

SOUTH PACIFIC COMMISSION
23RD REGIONAL TECHNICAL MEETING ON FISHERIES
(5-9 AUGUST 1991)

**AQUACULTURE DEVELOPMENT IN THE SOUTH PACIFIC: STRATEGY, STATUS
AND FUTURE APPROACH**

by

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1. INTRODUCTION

After World War II, developed countries urged Pacific island countries to develop aquaculture and subsequently tried to assist them carry out various aquaculture projects in the region in response to requests from the countries concerned. Unfortunately, the results were not always as good as expected and there was some criticism of past aquaculture projects in 1984. The Pacific island countries, however, have continuously shown a strong interest in aquaculture, which might be related to the recent decline of lagoon/reef resources caused by over-exploitation.

2. FAO SOUTH PACIFIC AQUACULTURE DEVELOPMENT PROJECT

The Food and Agriculture Organization of the United Nations approached the region to establish a regional aquaculture project in 1985. The South Pacific Aquaculture Development Project (SPADP) commenced on December 1986 with assignment of a Regional Aquaculturist based at Suva in Fiji. The project has served 15 countries in the South Pacific region: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Western Samoa.

The long term objectives of the project were the rational development of aquaculture in accordance with identified needs of the project countries for the purpose of diversifying the supply of fishery products to nationals, generating employment opportunities, increasing foreign exchange earnings and improving the management of the environment.

The immediate objectives of the project were to assist the project countries in their efforts to establish and develop economically and socially viable aquaculture industries in the project countries.

Specific objectives included:

- a) identification and evaluation of needs for aquaculture development and reef management;
- b) assistance and development of economically and socially viable aquaculture projects;
- c) establishment of a system of collection, processing and dissemination of information and particularly relating to aquaculture, marketing, trade and reef management schemes in the region;
- d) identification of training requirements for the region and the implementation of appropriate training activities for aquaculture development;
- e) promotion of technical and economic cooperation with the aim of eventual regional self-reliance.

The project's direct activities have been concentrated on providing advisory services for planning appropriate programmes and improving culture technics, management, post-harvest and marketing; surveys and studies for assessing socio-economic constraints and identifying development potential; trainings, regional seminars/workshops and study tours for individual or regional needs; essential and/or urgent equipment and materials required for boosting a primary operation, supporting on-going programmes or extension services.

3. DEVELOPMENT STRATEGY UNDERTAKEN BY THE PROJECT

Prior to establishing a clear vision of the project's technical approach for facilitating the national and regional aquaculture development, the project has recognized that all aquaculture programmes in the project countries may be categorized by the following scopes of objectives. Those are:

- A. Export oriented aquaculture,
- B. Subsistence aquaculture,
- C. Domestic commercially-oriented aquaculture, and
- D. Aquacultural resource enhancement.

Then the project has identified specific criteria and requirements necessary for fostering successful aquaculture practices in the region in each category. The following are those conditions and requirements.

3.1 Export-oriented Aquaculture Development

The successful export marketing of fisheries products from the South Pacific islands would be dependent upon the following criteria:

- a) to minimize the cost of shipping, commodities should be of small size or dryable and compressible ones,
- b) luxurious or high commercial-valued commodities so that can pay the shipping cost,
- c) commodities not produced in other areas or unique ones only able to be produced in the South Pacific region,
- d) commodities that require simple post-harvest technology, and/or
- e) non-perishable commodities.

Under this category, some aquacultural commodities are at present exported successfully from several countries, for instance, black pearl from French Polynesia and the Cook Islands; dried seaweed from Kiribati and Fiji; crocodile skin from Papua New Guinea. These satisfy some of the above criteria. In recent, the Federated States of Micronesia has started successfully an experimental culture of marine sponge which is a potential species for export-oriented aquaculture development as this species satisfies the above conditions. The object commodities for this category is so limited in numbers at the moment that SPADP has intended to find other potential species, for instance, sea-cucumber. There is recent interest in this species particularly in the Asian region due to its strong

market demand. There seems also a development potential in the South Pacific region. Since, however, its culture technique is not established yet at this moment, SPADP has maintained in collection of updated information on the recent research and encouraged institutes in the region to develop research in this field and to look at further feasibility in the region with dissemination of that information.

Meanwhile, a marketing development of aquacultural products was also one of the most important subjects of SPADP. SPADP has provided active assistance in marketing study, sales promotion and establishment of export trading channels.

