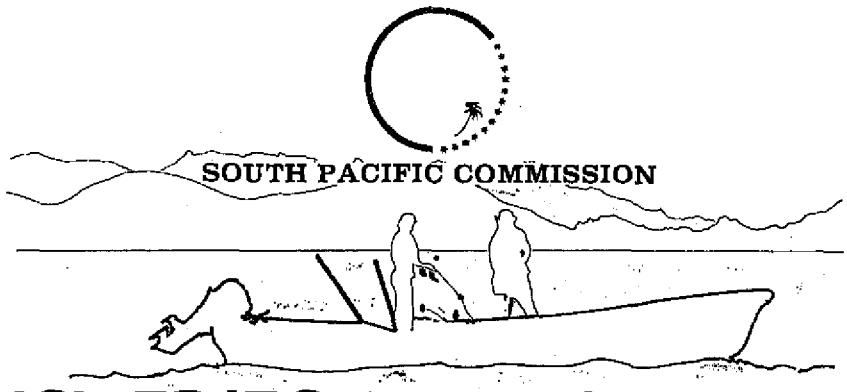

FISHERIES NEWSLETTER

No. 24 January-March 1983

The Newsletter's New Format

Readers already familiar with the SPC Fisheries Newsletter will realise that this issue appears in a substantially revised format. The new appearance involves less time and labour in the preparation and printing process which will allow for regular quarterly publication and will, we hope, enable us to present timely information on current events or matters of interest in the region, as well as the more specialised articles to be found in past issues. A great many fisheries workers in the SPC area are isolated from each other by distance and lack of communication and are often unaware of the successes and failures of others working in the same or similar fields. By presenting the reports of travelling SPC staff and information solicited from local correspondents, we hope that the Newsletter will come to act as an effective vehicle for the regular exchange of information and experience amongst the fisheries officers of the region. In this context, the editors would be very happy to receive news, views, letters, articles, project reports, press cuttings or other information of relevance to the Pacific fisheries scene.

Contents

In addition to current information on fisheries activities in the region by SPC, national governments and other organisations, contained in the first part of the Newsletter, we also plan to append more specialised papers on particular topics. Three such papers to be found in this issue are:

P.O. Box D5, NOUMEA CEDEX, New Caledonia • Telephone: 26.20.00 • Cable: SOUTHPACOM NOUMEA • Telex: 139 NM SOPACOM

SPC ACTIVITIES

Deep Sea Fisheries Development Project Notes

Cyclone relief work in Fiji

The Deep Sea Fisheries Development Project has become involved in cyclone relief activities in Fiji, following an urgent request from the Government for assistance with a comprehensive project, coordinated by UNDP, which will aim at the early rehabilitation of fishing communities in areas ravaged by recent cyclones Oscar and Sarah. It will involve the reconstruction of damaged fishing punts, replacement of outboard motors, nets and fishing equipment, and the distribution of the catch to areas most in need. SPC masterfisherman Pale Taumaia arrived in Fiji on March 22nd and will work from Lautoka, on the west coast of Viti Levu, with four government vessels and a fleet of small local boats. Masterfisherman Lindsay Chapman will be based in Suva from mid-April and will conduct a similar operation around the islands of Kadavu, Beqa, and the inner part of the Lau group. SPC involvement will be short-term, the principal aim being to stimulate interest in fishing activities and to assist local fishermen wherever possible.

Niue

Master fisherman Paul Mead concluded a 7-month project visit to Niue in February prior to moving to the Cook Islands. Paul's work in Niue mainly involved the development of appropriate techniques to harvest the pelagic fish associated with fish aggregation devices (FADs), although he has also been deep bottom fishing and coastal trolling for both resource assessment and training purposes.

Since Paul's arrival, Niue's first five FADs have been installed and experimental vertical longline and ika-shibi fishing conducted around them. More time went into refining the first of these two techniques, and a critical factor affecting catches proved to be the type and quality of the bait used. Early longline catches using locally caught skipjack and frozen pilchards from New Zealand were discouraging, but improved dramatically after Paul hung a simple fish trap from one of the rafts to catch the small bait species (Decapterus and Selar) which congregated around the FAD and used these as live or very fresh bait. The line was set from a buoy tied to the FAD, with up to 30 hooks spaced at intervals of 5-10 fathoms. The purpose of the longline was not so much an attempt to catch several fish at a time, but a means to ensure that fishing is being carried out at the depth where the fish are, as their vertical movements appear to be fairly extensive. The line was hand-hauled each time a fish was hooked, most fishing being done from a 12-foot dinghy.

While the technique was principally aimed at large, deep-swimming tunas, an unexpected feature of the catch was the presence of albacore, a species rarely captured by local fishermen, all of which were caught on the deepest set hooks. Of the 72 fish (weighing 791 kg) taken by this method, 21 were albacore, and only one of these was taken from a hook set at less than 100 fathoms depth. 15 fish were taken between 120 and 160 fathoms, the latter being the maximum fishing depth. Detailed analysis of the vertical longline catch and effort has not yet been completed, but a preliminary examination indicates that catch per unit effort figures will be substantially higher in the deeper waters.

Ika-shibi fishing, using baited handlines in conjunction with 12-volt underwater baitfish-attracting lights, was less productive, but much less time was spent in developing the method. In particular, no ika-shibi fishing was done using Decapterus and Selar for bait. As this was thought to be the major factor affecting longline catches, the true potential of the technique remains untested.

Niuean fishermen were very quick to adopt the new techniques as soon as their effectiveness was demonstrated, and fish landings are estimated to have doubled since the FADs were installed. The enthusiasm of the local fishermen not only confirmed the applicability of the experimental work and the availability of the resource, but proved a great encouragement to Paul during his stay.

Western Samoa

SPC master fishermen Pale Taumaia and Lindsay Chapman concluded a deep-bottom resource assessment survey in Western Samoa in early January. The purpose of the three-month visit was to try to confirm or deny fears that the bottom fish resource in some fairly heavily fished areas close to Apia was suffering from over-exploitation. Both Fisheries Department and private fishermen accompanied the master fishermen on survey fishing trips which, despite being hampered by rough weather, demonstrated that good deep-bottom catch rates could be achieved in the study areas. As the survey progressed it became clear that most local fishermen were achieving substantially lower catch rates than the master fishermen, because of the unavailability of the right gear, and because most operated in the shallower waters inside the outer reef slope, which is 10-15 miles offshore along much of the Upolu coast. Examination of available records of fish landings over the past 5 years also gave no indication of a decline in either the landings or the average size of deep bottom fish which passed through the government fish market, either of which may suggest overfishing. The same was not necessarily true of the shallower water species but records of landings of these fish were not so easy to interpret. Analysis of the survey and historical data has not yet been completed.

Vanuatu

Master fisherman Lindsay Chapman arrived in Vanuatu in late January to commence gear development and training work. The Fisheries Department have deployed a number of Fish Aggregation Devices and Lindsay will spend a couple of months testing and improving both novel and more well-established techniques around them. Lindsay has already completed a small number of trolling, vertical longlining and bottom fishing trips using standard equipment and with mixed results. He now plans to do some subsurface trolling using wire lines, and set multifilament gill nets for tuna and sharks. Contrary to the situation in Niue, sharks are numerous on the FADs in Vanuatu and regularly attack hooked fish, while similar shark problems have been reported in Fiji.

Fish handling and onboard processing

Master fisherman Lindsay Chapman spent ten days in Fiji in January with SPC Educational Broadcasts Officer Hima Douglas to work on the production of a video on proper methods of fish handling and on-board processing. In conjunction with Fiji's Fisheries Division, Lindsay fished for several days around Suva, varying the bleeding, gutting and icing of the catch so as to yield finished products of varying quality. This variation was then illustrated in the video during demonstrations of processing and packing methods aimed at

minimising waste and maximising product value. The video will be presented at the SPC's 15th Regional Technical Meeting on Fisheries to be held in Noumea, from August 1st to 5th, 1983.

SPC Fisheries Officer Course at Nelson Polytechnic (N.Z.)

The 18-week course commenced on February 7th with the largest intake to date of 15 students from 13 different countries. Subjects covered in the 11 weeks block course at the college include: Practical Netting and Seamanship, Navigation and Chartwork, Refrigeration, Quality Control of Fishery Products, Marine Engineering, Outboard Motor Maintenance, Fibreglassing, Welding, and general fishing subjects. In addition, students will spend four weeks at sea on board a variety of commercial fishing vessels, and a further three week period working in a small or medium sized fish processing establishment. Funding agencies include SPC, the New Zealand Government, the Commonwealth Foundation and the United Nations Development Project.

SPC Fish Aggregation Device Design Study

The US Department of Commerce's National Data Buoy Center, which has over twenty years experience in the field of deep water oceanic moorings, has kindly offered to assist the Commission with this important study, and will provide technical assistance as outlined in the original project document. The Director, Dr J. McCall, will ensure expert technical direction for the study, with staff member Lt. R. Boy assigned as consultant engineer to the project. Recognising that each location faces its own specific problems regarding the availability of materials and funds, weather, ocean floor topography, etc., the consultant, together with the Fisheries Adviser, Mr B. Smith, will visit a number of countries in the SPC area with active FAD development projects, to evaluate current FAD designs, and to gather background information for the study. The consultant should also be able to provide advice to fisheries officers on possible improvements, particularly as regards simple design changes which could increase effective life, materials used, and suitable deployment and maintenance strategies. Unfortunately, the twin constraints of time and airline schedules will limit the countries visited to Hawaii, Cook Islands, Fiji, Western Samoa, American Samoa, Vanuatu, New Caledonia, and French Polynesia. The final report of this study will be completed by June, and will be discussed in detail during the 15th Regional Technical Meeting on Fisheries.

