BAY OF BENGAL PROGRAMME

DEVELOPMENT OF SMALL-SCALE FISHERIES

REVIEW OF BRACKISH WATER AQUACULTURE DEVELOPMENT IN TAMILNADU

BOBP/WP/18

TECHNICAL COOPERATION (TCDC)

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REVIEW OF BRACKISHWATER AQUACULTURE DEVELOPMENT IN TAMIL NADU

BOB P/WP/1 8

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This working paper is the report of a two member mission from the Directorate General of Fisheries, Thailand which visited Tamil Nadu for about a month during September—October 1981 at the request of the Government. The FAO/SIDA Bay of Bengal Programme (BOBP) acted as supporting agency for the mission in accordance with the Buenos Aires Action Plan of the United Nations to foster Technical Cooperation among Developing Countries (TCDC).

Several people from Tamil Nadu assisted the mission during the study: Mr. C. Chellappan, Director of Fisheries, and fishery officers in Madras and at various districts provided information and made arrangements for field visits and interviews. Logistic support from district collectors and sub-collectors greatly facilitated the work of the mission.

Dr. M. Karim of the BOBP assisted the mission during the study and the report preparation. The costs of travel, of servicing the mission and of preparing this report, were met by the BOB P.

The BOBP is funded by the Swedish International Development Authority (SIDA) and executed by the Food and Agriculture Organisation of the United Nations. Five countries—Bangladesh, India, Malaysia, Sri Lanka and Thailand—are members of the Programme. Its main aims are to develop and demonstrate technologies and methodologies to improve the conditions of small-scale fisherfolk and the supply of fish from the small-scale sector in the Bay of Bengal region.

The views and recommendations presented in this paper are those of the mission members and not necessarily those of the Directorate General of Fisheries, Thailand or the FAO.

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1.2 Terms of reference, composition and itinerary

1.2.1 The detailed terms of reference of the mission are set out in Appendix 1. In fulfilling the terms of reference, the mission had at all times in mind the need to:

(1) Observe the existing activities in shrimp and fish culture.
(2) Recommend improvements to the existing brackishwater fish and shrimp farming projects.
(3) Point out suitable sites for demonstration of mono- or polyculture.
(4) Examine the resources available for promotion and extension of coastal aquaculture.
(5) Select a site for a hatchery and recommend a suitable system for hatching shrimp.

1.2.2 The two-member mission consisted of Mr. Kasemsant Chalayondeja, Fisheries Biologist in the Aquaculture Research Section, Brackishwater Fisheries Division, Department of Fisheries; and Dr. Anant Saraya, Fisheries Biologist, Aquaculture Survey Resources Section, Brackishwater Fisheries Division, Department of Fisheries.

1.2.3 The mission arrived in Tamil Nadu on 23 September 1981 and left for Bangkok on 25 October 1981.

Appendix 2 gives details of their itinerary and activities, Appendix 3 a list of persons met, and Appendix 4 a list of documents consulted.

2. CURRENT SITUATION

2.1 Geography

2.1.1 **The state of Tamil Nadu is** in the extreme southeast of India; **it lies between 8°15' and** 13°35' north, and 76°15' and 80°20' east. It is bordered by the state of Andhra Pradesh in the north, Karnataka in the northwest, Kerala in the west, and has a coastline of about 1000 ha washed by the Arabian Sea in the southwest, the Indian Ocean in the south, the Gulf of Mannar in the southeast, and by Palk Bay and the Bay of Bengal (the Coromaridel Coast) in the east. The area of continental shelf bounded by the 200 m depth contour is 41,400 km^2.

2.1.2 The climate is tropical with temperatures ranging between the extremes of 43°C and 13°C. Total average rainfall is about 950 mm. There are two monsoon periods, the northeast monsoon (October—December) which contributes 60 per cent of the total rainfall and the southwest monsoon (June—September) about 28 per cent. The wind speed in the monsoon months is 15 to 20 knots; winds of 60 knots or more can be experienced during cyclones, which are not infrequent.

Sea surface temperatures in the Bay of Bengal are between 27°C and 29°C. There is a peak of phytoplankton production during each monsoon; zooplankton is at its highest densities in June and October.

Besides the potential for culture of fish and shrimp already noted, there may be opportunities for cultivating pearls and certain types of seaweeds.

2.2 Fisheries development

2.2.1 The Government attaches high priority to the development of the fisheries and assists and encourages fishery enterprises in various ways. Among their stated objectives in the Sixth Five-Year Plan that are germane to the objectives of the present mission are:

- "to popularise and launch coastal aquaculture projects with special reference to the culture of prawns, brackishwater fishes, edible oysters, mussels, seaweeds, etc.
- "to step up the production of quality fish seed and management techniques.

— "to re-orient fishery research and development programmes with adequate extension facilities for achieving the objectives of increased fish production and of proper utilization.

— "to train the Fisheries Department personnel in various specialised areas to facilitate the speedy and effective implementation of the development projects.

— "to improve the socio-economic conditions of fishermen and fisherwomen.

— "to generate employment potential."

The various development programmes to fulfil the above objectives were to include, *inter alia:*

— provision of infrastructure and social inputs.

— reorganization of fishermen's cooperative societies.

— aquaculture in marine, brackish and fresh waters.

problem-oriented research.

— extension and survey.

— training programmes.

2.2.2 Accordingly, the Government planned, as noted earlier, to develop about 1000 ha of coastlands and intertidal flats mainly for shrimp culture. In 1979 the Directorate of Fisheries began to construct ten 2-ha demonstration farms in selected areas at a cost which was not to exceed Rs. 75,000 each. The individual farms will consist, when complete, of two to four nursery ponds of 0.1 ha and one or two rearing ponds covering 1.2 to 1.4 ha.

2.2.3 Meanwhile some aquaculture enterprises have been developing in the private sector and at least one state corporation and one cooperative are showing active interest.

2.2.4 These various projects, and associated work in research institutes and similar organizations, are described and commented upon in the next chapter.

3. FINDINGS AND COMMENTS

3.1 Adyar brackishwater fish farm

3.1.1 This experimental farm is owned and operated by the Directorate of Fisheries. It is sited in the San Thome district of Madras, and covers a total area of 8 ha near the Adyar creek.

3.1.2 There are 6 nursery ponds of 0.1 ha each, one 1.4 ha rearing pond, and one 1.5 ha catching pond. These ponds are at present employed mostly for shrimp culture. The staff consists of **16 persons.**

3.1.3 In accordance with the programme of research, the following projects were in hand:

(1) to investigate brackishwater prawn and fish seed in the Adyar and Marakanam estuaries.
(2) to experiment on monoculture of commercially valuable shrimp species.
(3) to experiment on polyculture of shrimp and fish.
(4) to transfer the results of the work to the private sector.

3.1.4 The trials already completed on the culture of shrimp and fish have achieved satisfactory results: in monoculture of *Penaeus monodon* a productivity of approximately 514 kg/ha in 90 days was recorded while that of *Penaeus indicus* was 440 kg/ha in 3—4 months. In a polyculture trial, the production of *Chanos chanos* together with *Penacus spp* was 1200—1500 kgf ha in 5—6 months. The juvenile shrimp with which the ponds were stocked were quite large (40—50 mm), which makes for high survival rates.

At the time of the visit, some of the nursery ponds were stocked with *P. indicus* at the rate of 40,000 specimens per hectare. The growth rate is from an initial size of 20 mm to 60 mm in a month, without supplementary feeding. Salinity is approximately 24—25 ppt as measured by refractosali nometer.

3.1.5 There are some constraints and potential problems at this fish farm which need attention, as follows:

(1) Domestic waste from the housing complex located just in front of the farm may pollute the Adyar estuary.

(2) The existing nursery ponds and rearing ponds cannot be drained completely because their bottom levels are lower than extreme low water.
This can be solved by using a pump. However, the dykes must be proof against seepage.

(3) If the ponds had been constructed with higher bottom levels, the use of pumps would have been unavoidable because of the small tidal amplitude: 0.5—0.7 m.

(4) Although the salinity is normally between 24—32 ppt it may reach 40 ppt during summer time because of the shallowness of the ponds.

(5) Abundance of "Kotipu" *(Brachionus sp)* may cause serious oxygen depletion during darkness.

3.1.6 The facilities of the farm include a 100 m^2 hatchery shade, collapsible plastic tanks, a 3 hp compressor air pump, and 7.5 hp diesel-driven centrifugal water pump with 10 cm diameter outlet.

3.1.7 There is a potential site for a shrimp hatchery at this farm. Before establishing such a hatchery, several factors have to be considered, viz., transportation, availability of brood stock, clear and clean seawater supply, infrastructure, etc.

As regards availability of gravid shrimp, *P. indicus* and *P. monodon* are always to be found by trawling, the peak season being from August to September; moreover, juveniles of *P. indicus* are available almost throughout the year. Using appropriate gear, a man-hour of effort produced between 8,000 and 10,000 juveniles during September in both 1976 and 1977. The fishermen will sell gravid shrimp at Rs. 1 5—25 each tothe hatchery. It is reported that *P. indicus* constitutes 70—80% and *P. monodon* 5—8% of the total shrimp catch.

