

ALBACORE OF HAWAIIAN WATERS

• *Thunnus alalunga* •

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Only a small quantity of albacore is caught in Hawaiian waters by the long-line fishery, incidental to catches of other species of tunas and billfishes. The fish are large and appear to be part of the reproductive component of the North Pacific albacore population. The albacore arrive in Hawaiian waters in early summer after spending about 6 years in the temperate North Pacific.

This paper documents their occurrence, describes their size composition and abundance, and discusses their possible role in the North Pacific population.

In their model of albacore migration in the North Pacific Ocean, Otsu and Uchida postulated in 1963 that the albacore in Hawaiian waters belong to the reproductive segment of the North Pacific population. The history of the fish would be this: they spent several years in the temperate North Pacific where, alternately, they were exposed to American and Japanese fisheries during their extensive east-west migrations. After attaining sexual maturity at about age 6 (90 cm. in length), they migrated south into subtropical waters.

The inferred spawning grounds of the albacore extend in a wide belt centered along lat. 15° N., and reach from the Philippines in the west to about the Hawaiian Islands in the east. Thus, say Otsu and Uchida, the albacore in Hawaii are probably the easternmost component of the North Pacific spawning population.

The albacore are only a small part of the landings of Hawaiian fisheries: in weight, less than 3% of total tuna and billfish landings. Though relatively scarce, these albacore are, nevertheless, an important reproductive component of the North Pacific population.

NORTH PACIFIC ALBACORE FISHERIES

There are three major fisheries for albacore in the temperate North Pacific Ocean: (1) the Japanese live-bait fishery during April-July off Japan (Van Campen, 1960);

(2) the Japanese long-line fishery during October-March from Japan east to about long. 170° W. (Nankai Regional Fisheries Research Laboratory, 1954); and (3) the U.S. west coast trolling and live-bait fishery during June-November between Baja California and the Pacific Northwest (Clemens, 1955). These account for virtually all the commercial landings of albacore in the Northern Hemisphere.

Albacore are also taken in small quantities throughout the tropical and subtropical regions of the Northern Hemisphere by the Japanese long-line fishery (Nankai Regional Fisheries Research Laboratory, 1959), and off Hawaii by the Hawaiian long-line fishery.

The albacore in Hawaiian waters are found only at great depths, perhaps 150 or 200 m. They are taken by deep-fishing long-line gear (Yoshida, 1966)--unlike albacore in temperate waters, which also occur at the surface. In the temperate waters, they are taken by surface fishing: surface trolling and live-bait fishing by Americans in eastern Pacific, live-bait fishing by Japanese in western Pacific.

Young albacore (less than about 90 cm. long) are found in temperate latitudes. In temperate North Pacific, between Japan and the U.S., they are both at surface and at considerable depth. The adults migrate south into tropical and subtropical waters, where

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they are exclusively at great depths (Otsu and Yoshida, 1967). The fisheries are geared to take advantage of this unwavering regularity in the fish's life pattern. Thus, throughout the tropics, including Hawaii, the long-line method is the only way known for capturing these deep-swimming albacore.

The Fleet and the Catch

In Hawaii, the long-line fishery operates mostly in "inshore" waters; boats range in size from 5 to 38 gross tons (Hida, 1966). In 1950, the fleet consisted of 76 boats; not all fished full time. The number has dwindled steadily since then and, by 1968, only 22 boats operated. The boats have crews of two to five men and make trips averaging about 9 days. Although most fishing is within 40 km. of the main Hawaiian Islands, a few boats occasionally have ventured as far as 500 km. from port. A new long-line vessel, the 'Kilauea', joined the fleet in 1969. She has made regular trips to fishing grounds 500 to 800 km. south of Honolulu.

The principal long-line catches in Hawaiian waters are the bigeye tuna, *Thunnus obesus*, and the yellowfin tuna, *Thunnus albacares*. Among the billfishes, the Pacific blue marlin, *Makaira nigricans*, and the striped marlin, *Tetrapturus audax*, are the most abundant. Less abundant species are the broadbill swordfish, *Xiphias gladius*; sailfish, *Istiophorus orientalis*; shortbill spearfish, *Tetrapturus angustirostris*; black marlin, *Makaira indica*; wahoo, *Acanthocybium solandri*; skipjack tuna, *Katsuwonus pelamis*; dolphin, *Coryphaena hippurus*; and the albacore.

More detailed descriptions of the Hawaiian long-line fishery are found in June (1950), Otsu (1954), Shomura (1959), Hida (1966), and Yoshida (1966).

