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FOOD OF ALBACORE TUNA, *THUNNUS GERMO* (LACÉPÈDE), IN THE CENTRAL AND NORTHEASTERN PACIFIC

BY ROBERT T. B. IVERSEN

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ABSTRACT

The stomach contents of 544 albacore tuna, *Thunnus germo* (Lacépède), captured during the years 1950–57 were analyzed in order to identify the organisms eaten, to determine if the abundance and distribution of albacore is related to the abundance and distribution of their food, and to relate feeding to size, method of capture, geographic location, season, distance from land, time of day, and water clarity.

Stomach contents were mainly a variety of fish, squid, and crustaceans, the percent volume of each differing according to the method of capture.

The latitudinal abundance of albacore in the equatorial Pacific was not related to the amount of food eaten. During the summer in the temperate North Pacific, high stomach volumes were found south of successive peak volumes of organisms captured by midwater trawling and zooplankton tows. This suggests successive trophic levels associated with an advancing oceanographic and biological "frontier" in the Transition Zone. There was little seasonal difference in food volumes. Reef-associated organisms appeared most frequently in the diet of albacore caught near land.

Troll-caught albacore in the North Pacific fed throughout the day, but evidence of distinct feeding periods was not clear. There is evidence that albacore also feed at night. The higher stomach volumes of troll-caught albacore occurred in waters of midclarity. Some competition for food may exist among albacore, yellowfin, and bigeye tuna in the equatorial Pacific.

FOOD OF ALBACORE TUNA, *THUNNUS GERMO* (LACÉPÈDE), IN THE CENTRAL AND NORTHEASTERN PACIFIC

By ROBERT T. B. IVERSEN, *Fishery Biologist*
BUREAU OF COMMERCIAL FISHERIES

The food study described in this report was undertaken at the United States Bureau of Commercial Fisheries Biological Laboratory, Honolulu,[1] as part of research studies on the highseas fishery resources of the tropical, subtropical, and temperate central Pacific. These studies have centered mainly on tunas since, as a source of human food, they are the most widely exploited pelagic species in this area.

Investigations on the food and feeding habits of tunas were initiated because other studies have indicated that the availability of food is an important factor in the abundance and distribution of some fish (Hardy, Lucas, Henderson, and Fraser, 1936; Hansen, 1949).

Albacore are widely distributed throughout the tropical, subtropical, and temperate waters of the Pacific. In temperate waters they are taken by surface trolling, pole-and-line, gill netting, and by longline fishing (Graham, 1957; Suda, 1954), while in tropical waters they are found only subsurface and are captured by longlining (Murphy and Shomura, 1953). Results of tagging experiments have shown that albacore are capable of extensive migrations. For example, two fish tagged off the west coast of North America were retaken in the vicinity of Japan; the distances traveled were 4,230 and 4,300 miles respectively. Such tagging results suggest that one population of albacore in the North Pacific may be supporting three fisheries (Otsu, 1960). In the temperate North Pacific albacore are fished by the Japanese in the west mainly during the spring and summer, in midocean in the winter, and by North Americans off the west coast during summer and fall. Japanese also take albacore in a longline fishery in the central and western Pacific from equatorial waters to about latitude 30° S.

The purposes of this study were:

1. To describe the food of albacore tuna caught in the central and northeastern Pacific.
2. To determine whether the abundance and distribution of albacore are related to the abundance and distribution of their food.
3. To determine whether feeding is related to such variables as method of capture of the albacore, their size, geographic location, season, and environmental factors.

There are numerous accounts in the literature of the food of albacore. Although reports for Pacific albacore outnumber those (principally by French workers) for the North Atlantic, most are fragmentary.

One of the earliest notes on the Pacific stocks (Bennett, 1840) described albacore as "voracious and miscellaneous feeders," and reported flying fish, "calmars," and small schooling fish as their natural food. Bennett listed the following as having been found in albacore stomachs: "Ostracions," filefish, sucking fish, "janthina shells," pelagic crabs, bonita, dolphin, and paper nautilus. Phyllosomas, larval sunfish, and part of a bigeye tuna had been eaten by albacore taken near the Bonin Islands (Kishinouye, 1917). The Japanese Bureau of Fisheries (1939, 1940) reported albacore food as sardine, saury, pomfret, squid, octopus, isopods, mysids, euphausiids, and heteropods. Kanamura and Yazaki (1940) found squid, octopus, stomatopods, barracuda, "hairtail," "flathead," "ginkagami" (*Mene maculata*), and "sardine" (*Bathylagus nakazawai*) in the stomachs of albacore from the South China Sea. Hart, et al. (1948) have presented a summary of albacore stomach contents sampled off Vancouver Island and the coast of Washington from 1941 to 1947. Saury, anchovy, lantern fish, pilchard, "red feed" (i.e., euphausiids), and squid were frequently occurring food items. Powell (1950) recorded small rockcod as an important food of albacore taken in the northeastern Pacific, with squid, saury, blackcod, and myctophids also present.

[1] Formerly the Pacific Oceanic Fishery Investigations (POFI).

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In a food study of 321 albacore troll-caught off California and Baja California, McHugh (1952) reported each of these 11 food items occurring in more than 10 percent of the stomachs: squid, saury (*Cololabis saira*), euphausiids, amphipods, the decapod crustacean *Pleuroncodes planipes*, paralepidids, rockfish (*Sebastodes* sp.), the gonostomatid *Vinciguerria lucetia*, hake (*Merluccius productus*), myctophids, and the anchovy *Engraulis mordax mordax*. The bulk of the food, however, was composed of saury (50 percent), squid (12 percent), and *P. planipes* (11 percent). Yabuta (1953) found barracuda, the trunkfish *Ostracion diaphanus* (=*Lactoria diaphanus*), and a species of "sand borer" in the food of albacore from seas adjacent to the Bonin Islands. He states, however, that "their feed are mostly crustacea and very small cephalopoda; therefore it is considered to have strong characteristics of a plankton feeder."

Koga (1958a, 1958b) described the food of albacore from the western Indian Ocean and the equatorial South Pacific. Twelve fish families occurred in the stomach contents of the western Indian Ocean albacore, with Plagyodontidae (=*Alepisauridae*), Triacanthidae, Carangidae, and Acinaceidae (=*Gempylidae*) found in 10 percent or more of the stomachs. Among the Crustacea, isopods, decapods, and stomatopods occurred in 10 percent or more of the stomachs. Squid occurred in 67 percent. Koga also found 12 fish families represented in the food of equatorial South Pacific albacore, with the following present in the food by 10 percent or more: Plagyodontidae, Triacanthidae, Acinaceidae, Ostraciidae, and Menidae. Decapod crustaceans occurred in 15 percent, squid in 50 percent, and octopods in 10 percent of the fish.

In the eastern North Atlantic albacore food was studied by Collett (1896), who reported finding these nine categories of fish in albacore taken in the Gulf of Gascony: horse mackerel (*Trachurus trachurus*), boarfish (*Capros aper*), barracudina (*Paralepis pseudocoregonoides*), lancet fish (*Plagyodus* sp.), *Scomberesox saurus* (the Atlantic counterpart of the Pacific saury), hatchet fish (*Sternoptyx diaphana*), gonostomatids (*Maurolicus* sp.), and pipefish (*Syngnathus aequoreus*). Joubin and Roule (1918) found *S. saurus*, the amphipod *Euthemisto bispinosa*, and *Paralepis* sp. to be the most important items of the diet of albacore caught off the coasts of Brittany, but also found the hatchet fish, *Argyropelecus olfersi*, a hoplophorid crustacean of the genus *Acanthephyra*, the euphausiid *Meganyctiphanes norvegica*, the amphipod *Phronima sedentaria*, and the squid *Gonatus fabricii*. They correlated good catches of albacore with many *E. bispinosa* and *S. saurus* recovered from the stomachs. Le Danois (1921, 1922) related the feeding of albacore with the presence of the amphipod *E. bispinosa* in waters whose temperature, at a depth of 50 m., was not less than 14° C. He also found juvenile anchovy (*Engraulus encrassicholus*), horse mackerel (*T. trachurus*), saury (*S. saurus*), smelt (*Argentina* sp.), and lantern fish (*Myctophum* sp.) in albacore stomachs.

Legendre (1932, 1934, 1940) and Bouxin and Legendre (1936) have published the most detailed reports dealing with the food of albacore from the eastern North Atlantic. Legendre (1940), for example, summarizes the food of albacore from 1929 to 1933 in a list comprising 106 species from five phyla. The ten most important food items reported by Legendre were similar to the most important food items of albacore captured off California and Baja California (McHugh, 1952). Le Gall (1949) has reviewed the albacore food studies by French workers and noted the differences in stomach contents of fish taken over a period of almost 30 years.

SOURCE OF MATERIALS

A total of 544 albacore stomachs were examined. They were collected on 24 cruises of the *Hugh M. Smith*, *Charles H. Gilbert*, and *John R. Manning*, during the years 1950–57. The data for the 24 cruises are summarized in table 1 and the overall collection area is shown in figure 1. Stomachs were taken from albacore captured by longlining, trolling, and gill net fishing. Murphy and Shomura (1953) have discussed the method of longline fishing used on these cruises, and construction details of the gear have been described by Mann (1955). Trolling procedures have been decribed by Shomura and Otsu (1956) and Graham (1957, 1959), and the use of gill nets and construction details were reported by Graham and Mann (1959).

These three different fishing techniques did not sample the same sizes of albacore, as the smaller (≦85 cm.) fish were taken primarily by trolling and gill netting at the surface and the larger (>85 cm.) albacore were caught by the deeper fishing longline. Length frequency distributions of the albacore from which stomachs were collected are shown in figure 2.

METHODS

The stomachs were removed as soon as possible after the albacore came aboard, but the time interval between the moment of capture by the fishing gear and removal of the stomach varied considerably. Stomachs of troll-caught fish were removed immediately after capture, while the stomachs of some fish caught by longline or gill net were undoubtedly not removed until several hours had elapsed between the hooking or gilling of the fish and the hauling of the gear.

Of the 544 stomachs examined, the contents of 196 were analyzed at sea during *John R. Manning* cruise 36. This analysis consisted of measuring the total displacement volume ($\geqq$ 5cc.) of each stomach's contents and recording the numbers or presence of the following food groups: squid, saury (*Cololabis* sp.), other fish, shrimp-like plankton, copepod-amphipod-like plankton, and unidentifiable remains.

The other 348 stomachs were preserved for examination in the laboratory by placing them in muslin bags, along with any regurgitated material

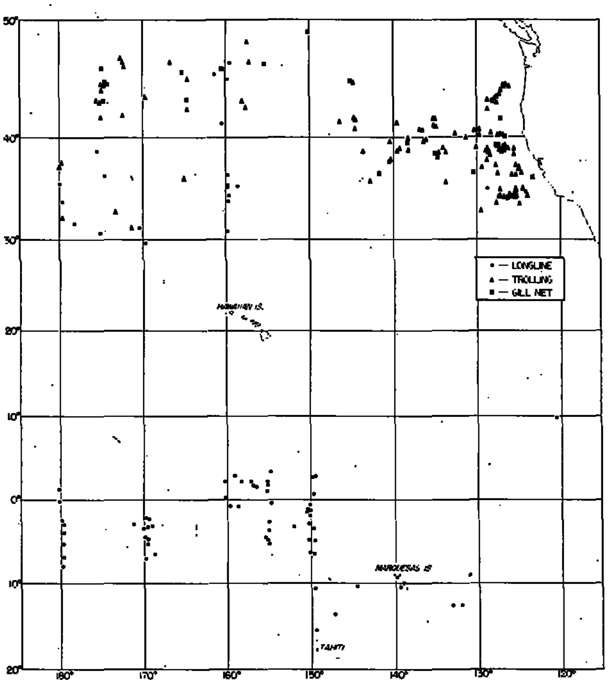

FIGURE 1.—Locations where stomach samples were taken from albacore captured by longline, gill net, and trolling in the central and northeastern Pacific, 1950–57.

