TUNA LONGLINE FISHERY AND FISHING GROUNDS

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TUNA LONGLINE FISHERY AND FISHING GROUNDS

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TABLE OF CONTENTS

Page

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by

Hiroshi Nakamura

Introduction

The Japanese tuna fishery, which formerly had for its fishing grounds almost the whole western Pacific and a part of the Indian Ocean, wherein its small vessels roamed at will, was reduced by the Pacific war to such a nearly complete state of destruction that little was left to remind one of its former condition.

On the one hand it was forced to accept restrictions which can only be called mortal in the form of an iron chain of limitations upon its fishing areas, and on the other hand it lost a large number of fishing vessels and the excellent advanced bases in Okinawa, Formosa, the Ogasawara Islands, and the mandated South Sea islands. With even the materials necessary for fishing difficult to obtain, the problems faced by this fishery were certainly not easy ones.

When we look at the course taken by this fishery from the end of the war to the present day, we see that despite the many difficulties and obstacles mentioned above the tonnage of its fishing vessels has already in a comparatively short period recovered to a level close to that of before the war. This fact demonstrates the unstinted efforts of the people engaged in this fishery, efforts which are truly worthy of admiration. However, considering this situation coldly, we must also admit that the rapid tempo of recovery in this fishery reflects the confusion in Japanese fisheries circles after the war and the fact that this fishery became the object of investment as a measure to relieve the depression in other industries. Consequently, it can hardly be said that this fishery has undergone a substantially healthy recovery. In fact, it has a character which can hardly be considered under the heading of rapid progress. Now, 4 years after the war, the tuna industry cannot be said to be as promising as was hoped at the beginning of its new start, but it appears rather to be fraught with many problems and hardships.

The cause of these problems and hardships is probably the same as that of the hardships which beset the Japanese fishing industry as a whole, that is the restriction on fishing grounds. In part too it should probably be considered due to the overall abnormality of the Japanese fisheries in recent years caused by so-called oceanographic abnormalities.

Because the waters opened to Japan's fisheries are largely those off her Pacific coast, a good deal of objectivity can probably be detected in the fact that the tuna fishery has been temporarily in the spotlight and has come in for a great deal of attention. When we come to the question of how much of a scientific nature there was in the manner in which this attention was given to the fishery, we cannot unfortunately give any answer. The sad fact is that we have hardly any scientific knowledge which could have been considered in connection with this fishery. Expressed concretely, what we mean by knowledge of a scientific nature would be such things as how many vessels should be permitted to operate in the waters allowed to us, in view of the size of the resources, and how much they could be expected to produce. With regard to such questions, is there not at present almost no one who could give an accurate analysis?

The tuna, along with the snapper and the carp, is among the fish with which the Japanese are best acquainted, its name being known even to 3-year-old children. However, scientific knowledge concerning these fishes is extremely poor and this fishery can be thought to be the most primitive in character which we have.

The reasons why the tuna fishery is productively at an extremely low ebb are set forth in this book in the section on the characteristics of the tuna fishery, but to put it briefly, it is because this fishery is largely lacking in planability or stability. The reasons for this are that, because the range of distribution of the fishes which are the object of the fishery is extremely broad and these fishes perform migrations on a large scale, not only can the essential nature of the resource not be easily grasped, but the investigation of the paths of the migrations and the factors controlling them are accompanied by remarkable difficulties and require great expenditures: for which reason we can hardly be said to have any knowledge concerning these phenomena.

Up to the end of the war the writer spent over 10 years in Formosa, where he was mainly occupied in the study of the ecology of these fishes. After the war he was ordered to undertake the study of the resources of the tuna fishery at this research station, in which work he is presently employed. In order to determine research policies corresponding to the new conditions, the author has attempted to bring together data from tuna fishing experiments and fishing ground surveys carried on by fishery research agencies throughout the whole country during more than 10 years past. The object has been to see if it were possible by means of these data to get some knowledge concerning the migrational patterns and the stock and thereby to make some contribution to the stabilization of the tuna fishery. What has been accomplished in regard to these problems is, however, very little.

In the beginning the intention was only to write concerning the data referred to above, but the decision was made to cover in outline fishing gear, fishing methods, and other general matters concerning the tuna fishery. Consequently, the work is in part a repetition of some of the material in the author's book, The Tuna and Their Fisheries, published by the Takeuchi Book Store.

The tuna fishery is at present in a somewhat congested condition, but unlike other fisheries its fishing grounds are extraordinarily broad and are for the most part on the high seas away from territorial waters. What sort of treatment Japan's tuna fishery will receive in the future when the peace treaty is concluded, I do not know in the least. However, if the general international concept of the high seas continues to be guaranteed in the future, the time will surely come when this fishery will be permitted to operate freely. Until that day I hope to continue studying the essential character of the resource insofar as I am able, and attempting to contribute to the establishment of a planned, stabilized tuna fishery without any diminution of the resource. Corrections and contributions of data from the readers are requested.

I have dared to undertake the writing of this report, despite my lack of talent, in the hopes that my little knowledge and feeble effort might be of some use. A direct motive has been the urging of the director of this station, Dr. Morisaburo Tauchi, from whom I have received various assistance. I wish here to express my deep thanks to him. (January 2, 1948)

P.S.

During the writing of this manuscript a great revolution in fisheries research agencies has taken place, the former Fisheries Experiment Station of the Ministry of Agriculture and Forestry has been abolished, and the regional fisheries laboratories have been established. The writer has been appointed director of the Nankai Regional Fisheries Research Laboratory. Consequently, this report, which was to have been published by the Fisheries Experiment Station of the Ministry of Agriculture and Forestry, has been changed to a report of the Southern Regional Fisheries Research Laboratory.

March 30, 1950)

I. Types of Fisheries and Their General Description

There are three major types of fisheries for the tunas and spearfishes. The first is the net fishery, the second the hook and line fishery, and the third is the harpoon fishery.

A. Net Fisheries

There are two types of net fisheries having the tunas as their object. The first is that called the set-net or trap fishery, where the net is permanently fixed at a definite location. The second includes fisheries using movable nets, not fixed in one place, and it comprises round haul nets, drift nets, and gill nets.

1. Stationary net fisheries

An example is the large set-net. This type of net is held at one location by the use of anchors and floats and sinkers, so it is necessary that the place where the net is set up be not very deep. As it is naturally impossible to move the net at will, unless it is set up across paths travelled by the fish, it will be difficult for it to attain its objective of catching fish.

These two conditions place basic limitations on the establishment of this type of fishery. Places which fulfill these conditions are not to be found everywhere but are naturally extremely limited.

Places which meet the above two requirements, that is, locations suitable for the set-net fishery, are either on coasts where the water is comparatively deep close to shore, where the effect of run-off from the land is small, and where the coast faces directly on areas of warm current, or they are at places having such topography as the tips of capes or peninsulas at the mouth of large bays. However, even if these conditions are perfectly met, if the current and tides in the area are very strong, it will be impossible to set up the gear and the location will, of course, be unsuitable as a fishing ground.

Thus this type of gear does not have the positive character of chasing and catching the fish, but rather waits for the fish to come of its own accord into the net. Consequently, because of changes in oceanographic conditions and abnormalities in the weather, even though a net of the same construction is set up in exactly the same place, the catch will be good or bad from year to year and fluctuations in the catch will be difficult to avoid. The catch of such gear is not limited to the tunas, but other fish such as yellowtail and skipjack large enough to enter the net will all be taken by this type of fishery.

As this net is on a large scale it requires a considerable amount of capital to establish one. It may be thought that large sums of money can be earned in the course of one night with this type of gear, but when poor fishing continues for sometime and there is damage from rough weather, it is often found that one fine morning the whole property has been lost.

As the figure shows (Translator's note: figure omitted), the net consists of two parts, the lead and the heart. The lead cuts off the path of the fish and acts to direct them into the heart.

When a tuna comes swimming along and encounters the lead, he is frightened by the net and tries to escape, follows the net out to sea, and at last enters the heart of the trap. When fish enter the heart of the trap, a lookout who is on watch signals at an appropriate time to the tender boat. The boat is standing by the mouth of the heart and when the signal is received the men in the boat quickly close the opening of the heart so that the fish cannot escape. They then gradually haul the net in such fashion that the fish are driven into the bunt from which they are brought into the boat by means of gaff hooks.

There are among the tunas, as is set forth in a later section, several species. The different species each have their different habits. The bigeye tuna, the albacore, and the yellowfin tuna do not often approach coasts suitable for the use of large set-nets and therefore they are hardly taken by this type of fishery. Immature yellowfin, however, do tend to enter coastal waters and at their immature stages they are often taken. The black tuna and some of the spearfishes characteristically enter coastal water areas and therefore the catch of the set-net is principally these species.

It is not known when or by whom the set-net was invented and put into actual use. However, it is certain that the invention and application of this gear took place an extremely long time ago. The tuna trap shown in the figure is extracted from the Nippon Suisan Saihoshi[1/] and the outline of its construction is as follows.

"A large net in the county of Kochika in the province of Rikuzen is designed chiefly to take tuna, however, as it is a fixed fishing gear snappers, yellowtail, sardine, skipjack, tuna, and sharks all enter it.... The fishing ground is at the point of a cape where trees grow luxuriantly and where the coast line forms a rounded bay. It is located over 400 ken (200 yards) from shore in waters 25 - 26 fathoms deep and is set up in such a way as to embrace the mouth of the bay. The local tradition concerning the origin of this net ascribes its invention to one Saburō Torimi of the Abe clan, who taught the method to the fisher-folk. Under the old Sendai feudal lords, the net was insured by a grant of money from the local ruler for the repair of the net when it was damaged by stormy weather."

The catch of tunas by fixed gear according to statistics of the Ministry of Agriculture and Forestry for 1941 amounted to a total of 9,258,324 pounds. According to the same statistics, regions in which the catch amounted to over 10,000 kan (82,700 pounds) were as shown in the following table. From 1942 on the migrations of black tuna into Japanese coastal waters dropped off markedly, and for this reason the catch of tunas by fixed gear has diminished to almost nothing.

Table 1.--Catch by fixed gear in various regions (in pounds)

Region	Catch	Region	Catch
Hokkaido	2,050,629	Fukui	182,279
Iwate	2,919,781	Shizuoka	135,430
Akita	1,087,505	Tottori	619,357
Miyagi	558,605	Ehime	149,844
Toyama	144,799	Kochi	162,911
Ishikawa	156,055	Nagasaki	138,307

Notes: (1) According to Ministry of Agriculture and Forestry statistics for 1941.
(2) Only those prefectures having a catch over 10,000 kan (82,700 pounds) are shown.

2. Drift-net fishery

In this fishery, unlike the trap fishery, the nets are loaded into the fishing boat and carried to the place where they are to be used. Consequently, it has the characteristic of mobility, and can be said to be of a more positive character than the trap fishery.

In catching small birds a so-called "mist net" is used, and the drift-net may be thought of as a mist net used in the sea. In short, the net is stretched across the path of the fish, and waits for passing fish to be caught in it.

Tuna generally swim in the direction of flow of the current, and therefore the net must be set roughly at right angles to the current. Furthermore, as the depth of the net is quite

1/ Published by the Fisheries Bureau of the Ministry of Agriculture and Commerce in 1910. The author has supplied suitable diacritical marks to assist in the reading of the Chinese-style text of the description.

insignificant in comparison with the depth of the sea, it goes without saying that it can take only those fish which swim at the very surface. Consequently unless this gear is used at a place and at a time where the tunas swim in the surface layer, it will not attain its objective of catching fish. Also, the tunas naturally have the power of sight, and when they encounter a net, they will try to escape, so this gear is useless unless employed at night, when the meshes of the net cannot be seen.

The factors which control the vertical distribution of the tunas are thought to be principally such things as light, temperature, and water pressure. As far as light is concerned, fishes in general share the characteristic of inhabiting deeper levels during the day than during the night. This characteristic appears also in the tunas, and is particularly marked in the case of the bigeye tuna.

With respect to temperature, the majority of tuna species are basically warm-water fishes, preferring to inhabit sea areas having warm waters. They are thought to be extremely sensitive to changes in temperature, but this means only that the limits of the temperature at which they will live are clearly marked, and does not mean that the range of temperatures which they can withstand is narrow. It is thought that the range of temperatures which they can endure is rather broad. It is known in the waters of the low latitudes they generally swim at fairly deep levels. In such areas temperatures at which the tunas can live are found at the surface, at the 100-meter level, and in some cases even deeper. From an examination of a considerable amount of data, it appears that in the waters of the low latitudes, the tunas are generally most abundant in the vicinity of the 100-meter level. Compared with the temperatures which are thought to be most favorable for the occurrence of tuna in Japanese waters, the water temperatures at the 100-meter level in tropical seas are rather high. This fact is thought to show that in some circumstances the effect of water temperature on vertical distribution is not very great, indicating that the action of light is more important. The above-expressed opinion that the density of distribution is greatest in the vicinity of the 100- meter level is not actually based on any study of the density of distribution, but rather on the circumstances under which catches are made in the longline fishery, and therefore it may naturally be thought that the strength of the light rays may be a factor in making the fish easier to catch. However, at present it is impossible to conclude whether light or temperature is the most important factor in determining the vertical distribution of the tunas.

As far as water pressure is concerned, the adaptability of the tunas to changes in this factor is thought to be extraordinarily great. In tropical waters, for example in the Celebes Sea, they occur in considerable density as deep as well over 100 meters, and they also occur practically on the surface. In short, it is thought that they can withstand water pressures ranging from about 1 to well over 10 atmospheres.

Other fishes are known which can withstand considerable changes in water pressure where the changes occur gradually, but ordinarily they cannot withstand sudden changes. The tunas, however, are thought to have remarkable resistance against sudden changes in water pressure. For example, if we look at the behavior of tunas when they are hooked, we see that they sometimes make one deep dive, going so deep that the glass ball which is used as a float is crushed by the water pressure. As was noted above, in tropical sea areas the identical species is distributed at markedly greater depths than it is in waters of higher latitudes, and is thought to be able to withstand more violent changes in external pressure, for which reason it can be concluded that the effects of external pressure are not very important in determining the vertical distribution of the tunas.

It has already been stated that temperature and light are the main causes of the vertical movement of the fish. In Japanese waters, off Hokkaidō and the northeastern coast of Honshū, a warm current forms a shallow layer on the surface, below which runs the cold current of the Oyashio. In waters presenting oceanographic conditions of this sort, the tunas naturally are distributed only in the surface layer, affording favorable conditions for the drift-net fishery.

A boat which has arrived on the fishing ground sets nets in the evening. As was stated earlier, the net is set at a right angle to the flow of the current. Buoys are attached to the net, as shown in the figure, and a line called the myakuzuna ("pulse-line") is fastened to the boat, which turns its bow upcurrent and drifts, waiting for the fish to strike the net. The myakuzuna not only performs the function of connecting the boat and net, but it also transmits to the boat the impact when the tunas strike the net. The hauling in of the net and the taking of the fish are generally begun at dawn, but when the catch is large the nets may be hauled several times during the night.

This fishery has completely decayed in recent years, and there are no boats engaged in it at present.

(Translator's note: figure 2, a rough sketch of a drift-net, is omitted.)

3. Round haul net fisheries

This type of fishery can be said to have an even more positive character than the drift-net fishery. In fact it can be said to be the most positive of all the tuna fisheries. There is one method which has been in use in Japan since ancient times, and another, the American-type purse seine, which has been imported from America in recent years. Concerning the old method, the following description has been abridged from the Nippon Suisan Saihoshi.

Ordinarily from three to five boats form a team, with 10 to 15 fishermen on each boat. Arriving on the fishing grounds these boats separate and quickly surround an area of the sea with their nets, cutting off the escape of the tunas and finally driving them into the bunt of the net.

The American-type purse seine has already been in use for over 20 years in America and its use is increasing from year to year, the catch by this method having gradually approached and in some regions surpassed that from the pole and line fishery. The catch appears to be mainly young tunas and skipjack.

This fishing method was imported into Japan after the end of the second World War. In 1948 the Suisan Kenkyū Kai, in cooperation with the Tokyo Fisheries Company, tested this fishing method with the Shiroyuri Maru (100 tons). During the trial period of about 1 month a total of about 80 tons of skipjack and tunas (about 21,000 kan) were taken, attesting the feasibility of this fishing method. In 1949 five purse seiners fished and took about 744,300 pounds. The principal catch was skipjack and young bigeyed tuna.

The construction of the gear varies depending upon the type of boat, but figure 3 shows one type in use (Translator's note: figure omitted). The following table lists the materials employed.

The materials used in the net shown in figure 3 are listed in the following table. (knotless net was used).

When a school of fish is sighted, the net is set so as to cut across the line in which they are moving, it is hauled around the school, the lead line is pursed up, and the fish are captured. These operations are almost entirely carried out by the use of machinery, making the operation extremely efficient.

The fishing grounds up to the present have been almost completely limited to the waters off northeastern Japan. As this area presents oceanographic conditions which make the tunas and skipjack swim in the surface layers, it is well suited to this fishery. The question of whether or not this fishery can be established in the warm currents of the south, where oceanographic conditions are different, can only be clarified by future experimentation.

Table 2.--Materials required for an American-style purse seine

Item	Type: Size (thread)	Mesh (sun)*	Depth (meshes)	Quantity	Unit weight 100 meshes, 600 ft.	Total weight
					kan*	kan*
20-count cotton	90	4	100	600 x 2	33,600	367,200
"	70	3,5	100	600 x 7	23,800	999,600
"	120	6,5	50	606 x 1	40,800	244,800
Total						1,611,600
20-count cotton	(spares 20%)					320,000
"	(for repair 5%)					80,000
"	(for sewing 3%)					50,000
Total						2,061,600
Rope						4,000 pounds
Wire rope						1,000 kg
Lead						2,000 kg
Rubber						300 kg
Coal tar						6,000 kg

Note: This table and figure 3 are both taken from the Suisan Kenkyū Kaihō No. 2, November 1949.

(Translator's note: *1 sun = 1.2 inches **1 kan = 8.27 pounds)

The amount of the catch by the drift-net fishery is not known, but according to Ministry of Agriculture and Forestry statistics for 1941 the catch by round haul nets was 1,627,263 pounds. This was about 1/6 as much as the catch by set-nets for the same year.

B. Hook and Line Fisheries

The mainstay of the tuna fisheries at present are the hook and line fisheries. If, for example, we consult the statistics of the Ministry of Agriculture and Forestry for 1941, we find that the total catch of the net fisheries was about 10,751,000 pounds, while the catch by the hook and line fisheries, as shown in the following table, was about 6 times as great.

Table 3.-- Tuna catch by the hook and line fisheries (Ministry of Agriculture and Forestry statistics, 1941)

Type of Fishery	Amount of Catch (pounds)
Longline fishery	51,524,606
Pole and line fishery	12,867,797
Total	64,392,403

The above table gives only the tuna catch, but the longline fishery took in addition 13,298,061 pounds of spearfishes, giving a combined total for tunas and spearfishes of 77,690,464 pounds. In addition it is estimated that the shark catch by the longline fishery amounts to around 45,485,000 pounds, so if all of these are included, the catch will be a little less than 124,050,000 pounds.

The hook and line fisheries are, as shown in table 3, divided into the longline fishery and the single line fishery, the latter being further divided into trolling and pole and line fisheries.

1. Trolling

In trolling a number of lines are paid out from the fishing boat with artificial lures or baited hooks attached to their ends. The boat runs back and forth pulling these lines and captures tunas, bonitos, and spearfishes. The use of hooks with artificial lures is like the use of flies in fishing in streams. Various forms of artificial lures are used, depending upon the type of fish sought and the locality. (Translator's note: figure 4, a sketch of a trolling jig, is omitted.)

This is a fishery which is carried on widely, not only in Japan but also in Europe, America, Indonesia, and Micronesia, and everywhere upon exactly the same principles. The contrivances used in this type of fishing in America are more refined than those employed in Japan. Two or three feet ahead of the lure they attach what is called a "teaser." When the gear is trolled, the teaser appears to be a small animal being pursued by the lure, which is in turn seized by the tuna or skipjack. This is a very rationalized system and is probably advantageous because of the greater visual stimulus to the fish, but it is not known whether or not it improves the catch because there are no data from comparative experiments. It is recorded that the natives in the New Guinea area catch fish by using a kite made of nipa palm leaves to the tail of which a fish hook is attached.

Throughout Japan the trolling fisheries are just small scale coastal fisheries using small boats. The main items in the catch are skipjack, Auxis, Sarda, young tuna, dolphin, and cybiids. However, it is reported that in the times when black tuna occurred in very large numbers on the fishing grounds around Tanegashima and off Hokkaido, a rather large amount of black tuna was taken by this method. Aside from these vessels that specialize in trolling, the longline vessels in most cases troll one or two lines on their way to and from the fishing grounds.

2. Pole and line fisheries

In these fisheries poles are used to catch fish by hand. The tunas taken by these fisheries are mainly albacore and the young of other species. However, as will be described later, under some circumstances fairly large fish are also taken.

The number of fishermen varies with the size of the boat, but it runs from 10 to 30 or more. The boats have live-wells in which sardines are kept to be used as live bait. When the boats arrive on the fishing ground and a school of tuna is sighted, bait is scattered to concentrate the fish, which are then caught using either artificial lures or baited hooks.

The fishing method is exactly like that used in taking skipjack. When the schools consist of large tuna, two fishermen sometimes work together as a team. As figure 5 shows (Translator's note: figure omitted), the lines from two poles are joined together and attached to a single hook. As this means that the number of hooks is cut in half it might be thought inefficient, but since even slightly large tuna cannot be easily brought into the boat by the strength of one man, this use of two-man teams actually results in greater efficiency. By this method even large fish of about 30 kg weight can be lifted into the boat with one swing.

In America, as has already been stated, purse seining and pole and line fishing are the main methods employed in catching tuna, there being no longline fishery. It appears that plans are already being made for the advance of this fishery into the former South Seas Mandate area, and studies are being made of the distribution of bait and of tunas and skipjack.

Compared to the tuna longline fishery, this method has the advantage on the score of the exertion required of the individual fisherman, however, the essential weakness of this fishing method lies in the fact that it always requires live bait. According to the above-mentioned report of American explorations in the waters of the former South Seas Mandate, the establishment of this fishery in that region appears doubtful because of the bait problem. However, as everyone knows, the waters of that region are an excellent fishing ground for the longline fishery. The value of those fishing grounds will be discussed in a later section.

3. Drift line (nagashiyoma) fishery

This fishery has been carried on in the past, but it is not known whether it is at present. A brief account of it is given here because its concept contains some very interesting features. It is called nagashiyoma in the Nagasaki area and nagashinawa in the Izu region.

The fishing gear consists of a barrel, line, and hook. The barrel performs a double function as a float and a reel, with the line wound around it. A hook is attached to the tip of the line exactly as in the case of the longline, which will be described later, with a wire leader and a sekiyama. For bait sardines and squid are mainly used, and the gear is chiefly employed with the object of catching albacore (Translator's note: figure 6, depicting this gear, is omitted.)

When the hook has been baited, the line is paid out to a suitable length and allowed to hang down into the sea, the remainder of the line being then secured either to the barrel or upon itself with a thin string so that no more will unreel off the barrel. The string used for stopping the line must be neither too strong nor too weak. When a tuna takes the hook and begins to fight, it is necessary that the string be strong enough to set the hook thoroughly in the fish's mouth. When the hooked tuna attempts to dive deep, the string must be of such strength that it will break from the combined force of the buoyancy of the barrel and the pull of the fish.

When a tuna is hooked, the string breaks and the barrel spins violently, paying out the line. The fishing boat, which is standing by, immediately is rowed to the barrel and the line is pulled in by hand. The spinning of this barrel is described in old books as being just like a mill wheel.

Ordinarily one boat operates about 8 tubs, which are set in a line at suitable intervals. This is thought to have been the origin of the longline, which will be described later, but the relationship is not well known.

When the tunas are hooked, they tend to dive violently and deep. If the tub with its great buoyancy were acting directly as a float, there would be danger of the line's parting. On the other hand, if a float of small buoyancy were employed, there would be danger of its being pulled under by the fish. The idea of fastening the line to the barrel with suitable string, having this string broken by the pull of the tuna, and having the barrel revolve and pay out the line is the same in principle as the modern reel.

The catch of the hook and line fishery was mentioned earlier, the amount exceeding the catch by all net fisheries for the same year. Prefectures with a catch of over 10,000 kan (82,700 pounds) and the amount of their catch are given in the following table.

Large catches are shown for Miyazaki, Kagoshima, Shizuoka, and Okinawa prefectures. This pattern corresponds at many points with the skipjack landings, showing the relatedness of these two fisheries.

Table 4.--Tuna catch by hook and line fisheries in various localities (1941, Ministry of Agriculture and Forestry statistics)

Locality	Catch (pounds)	Locality	Catch (pounds)
Miyagi	1,045,957	Fukushima	250,689
Chiba	119,105	Tokyo	156,683
Kanagawa	160,769	Shizuoka	2,640,495
Mie	1,077,912	Wakayama	505,371
Tokushima	198,166	Kochi	197,405
Nagasaki	134,942	Miyazaki	4,024,959
Kagoshima	1,387,590	Okinawa	874,280

4. Longline fishery

The longline fishery is the most important of the tuna fisheries, both in terms of the scale on which it is prosecuted and in terms of the catch.

The gear is built around one trunk line to which float lines (ukinawa or abanawa) and branch lines are fastened. In the old days hemp was used as material for the lines, but at present cotton is generally employed. The gear used in the spear-fishery of Kagoshima Prefecture employs lines of about 7 momme weight, but ordinarily 9 momme or 10 momme line is employed. This designation shows the weight in momme of five shaku of line (1 momme = 0.1325 ounce, 1 shaku = 1 foot).

The thickness of the line used has gradually increased in recent years, the main reason being the increase in the size of fishing boats with the increase in the number of units of gear used as another reason. At the end of the branch line a sekiyama is attached with a swivel. Formerly the sekiyama was made of a heart of high-grade Noshū hemp wound with cotton line, but at present this is hardly used at all, the ordinarily employed sekiyama being made of nine strands of No. 28 steel wire wrapped with cotton. A wire leader is attached to the end of the sekiyama. This leader is usually nine strands of No. 27 steel wire, but some fishermen claim that seven strands of No. 25 wire is best. The hook is attached to the end of the leader wire.

A glass ball 30 cm in diameter, with walls 8 mm thick, wrapped in netting, is attached to the float line as a float. Sometimes billets of paulownia wood about 3 inches in diameter are used as floats. In recent years iron or aluminum ball floats have come into use. The floats combine the functions of supporting the line, signaling the presence of fish on the line, and identification. The float functions and the marker functions are the most important. Ordinarily a flag of cloth or of palm fiber is attached to a bamboo pole to mark the float. At night in order not to lose sight of the line, light buoys are attached here and there. Formerly carbide lamps were used for this purpose, but at present battery-powered lights are generally used. As the disappearance of the line means a very serious loss, recently such plans as the attachment of a device to the float to transmit electrical waves which could be received by the fishing boat have been devised and will probably be put into actual use in the near future.

The construction of the lines varies depending on the type of fish sought, the locality, or the individual fisherman, but the basic form is invariable. In any case there is a single main line with a number of branch lines and float lines made so as to hang the hook at a suitable depth.

Gear is ordinarily counted in terms of baskets or of skates. Formerly each section of line was put away separately in a basket, but these are hardly used at all at present because of their bulk. The unit of gear is a hold-over from this former practice.

The length of the main line of one basket is subject to various changes, but those in use at present are generally of about 300 meters. To this usually one float line is attached. The float line's length is not fixed but can be suitably adjusted depending on the fishing ground. The branch lines in common use at present have a cotton part of about 15 meters, and sekiyama and wire leaders of 3 to 5 meters each. This, however, is not invariable but differs with oceanographic conditions and the species of fish that is sought. A particularly marked example of variation is found in the gear used for black tuna in Miyazaki Prefecture, in which each basket has only one branch line, a rather long one. In gear designed to take spearfishes and albacore generally the branch lines are short and numerous, there sometimes being more than 10 branch lines in one basket. In recent years, however, even albacore lines show a trend toward longer branch lines and a smaller number per basket. The reasons are thought to be related both to the supply of material and to catch rates.

The number of units of gear employed at one time varies with the size of the vessel, in recent years it has increased rapidly so that the large boats are actually using 300 to 350 baskets. Assuming that each basket has 5 hooks, the number of hooks fished each time ranges from 1,500 to 1,750. If the length of the main line is, for example, 300 meters, the total length of the gear will be 90 to 100 kilometers. In actuality the main lines are not stretched taut but sag about 60 percent. The use of such large quantities of gear is principally for the purpose of increasing the catch per day, but it can also be thought to increase the chance of the line's encountering schools of fish. However, as considerable strain is put on the material, this cannot help shortening the life of the line.

If the scale of operations outlined above is compared with the trolling and pole and line fisheries, it should be clear that the longline fishery is in quite a different category as far as the size of the undertaking is concerned.

Both large and small vessels are engaged in this fishery. Before the war vessels in the 200-ton class were being constructed. Since the war there are some boats in the 200-ton class, but the majority of them have followed the standards for the 45, 75, 90, and 135-ton classes. The present fleet numbers 1,236 boats, with a total tonnage of 101,260.26 tons and total horsepower of 192,233.6. The following table gives a breakdown.

This fishery has grown up in very close association with the skipjack pole and line fishery. In the past the boats engaged in the skipjack fishery during the summer have shifted to this fishery during the winter, however, in recent years there has been a tendency for the number of fishing boats specializing in this fishery to increase and about 25 percent of the boats listed above are full-time tuna longliners.

As the large vessels ordinarily require 60 days or longer per voyage, they can make about 4-1/2 to 5 cruises per year. Hitherto the catch has generally been preserved by means of ice, but recently there has been a tendency toward a gradual increase in the number of vessels equipped with refrigeration machinery.

Having completed the loading of provisions, drinking water, fuel, fishing gear, bait, and ice, and with all preparations complete, the vessel leaves its base and heads for the fishing grounds. As soon as it arrives on the scheduled grounds, the work commences.

Table 5.--Present fleet of skipjack and tuna boats

(as of Sept. 20, 1949)

Size	<50 ton	50-100 ton	100-150 ton	150-200 ton	200 ton <
Number of vessels	377	572	135	148	4
Percentage	30.5	46.3	10.9	13.4	0.4

Note: From *Suisan Jihō*, April 1950.

Setting of the lines ordinarily begins before dawn. The lines are thrown from the deck at the stern while the vessel is underway. The joining of the trunk lines, transportation and attachment of bait, the attachment of floats and light buoys, etc., are performed rapidly by a skillful division of labor. When the setting of the scheduled number of baskets of line has been completed, the vessels begin patrolling back along the line. The floats are kept under observation and if there is any catch on the line the fish are brought into the boat. When the number of units of gear set was small, the vessels patrolled the lines several times and ordinarily began hauling lines around sunset. However, at present, when the number of baskets of gear set at one time is extremely large, the time needed for hauling lines is long and there is no opportunity to patrol the lines carefully.

A line-hauler is used to haul the lines. In some cases the line-hauler is powered by electricity, but in other cases it is turned by a belt operated directly off the boat's engine. The machine is of simple construction with two rollers turning in opposite directions. In order to prevent slippage of the line, the rollers are covered with rubber.

The speed at which the line-hauler is run and the speed of the vessel must be adjusted in various ways depending on the condition of the line. The line-haulers in use at present can ordinarily handle 400 to 800 feet per minute. Although the machine does wind in the line, it is not a case of simply hauling the line into the boat by force. When there are fish on the hooks, they must be brought into the boat, and if the line is tangled, the tangles have to be cleared so that the gear will be ready for use the following morning. Consequently it takes over 10 hours to get the line in and it not rarely happens that the work is carried over to the following day. This work is also carried on by a very systematic division of labor.

Working in this fashion from before dawn to midnight with almost no time to rest, living in a small boat with no comforts or recreation, and repeating the same operation 20 or 30 times, the exertions of the men employed in this fishery are by no means commonplace.

Squid, saury, mackerel, and sardines are most commonly employed as bait. *Trichiurus* has also been used with good results and herring are sometimes used. The fact that live bait is not necessary as it is in the pole and line fishery is an extremely strong point of this fishing method. This fact makes it possible to operate over long periods of time and to develop fishing grounds at great distances. Bait is brought from the base in ice or frozen. At times even salted bait is used. In former times when the number of units of gear fished was smaller, some boats eked out their supply of bait by catching squid on the fishing grounds after hauling the lines. Boats based in Formosa used to employ as bait chiefly milkfish (*Chanos chanos*), which were raised in ponds. As this fish is cultured widely throughout the southern areas, it offered the possibility of large scale utilization as longline bait in cases where we were able to have bases in the south where bait fish are scarce. Besides the milkfish, the ginkagami (Mene maculata) was used, particularly where spearfishes were the objective of the fishery.

Considerable attention is given to the selection of bait because of the idea that the type of bait will cause variation in the species making up the catch and in the success of the fishing. However, in actuality the effect that the type of bait has on fishing success is not well understood and it cannot be thought that it makes such a very great difference. For example, in the data from investigations of yellowfin grounds in southern waters it is difficult to perceive any noteworthy differences in the catch rate whether squid, frozen sardine, frozen herring, or salted sardines were used. Furthermore, when we examine the stomach contents of tunas and spearfishes, we find that they are quite heterogeneous, the foods which are most abundant in the area of catch or those which are thought to be comparatively easy to capture being predominant. It is considered that these facts indicate that these fishes have a low degree of preference or selectivity with regard to their food.

The suitability of a bait, though of course it varies with the species, is determined by whether it keeps well on the hook, whether it is of a handy size, and whether it will easily catch the eye of the tuna. The matter of the keeping qualities of the bait, of course, means the state of its preservation. As far as ability to catch the eye of the fish is concerned, the optimum condition is probably a bait which is alive and moving about.

It is not known when the longline fishery began nor who started it. It is said however that it has been carried on since quite ancient times. The author has not yet had an opportunity to investigate its history and consequently knows none of the details about it.

The fact that the tunas have borne a deep relationship to the inhabitants of the Japanese archipelago since very ancient times is clearly shown by the fact that tuna bones are often discovered in shell mounds.

We have no way of knowing by what method the tunas were taken in those times. It is very hard to believe, however, that in that period when dug-out canoes were used the people were carrying on a very large scale fishery. It is imagined that the fish were taken by simple hooks, perhaps by some sort of fixed gear along the coast, or by harpooning. As far as the hook and line fisheries are concerned they probably developed on a gradually increasing scale from pole and line or hand line gear to trolling and drift lines, the tuna longline finally being devised as a development from the drift line or the bottom longline.

It has been recorded that longlines of the same type of construction as those in use at present were fished in the Bōsō area well over 200 years ago and that they had considerable success even at that time. The tradition in the Izu region is that the gear was originated by one Fujii in the Kaei Era (1848-53). In any case, considering the size of the fishing boats of that time, it seems certain that the fishery was on a small scale and that the fishing grounds were limited to coastal waters.

From the beginning of the Meiji period (1868) to about the 40th year of the Meiji Era (1907), when engines first began to be employed in fishing boats, the course of development of the fishery as given in the Awa Suisan Shi was generally as follows.

The tuna longline boats used in the Bōsō region before the Meiji period were rarely of greater than 6-foot beam. In the early years of Meiji the boats increased somewhat in size, but even so the maximum was about 6-foot 3 to 4 inches beam. The standard gear in use before the Meiji period had a trunk line of 300 fathoms with 15 branch lines per skate. The amount of gear employed by a boat at one time appears to have been about 5 skates. This would be about 75 hooks. As the years passed the size of the vessels and the number of crew members gradually increased.

Around the 14th and 15th years of the Meiji Era (1881-82) shipbuilding techniques progressed greatly, the size of the vessels gradually increased, and the fishermen began to spend 2 to 3 days at sea on each trip. As the size of the vessels increased, the area of operations also gradually extended.

In the early years of the Meiji period the area of operations did not exceed the distance of 25 miles from the coast, by the 15th year it had been extended to 38 miles, by the 20th year to 50 miles and thereafter until around the 40th year of the Meiji era (1907), it was extended at approximately the rate of 1 ri (2.5 miles) per year until the fishing boats from the Bōsō (Chiba Prefecture) area were active from waters off Chōshi to the coastal waters of the Izu archipelago.

Thus the fishing grounds were extended from year to year, with the small sail- and oar-propelled fishing boats of that time. This extension of the fishing grounds was accompanied by an increase in losses of vessels and a great increase in the number of fishermen lost. For this reason in the Tomisaki area this gear was called the "widow line". This strange name is an expression of the extremely tragic situation in which a large number of young men were lost in this fishery, leaving behind numerous widows. (The foregoing is abstracted from the Awa Suisan Shi.)

In this manner the fishery has advanced step by step, however, the tempo of that advance was by no means fast and in the process a great many lives were lost. In the latter years of the Meiji Era internal combustion engines came to be used as propulsive power in fishing boats, and this brought about a great change which might be called the industrial revolution in this fishery.

It is said that the first man to consider and try the use of a fishing vessel powered by an internal combustion engine was Mr. Bunshichi Maruo of Shizuoka Prefecture. He was not a fisherman but rather was engaged in ocean freight carrying, but in the course of his voyages he had often encountered large schools of skipjack and conceived the idea of attempting to operate a skipjack fishing vessel powered by an engine. Mr. Maruo installed a 5-horsepower engine in a 20-ton Western-style sailing vessel and began fishing for skipjack out of the port of Shimizu. That was in Meiji 36 (1903).

Mr. Maruo's experiment unfortunately ended unsuccessfully, but it provided the motive for the construction of a powered vessel, the Fuji Maru, in 1906 as the Shizuoka Prefecture experimental fishing vessel.

When the Fuji Maru began its work it was the focus of attention in skipjack fishing circles, and as the results of its operations were extremely successful, it provided a strong stimulus to the industry. In view of the success of this vessel, the Shizuoka Prefectural authorities adopted an extremely appropriate and positive subsidization policy with the result that in 1909, only 3 years after the construction of the Fuji Maru, there were actually 150 powered vessels in the Prefecture.

Next the Isuzu Maru was constructed as an experimental vessel by Mie Prefecture. This vessel, too, enjoyed good success and the industrial revolution in this fishery spread throughout the country with the rapidity of a prairie fire.

At that time fishing boats were generally of about 20 tons and 20 horsepower, but thereafter they gradually increased in size until steel vessels of 200 tons and 400 horsepower were built for skipjack and tuna fishing.

At the time when power boats first came into use the fishing grounds were limited to coastal waters, but with the increase in size of the vessels, the navigational techniques of the fishermen were greatly improved, and the radius of operations extended from year to year. In the late years of the Taishō Era (1912-25) boats were fishing from the waters off northeastern Honshū to the Ogasawara and Okinawa islands, and in the early years of the Shōwa Era (1926-)

the so-called Nojimasaki fishing grounds for albacore in the central Pacific were developed. At about the same period fishing vessels from prefectures in western Japan such as Kagoshima, Kōchi, Wakayama, and Mie, led by their prefectural research and exploratory fishing vessels, began to fish in the distant South China Sea, Sulu Sea, and Celebes Sea. After 1936 it gradually became clear that the waters of the former Japanese mandated South Sea islands were excellent yellowfin fishing grounds and large boats based at the port of Misaki in Kanagawa Prefecture began to compete with each other in fishing that region. This condition continued up to the beginning of the war, with the Misaki fleet fishing tuna grounds within an operating radius of about 2,000 miles.

There was also a large number of fishing boats based in Formosa and in the South Sea islands. Those based in Formosa numbered 700 vessels, with a total tonnage of 6,000 tons, and they fished grounds in the waters east of Formosa, in the South China Sea, the Sulu Sea, the Celebes Sea, and the East Philippine Sea, their operating radius extending about 1,000 miles from the port of Takao.

The above figures give the operating radius for single vessel operations, but in mothership-type tuna fishing carried on experimentally from Takao before the war the range was further extended to take in the Banda, Flores, and Timor seas, and the Indian Ocean coast of the Greater and Lesser Sunda archipelagos.

The foregoing are the ranges within which commercial vessels actually fished, but many research vessels and the training ships of the Fisheries Institute surveyed in addition to the areas mentioned above the coastal waters of New Guinea and the Solomons to the south, the coastal waters of Sumatra, the Andaman, and Nicobar islands to the west, and even went as far as the Maldive Archipelago in the middle of the Indian Ocean. Thus the waters in which Japanese actually set their tuna longlines in one way or another cover an extremely broad area from 70° E. longitude to 165° W. longitude and from 15° S. latitude to 45° N. latitude. If to this we add the waters fished by Japanese emigrants in Hawaii and California, it is probably no exaggeration to say that all of the warm seas from the central Indian Ocean east across the whole Pacific have been developed by Japanese or by Americans of Japanese origin. There is probably room for reconsideration and reason for criticism concerning the question of whether or not the measures, methods, and spirit with which this development was undertaken were all that they might have been, but leaving aside that problem, development of these fishing grounds can be expected to make no small contribution to the prosperity of the human race in the future. From this point of view it is truly a great accomplishment which deserves to be writ large on the pages of the world's fisheries history.

As was stated earlier, the tuna longline fishery made a great revolutionary step forward through the application of internal combustion engines to fishing boats. The adoption of the line-hauler, too, was another extremely significant force for the development of this fishery.

It is recorded that the line-hauler was imported from England and first came into use in 1911. The length of the main line of one skate of gear is about 300 meters. As from several score to 300 to 350 skates may be used at one time, it would be absolutely impossible to raise the gear in a short time by the use of manpower. The adoption of the line-hauler can be said to have supplied the solution to this problem of time and labor. In other words the utilization of the internal combustion engine increased the operating radius of the fishing boat and the adoption of the line-hauler remarkably improved the efficiency of the work.

Thus the utilization of machine power was a force which operated for the rapid development of this fishery, and the progress of that development in terms of catch is shown by the following table.

Table 6.--Landings in Japan (from Ministry of Agriculture and Forestry statistics for the tuna longline fishery)

Year	Catch (pounds)	Index
1925	28,578,622	52
1929	49,092,209	81
1930	54,874,940	100
1934	54,062,098	99
1935	47,903,702	87
1936	67,316,014	123
1937	61,071,345	111
1938	69,543,315	127
1939	94,637,530	172
1940	77,750,694	142
1941	51,524,606	94

Note: 1. The index number takes 1930 as 100.
2. The reasons for the decline in 1934 and 1935 are unknown.
3. The sharp drop in the catch in 1941 is assumed to be due to a decrease in the number of vessels fishing because of the war.

The above figures represent only the catch of tunas, but in addition there were 3,000,000 to 4,000,000 pounds of spearfishes and an unknown but large amount of sharks. As for the situation outside of Japan proper, in Formosa the Government-General began investigations in 1913 and continued collecting statistics regularly thereafter. The catch for that region is shown in the following table.

Table 7.--Tuna longline catch in Formosa (Formosan Fishery Statistics, 1936)

Year	Tunas (pounds)	Spearfishes (pounds)	Total (pounds)
1932	6,669,136	7,156,967	13,826,104
1933	6,708,371	7,078,450	13,786,821
1934	7,069,623	9,817,720	16,887,346
1935	6,699,488	9,327,267	16,422,755
1936	11,120,212	8,694,086	19,814,298

Note: (1) Converted from <u>kin</u> to pounds at the rate of 1 <u>kin</u> = 1.32 pounds.
(2) Figures in this table are not actual values but deduced values, however, their accuracy is rather high.

As I do not have at hand statistics for the years from 1937 on I cannot show the situation in recent years, however, the catch in 1940 appears to have been around 37,215,000 pounds. As will be described later, the catch at Formosan bases had a very high proportion of spearfishes, in many cases over half. In addition the catch of sharks by longlines was around 4,000,000 to 4,500,000 pounds.

With the beginning of investigations by the former South Seas Government-General, the waters of the so-called Inner South Seas area were gradually revealed as superior fishing grounds. From around 1936 on this area was fished by large boats based at the port of Misaki in Kanagawa Prefecture in addition to the boats based within the South Seas. The following table shows the operations and catch of Misaki-based boats.

Table 8.--Number of vessels operating in waters of the South Seas Government-General and their catch (Ministry of Agriculture and Forestry statistics)

Year	Boats (cruises)	Catch (pounds)	Catch per Boat (pounds)
1936	84	4,335,688	51,613
1937	128	8,496,515	66,375
1938	191	7,991,483	41,846
1939	84	5,699,403	67,847

Note: (1) The above figures are the total for tunas and spearfishes but do not include sharks.
(2) About 75 percent of the catch was yellowfin.

With this extension of the fishing grounds the actual number of fishing days gradually decreased in relation to the number of days required for a cruise. In other words, the number of days required to go to and from the fishing grounds increased until it was equal to or greater than the number of days during which fishing was actually carried on. In single vessel operations this sort of situation arises naturally, and in such a situation the overhead expenses naturally rise. Furthermore, as the China Incident gradually became more serious the supply of materials required for the fishery became very uncertain due to preparations for the Pacific war. In particular the strengthening of controls on fuel and strong demands for its conservation made it very difficult for vessels to operate singly in the southern region. The so-called mothership-type tuna fishery was conceived as a device to overcome these difficulties. Within Japan proper its chief proponent was the Kaiyō Gyogyō Kyōkai, which began a campaign to interest all parties concerned.

The plan proposed by the Kaiyō Gyogyō Kyōkai, as can be seen from the following summary, combined the mothership-type operation with advance base facilities and therefore can hardly be called a pure mothership-type operation. However, the plan is presented here for the reader's reference because in these postwar days the necessity of mothership-type tuna fishing is again being strongly urged. Under the completely changed conditions of the present day it need hardly be said that the part of the plan relating to base facilities is out of the question.

Plan for the development of the tuna fishery in the South Sea islands (From Kaiyō Gyogyō, Volume 5, 1940):

The tunas are distributed over an extremely wide range in the South; the stability of their fishing grounds has been in general established by various investigations undertaken in the past. However, because of the distance of these grounds from Japan and the fact that they lie within the tropics, the only exploitation of the area has been the fishing done in the South China Sea, the Sulu Sea, and the Celebes Sea by boats based in Formosa. Boats from Japan have generally operated in the Pacific Ocean grounds in the vicinity of 180° longitude.

With the recent strengthening of the controls on fuel oil and other materials essential to the fishery, the vessels operating in the North Pacific have made a 90° turn and have sought fishing grounds in the southern Caroline Islands. Good results were obtained and an increasing number of vessels have continued to fish in this area. In 1938 a total of 39 large vessels made 145 cruises to take a catch valued at 1,560,831 yen. At the same time the researches of the South Seas Government-General Fisheries Experiment Station and surveys carried on by the Nankō Fisheries Company have shown the value of these grounds and the South Sea island grounds have quite suddenly become the center of the tuna fishery.

However, the present type of single vessel operation from Japan still has some disadvantages. As we fortunately have suitable advance bases in the area, it should be profitable to call together the large fishing vessels now operating singly, form them into an organized fleet, and assign to that fleet refrigerated cargo vessels which would carry the catch to Japan. (The rest of the plan is omitted.)

It was planned to use as motherships diesel-powered vessels of 500 tons, each mothership to transport the catch and supply necessary materials for six fishing vessels. It is imagined that the comparison between the income and expenditure of this type of operation and single vessel operation would be as shown in the following table.

Table 9.--Comparative income and expenditures of single vessel and mothership-type operations (plan of the Kaiyō Gyogyō Kyōkai)

Item	Single vessel (yen)	Fleet (yen)	Difference (yen)
Income	3,600,000	5,400,000	1,800,000
Expenditures	2,639,880	3,860,760	1,220,880
Profit	96,120	1,539,240	579,120

Note: (1) Catch per fishing boat per trip 82,700 pounds.
(2) Calculated at the price of 1 yen per kan (8.27 pounds).
(3) The foregoing table is for 6 fleets, a total of 36 fishing boats.
(4) From Kaiyō Gyogyō, Volume 5, 1940.

As was made clear above this plan is not for a pure mothership-type fishery, as it envisages the establishment of an advance base, and the reduction of the overhead expenses of single vessel operations by having the so-called mothership transport the catch and the operating materials for a number of fishing boats. In actuality this scheme never got beyond the planning stage and was never put into operation.

Mothership-type tuna fishing was tested by the late Technician Mokuichi Shimoda in 1932 and 1933. Earlier, beginning in 1930, the Fisheries Institute training vessel Hakuyō Maru had practiced tuna longline fishing in various regions of the South. As the exercises of the Hakuyō Maru could be considered a sort of mothership-type operation, the mothership experiments of Technician Shimoda were probably inspired by the Hakuyō Maru's results.

Technician Shimoda's mothership-type tuna fishing was a system in which the 1,537-ton Haruna Maru was employed as a mothership with two 9.6-meter, 45-horsepower boats and six 7.8-meter, 6-horsepower boats as catchers. The catcher boats were carried aboard the mothership, lowered each time they fished, and brought back aboard when the fishing was finished. As the mothership had refrigeration equipment and canning machinery and the catch was processed aboard the ship, it might be more appropriately called a combination floating cannery and mothership rather than a pure mothership-type vessel.

With this system the Haruna Maru operated experimentally off the Indian Ocean coast of Sumatra, around the Nicobar Islands, and in the vicinity of Timor. On the basis of its results it was concluded that mothership-type tuna fishing offered good possibilities.

However, to cite the weak points of the Haruna Maru's system,

1. A little rough weather makes it difficult to lower and bring aboard the fishing boats.

2. As the fishing boats are small, their activity is greatly limited by the weather.

3. Even in calm weather the fishing boats must always operate within sight of the mothership because they are unable to navigate on their own account.

4. No scouting vessels were employed as they are in the case of a whaling mothership.

Even in the so-called doldrums of low latitude seas the northern and southern monsoons sometimes blow with considerable force. Furthermore, sudden winds accompanied by fierce squalls often spring up making the use of portable catcher boats dangerous and interfering greatly with their operation.

While the practicability of mothership-type tuna fishing was being argued in Japan, an early start was made in Formosa. At the end of 1940 the Tōbu Suisan Company, a subsidiary of the Nippon Suisan Company, with the assistance of the Formosa Government-General, planned such an operation and began to put the plan into execution at the beginning of 1941.

The Tōbu Suisan Company employed as motherships the Ōi Maru and the Kitakami Maru, both of 500 tons, based at Takao. Six catcher boats were assigned to them. As these were fishing vessels of the 60 to 80-ton class, they were of course capable of navigating for themselves. One of the two motherships was on the fishing grounds at all times, directing the fishing fleet and freezing the catch aboard in the form of fillets. A mothership would remain with the catchers on the fishing grounds for about one month, during which time the other mothership was carrying the catch to the base, and loading provisions, fuel, bait, and other necessary materials to be carried to the fishing grounds. On arriving on the fishing grounds, this ship would take over direction of the fleet and the other mothership would head for the base.

When it was attempted to put this system into actual practice, it became painfully obvious that the catcher boats were too small. If they were unable to utilize the lee of an island, the transfer of catch and supplies at sea presented various difficulties and obstacles. The welfare of the catcher boat crews operating at sea over long periods also was probably a major problem.

Several operations were carried on by this method, the fishing being done in the East Philippine Sea, the Celebes Sea, the Banda Sea, the Flores Sea, and the Indian Ocean area. The results were disappointing at first because of unfamiliarity with the fishing grounds but they gradually improved. However, as this enterprise was subsidized by the government and was subject to the influence of the controlled economy of China Incident days, it differed considerably in character from an enterprise in a free economy, and though the results may be of value for reference they cannot be applied in their entirety to present conditions.

At about the same time the Hayashikane Shōten Company planned the same sort of an enterprise using a Formosan base, but this plan was not put into effect and the Tōbu Suisan Company also ceased its operations just before the outbreak of the Pacific War.

The tuna longline fishery, like other high seas fisheries, was forced to cease functioning during the latter half of the war. During that period more than half of the fishing boats were lost. At the end of the war the rebuilding of the fishery was viewed pessimistically, but recovery has proceeded at a surprisingly fast rate and today, 4 years after the end of the war, the number of vessels engaged in the fishery is nearly as high as it was before the war. As reasons for this rapid recovery we may cite the fact that the skipjack and tuna fisheries require less material than other fisheries and therefore were easy to enter in the postwar period of scarcities, the fact that postwar Japanese financial circles took a great interest in fisheries, and the fact that much of the area open to fishing by SCAP was skipjack and tuna grounds while there was little room for the expansion of other fisheries.

We cannot, however, be satisfied with the superficial type of recovery indicated by an increase in the number of fishing vessels. Whatever future developments may bring, we must face directly as a present problem the extremely difficult business conditions in this fishery. In the turbid whirlpool which defeat in the war made of the Japanese fishing industry it is impossible that this fishery alone should attain prosperity while almost all other industries are in difficulties. It may also be thought that this fishery is involved in the general depression in the fishing industry brought about by abnormal oceanographic conditions of recent years. Another factor inhibiting the prosperity of this fishery can be thought to be its lack of planability resulting from its primitive character. However, as the most fundamental factor we must probably take up the problem of fishing grounds. It seems necessary to examine thoroughly the character as fishing grounds of the areas which have been opened to us. It is no exaggeration to say that of the areas in which the Japanese have been permitted to fish, the only ones which have much value as tuna grounds are the albacore grounds of the north central Pacific during the season from November to March and the subtropical spearfish grounds, where the season is May and June.

Concerning such questions as when the day will come when Japan can play an independent role on the international scene and what waters may be opened to Japan at that time I have no answer at all. I only know that the tuna fishery cannot continue as it is at present. It is said that a peace treaty is to be given to us, and that we cannot now ask for anything. However, if it may be permitted to hope, I should wish that all restrictions which might be the cause of useless dispute might be withdrawn from the tuna fisheries, whose grounds are entirely on the high seas. I do not, however, hope for an unconditional withdrawal. A fair agreement for the maintenance of the resource should be made among the countries surrounding the Pacific and Indian oceans and suitable control should be carried on under that agreement. What we should do here in Japan is to strive to become an influential member of the international fisheries organization, the founding of which can be foreseen to come about naturally in the future, by attempting the improvement of the personnel employed in the tuna fishery, by thoroughly respecting any international agreement, and by having persons in the industry and fisheries researchers unite in a basic study of the resource.

C. Harpoon Fishery

The spearfishes are the principal objective of this fishery. However, besides the spearfishes, tunas, sharks, rays, porpoises, sunfish, turtles, and indeed anything of use or value which appears on the surface of the sea may be harpooned in this extremely primitive but heroic fishery.

It is of great interest that a fishery exactly like this one is carried on in the Mediterranean Sea around the island of Sicily. The harpoon fishery of the Mediterranean Sea is very old, its origin being said to go back several centuries before the Christian era. In this region the objective of the fishery is principally the broadbill swordfish. On the fishing boats, a crowsnest is rigged at the top of a tall mast from which a look-out surveys the surrounding waters. When a broadbill is seen swimming on the surface, the boat is headed toward it and the harpoon is thrown as the fish comes within range. It appears that natives of southern regions catch fish with bows and arrows, but I know of no details concerning this fishing method.

There are no complete records of the history of the harpoon fishery in Japan so its details are not clear, but in view of the character of this fishery it is not difficult to imagine that it must have a long history.

The gear consists of a harpoon head, shaft, harpoon line, and leader or sekiyama. As the figure shows (Translator's note: figure 7 is omitted.), a steel shaft is fitted to the tip of an oak pole of 12-15 (usually 15) feet. Sometimes there is a single iron rod but ordinarily there are 3 prongs. On the tip of each of theprongs a harpoon head is fitted.

The harpoon head is of steel and is about 4 inches long. A sharp triangular blade is fixed to its tip. A rod is attached at the center of the wing-like part of the blade which slopes back from the point, and the posterior part of this rod is hollowed out and expanded so that the end of the shaft will fit into it. The back edge of the socket is bent out into an oblique projection. A leader of high quality hemp is attached to the neck of the harpoon head and is connected to the harpoon line with sekiyama.

The boats used in this fishery have a simple observation platform above the bridge, and here a lookout stands and keeps constant watch on the surrounding water. Boats which engage in this fishery only part-time do not usually have such a lookout platform. At the bow there is a platform called the pulpit, and it is here that the harpooner stands. On boats which specialize in this type of fishing, the pulpit is large and can accommodate 2 harpooners at a time.

Spearfishes have the habit of swimming with the upper lobe of the caudal fin protruding from the surface of the water. Sometimes a portion of the dorsal fin also protrudes from the water. Fish swimming in this manner can be seen at all times, but it is said that they are particularly numerous in cases where the wind and the current are running in opposite directions causing waves on the surface. It appears that this phenomenon is also often seen during spawning when the fish are chasing each other.

In Japanese coastal waters the fishing season is from April to September. The Hyūga Nada, and the waters off Kishū, Izu, and the Bōsō Peninsula are famous fishing grounds. The coastal waters of eastern and northeastern Formosa are also famous as a fishing ground for this fishery with 14-15,000 spearfishes of various species being taken. The fishing season is from October to April, during the northeast monsoon. White marlin are most numerous, making up 40-50 percent of the total catch.

When the lookout sights a spearfish, the boats give chase at full speed. Arriving within range, the harpooner in the pulpit throws the harpoon. If a hit is scored, the harpoon head comes off the shaft and remains in the body of the spearfish, which is then hauled in by hand by means of the harpoon line.

II. Characteristics of the Tuna Longline Fishery

It is probably no great mistake to consider that the character of a fishery is determined by the character of the resource which is its object, and that the character of the resource is determined by the species which compose it and their environmental conditions. Consequently, if it is possible to reveal and grasp the biological characteristics of the species which is the object of the fishery and the environmental factors which control the occurrence, progagation, and migration of that species, the character of the fishery can thereby be analyzed.

As was stated earlier, there are a number of different fisheries which have the tunas as their objective, but among them the longline fishery is the most important both in terms of the scale on which it is prosecuted and in terms of the catch. I shall, therefore, take up the longline fishery as a representative of the tuna fisheries and shall give some consideration to its character. The number of species of tunas, spearfishes, and sharks which are the principal catch of the tuna longline fishery is, as will be detailed later, rather great. The majority of them are, from the biological point of view, distributed throughout the open sea from the Equator to the vicinity of 35° - 40° N. latitude. The distribution in the Southern Hemisphere is not yet well known, but it appears that the species are distributed to latitudes about as high as those at which they occur in the Northern Hemisphere. The species have this extremely extensive range of occurrence, however, the density of their occurrence is not the same everywhere within this range, being subject to great fluctuations seasonally and presenting differences in the location of the center of distribution of the various species. In other words, in different regions of the sea the composition of the catch is different, and seasonal changes give rise to other variations.

Put in very broad terms, the differences in the density of occurrence of the majority of the species making up the resource of the tuna fishery appear to be mainly related to latitude. This probably indicates that among the environmental factors which control the distribution of these fishes, temperature is a great limiting condition. The foregoing, of course, only states a general tendency and there are cases in which some species show a marked trend toward variations in an east-west direction. In other cases it is thought that the density of distribution is affected by topographical conditions. In still other cases, changes in the density of distribution from one region to another appear to accompany growth. However, an extremely broad range of occurrence, a high degree of mobility of the fish, and migrations extending over broad areas of the sea are common characteristics of these species which make up the resource of the tuna fishery, giving them a very different character from the resources of the coastal fisheries or the bottom fisheries.

The information which we have been able to gather concerning the spawning and growth of these fishes is as yet extremely poor. Among the fishes taken by the tuna fishery, the sharks are viviparous and therefore are already possessed of fairly strong powers of survival at the time they leave their mothers' body. The tunas and spearfishes are oviparous and for sometime after hatching they have extremely poor powers of resistance. In the case of the sharks, if we know the number of times they produce young in one year and the number of young produced at one time, it is possible to clarify the question of their reproductive potential comparatively easily. In the case of the oviparous tunas and spearfishes, however, even though we may be able to calculate the number of eggs contained in a matured ovary, we cannot easily ascertain the proportion of those eggs that are fertilized and hatched. Furthermore, judging from the fact that the larval and juvenile fish are extremely weak, it is not difficult to imagine that attrition during the early stages of their life is at a rather high rate. In actuality it is by no means rare to find tunas and spearfishes of 10 to 40 cm. in length among the stomach contents of adult fishes of the same species. From our present knowledge of several species, it appears that the number of eggs spawned at one time by these species may range from several hundred thousand to several million, but it is difficult to believe that very many of these eggs grow into mature individuals, and the attrition accompanying growth is probably rather drastic.

In the viviparous fishes like the sharks variations in reproductive potential from year to year are probably comparatively small. We do not know much as yet about the number of times the young are produced each year, but the number of young sharks produced each time varies greatly with the species, being always two in the case of thresher sharks, less than 10 in the case of mako sharks, and from 10 to 40 in the case of great blue sharks. In the case of the oviparous tunas and spearfishes, it can be imagined that the effect of environmental conditions is very great and that fluctuations in reproductive power from year to year are marked. In other words, the number of eggs spawned is enormous and therefore even slight variations in environmental factors will be reflected on a large scale in the total stock through their action on fertilization, hatching, and growth.

The spawning habits of the tunas and spearfishes are not yet well known, but the degree of maturity of various individuals in a single school is extremely variable, the distribution of sexually mature individuals is extremely extensive, and it appears that the occurrence of juvenile fish is also remarkably broad but very sparse so that they cannot be collected in large numbers. Furthermore, juvenile fish of various sizes can be taken in the same area at the same season, and it is thought that all of these phenomena indicate that it is the habit of these fishes to spawn over a wide area throughout a rather long period of time.

When we consider the oceanographic characteristics of the low latitude seas which are the spawning grounds of these fishes, we see that the content of nutrient salts in the sea water is small and that it varies little throughout the year. This means that the quantitative distribution of plankton is small and that its seasonal variation is also small. Accordingly, it may be thought that the food for juvenile tunas and spearfishes is not very abundant and that the seasonal changes in its quantity are not very pronounced. Such characteristics are markedly different from those of the waters of high latitudes. In the seas of high latitudes we find seasons of conspicuous proliferation of plankton accompanying changes in temperature. In coastal waters nutrient salts are constantly supplied from the land by rivers and by other agents. However, in the very middle of the ocean there is no source of supply for these nutrient salts. Consequently, in the seas of the low latitudes where these fishes spawn and pass their juvenile stages, the conditions are like those in overworked soil with an insufficient supply of fertilizer. It is thought that the reason that the spawning of tunas and spearfishes in such waters extends over such a broad area and such a long period of time is that this is the most reasonable way of attaining the objective of maintaining the species. In short, spawning over a broad area and throughout a long period is in better agreement with the environmental conditions in the seas in which these fishes spawn, from the point of view of the maintenance of the race, than would be spawning in a comparatively restricted area and a short period of time, as is the case with fishes of the high latitudes.

No connected study of the food habits of the tunas and spearfishes has been made and they are not well understood. There is no room for doubt that their food in the juvenile stages consists of various kinds of plankton. The natural food of the adult is indeed heterogenous, and it is very doubtful whether they exercise a great deal of selection with regard to their food. It is thought rather that they eat whatever is most abundant in the area where they occur or whatever is comparatively easy to catch. The spearfishes and sharks eat mainly large fish and squid. The tunas eat, in addition various kinds of large plankton. The plankton feeding character seems to be most pronounced in the albacore. At some places and seasons _Alepisaurus,_ deepsea fishes, and fishes such as _Bentenia,_ which are thought of as rare species, are very commonly found in their stomachs.

If we take all of these factors into consideration, we may think that the resource of the tuna longline fishery is propagated and maintained throughout an extremely broad expanse of ocean. If we consider this resource in terms of the sea which supports it, the density of distribution expressed as fish per unit of area can naturally be thought to be rather low in comparison with the resources of the coastal fisheries or of the fisheries in northern waters. However, as regards the absolute quantity of the resource, we cannot conclude that they are necessarily inferior to other fisheries resources, if we consider the area of the seas in which they occur.

The fact that the density of distribution of the resource is low in terms of fish per unit of area is not an advantageous condition from the standpoint of the fishery. If the tunas and spearfishes led a sedentary existence with a low density of distribution, they would be difficult to catch and they would have an entirely different significance as the objectives of a fishery. However, they do not live in this way, but rather form schools and migrate and the fishery is established by utilizing this migratory character. Furthermore, the location and nature of the fishing grounds and fishing seasons are naturally determined by these migrations. Unfortunately, our knowledge concerning this migratory character is as yet extremely inadequate, and we cannot utilize this characteristic fully, this being the greatest reason for the lack of stability in the tuna longline fishery. The number of species which make up the resource of the tuna fishery is rather large. We have not yet reached any solution to the problem of whether each of these species is a single stock or whether there are a number of independent stocks in the Pacific and Indian oceans.

There are some people who think that each of these species which is distributed throughout the whole Pacific Ocean is a single stock and that at some time in their lives all of the fish of each species migrate into Japanese waters. The migrations into Japanese waters occur each year at about the same season and are made up of fish of about the same size each year. Considering only these facts, it may be thought that this theory is correct. However, when we consider the extent of the Pacific Ocean, there are some facts which give rise to doubts concerning the above opinion and we know of some phenomena which can be thought to indicate the existence of distinct races.

The solutions to all of these problems must await future research, but they are problems which must be solved in order to determine the character of the resource.

Dr. Tauchi[2/] has studied the effects of fishery on the stock and has reported that the catch rate for the tunas in Japanese waters ranges from 10 to 55 percent[3/], varying with the species and among various age groups within a species. In every case he gives rather high values. However, as was mentioned earlier, there is doubt as to whether or not all of the tunas necessarily at some time in their life migrate into Japanese waters, and therefore even though Dr. Tauchi's values may correctly show the catch rate in Japanese waters, it is naturally doubtful whether the tunas of the whole Pacific are being caught at catch rates like those cited above.

If we consider the relationship between fishing effort and catch in the past, based on statistics of the Ministry of Agriculture and Forestry, the Colonial Office, and the Formosa Fisheries Experiment Station, we cannot perceive any very clear correlation. It appears that a tendency toward an increase in the catch with an increase in fishing effort can be detected, but we can see conspicuous fluctuations in the amounts of the catch from year to year.

Statistics showing fishing effort are almost entirely limited to the number of vessels engaged in the fishery and their total tonnage and therefore the fishing effort is shown by deduced values which do not make very good data. Figure 8 shows the total catch, the number of vessels engaged, and the total tonnage of the vessels for the period from 1930 to 1940. The graph shows index figures with 1930 as 100. It can be seen from the figure that the increase in the size of the fishing vessels from 1934 on was very conspicuous.

2/ Tauchi, Morisaburo. 1940. Bull. Jap. Soc. Sci. Fish., Vol. 9, No. 4, pp. 133-135, 136-138, 139-141.

3/ Catch rates here mean the proportion of the stock represented by the total catch.

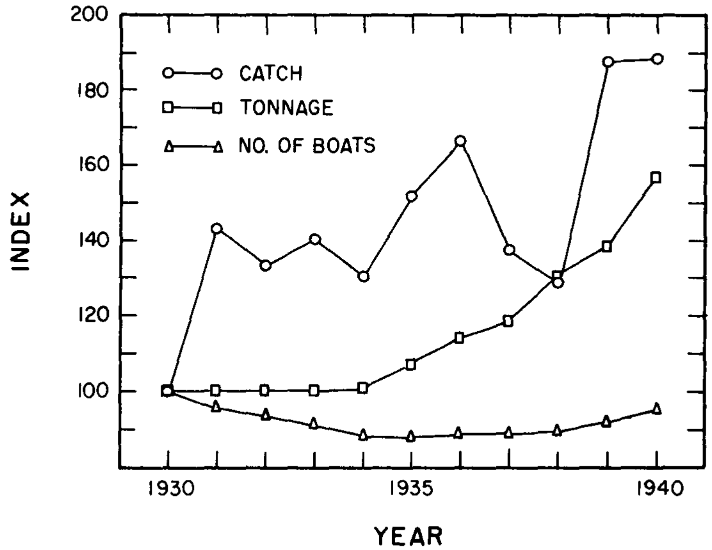

Figure 8.--Catch in relation to number of boats and total tonnage of vessels.

It is considered that both increases and decreases in the number of operating vessels and changes in the size of the vessels show increases or decreases in the fishing effort. It is not, however, reasonable to consider these simply as increases or decreases in the fishing effort applied to the same resource. The reason for this is that in many cases an increase in the size of the vessel means an extension of the operating area to more distant fishing grounds and with the change in fishing grounds there is a great possibility that different kinds of fish will be taken. Furthermore, it may also be thought that a shift to more distant fishing grounds will result in a reduced number of operations in the course of a year so that in some cases at least larger vessels do not mean an increase in fishing effort. Consequently this comparison of the total catch of the tunas with the number of boats and their total tonnage does not enable us to discuss the correlation between fishing effort and the stock.

These factors must nevertheless be thoroughly considered. In figure 8 we can see fluctuations of about 10 percent in the number of vessels, and from 1934 on the total tonnage increased sharply. Wide variations from year to year in the total catch can be seen, but through these variations is shown a tendency for the catch to rise. It should be noted that the catch shown here is a total of tunas and spearfishes and does not show any particular species. At any rate, even though some degree of correlation can be detected between the total catch and fishing effort, it may be thought that there are some other factors operating outside this correlation to bring about fluctuations in the catch. The most important of these factors are thought to be changes in the migrational pattern accompanying changes in oceanographic conditions and variations in the recruitment to the stock caused by changes in environmental factors. In any case there is something which operates independently of fishing effort to control the variations in the catch, and if the effect of fishing effort on the increase or decrease of the stock can be ignored, it cannot be thought that this condition implies overfishing.

Overfishing means that the catch exceeds the natural increase of the stock. Deciding whether or not a particular stock is being overfished is an extremely difficult problem. As far as the resources of the tuna longline fishery are concerned, up to this stage in their development no one has put forward any definite views as to whether or not they are being overfished.

The danger that the fisheries resource may be overexploited arises from the relationship between the reproductive potential and area of distribution of the resource and the effectiveness of the fishing. In fishes which have a high reproductive potential, there is comparatively little danger of overfishing. The same is true of fishes which have an extremely broad range of occurrence. However, where the fishing is extremely efficient and effective, it may naturally be thought that there is danger of its outweighing such considerations as the reproductive potential.

Except in some special cases, net fishing has not become established in the tuna fisheries. The longline fishery is the nucleus of the fishery. The great majority of the fish taken by longlines are already mature. The fishing implement is a hook, and the manner of its use traces across the open sea a broken rather than a solid line. Consequently, there is almost no danger of cleaning up a school of fish with one set, as happens in net fisheries. It is more reasonable rather, at least under present conditions, to think of it as a kind of thinning out. As yet no one has expressed a definite opinion as to whether or not the resources of the tuna longline fishery are being overfished. This can be thought to mean that there are no data with which to arrive at a definite opinion.

To sum up the foregoing, it is considered that the resources of the tuna longline fishery are of such character that there is little danger of their being overfished, judging both from the conditions under which they are propagated and maintained and from the type of gear and the fishing method used. In short, the effect of man's effort on the resource is really very slight when compared with the effect of natural conditions. This means, on the other hand, that this fishery is lacking in planability and stability and this is the reason why it is one of the most primitive in character of all fisheries.

III. General Outline of Fishing Grounds and Fishing Seasons

The longline fishery for tuna has developed in very close association with the pole and line live-bait fishery for skipjack. The majority of the boats in this fishery fish for skipjack approximately half of the year, including the summer season, and engage in the longline fishery during approximately half the year, including the winter season. This manner of operation, in general, is connected with the prospects for profit to the operators. As was stated earlier, the vessels which engage only in this fishery, taking no part in skipjack fishing at any time of the year, now amount to 25 percent of all skipjack and tuna vessels. Furthermore, in areas where the geographical distribution of the fishes makes longline fishing profitable, the boats engage in longlining even during the summer season. The longline fishery for spearfishes on the grounds west of Kyūshū is an example, although in recent years the catch has dropped to nothing and the fishery has been abandoned, and the fishery for black tuna off northeastern Honshū and Hokkaidō is a good example as the fishing season is chiefly during the summer.

The tunas and spearfishes are basically warm-water fishes. A short account of their species will be given in the next chapter, but the number of species is rather large and they differ among themselves as regards the areas around which their distributions center, and they differ too in the seasons and routes by which they migrate into Japanese waters.

The black tuna is the most resistant to low temperature of all the tunas, migrating as far as Hokkaido and the coast of Sakhalin, where it is found in waters as cold as 5° C. This is, however, rather exceptional, and in Japanese waters this species is taken in the greatest numbers in water having temperatures of 14° - 15° C. to 20° C. As far as is known at present the warmest waters in which this species occurs are off the Philippines, where temperatures reach 26° to 29° C. This is the southern limit of their distribution in the North Pacific Ocean. This species has the characteristic of penetrating into coastal waters and occurs in the Japan Sea. There are records of their having been taken by fixed gear from Kyūshū to southern Hokkaidō and on the Japan Sea coast of Sakhalin.

The albacore is said to occur in areas having water temperatures of 17° to 26° or 27° C. The northern and southern limits of its distribution extend from the Equator to past 40° N. latitude. In Japanese waters they are most abundant in areas where the water temperature is around 20° C. and generally occur only in offshore waters, seldom appearing in the coastal areas.

For a tuna the bigeye has a peculiar pattern of distribution. It shows little change in density with changes in latitude, but appears to be evenly and sparsely distributed all over its range. Like the albacore it does not appear to enter the coastal waters and tends to become more numerous as one goes offshore. It is said that the level at which it swims differs from day to night and that it shows a conspicuous tendency to swim at deep levels during the day and to appear at the surface during the night.

