DEVELOPMENT POTENTIAL OF UNDERUTILIZED TRAWL FISH IN THE SOUTH ATLANTIC BIGHT

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Underutilized fish resources available to demersal trawling in the South Atlantic Bight include (1) demersal finfishes, (2) pelagic species, and (3) demersal elasmobranchs. Brief descriptions of species and size composition, relative availability, geographic range, and depth distribution are provided for each component.

The demersal finfish complex inshore of the shelf break is dominated by a few species characterized by small individual size, limited availability, and wide dispersal. These fishes include the southern porgy (Stenotomus aculeatus), orange filefish (Aluterus schoepfi), planehead filefish (Stephanolepis hispidus), sand perch (Diplectrum formosum), and lizardfishes (Synodus spp.). Trawlable pelagic species, which include the round scad (Decapterus punctatus), Spanish sardine (Sardinella aurita), and butterfish (Peprilus triacanthus), appear to occur in small, widely dispersed schools inshore of the shelf break. The bulk of the biomass taken in research surveys in coastal waters consisted of elasmobranchs, primarily large stingrays (Dasyatis spp.). The total amount of available fish decreased with increasing depth. The extent of resources deeper than 200 m is not well-documented, although some survey results suggest the presence of substantial quantities of butterfish and round herring (Etrumeus teres).

Preface

This study was initiated with support from the Gulf and South Atlantic Fisheries Development Foundation under contract GASAFDFI No. 11-09-27613. Preliminary results and our interpretation of them as they relate to the development potential of the resources are contained in a contract report filed in October, 1980. Some additional information has become available since then. This report consists of an updated review of available factual information regarding aspects of the life history, distribution, and catchability of the resources that affect their development potential. Transformation of such information into an assessment of practical possibilities for commercial utilization is an intuitive, subjective, and somewhat speculative process beyond the scope of this report. Our views in that regard are expressed in the contract report.

Acknowledgements

We are grateful to Dr. Roger Anderson and the Gulf and South Atlantic Fisheries Development Foundation for their initial support. We also thank the personnel of the Marine Resources Monitoring and Assessment Program (MARMAP) of the Marine Resources Research Institute for their assistance in providing access to unpublished data.

Introduction

The National Marine Fisheries Service, in the 1977 draft Fisheries Development in the United States, indicated that the potential annual production of trawl groundfish in the southeast might reach 1.5 million metric tons (mt). Such a resource could provide alternative opportunities for vessels presently equipped for foodfish trawling and shrimpers seeking additional income during the off season. To investigate the potential of this resource, the Gulf and South Atlantic Fisheries Development Foundation contracted the Marine Resources Center of the South Carolina Wildlife and Marine Resources Department. Objectives were to (1) describe underutilized demersal fish resources of the South Atlantic Bight; (2) evaluate their development potential relative to (a) abundance, (b) availability, (c) allowable level of exploitation, and (d) suitability for harvesting; and (3) assess relationships with co-occurring stocks and with the habitats that affect their utilization.

This report is a review of scientific publications, trade journals, cruise reports, and unpublished survey data of state and federal agencies. Consideration was limited to (1) demersal teleosts, (2) trawlable pelagic species, and (3) demersal elasmobranchs. Composition and distribution of groundfish in the South Atlantic Bight have been investigated in surveys dating back to at least 1950 (Powell 1950; Cummins et al. 1962; Struhsaker 1969; Wilk and Silverman 1976; Wenner et al. 1979a, b, c, d, 1980). These surveys employed numerous types of otter trawls in depths to 400 m. Recent foreign surveys, targeted at squid, have explored greater depths (Massey and LaCroix 1977; Gutherz et al. 1978; National Marine Fisheries Service 1979). The diversity of sampling gear permits an evaluation of the kinds of fish available to trawls when the data are pooled over time. It is impossible, however, to evaluate long-term trends in relative species composition and abundance because there are no synoptic observations using standardized gear and procedures within any area or depth zone. All stock estimates are based on data collected since 1972; their status relative to historic population levels is not known.

Practical interest can be directed at (1) a complex of species within a particular depth range or (2) a particular species throughout its range. In the first section below, the species associations in each depth zone are described by area and habitat, with availability and stock size being considered for the entire complex. Depth strata were 9-18 m, 19-27 m, 28-55 m, 56-110 m, 111-183 m, and 184-366 m. These correspond to six habitats having the following principal characteristics:

Habitat	Depth Range(m)	Surface Area (km^2)[a]
Coastal	0-18	18,083 (9-18 m)
Open-shelf	19-27	16,100
	28-55	22,367
Live-bottom	18-55	6,524[b]
Shelf-edge	56-110	4,775[b]
Lower-shelf	111-183	3,615[b]
Slope	184-366	9,724[b]

Habitat	Physical Features
Coastal	Smooth, sandy-mud bottom; unstable thermal structure
Open-shelf	Smooth sand bottom; relatively stable thermal structure
Live-bottom	Small areas of broken relief with a sessil invertebrate fauna
Shelf-edge	Smooth to highly broken bottom; thermal structure variable
Lower-shelf	Smooth mud bottom
Slope	Smooth mud bottom

[a]From Wenner et al. (1979a) and Barans and Burrell (1976)

[b]Cape Fear to Cape Canaveral

Struhsaker (1969) described the five shallower habitats and their associated fish fauna. Wenner et al. (1979a) described the slope habitat. Oceanographic descriptions are contained in Mathews and Pashuk (1977, 1982) and Stefansson and Atkinson (1967).

Section 2 consists of brief descriptions of life history aspects, size composition, and relative availability of major species. These are not intended to be comprehensive and are limited to factors having a direct impact on exploitation potential.

Groundfish Composition by Depth and Area

Bullis and Carpenter (1968) estimated that the U.S. Atlantic coast south of Cape Hatteras has a potential annual production of about 1.3 million mt of industrial fish. Combs, Inc. (1978) estimated that potential groundfish production could be increased from 100,000 to 200,000 mt over the 1977 level. Their estimate is for the Gulf of Mexico and South Atlantic Bight combined and refers primarily to the incidental catch of fish by shrimpers.

The trend in abundance of demersal teleosts (not including pelagics, elasmobranchs, stocks inshore of 9m, and stocks over live-bottom) is illustrated in Fig. 1. These estimates are from data collected by the Marine Resources Research Institute under contract to the National Marine Fisheries Service. The estimates for summer 1977, fall 1978, and summer 1979 include an average value (697 mt) for the 1984-366 m stratum, since no sampling was done there. The slope (-2.368; 95% CL -0.768, -3.968) of the trend line differs significantly from 0 at the 95% level ($t = 3.412$). The relative contribution of demersal teleosts to total fish biomass (in the survey catches) is indicated in Fig.2.

Combs, Inc. (1978) estimated the potential increase in annual production of herring-like fishes (clupeids, engraulids, and carangids) at more than 800,000 mt for the southeast (including the Gulf of Mexico). Spanish sardines (Sardinella aurita), round scad (Decapterus punctatus), and round herring (Etrumeus teres) are occasionally taken in bottom trawls. There are no valid stock estimates for these species in the South Atlantic Bight as a whole. Pelagic species represented < 15% of the total fish biomass of MARMAP trawl catches.

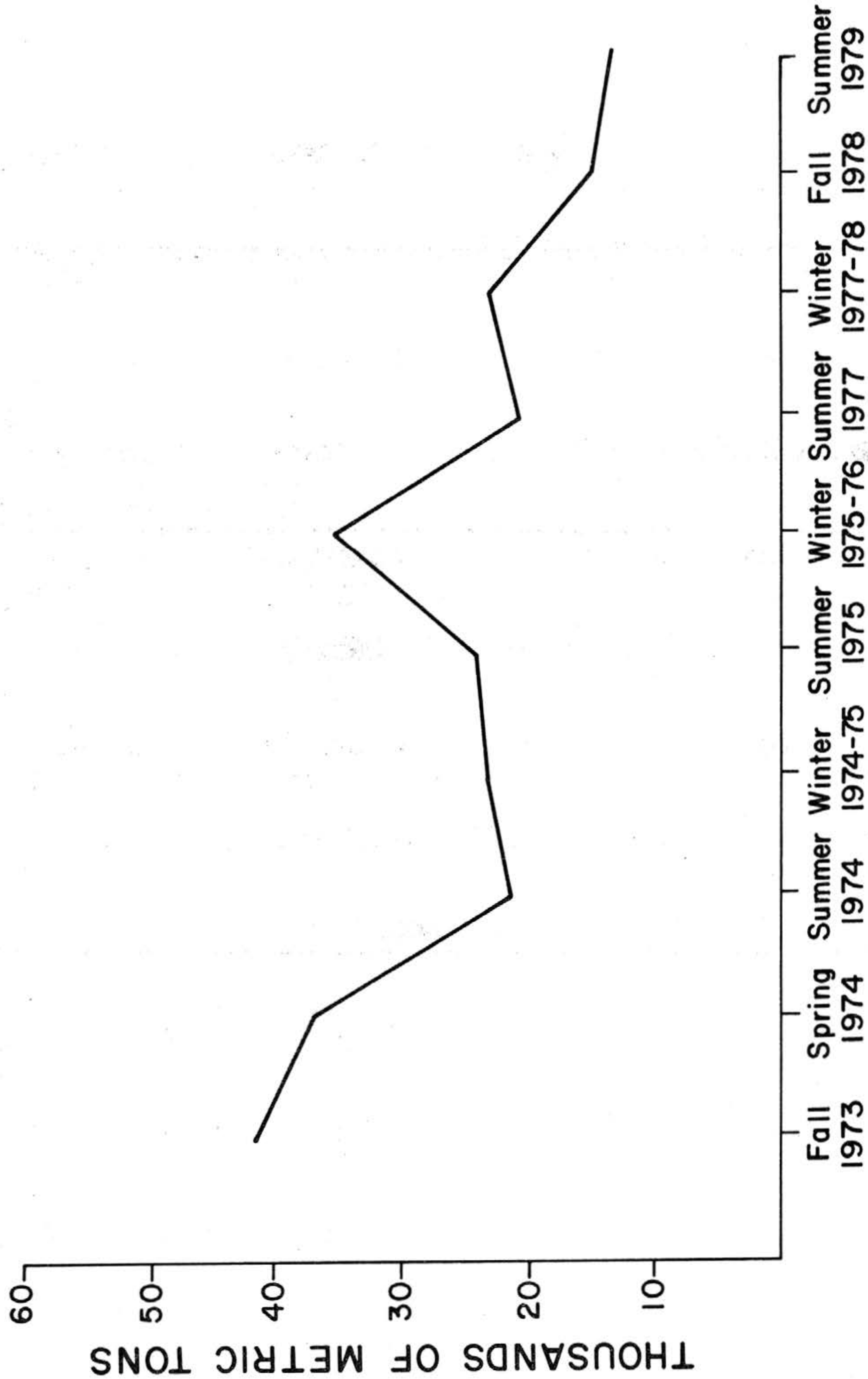
Precise stock estimates for demersal elasmobranchs also have not been calculated. Elasmobranchs comprised 50-65% of the total fish biomass in MARMAP catches, most of this being attributable to small numbers of large stingrays (Dasyatis centroura)

