed within smooth bottom areas. Knowledge of location and extent of this habitat is minimal.

Table 1. Bottom habitat of the continental shelf between Cape Fear, North Carolina and Cape Canaveral, Florida

Habitat Type	Struhsaker (1969a) Depth Strata (m)	Present Study Depth Strata (m)	Estimated Bottom Area (km^2)	Minimum Number of Tows/Cruise
Coastal[1]	0 - 18	0 - 9		0
		10 - 18	18,083	16
Open-shelf	18 - 55	19 - 27	16,100	16
		28 - 55	22,367	20
Live-bottom	18 - 55	19 - 55	6,524	0
Shelf-edge	55 - 110	56 - 110	4,775	14
Lower-shelf	110 - 183	111 - 183	3,615	10
		184 - 366	9,724	10
TOTALS	0 - 183	10 - 366	81,188	86

[1]Nearshore (0 - 10m). Sampling limited by ship's draft.

Combined Catch

Total catch for a single cruise during this study ranged from 2,543 kg (27 kg/tow) in summer 1974 to 7,684 kg (66 kg/tow) in spring 1974. The average catch per 30-minute trawl throughout the sample area was 45.7 kg.

Relative abundance of the total demersal fish resource over an annual cycle, as indicated by the total weight of fish caught per trawl, was greatest at depths between 10 and 27 m (Table 2). Depths < 10 m could not be adequately sampled due to vessel draft. Total catch per trawl by depth strata and season (Table 2) appeared to increase progressively from nearshore (10-18 m) in summer and fall to deeper waters in winter (19-27 m) and spring (56-110 m). The mean catch per trawl was greatest during spring (65.8 kg/tow), when substantial catches of rays and sharks were taken, especially near Cape Hatteras. Moderate catches were taken during winter (46.3 kg/tow) and autumn (37.0 kg/tow). The smallest catches were taken in summer (27.4 kg/tow).

Table 2. Mean fish catch (kg/tow) by habitat depths

Seasons	Habitat Depths 10-18 m	19-27 m	28-55 m	56-110 m	111-183 m	184-366 m	Seasonal Mean
Fall 1973	77.6	56.5	22.9	14.3	19.1	3.7	37.0
Spring 1974	79.6	70.4	65.8	117.6	25.3	3.2	65.8
Summer 1974	47.2	26.5	37.8	13.5	12.9	11.3	27.4
Winter 1975	40.9	97.8	58.4	20.8	23.5	2.3	46.3
Depth Mean	61.7	61.9	48.7	48.2	20.5	5.1	

Major Fish Groups

Total catch information from bottom trawls was separated into three major fish groups: elasmobranchs, pelagic teleosts and demersal teleosts. Although relatively low numbers of sharks, skates and rays were collected in the bottom trawl, such species greatly distorted the total catch data for groundfish because of the relatively large size of individual specimens. This group has frequently been regarded as a resource separate from bony fish species (MacMillan 1964) and is treated as such here. Sporadically, large catches of highly motile pelagic species also tend to confuse interpretation of total catch information. Pelagic fishes were considered a separate group because they are less vulnerable to the otter trawl than bottom dwelling species. Those fish which possess bone and are closely associated with the bottom as adults were considered demersal bony fish.

Table 3. Weights (kg) of catches of major fish groups by season

	Total No. Trawls	Demersal Teleosts	Elasmobranchs	Pelagic Teleosts	Total	Seasonal Mean
Fall 1973	87	1,921	756	542	3,219	37.0
Spring 1974	115	1,931	5,307	329	7,568	65.8
Summer 1974	88	950	963	494	2,407	27.4
Winter 1975	90	1,644	2,298	229	4,171	46.4
TOTALS	380	6,446	9,325	1,594	17,365	45.7

Rays and sharks contributed most in terms of biomass to the total catch during three seasons and to the four season total (Table 3). Catches of this group averaged 24.5 kg per trawl tow over the four seasons (Table 4). Elasmobranchs were most abundant in trawl catches during spring, when a catch of 1,288.6 kg from a single tow (24% of the total catch) occurred in 79 m of water just south of Cape Hatteras. Over the annual cycle, catch per tow values were greatest between depths of 10-18 m and 56-110 m (Table 4). Omitting the single large catch mentioned above, the catch per trawl tow dropped from 34.4 kg/tow to 12.9 kg/tow in the 56-110 m depth range, which probably indicates a general decrease in the catch of rays and sharks with increasing depth.

Total weight of demersal bony fish was less than that of cartilaginous species except in autumn. Average catch per tow throughout the year was 17.0 kg. Catches were fairly similar in fall (22.1 kg/tow), winter (18.3 kg/tow) and spring (16.8 kg/tow). In summer they averaged only 10.8 kg/tow. The decrease in catch per trawl during summer corresponds to a similar decrease for rays and sharks during the same season. Demersal bony fish were most abundant in the 19-27 m depth range, and catches decreased with depth.

Pelagic fish species contributed very little to the total catch, with an average annual catch per tow of 4.2 kg. Catches were greatest in summer (5.6 kg/tow) and fall (6.2 kg/tow) and least in winter (2.5 kg/tow) and spring (2.9 kg/tow). Unlike the cartilaginous fishes and groundfish, pelagic species were most abundant in deep waters (111-183 m), where their weight exceeded that of the groundfish. In waters of 184-366 m, the catch of pelagic species exceeded that of both the cartilaginous and demersal bony fish combined. The predominance of pelagic species at deep water stations may be partly due to the longer period that trawls are in midwater during setting and retrieval and to an affinity for many species of pelagic fish for Gulf Stream water.

Table 4. Annual mean catch (kg/tow) by major fish group and habitat depth

	Habitat Depth in Meters						
Group	10-18 m	19-27 m	28-55 m	56-110 m	111-183 m	184-366 m	Group Mean
Demersal Teleosts	21.3	30.3	19.8	11.0	4.6	1.9	17.0
Elasmobranchs	35.2	26.7	26.5	34.4	8.3	0.1	24.5
Pelagic Teleosts	5.2	4.9	2.4	2.9	7.7	3.1	4.2

Diversity

This survey indicates that diversity in the habitats sampled is high in this area (324 identified species). This is similar to the 307 species reported by Struhsaker (1969a). Total species count is lower than the 355 species previously reported from waters of South Carolina (Bearden 1969), 326 from Georgia (Dahlberg 1975), and 618 from Florida (Briggs 1958). These studies included nearshore species and those caught with a variety of gear types. The diversity of the assemblage observed during this survey is related to the overlap of warm temperate and tropical faunas, together with the interspersion of small areas of high diversity live-bottom communities (described by Struhsaker, 1969a, as areas of broken relief with a rich sessile invertebrate fauna). The large number of species found in the 10-55 m depth range strongly reflects the number of species common to the live bottom habitat within that depth zone (Table 5).

A seasonal shift in maximum numbers of species from the 10-27 m habitat depth in autumn to the 28-110 m depth in spring was apparent (Table 6), even though a smaller number of tows was made in deep areas. The number of species collected decreased with increasing water depth in summer and fall and was highest at intermediate depths in winter and spring.

Although an index of diversity relating to community interrelationships, stability and productivity might be helpful for future fisheries management, standard indices of diversity have not been caluclated because of the growing dissatisfaction with their responsiveness to sample size (Peet 1975). In this report, the total number of species is used to document presently existing community conditions.

