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PRELIMINARY FISHERIES SURVEY OF THE HAWAIIAN-LINE ISLANDS AREA

PART I - THE HAWAIIAN LONG-LINE FISHERY

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PREFACE

This survey was undertaken for the purpose of gathering information on the tunas and tuna bait fishes of the Hawaiian-Line Islands region to be used in planning the operations of POFI research and exploratory fishing vessels in the waters of the tropical and sub-tropical central Pacific Ocean. Since commercial tuna fisheries now exist in this region only in the Hawaiian Islands proper, some emphasis has been placed on a study of the fisheries of this island group.

This report is based upon the information gathered between January 3 and June 30, 1949. The data were gathered from trips aboard fishing vessels, field trips to outlying islands, examination of catches landed at local markets, and discussions with fishermen and market personnel. There has been opportunity to study the tuna fisheries of a small section of the central Pacific Ocean. The data compiled on places of occurrence, abundance, species, and methods of capture of tunas, spearfishes and bait fishes include information which will be of value toward understanding the vertical and horizontal distribution, seasonal changes in occurrence, and habits of these fishes in this area.

It was originally planned that the results of the entire survey be presented in a single report; however, it seems desirable that certain phases of the work should be summarized at present in order that this information may be made readily available during the early stages of planning vessel operations. This paper is Part I of the complete report. Other parts will follow.

INTRODUCTION

The tuna long line has become an important fishing gear for exploiting the large pelagic tunas and spearfishes[1/] that enter the coastal and offshore waters of the Hawaiian Archipelago. This island group is the only region in the tropical central Pacific Ocean where a long-line fishery is now established.

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1/ Spearfishes include the marlins, swordfishes, and sailfishes.

NOTE: Many persons aided the reconnaissance survey of the Hawaiian-Line Islands region. Mr. Vernon Brock, Director of the Territorial Division of Fish and Game, made available the catch statistics of the tuna landings in Hawaiian waters and gave much valuable advice and assistance. Grateful acknowledgment must be made of the services extended by Mr. Paul Lexton, British District Officer at Canton Island and Mr. Walter Backus, Civil Aeronautics Administration Administrator at Canton Island. CAA and the U. S. Coast Guard provided transportation to the various islands visited. Besides these persons and government agencies, many fishermen, officials at the Honolulu Market Place and Service personnel offered their fullest cooperation.

Prior to World War II, Japanese tuna boats conducted similar operations in the waters south of Japan, including the former Mandated Islands region, and offshore from Japan to the longitude of Midway. The bulk of the tunas which were caught in these areas was landed at Japanese home ports. At present SCAP regulations do not permit the Japanese to fish south of 24° N. latitude or east of 180° E. longitude. Within the authorized area, however, an extensive long-line fishery is conducted.

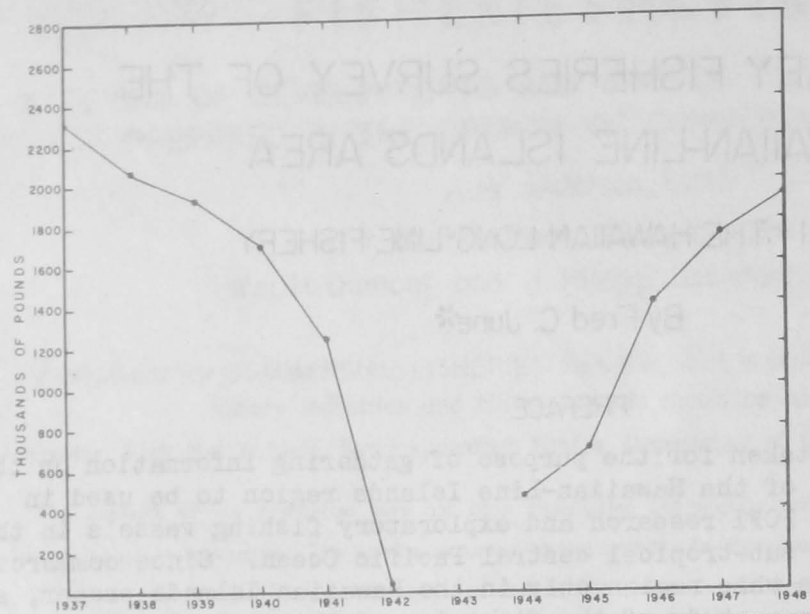

FIGURE 1 - TUNA CATCH (YELLOWFIN AND BIG-EYED TUNAS AND ALBACORE IN THE TERRITORY OF HAWAII, 1937-48. NO DATA AVAILABLE FOR 1943. CATCH FOR 1944 INCLUDES MARCH THROUGH DECEMBER ONLY. DATA OBTAINED FROM CATCH RECORDS OF TERRITORIAL DIVISION OF FISH AND GAME.

The waters about the Hawaiian Islands provide favorable conditions for a dependable concentration of these commercially important fishes throughout the year. Early Japanese immigrants recognized the potentialities of the Hawaiian Archipelago as a fishing ground for many of the oceanic fishes; however, it was not until the year 1917 that a Japanese fisherman by the name of Imose, began exploiting, by means of long lines, the sub-surface levels for the large tunas in the waters off the Waianae coast of Oahu. Following the introduction of the Japanese long-line technique, it became possible to exploit the coastal and offshore waters more efficiently. Thus, the Hawaiian tuna fishery, which had previously been limited to surface fishing by trolling and pole and line, expanded considerably, once it was demonstrated that these large oceanic fishes occurred in sufficient abundance to support the present existing commercial fishery.

Table 1 - Tunas and Spearfishes Landed at Hawaiian Ports, by Species, July 1945 through December 1948

Species	1945 1/	1946	1947	1948
	Pounds	Pounds	Pounds	Pounds
Yellowfin (Neothunnus macropterus)	455,972	1,342,767	1,314,349	1,159,598
Big-eyed (Parathunnus sibi)	12,379	126,445	340,118	677,430
Albacore (Thunnus germo)	10,426	43,116	114,672	106,065
Striped marlin (Makaira mitsukurii)	41,049	201,741	384,008	482,168
Black marlin (Makaira mazara)	69,732	163,993	445,191	700,465
Swordfish (Xiphias gladius) 2/	21,680	88,051	128,276	109,319
Sailfish (Istiophorus orientalis)	20,360	66,835	141,796	189,575
Total	631,598	2,032,948	2,868,410	3,424,620

1/For only 6 months - July to December.
2/Probably includes some marlins.
Source: Catch records of the Territorial Division of Fish and Game.

The main species exploited by the local long-line fishery include: Yellowfin tuna (Neothunnus macropterus), big-eyed tuna (Parathunnus sibi), black marlin (Makaira mazara), and striped marlin (Makaira mitsukurii). Albacore (Thunnus germo), white marlin (Makaira marlina), short-nose marlin (Tetrapterus brevirostris), and sailfish (Istiophorus orientalis) are taken with the other species but compose only a small part of the catch. Catches obtained by the long-line fleet constitute a large part of the offshore fishery production of the Territory. Total landings from Hawaiian waters in recent years are shown in Figure 1 and Table 1. For 1947, the Territorial Division of Fish and Game reported a catch of over 2,800,000 pounds of tunas and spearfishes. The 1948 production showed an increase, with total landings reaching nearly 3,400,000 pounds. Catch data already compiled for the early part of 1949 indicates an even greater production for this year.

THE LONG-LINE BOAT

The long-line boat used for taking the large tunas and spearfishes in Hawaiian waters has evolved from the Japanese sampan-type live-bait boat. The design includes such features as a high, narrow, clipper-type bow, angular lines, a modified V-bottom, with moderate freeboard aft. Boats range in size from 40 to 63 feet in over-all length; the most typical is about 60 feet over-all, with 12-foot beam, and 6-foot draft. The following description is, in general, typical of the local fleet; however, it must be borne in mind that considerable variations in detail exist from boat to boat.

General arrangement of the hull follows the lines shown in Figures 2 and 3. On the main deck is the pilot house, located slightly forward of amidships, housing the radio equipment, steering, and engine controls. A flying bridge is frequently installed above the pilot house and is fitted with additional steering and engine controls. The flying bridge may be completely enclosed or simply protected by means of a canvas wind-screen.

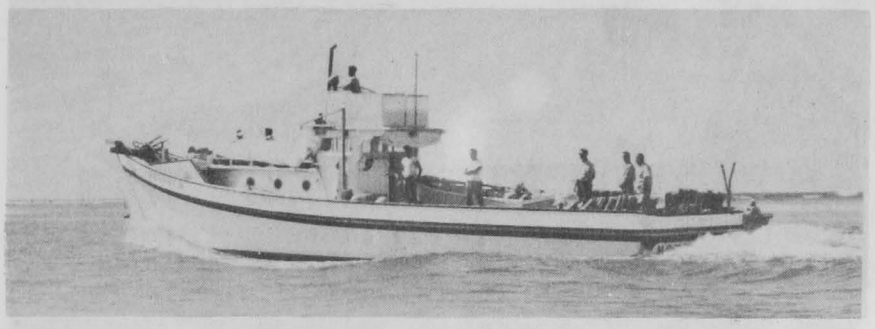

FIGURE 2 - TYPICAL LONG-LINE BOAT USED IN THE HAWAIIAN LONG-LINE FISHERY. (PHOTOGRAPH COURTESY A. G. HANSEN, TAKEN DURING TRIAL RUN.)

Forward of the pilot house is the raised trunk cabin, which generally provides storage space for fishing gear. The skiff, as a matter of convenience, is lashed along the starboard side of the raised trunk. The engine room is located directly below the trunk and houses the main engine, auxiliary generator, work bench, fuel tanks, and the outboard motor used to propel the skiff during baiting operations. The main engines of the long-line boats are diesel, varying from 115 to 165 horsepower, and are usually of the high-speed type, driving a single screw through a reduction gear. Engines with a reverse gear are preferred over the direct-reversible type because of the maneuvering necessary in handling the fishing gear.

