BAY OF BENGAL PROGRAMME
Development of Small-Scale Fisheries

BOBP/REP/20
(GCP/RAS/040/SWE)

Coastal Aquaculture Demonstration Project for Shrimp and Finfish at Ban Merbok, Malaysia

SWEDISH INTERNATIONAL DEVELOPMENT AUTHORITY

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

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COASTAL AQUACULTURE PROJECT FOR SHRIMP AND FINFISH IN BAN MERBOK, KEDAH, MALAYSIA

Executing Agency :

Food and Agriculture Organization of the United Nations

Funding Agency :

Swedish International Development Authority

Development of Small-Scale Fisheries in the Bay of Bengal
Madras, India, December 1984

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This paper describes the background, objectives, modus operandi and implementation of a coastal aquaculture project in Ban Merbok, Kedah, Malaysia. It was executed by the Department of Fisheries, Government of Malaysia, with technical assistance from the small-scale fisheries project of the Bay of Bengal Programme (BOBP). Preliminary activities commenced in June 1979 and the project terminated in October 1983.

The document describes the pre-culture and culture practices for shrimp and finfish undertaken by the project, the problems encountered, the results obtained; it also outlines the project's training activities, both in hatchery management and in culture practices. It contains observations on the basis of the project's experience.

The portion of the report dealing with culture trials and hatchery technology is based on the unpublished work of the BOBP consultant master fish farmer Mr. A. K. Rasul and the consultant hatchery technologist, Mr. Niwes Ruangpanit.

The BOBP's technical assistance consisted of engineering, design and aquaculture studies in the planning phase; hatchery technology and the pond culture of shrimp and finfish in the operational phase. Up to the end of 1980 technical support inputs were handled on behalf of BOBP by the South China Sea Fisheries Development and Coordination Programme (SCSP).

The small-scale fisheries project of the Bay of Bengal Programme is funded by the Swedish International Development Authority (SIDA) and executed by the Food and Agriculture Organization of the United Nations (FAO). Started in 1979, the project covers five countries that border the Bay of Bengal — Bangladesh, India, Malaysia, Sri Lanka and Thailand. Its main aims are to develop, demonstrate and promote appropriate technologies and methodologies to improve the conditions of small-scale fisherfolk and the supply of fish from the small-scale sector in member countries.

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CONTENTS

Tables

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1. BACKGROUND

Because of intensive fishing effort in the Malacca Strait, most major coastal stocks in these waters have reached or gone beyond the maximum sustainable yield. This has hit the livelihood of many small coastal communities on the west coast of peninsular Malaysia, particularly in mangrove swamp areas where the land is often unsuitable for farming. The Government has accorded a high priority to improving the socio-economic conditions in rural areas; attention was focused on the possibility of introducing coastal aquaculture as a means to supplement incomes and open up new opportunities for employment.

The Merbok estuary in Kedah state is one such area. It has a population of about 15,000, traditionally dependent on paddy cultivation and fishing, who are as a whole economically depressed. The area contains some 5,200 ha of mangrove swampland. In the period 1961-66, a 2m-high, 32 km-long earth bund was built along the estuary for tidal control and salt water exclusion resulting in the reclamation of about 1,400 ha of mangrove swamp. The agricultural productivity of the redeemed land, however, was low.

A study carried out in the area during 1978 identified brackishwater aquaculture as an activity with potential; it would better utilize existing mangrove swampland as well as the low-lying parts of the redeemed land. A pilot scale aquaculture project, involving the construction of ponds in a 10 ha area inside the bund was recommended; if the results were positive the pilot project would be followed by the first phase of a development programme to extend pond culture to a 120 ha area. Detailed aquacultural and engineering studies for this purpose were agreed to by the Government-which felt, however, that the studies should cover the area outside the bund as well. The studies, which constitute the preparatory activities of the Ban Merbok project, are described in Chapter 5. The approximate location of the pilot project at Ban Merbok is given in Appendix 1.

2. OBJECTIVES

The initial project concept was to establish small-scale (1.6 ha) farm units with 1.2 ha of ponds and 0.4 ha of land for other purposes. These were to be operated by small fishermen and farmers, providing them with incomes well above the poverty line.

The objectives were therefore initially spelt out in 1979 as follows:

- to assist farmers and fishermen in the Ban Merbok area to develop alternative means of employment by utilizing existing and adjacent unused lands;
- to serve as a demonstration project for coastal aquaculture in Kedah/Perlis;
- to uplift the social and economic status of farmers and fishermen in the Merbok estuary.

These objectives underwent a change early 1981 following a change in Government policy. Under the new policy the project aim was said to be the establishment of a brackishwater aquaculture demonstration and training centre with the following objectives:

- to provide short-term training in brackishwater aquaculture for fishermen and farmers who would be participating in Government/self-sponsored aquaculture land development schemes.
- to verify the economic viability of small brackishwater aquaculture family farm units involved in shrimp and finfish culture
- to serve as a demonstration centre for brackishwater shrimp/finfish culture
- to verify new techniques of brackishwater shrimp/finfish culture
- to provide training in brackishwater aquaculture for the staff of the Fisheries Division and other related Government agencies.

These objectives governed the operation of the project up to its conclusion in October 1983.

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3. MODUS OPERANDI

In both the planning and implementation of the project, major inputswereprovided by the Government of Malaysia through its Department of Fisheries. These included national personnel for the project team that carried out detailed studies at the preliminary stage; national personnel who handled the operations of the Ban Merbok pond complex and the hatchery at the Glugor Fisheries Research Institute (GFRI), Penang ; vehicles, equipment, supplies and materials used at various stages of the project: land, construction costs of the pond complex and all operating costs.

The inputs by the FAO/SIDA project, "Development of Small-Scale Fisheries in the Bay of Bengal," GCP/RAS/040/SWE, comprised technical assistance and training.

The technical assistance provided concerned

- engineering studies and design in the planning phase (R. Hechanova 2 m/m)
- aquaculture studies in the planning phase (B. Tiensongrusmee 0.25 m/m)
- hatchery operation and management (N. Ruangpanit 4 m/m)
- pond culture of shrimp and finfish. (A. K. Rasul 18 m/m)

Details of the training provided are given in Chapter 7.

The project team which carried out the detailed studies at the preliminary stage comprised two consultants, personnel from the Department of Fisheries and the Department of Irrigation and Drainage. It was led by an officer from the Fisheries Research Institute, Glugor.

When the pond complex was complete, the project came under the extension wing of the Department of Fisheries. The administrative office of the project was located at Bedong, about 17 km from the project site. Administrative back-up for the project was also provided by the Kedah State Department of Fisheries.

The original plan was to select some farmers/fishermen living in the vicinity of the project to work as farm labourers. The farm units would be handed over to them on a partial cost repayable basis after they were fully operational and found to be economically viable (i.e. after a period of about three years). In view of the subsequent change in objectives, however, this approach was not followed and all operations at the pond complex were carried out by employees of the Department of Fisheries.[1]

The original concept of the project included provision for a hatchery which would mainly.serve the purpose of mass-producing brackishwater fish and shrimp seed for the project complex as well as for aqua-farmers. A small temporary hatchery facility was constructed at Pulau Sayak. The Government, however, planned to replace this facility with a full-scale hatchery, and the former was used for the spawning of freshwater prawn. The technical assistance provided in hatchery operation and management was, therefore, utilized for upgrading the capability of hatchery personnel[2] at the Glugor Fisheries Research Institute and this hatchery provided part of the seed requirements of the project.

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[1] Mr. V. Palanisamy, Officer-in-Charge; Mr. Zainuddin Dahban, Fisheries Administrative Officer; Mr. Ku Bahrom, Fisheries Assistant; Mr. Abdulla Ali, Fisheries Assistant,

[2] Mr. Kamal Zaman Mohamed, Fisheries Officer (shrimp hatchery) ; Mr. Ali Awang, Fisheries Officer (fish hatchery) ; Mr. Azlan Hasan, Fisheries Officer (fish hatchery).

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Up to the end of 1980, external support for the execution of the project was handled by the South China Sea Fisheries Development and Coordinating Programme (SCSP) on behalf of GCP/RAS/040/SWE, with funding provided by the latter. The external support was thereafter handled directly by GCP/RAS/040/SWE.

The preliminary activities commenced in June 1979 and the culture activities were concluded in October 1983. The time schedule for implementation of the main project activities is given in Appendix 2.

4. PREPARATORY ACTIVITIES

4.1 Site survey

On the basis of certain technical, biological, social and economic criteria, the initial study recommended the selection of a site outside the bund. This recommendation was not readily accepted by the Ministry of Agriculture and it was decided that the site should be located within the bund. This decision was later reviewed in January 1980 in favour of a site outside the bund, but in the process, a delay of about 6 months ensued in the technical work that had to be carried out for selection of the specific site.

The recommendation was preceded by a preliminary survey which included sampling of soil and water to obtain indications of pH, salinity, dissolved oxygen and ammonia levels.

From January 1980 more detailed surveys were conducted which included the following :

- a study of rainfall, evaporation and sunshine records of the Malaysian Meteorological Department
- a detailed topography and contour survey of the land
- soil sampling from 23 locations and testing of the samples for pH variations
- tidal observations using an automatic level recorder and stick gauge
- water sampling from five locations and analysis of the various chemical parameters
- a prawn and seed survey to obtain an indication of the availability of penaeid prawn fry at several landing sites.

4.2 Pond design and layout

The engineering design for the pond complex was selected after considering three possible design alternatives :

(i) pumping for water supply and gravity flow for drainage at all times

(ii) pumping during neap tide and gravity flow supplemented by pumping during spring tide for water supply; gravity flow for drainage

(iii) gravity flow for water supply and pumping-cum-gravity flow for drainage.

In view of the high cost anticipated for pumping water, the design selected was a modified version of the second alternative, which provided for gravity flow only, i.e., water supply by gravity during spring tides only, but drainage during both spring and neap tides.

The original pond layout provided for twelve 0.55 ha rearing ponds and six 0.02 ha nursery ponds. The layout is shown in Appendix 3, and Appendix 3-A shows the cross section and linear measurements of the rearing and nursery ponds.

4.3 Construction of pond complex and hatchery

The construction of the pond complex was carried out by a private sector contractor at a cost of M$ 730,000. Construction work commenced in the later part of 1980 and was completed late 1981. The temporary hatchery at Palau Sayak was also completed by end 1981 but, as stated above, this facility was not eventually utilized for the spawning of brackishwater fish and shrimp.

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5. CULTURE TRIALS

5.1 Pond preparation

The pond preparation procedure required for both shrimp and fish was the same. For undertaking any culture trials, the ponds needed repairs, pH correction, pest eradication, screening, manuring, provision of artificial shelters followed by filling with appropriate levels of water. The repairs included correction of water control gates, plugging of leakages along the dykes and side walls of water control gates, desiltation and correction of gradient of the sheltering canals in the rearing ponds, etc.

The project is located in an area where the soil is acidic. The acidity of surface soil in an area which is alternately washed by tides and exposed to the sun, gradually gets neutralized. If the surface soil is removed for pond construction, the acid soil is exposed as happened with the project ponds. Soil pH in the project ponds was as low as 3-4 and this turned the pond water highly acidic and unsuitable for aquaculture. The acceptable range of water pH for aquaculture purposes is 6.5-8.5. Improvement of the soil pH to a suitable level was effected with a series of measures which were laborious, repetitive, time-consuming and expensive :

- Thorough ploughing of the soil to break soil clods and expose the acidic chemical contents of the soil to sunlight and oxygen
- Dyke washing by trenching, and V-lining for trapping acid laden silt and rain water run-off
- Drying of soil under the sun for a duration of two weeks to oxidise the acid sulphate content of soil
- Submerging the soil in water for a duration of two weeks to dissolve the acids from the soil particles
- Draining of ponds to leach out the dissolved acids.

The above process of drying and draining was repeated for 3-5 cycles. As a result, the soil pH gradually increased from the initial level of less than 5 to levels above 6 within a period of 3 months in rearing ponds 2, 3, 4, 5, 8, 9 and 10.

