New Pacific Records of Juvenile Albacore *Thunnus alalunga* (Bonnaterre) from Stomach Contents

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BECAUSE THE ALBACORE, *Thunnus alalunga* (Bonnaterre), is commercially one of the more valuable species of tuna, a great deal of effort has been expended in investigating its biology. Although much has been learned in recent years about the albacore, its age and growth, movements and migrations (Otsu, 1960; Clemens, 1961; Otsu and Uchida, 1963), many facets of the biology of this species still need to be studied. As part of the Albacore Ecology Program, staff members of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii, have been studying the early life history of albacore in order to fill the gaps in our knowledge.

There is a paucity of information on the juvenile[2] and larval stages of albacore due in part to two factors. One is the limited success of efforts to collect the young, and the other is the difficulty of identifying them, since adult morphological characters are often inadequate for identifying the young stages. Although there has been some success in collecting juvenile tunas with various types of midwater trawls (Matsumoto, 1961), most of the juvenile tunas recorded in the literature have come either from stomachs of predators or from dipnetting at nightlight stations. Yabe, Ueyanagi, Kikawa, and Watanabe (1958) reported on five juvenile albacore less than 30 cm discovered in stomachs of predators caught in the western North and South Pacific Ocean. So far as I know, theirs is the only documented record of juvenile albacore in the Pacific Ocean, and it has positively demonstrated albacore spawning in these areas.

In June 1960, a program was initiated at the Biological Laboratory, Honolulu, to sample stomachs of large pelagic fishes for juvenile albacore. This paper presents the results of sampling through November 1962. Twelve juveniles were found in stomachs of predators caught in the central North and South Pacific, thereby extending known or demonstrating new spawning grounds for albacore. Although the number of specimens is small, I consider it important to report them promptly since juvenile albacore are not very often collected and the information may be of value to other investigators studying the biology of the albacore.

SOURCE OF MATERIALS

Two sources of stomach samples that were readily available to the author were the large fishes landed by the Hawaiian commercial longline fishery and by exploratory fishing cruises of the Bureau of Commercial Fisheries' research vessel "Charles H. Gilbert."

The Hawaiian longline fishery is usually conducted within 20 miles of the main islands, with most of the boats in the fleet operating out of Honolulu, while smaller numbers fish out of Hilo and Kona on the island of Hawaii, and from Port Allen on the island of Kauai (Otsu, 1954). The catch of this fishery consists of a variety of large pelagic fishes, including striped marlin (*Makaira audax*), blue marlin (*Makaira ampla*), black marlin (*Istiompax marlina*), broadbill swordfish (*Xiphias gladius*), and shortnose spearfish (*Tetrapturus angustirostris*), among the spearfishes. Among the tunas, bigeye (*Thunnus obesus*), yellowfin (*Thunnus albacares*), and small numbers of albacore and skipjack (*Euthynnus pelamis*) are taken.

Stomachs were sampled at the auction markets of the United Fishing Agency, Ltd., and the Hawaiian Fishing Co., Ltd., in Honolulu. Since it has been shown that juvenile tunas occur more frequently in stomachs of spearfishes

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[2] Unless otherwise noted, the term "juvenile" as used herein includes albacore up to 30 cm long.

