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JAPANESE SKIPJACK (KATSUWONUS PELAMIS) FISHING METHODS

By Fred C. Cleaver* and Bell M. Shimada*

INTRODUCTION

The Japanese have had centuries of experience fishing for tunas. Because the fishery developed in a culture much different from that found in other countries, it differs in many ways from the methods in use in the United States. The urgent necessity of securing food from the sea has provided strong motivation for the development of effective fishing methods. For the purpose of exploitation, research into the habits and ecology of fish has advanced more rapidly than elsewhere. Particularly in the warmer portions of the western Pacific, only the Japanese engaged in extensive exploratory tuna-fishing enterprises.

This report shall discuss only the Japanese live-bait fishery for skipjack (Katsuwonus pelamis Kishinouye). Personnel of the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service, who visited Japan to investigate Japanese tuna research and fishing methods, gathered the information in this article between November 1948 and June 1949 from discussions with fishermen, and officials of the fishing companies, and to a lesser extent from scientists and translated writings. Since the fishery was at a seasonal ebb during most of the investigation and fishing was abnormally poor during the latter part of the reconnaissance, when good catches might have been expected, direct observations were largely limited to the vessels and gear while at the docks. Because of the limited time available for reconnaissance, it was possible to make only one trip to the fishing grounds. The lack of first-hand observation is partially compensated by an extensive series of interviews with fishermen at ports from Tokyo to southern Japan. Although every possible precaution was taken to get a complete and accurate coverage of fishing methods, it is possible that errors have been inadvertently included. Such would arise from two sources, the most important of which is the language difficulty. It was often evident that while an interpreter understood the meaning of the words in a question, the thought was erroneously interpreted. Frequently answers were received which had no conceivable connection with the question asked. Secondly, Japanese fishing centers are so numerous that it was impossible to examine all of them, even where differences in operating methods were known to exist.

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*FISHERY RESEARCH BIOLOGISTS, PACIFIC OCEANIC FISHERY INVESTIGATIONS, U. S. FISH AND WILDLIFE SERVICE.

HISTORY

The regular capture of skipjack for use in Japan as food cannot be traced in prehistoric times as is the case with some of the other tunas (Imamura 1949). However, regulations mentioning the use of skipjack as food were promulgated in the eighth century A. D., so it may be assumed that fishing began some time previously. Because this species has been highly prized as an article of diet since early times, considerable thought and energy have been devoted to increasing the catch.

In the earlier days, when fishing was conducted near land, only those schools that could be reached in small vessels powered by hand or sail were utilized. The fishermen rarely ventured as much as 10 miles from shore. In spite of equipment limitations, the industry was quite productive even at that time. The season was short. Fishermen were unable to follow the seasonal migrations, but had to depend upon schools which appeared within a few miles of shore. Despite the high value of skipjack, only minor changes occurred in the fishing techniques for hundreds of years.

With the advent of powered craft during the first two decades of the twentieth century, the fishery began to expand rapidly. At first explorations extended in an eastward direction, but after 1920 a southerly expansion began which continued until 1940. Just before the outbreak of World War II in 1941, the Japanese skipjack fishery extended eastward from Japan to 700 miles offshore, and southward to equatorial portions of the western Pacific Ocean. This latter area not only included the former Mandated Islands area and adjacent island chains, but also embraced the Sulu, Celebes, Java, and South China Seas, as well as other portions of the Indo-Australian Archipelago. To fish in this vast area, it was necessary that changes be made in equipment and techniques. The vessels became larger, and more powerful engines were installed. The southern extremity of the fishery pushed into areas where climatic conditions varied so greatly from those in Japan that methods peculiar to the South Seas were developed. Because these were in some respects quite different from methods found in the northern fishery, they will be described separately where necessary.

The trend of Japanese skipjack production in home waters and abroad has been presented by Shapiro, 1948. Total annual catch of skipjack from inshore waters since 1908 and for offshore waters since 1915 are also contained in a previous statistical report issued by the Natural Resources Section (Espenshade 1947). The 5 years from 1936 to 1940, inclusive, represent the highpoint in Japanese skipjack production. During this period, annual catches (including those made in both inshore and offshore waters) averaged approximately 238,000,000 pounds. The average annual production prior to 1936 was about 190,000,000 pounds. About 42,000,000 pounds were also caught yearly in the former Mandated Islands area in the years immediately preceding World War II. Statistics for this period for catches made in other colonial waters and for the Indo-Pacific region (where a skipjack fishery was known to exist) are not available. Catches in these areas were probably nominal, but indicative of the commercial abundance of skipjack. In 1936, 3,625,000 pounds of skipjack were brought to Formosan ports as contrasted to landings of 271,935,000 pounds and 31,455,000 pounds for the same year in Japanese and South Seas ports, respectively.

BIOLOGY AND ECOLOGY

The skipjack is closely related to the other tunas and mackerels. Remarkably streamlined in form, it is one of the smaller tunas. While it reaches a maximum

length of about 40 inches with a weight of approximately 40 pounds, the greater part of the Japanese catch is comprised of fish weighing less than 10 pounds. It is a warm-water species which may be found throughout the Pacific Ocean wherever suitable temperatures exist. Traveling in schools that may in some cases extend for miles, this species feeds upon various smaller marine animals, which in some instances include juvenile skipjack.

Although not conclusively demonstrated, it is generally accepted by the Japanese that skipjack caught in homeland waters are members of two general stocks, each including both migratory and resident populations. One stock, believed to originate in the region near the Celebes Sea, is thought to enter the Japanese fishery by following north along the Ryukyu Islands. Skipjack which are caught throughout the year near the shallow banks of the Ryukyus are assumed to be fish of this stock which have lost their migratory urge and have become sedentary. These are called "resident" fish. The former Mandated Islands are thought to contribute another migratory stock which moves toward Japan along the Bonin and Izu Islands, and also by way of the Kinan reefs. Resident fish are caught in these areas at practically all times of the year.

Although sufficient data are lacking from morphometric and marking studies to bring out the exact population relationships of skipjack caught in Japanese waters, the fact that the center of fishing moves progressively to the north from spring until autumn is a fairly good indication that the skipjack schools have migratory tendencies.

To further the exploitation of the skipjack stocks, the Japanese have studied extensively the relationship of ocean temperatures and currents to the catch of fish. Temperature ranges for the various species of tuna have been defined and these serve as guides for locating fish. Skipjack may be found in waters contiguous to Japan at temperatures from 63° F.-88° F. but occur most abundantly in waters ranging from 66° F.-79° F. In the South Seas, water temperatures above 82° F. are considered optimum for skipjack.

Skipjack in Japanese waters are said to be "isothermic." If the first good catches of the year are made in water of a certain temperature, experience has shown that water of this temperature will contain the schools as it moves northward in the spring with the Japan Current (Kuroshio). Large schools are particularly apt to be found in warm water pockets which have been isolated by masses of cold water. As the surrounded warm water mass decreases in size, it is believed that the fish are concentrated because they remain in the area instead of crossing the thermal barrier. Such "impounded" schools provide excellent fishing.

The decline in Japanese skipjack catches in recent years is provisionally attributed to a change in oceanographic conditions. However, the precise factors which bear upon the problem are not known, and conflicting views on this subject are held both by Japanese scientists and fishermen.

FISHERY FOR BAIT

GENERAL: The habits of the skipjack are such that the use of live bait has come to be the basis for the highly specialized fishing techniques. Consequently, it is felt necessary to include a description of the baiting procedure. In the main, the homeland fishery for skipjack bait and the fishery for skipjack themselves are entirely separate. Exceptions to this procedure in Japan are the small vessels which operate in a marginal skipjack fishery. These vessels are able to make good catches

only when the schools approach land and account for a minor portion of the total Japanese skipjack catch. The Japanese have found over a period of years that it is far more economical to employ a smaller number of men and less expensive equipment to fish exclusively for the needed bait than to cause the fleet to lose fishing time in search of bait. The advantages entailed are manifold. As pointed out above, it is not necessary for a fishing vessel to lose potential fishing time in baiting. This is particularly valuable during periods of good catch. Perhaps more important, it is possible for the bait fishermen to accumulate and impound a surplus of bait during periods of abundance of bait-fish schools. In this type of tuna fishing, it seems, both in the United States and Japan, that often bait-fish schools are scarce at just the time when tuna schools are most abundant and the need for bait is greatest. Since a ready supply of live bait is indispensable in avoiding costly delays in fishing, it is felt that this feature of the Japanese technique may be superior to that of the United States, and might be profitably investigated.

Fishing vessels usually purchase bait directly from the bait fishermen by stopping at the bait grounds before putting out to sea. During the peak of the skipjack fishing season, however, "bait carriers" (vessels which engage solely in the transport of bait) supply the fishermen at sea (Figure 1). These bait carriers (up to 50 gross metric tons in size) are generally operated independent of the bait and skipjack fisheries and profit by serving the needs of both. The bait fishermen are assured of a steady demand and the skipjack fishermen are able to save valuable time by not having to go far out of their way to secure bait. Furthermore, by being supplied with bait at sea, fishing vessels can load up with maximum catches when fishing is good. Bait carriers are especially active in central Honshu and ply their trade between the bait grounds in Tokyo Bay and the skipjack fishing grounds farther to the north. As a rule, these vessels do not transport fish back to port on their return trips, because of inadequate preserving facilities.

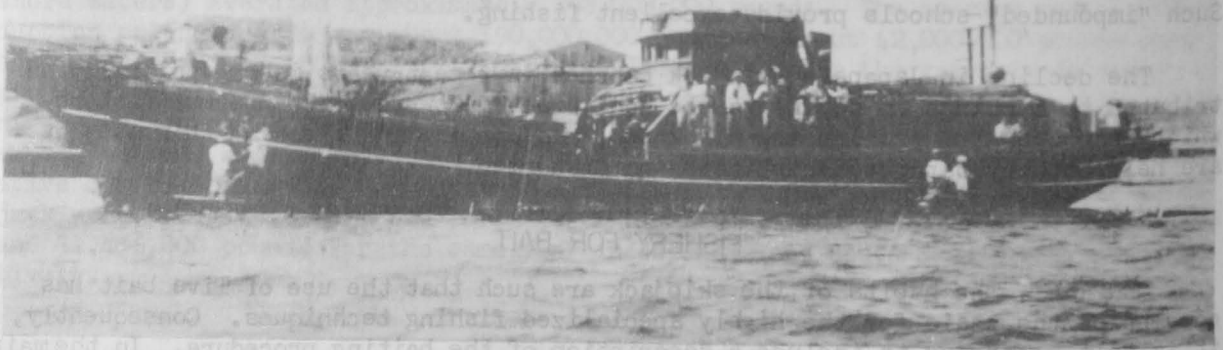

FIGURE 1 - JAPANESE BAIT-CARRIER VESSEL TAKING A LOAD OF BAIT FROM LIVE BOX. TOKYO BAY.

Although several other species are frequently used, the most common skipjack bait fishes in Japan are the anchovy (Engraulis japonicus) and the sardine (Sardinops melanosticta). The anchovy is said to be the better bait because it may be kept in the live wells more successfully than the sardine.

