REPORT ON MARINE FISHERIES AND AQUACULTURE

IN THE SOUTH PACIFIC COMMISSION REGION

by

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0 INTRODUCTION

0 – 1 Geographical sector under study

This study covers all the territories of the South Pacific Commission. The ocean area under consideration necessarily extends beyond the territorial limits.

In order to meet the recommendations of Item XII of the Fourth Fisheries Technical Meeting, held in Noumea 21-29 October 1970, and at the same time allow for geographical realities, the following limits have been adopted :-

In the West – 130° east from 25° north to the equator, 140° east from the equator to 10° south, 150° east from 10° south to 15° south, 160° east from 15° south to 30° south.

In the East – 175° west from 25° north to 5° north, 130° west from 5° north to 30° south.

In the North – 25° north from 130° east to 175° west, 5° north from 175° west to 130° west.

In the South – Equator from 130° east to 140° east, 10° south from 140° east to 150° east, 15° south from 150° east to 160° east, 30° south from 160° east to 130° west.

In this area the following subdivisions have been made:

Sector 1 – North Tropical Western Pacific

Between 25° north and 5° north and 130° east and 175° west, which corresponds exactly to the sector defined in the recommendations. Included are the Trust Territories of Micronesia and the American territory of Guam. Included also are the Marianas Group, Carolines and the Marshalls. It includes also Wake Island and the western half of the ocean space between the Marshalls and Hawaii.

Sector 2 – Equatorial Western Pacific

Between 5° north and 10° south, the western limit, being located at 130° east between 5° south and the equator, and 140° east from the equator to 10° south. The eastern limit is 175° east. The Western Irian littoral waters are therefore not included. The sector thus includes Papua/New Guinea, the Solomons, the Republic of Nauru, the Gilbert and Ellice Islands Colony and the southern ocean strip of the Micronesian Trust Territories.

In this sector there is a marked difference between the south-western part of the large Melanesian islands and the northern and eastern part of the Micronesian groups.

Sector 3 - <u>Sub-tropical Western Pacific</u>

Between 10° south and 30° south, the western limit is located at the 150° east between 10° south and 15° south, at 155° east between 15° south and 25° south, and at the 160° east between 25° south and 30° south which excludes the western part of the Coral Sea off the Australian coast. To the east the limit remains 175° east.

Having thus been defined, this area includes mainly the Melanesian groups of New Caledonia and Dependencies, the Condominium of the New Hebrides and the Fiji State islands. To the north, it includes a strip which includes the extension of eastern Papua and of the southern Solomons with a few Polynesian islands such as Rotuma, Wallis and Futuna. To the south it includes Norfolk and Kermadec and the northern part of the ocean space between the Melanesian groups and New Zealand.

Sector 4 - <u>Equatorial Central Pacific</u>

Between 5° north and 10° south and 175° west and 130° west. This follows the recommendations. It is a vast and almost empty ocean space where the groups are so spread out that maritime sovereignty areas can be extended - Phoenix Island (Great Britain), Tokelau (New Zealand), Line Islands (Great Britain and U.S.A.) and Marquesas (France).

Sector 5 - <u>Sub-tropical Central Pacific</u>

Between 10° south and 30° south and 175° east and 130° east; also in accordance with the recommendations.

This is essentially a Polynesian area with the Kingdom of Tonga, the state of Western Samoa, the territory of American Samoa, the island of Niue, the Cooks and French Polynesia. To it should be added the British colony of Pitcairn.

0 - 2 Physical and ecological characteristics of the areas under study

0 - 2.1 Hydrology and bio-geography

The sectors under study are influenced by the dynamics of inter-tropical water masses which determine currents and counter-currents systems. The east-westwards north equatorial current affects the first sector between 25° north and 10° north.

The east-westwards equatorial counter-current is between 10° north and the equator and affects the south of the first sector and the north of the second and fourth sectors. The east-westwards southern equatorial current is felt in the whole of sectors 3 and 5 and in the south of sectors 2 and 4. The limits of the sectors defined in our study correspond to a remarkable degree to a number of hydrological phenomena.

The fronts of sub-tropical convergencies are in the north about 25° north and in the south about the 30° south, whereas in the equatorial sector 5° north corresponds to the equatorial divergence. The major current systems cause well-defined water masses. The surface waters are made up of four masses.

Water masses	Temperature °centigrade	Salinity ‰	Dissolved oxygen ml/l	Positions
Tropical north	25-28	34.5-34.8	4.0 - 4.8	25° N to 10° N Sector 1
Equatorial	26-29	34.0-34.5	4.2 - 4.8	10°N to 0° Sectors 1 - 2 - 5
Sub-tropical	25-29	35.0-35.5	4.0 - 4.6	0° to 10° S to East (130°W), to 0° to 25°S to West(155°E) Sectors 4 - 3 - 2
Sub-tropical south	20-25	35.5-36.45	4.0 - 5.2	From 10° to 30°S to E (130°W)to 25°S to 30°S to West (155°E) Sectors 5 - 3

These surface water masses are separated from the sub-surface water masses by a well-marked thermocline whose depths varies according to seasons depending on the dynamics of water masses. The sub-surface water masses drift and there is either penetration of surface waters into lower layers according to the convection phenomena or lateral mixing and exchanges. There are three sub-surface water masses.

