THE JAPANESE TUNA FISHERIES

UNITED STATES DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary

FISH AND WILDLIFE SERVICE
Albert M. Day, Director

FISHERY LEAFLET 297

Washington 25, D.C. April 1948

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NATURAL RESOURCES SECTION
REPORT NUMBER 104
9 March 1948

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SUMMARY

1. Japan is admirably situated for exploiting the tunas, as many tuna species enter its waters at some time during their wide migrations. It has thus been possible for the Japanese to catch these species and to recognize them as desirable food items since ancient times.

2. Prior to and during most of the Meiji Era (1867-1912), tuna fishing operations were on a small scale and confined to coastal waters. With the introduction of motor-driven vessels, however, taking increased amounts of tuna became possible, especially from the offshore pelagic waters. The fisheries were therefore able to expand until they now rank as a major Japanese industry.

3. During the 1930's the tuna catch in coastal and offshore home waters approached its maximum, and it became evident that increased production would require the exploitation of overseas fishing grounds. Moreover, the opening of foreign markets for tuna products in 1929 created additional enthusiasm for developing the fisheries further. In the years prior to World War II explorations were undertaken to determine new areas that could contribute materially towards an increased tuna catch. Albacore fishing grounds were located in the mid-Pacific area and were fished intensively. Major fishing grounds for the yellowfin tuna were discovered in the tropical zone. Commercial fishing operations in the former Mandated Islands began in 1938, but the catch never reached large proportions because fuel allotments to fishing vessels operating from home ports were considerably curtailed by the army and navy. Thus, in the years before World War II, Japanese tuna operations were confined largely to home waters, although much information was obtained which indicated the possibility of further expansion in the fisheries.

4. Knowledge of the extent of the tuna grounds in the western Pacific Ocean is most complete for the commercially important species. The research on this group of fishes also reflects their importance to the Japanese. The skipjack, black tuna, albacore, and yellowfin tuna are the only tunas for which biological information of any consequence has been obtained. However, much of this information is unco-ordinated and scattered through the literature.

5. The main types of fishing gear used in the tuna fisheries are the pole and line and the long line. Pole and line angling, employing live bait or a jig as a lure, is practiced for surface fishing. The species most commonly obtained by this method is the skipjack. Albacore, yellowfin tuna, or big-eyed tuna of small size, found feeding on the surface, are also taken with this gear. The long line technique has been developed to a high degree of perfection by the Japanese in order to fish below surface levels in the offshore pelagic waters. Albacore, black tuna, yellowfin tuna, and big-eyed tuna are taken largely by this method. Marlins, swordfish, and sailfish are also caught in considerable numbers on long lines and are included by the Japanese in the species comprising the tuna fisheries. Other tuna gear of lesser importance are the huge trap-like set nets, drift nets, circling nets, trolling jigs, and spears.

This report was prepared by Dr Sidney Shapiro, scientific consultant, Fisheries Division. Dr Katsuzo Kuronuma, biologist at the Tokyo Central Fisheries Experimental Station, aided materially in compiling the data. All illustrations were made by Katsuyuki Kita and Saburo Satouchi, draftsman and artist respectively for Fisheries Division.

INTRODUCTION

During the last several decades the tunas have assumed a position of major importance in commercial fisheries throughout the world. Much interest now centers in this group because of the tremendous demand in many countries for canned tuna products either for indigenous consumption or for their value as export items. Important fisheries consequently have been developed in North American and northern European countries. In Japan and in the Mediterranean region, however, not only are the tunas of considerable present-day importance but they have been taken since ancient times and have been among the most esteemed of all fish.

Japan is admirably situated for exploiting the large oceanic species, many of which perform wide migrations and enter its coastal and offshore waters at some time during their life histories. Two island chains, the Philippine-Ryukyu and the Marianas-Bonin-Izu, converge into the southern half of Japan (Figure 1). These island groups, with shallow water and adequate food present in their immediate vicinity, provide a series of stepping stones for the northward migration of large fish. In Japanese waters, the tunas are able to find an abundance of the small fish and pelagic crustaceans that comprise the bulk of their diet.

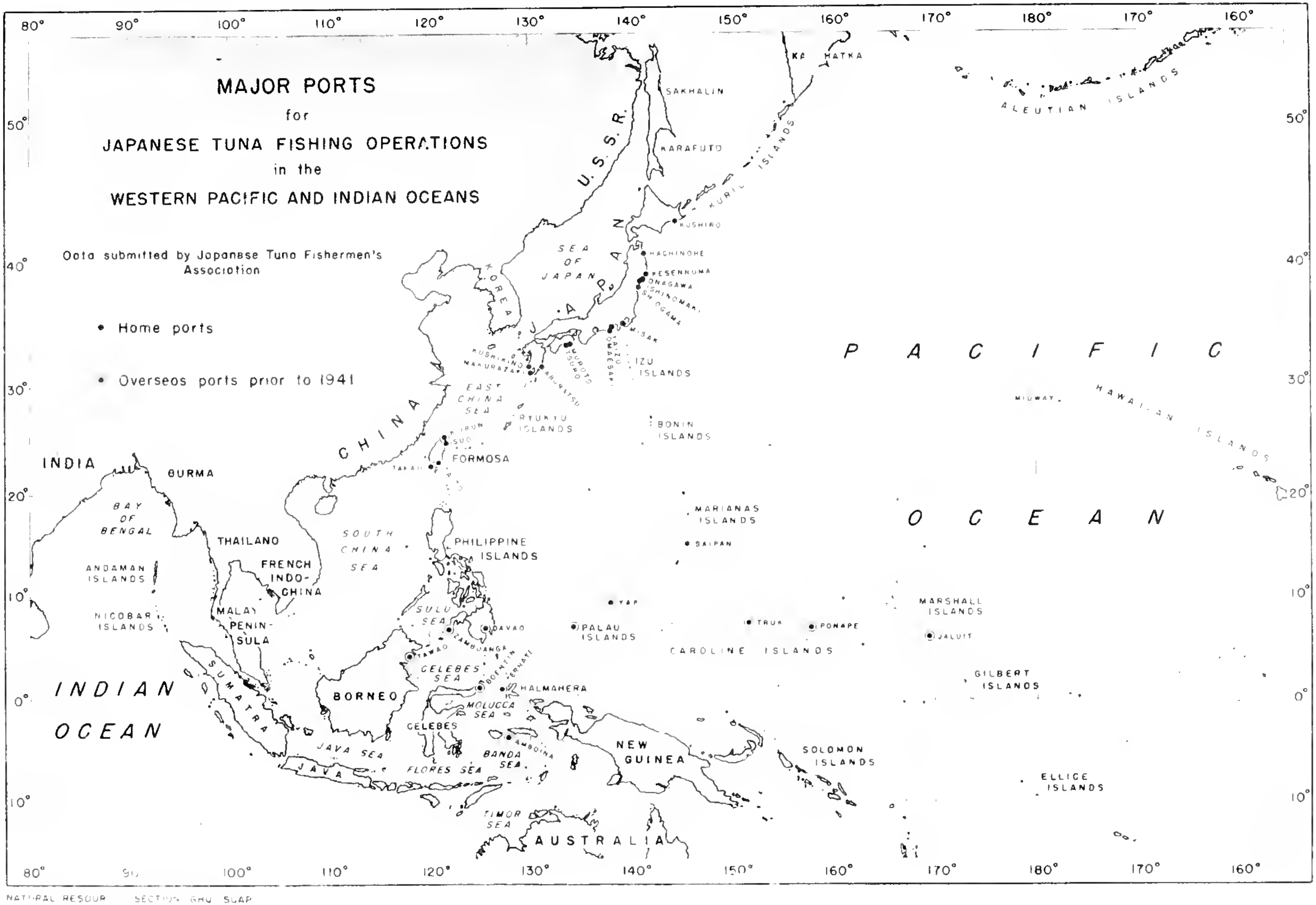
Other features of the western Pacific Ocean are also responsible for directing the far-ranging tunas into Japanese sea regions. Since the tunas are primarily warm water forms, they enter Japanese waters during the summer months because of the widening influence of the North Equatorial Current and the consequent progressive warming of the waters along the Japan coasts (compare Figures 2 and 3). The areas through which the currents (the Kuroshio on the Pacific side and the Tsushima in the Sea of Japan) flow have been the major regions for tuna operations. The fishing season for the most important commercial species reaches its peak during the late summer in the sea regions east of northern Honshu. Current and temperature are important in determining the seasonal occurrence and abundance of the tunas, and any variation from the normal profoundly affects the fisheries for these species.

Numerous references to the tunas as articles of diet occur in Japanese classical literature. These indicate the ancient status of the fisheries, but, unfortunately, few hints in the old writings show what the earliest fishing methods were. Authorities assume that the most primitive fishing technique was hook and line, spears, or traps set in places ordinarily visited by those tunas that enter shallow coastal waters during their migrations.

Prior to and during most of the Meiji Era (1867-1912), rowboats (tekogibune) or small sailing vessels (shohansen) were used for tuna fishing. Thus, operations were necessarily confined to coastal waters. The introduction of motor-driven vessels made it possible to develop the pelagic offshore fisheries. In 1906 the first skipjack vessel equipped with an engine was operated successfully, and the following year an engine was installed in a tuna long line boat. 1/ Fishing in the Bonin Islands by vessels operating directly from a Japanese port began in 1909. By 1910-11 all vessels operating in the offshore waters were equipped with engines. Larger boats were constructed and practical fishing operations became possible at increasingly great distances from land.

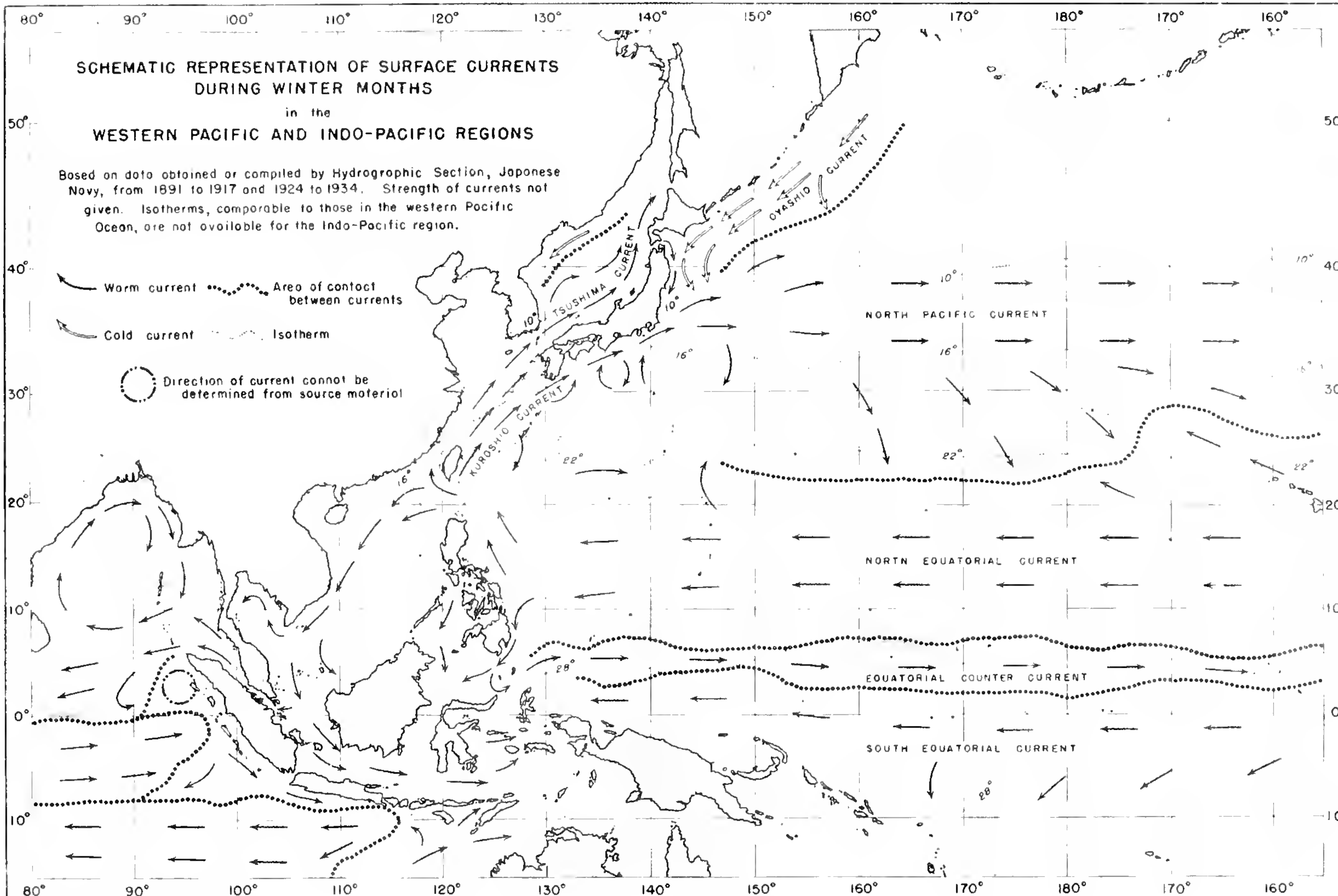
At first the skipjack 2/, which was in great demand by the Japanese housewife for use as a condiment, was the only species exploited by the offshore fishermen to any great extent. The skipjack remained the most important member of the group of large pelagic species, but, following the first shipment of canned albacore from Japan to New York in 1929, an increasing demand arose for tuna products to supply a growing export market. In later years the export of canned and frozen tuna products in large quantities became increasingly necessary to the Japanese Government because of its efforts to establish credits for world trade.

1/ See section on Tuna Fishing Vessels, for explanation of types of vessels.
2/ This species (*Katsuwonus pelamis*) has a worldwide distribution and is known by a variety of vernacular names, for example, bonito, oceanic bonito, striped-bellied bonito, striped tuna, and skipjack. English translations of Japanese fishery papers refer to the species as the bonito. However, skipjack is the preferred name in this paper, because this term is used in United States statistical reports.



MAJOR PORTS
for
JAPANESE TUNA FISHING OPERATIONS
in the
WESTERN PACIFIC AND INDIAN OCEANS
Oota submitted by Japanese Tuna Fishermen's Association
• Home ports
• Overseas ports prior to 1941
U.S.S.R.
SAKHALIN
KARAFUTO
KURIL ISLANDS
ALEUTIAN ISLANDS
KUSHIRO
HACHINOHE
KESENNUMA
ONAGAWA
ISHINOMAKI
SHIOGAMA
MISAKI
YAIZU
OMAESAKI
MUROTO
TSURO
KAGOSHIMA
MAKURAZAKI
SEA OF JAPAN
JAPAN
KOREA
CHINA
EAST CHINA SEA
RYUKYU ISLANDS
IZU ISLANDS
BONIN ISLANDS
FORMOSA
INDIA
BURMA
BAY OF BENGAL
THAILAND
FRENCH INDO-CHINA
SOUTH CHINA SEA
PHILIPPINE ISLANDS
ANDAMAN ISLANDS
NICOBAR ISLANDS
MALAY PENIN-SULA
SULU SEA
DAVAO
ZAMBOANGA
TAWAO
CELEBES SEA
TERNATE
HALMAHERA
MOLUCCA SEA
BORNEO
CELEBES
SUMATRA
JAVA SEA
JAVA
FLORES SEA
BANDA SEA
AMBOINA
TIMOR SEA
AUSTRALIA
NEW GUINEA
INDIAN OCEAN
PACIFIC OCEAN
MARIANAS ISLANDS
SAIPAN
YAP
PALAU ISLANDS
TRUK
PONAPE
CAROLINE ISLANDS
MARSHALL ISLANDS
JALUIT
GILBERT ISLANDS
SOLOMON ISLANDS
ELLICE ISLANDS
MIDWAY
HAWAIIAN ISLANDS
NATURAL RESOUR SECTION GHQ SCAP

Figure 1



NATURAL RESOURCES SECTION GHQ

Figure 2

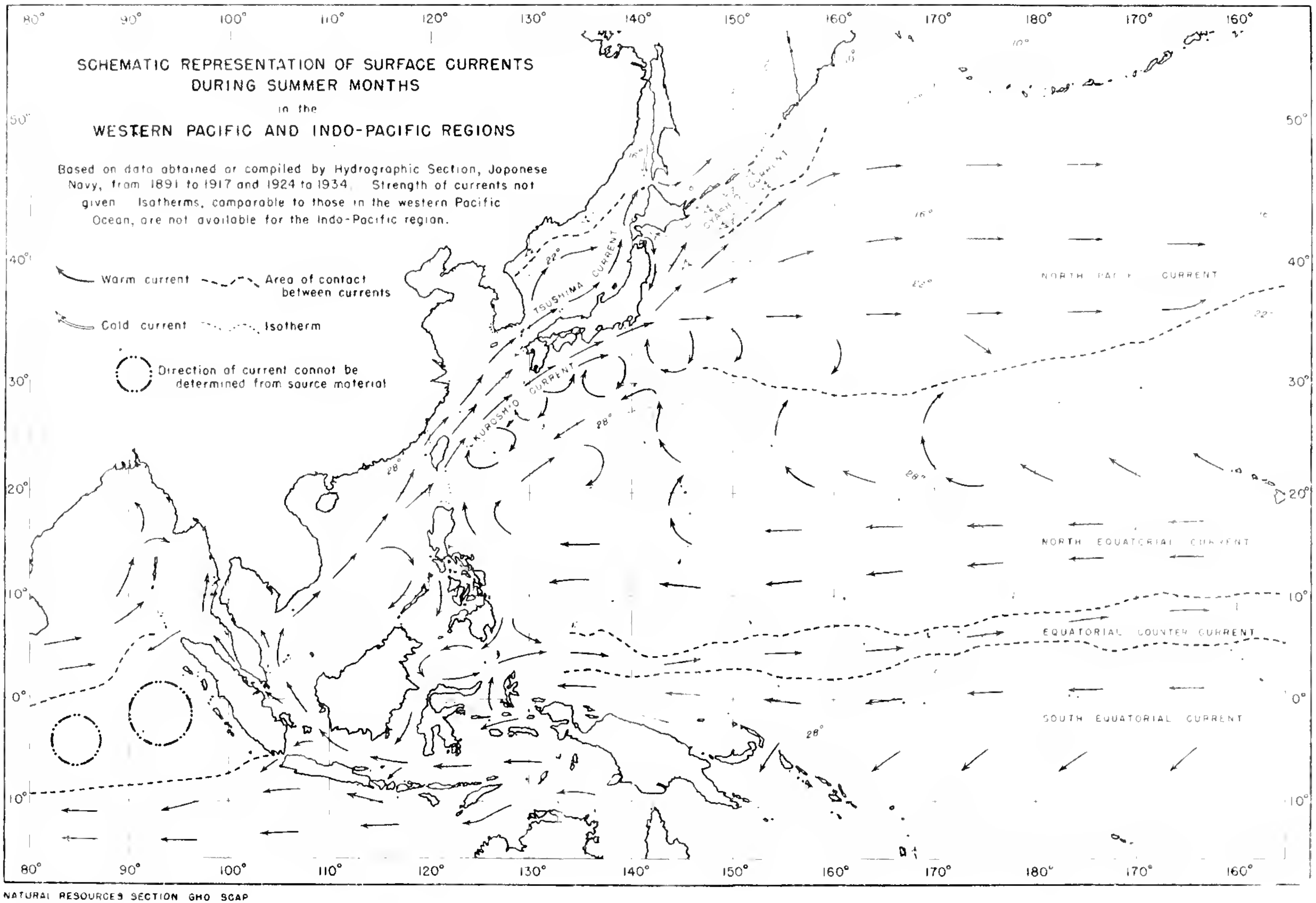

SCHEMATIC REPRESENTATION OF SURFACE CURRENTS
DURING SUMMER MONTHS
in the
WESTERN PACIFIC AND INDO-PACIFIC REGIONS
Based on data obtained or compiled by Hydrographic Section, Japanese Navy, from 1891 to 1917 and 1924 to 1934. Strength of currents not given. Isotherms, comparable to those in the western Pacific Ocean, are not available for the Indo-Pacific region.
Warm current
Area of contact between currents
Cold current
Isotherm
Direction of current cannot be determined from source material
TSUSHIMA CURRENT
KUROSHIO CURRENT
OYASHIO CURRENT
NORTH PACIFIC CURRENT
NORTH EQUATORIAL CURRENT
EQUATORIAL COUNTER CURRENT
SOUTH EQUATORIAL CURRENT
NATURAL RESOURCES SECTION GHQ SCAP

Figure 3

With the increasing demand for tuna products, operations in home waters approached their practical maximum, and it became evident that a further increase in production would require exploitation of new fishing grounds. During the decade prior to World War II the Japanese tuna clippers ranged throughout the entire western Pacific Ocean, as far east as the Hawaiian Islands, south to the areas around New Guinea and the Dutch East Indies, and southwest into the Indian Ocean. Many of the voyages, especially to the Indo-Pacific region and the Mandated Islands area, were surveys made to determine the best fishing grounds for future exploitation. Since the albacore had the greatest export value of all the tunas, fishing grounds for this species were surveyed and became more extended each year. The mid-Pacific area proved to be an important fishing ground for the winter albacore. Major fishing grounds for the yellowfin tuna and marlins 3/ were located in the tropical zone, and in 1938 commercial fishing by vessels based in Japan was started in the Mandated Islands area. Tuna fishing was also conducted near the southern California coast. The amount of catch in Hawaiian and California waters was insignificant as the trips to these localities were primarily naval operations.

The extent of Japanese operations in various fishing areas can be realized from the general tuna survey conducted by the Tokyo Central Fisheries Experimental Station in 1939. The data permit determination of the comparative amounts of the total catch obtained in each of eight major fishing regions (Figure 4). It is evident that the distant offshore tuna fisheries, despite the efforts of the fishermen and encouragement by various government agencies, were undeveloped and never reached the proportions attained in Japanese home waters. The chief limitation was the curtailment by the Japanese army and navy of fuel allotments to the larger fishing vessels. In order to conserve fuel, plans were under way for operating mother-ship fleets, as the salmon and crab industries did in northern waters, but they did not materialize because of the outbreak of the war.

The present publication is a digest and analysis of the information obtained from the Japanese on the tunas. It is based on a survey of available literature, conferences with research personnel and Bureau of Fisheries officials, and discussions with fishermen. Because of the difficulty of translating much of the original material into English, this report will be augmented by future work.

Realizing the importance of the fisheries, the Japanese have completed numerous studies, especially on the commercially valuable species, but their research has been guided mainly by efforts to locate areas of greatest concentration. Considerable oceanographic data have been accumulated for several of the species, but, here again, for the primary purpose of determining the conditions under which the fish can best be found and caught. Information on the life histories and migrations of even the better known species is almost totally lacking. Age and growth studies are still in the initial phases of investigation. The types of fishing vessels and the fishing techniques used by the Japanese in the tuna fisheries are reported in considerable detail. Available data on the economics of the fisheries, pre- and postwar, are given, but the compilation of complete statistics has been neglected by the Japanese, and the many gaps in their information prevent the presentation of a complete picture.

3/ Tuna long line boats operating in the offshore pelagic waters take a large proportion of the marlin, swordfish, and sailfish catch. Traditionally the Japanese include these species in the tuna fisheries, without regard to biological relationships. This practice often leads to difficulties as this grouping generally has been followed in compiling tuna fisheries statistics. Separation by species is rarely made, and the Japanese use the term "tuna" to include all true tunas (maguro) plus these allied forms. Occasionally marlins, swordfish, and sailfish are distinguished from the true tunas and grouped into a separate category, the spearfishes (kajiki).

