# COMMERCIAL FISHERIES REVIEW

September 1954 Washington 25, D.C. Vol.16, No.9


# ANALYSIS OF THE HAWAIIAN LONG-LINE FISHERY, 1948-52


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SUMMARY

1. The long-line method is presently the only means of efficiently catching the subsurface resource of tunas and spearfishes in the vicinity of the Hawaiian Islands.

2. The tuna landings have steadily increased following a period of restricted fishing during World War II.

3. The species composition of the tuna landings have changed from a predominance of yellowfin to one of big-eyed during the postwar years.

4. There is a marked seasonal variation in abundance among the tunas, with yellowfin occurring in greater numbers during the summer and the big-eyed during the winter months. There is less variation in seasonal abundance among the spearfishes, with the black marlin generally more abundant during the summer months and the striped marlin in the winter.

5. This seasonal variation in species composition is dependent upon the movements and local abundance of the fish. Both of these factors may be influenced by any of a number of environmental factors; e.g., sea temperature is frequently believed to be important, however, the available data are too scanty to be conclusive.

6. There is a possibility that the occurrence of yellowfin in greater numbers during the summer is related to spawning.

7. The possibility also exists that yellowfin are responding to a slightly more abundant food supply during the summer months in island waters.



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8. The average total catch rate (catch per 100 hooks fished per day) is about 3.0, which compares favorably with the Japanese catch in their home waters but falls below their catch in various tropical and subtropical areas.

9. The amount of effort expended by the fleet from year to year did not vary significantly during the years surveyed.

10. There appears to be a seasonal shifting of the more productive fishing grounds. Windward waters are said to be more productive during the winter months.

11. Noticeable variations in boat efficiency may be attributed to differences in the productivity among various areas, since certain of the low-catch boats fish exclusively in one area regardless of productivity.

12. The long-line fishery catches yellowfin over 90 pounds in weight, with the bulk of the catch falling between 100 and 160 pounds. The big-eyed are somewhat larger, with the bulk falling roughly between 100 and 200 pounds. Yellowfin average around 140 and the big-eyed around 160 pounds.

13. The sex ratio among long line-caught yellowfin and big-eyed tuna differs significantly from 50:50 (or 1:1) with males predominating in both species.

14. There is a possibility that yellowfin spend their first year or two at the surface before descending to subsurface levels. This may be a basis for a method of predicting the abundance of subsurface yellowfin a few years in advance.

15. The limited market makes the price especially sensitive to supply and consequently serves to limit fishing intensity.

## BACKGROUND

The long-line fishery of Hawaii catches the deep-swimming pelagic tunas and spearfishes in the coastal and offshore waters of the Hawaiian Islands. Having had its beginning in 1917, when a Japanese immigrant introduced the Japanese technique of fishing subsurface levels in waters off Waianae, Oahu, this fishery has rapidly developed into a major source of fish in the Territory; its landings are valued at over a million dollars annually.

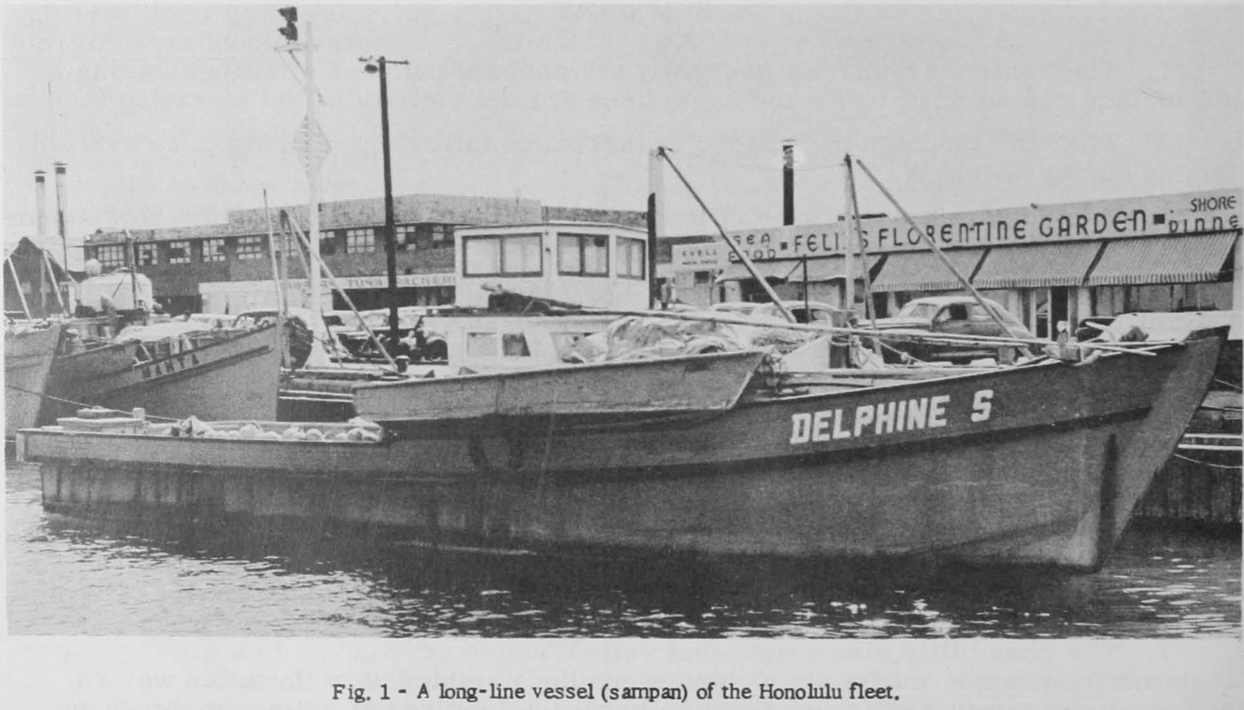


Fig. 1 - A long-line vessel (sampan) of the Honolulu fleet.

Since this is the only tuna long-line fishery in the central Pacific Ocean, a thorough understanding of it is important in evaluating data gathered from equatorial regions which the Service's Pacific Oceanic Fishery Investigations (POFI) has been exploring. June (1950) described the fishery in some detail; this report is intended as a supplement and includes data on the catch and its trends and some observations on the biology of the tunas.

This report, which covers the period from 1948 to 1952, is based largely on statistics provided by the Division of Fish and Game, Board of Agriculture and Forestry, Territory of Hawaii. These have been supplemented by information gathered through discussions with fishermen and dealers and by examination of catches landed at the local markets.

The principal center of the long-line fishery is Honolulu, where a fleet of 31 to 33 boats operates throughout the year and accounts for approximately 70 percent of the Territory's long-line landings. Next in importance is Hilo, on the island of Hawaii, with a fleet of about 10 boats. Smaller fleets are based at Kona on the island of Hawaii and at Port Allen, Kauai.

The Hawaiian long-line boats are built along the lines of the Japanese sampan-type live-bait boats, with a high and narrow bow, a modified V-bottom, and a moderately low freeboard aft (fig. 1). The after deck has sufficient space for handling the fishing gear efficiently. They range in size from 40 to 63 feet in over-all length, with about a 12-foot beam and a 6-foot draft on 60-foot boats. They are powered with a Diesel main engine of 115 to 165 horsepower, usually of the high-speed type, driving a single screw through a reduction gear. Since none of the boats are equipped with any sort of mechanical refrigeration, the fish are stored in crushed ice. At the outset of a trip the fish holds are packed with the necessary amount of cake ice, generally in a ratio of about four pounds of ice to each expected pound of fish. The larger boats carry a crew of 4 or 5 while the smaller boats employ a crew of only 2 or 3 men.

The gear is a drifting long-line made up in units referred to as "baskets" (June 1950, Niska 1953). Each "basket" consists of a main line 140 to 200 fathoms long suspended at intervals by floats and supporting in turn a series of 5 or 6 vertical branch lines. The hooks are usually baited with frozen sardines (Sardinops caerulea) or herring (Clupea pallasii). From 20 to 35 "baskets" of gear are connected in a set, thus covering a considerable expanse of water.

## SPECIES COMPOSITION OF THE LONG-LINE CATCH

The catches of the long-line boats include an interesting variety of tunas, spearfishes, and miscellaneous pelagic fishes. Among the tunas, which constitute approximately 65 percent of the landings, the yellowfin (Neothunnus macropterus) and the big-eyed (Parathunnus sibi) are the two principal species. Albacore (Germo alalunga) makes up from 1 to 4 percent of the total landings, whereas the long-line catch of skipjack (Katsuwonus pelamis) is negligible and is practically never landed at the markets. Among the spearfishes, the black marlin (Makaira mazara) and the striped marlin (Makaira mitsukurii) are the most abundant. Other species taken in lesser quantities are the sailfish (Istiophorus orientalis), short-nosed spearfish (Tetrapturus brevirostris), white marlin (Makaira marlina), and broadbill swordfish (Xiphias gladius). During the period studied, the several species of spearfishes together have constituted from 24 to 45 percent by weight of the annual long-line landings in the Territory. In addition to the tunas and spearfishes, small quantities of wahoo (Acanthocybium solandri), dolphin (Coryphaena hippurus), and sharks also appear in the landings.