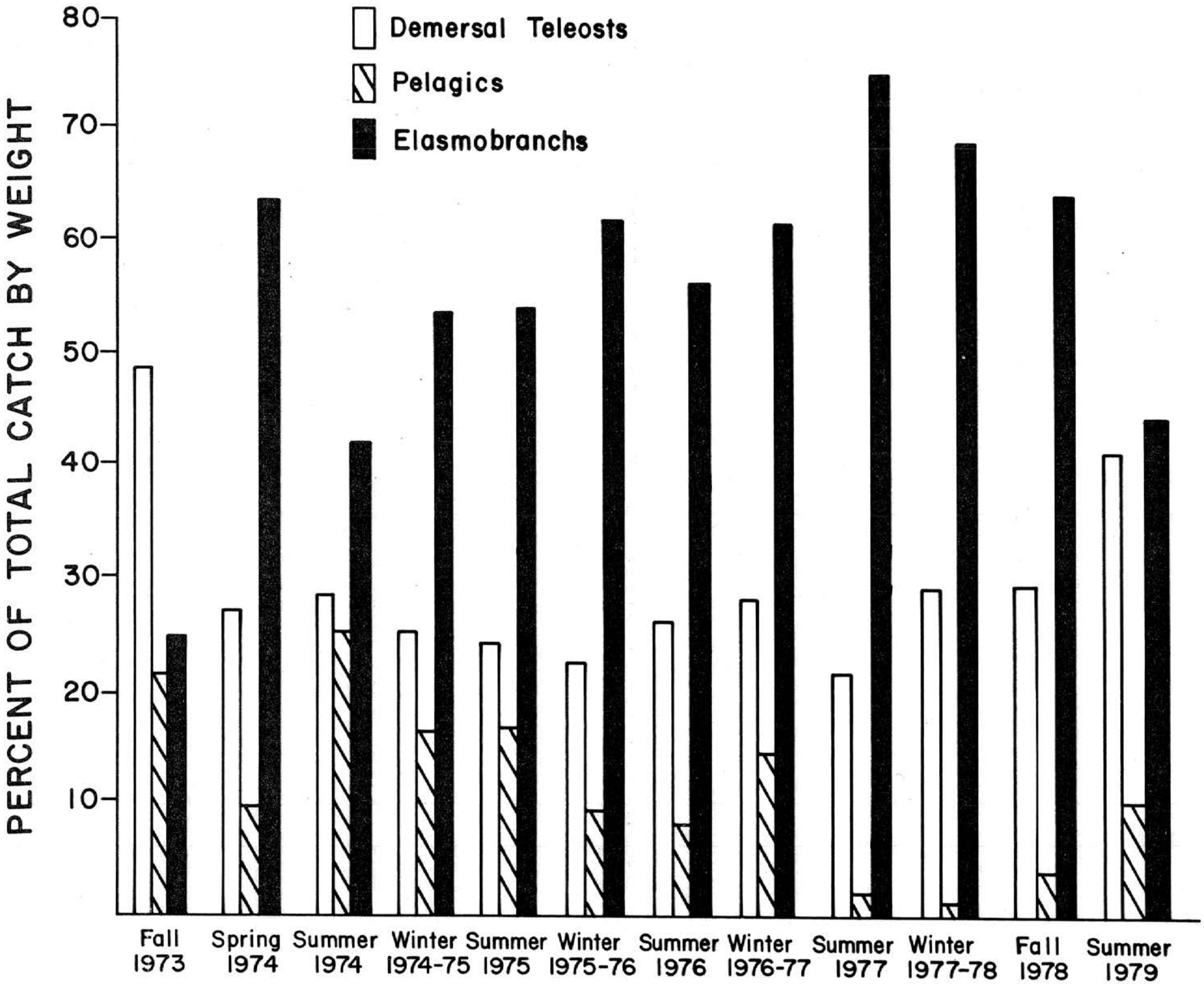
Nearly all of the current harvest of groundfish inshore of 18m consists of incidental catch from the shrimp fishery. Since Field's (1907) report, the federal government, state agencies, and shrimp industry have sought ways to profitably utilize this catch. The regional shrimp management plan (Eldridge and Goldstein 1975) noted that overboard disposal of this fish is a problem and recommended that "...methods should be devised to utilize the incidental catch for the good of the industry." Twenty years ago, the estimated annual incidental fish catch in the South Atlantic Bight was 17,000-18,000 mt (Lunz 1960). Keiser (1977) calculated an average annual figure of 31,545 mt from 1973-1975. More recent estimates are not available.

Keiser (1977) prepared area-by-area estimates of incidental fish catches. His estimates (in mt) for North Carolina were:

Year	Lower Limit	Mean	Upper Limit
1973	3,914	9,209	24,174
1974	6,536	15,379	40,370
1975	3,669	8,632	22,660

About 5% was landed for market. Estimates of catch rates are not available. Wolff (1972 estimates that 37,544 mt of fish were discarded by shrimp trawlers between July 1969 and June 1971 and reported the following June-August 1970 composition for species comprising ≥5% of the catch by weight:


THOUSANDS OF METRIC TONS
60
50
40
30
20
10
Fall 1973
Spring 1974
Summer 1974
Winter 1974-75
Summer 1975
Winter 1975-76
Summer 1977
Winter 1977-78
Fall 1978
Summer 1979



Demersal Teleosts
Pelagics
Elasmobranchs
PERCENT OF TOTAL CATCH BY WEIGHT
80
70
60
50
40
30
20
10
Fall 1973
Spring 1974
Summer 1974
Winter 1974-75
Summer 1975
Winter 1975-76
Summer 1976
Winter 1976-77
Summer 1977
Winter 1977-78
Fall 1978
Summer 1979

Species	% of weight of discarded fish
Leiostomus xanthurus	39
Micropogonias undulatus	24
Orthopristis chrysoptera	8

During the early 1960's, a small industrial fishery in Raleigh Bay produced annual catches of 3,600-5,000 mt (Fahy 1966). Juvenile sciaenids and butterfish, with individual mean weights <50g, comprised about 80% of these landings. Wolff (1972) reported the following catch composition for the industrial trawl fishery in the early 1970's:

Species	% of weight of discarded fish
Micropogonias undulatus	20
Cynoscion regalis	15
Leiostomus xanthurus	13
Bairdiella chrysura	13
Orthopristis chrysoptera	10

Keiser (1977) calculated the following estimates (in mt) of annual fish catch by shrimpers in South Carolina:

Year	Lower Limit	Mean	Upper Limit
1973	3,160	6,656	20,937
1974	3,650	4,128	16,594
1975	3,335	7,250	15,197

About 2% was landed. Catch rates were highest in June and July (139 and 244 kg/hr in 1974, 90 and 98 kg/hr in 1975). The average rate during August-December 1974 was 54 kg/hr. Keiser's (1976) estimates for the closed shrimp season were based on research catches. Fishing power of the research vessel relative to that of commercial boats was unknown. Simulated minimum commercial catch rates ranged from 24 kg/hr in January to 147 kg/hr in April, with a January-May average of 80 kg/hr. Corresponding maximum estimates are a range of 55-343 kg/hr and an average of 186 kg/hr. Species and length composition during May-December 1974 and May to mid-August 1975 were:

Species	% of weight of discard
Leiostomus xanthurus	40
Brevoortia tyrannus	10
Micropogonias undulatus	9
Stellifer lanceolatus	5
Menticirrhus americanus	5

Species	Length (cm) Range	Mean
Leiostomus xanthurus	4-25	14
Brevoortia tyrannus	8-28	16
Micropogonias undulatus	4-22	11
Stellifer lanceolatus	3-16	10
Menticirrhus americanus	6-28	15

Monthly species composition is given in Table 1.

Keiser's (1977) estimates (in mt) of annual incidental fish catches by Georgia shrimpers were:

Year	Lower Limit	Mean	Upper Limit
1973	3,762	9,828	17,008
1974	3,287	8,586	14,455
1975	3,660	9,561	14,857

About 2% was landed. Anderson (1968) and Knowlton (1972) reported wide fluctuation in both monthly and annual catch rates. Knowlton (1972) estimated a maximum rate of 113 kg/hr in May and a minimum rate of 36 kg/hr in October. During January, March, April, and December, the average was about 41 kg/hr, while in other months it exceeded 54 kg/hr. The overall average was about 59 kg/hr. He reported the following species composition during July 1969 to June 1971:

Species	% of weight of discard
Leiostomus xanthurus	28
Micropogonias undulatus	21
Menticirrhus spp.	9
Brevoortia tyrannus	7
Cynoscion regalis	7

Beaumariage (1968) estimated that Florida shrimpers operating north of Ft. Pierce discarded about 591 mt of fish annually. Keiser's (1977) estimates were:

Year	Average Catch (mt)
1973	4,860
1974	6,111
1975	45,314

In 1974, about 7% was landed for market. Siebenaler (1952) estimated that 1951 catch rates ranged from 155 kg/day in September to 332 kg/day in May.

In July-September 1980 and April-June 1981, MARMAP conducted inshore surveys in two depth strata (5-10 m and 10-20m) from Cape Canaveral to Cape Hatteras. A 22-m double-rigged shrimp boat towed 40/60 4-seam trawls in 20-minute tows at randomly determined locations within these depth ranges. The catch rates listed in Table 2 do not include elasmobranchs because an occasional catch of a large stingray or shark distorts the relative abundance for other species. There was no significant difference in catch rates for shallow and deep strata in 1980 (paired $t_{\alpha .05,\ 7\ df} = 0.78$), while in 1981 the catch rates in the shallow zone were considerably higher than those in the deep zone. The 1981 catch rate in the shallow zone was significantly greater than that in 1980 (Wilcoxon sign-rank T = 2). There was no significant difference in catch rates in the deep stratum in 1980 and 1981 (paired $t_{\alpha .05,\ 7\ df} = 1.35$). Catch rates in both years were highest in Florida, lowest in Georgia, and intermediate

TABLE 1. Most abundant species by weight in 1974-1975 South Carolina shrimp trawl catches on a monthly basis. Percent represents percent of the total weight of fish (from data in Keiser 1976).

January		February		March		April	
Species	Percent	Species	Percent	Species	Percent	Species	Percent
Brevoortia tyrannus	24	Leiostomus xanthurus	53	Urophycis regia	21	Urophycis regia	26
Squalus acanthias	19	Mustelus canis	9	Raja eglanteria	15	Odontaspis taurus	19
Raja eglanteria	14	Squalus acanthias	9	Leiostomus xanthurus	14	Leiostomus xanthurus	15
Symphurus plagiusa	6	Raja eglanteria	7	Brevoortia tyrannus	13	Rhinoptera bonasus	12
Dasyatis sabina	5	Dasyatis sabina	4	Mustelus canis	--	Symphurus plagiusa	6
May		**June**		**July**		**August**	
Species	Percent	Species	Percent	Species	Percent	Species	Percent
Leiostomus xanthurus	39	Leiostomus xanthurus	47	Leiostomus xanthurus	53	Leiostomus xanthurus	32
Brevoortia tyrannus	21	Brevoortia tyrannus	11	Micropogonias undulatus	9	Micropogonias undulatus	17
Urophycis regia	9	Arius felis	9	Brevoortia tyrannus	7	Brevoortia tyrannus	9
Stellifer lanceolatus	5	Micropogonias undulatus	8	Stellifer lanceolatus	6	Cynoscion regalis	5
Menticirrhus americanus	2	Stellifer lanceolatus	4	Menticirrhus americanus	4	Menticirrhus americanus	5
September		**October**		**November**		**December**	
Species	Percent	Species	Percent	Species	Percent	Species	Percent
Leiostomus xanthurus	20	Rhinoptera bonasus	31	Brevoortia tyrannus	32	Brevoortia tyrannus	27
Micropogonias undulatus	11	Stellifer lanceolatus	10	Leiostomus xanthurus	22	Menticirrhus americanus	18
Stellifer lanceolatus	10	Brevoortia tyrannus	8	Menticirrhus americanus	14	Stellifer lanceolatus	6
Menticirrhus americanus	9	Menticirrhus americanus	8	Peprilus triacanthus	5	Dasyatis sabina	6
Chloroscombrus chrysurus	6	Leiostomus xanthurus	7	Cynoscion regalis	3	Symphurus plagiusa	6

TABLE 2. MARMAP inshore catch rates[a] (kg/hr) of fish in July-September 1980 and April-June 1981, using 40/60 4-seam shrimp trawls from a double-rigged 22-m shrimp boat. N = tows.