Tuna and Billfish Assessment Programme

Tuna Programme work has been concentrated on the designated high priority projects, in particular projects 1, 2 and 4.

Project 1 - Development of the regional statistical programme

All hardware necessary for this programme remains fully operational and programming for the establishment of the data base has been completed. Two full-time data entry operators have been recruited and all data submitted to the SPC prior to 25 February 1983 has now been punched and verified. The backlog of data accumulated prior to the commencement of the Tuna Programme has been completely removed. Data has been received from the Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, New Caledonia, Palau, Papua New Guinea, Solomon Islands, Tonga and Tuvalu. Statistical summaries and maps of the distribution of fishing effort have been prepared and distributed to the respective countries.

Project 2 - Assessment of the effects of purse seining and pole-and-line fishing on the stocks of skipjack and yellowfin and the interaction between gear types

Results from the statistical programme, in combination with information generated from the skipjack tagging programme, demonstrate that interaction does occur. The lack of detailed statistics from Japan on their pole-and-line fishery after 1979, and for the whole of the western Pacific purse seine fishery ,still prevents detailed assessments. Gaps in the coverage of the region by the statistical programme also hamper analyses. Nonetheless, preliminary analyses are being concluded and summaries of these will shortly be available for distribution to the fisheries officers of the region and for discussion at the SPC Fifteenth Regional Technical Meeting on Fisheries in August.

Project 4 - Update of analysis of skipjack resources

Recovery of tagged skipjack released during the Skipjack Programme has now ceased. Analyses based on release and recovery information are virtually completed. Overall assessment of the resources previously outlined has been confirmed and the analytical methods used by SPC scientists in evaluating the skipjack resources have been validated by external review. Concluding reports describing in detail the methods the Programme used and the overall results are now in press or final manuscript form. Country reports covering the Skipjack Programme's work in Fiji, Cook Islands, Solomon Islands, Pitcairn Islands, Kiribati and New Zealand have been printed, while the report for French Polynesia is in press. Reports for New Caledonia, Tokelau, Tonga, Tuvalu and Vanuatu are virtually completed and work has commenced on the remainder. Analyses necessary to complete final country reports for many countries have had to be postponed because of the lack of statistics from distant-water pole-and-line purse seine fisheries which, in many cases, were the major source of effort and catch, and thereby tag recoveries.

NEWS FROM AROUND THE REGION

These are information snippets gleaned by travelling SPC staff or supplied by in-country correspondents. The editors would welcome information from readers.

Palau Fisheries get Japanese help

The Palauan government received over US$1.3 million worth of Japanese aid in the form of boats, fishing gear and ice-making equipment in January, as part of a comprehensive fisheries development project. The aid package comprised a fleet of 11 35-foot fibreglass Yanmar fishing boats with 70 h.p. diesel engines, eight ice plants each with a capacity of 1 ton of flake ice/24 hours, one 5-ton ice plant, and a miscellany of fishing gear. The boats, which have 3 tons hold capacity, are equipped with line/net haulers, trolling booms and safety equipment, and it is anticipated that they will conduct fishing trips of up to a weeks duration with a crew of five on board.

The boats and ice-plants will be distributed in different states throughout Palau, and will be operated by state fishing co-operatives. Officers from each of the recipient states have already been trained in their operation and maintenance, under Japanese supervision. The boats will not be given free, however, but sold interest-free for one half of their value, with payments scheduled over 20 years. Payments received will be held within the project for

maintenance and possible expansion of the fleet, and to provide support services and follow-up work during the first two years of the boats use.

Rural Fisheries Development Project in Vanuatu

Vanuatu's Fisheries Department has initiated an integrated project to encourage the development of small fishing co-operatives throughout the country. The Division's boatyard on Espiritu Santo is producing 9m plywood 'alia' catamarans of the FAO type designed in Western Samoa. These are then sold to village fishing groups on concessionary terms, the groups being required to make an initial financial commitment by paying a percentage of the vessel's cost, which is about US$10,000, fully equipped with 25 h.p. outboard, spare 8 h.p. outboard and wooden fishing reels. The fishing group is encouraged to practice deep-bottom fishing which minimises fuel consumption and maximises product quality, and each group is advised for the first two years by a Canadian volunteer who assists with various aspects of the group's activities, from fishing to book keeping. So far 8 groups have been established and are in various stages of development. Depending on market access some groups have been equipped with small ice machines, while others will benefit from the installation of nearby FADs to reduce the problems of obtaining bait, which can be limiting or very costly (in terms of fuel used while trolling) in some areas. Some of the groups' production is sold locally, while a good deal is brought into Vila, where demand continues to exceed supply. With fish prices as much as 100 VT/lb (US$2.26/kg) higher in Vila than in the more remote localities, the costs of 30 VT/lb (US$0.68/kg) for refrigerated transport of fish from areas such as Lamap, on Malekula, to Vila is easily recovered.

A big boost to the project will be the opening shortly of a new fish market in Port Vila, and a smaller one in Luganville on Espiritu Santo. These were provided as part of a Japanese aid package and consist of compact modern buildings equipped with chill stores, freezers, and processing facilities. It is anticipated that much of the market's fish supply will come from the rural fishing groups.

Seaweed Farming Trials in Kiribati

A UK-sponsored research programme is under-way in Kiribati to assess the technical and economic feasibility of farming the red seaweed Eucheumea, or agar-agar. Growing trials conducted by Technical Co-operation Officer Stephen Why in Tarawa lagoon, have given encouraging growth rates. Nine other lagoons in the Gilberts group also show similar environmental conditions and appear to offer potential growing sites. Using a culture system of horizontally positioned nets and lines, the project has been growing and drying Eucheumea for the past year and is about to make a trial 2-tonne export shipment shortly. The end use of seaweeds is mainly in the manufacture of gums for use as binding or gelling agents in foodstuffs, medicines, cosmetics, and the paint and printing trades. Potential market outlets for Kiribati's produce have been identified in Europe, New Zealand and the USA. I-Kiribati families will be encouraged to set up their own small farming enterprises, before the termination of the research work at the end of 1983. Regional dissemination of the results is intended, and further information is available from the Fisheries Division, Tarawa, Kiribati.

Good results from Tonga's longlining venture

After its first year of commercial operation, the Tongan Government's longline vessel 'Lofa' is running at a sound profit, at a time when longliners

the world over are finding it hard to break even, according to Tongan Fisheries Technical Officer Taniela Koloa. 'Lofa' is crewed almost entirely by Tongans and fishes mainly within Tonga's territorial sea. The high-value portion of the catch, albacore and yellowfin, are sold to the tuna cannery in Levuka, Fiji, and generate valuable foreign earnings for the government. The rest of the catch, which is skipjack, sharks, swordfish and others are cut up and sold locally in Nuku'alofa for 50-60 cents/lb. Not only does this help to satisfy the apparently insatiable local demand for fish, but it goes some way towards reducing the consumption of imported canned fish so common in many of the more urbanised Pacific islands.

The Tongan Government is very satisfied with the progress of this venture, and is now considering the formation of a fishing company which will take over the operation of the vessel.

Giant clam culture in Palau

During the past four years, staff of the Micronesian Mariculture Demonstration Centre (MMDC) in Koror, Palau, have successfully reared four species of giant clam (family Tridacnidae), two to male maturity, from larvae spawned in their own hatchery tanks. During 1982 over 10,000 giant clam juveniles of seed size (2-3 cm) have been produced in outdoor sunlit raceways, and production of 5,000-10,000 5 mm seed per tank per 4-month rearing cycle has been achieved on six occasions. The process relies on natural spawning of clam broodstock, low larval stocking densities, and larval feeding with phytoplankton. A more detailed account of this research is presented in a short article by Heslinga and Perron (this issue).

French Polynesia offers aquaculture training course

LEPA, the Agricultural College on Moorea run by French Polynesia's Ministry of Agriculture, is offering two aquaculture courses commencing in 1983. The 6-7 week Beginners courses are intended to train field workers or foremen in the practical aspects of running prawn hatcheries and ponds. The Advanced courses last for 14-15 weeks and are designed to train managerial level staff in skills such as basic accountancy, prawn biology and water chemistry. The courses cover aspects of both freshwater and brackish water prawn culture (Macrobrachium rosenbergii and Penaeus spp.) but also consider the culture of a variety of other organisms including oysters, mussels, crab, carps, tilapia, trochus and clams.

Details of the courses are available by writing to the Director, LEPA, B.P. 4, Moorea, French Polynesia.

UK college commences annual course in Fisheries Planning and Management

The Centre for Fisheries Studies at Humberside College of Higher Education, in Hull, England, is offering an annual 3 month Post-Experience Course in Fisheries Planning and Management, the first one being planned for April-June 1984.

The course has been designed by the college in conjunction with the Fisheries Advisers of the UK Overseas Development Administration, and is intended for middle to senior level officers employed in fisheries administration, and with substantial work experience in fisheries. The course covers a broad spectrum of issues related to the two major themes of fisheries management at domestic level and international negotiations on fisheries resources,

these including topics such as project preparation, international funding, and the economics of marketing and processing.

