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# CHANGES IN TUNA LANDINGS OF THE HAWAIIAN LONGLINE FISHERY 1948–1956

BY RICHARD S. SHOMURA

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## ABSTRACT

This study was undertaken to determine the cause of a change in species dominance in the catch of the Hawaiian longline fishery from yellowfin (*Neothunnus macropterus*) to bigeye tuna (*Parathunnus sibi*) during the period 1948–49. The available commercial catch records showed that the reversal in species resulted from a shift by the larger vessels of the fleet from fishing grounds in the leeward waters of the northern islands to grounds located in the windward waters of the southern islands. Bigeye tuna are more available to the fishery in the windward waters than in the leeward, whereas the yellowfin tuna are taken in greater numbers in the leeward areas. The bigeye season extends from October through May, whereas the best yellowfin catches are made during the summer months, June through August.

A hypothesis is given to explain the distribution and migration of the bigeye tuna in the central Pacific. Essentially, it postulates spawning in the tropical waters south of the Hawaiian Islands, a migration of young fish northward, a seasonal north-south movement of the adult population, and finally a continued southward movement to the tropical spawning grounds by adults in imminent spawning condition.

# CHANGES IN TUNA LANDINGS OF THE HAWAIIAN LONGLINE FISHERY, 1948–1956

By RICHARD S. SHOMURA, *Fishery Research Biologist*

BUREAU OF COMMERCIAL FISHERIES

The Pacific Oceanic Fishery Investigations[1] (POFI) of the U.S. Fish and Wildlife Service has studied the hydrography and productivity of the central Pacific Ocean and has carried out exploratory fishing cruises to encourage the maximum development and utilization of the high-seas fishery resources of this area.

One segment of POFI's task has been to gain an understanding of the nature and problems of the existing commercial fisheries in the central Pacific. Although small quantities of tuna are taken in Hawaiian waters by trolling and handline, the two major fisheries in the islands are the pole-and-line fishery for skipjack (June 1951, Yamashita 1958) and the longline (flagline) fishery (June 1950, Otsu 1954) for the larger subsurface tunas. In a good year (1951) the skipjack fishery landed 12,900,000 pounds with a value of $1,700,000 (Yamashita 1958). The longline fishery in 1952, a good year for that fishery, landed tunas and marlins totaling 4 million pounds and valued at $1,200,000 (Otsu 1954). Though these fisheries are small in respect to total landings, their strategic occurrence in midocean makes them ideal laboratories for the study of certain problems concerning midocean tunas.

The present study of the Hawaiian longline fishery was stimulated by Otsu's (1954) finding that from 1946 to 1952 there was a decline in landings of yellowfin (*Neothunnus macropterus*) and an increase in landings of bigeye (*Parathunnus sibi*), with the reversal in dominance between 1948 and 1949. The change in the bigeye landings is especially noteworthy since it involved an increase from 12,000 pounds in 1946 to 2,200,000 pounds in 1952, without a corresponding increase in the overall fishing effort as indicated by the total number of trips (Otsu 1954). The purpose of the present study was to describe the seasonal and long-term trends in the landings of the two species, and if possible, to determine cause of the fluctuations.

The basic catch data utilized in this report were supplied by the Hawaiian Division of Fish and Game, through the courtesy of Director Vernon E. Brock. T. Shimizu of the Division's staff helped to assemble the data for analysis. The longline fishermen provided valuable information on the fishery and personnel of the auction firms, Kyodo Fishing Co., United Fishing Agency, and Hawaii Fishing Co., made auction records available.

## DESCRIPTION OF THE FISHERY

The Hawaiian longline fishery is the only American commercial fishery utilizing the longline method, as developed by the Japanese (Shapiro 1950), to capture subsurface tunas. The history and recent status of the fishery in Hawaii have been described by Brock (1949), June (1950), and Otsu (1954).

The longline fishery is dependent on vessels located at various ports throughout the Hawaiian Islands chain; however, the two major fleets are based at Hilo, Hawaii, about 10 vessels, and at Honolulu, Oahu, 31 to 33 vessels (Otsu 1954). These vessels range from 28 to 62 feet in length and are constructed along lines similar to the sampans used in the pole-and-line fishery (June 1951). They have a high, narrow bow with the wheelhouse and sleeping quarters located forward, leaving a spacious afterdeck of low freeboard. The latter facilitates the landing of large fish which, in the case of the marlins, occasionally exceed 1,000 pounds in weight. The vessels are

[1] Redesignated Bureau of Commercial Fisheries Laboratory, January 1, 1959.

NOTE.—Approved for publication, July 1, 1958. Fishery Bulletin 160.

generally powered by high-speed diesel engines, and since they lack mechanical refrigeration systems the catch is stored in crushed ice.

The longline is made up of a number of units of gear called baskets which are joined in a series and allowed to drift free of the vessel (June 1950). Each basket of gear is composed of a cotton mainline section from which are suspended 4 to 6 branch lines each bearing a single hook. The longline is supported at the surface by wooden, glass, or metal floats. The number of baskets fished per day varies with the individual vessel but rarely does it exceed 40 baskets. By comparison, Japanese fishermen operating on a considerably larger scale may use more than 300 baskets of gear per set (Ego and Otsu, 1952).

The average length of a trip for a Honolulu-based vessel is 8 or 9 days and a majority of the trips are made within sight of land. The gear is set in the morning and retrieved in the afternoon. During the intervening period the line is patrolled and, if the fishermen are able to recognize the presence of a hooked fish by a submerged buoy, the fish is landed and the hook reset.

Composition of the longline catch is varied and consists of a number of species of tunas and spearfishes. In addition to bigeye and yellowfin, the tuna catch includes small numbers of albacore (*Germo alalunga*), skipjack (*Katsuwonus pelamis*), and on rare occasions bluefin tuna (*Thunnus orientalis*). Among the spearfishes the most commonly taken species are the striped marlin (*Makaira audax*) and black marlin (*Makaira ampla*),[2] while lesser numbers of white marlin (*Istiompax marlina*),[3] broadbill swordfish (*Xiphias gladius*), and shortnose spearfish (*Tetrapturus angustirostris*) are taken. Other species caught on the longline include the dolphin (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), and various species of shark. Because of the wide variety of species taken and different periods of seasonal abundance, the fishery is capable of year-round operation.

## MATERIALS AND METHODS

The basic data used in this study were derived from fish catch reports submitted by members of the fishing industry to the Hawaiian Division of Fish and Game. The form of this report used in the longline fishery has undergone several modifications; a sample of the present form is shown in appendix figure 1, page 105. The areas fished were reported in code numbers indicated on a fisheries chart (app. fig. 2). The reported data were compared with records kept by the auctioning firms and some adjustments made, especially for the early years when individual boat owners filled in the fish catch reports, for they occasionally combined the catches of several trips and reported them as a single trip. Also, the yellowfin and bigeye catches often were not separated according to species, but were combined in one or the other species category. In recent years the auction firms have filled out the forms after obtaining the essential data from the fishermen.

In addition to the sources given, more detailed information was obtained from 1949 to 1952 by interviewing vessel captains. These data formed the basis of Otsu's (1954) study and have also been utilized in this report.

Preliminary examination of the data showed that for an accurate evaluation of the fishery some selection of data would be necessary. Description of the method used follows.

### SELECTION OF FLEET AND VESSELS

Initially, the study was limited to the Honolulu-based fleet, because the landings from this fleet comprised more than 80 percent of the total Hawaiian longline landings and accessibility of the Honolulu auctioning records made it possible to check doubtful data. Limiting the study to the Honolulu fleet does not imply that the fishing area was proportionately restricted, since the larger vessels at least fished throughout the major Hawaiian Islands group.

It was also decided to limit the sampling to vessels operating 5 or more of the 9 years under consideration. This eliminated recent additions to the fleet, which were known to fish for longer periods and with more units of gear than the older vessels. Evidence that the bulk of the fleet was the same throughout the period 1948 to 1956 is indicated by the operation during 1956 of 23 of the total of 31 vessels comprising the 1948 fleet. This stability is in part a reflection of the short period under study and the fact that most of the vessels were comparatively new. Of the 39 vessels

[2] Called blue marlin by continental Americans.
[3] Called black marlin by continental Americans.

fishing from 1948 to 1956, 21, or more than half of the total were launched during 1946 or 1947.

### SEPARATION OF FLEET BY SIZE OF VESSEL

Otsu (1954) stated that some of the Honolulu-based longline vessels fished in waters around Oahu continuously throughout the year while others roamed the entire area, fishing as far as the northeastern shore of the island of Hawaii (fig. 1). The records showed that vessels fishing exclusively around Oahu were smaller in size (registered length [4] of 45 feet or less) and fished fewer units of gear and fewer days per trip. Accordingly the vessels were classed, based on our knowledge of the fishery, as small or large and the catch data for each class were treated separately.

### THE TRIP AS A MEASURE OF EFFORT

Longline catch data have ordinarily been presented in terms of catch per 100 hooks (Murphy and Shomura, 1953). For the Hawaiian fishery, some data are available on the number of boat-days and the number of baskets fished in the early years, 1949 to 1952 (Otsu 1954), and for the years subsequent to 1955 the revised fish catch report includes the number of days at sea (app. fig. 1, p. 105). For the intervening years, 1953 to 1955, no such measures of effort are available. Even for the earlier period, 1949 to 1952, the data on the number of days fished are inadequate for a comprehensive study.

The only measure of fishing effort available for the entire period, 1948–56, is the number of trips. Thus, through necessity, the catch per unit of effort must be based on the catch per trip. To justify the trip as a measure of effort it was necessary first to determine whether there had been any changes in the length of trip during the period. Before 1952–53 some data were available on the number of days fished per trip, whereas for the subsequent years data were available on

[4] The vessel lengths were obtained from Annual Merchant Vessels of the United States, compiled by the U.S. Treasury Department.