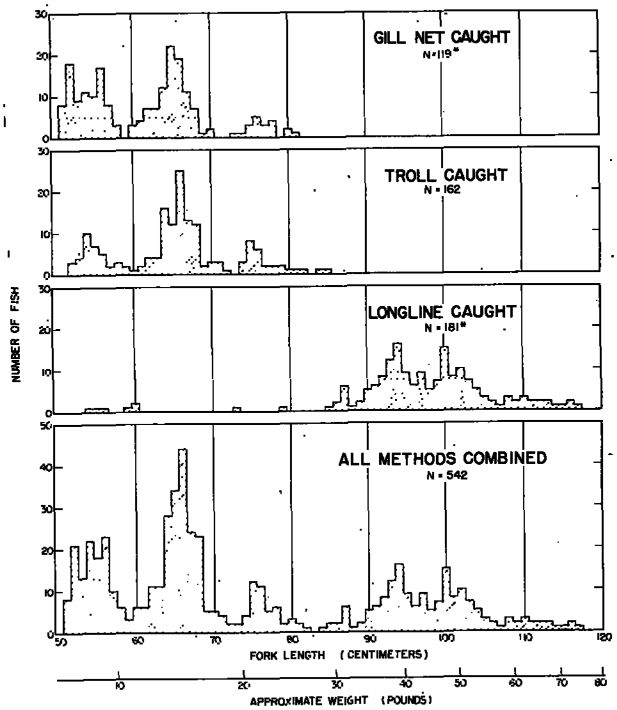

FIGURE 2.—Length frequency distributions of albacore tuna from which stomachs were collected. (Asterisk indicates one shark-mutilated specimen not included.)

recovered, in 10 percent formalin. Collection data, including vessel, cruise number, locality, date, fork length, time of capture if known, method of capture, bait species, and the observer's initials, were recorded on a cloth label which was placed in the muslin bag with the stomach.

In the laboratory the stomachs were soaked overnight in fresh water to remove excess formalin. The stomachs were then opened and the various food organisms separated according to species or to whatever taxon the precision of identification permitted. The number of individuals in each species or group was counted, and their volume determined by the displacement of water in a graduated cylinder. Bait found in the stomachs of longline-caught albacore was excluded.

A checklist of food organisms from 348 stomachs analyzed in the laboratory appears in the Appendix table. The contents of the 196 albacore stomachs analyzed at sea have been reported by Graham (1959). In a number of instances the data obtained from these two groups of stomachs could not be analyzed together due to the differences in the method of recording data.

Stomachs were randomly selected except on *John R. Manning* cruise 36, when 48 stomachs

TABLE 1.—*Albacore stomachs collected from the central and northeastern Pacific from 1950 to 1957 by vessels of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, according to cruise, time of year, locality, fishing method, and place of examination*

Vessel	Cruise number	Cruise period	Collecting area		Fishing method	Number of albacore captured	Number of stomachs examined	Percent of catch examined
			Range of latitude	Range of longitude				
Hugh M. Smith	5	June–Aug. 1950	3° S.	171° W.	Longline	4	2	50
Hugh M. Smith	11	Aug.–Oct. 1951	1° N.–2° S.	150° W.	do	4	4	100
John R. Manning	11	Jan.–Mar. 1952	3° N.–8° S.	155° W.–180°	do	64	22	65
John R. Manning	13	Oct.–Dec. 1952	2° S.–5° S.	152° W.–170° W.	do	22	6	27
John R. Manning	14	Jan.–Mar. 1953	1° S.–16° S.	144° W.–150° W.	do	40	25	62
John R. Manning	15	Apr.–June 1953	3° N.–7° S.	150° W.–170° W.	do	67	39	58
John R. Manning	16	July–Sept. 1953	3° N.–4° S.	155° W.–160° W.	do	21	15	71
John R. Manning	18	Nov.–Dec. 1953	5° S.	155° W.	do	2	1	50
John R. Manning	19	Jan.–Mar. 1954	31° N.–35° N.	160° W.	do	47	11	23
Charles H. Gilbert	15	Feb.–Apr. 1954	2° N.–9° S.	121° W.–155° W.	do	13	10	77
John R. Manning	20	May–June 1954	3° N.–0°	157° W.–160° W.	do	7	6	86
John R. Manning	22	Sept.–Nov. 1954	36° N.–46° N.	159° W.–175° W.	do	26	11	42
Charles H. Gilbert	17	Sept.–Nov. 1954	37° N.–45° N.	165° W.–172° E.	Trolling	48	16	33
John R. Manning	23	Dec. 1954–Feb. 1955	29° N.–36° N.	159° W.–180°	Longline	50	14	28
					Trolling	2	1	50
Hugh M. Smith	27	Jan.–Feb. 1955	32° N.–33° N.	173° W.–179° E.	do	2	2	100
John R. Manning	25	May–June 1955	36° N.	165° W.	do	1	1	100
Hugh M. Smith	30	July–Aug. 1955	46° N.–48° N.	157° W.	do	8	4	50
John R. Manning	26	July–Sept. 1955	35° N.–40° N.	128° W.–129° W.	Longline	6	1	17
					Trolling	64	1	2
Charles H. Gilbert	23	Sept.–Nov. 1955	41° N.–46° N.	145° W.–165° W.	Longline	1	1	100
					Trolling	66	10	15
					Gill net	11	8	73
John R. Manning	32	July–Sept. 1956	42° N.–49° N.	145° W.–175° W.	Trolling	104	11	10
					Gill net	498	46	9
Charles H. Gilbert	30	Aug.–Sept. 1956	9° S.–14° S.	132° W.–140° W.	Longline	26	13	50
Charles H. Gilbert	31	Oct.–Dec. 1956	34° N.–41° N.	125° W.–144° W.	Trolling	154	17	11
					Gill net	1	1	100
John R. Manning	33	Oct.–Dec. 1956	39° N.	130° W.	Trolling	79	1	1
John R. Manning	36	June–Aug. 1957	33° N.–45° N.	124° W.–143° W.	Longline	1	1	100
					Trolling	226	[1] 98	43
					Gill net	149	[2] 145	97

[1] Of this number, 83 were examined at sea.

[2] Of this number, 113 were examined at sea.

were chosen for analysis in the laboratory because they were thought to contain food. However, many of these stomachs were empty or nearly so, and it is considered that any bias introduced into the sampling was slight.

The reporting of results has followed the approach used by Reintjes and King (1953) and King and Ikehara (1956). This takes into account the number of organisms, the frequency of their occurrence, and their individual and aggregate total volumes. An expression used throughout this report is that of volume (in cc.) of stomach contents per pound of body weight of the individual fish. Since the capacity of an albacore's stomach depends upon the size of the fish, the comparison of the stomach volumes of large and small fish together would tend to bias the data in favor of the larger fish. Figure 3 shows the relationship between volume (cc.) per pound body weight and body weight. The points are somewhat scattered and are probably not normally distributed, but there is an indication of an overall decrease in average stomach content per unit of body weight with increase in fish size, a situation similar to that reported for yellowfin (*Neothunnus macropterus*) and bigeye (*Parathunnus sibi*) tuna by King and Ikehara (1956).

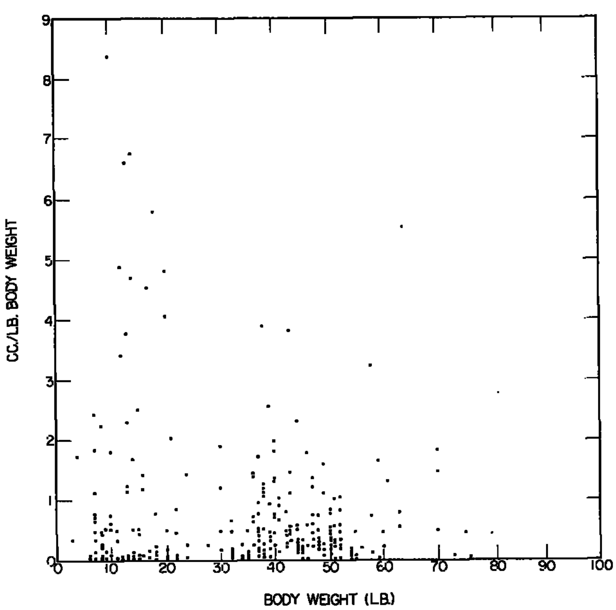

FIGURE 3.—Relationship between food volume per unit of body weight and total body weight of 260 longline- and troll-caught albacore tuna.

Gill net-caught albacore were not included in figure 3 since a high percentage of their stomachs were empty or nearly so, which may reflect the time of feeding or a variable introduced by the fishing method. Where albacore of approximately the same size were considered, the average volume of food per stomach was also used as a basis for comparison. In some instances, weights of the albacore were estimated from length to weight tables developed at the Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

Statistical tests of significance have not been made, for, as King and Ikehara (1956) pointed out: "Regardless of the mehods of analysis used, there are many uncontrollable variables inherent in food studies which detract from the precision of the results." There is evidence (Reintjes and King, 1953, fig. 4) that the parameters involved are not independent, and therefore the assumptions underlying the common tests of significance would be violated.

In a number of my comparisons of stomach content data with environmental variables, the stomach data represent catches made during different cruises and years. Little can be done to rectify this weakness, since further grouping of the stomach data into subclass numbers more discrete than those shown would produce subsamples of very small numbers.

RESULTS

VARIATION IN FOOD WITH FISHING METHOD AND SIZE OF THE ALBACORE

The following discussion of variations in the food of albacore with the method of capture by inference is a generalization on variations in food with albacore size, since the methods of capture sampled different size groups (fig. 2).

There are distinct differences in the average volume of food per stomach and in the composition of the foodstuffs depending upon which fishing method was used. Table 2 shows the average volume per stomach, figure 4 shows the distribution of these volumes, and figure 5 shows the comparative importance, by volume, of the major food groups of stomach contents, according to method of capture.

Table 2.—*Average stomach volumes of 348 albacore, according to method of capture*

Method of capture	Number of stomachs	Average volume (cc.) per stomach
Longline	182	26.7
Gill net	87	9.8
Troll	79	15.1

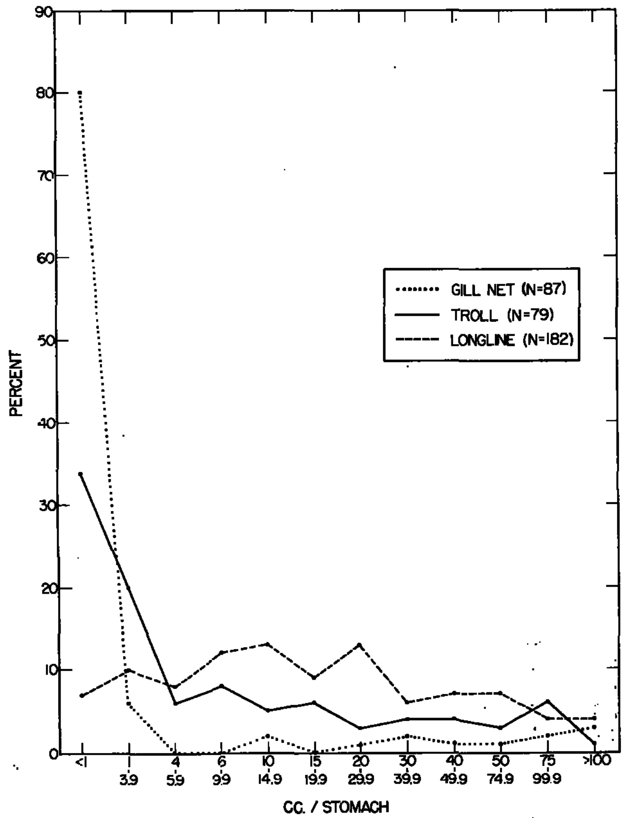

Figure 4.—Distribution of stomach content volumes of 348 albacore, according to method of capture.

The higher average volume per stomach of the longline-caught albacore is undoubtedly due to their larger sizes, since the longline captured all the albacore longer than 85 cm. Only 9 percent of the longline-caught fish were under 85 cm. while the majority of the gill net- and troll-caught albacore were in the 50–70 cm. range.