3.2 Subsistence Aquaculture Development

The SPADP has recognized that subsistence aquaculture in the South Pacific plays an important role in the rural areas, particularly in high-islands, where there are insufficient supplies of animal protein as a result of low income and poor transportation infrastructure, and also in the outer islands where the existing supplies of fresh fish are occasionally interrupted by seasonal natural disasters. The following criteria have been considered to identify appropriate type of subsistence aquaculture for the region:

- a) low capital investment,
- b) easy to obtain seed with minimum cost,
- c) low production technology,
- d) less management and maintenance,
- e) low operation cost, and
- f) high community acceptance.

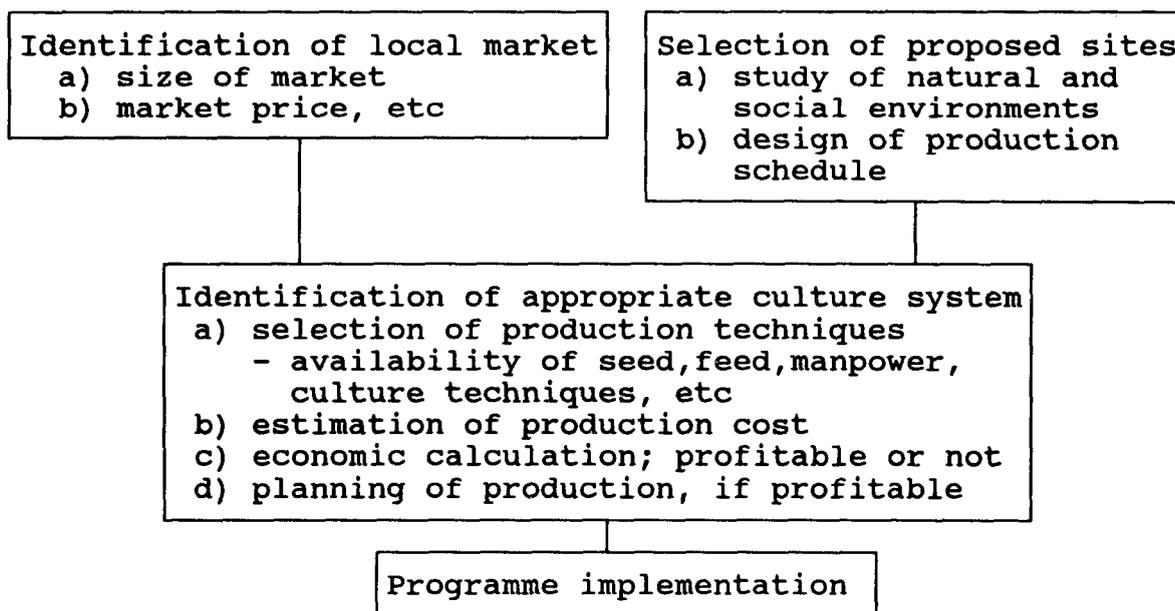
It is also anticipated that subsistence aquaculture might become more important with the increase of island population particularly in the narrow fringing-reef islands where reef resources are limited.

Since the reasonable methodology of subsistence aquaculture practice by direct-use of reef or lagoon areas is not developed yet at the moment, SPADP has encouraged to at first utilize inland lakes/lagoons for this purpose, which are considerably available in many islands, but generally not used actively in production. For utilizing those inland waters, stocking or extensive culture of milkfish, mullet and tilapia would meet with the above criteria.

3.3 Domestic Commercially-oriented Aquaculture Development

This type of aquaculture will create employment opportunities, activate island economy and substitute food importation, and will be also beneficial in satisfying local consumers' demand for fish and seafood products. Because of the small domestic market in general, however, in the most Pacific islands, the production in this category would be restricted. This may in turn restrict the economic viability of such practices. SPADP has understood that most of the past failures in the region were in this category. It is, however, true that there is a growing indication that this type of aquaculture could be economically feasible in some countries due to the recent increase of public purchasing power and fish price in urban areas, though its production scale should be restricted. In general, the development potential in this category may be rather high in the tourism-oriented islands or densely populated islands with a high level of islanders' income.

In order to assist in setting up such economic viable aquaculture practices in the region, SPADP has followed the below procedures for forwarding the initial study:



3.4 Aquacultural Resource Enhancement Development

There is a number of examples throughout the Pacific islands where the reef and lagoon resources are subjected to overfishing and harmful harvesting practices. Important sedentary species, particularly giant clams, sea-cucumbers, trochus, pearl shells and other snails and bivalve shells, are rapidly disappearing from reefs in accordance with the recent increase of population and the development of monetary economy. Those resources would never recover to the past level under the present situation.