Although the size of the bait fish used often depends upon what may be available, fish from 3 to 5 inches in length are considered most desirable. The bases for choice are that the smaller fish are most resistant to death from confinement, although more liable to injury from handling, and can also be used more efficiently; a smaller bait fish seems to be as attractive to the skipjack as a larger fish would be, if not more so in some instances, and a greater number of the smaller fish can be carried per unit of bait-well space.

METHODS OF CAPTURE: The bait fishery operates concurrently with that for skipjack. In southern Japan this means that with the possible exception of January and February, bait is caught in the bays throughout the year. In central Japan the season is from April to November, reaching a peak during the summer months. Little bait is caught in northern Japan. The major bait-producing regions are Kagoshima Prefecture, and the area within 150 miles of Tokyo. Bait fishing is done primarily in the protected bays and inlets along the coast. Bait is more abundant in sheltered waters, and because the handling of the fish after capture must necessarily be gentle, the use of outer waters is almost precluded. Purse seines, lift nets, and weirs are the major forms of gear used.

The purse seines used in Shizuoka Prefecture are 300 fathoms long by 60 fathoms deep. They are made of cotton mesh ranging from about 1/4-inch stretched measure to 1/2-inch stretched measure, the smaller web being used in the bunt of the net. An illustration of this net may be found in the SCAP report on "Japanese Fishing Gear" (Kask 1947). The gear is set by two vessels, each of which carries half of the net. After pursing, the catch is crowded into a relatively small area of net between the two vessels, and is transferred to live boxes.

From the time the fish are first enclosed in the net until they are finally used as bait, extreme care is exercised to prevent damage to the fish. As the purse seine is dried up, the webbing is raised evenly to prevent the formation of folds in which the bait may be trapped and chafed or smothered. After capture is completed, the edge of the seine is submerged and the bait is gently crowded into the live box, the edge of which is also submerged so that the bait may swim into confinement without being handled.

A second popular method of bait capture is by means of the lift net. Basically, this consists of an apron of netting that is set in the water to catch fish which are lured into reach by lights hung near to or under the water during the hours of darkness.

Lift nets are of several types. The simplest (Figure 2) is a fine meshed rectangle which is generally about 50 percent deeper than wide, the width being roughly two-thirds the length of the vessel which fishes it (Takayama 1949). One edge of the net with the narrower dimension is buoyed by a bamboo pole 6 inches in diameter and long enough to project several feet at each side of the net. Two more poles are lashed, one to each end of this float pole, to hold it at a distance of 30 or 40 feet from the vessel. The opposite edge of the net is lightly weighted with 10 or 20 pounds of lead so that the net, when in the water, hangs as a vertical wall some distance from and parallel to the boat. From four to six lines are made fast to the bottom of the net so that it may be hauled up and toward the boat to enclose

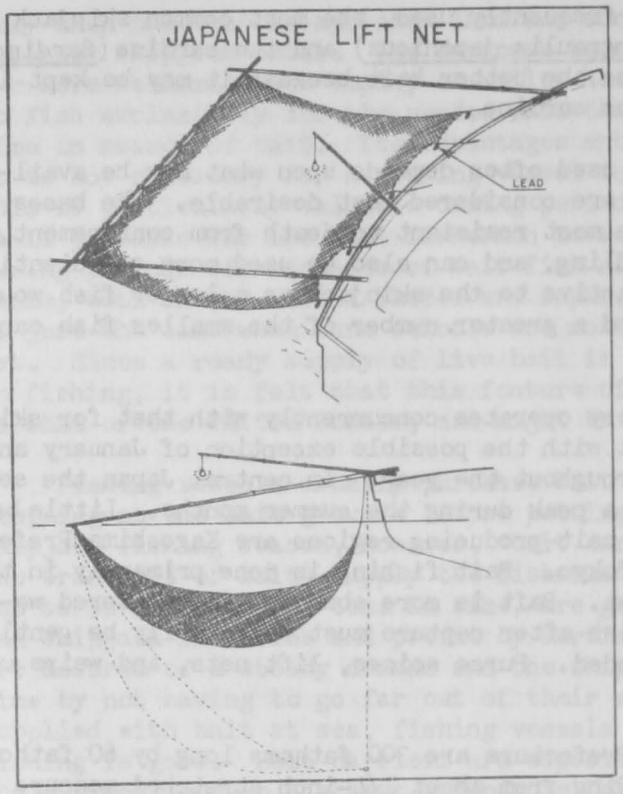

FIGURE 2

any fish that may have been attracted to the lights which are in the rectangle formed by the poles. The net is constructed in a manner to allow the middle to sag and form a shallow pocket. This is done by sewing about 4 feet of webbing to 3 feet of line for most of the net. The net near the float pole is "hung in" more. There, about 5 feet of mesh are "hung" on 3 feet of line. As the net is lifted, the float pole is pulled to the vessel by drawing in the poles which held it away from the boat. After the fish are closely confined they are transferred to a holding box.

Another method of using a lift net requires five or more boats. Four are anchored to form the corners of a square of the same size as the net. The net is weighted and sunk between them, while the fifth vessel remains over the center of the net with a strong light to attract the fish. When a school of sufficient size has been attracted to the light, the men in the boats at the four corners of the net quickly raise the margins of the net to trap the fish. The fifth boat extinguishes the light and leaves the net by slightly submerging one of the raised sides. The net is then carefully pulled into the boats to confine the fish in a small portion of the net without injuring them.

Use of lights in bait fishing varies widely. In the method of fishing just described, all five vessels may carry lights to attract bait. After the fish have collected, the four outer boats will darken their lights so that the fish will assemble over the net. In the single-vessel type of net, lights may be hung on the side away from the net, both sides, or all around the boat. When fish have collected, the others are extinguished and the light inside the net may be turned on, or left on as the case may be, to lure the schools into the net. Lights on a string of floats may be used with wiring which permits the outer lights to be darkened first. Another variation is to have a small fleet of scouting boats with lights which may scatter to locate a school. When fish are found, the fishing vessel moves to the spot, sets the net, and turns on lights. The scout boat is then darkened so that the school will move to the lighted vessel.

The type of light used also varies considerably. Some boats will use gasoline lanterns, or an electric light of fairly high wattage (100w-500w) suspended over the water. Others use underwater lights which are suspended just beneath the surface. The underwater light seems to be more efficient although more difficult to rig and use. A reflector is generally employed to direct a diffused light into the area where the fish may be caught. Because the fish, while attracted more strongly to a bright light, may remain at a relatively greater distance from brilliant illumination, a rheostatic control can be provided to dim the light so that the school will gather closely about it.

A form of gear that is very useful in Chiba Prefecture, central Honshu, is the trap or weir. Set near the entrance to a bay, or in a spot where bait often congregate, large quantities are readily taken. These are gently transferred to a live box and towed to a sheltered location.

HOLDING: After capture, the bait fish are generally held in a live box for one to several weeks. To provide safety for the gear and the fish, the box or pen must be anchored in a protected area. To keep the fish alive there must be a gentle circulation of water through the box.

The live box that seems to be most successful is a net supported by an octagonal frame (Figure 3) of eight 6-inch by 8-inch timbers (roughly 10 feet long) which are used to provide rigidity and buoyancy. The ends are carpentered so that a tongue on the end of one will socket firmly in a hole in the end of that adjoining, and may be pegged in place. A bag of fine-mesh netting that measures about 1/4 inch on a side of a mesh is constructed to fit the frame and extend below it for 9 feet into the water. This netting may be either of cotton or palm fiber. The cotton is easier to work with as well as being smoother to the touch, but the coarse palm fiber was said to last for two seasons without treatment. The cotton must be treated with tanbark or other preservative every few weeks to prevent deterioration. A vertical row of four rope loops are sewn to the net every 3 or 4 feet around the circumference so that the net can be held in shape by sticks which pass through the frame.

The advantages of this live box are several. It may be readily taken apart for transport or repair; in fact, the frames may be made of light paulownia wood so that they can be carried about on the fishing vessel until bait is caught. There is no difficulty involved in removing the fish because the sticks which hold the net in shape may be removed to allow the fish to be crowded into any portion of it.

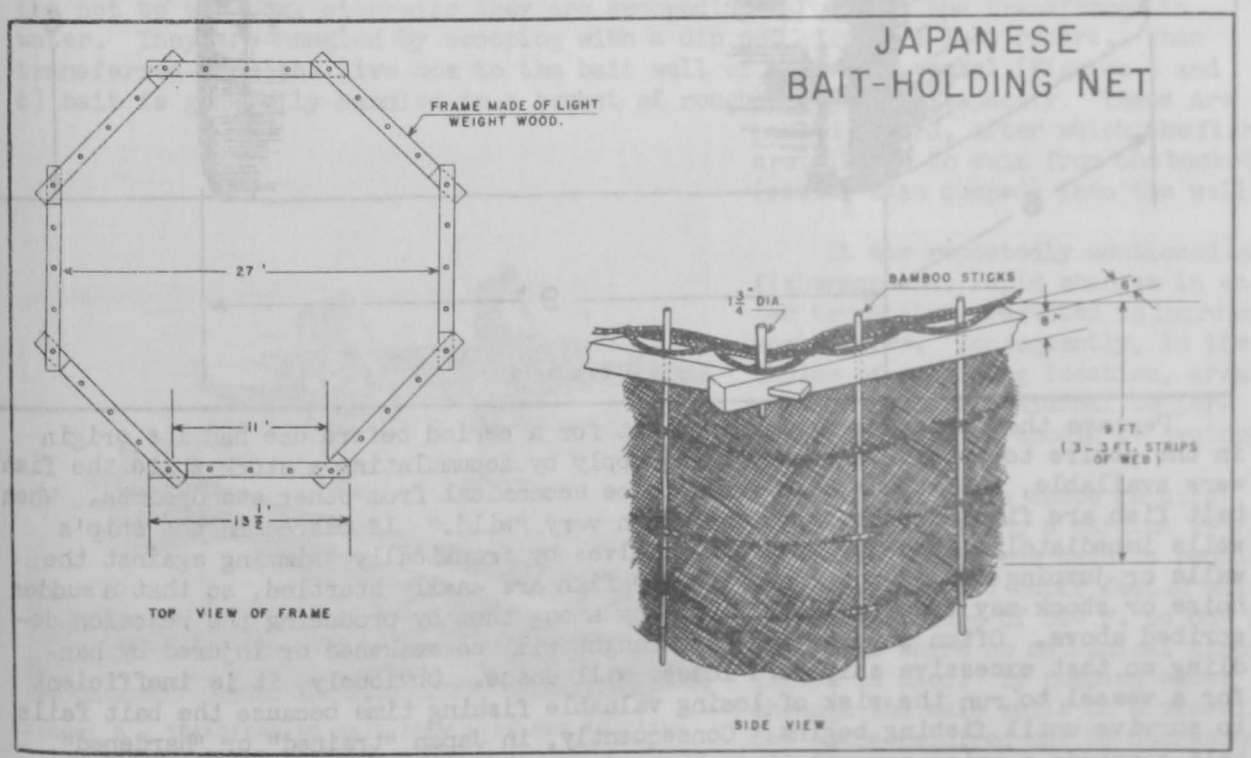

FIGURE 3

Further, it is very nearly round in shape which seems to encourage the fish to circle the box and become more quickly adapted to living in confinement with minimum losses.