Table 5. Groundfish species commonly associated with sand and live bottom habitat areas of the continental shelf of the southeastern United States

Sand Bottom	Live Bottom
Diplectrum formosum	*Calamus leucosteus*
Aluterus schoepfi	*Pagrus sedecim*
Synodus foetens	*Lagodon rhomboides*
Monacanthus hispidus	*Rhomboplites aurorubens*
	*Lutjanus campechanus**
	Haemulon aurolineatum
	Haemulon plumieri
	Holocanthus bermudensis
	Chaetodon sp.
	Centropristis striata
	*Epinephelus drummondhayi**
	*Epinephelus niveatus**
	*Mycteroperca microlepis**
	*Mycteroperca phenax**
	Chromis enchrysurus
	Holocentrus bullisi

*Snappers and groupers were poorly represented in catches of the 3/4 Yankee trawl.

Table 6. Total number of fish species collected at each depth during four seasons

	Habitat Depth in Meters					
Season	10-18 m	19-27 m	28-55 m	56-110 m	111-183 m	184-366 m
Fall 1973	102	106	79	74	58	23
Spring 1974	77	91	102	122	74	42
Summer 1974	102	79	85	88	43	24
Winter 1975	74	95	88	93	55	32

Major Fish Species

"Importance" or "value" of a particular fish population or community may be expressed either ecologically, economically, or both. Ecological importance implies significance in community interactions and is seldom related to the potential for usefulness to man in terms of available protein or economic value. The species contributing the greatest weights to trawl catches were considered of ecological significance (Table 7). Species of commercial value are often either pelagic or abundant only over a small proportion of the total shelf habitat; neither situation was adequately sampled in this study. These species are of course important, but comments must be given with reservations because of the dearth of information. We have chosen one or more species from each of the major fish groups (cartilaginous, pelagic bony and demersal bony) and from each "importance" category for this preliminary assessment.

Table 7. Twenty species ranked by weight of total catch over four seasons

Species	WT. (kg)
Dasyatis centroura	6,666.3
Stenotomus sp.	2,285.3
Myliobatis freminvillei	870.8
Aluterus schoepfi	738.8
Decapterus punctatus	528.8
Mustelus canis	325.5
Haemulon aurolineatum	307.7
Peprilus triacanthus	285.8
Ginglymostoma cirratum	283.5
Dasyatis americana	276.8
Sardinella anchovia	260.8
Etrumeus teres	256.2
Dasyatis sayi	252.5
Monacanthus hispidus	239.9
Synodus foetens	225.6
Rachycentron canadum	186.8
Diplectrum formosum	183.6
Odontaspis taurus	163.3
Urophycis regius	148.3
Calamus leucosteus	143.6
	14,629.9

The roughtail stingray, Dasyatis centroura, and southern porgy, Stenotomus sp.[1], together represented 51.6% of the total catch by weight. These two species commonly contributed the greatest weight in several habitat depths (Table 8). D. centroura represented 71.5% of the total catch of rays and sharks and Stenotomus sp. made up 35.4% of the total catch of demersal bony fish by weight.

Although not frequently caught in large numbers, pelagic species were major contributors to the biomass of several depth strata during some seasons. The round scad, Decapterus punctatus; butterfish, Peprilus triacanthus; Spanish sardine, Sardinella anchovia; and round herring, Etrumeus teres accounted for 83.5% by weight of the total pelagic species caught (Table 8).

Species of the shallow-water sand bottom community which occurred very frequently in catches included orange filefish, Aluterus schoepfi; inshore lizardfish, Synodus foetens; sand perch, Diplectrum formosum; and planehead filefish, Monacanthus hispidus. Of these, only Aluterus and Diplectrum are of possible commercial or recreational interest.

Species which prefer hard or live bottoms were caught in relatively small numbers during the present study, because these habitats make up only a small portion

[1] Stenotomus sp. (possibly S. aculeatus) is in the process of taxonomic revision; it appears most similar to S. chrysops, and least similar to S. caprinus (to which it has been referred repeatedly in the literature).

Table 8. Fish species which dominated (weight) trawl catches

Season	Habitat Depth Range 10-18m	19-27m	28-55m
Fall	Stenotomus sp. Dasyatis centroura	Stenotomus sp. Dasyatis centroura	Stenotomus sp. Dasyatis centroura
Summer	Dasyatis centroura Stenotomus sp.1	Sardinella anchovia Aluterus schoepfi	Dasyatis centroura Decapterus punctatus[1]
Spring	Dasyatis centroura Myliobatis freminvillei	Dasyatis centroura Stenotomus sp.	Dasyatis centroura Stenotomus sp.
Winter	Dasyatis sayi Mustelus canis	Dasyatis centroura Stenotomus sp.	Dasyatis centroura Stenotomus sp.
	56-110m	111-183m	184-366m
Fall	Decapterus punctatus Syacium papillosum	Etrumeus teres Urophycis regius	Urophycis regius Raja garmani
Summer	Mycteroperca interstitialis Calamus nodosus	Dasyatis centroura Urophycis regius	Peprilus triacanthus Helicolenus dactylopterus
Spring	Dasyatis centroura Dasyatis americana	Dasyatis centroura Peprilus triacanthus	Urophycis regius Etrumeus teres
Winter	Dasyatis centroura Pagrus sedecim	Peprilus triacanthus Etrumeus teres	Helicolenus dactylopterus Urophycis regius

[1]Single large specimen of Ginglymostoma cirratum omitted.

of the area surveyed and were not sampled very often. These species include, however, those of highest economic value. Black sea bass, Centropristis striata, and vermilion snapper, Rhomboplites aurorubens, were the two most commonly encountered species of economic importance, but together they accounted for only 1.3% of the total fish catch by weight. Both rank high in the groundfish harvested by commercial and recreational fisheries of the southeastern seaboard states. The 1972 commercial catch approximated 616,442 kg (1,359,000 lbs.) of black sea bass and 37,649 kg (83,000 lbs.) of vermilion snappers respectively in this region (NOAA 1975).

The roughtail stingray, Dasyatis centroura, contributed the greatest biomass to total catches during all seasons but fall, although the catches were sporadic. D. centroura was most abundant (35.2 kg/tow) in spring and least abundant (7.3 kg/tow) in fall; they were found in depths ranging from 10 to 183 m in spring and summer but only between 10 and 55 m in fall (Fig. 2). Largest numbers usually occurred in waters less than 55 m, except in spring when most were caught between 55 and 110 m.

According to Struhsaker (1969b), D. centroura winters off the coast of Florida and then moves north in spring. Ony small numbers remain south of Cape Hatteras during summer; during autumn southward migration from New England coastal waters occur. The optimum temperature range for D. centroura appears to be 15-22°C.

The southern porgy, Stenotomus sp., was the most abundant groundfish caught between Cape Fear and Cape Canaveral, ranking second in biomass. Catches of southern porgy ranged from 9.8 kg/tow in fall to 1.9 kg/tow in summer, with average catch over the four seasons 6.0 kg/tow. Stenotomus sp. was collected in most depth strata (10-183 m) but was most abundant between 10 and 55 m (Fig. 3). This species was more abundant in depths of 10-27 m during spring, summer and fall and in 19-55 m during winter. Other information on distribution of this species is of doubtful value until taxonomic problems are settled.

Large catches of sparids other than Stenotomus sp. were associated with live bottom habitats, and contributed significantly to the total catch. Species abundant in catches included whitebone porgy, Calamus leucosteus; knobbed porgy, C. nodosus; red porgy, Pagrus sedecim; pinfish, Lagodon rhomboides; and sheepshead, Archosargus probatocephalus.

