THE FOOD OF SKIPJACK AND YELLOWFIN TUNAS IN THE ATLANTIC OCEAN[1]

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ABSTRACT

Samples were examined from the stomachs of 1,060 skipjack tuna and 611 yellowfin tuna captured by live bait, longline, trolling, and purse seine in the eastern and western tropical and subtropical Atlantic Ocean in 1965 and 1966. Fish, mollusks, and crustaceans were the principal foods of both species. The major families of fish represented were Scombridae, Carangidae, Serranidae, Balistidae, Gempylidae, and Tetraodontidae; mollusks consisted chiefly of cephalopods (squids); and crustaceans were principally larval macrozooplankton. Frequency of occurrence and displacement volume are given for all taxons of food organisms identified from the stomachs of each species.

Fish was the predominant forage volumetrically throughout the Atlantic Ocean and numerically in the western Atlantic; crustaceans were predominant numerically in tunas caught in the eastern Atlantic. In general, crustaceans predominated in the stomachs of the smaller tunas and fish in the stomachs of the larger ones. When the mean percentages of the three principal sources of tuna food—fish, mollusks, and crustaceans—were compared (for tunas caught concurrently), the evidence was that skipjack tuna ate more crustaceans than did yellowfin tuna. Juvenile tunas were eaten by both skipjack and yellowfin tunas.

This report on the food and feeding habits of skipjack and yellowfin tunas in the Atlantic Ocean is part of an investigation of the ecology of Atlantic tunas carried on at TABL (Tropical Atlantic Biological Laboratory) of BCF (Bureau of Commercial Fisheries). A thorough knowledge of food and feeding habits of tuna is important to an understanding of the biology, abundance, and distribution of tuna species (Reintjes and King, 1953; King and Ikehara, 1956; Iversen, 1962; and Nakamura, 1969).

Atlantic tuna fisheries are sustained in great part by five species considered of worldwide importance: yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), albacore (*T. alalunga*), bigeye tuna (*T. obesus*), and bluefin tuna (*T. thynnus*).

The literature on the food and feeding habits of tunas in the Atlantic Ocean was reviewed by Dragovich (1969). Many publications are available on the feeding habits of the various species of Atlantic tunas, but most of them are based on casual observations involving small samples. Some papers consist of mere taxonomic listings of forage organisms found in tuna stomachs; others contain lists of forage organisms and morphometric measurements; few include quantitative analyses of data, or consideration of the relation of forage organisms to geographic areas, to the size of tunas, or to the habitat.

MATERIALS AND METHODS

Of 1,671 tuna stomachs examined (table 1), about 55 percent were collected on cruises by the research vessels *Geronimo* and *Undaunted* of TABL; 23 percent were supplied to TABL by ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer), Pointe Noire, Africa; and the rest came from other BCF laboratories and commercial vessels. All data were collected during 1965 and 1966, from three arbitrarily defined areas of the Atlantic Ocean (fig. 1).

In area 1, skipjack tunas were caught by purse seine and yellowfin tunas on longlines; in areas 2 and 3, all tunas were caught at the surface by live bait and trolling.

The fork lengths of the fish measured (figs. 2 and 3) ranged from 22 to 81 cm. for skipjack

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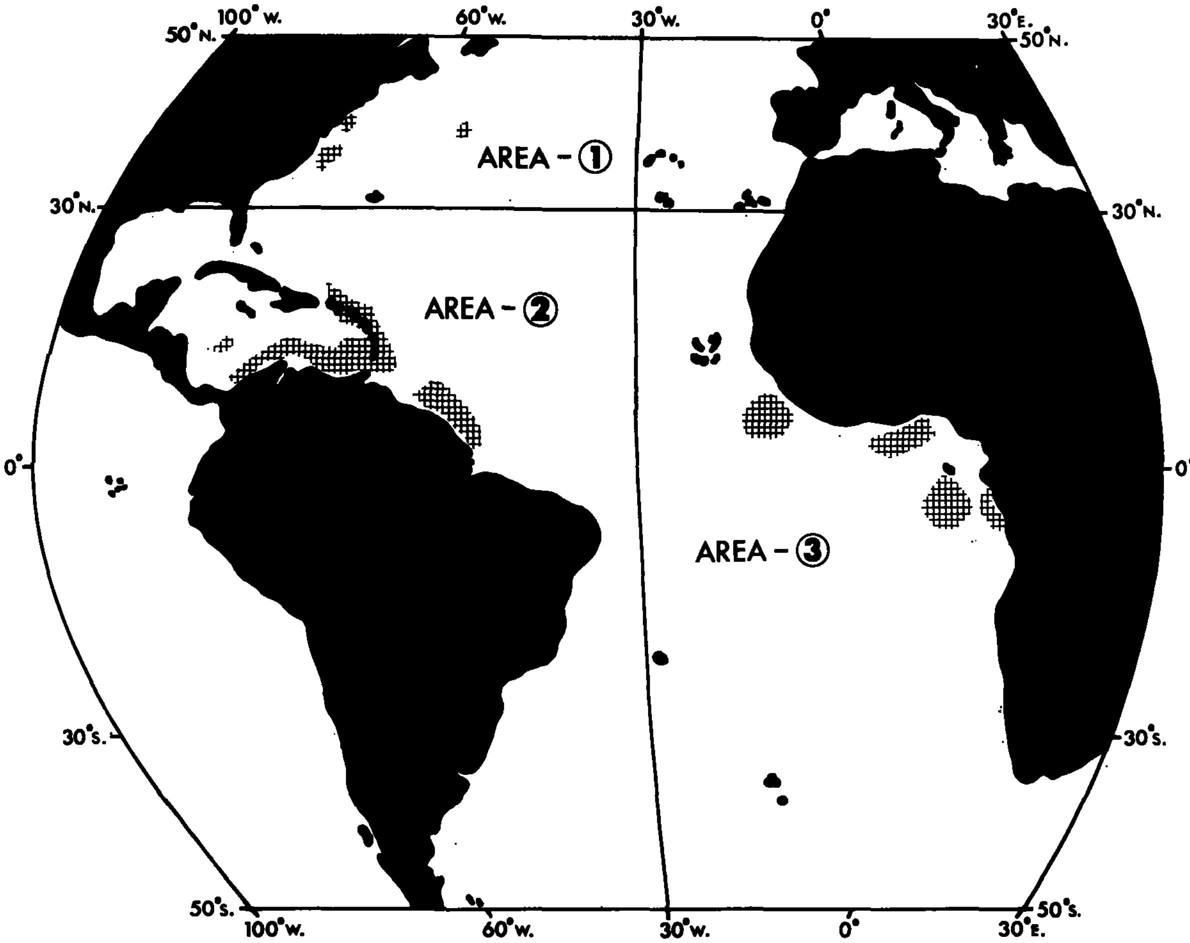

FIGURE 1.—Crosshatching shows localities in areas 1, 2, and 3 where stomachs of skipjack and yellowfin tunas were collected.

tuna and 40 to 155 cm. for yellowfin tuna. (Not all tunas were measured.) Most of the tunas were caught in areas 2 and 3 (table 1).

The interval between capture of fish and removal of stomachs varied considerably, from a few minutes for fish captured by live bait to several hours for some of the fish caught by longline and purse seine. In most collections, each stomach was pierced in several places and then placed in an individual polyethylene bag that contained 10 percent Formalin.[2]

Samples from West African waters were preserved in Formalin and shipped to TABL in sealed metal drums; samples from BCF laboratories or from commercial tuna vessels arrived at TABL either frozen or preserved in Formalin.

At the laboratory, frozen stomachs were thawed and the contents were removed, preserved in 10 percent Formalin, and later sorted. Before forage organisms were sorted and identified, the stomach contents were leached in fresh water for 12 to 24 hours to remove the Formalin. After the food items had been sorted into major groups, they were identified as completely as possible and the number of each taxonomic entity (species or higher taxonomic group) was recorded on data sheets for each stomach. Each taxon was measured volumetrically by the displacement of water in a graduate cylinder of appropriate size. Bait found in the stomachs was not included as food.

[2] Trade names referred to in this paper do not imply endorsement of commercial products by the Bureau of Commercial Fisheries.

