COMMERCIAL FISHERIES REVIEW

February 1951 Washington 25, D.C. Vol.13, No.2

PRELIMINARY FISHERIES SURVEY OF THE HAWAIIAN-LINE ISLANDS AREA[1/]

PART III - THE LIVE-BAIT SKIPJACK FISHERY OF THE HAWAIIAN ISLANDS

By Fred C. June*

INTRODUCTION

The Hawaiian name for the skipjack tuna, Katsuwonus pelamis, is "aku." Presumably, it is the same species that is found throughout the tropical waters of the Pacific Ocean and other warm seas of the world (Kishinouye, 1923; Godsil and Byers, 1944). In the waters about the Hawaiian Islands, where it occurs in great numbers, the skipjack is the object of a rather intensive localized fishery. In terms of poundage and value to the fishermen, it is the most important commercial fish in the Territory. In 1948, total skipjack landings for this island group were in excess of 8,355,000 pounds, which was the largest catch since the fishing fleet resumed operations following a break during World War II. The largest annual catch recorded was for 1940, when over 13,420,000 pounds of skipjack, valued at $527,666, were taken from these waters. The previous record catch was in 1937, when landings amounted to over 12,787,000 pounds, valued at $497,037. The annual skipjack production for the period 1937-1948 is shown in figure 1.

During the war years the fishing fleet became virtually inactive, and complete catch records are not available for this period. The fish catch was not reported by species for the first two months of 1944, but skipjack landings for the last ten months of that year amounted to roughly 732,000 pounds. By the end of 1945, the skipjack fleet had regained its prewar size; however, fishing that year proved to be poor, and the total production amounted to only 3,907,000 pounds.

As in the United States, the skipjack is utilized primarily for canning. The bulk of the catch in the Islands is processed by a single cannery which packs the fish for the local market and for shipment to the U. S. mainland. Important quantities are also sold on the fresh market, for the skipjack is an important item in the diet of many of the Oriental peoples, who prefer it in the raw form or as dried fish.

TABLE OF CONTENTS

* FISHERY RESEARCH BIOLOGIST, SECTION OF RESEARCH AND DEVELOPMENT, PACIFIC OCEANIC FISHERY INVESTIGATIONS, U. S. FISH AND WILDLIFE SERVICE, HONOLULU, T. H.

1/ PART I - "THE HAWAIIAN LONG-LINE FISHERY," BY THE SAME AUTHOR APPEARED IN COMMERCIAL FISHERIES REVIEW, JANUARY 1950, PP. 1-23 (ALSO AVAILABLE AS SEPARATE NO. 244); PART II - "NOTES ON THE TUNA AND BAIT RESOURCES OF THE HAWAIIAN, LEEWARD, AND LINE ISLANDS," APPEARED JANUARY 1951, PP. 1-22 (ALSO AVAILABLE AS SEPARATE NO. 270).

DESCRIPTION AND NOTES ON BIOLOGY OF SKIPJACK

The skipjack, Katsuwonus pelamis (Linnaeus 1758), is a member of the tuna family (Thunnidae), although many taxonomists consider this species sufficiently distinct from other members of the tuna group to warrant placing it, together with the genera Euthynnus and Auxis, in a separate family (Katsuwonidae). The skipjack is a circumtropical species, ranging into temperate waters only during the warmer months. In the Pacific it is distributed from the coast of Canada off Vancouver Island southward along the coastlines of the United States and Central America to Chile, westward through the Hawaiian, Caroline, Marshall, and Marianas islands to St. Helens in Tasmania, thence northward through the southern parts of New South Wales, the Republic of the Philippines, Formosa, and along the entire Pacific Coast of Japan to northern Hokkaido (Kishinouye, 1923; Herre, 1940; Serventy, 1941; Clemens and Wilby, 1946; Roedel, 1948; Shapiro, 1948; Imamura, 1949). It is also found on both sides of the Atlantic, the Mediterranean Sea, and the Indian Ocean (Gunther, 1860; Day, 1878; Breder, 1929; LaMonte, 1945).

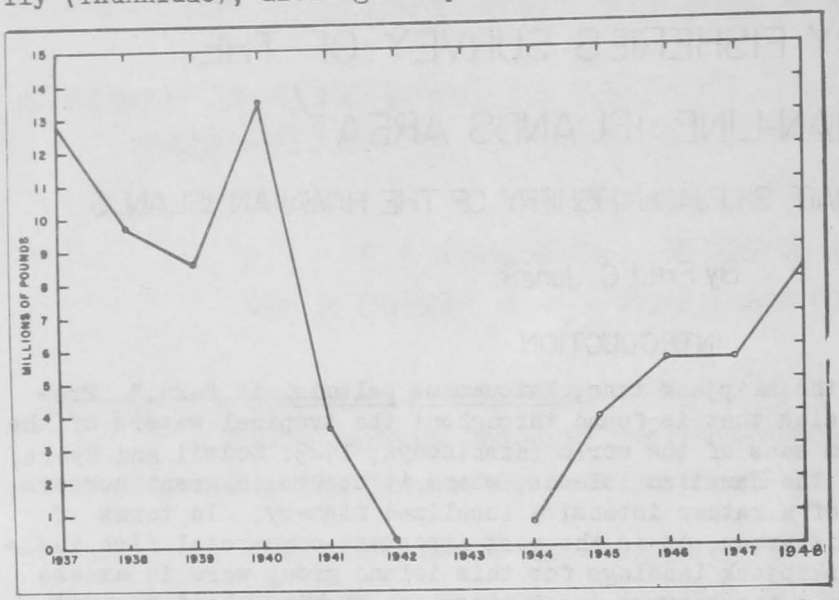

FIGURE 1 - SKIPJACK LANDINGS IN THE TERRITORY OF HAWAII, 1937-48. (NO DATA AVAILABLE FOR 1943. CATCH FOR 1944 INCLUDES MARCH THROUGH DECEMBER ONLY. DATA OBTAINED FROM THE CATCH RECORDS OF THE TERRITORIAL DIVISION OF FISH AND GAME).

The skipjack may be recognized by the four or more dark longitudinal stripes on the silvery belly and along the sides below the lateral line. The back is dark bluish-violet in life, becoming faded when the fish dies. The structure of the body is remarkably streamlined, with the first dorsal, pectoral, and ventral fins fitting into grooves when they are folded back. The body is nearly round in cross-section and pointed at both ends; it is naked except for a corselet of scales in the region around the pectoral fins and a few minute scales scattered over the remainder of the body. There is a median keel on each side of the slender caudal peduncle. A series of 7 to 9 finlets follow the second dorsal and anal fins. The head is rather large and conical. The mouth is terminal in position, with a single row of teeth on both jaws. The skipjack reaches a maximum weight of about 40 pounds. In Hawaiian waters the average size taken by the commercial fishery is approximately 15 pounds.

The skipjack is a fast-swimming, migratory fish that characteristically travels in schools which are often composed of many hundreds or even thousands of individuals. The schools found in Hawaiian waters are generally rather small, although Herre (op. cit.) mentions one school reported off the coast of Oahu that was about ninety miles long and ten miles broad. It has been demonstrated (Schaefer, 1948) that this species shows a marked tendency to aggregate by similar sizes. Schools are often encountered in which big-eyed and yellowfin tuna of comparable sizes travel together with skipjack.

Recent studies by Japanese investigators (Imamura, op. cit.; Suyehiro, 1938) on the feeding habits and stomach contents of this species have shown that its food consists of a great variety of organisms, the most important of which include squid, crustacea, sardines, anchovies, flying fish, etc. Kishinouye (op. cit., p. 454) stated that the food of the skipjack taken in Japanese waters generally consisted of "medium-sized plankton: amphipods, Squilla's larvae and other crustaceans, pteropods, heteropods (chiefly Atlanta), calamaries, and immature or small fishes, etc."