Among the numerous types of fishing methods employed in Hawaiian waters, the long-line is responsible for practically all the landings of yellowfin, big-eyed, and albacore tuna, and the various species of spearfishes. The skipjack pole-and-line fishery accounts for a few tons of small yellowfin which are taken at the surface when occurring in mixed schools with skipjack or in independent schools (table 14), but these amount to less than 4 percent of the annual landings of this species. Hand-line fishermen, operating in waters to about 50 fathoms in depth, contribute about 10 percent to the yellowfin landings (10- to 30-pound fish). A considerable number of spearfishes are also landed by the sport fishery, but here again, these constitute only a small percentage of the total spearfish landings.

Table 1 - Annual Landings by the Long-line Fishery in the Territory of Hawaii1/

| Species | 1952 | 1951 | 1950 | 1949 | 1948 | 1947 | 1946 | 19452/ |
|---|---|---|---|---|---|---|---|---|
| | ................ (Thousands of pounds) ................ | | | | | | | |
| Yellowfin tuna ... | 719 | 661 | 605 | 817 | 1,006 | 1,314 | 1,343 | 456 |
| Big-eyed tuna ... | 2,193 | 2,031 | 1,842 | 1,086 | 640 | 340 | 126 | 12 |
| Albacore tuna ... | 101 | 55 | 60 | 70 | 94 | 115 | 43 | 10 |
| Black marlin .... | 534 | 597 | 536 | 512 | 679 | 445 | 164 | 70 |
| Striped marlin ... | 371 | 382 | 570 | 431 | 453 | 384 | 202 | 41 |
| Other spearfishes3/ | 47 | 138 | 171 | 206 | 283 | 270 | 155 | 42 |
| Total4/ ..... | 3,965 | 3,864 | 3,784 | 3,122 | 3,156 | 2,868 | 2,033 | 632 |
| | ............. (Percentage Composition) ................ | | | | | | | |
| Tunas .......... | 76.0 | 71.1 | 66.3 | 63.2 | 55.2 | 61.7 | 74.4 | 75.9 |
| Spearfishes ..... | 24.0 | 28.9 | 33.7 | 36.8 | 44.8 | 38.3 | 25.6 | 24.1 |

1/From records of the Territory of Hawaii Fish and Game Division. Landings shown for 1945-47 include catches made by other than long-line fishery.
2/1945 is considered a "war year" in which a restricted fishery operated and includes the July to December landings only.
3/Includes the sailfish, short-nosed spearfish, white marlin, and broadbill swordfish. Also included here are spearfishes which were not identified in the fishermen's reports. Detailed figures are not given for each species because they are frequently misidentified.
4/Totals may not be exact due to rounding off of figures.

Perhaps the most significant observation to be made from the records of the annual landings of the long-line fishery is the shift in dominance between the yellowfin and big-eyed tuna. The yellowfin, which reportedly was the dominant species of tuna in the prewar fishery,1/ declined in the catch from 1,343,000 pounds in 1946 to a low of 605,000 pounds in 1950 (table 1). Subsequently there was a small increase to 719,000 pounds in 1952. Meanwhile, the catch of big-eyed tuna increased tremendously and steadily from 126,000 pounds to 2,193,000 pounds. Thus the species composition of the tunas has changed from a predominance of yellowfin to that of big-eyed in 5 years (fig. 2).

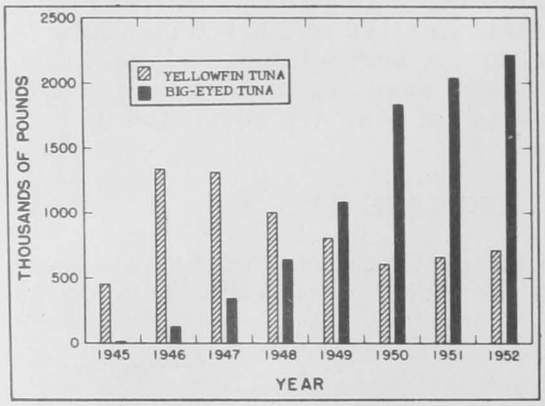


Fig. 2 - Annual landings of yellowfin and big-eyed tuna by the Hawaiian long-line fishery, 1945-52 (thousands of pounds).

## SEASONAL VARIATIONS IN THE CATCH

A prominent feature of the Hawaiian long-line fishery is that its total production is relatively steady throughout the year. Although there are seasonal variations in abundance of the several principal species, the decline in abundance of one species is usually followed by an increase of another. Among the tunas, the big-eyed occur in greatest numbers during the winter months from October to May and the yellowfin from May to September (fig. 3 and table 16). Such seasonal variations in abundance are also seen among the spearfishes, although not as distinct as in the case of the tunas (fig. 3). The black marlin are generally abundant between July and October, while the striped marlin are plentiful during the winter months.

1/Detailed catch records are not available for prewar years.

Seasonal variation in species composition of the long-line catch is dependent upon the movements and local abundance (or availability) of the fish rather than upon any changes in the practice of the fishermen. These movements may be influenced by any of a number of environmental factors, of which sea temperature is frequently believed to be of importance. Bathythermograph observations between January 1941 and November 1947 in Hawaiian waters show that the months of March and September have respectively the lowest and highest average temperatures (Leipper and Anderson 1950). June and December are typical transition months. The maximum average surface temperature recorded for this period was 82° F. and the minimum 66° F. Since the landings of yellowfin show a marked increase during the summer months, becoming greater as the water warms, and since the big-eyed tuna is captured in greatest numbers during the winter months, the implications are that the yellowfin prefers warm water and the big-eyed tuna cooler water.

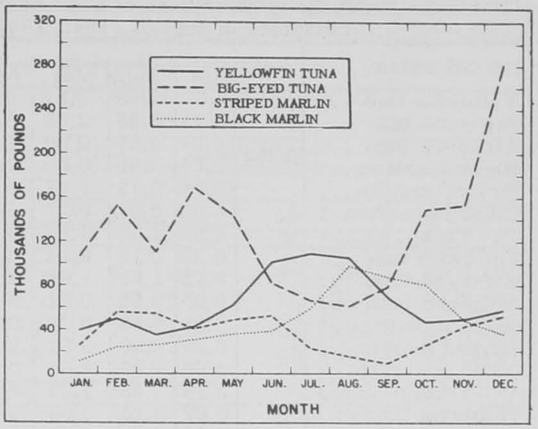

Fig. 3 - Average monthly landings (1948-52) of the four principal species by the Hawaiian long-line fishery (from catch statistics of the Territory of Hawaii Fish and Game Division).

However, not much reliance can be placed in a simple temperature relationship because yellowfin have been found in a much wider range of temperatures than occurs in Hawaii. In Japanese waters yellowfin have been taken by long line when the surface temperature ranged from 14° C. (57.2° F.) to 27° C. (80.6° F.) (Takayama and Ando 1934). It is possible that the race of yellowfin occupying the central Pacific could, through adaptation, have different temperature limitations or preferences than fish of the same species farther to the westward. Further research is necessary before it can be established whether or not sea temperature is at least partly responsible for the marked seasonal changes in catch for these two species. We should not overlook the possibility, however, that temperature may merely be a function of more complicated environmental factors, such as currents, chemical nutrients, or food organisms which influence the distribution of the fish.

June (1953) points to the possibility that the long-line fishery for yellowfin tuna is based on a "spawning run," since the period of spawning of the Hawaiian yellowfin coincides with its peak fishing season. A similar study being conducted on the big-eyed tuna indicates that this species does not spawn in Hawaiian waters. Their appearance in greater numbers during the winter months is probably not directly related to spawning.

Further mention should be made here of food as a possible factor influencing the seasonal distribution of these species. The occurrence of yellowfin in greater numbers during the summer is in all probability not a response to a particular type of food present in the area during that season. Reintjes and King (1953) have shown that this species feeds on a great variety of animal food from small plankton to fish one-third the length of the tuna, taking advantage of whatever food is most abundant in the area at the time. Since it has been found, however, that plankton is slightly more plentiful during summer than in winter in Hawaiian waters (King and Hida 1954), the possibility remains that yellowfin are responding to a more abundant food supply.

