DISTRIBUTION, APPARENT ABUNDANCE, AND SIZE COMPOSITION OF ALBACORE (*THUNNUS ALALUNGA*) TAKEN IN THE LONGLINE FISHERY BASED IN AMERICAN SAMOA, 1954–65

By Tamio Otsu, *Fishery Biologist*, and Ray F. Sumida, *Biological Technician*
Bureau of Commercial Fisheries Biological Laboratory
Honolulu, Hawaii 96812

ABSTRACT

This fishery began in 1954 when tuna canning began in Pago Pago, American Samoa, with fish delivered by seven Japanese longline vessels. The size of the fishing fleet grew rapidly. In 1963, a second cannery began operating in Pago Pago. The 105-vessel fleet fishing during the last quarter of 1965 had 62 vessels from Japan, 30 from the Republic of Korea, and 13 from the Republic of China. The fishery was close to the Samoa Islands in the early years but expanded rapidly to the east and south; in 1965 it covered an area of about 23 million square kilometers (6.7 million square nautical miles) in the central and eastern South Pacific Ocean.

Albacore is fished selectively by the fleet because it commands the highest prices at the canneries. Data from the American Samoa-based fishery are complete, therefore, only for the albacore catches. Data on the other tuna species are not analyzed. The landings of albacore in American Samoa have increased from 338 metric tons in 1954 to 15,588 metric tons in 1965. In general, the annual landings have tended to be directly proportional to the total amount of fishing effort.

Various indices of apparent abundance of albacore (catch per trip, catch per day, and catch per 100 hooks fished) are examined. The catch per unit of effort in 1954–65 showed relatively little change in terms of numbers of fish, but a rather marked downward trend in terms of weight. This decline was due largely to a decrease in the average size of the albacore. Among the possible causes for the decrease in fish size are (1) fishing ground selection, (2) decrease of older, larger fish in the stock due to fishing and natural mortalities, (3) entry into the fishery of an abundant year class, and (4) change in sex ratio of the albacore taken.

Before World War II there was almost no longline fishing for tuna in the South Pacific Ocean. After the ratification of the Peace Treaty in April 1952, the South Pacific Ocean became accessible to the Japanese. They started fishing in the western South Pacific near the Solomon Islands, principally for yellowfin tuna (*Thunnus albacares*). The Japanese sent fishing expeditions to waters as far south as lat. 15° S. in late 1952 and extended fishing to lat. 25° S. in the western South Pacific Ocean in 1953 and 1954 (personal communications, Nankai Regional Fisheries Research Laboratory, Kochi, Japan).

In 1954, the tuna fishery based in American Samoa began with a small fleet of Japanese longline vessels. A base was also established by the Japanese at Espiritu Santo in the New Hebrides in 1958 and in the Fiji Islands in 1963. Many independently operated vessels, without the support of foreign land bases or of mother ships, are fishing in the South Pacific and landing their catches of tunas and billfishes directly in Japanese ports. Unquestionably, fishing effort in the South Pacific Ocean has increased substantially over the last decade.

The fishery was conducted exclusively by the Japanese in the early years, but, beginning about 1958, more and more vessels from the Republic of Korea and the Republic of China have been participating. The Japanese early discovered the value of albacore (*T. alalunga*) as a high-quality export product. Since 1956 most of the fishing effort of the American Samoa-based fleet has been concentrated on albacore rather than yellowfin tuna.

Published July 1968.

323-489 O - 69 - 4

This paper describes the American Samoa-based fishery, gives biological data (size and sex) on albacore, and presents results of some preliminary analyses of the catch rates (catch per unit of effort) of albacore as a measure of apparent abundance. The exact amount of fishing effort expended by the American Samoa-based vessels relative to the total longline fishing effort in the South Pacific Ocean is not known. Although no reliable estimates are available, it is apparent that the relative effort changes from year to year. Apparently, the American Samoa effort decreased progressively in relation to the total South Pacific fishing effort from 1954 at least through 1962. Because of this, we have incorporated data from Japan-based longline vessels fishing in the same general area, wherever possible, to supplement the data collected from American Samoa.

In late 1962 the BCF (Bureau of Commercial Fisheries) Biological Laboratory, Honolulu, began to record the size and sex of albacore landed in American Samoa. Because of the rapid growth of the longline fishery we decided to attempt to follow the effects of the fishery on the resource by also collecting catch and effort statistics. In April 1963 a field station, manned by personnel from the BCF Biological Laboratory in Honolulu, was established in Pago Pago, American Samoa, to conduct intensive sampling of the fishery.

Data are collected both on the biology of the albacore landed at the canneries and on fishing operations as recorded by the vessel operators. The length, weight, and sex of 50 albacore, randomly chosen, are being obtained from each trip landing. Detailed catch and effort data are provided voluntarily by fishing vessel operators. The cooperation of vessel operators has been gratifying; data are returned from about 85 percent of the fishing trips. These data provide information on the daily fishing effort (number of hooks fished per set) as well as the catch in numbers of the various species.

THE AMERICAN SAMOA-BASED FISHERY

The past two decades have seen the establishment of two tuna canneries in American Samoa. In 1949, a small tuna cannery was installed on the north shore of Pago Pago Bay on Tutuila Island, American Samoa, by Island Packers, Inc. Attempts to supply this cannery with tuna by live-bait fishing and purse seining in Samoan waters failed, and the plant never operated. The Government of American Samoa, owner of the land and the buildings, purchased the cannery equipment to prevent its being dismantled and sold abroad. In 1953, the Van Camp Sea Food Company obtained a lease with a renewal option (Van Campen, 1954). Today, the tuna cannery, much improved by the installation of new equipment and modernized facilities, is being operated by the Van Camp Sea Food Company-Samoa. In the latter part of 1963, Star-Kist Samoa, Inc. began operating a new cannery adjacent to the Van Camp plant.

The two canneries depend entirely upon foreign flag vessels and fishermen for their catch. Vessels from Japan, the Republic of Korea, and the Republic of China are placed under contract for specified periods, either directly with vessel owners or more generally through fishing companies, to deliver their catches to these American tuna canneries.

The fish are caught by longlines in the South Pacific in an extensive area covering 23 million square kilometers; the 1965 fleet of 154 vessels landed 15,588 metric tons of albacore and lesser quantities of other pelagic species. The following sections give details on the fishing method, fishing grounds, the fleet, and the fish landings.

FISHING METHOD

The American Samoa-based vessels fish with longlines (fig. 1). The basic unit of longline gear ("basket") consists of a length of mainline 200 to 400 m. long, from which are suspended branch lines (usually five or six) with baited hooks. The mainlines are buoyed to the surface by float lines. About 300 baskets of gear are joined in a series. The gear, thus, extends about 100 km. in a single fishing operation. In 1965, the vessels from American Samoa fished an average of 1,400 hooks in a single set. A fishing operation requires upward of 20 to 22 hours from the time the gear is set (about 0400 hours) until it is completely retrieved (about 0100 the following morning).

FISHING GROUNDS

The geographical expansion of the fishery is illustrated in figure 2. In the early years the fishery was confined largely to the vicinity of the Samoa Islands, but the vessels have gradually extended their operations to more distant waters. By 1956,

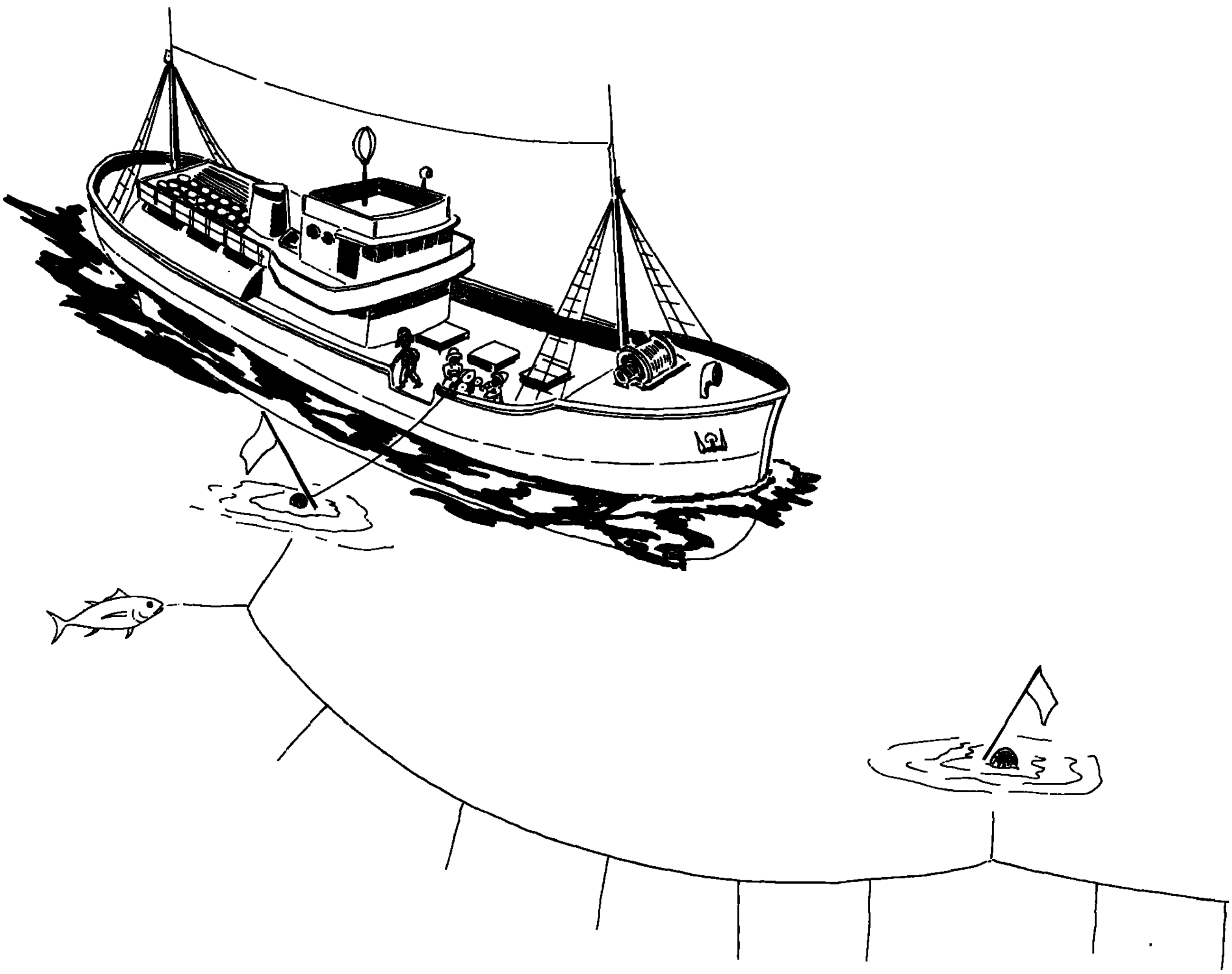


FIGURE 1.—Schematic representation of the longline fishing method used in the American Samoa-based fishery.

considerable fishing had already taken place as far south as lat. 28° S., in waters southeast of the Tonga Islands. The greatest expansion of grounds was in 1958, however, when vessels extended fishing eastward to the Marquesas Islands. In 1965, the vessels fished in an extensive area from the Equator to lat. 30° S. and from about long. 175° E. to about long. 120° W., an area of about 23 million square kilometers (6.7 million square nautical miles). Vessels have fished as far as 5,500 km. (3,000 nautical miles) from their base.

FISHING FLEET

Beginning in 1954 with 7 fishing boats contracted from Japan (a total of 16 different vessels participated in the fishery for varying periods during the year), the fleet in American Samoa has continued to increase over the years (fig. 3). Despite year-to-year fluctuations, the trend has been one of rapid increase; in 1965, 154 different vessels fished from American Samoa. The tremendous increase in fleet size in 1963 reflects the start of operations that year of the Star-Kist tuna cannery.

The composition of the fishing fleet, in terms of the country of origin of the vessels, has changed over the years. In the early years of the fishery, the entire fleet was Japanese. Vessels from the Republic of Korea began operating in the area in 1958 and vessels from the Republic of China in

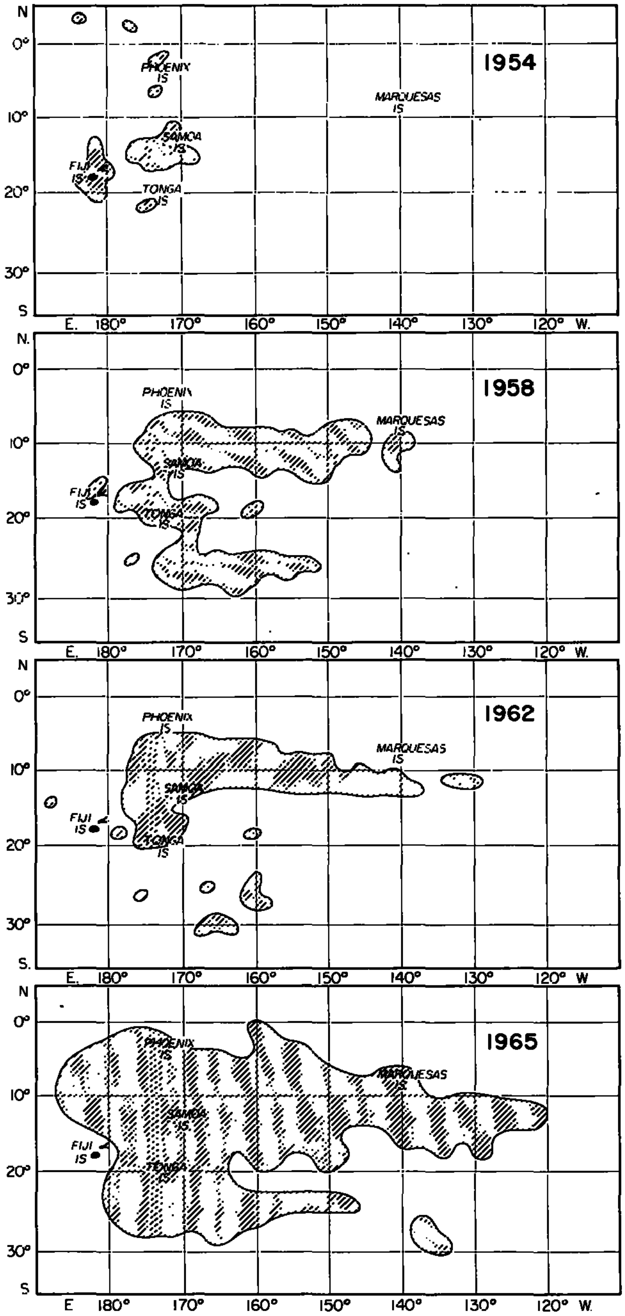


FIGURE 2.—Geographic expansion of fishing grounds of American Samoa-based vessels, 1954–65.

