AQUACULTURE IN EQUATORIAL AND TROPICAL PACIFIC ISLANDS: PRESENT STATUS AND PROSPECTS OF FUTURE DEVELOPMENT

by

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INTRODUCTION

Tropical and equatorial Pacific islands generally have only a small emerged land area. But a particular structure has evolved through geologic evolution and coastal coral reef morphology which provides a very wide surface of controlled water. In the global search for new sites capable of supporting squaculture, development of such islands emerges as the most promising.

NATURAL BACKGROUND

Best aquatural sites

(1) Completely or partially enclosed atoll lagoons.

Fully enclosed lagoons retain all the fertilization produced by washing and leaching of the coral barrier. By dividing off sections into ponds such lagoons offer the easiest management possibilities. It is also possible to use their potential as a whole by introducing new species which cannot then escape. Where a narrow and shallow passage breaks the coral ring it is possible, easily and inexpensively, to organize an effective exchange of water masses.

About one hundred atolls in the tropical and equatorial Pacific have completely or partially enclosed lagoons, mainly in the Tuamotu Islands, the outer islands of the Society archipelago, Line Islands, Phoenix, Gilbert and Ellice and Marshalls.

(2) Karstic-dissolved pools in old coral reef structures.

Many emerged reefs have small karstic-dissolved pools where the sea water enters by filtration. Usually the surface of such a basin is no more than one or two hectares and the depth one metre. But some raised reef islands have pools of different sizes from one to one hundred hectares with a greater depth of up to ten metres or more. Such sites offer the best conditions for marine farming as fences may be built easily and at a low cost and a system devised for circulation of water from pool to pool. Christmas Island has more than 5,000 hectares of such structures and others are well developed in Palau (Western Caroline Islands) and in Vavua (Tonga).

(3) Inland bays with deltas and mangroves.

Some continental or volcanic islands have large delta areas with mangroves. Many enclosed brackish-water ponds and deep channels provide good sites for aquaculture. But the best places are the salt flats which lie between the mangrove fringe and the land. The main deltas are in New Caledonia (St. Vincent Bay 20,000 hectares, Diahot 10,000 hectares, Dumbea), in Fiji (Rewa 30,000 hectares, Ba 30,000 hectares, Daku 12,000 hectares, Lombasa 10,000) and in the Solomon Islands - but such sites also exist in other places such as Palau or Ponape in Micronesia.

Natural stocks

Often the best sites for aquaculture have existing natural stocks which can be used for initial experiments in development.

(1) Molluscs.

Enclosed lagoons often have extensive beds of mother-of-pearl oyster shell (Pinctada margaritifera), the best grounds occurring in the Tuamotu Islands and northern Cook Islands. Edible mangrove oyster, Crassostrea glomerata, extends over many areas with heavy concentrations in New Caledonia, Fiji and Society Islands. Rock oyster, Crassostrea echinata, which is larger in size and is of a stronger flavour, covers rocky areas of New Caledonia, New Hebrides and also Palau. Many other edible shells occur on sandy beaches such as arkshell claim, Anadara, and venerid shell, Gafrarium.

(2) Crustaceans.

Surveys have recently recorded several high-density stocks of Penaeides shrimps in deltas, muddy flats and mangrove channels: in New Caledonia Penaeus monodon, P. merguiensis and P. semisulcatus and in Fiji P. monodon and P. semisulcatus. Penaeides shrimps can adapt their biological cycles to a pure atoll environment (two species were recently discovered on Tarawa Atoll, Gilbert Island). Macrobrachium (giant fresh-water shrimp) occurs in heavy density in every river of continental and volcanic islands.

(3) Fish.

All over the tropical and equatorial Pacific it is relatively easy to catch from natural stock fish-fry of grey mullet (Mugil cephasus), blue tail mullet (Mugil scheli) and milkfish (Chanos chanos). Rabbitfish (Siganus sp.) are also quite common, their fry reaching the coral reefs in April/May in Micronesia and December/January in Melanesia.

(4) Turtles.

Green turtles (Chelonia mydas) and Hawksbill turtles (Eretmochelys imbricata) nest in breeding grounds of some of the remote islands affording easy collection of eggs for hatchling cultivation.

