Southwest Fisheries Center Administrative Report H-89-10

STATUS OF THE TUNA LONGLINE FISHERY IN HAWAII, 1987-88

Kurt E. Kawamoto, Russell Y. Ito, Raymond P. Clarke, and Allison A. Chun
Southwest Fisheries Center Honolulu Laboratory
National Marine Fisheries Service, NOAA
Honolulu, Hawaii 96822-2396

September 1989

INTRODUCTION

A Japanese immigrant introduced tuna longline fishing to Hawaii in 1917 (Otsu 1954). This fishing method capitalized on a previously unexploited subsurface resource--large yellowfin tuna, *Thunnus albacares*, and bigeye tuna, *T. obesus*. It quickly developed into a major fishery in Hawaii. Prior to the introduction of longlining, most commercial tuna landings were made by the pole and line fishery for skipjack tuna, *Katsuwonus pelamis*. Other tuna landings produced by trolling and hand-lining (Hawaiian palu ahi method) during this time period were unknown.

Over the past 70 years, longlining has efficiently increased the exploitation of the pelagic fishery resources and is the major producer of large tunas. Every aspect of the fishery has undergone changes: from vessel and gear technology, to the size and species composition of the catch, to the markets and marketing strategies. Historical information on the longline fishery has been discussed by June (1950), Otsu (1954), Shomura (1959), Lyman and Hawaii Opinion (1984), and Honda (1984).

Currently, a segment of the Hawaii longlining fleet is changing its gear technology. New vessels are entering the fishery, and new marketing strategies are being established. This report presents historical information and updates the status of the fishery for the 1987-88 period.

VESSELS

History

Vessel participation in the Hawaiian longline fishery during the post-World War II period has been documented in published reports (e.g., June 1950; Otsu 1954; Shomura 1959; Hida 1966; Otsu and Sumida 1970; Yoshida 1974) and unpublished reports and surveys. The number of vessels in the Honolulu-based fleet significantly expanded immediately after World War II (1946-48) and consisted of 31-33 vessels during 1949-52 (Otsu 1954). The longline fleet in the post-World War II period apparently was homogeneous with respect to physical characteristics (vessel types and gear) and operational activities.

Otsu (1954) reported the number of trips made each year by the longline fleet increased during the time period from 1949 to 1952 but noted a corresponding decline in trip length motivated by high catch rates and market conditions. Shomura (1959) said that the total number of trips peaked during the 1953-55 period at about 20% higher than in 1948-49. Otsu (1954) and Shomura (1959) concluded that effort, in terms of vessel participation, did not change much during 1948-56.

The number of vessels began declining after 1957, and by 1964, only 24 longline vessels were based in Honolulu (Hida 1966). Yoshida (1974) reported that 42 vessels, including 10 Hilo-based vessels, were active in 1952, 31 vessels in 1964, and only 20 by 1970. Otsu and Sumida (1970) counted 22 active vessels in 1968. Despite this decline, a new steel-hulled vessel with an extended cruising range was completed in July 1969

(Kanayama 1970). Although this new technology suggested some hope for a revitalized fishery, the increasing age of the remaining vessels in the fleet contributed to its continued decline. Only 14 vessels fished full time in 1979.

The number of vessels longlining increased in the early 1980's. Honda (1984) counted 37 vessels with longline gear in 1983, although only 13 vessels were registered with the State of Hawaii as longliners. The discrepancy was speculated to reflect the seasonal nature of longline fishing and part-time participation by several vessels not registered as longliners. Another theory suggests that a change in the State's data recording system for commercial licenses may have resulted in underreporting of vessel participation and landings (S. G. Pooley, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96822-2396, pers. commun.).

During the latter part of the 1980's, increased demand for longline-caught fish was realized when exports to both domestic (U.S. mainland) and foreign markets increased. Consequently, recent years have seen an upsurge in the number of participants in this fishery. Today, the fleet is composed mainly of newer, metal-hulled vessels. The vessels have a host of new technological aids ranging from powerful, color video echo sounders to satellite navigation and weather facsimile machines. The technological advances simplify navigation and provide increased safety to exploit distant fishing grounds during periods of low catch rates in the vicinity of the Hawaiian Islands. Trip length is now limited only by the shelf life of the catch.

Current Participation of the Fleet

Tracking the vessel participation is complicated by the lack of an accessible, accurate, up-to-date permit system. Vessels in this fleet frequently change owners and names, dictating that monitoring be fairly comprehensive and timely to determine the number of active participants. Fleet participation is presently monitored by the National Marine Fisheries Service (NMFS) via market landings. In addition to the Honolulu-based longline vessels, at least two vessels were based at the Island of Hawaii (Big Island) but were excluded from this report.

During the past 3 years (1986-88), total vessel participation in the Hawaiian tuna longline fleet has grown from 37 to 50 vessels. Approximately 20% of these vessels also participate in the Northwestern Hawaiian Islands (NWHI) bottom fish fishery as part of their normal operations each year. In addition to those bottom fishing vessels, some may also troll for albacore, *T. alalunga*; trap lobster or shrimp; or even drag for precious coral. Vessels that seasonally exit the longline fleet to enter other fisheries normally depart during the summer (June-September) of each year. However, these seasonal participants derive a predominant portion of their annual earnings from longline fishing.

In 1986, 39 vessels participated in the Hawaiian longline fishery (Fig. 1). Three of the vessels were new to the fishery. At least five of the vessels also engaged in the NWHI bottom fish fishery, and one entered the NWHI lobster fishery.

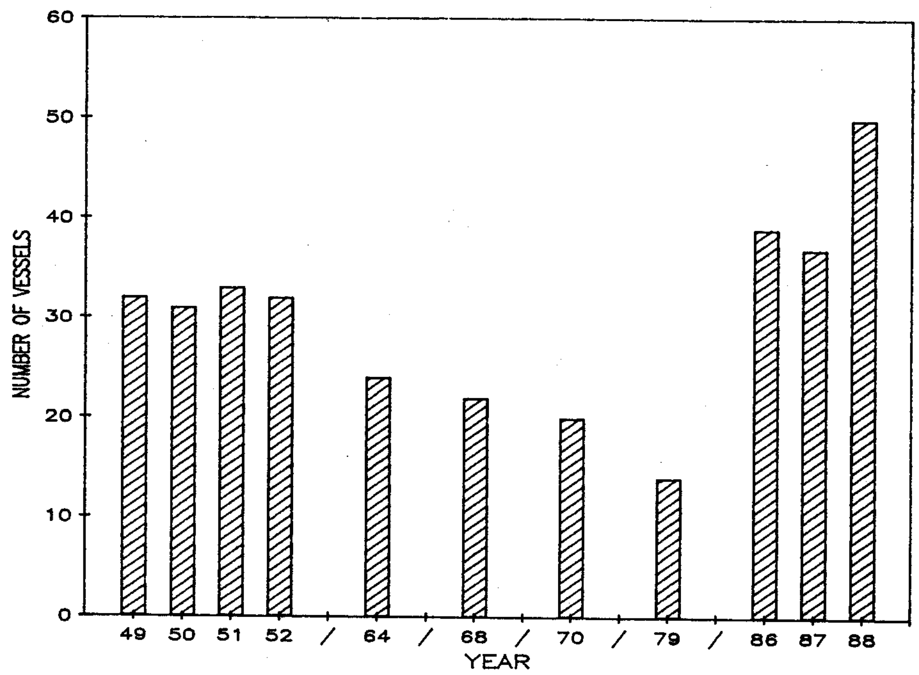

Figure 1.--Number of Hawaii longline vessels in various years in 1949-88 (1949-52 from Otsu (1954), 1964 from Hida (1966), 1968 from Otsu and Sumida (1970), 1970 from Yoshida (1974), and 1979 from Uchida (1979)).

In 1987, 37 vessels participated in the longline fishery. Two were new to the fishery, at least six also engaged in the NWHI bottom fish fishery, and one vessel also joined the NWHI lobster fishery. Two vessels departed for unknown destinations.

Of the 50 vessels in 1988, 19 were new to the fishery. New participants included 2 NWHI bottom fish vessels, 4 NWHI lobster vessels, 1 tuna handline vessel, and 12 additional vessels, more than half of which were new to Hawaiian waters. Most of the new entrants came from the U.S. west coast, and at least three from the Gulf of Mexico. Only one vessel also participated in the NWHI bottom fish fishery, and one vessel entered the precious coral fishery.

Physical Characteristics

Data on the physical and operational characteristics of the 1988 tuna longline fleet (Table 1) were collected from a variety of sources including U.S. Coast Guard documentation files, State of Hawaii records, and informed industry sources. These data represent preliminary findings and should be viewed as such. Vessels participating in the Hawaiian longline fishery are of a wide variety of sizes and configurations (Fig. 2A-C); few originally were constructed specifically for longlining. Many of the more recent entrants are from the west coast, the point of origin of many commercial fishing vessels presently active in Hawaii.

Table 1.--Physical and operational characteristics of the Hawaiian longline fleet, 1988. *N* = sample size.

Characteristic	Fleet average	*N*	Range
Physical			
Vessel length overall (feet)	65.8	49	44-96
Fuel capacity (gallons)	8,500	39	1,500-30,000
Hull age (years)	18.5	48	1-63
Horsepower	322	48	180-800
Construction (%)			
Wood	26	12	--
Wood-fiberglass	13	6	--
Steel	61	29	--
Operational			
Crew (No.)	5	38	4-7
Gear type (%)			
Basket	59.2	29	--
Monofilament	28.6	14	--
Bin	12.2	6	--
Hooks hauled (No./day)	1,050	21	650-1,700

Figure 2A.--A traditional longline sampan.

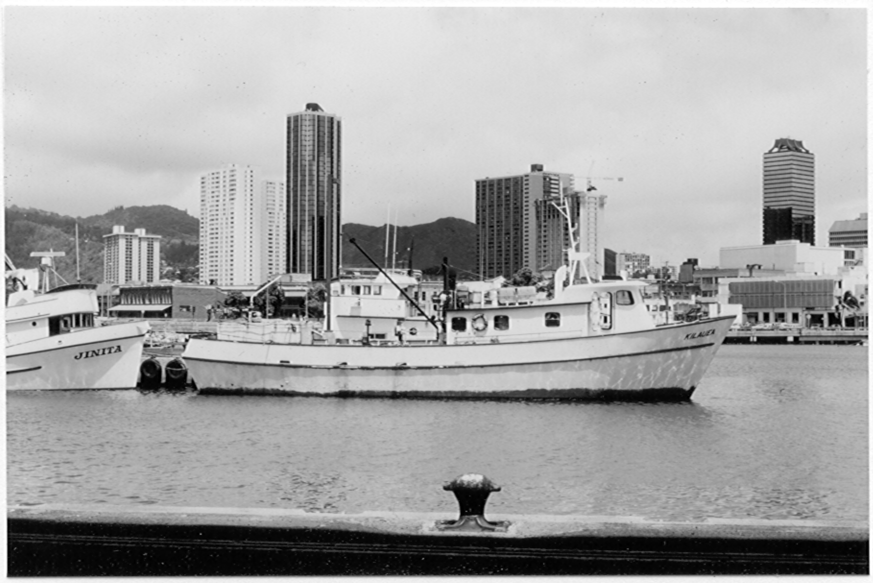

Figure 2B.--A steel hulled longline vessel.

Figure 2C.--A recent entrant to the Hawaiian tuna longline fishery.

Characteristics of individual vessels vary greatly. Vessel length is reported in two ways, either as "registered" or by "overall length." If only registered length was reported, that figure was converted to overall length by multiplying by a factor of 1.1 (Table 1). Vessel horsepower is reported for the main engine only and does not include auxiliaries. The number of hooks hauled per day represents the average from 21 vessels sampled. This figure is slightly higher than the weighted average calculated by gear type. Vessels using basket gear hauled an average of 850 hooks per set ($N = 9$) while vessels using monofilament gear hauled an average of 1,250 hooks per set ($N = 11$). The only vessel using bin gear was surveyed in our sample; it averaged 900 hooks per set. Given this, the weighted average is 975 hooks per set, with the entire Hawaiian longline fleet having a maximum capacity of 48,300 hooks.

Several physical factors reveal the diversity of the vessels participating in the longline fishery. Vessels of wooden construction ($N = 10$) have an average hull age of 32.2 years; steel-hulled ($N = 22$) vessels, 11.9 years; and fiberglass vessels ($N = 4$), 10.8 years. Basket gear was observed on 11 wooden-, 14 steel-, and 3 fiberglass-hulled vessels and was fairly evenly represented throughout the fleet. Monofilament gear was observed on 12 steel-, 3 fiberglass-, and no wooden-hulled vessels. One wooden vessel was reportedly placing monofilament gear aboard and should be fishing by early 1989. This information along with additional operational data may provide a basis to segment the fleet into distinct vessel classes in future analyses.