1964 (fig. 3). The 105-vessel fleet operating during the last quarter in 1965 had 62 vessels from Japan, 30 from the Republic of Korea, and 13 from the Republic of China.

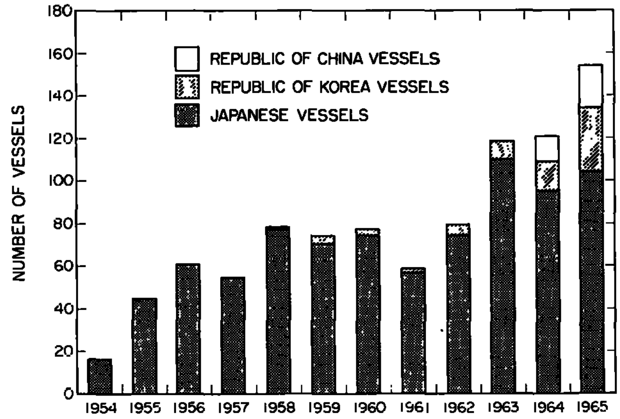


FIGURE 3.—Number of vessels in the American Samoa-based longline fishery, 1954–65.

SPECIES COMPOSITION OF THE LANDINGS

Albacore commands the highest price at the cannery and is, consequently, fished for selectively by the fleet. This selection occurs both by the choosing of areas in which albacore are most plentiful instead of areas with the greatest combined species catch and (on occasion) by the discarding of other species caught to conserve storage room for more albacore. Thus, the albacore catch alone is delivered in its entirety to the cannery.

Yellowfin tuna constitutes the second most important species delivered to the canneries, but makes up only about 15 percent of the weight of fish landed. Other species taken by the fishery include the bigeye tuna (*T. obesus*), southern bluefin tuna (*T. maccoyii*), skipjack tuna (*Katsuwonus pelamis*), wahoo (*Acanthocybium solandri*), and various billfishes, sharks, and other pelagic species. Because catches that are not kept for delivery are often not recorded, no reliable data are available on the apparent abundance of species other than the albacore.

ANNUAL AND SEASONAL LANDINGS OF ALBACORE[1]

The albacore landings by the American Samoa-based fleet have gradually increased from 338 metric tons in 1954 to 15,588 metric tons in 1965 (fig. 4). The upward trend was broken in 1961 and 1964, when landings smaller than those of the pre-

[1] Catch statistics in this report are based on dates of capture and may not agree with figures previously reported from this fishery, which were based on dates of delivery.

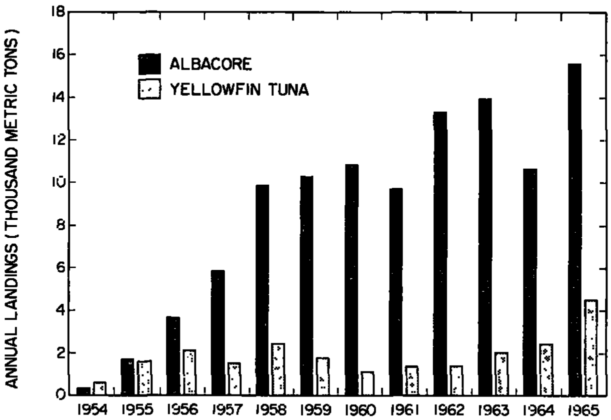


FIGURE 4.—Total annual albacore and yellowfin tuna landings in American Samoa, 1954–65.

ceding year were registered. Although yellowfin tuna was the dominant species landed in 1954 and in parts of 1955 and 1956, the albacore has dominated the catch since 1957.

Albacore are taken throughout the year (fig. 5). In most years for which we have data, slightly better landings have been made during the latter half of the year. In some years (e.g., 1961, 1963, 1964), however, no seasonal trend is evident.

APPARENT ABUNDANCE OF ALBACORE

Various indices of apparent abundance of albacore are examined in the following sections. These include catch per trip, catch per day, and catch per 100 hooks fished.

CATCH PER TRIP AS A MEASURE OF APPARENT ABUNDANCE

The apparent abundance of tunas taken by a longline fishery is generally measured by the catch per 100 hooks fished. We did not, however, begin to collect information on the number of days fished per trip until 1959 and did not begin to collect data on the number of hooks fished per day until 1963. We were compelled, therefore, to use the fishing trip itself as the unit of effort to indicate trends in apparent abundance of albacore for the entire period of existence of the American Samoa-based fishery.

Admittedly, the catch per trip is an inexact measure of apparent abundance because it is greatly influenced by changes in number of days fished

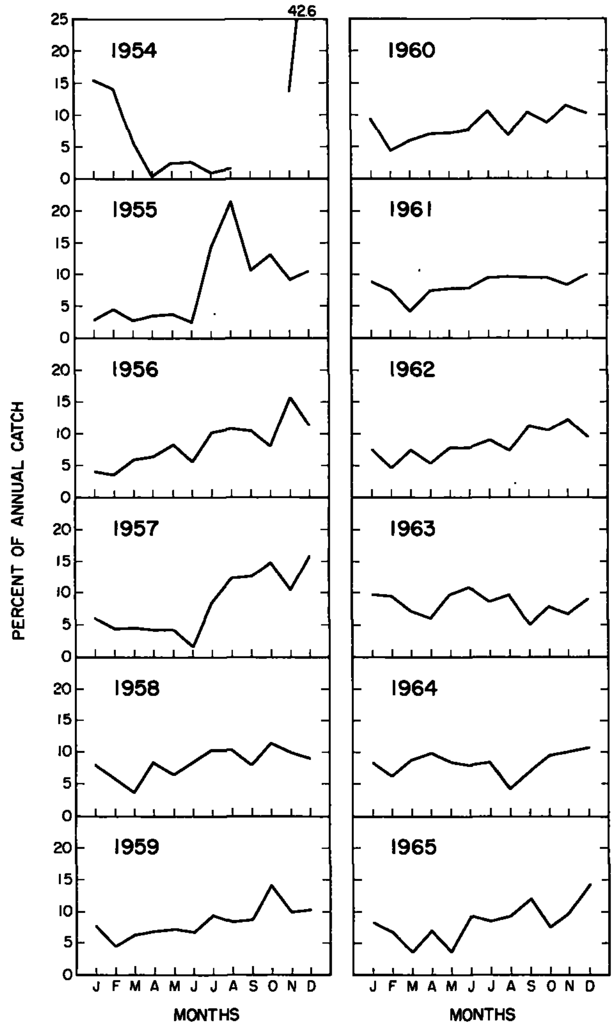


FIGURE 5.—The monthly catch of albacore, in percentages of annual total, by American Samoa-based vessels, 1954–65.

per trip and by size composition of vessels in the fleet. The average number of days fished per trip by the American Samoa-based vessels has, however, remained relatively steady from year to year, at least between 1959 and 1964 (fig. 6). As we show later, size composition of vessels also changed little during the entire 1954–65 period. Furthermore, the close relation between the monthly average catch per trip and the monthly average catch per day fished, assuming that catch per day is a more reliable index (fig. 7), indicates that the catch per trip is a satisfactory measure of apparent abundance.

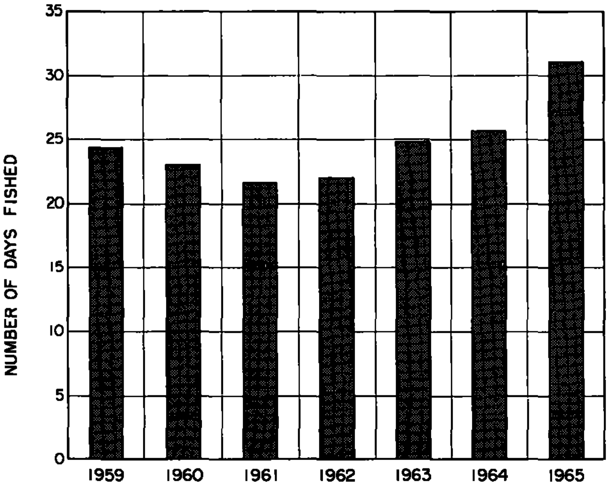


FIGURE 6.—Average number of days fished per trip by vessels based in American Samoa, 1959–65.

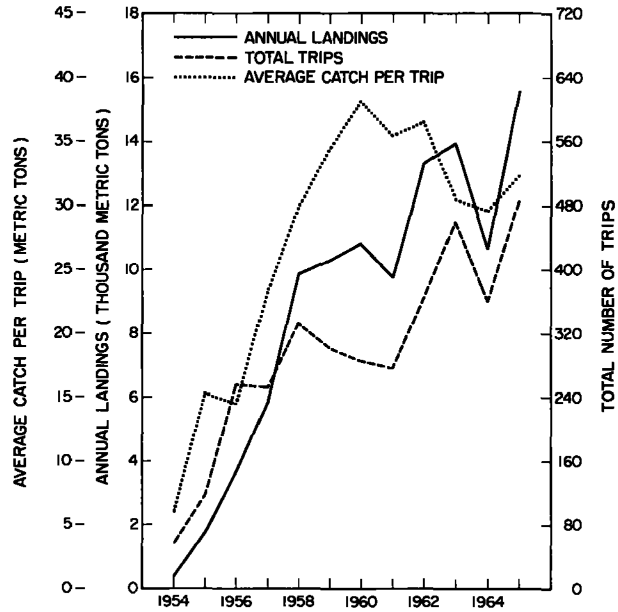


FIGURE 8.—Total annual number of fishing trips, average catch of albacore per trip, and annual albacore landings, by American Samoa-based vessels, 1954–65.

In figure 8 are shown the total number of fishing trips and the average catch of albacore per fishing trip, along with the annual landings of albacore, for 1954–65. Annual landings have fluctuated with fishing effort. Between 1958 and 1960, however, landings increased despite a decrease in fishing effort. This increase was due to increased average catch of albacore per trip during the period. The rather sharp decline in landings in 1964 resulted from the combined effects of a decrease in average catch per fishing trip and a drop in fishing effort.

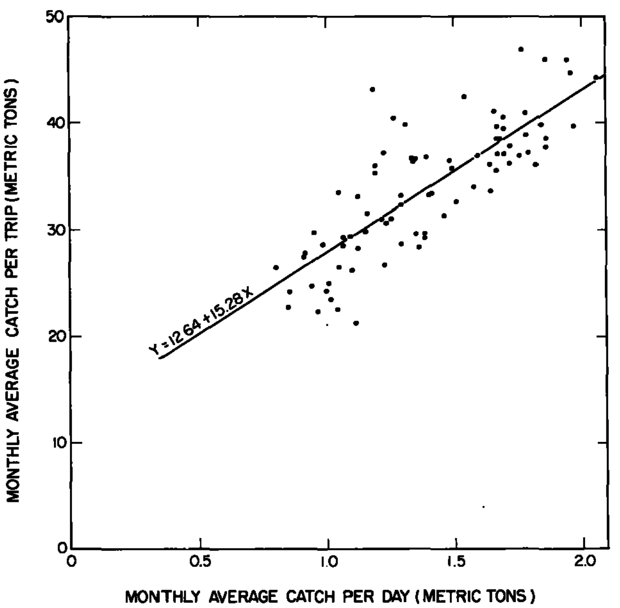


FIGURE 7.—Relation between monthly average catch of albacore per trip and monthly average catch per day by American Samoa-based vessels, 1959–65.

From 1954 through 1960 the catch per trip increased, then tapered off and stabilized at a lower level in 1963–64, and finally increased slightly in 1965. The upward trend in 1965 was attributable primarily to the increased length of the average trip (fig. 6). The catch per trip, in metric tons, averaged 35.7 in 1961–62, 30 in 1963–64, and 31.6 in 1965.

The total annual landings declined in 1964 although the size of the fleet had increased since 1963. The number of fishing trips, however, declined sharply, from 451 to 359, and the average number of days fished per trip increased only slightly, from 24.9 to 25.7 days.

The Japan Fisheries Agency (1966), in its publication of the 1963 Japanese tuna longline data, pointed to a rather marked decline in albacore catch rates throughout the South Pacific Ocean during 1963, with the possible exception of the "newer" grounds east of long. 130° W. (table 1). It noted that although fishing effort had increased 16 percent, from 58.2 million hooks fished in 1962 to 67.7 million in 1963, the catch of albacore had decreased 14 percent, from 2.1 million fish to 1.8 million. For example, in the western South Pacific between long. 150° E. and 180°, the catch rates decreased from 3.1 albacore per 100 hooks in 1962 to 1.9 in 1963, and in the central South Pacific (between 180° and 130° W., corresponding to the fishing grounds of the American Samoa-based vessels) the decrease was from 4.6 to 3.1 albacore per 100 hooks. Unlike the relatively low catch rate of 3.1 reported by the Japanese for 1963, our data from American Samoa-based vessels show an average of 4.9 albacore per 100 hooks for the year (fig. 9). This difference may possibly be attributable to a greater degree of selectivity for albacore on the part of the American Samoa-based vessels. The decrease in 1963, pointed out by the Japanese, is, however, paralleled by a similar decrease in our data on catch per trip beginning early in 1963.