On the starboard side of the main deck is a compartment, 3 by 2 feet and 2-1/2 feet high, that houses a gasoline stove used for cooking. A considerable amount of free deck space is provided aft of the pilot house to permit the

operation of gear. A rack, located on the starboard aft bulwark and consisting simply of two Y-shaped limbs, provides storage space for the flag poles. The rudder post projects from the aft deck, with a socket provided for insertion of the tiller. A plank rail extends completely around the main deck and functions as a bulwark. A bin rail, 8 inches high, extends along either side of the main deck, 18 inches inside the bulwark. The intervening space ordinarily provides storage for the floats. It also serves to retain the fish on deck during fishing operations, until they can be stowed below.

Forward of the engine room, but separated from it by a bulkhead, are sleeping accommodations for the crew, consisting simply of a tier of bunks. Abaft the engine room and similarly separated by a bulkhead, is the fish hold, which continues aft to the water tank and lazaret. The hold consists of three compartments, insulated along the sides and bottom with 2-inch cork laid between the beams and covered with galvanized sheet metal, and with a total fish capacity of from 15,000 to 20,000 pounds. Since none of the boats are equipped with any sort of mechanical refrigeration, ice is required in large quantities and is taken aboard in the form of cakes, weighing about 300 pounds; any resulting space may be filled with crushed ice to form a solid pack. An ice load of 25,000 to 30,000 pounds is considered to be adequate for a fishing trip, lasting about 14 days, and an average catch of about 7,000 pounds. The high ice to fish ratio is required because of tropical temperatures.

FIGURE 3 - DECK ARRANGEMENT OF A TYPICAL LONG-LINE BOAT USED IN HAWAIIAN LONG-LINE FISHING.

CREW

The crews that man the long-line boats are predominantly of Japanese extraction, though Filipinos and Hawaiians are represented in fair numbers. Most of the larger boats maintain a crew of five, while the smaller boats employ a crew of only two or three men. For various reasons, however, boats frequently put to sea with less than a normal complement.

A five-man crew comprises a captain and four fishermen. The captain, who is frequently a partner in the ownership of the boat, makes all decisions relating to the fishing operations, and in addition, ordinarily performs the navigation as well as the maintenance and repair work on all machinery. The fishermen operate the gear and share the duties of preparing the food; also stand a regular turn at the wheel and assist in the repair of gear and the performance of other maintenance work on deck.

Fishing is done on a share basis. Generally, the fish are sold at auction by the operators of the wholesale fish market, who render the additional service

of preparing a final settlement for the crew. Deductions for fuel, cartage, ice, market commission, and bait, if purchased, are made from the gross price received for the fish. After the deduction of these expenses, the net is then divided among the members of the crew and the boat owner as follows: the boat owner receives 30 percent and the captain receives 5 percent as a bonus; the remaining 65 percent is divided equally among the crew members and the captain. Expenses for food and provisions for the trip are paid out of the latter share.

DESCRIPTION OF GEAR

The tuna long line is designed for the purpose of catching tunas, spearfishes, and other species, by means of a series of baited hooks, placed below the surface of the water. It consists of a main line, which is supported at intervals by lines with attached surface floats or buoys, and which, in turn, supports a series of vertical branch or hook lines.

The description of the long line which follows is typical of the gear employed throughout the waters of the Hawaiian Islands. While certain variations in detail from boat to boat exist, the differences are a matter of preference with the individual fisherman. The long line (Figure 4, see page 6) is assembled by either splicing or tying together 13 to 15 lengths of main line, each varying from 1-1/3 to 25 fathoms. These, with attached float lines and branch lines, are designed to complete a basic unit 140 to 203 fathoms in length called a "basket."[2/] Twenty to 34 baskets are tied in a string, with two additional hook lines (end branch lines) attached at the ends, completing the set. The various assembled sections of one complete basket are coiled and are placed in a wooden box or a bamboo basket for stowage (Figure 5).

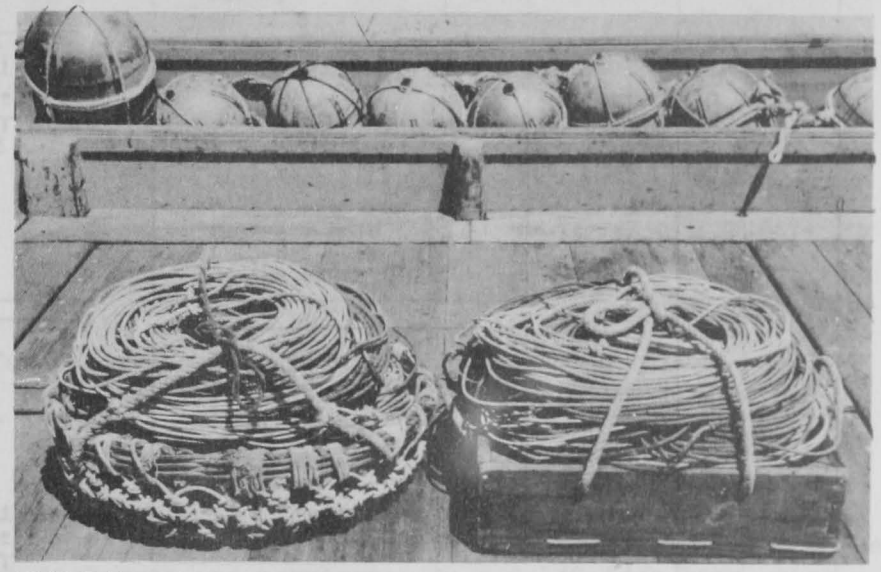

FIGURE 5 - WOVEN BAMBOO AND WOODEN CONTAINERS USED FOR STOWING THE COILED SECTIONS OF ONE COMPLETE BASKET OF LONG-LINE GEAR.

The "basket" is made up of the following parts:

(1) Main Line: The main line supports the pendant vertical branch lines, and is, in turn, supported by lines attached to floats. Medium-hard laid cotton twine, varying between 240 and 260 thread, is used almost exclusively for the main line.

(2) Branch or Hook Line: The branch line consists of four pieces: a length of cotton line, the "shanawa," the leader, and the hook. The upper end of this

2/ The term "basket" is derived from the special type container, woven of bamboo, in which the gear is stowed.

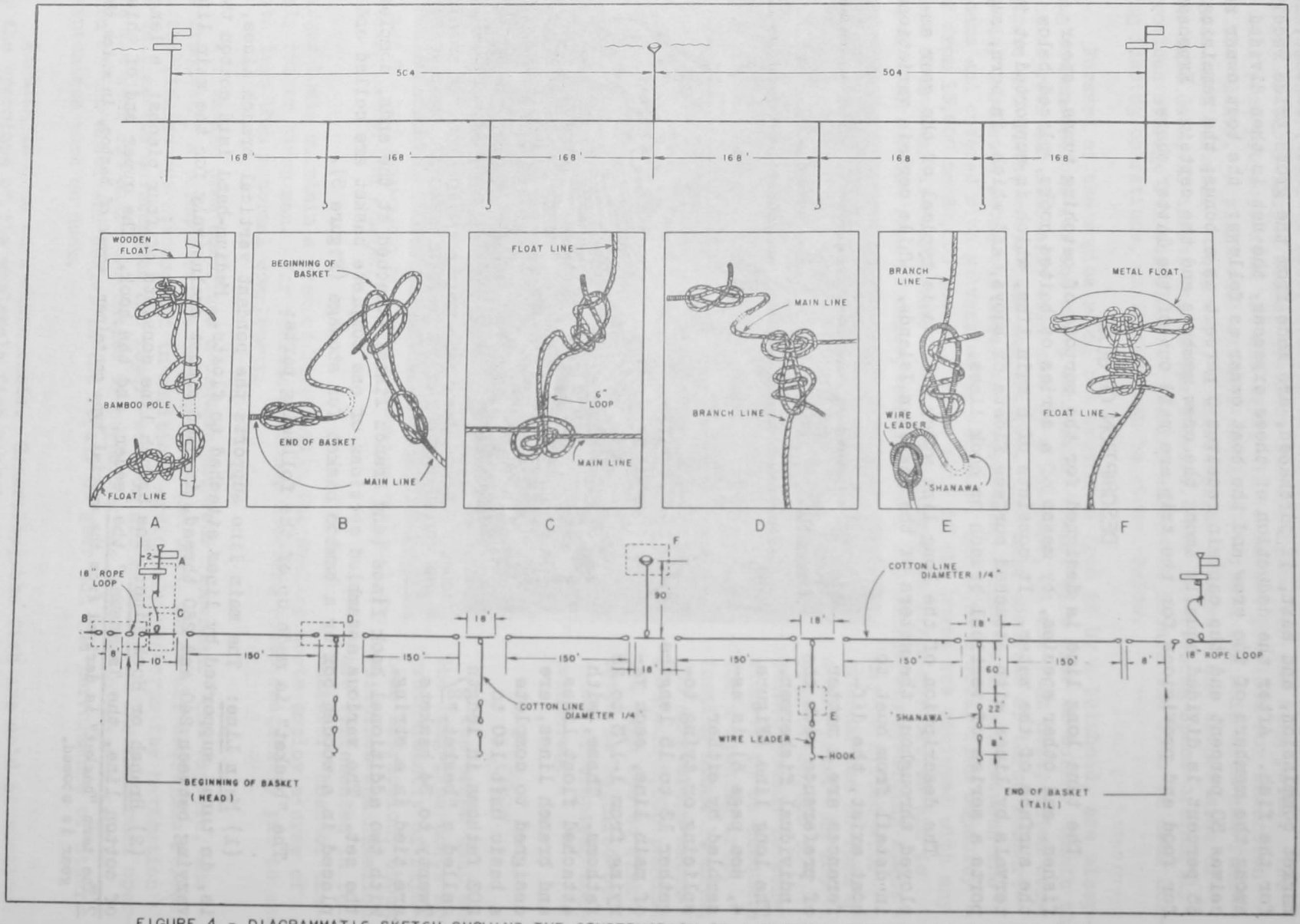

FIGURE 4 - DIAGRAMMATIC SKETCH SHOWING THE CONSTRUCTION OF A TYPICAL BASKET OF LONG-LINE GEAR.

line may be tied directly to the main line, or it may be fastened to a loop, 6 to 8 inches in length and of 1/4-inch cotton or 1/2-inch manila hemp, which is attached to the main line. The branch line may vary from 65 to 90 feet in length, and is usually of the same material as the main line. Many fishermen, however, prefer hard rather than medium-hard laid twine for the branch line.