State	Area	1980	N	1981	N
	5-10 m Depth Zone				
Fla.	C. Canaveral-St. Augustine	132	2	---	--
	St. Augustine-Cumberland Is.	52	8	244	3
	Mean	92		---	
Ga.	Cumberland Is.-Sapelo Is.	46	11	153	6
	Sapelo Is.-Savannah River	66	19	238	6
	Mean	56		196	
S.C.	Savannah River-Charleston	36	18	362	9
	Charleston-Winyah Bay	72	18	111	6
	Winyah Bay-Frying Pan Shoals	84	10	194	9
	Mean	64		222	
N.C.	Frying Pan Shoals-Cape Lookout	101	7	22	3
	10-20 m Depth Zone				
Fla.	C. Canaveral-St. Augustine	104	16	102	12
	St. Augustine-Cumberland Is.	136	8	68	6
	Mean	120		85	
Ga.	Cumberland Is.-Sapelo Is.	16	7	37	6
	Sapelo Is.-Savannah River	53	10	99	6
	Mean	35		68	
S.C.	Savannah River-Charleston	54	11	54	9
	Charleston-Winyah Bay	43	8	137	6
	Winyah Bay-Frying Pan Shoals	34	8	97	9
	Mean	44		96	
N.C.	Frying Pan Shoals-Cape Lookout	50	1	83	13
	Cape Lookout-Cape Hatteras	---	--	46	6
	Mean	---	--	65	

[a]These were calculated by adding the catches of both nets for each tow, then multiplying by three to obtain an hourly vessel catch rate. Then the mean of these values for each stratum and area was calculated. The means for each state were calculated as $\frac{\Sigma \text{ area rates}}{\text{N areas}}$ to equalize for the different numbers of tows in each area.

in South Carolina. During both years and in both depth strata, catches consisted primarily of small sciaenids, with Leiostomus xanthurus being the dominant species.

Since 1973, MARMAP has conducted numerous surveys over sand-mud bottom using a 3/4 scale Yankee No. 36 trawl in a stratified (by depth) random sampling design with tow duration of 30 minutes. Minimum estimates[1] of the total weight (in mt) of demersal teleosts based on catch rates in Wenner et al. (1979a, b, c, d, 1980) and unpublished MARMAP data are listed below:

	Depth Stratum (m)		
	9-18	19-27	28-55
Fall 1973	21,245	19,678	4,455
Spring 1974	7,731	13,998	12,077
Summer 1974	7,620	8,888	4,476
Winter 1974-75	2,567	8,451	10,613
Summer 1975	7,215	6,910	7,867
Winter 1975-76	9,380	6,720	20,859
Summer 1977	4,544	4,247	8,515
Winter 1977-78	4,060	4,547	12,105
Fall 1978	4,313	2,673	6,528
Summer 1979	2,834	4,357	3,561
	56-110	111-183	184-366
Fall 1973	908	811	1,427
Spring 1974	2,801	591	872
Summer 1974	672	367	204
Winter 1974-75	1,163	1,117	944
Summer 1975	637	401	215
Winter 1975-76	429	656	519
Summer 1977	1,541	669	-
Winter 1977-78	1,410	747	-
Fall 1978	1,295	297	-
Summer 1979	1,452	1,085	-

Conversation with MARMAP personnel indicated that the fall 1973 values for shallow strata were probably anomalously high due to sampling artifacts (C. Wenner, pers. comm.). With the fall 1973 observation deleted, the slope of the regression of stock size on time for the 9-18 m stratum does not differ significantly from 0 ($t = 1.739$). For the 19-27 m stratum, with the fall 1973 value again deleted, the slope (-1.128) does differ significantly from 0 ($t = 5.56$). The slopes for the 28-55 m, 56-110 m, and 111-183 m strata (-0.016, -0.05, and 0.007, respectively) equate to 0.

Wenner et al. (1979a, b, c, d, 1980) give detailed descriptions of species composition and fish assemblages characteristic of each depth stratum (see Table 3). Summing the ranks for each depth zone and assigning highest priority to the species with the most points, the dominant species are:

9-18 m	19-27 m
Stenotomus aculeatus	Aluterus schoepfi
Aluterus schoepfi	Stenotomus aculeatus
Leiostomus xanthurus	Diplectrum formosum

28-55 m	56-110 m
Aluterus schoepfi	Syacium papillosum
Diplectrum formosum	Synodus spp.
Stenotomus aculeatus	

111-183 m	184-366 m
Urophycis regia	Urophycis regia

MARMAP catch rates in kg/hr were:

	Depth Stratum (m)		
	9-18	19-27	28-55
Fall 1973	67	69	11
Spring 1974	24	49	31
Summer 1974	24	31	11
Winter 1974-75	8	30	27
Summer 1975	23	25	20
Winter 1975-76	29	24	53
Summer 1977	14	15	22
Winter 1977-78	13	16	31
Fall 1978	14	9	17
Summer 1979	9	15	9
	56-110	111-183	184-366
Fall 1973	11	13	8
Spring 1974	33	9	5
Summer 1974	8	6	1
Winter 1974-75	14	18	6
Summer 1975	8	6	1
Winter 1975-76	5	10	3
Summer 1977	18	10	-
Winter 1977-78	17	12	1
Fall 1978	15	5	-
Summer 1979	17	17	-

Catch rates for larger, more efficient trawls during years covered by MARMAP surveys are not available. Earlier survey efforts consisted of tows of variable duration using a variety of trawls without any pre-determined sampling design (Powell 1950; Cummins et al. 1962; Struhsaker 1969). The gear used in these surveys was larger and of different design than the net used by MARMAP. Although data from these surveys are of no value in estimating stock size, they do provide insight into catch rates. Principal findings of these surveys are summarized in Table 4.

Relatively little exploratory demersal trawling has been done in depths >110 m, other than the work conducted by MARMAP. Powell (1950) reported very small catches off North Carolina. Struhsaker's (1969) results for winter and spring suggested the presence of considerable quantities of spotted hake and butterfish off South Carolina and Georgia in 111-183 m of water. Soviet and Spanish stern trawlers have conducted recent surveys (although targeted at squid) in this depth range, using large, commercial-type nets. A 30-minute tow by the Soviets in 150 m of water off Jacksonville, Fla. yielded a small fish catch consisting primarily of chub mackerel (Scomber japonicus) averaging 215mm total length (Massey and LaCroix 1977). The Spanish reported catch rates of up to 434 kg/hr of butterfish

[1]ALL MARMAP figures are based on transformed data and Bliss (1967) approximations of mean CPUE.

TABLE 3. Dominant demersal teleosts by weight in MARMAP demersal trawl catches (from Wenner et al. 1979 a, b, c, d, 1980 and unpublished MARMAP data).

Depth Zone (m)	Fall 1973 Species	Rank	% of Total Weight	Spring 1974 Species	Rank	% of Total Weight	Summer 1974 Species	Rank	% of Total Weight
9-18	Stenotomus aculeatus	4	54	Stenotomus aculeatus	4	48	Stenotomus aculeatus	4	30
	Aluterus schoepfi	3	13	Aluterus schoepfi	3	19	Arius felis	3	14
	Synodus foetens	2	6	Leiostomus xanthurus	2	11	Aluterus schoepfi	2	11
	Leiostomus xanthurus	1	5	Synodus foetens	1	6	Diplectrum formosum	1	6
19-27	Stenotomus aculeatus	3	54	Aluterus schoepfi	3	38	Aluterus schoepfi	5	44
	Haemulon aurolineatum	2	10	Stenotomus aculeatus	2	36	Diplectrum formosum	4	11
	Aluterus schoepfi	1	5	Diplectrum formosum	1	7	Stephanolepis hispidus	3	10
							Stenotomus aculeatus	2	10
							Synodus foetens	1	6
28-55	Aluterus schoepfi	5	37	Stenotomus aculeatus	5	50	Aluterus schoepfi	4	41
	Diplectrum formosum	4	13	Aluterus schoepfi	4	10	Diplectrum formosum	3	22
	Synodus foetens	3	12	Diplectrum formosum	3	7	Synodus foetens	2	15
	Prionotus carolinus	2	7	Prionotus carolinus	2	6	Syacium papillosum	1	5
	Stephanolepis hispidus	1	5	Syacium papillosum	1	5			
56-110	Syacium papillosum	5	23	Synodus foetens	5	22	Trachinocephalus myops	4	19
	Prionotus carolinus	4	11	Rhomboplites aurorubens	4	15	Synodus poeyi	3	18
	Synodus foetens	3	8	Stenotomus aculeatus	3	13	Calamus leucosteus	2	15
	Pagrus pagrus	2	7	Syacium papillosum	2	10	Syacium papillosum	1	14
	Serranus phoebe	1	6	Mullus auratus	1	5			
111-183	Urophycis regia	3	62	Urophycis regia	4	30	Urophycis regia	1	63
	Stenotomus aculeatus	2	9	Stenotomus aculeatus	3	25			
	Antigonia capros	1	7	Peristedion gracile	2	7			
				Mullus auratus	1	6			
184-366	Urophycis regia	2	86	Urophycis regia	5	42	Helicolenus dactylopterus	3	27
	Prionotus alatus	1	5	Citharichthys arctifrons	4	11	Laemonema barbatulum	2	25
				Peristedion spp.	3	9	Chlorophthalmus agassizi	1	10
				Polymixia lowei	2	8			
				Merluccius albidus	1	5			

TABLE 3. Continued.

Depth Zones (m)	Winter 1974-75 Species	Rank	% of Total Weight	Summer 1975 Species	Rank	% of Total Weight	Winter 1975-76 Species	Rank	% of Total Weight
9-18	*Pogonias cromis*	6	31	*Stenotomus aculeatus*	3	55	*Pogonias cromis*	2	71
	Aluterus schoepfi	5	11	*Arius felis*	2	11	*Leiostomus xanthurus*	1	16
	Stenotomus aculeatus	4	10	*Diplectrum formosum*	1	8			
	Menticirrhus americanus	3	9						
	Chaetodipterus faber	2	8						
	Synodus foetens	1	7						
19-27	*Stenotomus aculeatus*	5	26	*Stenotomus aculeatus*	4	37	*Stenotomus aculeatus*	4	38
	Aluterus schoepfi	4	20	*Aluterus schoepfi*	3	15	*Diplectrum formosum*	3	22
	Leiostomus xanthurus	3	20	*Diplectrum formosum*	2	10	*Synodus foetens*	2	16
	Diplectrum formosum	2	8	*Synodus foetens*	1	9	*Aluterus schoepfi*	1	15
	Micropogonias undulatus	1	6						
28-55	*Aluterus schoepfi*	4	46	*Aluterus schoepfi*	5	20	*Stenotomus aculeatus*	3	56
	Calamus nodosus	3	8	*Synodus foetens*	4	14	*Aluterus schoepfi*	2	11
	Syacium papillosum	2	6	*Diplectrum formosum*	3	12	*Chaetodipterus faber*	1	10
	Haemulon aurolineatum	1	5	*Stenotomus aculeatus*	2	7			
				Syacium papillosum	1	6			
56-110	*Stenotomus aculeatus*	5	26	*Syacium papillosum*	4	29	*Urophycis regia*	5	19
	Syacium papillosum	4	16	*Synodus* spp.	3	22	*Syacium papillosum*	4	18
	Synodus foetens	3	7	*Trachinocephalus myops*	2	13	*Pagrus pagrus*	3	10
	Urophycis regia	2	7	*Balistes capriscus*	1	8	*Calamus leucosteus*	2	5
	Lagodon rhomboides	1	6				*Leiostomus xanthurus*	1	5
111-183	*Urophycis regia*	4	32	*Urophycis regia*	3	22	*Urophycis regia*	4	37
	Peristedion gracile	3	16	*Antigonia capros*	2	17	*Leiostomus xanthurus*	3	31
	Polymixia lowei	2	13	*Neomerinthe hemingwayi*	1	8	*Kathetostoma albigutta*	2	9
	Saurida normani	1	6				*Sphoeroides pachygaster*	1	7
184-366	*Helicolenus dactylopterus*	2	49	*Urophycis regia*	4	36	*Urophycis regia*	2	65
	Urophycis regia	1	31	*Merluccius albidus*	3	14	*Synagrops bella*	1	21
				Saurida normani	2	14			
				Laemonema barbatulum	1	12			