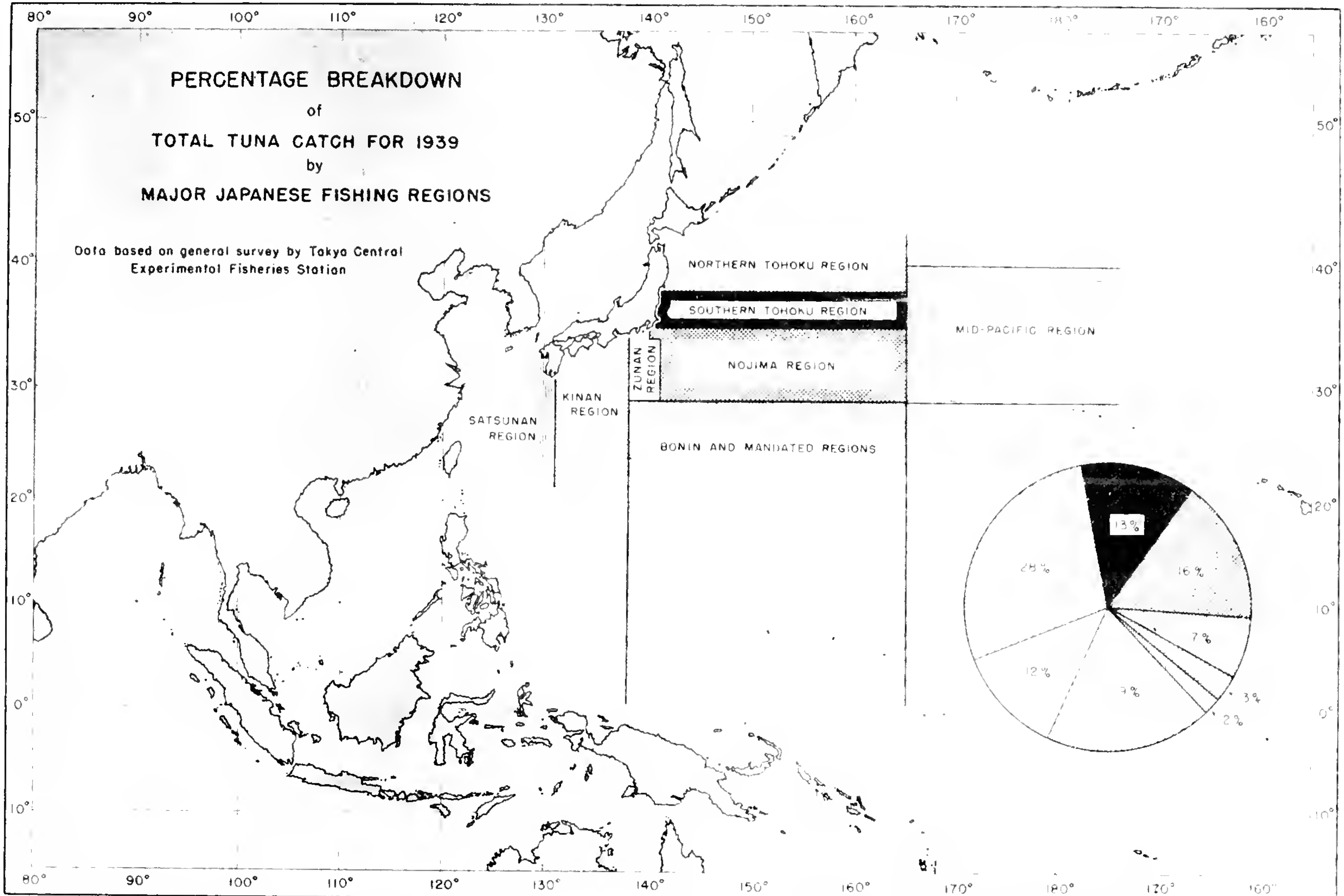


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Figure 4

CLASSIFICATION

1. General

The pelagic species discussed in this paper are members of two orders of fishes, the Scombriformes and the Xiphiiformes. Despite the fact that the majority of the species are well known to the layman and have been fished intensively in many parts of the world for both sport and commercial purposes, their classification is still unsettled. The huge size of many of the species prevents museums from preserving specimens, and scientific workers have been unable to obtain adequate material from different regions for comparison.

A brief outline of the generally accepted major families within each of the two orders is presented below merely to orient the reader, as it is not within the scope of this paper to discuss either classification or nomenclature. Representative species in each family are given, followed by widely used English and Japanese common names. The species marked with an asterisk are the commercially important Japanese oceanic forms.

Order SCOMBRIFORMES

Family Scombridae (mackerels: saba)
- Scomber japonicus (common mackerel: honsaba, masaba)

Family Katsuwonidae (small tunas: katsuo)
- * Katsuwonus pelamis (skipjack: katsuo)
- Euthynnus yaito (mackerel tuna: yaito)
- Auxis tapeinosoma (frigate mackerel: marusoda)

Family Thunnidae (tunas: maguro)
- * Thunnus orientalis (black tuna: kuromaguro)
- * Thunnus germo (albacore: bincho)
- * Parathunnus mebachi (big-eyed tuna: mebachi)
- * Neothunnus macropterus (yellowfin tuna: kihadamaguro)

Family Cybiidae (seer-fishes: sawara)
- Sawara niphonia (Spanish mackerel: sawara)
- Sarda orientalis (oriental bonito: hagatsuo)

Order XIPHIIFORMES

Family Istiophoridae (sailfish and marlins: kajiki)
- * Makaira mitsukurii (striped marlin: makajiki)
- * Makaira mazara (black marlin: kurokajiki)
- * Makaira marlina (white marlin: shirokajiki)
- * Istiophorus orientalis (sailfish: bashokajiki)

Family Xiphiidae (swordfish: kajiki)
- * Xiphias gladius (broadbill swordfish: mekajiki)

The scombriform fishes are characterized by a series of finlets which extend from the dorsal and anal fins back to the base of the caudal fin. On the sides of the caudal region they possess two or three pairs of lateral fleshy outgrowths which act as keels. All scombroid fishes are remarkably streamlined, with the forward fins (pectorals, pelvics, and first dorsal) fitting into grooves or slots when they are folded, but perfect streamlining is more nearly attained in the plump spindle-like form characteristic of the truly oceanic types. The scombroids include species that are primarily coastal in their habitat preference (for example, the common mackerel and the Spanish mackerel). However, the more spectacular species are those that attain gigantic sizes. They are inhabitants of the offshore pelagic waters, although several species, notably the skipjack and the black tuna, enter shallow coastal waters in considerable numbers, apparently for the purpose of feeding. These offshore forms, together with the xiphiiforms (discussed below), are the species that support the Japanese tuna fisheries.

The xiphiiforms possess an upper jaw prolonged into a spear or sword composed of consolidated bone. The body, like that of the mackerel fishes, is streamlined, and, here too, the forward fins fit into grooves or slots. One or two pairs of lateral keels are present on the caudal region. Pelvic fins are either very thin and elongated or are missing. All species attain gigantic size and are highly prized by sport fishermen for their fighting qualities. In Japan, however, the sailfish, swordfish, and the marlins are fished only by commercial methods. Little is known about the biology of these species.

As stated previously, the Japanese research on the oceanic fishes reflects the commercial importance of each. Resumés of the available knowledge on the four most important species follow. These species, the skipjack, the black tuna, the albacore, and the yellowfin tuna, are virtually the only ones for which biological information of any consequence has been obtained.

SKIPJACK
Katsuwonus pelamis (Linnaeus)
Katsuo, Katsuu, Mandara, Magatsuo

1. General

Evidence indicates that the skipjack has, from ancient times, been an important article of diet for the Japanese people. Prehistoric remains of skipjack bones have been found, along with those of the black tuna and other species, in shell mounds excavated in northeastern Honshu. Since hooks, spears, and sinkers made of the horn or bone of land animals were occasionally found beside these bone remains, it is assumed that the ancient people took the skipjack either by angling or by spearing when it entered shallow coastal waters.

The oldest recorded reference to the skipjack is in the Kojiki, written about 712, in which it is stated that the "katsuo" (hard fish) was dried on the roofs of the fishermen's homes. According to the Nippon Shoki, published in 720, the skipjack was eaten raw at that time. In the Engishiki, a classical work on court ceremonies published in 907, the skipjack was described as being caught in the waters off Mie, Shizuoka, Kanagawa, Chiba, Kochi, Miyazaki, and Wakayama prefectures (Yamamoto, 1942, pp 138-143). A variety of foods were prepared from it, many of which were given to the government and court as tribute.

During the time of the Tokugawa Shoguns (1603-1867) extravagant prices were paid for the quick delivery at Yedo (Tokyo) of the skipjack taken in the late spring, the season during which the fish was in prime condition for being eaten raw. Thus the skipjack has, from early times, been a highly prized fish, and even today the Japanese consider it the most valuable of the pelagic species.

The skipjack fisheries were restricted to coastal waters until the development of motor-driven vessels permitted the gradual extension of the fishing grounds from the shore to the open sea. The great demand for this species was sufficient incentive to warrant extending the fishing grounds until, in the northwest Pacific region, they reach a distance of almost 600 miles from the Japanese coast. Thus the shore fishery has declined in relative importance, and the offshore grounds, which contain the larger populations of skipjacks, now supply the bulk of the catch.

2. Diagnostic Characteristics

The skipjack (Figure 5) may be recognized by the four or more dark, longitudinal bands against the white pigment on the lower half of the body. The back is dark bluish violet, with some faint transverse light-colored markings on the posterior half. All fins are dusky in appearance although the second dorsal, anal, and caudal are lighter than the others. The body is plump, sharply pointed, and almost circular in cross-section. The skipjack is naked except for a corselet of scales found in the region of the anterior fins and a few islolated, minute scales scattered over the remainder of the body.

3. Distribution and Migration

Although data on the skipjack are more complete than for any of the other scombroid fishes, the Japanese literature contains few precise statements regarding its distribution

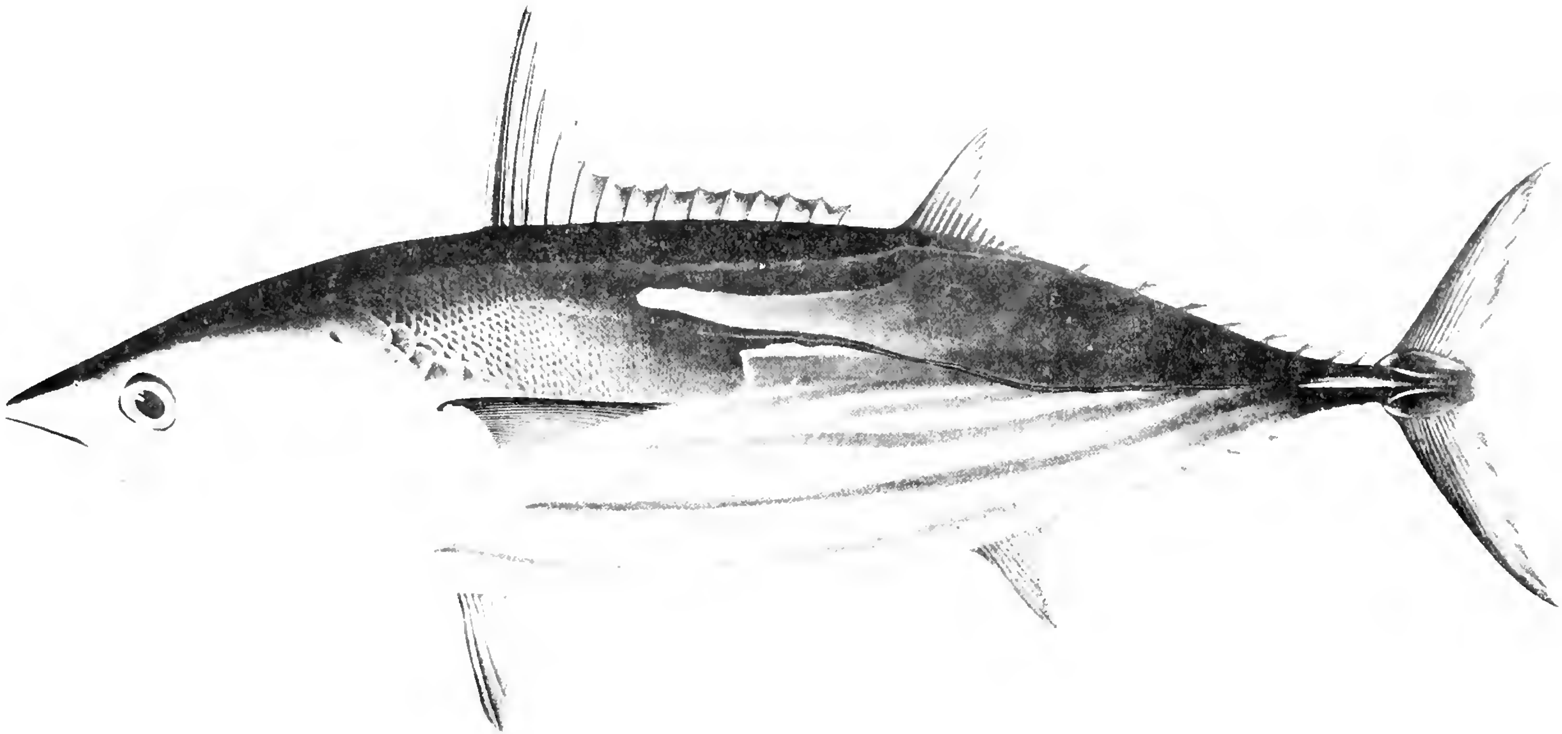


Figure 5. - Skipjack (Katsuwonus pelamis), drawn from a specimen taken by pole and line 130 miles east of Cape Kinkazan, Miyagi Prefecture, 28 June 1947; total length 58.5 centimeters (23.0 inches).

and migration paths in the western Pacific Ocean. The following information is based on fragmentary material presented in various scientific journals, augmented by reports submitted by fishing and research vessels.

Evidence, based on fishing areas, density of the populations in different regions, and the months of the year in which the species generally appears in different localities, indicates that two major groups of skipjacks migrate into Japanese waters (Figure 6).

One group, which fishermen believe orginates in the Celebes and Molucca seas, proceeds northward along the Philippine Islands and enters the waters of the Ryukyus. Skipjacks are present in the Ryukyu waters throughout the year. Weather conditions, however, make fishing operations impossible in January. Two types of fish are taken in these waters: resident schools, which are fished principally in the areas around the small islands and on shallow banks; and migratory shoals, which are found in any part of the region, although usually they are taken in the open sea over deep water. The migratory fish are distinguished from the nonmigratory forms by their relatively heavier bodies. They comprise about 60 percent of the total catch in the Ryukyus (Aikawa, 1937, pp 17-21). In the early spring the migratory shoals move northward and between April and June appear off Japan in the vicinity of Shizuoka and Kanagawa prefectures, east central Honshu. A few schools occasionally enter the Sea of Japan, and skipjacks are taken there in small numbers in late autumn or early winter (Kishinouye, 1923, p 454).

The other group of skipjacks, which it is believed originates in the area of the former Mandated Islands and New Guinea, moves northward through the Marianas and Bonin island chains. Members of this group are present in Bonin waters at all seasons of the year, but fishing operations are not carried on in January and February because of unfavorable weather conditions. This group also consists of resident and migratory populations. During the spring the migratory schools move northward into Japanese waters and meet the shoals advancing from the Ryukyus.

The large concentrations of skipjacks advancing along the Pacific coast of Japan reach the area off the northeastern coast of Honshu, known as the Tohoku sea region, by late summer. When oceanographic conditions are favorable the shoals occasionally advance to Itrup and Shikotan islands in the Kuril Islands. In an analysis of the skipjack schools appearing in the Tohoku sea region during 1934 and 1935, Aikawa (1937, p 21) presented evidence that they were composed of 80 percent Ryukyu and 20 percent Bonin stock.

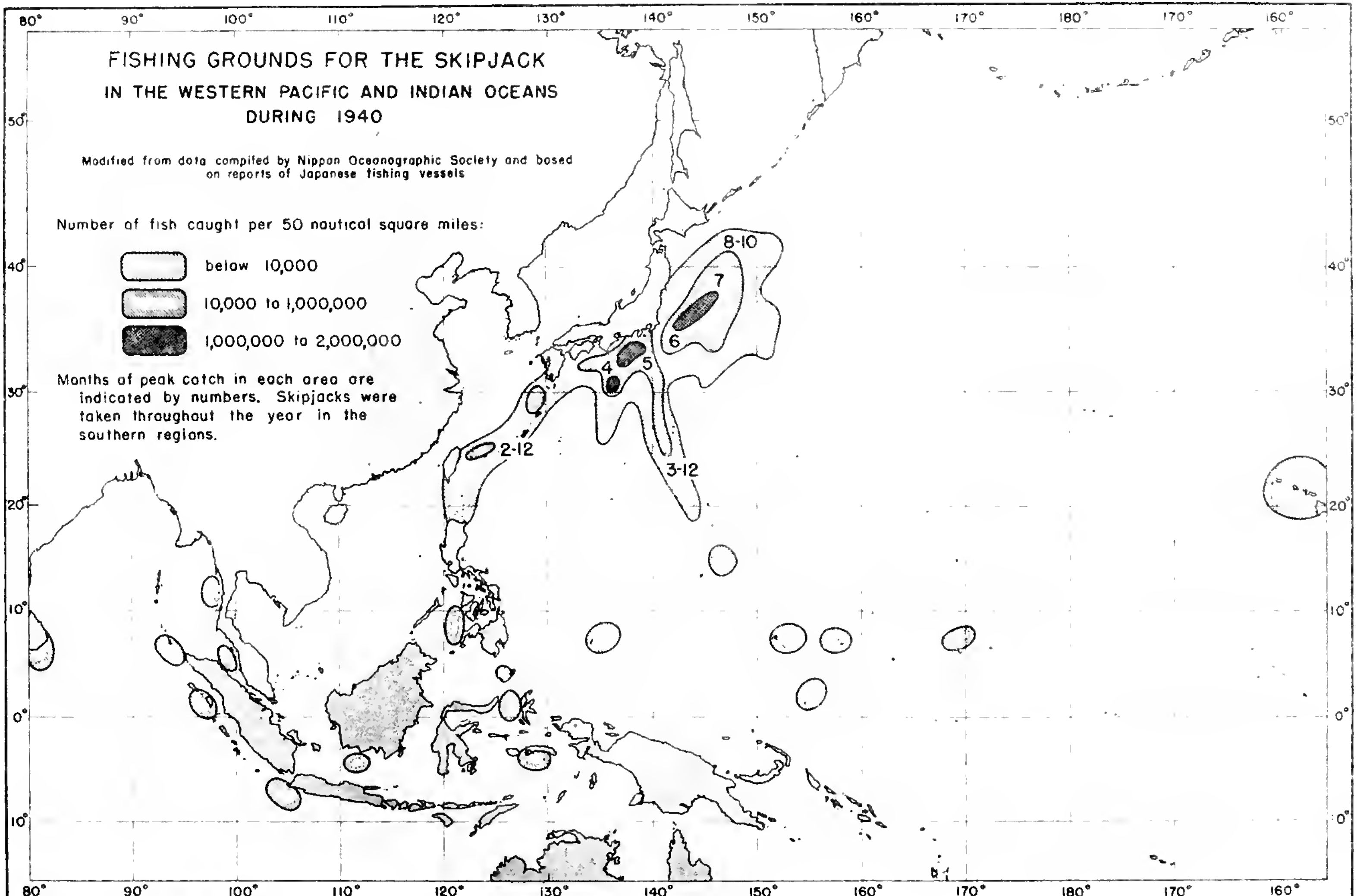
Skipjacks entering Japanese waters during the summer are sexually immature. It is quite evident that they migrate northward solely for the purpose of feeding. The average weight of the individuals landed is about four kilograms. The maximum weight obtained rarely exceeds eight kilograms (Yamamoto, 1942, pp 138-139).

Usually the skipjack migrates as far north as 43°N latitude and then returns south to about 40°N. During late September and October the fish begin to disappear and are no longer seen at the surface. The direction of migration is not definitely known, but during late fall and winter months tuna boats operating long lines in the mid-Pacific region have taken skipjacks swimming in deep waters. It may be inferred that the fish are moving either directly east or southeast.

Some workers claim that the species performs one great migration covering the whole area of the Pacific. To support this contention they cite the fact that large schools of fully mature individuals have been caught from May through July in the region where the Counter Equatorial Current passes through the former Mandated Islands (Caroline, Marshall, and Palau groups). These fish are seen approaching from the east. Other biologists maintain that several races of skipjacks exist, each peculiar to a different locality and each making feeding and spawning migrations of its own. Neither school of thought has been able to supply factual data to establish its contention.

The fishing grounds for the skipjack in the southern regions are not truly indicative of its distribution (Figure 6). Fishing operations for the species were of a local nature, carried on by small companies located at selected island bases. According to T. Nakayama, skipjack expert for the Japanese Tuna Fishermen's Association, the species is

Figure 6



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scattered over the wide area extending from the Mandated Islands west through the Philippines and the Dutch East Indies into the Indian Ocean. The fish are found everywhere throughout this enormous area, although they tend to congregate around the island groups where more food is presumably available. The density of the populations is about one percent that of the schools found in Japanese waters. However, because weather conditions are uniform and mild all year round, operations can be carried on over long periods of time, and vessels can make over-all catches comparable with those in northern waters.

Many of the skipjack schools found in the southern regions are composed of very small, immature fish, indicating that the spawning grounds may be located in this area. A young specimen measuring six inches in length, the smallest recorded by the Japanese, was taken in the vicinity of the Bismarck Islands. Other reports indicate that the Molucca and Celebes seas may also be areas of spawning activity. Ripe individuals have been taken from schools entering Gorontalo Bay (an arm of the Molucca Sea). When leaving the bay the fish had spent ovaries.

4. Oceanographic Data

Studies have been undertaken to determine the water temperatures and current conditions most suitable for large concentrations of skipjacks. Information of this nature could be valuable for predicting the future location of important fishing grounds, but the work on the species is in its initial phases and does not cover the full possibilities of this type of research.

Surface temperatures in relation to fishing success were analyzed by Takayama, Ikeda, and Ando (1934, pp 55-56) from information obtained in 1930 by commercial and research vessels operating along the Pacific coast of Japan. The results indicated that the range of temperature in which skipjacks were taken was between 17° and 31°C, with the most favorable temperatures between 20.5° and 26.5°C. As the migration proceeded northward the temperature for the fishing grounds yielding the peak catch changed from the higher (26.5°C) to the lower (20.5°C).

The fluctuations of the catch for three prefectures, Miyagi (northern Honshu), Shizuoka (central Honshu), and Kagoshima (Kyushu), were correlated with surface water temperature over a nine-year period, 1929-37 (Uda, 1938, pp 77-78). Forecasts based on water temperature during the winter indicated the probable productivity of the major fishing grounds during the following spring and summer. In the years when the water temperature during the winter was higher than normal, the catch was relatively small in the south and abundant in the north. Reverse conditions prevailed when the water temperature in winter was colder than normal. For example, cool waters in the vicinity of Kyushu during the winter months were followed by a good catch in that region during the spring, whereas the catch off the northeastern coast of Honshu during the summer was poor. The author believed that when the temperature was comparatively low in the southern waters the schools tended to stay longer and move about in densely concentrated shoals. Thus fewer fish broke away and migrated into the Tohoku region.

Fishing conditions for the skipjack in relation to oceanographic features such as ocean currents and the vertical distribution of temperature gradients were analyzed by Uda (1940, pp 145-147). In the Tohoku region the best catches were made when the difference in temperature between the surface and 100 meters was at its maximum (10° to 16°C). Whether this difference was instrumental in forcing skipjacks to the surface or the concentrations of sardines and copepods (natural foods of the skipjack) at the surface was the determining factor is not indicated. The peak catches were taken in the Kuroshio Current and were most often found in the tongues of warm water extending into the cold current. In this connection several research workers have pointed out that during the past 20 years the appearance of the skipjack has been delayed annually, although no effect on the general migration route is yet apparent. This yearly trend corresponds to the recent tendency of the warm Kuroshio Current to be deflected southward, as shown in the oceanographic charts prepared by the Tokyo Central Fisheries Experimental Station.

5. Habits

When moving about, the skipjacks are often grouped into shoals composed of several hundred to many thousands of fish. The fish seem to prefer the waters of the Kuroshio Current, which are warmer than those closer inshore, for the offshore schools are larger and more numerous than those in coastal waters. When skipjacks attack a school of fish such as sardines or anchovies, they surround them until a dense spherical mass is formed. Then, as stragglers become detached from the school of small fish, the skipjacks prey upon them.

The earliest study on the feeding habits of the skipjack was made by Okamura and Marukawa (1909). Analysis of the stomach contents of fish collected by various fisheries experimental stations throughout Japan showed the food of the skipjack to consist mainly of sardines, gastropods, and large crustaceans. Succeeding studies have yielded similar results, and Kishinouye (1923, p 454), summarizing these works, stated the food to be medium-sized plankton (such as amphipods, larvae of Squilla and other crustaceans, pteropods, heterpods, calamaries) and immature or small fish. In all food studies the sardine is listed as the principal food, but it is highly probable that a large part of the food analyzed was the bait used to catch the skipjack. Therefore, it is difficult to evaluate the importance of the sardine as a natural food.