LANDINGS OF ALBACORE IN HAWAII

The annual landings of albacore in the Hawaiian long-line fishery in 1948-68 ranged from 3 metric tons in 1965 to 48 metric tons in 1952 (fig. 1); these accounted for 0.4 to 3.0% of total tuna and billfish landings (table 1). The catches were relatively higher in earlier years of study period, 1948-53, when 23 to 48 metric tons were landed each year. Since then, however, the landings have been considerably lower: less than 13 metric tons.

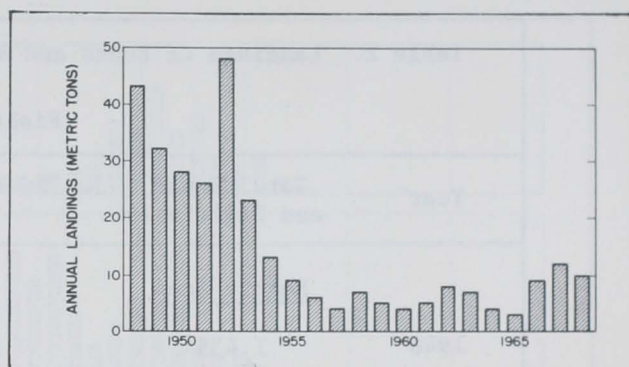


Fig. 1 - Annual landings of albacore in Hawaiian long-line fishery, 1948-68.

Monthly landings of albacore increase markedly in June and are relatively good for remainder of year (fig. 2). The best catches, however, are between June and October.

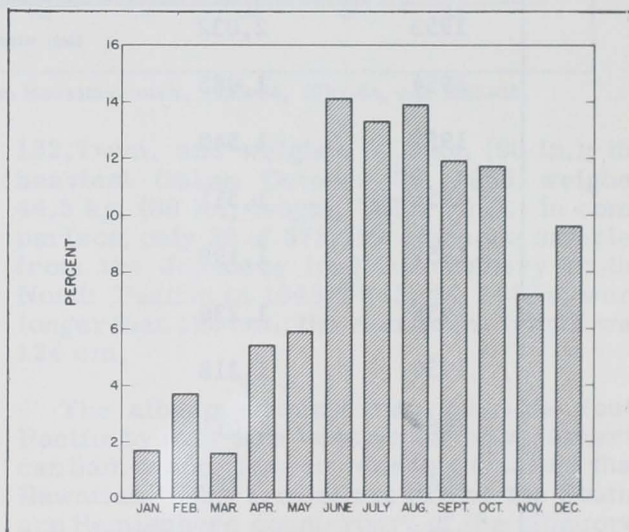


Fig. 2 - The average monthly landings, in percent, of albacore in Hawaiian long-line fishery, 1948-68.

SIZE COMPOSITION OF CATCH

The albacore taken in Hawaii are generally large fish; they range in length from about 85 to 130 cm. (14 to 44 kg.). Eighty percent of the fish landed are longer than 100 cm. (21 kg.). The males are larger and more numerous than the females. The average length in 1965-68 was 102.2 cm. for females and 106.0 cm. for males; the males outnumbered females 1.9 to 1. There has been a marked decline in albacore lengths since the 1950s. Because so few albacore are landed each year, the size data were grouped into three time

Table 1. Landings of Tunas and Billfishes in the Hawaiian Long-line

Fishery, 1948-68^{1/}

Year	Total Tunas and Billfishes	Total Albacore	Albacore Landings
	<u>Metric Tons</u>	<u>Metric Tons</u>	<u>Percent</u>
1948	1,435	43	3.0
1949	1,419	32	2.2
1950	1,787	28	1.6
1951	1,811	26	1.4
1952	1,876	48	2.5
1953	2,032	23	1.1
1954	1,985	13	0.7
1955	1,540	9	0.6
1956	1,511	6	0.4
1957	1,198	4	0.4
1958	1,236	7	0.6
1959	1,218	5	0.4
1960	1,016	4	0.4
1961	926	6	0.7
1962	976	8	0.8
1963	865	7	0.8
1964	939	4	0.5
1965	849	3	0.4
1966	817	9	1.1
1967	798	12	1.5
1968	704	10	1.5

^{1/}Data obtained from State of Hawaii, Division of Fish and Game Statistics, Annual Summary, and may include small amounts of tunas and billfishes taken by methods other than the long-line.