GEAR

Tuna longline gear used in the Hawaiian Islands has undergone a major change within the past few years. The three types of longline gear systems--basket, bin, and monofilament presently employed in the Hawaiian tuna longline fishery are described below.

Basket Gear

Basket gear is a scaled-down version of that traditionally used by the Japanese, Korean, and Taiwanese high-seas tuna longline fleet (Yoshida 1966). Each basket (Fig. 3) is approximately 360 fathoms long. A series of 60-70 baskets are connected to form a continuous main line that is about 20-30 nmi long. The main line is suspended at intervals by float lines attached to surface floats (Fig. 4). Float lines are 10-12 fathoms long but may be lengthened or shortened to assist in controlling the depth of the main line. Depth is primarily controlled by the sag of the main line between the float lines. Branch lines, terminating in hooks and measuring approximately 12 fathoms long, are suspended from the main line. There are normally 12 hooks per basket of gear. Each hook is spaced at 30-fathom intervals. Most vessels deploy 750-900 hooks. Main, branch, and float lines are made of cotton, nylon, or other synthetic material coated with tar. The gear is deployed by hand and hauled by a mechanical line hauler and coiler (Fig. 5). Branch and float lines are hauled and coiled by hand.

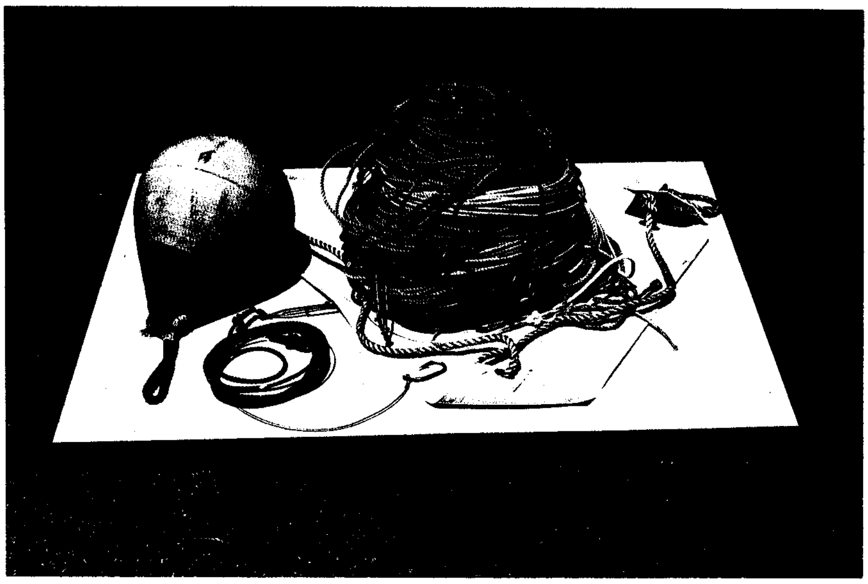

Figure 3.--A unit of basket gear.

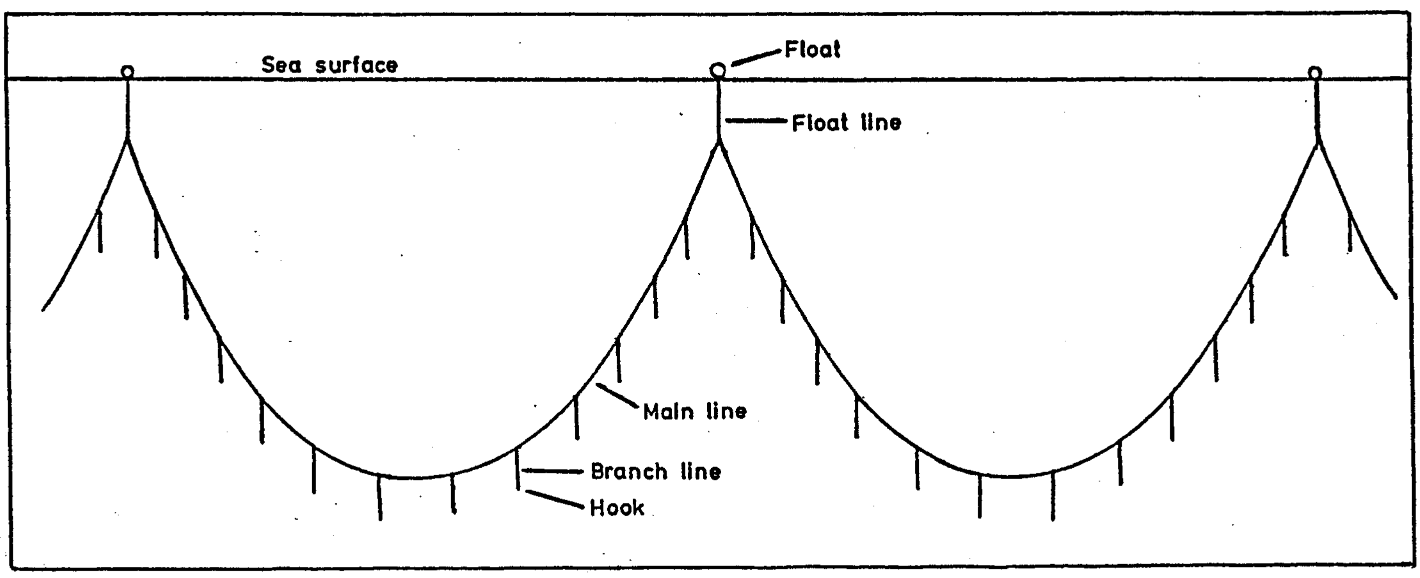

Figure 4.--Section of longline with catenary formed by the sag in longline gear (adapted from Suzuki and Warashina 1977).

Figure 5.--A mechanical line hauler.

Bin Gear

The main, branch, and float lines are made of the same materials as the basket gear. However, the main line is one continuous length of line that is stored in large bins rather than tied in bundles (Fig. 6). The spacing and number of hooks between floats are approximately the same as with the basket gear. In use since 1970, this system requires three machines for operation. The main line is deployed by a mechanical line thrower and retrieved by a line hauler. The main line is conveyed through a series of guides to a line arranger, which is located on a track above the bins and directs the main line into the bins. This bin system allows the use of minimal crew during the fishing operation.

Monofilament Gear

The monofilament longline gear has been in regular use by at least one vessel since 1985 and is becoming more widespread in the tuna longline fishery in Hawaii. In early 1988, 2 out of 38 vessels (5%) were using monofilament gear, and by the end of 1988, 14 vessels (29%) were using this system. Monofilament gear appears to be more popular with the recent entrants into the fishery, although basket gear remains popular with certain segments of the fleet. This may be due in part to the reportedly high initial cost of the monofilament gear. Other fishermen are skeptical as to the ability of the monofilament gear to catch the preferred species, bigeye tuna. In addition, there may be some resistance to gear changes by traditionally oriented participants within the fleet.

The main line and branch lines in this system are made of 900- to 1,100-pound test and approximately 450-pound test monofilament, respectively. Float lines are either made of tarred line as in the other

Figure 6.--Longline bin gear.

systems or may be of monofilament. Vessels with monofilament gear normally deploy between 900 and 1,400 hooks. The number of hooks and their spacing vary depending on the desired depth, which may be attained by a variety of methods, such as changing the length of the float line and increasing or decreasing the distance of the main line between floats to control the catenary (depth) of the main line. The 30- to 60-mile-long monofilament main line is stored on a hydraulically operated reel (Fig. 7). The main line may be deployed directly from the reel or through the use of a mechanical line thrower (Fig. 8). When deployed with enough slack for the deep hooks to reach a depth of 150 fathoms, this gear extends over a distance of 17-33 miles. The main line is hauled by the main line reel. Branch lines (7-11 fathoms long) are retrieved either mechanically or manually and stored uncoiled in leader bins.

TRIP ACTIVITY

Honolulu is the principal port for off-loading in Hawaii, but longline vessels also off-load on the Big Island and, on a few occasions, in Kahului, Maui. Landings from the vessels based on the Big Island are not covered in this report.

Fishing Effort

Fishing effort is expressed as the estimated number of trips made by the Hawaiian tuna longline vessels off-loading at the Honolulu market from January 1986 to December 1988 (Fig. 9). Fishing effort decreased from 537 trips in 1986 to 435 trips in 1987 (18% decrease), then increased dramatically to 627 trips in 1988 (44% increase). Vessels averaged 12 trips per year.

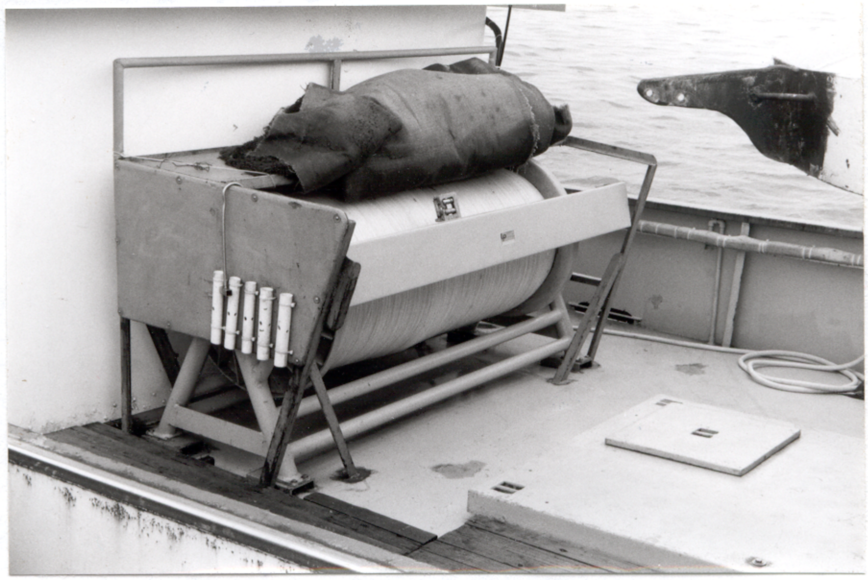

Figure 7.--Monofilament main line wound on a reel.

Figure 8.--Monofilament line thrower.

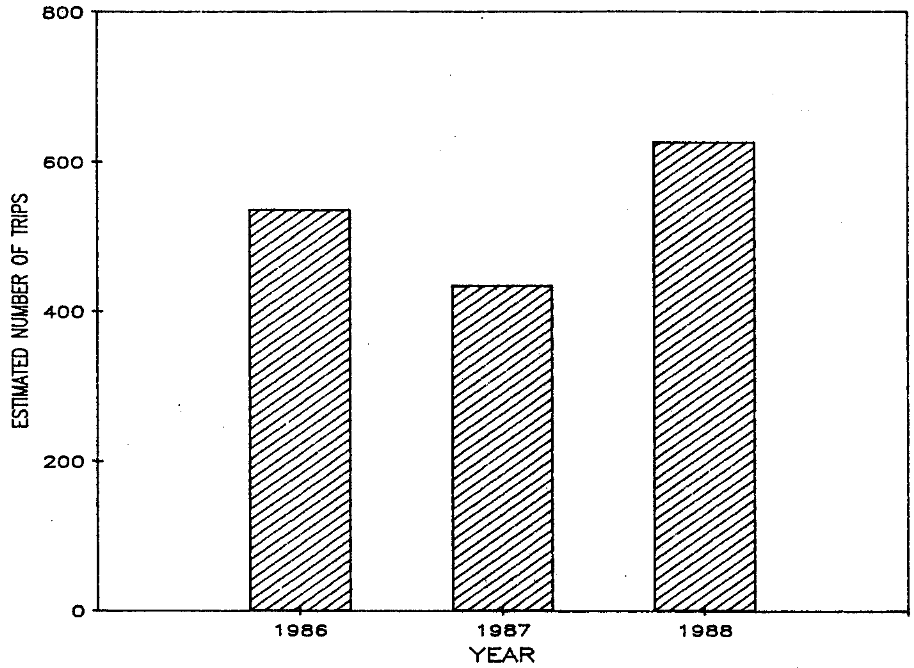

Figure 9.--Number of trips made by the Hawaiian longline fleet, 1986-88.

Fishing effort in 1986-88 had a distinct seasonal pattern (Fig. 10). Effort usually was at its lowest point in summer and early fall before peaking in winter and spring.

During summer and early fall in 1986-87, a large segment of the tuna longline fleet exited the fishery to bottom fish or to complete annual vessel maintenance and gear repair. Good catch rates and ex-vessel prices of the 1987 winter season prompted more vessels to enter the fishery in 1988. Many of these new vessels entered during summer. Fishing during the off-season allowed the new entrants the opportunity to familiarize themselves with new equipment and methods. The result was that effort, in terms of number of vessels and trips, did not decrease as substantially in the 1988 off-season. Many of the new entrants made shorter trips and fished fewer days than the more experienced fishermen. In 1988, the off-season movement out of the longline fishery and into other fisheries did not occur at the levels seen in the previous 2 years.