Under this circumstance, there is a growing interest in the region in the development of reef resources management by aquacultural means, such as reef restocking which is assumed to be of benefit for recovering over-fished resources. In order to ensure the effective application of such restocking practices, strengthened fisheries legislation and management should be introduced in parallel with implementation of these restocking programmes. Therefore, the project has encouraged to carry out a public awareness campaign for educating people to understand the importance of fisheries regulation and management concerned.

This type of management can be called "reef ranching", and may be practically categorized as follows:

- a) direct restocking of juveniles produced from hatchery or collected from other waters, for increasing natural stock,
- b) setting-up of brood stock sanctuary by placing cultured grow-up animals or by transferring naturally matured animals from other waters, for accelerating resource recruitment,
- c) transplantation or introduction of matured animals from other region for establishing new resources, and
- d) trapping of natural juveniles by artificial structures or improving environment, for accelerating settlement.

Based on the above categories, SPADP has provided assistance for developing reef ranching trials in the region. SPADP has also supported in carrying out stock surveys of important reef organisms to obtain the primary information which is necessarily required for building up outlines of fisheries regulation and management plans.

As the concept of reef ranching is new in the region and its results are uncertain, SPADP has studied on this concern, particularly in collection and dissemination of information on the similar practices undertaken in other regions in order to identify criteria for successful practices and potential success of reef ranching in the region.

4. PRESENT STATUS OF AQUACULTURE DEVELOPMENT IN THE REGION

4.1 Outline

In the South Pacific region, aquaculture practices are currently much concerned in export-oriented aspect in many islands, particularly with black pearl, sea-weed and giant clams. Interest in subsistence aquaculture is increasing particularly in outer islands and rural areas of some countries. Milkfish, mullet and tilapia are possible species for this concern. Some practices have already developed and are playing an important role for subsistence purpose in some localities. Commercial aquaculture for domestic consumption has become interested and is growing in higher populated islands such as Fiji, Papua New Guinea and Western Samoa, though some development has already made in commercial aquaculture in tourism developed countries such as Hawaii, French Polynesia and New Caledonia. Shrimp culture is a common practice for domestic commercial operation.

Interest on reef resource enhancement, particularly in invertebrates, by application of aquacultural means, that is, "ranching" or releasing hatchery-produced juveniles into the natural environment, is growing in the region probably as a result of the increasing depletion of reef resources.

The following is the present situation of aquaculture practices by development type in the region.

4.2 Export Oriented Aquaculture

Owing to few success in the aquaculture projects in 1950s to 1970s, aquaculture practices in the Pacific subregion have narrowed its object species down in 1980s, and a new approach to aquaculture development was demanded as reconsiderations. Under this circumstance, giant clam was successfully re-produced at the Micronesia Mariculture Demonstration Center(MMDC) in Palau with low technique, less management and low cost. This success was followed by a regional interest of giant clam culture and encouraged island countries to set up their own hatcheries in their countries. Other research institutes such as the James Cook University and ICLARM, have also joined to start their research on this new face. Many bilateral and international aid organizations have supported and encouraged in promotion of giant clam culture mainly for aiming at the economic development of the islands. As a result, giant clam hatcheries have been set up in many countries. As of July 1991, there is a national hatchery in American Samoa, the Cook Islands, Pohnpei and Kosrae of the Federated States of Micronesia, Fiji, Guam, Palau, Solomon Islands, and Tonga, and one private hatchery in Marshall Islands. Thus, giant clam culture is currently booming in the region. Those hatcheries, however, are generally not generating income, except Palau. Their operation costs are mostly subsidized by the government or aid programmes.

Research pioneers has believed that giant clam culture is economically viable with selling adductor muscle after five to six years grow-out period. This, however, has not been proved yet in any country, despite of the fact that more than ten years have been passed since successful mass seed-production was undertaken in Palau. In recent, Palau has started exportation of young clams to Okinawa successfully since 1989 as food consumption by assistance of SPADP. Sales of giant clam at MMDC seemed doubled in 1990 with US\$120,000. No other country has exported giant clam as yet.

Meanwhile, giant clam stock enhancement programmes by using hatchery produced juveniles have been recently attentioned in several islands where giant clams have been already depleted by overfishing, though this methodology has not yet been studied.

There are at present two private giant clam farms in the South Pacific islands; one in Marshall Islands established in 1985, one in Western Samoa established in 1990. Those, however, have not yet produced a profit. There have been also two private farms in Cairns, Australia, but no longer in operation because of no economic viability. Those are seeking a new partners or for sale. To assist in establishing economically viable giant clam farm, intensive marketing and economic studies have been carried out by several aid organizations.

