


**BASIC DESIGN STUDY REPORT
ON
MARINE SHRIMP CULTURE
EXPERIMENTAL STATION PROJECT
IN
MAURITIUS**

MARCH, 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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86-35

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PREFACE

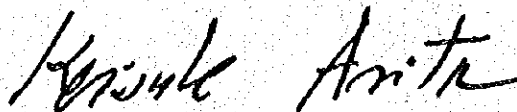
In response to the request of the Government of Mauritius the Government of Japan has decided to conduct a basic design study on the Construction Project of Marine Shrimp Culture Experimental Station and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Mauritius a study team headed by Mr. Soichiro Shirahata, National Research Institute of Aquaculture, Fisheries Agency from November 20 to December 14, 1985.

The team had discussions on the Project with the officials concerned of the Government of Mauritius and conducted a field survey in Albion area. After the team returned to Japan further studies were made, a draft report was prepared and a mission to explain and discuss it was dispatched to Mauritius. As a result, the present report has been prepared.

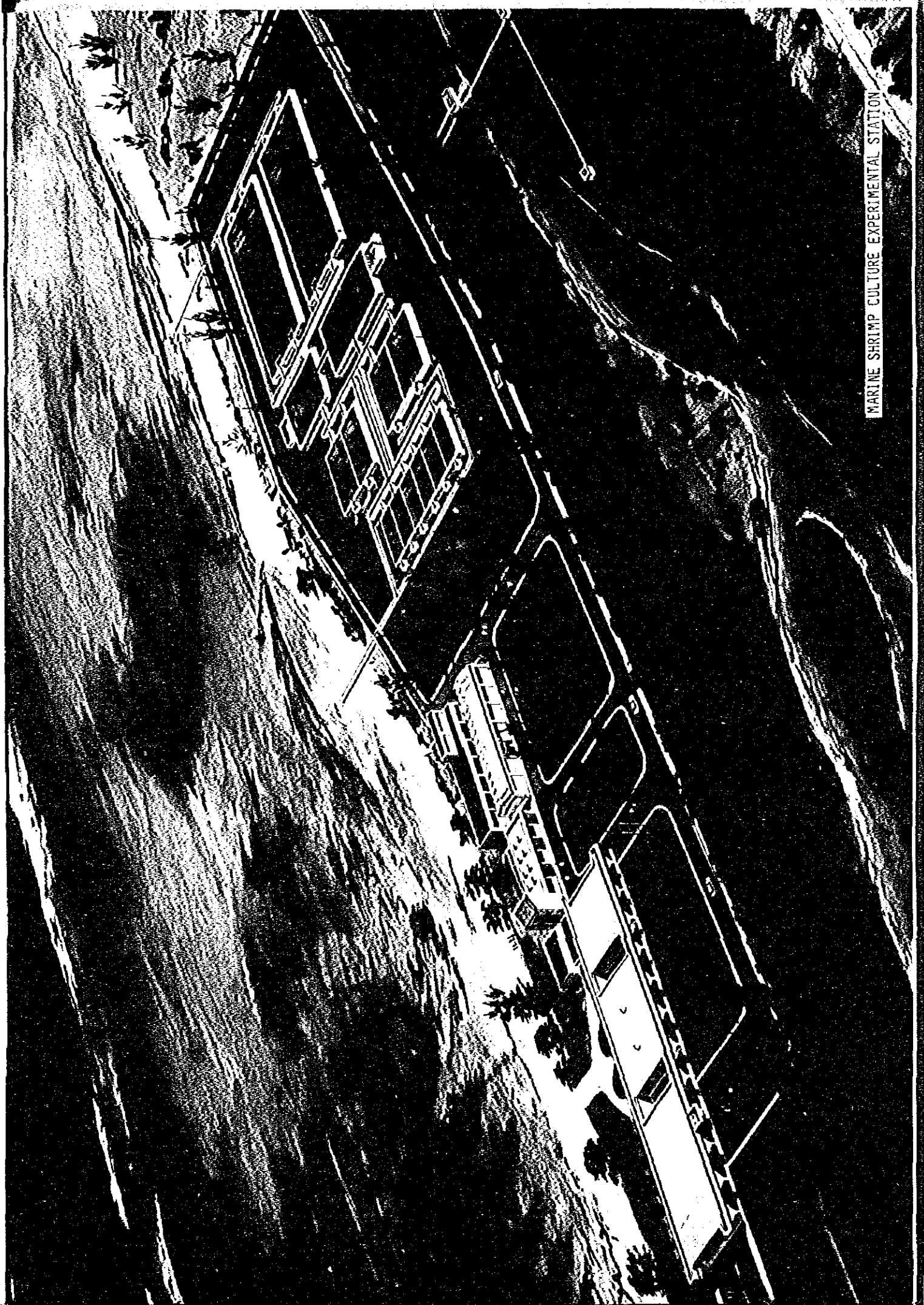
I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Mauritius for their close cooperation extended to the team.