Another type of live box in common use is of woven bamboo strips. These strips (about 1 inch wide) are woven loosely to form a rectangular box, 9 feet by 6 feet by 6 feet. The box is wired to a frame of 6-inch bamboo poles which act as floats (Figure 4). The advantages of this type of live box are that construction is relatively cheap in Japan, and it is darker inside, which is said to quiet the fish. This assumption is open to question, because bait wells aboard ship are generally painted white as well as lighted at night for the same reason. Fewer fish can be held in the bamboo box because circulation within it is not as effective as in the boxes of netting.

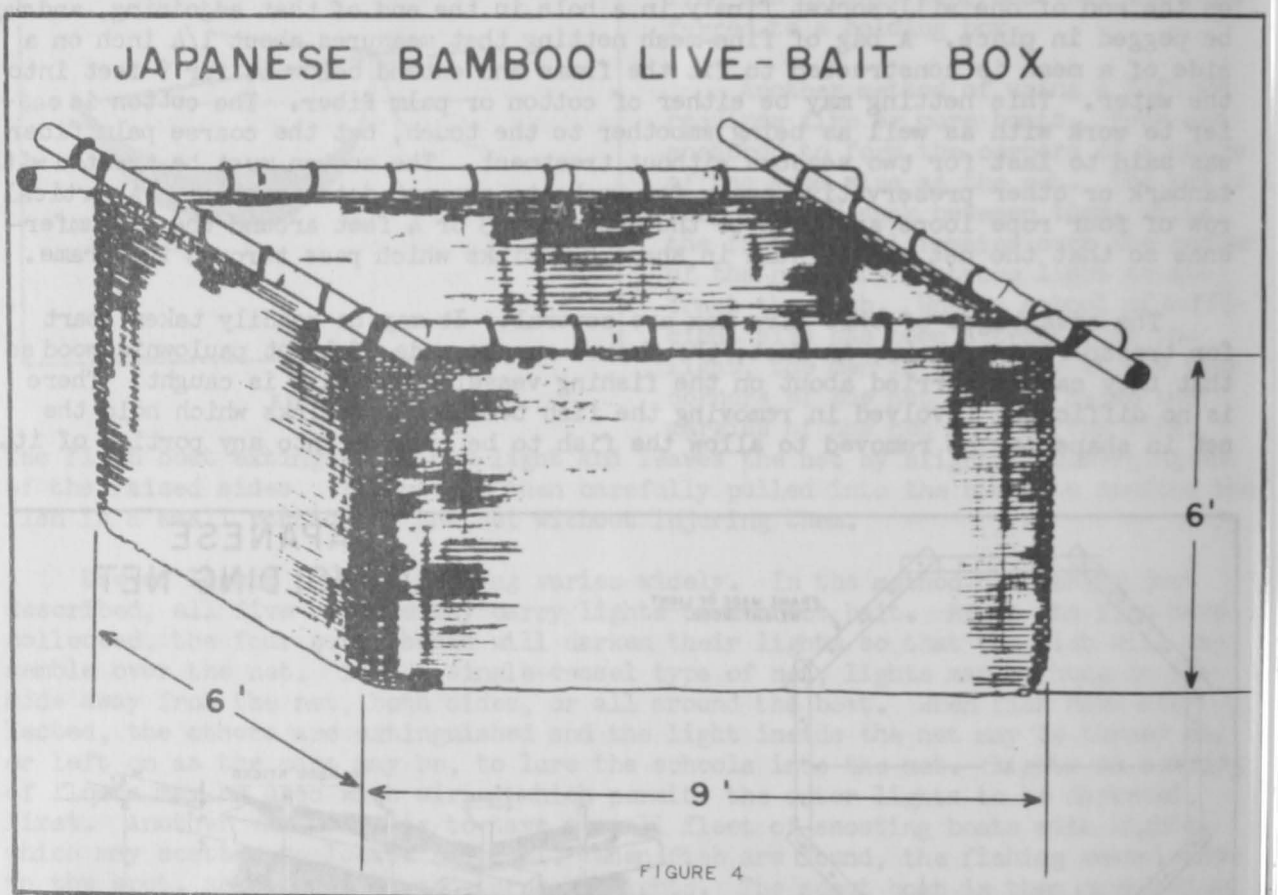

FIGURE 4

Perhaps the practice of holding bait for a period before use had its origin in the desire to provide a steady bait supply by accumulating a stock while the fish were available, but it has been found to be economical from other standpoints. When bait fish are first caught, they are often very "wild." If placed in the ship's wells immediately, they may injure themselves by frantically swimming against the walls or jumping out of the tank. "Wild" fish are easily startled, so that a sudden noise or shock may cause a large mortality among them by producing the reaction described above. Often some of the bait caught will be weakened or injured by handling so that excessive shipboard losses will ensue. Obviously, it is inefficient for a vessel to run the risk of losing valuable fishing time because the bait fails to survive until fishing begins. Consequently, in Japan "trained" or "hardened" bait commands a price several times that of freshly-caught bait.

In the holding process, the bait fishermen confine the bait closely in preparation for use in fishing. The weak and injured die in the live boxes and are removed to prevent fouling. These losses may ordinarily run from 40 to 60 percent, and occasionally approach 100 percent of the fish when first confined. The surviving bait fish become accustomed to living in a small space so that when placed in the wells of a fishing vessel they adapt themselves readily. The close confinement also serves the purpose of partially starving them so that they are more hardy and less susceptible to injury. "Well-trained" bait may be recognized by the fact that it is thin, circles easily in the bait wells, and does not become excited or frantic when approached.

FIGURE 5 - TRANSFERRING BAIT FROM LIVE BOX TO FISHING VESSEL, TOKYO BAY.

Care is emphasized at all times in handling the bait. When removed from the net after capture, if possible, the fish are allowed to swim from the net into the live box. This is accomplished by submerging a portion of the live box with the edge of the net closely applied to it, and gently herding the fish from the net to the box; otherwise they are scooped up in buckets and transferred in water. They are handled by scooping with a dip net only as a last resort. When transferred from the live box to the bait well of a fishing vessel (Figures 5 and 6) bait is generally handled in a bucket of roughly 5 gallons capacity. These are passed aboard, after which the fish are allowed to swim from the bucket (rather than dumped) into the well.

FIGURE 6 - TRANSFERRING BAIT FROM LIVE BOX TO FISHING VESSEL, TOKYO BAY.

It was repeatedly mentioned by fishermen that rapid changes in water temperature resulted in increased mortalities. Consequently, in the choice of a holding location, areas subject to marked diurnal temperature fluctuation should be avoided.

Regarding the space requirements of bait fish, a sardine 2-3/4 inches in length was said to require approximately .07 cubic feet of water at a temperature of 64° F. to 68° F. in a well where no mechanical circulation is used. By pumping water through the bait wells on a vessel, the space required may be decreased to .05 cubic feet. The density of

bait carried in a well varies. In southern Japan it was said that in a well (without mechanical circulation) 8 feet by 8 feet by 7 feet, up to 1,000 pounds of bait can be carried. The figures given for central Japan were about the same. At temperatures of 73° F. or less, 50 buckets may be kept in a well 6-3/4 feet by 6-3/4 feet by 9-5/6 feet without circulating equipment. A "bucket" of bait is a very indefinite amount, probably averaging in the neighborhood of 15 to 20 pounds of fish.

At Yaizu in central Japan, the catch seems to average about 1,000 pounds of skipjack per bucket of "hardened" bait. In Kagoshima Prefecture (southern Japan), the fishermen quoted figures which tended to indicate that from 2,000 to 4,000 pounds of skipjack may be caught per bucket of bait. These figures seem high, but the Japanese are known to be very economical in use of bait fish. In some cases, the assistant chummer will use a dip net to retrieve bait fish which have escaped the skipjack and sought protection by the hull of the vessel, so that they may be used again.

As a rule, the bait is fed very little except on extended fishing trips. During the winter or when natural food is scarce, the bait may be fed ground fish, rice bran, or silkworm pupae.

BAIT FISHING IN THE SOUTH SEAS: The bait-fishing techniques of the South Seas skipjack industry had their origins in the practices of the homeland. Because the familiar species and hydrographic conditions did not occur south of 20° north latitude, it was necessary to experiment with various new techniques for the fishery before a satisfactory system was improvised. The same procedures could not even be followed from one season of the year to another or between island groups. In this connection, it is worth while to mention that the Japanese skipjack fisheries in the South Seas were developed only after a lengthy period of persistent effort. Even with governmental subsidies, early efforts failed until suitable methods of catching and handling the fish had been evolved. It may be expected that any other nation which attempts to develop similar fisheries will find it necessary to spend a like amount of time and effort before a workable arrangement is discovered.

Whereas a few species provide a bulk of the bait in Japanese waters, because of scarcity it was found necessary to use a wide variety of reef fishes belonging to several families, in addition to the anchovies and herring-like fishes (Table 1). Because the fish so utilized are known only by the names given to them by the fishermen, it is difficult to identify many of them with described species. Sufficient

Table 1 - Some Bait Fishes Used by the Japanese Skipjack Fishery1/

JAPAN AND RYUKYU ISLANDS			
Scientific Name	Common Names	Scientific Name	Common Names
Amia notata	kurohoshi-tenjikudai, ufumi	Harengula zunasi	sappa
Amia truncata	ufumi	Lutjanus vaigiensis	mochinogwa, okifuefuki
Atherina bleekeri	tōgoro-iwashi	Pomacentrus anabatoids	hichigwa, hikigwa
Atherina tsurugae	aoharara, gin-isō-iwashi	Pseudupeneus sp.	himeji
Beryx decadactylus	gasagasa, nanyō-kinmedai	Sardinella mizun	mizun
Caesio caerulaureus	saneera, shimamuro-gurukun	Sardinia immaculata	hoshinashi-iwashi, shiira
Caesio digramma	gurukun	Sardinia melanosticta	ma-iwashi
Caranx djeddeba	gatsun	Scomber japonicus	ōsabanoko, saba
Engraulis japonicus	katakuchi-iwashi, segurō-iwashi, tarekuchi-iwashi		
SOUTH SEAS			
Amia sp.	akadoro	Harengula molluciensis	ma-iwashi, nanyō-ma-iwashi
Apogon sp.	akadoro	Labracoglossa argentiventris	takabe
Archamia bleekeri	atohiki-tenjikudai	Mullus sp.	ojisan
Atherina sp.	kokera, tobi-iwashi, tōgoro-iwashi	Sardinella leiogaster	mangurōbu-iwashi
Atherina valenciennesii	nanyō-tōgoro-iwashi	Scomber kanagurta	saba
Caesio chrysozonus	akamuro, gurukun, saneera, umeiro	Sphyraena obtusata	kamasu
Caranx leptolepis	sji	Spratelloides delicatulus	ao-iwashi, baka, nanyō-kibinago, shiira
Caranx malibalicus	shima-aji	Trachurops crumenophthalma	me-aji
Caranx sp.	sji, gatsun	Trachurus japonicus	ma-aji
Chilodipterus sp.	akadoro	Upeneus sp.	ojisan
Dascyllus trimaculatus	montsuki	Upeneus tragula	yomehimeji
Decapterus russelli	akamuro	Upenoides sp.	ojisan
Decapterus sp.	muro, shima-muro	Stolephorus heterolobus	nanyō-katakuchi-iwashi, tarekuchi
Gazza equulasformis	hiiragi	Stolephorus japonicus	bakasako, kibiko-iwashi, sururu

1/The bait species listed herein were not limited in use exclusively to the area for which listed. They were used by the fishery wherever available in quantity.