Reasons for decreasing effort during summer are both economic and fishery related. Increased activity by recreational fishermen, both charter and private, and the ika-shibi and palu-ahi (traditional Hawaiian tuna handline technique) commercial fisheries, target yellowfin tuna, which are more abundant in summer. Increased landings of pelagic fish from these fisheries during summer contribute to the decline in the average wholesale price of tunas. In addition, pole-and-line landings of skipjack tuna are greatest during the summer months (Pooley et al. 1988). When skipjack and yellowfin tunas are abundant and prices are cheap, many consumers are willing to substitute them in place of bigeye tuna (Pooley manuscr. in prep.). Furthermore, the abundance of bigeye tuna in the vicinity of the Hawaiian Islands is relatively low during the summer (Otsu 1954; Shomura 1959; Hida 1966). Thus, many tuna longline vessels may seek alternative

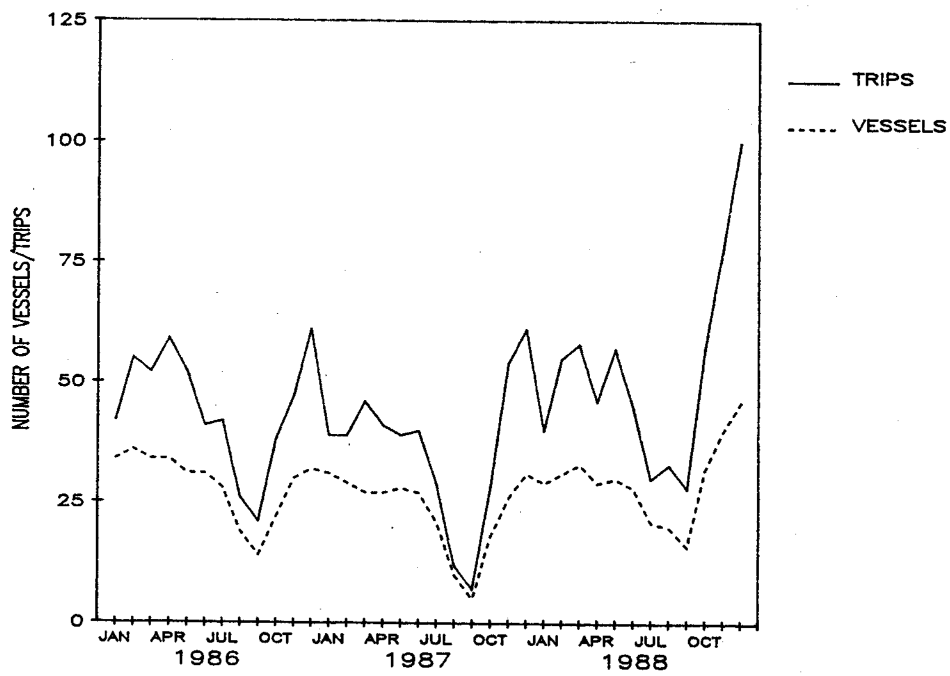

Figure 10.--Seasonality of longline activity, 1986-88.

sources of revenue from other fisheries or forgo fishing during the summer to prepare for periods when effort is more rewarding.

The increased fishing effort in the winter and spring seasons also is economic and fishery related. Greatly increased demand for tuna primarily as "sashimi" during the holiday season is coupled with the seasonal abundance of bigeye tuna. These two factors provide incentive for the longline fleet, and as a result, vessel participation, number of trips, and trip frequency are highest during this period.

Trip Duration

Data on trip length and number of days fished are critical for describing operations and fleet performance. Trip information coupled with vessel gear information can yield a more accurate assessment of catch per unit effort (CPUE), usually expressed as pounds or number of fish per 100 or 1,000 hooks. Estimating average trip duration is difficult because of the lack of comprehensive data reporting. Information has been supplied to NMFS on a voluntary basis and collected opportunistically at dockside only since late 1988. At present, fishermen may mention total trip length, number of fishing days or sets (one set equals 1 day of fishing), and number of hooks per set.

A review of the data collected thus far indicates that, during the last 4 months of 1988, average trip duration was 10 days with 8 days fished per trip (*N* = 34 trips out of an estimated total of 275, with information from 21 different vessels). These data should be viewed with caution because of the sample size and skew toward vessels fishing with monofilament gear (48% of the sample came from monofilament vessels). During the sample period, many vessels were novices with the monofilament system; therefore, mechanical and operational problems were common.

Area of Fishing

Historical data show that while vessels had the capacity to venture far offshore, they seldom fished >20 miles from land (June 1950). Some Honolulu vessels did travel 150-200 miles in quest for fish and ranged from the waters off Hilo and Kona to Kauai and Niihau (Otsu 1954) (Fig. 11). Trips of 100-400 miles south of the islands increased during the 1960's (Hida 1966) and presently are occasionally reported to occur in excess of 800 miles from the main Hawaiian Islands.

In 1952, the area that received the most effort (37.1% of trips sampled) by Honolulu-based longline vessels was the Waianae coast of Oahu, followed by Maui (18.4%), Kauai-Niihau (16.6%), and Kahuku, Oahu (13.0%) (Otsu 1954). Shomura (1959) stated that during 1948-56 vessels that were 45 feet or less made 80% of their trips around Oahu, and of these, the leeward areas received the greater effort. The larger (>45 feet) vessels generally directed their fishing effort to the leeward side of the northern islands and the windward side of the southern islands. Effort changed to fishing mainly the windward sides of islands toward the end of the study period (Shomura 1959).

Presently, fishermen report that, although a substantial portion of their operations occur far offshore, during certain times of the year, fishing occurs in traditional inshore areas and remains productive. Current data (1987-88) on area of catch are unavailable because of incomplete and inconsistent reporting by fishermen.

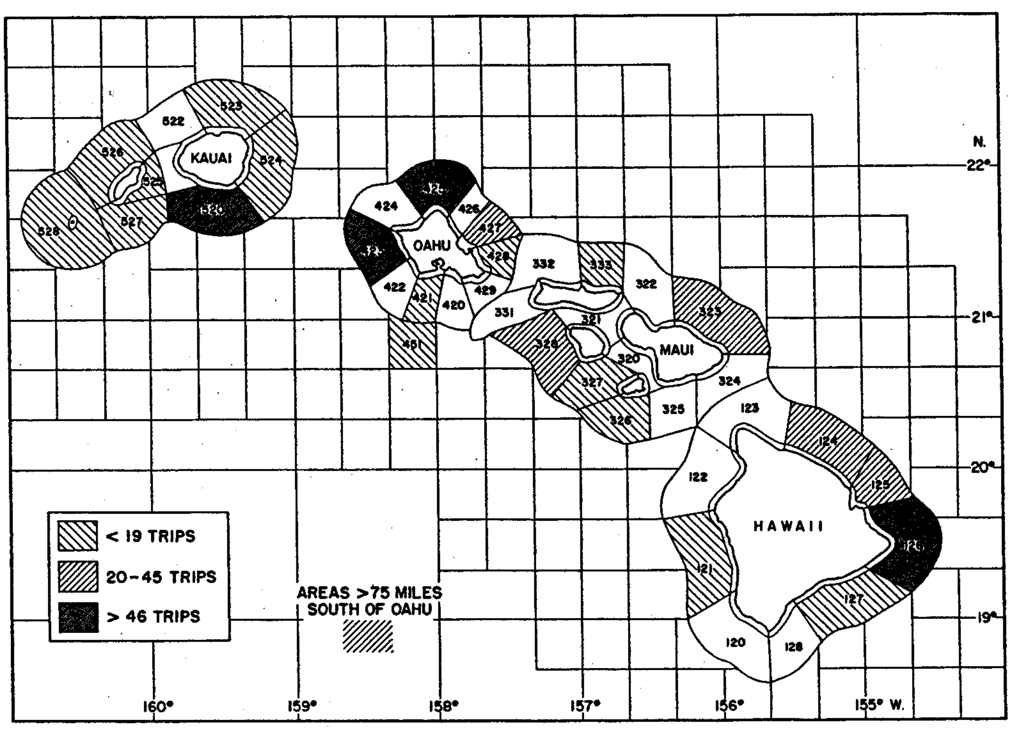

Figure 11.--Area of catch by Hawaii Division of Aquatic Resources statistical areas (adapted from Hida 1966).

LANDINGS

In terms of total landings (by weight), longlining ranked as the third largest fishery in Hawaii in 1987 (Pooley 1988). Longline-caught fish represented 24.8% of the total landings made by all commercial fisheries in Hawaii. Longliners caught a substantial proportion of bigeye tuna (90.6%) and billfishes (50.8%). Because of the confidential nature of the landings data, only indexed values are shown in this report (1987 = 1,000) (Fig. 12). The annual landings increased 68.2% from an index of 1,000 in 1987 to 1,682 in 1988. The increase in landings may be attributed to a number of factors, including an increase in the number of trips and vessels.

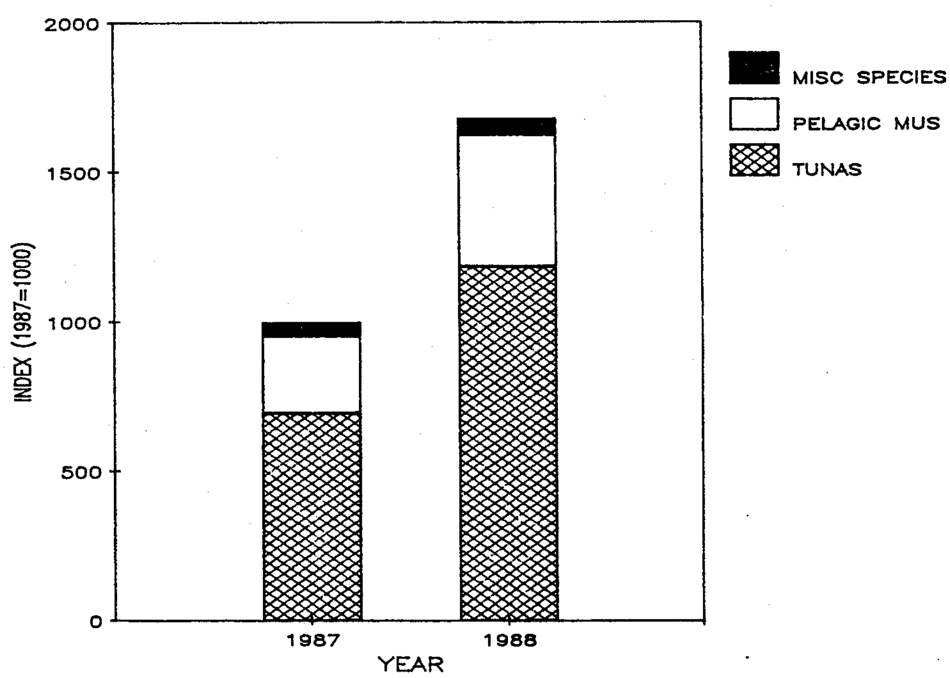

Figure 12.--Index of total landings by the Hawaiian longline fleet, 1987-88 (MUS = management unit species).

Species Composition

The species commonly landed by the tuna longline fleet are grouped into three major categories: 1) tunas, 2) pelagic management unit species (PMUS), and 3) miscellaneous species (Table 2). The PMUS are determined by the Pelagic Species Fishery Management Plan of the Western Pacific Regional Fishery Management Council (WPRFMC). These regulated species include all billfish, mahimahi (primarily *Coryphaena hippurus*), ono, and sharks.

Large bigeye and yellowfin tunas are the target species for the tuna longline fishery. Albacore and other tuna species are also landed but do not approach the weight or value of the larger bigeye and yellowfin tunas. Billfish, although not specifically targeted, are also landed in considerable quantities. The bulk of the billfish landings are composed of striped marlin, blue marlin, and shortbill spearfish. Other miscellaneous species make up a relatively small percentage of the landings.

Table 2.--Longline-caught species observed at the Honolulu market.