In a recent study (Suyehiro, 1938, pp 93-101) the stomach contents of 220 individuals taken under various fishing conditions were analyzed. The main foods of the skipjack were shown to be sardines, anchovies, cuttlefish, and pelagic crustaceans. The author also distinguished between the food habits of the resident and the migratory skipjack. The resident populations living in shallow coastal places where abundant food (sardines, mackerel, horse mackerel, shrimp, amphipods, crab larvae, etc) is available eat almost anything and can always find food. In contrast, the migratory skipjacks swimming in the open sea or the deeper coastal waters generally subsist on the crustacea, cuttlefish, flying fish, and the occasional schools of sardines found in the open ocean and appear to be continually hungry. Since the quantity of food present in the open sea is insufficient for the number of fish present, the migratory skipjacks are more easily taken by the fishermen.

6. Economics

The skipjack is eaten raw, boiled, or roasted but is most valuable when processed into "katsuobushi" (dried skipjack stick). The methods utilized in preparing katsuobushi were probably developed at an early stage in the history of skipjack fishing, since the species is soft-fleshed and decomposes rapidly during hot weather, which coincides with the period of peak catch. The skipjack stick is prepared as follows:

The flesh is first fileted from the bone and steamed. At this stage it is known as "namaribushi" and will remain without spoiling for about a week or 10 days. A large part of the catch is distributed in this manner. If processing is continued, however, the namaribushi is subjected to alternate smoking and drying for a period of about three weeks, and the weight is decreased to 20-30 percent of the original. Sun drying for one day follows, and then the filets are placed in a barrel where normal growths of Asperigillus (the penicillin-producing mold) form on the surface. In addition to flavoring and dehydrating the fish, the mold aids in removing fat and in breaking down complex amino acids into their simpler forms. The growth and scraping off of the mold, followed by sun drying, are repeated several times. Mold growth ceases entirely when the flesh is thoroughly dehydrated. The weight has now been reduced to about 17-18 percent of that of the original fresh filet. This finished product in appearance and texture resembles a stick of hardwood, hence the name "dried skipjack stick" Katsuobushi is one of the most appreciated condiments in the Japanese diet. The sticks are shaved and the shavings used to flavor soup and other dishes.

BLACK (OR BLUEFIN) TUNA
Thunnus orientalis (Temminck & Schlegel)
Maguro, Kuromaguro, Kuroshibi, Meji (immature)

1. General

The black tuna approaches the Japanese coast during its seasonal migration and enters shallow waters in great numbers. Thus the Japanese people have long been able to use it as an important article in their diet and have considered it a favored fish. Evidence that the black tuna was eaten by the ancient people has been unearthed during excavations of shell mounds in the Kanto and Tohoku regions. Bones which are identifiable as those of the black tuna were uncovered from these mounds. Little exists, however, to indicate the first fishing techniques used to capture these giant fish. Authorities believe that huge traps placed in shallow waters were the most primitive method by which they were caught. When the fish entered these traps they were either clubbed to death or speared and drawn up on shore. Until comparatively recent times the black tuna was taken almost solely in coastal waters by set nets which were a natural development from simple traps. With the introduction of motor-driven vessels it was possible to use other gear for taking black tunas in the deeper offshore waters. Today the species is caught for the most part by set nets located close to shore and by long lines in the deeper sea regions.

2. Diagnostic Characteristics

The black tuna (Figure 7) can be recognized by the short tapering pectoral fin, which scarcely reaches the origin of the second dorsal fin, and by the sharp upward bend of the lateral line at a point above the origin of the pectorals. The lateral line then bends gradually downward and posteriorly. The back is nearly black, changing to a grayish blue with metallic reflections in the posterior part. The belly is grayish with many colorless dots. In mature specimens these markings tend to disappear. The first dorsal and the ventrals are grayish, the second dorsal is grayish with a yellow tip, the dorsal finlets are yellow, the anal and the anal finlets are silvery, and the pectorals are nearly black.

Several differences between the Japanese species and the California bluefin tuna, such as color of the fins and ramification of the cutaneous blood vessels, were noted by Kishinouye (1923, p 440). However, detailed comparisons between these forms and the Hawaiian and Australian common tunas have not been made, and the exact relationships of the various geographically separated Pacific units are as yet undetermined.

The mature black tunas taken in Japanese waters generally weigh between 125 and 200 kilograms, but the species attains even more gigantic sizes. Kishinouye (1923, p 439) reported specimens weighing about 375 kilograms taken near Odawara in 1913, and more recently (date unknown) a specimen weighing 450 kilograms was taken in Toyama Bay on the Sea of Japan coast of Honshu.

3. Distribution and Migration

The distribution of the black tuna is known only from the areas in which commercial operations take place. Therefore, its known distribution is more indicative of areas where the fish tend to shoal or congregate, thus making commercial operations feasible, rather than of true range. The fishing grounds in the northwestern Pacific Ocean extend from Sakhalin and and the southern Kuril Islands south along both coasts of Japan and the Korean coast, through the Ryukyus and the Bonins to the area between southern Formosa and northern Luzon (Figure 8). Records show that in recent years black tunas have been obtained in offshore waters east of Japan by long line vessels fishing primarily for albacore or swordfish (Kimura, MS). The known distribution of the species has thus been extended, but its true range will not be ascertained until research workers begin critical compilation of all records obtained throughout the western Pacific.

Data of value concerning the migratory routes followed by the black tuna in Japanese waters are based solely on reports given by vessels as to seasonal changes in major fishing grounds. Dr K. Kimura, of the Tokyo Central Fisheries Experimental Station, is now preparing this material for publication. For Philippine waters, information has been supplied by Dr H. Nakamura, formerly of the Formosa Fisheries Experimental Station.

As the black tuna is found in the southern Ryukyus during June and in the Tohoku coastal region (northeastern Honshu) at the same time, several races within the species are postulated by Japanese scientific workers. Morphological analysis to support this belief has not been attempted, but a division into Japanese and Philippine units appears to be valid from the evidence at hand. The information presented indicates the complexity of the life

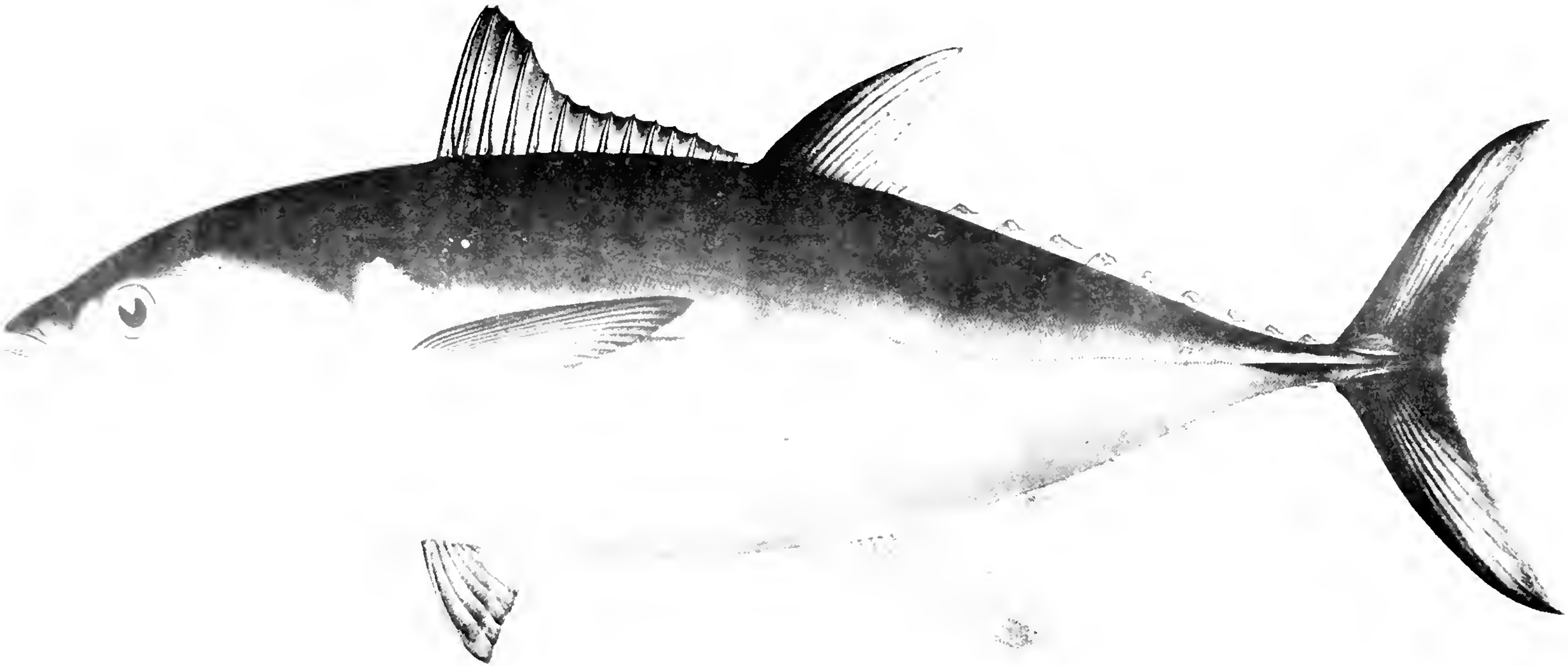

Figure 7. - Black tuna (Thunnus orientalis), drawn from photograph of a specimen obtained near Shiogama, Miyagi Prefecture, October 1947; weight about 225 kilograms (495 pounds); no other data available.

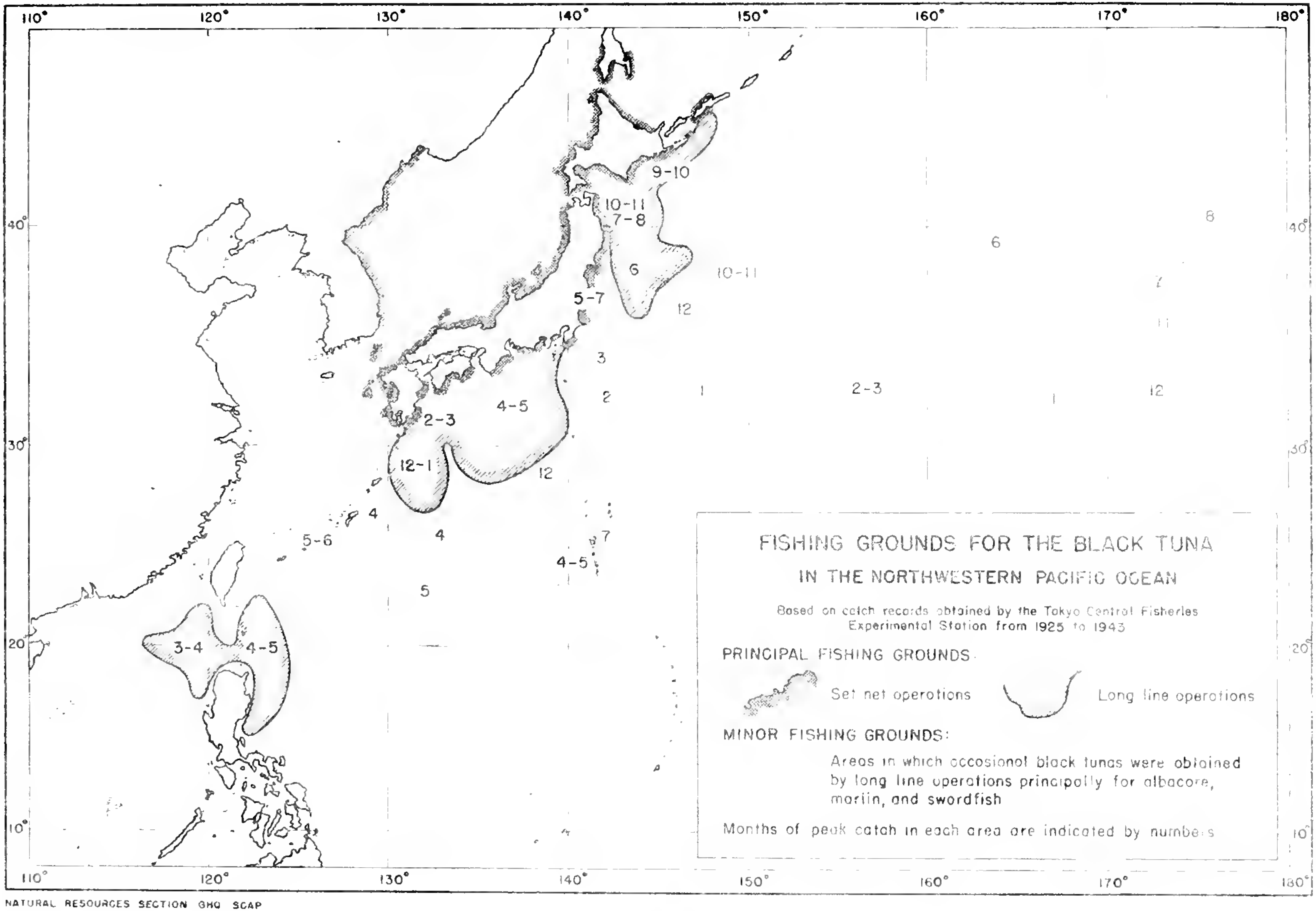
FISHING GROUNDS FOR THE BLACK TUNA
IN THE NORTHWESTERN PACIFIC OCEAN
Based on catch records obtained by the Tokyo Central Fisheries Experimental Station from 1925 to 1943
PRINCIPAL FISHING GROUNDS
Set net operations
Long line operations
MINOR FISHING GROUNDS:
Areas in which occasional black tunas were obtained by long line operations principally for albacore, marlin, and swordfish
Months of peak catch in each area are indicated by numbers
9-10
10-11
7-8
6
5-7
3
2
2-3
4-5
12-1
12
4
5-6
5
7
4-5
3-4
10-11
1
8
110°
120°
130°
140°
150°
160°
170°
180°
10°
20°
30°
40°
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Figure 8

history of this migratory species; much intensive research is needed before it can be satisfactorily understood.

Japanese Stock: During December and January, the black tuna is found in the sea region directly south of Kyushu (Figure 8). From February through April, as the warm Kuroshio Current extends its influence northward, the schools begin migrating along the eastern coast of Kyushu and Shikoku. Kimura (unpublished data) has evidence that, in this region, the shoals begin to separate into two groups. One continues northward along the Honshu coast while the other moves southward to the areas around the Bonin, Daito, and Ryukyu islands.

The shoals moving northward appear off the Shizuoka and Chiba prefectural coasts (east central Honshu) during April and May and generally reach the Tohoku region during the late spring and summer months (May through July). Many of the females taken in the Tohoku area are spent. Kishinouye (1923, p 441) believed that they spawned in the offshore waters east of Honshu but presented no evidence to support this belief, other than that ripe individuals disappear from the Chiba sea region and then reappear further northward in spent condition. From July to November the tunas are taken in the vicinity of Hokkaido. A migration southward then occurs, but the fish are not schooled and are spread over a wider area than during their northward movement. After they leave the Hokkaido and Tohoku regions the shoals appear in the offshore waters east of Honshu. Two general paths southward seem to be indicated, one along the eastern side of the Kuroshio Current, and one in the mid-Pacific region.

The black tunas moving southward from the Shikoku sea region appear in the waters of the Bonin-Daito-Ryukyu area between May and July in ripe condition. It is believed that the group spawns in this area since spent individuals are also taken here.

During August very small black tunas, about six inches in length, have been taken in great numbers along the coast of Shizuoka Prefecture (Kimura, MS). Possibly they are the young of adults that have spawned in the islands of the southern latitudes.

On the west coast of Japan the black tuna follows a similar seasonal sequence in its northward migration. Tagging experiments, the only ones successfully attempted by the Japanese with any of the tunas, were made on the black tuna by the Hokkaido Experimental Station at Yoichi and offer some evidence on the movements of the species. Kawana (1934, pp 10-11) released nine tagged fish at Yoichi on 8 July 1932. Three of these were recaptured in the same vicinity 23, 60, and 93 days later. Of 39 tagged fish liberated in the same vicinity on 28 September 1932, three were recaptured, two close to Yoichi and one at Morohashi, Ishikawa Prefecture, west central Honshu. The author concluded that in the summer months the fish remain in almost the same water, but with the drop in temperature in the fall they migrate south along the west coast of Honshu.

Philippine Stock: Black tunas are first seen in the Philippine area about 20 March, when they appear in the waters around Platas Island. During April and May large schools of the fish disperse into the broad area between Formosa and northern Luzon and are in sufficient numbers to warrant intensive commercial operations. These schools begin to migrate northward and are found in the southern Ryukyus during late May and June.

The spawning behavior of the Philippine schools has not been determined, but many ripe individuals have been taken in the Formosa-Philippine area during the middle of May. In June, however, the fish in the southern Ryukyus were spent.

4. Oceanographic Data

Data on catch statistics in relation to water temperature and the movements of water currents are too few to permit generalizations regarding these factors as they affect the distribution of the black tuna. The studies reported in the literature, however, do indicate that the migration and abundance of the species in Japanese waters may be directly concerned with oceanographic conditions.

Takayama and Ando (1934, pp 6,20) analyzed catch records in relation to surface water temperature in the fishing grounds off the sourthern half of the Japanese Pacific coast.

The range of temperature in which specimens were taken was between 12° and 27°C. The greatest number of fish per haul (by long line) was obtained at temperatures of 23° and 24°C, but optimum temperatures apparently differed annually and with locality and season of year. Kawana (1934, pp 11-13) obtained results during drift net operations off southeastern Hokkaido which show not only that the amount of catch is correlated with water temperature but that the optimum temperature is lower for the northern latitudes. Black tunas were taken in this area when the water temperature reached about 14°C. Maximum catches, however, were obtained between 15° and 18°C. The greatest number of fish was seen in the area where warm and cold currents meet, for example, off Shiria Cape, where the Tsugaru warm current converges with the Hokkaido coastal cold current, and in the neighboring waters of Shikotan Island, where branches of the Kuroshio warm current, the Okhotsk cold current, and the Hokkaido coastal cold current meet.

Ishisa (1939, pp 143-144), in a study dealing with catch in relation to oceanographic conditions off southern Kyushu, also obtained information which indicates that T. orientalis occurs mainly near the line of convergence between the warm and cold currents and in the waters where complex tidal currents are created by the area of contact. The greatest number of fish was caught in the area where warmer waters were in contact with the colder waters to the north. During January the maximum catch was along the 20°C isotherm. In February, as the 19° isotherm (cold current) began to swing southward between the Kyushu coast and the 20° isotherm (warm current), the best fishing grounds shifted, and during March the optimum catches were obtained chiefly on the 19° isotherm in a locality further south and within a pocket formed by a projection of the 19° isotherm into the 20° isotherm.

Kawana (1934, pp 16-18) presented data which show that a definite relationship may exist between the amount of the catch and the difference between surface temperature and temperature at a depth of 50 meters. A difference of 6° to 8° resulted in maximum catch (by drift nets) in Hokkaido waters. With differences of higher or lower magnitude the catch decreased markedly.

Such data on oceanographic conditions are desirable in order to predict the location of fishing grounds and the areas where the maximum catches can be obtained. The studies outlined above indicate that the Japanese scientists have made a beginning toward obtaining such information. However, much remains to be done before oceanographic data can be utilized with some degree of accuracy to predict the yearly migration and availability of the species.

5. Recent Changes in Fishing Grounds

Prior to 1937 the black tuna was taken in sufficient abundance to warrant commercial operations as far north as Etorofu Island along the Pacific coast and Sakhalin along the Sea of Japan coast (Figure 8). During the last decade, however, changes in the extent of the migrations have taken place. The northern limit of abundance of the black tuna along the Pacific coast is now the Volcanic Bay area, Hokkaido. In the Sea of Japan only occasional catches are made. Fishermen and research workers believe that the recent decrease in numbers in the more northern latitudes and along the west coast of Japan is due less to depletion than to a lowering of water temperature. Monthly oceanographic charts for 1936-40, prepared by the Tokyo Central Fisheries Experimental Station, show a gradual yearly lowering of water temperature in the waters along the Japanese coast with a resulting shift southward in the course of the warm Kuroshio Current. This is believed to be the major factor in altering the migratory path of the black tuna and thus its presence in known fishing grounds.

6. Habits

Black tunas are migratory but often remain for a considerable period of time over banks in waters as deep as 200 meters. When migrating the schools swim near the coast. According to Kishinouye (1923, p 440) the black tuna feeds chiefly on different kinds of fish, such as the sardine, anchovy, flying fish, scad, and sand-eel, which are more or less pelagic in habit. Sometimes fishes living near the bottom are found in its stomach. Invertebrates such as calamaries, pteropods, pelagic crustaceans, larvae of brachyurans and stomatopods, and anomolous amphipods are also eaten. Later studies (Hokkaido Fisheries Experimental Station, 1928; Hujii, 1932; Hyogoken Fisheries Experimental Station, 1935; Suyehiro, 1942) confirm this diet and also indicate that the food varies with the locality. For example, during the migration into the more northern localities the food consists mostly of small herring, cod, and sardines.

7. Economics

The black tuna is held in much esteem by the Japanese and is mainly eaten raw. The flesh is dark red and is best during the cold months of the year. Immature two-year-olds, known as "meji", are considered a delicacy.

ALBACORE
Thunnus germo (Lacépède)
Bincho, Binnaga, Tombo-shibi

1. General

Literature records show that as early as the beginning of the 19th Century the Japanese took the albacore incidentally while fishing for other tunas. Since the flesh of the albacore is soft and is considered unpalatable as "sashimi" (raw fish), the traditional manner in which the tunas are eaten, the fishermen avoided catching the species by placing long lines at a depth more suitable for taking other tunas.

In recent years, however, a large export market for the albacore was created when the demand for canned white-meat tuna developed in the United States. During the decade from 1930 to 1940 Japanese fishermen conducted intensive pelagic fishing for this species. Special long line gear in which more branch lines could be used were constructed for the capture of the albacore, and the prewar years saw the Japanese extending their operations into the distant waters to the east of Honshu and as far off as Midway Island.

2. Diagnostic Characteristics

The albacore (Figure 9) is sharply characterized by the saber-shaped pectoral fin which extends beyond the last rays of the dorsal and anal fins to about the first finlet. This feature makes identification of the species almost always certain, and fishermen, recognizing its distinctiveness, have named the fish "tombo-shibi", meaning dragonfly tuna. Other distinguishing characteristics are the second dorsal fin higher than the first, and the fact that the body is more slender than that of other species of tunas. Other characteristics agree with those of the species comprising the genus *Thunnus*. For this reason Kishinouye (1923, p 434) discontinued the use of the generic name *Germo* for the albacore and included the species in the genus *Thunnus*, remarking that too much stress was placed on the single character of the long pectoral. Further investigations are necessary to clarify the status of the albacore, although most authors agree the Pacific forms are a single species.

The color is blackish blue on the back with a greenish luster towards the caudal fin. The sides and the belly are silvery. The first dorsal is nearly colorless but with a dusky border, the pectorals are black, the ventrals and the second dorsal dusky, and the anal nearly colorless. The dorsal finlets are dusky with a yellowish flush, and the ventral finlets are dusky. In young specimens, about 60 centimeters in length, five or six dark, irregular longitudinal bands run near the ventral median line. They become more distinct on the caudal region. The bands are more or less united in the form of an irregular network.

3. Distribution and Migration

Since the albacore has only recently assumed a position of importance in Japanese pelagic fishing operations, information concerning its migrations and life history is in the initial stage of investigation. The rapid development of intensive commercial operations has yielded many catch records, however, and the important fishing grounds in the western Pacific are well known. The albacore is truly an oceanic fish, for the areas of greatest abundance are in the offshore waters. At some places it approaches close to the Japanese coast but does not enter shallow water.

In the northwestern Pacific Ocean the albacore is abundantly distributed throughout an area extending east from the coast of Japan for about 2,000 miles and situated north of the line of convergence between the North Equatorial and the North Pacific currents (compare Figures 2, 3, and 10). This species has not been reported from the Sea of Japan. Albacores have been taken from March to September in small quantities by experimental vessels exploring the waters of the former Japanese Mandated Islands for this species and by vessels operating for yellowfin tuna in these same areas. During the winter months these operations were on a small scale but a few reports indicate that the albacore may occur in scattered shoals over a wide area at that season of the year.

