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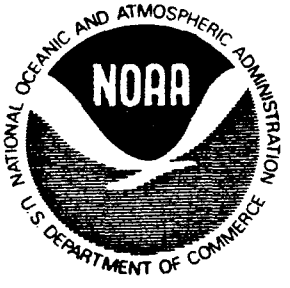

Food of Spanish mackerel, Scomberomorus maculatus, from the Gulf of Mexico and southeastern seaboard of the United States

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ABSTRACT

The stomachs of 6,933 Spanish mackerel were examined. The mackerel were caught by hook and line, seines, and gill nets between August 1977 and November 1981 from continental shelf waters off Texas, Louisiana, northwest Florida, east central Florida, and North and South Carolina. Differences in stomach contents by area, gear, size of predator, year, and season were studied. Data are presented as percentage volume and percentage frequency of occurrence. About 64% of the stomachs were empty. Among stomachs with food the percentage volume of fish, the dominant food category, ranged from 95.6% in Texas to 99.1% in east central Florida, while the percentage frequency of occurrence of fish ranged from 94.3% in Louisiana to 97.6% in North and South Carolina. Shrimp or squid, depending on the area, was the second most important prey. Eleven families and 24 species of fishes were represented in the diet, with Engraulidae being the most prevalent group of fish prey. Small Spanish mackerel ate mainly anchovies. Larger Spanish mackerel consumed increasingly larger amounts of other fishes, crustaceans, and squid. The stomachs of net-caught Spanish mackerel contained higher percentages of digested fish remains and were more frequently empty than stomachs from hook-and-line caught Spanish mackerel. Clupeidae and Carangidae were represented more in stomachs of Spanish mackerel caught by hook and line than in those caught by nets.

INTRODUCTION

The Spanish mackerel, Scomberomorus maculatus, is fished by both commercial and recreational fishermen along the coast of the southeastern United States including the Gulf of Mexico. The fisheries for this species have been described by Trent and Anthony (1979). In 1979, more than 6 million pounds (2.7 million kilograms) were landed by commercial fishermen, while more than 3 million pounds (1.4 million kilograms) were landed by recreational fishermen (U.S. Dep. Commer. 1980a, b).

The distribution of Spanish mackerel is confined to the Gulf of Mexico and the Atlantic coast of the United States, with those occurring between New York and the Gulf of Maine considered as strays. References to S. maculatus in areas south of the Yucatan Peninsula, that is, along the Atlantic coasts of Central and South America, are actually references to S. brasiliensis (Collette, Russo, and Zavalla-Camin 1978). Two other species of Scomberomorus also occur in the U.S. Atlantic waters, namely, S. cavalla and S. regalis, the king mackerel and the cero, respectively. A summary of available information on the biology of Spanish mackerel is presented by Berrien and Finan (1977).

Past studies of the food of Spanish mackerel have been made from specimens collected in shelf waters off the coast of Texas or other localities along the U.S. Atlantic coast. Knapp (1949), Miles (1949), Kemp (1950), Miles and Simmons (1951), Rice (1979), and Naughton and Saloman (1981) reported on stomach contents of fish obtained off Texas. Earll (1883), Goode (1887), Carson (1944), Klima (1959), and Naughton and Saloman (1981) reported on stomach contents of fish obtained from various areas off the U.S. Atlantic coast. Except for Naughton and Saloman (1981), whose collection localities included Cape Canaveral, Florida and Galveston, Texas, no comparative food study over a broad geographic range had been conducted previously for this species. We present the results of a comparative food study of Spanish mackerel obtained from five localities, two along the U.S. south Atlantic coast and three in the northern Gulf of Mexico.

MATERIALS AND METHODS

Stomach samples were obtained from Spanish mackerel caught by hook and line, gill net, and beach seine from August 1977 through November 1981 in five areas (Fig. 1). The numbers of stomachs were: 1,908 from North and South Carolina; 1,067 from east central Florida; 2,779 from northwest Florida; 887 from Louisiana; and 292 from Texas. The fork length (mm) of each fish was measured before removing the stomachs. The stomachs were wrapped in gauze and preserved in 10% formalin.

In the laboratory, the stomachs were rinsed in water and cut longitudinally; stomach walls were scraped lightly with a spatula to remove fish scales, helminths, and small bones. The contents were placed in a glass dish and were sorted into taxonomic groups, identified, drained of water, and blotted dry. Volumes to the nearest 0.1 ml of each food item were determined by water displacement in a graduated cylinder. Volumetric

data were presented as percentages of the total volume of the stomach contents. Numbers of individuals of each taxon could not always be accurately determined due to digestion. Frequency of occurrence of each food type was obtained by counting every fish that contained the specific item. Relative frequency of occurrence (%) was calculated by dividing the number of fish that contained a specific food by the number of fish that had food in their stomachs and multiplying by 100. A summary of the number of stomach samples by area and fish length is given in Table 1.

The number of stomachs examined in this study was 6,933; of these, 63.7% were empty (Table 1). Data obtained from food-containing stomachs were examined for variations associated with areas of capture, sizes of the Spanish mackerel, years, seasons, and types of capture gear. Specific data on depths of water or distances from shore of the capture sites and on time (of day) of capture were unavailable. The stomachs were obtained over a period of several years (Table 2).