## CATCH PER UNIT OF EFFORT

Total landings may not indicate directly the magnitude of the population available to the fishermen. Instead, landings tend to reflect the relation between the number of fish in the available population and the amount of effort expended. To measure changes in abundance of the fish population or to compare the relative abundance

Table 2 - Catch Rates (Numbers of Each Species per 100 Hooks Fished) of Tunas and Spearfishes in the Territory of Hawaii, 1949-1952 1/ (Honolulu-based Long-line Fleet)

| Species | Year | Month | | | | | | | | | | | | Annual Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | |
| Yellowfin tuna ... | 1952 | 0.07 | 0.26 | 0.11 | 0.14 | 0.47 | 1.36 | 1.19 | 0.92 | 0.33 | 0.08 | 0.05 | 0.16 | 0.43 |
| Big-eyed tuna ... | | 3.71 | 2.58 | 2.08 | 4.98 | 2.60 | 0.38 | 0.29 | 0.25 | 0.45 | 0.95 | 1.47 | 1.82 | 1.80 |
| Albacore tuna ... | | 0.01 | 0.01 | 0.00 | 0.00 | 0.12 | 0.67 | 0.42 | 0.26 | 0.28 | 0.22 | 0.06 | 0.15 | 0.18 |
| Black marlin .... | | 0.05 | 0.08 | 0.05 | 0.06 | 0.09 | 0.07 | 0.12 | 0.40 | 0.34 | 0.40 | 0.16 | 0.07 | 0.16 |
| Striped marlin ... | | 0.66 | 0.72 | 1.43 | 0.37 | 0.56 | 0.46 | 0.18 | 0.08 | 0.06 | 0.39 | 0.57 | 0.74 | 0.52 |
| Other spearfish . | | 0.00 | 0.02 | 0.02 | 0.07 | 0.07 | 0.01 | 0.01 | <0.01 | 0.00 | 0.00 | 0.02 | <0.01 | 0.02 |
| Total ....... | | 4.50 | 3.66 | 3.69 | 5.62 | 3.92 | 2.96 | 2.20 | 1.90 | 1.45 | 2.05 | 2.33 | 2.95 | 3.10 |
| Yellowfin tuna ... | 1951 | 0.25 | 0.19 | 0.15 | 0.34 | 0.56 | 0.86 | 0.51 | 0.52 | 0.52 | 0.30 | 0.10 | 0.03 | 0.36 |
| Big-eyed tuna ... | | 2.12 | 1.65 | 1.69 | 2.19 | 1.27 | 0.82 | 0.63 | 0.32 | 0.64 | 2.12 | 2.28 | 4.40 | 1.68 |
| Albacore tuna ... | | 0.00 | 0.00 | 0.01 | 0.00 | 0.03 | 0.05 | 0.10 | 0.07 | 0.14 | 0.13 | 0.11 | 0.00 | 0.05 |
| Black marlin .... | | 0.05 | 0.12 | 0.07 | 0.09 | 0.13 | 0.14 | 0.22 | 0.56 | 0.58 | 0.63 | 0.40 | 0.05 | 0.25 |
| Striped marlin ... | | 0.76 | 0.98 | 0.91 | 0.84 | 0.82 | 0.77 | 0.26 | 0.05 | 0.03 | 0.14 | 0.19 | 0.36 | 0.51 |
| Other spearfish 2/ | | 0.00 | 0.09 | 0.04 | 0.13 | 0.12 | 0.03 | 0.02 | 0.03 | 0.05 | 0.11 | 0.10 | 0.00 | 0.06 |
| Total 3/ ..... | | 3.18 | 3.03 | 2.87 | 3.54 | 2.93 | 2.67 | 1.75 | 1.56 | 1.97 | 3.43 | 3.18 | 4.84 | 2.92 |
| Yellowfin tuna ... | 1950 | 0.07 | 0.12 | 0.05 | 0.06 | 0.04 | 0.63 | 0.79 | 1.00 | 0.55 | 0.13 | 0.27 | 0.20 | 0.33 |
| Big-eyed tuna ... | | 2.95 | 1.53 | 1.31 | 1.08 | 2.11 | 1.11 | 0.83 | 0.19 | 0.57 | 1.24 | 1.15 | 1.95 | 1.33 |
| Albacore tuna ... | | 0.00 | 0.00 | 0.00 | 0.01 | 0.06 | 0.05 | 0.07 | 0.18 | 0.15 | 0.52 | 0.24 | 0.27 | 0.13 |
| Black marlin .... | | 0.20 | 0.04 | 0.10 | 0.10 | 0.09 | 0.10 | 0.25 | 0.31 | 0.49 | 0.28 | 0.30 | 0.15 | 0.20 |
| Striped marlin ... | | 1.47 | 1.15 | 2.06 | 1.16 | 0.54 | 1.25 | 0.65 | 0.09 | 0.06 | 0.50 | 1.29 | 1.15 | 0.95 |
| Other spearfish .. | | 0.00 | 0.01 | 0.04 | 0.07 | 0.10 | 0.07 | 0.03 | 0.06 | 0.02 | 0.12 | 0.07 | 0.09 | 0.06 |
| Total ....... | | 4.69 | 2.86 | 3.56 | 2.49 | 2.94 | 3.21 | 2.63 | 1.83 | 1.85 | 2.78 | 3.32 | 3.81 | 3.00 |
| Yellowfin tuna ... | 1949 | - | - | 0.04 | 0.32 | 0.08 | 1.01 | 1.21 | 0.76 | 0.36 | 0.31 | 0.08 | 0.06 | 0.42 |
| Big-eyed tuna ... | | - | - | 1.03 | 1.26 | 1.27 | 0.46 | 0.20 | 0.16 | 0.29 | 1.01 | 1.98 | 3.06 | 1.07 |
| Albacore tuna ... | | - | - | 0.04 | 0.02 | 0.11 | 0.37 | 0.17 | 0.15 | 0.24 | 0.44 | 0.17 | 0.01 | 0.17 |
| Black marlin .... | | - | - | 0.15 | 0.24 | 0.13 | 0.14 | 0.22 | 0.45 | 0.38 | 0.36 | 0.28 | 0.09 | 0.24 |
| Striped marlin ... | | - | - | 2.07 | 1.33 | 0.65 | 0.81 | 0.37 | 0.03 | 0.10 | 0.42 | 0.59 | 0.50 | 0.69 |
| Other spearfish 2/ | | - | - | 0.06 | 0.13 | 0.05 | 0.09 | 0.02 | 0.03 | 0.02 | 0.07 | 0.13 | 0.20 | 0.08 |
| Total 3/ ...... | | - | - | 3.40 | 3.29 | 2.30 | 2.88 | 2.19 | 1.58 | 1.39 | 2.61 | 3.24 | 3.91 | 2.68 |

1/Based on information obtained through interviewing randomly-selected Honolulu fishermen.
2/Includes sailfish, short-nosed spearfish, white marlin, and broadbill swordfish.
3/Columns may not agree exactly with the totals because figures were rounded off.

of fish in different areas, it is necessary to rely on some other measure, such as the catch per unit of effort, which in the case of the long-line fishery may conveniently be the catch per 100 hooks fished per day. Table 2 lists the catch rates (catch per 100 hooks per day) of tunas and spearfishes for the years 1949-52. These rates are based on information obtained by interviewing randomly-selected Honolulu fishermen at the termination of their trips.

Table 3 - Average Catch Rates of the Japanese Tuna-Mothership Expeditions, June 1950 to October 1951 1/

| Species | Number of Fish Per 100 Hooks |
|---|---|
| Yellowfin tuna ... | 2.14 |
| Big-eyed tuna ... | 0.62 |
| Albacore tuna ... | 0.07 |
| Skipjack tuna .... | 0.05 |
| Black marlin .... | 0.53 |
| Striped marlin ... | 0.01 |
| Other spearfish 2/ | 0.04 |
| Total tunas and spearfishes 3/ .. | 3.45 |

1/Reproduced in part from table 2 (Van Campen 1952).
2/Largely sailfish and short-nosed spearfish.
3/The total catch rate was 4.10, including sharks and other miscellaneous species.

The monthly catch rates in this table clearly indicate the seasonal variation in abundance of the principal species already mentioned in a foregoing section. Also notable is the fact that the total annual average catch rate has remained fairly constant during the years for which data are presented. The average long-line catch rate in Hawaiian waters of tunas and spearfishes combined is about 3 fish per 100 hooks, which compares favorably with the Japanese catch in their home waters, but falls below their catch in the various tropical and subtropical areas (June 1950). The Japanese tuna expeditions to the western equatorial Pacific waters between 1° and 13° N. latitude, 134° and 179° E. longitude, between June 1950 and October 1951, averaged 4.10 fish per 100 hooks, including sharks and other miscellaneous species (Van Campen 1952, also partly reproduced as table 3). Considering only the tunas and spearfishes, the average catch rate for the Japanese expedition was 3.45, somewhat higher than the Hawaiian catch rate.

## FISHING EFFORT

The Honolulu long-line fleet consists of 31 to 33 boats which operate throughout the year. These boats remain at sea for a period of 10 to 12 days, fishing an average of 8 or 9 days per trip. Data on the number of trips made each month by these boats (table 4) have been obtained from records kept by the two auction markets and therefore include only trips on which some fish were caught and marketed.

