COMPARATIVE STUDY OF FOOD OF SKIPJACK AND YELLOWFIN TUNAS OFF THE COAST OF WEST AFRICA[1]

ALEXANDER DRAGOVICH AND THOMAS POTTHOFF[2]

ABSTRACT

Stomach contents of 711 skipjack tuna (*Katsuwonus pelamis*) and 132 yellowfin tuna (*Thunnus albacares*) captured in 1968 by live bait and trolling off the coast of West Africa were examined. A marked taxonomic similarity was noted between the organisms in the diets of the two tunas. Frequency of occurrence, displacement volume, and numbers of each food item identified are presented for each species of tuna. Fishes, mollusks, and crustaceans were the principal foods with fishes generally dominant. The most prominent fish families were Acanthuridae, Carangidae, Dactylopteridae, Gempylidae, Gonostomatidae, Lutjanidae, Mullidae, Priacanthidae, Scombridae, Serranidae, and Trichiuridae; mollusks were chiefly cephalopods (squids), and crustaceans consisted mostly of macrozooplankton. Juvenile tunas were present in the diet of both species of tunas.

Estimates of the size of forage organisms were primarily based on displacement volumes. In the majority of observations, food organisms displaced less than 1.0 ml and the displacement volumes of stomach contents varied for skipjack tuna from 0.1 to 20.0 ml and for yellowfin tuna from 0.1 to 60.0 ml.

Spearman's rank correlation analysis was used to test for a relation between the food type (in volume and frequency of occurrence) and the lengths of skipjack and yellowfin tunas. Significant correlations were noted between the size of skipjack tuna and both the volume and the frequency of occurrence of forage fish.

A comparison between the findings of our study and that of other food studies off the coast of West Africa showed greater taxonomic similarity in tuna forage when the studies were made in the same general area and that only several types of food were of primary importance in each given area. Seasonal changes in taxonomic composition of forage organisms were also discussed.

The method used to evaluate food organisms consisted of ranking the organisms according to their dispersal indices, abundance indices, and biomass contribution. Stomatopods, the amphipod *Phrosina semilunata*, Teuthoidea, Carangidae, Serranidae, and megalopal stages were most important constituents of food throughout the investigation area.

The principal surface tuna fishery in the tropical Atlantic Ocean is located off the coast of West Africa (Jones, 1969). One of the major tasks of the Southeast Fisheries Center, Miami Laboratory, has been the study of the biology and ecology of tunas and tunalike fishes in the tropical Atlantic Ocean. In view of the recognized importance of food as an ecological factor in the life history of tunas, one project of this investigation consisted of a study of the food and feeding habits of skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*) tunas — the two predominant species in commercial catches in those waters.

We describe and compare the food of skipjack and yellowfin tunas and discuss the relative importance of different forage organisms. We compare our findings with those of other investigators working in the same general area. This

[1] Contribution No. 218, National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory, Miami, Fla.

[2] National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory, 75 Virginia Beach Drive, Miami, FL 33149.

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information may be used to study the relationship between the distribution of food organisms and occurrence of tuna schools.

Most of the information up to 1969 on food of various tunas off the west coast of Africa may be found in the review of studies of tuna food in the Atlantic Ocean by Dragovich (1969). Dragovich (1970) also reported on the food of skipjack and yellowfin tunas off the west coast of Africa.

MATERIALS AND METHODS

Samples on which the present report is based were collected during February, March, April and September, October, November of 1968 on two cruises (UN6801 and UN6802) of the research vessel *Undaunted* of the Bureau of Commercial Fisheries (now National Marine Fisheries Service) (Figure 1). All tunas sampled for

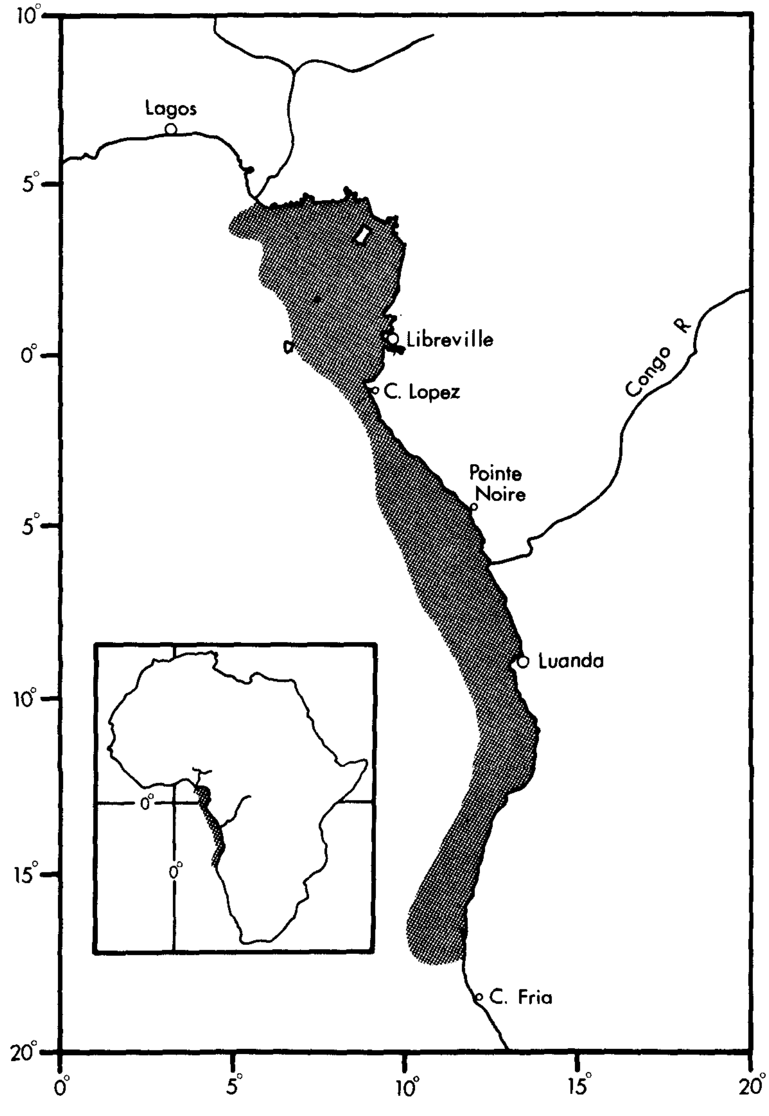

FIGURE 1.—Shaded area shows localities where stomachs of skipjack and yellowfin tunas were collected.

this study were caught by pole and line or by trolling (Table 1). A total of 711 stomachs from skipjack tuna and 132 from yellowfin tuna were examined. The skipjack tuna studied varied in fork length from 36 to 63 cm and the yellowfin tuna from 52 to 94 cm (Figure 2).

Sampling of catches for stomach samples was carried out as other requirements of the program and circumstances permitted. Immediately after completion of the morphometric work aboard the ship the stomachs were removed by opening the abdominal cavity and by severing them from the intestine and the esophagus. Each stomach was pierced in several places to allow

TABLE 1.—Distribution of skipjack and yellowfin tuna stomachs collected during 1968 from the eastern tropical Atlantic Ocean, identified by month, cruise, and method of capture.

February UN6801[1]		March UN6801		April UN6801		September UN6802[2]		October UN6802		November UN6802		Total		
With food	Empty	With food	Empty	With food	Empty	With food	Empty	With food	Empty	With food	Empty	With food	Empty	Method of capture
							Skipjack tuna							
		20	28	292	36	70	4	104	69	25	5	511	142	Live bait
41	8	3	3					3				47	11	Trolling
							Yellowfin tuna							
				67		24	4	18	1			109	5	Live bait
4		9	1	3						1		17	1	Trolling

[1] UN6801 = RV *Undaunted* 6801 cruise.
[2] UN6802 = RV *Undaunted* 6802 cruise.

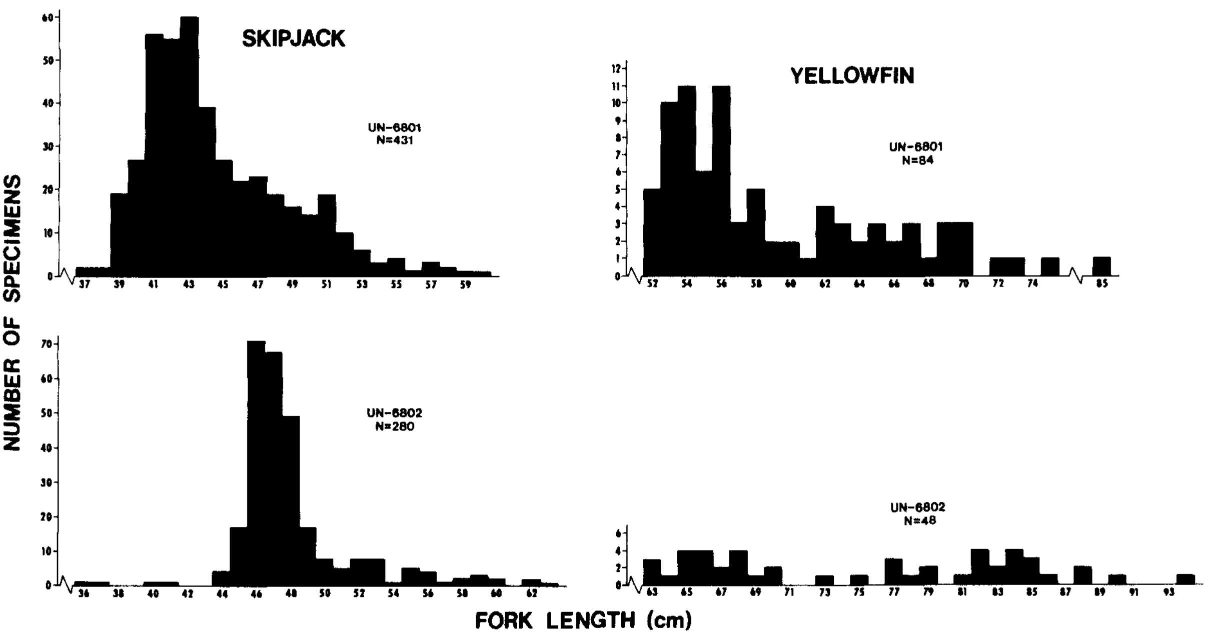

FIGURE 2.—Length-frequency distribution of skipjack tuna and yellowfin tunas from which stomachs were collected.

penetration of Formalin[3] and placed in a labeled polyethelene bag containing 10% Formalin.