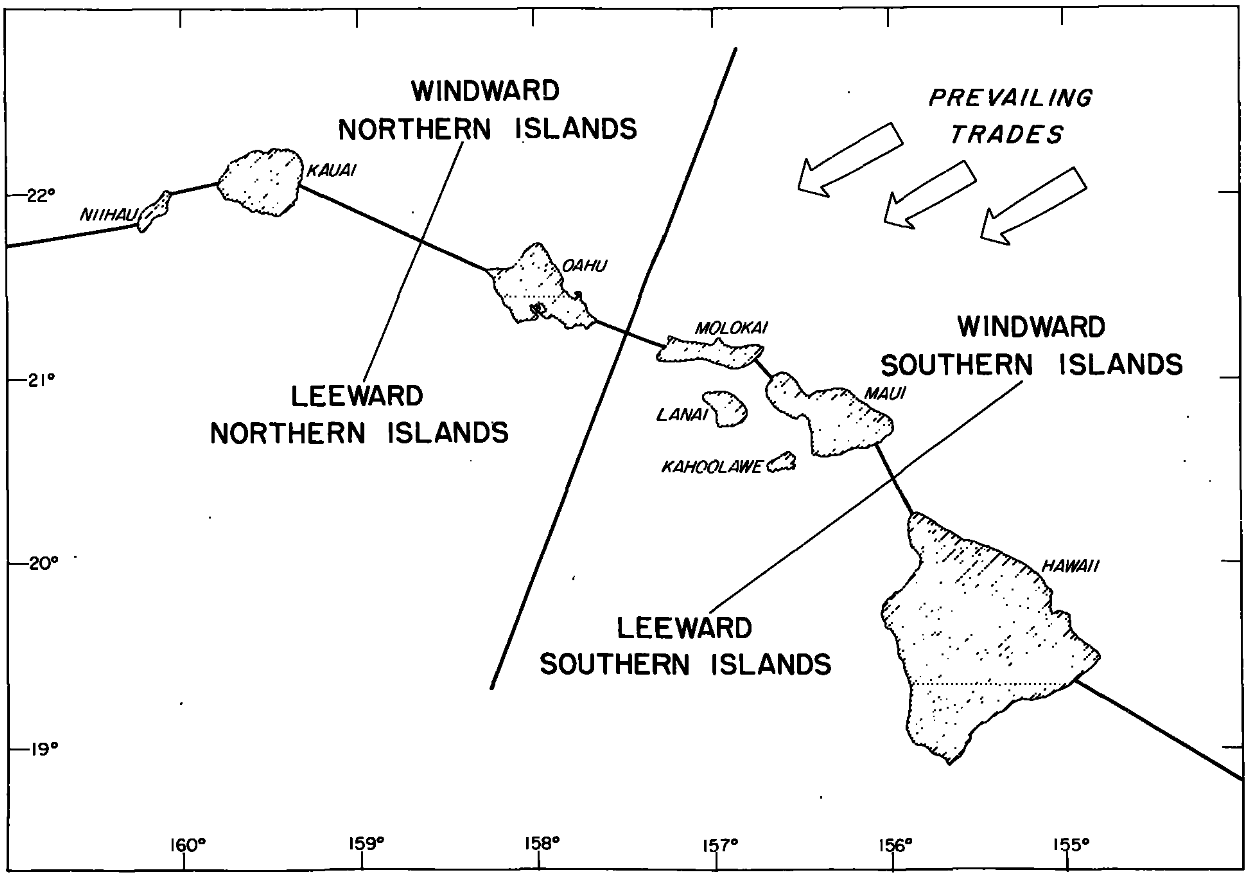


FIGURE 1.—Chart of the major Hawaiian Islands subdivided into windward and leeward zones for areal studies of catch.

the number of days at sea. Excluding weather as a factor, these two measures are essentially the same for the small vessels. These vessels generally fish in the immediate vicinity of Oahu and are thus able to return to port the night of the last fishing operation. On the other hand, if the large vessels fish in the windward areas of the southern islands, they must travel from 120 to 200 miles from the fishing grounds to Honolulu. This introduces a possible differences of at least 1 day, depending on the area fished, between the number of days fished and the number of days at sea. Table 1 gives the average number of days of fishing per trip for small and large vessels (the latter adjusted for traveling time). There are no evident trends in length of trip for either vessel category. For the small vessels the average trip ranged from a low of 7.7 days during 1954–55 to a high of 8.4 days in both 1951–52 and 1955–56, with an overall average of 8.1 days for the entire period. For the large vessels, the number of days fished per trip (adjusted) ranged from a low of 8.4 days during 1951–52 to a high of 9.7 days for 1949–50. The overall average length of trip for the entire period for the large vessels was 9.1 days.

TABLE 1.—*Number of days fished per trip, by size of vessel, 1949 to 1956*

[Vessels selected]

| | 1949–50 | 1950–51 | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 |
|---|---|---|---|---|---|---|---|
| Small vessels (<45 feet): | | | | | | | |
| Number of trips | 41 | 52 | 47 | 107 | 88 | 201 | 183 |
| Average number of days fished per trip | 8.3 | 8.2 | 8.4 | 8.0 | 7.9 | 7.7 | 8.4 |
| Large vessels (>45 feet): | | | | | | | |
| Number of trips | 125 | 132 | 165 | 165 | 178 | 321 | 316 |
| Average number of days fished per trip | 9.7 | 9.0 | 8.4 | 8.6 | 9.2 | 9.4 | 9.3 |

Another factor that should be considered in this evaluation of fishing effort is the number of baskets fished per day. As mentioned previously, the amount of gear fished per day was related to the size of the vessels, the larger vessels fishing more baskets of gear than the smaller. This difference is reduced in importance by the separation of the fleet into the two size categories. Some data are available on the number of baskets fished per day for the years 1950, 1952, and 1955 (table 2). There is some evidence that 1952 was an atypical year (Otsu 1954). If this year is omitted and only 1950 and 1955 considered, it appears that the number of baskets fished per day did not change materially for either the small or the large vessels. In both years the small vessels fished an average of 26 baskets of gear per day, whereas the large vessels increased the amount of gear fished per day from 30 baskets in 1950 to 31 baskets in 1955.

TABLE 2.—*Number of baskets of gear fished per day, by size of vessel*

[Vessels selected]

| | 1950 | 1952 | 1955 |
|---|---|---|---|
| Small vessels (<45 feet): | | | |
| Number of vessels | 8 | 12 | 7 |
| Average number of baskets fished per day | 26 | 24 | 26 |
| Range (baskets) | 22–30 | 21–31 | 20–30 |
| Large vessels (>45 feet): | | | |
| Number of vessels | 17 | 18 | 16 |
| Average number of baskets fished per day | 30 | 28 | 31 |
| Range (baskets) | 21–36 | 25–32 | 24–35 |

A final test of the trip as a measure of fishing effort is afforded by a comparison of the catch per trip with the catch per 100 hooks in those periods for which both kinds of data are available. Unfortunately, however, the only year with adequate data was 1952, which has been considered atypical. Nevertheless, a plot (fig. 2) of these two units shows that the two variables are

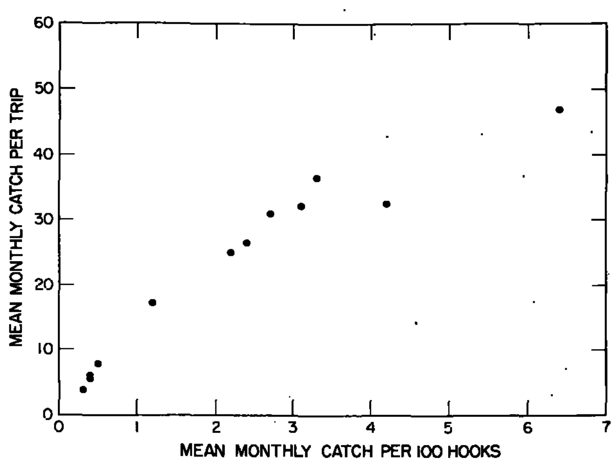


FIGURE 2.—Comparison of monthly mean bigeye catch per 100 hooks and per trip in 1952.

closely correlated and exhibit a linear relation. We believe, therefore, that the catch per trip is the best attainable measure of availability of the two species of tuna to longline gear.

## ANALYSIS OF THE DATA

The total Hawaiian landings of bigeye and yellowfin, shown in figure 3,[5] include catches made by various methods of tuna fishing, e. g., the longline, pole-and-line, trolling, and handline fishing. The yellowfin catch has shown a steady decline from 1,325,000 pounds in 1946 to 446,000 pounds in 1955, whereas the bigeye catch increased from a low of 199,000 pounds during the 1946–47 season to a high of 2,710,000 pounds for the 1953–54 season. Since 99 percent of the bigeye and about 85 percent of the yellowfin are caught in the longline fishery, the longline landings parallel the total landings.

The trend in yellowfin landings of the Honolulu-based vessels shows some divergence from the trends in the total catch by all methods and in the total longline landings (fig. 3). Despite the steady decline observed in the overall catch, the yellowfin landings of the Honolulu fleet remained at a relatively stable level, averaging 375,000 pounds annually from 1948 through 1952. Then in the 3 years that followed, 1953 to 1955, the Honolulu landings dropped 30 percent to an average annual figure of 275,000 pounds. Even this drop failed to keep pace with the decline of the overall catch, with the result that the Honolulu landings, which in 1948 and 1949 made up only 36 and 38 percent of the total yellowfin catch of the longline fishery, averaged 64 percent during the next 6 years, 1950 through 1955. This failure of the trend in the Honolulu yellowfin landings to parallel that for the Territory as a whole cannot be fully explained at present; it appears to be associated with operational aspects of the fishery to be discussed later in this report. It should be mentioned, however, that while the data for the Honolulu fleet have been checked and corrected by means of various sources, the same has not been done for the remaining Hawaiian longline data.

[5] Since the bigeye season occurs in the winter and spring months, the annual period for bigeye extends from July of one year through June of the following year. For yellowfin the calendar year is retained, inasmuch as the yellowfin landings reach a peak during the summer months.



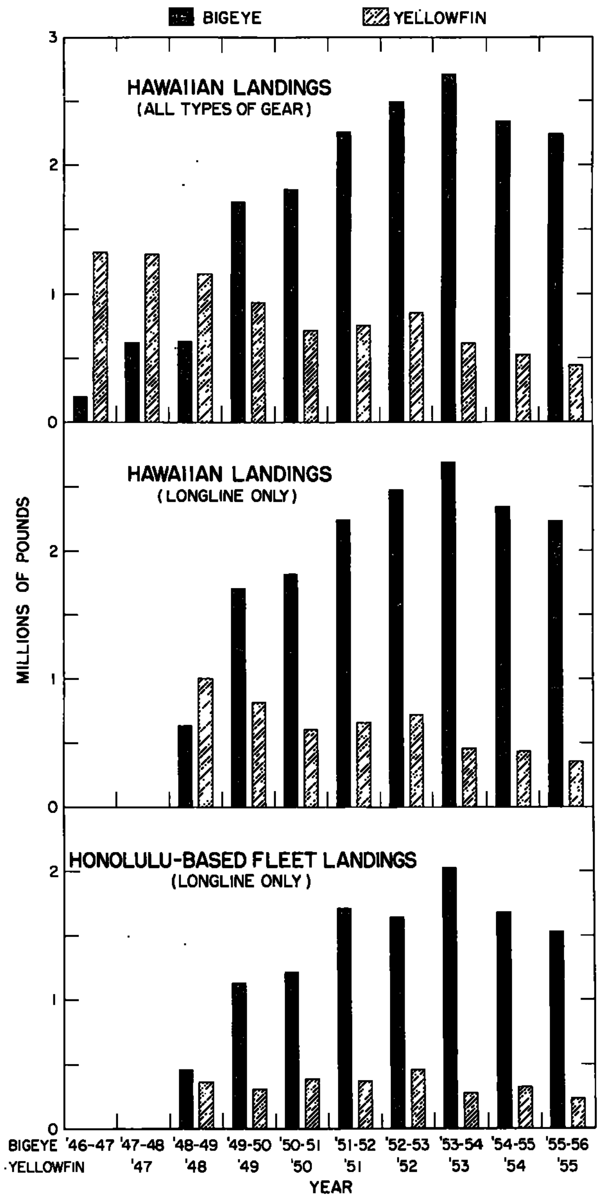


FIGURE 3.—Landings of bigeye (by fiscal year) and yellowfin (by calendar year), 1946 to 1956. (See appendix table 1.)

