THE FISHERIES INDUSTRY OF FRENCH POLYNESIA

by

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INTRODUCTION

At the request of the Administration of French Polynesia, we made a general investigation of fisheries in Tahiti, Moorea, Raiatea, Tahaa and Bora Bora in the Society Islands, and in the atolls of Takaroa and Takapoto in the Tuamotou archipelago(1).

The above-mentioned islands were reached by seaplane or by ship, and local investigations were conducted using small boats and motorcars.

The keenest interest in the survey and some very helpful encouragement was expressed by His Excellency the Governor of French Polynesia. The utmost co-operation was offered by the Chief of the Department of Animal Industries, Dr. M. Gug, as well as by the administrators of the various circumscriptions visited and their staff; by the gendarmes and a number of private persons, including fishermen, pearlshell divers, merchants, etc.

It has been our intention, in writing this report, to make constructive suggestions without in any way binding future Fisheries Officers in French Polynesia to any strict programme. Our survey was too short in duration and too wide in scope for us to define a programme. The summary of recommendations attached at the end of the report should therefore be considered as far from exhaustive. It merely points out a few possibilities of a more or less immediate character. We nevertheless hope to have contributed to the development of Fisheries in French Polynesia as much as circumstances permitted.

GEOGRAPHY

General

French Polynesia includes 125 small islands divided into five groups.

A general distinction can be made between the high islands (Society Islands, Austral Islands, Marquesas, Gambier) of volcanic origin, and the low islands (coral atolls) of which all but a few belong to the Tuamotou Archipelago.

These islands have a total land area of less than 1,540 square miles and are scattered over 1,540,000 square miles of ocean, from 134° to 155°W. longitude, and from 8° to 27° S. latitude. A census taken in 1951 showed a total population of 62,800.

Some details will be given here only in respect of the groups and islands visited in the course of our survey.

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(1) Mr. H. van Pel stayed in the territory from 22nd March to 21st April 1957, and Mr. L. Devambez from 22nd March to 5th May 1957.

Tahiti and Moorea

These islands are part of the Society Group. Together with a few much smaller volcanic islands and one atoll, they form the administrative circumscription of Tahiti and dependencies, also known as the Windward Islands.

In these two main islands, the comparatively high mountain ranges occupying most of the interior separate two distinct zones, the N.W. or leeward side being comparatively dry, the S.E. and E. coasts receiving more rain.

There are numerous streams of varying importance. Those on the leeward side of the islands generally dry up between June and September, while the more important rivers, situated on the windward side, are permanent.

The temperaturesare very even throughout the year, oscillating between 68° and 86°F. approximately. Storms are very seldom recorded.

Tahiti is by far the most heavily populated island in the Territory; the last census (1951) recorded a total of 30,500 inhabitants, of whom 15,220 reside in the capital, Papeete. The population of Moorea is estimated at 1,760.

Raiatea, Tahaa, Bora Bora

Four volcanic islands, including the three mentioned here and the island of Huahine which was not visited, together with four atolls, form the administrative circumscription of the Leeward Islands and are included in the Society Group.

Their general characteristics are quite similar to those of Tahiti and Moorea. However, the flat coastal belt is much narrower here than in Tahiti and a large proportion of it is swampy, being alternately flooded by run-off from the foothills and by the sea during periods of heavy weather.

The barrier reef is generally higher than in the Windward Islands and the lagoon is comparatively wider. It should be mentioned that the islands of Raiatea and Tahaa are surrounded by a single barrier reef.

The total population of the Leeward Islands is in the vicinity of 14,500. The census of 1951 showed 4,813 inhabitants in Raiatea, 3,359 in Tahaa and 1,738 in Bora Bora.

Takaroa, Takapoto

These two atolls are part of the Tuamotou Archipelago, which includes about sixty atolls in all. These low islands have been grouped with the small Gambier group of volcanic islands to form the administrative circumscription of the Tuamotous-Gambier.

Although both these islands are atolls and have in common a number of characteristics, some differences between them are worth mentioning.

Takaroa is an "open" atoll, i.e., the belt of land surrounding its lagoon is broken, in addition to minor passes impracticable to any craft, by a deep pass through which water rushes in an out with the tides. Takapoto, on the other hand, is a "closed" atoll, and its belt, noticeably higher than that of Takaroa, only offers minor depressions, very few of which admit any water into the lagoon.

Unlike the high islands, atolls have no streams and further suffer from a very dry season from July to October. Temperatures are noticeably higher than in the Society Islands.

The population of Takaroa is approximately 220; that of Takapoto 260.

Meteorological data

The island of Tahiti receives an average of 79" of rain annually. Average temperature is 77° F. The winds are mostly from the NE and ENE. The Leeward Islands receive an average yearly rainfall of 98" and the average temperature is 80.6°F.

In the Tuamotou Islands, records from two weather stations show average yearly rainfalls of 3.9 and 4inches with average temperatures of 80.6°F.

In both the Leeward Islands and the Tuamotus the winds generally come from the East.

THE EXISTING FISHERIES INDUSTRY

General

Both subsistence and commercial fishermen are fairly active in French Oceania and it is sometimes difficult to draw a line between these two aspects of fisheries. A large part of the population takes part in some form of fisheries activity, although the number of full-time commercial fishermen is comparatively small (it was assessed at 229 for the whole territory in 1955).

As already mentioned, the population is concentrated on the seaside in high islands and lives on the narrow belt of land between lagoon and sea in the atolls. The waters near at hand are generally sheltered and the existence of reefs and lagoons make fishing possible with simple gear. Various types of fishing are practised in the open sea, on the reefs and in the lagoons and, to a lesser extent, in streams and estuaries.

The fishing gear observed included fixed traps made of stone, nets or wire; wire and bamboo bottom traps; handlines, trolling lines, pole and line with lures, pole and line with baited hook; scarelines, crabnets, gillnets, castnets, dipnets, seines, spear-guns and hand-spears. Bonito and tuna are generally caught with pole and line using a lure, often made of mother-of pearl shell, although some metal jigs, with or without feathers, are now coming into

use. This method is used with small motorboats or paddling canoes. Two small species of pelagic fish, ature and operu, are caught in deep passes with huge surrounding nets.

It seems that explosives and various poisons are also used for fishing.

As in many other tropical areas, fish species are numerous, especially on the reefs, but each species is represented by comparatively small numbers. However, as indicated earlier, pelagic species such as Decapterus sanctaehelenae (operu) and Selar crumenophtalmus (ature, orare) come near the reef and into the deep passes in very large schools. Other pelagic species commonly caught include large numbers of bonito and tuna, with an occasional marlin; flying fish are also present. The main catch from the open sea is provided by bonito, which are usually spotted by the observation of sea birds which follow the schools of bonito and prey on the same small fish.

The small rivers and streams contain few fish. The freshwater fauna is composed mainly of various Kuhlia, mullet and freshwater shrimps. Only the latter are being caught to any noticeable extent as they are considered a delicacy.

Fish culture is not practised. In several places along the coast of Tahiti small bays have been cut off from the sea by a causeway supporting the main road which runs round the island. These are generally populated with mullet, milkfish, trevally and other lagoon species, which enter these ponds through various openings in the causeway when still very young. These fish grow up to a fair size in these enclosures and are periodically taken with hook and line or with nets by the owners of the ponds or their relatives and friends.

In comparison with other South Pacific territories, French Polynesia is better supplied with sea foods, including shellfish. Practically all of the catch is absorbed by local consumption, either at the subsistence level or through the local market. One exception is found in Makatea, where the labour of the phosphate company are supplied from outside sources (the nearby atolls of Tikehau and Rangiroa).

Except for a quite negligible portion of the catch, fish is consumed fresh - cold-stored fish is not popular. The difficulties attendant upon the marketing of fish under these conditions are partly solved in some cases by keeping large catches alive in pounds improvised from old fishnets or from chicken wire and stakes. In certain places rock or bamboo enclosures are also used, and live-boxes made of bamboo are found everywhere and used either to keep live bait or to hold live fish for the market.