"Shanawa" or "Sekiyama:" The "shanawa" is fabricated by hand from 15 strands of No. 8 Irish linen, twisted together, and tightly wrapped with No. 6 cotton thread which provides a fairly rigid length of line. The outer surface is coated with tar which acts as a preservative and further adds rigidity to this section. The "shanawa" thus prevents the lower section of the branch line from twisting and becoming fouled when the branch line carries a hooked fish. It has a finished diameter of 3/16 inch and may vary from 18 to 22 feet in length, depending on preference. At each end of the "shanawa" a served loop, about 6 inches in length, provides for the attachment of the lower end of the branch line and the upper end of the wire leader.

FIGURE 6 - FLOATS USED IN THE HAWAIIAN LONG-LINE FISHERY. THE ALUMINUM OXYGEN TANKS AND THE GALVANIZED METAL FLOATS ARE USED TO SUPPORT THE MAIN LINE AT THE CENTER OF A BASKET. THE WOODEN FLOAT IS FASTENED TO THE FLAGPOLE AND IS ATTACHED AT THE "HEAD" OF THE BASKET.

Leader: The leader is made of 3/32 inch diameter 1 x 7 galvanized steel wire. The end engaging the "shanawa" is fitted with a 6-inch served loop which prevents undue fraying of the "shanawa" and facilitates disassembling. The leader may vary from 8 to 10 feet in length and terminates in a 2 1/2-inch loop which passes through the eye of the hook.

Hooks: The hooks are made of approximately 1/4-inch diameter tempered steel. The two most common sizes are 9/0 and 8/0, having wire lengths (over-all length) of 5-5/8 and 4-5/16 inches, respectively. The latter is comparable to the Japanese 4-sun hook.

(3) Float or Buoy Line: The lower end of the float line is tied directly to the main line, or it may be attached to a 6-inch loop fastened to the main line. The twine used for the float lines is the same diameter as is used for the main and branch lines. Many fishermen use frayed or worn line from these sections, since it is not necessary that heavy twine be used for attachment of the floats.

Floats: Floats may be either Army surplus aluminum oxygen tanks of 1,000 to 2,100 cubic inches capacity or galvanized iron floats which are commonly used in the north Pacific otter trawl fishery (Figure 6). These metal floats are painted a bright color to increase visibility. Wooden floats, of California redwood,

4 x 4 x 30 inches, are used for attachment to the flagpole. The latter are less buoyant than the metal floats; however, they are adequate for supporting the pole and float line at the surface and at the same time occupy less space on board the fishing boat.

FIGURE 7 - ATTACHMENT OF WOODEN FLOAT TO THE FLAGPOLE. NOTE THAT THE LOOP ON THE FLOAT IS SET OFF CENTER; THIS FEATURE CAUSES ONE END OF THE FLOAT TO PROTRUDE ABOVE THE SURFACE WHEN A FISH HAS BEEN HOOKED ON A BRANCH LINE NEAR THE FLOAT.

Flagpole: The flagpoles are attached to the wooden floats at a point a little over 1/3 of the way up from the base of the pole (Figure 7). The upper end of the float line is attached to a 6-inch loop which is spliced through the base of the flagpole. Each pole and float is thus placed at the "head" or beginning of each basket and marks the union of the two ends of the main line between successive baskets. It serves as a marker to indicate the position of the main line, for in a rough sea the small floats are not easily seen at a distance. The flagpoles are made from Japanese bamboo, 14 to 16 feet in length. A piece of red or white cloth, tied to the upper end of the pole, makes a flag that can be readily seen. Usually the flags on one half of an entire set are red and on the other half are white, with a red and white flag tied to the pole located at the center of the set. A bit of frayed coconut husk is usually tied to the tip of the pole for ornamentation.

All lines are periodically treated with a "tanbark" solution--150 pounds, of either oak or cypress tanbark, are added to about 300 gallons of water, and this mixture is boiled until a chocolate-brown liquid is obtained. For a period of 24 hours the lines are then soaked in this solution.

FIGURE 8 - DRYING LONG LINES IN PORT. HERE THE COILED SECTIONS HAVE BEEN REMOVED FROM THE BASKET AND SPREAD OUT ON THE DOCK FOR DRYING.

Upon completion of each fishing trip, all lines are washed

with fresh water. The various sections of each basket are either removed from the container and spread out for drying (Figure 8), or the lines are merely separated and allowed to dry in the containers (Figure 9).

FIGURE 9 - DRYING LONG LINES IN PORT. HERE THE COILED SECTIONS OF EACH BASKET HAVE SIMPLY BEEN SEPARATED AND ALLOWED TO REMAIN IN THE BASKET.

BAIT

The bait used for long-line fishing may be salted opelu, sardine, or akule, about 12 inches total length, or squid of approximately similar size. Most fishermen, however, prefer salted opelu (Decapterus sanctae-helenae Cuvier). This species is most satisfactory for use as bait, because of its availability. Another reason is that the fish may be freshly caught and then salted. Bait handled in this manner does not decompose as rapidly as frozen fish and may be used for several resettings of the gear. For the same reason, frozen sardines are not as desirable for bait. Fresh or frozen squid has proved to be a very satisfactory bait and several long-line fishermen use it almost exclusively.

Bait is not a problem of great concern in the long-line fishery. Opelu may be purchased in the fresh form on the commercial market, or it may be caught by the long-line fishermen prior to long-line operations. During the spawning season, which may extend from late May until early August, opelu are not taken in sufficient numbers to supply the boats and other bait is used to supplement the catch. Frozen sardines and squid are imported from the mainland, and while a small number of fishermen use this source of supply solely, the majority only use it as a supplement during the slack opelu season.

Long-line boats fish for opelu in waters 15 to 30 fathoms in depth, just outside the fringing reef of small bays and coves along the coastline of most of the Hawaiian Islands. Some of these more productive areas include the waters in the vicinity of Kaumuhonu Bay, Niihau, the waters lying between Lahilahi Point and Kaena Point along the Waianae coast of Oahu, Hilo Bay, and the numerous small coves and bays along the Kona coast of Hawaii. Generally, the opelu grounds exploited by the long-line fishermen are those which lie in the near vicinity of the areas where long-line fishing is to be conducted.

Inshore fishermen catch opelu by using a surround net, while long-line fishermen use a funnel-type hoop net when catching opelu for bait. The hoop net consists of two bamboo rods, each 30 feet in length, jointed together at the ends to form

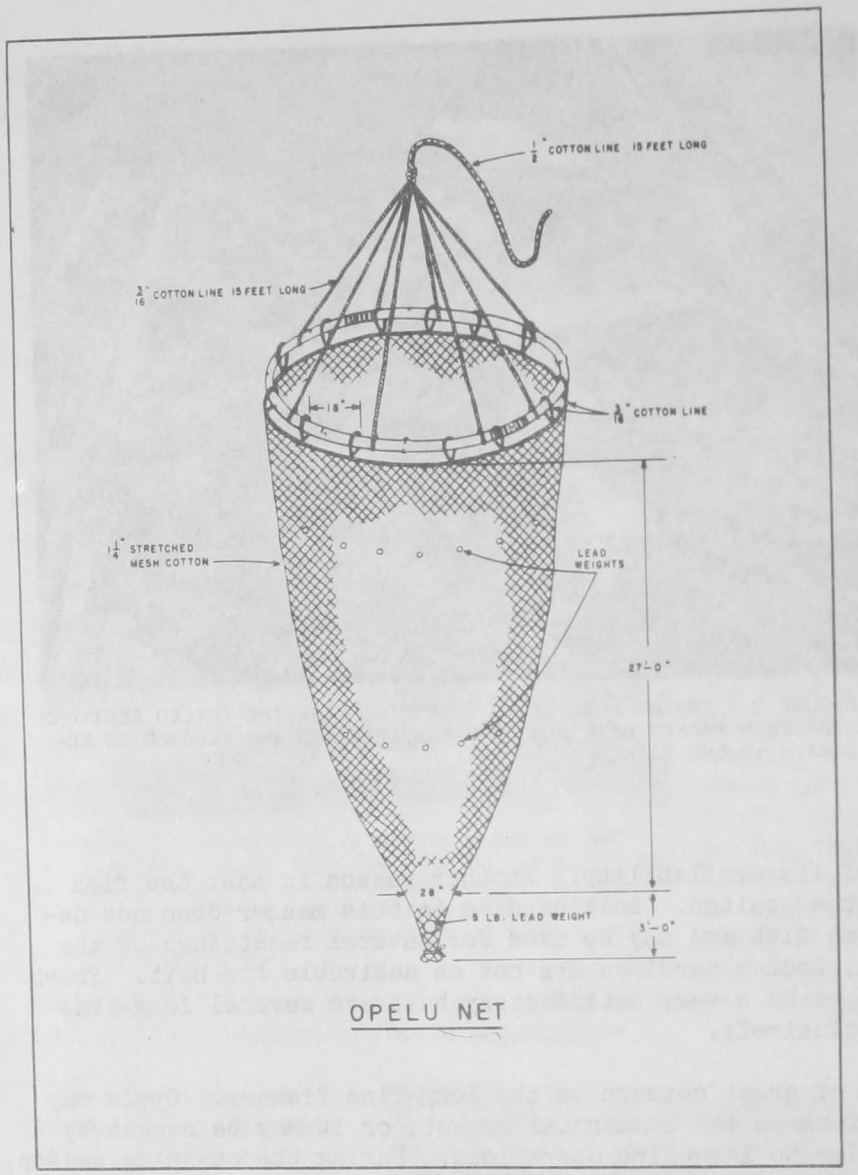

FIGURE 10 - THE OPELU NET IS USED FOR CATCHING LONG-LINE BAIT. THE NET IS LOWERED INTO THE WATER AND CHUM IS USED TO LURE THE FISH. WHEN THE NUMBER OF FISH ABOVE THE NET IS CONSIDERED SUFFICIENT, THE NET IS LIFTED.