Among the tunas the yellowfin is the one which most belongs to the waters of the low latitudes, its density of distribution being high in an area centered along the Equator. At some seasons it appears also in the waters of rather high latitudes, but these seasons are short. In general it lives offshore, but it also enters enclosed bodies of water. It is taken, although rarely, in the Japan Sea. As a young fish, when it is called kimeji, it enters the coastal waters and is not rarely taken in fixed gear.

Differences in the distribution of the various species of spearfishes can also be detected. Excepting the broadbill, it appears that the other species on the whole prefer higher temperatures than do the tunas, and the greater part of the catch is made in water temperatures of 20° - 28° C. Except for the broadbill, all the other species in general appear to have more or less of a tendency to be more abundant in coastal water areas, so that the catch seems to be greater in the vicinity of islands. The broadbill has a wide range of distribution, and in Japanese waters its catch pattern to some extent resembles that of the albacore. However, it is scarce in the very far offshore areas frequented by the albacore. In the white marlin and the sailfish the the coastal character is particularly strong and they are most abundant from the 100 fathom line of the continental shelf to Taiwan and the shores of the Philippines. The striped marlin is most abundant in the subtropical central Pacific and its distribution extends to the vicinity of 40° N. latitude. The black marlin is abundant in the Equatorial Countercurrent and the North Equatorial Current. It migrates to the north, but its range of distribution appears to be more restricted to warm seas than that of the striped marlin.

As stated above, the distributional pattern of these species appears to vary mainly from north to south. This phenomenon is thought to indicate that temperature bears an important relationship to the distribution of these fishes. Nevertheless, the range of temperatures which these fish can withstand is, as indicated above, rather broad. In the past these fish were taken as representative of the so-called stenothermal fishes, however, they can be thought of as not necessarily stenothermal but as rather eurythermal.

As has already been said, temperature bears a very important relationship to the distribution and migration of these fishes. However, the range of temperature change which they can endure is rather great and in sea areas which are within that range there is a possibility solely from the standpoint of temperature of the occurrence of these fishes. Water temperatures which limit the possibility of occurrence of these species can become a controlling factor as regards fishing grounds and fishing seasons, but in waters where the temperatures are favorable for their occurrence at all times we can hardly think that temperature has a controlling influence on the establishment of fishing seasons and fishing grounds. It goes without saying that the resources of the oceans are in the last analysis controlled by the chemical characteristics of their waters and the energy of the sun. But it need hardly be said that these fishes, which are living things, have the instinct for self-preservation and the instinct for the preservation of the species, and they act in accordance with these objectives. Studies in this field have advanced so extremely little that we unfortunately have no data on which to base a discussion of the relationship between the distribution and migrations of the tunas and their ecology and physiology.

When it comes to the problem of fishing grounds, the biological distribution and the potentiality of distribution are naturally different. In order that a body of water may have significance as a fishing ground, it is essential that fishing operations be actually carried on in those waters and that the catch be at least such as to pay the expenses of the fishermen.

As has already been said several times, although the centers of distribution of these fishes vary somewhat, they are essentially warm-water animals and consequently most of them occur at all times in the waters of the low latitudes. In the case of the black tuna, the albacore, and the broadbill it appears that the center of their distribution lies in rather high latitudes. In any case, none of these species leads a sedentary life within a narrow area of the sea, but they all move through extremely broad reaches of the ocean. The fishing grounds and fishing seasons change in response to these movements.

Looking at the situation in Japanese waters, we see that from spring to summer the Japan Current (Kuroshio) increases in strength, so that warm sea water is brought far to the northward, at the same time all of the seas of the northern hemisphere grow warmer, and the tunas and spearfishes gradually move toward the north. The reverse occurs from autumn to winter, when the temperatures in the northern hemisphere gradually fall, accompanied by a return to the south on the part of the fish. The outlines of these movements will be set forth below, but in recent years the patterns of migration have undergone much change, the black tuna, for example, scarcely appearing in the coastal waters of Japan and no mass migrations of this species being seen at all.

In the waters of Hokkaidō the black tuna generally appears in July. At about that time the area 20 - 40 miles south southwest of Erimozaki becomes a good fishing ground. By September the schools are usually densely congregated within 30 to 40 miles of the coast from south of Kushiro to Erimozaki. In October all of the offshore waters between Erimozaki and Ezanmisaki are fishing grounds, but from this month on the fish finally begin to disappear from this area. Thus the fishing season on the Hokkaidō coastal ground is from July to October, but in recent years there has been hardly any catch. The longline catches in this area are almost entirely composed of black tuna, other tunas and spearfishes being almost completely absent from the catch and only a few sharks being taken.

In the offshore waters from Iwate Prefecture to Fukushima Prefecture, the so-called Sanriku region, the fishing season is longer than in the Hokkaidō coastal areas. In some years black tuna are taken as early as April, but the season of greatest catch is the 3 months from June to August. Thereafter the fish gradually disappear, but around November they again begin to be caught and scattered catches are made until around January. The fish taken from June to August are called "ascending fish," while those taken after November are called "descending" or "returning fish." In these waters striped marlin are taken in fairly large numbers during the summer and broadbill are numerous in the winter. In some years bigeye tuna are also abundant. Furthermore, during two seasons, in the summer and winter. an extremely large number of rakudazame (Isurus nasus) are taken by the so-called mōkanawa longline fishery.

Off the east coast from Ibaraki Prefecture to Chiba Prefecture, black tuna, bigeye tuna, albacore, and broadbill begin to be taken around November and catches continue to be made until around April of the following year. In the summer the composition of the catch changes, the striped marlin and black marlin increase, and at the same time quite a few yellowfin are taken.

Farther to the southwest in the waters from the Izu Peninsula to the Izu Shichitō islands black tuna begin to be taken around November, the season at which they are caught most abundantly being from January to February. In some years scattered catches are also made in April and May. Bigeye tuna are also taken at about the same time, but their fishing season begins about a month earlier and lasts about a month longer than that for the black tuna. It appears that albacore begin to be taken in some numbers on the longlines around March to May. In early years the yellowfin begin to appear around April and are taken in greater or lesser amounts until November. Striped marlin occur almost throughout the year, but they are most abundant from June to September and are mainly taken with the harpoon. The fishing season for black marlin appears to begin about 1 month later than that for striped marlin. The broadbill are most abundant in the winter, the season being centered around January and February, with the center of their fishing grounds lying to the east of the Shichitō islands.

Farther west in the waters off the Kii Peninsula the yellowfin and bigeye tuna are rather abundant and albacore are taken in some numbers from September to November. From December on the yellowfin and bigeye gradually begin to decline, while on the other hand the albacore catch gradually increases. The albacore fishery is quite active from December to March. The catch situation for the spearfishes is not greatly different from that in the Izu Shichitō region except that in this area broadbill are hardly taken at all. Black tuna are caught sporadically from December to March. A little to the southward on the so-called Kinan Reef fishing grounds centered around 28° to 30° N., 135° E., the albacore fishing is very active in the period from January to March, and at the same time bigeye tuna are fairly abundant and spearfishes and yellowfin are also mixed in the catch to some extent.

Farther to the west in the waters off Tosa (southern Shikoku) yellowfin are taken in rather large numbers from October to December, while the bigeye catch shows more or less of a tendency to increase in January and February. In March and April the albacore catch is large, the fishing grounds lying rather close along the shore.

The so-called Satsunan area (south of Kyūshū) has been a famous black tuna ground since ancient times. As was stated earlier, in recent years there has been hardly any migration of black tuna into this region and consequently there has been no catch. At present the only catch is some bigeye tuna which are taken in the winter. The good fishing grounds for black tuna in general were from 30° - 32° N. latitude, 130°- 132° E. longitude. Formerly, when the black tuna fishery was flourishing, the catch gradually increased from about the middle of December and reached its peak from January to the latter part of February, in some years extending to the first part of March. At this season the port of Aburatsu in Miyazaki Prefecture was bustling with a large number of boats from other prefectures. After the first or middle part of March the catch declined rather abruptly and ordinarily the fishing was completely ended by the latter part of April or the early part of May. As will be related in a later section (V. Fishing Grounds, 11. Nankai Sea Area), the black tuna catch in this area declined abruptly after 1940 and from 1945 on there has been no catch at all. Different people give different explanations for this phenomenon, but it should be noted well that it parallels perfectly the decline in the catch of sardines. No quick decision can be made as to whether it is a falling off of the catch caused by a cyclical decline in the black tuna stock accompanying changes in oceanographic conditions, or whether the fishing grounds have deteriorated because the black tuna changed the course of their food-seeking migration after the sardines ceased to congregate for spawning in this region. Yellowfin are usually slightly more abundant around October and the bigeye show approximately the same pattern, but these species do not present such a clearly defined fishing season as did the black tuna. The albacore catch in this region is extremely small.

The waters to the west of this region from the west coast of Kyūshū to Saishūtō (Quelpart Island) are famous as a fishing ground for the spearfishes. Around March to May some of the black tuna which enter the Japan Sea with the Tsushima Current are also taken there. The spearfish season begins in July to September in the Saishūtō (Quelpart Island) area and the fishery gradually moves southward with the progress of the season. The positions of the fishing grounds generally lie along the 100-fathom line of the continental shelf. Almost all of the tuna taken in the Japan Sea are black tuna. There are extremely rare reports of yellowfin being taken there. The Tsushima Current, which branches off from the main Kuroshio south of Kyūshū, passes through the Tsushima Strait and then flows north along the Japanese coast, while on the continental side there is a southward flowing cold current. For this reason the fishing grounds for the black tuna are naturally limited to the Japan coast and they are only extremely rarely taken along the Korean or Siberian coasts. During the summer the schools gradually move northward and in years when the warm current is very strong they sometimes pass along the west coast of Hokkaido to be taken on the coasts of Sakhalin. In the Japan Sea area there is no longline fishery at all, the tuna being taken entirely with fixed gear.

The central part of the Pacific Ocean eastward from 150° E. longitude and south from 40° to about 26° N. latitude is famous as an albacore ground. In this area most of the catch is made in the northern portion around October, but the center of the fishing grounds gradually moves southward until in the latter part of March it is at around 26° to 28° N. The fishing season in this region ends from around the end of March to the early part of April. The various fishing grounds centered respectively at 160° E. longitude, 175° E. longitude, and 175° W. longitude all differ more or less in their characteristics, but data are scarce and a thorough analysis is impossible. Besides albacore, bigeye tuna are taken rather plentifully, particularly around December. Striped marlin and broadbill are also taken in some numbers, and throughout the seasons scattered catches of black tuna and yellowfin are made.

In the coastal waters of the Ogasawara chain some fish are caught throughout the year. Chief among the tunas taken are the yellowfin and the bigeye tuna. The black tuna is also taken, although very rarely, in the northern part of this sea region around May and June. The albacore catch increases somewhat from March to May. Skipjack boats which operate in this area take albacore on pole and line at about that season. The season of greatest abundance for yellowfin is from May to July and there is another increase in the catch around November. A tendency for the rise and decline in the bigeye catch to be about 1 to 2 months later than that for the yellowfin can be discerned. The most important fish in this region are the spearfishes. Among them the striped marlin catch in general rises and declines at about the same times as the yellowfin, but the increase in the yellowfin catch in November is not paralleled by a similar increase in the striped marlin catch. The rise and fall of the black tuna catch roughly parallels that of the bigeye. Broadbill are rather abundant in the northeastern portion of this sea area, the season being centered around February. In addition there is also a very large shark catch which is chiefly great blue shark.

In the Okinawa region, too, fishing proceeds throughout the year. In this region schools of black tuna appear everywhere from April to June. These schools are thought to differ in age from the previously mentioned schools of the Satsunan Sea area. Yellowfin are rather abundant along the eastern boundary of the Kuroshio and spearfishes are plentiful from the western boundary of the current to the 100-fathom line of the East China Sea. The spearfish catch begins to increase gradually around March and the fishing grounds gradually move northward. At the beginning of the season white marlin are most numerous, followed by striped marlin, after which comes the season for black marlin and sailfish. On the whole the seasonal changes in the catch of these fishes closely resemble the pattern seen in coastal waters of the Ogasawara Islands.

Spearfishes are extremely abundant east of Formosa where the harpoon fishery is very active from October to April, that is, during the season of northeasterly winds. The fishing grounds are within 30 miles of the coast. At the same season in the same areas there is a flourishing longline fishery for sharks, mainly species of Carcharhinus and hammerheads. From April to June the black tuna migrate into these waters and at the same season sailfish are abundant.

In the South China Sea the most numerous species is the yellowfin, its fishing season being the season of northeasterly winds. From March to the early part of June albacore fishing is active from the Bashi Strait to the northeastern part of this sea area. Black marlin and sailfish become abundant from June to August. Albacore are rather plentiful around March in the northeastern part of the sea area.

Black marlin and yellowfin tuna are densely distributed in the waters 60 to 200 miles east of the Philippines during the season of southwesterly winds, the former being more abundant in the north while the latter is more numerous in the southern part of the area. Fishing for black tuna is very active from March to June in waters comparatively close to the coast of northeastern Luzon.

In the Sulu Sea yellowfin are most numerous followed by the spearfishes, and fishing proceeds throughout the year. The Celebes Sea is also an excellent fishing ground with yellowfin tuna most numerous, followed by the spearfishes, of which the chief is the white marlin. The fish are caught there throughout the year, but the peak of the season is during the season of southwesterly winds, the fishing situation appearing to resemble that of the southernportion of the East Philippine Sea.

In the low latitudes of the Pacific, in the grounds centered along the Equator, yellowfin are very abundant, forming about 75 percent of the catch (excepting sharks). Bigeye tuna are about 10 percent and spearfishes about 15 percent. Some albacore are taken, but there are absolutely no records of black tuna being caught there.4/ Seasonal changes in the fishing situation are slight, but in general catch rates are better during the season of southwesterlies than during the season of northeasterly winds. Proceeding northward from the vicinity of the Equator the catch rates for yellowfin fall off sharply, the catch rate curve dipping to a low in the vicinity of 10° N. The spearfishes are most abundant in an area centered on 20° N. latitude.

The preceding is an outline of the fishing seasons and fishing grounds in the western part of the Pacific Ocean north of the Equator. In general the density of distribution of these fishes in this area increases during the summer. However, the albacore and broadbill are more abundant during the winter. From a geographical point of view, the yellowfin are very densely distributed in the Equatorial Countercurrent, spearfishes are most abundant in the North Equatorial Current, and albacore are most plentiful to the north of the subtropical convergence. Broadbill are also more numerous north of the subtropical convergence, but there the principal zone of distribution is narrow in an east-west direction. Bigeye tuna are caught in roughly equal abundance all over the whole area. The black tuna appears to occur chiefly in the area of the Kuroshio.

IV. Fishes Taken by Tuna Longline Fishery

The tunas are among the fishes with which the Japanese are best acquainted, but this is only true of tuna which has been made into sliced raw fish or served on top of rice balls. There are actually few people who know what the fish look like, and even fewer who can tell one species from another. Still fewer people know where and by what methods such fish are taken.

As indicated by the number of names cited in the preceding chapter, the number of species is fairly large. They all migrate extensively in the open sea and their capture is attended by extremely hard labor on the part of the fishermen, who sail the broad sea in small vessels and do battle with the elements.

As has been stated previously, the greatest among the tuna fisheries is the longline fishery. The principal objects of this fishery are of course the various species of tuna, but at some times and places the spearfishes also have an extremely important significance. Although they do not have the economic value of the other fishes, the sharks are also important in the catch of this fishery. The following is a brief account of the habits and form of these fishes.

4/ The capture of a few individuals was reported from mothership-type operations carried on from June to September 1950.

A. Tunas

These fishes all belong to the family Thunnidae, and are very closely related to the mackerels and bonitos.

The body is almost perfectly spindle-shaped and is adapted to swimming at high speed. The root of the tail (caudal peduncle) is extraordinarily slender and is broader than it is deep. This form is well-adapted to a violent, side to side motion of the tail fin. The tail fin is large and strong. As the majority of these fishes are essentially warm-water fish, they are most numerous in warm seas, and they characteristically make large-scale migrations along warm currents. A very great number of species has been reported from the seas of the world, but in actuality it is doubtful whether the number of species is so large. Even though the species may be numerous, they do not after all have any great concern for us, so only the five species which occur in Japanese waters will be described here.

1. Black tuna, Thunnus orientalis (Schlegel)

Bluefin tuna (America).

Depending on the locality and the size of the fish, this species has many names, such as, maguro, kuromaguro, kuroshibi, mejimaguro, yokowa, kakinotane. This is the largest species in the family Thunnidae, attaining a length of 2.5 meters and a weight of 300 to 350 kilograms.

The species is characterized by short pectoral fins, the tips of which do not reach to below the middle of the first dorsal fin. They can easily be distinguished from the other species by this character alone. The back is a light black and the sides are greyish white. The finlets (the disconnected small fins) behind the dorsal and anal fins are yellowish on the back and silvery white on the belly. There are very similar fish on the American side of the Pacific and in the Australian area and by some scholars they are considered to be the same species, but it is said that the dorsal finlets are blue, a characteristic which is indicated by the name bluefin.

The flesh is dark red with something of a blackish tinge. The flesh of the belly contains a great deal of fat, causing its color to vary in different parts from the white-spotted so-called "middle belly meat" to the almost pure white "great belly meat." This part of the flesh is prized as material for sliced raw fish and rice balls garnished with fish. This species is delicious during the winter, but fish taken in the summer are poor eating, except for the small specimens. This is related to the spawning season of these fish, the fish being fat and well-flavored before spawning but lean and tasteless immediately after spawning. It is said that they spawn in Japanese waters around June and July. The fish taken during the summer from the waters off northeastern Japan and the coast of Hokkaidō are fish that have already spawned. These are called Sendai tuna and are regarded as inferior fish.

This species can withstand low temperatures better than any of the other tunas, and because it has the characteristic of coming comparatively close into shore, it is taken with stationary gear. As far as is known at present, the southern limit of its distribution is in the vicinity of 15° N. latitude on the east coast of the island of Luzon. It is not clear whether it occurs farther to the south, but it is thought that its range probably extends south of the Equator. Until recent years it was believed that the southern limit of the distribution of this species was in the vicinity of 30° N. latitude, however, this fish began to be taken in Formosa in 1935 and before the war its annual production there reached a value of 1,500,000 yen. The northern limit of distribution is around 45° N. latitude. In the western Pacific during the winter there are some catches of this species over an extensive area from east to west in the vicinity of 30° N. latitude. Before the war splendid catches were made in January and February to the south of Kyūshū, but this fishery has completely died out in recent years. The schools which appear to the south of Kyūshū moved to the northeast as it grew warmer, and a part of them followed the Tsushima Current into the Sea of Japan.

These fish are frequently seen to leap into the air. When they are hooked they make one deep dive with tremendous strength, and it not rarely happens that they break the branch line or drag a glass ball float of 30 centimeters diameter so deep that it is crushed by water pressure.

2. Albacore, Germo germo (Lacépède)

This fish is called both binnaga and binchō and in western Japan it is generally called tonbo or tonboshibi. It is small for a tuna, specimens of about 100 centimeters long and 30 kilograms in weight being considered large.

A peculiar characteristic of this species is the long pectoral fins, the tips of which reach back beyond the base of the second dorsal. The back is blue-black in color and the belly is silvery-white.

The color of the flesh is pale pink, almost white, and the flesh is extremely soft, making it rather unsuitable for consumption as sliced raw fish. When it is cooked, it does not become hard as the other tunas do, and as the flavor is said to resemble chicken, it is highly prized by Americans, who call it the "chicken of the sea." Before the war this species was exported in large quantities canned in oil. The center of this canning industry was in Shizuoka Prefecture. Besides this canned fish, rather large quantities of fresh fish were exported as raw material for canning. Even today after the war, the demand from America appears to be rather great.

This is a very widely distributed species, ranging from the Equator to about 45° N. and S. latitudes. The center of their distribution in the North Pacific, however, appears to be between 30° and 40° N. latitude. They are abundant in Japanese waters and are taken in large numbers by skipjack boats fishing with live bait in the summer. From December to March, they are taken over an extremely broad area centered around 30° N. latitude, principally by longlines.

Some scholars think that the albacore of Japanese waters, of the Southern Hemisphere, of the Indian Ocean, and of the Atlantic Ocean are all the same species. In view of their distribution, this opinion may be thought reasonable, but the ultimate decision remains to be made in the future.

3. Bigeye tuna, Parathunnus sibi (Temminck and Schlegel) = Parathunnus mebachi (Kishinouye)

This fish is also called bachi, darumashibi, and mebachi. Among the tunas it is the next largest to the black tuna, attaining a length of about 2 meters and a weight of about 150 kilograms.

Characteristics peculiar to this tuna are the stout body, the short tail portion (from the vent back), and the large head and eyes. The name darumashibi applies chiefly to immature fish, the thick, chunky body probably being reminiscent of a statue of Daruma. The pectoral fins are long, their tips reaching to a point roughly below the insertion of the second dorsal. The back is bluish black and the belly is white.

The flesh has a rather pale but beautiful red color. When it is served as sliced raw fish, the flavor is not considered particularly good, but it is at its best in the spring and autumn. The fact that the flesh is somewhat soft is considered a defect. Besides being eaten fresh, it is utilized along with yellowfin for canning.

The species has not yet been reported from the Sea of Japan, but it has a very wide distribution. It is an interesting fact that this species has no clearly apparent focus to its distribution, being taken in about equal abundance everywhere from 0° to 40° N. The trends of the catch rates are not correlated with latitude, but they appear to improve toward the center of the Pacific. In the overall picture the bigeye is taken at a rate of about 0.5 fish per hundred hooks. The species appears to be most abundant in Japanese waters from September to December. It generally prefers to live at deep levels, however, it is not yet known with certainty exactly what depth it prefers. As it has the habit of coming into the surface levels at night, it is sometimes taken in drift nets and it is said that this occurs particularly often on moonlight nights. These fish tend to be somewhat more abundant in tropical seas, and in both the Pacific Ocean and Indian Ocean areas they are taken in the proportion of about 10 percent of the yellowfin catch.

4. Yellowfin tuna, Neothunnus macropterus (Temminck and Schlegel)

This fish is also called gesunaga, hirenaga, kibire, and itoshibi. In the southern Kyūshū area when the word shibi is used, this species is meant. Jordan distinguished the yellowfin and the itoshibi, giving to the latter the scientific name Neothunnus itosibi, but this is thought to have been clearly a mistaken interpretation of the characteristic morphological changes which accompany growth in this fish.

Yellowfin are generally somewhat smaller than bigeye tuna, attaining a length of about 2 meters and a weight of around 70 kilograms.

A characteristic of this fish is the length of the caudal portion, that is the part of the fish behind the vent. In mature fish the second dorsal and anal fins are remarkably elongated. The names hirenaga and itosibi are expressive of this peculiarity. These fins and the finlets which follow them are of a bright yellow color. The names kihada and kibire are based on this characteristic. The pectoral fins are rather long, reaching to a point slightly back of the insertion of the second dorsal.

The color of the flesh is a rather pale red which looks extraordinarily bright to the eye. In western Japan this fish is generally more highly regarded than the black tuna. When eaten raw the flavor is rather faint, but it is particularly delicious during the summer. Besides being consumed fresh, it is exported canned in oil and the scrap meat produced by the canning operation is made into stew. The young fish are frequently taken in fixed gear or by pole and line and are manufactured into the so-called shibibushi by the same methods used in making dried skipjack sticks.

The range of distribution extends from the Equator to about 35° N. latitude, but the areas in which this species is the object of a fishery are a comparatively narrow belt along the Equator, and the series of enclosed waters comprising the South China, Sulu, and Celebes seas. The yellowfin become more abundant in the North Pacific during the summer, and are most numerous in the waters of the Ogasawara Islands from June to July and in November. At that time they are caught at a rate of about 1.5 fish per hundred hooks. They are taken, though extremely rarely, in the Sea of Japan.

5. Koshinaga, Kishinoella rara (Kishinouye)

Northern bluefin (Australia).

This fish is also called bintsuke. In Formosa it was called the seiban maguro. This is the smallest of the tunas, fish of about 70 centimeters long and weighing about 7 kilograms being already mature. Dr. Kishinouye placed this fish in the same genus with the yellowfin tuna, but it is given here as Kishinoella in accordance with the opinion of Jordan and Evermann, who said that because of morphological differences it should be placed in a separate genus. According to recently received reports, K. rara is a synonym of the northern bluefin, K. tonggol, which has long been known in the coastal waters of Australia.

In outer appearance this fish closely resembles young yellowfin and is difficult to distinguish from them, but the color of the flesh is a great deal paler than in the yellowfin, being nearly white. The back is bluish-black, the belly is greyish white, and like the young stages of other tunas, it has oblique rows of long and narrow colorless dots, which may appear grey depending upon the angle at which they are seen. The second dorsal and the anal are not prolonged into filaments. The finlets are yellow as in the yellowfin but are edged with black. The pectoral fins are rather long, reaching to a point somewhat behind the insertion of the second dorsal fin.

The flesh is pale red, almost white, and when served as sliced raw fish, it has a very beautiful appearance and a very fine flavor. It is particularly delicious during the summer. This species is rare in Japan, being taken by trolling during the winter off the south coast of Kyūshū. It is a great deal more coastal in character than the other tunas, and is common in the vicinity of small islands in the tropics and sub-tropics. In Formosa it is taken throughout the year by trolling, and is particularly abundant from February to March and around August.

The above five species are all of the tunas that occur in Japanese waters. The koshinaga is entirely without significance as an element in the tuna longline catch.

B. Spearfishes

As with the tunas, a great number of species of spearfishes have been reported from various parts of the world, the number being actually in excess of 30 species. It is, however, very doubtful whether so many species really exist. The reason that such a large number of species have been reported is probably that these fish are difficult to study and there has been no thorough comparative study made.

The writer has some new opinions considering the classification of the spearfishes, but as these will be published elsewhere, the notes given here are based on the hitherto accepted classification.

1. Shortnosed spearfish, *Tetrapturus angustirostris* (Tanaka)

? *angustirostris* = *belone* = *brevirostris*

This fish is also called sanmakajiki. It is the smallest of the spearfishes and rarely surpasses a length of about 2 meters and a weight of about 20 kilograms. It is easily distinguished from other species by such remarkable characteristics as the shortness of its lanceolate upper jaw, the height of the central portion of its dorsal fin, and the absence of markings on the sides of its slender body.

The flesh is of the so-called "spearfish color" but rather pale, and although it has a beautiful appearance when served as sliced raw fish, it is lacking in fat and is not very well flavored.

This is a remarkably pelagic species, and it appears not to occur in coastal nor in enclosed seas. In Japanese waters it occurs in the open sea south of 35° N. latitude, but its density of distribution is not very high. It occurs rather densely in the waters east of Formosa and the Philippines from November to January, at which season it spawns. Up to the present it has not been of great importance to the fishery. The name *angustirostris* was given to this species by Dr. Shigeo Tanaka, however, this is probably the same species as that reported from the Atlantic Ocean under the name of *belone* and from the Indian Ocean as *brevirostris*.

2. Sailfish, Istiophorus orientalis (Temminck and Schlegel)

Umbrella spearfish (Formosa).

This species is also called nairagi, nōrage, baren, and sugiyama. It attains a length of about 3 meters and a weight of about 60 kilograms. The spearshaped upper jaw is comparatively long and the development of the ventral fins is also remarkable. The body is notably compressed laterally and elongated and there are between 10 and 20 transverse bands formed of cobalt colored spots on the sides of the body. The most remarkable characteristic is the very great development of the first dorsal fin. Most of the names for this fish are based on this character.

The flesh is rather dark pink, inferior in appearance to other species, and the flavor also appears inferior. It is, however, very well flavored at some seasons, particularly from April to June.

The sailfish occurs throughout the year comparatively close to islands in warm seas, and it appears in Japanese waters in the summer. It spawns in Formosan waters from April to August. The juvenile fish differ greatly in appearance from the adults, and have conspicuous spines on their heads.

The spearfishes, when they are hooked, generally make a series of leaps into the air, after which they struggle at the surface attempting to flee in a horizontal direction so that they tangle the lines and are very troublesome. They also have the habit of swimming at the surface with the upper lobe of the caudal fin and sometimes a part of the dorsal fin exposed. This habit is utilized by the harpoon fishery which is carried on at a number of widely separated places.

3. Striped marlin, Makaira mitsukurii (Jordan and Snyder)

Spearfish or Blue-marlin (?) (America).

Red-fleshed spearfish (Formosa).

This species is sometimes called akakajiki (red marlin) to contrast it with the white marlin and black marlin. It is not very large for a spearfish, but it does attain a length of about 2.5 meters and a weight of around 120 kilograms.

The body is elongated and strongly compressed laterally with between 10 and 20 transverse bars on its sides formed by assemblages of cobalt spots. The third to fifth spines of the first dorsal fin are the highest, the height exceeding the body depth. The upper jaw is longer in proportion to the lower jaw than in other species of spearfish.

The flesh is a beautiful pale red color, the so-called "spearfish color," and both its appearance and its flavor are considered very good when it is served raw. The price is consequently high.

These fish are always present in warm seas. They are quite pelagic in nature and appear to be taken in rather large numbers in the vicinity of small islands in the open ocean. In the Ogasawara Islands area they are most abundant from May to July, and they appear to range north to the vicinity of 40° N. latitude. In Formosan waters the catch of this species begins gradually to increase in January and is at its peak in May at which time the fish spawn. They appear to move north along the continental side of the Kuroshio and are rather abundant on the East China Sea side of the Okinawa archipelago. They also appear in the Tsushima Strait area and some of them seem to enter the southern part of the Sea of Japan.

4. White marlin, Makaira marlina (Jordan and Hubbs)

Black marlin (America).

Standing-wing spearfish (Formosa).

This fish is also known as the shirokawa kajiki, shiro, and katahari. This is the largest of all the tunas and spearfishes, the biggest specimen the writer ever encountered in his studies having been slightly less than 4 meters in length and 564 kilograms in weight. According to the fishermen, there are records of even larger specimens having been taken.

The body depth is great, and that portion of the body forward of the vent is strongly compressed laterally. The part of the body anterior to the insertion of the first dorsal fin rises up sharply, giving rise to the name katahari ("square shoulders"). No bands of cobalt spots can be seen on the sides of the body. The structure of the pectoral fins is completely different from that of the other species, and as these fins stand out at approximately right angles from the sides of the body, this fish is called the "standing-wing spearfish" in the Formosan language. In all of the other species the pectoral fins can be folded in along the sides of the body, but the white marlin is conspicuously characterized by the fact that this cannot be done without destroying the articulation of these fins.

The color of the flesh appears to be somewhat lighter than that of the striped marlin. It is difficult to generalize on this point because in this species, as in others, the color of the flesh appears to vary somewhat with the area and the season. Both the appearance and the flavor are very good when the fish is served sliced raw. It is especially flavorful when there is abundant fat.

These fish occur throughout the year in warm seas. It appears that their distribution extends to rather high latitudes and the northern limit of their distribution in Japanese waters is not clearly known. In the southern sea areas they appear to be particularly abundant in such enclosed waters as the Celebes Sea, Sulu Sea, and South China Sea, and it seems that they are generally numerous in the vicinity of islands. In Formosan waters they are taken in the greatest numbers on the South China Sea side from October to December, and they are most abundant in the Kuroshio in February and March. In the East China Sea in general, they are taken along the 100-fathom line, and they reach the Saishūtō (Quelpart Island) area.

It is an interesting fact that there is a marked difference in size between the sexes, the males being generally small and the females large. The males reach a maximum weight of 130 kilograms, but the biggest female recorded was 564 kilograms. The same phenomenon is seen in the case of the black marlin, as will be noted later, but in this case the males attain weights of only about 100 to 120 kilograms and all fish over this size are females. As yet no adequate biological explanation can be given for this phenomenon.

5. Black marlin, Makaira mazara (Jordan and Snyder)

Crow-skin spearfish (Formosa).

This fish is also called kūro, kurokawa, and genba. It is not clear what this species is called in the United States. The name mazara is derived from the name mazaara used in the Bōshū region, but it is very doubtful whether the fish reported as a new species by Jordan and Snyder was a black marlin, the present author inclining to the opinion that it was not. However, the presently accepted name mazara will be employed here.

The body is very stout with the lateral compression less marked than in other species. The fish looks shorter than other species. There are from 10 to 20 transverse bars on the sides of the body made up of cobalt spots. Scales are more deciduous than in other species, and where they come off the body is a brownish color. The snout tapers sharply, and the length of the upper jaw is slightly more than twice that of the lower jaw. The lateral line is extraordinarily obscure, but when carefully examined it can be seen to be not simple but complexly branched, a characteristic of this species.

The color of the flesh is not greatly different from that of the striped marlin or the white marlin, but this species generally contains more fat, and those taken in Formosa from March to May are sometimes called "oily spearfish." The flavor is considered inferior to that of the striped marlin, but this depends upon the season and the area, and those taken around April and May make extremely delicious sashimi.

These fish are particularly abundant in the open seas of warm latitudes, and they appear everywhere in the North Equatorial Current. In the coastal waters of the Ogasawara Islands they appear after the striped marlin. They range farther to the north, but the northern limit of their distribution is not known. In the southern portion of the Kuroshio, that is off Formosa and the Philippines, they gradually increase in abundance beginning around March and reach their peak around August and September. This does not differ greatly from the situation in the Ogasawara area. In August and September they are rather abundant in waters west of Kyūshū and the vicinity of Saishūtō (Quelpart Island). They spawn east of Luzon from May to July.

6. Broadbill swordfish, Xiphias gladius (Linnaeus)

Swordfish (England-America).

This fish belongs to a different family from the spearfishes listed above. It is also called meka and tsun, the former name being used in the area around Tokyo and the latter being employed in Kyūshū.

The upper jaw is very long, being more than 7/10 of the length of the body. In most of the spearfishes, the upper jaw is slender and cylindrical, but in this species it has the form of a two-edged sword. A remarkable characteristic of this fish is the complete absence of ventral fins, of which there is not even a trace. It also differs notably in outer appearance from the other spearfishes in that there are no scales, both jaws are without teeth, and the keels on the caudal peduncles, of which there are two pairs in the istiophorids, are single in this species. The back is bluish-black with a leaden cast, and the belly is white, but the fish appears to have an all-over yellowish-brown cast. The flesh is nearly white, soft, very oily, and not particularly prized as sashimi. It is however, palatable when cooked and seasoned and is greatly liked by Americans.

This fish has a wide range of distribution and is known from warm seas throughout the world. In Japanese waters, it is abundant off northeastern Japan and although a fish of temperate seas, it is numerous in rather high latitudes. It is taken by harpooning and by the longline fishery.

In addition to these tunas and spearfishes, the tuna longline fishery takes cybiids, dolphin, skipjack, moonfish, and sharks. Aside from the sharks, these other fishes can hardly be said to be important in terms of numbers. The sharks not only are taken in large numbers and have an important significance as part of the catch, but they also demand attention as pests which damage the fish caught on the longlines. Leaving aside this purely commercial significance, they are worthy of considerable attention from the biological standpoint.

C. Sharks

There are a great many species of sharks, but among them the following 10 or so species have an especially close connection with the tuna longline fishery.

Differences can be detected in the habits of these various species. Some of them have a distribution and a migrational habit resembling that of the yellowfin, while others move in a way resembling some of the spearfishes. In some cases their migrations precede and in others they follow those of the tunas and spearfishes. As almost nothing is known as yet of these relationships, it is far from the stage of practical application, but if thorough studies are made, it may be thought that there is ample possibility of using these sharks as indicators of fishing grounds and fishing seasons. Hitherto, there have been no studies at all from this point of view, however, but in the future this sort of work should be emphasized.

1. Aozame, Isurus glaucus (Müller and Henle)

Also called aoyagi, iragi, and shibibuka.

The body is spindle-shaped, and the snout is pointed and equipped with sharp teeth. It reaches a length of about 4 meters. The back is a deep indigo blue and the belly is white. This fish occurs widely in warm seas south of central Japan, but is not abundant. The skin is said to be the best for leather of any shark skin.

2. Rakudazame, Isurus nasus (Bonnaterre)

Also called mōka and nezumizame. This fish is stouter than the aozame. Whereas the aozame is a warm-water species, this species prefers cold waters and is numerous from northeastern Japan northward. In northeastern Honshū a longline fishery has developed which has this shark as its special object. This is the so-called mōkanawa.

3. Hachiware, Alopias profundus (Nakamura)

Foxshark or thresher shark (England).

This is one of the thresher shark family and its caudal fin is broad and equal in length to the rest of the body. The eyes are large and of the shape of a gourd turned upside down. This shark attains a length of more than 4 meters and inhabits warm seas.

4. Onagazame, Alopias pelagicus (Nakamura)

Foxshark (England).

This shark resembles the preceding species, but its caudal fin is longer than the rest of the body and narrow. The eyes are small and of a green-gray color whereas in the preceding species the eyes are of a blackish-gray color. This species is widely and generally distributed in warm seas. Both species attain a length of about 4 meters. It appears that there is yet another very similar species but little is known of it at present.

5. Itachizame, Galeocerdo arcticus (Faber)

There are brown markings on the body. Large specimens attain a length of 3 meters. This is a very widely distributed shark, ranging from the Equator to the vicinity of 80° N. and S. latitude. It is generally most abundant in the vicinity of islands and often eats gulls and other water birds, for which reason it is called the "bird shark" in Formosan Chinese. It is an extraordinarily voracious animal, and human bones and so forth are found from time to time in its stomach.

6. Dotabuka, Carcharinus brachyurus (Günther)

This shark will grow to a length of about 2 - 2.5 meters. The first dorsal fin is notably small and is located mid-way between the snout and the caudal peduncle. The second dorsal fin is smaller than the second anal fin and is located diametrically opposite it. The snout is blunt. This is one of the species of sharks commonly seen in warm seas.

7. Yashibuka, Carcharinus sp. (gangeticus?)

This shark resembles the preceding one but can easily be distinguished by its remarkably large first dorsal fin. This fin is the best for making dried shark fins used in Chinese cooking and is of high value. This species is abundant in warm seas. They are particularly numerous in the waters east of Formosa in February and March.

8. Mejirozame, Carcharinus japonicus (Temminck and Schlegel)

Characteristics peculiar to this species are the small eyes and gill openings. They are said to be very abundant in Japanese waters, but it is doubtful whether all the sharks to which the name mejirozame is applied are of the same species. It is thought that there is need for further study on this point.

9. Tsumaguro, Carcharinus melanopterus (Quoy and Gaimard)

Particularly outstanding characteristics of this shark are the intensely black tips and edges of all the fins. It attains a length of 2 - 2.5 meters. As it is abundant in southern seas, it is taken in rather large quantities. These sharks appear to be particularly numerous in the South China Sea area.

10. Tsumajiro, Carcharinus albimarginatus (Rüppell)

This species is distinguished by the white tips and edges on all of its fins. It does not grow very large, the maximum size being about 2 meters long and 30 kilograms in weight. This species is very commonly seen in warm seas. There is another separate species called the yogorebuka or baka, but it is not yet well known biologically. In this species the tip of each fin has cloud-like irregular white spots.

11. Shūmokuzame, Sphyrna zygaena (Linnaeus)

The head is in the form of a wooden mallet with the eyes on the tips. In western Japan it is generally called kasebuka or kase. One species occurs in Japanese waters, but three species have been reported from the south. It is wondered whether those occurring in Japanese waters should not also be separated into three distinct species.

V. Fishing Grounds

As has been stated earlier, the fishing grounds of the tuna longline fishery are located within the area from the Equator to about 40° to 45° N. latitude in the open sea and in coastal waters facing on warm currents. We do not as yet have adequate data concerning the situation in the Southern Hemisphere and therefore know little about it, but it may naturally be supposed not to be greatly different from that of the Northern Hemisphere. The occurrence of many species of tuna and spearfish has been reported from Australia and the New Guinea area. It appears that recently tuna fisheries are being developed in that region.

Until recent years tuna fishing grounds were limited to coastal waters and to the vicinity of islands and shoals (eminences in the sea floor) scattered throughout the open sea. This was partly because the fishes sought after are abundant in waters having this topography, but it was also due to the impossibility of operating in the open sea without landmarks when the capabilities of the fishing vessels and the navigational arts of the fishermen were so inadequate.

The abundance of fish in the vicinity of oceanic islands and shoals is explained principally from the point of view of the food supply as the sea waters are stirred up in the vicinity of such places enriching the surface layers with nutrient salts from the rich, deep layers and promoting the growth of plankton while gyrals concentrate the small animals which serve as food for the tunas. There is still room for doubt as to whether or not this sort of explanation exhausts the subject, but at any rate the tunas are observed to remain during certain periods of time in the vicinity of such topographical features. This phenomenon is called "setsuki" and such fishing grounds are called setsuki or shoal fishing grounds. On such fishing grounds fish are always comparatively abundant, offering superior conditions for fishing.

Formerly there was a time when it was believed that such topography was probably essential to the development of tuna fishing grounds and at that time explorations for new fishing grounds meant a search for islands and shoals. In recent years with the progress of the shipbuilding art and the improvement of navigational techniques, fishing grounds have been very rapidly extended and the foregoing concept has been completely abandoned as it has come to be realized that any place in the ocean can become a fishing ground if one succeeds in intercepting the route of migration of the schools. The mid-Pacific albacore grounds are a good example.

Under the heading "General Outline of Fishing Grounds and Fishing Seasons" a brief account was given of the fishing grounds in Japanese waters. In the present section the Indian Ocean and the Pacific Ocean will be divided into a number of areas each of which will be described in terms of its characteristics and significance as a fishing ground.

The data used here are all the results of the work of research vessels. The data gathered by ordinary commercial fishing vessels have many shortcomings and there are grave doubts concerning their reliability. For this reason, I have decided to use none of them. I understand to some extent the feeling of the commercial fishermen in not wanting to inform others of their good fishing grounds, but it goes without saying that this attitude is extremely disadvantageous as an obstacle to the mutual interchange of knowledge and experience. The interchange of accurate data is desirable both for the present mutual profit of persons engaged in the fishery and for the healthy development of the industry.

Some of the data gathered by research vessels have been lost. In others there are imperfections and doubtful points, which in most cases have not been corrected despite the passage of time since they were gathered, and from these points of view I have found not a few occasions for dissatisfaction. Furthermore, because the distribution of the data by area and by season has been extremely uneven, it has been almost impossible to find out the changes in the fishing seasons and the movements of the schools throughout the year for all the fishing grounds. It is believed that the reason for this is to be found in the defects in the system which has operated hitherto. That is, each research vessel has, in addition to the duty of providing guidance for the fishing vessels from its locality, had to bear the burden of a very heavy income budget. For this reason, they have carried out their obligations to the income budget rather than try to attain the basic purposes of a research vessel, and have all striven to fish on the same grounds at the season when they could anticipate sure catches.

It is highly regrettable that this situation has not only not been completely corrected at present, but in fact has rather been aggravated. This fact should give an important suggestion concerning the proper management of fisheries research activities. The objectives of the study of oceanic resources cannot be attained by having each research vessel operate in accordance with its own particular opinions and with the main objective of catching fish. However, the execution of a research program based on a coordinated plan for the disposition of the vessels and ignoring the question of income would require a great deal of money and would be completely impossible to a weak economy.

What has been said here does not mean of course that the work of research vessels in the past was completely without significance. As will be set forth in the following, it is possible in some degree to learn the characteristics of the various fishing grounds. It has, however, been possible to learn only very little concerning the movements of the schools and the accompanying changes in fishing grounds and fishing seasons, questions which it was hoped at first would be clarified by this study.

A. Indian Ocean Region

The waters to the south and west of the Greater and Lesser Sunda archipelagos will be described as the Indian Ocean Region. Almost all of the data for this area were gathered by the training ship Hakuyō Maru of the Fisheries Institute of the Ministry of Agriculture and Forestry and the research vessel Haruna Maru of the Fisheries Bureau of the Ministry of Agriculture and Commerce. In addition the fisheries research vessel Shōnan Maru, of the former Formosa Government-General and the mothership-type tuna fleet of the Tōbu Fisheries Company operated experimentally in this region. There is also a small amount of data for the area from the research vessel Zuihō Maru of the South Seas Government-General.

It appears that before the war some Japanese fishermen were trolling out of Singapore, but there was no real tuna fishery operated either by Japanese or by the natives of the region. During the war many fishing boats operated in this area in order to supply food for the troops. They appear to have been fairly successful, but they left no records at all.

Nothing is known of the situation since the war. As the natives have no knowledge or experience of this type of fishery, it cannot be thought that there is any possibility at present of their operating a longline fishery. Consequently, it is believed that these waters remain almost completely virgin grounds for the tuna fishery. However, as has already been said, it appears that a start has already been made in Australia, and Ceylon and Pakistan also seem to be showing an extraordinary interest in fisheries, so the waters of this region will probably be developed as fishing grounds in the not far distant future.

This region has been subdivided as follows:

1. Waters around the Andaman and Nicobar islands.
2. The west coast of Sumatra.
3. Waters around Java.
4. Waters around the Lesser Sunda archipelago and Timor.

In addition to these four areas, the Hakuyō Maru made a survey in the vicinity of 4° N. latitude, 75° E. longitude, but as the data were few they have been omitted from consideration.

1. Waters around the Andaman and Nicobar islands (6° to 15° N., 90° to 97° E.).

As we have very few data concerning oceanographic conditions in this sea area, their details are unknown. In this region the year is divided into two seasons, in one of which the northeast winds blow continuously, while in the other southwesterly winds prevail. The former corresponds to the winter of the Northern Hemisphere and the latter to the summer. These seasonal changes are accompanied by marked differences in oceanographic conditions.

The currents during the period from July to September when the southwesterly winds are at their strongest are roughly as follows. There is a current which flows in the vicinity of 5° N. and this current divides into two branches to the west of the northern tip of Sumatra. One branch flows to the southeast along the west coast of Sumatra; the other flows north-northeast along both sides of the Nicobar and Andaman archipelagos. The speed of these currents is about 0.5 to 1 knot.

From January to March, when the northeasterly winds prevail, the ocean currents are almost completely opposite to their pattern during the period of southwesterly winds. They flow in a clockwise direction in the Bay of Bengal, flow south along the islands, and turn to the westward in the vicinity of the northern tip of Sumatra.

As we have no data for the season of southwesterly winds, it is impossible to explain the situation as regards water temperatures and salinity. Combining the data for the period from December - January, it is indicated that the surface water temperature is slightly less than 28° C., the temperature at the 50-meter level about 27.5° C., at 100 meters 23° to 24° C., and at 200 meters about 14° C. Transparency shows rather low values, within the range of 9 to 18 meters. The water color is generally III on Forel's scale.

During the season of northeasterlies, strong winds blow from time to time and it is thought that it would sometimes be difficult for small vessels to operate. However, in general, fine weather prevails and it is believed that weather would prove no obstacle to the operation of large vessels. As the season of southwesterly winds corresponds to the rainy season in this region, there are many squalls and typhoons attack the region from time to time, so there would probably be not a few cases in which the weather would interfere with fishing operations.

In the investigations of the Hakuyō Maru frozen squid were used as bait, frozen herring and squid having been used by the Haruna Maru. The Hakuyō Maru also investigated local bait supplies and concluded that while it would not be impossible, it would be extremely difficult for a fishing boat to obtain its own supplies of bait in the area.

The surveys of the Hakuyō Maru and the Haruna Maru were made between 1930 and 1933. The investigations were carried on only during December and January, so that there are no data at all for any other seasons of the year. Consequently the oceanographic conditions at other times are completely unknown. Table 10 shows the fishing conditions revealed by these explorations. The figure in the table is the number of fish captured per hundred hooks fished. This will be referred to hereafter as the catch rate.

Table 10.--Fishing conditions in the Andaman and Nicobar islands

Number of hooks fished	Yellowfin		Bigeye		Spearfishes		Total	
	Fish	Catch rate	Fish	Catch rate	Fish	Catch rate	Fish	Catch rate
17,348	1,179	6.80	43	0.25	70	0.40	1,292	7.44

The combined catch rate for tunas and spearfishes is 7.44, indicating a rather superior fishing ground.

As for the composition of the catch, yellowfin tuna were most important, being more than 91 percent of the total tuna and spearfish catch. Bigeyed tuna were slightly more than 3 percent and spearfishes slightly less than 5 percent. If these values are compared with those for other sea areas, they indicate that at the season when the survey was made, the catch of bigeyed tuna and spearfishes in this area is remarkably low. As we have no data, we know absolutely nothing of the fishing conditions and the composition of the catch at other seasons.

Looking at the variations in the fishing situation by areas, it is clearly indicated that the catch rates tend to be high in the south and low in the north. On the other hand, a trend is indicated for the size of the yellowfin to be greater in the north and smaller in the south. In other words, in the south the catch rate is high but the fish are small, while in the north the catch rate is low and the fish are large.

Looking at the changes in the fishing conditions by seasons, within the period December-January there is clearly a tendency for the catch rates to rise gradually with the passage of time. From January 27 to 31, 1932, the catch rates of the Hakuyō Maru showed an astonishingly high average of 19.65, and on the 27th and 28th of January 1930, the catch rates were also high, being 16.67 and 12.33 respectively.

This trend of increase and decrease in the catch rates with the season is similar to that which can be seen in the waters off the west coast of Sumatra which adjoin this sea area to the south, and therefore can be thought to indicate the migrational pattern of the schools in the northeastern part of the Indian Ocean. As will be detailed later, in the northern part of the Sumatran waters the catch rates gradually increase from November on, showing a tendency to a continuing increase until at least February.

The foregoing is a general outline of fishing conditions for tunas and spearfishes. The Hakuyō Maru's reports contain absolutely no records concerning sharks, which follow these fishes in importance. According to the reports of the Haruna Maru, the catch rate for sharks was 1.84. This means that at that season sharks were taken at the rate of about 2 for every 100 hooks fished. Damage to the catch by sharks appears to have been rather great, but we have no detailed information on it. Miscellaneous fish mixed in with the catch were skipjack, dolphin, and cybiids, but they were few in number and of little significance.

The gear used by the Hakuyō Maru had branch lines of two different lengths, the construction being as follows:

Type of branch line	Number of branch lines	Length in feet
Long branches	2	99
Short branches	4	30

The length of the float lines was 90 feet. The following table shows the catch made by the long and short branch lines of this gear.

Table 11.--Fishing results by type of branch line (Hakuyō Maru, waters of Andaman and Nicobar islands)

Date	Long branch lines		Short branch lines	
	Number of fish	Percentage	Number of fish	Percentage
Jan. 1931	81	71	32	29
Dec. 1931	76	73	28	27

The percentage figures in this table are the proportion of the total catch taken by each type of branch line.

As the foregoing table shows, the long branches gave much better results than the short branch lines. Indeed, if we compare the number of hooks actually used on each type of branch line, there were twice as many short branches as long branches used, and therefore the catch rate of the long branch lines was from 5 to 6 times greater than that of the short branch lines. These facts indicate that short branch lines are much less suitable than long ones as fishing gear for this sea area. If we assume that the sum of the float line and branch line lengths gives the depths at which the hooks are hanging, the depth was 120 feet in the case of the short branches and 189 feet in case of the long branches. As there is in actuality considerable sag in the main line, the positions of the hooks were deeper than this. The problem of what depth gives the best catch rates cannot be settled simply by this sort of comparison of two kinds of branch lines, however, in view of the length of these long branch lines it is believed that the yellowfin swim at rather deep levels in this sea area.

Because of the lack of data we have no way of knowing anything about seasonal changes in fishing conditions, but it is at any rate certain that this is a rather superior fishing ground from December to January. Judging by analogy with the fishing conditions in the waters off Sumatra, it is probable that the good fishing continues through February and that the fishing improves with the passage of time during this period.

2. West coast of Sumatra (6° N. to 8° S., 90° to 105° E.)

Most of the data for this sea area are from the operations of the Haruna Maru and the Hakuyō Maru. In addition a small amount of data has been reported by the Shōnan Maru. These investigations were confined to waters very close to shore and the situation farther offshore is not known.

The pattern of the currents is roughly as follows. During the period from July through September, when southerly winds blow continuously, there is a rather strong current flowing eastward at 5° N. from the central portion of the Indian Ocean. The current divides into two branches near the northern end of this sea area, one branch running north along the Nicobar and Andaman islands, and the other flowing southeast along the coast of Sumatra. In the vicinity of 5° S., that is near the Sunda Strait, there is a very clear current boundary. This boundary extends southwest from the vicinity of Sunda Strait, and from around 100° E. longitude it runs west approximately along the line of 8° S. latitude. South of the boundary a strong current flows west from the waters off the south coast of Java while to the north of the boundary the current flows southeast as mentioned before.

From January through March, the season when northerly winds prevail, the pattern of the currents changes completely. At this season a current boundary appears running east and west along the Equator; north of this boundary, the currents flow northeast and south of it there is a current flowing southeast along the shores of Sumatra. The current north of the Equator turns westward in the vicinity of the northern extremity of this sea area around 5° N. latitude and joins the current flowing south along the Nicobar Islands. Another conspicuous current boundary appears around the southern limits of this sea area. This boundary runs approximately east and west in the vicinity of 8° to 10° S. latitude, and on its south side the cold current flowing up the west coast of Australia turns to the westward. Because of this current, the current flowing southeast along the west coast of Sumatra is pressed against the coast of Java, forming a narrow but strong flow to the eastward. During the season of northeasterly winds, as remarked earlier, this sea area is cut off from adjacent waters by conspicuous current boundaries at its north in the vicinity of 5° N. latitude and to the south in the vicinity of 8° S. latitude. There is another current boundary at about the center of the area near the Equator. The line of this boundary runs east and west along the Equator, turning to the southwest in the vicinity of 98° E. longitude. Accordingly, this sea area is divided into a number of parts having currents of different character.

These various currents appear to be rather strong, and according to the reports of the Haruna Maru, speeds of 2 to 3 knots were frequently measured.

As we have no data for the season of southerly winds, we know nothing of oceanographic conditions at that time of the year. During the season when northerly winds prevail, the water temperatures are in general higher than those of the Nicobar Islands region, with slightly over 28° C. at the surface, slightly less than 28° C. at the 50-meter level, and around 24° to 25° C. at the 100-meter level on the average. Higher values are shown for transparency than in the Nicobar and Andaman islands waters, the values running about 30 meters. The water color is in most cases I or II on the Forel scale.

The season of southerly winds corresponds with the rainy season in this region and there are many squalls. Wind and waves are generally high and typhoons occur from time to time. It is thought that the weather will interfere frequently with fishing operations. This sea area, except for its northern extremity, is generally calm during the season of northerly winds and fishing operations are usually very easily carried on.

The investigations of the Haruna Maru and the Hakuyō Maru cover the period from November through February. The data from the Shōnan Maru were collected in August in the vicinity of the Sunda Strait. It is said that the mothership-type operation of the Tōbu Fisheries Company also entered this area, but as there are no data from this venture we do not know what conditions they found there. If we summarize these various data in a table, the fishing conditions in this sea area may be shown as follows.

Table 12.--Fishing conditions off the west coast of Sumatra

Number of hooks used	Yellowfin		Bigeye		Spearfishes		Total tunas and spearfishes		Total sharks	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
151,508	12,904	8.52	1,350	0.89	1,078	0.71	15,332	10.12	1,530	1.01

As the table shows, the combined catch rate for tunas and spearfishes is over 10, indicating that this sea area is an extremely good fishing ground.

Compared with the waters of the Andaman and Nicobar islands described above, the catch rates in this sea area are conspicuously higher. Yellowfin, bigeye tuna, and spearfishes are all shown to be more abundant in this area. The shark catch rate on the other hand is lower. The table shows that the main factor in the greater catch rate in this area is the increased catch of yellowfin tuna, but note must also be taken of the remarkable increase in the bigeye catch.

The data are limited to the period from November through February, but they afford a basis for considering that the seasonal changes in fishing conditions are fairly great. The following table shows the catch rates for each species grouped by months.

Table 13 brings together data from investigations covering several years. It may naturally be thought that there is a certain amount of variation from year to year, however, for the period from November through February, a general tendency for the catch rates to gradually rise with the passage of time can be clearly detected. Data for the season of southerly winds are, as the table shows, very few and are inadequate as a basis for forming any sort of an opinion, but it is thought that some catch can be anticipated at this season.

Table 13.--Fishing conditions by months (off the west coast of Sumatra)

Month	Number of hooks used	Yellowfin		Bigeye		Spearfishes		Sharks	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Aug.	300	9	3.00	0	0.00	2	0.66	4	1.33
Nov.	7,800	341	4.37	65	0.83	31	0.40	40	0.51
Dec.	51,488	4,540	8.80	575	1.12	249	0.48	457	0.89
Jan.	75,568	6,782	8.98	615	0.81	612	0.81	866	1.15
Feb.	16,352	1,732	10.59	95	0.58	184	1.13	163	1.00

In the composition of the catch, the yellowfin are overwhelmingly predominant, amounting to 84 percent of the total for all tunas and spearfishes. Bigeye tuna are slightly less than 9 percent and spearfishes slightly more than 7 percent of the catch, these proportions representing a conspicuous increase over the catch of the species in the Nicobar region.

The seasonal changes in the catch rates for the various species are as shown in the foregoing table. The bigeye catch rate reaches its peak in December and thereafter gradually declines. Both the spearfishes and the yellowfin tuna show a tendency to a gradual increase with the passage of time, at least up to the end of February. The sharks in general exhibit the same trends of increase and decrease as the yellowfin and spearfishes, but in addition to the seasonal changes they also appear to vary remarkably from one area to another, the catch rates appearing to be larger close to shore.

Damage to the catch by sharks appears on the whole to be proportional to the catch rate of sharks, and on the days when large numbers of sharks were taken the damage from sharks was also great. According to the reports of the Haruna Maru, the maximum shark damage was actually 40 percent. This high rate was however rather exceptional and in general the damage rate was about 10 percent.

Considering the situation in the various parts of the area, it appears that whereas the fishing conditions north of the Equator were comparatively stable, to the south of the Equator and particularly in the waters off the Sunda Strait, which are at the southern limit of this area, the fluctuations in the fishing conditions appear to have been extremely pronounced.

The average weight of the fish in each day's yellowfin catch was reported. The data indicate that the majority of the fish taken north of the Equator were centered around 35 kilograms. A tendency can be detected for the fish to be somewhat smaller to the southward and larger to the northward. An interesting phenomenon is seen in the fact that on days when the average weight of the fish was around 35 kilograms, the catch rates were generally high whereas the catch rates declined very greatly on days when the fish were much larger or smaller than this. According to the reports of the Haruna Maru, very small fish of 10 to 20 kilograms were taken on one or two days at almost regular periods several days apart, and on these days the catch rates were very low. The fishing stations were so close together that they can be quite properly regarded as a single location. The significance of this sort of phenomenon cannot be adequately explained, but it is thought to be worthy of attention both from the biological and the fishing points of view.

The size of the yellowfin in the sea area south of the Equator appears to have been completely different on either side of a boundary line in the vicinity of 6° S. latitude. The fish from the north side of this line did not differ greatly in size from those taken in the vicinity of the Equator, but those taken south of the line had an average weight of about 50 kilograms. As the season at which the data were collected was, of course, the same for this area and for the areas along and north of the Equator, it appears that different age groups occur south of 6° S. latitude and in the vicinity of the Equator. Furthermore, as was noted earlier, south of 6° S. latitude there are wider fluctuations in the catch rates and a more unstable fishing situation than along the Equator or to the north of it.

Although there are these differences in the character of the fishing grounds in different parts of the area, it is recognized that the waters off western Sumatra are excellent fishing grounds during the season when the northeasterly winds are at their strongest. The significance of the area as a fishing ground during the season of southwesterly winds is not clear.

3. Waters off Java (6° to 13° S., 105° to 115° E.)

The sea area between the Sunda Strait and the Lombok Strait is that referred to here as the waters off Java. During the season of southerly winds the sea currents in this area are quite simple, with the current which runs along the south coast of the Lesser Sunda archipelago, which lies immediately to the east of Java, simply continuing to flow westward along the south coast of Java. The velocity of this current is rather high, speeds of 1 knot per hour or more having been recorded. A pronounced current boundary appears running southwestward from the vicinity of the Sunda Strait and the coastal waters of Sumatra to the north of this boundary form a completely distinct water system.

From January through March, when the northerly winds blow continuously, the pattern of the sea currents changes completely and becomes remarkably complex. To describe them in a rough outline, there is a conspicuous current boundary trending generally east and west in the vicinity of 8° to 10° S. latitude, and this boundary turns to the southwestward in the vicinity of Lombok Strait at the eastern extremity of this sea area. On the south side of this boundary the currents flow generally westward. The current coming south off the coast of Sumatra turns and flows to the eastward. The current on the north side of the boundary is pressed in very close to the shores of Java by currents on its south side and its velocity is high although the current itself is extremely narrow. The currents on the south side of the boundary come out of the central part of the southern Indian Ocean flowing to the northeastward, and impinging upon the island of Java they turn to the west. To the east of the current boundary in the vicinity of Lombok Strait, the current flowing north along the west coast of Australia turns to the northeast and thereafter turns eastward to flow along the Lesser Sunda archipelago.

As indicated by the above brief description, during the season when northerly winds predominate, the coastal waters of Java are almost completely cut off from and are under the influence of different currents from the adjacent sea areas to the east and the northwest.

Sea conditions in the season of southerly winds are unknown because there are no data. During the season of prevailing northerlies surface water temperatures in this sea area are not greatly different from those of the west coast waters of Sumatra, but the temperatures at the 50-meter and 200-meter levels seem to be rather markedly lower.

The season of southerly winds is the rainy season in this sea area and the weather is bad and the sea rough. Furthermore, typhoons occur from time to time and it is thought that interference with operations by the weather will be frequent. During the season of northerly winds there is continuous good weather, the sea is extremely calm, and operating should be easy.

Data on past investigations in this sea area are available only from the Hakuyō Maru and the Haruna Maru. Investigations of the Haruna Maru were carried on during December 1933, and the area investigated was limited to the eastern and western extremes of this sea area, that is, the vicinities of the Lombok and Sunda straits. The explorations of the Hakuyō Maru were carried out in June 1926 and were scattered throughout this whole area. These data have been brought together to show the fishing conditions in the waters of Java in the following table.

Table 14.--Fishing conditions in Java waters (Hakuyō Maru, January 1931; Haruna Maru, December 1933)

Vessel	Number of.hooks	Yellowfin		Bigeye		Spearfishes		Tunas and spearfishes		Sharks	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Hakuyō	900	10	1.11	0	0.00	0	0.00	10	1.11	10	1.11
Haruna	8,720	280	3.21	63	0.72	61	0.70	404	4.63	180	2.06
Total	9,620	290	3.03	63	0.65	61	0.63	414	4.30	190	1.97

As the data are not only very scarce but extremely unevenly distributed, there is danger in drawing conclusions on the basis of just these data, however, if the facts shown in the foregoing table are compared with the data from the waters of Sumatra and the Lesser Sunda archipelago (to be discussed below), it may be thought that fishing conditions in Java waters during the season of northerly winds are markedly slack in comparison with adjacent sea areas. Furthermore, as has already been stated, the investigations of the Haruna Maru were confined to the eastern and western extremities of this sea area and therefore it can be seen that fishing was extremely poor off the central part of Java (! sic). The season at which the investigations were carried on coincides with the season of extremely good fishing in the waters off Sumatra. It is consequently difficult to believe that the reason for the marked inferiority of the fishing in this sea area as compared with coastal waters of Sumatra was due to seasonal changes.

The foregoing facts seem to give important indications for the consideration of the distribution of tunas (principally yellowfin) in the Indian Ocean region. The above table makes it appear that the distribution of yellowfin is extremely sparse in the currents which flow into the waters off Java from the central portion of the southern Indian Ocean, or in other words on the offshore side of the current boundary which runs east and west in the vicinity of 8° to 10° S. latitude. Unfortunately, data are very few and a thorough evaluation is impossible, but it is believed that not only yellowfin but bigeye tuna and spearfishes are extremely scarce or almost completely absent in this current.

The investigations of the Haruna Maru showed that, as might have been expected, the fishing picked up somewhat near the eastern and western extremes of this sea area and that here the composition of the catch and the size of the yellowfin, which were the principal element in the catch, agreed well with the catches made in the adjacent Sumatra and Lesser Sunda regions.

From the foregoing it appears that during this season of northerly winds the waters south of Java cannot be expected to have any very great value as tuna fishing grounds.

As there are absolutely no data for the season of southerly winds, we have no way of knowing fishing conditions at this time of year. However, at this season the pattern of the sea currents changes conspicuously, and the current which comes flowing from the Lesser Sunda archipelago on the east continues right along the island of Java to the westward. As will be explained in a later section, fishing in the waters of the Lesser Sundas during the season of southerly winds is quite active, and therefore it is thought that a certain amount of fishing can be anticipated in the waters off Java at this season. However, as has already been stated, unfavorable weather conditions at this time of year must naturally be taken into account.

4 Waters around the Lesser Sunda Islands and Timor (8° to 15° S., 115° to 130° E.)

This sea area of about 350,000 square miles adjoining on the east the area described in the foregoing section will be characterized as the waters of the Lesser Sunda archipelago and and the island of Timor.

The pattern of the ocean currents from July to September, the season in which the southerly winds are most predominant, is roughly as follows. There is a conspicuous current which comes from the region of the Arafura Sea to the southeast and passes in a westerly direction through this sea area. In the vicinity of the eastern end of the island of Timor this current divides into two branches, one flowing north into the Banda and Flores seas while the other branch continues flowing westward through this sea area. Its velocity is rather high, exceeding 1 knot per hour.

From January to March, when the northerly winds are strong, the pattern of the ocean currents changes completely. A rather strong current which flows northeastward along the west coast of Australia passes away to the eastward along the southern side of the archipelago, and along the northern side of the islands there is a current which flows in an easterly direction from the Java Sea area. These two currents of different origins unite in the vicinity of the eastern extremity of this sea area and flow into the Arafura Sea region. As was noted earlier in the section on the waters off Java, a conspicuous current boundary appears running southwestward from the vicinity of the Lombok Strait at the western extremity of the area, and the water systems of this area and those of the waters off Java are completely different.

The color of the water during this season of southerly winds is about II to III on Forel's scale. Transparency also appears to be rather low. Water temperatures are generally low, with 25° C. to 27° C. indicated for the surface layer, 24° C. to 26° C. at 50 meters, and about 20° C. at 100 meters.

During the season of northerly winds the water color is about I to II on the Forel scale, and transparencies range from 25 to 30 meters. Water temperatures are conspicuously higher than during the season of southerly winds, the surface layer having 29° C. or even higher, with 27° C. to 28° C. at 50 meters, and 23° C. to 26° C. at 100 meters, subject to local variations.

The data available for this area are the results of the investigations of the Hakuyō Maru, Haruna Maru, Shōnan Maru, Zuihō Maru (research vessel of the former South Seas government, and the Kiyō Maru (former research vessel of Wakayama Prefecture). Furthermore, the mothership-type tuna fishing operations of the Tōbu Suisan Company also extended into this area, but it is not known what success they had. The following table is a summary of these data.

Table 15.--Fishing conditions in the waters of Timor and the Lesser Sunda Islands

	Yellowfin		Bigeye		Spearfishes		Total tunas and spearfishes		Sharks	
Number of hooks	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
48,274	4,032	8.35	161	0.33	322	0.66	4,515	9.37	701	1.45

On the whole the catch rates are, as shown in the foregoing table, rather high and this area is adjudged to be an excellent fishing ground. Data are scarce so it is difficult to make a thoroughgoing comparison, however, the following table compares the fishing situation during the two seasons.

Table 16.--Fishing situation by seasons (waters of Timor and the Lesser Sunda Islands)

Season	Number of hooks	Catch rates
SE winds	46,059	9.43
NW winds	2,215	6.23

Note: Southeasterly winds -- April to September
Northwesterly winds-- October to March

There are very few data available for the season of northwesterly winds so a comparison is difficult, but within the scope of the data the fishing is better during the southeasterlies.

During the season of northwesterly winds the catch rates are at their highest around November, falling off rather sharply from December on. However, as stated earlier, this view is based on scanty data and therefore it is difficult to determine whether or not this is actually the case without further amplifying the data. If there is such a change in the fishing situation, its cause may be thought to be the change in the currents which accompanies the change of season. As we have no data, we know nothing of the changes in the fishing situation after the first part of December.

The yellowfin is the most numerous species in the catch, making up somewhat less than 90 percent of all tunas and spearfishes. The size of the fish appears to be generally larger, most of them weighing about 48 to 55 kilograms. Of course, fish of 20 to 40 kilograms are also taken, but they are proportionately few, and the average weight appears to be between 48 and 50 kilograms. Next to the yellowfin the spearfishes are most numerous, and bigeye tuna are scarce. The catch rates for the species are markedly lower than those of the coastal waters of Sumatra. However, it must be noted that these observations are based on investigations covering an extremely short period of time. The catch rate for sharks is about 1.5, a usual value for the tropics.

As regards the size of the yellowfin and the frequency of occurrence of bigeye tuna and spearfishes this area more closely resembles the adjacent Banda Sea and Flores Sea area to the north than the various sea areas adjoining it on the west. In other words, the size and composition of the catch appear to be close to those found in the Banda Sea area. It is inferred that this sort of phenomenon provides a hint as to the migratory route of the schools which migrate into this area, however, there are no data available which would show this relationship between them concretely. Consequently, it might be thought that this was a mere chance agreement, but a consideration of the pattern of ocean currents makes the foregoing inference seem reasonable. The following table provides a comparison of fishing conditions, catch composition, and the size of yellowfin tuna in this sea area and in the various areas of the Indian Ocean region, the Banda Sea, and the Flores Sea.

This area is sometimes visited by rough weather during the season of southeasterly winds, but in general throughout the year it is calm and it is believed that there is hardly ever any weather such as would interfere with operations. The migrational patterns of the schools are not as yet understood, but within the scope of the investigations which have been made it is probable that this can be called an excellent fishing ground.

Table 17.--Fishing conditions, catch composition, and size of yellowfin tuna compared

Sea area	Catch rate	Percent yellowfin	Percent spearfishes	Percent bigeye	Average weight of yellowfin
Banda Sea and Flores Sea	8.40	89.5	7.2	3.3	48.5
Waters around the Lesser Sundas	9.37	88.6	7.6	3.8	48.0
Waters off Java	4.30	70.0	14.8	15.2	49.6
Waters off Sumatra	10.12	85.9	7.1	8.2	33-35

Notes: 1. The catch rate is the number of tunas and spearfishes caught per hundred hooks.

2. The percentages for tunas and spearfishes are the proportion of those species in the total catch.

Taking a general view of the Indian Ocean region described above, fishing conditions are on the whole better during the season of northerly winds with poorer catches during the season of southerly winds. It is to be regretted that we have very few data for the season of southerly winds, but if it is assumed that the tendency described above can actually be detected, it is deeply interesting to compare it with the situation in the Pacific Ocean areas to be described below.

B. Pacific Ocean Region

Under this heading will be discussed the area from 15° S. latitude to about 43° N. latitude and west of 180° E. longitude. This includes the various seas to the north of the Lesser Sunda Islands. As in the case of the Indian Ocean region, this region has been divided up in accordance with the topography and oceanographic conditions, and an outline of the characteristics of each sea area as a fishing ground will be presented. As there are no standards for subdivision in the central part of the Pacific Ocean, that area will be divided for convenience by latitude and longitude.

1. Molucca Strait, Banda Sea, and Flores Sea (0° to 8° S., 115° to 130° E.)

This sea area is bounded by the Lesser Sunda archipelago, the Molucca Islands, the island of Celebes, and New Guinea. From July to September, that is, during the season when the southerly winds are at their strongest, the current flowing southeast from the Arafura Sea area spreads into the vicinity of the eastern tip of Timor and one of its branches flows westward into the southern part of this sea area. This current again divides southeast of Celebes with one branch advancing northward off the east coast of Celebes, passing through the Molucca Strait, and flowing into the Pacific Ocean. The other branch flows west along the north side of the Lesser Sunda archipelago and enters the Java Sea. Another current of a completely different system flows from the Celebes Sea region through the Macassar Strait and into the western part of the Flores Sea. This current is rather strong, but its effect on fishing is not known.

The ocean currents from January through March, that is, the season at which the northerly winds are at their strongest, are almost completely opposite to the pattern seen from July to September. A current appears flowing eastward from the Java Sea region, and another flows south through the Molucca Strait, the two of them joining southeast of Celebes and flowing into the Arafura Sea region. The current flowing southward through the Macassar Strait from the Celebes Sea region remains as it was in the period from July to September, but its force becomes extremely weak.

The sea is generally calm in this area throughout the year, and it is believed that there will be no interference with operations because of bad weather. As is shown below, the fishing is extraordinarily good and this fact, together with the good climatic conditions, makes this an excellent fishing ground.

The skipjack and tuna fishing grounds of this area have a rather deep relationship to the Japanese. Around 1930 the late Mr. K. Hara, who was at that time a representative in the Diet for Kagoshima Prefecture, settled in Amboina with a number of fishermen from Kagoshima and started a skipjack fishery based there. This party had two fishing vessels which they operated from Menado in the Celebes and other places. This enterprise was affected by the deterioration of the international situation accompanying the Manchurian Incident, which occurred soon after, it was subjected to the opposition of the Netherlands East Indies government, and it finally ended in failure. Before the war, Japanese fishermen based at Menado carried on operations to some extent in the Molucca Strait area.

In this sea area, as in other areas of the south, there is a small-scale fishery carried on by natives using dug-out canoes. In order to supply military needs during World War II a large number of Japanese fishing vessels were mobilized in this region to carry on skipjack and tuna fishing, but no concrete data concerning their success remain. At any rate, this may well be considered a completely untouched fishing ground.