Common name	Scientific name
TUNAS	
Bigeye tuna	*Thunnus obesus*
Yellowfin tuna	*Thunnus albacares*
Albacore	*Thunnus alalunga*
Skipjack tuna	*Katsuwonus pelamis*
Kawakawa	*Euthynnus affinis*
PELAGIC MANAGEMENT UNIT SPECIES	
Striped marlin	*Tetrapturus audax*
Blue marlin	*Makaira mazara*
Shortbill spearfish	*Tetrapturus angustirostris*
Black marlin	*Makaira indica*
Sailfish	*Istiophorus platypterus*
Broadbill swordfish	*Xiphias gladius*
Pacific blue shark	*Prionace glauca*
Mako shark (short-finned)	*Isurus oxyrinchus*
Mako shark (long-finned)	*Isurus paucus*
Oceanic whitetip shark	*Carcharhinus longimanus*
Thresher shark	*Alopias vulpinus*
Tiger shark	*Galeocerdo cuvieri*
Shark (miscellaneous)	--
Mahimahi	*Coryphaena hippurus*
Small mahimahi	*Coryphaena equiselis*
Wahoo (also called ono)	*Acanthocybium solandri*
MISCELLANEOUS SPECIES	
Moonfish	*Lampris regis*
Great barracuda	*Sphyraena barracuda*
Miscellaneous	--

Catch Composition

The longline catch consisted mainly of tunas and billfishes with some incidental catches of other species. Tuna comprised about 70% of the total landings in 1987 and 1988. Although dominating the catch, bigeye tuna decreased from 46% of the total landings in 1987 to 41% of the total landings in 1988 (Fig. 13). Yellowfin tuna constituted the second highest proportion of the tunas caught, increasing from 15% of the landings in 1987 to 20% in 1988, and was followed by albacore, which made up 8.5% of the tunas caught in 1987 and 10% in 1988. Landings of other tuna species were negligible.

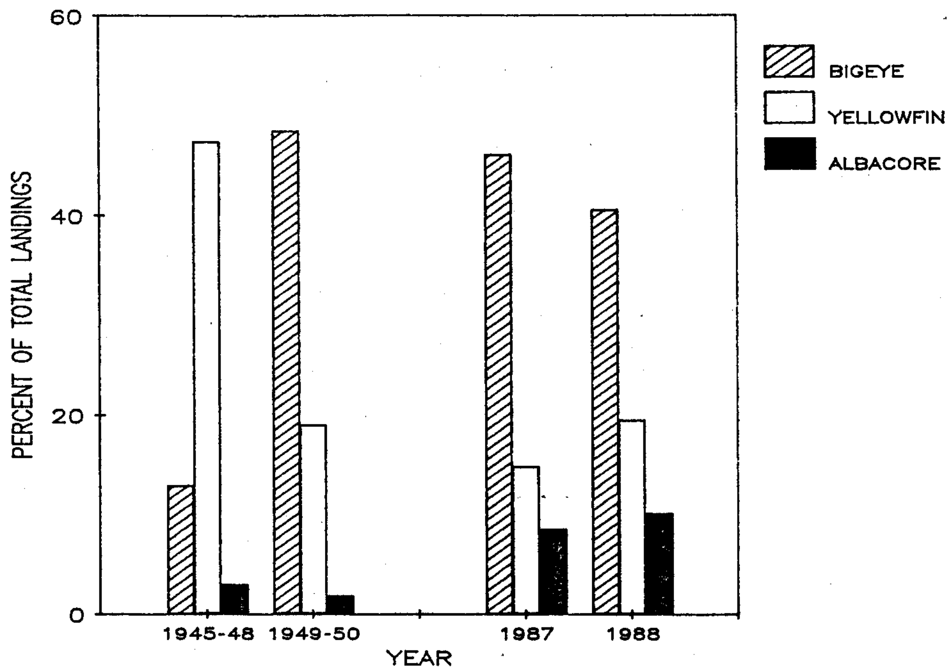

Figure 13.--Species composition of tunas 1945-50 and 1987-88 (1945-54 from Otsu 1954).

Like tunas, the proportion of PMUS landings changed little (25.8% in 1987 and 26.2% in 1988). Billfish comprised 22.1% of the landings in 1987 and 22.9% in 1988. The predominate species of billfish landed by longliners was striped marlin. Striped marlin made up 15.4% of the total landings in 1987 and 16.5% in 1988; blue marlin, 2.9 and 3.4%; and spearfish, 2.4 and 2.2% (Fig. 14).

Small catches of moonfish, pomfrets (Bramidae), barracuda, and other miscellaneous species made up 4.7% of the landings in 1987 and 3.3% in 1988. Published historical data give little detail on the composition of the miscellaneous species category. However, current data indicate the value has increased substantially for some of these species, e.g., pomfrets and moonfish, which are now marketed successfully.

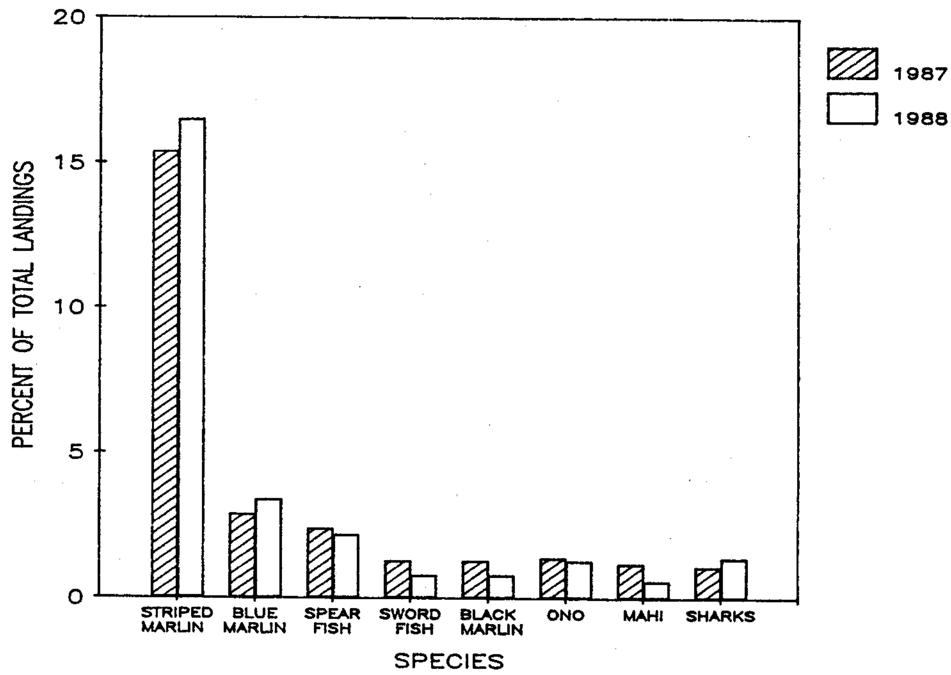

Figure 14.--Composition of pelagic management unit species landings, 1986-88.

The species composition of landings has changed during the history of the fishery. The post-World War II composition of landings changed from a preponderance of yellowfin tuna in 1945-48 (47.4% yellowfin tuna and 12.9% bigeye tuna) to bigeye tuna in 1949-52 (48.5% bigeye and 19.0% yellowfin) (Otsu 1954). During 1945-48 when landings were dominated by yellowfin tuna, billfish landings averaged 36.7% and constituted as much as 44.8% of the total landings (Otsu 1954). The billfish catch subsequently decreased to 30.5% in 1949-52 when landings were dominated by bigeye tuna. Yoshida (1974) reported that during 1964-67 the billfish landings comprised approximately 33% of the catch. Blue marlin dominated the billfish catch during 1952-61 but was displaced by striped marlin as the dominant billfish species landed thereafter.

Seasonality

The seasonality of landings is dependent on environmental, biological, and operational factors. Many of the factors are interrelated, such as fishing effort and methods, seasonality of target species, relative abundance, value of the catch, and weather conditions.

Indexed monthly landings varied widely in 1987-88 (January 1987 = 100) (Fig. 15). The landings for both years generally did not fluctuate greatly in January-June but declined to a low level during July-September, before rapidly increasing in October-December and peaking in December of both years when demand was highest. The 1987 index of landings ranged from 8.4 in September to 258.5 in December; the 1988 index of landings ranged from 79.8 in July to 388.0 in December. In 1988, summer landings did not decline as drastically as in 1987 because of the number of new entrants that participated in the fishery during the time period when activity in the longline fishery is usually low.

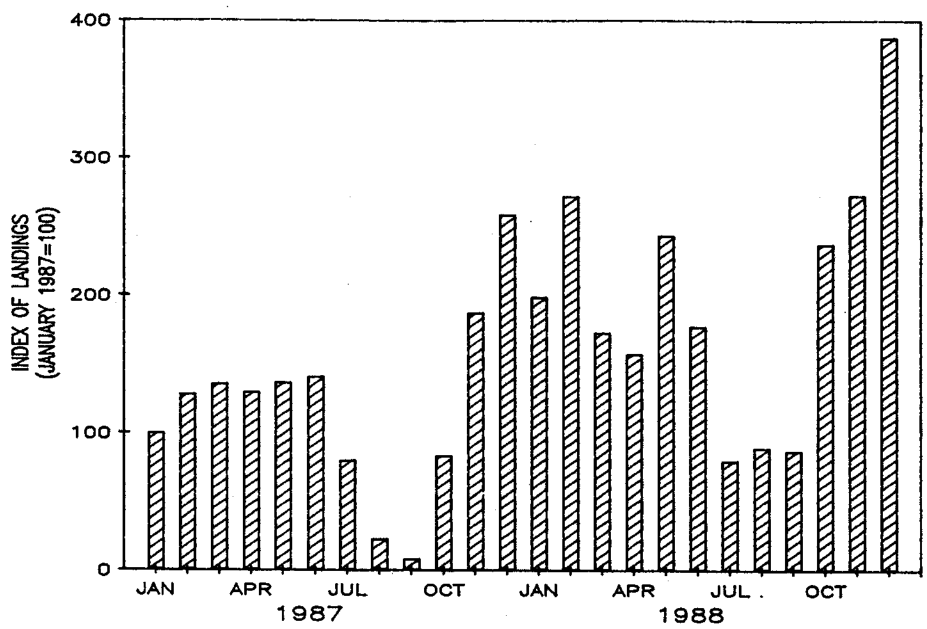

Figure 15.--Index of monthly total landings, 1987-88.

Monthly composition of the tuna landings had multiple peaks caused by the inclusion of individual species with differing seasonality. The 1987 and 1988 landings of bigeye tuna were highest during spring and winter and were lowest during summer (Fig. 16a). Monthly bigeye tuna ranged from 39.7 to 66.6% of the total landings during the peak seasons to 12.8 to 25.4% during the off-seasons. The proportion of yellowfin tuna was highest in summer, reaching highs of 28.2% in 1987 and 41.1% in 1988. Albacore landings peaked during summer of 1987 and 1988 and was the most dominant species landed in July 1987 (26.7%) and May 1988 (32.2%) (Fig. 16b).

Comparisons with historical data show similarities in the seasonal abundance of tunas. Bigeye tuna are abundant in winter and spring, yellowfin tuna are abundant during summer (Otsu 1954; Shomura 1959; Hida 1966; Yoshida 1974), and albacore are abundant from June to October (Otsu and Sumida 1970).

The catch composition of PMUS (Fig. 17) in the spring, fall, and winter followed patterns set by striped marlin, which dominated the landings. Landings of striped marlin peaked in October 1987 (33.2%) and in May 1988 (31.4%). Summer landings were dominated by blue marlin. Blue marlin peaked in September 1987 (12.5%) and July 1988 (11.4%). Blue marlin landings were lowest in February of both years. Landings of shortbill spearfish had a seasonal pattern, but it was not as apparent as those of striped marlin and blue marlin. Shortbill spearfish landings were greatest in spring and winter (Fig. 16b).

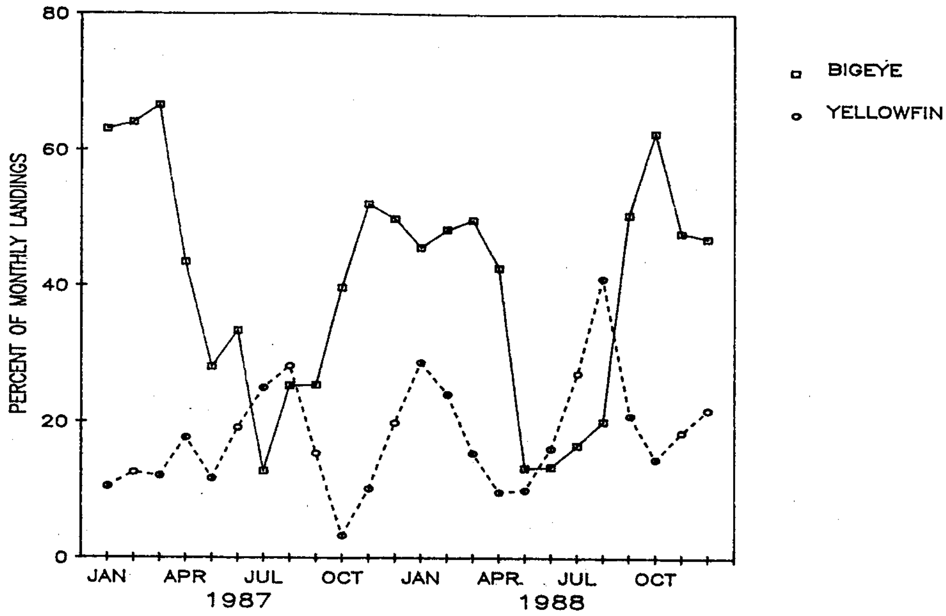

Figure 16a.--Percentage of bigeye and yellowfin tunas in the total monthly tuna landings, 1987-88.

