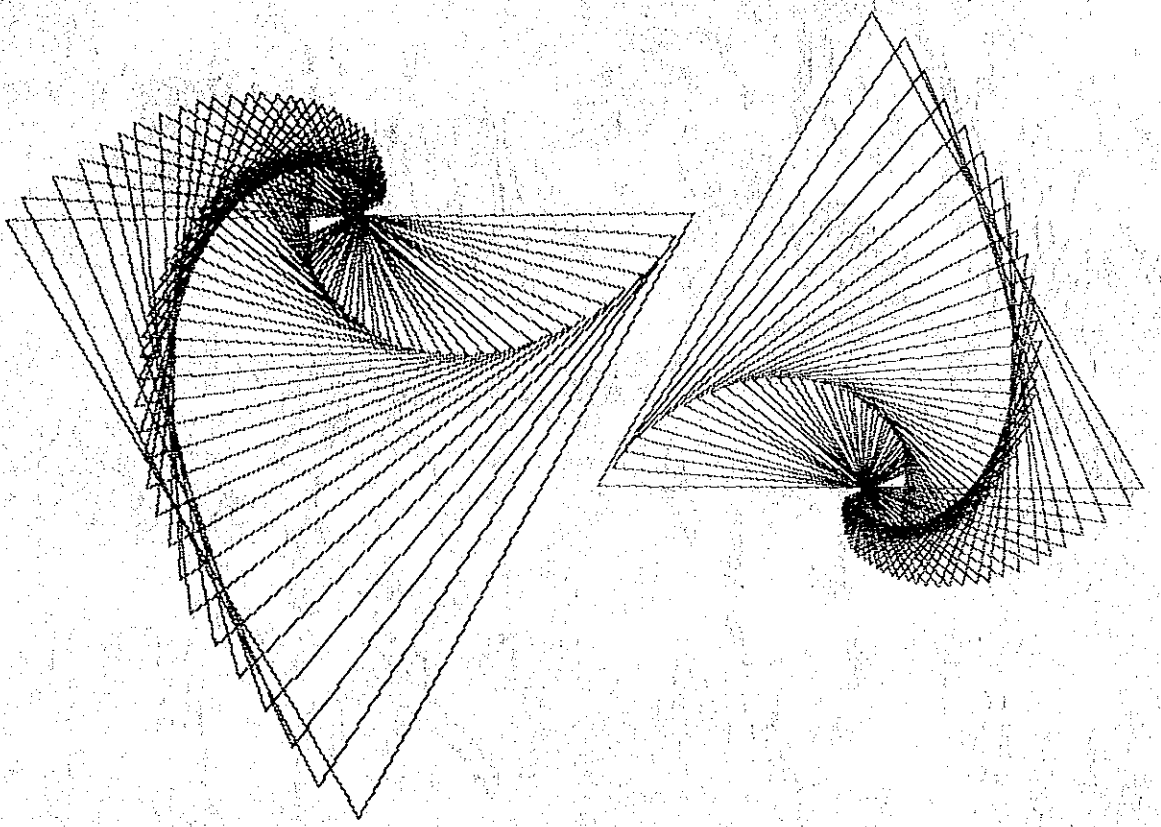
AQUACULTURE PROJECT

(FIJI)



March 1989

Institute for International Cooperation
Japan International Cooperation Agency (JICA)

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(Fiji)

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PREFACE

The Project-type Technical Cooperation is an integrated form of cooperation whose aim is to realize technology transfer to relevant personnel of the project in the recipient country, by effectively combining such assistances as dispatch of experts, training of counterparts in Japan, and supply of equipment as required. It is intended to assure smooth and systematic implementation of technical cooperation program through planning, implementation and evaluation.

The duration of cooperation is usually about five years. When the project is actually commenced, a variety of survey teams and experts are dispatched to the recipient country, preparing work reports.

This case study of Project-type Technical Cooperation has been compiled originally in Japanese, then translated into English, based upon a number of these reports prepared at each stage of planning, implementation and evaluation of the project.

We would be pleased if it would be of some usefulness as reference material for those who are interested in our technical cooperation.

March 1989

Director
Institute for International Cooperation
Japan International Cooperation Agency (JICA)

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Outline of the Project

Fiji was promoting the supply of protein to its people, clearance of water plants from its rivers, and the development of substitutes for imported aquatic products as a part of its 8th 5-year Development Plan. In order to cooperate for the achievement of these plans, the Governments of both Japan and Fiji agreed to implement research and development on freshwater and seawater culture. Research has been conducted on freshwater fish such as grass carp and other carp families, freshwater prawns such as the macrobrachium species, and marine shellfish, mainly oysters. From the research, suitable species for culturing in Fiji were selected. Mass production of seed stock and nursing techniques were developed, subsequent liberation of fish assessed and the marketability evaluated.

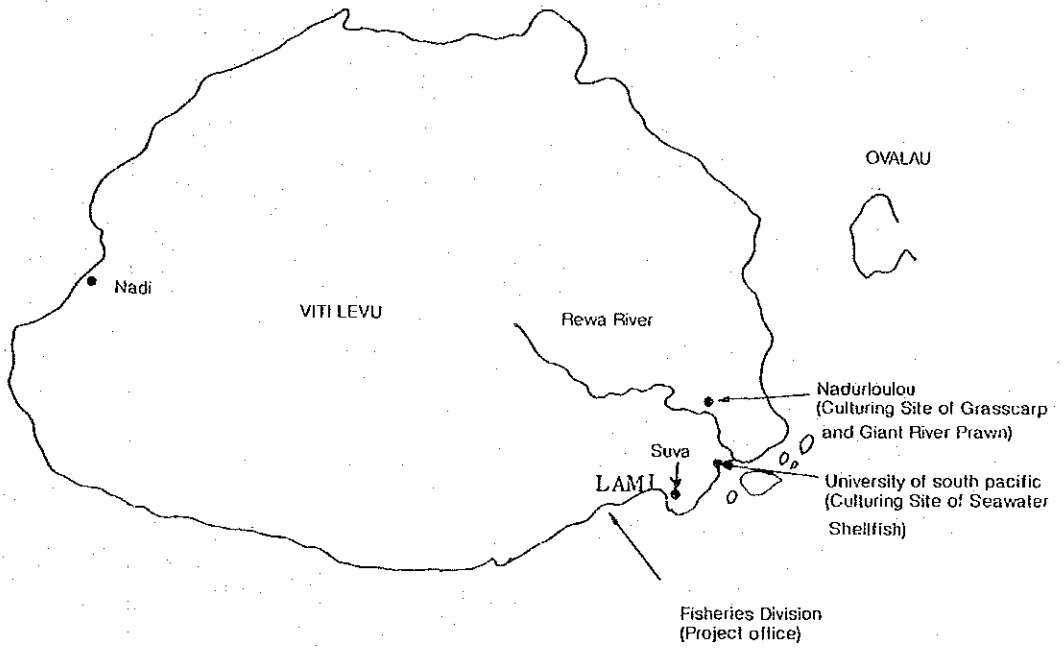
This Project was completed in July, 1987 after 3 years (the first period) with an extension of 2 years (the second period) and a follow-up of 2 months. In the first 3 years, research was conducted on freshwater fish, prawns, and marine shellfishe. In the second 2 years, research continued on the two freshwater species.

The research purpose of the freshwater, fish was to clear the water of water plants and to supply protein to the local residents. During the first 3 years, the main emphasis was to rear adult fish. Seed stock collection using hormones succeeded in the third year. During the last 2 years, a follow-up survey was made on rivers where seed stock were released. The satisfactory growth of released fish and significant effect on water plants were assessed.

Regarding freshwater prawns, seed stock production was carried out for the giant river prawn species primarily. A production method was established to produce 2 million post larvae per year of this introduced species. An investigation of native species was also made but none could be found suitable for culture.

As for marine shellfish, based on the research done on the mangrove oyster, it was found that spat grow quickly but their growth later slows down. Because the adult size of these oysters is small, they were judged unsuitable for culture. Research was also done on Japanese oysters (Crassostrea) which had been already introduced from Japan. It was found that their spat grow fast but die in large numbers near maturation. Based on these facts, it was concluded that oyster culture is not suitable in Fiji. On the other hand, green mussels were introduced from Tahiti for research and as good results were obtained in their growth test, study of them was continued in the extended period. Unfortunately, seed stock collection hasn't been successful.

Map of the Project Site



Outlined Schedule of the Project

Name of the country: Fiji Name of the project: Aquaculture Research and Development Project in Fiji
Date of the request: November 25, 1980 Date of R/D signed: November 18, 1981
R/D period: From November 18, 1981, to March 31, 1987 Follow-up period: From April 1, 1987, to June 2, 1987

Fiscal Year	1981	1982	1983	1984	1985	1986	1987
Connection with the cooperation in grant aid	No						
Dispatch of survey team	Preliminary survey (3) 7/1~8/30 Implementation survey (5) 11/4~11/19		Mutual Consultation (4) 2/24~3/8	Technical guidance (2) 12/17~12/22	Evaluation (3) 1/28~2/9 Technical guidance (2) 9/10~9/18	Evaluation (3) 11/28~12/4	
Dispatch of experts							
(1) Long-term experts							
Leader		8/9 ——		—— 8/8	6/3 ——	——	—— 6/3
Coordinator		6/18 ——				—— 3/31	
Freshwater fish		11/29 ——				—— 3/31	
Freshwater prawn		6/18 ——				—— 3/31	
Seawater shellfish		2/21 ——		—— 3/31			
(2) Short-term experts							
Freshwater fish		12/13~3/11	10/21~12/24	12/22~3/19	11/16~3/15 12/24~1/17	11/11~12/9	
Freshwater prawn			10/21~12/24 3/9~4/8	1/21~3/16	11/16~2/11	9/6~10/4	
Seawater shellfish			2/24~4/19	1/29~2/16			
Survey and work execution	11~12/3	8/16~10/21 11/26~12/23	1/24~3/12 3/25~4/23	12/15~3/30			
Acceptance of Counterpart							
Aquaculture in general	1/17 ——	—— 6/17 (1)					
Freshwater fish			4/18 ——	—— 8/6 (1)			
Freshwater prawn			1/25 ——	—— 5/18 (1) 7/18 ——	—— 11/4 (1)	8/15 —— —— 12/15 (1)	
Seawater shellfish				8/8 ——	—— 12/14 (1)		
Freshwater culture						6/1 ~ 7/27 (1)	

Brief History of the Project

1980 - May	Mr. Mala, the Prime Minister of Fiji, made an official visit to Japan. Talks were held with the late Prime Minister Ohira, concerning technical cooperation for fish propagation and culture.
September	The Government of Fiji officially requested that the Government of Japan extend project-type technical cooperation.
December	The Project Finding Survey Team was dispatched Agriculture and Fishery cooperation).
1981 - July	Based on the results of the above-mentioned survey, the preliminary survey (under taken by long-term researchers) was implemented over a period of 2 months.
November	R/D was signed by the Japan Implementation Survey Team.
1982 - April	Technical cooperation for aquaculture in Fiji begun.
June	Dispatch of experts begun, based on R/D.
1983 - January	The first trainee was accepted for training according to R/D.
February	Mutual Consultation Team was dispatched for arrangement of project planning.
April	Technical Guidance Team was dispatched to provide instruction based on model infrastructure works.
1984 - August	Honjo, the project leader, returned to Japan at the expiration of his term of office.
December	Technical Guidance Team was dispatched to investigate problems arising in the final year of the first project period.
1985 - January	Evaluation Team was dispatched for appraisal of the first period of project.
March	R/D was signed for the extension of period.
June	Kanemitsu, the team leader, was dispatched.
September	Survey Team was dispatched to create a cooperation plan for the extended 2 years.
September	Joint committee meeting was convened. The above-mentioned team attended the meeting.
1986 - April	Joint committee meeting was convened to prearrange the implementation plan for the final year.
November	Evaluation Team was dispatched.
1987 - March	Upon completion of the Project, experts, exclusive of the leader, return to Japan.
June	Upon completion of the project follow-up for 2 months, the leader returned to Japan.