## CATCH STATISTICS

Unless otherwise stated, the following discussions on landings and catch rates are in terms of numbers of fish rather than weight.

The bigeye catch of the selected large vessels varied directly with the landings of the entire Honolulu fleet, with a 300-percent increase between 1948–49 and 1953–54 and a decline thereafter (fig. 4). In contrast, the catch of the small

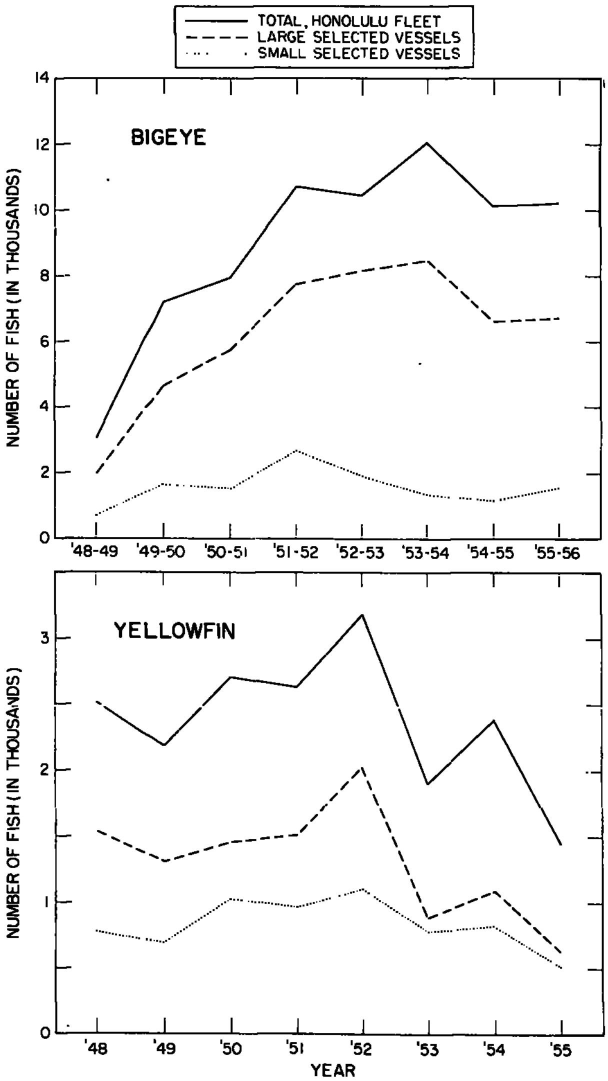


**Figure 4.—Bigeye catch (by fiscal year) and yellowfin catch (by calendar year), by size of vessel.**

selected vessels showed a slight rise from 1948–49 to 1951–52 and a decline thereafter. Thus, it appears that the tremendous increase in overall production was contributed by the large vessels.

The yellowfin landings, likewise, suggest that changes in the total catch were caused by changes in the landings of large vessels only. The most distinctive feature of the yellowfin landings (fig. 4) is the shift in relative proportion of the total catch obtained by the two classes of vessels. The proportion of the total yellowfin catch taken by the larger vessels was much higher before 1953 than it was during the last 3 years of the study, 1953 through 1955. Since this shift was coincident with the increased bigeye catches of the large vessels, it is evident that the changes in landings are related to factors affecting only the large vessels.

## FISHING EFFORT

Examination of the number of baskets fished per day and the number of days per trip indicated only slight variations in these measures of effort; thus, any substantial changes in the overall effort, if they did occur within the Honolulu fleet, should be revealed in the number of trips made each year. Figure 5 shows that there was a steady increase in the total number of trips from 1948–49 to 1953–54 and a decline in the last two seasons 1954–55 and 1955–56. The increase was the result of more trips being made per boat, as shown by the higher number of trips per boat-month (fig. 5), and also the result of more vessels being added than were lost to the fleet. The latter is indicated in table 3 by the increased number of trips of the nonselected vessels, which presumably were recent additions.

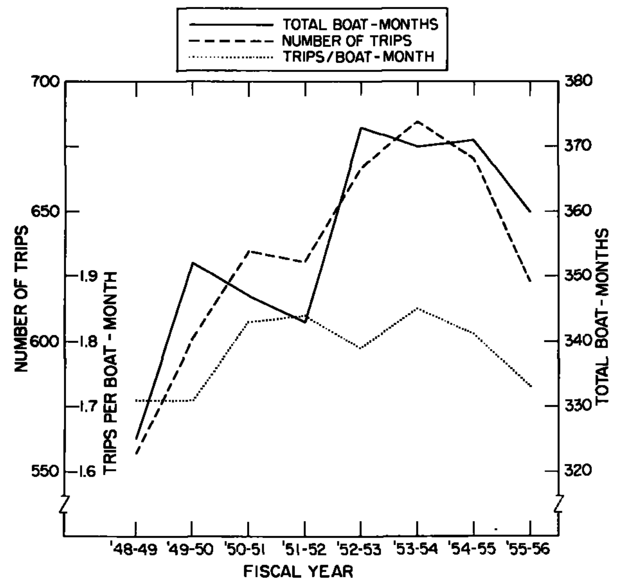


**Figure 5.—Trends in fishing effort of Honolulu-based fleet, 1948–49 to 1955–56.**

In a comparison of the effort expended (fig. 6) we find that both the small and large selected vessels followed the trend of the entire fleet.

TABLE 3.—*Effort expended by Honolulu-based fleet, 1948–49 to 1955–56*

| Measure of effort | 1948–49 | 1949–50 | 1950–51 | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 |
|---|---|---|---|---|---|---|---|---|
| Boat-months: | | | | | | | | |
| Selected small vessels | 105 | 119 | 119 | 136 | 141 | 108 | 111 | 100 |
| Selected large vessels | 186 | 195 | 196 | 199 | 213 | 207 | 199 | 194 |
| Total | 291 | 314 | 315 | 335 | 354 | 315 | 310 | 294 |
| Nonselected small vessels | 4 | 4 | 5 | 1 | 12 | 12 | 12 | 12 |
| Nonselected large vessels | 30 | 34 | 27 | 7 | 7 | 43 | 49 | 54 |
| Total | 34 | 38 | 32 | 8 | 19 | 55 | 61 | 66 |
| Trips: | | | | | | | | |
| Selected small vessels | 197 | 215 | 236 | 263 | 264 | 218 | 219 | 193 |
| Selected large vessels | 309 | 327 | 344 | 354 | 374 | 370 | 344 | 323 |
| Total | 506 | 542 | 580 | 617 | 638 | 588 | 563 | 516 |
| Nonselected small vessels | 4 | 6 | 8 | 2 | 19 | 24 | 27 | 19 |
| Nonselected large vessels | 47 | 53 | 46 | 12 | 10 | 73 | 81 | 88 |
| Total | 51 | 59 | 54 | 14 | 29 | 97 | 108 | 107 |
| Trips per boat-month: | | | | | | | | |
| Selected small vessels | 1.88 | 1.81 | 1.98 | 1.93 | 1.87 | 2.02 | 1.97 | 1.93 |
| Selected large vessels | 1.67 | 1.68 | 1.76 | 1.78 | 1.76 | 1.79 | 1.73 | 1.66 |

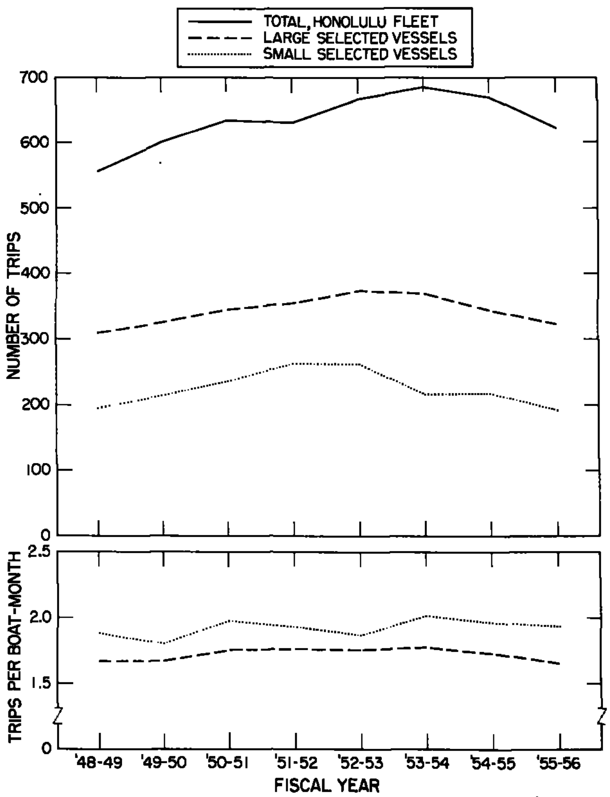


FIGURE 6.—Trends in fishing effort of small and large vessels, 1948–49 to 1955–56.

## CATCH PER UNIT OF EFFORT

The marked seasonal variation in catch per unit of effort for the bigeye and yellowfin tuna is shown in figure 7. The peak catch of yellowfin occurred during the summer and of bigeye during the winter and spring months. Of interest is the difference in catch rate for the two species in relation to size of vessel. The bigeye catch of the large vessels was considerably higher than that of the small vessels, the difference being more evident during the later years. On the other hand, with respect to yellowfin, the large and small vessel catch rates were nearly equal, the large vessels having only a slightly higher average catch.

The increase in bigeye catches and the difference in relative fishing success by vessel size for the two species can be better illustrated by the average annual catch rates (fig. 8). The large vessels experienced a sharp increase from 6.5 bigeye per trip during the 1948–49 season to 21.9 during the 1951–52 season, an increase of about 240 percent. The catch rates in subsequent years were stable at this high level, with only a slight decrease during the last two seasons, 1954–55 and 1955–56. The small vessels, on the other hand, exhibited minor fluctuations in the bigeye catch rate during the eight seasons, but the catch remained at a relatively low level.