the hoop, with a bag about 27 feet in depth and of 1 1/4-inch stretched mesh cotton netting supported by the rods. A steel rod is inserted in the core of the bamboo and runs the full length of the rods. The outer surface of the bamboo is wound with 1/8-inch cotton line and coated with tar. The entire framework is suspended by means of eight cotton lines, 3/16 inch in diameter and approximately 15 feet in length, fastened at the upper ends, to a cotton line about 15 feet long and 1/4-inch diameter (Figure 10). The various details and dimensions of the net may vary from boat to boat, though the principal design remains the same.

Ground vegetable matter is used to attract the opelu over the bait grounds. In earlier years the Japanese fishermen preferred ground "aku" (Katsuwonus pelamis) for use as chum, while the Hawaiians claimed that vegetable matter was more desirable. The objection to the use of animal chum was that it attracted various large-sized predatory fish that scattered the opelu from the chum and destroyed the bait species. It is now unlawful to take opelu with fish or animal bait within the waters of the Territory, except with hook and line. Taro (Colocasia antiquorum Schott) is most often used for vegetable chum, with potatoes and other vegetable sometimes added; all are thinly sliced and boiled until a thick paste is obtained.

It is interesting to note that in ancient days the Hawaiians would feed the vegetable chum to the fish at a designated place close to shore. After this feeding had been carried on for a period of time, generally some six months, the actual fishing operation, in which a surround net was used, was carried out. This method produced enormous catches of opelu.

The sampan is anchored outside the reef in waters where bait fishing is to be carried on. A skiff is secured a short distance off the stern of the sampan,

with the net piled along one side of the skiff and the rods disjointed. One of the fishermen chums from the skiff by pouring about a cupful of ground vegetable matter into a piece of heavy denim cloth that is folded into an envelope. The folded cloth, containing the chum, is cast over the side and carried downward by means of a small lead weight attached to the cloth. With a sharp pull on a retaining line, fastened to the upper corner of the cloth envelope, the contents are released at a desired depth. By means of a glass-bottom box, the chummer observes the concentrations of opelu about the chum.

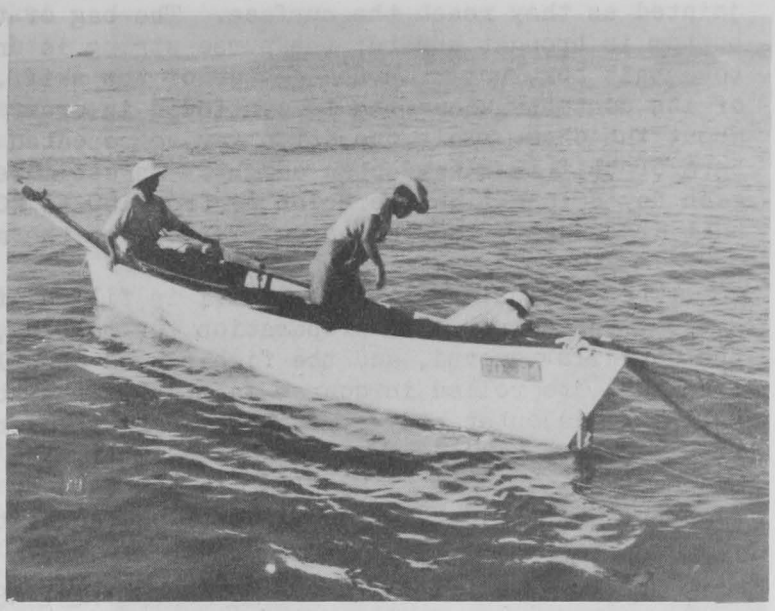

FIGURE 11 - BAIT FISHING FOR OPELU. THE SKIFF "IS TIED" OFF THE STERN OF THE LONG-LINE BOAT AND THE "CHUMMER" IS OBSERVING A SCHOOL OF OPELU LURED BY THE CHUM. NOTE ANOTHER LONG-LINE BOAT IN THE BACKGROUND.

This operation is repeated until sufficient numbers of opelu have been attracted by the chum. At a signal given by the chummer, two fishermen board the skiff; the skiff is cast off from the sampan and moved directly over the opelu school (Figure 11). Frequently, predatory species may cause the bait fish to move about rapidly, or a fast-moving current will carry the chum away, with the school in pursuit. In order to maintain contact with the fish, when such a condition exists, an outboard motor, attached to the skiff, may be used. As the skiff is brought into position directly over the opelu school, two of the fishermen lower the net into the water. The two bamboo rods are joined together at the ends and the entire framework is lowered to a depth slightly below the level at which the opelu are feeding. Chumming is continued as the net is brought to rest near the fish, with the chum directed toward the center of the hoop. The opelu follow the chum down into the lower end of the bag, and when sizable numbers of fish are concentrated in the bag, the net is quickly brought to the surface. The bamboo rods are dis-

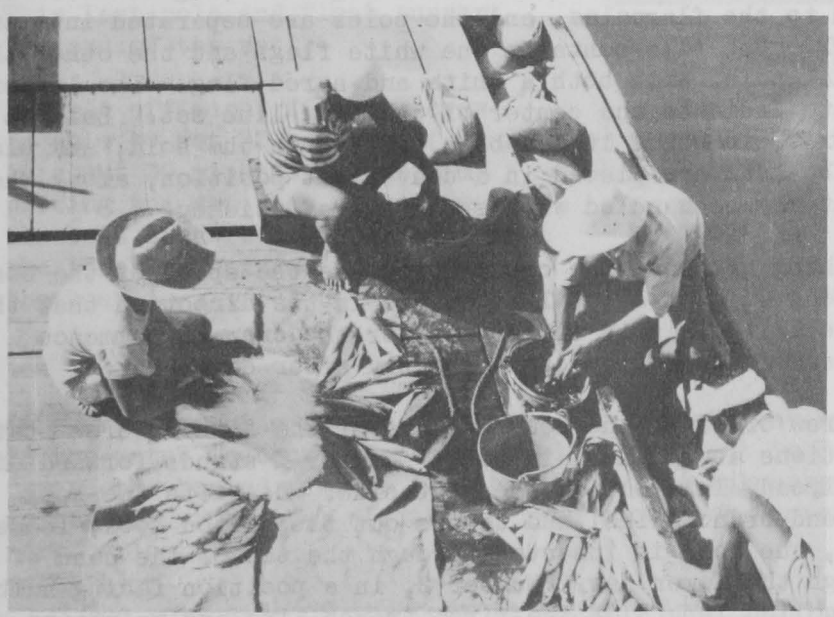

FIGURE 12 - SALTING FRESHLY-CAUGHT OPELU FOR USE AS LONG-LINE BAIT. AFTER SALTING, THE FISH ARE PACKED IN WOODEN BOXES AND STOWED IN THE HOLD.

jointed as they reach the surface. The bag of the net is hauled upward until the bottom is brought aboard; the purse string is untied and the fish are released into a bait box, built in the center of the skiff. While the net is being emptied of its contents, chumming is continued in order to hold the opelu still milling about the chum. This operation may be repeated many times until sufficient numbers of bait fish have been caught. An estimate of the amount of bait needed for each day's long-line operation is from 150 to 200 pieces. About 1,000 pieces of bait are usually considered sufficient for the average long-line trip.

When the bait box in the skiff is filled, the opelu are transferred to the deck of the sampan. In preparation for salting, a slit is made along the belly, the entrails removed, and the fish placed in a large bucket of sea water. The fish then are rolled in coarse salt until the abdominal cavity is filled with salt and the outer body surface completely covered (Figure 12, see page 11). The fish are then packed in wooden boxes, bellyside up, with more salt added between successive layers of fish. The packed boxes of bait are stowed in the fish hold. Sardines that have been imported for use as bait are similarly prepared.

SETTING THE LINE

In preparation for the long-line operation, the crew assembles the baskets of gear on the main deck the night before fishing is to begin, or preparations take place during the trip to the fishing grounds.

The first three or four baskets to be set are placed in successive order on the mid-deck, in a row perpendicular to the port gunwale and the ends of the main lines between these adjacent baskets are fastened together (Figure 13). The wooden floats are fastened to the flagpoles and the poles are separated into two equal piles on the aft deck. One pile contains the white flags and the other the red flags with an additional pole, with both a white and a red flag. The latter is later used as a marker to indicate the center of the long line set. Bait is removed from the wooden boxes, in which it has been carried in the hold, and placed in buckets of water. The buckets are placed in a convenient position, along the port deck, so that the bait may be handled with speed and efficiency.