In the case of large fish, such as bonito, tuna and other deep-sea fish, the catch is gutted as soon as possible and the fish may be sold either on the same day or on the following day. In spite of the care taken to clean the fish, it cannot be said that its quality is improved by keeping it in the open air overnight.

Shellfish are gathered either for family consumption or for the market. Some species of particular ornamental value, often quite common, are gathered for the curio industry. A separate category should be created for mother-of-pearl shell, which is essentially an export product, although a small proportion of the take is used locally by the curio industry.

Tahiti Cannery

A small-scale cannery operated for a while in Tahiti, processing bonito in coconut oil and pineapple. Various factors led to the failure of this enterprise and most conspicuous as regards the fish-canning activities are :

(1) the irregularity of the supply and the total absence of cold-storage facilities;

(2) the unsuitability of coconut oil for canning, which made for a low quality product.

The failure of this attempt should not be construed as a proof that the canning industry cannot be established in Tahiti. On the contrary, it would seem that the abundance of semi-skilled labour in this territory would be favourable to the introduction of industrial activities on a fairly large scale. One of the first concerns, however, should be the good quality of the product. It would also be essential to secure fairly large supplies of fish, and to have capacious cold-storage facilities to absorb the irregularities in the deliveries of fish.

The Municipal Fish Market of Papeete is the largest and best-organized in the South Pacific Commission's area. Accurate statistics are kept both as to quantity and value. Most of the fish marketed in Tahiti is sold on the Papeete market, although small quantities are disposed of in the district villages.

Regulations have been enacted to cover pearl-shell diving, including the minimum legal size of the shell, to prohibit the use of explosives and drugs, and to establish closed seasons and minimum sizes for the protection of fresh-water fish and shrimps as well as of spiny lobster.

Cold storage facilities and ice are available in Papeete, but are not used to any extent for fish preservation.

Although there are no large-scale fishing industries, with the exception of pearl-shell diving, it can be said that local fisheries and the resultant marketing organization and regulations are more advanced than anywhere else in the Commission's area.

The fishing industry as a whole is placed under the supervision of the Animal Industries Department, which produces a yearly report including a chapter on fisheries. Various investigations in fisheries have been made in French Polynesia in the past, including a survey by Mr. M. Legand on fisheries methods, a study of the depopulation of the pearl-shell lagoons, by Professor

G. Ranson, and some oceanographic surveys of the northern part of the territory by P.O.F.I., to quote only the more recent ones. A complete list of fisheries surveys and investigations in the territory would be much too cumbersome for insertion in this report.

TABLE I.

Imports of canned fish, crustaceans and molluscs

(in metric tons)

Country of Origin	Salmon and Pilchard			Other canned fish and molluscs			All canned seafoods
	1953	1954	1955	1953	1954	1955	1956
France			0.021	32.1	31.786	27.845	24.6
U.S.A	76.7			138.9	130.734	223.726	147.8
Holland	26.1	0.717	2.400	21.2	21.805	24.564	
Canada	99.8	97.992	94.809	0.3	0.015		26.7
Morocco			0.407	22.8		17.929	1.0
U.K.		1.406		0.4	0.143	0.035	
New Zealand				5.5	58.453	5.532	
Australia				0.1	0.157	0.855	
China				2.9			
Denmark		1.915		1.6		0.508	
Japan		8.228		5.6	8.059	1.032	0.5
Other Countries		0.174		0.5	7.758	13.930	4.2
Totals :	202.6	110.432	97.637	231.9	258.910	315.956	204.8

TABLE II

Mother of Pearl shell exports

Year	1950	1951	1952	1953	1954	1955	1956
Metric Tons	490	763	550	587	650	729	520

TABLE III

TUAMOTU-GAMBIER AREA

Production of Mother-of-pearl shell

Island	1951		1952	
	Kgs.	Value in CFP francs	Kgs.	Value in CFP francs
Hikueru	193,639	7,774,381.0	139,831	6,305,357.50
Takapoto	1,025	48,687.5	50,618	2,242,750.0
Takaroa	20,193	629,502.5	83,320	2,551,625.0
Takume	1,683	50,490.0	34,508	1,542,700.0
Katiu	215	5,375.0		
Makemo			9,777	441,584.0
Aratika	911	27,330.0		
Marokau			2,753.50	124,357.50
Tauere	190	9,025.0	600	21,155.50
Amanu	992	47,120.0	6,570	207,394.50
Manihi	4,688	140,640.0		
Hao			8,508	379,940.0
Taenga			7,767	350,332,51
Anaa			650	31,302.50
Reitoru			208	8,200.0
Marutea-Sud	244,269	9,770,760.0	3,834	168,715.0
Gambier	69,332	2,732,490.0	68,703	2,954,955.0
Totals :	537,137	21,235,801.0	417,647.50	17,330,369.01

TABLE III (Contd.)

Island	1953		1954	
	Kgs.	Fr.CFP	Kgs.	Fr.CFP
Hikueru	208,222	9,282,227.5	138,664	7,447,553.0
Takapoto	43,977	2,096,440.0		
Takaroa	125,411.50	6,104,117.5	80,674	4,277,581.0
Takume	20,414	979,865.0	15,767	991,100
Raroia	9,088	454,400	2,437	123,015
Katiu	759	34,155	20,477	1,091,098
Makemo	4,943	233,250	6,247	429,829
Aratika			24,463	1,338,055
Fakarava	3,139	150,034	2,009	110,292
Marokau	28,157	1,382,845	8,231	426,295
Tahanea			8,826	496,127
Amanu	9,286	473,665	2,820	158,030
Manihi			22,330	1,163,865
Nukutepipi			526	26,300
Ahe	6,253	302,645		
Hao	3,823.50	184,252.5	4,383	260,277
Hereheretue			762	40,100
Taenga			308	18,480
Nihiru	286	13,156		
Anaa			3,625	207,220
Motutuga	9,111	447,175		
Raraka	7,039	297,440		
Marutea-Nord	5,122	256,100		
Arutua	4,398	219,900		
Apataki	481	20,045	198	9,900
Vahitahi	1,765	88,250		
Kaukura	827	41,350		
Ravahere	658	32,900		
Faaite	252	10,710		
Rairoa	121	5,445		
Marutea-Sud			269,063	14,066,085
Gambier	39,508	1,912,385	38,882	2,078,398
Totals :	533,041	25,026,752.5	650,692	34,759,600

TABLE III (Contd.)

Island	1955		1956	
	Kgs.	Fr.CFP	Kgs.	Fr.CFP
Hikueru	285,780.70	20,285,342		
2nd sector			251,862.64	34,635,193
Takaroa	48,041	2,668,635		
2nd sector			99,530.40	12,531,993
Takapoto	167,604.60	10,923,450		
Takume	63,471.90	4,223,024		
Gambier	124,450.60	7,853,796	31,758.80	3,582,070
Moruroa	20,654	1,239,240		
Manihi (remainder of 1954 season)	840	50,400		
Hao (whole lagoon)			20,972.90	2,179,612
Raroia(" ")			9,803	1,081,510
Raraka(" ")			6,227.30	781,345
Marokau(1st sector)			26,409	3,392,300
Marutea-Nord (whole lagoon)			20,199.50	2,237,680
Ahe (whole lagoon)			14,772	2,097,440
Nego-Nego (whole lagoon)			588	88,200
Totals :	710,842.80	47,243,887	482,123.54	62,607,343

The main buyers of pearl-shell from French Polynesia are :

France	284,855 Kgs.
United States	34,032
United Kingdom	20,090
Hawaii	160
Germany	273,675
Holland	47,379
Italy	25,868
Total .	686,059 (net.)

(French Polynesia Animal Industries Annual Report 1955)

OBSERVATIONS AND RECOMMENDATIONS

Tahiti

As mentioned earlier, Tahiti is a volcanic island on which the population is concentrated near the sea. Rivers and streams are numerous but small. A narrow reef barrier surrounds the island, enclosing a small lagoon which can be very shallow in places, although small boats can generally navigate it. This reef is cut by numerous passes; it is in most places covered with aquatic plants and practically its whole surface is under water or at least washed by the seas at high tide.