The orange filefish, Aluterus schoepfi, was frequently encountered over sand bottom habitats between 10 and 55 m. It was most abundant in spring (2.3 kg/tow) and least abundant in fall (1.54 kg/tow) and appeared to move only slightly within the 10-55 m depth strata. During winter the greatest number of orange filefish were caught between 28 and 55 m while during spring and summer most fish were taken at intermediate depths of 19-27 m (Fig. 4).

The round scad, Decapterus punctatus,

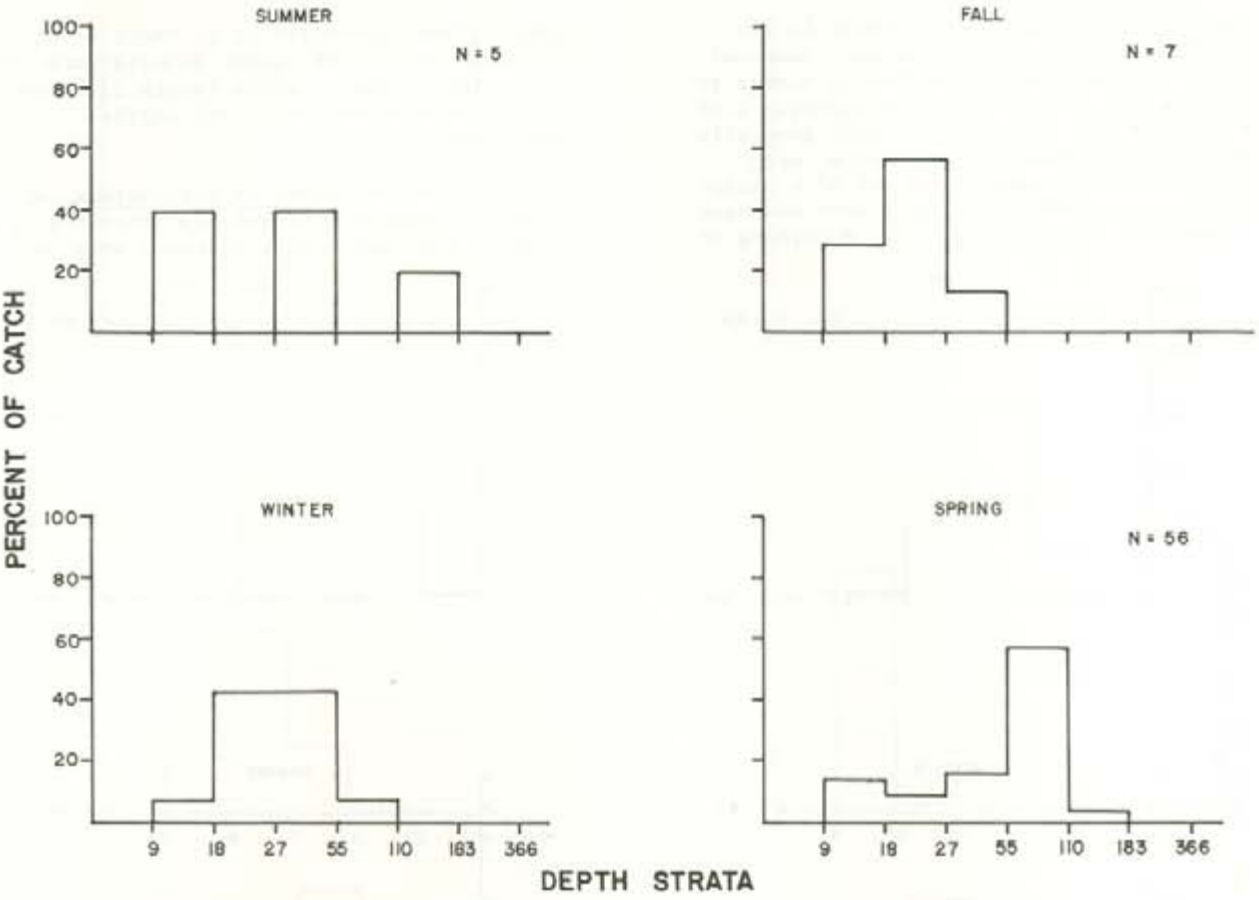

Figure 2. Seasonal depth distribution of the roughtail stingray (Dasyatis centroura).

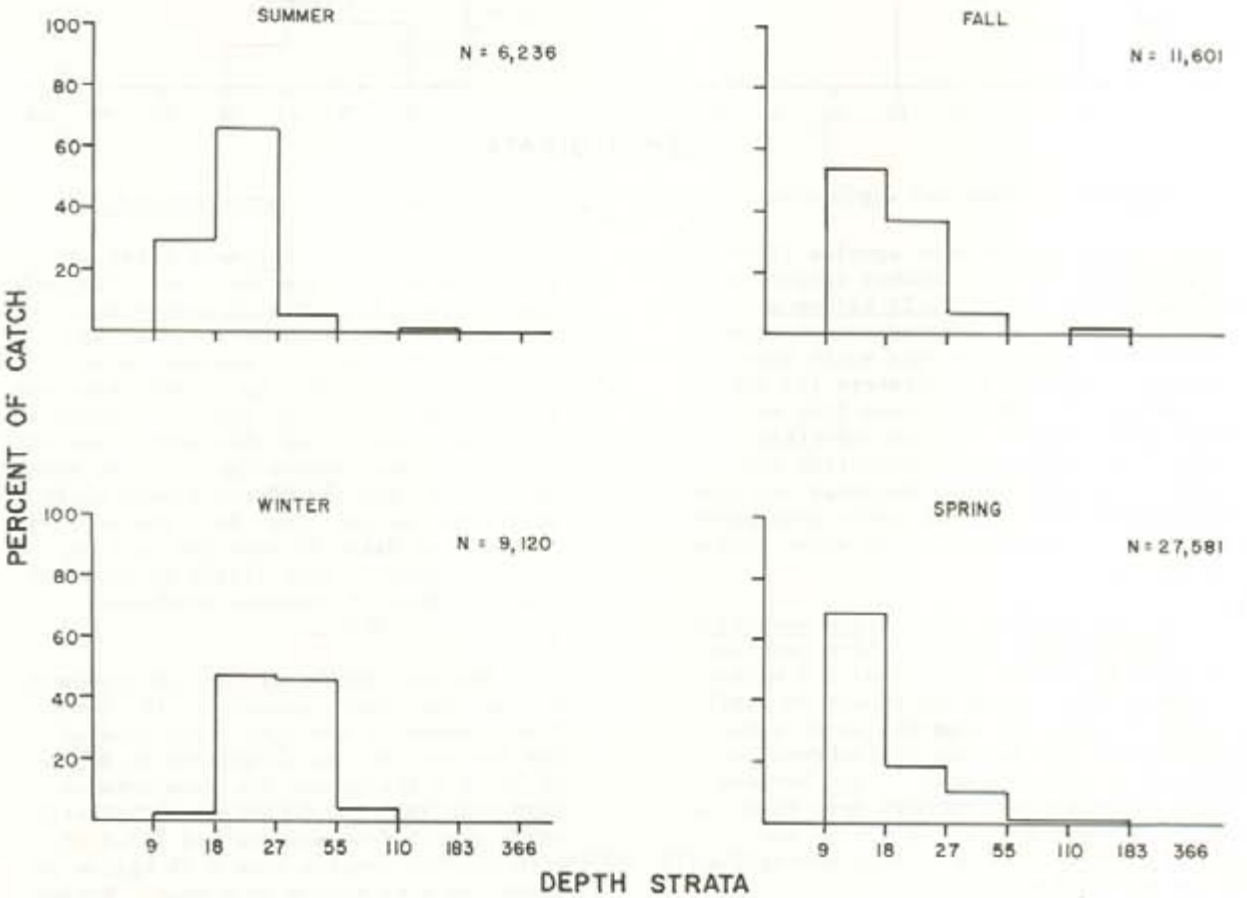

Figure 3. Seasonal depth distribution of the southern porgy (Stenotomus sp.).

contributed the greatest biomass to the total catch of pelagic species. Seasonal catch ranged from 0.85 kg/tow in summer to 2.74 kg/tow during fall; and averaged 1.39 kg/tow for all seasons. They were generally distributed between 10 and 110 m, with largest catches between 18 and 55 m except during spring when they were most abundant between 10 and 18 m (Fig. 5). According to Berry (1968) juveniles up to about 80 mm standard length are caught to a distance of 270 miles offshore, while larger fish are caught at the surface or mid depths nearshore.