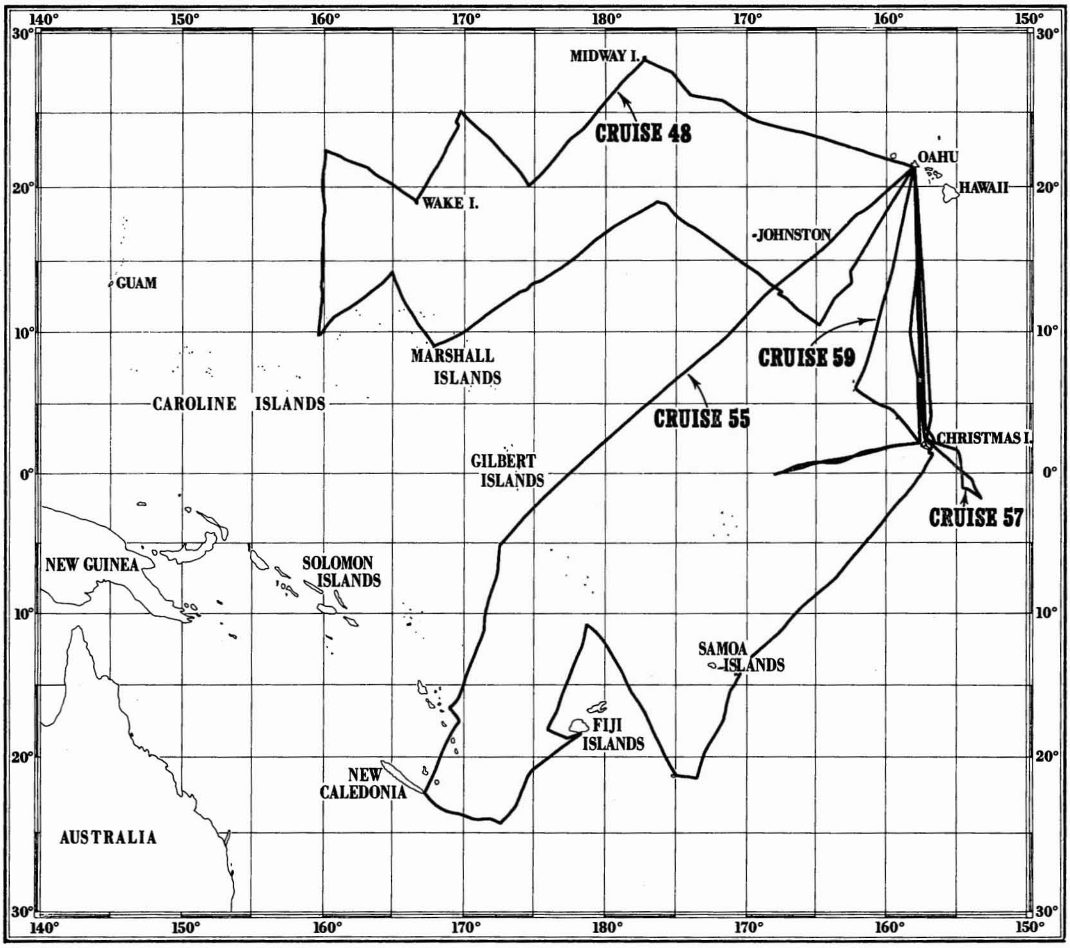

FIG. 1. Tracks of the "Charles H. Gilbert," cruises 48, 55, 57, and 59 (June 1960 to November 1962).

than of adult tunas (Yabe et al., 1958), and because it was not possible to sample all the fishes landed at the markets, emphasis was placed on sampling the spearfishes.

Other stomachs sampled were from fishes caught by longlining on four cruises of the "Charles H. Gilbert" during the period covered by this study and from fishes caught during the 1962 Hawaiian International Billfish Tournament held at Kona, Hawaii, from July 31 through August 4, 1962. The cruise tracks of the "Charles H. Gilbert" are shown in Figure 1.

IDENTIFICATION OF JUVENILE ALBACORE

As would be expected of specimens found in stomachs, our juvenile albacore specimens were in various stages of digestion. Specimens that retained most of their flesh were easily recognized as scombrids by the body contours and shape of the head (Fig. 2). Aside from the general shape, few of the external features of the specimens had escaped digestion sufficiently to be of any use in species identification. However, this was not a serious handicap, since the hard parts of the fish were relied upon for identification. In two of the specimens practically all of the flesh had been digested away and all that remained were the bony parts, but even these fish could be identified as albacore.

Yabe et al. (1958) discovered a striking vertebral character that is distinctive for albacore and used it in identifying juvenile albacore as small as 12.4 cm in standard length. This character is the laterally flattened shape of the haemal spine of the first caudal vertebra (first elongate haemal spine) which is unique to albacore. It is interesting to note that although several investigators have studied the anatomy and morphology of albacore in great detail, the significance of this character was not recognized by them. Recently, Matsumoto (1963) investigated this structure in detail and showed conclusively that among the tunas it is only found in albacore.

The 12 juvenile albacore reported on here were identified on the basis of this character (Fig. 3). The flat haemal spine was readily observable in all of the specimens, the smallest of which measured an estimated 61 mm in standard length. The width of the spine was from about 1.3 to 2.3 times the width of the haemal spine following it. Furthermore, the juveniles possessed other albacore characters. As in adults, the juveniles had 7–9 + 1 + 19–21 = 27–30 gill rakers and 39 vertebrae (18 precaudals and 21 caudals).

