DISTRIBUTION, APPARENT ABUNDANCE, AND LENGTH COMPOSITION OF JUVENILE ALBACORE, *Thunnus alalunga*, IN THE SOUTH PACIFIC OCEAN

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ABSTRACT

The distribution, apparent abundance, and length composition of juvenile albacore, *Thunnus alalunga*, were deduced from 127 specimens found in the stomachs of 2,297 billfishes collected in the South Pacific between January 1964 and July 1966. Juvenile albacore were found in the South Pacific from lat 5° to 31° S, between long 153° and 179° W. Billfish stomach samples were collected from as far east as long 135° W, but juveniles were not in the stomachs east of long 153° W. The juveniles were consistently more numerous between lat 10° and 20° S than in the area farther north. The mean length of the juveniles increased from north to south but not from east to west (or vice versa). A southward migration of juveniles is postulated.

In April 1963, the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries), Hawaii Area Fishery Research Center established a field station in Pago Pago, American Samoa, to collect information on the longline fishery based there. A fleet of vessels from Japan, the Republic of Korea, and the Republic of China has supplied two American-owned canneries with albacore, *Thunnus alalunga,* and other tuna. In 1965 the fleet was composed of 154 vessels which landed 15,588 metric tons of albacore (Otsu and Sumida, 1968).

The field station was established primarily to study the effects of the fishery on albacore. As part of this study an investigation was started to determine the early life history of albacore in the South Pacific.

Beginning in 1964, arrangements were made with several longline fishing vessels based in American Samoa to collect stomachs of billfishes, which are known to prey on juvenile tunas (Yoshida, 1965, 1968). The distribution, apparent abundance, and length composition of juvenile albacore, here defined as fish smaller than 400 mm standard length, were determined by specimens found in the stomachs of the predators.

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MATERIALS AND METHODS

The longline vessels based at American Samoa fished primarily for albacore; billfishes were taken only incidentally. The crews of the cooperating longline vessels collected 2,297 billfish[2] stomachs between January 1964 and July 1966. These stomachs were also used in a study of juvenile skipjack tuna, *Katsuwonus pelamis* (Yoshida, 1971).

In the laboratory, all the tunas and tunalike specimens were first sorted from the stomach contents. The juvenile tunas were identified by the use of skeletal characters; juvenile albacore were easily identified by their definitive skeletal characters (Matsumoto, 1963; Yoshida, 1965). Standard length (SL) was taken for all intact juveniles and is the measurement used throughout. For fragmentary specimens, the standard length was estimated from previously determined relations between standard length and various vertebral segments (Yoshida, 1968). A total of 127 juvenile albacore was found in the billfish stomachs (Table 1).

[2] For the purpose of this paper the term billfish, in addition to the Istiophoridae, includes the swordfish, *Xiphias gladius.*

TABLE 1.—Juvenile albacore found in billfish stomachs from the South Pacific.

