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SRI LANKA SHRIMP CULTURE

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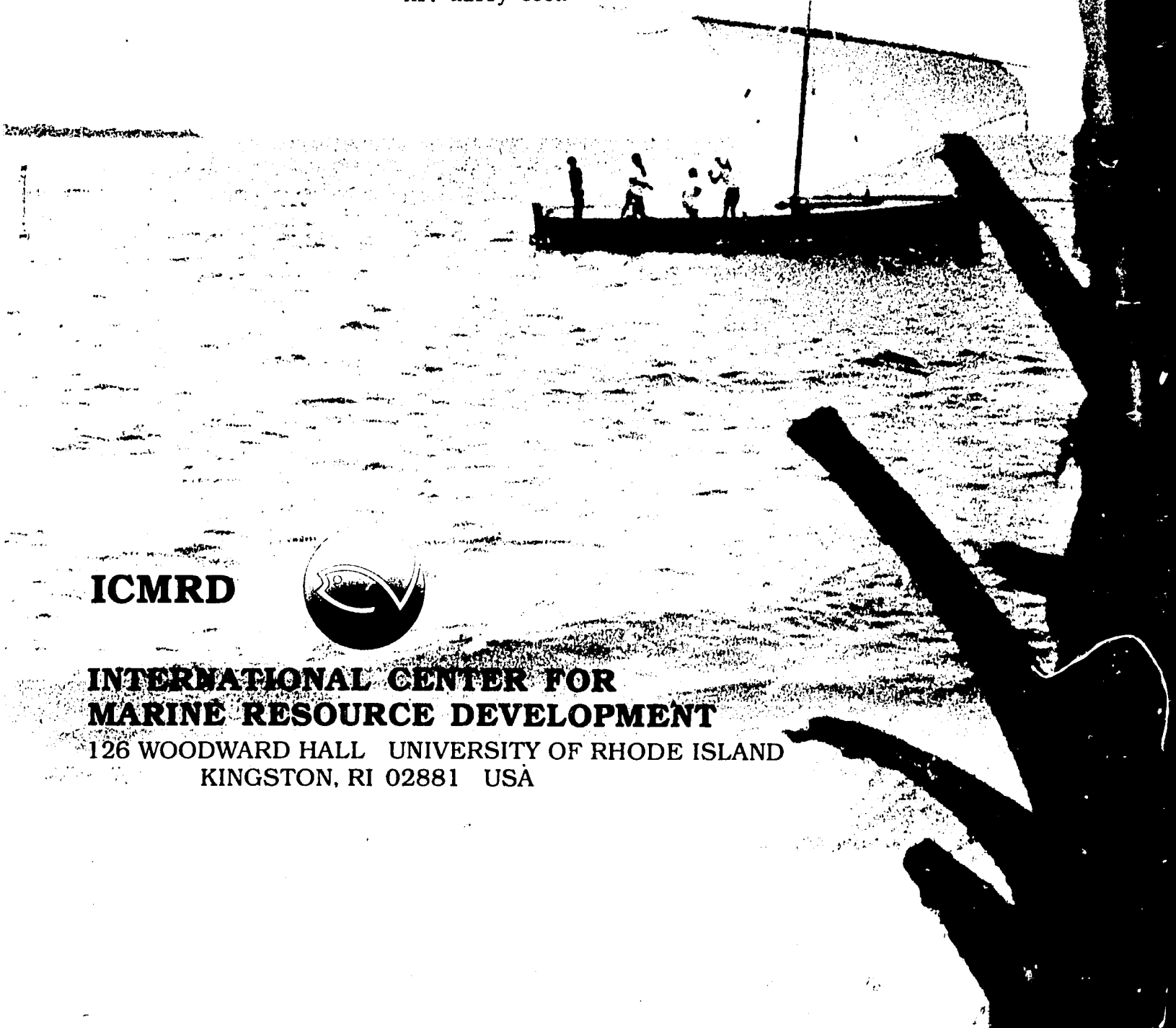
Prepared by: Dr. Clarence P. Idyll and
Mr. Harry Cook