Differences between high and low water are small and do not exceed 50 cm. At the time of our visit the salinity of seawater around Tahiti was 35.4 for a water temperature of 82° to 83° F.

There are a number of full-time fishermen and it can be said that most of the population takes part in part-time fisheries activities. Fishing nets can be seen hanging from trees in many places around the island. These nets are not tanned; they are, for the greater part, used for catching ature and orare, that is the juvenile and adult forms of Selar crumenophtalmus respectively. Ature nets are generally of considerable dimensions, some reaching a length of 500 fathoms and a depth of 6 to 7 fathoms. The mesh size is generally about 2-inch stretched or a little smaller. The cost of such a net and of the necessary canoes is said to be in the vicinity of 500,000 fr. CFP. Its use requires some large canoes and a number of fishermen.

Ature catches are evaluated locally in terms of "strings". Each string includes 24 to 25 ature or 8 to 10 orare and weighs from 3 to 4 lbs. An exceptional catch of 11,000 strings was mentioned to us, but normal hauls amount to 2,000 to 3,000 strings.

Owing to the difficulty of marketing such large catches, only a small proportion is sold every day, the rest being held alive in a net or chicken-wire enclosure. Under favourable conditions of current and food supply, these fish can be kept alive up to 3 weeks or a month.

Some large nets of stronger material are also used to catch trevally. Many of these nets are hand-made, generally by the pink-knot method.

Small seines made of small meshes, including even mosquito netting, were also seen. These are mainly used to catch brackish and freshwater shrimps in rivers and estuaries.

Bottom traps made of wood, bamboo or wire, are used successfully. Bamboo live boxes of very ingenuous construction are used everywhere and their size can vary from 1 ft. to 12 or 13 ft. Crab nets and lobster pots were also observed.

Spear guns and ordinary hand spears are widely used. The gathering of shells for food or for the curio industry is a common part-time occupation.

Some fishermen catch yellowfin tuna over deep areas generally termed "tuna holes", which may be situated in the reef passes or outside the reef barrier. They use a cotton line about 200 fathoms long with a wire leader and tinned tuna hook baited with ature. The hook is let down to about 60 to 90 fathoms with the aid of a flat rock. The technique consists of first crushing some ature or other bait fish on the rock around which the leader and a portion of the line are then wrapped and tied with a slip-knot. Once the desired depth has been reached, the stone is slipped off, thus liberating the crushed chum. The fishermen are limited by the number of rocks they can carry safely in their canoes. The catches are very irregular and, while a fisherman may come back with two or three tuna on a good day, he very often returns empty-handed. Tuna up to 120 lbs. have been caught by this method.

A more important industry is bonito fishing with small motorboats using pole and line with a lure. This method will be described in some detail here, since it is quite important in French Polynesia and may be of great interest in other parts of the South Pacific where it is unknown or practised only with paddling canoes.

Up to 16 bonito boats were observed at one time in Papeete harbour. There are, however, more boats fishing for bonito out of Papeete and other places in Tahiti. These craft have a length of 20 to 25 ft., a beam of $6\frac{1}{2}$ to $7\frac{1}{2}$ ft. and a draught of about 2 ft. A small deck and a roofed cabin occupy the fore half of the boat, while the after part is taken by a self-bailing cockpit. These boats are equipped with diesel engines, 15 to 20 h.p. and attain a speed of 6 to 8 knots. The crew includes two to three fishermen. The poles used are made of bamboo, about 15 ft. long, each pole being equipped with one or two cotton lines 10 to 12 ft. long, followed by a steel wire leader made of two or three separate pieces to which is attached a lure which can be made of pearl-shell, metal, metal and feathers, or horn and feathers. The hooks on these lures are not barbed.

When a school of fish has been spotted through the activity of sea-birds above it, the boat makes for it, trying at all times to stay on the fringe of the school and just ahead of it.

The lures are dragged on the surface of the water and when a fish bites it is lifted out of the water and literally thrown into the cockpit. The ideal is to unhook it in the middle of its trajectory, the fisherman then dodging the fish and throwing back his lure into the water without wasting any time.

As mentioned earlier, the poles are often equipped with two lines and two different kinds of lures. Only one line is used at a time, but, if the lure proves unsuccessful, the second line is tried out, the first lure

being hooked into a hole provided for that purpose in the butt of the pole.

It is sometimes very difficult to induce the fish to bite and often the fishermen drag bunches of banana leaves or coconut palm leaves in the water in an attempt to attract ature. The leaves are then taken aboard and the ature usually take refuge under the boat itself, thus attracting the bonito near the stern. A number of boats can often be seen circling in very close proximity to each other during this manoeuvre and accidents are only prevented by skilful handling and the very great manoeuvrability of this type of craft.

At other times small pieces of fish are thrown out astern to attract bonito.

This type of fishing is practised only in the daytime. The catches are very irregular during part of the year, but can reach 200 bonitos per boat per day in season. During our stay, catches of nil to 85 bonito have been observed.

In spite of the fact that fishermen know the bonito season well, they go out whenever the weather permits, since, during the off-season, the prices of bonito rise considerably.

The fish are gutted and laid on a rack as soon as there is a lull in fishing. On an average they reach a weight of 6 to 10 lbs. The crew is paid on a share basis. Usually the costs of fuel and oil are subtracted from the proceeds of the day's catch, the rest being divided half-and-half between the owner of the boat and the crew.

A considerable quantity of spiny lobsters is sold annually on the Papeete market. In spite of the fact that a regulation prohibits the taking of these lobsters for a certain season of the year, there is no size limit for these shellfish and many of the specimens seen on the market were very small (7 to 8 inches). It seems advisable that a minimum size of 1 ft., exclusive of the antennae, be established.

The comparatively poor population of the reef around Tahiti is usually attributed to gross overfishing. However, a careful study of market statistics shows a maximum difference of 9 tons in monthly averages over the last four years. Actually, the difference may be much less, since it is probable that crustacea, which have been taken into account for 1954, the year of maximum production, have not been included in statistics for 1956, year of minimum production.

It is felt that differences of about 7 tons in monthly averages can well be explained by the irregularity of production characteristic of fisheries barely above the subsistence level.

It would therefore seem that the various species now forming the bulk of lagoon fish marketed in Papeete can well stand the present level of exploitation.

Données météorologiques

Pluviométrie (en mm.)

Stations	Jan.	Fev.	Mars	Avr.	Mai	Juin	Juil.	Août	Sep.	Oct.	Nov.	Dec.
Papeete (Moyenne de 13 années, 1935-1947)	376.4	319.8	122.8	144.8	139.3	71.6	77.8	50.9	88.7	87.9	197.4	279
											Total :	1956.4
Moyennes de toutes les stations côtières sur 5 ans 1950-1954	294.6	229	162.8	148.1	207.2	110.5	88.8	105	101.5	164	174	300.2
											Total :	2085.7

Humidité Relative (en degrés)

Papeete 8 heures moyenne 8 ans 1949-1956	81	83	82	80	84	82	80	76	73	74	76	76
											Total :	947
											Moyenne :	79
14 heures moyenne 8 ans 1949-1956	75	74	72	69	69	67	65	67	69	69	71	72
											Total :	839
											Moyenne :	69.9
20 heures moyenne 8 ans 1949-1956	84	85	85	84	86	84	81	79	80	80	82	81
											Total :	991
											Moyenne	82.5

Température de l'air en degrés centigrades

Papeete Moyenne de 6 ans 1949-1954 maxima	29.7	30	30.2	30.2	29.5	29.1	28.5	28	28.2	28.8	29.1	29.3
											Moyenne générale	29.2
Minima	22.2	22.3	22.6	22.4	21.7	20.6	20.2	20.2	20.6	21.4	21.8	22.2
											Moyenne générale	21.5

Iles-sous-le-Vent

Pluviométrie (en mm.)