Water masses	Temperature °centigrade	Salinity ‰	Dissolved oxygen ml/l	Positions
Sub-tropical north	15-20	34.7-35.33	4.5 - 4.8	25°N to 5°N Sector 1
Equatorial west	20-25	34.8-34.9	2.0 - 3.5	5°N to 0° Sectors 2 - 4
Sub-equatorial south	10-20	34.8-36.3	0.4 - 4.5	0° to 30°S Sectors 2-4 3-5

At a depth of several hundred metres are found the intermediary water masses which are divided into Pacific North Intermediary waters (Sector 1 up to about 10° north): temperature 3°C to 5° C, salinity 33.90‰ to 34.30‰, dissolved ocygen 0.3 to 4.3 ml per 1. Equatorial Intermediary waters (from 10° north to 20° south Sectors 1, 2 and 4, north of Sectors 3 and 5): temperatures 4.5° C to 6.5° C, salinity 34.55 to 34.65‰, dissolved oxygen from 0.0 to 2.5 ml per 1. South Pacific Intermediary waters (south of 20° south, Sectors 3 and 5): temperature 3°C to 6° C, salinity 34.1 to 34.5‰, dissolved oxygen 0.3 to 5.8 ml per 1.

The characteristics of the water masses determine the composition, density and the distribution of marine stock. From work carried out by Russian, Japanese, American and French experts, it is clear that plankton zones are on the whole determined by hydrological phenomena. The equatorial counter-current system causes a hinge which constitutes a relatively fertile zone of 50 to 100 mg per cubic metre of zoo plankton in the 0-150 metre layer between 5° south and 10° north. On the other hand, on either side, the zones affected by the south and north equatorial currents are the poorest (less than 25 mg per cubic metre of zoo plankton in the 0-150 metre layer).

In the transition areas with sub-tropical convergencies, there is again a better productivity - from 25 to 50 mg per cubic metre of zoo plankton in the 0-150 metre layer.

The location of the various species confirms this distribution of water masses productivity. The north and sub-tropical water masses have a marine stock which is largely dominated by peridinians whereas the equatorial hinge and the transition zones of sub-tropical convergencies have a balanced marine stock of peridinians and diatomae.

Where the true equatorial waters and the tropical masses meet, there is a selective distribution of many species of zoo plankton.

These biological phenomena linked to the water masses explain on the whole the distribution of exploitable fauna especially in the case of scombridae and thonidae but other factors should be borne in mind, such as the very many modifications and changes in this relatively simple general picture caused by continental land masses and islands.

0 - 2.2 Situation and types of islands

The geographical situation of continental land masses and of island groups conditions the grouping of reef formations. It is therefore essential to know their characteristics if we are to undertake an estimation of their resources and potential.

The region, taken as a whole, consists of two distinct structures:

1. A peri-continental zone

Island garlands linked to geosynclinals form a curved chain bordered by abyssal deeps. These are found west of Micronesia and in the whole of Melanesia. In some places fragments of the shelf are incorporated in the geosynclinal complex as in New Caledonia, Fiji and New Guinea. This results in considerable heterogeneity of sedimentation in the lagoons and differentiates the internal and external reef areas.

2. An oceanic zone

In a large voussoir or arch stone which is sinking (Darwin's dorsal) and which is aslant the tropical Pacific, fractures and volcanic ranges usually orientated north-west south-east enclose large oceanic basins. In this area emerged islands are minute and mostly made of either eruptive rock or coral deposits. Many volcanic structures are submerged, as some did not reach the surface. Some, on the other hand, have already been eroded (guyots). Recent Russian and American exploration campaigns have shown clearly that throughout the ocean area of the Darwin's dorsal complex there were many structures of this kind.

In particular, the following guyots should be mentioned which are on either side of 20° north between 165° north and 145° east and which are only covered by 1,000 to 1,800 metres of water and those which are in similar depths between the Marshalls and the Marianas. The distribution of structural factors thus gives an originality to each of the sectors concerned.

Sector 1 - North tropical West Pacific includes (a) in the west a vast geosynclinal complex with two island garlands (inside the dorsal, outside the dorsal of the Marianas doubled and bordered by a deep pit); (b) at the centre and to the east four oceanic bulges on which are the Marshall Islands, the Carolines and many guyots.

Sector 2 - Equatorial West Pacific. This mainly makes up the complex New Guinea, Solomons to the west and south, and large oceanic basins in the north and to the east with the Gilbert and Ellice Islands.

Sector 3 - <u>South sub-tropical West Pacific</u> with the Melanesian island groups linked to the continental blocks of New Caledonia and Fiji.

Sectors 4 and 5 - <u>South sub-tropical equatorial Eastern Pacific</u>. These are exclusively oceanic with volcanic ranges and fractures at right angle north-east south-west and north-west south-east which give a vast grid of basins separated by island arches.

The geological background and the structural data give varied types of islands which can be classified according to the quantity of the three basic elements.

(a) <u>Complex continental shelves</u> with considerable soil sedimentation which can often affect the balance of coastal conditions. These shelves have a fringe resulting from the geological structure and the erosion caused by inland waterways networks which can be of some size. Thus, in New Guinea, New Caledonia, Fiji, some of the Solomon Islands and the New Hebrides one finds large deltas with mangroves. One sometimes finds submerged coasts with rias (east of New Caledonia) or large flood bays (St. Vincent Bay in New Caledonia).

(b) <u>Recent, and in places active, volcanic structures</u>. They are always unstable and can be subject to rapid movements of uplift or subsidence. The sharp cones generally made of basic lava do not give enough sediment to change noticeably the balance of coastal formation.

(c) <u>Coral formations</u> are found on most coasts. Fossile formations give huge blocks which develop by karstification.

Present formations with their vegetable and animal resources provide abundant sedimentation materials which make for quick growth. All coral structures are on a shelf (volcanic or continental) which, depending on its form and its movements, determines the thickness and the shape of the reef.

When the shelf is emerged we have mixed structures. When the shelf is immersed the coral structure which alone protrudes above the surface is usually an atoll whose size and shape have the characteristics which the shore nearby had at the beginning of fixation of the coral reef.

In the inter-tropical Pacific sector, the instability of peri-continental island garlands and of fragments of shelves have led to a wide variety of reef structures in Melanesia.