The Adyar farm is quite near Madras city, so there should be no problem regarding transportation of stock for commercial farms. The farm is already gathering shrimp seed and *Chanos* fry for nursery rearing and subsequent distribution to commercial fish farms.

A proposal for a research-cum-pilot project for a prawn hatchery at San Thome is to be submitted to the State Government. Because the site is not ideal, and there is a need to establish very soon the first state shrimp hatchery, the mission, in cooperation with Fisheries Department Officers, looked for other more suitable sites on which to establish it, during visits and travel in the other coastal areas of the state. The mission bore in mind that a suitable place should have certain special attributes, viz., clear and clean seawater and fresh water supplies (both free from industrial and domestic effluent), adequate transportation and communications, as much protection as possible from the monsoon, adequate electricity supply, etc.

An area of eight hectares in Neelankarai village, approximately 10 km from San Thome Fisheries Farm, is probably suitable and available for establishing a shrimp hatchery. Although the sandy soil would be a problem in pond construction, this site is suitable for a hatchery, as such an installation requires concrete ponds and/or collapsible plastic tanks. Supervision of the design and construction of the seawater supply system, involving a long suction line and pump, would best be entrusted to qualified engineers.

3.2 Pulicat

3.2.1 The Pulicat Brackishwater Research Centre was established in 1973 by the Department of Fisheries. The main purpose of this centre is to provide an extension service; however, there are six 0.02 ha nursery ponds for young shrimps destined for distribution to the fish farmers. Wild shrimp seeds collected from adjacent waters are being nursed to the size of 25—35 mm

with supplementary feeding. There are four 0.15 ha rearing ponds where modern methods of shrimp culture are being tried out using *Penaeus indicus.* Trials of potential improvements in nursery management techniques are also being conducted. Existing facilities include one collapsible plastic tank of 3 m diameter and one 7.5 hp diesel pump.

3.2.2 There are fisheries of significant size in Pulicat lake, which is the second largest brackish-water lake in India. It lies approximately 60 km northeast of Madras city, partly in Tamil Nadu and partly in Andhra Pradesh. Its total area is 461 sq.km; only 4,800 ha of water surface are in Tamil Nadu. Three rivers viz., Aranier, Kalangi and Swarnamuki, supply fresh water to the lake during the rainy seasons; the Aranier flows into the lake near Pulicat village in Tamil Nadu while the other two are in Andhra Pradesh.

Some hydrological data are available for the lake waters. The essential parameters are well within the tolerance range of fish and shrimp.

However, during severe summer when there is little or no rain and no fresh water influx through the rivers, the salinity rises very high, at places well exceeding 40 ppt. due to heavy evaporation and no dilution. During this period, the barmouth also remains closed, not permitting any water exchange between the lake and the open sea. The average ranges of some of the selected parameters are indicated below.

Hydrological data of Pulicat Lake in 1980

	Bar mouth	Karimanal	Pulicat
Temp. (°C)	25.4—30.1	25.3—30.0	25.4—30.8
Free CO2(ppm)	Nil	Nil	Nil
M.O. Alkalinity (ppm) ..	90.0—1 21 .6	90.0—1 24.6	90.0—1 20.0
pH	8.4—8.7	8.4—8.7	8.4—8.7
D.O. (ppm)	4.8—8.2	4.5—8.4	2.4—8.2
Salinity (ppt.)	10—40	10.5—38.0	10.4—38.0

Source.' Department of Fisheries, Government of Tamil Nadu.

The fishermen of 15 villages around the lake operate about 800 country craft and use various kinds of net, such as bag net, drag net, stake net, cast net and shore seine; hook and line are also commonly used. Although the average depth of the lake is 0.8 m, in certain areas close to Domrivu village it may reach 7 to 8 m. The daily catches are usually landed at Arambakkam, Sunnambukulam and Pulicat. The average annual production is approximately 350 tonne, of which shrimps constitute 30—40%. The composition of commercially important species and their seasonal abundance are given in the tables.

Composition of important species in Pulicat Lake

Mugil spp	15%
Nematolosa sp	5%
Sillago sp	4%
Sciaena sp	4%
Lates sp	2%
Eleutheronema sp	2%
Chanos	1%
Penaeus indicus	30%
Penaeus monodon	4%
Miscellaneous	33%

Seasonal abundance of fry of cultivable species in Lake Pulicat

P. indicus	:	**February—March, April** June—August, October, November
P. monodon	:	January, March—May, September, December
P. semisulcatus	:	January, February—May, August—September, October
Chanos		February, March, April, June, September
Mullet	:	February—June
Etroplus	:	All round the year
Polynemus	:	All round the year.

3.2.3 This productive lake could be developed for pen culture, floating cage culture and pond culture.

(a) *Pen cufture*

Because the average depth of the area is 0.8 m, and tidal amplitude is quite small, pen culture is the obvious system to try in areas of 1—2 m depth. There is already an experiment in shrimp pen culture near the Pulicat fish landing place run by CIFRI (Central Inland Fisheries Research Institute) (see 3.16 below). To demonstrate the potential of pen culture, it could be tried on the sandy clay loam flat off Sattankuppam village. Pen culture would probably be best operated through cooperation of the villagers and/or primary school students of the village under the auspices of the school.

Eradication of crabs could be accomplished by using a baited trap net.

(b) *Cage culture*

Cage culture of fish could also be considered, even though most of the fishermen are at present interested only in shrimp culture. Sea bass fry occurring naturally could be collected and grown in floating cages, in the 7—8 m deep portion of the lake in front of Donirevu Kuppam. An area of 16 hectares could be thus utilized by the fishermen of nearby villages. One problem, navigation of local fishing boats, might be solved by the heads of the villages and Fisheries Department officers. Any such enterprise would be best handled by a cooperative in order to solve such local problems. Operating period could be from October to March.

(c) *Pond culture*

At present there are seven private shrimp pond farms in Pulicat. One of the farms reports a productivity of 150—200 kg/ha in 3—4 months.

A model brackishwater shrimp pond farm with an extent of 1 hectare is under construction close to the fish landing centre by the Pulicat Research Centre. However, it should be noted that the soil around Pulicat is mostly sandy loam; care would have to be taken by the engineers to provide means to prevent seepage through pond dykes and bottoms.

3.2.4 Comments on existing shrimp ponds, ponds under construction, and ponds being planned are as follows:

(a) At times, where pond bottoms are below the level of the lowest low tides, resort to pumping may be necessary.

(b) High rates of sedimentation and sand erosion are destroying the usefulness of peripheral ditches in the existing ponds.

(c) It is always necessary for the bottoms of ponds and dykes to be compacted according to the advice and under the supervision of an engineer knowledgeable and experienced in pond construction.

3.3 Marakkanam Research Centre

3.3.1 This centre, belonging to the Department of Fisheries, is located about 140 km from Madras, close to the Buckingham canal. The area is isolated from the nearest town and flooded during the monsoon season (October—December). Existing facilities include one office building, two 0.2 ha ponds with sluice gates, one 7.5 hp diesel driven pump and other essential equipment. Because of the heavy flooding during the monsoon, the dykes of the ponds are as high as 3.5 m, and represent a considerable financial outlay.

3.3.2 Experience of trials on shrimp culture shows that 75 kg per 0.2 ha could be harvested in a single crop, and staff say that two crops could be taken in a year, from January to April and June to August. During the mission's visit, salinity in the pond was 31 ppt; it was stocked with *Penaeus indicus* seeds collected from adjacent waters with an initial size of 50—60 mm. Stocking density is reported as 7000 specimens per 0.2 ha. They were said to grow to the size of 120 mm after 48 days.

3.3.3 At the present stage of development of aquaculture, this general area is not suitable for shrimp pond culture because of the heavy flooding, unless heavy investment on dyke construction is acceptable. An alternative role for the centre would be collecting shrimp seeds and distributing them to the shrimp farmers of the other areas.

3.4 Porto Novo fisheries farm

3.4.1 This fisheries farm is located near the Centre of Advanced Study in Marine Biology of Annamalai University. It belongs to the Department of Fisheries. There are six **0.5 ha ponds for** experimenting on shrimp culture, some of which are now being stocked with seeds of *P. monodon* and some with *P. indicus.* Stocking rate is approximately 15,000 specimens/ha with an initial size of 40 mm. Salinity range of the water in the area is between 13 and 23 ppt.

3.4.2 Once again the bottoms of these experimental ponds are at a lower level than the lowest tides, so draining of the ponds is impossible unless a pump is employed. Water supply to the ponds is through sluice gates that are so small that the water in the ponds would never reach the desired depth; to solve this problem, a pump has to be employed. To prevent seepage red soil has to be used as the core of the dykes. The bottom soil of some ponds is of a black colour and there is a smell of hydrogen sulphide. Blooming of *Cerithidium* (a filamentous algae) may reduce space available for shrimp as well as interrupt the desired food chain in the ponds. Spraying quicklime (CaO_2) is one way that could be tried to get rid of *Cerithidium.* Burrowing organisms could be eradicated by applying quicklime (CaO_2) into the holes.

3.4.3 Close to the fisheries farm, a demonstration prawn farm is under construction. This area seems to be an ideal place for demonstration and extension of shrimp pond culture: salinity ranges from 13 to 23 ppt; sea water from the Vellar estuary could be drawn through a pump to the ponds.