March, 1986

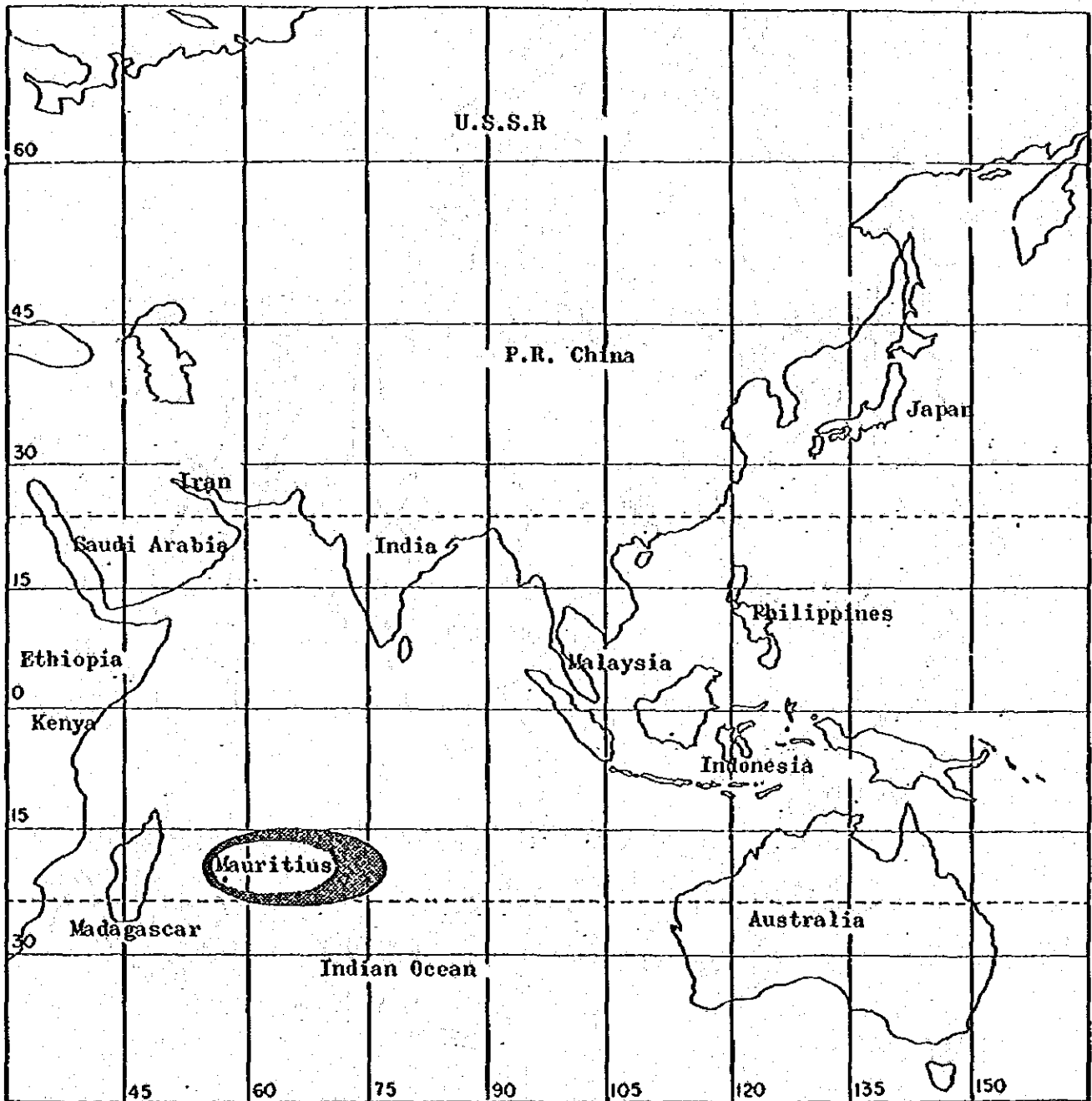


Keisuke Arita
President
Japan International
Cooperation Agency

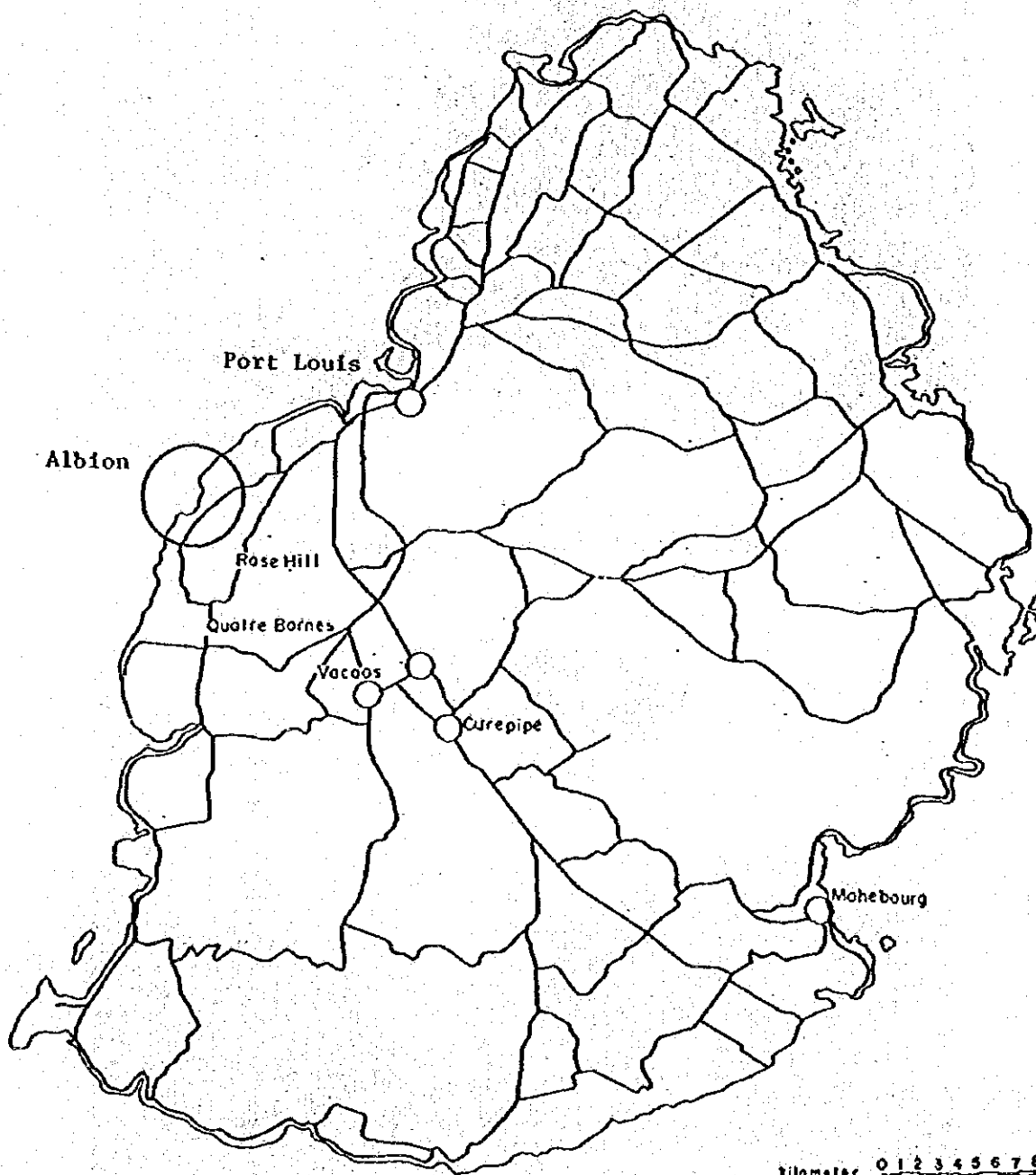


MARINE SHRIMP CULTURE EXPERIMENTAL STATION

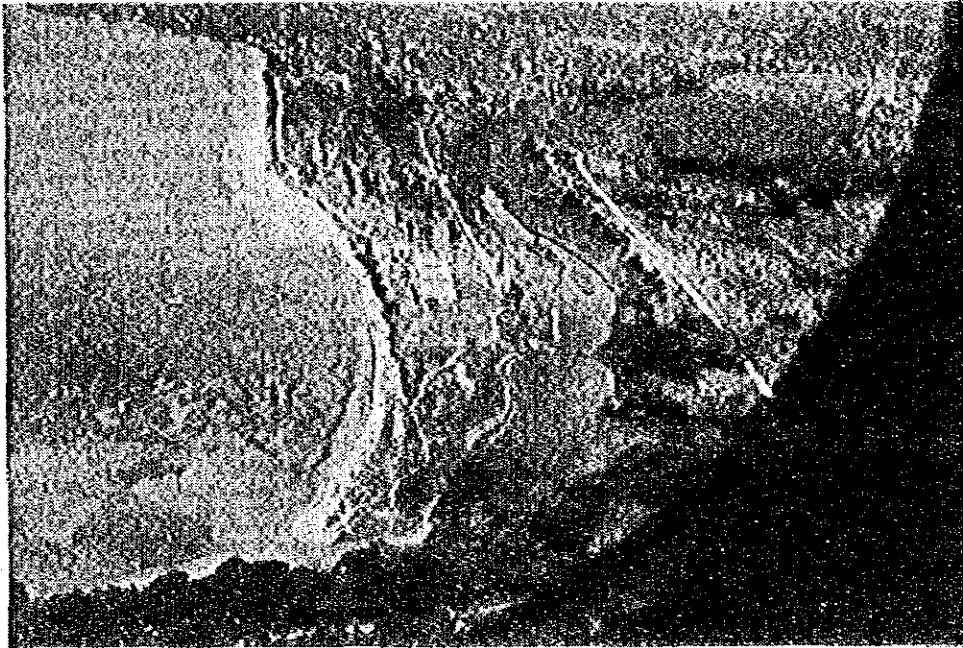
Map of Mauritius



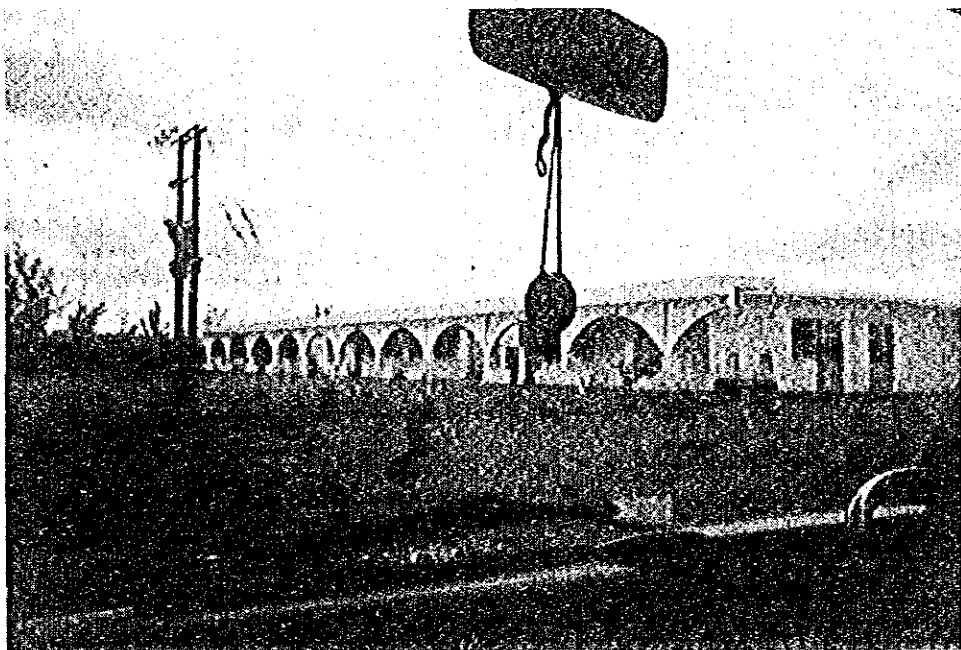
Location Map of Albion



Kilometer 0 1 2 3 4 5 6 7 8



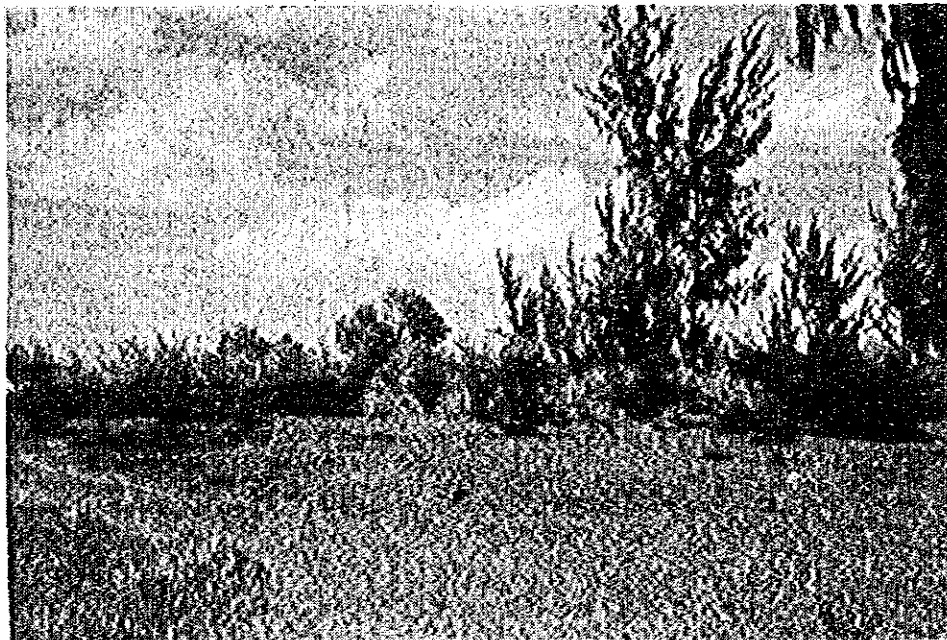
Candidate Site of the Project



Albion Fisheries Research Centre



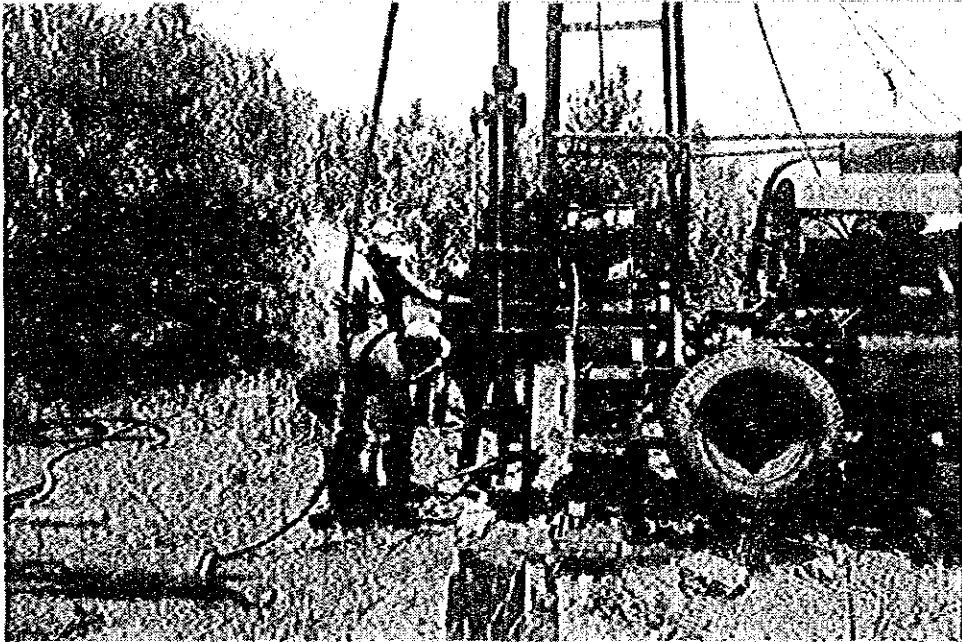
Candidate Site of Albion



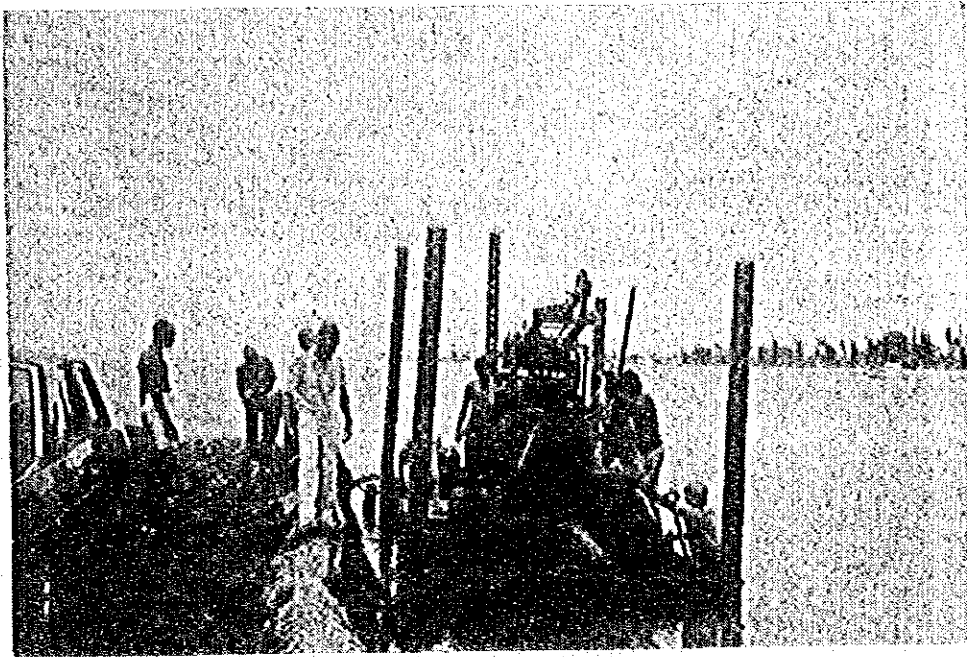