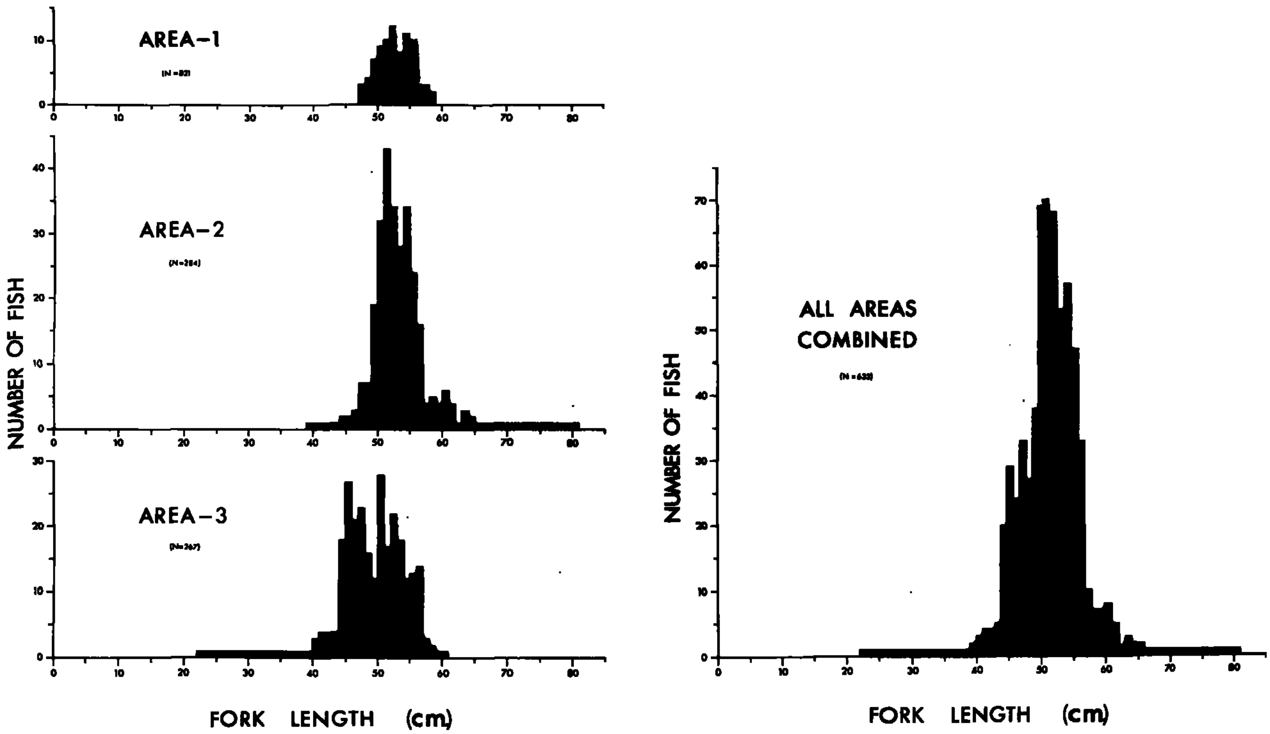

FIGURE 2.—Length-frequency distribution of skipjack tuna from which stomachs were collected.

TABLE 1.—*Tuna stomachs examined from three areas of the Atlantic Ocean*

[See figure 1 for locations of the areas]

Area	Skipjack tuna				Yellowfin tuna			
	Total	With food	Empty		Total	With food	Empty	
	No.	*No.*	*No.*	*Percent*	*No.*	*No.*	*No.*	*Percent*
1	150	82	68	45.3	16	16	0	0
2	389	347	42	10.8	41	39	2	4.9
3	521	257	264	50.7	554	520	34	6.1
Total	1,060	686	374	35.3	611	575	36	5.9

IDENTIFICATION OF TUNA FORAGE ORGANISMS

The identification of tuna forage was complicated by the poor condition of many of the organisms and by the predominance of juvenile or larval forms, for which taxonomic literature is practically nonexistent. Partially digested organisms also were difficult to identify. The organisms that lacked external protective devices (such as the scales of fish or the exoskeletons of crustaceans) were digested most rapidly and were, therefore, the most difficult to identify. Cephalopods, for instance, presented difficulties because they are identified primarily on the basis of skin, suckers, and fins. Squids were separated from octopuses on the basis of number of arms (10 in squid and 8 in octopus), lack of a gladius ("pens," or internal skeleton) in the octopus, and the shape of the beaks. Ommastrephid squids were identified by the inverted T-shaped funnel (known as the locking apparatus), which distinguishes this family from all others, even in the youngest stages.

The shelled mollusks, heteropods, pteropods, and nautiloid cephalopods were identified from their shell remains. Exoskeletons provided diagnostic characters for identification of arthropods.

The crustaceans were identified mostly on the basis of their remaining exoskeletons. Larvae of crustaceans were sorted into zoea and megalopae or their equivalent stages, and then identified as far as was possible.

Identification of fish was troublesome because their best diagnostic features (scales, fins) are external and are the first to be digested. Partly digested teleost fishes that lacked external characters were identified from skeletal remains. Other characters used were scutes, dorsal spines, gill rakers, photophores, teeth, and body shape.

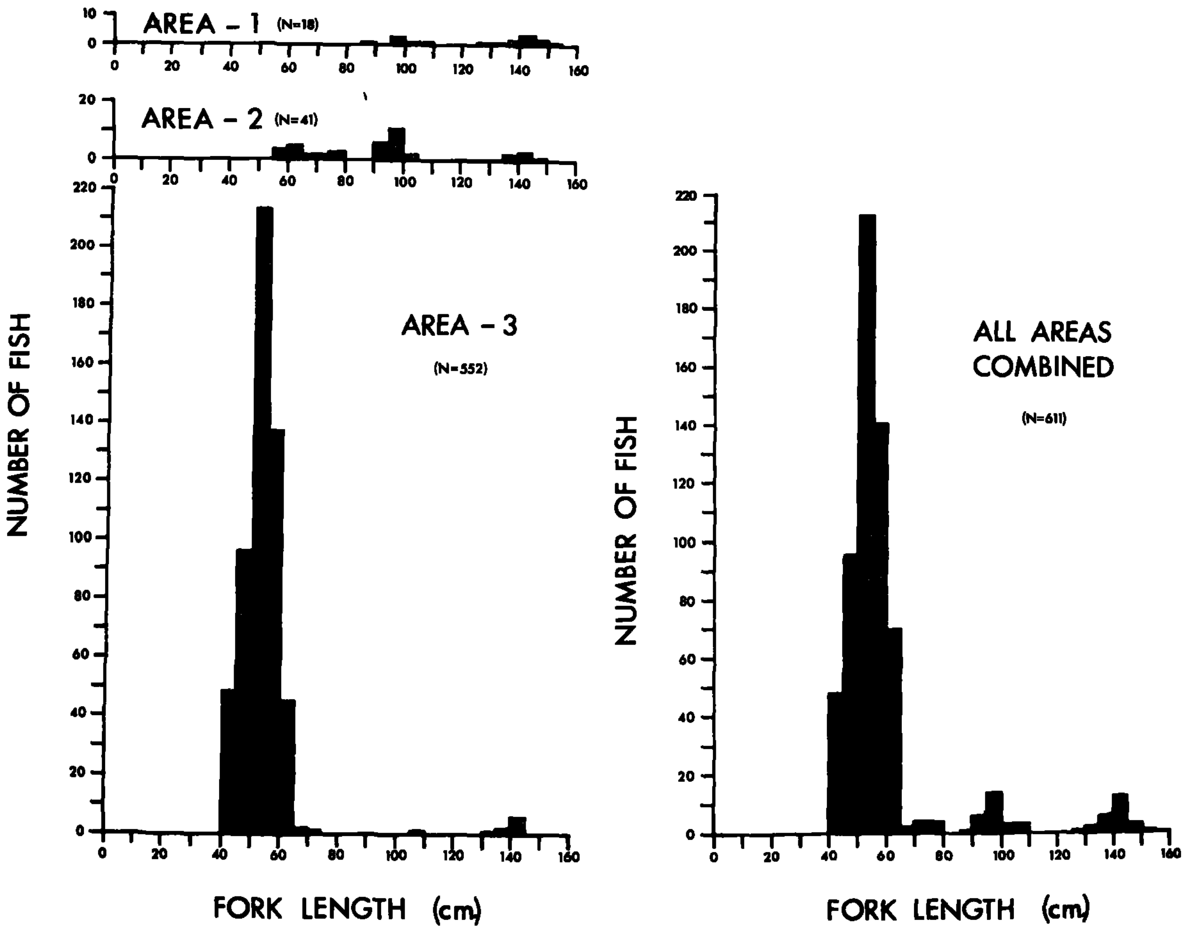

FIGURE 3.—Length-frequency distribution of yellowfin tuna from which stomachs were collected.

METHODS USED IN THE EVALUATION OF DATA

The data were evaluated by percentage frequency of occurrence and percentage of total volume (Reintjes and King, 1953). Statistical analyses were based on Spearman's rank correlation test and a paired t-test of difference between means.

COMPOSITION OF FORAGE ORGANISMS FOUND IN THE STOMACHS OF SKIPJACK AND YELLOWFIN TUNAS

The identified food of skipjack and yellowfin tunas consisted chiefly of three major categories—fish, crustaceans, and cephalopods (fig. 4). Appendix tables 1 to 6 list all individual food items identified from stomachs of skipjack and yellowfin tunas. These tables include for each area the food item, the number of stomachs in which it occurred, the percentage frequency of occurrence, the displaced volume, and the percentage of the total volume examined. The food items are listed in order of frequency of occurrence by families (fishes) or broader categories (mollusks and crustaceans).

The numbers of taxa found in the stomachs of the two species were similar—159 in skipjack tuna and 174 in yellowfin tuna; 102 were in stomachs of both species (59 fishes, 29 crustaceans, and 14 mollusks).