ICMRD

INTERNATIONAL CENTER FOR
MARINE RESOURCE DEVELOPMENT
126 WOODWARD HALL UNIVERSITY OF RHODE ISLAND
KINGSTON, RI 02881 USA

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REPORT OF A CONSULTANCY TO DETERMINE ACTIONS WHICH MIGHT BE TAKEN TO ACCELERATE THE DEVELOPMENT OF COMMERCIAL SHRIMP CULTURE IN SRI LANKA

United States Agency for

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Fishery Development Support Services

Project Office S&T/AGR/RNR

Project No. 936 4024

ICMRD/University of Rhode Island

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THE MISSION

In response to a request from the Ministry of Fisheries of Sri Lanka, AID, through the University of Rhode Island and the International Center for Marine Resource Development's Cooperative Agreement with the Bureau of Science and Technology, provided advice on activities and actions which might accelerate the development of commercial shrimp farming in that country. Dr. Clarence P. Idyll and Mr. Harry Cook spent the period from February 29 to March 1 in Manila, Philippines, consulting personnel from the Asian Development Bank, USAID and the International Center for Living Aquatic Resources Management. From March 2 to March 17, they were in Sri Lanka consulting officials of the Ministry of Fisheries and other government people, and persons in the public sector interested in shrimp culture. A list of those consulted is provided in an appendix. A trip was made to examine two brackish water field stations operated by the Government.

Grateful acknowledgement is made to the staffs of the Ministry of Fisheries for many courtesies during our Mission, expecially to Mr. K. Thayaparan, Director of the Inland Fisheries Division and his staff. Thanks are also extended to the staff of the USAID Mission in Sri Lanka, particularly to Mr. Mike Korin, Chief, Agriculture and Rural Development. And members of the private sector were generous with their time and information.

SUMMARY

The purpose of the consultancy was to relate the status of shrimp culture in Sri Lanka to other commercial and environmental activities and problems and to summarize actions needed by the Government of Sri Lanka and of external aid agencies to guide the orderly development of shrimp farming in Sri Lanka.

Commercial shrimp culture is in its earliest beginnings in Sri Lanka. Two large joint venture companies have well-developed plans to farm shrimp, and three others have plans for this activity. There are no small holder shrimp farmers yet.

The Government of Sri Lanka, with the leadership of the Ministry of Fisheries, is actively encouraging investment by joint venture capital in shrimp farming and is engaged in a number of research and development activities to back this policy, as well as to make it possible for small holders to enter the business. Much of this Ministry of Fisheries activity is with the support of the Asian Development Bank, FAO/UNDP and other external aid organizations. Most of the professionals in the Ministry who are working on aquaculture projects are concerned with freshwater fish culture (carps, tilapia, milkfish) but a small number are concerned with brackish shrimp culture. Many more will have to be engaged with this activity soon if the Government responsibilities are to be fulfilled.

The official research arm of the Ministry of Fisheries is the National Aquatic Resources Administration (NARA). It is performing some research which is likely to be useful in supporting shrimp farming, most of which is not involved specifically in the solution of practical problems. Certain applied research needs to be done, including engineering trials on pond design and construction, feeding regimes and nutrition, disease detection and control, and others. A coastal research station run by NARA or the Department of Fisheries is needed for research and development support of shrimp farming.

The technical personnel of the Ministry of Fisheries required for performing, monitoring and applying the results of the several fish and shrimp culture projects underway and contemplated is inadequate. The ADB project alone calls for 375 skilled personnel, in addition to those now on the Ministry staff and already fully engaged in professional activities. Some of these new people will probably come from the ranks of the present staff, in which case new professionals will have to be hired and trained to replace them. Other professionals must be recruited and trained. A training program substantially greater than so far contemplated in any document we have seen is needed.