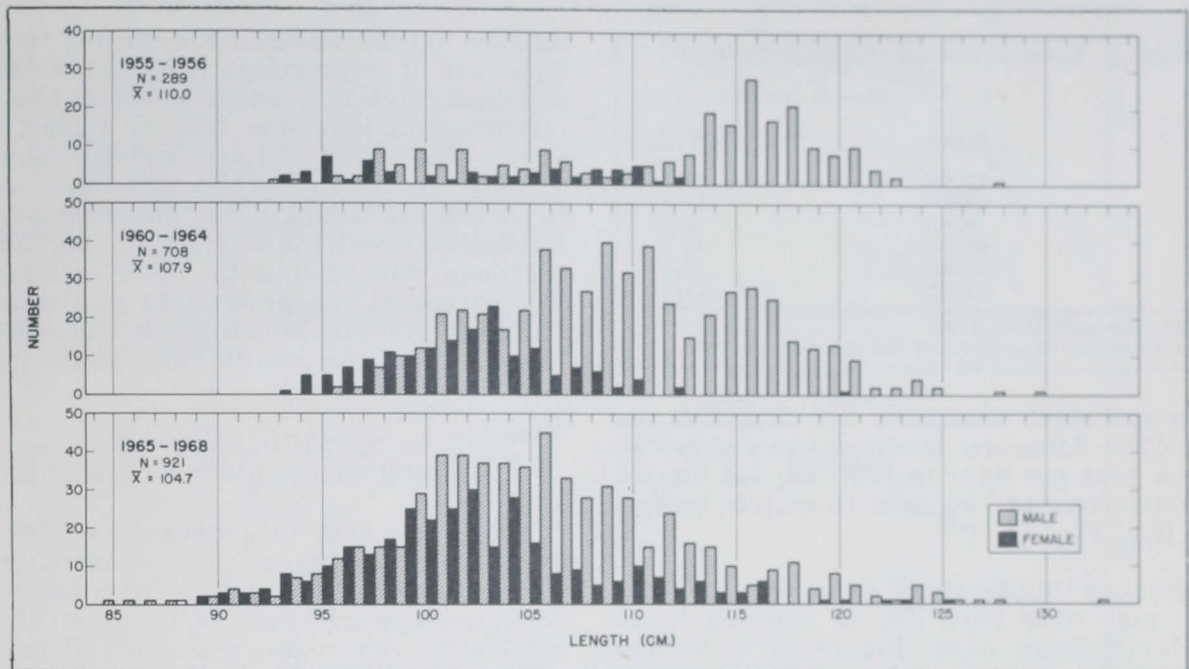


Fig. 3 - Length frequency distributions of albacore from Hawaiian waters, 1955-56, 1960-64, and 1965-68.

periods: 1955-56, 1960-64, and 1965-68 (fig. 3). No data are available for 1957-59 because the Honolulu markets were not sampled then. The average length (sexes combined) of 110.0 cm. in 1955-56 decreased to 107.9 cm. in 1960-64, and to 104.7 cm. in 1965-68. This decrease is even more striking when males are considered separately. The modal sizes decreased from about 116 cm. in 1955-56 to 109 cm. in 1960-64, and to about 105 cm. in 1965-68. There was no reduction in mean size of females over the years.

An outstanding feature of the albacore taken in Hawaii is their very large size; in fact, they are generally larger than those taken anywhere else in the Pacific. Otsu and Uchida reported in 1959 a 127.6-cm. (42.2 kg. or 93 lb.) male as the largest albacore landed in Hawaii in 1955 or 1956. Since sampling was resumed in 1960, four unusually large specimens (all males) have been recorded (table 2). The longest (taken July 21, 1966) measured

132.7-cm. and weighed 40.8 kg. (90 lb.); the heaviest (taken October 25, 1965) weighed 44.5 kg. (98 lb.; length, 128.4 cm.). In comparison, only 22 of 373,754 albacore sampled from the Japanese long-line fishery in the North Pacific in 1949-59 (Suda, 1963a) were longer than 120 cm.; the maximum length was 124 cm.

The albacore caught throughout the South Pacific by long-line vessels based at American Samoa are also considerably smaller than Hawaiian. They are believed to be the Southern Hemisphere counterpart of the albacore, which appear in the tropical and subtropical regions of the North Pacific (Otsu and Yoshida, 1967); populations in the North and South Pacific are believed to be separate. The albacore taken in the fishery based at American Samoa average about 90 cm. in length (16 kg. or 35 lb.). The largest caught in 1968 (in January, at lat. 18°S., long. 171°W.) was 113 cm. long (31 kg. or 68 lb.).

