THE AMERICAN SAMOA LONGLINE FISHERY, 1966-71

Howard O. Yoshida[1]

ABSTRACT

Aspects of the longline fishery based at American Samoa covering the period from 1966 to 1971 are described. The fishery is discussed primarily as it relates to the albacore, *Thunnus alalunga*, and to a small extent the yellowfin tuna, *T. albacares*. The landings of albacore fluctuated between 17,722 and 28,310 metric tons from 1966 to 1971. Although no downward trend was evident in the relation between total landings and total effort, the relation between CPUE (catch per unit of effort) and effort showed a definite downward trend. Generally, fishing effort was confined to the north of lat. 20°S in the first and fourth quarters. In the second and third quarters large amounts of effort were also expended south of lat. 20°S. The length-frequency distribution of albacore showed that albacore sizes were stratified by latitude. North of lat. 20°S the size of albacore was rather uniform, in that only a single mode was evident in the length-frequency distributions. South of lat. 20°S two or more modes were evident.

The Honolulu Laboratory of NMFS (National Marine Fisheries Service) has been involved in assessing and monitoring the fisheries resources and developing the high seas fishing industry of the territories and island possessions of the United States in the Pacific Ocean. Part of this work included an investigation of the longline fishery based in American Samoa, which resulted in a report describing the history of the fishery and the distribution, apparent abundance, and size composition of albacore, *Thunnus alalunga*, landed from 1954 to 1965 (Otsu and Sumida 1968). The present report describes the status of the American Samoa longline fishery from 1966 to 1971; it is timely because the fishery has changed considerably since 1965, particularly with regard to the apparent abundance of albacore. Data published by Otsu and Sumida will also be used, especially where they are useful in illustrating certain continuing trends.

The earlier report included a rationale for confining the study to the albacore, the principal species of tuna taken in the fishery. The data were reliable only with respect to albacore because the catches of the other species were often not sold in their entirety to the canneries and, therefore, were not included in the catch reports by the vessel operators. However, as will be discussed later, the vessel operators have expended a considerable amount of effort to catch yellowfin tuna, *T. albacares*, in recent years. It is believed that most of the yellowfin tuna are now included in the catch reports and this species has become an important factor in the American Samoa longline fishery, and can no longer be ignored.

The tuna canneries, operated by Star-Kist Samoa, Inc. and the Van Camp Sea Food Company, depend entirely upon deliveries made by foreign flag vessels and fishermen. One of the most notable changes in the fishery over the years has been in terms of vessel nationality. The fishery began in 1954 with seven Japanese vessels. Vessels from Korea entered the fishery in 1958, and from the Republic of China (Taiwan) in 1964. The Japanese continued to increase their participation until 1963, but thereafter began a gradual withdrawal. On the other hand, the vessels from Korea and Taiwan greatly increased in number until the fleet reached a peak in 1967. Due largely to the withdrawal of the Japanese, the fleet has decreased since 1967. During the last quarter of 1971 there were 209 vessels in the fleet, consisting of 4 from Japan, 90 from Korea, and 115 from Taiwan.

SOURCES OF DATA

The data in this report were obtained through the operation of a field station in American Samoa, established in 1963, and manned continuously through December 1970 by personnel from NMFS, Honolulu. In January 1971 the field station was taken over by the Office of Marine Resources, Government of American Samoa. In the begining, the length, weight, and sex of 50 albacore, randomly chosen, were obtained from each trip landing. For various reasons, e.g.,

[1]Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

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changes in cannery operating procedures, changes in the sampling procedures were necessitated in subsequent years. The collection of sex and weight data was discontinued in early 1971. Catch and effort data have been provided voluntarily by the fishing vessel operators from about 75% of the fishing trips.

The longliners on some occasions fish widely scattered areas on a single fishing voyage. Since there is no way to determine the origin of each fish in the catch and because the fish are sampled at random at the docks, it is probable that some samples included fish from several different locations. This problem was minimized by summarizing the length data by large geographical areas.

ANNUAL LANDINGS OF ALBACORE AND YELLOWFIN TUNA

Except for dips in 1961 and 1964, the albacore landings increased steadily from 1954 to 1965 (Otsu and Sumida 1968). In the 6 yr that followed, the landings fluctuated between 17,722 and 28,310 metric tons (Table 1).

The gain in importance of yellowfin tuna can be seen in the increased landings in the later years (Table 1). After a period (1954 to 1964) of reported landings of less than 2,500 metric tons, the reported landings increased substantially and fluctuated between 4,514 and 8,567 metric tons from 1965 to 1971.

TABLE 1.–Total annual albacore and yellowfin tuna landings in American Samoa, 1954-71.

	Landings (metric tons)	
Year	Albacore	Yellowfin tuna
1954	338	597
1955	1,760	1,628
1956	3,680	2,113
1957	5,873	1,537
1958	9,869	2,458
1959	10,292	1,780
1960	10,852	1,134
1961	9,740	1,331
1962	13,326	1,406
1963	13,972	2,057
1964	10,652	2,452
1965	15,591	4,514
1966	25,278	6,531
1967	28,310	5,326
1968	17,722	7,337
1969	18,767	8,207
1970	23,875	7,689
1971	22,193	8,567

APPARENT ABUNDANCE OF ALBACORE AND YELLOWFIN TUNA

Otsu and Sumida (1968) used various indices of apparent abundance in discussing the status of the fishery for albacore during 1954 to 1965. These indices included catch per trip, catch per day, and catch per 100 hooks. However, because data on number of hooks fished per day were not available for the entire period of their study, they elected to use the fishing trip as the basic measure of effort in analyzing the apparent abundance of albacore. They also examined the relation between catch and effort, and CPUE (catch per unit of effort) and effort, in evaluating the effect of fishing on the stock.

Ideally, in considering the mean annual CPUE as an index of apparent abundance, the fishery should affect all portions of the stock(s) under consideration equally throughout the years. However, since the geographical limits of the fishery have been expanding each year, the situation is almost certainly not ideal. In this section I will extend some of the analyses of Otsu and Sumida to determine if any changes have occurred in the apparent abundance of albacore from 1966 to 1971. Since there are now 9 yr of effort data in terms of the number of hooks fished, I will make greater use of the catch per 100 hooks to determine the apparent abundance of albacore. It is assumed that fishing efficiency is not influenced by the nationality of the vessels, for Skillman (1975) found no evidence to suggest that any gear modification or change in the nationality of the fleet has caused any change in the catchability coefficient of albacore in the Samoan fishery.

Apparent Abundance of Albacore

Otsu and Sumida (1968) analyzed the mean annual CPUE of albacore from 1954 to 1965 in terms of the catch per trip. They believed that the catch per trip was a satisfactory measure of apparent abundance because their analysis showed a close relationship between the monthly average catch per trip and the monthly average catch per day. However, there are some basic shortcomings in the catch per trip. One is that the catch per trip of any vessel is limited by its fish-holding capacity. Also, as indicated by Otsu and Sumida (1968), the catch per trip is influenced by changes in the number of days fished per trip and by changes in the size composition of the vessels in the fleet. Changes in the number of hooks fished per day can also affect the catch per trip. The data do indeed show that the mean number of days fished per trip has increased during recent years (Table 2). The increase in the mean number of days fished per trip may also, in part, indicate change in the size of the vessels. That is, larger vessels, which presumably have larger fish-holding capacities, probably fish more days to obtain a full load of fish.

TABLE 2.–Total trip length, days spent fishing, and traveling time per trip by longline vessels based at American Samoa.

	Mean number of days		
Year	Total trip length	Fishing time per trip	Traveling time per trip
1963	42.35	26.12	16.23
1964	41.26	27.39	13.87
1965	48.79	32.09	16.60
1966	50.58	33.74	17.05
1967	62.13	38.03	23.50
1968	68.02	43.20	24.82
1969	67.34	44.25	23.08
1970	70.74	45.03	25.72
1971	84.16	52.03	32.13

In their analysis of the apparent abundance of albacore from 1954 to 1965, Otsu and Sumida (1968) indicated that the mean catch per trip increased from 1954 through 1960 and then fell slightly and stabilized at a lower level in 1963-64. A continuation of this analysis (Figure 1) showed that the mean catch per trip continued to fluctuate around this lower level with no definite upward or downward trend. It is possible that the mean catch per trip is fluctuating near the mean fish-holding capacity of the vessels or near a level that is related to the profitability of the fishing trip. That is, a vessel may fish as many days as are needed to obtain a full load or until a catch that is at least profitable is obtained. The trip, as an index of effort, does not take this factor into consideration, and, therefore, the catch per trip is not an accurate indicator of the apparent abundance.

It would be useful then, to compare the catch per trip with the catch per day, which is not affected by as many variables as the catch per trip. The mean annual catch per trip from 1959 to 1971 fluctuated between 29.9 and 38.2 metric tons (Figure 2) and, as noted earlier, did not reveal any obvious trends. The mean annual catch per day during the same period fluctuated between 0.7 and 1.7 metric tons, and, contrary to the catch per trip, declined after 1962 suggesting that the longline vessels are fishing more days to compensate for the reduced catch per day. The mean total length of a fishing trip, number of days spent fishing, and number of days spent traveling on each trip (Table 2) all showed an increasing trend from 1963 to 1971, which indicates that, in general, the vessels are traveling farther away from the home base to fish and are fishing more days per trip.