Little is known concerning the spawning and early development of the skipjack inhabiting the Pacific Ocean. There is evidence, however, that one of the spawning areas for this species occurs in the eastern Pacific off the coast of Central America. Schaefer and Marr (op. cit.) report the capture of two juvenile specimens, 21 mm. and 44 mm. total length, in the oceanic waters off Costa Rica and upper Panama. Sexually mature and spent adults were also found to be present in the same area during the early months of the year. Marr (ibid.) indicates that a spawning ground for this species probably exists in or near the northern Marshall Islands area during the summer months. In addition, juvenile specimens, 113 to 183 mm. in length, have been collected in the vicinity of the Hawaiian Islands during the summer months (Eckles, 1949). There is some evidence that spawning also occurs in many other places in the Pacific (Kishinouye, 1927; Matsui, 1942; Hatai et al, 1941). Present knowledge indicates that the eggs, larvae, and juveniles, like the adults, are entirely pelagic.

DEVELOPMENT OF THE FISHERY

The skipjack fishery in the Hawaiian Islands has developed from a small-scale subsistence fishery carried on by the early native Hawaiians to the commercial fishery of today, conducted mostly by fishermen of Japanese ancestry. From the earliest times, Hawaiian fishermen sought the skipjack in the waters lying adjacent to the small villages scattered throughout the major islands in this group. The methods of capture and fishing gear used by these natives were similar to those employed in other parts of Polynesia (Beckley, 1883). The outrigger canoe was the characteristic craft found throughout this vast area. The canoes which were used for fishing in Hawaii varied from about 15 to 35 feet in length (Hornell, 1936). The smaller canoes usually carried but a single fisherman; however, when fishing specifically for skipjack, frequently several fishermen would combine forces. Two of the large canoes from which the outriggers had been removed were lashed parallel to each other with two cross-pieces. This simple arrangement provided a much safer sea-going craft than a single canoe carrying a lone fisherman, for the search for the skipjack often carried the fishermen considerable distances offshore. A double fishing canoe carried a crew of three in each hull, although only one man in each was actually occupied with the fishing; the others managed the canoe. The canoes were sometimes rigged with a single sail, but paddles were the most common means of propelling these craft.

The fishing technique used by the native Hawaiians for catching the pelagic skipjack were, in certain respects, similar to those practiced in the Islands today. Cobb's report, "The Commercial Fisheries of the Hawaiian Islands," published in 1903, gives an interesting account of native fishing:

> "ON REACHING THE FISHING GROUND THE FISHERMEN LOCATE THE FISH BY WATCHING THE SEA GULLS....AS SOON AS THE SCHOOL HAS BEEN SIGHTED THE CANOES ARE WORKED AROUND IN FRONT OF IT, AND THE FISH ARE ATTRACTED TOWARD THE BOAT BY MEANS OF A HANDFUL OR TWO OF SMALL LIVE BAIT THROWN INTO THE WATER.... TWO MEN STAND UP IN THE STERN OF THE BOAT, HOLDING IN THEIR HANDS A BAMBOO POLE ABOUT 12 FEET LONG WITH A LINE OF THE SAME

LENGTH ATTACHED, AND THE PEARL HOOK TIED TO THE END OF THIS LINE. BY A QUICK MOVEMENT THE LINE AND HOOK ARE SLAPPED VIOLENTLY ON THE SURFACE OF THE WATER AND THEN DRAWN TOWARD THE BOAT.... AS SOON AS THE FISH IS HOOKED, THE LINE IS SWUNG UP OVER THE FISHERMAN'S HEAD SO AS TO MAKE ALMOST A COMPLETE REVOLUTION. IT IS VERY NECESSARY THAT THE LINE SHOULD BE KEPT TAUT, AS, OWING TO THE FACT THAT THE HOOK HAS BUT A SLIGHT BARB, THE FISH WOULD SHAKE ITSELF LOOSE SHOULD THE LINE SLACKEN IN THE LEAST... AS THE HOOKED FISH IS DESCRIBING THIS REVOLUTION THE FISHERMAN SWINGS AROUND TO MEET IT AS IT NEARS HIM, BOWING OUT HIS RIGHT ARM. WHEN THE FISH COMES BETWEEN HIS ARM AND SIDE HE CLOSES THEM UP AND THE FISH IS CAUGHT, UNHOOKED, AND DROPPED INTO THE BOAT.

Containers of several different types were used for carrying live bait. The double fishing canoes usually carried a box about 20 feet long, 2 feet high, and 16 inches wide, lashed below the cross-pieces between the canoes. The sides and bottom of the box were perforated to allow sea water to enter and circulate.

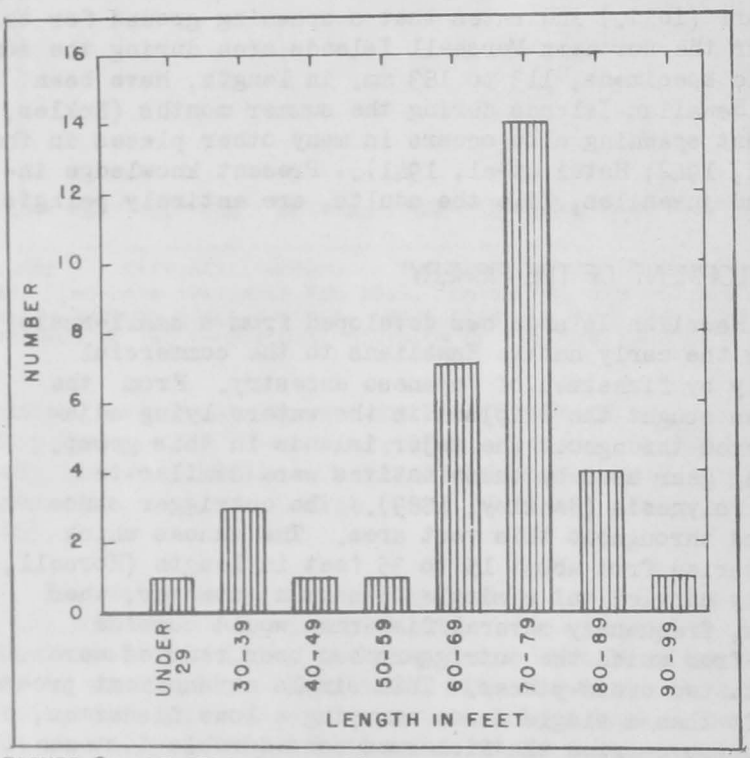

FIGURE 2 - LENGTHS OF THE 32 BOATS THAT FISHED EXCLUSIVELY FOR SKIPJACK IN THE TERRITORY OF HAWAII IN 1948.

At the time of Cobb's report, the skipjack fishery had already emerged as one of the more important commercial fishery enterprises in the Hawaiian Islands. In 1900, skipjack ranked fifth in poundage among the various commercial species caught in these waters, and total landings for that year amounted to slightly over 422,000 pounds. Of this catch approximately 401,000 pounds were sold on the fresh market, with the remaining 21,000 pounds processed as dried skipjack.

The early commercial development of the skipjack fishery in the Islands was due primarily to the efforts of the Japanese immigrants. According to a report, "Investigation on Fishing in Foreign Countries," published in 1938 by the Japanese government fisheries bureau, the first alien to be engaged in commercial operations in the Territory was a man named Kametaro Nishimura, an emigrant from Yamaguchi-ken, who began fishing here in 1885. It is not definitely stated, however, that Nishimura fished specifically for skipjack. In 1899, Gorokichi Nakasuji, a native of Wakayama-ken brought a fishing boat and gear from Japan to Hawaii and began fishing commercially for skipjack. Following the introduction of Japanese fishing methods and gear, the fishery underwent a period of rapid expansion.

The skipjack boats used by the early Japanese fishermen were of the sampan design. These boats were typically about 20 feet in over-all length, with a $4\frac{1}{2}$-foot beam, and a 16-inch draft. They were usually propelled by a scull, although many of the boats were also rigged for sails. Each was fitted with an overhanging stern which housed the rudder. There was a series of wells built into the center of the boat in which live bait was carried. The wells were from 12 to 15 inches deep and fitted with screened holes along the bottom to allow sea water to enter and circulate in the wells when the boats were under way. Most of the sampans carried a fishing crew of from 4 to 6 men.

The first gasoline-powered skipjack boat in the Islands was successfully operated in 1907. Soon afterward, larger boats were designed with many new features, making it possible for practical fishing operations to be carried on at increasingly greater distances offshore. Many of the improved features which were incorporated in the development of these boats have been attributed to a Japanese fisherman named Kitayama, who was active in the fishery in the 1930's. The first flying bridge was installed in 1931, and the first pump-spray systems, which are used during fishing, were added around 1935. Beginning about 1939, the design of the hull was altered to allow more freeboard forward.