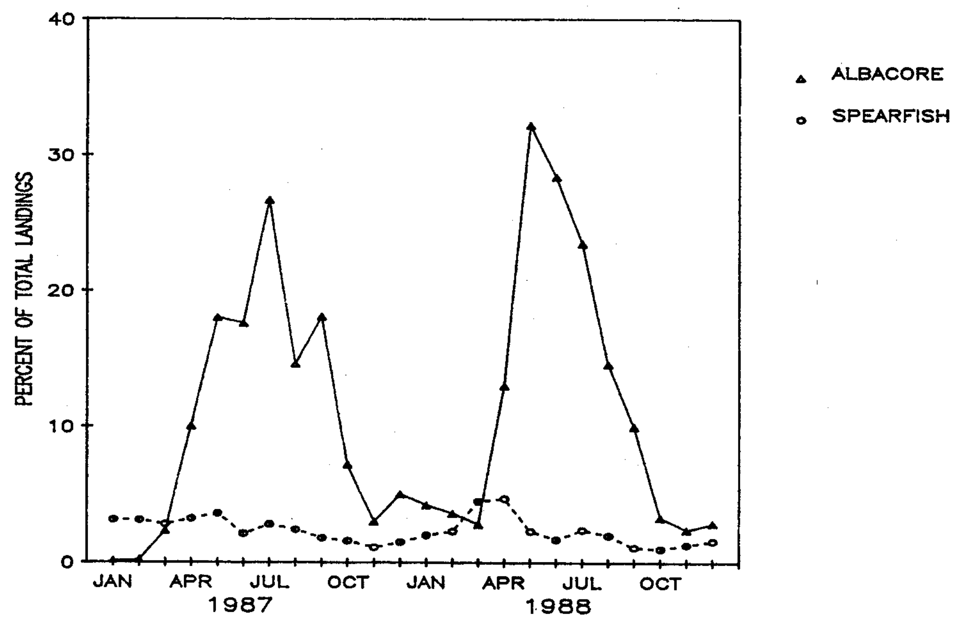

Figure 16b.--Percentage of albacore and shortbill spearfish in the monthly landings, 1987-88.

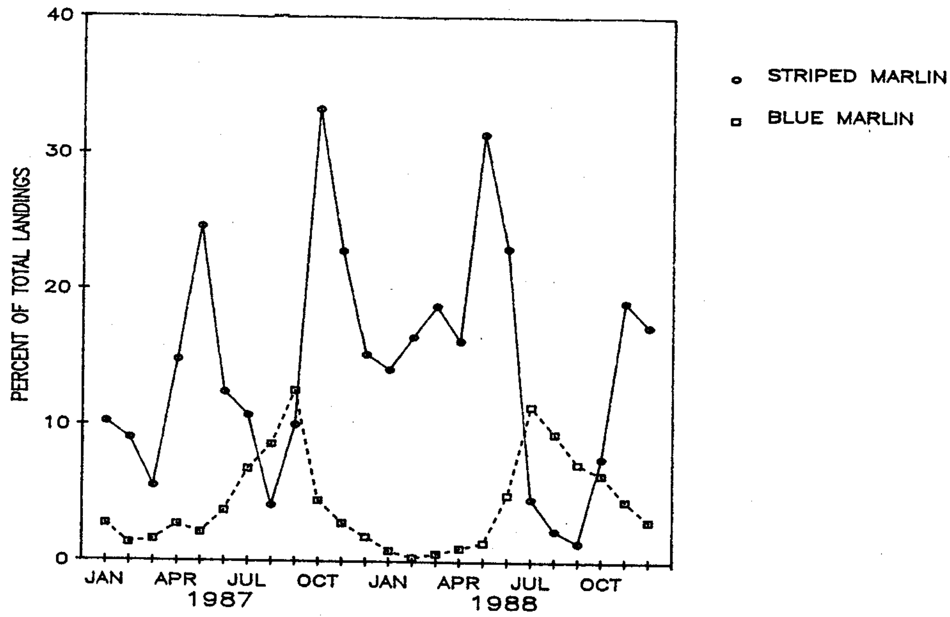

Figure 17.--Percentage of blue and striped marlin in the monthly landings, 1987-88.

CATCH AND EFFORT

The data presently collected on the number of hooks per set and the number of days of fishing effort have been insufficient for any accurate estimates. The only measurement of catch and effort available was average catch per trip. There are obvious shortcomings in using trips as a unit of effort due to the variations in vessel sizes, number of days fished or sets per trip, and number of hooks set per day fished. However, crude estimates of relative CPUE were produced by dividing the total landings in a particular year or month by the total number of trips. Data on catch per trip were available only for 1987 and 1988. The annual catch per trip increased 16.8% from an indexed value of 1,000 in 1987 to 1,167.5 in 1988 (Fig. 18).

Monthly catch per trip exhibited patterns essentially similar to those for monthly landings but with less dramatic variation (Fig. 19). The CPUE decreased during July-September 1987. Monthly landings fluctuated considerably because of the number of trips and catch per trip varied less and gave an indication of the performance of the average vessel. The indexed average catch per trip (index set to 100 for January 1987) ranged from 47.1 in September to 165.3 in December 1987. The indexed catch per trip in 1988 ranged from 103.7 in July to 193.7 in January.

SIZE OF FISH

The mean weights of tunas and PMUS caught by longliners in Hawaii during 1987-88 appears to be generally smaller than average weights reported during the immediate post-war period (1949-52), as well as those reported during an interim sampling period (1965-77) (Fig. 20).

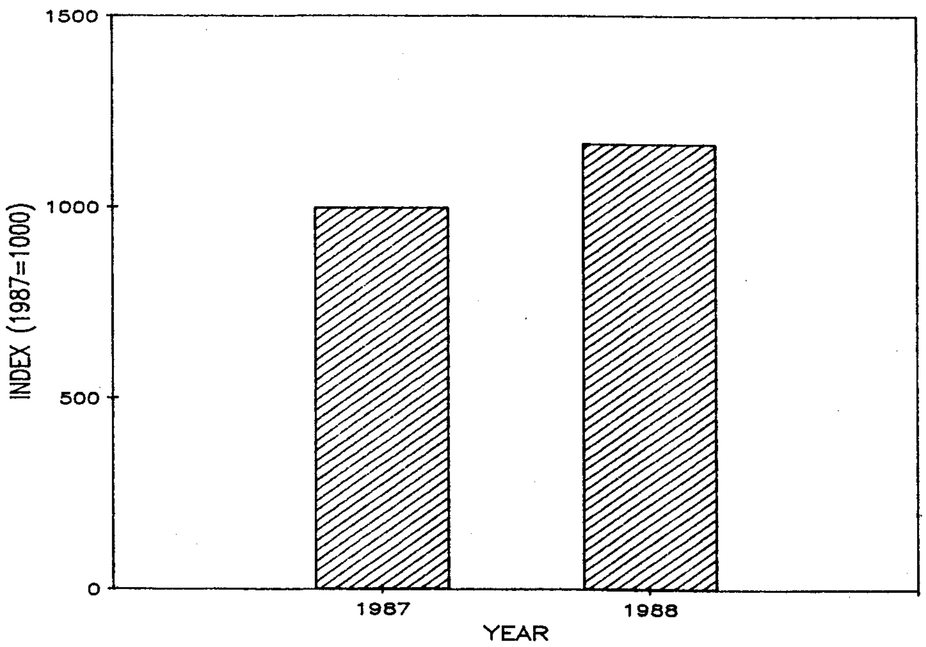

Figure 18.--Indexed average catch per trip, 1987-88.

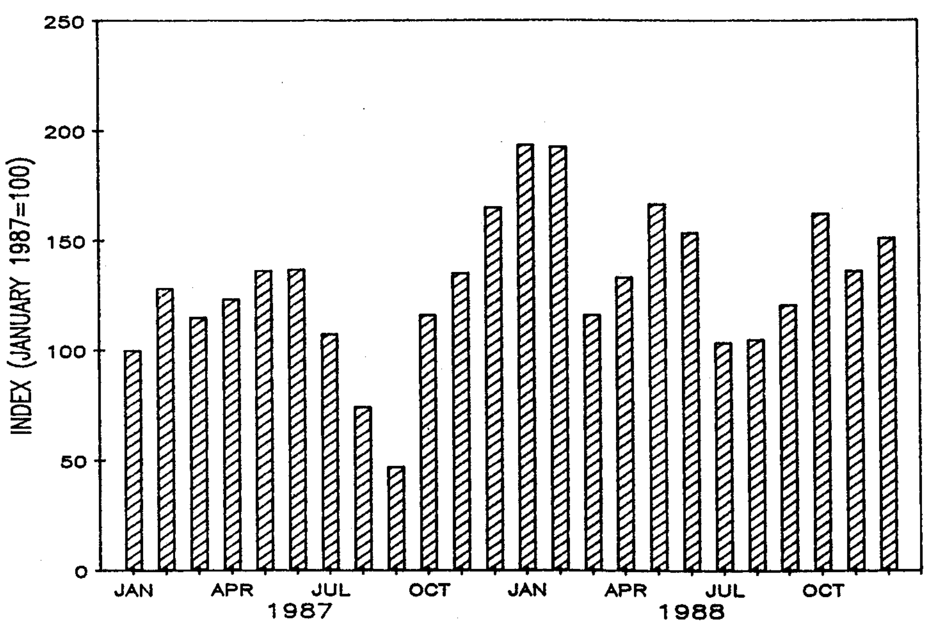

Figure 19.--Index of monthly average catch per trip, 1987-88.

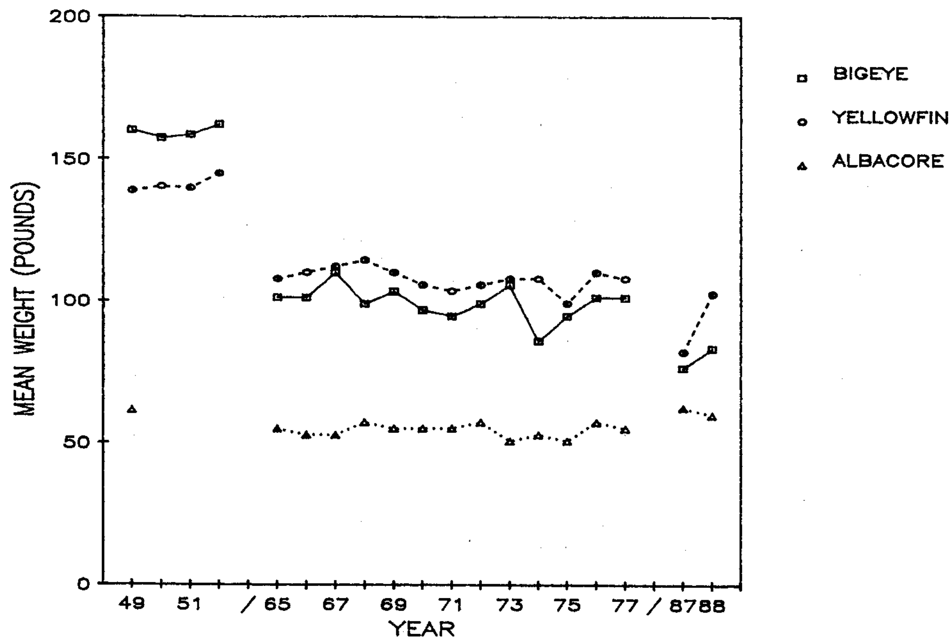

Figure 20.--Mean weights of tunas in various years in 1949-88 (1949-52 from Otsu (1954) and June (1950), and 1966-77 from Yong and Wetherall (1980)).

Bigeye and yellowfin tunas show a clear trend of decline in mean weights from the post-war period to the present while albacore remained stable. Bigeye tuna had a mean weight of 76.3 pounds in 1987 and 83.2 pounds in 1988. Otsu (1954) reported mean weights of 157.3 pounds (in 1950) and 162.1 pounds (1952), whereas Yong and Wetherall (1980) reported average weights for bigeye tuna ranged between 85.8 and 118.8 pounds during 1965-77. The mean weight of yellowfin tuna varied substantially during 1987 and 1988 (82.0 versus 102.5 pounds); however, the same trend seen for bigeye tuna is also apparent. The mean weight reported by Otsu (1954) was 144.8 pounds (1952) and ranged between 99.0 and 114.4 pounds for yellowfin tuna during 1965-77 (Yong and Wetherall 1980). Albacore mean weight was relatively stable in recent years (1987, $\bar{x} = 62.3$ pounds; 1988, $\bar{x} = 59.7$ pounds) and over the long term. June (1950) reported a mean weight of 61.3 pounds for 1949, whereas Yong and Wetherall (1980) reported 50.6-57.2 pounds for 1965-77.