In the laboratory the stomachs were first classified into those containing food and those that were empty. The stomach contents were then identified to the lowest possible taxonomic units which were subsequently sorted, counted, and their displacement volumes measured. Length measurements were taken of many forage organisms, particularly fishes. Bait fishes were found in some of the stomachs, but they were not considered as part of the regular diet of skipjack and yellowfin tunas; therefore, stomachs which contained only bait were considered empty. Stomachs that contained parasitic trematodes were also considered empty.

This study was no exception in regard to difficulties encountered in the identification of forage organisms (Dragovich, 1969). In numerous instances the identification of ingested fishes, particularly juvenile tunas, was made from vertebrae using methods employed by Potthoff and Richards (1970). Cephalopod identification was particularly difficult since many diagnostic external characters usually are the first destroyed during digestion.

The following methods of analysis were used: 1) the volumetric method—the individual volume of each taxon and the total aggregate volume of broad taxonomic groups, 2) frequency of occurrence method—the frequency of occurrence of a food item and of broad taxonomic groups, and 3) numerical method—number of individuals in the same taxonomic group.

Spearman's rank correlation test, χ^2 test of homogeneity, and paired t-test of difference between the means were used. A method consisting of ranking of food organisms according to their geographic distribution, relative abundance, and biomass was also employed.

COMPOSITION OF FOOD

Fishes, crustaceans, and cephalopods were the three principal food categories found in stomachs of both skipjack and yellowfin tunas (Figure 3). Food items that do not fall into these three categories consisted of mollusks other than cephalopods, salps, polychaetes, and siphonophores. Other mollusks and salps were found in both species of tunas; polychaetes and siphonophores were present only in stomachs of skipjack tunas. A checklist of all food items, number of organisms, frequency of occurrence, displacement volumes, and length measurements of some organisms are presented according to the cruises in Appendix Tables 1 to 4. Fishes were represented in the diet of skipjack and yellowfin tunas by 90 different taxa, crustaceans by 45, and mollusks by 24.

The percentage composition of five food categories in terms of number, volume, and frequency of occurrence is shown in Figure 3. Fish was the dominant food item by volume for both species of tunas, except for yellowfin tuna captured during UN6802, when cephalopods were dominant. Fish occurred most frequently in the diet of both species of tunas sampled during UN6801; however, crustaceans occurred most often in the collections from UN6802. In the diet of yellowfin tuna, fishes were numerically the most important food items during both cruises; in the diet of skipjack tuna, fishes were the most important by numbers during UN6801, but crustaceans were most numerous during UN6802.

The group of forage organisms classed as other mollusks consisted primarily of pteropods and heteropods. Salps, polychaetes, and siphonophores were the principal components of the group of forage organisms classed as miscellaneous—this group was not prominent by volume, frequency of occurrence, or by numbers.

FISHES

Fishes utilized as food consisted mainly of postlarval and juvenile forms of pelagic and reef fishes. Some adult fishes, primarily *Vinciguerria nimbaria*, were also present in the diet of both species of tuna. Although fishes were represented by a larger number of families, only a few families were important in terms of volume, frequency of occurrence, and numbers.

[3] Use of trade names does not imply endorsement by the National Marine Fisheries Service.

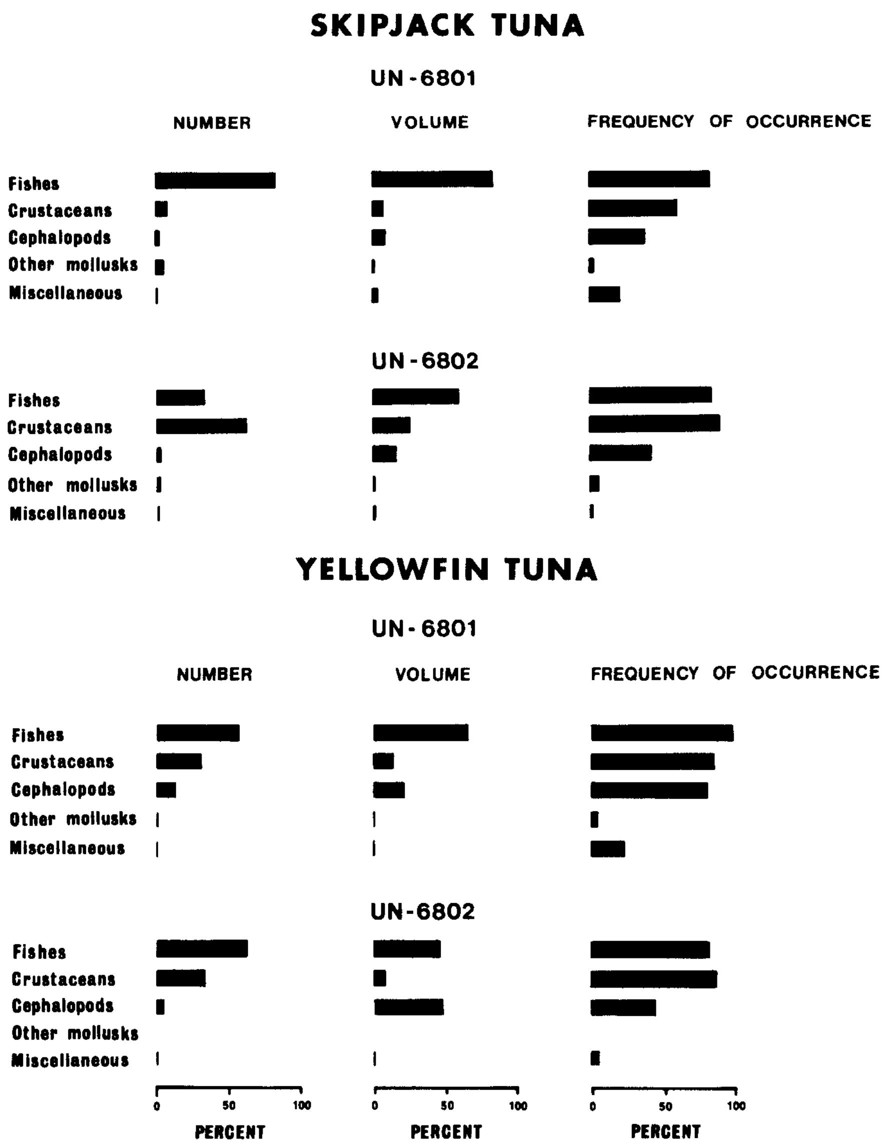

FIGURE 3.—Percentage of total food (by five categories) in stomachs of skipjack and yellowfin tunas captured during cruises UN6801 and UN6802 off the west coast of Africa. Food items are represented in terms of numbers, volumes, and frequency of occurrence.

For UN6801, fish families Acanthuridae, Carangidae, Dactylopteridae, Gempylidae, Gonostomatidae, Lutjanidae, Mullidae, Priacanthidae, Scombridae, and Serranidae ranked high in terms of volume and frequency of occurrence for both species of tunas. Owing to the large numbers of *V. nimbaria* in the diet of both species of tunas, the family Gonostomatidae was the most important forage item for both species in terms of volume. In the diet of skipjack tuna, important contributors by volume were Gonostomatidae, 44.7%; Engraulidae, 8.9%; Mullidae, 7.9%; Gempylidae, 2.7%; Serranidae, 2.5%; Lutjanidae, 2.0%; Scombridae, 1.6%; Carangidae, 1.6%; and Priacanthidae, 1.5%. Important contributors by volume to the diet of yellowfin tuna were Gonostomatidae, 22.1%; Mullidae, 14.8%; Tetragonuridae, 6.3%; Carangidae, 3.8%; Paralepididae, 1.5%; Priacanthidae, 1.2%; and Scombridae, 1.0%. The remaining fish families contributed less than 1% per family for both species of tunas. The high volumetric contribution by the family Tetragonuridae was due to the large size of only four *Tetragonurus cuvieri*, which were found in a single stomach of a yellowfin tuna.

During UN6802 most important fish families by volume and by frequency of occurrence were Carangidae, Gempylidae, Paralepididae, Scombridae, and Trichiuridae. Serranidae and Scorpaenidae were prominent in the diet of skipjack tuna, but entirely absent in the diet of yellowfin tuna. Important contributors by volume in the diet of skipjack tuna were Paralepididae, 28.4%; Percoidei, 8.6%; Carangidae, 3.1%; Serranidae, 1.5%; Trichiuridae, 1.4%; Gempylidae, 1.3%; and Scombridae, 1.2%. In the diet of yellowfin tuna important contributors by volume were Exocoetidae, 9.6%; Alepisauridae, 5.6%; Carangidae, 2.7%; Trachypteridae, 2.6%; Scombridae, 2.5%; and Percoidei, 1.4%. The remaining fish families and suborders in the diet of both species of tunas contributed less than 1% per taxon in terms of volume. The relatively high contribution by the families Exocoetidae and Alepisauridae was due to the large volumes of only three forage fish (Appendix Table 4). From our data we see that some of the prominent forage fish families for both species of tunas were common to both cruises and that others were important during only one cruise (Appendix Tables 1-4).

CRUSTACEANS

As shown in previous publications (Dragovich, 1969, 1970), crustaceans, because of their high numbers and high frequency of occurrence, were important components of tuna food. Crustaceans found in tuna stomachs during both cruises were similar. The majority were larval stomatopods, hyperiid amphipods, and different types of megalopae or their equivalents. The highest number (32) of taxa was noted in the diet of skipjack tuna during UN6801, while in the diet of yellowfin tuna for the same cruise, 20 different taxa were identified—16 of these were common in the diet of both species of tunas. During UN6802, 22 different taxa were identified in the diet of skipjack tuna and 10 in the diet of yellowfin tuna—7 were common to both species of tuna. Stomatopods were not identified further than order. *Phronima sedentaria*, *Phrosina semilunata*, and *Brachyscellus* spp. were the most common amphipods in both tunas for both cruises. Megalopal stages probably consisted of many species, but due to the lack of taxonomic literature, they were not identified further than class or family.