Open spaces for new species

Isolation increases from west to east in the wide tropical Pacific area and many potential but specific habitats remain unoccupied. It should be possible to successfully introduce useful species without damaging the existing equilibrium. Good examples are the transplant of a Trochus niloticus population in Micronesia between 1935 and 1940 and the same operation in 1957 from New Caledonia to Tahiti. Many areas appear to offer good potential for the Japanese oyster, Crassostrea gigas, and also for other edible tropical or subtropical molluscs such as the green mussel (Mytilus smaragdinus) from the Philippines and Perna canaliculus from New Zealand. Possibilities of introduction of brine shrimp (Artemia salina) appear good in salt marshes and lagoons of the drier islands.

TRENDS IN AQUACULTURE

Policy of development

In some islands (Gilberts, Tuamotus, Society, Tonga Tapu) people traditionally collect milkfish and mullet fry, placing it in natural ponds or fencing it off in closed lagoon areas so that there is always a ready and safe supply of fish. But, apart from the Mikimoto pearling venture on Palau Island between 1932 and 1942, no commercial aquaculture was attempted in the tropical and equatorial Pacific islands until 1959 when the Fisheries Division of French Polynesia started a programme for farming edible oysters in Tahiti and producing pearls in the Tuamotu Islands.

Since 1965 every territory in the area has launched an aquaculture enterprise in order to make best possible use of their natural resources. As such new fields of activity require the assistance of many specialists in various branches of scientific research and technology, widely-ranged international cooperation was promoted through the South Pacific Islands Fisheries Development Agency (SPIFDA) financed by UNDP, managed by FAO and with counterpart assistance from the South Pacific Commission. This Agency started its Plan of Operation during the year 1970 by undertaking surveys in the area to assess potential for fish and mollusc farming and also to assess turtle, lobster and beche-de-mer resources. Following on the recommendations of the consultants, the SPIFDA Consultative Committee took the decision in October 1971 to develop aquaculture demonstration centres in Palau, New Caledonia and Fiji; SPIFDA and other FAO experts were also to give support to research programmes in the Gilbert and Ellice Islands and in French Polynesia. National organizations were following other

programmes: Hawaii University has a project in the Christmas Islands, the Oceanic Institute (Hawaii) in the Cook Islands and in Tetiaroa (French Polynesia) and French CNEXO in Tahiti.

With the more promising prospect of profitable undertakings, some private business entered the field of aquaculture on their own account (oyster farming in New Caledonia, New Hebrides and French Polynesia, giant fresh-water shrimp farming in Tahiti, pearl products in Tuamotu).

Status and results as at January 1973

(1) New Caledonia.

Three private oyster farms are undertaking small-scale farming with native rock and mangrove oysters. Catching spat is relatively easy but achieving a marketable size product takes three years. Sydney oysters, Crassostrea commercialis, are imported and grow well but they give little spat for collectors. The experimental introduction of the Japanese oyster, Crassostrea gigas, has given excellent results both from natural spat from Japan collected on oyster shells and from artificial 'free' spat bred in California.

Commercial growth of Crassostrea gigas 'free' spat is being tried on the west coast; in the south (Prony), the centre (St. Vincent Bay) and in the north (Poya).

The Fisheries Division of New Caledonia is starting experiments in farming European flat oysters. One private farmer is experimenting with Ostrea edulis artificial spat from California.

The SPIFDA St. Vincent Bay aquaculture demonstration centre, supported by the New Caledonian administration, was completed in August 1972 with an experimental pond 12,000 square metres in surface and 20,000 cubic metres in volume. Water is changed by pumping at the rate of 1,200 cubic metres per hour. The present programme includes experiments in farming natural fry of mullet, rabbitfish and Penaeides shrimps and further research will include induced artificial breeding of such species; an Israeli FAO expert in rabbitfish breeding research is already appointed for a full year term. First results show evidence of the possibility of farming banana prawns, Penaeus merguiensis, from post larval to adult stage (12 g. males, 35-40 g. females) in less than four months.

(2) New Hebrides.

A private oyster farm in Espiritu Santo is based on collection of spat and farming of the native rock oyster, Crassostrea echinata. Cultivation of imported artificial Japanese oyster 'free' spat from California was started during October 1972 and results appear good.