DESCRIPTION OF JUVENILE ALBACORE

Although the specimens were partially damaged by digestion, counts and measurements were made on the juveniles whenever they could be made accurately (Table 1).

The shape of the juveniles is more or less fusiform. Each jaw has a single row of small teeth. Villiform teeth are present on the palatines and vomer. The snout is short and somewhat pointed; the mouth is moderate. The vertebrae number 18 + 21 = 39, including the urostyle. The first closed haemal arch is on the 10th vertebra. In two specimens the bones producing the arch on the 10th vertebra are in contact but not fused; in three specimens the arch is damaged. The angle made by the first closed haemal arch and the vertebral axis is

FIG. 2. Juvenile albacore 184 mm in standard length found in the stomach of a blue marlin caught off Kona, Hawaii, August 1, 1962. (The last few vertebrae became detached from the rest of the fish subsequent to measurement and are not shown in the photograph.)

approximately 75–90°. The first ventrally projecting parapophysis is on the 7th–9th vertebrae.

The posterior margin of the basioccipital, when viewed laterally, makes an angle of approximately 90° or more with the axis of the vertebral column in specimens smaller than 19 cm, and an acute angle in specimens about 25 cm and larger in standard length.

The intestine has the two folds characteristic of Thunnidae (Godsil and Byers, 1944).

Only one specimen had its first dorsal fin membranes intact; the fin membranes are covered with black pigmentation.

DISCUSSION

Although no attempt was made to study all the differences in the morphology of adult and juvenile albacore, a few of the more obvious ones were noted in some detail. As indicated earlier, the flattened haemal spine on the first caudal vertebra becomes definitive early in the life of albacore, since a juvenile 61 mm in standard length already possessed this character. A meristic character that also develops early is the gill raker count, for all of the juveniles already possessed the full adult complement. However, several morphological features of adult albacore were still in their early formative stages in the juveniles. These were the orientation of the parapophyses on the vertebrae preceding the ninth vertebra, the angle the first haemal arch makes with the axis of the vertebral column, the orientation of the bones constituting the first haemal arch, and the shape of the posterior margin of the basioccipital.

According to Godsil and Byers (1944) the parapophyses preceding the first haemal arch extend laterally in adults. In juveniles the tips of the parapophyses on the vertebrae as far anterior as the seventh may project ventrally. Presumably, with growth the anterior parapophyses tend to straighten out and extend later-