The Centre for Fisheries Studies has wide-ranging experience in diverse fisheries related fields, from fish technology to resource management, and is involved in a variety of research and consultancy work in developing countries. The course director is Dr Rowena M. Lawson, author of a number of textbooks on fisheries development and economics. Further details can be obtained from the director (college address: Cottingham Road, Hull, HU6 7RT).

Training opportunities in Japan

The Hyogo Prefectural Government of Japan has offered 9-month training programmes to workers from developing countries since 1971 under its Overseas Technical Trainees Aid Programme, and plans to continue to do so in forthcoming years. An annual total of seven trainees are accepted each year, to train with business organisations working in their selected fields. These fields need not necessarily be related to fisheries, but the opportunities for fisheries training are considerable since Hyogo prefecture is bounded on the north by the Sea of Japan and in the south by the Seto Inland Sea. Capture fisheries in 1979 produced over 100,000 tonnes of a variety of 'fish' including sardines, squid and shrimp, and aquaculture of seaweeds, yellowtail and sea bream another 50,000 tonnes. The prefecture also has a variety of light and heavy fisheries related industries, from hook and lure manufacture to boatbuilding. An unusual feature of this training offer is that it is open to potential students from private industry as well as the public sector, and in fact technical specialists from business organisations are preferred, particularly if the business has some sort of trade link with the prefecture. Applicants are required to submit their own proposals for the training programme they require, this being endorsed by their employer or sponsor. The Prefectural Government reviews each application on its own merit and those selected receive airfares, living and literature expenses, and a 9-month training attachment to one or more relevant organisations.

Further details of this programme and application procedures are available from the editors.

Publications

A number of SPC fisheries publications were produced this quarter. Fisheries Newsletter No. 23, the last one to appear in the previous format includes papers on 'akule' fishing, sea turtles and the use of sail power in fishing boats. The final report on the SPC Deep Sea Fisheries Development Project's visit to Tuvalu in 1980/81 was printed, and the reports of two consultancies carried out for SPC were published. Dr Michael G. King's Deepwater Shrimp Assessment Consultancy in Papua New Guinea aimed at demonstrating appropriate deepwater shrimp trapping techniques in a preliminary survey, and advising on the design and implementation of a comprehensive assessment project for this resource. The report contains the results of the survey work carried out, which identified the presence of six deepwater shrimp species in the survey area, several having potential commercial value, and offers recommendations for further resource assessment work. The Specimen Shell Resources of Fiji, prepared for the Commission by conchologist Brian J. Parkinson, reports on the potential for commercial development of a cottage industry based on souvenir or collectors shells in Fiji, and offers general recommendations as to the ways in which this might be promoted by a government body.

SPC Fisheries Newsletter No.24 January - March 1983

A SURFACE ALBACORE SURVEY IN THE CENTRAL AND WESTERN SOUTH PACIFIC OCEAN

by

Jean-Pierre HALLIER* and Jean-Yves LE GALL**

Important stocks of surface albacore (*Thunnus alalunga*) exist in the Atlantic and the North Pacific Oceans, where they support substantial fisheries (on average, 35 000 and 80 000 tonnes respectively). In the South Pacific, surface albacore are fished around New Zealand coasts during the summer season. The size of this fishery is still small but increasing (1468 tonnes for the 1979-80 season and 2085 tonnes for 1980-81). Between 10°S and 25°S, as in the North Pacific, albacore larvae are abundant in plankton net tows. Surface albacore are probably numerous at these latitudes from New Zealand's east coast to the eastern South Pacific and an important stock may therefore exist in these waters. However, very little information is available on the possible extent to which surface albacore occur in this part of the Pacific Ocean. Taking into account this lack of data within its tuna stock assessment programme for the entire region, ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer) organised a surface albacore survey in the Central and Western South Pacific.

The objectives of this survey were :

(1) to check for the presence of surface albacore using trolling lines;

(2) to describe the oceanographic conditions of the area surveyed and identify favourable conditions for concentration of surface albacore;

(3) to assess the importance of the subtropical convergence upon surface albacore concentration, and the usefulness of satellite SST charts for locating favourable albacore waters.

1. The survey

The survey prepared by the ORSTOM Centres of New Caledonia and French Polynesia, took place from 12 February to 4 March 1982 on board the *R.V. Coriolis* from Papeete to Noumea via 40°S. The area surveyed for albacore occurrence extended from 157°W to 180° between 38° and 42°S. The vessel track is shown in Figure 1.

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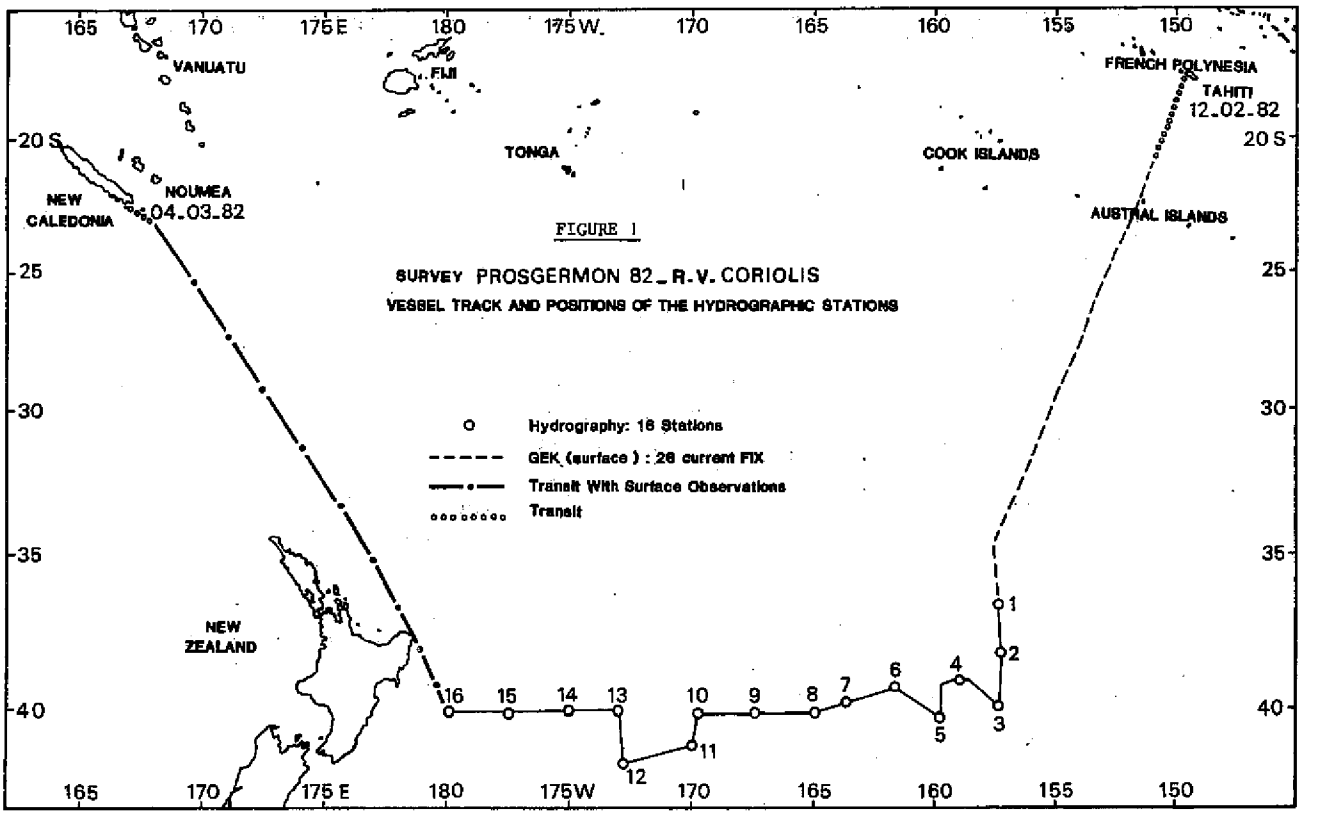


2. The vessel and fishing gear

Coriolis, a 37 metre research vessel, was fitted with two outriggers and 9 to 10 trolling lines. Three lines of between 50 and 75 metres length were set on each trolling pole and 3 or 4 lines were fixed at the stern of the vessel. This rigging is similar to that employed by the French albacore surface fishery in the North Atlantic Ocean.

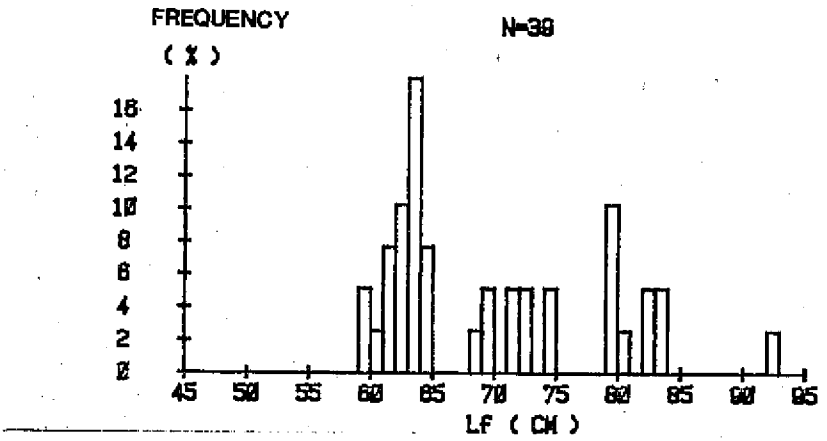
Trolling was performed from dawn to dusk at a speed of between 6 and 8 knots. The 21 cruising days were rather short for the completion of the 3925 nautical miles of the vessel track. Therefore the survey was not extended further than 42°S, and places where albacore were caught were not worked twice or in circle as they would have been by a commercial fishing vessel.