The taxonomic composition of forage organisms differed in the three areas. In areas 1 and 2, fish was the most important food item in volume and frequency of occurrence for both species (fig. 4). In area 3, crustaceans led fish and mollusks in frequency of occurrence for both species; by volume, crustaceans were more important than fish only in the diet of skipjack tuna. Cephalopods (chiefly squid) made up the major portion of mollusks in all areas; by volume, cephalopods were more important than

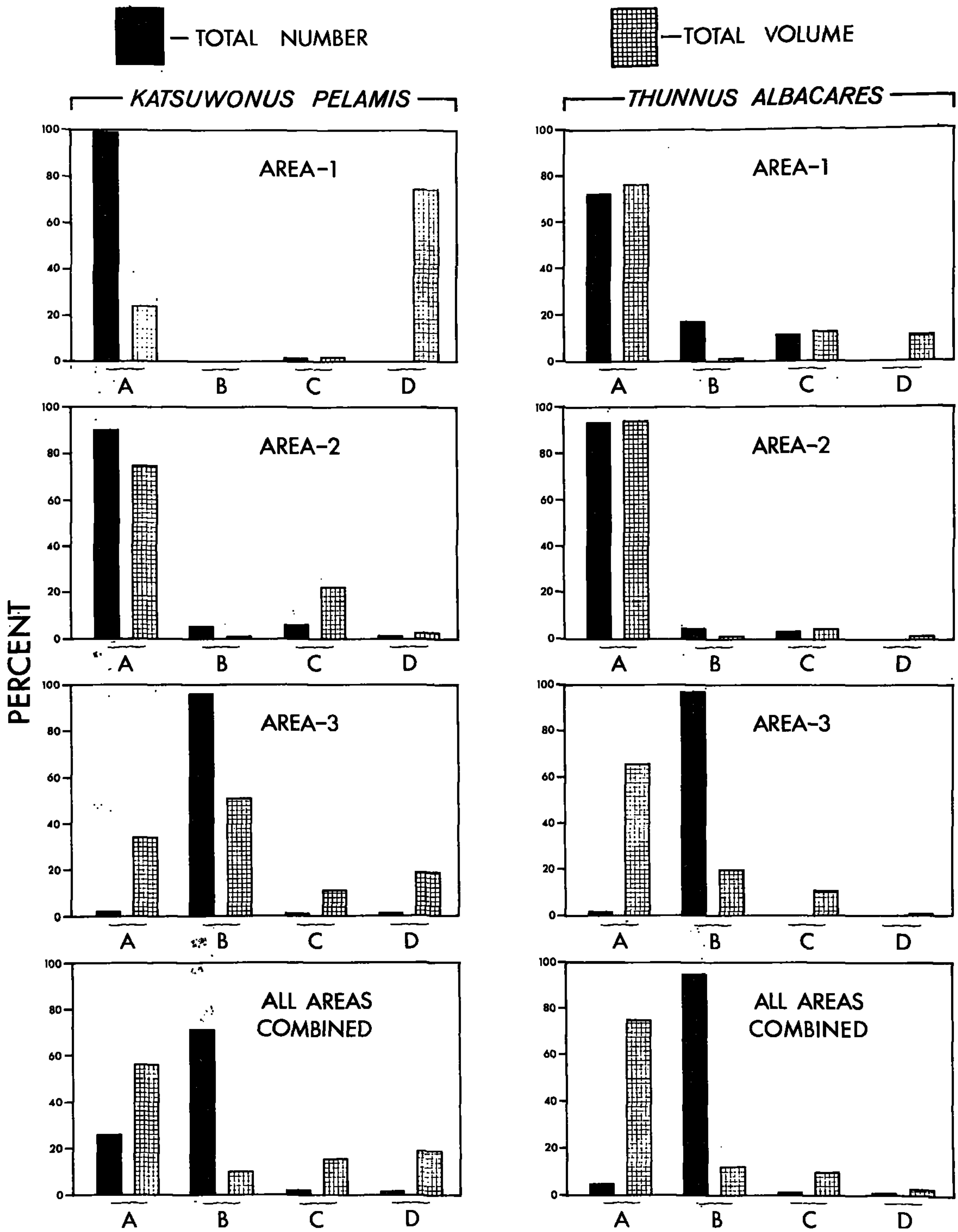

FIGURE 4.—Percentage of total food (by four major categories) in stomachs of skipjack and yellowfin tunas captured in various sections of the Atlantic Ocean. Solid columns represent the number of organisms and checkered columns represent volumes. A=fishes; B=crustaceans; C=cephalopods; D=other mollusks and unidentifiable.

crustaceans in areas 1 and 2, but less important than crustaceans in area 3. Animals other than fish, crustaceans, and mollusks—heteropods, pteropods, larval Tonnidae, and tunicates—amounted to less than 0.8 percent of the total volume of food in both species. Unidentifiable material consisted of semidigested masses of various food, some of which was recognizable as mollusks other than cephalopods. The percentage volume of unrecognizable material was low for both species in areas 2 and 3 but was extremely high—much higher than that for any other category of food—in skipjack tunas from area 1 (fig. 4).

FISHES

Forage fish consumed by skipjack and yellowfin tunas in all areas consisted primarily of juvenile and larval forms of pelagic fish.

In area 1 (appendix tables 1 and 2) the fish consumed by the two species differed. The forage of skipjack tuna was made up of scombrids (*Scomber* spp. and *Scomber scombrus*) and unidentifiable fish, whereas that of yellowfin tuna included fish from at least 15 families.

In areas 2 and 3, the food of skipjack and yellowfin tunas was similar (appendix tables 3–6). In area 2 (appendix tables 3 and 4), 29 fish families were recorded for skipjack tuna and 23 for yellowfin tuna; 19 were common to the two species. A wide variety of forage fishes was found in tunas from area 2, but only a few taxa ranked high in frequency of occurrence and volume for both species. Large numbers of *Paranthias furcifer, Dactilopterus volitans,* and *Holocanthus* spp. were present—the stomach of one yellowfin tuna contained 710 specimens of *P. furcifer*. In area 3 (appendix tables 5 and 6), 38 forage fish families were recorded for yellowfin tuna and 21 for skipjack tuna; 20 fish families were common to both.

Among the families of forage fishes, in frequency of occurrence and by volume, Scombridae constituted the most important food of skipjack and yellowfin tunas in area 1, and also of skipjack tuna in area 2 (appendix tables 1–6). Serranidae occurred most frequently in the diet of yellowfin tuna in area 2, and also ranked high as forage of skipjack tuna. Other fish in area 2 that ranked high in frequency of occurrence and by volume for both tunas were Scombridae, Carangidae, Dactylopteridae, and Chaetodontidae.

In area 3, Carangidae, Tetraodontidae, Gempylidae, and Serranidae were the most numerous forage fishes of yellowfin tuna; they also ranked high in frequency of occurrence and by volume in the diet of skipjack tuna.

CRUSTACEANS

Crustaceans in stomachs of skipjack and yellowfin tuna consisted of a wide variety of forms. Larval macrozooplanktonic forms, which made up the bulk of crustaceans in all areas, were different types of zoea, megalopae, or their equivalent stages. Amphipods (hyperiids), *Heterocarpus ensifer,* mysids, and euphausiids also were present but of less consequence.

Individual taxa of crustaceans contributed little to the total volume of forage organisms. Collectively—because of their substantial numbers and high frequency of occurrence—crustaceans were important in the forage of skipjack and yellowfin tunas in area 3, where counts of crustaceans exceeded those of fish (fig. 4). In frequency of occurrence but not in volume, crustaceans exceeded fish in the diet of yellowfin tuna in area 3. Crustaceans in the diets of tunas in area 3 consisted of 34 taxa for skipjack tuna and 39 taxa for yellowfin tuna; 25 taxa were common to both species (appendix tables 5 and 6). The chief constituents (frequency of occurrence and by volume) in the crustacean diet of the two species of tuna in area 3 were larval stomatopods, and megalopal stages listed as Decapoda (Brachyura) and hyperiid amphipods. Although many amphipods were present in the samples, they consisted of relatively few species. *Phrosina semilunata* was numerically the most important species by far in the diet of both species of tuna. *Heterocarpus ensifer* was the prominent shrimp in the diet of yellowfin tuna; hermit crab larvae (*Petrochirus pustulatus, Dardanus* spp., *D. arrosor,* and *D. pectinatus*) and various phyllosoma stages of *Scyllarus* sp. and *Panulirus rissoni* were important in the diet of both species in area 3 (appendix tables 5 and 6). In area 1, crustaceans found in the stomachs of only yellowfin tunas (appendix table 2) consisted of hyperiid amphipods and megalopal stages of Brachyura; one group of megalopae, Raninidae, was identified to family. In area 2, megalopal forms—Decapoda (Brachyura) and larval stomatopods—ranked high in frequency of occurrence. Mysis stages of *Cerataspis petiti* were present in the diet of yellowfin tunas in area 2 only (*C. petiti* has never before been reported from the Caribbean Sea).

MOLLUSKS

Numbers of identified mollusks were considerably fewer than those of fishes and crustaceans. Squids (Ommastrephidae) were most numerous in the diet of both species of tunas in all areas (appendix tables 1–6). *Illex illecebrosus* and *Ommastrephes* spp. were the only identified ommastrephids. Pelagic juvenile octopuses were present in the stomachs of both species of tunas. The identified octopods, *Tremoctopus violaceus,* were observed in area 2 (appendix tables 3 and 4).

OTHER FOOD

Heteropods and pteropods were prominent in frequency of occurrence for both species of tuna, but were unimportant volumetrically. The two groups of mollusks were present in the stomachs of skipjack tuna in areas 2 and 3 (appendix tables 3 and 5) and in yellowfin tuna in area 3 (appendix table 6). By frequency of occurrence and volume, heteropods and pteropods were more important in the diet of skipjack tuna than in that of yellowfin tuna in all areas. *Oxygyrus keraudreni, Cavolinia unicinata,* and *Diacria trispinosa* were identified from area 2; *O. keraudreni* was the heteropod found most frequently in both species of tunas in area 3.

Larval Tonnidae (including *Tona galea*) were present in the stomachs of skipjack tuna in area 2 only.

JUVENILE TUNAS AS FOOD FOR SKIPJACK AND YELLOWFIN TUNAS

Information on the distribution and occurrence of juvenile tunas is of great value in identifying the spawning areas of tunas, but the collection of juvenile tunas by standard means is difficult. Tunas themselves, however, are excellent collectors of many marine species, including other tunas. Juvenile tunas were present in all three areas (table 2). All tunas found in the stomachs of skipjack and yellowfin tunas in this study were juveniles; most were identified from vertebrae.