1. REQUEST FOR COOPERATION

1-1 Circumstances Preceding the Request

In the South Pacific Ocean, there are several island countries which can be divided into three groups according to origin. The three groupings are known as Micronesian, Melanesian, and Polyneian. For the purpose of discussing common matters of concern, such as political and economic issues in the region, they have two regional cooperation organizations. One is the South Pacific Forum composed of 13 member countries including Australia and New Zealand. Another is the South Pacific Commission composed of 24 member countries including those described as suzerain states such as the United States, Great Britain, France, Australia and New Zealand who possess territories in the Pacific region. In this situation, P.N.G. plays the leading role for the Melanesian group and Fiji plays the leading role for the Polynesian group. Each of these groups is closely united. It is felt that the effects of the technology transfer to Fiji will soon propagate to its neighboring countries because of this closeness. Also, of note is the fact that Fiji, representing the South Pacific groups, has come to play a major role among the members of the United Nations.

Among the economic assistance (in 1983) to these groups provided by industrialized countries, the $400 million provided by France is the highest followed by Australia, Great Britain, and New Zealand. Japan is fifth among aid providers with $12 million. In recent years, a new look has been taken at the importance of economic assistance to the South Pacific island countries. In contrast to this Fiji has strengthend its development plan since independence in 1970. In implementing the 8th 5-year Development Plan, Fiji intends to select the country most appropriate to request assistance from in each field necessary for its development. For example, Great Britain has been selected in the field of education, Australia and New Zealand in agriculture and forestry, and Japan's cooperation in fisheries.

Mr. Mala, the Prime Minister of Fiji, made an official visit to Japan in May 1980. At that time he met with Prime Minister Ohira and discussed technical cooperation for fish propagation and culture. On September 25 in the same year, the Government of Fiji officially requested technical cooperation from Japan for a project aimed at developing techniques for aquaculture of three species – (1) grass carp, (2) giant river prawn and (3) oysters.

1-2 Concrete Contents of the Request

As mentioned above, the Government of Fiji planned to promote the propagation and culture of fish as part of the 8th 5-year Economic Development Plan. The purpose was to develop rural fish farming in order to supply animal protein and to promote employment for the rural inhabitants. Small-scale pond culture was to be established in rural areas, and river propagation was to be undertaken in order to clear the rivers of water plants at the same time that the production of protein sources would be increased. Grass and other carp seed stock was to be mass produced for use in

stocking the rivers. Another purpose was to carry out domestic commercial culture of prime fish and shellfishes which were being imported from Australia and New Zealand to reduce the imports or to help obtain foreign exchange by exporting. In order to accomplish these development plans, the Government of Fiji requested help from the Government of Japan in the development of culture techniques for (1) grass carp, (2) giant river prawn and (3) oyster.

1) Grass Carp

The purpose was to develop culture techniques for grass carp and other carp species which was to be liberated to help in the clearing of the rivers of water plants as well as for rural fish farming. However, since grass carp are low natural reproducers, even if liberated, artificial seed stock production is required every year. For this, development and research were made on (1) breeding of adult fish (development of feed, and improvement of rearing environment), (2) egg removal using hormones, (3) rearing of liberated seed stock and development of pond culture techniques, (4) liberation in rivers and survey of growth status, (5) survey of drifting eggs from natural spawning and fry in the rivers and (6) culture experiments using of other carp (silver carp, big head carp).

2) Giant River Prawn

Giant river prawn shows good potential for culture in the freshwater area. For the rural fish farming it is well suited to polyculture with other fish, and can also be considered as a species for commercial culture because of its high market value. Thus, development and research were requested on this species as follows. (1) Development of seed stock production techniques (development of commercial mass production techniques), (2) breeding experiments (development of feed, and rearing environment), and (3) selection of species for culture (if any suitable species is found from among native species, development of culture techniques for such species).

3) Oyster

So far several experiments have been made on various suggested species without any successful result. Judging from this, oyster culture in Fiji seems fairly difficult, but since oysters are in great demand and high in market value, technical cooperation was requested from Japan, a nation especially advanced in oyster culture techniques. At the same time, a strong request was made the culture techniques for the hard-shelled mussel, including, (1) selection of species for culture (selection of the most suitable species for culture in Fiji including introduced and native species), (2) development of artificial seed stock collection techniques and (3) implementation of culture experiments.

2. IMPLEMENTATION CONSULTATION OF THE PROJECT

2-1 Dispatch of Project Finding Survey Team

In order to survey the feasibility of technical cooperation for the project system involving aquatic propagation and culture requested by Fiji, the South Pacific Project Finding Survey Team, headed by Mr. Akimitsu Koganezawa, Research Controller, Fishery Agency, Ministry of Agriculture, Forestry and Fisheries, was dispatched to Fiji for 14 days from December 6 to December 19, 1980.

2-2 Dispatch of Japanese Implementation Survey Team

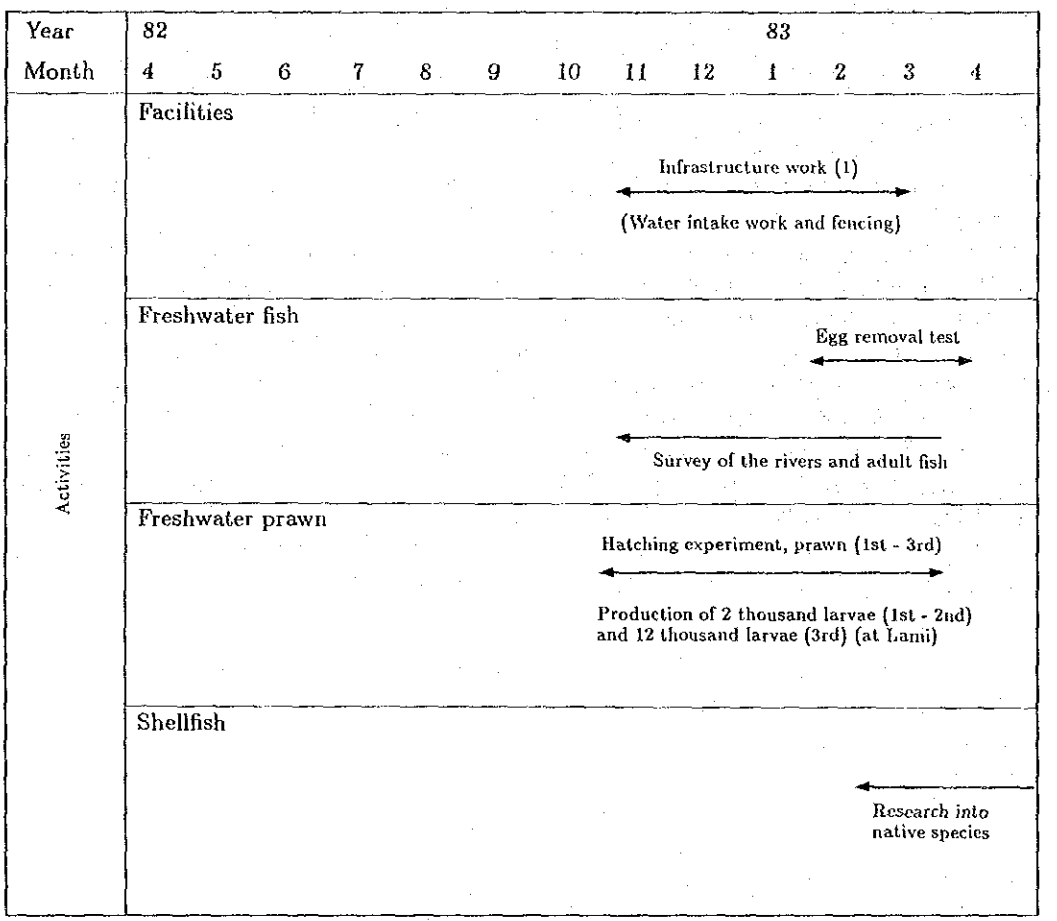
Following the Project Finding Survey Team (Dec. 6-19, 1980), the Long-term Survey Team conducted a survey on technical cooperation using the project system, for aquatic propagation and culture requested by the Government of Fiji. As a result of the survey, it was decided to implement technical cooperation using the project system in the fields of freshwater culture (grass carp, other carp and giant river prawn) and marine culture (oyster). For the preparation and agreement of the Record of Discussions on this technical cooperation plan, the Japanese Implementation Survey Team headed by Dr. Sho Morita, (Chief of Research Planning and Coordination Division, Tokai Regional Fisheries Research Laboratory, Fishery Agency, Ministry of Agriculture, Forestry and Fisheries), was dispatched from November 4 to November 19, 1981.

3. IMPLEMENTATION OF THE PROJECT

3-1 Activities by Fiscal Year

(1) First Fiscal Year (Apr., 19082 - Mar., 1983)

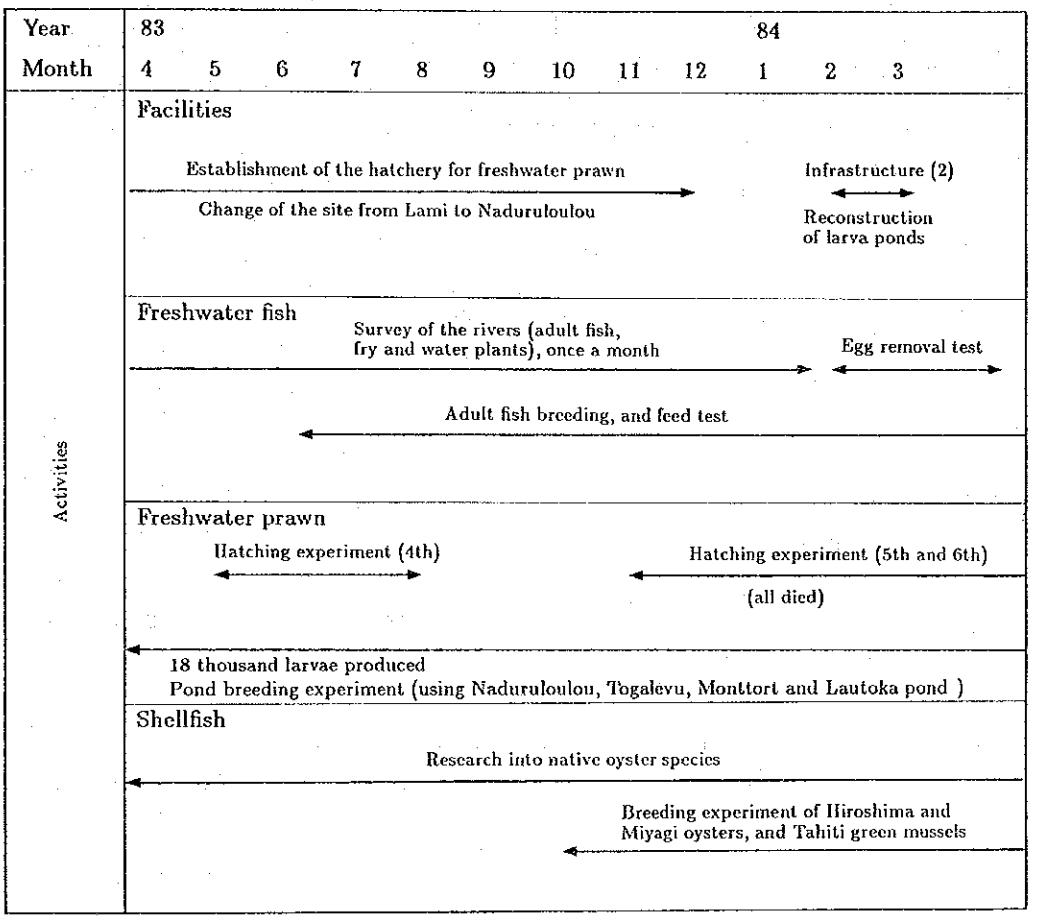
Table 1 Activities of the experts (the 1st F.Y.)