The major PMUS landings are predominantly of billfish. The two major billfish species mean weight mimic those of bigeye and yellowfin tunas. Striped marlin had a mean weight of 66.2 pounds in 1987 and 56.9 pounds in 1988. June (1950) reported a mean weight of 77.3 pounds in 1949, and Yong and Wetherall (1980) reported 55-70.4 pounds for 1965-77. Blue marlin had a mean weight of 161.4 pounds in 1987 pounds and 157.3 pounds in 1988. June (1950) reported a mean weight of 326.6 pounds (in 1949), and Yong and Wetherall (1980) reported 145.2-253 pounds for 1965-77. The mean weight of shortbill spearfish has changed little over the years (37.1 pounds in 1949, 33.6 pounds in 1987, and 31.0 pounds in 1988).

Weight-Frequency Distribution

Studies correlating weight frequency and growth have been done for bigeye tuna (Iverson 1955) and yellowfin tuna (Moore 1951). Weight-frequency distribution in this report was examined by major fish species grouped into 5-pound weight classes, e.g., 0-5, 6-10, and 11-15 pounds. The weight-frequency histograms show the intensity and progression of modal peaks of important tuna and billfish species landed by longliners. Few extremely large fish of several species were encountered. The extra large fish were included in the data but excluded from the histograms.

Quarterly histograms for species in which modal groups appeared to progress or had distinct seasonality by size were bigeye tuna, yellowfin tuna, striped marlin, and blue marlin. Annual histograms were included for bigeye tuna, yellowfin tuna, striped marlin, and blue marlin, as well as species for which no patterns were apparent or the sample sizes were too small for quarterly examination (albacore and shortbill spearfish).

The weight-frequency distribution of bigeye tuna was predominantly bimodal (Fig. 21). The 1987 first quarter histogram shows a dominant mode in the 56-60 pound weight class. The dominant mode shifts one weight class larger in the following quarter. In the third quarter of 1987, it is replaced by a dominant mode of smaller fish (26-30 pounds). This dominant mode of smaller fish also progresses to larger size classes at a rate of 1-3 size classes between quarters until the third quarter of 1988 when the dominant mode returned to the same level as that of the third quarter of 1987. Weight frequencies of bigeye tuna landed at the Honolulu market displayed unimodal and bimodal distributions in 1948-54 (Iverson 1955). Historical data show a preponderance of a much larger size class of fish in comparison to our 1987-88 data.

Yellowfin tuna also exhibited bimodal weight-frequency distributions (Fig. 22). The dominant modal peaks shift about two to three weight classes larger each quarter (with the exception of the third and fourth quarter of 1987 when the modal value for the smaller weight class of yellowfin tuna jumped seven-weight classes). In the second half of 1988, there was little representation of the smaller weight classes with weakly defined modal peaks.

Annual weight-frequency distribution, like the mean weight of bigeye and yellowfin tunas, also showed that smaller fish were caught in 1987-88 than in the postwar years. The annual weight-frequency distribution for bigeye tuna in 1987 showed a dominant mode in the 41-45 pound weight class. Two distinct modes (36-40 and 86-90 pound weight classes) were apparent for bigeye tuna in 1988 (Fig. 23). In comparison, weight frequencies for 1949-54 (Iverson 1955) also showed both uni- and bimodal frequencies but only for weight classes that were twice as large.

Yellowfin tuna showed two dominant modes in 1987 (31-35 and 81-85 pound weight classes) and appeared to have three modes (51-55, 86-90, and 116-120 pound weight classes) in 1988, the most dominant mode being the 86-90 pound weight class (Fig. 24). During 1948-49, the modal sizes for yellowfin tuna were 110-119 and 150-159 pounds (Moore 1951). Otsu (1954) further reported that, for 1949-52, the 150-159 pound group constituted about 60% of the total and less than 5% of the catch was made up of fish weighing 100 pounds.

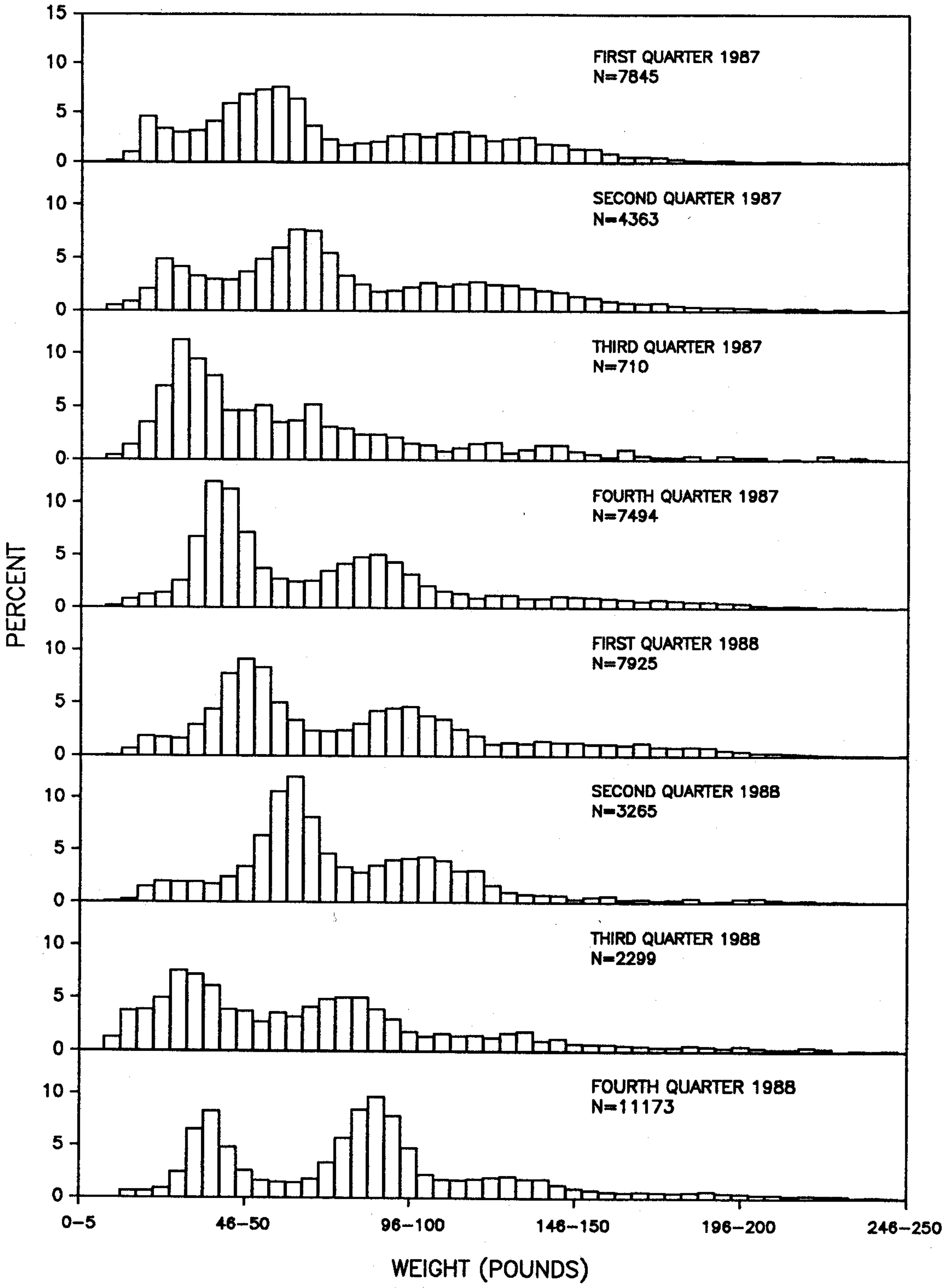

Figure 21.--Quarterly weight-frequency distribution of bigeye tuna captured by the tuna longline fleet in Hawaii, 1987-88.

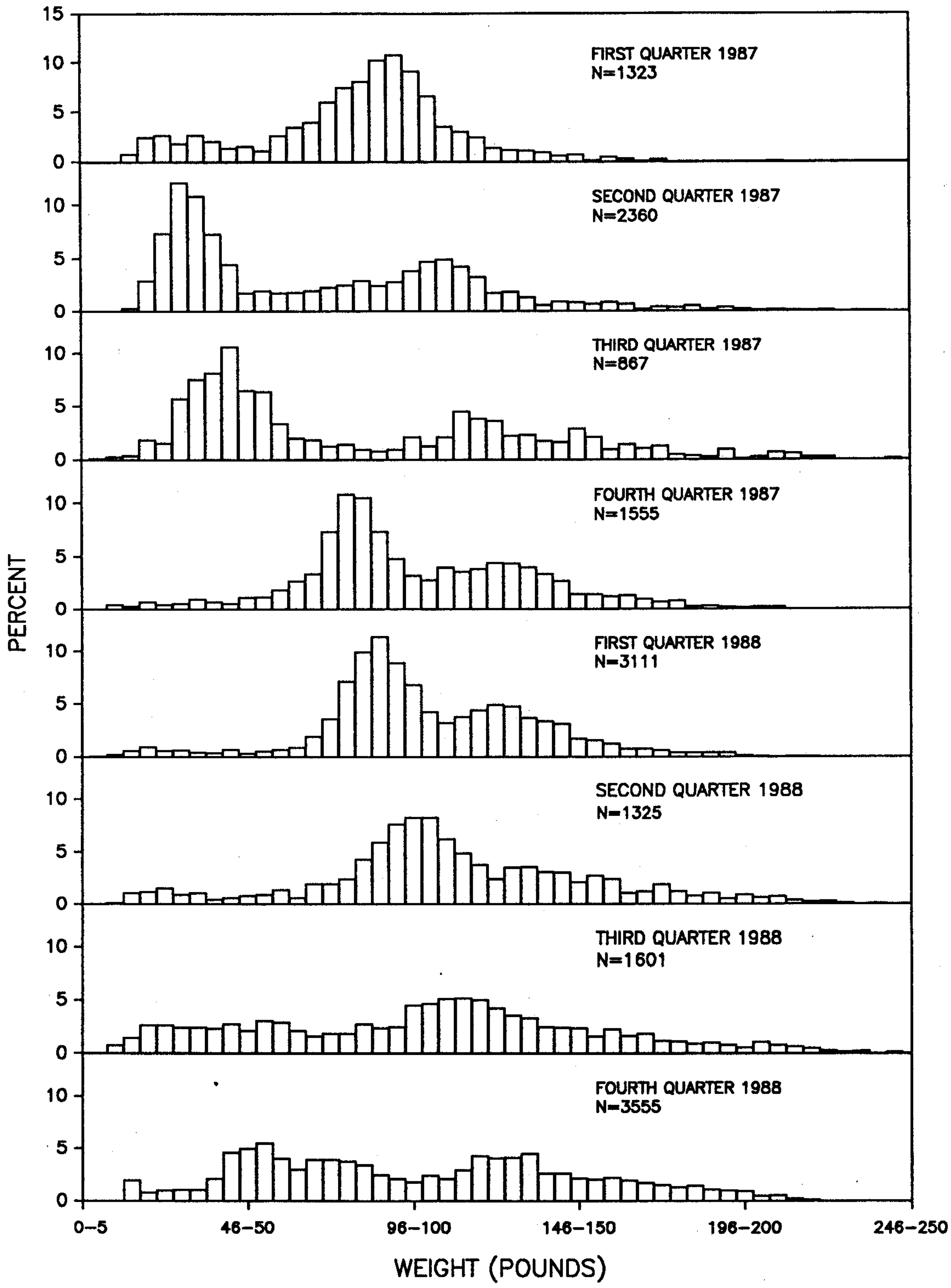

Figure 22.--Quarterly weight-frequency distribution of yellowfin tuna captured by the tuna longline fleet in Hawaii, 1987-88.

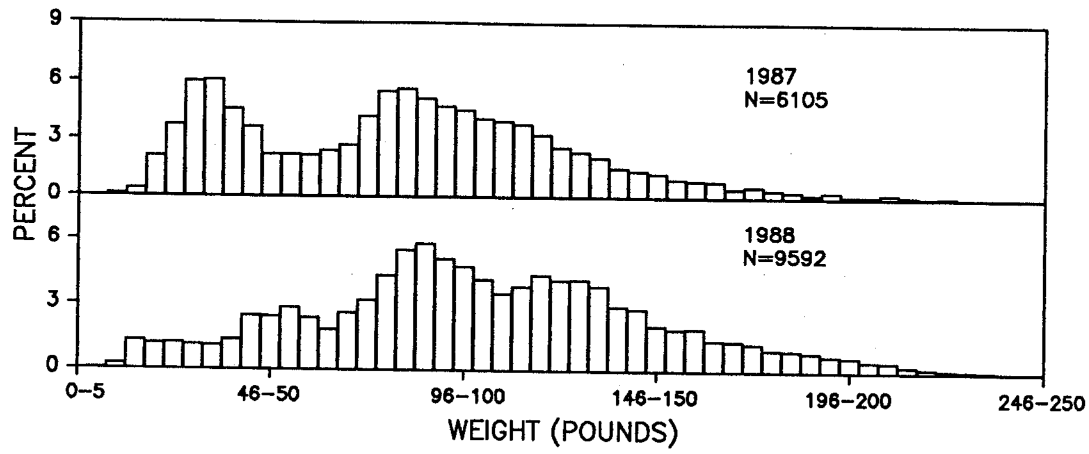

Figure 23.--Annual size-frequency histograms for bigeye tuna, 1987-88.