TABLE 1.—*Japanese data on catch and effort for albacore in the South Pacific Ocean, 1962 and 1963*

[This table is based on table 10, Japan Fisheries Agency, 1966]

Fishing area	Number of hooks		Number of albacore		Catch per 100 hooks	
	1962	1963	1962	1963	1962	1963
	Millions	*Millions*	*Thousands*	*Thousands*	*Number of fish*	*Number of fish*
Long. 150° E.–180° Lat. 10°–30° S.	27.7	17.9	846.2	333.1	3.1	1.9
Long. 180°–130° W. Lat. 5°–30° S.	25.6	32.0	1,167.3	997.3	4.6	3.1
Long. east of 130° W. Lat. 10°–30° S.	4.9	17.8	122.3	437.7	2.5	2.5
Totals	58.2	67.7	2,135.8	1,768.1	3.7	2.6

Catch per 100 hooks is an index of apparent abundance in terms of numbers of fish, whereas catch per trip is measured in terms of weight of albacore taken. The decrease in the latter index in 1963, 1964, and part of 1965 was caused in large part by a decrease in the average size of albacore.

Though fluctuating greatly, the catch in numbers per 100 hooks from 1963 to 1965 did not show a marked downward trend. On the other hand, the same data, converted into catch in weight per 100 hooks (by using the monthly mean weight of albacore sampled from the fishery), showed a decreasing trend through 1965 (fig. 9). Several possible causes for the observed decrease in the size of the fish are discussed later.

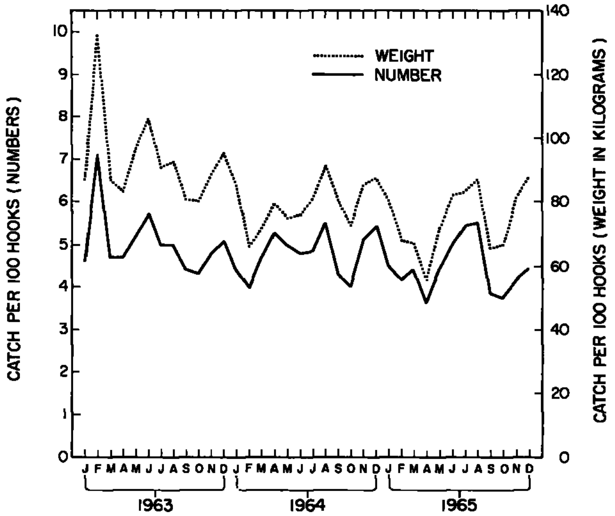


FIGURE 9.—Catch of albacore per 100 hooks, in numbers and in weight, by the American Samoa-based vessels, 1963–65.

RELATION BETWEEN CATCH AND EFFORT

The relation between annual total landings of albacore and total fishing effort (number of fishing trips) shown in figure 10, though seemingly linear, needs to be interpreted with caution, be-

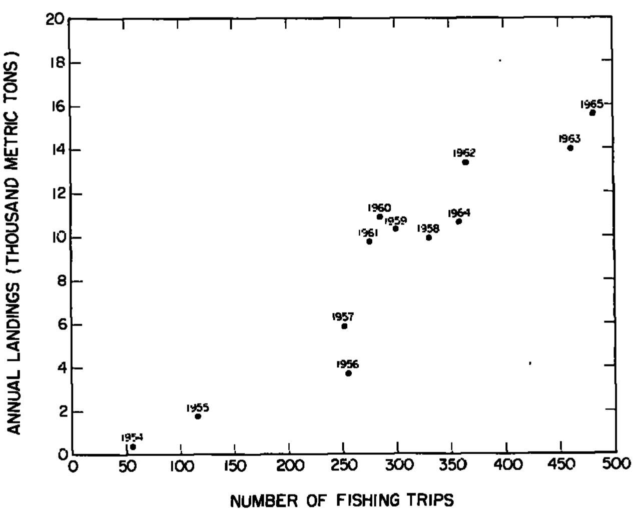


FIGURE 10.—Relation between annual total landings of albacore and total fishing trips of American Samoa-based vessels, 1954–65.

cause the data for the earlier years—particularly 1954 and 1955—are not strictly comparable with those of later years. As we already stated, fishing in the early stages of the fishery was aimed primarily at taking yellowfin tuna rather than albacore; thus, the catch of albacore per fishing trip was relatively small as compared with later years.

It is clear, however, that the annual landings of albacore have tended to increase with increasing fishing effort. Generally, it would be expected that the total catch would increase as fishing effort increases, until a point of maximum yield (not necessarily the point of optimum yield) is reached. After this point is reached, the catch would generally decrease despite further increase in effort. From the data presented in figure 10, it does not seem that the point of maximum yield of albacore has yet been reached in the American Samoa-based fishery. The extent of the growth potential, however, is a subject of another study—one which will require the analysis of all available South Pacific data, not merely those collected from the American Samoa-based vessels.

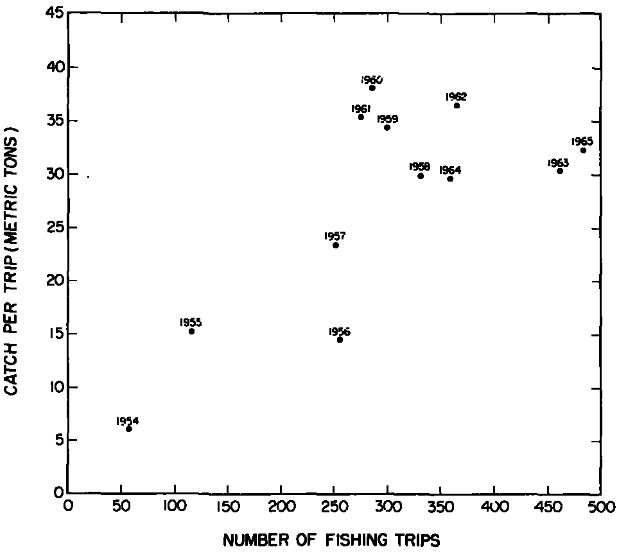


FIGURE 11.—Relation between average catch of albacore per trip and total fishing trips, of American Samoa-based vessels. 1954–65.

RELATION BETWEEN CATCH PER UNIT OF EFFORT AND EFFORT

The annual average catch per trip shows an apparent increase with increase in fishing effort (fig. 11). The catch per trip in 1963, 1964, and 1965, however, failed to increase at the rate seen before 1962. The data are far too few, however, to be conclusive.

VALIDITY OF CATCH PER 100 HOOKS AS MEASURE OF APPARENT ABUNDANCE

Under the assumption that the catch per 100 hooks is the better measure of apparent abundance of a species taken by the longline method, such data have been collected continuously since 1963. Estimates of abundance of fish based on catch per day or catch per trip might be influenced by the size of the fishing vessel. Although there seems to be no reason for believing that catch per 100 hooks would also be affected by vessel size, this question was examined inasmuch as it is conceivable that the larger vessels may be more attractive to fishermen than smaller vessels and, thus, may have a better choice of fishermen and fishing masters who would have the skill to catch more fish. If so, some efficiency factors would need to be incorporated in the use of catch per 100 hooks to adjust for differences among vessels.

A tabulation of albacore catch per 100 hooks by vessel sizes (gross tonnage) revealed a tendency for larger vessels to obtain higher catch rates than smaller vessels (table 2). In 1963, the smallest vessels (under 80 gross tons) averaged 4.6 albacore per 100 hooks, but catches trended upward to 5.8 albacore per 100 hooks for the vessels of 121 to 140 tons. The average catch rate was lower (5.1) for the largest vessels (those over 141 gross tons). In 1964, the trend, if any existed, was less obvious. To examine this apparent relation between vessel size and catch rate, the catch rate for each trip was plotted against vessel size for each of the 24 months. The scatter of points about the regression lines, fitted by the least squares method, was considerable; only the data for June and November 1963 and September 1964 showed statistically significant regressions ($P<0.01$). The data for these 3 months, however, were very heavily influenced by the results of a disproportionately small number of both the smallest and largest vessels in the fleet.

TABLE 2.—*Catch rates and fishing effort of American Samoa-based vessels*[1] *by vessel size groups, 1963 and 1964*

Item	Vessel size (tons)				
	<80	81–100	101–120	121–140	>141
Catch of albacore per 100 hooks:					
1963	4.6	4.9	5.1	5.8	5.1
1964	4.9	4.7	4.8	5.4	4.4
Number of fishing trips:					
1963	68	266	44	24	21
1964	23	171	59	27	36
Percentage of fishing trips:					
1963	16.1	62.9	10.4	5.7	5.0
1964	7.3	54.1	18.7	8.5	11.4

[1] Vessel-size data were not available for all vessels.

The higher average catch rates achieved by the larger vessels (121–140 gross tons) in 1963 and 1964, were probably due to the skill of the fishing master in selecting productive fishing grounds, or to subtle differences in fishing techniques rather than to vessel size alone. For example, the high average catch rate of 5.8 albacore per 100 hooks in 1963 was achieved by only six vessels, which rather consistently made good catches. One large vessel fished 2 months in 1963 with poorer than average results, but this vessel apparently left the American Samoa fishery soon thereafter.

Furthermore, the excellent performance of some of the smaller vessels also argues strongly against dependence of catch rates upon vessel size. A 60-ton vessel, for example, attained higher than average catch rates in 6 of the 9 months during 1963; its annual mean catch rate was 5.3 albacore per 100 hooks as compared with the average of 4.6 achieved by all vessels smaller than 80 gross tons.

It is, therefore, reasonable to conclude that catch rates (catch per 100 hooks) are not influenced by vessel size, and that they are valid indices of the apparent abundance of albacore.

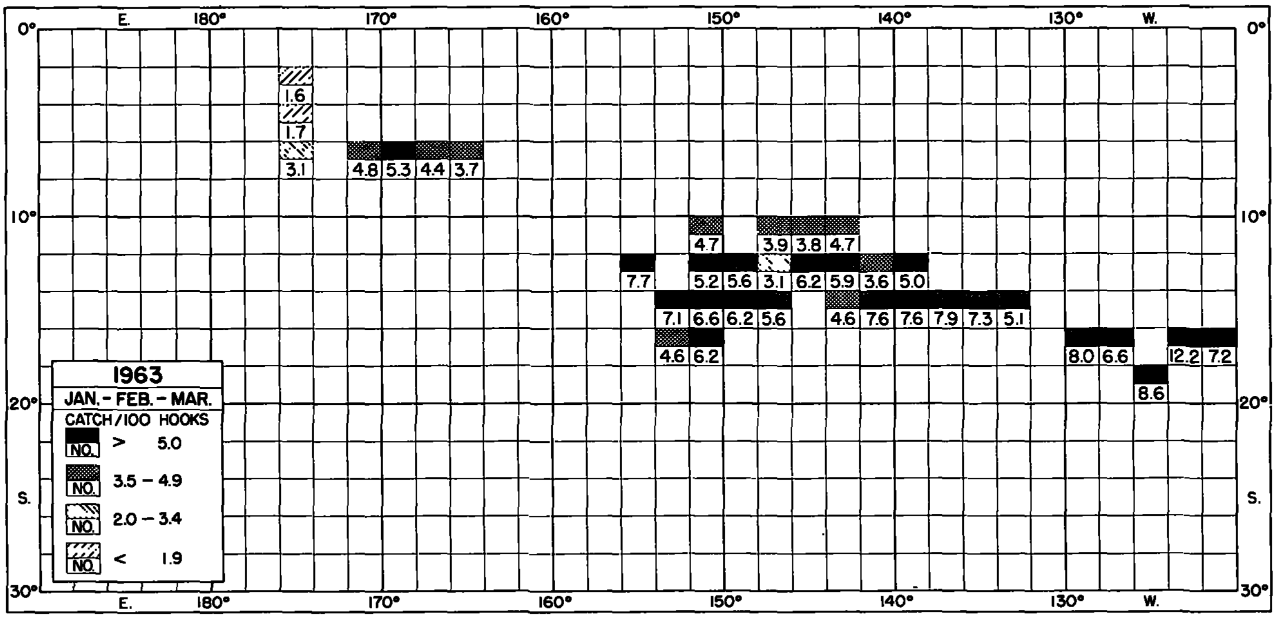
Although catch per day's fishing and catch per trip tend to increase with size of vessel, the fact that relatively few vessels in the fleet were larger than 120 tons or smaller than 80 tons enabled us to use average catch per trip as a gross index of apparent abundance for years in which data on catch per 100 hooks are not available. Fortunately, a very large proportion of the vessels in the American Samoa fleet has been those of about 100 tons during the period of this study.

SEASONAL AND GEOGRAPHIC VARIATIONS IN CATCH PER 100 HOOKS

The Nankai Regional Fisheries Research Laboratory (1959) has published charts of the average monthly albacore catch rate in each 1-degree square area fished in the Pacific and Indian Oceans by using all data available through March 1956. These charts are widely used today as representative of catch rates under average conditions. Koto (1966) published the average year's catch rates of albacore in the South Pacific Ocean by summarizing data obtained from the Japanese tuna longline fishery between January 1950 and December 1961. Many of the data from the American Samoa-based fishery are missing from both the above publications. For this reason and to make possible examination of the data for any time trends in catch per unit of effort, more recent data collected from the American Samoa-based vessels are presented in figures 12–14. The catch rates (catch of albacore per 100 hooks) have been averaged by quarterly periods for 1963, 1964, and 1965 and plotted by 2-degree square areas.