Upon reaching the fishing grounds, the captain reduces the speed of the boat to about 3 knots and proceeds on a straight-line course in the direction that the line is to be set (See page 17). This is the signal for the crew to commence laying the gear. These operations usually begin shortly after day break.

On boats carrying a crew of five, the four members of the fishing crew station themselves at various positions about the main deck. Number 1 stands forward of the first 3 or 4 baskets already laid out on the port side. He baits the hook of the first branch line (end branch line) and throws out the baited hook, leader, and "shanawa." In baiting, the hook is inserted through the top of the head of the fish and back up through the lower jaw. Number 2, in a position facing number 1, pays out the remaining coiled length of the first branch line and maintains tension on this line as it is paid out, in order to prevent fouling. Each succeeding branch line is similarly paid out. Meanwhile, number 3 has fastened the first flagpole and float to the first float line and as this section of the first basket is reached, he throws the flagpole and float over the side and pays out the coiled float line. Each succeeding pole and float together are handled in a similar manner. Number 3 also pays out each unit section of the coiled main line as the gear is being laid maintains a slight tension on the line as it is lowered into the water. Number 4 secures the floats to the respective float lines.

Thus, each unit section of a basket is similarly paid out until one basket has been completely set, at which time Number 2 moves the next basket up to the same position as the previous one occupied. Number 4 meanwhile, fastens together the ends of the main line of adjacent baskets. Boats carrying a crew of only 3 or 4 men handle gear in the same manner as described, each crew member, however, necessarily performs additional duties.

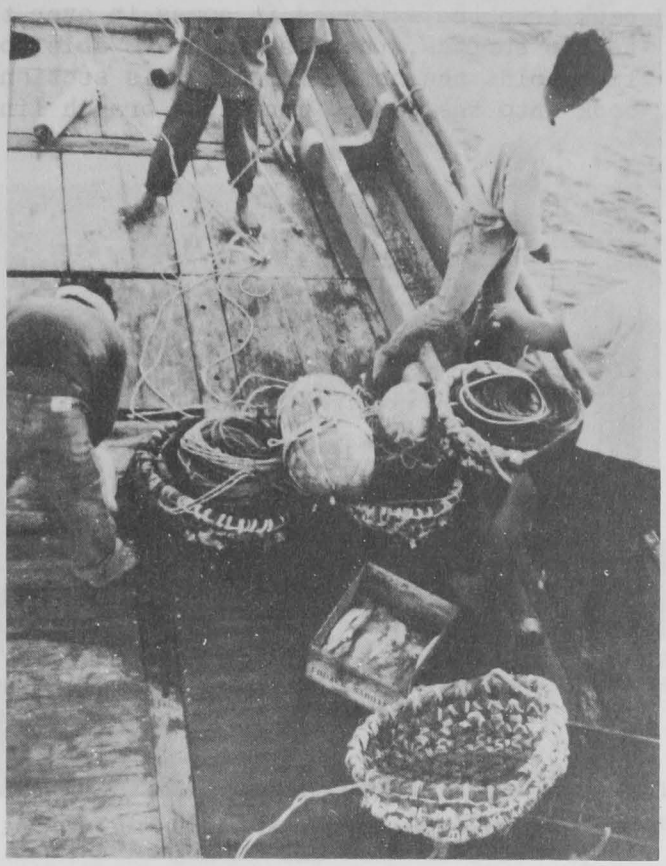

FIGURE 13 - SETTING THE LONG LINE. THE MAIN LINES OF THE THREE BASKETS SHOWN HAVE ALREADY BEEN TIED TOGETHER. THE FLOATS AND FLAG POLES HAVE ALSO BEEN ATTACHED TO THE FLOAT LINES. NOTE THE BAIT BOX; THIS PHOTOGRAPH WAS TAKEN NEAR THE END OF SETTING OPERATIONS AND THE EXTRA BAIT NEEDED WAS TAKEN DIRECTLY FROM THE BAIT BOX. THE BUCKETS ORDINARILY USED FOR HOLDING BAIT HAVE BEEN REMOVED.

These operations are repeated for each basket until the entire line is set. The last complete basket (the end of the set farthest from shore) is called the "head" basket. It differs from the other baskets in that there are two flagpoles and floats attached to the main line--one pole and float is attached at the head of the basket; an additional pole and float is attached at the tail (offshore end), together with an end branch line. This last pole and float support the end of the set.

An efficient five-man crew is able to set 33 baskets of gear in about 30 minutes. Upon completing the set, the captain moves the boat a short distance away from the line; the engine is cut and the boat is allowed to drift until the time for the first patrol of the line.

LANDING A HOOKED FISH

The long-line set is patrolled about every two hours during the time it is in the water, because sharks are fairly abundant in Hawaiian waters and frequently damage the hooked fish on the long lines. A submerged flag or float indicates to the fishermen that a fish has been hooked on a section of gear near the submerged float.

The port side of the boat is brought into position alongside the submerged float, and parallel to the main line. The float is retrieved with a gaff and brought aboard with the attached float line taken in over an outboard pulley, fastened to the port gunwale. Most boats commonly use an 8-inch pulley, extended 18 inches out from the gunwale by means of a 3/4-inch pipe fastened to a 4" x 4" or other suitable supporting member. The float line is pulled by hand and paid

back into the water as it comes in over the pulley.[3] As the main line is brought to the surface, the fishermen are able to determine which section of the main line holds the hooked fish. This section is taken in and simultaneously paid back into the water, until the branch line carrying the fish has been located. This branch line is hauled aboard until the fish has been brought to the surface (Figure 14). A gaff is hooked somewhere about the head, with two or three men lending assistance in bringing the fish aboard. The hook is removed from the fish, rebaited and thrown back into the water. The fish are allowed to remain on deck until the patrol has been completed, when the catch is stowed on top of the ice load and covered with burlap.

FIGURE 14 - LANDING A HOOKED FISH. THE MEN ARE PULLING THE BRANCH LINE CARRYING THE FISH. NOTE THE TWO MARLINS ALREADY LANDED DURING THE PATROL OF THE LINE.

The spear and flukes of the caudal fin of spearfish are usually removed before the fish are stowed. Most long line boats use a chain-fall assembly for landing spearfishes over 400 pounds. To further facilitate handling these large fishes, they are cut in two pieces near the anal fin prior to icing.

LIFTING THE GEAR

Most long-line boats are equipped with a power winch for pulling lines; however, on one or two of the smaller boats, lines are still pulled by hand. The winch may be a separate unit, powered by a 1-1/2 horsepower gasoline engine, or it may be connected to a power take-off from the main engine, by means of a line shaft and chain drive. The winch usually consists of a 10-inch drum mounted on an iron framework, and supported about 30 inches from the deck (Figure 15). The winch is located on the port deck, abaft the pilot house, and is mounted in position only during lifting operations.

The long line is taken in starting about 3 hours before dark, the end farthest from shore being pulled first. However, in the event of a strong current, the line is lifted in such a manner that the boat moves against the current to prevent fouling the lines. The boat is maneuvered into position, with the bow set about 30° to the main line, so that the line may be pulled from the port side. The captain controls the boat from the aft deck by means of a tiller (Kaji) inserted in the rudder post. Two lines leading from the stern are connected to the clutch lever by means of several small swivel-pulleys. With this arrangement the clutch may be engaged or disengaged from the aft deck. The throttle is set at the low position.

3/ When landing fish during patrols of the line, all line pulling is done by hand; a power winch is used only when lifting the gear at the end of the day.

As the boat comes alongside the first flag, the flagpoles and float are retrieved with a gaff and the float line brought aboard. The pole and float are untied from the float line and the line is brought over the outboard pulley, two turns being taken around the "nigger-head." Number 1 crewman operates the winch and pulls the lines (Figure 16). The first float line is coiled on the deck as it comes off the "nigger-head," until its junction with the main line is reached. As the first branch line (end branch line) comes aboard, Number 2 unfastens it from the main line and pulls it by hand. This line is coiled when about one half its length is aboard. When the hook is reached, the bait is removed; if the bait is still in satisfactory condition, it is placed in a bucket of water to be used again. The coiled end branch line is laid aside on the deck.

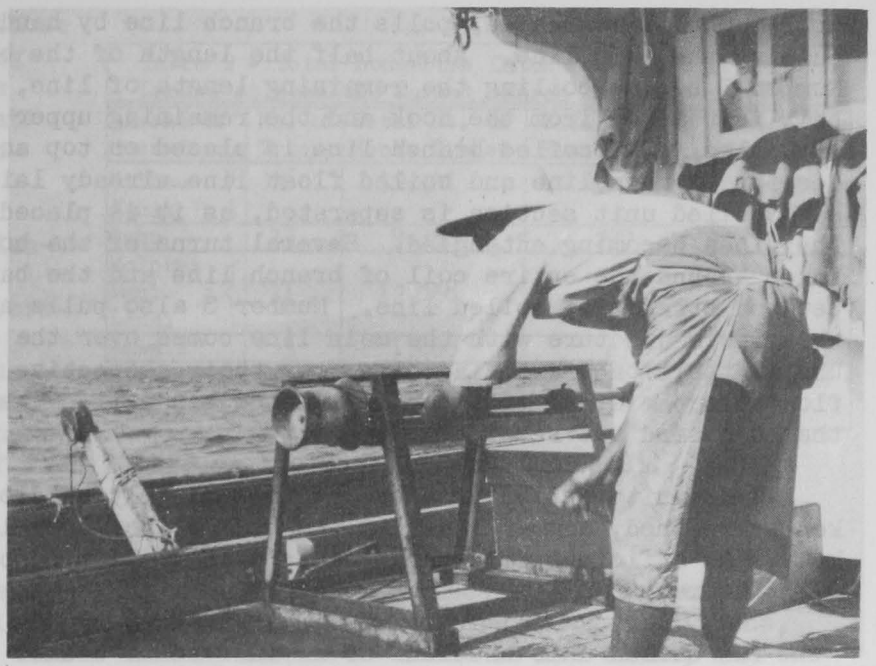

FIGURE 15 - WINCH USED FOR PULLING LINES WHEN THE GEAR IS LIFTED. NOTE THE LINE AT LOWER RIGHT; IT IS ATTACHED TO THE POWER TAKE-OFF AND CONTROLS THE OPERATION OF THE WINCH.