South End Part of Candidate Site



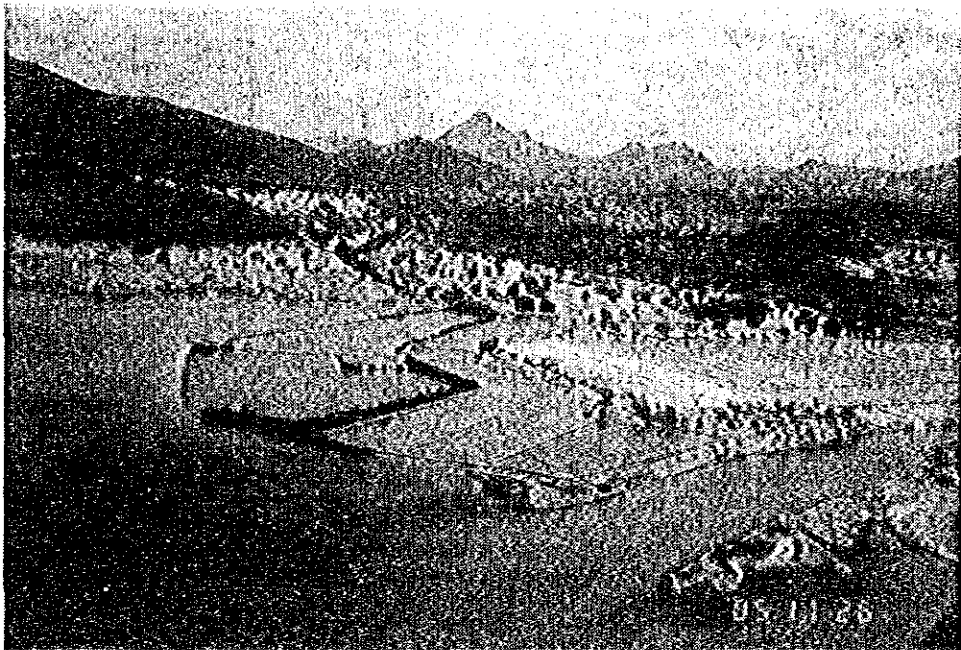
Albion Barachois



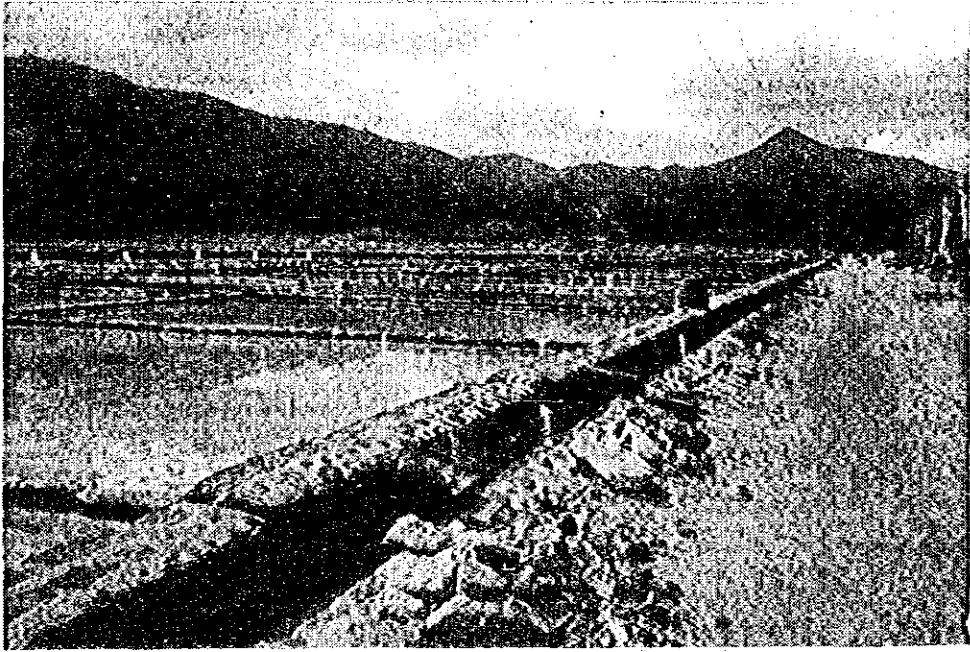
Boring Preparation at Land Site



Boring Preparation at Sea



View of Barachois and Salt Pans



Salt Pans in Petite Riviere Noire

SUMMARY

The country of Mauritius is situated in the area in the Indian Ocean centered at 20° South latitude and 57° East longitude and a volcanic islands country, being total area 2,040 km², comprising the Mauritius Island which is about 800 km away from the east coast of Madagascar, the Rodrigues Island and other islands.

