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Food of king mackerel, Scomberomorus cavalla, from the southeastern United States including the Gulf of Mexico

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ABSTRACT

The stomachs of 11,766 king mackerel caught between June 1977 and November 1981 from seven areas (North and South Carolina, Georgia, east central Florida, south Florida, northwest Florida, Louisiana, and Texas) were examined. Forty-one percent of the stomachs were empty. The percent volume of fish in non-empty stomachs ranged from 84.9% in northwest Florida to 99.6% in Louisiana. The percent frequency of occurrence of fish ranged from 77.5% in south Florida to 99.1% in Texas. Thirty-one fish families were contained in the diet. Clupeidae, the dominant family, was present in stomachs from all seven areas. Other families of importance were Carangidae, Sciaenidae, Engraulidae, Trichiuridae, Exocoetidae, and Scombridae. Decapterus punctatus was the most important fish species in Georgia and northwest Florida, whereas in each of the other five areas, a different species was most important: Brevoortia sp. in North and South Carolina, Sardinella aurita in east central Florida, Hemiramphus brasiliensis in south Florida, Cynoscion arenarius in Louisiana, and Trichiurus lepturus in Texas. Lengths of the four most abundant prey species exhibited little variation with the sizes of king mackerel. Squid was the dominant invertebrate in the stomachs from North and South Carolina, Georgia, east central Florida, and northwest Florida, while penaeid shrimp was dominant in south Florida and Texas. King mackerel were primarily piscivorous; they fed heavily on schooling fishes in all seven areas.

INTRODUCTION

The king mackerel, Scomberomorus cavalla, is a valuable commercial and recreational species normally found along the eastern and Gulf of Mexico coasts of North America. Its range extends to the coast of Brazil in South America (Berrien and Finan 1977). In the United States the commercial landings averaged over 8 million pounds (3.6 million kilograms) per year during 1973-77; recreational catches of king mackerel are believed to have been several times greater than the commercial catches (Manooch 1979).

Studies of the food of king mackerel have been reported by DeVane (1978) for North Carolina; Beaumariage (1973) and Naughton and Saloman (1981) for Florida; Knapp (1949), Miles (1949), Kemp (1950), and Simmons and Breuer (1964) for Texas; Menezes (1969) for Brazil; and Randall (1967) for the West Indies. No one, however, has conducted a comparative food study for this species.

Presented in this report are the results of food comparisons of king mackerel from seven areas in the Gulf of Mexico and southeastern seaboard of the United States (Figure 1). We compare the food between areas, seasons, and sizes of king mackerel. We also examine the sizes of food fishes eaten by king mackerel of various lengths.

MATERIALS AND METHODS

Stomachs were obtained from 11,766 king mackerel. The mackerel were caught by gill nets, seines, and recreational anglers from June 1977 through November 1981 as follows: 2,863 samples from North and South Carolina, 549 from Georgia, 589 from east central Florida, 1,472 from south Florida, 3,778 from northwest Florida, 1,007 from Louisiana, and 1,508 from Texas (Table 1). Fork length (FL) to the nearest millimeter was measured before removing stomachs and gonads, which were then wrapped in gauze and preserved in 10% Formalin.

In the laboratory, the stomachs were rinsed in tap water and cut longitudinally. Walls of each stomach 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, drained, blotted dry, and identified. Volumes were obtained by water displacement in a graduated cylinder to the nearest 0.1 ml. Numbers of individuals of each taxon could not always be accurately determined owing to digestion. Fork length measurements of food fishes were taken whenever possible. Frequency of occurrence of each food type was determined by counting the stomachs that contained the specific item; only stomachs containing food were used in our analyses.

STOMACH CONTENTS

Of the 11,766 stomachs of king mackerel obtained in the seven areas, 59.3% contained food while 40.7% were empty. The frequency of empty stomachs was highest in south Florida and lowest in northwest Florida (Table 1).

The major categories of items in the stomachs were fish, crustaceans, and mollusks. Of the fishes, 31 families and at least 62 species were identified. Of the crustaceans, 11 species, of which 7 were penaeid shrimps and 2 were crabs, were identified. Of the mollusks, three species, of which two were squids, were identified. Shrimp and squid were the two most important invertebrates (Table 2). Additional items found in the stomachs included other crustaceans (stomatopods, lobster, amphipods, isopods), gastropods, polychaetes, coral, trematodes, nematodes, and plants (Table 2). The trematodes and nematodes were parasites in the stomachs. The brown alga Sargassum and the turtle grass Thalassia as well as the hard coral were probably incidentally ingested.

AREA VARIATIONS

Comparisons between areas of the three major food categories (fish, shrimp, squid) showed clearly that fish by both percent volume and percent frequency of occurrence was considerably more important than invertebrates as food sources for king mackerel. The percent volume of fish ranged from 84.9% in northwest Florida to 99.6% in Louisiana, while the percent frequency of occurrence ranged from 77.5% in south Florida to 99.1% in Texas (Table 2). Shrimp and squid occurred much less frequently and comprised much less of the food volume (Figure 2). Squid was more important than shrimp in four of the seven areas. The three areas where shrimp was more important than squid were south Florida, Louisiana, and Texas.

Comparisons of the composition of food fishes among areas indicated that a pattern of variation based upon the importance of clupeids was discernible (Figure 3). Along the Atlantic coast (North and South Carolina, Georgia, and east central Florida), clupeids were of major importance as food fishes, while carangids, sciaenids, exocoetids, and scombrids were of moderate importance, and trichiurids and engraulids were of minor importance. In the other areas, clupeids were of moderate importance, while the most important family of food fishes differed by locality, namely, exocoetids in south Florida, carangids in northwest Florida, sciaenids in Louisiana, and trichiurids in Texas. Carangids were important in the Gulf of Mexico as either of major importance (northwest Florida) or of moderate importance (along with clupeids in Louisiana and Texas).

Of the 31 families of identified food fishes, Clupeidae was the only one found in stomachs of king mackerel from each of the seven areas (Table 2). More species were identified in Clupeidae than in any other family. Of the eight identified species, Sardinella aurita was eaten by king mackerel in each of the seven areas. Brevoortia patronus, the gulf menhaden, was eaten only in the northern Gulf of Mexico, the only known geographic distribution for this species and where it is the basis of the largest fishery in the United States (U.S. Dept. of Commerce 1982). Brevoortia tyrannus and B. smithi were eaten only in North and South Carolina and in Georgia where they too are the basis of a major fishery (U.S. Dept. of Commerce 1982); these two species do not occur in south Florida or in the Gulf of Mexico. Harengula jaguana and Opisthonema oglinum were eaten both in the Atlantic and the Gulf of Mexico; these two species are widely distributed in the western Atlantic Ocean.

Five fish families were represented in the stomachs from six of the seven areas (Table 2). Carangidae and Sciaenidae were present in all areas except south Florida, Scombridae in all areas except east central Florida, Mugilidae in all areas except northwest Florida, and Engraulidae in all areas except Georgia. Of the carangids, Caranx crysos, Chloroscombrus chrysurus, and Decapterus punctatus were the three most important species of the eight identified genera. Decapterus punctatus was especially important as prey in northwest Florida. Of the sciaenids, Cynoscion arenarius, C. nebulosus, Leiostomus xanthurus, and Micropogonias undulatus were the most frequently eaten; Cynoscion spp. and M. undulatus were especially important in Louisiana. Five identified species of scombrids were eaten, but none was particularly significant. Of the mugilids, Mugil cephalus was the most frequently eaten, but it was not especially noteworthy. The engraulids, which were found to be important food fishes for juvenile king mackerel (Naughton and Saloman 1981), were not very important to adult king mackerel.