Uda and Tokunaga (1937), in the most comprehensive study to date on the albacore, endeavored to analyze the various stocks present in the areas directly east of Japan. The seasonal changes in the fishing grounds were investigated and correlated with the size of the specimens and hydrographical features. Their conclusions, however, are based on inadequate data, and the designated migratory routes are largely hypothetical. Nevertheless, they are reported below.

The two major fishing grounds for the albacore in the northwestern Pacific Ocean are the summer grounds situated near the Japanese coast and the winter grounds in the mid-Pacific region (Figure 10). As the temperature of the water along the Japanese coast rises and the Kuroshio Current advances, the coastal schools begin their migration northward from the Shikoku region about April or May. They continue their migration through the Izu Islands chain and by June or July enter the Tohoku region. The maximum catches of "summer" albacore are obtained during May and June. The fish belonging to the coastal group are small, the majority of the individuals weighing less than 19 kilograms. Uda and Tokunaga assumed that the coastal albacores, which disappear suddenly during July, migrate southward along the east side of the Kuroshio Current.

The shoals in the mid-Pacific (occurring 1,000 to 2,000 miles offshore) appear in great abundance during the winter months and constitute the most productive albacore fishing grounds. The season begins in October, reaches a maximum from December to February, and ends in April. Uda and Tokunaga believed that the bulk of the mid-Pacific albacores perform a year-round migration in a large circle. From December to April the fishing grounds gradually move southward toward the area of convergence between the North Pacific and the North Equatorial currents in the region between 160° and 180°E longitude (Figure 10). Whether these schools turn eastward or westward upon reaching the line of convergence is uncertain, but albacores have been taken in the region north of the line between 150° and 160°E longitude. For this reason the authors believed that the mid-Pacific schools turn westward and migrate into the region directly east of the Izu Islands (about 145° to 150°E longitude and 25° to 35°N latitude). Turning northward from this point the fish are seen in the waters between 150° and 170°E longitude in the latitudes where the Kuroshio Current is running eastward. The fish taken in the mid-Pacific waters are mostly large, weighing 19 or more kilograms, although smaller ones are intermingled.

The above theory concerning the stocks and migrations of the albacore was based on inadequate data; moreover, the fish were obtained by different methods in the two major fishing grounds, thus making comparison of stocks unreliable. For example, the coastal albacores were taken mainly by hook and line operated by vessels of about 40 to 70 tons, whereas the mid-Pacific fish were obtained with long lines operated by vessels over 100 tons. Consequently, the fishing methods were selective in favor of smaller albacores being obtained from the coastal grounds and larger ones from the mid-Pacific area. The information is presented here merely because it is the only work of any consequence that has been done on the albacore. Other workers claim that there is only one stock in the northwestern Pacific Ocean, and that the schools in it make a great circular migration over the entire area discussed above. Too little is known about the albacores obtained in the Ryukyu area and in the former Mandated Island region even to indicate their possible relationships to the individuals taken in the northern latitudes.

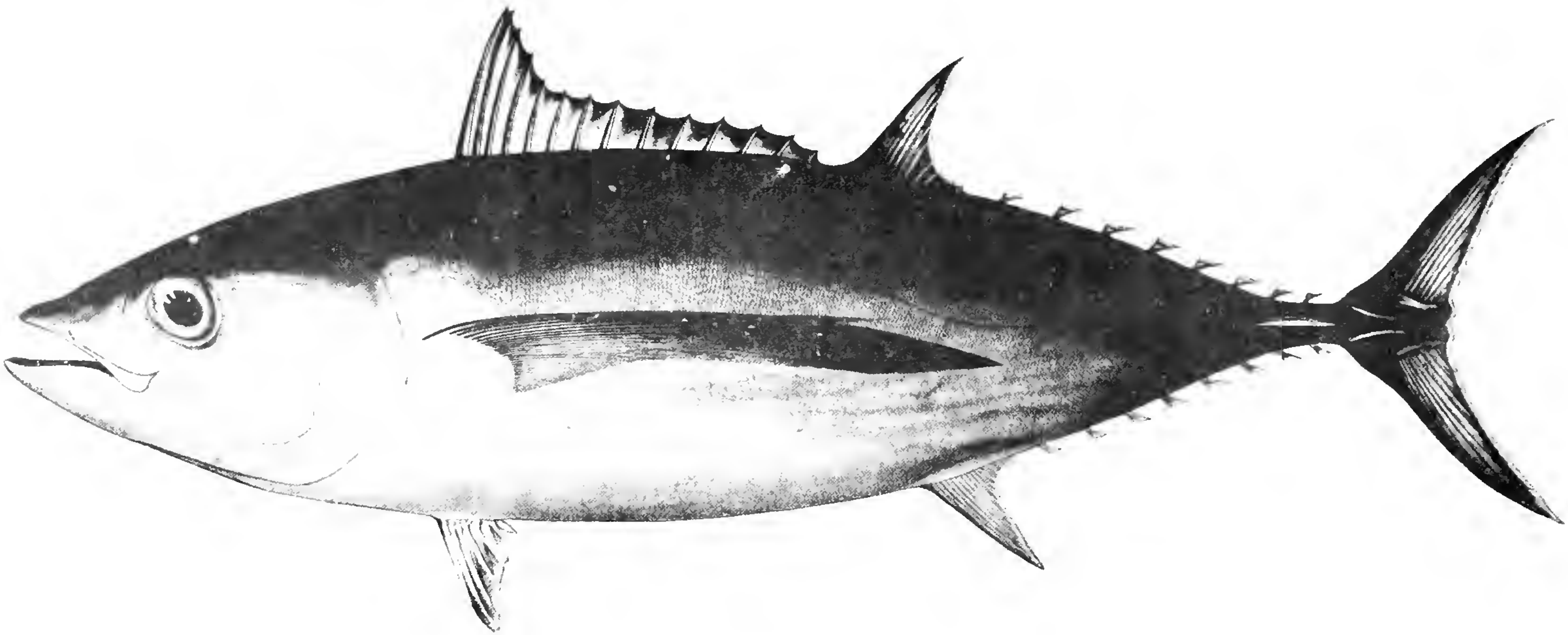
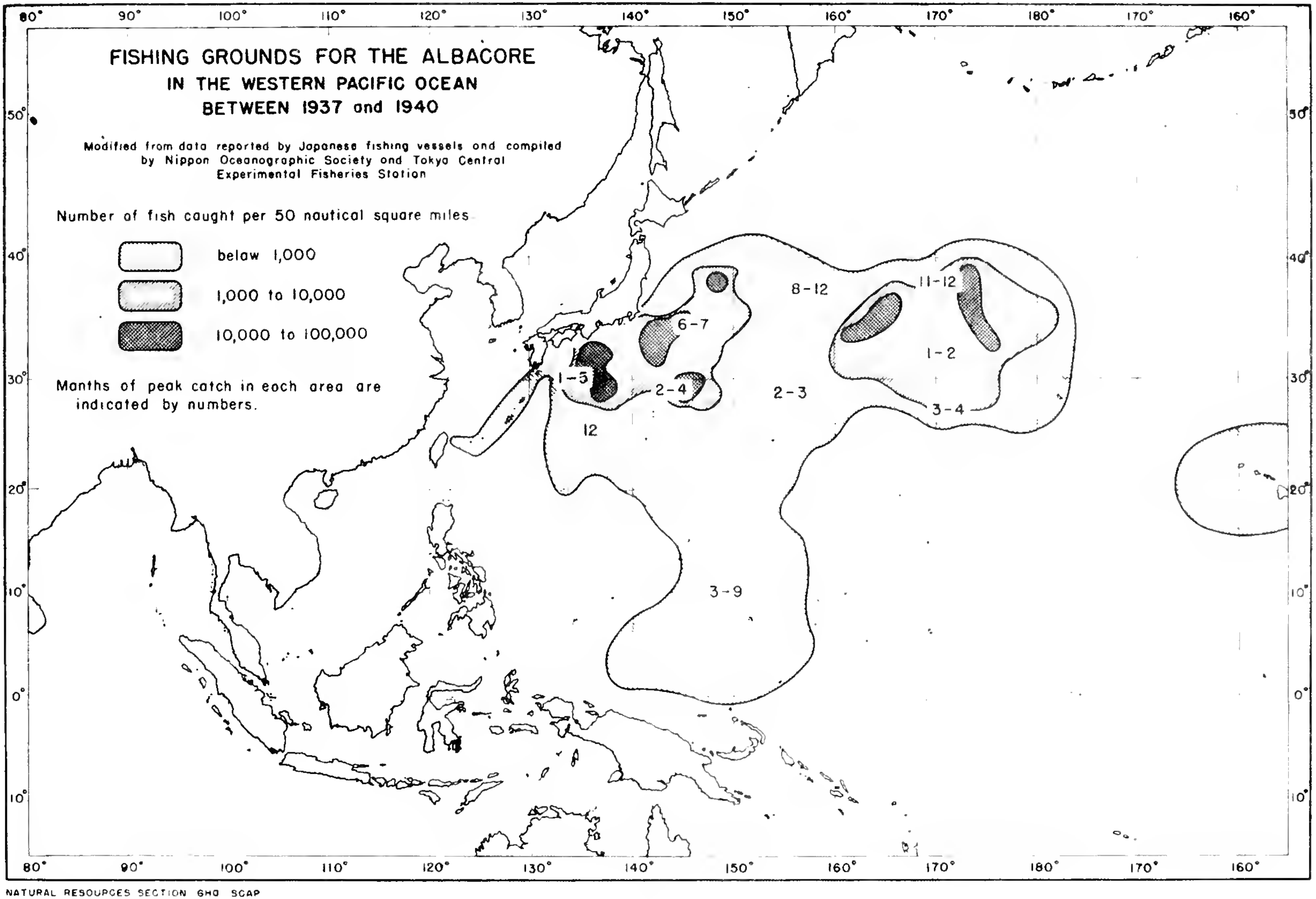


Figure 9. - Albacore (Thunnus germo), drawn from a specimen taken by pole and line 130 miles east of Cape Kinkazan, Miyagi Prefecture, 28 June 1947; total length 60 centimeters (23.6 inches).



FISHING GROUNDS FOR THE ALBACORE
IN THE WESTERN PACIFIC OCEAN
BETWEEN 1937 and 1940
Modified from data reported by Japanese fishing vessels and compiled by Nippon Oceanographic Society and Tokyo Central Experimental Fisheries Station
Number of fish caught per 50 nautical square miles
below 1,000
1,000 to 10,000
10,000 to 100,000
Months of peak catch in each area are indicated by numbers.
1-5
12
2-4
6-7
8-12
2-3
3-9
11-12
1-2
3-4
80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180° 170° 160°
50° 40° 30° 20° 10° 0° 10°
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Figure 10

4. Oceanographic Data

Takayama and Ando (1934, pp 6, 20), in their investigation of surface water temperatures in the seas adjacent to the Pacific coast of Japan, reported that albacores were caught when the temperature was between 14° and 31°C. The peak catches, per long line operation, were made at a number of different temperatures: 19° to 20°C; 22° to 25°C; and 30° to 31°C. The data were not analyzed by locality, but it was shown that, in general, optimum temperatures for all species of tunas are highest in the waters off Kyushu and become progressively lower in the more northerly sea regions.

Uda and Tokunaga (1937, pp 297-298), analysing fishing conditions in various albacore fishing grounds, stated that the optimum catches in the mid-Pacific region were made from December through February when water temperatures were 17° to 19°C, with maximum catches obtained at about 18°C. In the coastal grounds the optimum catches were made from May through June when water temperatures were between 18° and 21°C, the maximum catch being obtained at about 20°C.

5. Habits

The albacore is generally caught at a depth of about 30 meters, although it may be present at levels down to 80 meters. During the spring when water temperatures are rising and small fish, such as sardines and anchovies, come to the surface, the albacores are seen pursuing these fish.

No detailed studies on the food of the albacore have been made. Kishinouye (1923, p 437) stated that it feeds on pelagic crustaceans and small fish, the typical diet of large pelagic species. Young albacores were removed from the stomachs of larger individuals taken near the Bonin Islands on 20 January 1917.

6. Economics

The albacore, as previously stated, is an important Japanese export item, and in prewar years almost the entire catch was processed, either as frozen albacore or high-grade canned white-meat tuna, for shipment overseas. The waters in which the albacore is caught in large amounts are distant from the homeland, and the seas, especially during winter, are extremely rough. Consequently, the taking of this species involves expensive operations in terms of fuel and gear. The fish has little market value in Japan. Therefore, the continued success of the fisheries is dependent upon the re-establishment of foreign markets.

YELLOWFIN TUNA
Neothunnus macropterus (Schlegel)
Kihada, Ito-shibi, Hatsu, Hoshibi, Kimeji (immature)

1. General

The yellowfin tuna has long been taken in Japanese waters during the summer months by circling nets operated in shallow waters for small tuna, and more recently by vessels using long lines to obtain black tuna, marlin, and swordfish. The species, however, did not attain a position of importance in Japanese fisheries until the decade just prior to the recent war.

Between 1931 and 1933 survey ships were sent to the South Seas areas under the sponsership of the Bureau of Fisheries to locate new fishing grounds for the albacore. The surveys indicated that the albacore was thinly scattered in this area. Yellowfin tuna, however, was found to be abundant throughout the year in almost all parts of the tropical zone. Various fishing companies, with the intention of beginning large-scale operations for this species, continued intensive investigations in all regions of the equatorial zone to determine the density of the populations and the best fishing grounds.

Since the Japanese were only beginning to develop the South Seas fisheries on a large scale just prior to the beginning of World War II, biological data on the yellowfin tuna are almost negligible. The bulk of the information herein reported has been supplied by K. Okajima, former director of the Palau Fisheries Experimental Station, and H. Nakamura, former technician of the Formosa Fisheries Experimental Station, both of whom carried on research in the southern regions.

2. Diagnostic Characteristics

The yellowfin tuna (Figure 11) is characterized by a fusiform body with an elongated caudal region. The pectoral fin extends beyond the origin of the second dorsal. The second dorsal and the anal fin are much elongated, and their lengths are extremely variable. Japanese fishermen note a distinction between those yellowfin tunas having longer fins (ito-shibi) and those having shorter fins (kihadamaguro). Nakamura (1939) pointed out, however, that this is not a racial or specific difference but an example of fins increasing in length as the size of the fish increases.

The yellowfin tuna is nearly black on the back, and the sides are grayish with a series of oblique transverse silvery white lines alternating with lines of similarly colored dots. These markings tend to disappear in older fish. The first dorsal and the pelvics are grayish and tinged with yellow; the tips of the second dorsal and the dorsal finlets are bright yellow; the pectorals are black on the inner side and grayish or sometimes yellow on the outside; the anal and anal finlets are bright yellow.

3. Distribution and Migration

Japanese exploratory surveys and fishing operations by research and commercial vessels show the yellowfin tuna to be widely distributed throughout the western Pacific Ocean and the Indo-Pacific region (Figure 12). The northernmost limit of the species range in the western Pacific is usually about 35°N latitude, but occasionally it extends past 40°N latitude. The yellowfin tuna sometimes enters the Sea of Japan and has been recorded from Otaru, Hokkaido, in late summer (Kishinouye, 1923, p 437).

Catch records of tunas obtained by research and fishing vessels over a period of 11 years (1930-40) have been compiled by Nakamura (1943). The data show that the yellowfin tuna not only is widely distributed through almost the entire tropical southwest Pacific and Indo-Pacific zones but also is the most abundant of the giant pelagic fishes taken by long line in those areas (Table 1). The average weight of the species in each locality is also noted.

A further analysis of these data by seasons (Table 2) indicates that fishing conditions for the tunas are, for the most part, good throughout the year in almost the entire tropical zone. A breakdown by species is not possible since the data are incomplete. Differences in the amount of catch by seasons can be noted in several regions, the southern coast of Sumatra, Timor Island, Celebes Sea, and the area east of the Philippine Islands. The direction of the wind has much influence on surface currents, and thus, according to Japanese scientists, it affects the distribution and consequently the concentration of the species. Nevertheless, even in those areas where seasonal variations occur and the catch decreases markedly during a season, the number of tunas taken (except off Formosa and the Philippine Islands) compares favorably with the three to four fish obtained per 100 hooks in Japanese waters.

An analysis by latitudes of the catch of yellowfin tuna in the western Pacific Ocean is possible from the catch statistics gathered by the Shonan Maru, a research vessel surveying the areas east of the Philippine Islands and in the former Mandated Islands from July to September 1937 (Table 3). During the months surveyed the catch was greatest in tropical waters, particularly in the regions where the Equatorial Counter Current originates and flows, and was less in the more northern latitudes. Comparable data on other seasons of the year are not available, but, as noted (Table 2), evidence shows that shifts in the concentration of the species may occur with changing seasonal conditions.

Japanese scientists have no definite information regarding the migration path followed by the yellowfin tuna, but it is believed that during the spring, beginning about April, certain segments of the populations in the southern regions break away and move northward, over a wide area, into the temperate zone (Figure 12). The greatest concentrations, nevertheless, remain in the warm latitudes. The migratory yellowfin tunas are taken during the

Figure 11. - Yellowfin tuna (Neothunnus macropterus), drawn from a specimen taken by long line in the Bonin Islands region, November 1947; total length 140 centimeters (55.1 inches).

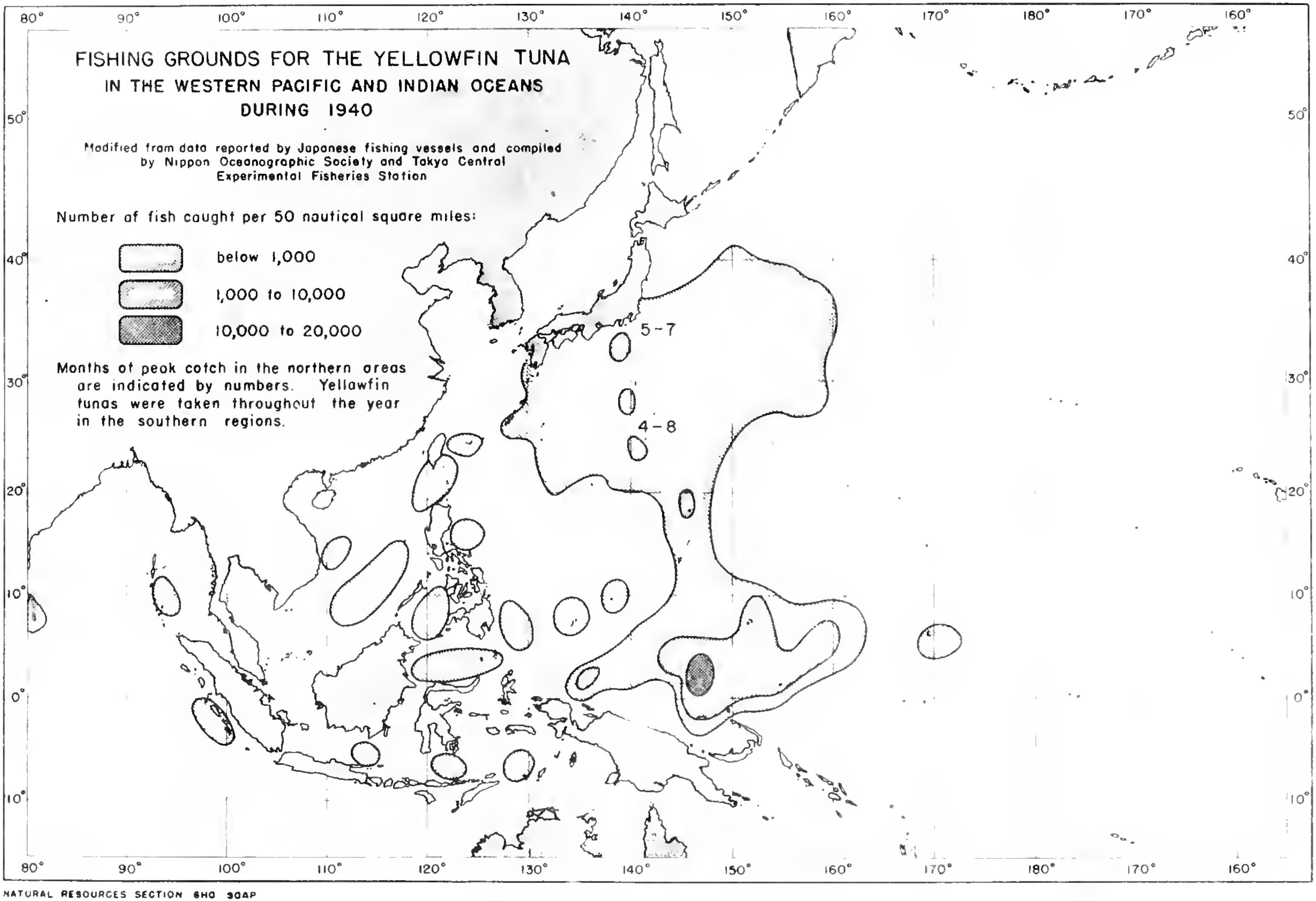

Figure 12

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summer in some numbers in the shallow waters surrounding the Bonin and Izu islands and in the Pacific waters off Japan. About August the fish begin their return journey southward. Since a few yellowfin tunas are taken by long lines from deep waters near Japan during the winter months, there is some indication that certain of these fish remain in the northern regions throughout the year.

4. Oceanographic Data

In Japanese waters the yellowfin tuna has been taken by long line when surface water temperatures ranged from 14°C to 27°C (Takayama and Ando, 1934, pp 6, 20). The optimum temperatures for greatest catch were at 21°C and 22°C.

Research and survey ships operating in the southern seas have been concerned only with determining the major fishing grounds for the yellowfin tuna. Water current, temperature, transparency, and other oceanographic factors as they relate to this species have been recorded incidentally. The data obtained by the research vessel Zuiho Maru, operated by the Government General of the South Sea Islands between 1938 and 1940, are the only information available to this writer at present. These data point out that the best yellowfin tuna fishing grounds are in the narrowest portion of the Equatorial Counter Current and at the places where this current mixes with the equatorial currents adjacent to it (compare Figures 2, 3, and 12). The best catches were made when the velocity of the surface current was 0.5 to 1.0 sea miles, the transparency of the water was between 25 and 35 meters, and the water temperature from the surface to a depth of 100 meters was over 20°C.

5. Habits

When in Japanese waters during the summer months the yellowfin tuna swims near the surface of the sea and approaches close to land. Small, immature fish about two kilograms in weight are often found in the offshore grounds accompanying schools of skipjacks. In the southern regions, the majority of the yellowfin tunas caught have been taken from depths between 75 and 100 meters.

Kishinouye (1923, p 448) stated that the food of the yellowfin tuna was flying fish, coffer fish, and some deep sea species, besides calamaries, pteropods, heteropods, Hyperima amphipods, larval and immature Squilla, megalops of crabs, etc, all typical food of a pelagic species. An analysis of the stomach contents of 401 yellowfin tunas taken by long line east of the Philippine Islands indicated that the food of the species in these waters was chiefly cuttlefish, followed in order of importance by unidentified fish, file fish, Leiognathus, shrimp, stomatopods, and puffer fish (Kanamura and Yazaki, 1940, pp 29-37).

6. Economics

The flesh of the yellowfin tuna is compact and pink in color. Because of its excellent flavor when eaten raw, it is in much demand for "sashimi". Small immature fishes are often boiled, then smoked and dried to make a product known as "fushi". The meat of the yellowfin tuna when canned becomes slightly dark and is known as "light" meat tuna, in contrast to the "white" meat tuna of the albacore. As a potential export item it ranks second to the albacore.

TUNA FISHING VESSELS

Two main classes of vessels have been constructed by the Japanese for the tuna fisheries. Since the fishing techniques used are specialized, these boats have developed into highly distinctive types which are easily recognizable.

Skipjack Vessels for Surface Fishing: The species most commonly taken by these vessels is the skipjack. Small albacore, yellowfin tuna, and big-eyed tuna are sometimes caught when found feeding on the surface. Pole and line, employing live bait or a jig as a lure, is the gear used by these vessels. Skipjack vessels are characterized by the presence of a fishing platform, bait tanks, and a spraying apparatus (Figure 13).