Date 1964	Position		Standard length	Date 1965	Position		Standard length	Date 1966	Position		Standard length
	Lat S	Long W			Lat S	Long W			Lat S	Long W	
			mm				mm				mm
3/9	07°00′	170°00′	143	1/5	14°00′	174°00′	122	1/7	15°00′	175°00′	107
3/20	06°00′	164°00′	116	1/5	14°00′	174°00′	97	1/9	15°00′	174°00′	89
3/21	05°00′	165°00′	67	1/22	14°00′	175°00′	96	1/9	15°00′	174°00′	83
4/4	08°00′	175°00′	102	1/22	14°00′	175°00′	78	1/9	16°00′	174°00′	110
4/5	08°00′	175°00′	136	1/22	14°00′	175°00′	84	1/9	16°00′	174°00′	113
4/9	07°00′	178°00′	78	1/24	14°00′	174°00′	102	1/9	16°00′	174°00′	133
4/9	07°00′	178°00′	137	1/25	14°00′	174°00′	109	1/17	12°00′	175°00′	106
4/12	07°00′	178°00′	26	1/26	11°00′	162°40′	81	1/23	12°40′	171°00′	133
4/16	07°00′	179°00′	57	1/27	14°00′	174°00′	118	2/8	09°00′	172°00′	130
4/19	07°00′	178°00′	102	1/29	14°00′	175°00′	110	2/8	09°00′	172°00′	137
4/20	07°00′	179°00′	66	1/30	14°00′	175°00′	102	2/8	09°00′	172°00′	130
4/20	07°00′	179°00′	66	4/4	07°10′	164°13′	123	2/8	09°00′	172°00′	93
4/20	07°00′	179°00′	106	4/12	07°10′	170°20′	102	2/13	07°02′	171°30′	102
4/24	09°00′	176°00′	115	4/22	07°00′	174°45′	86	3/7	06°35′	162°20′	58
4/25	08°00′	176°00′	67	4/22	07°00′	174°45′	86	3/14	07°20′	161°15′	89
4/26	08°00′	177°00′	119	9/1	13°00′	171°00′	96	3/16	08°10′	165°13′	67
5/8	07°54′	165°32′	118	11/7	16°30′	159°20′	152	3/22	11°32′	168°29′	104
5/8	07°54′	165°32′	113	11/7	16°30′	159°20′	158	3/22	11°32′	168°29′	116
5/8	07°54′	165°32′	104	11/7	16°30′	159°20′	142	3/28	09°10′	153°00′	168
5/8	07°54′	165°32′	113	11/8	16°20′	159°09′	152	5/5	08°13′	175°42′	83
5/8	07°54′	165°32′	88	11/22	17°00′	168°00′	105	5/5	08°13′	175°42′	92
5/8	07°54′	165°32′	106	11/29	17°07′	170°43′	119	5/5	08°13′	175°42′	97
5/8	07°54′	165°32′	125	11/29	17°07′	170°43′	115	5/7	08°00′	175°45′	94
5/10	07°46′	165°29′	121	11/29	17°07′	170°43′	91	5/9	08°28′	175°57′	53
5/10	07°46′	165°29′	88	12/14	17°50′	159°30′	137	6/8	07°15′	164°42′	74
5/19	05°29′	170°06′	48	12/14	17°50′	159°30′	148	6/29	30°49′	166°13′	314
5/19	06°00′	172°00′	47	12/17	16°11′	157°27′	100	7/12	28°50′	156°03′	297
5/23	06°00′	173°00′	58	12/21	17°52′	158°20′	138	7/15	28°05′	155°24′	317
5/26	06°23′	173°59′	99	12/22	10°00′	174°00′	159	7/23	28°44′	154°15′	321
6/1	05°52′	174°41′	48	12/25	18°00′	163°00′	130	7/23	28°44′	154°15′	316
6/1	05°52′	174°41′	73	12/25	18°00′	163°00′	164	7/24	28°22′	154°24′	301
6/20	06°43′	171°26′	53	12/28	17°30′	162°10′	162				
6/25	07°18′	172°53′	86	12/29	12°00′	171°00′	93				
8/18	26°00′	175°00′	357	12/30	12°00′	171°00′	115				
8/21	26°00′	176°00′	358	12/31	12°00′	171°00′	93				
9/4	24°00′	174°00′	328								
9/5	25°00′	174°00′	343								
9/9	25°00′	171°00′	333								
9/9	25°00′	171°00′	301								
9/13	18°00′	170°00′	230								
9/13	18°00′	170°00′	230								
9/13	18°00′	170°00′	223								
9/19	16°00′	173°00′	110								
10/4	09°00′	179°00′	93								
10/4	09°00′	179°00′	116								
10/4	15°00′	173°00′	93								
10/8	19°00′	173°00′	146								
10/9	17°00′	173°00′	185								
10/18	13°00′	174°00′	62								
10/22	15°00′	174°00′	83								
10/22	15°00′	174°00′	93								
10/22	15°00′	174°00′	78								
11/11	16°00′	171°00′	79								
11/13	16°00′	171°00′	62								
11/13	16°00′	171°00′	128								
11/14	16°00′	171°00′	133								
11/15	16°00′	175°00′	150								
11/16	16°00′	172°00′	110								
11/16	16°00′	172°00′	150								
12/18	14°00′	174°00′	102								
12/31	14°00′	175°00′	133								

LENGTH OF JUVENILES

The juvenile albacore in the billfish stomachs ranged from 26 to 358 mm (Figure 1). Two length groups were apparent in the length-frequency distribution: one with a mode at 110 mm and the other at 310 mm; another length group was suggested between 200 and 250 mm.