A student thesis submitted to Annamalai University states that there are five peaks in abundance of shrimp seeds in the estuary, of which the highest is during June and July.

This site is suitable for pond development; for layout, pond construction and engineering, an essential guide would be "Engineering Aspects of Brackishwater Aquaculture in the South China Sea Region," by T. Jamandre, Jr. and H. R. Rabanal, published by the FAO/CIDA South China Sea Fisheries Development and Coordinating Programme (SCS/75 (WP) 16; Manila 1975: 37 pp.). Blooming of *Cerithidiuni* and other filamentous algae will need guarding against.

3.5 Killai

3.5.1 The Killai backwaters are located about 15 km southwest of Chidambaram town in South Arcot district. They are a network of bodies of water connected to the Vellar Coleroon estuary with a total area of approximately 1380 ha. The soil is sandy, muddy loam; the average depth is 1.5 m; the amplitude of the tide is between 0.5 and 0.8 m.

The salinity regime in the backwaters remains comparatively low, up to 35—36 ppt, because the water bodies remain in communication with the open sea for most part of the year. Besides, the freshwater discharge through the Kaveri river exerts its influence on the salinity of this and other adjoining estueries. The highest salinity is generally recorded in July and the lowest, 1 ppt or sometimes even less, in November. Water pH is slightly alkaline (7.4—8.4) throughout the year. Dissolved oxygen as low as 2.02 ppmandwatertemperatures up to 32°Chave been recorded.

The water is light green to brown in colour depending upon season and occurrence of phyto and zooplankton. In some places there are mangrove trees; *Rhizopora apiculata* and *R. mucronata* are the dominant species; *Avicennia* occurs also. The area is highly productive, and a natural nursery ground for the larval stages of marine organisms such as *Penaeus indicus, P. monodon, Metapenaeus monoceros, M. dobsoni* and *Macrobrachium rudi,* which are prominent in the catches of the marine fishery. In 1978 a total of 325 tonne of fish and shrimps were landed from the Killai backwaters. There is reported to be an abundance of shrimp juveniles, specially *P. indicus,* all the year round.

3.5.2 The first 0.2 ha farm for culture of shrimp in pens was completed on 2 February 1980 and stocked with 9,885 *Penaeus monodon* juveniles. Supplementary feeds were supplied. The quantity harvested in June 1980 was 50.5 kg. This pen was stocked again with 10,000 *Penaeus indicus* juveniles on 23 July 1980 and was harvested several times from 2 September 1980 to 7 January 1981, yielding a total quantity of 61.7 kg.

A second pen with an area of 0.4 ha was stocked with 22,050 *P. indicus* juveniles. A total quantity of 114.65 kg was harvested. Then 22,000 *P. indicus* juveniles were cultured to yield 157.7 kg.

3.5.3 The State Government have approved the expenditure of 1.182 million rupees for constructing a 6 ha shrimp pond either in the elevated area or more probably on the extensive sublittoral sandy mud and loam flat at Killai. Nevertheless it seems to be an area much better suited to pen culture; indeed, it appears to be ideal. Shrimp and/or fish pen culture could be developed all over this productive area. The reasonable investment requirements for pen culture could encourage fishermen to change from production by capture to production by culture.

3.5.4 Potential problems mentioned during the visit of the mission included predators; burrowing fish like *Muraenesox,* and crabs. Such problems are amenable to remedies such as the application of appropriate amounts of tea-seed cake and mahua cake to eradicate predators and burrowing fishes, and using baited trap nets to get rid of crabs.

3.6 Vaniyanchavadi demonstration prawn farm

3.6.1 A pilot project on shrimp culture is under wayon the Kovalam backwaters in Chingleput district. Facilities include an office, a 1 ha rearing pond and a small number of *hapas* (the local name for small hanging-cage culture units of traditional design). The unit is about 2.5 km from the sea. The sandy loam bottom is more or less at water level. Water can be let into the pond through a concrete pipeline during high tide; however, there are plans to use pumps also. During the mission's visit, the refractosalinometer indicated 13 ppt; salinity may be as low as 1.0 ppt during the rainy season.

3.6.2 Up to now, the staff have experimented with culture of *Penaeus indicus* in *hapa* of 40 sq.m (8x5x1) and 10sq.m (5x2x1).Apparentlyahapa of 40sq.m can producea total of 12kg of shrimp after three months. Thus, if it were found possible to operate 200 hapas in an area of water of one ha, the total production might be 2,000—2,400 kg. This however cannot be assumed without further trials: first, in order to confirm the previous result; and second, to ascertain whether it is valid for large groups of *hapa* sited close together.

3.6.3 The mission has the following comments:

(1) Steps may need to be taken to ensure that water seepage cannot take place through the dykes of the demonstration pond.
(2) Erosion of the dyke is apparent.

(3) If satisfactory results on shrimp culture in *hapa* can be confirmed by further trials, as suggested above, the system would be at a sufficiently advanced state of development to allow it to be transferred to fish farmers through demonstration and extension.

3.7 Pazhanjore cooperative shrimp farm

3.7.1 This is situated in Pazhanjore village of Thanjavur district. A cooperative society was organised to help improve the economic status of the fishermen and to increase the value of production from available natural sources. The fishermen of the village are keen to participate. The layout of a rearing system recommended by the Thai mission is given in Appendices 12, 12b and 12c.

3.7.2 The first phase of the project is located close to two existing canals and approximately 600 m from the sea shore. The 100 ha area is flat land of clayey sandy loam. Proper design and construction of ponds will prevent seepage. Salinity fluctuates within the range 1—33 ppt depending upon season, but both saline and fresh water are available the whole year round. The existing canals (6 m wide and 1.5 m deep) could be enlarged by excavation to give adequate water supplies. Seeds of *Penaeus indicus* are available the whole year in the wild.

3.7.3 The favourable conditions make this area an ideal place for pilot work and demonstration of shrimp pond culture, the results of which would be transferable to village fisheries co-operatives through extension.

However, pond engineering and water management must be given close and competent attention in order to ensure there is no seepage through the dykes.

3.8 Eripurakkarai demonstration prawn farm

3.8.1 This site is located in Adirampattinam town, Eripurakkarai village. The total area of this farm is 1 ha, made up of one 0.7 ha rearing pond, one 0.2 ha nursery pond and one 0.1 ha catching pond.

3.8.2 A diesel pump of 7.5 hp is employed to draw the sea water from the supply canal into the pond through a 100 mm diameter pipeline. Water flows from pond to pond through 300 mm diameter pipes and screens of fine mesh silk bolting. The sandy soil of the dykes had eroded, and there was also erosion under the pipes; pipes were partially blocked; insufficient care had been taken to reinforce or compact the soils; and there are no berms to stabilise the dykes. Salinity during observation was 30 ppt.

3.8.3 Fish fry and shrimp seed are abundant, especially in the supply canal.

3.8.4 More attention needs to be paid to reinforcement and compaction of the soil to prevent erosion and seepage.

A canal of sufficient depth might be useful for water drainage from the ponds at the time of harvesting.

3.9 Kathumavadi demonstration prawn farm

3.9.1 This farm is situtated in Pudukkotai district approximately 500 m from the waters of Palk Bay. It is surrounded by salt pans and the waters are highly saline: in the ponds 40, 45 and 55 ppt, and in the supply canal 38 ppt at the time of the mission's visit. This high salinity may affect the growth of shrimps and fishes; nevertheless, a scoop with a fishing net in the supply canal showed an abundance of shrimp seed and mullet fry. The water management of this farm is dependent on a 7.5 hp diesel pump. Water flows from pond to pond through concrete pipes.

3.9.2 The mission had the following comments:

(1) Sluice gates might be better than the existing concrete pipes in order to allow larger quantities of water to pass through in a given time.
(2) Due to the high salinity in the ponds, frequent water exchange through well-designed sluice gates is probably necessary.
(3) Pen culture might be tried on a pilot scale on the sandy mud flat off the village.

3.10 Muthupet demonstration prawn farm

3.10.1 This is situated in Thondiakkadu village approximately 5 km from a shallow lagoon surrounded by thick mangrove forest *(Avicennia spp.).* Water supply to a fish farm could most easily be arranged by extraction from the Marakkakorayar river nearby, which flows into the lagoon. Salinity is generally low because of land drainage; during the mission's visit it was only 4 ppt in a 7 ha rearing pond and two 0.5 ha nursery ponds.

3.10.2 While the farm can continue to be used in accordance with the original objective of demonstrating prawn culture, there are other possibilities:

(1) Because of the long season when the water is virtually fresh, the site seems suitable for rearing of *Chanos, Mugil* and *Lates.*
(2) Planting of *Rhizopora* would increase natural nutrients and yield crops of timber.
(3) Pen culture, organised through cooperatives, should be possible in the lagoon.

3.10.3 In the existing farm, steps are necessary to prevent soil erosion.

3.11 Punnakayal demonstration prawn farm

3.11.1 This farm adjacent to the fish landing area in the Punnakayal estuary is still under construction. It is to have a 1 ha rearing pond, a 0.1 ha nursery pond and a 0.05 ha catching pond. The potential area for shrimp pond expansion may be 8 to 10 ha.