Table 4 - Number of Boat Trips by Months, 1949-52[1]/

| Month | Year | | | |
|---|---|---|---|---|
| | 1952 | 1951 | 1950 | 1949 |
| January | 40 (24) | 26 (22) | 32 (26) | 15 (14) |
| February | 51 (28) | 47 (26) | 49 (28) | 42 (29) |
| March | 56 (29) | 57 (27) | 50 (29) | 37 (25) |
| April | 60 (27) | 38 (26) | 43 (27) | 35 (26) |
| May | 51 (28) | 54 (28) | 54 (30) | 44 (27) |
| June | 61 (31) | 49 (29) | 50 (28) | 45 (27) |
| July | 48 (30) | 49 (27) | 52 (27) | 42 (28) |
| August | 56 (29) | 55 (30) | 61 (30) | 50 (28) |
| September | 56 (30) | 49 (29) | 53 (29) | 46 (28) |
| October | 53 (31) | 55 (30) | 54 (31) | 49 (29) |
| November | 50 (30) | 53 (28) | 52 (30) | 37 (27) |
| December | 78 (31) | 67 (30) | 76 (30) | 54 (28) |
| Total | 660 | 599 | 626 | 496 |
| Average number of trips per boat per year | 21 | 18 | 20 | 16 |

1/The number of boats which participated during the month is enclosed in parentheses.

The number of trips made each month of the year is relatively steady with the exception of the holiday season. More trips are generally made in December to take advantage of the great demand for fish, and fewer trips are made in January because a large part of the fleet remains in port on an extended celebration of the New Year's holiday. The total trips made each year have increased from 496 in 1949 to a high of 660 in 1952. Additional data obtained by interviewing fishermen permit a closer scrutiny of the fishing effort (table 5). The average number of days fished per trip showed a steady decrease from 9.4 days in 1949 to 8.2 in 1952, tending to offset the increase in total trips made. As a result, the average number of days fished per boat did not vary significantly from year to year.

Table 5 - Effort Expended by the Honolulu Long-Line Fleet, 1949-1952

| Item | Year | | | |
|---|---|---|---|---|
| | 1952 | 1951 | 1950 | 1949 |
| Total boat trips | 660 | 599 | 626 | 496 |
| Average number of fishing days/trip | 8.2 | 8.9 | 9.0 | 9.4 |
| Total fishing days | 5,412 | 5,331 | 5,634 | 4,662 |
| Number of boats in fleet | 32 | 33 | 31 | 32 |
| Average number of fishing days per boat | 169 | 162 | 182 | 146 |

The relatively high total of 660 trips in 1952 with a low average of 169 fishing days per boat reflects the following abnormal circumstances. In April 1952 the catch rate of big-eyed tuna reached the unusually high average of 4.98 per 100 hooks (table 2). As a consequence, the boats returned to port with capacity loads, flooding the local market. The price of tuna fell from the March average of 36.8 cents per pound to 22.2 cents in April (fig. 8). Faced with this situation, the boat owners voluntarily limited the larger boats to catches of 45 tuna and the smaller ones to 20. This action often resulted in trips of shorter than normal duration, since the boats catching their limits were forced to return to port regardless of whether or not they had provisions or capacity left for any more fishing.

In general, the data do not indicate any great changes in effort from year to year. The amount of effort being exerted by the fleet is by no means the maximum of which the fleet is capable, as it is generally agreed among the fishermen that the present limited market does not warrant the exertion of greater effort. In other words, the fishing effort is greatly regulated by market conditions so as to remain fairly constant from year to year as shown in table 5.

## VARIATION IN CATCH BY AREAS

While some of the smaller boats of the Honolulu long-line fleet fish regularly in waters off Oahu, others travel 150-200 miles in quest of fish. In fact, boats from Honolulu often range from the waters off Hilo and Kona in the east to the waters off Kauai and Niihau in the west. Generally, however, all fishing is confined to waters within 20 miles from land (fig. 4). There are indications that the most productive areas of fishing tend to change with the season, and the majority of the boats shift their operations accordingly. However, for various reasons, such as the small size of the vessels, the small number of fishermen in the crews, and a desire to work in calm waters near home, some boats fish exclusively in the leeward waters of Oahu, regardless of the higher productivity of more distant areas.

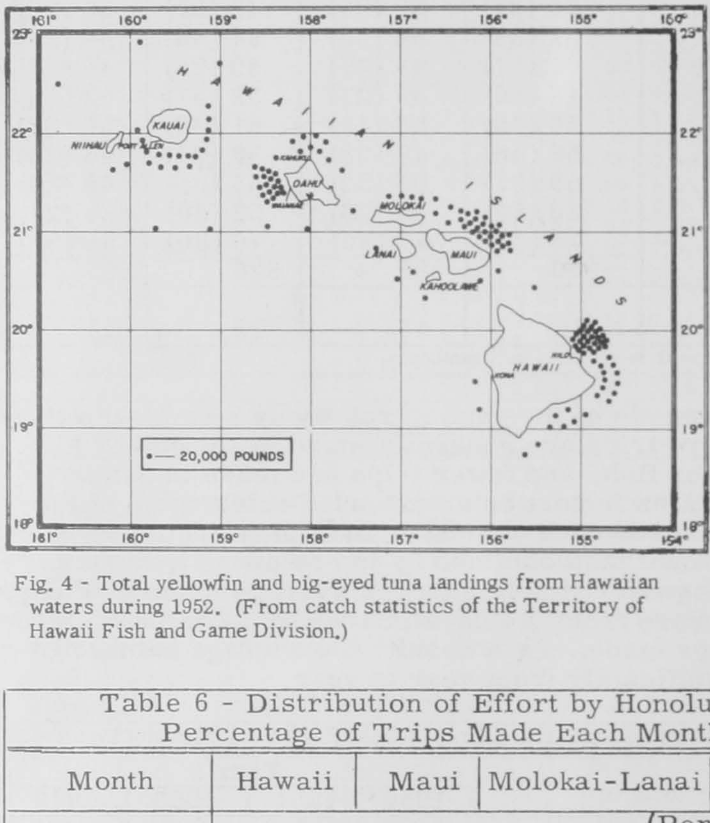


Fig. 4 - Total yellowfin and big-eyed tuna landings from Hawaiian waters during 1952. (From catch statistics of the Territory of Hawaii Fish and Game Division.)

Usually the area off Waianae, Oahu, provides the fishermen with fairly good catches for the greater part of the year. In 1952 over 50 percent of the total effort, in terms of number of trips made between June and September, was centered

Table 6 - Distribution of Effort by Honolulu Long-line Boats in 1952 in Percentage of Trips Made Each Month to the Various Areas[1]/

| Month | Hawaii | Maui | Molokai-Lanai | Oahu | | Kauai-Niihau |
|---|---|---|---|---|---|---|
| | | | | Waianae | Kahuku | |
| | (Percent) | | | | | |
| January | - | - | 20.0 | - | 80.0 | - |
| February | - | 26.7 | 26.7 | 26.7 | 6.7 | 13.3 |
| March | 11.1 | 33.3 | - | 44.4 | - | 11.1 |
| April | 6.7 | 20.0 | 26.7 | 13.3 | - | 33.3 |
| May | - | 55.0 | - | 5.0 | - | 40.0 |
| June | - | 8.0 | - | 56.0 | - | 36.0 |
| July | - | 3.7 | - | 59.3 | - | 37.0 |
| August | 2.0 | 9.8 | - | 54.9 | - | 33.3 |
| September | 7.4 | 20.4 | - | 53.7 | 1.9 | 16.7 |
| October | 15.4 | 21.2 | - | 28.8 | 28.8 | 5.8 |
| November | 10.9 | 32.6 | 4.3 | 34.8 | 15.2 | 2.2 |
| December | 11.9 | 9.0 | 26.9 | 23.9 | 28.4 | - |
| Annual Average | 7.2 | 18.4 | 7.7 | 37.1 | 13.0 | 16.6 |

1/Calculated from information obtained by interviewing randomly-selected Honolulu fishermen at the termination of their trips. The number of trips on which these percentages are based are shown in table 7.

in this area (table 6). Towards the latter part of the year, beginning around October, the major effort shifted to waters off windward Oahu, Hawaii, and to the Maui-Molokai-Lanai area, where better catches were experienced. Windward waters are said to be more productive than leeward waters during the winter months.

In studying variations in catch with areas, the 1952 data have been examined inasmuch as these are the most complete. Detailed records of randomly-selected boat trips are available only for the Honolulu fleet, as this information has been gathered solely by interviewing fishermen in Honolulu. There are no comparative data on the activities of long-line boats based on Hawaii and Kauai.