Black pearl culture is currently the largest successful export-oriented aquaculture industry in the region. Three countries, French Polynesia, the Cook Islands and Fiji, are at present producing black pearls. Most black pearls produced are being exported to Japan. Black pearl culture started in 1964 in French Polynesia with a Japanese pearl farmer, and it became today the national largest export industry earning over US\$50 million in a year.

Some 1,000 firms are engaging in pearl culture industry in French Polynesia. Its production is almost uncontrollable by the government. In 1985, the cultured black-lip pearl oyster became infested with unknown disease and a mass mortality occurred. It is believed this was caused by high intensive culture of pearl oyster. This outbreak resulted in deterioration in both production and quality of pearls. The mortality has still continued in some islands and a fear remains of a relapse of the mass mortality. Seed production technology of black-lip pearl oyster has recently developed in French Polynesia in cooperation with Japanese pearl producer.

The Cook Islands has succeeded in full-scale pearl production in 1989 and exported 26 kg of black pearls valued at US\$350,000 to Japan. This product was made from one outer island. The Cook

Islands and USAID are preparing a five-year pearl culture development programme, in order to expand pearl culture to other outer islands. Fiji farmer has struggled in collection of mother pearl oysters due to over-fishing. The Federated States of Micronesia, Kiribati, Marshall Islands, Tokelau and Tuvalu also have an interest in black pearl culture. Since, however, black-lip pearl oyster has been already almost depleted by over-fishing in many islands of those countries, development potential of pearl culture is limited unless the natural stock of black-lip pearl oysters recovers.

Silver pearls are produced in Palau by using silver-lip pearl oyster, but its production is unknown. The Solomon Islands and Papua New Guinea are also interested in silver pearl culture. An experiment of Mabe pearl production by winged pearl oyster started in December 1989 at Vava'u in Tonga under the direct supervision of SPADP. Some 7,000 shell are ready to produce pearl and 10,000 spats have been collected in 1991.

Seaweed(*Eucheuma*) culture is also presently a regional concern.

In 1986, Fiji became the major seaweed growing country in the region, with 200 mt of dried seaweed exported in 1986 and 277 mt 1987. However, seaweed culture deteriorated thereafter because of the socio-political changes in the country and the withdrawal of the sole buyer from New Zealand. After a substitute buyer from Europe, Fiji's seaweed culture was set to expand once more with a new farming and marketing company established in 1989. Owing to the damages to its farm, hit by repeated natural disasters, the company closed its operation in 1990. Due to the lack of a marketing operator in the country, the farmers were again discouraged in continuing their farmings. Another local marketing company was established again in the late 1990.

Seaweed production in Kiribati rapidly increased since 1989, and 800 mt of dried seaweed was exported to Europe in 1990. Those were produced mostly from two outer islands and earned US\$400,000. Almost of all copra farmers turned to seaweed farming in those islands because of the slumped copra market. A series of extension services are being scheduled to boost a rural economy of other outer islands. The government is planning to transfer the marketing and shipping business to private sector, which is currently managed by the Fisheries Division under using the revolving fund.

Seaweed culture is also practiced in the Federated States of Micronesia and Solomon Islands at present. Their production scales are, however, very small. Seaweed culture trials are currently being carried out in Tuvalu and Western Samoa.

After a half century's hiatus, bath sponge culture has been revived in the Federated States of Micronesia. One farmer has been successfully growing more than 4,000 pieces of sponges in Pohnpei since 1986. Owing to the depression of wild sponge production in the world, its commercial culture seems economically viable. A further requirement is to develop row sponge processing at local level. As a wild sponge resource is nearly extinct in Pohnpei, effort is directed to increasing the brood stock at the moment.

Papua New Guinea has been exporting 20,000 to 30,000 crocodile skins annually to Japan and France, of which earnings is approximately US\$2.5 to 3.0 million per year. The majority of crocodiles for the skin trade were of cultured animals which were raised from juveniles captured in the wild. The juvenile capture fishery and its farming provide an important income in many areas of the country. A local shrimp trawling company is planning a large scale crocodile farm by utilizing by-product trash fish of trawlers as bait. However, assessment of juvenile crocodile resource is unknown. The Solomon Islands undertook a feasibility study of a crocodile farming because of a decline of wild stock.

An export of farmed marine shrimp from New Caledonia began in 1988 mainly to Japan and France. Approximately 200 to 300 mt of shrimp is said to have been exported in 1990. A shrimp farm in the Solomon Islands has restored production and started exportation to New Zealand and neighboring countries, but its quantity is about 10 mt. Two marine shrimp farms in Fiji intend to

export product, but it is not achieved as yet.