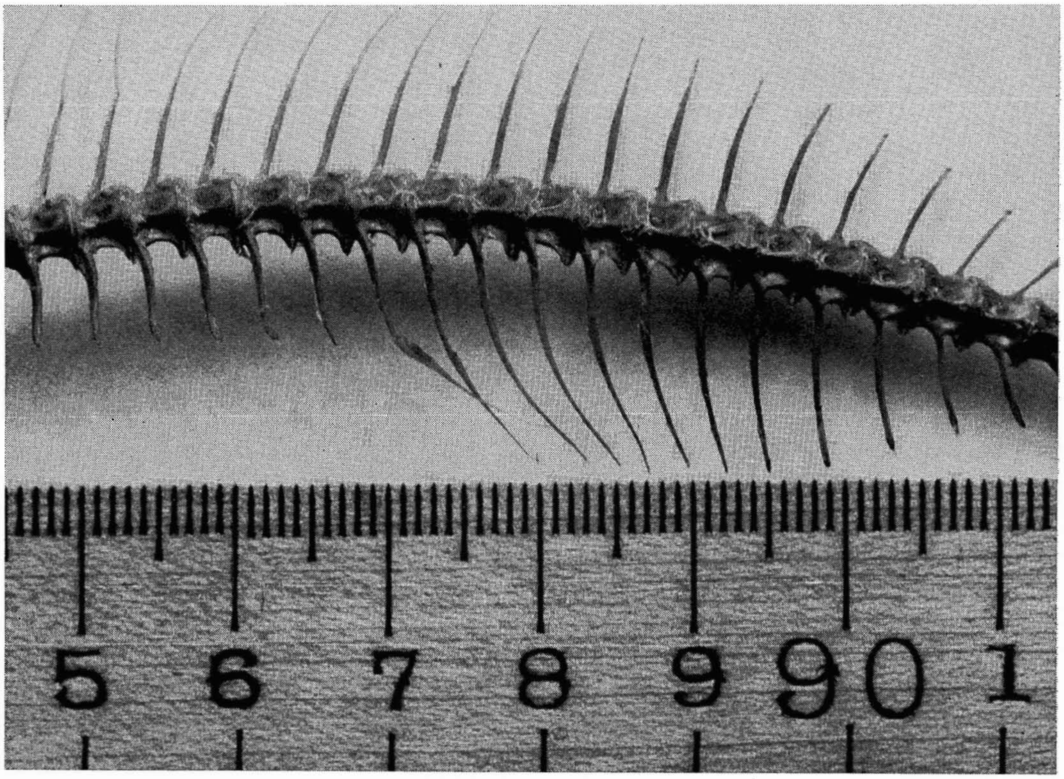

FIG. 3. Portion of axial skeleton of juvenile albacore showing unique, flattened haemal spine on first caudal vertebra.

TABLE 1

COUNTS AND MEASUREMENTS MADE ON JUVENILE ALBACORE
(Measurements in millimeters)

CHARACTER	SPECIMEN NUMBER 3	4	6	7	8	11	12
Standard length	—	—	88	74	184	—	—
Head length	—	—	—	19	48	—	—
Postorbital length of head	—	—	—	8	22	—	—
Iris diameter	—	—	—	6	—	—	—
Interorbital width	—	—	6	6	14	—	—
Snout length	—	—	6	5	—	—	—
Maxillary length	—	—	10	8	21	—	—
Snout to first dorsal origin	—	—	—	21	—	—	—
Snout to pelvic base	—	—	—	—	59	—	—
Longest pectoral ray	—	—	—	—	12	—	—
Gill rakers (number)							
Upper arch	7	7	7	9	8	8	7
Angle	1	1	1	1	1	1	1
Lower arch	20	20	19	19	21	20	20
Total	28	28	27	29	30	29	28
First dorsal fin	—	—	—	13	14	—	—

ally, starting with the anteriormost and ending with the parapophysis on the eighth vertebra. Actually, the tip of the parapophysis on the ninth vertebra projects ventrally and does not completely straighten out even in adults.

The first haemal arch in adult albacore makes an angle of 45° or less with the axis of the vertebral column, and the bones of the arch are flattened dorso-ventrally (Godsil and Byers, 1944). In juveniles the first haemal arch makes an angle of approximately 75–90°, with the greater angles generally occurring in the smaller specimens. The bones of the arch are flattened laterally. Evidently, as the albacore grows, the angle that the arch makes with the axis of the vertebral column becomes more acute. At the same time the posterior margins of the arch move forward and inward so that in adults the bones are compressed dorso-ventrally (Fig. 4).

Godsil and Byers (1944:84) state that the posterior margin of the parasphenoid and basioccipital, when viewed laterally, makes a prominent acute angle in adult albacore. However, a few paragraphs later (p. 85) they state that this margin may make an angle varying from slightly acute to somewhat obtuse. For our purpose, this character is perhaps best described as the angle the posterior margin of the basioccipital makes with the axis of the vertebral column. When the cranium is viewed from the side, this angle is acute in adult albacore. In small juveniles this angle is obtuse, but with growth it changes to approximately 90° and finally to an acute angle (Fig. 5). A juvenile measuring 257 mm already possessed a skull similar to an adult. However, in a 184 mm specimen, the angle was still 90°. Therefore, it appears that this character becomes definitive in albacore at a standard length somewhere between 184 and 257 mm.

Yabe et al. (1958) found that juvenile tunas occurred more frequently in stomachs of spearfishes than of tunas. However, they also found that this varied according to area. Juvenile tunas occurred in stomachs of spearfishes and yellowfin tuna caught in low-latitude waters, but not in bigeye tuna. North of 30° N, however, juvenile tunas were also found in bigeye stomachs. Yabe and his colleagues suggested that this was due to a difference in vertical distribution of tunas and spearfishes, which in turn was related to the hydrography of the different areas. Although our sampling program was not designed to make such a comparison, most of our juvenile albacore were found in stomachs of spearfishes (Table 2). Six were found in the stomachs of five blue marlin, three in the stomachs of three striped marlin, two in the stomach of