FIGURE 3 - A TYPICAL SAMPAN-TYPE FISHING BOAT USED IN THE HAWAIIAN SKIPJACK FISHERY.

The 1948 fishing fleet was comprised of 32 boats that fished exclusively for skipjack. Of these, 21 boats were based at Honolulu; 4, on the island of Maui; and 7, on the island of Hawaii. In addition to the regular fleet, there were a number of small boats that operated seasonally from various ports throughout the islands.

FISHING BOATS AND CREWS

The present-day Hawaiian skipjack boats have evolved from the Japanese sampan-type tuna boats which were introduced in these waters around 1900. Various modifications in design have given rise to a distinct type of vessel adapted to local needs and conditions. These boats have a high narrow bow, with moderate freeboard aft, and vary from 29 to 92 feet over-all (figure 2). The majority of the boats in the fleet are from 70 to 88 feet in length, with a beam of from 13 to 16 feet. They are powered by Diesel engines of either the slow-speed, heavy-duty type, ranging from 135 to 250 h.p. or of the high-speed type, ranging from 165 to 330 h.p. The general features of this type of vessel are shown in figures 3 and 4.

FIGURE 4 - DECK ARRANGEMENT OF A TYPICAL SKIPJACK FISHING BOAT, KEWALO BASIN, HONOLULU.

These boats are completely decked and fitted

with a pilothouse and flying bridge amidships. The engine room and a low trunk cabin are forward, with sleeping quarters for the crew provided in the forecastle and the pilothouse. The boats are equipped with radio, but only a few have adequate navigational equipment to permit long-range sea trips. There are from 2 to 6 live-bait wells fitted below the main deck abaft the engine room. Only two of the boats in the fleet are equipped with pump-circulating systems in the bait wells. On the remaining vessels, circulation is provided by a series of screened holes along the bottom of the well which allow sea water to enter when the boats are underway. If bait is carried aboard these vessels while lying at anchor in quiet water, it is necessary for the crews to rock the boats to insure proper circulation in the well; however, on boats that have pumps installed for fraining the bait wells, the pumps are used to circulate water in the wells when hove to under these conditions.

A sponson extends along both sides of the after deck and across the stern. It is from $3\frac{1}{2}$ to 4 feet wide and is raised about 2 feet above deck. Storage space is provided here for food and water. The sponson usually also houses a gasoline stove, since very few of the boats have any sort of galley. The skiff is lashed along the starboard side of the raised trunk cabin.

These boats are equipped with a series of nozzles spaced at 4-foot intervals across the stern and along the after port and starboard gunwales through which sea water is pumped during fishing. It is claimed that the spray excites the skipjack into biting; in addition, the spray may also serve to screen the boat and movements of the fishermen.

Stowage for the catch is provided in the bait wells as they are emptied of bait during fishing. Since most boats operate on daily runs out of port, refrigeration is not essential. However, an ice load of about 3,000 pounds is usually carried to insure preserving the catch should a fishing trip last several days. The total carrying capacities of the boats vary from about 10 to 30 tons.

The crews of the skipjack boats are predominantly of Japanese extraction. The larger boats in the fleet maintain crews of from 9 to 13 men, while some of the smaller boats employ crews of only 3 or 4. The crew consists of a captain, an engineer, and the fishermen. Usually one of the more experienced members of the fishing crew does the chumming.

Fishing is done on a share basis. The crews are usually paid at the end of each week, after operating expenses, such as fuel, oil, and ice, have been deducted from the gross. The boat owner's share is 30 percent; the captain receives a 5 percent bonus, and the remaining 65 percent is divided equally among the crew. Food expenses for the fishing trip are usually deducted from the crew's share, with all other than the above mentioned expenses being paid by the boat owner.

FISHING GEAR

The gear used for catching skipjack consists of a bamboo pole, to which is attached a length of line bearing a hook at its end. The poles, the largest of which are from $2\frac{1}{2}$ to 3 inches in diameter at the butt, vary from $7\frac{1}{2}$ to 15 feet in length. The shorter poles are generally used for landing fish weighing over 20 pounds, while the longer poles are used for catching fish of smaller size. A small loop of linen is seized to the upper end of the pole, to which is fastened a 6- to 12-foot length of line. The line is fabricated by hand by twisting together 2 strands of size 40-3 or 50-3 Irish linen thread, with from 5 to 10 threads to a strand. A 12- to 16-inch

length of galvanized or piano-wire leader, which bears the hook, is attached to the lower end of the line. The leader is fastened by a short length of linen line in such a manner that it may be rapidly removed and changed during fishing. A 2-inch loop of linen line at the lower end of the leader provides for attachment of the hook.

Galvanized barbless hooks are used in various sizes to suit the size of fish taken. A plain hook is used for fishing with live bait when the skipjack will not take the more commonly used artificial jig or striker. The jig consists of a hook, the shank of which is embedded in tubular lead or brass. Various colored feathers or threads are added to make an attractive lure. A bit of dried "mahimahi" (Coryphaena hippurus) skin or a short length of quill is fastened around the base of feathers to prevent fraying. Hooks of various types are shown in figure 5.

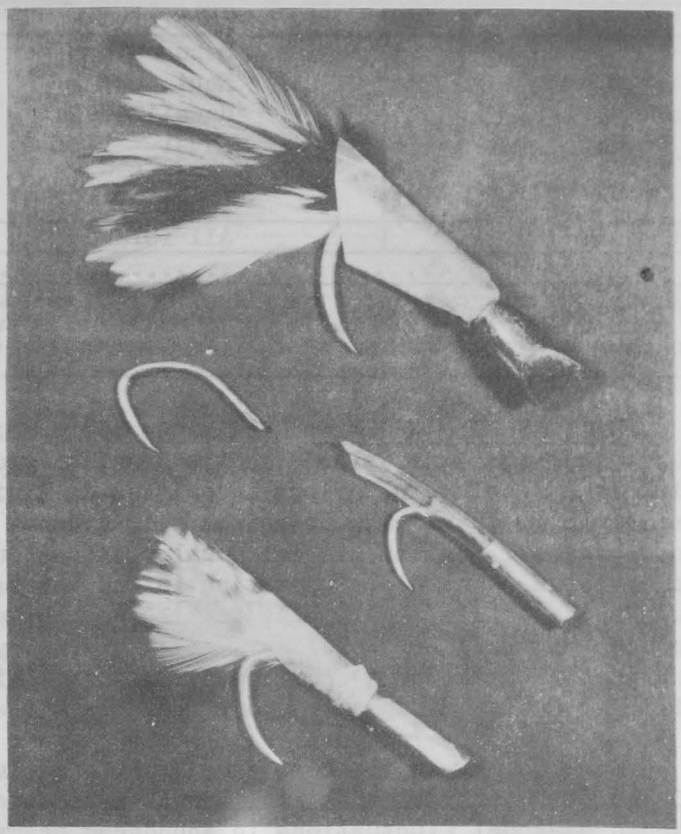

FIGURE 5 - VARIOUS HOOKS USED IN THE HAWAIIAN SKIPJACK FISHERY. THE UPPER JIG IS AN IMPORTED JAPANESE HOOK. THE BARE HOOK AT LEFT CENTER IS USED WHEN FISHING WITH LIVE BAIT. THE REMAINING TWO JIGS ARE OF THE TYPES MOST COMMONLY USED.

BAIT

BAIT SPECIES: Live bait is essential in pole-and-line fishing for skipjack. Several different types of small fish are used, depending upon their availability. The most common bait fish in Hawaiian waters is a small anchovy, with the local name "nehu," (Engraulis purpureus Fowler). It is a small omnivorous shore fish that occurs in schools over sand and mud bottoms in most of the larger bays and inlets that fringe the coastlines. It appears to have a rather short life cycle and grows to a maximum length of about 3 inches. This species is preferred above all others by the skipjack fishermen because, in addition to its good survival qualities in the bait wells, it characteristically "schools up" close to the boat when scattered as chum. Furthermore, nehu are not overly active in the water, and for this reason, the skipjack do not strike the hooks excessively hard in response to the chum. Nehu comprise about 95 percent of the total bait catch in the Territory (table 1).