As many as 13 juvenile tunas were found in the stomach of a skipjack tuna, and as many as 24 in the stomach of a yellowfin tuna. *Auxis* spp. (436 specimens, 23–134 mm. long) were the most numerous scombrid in the stomachs of both tuna species (unidentified Scombridae were the only other form recorded for both); *Euthynnus alletteratus* (40–42 mm. long), *Katsuwonus pelamis* (46–94 mm. long), *Thunnus* spp. (64–72 mm. long), and *T. atlanticus* (59 mm. long) were present in the stomachs of skipjack tuna only (one to three specimens per stomach); juvenile *Scomber japonicus* (83–222 mm. long) were present in the stomachs of yellowfin tunas only (one to four per stomach).

TABLE 2.—*Occurrence of juvenile scombrids in the stomachs of skipjack and yellowfin tunas in areas 1, 2, and 3*

[For the areas see figure 1]

	Area 1		Area 2		Area 3	
	Skipjack	Yellowfin	Skipjack	Yellowfin	Skipjack	Yellowfin
Scomber spp.	+			+		
Scomber japonicus						+
Scomber scombrus	+					
Other Scombridae	+		+	+	+	+
Scombroidei						+
Auxis spp.			+	+	+	+
Katsuwonus pelamis			+			
Euthynnus alletteratus			+		+	
Thunnus spp.			+			
Thunnus atlanticus			+			

That juvenile tunas are a part of the diet of adult tunas has been reported often. King and Ikehara (1956) found juvenile skipjack tuna in the stomachs of yellowfin and bigeye tunas; Nakamura (1965) reported a high frequency of occurrence (24.8–44.8 percent) of juvenile tunas in the stomachs of skipjack tunas; Suarez-Caabro and Duarte-Bello (1961) observed juvenile blackfin tunas (5–150 mm., fork length) and skipjack tunas (35–145 mm., fork length) in the stomachs of skipjack tunas; Reintjes and King (1953) found skipjack tuna and various other tuna species in the stomachs of yellowfin tuna; and Koga (1958a, b) and Alverson (1963) reported juvenile tuna in the stomachs of other tunas.

STOMACH CONTENTS OF FISHES INGESTED BY SKIPJACK AND YELLOWFIN TUNAS

Stomach contents of fishes ingested by skipjack and yellowfin tunas were examined to learn more about the food chain of yellowfin and skipjack tuna and the trophic dependence of ingested fishes. The results of this examination, as in the study by Nakamura (1965), further confirmed the dependence of forage fishes upon macrozooplankton. The stomach contents of fishes ingested by both species of tunas consisted primarily of crustaceans and fish remains, but some of the larger fishes contained remains of squid and juvenile fishes. A *Scomber japonicus* from the stomach of a yellowfin tuna collected off West Africa held three juvenile *Sardinella rouxi* (50–60 mm. fork length).

Because crustaceans were better preserved than fishes, I could distinguish broad taxonomic categories. Although I made no quantitative estimates, copepods appeared to be the dominant single group in the diet of most of the ingested fishes. As many as 60 to 100 were found in a single stomach. Among identifiable copepods from the western Atlantic, *Centropages typicus, Temora turbinata,* and other calanoids were most numerous; *Scolecithrix danae, Megacalanus princeps, Scolecithricella* sp. and other calanoids were most numerous in samples taken off the coast of Africa. Other identifiable crustaceans were: amphipods, euphausiids, shrimp, *Lucifer* sp., larval stomatopods, megalopal stages of Raninidae, and megalopal and zoeal stages of Brachyura.

VARIATION IN FOOD IN RELATION TO DISTANCE FROM LAND, TIME OF DAY, AND SIZE OF TUNA

Stomach contents of tunas collected at all locations were classified according to the distance from the nearest land. The arbitrary scale (0–24 nautical miles or 0–43.2 km., 25–49 nautical miles or 45.0–88.2 km., 50–74 nautical miles or 90.0–133.2 km., 100–149 nautical miles or 180.0–268.2 km., 150–200 nautical miles or 270.0–360.8 km., 201–300 nautical miles or 361.8–540.0 km., 301–400 nautical miles or 541.8–720.0 km. and 401 nautical miles or 721.8 km. plus) used in this study to delineate distances from land is the same as that used by King and Ikehara (1956). The mean volumes of 12 taxa most frequently identified as tuna forage from the stomachs of skipjack and yellowfin tuna were plotted for each area and distance. For most of the distances, however, the number of tuna stomachs was too small to warrant any conclusions.

Data were insufficient for analyses of monthly or seasonal variations, and the trend of feeding throughout the day could be considered only for skipjack tuna from areas 2 and 3. Average volumes of stomach contents were calculated for each hour of the day. The percentage of empty stomachs appeared highest, and the mean volume of food in stomachs lowest, near midday. A chi-square test of heterogeneity (Snedecor and Cochran, 1967: 248) indicated that the observed differences in percentage of empty stomachs near midday was significant ($P<0.005$) in areas 2 and 3.

The diurnal fluctuation in feeding was similar to that observed by other investigators (Talbot and Penrith, 1963; Nakamura, 1965; and Sokolov, 1967). Nakamura (1965) suggested that the diurnal feeding pattern of skipjack tuna was based on availability of food (movement of zooplankton and forage organisms, during the midday period of maximum illumination, to depths beyond those occupied by the surface-dwelling skipjack tuna) or to satiation of tuna after the morning feeding period.

The relation between the sizes of skipjack and yellowfin tunas and the taxonomic composition of food was studied in terms of frequency of occurrence and percentage volume of the three principal food categories (fishes, mollusks, and crustaceans). The occurrence of crustaceans tended to decline as the size of skipjack tunas increased; the frequency of occurrence of fish increased with the size of tunas of both species. I observed no relation between the size of tunas and the consumption of cephalopods and other mollusks.

Spearman's rank correlation analysis (Steel and Torrie, 1960: 409) was used to determine whether the frequency of occurrence of the two dominant forage food items (fish and crustaceans) in the stomachs of skipjack tunas was correlated with the size of tunas. Spearman's rank correlation coefficients of 0.771 for fish and –0.771 for crustaceans were not significant. I did not make a similar analysis of the sizes of yellowfin tunas and the frequency of occurrence of the three main food categories because the number of size classes (four) was too small.

Spearman's rank correlation analysis was also applied to test whether the percentage volumes of the forage food categories of skipjack and yellowfin tunas were correlated with the size of fish (table 3). All fish suitable for such a test (487 skipjack and 338 yellowfin tunas) were grouped into 10-mm. length-intervals. Correlations were performed for the two dominant food categories (fish and crustaceans or mollusks). The data from single cruises were treated separately, because each cruise is representative of the same general area and the same time. I observed a significant correlation (Spearman's rank correlation coefficient of 0.512, $P \leq 0.05$) only between yellowfin tuna and fish on one cruise, indicating that as the size of tuna increased, the percentage consumption of volume of forage fish increased also.

The size ranges of skipjack (410–639 mm. fork length) and yellowfin tunas (390–629 mm. fork length) were for the most part probably not great enough to relate possible differences in feeding habits to size. Even so, the fact that one significant correlation was noted for yellowfin tuna may indicate that larger tunas consume

TABLE 3.—*Spearman's coefficients of rank correlation (r_s) between the lengths of skipjack and yellowfin tunas and percent volumes of the dominant food categories for several cruises*

Cruise	Tuna species	Tuna examined	Fork length	Fish (r_s)	Crustaceans (r_s)	Mollusks (r_s)
		No.	*Mm.*			
Geronimo 7	Skipjack	12	460–579	0.077	----	0.107
Geronimo 5	do	17	410–579	.128	0.127	----
Do	Yellowfin	18	390–569	.512	----	–.337
Kuroshio Maru	do	19	410–629	.004	.132	----
Do	Skipjack	16	410–569	.087	.192	----
Undaunted 2	do	22	397–639	.150	----	.219

more fishes than do the smaller ones. The greater dependence of larger skipjack and yellowfin tunas on fish and of smaller skipjack tuna on crustaceans was also observed by other investigators (Nakamura, 1965; Yuen, 1959; and Alverson, 1963).

King and Ikehara (1956), who analyzed the relation between the volume of stomach contents and body weights for bigeye and yellowfin tunas from the central Pacific, found that the mean volume per stomach for both species increased with the size of the fish and the average content of stomachs per unit of body weight decreased with increase in size. Because about 98 percent of the specimens I studied fell into a narrow range of sizes (2–4 kg.), I was unable to make a similar analysis, but I did find—from examinations of scatter diagrams—that the relation between the volume of the stomach contents and the weight of the fish appeared to agree with King and Ikehara's results.

VARIATION IN VOLUME OF STOMACH CONTENTS

As indicated in the studies by Magnuson (1969), the maximum capacity of the stomach of a skipjack tuna is about 7 percent of the weight of the fish, but during 1 day a fish can consume the equivalent of 15 percent of its body weight. On the basis of Magnuson's study, I assume that the maximum capacity of yellowfin tuna stomachs is also about 7 percent of the body weight.

The volume of stomach contents was less than 20 ml. in 75 percent of the skipjack tunas and in 85 percent of the yellowfin tunas. Stomach volumes above 20 ml. were higher in areas 1 and 2 than in area 3—an observation that might be related to the fact that the diet of skipjack and yellowfin tunas in areas 1 and 2 consisted primarily of fish, which have higher average volumes than crustaceans. In their study of food of yellowfin tuna in the central Pacific, Reintjes and King (1953) found that food volume was less than 25 cc. in 58 percent of the stomachs of yellowfin tunas. Assuming that 1.0 ml. of stomach contents is equivalent to 1.0 g., I made a rough comparison between the estimated weight of the stomach contents and the body weight of tunas. My calculations showed that in 99 percent of the observations the stomach contents were well below the maximum capacity (7 percent of body weight) shown by Magnuson. Thus, my figure of 20 ml. probably does not represent the average daily ration for either species, particularly because the volumes were as high as 149 ml. in skipjack tuna and 499 ml. in yellowfin tuna. The fact that less than 20 ml. of food was found in most stomachs I examined (both species) also may suggest that (1) food is not always available and (2) the rates of digestion are rapid.