COMPARISONS BETWEEN AREAS

Fish was the dominant prey identified in the diet of Spanish mackerel from all areas. Percent volumes ranged from 95.6% in Texas to 99.1% in east central Florida. Percent frequencies ranged from 94.3% in Louisiana to 97.6% in North and South Carolina (Table 3). Three families (Engraulidae, Clupeidae, and Carangidae) of the 11 encountered were the most important components of Spanish mackerel diet.(Table 3). Based on volume, engraulids were dominant in North and South Carolina and Texas, clupeids in Louisiana and east central Florida, and carangids in northwest Florida. Based on frequency of occurrence, engraulids were dominant in North and South Carolina, east central Florida, Louisiana, and Texas; the three families were about equally important in northwest Florida. Prominant fish taxa were Anchoa spp., Sardinella aurita, and Chloroscombrus chrysurus, which were present in all five areas. Decapterus punctatus was present in 4 of the 5 areas and had its highest percent volume in east central Florida and northwest Florida (Table 3).

Shrimp or squid were second in importance in the diet of Spanish mackerel but together comprised less than 5% of the volume of the stomach contents (Table 3). The percent volumes and percent occurrrence of shrimp were highest in Texas and Louisiana and lowest in east central Florida. Squid was highest in percent volume in Texas and northwest Florida and highest in frequency of occurrence in east central Florida (Table 3). Penaeus spp. and Loligo pealeii were the principal invertebrate species. Results of other studies were similar to ours in that shrimp and squid were the most abundant invertebrates in the stomachs of Spanish mackerel, but invertebrates were of secondary importance to fish (Knapp 1949, Miles 1949, Kemp 1950, Klima 1959, Rice 1979, and Naughton and Saloman 1981).

The highest percentages in volume and occurrence of fish in the stomachs of Spanish mackerel in this study confirm the results of previous studies. Knapp (1949), Miles (1949), and Kemp (1950) found fish to be the abundant food item in Spanish mackerel off Texas. Rice (1979) recorded only fish in the stomachs of Spanish mackerel along the Texas coast.

Naughton and Saloman (1981) examined stomach contents of small Spanish mackerel (100 to 399 mm fork length) collected off Galveston, Texas, and Cape Canaveral, Florida, and found that fish occurred in 95% of the stomachs. However, few studies report the same species or families of fish to be predominant in the diet of Spanish mackerel as those we identified. In Texas, Chloroscombrus chrysurus was the dominant prey species reported by Rice (1979), Trichiurus lepturus by Kemp (1950), Mugil cephalus by Miles (1949), and Anchoa sp. by Naughton and Saloman (1981). In Florida, consumption of Engraulidae and Clupeidae was reported by Naughton and Saloman (1981) and Clupeidae by Klima (1959) and Carson (1944).

Parasites, namely nematodes and trematodes, were present in the stomachs of Spanish mackerel from all five areas, although no trematodes were in stomachs from Texas. Nematodes occurred frequently (19%) in stomachs from North and South Carolina, while in the other four areas the frequency of occurrence was at or below 5%. Trematodes had a frequency of occurrence of less than 1% in all areas (Table 3). The percentage of empty stomachs ranged from 39.5% for fish caught off Texas to 70.8% for fish caught off east central Florida (Table 1).

COMPARISONS BETWEEN FISH SIZES

In all areas the stomach contents were different between the smaller and larger Spanish mackerel (Figs. 2 and 3). Digested fish remains were not included in the figures. Percent volumes and percent frequencies of occurrence illustrated that Anchoa spp. were much more prevalent as prey of small Spanish mackerel (125, 175, 225, 275 mm midpoints), whereas fish families, excluding engraulids, were more prevalent as prey of large Spanish mackerel (525, 575, 625, 675 mm midpoints). The high volumes for crustaceans and mollusks in the 675 mm midpoint fish from North and South Carolina and from northwest Florida were based on only one and two fish, respectively. All three food types were important in intermediate-sized fish (325, 375, 425, and 475 mm midpoints) with a tendency for Anchoa sp. to be more important in the larger of this intermediate-sized group (Figs. 2 and 3).

Differences in diet with growth of fish has been documented for other scombrids. Generally, as scombrids increase in size, a higher percentage of fish and a lower percentage of crustaceans are found in their stomachs (Reintjes and King 1953, Yuen 1959, Magnuson and Heintz 1971).

COMPARISONS BETWEEN YEARS

Sufficient samples (>100) were available from only two areas (North and South Carolina and northwest Florida) for between-year comparisons of the stomach contents of Spanish mackerel. Data for North and South Carolina were obtained from 380 and 366 stomachs with food for the years 1980 and 1981, respectively. Data for northwest Florida were obtained from 163 and 656 stomachs with food for the years 1978 and 1980, respectively (Table 2).

In North and South Carolina, annual differences in the diet of Spanish mackerel were apparent in the consumption of anchovies and other fish

besides anchovies. In 1981 the percent volume of Anchoa spp. increased about two-fold over 1980, while the percent volume of the other fish families increased by more than three-fold over 1980. A notable increase of clupeids, namely S. aurita, was apparent in 1981 over 1980 (Table 4). Those differences could be masked by the decrease in volumes of digested fish remains from 77.7% in 1980 to 48.1% in 1981. In northwest Florida, differences were characterized by a drop of 17.5% in volume of clupeids and a rise of 5.1% of carangids from 1978 to 1980. In 1980 5 more fish species were consumed than in 1978 (Table 4).

COMPARISONS BETWEEN SEASONS

Sufficient samples (>100) were available from only two areas (North and South Carolina and northwest Florida) for seasonal comparisons of the stomach contents of Spanish mackerel. Data for North and South Carolina were obtained from the summer and fall (370 and 380 stomachs with food, respectively). Data for northwest Florida were obtained from the spring, summer, and fall (228, 194, and 419 stomachs with food, respectively). The months representing the seasons were March, April, and May for spring; June, July, and August for summer; and September, October, and November for fall.