The yellowfin catch rates (fig. 8) varied irregularly. The small vessels had a stable yellowfin catch rate of three to four fish per trip from 1948 through 1954 and a noticeable decline in 1955. On the other hand, the large vessels experienced two levels of fishing success. The first and higher level during 1948 through 1952, when the catches ranged from four to five yellowfin per trip, and the second and lower level persisting through the last three seasons, 1953 to 1956, with a catch rate

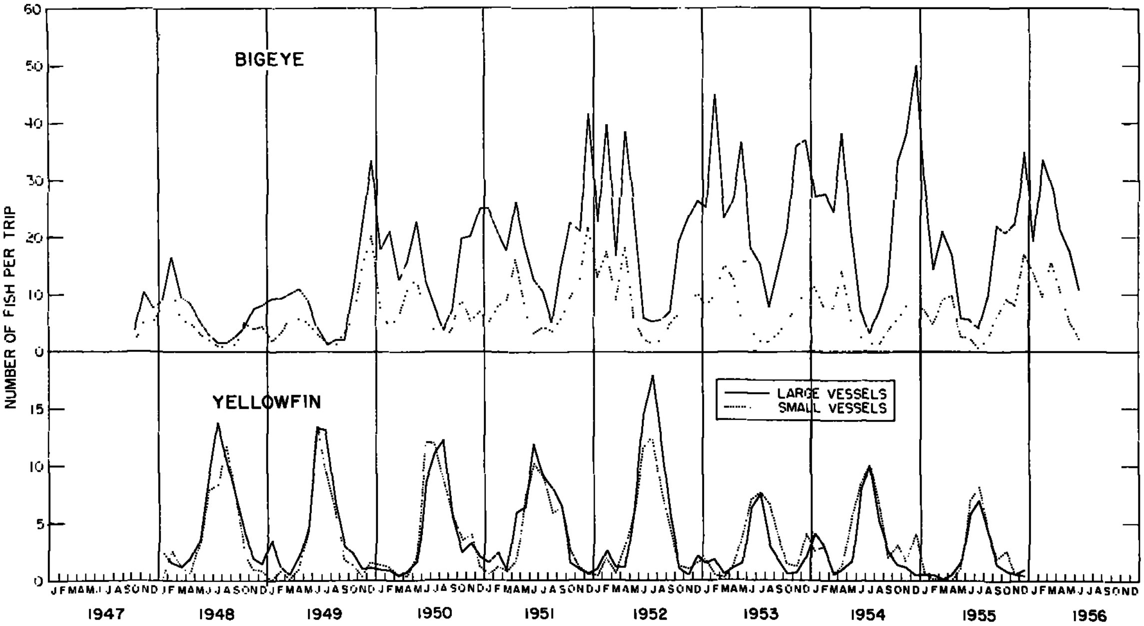


FIGURE 7.—Average catch per trip of bigeye and yellowfin tuna, by month and by vessel size.

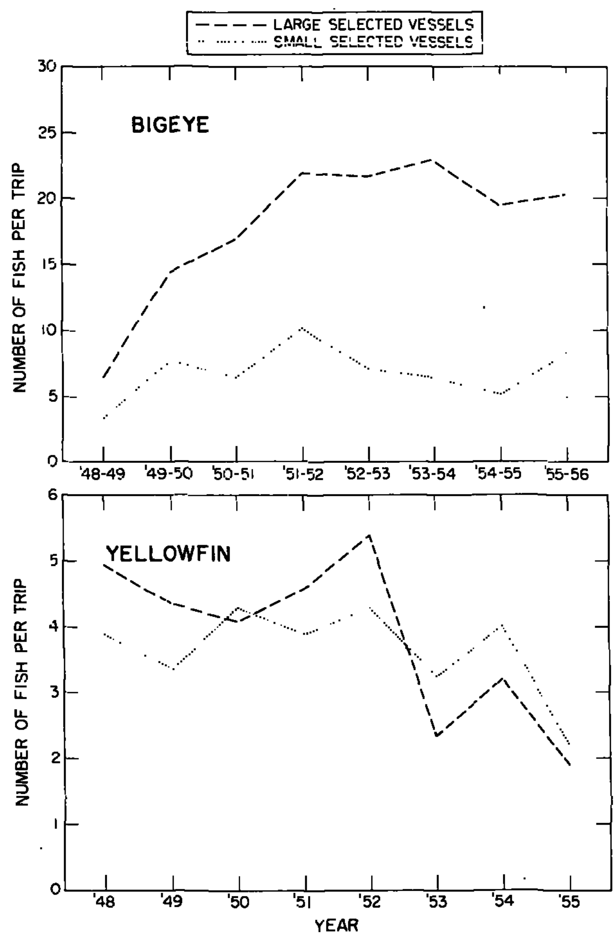


FIGURE 8.—Average bigeye catch (by fiscal year) and yellowfin catch (by calendar year) per unit of effort, by size of vessel.

of two to three yellowfin per trip. The most significant feature of this change in level is that for the last three seasons the catch rate of the large vessels was lower than that of the small vessels. This difference is surprising when it is realized that the large vessels fished more days per trip and more units of gear than did the small vessels.

Since the factors contributing to the trip as a measure of fishing effort have been analyzed and found to be stable, especially when vessel size has been adjusted, the discrepancies observed must be explained by changes in availability of the species, either by fluctuations in their actual abundance or indirectly by inherent differences in fishing success in the various areas fished. With regard to abundance, to explain the differences in bigeye catch by the two size groups of vessels would require an increase in the bigeye population which did not distribute itself uniformly throughout the fishing areas. This is possible, but improbable, when one must explain a simultaneous decrease in yellowfin abundance during the last three seasons—a decrease which would be confined only to the areas fished by the large vessels. The most probable explanation which satisfies all these varying points is a difference in availability of the two species among localities and an increased fishing effort by the large vessels in areas containing more bigeye.

## CHANGES IN FISHING AREAS AND EFFORT

Because of a limited range, the Honolulu-based small vessels must confine their fishing to the immediate vicinity of Oahu. The distribution of their trips, by season and area, is given in table 4. Aside from a seasonal shift in effort, there appears to be no general change in fishing area within the period studied. More than 80 percent of the trips of these vessels were to the windward and leeward areas of Oahu, and of these the leeward areas received the greater effort. The small vessels fished almost exclusively in the leeward areas during the summer months, and although there is a noticeable increase in fishing effort in the windward areas during the fall, winter, and spring months, the greatest percentage of the trips were made in the leeward waters at all seasons. The reason that the increase in effort was not more pronounced in the windward areas during the bigeye season may be that the small vessels prefer the calmer waters to leeward in spite of the greater availability of bigeye in the windward areas (Otsu 1954).

The distribution of trips by season and area for the large vessels is given in table 5. In general, these vessels tended to fish in the lee of the northern islands and on the windward side of the southern islands. During recent years there has been a pronounced shift in emphasis from the former to the latter area. With the exception of the winter of 1948–49, the majority of the fishing during the winter season has been in the windward areas of the southern islands. Also notable is the small yet consistent fishing effort in the windward areas of the northern islands, which could be in response to a greater availability of bigeye in these waters.

TABLE 4.—*Percentage distribution of trips of small vessels, by season and area, 1947 to 1956*

| Season | 1947 | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|---|---|---|---|---|
| Spring: | | | | | | | | | | |
| Northern Islands: | | | | | | | | | | |
| Windward Kauai | -- | -- | -- | 13 | 5 | 5 | 10 | -- | -- | -- |
| Leeward Kauai | -- | 6 | 23 | -- | -- | 10 | -- | -- | -- | -- |
| Windward Oahu | -- | 32 | 12 | -- | 5 | -- | -- | -- | 62 | 6 |
| Leeward Oahu | -- | 36 | 65 | 87 | 89 | 85 | 62 | 95 | 33 | 94 |
| Southern Islands: | | | | | | | | | | |
| Windward Maui-Molokai | -- | 6 | -- | -- | -- | -- | 3 | -- | -- | -- |
| Leeward Maui-Molokai | -- | 17 | -- | -- | -- | -- | 24 | 5 | 4 | -- |
| Windward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Leeward Hawaii | -- | 2 | -- | -- | -- | -- | -- | -- | -- | -- |
| Number of trips | -- | 47 | 52 | 54 | 57 | 20 | 29 | 22 | 24 | 16 |
| Summer: | | | | | | | | | | |
| Northern Islands: | | | | | | | | | | |
| Windward Kauai | -- | -- | -- | 2 | 2 | 2 | -- | -- | -- | -- |
| Leeward Kauai | -- | 17 | 8 | -- | -- | 2 | -- | -- | -- | -- |
| Windward Oahu | -- | 4 | -- | -- | -- | 4 | -- | -- | -- | -- |
| Leeward Oahu | -- | 76 | 92 | 98 | 95 | 88 | 100 | 100 | 100 | -- |
| Southern Islands: | | | | | | | | | | |
| Windward Maui-Molokai | -- | 2 | -- | -- | 3 | 4 | -- | -- | -- | -- |
| Leeward Maui-Molokai | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Windward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Leeward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Number of trips | -- | 46 | 48 | 60 | 60 | 51 | 27 | 27 | 25 | -- |
| Fall: | | | | | | | | | | |
| Northern Islands: | | | | | | | | | | |
| Windward Kauai | -- | -- | 2 | -- | -- | -- | -- | -- | -- | -- |
| Leeward Kauai | -- | 12 | 9 | 2 | -- | -- | -- | -- | -- | -- |
| Windward Oahu | -- | 12 | 2 | -- | -- | 12 | 4 | 9 | 28 | -- |
| Leeward Oahu | -- | 72 | 85 | 96 | 90 | 71 | 88 | 91 | 72 | -- |
| Southern Islands: | | | | | | | | | | |
| Windward Maui-Molokai | -- | 5 | 2 | 2 | 10 | 17 | -- | -- | -- | -- |
| Leeward Maui-Molokai | -- | -- | -- | -- | -- | -- | 8 | -- | -- | -- |
| Windward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Leeward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Number of trips | -- | 43 | 47 | 58 | 48 | 59 | 26 | 23 | 25 | -- |
| Winter: | | | | | | | | | | |
| Northern Islands: | | | | | | | | | | |
| Windward Kauai | -- | 3 | 4 | 3 | -- | -- | -- | -- | -- | -- |
| Leeward Kauai | 4 | 9 | 2 | -- | -- | -- | -- | -- | -- | -- |
| Windward Oahu | 24 | 14 | 8 | 3 | 12 | 14 | 8 | 29 | 58 | -- |
| Leeward Oahu | 44 | 71 | 86 | 76 | 69 | 73 | 76 | 58 | 42 | -- |
| Southern Islands: | | | | | | | | | | |
| Windward Maui-Molokai | 20 | 3 | -- | 15 | 19 | 11 | 12 | -- | -- | -- |
| Leeward Maui-Molokai | 8 | -- | -- | 2 | -- | 2 | 4 | 12 | -- | -- |
| Windward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Leeward Hawaii | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Number of trips | 25 | 35 | 51 | 59 | 26 | 44 | 25 | 24 | 19 | -- |