In the course of the study it became apparent that the larger juveniles were being taken between lat 20° and 30° S. To determine if differences existed in juvenile sizes by latitude, lengths were plotted against latitude of capture (Figure 2). The smallest individuals were taken north of lat 10° S and the largest south of lat 20° S. No specimens smaller than 290 mm were taken south of lat 20° S. The juveniles between lat 10° and 20° S were slightly larger (mean SL 120 mm) than those taken north of lat 10° S (mean SL 94 mm). The mean standard length of those from south of lat 20° S was 324 mm.

In contrast to the latitudinal differences in juvenile length, no longitudinal trends in length were evident. Juveniles larger than 300 mm were taken in the eastern as well as the more westerly portion of the area sampled.

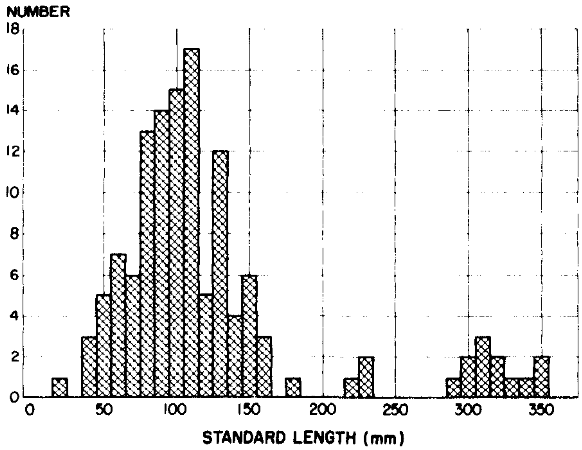

FIGURE 1.—Length-frequency distribution of juvenile albacore in the South Pacific.

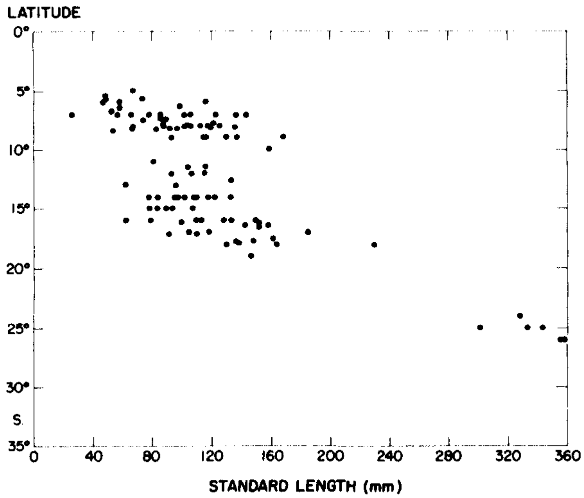

FIGURE 2.—The length of juvenile albacore plotted against latitude of capture.

MIGRATION OF JUVENILES

The differences in the lengths of the albacore in the three latitudinal bands may be caused by the migration of the juveniles. The increase in length of juveniles from north to south and the absence of any longitudinal trends in length suggest a southward migration. After attaining a length of nearly 200 mm the juveniles that originate between the equator and lat 10° S probably start migrating south. They apparently continue to move southward as they grow. This migration would explain the absence of large (>250 mm) juveniles north of lat 20° S.

These observations on the suspected migration pattern of juvenile albacore fit well with the accumulated information on the biology of albacore in the South Pacific. Observations on the length composition of commercial catches of albacore in the South Pacific indicate latitudinal differences in the size of albacore. Adult albacore tend to be small north of lat 15° S and largest between lat 20° and 25° S. They are smaller again south of lat 25° S (Otsu and Sumida, 1968). Length-frequency data published by the Nankai Regional Fisheries Research Laboratory (1959) show that albacore as small as 490 to 500 mm are caught on longlines south of lat 30° S. Thus, it could be that the juveniles move southward as they grow and are first taken by the longline fishery as preadults in the higher latitudes in the South Pacific. A similar pattern has been deduced for albacore in the North Pacific. Otsu and Uchida (1963) hypothesized that the juveniles in the North Pacific migrate from tropical and subtropical waters into temperate waters and are recruited into the adult population in higher latitudes, presumably north of lat 30° N. Generally speaking, then, the albacore in the North and South Pacific, which are believed to constitute separate subpopulations, follow similar migration patterns within their respective hemispheres. The adults are believed to spawn in lower latitudes, between the equator and lat 20° where the eggs hatch and the larvae develop into juveniles. The juveniles then migrate into higher latitudes as they grow and they join the adult population in the higher latitudes.