In North and South Carolina, clupeids were present only during summer and engraulids accounted for over one-third of the volume in the fall. Invertebrates consisted of 1.0% or less in both summer and fall (Table 5). In northwest Florida, seasonal variations were relatively minor. The predominant fish families were carangids and sparids during spring, clupeids and carangids during summer, and engraulids and carangids during fall (Table 5). Invertebrates never exceeded 4.8% of the volume in any seasons.

COMPARISONS BETWEEN CAPTURE GEAR

Sufficient data to compare stomach contents in relation to capture gear were available only from northwest Florida. Comparisons of hook-and-line-caught and net-caught Spanish mackerel from other areas were not made due to small sample sizes obtained by one or more gear types. The percent of empty stomachs was higher in fish caught by nets (73%) than by hook and line (59%); the percent occurrence of digested fish remains was higher in net-caught fish (96%) than in fish caught by hook and line (87%) (Table 6). These results may have resulted from: (1) Spanish mackerel regurgitating more readily when caught in nets; (2) fish caught by hook-and-line tending to be engaged in active feeding more often than those caught in nets; (3) digestion continuing while the fish were in the nets; (4) lack of feeding while in gill nets.

The presence of a higher percent volume and frequency of occurrence of clupeids and carangids and mollusks in the hook-and-line-caught fish (Table 6) may have resulted from less digestion time and thereby greater possibility of identification. The possibility of bait bias was present in these fish as well, as the popular bait for hook and line fishing in northwest Florida is the carangid D. punctatus. Hook-and-line-caught Spanish mackerel are

generally caught in deeper waters than net-caught fish. Clupeids, carangids, and mollusks may be more abundant in these deeper waters and, if so, would account for their greater prevalence in the hook-and-line-caught fish.

SUMMARY AND CONCLUSION

Data on the food habits of Spanish mackerel from the five geographical areas indicated that Spanish mackerel are primarily piscivorous and prey heavily on schooling fishes in the families Clupeidae, Carangidae, and Engraulidae.

These three families ranked high in frequency of occurrence and in volume in all five areas. Similarities in their diets were also evidenced by the occurrence of shrimps and squids in the stomachs from all areas. Spanish mackerel from Louisiana exhibited the most variety in their food habits, as the greatest number (9) of fish families, and the greatest variety of invertebrates were found in their stomachs (Table 3).

Small Spanish mackerel preyed mainly on anchovies, while larger Spanish mackerel consumed other fishes, mainly clupeids and carangids. This pattern existed to some degree in all five areas. Species in the other fish category changed slightly from area to area, but consisted mainly of S. aurita and D. punctatus in the Carolinas, east central Florida, and northwest Florida. In Louisiana and Texas other species were more important in their diet. Spanish mackerel are probably more opportunistic feeders as they increase in size. Annual variations in the stomachs of Spanish mackerel from North and South Carolina and northwest Florida changed in regards to the percent volume and percent frequency of occurrence of certain fish families, but the dominant fish prey remained the same for each area. Seasonal variations of stomach contents from North and South Carolina and northwest Florida exhibited more variation than annual, with two fish families being dominant in any one season. Results from net-caught and hook-and-line-caught Spanish mackerel in northwest Florida suggest that distance from shore of the capture site may influence stomach contents.

The high incidence of empty stomachs may indicate that either Spanish mackerel regurgitate easily or have a high rate of digestion. Other authors noted a high percentage of empty stomachs in Spanish mackerel, ranging from 38% to 60% (Miles 1949, Kemp 1950, Klima 1959, Rice 1979, Naughton and Saloman 1981). A rapid rate of digestion may account for the high percentage of unidentifiable fish. Saloman and Naughton (1981) reported frequency of occurrence of between 50-60% digested fish remains, and other authors studying scombrids noted a high percentage of digested fish remains or empty stomachs and attributed this to rapid digestion (Beaumariage 1973 for king mackerel; Morovic 1961 for Adriatic bluefin tuna. Thunnus thynnus).

In conclusion, our data clearly indicate that the Spanish mackerel is a major predator on small schooling fishes in the coastal pelagic ecosystems of the Gulf of Mexico and the southern U.S. Atlantic coast. The importance of engraulids, clupeids, and species of small carangids attests to this.

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Table 1. Summary of samples of Spanish mackerel stomachs.

Length group mm	North & South Carolina		East Central Florida		Northwest Florida		Louisiana		Texas		All Areas	
	With food	Total	With food	Total	With food	Total	With food	Total	With food	Total	With food	Total
50- 99	4	16	0	0	0	0	0	0	0	0	5	16
100-149	72	106	1	3	0	0	1	1	23	45	97	155
150-199	122	276	20	42	0	0	0	0	52	73	194	391
200-249	162	470	31	40	4	23	2	3	6	13	205	549
250-299	119	315	1	10	68	242	21	56	35	62	244	685
300-349	60	148	14	69	350	1,014	73	168	8	17	505	1,416
350-399	148	406	76	345	233	157	88	219	3	5	548	1,832
400-449	35	106	87	250	113	366	86	167	0	1	321	890
450-499	13	34	23	93	48	158	41	81	8	12	133	378
500-549	0	13	15	74	21	81	30	62	19	32	95	262
550-599	6	10	13	52	11	28	48	76	15	21	93	187
600-649	2	4	16	38	1	8	23	40	7	9	49	99
650-699	4	4	9	36	1	2	8	14	1	2	23	58
700-749	0	0	6	15	0	0	0	0	0	0	6	15
Total	757	1,908	312	1,067	850	2,779	421	887	177	292	2,517	6,933
% Empty	60.3		70.8		69.4		52.5		39.4		63.7	

Table 2. Numbers of Spanish mackerel stomachs by year and area.