Subsequent to soil pH improvement the usual pond preparation work followed. The ponds were drained out, screened, dried and limed. For liming, crushed limestone at 1.5-2.0 tonne/ha was used. Pest animals were eradicated from the shelter canal containing 20 cm deep water on the average by applying ground commercial tea seed cake at 30-40 kg/ha. For application, the ground tea seed cake was mixed with 50 litres of water. Organic and inorganic fertilizers were used at the following rates for a crop of 3-6 months:

Chicken dung	: 800-1000 kg /ha
or	
Cow dung	: 1000-1500 kg/ha
Urea	: 40 kg/ha
TSP (Inorganic fertilizer)	: 75-100 kg/ha

Artificial shelters and substrata were provided in the shrimp ponds with coconut fronds and bamboo twigs (Appendix 4). The ponds were first partially filled with 30-50 cm of water and maintained in that condition for 10-14 days, or until there was good algal growth in the ponds, and were then filled to a depth of 70-100 cm.

5.2 Fry supply and nursery practices

Fry supply

The fry was supplied by the GFRI about 80 km from the project site. At the research station the shrimp and fish fry were acclimatized to the salinity level of the Ban Merbok pond. Fry was trans-

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ported in plastic bags (75 x 45 x 0.02 cm) with oxygenated water kept cooled by ice bars packed in plastic bags. The temperature during the 2½-3 hour journey by road ranged from 23 to 30°C. For oxygenation, the plastic bags were inflated with oxygen at 5-8 pounds per square inch. The usual packing density of fry was as follows:

***P. monodon* = 2500-3000** (PL 5-PL 20)

***P. merguiensis* = 4000-6000** (PL 12-PL 20)

***L. calcarifer* = 600-l 000 (12-20** days old)

The survival during transport was generally above 90% for both shrimp and fish.

Nursery rearing

Nursery rearing for ***P. monodon*** could be done only in nursery pond 3 (NP3) as the other ponds were not ready. The pond preparation method was the same as already described in section 5.1. Special shelters were provided (Appendix 5). For adjustment of temperature the fry bags were kept floating in the nursery pond for 15-20 minutes.

Water depth ranged from 70 to 100 cm. About 30-40% of the water was changed during each spring tide. Rice bran and trash fish, minced or whole, were provided as supplementary feed. Other feeding details are provided in Table 1. The types of feeding trays and their positioning in the nursery pond are shown in Appendix 6.

Table 1

Feeding schedule of *P. monodon* in nursery

Period of nursery rearing	Feeding type and compostion	Feeding rate (% of body weight)	Method of feeding
First 7 days	Minced trash fish 100%	20-40	Minced trash fish scattered on the shallow parts of the pond bottom (at specific points). Recommended feeding time — evening.
8th day to 30th day	40% rice bran, 60% trash fish mixed together and formed into wet pellets.	20	Feed was placed on feeding trays. Feeding time in the evening, once a day only.
After the 30th day	Same as above plus whole trash fish.	IO-15	Whole trash fish placed on the polyethylene net feeding tray.

Nursery practice for ***P. merguiensis*** was tried only once in NP1. Since no other ponds were ready at the time, all the post-larvae had to be stocked in NP1 at high density (650/m^2). After two months the stock suffered mortality en masse, possibly due to oxygen depletion (1.0 ppm) at night, and possibly due to overcrowding.

5.3 Rearing practices

Stocking of rearing ponds was done with nursery-reared seed as well as by stocking of post-larvae direct from the hatchery. For direct stocking P. monodon PL5-PL20, **P. merguiensis** PL2-PL20 and L. calcarifer 12-20 days old were used. The stocking rate for shrimp ranged from 3.6-35/m^2 (see Table 4) and for fish, 1.5-6 /m^2. The depth of water on the pond platform was 70-100 cm and that in the trenches 120-l 50 cm. Water exchange to the extent of 30-50% was effected during the spring tides. Physico-chemical parameters were regularly monitored ; the values are presented in Appendices 7 and 8. At times, adverse water quality conditions were experienced ; these were :

(i) Depletion of dissolved oxygen

(ii) Low water pH after heavy rainfall
(iii) Presence of hydrogen sulphide (H_2S)
(iv) Discolouration of water
(v) Low salinity.

If any of these conditions were noticed, pond water was exchanged with fresh tidal water. Mechanical agitation of pond water by running a boat propelled by an outboard motor and recirculation of water by using a pump were resorted to, to increase the dissolved oxygen level whenever water exchange was not feasible. Excessive algal matter produced in some of the ponds was periodically removed when it accumulated in one corner due to wind action. When allowed to accumulate and decay, the algal matter produced toxic gases. The salinity level was never too low to be of concern for ***P. monodon,*** but it occasionally approached the lower limit of tolerance for ***P. merguiensis.***

Supplementary feed was given to the shrimp. The feeding schedule generallyfollowed for shrimp is given in Table 2.

Table 2

Feeding schedule for rearing ponds

Period of culture (days)	Type of feed	Feeding form	Feeding rate (% of shrimp's weight)
1-30	Trash fish	Fresh pellet	20-40
30-60	Trash fish & rice bran	Fresh pellet (60% minced fish, 40% rice bran)	20
Above 60	Trash fish and bran	Whole fish 50% and fresh pellet 50% (60% minced fish, 40% rice bran)	10

When a whole fish of good size was used as feed, it was inserted in between strings laced into a piece of polyethylene netting material rigged as a feeding tray. Small-sized fish was packed into a small bag made from 2.54 cm-mesh polyethylene net which was placed on the feeding tray (2 kg per feeding tray). Locally available chicken feed and imported shrimp feed were also occasionally supplied.

For seabass, natural feeding was made possible by allowing small animals to enter the ponds through selected screens. With the increasing size of the fish, the selective mesh size of the screens was progressively increased. Trash fish (of weight equal to 5-10% of the body weight of the culture species) was provided as supplementary feed.

The fish was periodically sampled, sorted and distributed to various ponds according to the size group. Efforts were made not to culture fish of various size groups in the same pond to avoid cannibalism.

The main pest intruders in the shrimp ponds were the predatory fish species of **Megalops, Glossogobious, Elops, Therapon, Lates,** etc., and crabs. The fish were removed by using mono-filament drag net of 2.5 cm mesh. Baited traps were used for crabs (Appendix 9). Although otters were seen in the vicinity of the pond complex, they were not able to enter the complex which was adequately fenced.

Harvesting of shrimp was done at night by draining out water through bag nets. Bright lights were used at the pond sluice to attract the shrimp and scoop netting and hand picking were carried out for complete harvesting. Fish was harvested by means of drag netting as well as by complete draining.

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5.4 Production results

Between the rime that the consultant master fish farmer and the counterpart officer-in-charge joined the project (around May 1982) and the termination of the project (in October 1983) two culture trials for penaeid shrimp were completed.

Rearing pond (RP) 9 with an area of 0.5 ha produced ***60*** kg of ***Penaeus monodon*** and 250 kg of ***P. merguiensis,*** which together accounted for a production of 620 kg /ha. Over a period of ***100*** days, ***P. monodon*** grew from an average weight of 6.23 g to an average weighr of 25.269. ***P. merguiensis*** grew from an average weight of 1.13 g to 9.53 g in 70 days.

A production rate of 473 kg/ha was achieved in RP 4 (0.49 ha) which actually produced 79 kg of ***P. monodon*** and ***153*** kg of ***P. merguiensis*** in 150 days. The latter species was not stocked' but it entered the ponds through defective sluice screens. Stocked at PL ***5-6, P. monodon*** reached an average weight of 27 g on the harvesting day. The size of ***P. merguiensis*** was small. Further details of the results are given in Table 3.

Table 3

Production results of RP 9 and RP 4

Pond no.	Species	Initial stocking		Final harvest		Production (kg)	
		Date	Av.wt. (g)	Date	Av.wt. (g)	Pond	per ha
RP 9 (0.5 ha)	***P. monodon***	16-11-82	6.23	27-2-83	25.26	60	620
	P. mergoiensis	19-12-82	1.13		9.30	250	
RP4 (0.49 **ha)**	***P. monodon***	22-11-82	PL5-6	20-4-83	27.0	79	473
	P. merguiensis*					153	

* Auto-stocking through defective screens.

The shrimp culture trials in rearing ponds 3, 5, 10 and a second trial in RP 4 and RP 9 were in progress at the time of termination of the project. Some experimental data on these trials are provided in Table 4.

Seabass culture was also in progress in ponds 1, 2, 6, 7, 8, 11 and 12. A trial harvest of the fish indicated a production of 270 kg/0.5 ha pond over a period of seven months.

Table 4

Ongoing shrimp culture experimental data

Rearing pond no.	Species	Stocking data		
		Date	Number stocked	Stocking size
3 (0.49 ha)	***P. monodon***	22-11-82	20,000	PL 5-6
4 (0.49 ha)	***P. merguiensis****	25-5-83	170,000	PL 12
5 (0.37 ha)	***P. monodon***	27-6-83	47,000	PL14
9 (0.49 ha)	***P. monodon****	22-3-83	14,000	PL12
	P. merguiensis	4-4-83	10,000	PL 7-9
10 (0.55 ha)	***P. monodon***	6-5-83	20,000	PL 4

* Second trials.

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6. HATCHERY TECHNOLOGY

As stated earlier, the technical assistance in hatchery operation and management was utilized mainly to upgrade the capabilities of hatchery personnel at the G.F.R.I. For this purpose, the consultant demonstrated the basic hatchery techniques -which included culture of food organisms and mass production of shrimp and fish seed with the active participation of the counterpart staff. The consultant also prepared a list of facilities required for a hatchery (Appendix 10) and a design for a fish hatchery together with design criteria for the same (Appendix 11).

6.1 Culture of organisms for shrimp /fish food

Culture techniques were demonstrated for diatom *Chaetoceros, Tetraselmis, Chlorella* and rotifers. Live organisms were cultured to feed the various larval stages of the shrimp and fish. Diatoms served as food for Zoea stage I *(Z-1), Tetrasetmis* for *Z-2, Chlorella* for rctifers and rotifers for shrimp mysis larvae and seabass larvae.

Diatom -the first stage culture -was maintained in 2-litre flask bottles in the algal culture room, illuminated with ordinary fluorescent lamps. After three days, diatoms grew at the density of 4-5 x 10^6 cells/ml and was used as a starter material for the intermediate stage of culture. Fibreglass tanks of 300 litre capacity were used for the intermediate stage culture. Sea water in each tank was inoculated with 15-30 litres of the starter material. Nutrients added were KNO_3 (potassium nitrate) 0.3 g, $Na_2HPO_4 12H_2O$ (disodium hydrogen orthophosphate) 0.3 g and Na_2SiO_3 (sodium silicate) 0.015 g, each per litre of water. The density of 2.4 x 106 cells could be obtained in three days.

The final stage for mass culture was carried out in 2-ton fibreglass tanks. An innoculum of 200 litre obtained from the previous stage was used in each tank, which received the same three nutrients as used in the intermediate stage. However, the proportions and concentrations of the nutrients were respectively 100 g, 10 g and 5 g per ton of water. After 3 days the diatoms were ready for harvesting.

Tetraselmis and *Chlorella* culture techniques were basically the same as for diatom culture, but the nutrients used were ammonium sulphate 100 g, super phosphate 15 g and urea 5 g, each per ton of water. For rotifer culture, *Chlorella* was added at a density of 10/ml; the density increased to 80-100/ml in 5 days. Chlorella and baker's yeast were added from time to time *to* maintain the rotifer culture.

6.2 Shrimp hatchery

The practical work in connection with training in shrimp hatchery included collection of gravid females of *P. merguensis* and *P. monodon* from the wild and their spawning under laboratory conditions. The techniques of induced ovary maturation of *P. monodon* in captivity and the art of rearing of shrimp larvae to post-larval stages were also demonstrated. The measures and precautions necessary for the transport of gravid females from their wild sources, the care of gravid females in the laboratory, the artificial spawning of the shrimp and the care of eggs, larvae and post-larvae, were practised in logical sequence from March to July 1982.

Twenty-seven gravid females of marine shrimp were collected from the wild, 22 of *P. merguiensis* and five of *P. monodon.* Only one shrimp spawned naturally, the others spawned with eye-stalk ablation. Nearly one million shrimp post-larvae were produced. The results are summarised in Table 5.

