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JAPANESE TUNA-MOTHERSHIP OPERATIONS IN THE WESTERN EQUATORIAL PACIFIC OCEAN

By Bell M. Shimada*

INTRODUCTION

Motherships were used by the Japanese with notable success to exploit the rich salmon and crab resources of the north Pacific Ocean in prewar days; however, these mobile processing units were not similarly associated with the tuna fisheries. Perhaps the most important of several considerations which precluded the introduction of the mothership system during the 1930's, when the expansion of the offshore fishery for tuna was at its greatest, were:

1. JAPANESE FISHING COMPANIES WERE ALREADY REAPING LARGE PROFITS FROM THE NORTHERN PACIFIC FISHERIES
2. BECAUSE THE POTENTIALLY RICH EQUATORIAL TUNA FISHERY WAS COMPARATIVELY UNDEVELOPED AT THAT TIME.

Consequently, they were not interested in transferring their large vessels to a then comparatively undeveloped equatorial Pacific Ocean tuna fishery.

Growth of the winter fishery for albacore in the mid-Pacific during this period focused some interest on motherships as a means of effectively harvesting this distant resource. However, no concrete efforts were made in this direction because it was thought that climatic conditions would present operational problems of insurmountable difficulty. Furthermore, the exigencies of war on the Asiatic mainland were already starting to have their effects on the Japanese fishing industry, and the larger vessels were being commandeered by the Navy. What plans, if any, the industry may have had for employing motherships in tuna fishing were completely disrupted by the outbreak of war with the United States in 1941.

Despite the lukewarm attitude of the Japanese fishing industry to proposals of using motherships in the tuna fishery, technical research of such operations was by no means lacking. In 1931, the Japanese Government sent a mothership to Indo-Australian waters for the dual purpose of investigating the possibilities of using a processing ship with its own auxiliary fishing vessels to exploit distant tuna resources and to discover new fishing grounds. The expedition was repeated in 1932 and 1933, and the results were published in Japanese government reports. As far as is known, however, no follow-up action was taken by the fishing industry even though these explorations revealed the presence of yellowfin tuna populations of sufficient magnitude to support a commercial fishery in the Celebes and Sulu Seas.

In 1948 and 1949, small mothership operations were attempted by the Japanese in waters around the Bonin Islands, and eastward to albacore grounds. These attempts were commercially unsuccessful because of poor fishing results and operational difficulties.

Elsewhere in the Pacific Ocean, the only other tuna-mothership operations were conducted experimentally by the United States with the Reconstruction Finance Corporation's Pacific Explorer, an American-built factory vessel. The Pacific Explorer,

* FORMERLY FISHERY BIOLOGIST, PACIFIC OCEANIC FISHERY INVESTIGATIONS, U. S. FISH AND WILDLIFE SERVICE.

equipped to dry-freeze and store tuna, operated from January to July 1947 in waters off Central and South America (Carlson 1948).

A new phase of the Japanese tuna fisheries was launched on May 11, 1950, approximately 4½ years after the close of World War II. The Commander-in-Chief Pacific and U. S. Pacific Fleet and High Commissioner of Trust Territory of the Pacific Islands, and the Supreme Commander for the Allied Powers (SCAP) gave permission to the Japanese (SCAP directive No. 2097,[1] May 11, 1950) to send tuna-mothership expeditions to defined areas of the high seas adjacent to the Caroline, Marianas, and Marshall Islands.

This permission was granted subject to the following terms and conditions:

1. THAT RECORDS OF FISHING AND FISH CATCHES BE KEPT BY THE JAPANESE OPERATOR, AS SPECIFIED BY THE HIGH COMMISSIONER, TRUST TERRITORY OF THE PACIFIC ISLANDS.

FIGURE 1 - HORIZONTALLY-LINED BORDER INDICATES EXTENT OF THE CINCPAC-SCAP AUTHORIZED JAPANESE FISHING AREA AS OF MAY 11, 1950. BROKEN BLACK LINE INDICATES AREA AUTHORIZED FOR JAPANESE INSPECTION VESSELS. DOTTED-STIPPLED BORDER SHOWS EXTENSION SOUTH OF 24° N. LATITUDE TO THE EQUATOR FOR JAPANESE TUNA MOTHER-SHIP OPERATIONS. SOLID BLACK LINE AROUND MARIANAS, MARSHALL, AND CAROLINE ISLANDS SHOWS THE U. S. TRUST TERRITORY OF THE PACIFIC ISLANDS.

1/ COMMERCIAL FISHERIES REVIEW, JUNE 1950, PP. 52-4.

2. THAT PROVISION BE MADE FOR A REPRESENTATIVE OF THE HIGH COMMISSIONER AND THE U. S. FISH AND WILDLIFE SERVICE TO BOARD OR ACCOMPANY VESSELS OF ANY EXPEDITION FOR PURPOSES OF OBSERVATION AND INSPECTION, AND THAT A REPRESENTATIVE OF SCAP ACCOMPANY EACH FLEET.

3. THAT PROVISION BE MADE FOR VESSELS OF THE FLEET TO REPORT THEIR POSITIONS DAILY BY RADIO.

4. THAT NO VESSEL OF THE EXPEDITION APPROACH CLOSER THAN THREE MILES TO ANY LAND NOT UNDER THE ADMINISTRATIVE CONTROL OF THE JAPANESE GOVERNMENT.

5. THAT SUPERVISION OF ALL OPERATIONS WAS BY RESPONSIBLE JAPANESE OFFICERS WHO WOULD INSURE UNDER ALLIED SUPERVISION RIGOROUS COMPLIANCE WITH ALL STIPULATIONS OF THE DIRECTIVE.

Immediately following the issuance of this directive, the work of organizing and conducting the first large-scale, commercial tuna-mothership expedition in Japanese fisheries history was undertaken by the Taiyo Fishing Company, Ltd., one of Japan's largest and most aggressive fishery concerns. The fleet consisted of a large refrigerated carrier ship detached from the company's Antarctic whaling fleet, 13 company tuna-fishing vessels, and 12 independently-owned vessels. It was assembled and outfitted for three months' operations in the newly-approved area (Figure 1). That a part of the mothership fleet was able to leave Tokyo on June 8, 1950, less than a month after formal approval, reflects not only the readiness of the Japanese to take advantage of their opportunity to fish the South Seas again, but also the haste with which preparations were made.

The following report deals with various aspects of Japanese tuna fishing and mothership operations observed while the author was with the expedition from June 12, 1950, to September 14, 1950, as a scientific and technical observer for the High Commissioner for the Trust Territory of the Pacific Islands and the U. S. Fish and Wildlife Service. Information and data regarding mothership practices and equipment were obtained largely through interviews with vessel personnel and through personal observation. Methods of fishing long-line gear were witnessed at sea aboard a fishing vessel attached to the fleet.

Statistics included in this report, together with other source material, were made available by the High Commissioner of the Trust Territories, the Supreme Commander for the Allied powers, and the Japanese Government.

OPERATING AREA AND SEASON

The mothership arrived on the fishing grounds on June 17, 1950. Fishing by 5 of her catchers commenced on that date in the vicinity of 4° 35' N. latitude and 143° 32' E. longitude (Figure 2). The remaining fishing vessels joined the fleet shortly thereafter, and the last catcher began her operations on July 14. As the season progressed, the expedition as a unit gradually moved eastward at a weekly rate of about 100 miles. The catchers confined their latitudinal activities between 1° and 9° N. latitude. Shifts in position of the mothership and fishing vessels and rate of longitudinal movement were determined largely by the success of fishing encountered in any one area. Fishing was conducted mostly between 1° and 5° N. latitude because of previous knowledge that the best catches of tuna could be made in this zone. When processing operations aboard the mothership were halted on September 2, the vessel's position was 5° 04' N. latitude and 157° 01' E. longitude. All fishing ceased on September 5, 1950, and the expedition headed back to Japan.

OPERATING RESTRICTIONS

Although the Japanese were authorized by SCAP to fish as far south as the Equator, for purposes of control the Japanese Government, through its representatives,

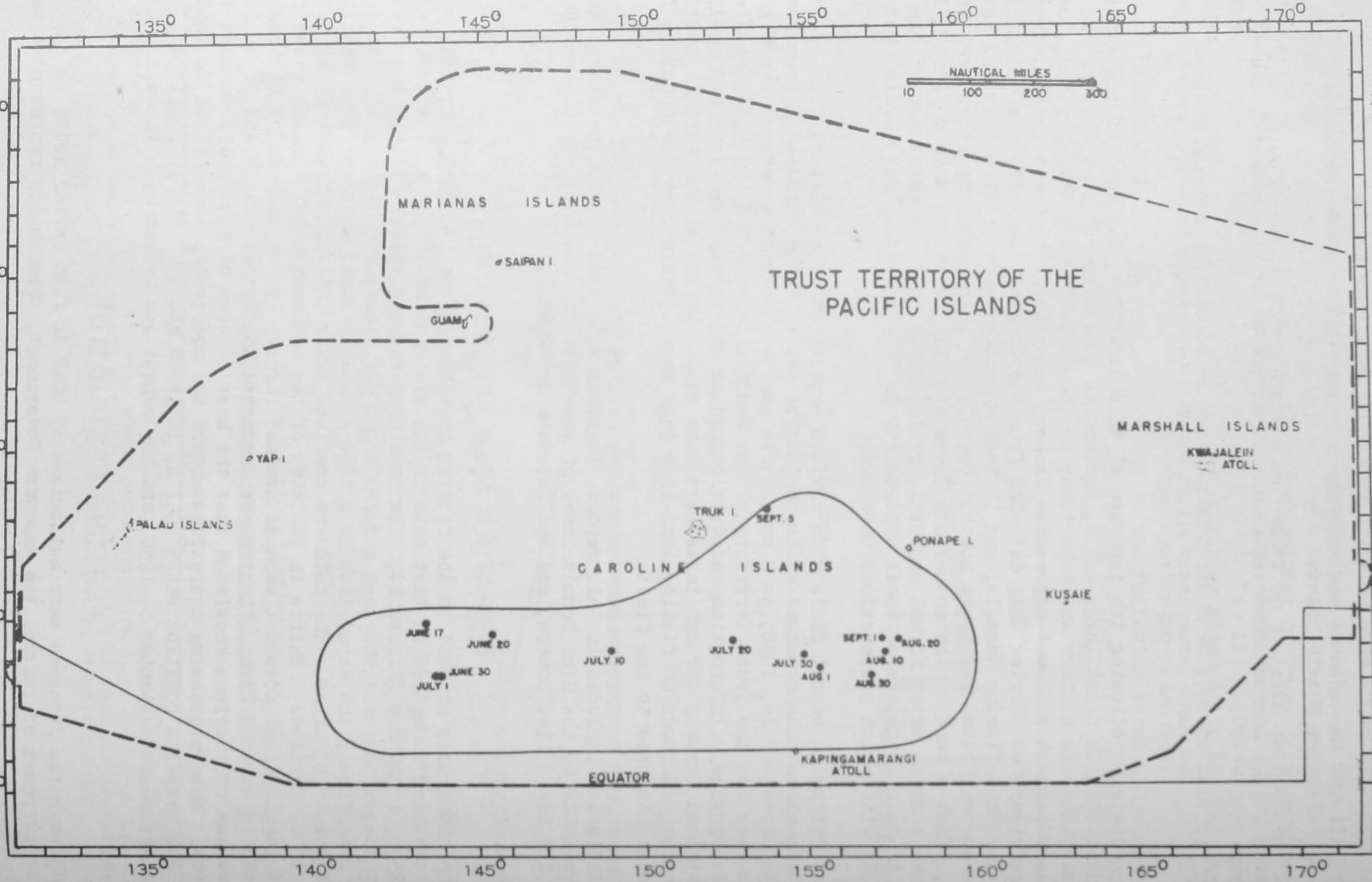


FIGURE 2 - GENERAL AREA OF OPERATIONS (SOLID BLACK LINE) IN WATERS SURROUNDING TRUST TERRITORY OF THE PACIFIC ISLANDS (DOTTED LINE) OF THE FIRST JAPANESE TUNA-MOTHERSHIP EXPEDITION. DATED POSITIONS ARE THOSE OF THE MOTHERSHIP DURING THE SEASON, FROM JUNE 17 TO SEPTEMBER 5, 1950.

limited the southward movements of the mothership to 3° N. latitude, and the maximum distance that any catcher boat could operate from the mothership was set at 200 miles. Catchers desiring to fish beyond the 200-mile limit were allowed to make application for permission to do so. Furthermore, no fishing was permitted south of 1° N. latitude or within 10 miles of any islands.