AGE AND GROWTH

Information on age and growth is useful in determining certain vital statistics for fish populations and it would be useful if the growth of juvenile albacore in the South Pacific could be determined. Around Hawaii juveniles (60-350 mm SL) were estimated to grow about 31 mm per month (Yoshida, 1968). It would have been interesting to compare this growth with that of juveniles in the South Pacific. A plot of juvenile albacore length by time of capture, however, did not indicate that the length of the juveniles was increasing with time.

DISTRIBUTION AND ABUNDANCE

Because the data for any one year were sparse, the data for all years were combined to determine the quarterly distribution of juvenile albacore (Figure 3). The apparent distribution of juvenile albacore may reflect the operations of the longline boats. The longline vessels based at American Samoa primarily were seeking albacore and selecting areas where albacore catch rates tended to be high. The vessels generally fished north of lat 20° S in the first half of the year and beginning in June or July moved southward to as far south as lat 30° S (Otsu and Sumida, 1968). The data indicated that the cooperating vessels generally followed this pattern. In spite of this shortcoming the data suggest some interesting features of the seasonal distribution of juvenile albacore.

In the first quarter billfish stomach samples were collected between long 150° and 178° W and lat 5° and 16° S. The juveniles were generally found throughout the sampling area west of long 153° W.

In the second quarter the longitudinal range of sampling was slightly greater but the juveniles were restricted to the west between long 165° and 179° W. Latitudinally, most of the stomach samples were from north of lat 10° S except for a few samples from about lat 31° S. Juveniles were taken between lat 5° and 9° S and at lat 31° S.

In the third quarter stomach samples were available from long 140° W to 178° E between lat 5° and 31° S. The juveniles were absent in samples from north of 14° S.

In the fourth quarter the sampling area was bounded by long 135° W and 178° E and lat 6° and 21° S. Juveniles were absent from the easternmost portion of the area. They were taken between long 157° and 179° W and lat 9° and 20° S. These observations suggest that the center of the spawning area is closer to the area between long 160° W and the 180th meridian than farther to the east.

Variations were also evident in the apparent abundance of juvenile albacore as indicated by the number of juveniles found monthly per 100 billfish stomachs (Figure 4).

Juvenile albacore were found in all months except July and August. Peaks in apparent abundance occurred in January, April, and November.

The data for all years were pooled because billfish stomachs were unavailable for some months in some years. Also, estimates of apparent abundance may be biased by the small sample sizes. The shortcoming of combining data for all years and considering a large area as an entity is that annual and areal variations in apparent abundance are obscured. For example, in 1965, except in April when four juvenile albacore were taken, no juveniles were found in billfish stomachs from north of lat 10° S.