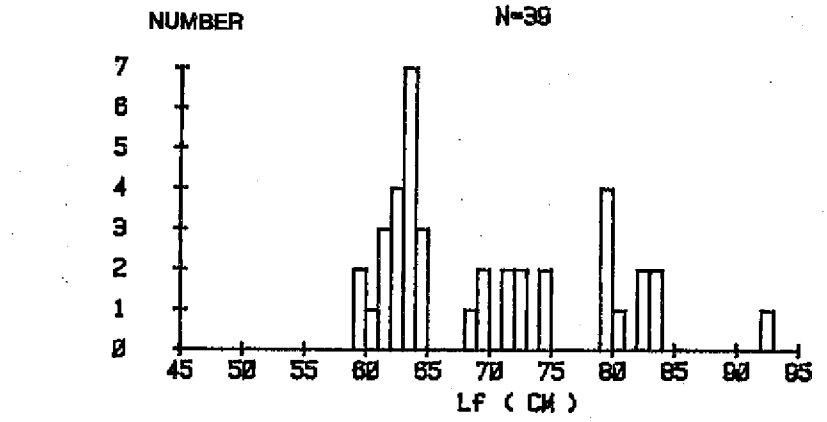
3. Scientific procedure

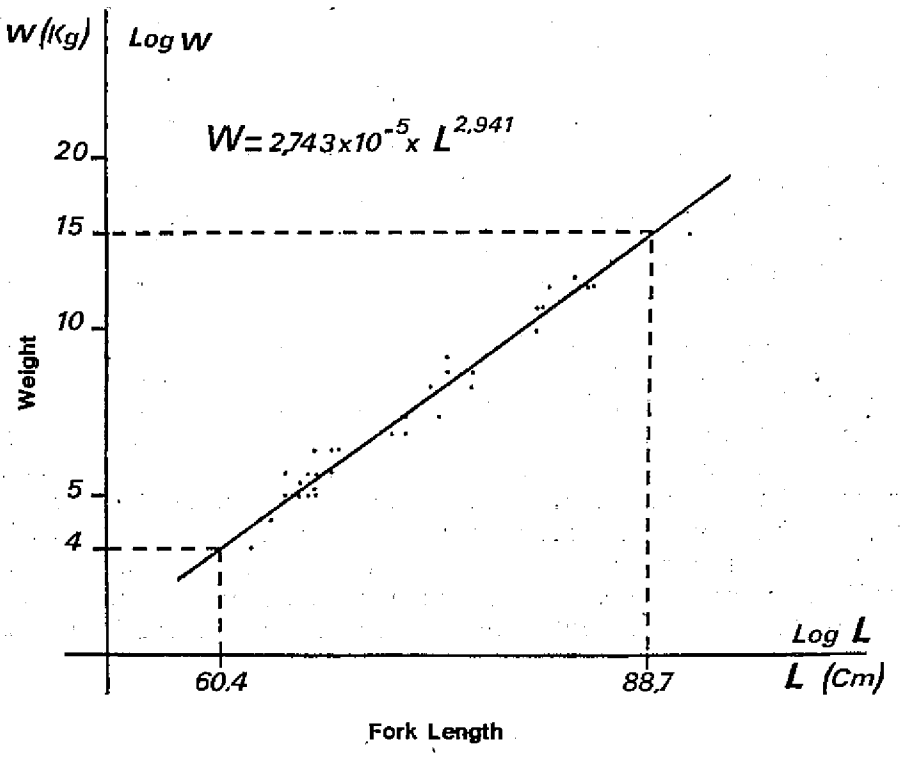
Hydrographic data were collected at 16 different stations. Recorded measures include temperature (°C), salinity (°/₀₀) and oxygen (ml/l) at twelve different levels between the surface and 500 metres deep, and chlorophyll 'a' (mg/m^3) at 8 levels between 0 and 200 metres. To obtain a better assessment of the hydrographic conditions of this area, scientists on board had also at their disposal all the oceanographic data of a previous cruise (19-01 to 08-02-82) which had surveyed the area from Papeete as far south as 37°S.

Ordinary biological data were recorded for each fish hauled on board : fork length ± 0.5 cm, weight ± 0.1 kg, sex, maturity, stomach contents and parasite occurrence.

FIGURE 2. Length frequency distribution and length-weight relationship for Albacore (*Thunnus alalunga*) caught during PROSGERMON 82 survey in the South Pacific Ocean.







Once the first albacore was caught, the track of the vessel was set so as to keep it in waters favourable to the occurrence of surface albacore. The track was also designed to obtain sufficient data to describe the hydrographic conditions of the area surveyed.

4. Results

4.1 Exploratory fishing

Trolling for fish commenced on the morning of 18 February at 38°S, but no albacore were caught until sea surface temperature was below 18°C (39°S). Owing to the lack of time and the fact that trolling for albacore can be performed only during day time, no more than 45 hours were spent fishing in favourable waters. During these 45 hours, 39 fish were caught and landed on board and about 30 more were hooked but lost.

Expressed per 100 line-hours, these catches represent a rate of 17 fish which is comparable with the rate of 19.3 fish per 100 line-hours obtained by the New Zealand albacore surveys from 1972 to 1975 (Roberts, 1980). No other species but albacore were captured, and no fish or bird schools were spotted during the time the vessel spent in "albacore waters".

4.2 Fish size

Albacore length frequency distribution as well as the length-weight relationship are given in Figure 2.

Albacore are from four different age groups, probably from two to five years. All fish but one (a female of 15 kg) were immature. Fish size distribution is similar to those of the New Zealand albacore fishery except for the lack of fish under 60 centimetres. This could be due either to the real lack of this size class fish at this time of the year in the area surveyed or to the selectiveness of our fishing technique (different trolling speed or gear).

4.3 Hydrographic conditions

Hydrographic data collected during this cruise confirmed that albacore are present in the surface or sub-surface layers of the sea when temperature is generally below 19°C. Albacore were caught in the subtropical convergence zone. This particular area represents the frontal zone between the tropical water to the north (sea surface temperature (SST) over 20°C and salinity over 35.35 °/₀₀) and the temperate or sub-antarctic water to the south (S.S.T. cooler and salinity constant and around 34.75₀/₀₀) (Figure 3). On the surface, the main characteristic of this convergence is the organisation of the 16°C to 19°C isotherms in a front (isotherms close together) (Figure 4)

In these waters, the thermocline is well marked. It is located between 50 and 75 metres deep and this could account for the lack of fish activity at the surface. The thermocline acts as a barrier to the fish: when it is shallow fish are close to the surface; when it is rather deep, as was the case here, they spread out in the entire water volume between the surface and the thermocline. Primary productivity in the frontal zone was much higher than further north in the tropical waters. This higher primary production is the base of a food chain and albacore stomachs were filled with small fish and crustaceans. These general conditions are similar to those prevailing in the North Pacific and Atlantic surface albacore fisheries.

Hydrographic data also showed that the subtropical convergence in the South Pacific Ocean does not exactly parallel lines of latitude and is located further south when moving west.

5. Conclusion and discussion

This survey demonstrates that hydrographic structures favourable to the occurrence of albacore at the sea surface are present in the central and western South Pacific Ocean during the summer season. Albacore were caught in these waters using surface trolling. The subtropical convergence induces the concentrations of albacore and the localisation of this convergence on satellite sea surface temperature charts corresponds to the 15°C to 19°C surface isotherms when they are organised in a front.

The small number of days spent in this area and the small size of the albacore sample do not allow any indication of the size of the stock available to a surface fishery.