Her total population is approximately one million and its majority is concentrated in the Mauritius Island. Because of her unique economic structure of mono-culture type depending on sugar-cane industry since before independence, the economy of Mauritius is easily affected by natural disasters as well as international market conditions. Under such circumstances, the Government of Mauritius has been aiming at diversification of industries since 1970. The present administrative power organized in 1983 set up a new National Development Plan (1984-86), and is contemplating development of agriculture (including fisheries), manufacture, tourism and so on, under the fundamental policy of developing income-generating and employment-generating sectors.

As to the agriculture and fisheries industries, since the rate of self-sufficiency of foodstuff is extremely low and the import of foodstuff amounts about 22 percent (1983) of total importing value, an increase of food production and diversification of industries are to be promoted. Particularly regarding fisheries, a positive target is set up that the total catch in 1990 be doubled the one of the present and the production by aquaculture in particular be eight times the one of the present.

The fisheries in Mauritius comprise artisanal fishery (lagoon fishery), bank fishery, pelagic fishery and aquaculture.

The annual catch by artisanal fishery (lagoon fishery) fluctuates considerably in the range of 1,000 - 2,500 tons and due to its limited fishing grounds in lagoons a maximum 2,500 tons catch is considered its upper limit.

The catch by bank fishery also has a large yearly fluctuation in the range of 1,500 - 3,800 tons. According to the FAO research, a 10,000 tons M.S.Y. is estimated to be there and though a modernization of old-aged fishing vessels and so are required, an increase of fish catch is expected to take place in future, thus the Mauritian government is endeavoring to promote bank fishery by securing of well-equipped fishing ports, etc.

Pelagic fishery is mainly skipjack and tuna fishery operated by joint-ventures and foreign fishing vessels and amounting yearly catch 3,000 - 4,000 tons, contributing considerably to foreign currency earning by export.

Aquaculture is classified into freshwater culture and marine culture. In the field of freshwater mariculture, Freshwater Giant Prawn has been successfully introduced since 1972. The Government is making an effort to spread the culture through artificial seed production and distribution of the seeds free of charge, but only some of the sugar producers are performing the business. The output of the prawn is about 25 tons annually. Meanwhile, carps (6 species including Chinese species and Indian species) are pushed to be cultured in ponds and reservoirs, but the output is only 5 tons.

In the field of marine culture, rabbit fish, mullet and oysters are cultured in Barachois, sections parted by heaping stones on the coastal area of lagoons, and the output is only 11 tons.

Meanwhile, since a Japanese expert dispatched from 1983 for technical cooperation (the Albion Fisheries Research Centre, which was constructed in 1982 by a grant aid from the Japanese government), has succeeded in experimental artificial hatching and seed production of Penaeidea shrimp in 1985, the expectation for marine shrimp culture industrialization is heightend rapidly. However, the present small-scale experimental facilities of the Albion Fisheries Research Centre is not enough for necessary technical development for marine shrimp culture industrialization, and the experimental facilities on pilot scale is considered necessary.

Therefore, the Government of Mauritius has requested a grant aid from the Japanese Government for construction of the marine shrimp culture experimental facilities on a pilot scale which is to be constructed adjacent to the present Albion Fisheries Research Centre.

In response to the request, the Japanese Government has decided to carry out, through JICA, a basic design study to review the appropriateness of the request and prepare the most appropriate plan of the facilities.

The Japan International Cooperation Agency conducted a field study in Mauritius in November 1985 and upon its analytical studies sent a study team for explaining the draft final report to the Mauritian side in March 1986.

Followings are the main results of the studies. As regards the viability of shrimp culture commercialization it is considered as follows:

- (1) The current shrimp consumption of Mauritius is 295 tons, out of which, 230 tons (equivalent to 78%) are imported, and an increase of consumption up to about 510 tons is foreseen in 1990. Shrimp price in Mauritius varies depending on quality and is about 20 to 30 percent higher than the international market price in Europe and Japan, etc. This is mainly because that shrimps are being imported to Mauritius from Madagascar, etc. by air cargo. However, provided that shrimp culture be realized in Mauritius, the production cost of cultured shrimp is estimated at about US\$6 - 7/kg (head-on 40 g shrimp). Meanwhile, the worldwide shrimp purchase price in 1990 by frozen shrimp packers is foreseen at US\$10 per kg. Therefore, the shrimp culture in Mauritius will be able to cope fully with the domestic and international market conditions, and expect enough profitability; thus its industrialization will be foreseen to be realized.
- (2) As to the suitable site for shrimp culture in Mauritius, 50 ha of mangrove area, 100 ha of other marsh area, 200 ha of convertible area from sugar-cane field or meadows and 150 ha of usable Bara-chois - totally 500 ha area is considered available where is enough

to culture shrimp for both domestic consumption and export purposes. From the standpoint of natural environment of Mauritius, however, that securing of freshwater or brackish water is limited should be noted. Therefore the object shrimp species should be selected as not only brackish shrimp but also marine shrimp.

- (3) From the technical standpoint of shrimp culture, seed production and growing-out experiments of brackish shrimp (Black Tiger Shrimp) have been carried out at the Albion Fisheries Research Centre and currently several technicians are engaging in development of shrimp culture techniques. Thus the basis of culturing techniques has been already established.
- (4) As to the dissemination of shrimp culture techniques, the above technicians can be the leaders and train extension officers and guide directly the culturing farmers. The culturing farmers are also the members of a fisheries cooperative society organized by coastal fishermen or converters from the sugar-cane industry, therefore, there will be a high coordination between diversification of agriculture and developmental measures for rural societies.

Judging from the above points, the development possibility for shrimp culture industrialization in Mauritius is considered high, however, for the realization of above, the facilities of experimental station for technical development of shrimp culture are required.

Taking into consideration the natural conditions, existing related facilities and architectural situations in Mauritius, the function, content and scale of the facilities most suitable for this project have been decided as follows:

Followings are the function of the marine shrimp culture experimental station: -

- (1) Establishment of the techniques for seed production and growing out for *Penaeidea* shrimp culture industrialization.
- (2) Development of research of the basic techniques related.

(3) Training for shrimp culture technicians and dissemination and extension of the techniques.

The facilities necessary for the above undertaking are summarized as follows:

Name of facility	Content of facility	Scale (m ²)
1. Technical Office Building	Divisional Scientific Officer Room	26.3 m ²
	Scientific Officer Room	29.3
	Technical Officer Room	60.8
	Laboratory (Wet)	73.6
	Plankton Culture Room	10.4
	Electricity Room	19.4
	Cold Storage	20.4
	Work Shop	33.6
	Others (Duty Rm, Observation Rm, WC, Stair Rm, etc.)	139.7
Total		413.5
2. Hatchery Facility	Hatchery Complex	442.2
	Hatching tank, Post Larval Tank	(56.25)
	Maturation Tank	(37.50)
	Plankton Culture Tank	(37.50)
Total		442.2
3. Growing-out Facility Production Section Others	Outdoor growing-out pond, nursery pond, breeder pond, and experimental pond	9,600
	Experimental Barachois	7,000
Total		16,600
4. Attached Facility	Water intake system	
Total		one set

These facilities will commence their operation from 1988 and the operation is to be divided into following three phases to accomplish the target of technical development for shrimp culture industrialization:

Phase I	1988 - 1990
Phase II	1991 - 1992
Phase III	in and after 1993

The content of operation of these facilities comprises experimental scheme, seed production scheme, growing-out scheme and training scheme as main stays, and development of basic techniques, development of pilot techniques, and training of extension officers are to be carried out.

The experimental scheme is to develop techniques for basic seed production and growing-out which will be the base of pilot techniques, and in Phase I, putting Black Tiger Shrimp as the priority species, its technical establishment is to be tried and concurrently the same for marine shrimps is to be tried. In Phase II and III, the technical development emphasized for marine shrimps is to be carried out.

The seed production scheme is to develop techniques for maturing adult shrimp, and carry out seed production which is required for growing-out experiment and the growing-out scheme. From the Phase II, the partial seed distribution to the general applicants is to be tried and in Phase III, the number of seed distribution is to be increased at about 1.9 million and dissemination of shrimp culture business is to be contemplated.

The growing-out scheme is to conduct pilot operations for growing-out at the growing-out ponds and Barachois, and contemplate technical development concerned. The production target in Phase I is rather low, but in Phase III it will be raised up to the degree securing the productivity on commercial basis.