TABLE 5.—*Percentage distribution of trips of large vessels, by season and area, 1947 to 1956*

| Season | 1947 | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|---|---|---|---|---|
| Spring: | | | | | | | | | | |
| Windward northern islands | ---------- | 20 | 3 | 28 | 41 | 2 | 19 | ---------- | 26 | 5 |
| Leeward northern islands | ---------- | 23 | 68 | 29 | 49 | 42 | 7 | ---------- | 12 | 11 |
| Windward southern islands | ---------- | 43 | 26 | 37 | 6 | 43 | 52 | 97 | 53 | 43 |
| Leeward southern islands | ---------- | 14 | 3 | 6 | 4 | 12 | 21 | 3 | 9 | 41 |
| Number of trips | ---------- | 70 | 68 | 86 | 81 | 81 | 42 | 35 | 34 | 37 |
| Summer: | | | | | | | | | | |
| Windward northern islands | ---------- | 10 | 18 | 12 | 43 | 25 | ---------- | 3 | ---------- | ---------- |
| Leeward northern islands | ---------- | 61 | 75 | 56 | 36 | 58 | 10 | 28 | 17 | ---------- |
| Windward southern islands | ---------- | 13 | 4 | 29 | 18 | 16 | 87 | 44 | 67 | ---------- |
| Leeward southern islands | ---------- | 16 | 3 | 4 | 3 | 1 | 3 | 25 | 17 | ---------- |
| Number of trips | ---------- | 69 | 71 | 84 | 67 | 89 | 39 | 32 | 36 | ---------- |
| Fall: | | | | | | | | | | |
| Windward northern islands | ---------- | 18 | 24 | 17 | 11 | 23 | ---------- | ---------- | ---------- | ---------- |
| Leeward northern islands | ---------- | 55 | 27 | 41 | 22 | 10 | ---------- | ---------- | ---------- | ---------- |
| Windward southern islands | ---------- | 18 | 48 | 41 | 67 | 65 | 95 | 97 | 98 | ---------- |
| Leeward southern islands | ---------- | 9 | 1 | 1 | ---------- | 1 | 5 | 3 | 2 | ---------- |
| Number of trips | ---------- | 77 | 82 | 83 | 85 | 77 | 43 | 34 | 40 | ---------- |
| Winter: | | | | | | | | | | |
| Windward northern islands | 21 | 24 | 24 | 14 | 24 | 19 | 2 | ---------- | 14 | ---------- |
| Leeward northern islands | 15 | 44 | 17 | 11 | 10 | 6 | 7 | ---------- | ---------- | ---------- |
| Windward southern islands | 52 | 31 | 59 | 74 | 67 | 75 | 86 | 100 | 78 | ---------- |
| Leeward southern islands | 12 | 1 | ---------- | 1 | ---------- | ---------- | 5 | ---------- | 8 | ---------- |
| Number of trips | 66 | 68 | 75 | 76 | 72 | 53 | 42 | 32 | 37 | ---------- |

Of the four seasons, the spring distribution of fishing effort was the most erratic. Even during this season, however, the effort was concentrated in the leeward areas of the northern islands and in the windward areas of the southern islands. In the earlier years, effort during the summer was concentrated in the leeward waters of the northern islands, but during the last three summers, 1953 through 1955, it noticeably declined.

The annual effort and catch of bigeye and yellowfin by the large vessels in the windward areas of the southern islands are summarized in figure 9. The effort increased from a low of 22 percent of the total annual trips made into this area during 1948–49 to a high of 88 percent during the 1953–54 season. The following two seasons showed a slight decline. Again the significant feature both of the bigeye and of the yellowfin catch is the position of each relative to the effort expended. It is evident that bigeye fishing was more successful in this area than elsewhere, judged by the consistently higher catch percentage, than would be expected from the amount of effort expended. On the other hand, the reverse is true for yellowfin, with the catch consistently lower than the effort expended, indicating that the area is not as good a fishing ground for yellowfin as for bigeye. From this it can be deduced that yellowfin are relatively more abundant in the leeward waters of the northern islands than in the windward waters of the southern islands.

The seasonal breakdown of catch and fishing effort for the windward areas of the southern islands is presented in figure 10. The bigeye and yellowfin catch and effort by season still follow the yearly trends. For all four seasons, the bigeye catch is consistently higher than expected from

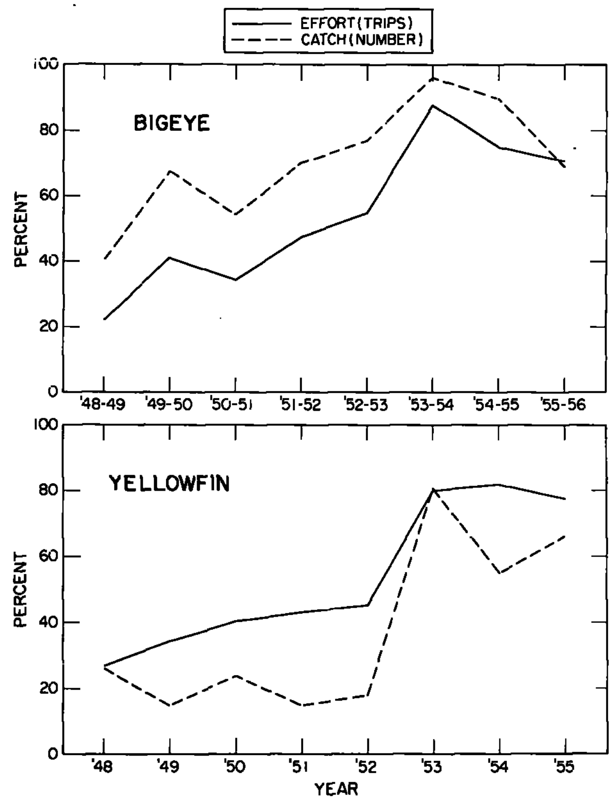


FIGURE 9.—Catch of bigeye (by fiscal year) and yellowfin (by calendar year) in respect to effort of large vessels in windward waters of the southern islands. (See appendix table 2.)

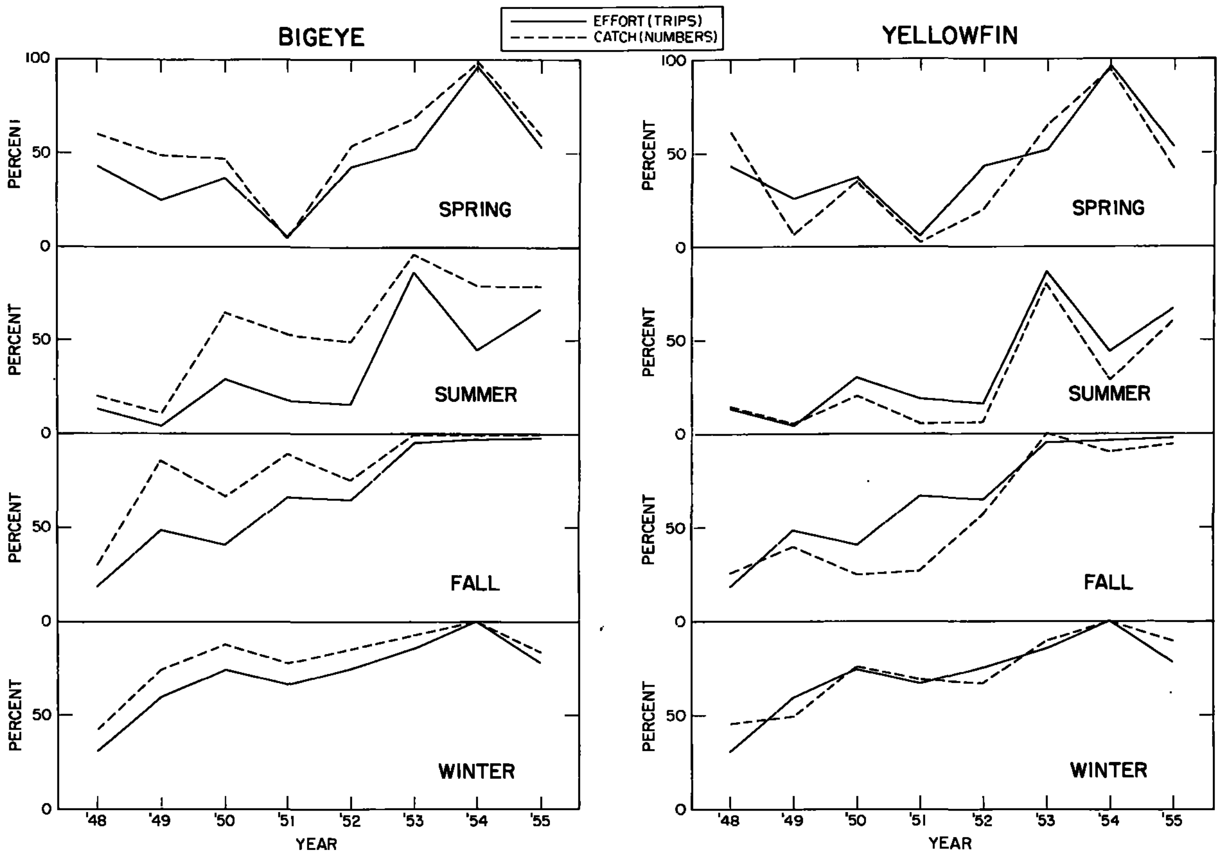


**Figure 10.**—Bigeye and yellowfin catch and fishing effort of large vessels, by seasons, in the windward waters of the southern islands. (See appendix tables 3 and 4.)

the amount of effort expended, whereas the reverse is true of the yellowfin catch. Thus it seems that the differences in availability of the two species in these windward areas are real and not due to a shift in effort among the four seasons.

Firm evidence of areal differences in the availability of the two species is shown by a comparison of the distribution of effort and the resulting catch in the windward area by the small vessels (fig. 11). To reduce the variation due to the seasonal shift in effort, this comparison has been confined to the winter and spring seasons, December through May. Considering the small amount of data available, the possibility of an error in the magnitude of the catches cannot be denied; however, the consistently higher percentage of bigeye taken from the windward areas for the effort expended gives evidence that bigeye were more available in the windward than in the leeward areas. Unfortunately, a similar areal comparison cannot be made for yellowfin, since the small vessels fished almost exclusively in the leeward waters during the height of the yellowfin season.

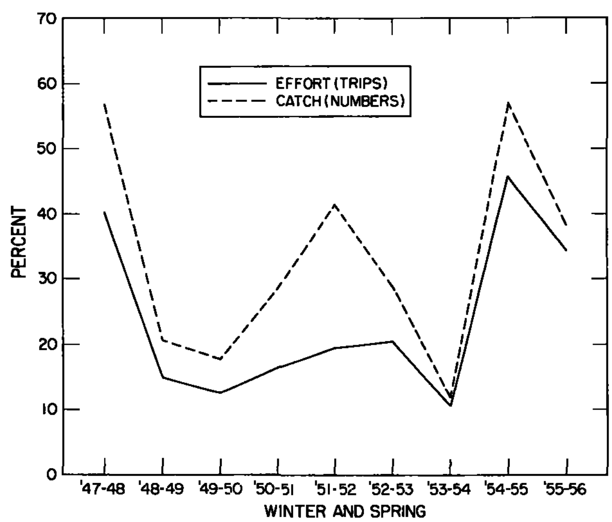


**Figure 11.**—Comparison of fishing effort and bigeye catch in windward areas by small vessels, winter and spring seasons combined. (See appendix table 5.)