These charts depict the shifting of the fishing grounds during the year. The vessels from Samoa tend to fish north of lat. 20° S. during the first and second quarters, although a few vessels venture farther south to about lat. 28° S. Vessels tend to scatter widely beginning about June or July, and many boats fish between lat. 25° and 30° S. The southern grounds are heavily fished during the latter part of the year. In general, the fishing grounds are in the north during the first half of the year, and both north and south during the second half. This situation probably holds true in most years and may reflect the movements of albacore in the South Pacific Ocean. Interviews with fishermen indicate that catch rates in northern waters are more favorable during the early months of the year. Suzuki (1961), in recording his observations on the Samoa fishing operations in 1956, attributed the seasonal shifts in fishing grounds to movements of fish. He observed that most of the vessels fished in the vicinity of lat. 27° S. in August and September and then followed the northward movement of the fish.

Seasonal and geographical differences in catch rates are not readily evident from these charts. High catch rates (more than five albacore per 100



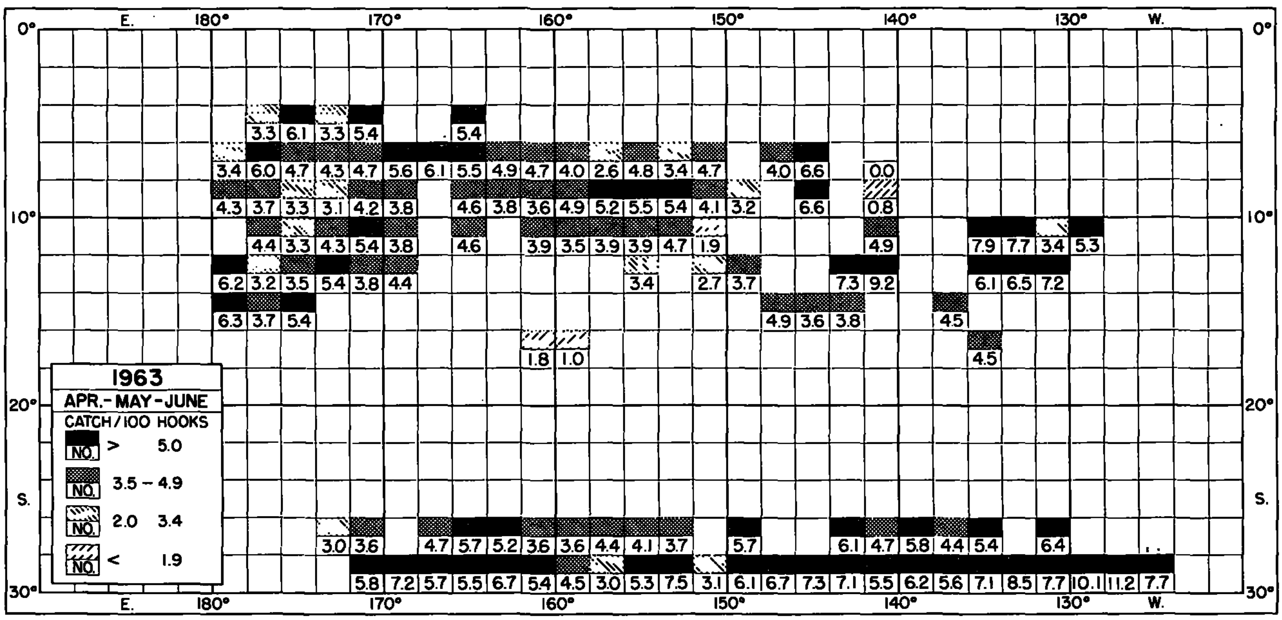
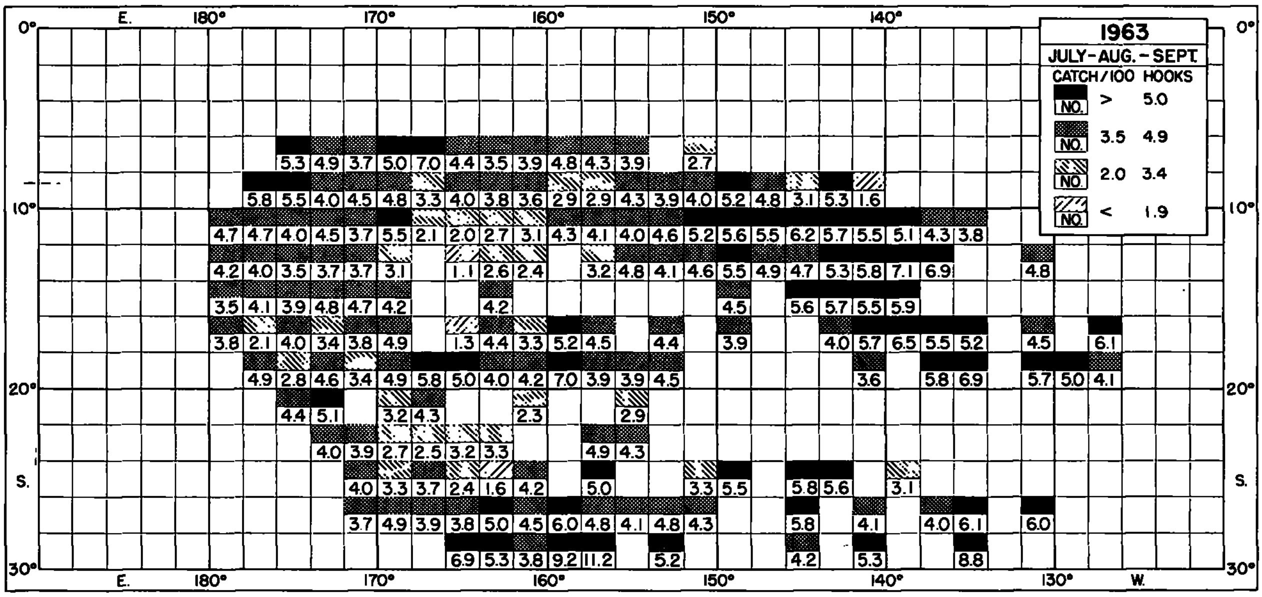
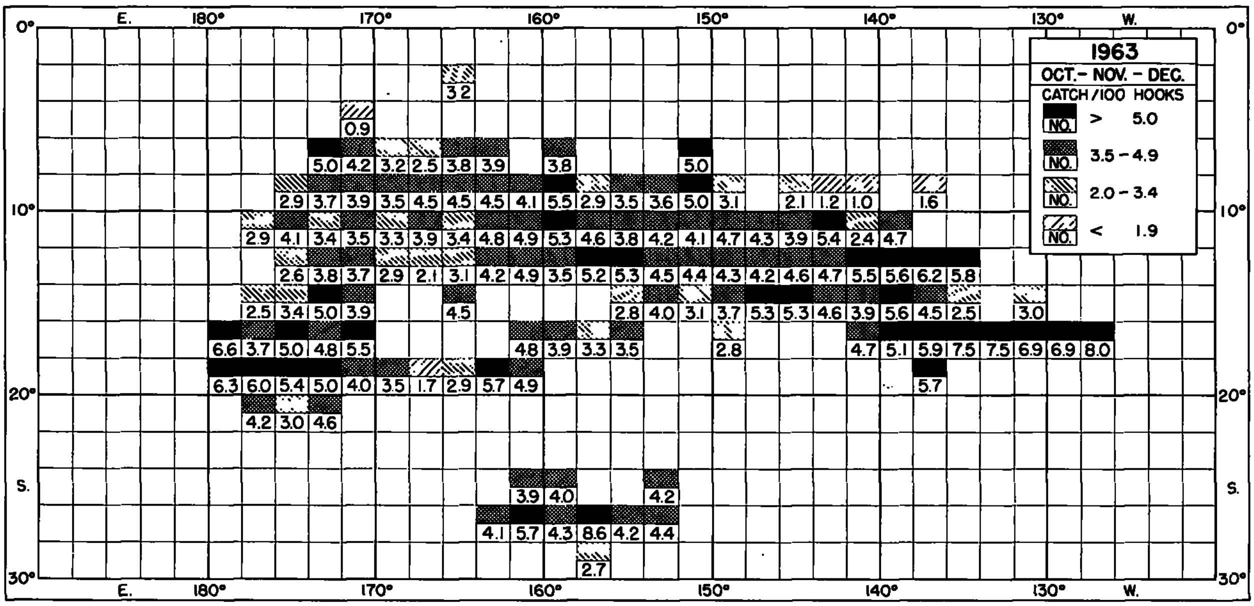
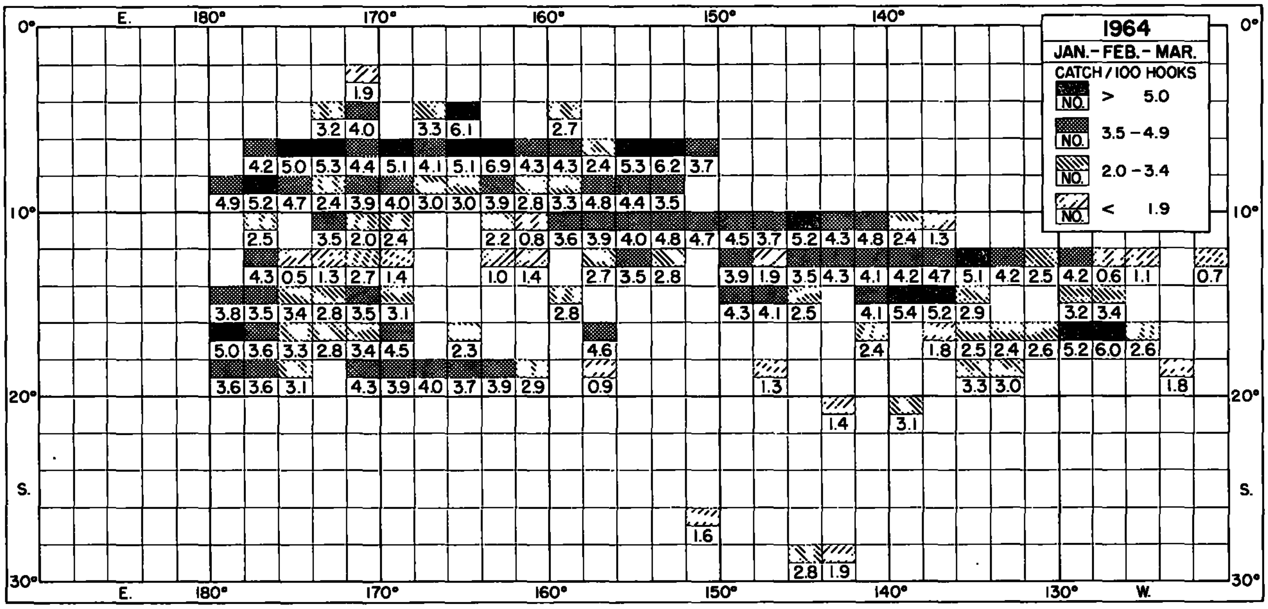


FIGURE 12.—The average catch rate (catch of albacore per 100 hooks) of American Samoa-based vessels shown by quarters of the year, 1963.


1963
JULY-AUG.-SEPT.
CATCH/100 HOOKS
NO. > 5.0
NO. 3.5 4.9
NO. 2.0 3.4
NO. < 1.9
E. 180° 170° 160° 150° 140° 130° W.
0° 10° 20° S. 30°


1963
OCT.-NOV.-DEC.
CATCH/100 HOOKS
NO. > 5.0
NO. 3.5-4.9
NO. 2.0-3.4
NO. < 1.9
E. 180° 170° 160° 150° 140° 130° W.
0° 10° 20° S. 30°