On the contrary, the volcanic chains in the oceanic area of Micronesia and Polynesia are much more simple. The subsidence movements towards the north-west and of uplift towards the south-east (with the exception of the Samoa group where the movement is reversed) explain the distribution and the grouping of the islands where the coral structures are increasingly more numerous from south-east to north-west.

The coral formation around the shelf is of major importance for the exploitation of marine resources, depending on whether there is or is not a lagoon creating an original intermediary zone between the shore and the ocean. The non-continental islands can therefore be classified as follows:

Island with practically no reef. Steep shore with little shelter - generally very recent volcanic islands. However, the Marquasas Island group should be singled out. It is in this category in spite of its geological age and sub-equatorial position.

Island with incomplete reef formation with a beginning of doubling of the reef creating a lagoon and giving an incomplete barrier: Tahiti, Moorea, Rarotonga, Upsolu.

Mixed islands with a complete reef crown showing some balance between the shelf and the reef. The shelf may be predominant as in Ponape, Yap, Wallis, Raiatoa, Tahaa, or it may be the reef as Bora Bora.

Coral island with a few volcanic peaks (Maupiti) which can produce large complexes as in Truk and Mangareva.

Exclusively coral islands forming mostly atolls: Marshall Islands group, Gilbert and Ellice, Tuamotu, Line Islands and many other isolated islands in other groups. The uplift movements which occurred after the reef formation may have toppled the structures and produced assymetrical islands which have kept, partially, their atoll characteristics (Ouvea, Tongatapu) or formed blocks being eroded quickly with only narrow fringes of live reef: Lifou, Niue, Rotuma. Some of these islands have a phosphate surface deposit: Makatea, Ocean, Nauru, Angaur.

The continental fringes have islands which may have four components: part of the shelf, a volcanic structure, an uplifted old reef and a present living reef: Palau, Espiritu Santo.

To complete the picture, mention must be made of under-water structures such as coral beds which did not remain emerged: either a volcanic structure which has been subjected to sub-aerial erosion (guyot) or which has never reached the surface of the ocean. Such structures can often be excellent fishing ground and often lead to changes in the dynamics of waters which, in turn, increase considerably the productivity. The physical characteristics of shore formation are therefore a basic consideration in the chouce of fishing grounds and in the organisation of rational exploitation of biological resources.

The complexity of island structures must be emphasised as this reduces partly the value of an attempt at general classification. Each island has many problems which are peculiar to it. In view of these special characteristics of islands an exhaustive survey and a complete study must be made if we want to ensure we have omitted nothing.

This creates almost insoluble difficulties in view of the vastness of the areas concerned and their scattered nature.

We must therefore begin now to study the use of methods which can cover vast areas if we are to draw up a valuable preliminary inventory of characteristic data of the groups.

0 - 3 Background to the exploitation of oceanic resources in the tropical Pacific island groups.

0 - 3.1 Pre-European indigenous exploitation

The use of marine resources by Melanesians, Micronesians and Polynesians during the pre-European years was limited by many factors.

Only the populations near the shore had access to the sea. In the islands where people lived inland, with rare exceptions they could not themselves exploit marine resources. They were dependent on exchanges with shore populations. There were few of these people as they had only meagre resources outside the reefs and the mangroves.

However, everywhere there were techniques for catching fish despite the lack of gear. Reefs, lagoons, the shore, always have resources which are considered their own property by a few people. These are collected at low tide everywhere. Mostly by women and children to supplement the household diet. Fishing is the business of men who use mostly light craft and thus can even go some distance offshore.

The gear consists mostly of hooks and harpoons, made of mother-of-pearl, bone, large fish bones and other hard materials such as giant clam shells.

The lines are braided and made of bark fibres such as that of Bourao (*Hibiscus tiliaceus*) and nets can even be made by putting together thin vegetable ropes. Everywhere vegetable poison is used to stun or paralyse the fish and torches and lamps are used on moonless nights to fish on the reefs or to attract fish to the craft.

Lastly, everywhere on the shore and on reef shelves tidal traps are set up to catch fish of all kinds. Traces of these large traps have been found in Yap and Ponape, in the Gilberts, Tuamotus, in Tahaa and Raiatea.

A great deal of cleverness and careful observation of lagoon life and that around the reefs has always enabled the Polynesians and the Micronesians to have abundant and varied food as a basis for their daily diet.

The Melanesians, on the other hand, were less concerned with the sea. They had a civilization and a socio-economic organisation concentrated inland. They attached little importance to shore resources though often the sea waters could have provided them with additional valuable food had they used the mangroves and the fauna available in estuaries and bays (Dugongs). In Melanesia fishing and shore gathering are generally reserved for a caste or a small number of groups, especially organised for this purpose, within a network of complicated exchanges, whereas in Polynesia and almost everywhere in Micronesia these activities are an integral part of the daily life of the whole population. In any event, whether through lack of fishing gear or transport or means of conservation or because of the lack of fishermen, the pre-European use of shore resources was limited and never reached a threshold which might have endangered the balance of marine resources.

0 - 3.2 European commercial exploitation

The change to an exchange economy was soon to alter this. English, French and especially American shipowners early in the 19th Century began to hunt cetaceans for lighting oil. This activity considerably upset many small islands in Polynesia and Micronesia and led to the gradual disappearance of most of the large cetaceans.

Paralysed by this reduction in stock, the whole industry in the tropical Pacific was doomed after 1880 when mineral oil replaced animal oils and grease for lighting.

The gradual setting up of commercial networks led to the use of such marine resources as the bêche-de-mer (holothuris) to export trepang to China, pearls found in shellfish of certain lagoons (Tuamotu), turtle scales and also shellfish for rough mother-of-pearl.

Under the direction and pressure of European traders and also the Chinese, the indigenous people began the commercial exploitation of marine resources.