FISHING OPERATIONS

Fishing Vessels: The fishing potential of the expedition was vested in the 25 long-line fishing vessels from various Japanese ports. These vessels ranged in size from four small 60-80 gross-metric-ton wooden vessels to modern steel-built ships of 150-200 gross tons, which comprised the rest of the fleet. Over-all length of the latter ranged from about 70 to 110 feet.

The typical Japanese long-line vessel resembles an Atlantic well-deck trawler and is characterized by a strong shear line (Figure 3). Power is usually supplied by a Diesel engine and, in many cases, auxiliary gaff-rigged sails are also carried to supplement the main engine. The wheel house is located amidships and the engine room is aft. This setup provides ample working space forward, which is free of excess deck structures, except for the long-line hauler which may be situated on the port or starboard side. Often, two long-line haulers are so installed that fishing gear may be taken in from either side. Removable doors are cut into the bulwark for bringing fish and gear aboard.

Holds for the catch are located beneath the well deck and are generally not equipped with refrigeration equipment. Ammonia coils, if present, are for the purpose of preventing the rapid melting of ice rather than for freezing fish.

Crew's quarters are located forward in the forecastle and aft of the engine room. Because of the number of men carried by a long-line vessel (18 to 27 according to size of boat), these quarters are generally cramped. The galley is on the main deck aft and has space only for the preparation of food; no room is provided for eating indoors.

Fishing Gear: The long line is a form of gear developed and used by the Japanese to fish deep levels of the ocean for large pelagic fish, such as tunas and spearfishes. A good description of the evolution of long-line gear, the construction of component parts, and methods of fishing is given by Shapiro (1950) in his report on the Japanese long-line fishery.

The basic unit of long-line fishing gear is the "basket".[2/] A basket consists of several sections of main or trunk line, usually cotton, to which are tied a number of branch lines and a float line (Figure 4). Each branch line is made up of a length of cotton line; or a "sekiyama" or "shanawa" (cotton thread wound around a core of wire or fiber); a wire leader and hook. Lines, including the "sekiyama," are coated with tar to prevent deterioration and to add rigidity for ease of handling.

The branch lines, float line, and sections of the main line comprising a basket are tied together with knots so that the gear may be easily taken apart (Figure 4. Insets 1, 2, 3, 4, 5, 6, 7). This is of advantage when it is necessary to replace a branch line or to remove a branch line or entire basket from the main set of gear. The knots that are used differ with the fishermen but are usually those which, while simple to tie and untie, are not bulky and will hold firmly. A swivel is sometimes placed at the end of the cotton section of a branch line before the "sekiyama" to keep the branch line from twisting and tangling.

2/THIS TERM ORIGINATED FROM THE FACT THAT FORMERLY SECTIONS OF LONG-LINE GEAR WERE KEPT IN BAMBOO BASKETS. THIS METHOD OF STOWING GEAR, ALTHOUGH STILL IN USE IN PARTS OF NORTHERN JAPAN, IS GRADUALLY BEING DISCARDED AND NOW A BASKET OF GEAR IS USUALLY TIED INTO A BUNDLE, USING A FOUR-PIECE SLING MADE OF OUTWORN COTTON LINE.

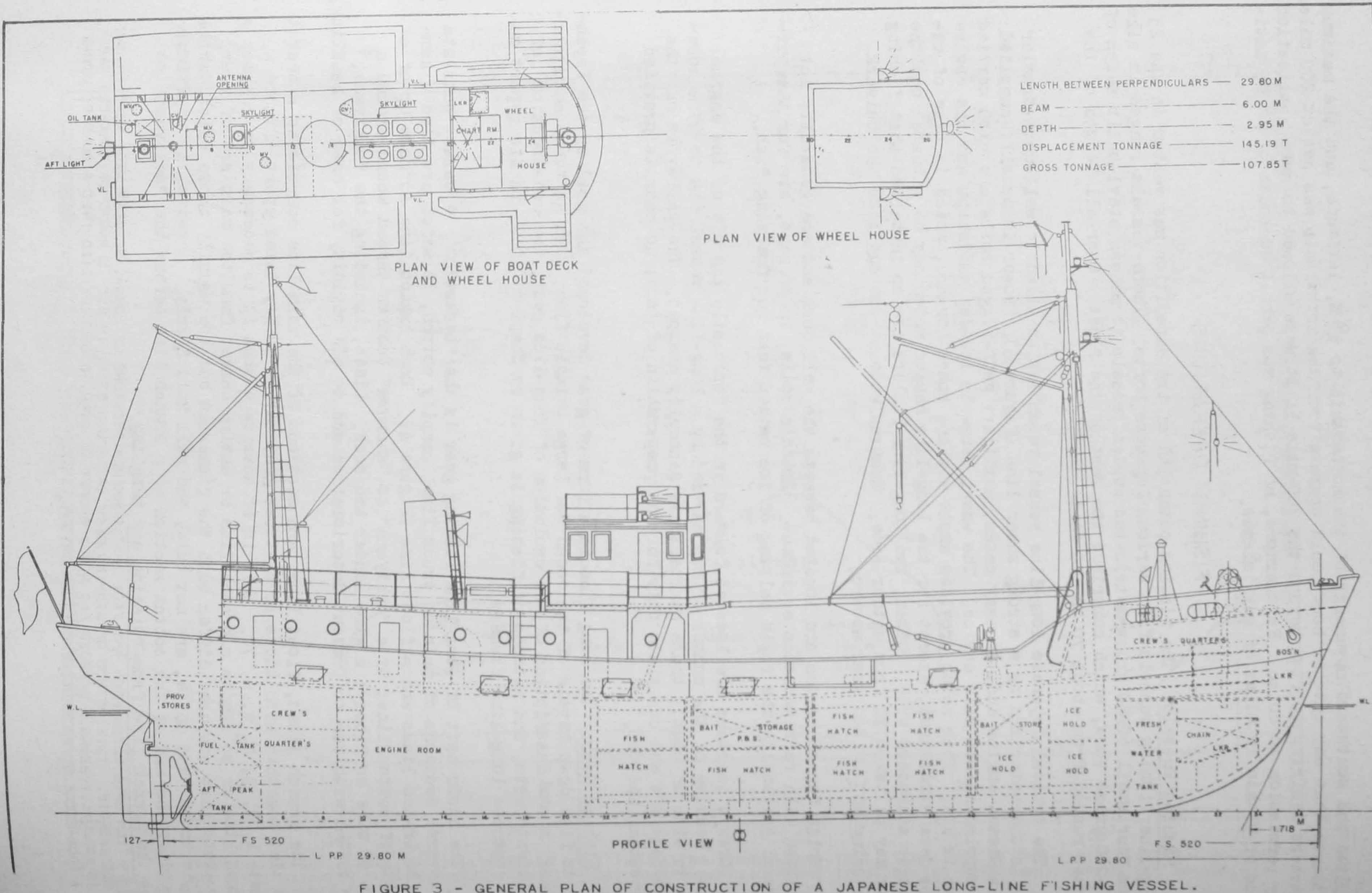


FIGURE 3 - GENERAL PLAN OF CONSTRUCTION OF A JAPANESE LONG-LINE FISHING VESSEL.
PART I - PROFILE OF VESSEL AND PLAN VIEW OF BOAT DECK AND WHEELHOUSE. MEASUREMENTS SHOWN IN METERS AND METRIC TONS.
(SEE NEXT PAGE FOR PLAN VIEWS OF MAIN DECK AND HOLD.)

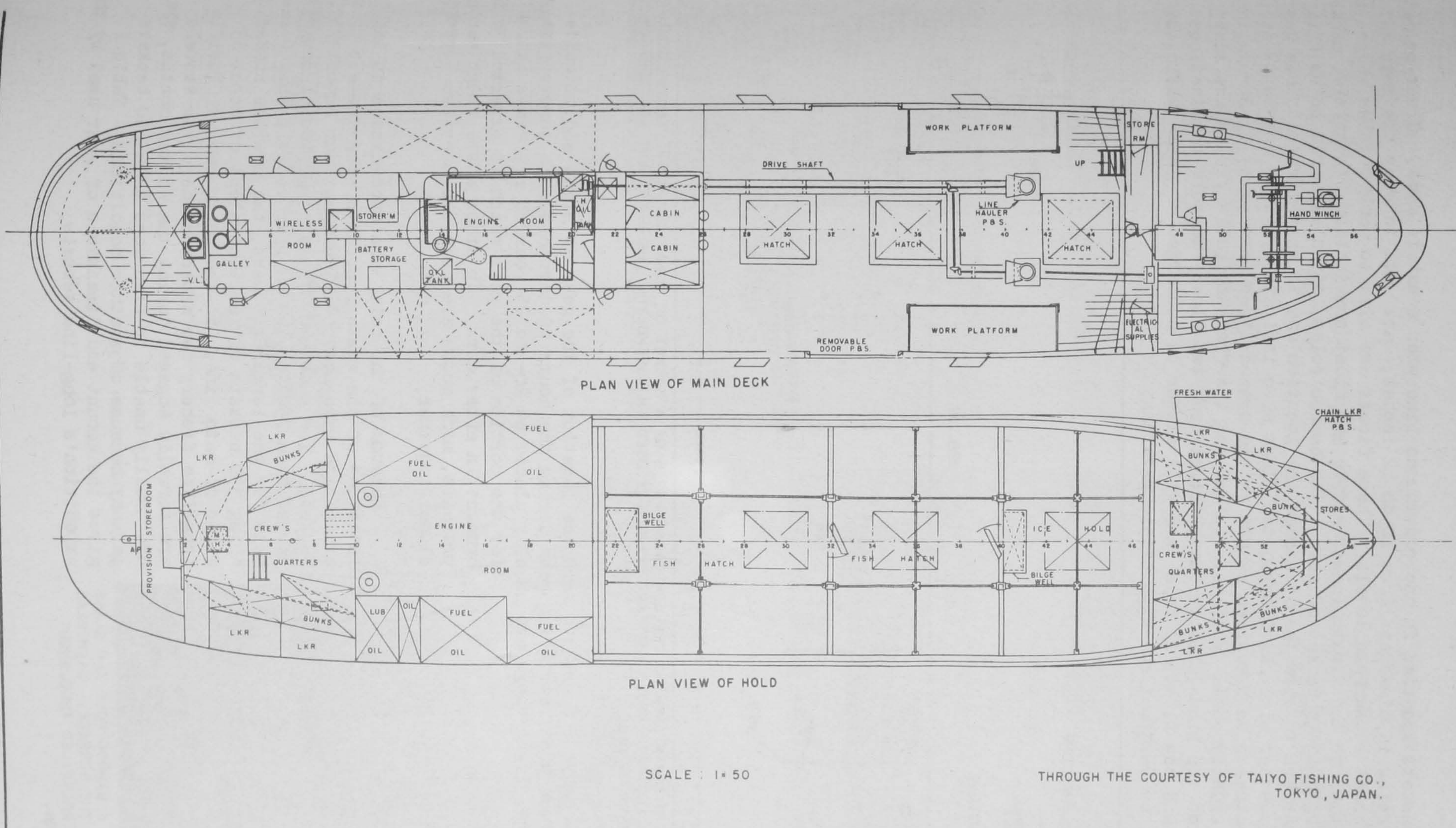


FIGURE 3 - GENERAL PLAN OF CONSTRUCTION OF A JAPANESE LONG-LINE FISHING VESSEL.
PART II - PLAN VIEWS OF MAIN DECK AND HOLD. MEASUREMENTS SHOWN IN METERS AND METRIC TONS.
(SEE PREVIOUS PAGE FOR PROFILE OF VESSEL AND PLAN VIEW OF BOAT DECK AND WHEELHOUSE.)