Investigations in this area have been carried on by the Shōnan Maru, Zuihō Maru, and Kiyō Maru. The mothership-type tuna fleet of the Tōbu Suisan Company also operated experimentally in this area. All of the data except those from the mothership-type operation are extremely fragmentary. Consequently there are many points at which these data are inadequate for assessing the value of fishing grounds in this area. The following table presents a summarization of these data.

Table 18.--Fishing conditions in the Banda Sea, Flores Sea, and the Molucca Strait area

Number of hooks used	Yellowfin		Bigeye		Spearfishes		Total tunas and spearfishes		Sharks	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
81,779	6,228	7.61	225	0.28	510	0.62	6,963	8.40	?	?

Note: This table includes data from mothership-type operations.

As the table shows, rather high values are indicated for the catch rates, and it appears that this area is a very superior tuna longlining ground.

The data are notably uneven in temporal distribution and therefore it is not possible to examine thoroughly the seasonal changes in the fishing situation, however, a comparison is shown in the following table.

Table 19.--Seasonal changes in fishing conditions (Banda Sea, Flores Sea, and Molucca Strait area)

Season	Number of hooks	Catch rate
Southeasterlies	80,089	8.56
Northwesterlies	1,690	7.34

Note: The catch rates are the combined totals for tunas and spearfishes.

As table 19 shows, fishing is somewhat poorer during the season of northwesterly winds than during the southwesterlies. Very few data are available for the season of northwesterly winds so it is difficult to affirm definitely that fishing is poorer during this season than it is during the southwesterlies. However, it is possible that this table represents accurately the seasonal changes in fishing conditions in this area because the same trends have been demonstrated (see table 16) for the seasonal changes in fishing in the Lesser Sunda archipelago area. (Translator's note: the discussion of seasonal winds in this paragraph does not check with the wind directions given in table 19, which shows a season of northwesterly and a season of southeasterly winds. Available references indicate that the designations used in the table are probably correct and that the southerly seasonal winds in this region actually blow from the southeast.)

Looking at the records of the yellowfin sizes, it appears that in general large fish predominate, with the average weight 48.5 kilograms. Catch rates for bigeye tuna and spearfishes are low, and it appears that bigeye are particularly scarce. The size of the yellowfin and the composition of the catch differ widely from those found in the adjacent Celebes Sea to the north and in the western part of the Pacific, while, as shown in table 17, they bear a remarkably close resemblance to the adjacent waters of the Lesser Sunda Islands. Such phenomena may be thought quite natural from a geographical point of view, and they may further be thought to give some very interesting hints as to the migratory paths of the schools which come into this sea area.

The fact that the size of the yellowfin is generally large, and the fact that they are present throughout the year with little change in density of occurrence are considered to indicate that this sea area may have an important significance in connection with the propagation of the yellowfin. However, nothing concrete has as yet been reported from this sea area concerning their spawning.

This sea area is not only, as stated above, an extraordinarily good tuna longlining ground, but it also appears to present various important problems from the point of view of yellowfin distribution and migrational routes as well as from the standpoint of ecology. In the same sense, the series of sea areas to the north--the Celebes Sea, Sulu Sea, and South China Sea--all having the character of enclosed basins, are thought to be all worthy of attention.

2. Celebes Sea

This sea area is inclosed by Celebes, Borneo, the Sulu archipelago, and Mindanao. To the east it connects with the western Pacific Ocean through the strait between Celebes and Mindanao, on the north with the Sulu Sea across the Sulu archipelago, and on the south with the Flores Sea region by way of Macassar Strait.

From July to September, the season in which the southerly winds predominate, there is a strong current flowing to the southwestward across the central part of this sea area from the strait between Sangi Island and Mindanao at the eastern end of the area. After flowing across this sea area, this current passes into the Flores Sea by way of the Strait of Macassar. This is a current of considerable force, but its strength is said to be affected by the tide. There is another weaker current flowing along the northern coast of Celebes in a direction generally opposite that of the current already mentioned. Another weak current appears in the northern part of the area flowing northward along the coast of Mindanao into the Sulu Sea. There is a weak current flowing in the opposite direction to this southward along the coast of Borneo into the Sulu Sea. Consequently, taking this sea area as a whole, it can be considered that there is a strong current flowing across the central portion from northeast to southwest, with other currents flowing generally in a counterclockwise direction around the edges.

As for water temperatures, they are 28° C. to 29° C. in the surface layer, and 27° C. to 29° C. at 50 meters. The water temperature at the 100-meter level differs markedly from one place to another, ranging from 21° C. to 26° C. with an average value of about 24° C. Water color is most often I to II on the Forel scale and transparency is high, 25 to 40 meters having been recorded.

From January through March, the season when the northerly winds are strongest, the current which flowed from northeast to southwest through the central portion of the area during the season of southwesterly winds is remarkably reduced in strength and it becomes impossible to find any conspicuous current throughout the area. Only the current flowing south along the island of Borneo from the Sulu Sea increases somewhat in strength.

Surface water temperature is 27° C. to 28° C., a drop of about 1° as compared to the season of southwesterlies. The 50-meter level, on the contrary, has temperatures about 1° higher and consequently shows temperatures somewhat higher than those of the surface water. Water temperatures at 100 meters are also in general slightly higher than during the southwesterlies, with values of 24° C. to 26° C. In some localities a rather pronounced thermocline appears sometimes in the vicinity of the 100-meter level. The color of the water in the central portion is generally I on Forel's scale with the frequency of II to III increasing toward the borders of the area. Consequently transparency is high in the central portion with values of around 30 meters, and with smaller values on the edges of the area.

During this season of northerly winds rather strong winds sometimes blow continuously, but it appears they would not be sufficient to interfere with operations. During the season of southerly winds the sea is generally extremely calm.

This sea area had already been developed as a fishing ground before the war. Some of the large fishing vessels based at Takao in Formosa occasionally operated in this area. Boats of the Borneo Fishing Company (operated by Japanese) based at Shamil Island in British North Borneo and of the Filipino-Japanese Sea Food Corporation based at Zamboanga were active in the area. The boats based at Takao were all longliners, but the others fished mainly with pole and line for skipjack and small yellowfin. Investigations have been carried on in this sea area by the Shōnan Maru and the Takao Maru (research vessel of the former Takao Province). The mothership-type tuna fleet of the Tōbu Suisan Company also operated experimentally in this area. An exploratory fleet from Kagoshima Prefecture also fished in this area with the objective of developing the skipjack pole and line fishery. The following table summarizes the data from these investigations.

For most of the data there are no records broken down by species so the catch rates for each species are not known. In the cases where such data are recorded, it appears that the catch of bigeye tuna is extraordinarily small. However, spearfishes (mainly white marlin) are extremely abundant, the catch rates averaging 2.37. Whether these high spearfish catch rates represent normal conditions in this sea area or whether they are a phenomenon which appears only at certain seasons cannot be determined because of the paucity of data. At any rate it is certain that the spearfishes are quite abundant. It is also certain, of course, that their catch rates show seasonal fluctuations.

Table 20.--Fishing conditions in the Celebes Sea

Number of hooks	Yellowfin		Bigeye		Spearfishes		Total		Sharks	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
157,156	?	?	?	?	?	?	6,553	4.16	?	?

The most numerous species in the catch is naturally the yellowfin. The density of distribution of the yellowfin appears to undergo large seasonal fluctuations as can be inferred from the following table.

Table 21.--Fishing conditions by season
(Celebes Sea)

Season	Number of hooks	Number of fish	Catch rate
April - Sept.	7,493	714	9.53
Oct. - March	146,662	5,839	4.06

Notes: (1) Catch and catch rate figures represent the total of tunas and spearfishes.

(2) April to September is the season of southerly winds, October to March that of northerly winds.

As the number of hooks fished during the season of southerly winds is very small, the numerical values for the seasonal changes in fishing conditions shown in the above table cannot perhaps be said to be accurate ones. However, it can be seen at any rate that within the scope of this table the seasonal changes in fishing conditions are extremely marked. The table indicates that the catch rates during the season of southerly winds are more than twice as much as those during the season of northerly winds, and it goes without saying that the greatest factor in this change in catch rates is an increase in yellowfin.

In addition to the surveys mentioned above, the Kōhō Maru of the Kōchi Prefecture Fisheries Experiment Station also investigated this sea area. This work was done in November and December of 1931. It is not possible to calculate the catch rate because the construction of the fishing gear employed has not been reported, but during the period mentioned, the Kōhō Maru fished a total of 721 baskets and took a total of tunas and spearfishes amounting to 341 fish. This is a catch of more than 47 fish per hundred baskets. If we assume that there were six hooks per basket, the catch rate would be about 8.0,a rather high figure.

There are few records concerning the size of the yellowfin and the details are not known. Consideration of a certain amount of data makes it appear that large fish are generally more numerous in the season of northerly winds with slightly smaller ones predominating during the season of southerly winds. The average weight for the whole year is about 44 kilograms, rather markedly smaller than the fish of the Flores Sea region and considerably larger than those from the equatorial Pacific. It is an interesting fact that if we compare the condition factor[5/] for yellowfin taken at the height of the season of northerly winds, those from the Celebes Sea give markedly lower values than those from the East Philippine Sea and the Sulu Sea (see Nakamura[6/]).

The Shōnan Maru carried on its investigations using a special kind of fishing gear with a float attached to each branch line. The object of using this sort of gear was to determine accurately the fishing level (or swimming level) for the tunas and spearfishes. With the gear commonly used it is not easy to determine the depth at which the hooks are hanging, but with the Shōnan Maru's gear the position of the hook could not be deeper than "length of branch line plus length of float line," so that the limit at one extreme was always given.

Looking at the results of investigations made with this sort of gear, we see that there are rather conspicuous differences in catch rates between branch lines. In one remarkable example the total length of the float line and branch line was 160 meters and a considerable catch was made, the catch rate being 6.0. In general the catch rates were highest where the total length of float line and branch line was about 100 meters, but rather high catch rates were also obtained where the total length was about 50 meters, which appears to indicate that there are two fishing levels (see Nakamura[7/]).

It is considered that the reason for the existence of two fishing levels is that the catch of spearfishes in this sea area is fairly great and that the spearfish catch rates show high values at about the 50-meter level while the yellowfin are taken in the greatest numbers at about the 100-meter level. The following table shows one example.

Table 22.--Fishing conditions at different depths (Celebes Sea, July-August 1934, Shōnan Maru)

Depth (meters)	Tunas		Spearfishes	
	Number of fish	Catch rate	Number of fish	Catch rate
45	65	6.25	26	2.50
76	182	8.76	36	1.75
106	205	9.86	20	0.95

Note: (1) Depths are length of branch line plus length of float line.

As was noted earlier, it appears that fishing conditions in this sea area vary markedly with the season. The local variations in the fishing conditions are not well understood, but it appears that they also exist. If the season and the locality are suitably taken into account

5/ Condition factor is $\frac{W}{L^3}$ x 1000; L = body length, W = weight.

6/ Nakamura, Hiroshi. Tuna Fishery Resources and Fishing Grounds, Fisheries Quarterly, II, December 1949.

7/ Nakamura, Hiroshi. The Tunas and Their Fishery, Takeuchi Shōbo, 1949.

as regards the construction of fishing gear, it is thought that this sea area will be an excellent tuna longlining ground. It has already been noted that from the standpoint of weather it offers superior conditions.

3. Sulu Sea

This body of water adjoins the Celebes Sea to the northward beyond the Sulu archipelago and is surrounded by Borneo, Palawan, Mindanao, and others of the Philippine Islands. To the northward it connects with the South China Sea beyond the island of Palawan. During the season of southwesterly winds a rather strong current, which flows northward from the Celebes Sea through this sea area into the South China Sea, appears somewhat east of the middle of this area. It is said that on the western side near Borneo, there is a very weak current flowing southward.

There are no data at all for this season so nothing can be said concerning the water temperatures and other hydrographic conditions, but it is assumed that they are not greatly different from those of the Celebes Sea region. During the season of northeasterly winds on the whole no very conspicuous currents can be seen in this area although there is a weak current around the center of the area trending southwest. It is said also that taking the area as a whole there is a weak circular current flowing in a counter-clockwise direction.

Water temperatures and other conditions during the northeasterlies are in outline as follows. Around October surface temperatures are 28° C. to 29° C., temperatures at the 50-meter level differ little from the surface, while the 100-meter level shows temperatures of 24° C. to 26° C. Water colors mostly of I to II on Forel's scale have been observed, and the transparency is high, figures of 30 meters or more being attained. Around February and March the water temperatures are markedly lower, with figures of 26° C. to 26.5° C. in the surface layer, about 26° C. at the 50-meter level, and 20° C. to 22° C. at 100 meters. At about this time a conspicuous zone of cold water appears centered on the line of 120° E. longitude about the middle of this sea area. This water mass shows temperatures about 2° lower than the surrounding waters. At the same time the water color changes greatly, III to IV on Forel's scale being reported in the majority of cases. Consequently, the transparency is greatly lowered, with values of 20 meters or less reported in most cases.

During the season of southwesterlies the sea is always calm and operations would be extremely easy. At the season when the northeast winds are strongest the area is visited from time to time by high winds and high seas making it difficult occasionally for small fishing vessels to operate.

This area has been for a good many years within the operating radius of fishing boats based at Takao. Fishing operations have also been carried on here by boats of the Borneo Fisheries Company based at Shamil, as mentioned in the section on the Celebes Sea, and boats of the Sea Food Corporation based at Zamboanga. Boats from Takao for the most part fish this region from September to the middle of October, taking principally yellowfin along with black marlin, white marlin, and striped marlin. It appears that a fairly considerable catch of broadbill is also made at this season. Ordinarily once this season is passed there are almost no fishing boats operating in this area, most of them appearing to turn to operations in the South China Sea. As will be explained in a later section on the South China Sea, the main fishing season in that area is the season of northeasterly winds from October on. The normal situation in most years is for fishing to be most active in the early part of the season in the waters adjoining the Sulu Sea.

When we put together the facts that fishing is at its most active in the Celebes Sea from July to September, that the greatest number of fishing vessels operate in the Sulu Sea in September and October, and that in the South China Sea adjoining to the north fishing begins from October on, beginning in the areas adjacent to the Sulu Sea, it may be thought that in this connected series of sea areas the schools move gradually from south to north. However, if we leave aside such observations based on fishing conditions, and consider the size of the yellowfin, it appears that we can get results which deny the existence of such a migratory route. That is, if we look at the condition factor of the yellowfin taken in these various sea areas at the same season, despite the fact that no conspicuous differences in size composition of the catch can be seen, the condition factor values vary widely, with the highest figures in the Sulu Sea, the lowest values for the Celebes Sea, and with the South China Sea in between.

Data for this sea area have been reported by the Shōnan Maru, Takao Maru, Kōhō Maru, and the Daijin Maru and Sasshū Maru from Kagoshima Prefecture. These surveys and commercial operations have been limited to the season of the northeasterly winds, so fishing conditions during the southwesterlies are completely unknown. Furthermore, there are no records of the fishing situation by species so no catch rates can be shown except for tunas and spearfishes combined. In the reports of the Kōhō Maru and the Sasshū Maru the number of hooks is not indicated, only the number of baskets of gear having been recorded. The following table shows the catch rates based on those data for which the number of hooks is known.

Table 23.--Fishing conditions in the Sulu Sea

Number of hooks	Number of fish	Catch rate
9,160	619	6.08

The catch rate is slightly greater than 6.0, better than that for the South China Sea, which will be discussed later, and even surpassing the year-round average for the Celebes Sea. Fishing conditions encountered by the Kōhō Maru and Sasshū Maru are shown in the following table.

Table 24.--Fishing conditions in the Sulu Sea (according to the Kōhō Maru and Sasshū Maru)

Number of baskets	Number of fish	Fish per 100 baskets
2,646	837	31.6

If we assume that there were 6 hooks per basket, the catch rate would be slightly less than 5.3.

We have no detailed knowledge of seasonal changes in fishing conditions, but it appears that fishing is good from around the end of the season of southwesterlies through the early part of the northeasterlies. Thereafter the fishing gradually falls off as the days pass and it appears that by February and March the catch rates fall to about 4.0 to 4.5, values not greatly different from those of the Celebes Sea region. At that time, as has already been remarked, a cold water mass appears in the central part of this sea area and within this cold water mass fishing seems to be very poor, with almost no catches made.

As already stated, the fishing situation for different species is not known, but yellowfin are the principal catch. It appears that spearfishes also occupy a rather large proportion of the catch, but the percentage cannot be shown because no data are available. Broadbill are extremely scarce and there has been as yet no report of albacore.

This sea area is of small extent and cannot accommodate a large number of fishing vessels at the same time. However, at some seasons it has rather high catch rates and probably can be said to be a good fishing ground. If it were possible to have a base in the Philippines or in northeastern Borneo, the fishery would be even more profitable. There may be some interference from the weather, but it is not of very great importance and if a base were available in this region, it would be possible to operate with quite small fishing vessels.

4. South China Sea

This sea area is bounded by the continent and the islands of Borneo, Palawan, Luzon, and Formosa. On the south it connects with the Sulu Sea and on the east through the Bashi Strait with the Pacific Ocean. On the west it is connected with the Gulf of Siam. Along the Asiatic mainland the so-called continental shelf is developed, but the central portion is deep and in the southern portion there are reef areas.

The pattern of the currents from July through September, when the southwest winds are at their height, is as follows. In the western part of this area there is a current flowing from the Java Sea region to the waters off Annam. This current, which is quite strong, divides into two branches off Cochin China. One branch flows to the northeast along the northwest side of this area, while the other flows in a circle clockwise. At the eastern side there is a current flowing north along the island of Luzon, part of which flows into the Pacific through the Bashi Strait and joins the Kuroshio, while another part flows north through the Formosa Strait. There is a weak cold current along the continental coast, which submerges and flows to the south.

From July to September water temperatures are about 28° C. to 29° C. at the surface, and about 26° C. at 50 meters. At the 100-meter level there is a conspicuous difference between the continental side and the portion east of the middle of the area. The side near the continent has low temperatures of 11° C. to 17° C. with a wide range of variation. From the middle of the area east, particularly along Luzon, temperatures are high, with values of 22° C. to 24° C. Water color for the most part is I to II on Forel's scale with consequent high transparencies of about 30 to 38 meters.

From January to March, when northeast winds predominate, the currents are roughly opposite to the pattern for the southwest monsoon. There is a strong current flowing southward along the continent, and it is said that throughout the area as a whole the circulation is in a counterclockwise direction, but it appears to be rather complex. The current flowing north along Luzon is weakened but continues in existence.

Surface water temperatures are 25° C. to 26° C. over broad areas, but there are also places with about 23° C. Temperatures at the 50-meter level are for the most part about 23° C., with values of 17° C. to 18° C. at some localities. At the 100-meter level water temperatures average about 19° C., with the lowest temperature recorded being between 14° C. and 15° C. In the general view the distribution of water temperatures is clearly high in the east and low in the west, with generally high temperatures along the Luzon side and conspicuously lower temperatures off the continent. A very conspicuous zone of low water temperatures appears in the central part of this sea area, with temperatures 2° C. to 3° C. lower than the surrounding waters. The extent and position of this cold water zone appear to vary with the season and from year to year, but fishing is generally very poor within this zone, showing a trend completely identical with that for the Sulu Sea. Transparencies also show a tendency to be high in the east and low to the westward, the water color off Luzon being in most cases I to II on the Forel scale, with transparencies of 30 to 40 meters being most common. On the continental side observations of water colors of II to III are most numerous, with transparencies in most cases of 20 to 30 meters.

During the season of southwesterly winds the sea is generally very calm. However, in the typhoon season the paths of the storms occasionally cross this sea area. Caution is necessary, particularly toward the beginning and end of the typhoon season, for at this time many typhoons cross the northern part of the area. During the season of northeasterlies strong winds blow continuously, the seas are high, and it is occasionally difficult for fishing boats to operate. Wind and seas are particularly high off Annam, making operations by small boats difficult. The waters off Luzon are generally calm.

The history of the development of the tuna longline fishery in this area is so closely tied up with that of the tuna fishery at Takao that they may be said to be the same thing. The tuna longline fishery based at Takao, which started around 1913 under the aegis of the former Formosa Government-General, developed year after year with the South China Sea as its principal fishing ground. At first sailing vessels were used, but very soon all the boats were powered, beginning with vessels of about 20 horsepower and gradually increasing in size with the years until many vessels of 100 tons and 200 horsepower were being constructed. In 1936 the number of vessels operating had increased to about 300. The fishing grounds were gradually extended to the southward from the southern portion of the Formosa Strait and the whole South China Sea came within the operating area. The boats then began going farther into the Sulu Sea, Celebes Sea, and East Philippine Sea regions, and before the war the catch had surpassed the value of 15 million yen per year.

The fishing season is for the most part during the season of northeasterly winds. Vessels which had been docked and overhauled during the typhoon season gradually go into operation from the latter part of September on and ordinarily continue fishing until about May of the following year. However, around June to August a fishery for sailfish with the gear called barennawa is carried on, so even during the typhoon season fishing does not stop altogether. Beginning in 1935 there was a rapid development of the black tuna fishery and its fishing season was from March to early June. As it became known that many black marlin could be taken during the southwesterlies the latter years of the Japanese occupation of Formosa saw longline fishing carried on almost throughout the year.

The following is a general outline of fishing seasons and the fishing situation in the South China Sea. At the beginning of the season around September some catches, principally of yellowfin, were made in the southeastern portion of the area, that is, the part adjacent to the Sulu Sea, and with the passage of time fishing gradually became active in the vicinity of Steward Bank and Macclesfield Bank, after which the fishing suddenly became good all over the whole area. However, around January to March, when a conspicuous cold water zone appears in the central portion of the area, as already noted, fishing becomes generally poorer in this central area. Toward the end of the fishing season the center of the fishing grounds shifts from the vicinity of Dangerous Ground to the waters off Cochin China and Annam, and at this time the fishing for spearfishes becomes active from this area to the vicinity of Hainan I.

The principal species in the catch is the yellowfin. Data from investigations covering the whole year indicate that about 90 percent of the fish in the total tuna and spearfish catch of the longline fishery in this region are yellowfin, the remaining 10 percent being bigeye tuna (?) and spearfishes. However, this is in the overall view and as was noted earlier, the situation is completely different as regards the so-called barennawa, which fishes especially for bigeye tuna and sailfish or in the case of the fishery between the waters of Annam and the Hainan I. region, where spearfishes are the main objective. The foregoing is the situation which obtained before the development of the black tuna fishery in recent years. The main component of the catch during the black tuna season was, it goes without saying, black tuna. In recent years the black marlin has followed the black tuna in becoming abundant in the catch, and taking Formosa as a whole it appears that in recent years the number of tunas and the number of spearfishes in the catch have been almost equal (see table 7).

The first captures of black tuna in this area were in 1935. Before that year there are no records of this species being taken, but it is questionable whether they were completely absent. Questioning of fishermen at Takao at that time revealed that every year at about the same season some large fish had been biting on the hooks and breaking the branch lines so that year they strengthened the fishing gear and for the first time took black tuna. Judging from the manner in which young black tuna appear from summer to autumn along the coast of Japan, it has been believed for many years that there was ample possibility of the occurrence of this species in this area.

A tendency has been seen for the black tuna season in the South China Sea area to become gradually earlier with the passage of the years, but in ordinary years the species begins to be taken around the middle or latter part of March and the fishery gradually becomes more active with the passage of time, reaching its peak during approximately 1 month from the middle of April to the middle of May. Thereafter the fishing gradually falls off until almost no black tuna are taken in the early part of June. Around the end of the fishing season in most years some fish are caught east of Formosa and in the Ryūkyū area, from which it is inferred that there is a rapid movement of the schools to the northward.

The first catch is often made along the 100-fathom line in the vicinity of Platas Shoal, after which it is said the fishing gradually shifts to the eastward. During the first 2 or 3 years after this fishery was started the grounds were confined to that part of the China Sea west of the Bashi Strait and it was thought that in general the fish did not occur south of Lingayen Gulf (16° N. latitude). However, with the passage of years the fishing grounds were extended to the eastward and it was discovered that there were superior fishing grounds in the Pacific Ocean east of the Bataan and Babuyan islands, while at the same time the grounds were extended to the southward along the east coast of Luzon until all of the waters east of Luzon north of 15° N. latitude became fishing grounds.

There are almost no data from surveys by research vessels in the South China Sea and the East Philippine Sea, but catch rates recorded by the author aboard commercial vessels and those obtained from data supplied by commercial vessels to the former Taiwan Government-General show catch rates of 2.0 to 3.0. As yellowfin and spearfishes were taken in addition to black tuna, the combined catch rate for tunas and spearfishes was 6.0 to 7.0. Accordingly it may be thought that the longline fishery in the area where black tuna were the main object was rather advantageous financially. Before the war fishing vessels from Kagoshima, Kōchi, and other prefectures operated in May and June from the waters east of Formosa to the coastal waters of the Ryūkyū Islands and produced a considerable catch. Since the war considerable fishing has continued in this region.

The black tuna of the South China Sea region are in general large in size, most of those taken around the beginning of the season weighing 300 kilograms or more. Toward the end of the season the fish gradually becomes smaller, but even so examples of fish weighing less than 200 kilograms are rare in the catch. It bears no direct relationship to the fishery, but it is known that at this season in this sea area the black tuna are spawning.

This fishery was almost completely discontinued in the latter part of World War II, and the post-war situation is completely unknown, so nothing can be said concerning the present state of the fishery. It appears possible, however, to discern a number of phenomena which make one wonder whether the black tuna fishery in this area may not be gradually declining. What is meant here by a decline in the fishery is not due to any human cause, such as the operation of commercial fishing vessels, but to a change in the migrational pattern of the black tuna. Investigations in this sea area by the Shōnan Maru, Takao Maru, Zunan Maru (former research vessel of the Okinawa Prefecture Fisheries Experiment Station), Kiyō Maru, the Gini Maru (research vessel of Mie Prefecture), Kōhō Maru, and Haruna Maru have been reported. Among these are some data which it is already impossible to obtain, but those which remain may be summarized to show the fishing conditions in this sea area as given in table 25.

Table 25. --Fishing conditions in the South China Sea

Number of hooks	Tunas and spearfishes		Sharks	
	Number of fish	Catch rate	Number of fish	Catch rate
119,074	5,453	4.58	871	0.73

In most of the data there are no records of fishing conditions by species, so the tunas and spearfishes have unavoidably been lumped together in this table. The overall catch rate is, as shown in the table, 4.58. This value is somewhat below that for the Sulu Sea, and somewhat better than that for the Celebes Sea. Consequently, taking distance into consideration, for vessels based at Takao of these three sea areas the South China Sea is thought to have the greatest value as a fishing ground. It should be thoroughly noted, however, that in this observation no account whatever is taken of seasonal changes in the fishing situation.

As very few data are available for the season of southwesterly winds, it is difficult to compare fishing conditions in this season with those during the northeasterlies. However, in recent years the spearfish catch has been rather large from May to August. Seasonal changes in the density of occurrence of the various species will be discussed later in the section headed "Distribution of the Tunas as Shown by Catch Rates."

In the early days of its development, the tuna longline fishery based at Takao used as bait the ginkagami (poito in Formosan), Mene maculata. For this reason the abundance or scarcity of the ginkagami directly controlled the operation of the tuna longline fishery. However, beginning around the end of the Taishō Era (1924) the sabahi, Chanos chanos, gradually came into use and in this way the greatest weakness of the fishery, that is, the bait supply, was taken care of. As is generally known, the sabahi is a fish which is cultured in ponds in southern Formosa. As this fish is cultivated over a broad area not only in Formosa but in the Philippines, Celebes, and Java, it is thought to have an important significance as bait for this fishery in the southern areas, where tuna longline bait is generally scarce. It may be possible to solve the bait problem of the tuna longline fishery based in the various southern areas by utilizing this fish. Tuna longline fishermen may, by a multiple operation, be able to carry on at the same time the culture of the sabahi and thus make an even more advantageous solution of their bait problems.

As was stated earlier, there are a number of shortcomings from the standpoint of weather because of the passage of typhoons and the strength of the seasonal northeast winds, but the South China Sea can probably be said to be a superior fishing ground. The value of this sea area as a fishing ground would be enhanced particularly if it were possible to get a land base somewhere around its shores.

5. Waters around New Guinea and the Solomon Islands (0° to 15° S., 130° to 170° E.)

That part of the Banda Sea extending from New Guinea to 130° E. longitude has already been discussed in the section on the Banda and Flores seas and therefore will be omitted here.

From January to March, when northwesterly winds prevail, the waters off the north coast of New Guinea have a rather conspicuous current flowing from northwest to southeast. This current impinges upon the island of New Britain, after which it does not appear to maintain a fixed direction of flow. On the east side of New Britain there is a current flowing roughly from northwest to southeast, and in the southern portion of the Solomon Islands there is a current flowing generally southward. Another current flows generally northward along the west side of the Solomon archipelago. However, these currents are all extremely weak and the islands make them remarkably complex.

Water temperatures from the Equator to 5° S. latitude are 27° C. to 29° C. at the surface, 24° C. to 28.5° C. at the 50-meter level, and 16° C. to 26° C. at 100 meters. They vary greatly from one locality to another. Farther to the south the temperatures are somewhat lower, but they still appear to be subject to wide local variation. Water color and transparency also show marked local fluctuations.

From July to September, the season when the southeast winds are strong, the currents generally flow from east to west and their strength becomes more marked. Under the influence of the topography the direction of the currents varies somewhat from place to place, but throughout the sea area as a whole the currents clearly flow from east to west.

Few data are available to show the water temperatures and other hydrographic conditions, and it is impossible to examine them in detail, however, in the vicinity of the Equator the temperatures appear to be about 28° C. to 29° C. at the surface, about 28° C. at 50 meters, and 20° C. to 26° C. at the 100-meter level. It is deduced that in the southern part of the Solomons area the temperatures will be somewhat lower than during the season of northwesterly winds.

It appears that during the season of northwesterly winds the area off the north coast of New Guinea has rather high winds and rough seas, and operating may be difficult at times. The seas of the Solomon Islands region are generally calm. It seems that during the season in which the southeasterly winds prevail, the wind and sea in the Solomon Islands region are high and from time to time fierce squalls visit the area so that care is probably necessary in conducting fishing operations. Off the north coast of New Guinea the sea is extremely calm.

Data for this area are principally those reported by the Hakuyō Maru. Some investigations were also carried on by the Zuihō Maru and the Kiyō Maru. The following table summarizes these data.

Table 26.--Fishing conditions in the waters around New Guinea and the Solomon Islands

	Yellowfin		Bigeye		Spearfishes		Tunas and spearfishes		Sharks	
Number of hooks	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
31,992	1,674	5.24	97	0.30	312	0.66	1,866	5.90	558	1.74

The overall catch rate is 5.9, a rather high figure. The above table also includes some data from the Banda Sea area east of 130° E. longitude. It can hardly be considered reasonable to discuss simultaneously two completely different sea areas. Consequently, the data of the above table have been divided into those for the Banda Sea area and those for the Pacific region and are presented in the following two tables.

Table 27. --Fishing conditions in waters off New Guinea (Banda Sea side)

Number of hooks	Yellowfin		Bigeye		Spearfish		Total		Sharks	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
9,600	1,016	10.58	32	0.33	22	0.23	1,070	11.15	64	0.67

Table 28. --Fishing conditions in waters off New Guinea and the Solomon Islands (Pacific Ocean side)

Number of hooks	Yellowfin		Bigeye		Spearfish		Total		Sharks	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
22,392	658	2.94	65	0.29	190	0.85	913	4.08	494	2.21

As tables 27 and 28 show, there are conspicuous differences between the catch rates in the two areas. And not only can differences in the fishing conditions be detected, but there are also conspicuous differences in the composition of the catch.

The Banda Sea catch rates are remarkably high, and the composition of the catch is similar to that of the Banda Sea and the Flores Sea already described (see table 18). On the Pacific Ocean side the catch rates are low and yellowfin are scarce while the spearfishes are much more numerous. There is also a marked increase in the number of sharks on the Pacific Ocean side.

The fishing situation in the waters adjacent to the Solomon Islands shows a tendency for a decline in the number of yellowfin in the catch as one goes south from the vicinity of the Equator. This trend is just like that which can be seen in the northern hemisphere. It appears that there is also a tendency for the catch of sharks and spearfishes to increase as the operations come closer to islands. Considered seasonally, it appears that fishing is somewhat poorer during the northwesterlies than during the season of southeasterly winds, but it is difficult to make a thorough-going comparison because of the paucity of data.

Before the war vessels based at Misaki were crossing the Equator to fish as far away as the north coastal waters of New Guinea. During the war, just as in other areas, a large number of vessels appear to have been active in this region with the object of supplying the military forces, but no data remain from these operations. At present no boats from Japan are fishing in the area and as the tuna fishery is completely undeveloped in these islands, it is believed that these waters are being completely neglected as fishing grounds. Seasonal variations in the fishing situation are as yet not well known, but it is thought that there is ample possibility that this sea area can afford superior fishing grounds at some seasons.

6. Southern part of former South Seas Mandate (0 to 10° N., 130° to 170° E.)

The current systems of this area from south to north are the South Equatorial Current, the Equatorial Countercurrent, and the North Equatorial Current. The boundary between the South Equatorial Current and the Equatorial Countercurrent is from the vicinity of the Equator to about 3° N. latitude and the boundary between the Equatorial Countercurrent and the North Equatorial Current is between 5° and 8° N. latitude. The boundaries between these currents are not straight lines but change with the topography and the season, however, in general they parallel the parallels of latitude. They are generally pushed to the southward during the season of northeast winds and tend more or less northward during the season of southwesterly winds. The pattern of the current in the vicinity of 130° E. longitude, that is, at the western extremity of this area, is affected by the proximity to land and is remarkably complex.

The following table shows monthly changes in water temperatures based on data from observations made at fixed stations by the former South Seas Government-General Fisheries Experiment Station in the vicinity of 7° 10' N., 134° 30' E.

Table 29.--Water temperatures for each month
(7° 10' N., 134° 30' E.)

Depth in meters	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0	28.56	28.15	28.40	28.82	29.35	29.31	29.14	28.85	29.13	29.43	29.32	29.05
50	27.50	27.54	28.08	28.61	28.80	28.55	29.07	28.67	29.06	29.12	28.93	28.51
100	23.31	22.48	24.45	25.92	24.93	25.15	24.92	26.12	25.64	26.04	25.37	23.44

Surface water temperatures are high in May and June and in October and November, low in February and March, and they also drop somewhat in August. The 50-meter level shows high temperatures above 29° C. in July and September and October, while in January and February the temperatures at this level are lowered to 27.5° C. At the 100-meter level the water temperature rises above 26° C. in August and in October, and in February it reaches its lowest point with readings between 22° C. and 23° C. Water color is I or II on Forel's scale and transparencies are 30 to 40 meters.

During the season of southerly winds the sea is extremely calm, and this is called the calm season. During the season of northeasterly winds the wind and waves sometimes rise rather high and it appears that at times difficulty is experienced in fishing.

After the South Sea islands in this region became a Japanese mandate, attention was first given to the skipjack grounds and efforts were made to develop them. As a result skipjack fisheries were fairly well developed on the grounds around the coasts of the various islands. However, the bait problem was not solved and the fishery was always in difficulties because of the uncertain bait supply and economic factors such as the falling price of the product (mainly dried skipjack).

The former South Seas Government-General, with the support of the Ministry of Agriculture and Forestry, undertook the investigation and development of tuna longlining grounds in this region, but for a long time they attracted very little attention. It appears that the reason the investigations had poor results at first and that it consequently was not understood that there were excellent fishing grounds in this region was mainly the unsuitable construction of the fishing gear. The gear in use at that time was exactly the same in construction as that used in Japanese coastal waters. Consequently it was unsuited to the markedly different environment afforded by the waters of this area; it is said that the branch lines were too short and did not reach the level at which the tunas swim.

Gradually measures were taken to improve the methods of investigation, and it was made clear that this region affords excellent fishing grounds, which were thus finally brought to the attention of the industry. The direct motive for the sudden development of the fishing grounds of this region was the full load of yellowfin brought back in 1936 by the Hidekichi Maru (90 tons) based at Misaki in Kanagawa prefecture. Stimulated by this, the large fishing boats based at Misaki began competing to fish on these grounds. Some mention of the history of this fishery has already been made in preceding chapters.

Fishing ground surveys and fishing experiments in this region were carried on by the former South Seas Government-General Fisheries Experiment Station with its research vessels Hakuō Maru and Zuihō Maru. Later when this region was being exploited as a longlining ground for tuna, principally yellowfin, a large number of prefectural research vessels also operated there and, as the following table shows, the data from their researches are quite abundant.

Table 30. --Fishing conditions in the southern portion of the former South Seas Mandate (0° - 10° N., 130° - 170° E.)

Number of hooks	Yellowfin		Bigeye		Spearfishes		Total	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
647,689	21,870	3.38	3,285	0.51	4,752	0.73	29,907	4.62

Note: The figure for yellowfin also includes 142 albacore.

The situation as regards sharks is not clear because there are many omissions in the data. However, calculations based on considerable material give a catch rate of about 1.5 .

As for the composition of the catch of tunas and spearfishes, yellowfin were most numerous forming slightly under 74 percent of the whole. Spearfishes were slightly more than 15 percent and bigeye tuna were 11 percent. In addition a very small number of albacore were caught, amounting to about 0.6 percent of the yellowfin. On the whole the catch rates in this area are somewhat better than in the Pacific coastal waters of New Guinea or the Solomon Islands, and not greatly different from those of the South China Sea or the Celebes Sea.

There appear to be fairly conspicuous differences in the fishing conditions in different parts of this region. The following table shows a comparison of fishing conditions north and south of the line of 5° N. latitude.

Table 31.--Comparison of fishing conditions on either side of the line of 5° N. latitude (southern part of former South Seas Mandate)

Area	Number of hooks	Yellowfin		Bigeye		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
0° - 5° N.	417,851	16,706	3.99	2,059	0.49	2,928	0.70	21,819	5.22
5° -10° N.	229,838	5,022	2.19	1,226	0.53	1,824	0.79	8,088	3.52

Note: Longitude is not taken into consideration in this table.

The above table shows the existence of a rather conspicuous difference in fishing conditions in the two areas. However, the reason for this difference is the difference in the catch rate for yellowfin. The catch rates for bigeye tuna and spearfishes do not differ greatly between the two areas, and, contrary to what occurs with the yellowfin, there is some tendency for the catch rates to improve for these species in the area north of 5° N. latitude. Consequently it appears that the significance of this area as a fishing ground differs somewhat north and south of the line of 5° N. latitude. The reason for this is that south of 5° N. latitude most of the area is in the Equatorial Countercurrent, while north of 5° N. it is partly in the Countercurrent but mainly in the North Equatorial Current. Thus the two areas are in different current systems. From the foregoing facts it can be seen that the yellowfin are distributed in a very great density in the Equatorial Countercurrent and that their density of distribution falls off sharply in the North Equatorial Current.

If this region is divided into four parts, each comprising 10° of longitude, and if the fishing conditions within these divisions are compared as in the following table, it appears that there is also some difference in fishing conditions from east to west.

Table 32.--Fishing conditions in the region divided into areas of 10° of longitude (southern part of former South Seas Mandate)

Area	Number of trials	Number of hooks	Yellowfin		Bigeye		Spearfishes		Totals	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
130°-140° E.	212	88,189	2,413	2.74	81	0.09	311	0.35	2,805	3.18
140°-150° E.	214	207,735	6,907	3.32	1,098	0.53	2,088	1.00	10,093	4.85
150°-160° E.	262	348,951	12,450	3.57	2,090	0.60	2,342	0.67	16,882	4.84
160°-170° E.	8	2,814	100	3.55	16	0.57	11	0.39	127	4.51

Note: The albacore are included in the figures for yellowfin. Their respective numbers in the four areas from top to bottom are 4, 2, 136, and 0.

There are remarkably few data for the area from 160° to 170° E., so that it is impossible to compare it with the areas farther to the west. For the whole region the areas centered on 150° E. longitude show the highest catch rates. The majority of the catch is composed of yellowfin in all of the areas. Except for the extreme western portion, there is little discernible variation in the yellowfin catch rates. In the case of the bigeye tuna, it appears that there is a tendency for the catch rates to increase as one goes eastward. The catch rate for spearfishes is highest in the vicinity of the area of 140° to 150° E. longitude, that is west of the Caroline Islands. The albacore was scarce everywhere, but was markedly more abundant in the waters of the Caroline Islands than in the other areas.

Table 32 is based on data collected in the past and it completely ignores fluctuations from year to year in the fishing conditions, seasonal changes in catch rates, differences in the longitude of the points surveyed, and changes in the catch due to the construction of the fishing gear. Of these variables, the changes from year to year in the fishing conditions cannot be discussed with the data we have at our disposal. Nor do we have data which will enable us to make any judgments concerning the changes in fishing conditions brought about by differences in the construction of the gear. The fact that there are violent fluctuations in fishing conditions due to latitude was shown in table 31 and it is naturally to be imagined that there will be conspicuous changes in the fishing situation accompanying the change of seasons.

In order to see the effect of latitude on the differences shown in table 32, the following table presents the same east-west divisions further divided by the line of 5° N. latitude into northern and southern portions.

Table 33.--Fishing conditions in divisions of 10° of longitude on either side of the line of 5° N. latitude (southern part of former South Seas Mandate)

Area	0° - 5° N.				5° - 10° N.			
	Number of stations	Number of hooks	Number of fish	Catch rate	Number of stations	Number of hooks	Number of fish	Catch rate
130°-140° E.	49	39,514	1,602	4.05	163	48,675	1,203	2.47
140°-150° E.	97	121,074	7,022	5.80	117	86,661	3,071	3.54
150°-160° E.	180	255,169	13,080	5.12	82	93,782	3,802	4.05
160°-170° E.	4	2,094	115	5.49	4	720	12	1.67

Note: The catch rates are combined for tunas and spearfishes.

Leaving out of consideration the area east of 160° E. longitude because of the lack of data, the highest catch rates south of 5° N. latitude were in the area between 140° and 150° E. longitude. North of 5° N. latitude the highest catch rates were between 150° and 160° E. Catch rates were low between 130° and 140° E. both north and south of 5° N.

In order to see how the data in table 32 are affected by seasonal changes in the fishing conditions, the following table has been made using the same areas as table 32 and dividing the data according to whether they represent the season of southwesterly or northeasterly winds. The area between 160° and 170° E., for which little data is available, has been eliminated from this table.

Table 34.--Seasonal fishing conditions (southern part of former South Seas Mandate)

Area	Season of northeasterlies			Season of southwesterlies		
	Number of hooks	Number of fish	Catch rate	Number of hooks	Number of fish	Catch rate
130° - 140° E.	48,431	1,209	2.50	38,714	1,594	4.12
140° - 150° E.	202,725	10,014	4.95	5,010	79	1.58
150° - 160° E.	253,067	11,254	4.45	95,894	5,628	5.87
Total	504,223	22,477	4.46	139,618	7,301	5.24

Notes: 1. Southwesterly winds--April to September
Northeasterly winds--October to March

2. The catch rates are for tunas and spearfishes combined.

In general there are much fewer data for the season of southwesterly winds than for the northeasterlies, the difference being particularly notable in the area of 140° to 150° E. In this area fishing conditions during the southwesterlies are much inferior to those during the season of northeasterly winds, but in the other regions the contrary is true, with the southwesterlies affording the better fishing. On the whole, catch rates during the southwesterlies have values a little less than 1 percent greater than those for the season of northeast winds. Not only are data for the season of southwesterly winds in the area 140° to 150° E. very scarce, but what data there are are mainly from north of 5° N. latitude. These data were collected mainly by the research vessels of the South Seas Government General Fisheries Research Station and most of them are among the earliest such data collected in this region. Consequently the poor fishing due to the construction of the gear must be taken into consideration. If we can assume that this is the reason for the fishing in the area of 140° to 150° E. being so poor in comparison with the other areas, we can conclude that for the southern portion of the former South Seas Government General as a whole fishing is better during the southwest seasonal winds than during the northeasterlies. The question as to whether or not fishing conditions differ markedly in the area of 140° to 150° E. in comparison with other areas, or in other words whether the distribution and migration of the fishes within this area differ from those of other areas, will be difficult to decide unless future investigations provide more complete data.

If we again look at table 32, we see that the region between 130° and 140° E. longitude has a catch rate somewhat inferior to those of the other areas. However, area-wise the data for this section are mostly from north of 5° N. latitude and as regards the season, the proportion of data from the season of southwest winds is greater than in the case of other regions. It must further be noted that these data were mainly collected during the first part of the research program of the South Seas Government General. As will be explained later, fishing conditions in the East Philippine Sea, which is the westward continuation of this area, appear to be rather good. Taking all these facts into consideration, it can be thought that the area from the Equator to 10° N. in the Pacific, at least as far east as the area around 170° E. longitude, shows little variation in the value as fishing grounds of its various portions. Of course, taking into consideration changes in the ocean currents brought about by islands and other topographical features, it cannot be thought that this broad expanse of ocean is completely homogeneous as regards its value as a fishing ground. Furthermore, as regards the catch, the bigeye tuna show a tendency to increase toward the eastward, the spearfishes are most abundant in areas comparatively close to islands, and the abundance of the albacore seems to be somewhat localized. From these points of view, it cannot be affirmed that all parts of this region have the same characteristics as fishing grounds.

Table 34 shows in very broad terms the changes in the fishing situation accompanying the change of seasons by dividing the data between the two halves of the year. Needless to say, if the data were more adequate, it would be possible to get a more accurate grasp of the seasonal changes in the fishing conditions by a more detailed breakdown of seasons and areas. As there are very few areas for which data adequate to this end have been gathered, a thorough analysis is impossible. In connection with this point, some comments have been made under the heading "The Distribution of the Tunas as Shown by Catch Rates." For one part of this area the fishing situation by months is shown by the following table.

Table 35.--Fishing conditions by months (0° - 10° N 150° - 160° E)

Month	Number of stations	Number of hooks	Yellowfin		Bigeye		Spearfishes		Total	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	37	42,915	949	2.20	430	1.00	257	0.60	1,636	3.80
Feb.	25	30,902	304	0.98	120	0.68	176	0.57	690	1.61
Mar.	12	12,455	638	5.12	3	0.02	58	0.47	699	5.61
Apr.	14	18,110	576	3.18	67	0.37	116	0.64	759	4.19
May	16	26,028	1,521	5.84	65	0.25	149	0.57	1,735	6.67
June	--	--	--	--	--	--	--	--	--	--
July	19	33,405	1,721	5.15	171	0.51	191	0.57	2,083	6.23
Aug.	4	7,126	297	4.17	53	0.74	62	0.87	412	5.78
Sept.	6	10,225	559	5.47	152	1.49	73	0.71	784	7.67
Oct.	29	39,985	1,639	4.10	197	0.49	329	0.82	2,165	5.41
Nov.	51	63,202	2,509	3.97	348	0.55	493	0.78	3,350	5.30
Dec.	45	54,593	2,002	3.67	368	0.67	292	0.54	2,662	4.88

As records on the measurements of the individual fish in the catch are inadequate, it is not possible to make any comparisons of their areal or seasonal variations. To summarize very roughly, yellowfin of around 35 to 37 kilograms are generally most numerous, those from 20 to 30 kilograms and above 40 kilograms appearing to be scarce. A consideration of a certain amount of data makes it appear that there are seasonal changes in the size of the fish, but nothing is known for certain.

As was stated earlier, this region affords rather superior fishing grounds for tuna longline fishing. The most important species in the catch is the yellowfin tuna, followed by the spearfishes. Changes in fishing conditions accompanying changes in the seasons can be detected, but these changes are comparatively slight, showing that these are generally stabilized fishing grounds throughout the year.

7. Northern part of former South Seas Mandate (10° to 20° N., 130° to 170° E.)

This region is in the North Equatorial Current so there are no great changes in the currents throughout the year, the water always flowing from east to west. In the vicinity of

145° E. longitude, that is in the waters around the Mariana Islands, they take on a rather complicated aspect due to the influence of the topography, and northward and southward flowing currents appear. In the extreme western portion of this region, which is at the source of the Kuroshio, the current runs approximately northwest.

Water temperatures during the northeast monsoon are 26° C. to 27° C. at the surface. Temperatures at the 50-meter level do not differ greatly from the surface, and temperatures at the 100-meter level are approximately the same. During the southwest monsoon surface water temperatures are 28° C. to 29° C., temperatures at the 50-meter level do not differ greatly from those at the surface, and the temperature at the 100-meter level is about 27° C.

Water color throughout the year is I or II in the Forel scale and the transparency is high, being 35 to 40 meters in most cases.

During the height of the season of northeasterly winds, rather strong winds blow continuously in the western portion of this region, but it becomes somewhat calmer as one proceeds eastward. During the season of southwesterly winds the sea is generally extremely calm, but during the typhoon season storms often originate in this area. In this part of the ocean typhoons generally move westward or northwestward and many of them pass through the western portion of the region, so care on this point is necessary in operating there.

The significance and value of this area as a fishing ground is as yet almost completely unknown. Actual fishing operations have been carried on only around the Marianas and data from surveys and fishing experiments are confined almost entirely to that vicinity; consequently it is impossible to ascertain the fishing conditions throughout the region as a whole. A tabular summary of these data follows.

The general overall catch rate is 2.5, and the catch rates are conspicuously low in comparison with those between 0° and 10° N. latitude.

Table 36.--Fishing conditions in the northern part of the former South Seas Mandate (10° to 20° N., 130° to 170° E.)

Number of stations	Number of hooks	Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
98	65,811	382	0.58	152	0.23	113	0.17	1,004	1.52	1,651	2.51

The reason for the lowering of the catch rates in comparison with the southern portion of the former South Seas Mandate is the decline in the yellowfin catch. The catch rate for yellowfin is about one-sixth that of the former sea area, and even the rate for bigeye tuna is reduced by about half. On the other hand, the spearfish catch rate is approximately double and there is also a rather conspicuous increase in the albacore catch. Thus it should be noted that not only are the catch rates different as between the two areas, but the composition of the catch is also quite different. This is thought to mean that, as was previously noted for the Indian Ocean region, the distribution of these fishes is controlled more by differences in water systems than by temperature.

Since the data are almost entirely confined to the period December to February, it is unfortunately not possible to give any explanation of the seasonal changes in fishing conditions.

However, judging by the activities of commercial fishing vessels, fishing for striped marlin and black marlin is rather good in the northern Marianas from this period to around March or April. And it appears that quite a few medium-sized vessels have operated at this season in this area and somewhat to the eastward.

The Ogasawara Islands area to the north and the western Pacific north of 25° N. latitude have been gradually subjected to exploitation over a long period of years, but because of the sudden development of the fishing grounds of the southern part of the former South Seas Mandate, the fishermen skipped over the area presently under discussion and went directly to fish in the vicinity of the Equator. As a result the fishing grounds of this region have been left with hardly any attention paid to them and their significance and value as fishing grounds have been left almost completely unknown.

8. East Philippines Sea (0° to 30° N., 120° to 130° E.)

The area between 0° and 20° N. at 120° to 130° E., excluding those waters belonging to the Celebes Sea, Sulu Sea, and South China Sea, will be described as the East Philippines Sea.

That part of the area north of 5° N. latitude outside the coastal zone of the Philippine Islands is the so-called Philippine Trench, which is extremely deep and without any reefs or shoals on the bottom. South of 5° N. latitude there are scattered small islands and both the topography and the oceanographic conditions are complex.

During the season of southwest winds the part of this region between 10° and 15° N. latitude lies within the North Equatorial Current. Because of the impingement of this westward flowing current upon the Philippine Islands, the currents in waters adjacent to the Islands are quite complex. North of 15° N. latitude the currents flow generally north or northwest, forming the origin of the Kuroshio (Japan Current). South of 10° N. the currents turn south or southeastward, part of them entering the Celebes Sea and the rest flowing into the Equatorial Countercurrent together with the current which flows north to the Molucca Strait.

North of the central portion of the area the water temperatures are generally high, with temperatures from May to September of 28° C. to 29° C. at the surface, about 28° C. at 50 meters, and about 27° C. at 100 meters. In the southern portion the vertical distribution of water temperatures is remarkably complex, with occasional temperatures of about 20° C. reported for the 100-meter level. This condition is particularly marked in those areas adjacent to the Molucca Strait, and it appears that in many cases there are two to three marked thermoclines between the surface and about 200 meters. In most cases water color of I to II on Forel's scale and high transparencies of 30 to 40 meters have been recorded.

During the season in which northeasterly winds prevail the principal currents do not differ greatly from the pattern which they exhibit during the season of southwesterlies, but the current which flowed north through the Molucca Strait disappears and a current appears flowing in the opposite direction southward through that Strait. The boundary between the Equatorial Countercurrent and the North Equatorial Current is pushed somewhat southward from its position during the season of prevailing southwesterly winds.

Little is known of the distribution of water temperatures because of the paucity of the data, but compared to the season of southwesterlies temperatures in the northern part appear to be lowered by 2° - 3° C. at the surface, and 1° - 2° at 50 and 100 meters. In the southern portion the temperatures appear to be lowered by 1° - 2° C. at all levels. There is no great difference from the season of southwesterlies in water color and transparency.

During the season of southwesterly winds the surface is generally extremely calm. However, during the typhoon season the northern part of this sea area is frequently crossed by these storms and operating during this season requires considerable caution. During the northeasterlies operations are not infrequently hampered by high waves and seas.

It is only very recently that this area has attracted notice as a tuna longline fishing ground. In the early years of the Shōwa Era (the late 20's) the research vessel Shunkai Maru (180 tons) of the former Formosa Government General made some surveys in the northern part of the area, but the results were extremely poor, the area was ticketed as being almost valueless as a fishing ground, and it was thenceforth neglected. According to the commonly prevailing opinion at that time, an area like this one without reefs or shoals, and indeed one of the two deepest parts of the world's oceans, was adjudged to be unsuitable for the establishment of the tuna longline fishery.

The investigations of the Shunkai Maru were made in February. The investigations of the Shōnan Maru in this sea area were undertaken from June to September of 1937. As a result of the work of the Shōnan Maru it became known that this area was an extraordinarily good fishing ground, the attention of commercial operators was suddenly attracted, and a constant procession of vessels based at Takao began fishing there. In the beginning the principal object of the fishing in the northern portion was the black marlin and the main catch in the southern portion was yellowfin tuna. Beginning in the following year (1938), it gradually became known that the northern portion was an extremely fine black tuna ground and there was a sudden increase in the number of vessels fishing there for this species. The fishing season for black tuna, as was stated in the section on the South China Sea, is from the latter part of March to early June. The main fishing season for black marlin is from April to August, the fishing ground for this species being generally slightly farther off shore than that for the black tuna. Consequently, although the positions of the fishing grounds differed somewhat, the northern part of this sea area was judged to have ample value as a tuna longline fishing ground from April to around August to September. After September, that is with the start of the season of northeasterly winds, the fishing appears to deteriorate sharply, but the details of this are not clear because of the paucity of data.

Because of the distance, the southern part of this area, where yellowfin were the main catch, was not fished very much, only an occassional large vessel having operated there. It is certain that at some seasons it is an extremely good fishing ground, and it appears that in the most southerly portion seasonal changes in the fishing conditions are comparatively slight.

Most of the investigations in this area were made by the Shōnan Maru, Shunkai Maru, and Takao Maru. There are also some data from operations of the Kiyō Maru and the Zuihō Maru in the southern part of the area. The data from these various sources are summarized in the following table to indicate fishing conditions in this region.

Table 37.--Fishing conditions in the East Philippines Sea (0° to 20° N., 120° to 130° E.)

Stations	Hooks fished	Black tuna		Yellowfin		Bigeye		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
85	28,203	2	0.01	1,311	4.65	53	0.18	323	1.14	1,887	5.98

Catch rates are fairly high, nearly 6.0 . On the whole the data are scarce, and there are none at all for January, October, and December, so the seasonal changes in the fishing conditions are not well known, however, the data in the foregoing table can be divided between the northeast and southwest monsoons as follows.

Table 38.--Fishing conditions by seasons (East Philippines Sea)

Season	Number of stations and hooks	Black tuna		Yellowfin		Bigeye		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
NE monsoon	27 10,745	0	0.00	507	4.72	21	0.20	45	0.42	573	5.33
SW monsoon	58 17,458	2	0.01	804	4.61	32	0.18	278	1.60	1,114	6.38

Note: Northeasterlies--October to March; southwesterlies--April to September

It can be seen from the foregoing table that there is no great seasonal change in the fishing for yellowfin and bigeye tuna, but that the spearfishes increase markedly during the season of southwesterly winds. However, this table has lumped together the whole area of the East Philippines Sea, which extends 1,200 miles from north to south. There is therefore a need to examine variations in fishing conditions by area and by seasons within the area.

First of all, in order to examine the fishing conditions by area, we will divide the region by 5° of latitude and show the catch rates within each of these divisions in the following table.

Table 39.--Fishing conditions by sections (East Philippines Sea)

Sections	Number of stations and hooks	Black tuna		Yellowfin		Bigeye		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
0° - 5° N.	30 16,023	0	0.00	889	5.55	28	0.17	70	0.44	987	6.16
5° -10° N.	19 4,320	0	0.00	270	6.25	18	0.42	85	1.97	375	8.68
10° -15° N.	19 3,840	0	0.00	83	2.16	3	0.08	87	2.27	173	4.51
15° -20° N.	17 4,020	2	0.05	44	1.09	3	0.07	80	1.99	127	3.16

The foregoing table shows that in general the fishing is best between 5° and 10° N., followed by 0° to 5° N., with the catch rates falling off as one goes north from 10° N.

Black tuna were taken only between 15° and 20° N. In the case of the yellowfin, there is a boundary in the vicinity of 10° N., with the catch rates dropping off sharply to the northward. South of 5° N. the catch rates are also somewhat lower than between 5° and 10° N. The spearfishes (chiefly black marlin) show their highest catch rates in the area between 10° and 15° N. Fishing is somewhat poorer between 5° N. and 10° N. and between 15° N. and 20° N., but the difference is slight. In the area from 0° to 5° N. the catch rates drop sharply as compared with the more northern areas, showing that there is a marked distributional boundary between 5° and 10° N. latitude. Bigeye tuna fishing is best between 5° and 10° N., with catches being made only rarely farther to the north. In general the fishing within this area is controlled by the catch of yellowfin and spearfishes and, as the foregoing table shows, the yellowfin in the southern part and the spearfishes in the northern part are the main species controlling the fishing situation.

The situation is not thoroughly known because of the scarcity of data, but between 0° and 5° N. it appears that there are no marked fluctuations in the fishing throughout the year. It appears, however, that fishing is particularly active around March and from July to September. North of 5° the spearfish catch increases from May to August.

The investigations of the Shōnan Maru cover almost the whole area north of 3° N. latitude from June to September. Based on these data, the catch rate curve from north to south for this sea area is shown in figure 9.

The variations in catch rate shown by the curve are rather large, but in general the yellowfin catch rates are clearly higher in the south and drop off sharply to the north. The spearfishes on the contrary are high in the north and low in the south. It is thought that the irregularity of these curves is due to the small number of fishing stations, and that if the number of stations were increased the curves would probably show more regular trends.

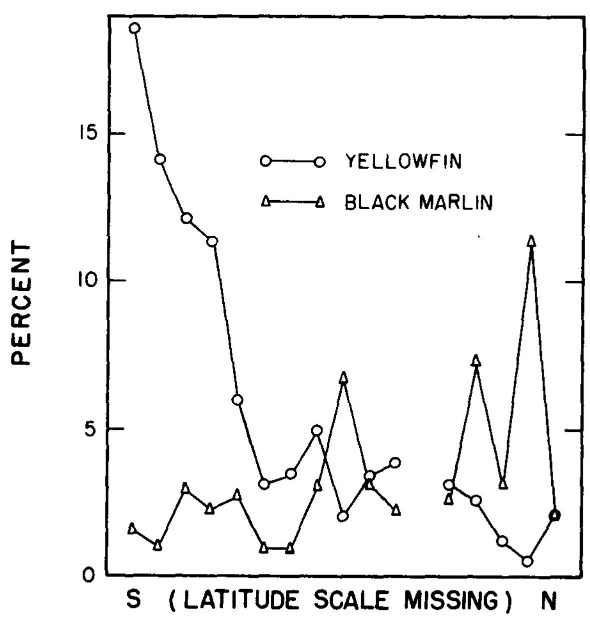

Figure 9.--Catch rates by latitudes (E. Philippines Sea)

The range within which the catch rate curves for the yellowfin and spearfishes intersect appears to be roughly from 10° to 15° N. Although differences can be detected in the numerical value of the catch rates, the situation outlined above appears to be exactly similar to that presented by the waters of the former South Sea Islands Mandate, which adjoins this area on the eastward.

If we attempt to compare these fishing conditions with oceanographic conditions, the area from 10° to 15° N. is where the North Equatorial Current impinges upon the Philippine Islands. Farther to the north the currents generally flow northward or northwestward and make up the origins of the Kuroshio. South of 10° N. the currents flow south or southeastward, corresponding in part to the area of origin of the Equatorial Countercurrent. The rest flow into the Molucca Strait area. Just as in the former South Sea Mandate farther to the east, yellowfin are abundant in the Equatorial Countercurrent and the spearfishes are abundant in the North Equatorial Current.

The only records concerning sizes of fish taken are the data from the Shōnan Maru's operations. Of 402 yellowfin taken in the course of the Shōnan Maru's work, the smallest was 2.8 kilograms, the largest 58 kilograms, and the average weight was 33 kilograms. Figure 10 shows the weight frequencies of these fish by 3-kilogram classes.

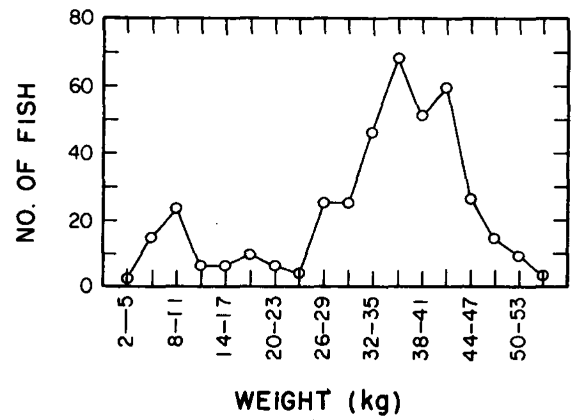

Figure 10.--Yellowfin weight frequencies (E. Philippines Sea)

As figure 10 shows, fish of about 35 - 38 kilograms were most numerous, with another peak at 41 - 44 kilograms. In the smaller sizes, there was a rather conspicuous peak at 8 - 11 kilograms. If we apply to these Professor Aikawa's age determination method, the peak of small fish represents fish in their fourth year, while the great majority are seventh- and eighth-year fish. The size distribution by latitude is not clear, but there seems to be some tendency for fish to be larger in the north and smaller in the south. The average weight of 33 kilograms is about the same as that for the former South Seas Mandate and is thought to show the identity of the populations. Nothing at all is known of seasonal changes in the size of the fish.

Weights of black marlin have been divided into 10-kilogram classes and their frequencies plotted as shown in figure 11. The data, like those for the yellowfin, are from the investigations of the Shonan Maru and the number of fish is 165. As is clear from the figure, there is a very pronounced peak at 40 - 50 kilograms. The curve falls off steeply in the smaller sizes and also in the larger sizes. It is an interesting fact that a great majority of these fish were males, females being only 9 percent of the total and almost all of these were a very large size. Judging from a number of data, it appears that fishing from the central section on northward is subject to violent seasonal fluctuations, and after September the composition of the catch changes and fishing suddenly becomes poor. Seasonal fluctuations do not seem so violent in the southern part of the area, but on the whole it is the season of southwesterlies which shows the best fishing. This pattern is thought worthy of note as it appears also in the former South Seas Mandate and is particularly marked in the Celebes Sea.

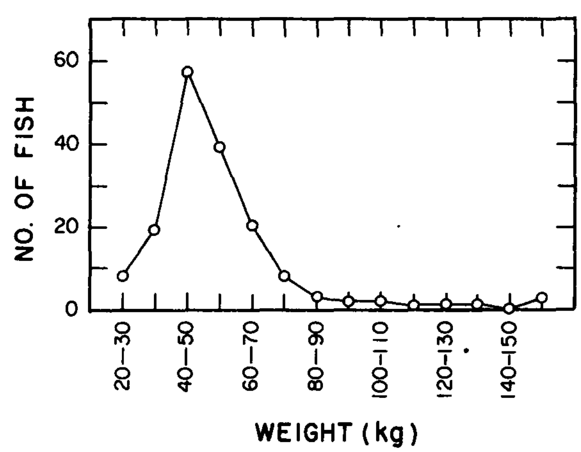

Figure 11.--Black marlin weight frequencies (E. Philippines Sea)

The foregoing facts indicate that, if area and season are taken into account, this region will also offer very superior fishing grounds.

9. East Formosa Sea and the waters of the Okinawan archipelago (20° to 30° N., 120° to 130° E.)

The waters of the East China Sea, east of the 100-fathom line and east of the Bashi Strait within the range of 20° to 30° N., 120° to 130° E. will be described as the East Formosa Sea and the waters of the Okinawan archipelago.

This area is almost all within the Japan current (Kuroshio) and, stated very broadly, the currents flow north or northeast throughout the year. However, in the western part of the area during the winter the effect of a cold current flowing south along the continent is fairly conspicuous. Furthermore, on the east side of the main Kuroshio current there is a great gyral flowing clockwise.

As this sea area stretches from the tropics through the subtropics to the temperate zone, there are rather conspicuous local and seasonal variations in water temperature and it is difficult to make a general discussion of the area as a whole.

Table 40 shows the changes in water temperature in the Bashi Strait at the extreme southern limit of this sea area.

Table 40.--Water temperatures in the vicinity of Bashi Strait (from Formosan Fishery Experiment Station Report for 1932)

Month	Depth (Meters)			
	0	25	50	100
February	23.9	23.9	23.9	23.5
May	28.1	27.0	25.1	21.6
August	28.7	28.6	27.9	23.9
December	24.9	24.9	24.8	23.7

The following table (table 41) shows the water temperatures for each month in the central part of the area at about the middle of the line between Suō (Formosa) and Yonakuni Island. The table is based on the regular sectional observations made by the Fisheries Experiment Station of the former Taiwan Government-General but do not all represent data from the same year, being averages of 13 years from 1919 to 1932.

According to this table the minimum surface water temperatures were 23° C. in March and the maximum 29.1° C. in August. Between 25 meters and 200 meters the minimum was in March and the maximum in September.

The data for the most northern part of this sea area are unequally distributed seasonally and therefore it is difficult to show changes throughout the year. Table 42 shows changes in the water temperatures based on data from sectional observations carried out by the Kagoshima Prefecture Fisheries Experiment Station. The values shown in the table are those from a station 50 miles off Yakushima on a line connecting Yakushima and Ōshima. The data do not all represent the same year but are a collection of data covering several years.

Comparing these three tables, it appears that there is little difference between tables 40 and 41. Even in table 42 little difference can be seen in the summer, but in the winter the temperatures are 2° - 3° C. lower.

Table 41.--Water temperatures in the vicinity of 25° N. (the center of the line from Suō to Yonakuni)

Depth	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	23.4	23.8	23.0	24.7	26.7	27.8	28.3	29.1	28.9	27.4	26.0	25.3
25	23.6	23.7	22.9	24.7	26.2	27.6	27.9	27.8	28.2	27.3	26.0	25.4
50	23.5	23.4	22.9	24.6	25.8	25.9	26.2	26.8	26.9	27.1	25.9	25.3
100	23.2	22.4	21.3	23.2	22.1	23.7	24.1	22.7	24.3	22.8	25.0	23.4
200	19.2	18.6	17.7	19.0	20.4	18.9	19.9	18.2	17.1	16.7	18.8	19.4
400	13.2	13.4	11.7	12.8	14.2	13.1	14.0	12.6	13.1	11.5	12.9	12.9

Note: From the report of the Formosa Fisheries Experiment Station for 1932.

Water temperature is generally I to II on Forel's scale and transparency values are generally high. However, close to the 100-fathom line of the continent these values are somewhat lower.

During the winter there are strong north or northeast winds in the southern part of this area and westerly winds in the northern part, and the sea is generally rough. During the summer it is generally calm, but during the typhoon season storms frequently cross this area so caution is necessary.

Table 42.--Water temperatures south of Yakushima

Depth	Month					
	Feb.	Mar.	May	July	Aug.	Nov.
0	21.2	20.8	25.1	25.9	29.5	24.7
25	21.3	20.9	24.8	25.8	28.9	24.7
50	21.3	20.6	24.7	25.4	28.6	24.8
100	21.2	20.5	23.8	18.8	28.4	23.8
150	20.6	19.2	21.8	17.4	25.9	22.0

This sea area has been exploited as a fishing ground for many years. The following is a general description of fishing conditions there from south to north.

The East Formosa Sea region was first exploited as a tuna fishing ground in the Taishō Era (1912-1925). In the beginning there was a skipjack fishery based at Keelung, and then attention was drawn to the fact that spearfishes were extraordinarily abundant in this area. The former Formosa Government-General established fishing ports at Keelung, Suō, Shinkō, and Karenko and made them bases for a fishery. At the same time fishermen were invited to emigrate from Ōita, Ehime, Kōchi, Wakayama, and Chiba prefectures and a positive program of fishery development was carried on. These emigrants mainly engaged in the harpoon fishery.

The spearfishes are very abundant in the waters off Formosa and the catch of these fishes rivals and at times surpasses that of the tunas, of which the yellowfin is the principal species. The Formosan spearfish catch is even greater than that of Japan proper.

The fishing season of the harpoon fishery in the East Formosa Sea is limited to the period of the prevailing northeasterlies from October to April. This is just the opposite of the situation in the waters of Japan proper, where this fishery is limited almost entirely to the summer season. In general the fishing is most active in the southern part of this sea area at the beginning of the fishing season and with the passage of time the center of the fishing grounds gradually shifts to the northward. In the middle of the season the grounds are centered off Suo, and at the end of the season the Hōkasho area becomes the center. There are also seasonal differences in the composition of the catch, with white marlin abundant at the beginning of the season, striped marlin increasing toward the middle of the season, and black marlin gradually increasing toward the end. However, in the overall picture white marlin are the most abundant. Table 43 shows the changes in the fishing situation from month to month.

Table 43.--Catch of the harpoon fishery, Suō, 1934 and 1943 (numbers of fish)

Month	Species			
	White marlin	Black marlin	Striped marlin	Sailfish
January	1,401	80	1,448	180
	934	12	82	7
February	902	258	913	181
	1,007	42	77	23
March	1,013	250	502	115
	1,114	45	92	51
April	462	169	97	97
	345	15	351	381
May	34	5	5	179
	97	21	48	434
June	6	3	6	256
	10	19	8	409
July	4	9	4	308
	1	4	2	73
August	11	30	1	253
	0	0	0	3
September	8	9	5	58
	0	0	0	0
October	648	49	632	786
	23	2	2	21
November	1,990	86	814	236
	433	3	31	119
December	1,264	116	1,030	61
	484	17	49	72
Total	7,748	1,064	5,497	2,710
	4,448	161	742	1,593

Note: The upper figures are for 1934, the lower figures for 1943. The marked decline in 1943 is due to the war.

At first the harpoon fishery was operated almost entirely by Japanese emigrants. There was, in addition, a flourishing longline fishery in this sea area carried on for the most part by Formosans. The catch of this longline fishery was mainly sharks, such as the hammerhead, yashibuka, dotabuka, and threshers, and few tunas or spearfishes were taken. The fishing ground and fishing season coincided completely with those of the harpoon fishery.

At about the time the harpoon fishery comes to an end, black tuna migrate into the southern part of this sea area, and by the middle of June they are taken all over the area. In the beginning of the season the fishing is comparatively concentrated, but toward the end of the season it gradually becomes more dispersed and the fishing grounds shift gradually from south to north. However, as there is sporadic fishing of black tuna at almost the same season in the waters contiguous to this area on the south and north, if the schools do move from south to north, it is in a remarkably dispersed state.

It is thought that from about the time the black tuna season ends, dense schools of black marlin migrate into the area, but we do not as yet have any concrete data concerning this fact. The basis for this supposition is, as was stated in the section on the East Philippines Sea, that between May and September dense schools of this species are seen in the North Equatorial Current and the region of the origins of the Kuroshio, and there are two or three records showing that quite a few black marlin are taken about the same time in the Yonakuni Island area. It is considered that their fishing grounds are probably farther off shore than the harpooning grounds, and as there have actually been hardly any fishing vessels operating there, nor any experimental or exploratory fishing, there are no data at all to offer as evidence.

As the foregoing shows, this area has hardly been considered as a fishing ground during most of the season of southwesterly winds. The fishing ground during the northeast monsoon, both in the case of the harpoon fishery and the longline fishery, is extremely coastal in character, being limited to within 30 miles of the shore. The situation farther off shore was investigated by the Shōnan Maru, Shichisei Maru (fisheries research vessel of the former Taihoku Province), and the Takao Maru, which caught considerable amounts of tunas, spearfishes, and sharks, however, it can by no means be thought to be a superior fishing ground.

The waters of the Okinawan archipelago are noted as a fishing ground for sedentary skipjack rather than as a tuna ground. Nevertheless, tunas and spearfishes are taken throughout the region and certain localities are known to be outstanding longlining grounds. There are excellent grounds between Uotsuri Shima and the Miyako Archipelago and south of the main island of Okinawa, and at the extreme northern end of the area is the famous black tuna ground around Tanegashima.