The training scheme is to commence practical training from 1990, and conduct training for extension officers of technical guidance for seed production and growing-out. Training term will be four months, and yearly six technicians - two each at one term - will be trained.

Planned site of this project is located about 10 km from Port Louis, capital of Mauritius. Adjacent to the existing Albion Fisheries Research Centre, it is provided with good access to the capital and well-established infrastructure such as water works and electricity. The area of the site is flat of about 6 ha and where the Belle Eau River flows.

The government organization in charge of this project is Fisheries Division, Ministry of Agriculture, Fisheries and Natural Resources, and the facilities of the project, after completion of construction, will be managed and operated as the attached facilities of Albion Fisheries Research Centre, which is under direct control of the Fisheries Division. The necessary staff are 20 persons and the yearly operational expenses are expected to be about 1.76 million RS (about 24.6 million yen).

The term needed for the construction of the facilities is expected to be totally about 22 months after conclusion of the Exchange of Notes by the two governments; about 4 months in detailed design, 2 months in bidding and construction contract and 16 months in construction including procurement and transportation of equipment.

As stated earlier, since the potentiality of shrimp culture industrialization is high, if technical development takes place and the way of industrialization is justified, shrimp culture business on a commercial scale will develop at a very rapid rate. By utilizing these facilities as a core, technical development and dissemination will be realized and smooth production and supply of seeds will be secured in the future; then they will contribute greatly to the development of fishery industry as well as of socio-economic development of Mauritius. Accordingly this project is concluded to be fully appropriate to receive a grant aid from the Japanese Government.

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CHAPTER I

INTRODUCTION

CHAPTER I INTRODUCTION

Mauritian economy is being maintained mainly by agriculture, whose main produce is the sugar-cane. The nation's economy is liable to be affected by unstable price of the plant in the international market. The Mauritian Government searches for various measures to keep economic, social stability by setting up National Development Plan (1984-86), consisting of diversifying primary industry, developing tourism and manufacture, etc.

Fisheries are no less important for Mauritius than agriculture, though their output is far less than that of agriculture. Fish has been a protein source for the people. Tunas produced by the pelagic fishery have been precious goods for export to earn foreign currency. But lately, people's fish consumption per capita per year decreased to the level of 12 kg from 18 kg during the past several years as the artisanal fishery and bank fishery have been declining. To stop this trend, the Government has set up Fisheries Development Programme which aims for doubling the present fish catch by 1990 to recover people's fish consumption to the level of 18 kg. But limited fisheries resources off the coast and present socio-economic conditions of the country are presenting some obstacles in carrying out the project.

In the meantime, Japanese aquaculture expert sent to this country succeeded in seed production and test growing of *Penaeidea* shrimp. The Government hoped for industrialization of the shrimp culture. Officials programmed a research and development project to establish industrial techniques and propagation methods of the culture. At the Albion Fisheries Research Centre built with the fund under Japan's Grant Aid programme, experimental shrimp culture on a small scale is available but it does not have enough capacity to perform pilot scale development project. In this connection, the Mauritian Government requested the Japanese Government to extend grant aid to build new facilities suitable to implement the shrimp programme. In response to the request, the Japanese Government decided to carry out a basic design study for this project, and Japan International Cooperation Agency (JICA) sent a basic study team headed by Soichiro Shirahata, the National Research Institute of Aquaculture, Japanese Fish-

ries Agency, to Mauritius for 25 days from November 20, 1985 to December 14, 1985, and assessed technical and economical viability of the project and determined optimum scale of this project and forge a basic design thereof. The second team to explain the draft design was sent to Mauritius from 1 to 15 March.

List of the members of participating in the study and schedule in Mauritius are attached in Appendices.

CHAPTER II

BACKGROUND OF PROJECT

CHAPTER II BACKGROUND OF PROJECT

2-1 Outline of Mauritius

Mauritius is one of the most densely populated countries in the world, with a population of 500 persons per km². Unemployment due to rapid population increase outstripping its economic development has been a serious problem. Though the income standard is comparatively high among the African countries, its economy has some weakness in that the business of the country is directly affected by fluctuation of the production and the international price of sugar, its main industry being the production of sugar. To cope with this situation, the Government has formed such measures as diversifying agriculture, developing manufacture, expanding tourism and promoting fisheries and it has been carrying out these programmes through the 3 year National Development Plan, 1984-1986, following the one set in 1980. The chief objectives of this plan are production increase and employment expansion-development of construction, transportation, services, and fisheries industries, promotion of cooperative activity, foreign trade and consumer protection, and so forth. Energy and regional development plans are also included.

2-2 Fisheries Situation

2-2-1 Fisheries

Fisheries of Mauritius are classified into artisanal fishery (lagoon fishery), bank fishery, pelagic fishery and aquaculture. The artisanal fishery is conducted in the lagoons and their adjacent waters in Mauritius Island and Rodrigues Island. It is operated in the shallow waters with such fishing gears as cages, lines, hooks and spears on board 6-7 m wooden or FRP boats, called pirogue. Less than half of the boats have been motorized yet. The main species caught are octopus, goat fish, surgeon fish, rabbit fish and so forth. The number of fishermen is 2,500 in Mauritius Island and 625 in Rodrigues Island, their annual catch totaling about 1,900 tons. So, average annual catch per fisherman is 0.6 t. The landing facilities in many places are of small scale and poorly equipped. Because the fish resources there have almost been taken out, no room is expected for production increase without going far away from the lagoons.

The bank fishery is conducted on an industrial scale in fishing grounds over the banks (seamount which is formed by rising seabed) of the Ridge and the Continental Shelf around the adjacent sea area. There are many banks in the waters between Mauritius Island and the Seychelles Islands and around Chagos Archipelago, forming good fishing grounds. A fleet of the bank fishing usually consists of 8-17 small boats with outboard engine each accommodating 3-4 fishermen and a mother ship (mostly former tuna fishing boat) equipped with refrigerating machines. The species, which are caught by angling, include emperor mainly, grouper, sea bass, rabbit fish and so forth. They are all frozen on the mother ship. The catch amounts to 2,500 tons annually.

The pelagic fishery is conducted on skipjack and tuna. Mauritius Tuna Fishing and Canning Company, a joint venture company with Japanese enterprises with annual catch of 3,000 - 4,000 tons. There is also another off-shore fishing consisting of Taiwanese

tuna long-line boats based on Port Louis as the catch transshipment base. Annual transshipment is 5,000 - 8,000 tons but the volume is decreasing year by year.

The aquaculture is classified into freshwater culture and mariculture. In the field of freshwater culture, Freshwater Giant Prawn has been successfully introduced since 1972. The Government is making an effort to spread the culture through artificial seed production and distribution of the seeds free of charge, but only some of the sugar producers are performing the business. The output of the prawn is about 25 tons annually. Meanwhile, carps (Chinese species and Indian species) are cultured in reservoirs. The output is only 5 tons. In the field of mariculture, rabbit fish, mullet and oyster are cultured in Barachois, sections parted by heaping stones on the coastal area of the lagoon. The productivity of Barachois culture is very poor due to small tide range there and no feeding. There are 22 Barachois, with total area of more than 300 ha, the largest being 50 ha. The catches of these fishings are shown in Table 1.

Table 1 Catch by Fishing Type, 1976 - 1984 (ton)

	Artisanal Fishery	Bank Fishery	Pelagic Fishery		Aquaculture
			Purse seine	Long line	
1976	2,500				
1977	2,121	3,835			
1978	1,964	3,390		14,000	
1979	1,945	2,228		11,000	
1980	1,235	1,686	1,061	6,000	
1981	1,212	1,768	1,755	3,000	
1982	1,054	3,793	2,337	7,000	
1983	1,370	2,741	2,907	8,000	
1984	1,375	2,838	4,125	5,000	41

(Source: Fisheries White Paper, Ministry of Agriculture, Fisheries of Natural Resources, Mauritius. September, 1985)

As shown in Table 1, the catch of the artisanal fishery was decreasing rapidly since 1976. The catch in 1982 was the lowest 1,054 tons. Since 1983, the trend has changed upward, even so the catch in 1984 was only half of that in 1976.

In the bank fishery the catch decreased continuously from 1977 to 1981. The catch recovered completely in 1982 but after 1983 a little downward trend began to be seen again. According to an FAO survey, the potential yield of bottom fish in the Indian Ocean is 15,000 tons. And that in Mauritius is estimated at 10,000 ton. Judging from the figures, the country's present catch does not seem to exceed 30% of the potential yield. There will be enough room for future production increase.

In the pelagic fishery, catch increase of purse seiners and catch decrease of long liners are noticeable. The catch fluctuation is mainly due to that of fishing efforts related to market conditions. But in the future, resources conditions would become a problem which can not be disregarded.

Aquaculture has not grown to an industry yet, but in the light of the present situations of the artisanal and bank fisheries and people's increasing fish demand, a rosy expectation can be placed on its development.

2-2-2 Marketing and Fish Consumption

Part of the catch of the artisanal fishery, besides that for fishermen's self-consumption, is collected and sold by fishing cooperatives. The rest is collected by brokers and sold at markets. The latter amounts to more than 80% of the catch.