COMPARISON OF FOOD OF SKIPJACK TUNA AND YELLOWFIN TUNA

When data from all areas are combined, the large number of forage taxa common to skipjack and yellowfin tunas indicates a marked similarity in the diets of the two species. When the taxonomic composition of the food in stomachs of the two species was compared at locations where they were caught simultaneously, however, less than half of the total taxa at 23 of 25 stations were common to both species—suggesting that feeding is selective. Crustaceans made up the greatest number of taxa common to both species, and fishes the least (fig. 5).

Consideration of feeding selectivity of skipjack and yellowfin tunas required that the data be examined quantitatively. The percentage volume for each food category (fish, mollusks, and crustaceans) and for each station was transformed by $Y=\text{arc-sin}\sqrt{x}$, where x is the fraction of the volume and y the transformed variate upon which the Spearman's coefficient of rank correlation was applied to see if the volume of fish among food constituents varied directly or inversely between the skipjack and yellowfin tunas. I found that the rank correlation coefficient of 0.241 was not significant. A comparison (paired *t*-test) of the mean percentages of the three main food categories (fish, crustaceans, and mollusks) at the same stations gave evidence that the mean percentage of crustaceans in the stomachs was greater in skipjack tuna than in yellowfin tuna ($P \leq 0.01$).

Findings by other investigators concerning selectivity in feeding by different species of tunas varied. Among fish from the same locations in the Pacific, Iversen (1962) found that the food of albacore was more similar to that of yellowfin tuna than to that of bigeye tuna—even though bigeye tuna and albacore inhabit deeper water than yellowfin tuna. Some selectivity in feeding might be inferred from Iversen's study. King and Ikehara (1956) studied the food of bigeye and yellowfin tunas in the central Pacific and concluded that their forage was, in general, remarkably similar. They stated that when the two species live in the same area, food habits are alike, and that food selectivity is probably attributable to a movement by the tunas to different feeding areas.

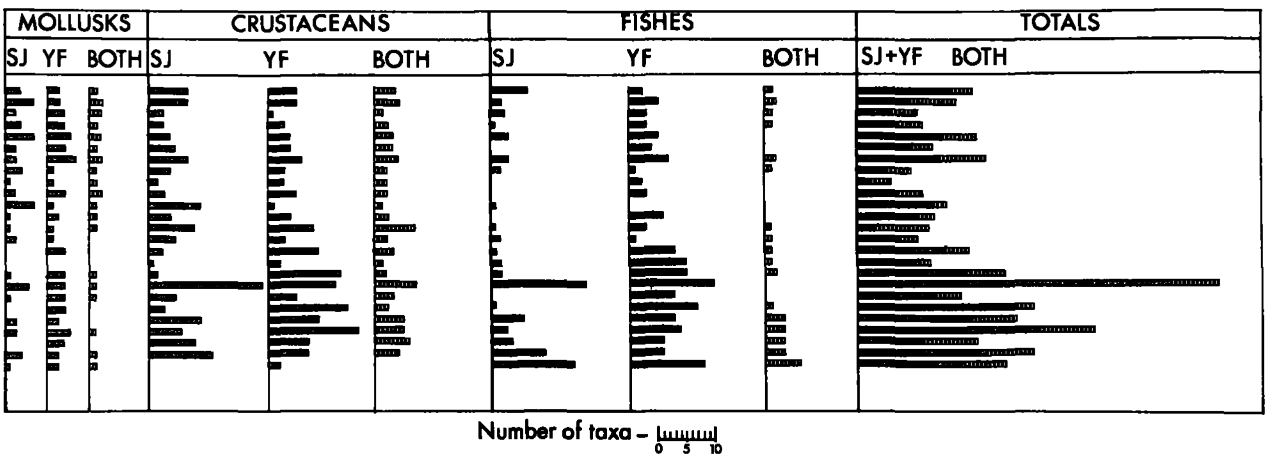

FIGURE 5.—Number of different forage taxa from the stomachs of SJ (skipjack tuna) and YF (yellowfin tuna), collected simultaneously at the same stations.

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APPENDIX

TABLE 1.—*List of forage organisms (arranged in order of frequency of occurrence) found in 82 skipjack tuna stomachs with food, collected from area 1*

[Frequency of occurrence and volume are given for each taxon. See figure 1 for location of area of sampling]

Taxon	Frequency of occurrence		Volume	
	No.	*Percent*	*Ml.*	*Percent*
Fishes:				
Unidentifiable	6	7.2	7.0	1.2
Scombridae:				
Scomber spp.	46	56.0	135.1	24.0
Scomber sombrus	35	42.6	373.2	66.3
Other Scombridae	3	3.6	6.6	1.2
Mollusks:				
Ommastrephidae	3	3.6	40.9	7.3

TABLE 2.—*List of forage organisms (arranged in order of frequency of occurrence) found in 16 yellowfin tuna stomachs with food, collected from area 1*

[Frequency of occurrence and volume are given for each taxon. See figure 1 for location of area of sampling]

Taxon	Frequency of occurrence		Volume	
	No.	*Percent*	*Ml.*	*Percent*
Fishes:				
Unidentifiable	14	87.5	257.2	21.8
Bramidae				
Collybus drachme	5	31.2	42.7	3.6
Brama rayi	1	6.2	3.9	0.3
Pterycombus goodei	1	6.2	3.0	0.2
Balistidae				
Balistes spp.	2	12.5	19.7	1.7
Other Balistidae	3	18.7	13.8	1.2
Gempylidae				
Gempylus serpens	4	25.0	62.0	5.2
Other Gempylidae	2	12.5	7.6	0.6
Dactylopteridae				
Dactylopterus volitans	5	31.2	23.7	2.0
Holocentridae				
Holocentrus spp.	3	18.7	19.3	1.6
Holocentrus vexillarius	1	6.2	9.2	0.8
Scombridae				
Auxis spp.	4	24.9	314.8	26.6
Triglidae				
Peristedion spp.	2	12.5	3.3	0.3
Monocanthidae				
Cantherines sp.	2	12.5	4.2	0.4
Exocoetidae	1	6.2	8.5	0.7
Belonidae	1	6.2	31.0	2.6
Syngnathidae				
Hippocampus spp.	1	6.2	1.0	0.1
Branchiostegidae				
Malacanthus sp.	1	6.2	4.6	0.4
Coryphaenidae				
Coryphaena spp.	1	6.2	94.0	8.0
Coryphaena hippurus	1	6.2	75.0	6.4
Acanthuridae				
Acanthurus spp.	1	6.2	3.9	0.3
Other Acanthuridae	1	6.2	0.2	<0.1
Molidae				
Mola mola	1	6.2	1.2	0.1
Mollusks:				
Cephalopoda				
Octopoda				
Argonauta sp.	1	6.2	23.5	2.0
Teuthoidea				
Unidentified Ommastrephidae	3	18.7	34.5	2.9
Unidentified Teuthoidea	5	31.2	106.0	9.0
Other Cephalopoda	2	12.5	0.2	<0.1

TABLE 2.—*List of forage organisms (arranged in order of frequency of occurrence) found in 16 yellowfin tuna stomachs with food, collected from area 1*—Continued

Taxon	Frequency of occurrence		Volume	
	No.	*Percent*	*Ml.*	*Percent*
Gastropoda				
Helisoma dury	1	6.2	0.3	<0.1
Crustaceans:				
Decapoda				
Brachyura (megalopae)	1	6.2	0.1	<0.1
Raninidae (megalopae)	1	6.2	0.8	<0.1
Amphipoda (Hyperiidae)				
Phrosina semilunata	3	18.7	11.3	1.0
Phronima sedentaria	1	6.2	0.2	<0.1
Brachyscelus spp.	1	6.2	0.5	<0.1
Other Hyperiidea	1	6.2	0.5	<0.1

TABLE 3.—*List of forage organisms (arranged in order of frequency of occurrence) found in 347 skipjack tuna stomachs with food, collected from area 2*

[Frequency of occurrence and volume are given for each taxon. See figure 1 for location of area of sampling]