Sea water will be extracted from the Gulf of Mannar. The clayey sandy loam soil seems more suitable for pond construction than the soils in other areas examined by the mission. However, although at present there is no sign of water pollution, in the next few years the growth of the population of fishermen living only 100 m from the farm may cause problems (as found at the fish landing area in Royapuram village, Ennore). Seeds of *Penaeus indicus* are abundant during November to March.

3.11.2 The mission had the following comments:

(1) When considering the layout of shrimp ponds it is desirable to take into account the strength and direction of the prevailing winds.
(2) Sluice gates are better than pipes for interconnecting ponds.
(3) There are possibilities of increased pollution which will need to be guarded against.

3.12 Keelavaipar demonstration farm

3.12.1 This site is located in Keelavaipar village, approximately 500 m from the sea shore and 600 m from the Vaipar river and surrounded by salt pans. Water spilling over from newly-filled salt pans deposits crystals of salt on the surrounding soil. The 2-ha farm is under construction close to an existing private 4-ha prawn farm.

3.12.2 The mission had the following comments:

(1) It seems to be impracticable to draw water of low salinity from the Vaipar river to correct the salinity of the water in the pond; at the time of the mission's visit there was no water in the river.
(2) Direct pumping of sea water straight to the farm seems feasible.
(3) Sound design and construction are essential in order to prevent water seepage through dykes.

3.13 Valinokkam: proposed shrimp farm

3.13.1 This area is under the responsibility of the Tamil Nadu Salt Corporation Ltd. The utilization of reservoir No. 1 for fisheries has been approved; it is approximately 50 ha in area and 0.9 m in depth. The soil seems to be of sandy clay and loam. Because of its isolation from factories and large human settlements, the sea water is clean and clear. The mission therefore regards the site as potentially suitable for development of shrimp culture and for a hatchery. However, the fluctuation of physicochemical and biological parameters of the sea water throughout the year must first be studied.

3.14 Karangadu: proposed cooperative farm

3.14.1 There is an area of salt marsh close to the Kottaigarai river in Karangadu village, with *Avicennia* growing in patches, of about 40 ha in extent. It floods during high tide and dries out at low tide, but the tidal range is small; pumping would be necessary if pond culture is to be established. The very favourable salinities, availability of natural shrimp seeds, and the strong interest of the villagers, combine to make this site a very attractive one at which to develop shrimp pond culture through the existing fisheries cooperative, which has 250 members. First, however, shrimp pond culture should be established on a pilot scale under the responsibility of a cooperative in order to confirm its feasibility and economics. Among other things, it is likely that *Cerithidium* may cause problems.

3.15 Athangarai: proposed shrimp farm

3.15.1 This site is located at the mouth of the Vaigai river, opposite Athangaral village. The area is approximately 45 ha. Sandy loam soil might cause problems in pond construction and a black film of surface soil suggests potential chemical problems.

3.15.2 Shrimp seed are locally abundant and could be collected for cultivation in *hapas.*

3.16 Central Marine Fisheries Research Institute

The mission had an opportunity to visit several CMFRI stations to observe the progress of some very interesting research projects.

3.16.1 *CMFRI at Kovalarn*

This research institute is mainly responsible for work on shrimp hatching, mussel culture and experiments on the hatching of the sea turtle, *Lepidochelys olivesea,* and growing of lobsters: *Panulirus pofyphagus* and *P. homarus.* The results are satisfactory, but further work is believed to be necessary.

3.16.2 *CMFRIat Tuticorin*

This institute is carrying out very interesting work on oyster culture *(Crassostrea madrasensis),* crab culture *(Scylla oceanica),* and culture of *Chanos* and *Mugil.* A new building to be used as a mollusc hatchery is now being constructed.

3.16.3 *CMFR/ at Mandapam*

The main work of this institution is on development and culture of eel *(Anguilla bicolor), Chanos* and mullet. They have also been successful in culture of seaweeds, especially *Gradilaria edulis.*

3.17 Private sector shrimp farms

Three private shrimp farms were visited by the mission, whose terms of reference called for a critical analysis of their problems and specific suggestions for improvements; however, it would be inappropriate to include such material in a published report. The observations which follow are of a general nature.

3.17.1 The Hindustan Lever Ltd. prawn farm is getting ready to expand hatchery operations, and brood stocks of *P. monodon* are being held for the purpose of breeding by the eye-ablation method.

3.17.2 The Tata Oil Mills Co. prawn farm is undertaking shrimp culture.

3.17.3 The third private farm seemed to be an ideal place for shrimp rearing, since it is close to the public supply canal of Paravai village. However, in certain seasons, low water salinity may create serious problems. At present,the farm is stocked with seeds of *P. monodon* and *P. indicus,* with the cooperation of fisheries biologists of CM FRI at Kovalam.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 General recommendations

4.1.1 Coastal aquaculture development should be encouraged in order to increase animal protein production for domestic consumption as well as for selective export.

4.1.2 Low tidal amplitude and the generally sandy nature of the soil in Tamil Nadu tend to limit the possibilities for pond culture, and this should be tried only at sites where soil, tidal range and salinity meet the normal requirements and specifications of experienced designers of brackish-water ponds. The abundance of shallow and protected backwaters make pen culture, and in certain deeper places floating cage culture, the preferred systems. Free water flow in and out through the fences of the pens make pen culture a more practical proposition for small-scale fishermen who cannot raise much capital than the construction of highly capital intensive and closed water ponds on sublittoral flat areas.

4.1.3 The supply of culturable shrimp seed and fish fry should be obtained as far as practicable from the abundance of wild juveniles. Hatcheries at this stage should be regarded as supplementary.

4.1.4 Although molluscs such as mussels, clams and oysters are not at present in demand within the state, they are plentiful and consideration should be given to utilizing them for export or as feed for poultry or farmed fish.

4.1.5 In due course, and after the necessary experience has been gained and training given, the fisheries extension service should encourage the lake fishermen to convert those of their fishing grounds that are low in productivity to fish farms that are potentially more productive.

4.1.6 The services of knowledgeable and experienced aquaculture engineers should be obtained to remedy or prevent the occurrence of water seepage through the bottoms and dykes of existing ponds.

4.1.7 It should be clearly understood by all concerned that the purpose of the demonstration farms is not only and not primarily to produce good research results of academic interest but also and more especially to provide direct support to the village fish farmers in their fish culture activities. This objective should be clearly laid down and reflected in the work plans of the individual demonstration farms.

4.1.8 Immediate steps should be taken to improve the level of management of farms. To this end, the technical staff of the Department of Fisheries should be reinforced with people possessing the requisite knowledge and experience (Appendix 7), trained in Thailand, the Philippines and Indonesia.

4.1.9 The government plan to increase the number of shrimp culture demonstration farms should be kept in abeyance for the time being, and until the existing demonstration farms are performing sufficiently well to fulfil their purpose.

4.2 Further recommendations

The following cover various more detailed and technical points, in order of priority:

4.2.1 Pen culture should be developed immediately on the sandy mud flats in Pulicat lake near Sattankuppam village and in the Killai backwater (South Arcot district) with its clayey and sandy loam flats.

4.2.2 Pen culture projects are best handled through fisheries cooperatives. At Sattankuppam village, participation of the village primary school should be encouraged. In each case, the head of the village must be approached and involved in the responsibility.

4.2.3 Mono- or polyculture of *Penaeus indicus* as well as *P. monodon* along with *Chanos chanos* collected from the wild stocks are recommended for the purpose of pen culture with additional feeds. Cost estimates are presented in Appendix 8 and a suggested layout in Appendix 9.

4.2.4 An area covering approximately 20 ha in Pulicat lake close to Donirevu village with a depth of water of about 8 m should be considered for a pilot project in floating cage culture of fish. Floating or hanging *hapa* for shrimp culture may be used alongside the fish cages. Commercial species of fish such as *Lates calcarifer* should be collected from the wild and raised in the cages. Trash fish or underprized species such as mussels, clams, etc. may be utilized as fish feed. Costs and layout of suitable designs of cage are presented in Appendices 8 and 10.

4.2.5 Where ponds are constructed, the design and general layout should be as in Appendices **12, 12B and 12C.**

4.2.6 If the proposed shrimp hatchery is proceeded with, it should be located at Neelankarai on the 8-ha site inspected by the mission, bearing in mind that this site is not suitable for pond construction, but is very suitable as regards water supply and other factors for a hatchery, which would be equipped with concrete ponds and/or collapsible plastic tanks.