The difference in average stomach volume between the troll- and gill net-caught fish is not as easily explained, since the fish of both groups were approximately the same size. One possibility is that this difference reflects the time of feeding of albacore, because the troll-caught fish are taken during the day and the gill netted albacore are thought to have been caught at night, even though the gill net is hauled aboard after dawn. An indication of this was provided by the 24-hour gill net station on *John R. Manning* cruise 36. No albacore were caught by the sets made from 0828 to 1531 hours and from 0230 to 0942 hours. Seventeen were caught by the set from 2003 to 0358 hours, and 6 albacore were caught in the set from 1502 to 2153 hours

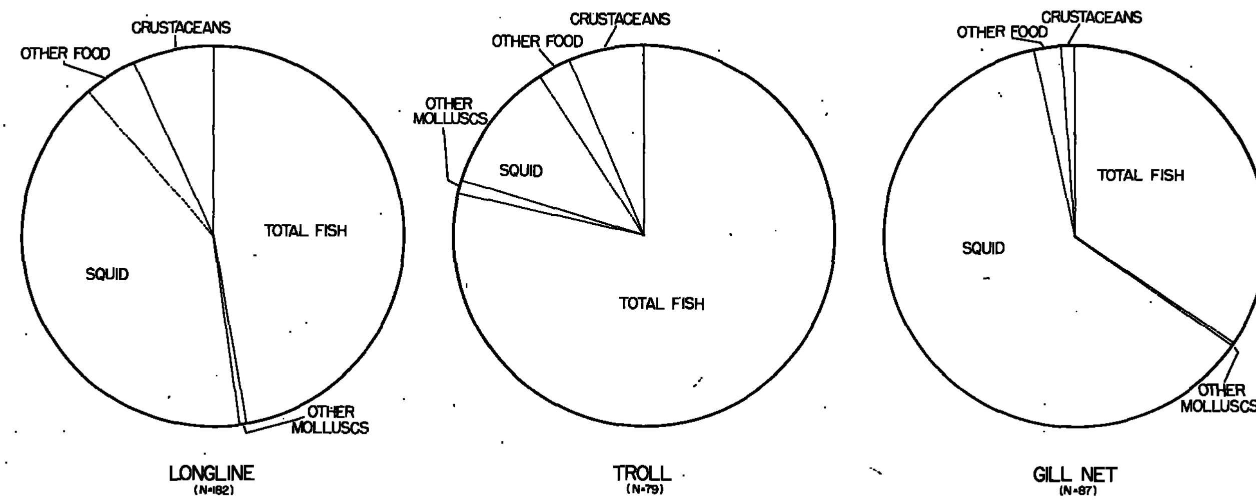

Figure 5.—Comparative importance, by volume, of major food elements found in 348 albacore stomachs, according to method of capture.

(Graham, 1959). Another possibility is that the gill net-caught fish regurgitated food while struggling to escape the net. A third possibility is that albacore do feed at night, but at a reduced rate. These suggestions are discussed more fully in the section dealing with feeding related with time of day.

Differences among the aggregate total volumes of major food items of albacore captured by trolling compared with longline-caught and gill netted fish are evident (fig. 5). Fish and squid formed approximately equal portions of the food of longline-caught albacore, while fish comprised 79 percent and squid comprised 11 percent of the diet of troll-caught albacore. This agrees with McHugh's data (1952), which showed fish as 68 percent and squid as 12 percent of the food volume of troll-caught albacore. In both cases saury, *Cololabis* sp., comprised the bulk of the fishes. Reintjes and King (1953) also found fishes to form a larger portion of the diet of troll-caught yellowfin tuna when compared with longline-caught yellowfin in both the Line Islands and Phoenix Islands areas.

Perhaps the trolling method, which employs a lure skipping and plunging along a few feet below the surface, may especially attract albacore previously conditioned by a diet of fish having the gross characteristics of a trolling lure. If this is true, and there were numbers of albacore in the trolling area which had been feeding on organisms (e.g. crustaceans) which do not have these characteristics, a portion of the available albacore might not be efficiently exploited. Joubin and Roule (1918), however, found that amphipods were the main food of troll-captured albacore in the Gulf of Gascony.

Yuen (1959) has pointed out that the feeding behavior of skipjack tuna (*Katsuwonus pelamis*) may be conditioned by previous feeding. He hypothesized that livebait fishing methods used in Hawaii take advantage of an already existing feeding excitement in the skipjack.

The frequency of occurrence of major food groups is shown in figure 6. Differences between the longline and gill net-caught fish are large, but even if the gill net data are considered atypical, there are still substantial differences between longline- and troll-caught fish. The spread between values for these two groups for three classes of food are as follows: squid, 35 percent; fish, 27 percent; crustaceans, 24 percent. It may be simply that the larger, longlined fish require more food than the smaller, troll-caught albacore and thus would be apt to have more types of food in their stomachs. Possibly the reason squid and fish dominate in gill netted albacore is that their hard parts (squid beaks and eye lenses and fish vertebrae) remain in the stomachs after other organisms have been completely digested.

Representatives of 32 fish families and 11 invertebrate orders were found in the food of longlined albacore, compared to 9 fish families and 10 invertebrate orders for troll-caught and 4 fish families and 5 invertebrate orders for gill net-caught albacore. The most frequently occurring fish families in the longlined albacore were Gempylidae,

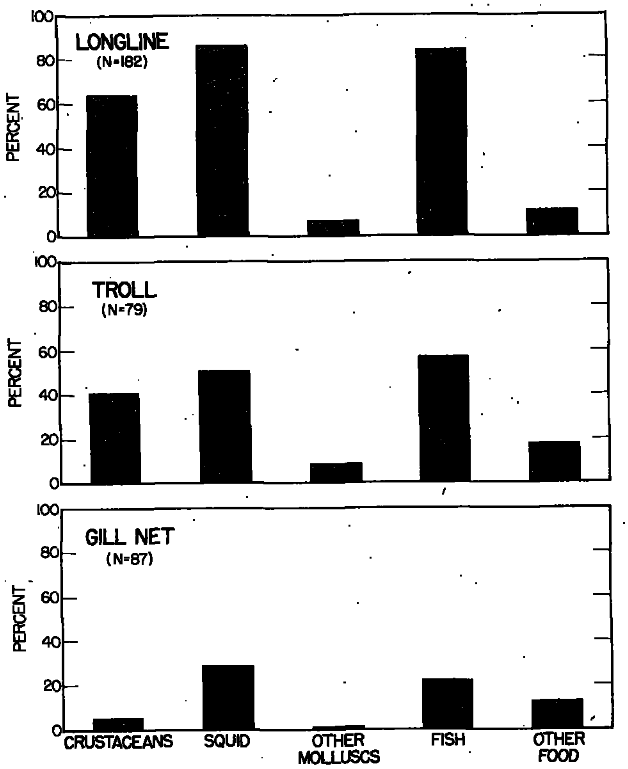

Figure 6.—Frequency of occurrence of major food groups in 349 albacore according to method of capture.

Bramidae, Sternoptychidae, Paralepididae, Myctophidae, Scomberesocidae, Chiasmodontidae, and Alepisauridae. Saury dominated in troll- and gill net-caught albacore, with myctophids next in frequency of occurrence. Squid were well represented in the albacore captured by all three methods.

Among the crustaceans, the main difference was the lack of stomatopods in the diet of troll- and gill net-caught albacore. This reflects the scarcity of stomatopods in the offshore plankton in the temperate North Pacific. For example, during *Hugh M. Smith* cruise 30, which covered the area north of Hawaii to approximately latitude 50° N., stomatopods occurred in only 2 of 124 plankton samples collected. These two samples were collected at 25° N. and 30° N., on the southern portion of the cruise.

VARIATION IN FOOD WITH LATITUDE AND LONGITUDE

Latitudinal variations in the volume of the food of longline-captured albacore from the equatorial Pacific are compared with variations in zooplankton, larger trawl-caught organisms, and the catch rate of albacore in figure 7.

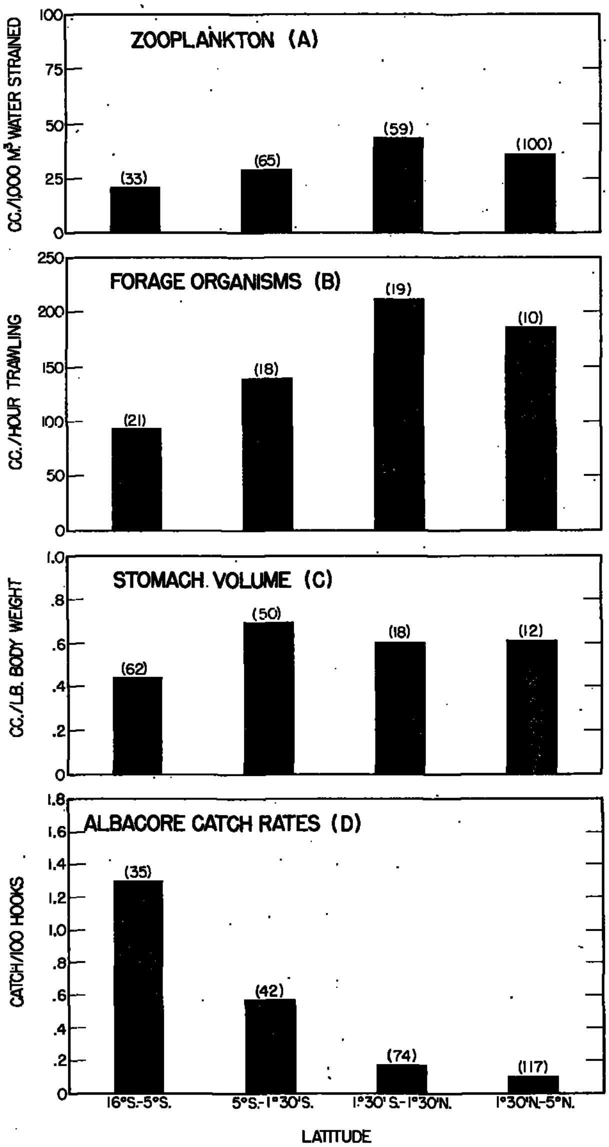

Figure 7.—Latitudinal variations in the equatorial Pacific of (A) zooplankton, (B) forage organisms, (C) volume of stomach contents per pound body weight of 142 longline-caught albacore, and (D) albacore catch rates. (Numbers in parentheses refer to sample sizes or (D) number of longline fishing stations.) Zooplankton data from King and Hida, 1957. Forage organism data from King and Iversen, 1962. (Catch rate data from the records of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu.)

The method used by King and Hida (1957), presenting data on zooplankton abundance in the equatorial Pacific according to the subdivisions of the equatorial current system, has been followed in constructing figure 7. In this report the subdivisions utilized are: (1) a zone of convergence in the westward-flowing South Equatorial Current (SEC) from approximately 5° N., to 1½° N.; (2) a zone of upwelling in the SEC from 1½° N. to 1½° S.; (3) the SEC from 1½° S. to 5° S., an area with a deep thermocline; and (4) the SEC from 5° S. to 16° S., the southern limit of sampling and a region of shoaling thermocline towards the south. This representation of the SEC does not take into account Reid's (1959) report of a weak easterly countercurrent near 10° S.

Values for zooplankton and trawl-caught organisms (small nekton for the most part) were highest near and just north of the Equator, where the abundance of albacore was lowest. The assumption has often been made that, all other things being equal, areas with the higher concentrations of zooplankton and small nekton should support the higher concentrations of large carnivores, such as albacore. The fact that this assumption is not supported by the data shown in figure 7 probably means that environmental factors other than the abundance of available food, such as water temperature, exert a strong influence on albacore distribution.

Whether or not the albacore captured in the areas of high zooplankton and nekton abundance were utilizing available forage to best advantage is not clear from figure 7, since the total range of stomach volumes was only 0.4–0.7 cc./lb. of body weight. The lowest stomach volumes occurred in the latitudes of best albacore catches, a situation similar to that found for yellowfin tuna in the equatorial area (King and Ikehara, 1956). One factor which adds to the uncertainty is that the trawling upon which the values shown in section B of figure 7 are based was done at night and many of the animals captured are not utilized by tunas as forage (King and Iversen, 1962). However, King and Iversen also found a high positive correlation between trawl catches and zooplankton abundance, and the assumption that trawling results are a valid estimate of potential tuna forage should not be dismissed, since some animals that make up a considerable portion of the trawl catches (e.g. myctophids) are actively pursued by animals which make up a large fraction of albacore food, such as squid.

The utilization of forage was further investigated by examining the occurrence and amounts of squid, fish, and crustacea in the diet of equatorial albacore. The results are shown in figures 8 and 9.