(3) Fiji.

In 1971 the Fisheries Division of Fiji started to develop an oyster farming scheme near Suva. Japanese artificial 'free' spat was imported from California and was put in raft cultivation after glueing on masonite sheets. Large scale operations in 1972 were successful, giving commercial-size Japanese oysters after only 9-10 months farming. The SPIFDA project includes plans to enlarge the scale of experimentation and to survey other areas where native stock is abundant but undersize. A prawn survey is to be initiated to investigate the possibility of using the local species for farming. Fish-ponds are already made for small-scale mullet and rabbitfish farming in connection with the mangrove reclamation scheme in the Ba area organized by the Agricultural Division; this fisheries project is to be run in conjunction with the SPIFDA St. Vincent Bay project in New Caledonia. An FAO oyster culturist is appointed for a one-year programme from March 1973.

(4) Western Samoa.

An experimental green turtle farm is being built by the Fisheries Division.

(5) Cook Islands.

An integrated aquaculture project, mainly for mullet, was started on the recommendation and responsibility of the Oceanic Institute of Hawaii which appears to be suffering difficulties of logistics and lack of support.

(6) French Polynesia.

The Fisheries Division is developing oyster farming on Tahaa Island in the Society Islands for the Tahiti market using the local Crassostrea glomerata. Fifty-two local farmers are forming a co-operative organization to market their products.

The main work of the Fisheries Service is concerned with pearl production. Increasing the production of natural beds by stocking them with 200,000 spat of mother-of-pearl shell was tried in Takapoto Island (Tuamotu). The fast growth of these shells warranted extension of such experiments by the co-operative societies of five other Tuamotu islands.

166 Polynesian islanders were trained in producing half pearls and blisters by co-operative socieites in Hikueru and Takapoto (Tuamotu) and in Gambier Islands. Many thousands of first grade round pearls are also being produced by a private French company on Maniki Island and by a Japanese company on Takapoto Island.

Movie actor Marlon Brando, owner of Tetiaroa Atoll north of Tahiti, is apparently co-operating with the Hawaii Oceanic Institute in another project of integrated aquaculture.

Giant fresh-water shrimp farming, started in 1970, has suffered major set-backs but will be on a new footing after the return of a local marine biologist trained in Hawaii. The national French CNEXO is just starting a shrimp farming operation with a five-year programme of integrated experiments including South Pacific and exotic species of Penaeides. Penaeus merguiensis breeding stock was transferred from New Caledonia in December 1972 and in January 1973. Central American Penaeides and Japanese Kurima Ebi will be the subject of applied study in regard to artificial breeding and cheap feeding formulas to be undertaken in 1973.

(7) Gilbert and Ellice Islands.

A general survey of aquaculture possibilities is being undertaken by the Fisheries Division in collaboration with SPIFDA. A FAO aquaculture expert from Taiwan is working for a two-year term in the territory. The main project is a scheme proposed by experts from the University of Hawaii for mass production of brine shrimp (Artemia salina) eggs on Christmas Island; if the local government gives support to this enterprise it would be the first aquaculture business on a world-wide scale to be established in the Pacific Islands.

(8) Trust Territory of the Pacific Islands.

While there are doubtless many sites affording excellent potential for aquaculture throughout the islands of Micronesia, Palau has been chosen as the focus of a wide programme of applied research and experimentation. Palau mariculture demonstration centre started as a SPIFDA project and is now supported only by American Sea Grant and the local Administration. Small-scale operations started in 1971 with a first attempt at collecting native oyster spat and raising young Hawksbill turtles. The programme for 1972 was enlarged to include commercial-scale edible oyster production and initial experiments in rabbitfish farming. Major development should be possible in 1973 with the appointment of a full-time American oyster expert using imported species. A project of rabbitfish and milkfish farming in Pelelui Island (southern Palau) is to be undertaken, using a natural 3-4 hectare lagoon.

PROBLEMS OF FUTURE DEVELOPMENT

Selection of site

Until the present time the choice of a coastal or lagoon site to develop aquaculture in tropical or equatorial Pacific islands has been made with only scant knowledge of natural environment and possible productivity.