(2) Second Fiscal Year (Apr., 1983 - Mar., 1984)

1) When the water intake works were completed at Naduruloulou, the adult breeding of grass carp was started using several ponds.
2) When the culture site of freshwater prawn was changed from Lami to Naduruloulou, the construction of a hatchery began (cost borne by the Fiji side). Additionally, a breeding experiment using post larvae prawn produced at Lami was made at Naduruloulou and in other private ponds.
3) As for shellfish, research into the native species was started using oysters introduced from Hiroshima and Miyagi.

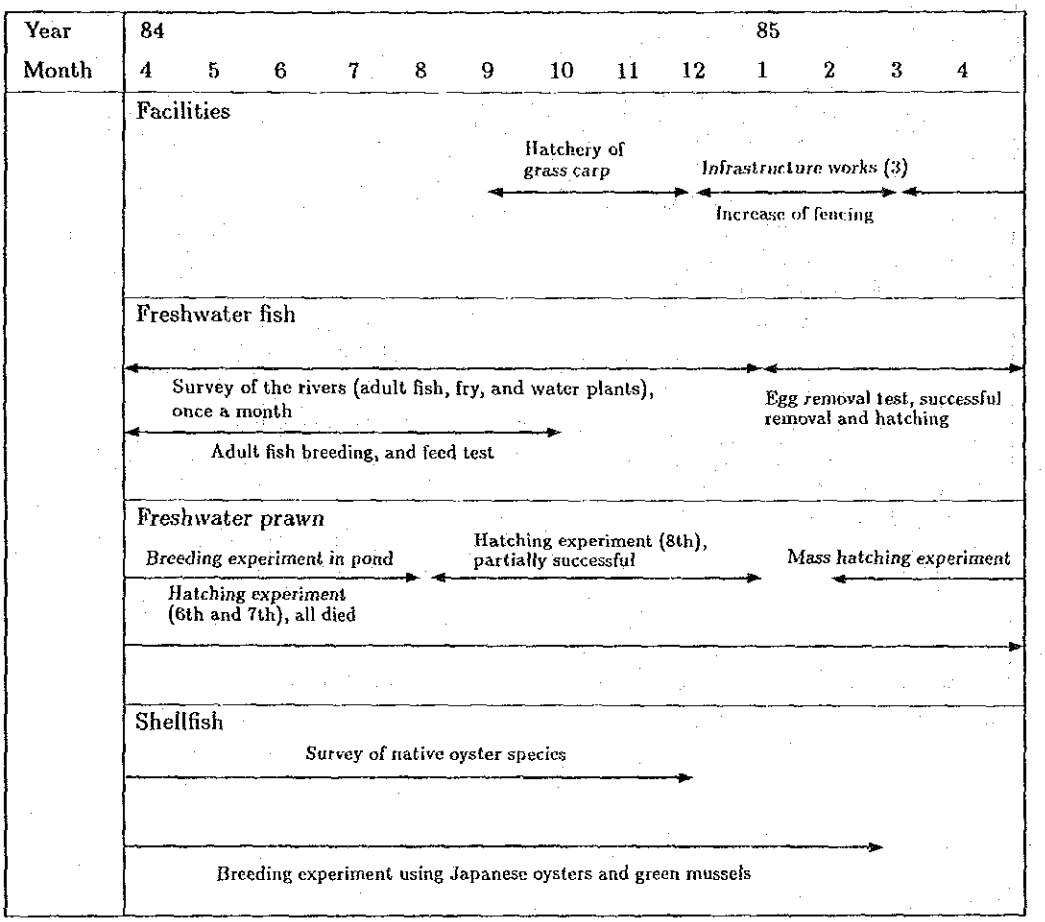
Table 2 Activities of the experts (the 2nd F.Y.)



(3) 3rd Fiscal Year (Apr., 1984 - Mar., 1985)

1) Survey of the rivers is performed once a month to investigate the growth, maturity, and reproduction of grass carp released into the river, and to observe the decrease in water plants which carps feed on. Since the site is located in the Southern Hemisphere, the spawning season was estimated to be between December and March. The egg removal experiment implemented during this season using hormone injections resulted in successful egg removal and hatching for the first time.
2) With the completion in November of the prawn hatchery at Naduruloulou, the site was changed to there from Lami and the hatching experiment was made. Unfortunately, however, the entire sac larvae died, after hatching but before becoming post larvae. The causes are under investigation.
3) The survey of native oyster species and the culture experiment of introduced oysters and hard shelled mussels were implemented.
4) Based on the evaluation results, it was decided to extend the Project for 2 years excepting for the oyster culture efforts.

Table 3 Activities of the experts (the 3rd F.Y.)



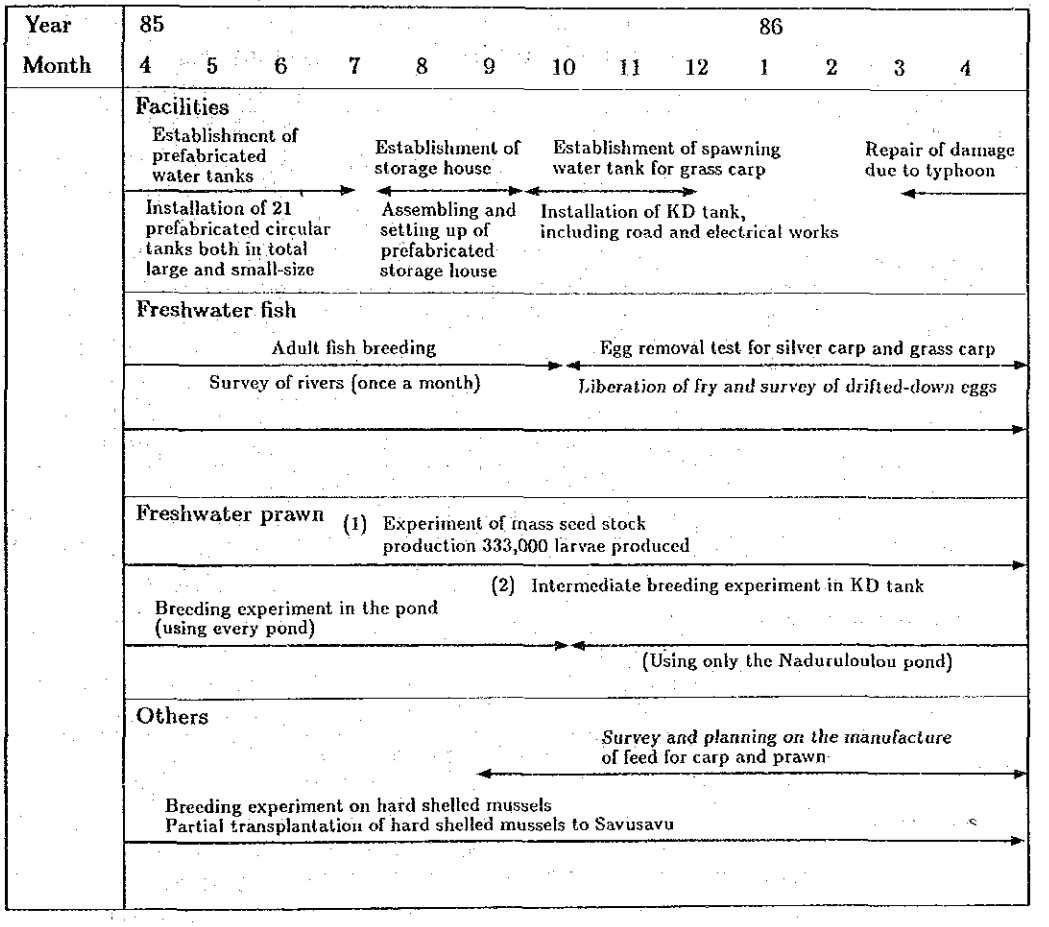
(4) The 4th Fiscal Year (Apr., 1985 - Mar., 1986)

1) The grass carp seed stock produced by the egg removal using hormones were liberated in the rivers for the first time. Survey of the rivers was made for eggs. The egg removal using hormones from silver carp was implemented successfully. Fry of grass and silver carp were newly introduced from Japan to improve the efficiency of egg nursing.

2) Mass seed stock production of giant river prawn udertaken to reduce the production cost. An intermediate breeding experiment was implemented to improve yields. The breeding experiments were concentrated at the Naduruloulou ponds.

3) Experimental manufacture of feed for grass carp and prawn was planned. Although oyster culture was terminated by the end of the first period, the culture experiment on green mussels was continued partially.

Table 4 Activities of the experts (the 4th F.Y.)



(5) The 5th Fiscal Year (Apr., 1986 - Mar., 1987)

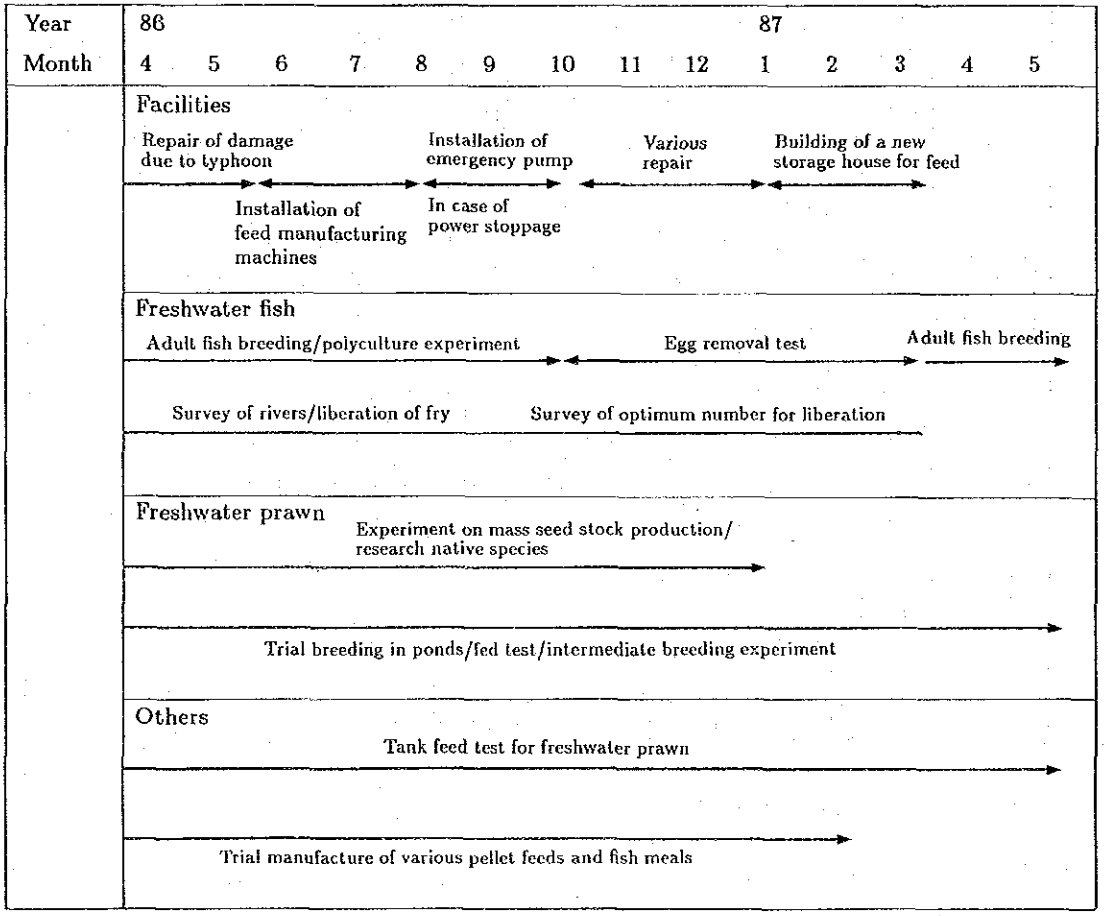
1) Concerning grass carp, the following activities were performed in addition to adult fish breeding, egg removal, and river surveys.
   a) Subsequent to the last project year, liberation of fry in four rivers.
   b) Estimation of optimum number of fry for yearly liberation.
   c) Polyculture experiment on grass carp, silver carp, big head carp, and giant river prawn.