The baskets are tied in one continuous line when a set is made. Glass or metal floats, varying in diameter from 10 to 12 inches, are used to buoy the main and branch lines at subsurface levels. These floats are tied to bamboo poles which, in turn, are tied to the float lines. A pole and float combination, therefore, marks the junction of each basket of gear. The bamboo poles, often referred to as "flags," serve as markers to show the fisherman the location and in what direction his gear is set. Together with the floats, the flags also indicate by their movements at the surface whether fish have been caught on the branch lines (Figure 5). Struggling fish will usually cause the floats to bob and the flags to fall over to one side. Dead fish on the lines will by their weight draw two float-and-pole combinations together, and the floats in this case will either be submerged or awash while the flags will be vertical and with little wavering.

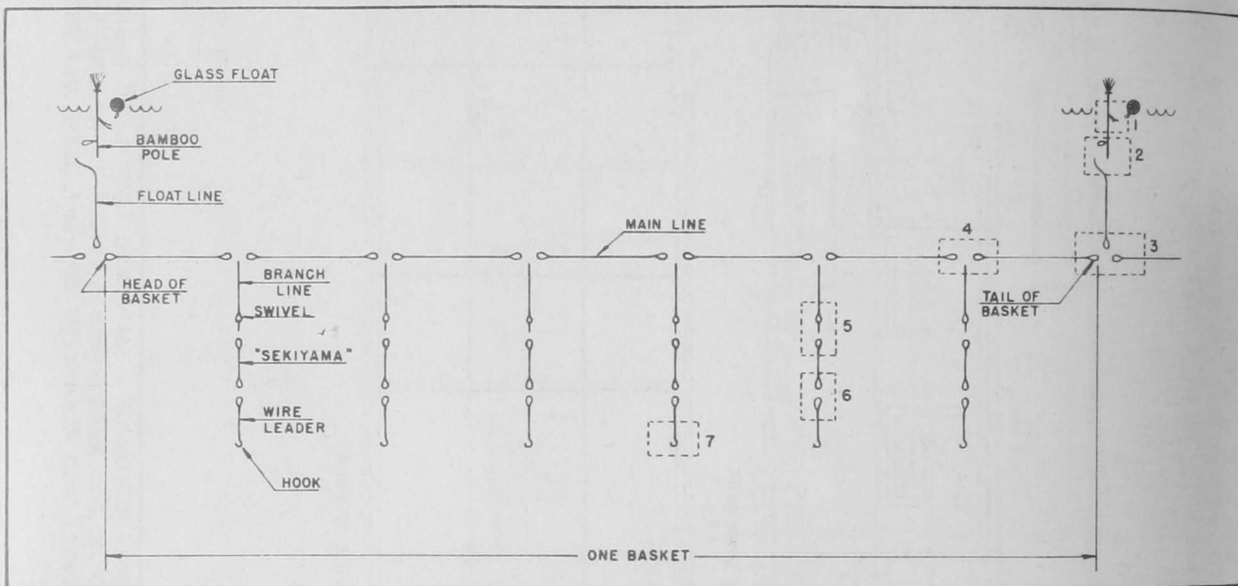


FIGURE 4 - DIAGRAM SHOWING THE COMPONENT PARTS OF A BASKET OF TUNA LONG-LINE FISHING GEAR. INSETS ILLUSTRATE KNOTS THAT ARE GENERALLY USED IN ASSEMBLING THE DIFFERENT SECTIONS. (SEE INSETS ON PAGE 9.)

Light buoys are used to mark the location of the gear at night and to guide the fishermen when retrieving gear during the hours of darkness. In comparatively calm waters, light buoys are usually placed at 20- to 25- basket intervals and only for the portion of the gear which is expected to be brought in after dark. In areas where rough weather prevails, more buoys are used and they are spaced closer together.

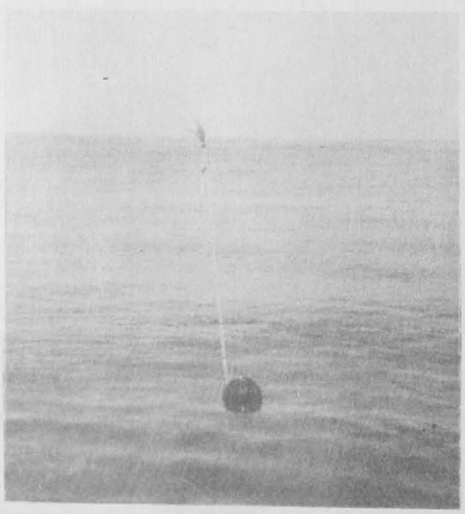
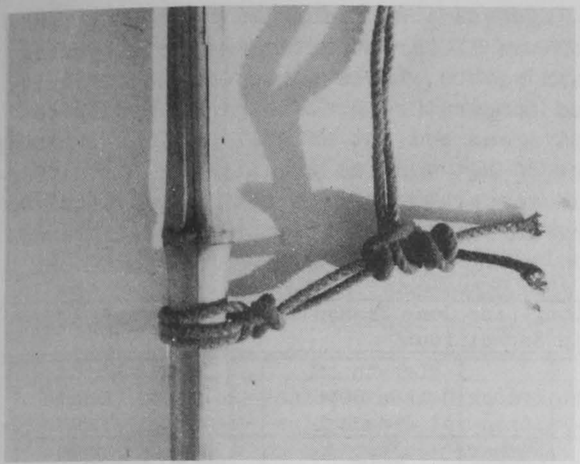
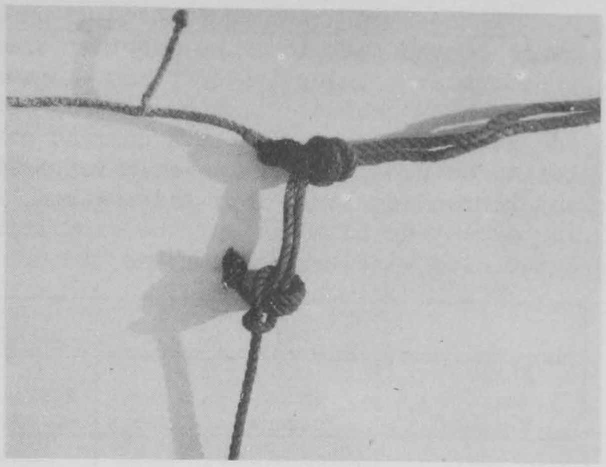


FIGURE 5 - A BAMBOO POLE AND GLASS FLOAT AT THE SURFACE. CALM SEAS AS SHOWN PREVAILED THROUGHOUT THE SEASON.

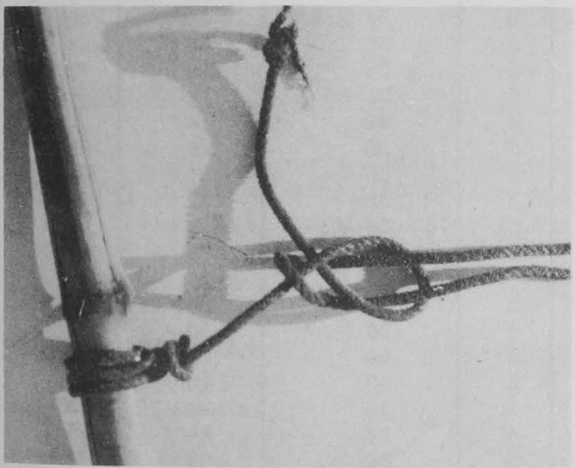
Because of the calm seas encountered in the low latitudes of the western Pacific, the vessels of the expedition were able to fish a maximum number of baskets. The number of baskets per vessel set daily varied from 250 for the smaller vessels to 400 baskets for the larger catchers, the average number being 350 baskets or the equivalent of about 65 miles of main line. In the north central Pacific long-line fishery for albacore, where the vessels are normally engaged during the winter months, they are usually unable to fish more than 250 baskets per day because of weather conditions. Table 1 gives the amount and dimensions of gear used by the expedition's long-line vessels.



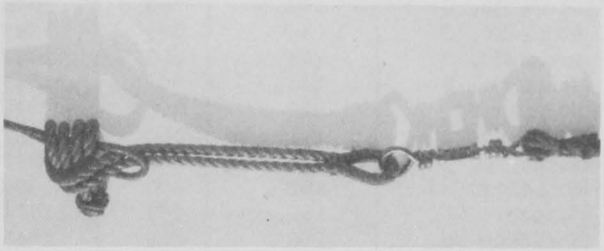
INSET 1



INSET 4

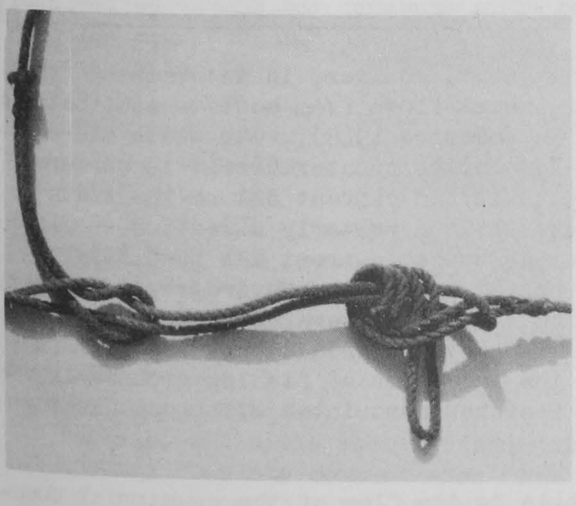


INSET 2

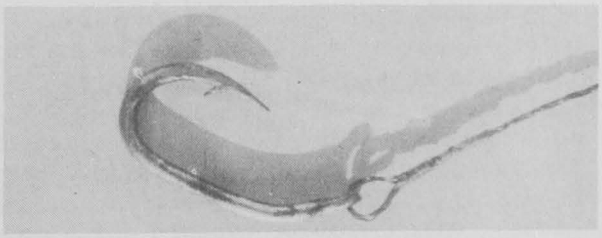


INSET 5

INSET 6



INSET 3



INSET 7

INSETS FOR FIGURE 4 WHICH APPEARS ON PAGE 8.

<u>Methods of Locating Fishing Grounds</u>: Japanese tuna fishermen have long been aware of the fact that the marginal areas of two different water masses in juxtaposition are productive of fish. In northern waters, these zones of discontinuity are usually characterized by a steep surface temperature gradient. According to the fishermen, however, such current contact areas are not as well defined in lower latitudes because surface water temperatures do not vary as greatly for the different current systems. For this reason, water temperatures were not relied upon to any extent by fishermen of the expedition as an aid to locating productive grounds associated with current borders.