At the same time there was a change in indigenous fishing techniques - local materials were replaced by metal and industrial textile fibre for fishing gear.

Explosives were introduced, causing problems, and new craft, at first with sails and then with engines, enabled fishermen to go farther out to sea and even visit occasionally remote islands.

However, the slow advance of these changes should be emphasised as it took several decades before any effect was felt in some remote groups.

The changes in indigenous fishing techniques which started in Polynesia about 1840-1850 only affected Micronesia and Melanesia after 1890-1900 and were only fully felt between 1940 and 1970 through the distribution of explosives during the Second World War, the use of synthetic fibre fishing gear and motorisation since 1950. Only after 1960 did, in fact, all the shore areas of the tropical Pacific topple into the full anonymity of industrial technology. It is therefore a recent phenomenon which has only had an effect in limited fields.

However, it was not long before the consequences were felt and took unexpected proportions as the requirements of subsistence economies suddenly increased with higher standards of living, an increase in the population of indigenous groups and the immigration of Europeans, islanders, Asians, swelling the demand for consumer goods of marine origin. Whereas in the past the lagoons and the reef only had to supply local consumers and a very small outside market, developing city centres and new consumers introduced quite a different notion of marketing and foreign speculation soon replaced what had been family and small scale fishing.

0 - 3.3 Asian fishing

Japanese industrial fishing affected the tropical Pacific later than the northern Pacific.

Established politically with a mandate from the League of Nations in Micronesia, the Japanese organised fishing activities in the Marianas, the Carolines and the Marshalls from 1930. They concentrated first on making the best use of reef and lagoon resources to meet the needs of an increased population of about 80,000 new inhabitants from Japan who wanted fish and shellfish of all kinds.

Between 1935 and 1942 they fished bonito with live bait for export to Japan and to produce a traditional dried and smoked commodity called Katsuobushi.

In 1938, 1939, 1940 some 30,000 to 40,000 tons of fresh fish were landed especially at Palau, at Truk and at Ponape. This activity was completely halted by the hostilities of 1942 to 1945.

The Japanese took an interest in tropical Pacific resources again after 1953 and the Korean war. When they rebuilt their deep-sea fishing fleet, the Japanese concentrated first on longliners to catch fish required for canning by the Americans.

All areas of the tropical Pacific were affected by Japanese tuna fishing with longliners from 1954 onwards. The base was Pago Pago

(American Samoa), then Santo (New Hebrides), then (temporarily) Noumea (New Caledonia) and Levuka (Fiji); they also used mother ships. The longline Japanese tuna boats of 80 to 180 tons had a particularly fruitful and intensive fishing campaign between 1956 and 1962. However, they met with difficulties when yields diminished and crews became scarcer. Old boats were replaced by more modern and bigger boats which could fish the Indian ocean and the Atlantic. In the Pacific, the most modern fleet drifted towards the south from tropical waters to sub-antarctic temperate waters and offshore of the American coast. The Japanese were replaced by Formosans and South Koreans who could find crews less demanding.

Regardless of the increase in domestic prices in Japan, tuna fishing with drifting longlines went through a serious crisis and has considerably reduced in the tropical Pacific since 1965. On the other hand, this has been followed by live bait bonito fishing based either on Japanese ports or on new land bases - Palau, Magang. Though the Americans have tried hard, bonito fishing in the Pacific area remains almost exclusively reserved to Asians.

1 Deep water resources

1 - 1 Definition and documentation

1 - 1.1 Definition

For the tropical Pacific sectors under study, deep water fishing is of pelagic and bathypelagic species. Benthic species are not considered as no waters have yet been found suitable for deep sea trawling.

Fish caught are mostly bonito, tuna and swordfish.

Two very different kinds of fish are caught:

Two very different kinds of fish are caught:- Surface fish, mostly striped skipjack, Euthynnus pelamis (Linnaeus)(skipjack in English, Katsuo in Japanese and, on the African coast, Listao in French), and also young yellowfin tuna, Thunnus albacares (Bonnaterre) (Yellowfin in English, kiwada in Japanese, albacore in French on the African coast).

- Deep water fish, mostly tuna albacore, Thunnus alalunga (Bonnaterre) (albacore in English, binnaga in Japanese, thon blanc germon in French.

Big-eye Thunnus obesus (Lowe) (big-eye in English, mebashi in Japanese, patudo in French on the African coast).

Yellowfin tuna (see above) and swordfish.

The true swordfish Xyphias gladius (Linnaeus) (broadbill swordfish in English, mekajiki in Japanese, espadons in French).

Sail swordfish Istiophorus platypterus (Shaw and Nodder) (sailfish in English, bashiyoukajiki in Japanese, espadon voilier in French).

Striped marlin Tetrapturus audax (Philippi) (striped marlin in English, makajiki in Japanese, marlin rayé in French).

Blue marlin Makaira mazara (Jordan and Snyder) (blue marlin in Englishm Kurojujiki in Japanese, marlin blue in French).

Black marlin Makaira indica (Cuvier) (black marlin in English, shirokajiki in Japanese, marlin noir in French).

Fishing is done exclusively with a drifting longline.

1 - 1.2 Sources of documentation

The most comprehensive and abundant documentation on pelagic fishing in the tropical Pacific is in Japan. The documentation for this report was obtained as a result of visits to such ports as Misaki, Yaizu, Isminomaki, Shiogama, Kagoshima and Yamakawa where the marketing and port authorities gave a great deal of written and verbal information.

I stayed several times at Shimisu where the Fisheries Department laboratory for long range fishing is situated and the very important section of Tokai University which deals with marine studies. The long range fishing study laboratory publishes (since 1960) a volume giving all information available on fishing and catches of Japanese longline tuna boats by major geographic zones. The latest edition published in April 1971 deals with 1969. The laboratory also publishes (since 1969) a review of high scientific quality in which many articles cover our sector.