2) Concerning freshwater prawn, the research on native species, simplified seed stock production of giant river prawn, intermediate breeding culture in the pond, and feed tests were implemented.

3) The installation of feed manufacturing machines, trial manufacture of feed for prawn, and feed tests were carried out.

4) The period of the project cooperation was concluded by the end of March, 1987. Follow-up was performed for about two additional months until June 2.

Table 5 Activities of the experts (the 5th F.Y. and follow-up)



3-2 Intermediate Evaluation

When the cooperation period for the Project was concluded on March 31, 1985, the Evaluation Team headed by Tairyo Matsuoka, (Chief of Planning and Research Room, Japan Cultivation Fisheries Association) was dispatched to Fiji for 13 days from January 28 to February 9, 1985. This team was to carry out an evaluation and review of the achievements the technical cooperation extended by Japan jointly with the Fiji. The results of the joint evaluation and review are described in the following:

(1) Progress and Evaluation of Each Project

1) Freshwater fish (grass carp and other carp)
   a) Experiments on grass carps were made using the two method. In order to produce subjects for culture and liberation, eggs were removed using hormone taken from bred adult fish. Ecological research was made on the spawning of grass carp released in the Rewa River to aid in collecting naturally spawned eggs.
   b) So far, the pituitary of the silver carp is effective as a hormone for injection, and the grass carp have matured well year by year due to the improved control of feed and ponds. Artificial egg removal and hatching however are not yet successful.
      Note: The egg removal and hatching succeeded soon after this evaluation survey.
   c) Although the collection of drifting-down eggs (naturally spawned eggs) hasn't been successful, the discovery of mature fish suggests the possibility.
   d) For other carp, trial seed stock collection was made for silver carp. The trial is already successful for some species but not yet for silver carp.
   e) Polyculture of grass carp, silver carp, big head carp and tilapia was tried but the test was suspended due to flooding.
   f) A portion of the 110 thousand fertilized, grass carp eggs introduced from Japan is being reared in ponds to breed adult fish, the remainder was liberated in the Rewa River to grow into natural adult fish.
2) Freshwater prawn (macrobrachium species)
   a) Experiments are planned for the seed stock production and culture of giant river prawn as an introduced species as well as for the selection of species suitable culture from among the native macrobrachium species and the production of their seed stock.
   b) In the initial period of the Project, some seed stock production experiments were successful, though only on a small scale.
   c) Subsequently, the site was moved to Naduruloulou and the hatchery for mass production was constructed to implement the experiment on seed stock production. During the about one year period leading up to October, 1984, however, death of larvae in large amounts occurred due to unknown causes and development was suspended. Possible causes for this included the influence of the Rewa River on the water quality, some plasticizer and hardener contained in the coating agent of the pond, as well as diseases and parasites. The cause could not be established in spite of repeated investigation.

As sterilization and the use of still water in the pond were continued the production became possible again.

d) Culture experiments in ponds were implemented at Lautoka, Togalevu, Montfort and Nadururloulou with satisfactory results yet produced.

e) For the survey of native species, Mr. Morokida, the short-term expert, was invited. It was made clear that 10 species of macrobrachium live in the rivers, mainly the Rewa River and among them M.lar, M.australe and M.equidem are considered to be suitable species for culture.

3) Shellfish

a) Surveys and experiment were carried out on three items to determine the suitability of shelfish for culture. This included environmental surveying, ecological research on native oyster species, and trial culture of introduced species.

b) This time, Since suitable species and sites for culture could not be selected based on the piecemeal data of the environmental survey, in order to compile the necessary data, the water temperature and salt density were measured twice every day, in the morning and the evening, and the degree of clarify and amount of plankton were measured once a week at principal places. Additionally, the intertidal observation for these items was made once a month.

c) From among the native oyster species, the mangrove oyster was selected. The study of gonads over an entire year showed that the spawing season is from December to March and the ideal seed stock collection period is, therefore, from January to April.

d) Culture experimentation was implemented using oyster seed stock obtained by trial collection. This revealed that oysters grow fast in the initial period but that they slow down later. After a year they measure 6 cm.

e) Japanese oysters were introduced from Japan and culture experimentation was implemented at three sites: Laucala Bay, Bay of Island and Fattening Area. The spat suffered greatly from predatory fish and one third were gone in a day and a half. After that experience, the experiment was continued using wire net fencing. Good results were produced at Fattening Area, the worst were produced at Laucala Bay.

f) The period of high water temperature in March caused large losses. Deaths in a large numbers occurred close to maturation as well.

g) Oysters from Mago Island (crassostrea echinata) were transplanted. Culture experiments produced no favorable results.

h) The culture experiment on green mussels introduced from Tahiti was made using fencing to protect them from predators. It produced good results with a survival rate of 80%. They grew to 57 m in average length after a year.

(2) Present Condition and Evaluation of the Whole Project

1) About the Team Leader

Since the team leader who stayed at the site during the initial period of the Project returned home for reasons of health, the post has been left unfilled and the coordinator on the spot has been compelled to serve concurrently as the leader.

A leader has the very important task of controling the progress of the Project as a whole, to solve the detailed technical and human problems which occur from time to time, and at the same time, to keep close contact with the counterpart team – it should be said that he is the main character representing the Project, and the coordinator himself has many other important tasks. This abnormal situation must be resolved as soon as possible.

2) Joint Committee

One curious matter in this Project, which may be an effect of the circumstances mentioned above, is that so far no joint committee has been held. Difference in the opinions of the teams, overemphasized data, and delayed progress of the Project, are believed to be mainly due to the fact that no joint committee has met.

3) Necessity of Development of Techniques adapted to the Country

Development of economical and simple techniques has been demanded repeatedly by the Fiji side. Unfortunate circumstances arose obstructing the satisfaction of these desires. The Japanese team at the beginning had to undertake basic research and experimentation; then the progress of the Project was finally somewhat delayed due to natural disasters and other accidents; and finally the inability to secure the seeds stock in sufficient amounts made it impossible to implement the experiments of the second stage including those on polyculture and large-scale culture by using this seed stock. Nevertheless, the development of a technique capable of producing river prawn at a remote place where electricity is unavailable, and the efforts to produce seed stock at a reasonable cost for Fiji, for example, are considered to be necessary along with the above demands. These are the essential items to be covered when the Project is extended.

3-3 Problems about Implementation and Administration of the Project

(1) Fiji expressed its dissatisfaction in that the Japanese draft of M/P contains too much research; that the Project will result in the cooperation for research without contributing to production which is the main objective of Fiji. They insisted that research be reduced and that production be included instead since the research into grass carp as well as giant river prawn had been progressed and Fiji believed that the production would become possible only if the techniques were transferred. In response to this, Japan explained that since its techniques must be improved so as to adapt to the conditions of Fiji before transfer, basic research is essential. Upon gaining Fiji's consent, the Project was started. Still, in implementing and administering the Project, desire was seen on the Fiji side to put the techniques to practical use in an early stage.
The necessary measure to cope with this problem was to explain our plans through a joint committee with full understanding of the insistence of the recipient country.

(2) Delay of the Plan
Delay of a plan was often experienced. The first cause was the delay of construction works for the infrastructure. In a developing country in particular the progress of works and the administration of office work were not so smooth in many cases as in Japan. On the Japanese side, the provision of equipment and materials often delays (the equipment and materials for the fisheries in particular including many small items for which procurement takes much time). Therefore, for the implementation and administration of a plan, a high rate of occurrence of these delays should be taken into account in planning.

(3) Local Cost
Local costs to be shared by both countries were agreed in R/D and budgetary measures were taken on the Fiji side for such costs. However, at the end of the fiscal year, at times the budget became deficient causing delay of the necessary works and thus obstructing the activities of the Project. Sometimes, depending on its contents, the cost would be considered as the operating expenses if this was judged to be effective from the overall viewpoint.

3-4 Change and Contents of Implementation Plans

(1) According to R/D, the agreed sites for the Project were Nadururloulou for grass carp and other carp, the Fisheries Division at Lami for freshwater prawn, and Lami or the experimental trial production farm to be newly established at Savusavu. On the Fiji side, no objection was made to place the base production farms at Lami for freshwater prawn and shellfish. Also Fiji made clear that it did not intend to implement seed stock production on a commercial basis at the Fisheries Division site but it does intend to establish a technical guidance center there for the production of prawns. After the team leader and other long-term experts had arrived at the site and examined the actual conditions, however, the partial change of the Project site was discussed. The main reasons for this were as follows:

1) Although the shortage of freshwater at Lami was known, the possibility of the dechlorination of tap water to cope with it was expected at the time the site was decided upon. Thereafter, Fiji introduced a new tap water purification process. Various agents are added in the course of pretreatment for purifying water and $0.3g/m^3$ copper sulfate contained in one of them is feared to affect the crustacean. Also, the ponds with pH in the 5.0 - 5.5 range are acid and possibily have similar effects.
2) In the present condition, it is impossible to depend on the tap water because of its quality, a deficiency in the quantity of water is conceivable.
3) Although the construction of hatcheries was planned, locating the site at Lami became impossible.

As a result of discussions at the conference of Ministers, a change of site was approved on the following conditions:

1) That the basic experiment and the activities having some exhibition value be performed at Lami to be agreed upon in consultations between the Fijian staff and the Japanese experts.
2) That no change is made in the existing R/D.
3) That the Fiji side provide necessary facilities and allocate Fijian counterparts to the freshwater prawn experts.

(2) Others

Due to delayed construction of the infrastructure and hatcheries and to trouble such as death of larval prawns from unknown causes soon after hatching, the experimental trial production farms strongly desired by the Fiji side could not be realized within the cooperation period. Except for this point, however, it was believed that the Project progressed as scheduled for the most part.

4. RESULTS AND EVALUATION OF THE PROJECT

4-1 *Results of Project Activities*

4-1-1 Results of Activities for Freshwater Fish

Since Grass carp (ctenopharyngodonidella), a freshwater fish of Chinese origin, feed on water plants in rivers and for this reason, they are transplanted to various parts of the world for clearing of these plants. Grass carp were introduced into Fiji from Malaysia in 1968 for the first time. Subsequently, import was tried several times and seed production was planned in 1974. The present Naduruloulou Freshwater Culture Station was established in 1976. The Project was started in 1982 with artificial hatching succeeding in 1985 for the first time in Fiji. The foundation of the plan for river liberation was established by 1987 when the Project was completed. Additionally the self supply of hormone necessary for the artificial seed stock collection from grass carp was successful as was the seed stock production for freshwater fish such as silver carp (hypophthalmichthys moritrix) and big head carp (aristichthys nobilis) for the purpose of polyculture. The results of the activities are outlined in the following:

(1) Adult Fish Breeding

Yearly systematic production of seed stock requires the securing of good adult fish. This in turn necessitates the appropriate control of adult fish.

1) Control of the Pond

If sampling and handling up are taken into account, the pond design of which control is most easy is a rectangular one 1,000 - 2,000m^2 in area and about 1.5m in depth, provided with necessary facilities for water supply and drainage. Male grass carp controlled in good condition can discharge sperm by the end of about two years growth. Since it generally takes 4 - 5 years, it is preferable to divide the ponds to rear fish according to age or maturity. For small-shape fish of 0 age and up to 2-3 kg in weight, a pond larger than the above-mentioned one can be used as they are not handled so frequently. The standard stocking density is 100-300 g/m^2 in general; but as for the ponds at Naduruloulou, since the fry and eggs of tilapia and other fish grown in them were mixing via the intake gates, it is proper to keep the density of less than 200 g/m^2 for safety's sake. The amount of water to be exchanged should be increased as much as possible in view of the deteriorated quality of water due to feeding, however, water was exchanged based usually on the standard volume of one rotation per week, in view of economy. The volume was doubled as the spawning season neared. Polyculture with silver carp and prawns is possible in these adult fish ponds.