Butterfish, Peprilus triacanthus, may be either demersal or pelagic according to time of day, but in this instance were considered among the pelagic species (Bigelow and Schroeder 1953). Catches ranged from 0.11 kg/tow in fall to 1.22 kg/tow during summer. During all seasons except summer, butterfish distribution was split into nearshore (0-18 m) and offshore (55-366 m) components. In summer, these fish were caught only between 184 and 366 m (Fig. 6). Horn (1970) stated that butterfish are widespread north of Cape Hatteras, and that size classes move independently during warm months and concentrate in deep water during cold months.

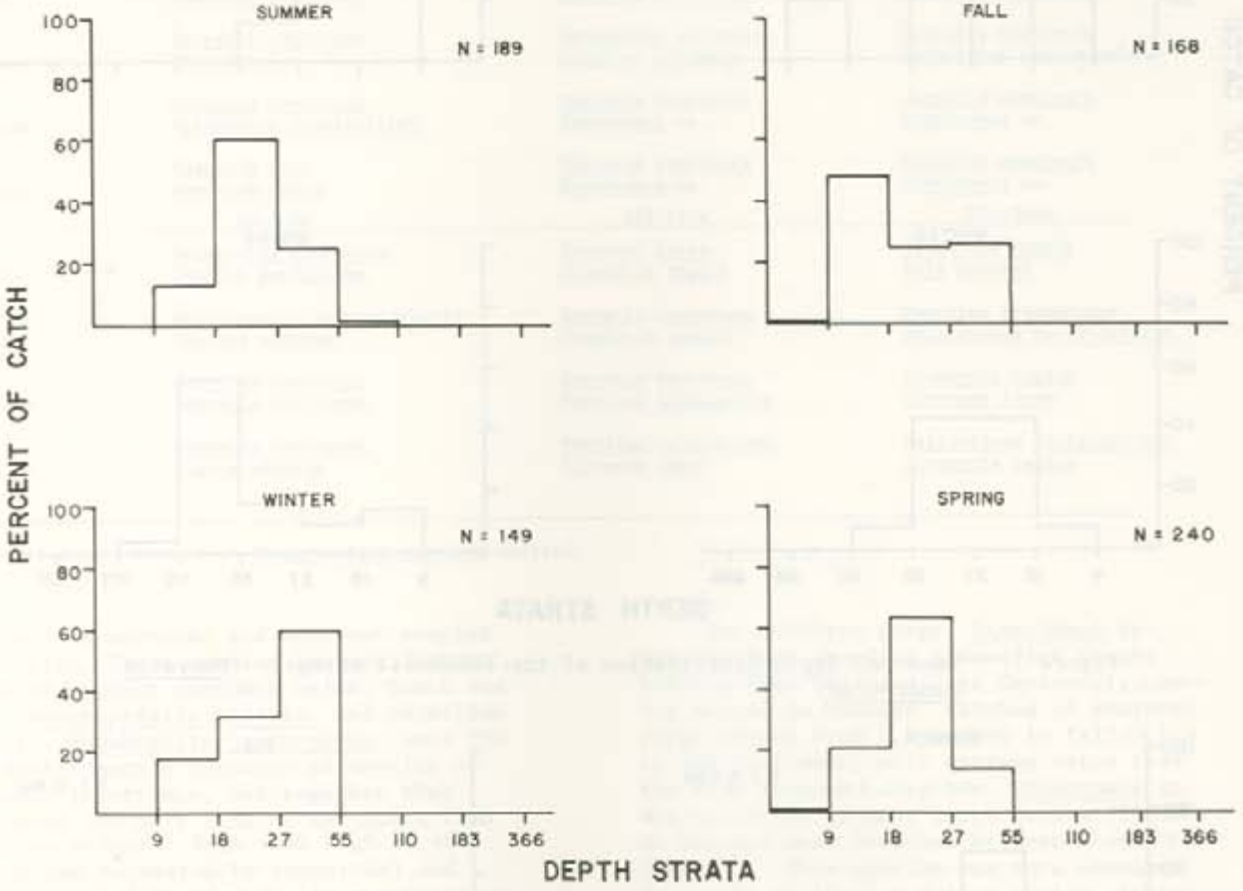

Figure 4. Seasonal depth distribution of the orange filefish (Aluterus schoepfi).

Spanish sardine, Sardinella anchovia, is a small pelagic species which contributed 0.03 kg/tow in winter and 1.6 kg/tow in summer. Their seasonal change in availability is expected from the known warm affinities of the species (Hildebrand 1963). Although S. anchovia were caught between 10 and 55 m, largest numbers were taken in the 10-18 m stratum during winter and spring and the 19-27 m stratum during summer and fall (Fig. 7).

Round herring, Etrumeus teres, a pelagic schooling species, ranged in abundance from 0.01 kg/tow in summer to 1.2 kg/tow in fall. A total of 256.2 kg was caught during the four seasons, with a single catch of 106.7 kg in fall biasing seasonal analysis. E. teres was found at depths between 10 and 366 m with a seasonal shift from deep waters (56-183 m) in summer and fall to shallow waters (10-27 m) in winter and spring (Fig. 8). The species ranges from Maine through the Gulf of Mexico, although very little is known of its abundance or seasonal movements (Hildebrand 1963).

The sand perch, Diplectrum formosum, did not contribute greatly to the total fish biomass of the shelf area studied, but the species was ubiquitous in depths of 10-55 m throughout the area between Cape Fear and Cape Canaveral. The total catch during four seasons was 183.6 kg, with catches ranging from 0.29 kg/tow in winter to 0.69 kg/tow in summer. During all seasons sand perch were common between