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Table 5

Initial mass production of shrimp larvae

Date 1982	No. of tanks	Rearing capacity (tonne)	No. of brood stock	Species	No. of larvae hatched	No. of post-larvae produced	Survival %
March	5	2	8	*P. merguiensis*	792,000	309,000	39.0
April	5	2	8	*P. merguiensis*	830,000	218,000	26.2
	I	2	1*	*P. monodon*	200,000	85,000	42.5
May	3	2	6	*P. merguiensis*	500,000	200,000	40.0
	4	2	4	*P. monodon*	569,000	180,000	31.6

* Natural spawning.

For induced maturation of ovary, the eyestalk ablation technique was employed. The eye of each female was pinched off. A total of 26 females were subjected to eyestalk ablation and they were kept with I4 mature males; I7 gravid females were obtained, but only 10 of them produced viable eggs. Of these only the larvae from four individuals survived until the post-larval stage. More information on the results of eyestalk ablation is provided in Table 6.

Table 6

Results of induced ovary maturation of *P. monodon*

Date, 1982	No. of gravid females	No. of nauplii	No. of post-larvae	Remarks
06 May	2	400,000	—	Died at Z_1
12 May	2	—	—	No hatching
19 May	1	180,000	—	Died at Z_1
21 May	2	—	—	No hatching
22 May	1	200,000	60,000	
24 May	1	—	—	No hatching
25 May	2	352,000	100,000	
27 May	1	60,000	—	Died at Z_1
30 May	1	165,000	20,000	
31 May	1	60,000	—	Died at Z_1
02 June	I	80,000	—	Died at Z_1
03 June	2	—	—	No hatching

6.3 **Fish hatchery**

Activities were limited to the seabass ***fates calcarifer.*** Practical demonstration work included the collection of broodstock from the wild, study of the criteria for selecting the appropriate

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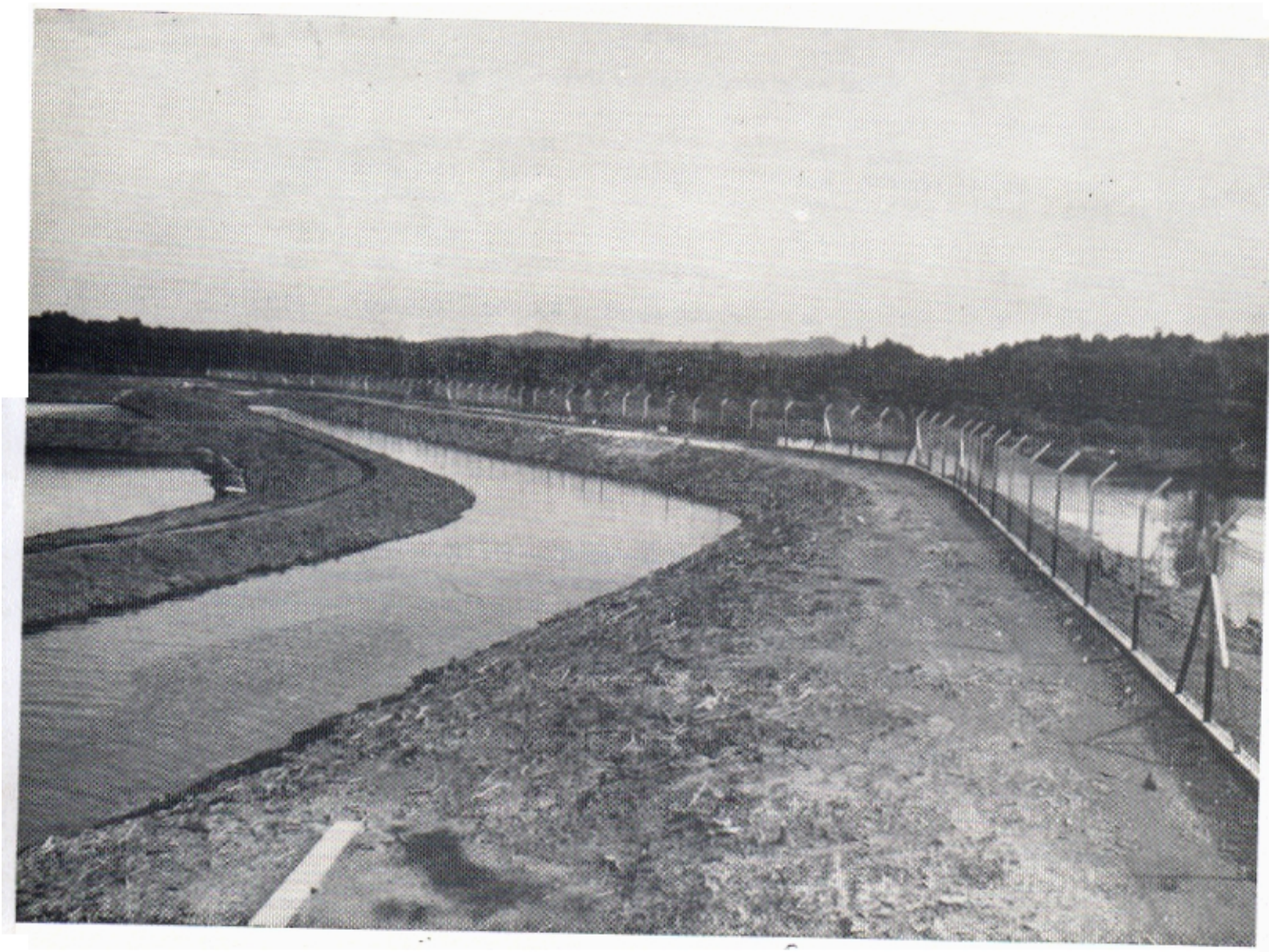
BAN MERBOK PROJECT IN PICTURES



Project landscape—the supply canal, the project fence and the mangrove vegetation around the fence.

Applying lime to the soil dyke to reduce acid suIphate, content of the soil.

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Project staff spray cow dung on the pond bottom to increase the pH content of the soil.

Digging of dyke trench is in progress—a prelude to water and lime treatment.

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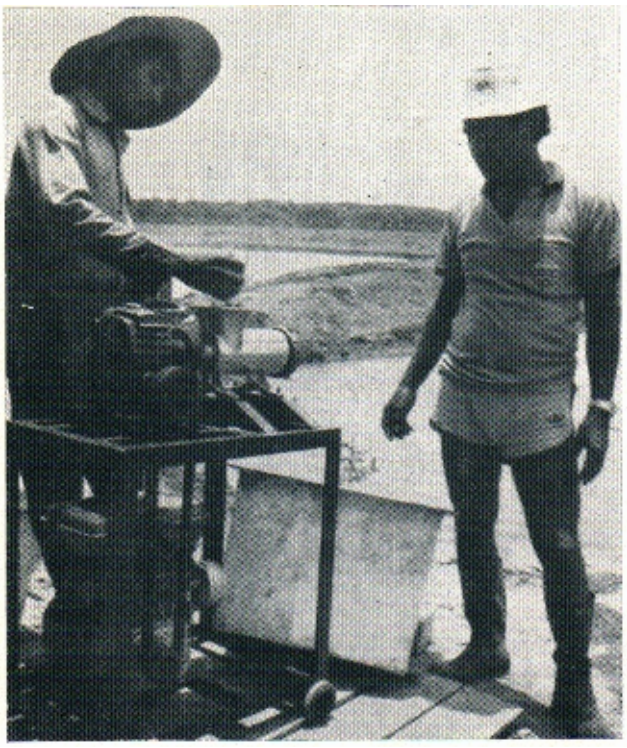

Pelleting of trash fish for feed.

Sampling of Penaeus monodon *from the shrimp pond —note the shrimp leaping out from the tray.*

A briefing on the project for fish farmers and their wives.

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broodstock, the technique of stripping and fertilizing eggs, testing the viability of eggs, hatching of the fertilized eggs to larvae and grading fry into various size groups.

in the absence of any hatchery reared seabass brocdstock, wild broodstock was used. Mature females with a distended belly were selected. Eggs were checked for ripeness and viability before they were stripped from the fish. Some eggs were sucked out with a narrow polyester straw. Healthy and viable eggs are round, pale yellow and float and roll smoothly in seawater of salinity 28-31 ppt. One or a few male fish will give sufficient milt to fully fertilize eggs collected from one female fish. Eggs stripped at one time from one female could number about 250,000-500,000.

Fertilization was effected by mixing the sperm and eggs together for five minutes and then adding clean sea water. The fertilized eggs were transferred to 2-tonne conical fibreglass tanks in which the water temperature was 30ºC. The eggs hatched in 12-13 hours. The newly hatched larvae were reared in a round fibreglass tank. About 400,000 larvae could be reared for 14 days in a tank 3 m dia x 90 cm depth (approx. 6 tonne in volume). The larvae were then thinned out into four tanks of the same size. In 15 more days the fish reached 1.0-1.5 cm in length and were ready for culture in earthen ponds. Rotifers and brine shrimp were fed for about three weeks after which the fry was trained to accept dead food organisms, such as Acetes, fish flesh, etc. Table 7 sets out the type of feed for seabass larvae at various stages.

Table 7

Feeding schedule of seabass larvae

Age (days)	Type of feed in %			
	Chlorella	Rotifer	Artemia	Acetes fish flesh
3-7	10	90	—	—
8-15	10	75	15	—
16-20	—	—	100	-
21-26	—	—	80	20
27-35	—	—	40	60
Over 35	—	—	—	100

Under the mass seed production activity 400,000 larvae were produced from broodstock comprising one female and one male. There were 200,000 surviving 30-day-old fry.

7. TRAINING

The training activities of the project covered three main areas-culture, hatchery technology and feed technology.

7.1 Culture

In 1979 a two-month fellowship was provided to the project's officer-in-charge to participate in a workshop on the farming of ***Macrobrachium rosenbergii*** in Hawaii. It was believed that freshwater prawn farming might be possible in some parts of the area within the bund at Ban Merbok.

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Also as part of preparatory activities, a two-week study tour was provided for two members of the project team -the team leader and an engineer of the Drainage and Irrigation Department — to observe small holder fish ponds and small-scale demonstration fish farms in Sumatra and Java, Indonesia.

In 1980, a one-week study tour of aquaculture in Japan was provided for a senior officer of the Extension Section of the Department of Fisheries following participation in an international conference in Kyoto.

In 1981, a two-week study tour was provided for a team of six officers (four fisheries officers from the Fisheries Department and two engineers from the Drainage and Irrigation Department) to observe culture and hatchery techniques and practices in respect of brackishwater fish, marine and freshwater shrimp in Thailand and Indonesia.

In May 1983, a two-week training session in brackishwater pond culture was conducted at the Ban Merbok pond complex for six fish farmers of Kedah.

7.2 Hatchery technology

Training in hatchery techniques was arranged at the National Institute of Coastal Aquaculture, Songkhla, Thailand, during February/March 1982 for the fisheries officer designated to be in charge of hatchery operations for brackishwater fish and shrimp at Ban Merbok.

The same officer, together with two other counterparts, was provided training in the spawning of ***L. calcarifer, P. mergoiensis,*** and ***P. monodon*** at the Fisheries Research Institute hatchery at Glugor, Penang, by the hatchery consultant during his four-month consultancy (see Chapter 6).

7.3 Feed technology

Due to the importance of fish feed formulation for the future development of coastal aquaculture and the lack of expertise in this technology, a three-month fellowship was provided to a fishery officer in January-March 1982 for institutionalized basic training in the fundamentals of fish feed formulation and manufacture and the nutritional requirements of fish, at the University of Washington, Seattle, USA.

8. OBSERVATIONS

8.1 Pond culture

(i) The master fish farmer and his counterparts felt that certain improvements are necessary to ensure better circulation and management of water in the pond complex. They suggested the following :

- Each rearing pond should have an inlet for entry and an outlet for discharge of pond water for batter water exchange and quality.
- Three water control structures should be constructed across the three main supply-cum-drainage canals for planned and quick distribution of high tide water to the various ponds according to need and also for quick disposal of water from a given section as and when required, without involving other sections of the pond complex.
- A control gate connecting each nursery pond with the two corresponding rearing ponds should be established. Whenever the nursery ponds are subject to excessive environmental stresses, as experienced in small ponds, this would enable the shrimp to swim into the bigger rearing ponds in which the environment remains more stable. Such a gate would also facilitate easy transfer of nursery stock to rearing ponds.