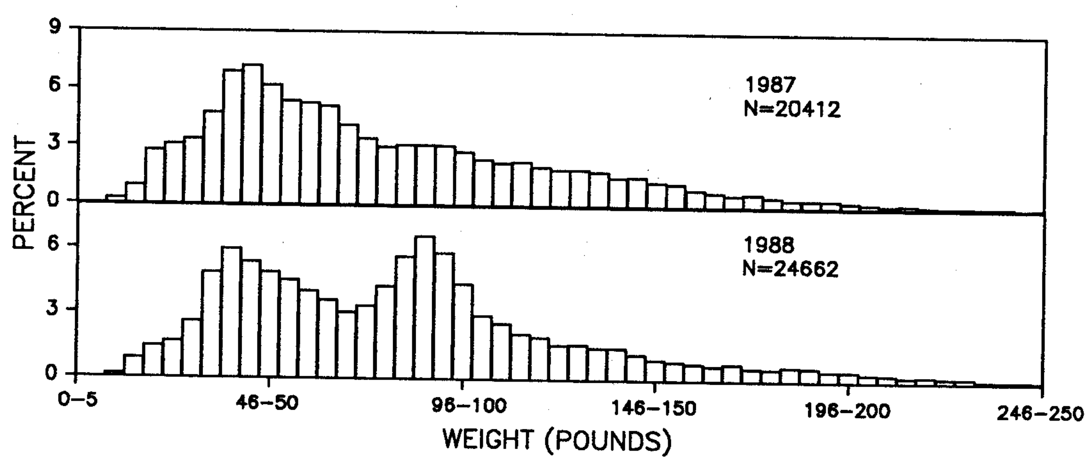

Figure 24.--Annual size-frequency histograms for yellowfin tuna, 1987-88.

There was no pattern in the quarterly weight-frequency distribution for albacore. The annual weight-frequency distribution was unimodal with a strong 46-50 pound class in 1987 and a more evenly distributed histogram, primarily above the 51-55 pound mode, in 1988 (Fig. 25).

The weight frequency of striped marlin for 1987-88, with the exception of the third quarter, showed a bimodal distribution throughout the year (Fig. 26). The modal peaks generally shifted two to three size classes larger each quarter. The dominant mode of 36-40 pound striped marlin in the first quarter of 1987 continued increasing through the third quarter of 1988. Another dominant mode of 31-35 pound fish appeared in the third quarter of 1987 but did not progress. A mode of 21-25 pound fish in the fourth quarter of 1987 began another series of increasing modal values through the fourth quarter of 1988. The dominant mode of the fourth quarter of 1988 was another mode of small marlin (26-30 pounds) that may signal the start of another progression.

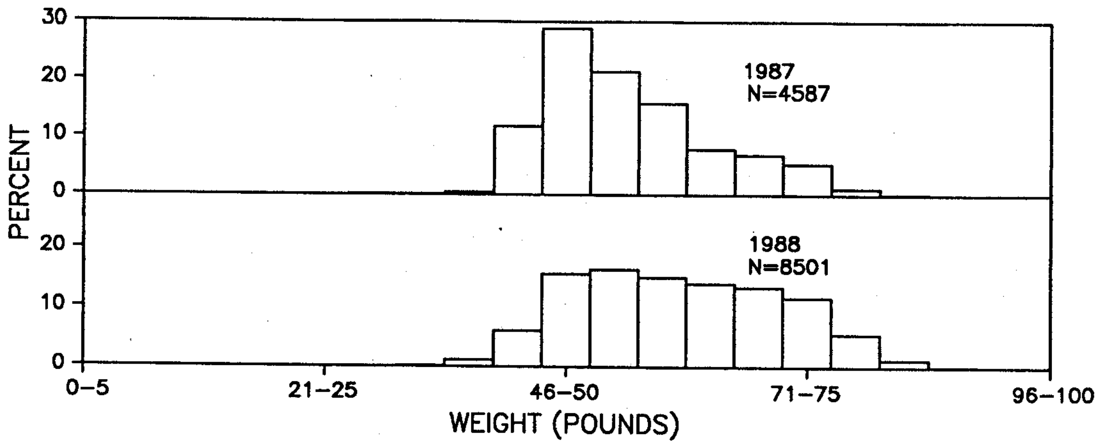

Figure 25.--Annual size-frequency histograms for albacore, 1987-88.

Composite histograms for 1961-70 (Yoshida 1974) showed a stronger representation of larger fish compared with 1987-88. This contrast was especially evident in the third quarter of both 1987 and 1988. The other quarters of 1987-88 showed bimodal distributions with similar modal frequencies as those described by Yoshida (1974).

Data for the quarterly histograms for blue marlin in 1987-88 were minimal in some quarters because of the seasonal nature of the landings (Fig. 27). The 1987-88 weight-frequency histograms were very similar, with a mode at 95-115 pounds.

The weight-frequency disribution of striped marlin for 1987 was evenly distributed, with weak modes in the 36-40 pound and 71-75 pound weight classes (Fig. 28). Two definite modes were present in 1988, a dominant mode at 26-30 pounds and a weaker mode at 66-70 pounds.

Annual weight-frequency for blue marlin showed scattered peaks, but distribution was toward smaller fish (Fig. 29). The modes were in the 101-105 pound class in 1987 and the 111-115 pound class in 1988.

Because the weight-frequency distribution of shortbill spearfish did not vary substantially throughout the year, only annual histograms are included (Fig. 30). The 1987 and 1988 histograms for shortbill spearfish are quite similar in appearance; most of the fish were in the 31-35 and 26-30 pound weight classes, respectively.

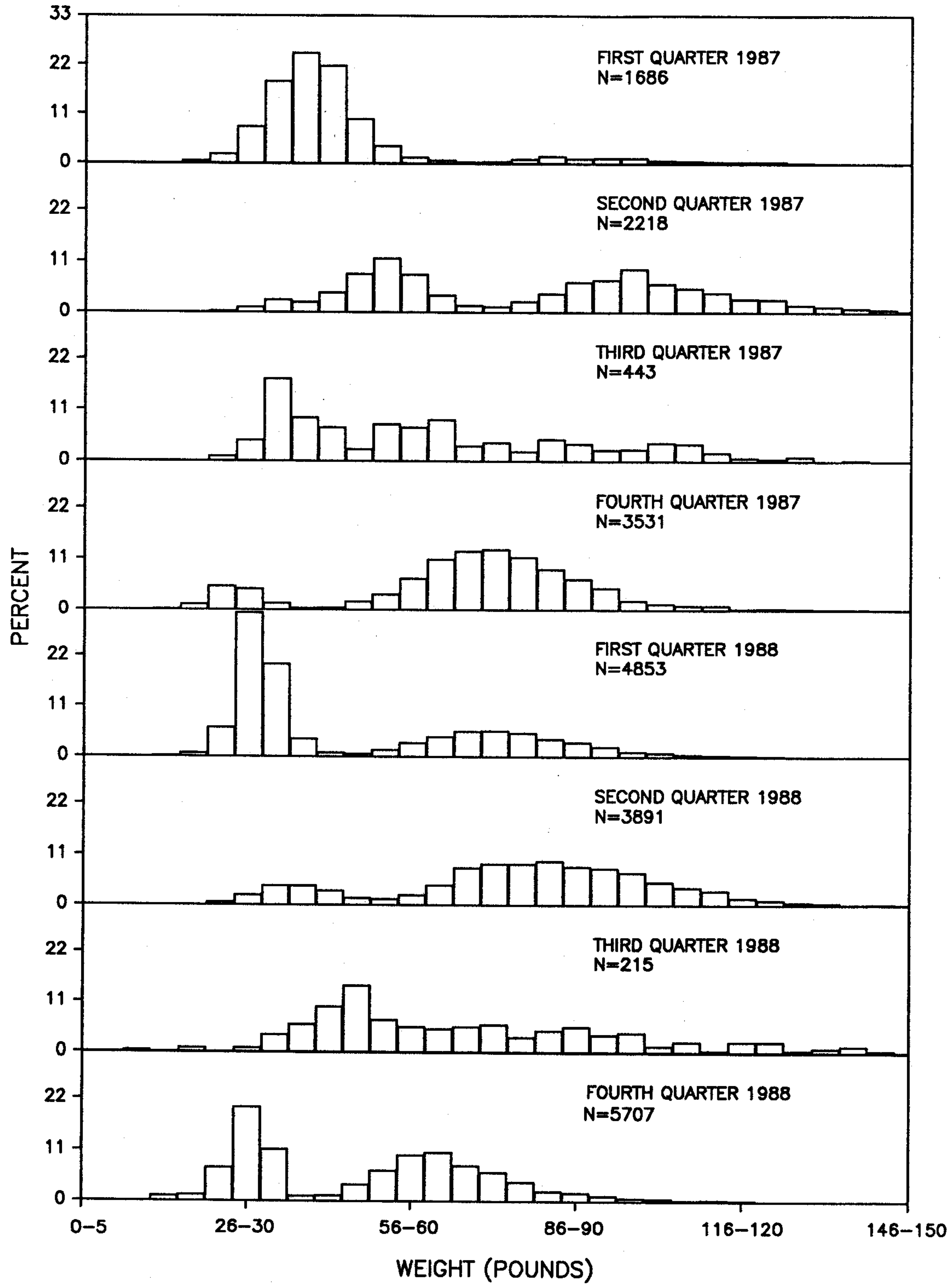

Figure 26.--Quarterly weight-frequency distribution of striped marlin captured by the tuna longline fleet in Hawaii, 1987-88.

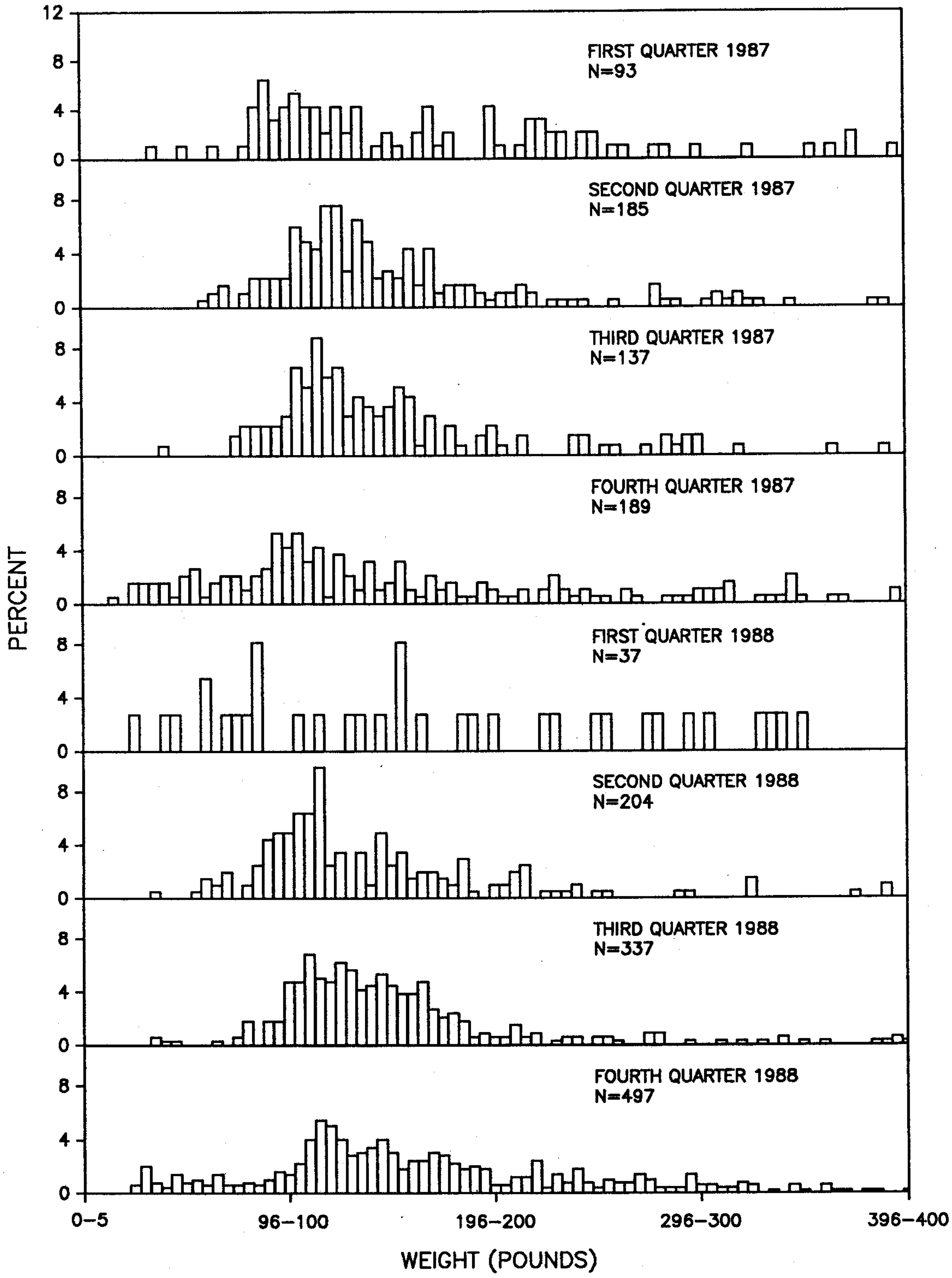

Figure 27.--Quarterly weight-frequency distribution of blue marlin captured by the tuna longline fleet in Hawaii, 1987-88.