The catch of the bank fishery is landed at the new port in Trou Fanfaron region of Port Louis built through Japan's Grant Aid Programme in 1985. The catch is purchased by private cold-storage companies, which market them, while stocking in their cold-storages, through brokers and retailers to consumers.

There are public fish markets in Port Louis, Curepipe and Quartre Bornes. In Port Louis scores of retailers do business in the mar-

ket building, in Curepipe ten-odd retailers in the market building and in Quartre Bornes several retailers, in the outdoor market place.

Freshwater Giant Prawns and carps are marketed directly from producers to hotels and restaurants. Consumption of fish and fish products in this country has a tendency of decrease, with a peak production in 1979 as in Table 2.

Table 2 Consumption of Fish Products, 1977 - 1983

	Consumption per Capita per Year	Supply (ton)	Import (ton)	Domestic (ton)
1977	18.1	16,010	10,432	5,578
1978	17.2	15,387	10,188	5,199
1979	19.3	17,601	13,350	4,251
1980	17.9	16,556	13,402	3,154
1981	18.6	17,481	13,800	3,681
1982	16.4	15,555	10,480	5,075
1983	12.3	11,707	6,758	4,949

The import includes canned, frozen, dried fish and shrimp. The volume of these four items is more than half of the total import. The government tries to keep people's fish consumption per capita per year at 18 kg or more, especially through domestic fish production increase, considering saving foreign currency of the country. The production increase programme includes in the National Development Plan, 1984 - 1986 as one of the most important policies.

The recent annual consumption of shrimp in Mauritius is totally about 300 tons, comprising import of frozen shrimp at 80 tons, import of dried shrimp at 150 tons, domestic rock lobster at 40 tons and cultured Freshwater Giant Prawn at 25 tons. Estimated consumption of shrimp in hotel and restaurant by tourists and the amount consumed in Chinese and Indian restaurants by Mauritian people are as follows:

- Consumption at seafood restaurant by tourists
130,000 men/year x 11 days x 1/3 (one per 3 days) x 7 pieces x 40 g
= 133 tons (head-on)
- Consumption by Mauritian people (mostly dried shrimp of small size)
1,000,000 men/ x 10% (one person per 10 persons) x 12 times/year
x 0.12 kg (one day consumption) = 168 tons

Thus consumption by tourists is estimated to amount about 45 per cent of total consumption and to be occupied mostly by frozen shrimp. Since the Mauritian Government is pushing development of tourism as a matter of emphasis, the number of tourist is so rapidly increasing that it is expected to double by 1990.

Considering further that the amount of shrimp consumed by Mauritian people may be enlarged by about 50 per cent, the estimated demand of shrimp in Mauritius will be over 500 tons in 1990. This will bring a serious problem for Mauritius, whose policy is set as allotting foreign currency on priority basis to importing productive materials, and regulating import of non-productive materials such as food, etc. For this reason, the Mauritian Government is now very much interested in the development of shrimp culture industry.

Table 3 Prospect of Shrimp Demand in 1990

			(Unit : ton)
	1985	1986	Remarks
1) Import	230	400	* Increase of imported frozen shrimp is expected.
Frozen shrimp	80	200 *	
Dried shrimp	150	200	
2) Domestic Production	65	110	**The Gov't is much interested in development of shrimp culture, which will replace import of frozen shrimp
Freshwater Giant Prawn, cultured	25	70	
Rock lobster marine & freshwater shrimp, cultured	40	40	
	0	- **	
Total	295	510	

2-2-3 Aquaculture and Related Research Organization

Aquaculture has not developed yet to form an industry. The output of freshwater culture (Freshwater Giant Prawn, Carps) and mariculture in Barachois (Fishes, Oyster) altogether is about 40 tons, only 0.5% the total fish catch. Main operators of freshwater culture are sugar manufacturers and those of the Barachois culture are hotel businessmen, fishermen cooperatives and others. In Barachois culture, seeds caught around lagoons and those flown naturally into Barachois are not fed or fertilized. The productivity of the culture is very low and its output, with total area of 302 ha, is only 41 tons - 136 kg per ha or 13.6 g per m².

Most of Barachois are owned by the Government and leased to private persons or enterprises, but some Barachois are owned by Fishermen's cooperatives or private persons. Expansion of Barachois culture is expected because there exist vast lagoons and abundant stone supply. The productivity increase of the culture is expected by fertilizing, though introduction of feeding may not be applicable due to its sizable financial charge.

Study and Research of aquaculture is performed at the Albion Fisheries Research Centre and at the La Ferme Freshwater Aquaculture Station. Neighboring Pte Aux Sables Fishing Station was merged into the Albion Fisheries Research Centre at the foundation of the Centre in 1982. The functions of the Trou d'Eau Douce Freshwater Giant Prawn Hatchery in the East Coast were absorbed by the La Ferme Freshwater Aquaculture Station at its foundation in 1984. The business of the Mahebourg Fishing Farm also has been suspended.

At the Albion Fisheries Research Centre, study of ocean environment such as plankton and ciguatera research, marine lives, fish resources and aquaculture are being conducted. At the centre, seed production of Freshwater Giant Prawn is also being operated. The capacity of the Centre, however, is not necessarily satisfactory. The La Ferme Freshwater Aquaculture Station is in charge of seed production and test breeding of carp and silver carp and also of Freshwater Giant Prawn.

The Albion Fisheries Research Centre has hatching and seed production facilities and growing-out facilities as aquaculture facilities. The hatching and seed production facilities consist of 8 outdoor plankton culture tanks (10 m³ each); 6 hatching tanks (2 m³ each) and 4 hatching tanks (1 m³ each) in a 140 m² hatching test building; 2 outdoor hatching tanks (4 m³ each); and 4 Artemia hatching tanks. The growing and seed production facilities consist of a 40 m³ tank (diameter: 7 m, depth: 1.2 m) and 3 tanks (2 m³ each) and so forth. The seed production and growing-out test of the Freshwater Giant Prawn are being operated. The fixed-type seawater intake system has not worked well due to theft or destruction by stormy waves. The moving-type engine pumps are used now for intake of seawater from coastal area. The aquaculture facilities of the La Ferme Freshwater Aquaculture Station consists of 29 nursery ponds and growing-out ponds with total area of about 4.2 ha in all.

2-2-4 Fisheries Administration Organizations

The fisheries administration of Mauritius is managed by the Fisheries Division of the Ministry of Agriculture, Fisheries & Natural Resources. The Fisheries Division is divided into two sections - the Research Section and the Administration Section. The former supervises the Albion Fisheries Research Centre and the latter is in charge of general affairs, finance, material management and surveillance (Figure 1).