Two large and well-financed companies plan to raise shrimp commercially. Lever Aquaculture, Ltd. has an investment of Rs.7.5 million and plans to build a hatchery and 80 acres of ponds near Negombo. This firm produced 1½ tons of marine shrimp in 1983 and hopes to increase production markedly in 1984. Serendib Seafoods, Ltd. with foreign capital of Rs. 52 million has well advanced plans to build a

hatchery near Negombo and 500 acres of ponds (later, another 500 acres) in the Batticaloa region. This company hopes to supply other shrimp farmers with postlarvae for pond stocking.

Three other companies are developing plans for shrimp farming. Geeseed, Ltd. is a joint venture company with national technical input. It plans to develop 15 acres of fresh water shrimp (Macrobrachium) ponds near Negombo. Lankua Fisheries is a joint venture between the Government of China and Ceylon Fisheries Corporation, a Sri Lankan Government agency. Most of the planned activity is fishing-oriented but plans also call for a penaeid shrimp farm of 32 acres near Panadura, with a projected annual production of 37 tons. Finally, a local company with no foreign partnership, the Aqua-Tec Prawn Culture project, plans 20 acres of penaeid shrimp ponds at Kalpitiya. Seed will be obtained by capture or wild post larvae from the Puttalam Lagoon.

The Ministry of Fisheries maintains two brackish water stations, at Pitipana and Pambala. Neither was designed for shrimp culture research and development, their main function being to raise milkfish fry caught in the wild to a size suitable for planting in tanks (reservoirs) and farm ponds.

Neither station is well designed and does not perform its function well. Staff are frustrated by poor ponds and equipment, and future performance as milkfish nurseries seems likely to continue to be mediocre to poor.

The hope of making efficient use of these stations for shrimp culture research and development seems small. Substantial changes, including new ponds and improved equipment, would be necessary to accomplish such a goal. Best economy would probably be obtained by closing the Pambala station; the Pitipana station could possibly be upgraded successfully.

Aquatic research is carried out by the National Aquatic Resources Agency (NARA), an arm of the Ministry of Fisheries separate from the Department Fisheries, the executive branch of the Ministry. This kind of separation creates the danger that research can become less relevant to the problems faced by administrators of fisheries and aquaculture, and despite a Technical Committee with representation from the Department, this may be the case to some degree in Sri Lanka. A number of research programs of value to the industry and program administrators are under way at NARA. More of an applied and practical nature are required.

The principal support for aquaculture development in Sri Lanka will be a sizeable project financed by a loan from the Asian Development Bank. This project will be largely to develop inland farming for fishes, but there is also a significant shrimp culture component. External aid programs related to shrimp culture besides the large ADB loan project include the FAO/UNDP Aquaculture and Development and Training Project; the FAO Bay of Bengal Development and Demonstration of Coastal Aquaculture Techniques Project; the Indian Technical and

Economic Cooperation Project; the Government of China Breeding of Chinese Carps Project; the UNDP/UNESCO Institutional Support for NARA Project.

It will be noted that most of these projects do not have a shrimp culture component, but all are involved with aquaculture and all require monitoring, training activity and other time of professionals on the Ministry of Fisheries staff.

The shrimp component of the ADB loan project is technically and logistically sound in our view. It would be desirable to precede the building of ponds by some trials to determine the best methods of constructing dikes in the sandy soils of the coastal areas, and it is hoped that enough time will be provided for this.

The proposed FAO/Bay of Bengal Programme Project to test cage culture of shrimp in the Negombo Lagoon may be duplicative and less than effective in terms of the probable returns compared to local effort required.

The destruction of vegetated areas (grass flats and mangrove forests) to build shrimp ponds or other structures should be discouraged by the Government, both on grounds of possible serious economic and environmental loss and because ponds build in such areas (below the low tide mark) have significantly less chance of being profitable.