Furthermore, the Applied Ecology Department of Tokai University under Professor Motoo Inoue publishes a bulletin called Tuna Data giving maps prepared by the laboratory during the fishing season from information received daily from fishing vessels. I was able to make use of Nos. 41, 43, 46 and 50 covering the years 1965 to 1969.

Lastly, the laboratory of the Shiogama Fisheries Agency has started publishing statistical data by geographical sectors on Japanese live-bait fishing. The first volume published in March 1970 for 1968 has been scrutinised but the second volume for 1969 had not been published as of September 1971.

In addition to Japan, documentation was obtained from the Fisheries Department of American Samoa, French Polynesia, New Hebrides, Fiji, American Trust Territories of Micronesia. In April 1971 a visit was made to the Van Camp Society freezing plant at Koror, Palau, and in July 1971 to that of the South Pacific Fishing Company of Pallicolo, Santo, New Hebrides.

1 - 2 Fishing of pelagic and bathypelagic species with drifting longline.

On the whole, Japanese fishing has increased in the western tropical northern sector, Sector 1, and been rediced by some 30% in the other four sectors. Table I shows that for 1962 to 1966 the yearly average number of hooks used by the Japanese tuna longliners operating in the South Pacific sector was over 100 million whereas since 1967 it had fallen to around 70 million. It should, however, be noted that this reduction would be even more marked should we exclude from the Table fishing south of the 30° south which is outside our area and where catches of blackfin tuna have increased noticeably.

Thunnus maccovii (Castelnau) (southern bluefin tuna in English, miniami kuro maguro in Japanese). The number of hooks used in 1964 in the viciinity of south-east Australia and New Zealand can be estimated at about 10 million. In 1969 the number went up to more than 20 million. The Japanese are very keen on southern blue tuna fishing. The price, which was below or much the same as that of other species of tuna up to 1965, has since gone up considerably and this species has become one of the dearest products on the home market (on average 70 yens per kilo in 1956-1959, 100 yens per kilo on average for 1960-1963, 159 yens in 1965, 349 yens in 1968, 435 yens in 1969 and 579 yens in 1970). Furthermore, yields have only slightly reduced for this species whereas they have crashed for others. Drifting longline fishing techniques vary according to sectors.

Twenty to fifty-ton vessels usually operate in Sector 1 and the north of Sector 2; in other words, they seldom cross the equator and fish mostly yellowfin tuna. Fifty to hundred-ton vessels are found in much the same area but seem to tend to concentrate on either side of 5° north. Only vessels of 100 to 200 ton fish Sector 3 (Coral Sea) and 4 - on either side of the equator. Vessels over 200 tons keep mostly to Sector 4 (north of the Marquesas) and off Australia and New Zealand.

One of the major problems facing the Japanese longline tuna fishing is the decrease in catches and this shows the danger of overfishing. Albacore fishing virtually collapsed after 1967 (Table II). But the yellowfin tuna was also seriously affected (reduction in yield of 50% for 1967-69 as against 1964-1966). It seems that the big-eye and swordfish were less affected (Table II). There are very marked seasonal differences (Table IV).

TABLE I

Japanese long-line tuna fishing in the South Pacific sector south of 5° north, west of 130° west,
east of 120° east from 5° north to the equator
from 140° east from the equator to Australia
from 145° east to south of the equator

1 000 fish

Year	Hooks	Southern Bluefin: Thon Rouge Austral	Albacore: Thon blanc Germon	Bigeye: Thon obèse à gros yeux	Yellowfin: Thon à Nageoire jaune	Broadbill Swordfish: Espadon	Striped marlin: Marlin rayé et blanc	Blue marlin Marlin bleu	Black marlin: Marlin noir	Sailfish: Espadon voilier	Skipjack: Bonite ventre rayé
1962	109 183	275	2 185	527	1 585	21	59	143	26	61	6
1963	130 976	421	1 543	747	1 823	27	49	148	23	52	19
1964	81 248	279	1 052	347	1 296	13	28	75	16	26	14
1965	92 226	318	1 096	429	1 199	26	29	63	23	35	44
1966	104 382	318	1 312	334	1 566	25	30	67	24	50	35
1967	70 615	200	964	239	646	21	17	42	12	26	39
1968	71 040	235	481	263	833	30	14	35	10	23	30
1969	70 114	215	323	277	756	23	14	38	13	13	21

TABLE II

Number of fish caught per thousand hooks in the South Pacific sector by Japanese long-line tuna boats

Year	Southern Bluefin	Albacore	Big-Eye	Yellow-fin	Broadbill Swordfish	Striped marlin	Blue marlin	Black Marlin	Sail-fish	Total
1964	3.4	13	4.3	16	0.2	0.3	0.9	0.2	0.3	38.6
1965	3.4	11.9	4.7	13	0.3	0.3	0.7	0.3	0.4	34.9
1966	3	12.6	3.2	15	0.2	0.3	0.6	1.2	0.5	35.7
1967	2.8	13.7	3.4	9.2	0.3	0.2	0.6	0.2	0.4	30.7
1968	3.3	6.8	3.7	11.7	0.4	0.2	0.5	0.1	0.3	27.1
1969	3.1	4.6	4	10.8	0.3	0.2	0.5	0.2	0.2	23.9