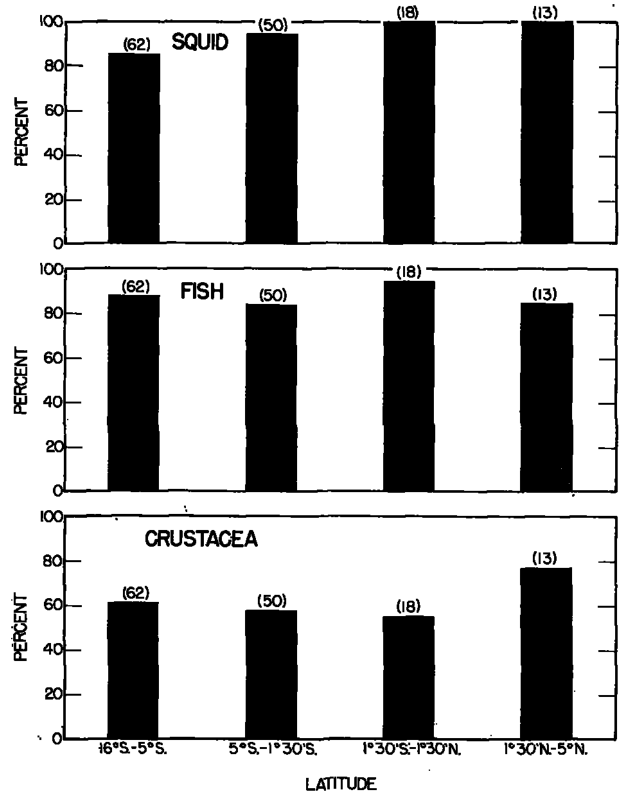

FIGURE 8.—Percent occurrence of major food items in the diet of equatorial longline-caught albacore, 120° W.–180°. (Numbers in parentheses indicate sample sizes.)

Squid occurred more often and in larger amounts than fish in the stomachs of albacore taken from 1½° S. to 5° N. This is contrary to the findings of King and Ikehara (1956), who found that fish formed overall a larger portion of yellowfin and bigeye food in equatorial waters than did squid.

There were also differences in the fish consumed by longline-caught albacore in the equatorial Pacific when compared to longline-caught albacore from the temperate North Pacific (table 3). It is puzzling that no bramids or gempylids were found in the stomachs of longline-caught albacore from the temperate North Pacific, since species of both families occur in this area. It may be that bramids and gempylids are distributed close to the surface in the north and in deeper water in the equatorial area. In such a case they would not be as available to the albacore fished with longlines in the north as they would be to the albacore exploited by the same gear in equatorial waters. A possibly analogous tropical submergence or deepening of habitat with decrease in latitude has been demonstrated for the great blue shark (*Prionace glauca*) in the central Pacific by Strasburg (1958).

Table 3.—*Percent occurrence of fishes prominent in the diet of longline-caught albacore, according to area of capture*

Family	Area of capture	
	Equatorial Pacific	Temperate North Pacific
Gempylidae	28.5	----------
Bramidae	21.5	----------
Scomberesocidae	----------	18.4
Sternoptychidae	8.3	10.5
Myctophidae	4.2	5.3
Alepisauridae	2.1	5.3
Paralepididae	4.9	2.6
Chiasmodontidae	4.2	----------
Number of stomachs examined	143	38

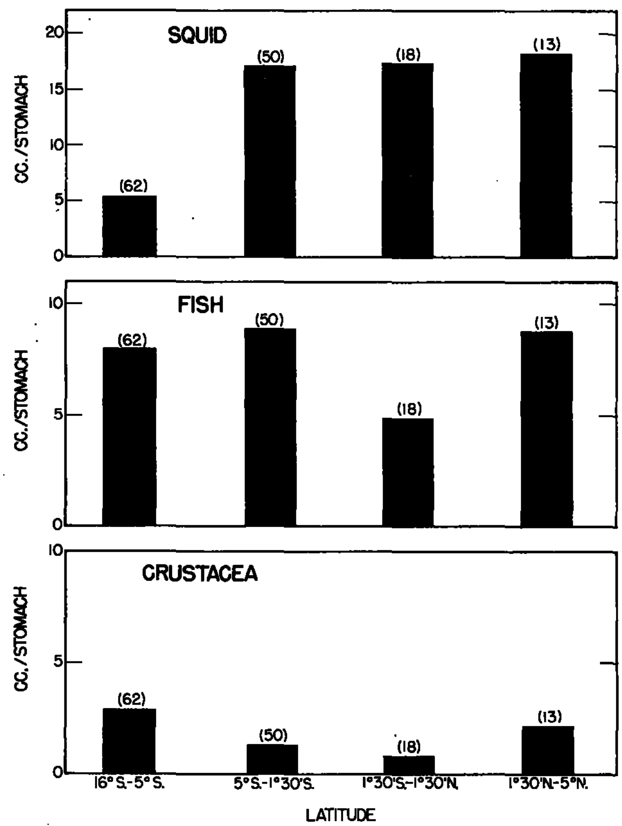

Figure 9.—Variation (cc./stomach) of major food items in the diet of equatorial longline-caught albacore. 120° W.–180°. (Numbers in parentheses indicate sample sizes.)

Latitudinal variations in the temperate North Pacific for zooplankton, forage organisms obtained by midwater trawling, and volumes of the stomach contents of longline- and troll-caught albacore are shown in figure 10.

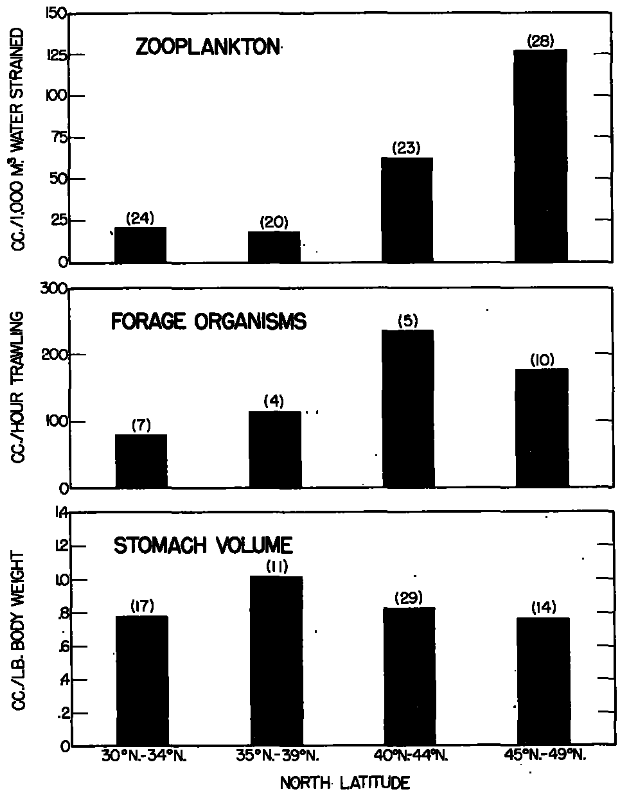

Figure 10.—Latitudinal variations in the temperate North Pacific (140° W.–180°) of zooplankton, forage organisms, and in the volume of stomach contents per pound of body weight of 71 albacore caught by longline and trolling. (Numbers in parentheses refer to sample sizes. Data obtained during summer and fall cruises, except for stomach volumes from 30°–34° N., which were obtained in winter. Zooplankton data from McGary, Jones, and Austin, 1956. Forage organism data from King and Iversen, 1962.)

It appears from figure 10 that zooplankton volumes are highest to the north, trawling volumes are highest south of the zooplankton peak, and the albacore stomach volumes are highest south of the peak trawling volumes—indications of what may be the development of successive trophic levels.

McGary, Jones, and Graham (1958) have shown the existence of a "Transition Zone" in the central North Pacific between the Central Water Mass and the Subarctic Water Mass. This Transition Zone, which has temperature-salinity qualities intermediate between those of the Central and Subarctic Water Masses, is characterized by a northward movement of the isotherms starting in the spring as the surface layer is warmed and a marked thermocline develops. In the summer the northern limit of the warmed surface layer is at about

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47°–48° N. McGary, Jones, and Graham state: "The frontier of this warming layer apparently offers optimum conditions for a phytoplankton bloom followed by an increase in zooplankton abundance."

As such a "frontier" with an associated trophic level (zooplankton, for example) moves northward, one might expect it to be followed by other trophic levels, each successively exploiting the one preceding it. In this case (fig. 10) it is postulated that zooplankton are exploited by forage organisms which are most abundant south of an advancing frontier of high zooplankton abundance. The forage organisms (sauries and squid, not necessarily those captured by midwater trawling) are in turn exploited by the albacore, and the largest stomach volumes are found to the south of the area of highest trawling volumes.

The consumption of food by albacore captured by troll and longline from 120° W. to 140° W. and from 140° W. to 180° during summer and fall in the temperate North Pacific is compared with the abundance of zooplankton in these two areas in figure 11. Such a comparison provides another estimate of the utilization of forage by albacore, although the zooplankton is usually considered two trophic levels removed from the albacore.

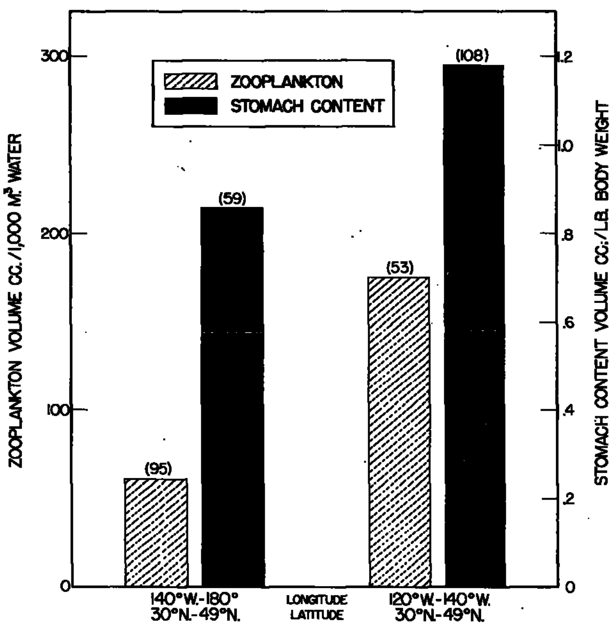

FIGURE 11.—Stomach content volumes of albacore captured by troll and longline and zooplankton volumes from the temperate North Pacific. Plankton data from McGary, Jones, and Austin, 1956, and Norpac Committee, 1960. (Numbers in parentheses refer to sample sizes.)

Albacore captured at 120° W.–140° W. had more food in their stomachs than albacore captured at 140° W.–180°, even though the data upon which figure 11 is based favor the latter. This bias occurs because most of the fish captured at 120° W.–140° W. were examined in the field and only stomach content volumes of 5 cc. or greater were recorded. In the construction of figure 11, any field-examined stomach with less than 5 cc. was considered empty, while values from 0 to 5 cc. were recorded for stomachs examined in the laboratory. It appears, therefore, that albacore captured at 120° W.–140° W. were utilizing the larger amount of food available to them, as indicated by the higher zooplankton volumes recorded at 120° W.–140° W.

East-west variations in stomach content volumes of longline-caught albacore in the central equatorial Pacific are compared with zooplankton volumes in figure 12. These differences may reflect the east-west variation in the equatorial circulation and tend to support the hypothesis advanced by King and Iversen (1962) that decreasing zooplankton abundance from east to west in the equatorial Pacific may be related to predation by an expanding population of forage organisms. The latter in turn are eaten by climax predators, such as albacore. This is indicated by the high stomach content volumes recorded near 180°. As newly upwelled water from the eastern Pacific is carried westward, the inorganic phosphate present decreases, the temperature increases, and the thermocline deepens (Austin, 1958). The decrease in inorganic phosphate presumably indicates an increase in organic production by expanding populations of phytoplankton and zooplankton. However, such an increase in the abundance of zooplankton from east to west is not shown by the data (fig. 12), and it is to explain this phenomenon that the importance of predation by forage organisms has been suggested. King and Iversen (1962) have reported the amount of forage organisms captured by midwater trawling to be higher at 140° W.–160° W. than at 110° W.–140° W., indicating a westward increase in such predators, many of which depend upon zooplankton as food.