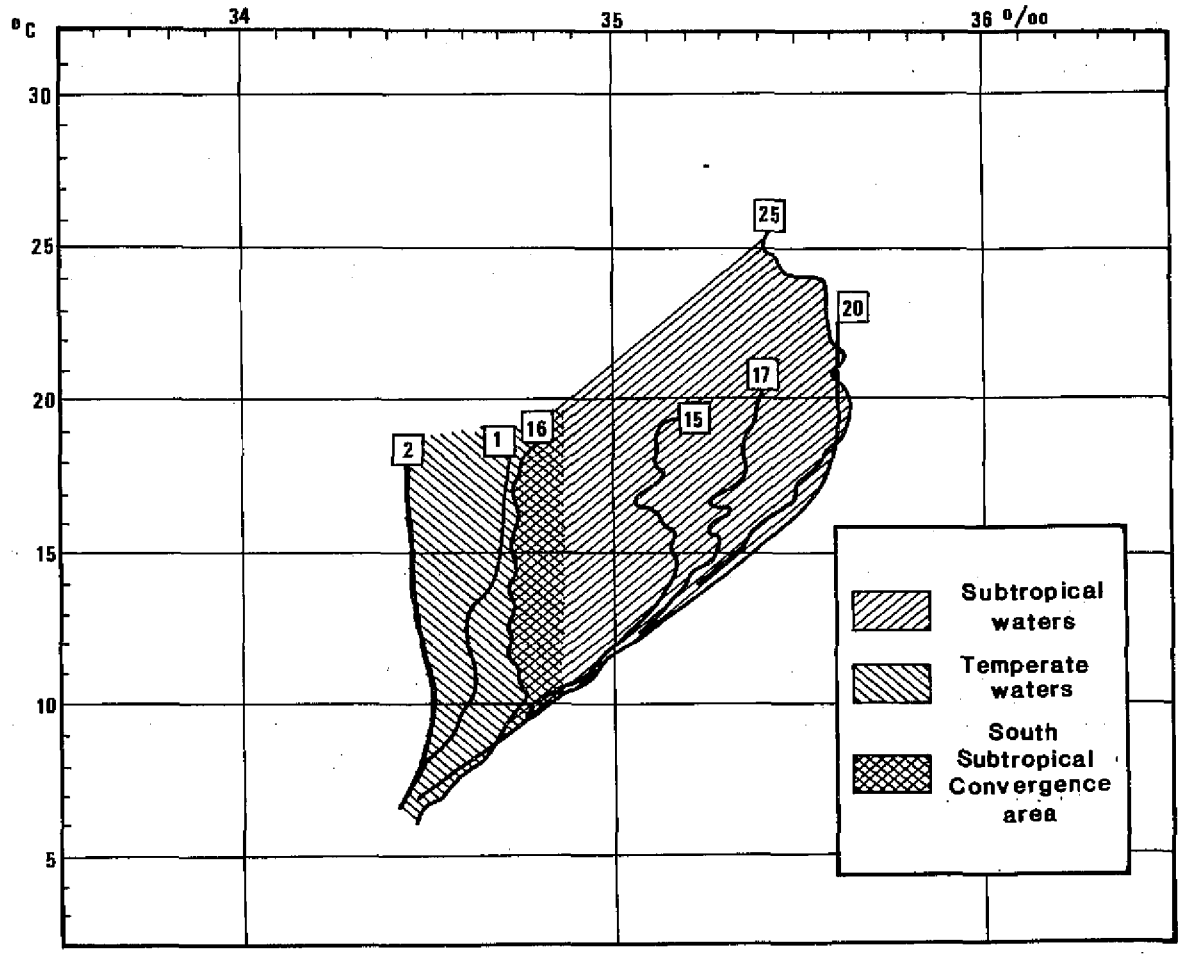


FIGURE 3. Temperature-Salinity diagrams which show the progression from the tropical waters (POLYDROTHON Stations 20 & 25) to the temperate waters (POLYDROTHON Station 16 and PROSGERMON Stations 1 & 2) meridian band 157-159°W - latitude 15-40°S.

The lack of fish and bird activities at the surface could certainly make trolling more difficult and less productive. However, the use of depressors to keep the lines under the surface would probably increase the hook rate as albacore seem to stay in subsurface waters. Line pullers to haul the lines in would also make fishing more efficient. Albacore gillnet fishing recently developed by the Japanese in the Central North Pacific could well be used in the South Pacific.

An offshore summer albacore fishery in the South Pacific Ocean should be based on the east coast of New Zealand or on Rapa Island, the southernmost island of French Polynesia in the Australs group. Easter Island from Chile could also be used as a base for such a fishery. These two islands are within two to four steaming days from the albacore waters.

From New Zealand the present albacore fishery can extend its activities eastwards. A gillnet fishery could work also to the east of the coastal fishing grounds in the Central South Pacific.

Of course, more scientific and exploratory surveys are necessary before any commercial fishery can be developed in this area. The first results on this cruise need to be confirmed and more data need to be collected, and ORSTOM therefore plans to conduct another survey by the beginning of 1984. This second survey will cover the same area, to confirm the results of the 1982 survey, and will extend further east, up to the south of Easter Island (Figure 4).

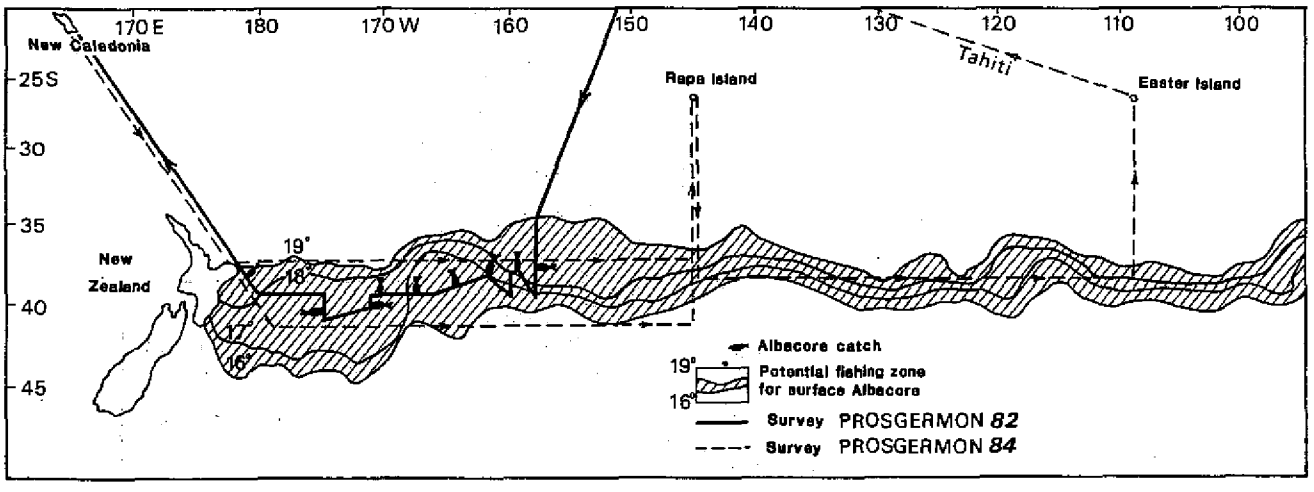


FIGURE 4. Potential fishing zone for surface Albacore in the Central South Pacific Ocean.

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The Status of Giant Clam Mariculture Technology in the Indo-Pacific

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Market Perspective

Fisheries personnel in the South Pacific Commission region are by now well aware both of the commercial value of the tridacnid clam resource and of the recent extensive exploitation of these molluscs by Asian fishermen. According to Taiwanese dealers recently interviewed, Taiwan alone imports 200-300 tons of giant clam adductor muscle annually, worth an estimated $US 20-25 million at retail. Other large markets for giant clam muscle exist in Hong Kong, Singapore and Japan, suggesting that the annual value of the giant clam industry may approach or exceed $US 100 million. It is at present impossible to compile accurate catch statistics because most of the harvest is illegally taken and not reported. What is clear, however, is that an increasingly profitable trade exists for Tridacna meat, and this explains why Taiwanese crews persist in risking capture, imprisonment, fines and vessel forfeiture in their pursuit of clam muscle. One direct result of their activities is that clam stocks have been virtually eliminated from some areas. This year the larger tridacnids (T. gigas, T. derasa and Hippopus hippopus) were added to the international list of threatened species, published by the IUCN in England.

Mariculture Efforts Revived in Palau

In response to this evidence of widespread overharvesting of tridacnid clams and mismanagement of the resource, the staff of the Micronesian Mariculture Demonstration Center (MMDC) in Palau is re-examining the practicality of producing large numbers of juvenile clam seed in the laboratory. The project will be successful only if enough juveniles can be produced to have a significant impact on existing clam densities in nature. Although tridacnid larvae have been cultured before by workers at other laboratories, insufficient numbers of juveniles were produced to permit reseeding trials or to encourage commercial involvement. The goals of the present Palau project are to refine methods for hatchery production, initiate experimental growout and re-introduction programs, and to investigate the possibility of clam farming for local consumption and commercial export.

Advances in Hatchery Technology

The first objective, reliable hatchery production, has in part already been achieved in Palau. The MMDC staff has produced some 30,000 healthy giant clam juveniles, primarily T. gigas and T. derasa, which are the largest and most heavily exploited species. The estimated production capacity of the MMDC facility in its present form is 50,000 1-cm juveniles per year, employing two biologists. This production capacity could be increased by addition of more tanks. The larval rearing process currently used relies on natural spawning of clam broodstock, rather than inducement of spawning by chemical means. Mature clams held in tanks in Palau spawn on a predictable lunar cycle, which makes

collection of fertilized eggs a simple process. This natural spawning periodicity has not been demonstrated in other areas, however, and more work is needed on the factors responsible for gamete development and release.

Field Release Experiments

Some 10,000 clams have been planted on patch reefs near the MMDC. It has become evident that clams smaller than 10-15 cm suffer heavy losses from fish predators unless some form of protective enclosure is provided. Hatchery reared clams in the 2-3 cm range can survive and grow well in nature if placed in simple plastic mesh cages. At present all of our outplanted juveniles are protected by such cages. Clams larger than 15 cm can be placed directly on a sandy or coral rubble substrate with a very high probability of survival.

Juvenile giant clams, four months old, raised in laboratory tanks at the Micronesian Mariculture Demonstration Center. Clams of this size may be reared either in land-based raceways or in protective cages on the reef.

Growth and Productivity

Our results to date indicate that giant clams are not only the fastest growing bivalve molluscs in existence, but that they possess an astonishing capability for producing large quantities of edible meat with minimal inputs. Clams reared over a 3 year period in the MMDC raceways produced a mean of 1.6 kg edible meat/m^2/year with no supplemental feeding. To our knowledge this rate of meat production far exceeds that of any terrestrial food production system; in the marine environment only raft-cultured mussels (*Mytilus sp.*) raised in highly productive bays can deliver more meat per unit of surface area than tridacnids. A major difference is that tridacnids occupy essentially a two-dimensional environment (the sea bottom), and their culture on a large scale would not compete with existing food production systems or with coastal navigation. Shallow, sandy back reef areas that do not support extensive coral growth appear to be suitable habitats for giant clam culture.