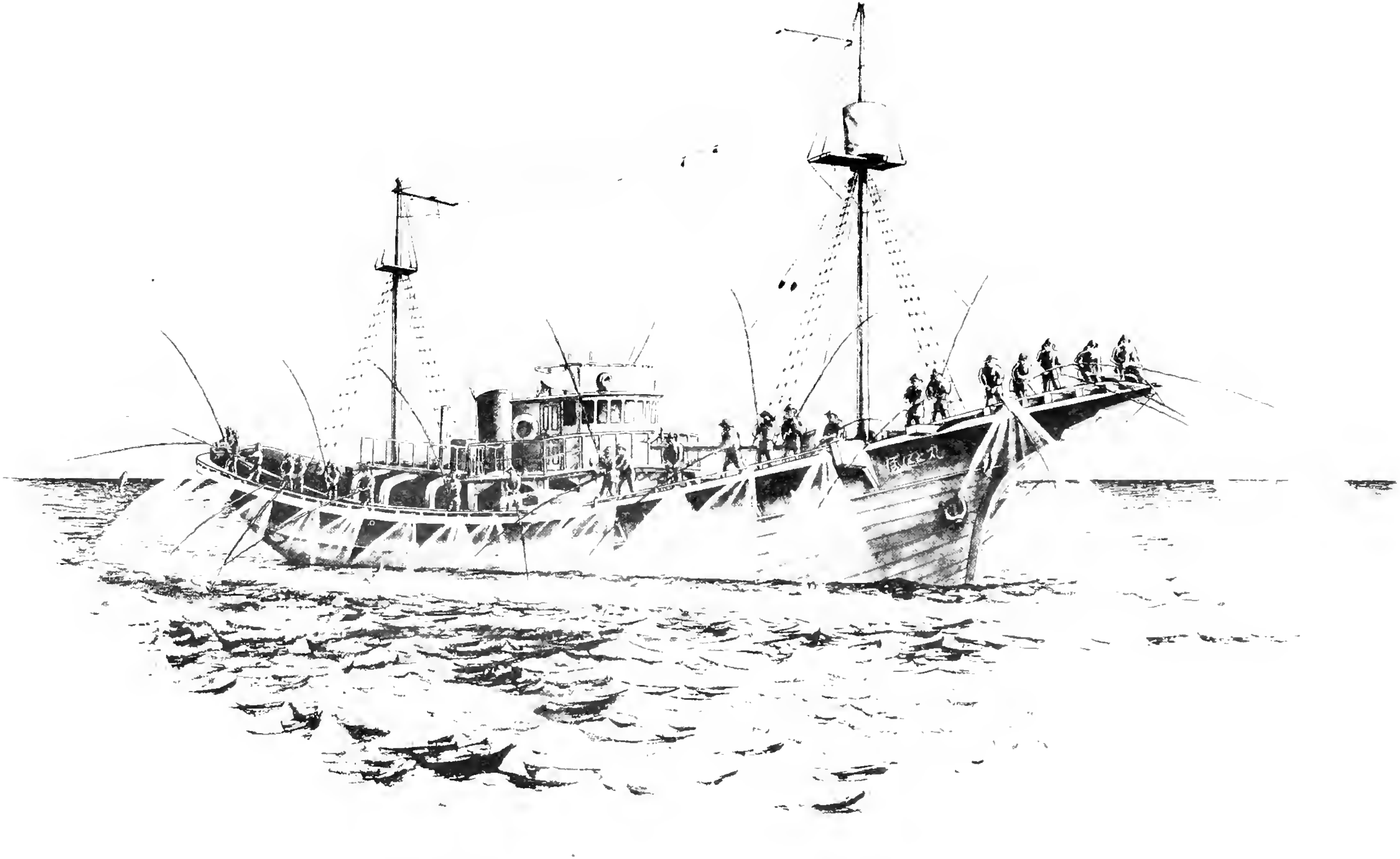


Figure 13. - Skipjack Fishing Vessel; wooden type, 95 gross tons.

Tuna Long Line Vessels for Taking Fish below Surface Levels: Species such as the albacore, black tuna, yellowfin tuna, big-eyed tuna, marlin, and swordfish are caught by the long line technique, a method of fishing developed to a high degree of efficiency by the Japanese. Long line vessels are called tuna boats by the Japanese and differ from skipjack boats in lacking the fishing platform, bait tanks, and the spray apparatus (Figure 14).

During the past few years a combination pole and line and long line vessel has been constructed in increasing numbers. These vessels practice pole and line surface fishing in the summer and operate long lines for the tunas taken below surface level during the winter.

In coastal waters vessels of small size, 5 to 20 tons, are used and generally are built along the lines of the larger skipjack boats.

The tuna fleets during the early decades of the 20th Century were composed largely of vessels of small tonnage; only when the Japanese began to exploit the more distant fishing grounds during the 1930-40 decade did the emphasis shift to vessels of larger tonnage. The operation of skipjack vessels of larger tonnage showed that they can obtain a larger catch per ton of vessel (Table 4), can cruise at higher speeds more economically in a fishery where speed is vital, and need to make fewer trips since their hold capacity is larger than that of smaller vessels. Experienced fishermen are now following the trend towards larger vessels, even for fishing close to the Japanese mainland.

The most reliable data available on the tonnage of tuna fleets during the prewar years was obtained through a census made by the Bureau of Fisheries in 1940 (Table 5). This tonnage operated for the most part in Japanese home waters except for a small number of vessels that were sent to the southern seas from the home ports of Misaki, Tsuro, and Muroto.

During the war much of the tuna fleet was taken over by the Japanese navy for coast guard patrol and aircraft spotting. A considerable number of these vessels were sunk, leaving the fleet at an estimated postwar strength of about 22,000 tons, compared to the prewar tonnage of 52,665. The loss since World War II of major fishing areas (for example, salmon and crab grounds in northern waters and trawling grounds in the Yellow Sea) caused many fishermen to shift to other types of operations. Since many major tuna grounds are located within the present authorized fishing areas (see Figures 6, 8, 10, 12, and 15), the postwar rebuilding of the fleet has been hastened by the desire of the fishermen to exploit these fisheries.

Data on the tuna fleet that will be available for fishing in 1948 have been compiled by the Japanese Tuna Fishermen's Association (Table 6). The trend toward building vessels of larger size, for the reasons noted above, is evident. The increase in the number of vessels for combined operations (pole and line and long line) is attributed to the shortage of gear.

TUNA FISHING GEAR

1. General

As stated previously, the tunas are primarily inhabitants of the offshore pelagic waters, although certain species, notably the skipjack and the black tuna, enter coastal waters in considerable numbers. The schooling habits and the depths at which the tunas are found differ not only by species but also within the species according to locality and season of the year. Consequently fishing techniques are numerous and varied. Pole and line for surface fishing and long line for fishing below surface level are the most efficient and widely used tuna gear. Other gear are limited in their application.

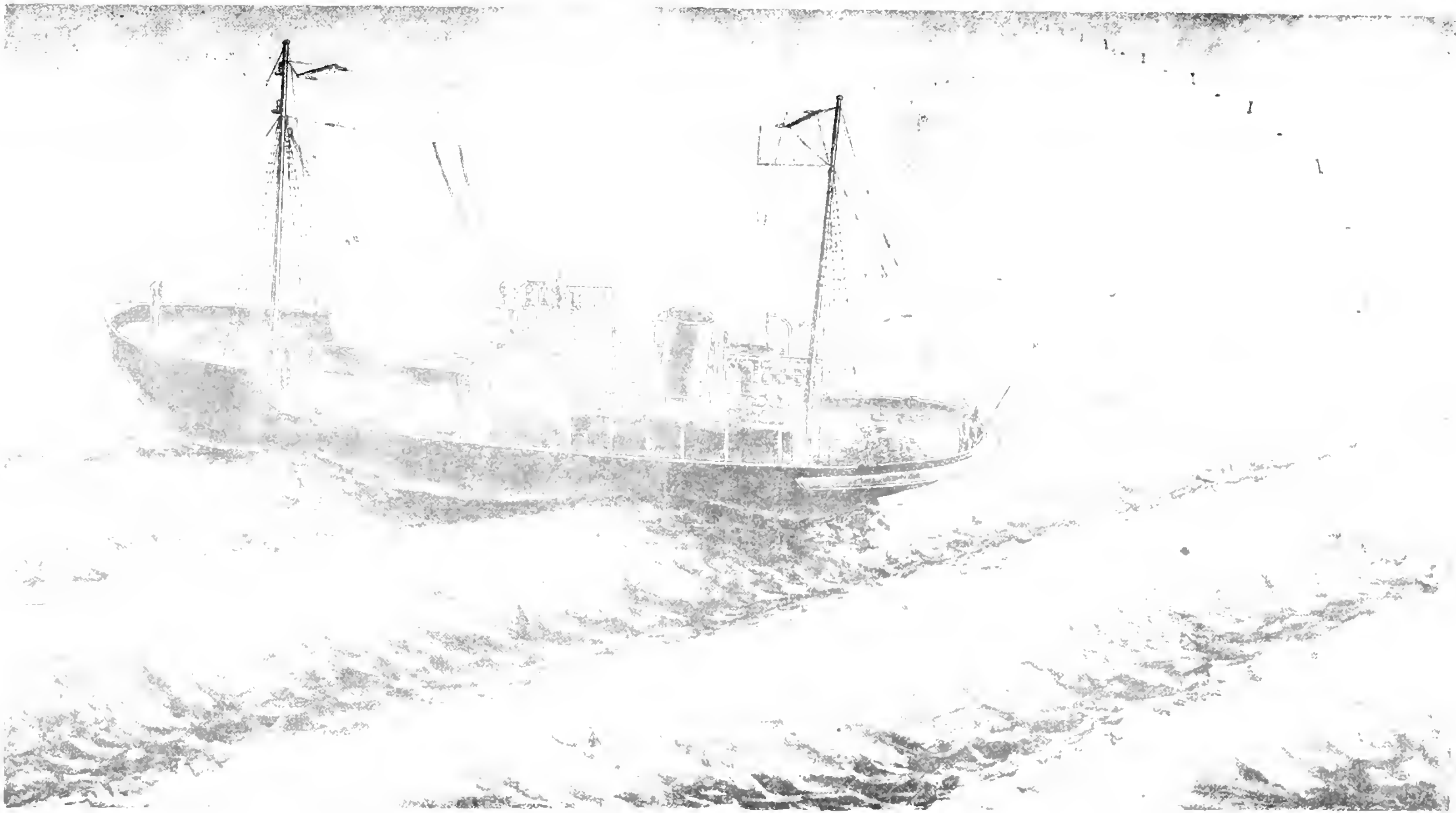
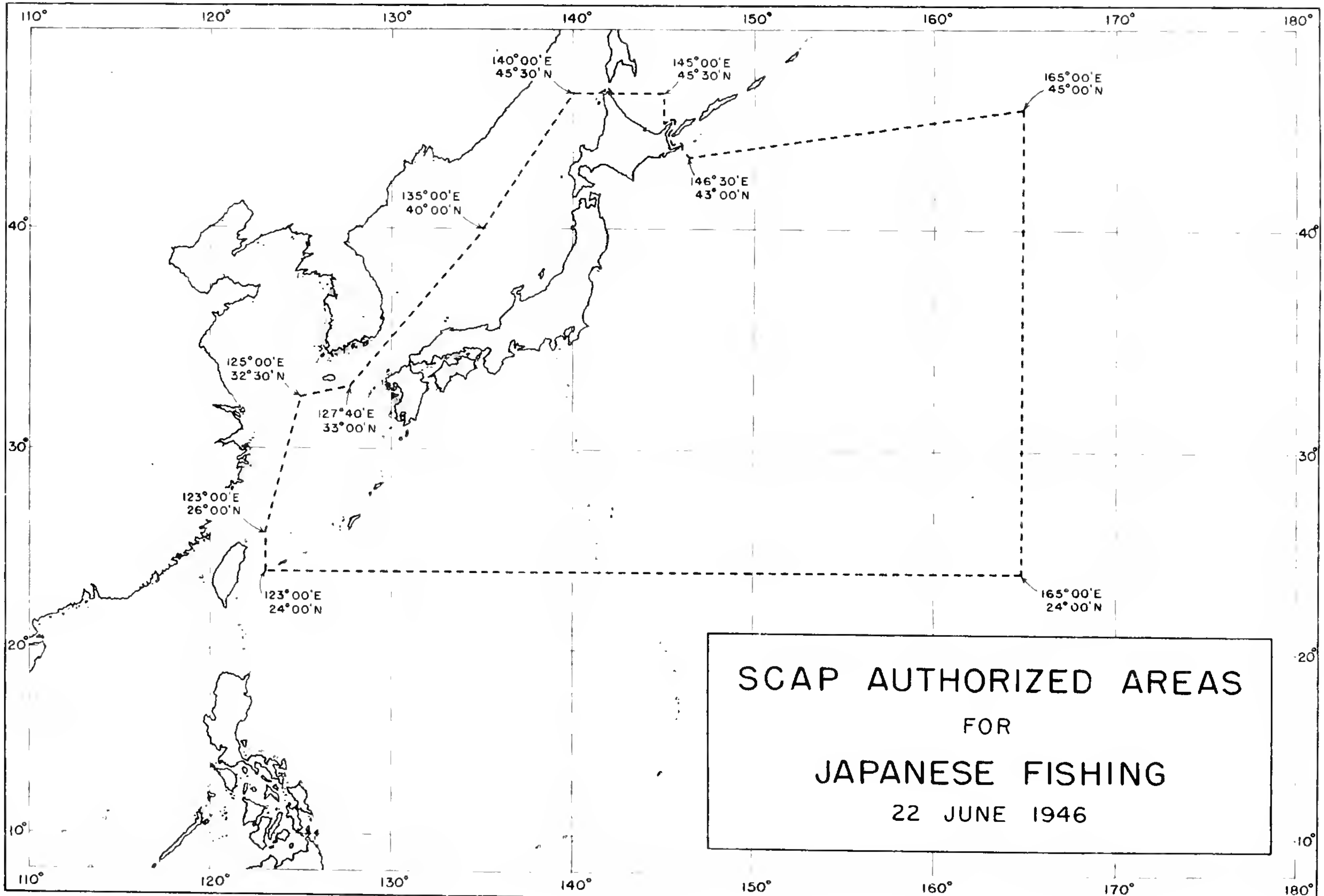


Figure 14. - Tuna Long Line Fishing Vessel; steel type, 135 gross tons.



NATURAL RESOURCES SECTION GHQ SCAP

Figure 15

The Japanese divide their tuna operations into two categories:

Coastal 4/: The set net and the pole and line are used mostly for inshore operations. Other gear of lesser importance are the drift net, the circling net, spears, and trolling jigs. Long lines are operated close to the shore during February and March in the area west of Kyushu.

Offshore: The skipjack pole and line and the tuna long line are used exclusively in the offshore areas.

2. Tuna Set Net

Nothing is known about the construction of the tuna set net (maguro daibo) prior to the 16th Century. Records are available, however, which show that set nets were used during the Keicho Era (1596-1614) to catch the giant black tunas as they migrated northward along the coast in shallow water.

At first the size of the mesh was made large enough to hold only black tunas, but mesh size was gradually decreased in order to catch yellowtail, horse mackerel, and other migratory coastal species. Today, set nets for the black tuna and for the smaller species are similar, except that those designed specifically for black tuna have a wing net constructed of rice straw. For smaller species the wing net has smaller mesh and is made of cotton.

The tuna set net (Figure 16) is placed in shallow water, 40 to 80 meters deep, in a position where water currents are advantageous for directing the fish into the net. The dimensions and structure of the net vary according to the preferences of the fishermen and the topography of the ocean bottom.

The wing or lead net may be from 900 to 3,600 meters long and is, as already noted, made of rice straw rope. The mesh size varies from 90 to 120 centimeters stretched. The main body of the set net is generally from 180 to 360 meters long and from 72 to 115 meters wide, and is divided into two parts. The belly, or playground, is composed of mesh measuring 6 to 12 centimeters stretched. The pocket, which is raised when the fish are removed, is constructed of mesh measuring 4 to 6 centimeters stretched. The mesh is made of cotton or manila twine. The head ropes are made of wire or manila rope. Bamboo sticks, 8 to 14 in number depending on the size of the net, are usually used to construct the floats. In Hokkaido, the floats are glass spheres.

3. Drift Net

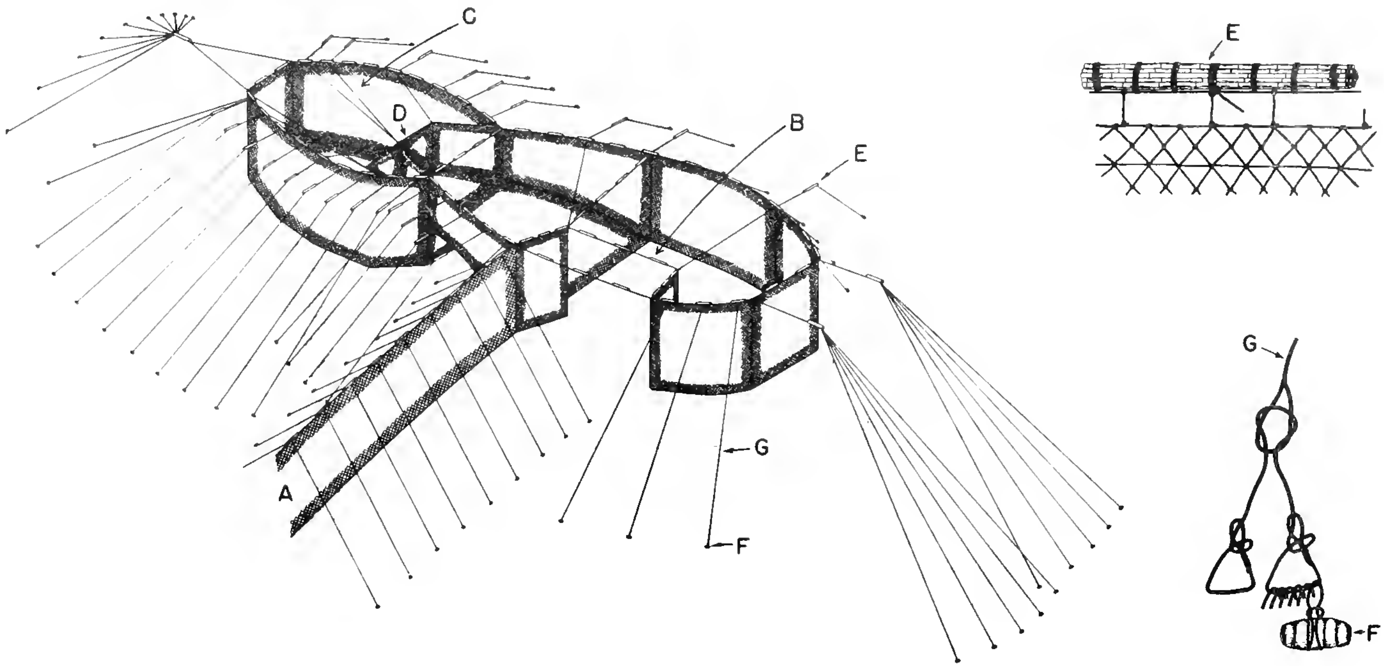
At one time the drift net (maguro nagashiami) was the most common gear used to catch both the black tuna in the sea regions off Hokkaido and the yellowfin tuna in Sagami Bay, localities where the species come close to the surface of the water. Since the gear is expensive, occupies considerable space in a boat, and is difficult to handle in rough and stormy weather (the time during which the best catches of the fish are generally made), its use declined when other fishing techniques were developed. In Hokkaido waters the long line provided fishermen with an equally good and much cheaper method of fishing, and in Sagami Bay the circling net replaced the drift net as a means of taking yellowfin tuna.

A few drift nets (Figure 17) are still operated, to catch the black tuna. It is used chiefly along the southeastern coast of Hokkaido where the warm and cold currents meet and the fish tend to concentrate and swim near the surface. The fishing grounds are situated from the coast seaward for a distance of about 100 miles.

In olden times linen was used to make the mesh of the drift net. This proved to be too costly, and Nanking hemp (*Boehmeria tenacissima*) or, rarely, silk has been used in its place with good results. A section of the drift net measures about 38 meters in length. The float line, however, is only about 20 meters in length. When placed in water the net therefore occupies a distance of about half its length and hangs loosely in a wavy band. Sinkers are not attached to the bottom, and the fish easily become entangled as they strike against the net. They are not gilled. The twine used to make the mesh of the net is about 2 millimeters in diameter, and the mesh is about 50 centimeters stretched. From 22 to 25 meshes,

4/ The areas designated as "coastal" have been arbitrarily fixed by the Tokyo Central Fisheries Experimental Station and the Bureau of Fisheries as those waters extending from the coast seaward for a distance of 50 miles.

TUNA SET NET

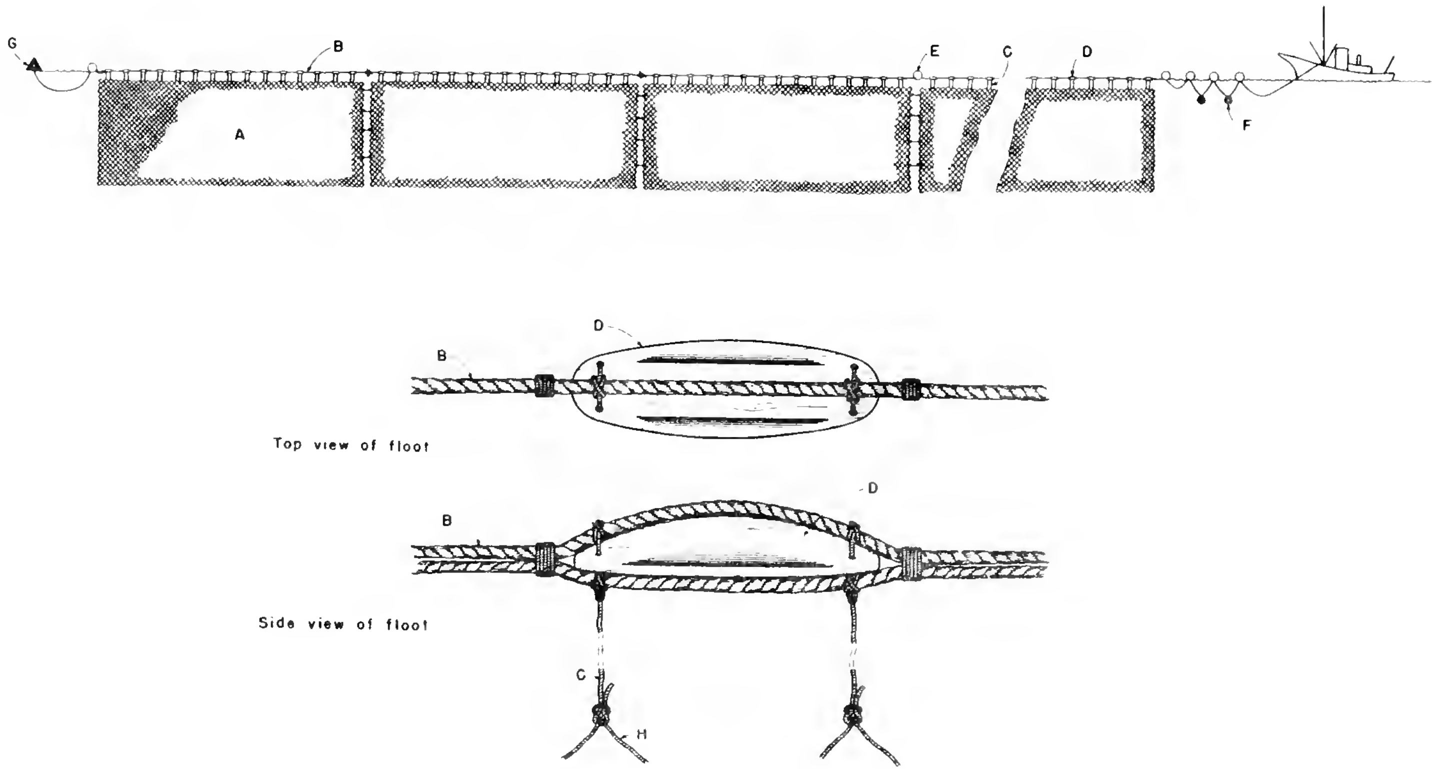


A	WING OR LEAD NET	E	BAMBOO FLOAT
B	BELLY OF NET (PLAYGROUND)	F	SANDBAG
C	POCKET OF NET	G	WIRE OR MANILA ROPE
O	EXIT FROM PLAYGROUND		

NATURAL RESOURCES SECTION GHQ SCAP

Figure 16

TUNA DRIFT NET



A	Section of drift net	E	Glass buoy
B	Float line	F	Stone
C	Lift line	G	Light buoy
D	Wood float	H	Webbing of net

NATURAL RESOURCES SECTION GHQ SCAP

Figure 17

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depending on the preference of the fishermen, may be contained in the depth of the net. The float line is constructed of two ropes, one wound right hand and the other left hand (Figure 17). The double rope prevents the float line from twisting and causing the floats to tangle in the net. The floats, about 35 centimeters in length and spaced about a meter apart, are made of paulownia wood (Paulownia imperialis). The lift lines, made of cotton or Nanking hemp, are about 5 millimeters in diameter and 35 centimeters in length.