FIGURE 16 - LIFTING THE GEAR AT THE END OF THE DAY'S FISHING. NOTE THE TWO ROPES LEADING FROM THE ENGINE ROOM; THESE ARE ATTACHED TO THE CLUTCH LEVER AND ALLOW THE CAPTAIN TO CONTROL THE BOAT FROM THE AFT DECK.

Number 1 meanwhile, continues pulling the main line and allows it to coil on deck as it comes off the "nigger-head." Number 2 places the float line in the basket, after coiling, retrieves the coil of main line, and continues coiling the incoming line. As the junction of the main and branch lines comes over the outboard pulley, Number 2 places the coiled section of main line in the basket. To prevent fouling the lines, one turn of the main line is cast-off the drum as the junction of the main and branch lines comes in over the "nigger-head."

Number 3 meanwhile, pulls the branch line by hand, as Number 1 continues pulling the main line. About half the length of the branch line is pulled before Number 3 begins coiling the remaining length of line, "Shanawa," and leader. The bait is removed from the hook and the remaining upper length of the branch line is coiled. The coiled branch line is placed on top and to one side of the coiled section of main line and coiled float line already laid in the basket. Thus, each coiled unit section is separated, as it is placed in the basket, to prevent the lines becoming entangled. Several turns of the hook end of the leader are taken around the entire coil of branch line and the barb of the hook is inserted between strands of coiled line. Number 3 also pulls and coils the float lines when their juncture with the main line comes over the outboard pulley. Number 4 unties the floats and flagpoles from their respective float lines and stows all floats in the space provided inside the bin rail. The flagpoles are placed in the starboard aft rack.

Each unit section of a basket is similarly handled. As the end of one basket is reached, Number 1 unties the ends of the main line between adjacent baskets. An efficient five-man crew is able to lift 33 baskets of gear in about 2-1/2 hours.

The coiled unit sections of an individual basket are staggered as they are placed in the bamboo basket in the following order: (from the bottom up) (1) main line, (2) branch line, (3) main line, (4) branch line, (5) main line, (6) float line (detached from the metal float), (7) main line, (8) branch line, (9) main line, (10) branch line, (11) main line, (12) float line (detached from the flagpole and wooden float).

During lifting operations the boat may be stopped many times because of fouled lines. Fouled unit sections are removed and replaced with coiled sections that have already been assembled. These unit sections are quickly tied in place and the entangled lines are allowed to remain on deck until lifting operations have been completed.

Upon completion of lifting operations, most boats put into port for the night if fishing has been carried on in an area where docking facilities are available. If port facilities are not available, the boats are usually anchored in the protected waters of a bay or cove along the coast of one of the islands.

FISHING AREAS AND DEPTHS

Generally, long-line hooks are fished between 30 and 50 fathoms. Most long-line boats operating out of Honolulu set the lines at the same depth throughout the year. Only a few boats make adjustments in the lengths of the float lines, to allow changing the depth at which the gear is fished. Certain fishermen, operating along the Kona coast of Hawaii, shorten the float lines during the summer months when fishing for yellowfin tuna. The hooks are fished at 17 to 25 fathoms during this season, for the fishermen believe that yellowfin tuna swim closer to the surface. Conversely, when fishing for big-eyed tuna in Hilo waters during the winter months, the hooks are fished at deeper levels.

In general, long lining is carried on in waters varying in depth from 100 to over 1500 fathoms off the coasts of all of the major islands and from 2 to 20 miles from shore. Certain areas continually yield good catches and fishing is conducted over these grounds the year round. Certain other areas seem to yield good catches only during particular seasons. Through experience the fishermen

have become familiar with those waters producing fluctuating catches and fish such areas only during the periods that they may be expected to produce abundantly.

Table 2 - Total Long-Line Catch From 53 Boat Trips Landed at Honolulu Market, March through June 1949

Areas of Operations	No. of Trips	Total No. of Hooks Fished	Total No. of Fish Caught 1/	Catch Per 100 Hooks
Niihau, Kauai	26	32,401	960	3.0
Oahu	13	9,358	290	3.1
Molokai, Maui, Lanai	11	12,058	396	3.3
Hawaii	3	1,668	47	2.8

1/Includes albacore, yellowfin and big-eyed tunas; and striped, black, short-nose, and white marlins.

The most productive fishing grounds for tunas and spearfishes include the waters south of Kauai, the areas north of Niihau, the Waianae coast of Oahu, the areas north of Molokai and Maui, and the Kona and windward coasts of Hawaii (Figure 17, page 18, and Table 2).

FISHING TIME

The length of time the lines are fished is determined by the number of daylight hours. During the winter months and under normal operating conditions, the maximum period of time that a hook is fished is about 12-1/2 hours, and the minimum time is 8-1/2 hours. The lines are set in the morning starting between 6:15 and 6:45 a.m. A five-man crew can handle 33 baskets of gear in about 30 minutes; lines are brought in starting at 4:00 p.m. and the operation is completed by 6:30 p.m. During the summer months, most boats set the lines starting at 5:30 a.m. The lines are taken in about 5:00 p.m. and the operation is usually completed by 7:30 or 8:00 p.m.

The number of days of fishing per trip varies from boat to boat and with each trip. Of 88 boat interviews during the period from March through June 1949, the largest number of fishing days during any one trip was 17 and the smallest was 6. The average number of fishing days per trip was 10.5.

CURRENTS ON THE FISHING GROUNDS

The waters in the vicinity of the Hawaiian Islands are subject to strong and variable currents throughout the year. In general, currents run northerly and westerly close inshore, but run southwesterly and westerly offshore. Rough seas prevail during most of the year in areas surrounding Niihau, Kauai, Molokai and Maui.

In certain areas, especially waters lying in the vicinity of Niihau and Kauai, current changes are unpredictable and often foul the set lines. Along the southern coast of Kauai, the current generally follows a clockwise circular pattern, extending a distance of about 30 miles offshore. This area in particular is given to suddenly changing currents. It is often necessary for boats operating in these waters to remove one or more complete baskets of gear, during a daily operation, when a convergent current causes the main line to buckle. Frequently a shifting current causes the main line to become taut to the point of breaking, and when this condition exists, the entire set is lifted.

Along the Kona coast of Hawaii, boats are able to operate in calm waters for at least 11 months of the year. During periods of prevailing south wind, it is occasionally necessary to suspend fishing operations. The currents in this region generally flow either north or south along the coast, however, during