Two other species of food fishes were important. Hemiramphus brasiliensis was a major prey for king mackerel in south Florida, while Trichiurus lepturus was a major prey in Texas.

Others also have found that fish is the most important item in the diet of king mackerel. As in our study, Clupeidae was found to be the most important family of fish based on frequency of occurrence by Menezes (1969) in Brazil, Beaumariage (1973) in south Florida, DeVane (1978) in North Carolina, and Kemp (1950) and Miles (1949) in Texas. Naughton and Saloman (1981) in northeast Florida found clupeids ranked second to engraulids in frequency of occurrence, while Knapp (1949) ranked clupeids fourth in frequency of occurrence off Texas.

Of the clupeid species, Menezes (1969) in Brazil and Beaumariage (1973) in south Florida recorded O. oglinum to have the highest percentage frequency of occurrence, while DeVane (1978) found B. tyrannus to have the highest percentage of occurrence in North Carolina. The scaled sardine, H. jaguana, was ranked second in frequency of occurrence by Knapp (1949) and Beaumariage (1973), while DeVane (1978) listed O. oglinum second. Kemp (1950) and Miles (1949) listed Brevoortia spp. as the dominant fish found in king mackerel stomachs from Texas waters.

The lesser importance of squid and shrimp in the diet of king mackerel is in agreement with Knapp (1949), Menezes (1969), Beaumariage (1973), DeVane (1978), and Miles (1949). Naughton and Saloman (1981) recorded a frequency of occurrence of 23.6% for squid in the stomachs of juvenile king mackerel from east central Florida, but recorded no shrimp.

SEASONAL VARIATIONS

For seasonal comparisons, the data were segregated into spring (March, April, May), summer (June, July, August), fall (September, October, November), and winter (December, January, February) for the seven areas. Data were not available for all seasons in every area (Figures 4 and 5).

Of the major food categories, the only notable seasonal variation appeared to be the greater importance of squid as food in summer and fall in all areas (Figure 4). As expected, fish was the primary food source in every instance. The importance of shrimp appeared to be related to area (e.g., south Florida and Texas) rather than season.

Examination of seasonal variations of the major food-fish families in the stomachs of king mackerel revealed notable features in east central Florida, south Florida, Louisiana, and Texas (Figure 5). In east central Florida, engraulids were especially important as food in fall and to a lesser extent in winter. In south Florida, exocoetids were especially important in fall and winter. In Louisiana, clupeids were especially important in summer and fall. In Texas, carangids were as important as trichiurids in the spring, but were of lesser importance in summer and fall. In Georgia, where data were available only in summer and fall, clupeids were the most important in summer, whereas clupeids, exocoetids, and scombrids were important in fall. In the remaining two areas, variations in composition of food-fishes appeared to be associated more with area then with season.

SIZE VARIATIONS

Stomach contents were analyzed by three size groups of king mackerel. The three groups were divided as follows: small (0-599 mm FL), medium (600-999 mm FL), and large (1,000-1,599 mm FL). Squid and shrimp were eaten more frequently and made up a larger volume in small and medium king mackerel than in large king mackerel (Figure 6). As expected, fish was the most important food source for all three sizes of king mackerel.

Several notable variations were evident in examining food-fish families between size groups of king mackerel within an area (Figure 7). In North and South Carolina, engraulids decreased and scombrids increased with increasing sizes of king mackerel. In east central Florida, engraulids were important only to small king mackerel. In south Florida, exocoetids were more important to small and medium king mackerel than to large king mackerel. In northwest Florida, scombrids were eaten only by large king mackerel. In Louisiana, clupeids were most important to medium king mackerel, while sciaenids were most important to large king mackerel. In Georgia and Texas, notable variations were not evident.

PREY LENGTHS

Most of the species of food fishes taken from king mackerel stomachs were less than 200 mm FL and averaged generally between 100 and 150 mm FL. The exceptions were Anchoa spp. (25-114 mm FL), Hemiramphus brasiliensis (208-374 mm FL), and Trichiurus lepturus (114-800 mm FL). Of the measured prey, four species were sufficiently abundant to evaluate the relation between predator and prey lengths (Figure 8). The average length of each prey species changed little in relation to length of king mackerel.

DISCUSSION

King mackerel probably have a high rate of digestion as evidenced by the high incidence of empty stomachs and the high frequency of unidentified fish remains in the stomachs. Others have suggested this for king mackerel (Beaumariage 1973) as well as in other scombrids (e.g., Morovic 1961).

The treatment of bait in food studies has been a concern. In some studies it has been ignored (Beaumariage 1973, DeVane 1978). Menezes (1969) listed the baits found in order of frequency, but did not state whether or not the bait was included as stomach contents. In studies on tuna where the bait used for capture did not occur in the fishing area, the bait has been omitted from the analysis (Reintjes and King 1953; King and Ikehara 1956; Nakamura 1965).

In the recreational hook-and-line fishery of the southeastern United States and the Gulf of Mexico, baits vary considerably, but in each area, one type of bait is usually more popular. The popular bait used in four of the seven areas (south Florida, H. brasiliensis; northwest Florida, D. punctatus; Louisiana, sciaenids, either C. arenarius or M. undulatus; and Texas, T. lepturus) all ranked either first or second in frequency of occurrence in the respective areas. The most popular bait used in the Carolinas and Georgia is strip bait attached to an artificial lure and off east central Florida, spoons and trolling feather are popular. In this study, bait that was used to catch the king mackerel was virtually impossible to identify, and therefore the entire contents of the stomachs were included. The mode of feeding in king mackerel also made it difficult to determine the bait used. A whole fish occurred rarely in the stomach, as king mackerel usually bit or chopped the prey in half. If the data on the most popular bait species used for capture were deleted, the composition of their diet would be essentially clupeids, squid, and shrimp.

That king mackerel are primarily piscivorous is apparent. Equally apparent is the propensity of king mackerel to feed upon schooling prey. The clupeids, carangids, sciaenids, trichiurids, exocoetids, engraulids, and scombrids, all of which were found to be very, or moderately, important food sources, are all schooling fishes. That king mackerel are also opportunistic is evidenced by the occurrence of non-schooling or non-aggregating species, such as synodontids, triglids, and other fishes, as well as some of the invertebrates.

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Table 1. Summary of stomach samples of king mackerel obtained from June 1977 through November 1981 in seven areas of the southeastern United States.

Area	Total stomachs	Stomachs with food	% empty
North and South Carolina	2,863	',468	48.7
Georgia	549	243	55.7
East central Florida	589	210	64.3
South Florida	1,472	518	64.8
Northwest Florida	3,778	2,784	26.3
Louisiana	1,007	707	29.8
Texas	1,508	1,052	30.2
Total	11,766	6,982	40.7

Table 2. Summary of stomach contents of king mackerel from seven areas of the southeastern United States. Dashes indicate less than 0.5%.