Table 1 - Amount and Dimensions of Long-Line Gear Fished by Vessels of the Tuna-Mothership Expedition1/

Name of Vessel	Gross Tonnage	Baskets	Total Length of Basket	Branch Lines	Length of Cotton Section of Branch Line	Length of "Sekiyama"	Length of Float Line
	Metric Tons	Number	Feet	Number	Feet	Feet	Feet
Asahi No. 1	60	250	894	5	36	24	72
Asahi No. 7	84	250	894	5	42	24	95
Azuma No. 1	138	360	1253	6	36	24	78
Azuma No. 2	139	400	894	5	48	24	84
Azuma No. 3	147	350	1043	6	39	24	66
Azuma No. 5	146	380	894	5	39	24	66
Azuma No. 6	145	350	1043	6	36	24	72
Azuma No. 7	145	340	1043	6	36	24	60
Daikoku No. 12	136	370	894	5	48	24	72
Genei No. 1	149	350	917	7	36	30	78
Kaiko	147	352	894	5	36	24	66
Kotoshiro No. 1	157	400	894	5	36	22	48
Kuroshio No. 7	160	370	1074	5	36	24	89
Marutaka No. 11	146	320	1043	6	36	18	66
Nankai No. 2	76	250	894	5	36	24	75
Nankai No. 3	80	300	894	5	36	24	95
Reiyo	142	370	1043	6	36	30	42
Sasayama No. 7	158	350	894	5	24	24	72
Seiyo No. 2	144	360	1127	6	48	15	72
Shinko No. 30	150	350	1074	5	36	24	72
Shinko No. 80	206	360	1043	6	24	24	95
Shinyo No. 8	154	340	1074	5	36	24	72
Shiratori	158	404	1074	5	36	24	63
Sumiyoshi No. 6	196	380	1043	6	36	21	78
Sumiyoshi No. 21	158	333	1043	6	30	24	72

1/LEADER LENGTHS, NOT INCLUDED, AVERAGED 6 FT.; ALL LENGTHS ARE TO THE NEAREST FOOT.

Current direction was used as a general guide, however, in determining the eddy areas of the equatorial countercurrent, which flows from west to east between 2° and 10° N. latitude in the western Pacific (Shapiro 1948). Its width and position depend upon the season and area. The equatorial countercurrent is bordered on the north by the westerly flowing north equatorial current and on the south by the south equatorial current, which also travels in a westerly direction. Since the average seasonal position of the equatorial countercurrent has been fairly well determined for the western equatorial region by Japanese hydrographic surveys, the fishermen were able to estimate where the boundaries were in general by the use of charts. The drift of vessels and gear then served as additional checks. (A general discussion of factors which govern the selection of fishing grounds in the equatorial countercurrent and hydrographic features associated with good fishing may be found in a report by Inanami, 1942.)

Long lines were generally set at an angle to the flow of the equatorial countercurrent to assure the gear a greater chance of fishing a part of the current contact zone and to prevent tangling of the lines. When certain sections of the gear yielded better catches than others, the lines were reset to fish such areas more heavily. Sets were seldom made in the vicinity of islands because of operating restrictions and the opinion that larger fish are not to be found near the islands. Furthermore, it was believed that sharks were more abundant in inshore waters than in areas removed from land.

Methods of Fishing Long-line Gear: The techniques of setting and retrieving gear as well as other operational aspects of a typical long-line vessel will be described in detail for one of the more productive catchers of the fleet, the *Shiratori Maru* (Figure 6). This 158-gross-metric-ton vessel was built in 1949 at a cost of about 30 million yen (approximately US$83,000 at present exchange rates). Specific details of her dimensions and propulsion machinery are given in Table 2.

Table 2 - Dimensions and Mechanical Equipment of the *Shiratori Maru*

Gross tonnage - 158.21 metric tons	Fresh water capacity - 11.79 metric tons
Over-all length- 29.5 meters (96.8 ft.)	Maine engine - 400 h.p., 4 cycle, 6 cyl. Diesel
Beam - 6.1 meters (20 ft.)	Auxiliary engine - 60 h.p., 4 cycle Diesel
Depth - 3.05 meters (10 ft.)	Generators - 1-40 kw., 1-3 kw. generator
Fuel capacity - 58.4 metric tons	Refrigeration equipment - 1-8.5-metric ton refrigeration machine

The *Shiratori Maru* had a complement of 27 men, the largest crew of any of the catchers; crews on other long-line vessels numbered from 18 to 25. The actual master of the vessel was the master fisherman and not the captain. On some ships the duties of captain and master fisherman are fulfilled by one man, but in most cases, these two positions are held separately. The former is usually held by a young man who has qualified for a license as recently required by Japanese maritime regulations, and the latter is held by an older, experienced fisherman. All responsibilities connected with the navigation of the *Shiratori Maru* to and from the fishing grounds and the keeping of necessary logs and records were delegated to the captain, while the master fisherman not only determined when and where to fish, but assumed complete command when fishing began. The captain at this time was relegated to the position of an ordinary fisherman. Major decisions affecting vessel operations were made by the master fisherman who also maintained discipline among the crew.

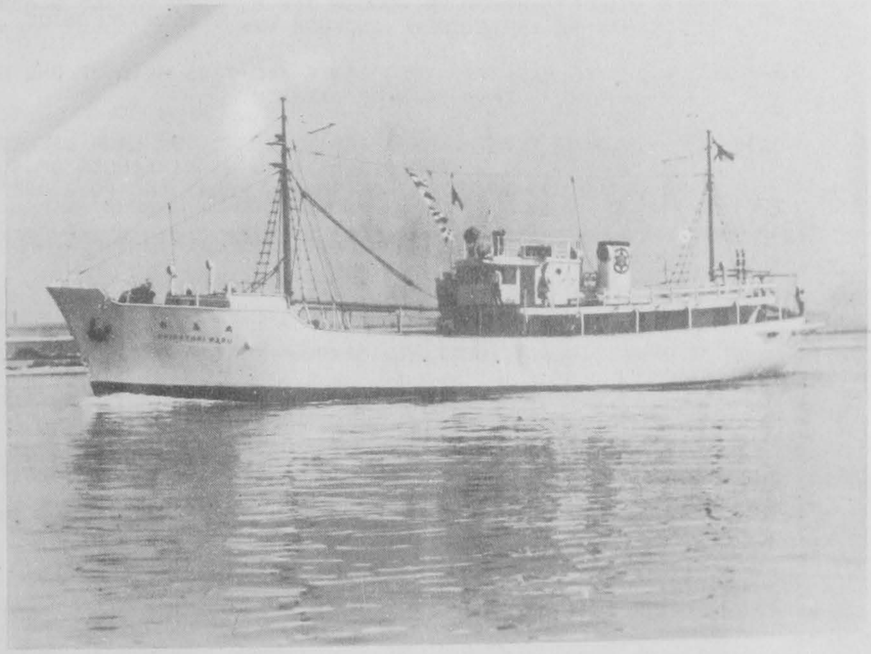


FIGURE 6 - THE *SHIRATORI MARU*, A JAPANESE TUNA LONG-LINER.

As is common practice among most long-line vessels, the baskets of long-line gear and floats aboard the *Shiratori Maru* were stowed behind the wheelhouse on the boat deck. Bamboo poles and light buoys were kept in racks located in the main deck passageways.

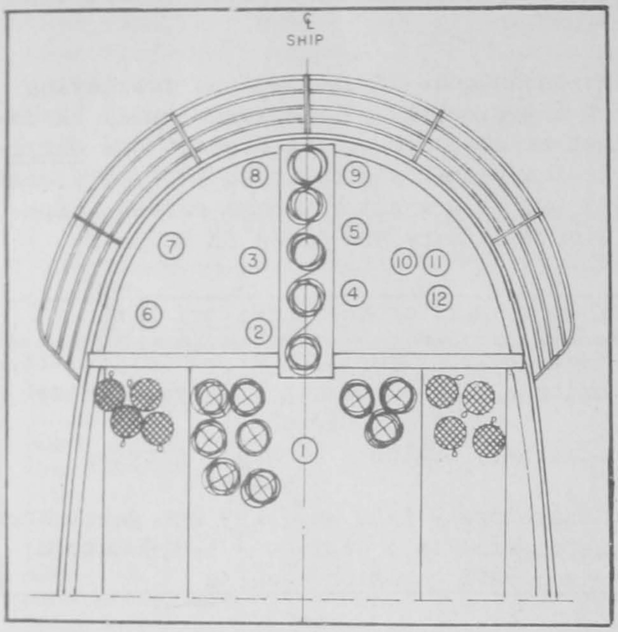


FIGURE 7 - DIAGRAM SHOWING USUAL POSITIONS OF THE FISHERMEN WHEN SETTING LONG-LINE GEAR FROM THE STERN OF THE SHIRATORI MARU.

When ready to make a set, bait, either frozen sardines (Sardinia melanostica), or sauries (Colalabis saira), or both, was brought aft to the stern from the forward bait-storage hold. The work of assembling, baiting, and setting the long lines from the stern then commenced. The sequences of preparing and setting long lines and the work done by the crew members can probably be better understood by referring to the diagram in Figure 7. The corresponding numbers given below outline the duties of each crew member participating in the setting operation. As illustrated in the diagram, the Shiratori Maru had an outboard fishing rack for pole-and-line fishing which served as a platform for setting long-line gear. A wooden table was inclined from the boat deck to the stern rail to bring the gear below.

MAN NO. 1 - UNTIES SLING HOLDING INDIVIDUAL BASKETS TOGETHER AND SLIDES LOOSE BASKETS BELOW ON WOODEN TABLE; ALSO PASSES GLASS FLOATS TO NO. 6; MAY BE ASSISTED BY ANOTHER MAN.

MAN NO. 2 - SHOVES BASKETS ALONG TABLE AND TIES HEAD OF ONE BASKET TO TAIL OF ANOTHER, THUS JOINING BASKETS.

MAN NO. 3 - UNCOILS FLOAT LINE WHICH IS ON TOP OF EACH BASKET, PASSES FREE END TO MAN NO. 7, AND STANDS BY WITH REMAINDER OF COIL; THROWS FLOAT LINE OUT WHEN MAN NO. 7 LETS FLOAT AND POLE OVERBOARD.

MAN NO. 4 - FREES TUCKED-IN HOOKS FROM COILS (LEADER AND "SEKIYAMA") AND BAITS HOOKS.

MAN NO. 5 - ASSISTS IN BAITING.

MAN NO. 6 - TIES GLASS FLOATS TO BAMBOO POLES AND PASSES POLES TO MAN NO. 7.

MAN NO. 7 - RECEIVES END OF FLOAT LINE FROM MAN NO. 3 AND TIES TO BAMBOO POLE WITH FLOAT ATTACHED; THROWS COMBINATION OVERBOARD AT BEGINNING OF EACH BASKET IN COORDINATION WITH MAN NO. 3

MAN NO. 8 - THROWS OUT COILS OF MAIN LINE.

MAN NO. 9 - THROWS OUT BAIT HOOKS AND BRANCH LINES.

MEN NOS. 10 AND 11 - BREAK OUT BAIT FROM BOXES AND SEPARATE INTO INDIVIDUAL FISH, DISCARDING POOR ONES.

MAN NO 12 AND OTHERS - ASSIST WITH BRINGING LIGHT BUOYS AFT AND TYING ON LIGHT BUOYS AS REQUIRED; RENDER GENERAL ASSISTANCE AND SERVE AS RELIEF.

A basket of gear is set as follows: (1) the glass float and bamboo pole to which is tied the float line of the basket is thrown overboard to starboard as the vessel is under way; (2) the section of main line following the float line is cast directly astern; (3) a baited branch line is then cast to port and the main line following is cast to stern again. The procedure is repeated until the entire basket of gear has been laid. An extra float line and large marker flag is used to begin the first basket of a set and to end the last basket.

Whenever possible gear is set along a straight course. The baskets are laid while the vessel is fully under way, the speed varying from 6 to 8 knots. The Shiratori Maru usually set 400 baskets of gear daily and required from $3\frac{1}{2}$ to 4 hours to get the lines into the water, an average of about half a minute being required per basket. The actual distance travelled by the vessel was about half the total length of the main line because of the slack allowed for sag and adjustment of the gear to current forces. Setting usually commenced before sunrise at about 3 a.m. and was completed by 7:00 a.m. at the latest. The vessel then either drifted for several hours within sight of the flag marking the end of the set or headed back up the line of gear. The decision to remain at the end of the set or to return to the head was made by the master fisherman and was determined largely by the direction in which the following set was to be made and noon catch reports of other long-line vessels. If, for example, a set was made in a westerly direction and the plan was to fish in this general direction, the vessel returned to the head of the set. After the job of retrieving the gear was completed, there was time enough for the short run to the next day's fishing area. However, if reports hinted that there was better fishing to the east, the plan of operation was altered accordingly. The vessel would pick up the gear from the end of the line set last after allowing the gear to fish a while, thus reversing the direction of the sets.