The practice of mining coral blocks from reefs is seriously damaging to the near-shore ocean environment, reducing the productivity of fish, shrimp and other living populations, and exposing shorelines to erosion. These losses are far greater than the monetary gains from the times produced by coral mining.

Sand mining requires to be strictly monitored since unplanned and uncontrolled removal of sand from some near-shore areas can affect both the environment of fish and shrimp and the organisms on which they depend, but also create erosion of the shorelines.

Development of shrimp farming on a substantial scale, as envisioned by the Government, will put a strain on the present social and economic fabric of some coastal communities. Tensions have already surfaced resulting from actual or threatened competition for space - fishing grounds, beaching and docking areas - and for fish stocks. Possible threats to markets and to other long-established values also make communities and individuals apprehensive. Sympathetic consideration should be given to such possible threats to the success of shrimp culture, and appropriate study made of their causes and how to alleviate them should be part of the Government program.

Suggestions and recommendations for actions to accelerate the development of commercial shrimp culture in Sri Lanka are as follows:

1. The Government should make certain policy decisions.

2. A substantially larger training program, involving supervising aquaculturists, farm managers, extension agents and farmers, should be carried out.

3. A program of applied research in support of aquaculture should be initiated.

4. To overcome the handicaps created by the low tide amplitude and the nature of local soils, engineering tests should be conducted on various types of pond design and construction.

5. The Government should encourage both Ministry of Fisheries and private sector activities to develop hatchery and farming techniques for shrimp culture suitable for Sri Lankan conditions.

6. Economic and social tensions which are likely to arise from the development of shrimp farming should be anticipated and plans made ahead of time, based on appropriate studies.

7. A study should be made of the feasibility of creating "shrimp farm estates" as a possible way of encouraging small-holder activities.

8. The Government may be over-extended in its ability to supervise and promote aquaculture and it should consider consolidation of present activities rather than undertaking additional tasks.

Substantial external aid is being supplied to Sri Lanka to assist in the development of commercial fish culture, including a significant amount for shrimp culture. We have noted some gaps in the programs for shrimp culture, and have recognized opportunities for projects which could strengthen this kind of activity. The projects might be supported by any of a number of foreign aid agencies. These projects are listed here, not in any order of priority:

1. <u>A larger training program for technical personnel and farmers who will be engaged in shrimp culture.</u> The component which will determine to the greatest extent whether a shrimp farming operation suceeds or not will be the competence and skill of those engaged, whether at the technical or the farming level. The very substantial requirements for trained persons in the presently ongoing and projected programs will not be fully met by the training to be provided. An additional shrimp culture trained program is suggested.

2. <u>Technical assistance to plan a project for improving the design and conduct of the fish culture training programs.</u> We are of the opinion that existing and future training programs could be made more effective by technical assistance from trained experts who can teach local professionals in training methodology, preparation of teaching aids and manuals, and in extension methodology.

3. Engineering technical assistance in problems of siting ponds, pond construction and pump design and construction. We believe that presently accepted shrimp pond siting and design in Sri Lanka significantly lowers the chance of profitable operations. The building of ponds below the tide level so that they cannot be completely drained and dried, the building of earthern dikes without support, and other practises, threaten to lower the productivity of ponds over a period of years. Technical assistance would be valuable to advise in the design of several possible pond configurations to be tested, and to design methods of preparing dikes which can withstand erosion of the local sandy soils. Adaptation of inexpensive pumps developed elsewhere in Asia should also be included.

4. Applied research support for shrimp farming. Like land agriculture, aquatic farming requires the continued backing of research. NARA is engaged in some research activities which will be helpful to Sri Lankan shrimp farming, but a research station requires to be set up and applied research programs established if sustained profitability of shrimp farming is to be ensured. NARA or the Department of Fisheries could run this. Technical assistance by a foreign expert would be valuable in the design of the facility and the research program.