4.2.7 Regarding the sea water suction line and pumping system, a qualified marine engineer should be consulted.

4.2.8 Any government-run hatchery would best be part of an integrated project which should include a hatchery unit, a culture unit and an extension unit. The hatchery would require eight professional staff — three hatchery biologists, two phytoplankton culturists, two chemists and a unit chief for overall management and supervision. The organizational link of the hatchery with other units of the proposed integrated project is indicated in Appendix 7. The basic physical requirements of the hatchery are indicated below:

Land	2—4 ha
Rectangular concrete tank, capacity 40 tonne	12 units
Plastic/fibreglass circular tank, capacity 1 tonne	10
Sea water storage tank, capacity 100 tonne	1
Fresh water storage tank, capacity 50 tonne	1
Marine pump 15 hp	2
Air blower 10 hp	2
Electric generator 40 kVA (for stand-by)	1
Office, laboratory	1
Accommodation for staff	

4.2.9 The layout of the hatchery system is given in Appendix 11.

Appendix 1

TERMS OF REFERENCE FOR THE THAI TCDC AQUACULTURE MISSION FOR TAMIL NADU

The mission will explore the possibilities for coastal aquaculture development in Tamil Nadu and will in particular:

- review the on-going activities in shrimp/fish culture and visit the private shrimp farms at Pulicat, Porto Novo and Nagapattinam, critically analyse their present problems and make specific suggestions to improve them.
- suggest a detailed methodology for survey of shrimp and fish seed resources in selected areas (viz. Killai, Porto Novo, Adirampattinam, Valinokkam, Karangadu and Punnakayal) indicating equipment and technical assistance requirements.
- select the site and prepare a development design and management programme for shrimp hatchery.
- prepare project(s) including engineering design of the farm(s) at one or more suitable locations and outline the requirements for implementing the project(s) in a phased manner with specification of
  - physical facilities
  - technical assistance
  - training
  - capital and operating costs.

in assessing the requirements, the mission will particularly keep in view the land distribution policies of the Government and the need to develop and demonstrate technology appropriate to the small-scale sector with optimum utilization of locally available resources and skills.

Appendix 2

DIARY AND ITINERARY

September 23, 1981	Mission left Bangkok for Madras via Sri Lanka.
September 24, 1981	Mission met FAO and Fisheries Department officers and held discussions.
September 25, 1981	Mission met Director of Fisheries and held a discussion with fisheries officers.
September 26, 1981	Discussion on pond engineering.
September 28, 1981	Adyar brackishwater fish farm.
September 29, 1981	Pulicat: visit to Pulicat Fisheries Research Centre and discussions with research officers and private prawn farmers.
September 30, 1981	Marakkanam: visit to research centre and backwaters; **Porto Novo; visit to Annamalai University; thence to** Chidambaram for overnight halt.
October 1, 1981	Killai: inspection of backwaters, pen culture and mangrove areas; return to Madras.
October 3, 1981	Visits to Hindustan Lever hatchery; CMFRI at Kovalam; Vanianchavadi farm, and back to Department of Fisheries **to meet Commissioner and Secretary to Government,** Forests and Fisheries Department. Showing of five reels of films on brackishwater culture in Thailand.
October 4, 1981	Travel to Pattukottai by train.
October 5, 1981	Visit Adirampattinam and Eripurakkarai to inspect potential sites and demonstration farms under construction and proceed to Thiruthuraipoondi for the night.
October 6, 1981	Travel to Thondiakkadu to inspect demonstration farms under construction; inspect site for proposed project, and proceed to Muthupet. To Nagapattinam to visit private prawn farm and to Poompuhar for overnight halt.
October 7, 1981	Leave Poompuhar for Madras.
October 9, 1981	Visit fish landing centre at Royapuram village and proceed to Marine Regional Station, Ennore.
October 12, 1981	Travel to Madurai by air and proceed to Tuticorin to observe demonstration prawn farms under construction at Punnakayal; inspect other possible sites. Overnight halt at Tuticorin.
October 13, 1981	Leave Tuticorin for Keelavaipar and Valinokkam to visit demonstration prawn farm under construction and salt factory reservoir. Proceed to Ramnad. Visit Karangado to inspect marsh for possible aquaculture development. Back to Ramnad for overnight halt.

October	14,1981	Travel to Athangarai village to inspect the site for prawn farm and proceed to CMFRI at Mandapam, then back to Madural for overnight halt.
October	15, 1981	Leave Madurai for Madras by air.
October	16, 1981	Report writing.
October	17, 1981	Visit possible site for shrimp hatchery at Neelankarai village.
October	19, 1981	Discussion with BOBP staff on major findings and recommendations.
October	20—23, 1981	Report writing.
October	25, 1981	The mission leave Madras for Bangkok, Thailand.

Appendix 3

PERSONS MET

Tamil Nadu officials and scientists:

Mr. F. J. Vaz, IAS	Commissioner and Secretary, Department of Forests and Fisheries
Mr. C. Chellappan, IAS	Director of Fisheries
Mr. S. T. Chari	Joint Director of Fisheries
Mr. A. D. Isaac Rajendran	Joint Director of Fisheries
Mr. R. Ananthanarayanan	Assistant Director of Fisheries
Mr. V. Venkatesan	Assistant Director of Fisheries
Mr. V. Natarajan	Assistant Director of Fisheries
Mr. L. Lawrence	Research Assistant
Dr. R. Natarajan	Director & Professor, Annamalai University
Dr. K. Krishnamurthy	Professor, Annamalai University
Mr. N. Ramsingh	Assistant Engineer
Mr. Veerabalan	Assistant Executive Engineer
Mr. P. Krishnan	Deputy Director of Fisheries
Mr. T. Linguraja	Assistant Director, Brackishwater Fish Culture, Pattukottai
Mr. Durai Sundaresan, IAS	Collector of Thanjavur
Mr. C. Maravan Pillai	Government Pleader
Mr. Rangarajan	Officer in charge, CMFRI, Kovalam
Mr. Subbarao	**Asst. Director of Fisheries**
Mr. M. S. Jayasingh	Inspector of Fisheries, Kathumavadi
Dr. Mohan Varghese Chunthah, IAS	Sub-Collector
Mr. R. Marichamy	CMFRI,Tuticorin
Mr. K. Subbaiya	Deputy Director of Fisheries, Tuticorin
Mr. H. M. Pandey, IAS	District Collector, Mad urai
Dr. B. R. James	**CMFRI, Mandapam**

Private sectors for shrimp hatcheries and farming:

Mr. K. M. V. Nair	Tata Oil Mills Co. Ltd.
Mr. P. Kallat	Hindustari Lever Ltd.
Mr. R. Sundaram	Hindustan Lever Ltd.
Mr. P. Gangadharan	Paravai prawn farm
Mr. K. Nagaimugan	Tamil Nadu Salt Company

FAO staff:

Mr. Lars O. Engvall	Programme Director
Mr. Vernon L. C. Pietersz	Development Adviser
Dr. M. Karim	Fisheries Adviser
Ms. Patchanee Natpracha	Sociologist

Appendix 4

LITERATURE AND DOCUMENTS CONSULTED

A review of brackishwater shrimp farming in Tamil Nadu and Andhra Pradesh. RAS/77/044—Working Paper No. 33, FAO/UNDP, Madras, India 1980.

Brackishwater resources of Tamil Nadu, Department of Fisheries, Madras 1981.

Inventory of kattumarams and theirfishing gear in Andhra Pradesh and Tamil Nadu, BOBP/WP/2

byT. R. Menon, Madras 1980.

Present status of coastal aquaculture in countries bordering the Indian Ocean. Symposium on coastal aquaculture held at Cochin from 12th to 18th January 1980.

Andhra Pradesh aquaculture, mimeograph.

Monoculture of tiger prawn, *Penaeus monodon* Fabricius, in a brackishwater prawn farm at Madras, India, by D. Soundararajan *et aL,* Aquaculture 16 (1979) 77—75.

A note on the prospects, progress and programmes in brackishwater fish culture in Tamil Nadu, Government of Tamil Nadu 1977.

Prawn seed resources of Adyar estuary at Madras by S. Victor Chandra Bose *et al,* Tamil Nadu Fisheries Department, in "Proceedings of the first national symposium on shrimp farming" conducted at Bombay, 16—18 August 1978.

An approach to the development of brackishwater prawn farming in Tamil Nadu by V. Venkatesan *et al.,* Tamil Nadu Fisheries Department, in "Proceedings of the first national symposium of shrimp farming" conducted at Bombay, 16—18 August 1978.

Brackishwater fish and prawn culture at San Thome brackishwater fish farm, Madras by D. Sundararajan *et al.,* founder of the Indian Fisheries Society of India, Vol. II, No. 1, June 1979.

Prospects and problems of brackishwater fish culture in Tamil Nadu by Srinivasan *et al.* Paper presented at the "Seminar on Coastal Aquaculture", at Tuticorin, May 1980.