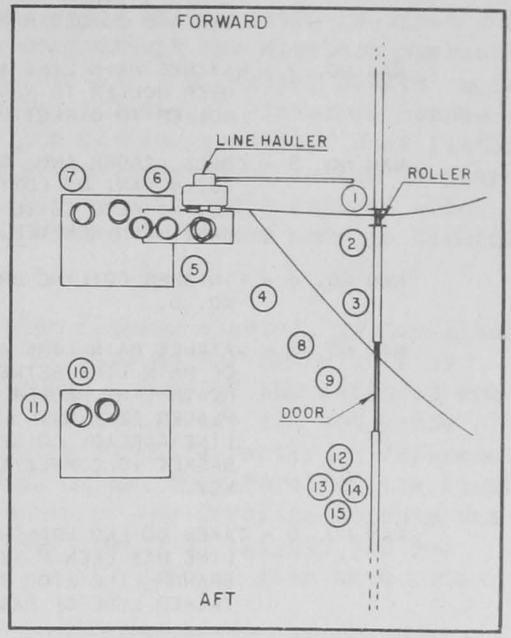


FIGURE 8 - DIAGRAM SHOWING USUAL POSITIONS OF THE FISHERMEN WHEN RETRIEVING LONG-LINE GEAR.

When returning to the head of a set, a watch was continually kept to see whether fish had been caught on any of the branch lines. If there were signs of captured fish, the basket or baskets were taken in without untying them from the main set. The fish were removed, and the branch lines were rebaited and returned to the water. This not only prevented fish from being damaged by sharks but increased the efficiency of the gear.

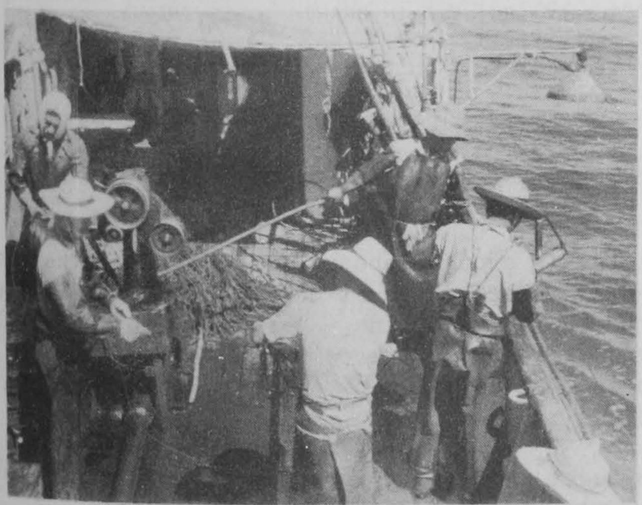


FIGURE 9 - RETRIEVING LONG-LINE GEAR ABOARD THE SHIRATORI MARU. NOTE THE CONSTRUCTION OF THE LONG-LINE HAULER. ROPE SLINGS FOR BUNDLING INDIVIDUAL BASKETS ARE PILED UP BEHIND THE HAULER.

The laborious task of picking up the long lines usually started around noon and continued without stop until midnight. The average time required to bring in 400 baskets of gear was about 12 hours, but varied from 10 to 14 hours depending upon the number of fish that were caught.

In picking up gear, the vessel was kept constantly under way at a speed of two to three knots. The necessary maneuvering required to maintain the ship at a 15°-45° angle to the main line required close coordination between the bridge and engine room, and a bell system was rigged between these two stations to expedite communications. The usual procedure was to run the engine intermittently to approximate the speed with which the line could be brought in. Reverse was seldom used. Figures 8 and 9 show the position of the crew members when recovering gear from the head of a set. The duties of individuals and sequences of handling are:

MAN NO. 1 - HANDLES CLUTCH OF LINE HAULER AND REGULATES SPEED AT WHICH MAIN LINE IS TAKEN IN; WATCHES DIRECTION FROM WHICH MAIN LINE IS COMING AND GUIDES MAN AT WHEEL BY HAND SIGNALS.

MAN NO. 2 - WATCHES MAIN LINE AS IT COMES IN AND PASSES BRANCH AND FLOAT LINES OVER ROLLER TO MAN NO. 3 AS KNOTS GO THROUGH LINE HAULER; ADJUSTS ROLLER TO DIRECTION OF LINE.

MAN NO. 3 - COILS LEADER AND "SEKIYAMA" AND TUCKS HOOK AROUND THIS COIL, THEN COILS PART OF COTTON SECTION OF BRANCH LINE AND HANDS ALL TO MAN NO. 4; ALSO COILS PART OF FLOAT LINE AFTER BAMBOO POLE AND FLOAT HAVE BEEN REMOVED.

MAN NO. 4 - FINISHES COILING BRANCH AND FLOAT LINES AND GIVES COILS TO MAN NO. 6.

MAN NO. 5 - WATCHES MAIN LINE AS IT COMES THROUGH LINE HAULER AND WHEN SECTION OF MAIN LINE BETWEEN BRANCH LINES IS COILED, MOVES COIL FROM BENEATH LINE HAULER TOWARD MAN NO. 6; WHEN BRANCH LINE HAS BEEN PLACED ATOP MAIN LINE BY MAN NO. 6, TAKES NEXT SECTION OF MAIN LINE ALREADY COILED AND PLACES IT ATOP BRANCH LINE; REPEATS UNTIL BASKET IS COMPLETE; UNTIES TAIL OF BASKET FROM HEAD OF NEXT BASKET.

MAN NO. 6 - TAKES COILED BRANCH LINE FROM MAN NO. 4 AND WHEN SECTION OF MAIN LINE HAS BEEN MOVED FROM BENEATH LINE HAULER BY MAN NO. 5, PLACES BRANCH LINE ATOP THIS COIL; COILS FLOAT LINE, WHICH IS LAST ATTACHED LINE OF BASKET TO COME IN, AND HANDS TO MAN NO. 7.

MAN NO. 7 - ARRANGES COILS OF MAIN LINE, BRANCH LINES, AND FLOAT LINE IN ORDER, BUNDLES BASKET TOGETHER WITH A FOUR-PIECE COTTON ROPE SLING AND TAKES BASKET AFT FOR STOWAGE.

MAN NO. 8 - PULLS IN BAMBOO POLE AND BUOYS; UNTIES FLOAT LINE FROM POLE.

MAN NO. 9 - ASSISTS MAN NO. 8 IN PULLING IN POLES AND BUOYS; REMOVES GLASS FLOATS.

MEN NOS. 10 AND 11 - REARRANGE BASKETS NOT PROPERLY COILED; TIE IN BRANCH LINES PREVIOUSLY REMOVED AND REPLACE WORN LEADERS; ASSIST MEN NOS. 2, 3, AND 4 WHEN NECESSARY.

MEN NOS. 12, 13, 14, 15, AND OTHERS - BRING IN FISH; GUT AND STORE CATCHES; STOW FLAGS, BUOYS AND GEAR; ACT AS RELIEF.

The sequence in which a basket of gear is brought aboard is reverse of that in which it is set; that is, (1) the main line is coiled as it comes aboard, and (2) a branch line is taken in and placed on top of the main line. This is repeated until all five branch lines have been retrieved. The basket is completed by bringing in the float line. The head of the basket is then untied from the tail of the next basket and the basket is bundled and stowed.

Fish hooked on branch lines were brought in quickly by two or three of the crew members and gaffed when alongside. They were then pulled aboard through the door cut in the rail, killed if necessary, and immediately eviscerated if of a species other than yellowfin or albacore tuna. The landing of larger marlins and sharks frequently gave considerable trouble and, furthermore, tangled the lines badly. These fish, as well as any tuna which were taken alive, were killed by the fishermen who beat them on the head with large wooden mallets. Fish were usually stored below in ice immediately after capture, but occasionally when fishing was productive and the crew was busily engaged in hauling in both fish and lines, the catch was allowed to lay on deck for about fifteen to thirty minutes before storage. During the afternoons when air temperatures were high, the practice was to ice the fish as soon as practicable.

The work of retrieving and stowing gear and disposing of the catch required the immediate services of about 18 men, and everyone aboard except the wireless operator participated in the operations at some time during the day. No regular shifts were employed, and the men took turns at various jobs. The individual fishermen consequently worked from 16 to 18 hours per day when on the fishing grounds. What little rest they obtained was either during the few hours after the work of taking in gear had been completed or when a set was finished. Longer respites were enjoyed when the catcher proceeded to and from the mothership or when a shift was made in fishing grounds.

Total Landings of Fish: From June 17, 1950, when fishing started, to the close of processing operations on September 2, deliveries of fish to the mothership by long-line vessels totaled approximately 7,683,000 pounds. Many of the catchers continued to fish after making their last trips to the mothership and did not cease operations until September 5. These later catches were landed directly in Japanese ports and amounted to over 435,000 pounds. The total catch, therefore, of the first long-line fleet in 79 days of operation in waters south of the Caroline Islands was about 8,118,800 pounds (Table 3) with a reported landed value of 145,493,500 yen (about US$404,000). To catch this quantity of fish, 1,417 sets of gear were made

Table 3 - Total Catch, by Species, of the First Japanese Tuna-Mothership Expedition, June-September, 1950[1]

Species	Quantity Caught
	Lbs.
Yellowfin tuna (*Neothunnus macropterus*)	4,574,358
Big-eyed tuna (*Parathunnus sibi*)	699,014
Albacore (*Thunnus germo*)	65,378
Bluefin tuna (*Thunnus orientalis*)	3,430
Skipjack (*Katsuwonus pelamis*)	6,968
Black marlin (*Makaira mazara*)	1,760,389
White marlin (*Makaira marlina*)	48,182
Striped marlin (*Makaira mitsukurii*)	1,229
Sailfish[2] (*Istiophorus orientalis*)	28,160
Swordfish (*Xiphias gladius*)	13,656
Shark	895,022
Others[3]	23,048
Total	8,118,834

1/STATISTICS PROVIDED BY THE JAPANESE FISHERY AGENCY AND CONVERTED TO POUNDS, USING THE CONVERSION FACTOR OF 8.27 LBS. = 1 KAN.
2/INCLUDES SHORT-NOSED MARLIN (*TETRAPTURUS BREVIROSTRIS*).
3/INCLUDES BARRACUDA (*SPHYRAENA ARGENTEA*), WAHOO (*ACANTHOCYBIUM SOLANDRI*), AND DOLPHIN (*CORYPHAENA HIPPURUS*).

by the vessels, equivalent, if joined in one continuous line, to 93,000 miles of line, more than enough to encircle the world three and a half times. Incidental catches of the smaller tuna were made by pole-and-line gear, but these were of minor quantity.

Composition of Catch: Fish included in the catches may be conveniently separated into four general categories: the tunas, spearfishes, sharks, and miscellaneous varieties of fish. Of these, the tunas and spearfishes, being commercially the most valuable, were the species most sought after by the fishermen.

The tunas were represented in the catch by the yellowfin tuna (Neothunnus macropterus), big-eyed tuna (Parathunnus sibi), oceanic skipjack (Katsuwonus pelamis), albacore (Thunnus germo), and the bluefin tuna (Thunnus orientalis). The yellowfin tuna was by far the most abundant of these five species, comprising over 50 percent of all the fish landed. Catches of this species occurred throughout the area fished, from 1° N. latitude to 9° N. latitude and from 143° E. longitude to 160° E. longitude. The full range of this particular species was not covered by the fishing vessels, but fishing results seemed to verify the observation that in western equatorial waters of the northern hemisphere, yellowfin tuna are most concentrated in the zone between the Equator and 5° N. latitude.