The second most important species used for live bait is a member of the silversides family, to which belongs the jack smelt and the grunion found off the Pacific Coast of the United States. This bait fish is known locally as "iao" (Atherina insularum Jordan and Evermann), and although it is not as abundant in this locality as the nehu, it is a much hardier bait and is readily taken by the skipjack. Many fishermen claim, however, that because of the larger size of the iao, it is not as suitable for bait as the nehu. Several members of the herring family (Spratelloides delicatulus Bennett, locally called "piha" and Etrumeus micropis Schlegel, called "makiawa"), when obtainable, are also utilized.

Table 1 - Live Bait Fish Catch in Boxes[1/] Taken by the Skipjack Boats, Territory of Hawaii, 1946-48

Species	Locality	1946	1947	1948
Nehu	Oahu	2,788	3,615	4,193
	Maui	1,134	908	1,899
	Hawaii	235	245	624
	Kauai	12	89	155
	Molokai	34	25	82
	Lanai	-	-	15
Other Bait Fish	All Islands	107	243	339
Totals		4,310	5,125	7,307

1/USUALLY 6 BUCKETS OF BAIT ARE PLACED IN EACH BAIT WELL WHICH IS CALLED A BOX. (A BUCKET MAY CONTAIN ANYWHERE FROM 25 TO 75 PERCENT FISH BY VOLUME. (SEE TEXT, PP. 10 AND 12)
SOURCE: BASED ON CATCH RECORDS OF THE TERRITORIAL DIVISION OF FISH AND GAME.

BAIT FISHING GROUNDS: While the above bait species are generally distributed throughout the main islands in the Hawaiian group, the relative abundance of the different species in various localities is limited by the habitats of suitable types available to them. The principal bait grounds on the island of Oahu are Kaneohe Bay, Pearl Harbor, and the Ala Wai Canal, with secondary areas located at Heeia, Waikane, and Waialua. The boats operating in the waters adjacent to the island of Hawaii obtain the bulk of their bait in Hilo Bay, Kawaihae Bay, and Kalihi. The chief bait grounds off Maui are Kehei Bay, and Maalaea Bay, while along the coast of Molokai, Kaunakakai is the only area worthy of note. Minor bait grounds also occur at Nawiliwili Bay and at Hanapepe Bay off the island of Kauai.

Kaneohe Bay is the most consistently employed baiting ground of all. Between 50 and 60 percent of the total annual nehu catch is taken from this area alone. Although seasonal fluctuations in abundance occur, both nehu and iao, as well as the other species mentioned, can be taken here throughout almost the entire year. Pearl Harbor supports considerable quantities of both nehu and iao, but baiting operations in this area have been restricted by various Naval regulations, and for this reason, it has not been visited by the skipjack boats as often as some of the other areas.

The available bait supply in the main Hawaiian islands is not greatly in excess of the needs of the present fleet, and any great increase in the number of live-bait fishing boats using these baiting grounds is not to be expected. Hence, much expansion and development of the live-bait fishery for skipjack in these waters would require that bait be obtained from other regions. Such areas as those adjacent to French Frigate Shoals and other islands in the leeward chain may prove to be substantial baiting grounds. Iao, for example, are known to occur in quantities at times in the vicinity of French Frigate Shoals (Smith and Schaefer, 1949; Eckels, 1949). Other species suitable for use as live bait have also been captured in the same area.

METHODS OF CAPTURE: Lift nets are used at night for catching nehu and piha. The nets are from 15 to 25 fathoms long and about 12 fathoms deep. The dimensions and rigging of a net of this type are shown in figure 6. This gear is operated in combination with a submarine light which is used to attract the fish as the fishing boat lies at anchor over the bait grounds. The light is attached to the end of a pole and supported about 20 feet out from the port side of the boat. To prevent the light from splashing and possibly frightening the fish as the boat rolls, the globe is hung several feet below the surface of the water. The light is turned on about dark, and it is usually left on until about an hour before daybreak when a bait haul is made. If bait is especially plentiful, the net may be set whenever

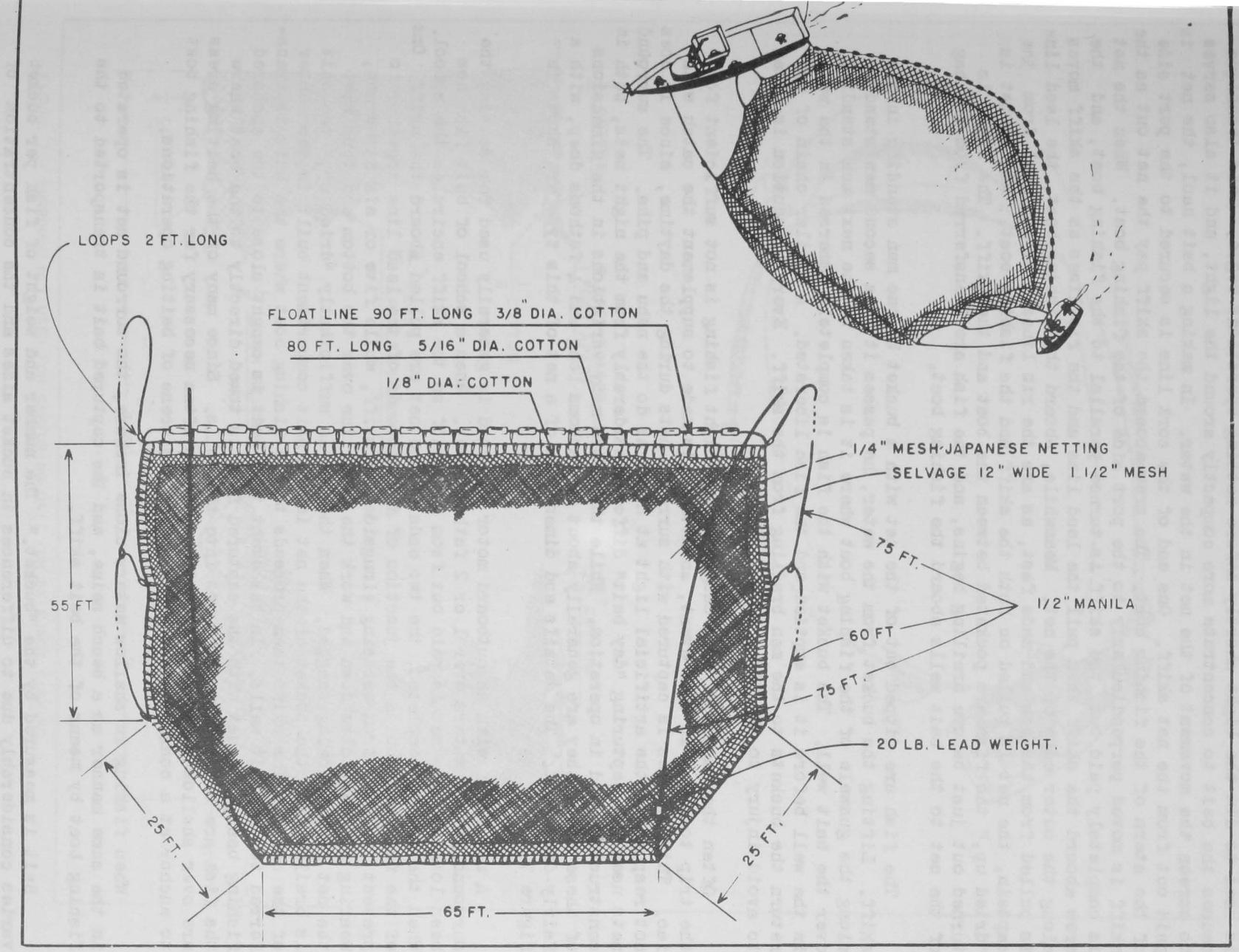

FIGURE 6 - LIFT NET USED FOR CAPTURING BAIT FOR SKIPJACK FISHING

sufficient numbers of fish have been attracted by the light. Frequently, a rheostat is used to dim the light shortly before netting operations begin. This technique causes the bait to concentrate more compactly around the light, and it also serves to screen the movement of the net in the water. In making a bait haul, the net is paid out from the net skiff. One end of the cork line is secured to the port side of the stern of the fishing boat. The crew aboard the skiff pay the net out as the skiff is moved perpendicularly to the port side of the fishing boat. When the net is completely paid out, the skiff is turned parallel to the fishing boat, and the crew aboard the skiff then pull the lead line and the rib lines as the skiff moves along the outer edge of the net. Meanwhile, aboard the fishing boat, the lead line is pulled from the bow and made fast, as are the rib lines. At a signal from the captain, the net is pulled on both the skiff and the fishing boat. As the net is "dried up," the fish are pocketed between the boat and the skiff. The light is turned out just before brailing begins, and the fish are transferred from the bag of the net to the bait wells aboard the fishing boat.