Table 7 - Average Monthly Tuna Catch Rates1/ (Number per 100 Hooks) in the Six Principal Areas in the Territory of Hawaii, 1952

| Month | Hawaii | Maui | Molokai-Lanai | Oahu | | Kauai-Niihau |
|---|---|---|---|---|---|---|
| | | | | Waianae | Kahuku | |
| January .... | - | - | 4.46(2) | - | 3.34(8) | - |
| February ... | - | 5.40(4) | 2.73(4) | 1.80(4) | 1.02(1) | 1.56(2) |
| March ..... | 1.84(1) | 3.67(3) | - | 1.57(4) | - | 1.41(1) |
| April ...... | 2.89(1) | 6.09(3) | 9.00(4) | 2.63(2) | - | 3.86(5) |
| May ....... | - | 3.79(11) | - | 4.42(1) | - | 2.79(8) |
| June ....... | - | 2.43(2) | - | 2.10(14) | - | 2.88(9) |
| July ....... | - | 3.78(1) | - | 1.90(16) | - | 1.76(10) |
| August ..... | 0.99(1) | 2.32(5) | - | 1.02(28) | - | 1.65(17) |
| September .. | 0.76(4) | 1.33(11) | - | 1.03(29) | 1.02(1) | 2.14(9) |
| October .... | 1.72(8) | 1.35(11) | - | 0.90(15) | 1.21(15) | 1.03(3) |
| November .. | 3.00(5) | 2.43(15) | 1.56(2) | 0.57(16) | 1.24(7) | 1.13(1) |
| December .. | 2.97(8) | 2.20(6) | 2.79(18) | 1.12(16) | 1.90(19) | - |
| Annual Average ... | 2.02 | 3.16 | 4.11 | 1.73 | 1.62 | 2.02 |

1/The tunas include yellowfin, big-eyed, and albacore. These catch rates are derived from data obtained by randomly interviewing Honolulu boat captains at the termination of their trips. The number of boat trips on which these monthly average rates are based is given in parentheses.

Table 7 shows the average monthly catch rates of tuna at the six principal fishing areas. The seasonal shifting of the more productive areas is indicated. In general, the Maui-Molokai-Lanai waters are seen to be most productive, while the waters off Oahu show the lowest catch rates.

## BOAT EFFICIENCY

Fishermen the world over depend, in part, upon chance in making good catches. However, it is more than pure luck alone. There are certain factors which are responsible for consistent differences in the catches made by the various boats of a fleet. These differences may lie in the intrinsic ability of the boat captains in locating good fishing grounds, the skill and experience of the fishermen, or perhaps in certain gear differences. The differences may also arise when certain boats consistently fish in more productive waters than the others. The latter appears to be particularly true of the situation existing in the Hawaiian long-line fishery.

Table 8 - Analysis of Variance of Monthly Catch Rates of 27 Boats for September to December 19521/

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F | P |
|---|---|---|---|---|---|
| Boats .................... | 26 | 58.4788 | 2.2492** | 3.11 | $< 0.01$ |
| Months .................... | 3 | 24.6993 | 8.2331** | 11.37 | $< 0.01$ |
| Discrepancy ............... | 78 | 56.4703 | 0.7240 | | |
| Total ............... | 107 | 139.6484 | | | |

**Indicates a significant ($P < 0.01$) mean square value.

1/These months were selected because the most complete data are available for analysis. Four boats which did not fish regularly during this period were omitted from the analysis.

In a test to determine differences in boat efficiency, the average catch rates (as tunas per 100 hooks) of 27 Honolulu boats for the months of September through December 1952 were used. A two-way analysis of variance (Snedecor 1948) was used to test differences between boats, eliminating differences due to season (months). The data are presented in table 17. The test indicated highly significant differences between boats as well as between months (table 8).

Table 9 - Comparison of the Areas of Operation of Boats With High- and Low-Catch Rates During the Period September-December 1952 1/

| Boats With High-Catch Rates 2/ (13 in Number) | | | Boats With Low-Catch Rates 3/ (14 in Number) | | |
|---|---|---|---|---|---|
| Area | Number of Trips | Percent | Area | Number of Trips | Percent |
| Maui-Molokai ..... | 48 | 49 | Oahu ............. | 78 | 77 |
| Oahu ............ | 26 | 27 | Maui-Molokai ..... | 11 | 11 |
| Hawaii ........... | 18 | 19 | Kauai ............ | 8 | 8 |
| Kauai ............ | 5 | 5 | Hawaii ........... | 4 | 4 |
| Total......... | 97 | 100 | Total......... | 101 | 100 |

1/High- and low-catch boats were determined by the grand mean for this period of 1.62 tunas per 100 hooks fished.
2/Above 1.62 tunas per 100 hooks.
3/Below 1.62 tunas per 100 hooks.

A further examination of the data reveals that the significant between-boat differences are largely attributable to differences in the areas of operation. This is shown in table 9, which gives a comparison of the areas of operation between high- and low-catch boats. Each boat was classed either a high- or low-catch boat according to its mean catch rate for the 4-months period, high if the mean rate was greater than the grand mean of 1.62 tunas per 100 hooks (the grand mean of the 27 boats for the 4-months period) and low if less. Of 101 trips carried out by the 14 low-catch boats during the period, 77 percent were made in waters off Oahu, with the major concentration of effort in the leeward waters of Waianae. Furthermore, the data showed that five of these low-catch boats which had the lowest catch rates fished exclusively in Waianae waters. On the other hand, the 13 boats which experienced higher than average catch rates fished only 27 percent of the total of 97 trips in Oahu waters during the same period, having concentrated their efforts in the Maui-Molokai waters. Thus, some of the differences in catch rates between boats of the Hawaiian long-line fishery arise because certain boats consistently fish in one area, whether productive or not, while others operate in areas which are known to be most productive at any particular season.

## SIZE OF THE TUNAS

The tunas taken in Hawaiian waters by long line are usually large fish. In general, the fishery has been catching fish over 90 pounds in weight with the bulk of the yellowfin falling between 100 and 160 pounds and the big-eyed between 100 and 200 pounds. Yellowfin in excess of 250 pounds and big-eyed weighing around 300 pounds are sometimes taken. The annual average weights of these two species are given in table 10. The weight-frequency distributions of these two species for 1952, by months, 2/ are shown in figures 5 and 6, and these may be considered typical of those covering the period 1949-52.

Table 10 - Annual Average Weights of the Hawaiian Tunas

| Species | Year | | | |
|---|---|---|---|---|
| | 1952 | 1951 | 1950 | 1949 |
| | ....... (Pounds) ....... | | | |
| Yellowfin tuna . | 144.8 | 139.7 | 140.3 | 138.7 |
| Big-eyed tuna . | 162.1 | 158.5 | 157.3 | 160.1 |

A more detailed examination of the yellowfin weight data is presented in table 11. Here the yellowfin landings are broken down into components of various sizes, which are shown as percentages of the total landings. For this study the months of June,

2/Table 18 shows the monthly average weights of the tunas.

July, and August have been selected for each year, 1948 to 1952, as these are the months when the greatest yellowfin catches are recorded. The several components

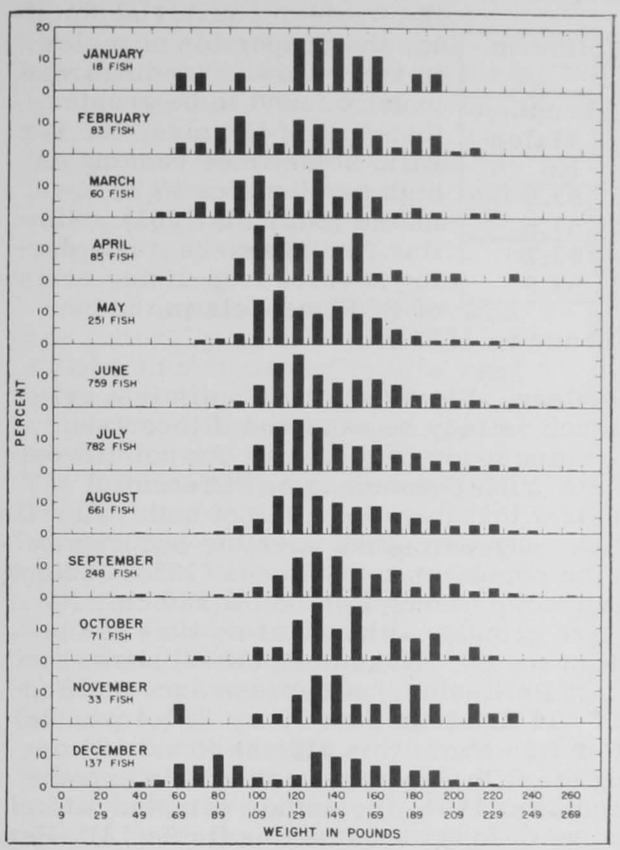


Fig. 5 - Monthly percentage weight-frequency distribution of yellowfin tuna landed in Honolulu in 1952.