The volumes of albacore stomach contents also parallel somewhat the east-west variation in stomach volumes reported by King and Ikehara (1956) for the bigeye tuna of the equatorial Pacific, which like the albacore also inhabits the

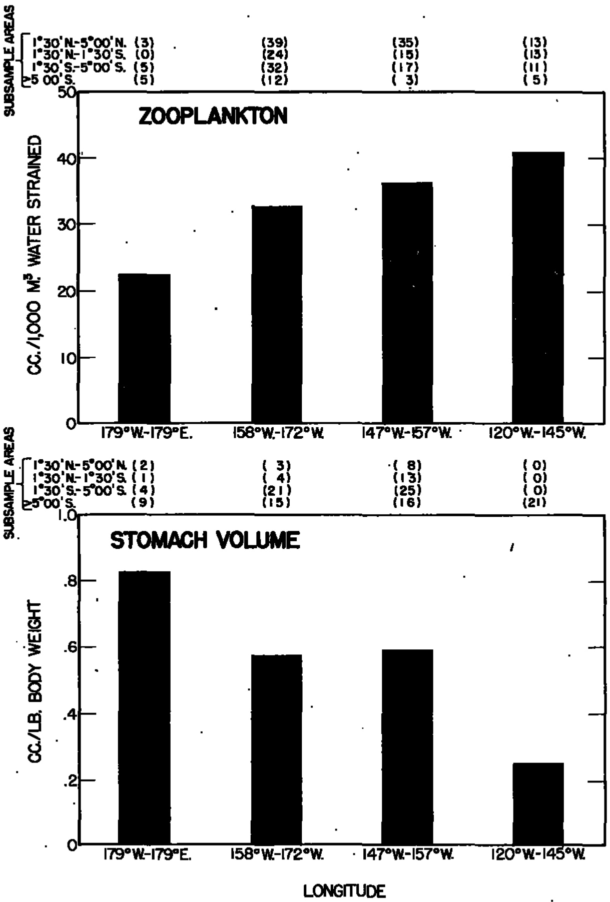

FIGURE 12.—Longitudinal variations in the equatorial Pacific of zooplankton and the volume of stomach contents per pound body weight of 121 longline-caught albacore. (Numbers in parentheses refer to sample sizes.) Zooplankton data are from King, Austin, and Doty (1957) and King and Hida (1957) and have been adjusted to remove the effect of diurnal variation according to the method of King and Hida (1954).

deeper waters. The highest bigeye stomach content volumes occurred in the western part of the sampling area (155° W.–180°).

VARIATION IN FOOD WITH SEASON

Seasonal variation in the food of 78 albacore troll- or longline-caught in the temperate North Pacific between 140° W. and 180° is shown in table 4. Summer and fall samples were combined, since most of the samples were obtained during the end of summer and beginning of fall. There is little difference between the summer-fall and winter values, although the range of sampling was 10° of latitude broader in summer than in winter.

TABLE 4.—*Seasonal variation in food of troll- and longline-caught albacore from the temperate North Pacific, 140° W.–180°*

	Summer and fall (30° N.–49° N.)	Winter (30° N.–39° N.)
Volume in cc./lb. body weight	0.85	0.79
Number of samples	54	24

Seasonal variation in the food of 143 albacore taken by longlining in the equatorial Pacific is shown in figure 13. From January through September the amounts of squid and fish per stomach do not vary greatly, but from October through December the amount of squid consumed approximately doubles. This may be due to the smallness of the sample. If we disregard the October through December results as a vagary of sampling, the next highest values were recorded for the April through June period, which agrees fairly well with the results shown by King and Ikehara (1956) for bigeye tuna in the equatorial Pacific, although their sampling period was from April through July.

VARIATION IN FOOD WITH DISTANCE FROM LAND

An examination of data on albacore stomach contents in terms of the distance of the point of capture from the nearest emergent land was un-

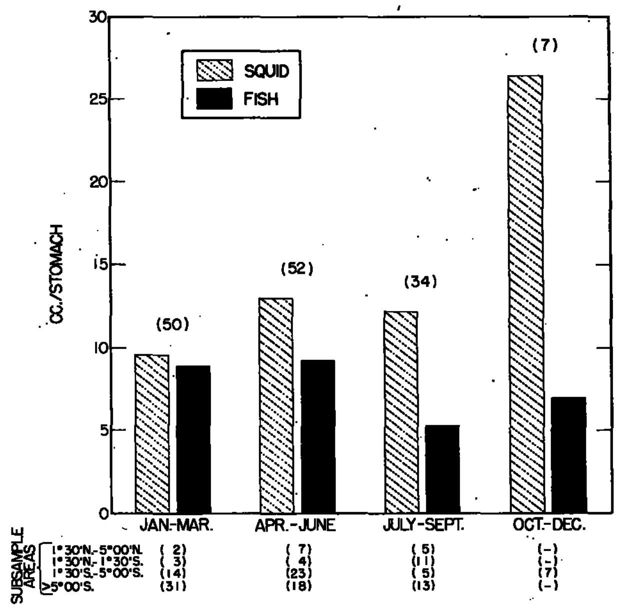

FIGURE 13.—Variation in the amount of squid and fish in the stomach contents of 143 albacore captured by longline in the equatorial Pacific, according to season. (Numbers in parentheses refer to sample sizes.)

dertaken only for the fish captured in the equatorial Pacific. Results are shown in figure 14. Samples from the temperate North Pacific were not included because: (1) no stomachs were collected from fish captured in the categories 0–24 and 25–99 miles from land, and (2) the fish from which stomachs were collected in the temperate North Pacific were much smaller, on the average, than fish captured in the equatorial Pacific.

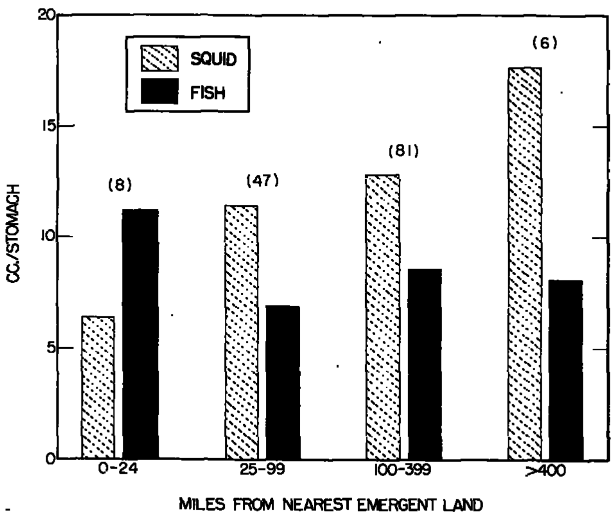

FIGURE 14.—Variation in food of 142 albacore captured by longline in the equatorial Pacific, according to distance from nearest emergent land. (Numbers in parentheses refer to sample sizes.)

Although two of the categories of figure 14 (0–24 miles and >400 miles) are based on small samples, the indication is that consumption of squid increases in an offshore direction. The percent occurrence of squid was as follows: 0–24 miles, 64 percent; 25–99 miles, 94 percent; 100–399 miles, 95 percent; >400 miles, 83 percent. King and Ikehara (1956) found generally similar results for the volume and percent occurrence of squid in the stomach contents of longline-caught bigeye in the equatorial Pacific, although they had no samples in the 0–24 miles category. This may reflect an offshore increase in the abundance of the deeper swimming squids in this area. The consumption of fish was highest in the 0–24 miles category, with lower, fluctuating values noted as distance increased away from land.

The appearance of reef-associated organisms in the diet of equatorial albacore, as might be expected, reflects the distance from land at the place of the albacore's capture. Their appearance is summarized in table 5. The indication is that fewer reef-associated organisms are eaten by albacore as distance increases offshore, presumably a reflection of the diminishing abundance of such organisms. This is further evidence that albacore are opportunistic feeders, taking whatever prey is available within broad food categories, an opinion expressed by several other writers on the subject.

TABLE 5.—*Percent occurrence of reef-associated organisms found in the stomach contents of albacore captured on longline in the equatorial Pacific, according to distance from nearest emergent land*

Organism	Miles from nearest land			
	0-24	25-99	100-399	>400
Crustacea:				
Larval Stomatopoda	50	40	16	-------
Crab megalopa	12	13	2	-------
Phyllosoma	-------	2	1	-------
Homaridae	-------	-------	-------	-------
Enoplometopus sp., postlarvae	-------	8	2	-------
Palinuridae,[1] postlarvae	-------	2	-------	-------
Scyllaridae,[1] postlarvae	-------	2	-------	-------
Fish:				
Synodontidae [1]	-------	2	-------	-------
Holocentridae [1]	-------	2	1	17
Holocentrus sp	-------	-------	1	-------
Apogonidae	-------	-------	-------	-------
Cheilodipterus sp	-------	2	-------	-------
Carangidae [1]	-------	2	-------	-------
Chaetodontidae [1]	12	4	1	-------
Acanthuridae [1]	-------	6	1	-------
Scorpaenidae [1]	-------	2	1	-------
Scorpaena sp	-------	-------	-------	17
Balistidae [1]	-------	2	-------	-------
Ostraciontidae [1]	-------	-------	1	-------
Lactoria diaphanus	-------	-------	-------	17
Tetraodontidae [1]	-------	2	-------	-------
Number of stomachs examined	8	47	82	6

[1] Unidentified.

VARIATION IN FOOD WITH TIME OF DAY

In order to examine the trend of feeding throughout the day, stomach volumes of albacore caught by trolling during five summer cruises in the temperate North Pacific were combined and plotted by 2-hour periods corresponding to the local zone time when the albacore were captured. Results are shown in figure 15. Stomachs from longline-caught albacore were not included, since the exact time of their capture could not be determined. Stomachs examined in the field during *John R. Manning* cruise 36 were included to increase the sample size. Forty percent of these field-examined stomachs were designated empty, since only values of 5 cc. or larger were recorded in the field. However, since figure 4 shows that 34 percent of all laboratory-examined stomachs had volumes less than 1 cc., a percentage reasonably close to the 40 percent of the field-examined stomachs designated empty, these stomachs were included.

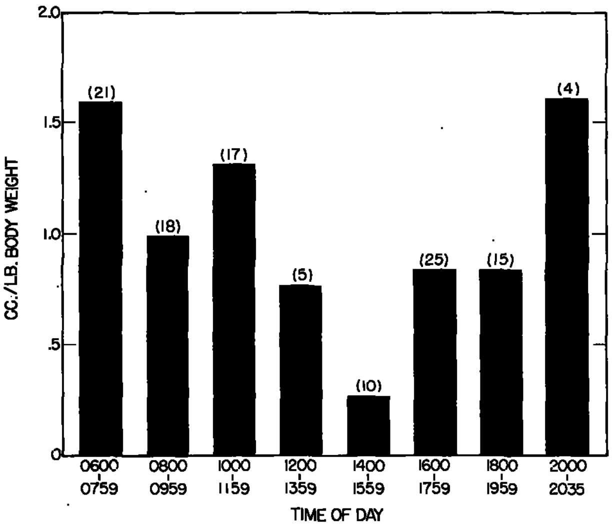

Figure 15.—Variation in stomach content volumes of 115 albacore caught by trolling in the temperate North Pacific during summer, according to time of day when captured. (Numbers in parentheses refer to sample sizes.)

Evaluating figure 15, one may say that while feeding takes place throughout the day, two general feeding periods are indicated—one in the early morning and another towards evening. The evidence for such an interpretation gains additional weight if the high value recorded for the 1000–1159 period is considered a sampling artifact, since one albacore accounts for 40 percent of the total value shown for that period.

Feeding periods have been reported by Uda (1940) and Nakamura [2] for skipjack tuna (*Katsuwonus pelamis*). Uda states that off Japan skipjack feed most actively in the early morning, again around noon, and presumably again near sunset. Nakamura found skipjack caught near the Marquesas Islands to be heavy feeders in the morning around 0900 hours, with little feeding around noon and another period of heavy feeding before sunset. The data shown in figure 15 more closely resemble conditions described by Nakamura for skipjack than those reported by Uda. As Nakamura points out, this probably reflects the lessened availability of tuna forage due to the downward daytime migration of zooplankton, the prey of much tuna forage.