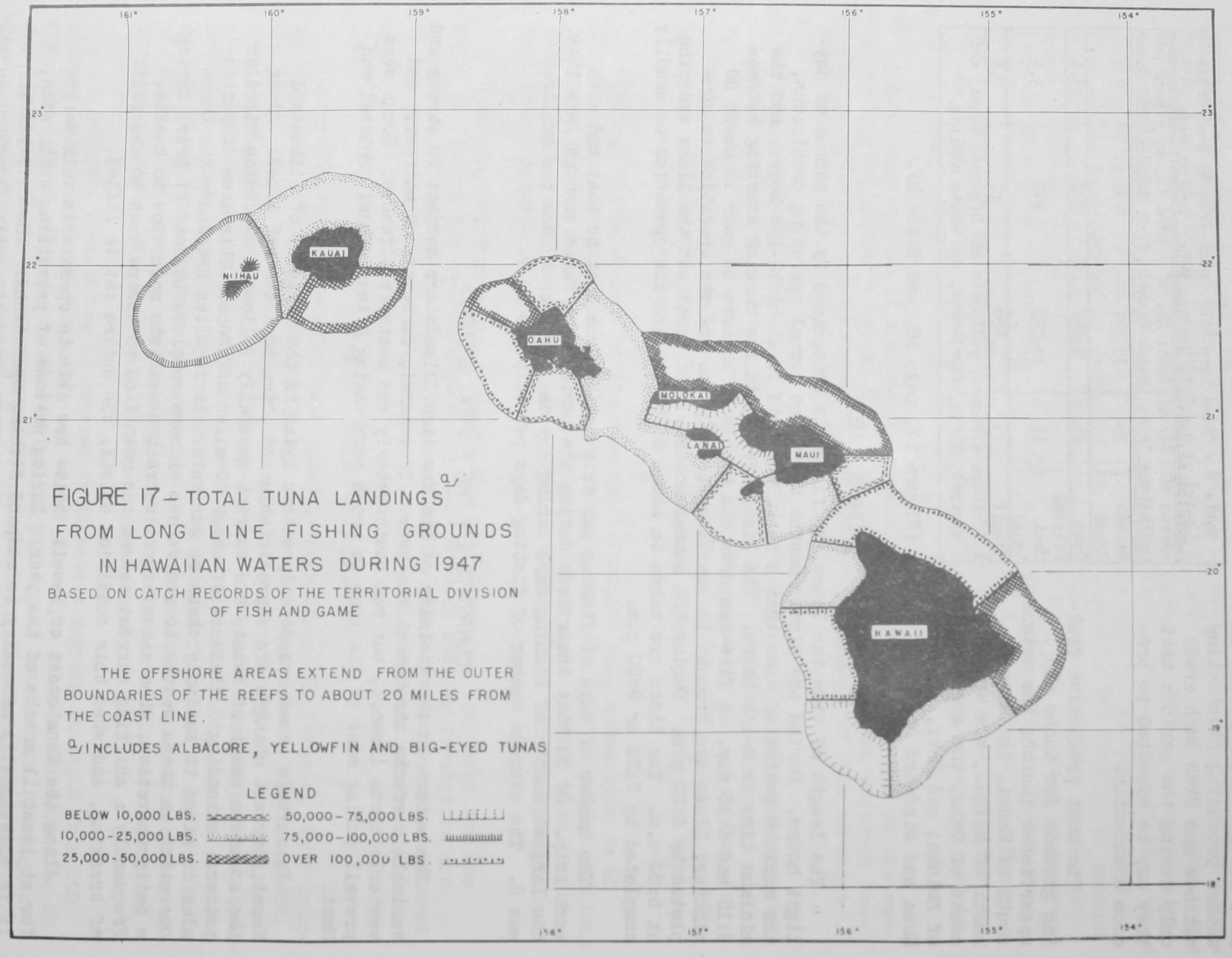

FIGURE 17 – TOTAL TUNA LANDINGS [a] FROM LONG LINE FISHING GROUNDS IN HAWAIIAN WATERS DURING 1947

BASED ON CATCH RECORDS OF THE TERRITORIAL DIVISION OF FISH AND GAME

THE OFFSHORE AREAS EXTEND FROM THE OUTER BOUNDARIES OF THE REEFS TO ABOUT 20 MILES FROM THE COAST LINE.

[a] INCLUDES ALBACORE, YELLOWFIN AND BIG-EYED TUNAS

March and April, sudden changes are frequent. Several fishermen operating in this area have noted that 1949 conditions were extreme in this respect, and fishing proved to be poor during the month of March.

When the current flows parallel with the coast, the best conditions for long-line operations appear to be present. Most fishermen meet this condition by setting the line perpendicular to the shore, beginning at a point 2 to 10 miles from land. When strong offshore currents prevail, the set is made at an angle of 45° with the current to avoid fouling the lines.

AMOUNT AND THE EFFICIENCY OF GEAR FISHED

About 30 boats operate out of Honolulu and can be considered constant long liners. Similarly, 16 boats operate from the port of Hilo, Hawaii. During the winter months the Hilo boats fish in the vicinity of the port on daily runs; however, during the summer season, tunas are not abundant in Hilo waters and the vessels operate off the Kona coast on week-long trips. Only about 3 boats are based at Port Allen and make daily runs off the coast of Kauai.

Table 3 - Long-Line Catch From 45 Boat Trips Landed at Honolulu Market, March through June, 1949

Month	No. of Boat Trips	Total No. of Hooks Fished	Total No. of Fish Caught 1/	Catch Per 100 Hooks
March	15	17,709	581	3.2
April	11	13,946	434	3.1
May	6	9,830	226	2.3
June	12	15,218	364	3.3

1/ Includes albacore, yellowfin and big-eyed tunas; and striped, black, short-nose, and white marlins.

Most long line boats operating out of Honolulu fish between 30 and 34 baskets of gear through the entire season, with 4 to 6 hooks per basket. Two additional hooks are placed at either end of the entire set. Occasionally during the summer months fishermen who have been fishing 4 hooks per basket add one or more hooks to each basket to increase the length of the set. The distance between adjacent hooks is not altered, however, as more hooks are added, since the sections of main line, with attached branch lines, are of comparable lengths and are simply inserted in the main line of the individual baskets.

Table 4 - Long-Line Catch of Tunas and Spearfishes by Monarch, March through June, 1949

Area of Operation	Total No. of Hooks Fished	Total No. of Fish Caught	Catch Per 100 Hooks	Total Weight of Fish Caught
N and NW of Lehua (off the coast of Niihau)	1,787	97	5.4	9,264
S of Port Allen, Kauai	1,250	32	2.6	4,346
E of Hanamaula Bay and Kahala Pt., Kauai	313	5	1.6	587
S and W of Waianae, Oahu	522	18	3.4	1,621
SW of Kokole Pt., Kauai	402	18	4.5	2,551
NE of Ilio Pt., Molokai	268	12	4.5	1,701
NE of Laie Pt., Oahu	120	2	1.7	261
NE of Makanalua Pen., Molokai	360	7	1.9	781
N and E of Cape Halawa, Molokai	360	7	1.9	782
NE of Pauwalu Pt., Maui	480	7	1.5	1,042
W of Kailua, Hawaii	360	7	1.9	782
Totals	6,222	212	-	23,718
Average Catch Per 100 Hooks			3.4	

The average efficiency (catch per hundred hooks per day's fishing) of long-line gear, based on a sample of the

fleet, was found to remain fairly constant, both with regard to time of year and fishing area (Tables 2 and 3), over the four-month period (March through June 1949) for which data have been collected. The low efficiency figure for May was due to the inclusion of the catch data of two boats that fished in an area where current disturbances arose during the early part of the month and fishing proved to be poor. While other boats in the fleet moved to different areas during this period, these two boats operated in spite of adverse conditions. The efficiency was computed on the complete catch data for 53 boat trips, including all areas where long lining is carried on in Hawaiian waters. The average catch for these areas and months was 3 fish per 100 hooks. The fishing operations for a typical boat from the fleet (Table 4) shows an average catch of 3.4 fish per 100 hooks, which is slightly above the average for the entire fleet during the four-month period.

Table 5 - Tuna Catch by Long-Line Operations in Southwest Pacific and Indo-Pacific Regions

Area	Total Catch per 100 Hooks[1]
East of Formosa: 20°-25° N. and 120°-130° E.	1.91
East of Philippine Islands to 130° E.	6.35
Former Mandated Islands: 0°-12° N. and 130°-170° E.	5.23
South China Sea off Palawan	4.65
Sulu Sea	3.96
Celebes Sea	4.37
North of New Guinea and Solomon Islands: from 130°-160° E.	4.21
Banda Sea: southeast and south of Celebes	8.40
Neighboring waters of Timor Island	9.19
Southern coast of Java	3.89
Southern coast of Sumatra	10.64
Neighboring waters of Andaman and Nicobar Islands	6.23

1/ In Japanese waters, the total tuna catch per 100 hooks averages between 3 and 4 fish. (Reproduced in part from Table 1. The Japanese Tuna Fisheries, F. L. 297, Fish and Wildlife Service.)

The catch per 100 hooks in Hawaiian waters is about equal to the long line catch in Japanese waters, which averages between 3 and 4 fish per 100 hooks. Comparisons between Tables 3 and 5 show the average Hawaiian catch to fall below the Japanese catch obtained in various tropical and sub-tropical areas.

CATCH COMPOSITION

The pelagic species taken by sub-surface long-line gear occupy a position of major importance in the fishery resources of the Territory. Yellowfin tuna, big-eyed tuna, striped marlin, and black marlin compose the bulk of the catch obtained by this method. Occasionally, white marlin, short-nose marlin, broad-bill swordfish, and sailfish are taken with the other species. Big-eyed tuna, albacore, and marlins comprise the bulk of the catch during the winter months (November through April). Yellowfin tuna enter the fishery in sizeable numbers in April and constitute the largest component of the catch through the summer months (Figure 18).

The entire tuna catch is consumed in the islands and provides an important item in the diet of the Oriental peoples, who prefer it as raw fish (sashimi). The marlins account for about half the total long-line production. Most of these are processed as fish cake for local consumption.

The monthly landings by the long-line boats are not a true indication of the abundance of tunas and spearfishes available to the fishery. While the species composition of the catches show seasonal variations, total production does not show such marked fluctuations (Tables 6 and 7, page 22). This condition may be considered in relation to limiting factors that are operative in determining the

vigor and intensity of commercial operations. The amount of fish landed is limited by local market outlets. The largest Honolulu market, which handles about 80 percent of the total landings, is capable of absorbing a maximum of about 5000 pounds