A variety of anomurans and caridean shrimp were consumed by both species of tunas. *Dardanus pectinatus* (Glaucothoë) was the most important anomuran for both tunas during both cruises. Carideans were more prominent during UN6801 than during UN6802.

Euphausia hanseni was eaten by both tunas during UN6801. During UN6802, *E. hanseni* occurred in high numbers in the diet of skipjack tuna but was entirely absent in the food of yellowfin tuna. Since *E. hanseni* are of minute size, they were probably accidentally ingested or the skipjack tuna were filter feeding. The same explanation may be applied to other organisms of similar size found in the stomachs of both species of tunas, for example, copepods and isopods. Another explanation is that some of the euphausiids, copepods, or isopods could be the remains of stomach contents of other fishes ingested by tunas.

Phyllosoma occurred in low numbers in the diet of both species during both cruises. The identified forms were *Panulirus rissoni*, *Scyllarus arctus*, *Scyllarus* sp., and *Scyllaridea* sp.

MOLLUSKS

Cephalopods formed the bulk of the molluscan food of both species of tunas during both cruises.

Teuthoidea (squid) were the most important by volume and by frequency of occurrence in the diet of both species. Most of the squid belong to the family Ommastrephidae. Among identified omasterphids, *Ornithoteuthis antillarum* was most frequently encountered. This species was especially numerous in the food of skipjack tuna during UN6802. Octopoda were less numerous and occurred with less frequency than Teuthoidea. The displacement volume of some of the Octopoda (*Argonauta argo* and *A.* sp.) was very large. Five specimens of *A. argo* consumed by yellowfin tuna during UN6802 displaced 165.5 ml—more than all other mollusks combined for that cruise or all the fishes for that cruise (Appendix Table 4).

Among other mollusks, pteropods and heteropods were found in the stomachs of skipjack tuna during both cruises. They were absent in the food of yellowfin tuna during UN6802 and occurred only in two stomachs during UN6801. A heteropod, *Cavolinia longirostris,* occurred in high numbers in the diet of skipjack tuna during UN6801. In terms of volume, both of these mollusks were of minor importance.

JUVENILE TUNAS AS FOOD OF SKIPJACK AND YELLOWFIN TUNAS

Knowledge on the distribution and abundance of juvenile tunas and tunalike fishes is very limited because existing collection methods for juveniles are inadequate. This information is very important, however, as an aid in identifying spawning seasons and areas of tunas. One of the major sources of juvenile tunas is from stomachs of adult tunas. Juvenile tunas and tunalike fishes were present in the diet of both species of tunas sampled on both cruises. As many as 20 juvenile tunas were found in a single tuna stomach. The most frequently encountered and the most numerous juvenile tunas were *Auxis* spp. and little tunny (*Euthynnus alletteratus*) (Table 2). Specimens of *Auxis* spp. were found in both species of tunas during both cruises. Specimens of *E. alletteratus* were present in the diet of both species of tunas, but only during UN6801. All the remaining species of juvenile tunas occurred infrequently in small numbers. *Katsuwonus pelamis* and *Thunnus*

TABLE 2.—Occurrence of juvenile scombrids in the stomachs of skipjack and yellowfin tunas during cruises UN6801 and UN6802.

	Total number	Standard length (mm)		Number of juveniles in a single stomach	Frequency of occurrence		Displacement volumes	
		Range	Mean		Number	Percent	ml	Percent
				Skipjack tuna UN6801				
Unidentified Scombridae	4	--	--	1, 2	3	0.8	0.5	<0.1
Auxis spp.	53	12-37	29	1, 2, 3, 4, 9	29	8.1	9.5	0.3
Euthynnus alletteratus	120	10-68	29	1, 2, 3, 4, 5, 10	66	18.5	28.1	1.0
Katsuwonus pelamis	2	20-32	26	1	2	0.6	0.3	0.3
Thunnus spp.	2	34-47	41	1	2	0.6	1.4	<0.1
				Skipjack tuna UN6802				
Auxis spp.	33	15-63	31	1, 6, 16	10	5.0	8.6	0.9
Sarda sarda	4	25-43	34	1	4	2.0	2.3	0.2
Scomber japonicus	1	--	40	1	1	0.5	1.3	0.1
				Yellowfin tuna UN6801				
Auxis spp.	7	12-50	22	1, 2	5	6.0	1.4	<0.1
Euthynnus alletteratus	58	11-70	33	1, 2, 3, 4, 5, 6, 8	21	25.3	16.0	0.7
Katsuwonus pelamis	1	38	38	1	1	1.2	0.2	<0.1
Thunnus spp.	3	29-40	36	1	3	3.6	0.8	<0.1
				Yellowfin tuna UN6802				
Unidentified Scombridae	15	--	--	1, 3, 8	6	14.0	0.8	0.2
Auxis spp.	53	15-34	22	1, 2, 4, 7, 20	11	25.6	7.4	2.1
Sarda sarda	4	15-21	18	1, 3	2	4.7	0.5	0.1
Scomber japonicus	1	--	28	1	1	2.3	0.1	<0.1

spp. were found in the stomachs of both species of tunas, but only during UN6801. *Sarda sarda* and *Scomber japonicus* were also found in both skipjack and yellowfin tunas, but only during UN6802.

The presence of juvenile tunas in the diet of skipjack and yellowfin tunas in various parts of the Atlantic Ocean has been reported by Dragovich (1969, 1970). Presence of *Auxis* spp. and *Scomber* sp. in the diet of yellowfin tuna from east African waters was noted by Williams (1966). Suarez Caabro and Duarte Bello (1961) noted juvenile blackfin tuna (*Thunnus atlanticus*) (5-150 mm fork length) and skipjack tuna (35-145 mm fork length) in the stomachs of skipjack tuna from the Caribbean Sea. Presence of juvenile tunas in the diet of adult tunas has been frequently observed in food studies in the Pacific Ocean (Reintjes and King, 1953; King and Ikehara, 1956; Alverson, 1963; Nakamura, 1965).

COMPARISON OF FOOD OF SKIPJACK AND YELLOWFIN TUNAS

As in a previous study by Dragovich (1970), our data show a marked taxonomic similarity of items in the diet of skipjack and yellowfin tunas for the investigation area as a whole (Appendix Tables 1-4). We also compared the taxonomic composition of forage organisms at the two locations where skipjack and yellowfin tunas were caught together in a mixed school. For those locations we performed χ^2 tests of homogeneity on the ratio of fish to total volume of food. The first test indicated that the percentage of fish consumed differs between the two locations ($\chi^2 = 6.74$; 1 *df*; $P < 0.1$) possibly reflecting differences in forage-at-large composition, times of day, size frequency of tuna, etc. Within-area difference in percent fish between yellowfin and skipjack tunas was significant in only one area ($\chi^2 = 62.51$; 1 *df*; $P < 0.01$).

TABLE 3.—The distribution of displacement volumes of individual forage organisms collected during the cruises of UN6801 and UN6802.

Food item	Total range of displacement volumes (ml)	Displacement volumes in 90% of observations
	Skipjack tuna	
Fish	0.1- 8.2	0.1-0.3
Crustaceans	0.1- 1.2	0.1
Cephalopods	0.1- 6.5	0.1-1.6
Other mollusks	0.1- 0.4	0.1
Salps	0.1- 3.5	0.1-0.7
	Yellowfin tuna	
Fish	0.1-55.0	0.1-0.5
Crustaceans	0.1- 1.0	0.1
Cephalopods	0.1-50.5	0.1-0.7
Salps	0.1	0.1

VARIATION IN FOOD AS RELATED TO SIZE OF TUNAS AND VOLUME OF STOMACH CONTENTS

The foods of skipjack and yellowfin tunas in the present study consisted principally of relatively small organisms, based on their displacement volumes (Table 3). The consumption of organisms of comparable size in similar proportions by skipjack and yellowfin tunas has also been observed by other investigators (Reintjes and King, 1953; King and Ikehara, 1956; Nakamura, 1965; Williams, 1966; Dragovich, 1970).

To observe the differences in consumption of food by volume and frequency of occurrence of the three major food categories as related to size of tunas, skipjack and yellowfin tunas were separated into 20 mm and 30 mm length intervals respectively (Figure 4). Spearman's rank correlation analysis (Steel and Torrie, 1960:409) was used to see if the volumes and frequency of occurrence of the two dominant forage food items (fishes and crustaceans) in the diet of skipjack and yellowfin tunas were correlated with the size of tunas. Significant correlations in the length-food data were noted between the size of skipjack tuna and percentage volume of fish forage (r_s 0.576, 11 *df*, $P < 0.05$) and percentage of occurrence of forage fish (r_s 0.565, 11 *df*, $P < 0.05$), suggesting that as the size of tuna increased, the percentage consumption of fish by volume and by frequency of occurrence increased.