2) Feed

As a result of the examination of feed for adult fish breeding, the following methods showed the most economic effect:

Table 6 Daily feeding rate by feed

Feed	Rearing period April-August	Spawning season September-March
Paragras	20-40	40-50
Assorted feed	2-4	1-2

Table 7 Composition of assorted feed

Ingredient	Composition
Fish meal	40
Rice bran	40
Coconut meal	10
Wheat germ	10

Additionally, good results were produced using feed mixed with the meat of bivalve caught in the Rewa River and bean sprouts instead of fish meal. Since the time cost of this feed were everly high feed of the composition shown above was recommended. Feeding was conducted once a day in the early morning. The amount of feed was reduced if the water temperature was high or the fish were inactive.

3) Sampling

Sampling of adult fish from the ponds was conducted once a month to examine the degree of growth and maturity. At the same time the proper amount of feeding was calculated according to the results of the examination. As a result of this calculation, it was found that the young adult fish group of 2-3 years in age was maturing and growing faster than the old group of 6 years or more in age, and thus the feeding amount was increased at a faster pace. In sampling, the use of narcotics was more effective to prevent the fish from stress.

4) Spawning Season

In Japan, the spawning season is said to usually be from May to June but, in Fiji, it seemed to continue from mid-September to mid-March judging from the maturation of the ovaries. Eggs of silver and big head carp could be removed in late September. For grass carps, egg removal was implemented from October to March. The time of maturation is a little earlier for male fish than for female fish, however, being from September to about January. Therefore, the optimum season of egg removal is believed to be from October to about January.

5) Selection of Adult Fish

The recognition of male and female grass carp before maturation is very difficult, but at the time of maturation or in the spawning season it becomes possible to distinguish them by the pectoral fin. The surface of the pectoral fin becomes rough in the male but it stays smooth in the female. If a male fish is pressed at its belly, milky sperm is discharged from the cloaca, for a female fish the cloaca is swollen pink. Usually, grass carp mature at five years or more in age, or 6 kg or more in weight. In Fiji, if the breeding is well controlled some fish discharge sperm at about 2 years in age and 2 kg in weight.

(2) Artificial Egg Removal

1) Adult Fish for Egg Removal

Sufficiently matured fish taken up from the adult fish pond and injected with hormone under anesthesia were put in the spawning tank. The fish density was adjusted to 100-150 g/m^2 and the ratio of female to male is 1:2 or 3 so that male become larger in number.

2) Spawning Tank

The existing water tank (7.0 × 6.3 × 1.4m) made of cement was used for the spawning tank. In addition, a circular prefabricated tank (ϕ8m × 1.4m) was set up to use as the spawning tank; a water flow generator was installed to stimulate the spawning and an egg collector was installed to gather discharged eggs. Since this tank is about 50m^2 in area, the appropriate number of fish to be placed is 5-7 fish if adults of 10kg on average are used. Thus it is proper to place 4-5 male fish in for every 2 female fish.

3) Hormone Injection

As mentioned above, the mature fish taken up from the adult pond are injected with hormone and transferred to the spawning tank for spawning. The most effective hormone for this purpose is a pituitary extracted from a mature silver carp. The fresh pituitary extracted from silver carp is immediately dehydrated using acetone and immersed in anhydrous acetone liquid to freeze for storage. The powder is then disolved in physiological saline water for use. Normally, one pituitary can be obtained from one silver carp, its dried substance is 5-8mg in weight. The injection is performed at the lower root of a pectoral fin. Although, in Japan, the usual amount of injection is 5mg per 1kg in weight of fish to be applied in one dose, in Fiji a multiple dose method was implemented. This method has the advantage that a smaller amount of hormone is required but care must be taken in handling, as the fish becomes susceptible to stress.

In the case of the multiple dose method, the first injection was applied only to female fish, 0.6-0.8mg per 1kg of body weight. A second injection of the same amount was applied to male fish, and the female was injected with 1.2-1.6mg per 1kg of body weight. In either method, spawning began 12-24 hours the first dose. If no spawning excurred, a third dose (0.6-0.8mg/1kg) was applied in some cases but with a low rate of success. In order to make the fish spawn during the period from dawn to early morning while it is calm and in water temperature is low, the first injection was preferable to be performed around the noon (11.00-13.00 hour) of the preceding day. If possible, a cloudy or rainy day when the water temperature was not so high was more desirable.

(3) Hatching and Feeding

1) Egg Collection and Hatching

Fertilized eggs discharged in water absorb water and swell to about 5mm in diameter. Since the eggs float, they are sent into the egg collection tank by the water flowing out from the overflow. The eggs collected are transferred to the hatching tank to which water circulation and ventilation are applied, and after 18-20 hours they hatch if the water temperature is about 26-28°C. For hatching, a conical tank of 200 liters and a flat-bottom circular tank were used. The proper density of eggs placed in these tanks was 150-200 eggs/liter.

2) Feeding of Sac Fry

Sac fry absorb the yolk by moving up and down only for about 2 days. Subsequently, as they become able to swim horizontally they begin to gradually eat feed. After having been reared in the tank by feeding for 8-10 days the fry were transferred to the nursery pond. The yolk of boiled egg was often used as bait for feeding. The amount of feeding was one yolk a day for 10 thousand fry and it was increased by 10% every day and fed by dividing into 5-6 times a day.

(4) Seed Nursing and Liberation

1) Seed Pond (nursing pond)

Sac fry whose feeding was completed were transferred to the nursery pond. Several nursery ponds, 300m^2 each, were used. Ponds drained 10-12 days before the transfer of fry and dried by sunlight were filled with water filtered through a screen of 1-2mm mesh after small fish and other organisms were removed. They were then fertilized usually with 25kg/100m^2 of fowl droppings. When plankton had begun to grow after 2-3 days the fry were released in the pond. The stocking density was usually 1500-2500 fry/m^2 for 20mm-size fry. In Fiji, as the control of fry was difficult due to high water temperature the stocking density was limited to 100-150 fry/m^2. The fry grew up to 4-5cm size after rearing for 40-60 days, with a yield of 70-80%.

2) Feed

Although the fry prey on plankton grown in the pond, the yolk of boiled egg was given as a supplement for 8-10 days after release to create some continuity from the larval fish period. Subsequently, the previously mentioned assorted feed for adult fish was given several times a day.

3) Liberation

Fry reared in the nursery pond for 40-60 days were caught with a net of 3-5mm mesh and placed once in a tank or kowari-type crawl provided additionally. Among these fry, large-size and lively ones were retained as adult fish candidates and the remainder was used as liberation candidates. The fry to be moved for liberation were usually put in a polyethylene bag (75 × 60cm) with 5-6ℓ water and oxygen gas enclosed in it for transport to the river. Although the amount of fish to be put in one bag differed depending on the temperature, time necessary for the move, and size of fish, about 3kg of fry could be put in one bag on average. In Fiji, as the spawning season continues for several months, this operation (from egg removal to liberation) can be repeated several times in one season.

(5) River Survey

The river survey was made once a month to examine the growth of the grass carp released in the rivers (mainly the Rewa), the status of sexual maturation, natural spawning (drifting-down eggs), appearance of fry, and thickness of water plants. As a result, mature fish were discovered several times. Topography which seems suitable for spawning is present in the upper stream of the Rewa River and from this fact the possibility of natural spawning is inferred. The river surveys made during the project period, hwoever, could not discover any drifting-down eggs or fry produced by natural spawning. As for water plants which grass carp feed on, the thickness tended to decrease yearly and this was considered to be the result of the liberation. In addition, for the planning of the liberation to be implemented yearly, the technology transfer was implemented regarding the examination of the proper number of fish to be released in each river.

4-1-2 Results of Activities for Freshwater Prawn

(1) Giant River Prawn

Giant river prawns (macrobrachium resenbergii) are of Malaysian origin. They are the largest in size among oriental river prawns (macrobrachium niphonese). Research has been conducted on them in Hawaii and they are cultured at various places in Southeast Asia. The giant river prawn was introduced into Fiji in 1979 for the first time.

1) Seed stock production

It is desirable to locate the hatchery at a place where freshwater and seawater of good quality, not contaminated by agricultural chemicals, can be obtained easily. At Naduruloulou, freshwater could be taken from the Rewa River without any trouble, but as seawater of good quality could not obtained from a nearby source, seawater pumped up at the Oyster Research Institute was carried by a tank lorry to the hatchery. Although hatching tank used for mass production are usually rectangular, at this hatchery, 20 conical tanks (each of 500 l) were used by placing them side by side. Since this method allowed the largest amount of egg delivery per unit volume of rearing water it was possible to reduce the amount of water used.

a) Adult Prawn

After selecting large-size and lively prawns, eggs were collected from the adult prawn pond and put in a 20% formalin solution for 30 minutes as a medical bath. Each prawn was placed individually in the hatching tank to wait for hatching. For rearing water, 5% seawater was used. The fecundity of a prawn of 10cm in body length is 1-3 thousand eggs at a time. After the eggs hatched the adult prawn was removed from the tank.

b) Control of Larval Prawn

The rearing water after the eggs hatched was increased in its seawater density gradually so as to become 8-12%. The water temperature was kept at 26°C-31°C and rapid fluctuations were avoided Ventilation was maintained at all times. In order to keep the rearing water in good condition, bait remaining was removed after breeding and 80% of the water exchanged once every 2 days.

c) Feed

Artemia and cow liver were used for feed. Larval prawns were fed with artemia twice a day from the second day. The amount of feed was controlled so as to become 1-5 artemiain 1mℓ of rearing water. Cow liver was fed from the 7th day (stage IV). Artemia eggs of 8 g and cow liver of 60 g were used for one tank of 500ℓ.

d) Post Larva

Larval prawns repeat metamorphosis 12 times, from stage I to stage XII, to become post larvae finally. Usually this requires 30-35 days. Prawns are placed in the hatching tank at a density of 30-50 prawns per 1ℓ. If controlled in good condition, 80-120 prawns can be placed in a tank it. When the metamorphosis of post larvae begins from about the 25th day, the seawater density is gradually reduced so as to become 7-8%. Upon completion of metamophosis, the post larvae were transferred to the large size tank (2,000 ℓ) and the water was reversed to freshwater within 2-3 days. Further, the post larvae, having been reared in the large-size prefabricated tank for 1-4 weeks, were released into the rearing pond.

2) Intermediate Breeding

When the post larvae produced in the hatching tank were transferred directly to the rearing pond the survival rate at the time of final cropping was low and the rate fluctuate greatly. A trial was made releasing post larvae once they had been bred intermediately, instead of transferring them directly to the culture pond. Experiments were made five times by using a prefabricated tank. In these experiments, investigation was made into the avoidance of excess feeding; improvement of the water quality by exchanging the rearing water at an increased rate; restrained growing of green dust; and the proper condition for rearing. The experiments found that although no satisfactory result was produced by intermediate breeding using the prefabricated tank, such a tank is effective fore temporarily storing the post larvae produced from seed stock until they are transferred to the rearing pond. In this case, the stocking density was less than 800 prawns/m^2. Usually the optimum density was 400-600 prawns/m^2 and good results were produced by limiting the period to less than 4 weeks.