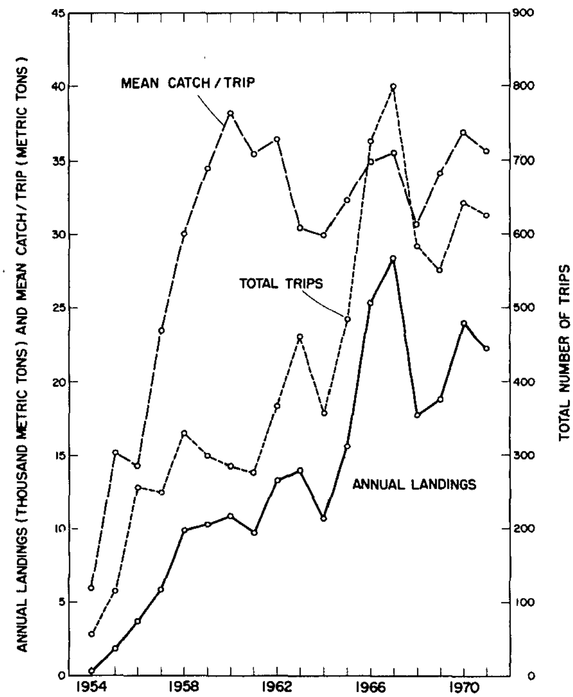

FIGURE 1.–Total number of fishing trips, mean catch of albacore per trip, and annual albacore landings, 1954-71.

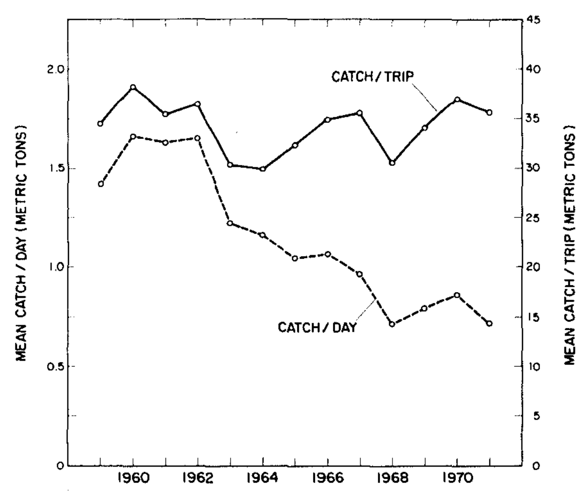

FIGURE 2.–Comparison of the mean catch per day and mean catch per trip of albacore, 1959-71.

The relation between the annual total landings of albacore and the total fishing effort (number of fishing trips) indicated that the annual landings increased with increasing fishing effort from 1954 to 1965. Based on this analysis, Otsu and Sumida (1968) concluded that the point of maximum yield of albacore had not been reached in the American Samoa-based fishery. The fishing effort continued to increase subsequent to 1965, and reached a peak of close to 800 fishing trips in 1967. The albacore landings also continued to increase with the increased effort. The relation between the annual landings and the effort, in total number of days fished, from 1959 to 1967 also showed that the landings increased with increasing fishing effort (Figure 3). The mean catch per day plotted against effort in total number of days fished, however, shows a decline in the CPUE from 1959 to 1971 with increasing effort (Figure 4).

As noted earlier, our laboratory has been obtaining, from the vessel operators, effort data in terms of number of hooks fished since 1963. Using these data, the mean monthly catch per 100 hooks of albacore from 1963 to 1971 was computed (Figure 5). A salient feature of Figure 5 is that the mean monthly CPUE fluctuated much more from 1966 to 1971 than they did from 1963 to 1965. It is not clear what caused this change in trends in the monthly CPUE after 1965. One possibility is that it is related to a geographical change in fishing effort. As will be discussed in more detail in another section, in the years after 1965 more fishing effort has been expended in latitudes south of lat. 20°S where good CPUE's of albacore are obtained in the second and third quarters of the year. This fact could also account for the definite peak in abundance of albacore in June or July during 1966 to 1971. It is also evident, however, that there is a slightly declining trend in the CPUE from 1963 to 1971.

A plot of the total annual catch of albacore against the estimated total annual effort in number of hooks fished from 1963 to 1971 is shown in Figure 6. During this period the estimated total effort ranged from about 13,165,000 to 51,092,000 hooks and the annual albacore catch from 10,652 to 28,310 metric tons. With some minor exceptions, there was a strong positive relation between the annual catch and effort for the 1963-71 period. Generally, the catches increased with increased fishing effort. Suda (1971) also found a similar relationship between albacore catch and fishing effort in the South Pacific from 1952 to 1968.

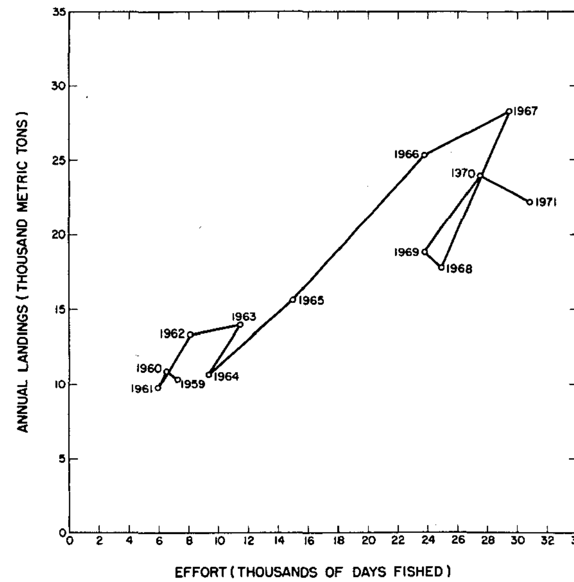

FIGURE 3.—Relation between annual landings of albacore and effort.

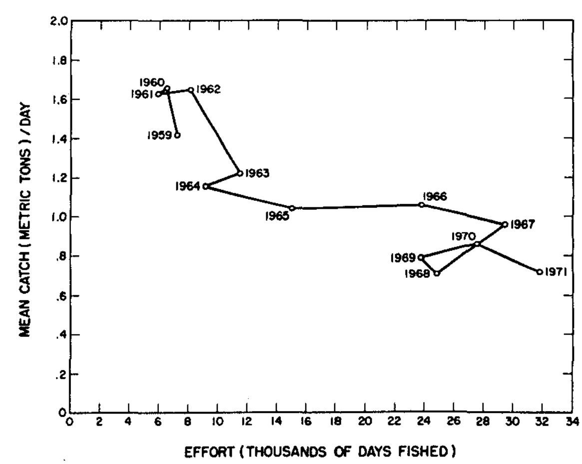

FIGURE 4.—Relation between mean catch of albacore per day and effort.

In Figure 7 is plotted the CPUE in number of fish and in weight per 100 hooks fished against the estimated total annual number of hooks fished from 1963 to 1971. Both plots show a negative relation between CPUE and effort; the CPUE decreased with increased fishing effort. Thus, although the catch has been increasing with increasing effort, it appears that the fishery has had some effect on the stock size in that the CPUE has been declining with increasing effort.

The analyses above reflect average conditions of

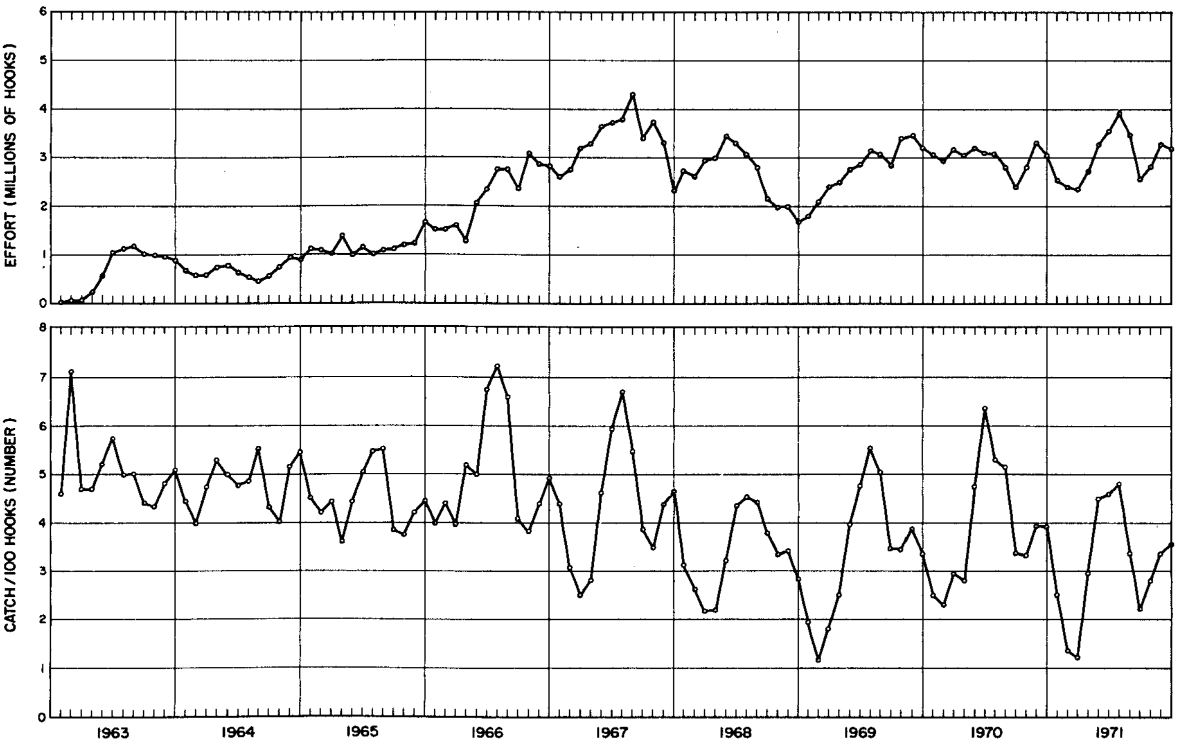

FIGURE 5.–Monthly mean albacore CPUE and effort, 1963-71.