Individual yellowfin captured by long lines ranged in size from 80 centimeters to 160 centimeters with fish of about 130 centimeters, averaging from 80 to 90 pounds. The largest individuals weighed up to 150 pounds while smaller fish, usually those caught at the surface by pole-and-line gear, weighed but a few pounds.

Of the total tuna catch, the big-eyed tuna (Parathunnus sibi) ranked second to the yellowfin tuna on the basis of weight and number. This species apparently prefers a more temperate distribution than the yellowfin for it was generally caught at deeper levels and appeared to increase in abundance north of 5° N. latitude. Like the yellowfin, the big-eyed tuna varied in size from small individuals of about 5 pounds in weight to large fish of over 150 pounds.

From all reports, the oceanic skipjack (Katsuwonus pelamis) abounds in waters bordering the many islands found in the western Pacific Ocean and is also found in offshore waters. Being more of a surface-inhabiting fish, however, the number of fish of this species caught by long-line vessels was small in contrast to the catches of the deeper-living yellowfin and big-eyed tuna. Schools of skipjack were often found to be congregated beneath the glass floats of the long lines and these schools were fished by pole and line, using artificial lures.

Albacore (Thunnus germo) and bluefin tuna (Thunnus orientalis), which are species normally confined to temperate waters, comprised a small percentage of the total catch and were caught throughout the season.

The spearfishes consisted of the black marlin (Makaira mazara), white marlin (Makaira marlina), short-nosed marlin (Tetrapterus brevirostris), striped marlin (Makaira mitsukurii), sailfish (Istiophorus orientalis), and the true swordfish (Xiphias gladius). On the basis of landings by weight, the black marlin was the most abundant of these species and was second to the yellowfin tuna. Some individuals of black marlin weighed upwards of 1,000 pounds.

Sharks brought in by the fishermen were not identified, but some species of these families were noted: Carcharinidae, Galeorhinidae, Alopiidae, Sphyrnidae and Lamnidae. Other fish delivered to the mothership were barracuda (Sphyraena argentea), wahoo (Acanthocybium solandri), and an occasional dolphin (Coryphaena hippurus).

Variations in Fishing Success: Throughout the season and over the entire fishing area, the daily catches made by the fishing vessels of the expedition fluctuated markedly. Figure 10 shows the average catch per boat reported for each day's operations. Fishing was generally good when operations first commenced. As the peak of productive fishing said to be associated with May and June passed and the catcher fleet was augmented, catches fell to an average of from 2-2½ metric tons per boat daily. With the eastward movement of the expedition and access to new grounds, the catches improved. Excellent fishing was experienced for several days during mid-July in waters adjacent to Kapingamarangi Atoll (1° 05' N.-154° 45' E.), from about

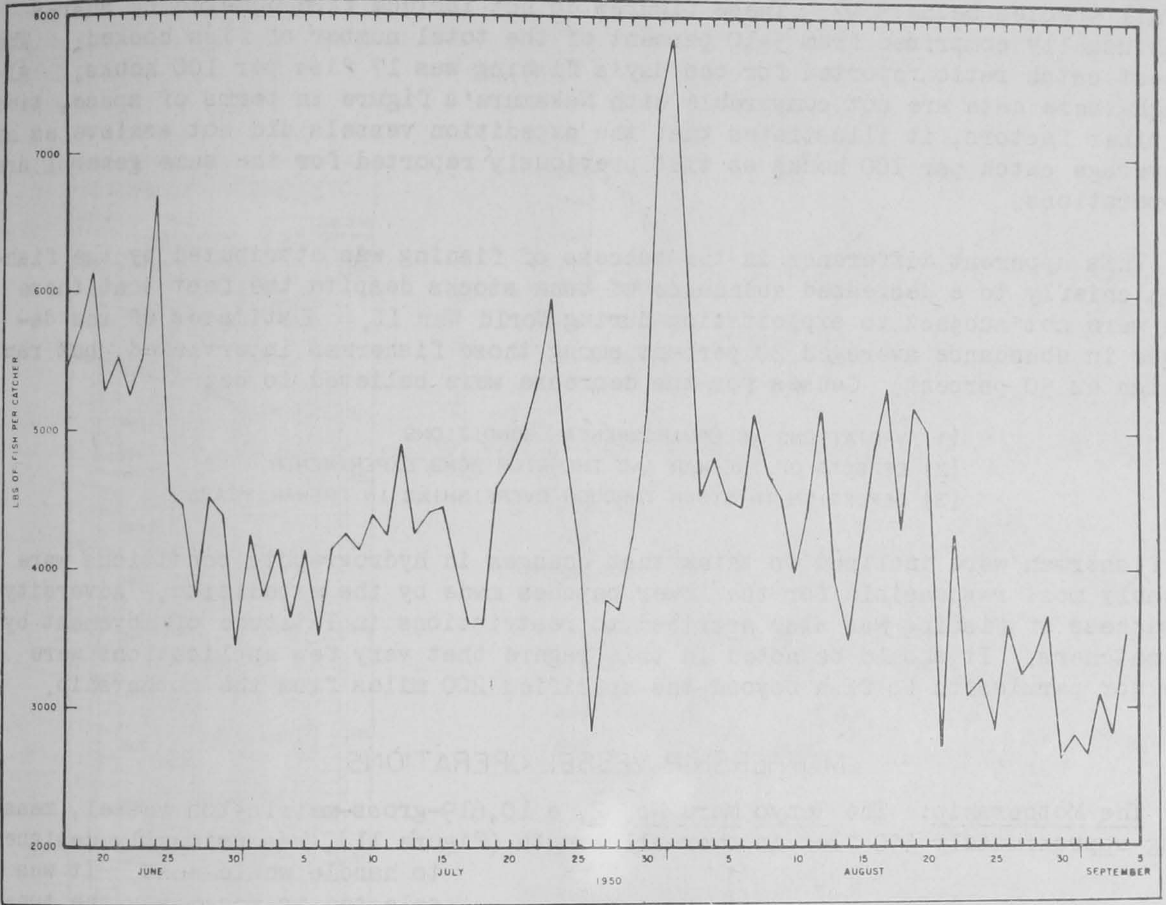


FIGURE 10 - AVERAGE CATCH OF FISH PER DAY PER CATCHER BASED ON DAILY REPORTED LANDINGS. (REFER TO FIGURE 2 FOR GENERAL AREA IN WHICH CATCHES WERE MADE DURING THE SEASON.)

153° to 154° E. longitude and between 1° and 2° N. latitude. The average landings per vessel decreased inexplicably thereafter to less than $1\frac{1}{2}$ tons per day as a majority of the catchers continued to fish in the same general area. In late July and early August, fishermen encountered the best fishing of the season in the area to the east of Kapingamarangi Atoll (between 156° and 158° E. longitude), and in the same parallels of latitude where good fishing was previously experienced (1° to 2° N. latitude). Judging from reported current drifts, this latter zone was probably within the equatorial countercurrent and close to its southern border. Here, some vessels caught as much as 8 tons per day's fishing and the highest reported individual catch for a single operation was 11 tons, mostly yellowfin tuna. Catches gradually fell to lower levels in middle and late August with a daily average below $1\frac{1}{2}$ tons per boat at the close of the season as the expedition shifted northward out of the productive areas in anticipation of the trip home.

The "catch per unit of effort" for the Japanese long-line fishery is usually expressed as the number of fish caught per 100 hooks fished per day. This is a useful index to the success of fishing at a particular time. Data of this nature have been compiled for the prewar Japanese long-line fishery in equatorial waters by Nakamura (1943). Based upon an analysis of fishing boat logs and research vessel records for a period of several years, Nakamura reported an average of 6.05 fish (tunas and spearfishes) for each 100 hooks set in the area between 0° and 5° N. latitude and between 130° and 180° E. longitude. In contrast, vessels of the 1950 expedition averaged 3.23 tunas and spearfishes for each 100 hooks fished, the average for all species being 3.97. These figures do not include fish damaged by sharks which usually comprised from 5-10 percent of the total number of fish hooked. The highest catch ratio reported for one day's fishing was 17 fish per 100 hooks. Although these data are not comparable with Nakamura's figure in terms of space, time, and other factors, it illustrates that the expedition vessels did not achieve as high an average catch per 100 hooks as that previously reported for the same general area of operations.

This apparent difference in the success of fishing was attributed by the fishermen chiefly to a decreased abundance of tuna stocks despite the fact that these fish were not subject to exploitation during World War II. Estimates of the decrease in abundance averaged 20 percent among those fishermen interviewed, but ran as high as 50 percent. Causes for the decrease were believed to be:

(1) VARIATIONS IN ENVIRONMENTAL CONDITIONS
(2) EFFECTS OF THE WAR AND THE ATOM BOMB EXPERIMENTS
(3) DEPLETION IN STOCK THROUGH OVERFISHING IN PREWAR YEARS

The fishermen were inclined to think that changes in hydrographic conditions were probably most responsible for the lower catches made by the expedition. Adversity in success of fishing was also ascribed to restrictions in latitude of movement by the catchers. It should be noted in this regard that very few applications were made for permission to fish beyond the specified 200 miles from the mothership.

MOTHERSHIP VESSEL OPERATIONS

The Mothership: The Tenyo Maru No. 2, a 10,619-gross-metric-ton vessel, measuring approximately 550 feet in over-all length (Figure 11), was primarily designed to handle whale meat. It was selected to accompany the tuna expedition as a mothership because her facilities could be used to freeze tuna and other fish at sea. The storage space of this vessel was sufficiently large to handle the tonnage of fish expected from the season's fishing. Furthermore it was idle during the summer and participation in the tuna operation would not prevent the vessel from engaging in the winter's Antarctic whaling. For this particular assignment no changes were made in the existing shipboard equipment because of the trial nature of the expedition and the lack of time for preparation. The only major addition was an ice crusher which was installed on the main deck. With this exception, the details of construction for the mothership are given in Figure 12.

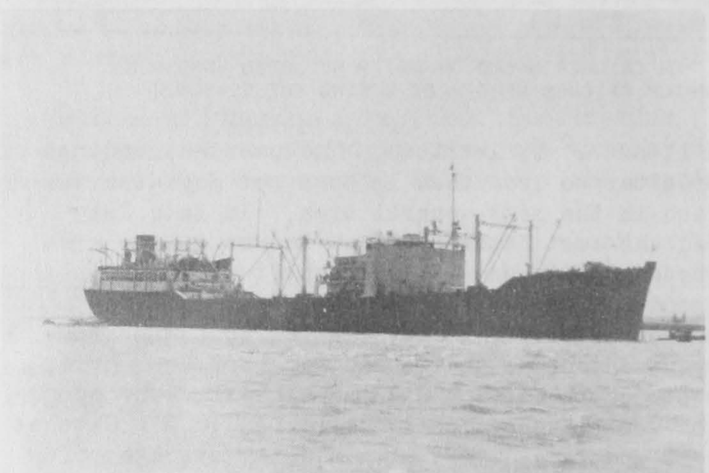


FIGURE 11 - THE MOTHERSHIP, TENYO MARU NO. 2.

A total of 171 persons was carried by the Tenyo Maru No. 2, including the ship's crew, workers, office and supervisory personnel, and the various observers required under the provisions of the SCAP directive. Table 4 shows the classification of shipboard personnel by activity and number.