The fish are dipped out of the net with a bucket by one man standing in the skiff. Lifting the bucket from the water, he passes it to a second man standing along the gunwale of the fishing boat where it is taken by the next man standing over the bait well. The bucket with the fish is completely immersed in the water in the well before it is emptied and the fish liberated. A similar chain of men return the buckets to the man brailing from the skiff. Every precaution is taken to avoid injury to the fish.

Often the amount of bait caught during night fishing is not sufficient for the trip to sea. In this event, an attempt is made to supplement the catch with iao. This species is captured with surround nets during the daytime, since it does not respond to the artificial light at night as do the nehu and piha. The surround nets used for capturing "day bait" differ considerably from the night nets, both in construction and in operation. While there are many variations in the dimensions of these nets, they are generally about 80 fathoms long and 4 fathoms deep, with a fairly deep bunt. The details and dimensions of a net of this type are shown in figure 7.

A net skiff with an outboard motor attached is generally used for setting the surround net in waters over 1 or 2 fathoms deep. When a school of bait fish has been located, the net is paid out from the skiff as the skiff encircles the school. When the set is completed, the two ends of the net are pulled aboard the skiff. One of the fishermen holds the junction of the two ends of the lead line together to prevent the fish from escaping alongside the skiff, while five or six fishermen, wearing goggles, dive down and work the lead line over the bottom and thus keep the net from becoming snagged. When the net is sufficiently "dried up," the bait is brailed from the pocket of the net into a bait compartment built in the center of the skiff. The skiff then proceeds to the fishing boat where the bait is transferred to the bait wells. In the event that bait is caught close to the anchored fishing boat, the net with the captured fish is towed directly to the boat where the fish are brailed from the net into the wells. Since many of the baiting areas are over shallow coral-studded bottoms, it is often necessary for the fishing boat to anchor at a considerable distance from the scene of baiting operations.

When fishing in shallow waters close inshore, the surround net is operated in the same manner as a beach seine, and the captured bait is transported to the fishing boat by means of the bait skiff.

Bait is measured by the "bucket." The number and weight of fish per bucket varies considerably due to differences in bucket sizes and the concentration of

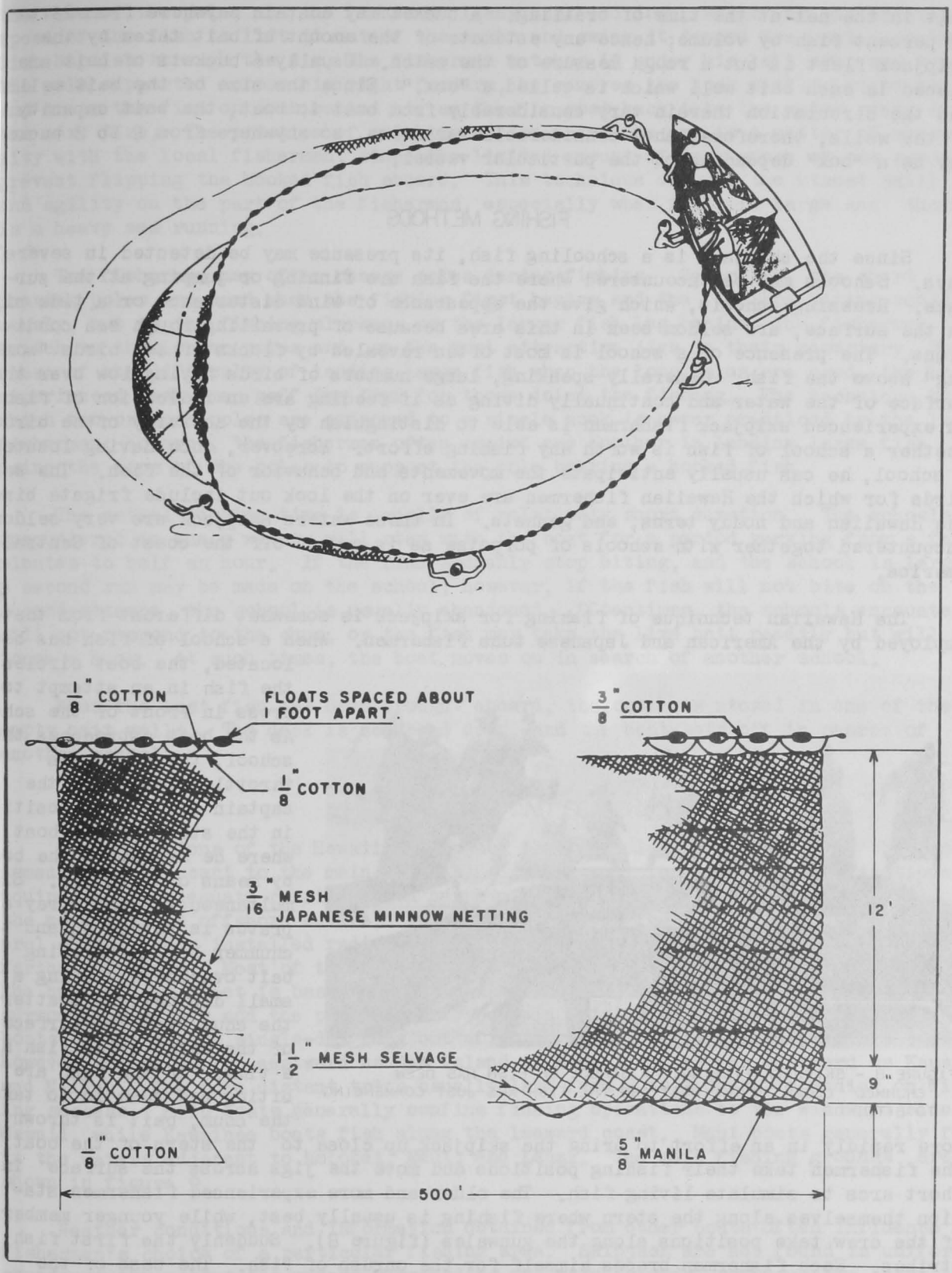

FIGURE 7 - SURROUND NET USED FOR CAPTURING BAIT FOR SKIPJACK FISHING.

bait in the net at the time of brailing. A bucket may contain anywhere from 25 to 75 percent fish by volume; hence any estimate of the amount of bait taken by the skipjack fleet is but a rough measure of the catch. Usually 6 buckets of bait are placed in each bait well which is called a "box." Since the size of the bait wells and the circulation therein vary considerably from boat to boat, the bait capacity of the wells, therefore, show considerable variation, so anywhere from 4 to 8 buckets may be a "box" depending on the particular vessel.

FISHING METHODS

Since the skipjack is a schooling fish, its presence may be detected in several ways. Schools may be encountered where the fish are finning or jumping at the surface. Breezing schools, which give the appearance of wind disturbance or a tide rip on the surface, are seldom seen in this area because of prevailing rough sea conditions. The presence of a school is most often revealed by flocks of sea birds "working" above the fish. Generally speaking, large numbers of birds flying low over the surface of the water and continually diving as if feeding are an indication of fish. An experienced skipjack fisherman is able to distinguish by the activity of the birds whether a school of fish is worth any fishing effort. Moreover, once having located a school, he can usually anticipate the movements and behavior of the fish. The sea birds for which the Hawaiian fishermen are ever on the look out include frigate birds, the Hawaiian and noddy terns, and gannets. In these waters skipjack are very seldom encountered together with schools of porpoise as is common off the coast of Central America.