Boats, generally about 20 tons, carry 130 to 150 sections of net. The fishing grounds are reached before evening, and the nets are set out in one continuous, connected line. One end is attached to the vessel by a rope to which an alternating series of floats and stones is fastened. This arrangement acts as a spring and prevents the net from breaking loose when the boat rolls and pitches. As the net drifts along, the boat keeps pace with it. Glass buoys about 35 centimeters in diameter are placed at every third section of the net. Buoy lights are set down at intervals to warn away other boats and to permit the fishermen easily to detect the position of their net. The net is patrolled by a small rowboat throughout the night. Since tunas, once trapped, die easily and are likely to be eaten by seals in the colder waters or sharks in the warmer waters, they are removed from the net as soon as the watch rowboat detects their presence. The entire drift net is taken up at dawn.

4. Circling Net

The circling net (makiami) for tunas was introduced from the United States as a purse seine designed to capture schooling fish of large size. It has been operated with little success in Japanese waters. In only a few localities do the tunas concentrate in sufficient numbers to warrant the use of the net. In Sendai Bay, Miyagi Prefecture, the circling net was formerly operated to take black tunas, but in recent years the fish have not entered the bay, and operations have been suspended. In Sagami Bay, Kanagawa Prefecture, the circling net is still operated for yellowfin tuna but has been modified from the original purse type. It is much simplified and resembles a lampara net. Purse lines have been removed, and the net, about 500 to 600 meters long, consists solely of two wings and a central pocket. At the ends of the wings the mesh is 18 meters stretched. The size of the mesh gradually decreases toward the pocket where it measures about 12 centimeters stretched. When the school of fish is surrounded, the two boats operating the net cross over and bring the wings together. This action causes the fish to swim to the rear of the net and enter the bag.

5. Spears

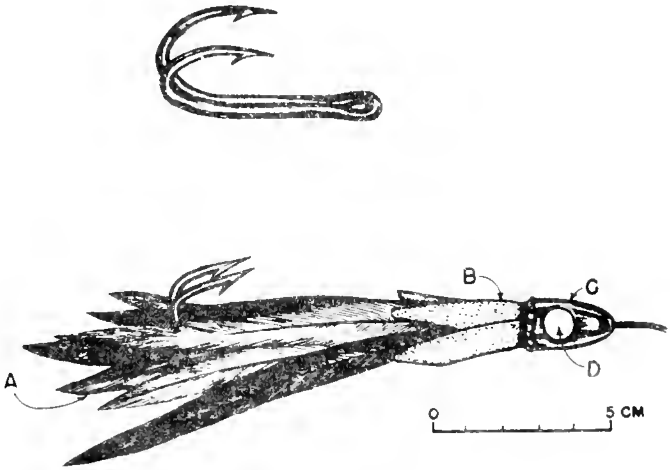
Fishermen are able to practice spearing (tsukinbo) for marlin, swordfish, and sailfish when these species bask on the surface. Spearing is done from June to August in the waters extending from the Izu Islands north to the Tohoku region. A special type of fishing boat is used, known as "tsukinbo bune", 4 to 20 tons in size and with a platform built on the bow. Since the fishing grounds are close to land the boats operate on single-day runs.

6. Trolling Jig

During 1932 and 1933 trolling for black tuna, with flying fish as bait, was carried on in the Tohoku region. At present no fishing boats are restricted to this type of fishing. However, vessels cruising over tuna fishing grounds always prepare a few trolling lines in anticipation of catching tunas which might be used as food for the crew or sold in the market. The trolling jig used (Figure 18) is generally made of the feathers of fowl wrapped in a piece of the ventral skin of the puffer or file fish. The hook is hidden among the feathers. The head of the jig may be lead, bone, or the snout of the marlin. If bait is used, a fresh mackerel, flying fish, or squid is tied fast to the hook. No special equipment is used to hold the trolling line on the boat.

7. Long Line

The method of catching tunas below surface level by placing long lines (maguro haenawa for black and yellowfin tunas, bincho nawa for albacore) across their path of movement has been practiced both in Japanese waters and in the broad area of the Indo-Pacific



NATURAL RESOURCES SECTION GHQ SCAP

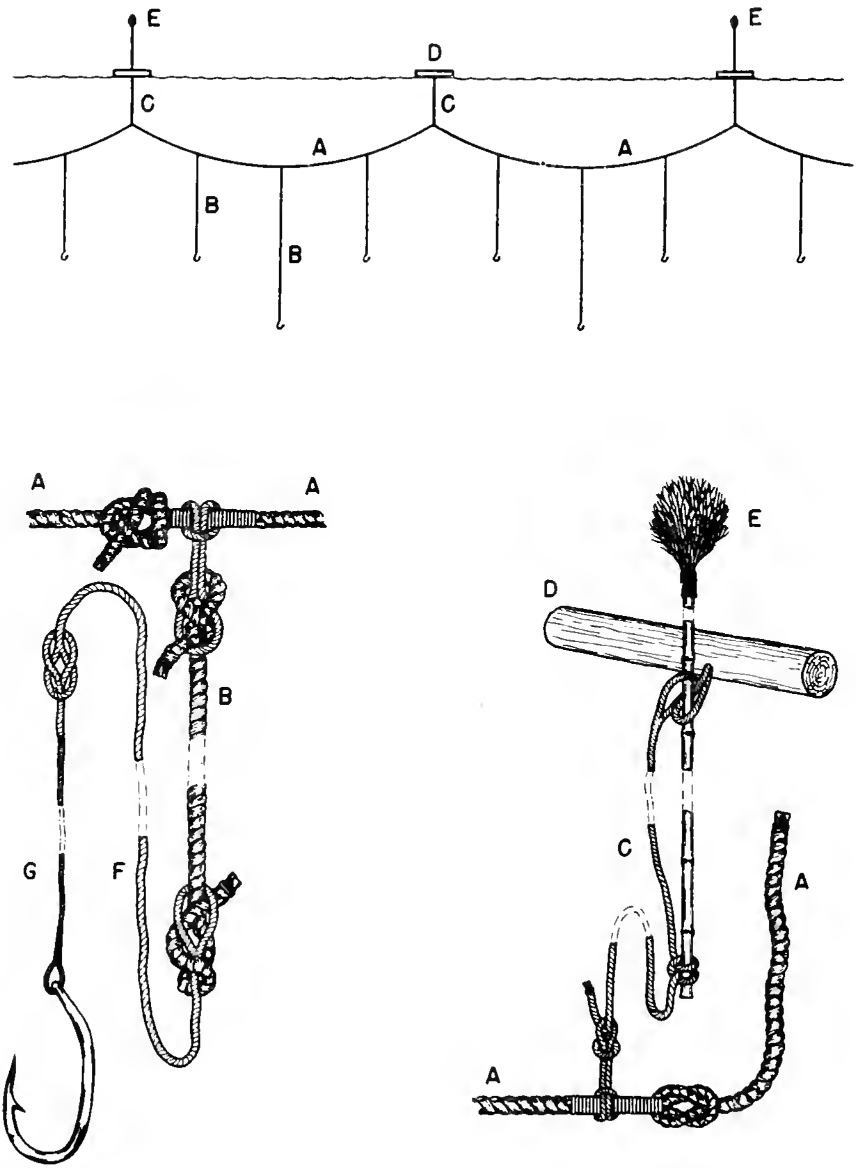
Figure 18

region. Until the advent of engined boats, long line operations were confined to waters not too distant from the coast. The main species obtained by these operations was the black tuna. Yellowfin tuna and other species were taken incidentally. When it became possible to exploit the offshore pelagic grounds the tuna long line assumed a position of major importance as a fishing technique. Black, yellowfin, and big-eyed tunas, albacore, marlins, and sharks provide the bulk of the catch obtained by this method. Occasionally swordfish and sailfish swimming at deep levels are also taken.

The structure of the gear (Figure 19, Table 7) and the depth at which the hooks are placed differ by species, oceanographic factors, locality, season, and preference of the individual fisherman. Generally, for the same species the hooks are placed in deeper water in the more southern latitudes and at higher levels in colder waters. The length of the float line can be changed to permit such adjustments. Long lines constructed primarily for black and yellowfin tunas are suspended to depths of 75 meters or more, and the hooks number from 2 to 10 per set (the distance between two flag buoys). Long lines designed mainly for albacore have the hooks placed at a depth between 30 to 60 meters, and the hooks number from 10 to 30 per set. The same long line may be operated for all species. If so, branch lines of various lengths are used on one set.

The material most often used for the main, float, and branch lines is cotton, which may range in diameter from 2.5 millimeters for albacore to 6 millimeters for large tuna. Nanking hemp or a mixture of hemp and cotton, about 8 millimeters in diameter, is sometimes used. For the "sekiyama" (Figure 19) cotton wound around a core of hemp is preferred, but wire is sometimes used as the core. In albacore lines the sekiyama and wire leader may be omitted and the hook attached directly to the branch line. Swivels are often placed at some point along the branch line to minimize tangling of lines.

TUNA LONG LINE



A Main line
B Branch line
C Float line
D Float
E Flag
F Cotton covered hemp (sekiyama)
G Wire leader

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Figure 19

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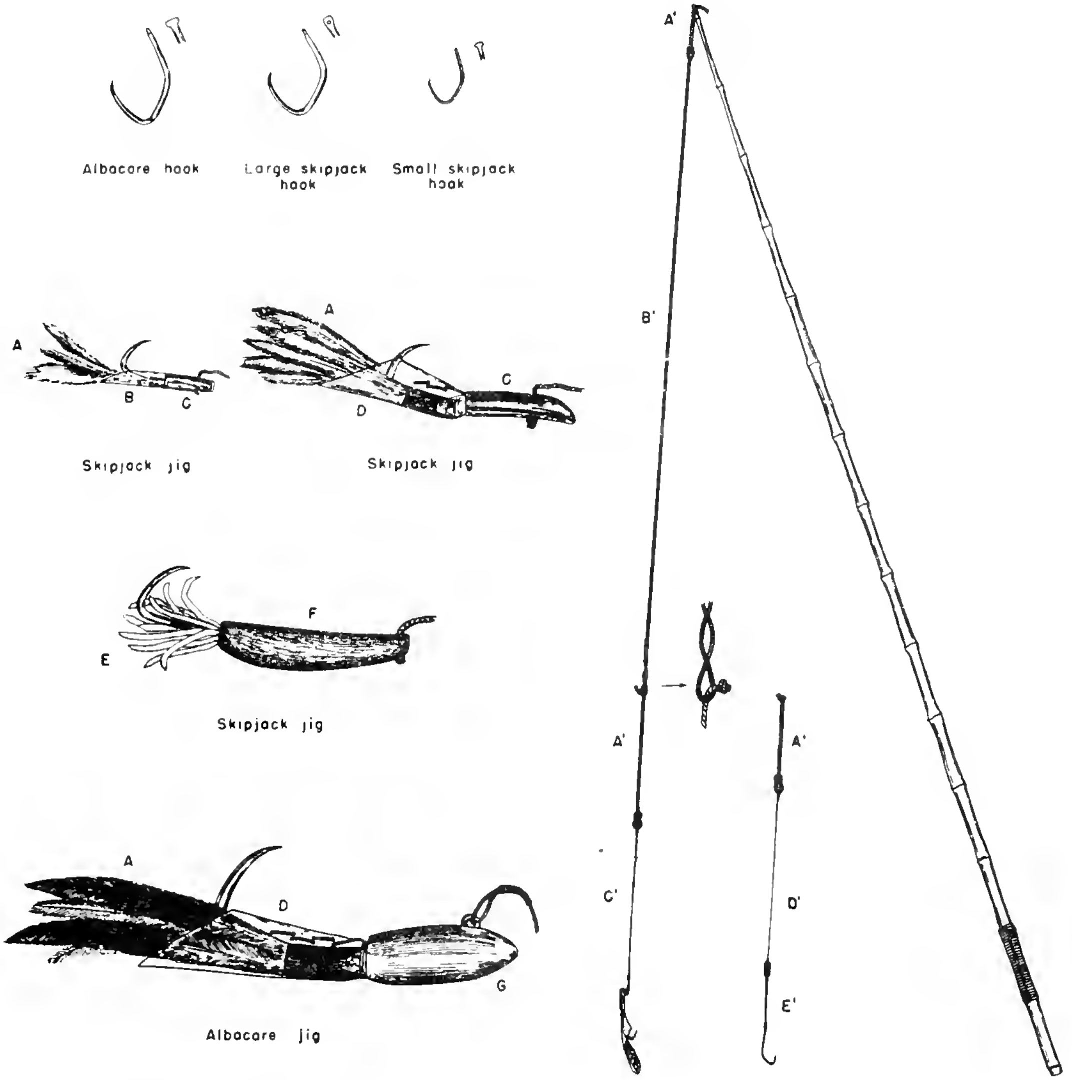
FISHING GEAR: SKIPJACK VESSEL



HOOKS AND JIGS
(1/3 natural size)

A	Hen or eagle feathers
B	Shaft of bird quill
C	Tin-plated brass
D	Oiled paper
E	Ventral skin of file fish
F	Bone
G	Horn

KAGOSHIMA PREFECTURE TYPE POLE AND LINE
(length of bamboo pole 3.0 to 3.8 meters)

A'	Nanking hemp
B'	Cotton covered hemp (sekiyama)
C'	3 Strand wire
D'	Piano wire
E'	3 Strand cotton

NATURAL RESOURCES SECTION GHQ SCAP

Figure 20

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A 135-ton tuna clipper (Figure 14) carries some 250 sets of long line which are put out in one continuous, connected line, usually before evening. The bait used may be salted sardine, anchovy, shark meat, saury, or flying fish. For fishing in the southern regions salted mackerel, sardine, or cuttlefish was brought from Japan. Small amounts of fresh flying fish, taken near Saipan, were occasionally used.

8. Pole and Line

The main gear for tuna fishing since olden times has undoubtedly been the pole and line (saozuri), and it has been used primarily by the Japanese for taking the skipjack. Since the skipjack provides roughly two-thirds of the annual catch of all tunas in Japanese waters, many special techniques have been developed to exploit the pole and line fishing to the fullest extent. The Japanese have also endeavored to increase the catch of skipjack by experimenting with surface long lines, drift nets, and purse seines designed specifically to take this species. However, the amount of skipjack caught with these gear have never been large enough to make commercial operations feasible, and pole and line angling is the sole method now used.

The skipjack fishing boats (Figure 13), characterized by deck-high platforms overhanging the sides of the vessel, live bait tanks, and water spraying apparatus, have changed from small wooden boats sculled by four fishermen to modern 135-ton wooden or steel vessels manned by 50 to 60 fishermen. The boats are equipped with radio for receiving and sending information concerning the presence of schools of fish.

Live bait is essential in skipjack fishing. For this reason an auxiliary fishery has been developed, the sole purpose of which is to provide small fish of suitable size as bait for the skipjack fishermen. Sardines or anchovies about 10 centimeters in length, are most commonly used, although small mackerel or horse mackerel, when obtainable, are also utilized. Fish of this size are found in many localities along the Pacific coast of Japan, thus insuring an adequate supply of bait for the skipjack fishermen. However, the main center for the bait fisheries is in Sagami Bay, where sardines and anchovies of proper size can be taken throughout almost the entire year.

The sardines or anchovies, once obtained by purse seine or lampara net, are transferred at the site of capture to a live bait container (ikesu) which is then moved to shallow water. The containers formerly were constructed of bamboo but are now made of netting, which is suspended from a wooden framework. Palm hemp, Trochycorpus excelsa, is the most desirable material for the net. The bait is confined for a week without food. The hardy leftovers are then taken aboard the skipjack boat to be used during the fishing operations. When fishing, some live bait is scattered over the water to draw the skipjacks close to the boat. Barbless hooks (Figure 20) baited with live sardines or anchovies are first used to catch the skipjack. If the fish bite well, the use of live bait is discontinued in order to conserve the sardines or anchovies, and the hooks are replaced with jigs.

Albacore and small yellowfin and big-eyed tunas are sometimes taken by pole and line when they come to the surface while chasing schools of small fish. The amount caught in this manner is significant, but small compared with the huge amount of skipjack obtained.

Since live sardines and anchovies are the most important of the species used for bait, the methods by which they can best be kept alive in a container have been studied by several investigators (Kimura, 1933 and 1935; Takayama, et al, 1933). The studies on confinement indicate that the sardine is more resistant than the anchovy to injury and irritation, but less resistant to asphyxiation. The anchovy, however, is preferred during hot weather, since it is more tolerant of high temperatures.

Although live bait is plentiful in Japanese waters it is difficult to obtain an adequate supply for skipjack fishing in the tropical regions. Sardines, young barracuda, horse mackerel, and atherinid fishes are used with good results when obtainable in sufficient amounts. These small fish are not found in clear water where they would be prey to larger fish, but are generally caught in mangrove swamps close to the islands.

The live bait tank aboard the skipjack vessel is an important item. It is always built midships below deck. Circulation of the sea water through pitching and rolling of the ship is made possible by the presence of small holes in the bottom of the tank hold. In a few boats the modern type of automatic water circulation has been installed.

For surface fishing the Japanese have devised the technique of spraying water on the surface of the ocean. It is claimed that ruffling the surface excites the skipjacks, thus causing them to bite better. The use of the spraying technique developed from the early efforts to improve fishing by beating the surface of the water with a bamboo stick. Now, however, an apparatus for spraying water from the sides of the boat is installed on every skipjack vessel. In the large modern 135-ton boats, a 7-inch pipe, having nozzles at intervals, is placed on the same level as the fishing platform. When a school is approached the spray is turned on, and its action is continued for the duration of the fishing. In addition to exciting the skipjack the spray serves to screen the vessel from the fish.

The skipjack fishing gear (Figures 20 and 21) varies in detailed structure with each locality, although following a similar general pattern. Bamboo poles are used exclusively. The line was formerly wire, but now it is generally either an artificial snood made of silk or a sekiyama (cotton wound around ramie or Japanese hemp).

The American method, by which two or more poles are attached to a single hook in order to catch fish of large size, is rarely practiced in Japanese waters. The fish taken by surface pole and line angling rarely exceed the size which can be handled by a single person.

TUNA CATCH

1. General

The pelagic tunas occupy a position of major importance in the economy of the Japanese nation. In quantity obtained they rank behind the sardine, herring, and cod, which are the leading species as regards amount landed in Japan (Espenshade, 1947, pp 13 and 17). However, the increasing value of the tunas, both for home consumption and for export trade, has in the past several decades brought the group to a commanding position in the fishing industry. In terms of monetary value the tunas are now considered to be, after the sardine, the most valuable Japanese marine resource.

The skipjack, Katsuwonus pelamis, has long been the most important of the tunas (including spearfishes 5/) both as to quantity caught and desirability for home consumption. The amount taken has always exceeded the total production of all remaining tunas combined (Figure 22). The species is eaten as raw fish (sashimi) or roasted, but its most preferred use is as dried skipjack stick (katsuobushi). About 50 percent of the skipjacks landed in Japan were processed in this manner prior to World War II (compare data for 1936-40, Tables 8 and 9). As articles of diet the other tunas also rank high on the list of fish most desired by the Japanese people and are generally consumed raw.

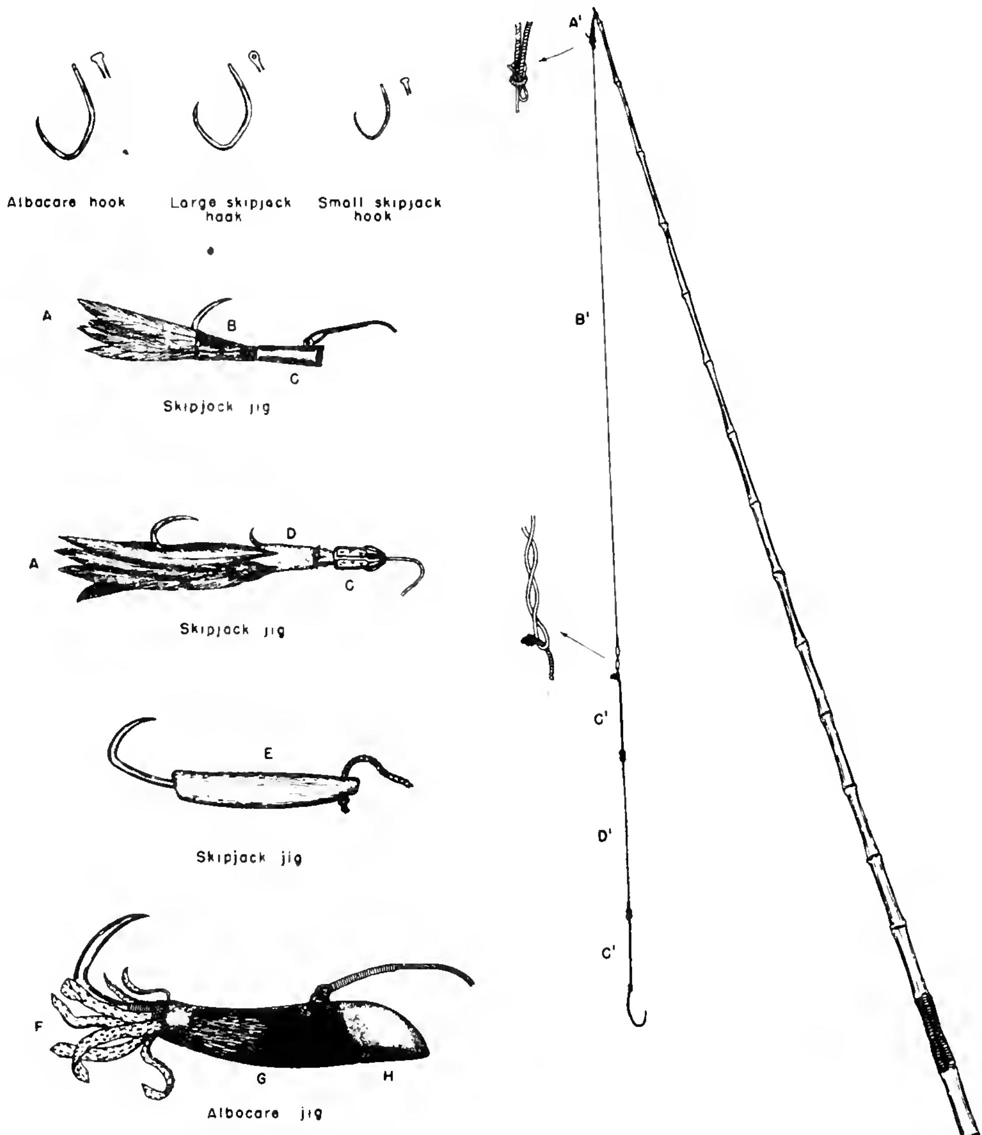
Before the recent war the Japanese displayed great energy in their efforts to expand their fisheries for the tunas, not only for home consumption but also because certain species were in great demand as frozen or canned export items (Tables 10, 11, and 12). The species most valuable for foreign trade was the albacore (Thunnus germo). Almost the entire catch of this fish was shipped abroad in the frozen state or as canned white-meat tuna. Smaller quantities of skipjack and swordfish (Xiphias gladius) were also exported. During the 1930's the fishery for the yellowfin tuna (Neothunnus macropterus) was in the process of being developed on a large commercial scale, but the possibilities offered by exploitation of this species failed to materialize, mainly because the vessels and fuel required were items needed for the China war effort and for possible conflict with the United States.