Throughout the area as a whole the spearfishes are most abundant, followed by yellowfin, bigeye, and black tuna, with albacore extremely scarce. The spearfishes are abundant throughout the year, but particularly from April to August and in general east of 125° E. longitude. The most abundant species is the white marlin, followed by the striped marlin and the black marlin. The seasonal changes in abundance of different species are the same as for the East Formosa Sea. The catch of sailfish also appears to increase during the summer. After August the fishing shifts to the vicinity of the 100-fathom line in the East China Sea, and the fishing grounds of this region, although they differ from season to season, extend through the waters west of Kyūshū on the north to the Tsushima Strait area.

Yellowfin are fairly abundant in April - May and November - December, and a tendency can be detected for catch rates to increase gradually to the eastward. Bigeye tuna are rather abundant from November to January but appear to be hardly taken at all at other seasons. There are two fishing seasons for black tuna; one is around December and January, with the fishing grounds in the extreme northern part of the region. However, fishing is not very good at this time and the catches are made at some distance from the center of the main fishing grounds. The other season is around April to June, with the grounds on the east side of the archipelago. The fishing is sporadic and there are no concentrated catches. Some albacore are taken from January to March, but they are not very abundant. Table 44 shows the fishing situation in this sea area on the basis of past surveys.

The overall catch rate is slightly less than 2.0, much lower than those of the various sea areas described earlier. Comparing those parts of the area north and south of 25° N. latitude, as the table shows, the catch rates are higher in the north for all fish except the yellowfin, and the overall average catch rate is higher in the north. It will be noted that the catch rates for black tuna and albacore are much greater in the northern part.

Table 44.--Fishing situation in the East Formosa Sea and the waters of the Okinawan archipelago (20° to 30° N., 120° to 130° E.)

Area	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
20°-25°N.	8	0.02	162	0.43	69	0.18	1	0.00	364	0.98	604	1.62
25°-30°N.	131	0.22	161	0.27	139	0.23	109	0.18	722	1.19	1,262	2.08
Total	139	0.14	323	0.33	208	0.21	110	0.11	1,086	1.11	1,866	1.90

Note: Number of stations fished 20° N. to 25° N. = 197
" " " " 25° N. to 30° N. = 227

Number of hooks fished 20° N. to 25° N. = 37,290
" " " " 25° N. to 30° N. = 60,694

Because of the extreme paucity of the data, a thorough comparison is impossible, however, tables 45 and 46 show the seasonal variations in fishing conditions.

Black tuna are taken in May. Yellowfin are most abundant from October to December. The spearfishes have a catch rate of about 1.0 throughout the year and show a potentiality for a higher catch rate in June.

Black tuna catches are centered around May, with fair numbers taken in April and June, and sporadic catches from October through November. Yellowfin are taken in all months except February, August, and September, and the catch rates increase from April through July and in December and January. Bigeye tuna show about the same variations as yellowfin, but the peak of their catch rate which appears in the summer is markedly lower than that for the yellowfin. Albacore are taken only in the winter, none at all having been caught in the summer. The spearfishes show rather high catch rates from June through September, but the fishing for them becomes remarkably poor in March and April. There are very few data for the southern part of the area, as shown in table 45, so it is not possible to make a thorough comparison with table 46, however, it can probably be recognized that both the northern and southern halves of the region show the same trends of rise and decline. In general, only a few of the summer months can be considered superior fishing in this sea area, the winter fishing season being shorter and having lower catch rates than the summer.

In tables 44 to 45 the difference in location from east to west is not taken into consideration at all. In the following table the fishing situation is presented with this area divided up by 2° of longitude without reference to latitude.

Black tuna are taken only between 124° and 126° E. longitude, that is in the waters around the Sakishima Islands. Yellowfin are caught at almost the same rate throughout, except for the most easterly area. There is some doubt however, as to whether this trend really exists because there are few data for the region between 128° and 130° E. longitude. The bigeye tuna appear comparatively close to the coast, and the spearfishes show a tendency for catch rates to increase to the eastward.

Table 45.--Fishing conditions by months (East Formosa Sea and southern waters of the Okinawan archipelago, 20° to 25° N., 120 to 130° E.)

Month	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	3,556	0	0	7	0.20	16	0.45	0	0	49	1.38	62	2.03
Feb.	6,794	0	0	15	0.22	15	0.22	0	0	69	1.02	99	1.46
Mar.	384	0	0	0	0	0	0	0	0	1	0.26	1	0.26
Apr.	--	--	--	--	--	--	--	--	--	--	--	--	--
May	1,557	8	0.51	2	0.12	3	0.18	0	0	11	0.71	24	1.52
June	873	0	0	2	0.23	0	0	0	0	36	4.35	38	4.58
July	675	0	0	0	0	0	0	0	0	7	1.04	7	1.04
Aug.	--	--	--	--	--	--	--	--	--	--	--	--	--
Sept.	--	--	--	--	--	--	--	--	--	--	--	--	--
Oct.	2,412	0	0	13	0.54	1	0.04	0	0	17	0.70	31	1.28
Nov.	5,824	0	0	15	0.26	0	0	0	0	48	0.82	63	1.08
Dec.	16,584	0	0	122	0.74	36	0.22	0	0	133	0.80	296	1.76

Table 46.--Fishing conditions by months (northern part of the Formosa-Okinawa area, 25° to 30° N., 120° to 130° E.)

Month	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	8,854	0	0	40	0.45	74	0.84	93	1.05	44	0.50	251	2.84
Feb.	1,064	0	0	0	0	0	0	0	0	17	1.60	17	1.60
Mar.	6,436	0	0	4	0.06	4	0.06	7	0.16	4	0.06	19	0.34
Apr.	1,026	4	0.38	14	1.36	0	0	0	0	3	0.29	21	2.03
May	7,326	98	1.34	46	0.63	5	0.07	0	0	139	1.90	288	3.94
June	5,402	27	0.50	15	0.28	1	0.02	0	0	117	2.16	160	2.96
July	684	0	0	8	1.17	0	0	0	0	23	3.36	31	4.53
Aug.	2,244	0	0	0	0	0	0	0	0	82	3.70	82	3.70
Sept.	4,348	0	0	0	0	0	0	0	0	98	2.25	98	2.25
Oct.	7,174	2	0.03	5	0.07	2	0.03	0	0	81	1.13	90	1.26
Nov.	8,939	2	0.02	14	0.15	21	0.23	4	0.04	73	0.91	114	1.35
Dec.	3,474	0	0	15	0.43	26	0.75	4	0.12	29	0.84	74	2.14

Table 47.--Fishing conditions by longitude (East Formosa Sea and southern part of Okinawan archipelago 20° to 25° N., 120° to 130° E.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
120°-122° E.	1,736	0	0	9	0.52	0	0	10	0.58	19	1.10
122°-124° E.	23,395	0	0	98	0.42	42	0.18	179	0.77	319	1.37
124°-126° E.	10,595	8	0.08	48	0.45	27	0.26	139	1.31	222	2.10
126°-128° E.	1,114	0	0	6	0.54	0	0	26	2.33	32	2.87
128°-130° E.	450	0	0	1	0.22	0	0	10	2.22	11	2.44

Table 48.--Fishing conditions by longitude (East Formosa Sea and northern part of Okinawan archipelago, 25° to 30° N., 120° to 130° E.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
122°-124°E.	6,201	0	0	0	0	0	0	0	0	98	1.58	68	1.58
124°-126°E.	10,926	37	0.34	16	0.15	11	0.10	12	0.11	224	2.05	300	2.75
126°-128°E.	26,753	88	0.33	82	0.31	19	0.07	59	0.22	315	1.18	563	2.11
128°-130°E.	16,814	6	0.03	63	0.37	109	0.65	38	0.22	95	0.56	311	1.83

Note: West of 122° E. is the continental shelf, where this fishery is not carried on.

As the table shows, there are no tunas taken at all west of 124° E., only spearfishes being taken there. Black tuna are most numerous from 124° to 128° E. and become scarcer farther out to sea. Yellowfin show a tendency to increase to the eastward, and this trend can also be detected in the bigeye and albacore. The spearfishes are fairly abundant over the whole area, but show their highest catch rates in the central part.

The overall catch rate for this area is slightly less than 2.0, remarkably lower than the 5.90 of the East Philippine Sea and somewhat lower than the 2.51 of the northern part of the former Mandate, that is, 10° to 20° N., east of 130° E. Consequently this sea area is thought to have less value as a fishing ground than the area to the south of it. However, if the distance between bases and fishing grounds is taken into account, the value and significance of an area as a fishing ground cannot be decided solely in terms of the catch rate. On this account the value of the fishing grounds of this sea area will naturally be enhanced. Particularly as it is clear that at some seasons there are rather high catch rates, it is considered that fishing in this area will be quite profitable if no error is made in selecting the fishing ground and the fishing season.

10. Western Pacific subtropical sea area (20° to 30° N., 130° to 180° E.)

The area between 130° and 180° E. longitude and 20° to 30° N. latitude will be discussed as the western Pacific subtropical sea area. This is an extremely broad area, but oceanographic conditions are comparatively uniform throughout the whole region. However, in the vicinity of the Volcano Islands, the Ogasawara Islands, and the northern Marianas where the topography is complex, the oceanographic conditions are also somewhat complicated. The same is true of the area around the Okinawan archipelago in the extreme west.

The area is generally under the influence of the Kuroshio Countercurrent. From the Volcano Islands to the Ogasawara Islands there is a rather strong northward flowing current along the east side of the island chains. This is called the Ogasawara Current and is particularly strong during the summer.

The southern part of the area is within the North Equatorial Current and here the current flows from east to west throughout the year. Along the northern edge of the North Equatorial Current there are here and there branch currents flowing northwest. These are particularly conspicuous in the summer at which season they generally change the direction of their flow from northwest to northward. In the northern part of the area there are branch currents of the Japan Current and the North Pacific Current flowing south or southeastward, and it is said that here and there great clockwise gyrals are formed. The North Pacific Current is the name given to that part of the Kuroshio (Japan Current) which leaves Japanese waters and flows eastward, and the southward or southeastward branches mentioned above are called the Kuroshio Countercurrent. Where the North Equatorial Current and the Kuroshio Countercurrent come into contact is the so-called subtropical convergence. This subtropical line of convergence runs approximately east and west along the parallels of latitude. Accordingly, completely different water systems are found to the north and south of the convergence.

The position of the subtropical convergence differs greatly with the seasons. When the water temperatures are at their lowest around February and March, it runs east and west along a line at about 23° to 24° N., and when water temperatures are at their highest in September, it moves far to the north and runs east and west in the vicinity of 30° N.

The distribution of water temperatures is controlled by the above mentioned currents and the isotherms run roughly parallel to the parallels of latitude. Around February and March the 22° C. isotherm runs east and west along the line of 24° to 25° N. or roughly at the center of this sea area. In the summer the 28° C. isotherm appears at approximately the same position. Table 49, based on data from the waters adjacent to the Ogasawara Islands, shows by months the water temperature, specific gravity, and transparency in the vicinity of 25° N. latitude.

As the table shows, the water temperatures are at their lowest in March with values of about 19.5° C. from the surface to the 30-meter level. The maximum is in July with 27.9° C. at the surface. Table 49 represents records for one year from April 1931 to March 1932. From the 10-year averages given in the same report, it appears that the minimum temperature at the surface is 20.6° C. in February and the maximum is 27° C. in August.

In the winter strong northwesterly or westerly winds blow continuously, being particularly violent in the northern part of the area. In the summer the sea is generally extremely calm except when typhoons are being generated.

This sea area was opened as a fishing ground around the middle of the Taishō Era (around 1920) and all parts of it have been fished by large numbers of fishing boats. The fishing grounds were expanded to the eastward and southward as the size of the fishing boats was increased, and the albacore grounds in the eastern part of the area were developed very rapidly after the early years of the Shōwa Era (from 1926 on). Thereafter, from 1936 on, the yellowfin grounds of the equatorial region attracted the attention of the fishing industry, and the fishing boats jumped directly to that area, so that except for particular localities the significance and value of the fishing grounds of the southern part of this sea area are in many ways not clearly known.

Table 49.--Oceanographic conditions by months in the waters of the Ogasawara Islands

Month	Water temperature (°C.)			Specific gravity			Transparency (meters)	Air temp. (°C.)
	0 m	15 m	30 m	0 m	15 m	30 m		
1931 Apr.	20.7	20.5	20.3	25.50	25.58	25.60	20.6	21.0
May	21.9	21.6	21.6	25.87	25.89	25.96	22.6	23.4
June	24.2	23.0	22.8	25.20	25.22	25.27	21.6	25.9
July	27.9	27.4	26.9	25.61	25.62	25.61	20.2	29.8
Aug.	27.2	26.5	26.1	25.66	25.63	25.74	21.8	29.3
Sept.	27.1	26.5	25.5	25.80	25.76	25.80	26.3	29.8
Oct.	27.8	26.7	25.5	25.99	25.96	26.01	27.8	29.3
Nov.	25.8	25.1	24.1	26.18	26.19	25.89	24.0	27.4
Dec.	22.5	22.2	22.0	25.71	25.68	25.72	24.9	22.7
1932 Jan.	21.2	20.9	20:7	25.72	25.67	25.72	31.5	19.7
Feb.	20.3	20.2	19.9	26.01	25.99	25.63	25.2	18.0
Mar.	19.7	19.5	19.4	25.79	26.13	26.10	21.2	20.0

Note: From report of Ogasawara Fisheries Enterprises for 1931.

Considering this sea area as a whole as a tuna longlining ground, it is by no means uniform everywhere, but presents fishing grounds of different character in different localities such as the black tuna grounds south of Tanegashima, the yellowfin and spearfish grounds from Daitō Island to the Kōhō Shoal area, the albacore grounds of the Kinanshō area, the spearfish grounds in the coastal waters of the Ogasawara and Volcano islands, and the bigeye tuna and albacore grounds to the eastward. And as will be explained, fishing conditions are quite different to the north and south of a boundary in the vicinity of 24° to 25° N.

In the following discussion this sea area is divided into three regions from west to east and the characteristics of the fishing grounds in each of these regions are discussed separately.

(a) 130° to 140° E. longitude

The northwestern part of this sea area forms part of the so-called Tanegashima black tuna grounds. In recent years the black tuna have completely disappeared and only a certain number of bigeye are taken during the season. In the vicinity of 30° N., 137° E. there are the famous Kinanshō fishing grounds and here albacore are abundant in the winter. The vicinity of 24° to 26° N., 131° E. is famous as the so-called Daitō Island fishing ground, and the principal catch here is spearfishes and yellowfin. The Kōhō Shoal, discovered by and named for the Kōchi Prefecture fishery research vessel Kōhō Maru, is at 26° N., 136° E. At certain seasons yellowfin and spearfishes are abundant on this ground.

Table 50 summarizes data from surveys carried out in this sea area.

The overall average catch rate is 2.4, with a slightly higher rate of 2.84 to the south of 25° N. as compared with 2.24 to the north. The composition of the catch is quite different north and south of 25° N. In the south yellowfin make up more than half the catch while albacore are most abundant in the north. Black tuna are taken only in the north, there being no record of their capture in the southern part of the area, and their average catch rate throughout the year is 0.22. There is almost no difference between the catch rates for the spearfishes, but the catch rate for bigeye tuna is somewhat higher in the south.

Table 50.--Fishing conditions at 20° to 30° N., 130° to 140° E.

Area	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
20°-25°N.	48,858	0	0	806	165	265	0.54	48	0.10	267	0.55	1,386	2.84
25°-30°N.	124,116	275	0.22	455	0.37	366	0.30	975	0.79	696	0.56	2,767	2.24
Total	172,974	275	0.16	1,261	0.73	631	0.37	1,023	0.59	963	9.63	4,153	2.40

Note: The number of fishing stations is 105 from 20° to 25° N. and 590 from 25° to 30° N.

Seasonal changes in the fishing conditions are not well known because of the scarcity of data, but table 51 shows what is known.

Table 51.--Fishing situation by months (20° to 25° N., 130° to 140° E.)

Month	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	4,579	0	0	52	1.13	8	0.17	4	0.09	17	0.36	81	1.75
Feb.	2,100	0	0	12	0.57	11	0.52	3	0.14	10	0.48	36	1.71
July	1,974	0	0	48	2.43	0	0	0	0	22	1.11	70	3.54
Oct.	576	0	0	0	0	1	0.17	0	0	0	0	1	0.17
Nov.	17,751	0	0	273	1.54	105	0.59	6	0.03	97	0.55	481	2.71
Dec.	21,588	0	0	406	1.90	128	0.60	33	0.15	88	0.41	655	3.06

Note: There are no data at all for months other than those shown on the table.

As the data are almost entirely limited to the winter, it is not possible to give any details on the fishing conditions in the summer, however, the data for July indicate that yellowfin are fairly abundant at that time and the spearfish catch rate is also high. There appear to have been almost no catches of other species. Yellowfin are shown to be fairly abundant for a 2- to 3-month period centered around December. Bigeye tuna are fairly numerous in November and December and increase also in February. Albacore are extremely scarce, but some are taken in the winter. Spearfishes are most abundant in July and are scarce in the winter.

This pattern appears to coincide in general with the trend of fluctuations in abundance in the adjacent East Formosa Sea area on the west, although there are some differences in the values (see table 45).

Table 52 shows the fishing situation by months north of 25° N.

Table 52. --Fishing conditions by months (25° to 30° N., 130° to 140° E.)

Month	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	31,864	168	0.53	20	0.07	32	0.10	6	0.02	194	1.61	420	1.33
Feb.	13,491	63	0.47	11	0.08	53	0.40	43	0.32	96	0.71	266	1.98
Mar.	40,809	266	0.65	12	0.06	52	0.12	347	0.71	107	0.25	784	1.79
Apr.	3,612	4	0.11	0	0	4	0.11	1	0.03	20	0.54	29	0.79
May	1,684	5	0.30	2	0.12	1	0.06	0	0	44	2.70	52	3.16
June	4,024	3	0.07	1	0.02	0	0	0	0	100	2.48	104	2.57
July	196	0	0	0	0	0	0	0	0	3	1.53	3	1.53
Oct.	12,664	1	0.01	136	1.07	84	0.68	3	0.02	29	0.23	253	2.01
Nov.	20,485	0	0	101	0.49	134	0.65	17	0.08	40	0.19	292	1.41
Dec.	22,235	12	0.05	50	0.22	159	0.71	16	0.07	64	0.27	301	1.32

Note: There are no data for August and September.

Black tuna are most abundant from January to March, and they appear to increase again somewhat around May. Fluctuations in fishing conditions throughout the year are not clear because data are lacking for August and September, but within the period covered by the table some black tuna were taken in all months except July and October. In general yellowfin are extremely scarce, with a catch rate of slightly more than 1.0 in October declining gradually from November on. Bigeye tuna are most abundant from October through December and show their highest catch rate of the year in the latter month. Albacore are taken only during the winter and the catch rate is at its peak in March. Spearfishes are more numerous in the summer, being most abundant around May and June. In the winter their catch rate increases somewhat in January and February. In general catch rates are higher in the summer, the main reason being that the catch of spearfishes increases.

Comparing these conditions with the Okinawa area adjoining on the west, a particularly marked difference can be detected in the black tuna fishing. That is, in the Okinawan region black tuna are taken only from April to June, with their highest catch rates in May. In this sea area there are, as explained above, two seasons for this species, the main one being from January through March, with another separate peak in the catch rate in May. It is naturally hypothesized that the schools which appear in May are the same as those which appear in the Okinawan area, but the relationships of the schools which come from January to March are not clear. It is thought that almost no difference can be seen in the two areas as regards fluctuations in fishing conditions for tuna species other than the black tuna. It appears, however, that in some cases there may be, depending on the species, more or less of a lag in the time of the peak season.

Regarding the spearfishes, which are the most important catch in both these of sea areas, it looks as if the seasonal changes in fishing conditions are of completely identical pattern, with the catch rate at its highest from May to August. Unlike the tunas, the spearfish catch rates are always fairly high throughout the year and there is no season at which none are taken.

In order to compare fishing conditions from east to west, the area has been divided into five parts by 2° of longitude and table 53 gives ithe fishing situation for each of these sections.

Table 53.--Fishing conditions by sections (20° to 25° N., 130° to 140° E.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
130°-132°E.	--	--	--	--	--	--	--	--	--	--	--	--	--
132°-134°E.	15,420	0	0	145	0.94	84	0.54	5	0.03	51	0.32	285	1.83
134°-136°E.	9,564	0	0	276	2.89	76	0.80	9	0.10	56	0.58	417	4.37
136°-138°E.	22,426	0	0	380	1.70	104	0.46	34	0.15	137	0.61	655	2.92
138°-140°E.	1,412	0	0	5	0.35	1	0.07	0	0	23	1.63	29	2.05

The yellowfin are most abundant around 134° to 136° E., that is, in the vicinity of Kōhō Shoal, as are bigeye too. Few albacore are taken, but they appear to show some tendency to increase to the eastward. The spearfishes tend to be most numerous in the extreme eastern portion, that is west of the Volcano Islands, but it is difficult to state this definitely because of the paucity of the data.

Table 54 shows fishing conditions in the same sections north of 25° N.

Black tuna clearly decrease sharply from west to east, and yellowfin are most abundant between 134° and 136° E. The bigeye have a distribution resembling that of the yellowfin, and albacore catch rates increase as one goes eastward, the so-called Kinanshō fishing grounds being thus shown to be a superior albacore ground.

It is difficult to detect any clear trend for the spearfishes, but the catch rates are somewhat better in the extreme western portion, and between 136° and 138° E.

Table 54.--Fishing conditions by sections (25° to 30° N., 130° to 140° E.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
130°-132°E.	72,044	249	0.34	133	0.18	290	0.41	53	0.07	481	0.67	1,206	1.67
132°-134°E.	10,077	21	0.21	33	0.33	25	0.25	23	0.23	43	0.43	145	1.45
134°-136°E.	24,810	2	0.01	168	0.70	153	0.62	8	0.03	64	0.26	395	1.62
136°-138°E.	9,785	3	0.03	5	0.05	28	0.28	266	2.74	82	0.83	384	3.95
138°-140°E.	7,400	0	0	0	0	29	0.39	388	5.24	26	0.35	443	5.98

Comparing tables 53 and 54, fluctuations in yellowfin fishing conditions show approximately the same trend, as do those for the bigeye. The trend for the albacore also appears to agree, but a very great difference in catch rates can be detected. The spearfishes appear to differ somewhat, but it is difficult to detect any clear-cut tendency.

Ample note should be taken of this complete change in the composition of the catch north and south of 25° N. latitude.

(b) Ogasawara, Volcano, and Mariana islands (20° to 30° N., 140° to 150° E.)

The northern part of this sea area has been exploited as a fishing ground since very old times. The southern portion, too, has quite a history as a fishing ground and has been fished by many vessels. The principal components of the catch are albacore and spearfishes in the north and yellowfin and spearfishes in the south. Among the spearfishes of the north quite a few broadbill are included, these being taken together with albacore during the winter. The spearfishes in the southern part of the area are mainly striped marlin and black marlin, and their season is in the summer.

Table 55 summarizes the data from investigations carried on in this area.

Table 55.--Fishing conditions in the waters of the Ogasawara, Volcano, and Mariana islands (140° to 150° E.)

Area	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
20°-25°N.	135,691	0	0	395	0.29	254	0.18	145	0.11	1,448	1.07	2,242	1.65
25°-30°N.	132,214	10	0.01	180	0.14	238	0.18	4,215	3.18	1,493	1.13	6,136	4.63
Total	267,905	10	0	575	0.21	492	0.18	4,360	1.63	2,941	1.10	8,378	3.12

Throughout this sea area as a whole the catch rate is slightly more than 3.0, a bit higher than that of the area of 130° to 140° E. adjoining on the west. The principal catch is albacore and spearfishes. There are vestigial catches of black tuna in the northern part, but they are not taken at all in the south. Yellowfin are abundant in the southern part, where their catch rate is twice that of the northern section. No local differences in the fishing situation for bigeye tuna north and south of 25° N. can be detected. Albacore are extremely scarce in the south but have a fairly high catch rate in the north. Spearfishes are somewhat more abundant in the north, but the difference is slight. Many sharks, of which the most important is the great blue shark, are taken in this area, their numbers rivaling the combined total for tunas and spearfishes and in many cases surpassing them.

If tables 55 and 50 are compared, rather conspicuous differences in the values of the catch rates can be seen, but the trends of changes in fishing conditions north and south of 25° N. are shown to be in good agreement. This fact is believed to show the similarity of the pattern of distribution of these fishes in both areas.

Tables 56 and 57 present the fishing conditions by months in order to show seasonal changes. The data are unfortunately not evenly distributed, but there are data for almost the whole year so that it is possible to ascertain the fluctuations in fishing conditions during the year.

Table 56.--Fishing conditions by months (20° to 25° N., 140° to 150° E.)

Month	Number of hooks	Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	3,188	19	0.59	22	0.69	7	0.22	95	2.96	144	4.49
Feb.	12,742	17	0.13	28	0.22	8	0.02	89	0.70	151	1.19
Mar.	37,196	83	0.22	84	0.22	31	0.08	385	1.04	583	1.57
Apr.	14,651	35	0.24	10	0.07	5	0.03	97	0.69	147	1.00
May	5,688	17	0.21	0	0	1	0.02	60	1.05	78	1.37
June	5,718	24	0.42	0	0	12	0.21	69	1.20	105	1.83
July	16,668	84	0.50	25	0.15	7	0.04	202	1.21	318	1.91
Aug.	400	2	0.50	2	0.50	0	0	6	1.50	10	2.50
Sept.	18,126	64	0.35	27	0.15	69	0.38	133	0.73	293	1.61
Oct.	--	--	--	--	--	--	--	--	--	--	--
Nov.	1,416	11	0.77	0	0	0	0	5	0.35	16	1.13
Dec.	1,200	9	0.75	5	0.42	0	0	20	1.67	34	2.83

The overall catch rate for all species reaches its maximum for the year in January with slightly under 4.5. The principal element in the catch is the spearfishes. There is a second peak when the catch rate increases from June to August. Here, too, the principal component of the catch is spearfishes. Yellowfin are most abundant in November and December, and their catch rate again increases in June to August. The bigeye tuna increase and decrease in roughly the same manner as the yellowfin, with their highest catch rate in January. No very regular changes in fishing conditions for albacore can be seen, but there are rather high catch rates in January, June, and September. Spearfishes are most abundant in December and January with fairly high catch rates also shown for the period from May through August.

Table 57 shows the situation for the area of 25° to 30° N. The overall total catch rate is at its maximum in January with slightly less than 11 percent. The greater part of the catch is albacore, other species being extremely scarce. From May through July the catch rates increase, with a catch rate of 4.57 in May. The principal species at this time are spearfishes, the other species being extraordinarily scarce. Some black tuna are taken in May and June. At other seasons there is a record of only one of this species in February. Yellowfin increase somewhat from May through August and from October through December, with the peaks in the catch rates in July and November. Bigeye tuna show roughly the came pattern of increase and decrease as the yellowfin, but the peak in the catch rates appearing in the summer is not very pronounced. Albacore are abundant from January through March, particularly in January, when the catch rate goes above 10.0. In the summer they are taken only very rarely. The principal fishing season for the spearfishes is from April through July.

Comparing tables 56 and 57, although there are differences in the values for the catch rates, the trends of increase and decrease are in good agreement. However, the conspicuous increase in the spearfishes shown for January in table 56 does not appear in table 57.

Comparing the area of 25° to 30° N., 130° to 140° E. shown in table 52 with the area shown in table 57, the patterns of changes in fishing conditions from month to month for each species, excepting the black tuna, are in extremely good agreement. The black tuna for the area shown in table 52 has a high catch rate from December through March. At this season in the area shown in table 57 almost none of this species are taken. It is thought worthy of note that from April through June, from the waters of the Okinawan archipelago on the west eastward to this sea area, black tuna are taken everywhere.

Table 57.--Fishing conditions by months (25° to 30° N., 140° to 150° E.)

Month	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	15,954	0	0	3	0.02	38	0.24	1,675	10.50	21	0.14	1,737	10.90
Feb.	37,898	1	0	22	0.06	67	0.18	1,198	3.16	249	0.66	1,537	4.06
Mar.	28,234	0	0	20	0.07	60	0.21	1,389	4.91	125	0.44	1,594	5.63
Apr.	548	0	0	0	0	0	0	0	0	11	2.01	11	2.01
May	15,486	5	0.03	44	0.28	0	0	0	0	652	4.21	701	4.57
June	13,959	4	0.03	51	0.37	4	0.03	1	0.01	328	2.35	388	2.79
July	3,632	0	0	25	0.69	4	0.11	0	0	60	1.65	89	2.45
Aug.	600	0	0	2	0.33	0	0	0	0	5	0.83	7	1.17
Sept.	4,140	0	0	7	0.17	1	0.02	1	0.02	9	0.22	18	0.43
Oct.	1,800	0	0	5	0.28	8	0.44	0	0	11	0.61	24	1.33
Nov.	780	0	0	6	0.77	2	0.26	1	0.13	1	0.13	10	1.29
Dec.	2,712	0	0	6	0.22	27	0.99	2	0.07	12	0.44	47	1.72

As the foregoing shows, in areas of about the same latitude, the changes in fishing conditions for each species from month to month are very similar, and this fact is an interesting indication in considering the migrational patterns of these fishes. It shows that in the sea area south of the Japanese sea islands, at any rate, it is difficult to think of these fishes as having any definite migrational paths.

Table 58 shows fishing conditions in this area divided up by 2° of longitude in order to compare the fishing from east to west.

Table 58.--Fishing conditions by sections (20° to 25° N., 140° to 150° E.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
140°-142°E.	19,982	0	0	87	0.44	18	0.09	21	0.11	146	0.73	272	1.37
142°-144°E.	25,931	0	0	68	0.26	31	0.12	11	0.04	234	0.90	344	1.32
144°-146°E.	25,361	0	0	46	0.18	20	0.08	17	0.07	270	1.07	353	1.40
146°-148°E.	26,655	0	0	110	0.41	81	0.30	52	0.19	372	1.39	615	2.29
148°-150°E.	19,690	0	0	55	0.28	42	0.21	40	0.20	207	1.05	344	1.74

For the yellowfin the local differences in fishing conditions are not marked. However, catch rates are somewhat higher from 140° to 142° E. and from 146° to 148° E. Local differences in bigeye catch rates are likewise not striking, but they appear to be higher in the east and lower in the west. Albacore also appear to exhibit a tendency to be high in the east and low in the west. The highest spearfish catch rates are in the section of 146° to 148° E.

Table 59.--Fishing conditions by sections (25° to 30° N., 140° to 150° E.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
140°-142°E.	14,180	2	0.01	45	0.32	29	0.20	35	0.24	191	1.34	302	2.11
142°-144°E.	59,085	8	0.01	94	0.16	90	0.15	1,057	1.79	865	1.45	2,114	3.56
144°-146°E.	41,886	0	0	47	0.11	68	0.16	1,551	3.70	419	1.00	2,085	4.97
146°-148°E.	16,173	0	0	4	0.02	22	0.13	1,492	9.22	17	0.11	1,535	9.48
148°-150°E.	990	0	0	0	0	0	0	80	8.08	1	0.10	81	8.18

Between 25° and 30° N., as table 59 shows, black tuna have been taken only in the section from 140° to 144° E. Yellowfin catch rates are highest in the west and tend to decrease gradually to the eastward, and similar trends appear for bigeye tuna and spearfishes. Albacore show the opposite trend, with catch rates low in the west and increasing gradually to the east.

In tables 58 and 59 no account at all is taken of the seasons, but it is clear from tables 56 and 57 that there are notable seasonal changes in fishing conditions. However, if the data in tables 58 and 59 are considered with attention to seasonal differences, these few data are further extended and diluted to the point where they do not have much significance. As tables 56 and 57 show, for the area from 20° to 25° N. there are more data for the summer (April to September) than for the winter (October to March). For 25° to 30° N., on the contrary, there are more data for the winter season, more than twice as much as for the summer, and this fact must be taken into consideration in comparing fishing conditions in the two areas.

Another problem which must be taken up together with the changes in the fishing conditions from season to season is that of the changes produced by differences in the fishing gear. This problem is not limited to only this sea area. The gear used in the winter north of 25° N. is mostly the so-called albacore line, and in view of its construction it goes without saying that some correction is necessary in order to judge the fishing conditions solely on the basis of catch rates. However, on the one hand, most of the data do not record the construction of the fishing gear and thus afford no clear basis for a correction, and on the other hand, as was set forth in Chapter 7, there is no accurate method of making such a correction. Consequently, in evaluating the fishing conditions for these species, and in considering the pattern of their distribution, the catch rates for yellowfin, bigeye tuna, and spearfishes north of 25° N. latitude cannot be said to have exactly the same significance as the catch rates south of that latitude. The same thing is true of the albacore. However, it is probably possible to discuss the patterns of distribution in terms of trends.

This sea area can be thought of as a comparatively stabilized fishing ground throughout the year. In the southern portion in December and January and for a few months in the summer the catch rates are high and the principal catch is spearfishes. In the northern part the catch rates are high from January through March and from May through July, with albacore the principal catch in the winter and spearfishes in the summer. Among the spearfishes taken in the summer striped marlin of 50 to 100 pounds predominate in the early part of the season. Thereafter the black marlin increase and at the peak of the fishing season, rather small black marlin of 80 to 160 pounds are most numerous. Many sharks, principally great blue sharks, are taken throughout the year, and at times they make up more than half the total catch.

(c) East of 150° E. (20° to 50° N.)

The only land in this area is Marcus Island at 24° 30' N., 154° E., and oceanographic conditions are comparatively uniform. The northern part of the area includes a part of the albacore grounds which extend on to the north and east and is an excellent ground for this species. The southern part, except for the vicinity of Marcus Island and on to the eastward, is almost a virgin fishing ground with few survey data, and its significance and value as a fishing ground are little known. The vicinity of Marcus Island is a fishing ground principally for spearfishes and yellowfin tuna, and the fishing situation there is in general similar to that of the Ogasawara Islands area.

The following table summarizes the survey data for this sea area.

Table 60.--Fishing conditions between 150° and 180° E. (20° to 30° N.)

Section	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
20°-25°N.	48,956	0	0	286	0.58	291	0.61	56	0.11	490	1.00	1,130	2.30
25°-30°N.	329,565	6	0	37	0.01	1,523	0.46	13,776	4.16	585	0.18	15,927	4.81
Total	378,521	6	0	323	0.09	1,821	0.50	13,832	3.65	1,075	0.28	17,057	4.51

The overall catch rate is slightly over 4.5. Fishing conditions north and south of 25° N. are very different, with spearfishes most abundant in the south followed by bigeye tuna and yellowfin. North of 25° N. albacore make up the majority of the catch. No black tuna have been taken in the southern part of the area, but some very scattered catches have been made in the northern part. Yellowfin are much scarcer in the northern part than in the southern part, there is no great difference in the abundance of bigeye, and albacore are extremely scarce in the southern portion, although they make up more than half of the catch in the northern part. The spearfishes are much less abundant in the northern part of this area.

If this is compared with the situation in the waters of the Ogasawara, Volcano, and Mariana islands described earlier, there are hardly any differences except that in the southern part the yellowfin and bigeye are quite a bit more abundant in this region. In the northern portion this area shows somewhat of a decrease in the number of yellowfin and spearfishes and a marked increase in bigeye. The albacore catch rate is also a little less than 1.0 per hundred higher in this sea area. It is a characteristic of this sea area that bigeyed tuna catch rates show a rather marked overall increase. However, it is thought that the reason for this is mainly the uneven seasonal distribution of the data.

Seasonal changes in fishing conditions cannot be determined accurately because the data are almost entirely limited to the winter. Changes in the fishing conditions from month to month for that part of the year for which data are available are presented in tables 61 and 62.

Table 61.--Fishing conditions by months (20° to 25° N., 150° to 180° E.)

Month	Number of hooks	Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	7,552	102	1.35	107	1.41	22	0.29	96	1.28	327	4.33
Feb.	15,681	108	0.62	113	0.72	22	0.14	246	1.56	489	3.12
Mar.	7,098	2	0.03	33	0.46	1	0.01	55	0.77	91	1.28
May	6,888	35	0.51	0	0	1	0.01	31	0.45	69	1.00
June	2,000	1	0.05	1	0.05	2	0.10	5	0.25	9	0.45
July	3,800	1	0.02	0	0	4	0.11	21	0.55	26	0.68
Nov.	1,953	26	1.33	18	0.92	0	0	3	0.15	47	2.40
Dec.	2,460	11	0.45	21	0.85	0	0	10	0.41	42	1.50

Table 62.--Fishing conditions by months (25° - 30° N., 150° - 180° E.)

Month	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	108,878	0	0	20	0.02	720	0.66	6,337	5.82	187	0.17	7,264	6.67
Feb.	86,723	1	0	10	0.01	502	0.58	3,142	3.62	160	0.19	3,815	4.40
Mar.	125,941	5	0	2	0	289	0.23	4,319	3.43	197	0.16	4,812	3.82
May	1,300	0	0	1	0.07	2	0.15	0	0	0	0.30	7	0.52
July	1,000	0	0	0	0	0	0	0	0	6	0.60	6	0.60
Dec.	2,996	0	0	2	0.07	5	0.17	2	0.07	32	1.07	41	1.38

In general the catch rate is low in the summer and high in the winter with the maximum in January. Although the data can hardly be said to be adequate, the yellowfin catch rate for November and January is over 1.0. The bigeye fluctuate in approximately the same fashion as the yellowfin. Albacore have their peak catch rate in January; spearfishes are most abundant from January through March with their peak in February. Data for the summer are inadequate, but it appears that catch rates increase from May through July.

If this is compared with the southern part of the Ogasawara Islands area(see table 56), the trends of increase and decrease for the yellowfin are roughly in agreement, although the catch rate values are different. Bigeye tuna and albacore are also quite similar, and approximately the same sort of trend is shown for the spearfishes.

Table 62 shows changes from month to month in the fishing conditions in the northern section (25° to 50° N.).

Fishing is good from December on, with the highest catch rate in January. During February and March catch rates fall off gradually. For the summer there are only a few data for May and July and no sort of analysis can be given with just these data, however they appear to show that fishing is extremely poor.

Considering the individual species, black tuna are taken very rarely in February and March; yellowfin appear to be taken throughout the year but in such numbers that it is hardly worth while discussing their significance in the catch. Bigeye tuna have their highest catch rate in January, are still fairly abundant in February, and thereafter gradually decrease. Albacore suddenly become abundant in January and continue to show rather high catch rates in February and March, but they appear to be taken hardly at all in the summer. The spearfishes show their highest catch rate of the year in December. From January to March they continue to be taken with no great changes in their catch rates. It appears that their catch rate again tends to increase in the summer, but as there are very few data it is difficult to describe the situation accurately.

If we compare the foregoing with conditions in the southern part of the sea area, the trends of increase and decrease are in agreement, although there are differences in the catch rate values for yellowfin, bigeye, albacore, and spearfishes. However, in the case of the spearfishes there is a difference in the month in which the peak catch rate appears in the winter, this being earlier (December) in the north and later (February) in the south.

Comparing table 62 with table 57 (northern part of the Ogasawara Islands area), the trends of seasonal fluctuations in the catch rates are very similar, but the peaks in the catch rate in the Ogasawara area appear to be generally about one month earlier.

The following table shows changes in fishing conditions with longitude.

Table 63.--Fishing conditions by sections (20° - 25° N., 150° - 180° E.)

Section	Number of hooks	Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
150°-152°E.	18,072	29	0.16	62	0.34	4	0.02	219	1.21	314	1.73
152°-154°E.	8,864	59	0.66	25	0.28	3	0.03	65	0.73	152	1.70
154°-156°E.	16,220	196	1.21	210	1.29	43	0.26	172	1.06	621	3.82
162°-164°E.	1,000	1	0.10	1	0.10	0	0	1	0.10	3	0.30
166°-168°E.	1,700	1	0.06	0	0	2	0.12	7	0.41	10	0.59
168°-170°E.	700	0	0	0	0	1	0.14	5	0.71	6	0.85
170°-172°E.	2,400	0	0	0	0	3	0.12	13	0.54	16	0.66

The catch rates are highest in the section between 154° E. and 156° E. In the sections farther to the west they are about 1.7, while to the eastward the rates are very low. Both yellowfin and bigeye are most abundant between 154° and 156° E., while spearfishes are most abundant in the extreme western part, with rather high catch rates centering around 155° E. This fact is thought to indicate that the vicinity of Marcus Island is a fairly good fishing ground for this species.

If changes in the fishing conditions resulting from the uneven seasonal distribution of the data are ignored, the highest catch rates are shown for the sections centered on 155° E., 165° E., and 175° E. Taking up the species individually, yellowfin are taken rarely throughout the whole area and it is difficult to recognize any local variations in the catch pattern. Bigeye show a tendency to be somewhat more abundant in the vicinity of 160° E., 165° E., and 175° E. Albacore are the most important element in the catch throughout the whole area, and the local variations in their catch rates agree perfectly with those of the total catch rate. Their pattern is also in rough agreement with that for the bigeye tuna. Spearfish catch rates are somewhat higher in the extreme western portion, that is, near to Japanese waters, and they appear to present roughly equal catch rates from the vicinity of 160° on eastward. South of 25° N. the data are scarce and are completely lacking for many sections, so it is almost impossible to make any comparison between the northern and southern parts of the area.

Table 64.--Fishing conditions by sections (25° - 30° N., 150° - 180° E.)

Section	Number of hooks	Yellowfin		Bigeye		Albacore		Spearfishes		Total	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
150°-152°E.	2,946	2	0.07	5	0.17	36	1.22	23	0.79	66	2.25
152°-154°E.	12,825	2	0.02	21	0.16	312	2.43	82	0.64	417	3.25
154°-156°E.	5,726	1	0.02	2	0.03	223	3.89	22	0.38	248	4.32
156°-158°E.	4,239	0	0	8	0.19	21	0.49	3	0.07	32	0.75
158°-160°E.	1,918	0	0	1	0.05	7	0.36	5	0.25	13	0.66
160°-162°E.	7,320	0	0	48	0.66	85	1.16	16	0.22	149	2.04
162°-164°E.	8,270	2	0.02	9	0.11	152	1.85	16	0.18	179	2.16
164°-166°E.	10,420	7	0.07	65	0.62	617	5.92	17	0.16	706	6.77
166°-168°E.	4,631	0	0	13	0.28	138	2.98	8	0.17	159	3.43
168°-170°E.	23,128	0	0	65	0.28	809	3.50	19	0.08	893	3.86
170°-172°E.	39,714	0	0	97	0.24	1,651	4.16	37	0.10	1,785	4.50
172°-174°E.	53,762	16	0.03	351	0.65	2,701	5.02	41	0.08	3,109	5.78
174°-176°E.	96,908	3	0	758	0.78	5,346	5.52	199	0.21	6,306	6.51
176°-178°E.	21,326	4	0.02	39	0.18	732	3.43	44	0.21	817	3.84
178°-180°E.	36,432	0	0	41	0.11	946	2.60	53	0.14	1,040	2.89

As mentioned earlier, data for the southern part of the area are almost limited to the vicinity of Marcus Island. Data for the northern part are generally distributed, however, seasonally they are restricted to the winter. Consequently we are not able on the basis of these data to clarify completely the total significance which the central subtropical Pacific sea area has as a fishing ground. Nevertheless, if we tally all the facts recorded above, it is clear that the whole area to the east of 150° E. longitude in the western Pacific subtropical zone may have a uniform significance and value as a fishing ground. As was stated earlier, the subtropical convergence runs east and west through this area, and north and south of that convergence the current systems and the significance of the fishing grounds are quite different. That is, to the south the principal components of the catch are yellowfin, bigeye tuna, and spearfishes, while to the north the main catch is albacore. However, at some seasons bigeye tuna may also be extremely important.

For the western Pacific subtropical sea area as a whole, it appears that there is, in addition to the north-south difference on either side of the subtropical convergence, a difference from east to west. This east-west difference is largely determined by the topography or the presence of islands, and in this sense the area may be divided into the Okinawa-Ogasawara-Volcano Islands region and the waters to the east of it, each having its own characteristics as a fishing ground. As will be related later, the distributional patterns of tunas and spearfishes quite definitely differ around the Izu and Ogasawara islands, and it is known that for some species the fishing conditions may differ markedly in the waters to the east and west of these islands.

11. Nankai sea area (30° to 35° N., 130° to 140° E.)

The waters from south of Kyūshū to off the Bōsō Peninsula, from 30° to 35° N., will be described under the provisional designation of Nankai sea area.

This area is almost entirely within the Kuroshio current, with the current flowing constantly east or northeast along the coast of Japan. The so-called Kuroshio Countercurrent appears off the Kii peninsula and east of the Izu Islands.

Table 65 shows the oceanographic conditions in this area based on considerable data. The water color is generally II or III on Forel's scale, and transparencies are low, about 20 meters.

The extreme western part of this area in the vicinity of Tanegashima is famous as a black tuna fishing ground, but in recent years no fish have been taken at all and no boats have been operating there. The fishing season was limited to the winter, beginning around December and with the peak of the season in January and February. The main base for this fishery was the port of Aburatsu in Miyazaki Prefecture, and the amount of landings and changes in the size of fish for a number of years at that port are shown in figure 12.

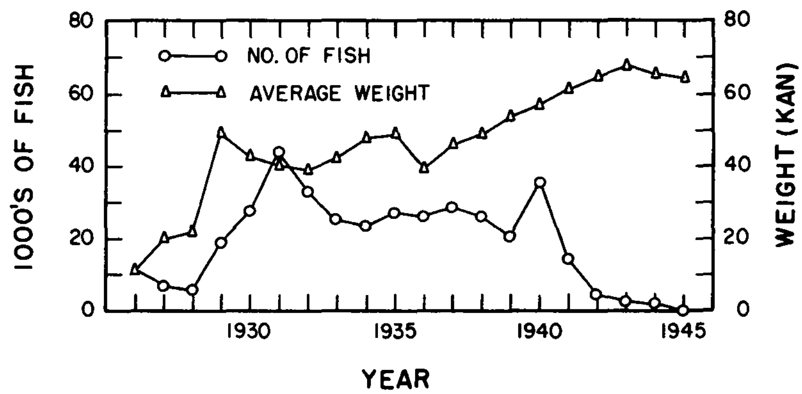

Figure 12.--Annual changes in black tuna landings and average weight at Aburatsu

Table 65.--Oceanographic conditions in the vicinity of 32° N., 133° 30' E.

Month	Temperature (°C.)			Salinity		
	0 m	50 m	100 m	0 m	50 m	100 m
Feb.	17.7	17.0	16.0	34.85	34.92	34.79
May	21.7	19.3	17.2	34.76	34.85	34.63
Aug.	27.7	26.7	23.8	34.11	34.14	34.56
Nov.	24.6	24.6	24.6	34.69	34.65	34.65

It is clear from the figure that a rapid increase in the number of black tuna landed at Aburatsu began in the early years of the Shōwa Era, the peak being reached in 1931 with landings of about 43,000 fish. From 1932 through 1933 there was a gradual decline, and then the landings continued without much change at around 20 to 30 thousand fish from 1933 to 1939. There was a fairly marked increase to 35,000 fish in 1940. From 1941 on the catch fell off steeply, and from 1945 to the present there has been hardly any catch at all.

As for the size of the fish, the average weight in 1927 and 1928 was around 165 pounds, in 1929 this suddenly increased to about 396 pounds. From 1930 to around 1938 the average weight fluctuated between 331 and 410 pounds. From 1939 on the fish increased in size from year to year and after 1942 the average was about 496 pounds.

Table 66.--Oceanographic conditions in the vicinity of 30° N., 134° 30' N.

Month	Temperature (° C.)			Salinity		
	0 m	50 m	100 m	0 m	50 m	100 m
Feb.	18.7	18.5	18.5	34.90	34.83	34.88
May	23.5	21.6	20.2	34.72	35.01	34.87
August	29.0	24.4	21.1	34.56	34.63	34.85
Nov.	24.6	24.6	23.3	34.54	34.69	34.78

Table 67.--85 miles south by east of Gozamisaki

Month	Temperature (° C.)			Salinity		
	0 m	50 m	100 m	0 m	50 m	100 m
Feb.	17.7	17.9	17.5	34.88	34.94	35.01
May	19.0	16.3	15.0	34.52	34.74	34.76
Aug.	27.3	18.2	16.0	34.16	34.49	34.49
Nov.	22.8	20.6	17.2	--	--	--

From the foregoing it appears that during the period when the fishery was in a stabilized condition, with no great difference in the number of fish taken from year to year, there were schools made up of approximately the same sizes of fish migrating into the grounds every year at a more or less definite season. However, as the size of these migrating fish increased, their numbers declined abruptly, and finally a condition was brought about where no fish were taken at all.

As explained in the foregoing, hardly any black tuna are now taken, but a certain number of bigeye tuna and spearfishes are caught at present, the bigeye tuna being the most important.

In the west coast waters of Kyūshū, which adjoin this sea area on the west, the catch is almost entirely composed of spearfishes. The fishing ground for the most part is along the 100-fathom line in the East China Sea. The best known fishing ground is in the vicinity of Saishū Tō (Quelpart Island), but some fish are also taken across the Tsushima Strait in the southern part of the Sea of Japan. In August and September the fishing grounds are centered around Saishū Tō, but thereafter with the passage of time they gradually shift to the southward.

Spearfishes are abundant from the waters around Tanegashima north to the region of the Hyūga Nada, and the harpoon fishery in this area is at its peak from April through June. Farther to the eastward, between the waters of Tosa and the Kishū region, the black tuna catch declines sharply and albacore become the most important item in the catch. Next to the albacore, bigeye tuna are the most abundant, and at certain seasons some yellowfin and spearfishes are taken. Farther to the eastward in the Izu Islands region, the makeup of the catch is again different, spearfishes being the most important element in the catch here and surpassing the tunas.

Thus the composition of the catch is different in the different sea areas, and fishing is carried on using gear of different construction. It may be thought that the differences in the catch are due to the differences in the construction of the gear, but the actual truth is probably that differences in the distribution of the species have brought about the changes in the construction of the fishing gear. The foregoing refers only to the longline fishery, and in actuality rather large numbers of albacore and young yellowfin, bigeye, and black tuna are taken by pole and line fishing, while the catch of fixed gear in some years is by no means small.

Table 68 summarizes data from the surveys which have been carried on in the Nankai sea area.

Table 68.--Fishing conditions in the Nankai sea area

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
815	257,001	807	0.31	106	0.04	745	0.29	4,754	1.84	622	0.24

The overall average catch rate is slightly over 2.7. From 60 to 70 percent of the catch is albacore, followed by black marlin and bigeye tuna. Yellowfin are almost without significance as an objective of the fishery.

If this area is divided into sections of 2^{o} of longitude, and the fishing situation for each of these sections is plotted, we get the following curves (figure 13).

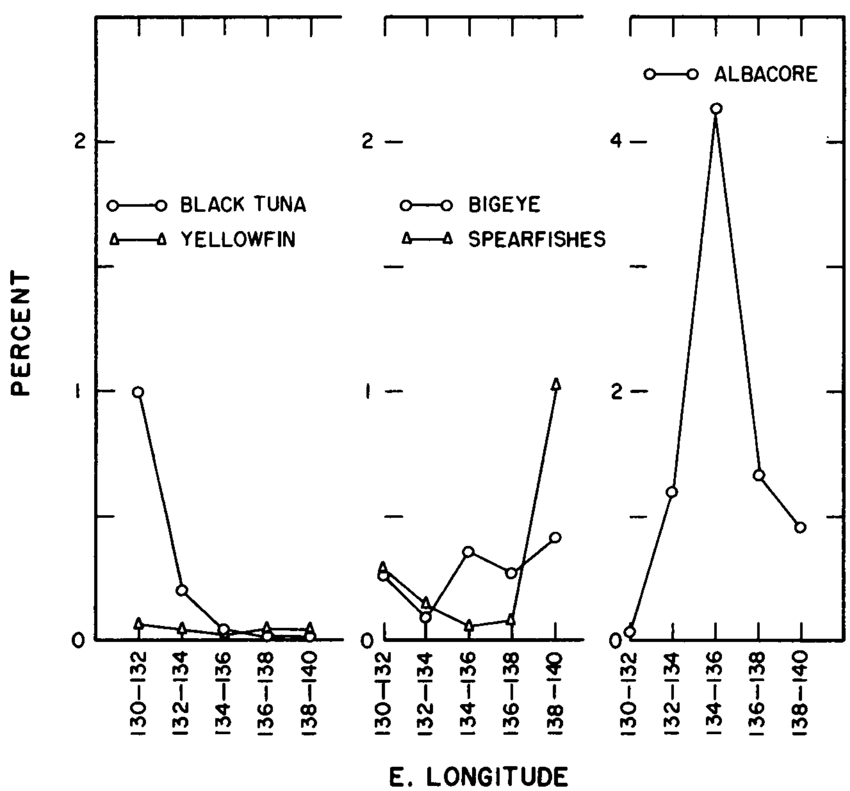

Figure 13.--Catch rates by 2^{o} sections (30^{o} - 35^{o} N., 130^{o} - 140^{o} E.)

As the figure clearly shows, black tuna have a catch rate of slightly under 1.0 in the section from 130° to 132° E. longitude, but farther to the east the decline in the catch rate is extremely conspicuous. The yellowfin catch rate is very low with little difference throughout the whole area. The bigeye tuna decrease somewhat in the section between 132° and 134° E. longitude, and tend to increase steadily to the eastward. Spearfishes decrease gradually from the extreme west toward the central portion, then increase sharply in the vicinity of the Izu Islands until the catch rate is slightly over 1.0. Albacore show a conspicuous increase in the central part of the area, where the catch rate is 4.2.

In the extreme western section around Tanegashima black tuna are the most important element in the catch, in the central part around the Kinan Shoals albacore are the main species, and in the far eastern section around the Izu Islands spearfishes make up the greater part of the catch. This situation is very clearly shown by the figure.

In order to see the seasonal changes in the fishing, catches for each month have been shown in table 69. The inequality in the seasonal distribution of the data is very great, and for this reason it is difficult to grasp fully the changes from month to month in fishing conditions. Leaving aside all considerations of areas and summarizing the data for this sea area as a whole, it is shown that black tuna are more abundant in the winter, with their highest catch rates for the year from March through April. Yellowfin are generally scarce, but they increase somewhat around April and then have their highest catch rates for the year from October through November. Bigeye tuna are not taken at all during the summer, their highest catch rate for the year being in October, after which they gradually decline. Albacore are hardly taken at all during the summer; their catch rates gradually improve from December to February, after which they decrease suddenly in March.

The foregoing is based exclusively on the longline fishery with no consideration of the pole-and-line fishery. The pole-and-line catch is fairly large at certain seasons, but the fish taken are generally small.

In addition the fishery with fixed gear takes some yellowfin and black tuna, and the catch in certain years is fairly considerable. The fishing season for these fisheries is mainly in the summer.

The situation is not entirely clear because there are very few data for July and none at all for August and September, but it is shown that in general spearfishes are abundant in the summer, with a truly high catch rate of 6.8 in June, showing that considerable catches can be anticipated. This high catch rate is based on data obtained almost entirely from the waters adjacent to the Izu Islands. There are no data for other parts of the area so they cannot be shown, but it appears that in recent years a large number of harpoon boats have operated in the Hyūga Nada area with fairly good success, the season extending from 2 to 3 months centered around May.

Fishing for spearfishes in the Ogasawara Islands area, which adjoins the Izu Islands area on the south, is, as has already been stated, good from April through July in the northern section (25° to 30° N.), with the catch rate reaching a high in May of 4.2. Consequently it is thought that there is a lag of about 1 month between the peak of the spearfish season in the northern Ogasawaras and the waters adjacent to the Izu Islands.

As was stated earlier, in the winter the central part of this region produces a large albacore catch, and in the most westerly part the black tuna fishery is at its peak. In the summer there is a general tendency for the spearfish catch to increase markedly, this trend being particularly conspicuous in the waters adjacent to the Izu Islands. However, the fishing season is short. From October on there is some increase in the yellowfin and bigeye catch.

The overall catch rate throughout the year is shown to be slightly more than 2.7, but if the distance between the bases and the fishing grounds is taken into consideration, it is not correct to say that the grounds of this sea area are very inferior. Besides the tuna and spearfishes, an equal or greater number of sharks are taken and considerable numbers of other miscellaneous fish are also captured, so it is believed that if no error is made in selecting a fishing ground and if consideration is given to the season, the grounds of this area present quite advantageous conditions for medium-sized and small vessels.

Table 69.--Fishing conditions by months (Nankai sea area)

Month	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	128	73,843	209	0.28	22	0.03	244	0.33	1,761	2.39	72	0.10
Feb.	293	81,460	366	0.45	10	0.01	177	0.22	2,430	2.98	186	0.22
Mar.	210	40,809	266	0.65	12	0.03	52	0.13	347	0.85	117	0.29
Apr.	23	1,014	29	1.51	5	0.26	1	0.05	0	0	3	0.15
May	11	3,704	3	0.08	2	0.06	0	0	0	0	70	1.89
June	9	1,764	0	0	1	0.05	0	0	2	0.11	120	6.80
July	2	800	0	0	1	0.12	0	0	0	0	4	0.50
Aug.	--	--	--	--	--	--	--	--	--	--	--	--
Sept.	--	--	--	--	--	--	--	--	--	--	--	--
Oct.	15	3,500	0	0	13	0.37	36	1.03	0	0	7	0.20
Nov.	27	10,249	1	0.01	24	0.23	52	0.51	15	0.15	8	0.08
Dec.	86	39,511	12	0.03	17	0.04	160	0.40	434	1.10	30	0.08

The Tanegashima area in the extreme western part of this region is famous as a black tuna ground, but at present it has almost entirely lost its significance and value as a fishing ground for this species. It is thought, however, that this condition is probably the result of cyclical changes in oceanographic conditions, and it is anticipated therefore that in the future it will recover its value as a fishing ground.

12. Area east of the Izu Islands (30° - 35° N., 140° - 150° E.)

The area from 30° - 35° N., 140°- 150° E. will be described under the designation "sea area east of the Izu Islands."

There are some fluctuations in the currents from year to year depending on the difference in the strength of the Kuroshio, but the greater part of this area is within the Kuroshio Countercurrent. The main stream of the Kuroshio flows along the northern edge of the area in a roughly easterly direction. As the subtropical convergence runs east and west at about the line of 30° N. latitude during the summer, there is in this area as a whole a clockwise gyral formed by the current flowing northward from the Ogasawara Islands region, the Kuroshio, and the Kuroshio Countercurrent. In the winter the subtropical convergence gradually moves southward and around February and March it is in the vicinity of 24° - 25° N. Because of this the south-eastward- or south-southeastward-flowing Kuroshio Countercurrent becomes more prominent in this sea area.

Table 70 shows oceanographic conditions in this sea area on the basis of data gathered on the cross-sectional observation line southeast of Cape Nojima. In February the heart of the Kuroshio is about 50 to 80 miles off the coast and the surface water temperature is about 20° C. Farther off shore the temperature is down to 17.3° C. around 100 miles from the coast, while in the vicinity of 120 miles off shore there is a zone of fairly warm water of 18° C. to 19° C. Farther off shore the water temperature again goes down to 17° C., continuing at this level to the vicinity of 260 miles off the coast. At 300 miles off shore the water temperature rises a little to above 18° C. Water temperature is approximately the same from the surface through the 100-meter level, showing that mixing is being carried on by convection currents.

Table 70.--Oceanographic conditions southeast of Cape Nojima

Month	Depth (meters)	50 miles		80 miles		100 miles		200 miles		300 miles	
		Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity
Feb.	0	19.4	34.81	20.0	34.81	17.3	34.83	17.4	34.83	18.1	34.81
	50	19.4	35.25	19.7	34.83	17.3	34.74	17.4	34.74	17.7	34.79
	100	19.0	34.97	19.7	34.87	17.3	34.79	11.4	34.76	17.7	34.87
	200	18.2	34.88	18.3	34.85	17.3	34.76	17.4	34.85	17.6	34.83
May	0	20.7	33.35	20.1	34.13	18.7	34.23	18.4	33.89	19.7	34.76
	50	20.3	34.31	20.1	33.64	18.7	33.87	17.8	34.27	17.8	34.52
	100	19.7	33.96	18.3	34.02	17.8	32.38	17.0	34.23	17.1	33.79
	200	18.3	34.29	17.8	34.14	17.3	32.94	16.8	34.31	16.8	33.66
Aug.	0	28.5	34.54	27.8	34.38	28.0	34.33	27.6	34.43	27.4	34.42
	50	25.2	34.81	24.4	34.45	22.4	34.54	22.6	34.42	22.4	34.45
	100	22.2	34.88	20.8	34.06	21.8	34.78	20.8	34.38	20.7	34.33
	200	21.1	34.87	19.6	34.63	21.4	34.81	18.6	34.52	20.7	34.49
Nov.	0	24.2	34.58	22.6	34.52	22.7	34.47	23.7	34.69	23.8	34.49
	50	23.8	34.56	22.0	34.74	22.4	34.49	22.5	34.69	22.5	34.34
	100	22.7	34.60	20.8	34.87	20.4	34.85	21.5	34.72	21.5	34.65
	200	20.6	34.85	19.6	34.79	19.2	34.87	18.8	34.76	18.8	34.87

Note: (1) The distances are shown from Cape Nojima as a starting point.

(2) This table is drawn from the Records of Oceanographic Investigations for 1937.

In May the zone with the highest water temperature is 50 miles off shore, where 20.7° C. is shown. From here on out to the 200-mile line temperatures gradually fall to between 18° and 19° C. In the vicinity of the 300-mile station they rise somewhat to 19.7° C. If one looks at the vertical distribution of the water temperatures, the tendency toward stratification is clear.

In August the coastal waters are up to 23° to 24° C., and the area of highest water temperatures is about 40 miles off shore, where the surface water temperature is 28.6° C. From 70 miles off shore on out the water temperatures are from 27° to 28° C., and the temperatures are at their lowest in the vicinity of 250 to 300 miles off shore.

In November the zone of highest water temperatures appears between 20 and 40 miles off shore with surface water temperatures of 24.6° C. From 80 to 180 miles off the coast the water temperatures are between 22° and 23° C., and from 200 miles off the coast on out the temperatures are from 23° to 24° C.

In the off-shore water the transparencies are highest in the summer, when the waters are stratified, with values of 25 to 28 meters. In winter, which is the season of convection, values are low, being about 17 to 20 meters. As for water color, II on Forel's scales generally most frequent, with III observed quite often.

This sea area is a part of the so-called winter albacore grounds, which extend on to the eastward. The fishing season is, of course, during the winter. At some seasons considerable numbers of bigeye tuna are taken. In the summer spearfishes, principally the striped marlin, are taken, and from late autumn to early winter considerable numbers of broadbill swordfish are caught.

Table 71 summarizes the data from surveys which have been made in this sea area.

Table 71.--Fishing conditions in the sea area east of the Izu Islands (30° to 35° N., 140° to 150° E.)

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
485	328,452	48	0.01	39	0.01	824	0.25	13,649	4.13	2,187	0.67

The overall average catch rate is slightly more than 5.0. The biggest catch is the albacore, making up more than 80 percent of the whole. Next to the albacore most important are the spearfishes, with the black tuna and yellowfin of little significance. Bigeye tuna have a catch rate little different from that of the Nankai sea area adjacent on the west.

In table 72 this area is divided into five equal parts of 2° of longitude each, and the fishing situation for each of these sections is shown separately.

Table 72.--Fishing conditions by longitude (sea area east of the Izu Islands)

Section	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
140°-142°E.	234	141,155	7	0.01	11	0.01	378	0.27	2,971	2.10	1,414	1.00
142°-144°E.	85	68,999	7	0.01	12	0.02	159	0.23	3,476	5.04	300	0.43
144°-146°E.	61	50,224	1	0.00	5	0.01	85	0.17	2,630	5.25	182	0.36
146°-148°E.	47	38,298	10	0.03	7	0.02	102	0.27	2,274	5.94	134	0.35
148°-150°E.	58	39,866	23	0.06	4	0.01	150	0.37	2,298	5.86	155	0.39

Looking at this sea area as a whole, with no consideration given to seasonal changes in fishing conditions, there is a tendency for black tuna to be more abundant farther off the coast. Yellowfin are vestigial, but they are taken quite uniformly, while bigeye tuna appear to show a tendency to be somewhat less numerous in the central part and more abundant at the eastern and western extremities, however, this tendency is not very conspicuous. Albacore are remarkably scarce in the most westerly part and tend to increase in numbers to the eastward. Spearfishes are abundant in the coastal waters of the Izu Islands and scarcer off shore and they are taken rather uniformly in the off-shore waters, with no great local variations in the catch.

Ignoring local variations in the fishing conditions, table 73 shows the fishing conditions by months for the whole sea area. There are very few data for the summer, so seasonal changes in fishing conditions are not clear, but within the scope of the table the fluctuations are approximately as follows. Catches of black tuna are recorded only for the months of January, February, and April. A few yellowfin are taken in each month throughout the year, and they appear to become somewhat more abundant around July and August. Highest catch rates for bigeye tuna appear in April, and they are generally abundant in December and January. Hardly any albacore are taken in the summer, the first catches being made in November with a rapid increase to January, which has the highest catch rate of 5.9. In February the catch rate drops somewhat from January, but it is still slightly over 5.0. From March on the catch rate falls off steeply. The spearfishes show a peak in their catch rate from June through July. In the winter catch the broadbill is most important; striped marlin and black marlin are most numerous in the summer.

Table 73.--Monthly fishing conditions (sea area east of the Izu Islands)

Month	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	151	100,163	33	0.03	8	0.08	327	0.33	5,973	5.90	610	0.61
Feb.	177	125,087	10	0.01	15	0.01	320	0.26	6,586	5.26	868	0.70
Mar.	84	49,172	1	0.00	4	0.01	120	0.24	843	1.71	496	1.01
Apr.	19	9,326	3	0.03	3	0.03	60	0.64	85	0.91	35	0.38
May	1	480	0	0.00	0	0.00	1	0.20	5	1.04	0	0.00
June	1	184	0	0.00	0	0.00	0	0.00	0	0.00	10	5.43
July	9	1,790	0	0.00	3	0.17	3	0.17	0	0.00	50	2.80
Aug.	6	1,142	0	0.00	4	0.35	0	0.00	0	0.00	8	0.70
Sept.	--	--	--	--	--	--	--	--	--	--	--	--
Oct.	1	420	0	0	0	0	0	0	0	0	5	1.19
Nov.	7	6,510	0	0	1	0.02	11	0.19	51	0.78	33	0.51
Dec.	34	15,840	0	0	1	0.01	47	0.30	577	3.71	87	0.55

Table 74 shows the seasonal and local distribution of the data.

As is shown in table 73, the greater part of the catch in the summer is spearfishes. It is clear from table 74 that the area from which the spearfishes are taken during the summer is restricted to the western part of the sea area, that is the vicinity of the Izu Islands, the situation in the off-shore waters being unclear because of the complete lack of data.

As for the winter season, when albacore are the main element in the catch, there are approximately uniform catch rates throughout the whole sea area in February, somewhat higher values being shown only for the section from 146° to 148° E. In December and January there are large local variations in the catch rates, and these variations show no definite trend. In March the catch rate is slightly over 4.0 in the extreme western section, but elsewhere in the more off-shore waters the catch rates generally go down steeply and the significance of the area as a fishing ground is diminished.

If fishing conditions in this area are compared with those in the Nankai sea area adjacent on the west:

1. The catch of black tuna is much less in this sea area.
2. The catch of albacore is much greater in this area.

3. Spearfishes are somewhat more abundant in this area, yellowfin are more abundant in the Nankai sea area, and there is almost no perceptible difference in bigeye tuna.
4. As for changes in fishing conditions from month to month, in the case of the most important species, the spearfishes and albacore, it appears that the fluctuations in fishing conditions show almost identical trends in the two sea areas. However, it appears that the peak of the albacore season is somewhat later in the Nankai sea area than in this area.
5. The highest catch rate for bigeye tuna in the Nankai sea area occurs in October, and it is difficult to make a comparison with this sea area because of the paucity of data.
6. The east and west sides of the Izu Islands show almost the same catch rates for spearfishes, but the species are not necessarily the same, as will be explained later.

It is observed that the fishing grounds to the east and west of the Izu Islands are not quite the same in character but have somewhat different characteristics.

Table 74.--Distribution of the data by months and areas (sea area east of Izu Islands)

Month	140° - 142° E.			142° - 144° E.			144° - 146° E.			146° - 148° E.			148° - 150° E.		
	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate
Jan.	38	18,988	3.27	15	12,165	10.88	31	27,648	7.24	19	14,426	5.43	38	26,886	8.07
Feb.	103	53,799	5.30	34	37,436	5.21	14	12,964	5.74	19	18,072	8.39	5	2,390	3.56
Mar.	47	25,626	4.12	21	14,480	1.85	12	6,966	1.75	3	1,800	0.89	1	300	1.00
Apr.	11	5,960	2.70	--	--	--	4	6,966	1.75	3	1,080	0.92	1	360	0.56
May	--	--	--	1	480	1.25	--	--	--	--	--	--	--	--	--
June	1	184	5.43	--	--	--	--	--	--	--	--	--	--	--	--
July	3	600	2.00	6	1,198	2.65	--	--	--	--	--	--	--	--	--
Aug.	3	542	0.92	3	600	1.17	--	--	--	--	--	--	--	--	--
Sept.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oct.	1	420	1.19	--	--	--	--	--	--	--	--	--	--	--	--
Nov.	--	--	--	1	402	0	5	2,597	1.12	4	2,910	1.17	25	16,600	1.84
Dec.	18	6,780	1.00	5	2,640	13.41	2	1,160	2.70	5	2,920	6.88	4	2,340	2.52

Note: The catch rate is combined for tunas and spearfishes.

If this sea area is further compared with the northern part of the waters adjacent to the Ogasawara archipelago on the south,

1. There is no great difference in the black tuna catch rates.
2. Yellowfin are somewhat less numerous in this sea area.
3. Bigeye tuna are somewhat more abundant in this sea area.
4. Albacore catch rates show values of about 1.0 per hundred higher in this sea area.
5. Spearfishes are somewhat less abundant in this sea area.

6. Variations in fishing conditions with longitude coincide completely in their trends, although there are some differences in the actual catch rate values.
7. The changes from month to month in fishing conditions for each species are also similar, but it looks as if the peak season for spearfishes is about 1 month later in this sea area.

The facts listed above show that this sea area is more closely related to the area adjacent to the south than to that on the west. In addition to the tunas and spearfishes there is a considerable catch of sharks, and therefore it can probably be said that, aside from the slack seasons of spring and autumn, this sea area affords rather good fishing grounds for small and medium boats. In the summer, besides the longline fishery, a harpoon fishery for spearfishes and pole-and-line fishing for small tuna and albacore are carried on. The weather, as is generally known, is extremely calm in the summer except when typhoons are originating. During the winter strong westerly winds blow continuously and the sea becomes quite rough with consequent difficulty in operating.

13. Northeastern sea area (35° N., 140° to 150° E.)

The area north of 35° N. latitude and between 140° and 150° E. longitude will be described as the northeastern sea area. Its northern boundary is in the vicinity of 42° N.

At the height of summer a part of the Kuroshio flows northward or north-northeastward from the vicinity of Inubō Misaki and passes through this sea area. The Oyashio flows southwestward from the Kurile Islands area in a direction roughly opposite to that of the Kuroshio. This current generally becomes submerged, but here and there it flows in wedge-shaped tongues into the Kuroshio. Also at times parts of the warm or cold currents get cut off from the currents of origin and become isolated water masses within different currents. Very close to the coast in the Sanriku area of northeastern Japan a tail end of the Tsushima Current, which has come through the Tsugaru Strait, flows southward. In the winter the strength of the Oyashio increases and it forces the Kuroshio southward so that the influence of the Kuroshio does not extend to the northward, but is deflected eastward into the central Pacific. The tail end of the Tsushima Current which has come through the Tsugaru Strait flows weakly south along the coast.

The foregoing is an outline of the distribution of ocean currents in this sea area, but because of this clash of sea currents of completely different character and because of the annual or seasonal differences in their strength, there are rather conspicuous fluctuations in oceanographic conditions from year to year, and in many cases there are violent short-term fluctuations so that the situation is a great deal more complicated than in the tropical and subtropical regions.

The following tables present oceanographic data for this sea area abstracted from the Report of Oceanographic Works for 1937.

As the table shows, the distribution of water temperatures in January is approximately uniform up to about 100 miles off the coast with temperatures of about 10.5° C., and with almost no change from the surface to the 100-meter level. In the vicinity of 150 miles off shore the water temperatures fall rather conspicuously to 8.6° C. at the surface and 8.1° C. at the 100-meter level.

In February the water temperatures are everywhere conspicuously lower, falling 2° to 4° C. At a point 50 miles off the coast the water temperatures at all levels from 10 meters on down are conspicuously lower than those at other points. At the station 150 miles off the coast just as in January the values are low at all levels.