In laboratory raceways, both T. gigas and T. derasa grow at an average rate of about 5 cm/year during the first 3 years after fertilization (the most rapidly growing member of one T. gigas cohort reached 10 cm in their first year). At 3 years of age, the clams begin to reach the male phase of sexual maturity, having attained mean meat weights of 100 grams, of which 15% is adductor muscle. Tridacnids are capable of thriving at high densities; 3 year old individuals may be stocked at a rate of 48/m^2. Progressive thinning is required as the clams increase in size.

Giant clams raised from eggs at the Micronesian Mariculture Demonstration Center reach an acceptable market size (15 cm) after three years.

Giant clams *(Tridacna gigas)* spawn on a predictable lunar cycle in tanks at the Micronesian Mariculture Demonstration Center in Palau.

Market Size

Little is presently known about growth in the larger tridacnids, but longevity probably exceeds several decades. There is evidence that absolute growth rate during the first 3 years may in fact be slow relative to that of later years. This is because in giant clams, as in many other marine invertebrates, the very young stages are characterized by a "lag" phase in growth rate. Large clams may add 10 cm or more per year in length.

The optimal size of harvest for a commercial operation is unknown and will depend on a number of factors, including hatchery costs, growth rates and mortality patterns. It is certain, though, that clams of an acceptable market size (15 cm) can be produced in about 3 years in a land-based mariculture facility or in a suitable ocean bottom site. If necessary, harvest could be delayed for many years or even decades.

Symbiosis

Giant clams are now known to derive most or all of their nutrition from symbiotic algal cells called zooxanthellae (Symbiodinium microadriaticum). These dinoflagellates reside in the exposed mantle region and release photosynthetically fixed carbohydrates into the tissues of the clams. Tridacnids may thus be termed "autotrophic" (self-feeding) or "phototrophic" (fed by the sun). They are the only animals of this kind suitable for human food production.

Re-introductions

In order to determine whether the giant clam mariculture technology developed in Palau can be applied in other areas, we have begun a series of trial shipments of seed clams to a number of distant locations. Successful shipments of young clams have already been made to Guam, Hawaii and the US mainland. T. gigas seed produced in Palau have been outplanted on Guam's fringing reef and are reportedly doing well. Requests for clam seed have been received from government representatives in Ponape, American Samoa and Mexico, and from fisheries personnel in the Caribbean region. Permit applications for these latter requests are pending. It appears that air shipment of large numbers of seed clams will present no major technical or cost constraints. The wisdom of introducing exotic species to new environments will always be subject to question and criticism, but our position is that giant clams are among the most benign of coral reef inhabiting animals, and that introductions should be attempted because of their potentially favorable economic impact.

Outlook

The Palau giant clam hatchery effort is at an early stage of its development and it would be premature to predict the long-range costs and benefits of the endeavor. We envision that a minimum 3-5 year research and development period will be needed to answer several critical questions regarding the biology of the clams and to apply this knowledge in a commercial context. Sociological factors are also obviously of paramount importance here and need closer scrutiny before large investments are made. However, it is already clear that a relatively simple hatchery like ours, properly sited, equipped and staffed, can produce enough clam seed to have a significant impact on tridacnid abundance in localized areas. Merely from the standpoint of conservation, then, a minor battle has been won already. We have developed a reasonably effective method for protecting young clam seed from predators, and we have demonstrated that clams larger than 15 cm are essentially immune from predation when reared on sandy substrates in nature. The meat yield per unit area for tridacnids is exceptionally high, especially when one considers that no supplemental feeding is required. This characteristic alone is of interest in the context of food production on a global scale, and warrants serious study in the future. The prospects for commercial production of giant clams on a profit-making basis appear favorable, but there remains a need for more experimental work before this can be realized on a broad geographic scale. We invite and encourage correspondence from fisheries personnel throughout the SPC region who may be in-

terested in active collaboration or simply in obtaining more information about our program.

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FISHERY POTENTIALS IN THE TROPICAL CENTRAL AND WESTERN PACIFIC

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(Paper presented at the 15th Pacific Science Congress,
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1.0 INTRODUCTION

Boundered in the west by the Philippines, Indonesia and northern Australia, and in the east by approximately 130°W, the tropical central and western Pacific Ocean, encompasses an area of more than 41 million square kilometres, or approximately eight per cent of the surface of the earth. Lying within this area are the 23 developing Island countries and territories for which the South Pacific Commission (SPC) works. The basic similarities amongst the numerous small developing Island states within the 29 million square kilometres of the SPC area (Figure 1) and the contrast between these and the larger bordering nations begs differentiation between the two when considering fishery potentials. Only the potentials of the Island states are considered here.

In defining the topic it is assumed that description of a fishery potential requires more than just identification of a fish resource, while at the same time acknowledging that there can be no potentials for development without appropriate resource bases. Only resources presently exploited, or with an identified prospect for exploitation, have been considered as known potentials.

Fish and fisheries have played a central role in the culture, sustenance and recreation of all small island communities. The ability of the traditionally exploited fish resources of the central and western tropical Pacific to continue to provide subsistence protein for island communities is arguably the greatest resource potential of the region, and yet it is one which is commonly overlooked in the quest for more spectacular development options. Not that alternative small scale fishery potentials do not exist, indeed there are many, particularly as improved fish catching techniques increase the potential yield from even traditionally exploited resources, and advanced processing technologies increase the utility of the harvest. Improvements in small scale fisheries technology and fishing techniques have also enabled the exploitation of previously untouched resources, particularly those in deeper waters or further from shore, thereby greatly expanding the horizons of subsistence and artisanal fishermen.

Developments in offshore waters have been pronounced in recent years. International acceptance of the principles of 200-mile zones of extended jurisdiction has highlighted potential for Island states to manage the fisheries resources in more than 29 million square kilometres of the central and western Pacific. Much of this vast oceanic area had been exploited for its extensive tuna resources since the late 1950s by distant-water fishing nations, but enactment of the principles of extended jurisdiction by Island states has seen dramatic change in their involvement in large scale fisheries and has undoubtedly opened up major new avenues for their fisheries development.

2.0 THE KNOWN RESOURCES AND THEIR POTENTIAL FOR DEVELOPMENT

Although there is some overlap amongst the various categories, the known fishery resources of the Pacific Island states can be classified as one of four categories:

2.1 Freshwater and shallow water coastal resources (including aquaculture and mariculture)

(a) Freshwater resources

Only the largest of the Pacific Islands (Papua New Guinea, Solomon Islands, New Caledonia and Vanuatu) have freshwater river or lake systems of sufficient size to support extensive freshwater fish resources. Papua New Guinea's tilapia (Tilapia mosambica) resources are by far the largest. They offer considerable promise for increased yields, primarily for local consumption, while the barramundi (Lates calcarifer), which is dependent for part of its life cycle on the freshwater reaches of Papuan rivers, should continue to support commercial fisheries (Kearney 1976). Freshwater fishery resources in the other above-mentioned countries and the smaller Pacific Island states are of more limited value being primarily the target of subsistence, small scale artisanal or recreational fishermen. One exception is the freshwater clam (Batissa violacea) fishery in Fiji which produces approximately 700 tonnes per annum.

Even though the known freshwater resources are limited and the size of the available freshwater habitat is unlikely to increase significantly, the potential for increasing yields from these waterways by improved fish husbandry techniques, including introduction and enhancement of selected species, should not be overlooked. The socio-economic return from increased yields in these fisheries, particularly in places such as the highlands of Papua New Guinea where animal protein is scarce, could well be relatively much greater than the benefits from similar increases in yields in coastal fisheries where production is relatively higher.

(b) Shallow water coastal resources

The small developing states of the tropical central and western Pacific are, in general, isolated islands or archipelagos. In most cases there is little, if any, continental shelf and the transition into depths exceeding 2,000 metres is normally precipitous. The smallness of the land masses greatly restricts the nutrient run-off available to enrich the surrounding ocean. Therefore, the waters surrounding them are typically clear and blue and, compared to continental coastal areas, of low productivity. As a result of this lack of extensive continental shelf or coastal enrichment, small Island states have limited inshore fish resources and hence restricted new inshore fishery potentials. On the other hand, the existing inshore fish resources have provided the bulk of the animal protein consumed by Pacific Islanders since the islands were first settled. In most cases modern gear developments should enable total catches to be increased, thereby realising a potential. With minimal appropriate management this invaluable potential should remain in perpetuity so long as total human populations remain within reasonable bounds. Management will, however, not be without its problems, some of which have been previously discussed (Kearney 1980).