(ii) Since the low pH condition is a general problem in and around the Ban Merbok area, the project team was of the view that the top soil should not be disturbed in the process of pond construction under such conditions and that soil for bund construction should be dug out from the sheltering canals or transported from nearby areas.

(iii) Since ponds with a low pH problem require frequent exchange of water, fertilization in such ponds should be cautiously planned to avoid unnecessary wastage of fertilizer.

(iv) The pond silt, principally composed of decayed algal matter, waste feeds and soil eroded from the dykes, should be periodically removed and deposited on the slopes of the dykes. This would benefit the ponds in at least two ways: the bottom will be free from poisonous material and gases; the silt deposited on the dyke slope will cover the acid soil and will thereby tend to reduce the acid load of the ponds during rainy and stormy weather.

{v) Although direct stocking of early post-larvae (for example PL 5) in some of the rearing ponds produced reasonably good results, the overall survival of the shrimp was low and unpredictable. Nursery rearing to grow the early post-larvae at least to PL 15-20 size was suggested for better survival of the shrimp. In addition to the low pH problem with the nursery ponds, the project team found the harvesting and transfer of seed from the existing nursery ponds to be cumbersome and time-consuming. The team, therefore suggested nursery rearing in removable net pens on an experimental basis.

(vi) In an attempt to maintain an optimum range of salinity (12-20 ppt) over a longer period of time, the provision of a deep tube well at the project site was suggested. Fresh water from this well could be used to suitably dilute the salinity of pond water which remained above 20 ppt during most parts of the culture operations (Appenaix 8).

(vii) The difficulty of changing the water in the ponds during the neap tide periods lasting for 5-9 days leads to deterioration in water quality by increasing the metabolite load and reducing the oxygen level in the ponds. It was suggested that the installation of a pump near the main gate to draw fresh brackish water from the creek could ameliorate the problem.

(viii) The project team was of the view that the shrimp at their earlier stages should receive proportionately more food than at the later stages. Supplementary feed at 50% of the body weight was recommended for 10-30 days old shrimp as against a rate of 15% for shrimp older than three months.

(ix) Draining the pond water through a bagnet installed at the pond sluice gate was found to be an effective method for total harvesting of the shrimp. Whenever selective harvesting of only the bigger-sized shrimp was intended, a specially designed trap, as illustrated in Appendix 12, would be useful. Positioning a gas lamp or a spotlight above the trap will attract the shrimp. Smaller shrimp that may enter the trap would be able to escape. The trap would also prove useful in a pond which is not completely drainable.

8.2 Hatchery

(i) During his period of service, the consultant noted that broodstock of the shrimp and fish were generally in short supply in the area. He therefore recommended a careful survey of broodstock supply prior *to* establishment of a new hatchery at Pulau Sayak.

{ii) Induced ovary maturation in captivity by eyestalk ablation should be done to produce gravid females of *P.* monodon because of the unpredictable supply of wild broodstock. Although it is known that the eyestalk ablation technique has a greater chance of success with wild shrimp, the consultant stressed the need for research on induced ovary maturation with farm-raised shrimp for easy availability of the latter.

{iii) In order to have a more reliable source of seabass broodstock for hatchery use, broodstock culture of the species should be initiated. Pending such culture, artificial spawning from wild broodstock has perforce to be resorted to.

(iv) In order to reduce the cost of brine shrimp the consultant suggested the mass production of freshwater flea (Moina sp.) and brackishwater caladoceran (Diaphonosoma sp.) or mass culture of brine shrimp up to 5-7 days for feeding seabass larvae of age from 2 weeks to 1 month.

(v) The consultant stressed the need for the following equipment/facilities for proper hatchery operation :

— A sea water supply system providing an adequate quantity of water and equipped with efficient filtering devices

— An adequate aeration system to oxygenate hatchery waters as well as agitate the food organisms in the hatchery tanks to remain suspended at a uniform distribution

— A stand-by power generator of 40-100 kVA

-Two units each of pumps for sea water and air blowers, one for constant operation and the other as stand-by.

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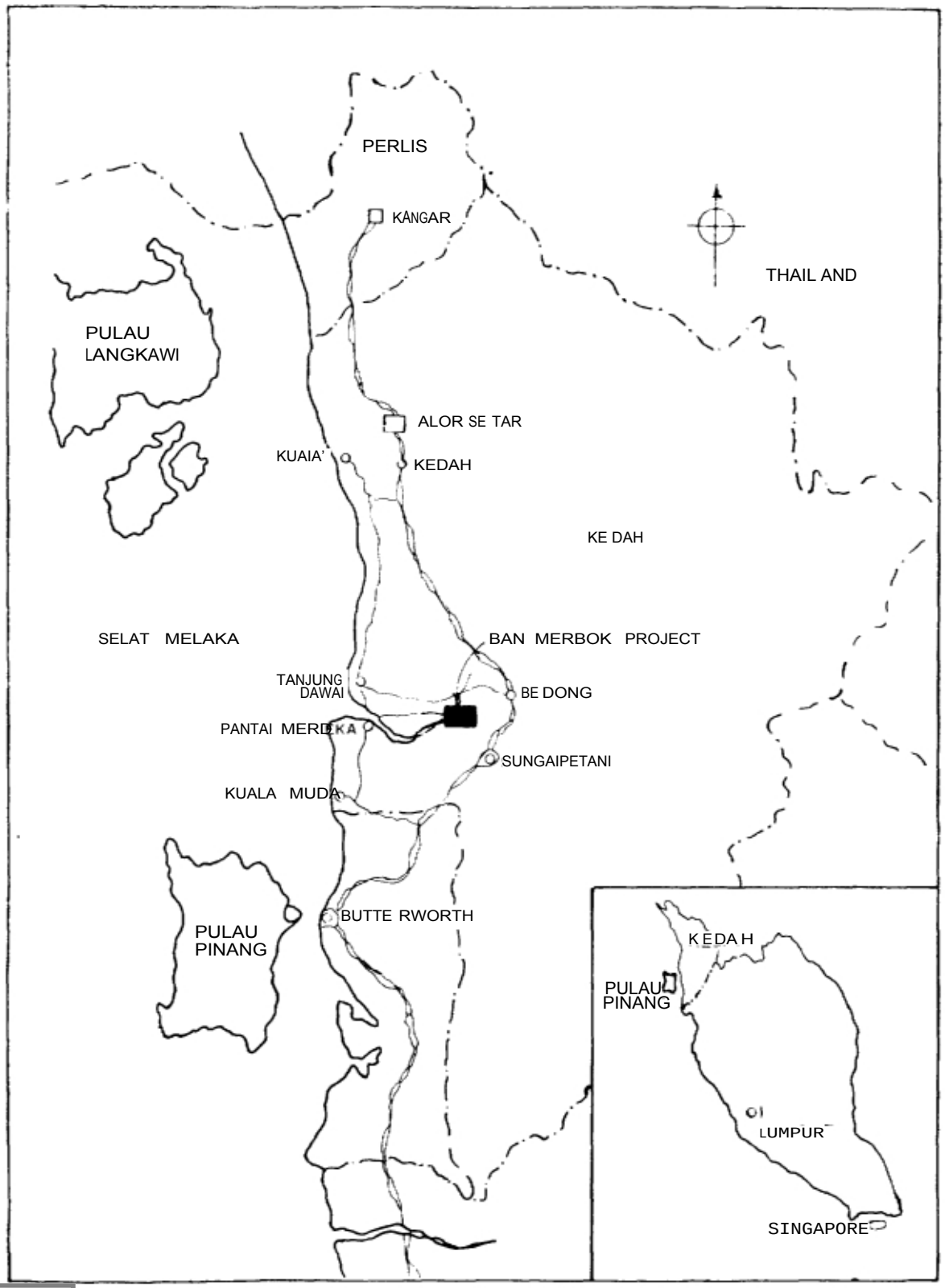
Appendix 1: MAP OF KEDAH STATE SHOWING THE APPROXIMATE LOCATION OF THE BAN MERBOK PROJECT



Appendix 2

TIME SCHEDULE OF ACTIVITIES

Activity	Initiating date or activity date	Completion date
1. Site survey and selection	June 1979	January 1980
2. Pond layout and design	January 1980	April 1980
3. Construction of pond complex	September 1980	September 1981
4. Additional construction work		
(a) Security fence and guard shed	June 1982	December 1982
(b) Mobile office	October 1982	
(c) Store	November 1982	
5. Purchase of equipment, material and supplies	May 1982	June 1983
6. Purchase of labsratory equipment	September 1982	December 1982
7. Establishment of office at Bedong	September 1982	
8. Culture preliminaries	May 1982	July 1982
(a) Clean up of ponds		
(b) Repair of water control gates, screens, dykes, pond platforms and sheltering channel		
9. Culture activities		
(a) Improvement of soil pH	June 1982	
(b) Pond preparation for stocking	June 1982	
(c) First stocking in NP 3	July 1982	
(d) First stocking in RP 3	November 1982	
(e) Harvesting from RP 3		February 1983
(f) First seabass stocking in RP 1	July 1982	
(g) First seabass trial harvest RP 2		February 1983
(h) Culture activities in RP 1 to RP 12 and NP 1 and NP 3	July 1982	October 1983
10. Hatchery work and training of counterpart staff in hatchery techniques	March 1982	July 1982
11. Training of fishermen	May 1983	

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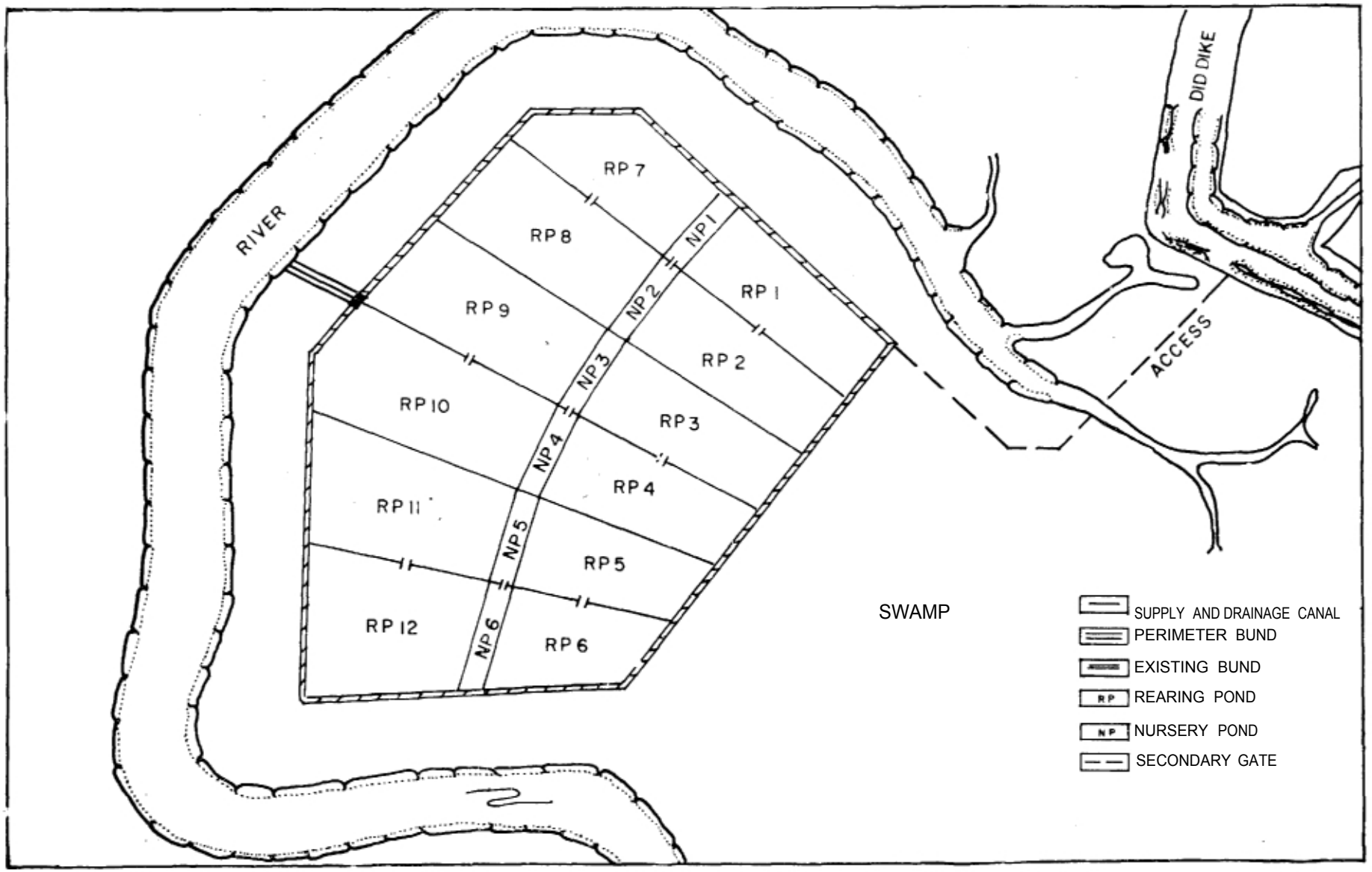
Appendix 3: LAYOUT OF POND COMPLEX