Note: The data was obtained from: Prog. Rept. Okinawa Pref. Fish. Exp. St. for 1937; Marukawa, H., South Sea Fisheries 5 (5), 1939; and Dr. Y. Hiyama, Tokyo University, Tokyo, Japan.

information is not at hand to allow a complete account of the baits used, but some are available for a few localities. At Saipan and Tinian Islands, the "fool bait" (Spratelloides delicatulus) was the preferred species, but young carangids, filefish, atherinids, and Caesio sp. were caught near the reefs for use as bait. In the Palau Islands, the best bait seemed to be the anchovy (Engraulis heterolobus?) but during periods of shortage, numerous kinds of fishes were used, including the same ones mentioned for Saipan. Fishermen who had fished at Ponape and Truk inferred that the bait used there was the young of Priacanthus sp. R. O. Smith (1947) stated that the one- or two-inch anchovy (Anchovella purpurea) were the best bait at Truk, but the bait shortages caused a curtailment of the fishery from February to July.

In general, the sizes of bait used were governed by the species available. Spratelloides sp. (1-1/2 inches in length) were considered to be good bait; conversely, the fishermen were forced to use some species of 6 or 7 inches, although these often failed to attract the skipjack in the desired manner.

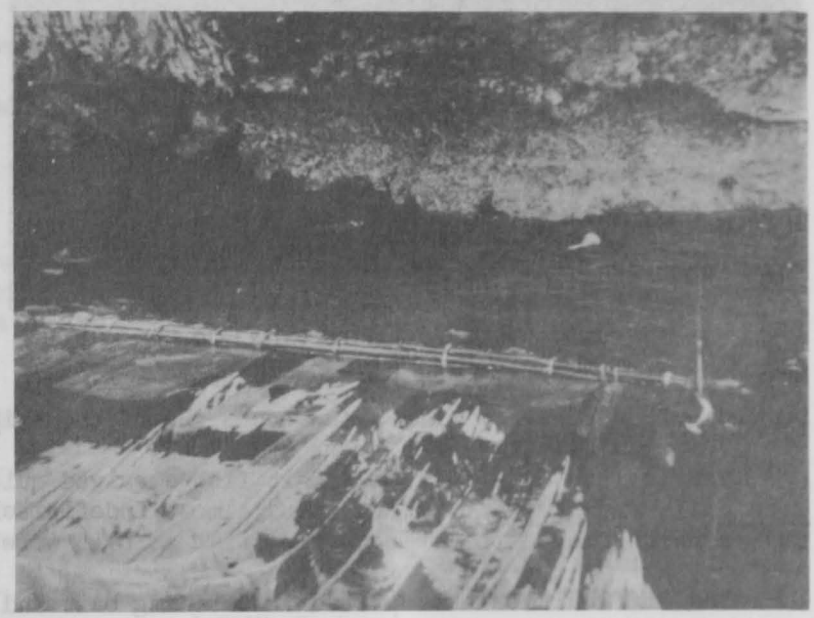

FIGURE 7 - SETTING LIFT NET FOR SKIPJACK BAIT, TINIAN, M. I.

Both of the net types described for the Japanese fishery as well as several others were used in tropical waters. Lights were particularly effective in the capture of bait in the Palaus when used with a lift net. A variation of the lift net was seen in the technique employed at Tinian (Figures 7 to 12). The fishing vessel would anchor near the cliffs and set the net. The crew would then swim along the cliffs, round up a school of "fool bait" (S. delicatulus), and herd them into the net.

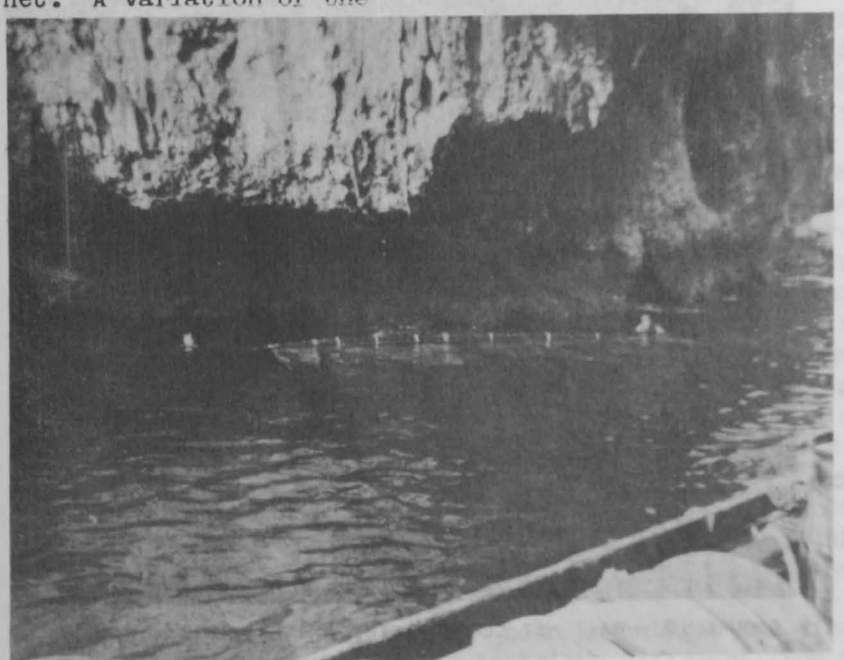

FIGURE 8 - LIFT NET SET FOR SKIPJACK BAIT, TINIAN, M. I.

The Okinawan drive-in net was used throughout the South Seas to catch reef fish. The net consisted of a large pocket flanked by wings of netting (Kask, 1947). This was set in an open space between the reefs. Fish were herded into the net by the swimmers who formed a large semicircle

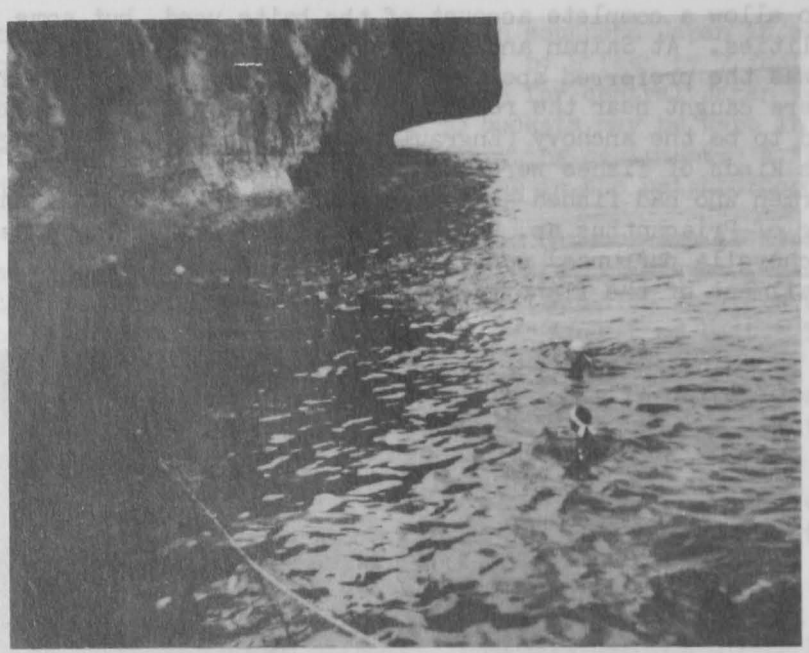

FIGURE 9 - SKIPJACK FISHERMEN DRIVING BAIT INTO NET, TINIAN, M. I.

which would converge on the net opening.

Bait was handled in an entirely different manner than is the case in Japan. The outstanding difference was in the fact that the bait was almost never held for any length of time prior to use. The anchovies and herring were found to be extremely delicate, so delicate in fact that they died after a day of impoundment. This obstacle was met by catching the bait during the night or early morning hours, and using it immediately. The bait surviving at the end of the day was frequently eaten by the fishermen. The system was practicable because the baiting grounds were within a few hours run of the skipjack fishing grounds.

Some of the less desirable bait fish survived quite well in the bait tanks. Caesio sp. and Priacanthus sp. lived almost indefinitely. In general, the reef fishes which proved to be less attractive as bait were easier to hold.

The difficulties encountered in catching bait and keeping it alive aboard a vessel caused the Japanese to investigate possible solutions to this problem. Attempts were made to fish the South Seas with large vessels by carrying bait from Japan. The sardines from central Japan were unable to survive the high temperatures encountered. Fishermen at Yaizu in Shizuoka Prefecture stated that the maximum water temperature which sardines could stand while in a bait tank was 77° F. Since higher temperatures are commonly found in the tropics such trials were not successful. Attempts were made to keep the bait through the use of refrigeration coils in the bait wells. Failure was encountered

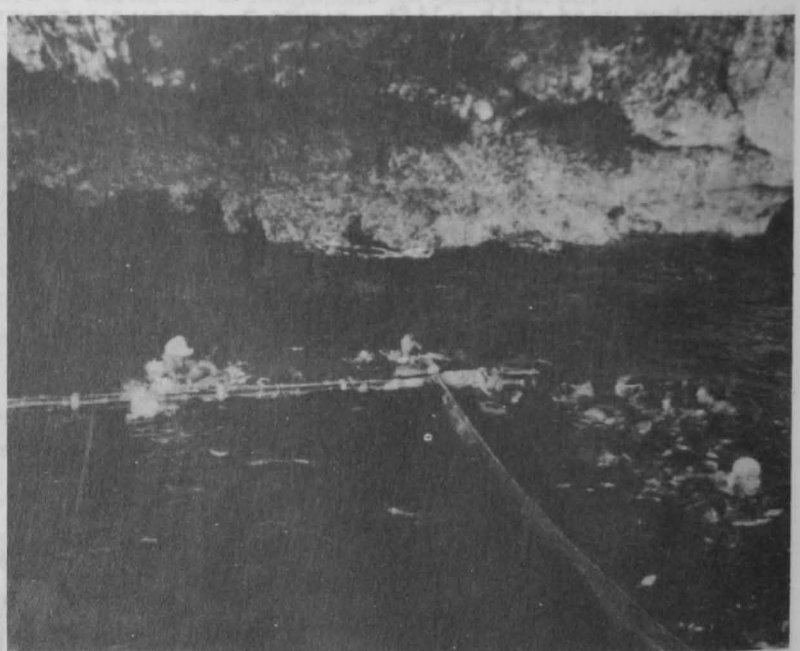

FIGURE 10 - BAIT NET CLOSED AFTER DRIVE, TINIAN, M. I.

because the fish become overcrowded and smothered while trying to get into the cooler water surrounding the coils.