Physical, chemical and biological data on a lagoon water mass has been compiled only from observation of a limited number of areas over short periods. No series of simultaneous observations can be drawn on to build up a comprehensive classification of the best grounds for aquacultural development. Nor is a great deal known about movement of water through the lagoon passage and phenomena of water exchanges between lagoon and open sea.

In view of the widely dispersed islands and the vastness of the area, one must find new techniques affording means of simultaneously assessing different factors, such as temperature and spectral components, over the largest possible surface. Remote sensing and scanning by micrometer may be achieved from aeroplanes thus providing quick and extensive coverage of coastal and lagoon area. Selection of a site should be based on a compilation of comprehensive scientific data of archipeligos having islands scattered along a length of over 2,000 kilometres as the Marshalls, Gilberts and Tuamotus. Observations by satellite would afford the only real possibility of collating chrono-sequential figures.

Hydrobiological control

As in all warm countries the water masses of the tropical and equatorial Pacific islands suffer quick stratification as happens in enclosed ponds. Dry season trade winds are less harmful than the relatively calm and wet rainy seasons. It is, in any case, absolutely essential to either use a system of mixing water or constantly adjust the water level through gates to correspond with the rise and fall of the tide or ensure an artificial flow by pumping. Subsurface water aerators can be used for mixing, as in Japan, for ponds ranging in surface from one to two hectares. Increase in oxygen will induce a higher productivity giving a good return for the expenditure incurred in installing an appropriate system. One of the major problems to be solved is the control of the fertilized enclosed lagoon or pond water without eutrophization by constant action of the physio-chemical factors. It is not necessary to have a very expensive or sophisticated pumping system introducing the deep outer-reef water thus increasing the productivity of the enclosed surface water by a higher mineral-dissolved content. This is necessary only for development of a long-term project involving considerable capital in keeping with a major world scheme. Setting aside such technology for the future, it appears that the main areas able to supply aquacultural development offer a fairly high level of productivity culminating in peaks of eutrophization as in some Tuamotu atolls.

Natural zooplankton, including copepods, frequently occurs with a sufficiently high density to support a high level of predation. For phytoplankton one solution would be to develop assocated cultures of heavy feeders like Artemia salina able to quickly clear a dangerous over-density and provide food supply for the carnivorous feeders.

Development of breeding and feeding for large-scale production.

Producing an adequate supply of spat and larvae is a basic requirement of any large-scale operation. It would not be safe to rely exclusively on natural stock except where it is quite impossiblecto obtain self-breeding, as in particular species such as milkfish (Chanos chanos). For development of oyster and shrimp farming, breeding centres are necessary having supporting field laboratories and the means of selecting breeding stock and despatching spat and post larvae all over the area. Hybrid species selected should be capable of making maximum use of the natural environment.

But the main problem to face in large-scale projects for shrimps and also turtles, and even fish, is concerned with formulas of cheap feed. As all the islands suffer a total lack of second-class fish and shellfish to be used large-scale as natural feed, it would appear necessary to restrict farming to the herbivorous species or to import large amounts of dry pellets from USA or Japan. However, the associated development of Artemia salina farming should provide the necessary support for integrated shrimp farming and the present search for new bonito and tuna fisheries may furnish the opportunity to use side-products from freezing plants in some places in Micronesia, the Gilbert and Ellice Islands and Fiji. In the same way aquaculture opens a new means of using side-products of some local industries such as coprah mills and beer factories.

Logistics

The main problem in the tropical and equatorial Pacific is not to select convenient places for aquaculture - there are plenty and perhaps too many - but to have sound logistic support of transport and maintenance in such an area. Many islands are too isolated for the development of any new enterprise. It would seem absolutely essential to locate new aquaculture ventures near established and developed centres which can provide the necessary facilities: energy, machinery, feed, storage, laboratory control, etc. In the present economic position of the area, the only way to success is to promote projects in the simplest form in the vicinity of the main centres. Exceptions should only be made when a considerable investment is being or has already been made in a remote area for some other objective such as a military project or atom testing plant. The scheme for large brine shrimp egg production on Christmas Island is acceptable and promising because of the abundant facilities and equipment built up ten years ago for the Anglo-Australian-American atomic tests. The same may be said of some Tuamotu islands when the present French experiments are terminated.