5. Development of brine shrimp culture. Brine shrimp (*Artemia*) is still the most desirable and efficient food for young stages of many cultured fish and invertebrates, despite attempts to find substitutes. Brine shrimp are expensive and local sources could save foreign exchange by avoiding imports and by establishing an export market. Brine shrimp resources exist in Sri Lanka. NARA has a small research project which will describe the size and location of the resource. Another project, perhaps similar to the successful one completed recently in Thailand, could be launched to develop methods of large-scale culture of brine shrimp on a commercial basis. An expatriate export should be involved for a relatively short time.

6. Survey to select areas to be reserved for small-holder shrimp farms. Land suitable for brackishwater shrimp farming is limited in Sri Lanka. Government policy is to encourage both large-scale industrial level shrimp farming and small-holder operations, but there is a real danger that present policies of granting requests for large tracts of wetlands and near-shore areas by industrial concerns may preempt the most suitable land. A survey is needed to identify land which could be set aside as reserves for small-holder shrimp complexes. Such a project would need to be preceded by decisions as to the kind of technology to be used (perhaps more than one).

THE STATUS OF SHRIMP CULTURE IN SRI LANKA

There are essentially no commercial shrimp farming operations in Sri Lanka. Public sector interest has increased, with five companies having secured Government permission to proceed with building of hatcheries and farms, but no production (except on a small experimental scale by one company) has yet been made. This may change soon.

The Government is actively pursuing policies to encourage the creation of small-holder shrimp farming, this effort being supported materially by a loan from the Asian Development Bank.

Government Programs of Research and Development in Shrimp Culture

All projects with foreign components, either of capital or technical input, must have the approval of the Policy and Planning Division of the Department of Fisheries. Promoters of the proposed enterprise must submit a detailed plan of development; if everything is in order, approval can be obtained in one month. Progress is monitored by the Policy and Planning Division. Each enterprise must submit a quarterly report and if questions about progress arise, fishery officers visit the farm to investigate the problem.

Most of the land considered suitable for coastal aquaculture development is owned by the Government. Its use is controlled by the local Government Agent, who can approve a lease for up to five years on his own authority. Longer leases, up to 99 years, must be approved by the Land Commission, which generally follows the recommendation of the Government Agent. Since, traditionally, all coastal wetlands have been considered wasteland, in the past most leases have been given freely, and for long periods of time on concessionary terms. Recent concern over the use of coastal land has resulted in a written administrative agreement that any new lease application for coastal land must be reviewed by the Coast Conservation Division of the Department of Fisheries. This agency assesses the environmental impact of the proposed project.

The Coast Conservation Division has responsibility for overseeing development in a zone including the foreshore, 300 meters inland from the shoreline and 2 km into the sea. Their authority also extends 2 km up rivers and lagoons from natural entry points. Within this area every development activity, except fishing and agriculture, must have a permit. Aquaculture is considered a development activity requiring a permit because it usually entails activities such a building ponds and dredging.

In order to encourage development of the fisheries sector, the Government has developed incentives which apply to aquaculture. These include:

- Exemption from income tax on profits and/or income from exports for a period of five years from the date when the first export is made.
- Exemption from income tax on dividends from investments during the tax holiday period and the following year.
- The investment can be deducted from personal income.
- The full cost of capital expenditure can be deducted from profits.
- Customs duty concessions on imported inputs.
- Foreign investors are permitted to repatriate their capital contributions to equity of a company after sale or liquidation. Profits and dividends can also be remitted freely.
- Investors are permitted to employ expatriate personnel, and such personnel can remit up to two thirds of their earnings.
- Foreign participation in joint ventures is normally limited to 49% but for ventures with needs for high technology, foreign equity participation can be up to 60% or 70%.

Private Sector Shrimp Farming Enterprises

Serendib, Ltd. is a joint venture with foreign technical input. Its investment is 52 million Rupees. The building of a penaeid shrimp hatchery near Negombo Lagoon began in December 1983, and 1,000 acres of shrimp ponds near Batticaloa are planned.