The fishermen from Makurazaki in Kagoshima Prefecture were able to carry anchovies to the Sulu Sea for use in skipjack fishing. They gave the maximum temperature tolerance of bait sardines as 81° F. and that of anchovies as 86° F. Since they pursued a winter fishery in the Sulu Sea, at which time the prevailing water temperatures were 79° F.-81° F., this allowed a small margin of safety for the use of anchovies.

FIGURE 11 - BAIT NET DRIED UP FOR TRANSFER AT TINIAN, M. I.

FISHING GEAR

Although the Japanese vessels and gear resemble in a general way those used in the United States for live-bait tuna fishing, the interchange of ideas has been by no means complete. The fleet in Japan is composed of both wooden and steel vessels. As in the United States, there has been a marked tendency toward larger vessels. The number of boats of greater than 60 gross metric tons increased from 3 in 1924 to 342 in 1938. Many of the newer vessels are in the 100- to 200-gross-ton class. There appear to be two general types of construction in the skipjack fleet. The majority of the vessels, including all of the smaller boats, are built along the lines of a sampan. Some of the larger ships are combination live-bait and tuna long-line vessels which are modeled to resemble the North Atlantic trawlers.

Among the outstanding differences between U. S. and Japanese fishing methods are the larger crews found in the Japanese fishery. The smallest vessels, which are under 30 feet in length, may have a crew of five or more men, while a 160-gross-ton vessel (about 90 feet over-all) will carry a crew of 60 men. This is desirable from the boat owner's standpoint for it assures a maximum catch when fish are found. It is possible to use such a large crew only by carefully training the fishermen and equipping the vessel in a manner to permit many fishermen to work. The fishermen serve years of apprenticeship before they are able to catch fish effectively under crowded conditions. The vessels have an outboard walk or rack which extends around the stern, along one side of the vessel and round the bow. On a smaller portion of the fleet this walk extends completely around the deck (Figure 15). Because the fishing walk is at deck level, or slightly above, and the deck is relatively high in Japanese vessels, Japanese fishermen fish at a position which may be from 5 to 10 feet above the surface of the sea, depending upon the size of the vessel.

This elevated position has both advantages and disadvantages; in any event it necessitates use of a fishing technique different from that of the United States.

The height above the water is said to allow fishing operations to be conducted under sea conditions which would cause an American tuna clipper to cease fishing because the fishermen could not stay in the racks. The major drawback seems to be that the greater distance above the sea surface increases the difficulty of landing fish.

FIGURE 12 - LOWERING SCOOP OF BAIT INTO BAIT WELL AT TINIAN, M. I.

Whether or not the height of the fishing platform is the primary reason, the Japanese skipjack fishermen use a bamboo pole much longer than is common in the United States tuna fisheries. For large fish a pole as short as 10 feet may be used, but the ordinary skipjack pole may be as much as 18 or 20 feet in length. Such poles are 1-1/2 to 2 inches in diameter at the butt, and from 1/2 to 1 inch in diameter at the tip. The pole is of necessity very springy. The great length makes it difficult or impossible for the fishermen to lift large fish.

The line is 1 or 2 feet shorter than the pole so that the fisherman can catch the fish under his arm. The line itself is not particularly unique. The upper portion is fastened in a loop at the rod tip. The lower portion is fastened to a twisted cotton piece about 1 foot in length which has a knot at the bottom end to facilitate the rapid changing of the leader that is attached to the lure.

The material and weight used in the line, as well as the length of the pole, may be varied to suit the vigor with which the fish strike. If the fish are biting excitedly, shorter poles, and strong, coarse lines may be used. Should the school be wary, longer poles and lighter line or silkgut line may be used.

Two general types of lures are used. These are the artificial squid and live bait. The artificial lures are made of a barbless hook to which is attached a metal or bone "head" and which may or may not have a "body" or feathers or other material. The lures, which are quite similar throughout the world were illustrated by Kask (1947).

The equipment of the ship varies somewhat from that used in the United States. This is true of the bait wells in particular. The bait carrying space is all below decks, generally in or slightly ahead of the middle portion of the vessel. Construction is relatively simple; the fish holds are built rather small, and have watertight bulkheads so that they may be flooded to carry bait. Very few ships have pumps to circulate the water. Instead, holes are cut through the hull so that circulation will be provided by the rise and fall of the ship. Vessels of 125 gross tons will

have 4 or more wells. A well 7 feet by 7 feet by 9 feet will have in the bottom 16 screen-covered holes, 8 inches in diameter. The holes are furnished with either plugs or metal caps so that they can be made watertight (Figure 14). To empty the well for storing the catch, the fishermen swim down and plug the holes so that the space may be pumped dry. The simple bait retention facilitates used aboard the Japanese ships are advantageous from the standpoint of economy of installation and operation. However, a mechanical circulation system, such as used on the West Coast of North America, enables the vessel to carry a greater quantity of bait in the available space. Further, the bait can be held while at anchor in calm water, because the motion of the ship has no relation to circulation within the bait tanks. The Japanese meet this problem by carrying a collapsible bait box such as described earlier. When it is anticipated that the vessel will be at anchor for any length of time in sheltered waters, the bait is transferred from the wells to the live box for safe keeping.

FIGURE 13 - SKIPJACK FISHING FROM JAPANESE SAMPAN.

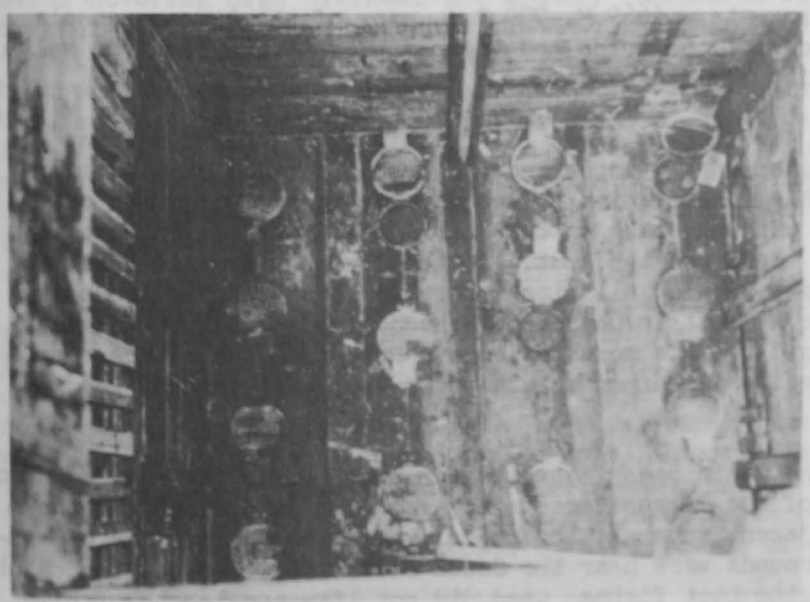

FIGURE 14 - CIRCULATION PORTS IN BAIT WELL.

A development which is unique to the Japanese style of live-bait fishing is the spray system (Figure 13). All of the skipjack vessels have this equipment. It consists of a power-driven pump which

supplies a constant flow of sea water to a number of spray outlets which are situated at 3-to 4-foot intervals along the walk from which the fishing is done. A 125-gross-ton vessel will have one or two centrifugal pumps with 4- to 5-inch intakes. These deliver water into one or two header pipes, depending on whether fishing is done from one or both sides of the ship. A distributing pipe is laid along the fishing walk (Figure 15). Near the header this pipe is 4 or 5 inches in diameter, but may taper to 1 or 2 inches in diameter at the end. From the main pipe, short lengths of 3/4-inch-diameter pipe point outboard. A few feet of rubber hose, bearing a piece of brass tubing, are attached to the end of this pipe. The brass tubing is flattened to squirt water as a horizontal, fan-like spray. The water pressure is low and such that a gentle spray falls between 6 and 18 feet from the hull of the vessel, forming a ruffled band which will be from 4 to 8 feet in width.

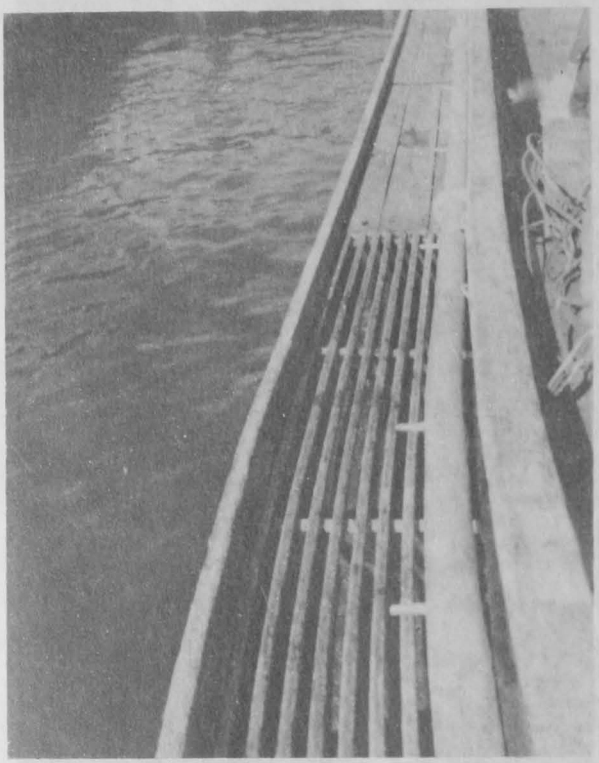

FIGURE 15.- FISHING RACK OF A 150-TON JAPANESE SKIPJACK VESSEL.

Because the major portion of the catch in the past has been consumed fresh (unfrozen) or dried, mechanical refrigeration equipment in the skipjack vessels is lacking or of relatively small capacity. Only recently has there been serious investigation of brine-freezing of tuna aboard the vessel for canning on shore. In most cases ice is carried to prevent spoilage, and voyages are short in duration. It must be noted that this applies only to the skipjack fishery. The tuna long-line vessels (which catch other tunas) may spend a month or more fishing. However, since the skipjack are taken in warm waters (66° F.-79° F.), many of the larger vessels have small ammonia systems to cool the holds and thereby prevent the ice from melting as rapidly as it ordinarily would.

The use of radios among the fishing fleet is of a highly organized nature. In almost every tuna fishing center of any importance, there is a radio station maintained by the local tuna fishing association. These are of value in that not only is the ship in daily contact with the base so that the date of arrival in port as well as size of landings can be forecasted, but also they promote greater fleet efficiency. The entire fleet may know at all times where the best catches are being made; consequently, less time is lost in unproductive scouting. Also, the regular contact makes aid to distressed vessels more reliable. Recently, the severe competition in some areas has made the fishermen reluctant to broadcast news of good catches.