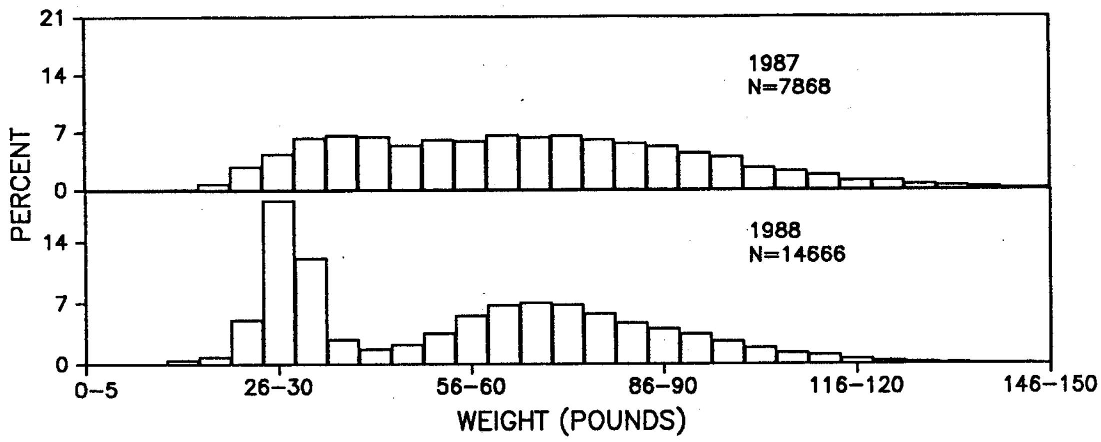

Figure 28.--Annual weight-frequency histograms for striped marlin, 1987-88.

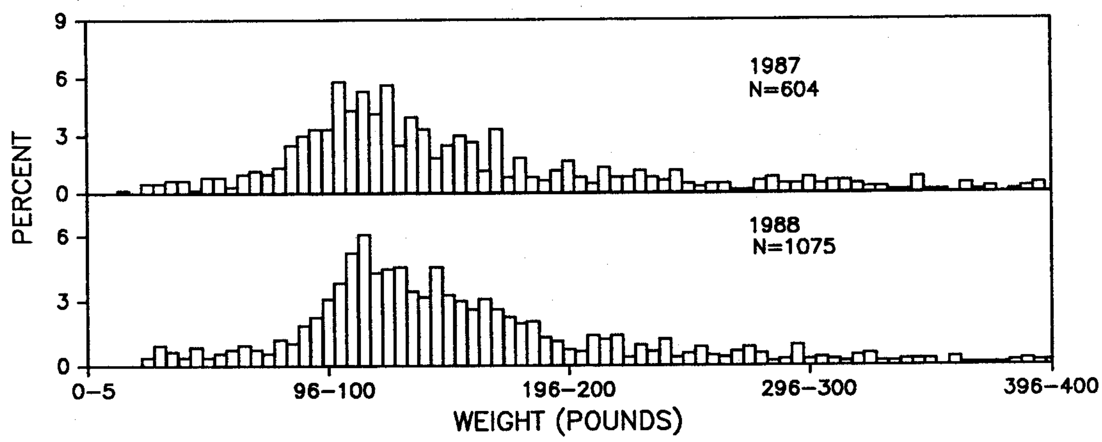

Figure 29.--Annual weight-frequency histograms for blue marlin, 1987-88.

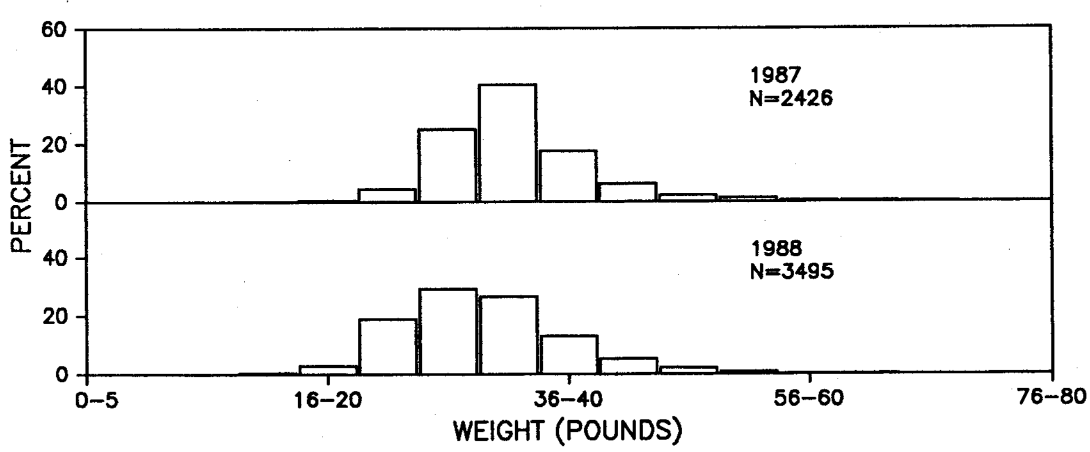

Figure 30.--Annual weight-frequency histograms for spearfish, 1987-88.

DATA

Fishermen are required by law to submit the State of Hawaii's flag-line catch report, which asks for the specific location of the catch, the number of days fished, and the amount of effort expended. At this time, a number of reports are not completed properly or not submitted by many longline fishermen. The present lack of compliance and lack of enforcement of the data submission regulations are major obstacles to comprehensive data collection. Data on fishing effort by number of hooks per set, number of days fished, and general catch location are collected on a voluntary and confidential basis by the NMFS. Data collected daily at the fish market were vessel, species, number of pieces, weight, price, and buyer as well as other information gathered through conversations with vessel captains. Length measurements (fork length) and sex data were not collected because of time and personnel limitations and to avoid interference with auction procedures.

Prior to 1988, most longline-caught fish were delivered whole (in the round). The advent of new export markets in the late 1980's for quality fish, mainly tunas, led to a growing concern for improving the quality of the catch. The higher relative prices received for the fish destined for export induced fishermen to employ techniques to improve quality and extend shelf life. Consequently, longline fishermen increased their onboard processing of some tunas through the use of the Taniguchi tool to destroy the central nervous system of fish, different bleeding techniques, gilling and gutting, and heading and gutting. As the proportion of these processed fish increased, compensation for the processed weight became necessary for comparative and management purposes. Conversion of processed fish weights for a variety of the commercially significant species to round, whole weights was initiated in June 1988.

SUMMARY

Total vessel participation in the Hawaiian tuna longline fleet was 39 in 1986, 37 in 1987, and 50 in 1988. The annual number of trips decreased (18%) from 537 in 1986 to 435 trips in 1987 and increased dramatically (44%) to 627 trips in 1988. Vessel participation and trip frequency in the fishery were seasonal during the past 3 years. The lowest activity occurred during the third quarter but was followed in the fourth quarter by the period of highest activity.

The annual fleet landings increased 68.2% from 1987 to 1988 while the annual average catch per trip increased 16.8%. Tuna constituted 69.5% of the total landings by weight in 1987 and 70.4% in 1988. The PMUS landings were nearly static, comprising 25.8% of the total landings by weight in 1987 and 26.2% in 1988. The combined billfish landings for the 2 years were 22.1 and 22.9%, respectively.

Percentages of the major species landed are as follows. Bigeye tuna, which dominated all species in the catch, decreased from 46.1% in 1987 to 40.6% in 1988. Yellowfin tuna, second in catch, increased from 14.8% in

1987 to 19.5% in 1988, followed by albacore, which made up 8.5% in 1987 and 10.1% in 1988. Landings of other tuna species were negligible. Among the PMUS, striped marlin (15.4% in 1987, 16.5% in 1988), blue marlin (2.9% in 1987, 3.4% in 1988), and shortbill spearfish (2.4% in 1987, 2.2% in 1988) were the most abundant species by weight. Although the weights of the major species landed increased from 1987 to 1988, comparisons with historical data indicated that mean weights and size frequencies have noticeably diminished.

ACKNOWLEDGMENTS

Many thanks are extended to the individuals who helped with the data collection. Special thanks to the United Fishing Agency, Ltd. and staff for their permission to conduct monitoring activities and their patience and help over the many years of data collection. The authors appreciate the help and guidance of Ray F. Sumida. Also, thanks to the data support specialists of the Honolulu Laboratory, especially Ann Todoki and Richard Uyeda. We would like to thank Christofer H. Boggs and Samuel G. Pooley for critically reviewing this paper.

REFERENCES

Hida, T. S.
1966. Catches of bigeye and yellowfin tunas in the Hawaiian longline fishery. In T. A. Manar (editor), Proceedings, Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, Honolulu, p. 161-167.

Honda, V. A.
1984. An updated description of the Hawaiian tuna longline fishery. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., Honolulu, HI 96822-2396 (unpub. rep.), 28 p.

Iverson, E. S.
1955. Size frequencies and growth of central and western Pacific bigeye tuna. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 162, 40 p.

June, F. C.
1950. Preliminary fisheries survey of the Hawaiian-Line Islands area. Commer. Fish. Rev. 12(1):1-23.

Kanayama, R. K.
1970. Kilauea: Hawaii's first modern tuna boat. Hawaii Aloha Aina. Dep. Land Nat. Resour., State of Hawaii 1(3):3-5.

Lyman, A. L. and Hawaii Opinion, Inc.
1984. Economic and financial analysis of Hawaii's longline and handline fisheries. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-84-17C, var. pag.

Moore, H. L.
1951. Estimation of age and growth of yellowfin tuna in Hawaiian waters by size frequencies. [U.S.] Fish Wildl. Serv., Fish. Bull. 52:133-149.

Otsu, T.
1954. Analysis of the Hawaiian long-line fishery, 1948-52. Commer. Fish. Rev. 16(9):1-17.

Otsu, T., and R. F. Sumida.
1970. Albacore of Hawaiian waters. Commer. Fish. Rev. 32(5):18-26.

Pooley, S. G.
1988. Western Pacific pelagic fisheries in 1987. Southwest Fish. Cent., Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-88-11, 26 p.

In prep. Market responsiveness in Hawaii's commercial fishery. Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, 2570 Dole St., Honolulu, HI 96822-2396.

Pooley, S. G., S. Teramoto, and A. C. Todoki.
1988. Hawaii's aku boat fishery in 1986 and 1987. Southwest Fish. Center, Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-88-16, 15 p.

Shomura, R. S.
1959. Changes in tuna landings of the Hawaiian longline fishery, 1948-1956. U.S. Fish Wildl. Serv., Fish. Bull. 60:87-106.

Suzuki, Z., and Y. Warashina.
1977. The comparison of catches made by regular and deep-fishing longline gear in the central and western equatorial Pacific Ocean. [Translation from the Japanese of a draft manuscript received March 1977.] (Engl. transl. by T. Otsu, 1977, 38 p., Transl. No. 20; available Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396.)

Uchida, R. N.
1979. Current status of fisheries in the Hawaiian Islands. Southwest Fish. Center, Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-79-21, 14 p.

Yong, M. Y. Y., and J. A. Wetherall.
1980. Estimates of the catch and effort by foreign tuna longliners and baitboats in the fishery conservation zone of the central and western Pacific, 1965-77. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-2, 103 p.

Yoshida, H. O.
1966. Tuna fishing vessels, gear, and techniques in the Pacific Ocean. In T. A. Manar (editor), Proceedings, Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, Honolulu, p. 67-89.

1974. Landings of billfishes in the Hawaiian longline fishery. In R. S. Shomura and F. Williams (editors), Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972. Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS-675, p. 297-301.