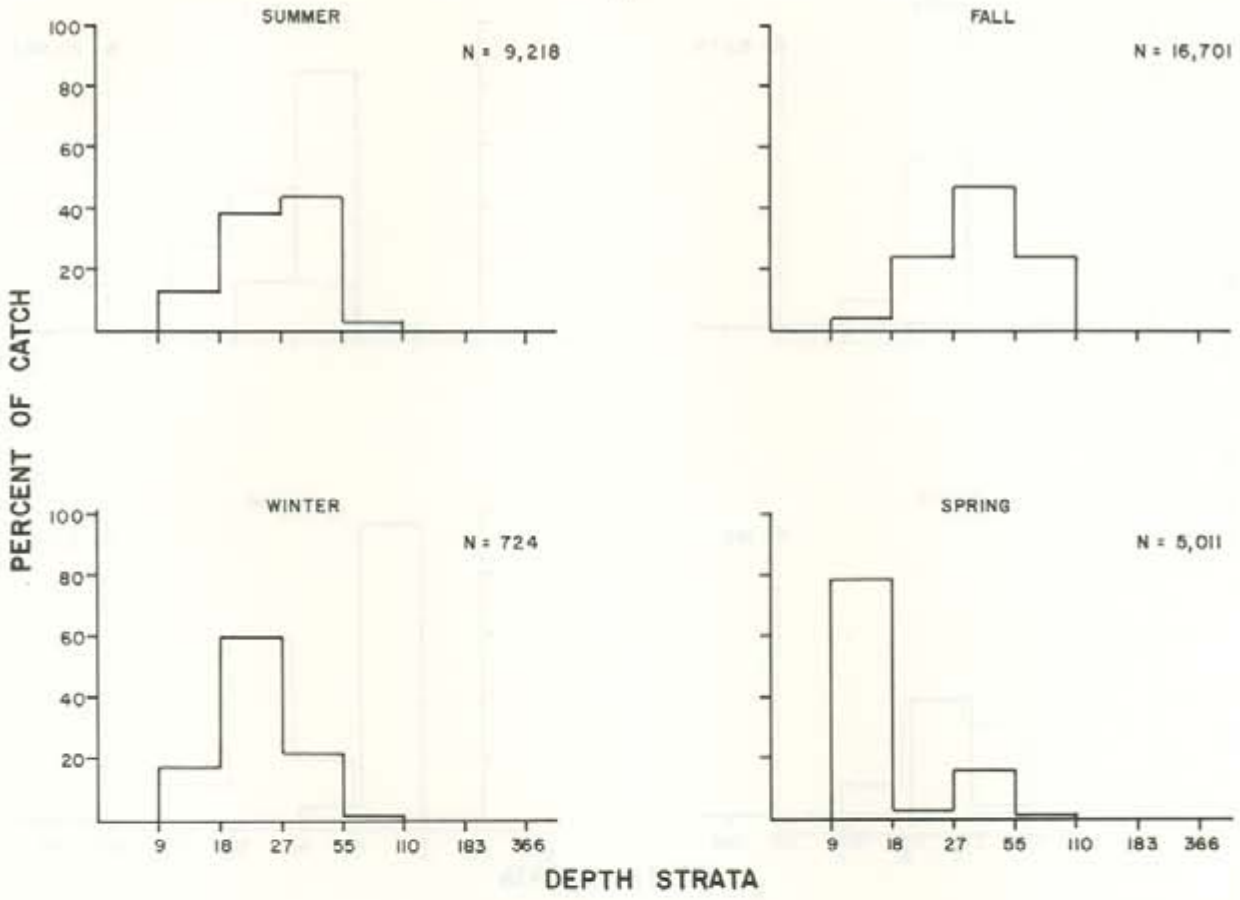

Figure 5. Seasonal depth distribution of the round scad (Decapterus punctatus).

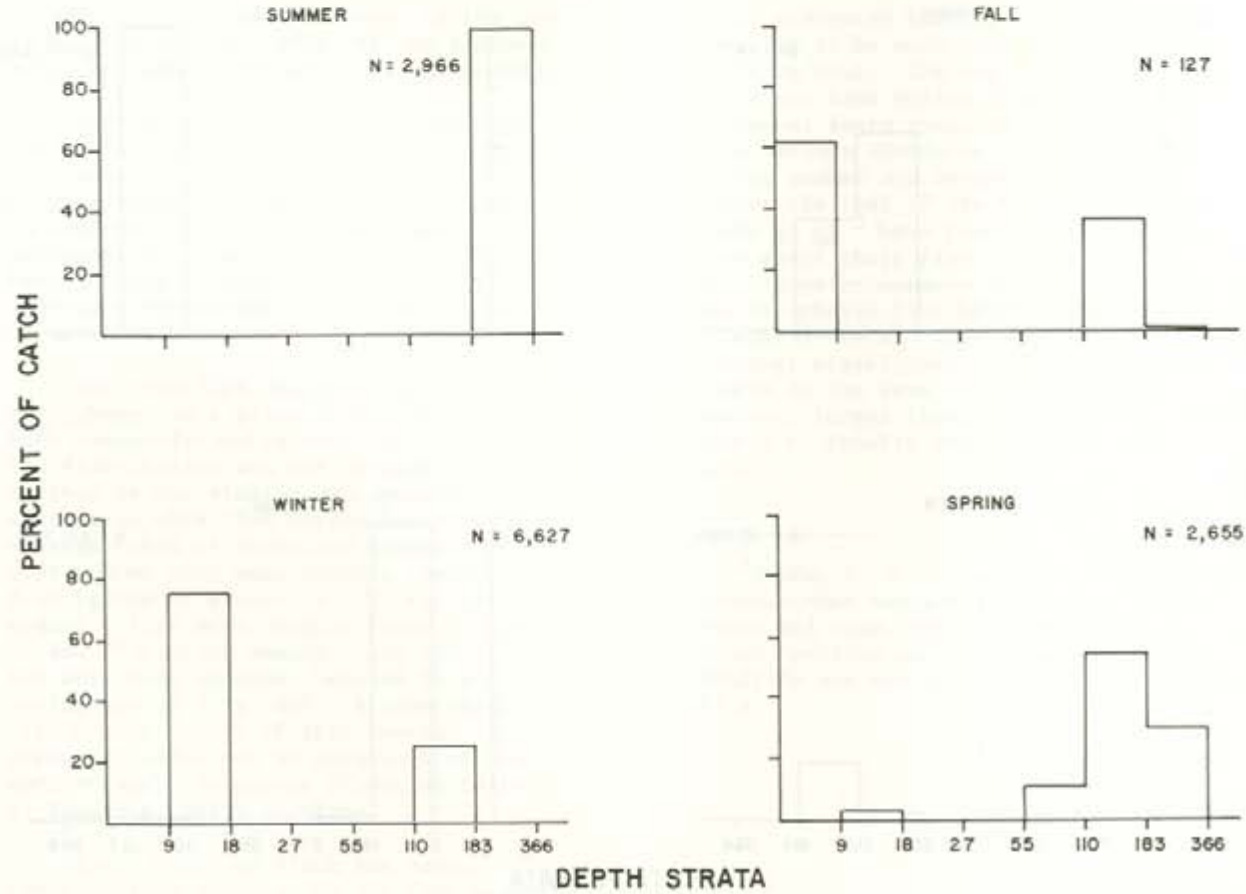

Figure 6. Seasonal depth distribution of the butterfish (Peprilus triacanthus).