Year	North & South Carolina		East Central Florida		Northwest Florida		Louisiana		Texas		All Areas	
	With food	Total	With food	Total	With food	Total	With food	Total	With food	Total	With food	Total
1977	8	17	0	0	17	24	34	48	0	0	59	89
1978	3	17	52	107	163	377	45	82	126	214	389	797
1979	0	0	20	22	14	41	0	0	0	0	34	63
1980	380	770	73	195	656	2,337	342	757	51	78	1,502	4,137
1981	366	1,104	167	743	0	0	0	0	0	0	533	1,847
1977-81	757	1,908	312	1,067	850	2,779	421	887	177	292	2,517	6,933

Table 3. Food of Spanish mackerel from five areas. Percentages of categories above genus include contents not identified to lower taxa.

Food Item	Percent Frequency of Occurrence					Percent Volume				
	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas
PISCES	97.6	96.2	96.8	94.3	96.0	97.7	99.1	97.4	97.5	95.6
ENGRAULIDAE	16.5	9.3	1.9	5.9	27.7	29.7	14.8	6.0	7.8	21.5
Anchoa sp	15.8	0.5	1.9	5.5	27.7	28.0	14.8	6.0	7.1	21.5
Anchoa mitchilli	0.7	0	0	0	0	1.7	0	0	0	0
Anchoa hepsetus	0	0	0	0.5	0	0	0	0	0.7	0
CLUPEIDAE	0.8	5.8	2.5	2.8	2.8	4.3	33.3	8.8	21.8	7.9
Sardinella aurita	0.5	3.2	2.0	0.7	0.6	3.1	20.4	6.3	2.9	2.2
Harengula jaguana	0.1	0	0.2	0.2	0	0.7	0	1.6	2.8	0
Opisthonema oglinum	0	0.6	0	0.2	0	0	6.6	0	0.8	0
Alosa chrysochloris	0	0	0.1	0	0	0	0	0.7	0	0
Brevoortia sp.	0	0	0	0.5	0.6	0	0	0	3.1	0.9
Brevoortia tyrannus	0	0.3	0	0.5	0.6	0	2.6	0	7.3	2.1
Brevoortia gunteri	0	0	0	0.2	0	0	0	0	3.1	0
CARANGIDAE	0.5	2.6	2.2	1.7	3.4	3.3	11.3	12.7	3.7	15.6
Chloroscombrus chrysurus	0.4	0.3	0.1	1.4	2.8	1.3	0.1	1.2	2.9	10.5
Decapterus punctatus	0.1	1.3	2.0	0	0.6	2.0	10.3	10.6	0	5.2
Selar crumenophthalmus	0	0.3	0	0	0	0	0.4	0	0	0
Selene setapinnis	0	0	0	0.2	0	0	0	0	0.8	0

Table 3. Continued

Food Item	Percent Frequency of Occurrence					Percent Volume				
	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas
Caranx crysos	0	0	0.1	0	0	0	0	0.9	0	0
Caranx ruber	0	0.3	0	0	0	0	0.4	0	0	0
SCIAENIDAE	0	0.3	0.1	0.5	2.3	0	<0.1	1.7	3.6	7.8
Cynoscion sp.	0	0	0	0	0.6	0	0	0	0	1.0
Micropogonias undulatus	0	0	0	0.5	1.1	0	0	0	3.6	6.5
SCOMBRIDAE	0.1	0.3	0	0	0	0.2	0.3	0	0	0
Scomberomorus sp.	0.1	0	0	0	0	0.2	0	0	0	0
Scomberomorus maculatus	0	0.3	0	0	0	0	0.3	0	0	0
SPARIDAE	0	0	0.4	0.2	0	0	0	4.2	3.1	0
Lagodon rhomboides	0	0	0	0.2	0	0	0	0	3.1	0
TRICHIURIDAE (*Trichiurus lepturus*)	0	0	0	0.2	2.8	0	0	0	0.2	9.0
ATHERINIDAE	0.5	0.3	0	0.2	0	1.5	<0.1	0	0.2	0
Membras martinica	0.1	0	0	0.2	0	0.1	0	0	0.2	0
POMADASYIDAE (*Orthopristis chrysoptera*)	0	0	0	0.2	0	0	0	0	1.2	0
EXOCOETIDAE	0	0.3	0	0	0	0	0.8	0	0	0
BOTHIDAE (*Paralichthys* sp.)	0	0	0	0.2	0	0	0	0	<0.1	0
Digested fish remains	81.5	78.8	91.9	85.5	58.2	58.7	38.6	64.0	56.0	33.8