Stations	Jan.	Fev.	Mars	Avr.	Mai	Juin	Juil.	Août	Sep.	Oct.	Nov.	Dec.
Uturoa Moyenne/20 ans (1936-1956)	331.3	250.1	231.1	189.8	211.3	174.5	105.5	88.4	128.3	187	255.8	349.4
					Total : 2502.5							
Bora-Bora Moyenne/6 ans (1949-1956)	255.2	207.1	152.3	162.5	196.9	92.4	131.4	84.9	120.9	147.2	204	344.5
					Total : 2099.3							

Humidité Relative (en %)

Uturoa Moyenne/8 ans (1949-1956) 08 heures	86	86	87	86	88	85	84	83	82	82	84	83
					Moyenne Générale : 85							
14 heures	73	73	71	72	73	72	70	70	69	72	74	72
					Moyenne Générale : 72							
Bora-Bora Moyenne/6 ans (1951-1956) 08 heures	79	80	83	82	86	82	84	82	81	81	82	79
					Moyenne Générale : 81.7							
14 heures	72	72	72	73	76	72	72	70	72	72	74	73
					Moyenne Générale : 72.5							
20 heures	80	81	81	81	84	82	81	80	80	82	82	81
					Moyenne Générale : 81.3							

Température de l'air (en degrés centigrades)

Uturoa Moyenne/18 ans (1938-1956) Moyenne des Maxima	31.3	31.6	31.9	31.6	30.7	30.1	29.7	29.5	29.8	30.3	30.8	31.1
					Moyenne Générale : 30.7							
Moyenne des Minima	24.3	24.3	24.7	24.3	23.8	23.4	23.1	22.8	23.1	23.7	23.9	24.1
					Moyenne Générale : 23.8							

Température de l'air (suite)

Stations	Jan.	Fév.	Mars	Avr.	Mai	Juin	Juil.	Août	Sep.	Oct.	Nov.	Déc.
Bora-Bora Moyenne/6ans (1951-1956) Moyenne des Maxima	29.8	30.1	30.6	30.1	29.2	28.5	28.2	28.4	28.4	29.2	29.3	29.7
								Moyenne Générale : 29.3				
Moyenne des Minima	23.9	23.7	24.1	23.7	23.1	22.7	22.2	22.2	22.4	23.1	22.9	23.7
								Moyenne Générale : 23.1				

Iles Tuamotu

Pluviométrie (en mm.)

Takaroa Moyenne/4 ans (1952-1955)	229.35	106.15	110.8	173.6	122.8	80.8	58	34.3	33.5	64.2	135.3	128
								Moyenne Générale : 106.4				

Humidité relative

Takaroa Moyenne/4 ans (1952-1955) 08 heures	77	75	76	77	77	77	78	74	75	76	76	76
										Total :		914
								Moyenne Générale :				76
Moyenne/4ans (1952-1955) 14 heures	73	72	73	75	77	76	77	73	74	73	73	74
										Total :		890
								Moyenne Générale :				74
Moyenne/4 ans (1952-1955) 20 heures	80	79	78	78	80	79	80	78	79	78	80	79
										Total :		948
								Moyenne Générale :				79

Température de l'air

Takaroa Moyenne/2 ans (1952/1953) Maxima	29.9	31	30.8	30.6	30	28.3	27.7	28.1	28.5	28.9	29	29.9
										Total :		352.7
								Moyenne Générale :				29.4
Minima	24.6	25.6	26.2	25.7	25.2	25.2	24.7	24.7	25.1	25.2	24.8	25.3
										Total :		302.3
								Moyenne Générale :				25.2

On the other hand, it is quite apparent that some families, such as the Lutjanidae and Serranidae are very poorly represented on the market as well as on the reef. It would appear that these have been unable to withstand the fishing pressure exerted by the local population. There has probably been gross overfishing in respect of some species particularly susceptible to fishing. However, a kind of balance seems to have been reached years ago between the capaoity of production of the reef and its exploitation.

South of the isthmus of Taravao, in the deep bay of Port Phaeton, we found oysters growing wild on the rocks. Since edible oysters are very seldom available in Tahiti, it might be a profitable enterprise to start a small oyster park in this area. It is quite probable that by using proper collectors very good oysters could be harvested here. The salinity of the water at the head of the bay was 32.3 for a temperature of 83°F. at the time of our visit. Some small freshwater streams run into that bay. The largest wild oyster found there was 3" in length and had a very good flavour. In the same area two brackish water ponds or lagoons are formed by the causeway built to support the road. Oysters were also growing in these. In the largest (Tiopi lagoon) the salinity varied from 30.1 to 32.8 for an air temperature of 81°F. and a water temperature of 79.5°F. at 10 a.m. The smallest of these two ponds, situated between the Tiopi lagoon and Taravao, had a salinity of 26.5 for an air temperature of 78.5°F. and a water temperature of 81°F. at 5 p.m. Both these ponds contain various species of fish, including mullet, milkfish, trevally, etc. These are taken either by the owners of the ponds or by persons authorized by them, chiefly for subsistence purposes. Oyster parks could profitably be established in these ponds.

Tahiti has a good harbour, facilities such as boat-repairing yards, cold storage plants, an ice factory, skilled mechanics and good fishermen are available. There are also a considerable number of safe anchorages for small boats in Tahiti.

We visited the largest cold-storage plant in Papeete, which has a total available capacity of 2,754 cu.ft., divided equally between three units working respectively between 5°and 1.4°F.; between 10.4° and 5°F.; and at 33.8°F.

Users pay a storage rate of 1.10 francs per kg. for the first day and 0.20 francs per kg. for each succeeding day in the first two units. The third unit is chiefly used for the storage of fruit and vegetables.

A number of small cold-storage units are operated by various butchers and merchants in Papeete, but both their small capacity and irregularity of functioning makes them rather unsuitable for the preservation of fish.

The ice factory has a capacity of 10 tons a day and ice is sold in bulk quantities at a price of 1.80 francs per kg.

The quantities of fish sold in the Papeete fish market from 1953-1956 were as follows :-

TABLE IV

Fish Consumption

(Papeete Market statistics)

Quantities by species in kilograms :

Species	1953	1954	1955	1956
Bonito	261,222	323,960	278,852	370,697
Tuna	67,592	78,949	61,558	53,178
Ature		132,862	153,026	113,369
Lagoon (misc.)	362,445	380,414	302,863	283,264
Totals :	691,259	916,185	796,299	820,508

Total monthly sales in kilograms :

Month	1954	1955	1956
January	149,880	79,073	94,459
February	83,945	91,711	83,506
March	80,062	78,082	89,091
April	62,997	71,888	79,382
May	78,612	96,397	71,156
June	70,236	66,944	48,339
July	47,347	67,595	48,072
August	44,849	49,673	42,445
September	48,948	36,594	33,362
October	80,504	43,768	39,485
November	88,433	47,193	70,690
December	80,372	67,381	120,521
Totals	916,185	796,299	820,508

In addition to these amounts, 12 tons of crustacea were sold in 1954, and 17.042 tons in 1955.

A number of visits were paid to the market and it was observed that fish is sold chiefly in the morning, although an appreciable quantity of bonito is marketed in the afternoon immediately after the bonito boats return to the harbour. These fish are transported from the harbour to the market in small

trucks. Lagoon fish and ature sent from the districts are brought to the market by various trucks and buses, while fish from Moorea is brought over by fishing boats and carried to the market in small trucks.

Most of the fish are displayed in the market hanging from steel pipe racks, the lagoon fish, lobsters and ature in strings of 3 to 4 lbs., the larger fish singly or in pairs. Shellfish, crustacea and very large fish are laid out on tables.

It is regrettable that no use is made of cold storage or crushed ice, but, as already mentioned, the consumers on the whole are opposed to the idea of buying frozen or cold-stored fish and the same reluctance is present in the case of meat. In this connection it should be mentioned that this attitude seems to spring more from a lack of familiarity with these preservation methods than from any actual change detected in the taste of the product. Whatever the reason, some tuna and bonito were observed which had been kept overnight in the market and were distinctly beginning to decay. Very often some part of a day's catch cannot be sold in the evening and is left hanging in the market to be sold the next morning. It would certainly be preferable if the market was equipped with a cold store capable of keeping about 5 tons of fish near freezing point.