Table 2 - Records of the Five Largest Albacore (All Males) Taken by the Hawaiian Long-line Fishery and Sampled at the Honolulu Markets Since 1955

Date	Length Cm.	Weight Kg.
July 8, 1955	127.6	42.2
June 26, 1964	129.7	44.0
September 28, 1964	128.2	37.2
October 25, 1965	128.4	44.5
July 21, 1966	132.7	40.8

APPARENT ABUNDANCE

Because albacore have been uncommon in the landings of recent years, it is surprising to learn that Hawaii exported albacore to California in the late 1920s and early 1930s (table 3). These exports, probably not the entire catch, indicate that landings were considerably greater then. The relatively good catches may have continued into the early

Table 3 - Export of Hawaiian Albacore to California

Year ^{1/}	Amount Exported	
	Pounds	Metric Tons
1928	57,500	26.1
1929	43,054	19.6
1930	5,426	2.5
1932	98,720	44.9
1933	43,612	19.8
1934	25,900	11.8

^{1/}No albacore exported in 1931.
Source: California Department of Fish and Game, 1937.

1950s (no catch statistics are available for 1935-47). Albacore landings were under 10 metric tons per year in 1955-66, but totaled 12 metric tons in 1967 and 10 metric tons in 1968 (fig. 1).

Although this decrease in Hawaii albacore catch may have been due at least partly to smaller fishing effort (decrease in fishing vessels), it is reasonably certain that low

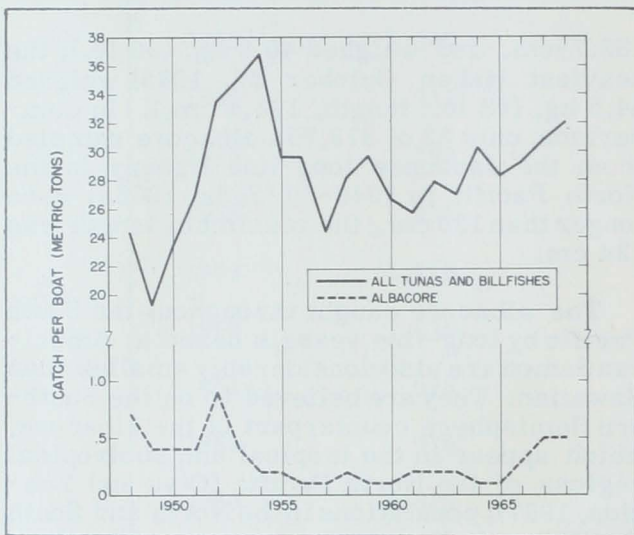


Fig. 4 - The catch per boat of tunas and billfishes and of albacore in the Hawaiian long-line fishery, 1948-68.

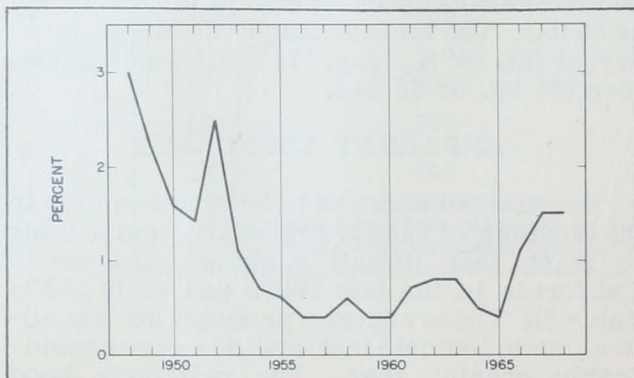


Fig. 5 - The proportion of albacore in the total tuna and billfish landings in the Hawaiian long-line fishery, 1948-68.

catches in 1954-65 were due largely to actual decrease in abundance. Figure 4 shows the per-boat catch of albacore and of all tunas and billfishes in long-line fishery from 1948 to 1968. The catch of tunas and billfishes per boat--except in 1952, 1953, and 1954--tended to increase gradually over the years, though fluctuating greatly from year to year. No such tendency was seen in the catch of albacore. Furthermore, the proportion of albacore in total tuna and billfish landings was markedly lower in 1954-65 than in other years (table 1 and fig. 5).