In summary, the increase in landings of bigeye and the decline in landings of yellowfin can be related largely to a shift in fishing area by the large vessels from the lee of the northern islands to the windward waters of the southern islands. However, this does not preclude the existence of natural fluctuations in availability, since the catch rates of the small vessels, which did not participate in this shift, show a peak in bigeye during the 1951–52 season. Otsu (1954) points out that on several occasions during this season the catches were limited to prevent flooding of the fresh-fish market. The yellowfin, too, show natural fluctuations, as evidenced by the decline in catch rate of the small vessels during 1955.

## SEASONAL DISTRIBUTION OF BIGEYE AND YELLOWFIN

A composite of the monthly average catch rates over the entire period is not the best means of depicting the seasonal distribution of bigeye and yellowfin tuna, but the lack of precise data precludes a detailed examination. This method, however, does show the seasonal trends and for this purpose the data are presented as such in figure 12.

The bigeye season can be considered to occur from October through May, when the large vessels made catches of better than 10 bigeye per trip and the small vessels from 5 to 12 bigeye per trip. The average monthly catches (fig. 7) for the large vessels showed considerable variation, which is reflected in the composite catch per trip, with peaks during December, February, and April and lows during January and March. On the other hand, the small vessel category shows only one depression covering January through March. This double peaking of the bigeye catches for the small vessels appears to hold true even for individual years; e.g., 1949–50 and 1953–54 (fig. 7). One possibility which could account for the low points would be the inability of the vessels to fish because of bad weather. This would be expected to affect the catch rates inasmuch as the trip is used as the unit of effort. A cursory examination of the days on which small craft warnings were issued by the U. S. Weather Bureau (table 6) shows that there is some correlation of low catches with bad weather. At the present time, however, we are unable to make any quantitative estimates of the effect of weather on catch and fishing effort.

The yellowfin season extends over the summer months and unlike the more gradual entrance of the bigeye into the fishery, the yellowfin enters abruptly during the month of June (fig. 13). This is indicated by the high catch rate of nearly 10 yellowfin per trip for both small and large

TABLE 6.—*Number of days with small craft warnings*

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May |
|---|---|---|---|---|---|---|---|---|
| 1951–52 | 2 | 4 | 1 | 3 | 0 | 9 | 1 | 0 |
| 1952–53 | 0 | 10 | 1 | 0 | 4 | 0 | 0 | 0 |
| 1953–54 | 1 | 6 | 1 | 3 | 2 | 3 | 1 | 0 |
| 1954–55 | 1 | 3 | 8 | 1 | 9 | 5 | 6 | 0 |
| 1955 | 0 | 9 | 2 | ------- | ------- | ------- | ------- | ------- |

NOTE.—Unpublished data furnished by U.S. Weather Bureau.

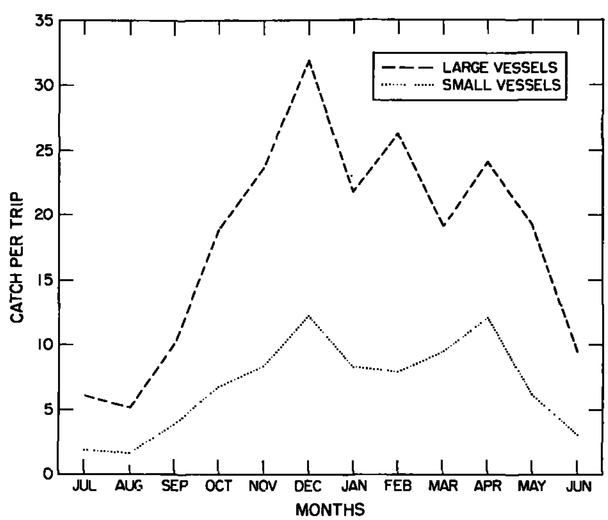


FIGURE 12.—Composite catch per trip of bigeye tuna for small and large vessels, July 1948 to June 1956.

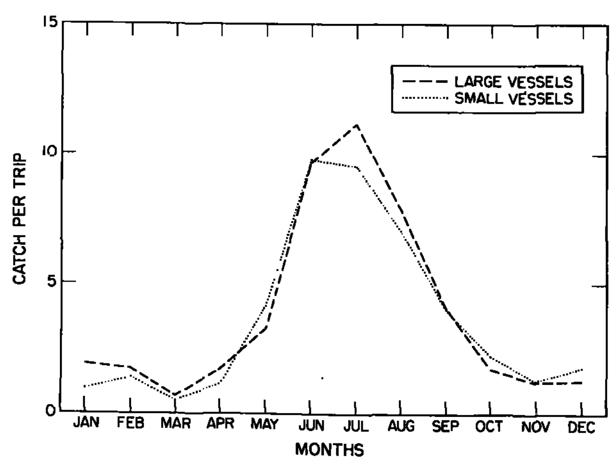


FIGURE 13.—Composite catch per trip of yellowfin tuna for small and large vessels, 1948 to 1956.

vessels during June compared with the low of about 4 fish per trip during the previous month. The rapid decline of the catch rates during August and September, from eight yellowfin per trip to four, also suggests a rather rapid movement of the yellowfin from the fishing grounds.

The yellowfin catch shows uniform single modes for both small and large vessels. This absence of fluctuations could possibly be due to a more uniform number of days fished per trip, a result of the generally good weather which prevails during the summer months. As pointed out in the earlier discussion, there are significant differences in the relative fishing success for bigeye and yellowfin, related to vessel size. The catch rates for yellowfin by small and large vessels were approximately equal throughout the year, whereas for bigeye the large vessels experienced 2.5 times better fishing than the small vessels.

## SIZE OF FISH

The Hawaiian longline fishery, by virtue of the method of fishing, primarily exploits the large tunas, a majority of the catch being composed of fish exceeding 100 pounds in weight. The lack of small fish in the catch is not due to their absence from the area, for Moore (1951) has reported that small bigeye and yellowfin are taken in Hawaiian waters by surface-fishing methods; but more likely it is due to a differential size segregation of the species with depth. Bigeye and yellowfin appear to spend their early life near the surface and their adult life in deeper waters, thus the small fish are not available to the deep-fishing longline gear (Murphy and Shomura, 1953).

As noted previously and shown in figure 12, good bigeye catches are made in Hawaiian waters from October through May and only during the summer months are the catches considered poor. In their work on albacore and bigeye (Honma and Kamimura, 1955; Suda 1954), the Japanese have shown that west of the 180° meridian these two species undergo a latitudinal migration, being taken farthest to the north during the summer period and to the south during the winter months. They also present some evidence that at any given time small fish are located to the north of the larger fish, the net result being a gradation in sizes with progressively larger fish to the south. Some evidence of such a phenomenon in the Hawaiian fishery is indicated by the changes in average size of the bigeye (fig. 14). Despite the variability of the averages from month to month, the catch was composed of consistently smaller fish during the winter months, as is to be expected if the larger fish in a population sorted by size did move to the south during the winter.

Another interesting size variability in the catch is the consistently lower average size of bigeye taken by the small vessels as compared with those taken by the large vessels. This difference, which is most noticeable during the winter months (fig. 14), is clearly indicated in a comparison of the annual average size of bigeye by size of vessel (fig. 15). Although the magnitude of the differences is not important, the consistency of the relation, i.e., small fish being captured by small vessels, is striking. This may be confirming evidence of the size gradation with latitude, inasmuch as the small vessels operate in waters farther north than the large vessels.

The yellowfin also show considerable seasonal fluctuations in average size, with the larger fish occurring during the summer months when the catches are best (fig. 14). Unlike the bigeye, there are no pronounced differences in the annual average size of yellowfin taken by small and large vessels (fig. 15).

## DISCUSSION

At present, little is known of the life histories of the various tuna species. Research has been conducted on various segments of the biology of the bigeye and yellowfin in Hawaiian waters (Brock 1949, June 1953, Otsu 1954, Iversen 1956, and Yuen 1955). Utilizing all available information, we have constructed a hypothesis to explain the presence of the bigeye in Hawaiian waters. In brief, this assumes that bigeye tuna spawn in tropical waters south of the Hawaiian Islands and that the young fish migrate to the north of Hawaii. Superimposed on this migration of the young fish are regular, seasonal north-south migrations of the adult population.

This explanation is based on the following information. Yuen (1955) established that the bigeye in Hawaiian waters are not in spawning condition, and thus their presence in the longline fishery cannot be attributed to a spawning run, such as was suggested for the yellowfin by June