2. Catch in Japan Proper

Catch statistics concerning the amount of tuna landed in Japanese ports are recorded for 1908-15 in the Statistical Yearbooks of the Department of Commerce and Agriculture

5/ See footnote 3/ p 10

FISHING GEAR: SKIPJACK VESSEL



HOOKS AND JIGS
(1/3 natural size)

A Hen or eagle feathers
B Colored cloth
C Tin-plated brass: lead filled
D Ventral skin of file fish
E Whale bone
F Ventral skin of puffer fish
G Horn
H Lead

MIE PREFECTURE TYPE POLE AND LINE
(length of bamboo pole 3.7 to 4.0 meters)

A' Cotton ring
B' Artificial snood: silk
C' Japanese hemp: indigo colored
D' 2 or 3 Strand wire

Figure 21

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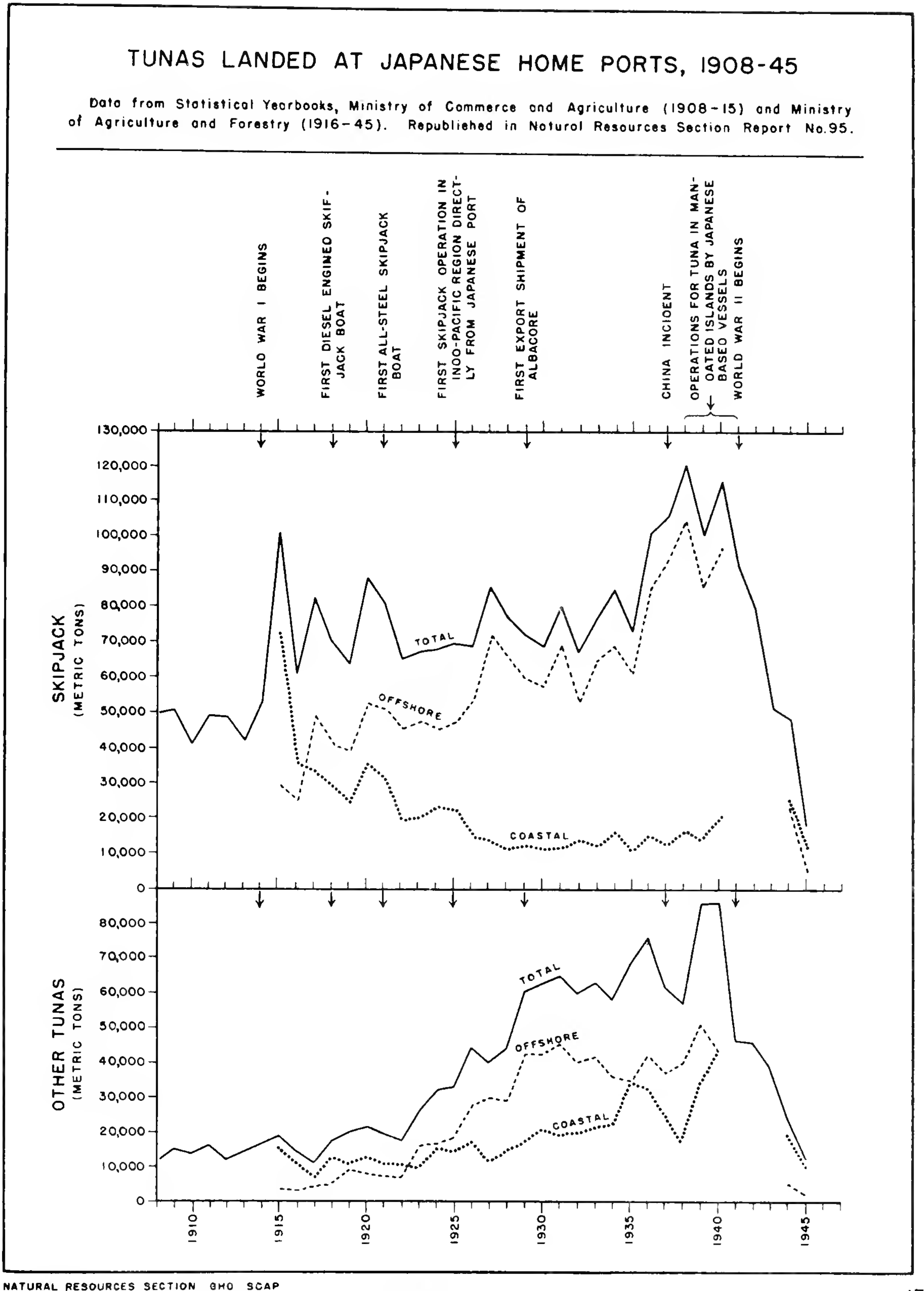

Figure 22

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(Noshomu Tokei), and for 1916-45 in the Statistical Yearbooks of the Department of Agriculture and Forestry (Norin Tokei). As noted in the sections on vessels and gear, the Japanese fishing operations for the tunas have been carried on primarily by two methods, surface pole and line for the skipjack, and long line for the remaining tunas and related species 6/. In official government reports this breakdown has been followed without considering other gear of lesser importance. The catch by species, moreover, has not been recorded. Two large categories, skipjack and tuna, have been designated. All species of tunas (with the exception of the skipjack) and spearfishes are included in the category "tuna" regardless of biological relationships. An undetermined amount of sharks may be included in the tuna catch since they are sometimes taken on long lines. The data (republished in Espenshade, 1947, Tables 3 and 7) are considered by Japanese fishery workers to be incomplete but are reliable to the extent that they indicate trends in the development of the tuna fisheries subsequent to 1908 (Figure 22).

A breakdown of the tuna catch into coastal and offshore categories prior to 1915 is not available. Beginning with 1915, however, this breakdown was made and continues to the present with interruption only for the years 1941-43. The criterion established for determining coastal and offshore categories has been the operating distance from shore 7/. In actual practice the breakdown was made according to size of boat, horsepower, and resulting ability to operate either near or at a distance from home port.

Following the introduction of skipjack and tuna long line motor-driven vessels during the first decade of the 20th Century, it became possible to exploit the coastal waters more efficiently and also to extend the fishing grounds into more distant areas where greater concentrations of certain species such as the skipjack, the swordfish, and the striped marlin were present. Thus the Japanese had the means and facilities for going further from shore and expanding the fisheries whenever increasing demand for various tuna products required such expansion.

The over-all production of the fisheries after the beginning of World War I showed a marked increase, a typical reaction to demand for food during a war-inspired effort. Moreover, the cumulative effects of the transition from sail and hand-powered boats to engined vessels were beginning to be felt in a fishery where the speed and maneuverability of the vessel is of vital importance. By 1915 offshore fishing, especially for the skipjack, had a noticeable effect on production, and by 1917 it had become more important than the inshore operations (Figure 22).

After 1915 the catch of skipjack in coastal waters began to drop sharply, and this decrease continued until 1928 when the catch leveled off at a low rate. Various reasons may be given for this trend. Among the more likely is a shift in fishing effort from coastal to offshore waters or a possible change in the criterion used to determine inshore and offshore categories. The movement offshore of the major concentrations of skipjack owing to changed hydrographical conditions, industrial pollution of inshore water, or heavy coastal boat traffic is also possible. The reason most favored by the Japanese is changed hydrographical conditions, but most of their fishery men are prone to explain decreases in production solely on the basis of changes in water temperature and to disregard the contributing effects of other important factors, such as technological development and increased intensity of fishing effort. Despite the marked decrease in the inshore catch, the skipjack fisheries as a whole were able to maintain their former level of production and to show an increased yield whenever the occasion demanded it.

Diesel engines and steel boats increased efficiency of operation for the offshore fisheries in the years following these innovations. This is reflected in a significant upward trend in the amount of tuna caught during the late 1920's. The increased catch not only was the result of increased demand, coupled with ability to make large catches, but also was accounted for by gradual extension of profitable fishing operations into waters at a distance from the Japanese mainland. For example, the region near the Bonin Islands, to which a Japanese-based skipjack vessel had first gone in 1908, now could figure importantly in the tuna fisheries.

6/ See pp 32 and 34
7/ See footnote 4/, p 37

In 1925, as a result of surveys made by several investigators, a skipjack vessel was sent directly from a Japanese port into the Indo-Pacific region. The amount of skipjack taken by such operations and landed at Japanese ports was extremely small by comparison with that in home waters. Nevertheless, these operations were significant in that boats fishing that region could observe and report to Japan the abundance and the types of fish present. Thus, when the Japanese chose to expand their pelagic fisheries they could turn their attention to an area which had some indication of being productive although located at a distance from home ports.

The next advance in the fisheries came with the opening of foreign markets for tuna products in 1929. In succeeding years albacore, either frozen (Table 10) or as canned white-meat tuna (Table 12), became the dominant export item in the fisheries. Smaller amounts of frozen skipjack and swordfish and an undetermined but minor quantity of canned skipjack were also exported. The United States was the chief importer of these products, buying all the frozen albacore, swordfish, and skipjack and well over 50 percent of the canned white-meat tuna exported by the Japanese. Canned skipjack was sent to Asiatic and European countries during 1933 and 1934. The market for this item disappeared, and in the years following, white-meat tuna was the sole exportable canned product. Since the albacore was in such great demand fishermen now began to take the species in large numbers from the areas close to the Japanese mainland and also surveyed and located extensive new fishing grounds in the mid-Pacific. The surveys were extended into the southwest Pacific region, mainly between 1931 and 1934, but here it was shown that the yellowfin tuna, not the albacore, was the dominant commercial species.

A boost in the requirements of food for the Chinese-Japanese war effort intensified tuna fishing operations, with resulting increased catches from 1936 to 1940. A sustained increase during this period can be noted for the skipjack. This was almost completely the result of increased offshore operations. The behavior of the fisheries for the other species (taken chiefly by long line) is not quite so clear. The coastal catch of other tunas (Figure 22) showed increased yields for most of these years and almost approached the yield attained by offshore operations. This may be attributed to intensive fishing effort taking advantage of the fact that certain species, such as the black tuna, appear in Japanese waters periodically in great abundance (Table 8), and cause extreme annual fluctuations in catch. The period of survey in the Mandated Islands had shown that the yellowfin tuna could support a thriving fishery. Exploitation of the area, despite inadequate supplies of fuel and the drafting of large fishing vessels by the Japanese navy, was under way by 1938. Long line vessels obtained a sizable catch, considering the small number of voyages that were made to southern waters. This catch was landed at Japanese home ports and is included in the total catch of tunas. The boats used for the operations in the southern regions could not be used in Japanese waters; consequently the effect on the total tuna production (excluding skipjack) was not marked.

As the bulk of the catch was taken in the offshore waters, the tuna fisheries were adversely affected soon after the beginning of World War II (Figure 22). Operations were virtually suspended by the end of the war except for the small number carried on mostly in coastal waters. Two-thirds of the fishing fleet (especially vessels of larger size) was sunk, and many experienced fishermen lost their lives. Rebuilding of the postwar fleet has been rapid (see p 34 and Tables 5 and 6), and by 1948 the number of vessels will exceed those in operation prior to 1941. According to Japanese estimates, the catch of tuna in 1948 will approximate the high levels attained during the prewar years in those areas now authorized for Japanese fishing operations, providing fishing efficiency and other conditions are equal (compare Tables 8 and 13). The Japanese should be able to attain 90 percent of their total prewar tuna catch, since their prewar operations were largely confined to waters within the present authorized areas (compare Figures 6, 8, 10, 12, and 15). Except for the development of a large winter industry for the albacore in the mid-Pacific and the initial exploitation of the South Seas yellowfin tuna fisheries, the tuna fisheries were operated on a commercial basis in the waters nearer to the Japanese homeland. Experienced Japanese fishermen and fishery biologists state that the prewar exploitation of tuna had apparently attained its sustained peak in all areas with the exception of the southern regions.

During the decade prior to World War II the increasing importance of the tuna fisheries, especially for the purpose of obtaining export items, led to a much greater appreciation of the necessity for an accurate picture of the industry. The Tokyo Central Fisheries

Experimental Station, in line with a prospective program of intensive research on the commercially important species, made a special survey of the fisheries. As a result, catch figures, which are considered by fishery workers to be reliable, although they differ from those published by the Ministry of Agriculture and Forestry, are available for the years 1936-40 (Table 8). Moreover, the total tuna catch can be broken down by species and by amount taken in each area fished by Japanese vessels. It is this material that has been useful in determining the fishing grounds for each of the commercially important species (Figures 6, 8, 10, and 12).

In this survey the tuna catch (Table 8) includes not only the fish taken in Japanese waters but also those taken in the former Mandated Islands from 1938 to 1940 by vessels operating from Misaki and, to a lesser extent, from other home ports 8/. The amount of fish delivered by these vessels to Misaki port was, at most, 8,500 metric tons 9/. The catch obtained by vessels based in the southwest Pacific region is not included in the Central Fisheries Experimental Station tabulation and will be discussed later.

Comparable statistics by species for 1941-45 are not available, because tuna fishing operations were virtually suspended and the surveys discontinued. Catch records for 1946 (Table 8) have been compiled by the Japanese Tuna Fishermen's Association. The marked decrease in tonnage is attributed to the shortage of fishing vessels immediately after the cessation of hostilities, a lack of experienced fishermen 10/, a severe shortage of ice, and a decline in the availability of live bait owing to material shortages and the failure of sardines of proper size to appear in the localities where the skipjack fisheries are centralized.

3. Colonial Catch

The Japanese colonial possessions produced a comparatively small catch of tunas and related species despite the fact that several were situated in excellent fishing areas. The Japanese Government did not offer much encouragement for the development of extensive colonial fisheries. Fishing operations were organized by small companies with Japanese capital, utilizing, for the most part, imported Japanese or Okinawan fishermen. The greater part of the skipjack catch landed at colonial ports was processed into katsuobushi (dried skipjack stick) and exported to Japan Proper. The other species of tunas were mostly consumed fresh by the local inhabitants. An unknown but small part was shipped frozen to Japan.

Korea: The prewar catch of tunas by boats operating from Korean ports was insignificant, since the commercial fishing grounds for these species were located in waters east of Japan. Thus Korean-based vessels could not compete with those operated from Japan Proper. Catch figures are available for 1935-42 in the Fishery Statistic Yearbook of Korea, published by the Korean Government General (Table 14). The species of true tunas taken are not indicated. The spearfishes were primarily marlins, with a few swordfish and sailfish occasionally caught. Skipjack fishing was not practiced by the Koreans.

Formosa: Tuna fishing from Formosan ports was at first carried on in the seas to the east of Formosa, primarily for skipjack. As boats became larger, operations were gradually extended to the waters around the northern Philippine Islands, where long line operations for the black tuna were especially successful. In 1928 vessels based at Takao began to operate in the South China, Sulu, and Celebes seas for yellowfin tuna and marlin. During the early part of the 1930's, operations became more intensive, and increasingly larger catches were made by long line. This trend is shown in the records of landings of tunas (excluding skipjack) and spearfishes at Formosan ports for the years 1927-36 (Table 15). Catch statistics after 1936 are not available. A breakdown of the 1936 catch by types of fishing gear is possible (Table 16) and indicates that the pole and line (for skipjack) and the long line (for other tunas and for spearfishes) were the principal methods used, as in Japan Proper, for catching these pelagic species.

8/ See pp 51 and 52
9/ See Table 20
10/ Most experts state that it requires three years to train an experienced skipjack fisherman.

Southwest Pacific: In the Japanese Mandated Islands fishing was traditionally carried on by the natives who operated small hand-propelled boats near the atolls and islands. Tuna and spearfish were occasionally taken by trolling a feather jig behind a sailing outrigger canoe or by line fishing in depths to about 40 meters. The amount caught was negligible.

Soon after the Japanese obtained control of the islands (at the end of World War I) they began to take an interest in developing certain fishing operations in the southwest Pacific. Between 1923 and 1925 several fishery experts were sent into the region to evaluate prospects for establishing commercially feasible operations. Favorable reports regarding the presence of skipjack were brought back to Japan. Ease of fishing operations in calm seas and the fact that fish could be taken in profitable quantities throughout the year were added inducements.

By 1930 various companies had established bases in the Mandated Islands, the Philippine Islands, and the Dutch East Indies, primarily to take the skipjack. These companies utilized imported Japanese and Okinawan fishermen almost entirely. Although the density of the skipjack populations in the southwest Pacific is low in comparison with those in Japanese waters, the species can be found everywhere throughout the region. Therefore fishing was profitable. Major difficulties, however, were caused by lack of sufficient live bait and an inadequate supply of fresh water. When live bait was available the intense heat of the tropics killed the bait within a few hours. Therefore, operations were on a small scale and were mainly designed to catch the skipjack within 40 sea miles of the land bases during a single day's operation. Minor quantities of small yellowfin tuna swimming at the surface were also taken. Operation of boats over 30 tons was unprofitable in most of the localities. Nevertheless it was possible to make a good catch. Fisheries statistics published by the South Sea Government General (Table 17) show the trend in the development of the fisheries noted above, a negligible catch of skipjack 11/ prior to 1930, then rapid expansion of the fisheries during the following decade. Most of the skipjack was processed into katsuobushi and shipped to Japan. The large quantities (Table 9) placed on the home market caused a drop in the price of the processed article. Competition became especially severe in 1937, and protests from Japanese producers caused the Government General of the South Sea Islands to put into effect regulations limiting the number of skipjack boats that could operate locally. Data on the catch taken by Japanese-controlled companies in the Philippine Islands and the Dutch East Indies have been either lost or destroyed during the war. The Japanese Tuna Fishermen's Association, however, has managed to obtain enough information to indicate the scope of the operations in those regions (Table 18).

Tuna long line fishing was also practiced by the Japanese companies in the southwest Pacific, but on a very small scale (Table 19) because of the lack of capital and men experienced in this type of operation. Nevertheless, it soon became apparent that year-round long line fishing might be profitable. Ease of fishing operations was another inducement. Larger fishing companies in Japan began to show an interest in the southern regions, and during the 1930's, especially between 1931 and 1934, several companies and research stations made surveys to determine the fishing areas and the density of the populations in the broad area extending from the Mandated Islands west through the Dutch East Indies into the Indian Ocean. Their results (Tables 1 to 3) showed that possibilities of developing huge long line fisheries, chiefly for the yellowfin tuna and the marlins, existed in this vast area.

Experienced tuna long line operators in Japan became aware of the evidence accumulated on fishing possibilities in the Mandated Islands region, and in 1938 they began to send their large vessels to that area, primarily for yellowfin tuna and marlin. For a four-year period (1938-41) boats made the long trip from Japan to the area where the Equatorial Counter Current passes through the Mandated Islands and were able to operate profitably. The number of vessels sent was limited by the amount of fuel issued under Japanese army and navy control for such operations. Almost the entire catch of tuna obtained in the South Seas was landed at Misaki. A few vessels operated from Tsuro and Muroto and landed their

11/ The figures for the skipjack probably include the small amount of yellowfin tuna captured by pole and line fishing.

catches at those ports, but their records are not available. At most, according to reports collected from fishermen, the catch landed at other ports besides Misaki amounted to about 5 percent of the total Mandated Islands catch taken by all Japanese-based vessels. The catch taken by long line tuna vessels based in the Mandated Islands was also insignificant (Table 19). Therefore the records kept by the Misaki Fishermen's Association tell virtually the entire story of Japanese tuna operations in the South Seas for species other than the skipjack (Table 20).

Records are complete for all Misaki tuna long line operations in the western Pacific Ocean. They not only show the extent of tuna operations in the Mandated Islands prior to World War II, but permit comparison of fishing efficiency between major fishing areas. The Misaki catch records are presented in three categories: Japanese waters from 30°-40°N latitude; Ryukyu and Bonin waters from 24°-30°N latitude; and Mandated Island waters from the equator to 24°N latitude (Table 20). The fishing days per voyage and the average tonnage of the vessels operating in each of the three areas are known for 1939. This permits calculation of the average catch in metric tons per fishing day per ton of vessel (Table 21). On the basis of these data, the mandated area, with a higher catch per unit of effort, was profitably operated despite the distance involved and the difficulty of fishing without shore facilities. The principal species taken was yellowfin tuna, followed by sizable quantities of big-eyed tuna and black marlin, with lesser amounts of albacore, swordfish, and other marlins, and a very small number of sharks.

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12/ Dates given for government yearbooks are years for which statistics have been compiled, not publication dates.

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TABLE 1 - COMPOSITION OF TUNA CATCH OBTAINED BY LONG LINE OPERATIONS IN SOUTHWEST PACIFIC AND INDO-PACIFIC REGIONS

Area	Number of Hooks Used	Total Catch per 100 Hooks a/	Percent Composition of Tuna Catch				Avg Weight of Yellowfin Tuna (kilograms)
			Black Tuna	Yellowfin Tuna	Big-Eyed Tuna	Marlins	
East of Formosa: 20°-25°N and 120°-130°E	55,715	1.91	7.3	21.2	8.0	63.5	47.2
East of Philippine Islands to 130°E	10,234	6.35	0.0	56.4	2.3	41.3	33.0
Former Mandated Islands: 0°-12°N and 130°-170°E	220,526	5.23	0.0	79.2	9.3	11.5	33.0
South China Sea off Palawan	110,560	4.65	0.0	90.3	4.5	5.2	ND
Sulu Sea	4,600	3.06	0.0	ND	ND	11.1	47.1
Celebes Sea	157,156	4.37	0.0	ND	ND	16.3	44.0
North of New Guinea and Solomon Islands: from 130° to 160°E	21,792	4.21	0.0	71.8	7.1	21.1	37.0
Banda Sea: southeast and south of Celebes	51,779	8.40	0.0	89.5	3.3	7.2	48.5
Neighboring waters of Timor Island	48,756	9.19	0.0	88.6	3.8	7.6	48.0
Southern coast of Java	20,528	3.89	0.0	67.8	17.4	14.8	49.6
Southern coast of Sumatra	147,428	10.64	0.0	84.7	8.2	7.1	ND
Neighboring waters of Andaman and Nicobar Islands	15,568	6.23	0.0	89.4	4.4	6.2	40.0

a/ In Japanese waters the total tuna catch per 100 hooks averages between 3 and 4 fish.
ND: No data available
SOURCE: Data obtained by Japanese research and fishing vessels from 1930-40 and compiled by H. Nakamura of the Tokyo Central Fisheries Experimental Station.

TABLE 2. - SEASONAL TUNA CATCH BY LONG LINE OPERATIONS IN SOUTHWEST PACIFIC AND INDO-PACIFIC REGIONS

Area	Southwest Monsoon Season (Summer)		Northeast Monsoon Season (Winter)	
	No of Hooks Used	Total Catch per 100 Hooks a/	No of Hooks Used	Total Catch per 100 Hooks a/
East of Formosa to 120°30'E	900	1.78	7,032	2.94
East of Philippine Islands to 130°E	7,840	7.98	2,394	0.67
Former Mandated Islands: 0°-12°N and 130°-170°E	115,099	5.40	105,527	4.18
South China Sea off Palawan	4,158	3.32	106,402	4.69
Celebes Sea	10,493	8.86	146,663	4.06
North of New Guinea and Solomon Islands: from 130° to 160°E	10,500	4.39	11,292	4.04
Banda Sea: southeast and south of Celebes	80,089	8.56	1,690	7.34
Neighboring waters of Timor Island	2,215	6.23	116,546	9.33
Southern coast of Sumatra	300	3.67	147,128	10.72

a/ Includes yellowfin tuna, big-eyed tuna, and marlins.
SOURCE: Data obtained by Japanese research and fishing vessels from 1930-40 and compiled by H. Nakamura of the Tokyo Central Fisheries Experimental Station.

TABLE 3. - LONG LINE CATCH OF YELLOWFIN TUNA BY SHONAN MARU July to September 1937

Area	Number of Hooks Used	Number of Fish Caught	Catch per 100 Hooks
East of Philippines to 130°E			
15°-20°N latitude	1,117	19	1.7
10°-15°N latitude	1,428	50	3.5
3°-10°N latitude	2,947	289	9.8
Former Mandated Islands: 130° to 170°E			
5°-12°N latitude	75,010	1,285	1.7
0°-5°N latitude	145,610	8,882	6.1

SOURCE: Submitted by H. Nakamura of Tokyo Central Fisheries Experimental Station

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TABLE 4 - CATCH PER GROSS TON OF SKIPJACK VESSEL
(metric tons)

Year	Number of Vessels Surveyed a/	Total Tonnage of Vessels	Catch	Average Tonnage per Vessel	Annual Catch per Ton of Vessel
1930	1,042	28,224	59,520	27.1	2.11
1931	909	29,719	70,700	32.7	2.38
1932	883	28,487	58,062	32.3	2.04
1933	806	28,624	67,991	35.5	2.38
1934	787	33,691	72,475	42.8	2.15
1935	910	36,544	62,665	40.2	1.71
1936	1,044	39,209	87,023	37.6	2.22
1937	924	36,565	96,620	39.6	2.64
1938	891	37,192	101,131	41.7	2.72
1939	851	35,967	85,698	42.3	2.38
1940	800	33,115	100,573	41.4	3.04

a/ Does not include all vessels in operation
SOURCE: Statistical Year Book of Agriculture and Forestry (Norin Tokei) 1940

TABLE 5. - TUNA FLEET OPERATED DURING 1940

Size of Vessels	Tuna Vessels a/			Skipjack Vessels b/			Combination Tuna and Skipjack Vessels c/			Total		
	Number	Tonnage	Crew	Number	Tonnage	Crew	Number	Tonnage	Crew	Number	Tonnage	Crew
Over 100 tons	21	2,775	492	40	5,456	2,121	54	7,046	2,138 d/ 3,469 e/	115	15,277	2,630 d/ 5,590 e/
50-99 tons	79	5,194	1,545	106	8,186	4,959	81	6,395	2,139 3,796	266	19,775	3,684 8,755
20-49 tons	243	9,278	3,249	29	1,033	7,267	50	1,803	1,403 1,472	322	12,114	4,652 8,739
Below 20 tons	161	2,905	2,715	126	1,822	2,749	48	772	808 955	335	5,499	3,523 3,704
TOTAL	504	20,152	8,001	301	16,497	17,096	233	16,016	6,488 9,692	1,038	52,665	14,489 26,788

a/ Boats using long line fishing technique
b/ Boats taking fish at the surface by pole and line
c/ Practice both types of fishing depending on peak season
d/ Long line fishing
e/ Skipjack fishing
SOURCE: Bureau of Fisheries, Ministry of Agriculture and Forestry.