In spite of the present dislike for frozen or cold-stored fish, it is quite probable that a well-documented campaign of education would do away with this attitude. It should not be forgotten that in most European countries consumers had the same attitude towards frozen fish in the 'twenties and very extensive propaganda campaigns had to be staged in order to overcome this resistance.

The development of fisheries industries in Tahiti can only be achieved by the promotion of pelagic fisheries covering chiefly the main tuna species and the spear fishes. This could be achieved partly by an increase in the number of bonito boats and partly by the introduction of larger craft using longline gear in the same way as the Japanese fleet based in American Samoa or the Hawaiian tuna fishing fleet.

It would be possible to increase the consumption of fish in Tahiti if the population was willing to accept frozen fish so that stocks built up at times when the catches are large could be marketed when the production is low. However, the population is too small to allow for a very considerable increase in the sales.

Any large-scale expansion of the fishing industry would therefore require finding a market in other countries, possibly in France or in the United States. Two main possibilities are open :

(1) the export of frozen fish;

(2) the export of locally canned fish.

In the event that an outlet be found for one or both types of products, the first step to be taken would be to explore the possibilities of increasing the catches, Bonito would not be a problem, since it would merely be necessary to increase the number of small motor-boats of the type at present used in Tahiti and nearby islands, such as Moorea, Raiatea, Tahaa and Bora Bora.

Experiments with the longline would be more important. French Polynesia is in a favourable position in this respect, since bait is available in quantities, while it is lacking in many other South Pacific territories. Both operu and ature, or orare, are excellent bait fish and one or the other species is available in each of the islands mentioned above, as well as in Tahiti.

Trial sets would have to be made at first by some government agency or with the aid of a private fishing-boat subsidized by the government. Surveys have been made by the P.O.F.I. research vessel "JOHN R. MANNING" along the 132°W meridian from 4°30'N. to 14°S. in the second half of January 1957; among the Marquesas Islands from 1 to 10 February 1957, and along the 148° meridian West from 16°30'S. to 3°N. from 19 February to 5 March 1957. This vessel was using 60 baskets of longline carrying 660 hooks and the total catch over 38 stations included 355 yellowfin tuna, 51 big-eyed tuna, 24 albacore; 36 skipjack; 44 spearfish; 6 wahoo; 5 barracouda and 333 sharks.

These catches are not high and it is only in the Marquesas islands, south of Nuku Hiva that rates of 7.58 and 8.18 fish per 100 hooks were obtained on two stations. However, this covers only a very small part of the year and no conclusion can be reached regarding the abundance of fish from these results. Besides, it is quite possible that the lines were not set deep enough for albacore. Further investigations in this area were made by P.O.F.I. Research vessels "CHARLES H. GILBERT" and "HUGH M. SMITH". The work of the latter vessel was mainly in relation to physical oceanography and will not be related here. The vessel "CHARLES H. GILBERT" made live-bait fishing trials in the Marquesas area on a total of 99 tuna schools, obtaining good results from 12 of these schools with a total catch of 4,838 skipjack and 53 yellowfin. At the same time a survey of bait fish was made in the Marquesas Islands with quite good results.

A very short fishing trial with live bait was made by the same vessel in the northern Tuamotu Islands, where 237 skipjack and 17 yellowfin were taken from one school of each species.

It is quite possible that live bait fishing, a method very closely akin to that normally used by Tahitian bonito fishermen, would appeal more to the local crews than longlining. This possibility should be explored.

A longlining trial with a shortened version of the Japanese gear and a small motorboat will be made in Tahiti by two private fishermen. However, these trials will probably not give very reliable indications since the working

range of the boat will be limited by its small size. It would be better to use a total of 30 baskets of longline carrying 150 hooks and a 50 ft. motor-boat. This is small-scale longlining as practised in Hawaii. Japanese longliners usually set from 200-300 baskets, each containing about 180 fathoms of main-line. Further details on this method can be found in the July 1955 issue of the SPC Quarterly Bulletin.

The personnel of the Oceanographic Section of I.F.O. in Nouméa are acquainted with longlining techniques and, since French Polynesia lies within their scope, it might be advisable for them to undertake a survey of that area.

In conjunction with such developments as the promotion of longlining or live-bait tuna fishing, it might be possible to induce some large canning concern from France to establish either a large-capacity freezing plant or a cannery in Tahiti with a view to supplying the French market.

Trochus niloticus

Although some Trochidae are endemic in French Polynesia, the commercially valuable Trochus niloticus is not present there. No explanation can be given for this beyond the general observation recorded long ago by biologists working in the Pacific, that a number of species whose origin lies in South-east Asia and adjacent countries have never reached the eastern islands of the Pacific. This fact is noticeable both in land and marine fauna. Until recently the area of distribution of trochus extended only to the eastern islands of the Fiji group. More recently they have been transplanted to the Cook Islands, with apparently good results. They are endemic in New Caledonia, the New Hebrides, Australia, New Guinea, Fiji, the Solomon Islands and some parts of the Trust Territory of the Pacific Islands, to speak only of the South Pacific Commission area.

The trochus shell commands good prices on the world market and the animal itself is edible. Since trochus live mostly in shallow water (maximum depth 46'), the divers engaged in collecting this shell do not require the outstanding qualities necessary for mother-of-pearl diving.

The biological requirements of trochus are quite different from those of the blacklip pearl oyster, with which they compete neither for food nor for living space. Trochus are found chiefly on the outer edge and top of barrier reefs or fringing reefs well-exposed to the sea. They feed on short filamentous algae growing on rocks and they can travel to some extent in search of food; distances of 50 yards and more have been covered by trochus in one night. Trochus require clean seawater with a rather high oxygen content, such as is found at the edge of the reefs amongst the breakers. It cannot withstand a low degree of salinity and will not survive in muddy areas.

Excellent conditions for the establishment of trochus appear to exist on practically all the reefs surrounding Tahiti. Filamentous algae are abundant

the seawater has a salinity of 35.4 and the temperature of the water is approximately 82°F.

It is felt that the best place in which to establish the first transplant of trochus would be on the reef extending from Aiurua Pass to the Vaionifa Pass in the east of the Taiarapu peninsula, opposite part of the Tautira district.

In the course of two interviews, the chief of this district expressed great enthusiasm over the project and even stated that it would be quite feasible to obtain unanimous consent from the population for closing this part of the reef entirely to fishing if such a measure were necessary. In addition, this part of the reef is already much less frequented by fishermen than the part directly opposite the village of Tautira or the coast and reefs south of the Aiurua Pass.

It would be advisable to inform the population as fully as possible of the qualities and characteristics of trochus, at the same time issuing a warning that no trochus should be taken from the reef until further advice from the government.

The introduction of 1,000 medium-sized trochus is necessary to begin stocking a single island. Obviously the greater the number of trochus transplanted, the earlier one can expect a commercial production of some importance. Such a production, of course, cannot be expected from the first year after the transplantation.

Fiji is the nearest place from which trochus can be shipped to French Polynesia and other territories from which transplantation could possibly be made are New Caledonia, Wallis Island and the New Hebrides. Direct air liaison between New Caledonia and French Polynesia would facilitate transplantations from the New Hebrides or New Caledonia. The recently inaugurated air connection between New Caledonia and Wallis Island via Nadi may eventually make it possible to send trochus from the Wallis group to French Polynesia.