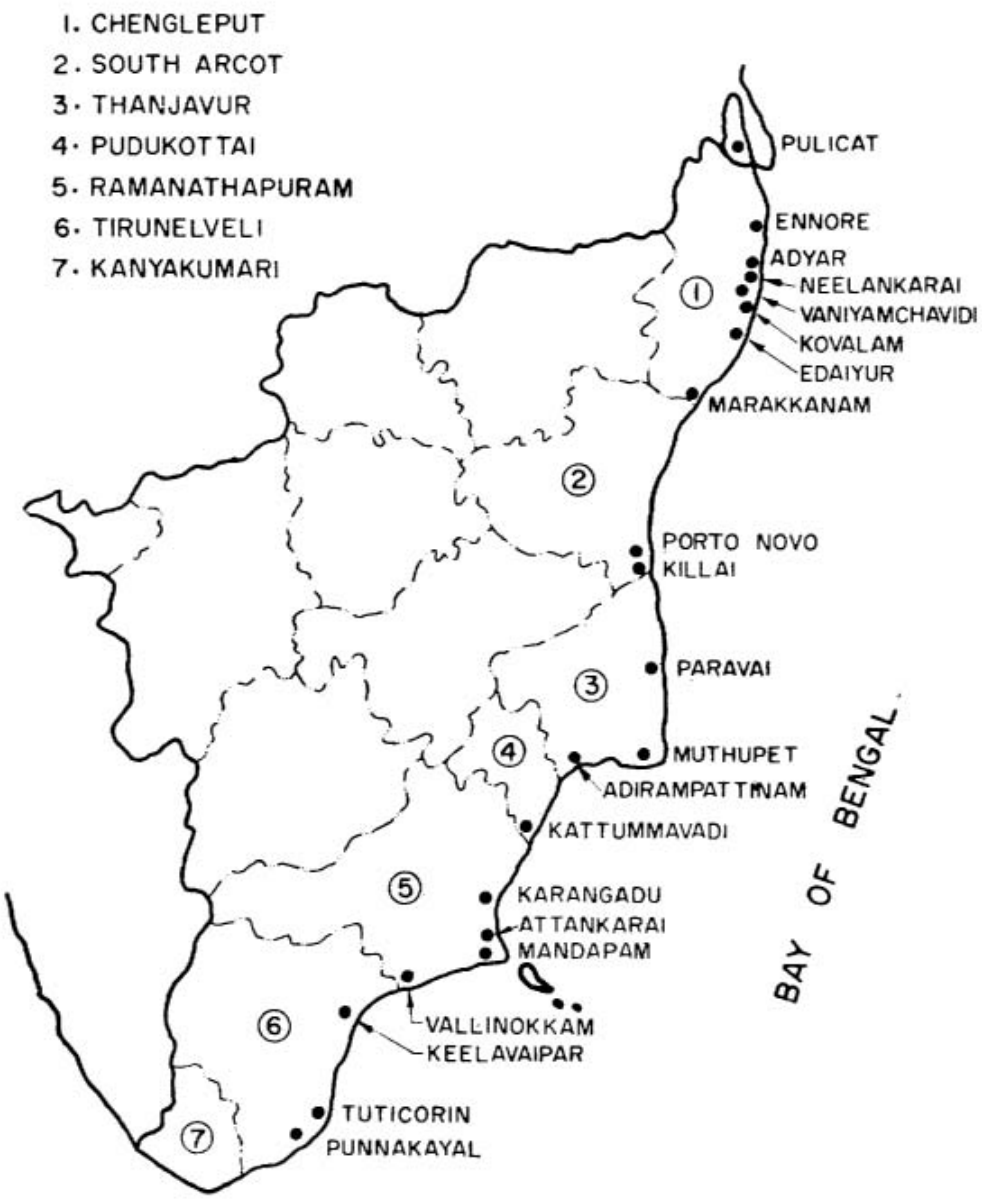
Brackishwater prawn and fish farming in Tamil Nadu by E. Ganapathy. Dissertation for Post-graduate diploma course in fishery science (1978—80).

Project report on the development of Pulicat Lake and its fisheries by Thiru P. Krishnan *et al.,* Department of Fisheries, Government of Tamil Nadu 1973.

APPENDIX -5

MAP OF TAMIL NADU, INDIA

SHOWING COASTAL DISTRICTS AND PLACES VISITED



Appendix 6

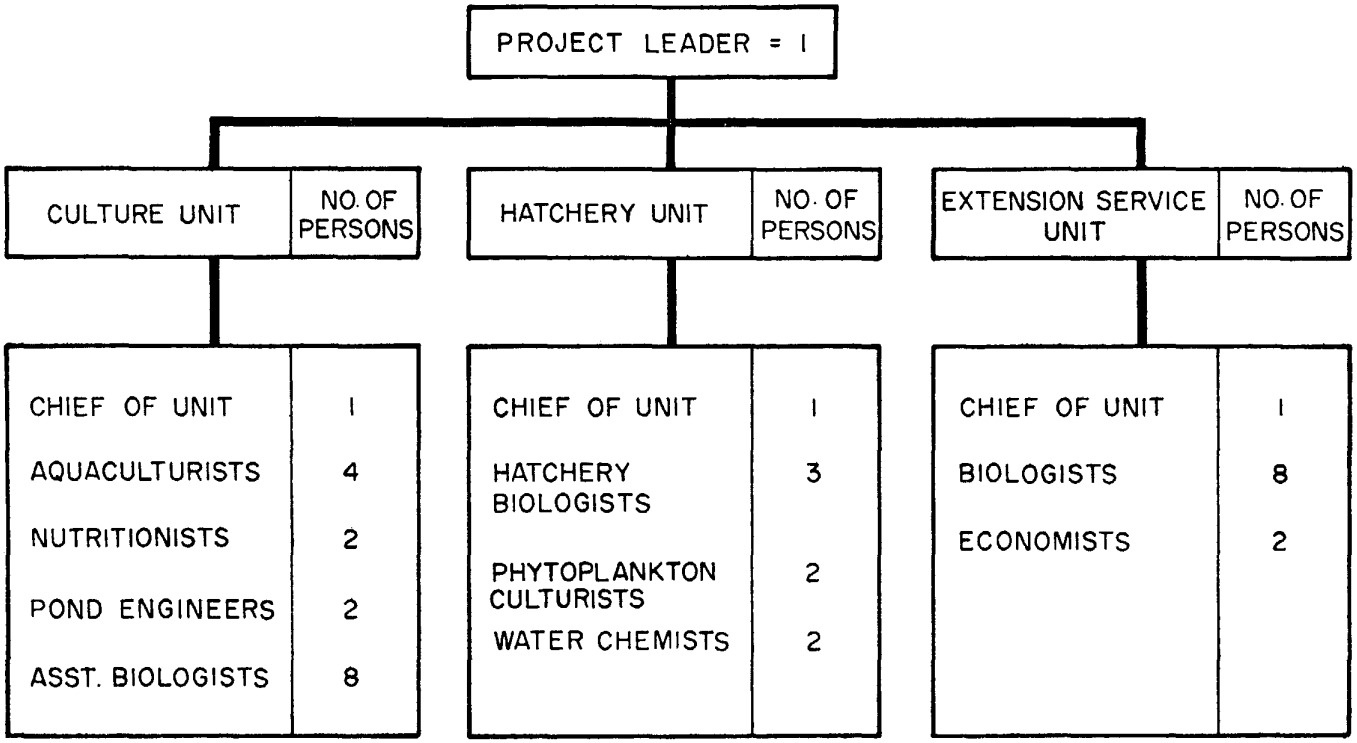
OCCURRENCE OF PRAWN SEEDS AND FISH FRY IN THE MAJOR ESTUARIES

District	P. monodon	P. indicus	P. semisulcatus	Chanos	Mullet	Etroplus
Chingleput	March—May September—December	February—May	February—May August—September	March—May	February—June	Year-round
South Arcot	January—June	January—April June—September	March—October	Year-round	February—May	Year-round
Thanjavur	January—March June	January—April June—September	March September—October	Year-round	Year-round	Year-round
Pudukottai	—This occurrence same as Thanjavur—			Not found	Not found	Not found
Ramanathapuram	March—June	Year-round	Not found	Year-round	February—June	Not found
Tirunelveli	January March—June	January—April June—September	March September—November	Year-round	March—July	Year-round
Kanyakumari	Not found	January—April	Not found	Year-round	February—June	Year-round

Source: Department of Fisheries, Government of Tamil Nadu.

APPENDIX 7

SUGGESTED STAFFING OF TAMIL NADU STATE BRACKISHWATER AQUACULTURE PROJECT



TOTAL ON THE STAFF 37

Appendix 8

COSTS OF CONSTRUCTION OF CAGES AND PENS

	Rs.
Floating cage 10 sq.m:	
(1) "Lumit" plastic (velon screen) measuring 5 x 2 x 1 (metre) with mesh size of 64 meshes/sq.in on all sides except top which is made of 25 g meshes/sq.in	425.00
(2) Bamboo poles for fabrication of a raft..	60.00
(3) Sinkers tied to each corner of the net	20.00
(4) Four floats for floatation made of sealed empty oil tins of 16.5 litres capacity coated heavily with coal tar	60.00
(5) Nylon rope and anchor made of cement	25.00
Total	590.00
Floating cage 40 sq.m:	
(1) Velon screen measuring 8 x 5 x 1 (metre) with 64 meshes/sq.in on all the sides, and top made of 256 meshes/sq.in	1,300.00
(2) Casuarina poles 25 numbers for fixing the cage	100.00
(3) Nylon rope	25.00
(4) Floats 6 numbers for floatation	600.00
(5) Sinkers 6 numbers	60.00
(6) Labour for fixing	30.00
Total	**2,115.00**
Fixed net cage (Happa) 10sq.m:	
(1) "Lumits" plastic (velon screen) measuring 5x2x1 (metre) with 64 meshes/sq.in on all the sides except top which is made of 256 meshes! sq.in	425.00
(2) Casuarina poles 6 numbers for fixing the cage	**20.00**
Total	445.00

Pen construction for one hectare:

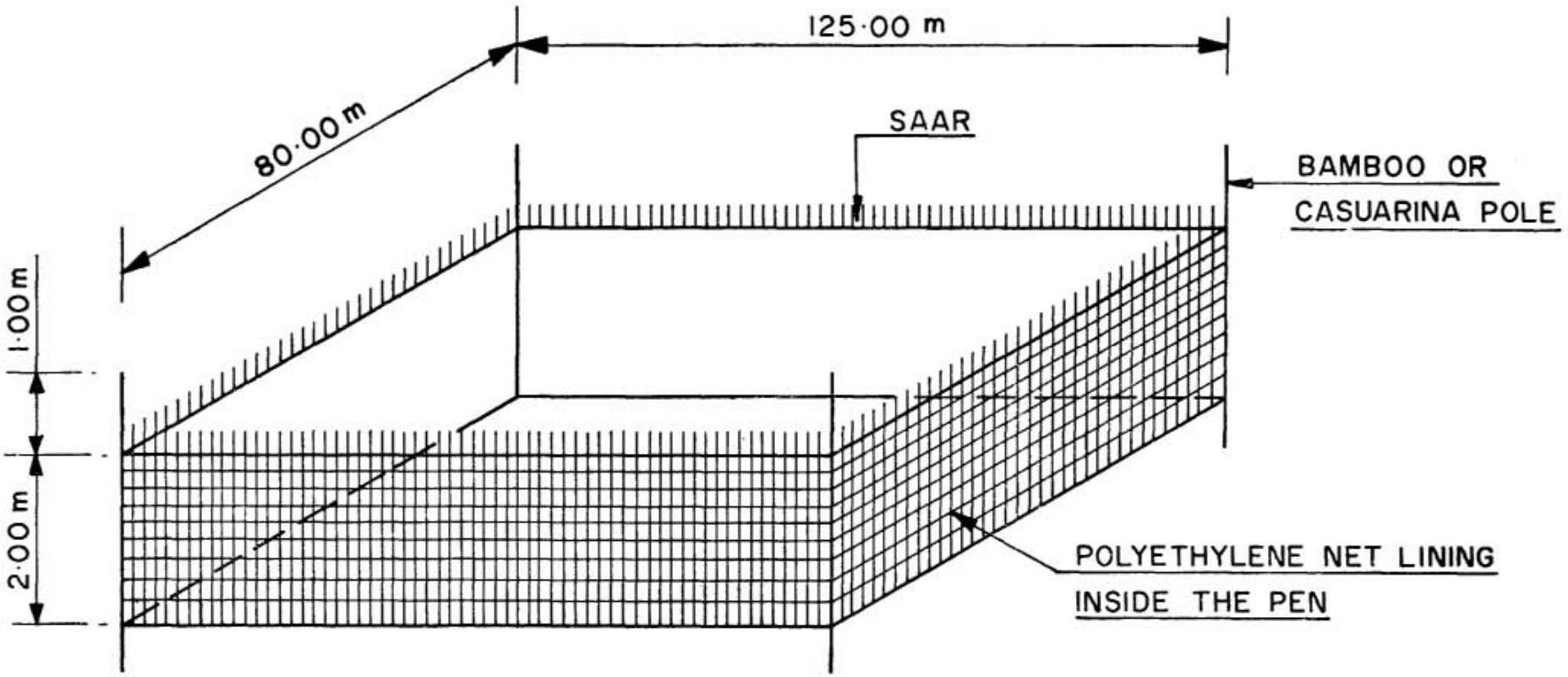
Length	125 m
Breadth	80 m
Circumference	410 m

Requirements:

(1) Saar 410 metres (Rs. 33/one saar of 3.4 metres) including transport charges	3,980.00
(2) Casuarina poles (Rs. 325/one ton) approximately 100 poles/ton; 1 pole for every 1 metre	1,335.00
(3) Nylon rope 12 bundles (Rs. 25 per bundle)	**300.00**
(4) Velon screen No. P.8 (8 Rs./m) 410 metres	**3,280.00**
(5) Coal tar	500.00
(6) Labour charges	500.00
Total	9,895.00

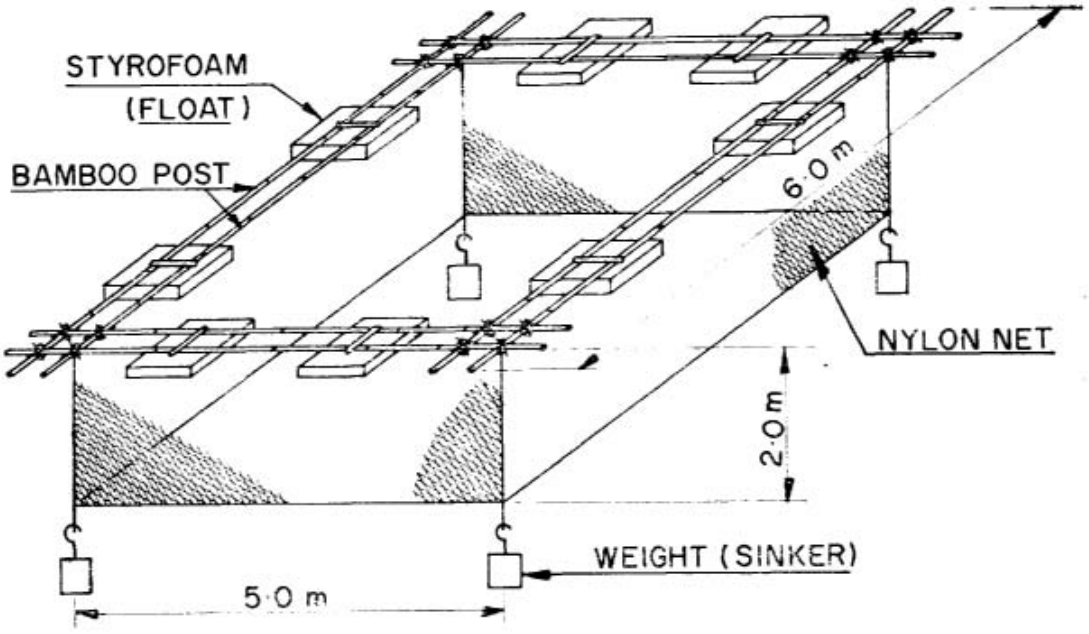
APPENDIX – 9

LAYOUT OF ONE-HECTARE PEN



APPENDIX —10

DESIGN OF FLOATING CAGE



There are three types of cages used in aquaculture:

(a) Cage size 2 m x 1 m x 1 m constructed with fine mesh-size nylon net for juvenile fishes.

(b) Cage size 6 m x 5 m x 2 m constructed with 2.0 cm mesh-size net for growing fishes. (Diagram above)

(c) Cage size 6 m x 5 m x 2 m, same size as (b), constructed with 4.0 cm mesh-size net for fishes of marketable size.

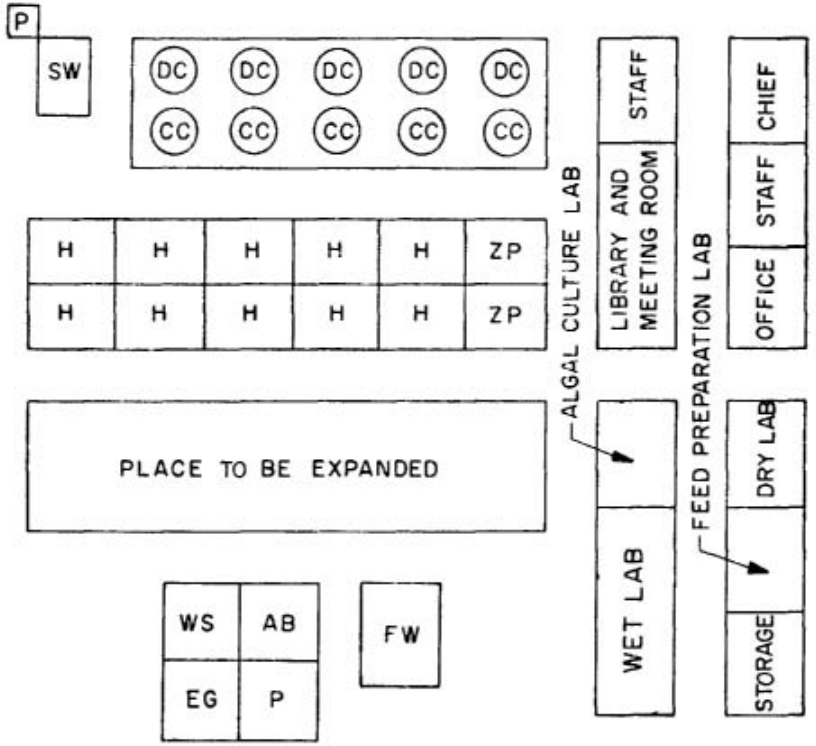
Materials needed for the cages:

1. Nylon nets of determined mesh-sizes.
2. Bamboo posts for frame
3. Styrofoams or gasoline drum.
4. Nylon rope for cage construction (different diameters).
5. Casuarina posts for fixing the cages at the selected sites.
6. Weights for stretching nylon nets.