Guam is culturing milkfish mainly for exporting to Nauru and Hawaii, with 10 mt or more annually. Cultured milkfish is also exported from Kiribati to Nauru, but its quantity is limited to just a few tones per year.

Hawaii started a large-scale commercial abalone farming since 1988, for aiming at exporting to Japanese market, by intake of a cold and nutrient enriched water from deep-sea. Its production, however, seems not satisfactory. Under the same application of deep-sea water, medicinal micro-algae is also being produced in Hawaii for both export and domestic markets.

3.3 Subsistence Aquaculture

In the large high-islands, it is not so easy for villagers living in inland areas to obtain fresh fish owing to limitations of transportation such as lack of public transport, road blockage in rainy times, recent increase of tariff, etc. In Fiji, to increase supply of animal protein for those villagers, the Rural Fish Farming Programme was initiated in 1975 in association with the US Peace Corps Volunteers by applying extensive culture technique with tilapia (*niloticus* species). This programme has gradually but successfully developed so far. New tilapia strain was introduced in 1988 from Thailand with SPADP's assistance. This strain has been well appreciated by subsistence farmers as well as commercial ones due to high performances of growth and meat rate. In the recent time, however, villagers' awareness to this programme has rapidly raised and constructions of fish ponds are extended in many areas. In response to the increasing demand for tilapia farming, the government is preparing to establish a second national tilapia hatchery in the other main island. Farmed tilapia is mainly consumed among villagers and some are supplied at cash or barter for crops. Some farmers are getting anxious to sell fish at neighboring villages and towns. This practice has currently expanded to school and church level.

Similar situation is occurring in the remote highlands of Papua New Guinea. Common carp is being used in the highlands area, but the extension service has not been satisfactorily undertaken yet due to insufficient seed production. In some localities in the high altitude area, restocking practices of rainbow trout is carried out from river to river by villagers. It is said that many fish ponds have been constructed at river side for farming/stocking trout in the mountainous area of the Central Province.

In contrast, in the small low-islands in the region, subsistence capture fishery which is a common and important practice for the people, has been often interrupted at length by bad weather and/or appearance of siguaterra poisoning at some localities. Such rough period also stops transportation of fishery products from other islands. Consequently, people suffered a lack of fresh fish in such periods. The recent increasing population might also cause further shortage of fish in the rough season. In some of those islands, there are a few practices for producing or keeping subsistence food to tide over such period, for instance, moving large giant clams to shallow areas closed to the village during calm season in Abemama Island of Kiribati, stocking milkfish in back-yard ponds in Vaitupu Island of Tuvalu, etc.

Although these practices generally have not been in common so far in the region, an awareness of subsistence aquaculture specifically for the purpose of mitigating shortages of fish during the rough season is now increasing among islanders. Subsistence fish stockings in general sense have been traditionally practiced in several places in the region, for instance, milkfish stockings in Nauru and in Manihiki and Pehnryn Islands of Cook Islands, and in several outer islands of Kiribati where milkfish is an essential food for the island feasts. Mullet fry obtained from Hawaii has recently stocked in Vava'u, Tonga. Subsistence aquaculture is recognized to be important in the narrow fringed-reef islands in which coastal fisheries resources are limited. Extension of this practice will also

contribute toward import-substitution in the country.

A milkfish stocking programme is on-going successfully in Mitiaro Island in the Cook Islands. In Western Samoa, development of mullet culture/stocking in the coastal areas is being promoted by the government to substitute the depleted wild mullet catch caused by over-fishing. Tuvalu is interested in milkfish stocking/culture programme for subsistence purpose. Kiribati is preparing an implementation plan of the outer islands milkfish culture programme.

3.4 Domestic Commercially-oriented Aquaculture

Owing to the small population of island nations and low cash income to islanders, local markets are generally not large enough to support a domestic commercial-oriented aquaculture business in the region. The many previous failures in the past were due to lack of detailed market survey in socio-economic aspects, introduction of unappropriated culture techniques and inadequate planning of production scale. Additionally, an insufficient feasibility study in selection of suitable sites was a critical point.

In the project countries, there is currently a little commercially sustainable aquaculture farm operating. Two private shrimp farms in Fiji and one shrimp farm in the Solomon Islands haven't reached to break-even point yet. Those farms are importing juveniles and pellets. Domestic demand of marine shrimp in Fiji is said to be some 30 mt yearly, while several tilapia farms in Fiji have recently gained an indication of economic viability. With an expansion of the Rural Fish Farming Programme, interest in tilapia is growing among urban people. Tilapia price is at present sold at US\$2.70 at Suva, the same as reef fish or more.