TABLE 3. Continued

Depth Zone (m)	Summer 1977 Species	Rank	% of Total Weight	Winter 1977-78 Species	Rank	% of Total Weight	Fall 1978 Species	Rank	% of Total Weight
9-18	*Stephanolepis hispidus*	5	16	*Leiostomus xanthurus*	5	33	*Leiostomus xanthurus*	5	19
	Stenotomus aculeatus	4	13	*Rhomboplites aurorubens*	4	17	*Larimus fasciatus*	4	14
	Diplectrum formosum	3	11	*Stenotomus aculeatus*	3	12	*Diplectrum formosum*	3	13
	Syacium papillosum	2	9	*Synodus* spp.	2	9	*Aluterus schoepfi*	2	9
	Prionotus carolinus	1	6	*Peprilus triacanthus*	1	5	*Haemulon aurolineatum*	1	7
19-27	*Aluterus schoepfi*	4	43	*Aluterus schoepfi*	3	64	*Diplectrum formosum*	2	56
	Diplectrum formosum	3	21	*Diplectrum formosum*	2	12	*Synodus* spp.	1	16
	Synodus spp.	2	13	*Synodus* spp.	1	10			
	Stephanolepis hispidus	1	10						
28-55	*Stephanolepis hispidus*	5	25	*Aluterus schoepfi*	6	15	*Aluterus schoepfi*	4	22
	Aluterus schoepfi	4	17	*Leiostomus xanthurus*	5	8	*Diplectrum formosum*	3	16
	Diplectrum formosum	3	9	*Syacium papillosum*	4	8	*Stenotomus aculeatus*	2	9
	Synodus spp.	2	9	*Synodus* spp.	3	8	*Synodus* spp.	1	6
	Syacium papillosum	1	6	*Stephanolepis hispidus*	2	7			
				Diplectrum formosum	1	6			
56-110	*Syacium papillosum*	2	71	*Urophycis regia*	3	55	*Urophycis regia*	4	21
	Centropristis ocyurus	1	5	*Syacium papillosum*	2	24	*Centropristis ocyurus*	3	9
				Synodus spp.	1	5	*Synodus* spp.	2	8
							Serranus notospilus	1	7
111-183	*Urophycis regia*	3	81	*Urophycis regia*	1	80			
	Peristedion gracile	2	6				*Urophycis regia*	1	29
	Syacium papillosum	1	5						

TABLE 3. Continued

Depth Zone (m)	Species	Rank	% of Total Weight
	Summer 1979		
9-18	*Diplectrum formosum*	4	21
	Stenotomus aculeatus	3	20
	Prionotus carolinus	2	6
	Synodus spp.	1	5
19-27	*Stenotomus aculeatus*	4	56
	Diplectrum formosum	3	13
	Aluterus schoepfi	2	10
	Synodus spp.	1	9
28-55	*Stenotomus aculeatus*	4	17
	Synodus spp.	3	11
	Diplectrum formosum	2	11
	Syacium papillosum	1	11
56-110	*Urophycis regia*	2	25
	Synodus spp.	1	6
111-183	*Urophycis regia*	2	29
	Glossanodon pygmaeus	1	15

TABLE 4. Major findings of early trawl surveys in the South Atlantic Bight in depths to 55 m.

Depth (m)	Area	Catch Rates	Dominant Species	Source
9-18	Onslow Bay	907-1,361 kg/hr	Small sciaenids, grunts, porgies, Spanish mackerel, and flounders	Struhsaker (1969)
19-25	North Carolina	< 907 kg/hr	Small croakers and butterfish	Struhsaker (1969)
26-46	North Carolina	45-272 kg/tow	Porgies, filefish, sea robins, lizardfish, flatfish	Struhsaker (1969)
		1,134-1,588 kg/tow (occasional)	Small porgies and puffers	Struhsaker (1969)
	South Carolina	Up to 680 kg/tow	Small porgies	Powell (1950)
		907-1,134 kg/tow Maximum, mean 159 kg/hr	Small porgies	Struhsaker (1969)
	N.E. Florida	159 kg/hr average	Small porgies and lizardfish	Struhsaker (1969)
40-55	North Carolina	Up to 1,814 kg/tow	Pleanhead filefish (in spring only)	Struhsaker (1969)
	South Carolina	Up to 4,082 kg/tow	Planehead filefish (in spring only)	Struhsaker (1969)
	Georgia	High	Planehead filefish (in winter and spring)	Struhsaker (1969)
	N.E. Florida	1,814-4,082 kg/tow	Planehead filefish (in winter and spring)	Struhsaker (1969)

and 60 kg/hr of round herring off South Carolina, using the type of net employed in their West African hake fishery (Gutherz et al. 1978).

Very little demersal trawling has been done in depths >184 m. Soviet catches were very small and consisted primarily of spotted hake and chub mackerel, the former averaging 199 mm total length and the latter 215 mm (Massey and LaCroix 1977). Spanish catches consisted primarily of butterfish and round herring, with one very large catch of the latter species being reported off South Carolina (Gutherz et al. 1978). In 1979, a West German stern trawler made 19 half-hour tows between Cape Hatteras and Cape Canaveral in 500-1,000 m, using a large demersal fish trawl. The net was set at random, rather than on fish traces. Fish catches were insignificant and consisted primarily of butterfish and several kinds of hake (National Marine Fisheries Service 1979).

Commercial finfish trawlers have operated over offshore areas of hard and live-bottom since 1976 (Ulrich et al. 1976). Species belonging to the snapper-grouper complex occupying these habitats are considered to be fully utilized by the South Atlantic Fishery Management Council (South Atlantic Fishery Management Council 1982). Surveys conducted with small-mesh research trawls have documented the presence of other species of little or no present utilization or economic value. Results of three MARMAP surveys are summarized in Table 5. Catch rates are for 10-minute tows (when tow duration was other than 10 minutes, the catch rate was calculated as $\frac{kg}{minutes} \times 10$). "Trashfish" include species of no economic value and large elasmobranchs are not included. The number of tows per area in the 1979 surveys ranged from three to eight. The overall average composition of the catch by weight was 79% "trashfish," primarily S. aculeatus, which accounted for half of the total catch. For the four reefs that were sampled in both April and September, the catch rates and "trashfish" contribution were similar for both seasons. The overall average catch rate (mean of the 12 values listed) was 31.4 kg/tow, equivalent to 188 kg/hr.

Derivation of even rough estimates of stock size for species inhabiting hard and live-bottom by the area-swept method is not practical, because of difficulties in defining the extent of the habitat. Although estimates of live-bottom area have been published (see, for example, Barans and Burrell 1976), there is no single estimate that is generally accepted. Continental Shelf Associates (1979) concluded that primary and secondary reef species are found on flat, hard bottom as well as the more elevated substrate traditionally associated with them. This led Miller and Richards (1980) to conclude that "estimates of reef fish biomass and production should include areas of flat hard bottom as well as elevated bottom."

Description of Major Underutilized Species

Our definition of "underutilized fishery resource" is intended to conform with provisions in the Magnuson Fishery Conservation and Management Act of 1976 (PL 94-265), specifically Sections 3(9) and 3(18)(B). Our interpretation of "underutilized" is that, in the absence of constraints imposed for economic or social reasons or purposes of stock rehabilitation, recent annual landings have been significantly below MSY. The major demersal teleost species characteristic of the various habitats and depth zones discussed previously, trawlable pelagic species, and demersal elasmobranchs are briefly described. These descriptions include only those aspects relevant to increased utilization.

Species comprising the incidental catch from shrimp trawling are not included. As Struhsaker (1969) noted, the shrimp by-catch consists primarily of juvenile food and recreational fishes. Such fish are not underutilized in the sense of being underharvested. Fish in the shrimp by-catch represent a unique case in that they are underutilized because they are discarded, due principally to small individual size and low market value.

Southern Porgy (Stenotomus aculeatus)

Southern porgies occur throughout the South Atlantic Bight, although they are relatively less abundant south of Brunswick, Georgia (Wenner et al. 1979a, b, c, d). During spring, summer, and fall, most of the catch during research cruises has been taken inshore of 28 m, while in winter the largest catches have been in 18-55 m (Barans and Burrell 1976). Southern porgies are widely distributed over both sand and hard bottom (including live-bottom) in association with sand perch (Diplectrum formosum), orange filefish (Aluterus schoepfi), planehead filefish (Stephanolepis hispidus), lizardfishes (Synodus spp.), tomtates (Haemulon aurolineatum), and black sea bass (Centropristis striata) (Wenner et al. 1979a, b, c, d, 1980). Their density appears to be relatively greater over live-bottom, based on catch-per-unit-of-effort (CPUE) observed during numerous trawl surveys. Barans and Powles (1977) considered southern porgies to be of possible forage value.

Length distribution is shown in Fig. 3. In winter and spring, the bimodal distribution suggests the presence of at least two age groups. Most of the population consists of fish 100-180 mm in fork length. Length tends to increase with depth, fish >150 mm being most common deeper than 28 m. Growth appears to be rapid, at least early in life.

MARMAP catch rates and population estimates derived from them for sand bottom in 9-55 m are

TABLE 5. MARMAP live-bottom trawl results for three surveys (unpublished MARMAP data).

Reef	Day Species	% Total Wt.	kg/ha[1]	Night Species	% Total Wt.	kg/ha
	May - June 1978					
1	Stenotomus aculeatus	30	36.8	Stephanolepis hispidus	21	17.7
	Haemulon aurolineatum	17		Haemulon aurolineatum	18	
	Holacanthus bermudensis	15		Holacanthus bermudensis	12	
2	Haemulon aurolineatum	46	19.6	Haemulon aurolineatum	29	20.2
	Balistes capriscus	21		Calamus leucosteus	16	
	Calamus leucosteus	6		Centropristis striata	14	
3	Stenotomus aculeatus	77	56.1	Stenotomus aculeatus	31	21.0
	Holacanthus bermudensis	10		Centropristis striata	15	
	Haemulon aurolineatum	6		Haemulon aurolineatum	11	
4	Stenotomus aculeatus	49	49.0	Stenotomus aculeatus	22	15.0
	Haemulon aurolineatum	14		Centropristis striata	19	
	Calamus leucosteus	13		Haemulon aurolineatum	17	
	(Day and night combined)					
5	Holacanthus bermudensis	46	22.7			
	Chromis enchrysurus	37				
	Rhomboplites aurorubens	6				
6	Calamus leucosteus	41	17.4			
	Haemulon aurolineatum	15				
	Stenotomus aculeatus	11				