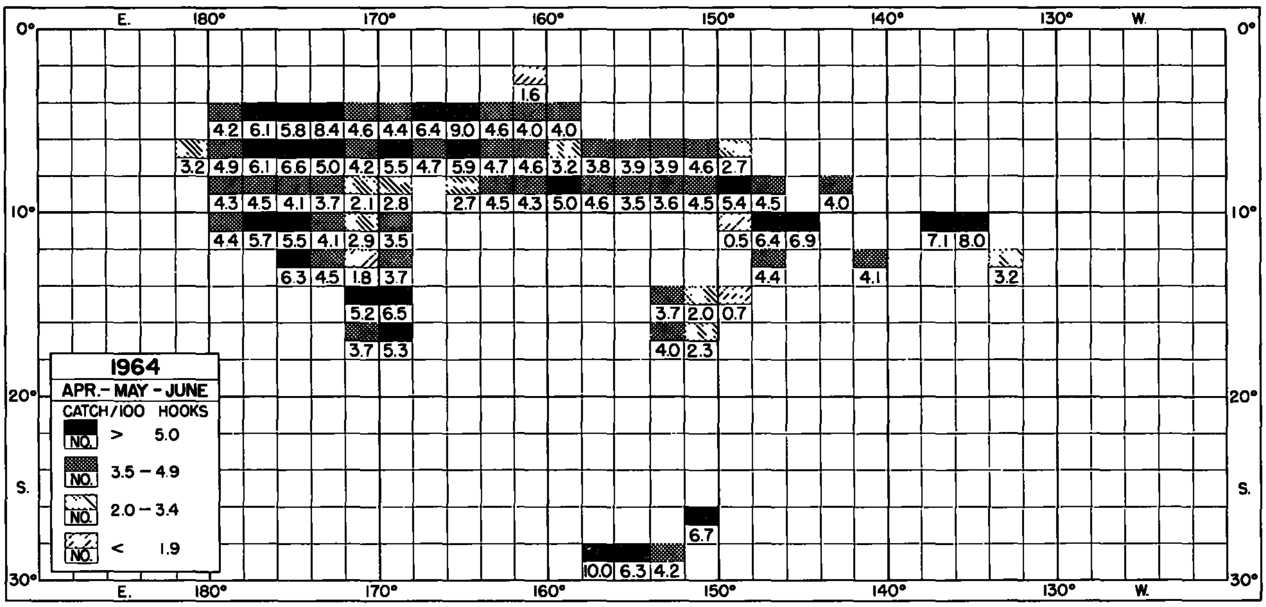
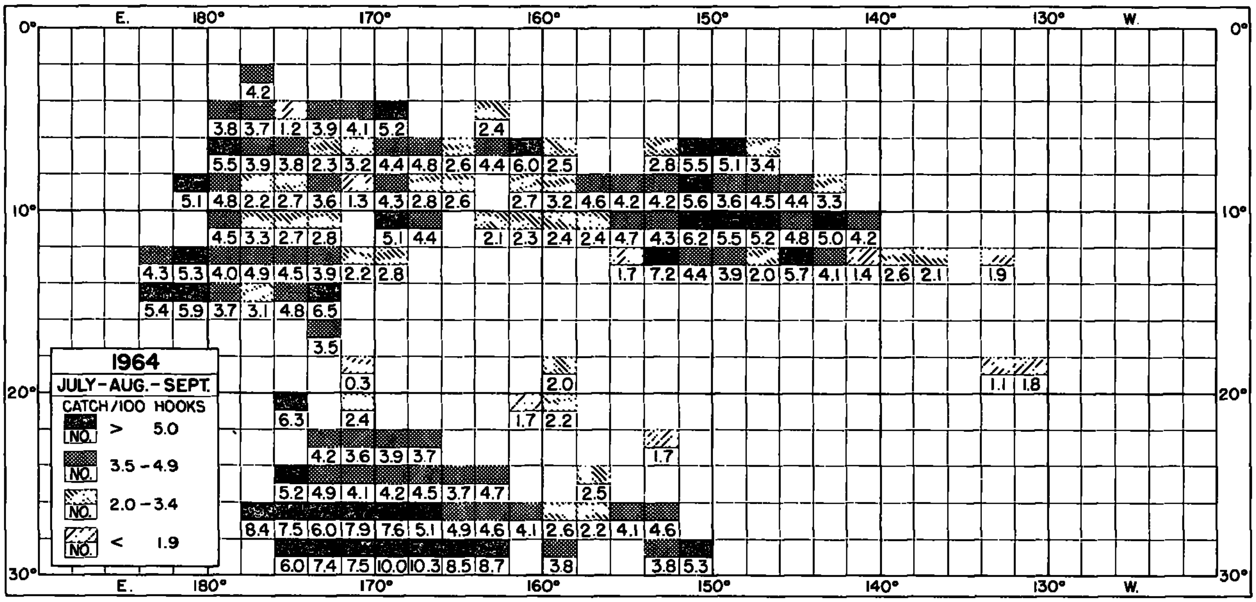
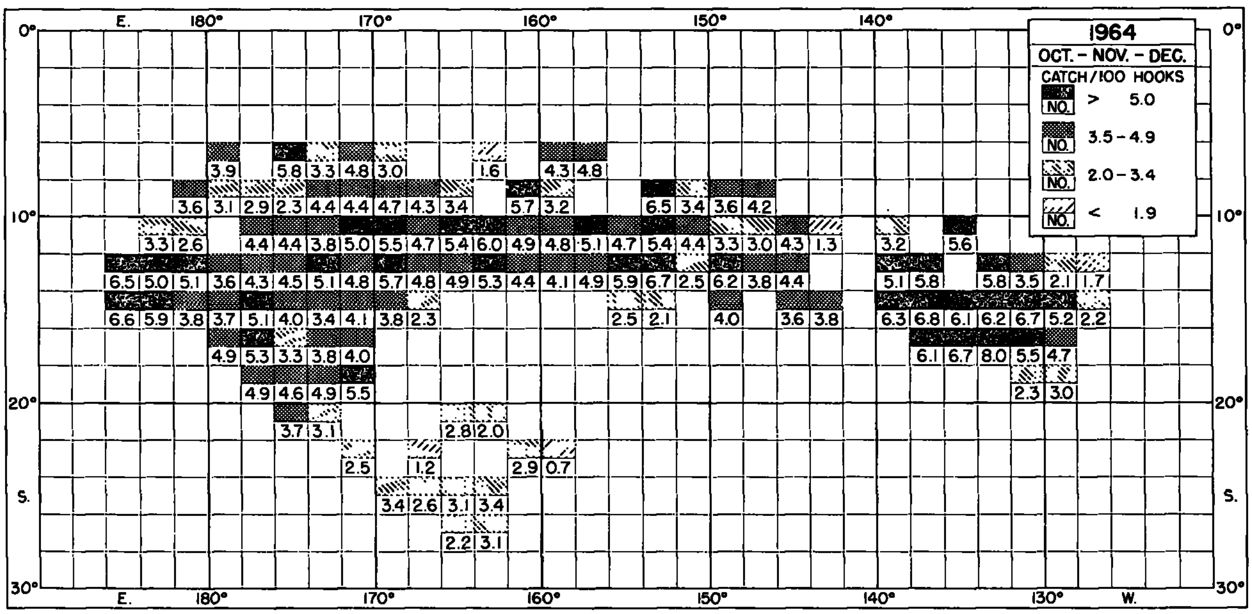


FIGURE 13.—The average catch rate (catch of albacore per 100 hooks) of American Samoa-based vessels shown by quarters of the year, 1964.


1964
JULY - AUG. - SEPT.
CATCH/100 HOOKS
NO. > 5.0
NO. 3.5 - 4.9
NO. 2.0 - 3.4
NO. < 1.9
E. 180° 170° 160° 150° 140° 130° W.
0° 10° 20° 30°


1964
OCT. - NOV. - DEC.
CATCH/100 HOOKS
NO. > 5.0
NO. 3.5 - 4.9
NO. 2.0 - 3.4
NO. < 1.9
E. 180° 170° 160° 150° 140° 130° W.
0° 10° 20° S. 30°

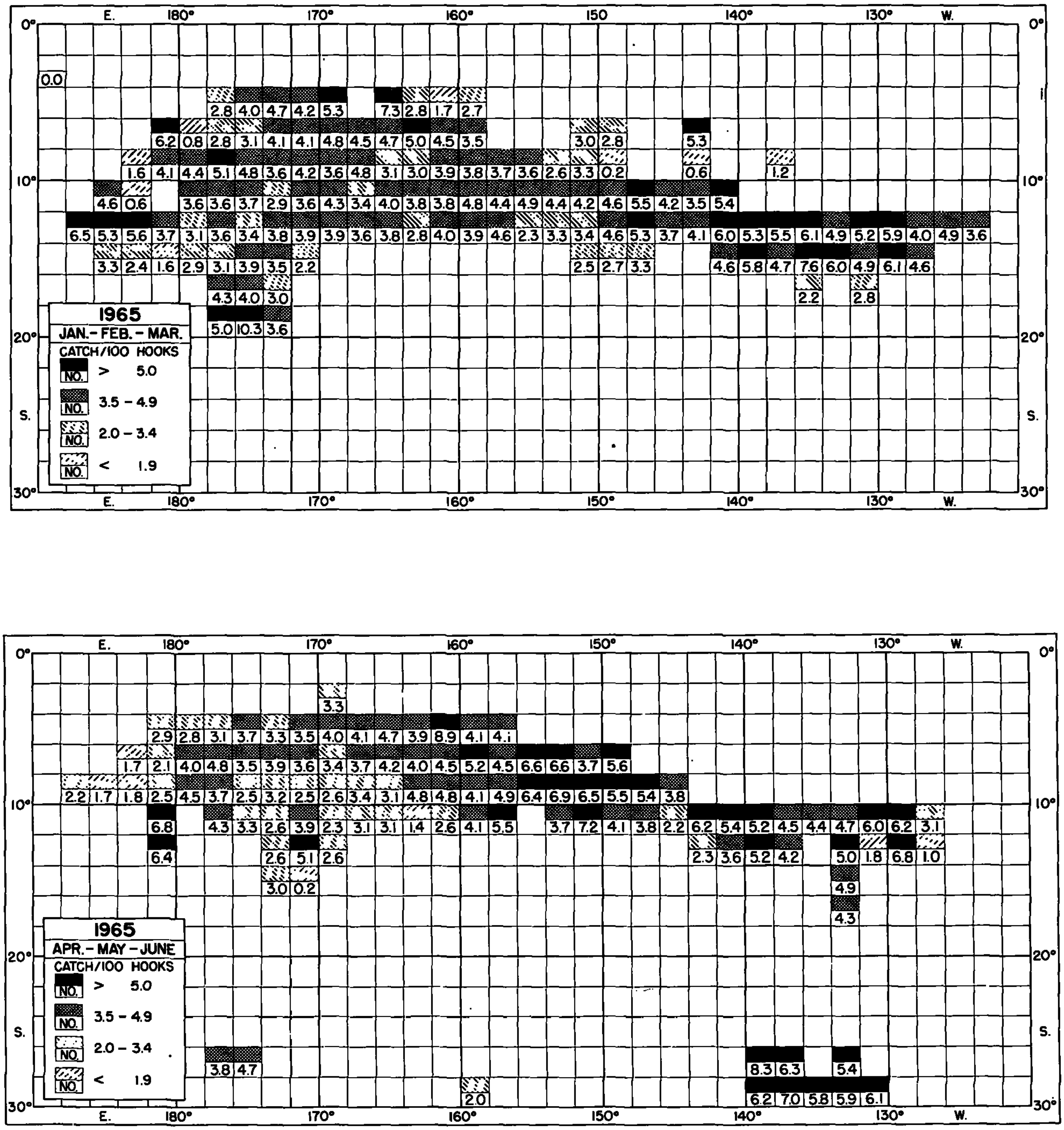
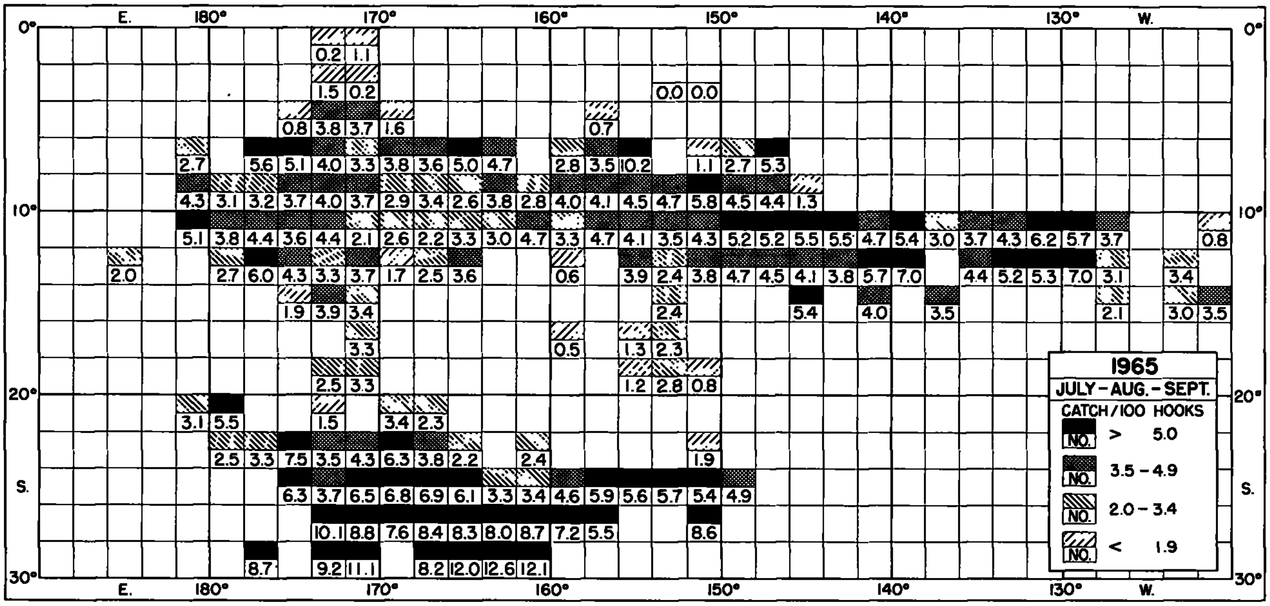
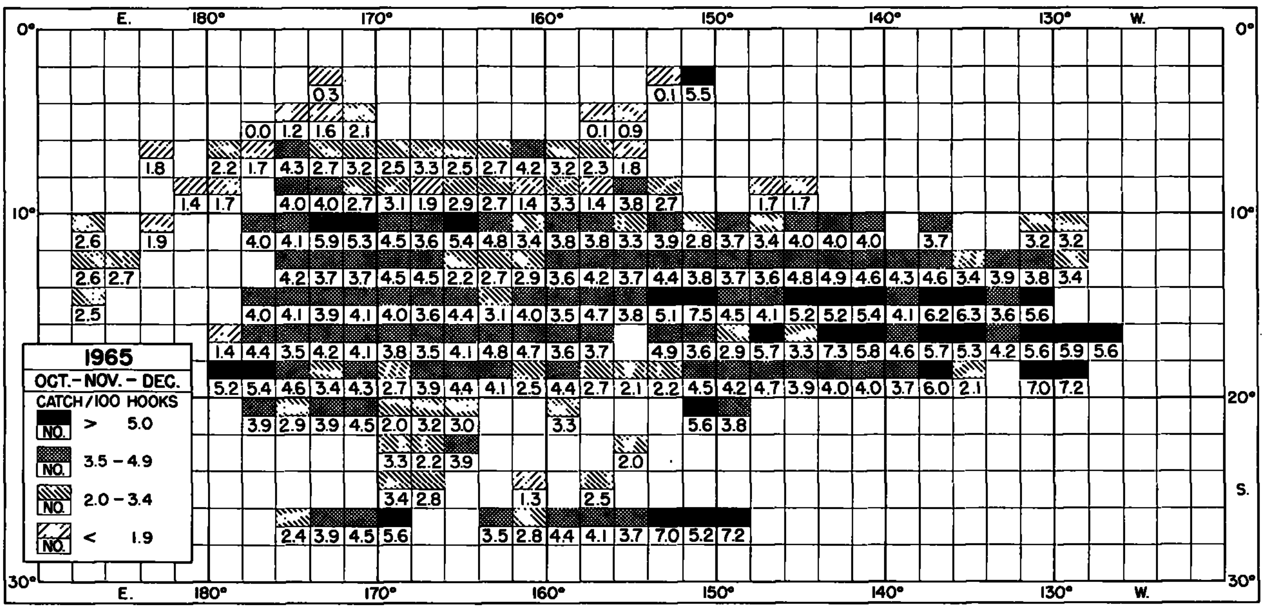


FIGURE 14.—The average catch rate (catch of albacore per 100 hooks) of American Samoa-based vessels shown by quarters of the year, 1965.