It is generally recognized that the amount and quality of food found in the stomach of tunas

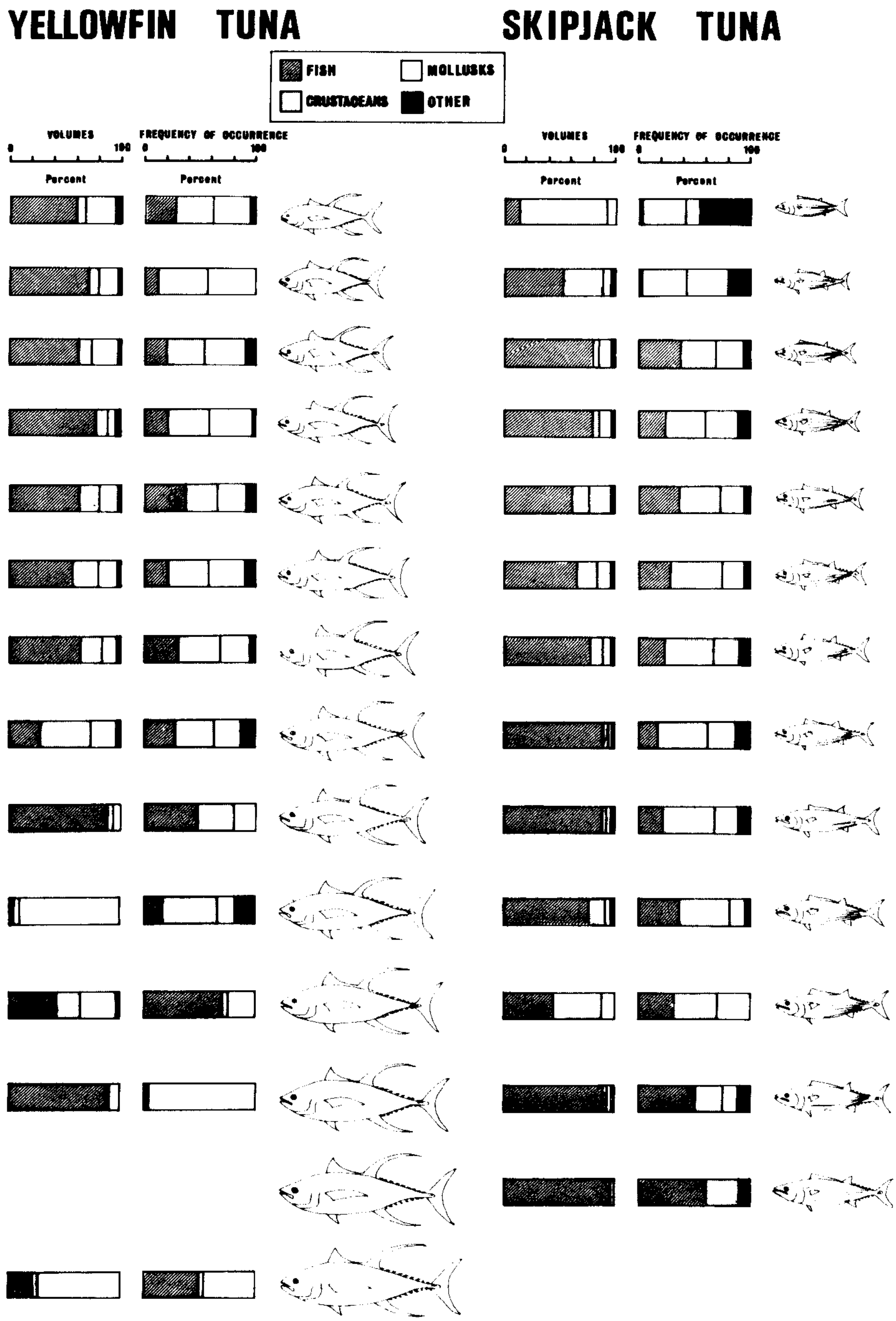

FIGURE 4.—The distribution of volumes and frequencies of occurrence of the major food categories (fish, crustaceans, mollusks, and miscellaneous) at various sizes of skipjack and yellowfin tunas off the west coast of Africa, The sizes of skipjack range from 370 mm to 610 mm (intervals 20 mm); the sizes of yellowfin tuna range from 520 mm to 910 mm (intervals 30 mm).

are important in studies concerned with energy that is converted into caloric equivalents of energy utilized for growth. We have the information only on the volumes of the stomach contents. This information may be of interest to the investigators concerned with energy budgets of tunas and with studies on transfers of energy within the food web. In our study, in the majority of observations, the displacement volumes of the total stomach contents of skipjack and yellowfin tunas varied from 0.1 to 20.0 ml and from 0.1 to 60.0 ml, respectively (Table 4). Information on the volumes of stomach contents of tunas in the Atlantic Ocean is found only in a limited number of investigations, as cited in the review of studies of tuna food in the Atlantic Ocean by Dragovich (1969). Dragovich (1970) noted volumes of stomachs of less than 20 ml in 75% of skipjack tuna sampled and in 85% of yellowfin tuna. Volumes of stomach contents of yellowfin tuna caught by longline off the coast of east Africa (Williams, 1966) were generally higher than those in our study. The majority of the volumes measured by Williams fell within a range of 3.0 to 499.9 cc. Higher volumes of stomach contents observed by Williams may be partially explained by the fact that tunas caught on longline are usually larger than fishes caught by surface methods.

To determine the relation between the volume of stomach contents and body weight of skipjack and yellowfin tunas, we have assumed that 1.0 ml of stomach contents is equivalent to 1.0 g. Comparisons on this basis were made between the estimated weight of the stomach contents and the body weights of tunas. Our calculations have shown that the total volume of stomach contents for both species of tunas in almost all observations was well below 1.0% of the body weight. This observation is in agreement with the findings by Dragovich (1970). The results of these calculations suggest that there was little difference in the total amount of food found in the stomachs of both species of tunas as related to the body weight. Possible explanations for such low volumes of stomach contents may be rapid digestion of food, long periods between the feedings, scarcity of food, and the fact that most of the forage organisms are very small macrozooplankton.

SEASONAL CHANGES IN TAXONOMIC COMPOSITION OF FORAGE ORGANISMS

Cruise UN6801 took place in the Gulf of Guinea during what is sometimes called the "warm" season (February, March, and April) and UN6802 during the "cool" season (September, October, and November). Berrit (1961) in his study on seasonal variations of oceanographic conditions introduced these terms. Results on studies by Sund and Richards (1967)

TABLE 4.—Distribution of the volumes of total stomach contents in 711 skipjack tuna and 132 yellowfin tuna stomachs. The data were collected during cruises UN6801 and UN6802.

Volume of stomach contents (ml)	Skipjack tuna			Yellowfin tuna		
	Number of stomachs	Percentage	Accumulated percentage	Number of stomachs	Percentage	Accumulated percentage
Empty	153	21.5	21.5	6	4.5	4.5
0.1-0.5	127	17.9	39.4	8	6.1	10.6
0.6-1.0	70	9.8	49.2	7	5.3	15.9
1.1-1.9	69	9.7	58.9	9	6.8	22.7
2.0-2.9	46	6.5	65.4	10	7.6	30.3
3.0-3.9	37	5.2	70.6	5	3.8	34.1
4.0-4.9	32	4.5	75.1	10	7.6	41.7
5.0-10.0	80	11.2	86.3	15	11.4	53.1
10.1-20.0	63	8.9	95.2	15	11.4	64.5
20.1-60.0	24	3.4	98.6	34	25.7	90.2
60.1-100.0	6	0.8	99.4	12	9.1	99.3
100.1-200.0	4	0.6	100.0	1	0.7	100.0

on the differences in the occurrence of forage organisms of skipjack and yellowfin tunas in the Gulf of Guinea between these two seasons are compared with ours.

In our study, the fish families present in the diet of both species of tunas only during the "warm" period were Mullidae, Dactylopteridae, Gonostomatidae, and Engraulidae. In the study of Sund and Richards (1967), Dactylopteridae were also present during the "warm" season only. A number of crustacean taxa were present in our study only during the "warm" season and absent during the "cool" season. Grapsidae (megalopal stages), *Petrochirus* sp. and *Streetia challengeri*, were found only during the "warm" period and absent during the "cool" period. Other prominent crustaceans observed by us in stomachs of both species of tunas only during the "cool" period were *Vibilia armata*, *Scyllarides* sp., *Scyllarus* sp., and *S. arctus*. Some of the crustaceans (*Phronima sedentaria*, *Phrosina semilunata*, *Euphausia* sp.) occurred only in one season in the observations of Sund and Richards (1967), whereas we observed them in both seasons. More extensive collections are needed before any final evaluation is made in regard to the significance of the occurrence of these organisms during different seasons.

EVALUATION OF FOOD ORGANISMS

In selecting the most important food organisms in a given area, many variables have to be considered. Reintjes and King (1953) stated that food items that rank high in number, high in volume, and high in frequency of occurrence are important foods—at the time and in the area sampled. Using these criteria plus the geographic distribution in evaluation of food organisms of both species of tunas, we have calculated dispersal and abundance indices and mean displacement volumes for each food taxon and ranked them accordingly.

The entire investigation area was divided into 27 one-degree squares. If a taxon was present in one square it was assigned a value of one. Using the data from both cruises and for both species of tunas combined, the number of occurrences of each taxon in 27 squares was divided by the number of squares—the quotient was called the dispersal index. An abundance index was calculated by dividing the total number of individuals in each taxon by the total number of all organisms. An approximation of biomass of each food item was represented by the mean displacement volume. The mean displacement volume of food items represented in Figure 5 varied from 0.1 to 0.7 ml.

Since a large number of taxa are represented, we have selected the 32 taxa with the highest dispersal and abundance indices and presented them in a descending order of magnitude (Figure 5). *Vinciguerria nimbaria* and *Anchoviella guineensis*, although with low dispersal indices, were included in the diagram because of their high abundance indices. From Figure 5 it is obvious that Stomatopoda, *Phrosina semilunata*, Teuthoidea, Carangidae, Serranidae, and megalopal stages were the most important identifiable food items throughout the investigation area while *V. nimbaria*, *Euphausia hanseni*, and *A. guineensis* were of great local importance.

In the evaluation of forage organisms by the present method we consider the geographic dispersal of food organisms to be the most important criterion for the survival of skipjack and yellowfin tunas, particularly since these tunas are migratory and widely distributed. In our study the tuna forage organisms were both widely distributed and abundant in the area of sampling as indicated in Figure 5. High abundance indices were usually associated with high dispersal indices. Thus these food organisms may be considered to be important in the food chain of skipjack and yellowfin tunas for the given time and area.