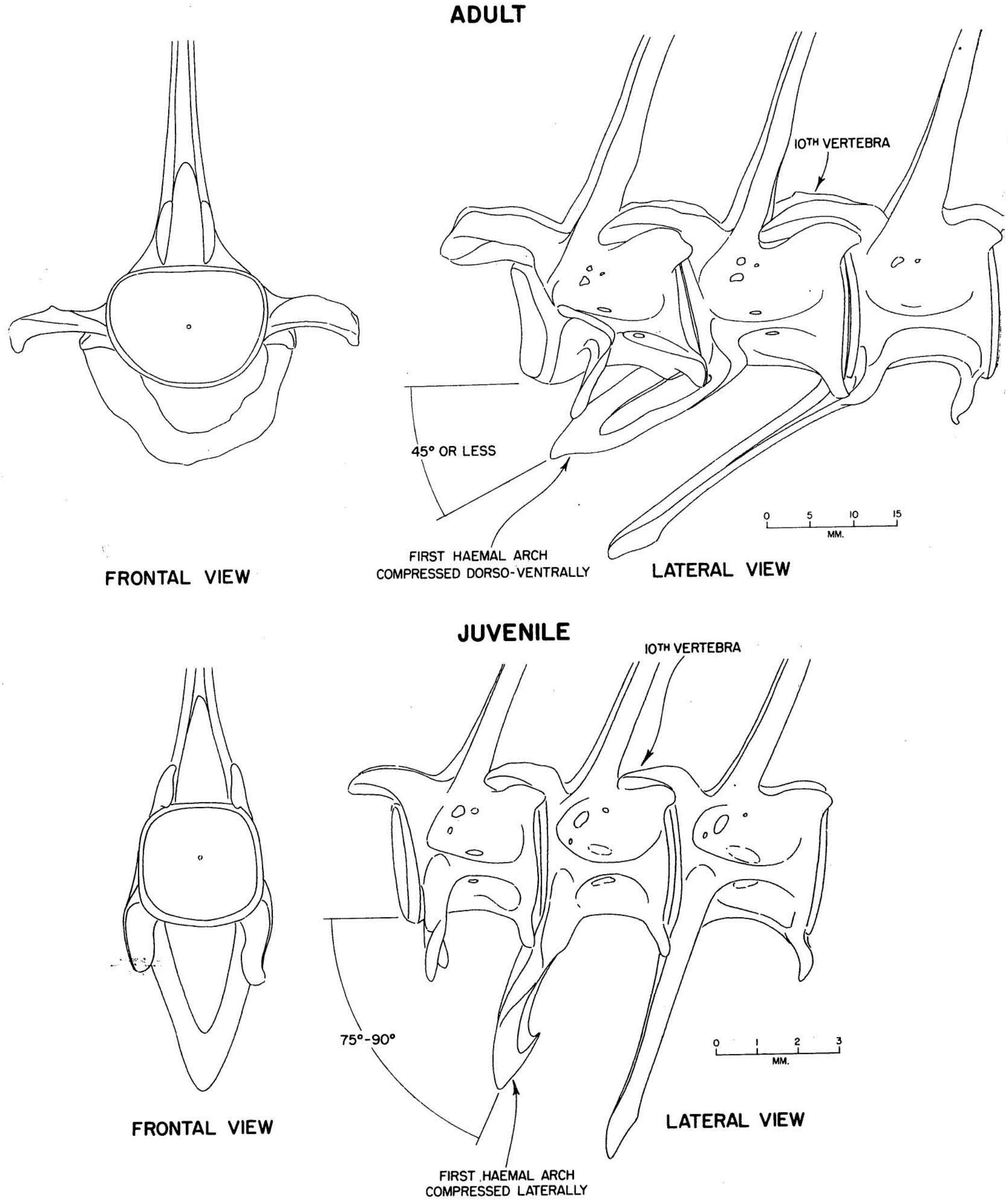

FIG. 4. First haemal arch of adult and juvenile albacore.