TABLE III

Japanese long-line tuna boat fishing in the South Pacific sector in 1969

Number of fish per 1 000 hooks

Bait	Southern Bluefin	Albacore	Big-Eye	Yellow-fin	Broadbill swordfish	Striped marlin	Blue marlin	Black marlin	Sail-fish	Total
Saury	1.2	2.4	5.3	15.2	0.3	0.2	0.7	0.3	0.3	25.9
Squid	7.9	2.6	1.1	1.6	0.3	0.1	0.1	0.1	-	13.9
Others	-	0.7	3.4	12.4	0.1	0.2	1.7	0.4	3.6	22.6
tons										
20- 50	-	0.1	4.3	26.1	0.1	-	0.9	0.1	0.3	31.9
50-100	-	0.2	5.3	24	-	-	1.1	0.1	0.2	31
100-200	2.9	3.7	4.1	9.6	0.6	0.2	0.6	0.2	0.1	22.1
+ 200	5.1	2.9	3.5	5.1	0.3	0.2	0.3	0.2	0.2	17.8

From January to March fishing is mostly for yellowfin tuna and big-eye. Yields everywhere are small. This takes place between 10° south and 10° north. Catches of yellowfin tuna vary between 10 and 20 fish per 1000 hooks where, however, better catches are made north-west of Sector 4 where more than 20 are caught per 1000 hooks and, on occasions, even 47 between the equator and 5° south and between 155° west and 160° west. Catches of big-eye are very much smaller though more regular (some 5 to 10 fish per 1000 hooks between the equator of 10° north).

From April to June fishing increases by 50% as compared with January to March but catches of yellowfin tuna double and those of albacore, which were very small during the previous quarter, exceed catches of big-eye.

For yellowfin tuna the best catches are made between 10° north and 10° south in Sectors 1 and 2 where the average catch is 20 to 40 fish per 1000 hooks; even better results are obtained up to 50 off the Solomons and the island groups of New Guinea.

In the same Sector (10° north, 10° south) catches of big-eye average 10 fish per 1000 hooks. On the other hand, the fishing grounds for albacore vary a great deal. First there is a sector situated north of Fiji and Samoa yielding 22 to 40 fish per 1000 hooks, between 5° south and 10° south and 175° east and 170° west. But the real fishing ground for albacore from April to June is north of New Zealand on either side of 30° south with yields of 40 to 100 fish per 1000 hooks at the southern limit of our sectors 3 and 5.

From July to September fishing remains at approximately the same level as the previous quarter. Yellowfin tuna and especially big-eye fishing reduce with no change in fishing grounds. Whereas albacore catches increase slightly as the fish proceed north. The best catches (40 to 80 fish per 1000 hooks) are made in Sector 5 between 10° south and 30° south with a maximum of 159 in the zone 15° south 20° south and 170° west - 165° west with extension to the south of Sector 3 between New Caledonia, Fiji and New Zealand.

From October to December fishing slows down by more than half. Yields of big-eye and yellowfin remain stable though better for the former in all of Sector 4, and for the latter in an area 10° north and 10° south astride the two Sectors 1 and 2. Albacore catches reduce by more than half and only a few are caught in the Coral Sea near Fiji and in French Polynesia where there are catches of 20 to 30 fish per 1000 hooks. So Japanese longline tuna fishing follows a well defined seasonal cycle with intensive fishing from March to September and a slowing down from October to February. The main species are found in fairly well defined areas where fishing grounds are as follows: albacore, south of 10° south (Sectors 3 and 5); big-eye from 15° north to 10° south (south of Sector 1, Sectors 2 and 4); yellowfin, high concentrations on the equatorial hinge from 5° north and 20 south (Sectors 2 and 4).

TABLE IV

Japanese long-line tuna fishing in the South Pacific - vessels using saury as bait

	Fishing Operations	Thousand of hooks	1 0 0 0 Fish									
			Southern Bluefin	Albacore	Big-Eye	Yellowfin	Swordfish	Black marlin	Striped marlin	Blue marlin	Sailfish	Skipjack
Jan/Feb/March												
Bases in Japan												
20- 50 tons	1 300	1 920	-	-	7	29	-	-	1	-	-	-
50-100 tons	900	1 614	-	1	13	18	-	-	1	-	-	-
100-200 tons	1 200	2 393	1	1	16	33	1	-	2	-	1	1
+200 tons	1 700	3 513	5	9	18	28	1	2	2	-	1	3
Foreign bases	700	1 243	-	7	7	22	-	-	1	-	-	2
TOTAL	5 800	10 683	6	18	61	130	2	2	7	-	2	6
April/May/June												
Bases in Japan												
20- 50 tons	1 400	1 829	-	-	11	68	-	-	2	-	-	-
50-100 tons	1 300	2 312	-	-	14	61	-	-	3	-	1	-
100-200 tons	2 300	4 553	9	20	25	61	2	1	4	-	1	1
+200 tons	2 700	5 805	10	19	44	60	2	1	4	-	2	6
Foreign bases	700	1 320	-	67	5	11	-	-	1	-	-	1
TOTAL	8 400	15 819	14	106	99	261	4	2	14	-	5	8
July/Aug/Sept												
Bases in Japan												
20- 50 tons	1 500	2 186	-	-	9	61	-	-	2	-	-	-
50-100 tons	1 400	2 723	-	-	12	79	-	-	3	-	-	1
100-200 tons	2 500	4 988	18	28	19	43	6	1	3	-	-	1
+200 tons	1 600	3 385	8	15	18	35	2	1	1	-	2	2
Foreign bases	800	1 363	-	75	3	3	-	1	-	-	-	-
TOTAL	7 800	14 645	26	118	61	221	8	3	8	-	2	4

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TABLE IV (continued)

	Fishing Operations	Thousand of hooks	1 0 0 0 Fish									
			Southern Bluefin	Albacore	Big-Eye	Yellowfin	Swordfish	Black marlin	Striped marlin	Blue marlin	Sailfish	Skipjack
Oct/Nov/Dec												
Bases in Japan												
20- 50 tons	600	893	-	-	2	23	-	-	1	-	-	-
50-100 tons	600	1 102	-	-	3	29	-	-	1	-	-	-
100-200 tons	1 300	2 500	-	8	11	31	1	2	1	3	1	1
+200 tons	1 500	3 146	1	7	15	25	1	2	2	5	-	2
Foreign bases	200	397	-	11	1	1	-	-	-	-	-	-
TOTAL	4 200	7 038	1	26	32	109	2	4	5	8	1	3

For the South Pacific sectors, south of 5^{o} north, Sectors 2, 3, 4 and 5, fishing by Japanese longline tuna boats can be estimated at an average value of marketable products of 18 kilos for albacore, 45 kilos for big-eye, 30 kilos for yellowfin and 80 kilos for swordfish and marlins (excluding sailfish which comes to only 20 kilos).