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Vertebrates	92.2	93.6	89.7	91.4	91.0	97.9	75.7	89.6	95.4	84.9	98.4	99.6	99.1	94.0
Bird bone	0	0	0	0	0	0	--	--	0	0	--	--	--	--
Fishes	92.2	93.6	89.7	91.4	91.0	97.9	75.5	89.6	95.4	84.9	98.3	99.6	99.0	94.0
CLUPEIDAE	7.6	21.1	9.9	20.5	17.1	39.7	2.3	4.4	9.2	14.8	32.7	26.8	6.2	10.9
Alosa chrysochloris	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Alosa sp.	--	--	0	0	0	0	0	0	0	0	0	0	0	0
Brevoortia patronus	0	0	0	0	0	0	0	0	--	0.7	7.2	9.5	--	0.8
Brevoortia smithi	0	0	0.8	2.6	0	0	0	0	0	0	0	0	0	0
Brevoortia tyrannus	0.7	3.6	0.8	1.6	0	0	0	0	0	0	0	0	0	0
Brevoortia spp.	1.4	5.6	1.6	2.9	0.5	--	0	0	--	--	4.7	3.3	1.3	2.8
Dorosoma petenense	0	0	--	1.3	0	0	0	0	0	0	0	0	--	0.8
Harengula jaguana	--	1.1	--	--	0.5	3.1	--	--	--	--	--	--	0	0
Opisthonema oglinum	--	1.5	--	--	0.5	--	0	0	--	--	6.8	7.8	0.5	2.1
Sardinella aurita	1.8	4.7	2.5	3.2	9.0	24.3	0.6	0.7	5.1	9.6	--	--	2.1	3.9
CARANGIDAE	2.9	5.6	6.2	9.7	0.0	1.0	0	0	33.2	38.4	11.3	10.4	9.1	12.6
Caranx crysos	--	1.5	0	0	0	0	0	0	--	1.2	1.6	5.0	--	--
Chloroscombrus chrysurus	--	0.6	1.2	2.4	0.5	0.6	0	0	0.6	1.5	3.7	1.8	4.4	6.9
Decapterus punctatus	1.6	2.2	3.7	6.4	0	0	0	0	25.6	29.9	1.3	--	3.0	3.8

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Oligoplites saurus	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Selene vomer	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Seriola sp.	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Trachinotus carolinus	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Trachurus lathami	0	0	0	0	0	0	0	0	--	--	0	0	0	0
SCIAENIDAE	--	--	4.1	7.9	1.0	0.5	0	0	--	--	22.9	43.0	1.0	1.2
Bairdiella chrysoura	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Cynoscion arenarius	0	0	0	0	0	0	0	0	0	0	6.1	18.2	0	0
Cynoscion nebulosus	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Cynoscion spp.	--	--	0	0	0	0	0	0	0	0	9.3	11.4	0	0
Leiostomus xanthurus	0	0	--	1.9	0	0	0	0	--	--	--	--	0.5	0.8
Micropogonias undulatus	0	0	2.5	4.4	0	0	0	0	0	0	5.9	12.4	--	--
Stellifer lanceolatus	0	0	--	--	0	0	0	0	0	0	0	0	0	0
SCOMBRIDAE	--	6.2	0.8	2.5	0	0	0	3.7	--	0.9	1.3	3.1	--	1.8
Euthynnus alletteratus	0	0	0	0	0	0	--	3.3	0	0	0	0	0	0
Sarda sarda	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Scomber japonicus	--	--	0	0	0	0	0	0	--	--	0	0	0	0
Scomber scombrus	--	0.5	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Scomberomorus maculatus	0	0	0	0	0	0	0	0	0	0	--	0.7	--	1.8
Scomberomorus sp.	0	0	0	0	0	0	0	0	0	0	0.6	1.6	0	0
LUTJANIDAE	0	0	0	0	0	0	1.4	10.9	--	--	0	0	--	1.4
Lutjanus campechanus	0	0	0	0	0	0	--	4.7	0	0	0	0	--	0.7
Lutjanus griseus	0	0	0	0	0	0	--	2.4	0	0	0	0	0	0
Lutjanus mahogoni	0	0	0	0	0	0	0	0	0	0	0	0	--	0.5
Lutjanus synagris	0	0	0	0	0	0	--	0.6	--	--	0	0	0	0
Ocyurus chrysurus	0	0	0	0	0	0	--	1.2	0	0	0	0	0	0
Rhomboplites aurorubens	0	0	0	0	0	0	--	2.0	0	0	0	0	0	0
SPARIDAE	--	2.0	0	0	0	0	--	--	--	--	0.6	1.1	--	0.8
Archosargus probatocephalus	0	0	0	0	0	0	0	0	0	0	--	0.5	0	0
Archosargus sp.	--	--	0	0	0	0	0	0	0	0	0	0	0	0
Lagodon rhomboides	--	1.6	0	0	0	0	--	--	--	--	--	0.6	--	0.7
Stenotomus caprinus	--	--	0	0	0	0	0	0	0	0	0	0	--	--
SYNODONTIDAE	--	2.4	0	0	0	0	--	--	--	0.7	--	--	0	0
Saurida brasiliensis	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Synodus foetens	--	--	0	0	0	0	0	0	--	--	--	--	0	0
Synodus sp.	--	1.4	0	0	0	0	0	0	--	--	0	0	0	0

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Trachinocephalus myops	--	--	0	0	0	0	0	0	0	0	0	0	0	0
MUGILIDAE	0.6	1.8	1.2	3.2	1.9	3.0	--	3.2	0	0	--	--	--	--
Mugil cephalus	--	--	--	1.8	0.5	2.8	--	1.2	0	0	0	0	0	0
Mugil curema	0	0	0	0	0	0	--	2.0	0	0	--	--	0	0
Mugil sp.	--	0.8	0	0	0	0	0	0	0	0	--	--	--	--
LABRIDAE	--	1.2	0	0	0	0	0	0	--	--	0	0	0	0
Bodianus pulchellus	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Halichoeres caudalis	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Hemipteronotus novacula	--	1.3	0	0	0	0	0	0	--	--	0	0	0	0
HAEMULIDAE	0	0	0	0	0	0	--	0.6	--	--	0	0	--	1.3
Haemulon aurolineatum	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Haemulon plumieri	0	0	0	0	0	0	0	0	0	0	0	0	--	0.6
Orthopristis chrysoptera	0	0	0	0	0	0	0	0	--	--	0	0	0	0
SERRANIDAE	--	2.7	0	0	0	0	--	1.7	--	--	0	0	0	0
Centropristis striata	--	2.9	0	0	0	0	0	0	0	0	0	0	0	0
Diplectrum bivittatum	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Epinephelus sp.	0	0	0	0	0	0	--	1.7	0	0	0	0	0	0
TRIGLIDAE	--	--	0	0	0	0	0	0	--	--	--	--	--	--

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total Vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Prionotus sp.	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Prionotus rubio	0	0	0	0	0	0	0	0	0	0	0	0	--	--
POLYNEMIDAE	0	0	--	0.8	0	0	0	0	--	--	--	--	--	--
Polydactylus sp.	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Polydactylus octonemus	0	0	--	0.8	0	0	0	0	--	--	--	--	0	0
ENGRAULIDAE	3.0	1.3	0	0	11.0	4.7	--	--	--	--	--	--	--	--
Anchoa sp.	0.9	--	0	0	0	0	0	0	--	--	--	--	--	--
Anchoa hepsetus	1.8	1.2	0	0	0	0	0	0	0	0	0	0	0	0
EXOCOETIDAE	0.7	2.3	3.3	4.4	1.4	3.9	20.3	34.6	--	--	0	0	0	0
Hemiramphus sp.	0	0	0	0	0	0	--	--	0	0	0	0	0	0
Hemiramphus brasiliensis	--	0.9	0.8	0.9	0	0	10.0	20.1	0	0	0	0	0	0
TRICHIURIDAE	--	--	--	0.8	0	0	0	0	--	--	6.1	3.1	20.5	24.9
Trichiurus lepturus	--	--	--	0.8	0	0	0	0	--	--	6.1	3.1	20.5	24.9
CORYPHAENIDAE	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Coryphaena hippurus	0	0	0	0	0	0	0	0	0	0	--	--	0	0
ELOPIDAE	--	--	0	0	0	0	0	0	0	0	--	--	0	0
Elops saurus	--	--	0	0	0	0	0	0	0	0	--	--	0	0