But, apart from such specific instances, there is little chance of success in developing aquacultural centres without the support of air transport, electricity, engineering services, laboratory analyses, etc. This severely restricts the choice in selecting a good site.

Marketing

On the basis of present population distribution and economic development the area of the tropical and equatorial Pacific has a somewhat limited local market. It must always be remembered that the total population as of 1973 is only 1,300,000.

(1) Family level consumption.

When heavy over-fishing endangers the reef and lagoon complex a good solution of island-level problems would be to build up small-scale traditional fish farming for mullet and milkfish. But as the population pressure is quickly decreasing in the outer islands through islanders migrating to the main islands with urban centres, such development is fairly limited in the future. The one big exception is turtle farming which, when successful in selection of feeding formulas, can provide a very popular and successful family occupation.

(2) Marketing at local and regional level.

Islanders now do not need food so much as money; aquaculture is accepted and regarded by local people only as an efficient cash-crop bringing a return of money. Some island markets are importing more and more sea products under pressure of the process of urbanization and the progress of tourism.

Having from 60,000 to 90,000 consumers enjoying a high level of living and having many tourists and expatriates, Guam Island, Tahiti Island and Greater Noumea City are each able to count on a yearly market of about one million dollars in sea food, mainly shrimps, fresh oysters and high quality fresh fish - and they can easily expand this market to more specialized products like half-pearl and blisters and small stuffed Hawksbill turtles to the extent of at least another half million dollars each. With the booming tourist industry and increase in local standard of living, Greater-Suva (Fiji) is rising to reach the same potential levels.

Prospects for regional markets as a whole are encouraging and, based on the general progress of the many urban centres serving as capitals for the different territories, have a potential yearly growth rate of more than fifteen percent.

(3) Supply of live baitfish.

Inasmuch as many recent successful surveys have located bonito and small yellowfin tuna schools throughout the year in

many island groups, there is clearly a strong need of baitfish to supply local fishing fleets. Samoa, Fiji, Gilbert and Ellice and the Marshalls are alreaey concerned by the need of such a supply. Producing baitfish is a fairly recent aquacultural objective but it is already a promising one as prices can reach one dollar a kilo for an appropriate selection of small fishes easy to keep alive. The success of this new field of aquaculture depends mainly on ability to select appropriate species to fulfil the requirements of tuna fishermen. As the estimated increase of livebait bonito fishing for the area is a minimum of 60,000 tons, there are marketing possibilities open for many hundreds of tons of cultivated livebait.

(4) World market.

Potential for aquacultural development is so high that it should easily be possible to supply regional requirements by using no more than one ten-thousandth of the available natural resources. For the furtherance of island development the real problem is to challenge the world market. But, as transport in the area is particularly hazardous and expensive, it is necessary to select for the purpose specialized products of sufficiently high value to absorb in their selling price the cost incurred in shipment. As the economics of feeding remains unsolved, the first species to be selected must be those requiring for their productivity only a natural environment.

Seen in this perspective the first choice must lie in pearl and jewellery products and brine shrimp eggs. Both provide a product of value, easy to store and to transport, and for which there is a wide-open world market for production of high waulity. Exploitation of both requires only improvement to their natural environment and the minimum of essential imported facilities. Both must compete with strong competition (Japan for pearls, America and Canada for brine shrimp eggs) but, as the world market needs a so much greater supply of top quality products, the Pacific islands can offer their large, unspoined, warm waters, having easily exploitable facilities, as a substitute for the polluted coastal areas of Japan and California. Such scope can attract large companies to enter Pacific islands aquaculture as a business investment. In the category of produce able to absorb the expense of export transport are live prawns for the fresh market or frozen pink shrimp tails, of which the first production would be easily taken up by regional requirements.

CONCLUSION

Through a combination of scientific research, private investment, economic development planning by the territories and international co-operation (UNDP, FAO and SPC) applied aquacultural projects have already been launched in the waters of the tropical and equatorial Pacific islands. Limiting factors such as lack of adequate knowledge of a large part of the area, difficulties of supply of stock for farming and of cheap feed, lack of logistics and hazardous marketing cannot impede the present movement towards better valorization of the most extensive mass of easy-to-control, unspoiled, warm water in the world.

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