A local businessman started giant clam farming in Western Samoa in 1990 with a financial assistance of a local bank. Initial seed clam was supplied from the government hatchery and Australia. However, further seed supply is uncertain because the government hatchery is not operated at the moment. He is aiming at selling two to three-year old clam *Tridacna squamosa* for local consumption, then export to New Zealand in the future. He is experiencing a considerable mortality caused by parasite snails. Economic viability is unknown yet.

In Kiribati, much improvement on bait milkfish production and its quality as well has been achieved successfully. Unfortunately, however, there is no demand of bait fish at the moment because of close down of the national skipjack fishing company. Farmed milkfish is sold commercially, but its demand is low because of the high price compared to that of reef or tuna fish sold locally. It is thought that price of farmed milkfish could be decreased and its sales should be promoted firstly within the country with some sort of post-harvest practices then in neighboring countries.

From technical point of view, one village cooperative is producing trout successfully in the highland of Papua New Guinea by fund from EEC, with imported eyed-ova from Tasmania and pellet locally available. Post-harvest and shipping arrangement of product is a major problem for trout farming in the remote highlands.

A trial of triploid Pacific oyster culture was carried out in Western Samoa in 1991. Triploid oyster was highly accepted by domestic market, while normal diploid oyster was assessed with no commercial potential.

Rabbitfish culture is undertaken at an experimental level in the Federated States of Micronesia and Palau. Tonga is preparing a research programme on mullet commercial culture with JICA.

There are a few commercially viable aquaculture ventures for domestic sales in tourism-oriented islands of Hawaii, French Polynesia, Guam and New Caledonia. In general, however, most of commercial farms do not produce a very satisfactory economic return, even in those tourist oriented islands.

3.5 Aquacultural Resource Enhancement

Following the successful trochus transplantations undertaken in Micronesia area in 1930s, the similar practices had repeated particularly in Polynesian area in 1950s and 1960s with successful results. In the early 1980s this practice again became active in several localities in the South Pacific.

The FAO/UNDP RFSP carried out a number of mass trochus transplantations in Tuvalu and Tokelau from Aitutaki in the Cook Islands in the period from 1986 to 1989. The SPADP co-sponsored the air-dropping in 1989. Western Samoa also introduced adult trochus from Fiji in 1990. Thus, trochus has been distributed throughout the region and its resource has been well established in many islands.

Today, trochus shell is one of the most important export commodities of the islands. Trochus button plunks are also produced locally and exported from the Federated States of Micronesia, Fiji, Solomon Islands and Vanuatu. Because of a strong fishing pressure due to the recent high market demand, the trochus resource has been rapidly decreasing in many localities. To recover this depleted resource, MMDC of Palau started restocking practices with hatchery produced juveniles since 1988. Other practices were also undertaken in New Caledonia in 1989, and in the Federated States of Micronesia 1990. Okinawa has started a regular restocking since 1988. Results of those practices, however, were not as good as expected because of low survival rates due to high predations occurring immediately after the stocking. In May 1991, a trial of trochus reseeding was carried out in Vanuatu with some 1,000 hatchery-produced yearling trochus. Its result was mostly favorable against those results observed in MMDC, New Caledonia and Okinawa.

Reef ranching of trochus juvenile seems at present not effective in terms of stock enhancement unless a certain restocking technology is developed. The higher survival rate is expected, the larger trochus juveniles released with. The problems, in this case, are that larger tanks are required for holding such grown trochus, and the longer trochus stays in the tanks, the more risk of mortality increases. Another critical problem in the island countries is on how to create an operation cost of the hatchery because the seed is not able to be sold in this case.

There is a strong regional interest in recovering depleted giant clam resources on reefs by restocking of hatchery produced clams. Unfortunately, this method is not practiced yet in the region despite of the successful development of seed production techniques available at the moment in the region. All of three leading giant clam research institutes, MMDC, JCU and ICLARM, have been focusing on developing hatchery and its farming techniques but not for reseeding ones. Meanwhile, trials of stock enhancement have been undertaken in Yap State of the Federated States of Micronesia and Tonga by set-up of clam sanctuaries with cultured or natural brood stock. This is called "giant clam circle" in Tonga.

Similar to trochus, several countries are interested in green snail transplantation as this species has a high commercial value, while green snail has been heavily over-fished in the producing countries. A feasibility study was carried out in the Federated States of Micronesia in 1988 with the potential success of its transplantation. There was a successful transplantation record of green snail to French Polynesia from Vanuatu in 1968. Seed production of green snail is not practiced in the region, though Okinawa has been producing seed since 1986.