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
BELONIDAE	--	--	0	0	0	0	0	0	0	0	0	0	0	0
Strongylura sp.	--	--	0	0	0	0	0	0	0	0	0	0	0	0
ELEOTRIDAE	0	0	0	0	0.5	--	0	0	0	0	0	0	0	0
Dormitator maculatus	0	0	0	0	0.5	--	0	0	0	0	0	0	0	0
CYNOGLOSSIDAE	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Symphurus sp.	0	0	0	0	0	0	0	0	0	0	--	--	0	0
BALISTIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0.6	1.4
Balistes capriscus	0	0	0	0	0	0	0	0	0	0	0	0	--	0.5
POMACANTHIDAE	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Pomacanthus paru	0	0	0	0	0	0	0	0	0	0	0	0	--	--
SPHYRAENIDAE	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Sphyraena borealis	0	0	0	0	0	0	0	0	--	--	0	0	0	0
POMATOMIDAE	--	0.5	0	0	0	0	0	0	0	0	--	0.9	0	0
Pomatomus saltatrix	--	--	0	0	0	0	0	0	0	0	--	0.9	0	0
SCARIDAE	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Sparisoma sp.	0	0	0	0	0	0	0	0	--	--	0	0	0	0
BOTHIDAE	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Paralichthys sp.	0	0	0	0	0	0	0	0	0	0	0	0	--	--

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
OPHICHTHIDAE	--	--	0.8	1.0	0	0	--	--	0	0	--	--	--	--
Ophichthus gomesi	--	--	0	0	0	0	0	0	0	0	0	0	0	0
EPHIPPIDAE	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Chaetodipterus faber	0	0	0	0	0	0	0	0	0	0	--	--	0	0
CHAETODONTIDAE	0	0	0	0	0	0	0	0	--	--	0	0	0	0
CONGRIDAE	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Digested fish remains	74.9	44.9	62.6	40.5	57.1	44.9	49.6	29.7	50.9	26.7	41.2	9.2	59.6	34.2
Invertebrates	30.2	6.4	44.9	8.6	19.0	2.1	34.2	10.4	56.0	15.1	9.0	--	24.9	6.0
Crustaceans	2.5	0.8	3.3	0.5	2.9	--	32.2	10.2	1.4	0.5	4.2	--	14.5	3.1
PENAEIDAE	2.1	0.7	1.6	0.5	1.0	--	31.7	9.1	1.1	0.5	4.0	--	11.5	1.8
Penaeus sp.	0.7	--	--	--	0	0	9.3	3.5	0.7	--	1.0	--	3.6	0.9
Penaeus duorarum	--	--	0	0	0	0	8.1	3.6	--	--	--	--	0.8	--
Penaeus aztecus	--	--	0	0	0	0	0	0	--	--	0	0	0.8	--
Penaeus setiferus	--	--	--	--	0	0	0	0	--	--	--	--	--	--
Sicyonia sp.	0	0	0	0	0	0	0	0	--	--	--	--	--	--
Sicyonia dorsalis	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Trachypeneus sp.	0	0	0	0	0	0	0	0	0	0	1.0	--	--	--

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Trachypeneus constrictus	--	--	0	0	0	0	0	0	0	0	0	0	--	--
Trachypeneus similis	--	--	0	0	0	0	0	0	--	--	--	--	0.8	--
STOMATOPODA	0	0	0	0	0	0	--	--	0	0	--	--	1.7	0.8
Meiosquilla sp.	0	0	0	0	0	0	0	0	0	0	--	--	0	0
Squilla empusa	0	0	0	0	0	0	--	--	0	0	0	0	1.1	0.5
CRAB	--	--	0	0	0	0	0	0	--	--	0	0	0.6	--
Callinectes ornatus	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Paguridae	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Pilumus dasypodus	--	--	0	0	0	0	0	0	0	0	0	0	0	0
Portunidae	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Portunus sp.	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Unidentified larvae	0	0	0	0	0	0	0	0	--	--	0	0	0	0
LOBSTER	0	0	0	0	0	0	--	1.0	0	0	0	0	0	0
Scyllarides nodifer	0	0	0	0	0	0	--	1.0	0	0	0	0	0	0
AMPHIPODA	0	0	0	0	0	0	0	0	--	--	0	0	0	0
Hyperiidae	0	0	0	0	0	0	0	0	--	--	0	0	0	0
ISOPODA	--	--	1.6	--	1.9	--	0	0	--	--	0	0	--	--
Limnoria lingnorum	0	0	0	0	0	0	0	0	0	0	0	0	--	--

Table 2. Continued

Item	North & South Carolina		Georgia		East Central Florida		South Florida		Northwest Florida		Louisiana		Texas	
	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.	% Freq. occ.	% Total vol.
Unidentified sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusks	13.1	5.5	22.6	7.7	11.9	1.8	0.6	0.2	39.2	14.5	2.1	--	8.5	2.9
GASTROPODA	--	--	0	0	0	0	0	0	--	--	--	--	0	0
Natica pusilla	0	0	0	0	0	0	0	0	0	0	--	--	0	0
NUDIBRANCHIA	0	0	--	--	0	0	0	0	0	0	0	0	0	0
SQUID	12.9	5.5	22.6	7.7	11.9	1.8	0.6	--	36.2	10.6	2.0	--	8.5	2.9
Loligo pealeii	1.1	2.1	1.6	1.2	0	0	0	0	2.2	2.8	0	0	0.7	0.8
Lolliguncula brevis	--	--	0	0	0	0	0	0	0.8	1.1	--	--	--	--
POLYCHAETA	--	--	0	0	0	0	0	0	0	0	0	0	0	0
CORAL (HARD)	0	0	0	0	0	0	0	0	--	--	0	0	0	0
TREMATODA	0.6	--	1.6	--	0	0	--	--	0.8	--	2.6	--	0	0
NEMATODA	14.0	--	16.9	--	4.3	--	1.2	--	14.5	--	0.1	--	0	0
Algae	0	0	0	0	0.5	--	0	0	0	0	0	0	--	--
Sargassum sp.	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Seagrass	0	0	0	0	0	0	--	--	0	0	0	0	1.2	--
Thalassia testudinum	0	0	0	0	0	0	0	0	0	0	0	0	0.7	--