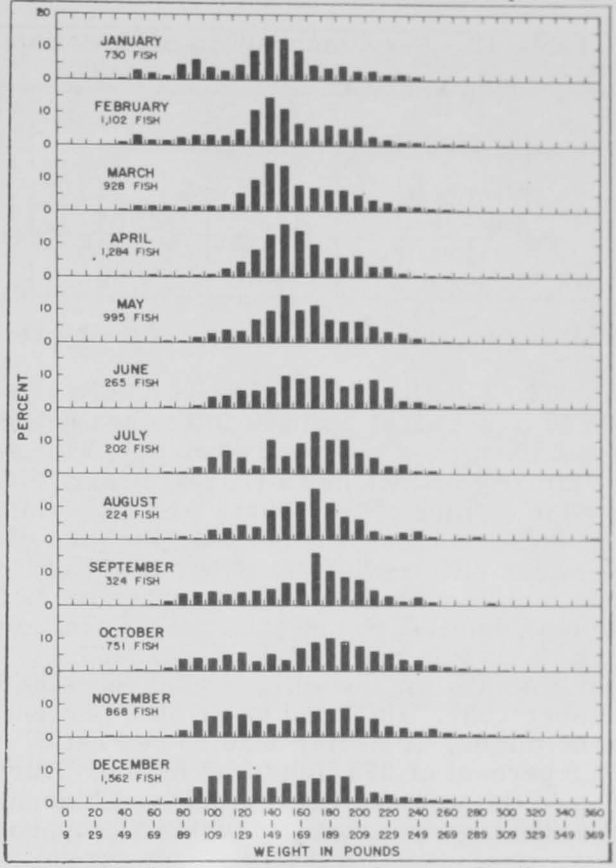


Fig. 6 - Monthly percentage weight-frequency distribution of big-eyed tuna landed in Honolulu in 1952.

of the landings indicate a regular distribution of size classes in the yellowfin catch from year to year, with a marked predominance of the 100- to 150-pound group, which constitutes approximately 60 percent of the total. Less than 5 percent of the catch is made up of fish weighing less than 100 pounds.

Table 11 - Size Composition of the Yellowfin Catch, 1948-52 1/

| Year | Size Groups in Pounds | | | | | |
|---|---|---|---|---|---|---|
| | 1-50 | 50-100 | 100-150 | 150-200 | 200-250 | 250-300 |
| | (Percent) | | | | | |
| 1952 | 0.1 | 2.7 | 56.2 | 32.3 | 8.3 | 0.4 |
| 1951 | 0.0 | 2.6 | 58.4 | 31.8 | 6.5 | 0.6 |
| 1950 | 0.2 | 3.9 | 67.2 | 23.5 | 5.0 | 0.1 |
| 1949 | 0.0 | 3.9 | 55.1 | 33.6 | 7.4 | 0.0 |
| 1948 | 0.0 | 3.9 | 56.0 | 33.2 | 6.8 | 0.1 |

1/Only the months of June, July, and August are represented here since these are the peak months of yellowfin landings.

## SEX RATIO OF THE TUNAS

Examination of the landings at the Honolulu Market during 1949 and 1951 revealed a predominance of males in both yellowfin and big-eyed tuna (table 12). Chi-square tests (Snedecor 1948) indicated significant deviations from the expected 50:50 sex ratio.

This situation appears to be common also in other areas where long-line fishing is carried on. During the first Japanese postwar mothership tuna expedition in the western equatorial Pacific, the proportion of males in the yellowfin landings was usually found to be greater than that of females, the sex ratio sometimes running as high as 80 males to 20 females (Shimada 1951). Similar findings were made during several long-lining cruises of POFI vessels in the central Pacific equatorial waters (Murphy and Shomura 1953).

Table 12 - Sex Composition of Hawaiian Yellowfin and Big-eyed Tuna

| Year | Tuna Species | Male | Female | Percentage of Males |
|---|---|---|---|---|
| | | No. | No. | No. |
| 1951 | Yellowfin | 547 | 313 | 63.6 |
| | Big-eyed | 733 | 542 | 57.5 |
| 1949 | Yellowfin | 114 | 65 | 63.7 |
| | Big-eyed | 346 | 238 | 59.2 |

The significance of these findings is not clear. We do not have sufficient evidence of seasonal changes in the sex ratios such as may be expected if these seasonal changes are directly related to the spawning cycle of the fish. As pointed out by Murphy and Shomura (1953), it may indicate such phenomena as differential growth or mortality. There are data which show that the sex ratios of both yellowfin and big-eyed tuna change with the size of fish, suggesting the possible occurrence of either differential growth or mortality in the populations. Shimada (1951) observed that female yellowfin tuna occurred more frequently among fish below 130 cm. in length (about 95 pounds) than among larger size groups, although at no time did he find the proportion of females exceeding that of males. Nakamura (1949) shows similar findings for the yellowfin taken in the East Philippine Sea between June and September 1937. He found 63 or 50.8 percent of 124 fish less than 37 kg. (81.4 pounds) to be males, or nearly a 50:50 sex ratio. For fish above this size he found 164 or 73.9 percent of 222 fish to be males. During the fifth Japanese mothership expedition in the western Pacific between March and June 1951, the author sampled a total of 1,293 big-eyed tuna, of which 70.5 percent were found to be males (table 13). Here again it was noticed that the predominance of males was especially pronounced among the larger fish. Out of 949 fish measuring over 120 cm. in total length (about 80 pounds), 77.3 percent were males. In the other group of smaller fish, males constituted only 51.7 percent of a total of 344 individuals examined. Thus the sex ratio in the catch below 80 or 90 pounds is about equal, whereas the males predominate among the larger big-eyed and yellowfin tuna.

Table 13 - Sex Determination on 1,293 Big-eyed Tuna Captured During the Fifth Japanese Mothership-Type Tuna Expedition in the Western Equatorial Pacific Ocean April-June 1951

| Month | <120 cm. (80 pounds) | | | >120 cm. (80 pounds) | | |
|---|---|---|---|---|---|---|
| | Males | Females | Percentage of Males | Males | Females | Percentage of Males |
| | No. | No. | % | No. | No. | % |
| April ..... | 31 | 29 | 51.7 | 111 | 43 | 72.1 |
| May ...... | 93 | 89 | 51.1 | 454 | 143 | 76.0 |
| June ...... | 54 | 48 | 52.9 | 169 | 29 | 85.4 |
| Total . | 178 | 166 | 51.7 | 734 | 215 | 77.3 |

## PREDICTING THE LONG-LINE CATCH OF YELLOWFIN

Yellowfin smaller than 50 pounds are seldom taken by the Hawaiian long-line fishery and those below 20 pounds are practically never caught (fig. 5). Smaller fish, on the other hand, are frequently taken by the skipjack pole-and-line fishery, which finds them at the surface either mixed with schools of skipjack or in independent schools. The absence of small fish in the long-line catch may result either from a selective action of the gear or from a general absence of small fish in the subsurface population. The second alternative appears to be more plausible as Murphy and Shomura (1953) have pointed out that there is no reason to believe that the long line is selective as to sizes of fish taken since skipjack as small as 10 pounds have often been captured by this method. In addition, small yellowfin have been taken by long line in the vicinity of the Line Islands in the central Pacific, indicating that small fish will be caught if present in the population.

Fig. 7 - POFI scientists examining tunas and spearfishes on the auction floor of the Honolulu Market.

The surface-caught yellowfin are generally small- to medium-sized fish and appear to be a segment of the yellowfin population which is ecologically separated into surface and subsurface groups. The surface fish may descend to deeper levels after attaining a certain age or size. If this assumption is true, it may be reasonable to expect the abundance of surface fish in one year to indicate the abundance of subsurface fish a few years later. Such a relationship, if real, would be of some value to the fishery in predicting the abundance of yellowfin a few years in advance. Since the long-line catches of yellowfin are largely made up of a few year-classes, with fish believed to be in their third year (Moore 1951) contributing the largest percentage to the fishery, the size of this year-class, at least, may be a reflection of the abundance of surface fish two years previous.