Lever Aquaproducts, Ltd. is a Sri Lankan subsidiary of Unilever. Its investment is 7.5 million Rupees. Plans call for development of 80 acres of ponds for marine shrimp in the Negombo area. They have British technical input.

Geseed Ltd. is a joint venture with national technical input. Plans call for development of 15 acres of freshwater prawns (*M. rosenbergi*) ponds in the Negombo area.

Lanhua Fisheries Joint Venture Co., Inc. is a joint venture between the Chinese Government and Ceylon Fisheries Corporation (a government agency). This is a large fishery-oriented project with a relatively small aquaculture component. Plans call for development of two brackishwater farms. A 32 acre penaeid shrimp farm is planned at Panadura and is projected to have an annual production of 37 tons of shrimp. A second farm of 25 acres will be used for fish culture. Chinese aquaculture experts will provide technical expertise.

Aqua-Tec Prawn Culture Project is a local company with no foreign technical input. Plans call for development of 20 acres of penaeid shrimp ponds at Kalpitiya in the Puttalam District. No hatchery is included, seed to come from the capture of wild young from the lagoon.

Government Facilities for Brackishwater Research & Development

Brackishwater Stations

The Inland Fisheries Division of the Ministry of Fisheries operates two brackishwater aquaculture stations, at Pitipana and Pambala. The station at Pitipana was built in 1952. The total area of the station is 4.4 ha. It has 13 earthen ponds covering an area of 3.4 ha. There are seven smaller concrete nursery tanks. It currently has a staff of three aquaculturists, two fishery inspectors and six laborers. In the past, experiments were carried out to culture penaeid shrimp, but no shrimp survived. The primary purpose of the station is as a nursery for milkfish fry. The Pambala station has a total area of 7 ha. It has seven ponds with earthen bottoms and concreted rock walls. It has a staff of three aquaculturists, two fishery inspectors and six laborers. The primary purpose of the station is to serve as a nursery for milkfish fry. A number of the station's concrete tanks are being used as a makeshift *Macrobrachium rosenbergi* hatchery.

Ponds at both of these stations were designed so that routine water exchange could be done by tidal flow. Since the daily tide fluctuation is inadequate for this, the ponds had to be excavated to a point where the pond bottoms were below low tide. This means that the ponds cannot be completely drained. To harvest the pond, water is pumped out and this is poor pond management practice. The fish fry left in the pond after most of the water has been pumped out suffer great stress in the muddy water, so that the fry delivered may be seriously weakened. Perhaps of greater importance, after water has been pumped out, seepage into the ponds is so great that there is always some water on the pond bottoms, and the important management step of drying the pond bottom to mineralize organic matter in the soil cannot be performed. Accumulation of organic matter in the bottom soil leads to anaerobic conditions and low dissolved oxygen levels in the bottom waters which results in low productivity. The ponds at Pambala actually suffer from seepage of ground water even when they are filled. Since the soil is acidic, the pond water also becomes acidic. Production from these ponds has always been low and it cannot be realistically supposed that conditions can ever be improved.

The facilities at these stations represent an important investment. The laboratory, staff housing, water supply, electrical connection and access road needed at a shrimp research and development facility would be costly to duplicate elsewhere but under the present circumstances the stations are a drain on the Inland Fisheries Division's resources. Their trained personnel could be utilized more effectively in other jobs. The stations should either be upgraded or closed and the personnel moved elsewhere.

It is recommended that the station at Pitipana be either closed or upgraded by building new ponds of the kind described in the report in order to conduct research on penaeid (marine) shrimp. An area of government land adjacent to the station could be used to build about 5 ha. of ponds with pond bottoms at an elevation high enough so they could

be completely drained and dried. The large laboratory building could be used as a wet lab to hold tanks for nutritional or other studies. This will entail removing the decrepit concrete stands which now occupy most of the building and installing a new water supply system. The concrete lined nursery ponds could be improved by partially filling them with earth to raise their bottoms sufficiently for adequate drainage. Water should be supplied by a pump. Two 2 h.p. air blowers should provide aeration for the nurseries. The nursery ponds are well suited for use as modified raceways. To convert them to this purpose, a divider of asbestos/concrete roofing material could be placed down the center of the pond and air lift pumps used to aerate and circulate water around the raceway.