1965
JULY - AUG. - SEPT.
CATCH/100 HOOKS
NO. > 5.0
NO. 3.5 - 4.9
NO. 2.0 - 3.4
NO. < 1.9
0°
10°
20°
S.
30°
E.
180°
170°
160°
150°
140°
130°
W.


1965
OCT. - NOV. - DEC.
CATCH/100 HOOKS
NO. > 5.0
NO. 3.5 - 4.9
NO. 2.0 - 3.4
NO. < 1.9
0°
10°
20°
S.
30°
E.
180°
170°
160°
150°
140°
130°
W.

hooks) are scattered throughout the areas fished in all quarters of the year. A tabulation of the data by 5 degrees of latitude (table 3) indicates no well-defined seasonal and geographical differences. Average catch rates declined slightly, however, in 1965 as compared with 1963.

TABLE 3.—*Quarterly mean catch rates (number of fish per 100 hooks) of albacore and (in parentheses) the fishing effort (number of hooks) in the central and eastern South Pacific Ocean (long. 170° E. to 120° W.)*

[From data of American Samoa-based vessels]

Item	Latitudes (S.), west of long. 150° W.								Latitudes (S.), east of long. 150° W.						
	0°–5°	6°–10°	11°–15°	16°–20°	21°–25°	26°–30°	31°–35°	Mean	5°–10°	11°–15°	16°–20°	21°–25°	26°–30°	31°–35°	Mean
1963:															
Jan.–Mar.	3.5 (22,456)	...	6.0 (14,390)	5.4 (2,600)	...	...	...	5.0	...	5.8 (85,455)	7.6 (31,260)	...	...	...	6.7
Apr.–June	...	5.0 (1,019,395)	3.8 (151,765)	1.4 (3,080)	...	4.9 (263,370)	5.9 (9,000)	4.2	3.5 (22,786)	6.3 (86,780)	4.3 (7,935)	...	7.9 (295,362)	...	5.5
July–Sept.	...	4.3 (758,552)	4.4 (766,280)	4.4 (280,592)	4.1 (103,045)	5.2 (212,192)	...	4.5	5.2 (48,836)	5.7 (909,246)	4.1 (195,783)	5.5 (15,575)	5.2 (30.140)	...	5.1
Oct.–Dec.	1.1 (8,750)	4.3 (581,867)	4.5 (838,114)	4.4 (363,583)	4.4 (19,420)	4.4 (89,752)	...	3.9	1.7 (22,385)	5.2 (670,923)	5.7 (230,335)	...	...	...	4.2
Mean	2.3	4.5	4.7	3.9	4.3	4.8	5.9		3.5	5.8	5.4	5.5	6.6	...	
1964:															
Jan.–Mar.	1.5 (8,268)	4.4 (862,704)	3.4 (253,000)	3.3 (285,409)	...	1.6 (1,338)	...	2.8	...	4.3 (306,511)	4.1 (109,120)	.6 (3,838)	2.4 (4,296)	1.0 (6,000)	2.5
Apr.–June	2.3 (6,100)	5.0 (1,902,756)	4.6 (97,870)	4.7 (27,030)	...	7.0 (12,650)	...	4.7	4.6 (78,958)	4.6 (63,780)	...	...	...	...	4.6
July–Sept.	3.4 (15,158)	4.2 (347,279)	4.4 (299,406)	1.9 (3,830)	3.1 (111,030)	6.7 (536,836)	...	4.0	4.1 (73,908)	4.8 (164,804)	1.3 (9,120)	...	...	...	3.4
Oct.–Dec.	...	4.4 (167,910)	4.9 (1,706,235)	5.3 (141,804)	2.9 (47,896)	3.1 (20,172)	...	4.1	3.6 (43,866)	4.4 (191,028)	5.6 (279,708)	...	...	...	4.5
Mean	2.4	4.5	4.3	3.8	3.0	4.6	...	...	4.1	4.5	3.7	.6	2.4	1.0	
1965:															
Jan.–Mar.	3.9 (296,751)	4.2 (1,421,053)	3.8 (568,327)	4.2 (74,584)	...	...	...	4.0	2.0 (3,120)	5.0 (836,168)	2.4 (24,930)	...	...	...	3.1
Apr.–June	2.6 (74,692)	4.3 (2,708,555)	4.7 (137,720)	...	...	3.1 (6,420)	1.7 (1,620)	3.3	5.5 (124,124)	5.6 (242,129)	4.3 (3,120)	...	6.6 (172,690)	7.7 (13,836)	5.9
July–Sept.	2.7 (63,400)	4.0 (970,613)	3.8 (447,249)	2.6 (38,976)	4.5 (249,438)	8.0 (739,899)	...	4.3	3.3 (109,834)	4.8 (566,903)	2.0 (5,894)	4.9 (5,170)	5.0 (3,600)	...	4.0
Oct.–Dec.	.2 (22,420)	3.0 (380,594)	4.1 (910,555)	4.0 (1,327,684)	3.7 (100,038)	3.7 (111,977)	...	3.1	1.7 (1,458)	5.4 (699,574)	4.7 (518,535)	3.8 (2,700)	7.2 (11,230)	...	4.6
Mean	2.4	3.9	4.1	3.6	4.1	4.9	1.7	----	3.1	5.2	3.4	4.4	6.3	7.7	

To gage the abundance of albacore in areas not fished by the American Samoa-based vessels, some Japanese data were tabulated (table 4). Data for 1958–63 indicate that albacore are not as abundant in the western South Pacific Ocean, between long. 140° E. and 180°, as in areas fished by vessels from American Samoa. The catch rates, averaging less than two albacore per 100 hooks, are lower than those in more eastern waters. Perhaps some of the difference may be due to the selective fishing for albacore by American Samoa-based vessels, whereas in more western areas, the vessels from Japan may be fishing primarily for other species. Subtle differences in the fishing gear, such as in the lengths of the various lines, are known to affect the catch rates of albacore. It is probable, however, that these catch rates reflect the actual abundance of albacore in these areas.

Seasonally, the best catch rates in the western South Pacific are obtained in May through September. Latitudinally, the mean catch rates increase southward from the Equator, and the best catches are generally made between lat. 15° and 30° S. Koto (1966) found the best catch rates in the South Pacific during 1950–61 between lat. 10° and 30° S. and reported peaks of abundance along lat. 20° S. The catch rates south of lat. 30° S. were lower. In the areas fished by the American Samoa fleet, the catch rates are also low near the Equator but do not change as markedly from north to south. Generally, catch rates are also higher in the southernmost areas fished, between lat. 25° and 30° S.

TABLE 4.—*Pooled monthly mean catch rates of albacore (catch per 100 hooks) in the western South Pacific Ocean (long. 140° E. to 180°), 1958–63*

[From data provided by the Nankai Regional Fisheries Research Laboratory, Kochi, Japan, and those published by the Japan Fisheries Agency (1965, 1966)]

S. latitude	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
0°–5°	<0.1	0.1	1.2	0.2	0.2	0.3	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.7
6°–10°	.3	.4	.5	.6	.8	1.7	1.5	1.3	.7	.5	.4	.2	.9
11°–15°	1.7	1.6	1.5	2.3	2.1	2.5	2.9	2.4	2.2	1.6	1.3	1.0	1.3
16°–20°	2.3	1.3	1.1	2.5	3.0	2.2	2.8	3.0	2.7	2.7	1.9	2.2	2.9
21°–25°	1.0	.8	.0	1.1	1.3	3.8	4.2	4.1	2.8	1.6	1.2	1.4	1.3
26°–30°	.2		.0	1.0	3.5	4.5	4.6	4.0	3.1	1.9	1.2	.8	2.8
31°–35°	1.4			1.6	2.7	3.8	.9	.8	.9	1.2	2.3	2.6	1.8
36°–40°	.6				1.3	1.2	.8	.6	.7	.8	1.1	2.3	1.0
41°–45°			.3	1.2	1.2	.8	.7			.2	1.2	1.6	.9
46°–50°				.6	.2	.2							.3
Mean	.9	.8	.7	1.2	1.6	2.1	2.1	2.0	1.6	1.2	1.2	1.3	

In general, the distribution of albacore is continuous from west to east, at least between long. 140° E. and 120° W. in the South Pacific Ocean. A difference between the eastern and western South Pacific Ocean is in the apparent abundance of albacore; catch rates are lower in the western South Pacific Ocean.

SIZE OF ALBACORE

The albacore taken by the American Samoa-based fishery generally range from about 70 to 110 cm. long; 95 percent of the fish fall between 80 and 105 cm. (fig. 15). Among fish longer than 90 cm., males greatly outnumber females. The average length of albacore in 1965 was 88 cm. for females and 93 cm. for males.

CHANGES IN SIZE OF ALBACORE

In 2 of the 3 years during which length data were obtained, the mean length of fish declined sharply during February-April (fig. 16). This decrease could have resulted from shifts in fishing grounds, seasonal variation in fish sizes on the fishing grounds, or both. The trend toward a decrease in length from February 1964 to August 1965 may have been caused by the entry into the

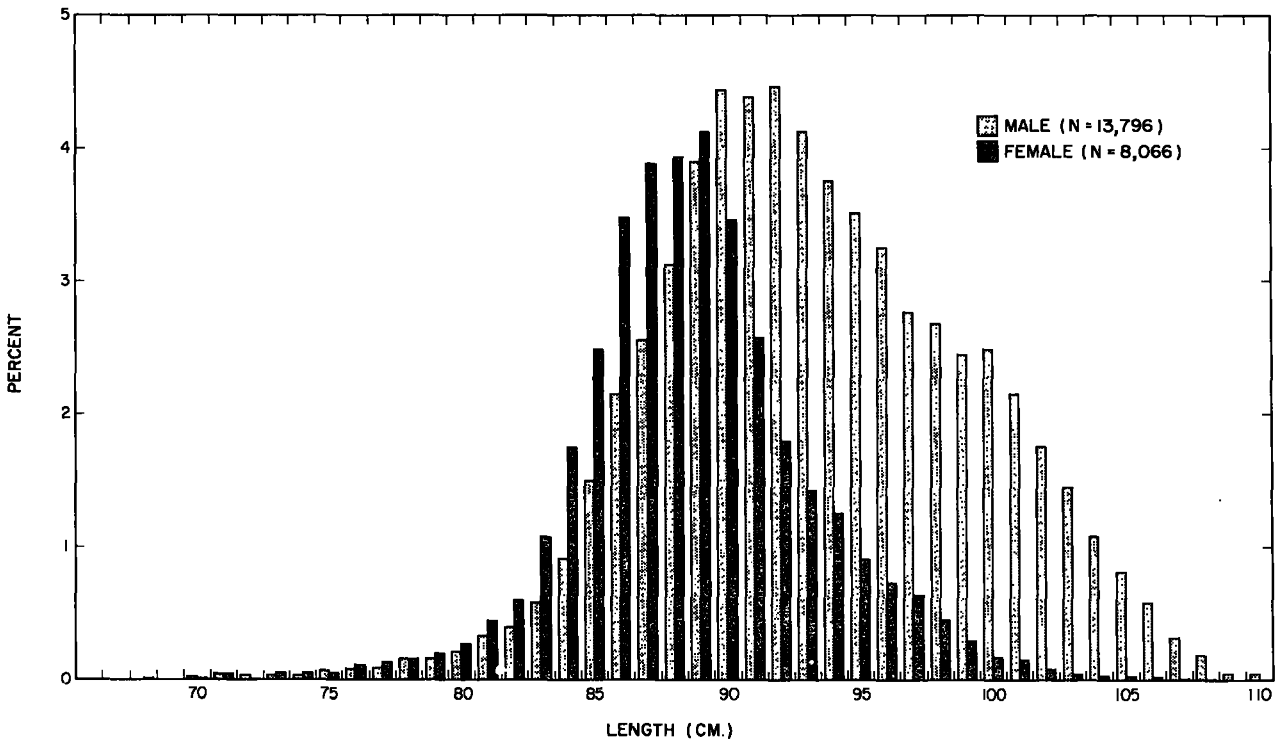


FIGURE 15.—Composite length-frequency distribution of albacore landed by the American Samoa-based longline vessels during 1965.

323-489 O - 69 - 5

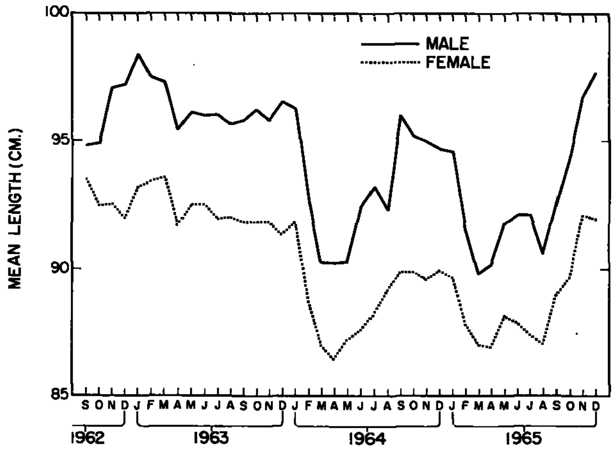


FIGURE 16.—Monthly mean lengths of albacore landed at American Samoa, September 1962 to December 1965.

fishery of an abundant year class or by a general decrease in the abundance of the older, larger fish in the stock. To determine if either of these factors might contribute to the decrease in mean length during February–April, we shall examine the size data in more detail.