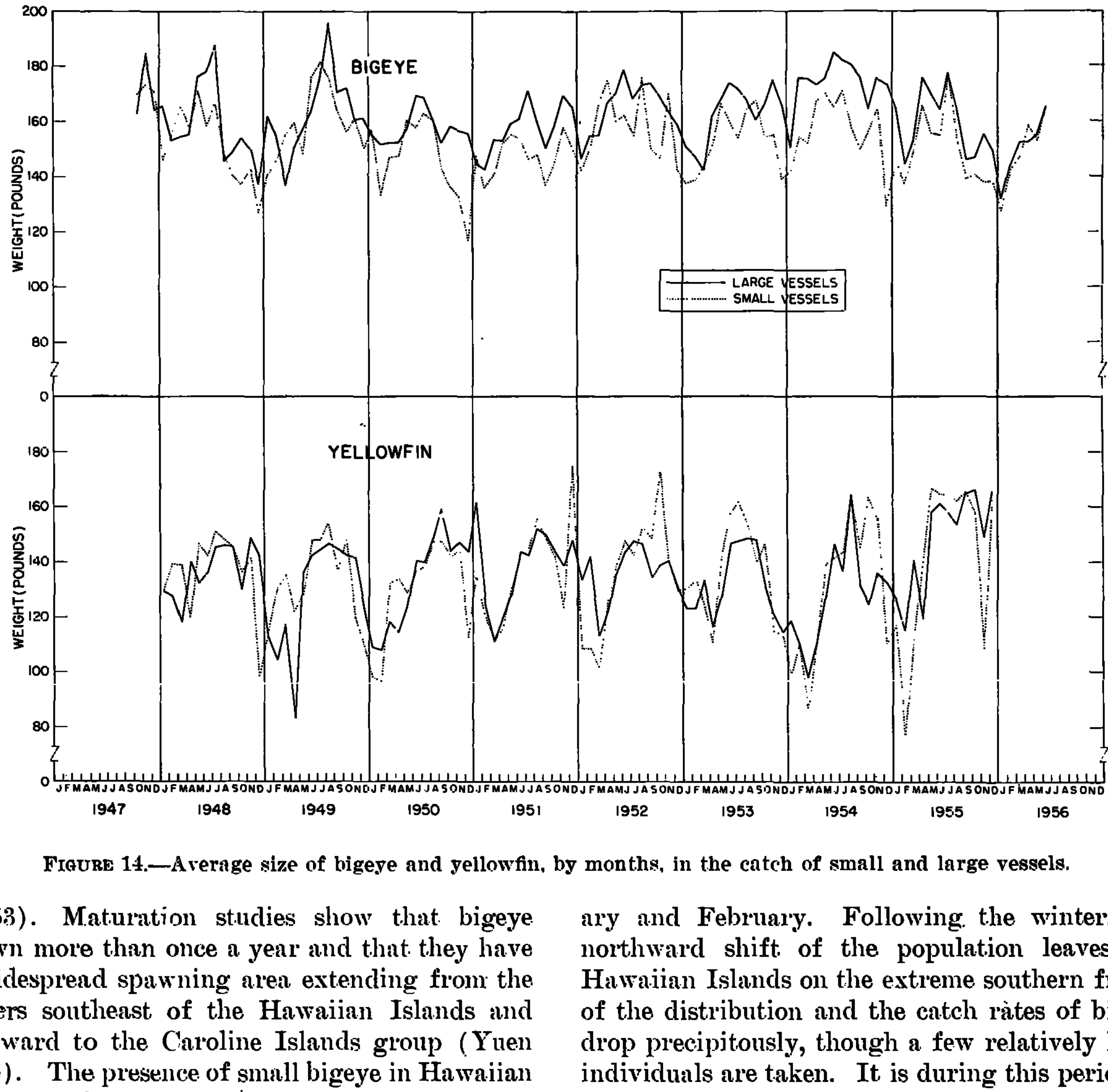


FIGURE 14.—Average size of bigeye and yellowfin, by months, in the catch of small and large vessels.

(1953). Maturation studies show that bigeye spawn more than once a year and that they have a widespread spawning area extending from the waters southeast of the Hawaiian Islands and westward to the Caroline Islands group (Yuen 1955). The presence of small bigeye in Hawaiian waters has been demonstrated (Moore 1951), but no studies have been made on the details of their distribution or seasonal variability.

According to our hypothesis, the adult bigeye population shifts southward during the winter, bringing the fish within reach of the Hawaiian fishery. Since the fish remain segregated by size, an auxiliary effect of this southern migration is to reduce the size of the fish taken in Hawaii in winter as compared with the size taken during the summer. Even during the winter it appears that the peak density of the population lies to the north of Hawaii, for Japanese vessels, specifically searching for bigeye, fish from 100 to 200 miles north of the Hawaiian Islands chain during January and February. Following the winter, the northward shift of the population leaves the Hawaiian Islands on the extreme southern fringe of the distribution and the catch rates of bigeye drop precipitously, though a few relatively large individuals are taken. It is during this period of low bigeye catch that the large yellowfin move into the Hawaiian Islands area.

## SUMMARY

1. A detailed examination of the catch records of the Honolulu longline fleet, covering the period 1948 to 1956, was made to determine the causes of a marked increase in landings of bigeye tuna and a decline in yellowfin.

2. A study of the fishing effort expended in the fishery showed a substantial increase in the total number of trips, resulting from an increase in the number of trips per vessel and from the addition of new vessels to the fleet. The magnitude of the increase in effort was not sufficient, however, to

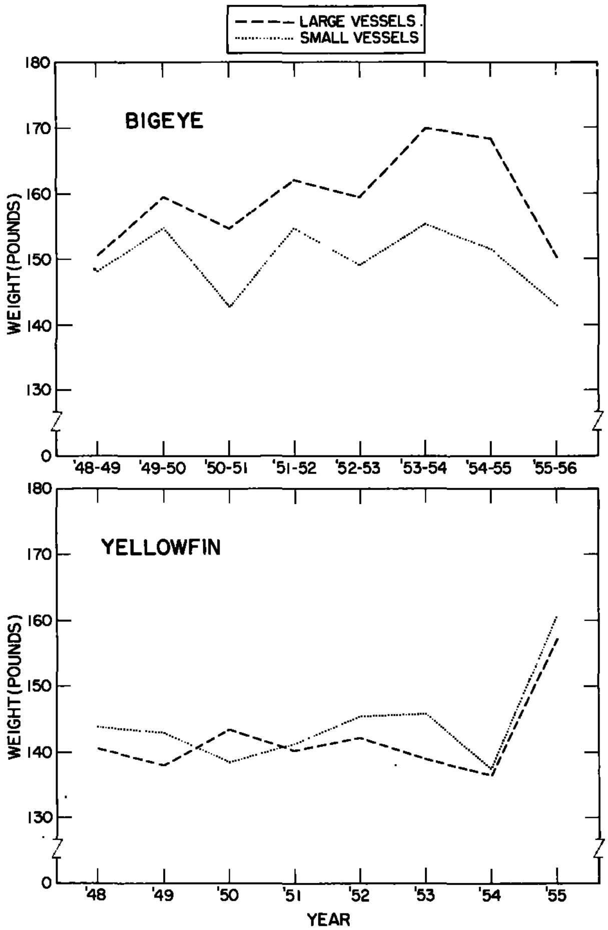


FIGURE 15.—Average annual size of bigeye (by fiscal year) and yellowfin (by calendar year) taken by small and large vessels.

account for all of the increase in bigeye landings and did not explain the decline in yellowfin.

3. When the catch-per-trip data were classified according to size of vessel, they showed a generally stable catch rate for both bigeye and yellowfin by the small vessels during the period under study but an increase in catch per trip for the bigeye by the large vessels, accompanied by a decline in yellowfin during the last 3 years (1953–55). This divergence was explained on the basis of a shift in area of fishing by the large vessels. The small vessels, which concentrated their efforts in waters surrounding Oahu, experienced uniform bigeye and yellowfin catches. The large vessels, on the other hand, shifted from the leeward areas of the northern islands to the windward areas of the southern islands. The increase in bigeye catch rate was due to the greater availability of bigeye in the windward areas as compared with the leeward areas. The decline in yellowfin catch rates by the large vessels during the last 3 years of this study was related to the increased fishing effort during the summer in the windward areas of the southern islands, which are areas of reduced yellowfin availability.

4. Annual variations in availability not due to areal shifts in the fishery were shown in the catch rates of the small vessels. The 1951–52 season was exceptionally good for bigeye, while the yellowfin showed a decline in availability during the 1955 season.

5. The bigeye captured by the small vessels were consistently smaller than those captured by the large vessels, and the smallest bigeye were taken during the winter months.

6. A hypothesis explaining the seasonal variability in bigeye distribution has been developed utilizing the results from various studies on the life history of the bigeye and on the commercial fishery. Essentially, it assumes that spawning takes place in tropical waters followed by a migration of the small fish northward to a center of abundance located north of the Hawaiian Islands. The adult population undertakes a north-south seasonal migration, spending the winter and spring months in Hawaiian waters, where it supports a sizable longline fishery.

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# APPENDIX

APPENDIX TABLE 1.—*Annual landings (pounds) of bigeye and yellowfin tuna, 1946 to 1956*

| Year | Total Hawaiian landings (all types of gear) | Total longline landings | Total landings Honolulu-based longline fleet | Year | Total Hawaiian landings (all types of gear) | Total longline landings | Total landings Honolulu-based longline fleet |
|---|---|---|---|---|---|---|---|
| Bigeye: | | | | Yellowfin: | | | |
| 1946–47 | 199,007 | | | 1946 | 1,324,767 | | |
| 1947–48 | 621,794 | | | 1947 | 1,314,349 | | |
| 1948–49 | 632,269 | 630,935 | 460,705 | 1948 | 1,158,111 | 1,006,460 | 365,717 |
| 1949–50 | 1,707,884 | 1,706,035 | 1,138,454 | 1949 | 929,239 | 817,057 | 307,201 |
| 1950–51 | 1,820,584 | 1,819,068 | 1,215,505 | 1950 | 720,537 | 605,315 | 383,916 |
| 1951–52 | 2,252,985 | 2,248,640 | 1,721,017 | 1951 | 757,199 | 661,314 | 368,686 |
| 1952–53 | 2,496,162 | 2,473,583 | 1,648,006 | 1952 | 855,655 | 719,326 | 454,819 |
| 1953–54 | 2,710,437 | 2,699,890 | 2,032,208 | 1953 | 621,654 | 459,196 | 272,214 |
| 1954–55 | 2,346,682 | 2,340,824 | 1,680,600 | 1954 | 525,770 | 435,551 | 322,237 |
| 1955–56 | 2,241,782 | 2,231,468 | 1,528,922 | 1955 | 445,769 | 352,781 | 229,191 |

APPENDIX TABLE 2.—*Catch of bigeye and yellowfin and fishing effort of large vessels in windward waters of the southern islands, 1948 to 1956*

I. BIGEYE (FISCAL YEAR)

| | 1948–49 | 1949–50 | 1950–51 | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 |
|---|---|---|---|---|---|---|---|---|
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 62 | 131 | 110 | 149 | 133 | 138 | 101 | 106 |
| Catch (number) | 740 | 3,053 | 2,919 | 4,922 | 3,540 | 4,170 | 3,179 | 2,786 |
| All areas: | | | | | | | | |
| Effort (trips) | 282 | 319 | 319 | 314 | 241 | 157 | 135 | 150 |
| Catch (number) | 1,823 | 4,528 | 5,360 | 6,999 | 4,595 | 4,332 | 3,539 | 3,529 |

II. YELLOWFIN (CALENDAR YEAR)

| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 |
|---|---|---|---|---|---|---|---|---|
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 76 | 99 | 138 | 129 | 150 | 129 | 110 | 112 |
| Catch (number) | 367 | 191 | 335 | 188 | 325 | 283 | 260 | 161 |
| All areas: | | | | | | | | |
| Effort (trips) | 280 | 288 | 340 | 298 | 328 | 161 | 134 | 144 |
| Catch (number) | 1,400 | 1,260 | 1,383 | 1,267 | 1,810 | 351 | 468 | 243 |