When shipped by airplane, trochus should be put in openwork wooden crates lined with clean sacks dipped in seawater. By ship it is preferable to carry the trochus in tanks with seawater circulation. Sudden changes of temperature should be carefully guarded against, although gradual changes will not harm the trochus. It is preferable to keep the temperature above 68°F. and to keep the crate in the cabin of the plane. On the transplant of trochus from Fiji to Aitutaki, electric bulbs were placed around the crates in order to regulate the temperature. In instances when the airplane makes an overnight stop en route, it is advisable to put the trochus in clean water on a reef, if possible in a wire or net enclosure. If this proves impossible, the crates should be dipped for a few minutes in seawater, avoiding sudden changes in temperature. It should always be remembered that trochus need clean seawater with a high oxygen content and also

that any enclosures should be closed at the top to avoid trochus escaping over the wire.

Fish Culture in Ponds

The only effort in that field is contemplated by Mr. Ah Chung, who plans to use some swampy land on his cattle estate at Taravao to build two large ponds, which he will stock with Tilapia at present kept in a very small concrete tank. Some information about the construction of such ponds was given him and he was also advised to check the pH of the water.

Fish ponds could be built in a number of places where a good supply of fresh or brackish water is available.

In case such ponds are built, those containing brackish water would best be used for raising mullet, which is quite popular in Tahiti. Large quantities of young mullet can be obtained with a cast-net or small seine. It would be preferable that the ponds should not be deeper than 2 to 3 ft.

While actual fish culture in ponds is not practised, some natural brackish water ponds are exploited more or less regularly, in particular at Paea and at Tiopi.

Raiatea

With the exception of freshwater shrimps, the fauna of rivers in Raiatea is not important. The very low coastal belt, which is periodically flooded by the heavy rains or by the sea in bad weather, might in places be used for fish culture.

Cylindrical traps made of chickenwire are commonly used in this island to catch mullet and reef fishes.

Operu are caught near passes in traps made of nets, stakes and bamboo floats.

Approximately a dozen bonito boats are operating around Raiatea and selling their catches at various places on the coast and on the Uturoa market. Five of these boats are based at Uturoa. According to local informants, marlin are regularly found in September of each year about 3 miles offshore. This combined with the fact that operu is available in small quantities around the island, would seem to advocate the establishment of a longline fishery.

Mother-of-pearl oysters are found in the Raiatea-Tahaa lagoon. In 1956, 16 tons of pearl shell were brought up by a very small number of divers.

Excellent conditions were found for the establishment of trochus on the outer reef around Raiatea as well as on the reef plateau in the channel between Raiatea and Tahaa.

Wild oysters were once collected fairly regularly in Raiatea, but have become rather scarce. At one place in particular, in Faaroa Bay, an abundance of small oysters was found on wooden wharf piles, rocks, etc. Mr. Colomès, a plantation manager living in this place, was advised to lift small oysters and try raising them to marketable size on woven bamboo panels fixed on stakes. The salinity of the water in this bay was 9.5.

Tahaa

Conditions on this island are very similar to those found in Raiatea. The reef offers good conditions for the establishment of trochus.

A number of places were visited where some primitive form of oyster culture might profitably be undertaken. Old shells, $3\frac{1}{2}$" to 4" long, were observed in several places.

Young "ava" (Chanos chanos Forsk.) were seen near Tautu islet (NNW of the mainland of Tahaa) and could eventually be used for pond culture.

The inhabitants go on turtle fishing expeditions near the small island of Tupai, near Bora Bora, during the breeding season from October to January. These turtles are shipped to the Tuamotou Islands during the diving season and fetch very good prices there.

Bora Bora

Except for the eastern side, the reef of Bora Bora offers good conditions for trochus. The salinity of the water near the reef was of 34.9 for a temperature of 83°F. at the time of our visit.

Operu are netted all the year round near passes. At the time of our visit (April) these fish were full of spawn.

Schools of bonito were sighted outside the reef.

Blacklip pearl shell are found in shallow water occasionally. It is possible that these are more plentiful in the deepest areas of the lagoon. Edible oysters were observed in one area in the Faanui district.

Moorea

In the course of two visits to Moorea, it was unfortunately impossible to visit the reef except at three points, one on the east coast opposite the village of Afareaitu and two on the north coast, respectively opposite Cook's Bay, east of the Avaroa pass, and opposite the village of Papetoai, west of the Tareu pass. At all three points fairly good conditions for the establishment of trochus were found. Salinities varied from 34.9 for a temperature of 83°F. at Afareaitu to 32.8 for a temperature of 80°F. opposite Cook's Bay. Information obtained

from various residents indicate that algae are abundant on the reef, chiefly on the east and north coasts.

The district of Papetoai apparently supplies large quantities of reef and lagoon fish for the Papeete market, and a few bonito boats based in this area also sell a large proportion of their catch in Papeete.

Tuamotou Islands

Mother-of-Pearl oyster

Pearl shell from Pinctada margaritifera is one of the very few important export products of French Polynesia.

This shell lives in clear seawater of high salinity. It is attached to rocks, old shells, coral debris, etc., by means of about 190 strong byssus threads, preferably at an angle of 90° to the support, although this is very often modified by the available space, and the oysters are commonly found growing in clusters.

The blacklip oysters are found in depths of 1 to 25 fathoms, although they are more numerous below 8 fathoms. They feed on plankton and grow rapidly during the first three years of their lives. In succeeding years their diameter increases more slowly, but the shell grows thicker.

The sexes can only be determined by examination under the microscope and there is a strong probability that these oysters change sex periodically. Enormous quantities of eggs and even greater quantities of sperm are spawned. Fertilization takes place rapidly and in 24 hours the eggs turn into very small larvae, which are already growing an embryonic shell after the second day. For 21 to 25 days the larvae remain in suspension in the water, at the mercy of the currents, although they can move within a limited area. During this period of planktonic life, a metamorphosis takes place. At the end of their planktonic life these larvae settle on the bottom. If they happen to fall on a suitable support, they remain attached to it for the rest of their lives. If, on the contrary, they happen to settle on an unsuitable bottom, they just die. A number disappear in this way and many more fall prey to their natural enemies, fish, crustacea and molluscs. Even during its young stages, the mother-of-pearl oyster is still exposed to a number of dangers.

Under good conditions, blacklip pearl oysters will reach a diameter of 6 to 7 inches (including the brittle, horny outer edge) in five years. This growth rate depends, however, on a number of factors which affect the increase in diameter and thickness of the shell.

To date, our experience has been that in open, deep lagoons where the water is regularly changed by the movements of tides, large pearl oysters are found in comparatively small quantities, while in closed or nearly-closed lagoons

these shells are found in great numbers, but reach a smaller diameter, although large shells can still be found there in the deepest areas. However, so many factors still remain unknown that this observation should not be taken as a final statement. Most of the data applied so far to the conservation of the blacklip oyster has, in fact, been derived from the facts known about other species of mother-of-pearl oysters.

Regulations have been made to protect the pearl oyster beds of French Polynesia and they cover the diving seasons and areas, the minimum size of the shells and the establishment of reserves. These regulations have so far been revised practically every year in the light of prognostics arising from previous years' yields. They are further adjusted to fit the conditions obtaining in particular lagoons.

On the whole, an attempt was made originally to ensure a three years' rest for each lagoon or portion of lagoon containing pearlshell. More recently, especially since the survey made by Professor Ranson, reserves have been established and an effort is now made to lengthen the rest period between open seasons in any lagoon or portion of a lagoon up to 4 years. The minimum size for pearl shell is 5.1" greatest diameter, measured on the clean shell. However, a minimum size of 3.9" has been set for the oysters of Tearai-Gambier and for the Takapoto lagoon in the Tuamotou islands.

In recent years some authorizations were given for aqualung diving in certain lagoons, but these had to be cancelled in view of the number of accidents caused by non-observance of safety rules.

Even a cursory study of the legislation over the past few years shows clearly that the authorities are earnestly trying to protect pearl oyster beds from over-fishing and, at the same time, to ensure a satisfactory yield from these beds. To a great extent these attempts have been successful, although some points are still considered as unsatisfactory.

Before trying to give any opinions it might be necessary to explain that our visit was confined to the two atolls of Takaroa and Takapoto, which, although very close to each other, offer quite different characteristics. The choice of these two atolls was quite fortunate in enabling us to observe a wide range of environments and activities.