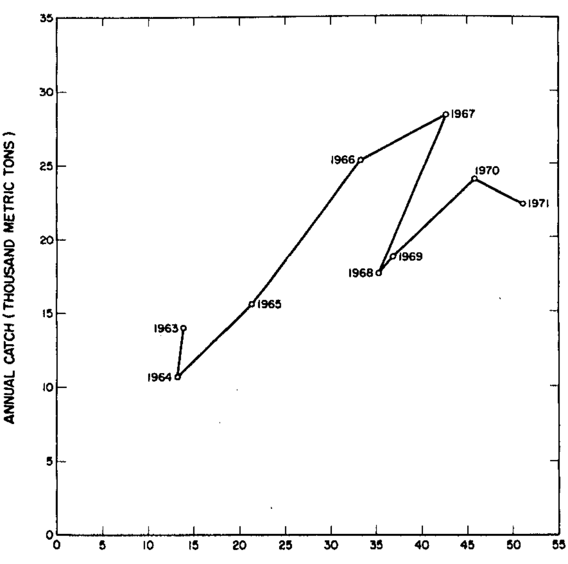

FIGURE 6.–Relation between total catch of albacore and total effort, 1963-71.

the fishery taken as a whole. It is of interest to compare the conditions north and south of lat. 20°S, especially since the geographic boundaries of the fishery have been expanding over the years. That is, it would be useful to see how the CPUE in the older fishing grounds north of lat. 20°S compares with that in the more recently exploited grounds south of lat. 20°S. The annual mean CPUE was computed for the area north of lat. 20°S, which represents the older fishing ground, and the area south of lat. 20°S, which represents the newer grounds (Figure 8). This analysis must be viewed with some caution, however, since total effort expended south of lat. 20°S is less than that expended in the north. Southern waters are fished heavily only in certain quarters of the year and these are the quarters when good catch rates are obtained. The mean catch rates in the southern waters therefore, may be overly weighted by the catch rates obtained in these quarters. However, the mean annual CPUE is higher in the newer grounds than in the old. The mean annual CPUE's

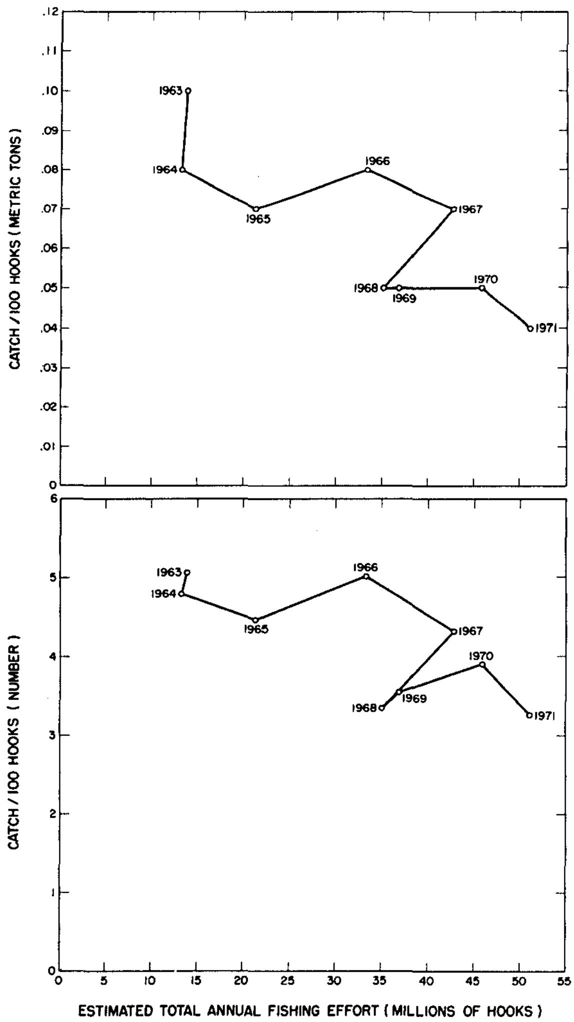

FIGURE 7.–Relation between CPUE of albacore in weight and numbers and total effort, 1963-71.

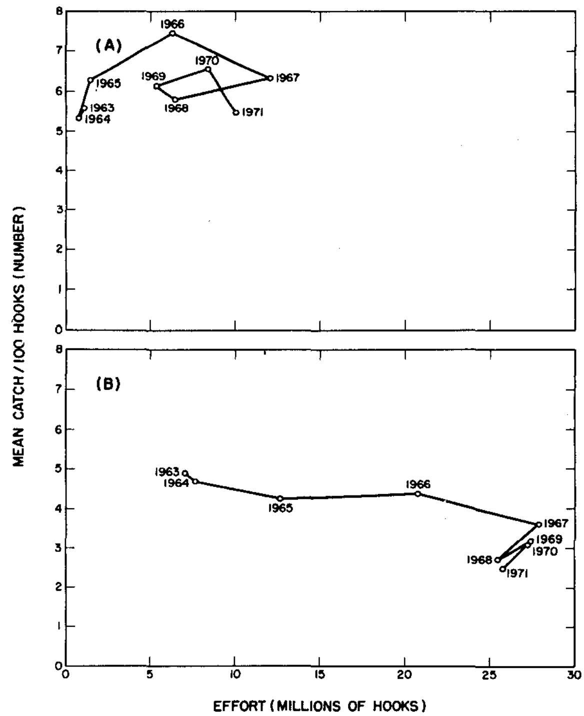

FIGURE 8.–Relation between CPUE of albacore and effort in areas south (A) of lat. 20°S and north (B) of lat. 20°S.

from 1963 to 1971 in the old grounds were all less than five albacore per 100 hooks, whereas in the new grounds they were all greater than five per 100 hooks during the same period. Another difference is that in the old grounds the mean CPUE has been declining with increasing effort. In the new grounds the CPUE increased with increasing effort from 1963 to 1966. In 1967, the CPUE declined slightly and from that year to 1971 the CPUE appears to have stabilized around six albacore per 100 hooks. These facts suggest that the albacore fishery has been able to maintain itself by continuously expanding geographically to take advantage of better CPUE in newer areas. It should be repeated here, however, that despite the expansion into new fishing grounds the overall trend for the fishery has been a decline in CPUE (Figure 5). Furthermore, in the southern grounds to which the fishery has expanded, the albacore catches, as will be shown in a later section, are composed of a large proportion of smaller fish. These smaller albacore may not be the optimum size at which to harvest the stock.

Apparent Abundance of Yellowfin Tuna

The discussion of the apparent abundance of yellowfin tuna will be primarily in terms of how it relates to the apparent abundance of albacore in the Samoan longline fishery. For one thing, although albacore are selectively fished for by the fleet, yellowfin tuna (and small numbers of other species) are also caught by the longlines, and the CPUE for one species may affect the CPUE of another (Rothschild 1967). The CPUE for one species may affect that for another species because, in computing the CPUE, the total effort expended was applied to the catch of each species without regard to the competition of the species for space on the gear. Furthermore, there is another complicating variable: the fishermen apparently seek out yellowfin tuna when the catches of albacore are poor. They do this by modifying the longlines to fish shallower and by fishing closer to the equator where yellowfin tuna catches are known to be better. The fact that the price of yellowfin tuna increased from an average of $270 a ton in 1965 to $394 a ton in 1970 may also have been a factor.

As noted earlier, the CPUE of albacore in relation to increased fishing effort has been declining, especiallv in the years subsequent to 1967. During 1968 to 1971, the yellowfin tuna CPUE was relatively good. It is apparent that as albacore fishing deteriorated, the vessels expended more effort to catch yellowfin tuna. The relation between albacore and yellowfin tuna CPUE in the Samoan longline fishery from 1963 to 1971 is shown in Figure 9. It appears that an inverse relation existed between albacore and yellowfin tuna CPUE: When yellowfin tuna CPUE was high, albacore CPUE was low, and vice versa. The correlation coefficient (r = -0.6636; df = 7), however, was not significant.

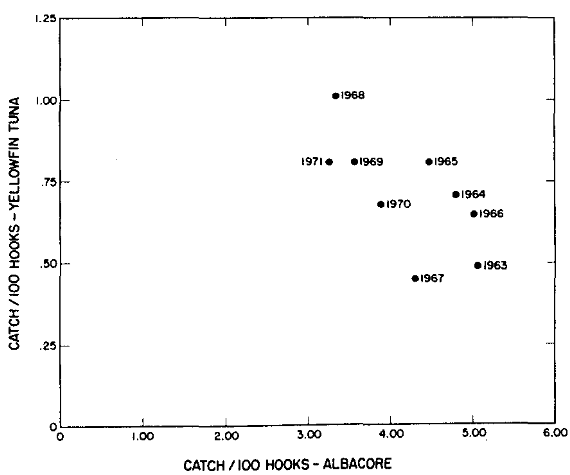

FIGURE 9.–Relation between albacore and yellowfin tuna CPUE.

SPATIAL AND TEMPORAL CONSIDERATIONS

Observations on the American Samoa fishery during the period from 1954 to 1965 indicated that the longline vessels shifted fishing grounds with season (Otsu and Sumida 1968). Seasonal and geographical differences in CPUE, however, were not readily apparent in the early years. In the following sections I will examine the spatial and temporal distribution of effort and CPUE in the fishery from 1966 through 1971.