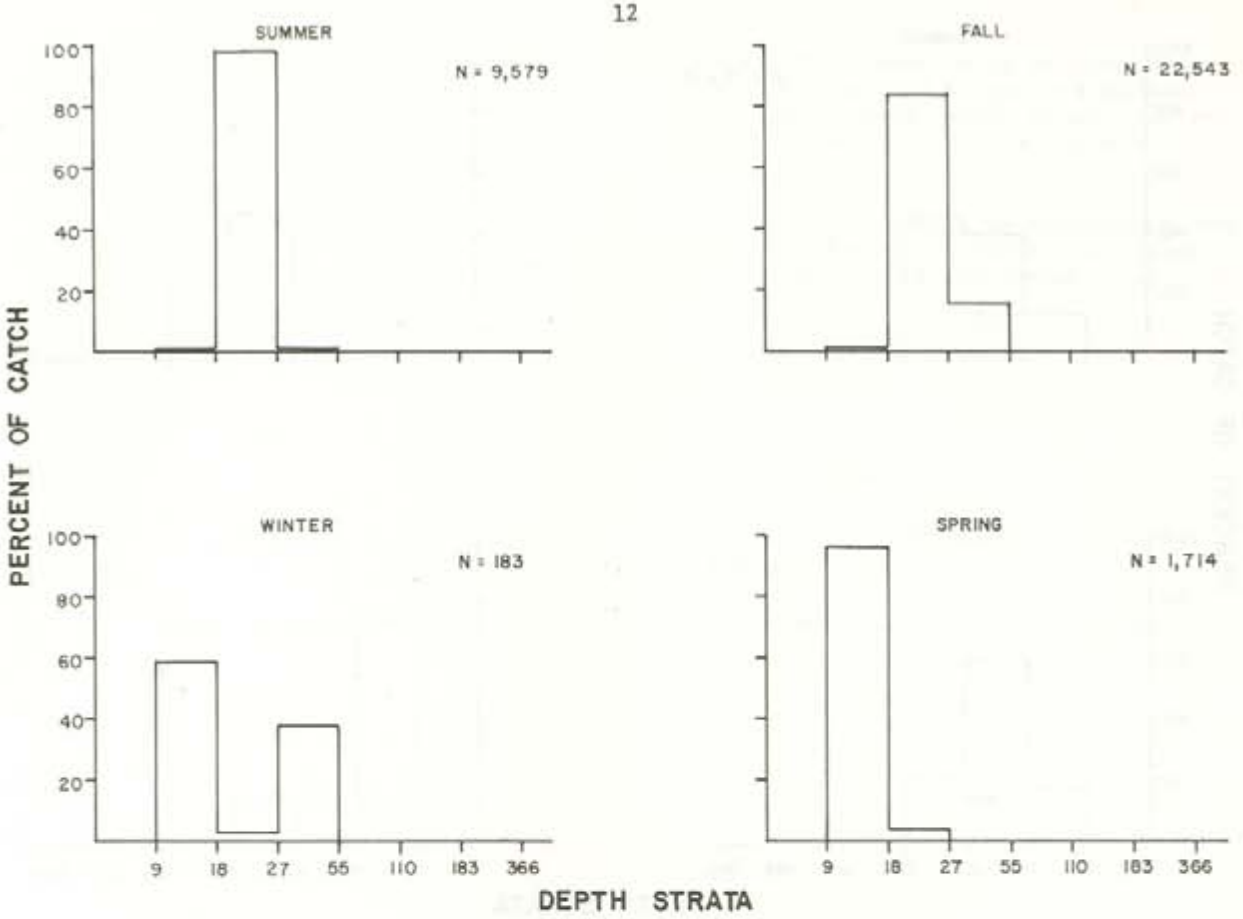

Figure 7. Seasonal depth distribution of the spanish sardine (Sardinella anchovia).

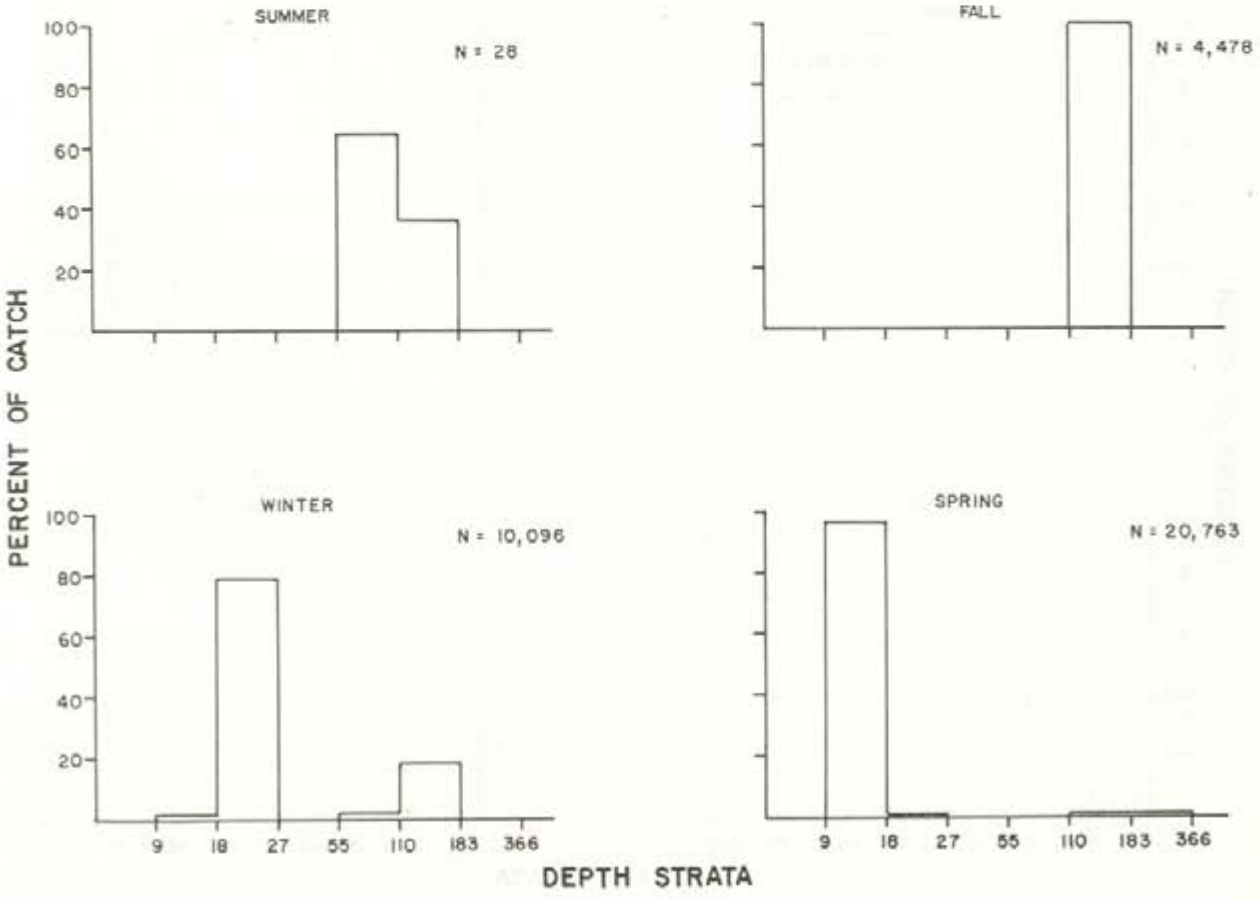

Figure 8. Seasonal depth distribution of the round herring (Etrumeus teres).