Takaroa and Takapoto

The atoll of Takaroa is $14\frac{1}{2}$ miles long and 4 miles in its widest part. It lies in a north-east to south-west direction. The lagoon itself is about $13\frac{1}{2}$ miles long with a greatest width of roughly $3\frac{1}{2}$ miles. Sea charts do not show any soundings inside the lagoon, but rough soundings taken during our visit showed a maximum depth of $14\frac{1}{2}$ fathoms, although it is quite possible that deeper areas can be found in this lagoon. Local residents mentioned depths of $30\frac{1}{2}$ fathoms.

Three sectors are numbered from (1) to (3), from north-east to south-west. A reserve has been established which straddles the limit between the first and second sectors, along the eastern side of the lagoon. The maximum depth found in this reserve at the time of our visit was 6 fathoms which does not seem to be sufficient. The reserve and the sectors are beaconed with round markers set on poles, sector limits showing white markers and reserve limits red markers with a horizontal white stripe. These markers are placed on submerged or barely-emerging reefs.

In addition to some shallow passages where water can stream in and out of the lagoon, a deep pass breaks the reef just south of the village of Te Avaroa and provides the main passage for seawater flowing in and out of the lagoon. Another passage situated just north of the village also admits an important volume of water.

The salinity in this lagoon is approximately equal to the salinity of ocean water outside the atoll, 35 at a temperature of 83°F.

The bottom of the lagoon is sand with coral debris and coral formations with a number of reefs and steeple-like coral formations reaching up to the surface of the water.

Some blacklip oysters were brought up from the bottom of the reserve. The largest had a diameter of 7 inches, including the horny edges; they were in good condition and in each was found a small pink shrimp 1-inch long. These parasites or commensals were also found later in Takapoto pearl oysters, while in the Cook Islands white glassy shrimps had been found in the blacklip oysters.

Sector (3) of this lagoon was open at the time of our visit, but the number of divers operating there was small. It appears that divers are not very keen to work in that particular sector, which they consider too deep and also too close to the pass and therefore frequented by large sharks. The weather conditions at the time of our visit were poor and further restricted diving operations. On an average, the few divers working in this lagoon brought in about 44 lbs. of shell a day. One diver checked in with about 55 lbs. of shell after diving from 8 a.m. till 3 p.m. The biggest shells seen had a diameter of 6.6", cleaned. Two valves of this size weighed together 1½ lbs.

A total production of 14 to 15 metric tons of shells had been obtained in the first month of diving (March). Three Chinese and one Polynesian merchant were buying the shell from the divers at the rate of 90 francs a kilogram.

The shell in this lagoon is generally steel-grey, although some golden-brown specimens are found. Generally speaking, the shells found in this lagoon are thicker than those taken in the Cook Islands from similar lagoons. The shells, especially those of large size, are often attacked by borers.

It would be difficult to forecast the results of this diving season in Takaroa, since it is expected that a number of divers will migrate there from Takapoto when the beds in this latter lagoon are partly exhausted around the middle of the season. It would be even more difficult to evaluate the quantities of shell still remaining in the open sector, in view of the small number of divers and the particular difficulties characteristic of that area.

After a brief stay in Takaroa we went to the Takapoto lagoon $6\frac{1}{2}$ miles away. The atoll of Takapoto is 9 miles long and 4 miles wide. It lies in a north east-southwest direction. The lagoon itself is $8\frac{1}{2}$ miles long and some three miles wide. No soundings are shown on the charts, but a maximum depth of 17 fathoms was found(in Sector 1) during our visit. It is quite possible that deeper areas exist in this lagoon. The atoll has no pass practicable to even the smallest boats.

To give an idea of the importance of the diving season, a brief description of conditions in Takapoto at the time of our visit will be given here. Normally, the population (circa 260) lives in the permanent village of Fakatopatere in the south-west of the atoll. During the diving season about 1,500 people, coming chiefly from Takaroa, Manihi, Ahe, Apataki, Arutua, Niau, Mataiva, Tikeau, Rangiroa, Fakarava and Katiu, congregate in a temporary village which was set up this year about 4 miles north-east of the permanent village.

A gendarme, combining the functions of administrative officer, pearl shell inspector, postmaster and police officer, had set up his quarters in this village. A field infirmary was operated by a qualified male nurse. A considerable number of merchants had set up shops where they sold most of the necessary commodities, from tinned foods and printed materials to heavy duty outboard motors. Four movie theatres catered for the social needs of the population and four churches for their spiritual needs. The houses, shops, etc., were built of raw timber and plaited coconut fronds and most were partly roofed with corrugated iron sheets as a means of catching rainwater, which is collected into empty petrol drums and used for cooking, drinking and, very sparingly, for washing. A number of bakeries were operated by shopkeepers. The village extended over a strip of land two miles long on the lagoon side of a small islet. Bicycles, some of them equipped with small motors, were not uncommon. Although kerosene pressure lamps were used in most households, the movie theatres and some of the shops had petrol-powered electric generators.

The main reason for merchants setting up shops in the diving lagoons is that they are thus able to keep an eye on the divers to whom they have made advances against their take of mother-of-pearl; in addition they are in a position to purchase shell direct.

From this brief description it is easy to assess the importance of pearl shell diving in these islands. The number of divers operating at Takapoto

at the time of our visit was estimated at 300. Some of them had made sea voyages of up to 200 miles in small power boats or small sailing cutters to come for the diving season, taking their families with them.

For their work the divers use plank-built canoes with one outrigger. These may be paddled or sailed to the diving-grounds, but most are powered with outboard engines of 1½ to 35 h.p. There is a marked preference for outboards 15 h.p. or over. Some merchants tow a string of canoes to the diving grounds and back for a fee of 2 kgs. of pearl shell per canoe per day, using small boats with a powerful outboard motor.

The canoes used are 16 to 20 feet long, their width and depth varying from 1'8" to 2'. The forward part is decked, the bottom is flat and the stern is usually square. In addition to the canoe, the working equipment of a diver consists of small copper goggles, a 20 to 30 fathoms ¼ inch manila rope attached to a lead weight weighing from 15 to 20 lbs., a heavy line, (generally ¼ inch cotton line) from 50 to 100 fathoms long, used as an anchor line with a lead weight or a piece of scrap iron for an anchor; a hoop net made of heavy cotton line or small cord and attached to a strong rope. The whole equipment, including the motor and canoe, represents a capital outlay of around 25,000 francs CFP (in the case of motors up to 15 h.p.).

Normally a diver has a tender with him. Sometimes two divers work with a single tender. After sailing to the diving grounds, which may be up to four miles from the village, the diver goes through a series of breathing exercises and goes down holding his diving rope between his toes just above the lead weight and firmly grasping it in his hand at breast level. The hoop-net is let down to the bottom just before the first dive. The diver usually holds a leg out in order to go down at a slant. He may come up in either of two ways. If he has time to reach the hoop-net, carrying perhaps an oyster, he puts this in the net and goes up by the net rope. If he has been exploring the bottom away from the net, he usually goes back to his diving rope and his tender pulls him up. In this latter case the diver brings up with him any oysters found during his dive. We checked some divers in depths of 11 fathoms and the duration of their dives was from 97 to 112 seconds. One instance was mentioned to us by a reliable witness who had clocked a dive of 135 seconds in a depth of about 17 to 18 fathoms.

When the area accessible to the diver has been worked out, the anchor line is lengthened or shortened, or it may be attached to a different point of the canoe or of the outrigger boom in order to shift the working area. As soon as an area has been worked, the hoop-net and its contents are pulled up and the shells dumped in the bottom of the canoe. Between dives the divers take short rests, generally while hanging from the side of the canoe or from the outrigger boom. During these rests they continue to take breathing exercises which mostly take the form of whistling, in order to refresh the air in their lungs. When two

divers operate from the same canoe, only one goes down at a time, as the tender cannot look after both at once. Tenders usually dive for short periods when the diver is too tired, and part of their duties is to rescue the diver should he have an accident at the bottom. Diving is usually learned young, beginning in shallow water and gradually working into greater depths. Exceptional divers may reach depths in the vicinity of 22 fathoms. Incautious divers are exposed to an occupational disease locally known as taravana, which may cause temporary paralysis, loss of mental faculties, and some severe shock effect. The local treatment includes rough massages and the administration of stiff doses of spirits, probably as a heart stimulant. The victims usually recover within a few days and may start diving again in shallow depths, gradually working down to their normal diving depths.