DIFFERENCES IN FISH SIZE BY LATITUDE AND LONGITUDE

The mean length of albacore taken within 5-degree latitudinal bands (fig. 17) tends to increase from north to south. The fish are smallest near the Equator and largest at lat. 20° to 25° S. Albacore tend to be small again south of 25° S. These results are in general agreement with the findings of Honma and Kamimura (1957), although in contrast to these workers, we did not observe any significant increase in the size of albacore to the north of lat. 10° S. with the exception of 1963.

No longitudinal trend is noticeable. Honma and Kamimura found a general tendency for the size of albacore to increase from west to east. These authors, however, examined data from the western South Pacific between long. 140° E. and 170° W.,

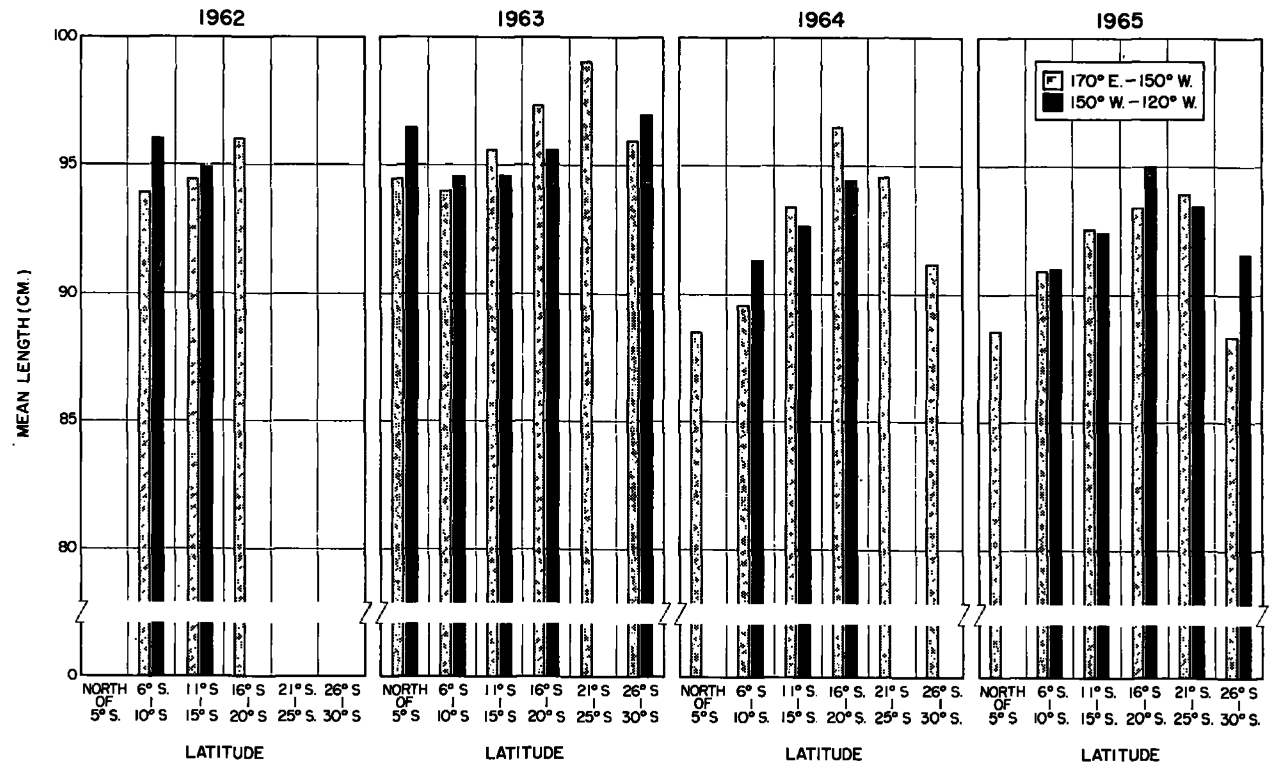


FIGURE 17.—Annual mean lengths of albacore (sexes combined) taken by the American Samoa-based vessels, by latitudes, 1962–65.

whereas our data cover a different segment of the ocean, from long. 170° E. to 120° W.

SIZE CHANGES DUE TO SHIFTS IN FISHING GROUNDS

Since average fish size is known for each area, it is possible to determine to what extent selection of fishing ground is responsible for changes in fish sizes in the landings. The shifting of the fishing effort from one area to another is readily seen (table 5). The regular shift of fishing grounds in 1964 and 1965 accounted for a large measure of the size changes in the landings. The average size of albacore decreased in March and April of both years when nearly all of the catches came from the area north of lat. 10° S. where the fish are smaller. For example, when the average size first began to decrease in February 1964, 68.7 percent of the catch was made between 6° and 10° S., where the albacore are small. During March, April, and May, when the average sizes were smallest of the entire year, 84.8, 93.5, and 93.0 percent, respectively, of the landings came from this area. The sizes gradually increased as fishing shifted to other areas. The same situation was repeated in 1965. In contrast, fishing was less concentrated in these northernmost waters during the early months of 1963. In March, April, and May, for example, only 20.0, 73.0, and 70.3 percent, respectively, of the landings came from lat. 6° to 10° S.

TABLE 5.—*The monthly mean length of albacore, and (in parentheses) the estimated percentage of the total catch from each locality by American Samoa-based vessels, shown by 5 degrees of latitude in the central South Pacific*

Item	Latitudes (S.), west of long. 150° W.						Latitudes (S.), east of long. 150° W.					
	North of 5°	6°–10°	11°–15°	16°–20°	21°–25°	26°–30°	North of 5°	6°–10°	11°–15°	16°–20°	21°–25°	26°–30°
1963:												
January	—	96.1 (10.7)	95.9 (38.4)	95.8 (14.3)	—	—	—	—	95.8 (25.0)	94.7 (8.3)	92.1 (1.5)	93.0 (1.7)
February	—	96.5 (25.0)	95.9 (32.1)	96.4 (25.0)	—	—	—	—	96.7 (17.9)	—	—	—
March	96.0 (5.0)	96.8 (20.0)	96.3 (20.0)	96.3 (25.0)	—	—	96.4 (5.0)	95.0 (10.0)	—	96.4 (15.0)	—	—
April	92.9 (2.5)	93.8 (73.0)	95.2 (2.5)	—	—	—	—	94.9 (14.3)	94.4 (5.1)	—	—	100.1 (2.5)
May	—	94.0 (70.5)	95.3 (3.1)	—	—	—	—	94.5 (2.0)	94.5 (3.1)	—	—	97.8 (21.5)
June	—	93.4 (40.7)	95.5 (14.9)	—	—	96.4 (20.2)	—	92.3 (4.0)	—	—	—	95.4 (2.2)
July	—	93.6 (50.0)	96.5 (3.6)	99.7 (10.7)	—	—	—	—	94.9 (21.4)	97.1 (10.7)	—	94.8 (3.6)
August	—	93.7 (19.5)	95.8 (34.1)	100.2 (2.4)	98.9 (2.4)	96.0 (2.4)	—	94.2 (2.4)	94.2 (29.2)	95.4 (7.3)	—	—
September	—	94.5 (31.0)	94.2 (6.9)	98.5 (10.3)	97.8 (6.9)	95.6 (3.4)	—	94.4 (3.4)	93.8 (37.9)	—	—	—
October	—	94.9 (19.3)	95.1 (19.3)	96.8 (9.7)	101.8 (3.2)	94.6 (6.5)	—	95.1 (6.5)	94.5 (32.3)	96.2 (3.2)	—	—
November	—	93.2 (31.5)	95.7 (19.6)	98.0 (4.6)	—	—	—	—	96.4 (31.7)	94.7 (12.5)	—	—
December	—	92.6 (35.4)	92.9 (5.6)	97.7 (30.9)	—	—	—	—	93.9 (8.4)	95.0 (19.6)	—	—
1964:												
January	—	92.5 (22.4)	94.9 (14.5)	96.8 (42.7)	—	—	—	—	93.8 (20.4)	—	—	—
February	—	90.3 (68.7)	94.9 (3.5)	96.5 (10.4)	—	—	—	—	92.9 (17.4)	—	—	—
March	89.2 (6.1)	88.7 (84.8)	—	—	—	—	—	87.8 (3.0)	92.5 (3.0)	95.2 (3.0)	—	—
April	—	88.9 (93.5)	94.1 (3.2)	—	—	—	—	—	88.9 (3.2)	—	—	—
May	—	88.7 (93.0)	—	—	—	90.6 (3.5)	—	90.0 (3.5)	—	—	—	—
June	87.8 (3.3)	90.2 (70.0)	90.4 (3.3)	95.5 (3.3)	—	—	—	91.5 (10.0)	91.2 (10.0)	—	—	—
July	—	90.7 (35.7)	96.0 (19.5)	97.7 (1.9)	—	87.9 (23.4)	—	91.9 (11.7)	92.3 (7.8)	—	—	—
August	—	89.6 (27.6)	94.2 (13.8)	—	89.3 (6.9)	91.0 (34.5)	—	92.3 (13.8)	93.6 (3.4)	—	—	—
September	—	91.8 (5.1)	95.2 (30.8)	—	95.1 (28.2)	94.4 (25.6)	—	92.9 (5.1)	91.3 (5.1)	—	—	—
October	—	92.2 (15.4)	92.9 (57.7)	98.2 (3.8)	97.0 (3.8)	95.8 (3.8)	—	91.0 (3.8)	91.0 (3.8)	93.7 (7.7)	—	—
November	—	91.0 (9.9)	92.6 (71.6)	95.4 (8.6)	—	—	—	—	94.0 (3.3)	95.1 (6.6)	—	—
December	—	90.7 (7.6)	92.9 (73.5)	95.0 (7.6)	—	—	—	—	93.9 (7.6)	93.5 (3.8)	—	—
1965:												
January	—	91.1 (16.8)	94.3 (23.5)	93.1 (16.8)	—	—	—	92.1 (2.8)	93.2 (40.1)	—	—	—
February	—	89.6 (63.3)	87.4 (3.3)	—	—	—	—	90.0 (3.3)	92.1 (30.0)	—	—	—
March	—	87.7 (88.9)	—	—	—	—	—	—	92.1 (11.1)	—	—	—

TABLE 5.—*The monthly mean length of albacore, and (in parentheses) the estimated percentage of the total catch from each locality by American Samoa-based vessels, shown by 5 degrees of latitude in the central South Pacific*—Continued

Item	Latitudes (S.), west of long. 150° W.						Latitudes (S.), east of long. 150° W.					
	North of 5°	6°–10°	11°–15°	16°–20°	21°–25°	26°–30°	North of 5°	6°–10°	11°–15°	16°–20°	21°–25°	26°–30°
1965—Continued												
April	87.6	88.9										
	(22.0)	(78.0)										
May	89.8	89.9	91.7					90.5				92.9
	(8.0)	(60.0)	(4.0)					(24.0)				(4.0)
June		90.0	94.6			88.4		91.2	90.8			90.2
		(60.5)	(4.9)			(7.4)		(4.9)	(17.3)			(4.9)
July	89.0	91.2	97.2	83.6		84.5		91.4	91.3			
	(3.1)	(37.5)	(6.3)	(3.1)		(15.6)		(18.7)	(15.6)			
August	87.1	90.0	87.3	90.3	89.5	85.8			91.9			
	(3.0)	(33.3)	(6.1)	(3.0)	(21.2)	(18.2)			(15.2)			
September	89.5	89.9	93.3	94.7	91.5	89.6		90.6	91.2	90.4	92.4	
	(6.8)	(13.7)	(11.0)	(2.0)	(33.3)	(13.7)		(2.0)	(9.8)	(3.9)	(3.9)	
October		91.0	91.5	97.6	96.7	89.0			92.5		94.5	
		(40.5)	(13.5)	(13.5)	(8.1)	(2.7)			(18.9)		(2.7)	
November		93.3	94.5	97.1	98.0	92.6			93.8	98.1		
		(11.4)	(25.0)	(38.6)	(2.3)	(2.3)			(18.1)	(2.3)		
December		97.9	94.0	97.5					94.6	96.5		
		(2.1)	(25.0)	(43.7)					(10.4)	(18.8)		

In spite of the widespread knowledge among fishermen that fish are smaller in the more northern waters (north of lat. 15° S.), they persist in fishing these waters during February–May because of their belief that the higher catch rates will more than compensate for the smaller sizes of fish. Fishing effort was concentrated in these waters during the early months of both 1964 and 1965. This type of selection has undoubtedly contributed to the general size decrease of albacore in the landings in those two years.

SEASONAL VARIATION IN FISH SIZES

Although we can generalize that sizes of albacore change with latitude, seasonal variation in sizes within the same areas is also considerable. For example, the average sizes of albacore taken from the area between lat. 6° and 10° S. were smallest during February–May in both 1964 and 1965, as compared with the rest of the year (fig. 18). The decrease in size may be explainable to a large extent by the fact that the vessels concentrate their fishing north of 10° S. where the fish are smaller; this effect on fish size is further aggravated by the coincidental presence of smaller fish in the area at that particular time of the year.

DECREASE OF OLDER FISH IN STOCK

Albacore taken in 1964 and 1965 were shorter on the average than those caught in 1963 and perhaps earlier (figs. 16 and 17 and table 5). This decrease in size may be attributable, at least in part, to an actual decrease of older, larger fish in the stock. A decrease of this magnitude might be expected when a stock undergoes exploitation, because increasing fishing mortality over the years increases total mortality. As total mortality increases, the average age and, thus, the average size of the stock must decline.