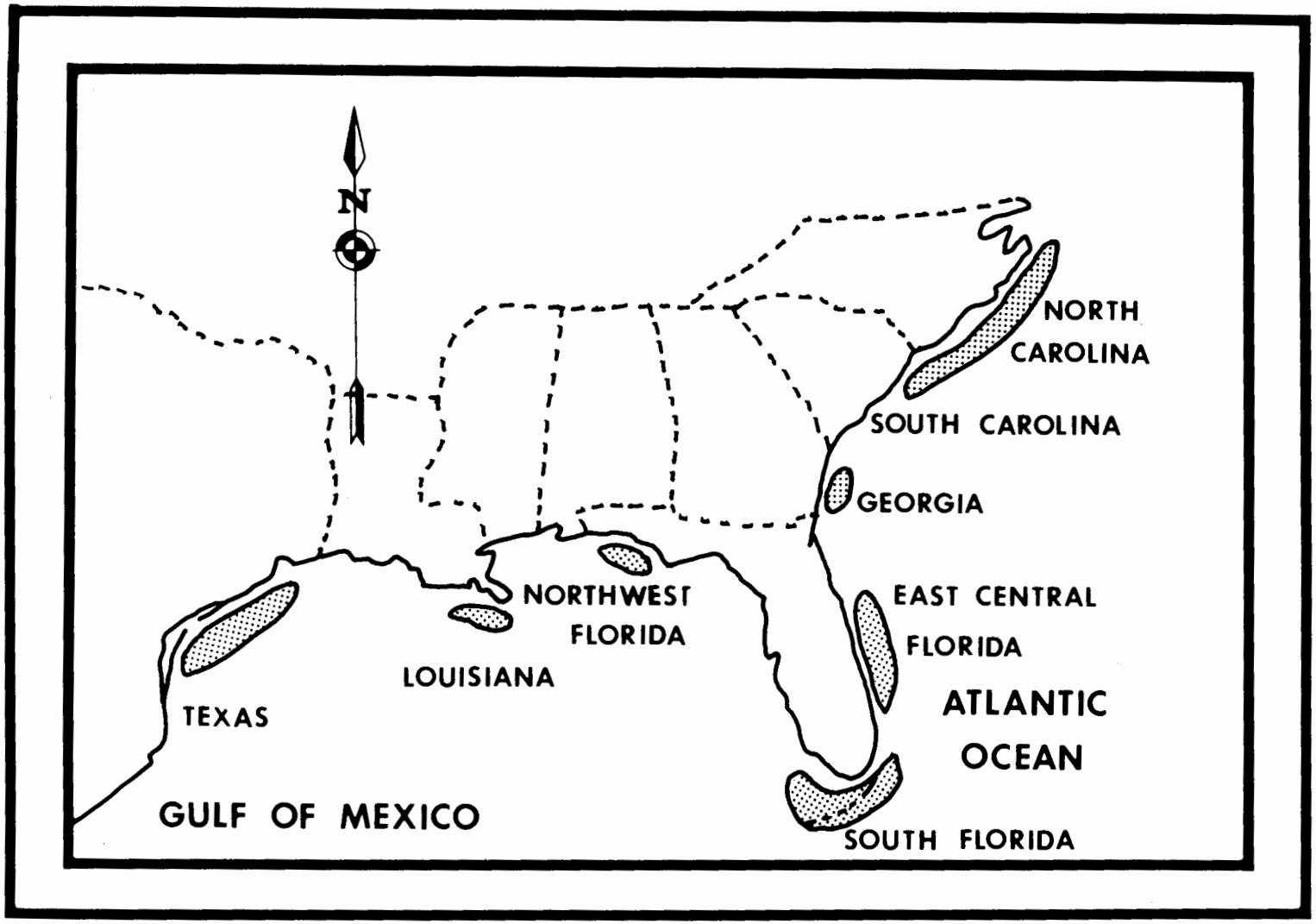

Figure 1. Sampling areas during 1977-81 for king mackerel food study.

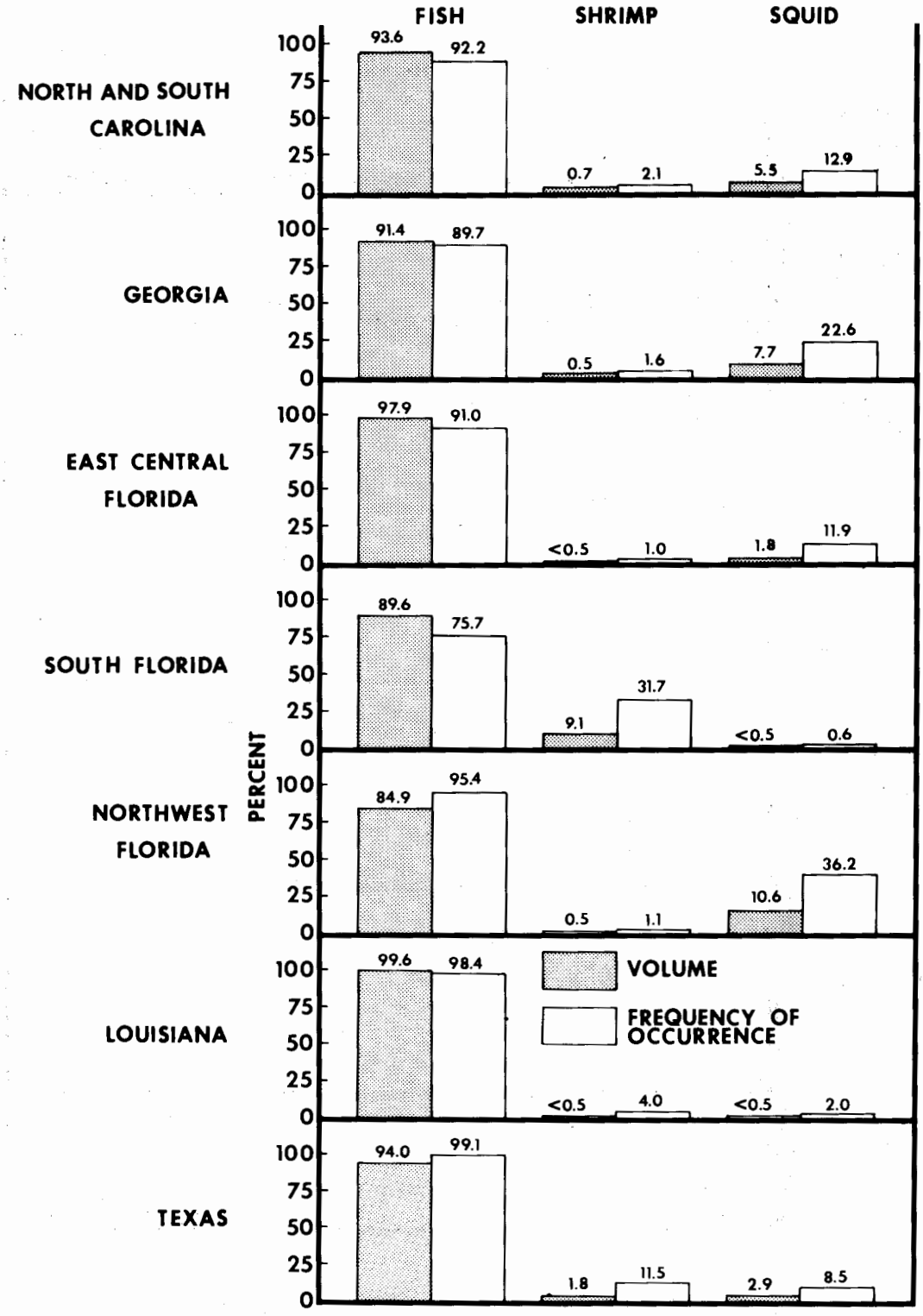

Figure 2. Percent volume and frequency of occurrence of fish, shrimp, and squid in stomachs of king mackerel by area.