The equipment used in the South Seas fisheries was essentially the same as that used in Japan; indeed, some of the larger vessels voyaged from central and southern Japan to the Sulu Sea and adjacent waters. The major difference was in size of vessels. Because the fishing grounds were near the South Seas bases, because the catch spoiled rapidly, and because the bait fishes used did not live any length of time

in the bait wells, small vessels which made daily trips were found to be more efficient. These sampans ranged from 26 to 50 feet in length, and carried crews of from 5 to 25 men. A factor which may have had a bearing on the size of vessel used, but which was not mentioned, was the difficulty often encountered in catching bait. Although enough bait might be caught to supply a small vessel, in most places bait was not found in sufficient quantity to supply a large vessel.

FISHING TECHNIQUES

LOCATING SKIPJACK SCHOOLS: Since the success of any live-bait fishing operation for skipjack depends largely on the ability of fishermen to locate fish schools and to fish these with maximum effectiveness, Japanese skipjack fishermen have learned to place much emphasis upon the ability to recognize signs of fish and to judge conditions which may directly or indirectly reveal the presence of fish. Some of their locating methods, such as the use of oceanographic data, are unique and may well be used to advantage by American tuna fishermen.

In general, Japanese live-bait fishermen rely on one of several factors or a combination of factors to find fish. Of primary importance perhaps is experience, born of long years at sea. By closely observing the conditions under which fish are usually found and by collating data from personal logbooks, the fishermen are able to predict with reasonable accuracy the availability of skipjack on the fishing grounds, both with respect to season and area, and plan their operations accordingly.

Although experience serves as a valuable guide in narrowing down the time and area of search, the actual spotting of skipjack schools at the surface is done by means of scouting. By watching for certain well-established signs which point to the presence of fish, the fishermen are able to find the schools. Of these signs, birds are considered to be the best since they are visible from a distance. Furthermore, schools of skipjack accompanied by birds generally offer excellent fishing. According to Japanese fishermen, the activity of bird flocks indicates whether or not the skipjack schools being followed can be fished. Schools of fish with birds hovering high overhead are usually considered to be "wild" fish - skipjack traveling at a fairly fast rate which will not stop to feed. On the other hand, "working birds" (birds which continually dive in and out of a school) indicate by their actions the presence of actively feeding skipjack. Such schools provide the best catches because they can be drawn to the side of a fishing vessel by bait fish. A flock of birds resting on the surface may point to the presence of a school at lower depths. As a rule, the size of the fish school is thought to be proportional to the number of accompanying birds; the greater the number of fish, the larger the flock.

As previously pointed out in the discussion on biology and ecology, water temperatures play an important part in the skipjack fishery. Knowing the temperature limits and optimum ranges for the occurrence of skipjack, the fishermen are able to delineate the areas where schools of fish are most likely to be encountered. Therefore, Japanese fishermen will take surface temperature readings almost constantly when searching for skipjack. Furthermore, a sharp fluctuation in temperature may indicate a zone of discontinuity between water masses of two different characteristics. These current contact areas are said to be especially good for skipjack fishing because the fish are attracted by the presence of natural food.

Other oceanographic conditions, such as, water color and current flow, are important to skipjack fishermen because they show the fishermen when they have entered

the Japan Current. Clear, dark blue water and a current flowing in a general northerly or northeasterly direction identify the warm Japan Current where most schools of skipjack are to be found.

In addition to visual and oceanographic signs, Japanese fishermen rely heavily on so-called "associations" to locate skipjack. They have discovered through experience that schools of fish are often found near floating driftwood, debris, and large marine creatures, such as, whales and basking sharks, which normally inhabit surface waters. Although the exact reasons why skipjack are attracted to floating objects are not known, it is possible that they congregate to feed on small fish and crustaceans which gather around flotsam. Whales and sharks are said to be symbiotically associated with skipjack - they act as scavengers and at the same time provide cover for skipjack.

Schools of skipjack which follow driftwood can be more readily fished, if they take live bait, than those found with sharks and whales. Large pieces of wood which are covered with barnacles, seaweed, and other marine growth and which float with the long axis vertically in the water, have been found to hold special attraction for skipjack. When such driftwood is located by fishermen, they range slowly alongside and chum with a few live bait fish. If skipjack are not seen, the fishermen continue on their way. This, however, depends upon the discretion of the captain. A vessel will often tie up to the driftwood, if it is large enough, or will remain in the vicinity until the captain is satisfied that skipjack are not to be found.

Trolling jigs are used to locate subsurface schools of fish. Jigs are dragged behind the fishing vessels at all times when approaching the fishing grounds and while on the fishing grounds. In Kagoshima Prefecture, fishing boats set out several feathered trolls as soon as they have entered areas having optimum water temperatures for skipjack, usually above 66° F. If while trolling a skipjack strikes at the lure, the vessel is stopped immediately and a few bait sardines or anchovies are thrown to bring the school to the surface. Fishing commences as soon as the skipjack start taking bait. Otherwise, the vessel continues on its way, trolling and scouting for fish.

Hookless trolling jigs are also used to find fish. Lines to which these lures are attached are held in hand while trolling and if a strike is felt, the vessel is stopped and bait is broadcast. This method is said to have an advantage over the use of hooked jigs in that the striking fish is not caught. A hooked fish may frighten the rest of the school by its effort to get free or may discourage other fish from taking bait by trailing blood if it escapes.

Skipjack also make their presence known by leaving a wake which is easily discernible on a flat sea. Patches of smooth water ("slicks") on a ruffled surface are also regarded as general indications of subsurface skipjack schools. Jumping and rolling fish often guide fishermen to the schools.

METHODS OF APPROACHING SCHOOLS: Once a school of skipjack has been sighted, the problems of how best to approach the school arise. There are many different views on this subject, all of which vary with locality and with individual captains. The following approaches are considered to be the best, but conditions do not always permit their use.

1. Kagoshima fishermen opine that the most effective approach is to draw the school towards the portside of the boat

by chumming live bait, maneuvering the vessel so that the fish are between the sun and the vessel.

2. Fishermen from Mie Prefecture, who are considered as being among the foremost of Japanese skipjack fishermen, claim that the best way to contact a school is from downwind.

3. Shizuoka fishermen and those of neighboring prefectures like to intercept the head of the school on the portside of the vessel.

In short, it may be concluded that there is no standard way of approaching a school of skipjack. The approach depends upon the situation and on the discretion of the individual captain.

CHUMMING AND USE OF SPRAY SYSTEM: "Chumming," or the scattering of live bait, is an essential preliminary to actual fishing. By this means schools of skipjack are attracted to the vessel and fished. The chummer holds an important position among the crew and is usually a man with considerable fishing experience. Upon him rests the responsibility of luring the skipjack towards the fishermen, of effectively "holding" the fish near the vessel, and of using bait supplies judiciously so that waste is avoided. Large vessels with crews of 40 or more fishermen usually have two men broadcasting bait when fishing, one at the bow and one at the stern. Small skipjack boats employ a single chummer. In the latter case, the chummer generally stands forward of the bridge where the bait wells are located, above the level of the fishing platform so that he can chum over the heads of the fishermen. When chumming from stern, bait is brought in buckets to the chummer.

As the vessel approaches a school of skipjack, the chummer throws a few handfuls of live bait, from 50 to 60 fish. If the fish take the bait, additional handfuls are scattered into the area ruffled by the spray system until the skipjack gather near the boat, which is now allowed to drift. A suitable species of bait fish when used as chum will swim back to the vessel for protection so that they lure the skipjack towards the fishermen. As soon as the skipjack become frenzied in their efforts to take bait, artificial lures are used and chumming is reduced to a minimum. Only a dozen or so fish are thrown every now and then. However, the amount of bait used and the duration of chumming is governed by the behavior of the school. If the school is wary and the fish will not take lures, the fishermen use live bait on the hooks, and chumming is continued at the same time as long as the fish bite. Dead or ground chum has been found to be almost useless for the purpose of attracting skipjack.

Chumming is generally done by hand from a small dipnet. The bait is kept in a small box or tub which is kept supplied from the main bait wells. Water is not circulated through these tubs. Live bait is never chummed directly from the bait wells as is the case in the United States tuna fishery.

An important adjunct to chumming is the use of the spray system. This modern technique was developed exclusively by the Japanese and finds common use among all skipjack fishermen regardless of the size of vessel used. No comparable method is used in the American fishery except in the Hawaiian Islands where Japanese immigrants have introduced the spray system into the local fishery. Over 35 years ago, when the present day Japanese skipjack fishery was still fairly young, Japanese fishermen who fished from small hand-propelled boats found that better catches of skipjack could be made by agitating water around the boat with bamboo rakes and other crude contrivances. Water was also scattered from the bait tub. This technique was later

adopted by powered boats when they entered the fishery and it resulted in the development of the spray system.

The chief advantages cited for use of sprays are:

1. The spray ruffles the surface of the water so that the vessel and fishermen are hidden to the fish.

2. Water agitation excites the fish into taking artificial lures, thus conserving bait supplies.

Whether or not these contentions hold true is open to question, but the fact remains that Japanese fishermen are all thoroughly convinced of the efficacy of sprays in increasing catches of skipjack.

Spraying accompanies chumming as the vessel approaches a school of fish; however, some boats only spray when the school has been drawn to the boat. The spray is continually operated when fishing and is turned off only when the fish have dispersed. It is used regardless of weather and water conditions.

In the South Seas, a slightly different technique was frequently used in chumming live bait. When a school of skipjack was located, the vessel was maneuvered slowly past the school at a distance of about 75 feet. Bait was then thrown in the direction of the school and as the vessel proceeded, a careful lookout was maintained to see whether the skipjack diverged from their course to take the bait. If skipjack were seen to feed, the vessel circled in a direction away from the school and chumming was resumed as the school was approached; fishing then commenced. If the fish failed to rise, this procedure was sometimes repeated.

FISHING: Fishermen on the larger vessels are usually stationed on both sides; on smaller vessels, they fish from only one side (Figure 16), either port or starboard. The most experienced fishermen are placed at the bow and stern while the less experienced members are stationed amidships. This is to take advantage of the tendency of skipjack to congregate near the ends of the vessel. Those fishing along the bowsprit have to be especially agile because of their precarious position. Fishing is generally done from a standing position.

In live-bait fishing, the fishing pole is gripped with both hands and the butt of the pole is placed firmly against the thigh. Pads are often used by fishermen to protect themselves from the butt of the pole. The baited hook is placed in the band of water ruffled by the spray and the fisherman then sets himself for the strike, which has to be almost anticipated for the momentum of the fish in rushing at the bait is used to aid in bringing it aboard. When the fish is lifted from the water, it is swung through the air in such a manner that it can be caught underneath the left armpit of the fishermen with the head of the fish pointing out and the stomach up. This enables the fisherman to remove the hook quickly and at the same time prevents bruising of the fish. To catch a skipjack beneath one's arm is a highly skilled technique and generally requires years of practice before proficiency is attained. Boys who are planning to become fishermen are trained to do this in fisheries schools where they use wooden fish models for practice.