Taxon	Frequency of occurrence		Volume	
	No.	*Percent*	*Ml.*	*Percent*
Fishes:				
Unidentifiable	241	69.4	895.9	16.9
Scombridae				
Auxis spp.	85	24.5	680.8	12.9
Katsuwonus pelamis	10	2.9	86.0	1.6
Euthynnus alletteratus	1	0.3	0.3	<0.1
Thunnus spp.	3	0.8	9.6	0.2
Thunnus atlanticus	1	0.3	2.0	<0.1
Other Scombridae	89	25.6	269.9	5.1
Gempylidae				
Gempylus sp.	1	0.3	0.9	<0.1
Gempylus serpens	40	11.5	103.2	1.9
Nesiarchus nasutus	2	0.5	11.7	0.2
Other Gempylidae	52	14.9	72.1	1.4
Chaetodontidae				
Holacanthus spp.	58	16.7	50.2	0.9
Holacanthus tricolor	2	0.5	0.5	<0.1
Holacanthus ciliaris	2	0.5	0.7	<0.1
Chaetodon sedentarius	1	0.3	0.1	<0.1
Chaetodon spp.	30	8.6	18.4	0.3
Mullidae				
Pseudupeneus spp.	1	0.3	8.8	0.2
Pseudupeneus maculatus	19	5.5	174.2	3.3
Other Mullidae	67	19.3	390.7	7.4
Serranidae				
Paranthias sp.	1	0.3	0.2	<0.1
Paranthias furcifer	75	21.6	440.1	8.3
Other Serranidae	4	1.1	2.0	<0.1
Acanthuridae				
Acanthurus spp.	55	15.8	71.7	1.4
Acanthurus coeruleus	18	5.2	21.6	0.4
Acanthurus bahianus	1	0.3	2.2	<0.1
Holocentridae				
Holocentrus spp.	61	17.6	58.5	1.1
Holocentrus vexillarius	4	1.1	2.2	<0.1
Myripristis jacobus	1	0.3	3.0	<0.1
Other Holocentridae	3	0.8	0.6	<0.1
Dactylopteridae				
Dactylopterus volitans	66	19.0	110.9	2.1
Monacanthidae				
Monancanthus spp.	13	3.7	5.8	0.1
Cantherines sp.	20	5.8	34.6	0.6
Cantherines pullus	1	0.3	9.0	0.2
Alutera spp.	1	0.3	0.2	<0.1
Other Monacanthidae	39	11.2	35.7	0.7
Carangidae				
Vomer setapinnis	22	6.3	26.1	0.5
Decapterus spp.	4	1.1	12.5	0.2
Decapterus punctatus	5	1.4	31.4	0.6
Caranx spp.	5	1.4	—	—
Caranx bartholomaei	3	0.8	3.4	<0.1
Trachinotus spp.	2	0.5	0.9	<0.1

TABLE 3.—*List of forage organisms (arranged in order of frequency of occurrence) found in 347 skipjack tuna stomachs with food, collected from area 2*—Continued

Taxon	Frequency of occurrence No.	Frequency of occurrence Percent	Volume Ml.	Volume Percent
Selar sp.	1	0.3	4.0	<0.1
Selar crumenopthalmus	2	0.5	3.0	<0.1
Other Carangidae	16	4.6	105.9	2.0
Balistidae				
Balistes spp.	17	4.9	78.8	1.5
Balistes vetula	4	1.1	76.5	1.4
Xanthichthys ringens	1	0.3	3.0	<0.1
Other Balistidae	10	2.9	9.1	0.2
Stromateidae				
Cubiceps spp.	20	5.8	128.0	2.4
Cubiceps gracilis	1	0.3	1.3	<0.1
Other Stromateidae	3	0.8	8.6	0.2
Tetraodontidae				
Sphaeroides spp.	8	2.3	6.3	0.1
Lagocephalus spp.	5	1.4	7.4	0.1
Lagocephalus pachycephalus	1	0.3	2.2	<0.1
Other Tetraodontidae	9	2.6	6.5	0.1
Priacanthidae				
Priacanthus spp.	6	1.7	9.6	0.2
Priacanthus cruenatus	2	0.5	2.0	<0.1
Priacanthus arenatus	1	0.3	1.0	<0.1
Pseudopriacanthus altus	4	1.1	4.7	0.1
Other Priacanthidae	9	2.6	9.1	0.2
Syngnathidae				
Syngnathus spp.	10	2.9	1.0	<0.1
Syngnathus floridae	2	0.5	0.3	<0.1
Hippocampus spp.	1	0.3	0.1	<0.1
Hippocampus erectus	2	0.5	0.7	<0.1
Other Syngnathidae	1	0.3	0.1	<0.1
Scorpaenidae				
Scorpaena spp.	10	2.9	1.8	<0.1
Other Scorpaenidae	5	1.4	0.6	<0.1
Ostraciidae				
Lactophrys spp.	10	2.9	2.3	<0.1
Exocoetidae				
Exocoetus obtusirostris	1	0.3	50.0	0.9
Hirundichthys sp.	1	0.3	0.9	<0.1
Other Exocoetidae	7	2.0	64.1	1.2
Congridae	7	2.0	2.2	0.1
Percoidei	7	2.0	7.1	<0.1
Molidae				
Ranzania laevis	3	0.8	9.2	0.2
Other Molidae	1	0.3	0.6	<0.1
Bramidae				
Collybus drachme	4	1.1	2.5	<0.1
Scombroidei	4	1.1	4.0	0.1
Anguilloidei	3	0.8	0.8	<0.1
Coryphaenidae				
Coryphaena spp.	1	0.3	1.5	<0.1
Balistoidei	1	0.3	0.3	<0.1
Diodontidae	1	0.3	0.2	0.1
Paralepididae	1	0.3	0.8	0.1
Branchiostegidae				
Malacanthus plumieri	1	0.3	1.5	<0.1
Chiasmodontidae	1	0.3	0.6	<0.1
Caproidae				
Antigonia capros	1	0.3	0.6	<0.1
Ophichthidae	1	0.3	0.6	<0.1
Polynemidae	1	0.3	16.5	0.3
Mollusks:				
Cephalopoda				
Octopoda				
Tremoctopus violaceus	1	0.3	0.5	<0.1
Unidentified Octopoda	2	0.6	0.3	<0.1
Teuthoidea				
Unidentified Ommastrephidae	63	18.2	439.1	8.3
Illex illecebrosus	28	8.1	321.6	6.1
Ommastrephes spp.	1	0.3	8.0	0.2
Teuthoidea	4	1.2	5.6	<0.1
Other Cephalopoda	33	9.5	205.7	3.9
Gastropoda				
Heteropoda				
Oxygyrus keraudreni	6	1.7	0.6	0.1
Atlantidae	1	0.3	0.1	<0.1
Pteropoda				
Cavolinia uncinata	8	2.3	1.0	<0.1
Diacria trispinosa	1	0.3	0.1	<0.1
Tonnidae (larval forms)				
Tonna galea	1	0.3	0.1	<0.1
Other Tonnidae	1	0.3	0.1	<0.1
Crustaceans:				
Decapoda				
Brachyura (megalopae)	30	8.6	3.6	0.1
Unidentified Raninidae (megalopae)	22	6.3	3.4	0.1
Macrura-Natantia				
Caridea (larvae)	2	0.6	1.1	<0.1
Macrura-Reptantia				
Unidentified (Phyllosomae)	1	0.3	0.1	<0.1
Stomatopoda				
Unidentified Stomatopoda (larval forms)	27	7.8	11.4	0.2
Amphipoda (Hiperiidea)				
Phronima sedentaria	1	0.3	0.2	<0.1
Other Hyperiidea	4	1.2	0.4	<0.1
Isopoda	2	0.6	0.2	<0.1
Other crustaceans	17	4.9	2.2	<0.1

TABLE 4.—*List of forage organisms (arranged in order of frequency of occurrence) found in 39 yellowfin tuna stomachs with food, collected from area 2*

[Frequency of occurrence and volume are given for each taxon. See figure 1 for location of area of sampling]

Taxon	Frequency of occurrence No.	Frequency of occurrence Percent	Volume Ml.	Volume Percent
Fishes:				
Unidentifiable	33	84.6	602.3	20.3
Carangidae				
Decapterus spp.	4	10.2	92.7	3.1
Decapterus punctatus	3	7.6	38.0	1.3
Vomer setapinnis	3	7.6	2.1	0.1
Caranx spp.	1	2.5	1.0	<0.1
Caranx bartholomaei	1	2.5	8.2	0.3
Uraspis sp.	1	2.5	—	—
Other Carangidae	11	28.2	90.5	3.0
Serranidae				
Paranthias furcifer	21	53.8	1689.5	56.9
Scombridae				
Auxis spp.	7	17.9	20.4	0.7
Scomber spp.	1	2.5	1.5	<0.1
Other Scombridae	12	30.7	71.7	2.4
Chaetodontidae				
Holacanthus spp.	8	20.5	6.2	0.2
Chaetodon spp.	2	5.1	0.9	<0.1
Dactylopteridae				
Dactylopterus volitans	9	23.0	96.2	3.2
Balistidae				
Balistes spp.	3	7.6	7.2	0.2
Xanthichthys ringens	2	5.1	3.7	<0.1
Acanthigaster sphcroides	1	2.5	2.0	0.1
Other Balistidae	1	2.5	1.0	<0.1
Bramidae				
Collybus drachme	5	12.8	8.2	0.3
Collybus sp.	1	2.5	3.0	0.1
Other Bramidae	1	2.5	0.3	<0.1
Gempylidae				
Gempylus serpens	3	7.6	12.1	0.4
Other Gempylidae	3	7.6	2.1	0.1
Tetraodontidae				
Cantherines sp.	1	2.5	2.3	0.1
Cantherines pullus	3	7.6	9.6	0.3
Sphaeroides spp.	2	5.1	1.2	<0.1
Holocentridae				
Myripristis jacobus	1	2.5	2.0	<0.1
Holocentrus sp.	1	2.5	0.1	<0.1
Holocentrus ascensionis	1	2.5	1.5	<0.1
Holocentrus vexillarius	1	2.5	0.2	<0.1
Other Holocentridae	1	2.5	1.0	<0.1

TABLE 4.—*List of forage organisms (arranged in order of frequency of occurrence) found in 39 yellowfin tuna stomachs with food, collected from area 2*—Continued