Table 4 - Personnel Aboard the Mothership, Tenyo Maru No. 2

Ship's Complement

Total - 82

Deck Department	Steward's Department	Engine Department
Captain	13 cooks, cook helpers, mess boys	Chief engineer
5 mates		6 assistant engineers
20 able-bodied seamen		26 firemen, oilers, water tenders, wipers
3 radio operators	**Medical Department**	2 refrigeration engineers
	Ship's doctor	1 refrigeration assistant
	Medical assistant	

* * * * * * *

Company Personnel	Observers and Others
Total - 83	Total - 6
General Manager	SCAP representative
2 assistant managers	Representative, High Commissioner of the Trust Territories
Interpreter	2 Japanese Government inspectors
25 deck workers	Japanese biologist
44 cold storage workers	Japanese news reporter
3 office workers	
5 workers assigned to Steward's Dept.	
1 worker assigned to Medical Dept.	
Ship repair specialist	

General Supervision: The general manager was in charge of all work connected with the handling, processing, and freezing of fish aboard the mothership. He was also responsible for conducting business with the fishermen. The actual performance of these duties was largely delegated to two assistants. One assistant manager took charge of deck operations, and the other served as a liaison man between the management and the fishermen. Control over the movements of the mothership, and consequently of the expedition as a whole, was also exercised by the general manager, subject to the approval of Japanese Government representatives aboard.

Unloading and Servicing of Catcher Boats: The mothership did not call upon the deployed catchers to pick up fish. Instead, an unloading schedule was set up based upon the freezing capacity of the mothership whereby two or three vessels returned daily to discharge their catches. This system of rotation allowed the catchers to stay out from seven to eight days per trip. Quite frequently, however, it was impossible to unload the vessels immediately because of the lack of freezer space or breakdowns in the refrigeration equipment. This, coupled with the fact that only one vessel could be unloaded at a time, often resulted in a backlog of vessels. When this happened an added strain was placed upon the mothership workers and the catcher fishermen were dissatisfied because of the unnecessary loss of valuable fishing time. Catchers sometimes had to wait as long as 24 hours before they were able to tie up to the mothership. The fishermen felt that a more realistic and flexible timetable could have been maintained by scheduling the catchers according to the ability of the mothership to process fish at a given time, and by notifying the catchers in advance of any revisions in their unloading date necessitated by break-downs or other emergencies.

The mothership generally laid broadside to the prevailing swell to afford the catchers a lee for moorage. Fishing vessels could have been handled on the weather side of the mothership but only with considerable difficulty. Thus, transfer operations were restricted to the leeward side of the mothership.

The catchers were made fast parallel to the mothership by hawsers fore and aft and a breast line of wire cable; no mooring booms were used (Figure 13). The danger of damaging the catchers through their bumping against the side of the mothership was reduced by the use of two or three large fenders made of bamboo strips or rubber tires placed around a core of wooden logs.

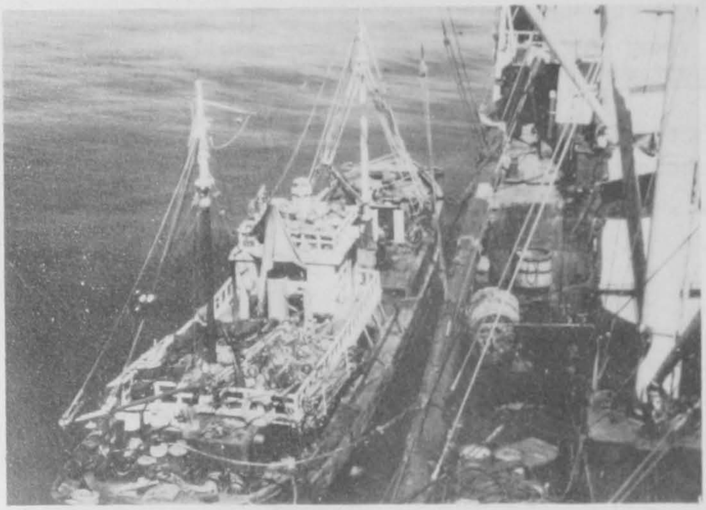


FIGURE 13 - A CATCHER BOAT TIED UP TO THE MOTHERSHIP.

The yard-and-stay method was used to transfer fish from the catcher. Since the catchers were generally moored on the port side, the after boom of pair masts No. 3, port, was swung outboard so that the main hoisting cable would drop directly on the deck of the catcher, forward of the bridge where the fish hatches are located. The winch of either the after boom of pair masts No. 3, starboard, or the forward boom of pair masts No. 3, starboard, was used in tandem with that of the port boom and served to swing the fish inboard after they were hoisted clear of the catcher. Both booms remained immobile during the transfer operations.

The ends of the two winch cables were shackled to a short length of chain fitted with an open cargo hook. Two slings of 2" diameter rope were attached to the hook. When ready to unload, the slings were lowered on to the deck of the catcher or, whenever possible, directly into the fish hatch. Small loops of stout cord or rope fitted beforehand around the tails of individual fish were then hooked on to the slings (see cover photograph). At a signal from a man supervising the work from the side of the mothership, the fish were lifted from the catcher and deposited on deck of the mothership. Although far from efficient, it was possible to unload about a dozen or so large tunas at a time by this method and at a pace fast enough to keep the processing crews busy. The rate of unloading was governed by the speed with which fish could be handled and processed, and usually averaged from 5 to 6 metric tons of fish per hour of uninterrupted work.

Immediately after unloading fish and replenishing its provisions, fuel, water, and bait, the catcher was moved forward beneath the ice crusher. Because of the proximity of the crusher to the unloading area, the catcher taking on ice prevented another vessel from tying up to the mothership. A catcher had to be completely serviced before others could be handled. Proper planning in the installation of the ice crusher would have, therefore, increased the efficiency of mothership operations.

Since ice could not be manufactured aboard the mothership, over 2,000 tons of block ice were brought in the cold-storage holds to the fishing grounds. In supplying a catcher with ice, 200-pound blocks were removed from the lower hold through the hatch next to the base of the ice crusher and lifted by winch and tongs to the bridge deck. On the bridge deck, the blocks were broken in half and fed into the rotary crusher, which was capable of crushing a ton of ice every $3\frac{1}{2}$ to 4 minutes. The crushed ice passed through a metal chute into a large canvas hose, the opening of which was guided by the fishermen below so that the ice would flow directly into the catcher's fish holds. The load of ice taken for a single trip varied from 15-20 tons for catchers without refrigeration systems, and from 5-10 tons for those with a means of maintaining low temperatures in the holds.

Handling and Processing of Fish: The various operations connected with the processing of fish for freezing aboard the mothership were confined to the weather deck aft of the bridge (Figure 14). Most of this working area, which extended over 2,500 square feet or more of open space, was covered with overhead canvas tarpaulins to protect the workers and fish from the weather and to prevent diffusion of light when working at night. Deck space forward of the bridge to the forecastle was utilized only as a storage area. Figure 15 shows the general lay-out of the main deck and the manner in which fish were routed for processing.

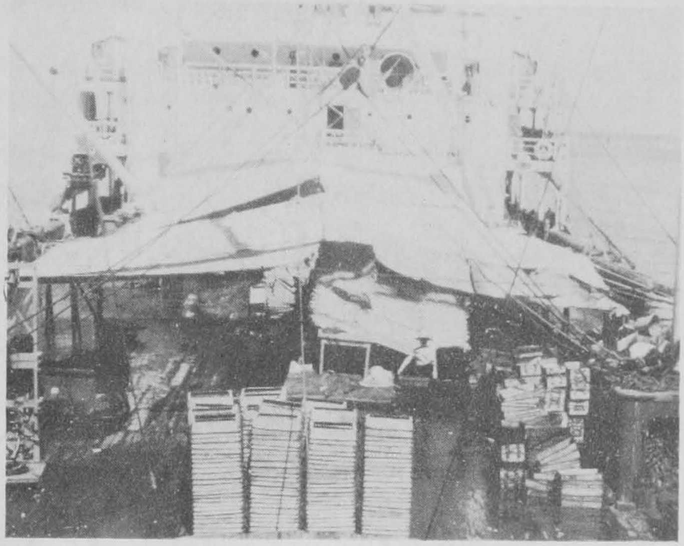


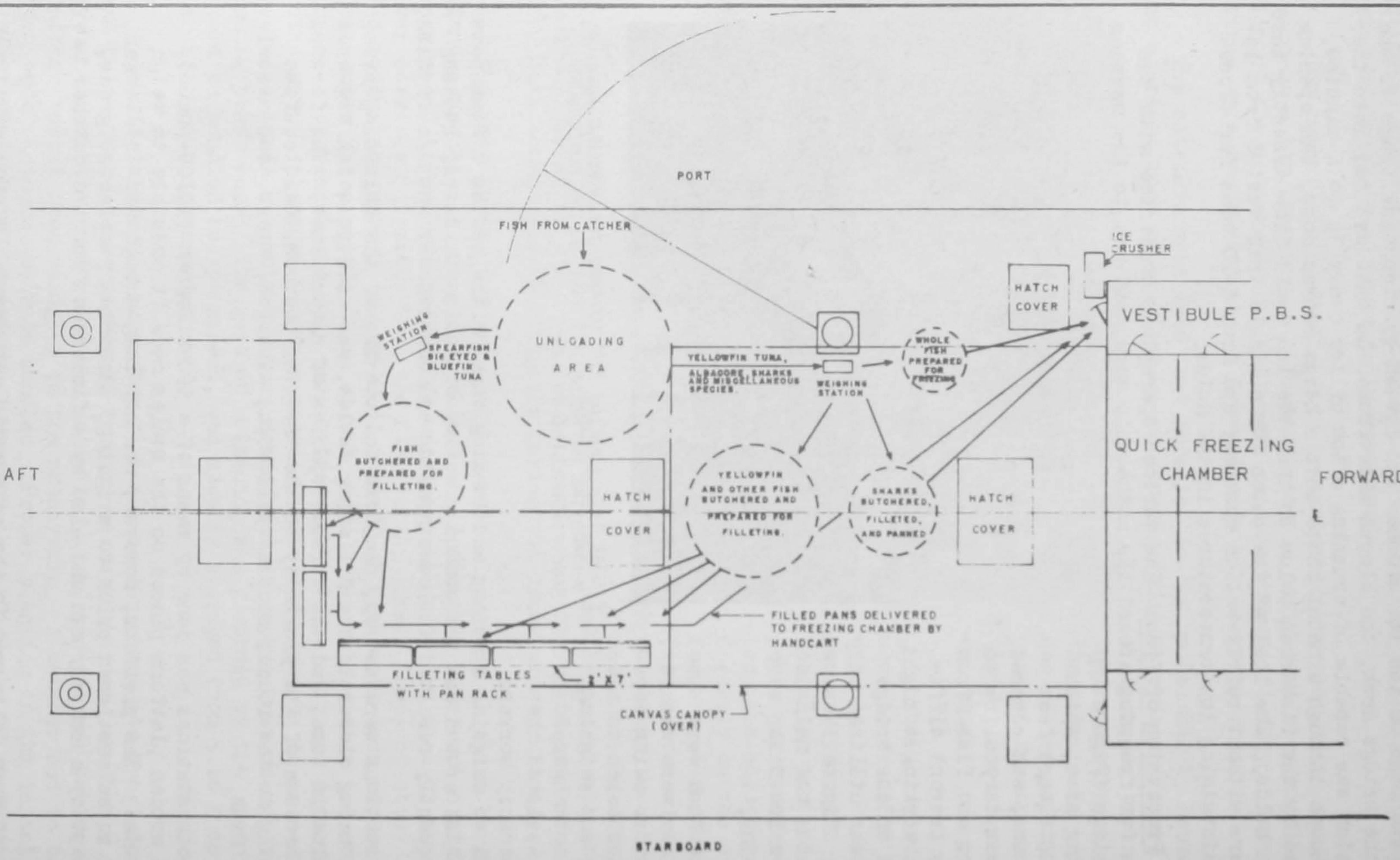
FIGURE 14 - LOOKING AFT TOWARDS THE WORKING AREA ABOARD THE MOTHERSHIP. PANS IN THE FOREGROUND ARE FOR HOLDING FILLETS.

As soon as the fish were deposited on deck, they were washed with salt water before being separated by species and taken to the scales for grading and weighing. Catcher fishermen not engaged in unloading usually assisted the three or four mothership workers in hauling the fish to weighing stations and loading them on the scales. Fish pews were used to move fish around and the common practice of indiscriminately hooking fish with pews frequently resulted in lower grading and unnecessary wastage of fish.