Table 75.--Transverse sectional observations directly east of Same

Month	Depth (meters)	10 miles		20 miles		50 miles		80 miles		100 miles		150 miles	
		Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity
Jan.	0	10.5	33.41	10.6	33.17	10.7	33.18	10.5	33.34	10.6	33.19	8.6	32.94
	10	10.4	34.69	10.4	33.04	10.6	33.19	10.5	33.20	10.5	33.13	8.6	33.04
	25	10.3	33.41	10.3	33.12	10.5	33.17	10.5	33.08	10.4	33.13	8.6	33.06
	50	10.3	33.41	10.3	33.12	10.6	33.12	10.4	33.12	10.5	33.19	8.5	33.02
	100	--	--	10.3	33.17	10.6	33.19	10.4	33.12	10.5	33.17	8.1	33.12
Feb.	0	8.6	32.03	8.0	32.74	8.0	33.64	8.5	33.95	8.0	33.71	7.6	33.68
	10	8.5	33.57	7.4	33.68	6.5	33.58	8.0	33.57	7.9	33.58	7.5	33.75
	25	8.5	33.64	7.7	33.65	6.5	33.58	7.9	33.75	8.0	33.77	7.5	33.75
	50	8.5	32.39	7.7	33.53	6.6	33.57	8.0	33.75	8.1	33.75	7.3	32.63
	100	--	--	7.5	33.68	6.4	33.55	7.9	33.75	8.0	33.75	7.3	33.77
Mar.	0	7.3	33.22	7.3	33.91	5.8	33.55	7.5	33.86	8.1	34.02	6.6	33.77
	10	7.3	33.93	7.3	33.93	5.7	33.57	7.3	33.84	8.0	33.96	6.5	33.51
	25	7.4	33.91	7.4	33.89	5.7	33.60	7.4	33.86	8.0	33.95	6.5	33.69
	50	7.4	33.93	7.5	33.89	5.6	33.51	7.3	33.84	8.0	34.00	6.5	33.68
	100	--	--	7.1	33.80	5.4	33.42	7.5	33.98	7.9	34.02	6.5	33.75
Apr.	0	7.9	34.14	7.6	33.75	9.8	34.58	1.7	33.01	8.5	33.73	--	--
	10	7.5	34.11	7.4	33.61	9.6	34.60	2.0	32.09	8.5	34.69	--	--
	25	7.4	34.34	7.4	33.86	9.8	34.73	3.8	33.17	8.5	34.07	--	--
	50	7.2	34.23	7.3	33.61	9.8	34.22	3.5	32.63	7.6	34.81	--	--
	100	--	--	7.3	33.75	9.6	34.06	4.2	33.18	5.8	33.47	--	--
May	0	9.2	33.86	9.1	33.66	8.0	33.31	8.4	33.33	8.0	32.28	9.4	34.00
	10	9.2	33.75	9.1	33.69	8.3	33.53	8.3	35.58	7.8	33.24	9.4	34.02
	25	9.1	33.80	9.1	33.75	8.0	33.44	8.2	33.57	7.9	33.48	9.4	34.05
	50	9.0	33.80	9.1	33.77	6.0	33.39	8.6	33.95	7.2	33.55	9.2	--
	100	--	--	8.9	33.86	5.9	33.55	7.7	33.77	3.5	33.35	9.0	34.07
June	0	12.5	33.49	12.6	33.42	12.0	33.44	13.5	33.31	13.0	34.02	--	--
	10	12.0	33.41	11.8	33.69	11.1	33.47	13.0	33.95	12.1	33.58	--	--
	25	10.8	33.46	11.2	33.58	10.6	33.55	12.5	33.98	11.4	34.10	--	--
	50	10.4	34.46	10.8	33.73	9.7	33.97	9.5	33.87	9.9	34.33	--	--
	100	--	--	10.0	33.84	9.5	33.71	9.0	33.47	8.4	33.96	--	--
July	0	17.2	34.07	16.9	33.17	17.0	33.22	16.4	33.17	17.2	33.61	--	--
	10	16.1	34.80	15.0	32.51	16.2	33.17	16.0	33.19	16.3	33.37	--	--
	25	13.9	33.55	13.7	32.51	14.6	32.58	14.4	32.87	15.8	33.37	--	--
	50	13.4	33.91	13.0	32.50	10.5	32.54	11.0	32.54	10.4	32.26	--	--
	100	--	--	12.0	32.51	10.2	32.51	10.9	33.06	7.9	33.26	--	--
Aug.	0	23.2	--	23.6	33.51	25.7	33.21	24.5	--	24.0	33.49	24.2	33.51
	10	20.5	--	21.3	33.64	21.5	33.46	23.6	--	21.0	33.40	20.0	34.16
	25	19.6	--	20.8	33.33	19.7	33.30	21.5	--	21.3	33.96	16.5	34.25
	50	16.0	--	7.0	33.26	7.5	33.24	7.7	--	9.0	33.98	18.5	34.34
	100	14.6	--	5.8	33.40	5.8	33.30	3.5	--	7.7	33.71	9.7	34.02

Month	Depth (meters)	10 miles		20 miles		50 miles		80 miles		100 miles		150 miles	
		Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity
Sept.	0	22.3	34.53	22.1	33.22	19.5	32.38	13.0	33.03	21.4	32.22	--	--
	10	22.3	33.35	22.0	33.18	19.5	32.38	17.5	32.38	21.4	33.11	--	--
	25	22.1	33.30	20.5	33.35	16.5	32.20	16.5	33.08	17.0	33.80	--	--
	50	21.2	33.34	19.5	33.30	15.4	33.40	15.4	33.08	11.0	33.60	--	--
	100	--	--	19.0	33.37	7.5	32.42	10.4	33.11	9.7	32.43	--	--
Oct.	0	17.8	33.55	19.3	31.79	18.7	33.74	15.3	32.75	15.3	32.62	--	--
	10	18.1	33.58	19.0	33.74	18.5	33.73	14.0	32.75	15.2	32.72	--	--
	25	17.5	33.87	18.5	33.39	18.5	33.58	13.9	32.75	15.2	32.47	--	--
	50	17.5	33.87	18.4	33.66	18.3	33.60	13.4	32.62	14.2	32.87	--	--
	100	--	--	17.9	33.78	17.8	33.74	10.5	32.99	8.6	32.97	--	--
Nov.	0	16.8	34.20	16.8	34.18	15.8	34.15	16.0	34.15	11.5	33.75	13.0	33.22
	10	16.8	34.02	16.7	34.11	15.5	34.16	16.0	34.20	11.5	33.55	12.5	33.26
	25	16.8	34.13	16.5	34.09	15.0	34.11	15.0	34.24	12.0	33.42	12.5	33.21
	50	16.8	34.09	16.5	34.15	14.7	34.09	15.0	34.24	10.5	33.73	9.5	34.07
	100	--	--	16.0	34.16	13.7	34.16	11.0	34.09	6.0	33.64	3.7	33.39
Dec.	0	12.7	33.15	12.5	33.78	10.7	33.78	6.4	33.40	8.2	33.53	--	--
	10	12.4	33.64	12.0	33.75	10.3	33.74	6.2	33.39	7.7	33.51	--	--
	25	12.0	33.78	11.8	33.77	10.6	33.77	6.0	33.38	7.5	33.64	--	--
	50	12.0	33.78	11.6	33.77	9.6	33.50	5.3	33.39	7.5	33.52	--	--
	100	--	--	11.5	33.66	8.4	33.58	4.3	33.41	7.4	33.80	--	--

Note: The numbers of miles show the distance east of the base point at Same.

In March the water temperatures are generally lower than in February. A rather conspicuous low-temperature water zone appears about 50 miles off the coast, while a zone of somewhat warmer water appears in the vicinity of 100 miles off the coast, with low temperatures again at 150 miles off shore.

In April the water temperatures are generally somewhat higher than those of March. However, there is an extremely pronounced zone of cold water at the 80-mile station, and the vertical distribution of water temperatures at this station shows an inverted pattern.

In May the water temperature at the 20-mile station is slightly over 9° C., the temperatures at the 50-mile and 100-mile stations are somewhat lower, while the rise in temperature at the 150-mile station is rather remarkable, with temperatures of 9° to 9.4° C.

In June the tendency toward stratification becomes clear, with water temperatures of 12° to 13.5° C. at the surface, 11° to 13° C. at 10 meters, 10.6° to 12.5° C. at 25 meters, 9.5° to 10.8° C. at 50 meters, and 8.4° to 10° C. at 100 meters. The water temperatures at the 50-mile station are generally lower than those of the other stations.

In July the rise in temperatures in the upper levels is remarkable, the temperatures being about 4° C. higher than those for June. The temperatures from the 50-meter level on down are somewhat lower at stations east of 50 miles off the coast than at the stations nearer to the coast.

In August the surface water temperature continues rising and reaches the maximum for the year at 23.2° to 25.7° C. The zone with the highest water temperatures appears 50 miles off the coast. Within about 100 miles of the coast there is a marked thermocline between the 25-meter level and the 50-meter level, with temperatures at the former of 19.7° to 21.5° C. compared with 7° to 9° C. at the latter. At the 150-mile station the thermocline is deeper, appearing between the 50-meter and the 100-meter levels.

In September the surface water temperatures have already begun to go down with 19° to 22.3° C. indicated at the surface. There are some differences between areas, but in general beyond 50 miles from the coast, the thermocline is between the 50-meter and 100-meter level.

In October the stirring of the sea water by convection is clearly apparent, and water temperatures at all levels above 100 meters show similar values. Water temperatures are highest at the station 20 miles off the coast, and the temperatures are rather conspicuously lower east of the 100-mile station.

In November the water temperatures go down even more with 16.8° C. at the 20-mile station, about 16° C. between 50 and 80 miles off the coast, and a sharp drop farther to the eastward to 11.5° to 12° C.

In December water masses with temperatures above 10° C. are within 50 miles of the coast, and within this area water temperatures gradually drop outward from shore. Water temperatures at the station 80 miles of the coast are much lower, 6° to 7° C., and at the 100-mile station they rise somewhat to over 8° C.

The following table presents some abstracted information for January and August from transverse sectional observations somewhat farther south off Shioyasaki.

If this is compared with the data from the Same section, the temperatures in January are generally higher except for the vicinity of 50 miles off the coast, and the difference becomes more marked the farther eastward one goes until in the vicinity of 150 miles off the coast the temperature is up to 19.5° C. The water mass centered around 50 miles off the coast is colder than the water off Same, showing that the main current of the Oyashio is located in this area.

On the other hand, in August up to 100 miles from shore the temperatures are lower than off Same, and east of 100 miles off the coast there is a zone of remarkably high temperatures. Off Same there was a conspicuous thermocline between the 25-meter and 50-meter levels, but in this sea area there is no particularly outstanding discontinuity apparent down to 100 meters.

Table 77 shows temperature and salinity data for January and August based on sectional observations due east of Inubōsaki near the southern extremity of this sea area.

As the table shows, in January the water temperatures gradually rise the farther one goes off shore, with the maximum water temperatures in the vicinity of the 50-mile station. Farther off the coast from this station the temperatures gradually fall. At the 10-mile station the water temperature at the 100-meter level falls rather steeply, but no direct effect of the Oyashio can be seen at the other stations down to 100 meters.

In August the highest temperature zone is about 50 miles from the coast, showing that this vicinity is about the center of the Kuroshio. From 10 to 20 miles offshore the water temperatures are conspicuously lower than elsewhere, and salinity values are also low in the coastal water zone.

Table 76.--Transverse section line east of Shioyasaki

Month	Depth (meters)	10 miles		20 miles		50 miles		80 miles		100 miles		150 miles	
		Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity
Jan.	0	15.2	34.67	11.4	34.09	9.0	33.62	16.9	34.78	19.0	34.87	19.5	35.01
	10	15.2	34.63	11.2	33.86	8.8	33.68	16.4	34.78	19.0	34.92	19.4	35.07
	25	14.9	34.45	11.2	33.78	9.0	33.68	16.2	37.78	18.6	34.88	19.5	34.90
	50	11.8	33.89	11.2	33.86	8.8	33.69	16.0	34.72	18.5	34.79	19.5	34.90
	100	11.0	33.77	11.2	33.77	8.2	33.84	15.2	34.76	15.0	34.29	19.2	34.90
Aug.	0	19.7	--	20.5	33.42	20.2	33.42	23.0	--	24.2	33.48	27.0	34.54
	10	17.0	--	18.2	33.62	19.3	33.60	51.5	--	22.2	33.62	27.0	34.52
	25	16.6	--	14.0	33.96	15.7	33.93	15.6	--	19.5	33.62	25.5	34.67
	50	13.0	--	12.5	33.42	15.2	33.73	15.0	--	18.5	33.57	21.5	34.60
	100	11.5	--	10.8	33.98	9.9	33.95	12.7	--	13.8	33.95	20.5	34.85

Note: (1) From Record of Oceanographic Works for 1937.

(2) The numbers of miles show the distance off the coast.

Table 77.--Sectional observations east of Inubōsaki

Month	Depth (meters)	10 miles		20 miles		50 miles		80 miles		100 miles		150 miles	
		Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity	Temper-ature	Salinity
Jan.	0	16.7	34.31	17.2	34.04	19.2	34.58	19.0	34.04	18.0	34.40	18.0	34.76
	10	16.7	34.31	17.2	34.56	20.0	34.52	19.6	34.49	18.8	34.31	18.2	34.85
	25	16.7	34.31	17.2	34.36	20.0	34.51	19.6	34.27	18.8	34.04	18.2	34.85
	50	16.5	34.49	17.2	34.36	20.0	34.25	19.6	34.31	18.8	34.31	18.2	34.58
	100	14.6	33.95	16.8	34.34	19.6	34.31	19.6	34.49	18.7	34.09	18.2	34.85
Aug.	0	19.8	33.28	21.0	34.45	28.3	34.31	27.4	34.51	27.8	34.42	27.2	34.65
	10	17.8	33..68	20.6	34.47	28.1	34.33	27.4	34.56	27.8	34.47	27.2	34.65
	25	14.7	33.80	20.3	34.40	27.0	34.45	26.0	34.63	27.0	34.51	27.0	34.67
	50	14.0	33.80	18.8	34.51	25.2	34.45	24.7	34.67	25.1	34.58	24.0	34.67
	100	13.8	33.82	17.2	33.95	24.0	34.65	19.9	34.76	21.0	34.70	23.5	34.69

Note: (1) From Record of Oceanographic Works for 1937.

(2) The numbers of miles show the distance offshore.

The northern part of this sea area is at the northern limit of the distribution of tunas and spearfishes. Considering the different parts of the area, black tuna are comparatively abundant in the coastal water region, with their fishing grounds stretching to the southern Kurile Islands. Off Kinkazan, spearfishes, principally the striped marlin, are taken, many broadbill are caught everywhere beyond 200 miles from the coast, and at times there are great runs of albacore. The bigeye tuna generally appear to show a trend to greater abundance the farther one gets off shore, but neither they nor the yellowfin have any very important significance. To the northward of the broadbill grounds there are shark fishing grounds, principally for Isurus nasus, and considerable amounts of these fish are taken.

Considered seasonally, the season for black tuna begins in early summer and the fishing grounds gradually shift from the south of the sea area to the north, with catches made until late autumn. Striped marlin are most numerous in midsummer, with some catches until early fall, after which hardly any fish are taken. Broadbill fishing is active from early autumn to early winter with the fishing grounds gradually extending from north to south. About the time broadbill fishing comes to an end, that is around December, large schools of albacore occasionally appear. The shark Isurus nasus is most abundant in April and September, with two fishing seasons during the year.

Of the species mentioned in the foregoing, black tuna in recent years have hardly been taken at all, consequently the fishery for this species has completely died out.

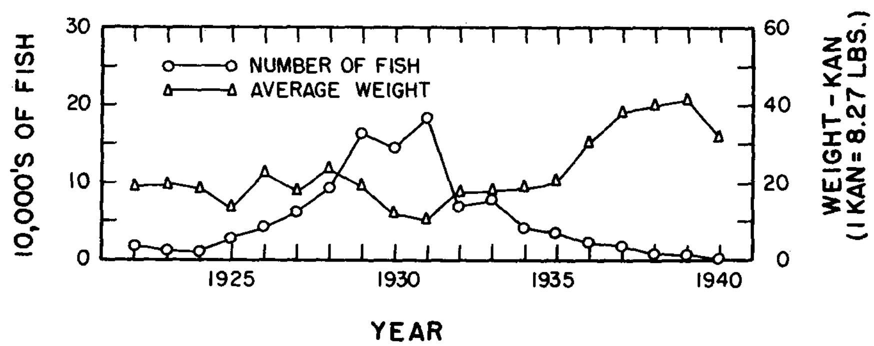

Figure 14.--Annual landings of black tuna at Kushiro

If this graph is compared with a similar curve for Aburatsu (see figure 11), there is agreement in the peaks which appeared in 1931, but the fluctuations in the catch thereafter are very different. At Aburatsu the catch from 1933 to 1939 did not vary greatly, and the fishing situation was shown to be comparatively stable. However, at Kushiro after the peak in 1931 the catch fell off steeply with no recoveries. A conspicuous peak in the catch for 1940 was shown for Aburatsu, but no tendency toward an increase appeared at Kushiro.

A certain degree of agreement can be detected in the average body weight curves in that a trend toward increase from year to year is clearly shown. However, the average weights at Aburatsu were generally about 80 pounds greater than those for Kushiro.

If we consider the relatedness of the fishing conditions and the schools of fish in this sea area and in the waters around Tanegashima, there appear to be at the same time elements which show a relationship between the two areas and elements which deny this relationship. Consequently, with only the data recorded above, it is difficult to either deny or affirm the relatedness of these two sea areas.

As was stated earlier, at about the same time as the fishing season around Tanegashima there are catches of black tuna all over the area around 30° N. latitude. However, one can detect a difference in that the catches around Tanegashima are highly concentrated, whereas those made in other sea areas are extremely scattered. Fairly considerable catches are also made from April to June between Luzon on the south and the Izu Islands, principally within the Kuroshio.

In view of the oceanographic character of this sea area, it appears possible that most of the fish from the various areas mentioned above may concentrate here. Furthermore, because of the conspicuous variations in oceanographic conditions from year to year, a high degree of variability in fishing conditions must also be taken into account. In other words, compared to the schools which congregate around Tanegashima, the fish which gather in this sea area are of many different migratory systems and age groups and the conditions change from year to year. The obvious difference between the average body weight at Aburatsu and at Kushiro, it is thought, can be explained from this point of view, but we do not yet have the data to prove it. In any case, it is a fact that black tuna in Japanese waters showed a peak in the catch curve for their representative fishing grounds in both the south and north in 1931 and thereafter, with some difference in the length of the period, they gradually declined. The phenomenon of a marked increase in the body weight of the fish accompanying this gradual decline in fishing was common to both grounds.

There appear to be various theories with regard to the poor fishing for black tuna in Japanese waters, but the writer thinks that it is probably a natural cyclical fluctuation due to cyclical changes in oceanographic conditions. It is expected, therefore, that there will be a natural recovery, but it is believed that the sort of phenomena described above will have an important significance in establishing policies for this fishery in the future.

Table 78 shows fishing conditions in this sea area based on data from experimental fishing. More data should have been included, as it is thought that quite a large part of the existing data were missed because of difficulty in obtaining them.

The overall catch rate is slightly less than 3.2. First place in the catch is occupied by albacore, which make up about 70 percent of the total. Next in importance are the spearfishes, followed by black tuna and bigeye, with yellowfin appearing only vestigially.

Table 78.--Fishing conditions in the northeastern sea area

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
305	126,841	187	0.15	6	0.01	122	0.10	2,820	2.22	865	0.68

Table 79 provides a comparison of fishing conditions north and south of the line of 40° N. latitude.

Table 79.--Fishing conditions on either side of 40° N. (northeastern sea area)

Area	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Yellowfin Number of fish	Yellowfin Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate
35°-40° N.	183	91,225	66	0.07	6	0.01	121	0.13	2,817	3.09	737	0.81
north of 40° N.	122	35,616	121	0.34	0	0.00	1	0.00	3	0.01	128	0.36

As the foregoing table shows, fishing is very different north and south of 40° N. The southern part has a markedly lower value for the black tuna catch rate than the northern section, but notably higher catch rates for all the other species. Besides the tunas and spearfishes, there was a catch of 182 sharks in the north and 1,705 sharks in the south. Consequently, the shark catch rate was 0.51 in the northern section and 1.87 in the south.

In the following table this sea area has been split up into five sections of 2° of longitude and the fishing conditions for each have been shown separately.

Table 80.--Fishing conditions by sections (northeastern sea area, 35° to 40° N.)

Section	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Yellowfin Number of fish	Yellowfin Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate
140°-142°E.	11	3,052	6	0.20	0	0.02	0	0.00	0	0.00	9	0.29
142°-144°E.	21	8,199	0	0.02	2	0.00	33	0.40	126	1.54	38	0.46
144°-146°E.	19	8,244	15	0.18	0	0.00	7	0.09	244	2.96	27	0.33
146°-148°E.	30	17,084	35	0.21	0	0.00	2	0.01	673	3.94	106	0.62
148°-150°E.	102	54,646	10	0.02	4	0.01	79	0.14	1,774	3.23	557	1.02

Looking at local changes in fishing conditions from east to west without considering the season, one can detect a trend in the foregoing table for the catch rates of both albacore and spearfishes to improve as one goes eastward. However, in the case of the other species, it is difficult to see any trends in the local variations in fishing conditions.

Table 81 shows the fishing conditions by sections in the part of the area north of 40° N. A thorough inquiry is not possible because of the paucity of the data, but it can be seen that black tuna are taken only west of 144° E. The spearfishes appear to show a tendency to increase to the eastward just as they did south of 40° N. The area where the greatest numbers of black tuna are taken is approximately off Erimo Misaki.

In order to see seasonal changes in the fishing conditions, the data have been shown by months in table 82.

Table 81.--Fishing conditions by sections (northeastern sea area north of 40° N.)

Section	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate	Total Number of fish	Total Catch rate
140°-142°E.	22	5,358	9	0.17	0	0.00	0	0.00	17	0.32	26	0.49
142°-144°E.	90	24,046	112	0.47	0	0.00	0	0.00	41	0.17	153	0.63
144°-146°E.	3	554	0	0.00	0	0.00	0	0.00	8	1.44	8	1.44
146°-148°E.	--	--	--	--	-	--	-	--	--	--	--	--
148°-150°E.	7	5,658	0	0.00	1	0.02	3	0.05	62	1.10	66	1.17

Table 82.--Fishing conditions by months (northeastern sea area, 35° to 40° N.)

Month	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate	Total Number of fish	Total Catch rate
Jan.	23	11,118	20	0.18	7	0.06	151	1.35	81	0.73	259	2.24
Feb.	6	2,010	0	0.00	0	0.00	0	0.00	4	0.20	4	0.20
Mar.	3	1,520	6	0.39	0	0.00	0	0.00	2	0.13	8	0.52
Apr.	6	1,318	0	0.00	7	0.53	2	0.15	3	0.23	12	0.91
July	3	1,044	0	0.00	15	1.44	0	0.00	8	0.70	23	2.20
Sept.	4	1,206	0	0.00	8	0.66	0	0.00	7	0.58	15	1.24
Oct.	11	4,150	0	0.00	0	0.00	0	0.00	63	1.52	63	1.52
Nov.	35	22,509	4	0.02	19	0.08	203	0.91	146	0.64	372	1.65
Dec.	95	57,116	44	0.08	66	0.11	2,463	4.31	432	0.76	3,005	5.26

Although they were omitted from the table, one yellowfin each was taken in July and September and four were taken in December. There are few data for the summer season, but as far as the table shows black tuna are taken only in the winter. Bigeye tuna are most abundant in the summer, with rather high catch rates appearing around July. Albacore show their highest catch rate of 4.3 in December, the main fishing season being from November to January. Spearfishes are scarce from February to April, but considerable numbers are taken in all other months, with the maximum catch rate of slightly over 1.5 appearing in October.

The data from tables 80 and 82 are combined in table 83. From this table it can be seen that the center of the albacore grounds in December is at 146° to 148° E., and that it shifts to 148° to 150° E. in January. In the other months the data are so poorly distributed that a comparison is completely impossible.

With regard to the spearfishes, which follow the albacore in importance in the catch, the following table shows the changes in their fishing by species. The table also includes sharks.

Table 83.--Fishing conditions by months and by sections (northeastern sea area, 35° to 40° N.)

Month	140° - 142° E.			142° - 144° E.			144° - 146° E.			146° - 148° E.			148° - 150° E.		
	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate	Number of stations	Number of hooks	Catch rate
Jan.	-	--	--	1	275	1.82	3	1,307	0.54	9	4,630	1.69	10	4,906	3.44
Feb.	4	1,060	0.38	1	260	0.00	1	690	0.00	-	--	--	--	--	--
Mar.	2	1,260	0.56	1	260	0.38	-	--	--	-	--	--	--	--	--
Apr.	-	--	--	6	1,318	0.91	-	--	--	-	--	--	--	--	--
July	-	--	--	3	1,044	0.20	-	--	--	-	--	--	--	--	--
Sept.	-	--	--	-	--	--	2	486	0.00	2	720	2.22	--	--	--
Oct.	-	--	--	5	1,300	1.08	1	240	0.00	3	1,170	1.62	2	1,440	2.08
Nov.	-	--	--	1	402	0.00	5	2,597	1.12	4	2,910	1.16	25	16,600	1.84
Dec.	5	732	0.55	3	3,340	4.25	5	2,774	4.43	16	8,374	9.16	66	41,896	4.70

Table 84.--Monthly fishing conditions for spearfishes and sharks (northeastern sea area, 35° to 40° N.)

Month	Number of hooks	Striped marlin		Broadbill		Sharks	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	11,118	20	0.18	61	0.55	125	1.12
Feb.	2,060	0	0.00	4	0.20	33	1.64
Mar.	1,520	1	0.01	1	0.01	64	4.21
Apr.	1,318	2	0.15	3	0.23	13	0.99
July	1,044	7	0.67	1	0.10	3	0.29
Sept.	1,206	5	0.40	2	0.16	68	5.64
Oct.	4,150	2	0.05	55	1.32	101	2.43
Nov.	22,509	5	0.02	140	0.62	502	2.23
Dec.	57,116	51	0.09	253	0.46	703	1.23

Considered geographically, the data show a tendency for striped marlin catch rates to be high in the south and low in the north, while the broadbill tends somewhat to be more abundant to the northward. Considered seasonally, striped marlin are most abundant in the summer while the broadbill increase from about October to early winter. No very marked regional differences in the shark catch can be detected, and seasonally they are most abundant in April and September, with rather high catch rates shown for the whole winter season.

Table 85 shows fishing conditions by months in the part of the area north of 40° N.

Of the spearfishes somewhat more than 73 percent are broadbill, the majority of the remainder being recorded as black marlin. The striped marlin and black marlin are taken only in September and October, at which season they make up slightly less than 40 percent of the total spearfish catch. However, data are almost entirely concentrated in the period from September to November, so it is impossible to make any concrete observations on fishing conditions at other seasons.

Table 85.--Fishing conditions by months

Month	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Feb.	1	216	0	0	0	0	0	0	0	0	11	5.10
July	2	720	3	0.41	0	0	0	0	0	0	0	0
Aug.	7	2,220	30	1.35	0	0	0	0	0	0	0	0
Sept.	32	8,532	23	0.27	0	0	0	0	0	0	12	0.14
Oct.	61	18,780	69	0.37	0	0	1	0	3	0.01	74	0.39
Nov.	19	5,148	1	0.02	0	0	0	0	0	0	32	0.62

If we compare the situation north and south of the line of 40° N., it appears that the fishing season in the northern section begins and ends from 1 to 2 months earlier than in the southern section. It can also be seen that the number of species taken in the northern section is less than in the south.

If we compare fishing conditions in general in the northeastern sea area with those in the area east of the Izu Islands adjacent on the south:

1. More black tuna are taken in the northeastern sea area, the peak fishing season for this species is earlier the farther north one goes, and the season is later and longer to the south.

2. Yellowfin are extremely scarce in both sea areas, but they clearly tend to decrease as one goes north.

3. Bigeye tuna are taken with a rather even geographical distribution in the winter season, but they are generally scarce in the summer and decrease as one goes to the northward, hardly any being taken in the extreme northern part of the area.

4. The peak fishing season for albacore is clearly from December to February, and hardly any are taken at other seasons. In both sea areas the catch increases toward the center of the Pacific Ocean.

5. The total catch rate for all species of spearfishes does not differ greatly between the two areas. In general, striped marlin and black marlin are most abundant in the summer season, with broadbill increasing in numbers from October on. Striped marlin and black marlin show a tendency to increase in numbers in early summer in the southern part of the area, with a second increase in the catch rates from late autumn to early winter. In the extreme northern part of the area they increase in numbers from late summer to early fall. These phenomena are considered to show a north-south migration of these species.

6. Sharks are rather abundant in both areas. There are two peak fishing seasons, one in the winter and one in the late summer.

Since this sea area is at the northern limits of the tuna and spearfish longlining grounds, the fishing seasons are more clearly marked than in warmer seas, and there are conspicuous variations in oceanographic conditions from year to year, accompanied by marked fluctuations in fishing conditions.

14. Area of 30° to 35° N., 150° to 180° E.

This sea area is for the most part under the direct influence of the North Pacific Current (the name given to that part of the Kuroshio which leaves Japanese waters and flows eastward), and in the northern part of the area the currents always flow to the eastward. In the southern part of the area a countercurrent branches off from the North Pacific Current and flows approximately southeastward. The subtropical line of convergence, as has already been stated, varies in position with the season, and in the summer it tends to move north, running east and west at about the line of 30° N. latitude. In the winter it moves to the southward. Consequently, it is said that in the summer along the southern border of the sea area great gyrals are formed here and there by the countercurrents branching off to southeastward from the North Pacific Current and currents branching off to the northwestward from the North Equatorial Current.

The vertical distribution of water temperatures and salinities is comparative uniform, the isotherms generally paralleling the parallels of latitude. Around February and March, when the winter water temperatures have reached their minimum, the 16° C. isotherm runs east and west at approximately the northern boundary of this sea area, while the 20° C. isotherm appears at the parallel of 30° N. In summer the surface water temperature over the whole sea area is about 27° C. with 22° to 23° C. at the 50-meter level, and 20° to 21° C. at 100 meters.

This sea area is well known as an albacore ground, and many boats fished there around 1935, but thereafter, as the yellowfin grounds in the equatorial region were developed, the number of vessels operating in this region declined markedly. However, because of the prohibition on fishing in the South Seas after the war, the vessels fishing in these grounds again increased and a rather large catch was produced.

The season is in the winter, with the main fishing season from December to February. Albacore are most numerous in the catch, but considerable numbers of broadbill are taken at the beginning of the fishing season. The catch of other species of tuna is generally almost vestigial, but spearfishes are rather abundant.

As was stated, the fishing season is during the winter and throughout the whole fishing season the west winds blow strongly and continuously, making operations difficult, and shipwrecks are frequent so that although the catch is large it is difficult to characterize this as a superior fishing ground because of the climate.

In the following discussion this area has been divided into three parts of 10° of longitude each, and the fishing conditions within each of these sections are discussed in general.

(a) 150° to 160° E. longitude

The following table summarizes data from past investigations in this section.

Table 86.--Fishing conditions between 150° and 160° E. (30° to 35° N.)

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
201	165,426	69	0.04	48	0.03	756	0.45	7,932	4.80	864	0.52

The overall total catch rate is slightly over 5.8, with albacore making up slightly under 83 percent of the catch. The catch rates for bigeye tuna and spearfishes are 0.45 and 0.52

respectively. The values for the black tuna and yellowfin catch rates are so low as to be vestigial.

If the section between 150° and 160° E. is divided into five parts by 2° of longitude, and fishing conditions within each of the resulting sections are compared, the results are as shown in the following table.

Table 87. -- Fishing conditions by sections (30° to 35° N., 150° to 160° E.)

Section	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Yellowfin Number of fish	Yellowfin Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate
150°-152°E.	53	37,688	55	0.15	5	0.01	106	0.28	962	2.55	228	0.60
152°-154°E.	22	15,147	0	0.00	5	0.03	62	0.41	379	2.50	100	0.66
154°-156°E.	70	42,863	12	0.03	9	0.02	229	0.53	2,509	5.83	320	0.75
156°-158°E.	39	47,061	1	0.00	27	0.06	220	0.47	1,315	2.79	133	0.27
158°-160°E.	21	23,337	1	0.00	3	0.01	143	0.61	1,188	4.09	75	0.32

Black tuna and yellowfin are extremely scarce, so no accurate conclusions can be drawn on the basis of this much data, however, it appears that black tuna tend to be more abundant to the westward, while yellowfin seem to be more abundant in the central portion. Bigeye tuna are taken rather uniformly everywhere, but they are somewhat scarcer at the western extremity and their catch rates appear to be high in the east and low in the west. Albacore are abundant in the area centered around 155° E. and show fairly high catch rates between 158° and 160° E. Spearfishes are abundant west of 156° E. and their catch falls off sharply to the eastward.

The following table shows the fishing situation by months for this sea area as a whole. The data are very unevenly distributed in time and there are only a few data for May and July, while data are completely lacking for the other summer months. Consequently it is impossible to know the changes in the fishing conditions throughout the year, but looking at the table it can be seen that black tuna are not taken from March to November. They are taken sporadically from December to February, and their highest catch rates are found in December. Some yellowfin are taken from the end of October to December, and their highest catch rates appear around October. No very marked changes in the bigeye tuna fishing situation can be detected, but they are more abundant in the winter season from October on with rather high catch rate values for October and December. The albacore increase suddenly after December, and reach their highest catch rate of slightly more than 8.0 in February. They appear to be scarce in the summer, but as they show a catch rate of slightly more than 3.0 in July there appears to be considerable possibility of expecting some catch at times. The spearfishes show their maximum catch rate of slightly under 2.0 in October, and thereafter with the passage of time they tend to decrease gradually.

If these seasonal changes in fishing conditions are compared with the sea area adjacent on the south, a thoroughgoing comparison is impossible because of the lack of data between 25° and 30° N. There is no record of black tuna being taken between 25° and 30° N., and although yellowfin are taken almost throughout the year, the amount is small. The highest bigeye catch rate appears in January, making it appear that there is a lag of about 1 month as compared with the area from 30° to 35° N., but the difference is not very conspicuous. Albacore are most abundant in January, reaching their peak one month earlier than the February maximum appearing in the area of 30° to 35° N. No very marked difference can be detected in the case of the spearfishes. Thus there are notable differences in the case of black tuna and the yellowfin, but no conspicuous differences can be detected for the other species.

Table 88.--Fishing situation by months (30° to 35° N., 150° to 160° E.)

Month	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Yellowfin Number of fish	Yellowfin Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate
Jan.	84	72,949	4	0.01	0	0	340	0.47	4,621	6.33	361	0.50
Feb.	40	25,632	11	0.04	0	0	88	0.34	2,058	8.03	53	0.20
Mar.	6	6,738	0	0	0	0	32	0.47	372	5.82	10	0.15
May	1	300	0	0	0	0	1	0.33	0	0	0	0
July	1	715	0	0	0	0	0	0	22	3.08	2	0.27
Oct.	6	2,462	0	0	3	0.12	14	0.57	1	0.04	48	1.95
Nov.	51	41,245	0	0	32	0.08	112	0.27	348	0.86	343	0.83
Dec.	37	34,159	54	0.16	14	0.04	173	0.51	962	2.82	108	0.31

As we compare this with the sea area east of the Izu Islands, which is adjacent on the west,

1. There appears to be some difference in the black tuna fishing situation as catches are made in the area east of the Izu Islands from January to April, and in this sea area only from December to February.

2. In the sea area east of the Izu Islands yellowfin are most abundant in August and some are taken throughout the year. In this sea area they are taken from October through December. As we have no data for August, it is not possible to make a comparison with the area east of the Izu Islands.

3. There does not seem to be any marked difference between the two sea areas with regard to the bigeye tuna, but in general this sea area appears to have higher catch rates. It should be noted that in the sea area east of the Izu Islands the peak catch rate is reached in April, but no comparison is possible because we lack data for April for this sea area.

4. The peak albacore season appears to be about 1 month later in this sea area.

5. The following table provides a comparison of fishing conditions for spearfishes and sharks in the three sea areas discussed above.

There are remarkably few data for the area from 25° to 30° N., 150° to 160° E., and they are unevenly distributed seasonally so it is difficult to make a comparison. In the case of the striped marlin, the maximum catch rates of the year appear around June and July at 30° to 35° N., 140° to 150° E. (sea area east of the Izu Islands). There are only a few data for July from this sea area, but the striped marlin catch rates are not very high. The maximum catch rates for this sea area appear in October. The broadbill catch rates show high values for October and March in the area east of the Isu Islands, with the maximum in March. In this sea area the maximum catch rate is attained in January. In the area of 25° to 30° N., 150° to 160° E. a rather high value is shown for March. The shark data for various species have been lumped together, so it is not possible to judge the fishing conditions for each species from the table. It can be seen that the catch rate tends to be high around October both in the sea area east of the Izu Islands and at 30° to 35° N., 150° to 160° E.

Table 89.--Comparison of fishing conditions for spearfishes and sharks (25° to 30° N, 150° to 160° E: 30° to 35° N, 140° to 150° E: 30° to 35° N., 150° to 160° E.)

Month	25°-30°N., 150°-160°E.				30°-35°N., 140°-150°E.				30°-35°N., 150°-160°E.			
	Number of hooks	Catch rates			Number of hooks	Catch rates			Number of hooks	Catch rates		
		Striped marlin	Broad-bill	Sharks		Striped marlin	Broad-bill	Sharks		Striped marlin	Broad-bill	Sharks
Jan.	8,931	0.28	0.04	0.44	99,933	0.10	0.51	0.80	72,949	0.06	0.43	0.45
Feb.	13,219	0.42	0.03	0.34	124,661	0.07	0.66	1.10	25,632	0.07	0.13	0.39
Mar.	2,008	0.10	0.45	0.35	49,172	0.10	1.01	1.63	6,738	0.07	0.07	0.06
Apr.	--	--	--	--	9,326	0.04	0.33	0.60	--	--	--	--
May	--	--	--	--	480	0.00	0.00	0.42	300	0.00	0.00	0.00
June	--	--	--	--	184	5.44	0.00	5.44	--	--	--	--
July	--	--	--	--	1,798	2.11	0.00	1.11	715	0.28	0.00	0.14
Aug.	--	--	--	--	1,142	0.61	0.00	2.10	--	--	--	--
Oct.	--	--	--	--	420	0.48	0.71	5.00	2,462	1.90	0.12	4.80
Nov.	--	--	--	--	6,510	0.25	0.26	0.51	41,245	0.56	0.21	0.91
Dec.	2,996	0.93	0.13	0.83	15,840	0.15	0.40	1.39	34,159	0.17	0.14	0.71

Note: (1) The striped marlin column includes some black marlin and sailfish.

In the case of both the tunas and the spearfishes, it appears that fishing conditions in this sea area differ somewhat from those in the sea areas lying adjacent on the west and south. In general the main fishing season for this sea area is in the winter, with striped marlin rather abundant around October, striped marlin and broadbill present in about equal numbers around December, and broadbill predominating thereafter. The albacore, which is the principal element in the catch, increases suddenly after December and reaches the peak of its fishing season in January and February.

(b) 160° to 170° E. longitude

The data for this sea area are summarized in table 90. The overall average catch rate is slightly less than 11.1. As the table shows, the main element in the catch is the albacore, making up 93 percent of the whole. It is followed in importance by the bigeye tuna, and spearfishes are scarce. Black tuna and yellowfin are vestigial.

Table 90.--Fishing conditions at 30° to 35° N., 160° to 170° E.

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
140	175,201	22	0.01	35	0.02	1,062	0.61	17,998	10.27	349	0.20

In table 91 this area has been divided into sections of 2° of longitude and fishing conditions in each of these sections are presented.

Table 91.--Fishing conditions by sections (30° to 35° N., 160° to 170° E.)

Section	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
160°-162°E.	34	42,971	12	0.03	4	0.01	176	0.41	6,419	14.91	70	0.16
162°-164°E.	20	21,858	0	0.00	16	0.07	104	0.47	2,542	11.63	24	0.11
164°-166°E.	28	35,377	5	0.01	8	0.02	210	0.59	2,992	8.46	53	0.18
166°-168°E.	28	38,159	3	0.01	5	0.01	278	0.73	2,880	7.55	93	0.24
168°-170°E.	30	36,836	2	0.01	2	0.01	294	0.80	3,165	8.59	109	0.30

On the whole, black tuna and yellowfin are present only vestigially, and do not appear to be centered on any fishing ground. Bigeye catch rates show a clear tendency to be high in the east and low in the west. The albacore show high catch rate values everywhere, but they are particularly high in the west. Spearfish catch rates show some tendency to be higher to the eastward and lower to the westward.

Fishing conditions by months are shown in the following table.

Table 92.--Fishing conditions by months (30° to 35° N., 160° to 170° E.)

Month	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	59	68,867	10	0.01	1	0.00	187	0.27	10,380	15.07	71	0.10
Feb.	17	26,447	9	0.03	0	0.00	159	0.60	2,451	9.28	55	0.21
Mar.	3	4,318	0	0.00	0	0.00	42	0.97	44	1.02	18	0.42
Apr.	3	5,511	0	0.00	0	0.00	69	1.25	208	3.77	4	0.07
Aug.	1	500	0	0.00	0	0.00	1	0.20	0	0.00	0	0.00
Oct.	6	2,463	0	0.00	3	0.12	14	0.57	1	0.04	37	1.50
Nov.	9	12,455	0	0.00	13	0.10	124	0.99	525	4.21	66	0.53
Dec.	41	50,875	2	0.00	24	0.05	455	0.89	4,193	8.24	98	0.19

Since data are almost entirely lacking for the summer, changes in the fishing conditions throughout the year are not clear. The table shows only small catches of black tuna in January and February and some yellowfin in November and December. The bigeye catch rate increases twice, once in March and April and once from October to December. The albacore catch rate increases rapidly after November and attains a peak of slightly more than 15.0 in January. The situation in March is not well known because of the paucity of data, but the trend appears to be for a rapid decline in the catch rate in March and somewhat of an increase in

April. However, because of the paucity of data for these two months, we cannot determine whether this sort of change represents a normal condition or whether there is a gradual decline in the catch rates from February through April. Spearfishes are generally scarce, but a catch rate of 1.5 in October shows that there is a possibility of taking certain amounts of them.

If the foregoing is compared with 150° to 160° E.,

(1) The patterns of increase and decrease for black tuna and yellowfin in the two sea areas are almost same.

(2) Bigeye catch rates are generally higher in this sea area, and the seasonal trends of increase and decrease agree well.

(3) Albacore catch rates are generally higher in this sea area, and the peak fishing season is about 1 month earlier.

(4) The spearfish catch rates are generally lower in this sea area, but the seasonal changes in the fishing conditions are in general agreement.

These factors show a very close relationship between the two sea areas.

The most important spearfishes are striped marlin and broadbill, with some black marlin mixed in. The following table shows seasonal changes in the proportions of striped marlin (including black marlin) and broadbill.

Table 93.--Composition of the spearfish catch (30° to 35° N., 160° to 170° E.)

Month	Total Number	Striped marlin		Broadbill	
		Number of fish	Percentage	Number of fish	Percentage
Jan.	71	31	43.7	40	56.3
Feb.	55	24	43.6	31	56.4
March	18	4	22.2	14	77.8
April	4	2	50.0	2	50.0
August	0	0	0	0	0
Oct.	37	35	94.6	2	5.4
Nov.	66	53	80.3	13	19.7
Dec.	98	48	49.0	50	51.0
	349	197	59.9	152	40.1

On the whole striped marlin make up 60 percent and broadbill 40 percent of the total. In October striped marlin are overwhelmingly predominant, but they gradually decline thereafter. On the contrary, the broadbill gradually increase and approximately equal the striped marlin in December, and they are in the majority in March. This is roughly the same situation that was seen in the area of 150° to 160° E. (see table 89).

There are many deficiencies in the data on sharks, so it is not clear what changes take place in the shark fishing.

As the foregoing shows, this sea area is an extremely good albacore fishing ground. The fishing season is completely confined to the winter, with the peak of the season in January. Bigeye tuna are next in importance to albacore, and they are taken most abundantly in November and December. As there are almost no data for the summer, the significance and character of the area as a fishing ground in summer are not yet known, however, judging by a certain amount of data it appears that the area can hardly be considered a very good ground.

(c) 170° to 180° E. longitude

The data from surveys of this area are summarized in table 94.

Table 94.--Fishing conditions from 170° to 180° E. (30° to 35° N.)

Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Yellowfin Number of fish	Yellowfin Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate
202	293,041	28	0.01	6	0.00	1,423	0.49	22,090	7.53	325	0.17

The overall average catch rate is slightly more than 8.0. Albacore are most numerous, making up slightly less than 93 percent of the total catch, followed by bigeye tuna. Spearfishes are scarce with a catch rate of less than 0.2. Black tuna and yellowfin are extremely scarce, almost vestigial, the catch of yellowfin being particularly small. The following table shows fishing conditions within this sea area for sections of 2° of longitude.

Table 95.-- Fishing conditions by 2° sections (30° to 35° N., 170° to 180° E.)

Section	Number of stations	Number of hooks	Black tuna Number of fish	Black tuna Catch rate	Yellowfin Number of fish	Yellowfin Catch rate	Bigeye Number of fish	Bigeye Catch rate	Albacore Number of fish	Albacore Catch rate	Spearfishes Number of fish	Spearfishes Catch rate
170°-172°E.	66	94,142	15	0.01	0	0.00	511	0.54	9,715	10.32	90	0.10
172°-174°E.	64	102,783	11	0.01	2	0.00	491	0.48	7,920	7.70	94	0.09
174°-176°E.	23	37,168	2	0.01	3	0.01	148	0.39	2,086	5.61	47	0.12
176°-178°E.	29	40,690	0	0.00	1	0.00	231	0.57	1,689	4.15	76	0.19
178°-180°E.	20	18,285	0	0.00	1	0.00	42	0.23	680	3.72	18	0.10

In a very general way, the table seems to show somewhat of a tendency for black tuna to be more abundant to the westward and scarcer to the eastward. The same tendency was also seen in the area of 160° to 170° E. No differences between sections can be detected in the yellowfin catch. Between 170° and 176° E. the bigeye tuna catch rates are high in the west and low in the east, and the highest catch rate for this species is between 176° and 178° E., with remarkably low values in the extreme eastern part of the area. The albacore show a clear tendency toward higher values in the west and lower values in the east, with a maximum catch rate of 10.32 in the extreme western part. The highest spearfish catch rates are between 176° and 178° E., but in general the local differences in fishing conditions for these fishes are not clear. Table 96 shows fishing conditions by months. There are few data for February, but black tuna have been taken only from November to January. Yellowfin are recorded for May, June, and

December. Bigeye tuna are abundant from January to April, with peaks in their catch rate in January and April and the maximum catch rate for the year in the latter month. The albacore catch rate improves suddenly after November and attains its high of the year, slightly over 9.5, in December. Thereafter it decreases gradually until March, and then the catch rate again improves in April to slightly less than 6.9. These fish are generally scarce in the summertime, but a catch rate of slightly more than 2.0 in June indicates a possibility that there may be good albacore fishing at times. Spearfishes are generally scarce, but they appear to become somewhat more abundant in the summer.

If the foregoing is compared with the area of 160° to 170° E. adjacent on the west,

(1) Black tuna begin to be taken 1 month earlier in this sea area and the season appears to end 1 month earlier.

Table 96.--Fishing condition by months (0° to 30° N., 170° to 180° E.)

Month	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	51	73,238	19	0.03	0	0.00	513	0.70	6,492	8.89	114	0.16
Feb.	3	3,899	0	0.00	0	0.00	23	0.60	291	7.05	4	0.10
Mar.	5	9,268	0	0.00	0	0.00	86	0.93	414	4.49	9	0.10
Apr.	3	5,566	0	0.00	0	0.00	56	1.01	382	6.86	12	0.22
May	3	1,500	0	0.00	1	0.06	5	0.33	6	0.40	3	0.20
June	12	1,400	0	0.00	1	0.02	12	0.22	110	2.04	0	0.00
Aug.	7	3,400	0	0.00	0	0.00	5	0.15	1	0.03	2	0.06
Nov.	12	21,010	3	0.01	0	0.00	51	0.24	1,323	6.25	9	0.04
Dec.	106	166,000	6	0.04	5	0.03	750	0.45	15,786	9.51	138	0.08

(2) It is difficult to detect any differences in yellowfin fishing conditions between the two areas, but the catch rates have smaller values in this sea area.

(3) Bigeye tuna are generally less abundant in this area, but the seasonal rise and fall in the catch rate is approximately similar.

(4) The albacore catch rates are also generally lower in this sea area, but the seasonal variations in fishing are generally similar. It appears that these changes tend to take place somewhat earlier in this sea area.

(5) It appears that there is little relation between the monthly changes in spearfish catch rates in the two areas.

For the principal species in the catch, the two sea areas appear to be related, but in general the fishing seasons in this sea area appear to be about 1 month earlier.

It was stated that there appears to be little relationship in the case of the spearfishes. If we look at the monthly composition of the catch, we see that in this sea area throughout the year striped marlin are more abundant than broadbill. In the area between 160° and 170° E., the broadbill increase in numbers in the winter, equaling the striped marlin around December and predominating thereafter. However, in this sea area also there is a clearer tendency for the broadbill to increase in the winter so that the two sea areas are in agreement in this trend.

In many cases the records pertaining to sharks are completely lacking so it is impossible to show the shark fishing situation in terms of catch rates.

15. Area of 35° to 40° N., 150° to 180° E.

This sea area is also for the most part under the direct influence of the North Pacific Current, and the currents flow generally eastward at all seasons of the year.

Since the ocean currents are thus comparatively uniform, there is also little variation in the distribution of water temperatures and salinities and the isotherms generally run parallel to the parallels of latitude.

During the winter, when the water temperatures are at their lowest, the 15° C. isotherm appears along the line of 35° N. and the 10° C. isotherm parallels roughly the line of 40° N. In the summer, when the water temperatures are at their highest, the isotherm of 20° C. runs along the line of 40° N. latitude and the 25° C. isotherm is in the vicinity of 35° N. Since these isotherms reach somewhat higher latitudes at the extreme western side of this sea area than they do to the eastward, they descend from west to east in a very gentle slope.

The extreme western part of this sea area is famous as a broadbill ground, the season being in November and December. In addition to broadbill, striped marlin are abundant, and their fishing season is in September and October. There is a flourishing shark longline fishery which takes principally rakudazame (mōkazame) (*Isurus nasus*) and the great blue shark. This fishery has two seasons, one in the winter and one in the summer. To the east of the area there are excellent albacore grounds. The albacore fishing season in this sea area is somewhat earlier than that on the grounds to the south and is of shorter duration. Some bigeye tuna are also taken. Hardly any black tuna are taken and yellowfin are also extremely scarce, but depending on the location considerably better catches are sometimes made than are found between 30° and 35° N.

If this sea area is divided into three sections each of 10° of longitude, the general outline of fishing conditions within each section is as follows:

(a) 150° to 160°E. longitude

The following table summarizes the data from surveys carried out in this section.

Table 97.--Fishing conditions at 150° to 160° E.(35° to 40° N.)

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
309	165,834	12	0.01	111	0.07	638	0.38	2,686	1.62	2,498	1.51

The overall average catch rate is slightly more than 3.5, to which a shark catch rate of 1.8 may be added. The composition of the catch, aside from sharks, is 44 percent albacore, 41 percent spearfishes, and 11 percent bigeye tuna, with yellowfin making up the greater part of the remainder.

If the catch rates given above are compared with those in the area of 30° to 35° N., which adjoins on the south, we find a markedly lower rate for black tuna, a notable increase in yellowfin, somewhat of a drop, although no great difference, in the case of the bigeye tuna, a conspicuous decline in albacore, and a value approximately 3 times greater for spearfishes.

In order to show regional variations in the fishing conditions from east to west this area has been divided into 5 parts of 2° of longitude each. Fishing conditions in each of these sections are shown in table 98. As the table shows, there are more data for the western part than for the eastern part of the area.

Table 98.--Fishing conditions by 2° sections (35° to 40° N., 150° to 160° E.)

Section	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
150°-152°E.	122	53,364	9	0.02	7	0.01	87	0.16	1,333	2.50	870	1.63
152°-154°E.	113	58,005	3	0.01	64	0.11	354	0.61	990	1.70	1,067	1.84
154°-156°E.	45	25,218	0	0.00	13	0.02	107	0.40	97	0.38	335	1.33
156°-158°E.	20	10,164	0	0.00	19	0.19	58	0.57	58	0.57	167	1.64
158°-160°E.	9	4,607	0	0.00	7	0.15	32	0.69	102	2.21	63	1.37

Black tuna were taken only west of 154° E. Yellowfin catch rates are notably lower in the sections of 150° - 152° E. and 154° - 156° E. than they are in the other sections. The distribution of bigeye catch rates resembles that of the yellowfin with a general tendency toward higher rates in the east and lower rates in the west. Albacore are shown to be somewhat more abundant at the eastern and western extremities of the area and scarce in the middle. The spearfishes are generally abundant, with catch rates between 1.3 and 1.8. Comparing localities, there are somewhat higher values west of 154° E. and in the section between 156° and 158° E. In general the most important element in the catch in this sea area is the spearfishes.

Table 99 shows monthly changes in fishing conditions in this sea area.

Table 99.--Fishing conditions by months (35° to 40° N., 150° to 160° E.)

Month	Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Jan.	32	18,720	0	0.00	0	0.00	57	0.30	29	0.15	291	1.55
Sept.	5	1,980	0	0.00	2	0.10	27	1.36	1	0.05	21	1.06
Oct.	53	23,148	0	0.00	50	0.21	203	0.88	110	0.48	546	2.36
Nov.	123	66,958	0	0.00	61	0.09	333	0.35	409	0.61	861	1.29
Dec.	106	61,208	10	0.02	0	0.00	125	0.20	2,147	3.51	779	1.27

The data are limited to the period of 5 months from September to January. The table indicates that black tuna are taken only in November and December. Yellowfin were taken only from September to November, with their highest catch rate in October. Bigeye tuna were taken throughout the whole period covered by the table, but they were most abundant in September and October. There were few data for September, but the maximum catch rate of 1.36 in that month shows the possibility of making fairly large catches of this species. Albacore were very scarce in September, but they gradually increased from October on and reached their highest catch rate of 3.5 in December. The catch rate dropped sharply in January, showing that the fishing season is extremely short. But within the scope of these data the spearfishes maintained a catch rate above 1.0 at all times and attained their maximum catch rate in October.

It is impossible to make a thoroughgoing comparison of these data with those from the area of 30° to 35° N. adjacent on the south because of differences in the seasonal distribution of the data. There appears, however, to be a recognizable tendency for fishing seasons for each species to begin and end about 1 month earlier in this sea area. In addition to this time lag in the fishing seasons, there are considerable differences in the values of the catch rates, but one can recognize many points of agreement in the trends of increase and decline in the catch rates, and it is thought that the populations in the two sea areas have something in common. If this area is further compared with the northern part of the northeastern sea area, which adjoins it on the west, a good agreement in the trends can be recognized just as in the case of the area of 30° to 35° N., 150° tc 160° E.

As was stated earlier, the most important element in the catch in this sea area is the spearfishes. Among these the most important are the striped marlin and the broadbill, with which some black marlin are mixed. Table 100 shows the changes from month to month in fishing conditions for sharks and in the composition of the spearfish catch.

Table 100.--Monthly changes in shark fishing conditions and the composition of the spearfish catch (35° to 40° N., 150° to 160° E.)

Month	Striped marlin		Broadbill		Sharks	
	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Sept.	19	90.5	2	9.5	118	6.00
Oct.	485	88.8	61	11.2	762	3.29
Nov.	435	50.5	426	49.5	1,689	2.52
Dec.	42	5.3	737	94.7	1,200	1.96
Jan.	4	1.4	273	98.6	422	2.25

Data for the summer are completely lacking, so the situation is not well known, but around September striped marlin (including a small number of black marlin and sailfish) are overwhelmingly in the majority, with broadbill appearing to be less than 10 percent of the total. In October the proportion of broadbill is increased somewhat over September, but striped marlin are still overwhelmingly predominant and make up 88.8 percent of the total spearfish catch. In November the proportion of broadbill increases sharply and striped marlin and broadbill appear to be taken in approximately the same proportions. From December to January the situation is exactly the opposite of that which obtained in September and October, with broadbill swordfish overwhelmingly in the majority. In January, particularly, the striped marlin catch becomes very small and indeed almost vestigial. We have no data from February on so we do not know what further changes take place.

The maximum catch rate for sharks appears in September, after which the catch rate gradually declines until December. They show a slight tendency to increase in January.

If this is compared with the area of 30° to 35° N., 150° to 160° E., where the month in which the proportions of striped marlin and broadbill in the catch became approximately equal was December, this sea area is about 1 month later. Compared with the northeastern sea area, which is adjacent on the west, and in which the two species attained approximately equal proportions around September, there is quite a conspicuous time lag. In the northeastern sea area the proportion of striped marlin was quite high even in January. The changes from month to month in these three areas are summarized in table 101.

Table 101.--Comparison of the percentage composition of the spearfish catch (35° to 40° N., 150° to 160° E.; 30° to 35° N., 150° to 160° E.; northeastern sea area)

Month	35°-40°N., 140°-150° E.			35°-10°N., 150°-160°E.			30°-35°N., 150°-160° E.		
	Number of fish	Striped marlin	Broad-bill	Number of fish	Striped marlin	Broad-bill	Number of fish	Striped marlin	Broad-bill
Jan.	74	17.6	82.4	277	1.4	98.6	361	12.7	87.3
Feb.	4	0.0	100.0	-	-	-	53	35.8	64.2
Mar.	2	50.0	50.0	-	-	-	10	50.0	50.0
Apr.	5	40.0	60.0	-	-	-	-	-	-
May	-	-	-	-	-	-	0	-	-
July	8	87.5	12.5	-	-	-	2	100.0	0.0
Sept.	5	60.0	40.0	21	90.5	9.5	-	-	-
Oct.	7	28.6	72.4	546	88.8	11.2	48	93.5	6.5
Nov.	145	3.4	96.6	861	50.5	49.5	319	72.7	27.3
Dec.	314	16.2	83.8	779	5.3	94.7	108	55.5	44.5

In addition to these seasonal changes, the changes in the composition of the spearfish catch at different latitudes are also remarkable. These fluctuations are shown in table 102. This table shows that from October on the striped marlin rapidly move from north to south and the broadbill then moves south as if following them.

Table 102.--Percentage composition of the spearfish catch by month and by latitude (35° to 40° N., 150° to 160° E.)

Month	35° - 36° N.		36° - 37° N.		37° - 38° N.		38° - 39° N.		39° - 40° N.	
	Striped marlin	Broad-bill	Striped marlin	Broad-bill	Striped marlin	Broad-bill	Striped marlin	Broad-bill	Striped marlin	Broad-bill
Sept.	-	-	-	-	-	-	90.5	9.5	-	-
Oct.	93.2	6.8	87.5	12.5	88.4	11.6	79.7	20.3	-	-
Nov.	78.2	21.8	81.3	18.7	59.9	40.1	34.0	66.0	2.1	97.9
Dec.	7.2	92.8	6.6	93.4	8.1	91.9	2.3	97.7	1.3	98.7
Jan.	1.5	98.5	0.0	100.0	0.0	100.0	-	-	-	-

As the foregoing shows, the principal elements in the catch in this sea area are the spearfishes, led by the striped marlin and the broadbill, and the albacore. The rakudazame (*Isurus nasus*) also has considerable significance in the catch. Some bigeye tuna are also taken, but the other tunas have hardly any significance as an object of the fishery. The fishing season is about half the year from September to January. At the beginning of the season striped marlin are abundant and there are also many sharks taken. With the passage of time the broadbill swordfish catch increases, and from December on this species is the principal item in the catch. In December the albacore catch also increases, and considerable numbers of these fish are taken.

(b) 160° to 170° E. longitude

The data from investigations in this section are summarized in table 103.

Table 103.--Fishing conditions from 160° to 170° E. (35° to 40° N.)

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
90	108,803	2	0.00	12	0.01	597	0.55	12,637	11.62	191	0.18

The overall average catch rate is quite high, being slightly less than 12.4. The most important element in the catch is the albacore, which makes up more than 94 percent of the total catch. Next most important is the bigeye tuna, which is 4.4 percent of the total catch. Spearfishes are extremely scarce, their catch rate being less than 0.2. Black tuna and yellowfin are almost entirely without significance as objectives of the fishery.

If this is compared with the above-described section between 150° and 160° E., which adjoins this section on the west, there is a rather conspicuous decline in the black tuna and yellowfin, and something of an increase in the catch rates of bigeye tuna. The increase in the albacore catch rate is extremely conspicuous, the catch rate in this sea area being 7 times that in the area described above. The spearfish catch rate has decreased sharply, being only one-ninth what it was in the previously described sea area.

Comparing this area with the section 30° to 35° N., 160° to 170° E. which adjoins it on the south, black tuna and yellowfin are rather conspicuously scarcer in this sea area, but otherwise, although there are some differences in the catch rates, the composition of the catch is very similar, showing that this area is more closely related to the area to its south than to the section to the west.

If we look at these phenomena without taking into consideration the factors to be discussed below, it appears that in the sea areas north of 30° N. latitude the distribution of the tunas and spearfishes which are taken by the tuna longline fishery does not differ greatly with latitude, that is from north to south, but varies mostly with longitude, that is from east to west, with a distributional boundary in the vicinity of 160° E. Of course this does not mean that the pattern of distribution in a north-south direction is completely identical throughout the year. One can detect marked seasonal changes from north to south, but these are mainly time lags and do not have the character of complete differences between regions in the composition of the catch at the same season.

The first cause of marked differences in the composition of the catch at different longitudes is differences in oceanographic conditions. In the sea areas adjacent to Japan the influences of the Kuroshio and the Oyashio work strongly, and the effects of the Kuroshio extend much farther north than they do to the eastward in the central part of the Pacific. The Oyashio extends here and there in wedges into this current. To the eastward the oceanographic conditions are generally uniform, with the isotherms lying approximately along the parallels of longitude. It goes without saying that this situation has a great effect on the distribution of the fishes discussed above. However, as the discussion of the distribution of these fishes has been based upon the catch rates of the longline fishery, we must take account not only of these differences in the oceanographic conditions but also of differences in the construction of the fishing gear and the bait that is used.

We can see certain local differences in the construction of the fishing gear. On the distant grounds off to the east lines especially designed to take albacore have been much used in the past, and the data which we have handled here are mainly derived from this type of line. These longlines usually have a large number of short branch lines. Here and there they have long branch lines called "burakuri", which are said to be intended to catch bigeye tuna. Longlines of this construction are not used on the fishing grounds of the northeastern area, where spearfishes and tuna other than the albacore are the objective of the fishery. Consequently, room is naturally left for further examination of the appropriateness of discussing the distribution of species and the characteristics of fishing grounds on the basis of the catch rates, as was done in the foregoing. There will doubtless be opportunity for further discussion of this problem in later chapters.

Table 104.--Fishing conditions by sections (35° - 40° N., 160° - 170° E.)

Section	Number of stations	Number of hooks	Bigeye		Albacore		Striped marlin		Broadbill		Sharks	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
160°-162°E.	2	2,582	4	0.15	299	11.67	0	0.00	3	0.12	19	0.74
162°-164°E.	24	26,617	166	0.62	3,468	13.03	17	0.06	8	0.03	143	0.53
164°-166°E.	16	16,989	35	0.21	3,889	22.90	23	0.14	5	0.13	103	0.61
166°-168°E.	19	25,594	173	0.68	2,420	9.50	32	0.12	33	0.13	100	0.39
168°-170°E.	29	37,021	219	0.59	2,561	6.89	33	0.09	37	0.10	79	0.21

In table 104 this sea area has been divided into five parts of 2° of longitude each, and fishing conditions within each of these sections are presented separately. From the table we can see that catch rates for bigeye tuna are low in the extreme western portion and in the center, with fairly high catch rates everywhere else. Albacore catch rates in the central portion are extremely high but tend to decline gradually to the westward. To the eastward they fall off sharply. Differences between localities in the fishing conditions for the spearfishes are not conspicuous. Sharks, on the whole, like the spearfishes are much less abundant than in the area from 150° to 160° E. As for localized differences, there is clearly a trend for the catch rates to be high in the west and low in the east.

If we compare this area with the area of 30° - 35° N., which adjoins it on the south, it is difficult to find any common trends for the principal items in the catch, which are bigeye tuna, albacore, and spearfishes.

The data are almost confined to the two months of November and December, so seasonal changes in fishing conditions are not clear, however, the data have been assembled in table 105 so as to show changes in fishing conditions from month to month.

For all species other than albacore the November catch rate values are higher than those for December. Albacore in December have an extraordinarily high catch rate of slightly more than 16.8. The situation in January is not clear because of the paucity of data, but the possibility of rather large catches is indicated. The data for February are also extremely poor, but they too appear to indicate the possibility of fairly high catch rates.

Table 105.--Fishing conditions by months (35° to 40° N., 160° to 170° E.)

Month	Number of stations	Number of hooks	Bigeye		Albacore		Striped marlin		Broadbill		Sharks	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Nov.	37	47,942	289	0.60	2,750	5.74	76	0.16	40	0.08	254	0.53
Dec.	49	57,332	319	0.56	9,708	16.83	22	0.04	39	0.07	181	0.32
Jan.	1	1,200	0	0.00	232	11.00	1	0.08	0	0.00	1	0.08
Feb.	1	828	0	0.00	65	7.85	0	0.00	0	0.00	0	0.00
June	1	400	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Aug.	1	400	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

If the foregoing is compared with the area from 150° to 160° E. which adjoins it on the west, rather conspicuous differences in the values of the catch rates can be detected, but the trends of increase and decrease are in good agreement for all species. If the area is further compared with the area of 30° to 35° N., 160° to 170° E. adjacent on the south, it can be seen that the trends of increase and decrease of the catch rates for bigeye tuna and spearfishes are in general agreement, however, there is clearly a lag in the peak of the albacore fishing season, the maximum catch rate at 30° to 35° N. appearing in January with a numerical value of 15.0.

If we compare the proportions of striped marlin and broadbill, at 35° to 40° N., 150° to 160° E. broadbill are about 60 percent of all the spearfishes. However, in this sea area the proportions are reversed and striped marlin are about 55 percent of the spearfish catch. As was stated earlier, in the northern areas in general the striped marlin increase markedly around September and October, then from November on they decrease rapidly and there is a conspicuous increase in broadbill. The data for this sea area are, as shown in table 105, almost entirely confined to November and December. Nevertheless, it is worthy of note that broadbill are scarce in comparison with striped marlin. It is considered that this sort of phenomenon is controlled by the distribution and migrations of the broadbill, and the two sea areas are adjudged to differ somewhat in their character as fishing grounds.

(c) 170° to 180° E. longitude

The data for this section are summarized in table 106.

Table 106.--Fishing conditions at 170° to 180° E. (35° to 40° N.)

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
108	157,354	12	0.01	1	0.00	754	0.48	13,182	8.38	176	0.11

The overall catch rate for tunas and spearfishes is slightly less than 9.0, a rather high figure. The most abundant item in the catch is the albacore, which makes up slightly more than 93 percent of the catch excluding miscellaneous fish. It is followed in abundance by the broadbill with slightly more than 5 percent. Spearfishes are scarce making up only slightly more than 1 percent. Black tuna and yellowfin are extremely scarce, and have almost entirely lost their significance in the catch.

If this is compared with the area from 160° to 170° E. which lies adjacent on the west, there is a slight increase in black tuna and a sharp decline in yellowfin. There appears to be somewhat of a tendency to decrease in the case of bigeye tuna, but there is no great difference, the spearfish catch rate has dropped by half, and the albacore catch rate is rather conspicuously lower. Compared with the area of 30° to 35° N. adjacent on the south, both black tuna and yellowfin are extremely scarce, but the bigeye catch rates show quite equal values. The albacore catch rate is somewhat higher in this sea area, but the difference is not as marked as that between this sea area and the area to the west of it. Spearfishes are scarce in both sea areas, but the decline is somewhat more conspicuous in this area.

The following table shows fishing conditions within the area by sections of 2° of longitude.

Table 107.--Fishing conditions by sections (35° to 40° N., 170° to 180° E.)

Section	Number of stations	Number of hooks	Bigeye: Number of fish	Bigeye: Catch rate	Albacore: Number of fish	Albacore: Catch rate	Striped marlin: Number of fish	Striped marlin: Catch rate	Broadbill: Number of fish	Broadbill: Catch rate	Sharks: Number of fish	Sharks: Catch rate
170°-172°E.	44	61,603	386	0.63	5,849	9.49	53	0.08	45	0.07	300	0.50
172°-174°E.	35	44,316	168	0.38	4,701	10.61	26	0.06	16	0.04	219	0.49
174°-176°E.	20	14,660	62	0.42	1,243	8.48	14	0.09	8	0.05	38	0.26
176°-178°E.	17	24,640	156	0.64	1,395	5.68	9	0.04	4	0.02	120	0.49
178°-180°E.	--	--	--	--	--	--	--	--	--	--	--	--

The bigeye catch rates are somewhat lower in the central section, and higher at the eastern and western extremities. In general albacore catch rates are high in the west and low in the east, with a maximum catch rate of 10.6 in the section from 172° to 174° E. The spearfish catch is so small as to be of no great importance, but although it is difficult to perceive any local differences in fishing conditions for striped marlin, the broadbill appear generally to have higher catch rates in the west and lower in the east. A remarkably low catch rate for sharks in the section from 174° to 176° E. is indicated, but elsewhere they generally show uniform values.

When these conditions are compared with those in the area of 30° to 35° N., 170° to 180° E., a very similar trend for bigeye tuna is indicated. In general albacore catch rates are higher in this sea area, but in both areas roughly the same trend of higher rates in the west and lower rates in the east can be detected. It is difficult to recognize any marked fluctuations in the case of spearfishes and sharks. These facts indicate that the two sea areas have the same characteristics as fishing grounds.

The local variations in fishing conditions from north to south have been shown in table 108 by dividing the area into sections of 1° of latitude.

From the table it is clear that the bigeye catch rates are high in the south and gradually decrease toward the northward. In the case of the albacore, on the contrary, the trend is for high rates in the north and lower in the south, but this trend is not as regular as in the case of the bigeye. For the spearfishes no definite trend can be detected, but the sharks clearly show higher rates in the south and lower rates in the north, just as do the bigeye tuna.

Table 108.--Fishing conditions by latitude (35° to 40° N., 170° to 180° E.)

Section	Number of stations	Number of hooks	Bigeye		Albacore		Striped marlin		Broadbill		Sharks	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
35°-36°N.	72	87,028	539	0.62	7,568	8.80	69	0.08	52	0.06	472	0.54
36°-37°N.	22	28,357	137	0.48	2,154	7.60	15	0.05	5	0.02	115	0.41
37°-38°N.	11	13,885	52	0.37	1,400	10.08	9	0.06	6	0.04	52	0.37
38°-39°N.	10	12,760	37	0.29	1,422	11.14	8	0.06	9	0.07	36	0.29
39°-40°N.	3	4,289	2	0.05	454	10.71	5	0.12	1	0.02	12	0.28

Table 109 shows changes in fishing conditions from month to month.

Table 109.--Fishing conditions by months (35° to 40° N., 170° to 180° E.)

Month	Number of stations	Number of hooks	Bigeye		Albacore		Striped marlin		Broadbill		Sharks	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Oct.	3	5,335	14	0.26	168	3.15	8	0.15	0	0.00	42	0.75
Nov.	52	78,702	316	0.40	5,677	7.22	50	0.06	28	0.04	441	0.56
Dec.	49	69,264	420	0.61	6,577	9.50	42	0.06	46	0.06	223	0.32
Jan.	3	3,753	4	0.11	760	22.92	1	0.03	1	0.03	0	0.00
June	1	300	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

The data are almost entirely concentrated in November and December, so it is difficult to show clearly the changes in fishing conditions from month to month. Judging from what is shown in the table, the bigeye gradually increase from October to December, reaching their maximum catch rate in the latter month. Like the bigeye, the albacore also increase with the passage of time from October on and attain a catch rate of 9.5 in December. In January the catch rate is slightly under 23, but because there are so few data it is not clear whether or not the rate is always that high, however, it may be considered that there is a possibility of a fairly high catch rate. The striped marlin tend to decrease gradually from October on, while the broadbill appear to increase somewhat in December. The shark catch rate shows a tendency to decrease gradually after October.

It can be seen that the conditions described above coincide perfectly with those in the area of 35° to 40° N., 160° to 170° E., which lies adjacent on the west. Only in the case of the albacore in January is there a marked difference, but this is considered to be due to the paucity of the data. It also appears that conditions here are in general agreement with the situation in the area of 30° to 35° N., 170° to 180° E., which lies adjacent to this area on the south.

Taking a general view of the whole area of 35° to 40° N., 150° to 180° E., it is, as has already been stated, an extraordinarily good albacore ground. The fishing season is from October to January, with the peak in December. The albacore are distributed all over this sea area, but there is some difference in fishing conditions from east to west so the distributional pattern is thought to differ. Not only is a difference in the density of distribution detectable, but there appear also to be local differences in the size of the fish that are taken, and on the basis of these differences Uda has reported the existence of three groups of fish. Differences from north to south in fishing conditions appear mainly to accompany the seasons, and there seems to be a tendency for the fishing season to be somewhat earlier in the north and later in the south.

The species next to the albacore in importance is the bigeye tuna. Bigeye catch rates are shown to be higher in the south and to gradually decrease to the northward. No very marked differences in fishing conditions can be detected in an east-west direction, although there appears to be some tendency for catch rates to be higher in the east and lower in the west. The fishing season is from October to December, with the peak of the season in the latter month.