Table 14 - Monthly Landings of Surface Yellowfin by the Hawaiian Skipjack Fishery, 1948-52[1]/

| Month | 1953 | 1952 | 1951 | 1950 | 1949 | 1948 |
|---|---|---|---|---|---|---|
| | (Pounds) | | | | | |
| January | - | - | 1,598 | 7,131 | 763 | 6,911 |
| February | - | 2,372 | 632 | 1,618 | 1,301 | 387 |
| March | - | 554 | 40 | 1,061 | 3,073 | 6,810 |
| April | - | 4,892 | 4,087 | 7,672 | 1,303 | 5,620 |
| May | - | 1,663 | 1,552 | 3,151 | 1,532 | 1,183 |
| June | - | 238 | 118 | 6,549 | 139 | 1,892 |
| July | - | 11,946 | 117 | 1,017 | 3,342 | 838 |
| August | - | 985 | 7,379 | 6,798 | 13,141 | 638 |
| September | - | 1,090 | 8,502 | 7,224 | - | 1,323 |
| October | - | 5,148 | 98 | 132 | 12,071 | 396 |
| November | - | 2,413 | 83 | 3,416 | - | 531 |
| December | - | 146 | 891 | 26 | 185 | - |
| Annual total | - | 31,447 | 25,097 | 45,795 | 36,850 | 26,529 |
| Yellowfin landings by long-line fishery | 2/535,000 | 719,000 | 661,000 | 605,000 | - | - |

1/From records provided by the Territory of Hawaii Fish and Game Division.
2/Approximate long-line landings of yellowfin for 1953. Data not available by months.

The landings of surface yellowfin by the skipjack fishery for the years 1948 to 1952 are presented in table 14. Also listed in the same table are the yellowfin landings by the long-line fishery for 1950 through 1953. There appears to be some relationship between the total landings of surface fish in one year with the catch of subsurface fish two years later; e.g., the 1948 landings of 26,529 pounds of surface fish with the 1950 catch of 605,000 pounds of subsurface fish; the 1949 landings of 36,850 pounds with the 1951 catch of 661,000 pounds; and the 1950 landings of 45,795 pounds with the 1952 catch of 719,000 pounds. The catch statistics for the year 1953 indicate estimated yellowfin landings by the long-line fishery of 535,000 pounds, a drop from previous years, which again agrees with the reduced surface yellowfin landings of 25,097 pounds in 1951. Unfortunately, available data are far too scanty to draw any conclusions. Even if such a relationship actually exists, we cannot expect to find perfect correlations as there are numerous factors which tend to make surface sampling inadequate and probably inaccurate. In the first place, the total landings may not indicate the true abundance of surface yellowfin in these waters as the skipjack fishermen may often forego schools of yellowfin when skipjack schools are numerous. Again, the amount of effort expended by the skipjack fleet from year to year might vary so much that total landings would not be indicative even of relative abundance of the species.

## FISH PRICES AND VALUE OF LANDINGS

The catch of a Honolulu long-line boat is unloaded at one of two auction markets where buyers from the several fresh fish markets, as well as individual fish peddlers, bid for the fish (fig. 7). Since at the present time there are no outlets for canning of these large tunas, the only markets are those for fresh fish. Fresh tuna is in great demand, especially by the island's oriental population, for consumption as sashimi (raw fish). Fortunately for the fishing industry, big fish are preferred for sashimi because of the higher oil content, which supposedly improves the flavor. The bulk of the spearfishes is sold to processors for use in making fish cakes (kamaboko), while a small part is handled as fresh fish.

While the local skipjack fishermen enjoy a relatively steady contract price because their catches are canned, the prices realized by the long-line fishermen fluctuate very widely. Only in times of extremely good catches are the canneries not able to absorb all of the fish which are landed by the skipjack fishery. These fish may be canned and held in warehouses, but the large tunas and spearfishes which are presently handled only as fresh fish are highly perishable, and consequently the prices paid for them are largely controlled by the factors of supply and demand. It is therefore not unusual that prices paid for long line-caught fish vary from day to day or even between the two auction markets on the same day.

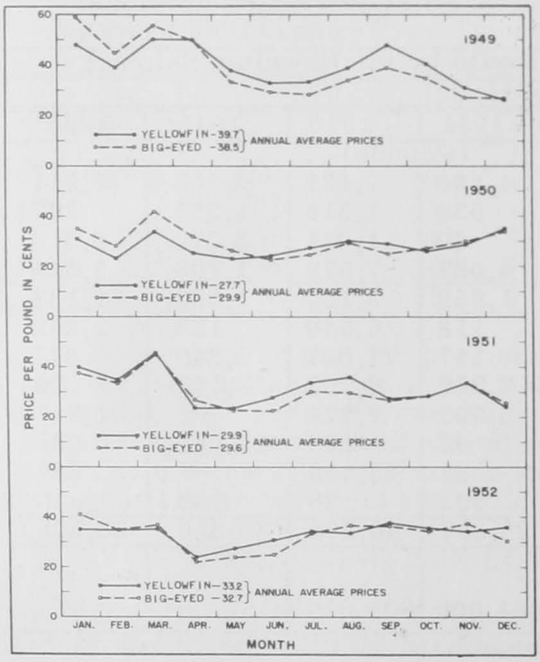


Fig. 8 - Average monthly prices paid to the fishermen for yellowfin and big-eyed tuna, 1949-52 (from records of the Territory of Hawaii Fish and Game Division).

Figure 8 presents graphically the monthly average prices of yellowfin and big-eyed tuna at the auction markets between 1949 and 1952. These prices are essentially what the fishermen receive for their catches, although some deductions are made by the auction firms for services rendered. Annual average prices for both species do not differ significantly although yellowfin generally commands a slightly higher price than big-eyed tuna. The prices are determined more by the size of the fish and condition of the meat (such as color and texture) than by species.

The ever-fluctuating fish price is an important factor which tends to influence the intensity of fishing. As shown in table 15, the annual values do not show any significant trend but remain rather steady at slightly over a million dollars. This is not in keeping with the steadily increasing annual landings (table 1), but appears to be the result of a limited market capacity which controls the price of fish according to supply and demand. As seen in figure 8, the annual average price for both species of tuna dropped markedly from about 40 cents per pound in 1949 to less than 30 cents in 1950, and has not shown any appreciable recovery since.

Table 15 - Value of Fish to the Fishermen Landed by the Long-line Fishery in the Territory of Hawaii, 1948-1952 1/

| Species | 1952 | 1951 | 1950 | 1949 | 1948 |
|---|---|---|---|---|---|
| | $ | $ | $ | $ | $ |
| Yellowfin tuna ...... | 230,412 | 206,038 | 178,111 | 313,024 | 438,611 |
| Big-eyed tuna ...... | 684,726 | 600,361 | 548,526 | 376,135 | 294,422 |
| Albacore tuna ...... | 22,611 | 13,933 | 11,591 | 23,894 | 32,541 |
| Spearfishes ........ | 309,030 | 335,092 | 322,114 | 412,157 | 504,422 |
| Total .......... | 1,246,780 | 1,155,424 | 1,060,342 | 1,125,210 | 1,269,995 |

1/Compiled from records of Territory of Hawaii Fish and Game Division.

Although all or nearly all of the fish are presently being absorbed by the buyers, the prices paid for them are often very low. While it is generally agreed that the coastal and offshore waters of the Hawaiian Islands contain a dependable supply of tunas and spearfishes to sustain a much more intensive long-line fishery, the limited market constitutes a serious block to any such expansion.

Table 16 - Monthly Landings (In Thousands of Pounds) by the Hawaiian Long-line Fishery, 1948-52 1/