Effort

In the early years of the fishery, the longliners confined their fishing largely to the vicinity of the Samoa Islands. Over the years, the vessels gradually extended their operations to more distant waters, and by 1965 the fishing grounds reached from about long. 175°E to about long. 120°W between the equator and lat. 30°S (Otsu and Sumida 1968). From 1966 to 1971 there was a further extension of the fishing grounds; the vessels fished from off the east coast of Australia to long. 100°W and from about lat. 10°N to about lat. 40°S. The fishing effort, however, was not uniformly distributed throughout the geographical limits of the fishery. Rather, there were distinct seasonal patterns in the spatial distribution of fishing effort.

A composite geographic distribution of the fishing effort on a quarterly basis for 1966 to 1971 summarized by 2° squares between the equator and lat. 40°S and east of long. 150°E is shown in Figure 10. As composite charts they can reflect only "average" conditions.

In the first and fourth quarters, the vessels generally fished to the north of lat. 20°S, and areas of concentrated fishing effort developed in about the same area each year. In the second and third quarters, the vessels expanded their operations to the south of lat. 20°S and, in addition to the usual area of concentrated effort to the north, an area of high fishing effort also developed to the south of lat. 20°S. However, there apparently has been a change from earlier years in the operations of the fleet because prior to 1966 the vessels fished in the north during both the first and second quarters (Otsu and Sumida 1968). These figures indicate that the vessels are moving south in the second quarter, earlier than previously. In any event, these seasonal changes in the concentration of fishing effort have been interpreted to reflect the movement of albacore in the South Pacific Ocean (Suzuki 1961; Otsu and Sumida 1968).

Catch Per Unit of Effort

The mean quarterly CPUE for 1966-71 plotted by 2° square areas is shown in Figure 11. In a

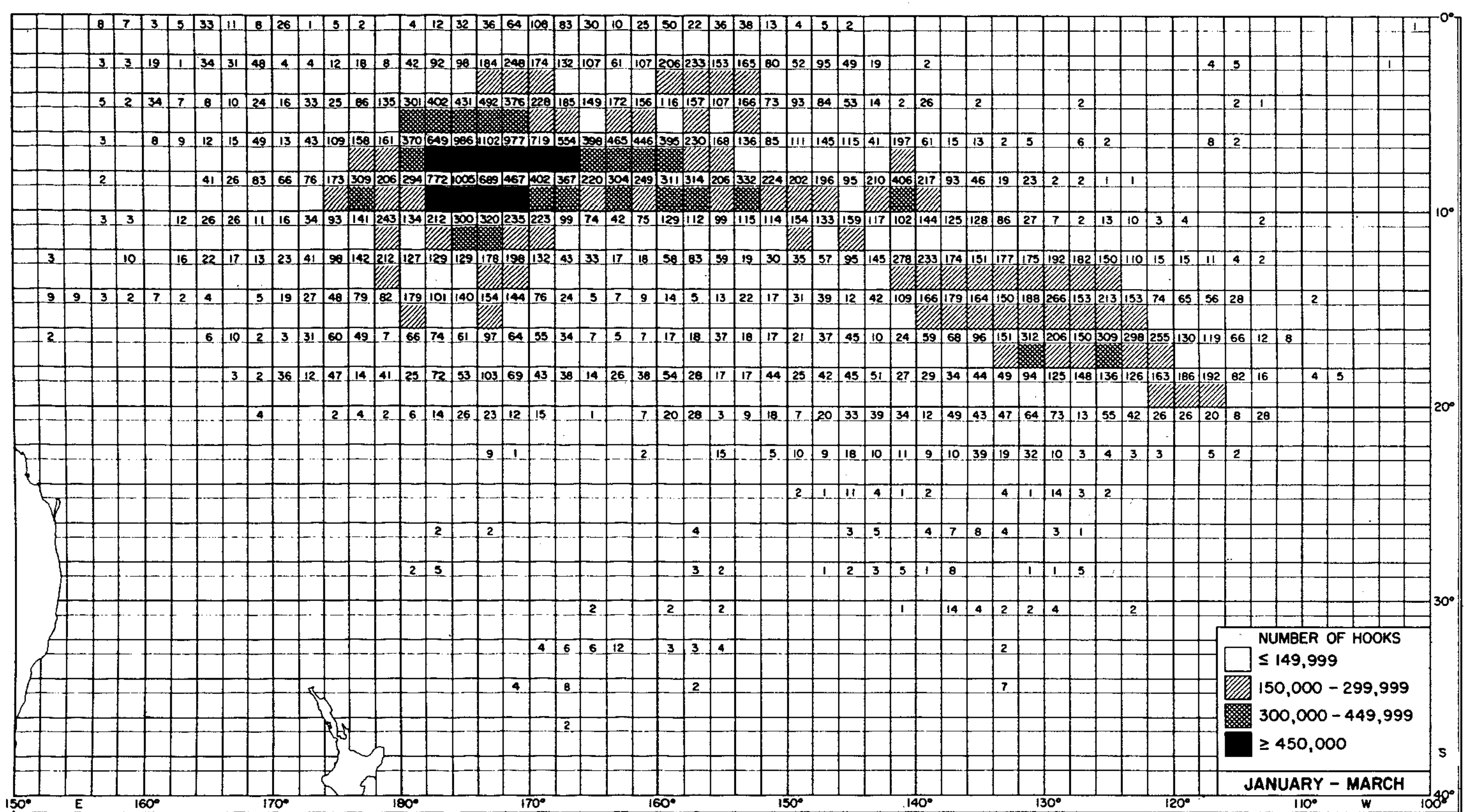

FIGURE 10.–Quarterly geographic distribution of effort, 1966-71. The numbers in the figures are in thousands.

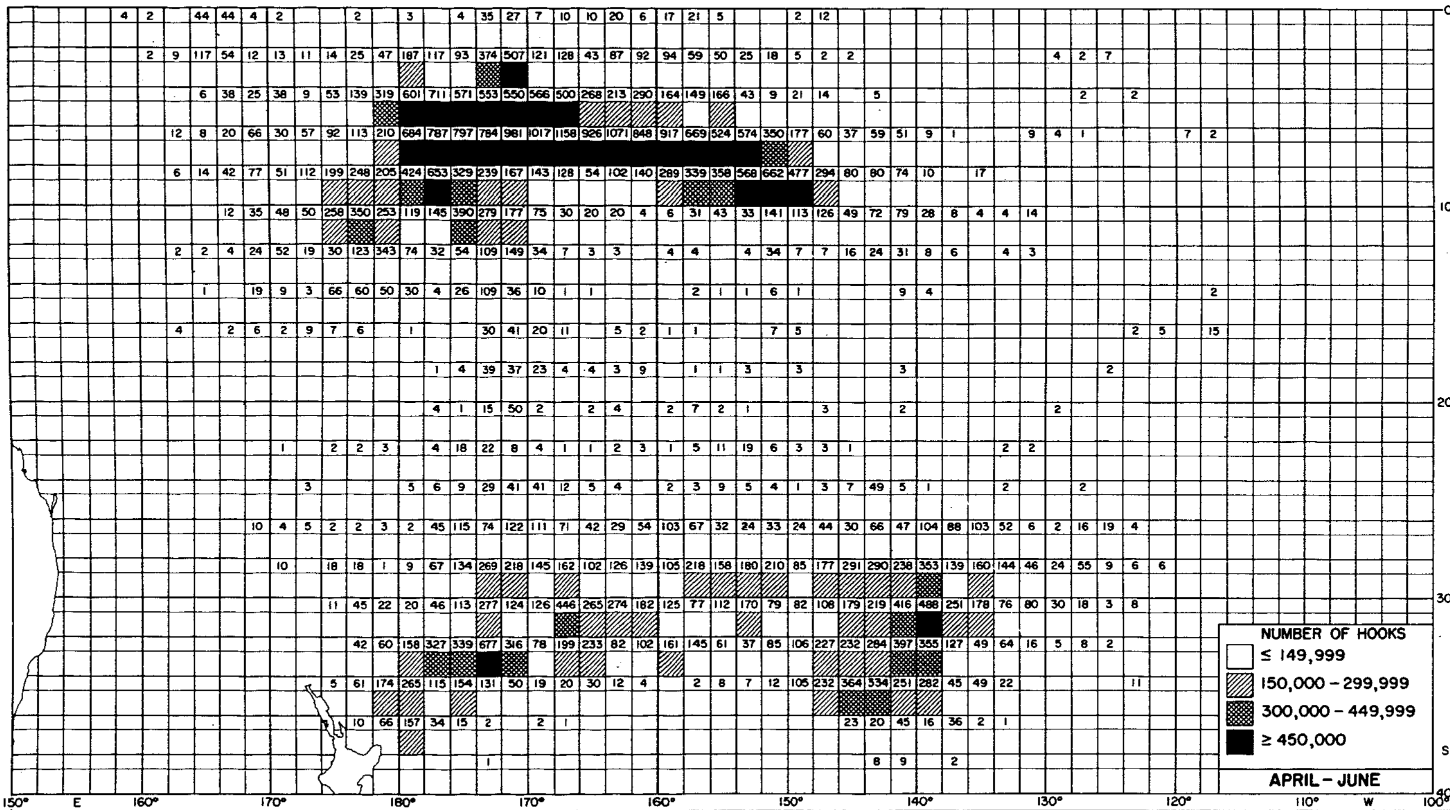

FIGURE 10.–Quarterly geographic distribution of effort, 1966-71. The numbers in the figures are in thousands.–Continued.