Statistics for 1964 give a good reference basis on fishing results which are shown in weight and apply to the whole of the Japanese fishing fleet in that sector. For 1969, on the other hand, catches are shown in number of fish and some 15 to 20 per cent of fishing vessels did not report their catches. Thus an adjustment must be made. With this in mind results give a very clear comparison (Table IV). Catches of vessels based in Japan have decreased by approximately one-third. This mostly for albacore. But fishing vessels which supply foreign bases have by far the most drastic reduction in fishing as 1969 is hardly a third of 1964. This is due to an increase in operating costs and decreasing yields which have put off Japanese owners from supplying fish to canneries and freezing plants in New Hebrides, Fiji and Samoa. Whilst higher prices on the Japanese market enabled ship owners to land their catch at Yaizu or at Misaki and compensate for part of the increase in operating costs. In 1966-1968 prices increased by more than 50% as compared with 1960-1965.

There was a further increase of 10 - 20% in 1969 and serious speculation for higher prices in 1970 (Tables VI and VII) which is continuing in 1971 and keeps in operation a fleet which has now been modernised and can justify an increase in operating costs, especially wages. In foreign bases, where fishing has continued and developed, boats from Okinawa, South Korea and Formosa have taken over from the Japanese.

The gradual withdrawal of Japanese vessels from the supply of freezing plants and canneries in the island groups has been more than compensated by the 200 longline South Korean and Formosan tuna boats. The most important centre remains Pago Pago, where, after the second cannery was opened in 1963, the processed tonnage increased quickly from 20,000 tons to 40,000 tons and then to more than 50,000 tons.

For the 1970 financial year (1 July 1969 to 30 June 1970) exports of the two canneries in Pago Pago (Van Camp and Starquist) amounted to approximately 50,000 tons at a declared value of more than US $ 36 million. Non-processed exported frozen fish: 4,300 tons, worth US $ 1,352,199, plus sharkfin worth US $ 121,836. Canned tuna: 2,854,265 standard cases (48 half pound cans) i.e. approximately 31,400 tons, worth US $ 33,018,237. Animal tin-food 593,543 cases i.e. approximately 6,500 tons worth US $ 2,004,757 and fish meal 1,900 tons, worth US $ 184,331.

TABLE V

Catches by Japanese long-liners in the South Pacific Area

Metric tons

	1964			1969		
	Japan-based	Foreign-based	Total	Japan-based	Foreign-based	Total
Albacore	10 000	8 400	18 400	2 100	3 100	5 200
Big-eye	13 000	2 600	15 600	11 500	800	19 500
Yellowfin	33 100	5 800	38 900	22 400	1 300	23 700
Swordfish	8 100	2 000	10 100	6 000	400	6 400
TOTAL	64 200	18 800	83 000	42 000	5 700	47 700

TABLE VI

Yearly average prices for tuna in Yaiza Market

Yen/kilo

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Albacore	109	1141	137	133	118	106	171	159	174	191	246
Big-eye	98	92	110	128	127	148	178	200	199	221	340
Yellowfin	97	108	118	129	134	148	177	186	183	200	259

TABLE VII

Average price (yen/kilo) for tuna landed and sold in Yaizu in 1970

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly average
Albacore	226	221	224	247	244	243	268	269	248	291	287	287	246
Big-eye	269	281	283	279	267	284	314	375	402	424	392	426	340
Yellowfin	233	242	247	210	230	210	237	283	317	295	271	309	259

Most of this is supplied by the local fishing fleet but there is a trend towards imports of frozen tuna from the New Hebrides and Fiji and bonito from the freezing plant at Koror, Palau (Trust Territory).

The quantity of fish landed by the South Koreans and the Formosans based on Pago Pago is at least 50,000 metric tons. As the Pallicolo Santo Centre has developed considerably with South Koreans and Formosans - about 6,000 tons 1966-1968; 8,000 tons worth US $ 3,500,000 in 1969 and 9,218 tons worth US $ 5,140,000 in 1970 and Levuka in Fiji is now well organised: 5,685 tons in 1968; 8,500 tons in 1969 - it is clear that Asian longline tuna fishing in the South Pacific has considerably increased, in spite of smaller yields, due to increased South Korean and Formosan fishing. Longline tuna Japanese fishing boats fished some 47,700 tons of tuna and swordfish in 1969 in the South Pacific, whilst the South Koreans and Formosans brought in over 60,000 tons.

Thus the harvest has grown from 90,000 tons in 1964 (83,000 tons Japan, 7,000 tons Formosa and South Korea) to about 110,000 tons (47,700 tons Japan, 62,300 tons Formosa and South Korea). This shows the need to look for new fishing grounds and the urgency of measures to be taken to avoid overfishing.

As a new freezing plant was set up early in 1971 in Papeete (Tahiti) and there are plans for Noumea, it is clear that the major canning American companies, more than ever short of raw material because of the growing Japanese home market, have nevertheless not given up trying to increase their catches of pelagic and bathypelagic fauna in the South Pacific. Consideration must be given to this when planning fishing policies in the island groups.