The disadvantage of the method is that the estimated geographic distribution of forage taxa as calculated from stomach contents may not represent the true distribution. The only other information nearest to the natural distribution of certain forage organisms found in our study was obtained from zooplankton double oblique tows which were made at about the same time of the capture of tunas from which stomach samples were taken. The preliminary analysis of the composition of zooplankton from these

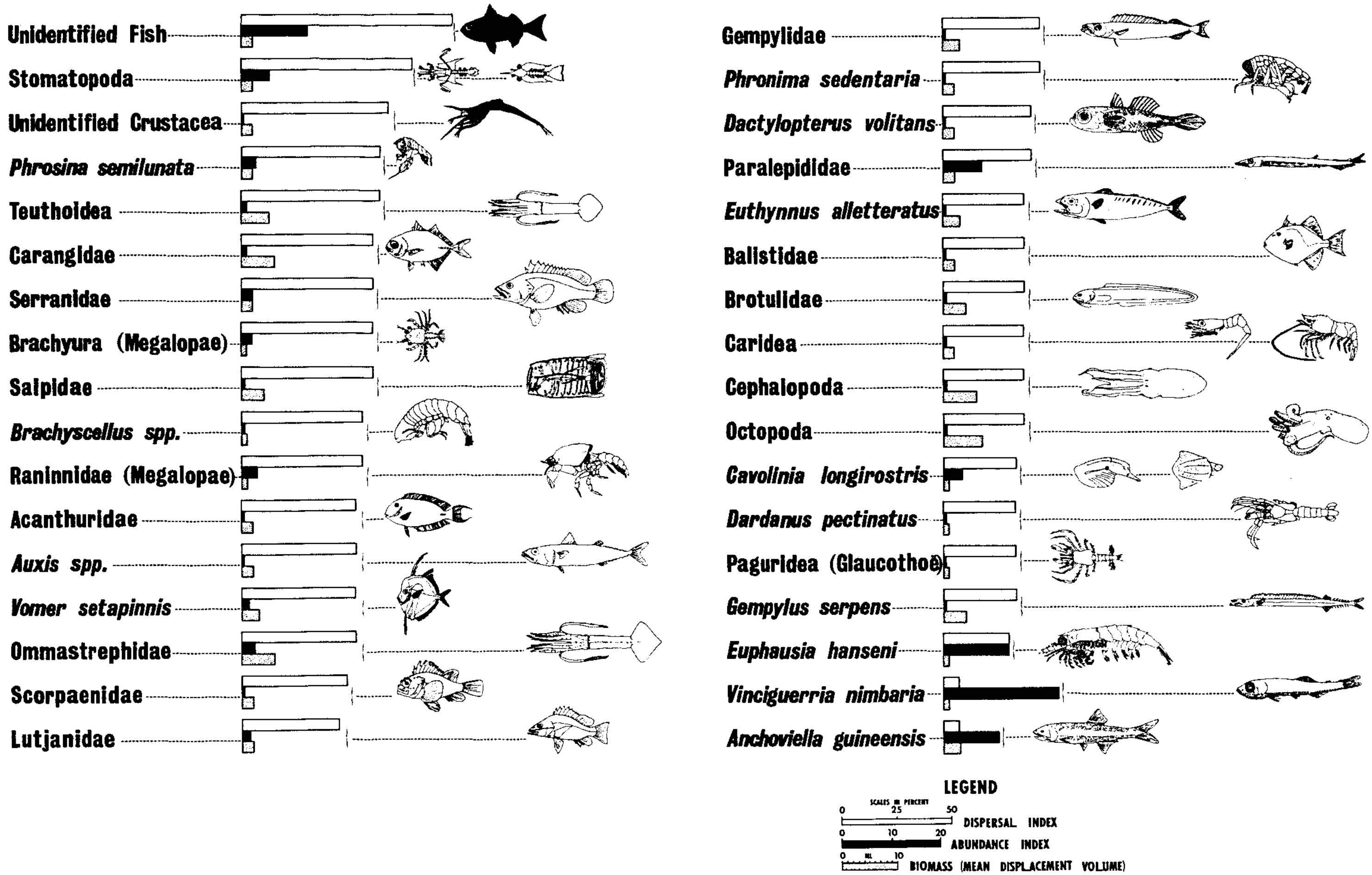

FIGURE 5.—The dispersal and abundance indices and biomass of forage organisms of skipjack and yellowfin tunas off the west coast of Africa. Dispersal and abundance indices expressed in percent. The biomass expressed in milliliters.

plankton samples showed that the major constituents were copepods and arrowworms. Arrowworms were entirely absent in the diet of both species of tunas. Although copepods were present in the stomachs of a few skipjack tunas, they may have been remains of the stomach contents of the ingested fishes. Among the minor constituents of zooplankton, 60 species and 10 genera of amphipods and 20 species and 3 genera of euphausiids were present in the plankton tows. Although all of the amphipods and euphausiids found in the tuna stomachs were also present in the plankton tows, their number represented only a small fraction of the number of taxa found in the plankton tows, thus suggesting selectivity in feeding of skipjack and yellowfin tunas. Our findings support those of Blackburn (1965), who stated that no species of tuna consumes all the species of net-caught micronekton or zooplankton.

COMPARISONS WITH RESULTS OF OTHER INVESTIGATORS

Investigations concerned with the food of skipjack and yellowfin tunas off the west coast of Africa are numerous (Postel, 1954, 1955a, 1955b; Marchal, 1959; de Jager, de V. Nepgen, and van Wyk, 1963; Penrith, 1963; Sund and Richards, 1967; de V. Nepgen, 1970; and Dragovich, 1970). Reliable qualitative comparisons of tuna forage between different studies are difficult because identification of organisms is usually incomplete. Quantitative comparisons between various studies of tuna forage usually consist of comparisons between the major food categories (fishes, crustaceans, and cephalopods). The nearest areas of the Atlantic Ocean to our investigation area for which valid comparisons can be made were investigated by Marchal (1959), Sund and Richards (1967), and Dragovich (1970).

The diet of yellowfin and skipjack tunas in the Gulf of Guinea was studied by Marchal (1959) and Sund and Richards (1967), respectively. From a long list of forage organisms presented by Marchal only several fishes (*Vomer setapinnis, Euthynnus alletteratus, Sternoptyx diaphana, Hyppocampus* sp., *Ophidion barbatum,* Brotulidae, Chiasmodontidae), a few crustaceans (Stomatopoda, *Heterocarpus ensifer,* Glaucothoë, megalopae (Brachyura)), and salps were common to both studies. All fish families in the diet of yellowfin tuna and skipjack tuna observed by Sund and Richards (1967) were also observed by us. The differences in the composition of tuna food between our study and that of Sund and Richards were on generic and specific levels except for cephalopods, where our findings differed entirely.

A striking similarity in the food of skipjack and yellowfin tunas was observed between our study and that of Dragovich (1970). Skipjack and yellowfin tunas in the study by Dragovich were captured off the coast of West Africa from Sierra Leone to Angola. All forage-fish families (21) in the diet of skipjack tuna noted by Dragovich were also observed by us. The most prominent fish families (Carangidae, Scombridae, Gempylidae) in terms of volume of frequency of occurrence observed by Dragovich were equally important in our study. We found the same groups of crustaceans as Dragovich. In the cephalopod diet ommastrephids were the principal food in both studies.

Postel (1955a) examined contents of stomachs of yellowfin tuna caught off the coast of Senegal. Of 30 species and 7 genera of fish and 12 cephalopod taxa listed by Postel, only *Euthynnus alletteratus, Katsuwonus pelamis, Sphyraena* sp., *Cranchia scabra,* and *Argonauta* sp. were observed by us. None of the identified species and genera of crustaceans by Postel was observed by us. The pronounced taxonomic differences of forage between our study and that of Postel may be partially explained by the different oceanographic regime off the coast of Senegal.

Postel (1955b), in his report on *Katsuwonus pelamis* off Cape Verde Islands, identified *Sardinella aurita, S.* sp., Myctophidae, *Hemiramphus* sp., *Hyporamphus* sp., *Gephyroberyx darwini, Scomber colias, Aphanopus* sp., and Mullidae in the diet of this tuna. Myctophidae and Mullidae were also observed by us in the diet of skipjack tuna. From cephalopods, only *Illex illecebrosus coindeti* was listed; this species was not identified in the diet of skipjack by us.

De Jager, de V. Nepgen, and van Wyk (1963), de V. Nepgen (1970), and Penrith (1963) reported that the food of yellowfin tuna caught off South Africa consisted mainly of fish. De Jager, de V. Nepgen, and van Wyk stated that lanternfish and anchovies occurred more frequently in the diet of yellowfin tuna than in the diet of other species of tunas; crab megalopae were by far the highest ranking crustaceans. Fish in de V. Nepgen's (1970) study consisted chiefly of garfish, lanternfish, and mackerel (*Scomber japonicus*). Most of the forage fishes reported by Penrith (1963) were surface fishes (*Scomberesox saurus, Coryphaena hippurus,* juvenile Bramidae). Among crustaceans Penrith (1963) found that yellowfin tuna fed chiefly on the deep-living prawn, *Funchalia woodwardii.* Megalopae also played an important role in the food of yellowfin tuna and were more important than amphipods. Mollusks consisted of unidentified cephalopods (squid), heteropods, and pteropods. In our study lanternfish and mackerel were unimportant as forage for yellowfin and skipjack tunas, and anchovies were not eaten by yellowfin tuna but occurred in great numbers in the diet of skipjack tuna; megalopae were among the highest ranking crustaceans. From a high number of forage fishes listed by Penrith (1963) only unidentified Carangidae, *Naucrates ductor*, unidentified Priacanthidae, *Priacanthus* sp., Acanthuridae, Scombridae, Balistidae, Blennidae, Bramidae, Coryphaenidae, *Coryphaena hippurus,* and Syngnathidae were also observed by us. Crustaceans common to Penrith's and our study were stomatopods, amphipods (*Phronima sedentaria, Phrosina semilunata*), and megalopae (Brachyura). Molluscan food for the most part was different between our study and that of Penrith (1963).

On the basis of the studies discussed in this section, it is evident that skipjack and yellowfin tunas consume a great variety of forage organisms. Fish, cephalopods, and crustaceans were the principal foods of both species of tunas in all investigations. The similarity in regard to the taxonomic composition of forage between different studies was greater when the investigations were made in the same general area. In each given area, only several types of food were important. Although occasionally bottom organisms were found in the diet of a skipjack and particularly yellowfin tunas, both of these species primarily feed on juvenile pelagic organisms.