Trials of cockle restocking were undertaken from island to island in Kiribati to enhance subsistence fishery. Some trials were successful and some were failed. Tonga is planning to carry out a research programme on shellfish stock enhancement under the proposed JICA's technical cooperation. Restocking of black-lip pearl oysters have been planned in Tokelau for restoring wild stock, but it has not been implemented because of difficulty in finding a source of seed supply.

Research on seed production of tropical sea-cucumbers is on going in the University of Guam. Asian and Southeast Asian countries are interested in farming sea-cucumbers with wild or artificially produced juveniles. Lack of biological and ecological information on tropical sea-cucumber obstructs planning in sea-cucumber stock enhancement development in the Pacific region.

4. FUTURE APPROACH FOR LONG TERM DEVELOPMENT

AA

4.1 Export oriented aquaculture

It is generally not so easy in the island countries to develop export oriented industries of land based commodities because of limited land space and natural resources. Export of capture fishery produce has struggled against difficulties in meeting with the importers' standard of quality or in facing a crisis of over-fishing in some species. On the other hand, utilization of extensive reef and lagoon areas is an ideal to create sustainable production of export commodities. Thus, it is natural for the island countries to have expectations concerning mariculture development in reefs and lagoons.

However, because of the logistic problems in marketing, that is, long distance to the potential export markets, economic viable commodities for export purpose are limited at the moment as mentioned earlier. Only black pearl, dried seaweed (*Eucheuma*) and crocodile skins have been so far economically feasible in the project countries. Giant clam and marine sponges are potential candidates. Those species are, however, not applicable for all over the islands. Black pearl culture is mostly suitable in atolls in where abundant brood stock is available, seaweed farming is good at shallow reef flats but requires a fairly extensive areas for producing in quantity, and crocodile farming is limited to Papua New Guinea and probably the Solomon Islands. Hence, it is recommended to diversify of suitable species for promoting export oriented aquaculture development in the region from the economic buildup point of view. This diversification will be able to encourage the country to produce unique export commodities and it will result in mitigating further marketing competitions that may be arisen among the same commodity producing islands.

It is, however, too difficult at present to diversify object species because of insufficient information available on biology of reef organisms and commercial value of each organism. Basic biological and ecological information are still missing even for important reef organisms such as sea-cucumbers, pearl oysters, trochus, green snail, sea-urchines, lobsters, algae, and other edible snails and bivalves. This is owing to the fact that regional research has been so far emphasized mainly capture fisheries. It is believed that more aquaculture potential species could be found if further studies on reef organisms continue. For instance, some reef-seaweed is known for medical use and it has a high commercial value, but its distribution and biology are unknown.

It is, therefore, recommended that region put more emphases on developing the regional research capability or set up a regional research institute for studying reef organisms and their resources. Although the function of this institute seems similar to that of the Inshore Fisheries Research Programme of SPC, it should carry out independent programmes under the systematic development strategy, because the present programme implementation system based upon countries requests seems difficult to arrange a long-term research development. This institute is also required to play a very important role in formulating the strategy of aquacultural resource enhancement of the region which is described later.

4.2 Subsistence aquaculture

Subsistence aquaculture receives attention in the region particularly in the rural areas/islands. This might be correlated to the recent population increase in the region and the over-fishing of reef resources in some localities. If so, subsistence aquaculture will become much more important in terms of food supply for the islanders. This will assist import-substitution, too.

There is a growing regional consent that management is necessary to sustain fisheries resources. This means fishing restrictions and legislation would be more strengthened for protecting fish and shellfish resources from over-fishing. This strengthened management will be most essential and important in the future particularly for reef resources which are subject to over-fishing because

of limited habitat. On the supposition of this, reef fish and shellfish would be strongly restricted to capture in a certain period particularly spawning season. Production from subsistence aquaculture might be able to tide over this period, and surplus production can be sold during this period as the fish price may rise due to lack of landings.

From the feature of subsistence point of view, less management is the point of this practice. In this regard, an extensive farming method of finfish by using inland waters is firstly recommended. Pond and pen cultures of milkfish, mullet and tilapia are suggested for subsistence aquaculture because those fish grow easy with no intensive feeding and, moreover, seed is generally available locally. As Fiji has a successful inland water subsistence aquaculture programme in the region, it is recommended for the high-island countries that Fiji be visited to study this programme. Secondary, giant clam farming seems a potential development for subsistence production, similarly to taro farming on land base. In this practice, a part of farmed giant clams should be sold at market for gaining some cash enough to buy seed clams for keeping the clam farm sustainable. Subsistence practices may lead to domestic commercial aquaculture development.