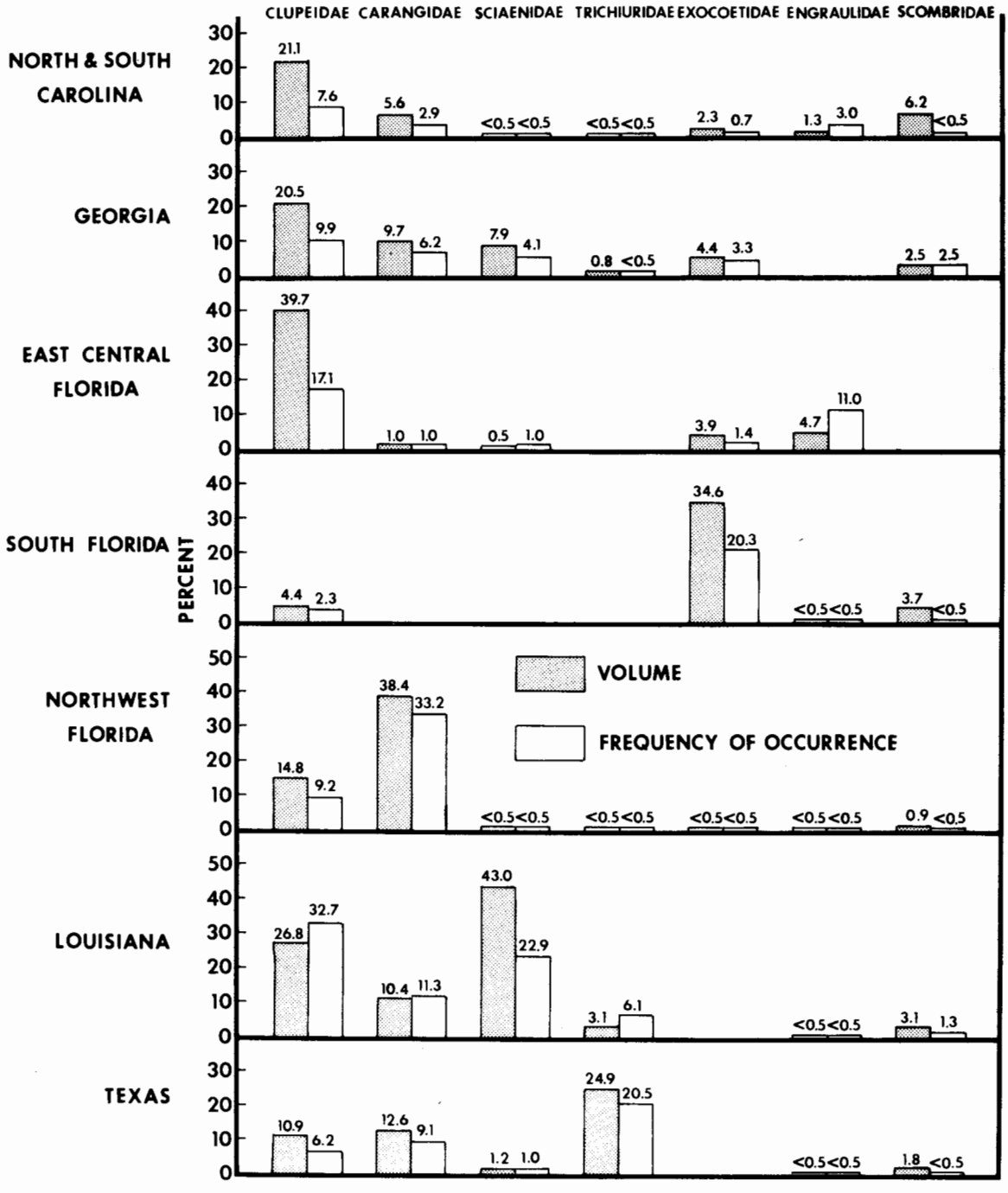

Figure 3. Volumes and frequency of occurrence of various fish families in relation to area.

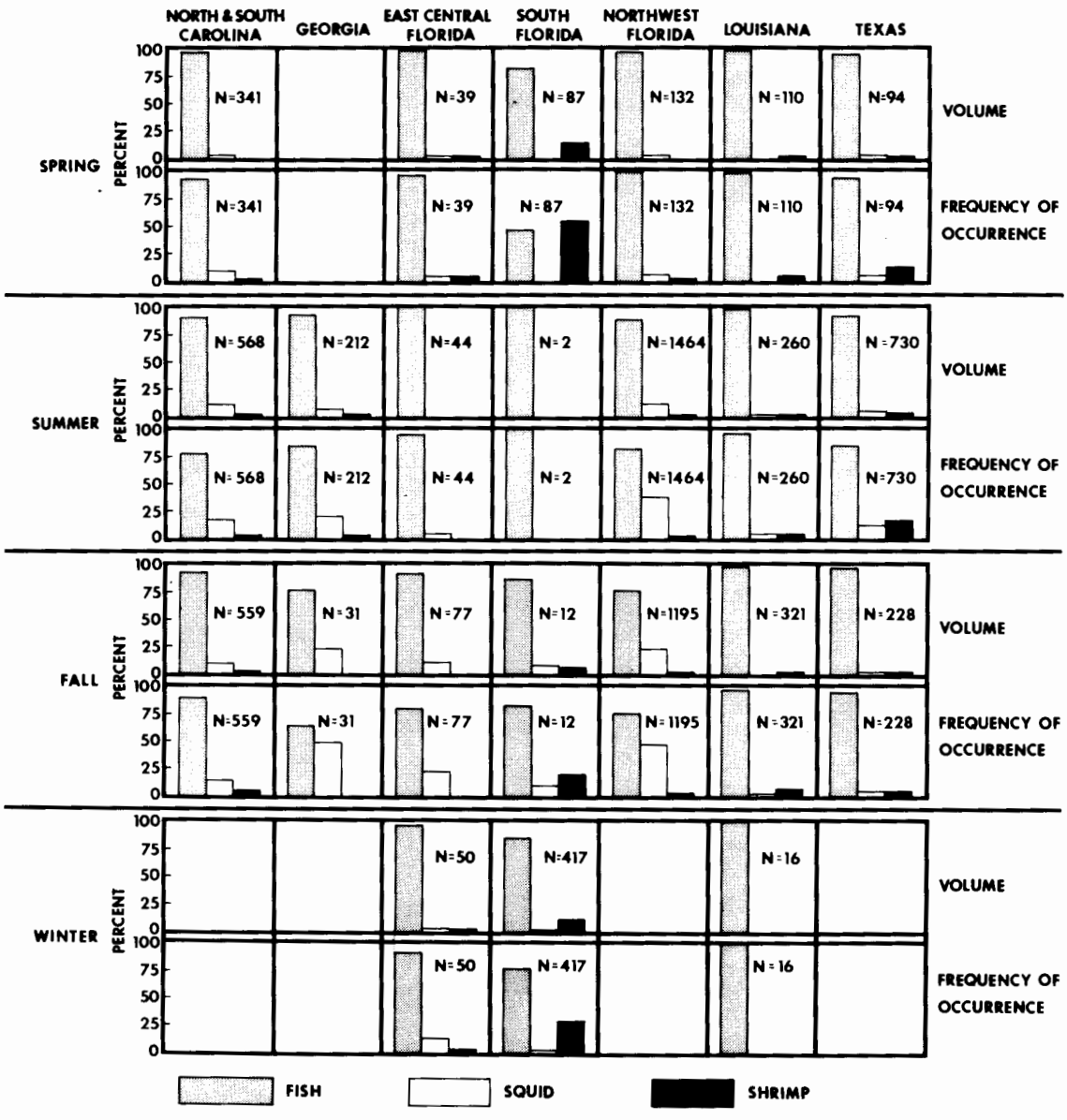

Figure 4. Volumes and frequency of occurrence of fish, squid, and shrimp in stomachs of king mackerel from seven geographical areas in relation to season.