Taxon	Frequency of occurrence		Volume	
	No.	Percent	Ml.	Percent
Acanthuridae				
Acanthurus bahianus	1	2.5	0.7	<0.1
Acanthurus chirugus	1	2.5	1.4	<0.1
Acanthurus spp.	1	2.5	0.8	<0.1
Other Acanthuridae	2	5.1	2.2	<0.1
Syngnathidae				
Syngnathus spp.	2	5.1	0.2	<0.1
Stromateidae				
Cubiceps spp.	1	2.5	5.1	0.2
Other Stromateidae	1	2.5	0.7	<0.1
Molidae				
Masturus lanceolatus	1	2.5	0.6	<0.1
Other Molidae	1	2.5	1.0	<0.1
Congridae	2	5.1	0.4	<0.1
Monacanthidae	1	2.5	1.0	<0.1
Ostraciidae				
Lactophrys spp.	1	2.5	0.2	<0.1
Priacanthidae				
Pseudopriacanthus altus	1	2.5	1.0	<0.1
Fistulariidae	1	2.5	0.2	<0.1
Anguilloidei	1	2.5	0.3	<0.1
Belonidae	1	2.5	0.5	<0.1
Coryphaenidae				
Coryphaena spp.	1	2.5	20.0	0.7
Pomacentridae				
Eupomacentrus sp.	1	2.5	0.1	<0.1
Chiasmodontidae				
Pseudoscopelus sp.	1	2.5	—	—
Mollusks:				
Cephalopoda				
Teuthoidea				
Ommastrephidae	9	23.0	68.4	2.3
Illex illecebrosus	1	2.5	11.0	0.4
Enoploteuthidae	1	2.5	0.5	<0.1
Other Teuthoidea	5	12.8	29.2	1.0
Other Cephalopoda	5	12.8	22.8	0.8
Crustaceans:				
Decapoda				
Brachyura (megalopae)	7	17.9	2.1	0.1
Raninidae (megalopae)	7	17.9	1.7	0.1
Grapsidae (megalopae)	7	2.5	0.2	<0.1
Stomatopoda (larval forms)	7	17.9	8.5	0.3
Macrura-Natantia				
Penaeidae				
Cerataspis sp.	1	2.5	0.4	<0.1
Cerataspis petiti	2	5.1	2.5	0.1
Amphipoda (Hyperiidea)	3	7.6	0.7	<0.1
Mysidacea	1	2.5	1.5	<0.1
Miscellaneous:				
Unidentifiable invertebrates	5	12.8	2.9	0.1

TABLE 5.—*List of forage organisms (arranged in order of frequency of occurrence) found in 257 skipjack tuna stomachs with food, collected from area 3*

[Frequency of occurrence and volume are given for each taxon. See figure 1 for location of area of sampling]

Taxon	Frequency of occurrence		Volume	
	No.	Percent	Ml.	Percent
Fishes:				
Unidentifiable	91	35.4	367.2	20.3
Gempylidae				
Promethichthys sp.	1	0.4	0.6	<0.1
Promethichthys prometheus	5	1.9	33.4	1.8
Nesiarchus sp.	1	0.4	1.8	<0.1
Gempylus serpens	1	0.4	0.1	<0.1
Other Gempylidae	9	3.5	46.1	2.5
Carangidae				
Vomer setapinnis	11	4.3	8.4	0.5
Selene vomer	1	0.4	0.6	<0.1
Decapterus spp.	1	0.4	2.0	<0.1
Other Carangidae	3	1.2	17.2	1.0
Serranidae	9	3.5	28.8	1.6

TABLE 5.—*List of forage organisms (arranged in order of frequency of occurrence) found in 257 skipjack tuna stomachs with food, collected from area 3*—Continued

Taxon	Frequency of occurrence		Volume	
	No.	Percent	Ml.	Percent
Acanthuridae				
Acanthurus spp.	2	0.8	2.4	0.1
Acanthurus monroviae	6	2.3	6.4	0.4
Scombridae				
Auxis spp.	2	0.8	16.2	0.9
Euthynnus alletteratus	1	0.4	<0.1	<0.1
Other Scombridae	4	1.6	7.9	0.4
Tetraodontidae				
Sphaeroides spp.	3	1.2	4.9	0.3
Other Tetraodontidae	3	1.2	0.6	<0.1
Bothidae	5	1.9	4.2	0.2
Bramidae				
Collybus drachme	1	0.4	1.7	<0.1
Brama rayi	1	0.4	0.8	<0.1
Other Bramidae	3	1.2	2.9	0.2
Anguilloidei	3	1.2	0.6	<0.1
Chiasmodontidae				
Pseudoscopelus sp.	3	1.2	7.8	0.4
Syngnathidae				
Hippocampus spp.	1	0.4	0.1	<0.1
Other Syngnathidae	2	0.8	0.6	<0.1
Scorpaenidae				
Scorpaena spp.	2	0.8	1.1	<0.1
Other Scorpaenidae	1	0.4	0.5	<0.1
Dactylopteridae				
Dactylopterus volitans	3	1.2	2.0	0.1
Chaetodontidae				
Chaetodon spp.	2	0.8	1.7	<0.1
Priacanthidae	2	0.8	2.6	0.1
Paralepididae				
Paralepis spp.	1	0.4	68.0	3.8
Other Paralepididae	1	0.4	3.5	0.2
Monacanthidae				
Monacanthus spp.	1	0.4	0.8	<0.1
Balistidae	1	0.4	0.7	<0.1
Trichiuridae	1	0.4	1.5	<0.1
Synodontidae				
Synodus spp.	1	0.4	0.1	<0.1
Congridae	1	0.4	0.2	0.1
Myctophidae	1	0.4	0.2	0.1
Mollusks:				
Cephalopoda (adults and juveniles)				
Octopoda				
Argonauta sp.	1	0.4	0.5	<0.1
Other Octopoda	1	0.4	3.2	0.2
Teuthoidea				
Illex illecebrosus	8	3.1	47.7	2.6
Ommastrephidae	5	1.9	34.3	1.9
Ommastrephes pteropus	1	0.4	19.0	1.0
Other Teuthoidea	2	0.8	1.6	0.1
Gastropoda (adults)				
Heteropoda				
Oxygyrus keraudreni	13	5.1	2.0	0.1
Atlanta sp.	4	1.6	0.4	<0.1
Protatlanta sp.	1	0.4	0.1	<0.1
Atlantidae	1	0.4	0.1	<0.1
Pteropoda				
Diacria trispinosa	9	3.5	1.3	<0.1
Cavolinia spp.	5	1.9	0.5	<0.1
Cavolinia longirostris	3	1.2	0.3	<0.1
Cavolinia uncinata	5	1.9	17.5	0.1
Opisthobranchia	1	0.4	0.1	<0.1
Other Cephalopoda	40	15.6	89.9	5.0
Other mollusks	2	0.8	0.2	<0.1
Crustaceans:				
Stomatopoda (larval forms)	122	47.5	452.8	25.0
Decapoda				
Brachyura (megalopae)	110	42.8	343.6	19.0
Raninidae (megalopae)	8	3.1	1.4	0.1
Grapsidae (megalopae)	1	0.4	0.4	<0.1
Anomura				
Paguridea (all Glaucothoe)				
Dardanus spp.	3	1.2	0.4	<0.1
Dardanus arrosor	1	0.4	0.3	<0.1
Dardanus pectinatus	6	2.3	5.9	0.3
Petrochirus pustulatus	3	1.2	0.5	<0.1
Diogenidae	1	0.4	1.2	<0.1
Macrura-Natantia				
Penaeidae (all larvae)				
Cerataspis spp.	1	0.4	0.1	<0.1
Cerataspis monstrosa	1	0.4	1.0	<0.1
Other Macrura-Natantia	2	0.8	1.2	<0.1

TABLE 5.—*List of forage organisms (arranged in order of frequency of occurrence) found in 257 skipjack tuna stomachs with food, collected from area 3*—Continued

Taxon	Frequency of occurrence No.	Frequency of occurrence Percent	Volume Ml.	Volume Percent
Caridea (larvae and juveniles)	4	1.6	0.6	<0.1
Brachycarpus biunguiculatus	4	1.6	0.6	<0.1
Heterocarpus ensifer	1	0.4	2.9	0.2
Enoplometopus sp.	1	0.4	0.4	<0.1
Palaemonidae	1	0.4	0.1	<0.1
Stenopodidae	1	0.4	0.6	<0.1
Macrura-Reptantia (all Phyllosoma larvae)				
Scyllarus sp.	5	1.9	2.0	0.1
Panulirus rissoni	1	0.4	0.1	<0.1
Other Macrura-Raptantia	2	1.9	1.2	<0.1
Amphipoda (Hyperiidea) (adults and juveniles)				
Brachyscelus spp.	27	10.5	16.5	0.9
Phrosina semilunata	20	7.8	7.4	0.4
Phronima sedentaria	6	2.3	1.3	0.1
Oxycephalus clausii	5	1.9	2.5	0.1
Platyscellus ovoides	5	1.9	2.3	0.1
Streetsia challengeri	3	1.2	1.0	<0.1
Streetsia porcela	2	0.8	0.2	<0.1
Anchylomera blossevillei	2	0.8	0.3	<0.1
Parapronoe crustulum	1	0.4	0.7	<0.1
Other Hyperiidea	57	22.2	19.4	1.1
Euphausicea (adults)	2	0.8	0.2	<0.1
Mysidacea	3	1.2	0.5	<0.1
Miscellaneous:				
Unidentifiable invertebrates	59	22.9	59.0	3.3

TABLE 6.—*List of forage organisms (arranged in order of frequency of occurrence) found in 520 yellowfin tuna stomachs with food, collected from area 3*

[Frequency of occurrence and volume are given for each taxon. See figure 1 for location of area of sampling]