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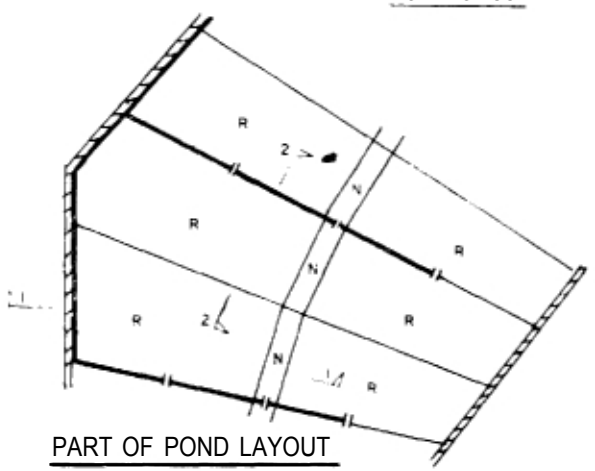
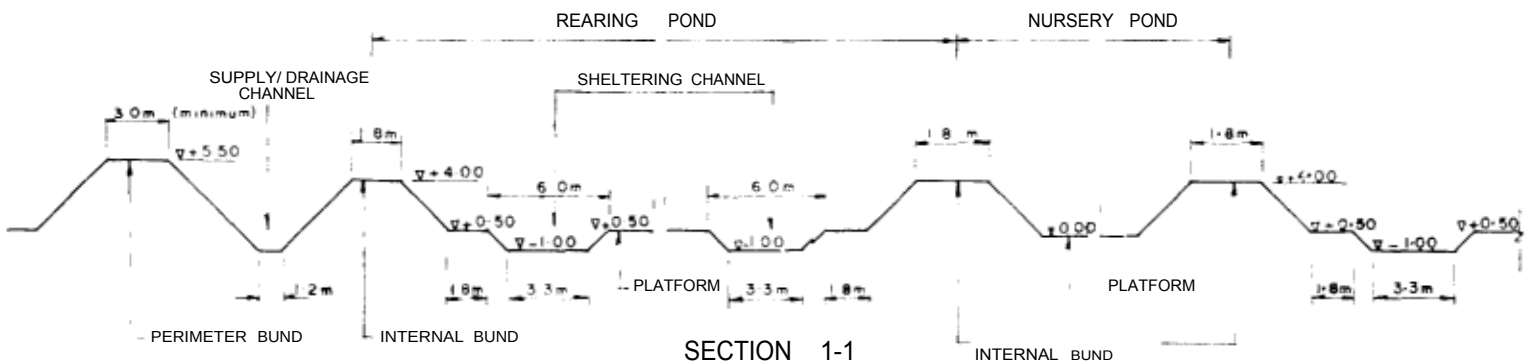
Appendix 3a: CROSS-SECTION OF REARING AND NURSERY PONDS

NOT TO SCALE

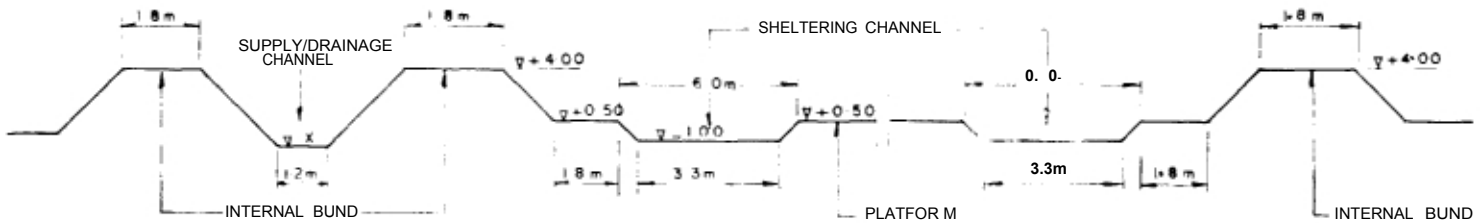


PART OF POND LAYOUT

SUPPLY AND DRAINAGE CHANNEL
PERIMETER BUND (PROPOSED)
SECONDARY GATE/GATES
REARING POND
NURSERY POND



SECTION 1-1



SECTION 2-2

NOTE 1) AVALUE BETWEEN — 1.00 TO— 1.40

2) ALL SLOPES ARE TO HAVE A HORIZONTAL VERTICAL RATIO OF 3:1

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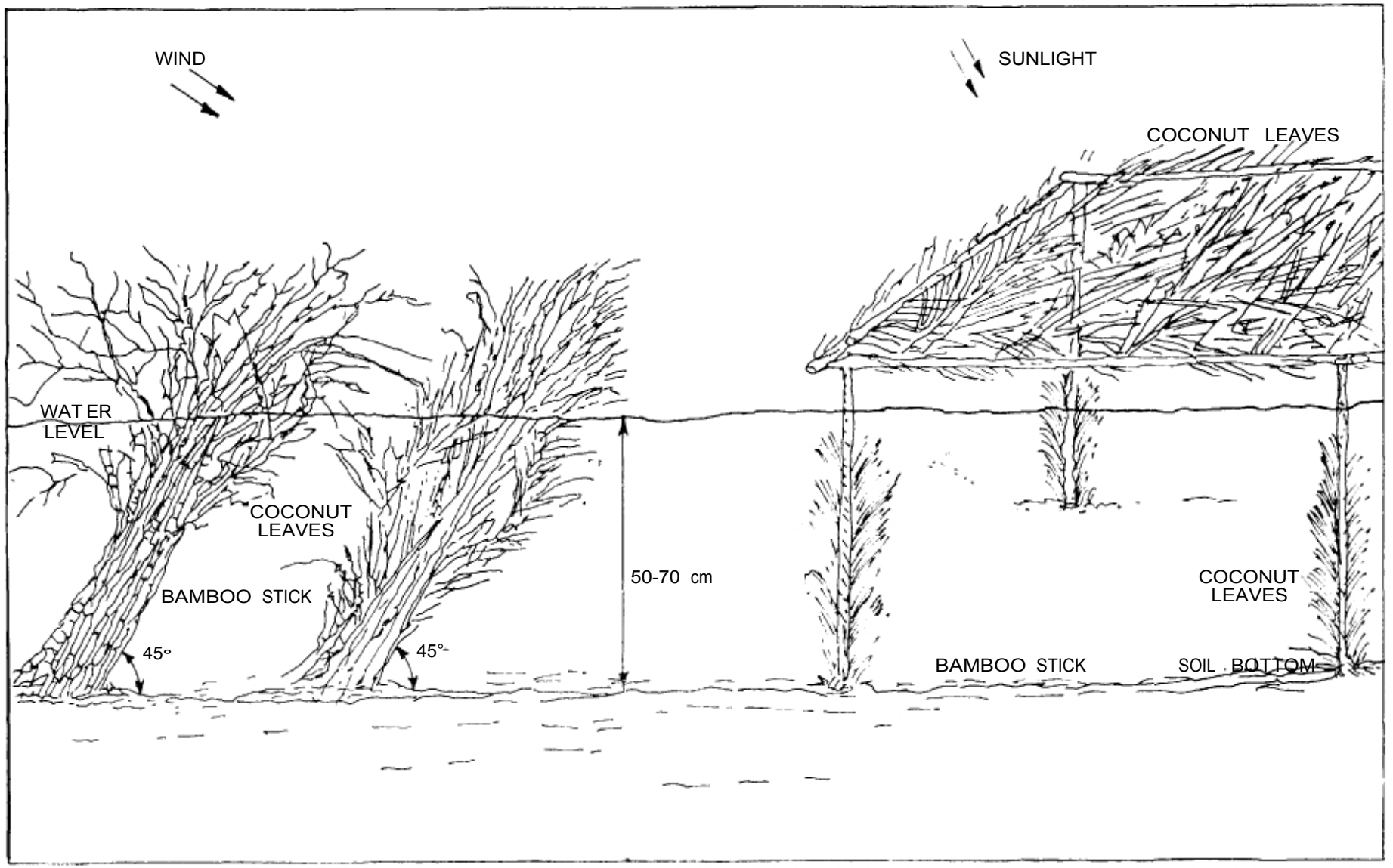
Appendix 4: ARTIFICIAL SHELTER SYSTEMS IN REARING PONDS



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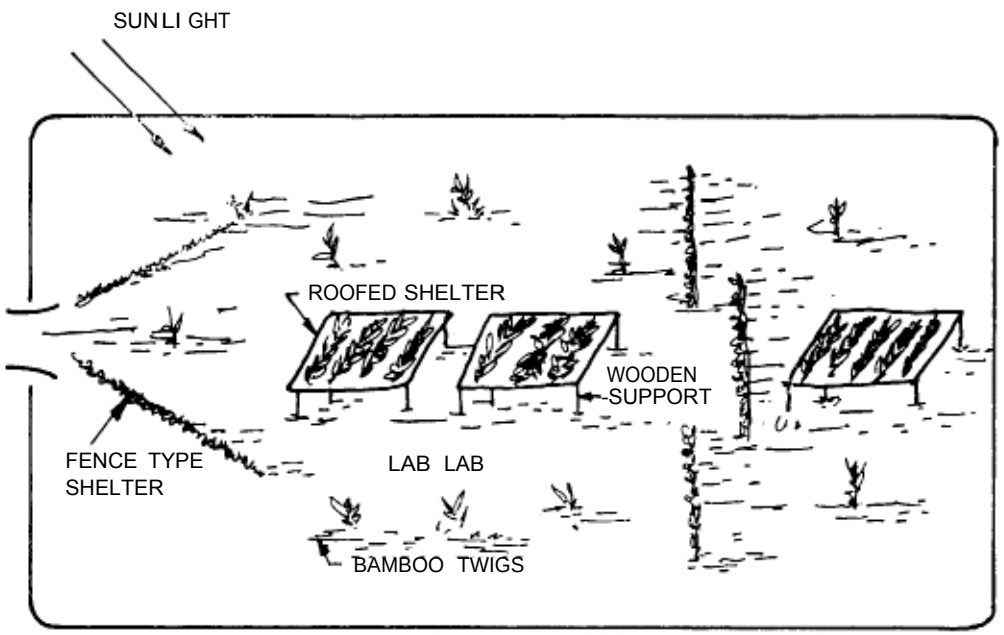
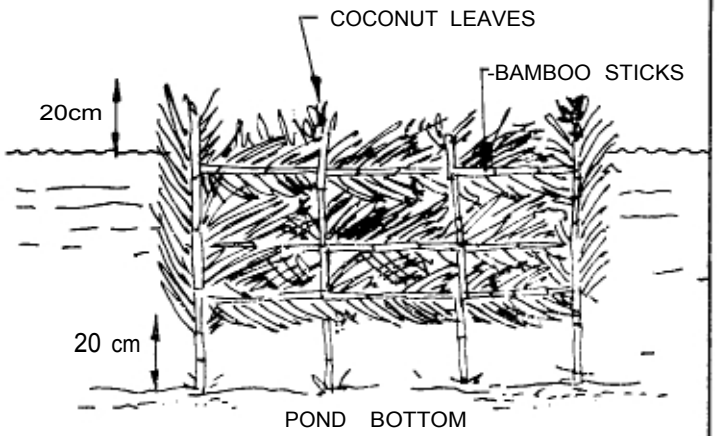
Appendix 5: SHELTERS IN NURSERY POND 3



SHELTER MADE FROM COCONUT FRONDS AND BAMBOO TWIGS IN NP 3.