Countries should realize that subsistence aquaculture may become more important for the future, and should take of planning for this development into account. It is recommended that a detailed study on fish resources, level of exploitation and availability of all inland waters including inlets, brackish swamps, etc., be made by countries and the potential of subsistence aquaculture in each island be identified. Those studies would be also very beneficial in obtaining important information required for preparation of reef resource enhancement programmes.

4.3 Domestic commercially-oriented aquaculture

Domestic commercially-oriented aquaculture has so far had limited success in the Pacific island countries. However, the recent progressive circumstances in and around the island has made this aquaculture economically feasible in some localities, particularly in populated high-islands, though its scale is limited.

In due consideration with the technical and socio-economic background of the Pacific islands, inland fish farming by extensive methods is suggested as a beginning, rather than with mariculture which generally requires higher management and higher investment. Additionally, it is important that this fish farming should be integrated with crop farming and husbandry to maximize a productivity under the limited situation of the island. It is recommended that the technical cooperation be better sought from the Southeast Asian or Asian countries as this type of fish farming is traditionally practiced and well developed in those countries.

In connection to the inland water aquaculture development, it should be recognized that bamboo is the most essential material for making various aquacultural equipment such as pens, sluices, cages, rafts, baskets, etc. as well as fishing gears such as fishing rods, set-nets, traps, floats, FADs, etc. It is not an exaggeration that today's development of aquaculture and diversification of fishing methods in Asian and Southeast Asian countries are brought about by availability of bamboo. Aquaculture development as well as coastal fishery development in the South Pacific region, in general sense, is hampered by lack of bamboo material. It is, therefore, recommended that countries be encouraged to plant more bamboo or introduce new bamboo strains which are strong and fit to the island nature.

Although commercial farming of high food valued bivalves, such as oysters or green mussel, is possible sporadically only in high populated high-islands, its potential is in general low in the region, because of lack of local seed availability. Construction of their hatcheries or remote-setting method by using imported larvae are not recommended at the moment from a technical management point of view. Intensive cage culture of groupers or rabbitfish is not recommended either, due to

unavailability of cheap feed and high operation costs. In order to promote commercial aquaculture development and to support the growing commercial aquaculture industry of the country it is recommended that the number of firms be controlled by the country to avoid ruinous competition from over production or importation of aquaculture commodities be restricted to protect domestic industry.

4.4 Aquacultural resource enhancement

The need for aquacultural resource enhancement is gaining recognition in the region for enhancing natural populations of exploited marine species of subsistence or commercial importance, particularly sessile or slow-moving invertebrates such as giant clam, pearl oysters, trochus, green snail, coconut crab, sea-cucumbers, and others. Several of those have been undertaken so far for trochus, giant clam and others. Some of them were successful and some were not or uncertain.

A joint research project of SPC Inshore Fisheries Research Project and SPADP on the aquacultural resource enhancement has shown potential to be of benefit to Pacific island fisheries in certain circumstances, but that these circumstances need to be evaluated very carefully in the connection with the natural environment, the existing knowledge of the biology of the species and the economic value of the fishery, as well as country-specific features. Subsequently, the joint research project suggests that a cautious approach should be taken to aquacultural resource enhancement.

A major concern is that the aquacultural resource enhancement needs to be considered as part of an overall management approach and not as an alternative to management. It is clear that the aquacultural resource enhancement will only be warranted if it is supplemented by additional measures such as fishery regulations, management, or environmental restrictions.

Another most important concern is that the reproductive and larval biology of the species will be major determinants of whether the aquacultural resource enhancement is likely to have biologically significant results. Unfortunately, little research has been conducted so far on the important reef animals in the region. Biological knowledge and information on the species, obtained through the hatchery practices should be compiled and utilized for the development of the aquacultural resource enhancement.

The SPADP also stresses a need for a comprehensive research particularly on relationship between the life cycle of the species, the water currents, and the bottom characteristics, that might be a key for success of the aquacultural resource enhancement. Thus, it should be also understood by countries that the aquacultural resource enhancement programmes require a great deal of research development effort, and funding before having observable benefits.

Such detailed and costly investigations might be beyond the capacity of most national and regional fisheries agencies. These, however, would possibly form the basis of university studies that meet the requirements of academic research programme that contributes at the same time towards fisheries development goals in the region. It is thus recommended that a regional need for such research programmes be addressed to universities and other research bodies located both within and outside the region, and also recommended that financial backup for such programmes be also addressed to donor organizations.

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