The overall abundance of juveniles was greater

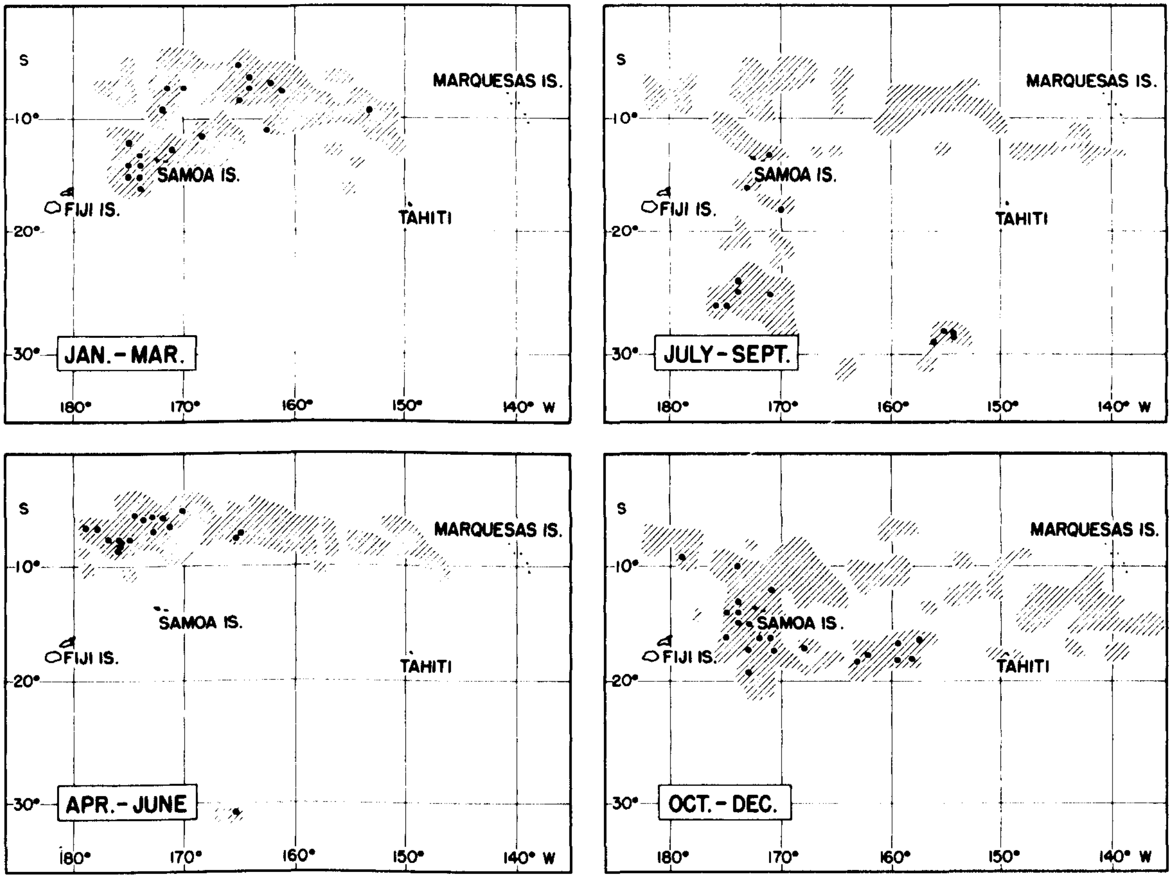

FIGURE 3.—The quarterly distribution of juvenile albacore in the South Pacific, all years combined. The shadings show areas from which billfish stomachs were collected. The dots show where juvenile albacore were taken.

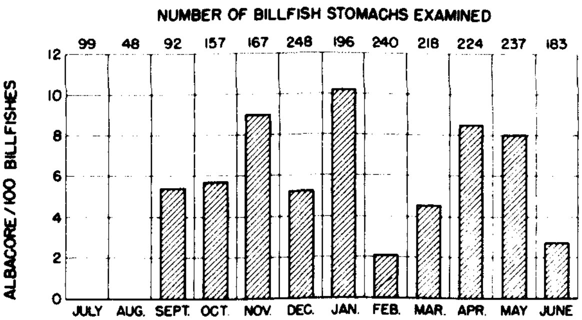

FIGURE 4.—Apparent abundance of juvenile albacore in the South Pacific.

between lat 10° and 20° S than in the area north of lat 10° S. Combining the data for all years, 7.5 juveniles per 100 billfishes were taken between lat 10° and 20° S, and 4.5 juveniles per 100 billfishes were taken north of lat 10° S. (Near Hawaii between July 1962 and April 1966, juvenile albacore were taken at a rate of 0.8 per 100 billfishes [Yoshida, 1968]. Thus, juvenile albacore are apparently more numerous in the South Pacific than around Hawaii.)