The consumption of saury and squid throughout the day was examined and the results are given in table 6, which allows a comparison with McHugh's (1952) data on diurnal variation in albacore food. For hourly periods when at least 10 stomachs were sampled, percentages were calculated when either saury or squid were dominant in the stomachs. The results generally agree with McHugh's in that saury dominated frequently throughout the day and squid did not dominate as frequently in the early morning and late afternoon hours as they did during other times of the day.

Circumstances of the catch of the four specimens in the period from 2000 to 2035 hours (fig. 15), in which lighting conditions were approaching total darkness, lead to a discussion of whether or not albacore feed at night, a question briefly alluded to earlier in this report. Three of these four albacore stomachs contained food in the following amounts: 40 cc., 15 cc., and 7 cc.

Table 6.—*Percentage of troll-caught albacore stomachs in which either squid or saury was the dominant food organism, according to time of capture*

[Data given only for hourly intervals when 10 or more stomachs were sampled]

	Time of capture						
	0600–0659	0700–0759	0900–0959	1100–1159	1600–1659	1700–1759	1900–1959
Food:							
Squid	0	10	27	9	21	9	8
Saury	27	40	36	18	21	27	25

Stomach volume data (table 2) from gill netted albacore show that there was, on the average, much less food in such stomachs than in the stomachs of longlined or troll-caught albacore. Since the gill net was fished at night, this difference suggests that albacore may feed less during the hours of darkness. By the nature of the gear, however, longlines and trolling lures are probably selective for actively feeding fish, while the passive gill net would take albacore which were not feeding. There is also a possibility that gill netted albacore regurgitate their stomach contents, but the high percentage of typically empty stomachs (with a narrow lumen and deeply convoluted rugae) in such fish makes this seem unlikely.

There is indirect evidence, discussed below, which indicates that albacore probably do feed at night. This conclusion is supported by the fact that some food has been found in the stomachs of albacore taken in night gill net fishing. The success of nighttime as compared with daytime feeding is difficult to estimate because of the selectivity of the different fishing methods.

[2] Nakamura, E. L., Food and feeding habits of Marquesan skipjack (*Katsuwonus pelamis*). MS., Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

Watanabe (1958) states that both bigeye and yellowfin feed at night, with the bigeye the more active feeder. He did not report on albacore. Matthews[3] conducted a histological examination of the retinas of yellowfin, bigeye, skipjack, and albacore. Among yellowfin, bigeye, and skipjack he found little evidence of differences in visual potentialities. According to Matthews: "The albacore are quite another problem. Here are retinas with cone potentials probably equal to those of skipjack, yellowfin, and bigeye tuna, but in addition, from the evidence I have observed, possess a greater development of their rods. This may account for the fact that they are frequently taken in turbid waters. . . ." He also stated that "One can say that in the albacore there are at least twice as many if not more rods than twin cones."

Since the rods are used for night vision, it appears that albacore have retinas with a capability for a comparatively keener vision at night or under conditions of low illumination. Ikeda's (1958) report of a luminous lure used at night by Japanese longline fishermen that "is especially good for albacore fishing" would tend to bear this out. The descents of Beebe (1934) and others attest to the amount of bioluminescence in the oceans. Myctophids, euphausiids and other kinds of crustaceans, and many cephalopods are noted for luminosity (Marshall, 1954). Even fishes or crustaceans which are not luminous may leave a luminous trail as they swim through waters inhabited by peridinians and other kinds of dinoflagellates (Harvey, 1952). An albacore with a theoretical capability of nighttime vision might be able to spot these luminous trails and track down its prey.

VARIATION IN FOOD WITH WATER CLARITY

In his paper on the effect of water clarity on albacore catches, Murphy (1959) considered the abundance of albacore as it is related to turbidity, a function of the amount of particulate matter in the ocean. He theorized that dense concentrations of phytoplankton might obscure available tuna forage from sight feeders, such as the albacore, which then might temporarily leave an area that had prior to the phytoplankton increase a forage concentration sufficient to sustain them.

In order to investigate the effect of water clarity on the amount of forage present in the stomachs of troll-caught albacore, stomach volumes were plotted against the depth of Secchi disc observations made during eight cruises to the temperate North Pacific. The results are shown in figure 16. Secchi disc observations were used rather than light penetration measurements made by a photometer because for some cruises only Secchi disc readings were available. Also, Clarke (1941) and Graham and Gooding,[4] have shown there is good agreement between observations made simultaneously with both the Secchi disc and the photometer. Secchi disc observations were made either once or twice a day while the vessels were running between stations. When more than two observations were made on the same day the observation made closest to the place of capture of the albacore was used.

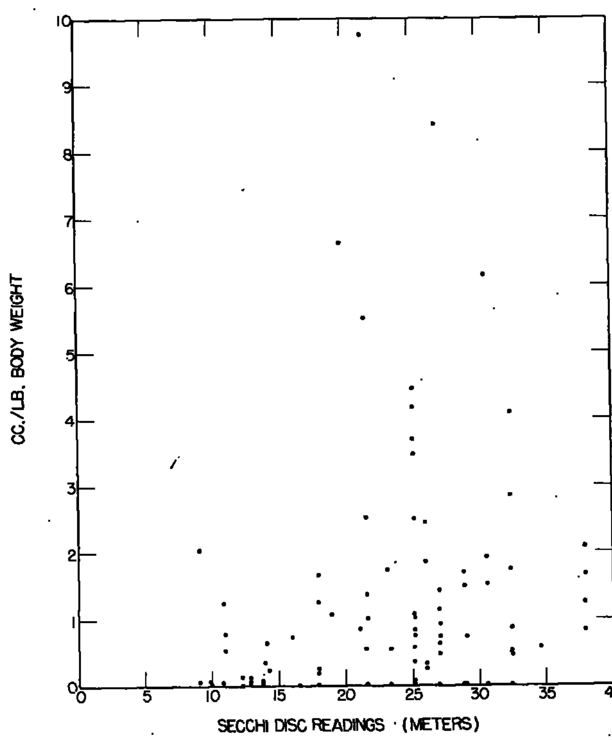

FIGURE 16.—Variation in the volume of stomach contents per pound body weight of 111 albacore caught by troll in the temperate North Pacific, according to Secchi disc readings.

The points shown in figure 16 for stomach volumes up to 3 cc./lb. body weight are fairly

[3] Matthews, D. C., A comparative histological study of the retinae of skipjack (*Katsuwonus pelamis*), yellowfin (*Neothunnus macropterus*), bigeye (*Parathunnus sibi*), and albacore (*Germo alalunga*) tuna. Manuscript, Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

[4] Graham, J. J. and R. M. Gooding, Northeastern Pacific Albacore Survey. Manuscript, Bureau of Commercial Fisheries Biological Laboratory, Honolulu.

well scattered throughout the range of Secchi disc readings, but the higher values for stomach contents are found in the mid-range of light penetration values, with the highest value recorded at a Secchi disc reading of approximately 22 meters.

An inference that can be made from figure 16 is that while foraging does take place in waters which vary considerably in clarity, the most successful foraging may take place in waters which represent a compromise between (1) heavy standing crops of tuna forage in waters of low clarity and (2) conditions of excellent visibility but where the amount of tuna food is less.

COMPETITION FOR FOOD AMONG ALBACORE, YELLOWFIN, AND BIGEYE TUNA

An investigation was made to determine whether albacore compete for food with yellowfin and bigeye tuna in the equatorial Pacific, since the three species are caught in this general area. King and Ikehara (1956) made an extensive comparative study of the food of yellowfin and bigeye from the equatorial Pacific and reported: "Despite the differences we have pointed out, the foods of yellowfin and bigeye are remarkably similar. We conclude, therefore, that when occupying the same general area the two species have the same feeding habits."

The taxonomic categories they found in the food of yellowfin and bigeye are compared in table 7 with those found in albacore stomach contents. Table 7 shows that fewer taxa in every category except one were found in albacore stomachs than either yellowfin or bigeye stomachs. However, more than twice as many yellowfin stomachs and 23 percent more bigeye stomachs were examined than albacore stomachs, which lessens the weight of evidence indicating more omnivorous feeding by the yellowfin and bigeye. Also, most of the yellowfin and bigeye studied by King and Ikehara were considerably larger than the albacore with which they are compared. One might expect a larger yellowfin or bigeye, requiring a greater daily ration than an albacore, to eat a greater variety of organisms while foraging. The overall similarities in the diets of yellowfin and bigeye are compared with albacore in table 7. Except in two cases, over half the taxa found in albacore stomachs were reported in the food of yellowfin and bigeye.

TABLE 7.—*Numbers of certain taxonomic categories represented in the food of albacore, yellowfin, and bigeye tuna taken on longline more than 25 miles from land in the equatorial Pacific*

[Figures in parentheses are numbers of such categories common to yellowfin or bigeye and albacore. Data on yellowfin and bigeye food from King and Ikehara (1956)]

Species	Invertebrates			Vertebrates (Pisces)		Number of stomachs examined
	Orders	Families	Genera	Families	Genera	
Albacore	10	20	12	30	21	135
Yellowfin	12(8)	31(14)	30(9)	48(24)	52(12)	439
Bigeye	9(6)	22(9)	17(3)	36(18)	38(8)	166

Table 7 does not provide, however, a comparison based on a restricted geographical area. Such data, available for cruise 11 of the *John R. Manning*, are given in tables 8 and 9, which compare the stomach contents of albacore with yellowfin and bigeye caught at the same location. In these instances, the food of albacore more closely resembled that of yellowfin than of bigeye, although the albacore is thought to inhabit, with the bigeye, deeper waters than the yellowfin in the equatorial Pacific. Nevertheless, the similarities in diet between both the albacore and the yellowfin and albacore and the bigeye in the same specific location, as well as in the same general area, are evidence that there may be some competition between the albacore and the other two species of tuna.

SUMMARY

1. This report is based upon the analysis of the stomach contents of 544 albacore tuna captured by longline, gill net, and troll fishing during 24 cruises by vessels of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, from 1950 to 1957.

2. Albacore from which stomachs were examined were captured in the equatorial and temperate zones of the central and northeastern Pacific. The limits of the sampling area were approximately latitude 16° S. to 49° N. and longitude 121° W. to 172° E.

3. Troll- and gill net-caught albacore from which stomachs were examined were 51–85 cm. in fork length, while longline-caught albacore whose stomachs were examined were between 54 and 117 cm., with 91 percent larger than 85 cm.

4. Stomachs of the larger albacore contained more food than did smaller albacore, but the larger fish ate less per pound of body weight.