The Hawaiian technique of fishing for skipjack is somewhat different from that employed by the American and Japanese tuna fishermen. When a school of fish has been located, the boat circles the fish in an attempt to cross in front of the school. As the boat approaches the school, the engine is throttled down, and the captain takes up a position in the stern of the boat, where he maneuvers the boat by means of a tiller. Simultaneously, the spray apparatus is turned on and the chummer begins throwing bait overboard. Using a small dip net, he scatters the chum over the surface of the water a few fish at a time. If the fish are biting and rush in to take the chum, bait is thrown more rapidly in an effort to bring the skipjack up close to the stern of the boat. The fishermen take their fishing positions and move the jigs across the surface in short arcs to simulate living fish. The older and more experienced fishermen station themselves along the stern where fishing is usually best, while younger members of the crew take positions along the gunwales (figure 8). Suddenly the first fish strikes. Each fisherman braces himself for the onrush of fish. The base of the pole rests against a denim pad hung in front of the groin. The left hand grips the pole and the right hand is free. When a fish strikes, the right hand quickly grasps

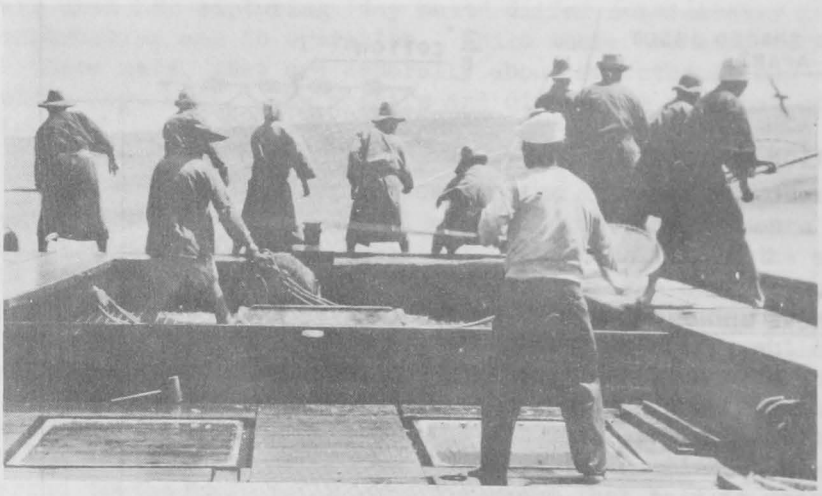

FIGURE 8 - SKIPJACK FISHING. A SCHOOL OF FISH HAS BEEN "CHUMMED" CLOSE TO THE BOAT AND THE FISH ARE JUST COMMENCING TO BITE.

the base of the pole, and the fisherman leans back and down, utilizing the initial speed of the fish to lift it out of the water and swing it toward the boat. As the fish hurtles through the air, the fisherman catches it under his left arm, and with the pole supported across his right forearm, he removes the hook with his right hand and drops the fish on deck behind him as the jig goes back into the water ready for the next fish. The practice of catching a fish under the arm is a matter of necessity with the local fishermen, since the limited amount of deck space on the sampans prevent flipping the hooked fish aboard. This technique demands the utmost skill and agility on the part of the fisherman, especially when fish are large and there is a heavy sea running.

The fishermen may often change poles during fishing. Generally, the short heavier poles are used when the fishing first begins and the fish are biting continuously, but as the fishing slackens or the larger fish lag behind, the fishermen switch to the longer poles and use the most attractive jigs in their repertory. Because of the difficulty of landing large fish when the long poles are used, the less experienced fishermen gaff the fish for those doing the fishing. The technique by which two or more poles are attached to a single hook is never practiced by the local fishermen; however, the fishermen often assist one another in landing large fish by using the tips of the poles to support the pole bearing a hooked fish.

The actual fishing time is usually of relatively short duration. The schools encountered in these waters will stay with the boat for a period varying from a few minutes to half an hour. If the fish suddenly stop biting, and the school is large, a second run may be made on the school; however, if the fish will not bite on the second attempt, the school is usually abandoned. Oftentimes, the schools encountered will not respond to the chum, or the fish may take the live bait readily but will not touch a hook. At such times, the boat moves on in search of another school.

When the last fish has been brought aboard, the catch is stowed in one of the empty bait wells. The deck is scrubbed down, and the boat sets off in search of another school.

FISHING AREAS AND SEASONS

The operations of the Hawaiian skipjack fleet are largely confined to the waters immediately adjacent to the main islands. In the past, lack of proper navigational equipment and adequate refrigeration has limited the extension of the fishery into the more distant offshore waters. It has been only during the 1949 season that several of the boats installed radio direction finders which permitted them to venture farther offshore. Most of the fishing is centered around the island of Oahu, since the bulk of the fleet is based at Honolulu. Moreover, the presence of fish in the surrounding waters and the proximity of the main baiting grounds permit many of the boats to operate on single-day runs out of port. Some of the larger Honolulu boats, however, range as far eastward as the island of Hawaii and as far westward as Kauai and Niihau. The more distant trips usually last from 2 to 3 days, depending on fishing success. Hilo boats generally confine fishing operations to the windward side of Hawaii, while Kawaihae boats fish along the leeward coast. Maui boats generally fish in the waters adjacent to Molokai, Maui, and Lanai. The main fishing grounds are shown in figure 9.

Weather conditions and information obtained from other boats often influence the fishermen's choice of a particular fishing area. Skipjack are not found in uniform abundance throughout the waters surrounding the main islands, consequently, considerable time on occasions may be spent in searching for schools of fish. Most of the boats fish throughout the year except for periodic maintenance lay-ups. The winter