SPAWNING

Variations in seasonal and geographic distribution and apparent abundance of juvenile albacore may be related to the spawning of the adults. Several investigators have made observations on the spawning of albacore in the South Pacific. On the basis of an examination of ovaries, Otsu and Hansen (1962) concluded that peak albacore spawning occurs in the southern hemisphere summer between the equator and lat 20° S. Their results also suggest a spawning season of at least 5 months. Ueyanagi (1969), who based his study on the distribution of larvae and on the stage of maturity of ovaries of adults, also suggested a southern summer spawning season. The seasonal apparent abundance of juvenile albacore does not disagree with the above conclusions. The fact that juveniles were found in all but 2 months of the year suggests a long spawning season. The presence of juvenile albacore during and beyond the southern hemisphere summer indicates some spawning during the summer. My data also suggest annual variations in adult spawning. The virtual absence of juvenile albacore north of lat 10° S in 1965 indicates little or no spawning in this area during that year.

COMPARISON WITH SKIPJACK TUNA

A comparison of the distribution and abundance of juvenile albacore and skipjack tuna offers some interesting contrasts. Although billfish stomachs were sampled from long 135° W to 177° E, juvenile albacore were found only between long 153° and 179° W (Figure 5). The juveniles were found throughout the latitudinal range of sampling between lat 5° and 31° S. Juvenile skipjack tuna are distributed over a wider area: between long 137° W and the 180th meridian from lat 5° to 32° S (Yoshida, 1971). These distributional patterns indicate that skipjack tuna spawn over a wider area than the albacore in the South Pacific.

Comparing the abundance of the two species, in 1964 juvenile skipjack tuna were more numerous north of lat 10° S than from 10° to 20° S, but in 1965 they were more numerous between 10° and 20° S than in the area to the north (Yoshida, 1971). Juvenile albacore were consistently more abundant between lat 10° and 20° S than to the north. Also, juvenile skipjack tuna apparently were from 4.5 to 15 times more numerous than juvenile albacore between the equator and lat 20° S (Table 2). It is also interesting that the apparent abundance of both species declined from 1964 to 1965.

TABLE 2.—Apparent abundance of juvenile albacore and skipjack tuna in the South Pacific. The apparent abundance is expressed as number per 100 billfishes. Data for juvenile skipjack tuna are from Yoshida (1971).

Year	North of lat 10° S		Lat 10°-20° S	
	Albacore	Skipjack tuna	Albacore	Skipjack tuna
1964	6.7	46.3	9.3	42.6
1965	1.9	28.8	5.8	35.6

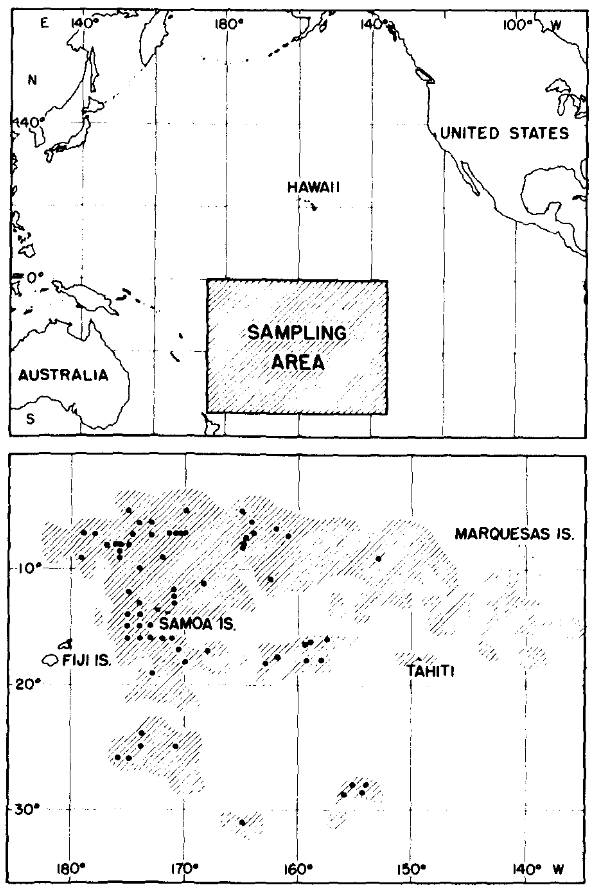

FIGURE 5.—The distribution of billfishes (shading) sampled by the cooperating longline vessels and the distribution of juvenile albacore (dots) found in the billfish stomachs.

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