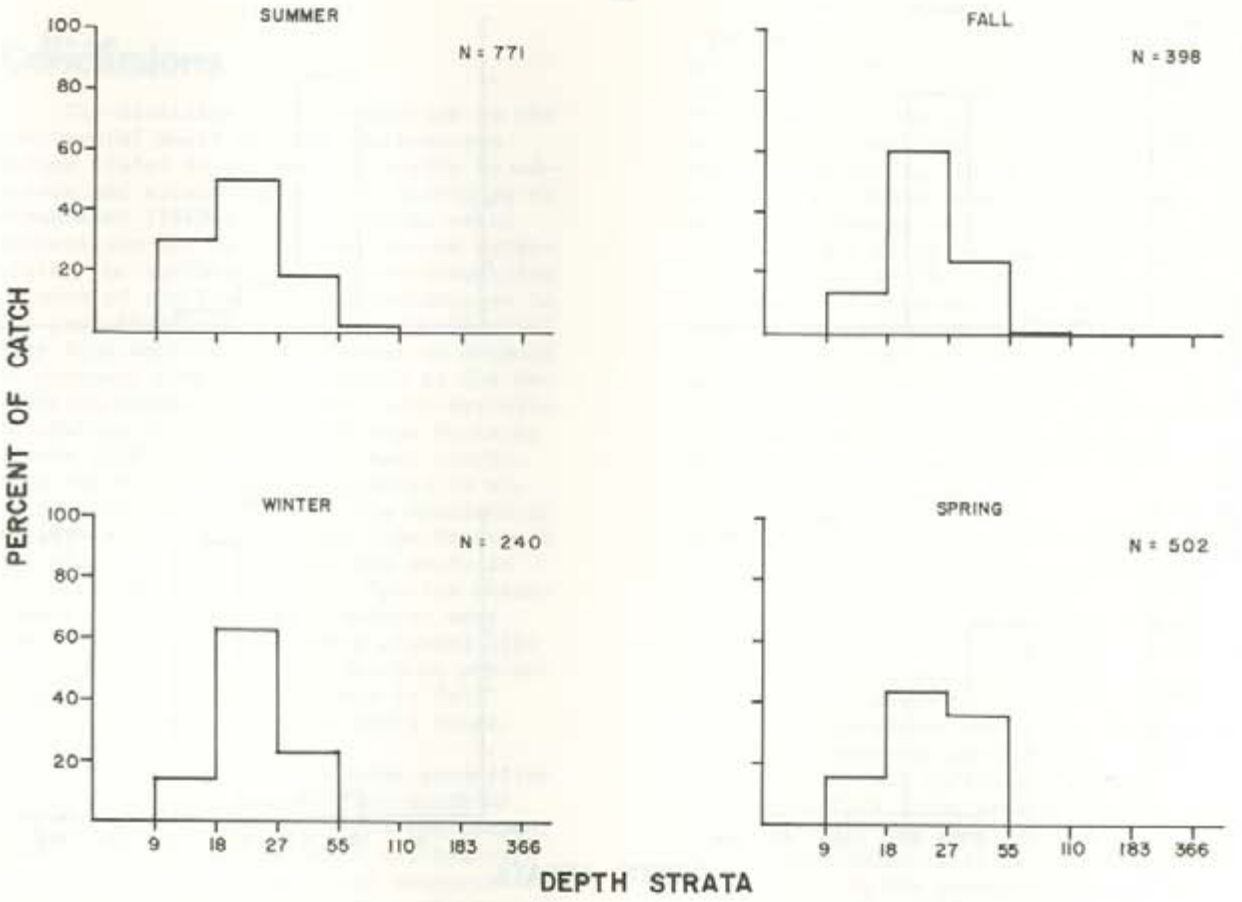

Figure 9. Seasonal depth distribution of the sand perch (Diplectrum formosum).

10-55 m and were most abundant in the 19-27 m depth interval (Fig. 9). No seasonal shift in depth distribution was discernable.

Bortone (1971) indicated that sand perch are found over sand bottoms, especially near bottom formations or obstructions. He also found that they are very territorial in behavior and defend home areas against intrusion by conspecific fish. Territorial behavior may account for their relatively uniform distribution throughout and area of suitable habitat.

The vermilion snapper, Rhomboplites aurorubens, is a prime food fish sought by both commercial and recreational fishermen. Its distribution was not adequately described by our studies, but appears closely associated with live bottom habitat. The average catch of vermilion snappers was 0.34 kg/tow, with mean catches ranging from 0.10 kg/tow in winter to 0.55 kg/tow in summer. Fish were usually found between 19 and 55 m during summer, fall and winter, but were most abundant between 56 and 110 m during spring (Fig. 10). A comprehensive life history study of this species is presently under way by personnel of the NMFS Atlantic Estuarine Fisheries Center at Beaufort, North Carolina.

Total catch of black sea bass, Centropristis striata, for all four seasons was 89.5 kg. This reflects the small proportion of tows made over live bottom, their preferred habitat. C. striata appeared to be most abundant during fall (0.59 kg/tow). The depth distribution of black sea bass during this study indicates an annual depth range of about 10-55 m, with maximum abundance between 10 and 18 m during summer and between 19 and 27 m during the rest of the year (Fig. 11). Cupka et al.[2] have found that many juveniles spend their first summer and fall in shallow water nursery areas, while most adults inhabit live bottom areas offshore between 20-60 m. They exhibit no apparent seasonal migrations. Although most fish remain in the same location for long periods, larger fish, predominantly males, appear to inhabit progressively deeper water.

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[2]Cupka, D. M., R. K. Dias, and J. Tucker (unpublished manuscript) Biology of the black sea bass, Centropristis striata, from South Carolina waters. South Carolina Wildlife and Marine Resources Department. 93 p.

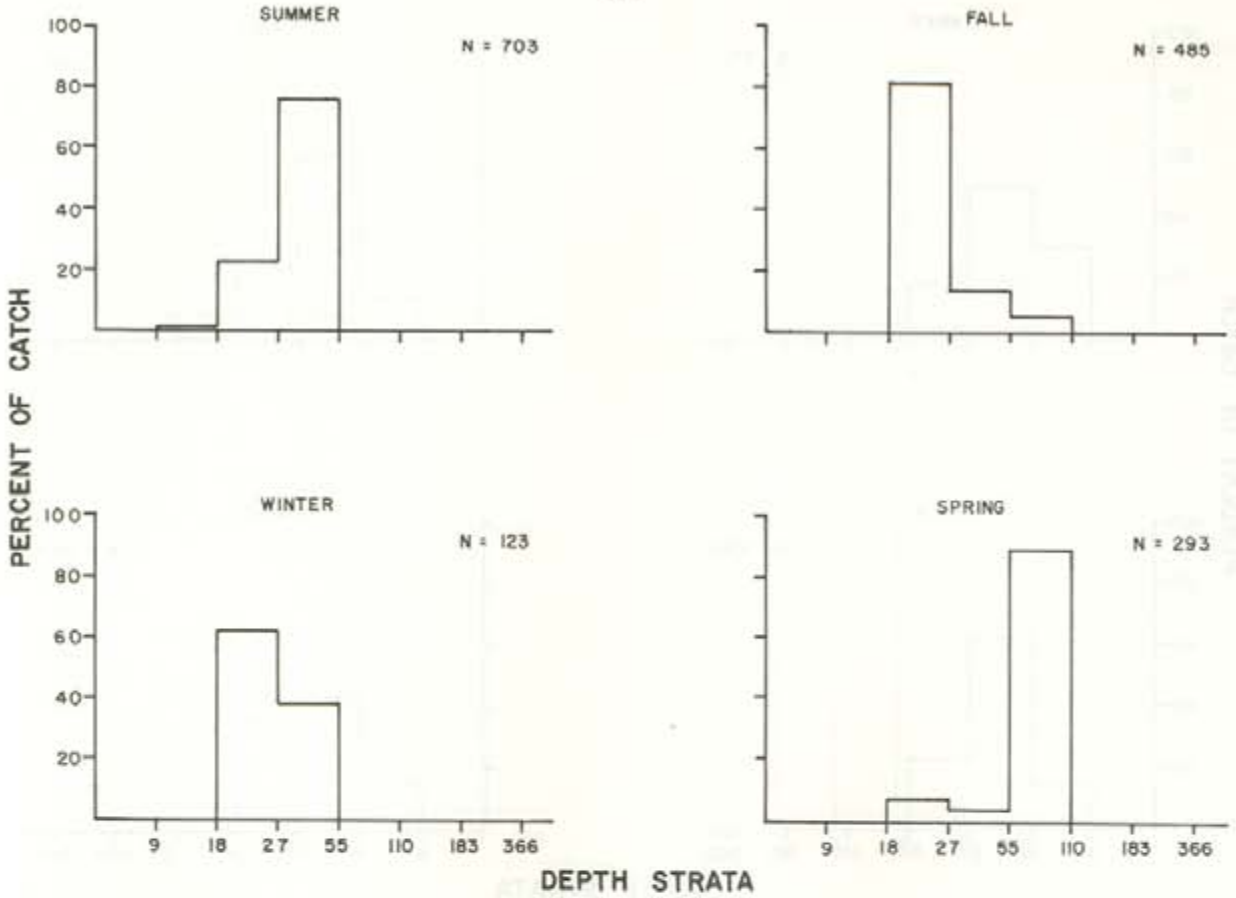

Figure 10. Seasonal depth distribution of the vermilion snapper (Rhomboplites aurorubens).