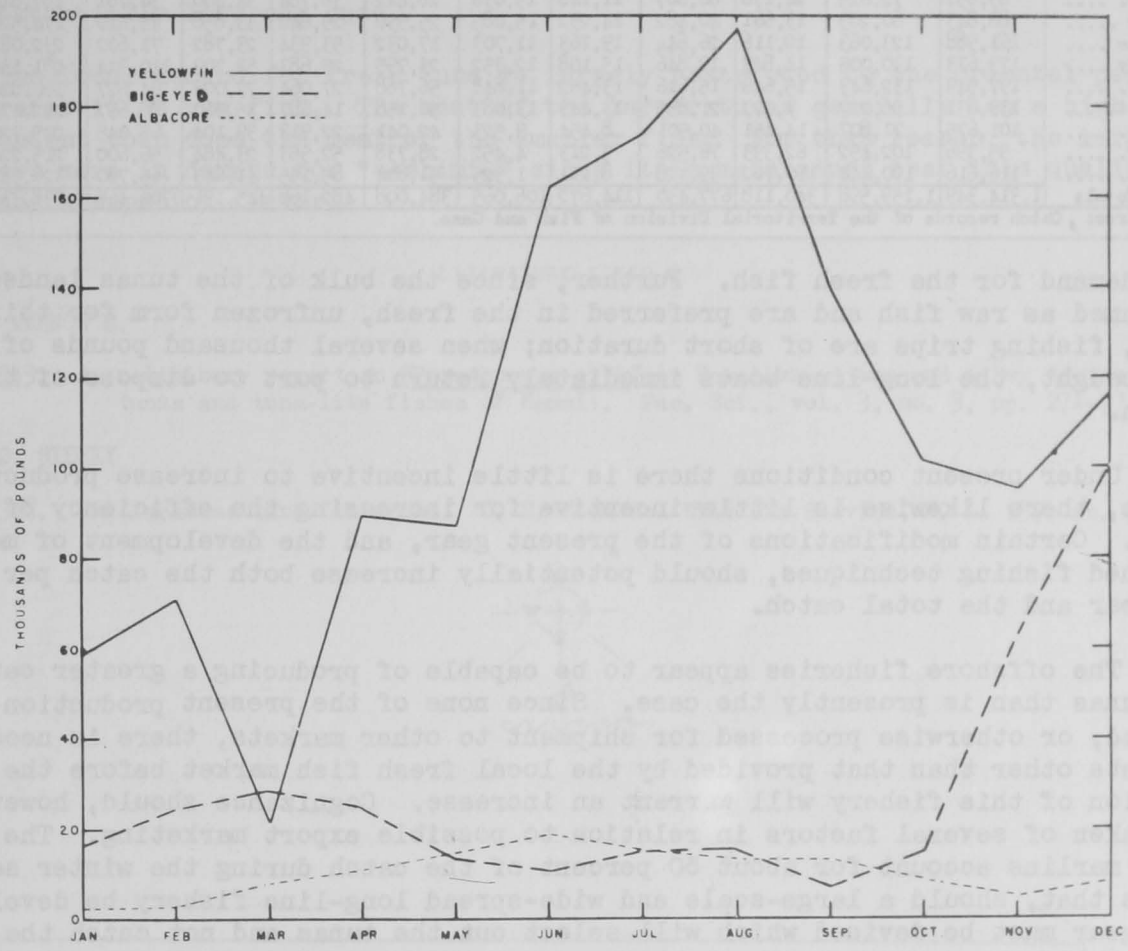

FIGURE 18 - TUNA LONG-LINE CATCH DURING 1947. DATA OBTAINED FROM THE CATCH RECORDS OF THE TERRITORIAL DIVISION OF FISH AND GAME.

of tunas and marlins each day. At present there are no facilities for disposing of large tunas except by local immediate use. Thus, the catch is about equal to

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Table 6 - Species Composition of Long-Line Catch from 87 Boat Trips Landed at Honolulu Market, March through June 1949

Month	March				April				May				June				Totals			
No. of Boat Trips	(32)				(22)				(13)				(20)							
Species	No. of fish Caught	Pct. By No.	Lbs. of Fish Caught	Pct. By Wt.	No. of Fish Caught	Pct. By No.	Lbs. of Fish Caught	Pct. By Wt.	No. of Fish Caught	Pct. By No.	Lbs. of Fish Caught	Pct. By Wt.	No. of Fish Caught	Pct. By No.	Lbs. of Fish Caught	Pct. By Wt.	No. of Fish Caught	Pct. By No.	Lbs. of Fish Caught	Pct. By Wt.
Tuna:																				
Big-eyed	299	33.0	40,576	40.1	206	32.3	32,612	41.0	167	38.8	25,815	46.5	83	13.8	14,251	18.8	755	29.3	113,254	36.3
Yellowfin	12	1.3	1,323	1.3	49	7.7	4,502	5.6	41	9.5	5,303	9.6	220	36.6	31,549	41.7	322	12.5	42,677	13.7
Albacore	12	1.3	734	0.8	3	0.5	159	0.2	15	3.5	690	1.2	68	11.3	4,195	5.5	98	3.8	5,778	1.8
Marlin:																				
Black	64	7.1	20,491	20.3	54	8.5	18,501	23.2	25	5.8	8,648	15.6	34	5.7	10,126	13.4	177	6.9	57,766	18.5
Striped	505	55.8	37,438	37.0	302	47.3	22,061	27.5	163	37.9	13,496	24.3	175	29.1	13,788	18.2	1,145	44.5	86,783	27.8
Short-nose	13	1.5	507	0.5	22	3.4	826	1.0	17	4.0	658	1.2	17	2.8	683	0.9	69	2.7	2,674	0.9
White	0	-	0	-	2	0.3	1,226	1.5	2	0.5	860	1.6	4	0.7	1,061	-	8	0.3	3,147	1.0
Totals	905	-	101,069	-	638	-	79,887	-	430	-	55,470	-	601	-	75,653	-	2,574	-	312,079	-

Table 7 - Tunas and Spearfishes Landed at Hawaiian Ports, By Species, During 1947 and 1948

Month	Yellowfin Tuna		Big-eyed Tuna		Albacore		Striped Marlin		Black Marlin		Totals	
	1947	1948	1947	1948	1947	1948	1947	1948	1947	1948	1947	1948
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jan.	58,277	88,257	14,496	65,161	2,327	376	15,550	33,017	17,013	17,669	107,703	204,480
Feb.	70,494	92,664	24,079	111,920	3,116	7,352	17,392	52,062	35,441	28,373	150,522	292,371
Mar.	21,955	89,162	28,472	78,764	801	3,328	20,318	46,266	29,782	29,557	101,328	247,077
Apr.	89,652	72,625	24,176	80,607	11,146	15,038	28,442	38,784	34,400	34,781	187,816	241,835
May	86,843	60,209	13,661	40,482	14,232	15,085	25,930	29,640	33,858	39,410	174,524	184,826
June	161,988	123,063	10,116	26,644	19,163	11,703	17,032	53,934	23,782	71,602	232,081	286,946
July	173,673	130,005	14,849	19,846	15,108	12,352	23,795	25,683	53,709	110,344	281,134	298,230
Aug.	197,949	132,643	15,646	15,616	13,452	11,848	56,768	27,064	77,009	94,627	360,824	281,798
Sept. ...	139,831	96,227	7,077	21,835	13,449	13,083	56,158	14,687	35,960	86,697	252,475	232,529
Oct.	101,675	71,807	14,451	40,901	8,454	9,523	42,041	22,913	39,104	65,045	205,725	210,189
Nov.	95,396	102,492	62,393	76,526	5,213	4,452	28,738	52,963	23,484	56,600	215,224	293,033
Dec.	116,616	100,444	110,702	99,128	8,211	1,925	51,804	85,155	41,649	65,760	328,982	352,412
Totals	1,314,349	1,159,598	340,118	677,430	114,672	106,065	384,008	482,168	445,191	700,465	2,598,338	3,125,726

Source: Catch records of the Territorial Division of Fish and Game.

the demand for the fresh fish. Further, since the bulk of the tunas landed are consumed as raw fish and are preferred in the fresh, unfrozen form for this purpose, fishing trips are of short duration; when several thousand pounds of fish are caught, the long-line boats immediately return to port to dispose of the catch.

Under present conditions there is little incentive to increase production, hence, there likewise is little incentive for increasing the efficiency of the gear. Certain modifications of the present gear, and the development of more refined fishing techniques, should potentially increase both the catch per unit of gear and the total catch.

The offshore fisheries appear to be capable of producing a greater catch of tunas than is presently the case. Since none of the present production is canned, or otherwise processed for shipment to other markets, there is need for outlets other than that provided by the local fresh fish market before the production of this fishery will warrant an increase. Cognizance should, however, be taken of several factors in relation to possible export marketing. The fact that marlins account for about 50 percent of the catch during the winter season means that, should a large-scale and wide-spread long-line fishery be developed: (1) gear must be devised which will select out the tunas and not catch the marlins (information on the distribution, migrations, and behavior of the species will undoubtedly be of aid in designing such gear), or (2) a market must be created for the disposal of the marlins, which, at present, are not in demand on the main land.

Tunas and spearfishes taken by long line in Hawaiian waters are almost all large fish (see cover picture). The average weights of the various species are shown in Table 8. Black marlins in excess of 1,500 pounds have been landed by the commercial boats. Brock (1949) reports that the maximum weight of the big-eyed tuna landed in these waters approaches or exceeds 300 pounds. Measurements taken on yellowfin tuna during this survey show recorded weights for this species in excess of 225 pounds. While fish of large bulk are preferred by local fresh fish markets, California canneries have a 150-pound limit on tunas. Large-sized tunas are undesirable for canning purposes because, (1) coarse muscle fibers and connective tissues produce a less fancy appearance in the pack,

Table 8 - Average Weights of the Species Taken by Long Line, Landed at the Honolulu Market, January through June 1949

Species	Average Weight
	Pounds
Big-eyed tuna	151.6
Yellowfin tuna	118.9
Albacore	61.3
Striped marlin	77.3
Black marlin	326.6
Short-nose marlin	37.1
White marlin	393.4

(2) processing of large fish tends to limit capacity of precooking equipment and complicates butchering, precooking, cooling, and cleaning procedures, since cooking time and subsequent stages of canning technique are dependant to a considerable degree upon the size of the fish, and (3) because of unfavorable quality differential with large fish, the cash return may be less per ton of raw material, and in some instances, the fish may actually be packed as chunk or grated tuna, selling at substantially less per case.

The local demand for fresh tuna is largely restricted to the Oriental peoples who prefer it as raw fish. The meat of the larger tunas generally has a higher oil content than does the meat of the smaller fish. For this reason, the large fish are more in demand for "sashimi," since it is maintained that this quality produces a superior flavor.

LITERATURE CITED

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1949. A preliminary report on "Parathunnus sibi" in Hawaiian waters and a key to the tunas and tuna-like fishes of Hawaii. Pac. Sci., vol. 3, no. 3, pp. 271-77.

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REFRIGERATED LOCKER STORAGE OF FISH AND SHELLFISH

If fish are placed directly in the refrigerated locker without suitable protective treatment, several undesirable changes will take place during cold storage. A gradual loss of moisture will occur until the fish are shrunken and dried. This dehydration not only causes an unsightly appearance and alteration in texture, but also results in loss in weight and flavor. If fish with appreciable fat content are not protected from the air of the cold storage room, oxidation takes place, causing discoloration and eventually total spoilage due to rancidity.

--Fishery Leaflet 128