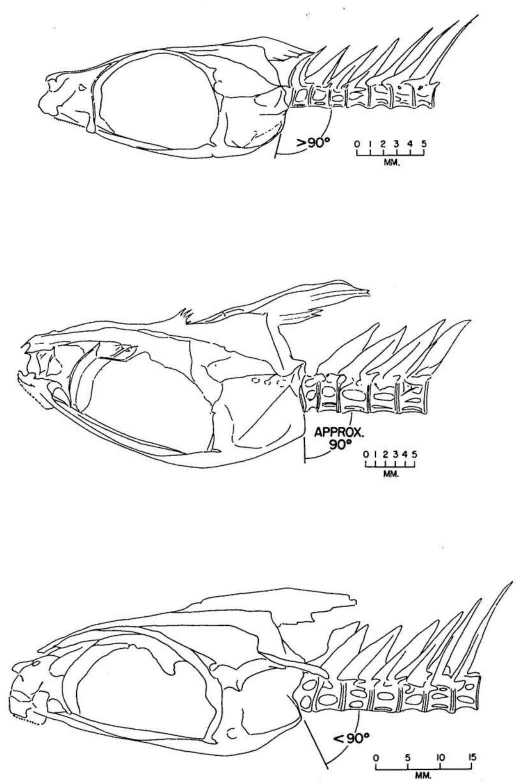

FIG. 5. Lateral view of skulls of juvenile albacore 88 mm (*top*), 184 mm (*center*), and 257 mm (*bottom*) in standard length.

a yellowfin, and one in the stomach of a wahoo (*Acanthocybium solandri*).

The occurrence of juvenile albacore in the Pacific Ocean is shown in Figure 6. Previously juvenile albacore were recorded from 18°38′N, 151°26′ E and 20°57′ N, 149°36′ E in the western North Pacific and 18°44′ S, 176°54′ E, 18°58′ S, 176°27′ E and 20°50′ S, 155°20′ E in the central and western South Pacific (Yabe et al., 1958). The discovery of the 12 juvenile albacore reported here establishes a new eastward distribution record for juveniles in the Pacific Ocean. The known distribution of juvenile albacore now extends as far east as the Hawaiian Islands in the North Pacific and as far as 162° W longitude in the South Pacific.

Although the number of specimens is small, the discovery of juvenile albacore in these areas supports the findings of past studies on albacore spawning based on gonad condition and also provides positive evidence of spawning. It had been hypothesized that albacore in the North Pacific spawn in a broad area extending westward from the Hawaiian Islands (Ueyanagi, 1957; Otsu and Uchida, 1959). Similarly, in the South Pacific (also on the basis of gonad studies) Otsu and Hansen (1962) indicate that albacore may spawn in a broad area north of 20° S. It can be seen in Figure 6 that juvenile

TABLE 2

JUVENILE ALBACORE FOUND IN STOMACHS OF PREDATORS

SPECIMEN NO.	DATE	LOCALITY	STANDARD LENGTH	PREDATOR
1	8-11-60	23°46′ N, 171°02′ E	131 mm*	blue marlin
2	8-11-60	23°46′ N, 171°02′ E	131 mm*	blue marlin
3	2-25-62	10°43′ S, 178°46′ E	85 mm	blue marlin
4	2-26-62	13°25′ S, 179°15′ W	61 mm*	yellowfin
5	2-26-62	13°25′ S, 179°15′ W	75 mm*	yellowfin
6	3-13-62	15°35′ S, 171°16′ W	88 mm	blue marlin
7	3-24-62	06°32′ S, 162°45′ W	74 mm	wahoo
8	8- 1-62	off Kona, Hawaii	184 mm	blue marlin
9	8-13-62	off Waianae, Oahu	135 mm*	striped marlin
10	9-13-62	off Waianae, Oahu	184 mm*	blue marlin
11	11- 2-62	off Waianae, Oahu	257 mm	striped marlin
12	11- 2-62	off Waianae, Oahu	283 mm*	striped marlin

* Estimated.