1 - 3 Live-bait bonito fishing

Supply difficulties of the Japanese and American tuna markets have caused an increased demand for substitute products such as skipjack and there has been in the last few years a considerable increase in fishing of this pelagic species. Bonito shoals are usually found around the islands during the calm and hot season (June-September north of the equator, November to March south). Bird flocks help locate these shoals which are found mostly near passes, in channels and straits between islands. Shoals sometimes even come into lagoons. Polynesians and Micronesians who like the firm red flesh of this fish are well aware of this and make use of these resources close to their islands.

But industrial skipjack deep-water fishing began off the Japanese islands much further north where the Kuro-Shio front gives sizeable concentrations of pelagic species during the hot season.

TABLE VII

Catches of Japanese live-bait bonito boats fishing in Micronesia in the North New Guinea area in 1968

metric tons

Geographic sector	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Around Truk	1700		100					200	100				2100
Between Truk and Yap	450	2700	3800								100		7050
Around Yap	2200	5900	1700	2300							1300	1700	15100
Marianas						900	3500	1900					6300
Equator North New Guinea				200					400	600	400	100	1700
TOTAL	4350	8600	5600	2500	-	900	3500	2100	500	600	1800	1800	33250

The seasonal rush of the Kuro-Shio hot front which is a real transgression of the waters of more than 20° C causes major concentrations not only of skipjack but also of albacore (especially in May-June at the peak of the transgression) and of many scombridae. The live-bait technique of fishing with specially adapted boats (fitted with artificial spraying) gives excellent results but has the disadvantage that a sufficient quantity of live-bait must be available (anchovies or small sardines) and it can only be practised near the Japanese islands during the hot season. Enterprising shipowners have resumed fishing in tropical areas so as to use their boats when the season is slack in Japan.

In 1965 the largest vessels were fishing up to 10° north and 145° east, in other words near the Marianas and Yap. The size of shoals found close by and some distance off the island induced shipowners to reach further and in 1968 they reached New Guinea, the Solomons and, later, Ponape.

In 1968 catches amounted to more than 33,000 tons in the sectors under study (Sector 1 and north of Sector 2). There is a marked seasonal distribution according to goegraphical zones. The best fishing grounds are in the Carolines, especially between November and April where during that period some 20,000 tons are caught. During that period also there is a second sector south of the equator.

From May to October the Kuro-Shio fishing grounds from the Rioa Kioa Island group up to 42° north by 160° to 170° east are fished by the best part of the fleet but a few vessels fish in the Marianas where they catch some 60,000 tons of fish. Japanese interests are therefore clearly oriented towards an additional fishing season for their national fleet which still have available good fishing in Japan from Spring to the beginning of Autumn. This is tropical and winter equatorial fishing which meets the needs of the Japanese shipowners and fishermen. This is why new expeditions were begun in New Guinea and the Solomons in 1969 and 1970.

Things are, of course, very different for the territories of the South Pacific Commission. What is required is to keep fishing continuous and to use the pelagic resources of island groups according to a schedule which corresponds to the migration of the species.

At present there is only one organised centre in the South Pacific Commission territories. It is the freezing plant of the Van Camp Company at Koror in the Trust Territory. This base is now supplied by a fleet from Okinawa and is developing rapidly and has obtained good results (Table VIII). The Palau lagoon has a good stock of live-bait, Clupeidae and Engraulidae which makes possible quick turn-round to the fishing grounds.

At present fishing at Palau is limited by the low capacity of the freezing plant which cannot process more than 100 tons per day and therefore fishing boats have quotas during the most productive period.

Extension works should bring production to 12,000 tons in 1972 and later to a ceiling of 15,000 to 18,000 tons.

It is interesting to note that for the fleet based at Palau the good fishing season begins in May at the time when all Japanese vessels have left Micronesian waters and goes on until the end of the year (Table VIII). The slack fishing season (from January to April) on the contrary corresponds to the best fishing season for the Japan-based fleet. During that period Palau produces a large quantity of immature juveniles of small size and it would seem advisable that the local fleet try to reach shoals of adult fish.

TABLE VIII

Activities of the Koror freezing plant (Palau Islands)

1969	Value in $US	No. of boats	No. of trips	Landings - Weight in lbs (453 gr.)		
				Yellowfin	Skipjack	Undersize
January	5 564	8	58	280	78 221	80 466
February	10 353	9	100	192	131 458	180 043
March	2 056	7	32	688	10 911	66 290
April	3 849	4	51	2 557	35 081	90 658
May	27 698	5	103	48 026	350 493	174 336
June	53 998	4	116	171 108	743 448	460 296
July	71 265	8	98	5 878	1 484 802	5 328
August	134 637	9	189	24 363	2 802 490	-
September	84 814	9	174	-	1 777 215	7 496
October	61 962	9	161	36 197	1 257 609	15 015
November	73 642	7	136	3 443	1 540 050	5 710
December		6	?	738	580 996	190 531
1970						
28.12.69 to 24. 1.70	35 060	7	118	738	624 122	233 657
25.1 to 21.2	22 172	7	91	-	337 623	268 604
22.2 to 21.3	18 190	6	102	-	342 851	82 041
22.3 to 25.4	42 125	7	148	-	840 842	91 590
26.4 to 23.5	105 358	9	250	-	2 176 275	75 275
24.5 to 20.6	180 878	9	196	-	3 602 801	49 137
21.6 to 25.7	258 138	9	269	-	5 173 566	-
26.7 to 22.8	116 042	10	150	-	2 324 814	2 189
23.8 to 30.9	15 535	4	24	2 886	307 072	3 058
1.0 24.10	18 370	5	40	-	337 495	-
25.10 21.11	62 519	5	122	-	1 148 577	-
22.11 26.12	40 468	6	114	-	738 816	11 126