FENCE TYPE 0R VERTICALLY DISPLAYED SHELTER

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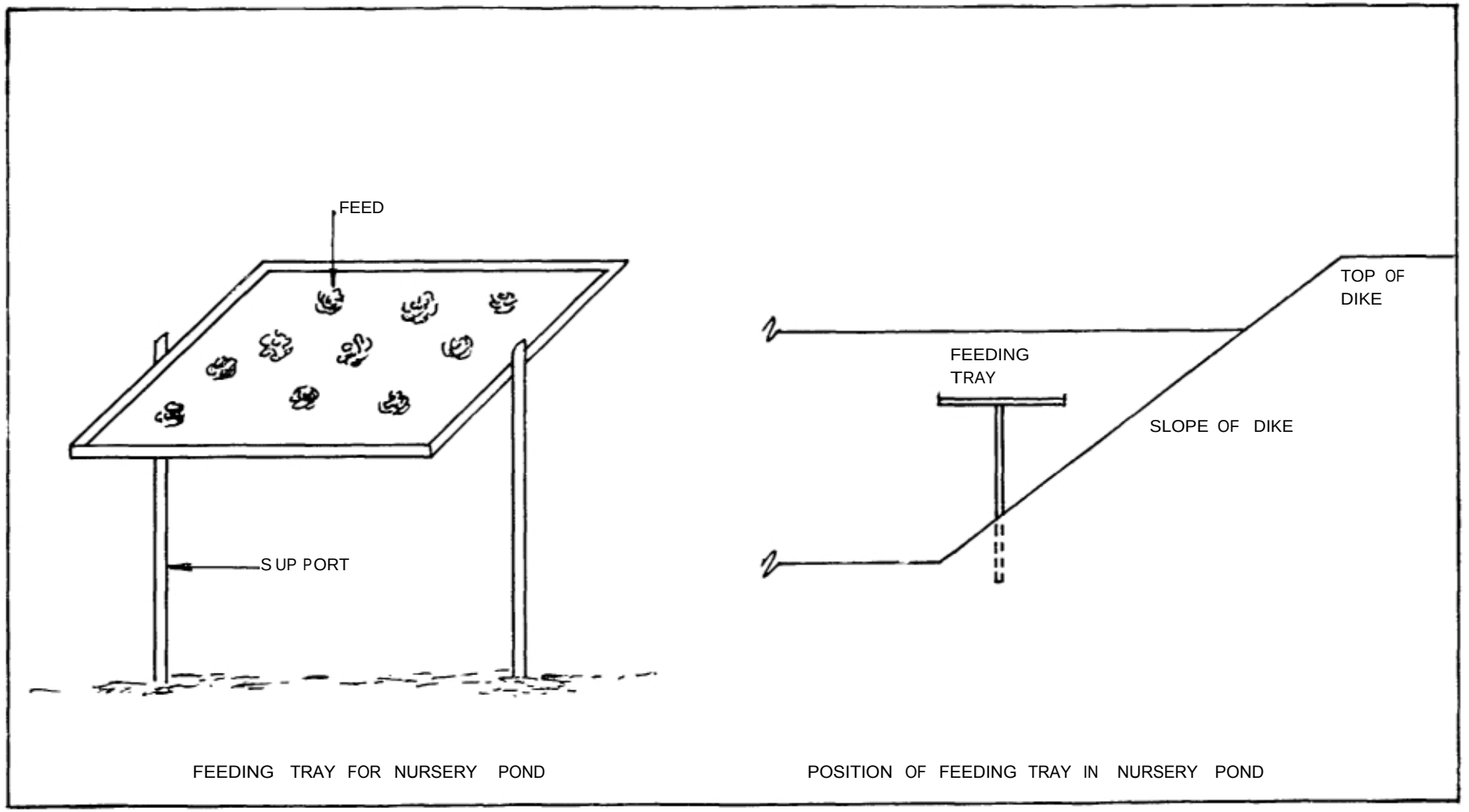
Appendix 6: FEEDING TRAY AND ITS POSITIONING IN POND



FEEDING TRAY FOR NURSERY POND

POSITION OF FEEDING TRAY IN NURSERY POND

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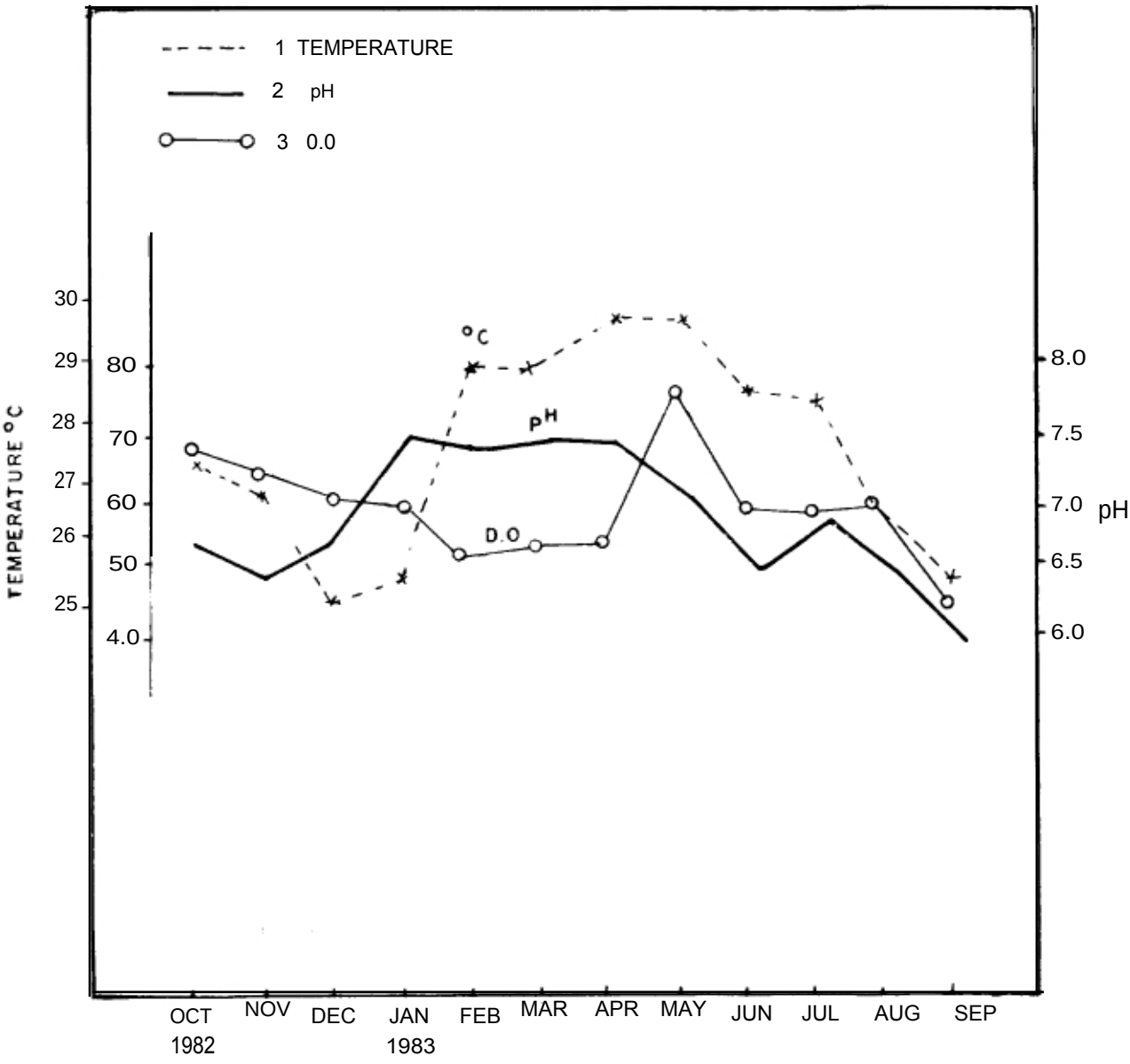
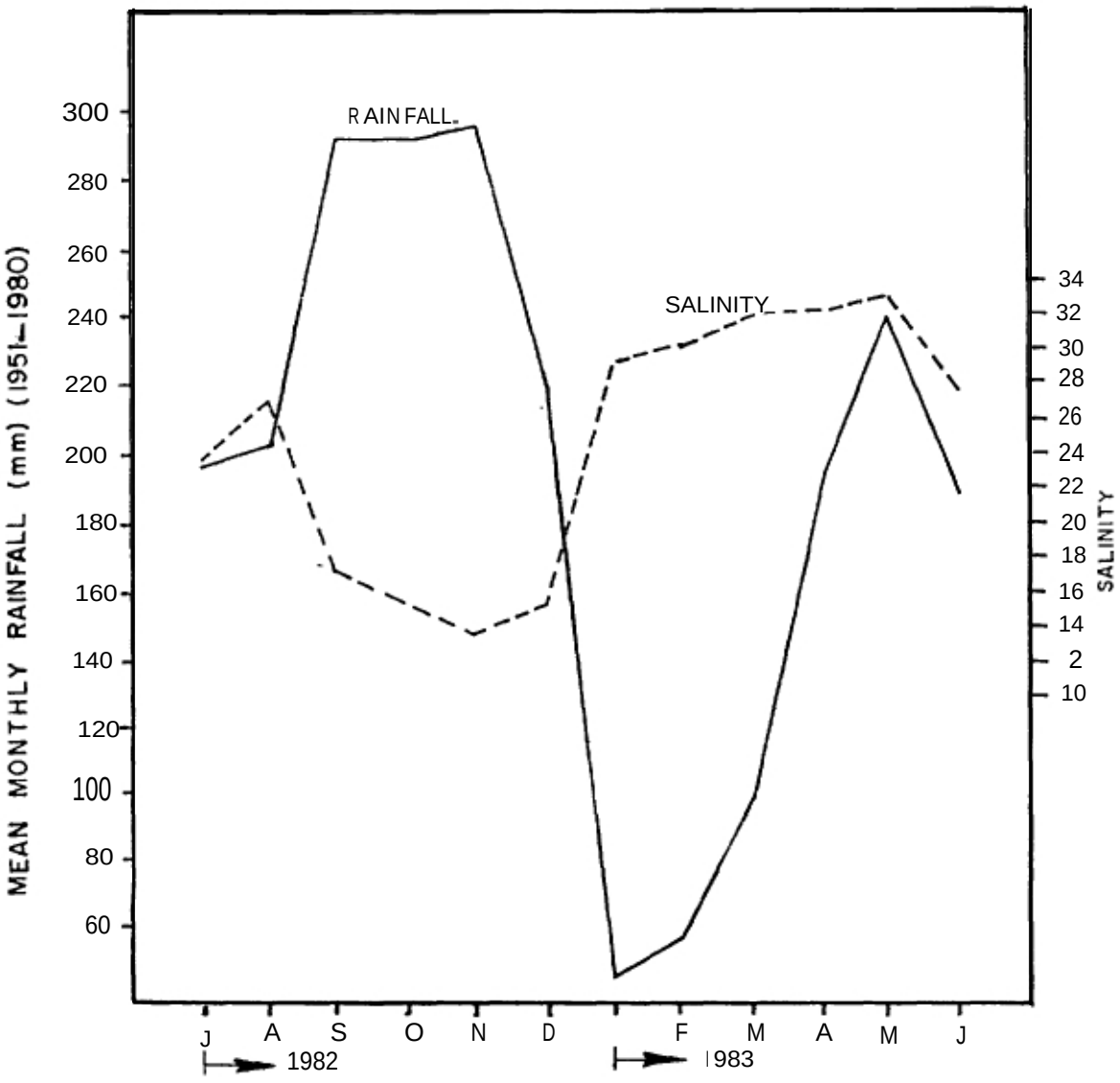
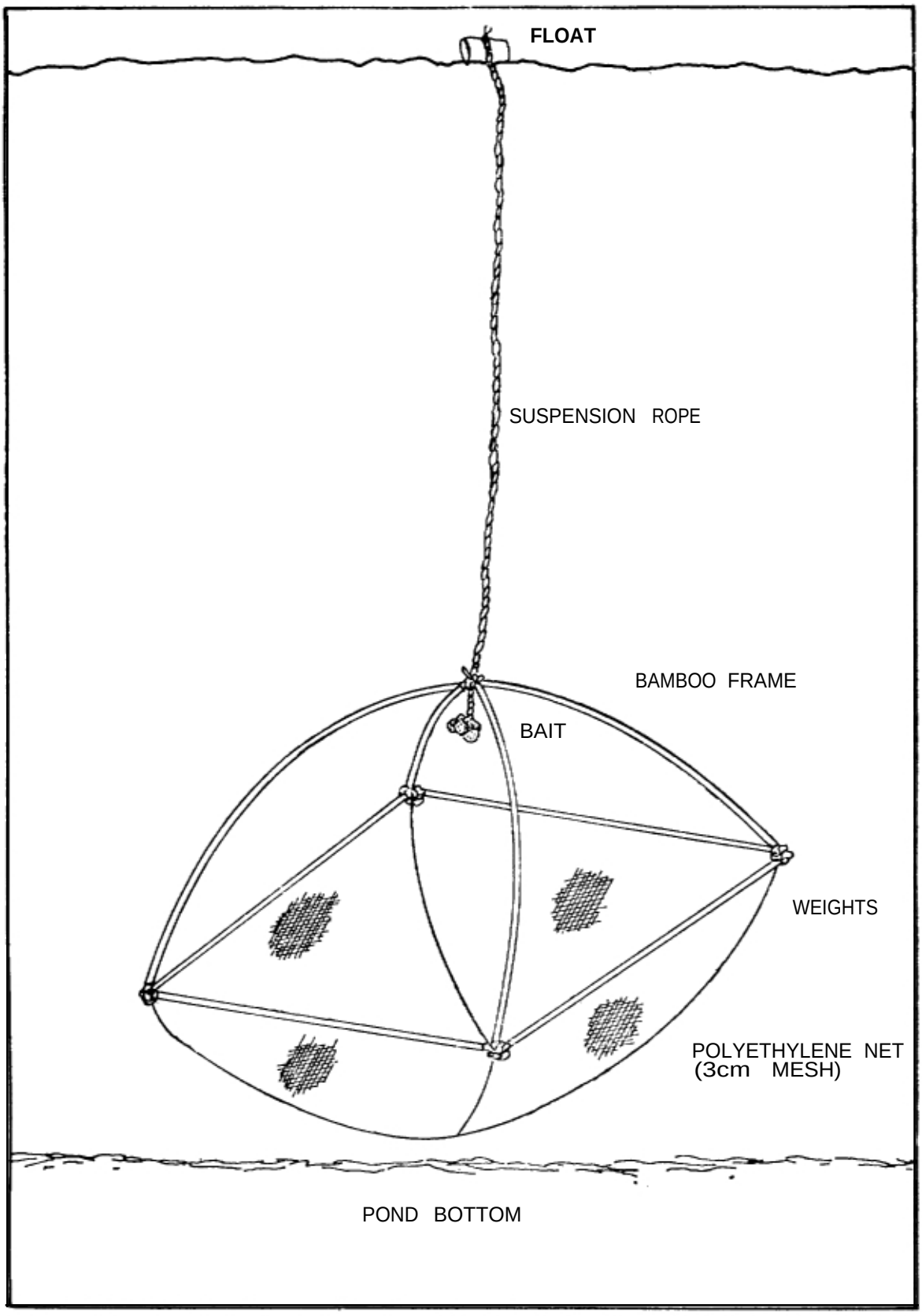
Appendix 7: AVERAGE TEMPERATURE, pH AND DISSOLVED OXYGEN DATA FOR REARING POND