Table 3. Continued

Food Item	Percent Frequency of Occurrence					Percent Volume				
	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas
CRUSTACEA	0.8	0.3	0.9	5.2	4.0	0.4	0.1	0.2	2.1	2.0
Shrimp	0.4	0.3	0.8	3.3	4.0	0.4	0.1	0.1	1.5	2.0
Penaeus sp.	0.3	0	0	0.5	4.0	0.2	0	0	0.2	2.0
Penaeus duorarum	0	0	0	0.2	0	0	0	0	0.2	0
Penaeus aztecus	0	0.3	0.1	0	0	0	0.1	<0.1	0	0
Penaeus setiferus	0	0	0	0.2	0	0	0	0	0.3	0
Trachypeneus similis	0	0	0	1.0	0	0	0	0	0.9	0
Trachypeneus constrictus	0.1	0	0	0	0	0.1	0	0	0	0
Stomatopoda	0	0	0	0.7	0	0	0	0	0.5	0
Squilla empusa	0	0	0	0.2	0	0	0	0	0.3	0
Isopoda	0.4	0	0	1.0	0	<0.1	0	0	0.1	0
Crab	0	0	0.1	0.2	0	0	0	<0.1	<0.1	0
MOLLUSCA	0.7	3.5	2.1	1.4	1.7	0.4	0.6	2.4	0.4	2.4
Squid	0.7	3.5	2.0	1.0	1.7	0.4	0.6	2.3	0.4	2.4
Loligo sp.	0.1	0	0	0	0	0.1	0	0	0	0
Loligo pealeii	0	0	0.1	0	0.6	0	0	0.3	0	2.2
Pelecypoda	0	0	0.1	0.5	0	0	0	<0.1	<0.1	0

Table 3. Continued

Food Item	Percent Frequency of Occurrence					Percent Volume				
	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas	North & South Carolina	East Central Florida	North-west Florida	Louisiana	Texas
Tellinidae	0	0	0	0.2	0	0	0	0	<0.1	0
Tellina sp.	0	0	0.1	0.2	0	0	0	<0.1	<0.1	0
NEMATODA	19.0	5.1	2.9	1.9	1.7	1.5	0.1	<0.1	<0.1	<0.1
TREMATODA	0.1	0.6	0.1	0.5	0	<0.1	<0.1	<0.1	<0.1	0
Miscellaneous (Cigarette filter)	0	0	0.1	0	0	0	0	<0.1	0	0

Table 4. Food of Spanish mackerel from North and South Carolina and northwest Florida in various years.

Food Item	North and South Carolina 1980 % Occurrence	1980 % Volume	1981 % Occurrence	1981 % Volume
Vertebrates (fish)	99.7	97.9	99.4	99.7
ENGRAULIDAE	11.8	19.4	21.9	39.4
Anchoa mitchilli	0	0	1.4	3.0
Anchoa spp.	11.8	19.4	20.5	36.4
CLUPEIDAE	0.3	0.3	1.4	7.4
Sardinella aurita	0.3	0.3	0.8	5.4
Harengula jaguana	0	0	0.3	1.3
CARANGIDAE	0	0	0.8	2.2
Chloroscombrus chrysurus	0	0	0.8	2.2
SCOMBRIDAE	0.3	0.5	0	0
Scomberomorus sp.	0.3	0.5	0	0
ATHERINIDAE	0	0	1.1	2.6
Digested fish remains	87.6	77.7	75.1	48.1
Invertebrates	2.1	2.1	1.1	0.3
CRUSTACEA	0.5	0.7	1.1	0.3
Shrimp	0.3	0.6	0.6	0.3
Penaeus sp.	0.3	0.6	0.3	<0.1
Trachypeneus constrictus	0	0	0.3	0.2

Food Item	Northwest Florida 1978 % Occurrence	1978 % Volume	1980 % Occurrence	1980 % Volume
Vertebrates (fish)	98.2	97.6	96.3	95.6
ENGRAULIDAE	2.4	4.2	1.5	7.1
Anchoa spp.	2.4	4.2	1.5	7.1
CLUPEIDAE	8.6	22.2	0.6	4.7
Sardinella aurita	8.0	18.6	0.3	2.4
Harengula jaguana	0.6	3.6	0.2	1.1
Alosa chrysochloris	0	0	0.2	1.1
CARANGIDAE	3.1	10.7	2.1	15.8
Chloroscombrus chrysurus	0	0	0.2	1.9
Decapterus punctatus	3.1	10.7	1.8	12.6
Caranx crysos	0	0	0.2	1.4
SCIAENIDAE	0	0	0.2	2.7
Micropogonias undulatus	0	0	0.2	2.7
SPARIDAE	1.2	2.8	0.2	5.5
Lagodon rhomboides	1.2	2.8	0.2	5.5
Digested fish remains	89.0	57.7	87.6	59.9
Invertebrates	3.1	2.4	3.2	4.3
CRUSTACEA	0.6	0.1	1.1	0.3

Table 4. Continued

Food Item	North and South Carolina 1980 % Occurrence	1980 % Volume	1981 % Occurrence	1981 % Volume
Isopoda	0.3	<0.1	0.6	<0.1
MOLLUSKS	1.6	1.4	0	0
Squid	1.6	1.4	0	0
Loligo sp.	0.3	0.2	0	0

Food Item	Northwest Florida 1978 % Occurrence	1978 % Volume	1980 % Occurrence	1980 % Volume
Shrimp	0.6	0.1	0.9	0.2
Crab	0	0	0.2	0.1
MOLLUSKS	2.4	2.3	2.4	4.0
Squid	2.4	2.3	2.1	3.3
Loligo pealeii	2.4	2.3	0.2	0.5
Pelecypoda	0	0	0.2	0.1
Tellina ap.	0	0	0.2	0.1
Miscellaneous (Cigarette filter)	0	0	0.2	0.1

Table 5. Food of Spanish mackerel from North and South Carolina and northwest Florida in various seasons. Percentages for categories above genus include contents not identified to lower taxa.