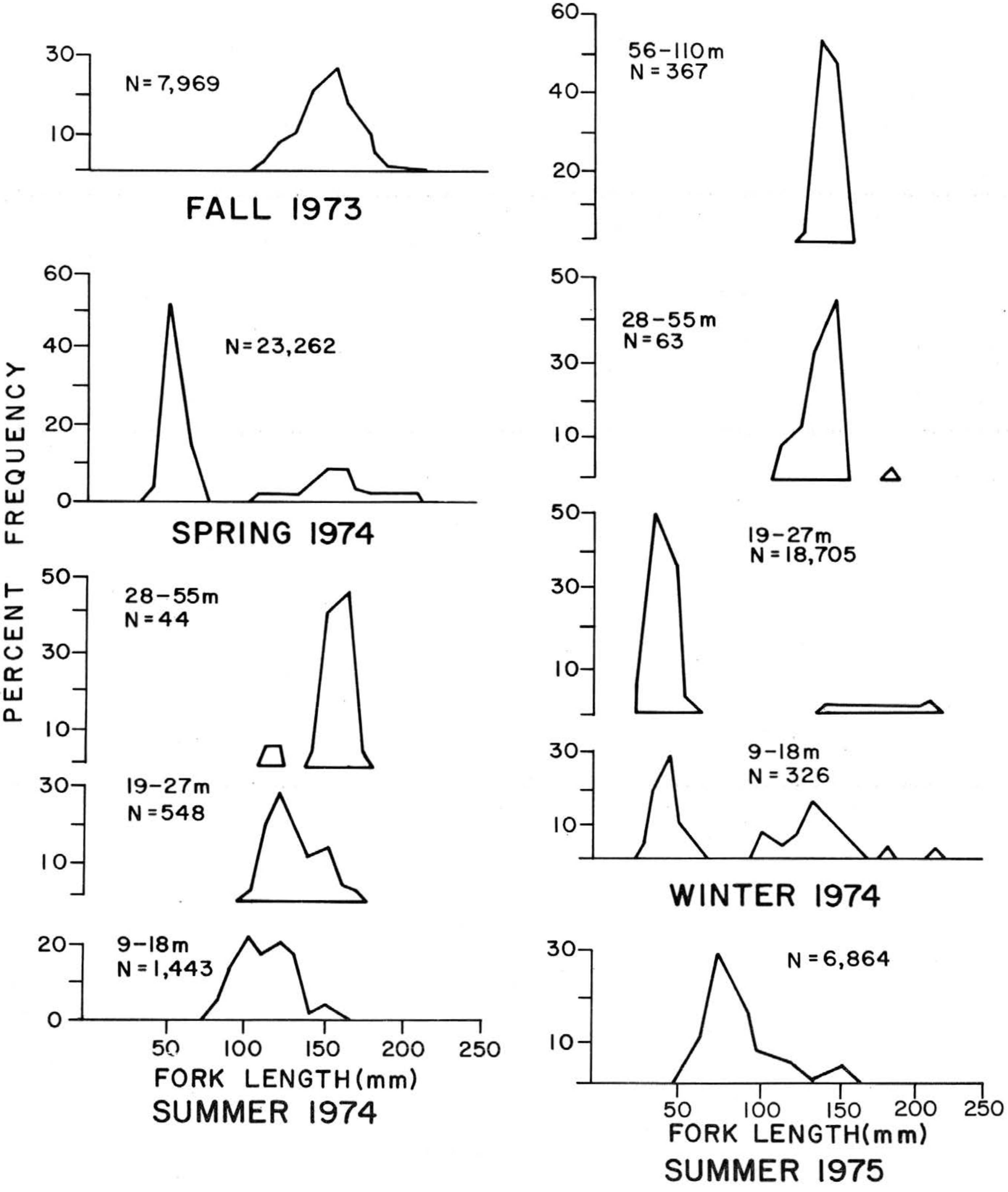
April 1979

Reef	Mean kg/tow	% Trashfish	Species	% Total Wt.
A	34.1	71	Stenotomus aculeatus	64
			Calamus leucosteus	7
			Archosargus probatocephalus	7
B	13.5	95	Stenotomus aculeatus	45
			Holacanthus bermudensis	11
			Stephanolepis hispidus	7
C	22.9	78	Stenotomus aculeatus	68
			Centropristis striata	7
			Calamus leucosteus	4
D	21.0	72	Stenotomus aculeatus	43
			Haemulon aurolineatum	13
			Calamus leucosteus	10
-	83.1	94	Stenotomus aculeatus	43
			Aluterus schoepfi	28
			Holacanthus bermudensis	10
-	18.1	71	Stenotomus aculeatus	73
			Haemulon aurolineatum	8
			Stephanolepis hispidus	7
-	15.3	62	Stenotomus aculeatus	43
			Calamus leucosteus	17
			Centropristis striata	6

TABLE 5. Continued.

Reef	Mean kg/tow	% Trashfish	Species	% Total Wt.
		September 1979		
A	33.0	63	Stenotomus aculeatus	22
			Centropristis striata	15
			Calamus leucosteus	13
B	26.3	94	Stenotomus aculeatus	62
			Haemulon aurolineatum	4
			Aluterus schoepfi	4
C	24.9	88	Stenotomus aculeatus	61
			Centropristis striata	6
			Haemulon aurolineatum	5
D	23.3	68	Stenotomus aculeatus	21
			Haemulon aurolineatum	11
			Stephanolepis hispidus	7
-	61.1	89	Stenotomus aculeatus	84
			Haemulon aurolineatum	2
			Stephanolepis hispidus	1

[1]Total Mean Density


PERCENT FREQUENCY
N=7,969
FALL 1973
N=23,262
SPRING 1974
28–55m
N=44
19–27m
N=548
9–18m
N=1,443
FORK LENGTH(mm)
SUMMER 1974
56–110m
N=367
28–55m
N=63
19–27m
N=18,705
9–18m
N=326
WINTER 1974
N=6,864
FORK LENGTH(mm)
SUMMER 1975

shown below (Wenner et al. 1979a, b, c, d, 1980, unpublished MARMAP data):

Year	Mean kg/hr	Mean $\hat{B}$ (mt)
Fall 1973	8	8,000
Spring 1974	7	6,500
Summer 1974	3	2,270
Winter 1974-75	1	1,170
Summer 1975	5	5,300
Summer 1977	4	3,660
Winter 1977-78	1	1,170
Fall 1978	2	1,630
Summer 1979	4	4,170

Ninety percent confidence limits for these population estimates (as well as for those for other species described in this section) range from ± 25-50% of the mean values listed.

Powles and Barans (1980) reported that southern porgies occur singly or in small groups when over live-bottom and derived an average density estimate of 737 kg/km^2. During ecological surveys conducted for the Bureau of Land Management by the Marine Resources Research Institute catch rates have ranged up to 416 kg/10-minute tow over live-bottom (G. Sedberry, pers. comm.). The highest reported catch rate for commercial-type gear (1½ Iceland trawl) was 680 kg/hr (Powell 1950), although bottom type was not specified.

It is difficult to make a practical evaluation of the relative advantages of trawling for southern porgies over sand vs. hard or live-bottom on the basis of catch rates alone. MARMAP catch rates over sand bottom were obtained with a 3/4 Yankee No. 36 trawl, considered by most knowledgeable observers to be a relatively inefficient gear, particularly when fished over live-bottom. Catch rates over live-bottom have ranged much higher, but are for more efficient gear (high-rise and fly nets). Yet the density estimate, based on visual observations, reported for live-bottom is very low when compared to these catch rates. Demersal trawling over live-bottom is a controversial issue and is opposed by many hook-and-line fishermen (South Atlantic Fishery Management Council 1981). It would therefore be difficult to support a significantly expanded trawl fishery over this habitat.

The wide fluctuations in seasonal population estimates (for sand bottom) reported by MARMAP suggest an unstable population. Although age composition of the southern porgy population is not known, a short-lived species with highly-variable recruitment would exhibit a trend in abundance such as that noted for this species.

Orange Filefish (Aluterus schoepfi)

This species is widely distributed over the open-shelf (including live-bottom) inshore of 55 m of water. Juveniles are pelagic and the adults occur in small aggregations. Most individuals are fairly large and the length distribution (Fig. 4) suggest several age groups. No distinct trend in size with depth has been reported.

MARMAP catch rates and population estimates for sand bottom in 9-55 m between Cape Fear and Canaveral are listed below (Wenner et al. 1979a, b, c, d, 1980, unpublished MARMAP data):

Year	Mean kg/hr	Mean $\hat{B}$ (mt)
Spring 1974	6	5,780
Summer 1974	6	4,180
Winter 1974-75	4	4,170
Summer 1977	8	7,890
Winter 1977-78	18	17,490
Fall 1978	9	8,770

We found no reference to large catches in surveys using commercial-scale gear.

Planehead Filefish (Stephanolepis hispidus)

Juveniles are found in the oceanic sargassum community (Berry and Vogele 1961) and in coastal grassbeds off south Florida (Low 1973). Adults are widely distributed in the South Atlantic Bight over the open-shelf (including live-bottom), primarily inshore of 55 m. The length distribution (Fig. 5) indicates that at least four or five age groups are represented (Wenner et al. 1979a). There is no well-defined relationship between length and water depth.

MARMAP catch rates and population estimates for sand bottom are shown below (Wenner et al. 1979a, b, c, 1980, unpublished MARMAP data):

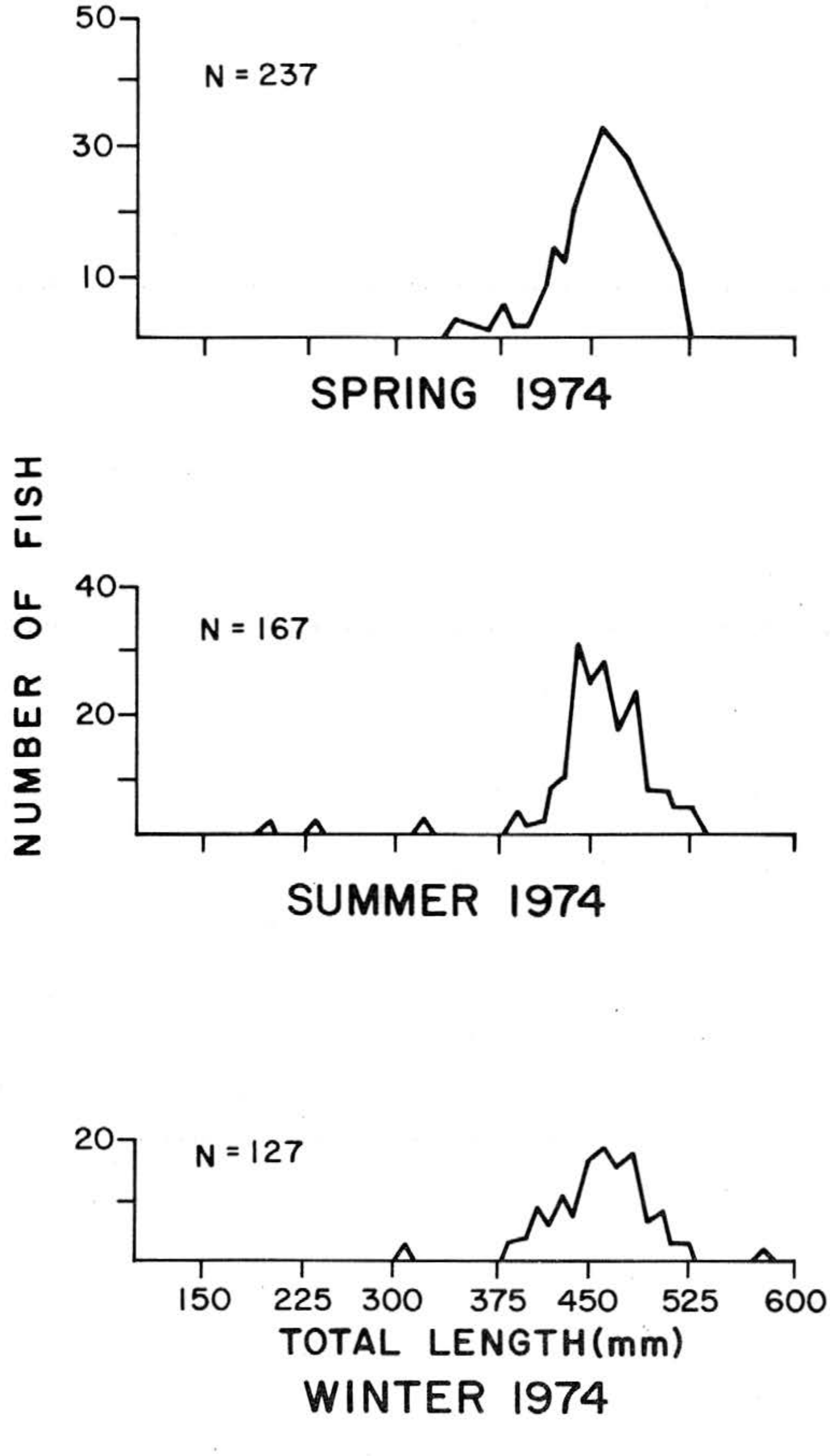
Year	Mean kg/hr	Mean $\hat{B}$ (mt)
Fall 1973 (9-110 m)	< 1	890
Spring 1974 (9-110 m)	< 1	790
Summer 1974 (9-55 m)	1	890
Summer 1975 (9-55 m)	< 1	410
Summer 1977 (9-55 m)	6	6,200
Winter 1977-78 (9-55 m)	2	1,700
Fall 1978 (9-55 m)	< 1	330
Summer 1979 (9-55 m)	< 1	300