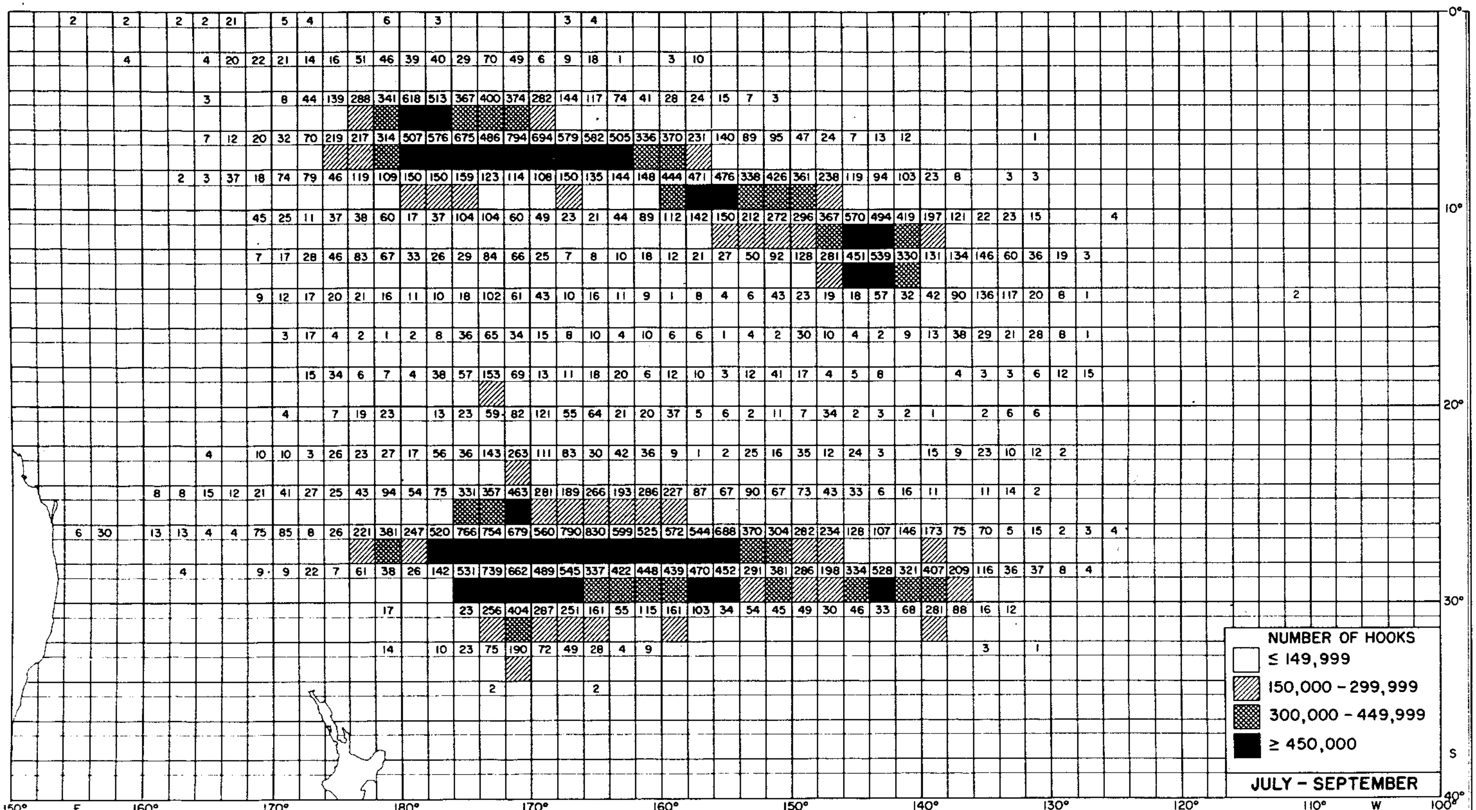

FIGURE 10.—Quarterly geographic distribution of effort, 1966-71. The numbers in the figures are in thousands.—Continued.

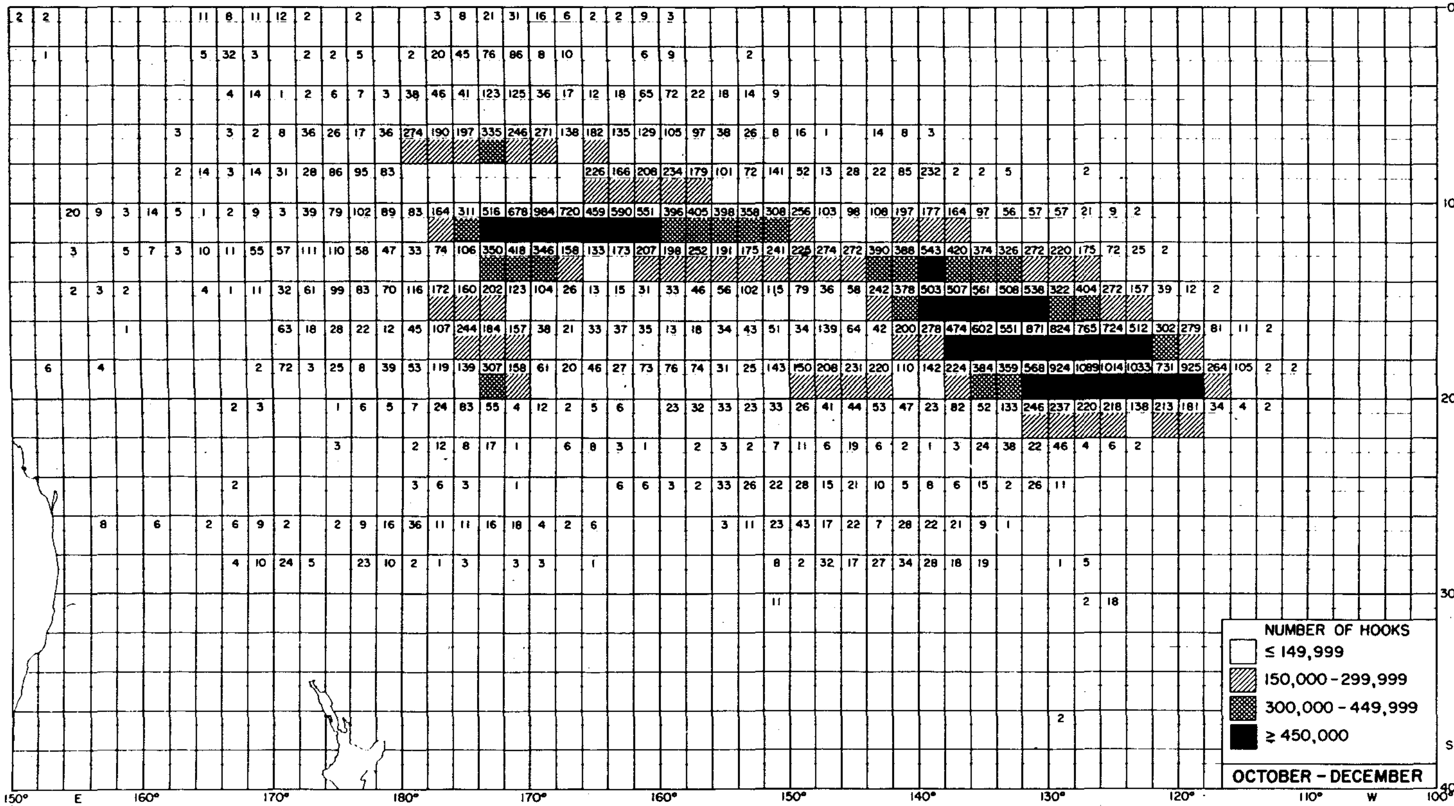

FIGURE 10.—Quarterly geographic distribution of effort, 1966-71. The numbers in the figures are in thousands.—Continued.