(c) Aquaculture potentials

There have been numerous attempts to establish aquaculture on a commercial basis in the islands of the Pacific; these have in general been notable for their lack of success. Closed system aquaculture in developing countries has, in the main, only been successful in the larger countries where incomes are very low, population densities are high and natural protein resources are restricted (i.e. in areas such as southeast Asia). In general, continuous access to a relatively high priced luxury market is required for most commercial aquaculture projects to be viable and these conditions are rare in the countries of the tropical central and western Pacific. Markets for specific items, such as live bait for tuna fishing, have been created in countries in which pole-and-line fisheries for tuna have been established, and yet aquaculture has still proven difficult to develop to a commercial level; reasons for this are given by Kearney and Rivkin (1981). Economic implications of developing aquaculture in the Island states of the region were considered by the SPC's Eighth Regional Technical Meeting on Fisheries. This meeting concluded that very few previous aquaculture projects in the Commission's area were at all successful and recommended "that detailed economic surveys should be carried out before any commercial scale aquaculture projects are initiated" and pointed out that such "surveys should include the economics of alternative use of both the land to be developed and the investment capital" (Anon 1975). Equally important is the need to consider the implications to existing fisheries resources from the conversion of so called "swamp land" for aquaculture purposes. Too often coastal mangrove or inter-tidal zones, which are natural breeding, or nursery, areas for coastal fish species, are converted without due consideration of the impact on existing fisheries. Therefore, while it would be foolish to disregard the potential of aquaculture for fisheries development in the central and western tropical Pacific, I feel that in the short-term this potential is restricted and proposed aquaculture projects should be given careful scrutiny.

2.2 Deepwater nearshore resources

At the periphery of the limited continental shelves of Pacific Islands, the reef slopes harbour resources of deepwater snappers (predominantly Pristipomoides spp. and Etelis spp.) which have only begun to be exploited since the exploratory work of the SPC in the early 1970s (Crossland and Grandperrin 1980) and which offer exciting new potentials for fisheries development. Catch rates, far in excess of those normally taken in shallow water handline fisheries, have been achieved throughout the central and western tropical Pacific with gear little more sophisticated than that required in traditional fisheries. In many countries commercial, exploitation of these resources has proven viable using inexpensive hand-reels and, to a lesser extent, small bottom longlines. While little is known of the magnitude of the available resource, or of the biology and behaviour of the species commonly exploited, the snapper resources of the reef slope are thought to represent one of the best potentials for fisheries development in this region and one of the very few resources suitable for exploitation by existing artisanal fishermen without enormous capital input. These deepwater resources have the additional advantages of being predominantly excellent quality food

fish and free from ciguatera poisoning. They therefore command high prices on most markets.

Resources of deep water shrimps (Heterocarpus spp.) and precious corals represent other possible potentials, but the economic feasibility of exploiting these resources in most Pacific Island states is still disputed.

2.3 Deepwater offshore resources

In the tropical central and western Pacific, areas suitable for large-scale harvesting of bottom-fish resources by conventional means are limited. However, recently developed fisheries for deep water species in other regions of the Pacific Ocean indicate that possibilities for development of fisheries for non-conventional species, or using non-conventional techniques, do need to be considered as fisheries potentials. In recent years fisheries for alfonsin (Beryx splendens) and pelagic armourhead (Pentaceros richardsoni) have been developed on the seamount chain to the northwest of Hawaii. In this area catch rates of pelagic armourhead by experimental Russian trawlers have been as high as 30 tonnes in 10 minutes and commonly of the order of 20-30 tonnes per 10 to 20 minute tow (Sakiura 1972). Other surveys and commercial fishing using bottom longlines and trawling gear have confirmed the resources of both pelagic armourhead and alfonsin in the north central Pacific (JAMARC 1973, Anon 1976). The prospects for developing similar fisheries in the more equatorial regions warrant investigation, particularly as the pelagic armourhead has already been proven to be a wide-ranging species (Sasaki 1974).

In addition, the recent spectacular catches of orange roughy (Hoplostethus atlanticus) by large trawlers in waters off New Zealand increases interest in the prospects of finding trawlable deepwater resources in more tropical areas of the Pacific, even though it is doubtful if commercial concentrations of this particular species (orange roughy) extend into this area. Furthermore, preliminary reports of favourable catches of deepwater species, especially the red snapper, Etelis carbunculus, in seamount areas in the waters adjacent to Solomon Islands, and the occurrence of numerous presently unfished seamounts and ocean plateaus in the central and western tropical Pacific, further suggest potentials for future fisheries. It does, however, appear likely that deepwater fish resources are less in tropical regions than in association with the larger oceanic plateaus in higher latitudes.

Exploitation of deepwater resources, even if proven economically viable in the tropical Pacific, would probably require very large vessels, possibly larger than 1,000 tonnes, and hence massive capital inflow plus input from many qualified and experienced personnel. Direct involvement of nationals of the region would therefore be anticipated to be minimal, at least in the short term. This does not mean that the potentials will, or should, therefore be ignored, or that Pacific Island states could not benefit from their exploitation. As later discussed, the increased rights of coastal states associated with changing attitudes to the Law of the Sea has opened up considerable potential for coastal states to become more involved in the exploitation of offshore resources.

2.4 Offshore pelagic resources

Fish catches from the tropical central and western Pacific in recent years have been completely dominated by the highly migratory tunas and billfish. In 1976, the last year for which complete statistics are available, 253,830 tonnes (88 per cent) of a total recorded fish catch from the region of 289,196 tonnes was tuna or billfish (Table 1). The comparative magnitude of these tuna catches, and their significance to any discussion of fishery potentials, warrants separate consideration of, firstly, the status of the resources and, secondly, the potentials for developing fisheries on these resources.

The resources

From the 1950s through to the end of the 1960s, tuna fishing in the region was dominated by longlining. In the early 1970s pole-and-line catches exceeded those of other gear types. While the Japanese distant-water pole-and-line fleet accounted for almost all of the catch in this fishery in 1970, locally based joint ventures increased quickly and by 1978 reached a peak in annual production of more than 70,000 tonnes. Total tuna catches by locally based pole-and-line vessels have declined considerably since this time, largely as a result of the cessation of the fishery in Papua New Guinea.

In recent years, catches by the Japan based pole-and-line fleet and the longline fleets of all nationalities have declined as a result of serious economic difficulties in the tuna industry. However, at the same time a tremendous increase in purse-seining by predominantly Japanese and United States vessels (Kearney 1981a) has maintained the relative magnitude of tuna landings from the region. Total catches of tuna by purse-seiners in the area conisdered here were probably of the order of 180,000 tonnes in 1982, more than four times the catch by the same fleet in 1978. Further major expansion in the fleet is anticipated, principally by the United States, Japan and Korea. The last thirty years have therefore seen the rapid expansion and, at least partial, collapse of three major tuna fisheries in this region (i.e. the longline, distant-water pole-and-line, and locally based pole-and-line fisheries) and the rapid increase in a fourth, the purse-seine fishery, which appears likely to produce total yields that exceed even the highest of earlier years. The decline in earlier fisheries does not appear to have been related to any short-comings in the tuna resources exploited by the various gear types. Failures appear to have been due largely to greater efficiency in production of other tuna fisheries competing for the same limited international tuna market. In fact, the available evidence suggests that most of the major tuna resources of the central and western tropical Pacific have remained underexploited.

Tuna fisheries in the tropical central and western Pacific target primarily on skipjack (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*). Skipjack accounted for well over 50 per cent of the total tuna harvest in recent years with annual landings of this one species exceeding 250,000 tonnes on several occasions (Kearney 1981b). Results from tag release and recovery experiments conducted by the SPC's recently completed Skipjack Survey and Assessment Programme indicate that the standing stock of skipjack in the area of the SPC is of the order of 3,000,000 tonnes. These

same results have been used to estimate the turnover rate of this resource at 16 per cent per month which suggests that the total annual throughput of skipjack through the region approaches 6,000,000 tonnes (Skipjack Programme 1982). The catch of this species in recent years of about 250,000 tonnes annually would therefore be much less than the resource could reasonably be expected to sustain. Skipjack Programme scientists, however, stressed that yields could only approach the maximum possible if fishing effort is distributed across this vast region in proportion to the distribution of the resource. They also demonstrated from tagging results that skipjack in this area are capable of extensive migrations and that fisheries scattered throughout the region will interact, particularly as fisheries of different nationalities or different gear types expand and overlap in time and space (Skipjack Programme 1981; 1982).

Yellowfin tuna traditionally have provided the bulk of catches of longline vessels operating in equatorial areas. Two recent estimates of the magnitude of the yellowin resource exploited by the longline fishery have suggested maximum sustainable yields of 60,000 to 70,000 tonnes annually (Far Seas Fisheries Research Laboratory 1978), and 80,000 to 90,000 tonnes annually (Anon 1980). In both cases levels of effort were considered to be at, or slightly above, the optimal level and an increase in effort was unlikely to result in increased catches. The recent expansion in the purse-seine fishery in the western Pacific has resulted in significant catches of yellowfin (approximately 50 per cent of catches by United States purse-seiners in 1981 were yellowfin tuna), not previously significantly exploited by surface fisheries. In a previous report (Kearney 1981b), I have outlined the problems of trying to evaluate the potential for increasing the total yield of yellowfin from this region by increasing the surface catch and concluded that "it is possible that the yellowfin resources of the western Pacific are at present not maximally exploited, but it is by no means certain that substantial development in the purse-seine fishery will increase the yellowfin yield without detriment to the longline fishery". Unpublished information from the Skipjack Programme presented to the SPC's Fourteenth Regional Technical Meeting on Fisheries suggested that, based on limited tag release and recapture information, the standing stock of yellowfin tuna in the SPC's area was perhaps of the order of 1,000,000 tonnes, with a turnover rate of approximately 17 per cent per month. A standing stock of this magnitude should indeed support total catches greater than previous estimates of the maximum sustainable.