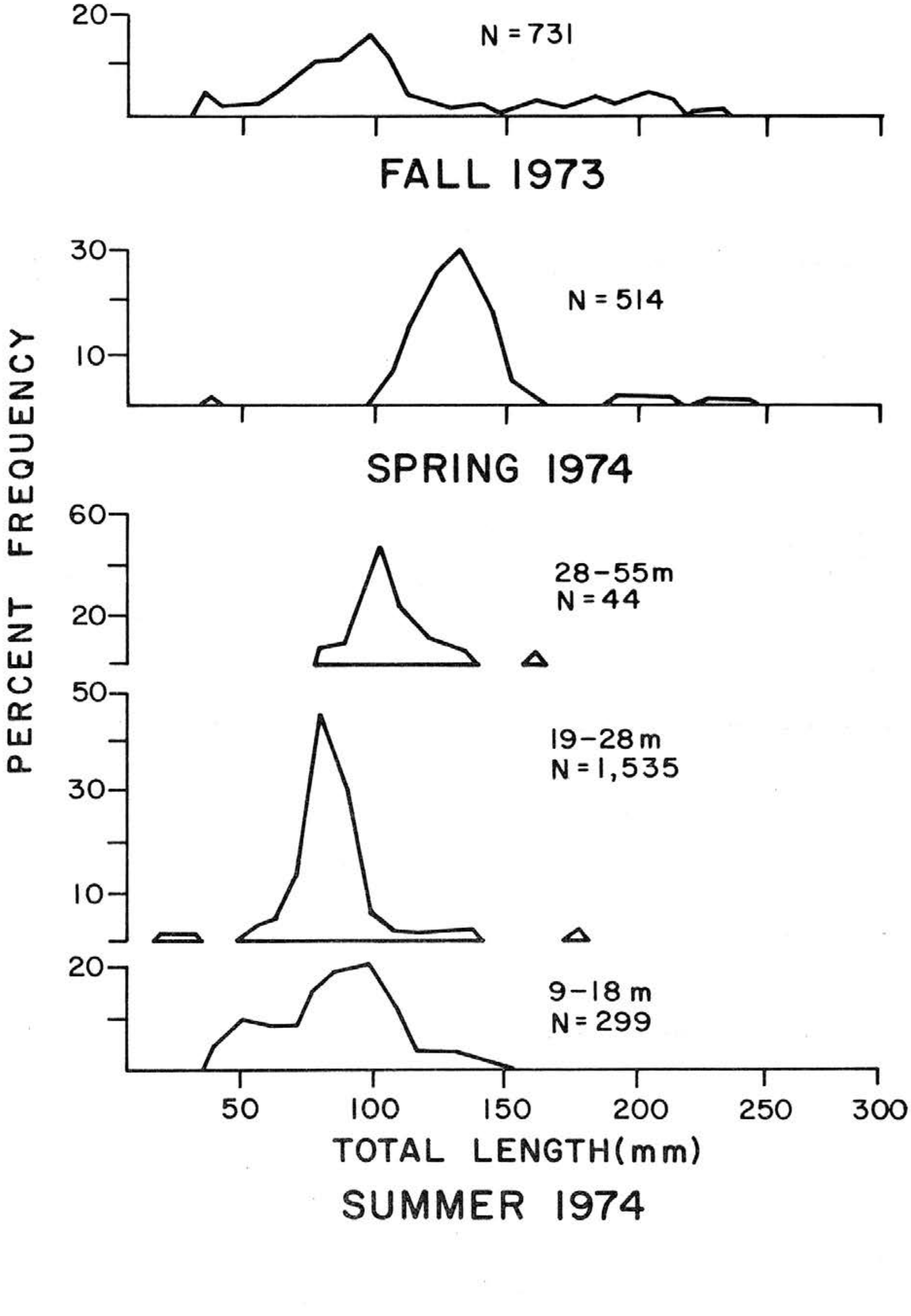
These catch rates are in marked contrast to those (up to 4,082 kg/tow in spring 1964) reported by Struhsaker (1969), although it should be noted that the gear used in the early survey was more efficient than that employed by MARMAP and sets were made directly on fish marks.

Sand Perch (Diplectrum formosum)

Sand perch are ubiquitous to a depth of 55 m, occurring as solitary individuals or in small aggregations. Mean size tends to increase with depth, with an overall average fork length of about 160 mm (Wenner et al. 1979a).

MARMAP catch rates over sand bottom in 9-55 m of water consistently ranged from 2-3 kg/hr.


50
30
10
N = 237
SPRING 1974
NUMBER OF FISH
40
20
N = 167
SUMMER 1974
20
N = 127
150 225 300 375 450 525 600
TOTAL LENGTH(mm)
WINTER 1974



20
N = 731
FALL 1973
30
10
N = 514
SPRING 1974
60
20
28–55m
N = 44
50
30
10
19–28 m
N = 1,535
20
9–18 m
N = 299
PERCENT FREQUENCY
50
100
150
200
250
300
TOTAL LENGTH(mm)
SUMMER 1974

Population estimates derived from them are as follows (Wenner et al. 1979a, b, c, unpublished MARMAP data).

Year	Mean $\hat{B}$ (mt)
Fall 1973	1,120
Spring 1974	2,030
Summer 1974	1,580
Summer 1977	2,140
Winter 1977-78	2,110
Fall 1978	2,980
Summer 1979	2,210

The sand perch population appears to be one of the most stable components of the sand bottom demersal toleost community.

Lizardfishes (Synodus spp.)

Lizardfish of several species are ubiquitous in the South Atlantic Bight. Inshore lizardfish (S. foetens) occur from estuarine areas to about 200 m, while offshore lizardfish (S. poeyi) are abundant in 30-350 m (Wenner et al. 1979a). The length distribution of inshore lizardfish (Fig. 6) suggests several age groups. Smaller juveniles are most common in < 55 m, while larger specimens are present in all depths. Barans and Powles (1977) considered inshore lizardfish to be of possible forage value.

MARMAP catch rates consistently averaged < 2 kg/hr. The following population estimates are for sand bottom between Cape Fear and Cape Canaveral (Wenner et al. 1979a, b, c, d, 1980, unpublished MARMAP data):

Year	Depth (m)	Species	Mean $\hat{B}$ (mt)
Fall 1973	9-110	S. foetens	2,110
Spring 1974	9-110	S. foetens	1,950
Summer 1974	9-110	S. foetens	780
Winter 1974-75	9-110	S. foetens	873
Summer 1975	9-55	S. foetens	1,900
Summer 1977	9-55	Synodus spp.	1,640
Winter 1977-78	9-55	Synodus spp.	1,870
Fall 1978	9-110	Synodus spp.	990
Summer 1979	9-55	Synodus spp.	1,010

Spotted Hake (Urophycis regia)

In colder months, spotted hake are widely distributed throughout the South Atlantic Bight (Wenner et al. 1979b), while in warmer months they are most abundant deeper than 110 m (Wenner et al. 1979a). The length distribution (Fig. 7) suggests several age groups, with the small juveniles occurring over the shelf and the larger fish in deeper waters. Barans (1972) reported that spotted hake in inshore areas grow faster than those offshore. Offshore of the 200-m curve, spotted hake co-occur with butterfish and round herring. Barans and Powles (1977) considered spotted hake to be of possible forage value and we have frequently found them in tilefish (Lopholatilus chamaeleonticeps.

Struhsaker (1969) speculated that large concentrations of spotted hake are available along the lower-shelf. MARMAP catch rates and derivative population estimates, however, were very low (Wenner et al. 1979a, b, c, unpublished MARMAP data):

Year	Depth (m)	Mean kg/hr	Mean $\hat{B}$ (mt)
Fall 1973	110-366	-	2,170
Spring 1974	9-366	< 1	660
Summer 1974	9-366	18	-
Winter 1974-75	9-366	< 1	698
Winter 1977-78	9-110	1	1,510
Summer 1979	28-183	4	2,150

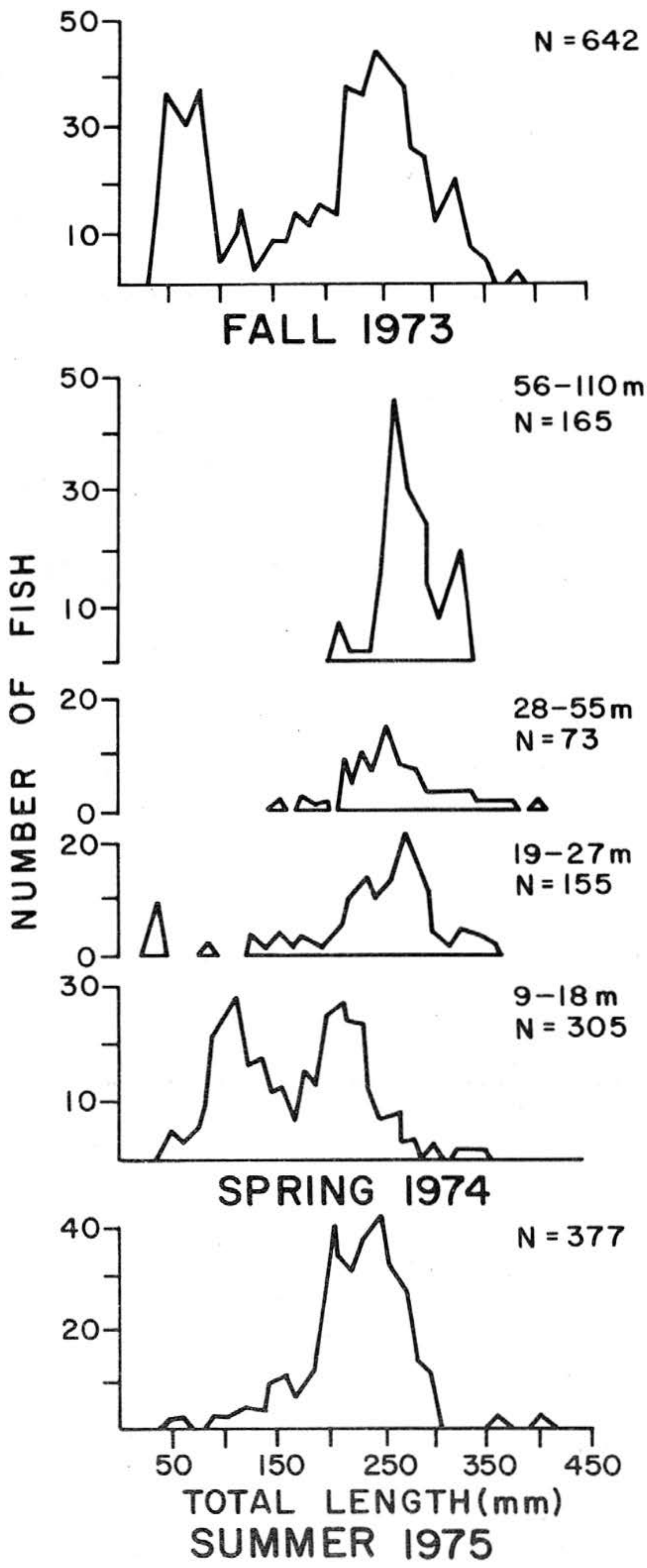
We have observed dense fish marks on the lower slope that we believe were spotted hake. These marks are widely dispersed, however, and could easily be missed in a sampling design such as that used by MARMAP. MARMAP's deep-water sampling has also been very limited.