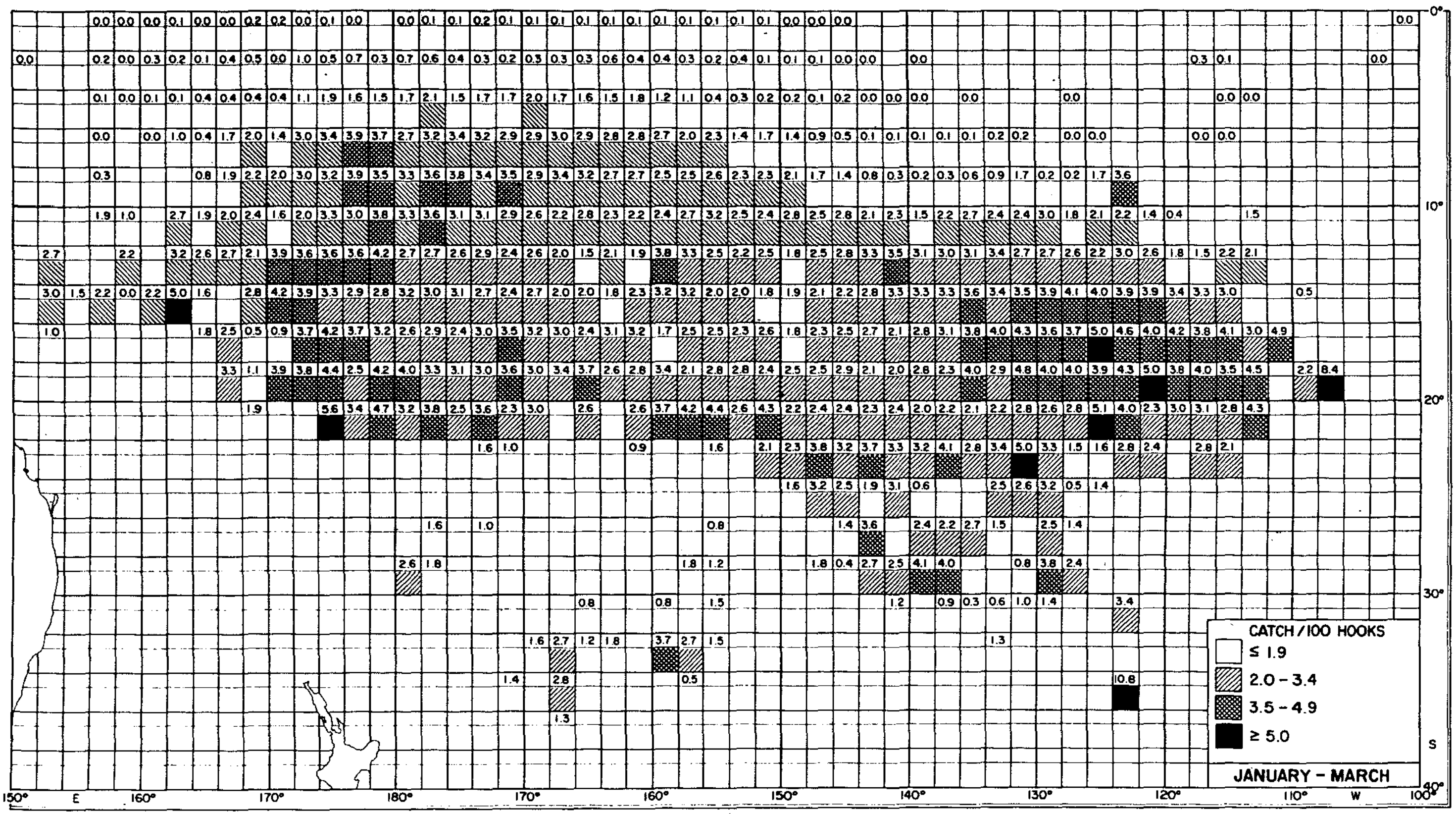

FIGURE 11.—Seasonal and geographic distributions of albacore CPUE, 1966-71.

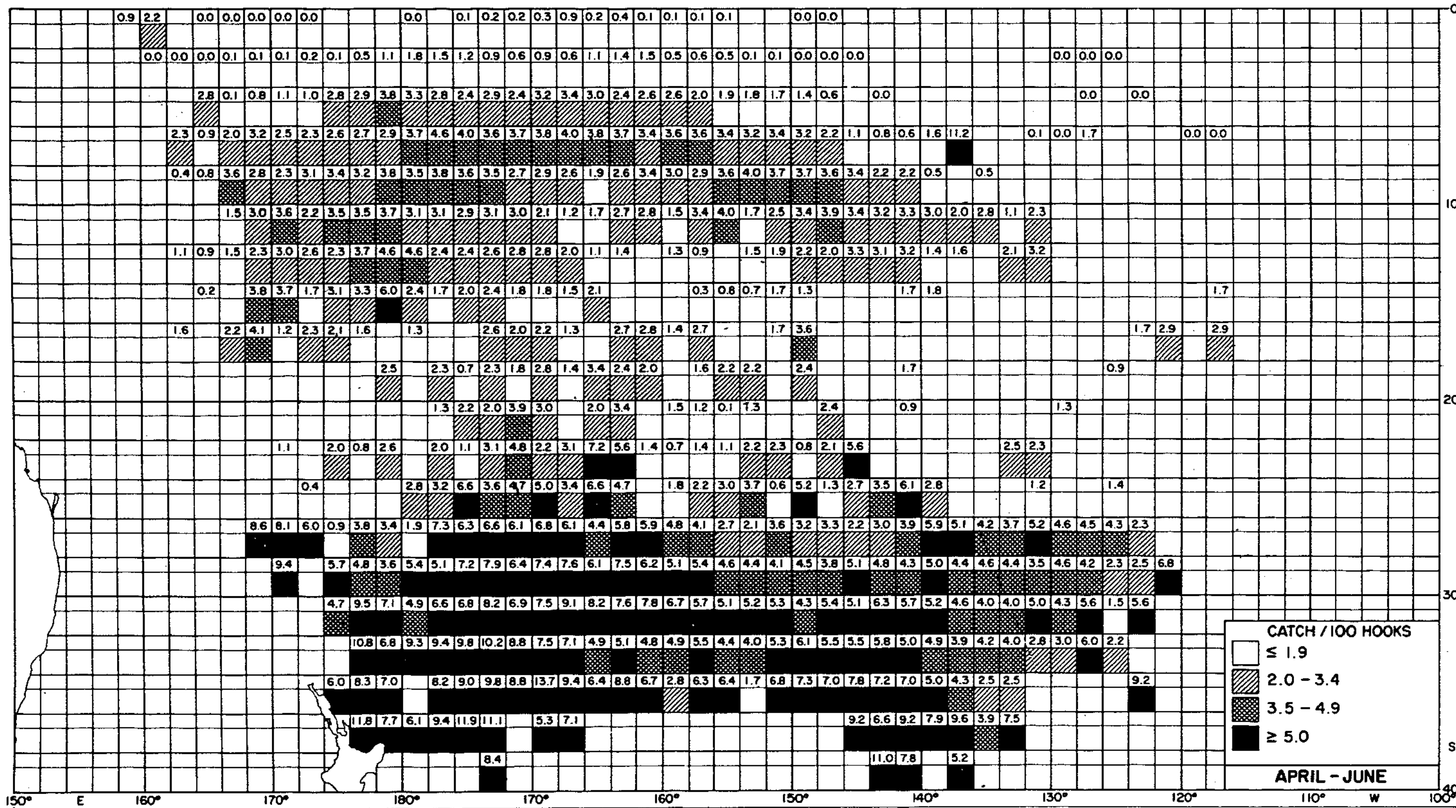

FIGURE 11.—Seasonal and geographic distributions of albacore CPUE, 1966-71.—Continued.

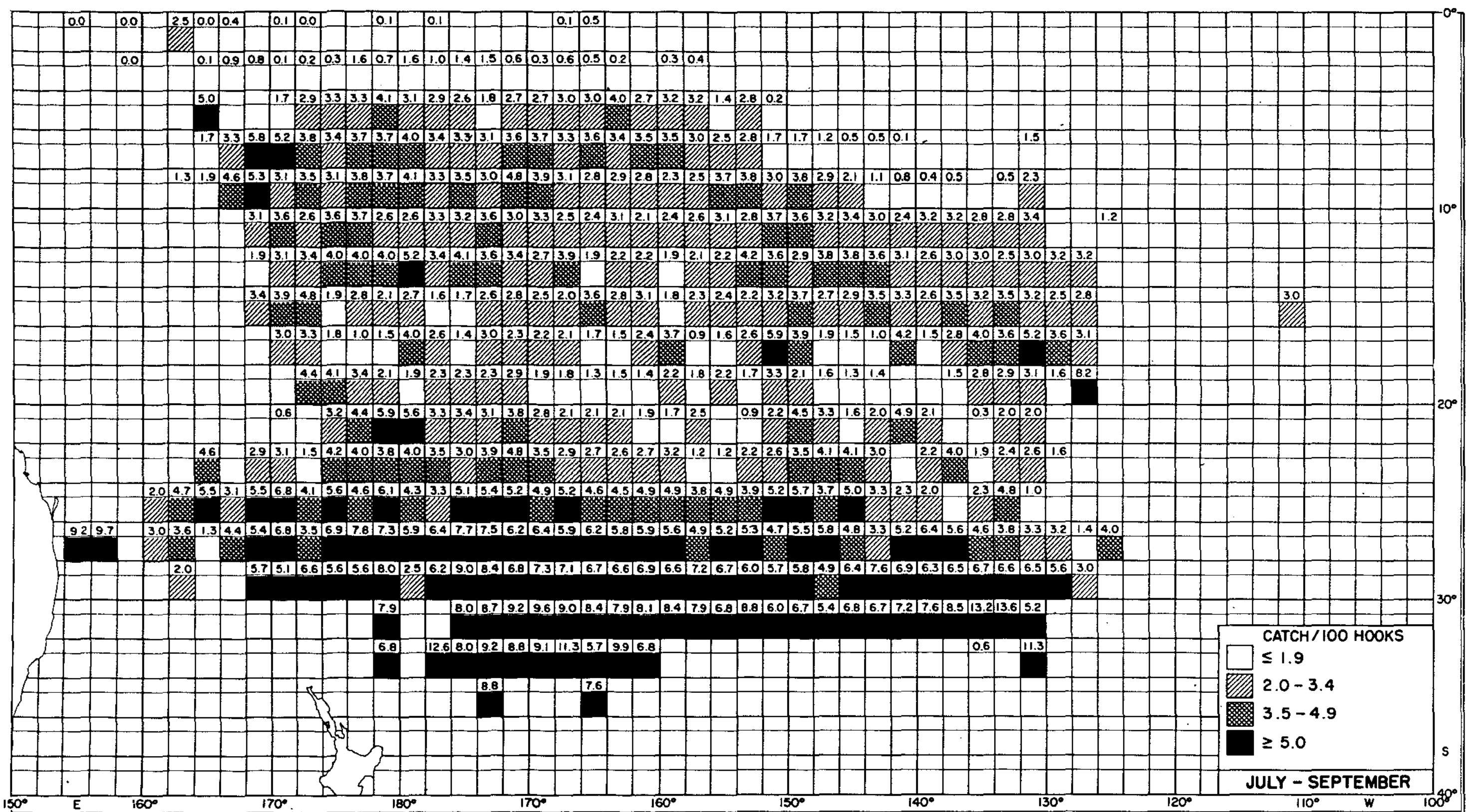

FIGURE 11.—Seasonal and geographic distributions of albacore CPUE, 1966-71.—Continued.