The American technique of fishing one hook with two poles has been adopted by Japanese fishermen for catching albacore and small yellowfin tuna up to about 50 pounds. There is no pole-and-line fishery for the larger fish as such. More often, however, fishermen continue to use one-pole lines and will assist each other in landing fish. When a man hooks a fish, the crew member on each side of him props

the tip of his pole under the one holding the fish, provided they are free to do so. All three men then bring the fish aboard together. This method has its advantage

FIGURE 16 - JAPANESE SKIPJACK FISHERMEN WORKING A SCHOOL OF FISH.

in that more lines can be fished at one time for a given amount of space. Dipnets may be used in landing large fish.

Aboard the vessel, each fisherman has a live box at his side which is built into the rail of the ship. These live boxes are connected to the spray system for water circulation, and are kept supplied with bait by "bait boys," youngsters who preform odd jobs aboard the fishing boat.

Various methods are used in baiting hooks, but the principle is the same—generally, fish are hooked in such a way that they will suffer the least injury and will be able to swim freely. Ordinarily, the hook is fastened through the head from beneath the jaws or through the back (Figure 17). Live bait is generally used when first fishing a school or when the fish are wary. If the skipjack become greatly excited, the fishermen quickly change over to artificial lures.

Artificial lures, usually feather jigs, are also worked in the band of water covered by the spray and are played on the surface. When a fish is hooked, it is jerked directly overhead so that the fish becomes unhooked in mid-air, and will fall behind the fishermen. This leaves the lure free to fish again. Since rebaiting is not necessary, the need for catching the fish is eliminated.

The vessel is usually allowed to drift with the wind and current while fishing, but in certain instances may be propelled slowly to keep up with the school. Deck scuppers are stopped with rags and waste to prevent blood from dripping into the water and discouraging fish from biting. Schools of skipjack which bite well may be fished as long as 30 minutes, during which time a 40-man crew can catch a maximum of 5 to 6 thousand skipjack or the equivalent of 20 to 25 metric tons. Schools once fished and lost may be refished, provided they can be attracted by chum.

Japanese skipjack fishermen, like all others of their profession, have certain beliefs, usually based upon experience, in regard to fishing conditions. A few of the concepts are:

1. Fishing is best after the passage of an atmospheric low pressure area.

2. Just before and after low and high water on the change of the tide.

3. A ruffled surface is conducive to good fishing.

4. Cloudy overcast weather is preferable to clear days.

5. In spring, an easterly wind is favorable for fishing; in fall, a westerly wind.

6. Skipjack which have brightly colored indigo backs bite better than do fish with pale backs. It was said that as the fish becomes excited, the color of the back brightens.

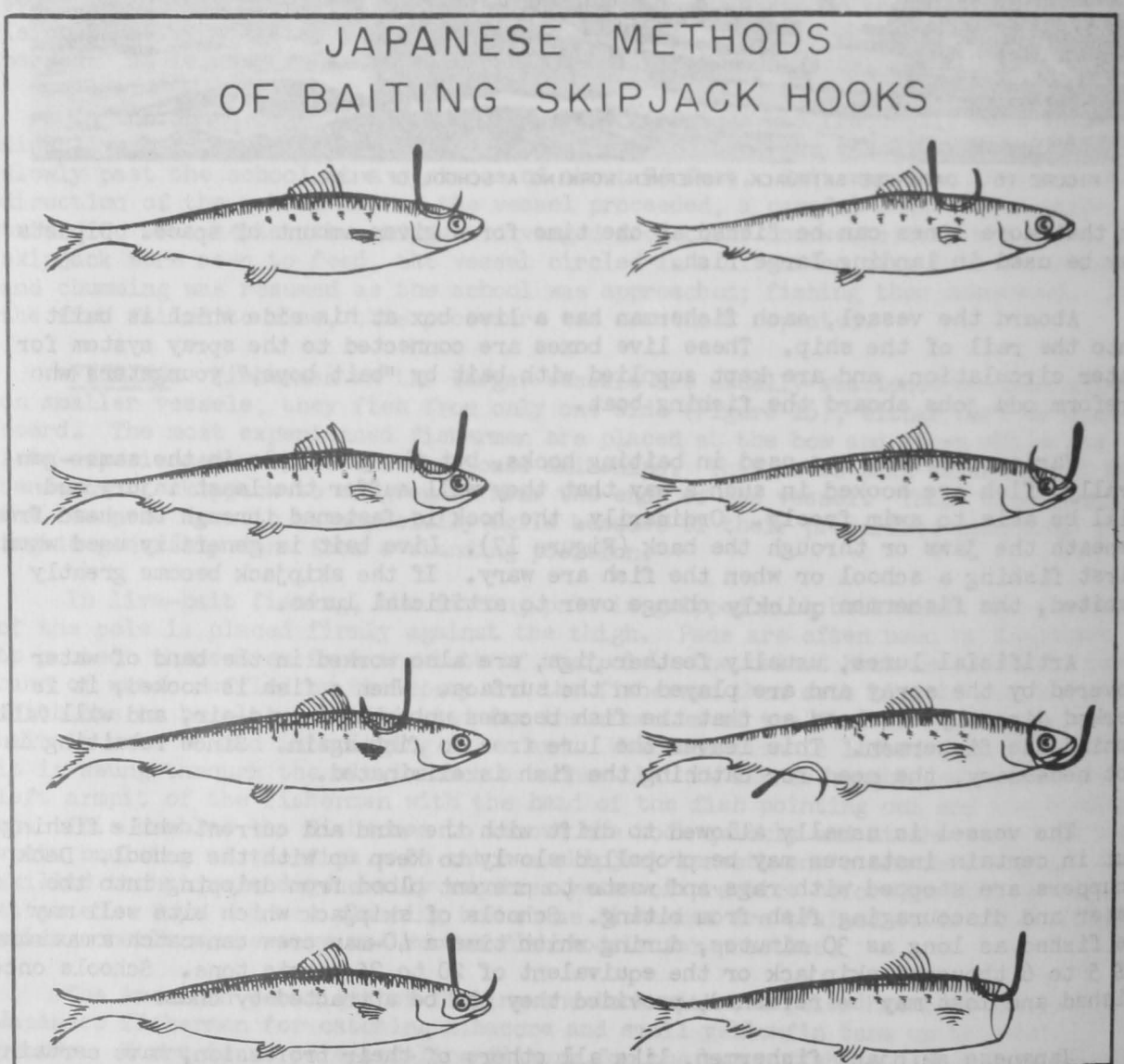

FIGURE 17

HANDLING OF CATCH

Because of the short duration of actual fishing time, catches are not stowed until the school has disappeared. When it is evident that fishing has ceased, all crew members, with the exception of the captain and lookouts, participate in icing down the catch. Since most Japanese fishing boats are not equipped with refrigeration systems, except for a few of the more recently built vessels, skipjack are preserved whole in crushed ice. Ice is loaded aboard the vessel in crushed form or in 200-pound blocks which are crushed with wooden mallets when needed. The fish are usually thrown from the deck into the hold where they are packed in ice. The amount of ice carried and fish-holding capacity depends upon the construction of the vessel, but in general, a 50-gross-ton vessel will carry about 15 tons of ice and will be able to handle 30 tons of fish.

Some fishing vessels use a combination of sea water and crushed ice in preserving their catches. This medium is often employed when bait wells are used as auxiliary fish holds. In this case, the holds are plugged. The fish are thrown into the ice-sea water mixture until the hold is full. Rice straw mats are then placed on top and covered with boards, which in turn are so braced that they will hold the fish and ice beneath the sea water.

Since insufficient care is frequently exercised in handling fish, catches are often in a poor condition by the time they reach port. This is especially true of small fishing vessels which have limited ice-carrying capacities. Coastal skipjack boats which go out for only a day or two do not carry ice. During peak seasons when large catches are being made, fishing boats will load up with as many fish as they can carry regardless of whether or not the fish can be adequately preserved. This results in poor quality fish. Also, skipjack fishing is best during warm weather so that unless careful precautions are taken to maintain the freshness of the fish, they will deteriorate rapidly. Under the present economic conditions in Japan where no premium is placed upon the quality of fish brought to port, the fishermen have no incentive to bring in fish in good condition. Thus far, they have had little trouble in disposing of their catches, fresh or stale.

In port, fish are unloaded from the vessel by hand. The fishermen form a line from the hold to the wharf and pass the fish two or three at a time along this line. Small fish under 5 pounds are handled in bamboo baskets. The landed fish are sorted on the pier into small, medium, and large sizes because the price of fish varies with size; the larger ones command the higher prices. After weighing, which is usually done with beam balances and baskets, the fish are either taken to processing plants for manufacture into dried fish sticks or are delivered to the fresh fish market.

FISHING GROUNDS AND SEASONS

GROUNDS: Fishing grounds in the Pacific Ocean to the east and south of Japan are arbitrarily broken down into four major areas, each of which is identified with some prominent landmark. These are from north to south, the Tohoku, Zunan, Kinan, and Satsunan areas. Projections of these four divisions to the east and south, and west in the case of the Satsunan region, are contained within the fishing area which is at present authorized by SCAP (Figure 18).

The Tohoku region, which is the most important of all skipjack fishing grounds from the standpoint of total catch, encompasses all waters north of an imaginary