Appendix 8: SALINITY AND RAINFALL DATA



Appendix 9: CRAB TRAP



Appendix 10

FACILITIES REQUIRED FOR SHRIMP AND FISH HATCHERIES

A. ***General hatchery facilities***

- sea water pump — ***2*** sets
- air blower — ***2*** sets
- emergency electrical generator 40-100 kVA — **1** set
- sea water reservoir, capacity 50% of total volume of hatchery with sand filter system
- sea water elevated tank

B. ***Facilities required for shrimp hatchery***

- tanks for maturation of broodstock : 4 m x 1.2 m deep — ***4***
- spawning and hatching tanks 1 m dia x 0.9 m deep — ***10***
- larval rearing tanks, 2 ton, conical — ***10***
- post-larval nursery tanks, 2 x 8 x 1 m — ***10***

C. Facilities required for finfish hatchery

- cages for holding and maturation of broodstock 10 x TO x 2 m — ***4***
- breeding and spawning tanks — 10 m dia x 2 m deep — ***2***
- larval rearing tanks 2 x 8 x 1 m — ***8***

D. ***Tanks required for culture of food organisms***

- Artemia hatching 0.5 m^3 — ***8***
- diatom culture 1 .0 m^3 — ***10***
- Chlorella culture 1.2 x 3 x 0.9 m — ***12***
- rotifer culture 1.2 x 3 x 0.9 m — ***12***
- Moina culture 2 x 8 x 1 m — ***8***

E. ***Associated facilities required for operation of hatchery***

- submersible pumps — ***4***
- plankton nets, various sizes
- various chemical reagents for checking water quality
- fertilizers for phytoplankton culture
- brine shrimp eggs
- others, as would be required

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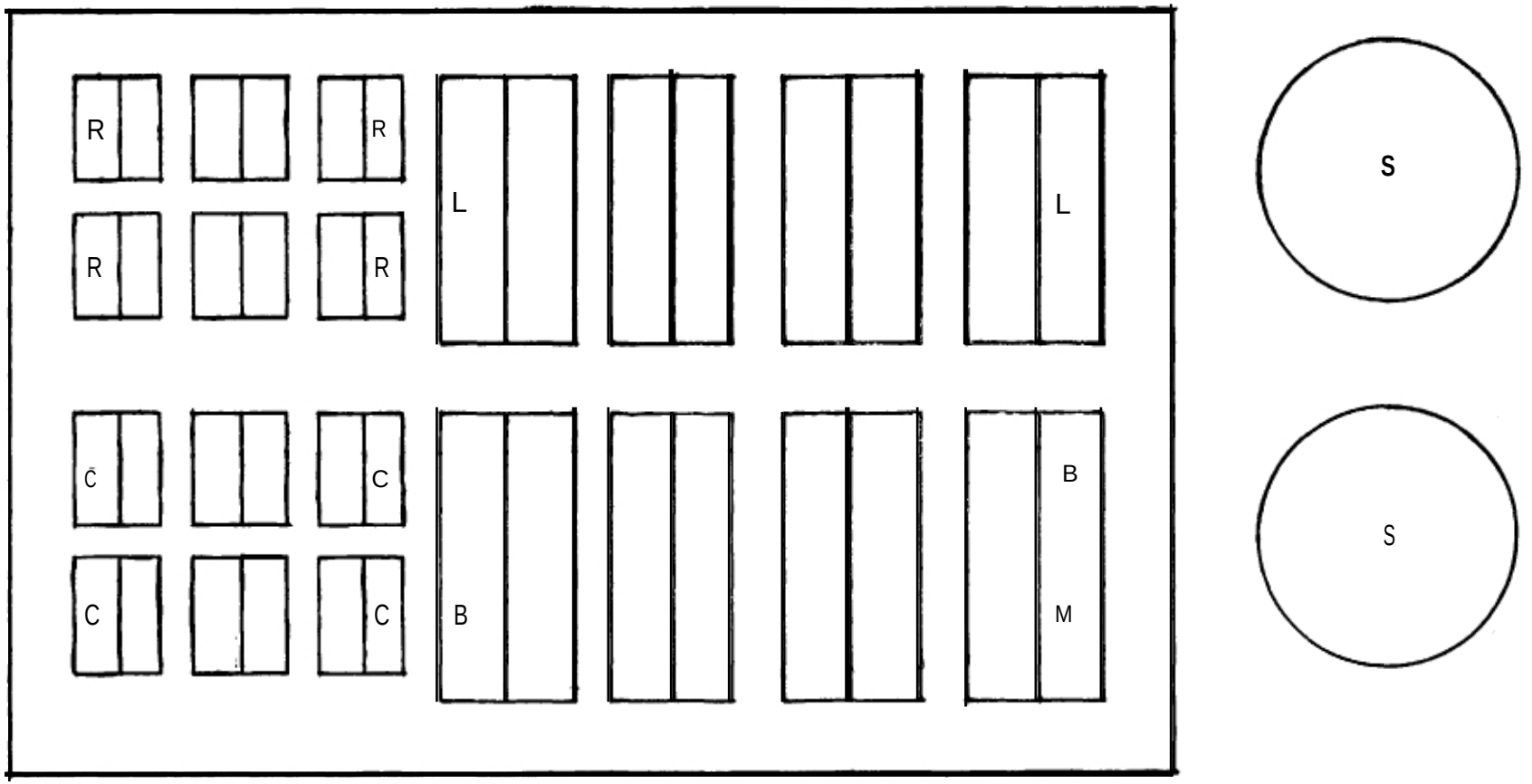
Appendix 11: FISH HATCHERY LAYOUT



FISH HATCHERY LAYOUT

S SPAWNING TANKS DIA. 10m x 2m DEPTH OUT DOOR

L LARVAL REARING TANKS 2 x1m

R ROTIFER CULTURE TANKS 1.2mx3x0.9m

C g CHLORELLA CULTURE TANKS 1.2x3x0.9m

MB= MOINA SP. OR BRINE SHRIMP CULTURE TANKS 2 x 8 x1m

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Appendix 11 -A

DESIGN CRITERIA FOR A FINFISH HATCHERY

The design criteria for a finfish hatchery are as follows:

(a) Spawning tanks are 10 m diameter with a height of 2 m holding 1.8 m water: 30-50% of the water is exchanged daily.

Each tank should be able to hold 24 broodstock; 12 females 12 males.

In one spawning period (3-4 nights) about 2-3 million larvae can be collected.

(b) Nursery tanks are 1 x 2 x 8 m holding 0.8 m depth of water or a volume of 12m^3. 50 % of the water in each tank is changed daily. The tanks are stocked with 1 -day old larvae and held till they grow to about 1-1.5 cm. Each tank is stocked with 350,000 larvae — a stocking density of 30,000/m^3 Estimated production of 1 cm fry, 1-month age are 3000-5000/m^3. Production of fish fry would be 288,000-480,000/cycle and total production about 1.4-2.4 million/year.

(c) Rotifer culture should be maintained at the density 100-250/cc.

(d) To reduce the cost of brine shrimp, Moina culture tanks are also maintained. Feeding with Moina after two weeks is recommended. These culture tanks can also be used to grow brine shrimp for feeding one-week old larvae.

(e) Hatchery building should have 70% clear roofing.

(f) Air blower capacity:

- Diameter of outlet and inlet 7.5-10 cm
- motor power: 10 hp, 1400-1500 r.p.m.
- air volume discharge about 214 cubic foot/minute at pressure 7-8 pounds/square inch.