3) Rearing

a) Preparation of the Pond

Before stocking prawn post larvae, the water of the pond is drained off with the all fish removed. Sprinkling rotenone or other agents is used to kill fish. Then, lime of 50-100g/m^2 is scattered to improve the quality of earth. The pond is filled with the water that has been filtrated to remove any fish egg or larva. Fowl droppings of 100 g/m^2 are spread for fertilization. The water of the pond becomes green after a week.

b) Stocking of the Post Larvae

The post larvae are released in the pond prepared. It is important to know the proper stocking density. If the number of released prawns is too many, a longer time is necessary to allow them to mature to marketable size. If the number is excessively few, they will mature fast but the amount of production will be less than optimum. In Fiji, the number has been set at 5 prawns/m^2.

c) Feeding

In a large pond, prawns are normally cultured by ordinary feeding methods but, in Fiji, because of the many small-scale ponds and relatively low water temperature, supplementary feeding is necessary. In Fiji, pellet feed for raising chickens that is available at low cost was used for feeding. The feed was spread at the periphery of the pond every day and the next day the amount remaining was examined for purposes of regulating the amount of feed. Based on the ratio of 5% of the body weight, feed added or reduced accordingly.

d) Harvesting

The prawns are harvested from the pond using a fishing net of 1.5-2 inch mesh. Growth of prawns varies widely, with some of them growing to 50-70 g in the fifth month after release while some to only about 10 g intermixed. The prawns are harvested 5-6 months after stocking and those of marketable size are selected for distribution among other districts. The smaller ones are returned to the pond immediately. Since too many harvesting tends to cause the death of smaller prawns, care is necessary for a successful operation. Harvesting is repeated in the same way after 1-2 months and the pond is drained to about a half of its water after 10 months to harvest the remaining prawns with the fishing net. Every prawn missed by the net is picked up after the pond is drained completely. Smaller prawns remaining are transferred to some other pond to mating.

(2) Native Species

Several macrobrachium species live in the rivers in Fiji and are utilized by the local residents. Among them, M.lar species are found to be distributed the most densely. Others are M.equidens, M.australe and M.lepidactyloides and are distributed widely. These native species are locally sold at F$6.50-7.50/kg. M.lar grows to 200-300 g but other species are small in size, about 20 g. Thus, for M.lar species, experimental seed production was attempted to determine whether or not this species would be suitable to culture.

Prawns carring eggs that were collected in the Nabukavesi River were brought back to Naduruloulou for an artificial hatching experiment. Pearing was attempted by varying the density of seawater.

In freshwater, larvae died within 3 days after hatching. When 20% amount of seawater is mixed in freshwater, some of larvae survived to stage II but died after 8 days. When 60% amount of seawater mixed, most died in 3-4 days, while only some survived to stage III. When 80% amount of seawater mixed, larvae survived for 12 days and some reached stage V. In 100% seawater, larvae were more lively than at any other experimental farm but almost all of them died after 12 days. These results, helped to show that for hatching and rearing of M.lar species, seawater which is higher in density than that for giant river prawn is necessary. However, the gamete production did not succeeded. Much research has been done on M.lar by other researchers but the zygote production of this species was more difficult to understand, than that of the giant river prawn. No advantages could be in terms of using it as a species for culture.

4-1-3 Results of Feeding Activities

The artificial hatching of grass carp succeeded during the first period of the Project. The amount of fish being reared at Naduruloulou including grass carps, tilapias and other fish increased every year to eventually reach nearly 4 tons for the amount stocked in the ponds. The amount of assorted feed that is necessary has increased to nearly 100 kg per day. Chicken pellets that are available at the local market were used as supplementary feed for a breeding experiment for freshwater prawns. Satisfactory growth of fish would not be achieved with this feed. Thus, a multipurpose machine for feed manufacturing was introduced experimentally in the second period of the Project. The machine can manufacture various types of feed on an experimental basis and also be used for practical use while capable of manufacturing 150 tons of pellets a day.

(1) Feed Manufacturing Machinery

1) The Fish Meal Manufacturing Machine
   50-24 kg raw fish were dried at a time by seting them on the machine, and rotated. It takes 6-8 hours to dry out 240 kg of fish. An oil boiler is attached to it.
2) Hammer Mill
   This machine pulverizes feed materials. The milling capacity is about 20 kg/h although it varies considerably depending on the materials.
3) Feed Mixer (2 units)
   The small-type mixer can mix materials of 20 kg a time and the large-type one-80 kg a time. The time it takes for mixing is about 10 minutes.
4) Pellet Molding Machine
   Moist pellets of different sizes can be molded by changing the diameter of the mesh plate. Dry pellets for prawn can be manufactured by drying 2-4 mm in diameter pellets. The molding capacity is 100 kg an hour.

5) Pellet Dryer
The rack-type pellet dryer can dry pellets of 100-150 kg at a time and it takes 6-8 hours to dry them.

6) Crumbler
Dried pellets are pulverized to a suitable size according to the size of the organism to be fed.

7) Rotary Sifter
Pulverized pellets can be sifted to 4 sizes – extra large, large, medium and small.

8) Fish Cutter
A frozen block of fish can be cut to a suitable size.

(2) Materials of Feed
Table-8 lists materials which can be obtained in Fiji when needed. In Fiji, PAFCO, a canning company that manufactures canned tuna, skipjack, etc., produces 1,000 tons of fish meal a year. Also, the Fisheries Division established a processing and marketing company (EMA) to promote the distribution of fishery products and is making efforts to spread them. The unused parts of the fish from this factory can be used to manufacture fish meal by drying them using the fish meal manufacturing machine. However, de-fatted soya bean meal cannot be obtained in Fiji where there is no oil mill for pressing soya beans.

Table 8 Feed Materials

Materials	Price F$.kg	Crude protein %	Crude fat %	Ash %
Fish meal (on the market)	0.64	53.4	5.9	10.3
Fish meal (home-made)	0.40	673.0	9.8	18.5
Soya bean meal	0.65	47.5	0.5	6/0
Wheat flour	0.28	2.0	1.2	1.5
Wheat bran	0.13	16.0	4.3	5.0
Broken rice	0.30	–	–	–
Rice pollard	0.15	13.0	0.6	3.5
Copra meal	0.14	21.0	5.8	–
Maize	0.26	9.0	4.0	1.4

(3) Experiment on Feed for Prawn
Feed of 21 kinds in total for prawn was manufactured by way of trial by using the said feed manufacturing machinery and the experiments were implemented 8 times. The experiments were made by using four 500-l tanks each with 8 prawns placed in it, four 1-ton tanks each with 10 prawns and five 2-ton tanks each with 15 prawns and the prawns of 1-3 g in weight were used in each experiment. The period of one experiment was 90 days. In the first half period, No.7 and No.9 trial feed resulted in good growth and, in the second half, No.17 and No.18 trial feed showed a good result as shown in Table-9.

Comparative experiment between the feed which showed good results in the above experiments with chicken pellets found that No.17 and No.18 trial feed produced the best results and the chicken pellets were the worst. No.17 and No.18 are of almost the same composition and the former is added with vitamin mix and mineral mix made in Japan. However, as these materials are difficult to obtain because of their high cost No. 18 trial feed is added with wheat germ instead of them.

Different from Japan, semi-extensive culture is carried on in Fiji and thus the feeding is supplementary to natural feed. Therefore, addition of a very small amount of nutrients was not considered so important and the emphasis was laid on economy. The composition of feed manufactured on an experimental basis is shown in Table-9.

Table-9 Composition of experimental feed for prawn

(%)

Material \ Trial feed No.	7	9	17	18
Fish meal	40	30	25	25
Soya bean meal	10	10	10	10
Wheat flour	20	25	25	25
Wheat germ	10	–	–	10
Wheat bran	10	–	–	–
Rice pollard	–	20	25	20
Copra meal	10	15	10	10
Mineral mix	–	–	4	–
Vitamin mix	–	–	1	–

4-1-4 Results of Activities for Seawater Shellfish

(1) Native Species and Environmental Survey

A survey of the environment and ecological research on native oysters were done as one of inquiry into the possibility of culturing suitable shellfish. As for the environmental survey, since the selection of suitable species and sites for culture could not be determined because of insafficient data, the water temperature and salt concentration were measured twice every day in the morning and the evening, and the degree of clearness and amount of plankton were measured once a week at principal places. Also, the intertidal observation were made once a month, and resulted in valuable data. Mangrove oysters were selected as a local oyster, and the study of the gonads over the entire year found that the spawning season is from December to March. The natural seed stock collection experiment made it clear that the proper seed stock collection season is from January to April. Trial cultures were made by using the spat obtained from the zygote collection experiment.

This made clear that spat grow fast in the initial period to 39 mm in 3 months and 50 mm in 5 months, but subsequently the growth slows down, with growth concluding at 6 cm after a year.

(2) Introduced Species

As for introduced species, the seed stock of the Japanese oyster, as the main object of this shellfish project, were carried in from Japan. Experiments in their culture were tried at 3 sites; Oyster Laboratory at Laucala Bay, Bay of Islands and Fattening Area. In these experiments, the spat suffered a great deal from predatory fish (from tetraodonidae in particular) and one third were devoured in one day. However, new knowledge which had not been recognized in any previous experiment made in Fiji was obtained and the trial culture was carried on with wire net fencing. Among the culture sites, the site in front of the Oyster Laboratory produced the worst results, perhaps due to the strong effect of the freshwater from the Rewa River. Fattening Area showed the best results. Regarding the period of introduction, a high level of death occurred in a period of high water temperature (March) in this country, but relatively good results were produced in November. Also, new knowledge was able to be obtained from the results of these experiments. The death of oysters in large amounts was recognized as occurring during the maturation period. In this country, however, the seed stock unit of a Japanese oyster is expensive with high air shipping costs, and unit cost becomes at about ¥40. Adding the expenses of fencing, even if 10 seeds survive from one collector it is impossible to be cost-effective. As the survival of 10 seeds could not be expected, judging from the results of the experiments, it was thought that the economic efficiency would be a problem, given the personnel expenses, toal costs and the expenses of the facilities were taken into account. Another oyster as an introduced species, the oysters that grow near Mago Island (crassostrea echinata) were transplanted for culture experiments, but no good results were produced.

Also as shellfish of an introduced species, a culture of green mussels was tried. The culture experiment of green mussels acquired from Tahiti had fencing for protection from predators, and it resulted in a favorable survival rate of 83% and data that they grew to 57 mm, on the average, in shell length after a year is fairly reliable.

4-2 Attainment of Objectives of the Project

4-2-1 Freshwater Fish

(1) Establishment of Techniques for Mass Seed Production (Attainment of 100%)

1) Adult Breeding

Usually, for grass carp, fish cannot be used as adult fish for egg removal until they are 5-years old, or 6 kg or more in weight. Planned annual production of a large amount of seed stock requires control of adult fish so taht mature fish of superior quality can be secured every year. Techniques to obtain mature fish earlier than usual were established through improvement of pond control techniques and feed. (Attainment of 100%)

2) Egg Removal using Hormones

The egg removal using hormones was successful by the 3rd year of the Project. Subsequently, the multi-dose method was examined in order to reduce the amount of valuable hormone used. At the same time, the zygote-collection and rearing methods for silver carp were established that enabled hormone collection on the spot, and the technology transfer was completed for this. (Attainment of 100%)

3) Fry Rearing

According to the initial plan, sac fry transferred to the pond were to be reared for 4 months for liberation and the yield was set at 50%. However, the hatching in many ponds was insufficient, and yields decreased. Therefore, an expedited growth of the fry was promoted by focusing on improving the breeding method, decreasing the stocking density and using feed of superior quality. Also, improvement of the yield was attempted by releasing the fry months after breeding. (Attainment of 80%)

(2) Rearing Experiment (Attainment of 80%)

1) Rearing of Grass Carp

The situation is the same as that afor breeding adult fish candidates. Additionally, the one-year culture method was examined as was its economic efficiency. (Attainment of 80%)

2) Polyculture Experiment

The polyculture was planned to be implemental during the second period of the Project, but satisfactory data could not be obtained due to the repeated flood damage suffered from April to June in the previous year. (Attainment of 70%)

(3) Liberation and River Survey (Attainment of 100%)

1) Liberation of Fry

During the Project period, 4 rivers (Rewa, Waindalice, Navua and Korovou) were stocked with more than 120 thousand fry in total. Although in the original program the liberation of 150 thousand fry was planned for one season, the target could not be reached due to the decreased yields of sac fry from the situation in the ponds. However, as the techniques of adult breeding and egg removal have been sufficiently established, the target is believed to be fully attainable in future. (Attainment of 90%)

2) Effect of Liberation

During the river survey that was conducted after liberation, grass carp of more than 4 kg frequently were caught frequently in the Rewa River. According to the information that was received, some local fishermen had caught grass carp. The percentage of the yield of the liberation is not clear. However, it is clear that the fry released are growing in the rivers. Also, the clearance of grass in the rivers has been effective judging from the decreasing number of water plants (hydrilla) year by year. (Attainment of 100%)

3) Survey of Flowing-Down Eggs and Fry

One type of river survey carried out, was a survey of drifting-down eggs and fry. This survey was implemented because some mature adult fish were detected in the rivers. Also, the possibility of natural spawning was suggested by the existence of suitable topography for spawning in the upper section of the Rewa River. However, no eggs or fry were discovered during the Project period. The fry released in large numbers will mature in the coming 1 or 2 years and the possibility of discovering some of the drifting-down eggs is anticipated. Regarding the survey techniques and the treatment of the information after its discovery, since the technology transfer has been sufficiently conveyed to the counterparts, results of the survey can be expected in the future. (Attainment of 80%)

4-2-2 Freshwater Prawn

(1) Establishment of the Mass Seed Stock Production Techniques (Attainment of 120%)

In the initial program, the yield planned for equalled 150 thousand prawns, and the figure for yields four times a year equalled 600 thousand prawns. Despite the delays in the program caused by the death of prawns in large numbers that occurred, midway through the first period of the Project, techniques for producing 500 thousand prawns at a time, or 2 million prawns a year, were established through improvements in the feed and in control techniques.