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APPENDIX TABLE 1.—List of forage organisms found in stomachs from 356 skipjack tunas, collected off the west coast of Africa during UN6801. Number of organisms, frequency of occurrence, and percentage of total volume are given for each taxon. Size ranges and mean sizes are given only for certain forage fishes. Fishes are listed in decreasing order of frequency of occurrence by families; crustaceans, mollusks, and miscellaneous groups are listed by broad categories.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Fishes:							
Unidentifiable	1,912	229	64.3	179.5	6.5	7-57	19
Carangidae							
Vomer setapinnis	174	88	24.7	25.3	0.9	8-33	15
Decapterus spp.	6	5	1.4	1.5	<0.1	20-43	25
Unidentified Carangidae	85	54	15.2	14.8	0.5	8-46	20
Scombridae							
Euthynnus alletteratus	120	66	18.5	28.1	1.0	10-68	29
Auxis spp.	53	29	8.1	9.5	0.3	12-37	29
Katsuwonus pelamis	2	2	0.6	0.3	<0.1	20-32	26
Thunnus spp.	2	2	0.6	1.4	<0.1	34-47	41
Unidentified Scombridae	4	3	0.8	0.5	<0.1		
Gempylidae							
Gempylus serpens	48	28	7.9	34.3	1.2	18-216	70
Nealotus tripes	13	11	3.1	10.2	0.4	20-85	51
Promethichthys prometheus	8	7	2.0	3.0	0.1	24-65	45
Nesiarchus nasutus	1	1	0.3	0.1	<0.1		
Unidentified Gempylidae	89	54	15.2	26.4	0.9	18-83	57
Mullidae							
Pseudupeneus prayensis	278	80	22.5	196.8	7.1	32-49	42
Unidentified Mullidae	45	18	5.1	22.1	0.8	40-48	44
Priacanthidae							
Priacanthus spp.	84	50	14.0	23.6	0.9	9-31	21
Priacanthus arenatus	24	14	3.9	15.8	0.6	22-33	30
Lutjanidae							
Unidentified Lutjanidae	392	64	18.0	55.3	2.0	10-36	18
Serranidae							
Unidentified Serranidae	395	62	17.4	69.8	2.5	11-28	20
Acanthuridae							
Acanthurus monroviae	21	11	3.1	10.1	0.4	13-30	24
Unidentified Acanthuridae	65	40	11.2	13.8	0.5	6-29	18
Dactylopteridae							
Dactylopterus volitans	62	49	13.8	16.5	0.6	11-34	19
Gonostomatidae							
Vinciguerria nimbaria	5,237	38	10.7	1233.9	44.6	27-48	35
Unidentified Gonostomatidae	26	6	1.7	1.9	0.1	32-41	37
Engraulidae							
Anchoviella guineensis	3,098	25	7.0	247.0	8.9	21-34	27
Synodontidae							
Saurida brasiliensis	108	8	2.2	11.0	0.4	14-32	25
Unidentified Synodontidae	106	17	4.8	11.9	0.4	23-39	31
Bothidae							
Unidentified Bothidae	43	23	6.5	5.0	0.2	16-30	23
Balistidae							
Unidentified Balistidae	22	19	5.3	5.1	0.2	4-20	15
Tetraodontidae							
Unidentified Tetraodontidae	22	18	5.1	3.5	0.1	10-18	13
Paralepididae							
Unidentified Paralepididae	64	13	3.7	5.9	0.2	34-71	46
Anguilloidei							
Unidentified Anguilloidei	20	13	3.7	2.7	0.1		
Holocentridae							
Unidentified Holocentridae	12	12	3.4	3.2	0.1	10-36	24
Scorpaenidae							
Unidentified Scorpaenidae	13	12	3.4	1.7	0.1	4-20	13
Blennidae							
Ophioblennius webbi	10	9	2.5	3.3	0.1	29-42	34
Aulopidae							
Aulopus spp.	5	4	1.1	1.4	<0.1	26-45	33

APPENDIX TABLE 1.—Continued.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Bramidae							
Pterycombus brama	2	2	0.6	1.4	<0.1	28-36	32
Taractichthys longipinnis	1	1	0.3	0.3	<0.1		
Unidentified Bramidae	1	1	0.3	0.2	<0.1		
Chiasmodontidae							
Dysalotus spp.	4	4	1.1	2.0	<0.1	18-39	32
Ophichthidae							
Unidentified Ophichthidae	2	2	0.6	0.2	<0.1		
Sternoptychidae							
Sternoptyx diaphana	2	2	0.6	1.4	<0.1	20-26	23
Myctophidae							
Unidentified Myctophidae	10	2	0.6	0.3	<0.1	7-9	8
Chaunacidae							
Chaunax pictus	2	2	0.6	0.2	<0.1	8-9	9
Brotulidae							
Unidentified Brotulidae	2	2	0.6	0.7	<0.1	28-44	36
Exocoetidae							
Unidentified Exocoetidae	2	2	0.6	2.7	<0.1		
Trachipteridae							
Trachipterus trachypterus	2	2	0.6	0.5	<0.1	47-51	49
Triglidae							
Chelidonichthys gabonensis	2	2	0.6	0.6	<0.1	20-22	21
Sphyraenidae							
Sphyraena spp.	3	2	0.6	0.5	<0.1	28-31	29
Uranoscopidae							
Uranoscopus spp.	2	2	0.6	0.5	<0.1	17	17
Trichiuridae							
Unidentified Trichiuridae	4	2	0.6	0.8	<0.1	42-83	68
Istiophoridae							
Unidentified Istiophoridae	2	2	0.6	0.2	<0.1	13-17	15
Monacanthidae							
Unidentified Monacanthidae	2	2	0.6	3.6	0.1	15-51	33
Ostraciontidae							
Unidentified Ostraciontidae	2	2	0.6	0.3	<0.1	8-10	9
Congridae							
Unidentified Congridae	1	1	0.3	0.2	<0.1		
Antennariidae							
Unidentified Antennariidae	1	1	0.3	0.3	<0.1		
Aulostomidae							
Aulostomus maculatus	1	1	0.3	0.2	<0.1		
Stromatedoidei							
Unidentified Stromatedoidei	1	1	0.3	0.1	<0.1		
Ariommidae							
Ariomma spp.	1	1	0.3	1.3	<0.1		
Chaetodontidae							
Unidentified Chaetodontidae	1	1	0.3	0.2	<0.1		
Crustaceans:							
Unidentified Crustacea	--	52	14.6	17.0	0.6		
Stomatopoda							
Unidentified Stomatopoda	346	115	32.3	49.8	1.8		
Decapoda							
Brachyura (megalopae)	268	26	7.3	13.3	0.5		
Brachyura (zoea)	7	1	0.3	0.2	<0.1		
Raninidae (megalopae)	473	55	15.4	44.0	1.6		
Grapsidae (megalopae)	2	2	0.6	0.3	<0.1		
Anomoura							
Porcellanidae (megalopae)	9	2	0.6	0.3	<0.1		
Dardanus pectinatus (Glaucothoë)	20	11	3.1	1.9	<0.1		
Petrochirus sp. (Glaucothoë)	4	4	1.1	0.5	<0.1		
Unidentified Paguridea (Glaucothoë)	11	11	3.1	0.4	<0.1		
Macrura-Natantia							
Sergestes sp.	1	1	0.3	0.3	<0.1		
Lucifer sp.	1	1	0.3	0.3	<0.1		

APPENDIX TABLE 1.—Continued.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Caridea							
Brachycarpus biuguinculatus (*Retrocaris spinosa*—larval stage)	33	23	6.5	2.8	<0.1		
Eretmocaris sp. (larvae of *Lysmata* sp.—Hyppolytidae)	1	1	0.3	0.1	<0.1		
Enoplometopus antilensis	1	1	0.3	0.5	<0.1		
Heterocarpus ensifer	7	6	1.7	1.0	<0.1		
Procletes stage (*Heterocarpus ensifer*)	4	3	0.8	0.4	<0.1		
Anisocaris sp. (larval Caridean genus)	1	1	0.3	0.2	<0.1		
Hippolytidae (larvae)	1	1	0.3	0.1	<0.1		
Unidentified Caridea	14	13	3.7	1.7	<0.1		
Macrura-Reptantia (all Phyllosoma stages)							
Unidentified Macrura-Reptantia	1	2	0.6	0.3	<0.1		
Panulirus rissoni	1	1	0.3	0.2	<0.1		
Amphipoda (Hyperidea)							
Phrosina semilunata	56	42	11.8	9.0	0.3		
Brachyscellus spp.	49	35	9.8	4.4	0.2		
Phronima sedentaria	52	41	11.5	7.9	0.3		
Oxycephalus clausii	10	10	2.8	1.1	<0.1		
Platyscellus ovoides	6	6	1.7	0.8	<0.1		
Anchylomera blossevillei	3	2	0.6	0.2	<0.1		
Vibilia cultripes	1	1	0.3	0.1	<0.1		
Streetsia challengeri	1	1	0.3	0.1	<0.1		
Platyscellus armatus var. *inermis*	1	1	0.3	0.1	<0.1		
Unidentified Hyperidea	9	4	1.1	1.8	<0.1		
Copepoda							
Unidentified Copepoda	6	3	0.8	0.3	<0.1		
Isopoda							
Cymathoidae	1	1	0.3	0.1	<0.1		
Euphausiacea							
Euphausia hanseni	5	5	1.4	0.5	<0.1		
Mollusks:							
Cephalopoda (adults and juveniles)							
Unidentified Cephalopoda	18	15	4.2	9.6	0.3		
Octopoda	27	13	3.7	10.0	0.4		
Argonauta argo	4	1	0.3	9.0	0.3		
Teuthoidea							
Unidentified Ommastrephidae	189	28	7.9	129.1	4.7		
Unidentified Teuthoidea	99	84	23.6	41.8	1.5		
Gastropoda							
Pteropoda							
Cavolinia longirostris	923	17	4.8	20.4	0.7		
Diacria trispinosa	1	1	0.3	0.1	<0.1		
Heteropoda							
Oxygyrus keraudreni	1	1	0.3	0.1	<0.1		
Atlanta peroni	2	2	0.6	0.2	<0.1		
Miscellaneous:							
Salpidae	85	49	13.8	63.0	2.3		
Polychaeta	1	1	0.3	0.2	<0.1		
Syphonophora	1	1	0.3	0.1	<0.1		
Unidentifiable		23	6.5	5.0	0.2		