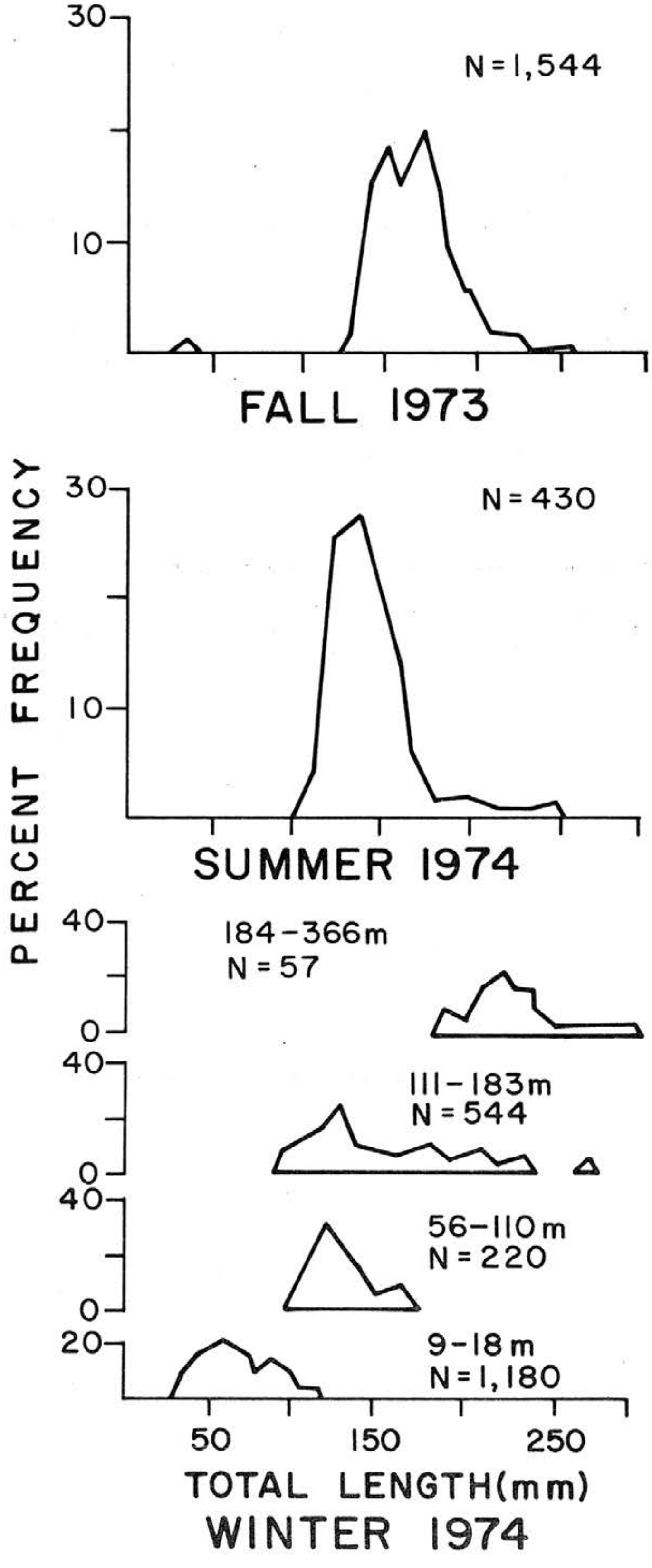
Butterfish (Peprilus triacanthus)

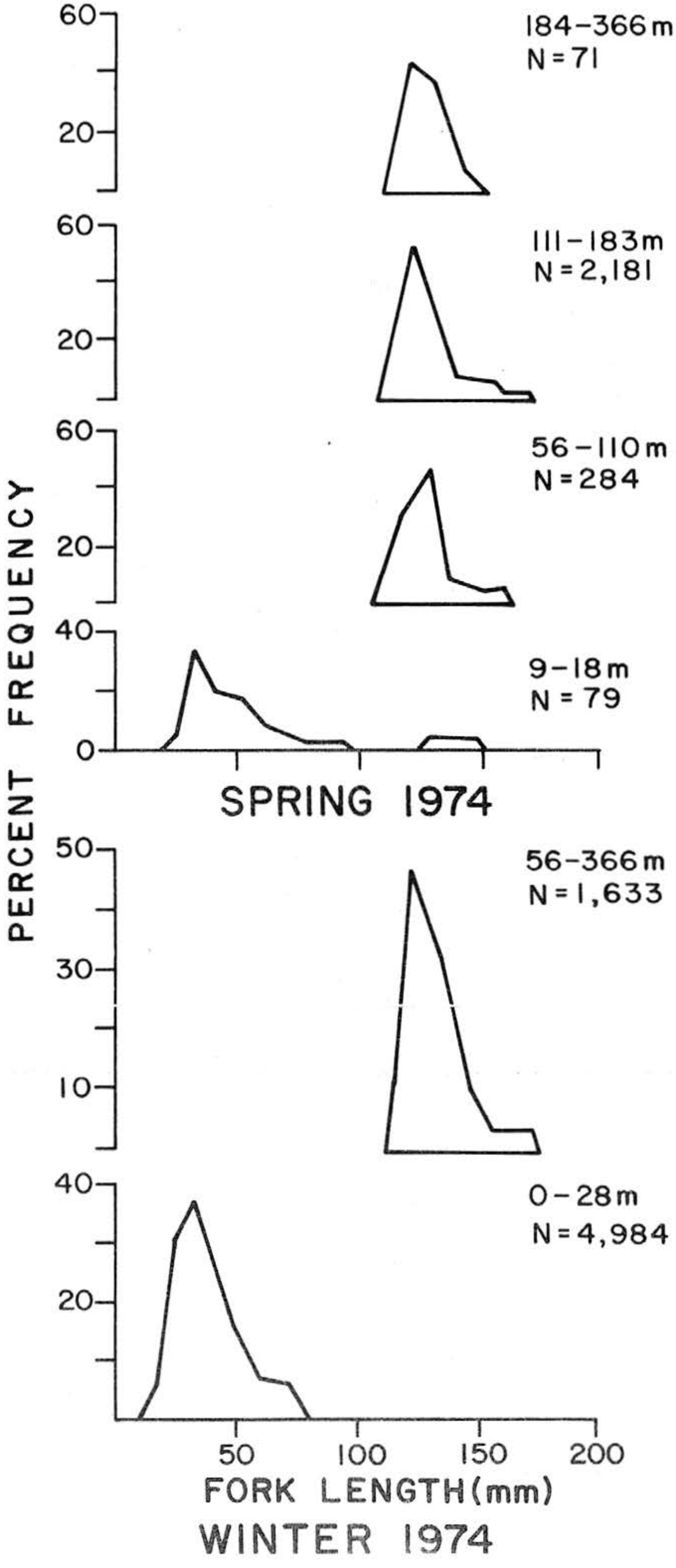
Caldwell (1961) identified two populations south of Cape Hatteras: (1) over coastal sand bottom and (2) over mud and silt in > 25 m of water. The deep-water population apparently is a southern extension of the population that occurs in the Mid-Atlantic Bight (Collete 1963, Horn 1970, Murawski and Waring 1979). In spring and summer, butterfish are most abundant offshore of 110 m, where spawning occurs, while in fall and winter the relative abundance of fish inshore increases (Barans and Burrell 1976, Martin and Drewry 1978). Butterfish are demersal in daytime and pelagic at night. Smaller fish predominate inshore, while larger fish are more abundant in deeper water (Fig. 8.).

Maximum age is about six years, with maturity being attained in two years at a standard length of 140-180 mm (Horn 1970). Martin and Drewry (1978) noted that butterfish grow rapidly and Murawski and Waring (1979) estimated that the instantaneous annual rate of natural mortality is at least 0.8. These characteristics are conducive to a relatively high rate of exploitation. Murawski and Waring (1979) estimated that the maximum sustained physical yield-per-recruit would be obtained at an exploitation rate of 55% when using 60-mm codend mesh (stretch measure). The greatest equilibrium yield-per-recruit that would not adversely affect recruitment would be obtained at a rate of 36%. These estimates were based on the Mid-Atlantic Bight population and would be most applicable to the offshore population in the South Atlantic Bight.

Spanish Sardine (Sardinella aurita)


50
30
10
N = 642
FALL 1973
50
30
10
56–110 m
N = 165
20
0
28–55 m
N = 73
20
0
19–27 m
N = 155
30
10
9–18 m
N = 305
NUMBER OF FISH
SPRING 1974
40
20
N = 377
50
150
250
350
450
TOTAL LENGTH (mm)
SUMMER 1975


30
N=1,544
10
FALL 1973
PERCENT FREQUENCY
30
N=430
10
SUMMER 1974
40
184-366m
N=57
0
40
111-183m
N=544
0
40
56-110m
N=220
0
20
9-18m
N=1,180
50
150
250
TOTAL LENGTH(mm)
WINTER 1974


184-366 m
N = 71
111-183 m
N = 2,181
56-110 m
N = 284
9-18 m
N = 79
SPRING 1974
56-366 m
N = 1,633
0-28 m
N = 4,984
PERCENT FREQUENCY
60
20
60
20
60
20
40
0
50
30
10
40
20
50
100
150
200
FORK LENGTH (mm)
WINTER 1974

Spanish sardines are widely distributed in the South Atlantic Bight inshore of 55 m (Barans and Burrell 1976) and are most abundant in summer and fall (Wenner et al. 1979a). It is likely that most of the population off the Carolinas migrates south in late fall. Length distribution is shown in Fig. 9. Low's (1973) observations suggest that the fish comprising the 60-100 mm group in fall 1973 represent young-of-the-year hatched that spring, while those in the 120-160 mm group are a year older. The Spanish sardine is a forage species (Barans and Powles 1977) and commonly occurs with round scad.

MARMAP trawl catches of Spanish sardines are usually very small, with an occasional larger catch when a school is encountered. Because of this pattern, population estimates cannot be developed from these demersal trawl catch rates. At night, Spanish sardines frequently school near the surface under lights and depth recorder traces suggest that they are widely distributed in the water column at night.

Round Herring (Etrumeus teres)

Round herring are widely distributed in the South Atlantic Bight. The length distribution (Fig. 10) suggests several age groups. In winter and spring, juveniles are common inshore of 28 m, while in summer and fall the adults occur in > 55 m of water (Barans and Burrell 1976). Round herring are a major source of forage in deep water (Barans and Powles 1977).

Occasional very large catches by foreign trawlers offshore of 200 m suggest that a sizeable quantity of round herring may be available in deep water during the fall.

Round Scad (Decapterus punctatus)

Round scad occur throughout the South Atlantic Bight, primarily inshore of 55 m (Barans and Burrell 1976). They grow rapidly and very few appear to survive past age two (S. Hales, College of Charleston, pers. comm.). Round scad are abundant over both open and live-bottom and are a major forage item (Barans and Powles 1977). At night, they frequently school at the surface under lights together with Spanish sardines. In daytime, schools in live-bottom areas vary from 20 to several hundred fish (Powles and Barans 1980). South Carolina offshore fish trawlers catch round scad regularly in winter and spring, but seldom in appreciable quantities. Small otter trawls and purse seines are used in the bait fishery for round scad off the west coast of Florida.

Demersal Elasmobranchs

Several species of demersal sharks, skates, and rays are abundant over smooth, soft bottom inshore of 18 m, particularly north of Florida (C. Wenner, pers. comm.). Elasmobranchs typically comprised the bulk of the biomass reported for MARMAP surveys, most of the contribution being in the form of a few very large stingrays (Dasyatis centroura). Off South Carolina, schools of spiny dogfish (Squalus acanthias) appear along the beach in early spring. Shrimpers occasionally run into very large schools of rays. Rough estimates of the total demersal elasmobranch population based on MARMAP data range from 25,000 to 100,000 mt.