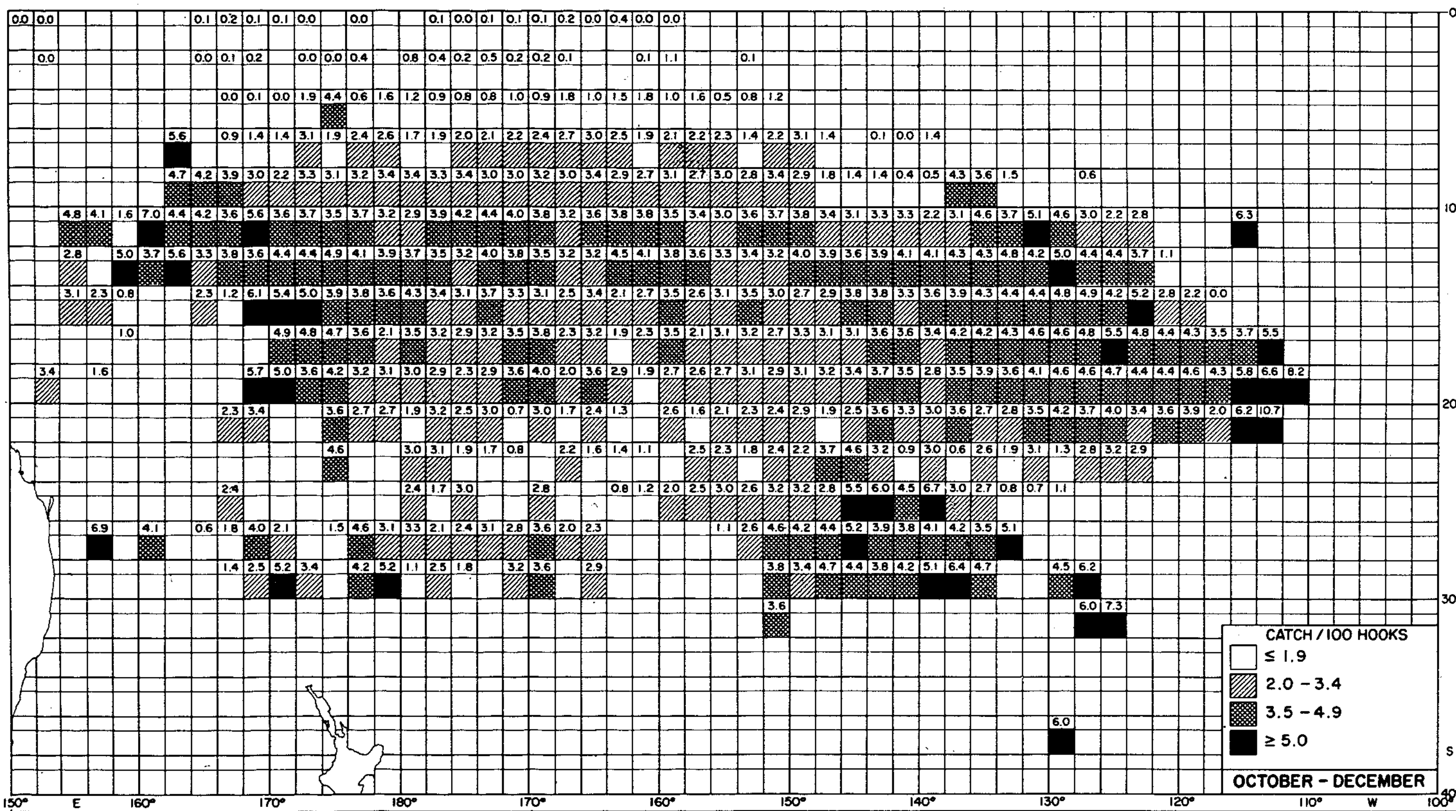

FIGURE 11.–Seasonal and geographic distributions of albacore CPUE, 1966-71.–Continued.

similar analysis covering a period from 1963 to 1965, seasonal and geographical differences in CPUE were not readily apparent (Otsu and Sumida 1968). For some reason that is not immediately clear, a distinct seasonal pattern in geographical differences in CPUE has developed in recent years. In the first quarter, there appeared to be no pattern in the distribution of areas with high CPUE (greater than five albacore per 100 hooks). However, the CPUE was better in the east-west extremes of the fishery. In the second and third quarters, an area of high CPUE developed between lat. 25° and 40°S. The fishery was also well developed north of lat. 20°S in the second and third quarters but as in the first quarter there were no well-defined areas of high CPUE. The situation in the fourth quarter reverted to approximately what it was in the first quarter. However, in some years there was a tendency for an area of high CPUE to develop in the eastern extreme of the area fished between lat. 10° and 20°S.

Because of geographical and temporal variations in the distribution of the fishing effort, the description of the geographical and temporal changes in CPUE as given above is incomplete. As noted earlier, very little fishing effort was expended south of lat. 20°S in the first and fourth quarters. It would be of interest to determine whether a high CPUE could be obtained south of lat. 20°S also in the first and fourth quarters. The possibility exists, of course, that very little effort was expended south lat. 20°S in the first and fourth quarters because the fishermen know from past experience that poor catch rates are obtained during those periods. Honma and Kamimura (1957) suggested that albacore in the South Pacific make north-south migrations and that the fishing vessels follow the movements of the albacore. In the eastern Pacific tuna fishery, Griffiths (1960) showed that the bait boat fishermen were able, on the average, to concentrate their effort on high densities of yellowfin tuna about 70% better than if their effort had been random. The data indicate that the fishermen may be able to predict the movements of the albacore with some degree of success in that areas of high fishing effort were usually associated with areas of high CPUE. There were quarters, however, in which areas of high fishing effort did not coincide with areas of high CPUE. Then, too, the fishermen may avoid fishing south of lat. 20°S in the first and fourth quarters because of bad weather or unfavorable conditions.

One other interesting observation is the division of the fishery at lat. 20°S. As noted above, the fishery develops north or south of lat. 20°S but seldom straddles it. This appears to be a well-established phenomenon, for Koto (1966) has made the same observation. Koto mentioned belts of high catch rates in the area between lat. 10° and 20°S and between lat. 20° and 30°S, and a belt of low catch rates centered at lat. 20°S. The data also indicate that the latitudinal belt centered at lat. 20°S is also a low-effort area. The causes of this phenomenon are not clear.

SIZE OF ALBACORE

Because the canneries have changed the method of handling the fish, the albacore that are sampled for length are no longer being sexed. Consequently, in the analysis of the length distribution of albacore only the data collected from 1966 to 1970, when sex data were available, are presented.

A composite length-frequency distribution of male and female albacore taken by the fishery from 1966 to 1969 is shown in Figure 12. The fish

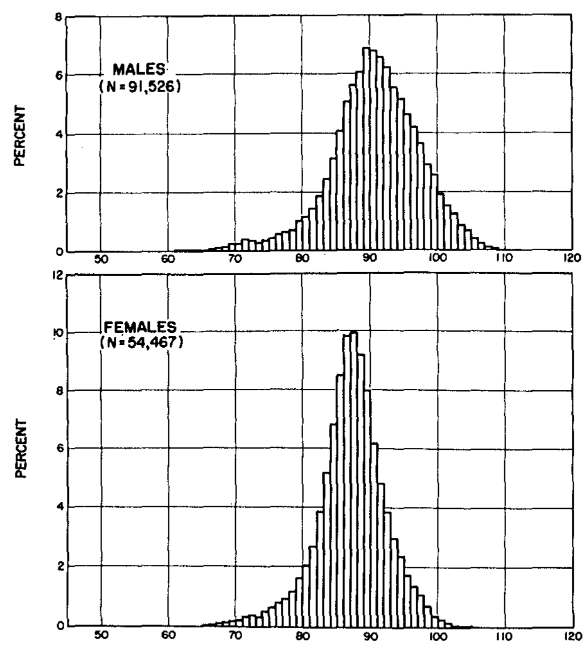

FIGURE 12.–Composite length-frequency distributions of albacore, 1966-69.

ranged in length from 50 to 120 cm. A single prominent mode was present in both the male and female distributions. For the males the mode was located at 91 cm and for the females at 88 cm.

The albacore size data were also summarized into smaller units of time and area to detect any variations which might exist. Initially the geographical area of the fishery was divided longitudinally at long. 150°W and by 10° of latitude from the equator to lat. 40°S. This was done on a quarterly basis, keeping all the years separate. This analysis did not indicate any obvious differences in the length-frequency distributions of albacore east and west of long. 150°W, nor did it show any consistent annual and seasonal differences within each geographical unit. There were, however, differences in the length-frequency distributions between the latitudinal subdivisions of the fishery. Therefore, the length data were rearranged by 10° of latitude but without regard to longitude, seasons, and year (Figure 13).