APPENDIX TABLE 2.—List of forage organisms found in stomachs from 83 yellowfin tunas collected off the west coast of Africa during cruise UN6801. Number of organisms, frequency of occurrence, and percentage of total volume are given for each taxon. Size range and mean sizes are given only for certain forage fishes. Fishes are listed in decreasing order of frequency of occurrence by families; crustaceans, mollusks, and miscellaneous groups are listed by broad categories.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Fishes:							
Unidentifiable	748	69	83.1	230.0	10.4	11-43	27
Carangidae							
Vomer setapinnis	101	36	43.4	23.3	0.9	8-32	16
Decapterus spp.	1	1	1.2	0.8	<0.1		
Naucrates ductor	1	1	1.2	55.0	2.2		
Unidentified Carangidae	107	31	37.3	14.3	0.6	9-40	19
Mullidae							
Pseudopeneus prayensis	386	24	28.9	227.4	9.3	23-51	42
Unidentified Mullidae	315	20	24.1	136.2	5.5	39-51	44
Priacanthidae							
Priacanthus spp.	66	31	37.3	17.3	0.7	13-34	20
Priacanthus arenatus	15	10	12.0	9.1	0.4	18-32	27
Priacanthus cruenatus	1	1	1.2	0.7	<0.1		29
Acanthuridae							
Acanthurus monroviae	50	8	9.6	11.3	0.5	15-27	23
Unidentified Acanthuridae	44	26	31.3	7.7	0.3	11-30	20
Scombridae							
Euthynnus alleteratus	58	21	25.3	18.0	0.7	11-70	33
Auxis spp.	7	5	6.0	1.4	<0.1	12-50	22
Thunnus spp.	3	3	3.6	0.8	<0.1	29-40	36
Katsuwonus pelamis	1	1	1.2	0.2	<0.1		38
Gonostomatidae							
Vinciguerria nimbaria	1,163	23	27.7	518.8	21.1	32-50	40
Unidentified Gonostomatidae	78	7	8.4	24.5	1.0	17-44	29
Bothidae							
Unidentified Bothidae	86	29	34.9	11.2	0.5	15-50	24
Dactylopteridae							
Dactylopterus volitans	45	25	30.1	5.9	0.2	10-25	17
Balistidae							
Unidentified Balistidae	84	23	27.7	16.0	0.7	10-19	14
Gempylidae							
Gempylus serpens	9	6	7.2	2.8	<0.1	44-118	65
Nealotus tripes	2	2	2.4	1.1	<0.1	19-71	45
Nesiarchus nasutus	1	1	1.2	0.2	<0.1		
Promethichthys prometheus	1	1	1.2	0.2	<0.1		
Unidentified Gempylidae	14	12	14.5	3.5	<0.1		
Serranidae							
Unidentified Serranidae	43	18	21.7	7.1	0.3	16-26	21
Lutjanidae							
Unidentified Lutjanidae	29	17	20.5	5.1	0.2	14-38	22
Tetraodontidae							
Unidentified Tetraodontidae	18	16	19.3	3.8	0.2	9-36	16
Blenniidae							
Ophioblennius webbi	27	14	16.9	7.8	0.3	15-40	32
Paralepididae							
Unidentified Paralepididae	130	13	15.7	37.2	1.5	36-100	66
Holocentridae							
Myripristis jacobus	2	2	2.4	0.6	<0.1	22-26	24
Unidentified Holocentridae	20	11	13.3	5.8	0.2	11-32	23
Scorpaenidae							
Unidentified Scorpaenidae	13	13	15.7	3.2	<0.1	11-29	18
Anguilloidei							
Unidentified Anguilloidei	25	11	13.3	2.7	<0.1		
Sternoptychidae							
Sternoptyx diaphana	7	5	6.0	7.0	0.3	25-32	29
Unidentified Sternoptychidae	4	3	3.6	1.9	<0.1	20-27	24
Unidentified Stromateoidei	8	6	7.2	1.8	<0.1	18-34	26
Aulopidae							
Aulopus spp.	11	5	6.0	5.7	0.2	26-49	38

APPENDIX TABLE 2.—Continued.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Trachipteridae							
Trachipterus trachypterus	8	5	6.0	4.0	0.2	45-70	53
Syngnathidae							
Hippocampus spp.	2	1	1.2	0.1	<0.1	16-22	19
Hippocampus punctulatus	2	2	2.4	1.2	<0.1	50-52	51
Unidentified Syngnathidae	2	2	2.4	0.3	<0.1		
Ophichthidae							
Unidentified Ophichthidae	19	4	4.8	2.1	<0.1	80-108	96
Bramidae							
Pterycombus brama	1	1	1.2	0.4	<0.1		
Unidentified Bramidae	2	2	2.4	0.4	<0.1	14-19	17
Nettastomidae							
Unidentified Nettastomidae	7	2	2.4	1.0	<0.1		
Congridae							
Unidentified Congridae	7	2	2.4	2.1	<0.1	80-178	129
Synodontidae							
Saurida brasiliensis	7	1	1.2	1.2	<0.1	31-32	32
Unidentified Synodontidae	1	1	1.2	0.1	<0.1		
Myctophidae							
Unidentified Myctophidae	3	2	2.4	0.3	<0.1	14-23	19
Antennariidae							
Unidentified Antennariidae	3	2	2.4	1.9	<0.1	16-21	18
Monacanthidae							
Unidentified Monacanthidae	2	2	2.4	1.2	<0.1	17-38	28
Ophidiidae							
Ophidion barbatum	23	2	2.4	1.4	<0.1	32-37	35
Fistulariidae							
Fistularia spp.	2	2	2.4	0.3	<0.1	70-86	78
Triglidae							
Unidentified Triglidae	2	2	2.4	0.5	<0.1	21-22	22
Diretmidae							
Diretmus argenteus	1	1	1.2	3.1	0.1		
Nemichthyidae							
Unidentified Nemichthyidae	1	1	1.2	0.1	<0.1		
Brotulidae							
Unidentified Brotulidae	1	1	1.2	0.8	<0.1		
Trachichthyidae							
Gephyroberyx darwini	1	1	1.2	1.0	<0.1		
Grammicolepididae							
Xenolepidichthys spp.	1	1	1.2	0.3	<0.1		
Caproidae							
Antigonia capros	1	1	1.2	3.1	0.1		
Trachipteroidei							
Unidentified Trachipteroidei	1	1	1.2	0.1	<0.1		
Coryphaenidae							
Coryphaena hippurus	1	1	1.2	0.1	<0.1		
Chaetodontidae							
Unidentified Chaetodontidae	1	1	1.2	0.1	<0.1		
Sphyraenidae							
Sphyraena spp.	1	1	1.2	0.2	<0.1		
Chiasmodontidae							
Dysalotus spp.	1	1	1.2	1.0	<0.1		
Istiophoridae							
Unidentified Istiophoridae	1	1	1.2	0.2	<0.1		
Tetragonuridae							
Tetragonurus cuvieri	4	1	1.2	154.0	6.3	165-183	174
Crustaceans:							
Unidentified Crustacea	--	12	14.5	11.2	0.5		
Stomatopoda							
Unidentified Stomatopoda (larvae)	1,081	63	75.9	161.9	6.6		
Decapoda							
Brachyura (megalopae)	287	19	22.9	31.3	1.3		
Unidentified Raninidae (megalopae)	235	23	27.7	25.1	1.0		
Unidentified Grapsidae (megalopae)	8	2	2.4	1.0	<0.1		

APPENDIX TABLE 2.—Continued.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Paguridea (all Glaucothoë)							
Dardanus spp.	3	3	3.6	0.3	<0.1		
Dardanus pectinatus	89	11	13.3	9.5	0.4		
Petrochirus sp.	1	1	1.2	0.1	<0.1		
Unidentified Paguridea	10	4	4.8	1.0	<0.1		
Macrura-Natantia							
Caridea							
Unidentified Pandalidae (larvae)	14	6	7.2	3.9	0.2		
Paciphaea semispinosa	10	1	1.2	4.0	0.2		
Heterocarpus ensifer	1	1	1.2	0.2	<0.1		
Procletes stage (*Heterocarpus ensifer*)	6	3	3.6	0.9	<0.1		
Anisocaris sp. (larval genus)	5	2	2.4	0.5	<0.1		
Eretmocaris sp. (larval genus)	2	2	2.4	0.3	<0.1		
Oplophorus sp. (larval genus)	1	1	1.2	0.1	<0.1		
Enoplometopus antilensis	6	5	6.0	2.0	<0.1		
Unidentified Caridea	16	9	10.8	4.6	0.2		
Macrura-Reptantia (all Phyllosoma stages)							
Scyllarus arctus	5	2	2.4	1.2	<0.1		
Unidentified Macrura-Reptantia	6	3	3.6	0.6	<0.1		
Amphipoda (Hyperiidea)							
Phrosina semilunata	73	29	34.9	14.6	0.6		
Brachyscellus sp.	58	14	16.9	4.8	0.2		
Phronima sedentaria	17	8	9.6	2.0	<0.1		
Oxycephalus clausii	9	6	7.2	0.9	<0.1		
Platyscellus ovoides	1	1	1.2	0.1	<0.1		
Streetsia challengeri	1	1	1.2	0.1	<0.1		
Euphausiacea							
Euphausia hanseni	26	6	7.2	1.3	<0.1		
Mollusks:							
Cephalopoda (adults and juveniles)							
Unidentified Cephalopoda	48	12	14.5	30.7	1.2		
Octopoda							
Argonauta sp.	1	1	1.2	1.5	0.1		
Tremoctopus violaceus	9	1	1.2	4.5	0.2		
Octopus sp.	5	2	2.4	2.8	<0.1		
Unidentified Octopoda	25	12	14.5	31.6	1.3		
Teuthoidea							
Unidentified Ommastrephidae	437	36	43.4	314.2	12.8		
Unidentified Chiroteuthidae	1	1	1.2	1.0	<0.1		
Ornithoteuthis antilarum	5	1	1.2	1.5	<0.1		
Liocranchia reinhardti	11	1	1.2	5.0	0.2		
Liocranchia sp.	1	1	1.2	0.2	<0.1		
Cranchia scabra	3	2	2.4	3.2	0.1		
Onychoteuthis banksi	1	1	1.2	0.4	<0.1		
Mastigoteuthis sp.	1	1	1.2	0.5	<0.1		
Onykia sp.	4	2	2.4	5.5	0.2		
Unidentified Cranchiidae	5	3	3.6	2.8	0.1		
Unidentified Enoploteuthidae	4	3	3.6	1.7	<0.1		
Unidentified Teuthoidea	204	45	54.2	124.6	5.1		
Gastropoda							
Unidentified Atlantidae	2	2	2.4	0.2	<0.1		
Miscellaneous:							
Salpidae	27	17	20.5	8.8	0.4		