TABLE 8.—*Comparison of stomach contents of equatorial albacore (A) and yellowfin (YF) tuna taken on longline more than 25 miles from land during cruise 11 of the* John R. Manning

[(+) denotes organism present, (−) denotes absent. Yellowfin data from files of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu. Sta. denotes station]

Organism	Sta. 8		Sta. 11		Sta. 12		Sta. 14		Sta. 15		Sta. 17		Sta. 19		Sta. 20		Sta. 21		All Stations	
	A	YF	A	YF	A	YF	A	YF	A	YF	A	YF	A	YF	A	YF	A	YF	A	YF
CRUSTACEA																				
Copepoda	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	+	−
Isopoda	−	−	+	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	+	+
Amphipoda																				
Phronima sp	+	+	−	−	−	+	−	+	−	−	−	−	−	+	−	−	−	−	+	+
Amphipoda [1]	+	+	+	−	−	+	+	−	−	−	+	−	+	+	−	−	+	−	+	+
Stomatopoda:																				
Squilla sp	−	−	−	−	−	+	−	+	+	−	−	−	−	−	−	−	−	−	+	+
Pseudosquilla sp	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−
Gonodactylus sp	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+
Euphausiacea	−	−	−	−	−	−	+	+	−	−	+	−	+	−	−	−	−	+	+	+
Decapoda:																				
Penaeidae	−	−	−	−	−	+	−	+	−	−	−	+	−	−	−	−	−	−	−	+
Crab megalopa	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	+	−	−	−	+
Phyllosoma larvae	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+
MOLLUSCA																				
Pteropoda	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+
Octopoda:																				
Argonautidae	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−	−	−	−	−	+
Octopoda [1]	+	+	+	−	−	+	−	+	−	−	−	−	−	+	−	+	−	+	+	+
Decapoda:																				
Loliginidae	+	+	−	+	+	+	+	+	+	−	+	+	+	+	−	+	+	+	+	+
Sepiolidae	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−
Decapoda [1]	+	−	+	−	−	−	+	+	−	+	−	−	−	+	+	−	−	−	+	+
CHORDATA																				
Tunicata																				
Salpidae	+	+	−	+	−	+	+	−	−	−	+	−	−	+	−	−	−	+	+	+
VERTEBRATA (Pisces)																				
Paralepididae	−	−	−	+	−	+	−	+	−	−	−	−	−	−	−	−	+	−	+	+
Bramidae	−	+	+	−	−	+	−	+	+	−	−	+	−	+	−	−	+	−	+	+
Leiognathidae	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	+
Chaetodontidae	−	−	−	+	−	+	−	−	−	−	−	−	−	−	−	+	−	−	−	+
Pomacentridae	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	+
Acanthuridae	−	−	−	+	−	+	−	−	−	−	−	+	−	−	−	−	−	−	−	+
Gempylidae	−	−	−	−	+	+	+	−	−	−	+	+	+	+	−	−	+	+	+	+
Thunnidae: *Katsuwonus pelamis*	−	−	−	−	−	−	−	−	+	+	−	+	−	+	−	−	−	−	+	+
Echeneidae	−	−	−	−	−	−	−	−	−	+	−	−	−	+	−	−	−	−	−	+
Balistidae	−	−	−	−	−	−	−	−	−	+	−	+	−	−	−	−	−	−	−	+
Monacanthidae	−	−	−	−	−	+	−	−	−	−	−	+	−	−	−	−	−	−	−	+
Ostraciidae	−	−	−	−	−	−	−	−	−	−	−	+	−	+	−	−	−	−	−	+
Tetraodontidae	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	+
Diodontidae	−	−	−	−	−	+	−	−	−	+	−	−	−	−	−	−	−	−	−	+
Number of stomachs examined	2	2	1	2	1	5	2	4	2	2	3	3	1	4	1	1	2	4	15	27

[1] Unidentified.

5. The food of albacore was found to consist mainly of a variety of fish, squid, and crustaceans, the percent by volume of each differing according to the method of capture, as shown by the following. Longline: fish, 47 percent; squid, 41 percent; crustaceans, 6 percent. Gill net: fish, 34 percent; squid, 62 percent; crustaceans, 2 percent. Troll: fish, 79 percent; squid, 11 percent; crustaceans, 6 percent. Representatives of 32 fish families and 11 invertebrate orders were found in the food of longlined albacore, compared to 9 fish families and 10 invertebrate orders for troll-caught albacore, and 4 fish families and 5 invertebrate orders for gill net-caught albacore.

6. Fishes of the families Gempylidae and Bramidae dominated in the fish portion of the diet of albacore from the equatorial Pacific, while sauries (Scomberesocidae, *Cololabis* sp.) dominated in albacore caught in the temperate North Pacific. Squid were well represented in the albacore captured by all three methods. The main difference in crustaceans was the lack of stomatopods (Squillidae) in the diet of troll- and gill net-caught albacore.

7. The higher average stomach content of longline-caught albacore (26.7 cc.) was attributed to the larger sizes of these fish. The differences in the average stomach content of approximately the same size gill netted (9.8 cc.) and troll-caught albacore (15.1 cc.) were attributed to differences in the method of capture. Gill netted albacore are taken at night, when feeding is probably at a reduced rate, since 80 percent of the gill netted albacore had stomach contents less than 1 cc.

TABLE 9.—*Comparison of stomach contents of equatorial albacore (A) and bigeye (BE) tuna taken on longline more than 25 miles from land during cruise 11 of the* John R. Manning

[(+) denotes organism present, (−) denotes absent. Bigeye data from files of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu]

Organism	Sta. 16		Sta. 18		Sta. 20		All stations	
	A	BE	A	BE	A	BE	A	BE
CRUSTACEA								
Isopoda	−	+	−	+	−	−	−	+
Amphipoda	+	−	+	−	+	−	+	−
Euphausiacea	−	−	−	+	−	−	−	+
Decapoda:								
Penaeidae	−	−	−	+	−	+	−	+
Homaridae: *Enoplometopus* sp.	−	−	+	−	−	−	+	−
MOLLUSCA								
Octopoda	+	−	−	−	−	−	+	−
Decapoda:								
Enoploteuthidae: *Enoploteuthis* sp.	−	−	−	+	−	−	−	+
Ommastrephidae	−	+	−	−	−	−	−	+
Decapoda [1]	+	−	+	+	+	−	+	+
VERTEBRATA (Pisces)								
Sternoptychidae	+	−	+	−	+	−	+	−
Paralepididae	−	−	+	+	−	−	+	+
Alepisauridae	−	+	−	+	−	−	−	+
Nemichthyidae	−	−	−	+	−	−	−	+
Myctophidae	+	+	+	−	−	−	+	+
Holocentridae	−	−	−	+	−	−	−	+
Bramidae	−	−	−	+	+	−	+	+
Chiasmodontidae	+	−	−	+	−	−	+	+
Gempylidae	+	−	+	−	+	−	+	−
Tetraodontidae	−	−	−	−	+	−	+	−
Molidae	−	−	−	+	−	−	−	+
Number of stomachs examined	2	1	7	3	6	1	15	5

[1] Unidentified.

8. In the equatorial Pacific, the larger stomach volumes were from albacore captured from latitude 5° S. to 1½° S., whereas the highest catch rates per 100 hooks for albacore occurred south of 5° S. It was concluded that the latitudinal abundance of albacore in the equatorial Pacific, as determined from catch statistics, is not related to the amount of forage consumed by albacore. There was only slight latitudinal variation in the percent occurrence of squid, fish, and crustaceans in the stomachs of equatorial albacore. The amount of squid per stomach was more than twice as much between 5° S. and 5° N. as it was south of 5° S. The lowest amounts of fish and crustaceans per stomach were recorded from 1½° S. to 1½° N.

9. Fishes of the families Gempylidae and Bramidae did not occur in the stomachs of albacore captured by longline in the temperate North Pacific, whereas they were found in 28.5 and 21.5 percent respectively of the stomachs of longline-caught albacore from equatorial waters. It is suggested this may reflect the vertical distribution of these food fishes in these two areas.

10. In the temperate North Pacific, the highest stomach volumes of albacore troll-caught in summer between 140° W.–180°, were found to the south of successive peak volumes of organisms captured by midwater trawling and zooplankton tows. This may show successive trophic levels associated with an advancing oceanographic and biological "frontier" during summer in the Transition Zone of the temperate North Pacific.

11. With respect to longitudinal variations in albacore food in the equatorial Pacific, the highest stomach volumes were recorded in the western portion of the sampling area while the high zooplankton values were recorded in the east central equatorial Pacific. In the temperate North Pacific albacore stomach volumes were higher from 120° W.–140° W. than they were from 140° W.–180°.

12. In the temperate North Pacific, there was little seasonal difference in the volume of albacore food. In the equatorial Pacific the amount of squid and fish varied slightly and irregularly from January through September. From October through December, based on a small sample, the amount of fish consumed was about twice the amount consumed by albacore during other months. In all months more fish than squid was eaten by the equatorial albacore.

13. The amount of squid eaten by equatorial albacore increased with an increase in distance of the place of capture from nearest land. The amount of fish eaten was highest near land (0–24 miles) and then varied irregularly in an offshore direction. Reef-associated organisms appeared most frequently in the diet of albacore captured near land.

14. Feeding by troll-caught albacore in the temperate North Pacific occurred throughout the day. While the lower stomach volumes were found in albacore captured during 1100–1600 hours, the evidence for distinct periods of feeding was not clear. Squid were found in more than 10 percent of albacore stomachs from 0900 to 1700 hours and sauries were common in albacore stomachs (more than 10 percent) throughout the day (0600–2000). Evidence is presented that albacore also feed during the night.

15. The higher stomach volumes of albacore troll caught in the temperate North Pacific occurred in waters of midclarity, as measured by Secchi disc observations.

16. A comparison of the stomach contents of equatorial albacore, yellowfin, and bigeye tunas indicates there may be some competition for food between the albacore and the other two species of tuna.

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APPENDIX

TABLE A1.—*Check list of food organisms found in the stomachs of 348 albacore tuna from the central and northeastern Pacific, 1950–57, according to method of capture*

[Family names of fishes as in Berg (1947) except when indicated. Unid. = Unidentified]

Organism	Longline					Gill net					Troll					All methods combined				
	Number of organisms	Stomachs in which occurred		Aggregate total volume		Number of organisms	Stomachs in which occurred		Aggregate total volume		Number of organisms	Stomachs in which occurred		Aggregate total volume		Number of organisms	Stomachs in which occurred		Aggregate total volume	
		Number	Percent	Cubic centimeters	Percent [1]		Number	Percent	Cubic centimeters	Percent [1]		Number	Percent	Cubic centimeters	Percent [1]		Number	Percent	Cubic centimeters	Percent [1]
COELENTERATA																				
Hydrozoa:																				
Siphonophora: *Dipheyes* sp.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	34	1	1.3	0.7	0.1	34	1	0.3	0.7	-----
Unid. Siphonophora	-----	-----	-----	-----	-----	20	1	1.1	1.0	0.1	3	3	3.8	0.8	0.1	23	4	1.1	1.8	-----
ANNELIDA																				
Polychaeta	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	2	2.5	0.3	-----	2	2	0.6	0.3	-----
ARTHROPODA																				
Crustacea	[1,454]	[116]	[63.7]	[314.5]	[6.5]	[30]	[5]	[5.7]	[10.3]	[1.2]	[585]	[33]	[41.7]	[78.0]	[6.5]	[2,069]	[154]	[44.3]	[402.8]	[5.8]
Copepoda	1	1	0.5	0.4	-----	-----	-----	-----	-----	-----	8	2	2.5	0.1	-----	9	3	0.9	0.5	-----
Isopoda:																				
Idotheidae	4	1	0.5	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4	1	0.3	0.2	-----
Unid. Isopoda	23	5	2.7	1.9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	23	5	1.4	1.9	-----
Amphipoda:																				
Hyperiidae	1	1	0.5	1.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	1	0.3	1.0	-----
Lycaeidae	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	150	1	1.3	6.0	0.5	150	1	0.3	6.0	0.1
Phronimidae:																				
Phronima sp.	75	19	10.4	27.7	0.6	1	1	1.1	0.1	-----	37	6	7.6	13.5	1.1	113	26	7.5	41.3	0.6
P. sedentaria	6	1	0.5	2.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	6	1	0.3	2.0	-----
Phrosinidae: *Primno* sp.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	15	1	1.3	2.6	0.2	15	1	0.3	2.6	-----
Oxycephalidae: *Oxycephalus* sp.	3	3	1.6	1.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	3	0.9	1.0	-----
Unid. Amphipoda	374	63	34.6	62.4	1.3	-----	-----	-----	-----	-----	72	19	24.0	8.3	0.7	446	82	23.6	70.7	1.0
Stomatopoda:																				
Squillidae:																				
Squilla sp.	119	4	2.2	25.9	0.5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	119	4	1.1	25.9	0.4
Pseudosquilla sp.	67	6	3.3	14.5	0.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	67	6	1.7	14.5	0.2
Lysiosquilla sp.	7	3	1.6	4.8	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	7	3	0.9	4.8	0.1
Coronida sp.	2	1	0.5	1.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	1	0.3	1.0	-----
Gonodactylus sp.	38	3	1.6	7.6	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	38	3	0.9	7.6	0.1
G. guerinii	2	2	1.1	1.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	2	0.6	1.7	-----
Odontodactylus sp.	17	2	1.1	4.0	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	17	2	0.6	4.0	0.1
O. hanseni	3	1	0.5	2.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	1	0.3	2.0	-----
Unid. Stomatopoda	288	28	15.4	81.4	1.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	288	28	8.0	81.4	1.2
Euphausiacea	121	14	7.7	9.1	0.2	-----	-----	-----	-----	-----	275	10	12.7	43.6	3.7	396	24	6.9	52.7	0.8
Decapoda:																				
Penaeidae:																				
Gennadus sp.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	1	1.3	0.1	-----	1	1	0.3	0.1	-----
Unid. Penaeidae	2	2	1.1	0.7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	2	0.6	0.7	-----
Pendalidae: *Heterocarapus* sp.	4	3	1.6	2.8	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4	3	0.9	2.8	-----
Sergestidae	-----	-----	-----	-----	-----	3	1	1.1	0.5	0.1	-----	-----	-----	-----	-----	3	1	0.3	0.5	-----
Hoplophoridae	76	2	1.1	14.9	0.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	76	2	0.6	14.9	0.2
Homaridae:																				
Enoplometopus sp.	32	5	2.7	14.0	0.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	32	5	1.4	14.0	0.2
Unid. Homaridae	1	1	0.5	1.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	1	0.3	1.0	-----
Palinuridae	3	2	1.1	2.8	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	2	0.6	2.8	-----
Scyllaridae	1	1	0.5	0.5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	1	0.3	0.5	-----
Portunidae:																				
Megalops larvae	41	1	0.5	5.5	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	41	1	0.3	5.5	0.1
Other crab Megalops larvae	40	8	4.4	9.3	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	40	8	2.3	9.3	0.1

See footnotes at end of table.