EFFECT OF ABUNDANT YEAR CLASS ON SIZE COMPOSITION

Numbers of larger fish of both sexes decreased from September 1962 to about May 1965, while smaller fish (<90 cm.) tended to increase (figs. 19 and 20). Superimposed on this general increase of smaller fish was an abrupt, exceedingly large increase beginning around February 1964. This rise of apparent abundance of smaller fish suggests the possibility of the entry into the fishery of an abun-

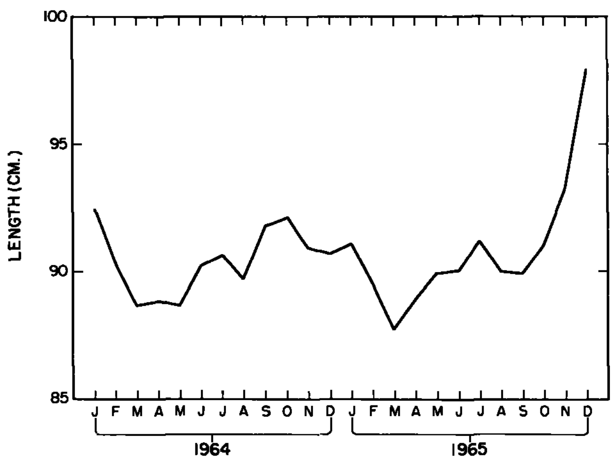


FIGURE 18.—The monthly mean length of albacore (sexes combined) taken by American Samoa-based vessels in the area 6° to 10° S., 170° E. to 150° W., in 1964 and 1965.

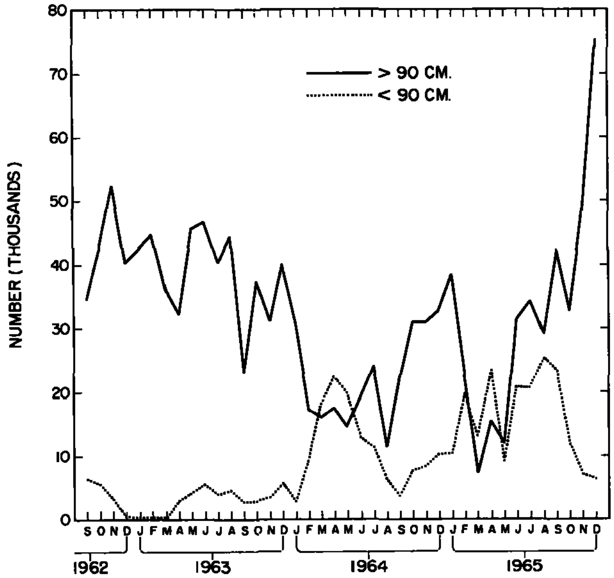


FIGURE 19.— Estimated numbers of two size categories of male albacore landed by the American Samoa-based fishery, September 1962 to December 1965.

dant year class. If so, we would expect that the numbers of larger fish—those longer than 90 cm.—would increase as this large year class moved through the fishery. Such an increase is indicated by the data. The abrupt increase in small fish in February 1964 was followed by an increase in larger fish toward the latter part of 1964. Near the end of 1964 and in early 1965, an increase in the number of small fish of both sexes was followed by an increase in longer fish a few months later.

A large part of this change in size composition is attributable to shifts of fishing grounds, as discussed previously. Year-class strength, however, is

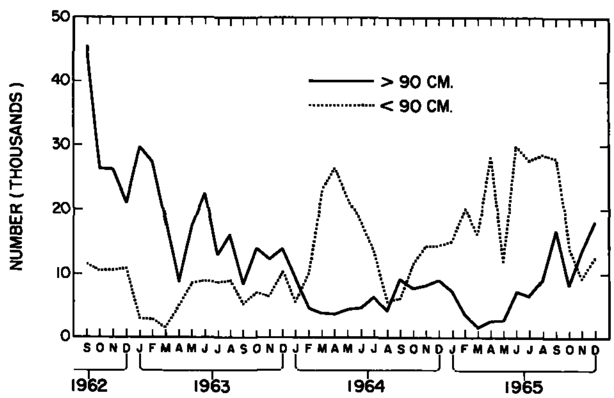


FIGURE 20.—Estimated numbers of two size categories of female albacore landed by the American Samoa-based fishery, September 1962 to December 1965.

probably also an important contributor to the apparent changeover in size composition during the 3-year period. Analysis of data from a few more years would clarify this question.

SEX RATIO OF ALBACORE

Changes in sex ratio could also affect the size composition of the landings since the monthly mean lengths of male albacore are from 1 to 6 cm. greater than those of females.

The proportion of males in the total landings (fig. 21) has fluctuated greatly without noticeable trend over the years. On the other hand, the proportion of males among the larger fish (>90 cm.) increased through September 1964, after which it tended to level out.

Although males averaged around 62 percent of the monthly landings between September 1962 and December 1965, their percentage did decrease in 1964 and 1965 during periods corresponding to months of reduced mean sizes (i.e., February–June 1964, February–August 1965). Though the mean lengths of both sexes decreased simultaneously during these months (fig. 16), the coincidental re-

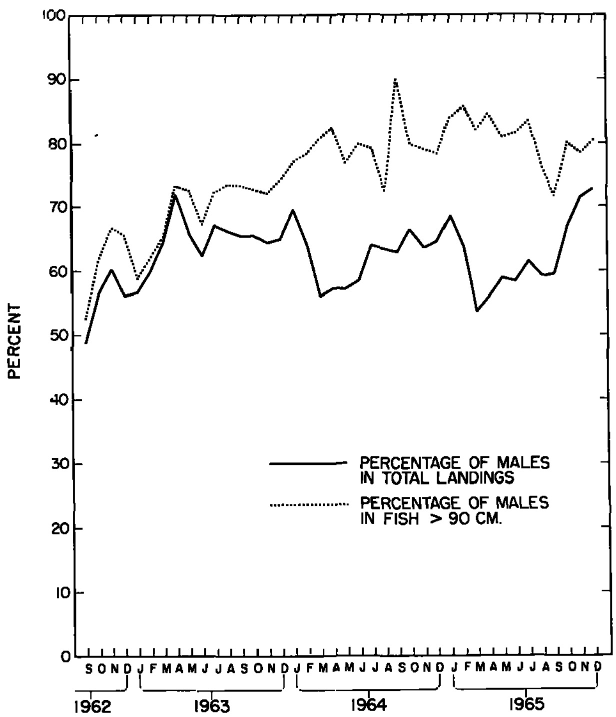


FIGURE 21.—Monthly sex ratio of albacore landed by the American Samoa-based vessels.

duction in the proportion of males has acted to amplify the general size decrease. This influence was reflected in the decreased catch per 100 hooks (by weight) during these months (fig. 9).

SUMMARY

1. This report is based on (a) data on landings provided by the two tuna packing firms operating in American Samoa, (b) catch and effort data provided by the operators of American Samoa-based fishing vessels, (c) size and sex data on albacore sampled at the tuna canneries in American Samoa, and (d) Japanese data made available to us by the Japan Fisheries Agency.

2. The tuna fishery based in American Samoa began in 1954 with a fleet of seven Japanese longline vessels. The fleet grew rapidly and in 1965, 154 vessels fished out of American Samoa. The composition of the fishing fleet, in terms of country of origin of the vessels, has changed. In the early years of the fishery, the fleet was composed entirely of longliners from Japan. The 105-vessel fleet operating during the last quarter of 1965 was composed of 62 vessels from Japan, 30 from the Republic of Korea, and 13 from the Republic of China.

3. The fishery was confined to the immediate vicinity of the Samoa Islands in the early years, but has expanded rapidly to the east and south. In 1965, the fishery area was bounded on the north by the Equator, on the south by lat. 30° S., on the west by long. 175° E., and on the east by about long. 120° W. These boundaries enclose an area of about 23 million square kilometers.

4. Though a variety of pelagic fishes is taken by the longline fishery, albacore command the highest price at the canneries and are, for this reason, fished for selectively. Data provided by the fishermen are complete only with respect to the albacore catches, the major species taken. Consequently, no attempt was made in this report to analyze the data on the other tuna species.

5. The annual landings of albacore in American Samoa have gradually increased from 338 metric tons in 1954 to 15,588 metric tons in 1965.

6. The occurrence of albacore in the South Pacific Ocean exhibits no clear seasonality although in most years landings have been slightly better during the latter half of the year.

7. The catch of albacore per fishing trip was used as the measure of apparent abundance for the entire period of the fishery's existence. No other unit of effort was available before 1959 when data first were recorded on number of days fished per trip and 1963 when we began to collect data on number of hooks fished per day. This index proved to be reasonably satisfactory, however, because neither the average number of days fished per trip nor the size composition of the vessels has varied appreciably over the years covered by our study.

8. The catch per trip (in terms of weight of fish) tends to increase with size of vessel, mainly because (1) larger vessels generally fish more gear than smaller vessels, and (2) their trips tend to be longer. However, the fact that relatively few vessels in the American Samoa fleet were larger than 120 tons or smaller than 80 tons permits the use of catch per trip as an index of apparent abundance.

9. The catch per trip tended to increase steadily through 1960, tapered off, and stabilized at a lower level in 1963 and 1964. There was again a slight increase in 1965.

10. Annual landings have tended to be directly proportional to the total amount of fishing effort.

11. The size of the vessel does not significantly affect the catch rate in terms of catch per 100 hooks fished.

12. The distribution of albacore is continuous from west to east in the South Pacific Ocean, at least between long. 140° E. and 90° W. The fish have their greatest abundance, however, in the central and eastern South Pacific Ocean between 180° and 120° W.

13. During the first half of the year, the American Samoa-based vessels generally fish north of lat. 20° S., where catches are most favorable. In later months, beginning about June or July, the albacore longline fishery moves southward to as far as lat. 30° S.

14. The number of albacore caught per 100 hooks did not vary appreciably in 1963–65. But owing to the decrease in average size of albacore caught, the weight of fish landed per 100 hooks declined significantly in 1964 and early 1965.

15. The mean lengths of albacore landed in American Samoa did not change significantly from September 1962 to January 1964, but suddenly became smaller in February 1964. Although the mean length increased slightly after May, the fish remained smaller than in 1962–63. The average

length again decreased in February 1965, but by the end of the year the albacore landed in Samoa were even larger than in 1962–63.

16. Several factors are responsible for changes in mean lengths of albacore. One of the primary causes is change of fishing grounds; fishing is confined during the early months of the year to more northern waters, north of lat. 15° S., where the albacore tend to be small. As some of the fishing shifts southward beginning about June or July, the lengths of albacore gradually increase since the largest fish occur near lat. 20°–25° S. Albacore are smaller to the south of lat. 25° S.

17. We found no longitudinal differences in average fish sizes.

18. The general decrease in average lengths of albacore taken in 1964 as compared to 1962–63, may have been due in part to an abundant year class of small albacore that entered the fishery early in 1964. As this year class moved through the fishery, average size increased slightly toward the latter part of 1964. The data suggest that another large year class of small albacore entered the fishery early in 1965.

19. Although albacore are generally smallest in areas north of 15° S., sizes also vary seasonally within the same areas. The fish are smallest during February-May when coincidentally the vessels tend to concentrate their fishing in this northern area.

20. Males average 1 to 6 cm. longer than females each month; therefore, any change in the sex ratio affects the average size of fish in the catch. Indeed, during the periods of reduced mean sizes in 1964 and 1965, the percentage of males decreased, permitting the smaller females to have an unusually depressing effect on the average size of the albacore. The smaller catch (in weight) per unit of effort could be attributed partly to the change in sex ratio.

ACKNOWLEDGMENTS

The early stages of the sampling (September 1962–April 1963) were supervised by Thomas Annastas, then Supervisor of Fisheries for the Department of Agriculture, Government of American Samoa. Our sampling field station in Pago Pago was established through the cooperation of Governor H. Rex Lee, of the Government of American Samoa, and the management of the Van Camp Sea Food Company in Samoa. The continued success of the field station in providing data from the fishery is due to the cooperation of the management and staff of the Van Camp Sea Food Company-Samoa and the recently established (1963) Star-Kist Samoa, Inc., who allow our personnel to sample the landings at their canneries. The fishing vessel operators from Japan, the Republic of Korea, and the Republic of China provided us with detailed information on their fishing operations.

The fishery technicians from the BCF Laboratory in Honolulu who have served and continue to serve at the field station have collected the data used in this study. Andrew Scanlan of Samoa assisted our personnel at the field station.

The following have read the manuscript and have offered suggestions: Marvin D. Grosslein, Cornell University, Ithaca, New York; Robert W. Hetzler, Star-Kist Food, Inc., Terminal Island, California; and Henry A. Regier, University of Toronto, Toronto, Canada. We also wish to thank Gordon Broadhead, Van Camp Sea Food Company, who read an early version of the manuscript.

LITERATURE CITED

HONMA, MISAO, and TADAO KAMIMURA.
1957. Studies on the albacore. V. The fishing condition and size of albacore taken in the South Pacific Ocean. Rep. Nankai Reg. Fish. Res. Lab. 6: 84–90. [In Japanese with English summary.]

JAPAN FISHERIES AGENCY.
1965. Annual report of effort and catch statistics by area on Japanese tuna long line fishery 1962. Res. Div. Fish. Agency Japan, 183 pp.
1966. Annual report of effort and catch statistics by area on Japanese tuna long line fishery 1963. Res. Div. Fish. Agency Japan, 322 pp.

KOTO, TSUTOMU.
1966. Studies on the albacore. XI. Distribution of albacore in the tuna longline fishing grounds of the South Pacific Ocean. Rep. Nankai Reg. Fish. Res. Lab. 23: 43–53. [In Japanese with English summary.]

NANKAI REGIONAL FISHERIES RESEARCH LABORATORY.
1959. Average year's fishing condition of tuna longline fisheries. 1958 ed. (Text and atlas.) Federation of Japan Tuna Fishermen's Cooperative Associations, Tokyo, text 414 pp. [In Japanese with English figure and table captions.]

SUZUKI, GORO.
1961. On tuna fishing at the Samoa base in 1956. Tuna Fishing (*Maguro gyogyō*) 76: 13-18. [In Japanese.]

VAN CAMPEN, WILVAN G.
1954. Tuna fishing at American Samoa, January–April 1954. Commer. Fish. Rev. 16(11): 1–9.