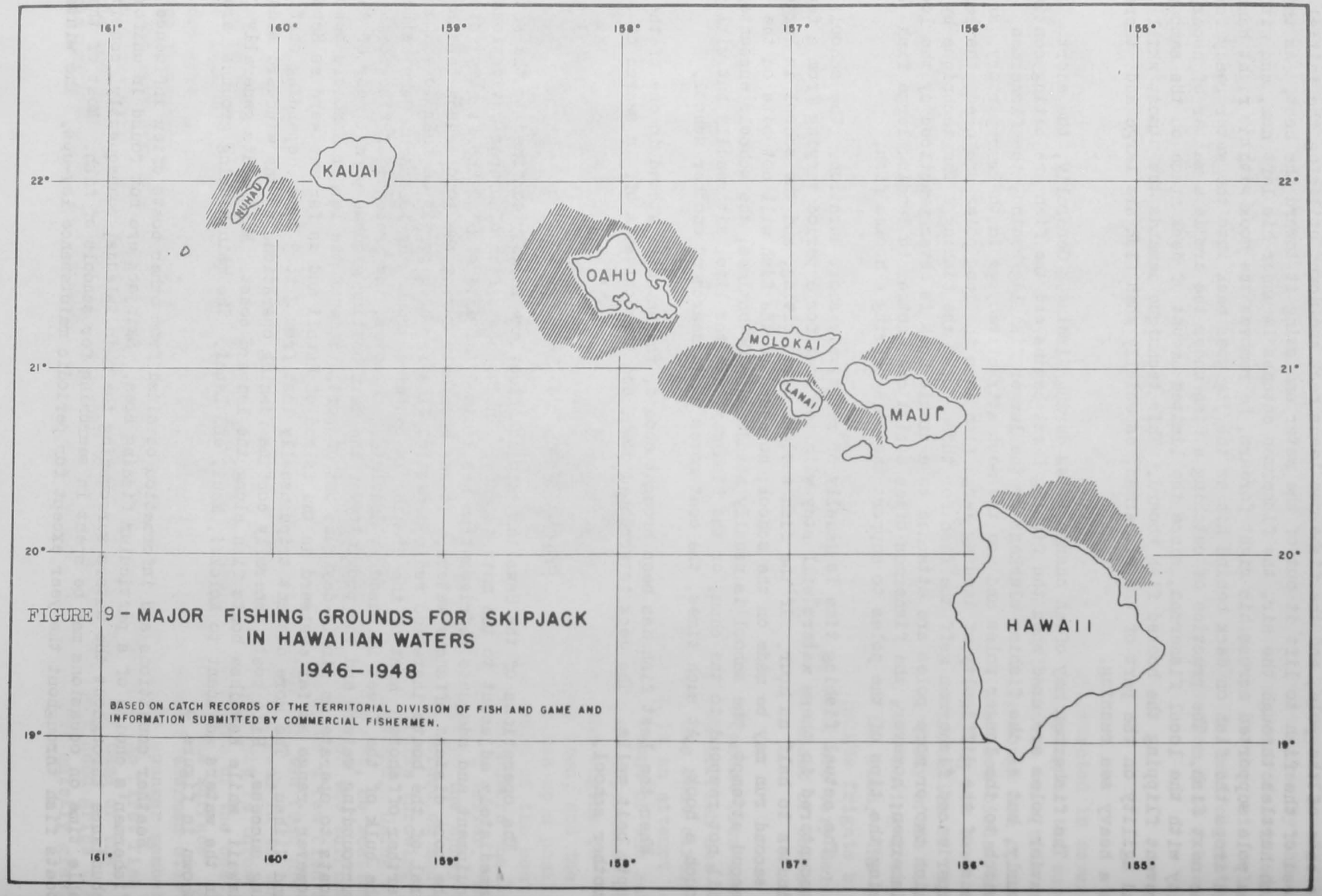

FIGURE 9 - MAJOR FISHING GROUNDS FOR SKIPJACK IN HAWAIIAN WATERS 1946-1948

BASED ON CATCH RECORDS OF THE TERRITORIAL DIVISION OF FISH AND GAME AND INFORMATION SUBMITTED BY COMMERCIAL FISHERMEN.

season is slack, however, as compared with the summer fishery. Unfavorable weather conditions often make it necessary for the fleet to suspend fishing operations during this period, especially during the month of December. Furthermore, during the winter the fish are less abundant in Hawaiian waters, and the schools are reportedly smaller than those encountered in the summer fishery. The first appearance of the fish marking the beginning of the summer season usually occurs in May. After increasing rapidly to a maximum in June or July, the catches drop off gradually (See figure 10). Figure 11 illustrates the season of peak catch, with average monthly catches expressed as percentages of the average annual catches for the three-year period ending with 1948.

DISPOSITION OF THE CATCH

Since many of the skipjack boats operate on short runs out of port, the fish are oftentimes landed at the dock within a few hours after they have been caught (figure 12). The chief port of landing for the skipjack fleet is Honolulu. During the summer season, the bulk of the catch is sold to Hawaiian Tuna Packers Ltd. for canning. The plant is located close to the dock where the fish are unloaded and transferred by trucks to the cannery to await processing (figure 13). In addition to the main packing plant, the cannery also maintains a small subsidiary at Hilo where fish are received for shipment to the plant in Honolulu. The price paid to the fishermen by the cannery for the fish is based on the prevailing price of skipjack on the Pacific coast, less a differential approximating shipping costs.

Only a few of the Honolulu boats sell their catches exclusively to fresh market outlets; however, during the winter months the skipjack landings are not sufficient to keep the cannery in operation, and the fish are then handled by the fresh markets. On most of the other islands, the entire catch is absorbed by the fresh market. The prices received by the fishermen for skipjack going to the fresh market fluctuates with the supply; generally, however, the average market price is slightly above the prevailing price paid by the cannery.

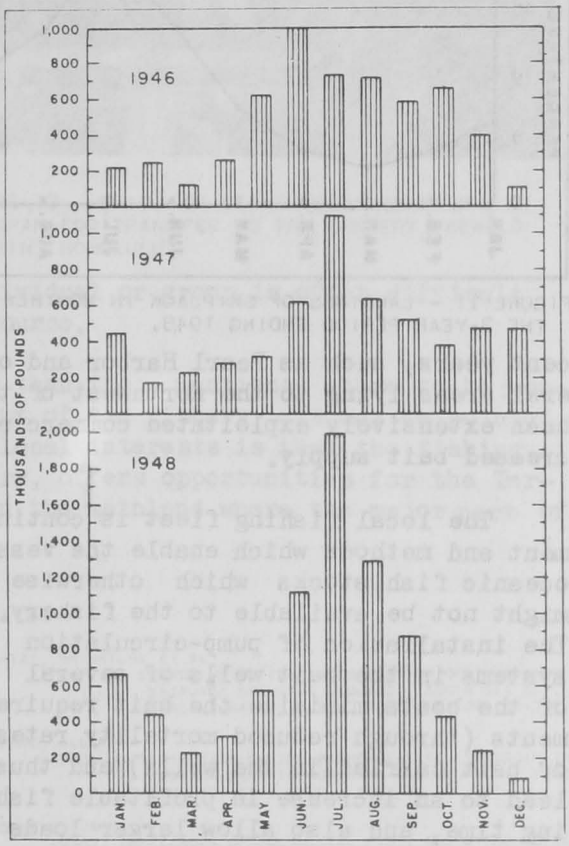

FIGURE 10 - SKIPJACK LANDINGS BY MONTHS IN THE TERRITORY OF HAWAII, 1946-48. (DATA OBTAINED FROM THE CATCH RECORDS OF THE TERRITORIAL DIVISION OF FISH AND GAME.)

FUTURE POSSIBILITIES FOR THE DEVELOPMENT OF THE FISHERY

There seem to exist excellent possibilities for expansion of the skipjack fishery based on the Hawaiian Islands. Intensive research is underway, both by the U. S. Fish and Wildlife Service Pacific Oceanic Fishery Investigations and other agencies, for exploring and developing the tuna resources of the Central Pacific. Data are presently being gathered for studies of the basic biology of the skipjack. In addition, exploratory and experimental fishing is also being conducted with the aims of locating potentially productive areas, developing new gear, and improving existing methods and techniques for catching fish. Concomitant with this work, oceanographi-

cal surveys are being carried on to correlate with the exploratory findings. The results of such research eventually should lead to a more efficient exploitation of local tuna resources and an extension of the fishery into adjacent geographical regions. The Line Islands and the expanse of islands and shallow-water banks extending northwestward from Niihau perhaps offer the most promising potential fishing grounds for immediate expansion.

As mentioned previously, the existing bait supply in the Hawaiian Islands is limited. Studies are now in progress to determine the factors in the physiology of the bait species related to handling and transporting them more effectively. Investigations with regard to the condition of the local bait fishery for nehu are being conducted by the University of Hawaii and the Territorial Division of Fish and Game for the purpose of determining the maximum yield that can be harvested without causing a serious decrease in the local populations. Hope for future expansion also lies in the further extension of bait fishing in areas which have not been fished intensively in recent years, such as Pearl Harbor and others previously noted. There are also several areas lying to the northwest of the main island group which have not as yet been extensively exploitated commercially and which offer possibilities for an increased bait supply.

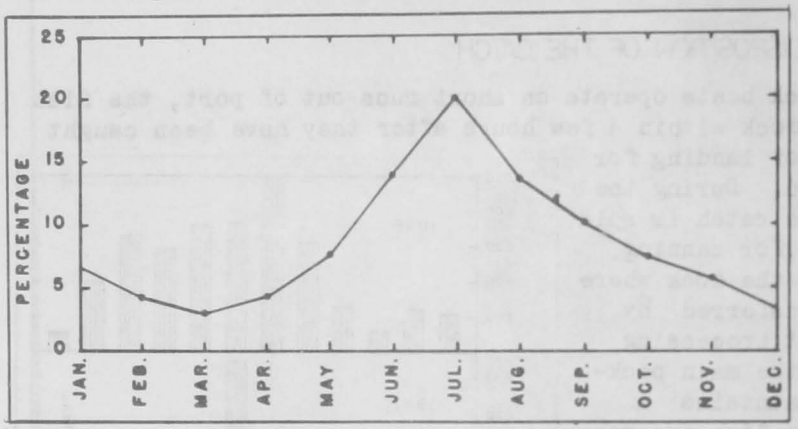

FIGURE 11 - LANDINGS OF SKIPJACK IN MONTHLY PERCENTAGES FOR THE 3-YEAR PERIOD ENDING 1948.