Almost without exception, the modal sizes of male albacore were larger than those of female

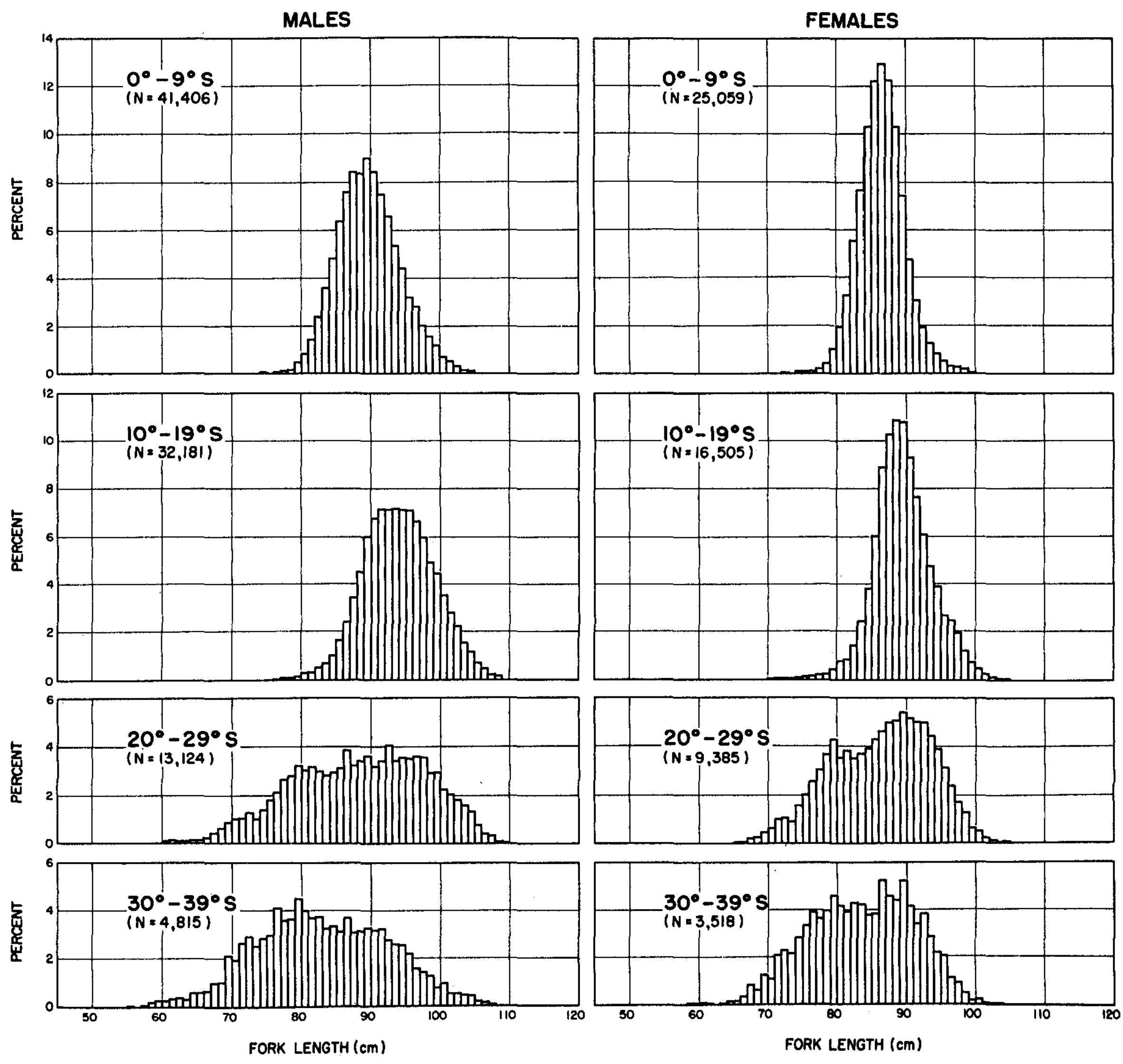

FIGURE 13.—Length-frequency distributions of albacore arranged by sex and 10° bands of latitude, 1966-70.

albacore in each of the latitudinal subdivisions. In the areas north of lat. 20°S, both male and female length-frequency distributions had a single well-defined mode. In the areas south of lat. 20°S the modes were less well defined. Koto and Hisada (1967) found a similar pattern in the length-frequency distribution of albacore in the South Pacific in 1961.

Otsu and Sumida (1968) computed the mean length of albacore in the fishery during the period from 1962 to 1965. They divided the fishery into 5° bands of latitude and noted that the fish were smallest near the equator, largest at lat. 20° to 25°S and tended to be smaller again south of lat. 25°S. The results agree in general with those of Otsu and Sumida; however, as seen above, the length-frequency distributions indicate a more complex situation than do the mean sizes. North of lat. 20°S the mean sizes may be good indicators of the general size of albacore because the length-frequency distributions showed that the fish were composed of single uniform size groups. South of lat. 20°S, the catches were composed of several size groups of fish and the mean does not indicate the presence of different size groups of fish. For example, although Otsu and Sumida stated that albacore south of lat. 25°S tended to be smaller, my data show that large fish were also present in these latitudes.

Although it is not readily apparent in the length-frequency distributions, there appears to be a declining trend in the mean size of albacore in the fishery. Otsu and Sumida (1968) noted that albacore taken in 1964 and 1965 were shorter on the average than those caught in 1963. My data show that the declining trend in the mean length of albacore has continued (Table 3).

TABLE 3.—Mean lengths of albacore, sexes combined, 1963-71.

Year	Mean length (cm)	Year	Mean length (cm)
1963	95.0	1968	89.8
1964	91.6	1969	90.4
1965	91.3	1970	88.6
1966	91.7	1971	91.5
1967	90.8		

The mechanisms that produced such a pattern in the distribution of sizes in the fishery are probably complex. The unique character of the length-frequency distributions among the four latitudinal bands must have resulted from some nonrandom distributional process. The larger numbers of smaller albacore in the more southern waters suggest that albacore are initially recruited into the fishery in the area south of lat. 20°S. The high CPUE experienced in the second and third quarters south of lat. 20°S may be an indication of this. Also, it has been shown that juvenile albacore which originate from spawning that takes place north of lat. 20°S migrate south as they grow larger (Yoshida 1971).

SUMMARY

A comparison of various indices of apparent abundance of albacore indicated that catch per day and catch per 100 hooks were better indicators of apparent abundance than catch per trip. The mean catch per day and catch per 100 hooks of albacore have generally declined over the years, which suggests that the apparent abundance of albacore has declined in the American Samoa longline fishery. To compensate for the reduced CPUE, the longliners fished more days per trip and traveled farther from the home base seeking areas of good catch rates.

The fishery apparently has had an effect on the albacore stock. Although the annual landings have continued to increase with increased fishing effort, the CPUE has declined. That the apparent overall effect was not greater was due to the fact that the fishing grounds have expanded, especially into areas south of lat. 20°S where good catch rates were obtained. The mean annual CPUE plotted against fishing effort for selected, discrete areas north and south of lat. 20°S indicated that the fishery has not as yet had as great an effect in the south as it has to the north. There are at least two possible reasons for the better condition of the fishery to the south. First, the area south of lat. 20°S has not been exploited as long as the area to the north. Second, it was shown that the albacore are first recruited into the fishery in the latitudes south of lat. 20°S, which may account in part for the higher apparent abundance.

There was some indication that there were temporal changes in apparent abundance of albacore south of lat. 20°S. Because of poor weather conditions or because the fishermen have learned through experience that catch rates are better during certain seasons, or a combination of these and other reasons, fishing effort expended south

of lat. 20°S fluctuates seasonally. Areas of concentrated fishing effort were evident in the second and third quarters in the area south of lat. 20°S. Very little effort was expended in these waters in the first and fourth quarters. Good CPUE's were experienced in these areas of high fishing effort in the second and third quarters. Although there were some indications that the apparent abundance of albacore was low in the southern waters in the first and fourth quarters, more data are needed to show this conclusively.

The apparent temporal changes in CPUE in the southern waters may be related to seasonal changes in recruitment of albacore into the fishery. The length-frequency distribution of albacore in waters south of lat. 20°S showed that several size groups of fish were represented in the catches, including groups of small fish not found north of lat. 20°S. The good CPUE in the second and third quarters may indicate periods of active recruitment. Generally, the albacore were stratified by size latitudinally; however, no such stratification was evident longitudinally. North of lat. 20°S the catches were composed of fish of a single size group. South of this latitude, as already indicated, the catches were composed of several size groups of fish.

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LITERATURE CITED

GRIFFITHS, R. C.
1960. A study of measures of population density and of concentration of fishing effort in the fishery for yellowfin tuna, *Neothunnus macropterus*, in the Eastern Tropical Pacific Ocean, from 1951 to 1956. Inter-Am. Trop. Tuna Comm. Bull. 4:41-136.

HONMA, M., AND T. KAMIMURA.
1957. Studies on the albacore. V. The fishing condition and size of albacore taken in the South Pacific Ocean. [In Jap., Engl. summ.] Rep. Nankai Reg. Fish. Res. Lab. 6:84-90.

KOTO, T.
1966. Studies on the albacore. XI. Distribution of albacore in the tuna longline fishing grounds of the South Pacific Ocean. [In Jap., Engl. summ.] Rep. Nankai Reg. Fish. Res. Lab. 23:43-53.

KOTO, T., AND K. HISADA.
1967. Studies on the albacore. XIII. Size composition of South Pacific albacore caught by longline. [In Jap., Engl. summ.] Rep. Nankai Reg. Fish. Res. Lab. 25:37-47.

OTSU, T., AND R. F. SUMIDA.
1968. Distribution, apparent abundance, and size composition of albacore (*Thunnus alalunga*) taken in the longline fishery based in American Samoa, 1954-65. U.S. Fish Wildl. Serv., Fish. Bull. 67:47-69.

ROTHSCHILD, B. J.
1967. Competition for gear in a multiple-species fishery. J. Cons. 31:102-110.

SKILLMAN, R. A.
1975. An assessment of the South Pacific albacore, *Thunnus alalunga*, fishery, 1953-72. Mar. Fish. Rev. 37(3):9-17.

SUDA, A.
1971. Tuna fisheries and their resources in the IPFC area. [Jap. summ.] Far Seas Fish. Res. Lab. (Shimizu), S Ser., 5, 58 p.

SUZUKI, G.
1961. On tuna fishing at the Samoa base in 1956. [In Jap.] Tuna Fish. (Maguro Gyogyō) 76:13-18.

YOSHIDA, H. O.
1971. Distribution, apparent abundance, and length composition of juvenile albacore, *Thunnus alalunga*, in the South Pacific Ocean. Fish. Bull., U.S. 69:821-827.