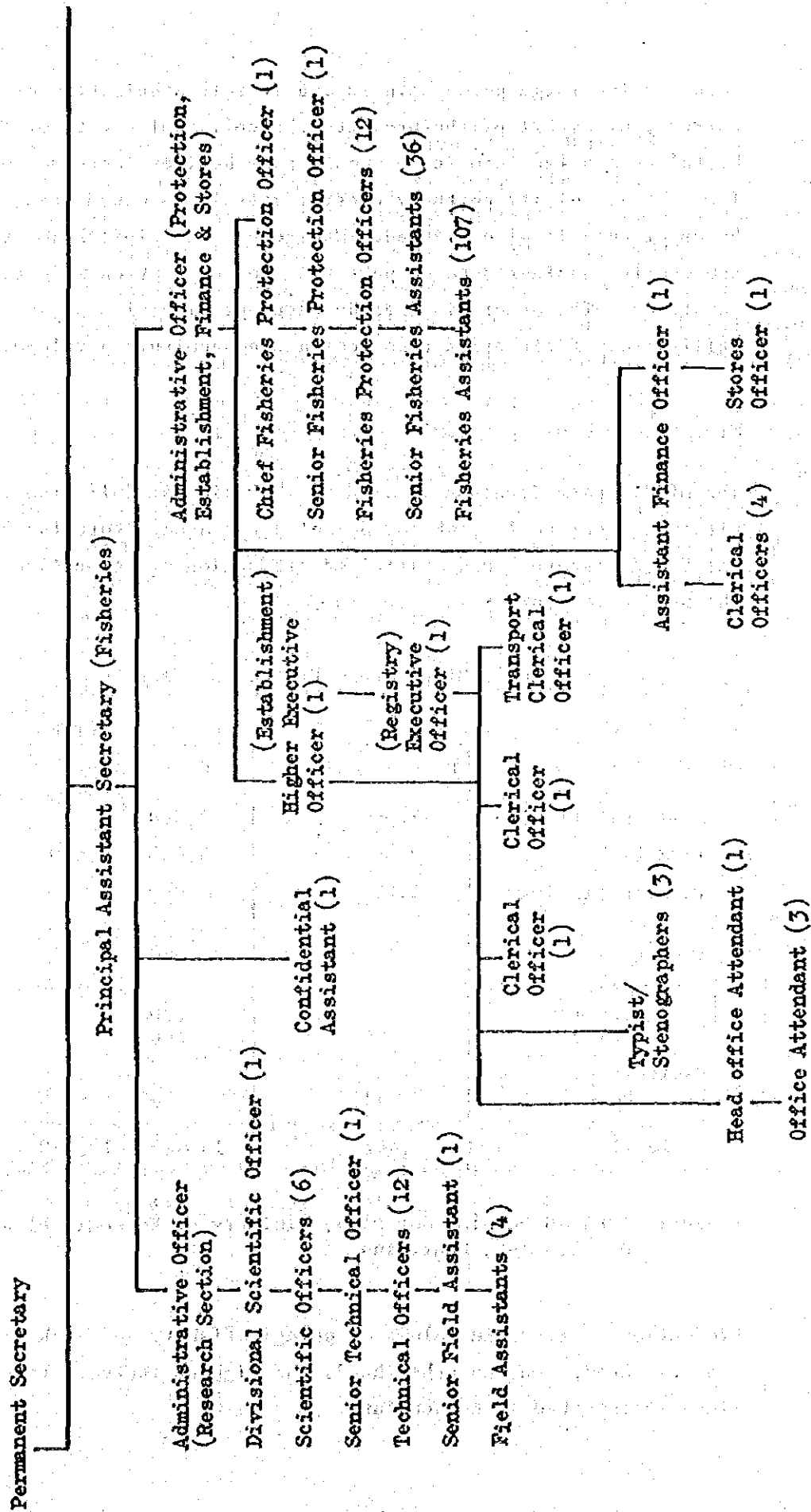
2-2-5 Fisheries Development Plan

The Government has framed strategies and targets of the fisheries development in the long, middle and short terms. The outlines are as follows:

(1) Long-term Development Plan

The long-term development plan is classified into two fields-pelagic and other fishings. The former aims at the maximum utilization of skipjack and tuna resources within its 200-mile economic zone by

Figure 1 ORGANIZATION CHART OF MINISTRY OF AGRICULTURE, FISHERIES & NATURAL RESOURCES
(FISHERIES DIVISION)



constructing large purse seiners and at full acquisition of foreign currency by export of the products thereof. Collection of foreign boats' access fee into its economic zone besides increased profit from the use of its ports by carrier-vessels as catch transshipment bases of tuna is also planned. Management of skipjack and tuna resources is considered to be performed in cooperation with related countries. The other fishings development plan aims at an effective utilization of fisheries resources and aquaculture development.

(2) Middle-term Development Plan

The middle-term development plan to 1990 aims at full promotion of fishings (artisanal, bank and pelagic) and aquaculture (both freshwater and seawater) and multiplied production of respective sectors. The production target is shown in Table 4.

Table 4 Middle-term Production Target

	Present catch	Catch target
Artisanal Fishing	1,900	2,500
Bank Fishing	2,500	5,000 - 7,000
Pelagic Fishing	3,000	8,000
Aquaculture	41	320
Freshwater		
Shrimp	25	70
Carp	5	200
Mariculture (Barachoir)	11	50
Total	7,441	15,820 - 17,820

Source: 1984-86 Development Plan, Ministry of Economic Planning and Development, Mauritius

Production increase in volume of pelagic fishery and bank fishery is most expected. On the other hand, the highest increase rate of 8 times is expected in Aquaculture.

Every sector, however, seems to have some problems in the way to reach its target. Judging from its wide catch fluctuation (1,000 - 2,000 tons) for years 1976 - 1984, the catch of the artisanal fishery seems to reach the resource limit. In this sector, illegal fishing and non-implementation close season for some years have effected the fishery, and guidance, surveillance and management and cultivation of the resources would be needed. The Maximum Sustainable Yield (MSY) of the fish resource in Indian Ocean, a part of which is being utilized by the bank fishing is estimated at 10,000 tons (FAO survey). So, there is enough room for the fishing to increase their catch in the future. But the existing fleet has been almost worn out. Construction of new fishing boats would become a financial burden for the country. There are several problems further in the management of the bank fishing-underdeveloped marketing organization, poor productivity by the existing labour custom and competition with chicken, lamb and other meat. Fish resources abundance for the pelagic fishery has no problem at all. But the pelagic fishery should be managed carefully because demand and price of the canned products thereof are very unstable subject to business conditions of the West.

(3) Short-term Development Action Plan

In order to accomplish the Middle-term Development Plan, framing up and carrying out immediate action measures are encouraged. In these measures priority is placed on the promotion and production increase of the bank fishery to maintain people's fish consumption at 18 kg or more per capita per year and to reduce import dependence of fish and fish products. Emphasis is also put on the improvement of marketing and the expansion of agroindustry which supplies fish products - frozen, canned and smoked fish.

2-3 Background and Contents of Request

2-3-1 Background of Request

The Mauritian Government considers the decreased consumption of fish and fish products due to continued low productivity of the artisanal and bank fishing as well as slack fish & fish products import as a social problem. But to increase import is not desirable to this country, whose foreign currency holding is not so plentiful. Consequently, the Government has incorporated domestic fish production increase in the Middle-term Development Plan as an important policy. In the meantime, at the Albion Fisheries Research Centre built through Japan's grant aid programme in 1980, artificial hatching and test seed production of the Black Tiger Prawn were successfully carried out and information and findings of shrimp culture were obtained by the aquaculture expert sent from JICA. The results were regarded as delightful news for the country's depressed artisanal and bank fishing, for there had been no marine shrimp culture study except for a result of Freshwater Giant Prawn culture. The Government, therefore, considers to make the establishment of marine shrimp culture industry one of the main policies of the Fisheries Development Project. The Government so requested the Japanese Government to construct the facilities necessary for technical development of marine shrimp culture through Japan's grant aid programme.

2-3-2 Objectives of Project

The First objectives of the project are to produce seeds of the Black Tiger Prawn and other marine shrimp on a pilot scale, to demonstrate the feasibility of the shrimps culture industry and to establish its techniques appropriate for local conditions. The second objective of the project is to transfer the techniques to the private sector. The Project aims to develop marine shrimp culture industry to commercial scale, save the foreign currency and

enlarge employment opportunities, and further earn foreign currency with export of shrimp products, while the shrimp currently consumed in Mauritius are mostly exported ones.

2-3-3 Contents of Request

The facilities requested are shown in Table 4. They are all projected relying on Japan's Grant Aid Programmes and there is no direct budgetary appropriation on the Mauritian side, nor cooperation from any other countries. The facilities will be built on the adjoining site of the Albion Fisheries Research Centre and managed as the Centre-attached facilities.

Table 5 Requested Facilities

Facility	Specification	Remarks
1. Pond, Tank		
Hatching Tank	100 tons (Total volume)	Indoors
Food Culture Tank	200 tons (Total volume)	Indoors, light, temperature control
Breeder Tank	20 - 50 m ²	
Nursery Tank	6 tanks, 40m x 30m x 1m	Outdoors, concrete wall, concrete base
Growing-out Pond	8 ponds, Total area: 4 ha	Concrete wall, sand base
2. Building		
Hatchery and Breeder Shrimp Shed	400 m ²	
Food Culture Shed	400 m ²	
Staff, Workers, Watchmen Room	100 m ²	
Garage, Store	100 m ²	
Machine Room	30 m ²	
3. Seawater Supply System	a set	
Pump, Reservoir, Filtering, etc.		
4. Freshwater Supply System	a set	
Well, Pump, Reservoir, etc.		

CHAPTER III

CONTENTS OF PROJECT

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3-1 Review of the Request

3-1-1 Possibility of Marine Shrimp Culture Industrialization

(1) Present Status of Technical Development

The techniques of marine shrimp culture were studied by Dr. Yoshimasa Enomoto, sent by JICA as an expert for two years starting from December, 1983. A research and development programme was also conducted under his instructions. The subjects of those studies were ecology of Penaeidea Shrimp around Mauritius Island, distribution and collection of mother shrimp and wild fry and development of culture techniques such as artificial hatching and growing-out demonstration. As a result, distribution of six species was confirmed and many biological findings were obtained. (Table 6)

Table 6 Distributed Penaeidea Species and their Biological Findings

Scientific Name	Name	Spawning Season (major)	Maturity of M.S.*	Distri. of W.F.*
<i>Penaeus monodon</i> (Fabricus)	Black tiger prawn	Sept.-May (Feb.-May)	Fully matured	
<i>Penaeus latisulcatus</i> (Kishinouye)	King prawn, Blue prawn	year around { Oct.-Dec. } { Mar.-May }	Step III	Coastal area
<i>Penaeus canaliculatus</i> (Oliver)	Striped prawn, Witch prawn	year around { Oct.-Nov } { Mar.-May }		
<i>Metapenaeus monoceros</i> (Fabricus)	Speckled shrimp	year around	Fully matured	Coastal area
<i>Metapenaeopsis mogiensis</i> (Rathbun)				
<i>Atypopenaeus compressipes</i> (Henderson)				

N.B. *M.S.: Mother Shrimp
*W.F.: Wild Fry

As the table shows, adults of the Black Tiger Prawn and the Speckled Shrimp with fully matured eggs are collected and the artificial hatching techniques have been developed with experimental stage. The growing test of these two species is being conducted in 2 (40 m³ each) round water tanks. Technical development is also being conducted on a test level.