Albacore has been commercially exploited in the tropical central and western Pacific only by longlining. The species does not normally occur in this area as surface schools. The only available index of the status of the stocks of albacore in the tropical south Pacific is that provided by catch and effort figures from vessels based in American Samoa. Catches by this fleet increased steadily from 1954 to 1967 before fluctuating widely, achieving an all time high in 1973. Relative abundance, as indexed by the catch rate per vessel, fell consistently from 1954 to 1975 and total landings were maintained only by substantial increases in total effort. Although precise figures are not available, there was a recovery in relative abundance in 1976, 1977 and 1978 (Kearney 1981b). The most recent general appraisal of the status of the stocks of albacore exploited by vessels based in the equatorial central and western Pacific is that resulting from a workshop on tuna resources in Shimizu, Japan in June 1979 - "The conclusion of workshop participants was that current fishing levels

do not appear to be adversely affecting the (South Pacific albacore) stock. Further increases in longline fishing effort would result in only a slight increase in yield, if any. The impact of the development of major surface fisheries on the stock is unclear and consequently the development of such fisheries should be closely monitored" (Anon 1980).

Statistics on catches of bigeye tuna are even more limited than those of other tuna species exploited in the western Pacific. The present status of the stocks cannot be accurately assessed, however, the species is generally considered underexploited.

Other species of tuna and numerous species of billfish are taken commercially in the central and western tropical Pacific, but mostly as incidental catches in fisheries for other tuna species. In their own right they represent very limited known potential for future development of commercial fisheries. However some species, particularly blue marlin (Makaira nigracans) and black marlin (Makaira indica) do constitute resources which could well support significant sport fisheries.

The potentials for tuna fisheries development, particularly by the coastal states of the region

In the preceding section it has been suggested that the resources of the major tuna species exploited in the central and western Pacific are, to varying extents, underexploited. Bearing in mind the significance of tuna to total regional fisheries, the major potential for increasing the total yield of fish from the region therefore lies in increasing the tuna catch, particularly that of skipjack. Increase in total catches in the near future appear most likely to result from expansion of the purse-seine fishery, which, with proper management, might well achieve total catches at least several times greater than at present. Furthermore, as present daily catch rates by purse-seiners in the western Pacific of approximately 20 tonnes per day (Tuna and Billfish Assessment Programme, unpublished data) are approximately twice those in the more mature eastern Pacific fishery, further rapid increases in total fishing effort in this region can be anticipated. In the longer term it would also appear more economical to process much of this fish in the western Pacific rather than ship it frozen to the world's major markets. The future for the tuna fishery in the tropical central and western Pacific therefore appears bright, provided reasonable management procedures can be agreed upon.

Even though the potential for increasing total tuna landings might be great, the potential for increased participation by the Island states of the region is not without problems. There is no doubt that the increased control by coastal states over the resources of their 200-mile zones, embodied in the new principles of the Law of the Sea, greatly increases the potential for Island states to become involved, and even to control policy in those fisheries. A whole range of possibilities for increased involvement exists, from the development of wholly owned, operated and controlled local fisheries, through the spectrum of joint venture alternatives, to the generation of revenue from totally foreign fleets. Of course, no one of these need be pursued exclusively and some balance of local and foreign enterprise could well be the most rewarding.

If coastal states do pursue the option of developing their own tuna fisheries, the major problems they encounter will include (modified from Kearney 1981c) :

(i) Fluctuations in the abundance of the resource.
Even though the area of ocean under the control of individual coastal states has increased dramatically as a result of 200-mile zones of extended jurisdiction, these areas represent only a part of the habitat of the highly migratory species. The abundance of these resources in any one 200-mile zone fluctuates markedly with season, particularly in the higher latitudes. It may, therefore, be impossible for most small Island states to maintain a fleet year-round, particularly as most of them have no other suitable fisheries in which to employ vessels and crew during off-peak seasons. Co-operation with neighbouring states, preferably on a broad regional basis, would help to alleviate this problem.

Highly migratory resources often show marked year to year variations in abundance in addition to seasonal variability. Companies or countries with limited financial resources find it very difficult to withstand successive poor seasons, or even a single very bad one.

(ii) The requirement for large expensive vessels.
An average (300 tonne) pole-and-line or longline vessel, used in the distant-water fisheries of the central and western Pacific, now has a replacement value of approximately US$2,000,000; an average United States tuna purse-seiner of 1,100 tons costs approximately US$11,000,000 to build and almost $3,000,000 annum to run. Few developing island nations can afford such expenses.

Small states generally do not have suitable slipping and docking facilities for larger fishing vessels, nor do they carry extensive stocks of spare parts and ancillary equipment.

(iii) Cost and availability of fuel.
In 1976, it cost approximately A$140,000 per annum for fuel for a 350 tonne pole-and-line vessel, A$100,000 for a 276 tonne longliner and A$240,000 for a 1,100 ton purse-seiner. The fuel costs for any one of these vessels exceed the entire national fuel bill for 1977 for each of two of the Island states of the South Pacific (Tuvalu and Niue) and represent a substantial fraction of the fuel consumption of several others. Fuel prices have increased dramatically since 1976. Fuel is not only becoming more expensive, but is also difficult to obtain in exactly the quantities required to supply a small number of vessels, which are refuelled on an irregular basis, making it difficult for any non-oil producing country to plan the development of fisheries which will necessitate substantial increases in fuel consumption.

Fuel is also far more expensive in remote areas. This makes it disadvantageous for foreign flag vessels to bunker there and hence difficult for small states to encourage these vessels to call and unload their catch. It also means that Island states have an extra economic disadvantage to contend with when catching fish to sell on an internationally competitive market.

(iv) Problems of smallness and economies of scale.
There are many problems of smallness and economies of scale relevant to fisheries development in the Pacific Islands. These have been covered in previous publications, e.g. Kearney 1980.

The inability of at least some small Island states to cope with these and other problems might suggest pessimism for their future in tuna fisheries. This is certainly not intended. The magnitude of the problems does suggest that some Island states will find it impossible to develop wholly owned, large scale tuna enterprises, but it does not al all detract from the countries' potential to develop small scale tuna fisheries, or joint venture operations in which they have limited equity, or to generate considerable revenue from the activities of foreign vessels in their fishing zones.

As the tuna resources are generally underexploited, there is obviously potential for increasing catches by subsistence or artisanal fishermen. This potential is being further increased throughout the region by adapting modern technology, such as fish aggregation devices, to small scale fisheries. The success of joint venture or co-operative tuna fishing ventures, such as those in Solomon Islands and Fiji, endorses the potential such arrangements have for further developments. Finally, the magnitude of the value of catches by distant-water fishing fleets in the 200-mile zones of coastal states, in some cases having fresh fish values greater than the gross national product of the country from whose waters they are taken (Kearney 1981a), coupled with the increased rights of coastal states in the new regime of the Law of the Sea, clearly demonstrate the potential for Island states to generate significant revenue from foreign fishing interests, particularly if realistic access fees can be negotiated.

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TABLE 1. LOCAL CATCHES AND CATCHES BY DISTANT-WATER FLEETS IN THE WATERS OF THE COUNTRIES OF THE SOUTH PACIFIC COMMISSION (after Kearney 1979b)

Country	Local Total Fish Catch (tonnes)	Local Tuna Catch (tonnes)	Longline Catch[8] in 200-Mile Zone by Foreign Fleets in 1976 (tonnes)	Pole-and-Line[8] Catch by Japanese Fleet in 200-Mile Zone in 1976 (tonnes)
American Samoa	220 ('78)[12]	20 ('78)[2]	387	29
Cook Islands	-	-	2,866	10
Fiji	11,594 ('77)[13]	7,262 ('77)[13]	1,553	233
French Polynesia	2,386 ('74)[4]	1,293 ('74)[5]	7,264	0
Guam	-[6]	-[6]	-[6]	-[6]
Kiribati	1,344 ('77)[1]	786 ('77)[1]	11,349	16,570
Nauru	0	0	1,845	8,224
New Caledonia	499 ('77)[13]	186 ('77)[13]	1,800	58
Niue	20 ('78)[1]	10 ('78)[5]	289	4
folk Island	-	-	700	2
Papua New Guinea	68,000 ('78)[1]	47,720 ('78)[8]	6,312	10,533
Pitcairn Island	-	-	1,090	0
Solomon Islands	17,444 ('76)[5]	15,787 ('76)[8]	2,709	17,248
Tokelau	-	-	450	1,645
Tonga	1,117 ('77)[1]	300 ('77)[5]	816	18
Trust Territory of the Pacific Islands	10,000 ('76)[5]	5,284 ('76)[8]	20,601	38,360
Tuvalu	80 ('78)[1]	40 ('78)[1]	1,886	7,611
Vanuatu	10,500 ('76)[7]	10,000 ('76)[7]	1,012	93
Wallis and Futuna	-	-	386	155
Western Samoa	1,700 ('76)[1]	850 ('76)[1]	160	24
TOTAL	124,904	89,538	63,475	100,817

[1] Figures from Crossland and Grandperrin (1979).
[2] Excluding unloadings to the Pago Pago canneries.
This includes only the catches which passed through markets.
[4] From Kearney (1977).
[5] Estimated by the author.
[6] Catches included under Trust Territory of the Pacific Islands.
[7] Mainly longline catches transhipped at Santo.
[8] From Kearney (1979a).

FIGURE A. THE AREA OF THE SOUTH PACIFIC COMMISSION.