Taxon	Frequency of occurrence No.	Frequency of occurrence Percent	Volume Ml.	Volume Percent
Fishes:				
Unidentifiable	268	51.5	845.4	13.4
Carangidae				
Vomer sp.	3	0.6	1.4	<0.1
Vomer setapinnis	32	6.1	29.0	0.5
Decapterus spp.	5	0.9	33.9	0.5
Selar crumenopthalmus	4	0.8	2,144.0	34.1
Uraspis sp.	1	0.2	3.5	<0.1
Other Carangidae	11	2.1	36.5	0.6
Tetraodontidae				
Sphaeroides spp.	10	1.9	17.0	0.3
Canthigaster sp.	1	0.1	42.0	0.7
Canthigaster rostratus	3	0.6	27.6	0.4
Lagocephalus lagocephalus	1	0.2	2.0	<0.1
Sphaeroides spengleri	1	0.2	1.6	<0.1
Other Tetraodontidae	24	4.6	115.2	1.8
Gempylidae				
Promethichthys prometheus	4	0.8	21.0	0.3
Nesiarchus nasutus	3	0.6	3.7	<0.1
Other Gempylidae	32	6.1	81.0	1.3
Serranidae				
Anthias anthias	2	0.4	2.0	<0.1
Paranthias furcifer	2	0.4	0.3	<0.1
Other Serranidae	18	3.5	11.0	0.2
Priacanthidae				
Priacanthus spp.	4	0.8	2.5	<0.1
Priacanthus cruenatus	2	0.4	2.5	<0.1
Priacanthus arenatus	1	0.2	1.2	<0.1
Cookeolus boops	1	0.2	1.1	<0.1
Other Priacanthidae	10	1.9	9.3	0.1
Scombridae				
Auxis spp.	5	0.9	19.2	0.3
Scomber japonicus	2	0.4	18.0	0.3
Other Scombridae	9	1.7	7.7	0.1
Bramidae				
Collybus drachme	8	1.5	5.0	0.1
Pterycombus sp.	1	0.2	1.7	<0.1
Other Bramidae	1	0.2	0.3	<0.1

TABLE 6.—*List of forage organisms (arranged in order of frequency of occurrence) found in 520 yellowfin tuna stomachs with food, collected from area 3*—Continued

Taxon	Frequency of occurrence No.	Frequency of occurrence Percent	Volume Ml.	Volume Percent
Zeidae				
Zenion hololepis	9	1.7	270.5	4.3
Dactylopteridae				
Dactylopterus volitans	8	1.5	10.2	0.2
Chaetodontidae				
Chaetodon spp.	3	0.6	1.1	<0.1
Chaetodon marcelae	5	0.9	7.4	0.1
Bothidae	5	0.9	2.7	<0.1
Gonostomatidae				
Maurolicus sp.	1	0.2	0.5	<0.1
Maurolicus mulleri	3	0.6	33.0	0.5
Other Gonostomatidae	1	0.2	0.7	<0.1
Exocoetidae				
Hirundichthys sp.	1	0.2	47.0	0.7
Other Exocoetidae	4	0.8	221.3	3.5
Scorpaenidae				
Scorpaena spp.	1	0.2	2.1	<0.1
Other Scorpaenidae	4	0.8	6.2	0.1
Ostraciontidae	4	0.8	2.5	<0.1
Stromateidae	3	0.6	6.0	0.1
Monacanthidae	3	0.6	12.0	0.2
Congridae				
Ariosoma sp.	2	0.4	9.9	0.2
Other Congridae	1	0.2	0.5	<0.1
Nomeidae				
Cubiceps spp.	2	0.4	3.3	<0.1
Cubiceps gracilis	1	0.2	2.5	<0.1
Chiasmodontidae				
Pseudoscopelus sp.	2	0.4	3.2	<0.1
Aulostomidae				
Aulostomus maculatus	2	0.4	8.9	0.1
Anguilloidei	2	0.4	17.3	0.3
Paralepididae				
Paralepis spp.	2	0.4	167.0	2.6
Trichiuridae	2	0.4	30.5	0.5
Acanthuridae				
Acanthurus monroviae	1	0.2	0.4	<0.1
Other Acanthuridae	1	0.2	0.8	<0.1
Syngnathidae				
Hippocampus spp.	1	0.2	1.6	<0.1
Dorichthus spp.	1	0.2	0.6	<0.1
Grammicolepididae				
Xenolepidichthys sp.	1	0.2	3.0	<0.1
Ostraciidae				
Ostracion sp.	1	0.2	1.1	<0.1
Scorpaenoidei	1	0.2	2.0	<0.1
Synodontidae				
Synodus spp.	1	0.2	1.0	<0.1
Uranoscopidae	1	0.2	0.2	<0.1
Triglidae				
Lepidotrigla spp.	1	0.2	0.2	<0.1
Pomacentridae	1	0.2	0.2	<0.1
Scombroidei	1	0.2	0.4	<0.1
Stomiatoidei	1	0.2	0.2	<0.1
Eugraulidae	1	0.2	0.3	<0.1
Caproidae				
Antigonia capros	1	0.2	1.2	<0.1
Anoplogasteridae	1	0.2	2.5	<0.1
Callionymidae	1	0.2	0.1	<0.1
Holocentridae				
Holocentrus spp.	1	0.2	0.3	<0.1
Berycoidei	1	0.2	0.4	<0.1
Blenniidae				
Blennius spp.	1	0.2	0.4	<0.1
Balistidae	1	0.2	0.9	<0.1
Mollusks (juveniles and adults):				
Cephalopoda (adults and juveniles)				
Octopoda				
Argonauta sp.	2	0.4	1.3	0.1
Other Octopoda	15	2.9	27.5	0.4
Teuthoidea				
Ommastrephidae	21	4.0	117.0	1.9
Ommastrephes spp.	2	0.4	0.5	0.1
Ommastrephes pteropus	4	0.8	17.0	0.3
Illex illecebrosus	17	3.3	174.3	2.8
Abralia sp.	2	0.4	1.0	0.1
Sepioidea	1	0.2	2.3	<0.1
Other Teuthoidea	19	3.6	76.6	1.2
Other cephalopods	173	33.3	332.9	5.3
Gastropoda				
Heteropoda				
Oxygyrus keraudreni	6	1.1	0.7	<0.1

TABLE 6.—*List of forage organisms (arranged in order of frequency of occurrence) found in 520 yellowfin tuna stomachs with food, collected from area 3*—Continued

TABLE 6.—*List of forage organisms (arranged in order of frequency of occurrence) found in 520 yellowfin tuna stomachs with food, collected from area 3*—Continued

Taxon	Frequency of occurrence		Volume	
	No.	*Percent*	*Ml.*	*Percent*
Pteropoda				
Cavolinia sp.	1	0.2	0.1	0.1
Cavolinia uncinata	1	0.2	0.1	0.1
Atlantidae	1	0.2	0.1	0.1
Tonnidae				
Tonna galea (larvae)	5	0.9	0.7	<0.1
Opisthobranchia	1	0.1	0.1	0.1
Other mollusks	3	0.6	0.3	<0.1
Crustaceans:				
Stomatopoda (larval forms)				
Lysiosquilla sp.	1	0.2	2.0	<0.1
Other Stomatopoda	366	70.4	573.4	9.1
Decapoda				
Brachyura (megalopae)	107	20.6	104.1	1.6
Raninidae (megalopae)	29	5.6	3.0	<0.1
Lyreidus sp. (megalopae)	1	0.2	0.1	<0.1
Grapsidae (megalopae)	4	0.8	2.0	<0.1
Anomura				
Paguridea (all Glaucothoe)				
Dardanus spp.	16	3.1	5.6	0.1
Dardanus pectinatus	12	2.3	2.2	<0.1
Dardanus arrosor	2	0.4	0.3	<0.1
Petrochirus pustulatus	4	0.8	0.5	<0.1
Diogenidae	1	0.2	0.1	<0.1
Other Anomura	31	5.9	13.8	0.2
Macrura-Natantia (Caridea—adults, juveniles, and larvae)				
Heterocarpus ensifer	26	5.0	255.6	4.1
Brachycarpus biunguiculatus	17	3.2	4.4	0.1
Stenopus hispidus	1	0.2	0.2	<0.1
Enoplometopus sp.	1	0.2	0.4	<0.1
Lucifer sp.	1	0.2	0.1	<0.1
Other Macrura-Natantia	20	3.8	7.6	0.1
Macrura-Reptantia (all Phyllosomae)				
Scyllarus sp.	26	5.0	5.3	0.1
Scyllarides sp.	3	0.6	1.6	<0.1
Panulirus rissoni	1	0.2	0.2	<0.1
Other Macrura-Reptantia	4	0.8	8.0	<0.1
Amphipoda (Hyperiidea)				
Brachyscelus spp.	67	12.9	12.3	0.2
Phrosina semilunata	55	10.6	17.3	0.2
Phronima sedentaria	19	3.6	2.7	<0.1
Streetsia challengeri	5	0.9	0.5	<0.1
Platyscellus ovoides	5	0.9	0.9	<0.1
Platyscelus serratulus	3	0.6	0.2	<0.1
Oxycephalus clausii	4	0.8	0.5	<0.1
Vibilia cultripes	4	0.8	0.7	<0.1
Anchylomera blossevillei	3	0.6	0.3	<0.1
Sympronoe parva	2	0.4	0.2	<0.1
Vibilia sp.	2	0.4	0.2	<0.1
Phronima spp.	1	0.2	0.1	<0.1
Pararpronoe crustulum	1	0.2	0.2	<0.1
Other Hyperiidea	45	8.6	10.4	0.2
Euphausiacea	3	0.6	0.6	<0.1
Mysidacea	1	0.2	0.1	<0.1
Copepoda				
Euchaeta sp.	1	0.2	0.1	<0.1
Miscellaneous:				
Unidentifiable invertebrates	129	24.8	134.1	2.1