Spearfishes are generally scarce, most of them being striped marlin and broadbill. Striped marlin catch rates are highest around October, after which they gradually decline to December and then drop off sharply in January. The situation in the summer is unknown because data are completely lacking. Broadbill swordfish gradually increase from October on and attain their highest catch rate around December. Considered geographically, both the striped marlin and the broadbill show a tendency to be most abundant in the extreme western part of this sea area and to decrease as one goes eastward. This tendency appears particularly conspicuous in the case of the broadbill. In a north-south direction, striped marlin are more abundant in the south and broadbill in the north. Black tuna and yellowfin are almost entirely without significance in the catch. Shark catch rates tend to be high in the west and low in the east, and if considered in terms of latitude, they appear to be generally high in the south and low in the north, but because many of the data are deficient, there appears to be need for further analysis of the catch rates given in the foregoing tables.

16. Area of 40° to 43° N., 150° to 155° E.

This sea area is located at the extremity of the tuna longline fishing grounds, so the season is short and the species in the catch are limited.

There are few data from investigations in this area, and table 110 summarizes them.

Table 110.--Fishing conditions at 40° to 43° N., 150° to 155° E.

Number of stations	Number of hooks	Black tuna		Yellowfin		Bigeye		Albacore		Spearfishes	
		Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
23	19,167	0	0.00	0	0.00	2	0.01	4	0.02	135	0.07

The overall average catch rate for tuna and spearfishes is only 0.8. As the table shows, there are no records at all of captures of black tuna or yellowfin. Catches of bigeye tuna and albacore are almost vestigial, and the spearfishes are the main part of the catch. Some sharks are also taken, indeed, shark fishing is, as will be related below, rather active.

Data exist only for the months of October and November, and the following table gives a comparison of fishing conditions in these two months.

Table 111.--Fishing conditions by months (40^{o} to 43^{o} N., 150^{o} to 155^{o} E.)

Month	Number of stations	Number of hooks	Striped marlin		Broadbill		Sharks	
			Number of fish	Catch rate	Number of fish	Catch rate	Number of fish	Catch rate
Oct.	15	14,391	1	0.01	124	0.86	187	1.30
Nov.	8	4,776	1	0.01	11	0.23	444	9.30

They have been omitted from the table, but bigeye tuna and albacore were only taken in October. Among the spearfishes, striped marlin were extremely scarce in both months and were quite vestigial, but broadbill were rather numerous and had a fairly high catch rate in October. However, they seem to have declined sharply in November. The sharks on the contrary showed a marked increase in their catch rate to 9.3 in November.

If this is compared with the area of 40^{o} to 43^{o} N., 140^{o} to 150^{o} E., which lies adjacent on the west, there was a considerable number of black tuna taken in October with a catch rate of 0.37 in the area of 140^{o} to 150^{o} E. However, in this sea area none of these fish were taken at all. Few bigeye and albacore were taken in either area, and these species appear to have almost no significance in the catch. Of the spearfishes, in October in the area of 140^{o} to 150^{o} E. the striped marlin (including black marlin and white marlin) had a catch rate of 0.13 and made up 30 percent of the total spearfish catch. In November they declined sharply, the catch rate was only 0.02, and they made up only 3 percent of the spearfish catch. However, in this sea area the proportion of striped marlin in the catch is very small in both October and November. These phenomena probably mean that the two sea areas have a quite different character as fishing grounds. Comparing this area with the area of 35^{o} to 40^{o} N., 150^{o} to 160^{o} E., which adjoins it on the south, in both October and November the catch of yellowfin, bigeye, and albacore in the latter area is much greater than in this area, as is the catch of spearfishes. As for the proportion of striped marlin and broadbill, in this sea area broadbill make up almost all of the catch in both months, while in the area of 35^{o} to 40^{o} N., 150^{o} to 160^{o} E. in October the striped marlin are slightly under 89 percent of all spearfishes and in December they are still more than 50 percent.

From the foregoing it is thought that this sea area differs somewhat in its character as a fishing ground from the sea areas surrounding it. In effect, this sea area is outside the range of distribution of most of the tunas and spearfishes or is at their extreme northern limit, and therefore only a vestigial distribution is indicated or the fish do not occur at all. Fishing seasons, as far as existing data show, are extremely short and the important species in the catch are limited to the broadbill and sharks.

VI. The Distribution of the Tunas and Spearfishes as Shown by Their Catch Rates

The preceding chapters have presented a discussion of the significance and characteristics of various sea regions as fishing grounds, based on data gathered by research vessels in the past. Thus the general outline of the distribution and seasonal changes in catch rates for tunas and spearfishes has already been set forth. The present chapter is an attempt to bring together and summarize the various facts concerning the distribution of tunas and spearfishes in the western Pacific Ocean.

The first question is what are we going to use as a criterion for determining the presence or absence of these fishes? It is, of course, impossible to observe their occurrence directly as in the case of land animals and plants. Consequently their presence can only be discussed in terms of the fish catch. Furthermore, the only suitable method which can be thought of for considering the density of their distribution is based on the fishing conditions.

Hitherto tuna fishing conditions have been expressed in terms of the catch per voyage or the catch within a certain area within a definite period, however, these modes of expression have the defect that fishing effort is not accurately expressed. In order to correct this defect, I have, as previously set forth, taken the catch per hundred hooks fished, called it the catch rate, and used it to show fishing conditions.

In the case of the skipjack live bait fishery, the so-called " biting qualities" of the schools greatly influence the fishing conditions, and even though the catch rate is calculated on the basis of the number of poles fished, it cannot be said to be always necessarily correlated with the density of distribution.

It is of course conceivable that we have the factor of biting qualities in the tunas and spearfishes too, but in the case of the longline fishery we can think of absolutely no means for evaluating this factor. This means that there are no grounds on which to refute the hypothesis that the catch rate is always in proportion to the density of occurrence of the fishes. In other words, at present we can think of no other method than to assume that the catch rate is proportional to the density of distribution of the fish.

Now if we do make this assumption, the chief problems which arise are differences in the construction of the fishing gear, differences in the bait used, errors arising from differences in the number of times fished and the number of units of gear employed, and fluctuations in the fishing conditions from year to year.

If all of our data represented the use of identical fishing gear, there would be no problem at all, however, the fishing gear has changed with the passage of time, different research vessels sometimes used different types of gear, and gear of differing design is used depending upon the fishing ground and the type of fish sought.

The effect of fishing gear construction on the catch rate has as yet not been sufficiently studied, but there are data which indicate that it is not to be taken lightly. For example, the data collected by the Hakuyō Maru in various southern areas show, as may be seen in the following table, that differences in the length of the branch lines greatly influence the catch rate.

Table 112.--Fishing results with branch lines of different lengths (Hakuyō Maru)

Year	Date	Area	Short Branches		Long Branches		Notes
			Fish	Percentage	Fish	Percentage	
1930	5 Nov.	Nicobar Is.	28	27	76	73	Fish were especially numerous on the long branches on four occasions and on the short branches on three occasions.
1931	6 Jan.	Sumatra-Java	32	29	81	71	
1933	8 Jan.	New Guinea-Solomon Is.	13	23	43	77	Fish were particularly numerous on the long branches on two occasions and on the short branches on one occasion. No record was made on ten occasions

"Percentage" does not represent the catch rate but the proportion of the fish caught which were taken on long and short branches.

The long branches were 99 feet long and there were two of them per basket of gear. The short branches were 30 feet long and there were four per basket. There was one 90-foot float line to each basket.

Table 112 shows that even in three different regions there was little variation in the proportions of fish taken by the two kinds of branch lines. Since there were twice as many short branches as long branches, the catch rate of the long branches was 5 to 6 times that of the short branches. There are almost no such data for Japanese waters, but a certain amount of similar data was gathered in southern waters by the Shōnan Maru and other research vessels. These data show a rather clear tendency for the catch rates for the tunas to be greater the deeper one goes, at least down to 100 meters, for the spearfish catch rates to be greatest at 50 to 60 meters, and for the shark catch rates to be greatest at shallow levels.

Most of the gear used by research vessels in exploratory fishing falls into three general categories. As a matter of fact, however, in many cases there are inadequate records of the gear that was used and for much of the data we do not know what type of gear was employed. Of the three types of gear, one is the albacore line, and the other is a line specially designed to catch spearfishes and sharks. The third type is that generally used to catch tunas and spearfishes. However, although we may say there are three types, it is not a matter of each type having a completely different construction, but simply that they differ with regard to the number and length of branch lines, the length of float lines, the shape of the hooks, and so forth.

On the albacore lines employed in the past, the branch lines were short and numerous. The number of branch lines was not standardized but ranged from 10 to 20 or 30 per basket. For the most part, about two long branch lines, called "burakuri", were hung among the short branches. The short branches were mainly intended to take albacore, while the burakuri were for catching bigeye tuna or other tunas and spearfishes. In the longlines designed to take sharks and spearfishes, the branch lines were short and most such gear had about nine branches per basket. The third type of gear, that commonly employed, has four to six branch lines per basket, the length of which is generally greater than those of the other two types of line.

From the geographical and seasonal point of view, we may say in a very general way that in the winter in waters north of 25° N. latitude, the gear used was almost entirely albacore line. To the south of this latitude, ordinary longlines are used throughout the year. The use of spearfish and shark longlines is comparatively localized, such gear being found in Formosan waters, west of Kyūshū, and in the waters of northeastern Honshū and Hokkaidō. The gear formerly used around Tanegashima to take black tuna was of a peculiar design.

Except for the slight amount of data presented above, almost nothing is known at the present time with regard to the question of what effect the length of the branch lines, or in other words, the depth at which the hooks hang, has on the catch rate for the various species. It is said that bigeye tuna are more often caught on long branch lines, or that spearfishes are more often caught in the shallow levels and so forth, but hardly any scientific demonstration of these facts has been made. Taking albacore lines as an example, black tuna, yellowfin, bigeye tuna, spearfishes, and sharks are all caught on this gear. If all species other than albacore were caught on the so-called burakuri and if the albacore were always taken on the short branch lines, the catch rate by species could be accurately calculated. However, as a matter of fact, all species are taken both on the short lines and on the burakuri. Consequently, in calculating the catch rates, the total number of branch lines, or in other words the number of hooks employed, must be used.

As was said earlier, it is thought that the effect of fishing gear construction on catch rates is not to be regarded lightly, and it is naturally to be considered that some correction for differences in gear construction is necessary in comparing catch rates for each species.

However, this correction is a problem which cannot be solved until future research has shown the effect which branch line length has on the catch rates for each species at different seasons and in different areas. Here we must, perforce, ignore the differences in construction of the fishing gear, and assume that it all has equal catching power, just as we earlier assumed that the catch rate is proportional to the density of occurrence of the fish, and on the basis of these two assumptions, we will examine the distribution of each species.

A. Black Tuna

Stated very roughly, the distribution of the black tuna extends all over the northwestern Pacific Ocean and the northeastern part of the South China Sea between 15° and 41° N. latitude and east of 120° E. longitude. Thus its range, if we except the South China Sea and the waters around the Ogasawaras, is definitely restricted to the Kuroshio and the North Pacific Current.

The waters with a high density of occurrence, that is to say waters with high catch rates, are extraordinarily limited. Citing them from south to north, they are the coastal waters east and west of Luzon, the waters off the Miyako chain and Okinawa, the waters around Tanegashima, and the northern part of the Northeastern Sea Area. They occur very widely between 30° and 35° N. latitude, and to the east of the meridian of 140° E. longitude, but the catch rates in this area are very low and fish are taken only sporadically.

The season on the fishing grounds off the east and west coasts of Luzon and near Formosa, although it may be slightly earlier or later from year to year, begins in March and ends in early June. In some years the first catches are made in the latter part of February, but fishing gradually becomes better from the latter part of March on. There are few data on the catch rates and the seasonal changes are not clear. The following table presents data for the period from March to May.

Table 113.--Black tuna fishing conditions in Luzon waters

Position	Date	Number of stations	Number of hooks	Number of fish	Catch rate
17° - 18° N. 120° -121° E.	Mar. 15-24, 1935	5	900	57	6.33
19° - 20° N. 120° -121° E.	May 10-21, 1935	6	960	43	4.48
18° - 19° N. 120° -121° E.	May 8-22, 1935	10	2,200	77	3.50
18° - 20° N. 122° -124° E.	May 5-14, 1939	10	2,400	68	2.83

Note: Data from vessels reporting to the Formosa Government-General. As this table shows, the catch rates were surprisingly high, indicating great density of occurrence.

The season in the Miyako Islands and Okinawa is chiefly in May and June, somewhat later than in the Luzon area; however, catches have been reported in April. Catch rates range from a low of 0.23 to a high of 9.37, with remarkably high catch rates being recorded from time to time. The catch rates of 9.37 and 3.76 were each recorded for only one trial and therefore should probably be interpreted only as meaning that there is a possibility of such catch rates occurring.

Turning next to the northward to the waters around Tanegashima, the peak fishing season is from December to February, catches continuing to be made into March, with fairly high catch rates being indicated in some years even in April. Farther to the east in the waters extending to 145° E. longitude and including the Ogasawara area, catches are made from April to June, but on the whole they are extremely scattered and the catch rates show very low values.

Considerable fish are taken in June and July off the Tokiwa region of eastern Honshū. Densely congregated schools again appear from the Sanriku region of northeastern Honshū to the south coast of Hokkaido and fish are taken continuously from July to November.

In the area east of 140° E. longitude and centering between 30° and 35° N. latitude some black tuna are taken, the season being from November to March. However, in this region there are practically no exploratory data for any season other than November to March, nor are there any vessels actually operating there except at this season, therefore, the occurrence of tuna at other seasons is completely unknown.

At almost the same time (November to March) that these sporadic catches have been made in the broad expanse to the east of 140° E. longitude, rather dense schools appear in waters around Tanegashima. The question of what route these schools follow before appearing in this area is not as yet concretely answered. However, judging from the changes in fishing conditions in this area and in other areas, it is thought that these are not already organized schools which have migrated in from other regions, but that the fish gradually congregate and form schools in this area. Up to the end of March these schools move extremely slowly with each succeeding day toward the northeast, but after the end of March, when they reach the waters of Miyazaki Prefecture, they suddenly disappear and the densely populated fishing grounds vanish. Hitherto the established theory has been that the schools follow the Japanese coast to the Northeastern Sea Area, but among the fishermen in the Aburatsu area there are some who claim that the direction of the migration shifts to the south from the vicinity of Toi Misaki (on the west coast of Kyūshū).

Around the end of the fishing season off southern Kyūshū, dense schools of black tuna appear in the northeastern portion of the South China Sea and fishing flourishes for an extremely short period on the east and west coasts of the island of Luzon. The peak of this fishery is in April and May, the fishing falling off rapidly in June. Judging from the changes in this fishery, it may be thought that the schools from this area gradually move along the Okinawa chain, but there is as yet no concrete proof that this is or is not the case.

At about the same period some black tuna are taken in the northern portion of the Ogasawara Islands area, and there is some catch in the waters off the Tokiwa region of eastern Honshū. It might be thought that this represents a movement of the schools which were densely congregated off southern Kyūshū, but if we consider the broad distribution this would entail, there is doubt as to whether or not the schools from the Tanegashima waters have become so widely distributed as to appear all over the whole area directly under the influence of the Kuroshio, from the waters off Luzon to the coasts of Japan proper, at almost the same time.

We have almost no data with which to investigate the relationship between the schools which appear around Tanegashima and those from the Luzon area, but they can be thought to be different schools in view of the following three points. The first point is the difference in the size of the fish. The schools which appeared around Tanegashima were mostly small fish of around 165 pounds in the early years of the Shōwa Era (1925 to 1930). With each succeeding year the fish have become larger and around 1940 their average weight was about 450 pounds (figure 13). Around Luzon the fish were very large when the fishery was first developed in 1935, with fish of 655 to 820 pounds in the early part of the season, gradually declining in size as the days passed until smaller fish of about 490 pounds were taken at the end of the season. It is very regrettable that there are no data to show this concretely. However, full account should be taken of this difference in the size of the individual fish.

The second point is the question of fishing seasons. As has already been said, about the time the schools in the waters around Tanegashima began to move slowly to the northeast, there was already a certain amount of fishing being done in the South China Sea. As was stated earlier, there is also a theory that the schools move south from the vicinity of Toi Misaki, and the coincidence of fishing seasons is not necessarily proof of the difference or identity of the schools. It is believed, however, that this coincidence of fishing seasons, together with the distance between the fishing grounds and the movements of the schools in the waters around Tanegashima, has a considerable significance as indicating the distinctness of the schools.

The third problem to be considered is the question of the sexual maturity of the two groups of schools. There have been absolutely no reports of fish with ripe or near-ripe gonads from the schools in the waters around Tanegashima, even at the end of the fishing season. It is believed that July is the center of the spawning season for black tuna in Japanese coastal waters (including the Japan Sea). In fish from the schools of the Luzon area the gonads are already very well developed at the beginning of the fishing season, in April and May the majority of the fish are ripe, and by the early part of June spawned-out fish already appear in the catch. As it is thought that these fish characteristically spawn over a rather long period and throughout a broad area, this difference in ripeness of the gonads cannot be said to have absolute significance as indicating the distinctness of the schools. Thus at present we have no data which would enable us to prove definitely the relationships between the schools which appear in these two areas and we must therefore wait for future studies to be made. However, the three points cited may be considered to indicate the distinctness rather than the identity of these schools.

B. Albacore

The appended chart II shows the distribution of catch rates for albacore. As has already been stated, the albacore is broadly and generally distributed in the western Pacific Ocean north of the Equator to the vicinity of 40° N. latitude and it also occurs to some extent in the South China Sea and the Sulu Sea. It can be said, however, that the area in which the catch rates are particularly great, or in other words where the density of distribution is high is the area from 25° to 40° N. latitude. Accordingly it can be said in extremely general terms that the main fishing grounds are in the area north of the Northern Equatorial Current, that is, north of 25° N., in the Kuroshio and its extension, the North Pacific Current.

Considered seasonally, this species occurs to some extent at all times of the year somewhere in the northern part of the western Pacific. The season of densest occurrence, however, is from November to March, particularly from December to February.

As our data are extremely uneven in their representation of areas and seasons, it is impossible to clarify the distributional pattern for each sea area throughout the year. If we select two or three sea areas for which data are comparatively adequate throughout the year, and plot the changes in the fishing conditions from month to month in those sea areas, we get the picture shown in the following figure.

Figure 15 shows the fishing situation in each month in the area 0° to 5° N., 150° to 160° E. In December, February, and March the catch rate is 0. Some fish are taken in all the other months, the catch gradually increasing from July on, with the highest catch rate of the year in September. The catch rate declines sharply in October, showing only a vestigial occurrence.

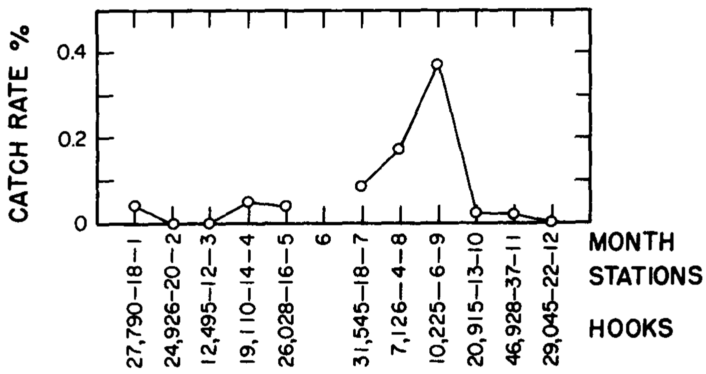

Figure 15. --Albacore fishing conditions in each month (0° to 5° N., 150° to 160° E.)

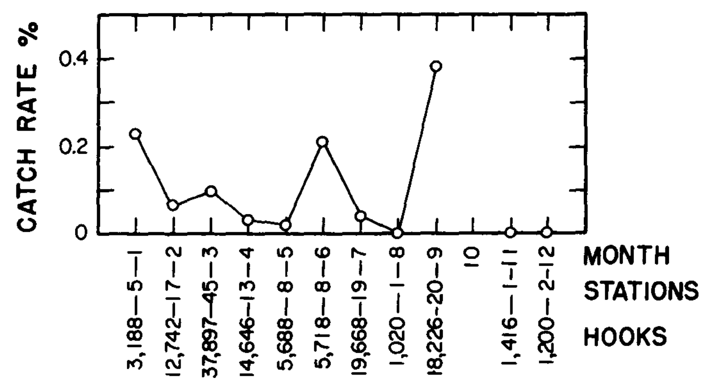

Figure 16. --Albacore fishing conditions in each month (20° to 25° N., 140° to 150° E.)

Figure 16 shows fishing conditions in the southern part of the Ogasawara Islands (20° to 25° N., 140° to 150° E.). Because of the scarcity of data, account must be taken of the error introduced by the operation of fluctuations in fishing conditions on the catch rate. However, the trend of the curve agrees well with that for the area closer to the Equator and the highest catch rate seems to occur in September.

The changes from month to month in albacore fishing conditions farther to the north in the area 30° to 35° N., 140° to 150° E. have already been shown in the section on the waters east of the Izu Islands, but for the convenience of the reader, these facts are plotted in the following graph.

The data are inadequate for many parts of the curve, particularly in September, where data are completely lacking. When this graph is compared with the two previously presented, we not only see a remarkable increase in the catch rate itself but a complete change in the seasonal pattern of fishing. The catch rate rises steeply from November to January until it attains a figure of about 6.0. In February it drops somewhat, but is still remarkably high. From March on it falls off steeply and during the summer there is hardly any catch. A great deal of attention should probably be paid to the difference between these areas in any consideration of the distributions and migrations of the albacore. As was stated earlier, the albacore is densely distributed in the area of the Kuroshio and the North Pacific Current, the boundary of its distribution being known to be the subtropical convergence. Not only is there this remarkable change in fishing conditions as we pass the boundary of the subtropical convergence, but there is also a very marked change in the size of the fish. If we compare fish taken during the winter, we find that those caught south of the subtropical convergence are for the most part a great deal larger than those taken to the north of it.

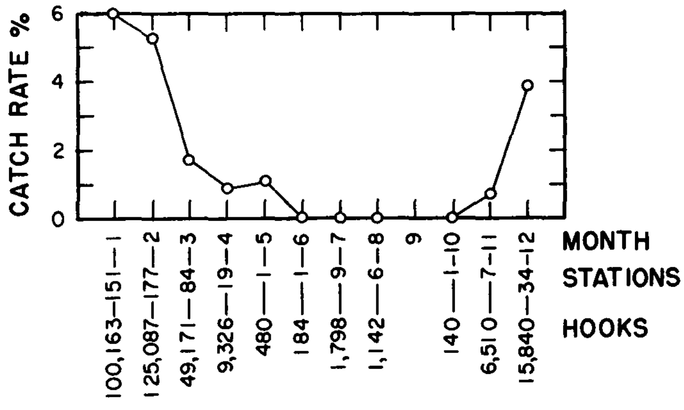

Figure 17.--Albacore fishing conditions in each month (30° to 35° N., 140° to 150° E.)

Monthly changes in the fishing conditions in the western Pacific north of 20° N. latitude in the period from November to March, which is the main fishing season, are shown graphically in the appended charts IIa-e.

In chart a (November) there appears to be an area of rather dense distribution 200 miles from east to west and 300 miles from north to south centered at 35° N. latitude, 150° E. longitude. There is no area of active fishing to the westward, nor does any area with high catch rates appear to the eastward as far as the vicinity of 150° E. longitude. East of 165° E. in the vicinity of 30° to 40° N. catch rates are high everywhere and a dense occurrence of albacore is indicated.

In chart b (December) the fishing grounds of the area centered around 150° E. are greatly extended compared with November. There is a series of excellent fishing grounds extending to the southwest from the vicinity of 38° N. to an area southeast of Hachijōjima at about 32° N., 141° E. Farther to the west there is an excellent but completely isolated fishing ground across the Izu Islands and south of Shionomisaki in the vicinity of 30° N. latitude. A tendency can be seen for the fishing grounds to broaden southeastward from the vicinity of 150° E., and the fishing is good over an extensive area along the parallel of 33° N. between 140° and 155° E. longitude. The center of the fishing grounds which appeared east of 165° E. in November has moved slightly to the southward and these grounds have extended towards the west, so that in terms of catch rates alone the boundary with the fishing grounds which appeared centered around 150° E. longitude has become completely obscured and the whole area centered around 35° N. latitude has become a good fishing ground.

In chart c (January) the center of the fishing grounds which were centered around 150° E. longitude has shifted to the southwest to the vicinity of 29° to 33° N., 143° to 147° E. In December the vicinity of 35° N. was the center of a fishing ground, but in January fishing has become remarkably poor north of 35° N. The isolated fishing ground which appeared in December south of Shionomisaki has become greatly enlarged and the catch rates are improved over those of December. East of 150° E. longitude there is little difference in the fishing situation from one area to another, the catch rates being everywhere about the same. Within the region for which we have data east of 150° E., the center of distribution has gradually moved southward, and east of 175° E., the center of distribution is south of 30° N. latitude.

When we come to chart d (February), we have much fewer data than we had for December and January, but on the whole there appears to be a tendency for the good fishing grounds to be isolated or scattered. On the west, the fishing ground south of Shionomisaki has become even more extensive than it was in January and the fishing is good there. Another fishing ground with rather high catch rates has appeared about 100 miles south of the Izu Peninsula, and another region of fairly good catch rates can be seen to the east of the Izu Islands in the vicinity of 31° to 34° N., 141° to 142° E. The fishing ground which was centered at 30° N., 145° E. in January appears to have moved to the southeast, with a good fishing ground in the vicinity of 28° to 31° N., 144° to 149° E. Between 150° and 160° E. there appears an area of high catch rates in the vicinity of 32° to 34° N., roughly in the center of this area, while somewhat to the south good fishing is also indicated around 26° to 27° N. The position of the fishing grounds at the center of this group is about 2° south of where it was in January. The question of whether these fishing grounds are connected or isolated cannot be answered because the data are scattered geographically. On the whole, fishing conditions east of 160° E. longitude show a distinct tendency to deteriorate from the levels reached in December and January.

Chart e (March), shows fishing generally much poorer than it was in February. The areas with high catch rates have shifted farther to the south than they were in February, with the principal fishing grounds between 27° and 30° N. latitude. The fishing grounds south of Shionomisaki have shifted to the southeast and their center is in the vicinity of 28° to 30° N., 136° to 139° E. Between 140° and 150° E. there is a fishing ground with rather high catch rates in the vicinity of 28° to 31° N. Eastward from 150° E. longitude to 165° E. there are hardly any data and the distributional pattern is not clear, but what data there are show a strongly fluctuating fishing situation with unstable catches. East of 165° E. the data are almost entirely confined to latitudes south of 30° N., and fishing is notably poor in comparison with February. The variation in catch rates between fishing operations is great and the catch is unstable.

The end of the longline fishing season in this area is around the end of March or the beginning of April, and almost no fishing is done after that time so there are practically no data. If however, we look at the few data we have for the period April to July, we see that from time to time during this period there are rather high catch rates and therefore we cannot believe that the albacore have entirely disappeared from the area. Because of the extreme paucity of the data, however, we cannot grasp the overall distributional pattern by means of longline catch rates.

During the summer albacore are taken almost entirely by pole and line. As a result the area covered by the fishing grounds coincides approximately with the fishing grounds for skipjack. As the fishing method employed at this season is completely different, it is not possible to make any comparisons of the density and pattern of distribution based on catch rates. Furthermore, the fish which are sought are generally for the most part young fish differing in size from the albacore taken in the longline fishery.

Uno[8/] has discussed the age composition of the albacore catch landed at Misaki in the summer. Uda[9/] has hypothesized the migrational routes for the albacore shown in the figure on the basis of the changes in the fishing conditions and the size of the fish taken in the longline and pole and line fisheries in 1935 and 1936. (The figure referred to has been omitted.)

The albacore taken by longlines during the winter from the waters of Japan's east coast to the area of Midway Island are thought to differ in size from area to area. In other words, it is thought that different age groups migrate within different regions. There are, however, data which indicate that there are rather marked variations from year to year in the size of the fish and in their growth and reproduction, and that fish of the same size are not always necessarily taken in the same fishing ground at the same season.

In the data used in preparing this book, records of the size of the fish taken are very few, and for this reason it is difficult to clarify the differences in distribution and the migrational patterns of the fish by reference to their size. Consequently, I have only been able to discuss

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8/ Uno, Michio. Composition of the catch of the tuna pole and line fishery east of Cape Nojima. Bull. Jap. Soc. Sci. Fish., Vol. 4, No. 5, pp. 307-309. 1936.

9/ Uda, Michitaka. The relationship of albacore fishing conditions to oceanographic conditions. Bull. Jap. Soc. Sci. Fish., Vol. 5, No. 5, pp. 295-300. 1937.

distribution and migration on the basis of catch rates. If we compare the charts a to e referred to above with the chart of migrations prepared by Uda,

1. At the beginning of the fishing season there are three groups of fish appearing separately in different areas. That is, in November the area centered around 150° E. and that centered at 165° E. each have one group, but in December the boundary between these two groups becomes unclear, while in the Kinan sea area, a group of schools completely separate from these two appears.

2. The subtropical convergence is a boundary, with the distribution of albacore to the south, that is, in the North Equatorial Current, quite vestigial, while the distribution is extremely dense to the north of the convergence.

On these most important points, there is clearly agreement. However, with regard to the migration routes,

3. It is difficult to detect with certainty any fixed direction except that the schools to the east of 165° E. longitude are already densely congregated in the vicinity of 30° N. by the middle of November, and both the schools distributed around 150° E. and those around 165° E. move slowly to the south with the passage of time. It can be seen that the schools in the vicinity of 150° E. tend to move to the southeast.

4. On the whole the schools appear to become gradually densely congregated within an area just like a rising tide, but the migrational routes by which the schools move there are not clear. This tendency appears most clearly in the Kinan sea area.

Thus, certain differences are apparent, however, Uda's conclusions are based on data from only about 1 year, while the data presented here cover a number of years, in some cases more than 10 years, and therefore it may be thought that differences from year to year in the pattern of migration may have obscured the migrational routes.

As was stated earlier, it is impossible under present conditions to correct the catch rates for differences resulting from the fishing gear. The longlines used on fishing grounds south of 30° N., particularly fishing grounds in the vicinity of islands, differ somewhat, as has been said, from the gear especially designed to take albacore. It is, however, probably no mistake to consider that the differences in catch rates in waters north of the North Equatorial Current and in those to the south clearly indicate a difference in the density of distribution of the albacore.

C. Bigeye Tuna

Appendix chart III shows the distribution of catch rates for bigeye tuna in the Indian Ocean, the western Pacific, and their contiguous sea areas. As the chart makes clear, the distribution of the bigeye tuna is extremely broad, extending from the Equator to 40° N. Little difference in the density of distribution throughout the whole region can be seen from the catch rates. In other words, the center of distribution is not clear.

The chart represents catch rates throughout the year, and shows that the catch rates in the South China Sea are greater than those in the Sulu Sea and the Celebes Sea. Leaving these contiguous waters out of consideration, the general picture in the Pacific is as follows:

1. South of 10° N. there is an area off Mindanao where the catch rates are rather high, and farther to the east from about 140° to 160° E. there is another area of high catch rates.

2. There are very few data for the latitudes between 10° and 20° N. so that the situation there is not well understood, however, areas with high catch rates appear in these latitudes in the vicinity of 135° E. and again between 145° and 155° E.

3. Farther to the north the catch rates are high in a rather broad area centered around 155° E. and in the waters east of 165° E.

4. In all of these cases, it appears that one can detect a tendency for the catch rates to increase as one goes eastward.

The foregoing remarks take no account of the uneven seasonal distribution of the data. Seasonal changes in the density of distribution cannot be thoroughly investigated because of this characteristic of the data, but the general outline of the distribution as between the various sea areas is as follows.

The following figures show graphically the changes from month to month in fishing conditions in the South China Sea. There are no data at all for April and May and very little for August. Within the range covered by the available data, there is no catch at all from June to August, while there is a rather conspicuous peak in September with a catch rate of 0.35. In October and November the catch rate gradually declines only to increase again in December. The highest catch rates of the year are reached in February with a figure of 0.53.

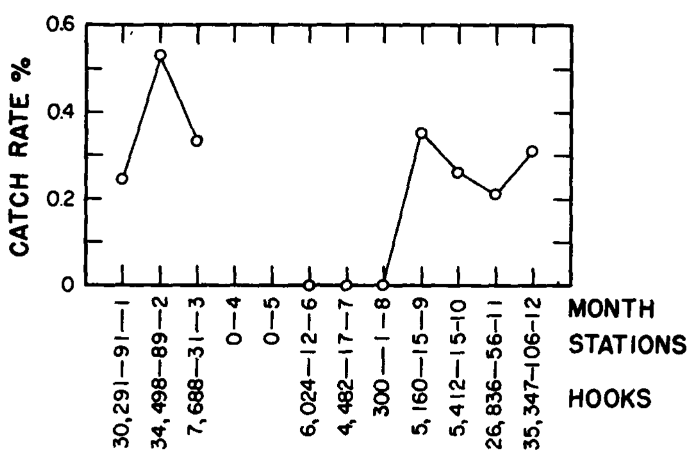


Figure 19.--Bigeye tuna fishing conditions by months

Data for such contiguous waters of the South China Sea as the waters east of Formosa, the Sulu Sea, and the Celebes Sea are unevenly distributed seasonally and therefore it is not possible to compare the monthly changes in the fishing conditions in these waters with those of the South China Sea.

Fishing conditions by months in the vicinity of the Equator from 0° to 5° N. and from 150° to 160° E. are shown in figure 20. The number of stations fished and the number of hooks employed are shown in the figure in the same manner as in figure 15.

Data are completely lacking for June. The catch rate reaches its low in March with a figure of only 0.02. Thereafter it shows a tendency to gradually increase and in September it reaches its highest point of the year with a rate of about 1.5. In October it drops off sharply and hits a low again in November, increasing slightly again from December to January and showing little difference between January and February. If this is compared with the curve for the South China Sea, there is agreement in the peak in September, but the January peak appears in February in the South China Sea. A conspicuous low appears in this area in March, but it seems to appear in the South China Sea after April.

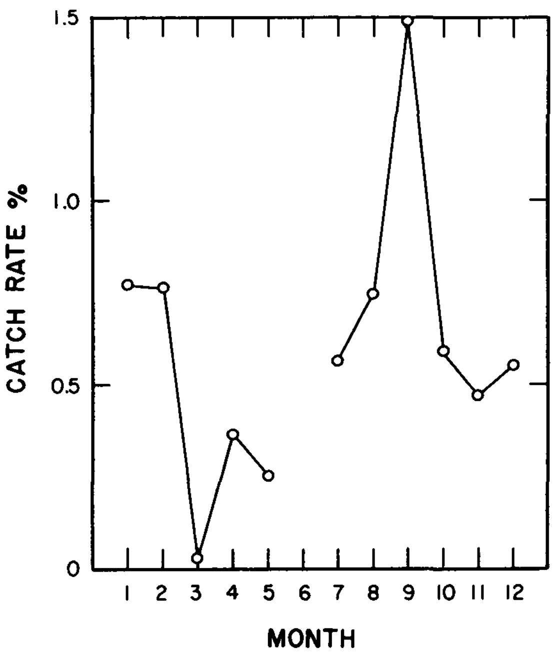


Figure 20.--Bigeye fishing conditions by months

As we have almost no data for the area from 10° to 20° N., it is impossible to make any comparison with changes in fishing conditions throughout the year there.

For the area from 20° to 25° N., 140° to 150° E., that is, from the southern Ogasawara Islands to the northern Marianas and eastward the data are summarized in figure 21.

As the figure shows, in this sea area catch rates for May and June are 0.0, but a rather conspicuous peak is seen in July. From July through September the catch rates continue to drop, and although there are no data for October, the catch rate continues to climb from the September low until it reaches the highest point of the year in January with a figure of slightly over 1.0. From February to May the catch rate falls off sharply.

The pattern shown by this curve differs rather markedly from that for equatorial waters, with a lag of 1 to 2 months, and it appears to show a trend which rather approximates the curve for the South China Sea.

Continuing to the northward, the fishing conditions by months for bigeye tuna in the area 30° to 35° N., 140° to 150° E., to the east of the Izu Islands, is shown in the following figure. The situation shown here differs conspicuously from that previously shown for the area south of the Ogasawara Islands. In this area the highest catch rates for the year appear as a sharp peak in April. From April to June the catch rates drop off sharply, but a low peak appears in July. However, our data for May and June are so few that it is not possible to decide whether or not the curve reaches a low point in June. From January on the catch rate gradually increases, with a blunt peak appearing again from December to January.

If this curve is compared with that for the area south of the Ogasawara group, there is agreement in the appearance in peaks in January. However, in the area south of the Ogasawaras this peak is extremely conspicuous, while in this area it is blunt and inconspicuous. The most outstanding peak in this area appears in April, and in this month the catch rate south of the Ogasawara Islands shows extremely small values. Small peaks appear in both areas in July, but as was said earlier, it is doubtful whether or not that which occurs in the curve for this area is really a peak at all.

Farther to the north the data are almost entirely confined to the winter and therefore the monthly changes in the fishing conditions throughout the year are not clear. As was already stated in the section on fishing grounds, the pattern of bigeye tuna fishing in this region varies from area to area, but in general the catch rates reach their highest point in November or December.

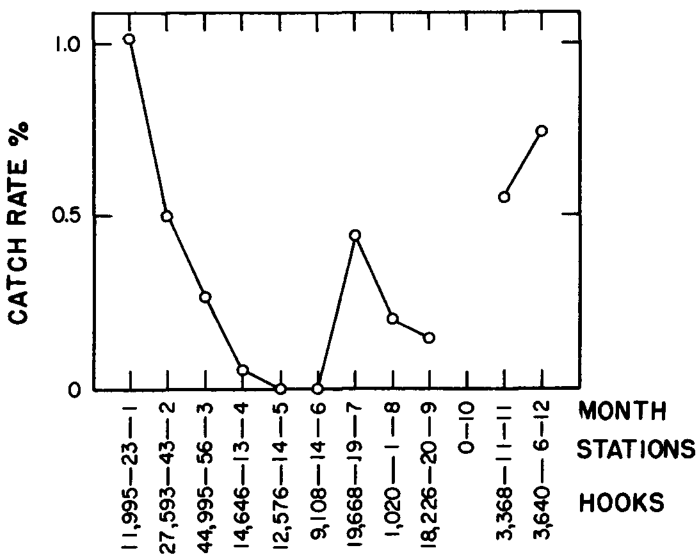
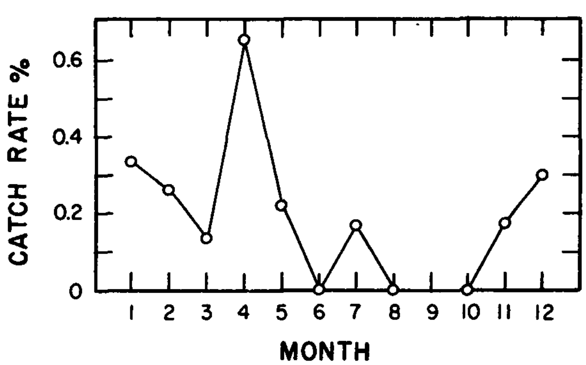


Figure 21.--Bigeye tuna fishing conditions by months (20° to 25° N., 140° to 155° E.)

Figure 23 shows the changes in fishing conditions by months for the waters of the Okinawa Islands, where the oceanographical environment differs more or less from that of other sea areas. The form of the curve somewhat resembles that for the waters south of the Ogasawaras. In the latter area, however, a second peak appears in July and no such peak appears in this area. There seems to be a blunt peak appearing around April and May, but it is extremely unclear.

As the foregoing figures show, the monthly changes in fishing conditions for bigeye tuna differ rather strikingly between areas, just as they did in the case of the albacore. Not only do they differ with respect to the months having the highest and lowest catch rates, but the values of the catch rates themselves differ markedly. However, in spite of the fact that the positions of the peaks and low points on the curves of monthly catch rates differ and despite the differences in the catch rates themselves, it seems possible to detect a common character more or less clearly shared by all of the curves for the various areas. For example, the catch rates begin to drop off sharply in the month after the highest catch rates are attained, and they reach their lowest point about half a year later with no catch or almost none. One or two months after the month in which the lowest point is reached, a secondary peak appears, and thereafter the catch rates gradually decline until one or two months before the month in which the catch rates reach their highest point. During this latter period there is no month without some catch. In other words, there are two peaks and two low points in the year, the period between the maximum and minimum catch rates being about half a year, and a second peak and the second low make their appearance during the half year between the minimum and the maximum. In the vicinity of the Equator from 0° to 5° N., and from 150° to 160° E., and in the Nankai sea area from 25° to 30° N., 130° to 140° E., this relationship is reversed, with the secondary peak and the secondary low



NOTE: NUMBERS OF STATIONS AND HOOKS SAME AS IN FIG. 15.

Figure 22.--Bigeye tuna fishing conditions by months (30° to 35° N., 140° to 150° E.)

appearing in the months between the maximum and the minimum, and with a tendency for the catch rates to increase gradually in the period extending from the minimum to the maximum. All of these areas, however, share the characteristic of two peaks and two lows in the catch rates in the course of a year.

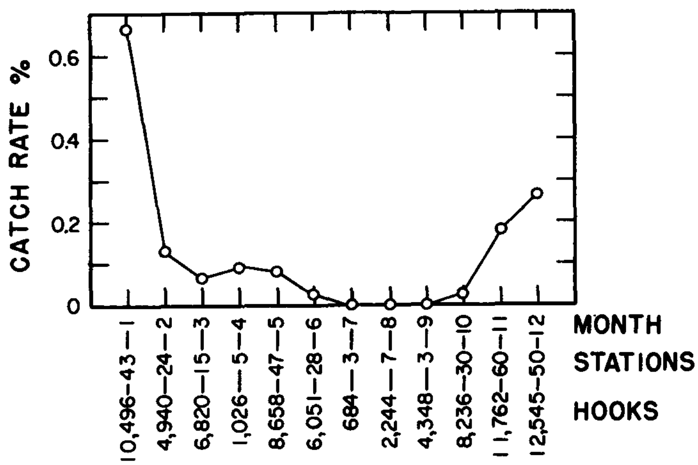


Figure 23.--Bigeye tuna fishing conditions by months (24° to 30° N., 120° to 130° E.)

The significance of these two types of catch rate curves is not clear at present. Furthermore, the problem of whether these two types indicate conditions prevailing at all times within the respective sea areas or whether they simply reflect an error due to the abundance or scarcity of the data can only be answered when future investigations have amplified the data and when not only comparisons of the fish catch rates but comparisons of the body dimensions of the fish have been thoroughly made. Thus at present it is difficult to come to a decision concerning this question, but problems of this sort can be thought to have an extremely important significance in the study of bigeye tuna resources, distribution, and migration.

D. Yellowfin

Appendix chart IV shows the distribution of catch rates throughout the year for yellowfin tuna. As is clear from the chart, the distribution of yellowfin is also extremely broad, extending from the Equator to the vicinity of 40° N. latitude. The species also occurs widely in the South China Sea, the Sulu Sea, the Celebes Sea, the Flores Sea, and similar enclosed waters. Areas with a high density of occurrence are, however, almost entirely limited to the waters of low latitudes, the distribution of this species in the high latitudes being almost vestigial. Consequently, the longline fishing grounds for yellowfin tuna are almost confined to the low latitudes.

Areas with a high density of occurrence, where catch rates are 5.0 or above, can be very broadly said to be south of 3° N. in the Pacific Ocean. Off the east and west coasts of the Philippine Islands, however, such areas extend farther north, waters with catch rates of 5.0 or more appearing as far north as 10°N. off the east coast. In such enclosed waters as the Celebes, Sulu, and South China seas the density of distribution is generally high and waters with catch rates above 5.0 can be found as far north as 20° N. In any case, in the western North Pacific the productively significant range of occurrence of yellowfin tuna can be considered to be south of 10° N. latitude.

The situation in the Southwest Pacific and Indian Ocean regions is not well known because of the paucity of data from these areas, but in the Solomon Islands area it appears that, as might be expected, the density of occurrence is greater in the low latitudes (sic) than it is south of 5° S. The data from the Banda Sea, the Flores Sea, and the waters of the Greater and Lesser Sunda archipelagoes represent chiefly the season of northwesterly winds (the southern summer), but in this region areas with catch rates of 5.0 or more extend southward to 12° S.

It is thought that this situation is controlled mainly by such geographical factors as the arrangement of islands.

The following figures show catch-rate curves for each month for the yellowfin tuna in areas for which data are fairly abundant throughout the year, just as was done in the case of the albacore and the bigeye tuna.

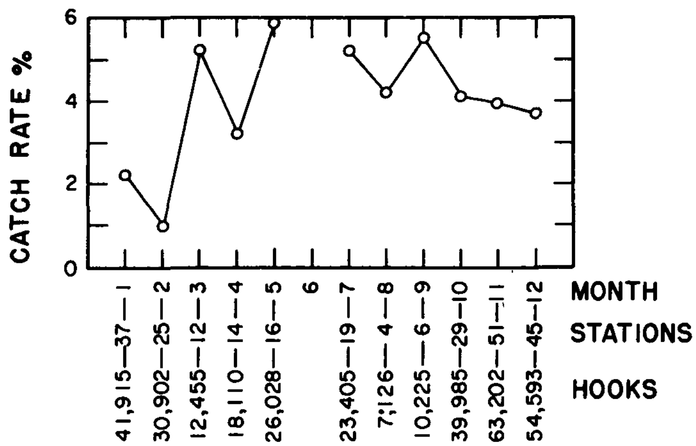


Figure 24.--Yellowfin tuna fishing conditions by months (0° to 10° N., 150° to 160° E.)

Figure 24 is a catch rate curve by months for the area extending from 0° to 10° N. latitude and from 150° to 160° E. longitude. The peaks on the curve appear quite clearly in March and September. We have no data at all for June, but it appears that the highest catch rates for the year occur in May and June. The minimum catch rate for the year appears in February, with a fairly clearly defined low in April and another less clear in August. From October to December the fishing is comparatively stabilized, with catch rates of about 4.0. As there are almost no cases in which data for the whole year are available for particular areas, the monthly changes in the fishing conditions in waters to the east and west of this area are not known, however, in some cases rather high catch rates are indicated in February and April so that it seems difficult to believe that these changes take place uniformly in the equatorial waters of the western Pacific. It is impossible to determine at present whether these changes indicate local differences in the fishing season or whether they are completely fortuitous.

Figure 25 shows the yellowfin fishing conditions by months for the vicinity of Palau, 7° to 8° N. latitude, 133° to 135° E. longitude. The data cannot be said to be complete, however, the figure shows the peaks on the curve to appear in May, October, and December. The May and December peaks are particularly conspicuous. The low points on the curve appear in March, July, and November, that in March being extremely conspicuous. Comparing this figure with the preceding graph, we find that the latter had peaks in March, May, June, and September with lows in February, April, and August. Thus the conspicuous peaks of May generally coincide, but the December peak did not appear in the former figure, and the other peaks and low points, with some lag, appear with about 1 month's difference.

Figure 26 shows the fishing conditions by months in the South China Sea. Data are completely lacking for April and May and therefore the year-round pattern is not known. There is an extremely conspicuous peak in October, but no outstanding differences in the fishing conditions can be detected from November to about March. There appears, however, to be a rather marked low point in January. The catch rate is at its lowest in August, a month for which we have few data. There are no data at all for April and May, but if we assume that there is a pronounced peak in May, the form of the curve would closely resemble that for Palau waters. If we further assume that the catch rate gradually declined from March to August, the curve would have two peaks and two low points and would show the same trend as the monthly catch rate curve for bigeye tuna.

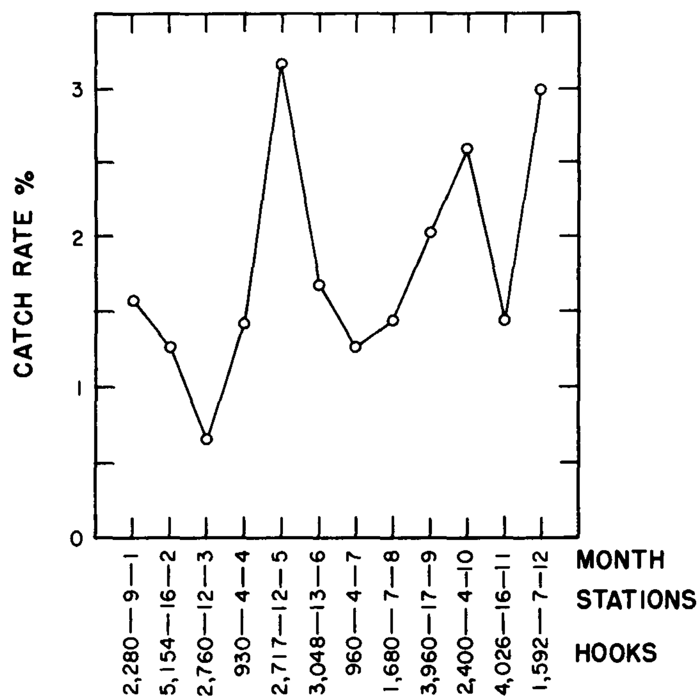


Figure 25.--Yellowfin fishing conditions by months, Palau waters (7° to 8° N., 133° to 135° E.)

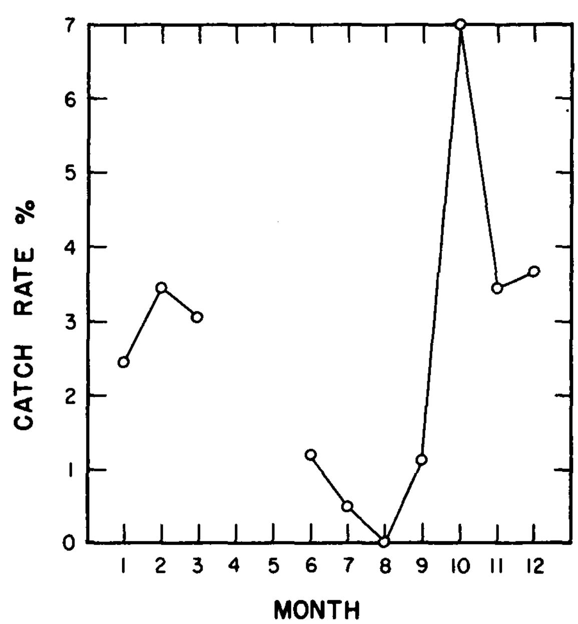


Figure 26.--Yellowfin tuna fishing conditions by months, South China Sea

Figure 27 is a curve of monthly catch rates for yellowfin tuna in the area south of Japan between 25° and 30° N., 130° and 140° E. Data are completely lacking for August and September. As may be seen in the figure, the catch rates are much lower than in all of the sea areas previously treated. There is a very outstanding peak in October falling off sharply from November on. There are no marked changes from January to March, the low point of the year being reached in April. The catch rate is low in May, but a more or less conspicuous peak does appear. The October high coincides with that of the South China Sea, while the May peak coincides with that of the equatorial region. On the whole it is assumed that the form of the curve approximates that for the South China Sea.

Figure 28 shows the monthly fishing conditions for yellowfin in the area from the Marianas Islands to the southern part of the Ogasawara archipelago. Data are lacking for the month of October.

As the figure shows, the maximum catch rate of the year for this area appears in December. From January through February the catch rate drops off sharply, with a low point in the latter month. In March and April it shows a tendency to rise somewhat, and in May a rather conspicuous secondary peak appears. Thereafter the catch rate again declines and reaches the low point of the year in July. As we have no data for October, it is not known whether a peak would appear in that month as it did in the various other sea areas. Comparing this figure with the curves for the various other sea areas already described, we find them completely alike in respect to the peak appearing in May. From the trend of the curve, it is difficult to think that a peak would appear in October, and in this respect the curve differs from those for other areas. Except for the

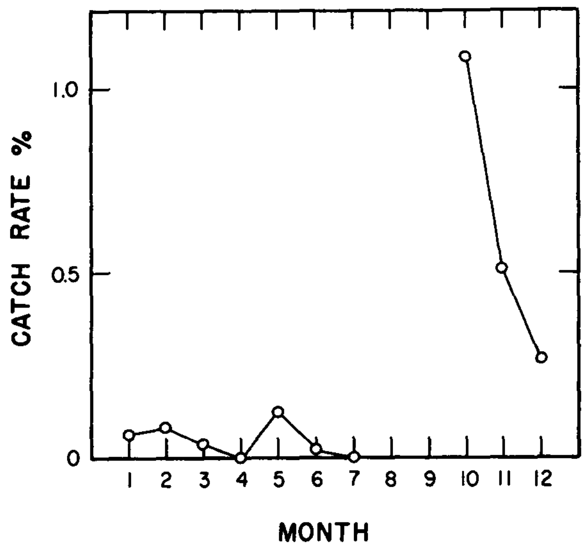


Figure 27.--Yellowfin fishing conditions by months (25° to 30° N., 130° to 140° E.)

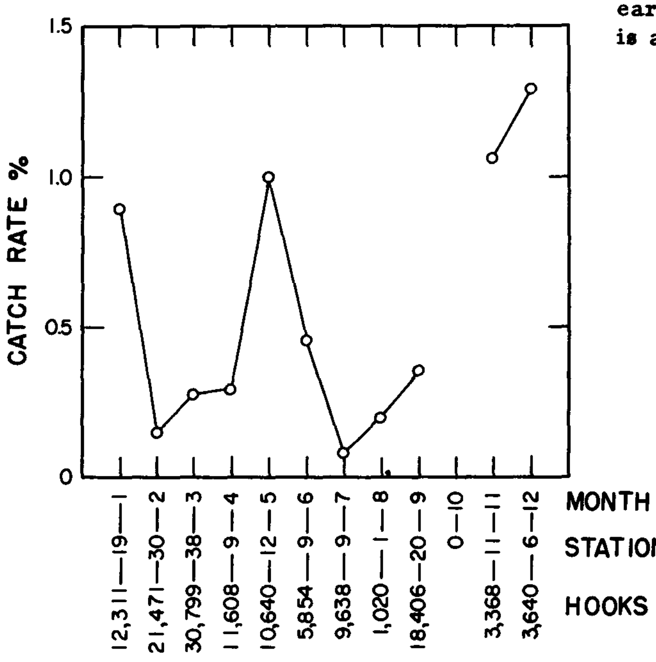


Figure 28.--Yellowfin fishing conditions by months (19° to 24° N., 140° to 155° E.)

situation existing in October, the form of this curve tends to coincide with that for Palau waters. It also shows a tendency to agree quite well with the monthly fishing conditions for bigeye tuna described above.

Figure 29 shows the monthly fishing conditions for yellowfin tuna in the area east of the Ogasawara Islands and connecting with the northern part of the area treated in the preceding figure. This figure shows the maximum catch rate in this area to occur in July with the secondary peak in November. The low points in the curve appear in January and October, with the January minimum being the lowest.

If this is compared with the preceding figure, the conspicuous peak which appeared in May, here appears in July, a difference of 2 months. The preceding sea area showed a peak in December, but in this sea area it appears 1 month earlier in November. The low points on the curve occurred in February and July in the preceding area, while in this area they are in January and October. The winter low is 1 month earlier in this area, while the summer low is about 3 months later. Although there are these seasonal differences between the two areas, the forms of the curves as a whole are in agreement, and they appear to have something in common with the curves for the bigeye tuna in the low latitude sea areas. As for the seasonal lag between the two areas, it may be thought that there is a lag in the time of the north-south migrations of the schools.

It is impossible to reach any definite decision on the basis of the amount of data available, however, it is thought that a difference in the migrational pattern of yellowfin tuna to the east and west of the line formed by the Izu Islands, the Ogasawara Islands, the Mariana Islands, and the Carolines can be detected. We cannot thoroughly examine the presence or absence of such a difference because of the scarcity and uneven distribution of the data.

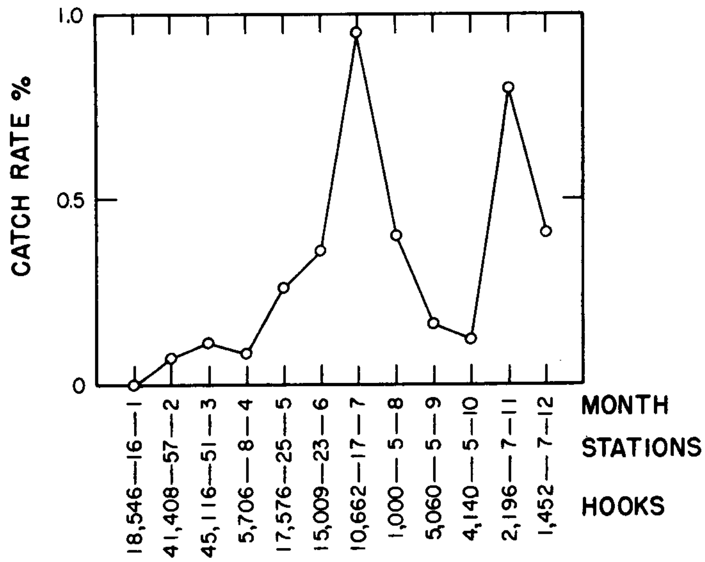


Figure 29.--Yellowfin tuna fishing conditions by months (24° to 30° N., 140° to 150° E.)

As we proceed farther north the yellowfin catch becomes extremely small and the seasonal distribution of the data becomes extremely uneven, for which reason we cannot discuss the distribution of the fish as shown by the catch rates. It appears, however, that the highest catch rates of the year occur in September and October, with only one peak in the curve during the year. This trend becomes more marked the farther north we go, and a tendency can also be detected for the peak to appear earlier. These facts are believed to indicate that we have reached or are approaching the limits of migration and distribution of this species.

Comparing the catch rate curves for the various sea areas described above, one can see considerable regional differences in the seasons at which the peaks and low points appear. There are cases like that of the area east of the Ogasawara Islands and the area east of the Mariana Islands, where such differences can be thought to indicate directly the movements and migrations of the schools, but it is difficult to grasp the direction of motion of these schools by means of these curves.

A peak appears in May through the whole area from 25° N., south to the Equator (the situation in the South China Sea is unknown because of the lack of data), and it is impossible to detect any trend which would indicate local movements of the schools from one region to another. In the waters to the west of the Izu, Ogasawara, Mariana, and Caroline archipelagoes a conspicuous peak appears everywhere in October. In addition to this commonly-shared peak, each area's curve shows a second peak, but the season in which the secondary peaks appear seems to vary greatly between areas.

In the case of the bigeye tuna it was stated that some agreement in the trend of the curves as a whole could be detected, even though there were seasonal differences in the position of the peaks and low points. The same sort of relationship can be detected in the case of the yellowfin tuna. The fact that the trends of the curves show resemblances between areas not only for the yellowfin but for a different species, the bigeye tuna, should have an extremely important significance in studying the distribution and migration of these fishes and the presence or absence of sub-species.

It has already been mentioned several times that the density of distribution of yellowfin tuna is high in the vicinity of the Equator and drops off as one goes into the high latitudes. The following graph shows catch rates for yellowfin in blocks of 10° of longitude and 2° of latitude between 120° and 160° E. longitude. Material from the Sulu Sea, the Celebes Sea, and the South China Sea, where environmental conditions are different, has been left out of the data for the area between 120° and 130° E. longitude.

As the figure shows, the catch rates are highest near the Equator, falling off sharply to the north, with the low point in the vicinity of 12° to 14° N. North of this latitude, the curve slowly rises again and there is a blunt peak in the vicinity of 18° to 20° N. North of this latitude, the curve again drops off steeply and from 30° N. latitude on to the northward the catch rate is practically zero, indicating only a vestigial occurrence of the species.

Thus the various curves taken together show a general trend, but there are regional differences of some extent in the position of the peaks and low points and also in their magnitudes. There are also cases like that of the area between 120° and 130° E. longitude where the inclination of the curve is conspicuously gentler than in other regions.

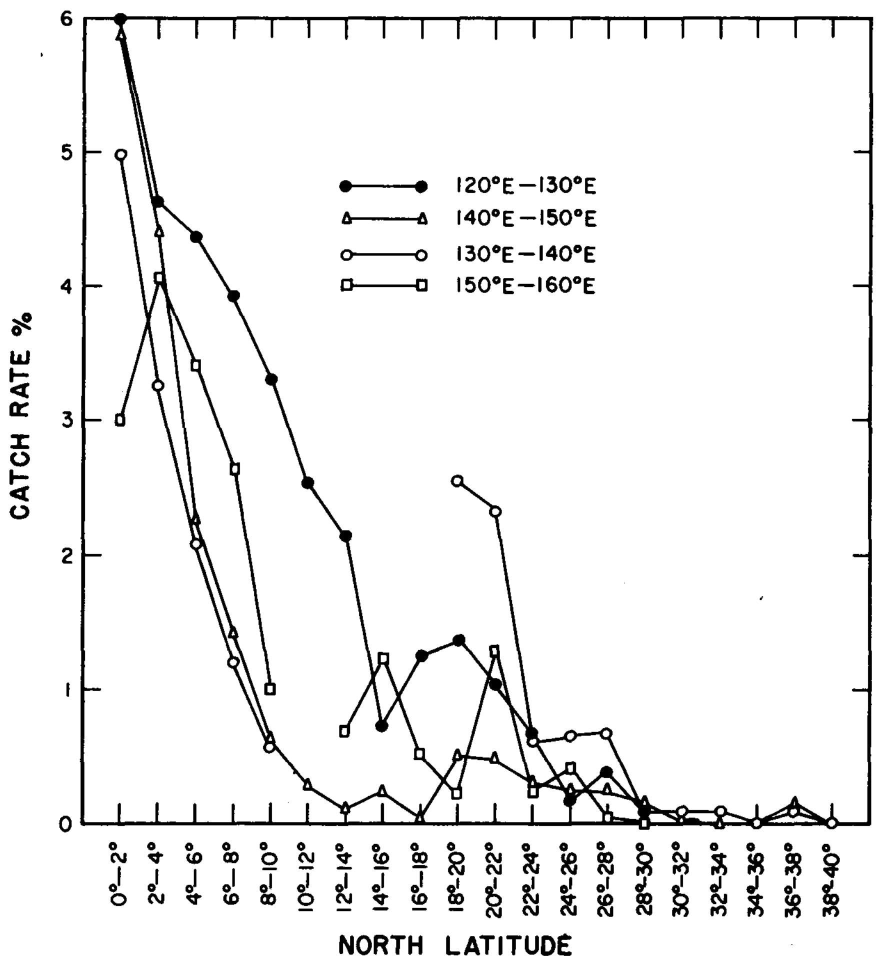


Figure 30.--Fishing conditions at different latitudes (yellowfin tuna)

As has already been stated, seasonal changes are apparent in the density of occurrence of the yellowfin. The data used in this figure are not equally representative of all seasons in all regions but show a marked tendency toward an uneven distribution. As the curve in this figure is a summarization of past data, with absolutely no account taken of seasons, there is naturally a need for correction based on a consideration of the data by seasons. Such a correction would probably change to some extent the magnitude and positions of the peaks on the curve and the differences in their slopes, but it can hardly be thought that it would give rise to conspicuous changes in the general trend of the curves. Therefore, this figure can probably be regarded as showing in general outline the distributional pattern of the yellowfin tuna in the northwestern Pacific Ocean as it relates to latitude. Because of the lack of fish measurements and other data, it is impossible to come to any decision at present concerning the relationships between the schools which make up the peak of the catch rate, that is of the density of distribution in the area centered around 20° N. latitude and the schools which make up the peak in the low latitude area centered around the Equator. Thus we cannot in the absence of further study come to any conclusions concerning such important questions as whether or not these schools belong to different stocks, whether they belong to the same stock but represent different age compositions, or whether fish of exactly the same stock have, because of oceanographic conditions or their relationships with other aquatic life, formed two centers of distribution where the density of occurrence is high in comparison with the surrounding waters. However, the phenomena of a generally improving catch rate throughout the area south of 25° N. in May and a similar simultaneous rise in the catch rates in the area west of 140° E. longitude in October are considered to be data which tend to deny the validity of the idea that there are a large number of stocks in the western Pacific region.

E. Spearfishes

Chart V shows the distribution of spearfish catch rates throughout the year. In the chart all of the spearfishes are lumped together.

If we look at the areas on the chart where the catch rates are over 1.0, we see that they include almost all of the Celebes Sea, the coastal waters on the east side of the Philippine Islands, Formosa and Okinawa, the vicinity of 7° to 10° N., 140° to 150° E., and the waters around the Izu, Ogasawara, and Mariana islands. Catch rates are also over 1.0 in the areas centered around 35° to 40° N., 150° to 160° E. Other sea areas where the catch rates are high are in the Kinan sea area and in the vicinity of 29° to 39° N. at 100° E. Other fishing grounds with comparatively high catch rates can be recognized south of 10° N. in the vicinity of 155° to 160° E. There are almost no data worth considering from the operations of research vessels, but judging by the reports of commercial vessels the Marshall Islands region also appears to be a superior fishing ground for spearfishes. From the foregoing it is seen that, with the exception of the broadbill swordfish, the good fishing grounds for other spearfish species are in waters comparatively close to islands or the continental shelf.

As for the catch by species, there are many cases in which it is impossible to tell because of deficiencies in the data, but in general it may be said that the waters adjacent to Formosa have an abundance of white marlin that is unparalleled elsewhere. Sailfish are also extremely abundant. The proportions of spearfish species in the catch are shown in the following table.

Table 114.--Catch by species in Formosa (Takao and Suō fish markets, 1943)

Place	Total number of fish	White marlin	Black marlin	Striped marlin	Sailfish
Takao	16,461	2,542	5,373	645	7,901
Suō	6,944	4,448	161	742	1,593
Total	23,405	6,990	5,534	1,387	9,494

As the table shows, the composition of the catches at Suō and Takao are quite remarkably different. In the total for both ports sailfish were most abundant, making up slightly over 40 percent of the total catch, while white marlin were slightly under 30 percent, black marlin slightly under 24 percent, and striped marlin slightly under 6 percent of the whole.

In the various sea areas toward the center of the Pacific the proportion of white marlin is very small and that of black marlin and striped marlin is higher. It is believed that this shows that the center of the distribution of white marlin is in the extreme western Pacific and in the adjacent waters of the South China Sea, Sulu Sea, and the Celebes Sea.

Toward the center of the Pacific Ocean the striped marlin, black marlin, and broadbill swordfish are most commonly taken. The centers of the distribution of these species appear to be determined principally by latitude.

The following figure shows the catch rates for each section of 2° of latitude between 140° and 150° E.

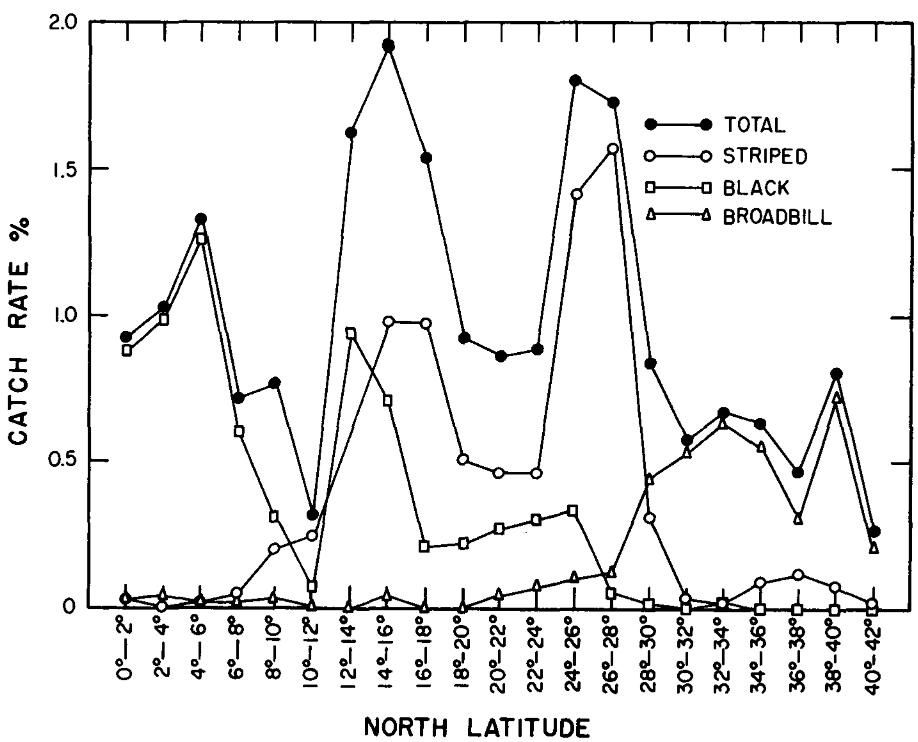


Figure 31.--Distribution of spearfish catch rates by latitude (0° to 40° N., 140° to 150° E.)

As the figure shows, for the spearfishes as a whole the peaks on the catch rate curve appear at 4° to 6° N., 14° to 16° N., 24° to 26° N., and 32° to 36° N., or at about every 10° of latitude. There is another fairly conspicuous peak at 37° to 40° N., but all of these more northerly peaks are composed of broadbill swordfish so it is doubtful whether they represent separate peaks or not.

The low points on the curve appear at 10° to 12° N., 20° to 22° N., 30° to 32° N., and 40° to 42° N., being separated by about 10° of latitude just as were the peaks. Among these various low points, it is doubtful whether the one at 10° to 12° N. is really as pronounced as it appears on the figure because there are very few data for this area. It is also thought worthy of note that the position of this low coincides perfectly with that on the yellowfin curve.

The peak on this curve which appears at 4° to 6° N. is almost entirely composed of black marlin, while that which appears at 14° to 16° N. is composed of black marlin and striped marlin. The peak appearing at 24° to 28° N. is composed almost exclusively of striped marlin while the peaks north of 30° N. are formed for the most part of broadbill swordfish. Consequently, to state it very broadly, we can recognize a successive distribution from south to north of black marlin, striped marlin, and broadbill swordfish. In the following figures the variations in fishing conditions from month to month are shown for each sea area, just as was done in the case of yellowfin and bigeye tuna.

First of all, figure 32 shows the situation in the vicinity of the Equator from 0° to 5° N. and from 150° to 160° E.

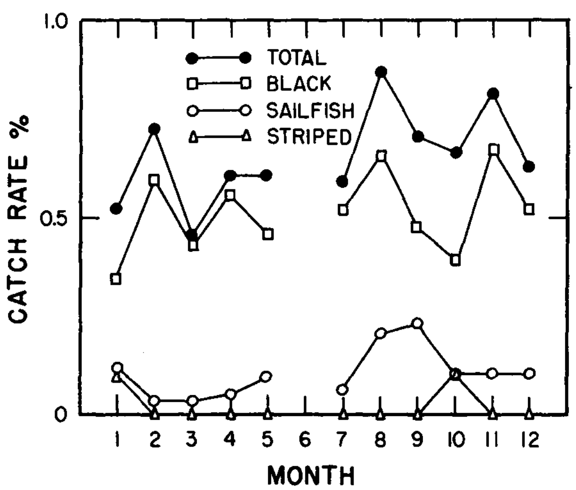


Figure 32.--Spearfish fishing conditions by months (0° to 5° N., 150° to 160° E.)

The increases and decreases in the catch rates are not very conspicuous, but in the catch rate for the spearfishes as a whole the peaks appear in February, August, and November. The catch is almost entirely made up of black marlin, with sailfish next in abundance and striped marlin extremely scarce. There are no data for June, but the sailfish appear to increase somewhat around August and September. Striped marlin become somewhat more numerous in January and October.

Figure 33 shows the fishing conditions in the waters around Palau.

As the figure shows, the peaks on the curve are in April, October, and December-January. The catch of each species is not known so we cannot show what these peaks are composed of, but from the form of the curve, it is difficult to conclude that they are all the same species. Compared with the preceding figure, the positions of the peaks and lows on the curve are quite conspicuously different.

Figure 34 gives the fishing conditions from 19° to 24° N., 140° to 155°.E., i.e., to the east of the area between the northern Marianas and the southern Volcano Islands.

For the total catch, the peaks on the curve appear in January, March, May, and August. They have been omitted from the figure, but from December to February broadbill swordfish increase somewhat in abundance. Striped marlin increase gradually from November on and form a rather conspicuous peak in March. In April they decline quite rapidly, but increase again sharply in May to attain their maximum catch rates of the year. From June on they drop off steeply and reach their low of the year in August.

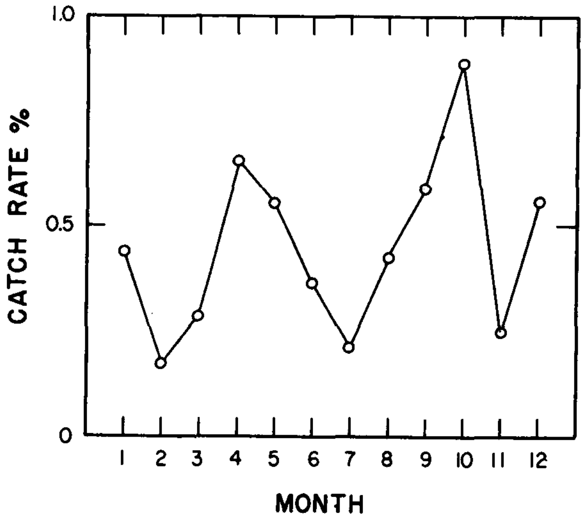


Figure 33.--Spearfish fishing conditions by months, Palau waters (7° to 8° N., 133° to 135° E.)

The black marlin catch rates do not change much from January to May. From June to August they increase gradually and attain their peak for the year in the latter month. In September they drop off sharply, and although there are no data for October, the low of the year appears to be reached about December. The area within which the black marlin has quite an important significance as an element in the longline catch extends generally to the vicinity of 25° N. Above this latitude there appear to be no fishing grounds on which the catch rate for this species gets above 1.0.