TABLE 6. - TUNA FLEET AVAILABLE FOR OPERATION DURING 1948

Size of Vessels a/	Tuna Vessels b/			Skipjack Vessels b/			Combination Tuna and Skipjack Vessels b/			Total e/		
	Number	Tonnage	Crew	Number	Tonnage	Crew	Number	Tonnage	Crew	Number	Tonnage	Crew
Over 100 tons	189	25,287	4,422	21	2,809	1,113	65	8,696	1,521 c/ 3,445 d/	275	36,792	5,943 c/ 4,558 d/
50-99 tons	130	10,259	2,539	69	4,710	3,222	212	16,828	4,134 9,900	411	31,797	6,673 13,122
20-49 tons	82	2,682	1,377	63	2,061	1,373	105	3,435	1,764 2,289	250	8,178	3,141 3,662
TOTAL	401	38,228	8,338	153	9,580	5,708	382	28,959	7,419 15,634	936	76,767	15,757 21,342

a/ Information on vessels below 20 tons is not available since such vessels are not required to register with the Bureau of Fisheries.
b/ See Table 5 for classification of vessels
c/ Long line fishing
d/ Skipjack fishing
SOURCE: Data compiled by Japanese Tuna Fishermen's Assn

TABLE 7 - CONSTRUCTION OF LONG LINE GEAR a/, AREA OF OPERATION, SEASON, AND SPECIES TAKEN BY VARIOUS JAPANESE TUNA VESSELS

Vessel	Tonnage	Area of Operation	Season	Species Taken	Length of Set b/ (meters)	Floats Between Flag Buoys	No Hooks per Set	Float Line Length (meters)	Longest Branch Line c/ (meters)	Distance Between Branch Lines (meters)	"Sekiyama" Length d/ (meters)	Wire Leader Length (meters)	Distance from Surface to Hook (meters)
Iwo Maru	10	Bonin Islands	Nov-Jan	Albacore Yellowfin tuna Big-eyed tuna	438	3	12	13.7	16.7	27.4	4.5	1.5	36.4
Fusa Maru	176	East of Chiba Pref	Nov-Mar	Black tuna Marlin Albacore Big-eyed tuna Shark	328	1	10	18.2	15.2	27.3	4.5	2.3	40.2
Toyo Maru	137	East of Chiba Pref	Oct-Mar	Black tuna Albacore Marlin	255	1	6	19.7	25.8	47.4	4.5	1.5	51.5
Suzu Maru	103	East of Chiba Pref	Nov-Mar	Albacore Big-eyed tuna	599	1	28	36.4	18.2	20.0	6.0	1.5	62.1
Horai Maru	70	East of Chiba Pref	Sep-May	Albacore Big-eyed tuna Black tuna Shark	365	0	14	30.4-38.0	22.0	25.5	4.5	2.3	59.2-66.8
Jingu Maru	60	Pacific coast	Oct-Mar	Black tuna Yellowfin tuna Marlin Shark	547	1	2	22.8-30.4	74.4	181.8	10.6	3.0	110.8-118.4
Taisho Maru	34	South of Kyushu	Dec-Mar	Black tuna	365	1	2	34.9	60.8	21.6	15.2	7.6	118.5
Daikoku Maru	54	East of Kyushu	Mar-May	Black tuna	438	1	2	28.8	48.6	216.0	15.2	6.0	98.6

a/ See Figure 19
b/ Distance between two flag buoys. In water the main line occupies a distance about 70 percent of its stretched length. Therefore, hooks in center of set or between two buoys reach greater depth than given total distance from surface to hook (final column).
c/ Branch lines of different lengths are generally placed on one set.
d/ Wire or hemp twine covered by a sheath of cotton twine
SOURCE: Data submitted by S. Takayama of Tokyo Central Fisheries Experimental Station

TABLE 8 - LANDINGS, BY SPECIES, OF TUNAS AND RELATED FORMS AT JAPANESE PORTS, 1936-40 AND 1946
(metric tons)

Species	1936	1937	1938	1939	1940	1946
Skipjack (*Katsuwonus pelamis*)	123,327	128,026	85,526	98,982	106,531	29,338
Black tuna (*Thunnus orientalis*)	21,292	23,580	4,293	17,453	20,368	802
Albacore (*Thunnus germo*)	21,387	26,873	29,179	17,069	18,440	582
Yellowfin tuna (*Neothunnus macropterus*)	3,277	3,188	106	7,994	5,705	2,096
Big-eyed tuna (*Parathunnus mebachi*)	4,791	11,733	12,368	7,242	5,444	915
Swordfish (*Xiphias gladius*)	5,301	3,843	3,537	2,967	1,977	633
Striped marlin (*Makaira mitsukurii*)	2,287	3,121	3,533	2,526	2,285	797
Black marlin (*Makaira mazara*)	ND	ND	1,259	1,865	2,040	203
White marlin (*Makaira marlina*)	ND	ND	17	17	41	9
Sailfish (*Isticphorus orientalis*)	ND	ND	45	45	131	498
TOTAL	181,662	200,364	139,863	156,160	163,062	35,903

ND: No data available
SOURCE: Data for 1936-40 compiled by the Tokyo Central Fisheries Experimental Station as part of a general survey of the tuna fisheries. Catch records for 1946 submitted by the Japanese Tuna Fishermen's Assn.

TABLE 9 - SKIPJACK STICK (KATSUOBUSHI) PRODUCTION IN JAPAN, FORMOSA, AND THE MANDATED ISLANDS, 1922-40
(metric tons) a/

Year	Japan	Formosa	Mandated Islands
1922	10,296.5	818.2	0.1
1923	10,600.1	823.1	ND
1924	9,619.3	589.2	1.1
1925	9,958.9	606.5	1.6
1926	9,654.0	556.1	9.9
1927	9,007.5	460.9	4.7
1928	9,514.2	583.0	18.9
1929	9,553.0	611.6	104.3
1930	7,405.2	383.9	279.1
1931	10,613.6	294.7	842.2
1932	8,900.5	142.3	972.9
1933	9,649.7	223.6	1,305.3
1934	11,561.4	338.2	1,695.4
1935	9,831.4	179.0	2,097.4
1936	12,758.0	220.9	2,422.9
1937	9,055.8	185.1	5,812.7
1938	7,767.8	43.6	2,501.2
1939	9,789.9	74.4	3,229.6
1940	10,022.0	ND	2,973.2

a/ Dried weight. This is 17-18 percent of original fresh weight.
ND: No data available
SOURCE: Data compiled from Statistical Yearbooks of Agriculture and Forestry, published by Ministry of Agriculture and Forestry, and Yamamoto, 1942.

TABLE 10 - FROZEN SKIPJACK, ALBACORE, AND SWORDFISH EXPORTED FROM JAPAN, 1929-39 a/
(metric tons)

Year	Skipjack	Albacore	Swordfish	Total
1929	0	3,213	56.4	3,269.4
1930	0	4,253	152.6	4,405.6
1931	0	3,331	527.9	3,858.9
1932	0	1,156	400.6	1,556.6
1933	0	1,541	482.4	2,023.4
1934	0	1,878	780.5	2,658.5
1935	0	3,124	1,311.8	4,435.8
1936	0	2,656	2,150.6	4,806.6
1937	2,270	3,367	3,442.6	9,079.6
1938	2,177	2,044	3,000.0	7,221.0
1939	519	3,204	2,830.0	6,553.0
TOTAL	4,966	29,767	15,135.4	49,868.4

a/ All frozen products listed were exported to the United States.
SOURCE: Bureau of Fisheries, Ministry of Agriculture and Forestry

TABLE 11 - PRODUCTION OF CANNED TUNA IN JAPAN, 1931-40 a/

Year	Production (cases) b/
1931	128,500
1932	364,799
1933	820,488
1934	396,195
1935	456,585
1936	438,500
1937	712,112
1938	807,924
1939	851,442
1940	967,056
TOTAL	5,943,601

a/ Records prior to 1931 and after 1940 are not available.
b/ Figures are in cases containing 48 cans each weighing 460 grams, or 96 cans each weighing 230 grams.
SOURCE: Data compiled by Japan Canning Co

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TABLE 12 - CANNED TUNA EXPORTED FROM JAPAN, 1931 - 40 a/

Year	Item	Unit Cases b/ Exported To: U.S.A.	Canada	Kwantung	In Pacific Area	Africa	England	France	Other European Countries	China	India	South America	Hawaii	Central America	Indo-China	Sakhalin	Australia	Others	Total
1931	White-meat tuna in oil	24,513	550	558	0	0	253	2,384	20	0	0	0	17	0	0	0	0	59	28,359
1932	White-meat tuna in oil	247,683	4,067	0	55	0	123	257	500	0	0	22	1,720	50	0	0	20	1,125	255,626
	White-meat tuna boiled, salt added	76	0	564	0	0	0	232	1,507	11	0	0	10	0	0	0	0	0	2,400
1933	White-meat tuna in oil	670,004	4,679	123	110	439	302	390	2,716	0	30	0	375	7	6	0	65	436	680,232
	Skipjack or mackerel boiled, salt added c/	0	[illegible]	3,519	1,930	0	0	0	2,607	32	0	0	0	0	0	0	0	733	8,871
1934	White-meat tuna in oil	225,663	10,782	25	0	8,886	2,265	433	25,330	278	25	0	53	179	260	0	0	7,536	281,715
	Skipjack or mackerel boiled, salt added	50	0	603	11,964	180	0	0	14,887	60	640	0	10	510	300	1,500	328	16,202	47,234
1935	White meat tuna in oil	267,186	27,982	5	10	7,534	3,100	347	50,313	48	0	378	50	446	426	0	99	20,165	378,199
	White-meat tuna boiled, salt added	51	0	12	38,337	2,003	51	0	14,316	7	3,162	21	255	440	0	500	1	9,955	69,221
	White-meat tuna seasoned d/	3,280	20	5,811	146	139	150	50	10	165	0	0	678	17	0	25	0	403	10,934
1936	White-meat tuna in oil	210,004	47,765	100	0	13,763	200	0	179	261	7	620	0	0	100	0	5	81,376	354,384
	White-meat tuna boiled, salt added e/																		31,004
	White-meat tuna seasoned e/																		94,920
1937	White-meat tuna in oil	401,934	34,410	31	35	27,273	1,125	376	98,028	59	73	1,137	400	644	183	0	100	17,501	583,699
	White-meat tuna boiled, salt added	2	0	517	112,925	4,049	0	2	7,408	100	33,817	1,605	65	2,207	0	1,000	35	1,245	145,157
	White-meat tuna seasoned	2,901	1,293	42,220	933	1,534	0	0	289	1,754	2	19	901	25	10	2	313	5	52,207
1938	White-meat tuna in oil	180,219	58,872	100	4	18,909	650	0	125	217	58	1,141	0	0	0	0	122	61,026	322,043
1939	White-meat tuna in oil	372,115	35,292	100	[illegible]	0	11,575	0	79,724	272	4	0	0	0	0	0	70	24,822	573,980
	White-meat tuna boiled, salt added	0	0	1,731	15,636	0	0	0	375	0	5,050	0	0	0	0	0	0	1,151	23,993
	White-meat tuna seasoned	565	565	170,115	126	0	0	0	33	19,002	0	0	231	0	0	0	3	146	190,786
1940	White-meat tuna in oil	121,465	26,724	50	0	0	11,513	0	230,947	558	27	0	0	0	6	0	0	5,815	397,105
	White-meat tuna boiled, salt added	2	0	0	7,752	0	42,809	0	3,978	0	854	0	0	0	2,131	0	0	2,564	60,090
	White-meat tuna seasoned	0	57	35,637	0	0	0	0	0	21,643	0	0	0	0	0	0	0	413	57,750
TOTAL		2,728,318	303,066	261,987	184,997	84,859	75,018	4,491	533,382	44,497	23,749	5,037	4,765	4,525	3,422	3,027	1,161	252,678	4,649,949

a/ Records are not available prior to 1930 and for 1941-46.
b/ Figures are standard cases - 48 cans, each containing 375 grams of fish. The gross weight of each can is 460 grams.
c/ The breakdown of these figures into skipjack and mackerel is not possible.
d/ Albacore scraps boiled with soya sauce and sugar added
e/ Destination unknown
SOURCE: Data compiled by Japan Canning Co

TABLE 13 - PREDICTED CATCH BY JAPANESE TUNA FLEET IN PRESENT AUTHORIZED FISHING AREAS a/ DURING 1948
(metric tons)

Size of Vessels	Tuna Vessels b/			Skipjack Vessels b/			Combination Tuna and Skipjack Vessels b/			Total Catch	
	No of vessels	Annual Catch per Vessel	Total Catch	No of Vessels	Annual Catch per Vessel	Total Catch	No of Vessels	Annual Catch per Vessel	Total Catch	No of Vessels	Catch
Over 80 tons	256	112.0	28,672	29	443.1	12,850	178	67.2 c/ 246.0 d/	11,961 43,788	463	97,271
50-79 tons	63	98.1	6,180	61	248.4	15,152	99	50.4 149.1	4,990 14,761	223	41,083
20-49 tons	82	61.3	5,027	63	202.2	12,739	105	57.2 83.5	6,006 8,767	250	32,539
TOTAL	401		39,879	153		40,741	382		22,957 67,316	936	170,893

a/ See Figure 15
b/ See Table 5 for classification of vessels.
c/ Long line fishing
d/ Skipjack fishing
SOURCE: Data compiled by Japanese Tuna Fishermen's Assn

TABLE 14.-TUNA AND SPEARFISH CATCH LANDED IN KOREAN PORTS, 1935-42
(metric tons)

Year	Tunas	Spearfishes
1935	129.9	135.5
1936	3.8	407.4
1937	16.6	631.3
1938	64.6	876.8
1939	88.1	307.4
1940	122.1	335.2
1941	184.6	200.3
1942	200.6	245.2

SOURCE: Fishery Statistic Yearbook of Korea, published by Korean Government General.

TABLE 15 - TUNA AND SPEARFISH CATCH LANDED IN FORMOSAN PORTS, 1927-36
(metric tons)

Year	Tunas (excluding skipjack)	Skipjack	Spearfishes
1927	2,009	2,949	2,645
1928	1,670	3,197	3,016
1929	2,881	3,266	3,362
1930	3,252	2,065	3,292
1931	2,899	1,853	107
1932	3,031	1,043	3,253
1933	3,049	2,052	3,217
1934	3,213	1,942	4,463
1935	3,005	1,281	4,240
1936	5,052	1,644	3,952

SOURCE: Fishery Statistic Yearbook of Formosa, published by Formosan Government General.

TABLE 16.-TUNA AND SPEARFISH CATCH LANDED AT FORMOSAN PORTS IN 1936, BY GEAR
(metric tons)

Fishing Gear	Tunas (excluding skipjack)	Skipjack	Spearfishes
Coastal Operations			
Set net	7.05	0.65	12.55
Circling net	9.05	2.49	0.14
Drift net	17.69	4.74	10.64
Gill net	0.27	0.84	0.94
Beach seine	17.74	17.01	0.00
Others	113.44	139.73	174.46
Offshore Operations			
Long line	4,590.23	50.02	2,242.38
Drift net	0.00	1.24	0.00
Trolling	29.56	112.43	0.00
Skipjack angling	222.02	1,015.79	0.00
Spearing	0.00	0.00	1,500.25
Others	36.19	208.60	0.00
TOTAL	5,052.24	1,644.18	3,951.86

SOURCE: Fishery Statistic Yearbook of Formosa, published by Formosan Government General

TABLE 17 - SKIPJACK CATCH LANDED IN FORMER JAPANESE MANDATED ISLANDS, 1922-40
(metric tons)

Year	Saipan	Yap	Palau	Truk	Ponape	Jaluit	Total
1922	2.36	ND	ND	3.60	3.75	ND	9.71
1923	2.81	1.46	ND	3.04	ND	ND	7.31
1924	9.10	1.76	1.56	5.21	0.11	ND	17.74
1925	14.81	1.99	8.53	6.05	4.95	ND	36.33
1926	44.84	2.16	42.41	2.76	0.11	ND	92.28
1927	28.11	0.73	14.77	7.50	1.62	0.22	52.95
1928	26.40	1.13	131.45	4.50	0.15	ND	163.72
1929	24.69	0.89	228.00	214.50	0.53	ND	469.51
1930	257.00	0.90	157.06	913.39	6.38	ND	1,335.73
1931	564.26	0.44	548.12	1,097.13	[illegible]	51.26	2,816.45
1932	1,309.73	ND	[illegible]	810.26	540.16	614.76	4,861.26
1933	1,762.30	ND	2,144.46	1,833.36	926.35	172.43	6,889.40
1934	2,516.00	4.19	1,778.65	1,199.98	1,202.46	255.13	6,956.41
1935	1,785.98	ND	5,390.99	3,002.43	1,313.12	229.73	11,722.30
1936	1,696.01	ND	3,835.97	5,870.23	2,695.84	167.73	14,265.78
1937	2,697.30	ND	13,774.70	12,433.53	4,063.96	91.30	33,060.79
1938	2,392.03	149.28	3,420.21	5,294.78	1,495.58	6.71	12,758.59
1939	2,086.99	36.06	3,548.77	7,639.63	3,707.75	ND	17,019.20
1940	3,379.05	3.64	6,047.38	7,217.09	1,586.30	0.51	18,233.97

ND: No data available
SOURCE: Statistical Yearbook of South Sea Islands published by South Sea Government General.

TABLE 18 - TUNA OPERATIONS BY VESSELS BASED IN THE SOUTHWEST PACIFIC, 1940

Base	Type of Operation	Vessels Operated	Fishing Grounds	Amount of Catch	Disposition of Catch
Philippine Islands					
Zamboanga	Pole and line fishing; live bait fishing	20-ton boats - 2 50-ton boats - 2	Within 20 sea miles of port	462 MT (80% skipjack, 20% yellowfin tuna)	Mostly canned or frozen for shipment to U.S.A.
Davao	Pole and line fishing; live bait fishing; tuna long line	Skipjack boats - 5 Tuna long line boats - 6 (tonnage not available)	Within Davao Bay	Only value of catch given: Skipjack - 80,000 pesos Other tunas a/ - 70,000 pesos	Mostly distributed for local consumption
North Borneo					
Tawao	Pole and line fishing; live bait fishing	20-ton boats - 9	Within 20 sea miles of Pungu and Shamil	4,643 MT skipjack and yellowfin tuna (1939)	Local distribution; part of skipjack catch processed into fish stick and shipped to Japan
Celebes					
Boentin	Pole and line fishing; live bait fishing	20-ton boats - 10	Within 10 sea miles of Boentin and Ternate	900,000 fish (skipjack and yellowfin tuna); weight not given	Mostly processed into fish stick and shipped to Japan
Amboina	Pole and line fishing; live bait fishing	20-ton boats - 3	Within 10 sea miles of port	360,000 fish (skipjack and yellowfin tuna); weight not given	Local distribution
Mandated Islands	Pole and line fishing; tuna long line, live bait fishing		Within 30 sea miles of port	(metric ton)	Skipjack mostly processed into fish stick and shipped to Japan
Saipan		Skipjack boats b/ - 25 Tuna long line boats d/ - 2 ND		Skipjack - 3,379.1 c/ Other tunas a/ - 84.5	
Yap				Skipjack - 3.6 Other tunas - 15.8	
Palau		Skipjack boats - 42 Tuna long line boats - 14		Skipjack - 6,947.4 Other tunas - 686.6	
Truk		Skipjack boats - 46 Tuna long line boats - 1		Skipjack - 7,217.1 Other tunas - 46.6	
Ponape		Skipjack boats - 17 Tuna long line boats - 5		Skipjack - 1,586.3 Other tunas - 17.3	
Jaluit		Skipjack boats - 2		Skipjack - 0.5 Other tunas - 8.0	

a/ Includes spearfishes
b/ Skipjack boats operated locally were less than 30 tons
c/ See Tables 17 and 19 for catch in other years
d/ Tuna long line boats operated locally were about 40 tons
ND: No data available
SOURCE: Data compiled by Japanese Tuna Fishermen's Association.

TABLE 19 - TUNAS, EXCLUDING SKIPJACK, LANDED IN MANDATED ISLANDS, 1922-40 a/
(metric tons)

Year	Saipan	Yap	Palau	Truk	Ponape	Jaluit	Total
1922	1.31	ND	ND	ND	2.36	2.40	6.07
1923	1.25	1.24	ND	ND	1.76	2.40	6.65
1924	1.53	1.54	6.75	ND	0.80	1.34	11.96
1925	1.40	1.44	5.31	ND	2.66	1.50	12.23
1926	2.31	0.75	48.30	0.34	4.50	0.83	57.53
1927	2.91	0.38	41.27	0.14	6.58	3.05	54.27
1928	1.26	1.05	15[illegible].33	ND	7.75	1.29	164.13
1929	0.56	0.76	107.94	0.40	1.62	0.22	[illegible]
1930	4.53	0.77	92.26	8.53	3.54	2.37	112.00
1931	16.73	0.46	156.61	29.43	4.33	3.85	211.41
1932	48.24	ND	137.62	5.18	34.69	135.72	361.45
1933	0.31	ND	242.23	55.39	41.42	25.87	365.22
1934	27.26	7.67	278.88	55.39	26.49	31.36	427.05
1935	42.42	0.58	301.18	98.50	23.50	13.91	480.09
1936	151.02	ND	217.26	172.02	29.96	14.85	587.11
1937	88.82	ND	129.78	342.18	56.37	3.96	681.17
1938	33.94	2.21	73.13	101.44	60.21	ND	270.93
1939	34.38	7.40	182.44	93.60	31.55	5.14	361.54
1940	84.61	14.82	686.57	46.62	17.31	7.97	85[illegible]

a/ Includes spearfishes
ND: No data available
SOURCE: Statistical Yearbook of South Sea Islands, published by South Sea Government General.

TABLE 20 - TUNA LONG LINE CATCH LANDED AT MISAKI PORT, 1938-41

Year	Area of Operation: Japanese Waters (30°-40°N latitude): No. of Voyages	Japanese Waters: Total Catch (metric ton)	Ryukyu and Bonin Area (24°-30°N latitude): No. of Voyages	Ryukyu and Bonin Area: Total Catch (metric ton)	Mandated Islands (0°-24°N latitude): No. of Voyages	Mandated Islands: Total Catch (metric ton)
1938	478	4,642	476	7,963	185	5,319
1939	455	4,824	309	5,306	236	5,148
1940	412	5,312	212	2,571	239	8,470
1941	167	1,361	137	2,844	124	5,373

SOURCE: Data compiled by Misaki Tuna Fishermen's Association

TABLE 21 - TUNA LONG LINE CATCH IN THREE MAJOR FISHING AREAS BY VESSELS OPERATING FROM THE PORT OF MISAKI DURING 1939

Area	Number of Voyages	Average Fishing Days per voyage	Average Tonnage per Vessel	Total Catch (metric ton)	Average Catch per Fishing Day per Ton of Vessel
Japanese waters: (30°N - 40°N latitude)	412	15	45	5,312	0.0191
Ryukyu and Bonin area: (24°N - 30°N latitude)	212	14	56	2,571	0.0155
Former mandated area: (0° - 24°N latitude)	239	13	113	8,470	0.0241

SOURCE: Data compiled by Misaki Tuna Fishermen's Association

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