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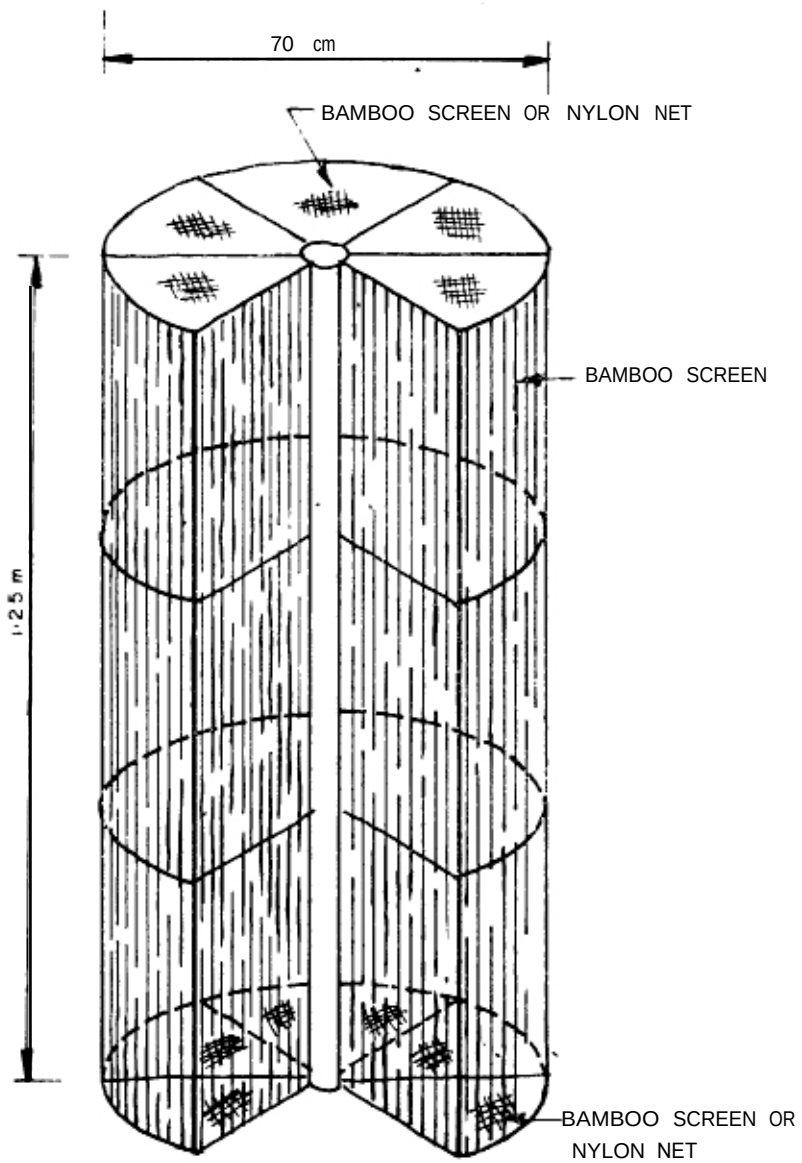
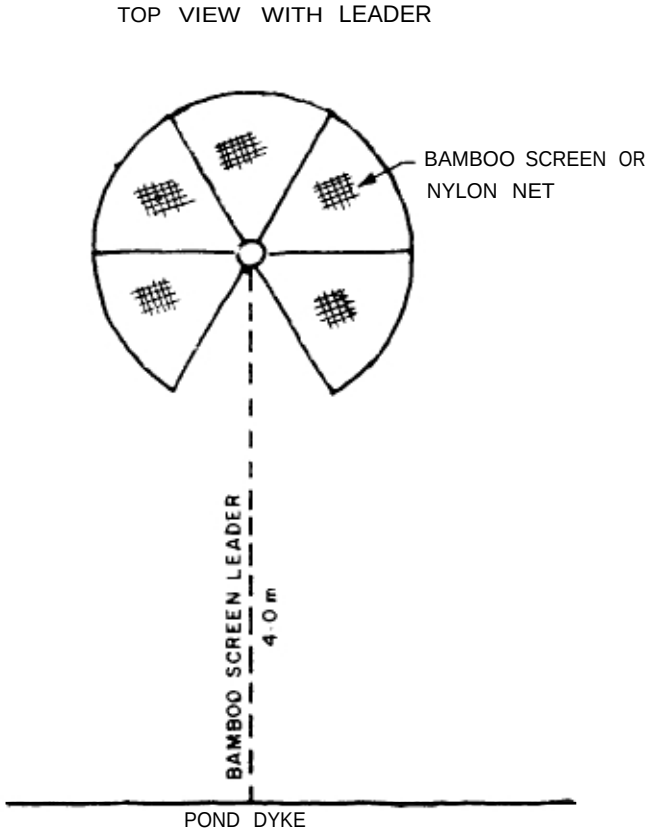
Appendix 12: SHRIMP TRAP





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Development of Small-Scale Fisheries (GCP/RAS/040/SWE)

Reports (BOBP/REP/. . .)

1. Report of the First Meeting of the Advisory Committee. Colombo, Sri Lanka, 28-29 October 1976. (Published as Appendix 1 of IOFC/DEV/78/44.1, FAO, Rome, 1978)
2. Report of the Second Meeting of the Advisory Committee. Madras, India, 29-30 June 1977. (Published as Appendix 2 of IOFC/DEV/78/44.1, FAO, Rome, 1978)
3. Report of the Third Meeting of the Advisory Committee. Chittagong, Bangladesh, l-10 November 1978. Colombo, Sri Lanka, 1978. (Reissued Madras, India, September 1980)
4. Role of Women in Small-Scale Fisheries of the Bay of Bengal. Madras, India, October 1980.
5. Report of the Workshop on Social Feasibility in Small-Scale Fisheries Development. Madras, India, 3-8 September 1979. Madras, India, April 1980.
6. Report of the Workshop on Extension Service Requirements in Small-Scale Fisheries. Colombo, Sri Lanka, 8-12 October 1979. Madras, India, June 1980.
7. Report of the Fourth Meeting of the Advisory Committee. Phuket, Thailand, 27-30 November 1979. Madras, India, February 1980.
8. Pre-Feasibility Study of a Floating Fish Receiving and Distribution Unit for Dubla Char, Bangladesh. G. Eddie, M. T. Nathan. Madras, India, April 1980.
9. Report of the Training Course for Fish Marketing Personnel of Tamil Nadu. Madras, India, 3-14 December 1979. Madras, India, September 1980.

10.1 Report of the Consultation on Stock Assessment for Small-Scale Fisheries in the Bay of Bengal. Chittagong, Bangladesh, 16-21 June 1980. Volume 1: Proceedings. Madras, India, September 1980.

10.2 Report of the Consultation on Stock Assessment for Small-Scale Fisheries in the Bay of Bengal. Chittagong, Bangladesh, 16-21 June 1980. Volume 2: Papers. Madras, India, October 1980.

11. Report of the Fifth Meeting of the Advisory Committee. Penang, Malaysia, 4-7 November 1980. Madras, India, January 1981.
12. Report of the Training Course for Fish Marketing Personnel of Andhra Pradesh. Hyderabad, India, 11-26 November 1980. Madras, India, September 1981.
13. Report of the Sixth Meeting of the Advisory Committee. Colombo, Sri Lanka, 1-5 December 1981. Madras, India, February 1982.
14. Report of the First Phase of the "Aquaculture Demonstration for Small-Scale Fisheries Development Project" in Phang Nga Province, Thailand. Madras, India, March 1982.
15. Report of the Consultation-cum-Workshop on Development of Activities for Improvement of Coastal Fishing Families. Dacca, Bangladesh, October 27-November 6, 1981. Madras, India, May 1982.
16. Report of the Seventh Meeting of the Advisory Committee. New Delhi, India, January 17-21, 1983. Madras, India, March 1983.
17. Report of Investigations to improve the Kattumaram of India's East Coast. Madras, India, July 1984.
18. Motorization of Country Craft, Bangladesh. Madras, India, July 1984.
19. Report of the Eighth Meeting of the Advisory Committee. Dhaka, Bangladesh, January 16-19, 1984. Madras, India, May 1984.
20. Coastal Aquaculture Project for Shrimp and Finfish in Ban Merbok, Kedah, Malaysia. Madras, India, December 1984.

Working Papers (BOBP/WP/.. .)

1. Investment Reduction and Increase in Service Life of Kattumaram Logs. R. Balan. Madras, India, February 1980.
2. Inventory of Kattumarams and their Fishing Gear in Andhra Pradesh and Tamil Nadu. T. R. Menon. Madras, India, October 1980.
3. Improvement of Large-Mesh Driftnets for Small-Scale Fishcries in Sri Lanka. G. Pajot. Madras, India, June 1980.
4. Inboard Motorisation of Small G.R.P. Boats in Sri Lanka. Madras, India, September 1980.
5. Improvement of Large-Mesh Driftnets for Small-Scale Fisheries in Bangladesh. G. Pajot. Madras, India, September 1980.

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6. Fishing Trials with Bottom-Set Longlines in Sri Lanka.
G. Pajot, K. T. Weerasooriya. Madras, India, September 1980.
7. Technical Trials of Beachcraft Prototypes in India.
0. Gulbrandsen, G. P. Gowing, R. Ravikumar. Madras, India, October 1980.
8. Current Knowledge of Fisheries Resources in the Shelf Area of the Bay of Bengal.
B. T. Antony Raja. Madras, India, September 1980.
9. Boatbuilding Materials for Small-Scale Fisheries in India. Madras, India, October 1980.
10. Fishing Trials with High-Opening Bottom Trawls in Tamil Nadu, India.
G. Pajot, John Crockett. Madras, India, October 1980.
11. The Possibilities for Technical Cooperation between Developing Countries (TCDC) in Fisheries.
E. H. Nichols. Madras, India, August 1981.
12. Trials in Bangladesh of Large-Mesh Driftnets of Light Construction.
G. Pajot, T. K. Das. Madras, India, October 1981.
13. Trials of Two-Boat Bottom Trawling in Bangladesh. G. Pajot, J. Crockett. Madras, India, October 1981
14. Three Fishing Villages in Tamil Nadu. Edeltraud Drewes. Madras, India, February 1982.
15. Pilot Survey of Driftnet Fisheries in Bangladesh. M. Bergstrom. Madras, India, May 1982.
16. Further Trials with Bottom Longlines in Sri Lanka. Madras, India, July 1982.
17. Exploration of the Possibilities of Coastal Aquaculture Development in Andhra Pradesh. Soleh Samsi, Sihar Siregar and Martono of the Directorate General of Fisheries, Jakarta, Indonesia. Madras, India, August 1982.
18. Review of Brackishwater Aquaculture Development in Tamil Nadu. Kasemsant Chalayondeja and Anant Saraya of the Department of Fisheries, Thailand. Madras, India, September 1982.
19. Coastal Village Development in Four Fishing Communities of Adirampattinam, Tamil Nadu, India.
F. W. Blase. Madras, India, December 1982.
20. Further Trials of Mechanised Trawling for Food Fish in Tamil Nadu.
G. Pajot, J. Crockett, S. Pandurangan, P. V. Ramamoorthy. Madras, India, December 1982.
21. Improved Deck Machinery and Layout for Small Coastal Trawlers. G. Pajot, J. Crockett,S. Pandurangan and P. V. Ramamoorthy. Madras, India, June 1983.
22. The Impact of Management Training on the Performance of Marketing Officers in State Fisheries Corporations
U. Tietze. Madras, India, June 1983.
23. Review of Experiences with and Present Knowledge about Fish Aggregating Devices.
M. Bergstrom. Madras, India, November 1983.
24. Traditional Marine Fishing Craft and Gear of Orissa. P. Mohapatra. (Under preparation)
25. Fishing Craft Development in Kerala: Evaluation Report. 0. Gulbrandsen. Madras, India, June 1984.
26. Commercial Evaluation of IND-13 Beachcraft at Uppada, India. R. Ravikumar. Madras, India, June 1984.
27. In preparation
28. Fishing Trials with Small-Mesh Driftnets in Bangladesh.
G. Pajot and T. K. Das. Madras, India, March 1984.

Miscellaneous Papers (BOBO/MIS/....)

1. Fishermen's Cooperatives in Kerala: A Critique. John Kurien. Madras, India, October 1980.

Newsletters (Bay of Bengal News) :

January 1981, May 1981, September 1981, December 1981.
March 1982, June 1982, September 1982, December 1982.
March 1983, July 1983, September 1983, December 1983.
March 1984, June 1984, September 1984, December 1984.

Information Documents (BOBP/IAF/. . . .)

1. Women and Rural Development in the Bay of Bengal Region: Information Sources.
Madras, India, February 1982.
2. Fish Aggregation Devices: Information Sources. Madras, India, February 1982.
3. Marine Small-Scale Fisheries of India: A General Description. Madras, India, March 1983.
4. Marine Small-Scale Fisheries of Andhra Pradesh: A General Description. Madras, India, June 1983.
5. Marine Small-Scale Fisheries of Tamil Nadu: A General Description. Madras, India, December 1983.
6. Marine Small-Scale Fisheries of Sri Lanka: A General Description. Madras, India, November 1984.
7. Marine Small-Scale Fisheries of Orissa: A General Description. Madras, India, December 1984.

Published by the Bay of Bengal Programme, FAO, 91, St. Mary's Road, Abhiramapuram, Madras 600 018, India. Printed at Amra Press, Madras 600

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