Because of the lack of data we cannot make any comparison between sea areas at the same latitudes, but the changes in fishing conditions for black marlin and striped marlin by months at Takao in Formosa are shown in the following tables.

The areas fished by boats based at Takao are at approximately the same latitude or somewhat to the south of the area covered by the preceding figure, and during the winter the South China Sea is the principal fishing ground. Because the number of vessels in operation is not known, it is not clear what the fishing effort was. Consequently the comparison of the number of fish landed in each month as shown in table 115 and 116 does not have the same significance as the increases and decreases shown in the preceding figure of the catch rate curves. For example, although the minimum number of fish caught appears in September, it is not known whether the number of vessels operating was the same as in the other months and the catch was actually down, or whether the number of fish taken decreased because of a decrease in the number of vessels operating.

Such factors must be taken into consideration, but it appears from table 115 that at Takao the catch of black marlin was at its peak in July and at its lowest in September. The second peak appears in November and a second low around March. There appears to be a third peak in May, but it is not very clear.

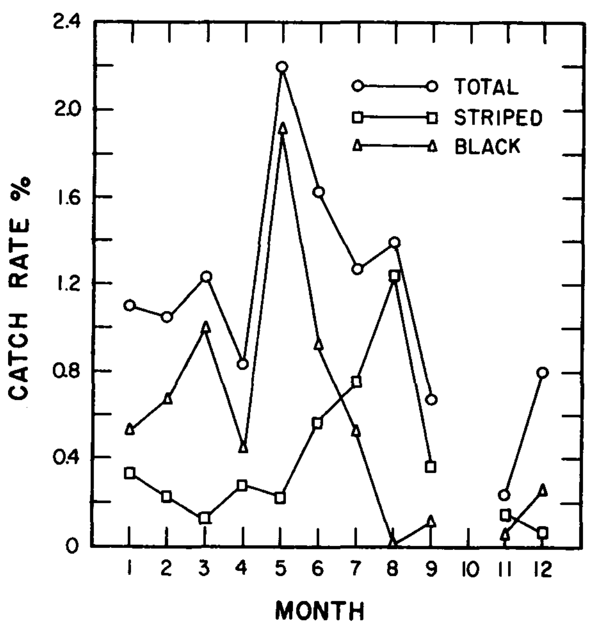


Figure 34.--Spearfish fishing conditions by months (19° to 24° N., 140° to 155° E.)

Table 115.--Numbers of fish by weight classes landed by months at Takao in 1943 (from Nakamura in the Journal of the Formosan Natural History Society, Vol. 34, No. 251)

Weight in kg	Black marlin												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
10-20	0	0	0	0	0	0	0	0	0	1	2	1	4
20-30	2	2	1	0	1	6	2	1	1	1	2	0	19
30-40	2	2	1	6	30	48	111	108	4	9	19	9	349
40-50	5	10	7	13	96	129	460	199	11	55	59	26	1,070
50-60	28	20	20	33	78	60	214	110	15	73	59	40	750
60-70	26	29	22	16	45	55	120	59	16	49	98	80	615
70-80	39	39	20	12	43	24	50	29	12	29	87	56	440
80-90	43	27	22	21	26	11	39	23	12	25	30	23	302
90-100	22	24	17	18	33	11	42	29	25	14	16	23	274
100-110	19	18	14	24	41	22	37	31	21	19	14	22	282
110-120	18	19	25	17	32	21	40	28	29	16	15	22	282
120-130	13	13	16	20	23	9	28	14	14	23	13	14	200
130-140	12	14	19	25	23	14	21	21	14	22	9	20	214
140-150	8	15	11	13	28	13	30	13	10	14	7	9	171
150-160	4	11	7	9	20	9	12	7	5	11	2	9	106
160-170	2	4	11	5	8	6	5	3	2	3	3	5	57
170-180	0	4	5	9	7	6	11	5	1	8	6	5	67
180-190	0	2	3	3	7	0	11	6	2	4	6	2	46
190-200	1	1	3	5	9	1	2	5	1	3	2	2	35
200-	2	1	5	12	22	10	13	9	2	4	3	7	90
Total	246	255	229	261	572	455	1,248	700	197	383	452	375	5,373
Total Weight (kg)	22,700	25,170	24,400	28,550	53,600	34,340	85,460	50,460	19,800	34,870	35,110	35,010	449,470

Table 116.--Numbers of fish by weight classes landed by months at Takao in 1943 (from Nakamura in the Journal of the Formosan Natural History Society, Vol. 34, No. 251)

Weight in kg	Striped marlin												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
10-20	1	1	1	14	4	1	1	0	1	0	0	0	24
20-30	1	0	1	4	20	1	0	2	0	0	0	0	29
30-40	3	6	3	3	48	13	1	0	0	2	0	10	89
40-50	12	17	15	18	59	15	14	4	0	2	2	13	174
50-60	12	14	5	20	46	33	11	4	3	15	4	14	181
60-70	3	6	4	18	21	7	15	2	1	9	6	15	99
70-80	3	2	1	5	5	0	0	0	0	0	0	4	20
80-90	1	1	0	3	4	1	0	1	0	0	0	0	11
90-100	0	1	4	6	0	0	0	0	0	0	0	0	11
100-110	1	0	2	0	0	0	0	0	0	0	0	0	3
110-120	0	0	0	1	0	0	0	0	0	1	0	0	2
120-130	0	0	0	0	0	0	0	0	0	0	0	2	2
Total	37	48	32	82	213	71	42	13	5	32	12	58	645
Total weight (kg)	1,929	2,482	1,677	4,126	10,072	3,419.2	1,757	660.6	2,419.6	2,040.6	611.7	4,227.4	35,422.1

For comparison, in the waters south of the Ogasawara Islands the highest catch rate appeared in August, 1 month later than at Takao. However, it is probably safe to consider that in the sea area centered around 20° N. the density of distribution of black marlin reaches its height around July and August.

Records of the weight of the fish taken are lacking for other sea areas so we do not know the body weight composition of the catch, but at Takao there was a conspicuous difference in the weight composition as between the fish taken in the summer and those taken in the winter. Fish caught in the summer were generally small, with the mode appearing at 40 to 50 kilograms while in November-December it appeared at 60 to 70 kilograms and in January at 80 to 90 kilograms. The weight composition of the fish taken from March to September showed two modes, one at 40 to 60 kilograms and one at 100 to 140 kilograms, (see Nakamura, Journal of the Formosan Natural History Society, Vol. 34).

Table 116 shows fishing conditions at Takao by months for striped marlin. The data are from the same source as those in table 115.

The number of fish taken was not very great, but the largest number appeared in May with the low of the year in September and a second peak appearing in December. This may be compared with the area south of the Ogasawara Islands, where the peak catch rate appeared in May. Thus, although there are points of disagreement between the rises and falls in the catch rate and the increase and decrease in the number of fish landed in each month at Takao, the peak months are the same in both cases and we can probably consider that, just as in the case of the black marlin, dense schools appear at the same season on approximately the same latitudes without regard to longitude.

In the following figures the adjacent area on the north between 25° and 30° N. has been divided into three sections of 140° to 150° E., 130° to 140° E., 120° to 130° E. and the fishing conditions by months have been shown for each of the sections.

As the figure shows black marlin are scarce in the area of 25° to 30° N., 140° to 150° E., but they are somewhat more abundant from April to August. There is an extremely conspicuous peak in the striped marlin catch rate in May with a value of slightly less than 4.0. Thereafter the catch rate falls off steeply and from August to October hardly any fish are taken. In November there is again a fairly conspicuous peak. For all the spearfishes as a whole there is a third peak in February, but this is formed principally of broadbill.

Comparing this with the area south of the Ogasawaras, which adjoins this area on the south (fig. 34), there is a peak in March which does not appear in this sea area but otherwise although there are differences in the numerical values for the catch rates, there is good agreement in the trend of increase and decrease in the striped marlin catch rates and we see no such conspicuous seasonal lag as was found in the case of the yellowfin. The black marlin catch rate curve in this sea area is quite irregular, and its agreement with the curve for the area south of the Ogasawaras is not as striking as it was in case of the striped marlin.

Fishing conditions in the Nankai sea area, 25° to 30° N., 130° to 140° E., are shown in figure 36. A thorough comparison is impossible because of deficiencies in the data, but the black marlin catch rate curve appears to be quite conspicuously different from those for the sea area east of the Izu and Ogasawara islands. In this region there is a fairly high catch rate in January, decreasing thereafter gradually to March and with almost no catch in April, followed by a second increase forming a rather conspicuous peak in June. For the striped marlin there is a conspicuous peak in May and a fairly high catch rate in June, but in July they decrease rapidly. The peak which was seen in the area east of the Izu and Ogasawara Islands in November does not seem to appear here. In the Hyūga Nada region, which adjoins this sea area to the north, striped marlin are abundant around April to June, and quite a few are taken by the harpoon fishery.

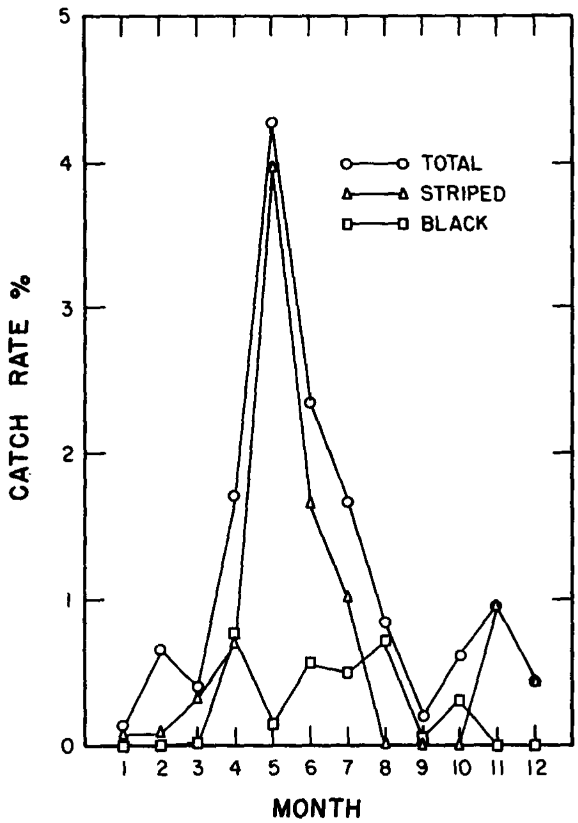


Figure 35.--Spearfish fishing conditions by months (25° to 30° N., 140° to 150° E.)

Shifting farther to the westward, fishing conditions in the waters around the Ryūkyū Islands are shown in figure 37. As the figure shows the pattern of increase and decrease in black marlin catch rates more closely resembles that of the sea area to the east of the Izu and Ogasawara islands than it does that of the Nankai sea area, although there is a lag of about 1 month.

The striped marlin catch rate rises sharply from April on and reaches its high of the year in July. After August it drops off steeply and forms a low in October, after which a fairly conspicuous peak is formed in November. This pattern resembles that for the sea area east of the Izu and Ogasawara islands. In December it again goes down and the second peak of the year is formed in January and February. In the area east of the Ogasawara Islands a peak appears for the spearfishes as a whole in February, but it is formed by broadbill swordfish and differs entirely in character from the January-February peak in this sea area.

As was stated above, the season of the highest catch rates in this sea area is about 2 months later than that in other areas in the same latitude. Furthermore, the period during which the catch rate is over 1.0 extends about half of the year from May to September, a situation which differs markedly from other areas of the same latitude.

The form of the striped marlin catch rate curve described above very closely resembles the increases and decreases in the number of black marlin taken each month in Formosa (table 115). As was stated at the beginning of the chapter, until recent years the spearfishes were not thoroughly classified and it is known that in some cases both the black marlin and the white marlin were recorded as striped marlin, so there is a suspicion that this may be such a case and that other spearfishes may have been recorded as striped marlin. In recent years, particularly, boats based at Kushikino in Kagoshima have been taking a rather large number of black marlin around July to September, and this makes the suspicion all the stronger. At any rate, if we construct a curve of catch rates on the basis of data from past surveys we get the results shown in the foregoing figure.

According to what has been said, the season in which the highest catch rates appear in the vicinity of 20° to 30° N. is everywhere about the same, although there are differences between areas in the numerical values of the catch rates. This is believed to show that the movements of the schools have no important relationship to longitude but that they move rapidly and simultaneously, chiefly in a north-south direction. In other words, this indicates the difficulty of postulating the existence of definite paths of migration. It appears that only the waters

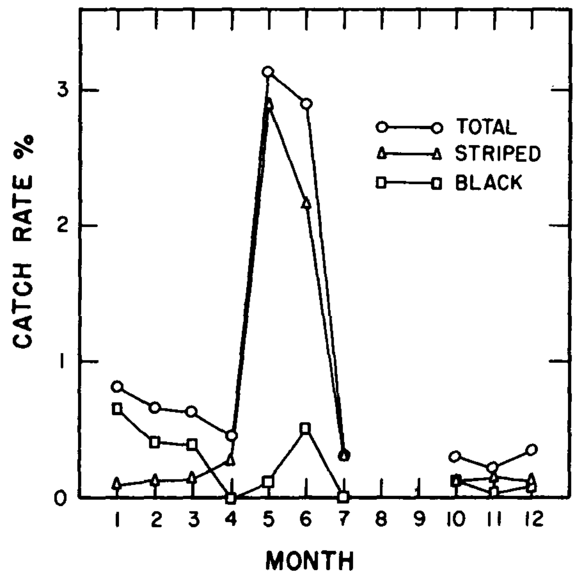


Figure 36.--Spearfish fishing conditions by months (25° to 30° N., 130° to 140° E.)

around the Okinawan archipelago differ somewhat in the character of the schools and of the fishing grounds, but the discussion of these relationships must wait upon more thorough researches to be carried out in the future.

North of 30° N. latitude the catch of striped marlin drops off sharply but off northeastern Japan they are rather numerous from July to September and, as figure 31 shows, there is a blunt peak in the catch rate curve in the vicinity of 36° to 38° N.

As was shown in figure 31, the catch rates for broadbill gradually increase beginning at about 20° N., and around 30° N. they make up more than half of the spearfish catch. As was stated in the chapter on fishing grounds, the areas of high density of occurrence are generally west of 160° E. and they decrease in abundance east of this longitude. The center of the fishing grounds is approximately at the same location as the central fishing grounds shown in the case of the albacore, and the movements of the fishing with the seasons generally resemble those of the albacore. The most important fishing season is almost entirely limited to the winter half of the year. Charts VI, f to k show the movements of these fishing grounds from October to March.

In the chart for October (f) the areas of fishing grounds of dense occurrence appear at 40° to 42° N., 149° to 154° E., although a thoroughgoing comparison is impossible because of the lack of data around the peripheral areas. Some areas of fairly high catch rates are also seen to the southeastward in the vicinity of 36° to 39° N., 155° to 156° E. Elsewhere there are scattered areas of fairly high catch rates off Iwate Prefecture, in the southern Izu Islands, southeast of Amami Ōshima, and east of Formosa.

In the chart for November (g) the fishing grounds have become conspicuously extended, and catch rates of more than 0.5 are indicated for the area from 41° to 31° N., 144° to 156° E. Comparing this with the situation in October, the grounds of dense concentration have extended to the west and south. There are no data for the waters around the Izu Islands, so no comparison can be made with October. In the Okinawa region the areas of high catch rates have shifted to the southwestward and appear off to the east and south of the main island of Okinawa. The fishing grounds to the east of Formosa appear at the same positions as in October, but the catch rates appear to have improved somewhat. Compared with the chart of the distribution of albacore catch rates for November, the broadbill are shown to be abundant somewhat more to the north and east.

In the chart for December (h) the center of distribution is farther south than in November in the vicinity of 55° N. and areas with catch rates of over 1.0 are recorded from the range of 35° to 40° N., 150° to 152° E. Compared with November, the fishing grounds are extended a good deal to the southwest and areas with rather high catch rates appear from off Bōsō

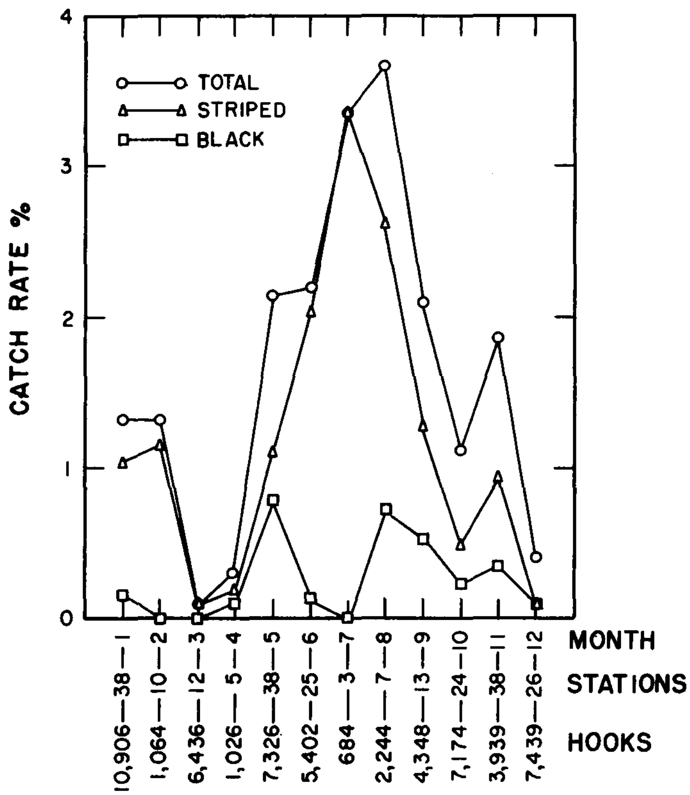


Figure 37.--Spearfish fishing conditions by months (25° to 30° N., 120° to 130° E.)

to the waters around the Izu Islands. Farther to the west there are fishing grounds with catch rates of over 1.0 about 300 miles south of Ashizuri Misaki and northwest of the main island of Okinawa, while fishing is quite active all over the sea area between them from 27° to 28° N., 128° to 133° E. Fishing is poor in the waters east of Formosa.

Compared with the albacore grounds centered around 150° E. in December, there is general agreement but the western tip of the broadbill grounds extends farther west than do the albacore grounds. At this season dense schools of albacore believed to be of a different stock appear south of Shionomisaki, but there are no broadbill there, although as previously stated fishing grounds with dense concentrations appear in the waters around Okinawa.

In the chart for January (i) the fishing grounds have moved farther south and are centered along 151° E., with the heart of the fishing grounds in the area of 32° to 38° N. The schools in the waters around the Izu Islands are separated from those which are broadly distributed to the eastward, and there appears to be a densely concentrated group of fish in the comparatively narrow area at 30° to 34° N., 134° to 137° E. Outstanding fishing grounds have disappeared from west of the Izu Islands, with the sole exception of some areas with rather high catch rates around the Miyako archipelago. Areas with catch rates of over 1.0 are to be seen in the vicinity of 29° to 50° N., 161° to 162° E., but there are few data from that region so it is difficult to determine whether these are merely fortuitous or actually good fishing grounds.

At the same season the center of distribution for albacore is, with the exception of the central part of the Pacific, at 29° to 33° N., 143° to 148° E. Consequently it can be seen that the center of distribution of the albacore is somewhat more to the south and west, however, the albacore catch rates in the waters around the Izu Islands are not very high. The albacore grounds in the Kinan sea area are greatly extended as compared with December.

In the chart for February (j) the center of the fishing grounds has shifted even farther to the southwest to the waters east of the line of the Izu and Ogasawara islands in the vicinity of 27° to 32° N., 140° to 145° E. The grounds of particularly high catch rates are in waters close to the line of islands. There are no fishing grounds with high catch rates farther to the westward in the Satsunan region except for a few areas of rather high catch rates east of Amami Ōshima. The grounds east of Formosa, which had disappeared since December, come back with some catch rates of over 0.5.

The center of albacore distribution in February is 1° or 2° east of that of the broadbill, but the pattern of distribution is very similar. The albacore grounds in the Kinan sea area are more extensive than in January and the fishing appears to be better.

In the chart for March (k) the center of distribution has moved somewhat north of its position in February and is within the range of 30° to 34° N., 140° to 147° E. To the southeast and separate from this center there is an area of high density of occurrence in the vicinity of 30° N. 152° E. It is impossible to determine whether these two areas are connected or whether they are completely separate because of the paucity of data. In the waters west of the Izu Islands, including those around the Ryūkyūs and Formosa, no areas of high catch rates are to be seen at all.

The center of distribution of albacore in March appears to be somewhat to the south of that of the broadbill, and in general the density of occurrence appears to have decreased. The albacore grounds in the Kinan sea area have moved somewhat to the south.

From the foregoing, it appears that the center of distribution of the broadbill, in a very general view, is in the vicinity of 140° to 155° E., and that the schools which in October are in the vicinity of 42° N. gradually move south with the passage of time. This southward movement is accompanied by an extension of the fishing grounds to the east and west, and it appears that from January on part of the schools remain in the waters east of the Izu and Ogasawara islands. It is unknown whether or not they cross to the westward of this line of islands, but judging from the distribution of catch rates it appears that they do not and the vicinity of 140° E. is considered the apparent boundary of their distribution and migrations. As has already been stated, at some seasons areas of a fairly dense distribution appear in the waters around Formosa and the Ryūkyū Islands, but the relationships between the schools appearing in this region and those which occur to the east of the line of the Izu and Ogasawara archipelagoes are completely unknown at present.

Broadbill do appear in the tropical sea areas to the south of the sub tropical line of convergence, but there are no fishing grounds on which concentrated catches of this species are made. However, there are many immature fish in this region and larval and juvenile forms appear to occur there, in many cases forming part of the food of other tunas and spearfishes. This phenomenon is not as yet well understood, but it probably gives an important clue to the area of reproduction of the broadbill and should be given serious consideration from the point of view of ecology and population studies. In any case, it is worthy of careful note that the fishing grounds of the broadbill swordfish appear to be limited on the south by the subtropical convergence, on the west by the line of the Izu and Ogasawara archipelagoes, and on the east by approximately 160° E.

In the foregoing we have attempted to consider the patterns of distribution and migration of each species based on the catch rates, and on this basis there appear to be for each species two types of patterns, the boundaries between which appear to be geographically the subtropical convergence, the area of contact of the Equatorial Countercurrent and the North Equatorial Current, and the line of the Izu and Ogasawara archipelagoes.

One of these two types of patterns is represented by the striped marlin, which extend over the whole area in the vicinity of 20° to 30° N., and the black tuna, which occur from the vicinity of Luzon to the area of the Kuroshio. In this type dense schools appear over a broad expanse of ocean in an extremely short period of time and then after a very short time disappear again, so that it is extraordinarily difficult to follow the paths of their migrations. For instance, the catch rate curves for striped marlin all show the highest peak of the year in May in the waters of the Marianas in the vicinity of 20° N., in Formosan waters, in the waters of the Izu

Islands around 30° N., in the Kinan sea area, and farther north in the Hyūga Nada. Because they make their appearance within a short time and then move away somewhere within a short time, the peak in the catch rate at this season is extraordinarily sharp.

In the second type of pattern the schools gradually become more concentrated in a comparatively limited area and the schools so formed move and migrate comparatively slowly. Examples of this type are the spearfishes which appear around Formosa in the winter, the black tuna around Tanegashima, the albacore of the Kinan sea area, the broadbill of the northeastern sea area, and the albacore of the central North Pacific. In this type the center of the fishing grounds does not make any very violent shifts, and the catch rates gradually increase with the passage of time and then gradually decline. Consequently in this type it seems as if the schools congregate successively in one sea area after another, and the center of the grounds moves comparatively slowly with the passage of time. As a result, it is easier to follow the paths of migration of the schools in this case than in the former type, and the slopes of the seasonal catch rate curves in a given area are comparatively gentle.

It is impossible at present to give a full explanation of the relationships between the ecological significance of these two types and oceanographic conditions, however, on the basis of what data we have it appears that the former is related to spawning while the latter is more deeply related to food hunting. Accordingly, the former is to be thought of as the spawning season type of migration and the latter as the food-seeking type of migration. However, in many cases it is difficult to draw the line clearly between these two types and opinions will differ on where to establish the criterion. Furthermore, more data are necessary in order to establish clearly whether or not these two types actually exist, and it goes without saying that we can arrive at no conclusion without further research.

Thus we can under the present conditions do nothing concrete about the biological and oceanographical essentials and their theoretical analysis, but from the point of view of the commercial fishery it can be imagined that these two types will have a rather important significance. It may also be thought that they would be highly significant from the point of view of population studies, and we feel keenly the necessity for tagging studies to trace the paths of migration, morphometric studies, more complete fish catch statistics, and thorough studies of the spawning and feeding habits of the fish.

VII. Conclusions

1. Data from past surveys covering about 20 years have been gathered and worked up. There are omissions because of the author's inability to obtain some of the past data.

2. An attempt has been made on the basis of these data to clarify the character of the tuna longlining grounds of the eastern Indian Ocean and the western Pacific.

3. A description in brief has been given of the existing tuna and spearfish fisheries and a discussion has been made of the character of the tuna fishery.

4. Tuna grounds hitherto had been discussed in terms of total catch and number of vessels operating, but this method leaves the relationship between fishing effort and catch unclarified. In order to explain this relationship the number of hooks has been taken as the unit of fishing effort. The number of fish caught per hundred hooks has been called the catch rate. Consequently the fishing grounds discussed in this book are limited to the grounds of the longline fishery.

5. Sea areas have been delimited mainly by longitude and latitude or by topography, the seasonal and geographical variations in fishing conditions have been recorded in terms of catch rates, and the character as fishing grounds of the various sea areas has been discussed.

6. At the same time it has been postulated that the catch rates are proportional to the density of distribution of these fishes and the distributions and migrations of the fishes have been considered on this basis.

7. In this manner some information has been gained, but unfortunately, because of the great unevenness in the seasonal and geographical distribution of the data, it has been impossible to arrive at as satisfying a conclusion as was hoped for at first.

8. However, in some sea areas data are fairly abundant and it can be thought they will have some value and significance as basic information for production plans.

9. When we consider the distribution and migration of these fishes on the basis of their catch rates, the ordinary pattern which we find is for a plot of the curve of catch rates by months in a given sea area to have two peaks and two low points in the year, one pair in the summer and one pair in the winter. The catch rates go from their maximum to their minimum in about half a year. Consequently it is thought that there is a 1-year cycle in the movements of the schools.

10. As was just stated, two peaks in the catch rates in 1 year can be detected, but they appear to differ somewhat in character. It is believed that usually the peak which appears in the summer is made up of so-called "ascending fish" and that appearing in the winter is made up of the so-called "descending fish".

11. These two types of migration appear in some species to be divided into spawning migrations and food-seeking migrations. In the cases which are thought to be of the spawning migration type, dense schools appear over a rather broad sea area in an extremely short period of time and then disappear with equal rapidity so that it is difficult to follow the paths of their migrations. In the cases which are thought to represent food-seeking migrations, the schools appear to congregate gradually in a comparatively limited area, the movements of the schools are comparatively slow, and the paths of migration can be determined quite clearly.

12. Under present conditions the matters discussed in the preceding paragraph are still completely within the realm of hypothesis. They must be clarified in the future by tagging experiments, fish catch statistics, and biological studies, but they are believed to have an important significance both from the point of view of the commercial fishery and from the point of view of population studies.

APPENDED CHARTS OF THE FISHING GROUNDS

(Translator's note: The following charts have been given the same numbers by which they were referred to in the text, however, they have been bound out of numerical order, with the larger charts last, for convenience in making up the book. This inconsistency, although regrettable, is necessitated by a similar inconsistency in the make-up of the original work.)

Chart IIa-e

Albacore catch rate distribution by months for January, February, March, November, and December. The figures inside the 1-degree squares are average catch rates (fish caught per 100 hooks fished per day). The vertical hatching indicates rates of 1.0 to 3.0, oblique hatching 3.0 to 5.0, and cross-hatching over 5.0, however, this code is not used consistently. Squares containing zeros are those in which some fishing was recorded without any catch of albacore.

Chart VIf-k

Distribution of broadbill swordfish catch rates by months for January, February, March, October, November, and December. Squares with average rates of 1.0 or more are shaded.

Chart I

This chart of the combined average catch rates for all species of tuna and spearfish has been omitted from the translation.

Chart III

Distribution of bigeye catch rates. The figures within each 1-degree square are from top to bottom the average catch rate, the total number of hooks fished, and the number of stations fished. The shaded squares are those in which rates greater than 1.0 were recorded.

Chart IV

Distribution of yellowfin catch rates. Dark shaded squares are those with catch rates greater than 5.0, diagonally hatched squares are those with rates of 3.0 to 5.0, and gray shaded squares had rates of 1.0 to 3.0.

Chart V

Distribution of spearfish catch rates, all species combined. The 1-degree squares with catch rates of 1.0 or more are shaded.

CHART IIa

ビンナガ漁場圖（一　月）ALBACORE (JANUARY)

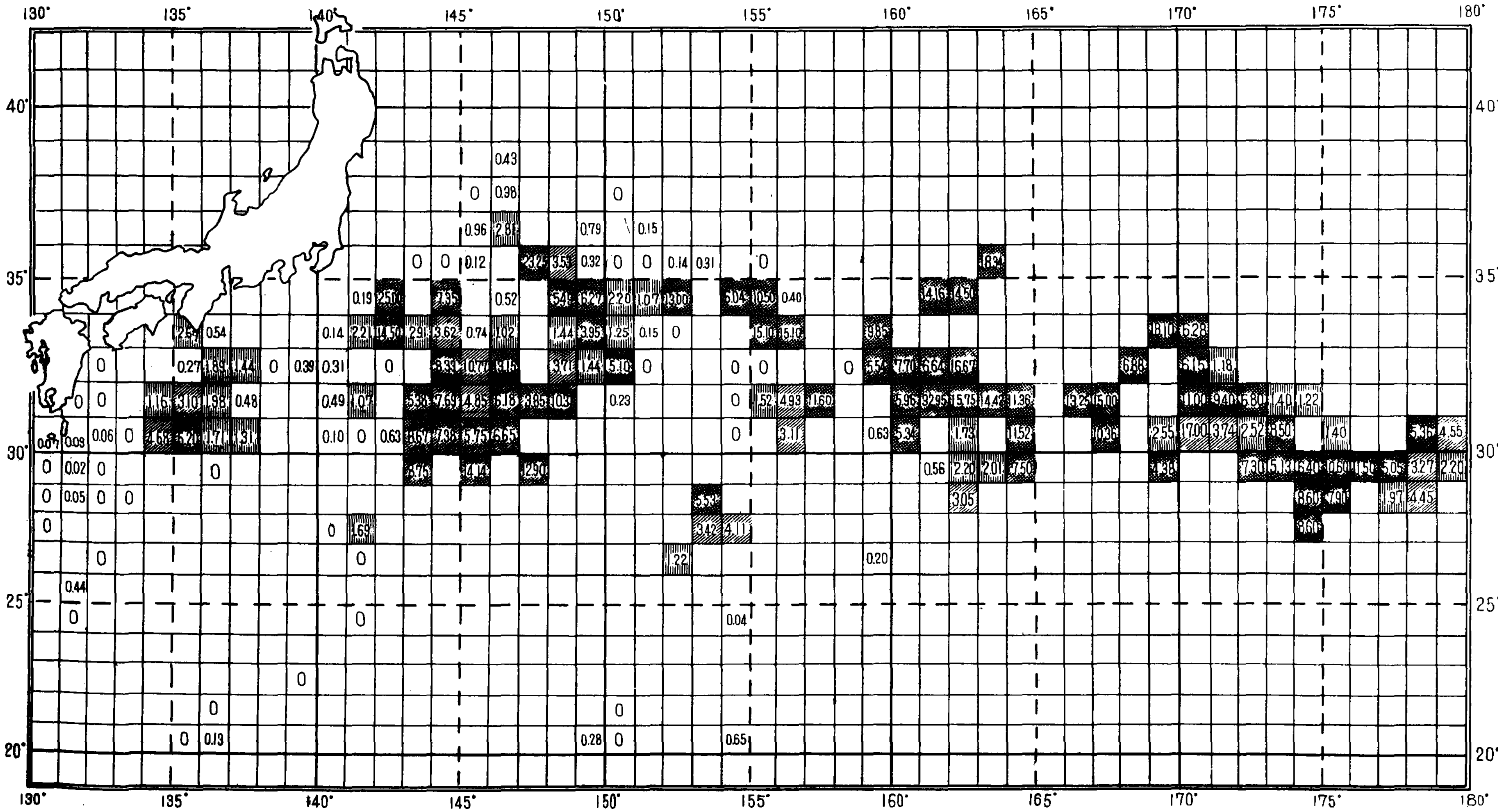


CHART IIb

ビンナガ漁場圖（二　月）ALBACORE (FEBRUARY)

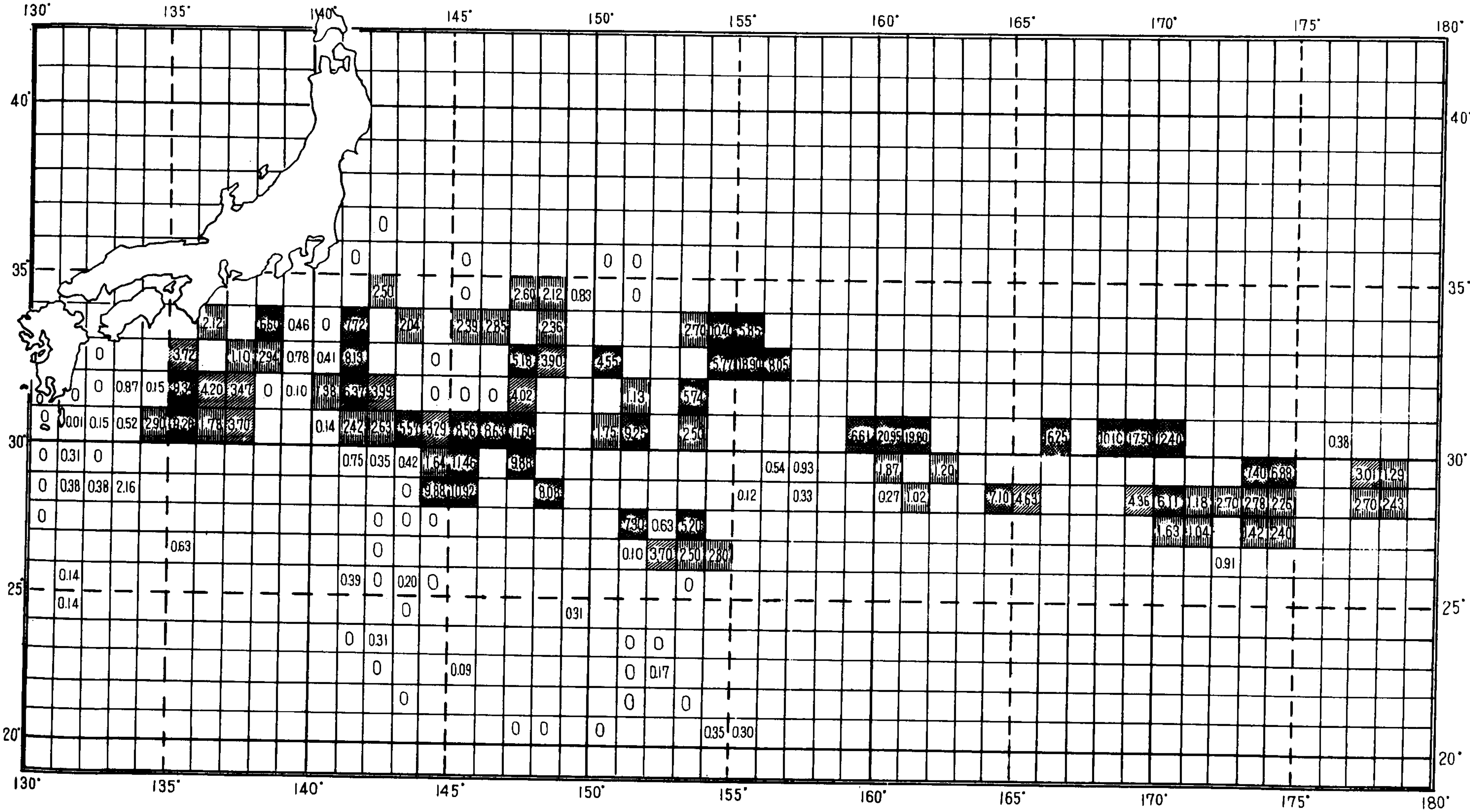


CHART IIc

ビンナガ漁場圖（三　月）ALBACORE（MARCH）

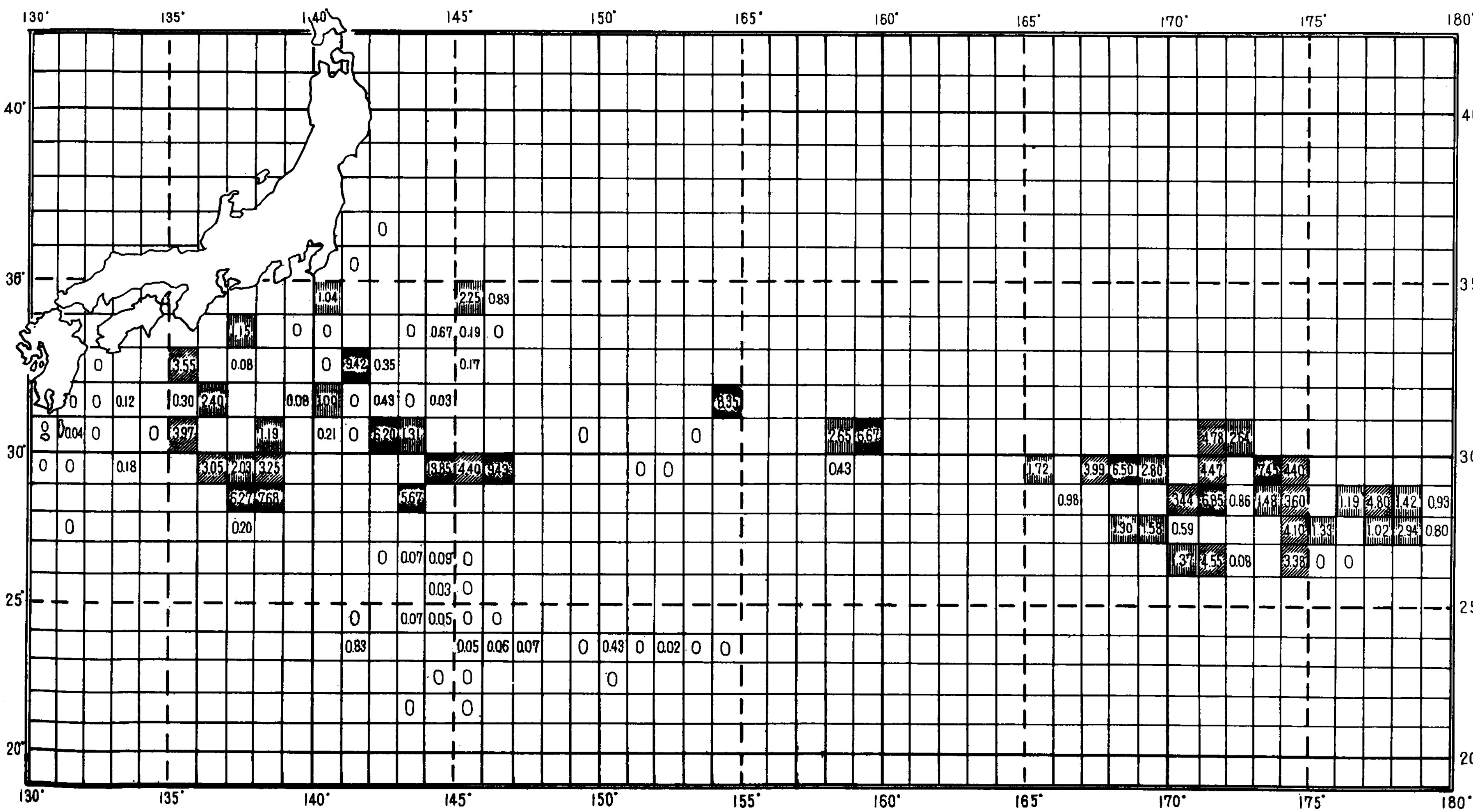


CHART IId

ビンナガ漁場圖（十一月）ALBACORE (NOVEMBER)

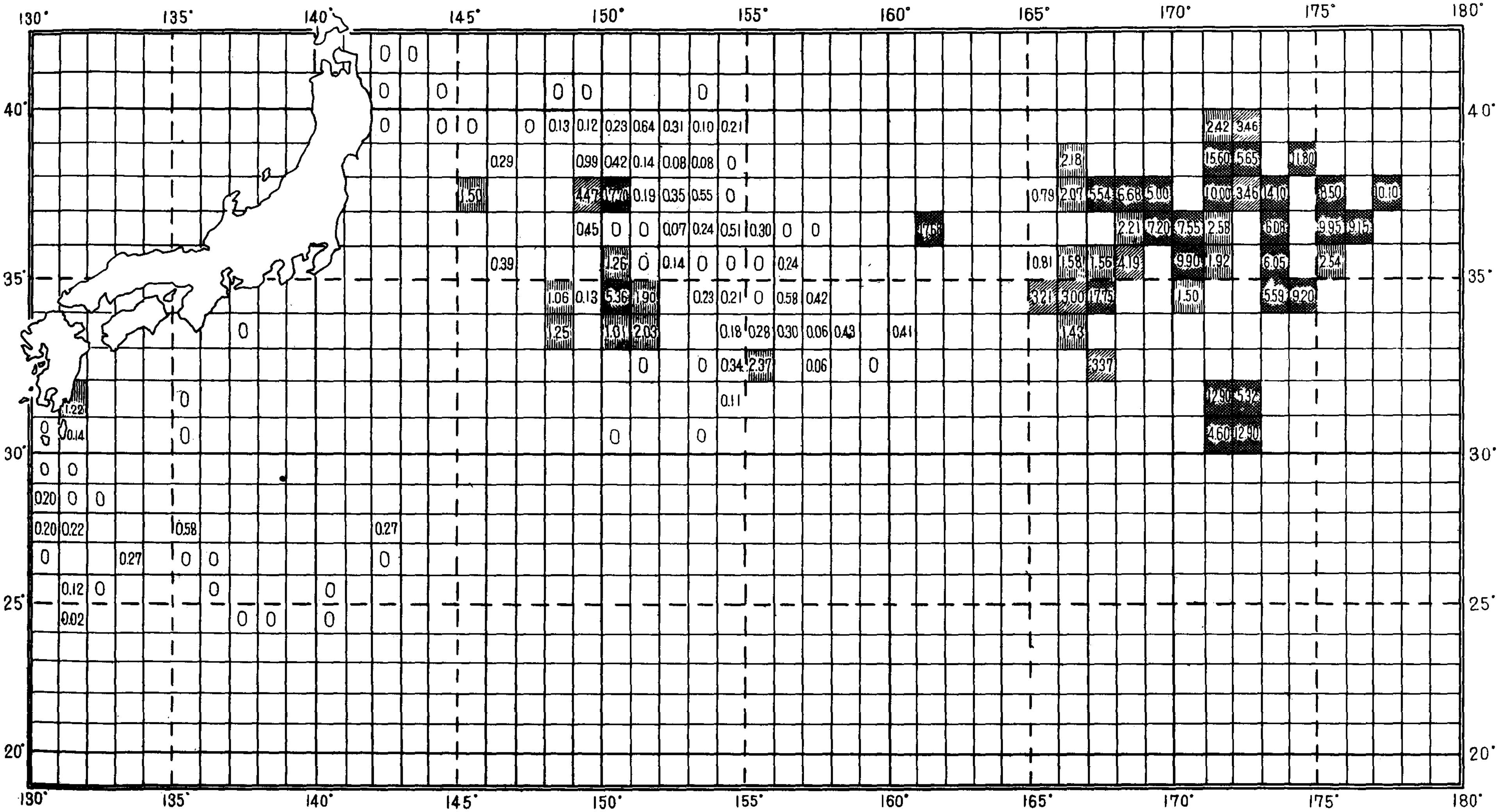


CHART IIe

ビンナガ漁場圖（十二月）ALBACORE (DECEMBER)

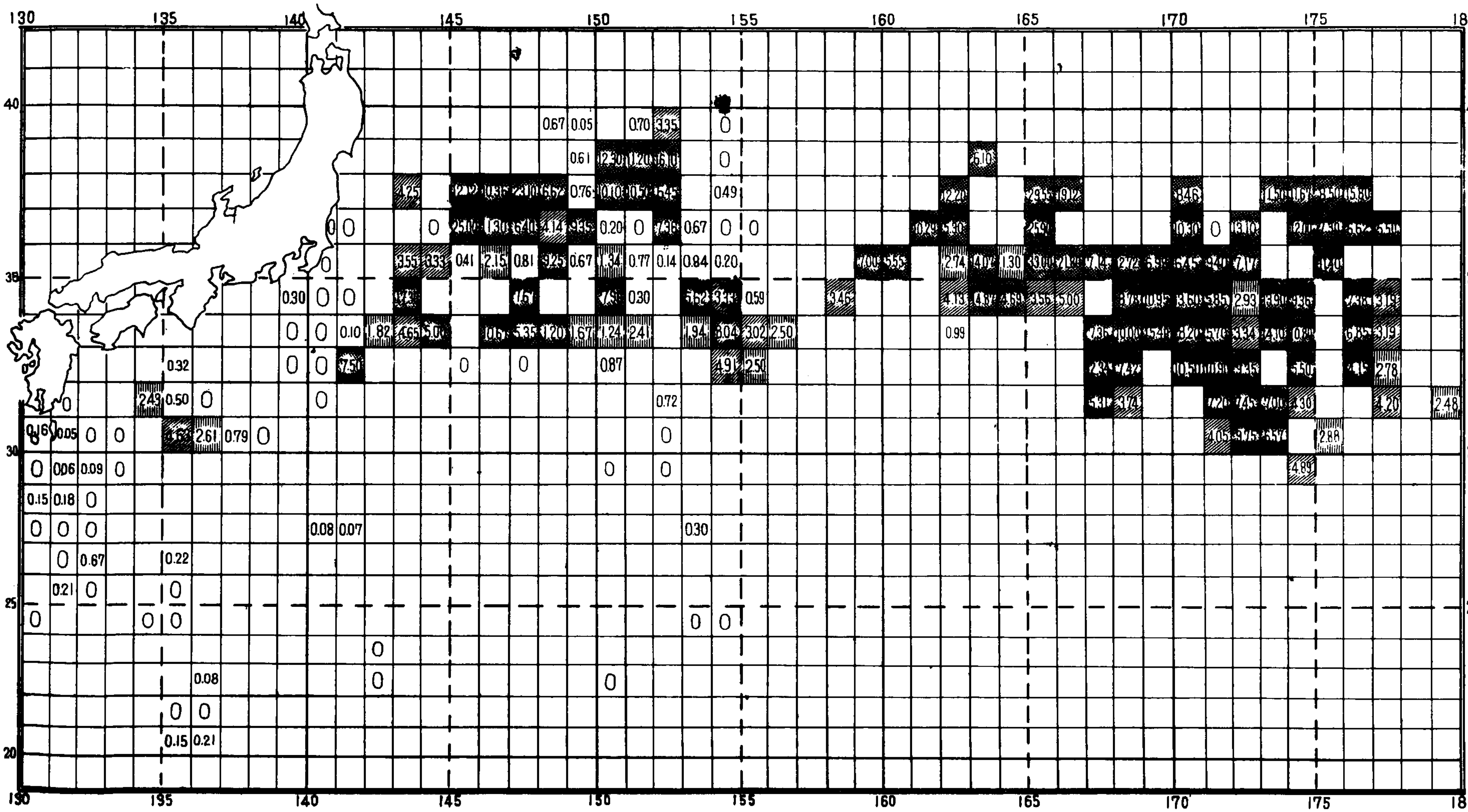


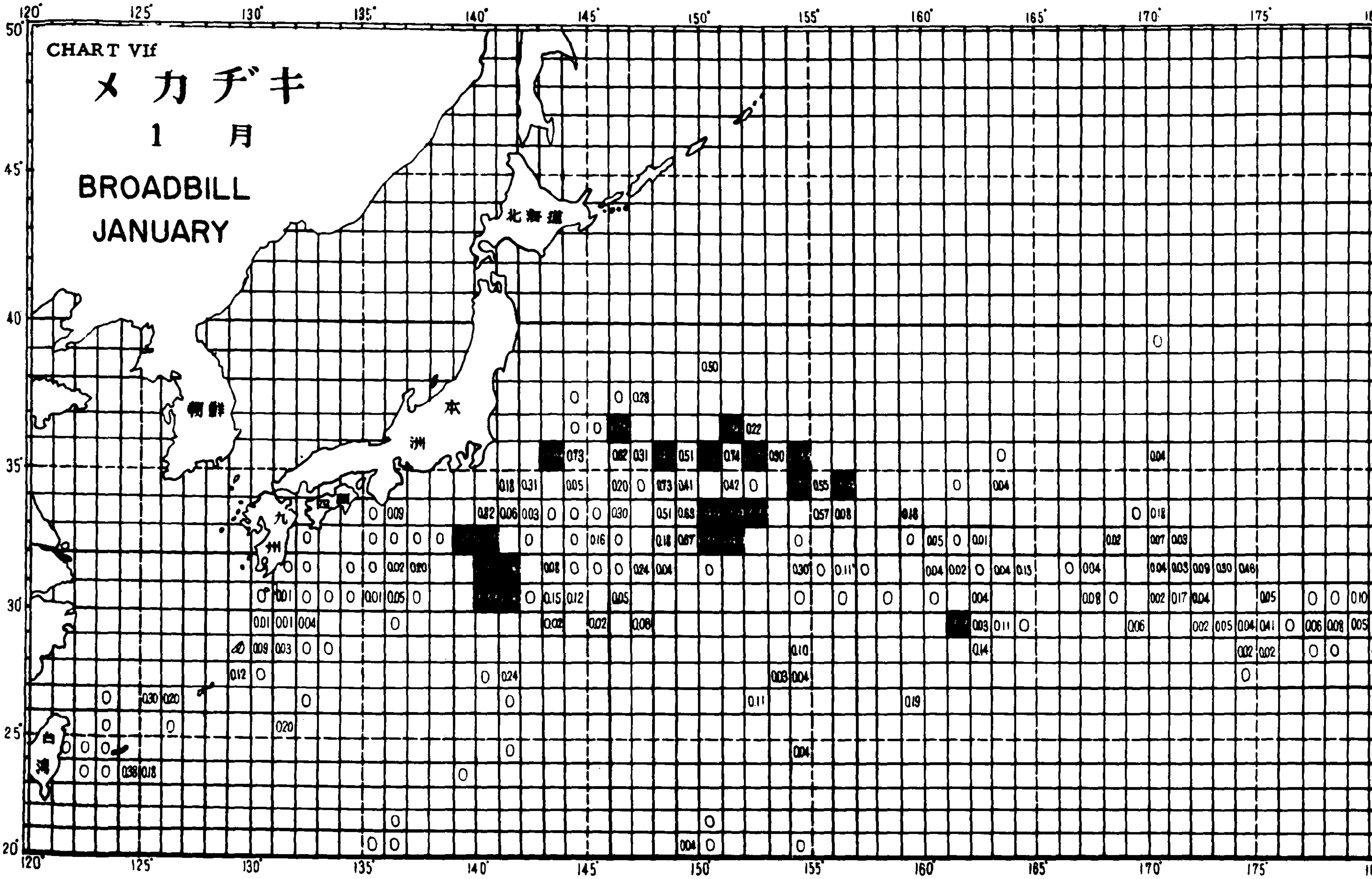
CHART VIf

メカヂキ

1 月

BROADBILL

JANUARY



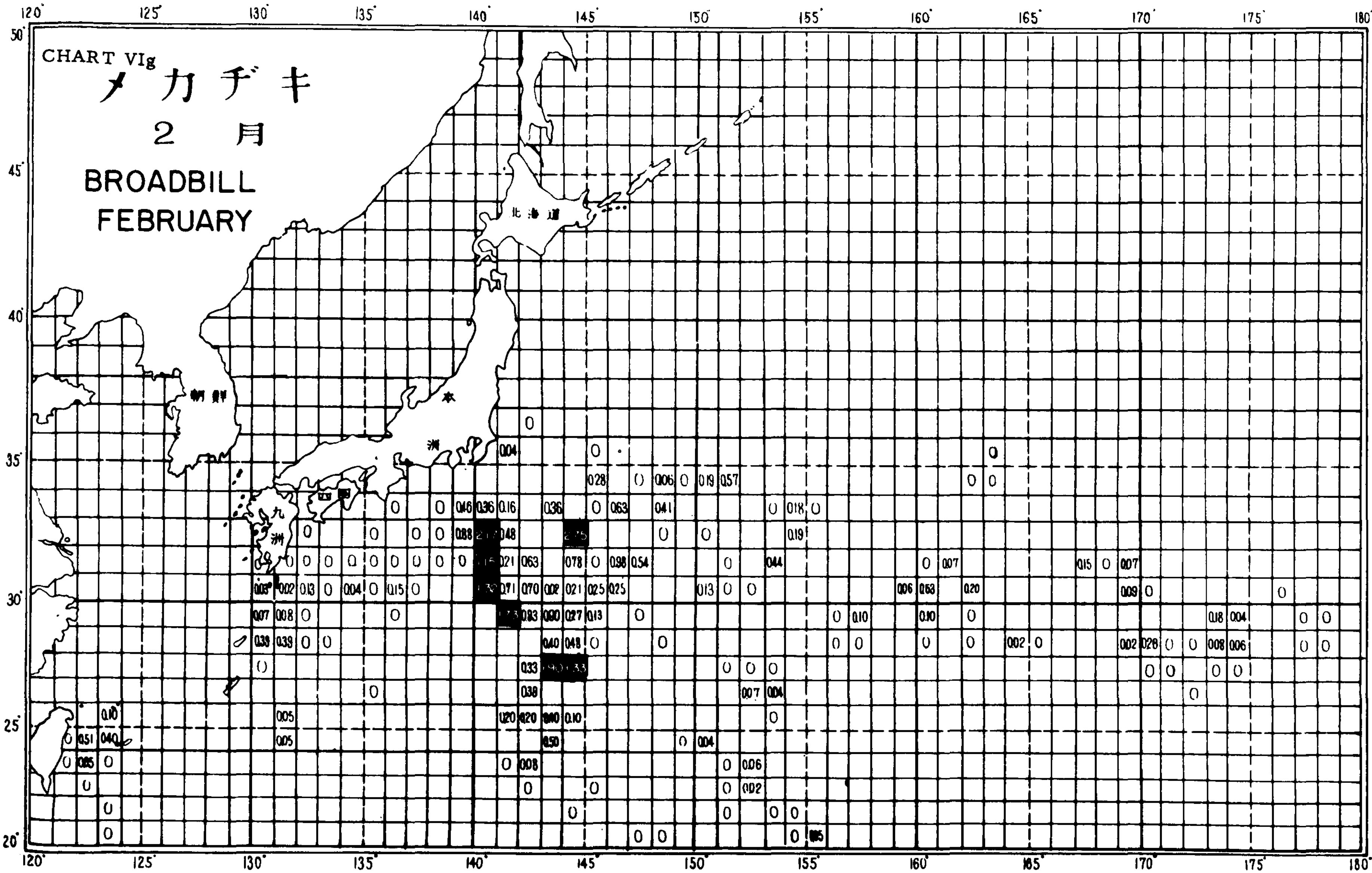


CHART VIg
メカヂキ
2月
BROADBILL
FEBRUARY
北海道
本洲
九洲
朝鮮

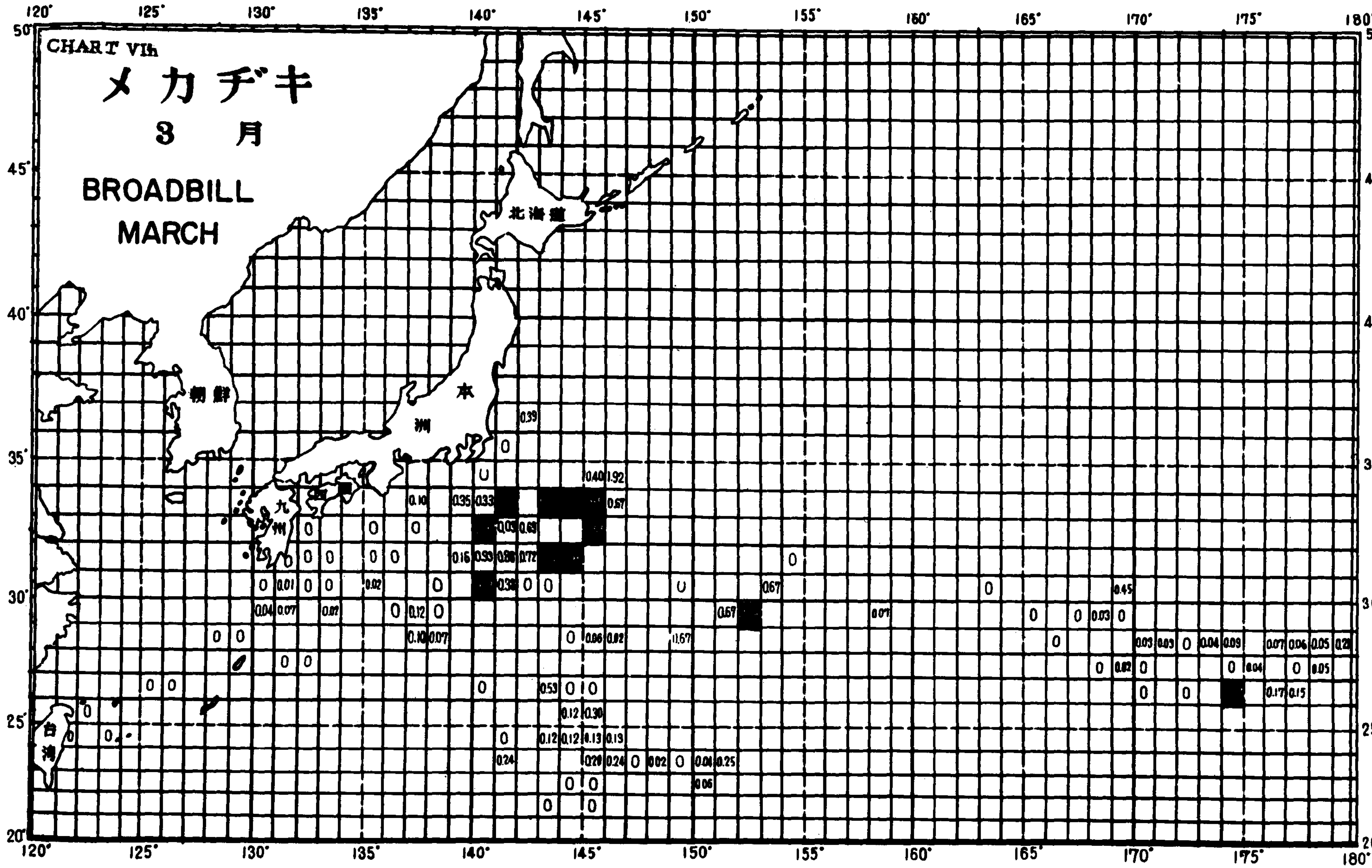


CHART VIh
メカヂキ
3 月
BROADBILL
MARCH
北海道
本
洲
朝鮮
九
州
台
湾

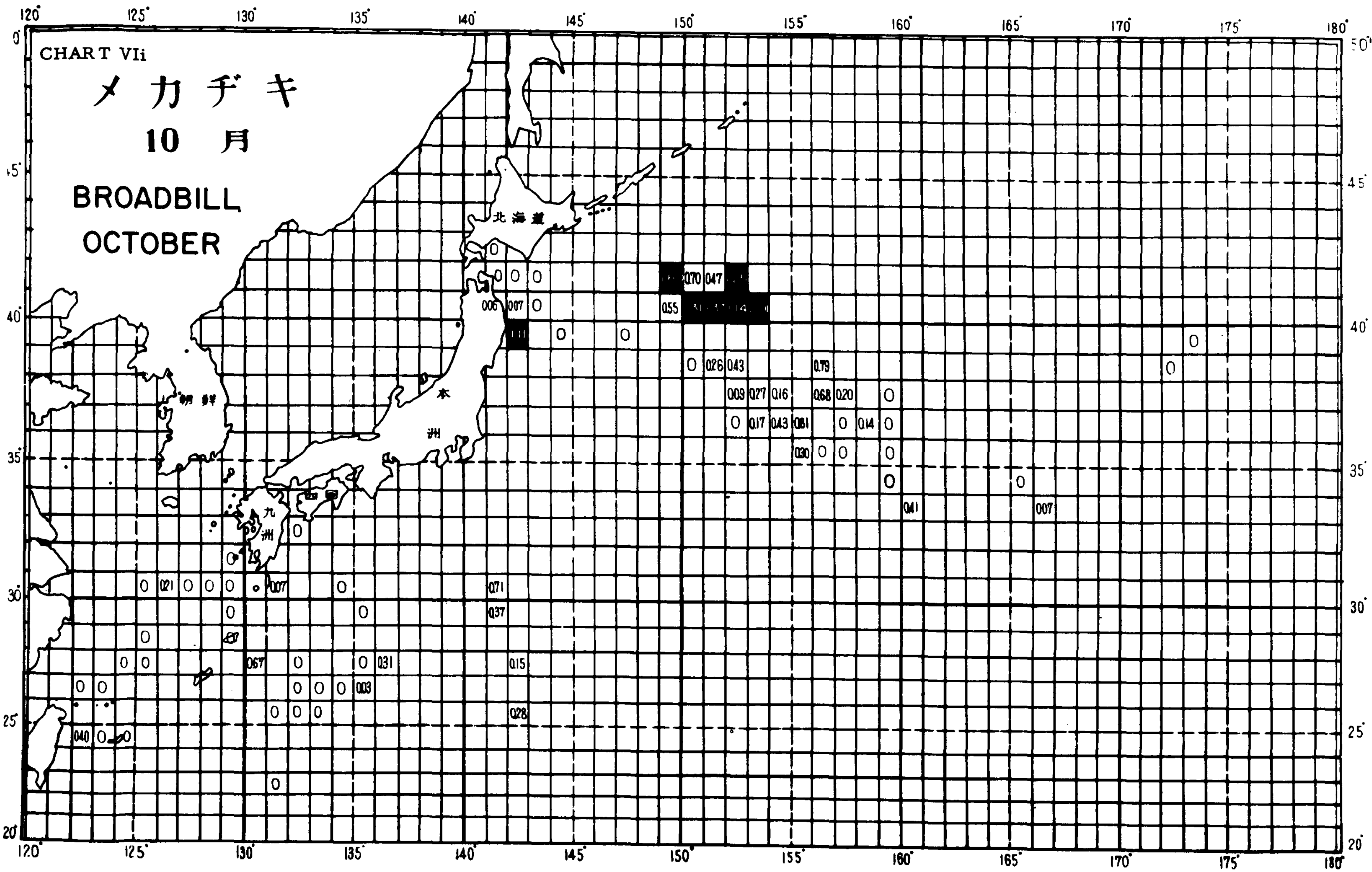


CHART VIi
メカヂキ
10 月
BROADBILL
OCTOBER
北海道
本洲
九洲
朝鮮

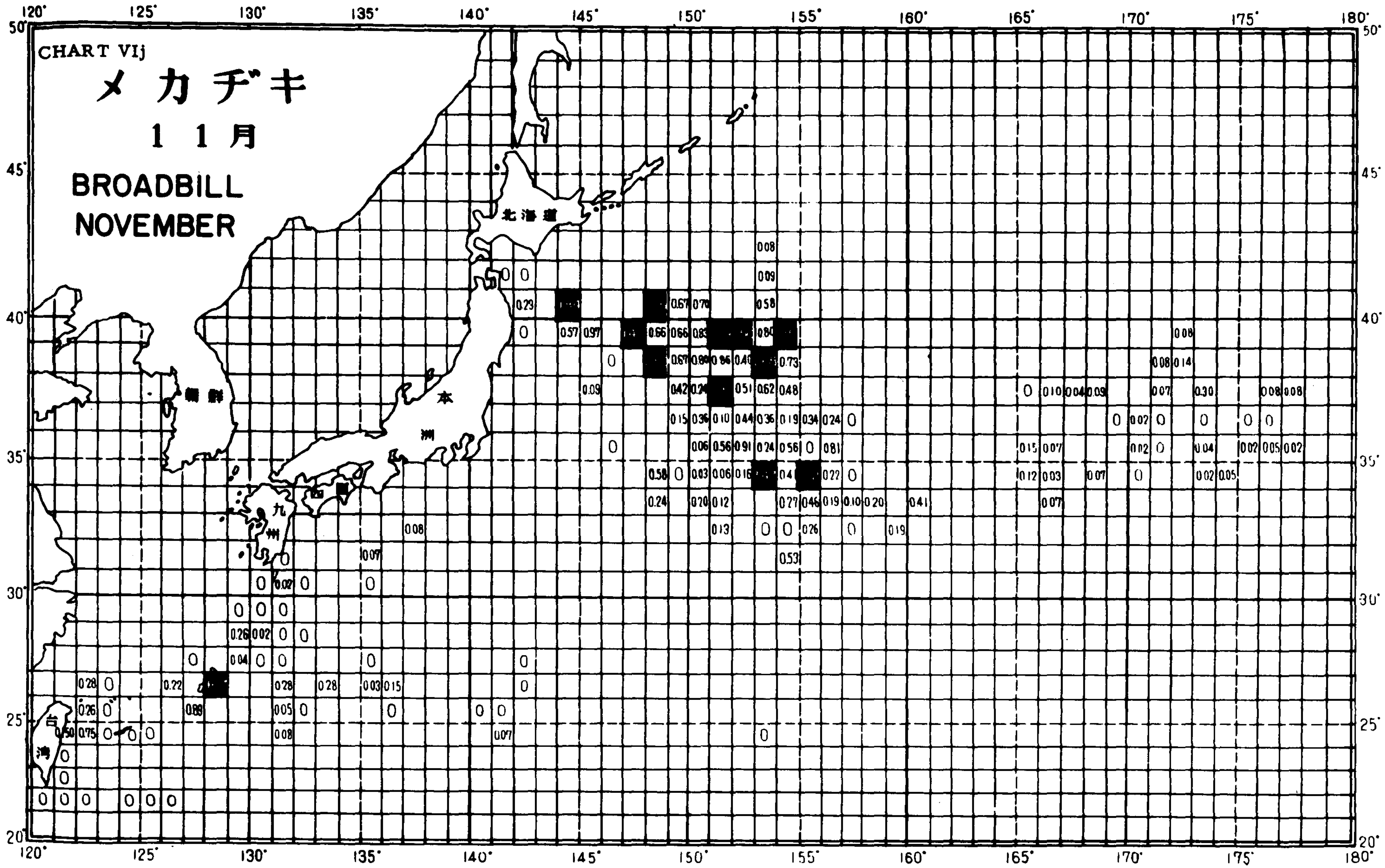


CHART VIj
メカヂキ
11月
BROADBILL
NOVEMBER

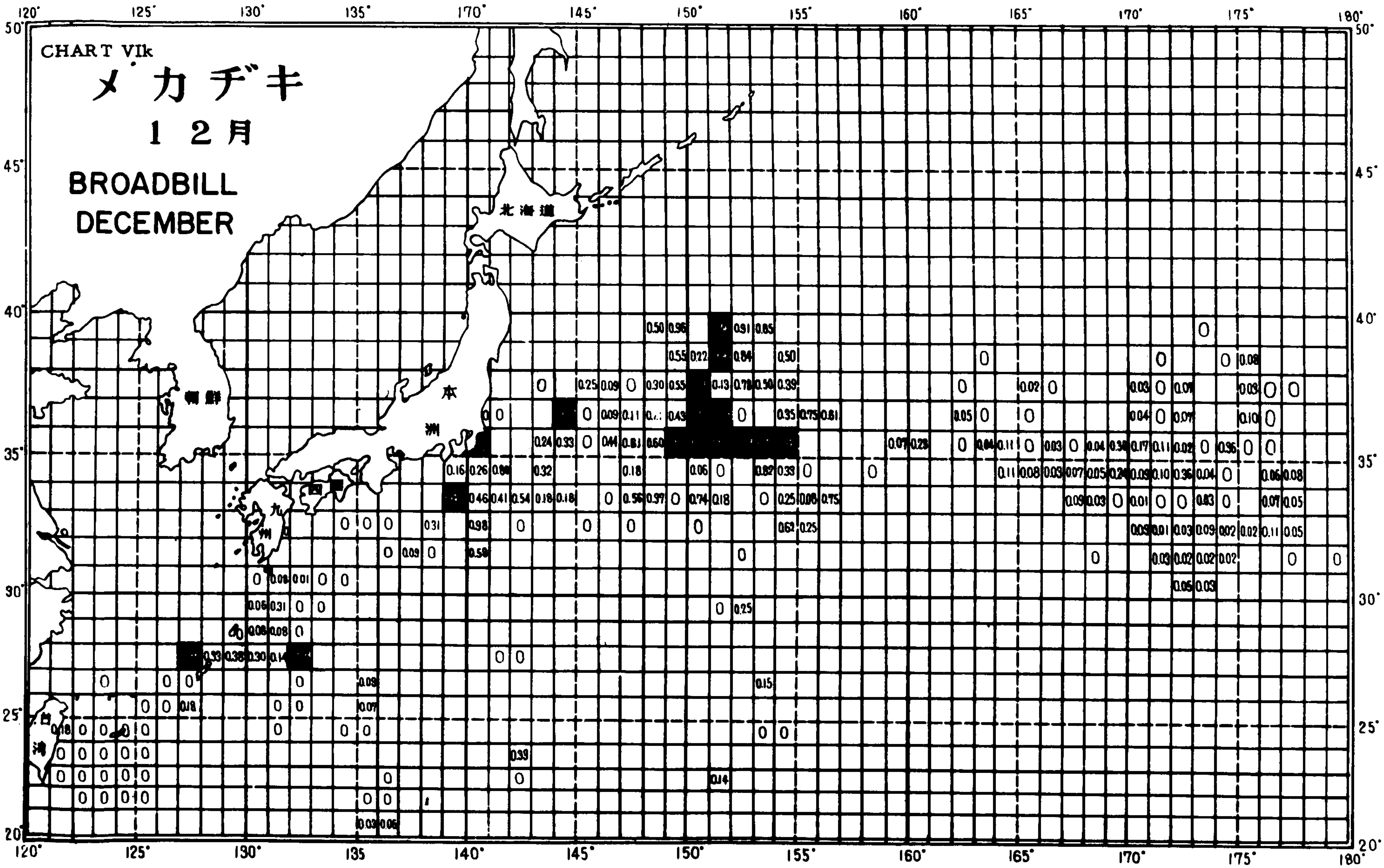


CHART VIk
メカヂキ
１２月
BROADBILL
DECEMBER
北海道
本
洲
朝鮮
九
州
四
台
湾

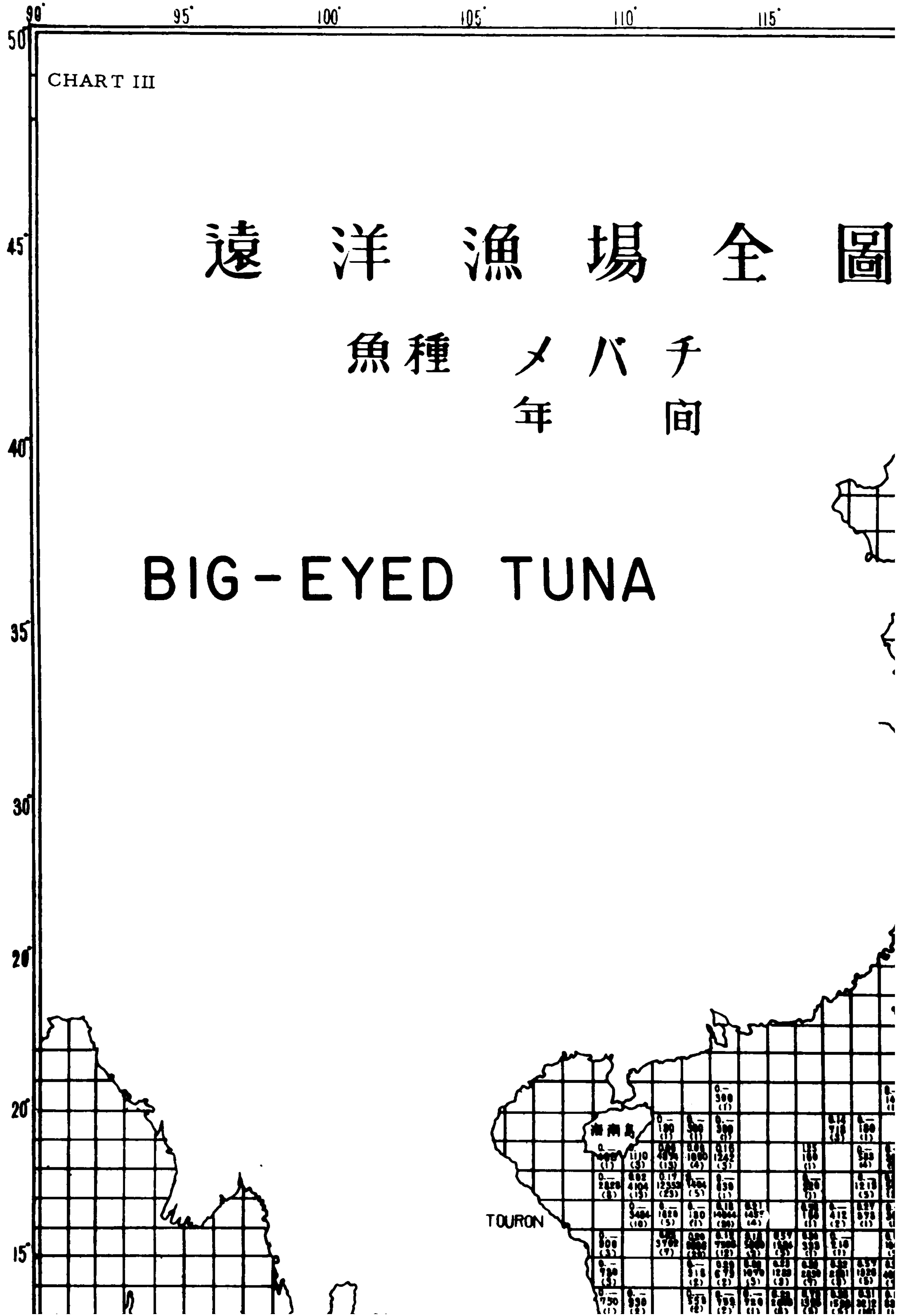


CHART III
遠 洋 漁 場 全 圖
魚種 メ バ チ
年 間
BIG-EYED TUNA
TOURON
海南島
90°
95°
100°
105°
110°
115°
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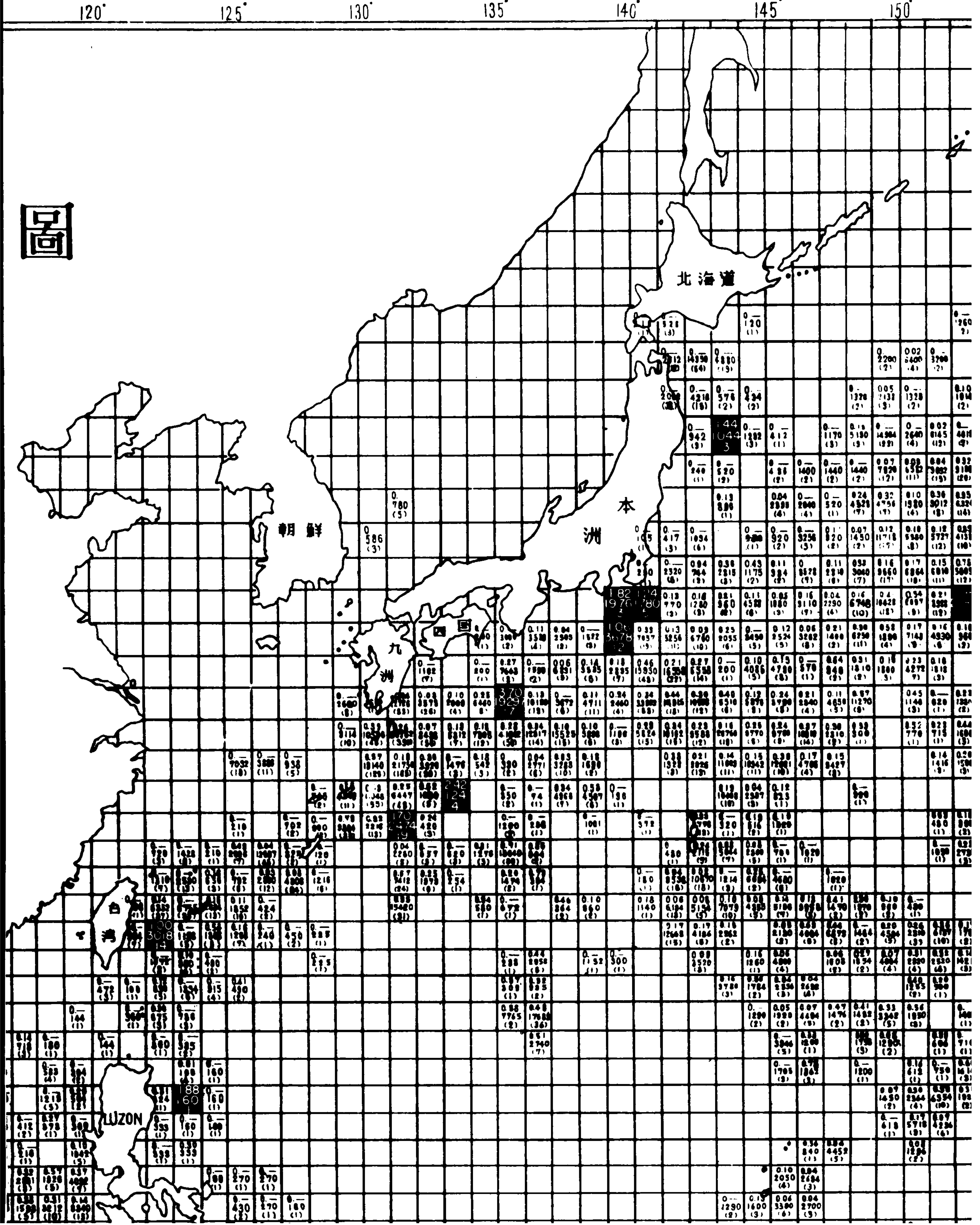
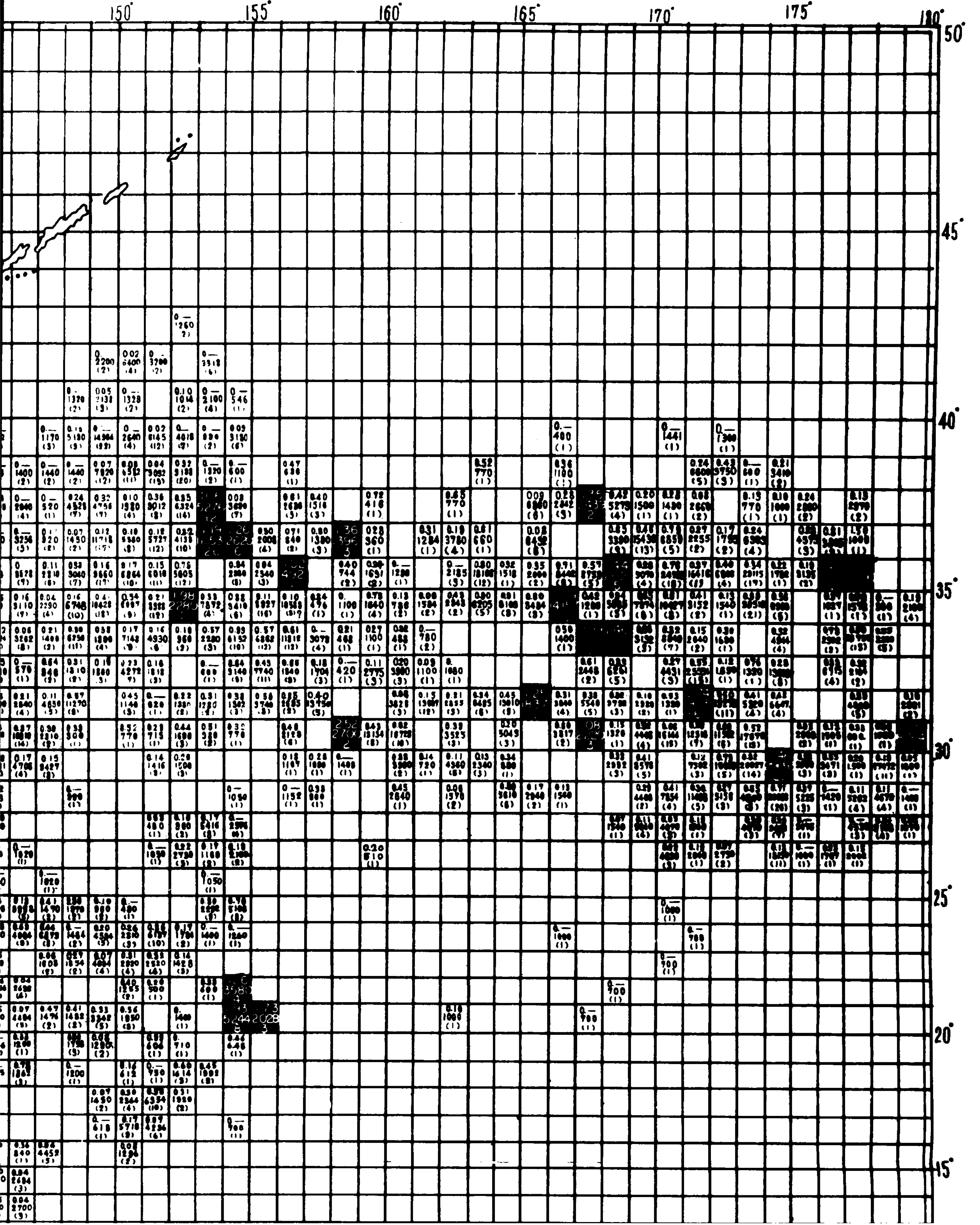
20°
15°