(2) Intermediate Breeding (Attainment of 80%)

An Intermediate breeding experiment was implemented through the use of prefabricated tanks for improving the yield of pond cultures. Because of the difficulties involved in rearing cultures in a tank such as the deterioration of water quality, green sediment growth and fluctuations in water temperature, long-term intermediate breeding at high stocking densities was difficult. However, by reducing densities from those originally planned, the tank was found to be an effective substitute for a stocking pond for seed stock for the first 4 weeks.

(3) Rearing Experiment (Attainment of 70%)

In the second period of the Project, the experimental ponds were constructed at the Naduruloulou pond in making efforts to improve the rearing control techniques. Production amounts varied widely, but over 100 g/m was produced annually optimum under conditions. However, the average was lower than this. If the development of feed for which the technology transfer has been completed is attained, increase in production can be expected.

(4) Native Species (Attainment of 90%)

For freshwater prawn, giant river prawn has been the subject of large-scale advanced study as a species suitable for culture. Any prawn found locally is considered for culture, the advantageous being that it is already suited to the environment. Therefore, surveys were conducted on the macrobrachium species of Fiji. A large member of the species was to be selected for further study to determine if it shoudl be cultured. The seed stock production proved to be more complicated than that of giant river prawn and no advantages could be found as a species for culture.

4-2-3 Fee

(1) The Installation of Machinery (Attainment of 100%)
The machines installed are suited to local conditions and can be used for various manufactuaring experiments, such as making fish meal from dried fish scraps, pulverization, the mixing of materials, the molding and drying of pellets, and can also be used for practical purposes.

(2) Manufacture of Feed for Freshwater Fish (Attainment of 90%)
The machines were utilized as a mixer and kneader of feed mainly for grass carp, in order to save manual labor. Pellets were made to prevent the feed from being scattered and lost in water. The machine were also used to mix medical agents in the feed in the event of an outbreak of any disease.

(3) Feed Test for Prawn (Attainment of 90%)
Various test samples were manufactured on an experimental basis to develop a feed which promotes more rapid growth of prawns than the formerly used chicken pellets. The technology transfer to the counterparts was completed for the purpose of examining the effects of the samples, including the economic efficiency of the sample, through breeding experiments in the ponds at a later date.

4-2-4 Seawater Shellfish

(1) Native Species and Environmental Survey (Attainment of 80%)
The surveys of the environment for and the sites suited to oyster culture were implemented. An ecological investigation was made into selecting mangrove oysters as native species. This species showed no suitablility for culture but valuable data were accumulated.

(2) Introduced Species (Attainment of 80%)
Oysters (crossostrea) of Japanese origin were introduced to implement culture experiments. Various problems were made clear and valuable data were obtained. The culture experiments for Mago Island-born oysters and green mussels from Tahiti were implemented and basic data were accumulated.

4-3 Summary of Evaluation

(1) Technical Evaluation
Regarding freshwater fish the principal goals are to remove water plants from the rivers by stocking them with grass carp, and at the same time, to increase the production of animal protein resources. The Project attained these objects by establishing the techniques to produce seed stocks of grass carp, Puntius (gorinotus), silver carp, and big head carp, and by confirming the effects of the liberation of these fish.
As regards freshwater prawns, techniques of mass seed stock production were established for the giant river prawn but the completion of the rearing techniques was delayed due to the change of the site midway through the Project and problems such as the death of larval prawns soon after hatching. The technology transfer was , however, completed sufficiently enough to have transferred the basic techniques about how to progress with subsequent research.

Although a plan for feed was established initially, it was only started in the second period of the Project because all possible efforts were directed mainly at developing the techniques of seed stock production. The techniques were transferred on how to install the machines, how to use feed prepared on an experimental basis and how to undertake feed tests. The techniques are already being utilized effectively for the rearing of grass carp and telapias. As regards the feed for prawns, the feed tests in tanks were completed and the techniques for putting it to practical use were transferred to the counterparts.

The experiments on the marine shellfish had been continued independently of the others from before the start of the Project, but no data were accumulated, nor were any problems clarified. Although the Project did not result in the development of a technique for oyster culture, the fact that the methods for undertaking developmental research accumulating data were established and that the controversial points were clarified can be said to be the the Project's important achievements.

(2) Operational and Administrative Evaluation

Team-work is important for any project. The cooperation among different experts is as important as the ability of each individual expert. As noted before, the role of the team leader is to control the progress of the whole Project, to solve detailed technical and human problem, and at the same time to promote the close connection with the counterpart team. This is very important. In this Project, after the first leader returned home at the expiration of his term of office, the post was left vacant for about one year due to circumstances on the recipient country side. It cannot be denied that a certain gap was created in the relation ship between the two parties despite of the endeavors of the coordinator substituting the leader.

(3) Project Site

At the Naduruloulou Laboratory, the site of this Project, one third of the ponds were submerged at least once every year due to floods, two thirds of them were submerged once every 2-3 years. Fortunately, since the seed stock production facilities located on high ground met with no flood during the project period, the development activities for seed stock production were not obstructed in particular. The breeding experiment in the ponds, however, suffered from submersion almost every year and this hurt development activities. The Naduruloulou experiment site was constructed in 1974 with the cooperation of the FAO. It has suffered from flood damage several times thereafter, and due to heavy flooding damage in April, 1980, the valuable adult grass carps fled into the Rewa River. In spite of such serious shortcomings it was important to locate the Project site at Naduruloulou because the very complicated landownership in Fiji, which makes it difficult to use a site even if it was suitable. The use of the Naduruloulou site was also strongly desired by the Fiji side. The site for prawn culture was initially planned to be located on the grounds of the Fisheries Division at Lami. Eventually, the use of the Naduruloulou site was inevitable due to deficient freshwater supplies and other problems as described in section 3-4.

The freshwater prawn breeding experiment was considerably obstructed. The importance of site selection was confirmed once again, though types of problems are unavoidable in cooperation projects in developing countries.

APPENDICES

1. The Record of Discussions (R/D)

The Record of Discussions between the Japanese
Implementation Survey Team
and the Authorities Concerned of the Government
of Fiji on the Japanese Technical Cooperation
for the Aquaculture Research and Development Project

The Japanese Implementation Survey Team (hereinafter referred to as "the Team") organized by the Japan International Cooperation Agency (hereinafter referred to as JICA) and headed by Dr. Sho Morita, Chief of Research Planning and Coordination Division, Tokai Regional Fisheries Research Laboratory, Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries visited Fiji from November 4 to November 19 for the purpose of working out the details of the technical cooperation program concerning the Aquaculture Research and Development Project in Fiji.

During its stay in Fiji, the Team exchanged views and had a series of discussions with the Fijian authorities concerned in respect of the desirable measures to be taken by both Governments for the successful implementation of the above-mentioned Project.

As a result of the discussions, the Team and the Fijian authorities concerned agreed to recommend to their respective Governments the matters referred to in the document attached hereto.

November 18, 1981

Dr. Sho Morita
Head of the Japanese
Implementation Survey Team

Dr. P. C. Hunt
Chief Fisheries Officer
Ministry of Agriculture and Fisheries

THE ATTACHED DOCUMENT

I. COOPERATION BETWEEN BOTH GOVERNMENTS

1. The Government of Japan and the Government of Fiji will cooperate with each other in implementing the Aquaculture Research and Development Project (hereinafter referred to as "the Project") for the purpose of developing freshwater and marine culture, particularly grass carp and other carp, macrobrachium species and shellfish, mainly oyster, which will provide the rural people with protein and substitute imports of fisheries products.
2. The Project will be implemented in accordance with the Master Plan which is given in Appendix I.

II. DISPATCH OF JAPANESE EXPERTS

1. In accordance with the laws and regulations in force in Japan, the Government of Japan will take necessary measures through JICA to provide at its own expense services of the Japanese experts as listed in Appendix II through the normal procedure under the Colombo Plan Technical Cooperation Scheme.
2. The Japanese experts referred to in 1 above and their families will be granted in Fiji the privileges, exemptions and benefits no less favourable than those accorded to experts of third countries working in Fiji under the Colombo Plan Technical Cooperation Scheme.

III. PROVISION OF MACHINERY AND EQUIPMENT

1. In accordance with the laws and regulations in force in Japan, the Government of Japan will take necessary measures through JICA to provide at its own expense such machinery, equipment and other materials necessary for the implementation of the Project as listed in Appendix III, through the normal procedures under the Colombo Plan Technical Cooperation Scheme.
2. The articles referred to in 1 above will become the property of the Government of Fiji upon being delivered c.i.f. to the Fijian authorities concerned at the ports and/or airports of disembarkation, and will e utilized exclusively for the implementation of the project in consultation with the Japanese experts referred to in Appendix II.

IV. PROVISION OF SPECIAL MEASURES

For fostering the smooth promotion of the Project, in accordance with the laws and regulations in force in Japan, the Government of Japan will take necessary measures through JICA in order to supplement a portion of the local cost expenditures for the execution of the physical infrastructure such as construction work of water supply and fencing when necessity arises.

V. TRAINING OF FIJIAN PERSONNEL IN JAPAN

1. In accordance with the laws and regulations in force in Japan, the Government of Japan will take necessary measures through JICA to receive at its own expense the Fijian personnel connected with the project for technical training in Japan through the normal procedures under the Colombo Plan Technical Cooperation Scheme.
2. The Government of Fiji will take necessary measures to ensure that the knowledge and experience acquired by the Fijian personnel from technical training in Japan will be utilized effectively for the implementation of the Project.

VI. SERVICES FOR FIJIAN COUNTERPART PERSONNEL AND ADMINISTRATIVE PERSONNEL

1. In accordance with the laws and regulations in force in Fiji, the Government of Fiji will take necessary measures to secure at its own expense necessary services for Fijian counterpart personnel and administrative personnel as listed Appendix IV.
2. As to the Fijian counterpart personnel, the Government of Fiji will endeavor to allocate the necessary number of suitably qualified personnel corresponding to each Japanese expert to be dispatched by the Government of Japan as specified in Appendix II, to fulfill the effective and successful transfer of technology under the Project.