The local fishing fleet is continually incorporating modern mechanical equipment and methods which enable the vessels to venture farther offshore to exploit oceanic fish stocks which otherwise might not be available to the fishery. The installation of pump-circulation systems in the bait wells of several of the boats minimize the bait requirements (through reduced mortality rates of bait carried in the wells) and thus lead to an increase in profitable fishing time, and also allow larger loads of bait to be carried. Radio direction finders are becoming standard equipment on an increasing number of boats. Hence, such vessels are no longer limited to coastal waters because of inadequate navigational aids. However, other modifications on the present boats would be necessary before their cruising range could be economically increased to any great extent. For instance, modern refrigeration adequate for holding a catch during extended fishing trips would have to be provided. Further improvement of living accommodations aboard the boats would provide greater comfort to the fishermen at sea.

FIGURE 12 - A SKIPJACK CATCH WAITING TO BE UNLOADED AT KEWALO BASIN, HONOLULU.

There are other considerations which must not be overlooked and which directly affect the development of the fishery. First, should there be a substantial increase in production, adequate facilities for handling the catch must be provided. The demands of the fresh market constitute only a small portion of the total annual skipjack landings, therefore, the greater part of the catch must be processed. In this respect, plans for another tuna canning plant to be located on the island of Kauai have already been formulated, and it is planned that it will be in operation by 1951. Second, there is at present a shortage of fishermen well trained in local fishing methods, hence, an increased demand for experienced personnel to man additional fishing boats would be even more critical unless additional fishermen could be trained, or the fishing methods were sufficiently modified to attract experienced fishermen from the U. S. mainland. Third, it is likely that problems would arise with regard to financing any new fishery enterprises. For example, financing the ownership and operation of a vessel by an individual or group is often difficult without substantial backing from an outside source.

FIGURE 13 - SKIPJACK BEING UNLOADED FROM A SAMPAN FOR TRANSFER TO THE CANNERY, KEWALO BASIN, HONOLULU.

There are, of course, many other factors than those mentioned above to be considered that will effect the future development of the fishery. It may be pointed out, however, that the general feeling among local interests is that the fishing industry, and particularly the skipjack fishery, offers opportunities for the Territory under favorable marketing conditions on the mainland where the major part of the Hawaiian tuna pack must be sold.

LITERATURE CITED

ANONYMOUS
1938. INVESTIGATIONS ON FISHING IN FOREIGN COUNTRIES /KAIGAI SUISAN CHOSA/. (TEXT IN JAPANESE). DEPT. AGRI., TOKYO, BUR. FISH., PP. 311-19.

BECKLEY, EMMA M.
1883. HAWAIIAN FISHERIES AND METHODS OF FISHING. ADVERTISER STEAM PRINT, PP. 1-21.

BREDER, C. M.
1929. FIELD BOOK OF MARINE FISHES OF THE ATLANTIC COAST FROM LABRADOR TO TEXAS. G. P. PUTNAM'S SONS, N. Y., 332 P.

COBB, JOHN N.
1903. THE COMMERCIAL FISHERIES OF THE HAWAIIAN ISLANDS. BUL. U. S. FISH COMM., VOL. 23, PT. 2, PP. 717-65.

DAY, FRANCIS
1875-78. THE FISHES OF INDIA. LONDON, 778 P., 198 PLS.

FOWLER, HENRY W.
1944. RESULTS OF THE FIFTH GEORGE VANDERBUILT EXPEDITION. ACAD. NAT. SCI., MONOGR. NO. 6, PP. 349, 373-74, 498.

GODSIL, H. C. AND R. D. BYERS
1944. A SYSTEMATIC STUDY OF THE PACIFIC TUNAS. CALIF. DIV. FISH AND GAME, FISH BUL. 60, PP. 1-131.

GUNTHER, ALBERT
1860. CATALOGUE OF FISHES IN THE BRITISH MUSEUM. LONDON, VOL. 2, PP. 1-548.

HATAI, SHINKISHI ET AL
1941. A SYMPOSIUM ON THE INVESTIGATION OF TUNA AND SKIPJACK SPAWNING GROUNDS. SOUTH SEA SCI. /KAGAKU NANYO/, VOL. 4, NO. 1, PP. 64-75.

HERRE, ALBERT
1940. DISTRIBUTION OF THE MACKEREL-LIKE FISHES IN THE WESTERN PACIFIC NORTH OF THE EQUATOR. PROC. 6TH PAC. SCI. CONG., VOL. 3, PP. 211-15.

HORNELL, JAMES
1936. THE CANOES OF POLYNESIA, FIJI, AND MICRONESIA: CANOES OF OCEANIA BY A. C. HADDON AND J. HORNELL. B. P. BISHOP MUS., VOL. 1, SPEC. PUB. 27, PP. 1-454.

IMAMURA, YUTAKA
1949. THE SKIPJACK FISHERY: THE TEXT OF THE FISHERY /SUISAN KOZA/, FISHING SEC., VOL. 6, PP. 17-94.

KISHINOUYE, KAMAKICHI
1923. CONTRIBUTIONS TO THE COMPARATIVE STUDY OF THE SO-CALLED SCOMBROID FISHES. JOUR. COLL. AGRI., TOKYO IMP. UNIV., VOL. 8, NO. 3, PP. 293-475, FIGS. A-Z, PLS. 13-33.

1926. AN OUTLINE OF STUDIES OF THE PLECOSTEI (TUNA AND SKIPJACK) IN 1925. SUISAN GAKKAI HO, VOL. 4, NO. 3, PP. 125-37.

LAMONTE, FRANCESCA
1945. NORTH AMERICAN GAME FISHES. DOUBLEDAY DORAN, N. Y. 202 P., 73 PLS.

MATSUI, KIZO
1942. ON THE GONADS OF SKIPJACK FROM PALAO WATERS. SOUTH SEA SCI. /KAGAKU NANYO/, VOL. 5, NO. 1, PP. 117-22.

ROEDEL, PHIL M.
1948. COMMON MARINE FISHES OF CALIFORNIA. CALIF. DIV. FISH AND GAME, FISH BUL., 68, PP. 3-142.

SERVENTY, D. L.
1941. THE AUSTRALIAN TUNAS. COUNCIL SCI. IND. RES., PAMPH. 104, 48 P., 4 PLS.

SCHAEFER, MILNER B. AND J. C. MARR
1948. CONTRIBUTIONS TO THE BIOLOGY OF THE PACIFIC TUNAS. U. S. FISH AND WILDLIFE SERVICE, FISH. BUL. 44, PP. 187-206.

SHAPIRO, SIDNEY
1948. THE JAPANESE TUNA FISHERIES. U. S. FISH AND WILDLIFE SERVICE, F. L. 297, PP. 5-60.

SUYEHIRO, YASUO
1938. THE STUDY OF FINDING THE REASONS WHY BONITO DOES NOT TAKE TO THE ANGLING-BAITS (TEXT IN JAPANESE WITH ENGLISH ABSTRACT). JOUR. IMP. FISH EXP. STA., NO. 9, PP. 85-101.

ALBACORF TUNA EXPLORATION IN ALASKAN AND ADJACENT WATERS--1949

Albacore, the white-meat tuna, has been fished commercially in California waters for many years, but only in the past decade has the industry been established in Oregon and Washington. In 1948, the commercial range was extended to waters off the Canadian coast. The 1949 exploration of the U. S. Fish and Wildlife Service's exploratory vessel Oregon was undertaken with the view of studying albacore movements in the northeastern Pacific and the possibility of establishing a tuna fishery in Alaskan waters.

Albacore were taken by the Oregon on trolled jigs during August and September in scattered areas from the Washington coast to the Welker Seamount, 300 miles offshore from Dixon Entrance. However, large schools, such as were present off the British Columbia coast in 1948, were not found in 1949, indicating possible annual variation in migration pattern.

Surface water temperatures were correlated with the appearance of albacore; fish were caught in waters as cold as 56.8° F., but best fishing was found at temperatures between 58° and 61° F.

Stomach analysis indicated that in the northeastern Pacific tuna feed almost solely on plankton and small fish. Euphausiids ("red feed") and small rockfish constituted the bulk of their diet. Methods of locating concentrations of these food organisms would probably be of benefit to the fishery.

From the experiences of 1949, it appears that obtaining live bait (anchovies, pilchards, etc.) is a very serious problem for the bait boats, and may at times prove even more difficult than finding the albacore. Although carrying live bait on two occasions, the Oregon did not locate large schools of tuna affording opportunity for its use.

--Fishery Leaflet 376