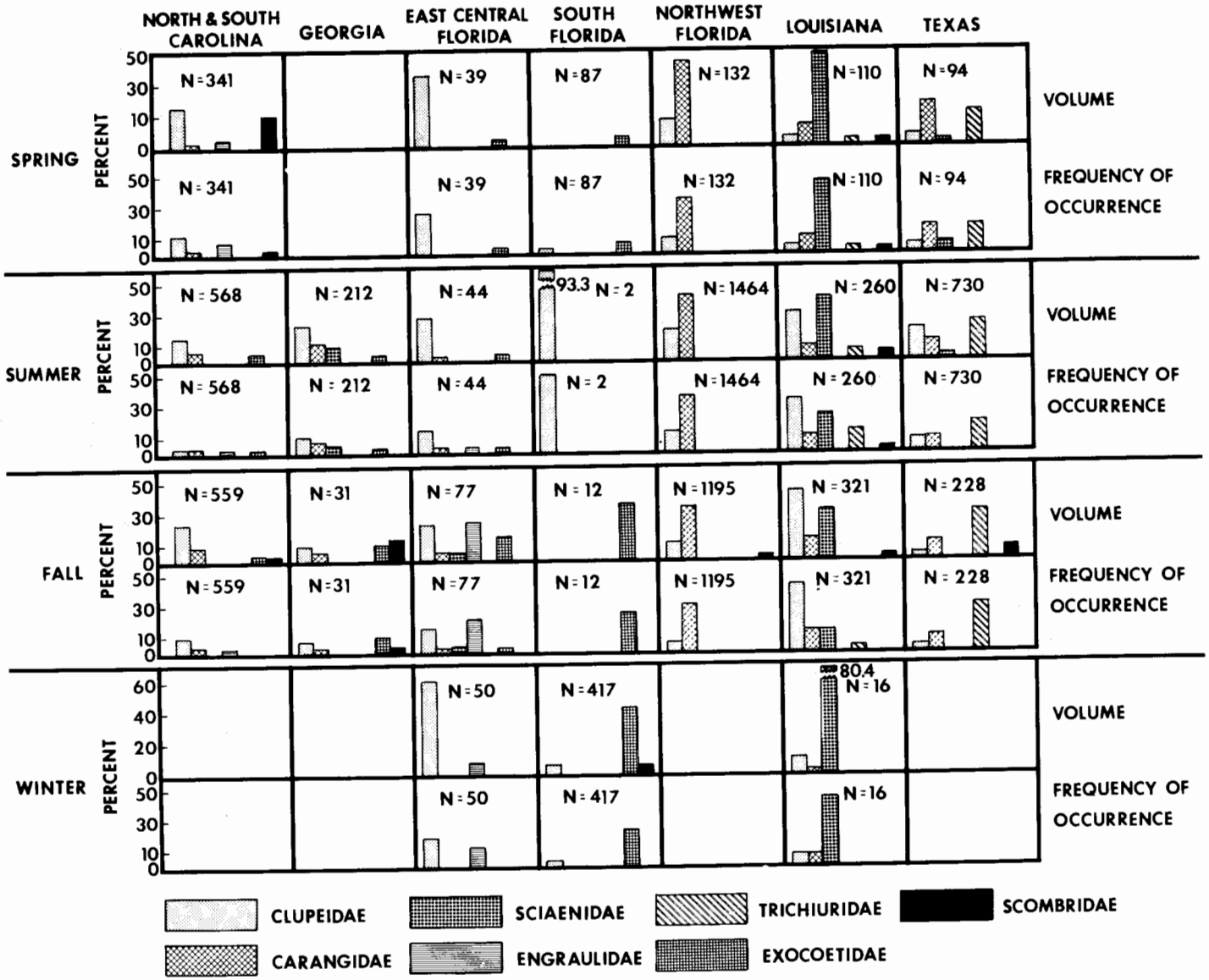

Figure 5. Seasonal volumes and frequency of occurrence of major fish families in the stomachs of king mackerel from seven geographical areas. Values below 1% were not plotted.

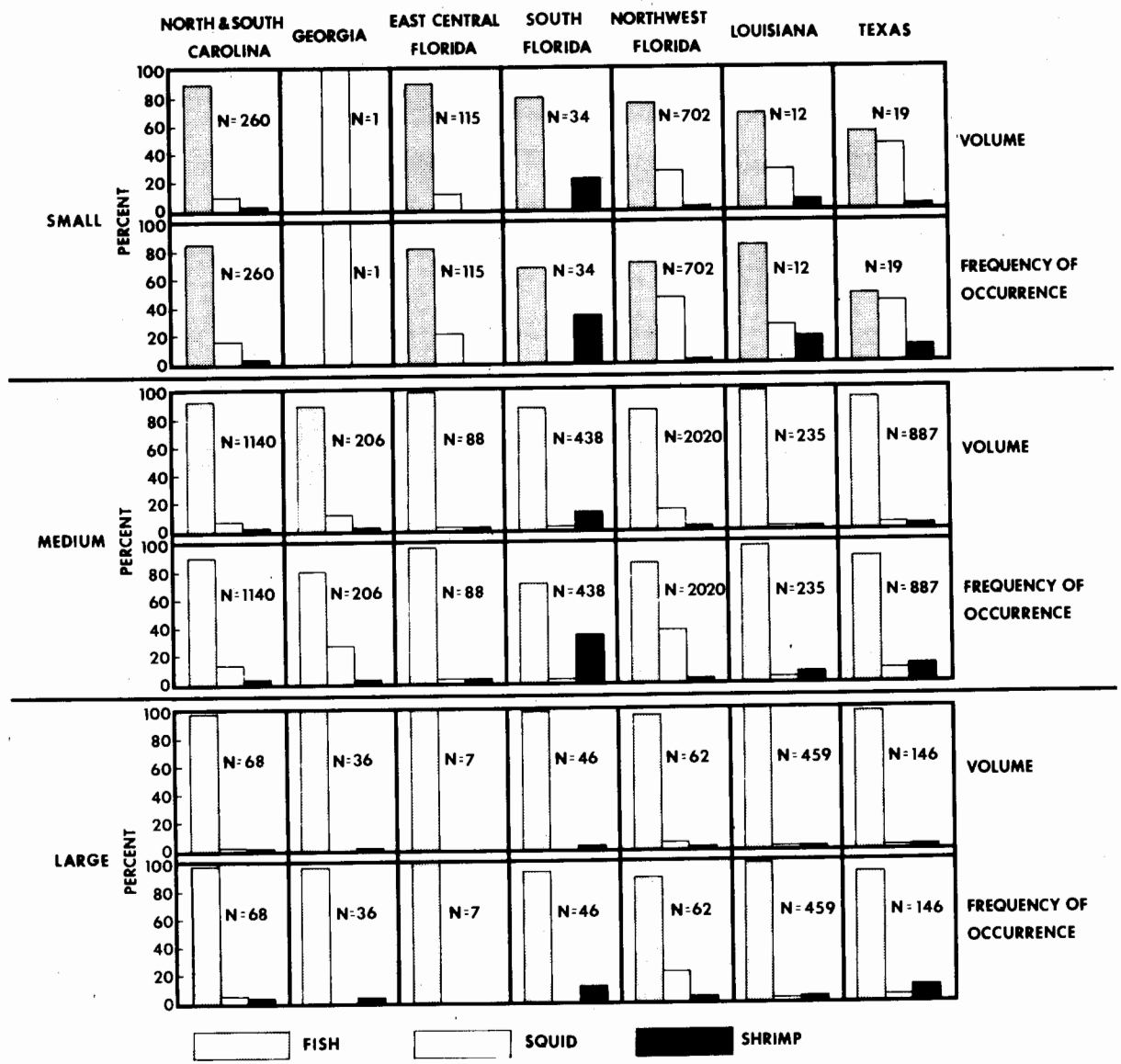

Figure 6. Volumes and frequency of occurrence of fish, squid, and shrimp in stomachs of small, medium, and large king mackerel from seven geographical areas.