圖

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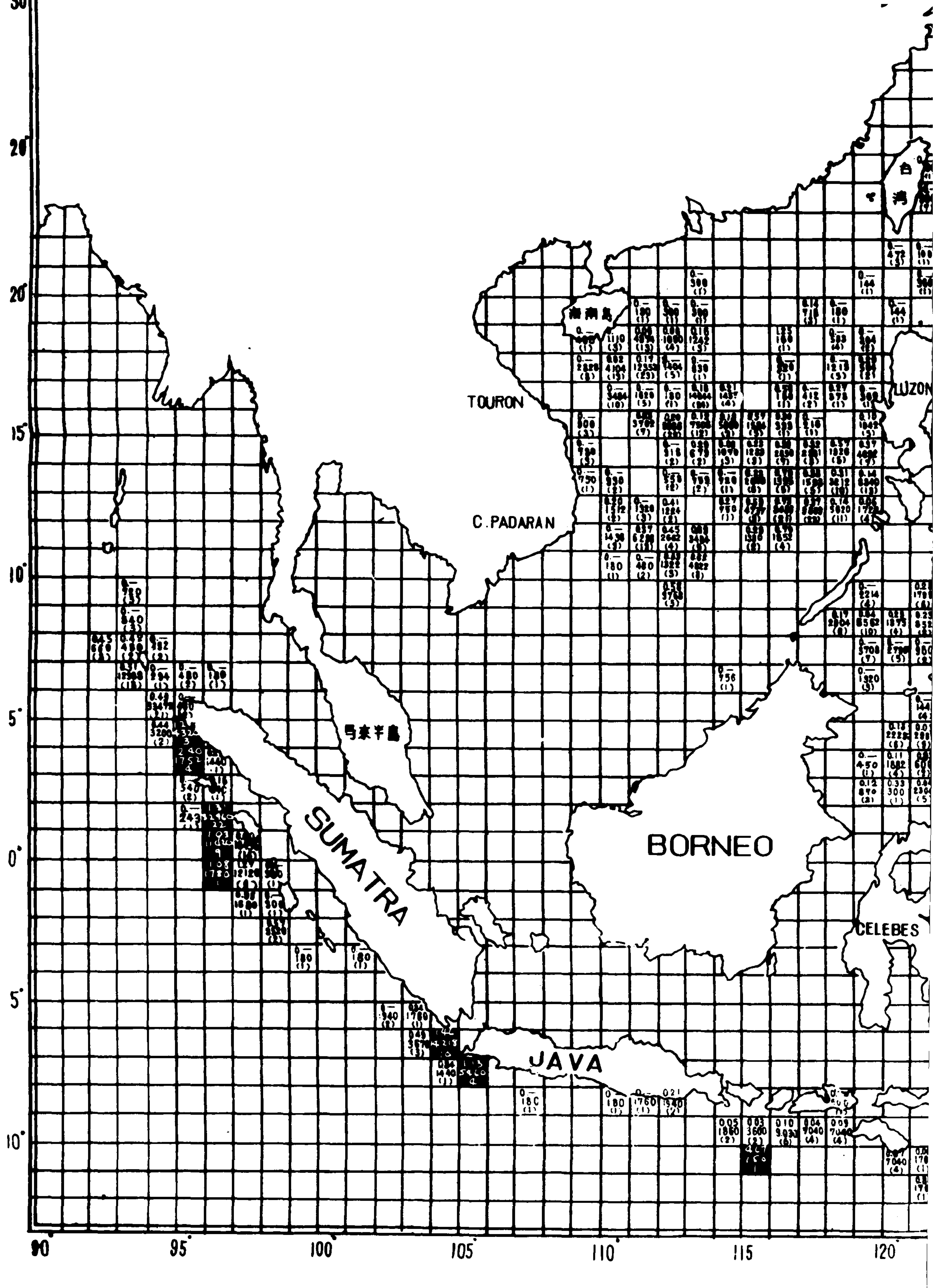

TOURON
C.PADARAN
LUZON
SUMATRA
BORNEO
JAVA
CELEBES
海南島
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15°
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90
95°
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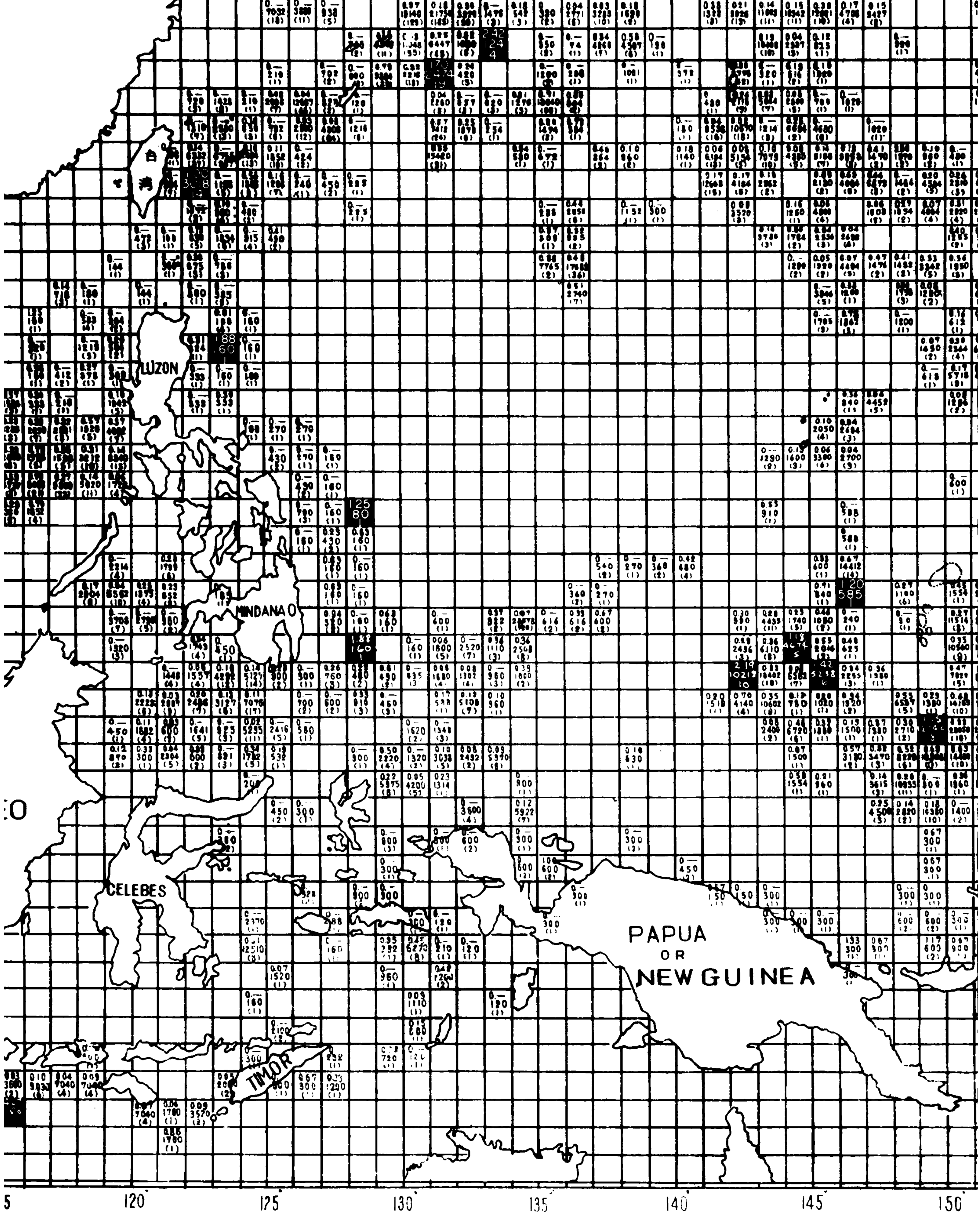
120°


台湾
LUZON
MINDANAO
CELEBES
TIMOR
PAPUA
OR
NEW GUINEA
120°
125°
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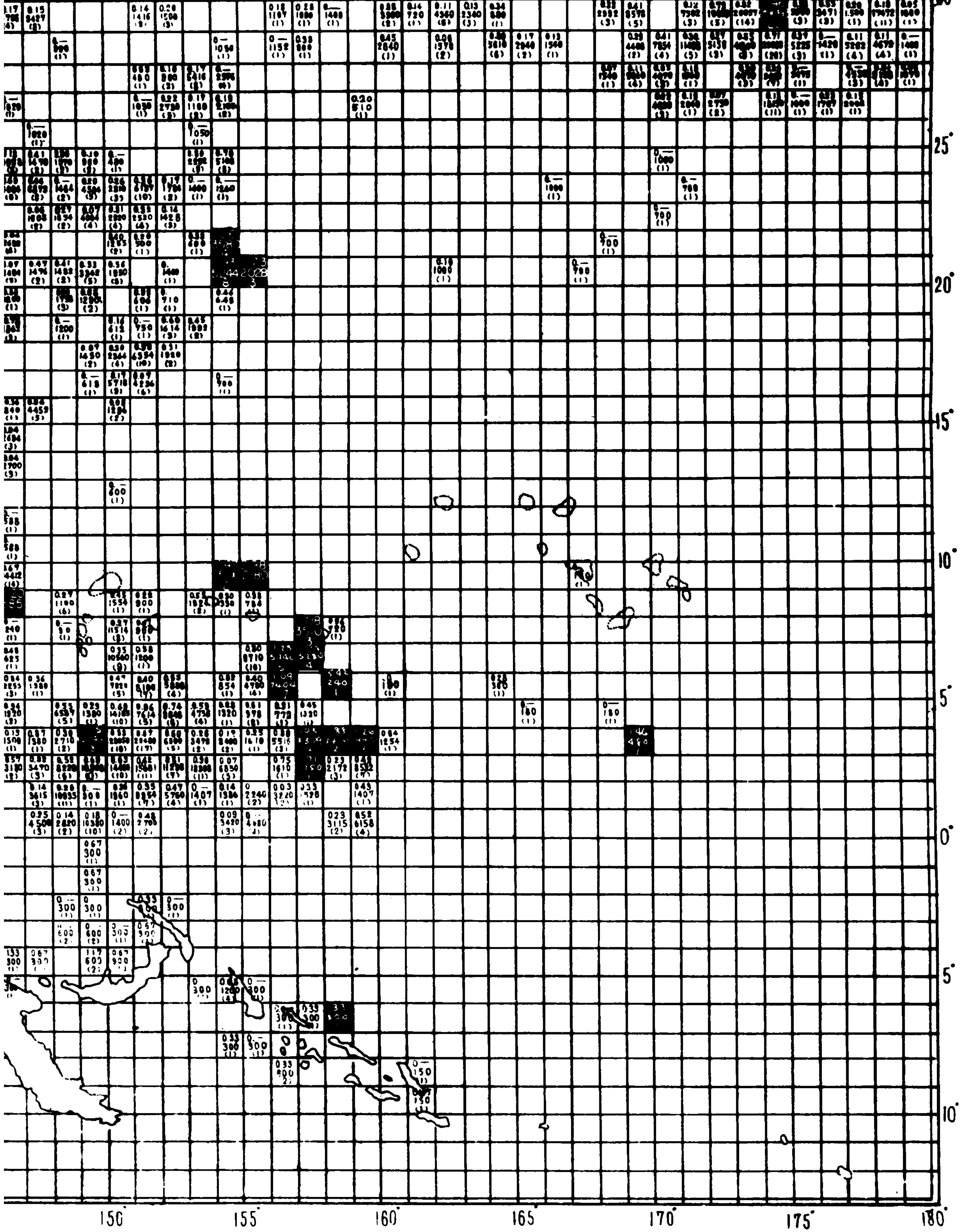
140°
145°
150°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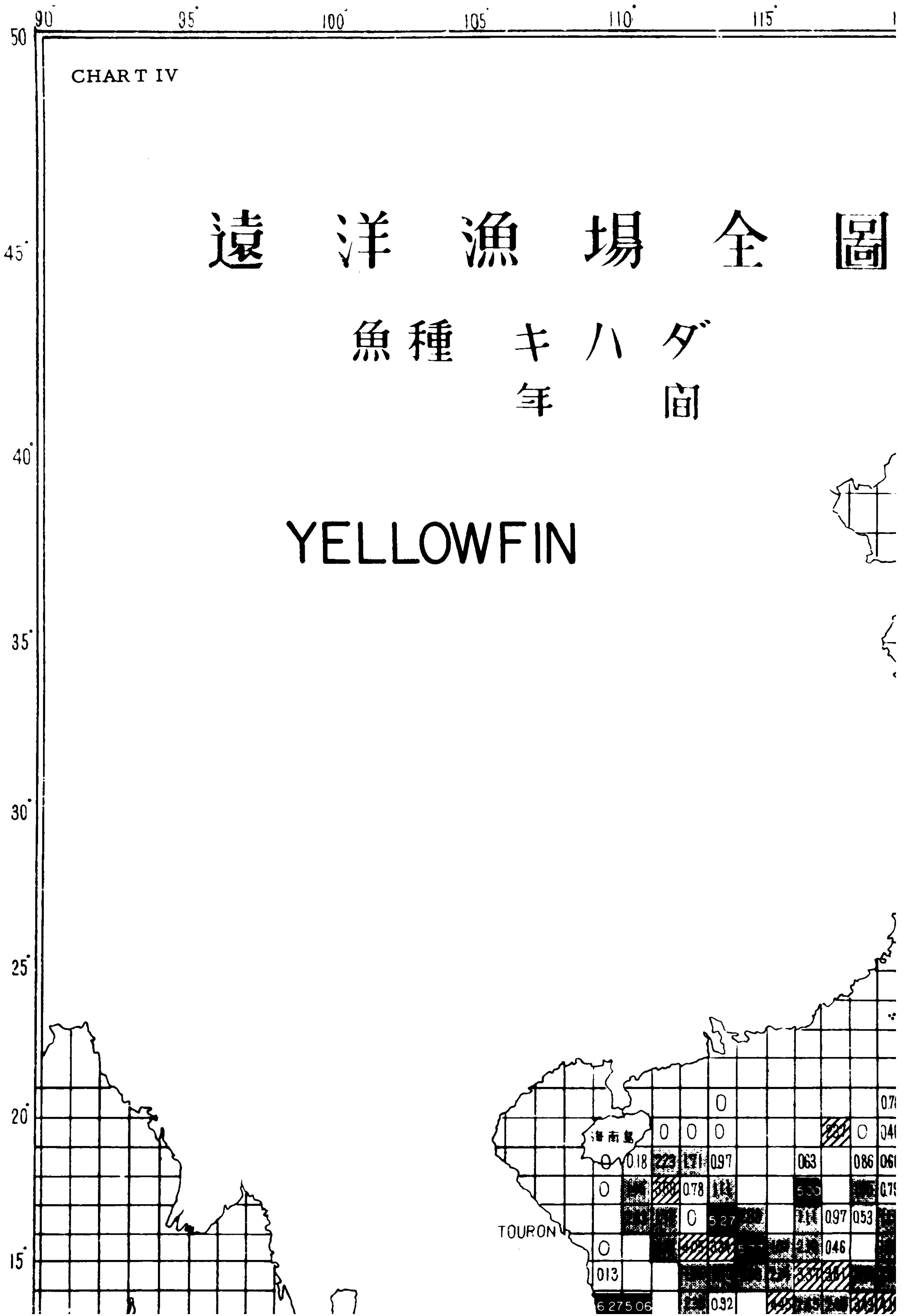

CHART IV
遠洋漁場全圖
魚種　キハダ
年　間
YELLOWFIN
海南島
TOURON
90°
95°
100°
105°
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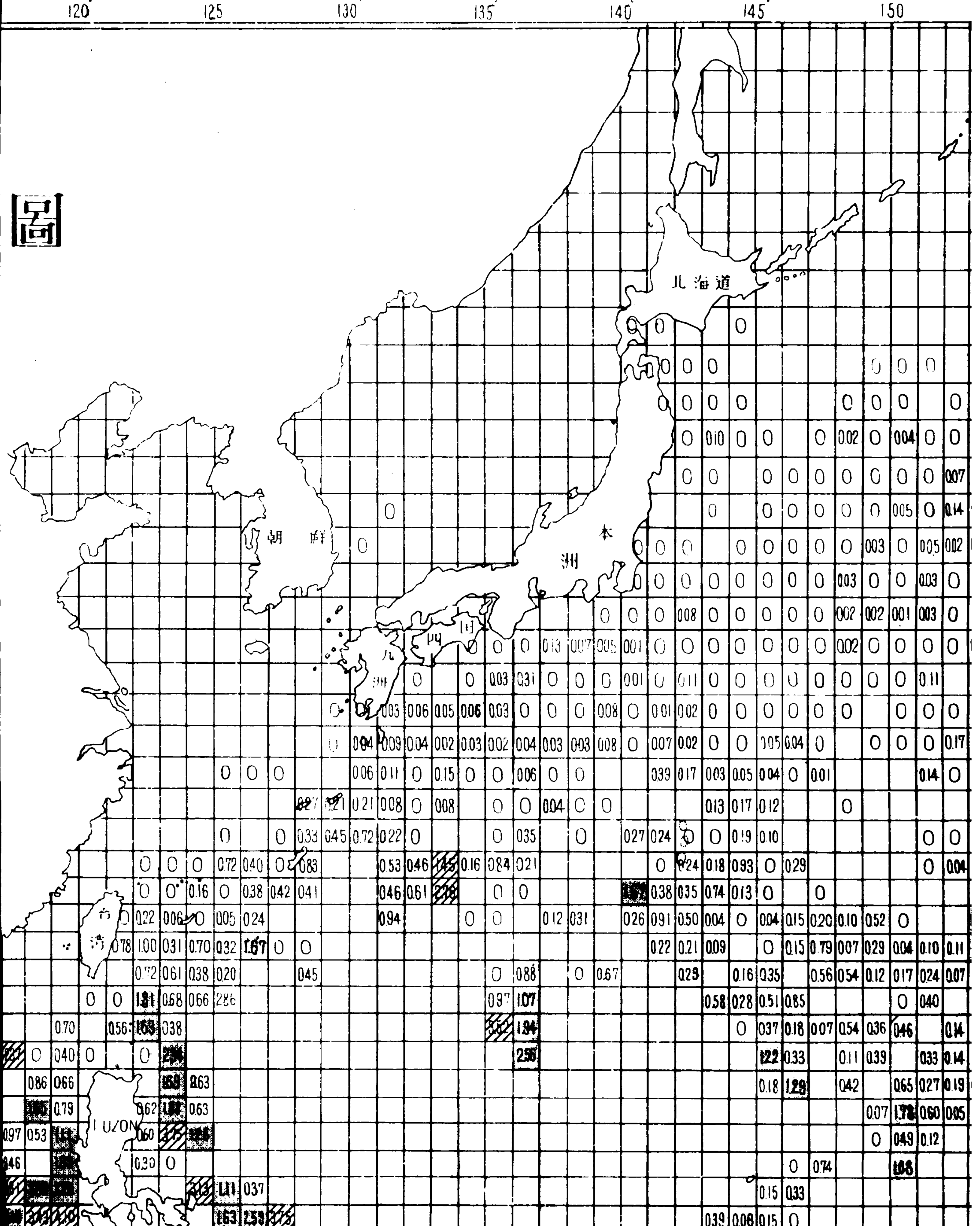
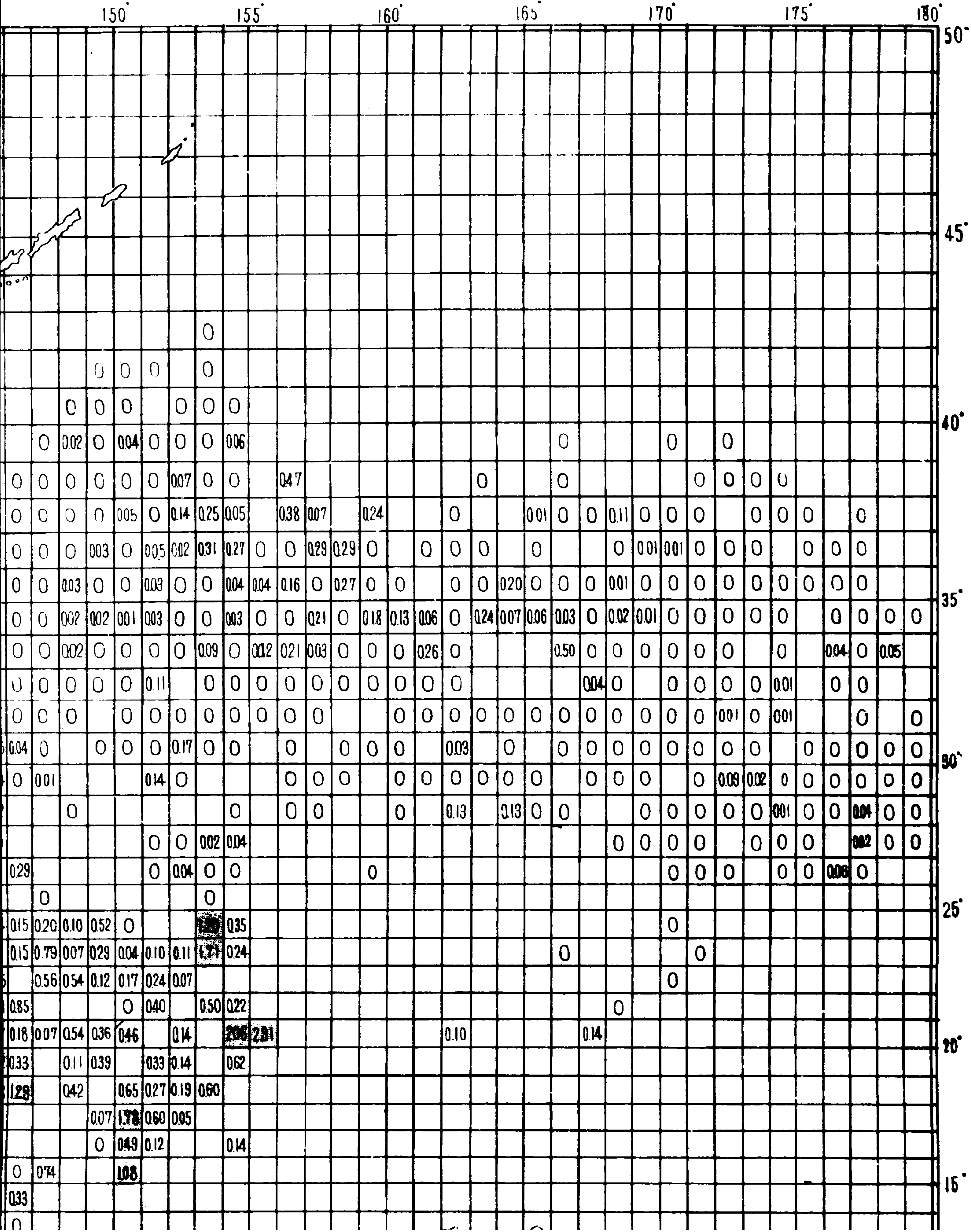
圖

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0 0 0 0 0 0 0
0 0.02 0 0.04 0 0 0 0.06 0 0 0
0 0 0 0 0 0 0.07 0 0 0.47 0 0 0 0 0 0 0
0 0 0 0 0.05 0 0.14 0.25 0.05 0.38 0.07 0.24 0 0.01 0 0 0.11 0 0 0 0 0 0 0
0 0 0 0.03 0 0.05 0.02 0.31 0.27 0 0 0.29 0.29 0 0 0 0 0 0 0.01 0.01 0 0 0 0 0 0
0 0 0.03 0 0 0.03 0 0 0.04 0.04 0.16 0 0.27 0 0 0 0 0.20 0 0 0 0.01 0 0 0 0 0 0 0 0 0 0
0 0 0.02 0.02 0.01 0.03 0 0 0.03 0 0 0.21 0 0.18 0.13 0.06 0 0.24 0.07 0.06 0.03 0 0.02 0.01 0 0 0 0 0 0 0 0 0
0 0 0.02 0 0 0 0 0.09 0 0.12 0.21 0.03 0 0 0 0.26 0 0.50 0 0 0 0 0 0 0 0.04 0 0.05
0 0 0 0 0 0.11 0 0 0 0 0 0 0 0 0 0 0.04 0 0 0 0 0 0.01 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.01 0 0.01 0 0
0.04 0 0 0 0 0.17 0 0 0 0 0 0 0.03 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0.01 0.14 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.09 0.02 0 0 0 0 0 0
0 0 0 0 0 0.13 0.13 0 0 0 0 0 0 0 0.01 0 0 0.04 0 0
0 0 0.02 0.04 0 0 0 0 0 0 0 0.02 0 0
0.29 0 0.04 0 0 0 0 0 0 0 0 0.06 0
0 0
0.15 0.20 0.10 0.52 0 0.35 0
0.15 0.79 0.07 0.29 0.04 0.10 0.11 0.24 0 0
0.56 0.54 0.12 0.17 0.24 0.07 0
0.85 0 0.40 0.50 0.22 0
0.18 0.07 0.54 0.36 0.46 0.14 0.10 0.14
0.33 0.11 0.39 0.33 0.14 0.62
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0.33
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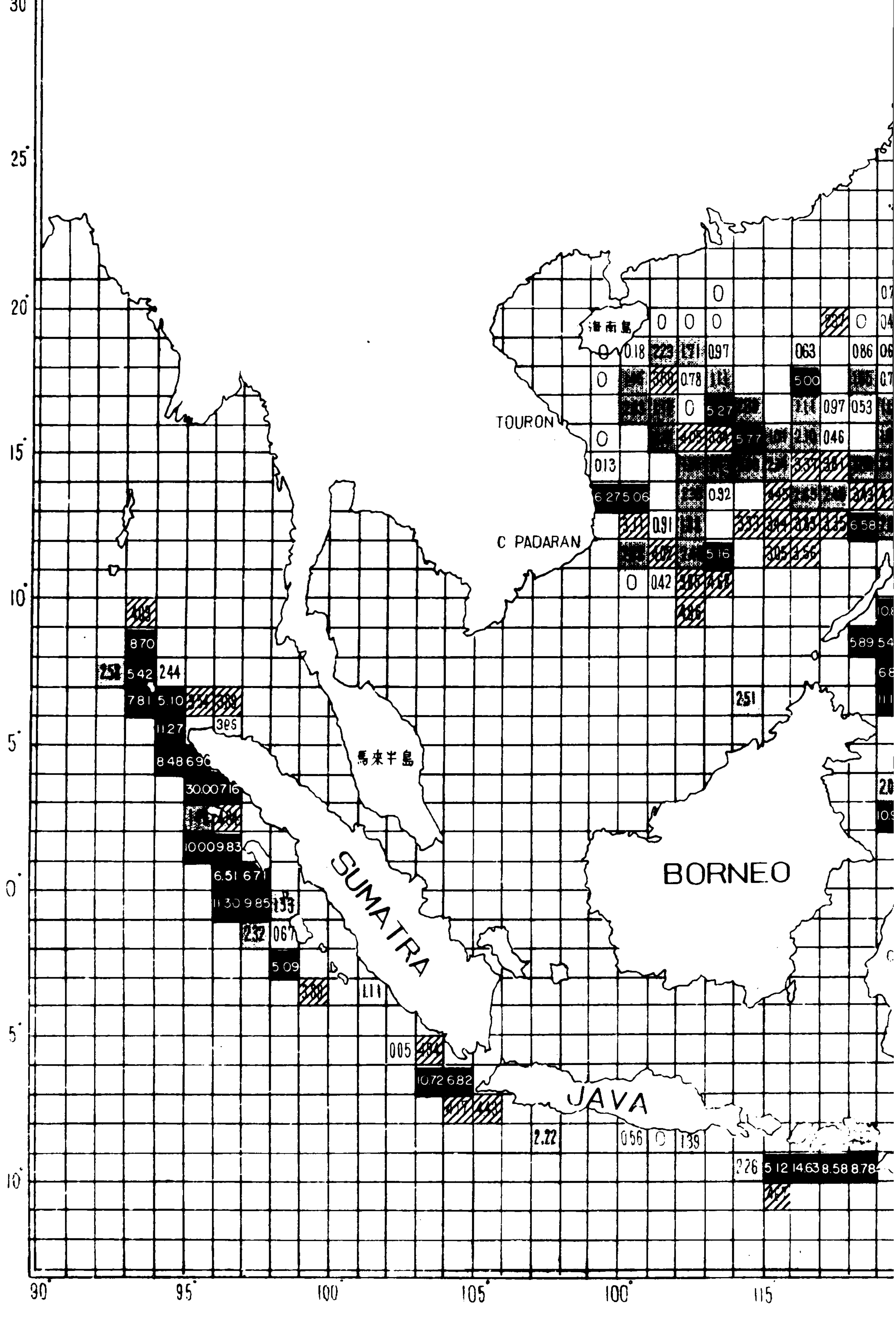

海南島
TOURON
C PADARAN
馬來半島
SUMATRA
BORNEO
JAVA
30°
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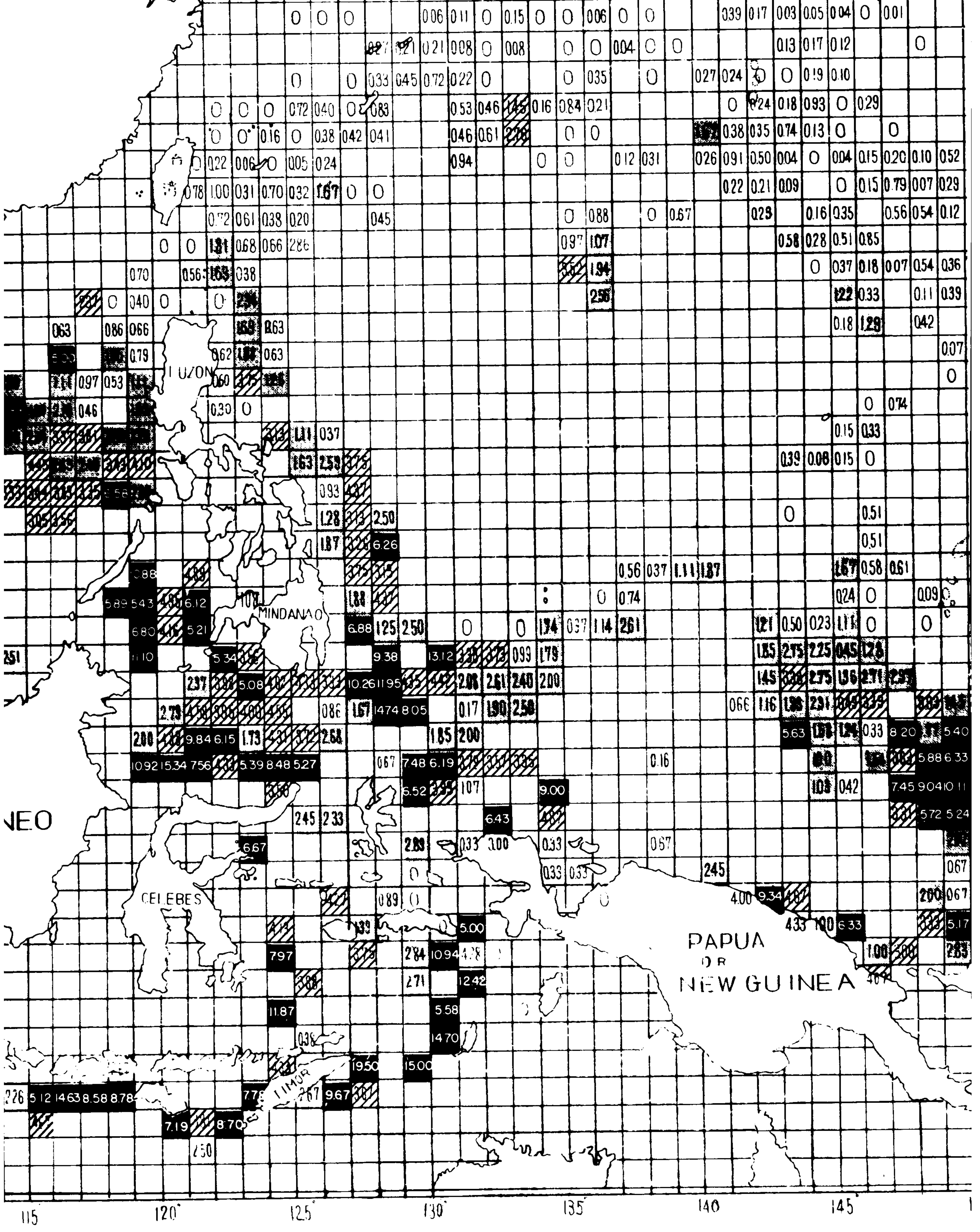
LUZON
MINDANAO
NEO
CELEBES
TIMOR
PAPUA
OR
NEW GUINEA
115°
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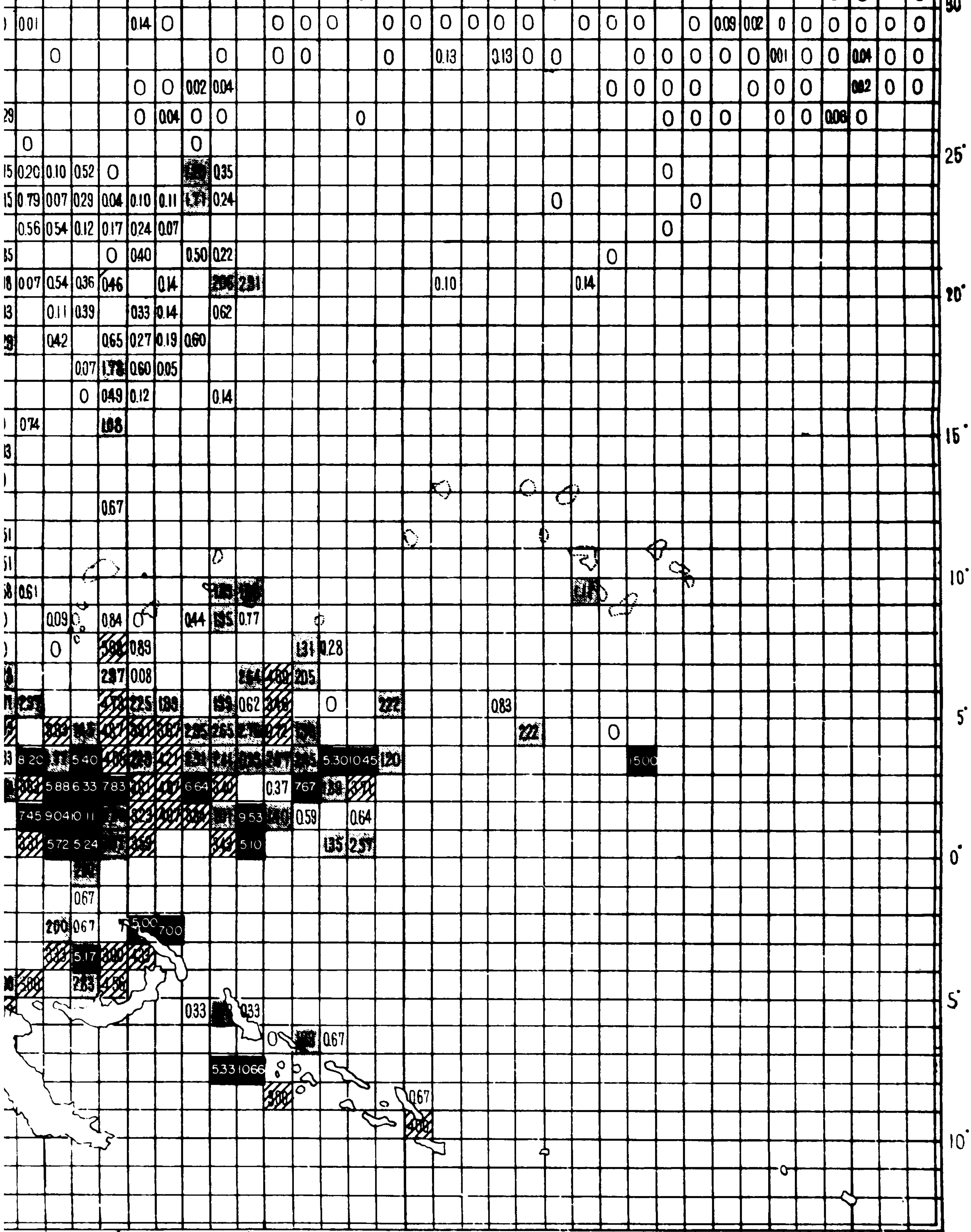

25°
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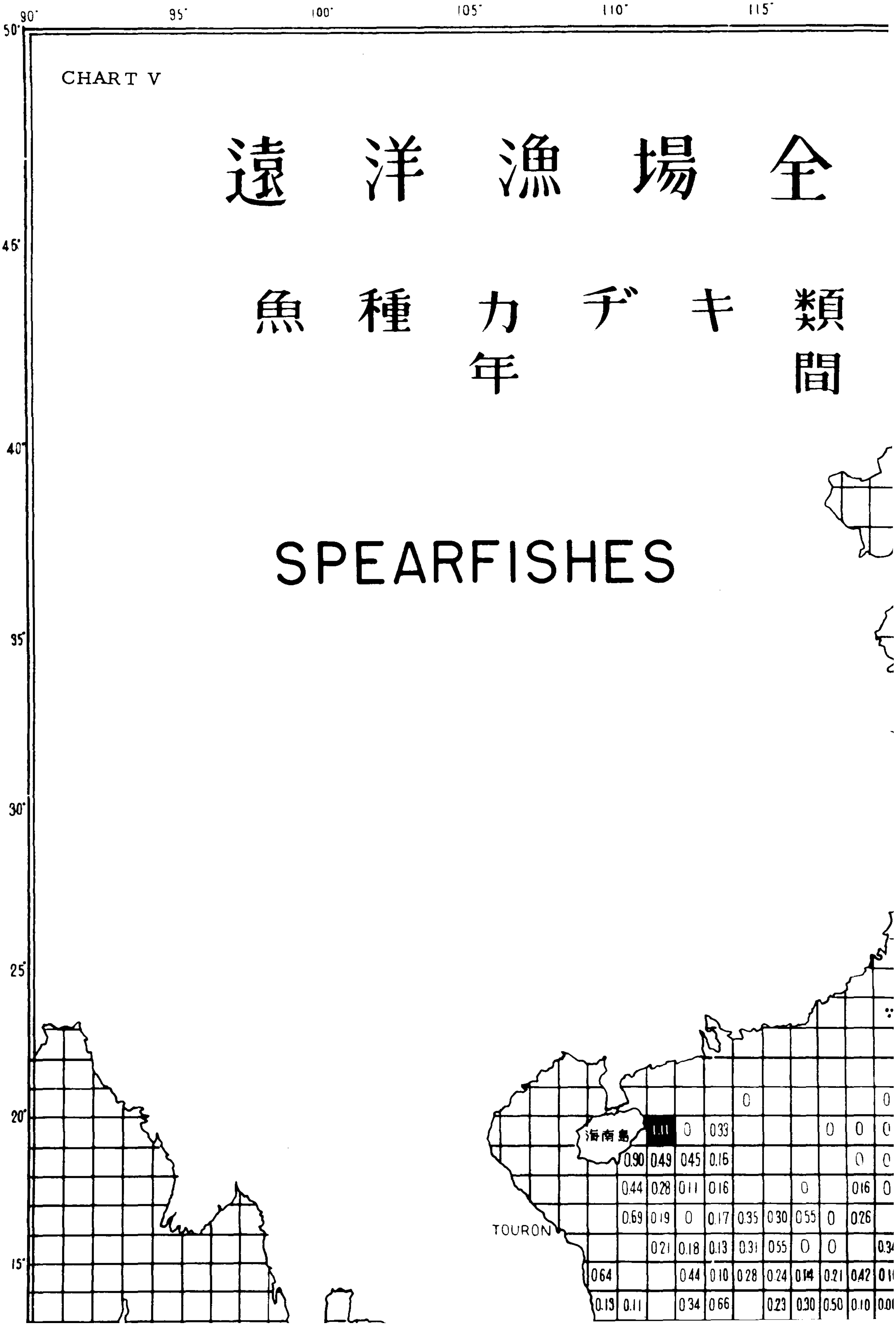
CHART V

遠洋漁場全

魚種カヂキ類

年間

SPEARFISHES



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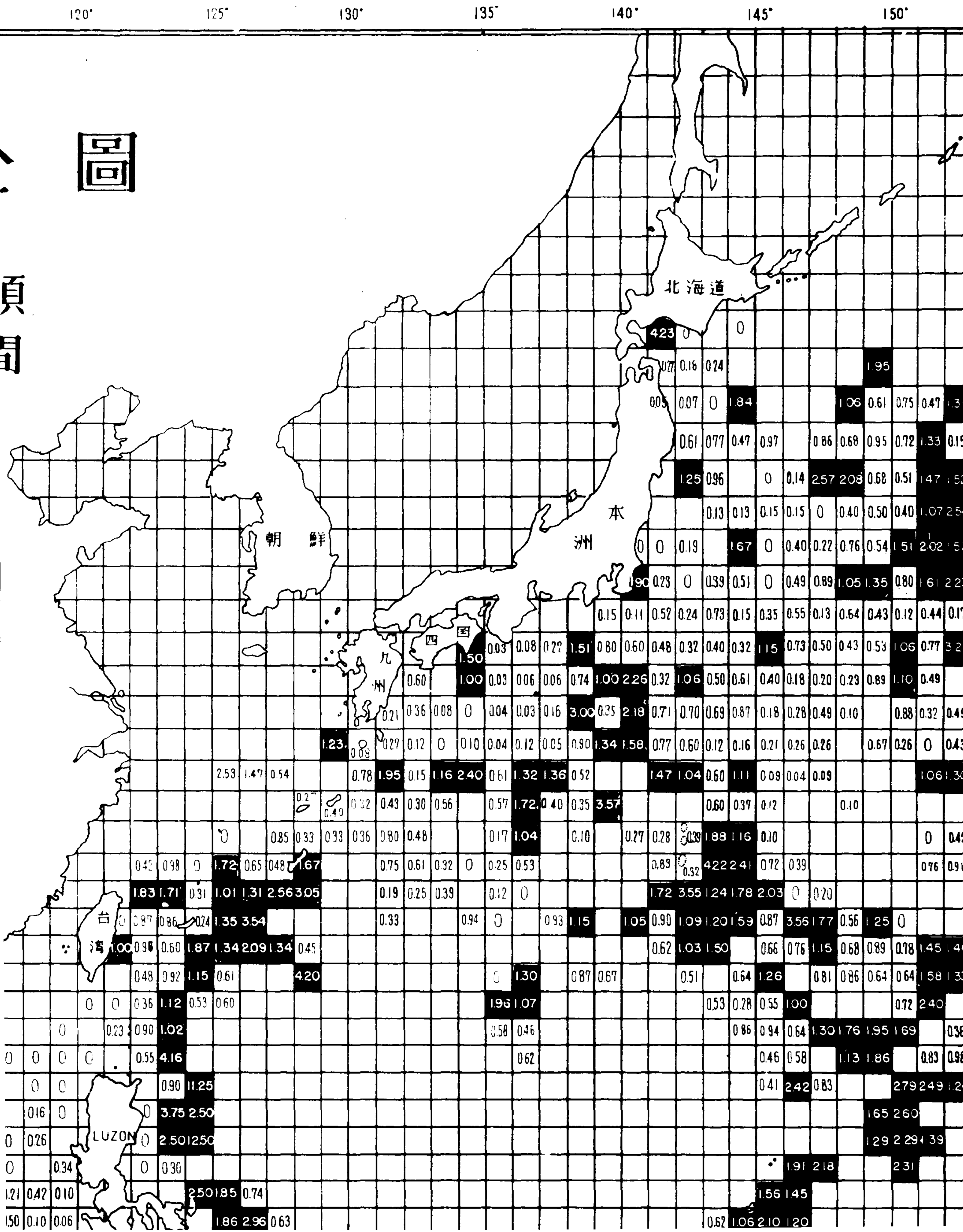

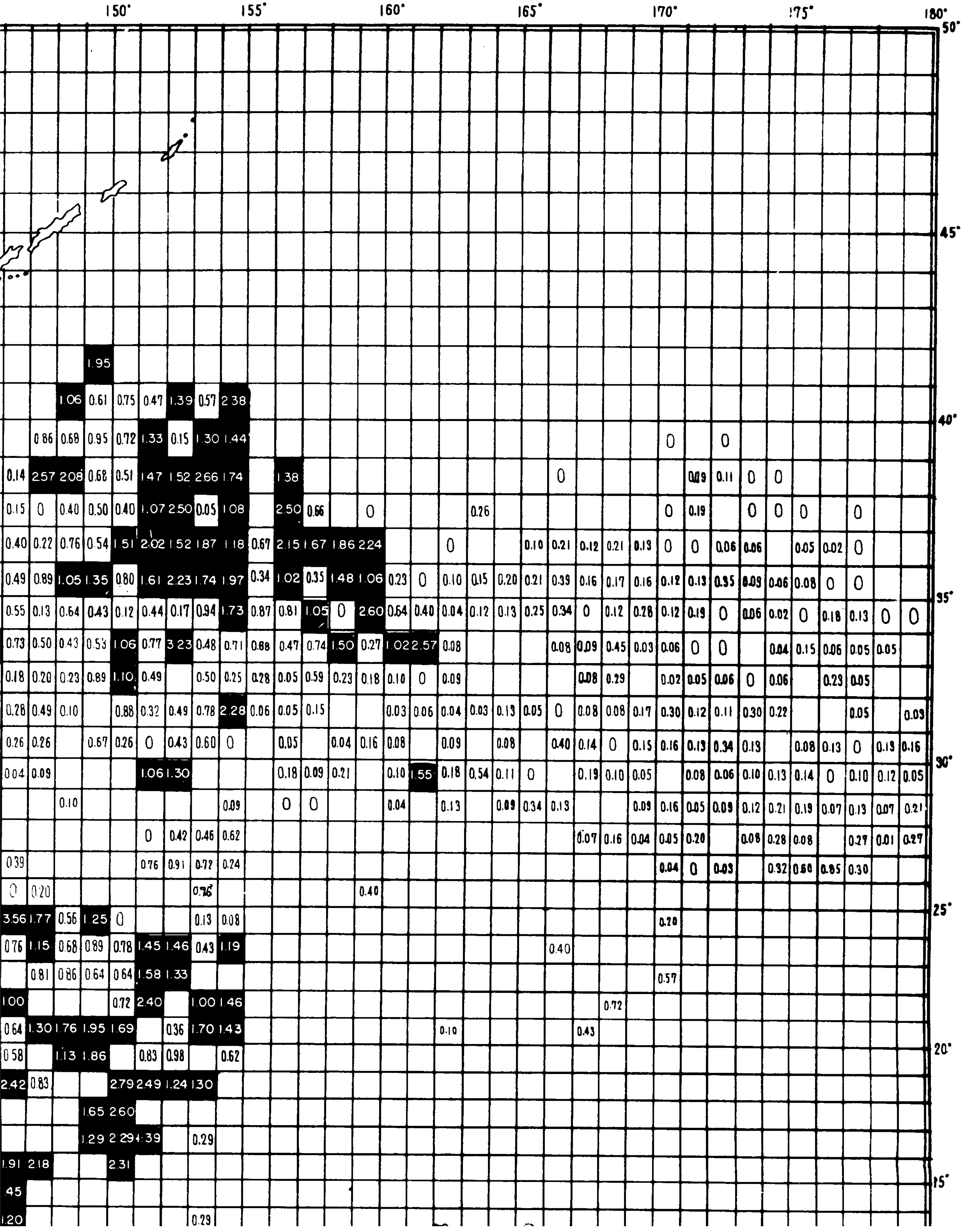
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50° 45° 40° 35° 30° 25° 20° 15°
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0.86 0.68 0.95 0.72 1.33 0.15 1.30 1.44 0 0
0.14 2.57 2.08 0.68 0.51 1.47 1.52 2.66 1.74 1.38 0 0.09 0.11 0 0
0.15 0 0.40 0.50 0.40 1.07 2.50 0.05 1.08 2.50 0.66 0 0.26 0 0.19 0 0 0 0
0.40 0.22 0.76 0.54 1.51 2.02 1.52 1.87 1.18 0.67 2.15 1.67 1.86 2.24 0 0.10 0.21 0.12 0.21 0.13 0 0 0.06 0.06 0.05 0.02 0
0.49 0.89 1.05 1.35 0.80 1.61 2.23 1.74 1.97 0.34 1.02 0.35 1.48 1.06 0.23 0 0.10 0.15 0.20 0.21 0.39 0.16 0.17 0.16 0.12 0.13 0.35 0.09 0.06 0.08 0 0
0.55 0.13 0.64 0.43 0.12 0.44 0.17 0.94 1.73 0.87 0.81 1.05 0 2.60 0.64 0.40 0.04 0.12 0.13 0.25 0.34 0 0.12 0.28 0.12 0.19 0 0.06 0.02 0 0.18 0.13 0 0
0.73 0.50 0.43 0.53 1.06 0.77 3.23 0.48 0.71 0.88 0.47 0.74 1.50 0.27 1.02 2.57 0.08 0.08 0.09 0.45 0.03 0.06 0 0 0.04 0.15 0.06 0.05 0.05
0.18 0.20 0.23 0.89 1.10 0.49 0.50 0.25 0.28 0.05 0.59 0.23 0.18 0.10 0 0.09 0.08 0.29 0.02 0.05 0.06 0 0.06 0.23 0.05
0.28 0.49 0.10 0.88 0.32 0.49 0.78 2.28 0.06 0.05 0.15 0.03 0.06 0.04 0.03 0.13 0.05 0 0.08 0.08 0.17 0.30 0.12 0.11 0.30 0.22 0.05 0.09
0.26 0.26 0.67 0.26 0 0.43 0.60 0 0.05 0.04 0.16 0.08 0.09 0.08 0.40 0.14 0 0.15 0.16 0.13 0.34 0.13 0.08 0.13 0 0.13 0.16
0.04 0.09 1.06 1.30 0.18 0.09 0.21 0.10 1.55 0.18 0.54 0.11 0 0.19 0.10 0.05 0.08 0.06 0.10 0.13 0.14 0 0.10 0.12 0.05
0.10 0.09 0 0 0.04 0.13 0.09 0.34 0.13 0.09 0.16 0.05 0.09 0.12 0.21 0.19 0.07 0.13 0.07 0.21
0 0.42 0.46 0.62 0.07 0.16 0.04 0.05 0.20 0.08 0.28 0.08 0.27 0.01 0.27
0.39 0.76 0.91 0.72 0.24 0.04 0 0.03 0.32 0.60 0.85 0.30
0 0.20 0.76 0.40
3.56 1.77 0.56 1.25 0 0.13 0.08 0.20
0.76 1.15 0.68 0.89 0.78 1.45 1.46 0.43 1.19 0.40
0.81 0.86 0.64 0.64 1.58 1.33 0.57
1.00 0.72 2.40 1.00 1.46 0.72
0.64 1.30 1.76 1.95 1.69 0.36 1.70 1.43 0.10 0.43
0.58 1.13 1.86 0.83 0.98 0.62
2.42 0.83 2.79 2.49 1.24 1.30
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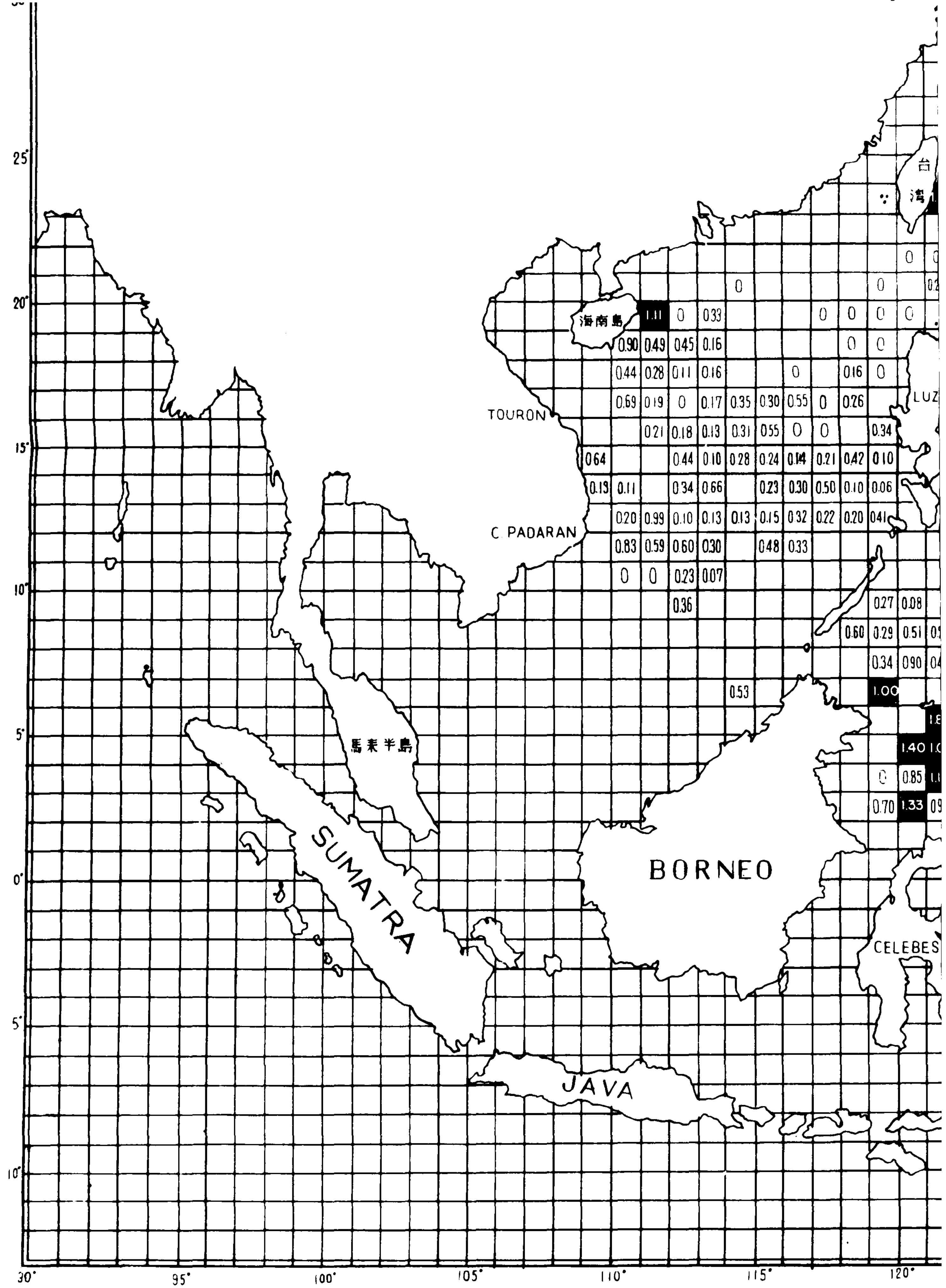

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0.44 0.28 0.11 0.16 0 0.16 0
0.69 0.19 0 0.17 0.35 0.30 0.55 0 0.26
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TOURON
0.21 0.18 0.13 0.31 0.55 0 0 0.34
0.64 0.44 0.10 0.28 0.24 0.14 0.21 0.42 0.10
0.13 0.11 0.34 0.66 0.23 0.30 0.50 0.10 0.06
0.20 0.99 0.10 0.13 0.13 0.15 0.32 0.22 0.20 0.41
C. PADARAN
0.83 0.59 0.60 0.30 0.48 0.33
0 0 0.23 0.07
0.36
0.27 0.08
0.60 0.29 0.51
0.34 0.90
0.53
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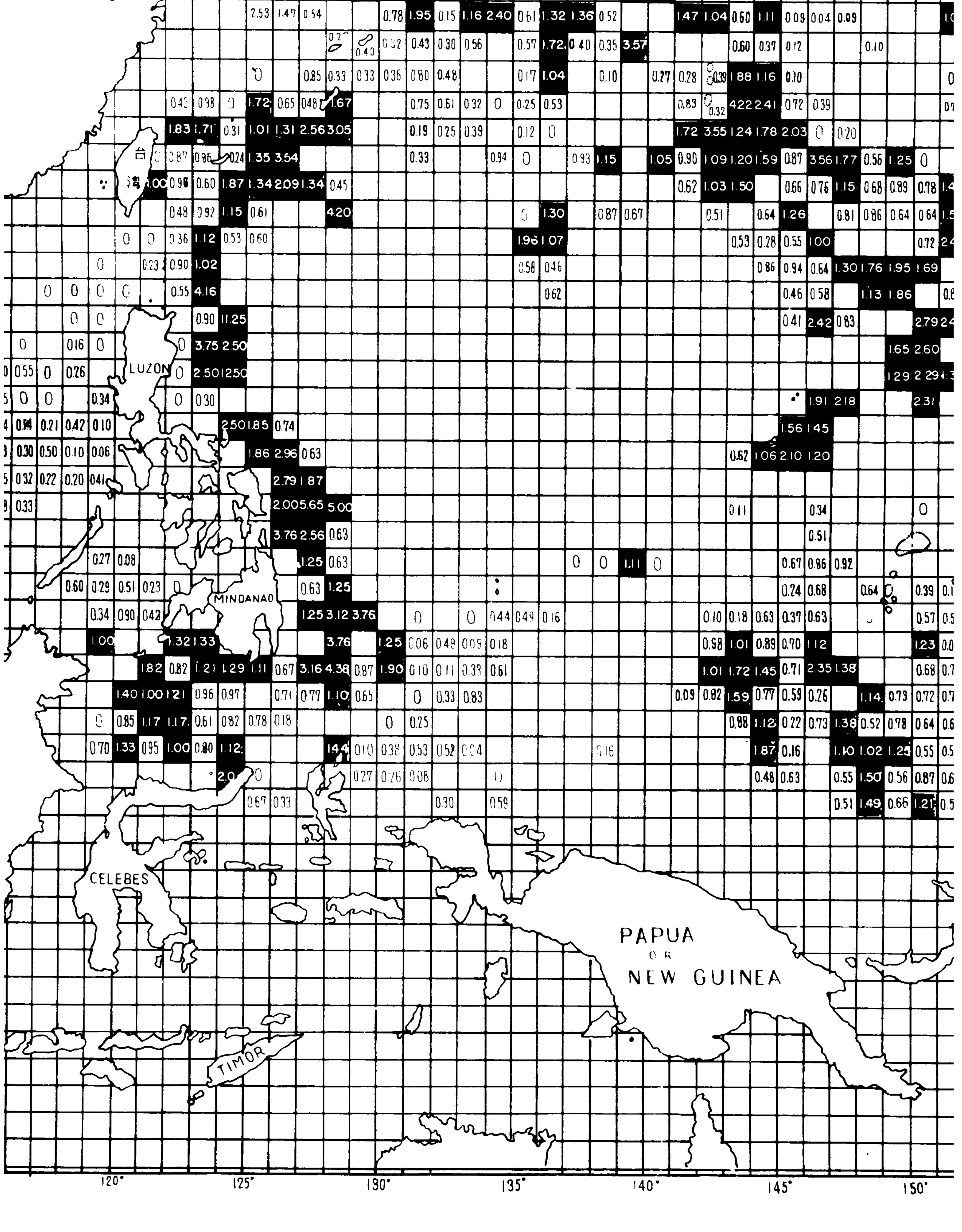
0.70 1.33
馬来半島
SUMATRA
BORNEO
CELEBES
JAVA


台
湾
LUZON
MINDANAO
CELEBES
TIMOR
PAPUA
OR
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120°
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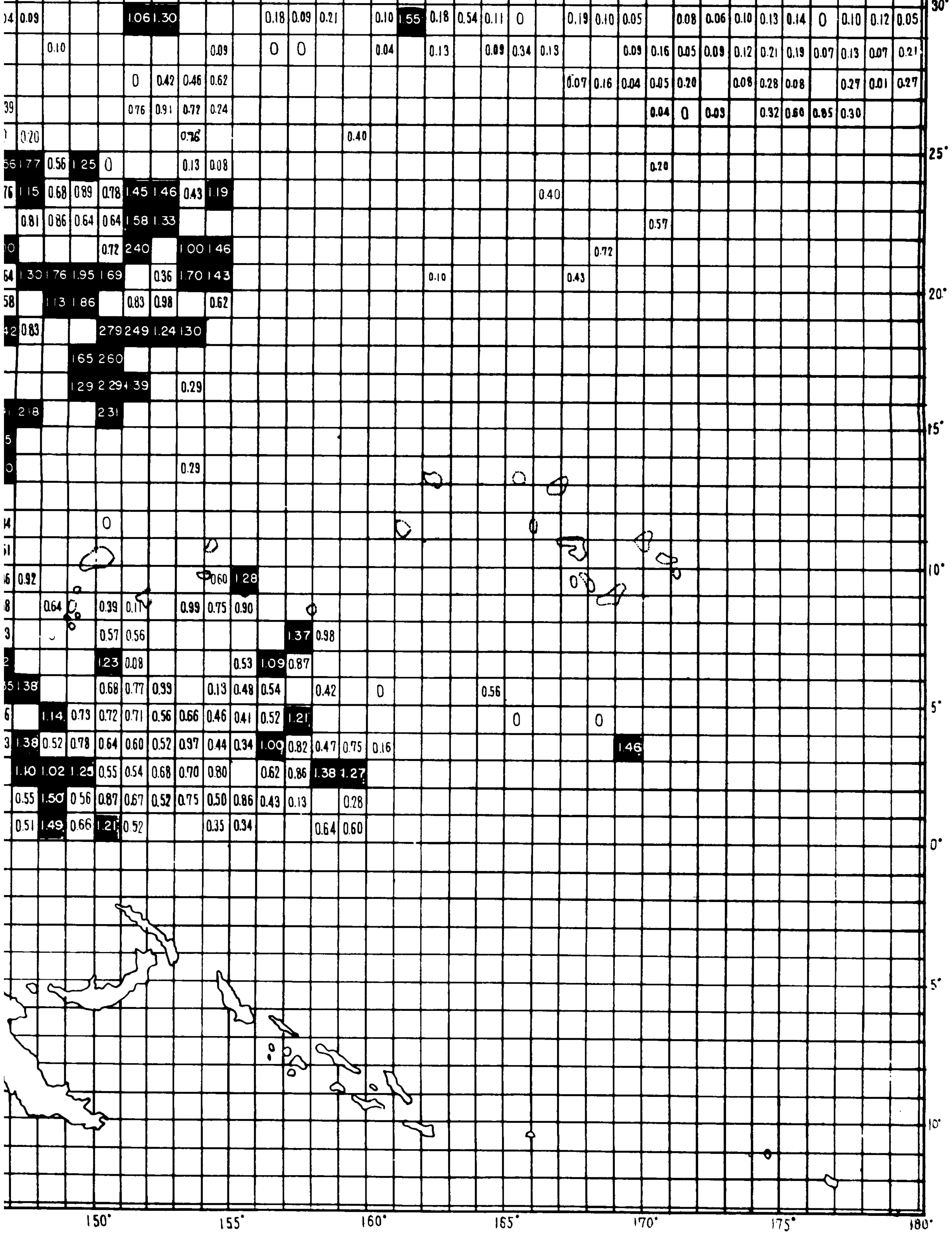
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0.10 0.09 0 0 0.04 0.13 0.09 0.34 0.13 0.09 0.16 0.05 0.09 0.12 0.21 0.19 0.07 0.13 0.07 0.21
0 0.42 0.46 0.62 0.07 0.16 0.04 0.05 0.20 0.08 0.28 0.08 0.27 0.01 0.27
0.76 0.91 0.72 0.24 0.04 0 0.03 0.32 0.60 0.85 0.30
0.20 0.76 0.40
25°
1.77 0.56 1.25 0 0.13 0.08 0.20
1.15 0.68 0.89 0.78 1.45 1.46 0.43 1.19 0.40
0.81 0.86 0.64 0.64 1.58 1.33 0.57
0.72 2.40 1.00 1.46 0.72
1.30 1.76 1.95 1.69 0.36 1.70 1.43 0.10 0.43
20°
1.13 1.86 0.83 0.98 0.62
0.83 2.79 2.49 1.24 1.30
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0.64 0.39 0.11 0.99 0.75 0.90
0.57 0.56 1.37 0.98
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1.38 0.68 0.77 0.39 0.13 0.48 0.54 0.42 0 0.56
5°
1.14 0.73 0.72 0.71 0.56 0.66 0.46 0.41 0.52 1.21 0 0
1.38 0.52 0.78 0.64 0.60 0.52 0.37 0.44 0.34 1.00 0.82 0.47 0.75 0.16 1.46
1.10 1.02 1.25 0.55 0.54 0.68 0.70 0.80 0.62 0.86 1.38 1.27
0.55 1.50 0.56 0.87 0.67 0.52 0.75 0.50 0.86 0.43 0.13 0.28
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