The divers usually set out between 8.00 and 9.30 in the morning and may return from 3.30 to 6.00 in the afternoon. Upon returning, they anchor off the village and clean their shells roughly, removing the oyster and hacking away the horny outer edge of the valves. The shells are then put in bags and brought to the buyers, where they are measured and weighed. Measurements are taken with a simple wooden gauge with an indentation the length of the minimum size in force in the particular atoll. Undersized shells and those damaged by borers are set aside and refused by the merchants. These shells are later shipped to Papeete on the local inter-island trading schooners. Different exporters buy them, sort the different qualities, pack the shell in barrels and export them to various countries, as indicated earlier.

The daily take of a diver varies greatly according to his ability and his luck in finding good diving grounds. Takes of 15 to 88 lbs. have been observed during our visit and some divers had been recorded with daily takes of up to 132 lbs. before we arrived at Takapoto.

The shell found in this lagoon is generally smaller and thinner than the shell taken in Takaroa. Two lots of 10 valves each were weighed. In the first lot the valves had a diameter of 4.9, 5.1, 5.1, 5.1, 5.1, 5.5, 5.7, 5.9, 5.9 and 6.2 inches for a total weight of 3.52 lbs. In the second lot the diameters were 4, 4, 4, 4,5, 4.7, 4.7, 4.9, 5.3, 5.5 and 5.5 inches for a total weight of 2.42 lbs. Single valves weighing 0.6 lb. each were also observed occasionally. Official records showed a total of 78 metric tons of shell at 30 March, and it was estimated that about 30 tons had not been registered yet. At the average weight of 3 lbs. for 10 valves, this represented a total of 400,000 pearl oysters. The number of days of work put in by a diver in each month is highly variable, as most take a few days' rest periodically. It can be estimated at from 16 to 23 days per month.

At the time of our visit the salinity of the water in the lagoon was very high, about 36.5 for a water temperature of 83°F., while the salinity of the

ocean water outside the lagoon was about 35.4 for the same temperature. This phenomenon is quite understandable since the supply of water flowing into the lagoon was at a minimum and it was apparent from marks left on the rocks that the water level sometimes reaches a point about 16 inches higher than it was at the time. The atoll has a number of shallow passages, but only two or three of these let any water flow into the lagoon. Most of this supply comes through a shallow passage in the south-west side of the atoll and the quantity of water flowing through that is appreciable only during two hours at high tide. A check extending over a number of days showed hardly any rise or fall in the water level of the lagoon. Fishtraps made of rocks are established in all the passages where water flows. It is certain that if these traps and the rocks lying in the passages were cleared away the water supply would be considerably improved. At present it is only during periods of heavy weather and at high tide that a reasonable quantity of water flows into the lagoon.

The growth of coral in this lagoon is not as extensive as in the Takaroa lagoon and this of course is favourable to the development of the oysters.

The reserve does not seem to have been well chosen. Most of the bottom is sand with few rocks and reefs and only the deepest parts seem to have any usefulness as a reserve. A depth of 11 fathoms has been recorded in this area.

In these regions, where prevailing winds come from the east practically all the year round, it is theoretically a good thing to establish the reserves of mother-of-pearl oyster on the windward side of the lagoons. However, conditions vary so widely from one lagoon to another and the distribution of oyster larvae is affected by so many factors other than wind-generated surface currents, that this general rule is far from being applicable to all the lagoons. The currents generated by winds will affect only a very shallow layer of water and other currents which may be of greater importance are usually found deeper down. The currents in a closed lagoon will be very slow, but in Takaroa, for instance, there are very strong movements of the water in the vicinity of the main pass, although the speed of the current slows down to quite an extent at a distance of a mile. From experience obtained in other areas, it is expected that in depths as found in the lagoons of Takaroa and Takapota, up to two or three horizontal currents may be found below the surface layer, in addition to some vertical movements of the water. It is therefore quite possible that objects in suspension in the water for a reasonable period of time may successively follow several directions and even come back to their starting point at a different depth from the one at which they originally started.

It is undoubtedly difficult to state in which direction oyster larvae will spread out. This requires a long-term investigation in each lagoon. One thing is fairly certain, and that is that prevailing winds are not the main factor in the distribution of oyster larvae, as there would be very little survival indeed if they were, considering the long planktonic life of these larvae.

Factors of greater importance in the establishment of a reserve are a suitable depth (over 8 fathoms) and a suitable bottom, ensuring the best living environment for the mother-of-pearl oyster. Under these conditions it can be expected that the oysters will be more numerous and closer to each other so that the fertilization rate of the eggs will be higher. The richest beds in any lagoon are therefore the ideal reserves.

A rest period of four years is preferable in any lagoon or portion of a lagoon where large numbers of divers operate during each open season. This measure is being gradually applied to the Tuamotou lagoons and, in this way, the oysters taken may have taken part in reproduction, thus increasing the productive capacity of the lagoon.

The appointment of a specially trained officer who will take charge of the mother-of-pearl industry will make it possible to carry out the necessary hydrographic and ecological surveys of the lagoons, which may lead to other and more effective measures regarding the location of the reserves, minimum legal size of shell, duration and timing of the diving seasons, etc. It seems, however, that present regulations, including the minimum size of 5.1", are generally adequate and may require only minor alterations.

Throwing into the lagoons a considerable quantity of old shells, coral debris, old coconut logs, rocks, etc., to provide more natural supports for the settling oyster spat, would certainly improve the production of any lagoon to a noticeable extent.

In a closed lagoon like Takapoto, where it appears that the mother-of-pearl oyster grows more slowly than in other places, the general regulations should still be enforced, but it is felt that the minimum legal size of shell should be increased to 4.3" cleaned.

Trochus

Favourable conditions for the establishment of trochus were found in Takapoto on the outer edge of the reef. In spite of its close proximity, Takaroa does not seem to offer adequate environment for this shell, at least if it is judged by the few points on the reef which we were able to visit. It is quite probable that trochus could be established around a number of the atolls in the Tuamotou Archipelago, and it is suggested that surveys be made to assess this possibility, preferably beginning with those atolls which do not produce mother-of-pearl shell.

SUMMARY OF RECOMMENDATIONS

A. Fish - Oysters - Crustacea :

1. The catches of pelagic fish could be increased in order to supply an export market. Immediate requirements in this connection are
   - Longlining trials
   - Live bait fishing trials

2. Oyster farming in some of its more primitive forms could be undertaken in a number of places in Tahiti and the Leeward Islands. A small but stable market exists in Papeete.

3. Mullet raising would be profitable in some of the semi-natural ponds in the vicinity of Taravao.

4. A minimum legal size of 1 ft. should be established in order to protect the spiny lobsters. Otherwise, present regulations seem to be adequate.

5. Some considerable improvements would be effected by the use of cold storage. Facilities are already available and a publicity campaign might help in solving this problem.

B. Mother-of-Pearl Oysters

1. A general hydrographic survey of all lagoons producing mother-of-pearl is necessary as a basis for the establishment of adequate reserves.

2. Minimum size of shell taken from the Takapoto lagoon should be brought up to 4.3" (cleaned shell).

C. Trochus

1. Trochus transplants should be organized to ensure adequate stocking of all islands where suitable conditions are found. A minimum of 1,000 medium sized trochus in each case would be necessary. These could be air-freighted from a number of territories mentioned in this report.

2. Rrotection of the trochus stock introduced and of the subsequent trochus population is essential until the reefs are well stocked. Careful management of the stock is advocated once the trochus fishery is open.