SIGNIFICANCE OF HAWAIIAN-CAUGHT ALBACORE

Albacore occur in temperate waters when they are young. They migrate seasonally from eastern Pacific, where they form basis of an American summer fishery, into central western Pacific, where they are basis of Japanese winter long-line fishery. They next appear in the Japanese coastal fishery in the spring; from there, they return once again to winter long-line fishery (fig. 6: Otsu and Uchida, 1963). One hypothesis is that when the fish attain sexual maturity, some adults in Japanese winter long-line fishery move south into subtropical waters during spring; there they form reproductive segment of North Pacific population. It has been postulated further that fish of this reproductive segment appear in Hawaiian fishery. These points are supported by the abrupt increase in albacore catches in Hawaii beginning in June, near the beginning of their spawning period in Hawaiian waters.

Otsu-Uchida Study

In their 1959 study, Otsu and Uchida found no albacore in spawning or near-spawning condition in temperate North Pacific, but they noted that albacore from Hawaii possessed well-developed gonads. The fish from the central equatorial Pacific were in an intermediate stage between the two groups; a few had ovaries in the "late developing" stage. The evidence presented by the Hawaiian albacore pointed to a summer spawning, probably between June and August.

Thus, it appears that the increased landings of albacore in Hawaii beginning in June mark the arrival of fish from the North Pacific Japanese winter long-line grounds. Furthermore, since increased landings correspond in time to spawning period, we may state with some confidence that the Hawaiian