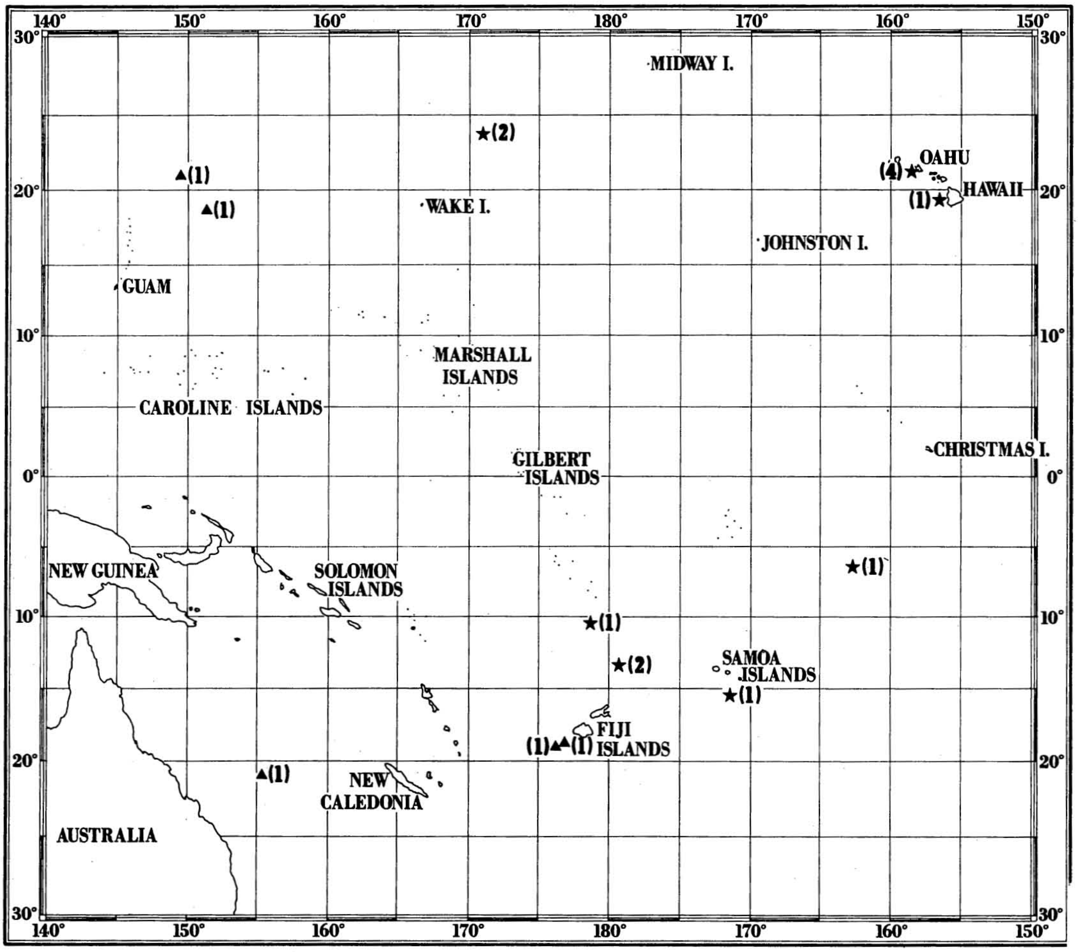

FIG. 6. Occurrence of juvenile albacore in the Pacific Ocean. Based on collections of Biological Laboratory, Honolulu, Hawaii (*stars*) and data in Yabe et al. (1958) (*triangles*). Figures in parentheses are numbers of specimens.

albacore have been captured in widely scattered areas in tropical and subtropical waters extending from approximately 150° E to 155° W in the North Pacific and 155° E to 162° W in the South Pacific. It would be interesting to discover whether albacore spawn randomly in these broad areas or whether there is concentrated spawning within them.

SUMMARY

Stomachs of large pelagic fishes collected during the period June 1960 through November 1962 were examined for the occurrence of juvenile albacore. The stomachs were obtained from fishes landed by the Hawaiian commercial longline fishery, captured during cruises of the research vessel "Charles H. Gilbert," and captured during the 1962 Hawaiian International Billfish Tournament at Kona, Hawaii.

Twelve juvenile albacore were discovered in the stomachs of predators: six from five blue marlin, three from three striped marlin, two from a yellowfin tuna, and one from a wahoo.

The juveniles were identified on the basis of the haemal spine on the first caudal vertebra, which in the albacore has a unique laterally flattened shape. The smallest specimen identified by this character measured an estimated 61

mm in standard length. Other supplementary characters confirmed the specimens as being albacore. The juveniles were described and counts and measurements were made.

The flattened haemal spine and full adult complement of gill rakers are developed relatively early in the life of the albacore. Certain other morphological features, including the angle the posterior margin of the basioccipital makes with the axis of the vertebral column, the orientation of the parapophyses on the vertebrae preceding the ninth vertebra, the orientation of the bones of the first haemal arch, and the angle the first haemal arch makes with the axis of the vertebral column, seem to develop more slowly and assume their adult form later in the life of the albacore.

A new distribution record for juvenile albacore was established with the discovery of these juveniles, demonstrating new or extending known spawning grounds for albacore in the Pacific Ocean. These captures of juvenile albacore support the conclusions of studies made on albacore spawning based on gonads, which indicated that albacore spawn in broad areas of the tropical and subtropical waters of the North and South Pacific Oceans.

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