APPENDIX . II

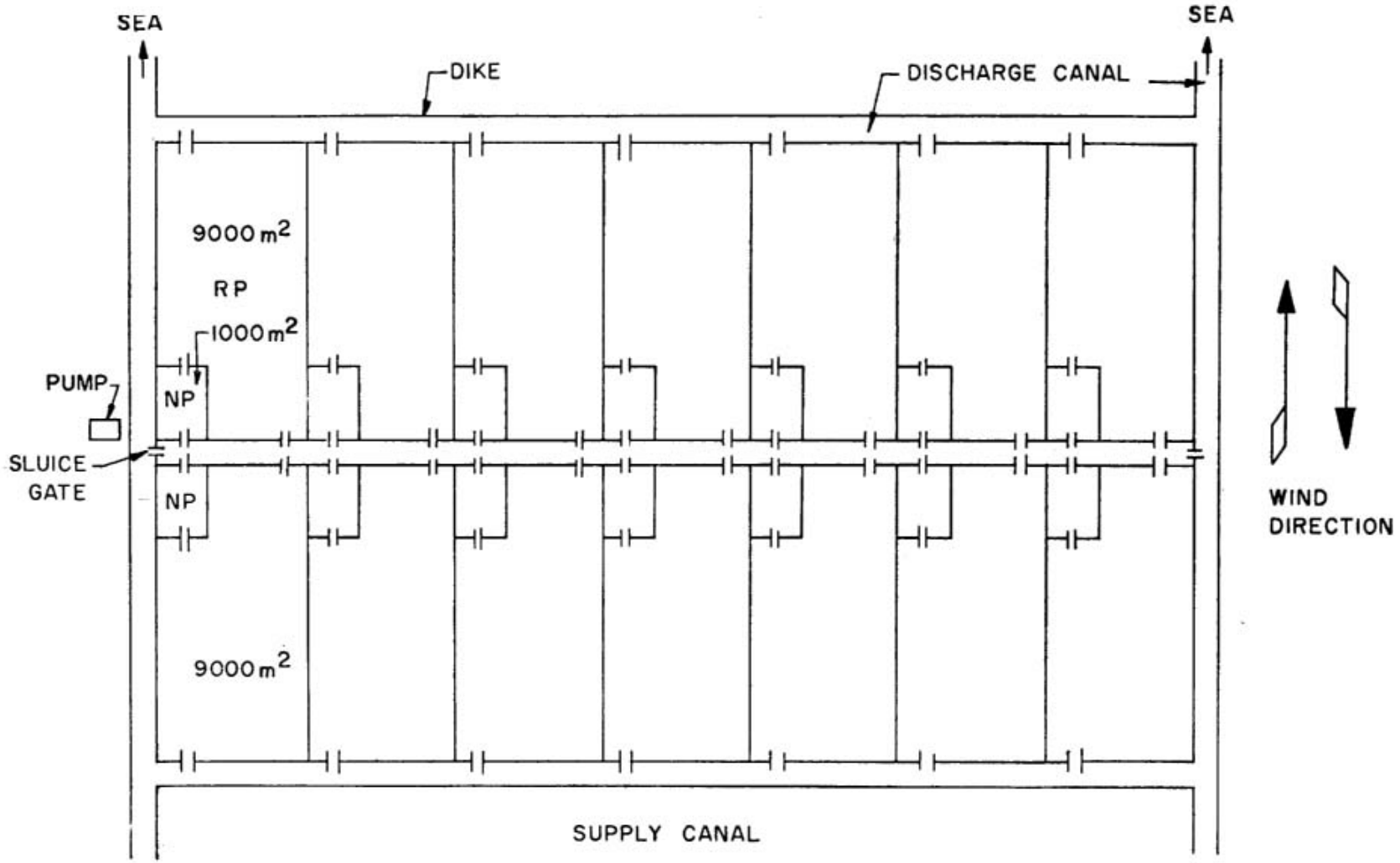
LAYOUT OF HATCHERY SYSTEM

AB – AIR BLOWER
CC – CHLORELLA CULTURE
DC – DIATOM CULTURE
EG – ELECTRIC GENERATOR
FW – FRESHWATER TANK
H – HATCHERY TANK
ZP – ZOOPLANKTON
SW – SEAWATER TANK
WS – WORKSHOP
P – PUMP



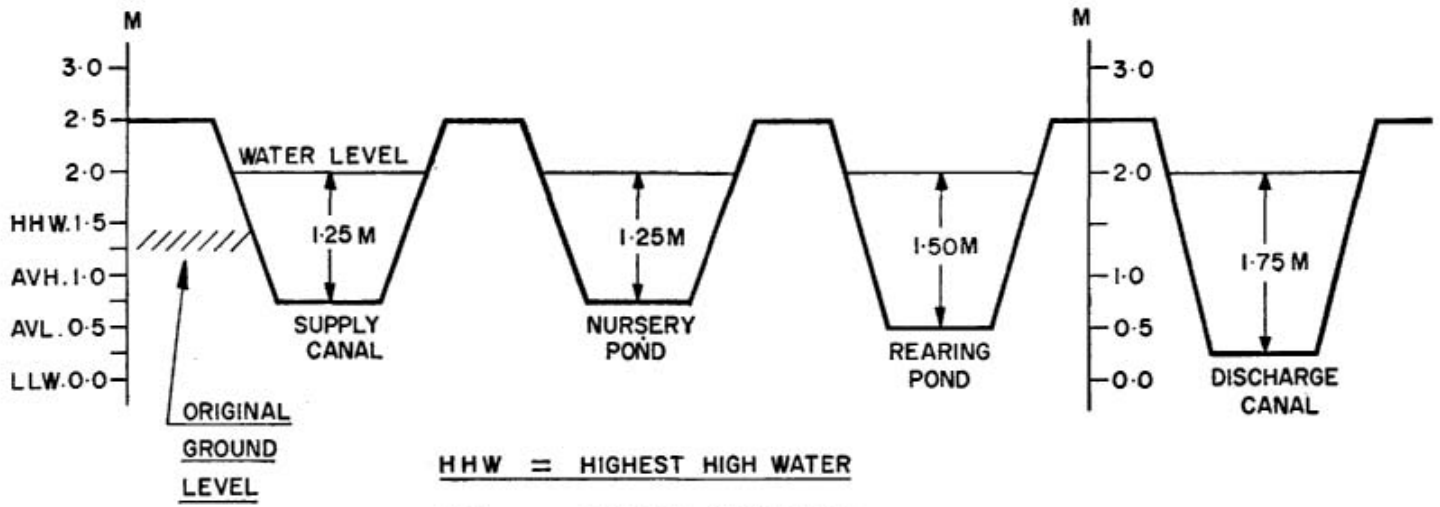
APPENDIX –12

RECOMMENDED LAYOUT OF REARING PONDS SYSTEM



APPENDIX-12 B

LEVELS OF SHRIMP POND, COMPLEX



HHW = HIGHEST HIGH WATER

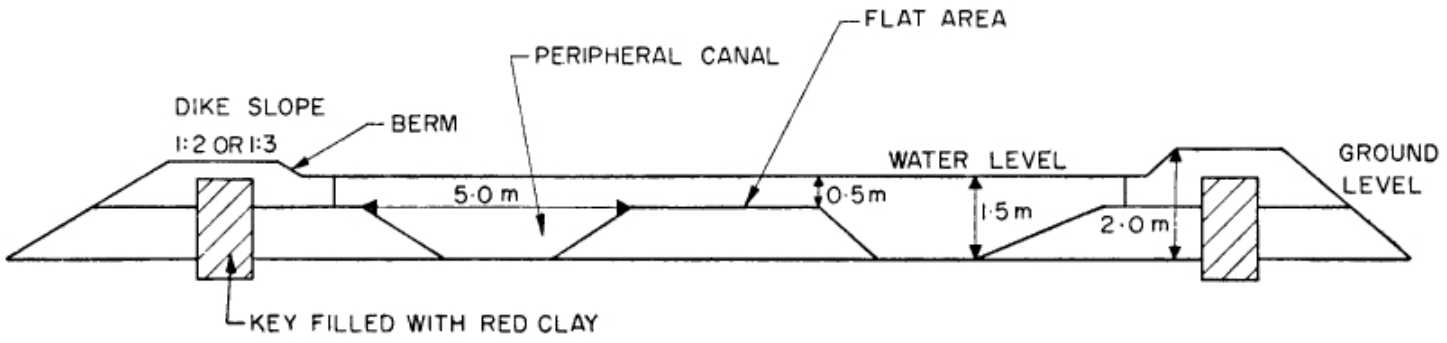
AVH = AVERAGE HIGH WATER

AVL = AVERAGE LOW WATER

LLW = LOWEST LOW WATER

APPENDIX – 12 C

CROSS-SECTION OF SHRIMP POND



Publications of the Bay of Bengal Programme (BOBP)

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, 1—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 December1981. 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 Consu!tation-cum-Workshop on Development of Activities for Improvement of Coastal Fishing Families. Dacca, Bangladesh, October 27—November 6, 1981. Madras, India, May 1982.

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 Fisheries in Sri Lanka.
   G. Pajot. Madras, 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.

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.
   ø Gulbrandsen, G. P. Cowing, R. Ravikumar. Madras, India, October 1980.

8. Current Knowledge of Fisheries Resouces 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, August1981.

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, Jakatta, Indonesia. Madras, India, August 1982.

18. Review of Brackishwater Aquaculture Development in Tamil Nadu.
    Kasemsant Chnlayondeja and Anant Saraya of the Department of Fisheries, Thailand.
    Madras, India, September 1982.

Miscellaneous Papers (BOBP/MIS/....)

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

Newsletters:

Bay of Bengal News. January 1981, May1981, September1981, December1981, March 1982, June 1982.

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