	North and South Carolina					Northwest Florida					
	Summer		Fall			Spring		Summer		Fall	
Food Item	% Occurrence	% Volume	% Occurrence	% Volume		% Occurrence	% Volume	% Occurrence	% Volume	% Occurrence	% Volume
Vertebrates (fish)	98.9	99.1	99.0	99.0	Vertebrates (fish)	99.6	98.4	96.4	95.2	99.0	97.2
ENGRAULIDAE	14.3	24.7	19.0	36.1	ENGRAULIDAE	0.9	2.0	1.6	2.6	2.6	10.2
Anchoa spp.	14.3	24.7	17.6	32.3	*Anchoa* spp.	0.9	2.0	1.6	2.6	2.6	10.2
Anchoa mitchilli	0	0	1.3	3.8	CLUPEIDAE	0.9	3.1	3.1	11.1	2.9	7.8
CLUPEIDAE	1.6	8.0	0	0	*Sardinella aurita*	0.4	0.4	2.6	8.1	2.4	5.6
Sardinella aurita	1.1	5.9	0	0	*Harengula jaguana*	0	0	0.5	3.0	0.2	1.7
Harengula jaguana	0.3	1.4	0	0	*Alosa chrysochloris*	0.4	2.8	0	0	0	0
CARANGIDAE	0.8	2.4	0.3	4.5	CARANGIDAE	0.4	8.9	4.6	22.0	2.2	10.2
Decapterus punctatus	0	0	0.3	4.5	*Chloroscombrus chrysurus*	0	0	0.5	5.0	0	0
Chloroscombrus chrysurus	0.8	2.4	0	0	*Decapterus punctatus*	0.4	8.9	3.6	13.5	2.2	10.2
ATHERINIDAE	1.1	2.8	0.3	0.3	*Caranx crysos*	0	0	0.5	3.6	0	0
Membras martinica	0	0	0.3	0.3	SCIAENIDAE	0	0	0.5	6.9	0	0
SCOMBRIDAE	0	0	0.3	0.4	*Micropogonias undulatus*	0	0	0.5	6.9	0	0
Scomberomorus sp.	0	0	0.3	0.4	SPARIDAE	0.5	13.3	1.0	2.7	0	0
Digested fish remains	82.7	61.2	79.7	57.7	*Lagodon rhomboides*	0.4	13.3	1.0	2.7	0	0
Invertebrates	1.9	0.9	1.3	1.0	Digested fish remains	96.5	71.1	88.1	49.8	93.3	69.0
CRUSTACEA	0.8	0.3	0.8	0.6	Invertebrates	2.6	1.6	5.2	4.8	2.6	2.8
Shrimp	0.3	0.3	0.5	0.6	CRUSTACEA	1.3	0.1	1.6	0.3	0.7	0.2

Table 5. Continued

Food Item	North and South Carolina Summer % Occurrence	Summer % Volume	Fall % Occurrence	Fall % Volume
Penaeus sp.	0	0	0.5	0.6
Trachypeneus constrictus	0.3	0.3	0	0
Isopoda	0.5	<0.1	0.3	<0.1
MOLLUSKS	1.1	0.6	0.5	0.4
Squid	1.1	0.6	0.5	0.4
Loligo sp.	0	0	0.3	0.2

Food Item	Northwest Florida Spring % Occurrence	Spring % Volume	Summer % Occurrence	Summer % Volume	Fall % Occurrence	Fall % Volume
Shrimp	1.3	0.1	1.0	0.1	0.7	0.2
Crab	0	0	0.5	0.2	0	0
MOLLUSKS	1.3	1.5	3.6	4.6	1.9	2.5
Squid	1.3	1.5	3.6	4.6	1.7	2.4
Loligo pealeii	0	0	0	0	0.2	0.7
Pelecypoda	0	0	0	0	0.2	0.1
Tellina sp.	0	0	0	0	0.2	0.1
Miscellaneous (cigarette filter)	0	0	0.5	0.2	0	0

Table 6. Data on stomachs and contents for Spanish mackerel caught by net and by hook and line in northwest Florida.

Item	Net	Hook and Line
Number of stomachs examined	2,147	632
Number of stomachs with food	583	258
Percent empty stomachs	72.8	59.2
Average fork length (mm)	362	380
Average stomach volume (ml)	2.2	3.1

	Net		Hook and Line	
Stomach Contents	% Occurrence	% Volume	% Occurrence	% Volume
Digested fish remains	95.7	75.4	86.8	45.6
Clupeidae	1.2	5.9	5.4	13.3
Carangidae	0.3	4.0	6.6	26.3
Engraulidae	1.9	7.9	1.9	3.0
Other fish families	0.2	5.7	1.2	6.1
Crustaceans	1.2	0.3	0.8	<0.1
Mollusks	1.2	0.8	4.7	5.8