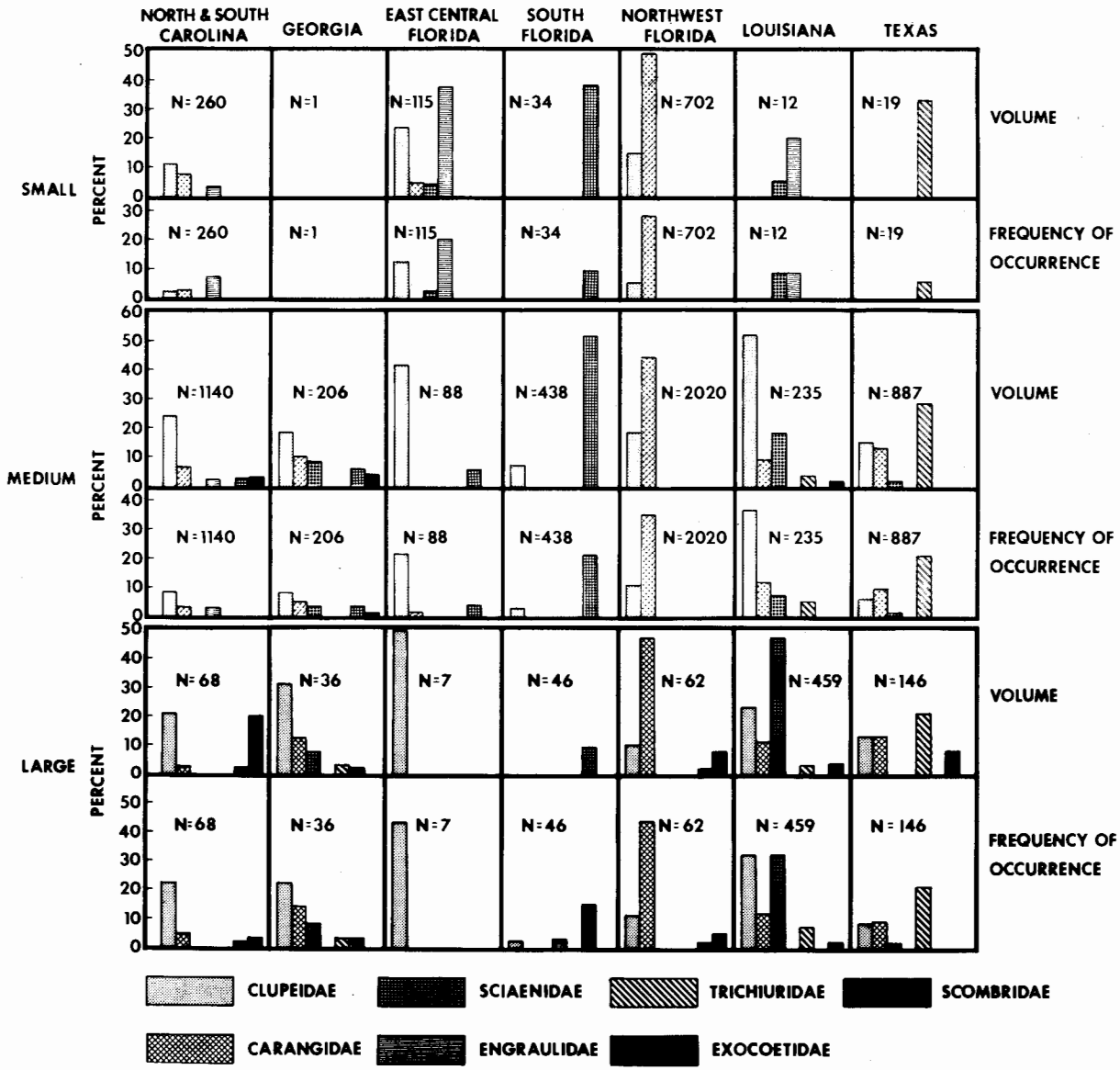

Figure 7. Percent volume and frequency of occurrence of major fish families in the stomachs of small, medium, and large king mackerel from seven geographical areas. Values below 1% were not plotted.

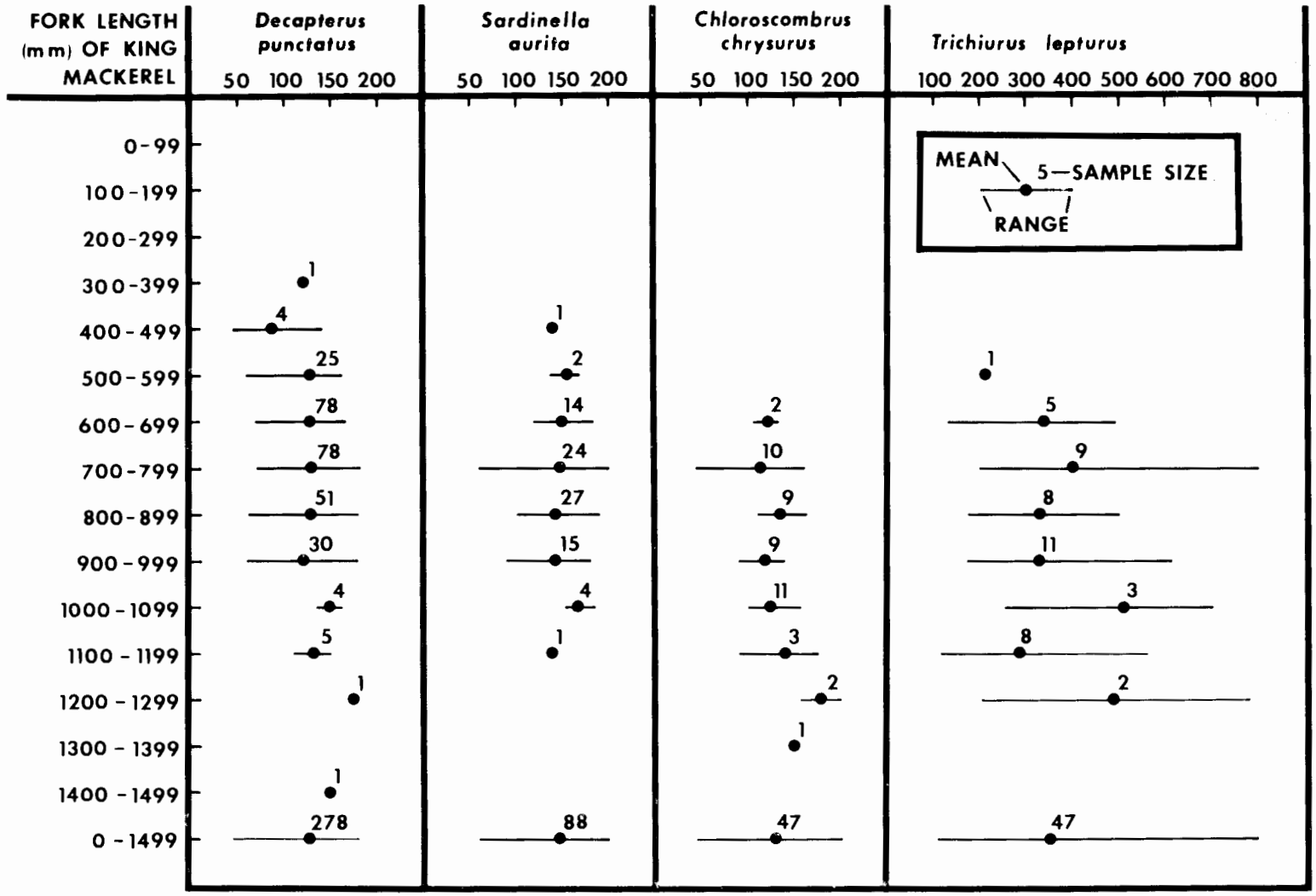

Figure 8. Mean and range of fork length (mm) of selected prey species in relation to size of king mackerel.