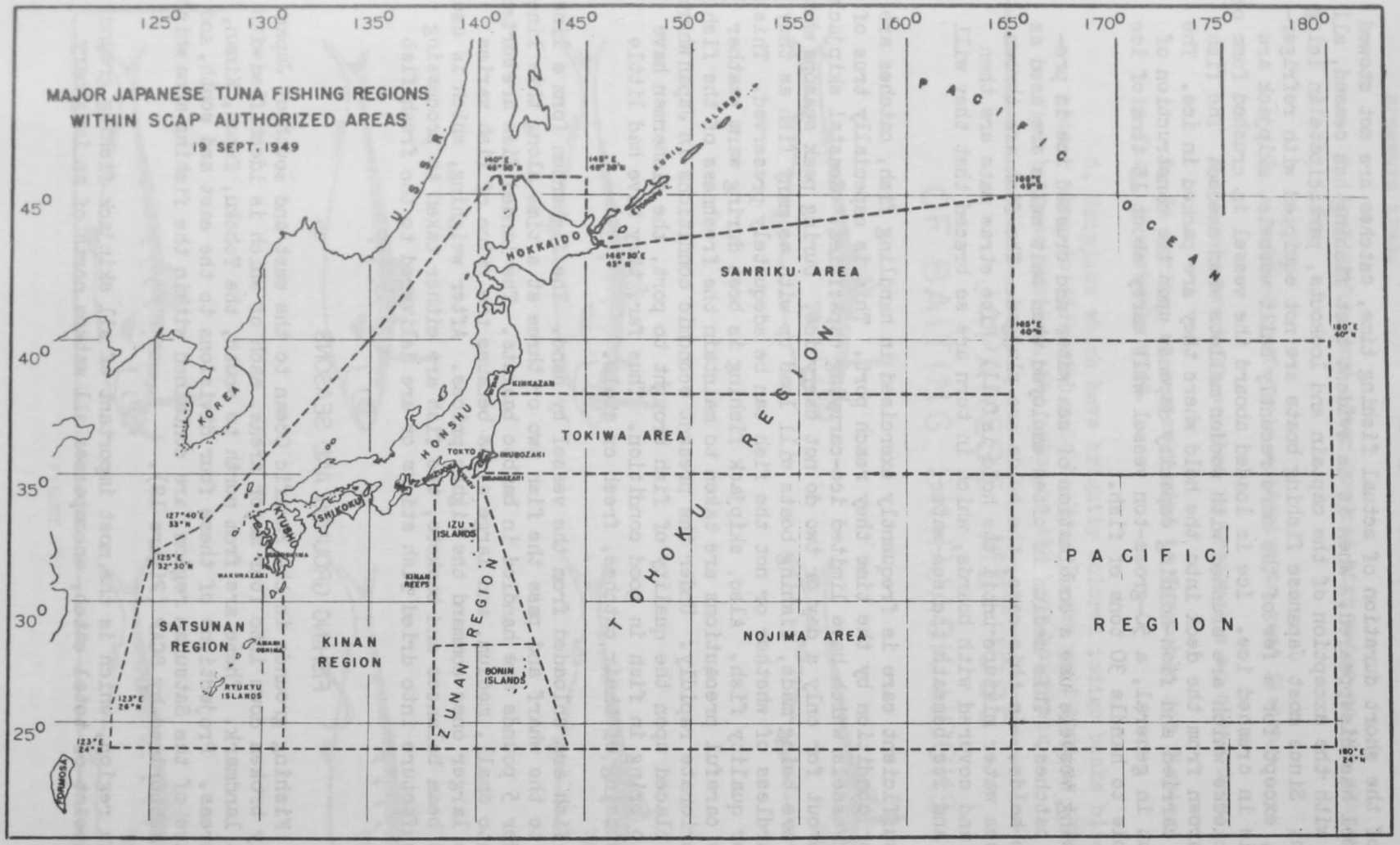

FIGURE 18

NOTE: AUTHORIZATION FOR THE OPERATION OF ONLY MOTHERSHIP-TYPE TUNA FISHING (SIMILAR TO THE ANTARCTIC WHALING EXPEDITIONS) IN THE AREA EXTENDING SOUTH FROM THE AUTHORIZED JAPANESE FISHING AREA TO THE EQUATOR WAS GRANTED BY THE SUPREME COMMANDER FOR THE ALLIED POWERS BY SCAPIN 2097 DATED MAY 11, 1950. THIS INCLUDES WATERS IN THE UNITED STATES TRUST TERRITORY AROUND THE CAROLINE ISLANDS, THE MARIANAS AND THE MARSHALL ISLANDS, BUT NOT THE GILBERT ISLANDS. (SEE COMMERCIAL FISHERIES REVIEW, JUNE 1950, PP. 52-4; JULY 1950, P. 46.)

line drawn in a south-southeasterly direction from Nojimazaki in Chiba Prefecture. This sea area is, in turn, subdivided into three smaller units: Sanriku, waters north of 38° north latitude; Tokiwa, 35° north latitude to 38° north latitude; and Nojima, waters to the south of 35° north latitude.

The Zunan region lies immediately south of the Tohoku region and has as its western limits 138° east longitude. The Izu and Bonin Islands, which are included in this division, form sub-regions of their own, being divided at approximately 28°20' east longitude.

The Kinan region lies directly off Shikoku and is delineated on the east by 138° east longitude and on the west by 131° east longitude.

Adjacent to Kinan on the west is the Satsunan region, which includes the northern Ryukyu Islands.

In Japan proper, there are a total of 20 or more prefectures which engage in skipjack fishing, most of which border the Pacific Coast. Of these, Miyagi Prefecture is usually the leading producer, followed closely by Shizuoka Prefecture farther to the south. The larger landings of Miyagi Prefecture are due to the strategic location of her ports in relation to the Tohoku area which is conceded to be the most productive of homeland fishing grounds for skipjack. Fishing vessels from Miyagi and nearby prefectures are able to exploit the numerous schools of skipjack which converge in Tohoku waters from July to October chiefly off Cape Kinkazan. Annual catches of these prefectures are therefore relatively higher than those situated elsewhere along the Japanese coast.

SEASONS: The Japan Current is assumed to be the controlling factor in the migration of skipjack from southern waters; therefore, it directly affects the yearly fluctuations of the fishery in Japanese waters. This warm-water system originates in the eastern Philippine Islands as a branch of the Equatorial Current. After flowing to the northeast of Formosa and passing through the Ryukyu Islands, the main current of the Japan Current proceeds northeast along the coasts of Kyushu, Shikoku, and Honshu until it reaches the vicinity of Inubozaki in Chiba Prefecture, approximately 37° north latitude. Here the Japan Current meets the Kamchatka Current (Oyashio), a cold current, coming along the coast from the north, and veers east to continue its way across the Pacific.

In the spring, with the rise in water temperature and the gradual extension of the Japan Current to the north, migratory skipjack schools start to appear in the Amami-Oshima region, south of Kyushu, in early February. As the season progresses, fishing around the numerous banks in northern Ryukyu waters improves and reaches a maximum in May and June. These banks are relatively shallow with depths of 100 fathoms or less. At this time, fishing vessels from as far as the northern end of Honshu move to southern Kyushu ports to engage in the fishery. The schools continue to proceed north with the Japan Current so that the centers of fishing activity gradually shift from the Satsunan region north to the Kinan and Zunan regions. It is believed that the fish which enter Japanese waters along the Ryukyu chain of islands are joined off eastern Kyushu and Shikoku by skipjack which have migrated from the south along the Kinan reefs. Schools which are abundant in May in the Kinan region are said to decrease markedly in number during the latter part of June, when they presumably join the northward migration. Skipjack from the Zunan region, which first appear near Torishima, are also numerous in May and June, and a part of these schools are said to travel northward in July; the rest remaining in the area

until autumn. In July and August, with the Japan Current reaching its maximum development and making its influence felt as far north as the southern Kurile Islands, approximately 46° north latitude, the migrating schools of skipjack converge in an area 150-200 miles east of Kinkazan in Miyagi Prefecture. Since further movement to the north is barred by the presence of the Kamchatka Current with its cold temperatures, the schools remain in the Tohoku area and provide excellent fishing until September. Occasionally, some schools ascend as far north as Etorofu Island, immediately north of Hokkaido.

With the gradual decrease in temperature in September, the Japan Current is deflected farther south and is weakened as the cold Kamchatka Current becomes dominant. At this time, the skipjack schools disappear. Where they go and by what routes is still unknown although various views are held on this subject. Some schools are said to have been seen returning southward about 300 miles offshore, presumably to their areas of origin; these schools have been fished. Not a few investigators contend that the skipjack travel due east at greater depths to complete a circular migration to the South Seas, possibly by way of the Hawaiian Islands and Central America. As evidence, they point to the fact that skipjack are often caught by the winter long-line fishery operating 1,500 miles east of Japan and at depths not normally fished for skipjack, approximately 300 feet. However, skipjack taken by these long-lines are usually much larger than those ordinarily caught in Japanese waters.

The so-called "resident schools" may be fished throughout the year around the Bonin, Izu, and Ryukyu waters. Fishing operations usually cease during the mid-winter months because of unfavorable weather and lack of bait. In addition, "resident skipjack" are not very abundant during the winter, and never furnish the highly productive fishing which is found during the warmer months.

SOUTH SEAS: In the former Mandated Islands region, fishing for skipjack was limited for the most part to waters proximate to the widely scattered major fishing bases of Palau, Saipan, Truk, Ponape, and more recently Kusaie and Yap, although it was recognized that there were other potential fishing grounds of importance. Since the fishing boats were of small size, ranging up to 25 and 30 tons, the fishermen usually fished outlying reefs and banks and rarely ventured more than 50 miles from land. Furthermore, trips were limited to a day's duration because it was impossible to keep bait alive for any length of time, not to mention the difficulties of maintaining the quality of fish under prevailing climatic conditions.

Weather conditions for fishing are generally ideal throughout the year in the low north latitudes, except from November to February when the northeast trade winds prevail. Although it is possible to catch skipjack during all seasons, fishing usually slacks off in January and February. The period from May to September is reported to provide the best fishing for skipjack.

OTHER FISHING GROUNDS: Although the Japanese at one time exploited skipjack resources of the Indo-Pacific and Philippine regions, detailed information regarding their areas of operation are lacking. However, the general location of fishing grounds in these two regions is presented in "The Japanese Tuna Fisheries" (Shapiro 1948).

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LITERATURE CITED

ESPENSHADE, A. V.
1947. JAPANESE FISHERIES PRODUCTION 1908-46. (A STATISTICAL REPORT), REPORT NO. 95, OCTOBER 1947, SUPREME COMMANDER FOR THE ALLIED POWERS, GENERAL HEADQUARTERS, NATURAL RESOURCES SECTION. (ALSO FISHERY LEAFLET 279, JANUARY 1948, U. S. FISH AND WILDLIFE SERVICE.)

IMAMURA, YUTAKA
1949. THE JAPANESE SKIPJACK FISHERY. THE TEXT OF THE FISHERY, VOL. 6 (MARCH 5, 1949), PP. 17-94 (IN JAPANESE).

KASK, J. L.
1947. JAPANESE FISHING GEAR. REPORT NO. 71, MARCH 5, 1947, SUPREME COMMANDER FOR THE ALLIED POWERS, GENERAL HEADQUARTERS, NATURAL RESOURCES SECTION. (ALSO FISHERY LEAFLET 234, MAY 1947, U. S. FISH AND WILDLIFE SERVICE.)

SHAPIRO, SIDNEY
1948. THE JAPANESE TUNA FISHERIES. REPORT NO. 104, MARCH 1948, SUPREME COMMANDER FOR THE ALLIED POWERS, GENERAL HEADQUARTERS, NATURAL RESOURCES SECTION. (ALSO FISHERY LEAFLET 297, APRIL 1948, U. S. FISH AND WILDLIFE SERVICE.)

SMITH, R. O.
1947. SURVEY OF THE FISHERIES OF THE FORMER JAPANESE MANDATED ISLANDS. FISHERY LEAFLET NO. 273, U. S. FISH AND WILDLIFE SERVICE.

TAKAYAMA, SHIGENE
1949. SAURY LIFT-NET FISHING WITH LIGHT. CENTRAL EXP. STA., TOKYO. PAPER PREPARED FOR U. N. CONFERENCE ON CONS. & UTILIZ. OF RESOURCES, APRIL.

U. S. PACK OF TUNA AND TUNA-LIKE FISH

DO YOU KNOW .....

That the 1949 United States pack of tuna and tuna-like fish, which amounted to 7,290,320 cases (141,700,593 pounds), valued at $97,710,325, was 252,562 cases greater than the 1948 production. However, canners received nearly 15 million dollars less for the pack in 1949 than in the previous year.