LIST OF FIGURES

Number

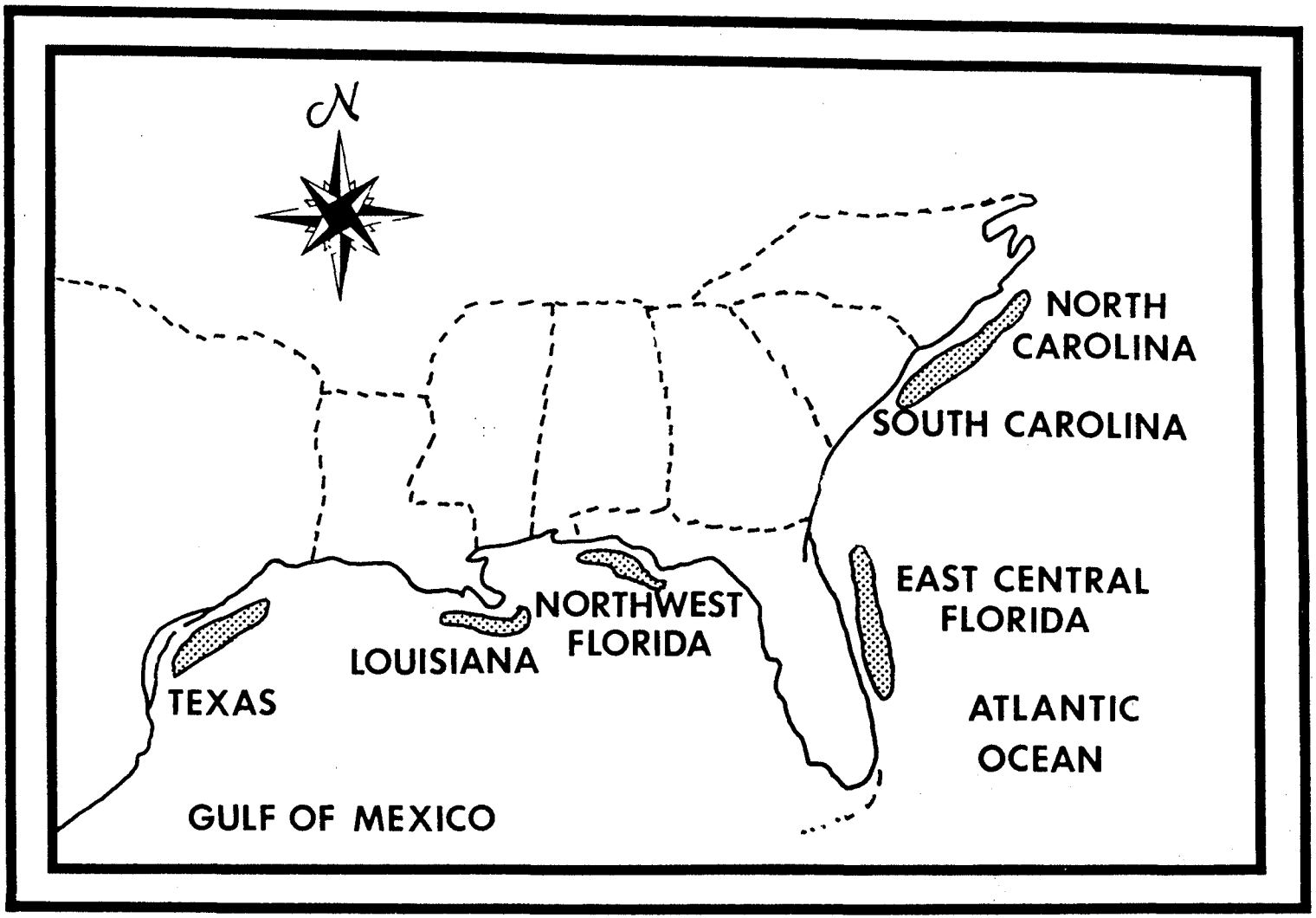

Figure 1. Sampling areas for Spanish mackerel food study.