| Species | Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellowfin tuna ... | 1952 | 28 | 41 | 34 | 49 | 78 | 113 | 120 | 128 | 64 | 28 | 14 | 22 |
| Big-eyed tuna ... | 1952 | 167 | 196 | 133 | 357 | 224 | 96 | 71 | 69 | 116 | 216 | 182 | 366 |
| Albacore tuna ... | 1952 | 1 | 1 | 1 | 10 | 4 | 19 | 15 | 14 | 16 | 11 | 2 | 8 |
| Spearfishes ..... | 1952 | 30 | 86 | 66 | 52 | 64 | 69 | 64 | 119 | 121 | 124 | 79 | 79 |
| Total ....... | 1952 | 225 | 324 | 233 | 468 | 370 | 297 | 270 | 330 | 317 | 379 | 277 | 475 |
| Yellowfin tuna ... | 1951 | 10 | 18 | 30 | 41 | 76 | 98 | 80 | 60 | 83 | 53 | 45 | 67 |
| Big-eyed tuna ... | 1951 | 142 | 172 | 131 | 197 | 204 | 110 | 115 | 105 | 109 | 200 | 177 | 370 |
| Albacore tuna ... | 1951 | 1 | 1 | 1 | 1 | 1 | 3 | 5 | 3 | 4 | 6 | 6 | 26 |
| Spearfishes ..... | 1951 | 37 | 46 | 90 | 79 | 135 | 104 | 88 | 136 | 114 | 121 | 108 | 59 |
| Total ....... | 1951 | 190 | 236 | 252 | 317 | 416 | 315 | 288 | 304 | 310 | 380 | 336 | 522 |
| Yellowfin tuna ... | 1950 | 14 | 22 | 13 | 23 | 39 | 73 | 100 | 121 | 66 | 54 | 45 | 35 |
| Big-eyed tuna ... | 1950 | 135 | 212 | 138 | 154 | 191 | 148 | 114 | 90 | 103 | 150 | 136 | 272 |
| Albacore tuna ... | 1950 | - | 1 | 2 | 1 | 2 | 4 | 9 | 10 | 6 | 8 | 6 | 13 |
| Spearfishes ..... | 1950 | 44 | 111 | 118 | 90 | 113 | 111 | 87 | 116 | 123 | 137 | 120 | 108 |
| Total ....... | 1950 | 193 | 346 | 271 | 267 | 344 | 335 | 310 | 338 | 299 | 349 | 307 | 428 |
| Yellowfin tuna ... | 1949 | 67 | 79 | 34 | 49 | 69 | 120 | 128 | 91 | 49 | 31 | 40 | 60 |
| Big-eyed tuna ... | 1949 | 33 | 74 | 78 | 62 | 69 | 42 | 16 | 23 | 49 | 136 | 200 | 304 |
| Albacore tuna ... | 1949 | 6 | 11 | 4 | 7 | 3 | 6 | 5 | 5 | 7 | 8 | 6 | 2 |
| Spearfishes ..... | 1949 | 55 | 141 | 108 | 108 | 110 | 93 | 80 | 113 | 66 | 104 | 89 | 83 |
| Total ....... | 1949 | 161 | 305 | 224 | 226 | 251 | 261 | 230 | 232 | 172 | 278 | 335 | 448 |
| Yellowfin tuna ... | 1948 | 77 | 89 | 64 | 50 | 42 | 99 | 114 | 121 | 85 | 67 | 99 | 99 |
| Big-eyed tuna ... | 1948 | 55 | 108 | 73 | 76 | 35 | 19 | 19 | 16 | 22 | 41 | 77 | 99 |
| Albacore tuna ... | 1948 | 1 | 6 | 2 | 15 | 13 | 11 | 5 | 12 | 13 | 9 | 4 | 2 |
| Spearfishes 2/ ... | 1948 | 46 | 99 | 96 | 84 | 76 | 142 | 157 | 159 | 122 | 111 | 133 | 191 |
| Total 3/ ..... | 1948 | 179 | 302 | 236 | 225 | 166 | 271 | 295 | 308 | 242 | 228 | 313 | 391 |

1/Compiled from catch statistics of the Territory of Hawaii Fish and Game Division.
2/Includes black marlin, striped marlin, and lesser quantities of sailfish, white marlin, broadbill swordfish, and short-nosed spearfish.
3/Totals may not be exact due to rounding off figures.

Table 17 - Analysis of the Catch Rates (as Tunas per 100 Hooks) of 27 Boats (September to December) by Months

| Boat | Month | | | | Mean | Boat | Month | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sept. | Oct. | Nov. | Dec. | | | Sept. | Oct. | Nov. | Dec. | |
| 1 | 0.67 | 0.52 | 0.99 | 0.47 | 0.66 | 15 | 0.91 | 1.38 | 2.27 | 1.97 | 1.63 |
| 2 | 0.97 | 0.55 | 0.20 | 1.22 | 0.74 | 16 | 1.83 | 1.90 | 0.86 | 1.98 | 1.64 |
| 3 | 0.64 | 1.05 | 0.31 | 1.24 | 0.81 | 17 | 1.38 | 1.48 | 2.32 | 1.64 | 1.70 |
| 4 | 0.80 | 1.12 | 0.36 | 1.02 | 0.82 | 18 | 0.76 | 1.29 | 1.77 | 3.13 | 1.74 |
| 5 | 1.08 | 0.98 | 0.37 | 1.18 | 0.90 | 19 | 1.52 | 1.19 | 2.03 | 2.48 | 1.80 |
| 6 | 1.02 | 0.54 | 0.66 | 1.86 | 1.02 | 20 | 0.78 | 1.08 | 2.90 | 3.33 | 2.02 |
| 7 | 1.09 | 1.26 | 0.31 | 1.53 | 1.05 | 21 | 0.67 | 0.72 | 4.74 | 2.09 | 2.06 |
| 8 | 0.67 | 0.90 | 1.15 | 1.57 | 1.07 | 22 | 1.34 | 1.60 | 3.48 | 1.96 | 2.10 |
| 9 | 1.61 | 1.02 | 0.68 | 1.17 | 1.12 | 23 | 1.71 | 2.01 | 2.56 | 2.61 | 2.22 |
| 10 | 1.22 | 1.56 | 0.87 | 0.92 | 1.14 | 24 | 1.46 | 1.67 | 2.16 | 4.03 | 2.33 |
| 11 | 0.57 | 0.84 | 1.20 | 2.11 | 1.18 | 25 | 1.72 | 1.20 | 5.06 | 3.65 | 2.91 |
| 12 | 0.92 | 0.89 | 1.92 | 1.78 | 1.38 | 26 | 1.32 | 1.78 | 3.63 | 5.71 | 3.11 |
| 13 | 0.80 | 1.50 | 1.32 | 2.37 | 1.50 | 27 | 1.92 | 1.79 | 5.69 | 5.08 | 3.62 |
| 14 | 1.64 | 0.41 | 0.22 | 3.89 | 1.54 | Grand mean of 27 boats ........ | | | | | 1.62 |

Table 18 - Monthly Average Weights of Yellowfin and Big-eyed Tuna in the Landings of the Hawaiian Long-line Fishery

| Month | Yellowfin tuna | | | | Big-eyed tuna | | | |
|---|---|---|---|---|---|---|---|---|
| | 1952 | 1951 | 1950 | 1949 | 1952 | 1951 | 1950 | 1949 |
| | (Pounds) | | | | | | | |
| January | 136.7 | 152.3 | 98.8 | 104.2 | 147.5 | 152.2 | 156.3 | 175.0 |
| February | 131.5 | 125.5 | 107.0 | 117.8 | 153.4 | 150.2 | 151.7 | 150.0 |
| March | 126.0 | 105.4 | 120.2 | 113.5 | 159.5 | 144.5 | 153.4 | 141.0 |
| April | 133.1 | 116.2 | 117.5 | 122.7 | 165.6 | 152.1 | 154.6 | 156.1 |
| May | 136.3 | 126.3 | 117.0 | 131.8 | 168.2 | 160.3 | 157.1 | 153.7 |
| June | 146.7 | 140.4 | 136.4 | 144.0 | 176.4 | 164.1 | 165.0 | 171.3 |
| July | 145.3 | 141.5 | 136.6 | 143.5 | 167.3 | 168.3 | 163.7 | 184.0 |
| August | 149.5 | 151.6 | 144.5 | 138.1 | 170.7 | 157.6 | 158.5 | 183.4 |
| September | 152.6 | 151.1 | 158.4 | 145.7 | 169.8 | 151.8 | 149.3 | 170.5 |
| October | 150.8 | 142.1 | 146.8 | 140.2 | 172.3 | 152.8 | 155.1 | 168.7 |
| November | 155.1 | 139.1 | 143.3 | 150.0 | 167.8 | 170.5 | 155.0 | 167.0 |
| December | 129.2 | 154.5 | 136.2 | 119.7 | 155.7 | 165.5 | 159.6 | 159.3 |
| Annual average | 144.8 | 139.7 | 140.3 | 138.7 | 162.1 | 158.5 | 157.3 | 160.1 |

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## ACKNOWLEDGMENT

The Fish and Game Division of the Territory of Hawaii, Board of Agriculture and Forestry, has provided much of the data on which this paper is based. The generous cooperation of the various dealers and officials of the Honolulu Market Place, the Kyodo Fishing Company, the United Fishing Agency, and the Hawaii Fishing Company in allowing examination and sampling of their fish is gratefully acknowledged. The captains and crews of the Honolulu long-line boats have been very cooperative in supplying information pertaining to fishing operations. The interview method of obtaining information was initiated in 1949 by Fred C. June, Fishery Research Biologist, formerly with the staff of the Service's Pacific Oceanic Fishery Investigations. Many others have helped in the collection of data, including fishery research biologists Isaac I. Ikehara, Richard Shomura, and Heeny Yuen. The figures were prepared by Tamotsu Nakata, draftsman for POFI.


## UNUSUAL SALMON MIGRATIONS

Several unusual recoveries of salmon marked in Oregon Fish Commission hatcheries were made during 1953 as part of the research program being coordinated by the Pacific Marine Fisheries Commission. On August 1, 1953, a marked silver salmon from the Klaskanine hatchery (lower Columbia River) was caught by a troller near the Farallon Islands off San Francisco. This fish was about 520 nautical miles from its home stream when captured.

At the other extreme, two marked spring chinook salmon from the Willamette River were taken by the Alaskan troll fishery and landed at Pelican during July 1953. One of these was taken at Lituya Bay, at the northern limit of the present troll fishery, which is over 1,000 miles from the Willamette River.

--Fish Commission Research Briefs, March 1954