APPENDIX TABLE 3.—List of forage organisms fond in stomachs from 202 skipjack tunas, collected off the west coast of Africa during cruise UN6802. Number of organisms, frequency of occurrence, and percentage of total volume are given for each taxon. Size ranges and mean sizes are given only for certain forage fishes. Fishes are listed in decreasing order of frequency of occurrence by families; crustaceans, mollusks, and miscellaneous groups are listed by broad categories.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Fishes:							
Unidentifiable	698	155	76.7	109.3	11.1		
Paralepididae							
Unidentifiable Paralepididae	1,026	59	29.2	280.5	28.4	52-112	68
Carangidae							
Vomer setapinnis	44	33	16.3	24.0	2.4	9-36	27
Trachinotus ovatus	4	4	2.0	0.6	0.1	17-23	19
Unidentified Carangidae	15	13	6.4	6.0	0.6	11-56	22
Gempylidae							
Gempylus serpens	1	1	0.5	0.3	0.1		
Unidentified Gempylidae	25	17	8.4	11.9	1.2	62-94	78
Trichiuridae							
Unidentified Trichiuridae	49	18	8.9	13.6	1.4	66-110	94
Scombridae							
Auxis spp.	33	10	5.0	8.6	0.9	15-63	31
Sarda sarda	4	4	2.0	2.3	0.2	25-43	34
Scomber japonicus	1	1	0.5	1.3	0.1		
Serranidae							
Unidentified Serranidae	152	12	5.9	15.0	1.5	14-25	19
Scorpaenidae							
Unidentified Scorpaenidae	13	10	5.0	2.6	0.3	15-25	18
Lutjanidae							
Unidentified Lutjanidae	9	7	3.5	1.4	0.1	15-24	19
Berycoidei							
Unidentified Berycoidei	8	8	4.0	1.4	0.1	13-17	15
Percoidei							
Unidentified Percoidei	257	6	3.0	85.1	8.6	19-32	27
Anguilloidei							
Unidentified Leptocephalus	6	5	2.5	0.7	0.1		
Bothidae							
Unidentified Bothidae	7	5	2.5	1.1	0.1	20-30	25
Acanthuridae							
Unidentified Acanthuridae	4	4	2.0	0.8	0.1	13-17	15
Trachipteridae							
Trachipterus trachypterus	4	4	2.0	2.6	0.3		
Triglidae							
Unidentified Triglidae	5	5	2.5	1.2	0.1	17-23	20
Chaetodontidae							
Chaetodon spp.	4	3	1.5	2.3	0.2	12-35	23
Clupeoidei							
Unidentified Clupeoidei	70	3	1.5	4.7	0.5		
Syngnathidae							
Unidentified Syngnathidae	2	2	1.0	0.7	0.1	100-113	106
Synodontidae							
Unidentified Synodontidae	14	2	1.0	2.0	0.2		
Alepisauridae							
Alepisaurus ferox	1	1	0.5	3.6	0.4		
Holocentridae							
Unidentified Holocentridae	1	1	0.5	0.5	0.1		
Ophidiidae							
Unidentified Ophidiidae	2	2	1.0	1.4	0.1		
Priacanthidae							
Priacanthus spp.	1	1	0.5	0.2	<0.1		
Stromateoidei							
Unidentified Stromateoidei	2	1	0.5	2.5	0.2	23-53	38
Tetraodontidae							
Unidentified Tetraodontidae	1	1	0.5	0.1	<0.1		
Uranoscopidae							
Uranoscopus spp.	1	1	0.5	0.8	0.1		

APPENDIX TABLE 3.—Continued.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Crustaceans:							
Amphipoda (Hyperiidea)							
Phrosina semilunata	561	139	68.8	83.8	6.2		
Brachyscellus spp.	281	94	46.5	18.9	1.4		
Phronima sedentaria	39	26	12.9	4.3	0.3		
Anchylomera blossevillei	27	3	1.5	1.2	<0.1		
Platyscellous ovoides	9	6	3.0	0.7	<0.1		
Vibilia armata	6	6	3.0	0.6	<0.1		
Platyscellus serratulus	2	2	1.0	0.4	<0.1		
Platyscellus armatus inermis	1	1	0.5	0.2	<0.1		
Oxcycephalus clausi	1	1	0.5	0.1	<0.1		
Decapoda							
Raninidae (megalopae)	112	58	28.7	9.0	0.7		
Brachyura (megalopae)	16	13	6.4	1.9	0.1		
Stomatopoda (larval forms)	43	31	15.3	5.4	0.4		
Euphausiacea							
Euphausia hanseni	3,556	19	9.4	118.0	8.8		
Anomura							
Paguridea (all Glaucothoë)							
Dardanus pectinatus	9	7	3.5	0.9	<0.1		
Macrura-Reptantia (all Phyllosomae larvae)							
Scyllarus arctus	5	5	2.5	0.9	<0.1		
Scyllarus sp.	2	2	1.0	0.2	<0.1		
Scyllarides sp.	1	1	0.5	0.1	<0.1		
Macrura-Natantia							
Sergestidae	1	1	0.5	0.2	<0.1		
Lucifer sp.	1	1	0.5	0.1	<0.1		
Caridea	1	1	0.5	0.1	<0.1		
Palaemonidae	1	1	0.5	0.1	<0.1		
Copepoda							
Arietellus armatus	1	1	0.5	0.1	<0.1		
Candacia varicans	1	1	0.5	0.1	<0.1		
Unidentifiable Crustacea				0.9	<0.1		
Mollusks:							
Cephalopoda (adults and juveniles)							
Unidentified Cephalopoda	14	13	6.4	3.2	0.2		
Octopoda							
Argonauta sp.	2	2	1.0	6.7	0.5		
Other Octopoda	1	1	0.5	0.1	<0.1		
Teuthoidea							
Ornithoteuthis antillarum	78	33	16.3	126.4	10.1		
Ommastrephidae	37	31	15.3	9.4	0.7		
Unidentified Teuthoidea	4	3	1.5	0.3	<0.1		
Gastropoda							
Pteropoda							
Cavolinia longirostris	39	12	5.9	1.8	<0.1		
Heteropoda							
Atlantidae	4	4	2.0	0.3	<0.1		
Atlanta sp.	2	2	1.0	0.2	<0.1		
Atlanta peroni	1	1	0.5	0.1	<0.1		
Oxygyrus keraudreni	1	1	0.5	0.1	<0.1		
Miscellaneous:							
Salpidae	8	7	3.5	1.1	<0.1		

APPENDIX TABLE 4.—List of forage organisms found in stomachs from 43 yellowfin tunas, collected off the west coast of Africa during cruise UN6802. Number of organisms, frequency of occurrence, and percentage of total volume are given for each taxon. Size ranges and mean sizes are given only for certain forage fishes. Fishes listed in decreasing order of frequency of occurrence; crustaceans, mollusks, and miscellaneous groups are listed by broad categories.

Taxon	Number of organisms	Frequency of occurrence		Volume		Size (mm)	
		Number	%	ml	%	Range	Mean
Fishes:							
Unidentifiable	238	38	88.4	61.1	17.1		
Scombridae							
Auxis spp.	53	11	25.6	7.4	2.1	15-34	22
Sarda sarda	4	2	4.7	0.5	0.1	15-21	18
Scomber japonicus	1	1	2.3	0.1	<0.1		
Unidentified Scombridae	15	6	14.0	0.8	0.2		
Carangidae							
Vomer setapinnis	14	10	23.3	4.5	1.2		
Unidentified Carangidae	3	3	7.0	5.3	1.5	21-98	48
Paralepididae							
Unidentified Paralepididae	10	5	11.6	2.1	0.6		
Gempylidae							
Gemyplus serpens	3	3	7.0	0.4	0.1		
Unidentified Gempylidae	2	1	2.3	0.1	<0.1		
Trichiuridae							
Unidentified Trichiuridae	4	3	7.0	2.1	0.6		
Chaetodontidae							
Chaetodon spp.	2	2	4.7	2.5	0.7	20-35	27
Exocoetidae							
Cypselurus spp.	1	1	2.3	27.5	7.7		
Unidentified Exocoetidae	1	1	2.3	7.0	1.9		
Percoidei							
Unidentified Percoidei	16	2	4.7	5.0	1.4	20-28	24
Trachipteridae							
Trachipterus trachypterus	3	2	4.7	9.2	2.6		
Alepisauridae							
Alepisaurus ferox	1	1	2.3	20.0	5.6		
Bothidae							
Unidentified Bothidae	1	1	2.3	0.1	<0.1		
Ophidiidae							
Unidentified Ophidiidae	1	1	2.3	2.0	0.6		
Syngnathidae							
Unidentified Syngnathidae	1	1	2.3	0.3	0.1		
Crustaceans:							
Stomatopoda (larval forms)	81	24	55.8	7.4	2.1		
Amphipoda (Hyperiidea)							
Phrosina semilunata	62	19	44.2	9.4	2.6		
Brachyscelus spp.	8	6	13.9	0.7	1.9		
Phronima sedentaria	8	4	9.3	1.3	3.6		
Vibilia armata	1	1	2.3	0.1	0.1		
Decapoda							
Brachyura (megalopae)	13	4	9.3	1.7	0.5		
Raninidae (megalopae)	5	4	9.3	0.4	0.1		
Anomura							
Macrura-Reptantia (all phyllosemae larvae)							
Scyllaridae sp.	2	2	4.6	0.2	0.1		
Scyllarus sp.	2	2	4.6	0.2	<0.1		
Paguridea (all Glaucothoë)							
Dardanus pectinatus	4	2	4.6	0.4	1.1		
Unidentifiable Crustacea				0.4	1.1		
Mollusks:							
Cephalopoda (adults and juveniles)							
Unidentified Cephalopoda	7	6	13.9	3.5	1.0		
Octopoda							
Argonauta argo	6	5	11.6	165.5	46.3		
Teuthoidea							
Ommastrephidae	10	2	4.6	4.6	1.3		
Ornitheteuthis antillarum	2	2	4.6	1.3	0.4		
Tetrenychoteuthis dusumieri	1	1	2.3	1.3	0.4		
Unidentified Teuthoidea	4	4	9.2	0.4	1.1		
Miscellaneous:							
Salpidae	4	3	6.9	0.3	0.1		