Distribution of wild fry of the King Prawn and the Speckled shrimp is confirmed. But the number so far found has hardly been enough to make seeds for industrial culture. However, though the collection of mother shrimp and wild fry are conducted by the staff of the Albion Fisheries Research Centre with an existing fishing gear of small scale, a plan is being formed at the Centre to utilize a larger-scale and different types of fishing gear so that easy catching and efficient study of ecology are secured.

As such the group of scientists led by Dr. Enomoto has endeavoured to develop the techniques concerned, and good results were obtained in seed production and seed growing of these two species on the experimental level.

The shrimp culture facilities of the centre are of small-scale and prepared insufficiently. Introduction of proper equipment and facilities combined with the existing techniques will produce a rapid improvement of shrimp culture techniques and industrialization thereof. To establish the techniques, however, many pilot tests would be needed. And successive technical cooperation from Japan would contribute to a smooth development of the nation's culture industry.

(2) Review of Possibility and Appropriateness of the Industrialization

The review on the possibility of industrialization was conducted from the both sides of the natural and socio-economic environments, which contain the following points:

- 1) Status and level of technical development of Penaeidea Shrimp
- 2) Availability of suitable places for shrimp culture
- 3) Acceptance of cultured shrimps by the sides of consumption and marketing
- 4) Contribution to the saving of hard currencies, etc.

In this respect, surveys of suitable area were made by aeroviewing from a helicopter and by a coast-walking method. The estimated area of the suitable zones concluded from these surveys and the results of studying existing data are as follows:

Table 7 Areas of Suitable Places for Marine Shrimp Culture

Zone	Area (ha)	Reference
Mangrove Swamp	50	
Other Swamp	100	*Sugar cane field, meadow salt firm, unutilized plane, etc.
Convertible Field*	200	
Barachois	150	
Total	500**	**minimum estimation

Among the suitable area, at a part of convertible fields and Barachois, brackish water is not available. Therefore, objective shrimp species should not be confined to the Black Tiger Prawn, and purely marine species such as Indian White Prawn (P. indicus) and Banana Prawn (P. merguinsis) should be included. That would bring more bright expectations to realize industrialization of marine shrimp culture. Further, in some cases hatching and growing tests of the Flower Prawn (P. semi-sulcatus) and the Western King Prawn (P. latisulcatus) should be considered. The distribution of the above three species has not confirmed yet in Mauritius and considering that the surveyed area for distribution of Penaeid shrimp is rather restricted to only a small area and the fishing gears used for survey are small and simple of one kind, further detailed surveys should be conducted. But even in the negative case for their distribution in Mauritian waters, the culture of these species will be carried out by transplanting of matured shrimps from foreign countries such as Singapore, etc.

The range of the tide on the coast of the country is very small - about 70 cm, so in watering of ponds constructed on the land, pumps are to be used. When using these ponds, semi-intensive culture system should be applied. When using Barachois sea, ponds are to be watered naturally. And in this case, extensive culture system would be preferable.

Production rate of the former is 1.5 ton/ha. on average and its turnover is twice per year and that of the latter is 0.5 ton/ha. and its turnover is also twice per year (refer to App. 9, 10). So total production in all of the areas suitable for the culture amounts to 1,245 tons. As the average weight of a shrimp at harvest is 40 g and the yield rate from the seed release to the harvest is 25%, 130 million seeds are needed.

Next, socio-economic survey was conducted and the following are the results of the survey. As regards the profitability of shrimp culture industry in Mauritius, none of unfavorable factors are considered to exist in the production cost, even if compared with that of each country of South-East Asia. Moreover, it is expected that the domestic demand of culture shrimp will grow to 370 tons in 1990 from 100 tons at present as mentioned earlier, and shrimp culture industry will be developed into the one having international competitive power with export outlet to Europe. Analyzing the various materials and information, the price for purchasing cultured shrimp of 40 g size in 1987-90 by expected packers is estimated at US\$ 10/kg. On the other hand, the production cost of cultured shrimp in Mauritius is expected to be around US\$ 6-7/kg, which would give enough basis for the viability of the shrimp culture industry. Furthermore, if the said projected farms of 500 ha. realize an yield of 1,245t of culture shrimp and if it is sold at US\$10/kg (estimated from the present value of US\$12/kg for cultured Freshwater Giant Prawns), the total turnover will be US\$12.45 million. This amount corresponds to about 1.5 times of US\$8.8 million, total value of catch of 4,400 tons at average consumer's price of US\$2/kg. currently produced by both artisanal fishery and bank fishery in Mauritius.

For Mauritius which is confronted with a lot of problems on the way to promote its coastal fisheries, development of shrimp culture industry can be said to be promising and feasible measure. Therefore the implementation of this project would be of great significance.

3-1-2 Review of the Request

Regarding the content of the request, from analytical results of field survey, the necessity of modified review on the following points was recognized:

- (1) The facilities necessary for not only brackish Black Tiger Prawn, but also other marine shrimps such as Indian White Prawn and Banana Prawn.
- (2) The most proper scale of seed production facilities, nursery facilities and growing-out facilities from the viewpoint of pilot technology.
- (3) The scale of these facilities from the viewpoint of correlation among them.
- (4) Details of each facility, specifically combination and number of tanks and ponds.
- (5) Each facility based on the conditions of the project sites, such as area and topography.
- (6) Construction of growing-out ponds utilizing Barachois.
- (7) Facilities supplying fresh and sea water based on the field survey.
- (8) Related equipment needed.

By analyzing the results of reviewing the above points, a basic designing was carried out in accordance with the basic plan established.

3-2 Basic Plan

3-2-1 Guideline for the Basic Plan

The facilities are to be the pilot plant to make basic experiment and demonstration test for the industrialization of the marine shrimp culture. The facilities should be so designed as to be suited for objective species, culture methods and scale of the project. A basic plan of the facilities is to be worked out to meet the above conditions. The details of the plan are as follows:

- (1) The chief objective species is to be the Black Tiger Prawn (*Penaeus monodon*). At the same time the Western King Prawn (*P. latisulcatus*), which is expected to grow in sea water with higher salinity, the Banana Prawn (*P. merguensis*) and the Indian White Prawn, both belonging to the white prawn, which distribute widely in the Indian Ocean area, such as Southeast-Asian countries and India, but whose distribution has not been found yet in the country, should be considered as desirable species. They are cultured in extensive culture ponds in these countries and the techniques of seed production and growing-out of these species have been developed. Accordingly the facilities are to be so designed as to be able to collect both fresh and sea water to supply the ponds with water of a wide range salinity.
- (2) In case of the Black Tiger Prawn and the Western King Prawn, collection of natural adults for seed production is available. But in industrialization, a large number of seed are to be secured. Maturation tanks for maturing the immature and breeder ponds for raising spawning adults are to be built.
- (3) In seed production, the mass projection system, say, with a 200 ton-tank is basically desirable. However, the mass production of shrimp seeds with such a large tank requires high technology and much experience. Therefore, the scale of seed production of the project should not be so big. For these two reasons, the culture method, in which larva are reared in a medium 10 ton-hatching tank from spawning to post larval stage and then they are transplanted to 20 ton-tank to

rear till PL15 - PL20 (the stage after 15 - 20 days from post larval stage), is recommended. The scale is planned not only for production of necessary brackishwater shrimp fry for the growing-out test but also for the development of hatchery operation of seawater shrimp. Distribution of fry to the public is planned after Phase II, subject to the result of the pilot test.

- (4) The buildings of hatchery were designed to be of closed type, because the temperature there (at Medine, the nearest observation station from Albion) falls to 17°C in winter and rises to 30°C in summer (from January to April). To prevent the strong sunlight, the roofs of the buildings were designed to have transparent parts and semi-transparent parts alternatively. Semi-transparent parts were equipped with blinds to control the sunlight.
- (5) As the seed feed at an early stage, phytoplankton in collected natural seawater is propagated by fertilization, and pure cultivation of selected phytoplankton is jointly used. As the seed feed at a later stage, animal plankton, such as nauplius of Artemia, and Rotifer are cultivated, the latter being fed by clorella. The facilities to cultivate these micro-organisms were designed.
- (6) Seeds produced in the hatchery are raised in the nursery to the size of 0.5 - 0.7 g, appropriate for releasing to the grown-out ponds. The facilities are planned for the operation.
- (7) In this country, Barachois culture is available besides pond culture. The test production facilities for both cultures are necessary.
- (8) In Barachois culture, the size of actual culture farm would be more than 50 ha per establishment. But for the sake of the efficient management, parting of the Barachois will be made, with one section being 1 ha - 5 ha. In pond culture, the size would mostly be less than 10 ha per establishment. So, unit area of 0.2 ha - 1.0 ha would be proper. The scale of growing-out ponds, nursery pond, breeder pond and Barachois were planned based on the above idea and the character of this project in which demonstration tests are conducted for industrialization.