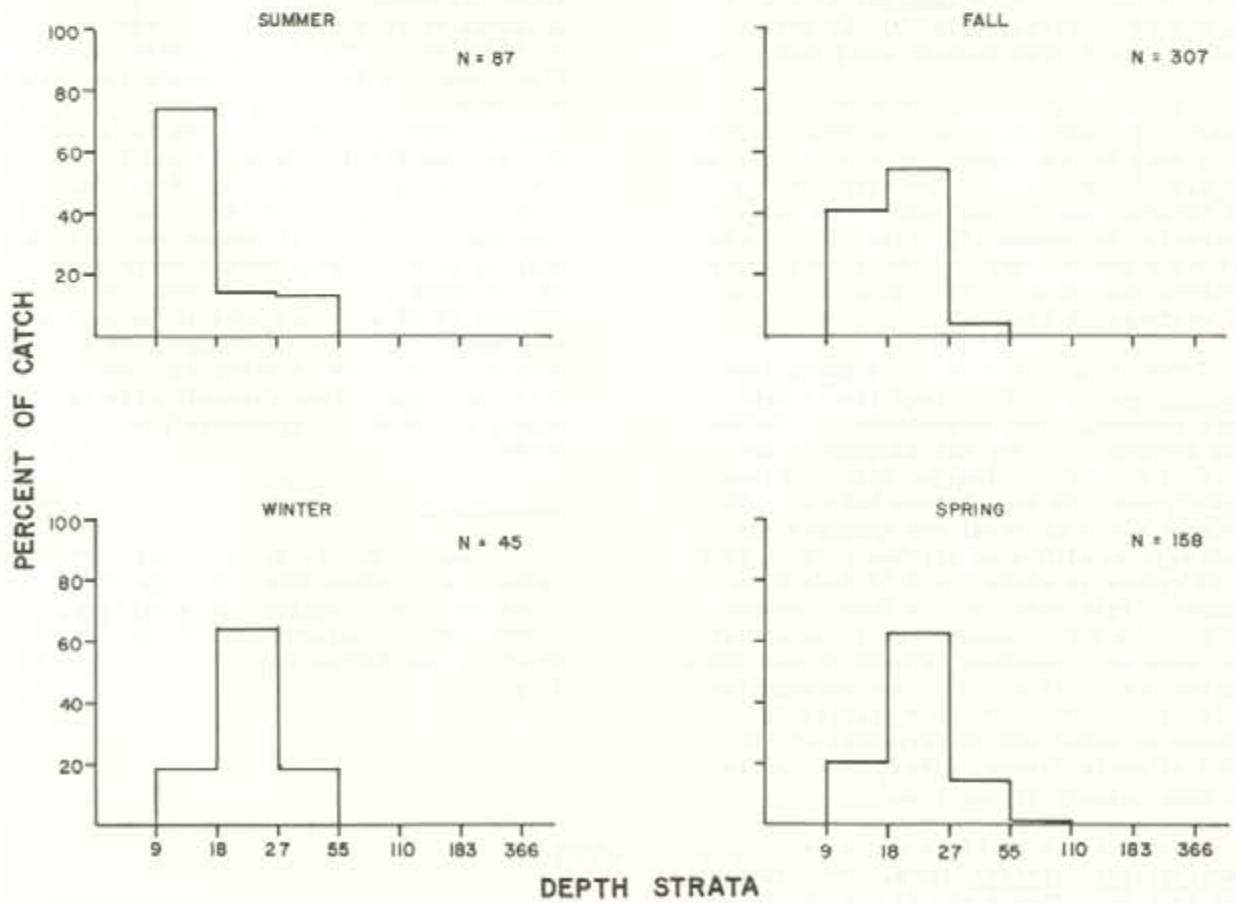

Figure 11. Seasonal depth distribution of the black sea bass (Centropristis striata).

Conclusions

The distribution of groundfish on the continental shelf off the southeastern United States is influenced chiefly by substrate and water temperatures according to Struhsaker (1969a). As expected, water temperature may be a primary factor determining the northern and southern boundaries of most of the fish species assemblages in the area (Briggs 1974). However, demersal bony fish species did not appear to respond to seasonal temperature changes by the onshore and offshore movements characteristic of similar species north of Cape Hatteras (Davis 1970). In contrast, many sharks, rays and pelagic species appeared to migrate north and south along the continental shelf between Cape Fear and Cape Canaveral and often displayed a seasonal shift in abundance on and offshore. Species assemblages of the live bottom habitat were limited to the discontinuous clumped distribution of that habitat which at present is poorly defined but appears to fall chiefly within the 10-55 m depth range.

A rough comparison between groundfish caught during a previous study north of Cape Hatteras (Davis 1970) and the present study south of Cape Hatteras may indicate differences between the total resources of the two continental shelf areas. Data were not directly comparable because of differences in vessels, trawling gear and sampling depth limits. In general, the average catch over the sample area was about 10 times greater north of Cape Hatteras (Table 9). Consideration of differences in trawl size and fishing efficiency might reduce this to five times. Greatest total groundfish abundance (catch per trawl) was during spring in collections south of Cape Hatteras and during winter in sampling north of Hatteras. These seasons correspond to a seasonal presence of two migratory species, the roughtail stingray in the south and the spiny dogfish in the north. These species in seasons of abundance make up 53.8% and 47.4% of the total catch respectively. Both studies indicate that the lowest average catches were during summer. This may be related to widespread distribution of groundfish across the shelf during periods of maximum bottom water temperature.

Continued sampling with present methods will permit refinement of estimates of relative abundance of groundfish over the broad area. However, sampling with techniques designed for specific target species over a particular type of substrate is necessary to delineate groundfish populations with enough precision to be useful in making management decisions. This study and others (Bearden and McKenzie 1971; Struhsaker 1969a) indicate that the live bottom habitats lying between depths of 18 and 55 m offer the greatest probability of supporting commercially exploitable groundfish stocks on the continental shelf of the southeastern United States.

Table 9. Average catch (kg) per 30 minute trawl tow over areas of the continental shelf between Cape May, New Jersey and Cape Hatteras, North Carolina and between Cape Hatteras, North Carolina and Cape Canaveral, Florida

	North of Cape Hatteras		South of Cape Hatteras	
	Total Catch	Catch Minus Spiny Dogfish	Total Catch	Catch Minus Roughtail Stingray
Summer	86.2	86.2	27.4	19.8
Fall	430.9	226.8	37.0	29.6
Winter	589.7	331.1	46.3	32.0
Spring	107.7	107.7	65.8	30.4

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