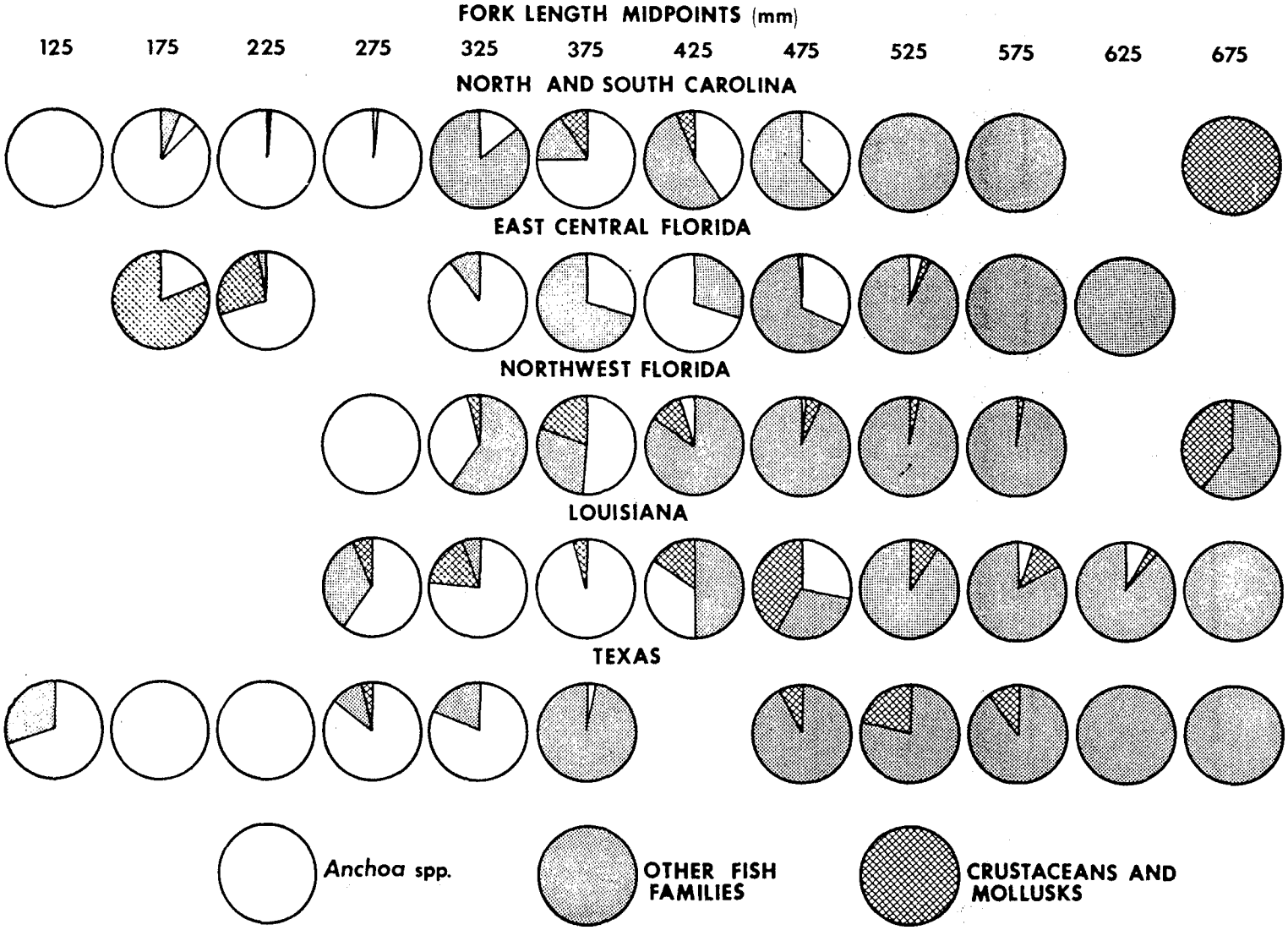

Figure 2. Percentage volumes of major identifiable food items in relation to size of Spanish mackerel. Other fish families include all families except Engraulidae.

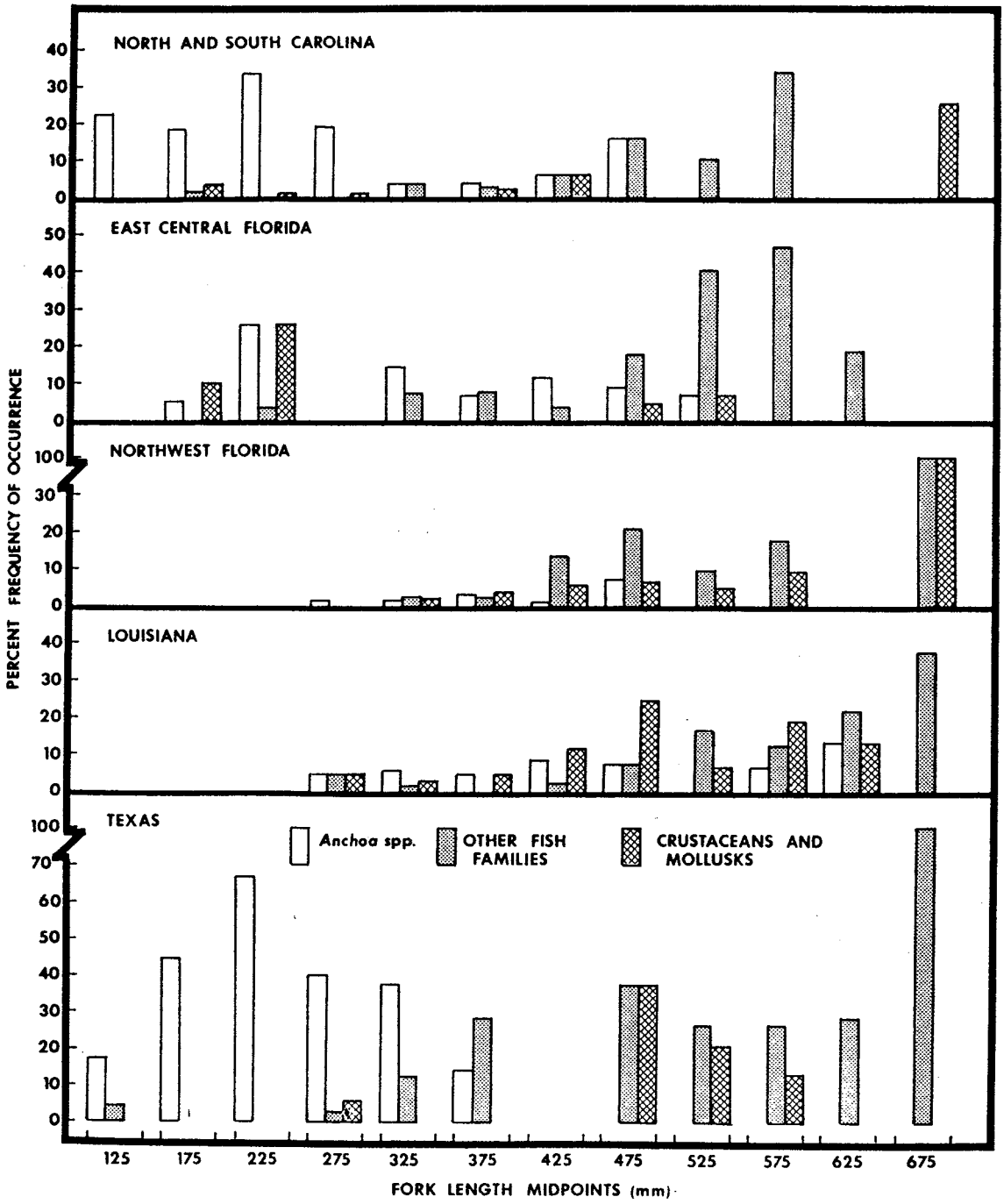

Figure 3. Percentage frequency of occurrence of major identifiable food items in relation to size of Spanish mackerel. Other fish families include all families except Engraulidae.