TABLE A1.—*Check list of food organisms found in the stomachs of 348 albacore tuna from the central and northeastern Pacific, 1950–57, according to method of capture*—Continued

[Family names of fishes as in Berg (1947) except when indicated. Unid. = Unidentified]

Organism	Longline					Gill net					Troll					All methods combined				
	Number of organisms	Stomachs in which occurred		Aggregate total volume		Number of organisms	Stomachs in which occurred		Aggregate total volume		Number of organisms	Stomachs in which occurred		Aggregate total volume		Number of organisms	Stomachs in which occurred		Aggregate total volume	
		Number	Percent	Cubic centimeters	Percent [1]		Number	Percent	Cubic centimeters	Percent [1]		Number	Percent	Cubic centimeters	Percent [1]		Number	Percent	Cubic centimeters	Percent [1]
ARTHROPODA—Con.																				
Crustacea—Con.																				
Decapoda—Con.																				
Phyllosoma larvae	2	1	0.5	0.2												2	1	0.3	0.2	
Unid. Decapoda	92	15	8.2	12.4	0.3						8	2	2.5	1.8	0.2	100	17	4.9	14.2	0.2
Other unidentified Crustacea	9	5	2.7	1.8		26	3	3.4	9.7	1.1	19	10	12.6	2.0	0.2	54	18	5.2	13.5	0.2
MOLLUSCA																				
Gastropoda:																				
Heteropoda:																				
Atlantidae	3	2	1.1	0.2							5	2	2.5	0.4		8	4	1.1	0.6	
Unid. Heteropoda	1	1	0.5	2.2							18	2	2.5	6.4	0.5	19	3	0.9	8.6	0.1
Gastropoda larvae						1	1	1.1	0.1							1	1	0.3	0.1	
Cephalopoda:																				
Octopoda:																				
Octopodidae	18	7	3.8	10.5	0.2						5	2	2.5	3.1	0.3	23	9	2.6	13.6	0.2
Argonautidae	5	4	2.2	17.6	0.4											5	4	1.1	17.6	0.3
Decapoda (squid)	[1,082]	[157]	[86.3]	[1,999.0]	[41.2]	[123]	[25]	[28.7]	[528.3]	[62.1]	[165]	[40]	[50.6]	[131.6]	[11.0]	[1,370]	[222]	[63.8]	[2,658.9]	[38.6]
Loliginidae:																				
Sepioteuthis sp.	1	1	0.5	0.5												1	1	0.3	0.5	
Unid. Loliginidae	65	17	9.3	193.7	4.0											65	17	4.9	193.7	2.8
Sepiolidae	1	1	0.5	1.6												1	1	0.3	1.6	
Onychoteuthidae	9	1	0.5	65.0	1.3						1	1	1.3	1.7	0.1	10	2	0.6	66.7	1.0
Enoploteuthidae	26	1	0.5	3.2	0.1											26	1	0.3	3.2	
Ommastrephidae:																				
Symplectoteuthis sp.	1	1	0.5	21.0	0.4											1	1	0.3	21.0	0.3
Unid. Ommastrephidae	25	1	0.5	102.5	2.1											25	1	0.3	102.5	1.5
Brachioteuthidae:																				
Brachioteuthis sp.						15	1	1.1	89.0	10.5						15	1	0.3	89.0	1.3
Cranchiidae	6	2	1.1	14.5	0.3											6	2	0.6	14.5	0.2
Other Unid. Decapoda	948	138	75.8	1,597.0	32.9	108	24	27.6	439.3	51.6	164	40	50.6	129.9	10.9	1,220	202	58.0	2,166.2	31.4
Other Unid. Cephalopoda	2	2	1.1	6.7	0.1						2	2	2.5	2.4	0.2	4	4	1.1	9.1	0.1
Other Unid. Mollusca											1	1	1.3	0.1		1	1	0.3	0.1	
CHORDATA																				
Tunicata:																				
Thaliacea: Salpidae [2]	104	25	13.7	38.9	0.8						10	1	1.3	8.5	0.7	114	26	7.5	47.4	0.7
Vertebrata (Pisces)	[733]	[152]	[83.5]	[2,282.2]	[47.0]	[30]	[19]	[21.8]	[293.9]	[34.5]	[323]	[45]	[57.0]	[937.5]	[78.6]	[1,086]	[216]	[62.1]	[3,513.6]	[50.9]
Argentinidae											1	1	1.3	1.0	0.1	1	1	0.3	1.0	
Gonostomatidae: [3]																				
Gonostoma sp.	2	1	0.5	2.1												2	1	0.3	2.1	
Unid. Gonostomatidae	2	2	1.1	3.0	0.1											2	2	0.6	3.0	
Sternoptychidae:																				
Sternoptyx sp.	20	9	4.9	33.7	0.7											20	9	2.6	33.7	0.5
Unid. Sternoptychidae	18	7	3.8	37.6	0.8											18	7	2.0	37.6	0.5
Stomiatidae:																				
Melanostomias sp.	3	1	0.5	3.0	0.1											3	1	0.3	3.0	
Unid. Stomiatidae	1	1	0.5	2.0												1	1	0.3	2.0	
Idiacanthidae:																				
Idiacanthus sp.											3	1	1.3	0.3		3	1	0.3	0.3	

Synodontidae[4]	1	1	0.5	2.7	0.1											1	1	0.3	2.7	
Paralepididae:[5]																				
Paralepis sp.	4	1	0.5	10.2	0.2											4	1	0.3	10.2	0.1
Unid. Paralepididae	13	6	3.3	34.5	0.7						1	1	1.3	0.8	0.1	14	7	2.0	35.3	0.5
Alepisauridae:																				
Alepisaurus sp.	9	1	0.5	11.0	0.2											9	1	0.3	11.0	0.2
Unid. Alepisauridae	9	4	2.2	23.3	0.5							1	1.3	1.8	0.2	10	5	1.4	25.1	0.4
Myctophidae:[6]																				
Tarletonbeania sp.	26	1	0.5	90.0	1.9						10	1	1.3	16.0	1.3	36	2	0.6	106.0	1.5
Diaphus sp.	1	1	0.5	6.1	0.1											1	1	0.3	6.1	0.1
Unid. Myctophidae	25	6	3.3	23.2	0.5	7	2	2.3	7.5	0.9	17	6	7.6	13.5	1.1	49	14	4.0	44.2	0.6
Scomberesocidae:																				
Cololabis sp.	30	8	4.4	925.0	19.1	11	10	11.5	225.2	26.5	167	20	25.3	733.8	61.5	208	38	10.9	1,884.0	27.3
Caulolepidae:																				
Anoplogaster sp.	1	1	0.5	1.0												1	1	0.3	1.0	
Unid. Caulolepidae	2	1	0.5	3.1	0.1											2	1	0.3	3.1	
Holocentridae:																				
Holocentrus sp.	1	1	0.5	1.2												1	1	0.3	1.2	
Unid. Holocentridae	4	3	1.6	3.0	0.1											4	3	0.9	3.0	
Apogonidae	1	1	0.5	1.4												1	1	0.3	1.4	
Scombropidae:																				
Hypoclydonia sp.	5	4	2.2	11.5	0.2											5	4	1.1	11.5	0.2
Unid. Scombropidae	2	1	0.5	1.0												2	1	0.3	1.0	
Carangidae	1	1	0.5	1.5		5	1	1.1	11.0	1.3	40	1	1.3	84.0	7.0	46	3	0.9	96.5	1.4
Bramidae:																				
Collybus drachme	10	9	4.9	36.5	0.8											10	9	2.6	36.5	0.5
Pteraclis sp.	1	1	0.5	6.1	0.1											1	1	0.3	6.1	0.1
Unid. Bramidae	49	22	12.1	83.2	1.7											49	22	6.3	83.2	1.2
Coryphaenidae:																				
Coryphaena hippurus	1	1	0.5	0.7												1	1	0.3	0.7	
Chaetodontidae	6	4	2.2	8.6	0.2											6	4	1.1	8.6	0.1
Champsodontidae	1	1	0.5	0.8												1	1	0.3	0.8	
Chiasmodontidae:																				
Chiasmodon niger	1	1	0.5	2.0												1	1	0.3	2.0	
Unid. Chiasmodontidae	13	5	2.7	21.6	0.4											13	5	1.4	21.6	0.3
Acanthuridae	13	5	2.7	13.1	0.3											13	5	1.4	13.1	0.2
Gempylidae:																				
Gempylus sp.	6	4	2.2	33.0	0.7											6	4	1.1	33.0	0.5
G. serpens	47	18	9.9	140.4	2.9											47	18	5.2	140.4	2.0
Rexea sp.	3	1	0.5	1.6												3	1	0.3	1.6	
Unid. Gempylidae	62	21	11.5	144.0	3.0	1	1	1.1	41.0	4.8	13	2	2.5	6.1	0.5	76	24	6.9	191.1	2.8
Trichiuridae	1	1	0.5	0.1												1	1	0.3	0.1	
Scombridae:																				
Scomber sp.	2	1	0.5	5.0	0.1											2	1	0.3	5.0	0.1
Unid. Scombridae	4	1	0.5	3.8	0.1											4	1	0.3	3.8	0.1
Tetragonuridae: *Tetragonurus cuvieri*	2	1	0.5	3.2	0.1						1	1	1.3	2.0	0.2	3	2	0.6	5.2	0.1
Stromateidae	1	1	0.5	4.6	0.1											1	1	0.3	4.6	0.1
Nomeidae	2	1	0.5	1.0												2	1	0.3	1.0	
Scorpaenidae: *Scorpaena* sp.	4	3	1.6	6.4	0.1											4	3	0.9	6.4	0.1
Thunnidae: *Katsuwonus pelamis*	9	2	1.1	25.1	0.5											9	2	0.6	25.1	0.4
Triacanthidae: *Halimochirurgus* sp.	1	1	0.5	0.3												1	1	0.3	0.3	
Balistidae	1	1	0.5	5.6	0.1											1	1	0.3	5.6	0.1
Ostraciontidae:																				
Lactoria diaphanus	1	1	0.5	6.0	0.1											1	1	0.3	6.0	0.1
L. sp.	1	1	0.5	0.4												1	1	0.3	0.4	
Tetraodontidae	1	1	0.5	0.2												1	1	0.3	0.2	
Molidae	4	2	1.1	0.4							15	2	2.5	2.4	0.2	19	4	1.1	2.8	
Other Unidentified fishes	305	93	51.1	497.4	10.3	6	6	6.9	9.2	1.1	55	21	26.6	75.8	6.4	366	120	34.5	582.4	8.4
Unidentified food and organic residue		12	6.6	180.5	3.7		10	11.5	17.8	2.1		10	12.7	23.6	2.0		32	9.2	221.9	3.2
Total food volume				4,852.3					851.4					1,193.4					6,897.1	
Number of stomachs examined				182					87					79					348	

[1] Given only when 0.1 percent or greater.

[2] The majority were ingested incidentally with the pelagic amphipod *Phronima* sp., which often lives in tests of salps.

[3] Gonostomidae in Berg, 1947.

[4] Synodidae in Berg, 1947.

[5] Sudidae in Berg, 1947.

[6] Scopelidae in Berg, 1947.

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