VII. MEASURES TO BE TAKEN BY THE GOVERNMENT OF FIJI

1. In accordance with the laws and regulations in force in Fiji, the Government of Fiji will take necessary measures to provide at its own expense:
   (1) Services of the Fijian counterpart personnel and administrative personnel as listed in Appendix IV;
   (2) Land, buildings and facilities as listed in Appendix V;
   (3) Supply or replacement of machinery, equipment, instrument, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than those provided through JICA under III above;
   (4) Transportation facilities and travel allowance for the Japanese experts for the official travel within Fiji;
   (5) Suitably furnished accommodation for the Japanese experts and their families.

2. In accordance with the laws and regulations in force in Fiji, the Government of Fiji will take necessary measures to meet:
   (1) Expenses necessary for the transportation within Fiji of the articles referred to in III above as well as for the installation, operation and maintenance thereof;
   (2) Customs duties, internal taxes and any other charges, imposed in Fiji on the articles referred to in III above;
   (3) All running expenses necessary for the implementation of the Project.

VIII. ADMINISTRATION OF THE PROJECT

1. The Chief Fisheries Officer, Fisheries Division, Ministry of Agriculture and Fisheries of the Government of Fiji will be for the administration and implementation of the Project and the Japanese experts will provide necessary technical guidance and advice for the implementation of the Project.
2. There will be close consultation on the matters concerning the implementation of the Project between both sides. For this purpose, the Joint Committee will e established with the functions and composition as specified in Appendix VI.

IX. CLAIMS AGAINST JAPANESE EXPERTS

The Government of Fiji undertakes to bear claims, if any arises, against the Japanese experts engaged in the Project resulting from, occurring in the course of, or otherwise connected with the discharge of their official functions in Fiji except for those arising from the willful misconduct or gross negligence of the Japanese experts.

X. MUTUAL CONSULTATION

There will be mutual consultation between the two Governments on any major issues arising from, or in connection with this Attached Document.

XI. TERM OF COOPERATION

This Record of Discussions will come into force on the date of signature and remain in force until March 31st 1985.

APPENDIX I. MASTER PLAN

1. The Project is to be implemented at the existing Naduruloulou Freshwater Culture Station for development of aquaculture production techniques of freshwater fish, and at the Lami Fisheries Office for basic aquaculture research and production of Macrobrachium species, and research into shellfish, mainly oyster. Experimental trial production farms will be established at Togalevu and Savusavu.
2. The activities of the project will comprise of:

   A. NATIVE SPECIES - SUITABILITY FOR AQUACULTURE.

   A-1 Collation of environmental and biological data on native species in order to determine their suitability for aquaculture.

   A-2 Examination of local species' characteristics.

   A-3 Production trials where warranted.

   B. EXOTIC SPECIES - INTRODUCTION AND PRODUCTION

   B-1 Liberation of selected species and assessing their establishment. This will include research into the suitable introducible species.

   B-2 Grass carp and other carps.

   (1) Experimental adult breeding (natural and induced) and production of various carp fry for distribution. This would include:

   1) egg collection, hatching and nursing
   2) fry production
   3) cultivation of plankton as feed.

   (2) Trial into pond culture including culture with other species (polyculture).

   Essential components would include grow out trials, nutrition and health control.

   B-3 Macrobrachium

   (1) Hatchery production of Macrobrachium seed for distribution.
   (2) Macrobrachium pond trials. This would include grow out trials, nutrition and health control.

   B-4 Shellfish (mainly oyster)

   Experimental trials in culturing suitable shellfish species and their seed production as required.
3. Technical cooperation to the experimental production farms will be extended as agreed by the Joint Committee, when the facilities described in Appendix V-2-2 are set up.

APPENDIX II. JAPANESE EXPERTS

1. Team Leader
2. Experts
   (1) Freshwater/Aquaculture
   (2) Freshwater/Brackishwater Aquaculture
   (3) Marine Aquaculture
3. Liaison Officer

Note:

Short-term experts in the field mentioned above and other fields may be dispatched in consultation with the Project Manager when necessity arises.

APPENDIX III. LIST OF THE ARTICLES

1. Machinery, equipment an material for seed production, seed collection and aquaculture research.
2. Machinery, equipment an material for environmental and ecological survey of aquaculture sites.
3. Machinery equipment and material for establishing aquaculture activities.
4. Work boats and vehicles (excluding passenger cars) necessary for the activities of the Project.
5. Eggs and seeds of freshwater fish, macrobrachium and shellfish, mainly oyster.
6. Other minor equipment, material and spare parts necessary for the implementation of the Project.

APPENDIX IV. LIST OF FIJIAN STAFF

1. Project Manager, the Chief Fisheries Officer of the Fisheries Division.
2. Counterpart Experts: at least
   (1) Freshwater Aquaculture (2)
   (2) Freshwater/Brackishwater Aquaculture (2)
   (3) Marine Aquaculture (1)
3. Technical and Research Assistants
4. Boat Operators
5. Clerical and Service Employees
6. Laborers

APPENDIX V. LIST OF LAND, BUILDINGS AND FACILITIES

1. Naduruloulou Freshwater Culture Station
   (1) Office (Administration and Research Buildings)
   (2) Experimental ponds
   (3) Experimental tanks and water supply system
   (4) Cage culture sites
   (5) Storage house and workshop
   (6) Utility services and other facilities necessary for implementation of the Project.
2. Lami Fisheries Office
   (1) Offices for Japanese Experts and a meeting room
   (2) Experimental trial production farms at Togalevu and Savusavu.
   (3) Workshop and storage house for Macrobrachium and oyster hatchery at Lami.
   (4) Other facilities necessary for implementation of the Project.

APPENDIX VI. JOINT COMMITTEE

1. Functions
   The Joint Committee comprising those members as listed under 2. below will meet regularly or as required to:
   (1) Formulate the annual operational plan of the Project.
   (2) Review the progress of the Project in line with the Master Plan.
   (3) Establish technical, budgetary and administrative procedures necessary for the implementation of the Project.
   (4) Recommend (to the respective Governments) the further necessary requirements for the successful implementation.
2. Composition
   (1) Chairman
   Permanent Secretary for Ministry of Agriculture and Fisheries
   (2) Fijian side ..... Chief Fisheries Officer
   Representatives of the Fisheries Division, Ministry of Agriculture and Fisheries. Representative of Ministry of Finance
   (3) Japanese side ..... Team Leader
   Japanese Experts appointed by Team Leader
   Liaison Officer
   Representative of JICA

Note:

Officials of the Embassy of Japan may attend the meeting of the Joint Committee as observers.

2. List of Main Machines and Equipment Granted

F.Y. 1982

Name	Specifications	Amount (yen)
Canter, Mitsubishi	3-ton truck, diesel	
Hilux, Toyota	LN46R-KR 4WD, diesel	1,307,800
Land Cruiser, Toyota	HJ47RP-K, pickup, diesel	1,698,840
Live fish tank	2-ton, for truck, FRP	1,029,600
Hatching tank	FRP, 500ℓ, conical bottom with stand, 21 units	6,420,960
Circular tank	FRP, MF-1100, 100ℓ, flat bottom, 10 units	1,445,600
Circular tank	FRP, MF 550, 500ℓ, flat bottom, 10 units	936,000
Rearing tank	FRP, rectangular, KF-2000 S, 2000ℓ, 10 units	2,373,840
Circular prefabricated water tank	ES-4 SR (900H), 9.6-ton, 3 sets	1,233,000
Circular prefabricated water tank	ES-5 SR (900H), 15-ton, 3 sets	1,515,000
Roots-blower	With engine, 3.3m^3/min, 400 mgϕ75m/m	1,030,000
Light tractor	Made by Kubota, L245DT, 4WD, with lawn mower, etc.	2,776,800
Gum boat with 3-HP outboard motor	With bottom board of over 5 × 2m, oars, and etc.	1,040,000
Diamond crossing wire gauge	2.3m/m (steel wire), 3.2m/m green, 212 sheets	2,544,000
Equal-angle steel	L-75 × 75 × 6m/m 5.5m, 298 pieces	1,147,300
Running-water sterilizer	UZ 110 MR	970,000
Circular prefabricated water tank	ES-8SR-1200H, with cover, 1.1-ton, 1 set	1,410,000
Circulating filter (15-ton)	For seawater, 3D-25, sand filter, with pump	1,330,000

F.Y. 1983

Name	Specifications	Amount (yen)
Binocular stereo-microscope with camera	Olympus XTR, PM- 10AD-2 type, 1 set	663,665
Universal biological microscope	Olympus 13HT-321 type, 2 sets	1,346,000
Universal projector	Nihon Kogaku, V-10 type	743,000
Salinity detector	Watabe Keiki, portable S-T, cable 10m	970,000
Large-size experiment stand	TR-RL-3, TR-NB-2, 2 units	1,198,000
Circular prefabricated water tank	ES 55 SR-1200 H, with cover, 10 sets	6,093,660
Circular prefabricated water tank	ES 5 SR-900 H, with cover, 10 sets	4,380,000
Prefabricated house	7.2 × 14.4, with 2 entrances	5,028,500
Copying machine	Contracted type, Mitamura, 2 sets	2,048,000
Toyota (2000 cc)	Station wagon, RX 60 RG-XWKDS, 2 cars	3,684,000
Set of raft materials for shellfish culture	Galvanized iron pipe, float, rope, etc., 3 sets	2,589,900
Electronic balance with printer	Shimazu, 200g/100mg, 200g/10mg	738,000

F.Y. 1984

Name	Specifications	Amount (yen)
Fry of grass carp and silver carp	60,000 fry	1,136,000
Fry of grass carp and silver carp	2,000 fry	1,140,000
Vinyl hose	Various size, 340 roles in total	1,910,000
Marine research instrument set	5 sets	1,050,000
Plankton net	Kitahara system vertical pulling, 7 sets	910,000
Purification ozonizer	For 10-ton water tank	2,800,000
Seawater salinometer	M 22/5, with cable of 50m	900,000
Supersonic wave washer	AV 300	744,200
Yasuda system water-wheel	0.75kW, underwater cord of 80m, 2 sets	680,000
Aeration cylinder	ECP-1/2 type, underwater cord of 80m, 2 sets	630,000
Camera set for microscope	PM-10-35 ADS-2 type, PMT-35 type, 2 sets	1,551,000
Outboard motorboat	40 HP, 25 HP, 15 HP, 3 boats	754,000
FRP boat	W-22 CF-1, sheet cover of 1 suit	849,000
Prefabricated storage house	2.5 ken × 3 ken, 1 house	900,000
Mitsubishi, Canter	3-ton truck, diesel	1,809,000

F.Y. 1985

Name	Specifications	Amount (yen)
Fry of grass carp and silver carp	50,000 fry	800,000
Artemia eggs	100 cans	680,000
Self-suction system pellet, with engine	Yammer 58-4 type, lift 17m, 700ℓ/minute	1,240,000
Mowing machine (Star)	Rotary cutter, MRC 150 C type, 1 unit	795,000
Light tractor (Kubota)	L-295 DT type, 1 unit	2,320,000
Towing net for pond (Hakodate Seimo)	Raschel webbing, 12m/m mesh size, 40 × 2.5m, 2 nets	750,000
Towing net for pond (Hakodate Seimo)	Raschel, 10m/m mesh size, 26 × 2.5m, 2 nets	830,000
Towing net for pond (Hakodate Seimo)	Raschel, black dyed, 28m/m mesh size, 41 × 2.5m, 2 nets	860,000
Wing net of towing net	Tetron raschel, 18 × 2m, 4 sheets	1,130,000
Voltage regulator	TA-2425-J3, Matsunaga Seisakusho, 6KVA	1,076,000

F.Y. 1986

Name	Specifications	Amount (yen)
Crumbler	RMS-10, 0.75kW	2,700,000
Sifter	ST-2, 0.4kW, with screen	2,215,000
Rack system pellet dryer	Chuko, KF-150, with spare burner	2,340,000
Fish cutter	Hamaji system	1,180,000
Mixer	KM-II	890,000
Screw feeder	For pulverizer HS-2 type	535,000

JICA