APPENDIX TABLE 3.—*Bigeye catch and fishing effort by seasons, of large vessels, 1948 to 1955*

| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 |
|---|---|---|---|---|---|---|---|---|
| Spring: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 30 | 18 | 32 | 5 | 35 | 22 | 34 | 18 |
| Catch (number) | 328 | 337 | 695 | 76 | 1,190 | 806 | 1,166 | 379 |
| All areas: | | | | | | | | |
| Effort (trips) | 70 | 68 | 86 | 81 | 81 | 42 | 35 | 34 |
| Catch (number) | 545 | 693 | 1,437 | 1,670 | 2,198 | 1,164 | 1,181 | 643 |
| Summer: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 9 | 3 | 24 | 12 | 14 | 34 | 14 | 24 |
| Catch (number) | 30 | 19 | 417 | 311 | 243 | 555 | 216 | 288 |
| All areas: | | | | | | | | |
| Effort (trips) | 69 | 71 | 84 | 67 | 89 | 39 | 32 | 36 |
| Catch (number) | 149 | 172 | 638 | 591 | 496 | 573 | 273 | 365 |
| Fall: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 14 | 39 | 34 | 57 | 50 | 41 | 33 | 39 |
| Catch (number) | 101 | 735 | 838 | 1,541 | 1,001 | 1,251 | 1,249 | 1,048 |
| All areas: | | | | | | | | |
| Effort (trips) | 77 | 82 | 83 | 85 | 77 | 43 | 34 | 40 |
| Catch (number) | 347 | 856 | 1,247 | 1,726 | 1,322 | 1,264 | 1,258 | 1,052 |
| Winter: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 21 | 44 | 56 | 48 | 40 | 36 | 32 | 29 |
| Catch (number) | 260 | 1,358 | 1,643 | 1,993 | 1,380 | 1,329 | 1,339 | 1,007 |
| All areas: | | | | | | | | |
| Effort (trips) | 68 | 75 | 76 | 72 | 53 | 42 | 32 | 37 |
| Catch (number) | 611 | 1,824 | 1,859 | 2,564 | 1,602 | 1,423 | 1,339 | 1,196 |

APPENDIX TABLE 4.—*Yellowfin catch and fishing effort, by seasons, of large vessels, 1948 to 1955*

| | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 |
|---|---|---|---|---|---|---|---|---|
| Spring: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 30 | 18 | 32 | 5 | 35 | 22 | 34 | 18 |
| Catch (number) | 100 | 10 | 28 | 6 | 45 | 22 | 50 | 8 |
| All areas: | | | | | | | | |
| Effort (trips) | 70 | 68 | 86 | 81 | 81 | 42 | 35 | 34 |
| Catch (number) | 162 | 153 | 82 | 339 | 221 | 34 | 53 | 19 |
| Summer: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 9 | 3 | 24 | 12 | 14 | 34 | 14 | 24 |
| Catch (number) | 111 | 40 | 177 | 33 | 81 | 158 | 75 | 101 |
| All areas: | | | | | | | | |
| Effort (trips) | 69 | 71 | 84 | 67 | 89 | 39 | 32 | 36 |
| Catch (number) | 784 | 803 | 881 | 608 | 1,260 | 198 | 269 | 168 |
| Fall: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 14 | 39 | 34 | 57 | 50 | 41 | 33 | 39 |
| Catch (number) | 90 | 71 | 76 | 62 | 100 | 46 | 61 | 32 |
| All areas: | | | | | | | | |
| Effort (trips) | 77 | 82 | 83 | 85 | 77 | 43 | 34 | 40 |
| Catch (number) | 341 | 181 | 307 | 233 | 176 | 46 | 67 | 34 |
| Winter: | | | | | | | | |
| Windward waters of southern islands: | | | | | | | | |
| Effort (trips) | 21 | 44 | 56 | 48 | 40 | 36 | 32 | 29 |
| Catch (number) | 61 | 33 | 117 | 57 | 78 | 100 | 24 | 26 |
| All areas: | | | | | | | | |
| Effort (trips) | 68 | 75 | 76 | 72 | 53 | 42 | 32 | 37 |
| Catch (number) | 134 | 67 | 153 | 83 | 116 | 111 | 24 | 29 |

APPENDIX TABLE 5.—*Bigeye catch and effort by small vessels in all windward areas, 1947 to 1956*

[Winter and spring seasons combined]

| | 1947–48 | 1948–49 | 1949–50 | 1950–51 | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 |
|---|---|---|---|---|---|---|---|---|---|
| Windward areas: | | | | | | | | | |
| Effort (trips) | 29 | 13 | 13 | 19 | 9 | 15 | 5 | 22 | 12 |
| Catch (number) | 231 | 83 | 191 | 279 | 272 | 221 | 63 | 255 | 260 |
| All areas: | | | | | | | | | |
| Effort (trips) | 72 | 87 | 105 | 116 | 46 | 73 | 47 | 48 | 35 |
| Catch (number) | 407 | 405 | 1,077 | 977 | 656 | 766 | 535 | 447 | 678 |

BOARD OF COMMISSIONERS OF AGRICULTURE AND FORESTRY

# FLAGLINE CATCH REPORT

DIVISION OF FISH AND GAME
TERRITORY OF HAWAII

C-5

Name of Permittee .................... Fisherman's License No. .......... Month.................19...

Name of Boat.................................... F.G. No. .................. No. of Baskets Used ..........

| Day of Landing | No. of Days at Sea | Area of Catch | Port of Landing | AHI (Yellowfin) 003 | | | BIG EYE (Bluefin) 006 | | | AHIPALAHA (Albacore Tombo) 004 | | | STRIPED MARLIN 009 | | | BLACK MARLIN 010 | | | SHORT-NOSE MARLIN 107 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. Caught | Lbs. Caught | Value | No Caught | Lbs. Caught | Value | No. Caught | Lbs. Caught | Value | No. Caught | Lbs Caught | Value | No Caught | Lbs Caught | Value | No. Caught | Lbs Caught | Value |
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| Day of Landing | No. of Days at Sea | Area of Catch | Port of Landing | SILVER MARLIN 108 | | | BROADBILL SWORDFISH 011 | | | AU LEPE (Sailfish) 012 | | | MAHIMAHI 013 | | | ONO 014 | | | OTHER (Give Name)* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | No. Caught | Lbs Caught | Value | No. Caught | Lbs Caught | Value | No Caught | Lbs Caught | Value | No Caught | Lbs Caught | Value | No Caught | Lbs. Caught | Value | Species Caught | Lbs. Caught | Value |
| | | | | | | | | | | | | | | | | | | | | | |
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## BAIT REPORT

| LOCAL BAIT | | | | | | IMPORTED BAIT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPELU** | | | OTHERS | | | MACKEREL (Saba) 96 | | SMELT 97 | | SARDINE 94 | | HERRING 95 | | OTHER 92 | |
| Date Caught | Pounds Caught | Locality Caught | Species Bought | Date | Lbs Bought | Date | Lbs. Bought | Date | Lbs Bought | Date | Lbs Bought | Date | Lbs. Bought | Date | Lbs. Bought |
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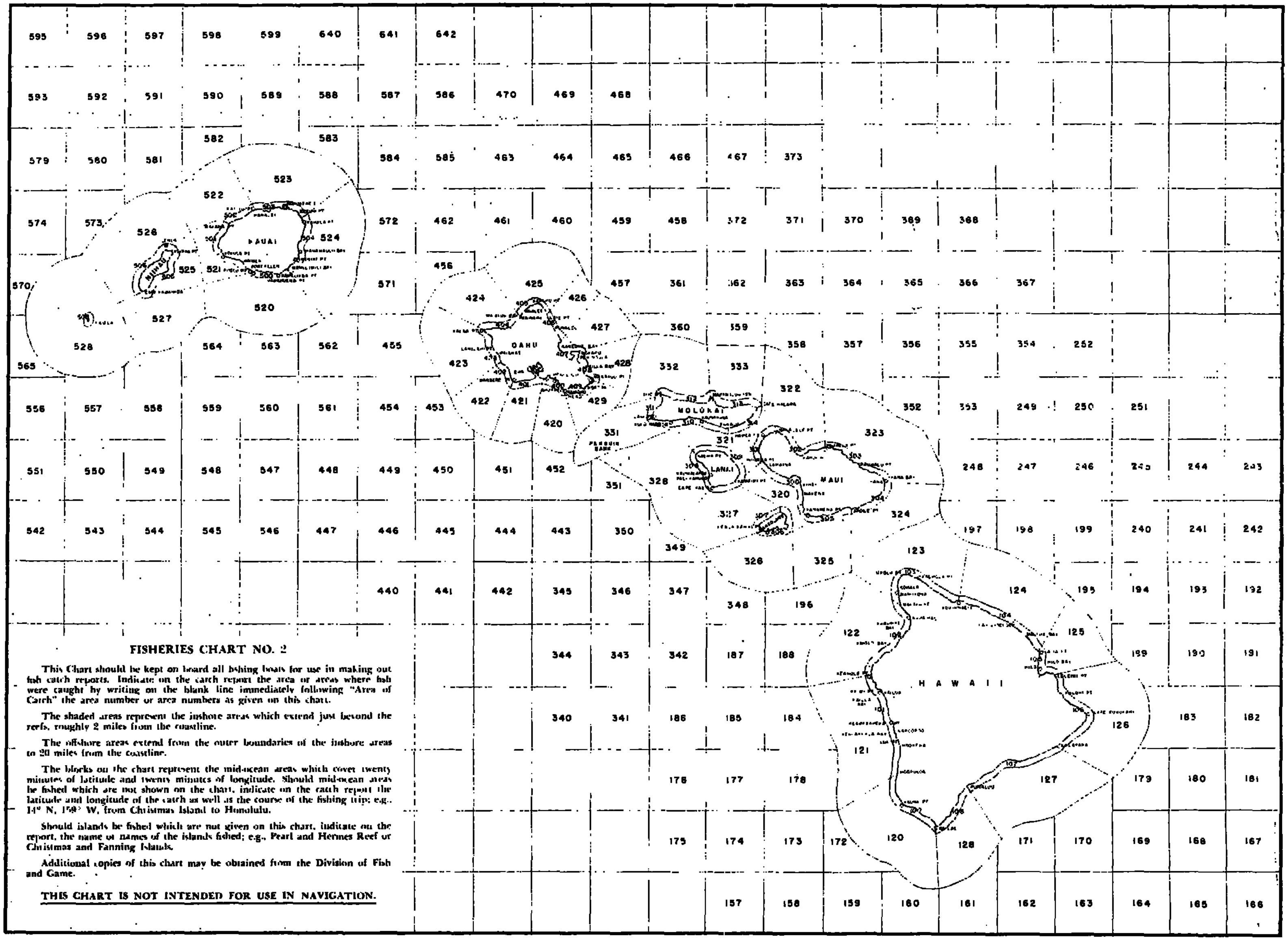
The reports contained hereon are true, correct, and complete to the best of my knowledge and belief.

Signature ........................................
*Permittee or Authorized Agent*

* If several species are taken on a trip, which are listed under "other," skip that number of lines when entering catch report for next trip.

** If opelu purchased from other fishermen write in "bought" under locality caught.

**APPENDIX FIGURE 1.—Presently used longline (flagline) fish catch report form.**




APPENDIX FIGURE 2.—Hawaiian Division of Fish and Game fisheries chart No. 2, showing the statistical areas.

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