Conclusions

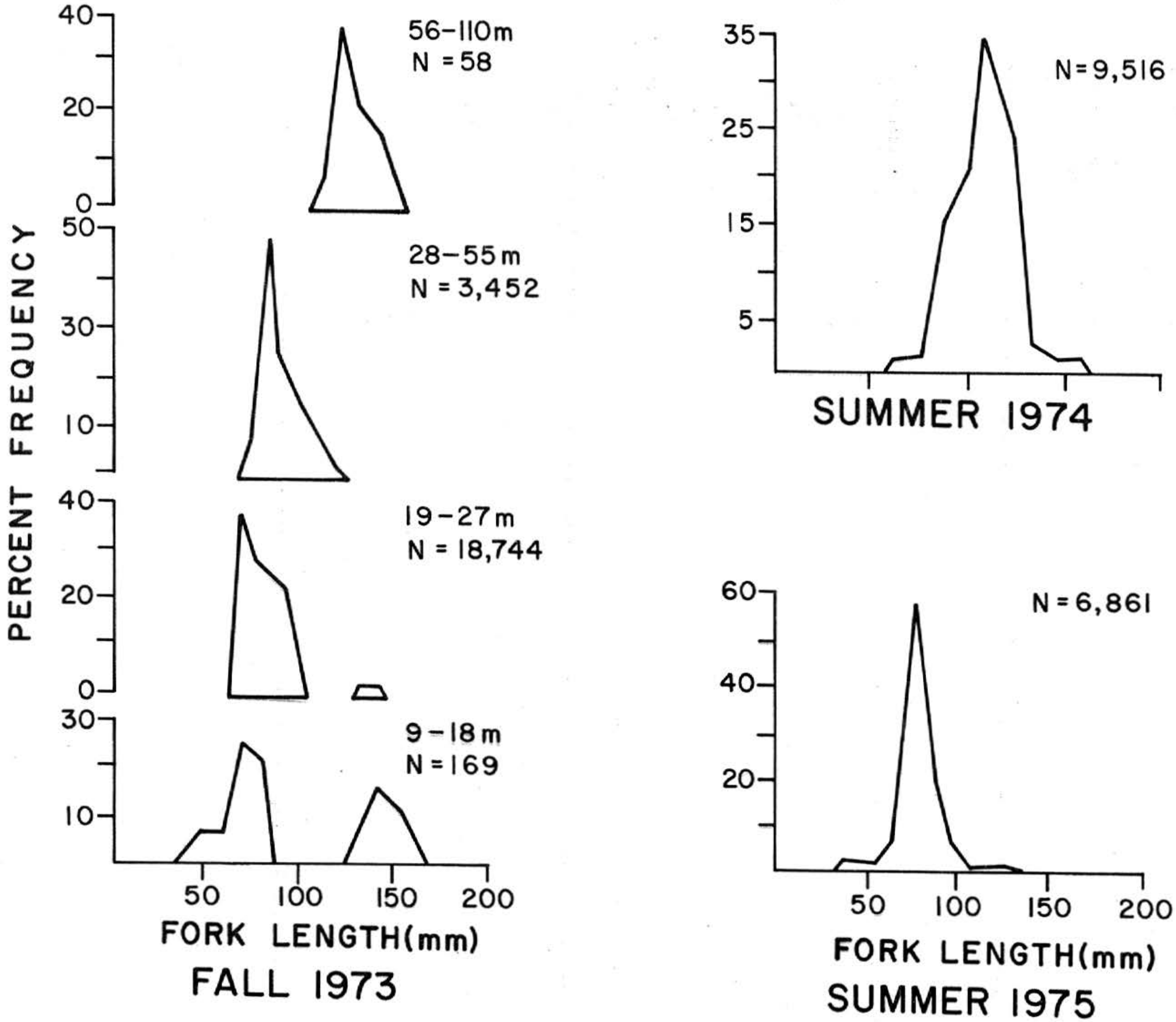
Coastal Finfish Resource

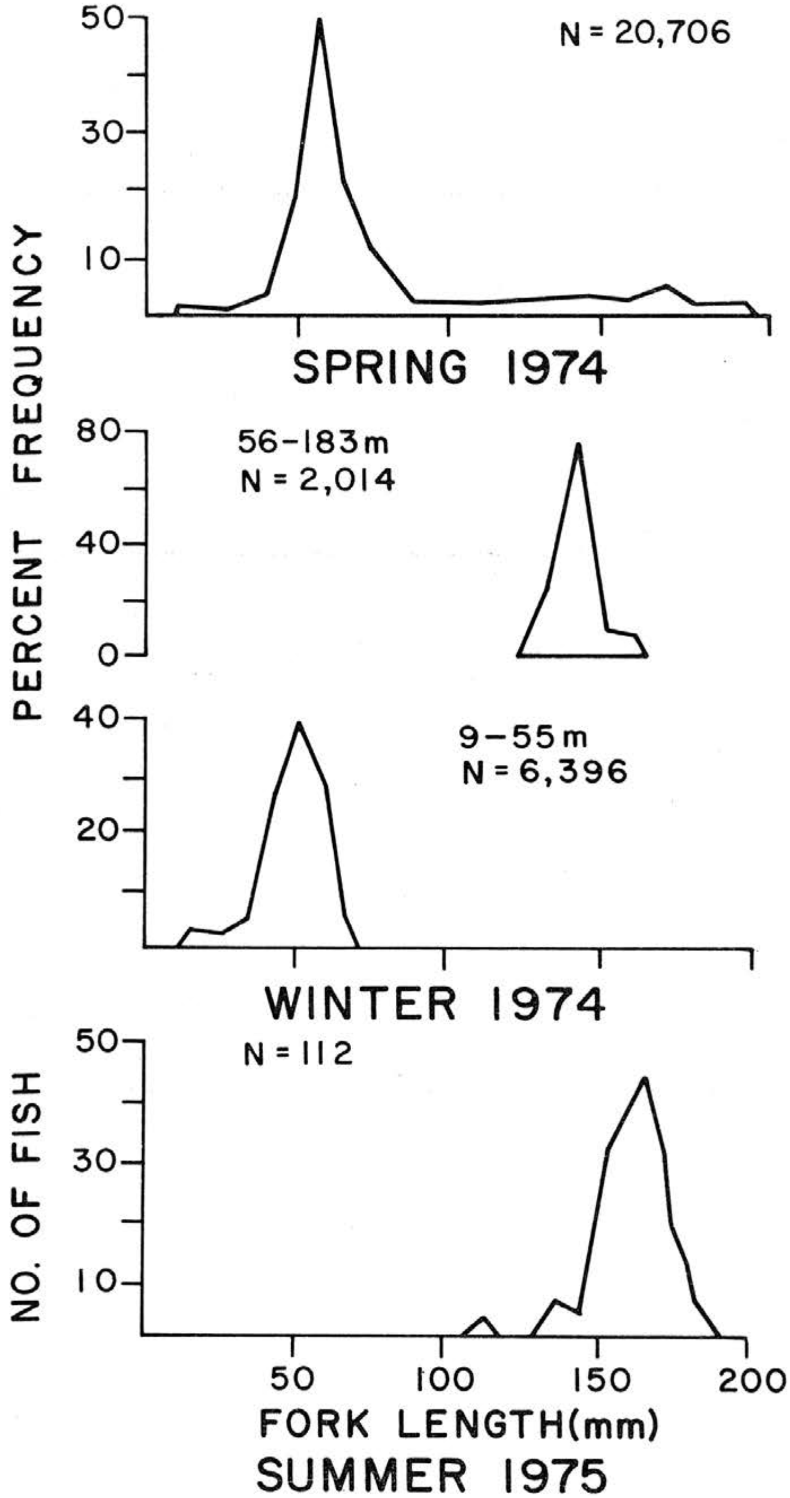
Less than 10% of the regional incidental fish catch of shrimpers is presently landed for market, due to small individual size, limited demand, and low ex-vessel prices. The dominant species are fish of traditionally low market value. Struhsaker (1969) concluded that increased utilization depends more on market development than on the status of the resource.

Avenues of this development include (1) exporting of fish in the round to countries where small fish are more acceptable, (2) processing them into edible products, or (3) reducing them for industrial products. The more likely export market for fish in the round is Africa (Combs, Inc. 1978), but the price offered is likely to be low, particularly in comparison to shrimp. Combs, Inc. (1978) concluded:

> "...as long as there is a large price differential between shrimp and the commercially underutilized species, the shrimp fleet cannot be expected to land groundfish."

A successful industry that produces either processed items or industrial products must have large volumes of low-priced raw materials constantly available to it. On the Gulf coast, considerable interest in utilization of croakers for surimi has developed and one plant is in commercial operation. Catches of croaker are much larger in the Gulf, however, and the individual size of the fish is greater. Jones (1960) presented an optimistic view of the potential of a petfood industry in the South Atlantic Bight, but it failed to materialize. Roithmayr (1965 estimated that the average catch rate in the Gulf industrial fishery was 548 kg/hr. Average catch rates in the coastal waters of the South Atlantic Bight, either by shrimp boats or research vessels, are well below that level. Hoese (1973) concluded that the inshore area lacks a fish resource necessary to support a pro-


PERCENT FREQUENCY
56–110m
N = 58
28–55 m
N = 3,452
19–27 m
N = 18,744
9–18 m
N = 169
50 100 150 200
FORK LENGTH(mm)
FALL 1973
N=9,516
SUMMER 1974
N=6,861
50 100 150 200
FORK LENGTH(mm)
SUMMER 1975


N = 20,706
50
30
10
PERCENT FREQUENCY
SPRING 1974
80
40
0
56-183m
N = 2,014
40
20
9-55m
N = 6,396
WINTER 1974
N = 112
50
30
10
NO. OF FISH
50
100
150
200
FORK LENGTH(mm)
SUMMER 1975

fitable industrial fishery. Taylor (1951) assessed the situation as follows:

> "...it does not pay to bring in trash fish even after they are caught because labor for handling cannot be compensated, to say nothing of preservation, without making the material too expensive for the manufacture of fish meal. It is, therefore, a disconcerting fact that in cost and with technical methods now available, the vast resources of the sea... are economically beyond reach for fertilizer and animal nutrition."

Even if the coastal finfish resource proves to be more extensive than our review would indicate, we concur with Keiser's (1977) conclusion that it is not wise to promote development of an industrial fleet. The resource supporting the Gulf fleet extends farther offshore and fishing occurs at a greater distance from inshore nursery grounds for shrimp and fishes of recreational value. In the South Atlantic Bight, the resource is located in shrimp nursery areas or adjacent to them.

Open-Shelf Demersal Teleost Resource

Struhsaker (1969) concluded that this resource offered poor foodfish potential, but that small porgies and filefish may be able to support a small industrial fishery. Bearden and McKenzie (1971) suggested that "definite potentials for the development of an industrial fishery for species such as filefish, sea robins, scup, etc. exist in the coastal and open shelf areas having smooth bottom." These assessments were made (1) at a time when no definitive stock estimates were available and (2) in an era of cheap diesel fuel.

Results from early surveys and the MARMAP program strongly indicate that a foodfish resource does not exist over the open-shelf. The fish are small, unattractive, and have low flesh recovery rates. The few species, e.g. southern porgies and sand perch, that might be suitable for processed edible products are not available in commercial quantity. In addition to their apparent low level of absolute abundance, they are widely dispersed and difficult to harvest efficiently.

The low catch rates reported for commercial gear and low population estimates of MARMAP suggest that it is very unlikely that demersal trawling over sand bottom of the open-shelf can produce industrial fish in sufficient quantities. Ulrich et al. (1976) noted that:

> "The feasibility of new ventures by an existing firm should be assessed in terms of the profit potential of the venture and its ability to yield greater returns than current uses of the firm's productive factors. In the case of South Carolina shrimp trawlers, the former translates to determining the relationship of gross returns and variable costs for new off-season ventures and also viewing the result in terms of existing off-season utilization of capital and labor."

Rephrased, an industrial fishery will have to offer a clear profit potential of sizeable magnitude before regional shrimpers will even consider it.

Because of difficulties in defining the extent of the habitat, the population size of underutilized species over hard and live-bottom is not well-known, although it is probably larger than that over sand bottom. These species, however, share many of the undesirable characteristics noted for the fish found over sand bottom. Then there is the potential habitat damage associated with an extensive demersal trawl fishery.

Lower-Shelf and Slope Demersal Teleost Resources

"The deeper lower shelf area has not been adequately surveyed at this time" (Bearden and McKenzie 1971). That still describes the situation and is relevant because Combs, Inc. (1978) noted that:

> "One of the factors affecting financing for the industry is a hesitancy on the part of investors to invest in an area in which there is very little knowledge about both the current resource and that resource's projected future."

The potential of the 110-366 m zone for demersal trawl production cannot be accurately evaluated with the limited data on hand.

Trawlable Pelagic Species

Combs, Inc. (1978) concluded that additional capitalization in newly designed and constructed vessels was necessary in order to increase catches of pelagic species in the southeast. The method of fishing used by menhaden seiners is not appropriate for harvesting small, widely dispersed schools, the apparent distribution in the South Atlantic Bight during most of the year. Pelagic species are most efficiently harvested with purse seines, lampara nets, or mid-water trawls, although they can also be caught at times with demersal trawls. To consistently catch significant quantities of pelagic fishes in the South Atlantic Bight, a boat would have to be capable of fishing all of these gears.

Demersal Elasmobranchs

Elasmobranchs comprised the bulk of the demersal fish biomass reported in research survey catches inshore of 28 m, although most of this contribution consisted of a few large rays. The relative abundance and availability of demersal sharks has not been adequately investigated.

As Holden (1977) noted, elasmobranch fisheries have not been studied intensively and little is known of stock reaction to exploitation. Most elasmobranchs produce only a few young per female during each spawning and live-bearing species have long gestation periods. Because of these factors, there appears to be a relationship between parent stock and recruitment for many species, which would render them very vulnerable to overfishing.

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