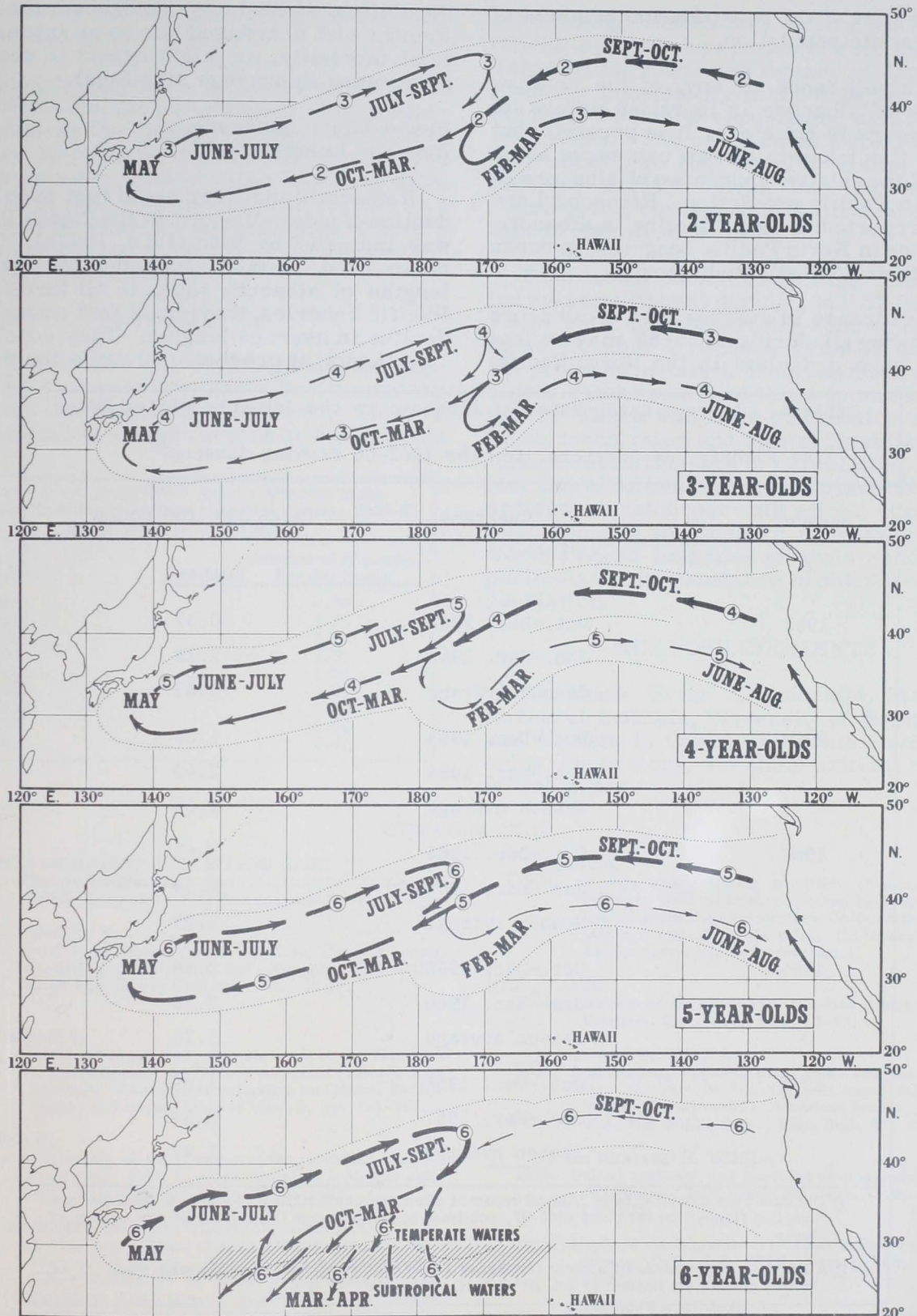


Fig. 6 - Model of albacore migrations in the North Pacific Ocean, by age groups (ages encircled). (Reproduced from fig. 9: Otsu and Uchida, 1963.)

fish are part of the reproductive segment of North Pacific population.

The significance, if any, of the relative scarcity of albacore in Hawaiian waters in recent years is not clear. It is possible that the few fish taken in Hawaii can serve as an index of the relative abundance of albacore in the North Pacific population. Rothschild and Yong* reported a clear decline in albacore abundance in North Pacific long-line grounds during their 1949-61 study period.

The decrease in average size of albacore taken in Hawaii during 1955-68 may reflect further such a decline in the North Pacific

population. If albacore abundance in the North Pacific had decreased due to an increase in total mortality, we might expect to see such a decrease in average size (age).

Fewer Older Albacore,
Average Lengths Stable

Rothschild and Yong noted that such a reduction of older albacore in the North Pacific was indicated by Suda (1959, 1963b). On the other hand, having computed the average lengths of albacore taken in all three North Pacific fisheries, they could find no apparent decline in average lengths. They concluded: "We cannot, at present, reconcile the decline

Table 4. Average Catch Rates of Albacore in the Japanese Winter Long-line Fishery, by Quarters, for the 1962-66 Fishing Seasons^{1/}

Season ^{2/}	Quarters	Catch Per 100 Hooks
		Numbers
1962	Oct.-Dec. 1962	0.57
	Jan.-Mar. 1963	1.18
	Season average	0.88
1963	Oct.-Dec. 1963	1.06
	Jan.-Mar. 1964	2.43
	Season average	1.66
1964	Oct.-Dec. 1964	0.41
	Jan.-Mar. 1965	1.54
	Season average	1.05
1965	Oct.-Dec. 1965	0.96
	Jan.-Mar. 1966	2.58
	Season average	1.76
1966	Oct.-Dec. 1966	1.09
	Jan.-Mar. 1967	2.54
	Season average	1.97

^{1/}The data were compiled from "Annual report of effort and catch statistics by area in Japanese tuna longline fishery" for the years 1962-67, published by the Research Division, Fisheries Agency of Japan.

^{2/}A fishing season extends from about October of 1 year through March of the following year. The fishing grounds are limited to lat. 20°-40° N., long. 140° E.-180°.

*Rothschild, Brian J. and Marian Y. Y. Yong. MS. Apparent abundance, distribution, and migrations of albacore, *Thunnus alalunga*, on the North Pacific longline grounds. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii 96812.

in one set of the Japanese data and the lack of a decline in the other."

Although a decline in average fish sizes in the North Pacific has not been clearly demonstrated in the Japanese data, reduction in relative abundance of the oldest segment of the population is evident in the Hawaiian data. We believe that this decrease is related to a decline in the apparent abundance of albacore in the North Pacific Ocean as a result of increased total mortality.

Catch Rates Compared

To determine this relationship, the Japanese catch rates in the North Pacific and the Hawaiian landings were compared. Table 4 shows the albacore catch rates in the Japanese

winter long-line fishery during the 1962-66 fishing seasons as compiled from data published by the Fisheries Agency of Japan. To maintain consistency in the data, we did not attempt to compile unpublished data for earlier years. The catch rates were generally low, under two fish per 100 hooks, but increased slightly during the 1965 and 1966 seasons; this corresponded to increased landings in Hawaii after 1966.

Suda (1958) published average catch rates for the same fishery during 1949-57 (table 5). These data are not strictly comparable with those in table 4 because different data sets are probably involved. Suda reported slightly higher catch rates than those in more recent years. There was little correlation between these catch rates and annual Hawaiian landings. Despite this lack of correlation, we feel that Hawaiian landings, particularly if standardized in catch-per-unit effort, should reflect changes in albacore abundance in the North Pacific long-line grounds--and, more particularly, in abundance of older fish in the population.

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