Two weighing stations were set up, one fore and one aft of the unloading area. The after station, being closer to the filleting tables, was used to weigh big-eyed tuna, occasional bluefin tuna, and the various species of spearfishes. The forward weighing station, because of its proximity to the freezing chamber, handled fish suitable for freezing in the round, such as yellowfin, albacore, shark, and miscellaneous species of fish.

Weighing at both stations was done by means of a 500-kilogram (1,100-pound) platform scale. A wooden platform placed on the scales made it possible to weigh several fish at a time. The platform, however, was not long enough for the larger marlins, which had to be sectioned prior to weighing. Records of weights, grade, and species were kept by a company man and also by a fisherman from the catcher being unloaded.

The condition of fish delivered to the mothership was generally good with very little spoilage because the fishermen made liberal use of their ice and the trips were of short duration. Salable fish was bought by the mothership management at a price which differed for species and quality of fish. Yellowfin and albacore commanded the highest prices because of their export value. Sharks brought the lowest



GENERAL LAYOUT OF THE MAIN DECK

WORKING AREA AND FLOW DIAGRAM

FIGURE 15

price. Quality was related to the general appearance of the fish, texture, firmness, and color of meat, and this was determined by organoleptic methods at the time of weighing by a company man. Yellowfin tuna were arbitrarily graded by condition into four and sometimes five grades; big-eyed tuna into three or four; albacore into two; marlin and other fish into two or three grades. Proportionally lower prices were paid for the poorer grades of fish. Shark prices did not change with species or quality.

Yellowfin tuna, albacore, and some of the smaller tunas were not gutted at sea like other species. At the company's request, however, gills of all yellowfin tuna were removed immediately after capture because it was believed that whole yellowfin so treated would be more acceptable for export. A monetary allowance was given the fishermen to compensate them for this loss of weight.

Shark and tuna livers were saved by all of the catcher boats and were either kept aboard each catcher or were transferred to the mothership for freezing and storage. By long-standing practice, the revenue derived from livers is divided among the fishermen. Livers derived from uneviscerated fish purchased by the company, however, did not revert to the fishermen but became company property.

After weighing, yellowfin tuna, albacore, wahoo, and small tunas suitable for freezing whole were thoroughly washed and scrubbed before being passed to the freezing chamber. Yellowfin tuna were checked for gill removal and for external wounds or abrasions which could result in their rejection when exported. Furthermore, for ease of handling, the long second dorsal and anal fins which are characteristic of mature yellowfin tuna were chopped off close to the base.

All tuna exceeding 11 inches in thickness and those not meeting quality standards for freezing as whole fish were prepared for filleting in the area immediately adjacent to the forward weighing station. Here, on the wooden deck, the fish were beheaded with cleavers, cleaned, and washed before being taken aft to the filleting tables. Except for the removal of the livers, no effort was made to utilize the viscera and heads which were thrown overboard.

Spearfish and big-eyed tuna were similarly processed for filleting near the after weighing station. Big-eyed tuna, weighing less than 10 lbs. and sections of the smaller sailfish were sometimes frozen whole depending upon the availability of shelf space in the freezers.

Sharks were cut into sections after weighing and pan-frozen for later sale to Japanese fish-cake manufacturers. The dorsal, pectoral, and caudal fins of these fish, highly esteemed by Orientals when dried, were also retained as a byproduct and frozen.

The six filleting tables were 7 feet long by 2 feet wide, with metal grates in front to serve as pan racks. Those on the starboard, usually the weather side, were sheltered by a backdrop of bamboo curtains in addition to the overhead canvas. A 200-watt lamp suspended over each table provided very poor light for night work, but the filleting tables were well lighted as compared to other areas of the deck where hazardous work, such as butchering, was often conducted in semidarkness.

The techniques used to fillet fish were essentially the same for all filleters and a skilled worker was able to dispose of a 60- to 75-pound fish in about 4 minutes on the average (Figure 16). The trunk of the fish was first slashed around the caudal peduncle anterior to the keel with a heavy keen-edged knife. The blade was then passed along one side of the backbone, ventrally and dorsally. Cutting down through and along the lateral line permitted removal of two loins. The remaining side of the fish was next separated from the backbone and halved. The four loins were then trimmed to fit a standard freezing pan measuring 23" x 13" x 4¾". These pans were capable of holding from two to three loins or about 50 pounds of fish each. The small left-over pieces were saved and placed in a separate pan for freezing. Spearfish sections were handled in the same manner as the tuna sections. The freezing pans were filled by a crew of three men who also kept the filleters supplied with fish. Pans when filled were marked as containing either first- or second-grade fillets, although the fish may have been purchased at lower grades. The filled pans are then loaded on push carts and wheeled to the receiving door of the freezing room.

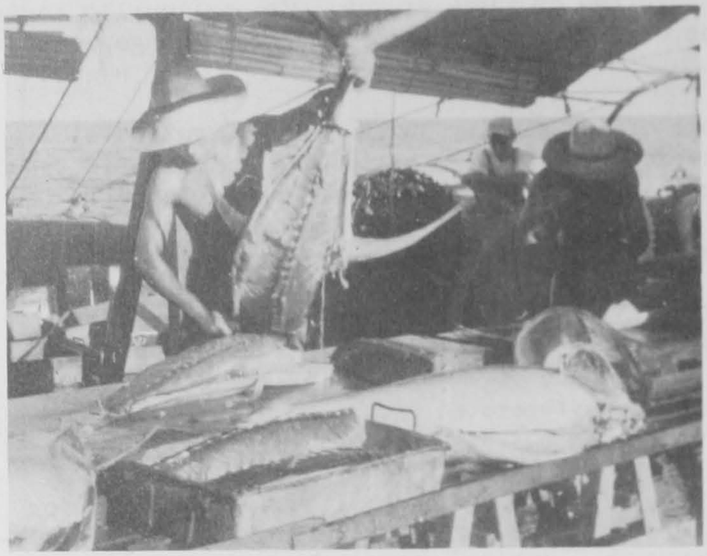


FIGURE 16 - A WORKER FILLETING A YELLOWFIN TUNA.

Often, the filleters were not able to keep up with the flow of fish from the butchers, in which case the fish were piled up on deck until they could be handled. The fish were covered on a few occasions with chunks of ice to prevent spoilage, but this procedure was dispensed with when it was determined that the time elapsing before the fish could be filleted was usually not long enough to materially affect the condition of the fish.

Freezing and Storage of Fish: A single-stage, direct-expansion ammonia system was used to freeze fish aboard the mothership. Four vertical compressors of Japanese manufacture were in operation, with a total rated capacity of 250 metric tons. Two compressors, one of 100 tons and one of 50 tons, were used for the freezers. The remaining two compressors formed part of the brine-cooling system which controlled temperatures in the cold-storage holds. Freezer temperatures were brought down to a minimum by the use of -50° C. ammonia; head pressure during normal operation was held at about 215 pounds per square inch.

The below-deck quick-freeze rooms, port and starboard, were not used mainly because of the inconvenience of supplying fish to these two chambers. The freezing of whole fish and fillets was, therefore, conducted in the large freezing chamber on the main deck. This chamber was divided into six freezing compartments connected at each end by an outer vestibule, or preparation room. Each compartment was provided with two banks of ammonia coils which formed nine shelves on a side. Each shelf was 7 pipes wide and each pipe 2 inches in diameter. Removable galvanized plates were placed on the shelves to increase the area of contact with the fish. The six upper shelves were for freezing pan fish and had a space of seven inches between coils. The three lower shelves were for whole fish and measured 11 inches apart. Each bank of shelves held 120 pans of fish (approximately 50 pounds per pan) and 72 whole fish weighing from 60-70 pounds apiece. The total freezing capacity for all six compartments was about 65 metric tons of fish during a 24-hour period.

Whole and filleted fish were passed through the door of the port vestibule and guided along portable metal grates, installed along the corridor, to a compartment. A similar device was used in the starboard vestibule for removing frozen fish. As the compartment was filled to capacity, grate extensions were removed, the doors closed, and temperatures were lowered. Often, it was not possible to completely fill a compartment in which case, if it were known that more fish would become available in a few hours, the usual practice was to postpone freezing the partially-filled compartment.

Fish were frozen in at least 24 hours at minimum temperatures varying between -20° and -30° C. Temperatures were taken twice daily by means of a thermometer inserted through a hole in the compartment wall above the door adjoining the starboard vestibule. To test whether whole fish were frozen satisfactorily, cores were taken from a sample fish of each lot and examined. A thermometer was inserted into the center of the body after removal of the core, and if the internal temperature read below 0° C., the fish was considered to be thoroughly frozen.

FIGURE 17 - WHOLE YELLOWFIN TUNA FROZEN AND STACKED IN A COLD STORAGE HOLD.

Frozen fillets were given a preliminary fresh-water glaze and removed from pans in the starboard vestibule. The pans were then passed out through the doorway to the main deck for cleaning and filling. The blocks of frozen fish were chuted below for a final glaze and packing into cardboard boxes for storage. Whole fish were individually glazed below and stacked in the main cold-storage holds (Figure 17) rather than in the side wings which were for boxed fillets.

Working Conditions: By United States standards there was considerable room for improvement in efficiency of operations which would have resulted in time and labor savings. It was apparent, however, that the mothership management was not interested in reducing the work through operational planning and the improvement of existing equipment because of the cheap, ample supply of available labor. Simple conveyor systems, for example, would have speeded up deck operations considerably. Lacking these and other labor-saving devices, workers assigned to the handling and processing of fish were subjected to rigorous working conditions and were on call 24 hours a day. These men were seldom able to rest for more than eight hours a day during most of the season and then for only two- or three-hour intervals instead of one continuous period. The ship's crew and those working in the freezer and cold-storage holds were more fortunate in that they worked on a shift basis. In relation to the work performed, all workers were poorly paid. A skilled filleter received as little as $40 per month beside room and board. Production was adversely affected towards the end of the season because of the cumulative effects of hard labor, inadequate rest, and the lack of monetary incentives which visibly affected the workers' efficiency and morale.

Production: According to statistical data provided by the Taiyo Fishing Company, approximately 6,236,000 pounds of final products, not including specialty items, such as shark fins and livers, were obtained from about 7,683,000 pounds of raw fish consigned to the mothership during the season. This represents a utilization of over 80 percent of all fish by weight, but as mentioned earlier, many of these fish were already gutted or gilled when delivered to the mothership. The leading product by

Table 5 - Products Produced Aboard the Mothership[1/]

Type of Product	Species	Quantity of Products Produced
		lbs.
Whole, frozen	Tuna	2,375,607
Fillets, frozen ..	Tuna	1,670,798
	Marlin	1,224,918
	Shark	575,275
	Other[2/]	172,949
Iced fish	Tuna	113,616
	Marlin	7,268
Livers	Tuna	17,007
	Shark	41,086
Other[3/]	-	37,452
Total		6,235,976

1/REPORTED FIGURES.
2/INCLUDES WAHOO AND SMALL TUNA FROZEN WHOLE OR WITH HEADS REMOVED.
3/MOSTLY SHARK FINS.

weight was frozen fillets, but the most valuable was the 2,375,000 pounds of whole frozen fish, almost entirely yellowfin tuna. 3/ (The itemized production is presented in Table 5.) Although most of these fish products remained aboard the mothership until her return to Tokyo, some 120,000 pounds of fresh yellowfin tuna, big-eyed tuna, and black marlin were picked up and transported back to Japan by a small refrigerated carrier vessel during the middle of August to take advantage of the high prices then prevailing in that market. Catches made at the season's end and brought back to port by the individual catchers were also sold as fresh fish.

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3/UPON RETURN OF THE EXPEDITION TO JAPAN, NEARLY ALL OF THE WHOLE FROZEN FISH WAS SOLD AND EXPORTED TO THE UNITED STATES.

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