It is more difficult to suggest improvements at Pambala. A good deal of the problem with the ponds at this station is associated with seepage of acidic groundwater into the ponds. This stems largely from the former use made of this area as a coconut plantation and the decomposition of organic waste from this activity has greatly lowered the pH of the soil. One partial remedy for this would be to pump water into the ponds to maintain a positive head, so that water seeps out of the bottom of the ponds instead of into them. The pond bottoms should be raised by partially filling them with earth so that they hold 80 cm. of water at full level. The dikes have a good covering of grass and since the ponds are small it should be possible to fill them above the rock walls without causing damage to the dikes. A new water supply system using a pump should be installed. The present water supply system could be used for drainage. There is an area next to the existing ponds which could be used for construction of perhaps two ponds with no excavation except peripheral canals to obtain soil for the dikes.

Government Aquatic Research

Aquatic research in Sri Lanka is performed by the National Aquatic Resources Agency (NARA), a component of the Ministry of Fisheries. It is separate from the Department of Fisheries in authority. Its programs are supervised and approved by a Technical Committee, whose membership includes representatives from the Department of Fisheries. There are six technical units: Marine Biological Resources, Inland Aquatic Resources, Oceanography, Fish Technology (post-harvest research), Fishing Technology (boat gear), Data Processing and Statistics. The Inland Aquatic Resources unit has eight research officers and eleven technicians. They carry on projects including the following:

1. The Integrated Puttalam Lagoon project collect hydrobiological data on the Lagoon water and certain observations on the fisheries there, and on manpower, as these parameters relate to fish culture. A research station is being built at Kalpitiya, to be in operation soon.

2. The mussel culture survey, testing methods for culturing the green mussel *Perna veridis*, using rafts. This is supported by IDRC. It is centered at Trincomalee.

3. A pollution study is analyzing water samples from waterways near Colombo.

4. A brine shrimp project, measuring the size of the resource and carrying some experiments on handling the cysts ("eggs").

5. A socio-economic study of the fishing communities on the Puttalam Lagoon.

6. Food trials of ornamental fishes, to assess growth under different feeding regimes.

7. Feed trials of cultured fishes and prawns.

8. Seaweed culture using different experimental techniques.

Some of the on-going research activities of NARA offer support for the brackishwater aquaculture component of the ADB loan. The survey of Puttalam Lagoon will furnish information needed to determine the suitability of various sites within the lagoon for aquaculture. Brine shrimp nauplii are one of the most essential feeds for crustaceans and marine fish larvae, and the study of brine shrimp resources should lead to utilization of a presently untapped natural resource, which should result in lower foreign exchange expenses to import brine shrimp eggs. We believe this work should be expanded to include culture of brine shrimp in ponds. A research proposal on this is included in our report. The feeding and nutritional studies for penaeid shrimp fill an important gap in the activities designed to develop brackishwater aquaculture under the ADB loan.

Test facilities at NARA appear limited. A system of experimental tanks should be installed at a site where a good supply of brackishwater is available.

PROGRAMS SUPPORTED BY EXTERNAL AID

The Asian Development Bank Loan Project

The heart of the Government's efforts to develop aquaculture is that the project be funded by an Asian Development Bank aquaculture loan. The major thrust of the project is to develop culture of freshwater fish in inland waters, but there is also a brackishwater component which is intended to lay the groundwork for further development of penaeid shrimp culture.

In order to relate the status of shrimp culture in Sri Lanka to commercial and environmental activities and problems, and to summarize actions needed by the Government and external assistance agencies to guide the orderly development of a shrimp farming industry in Sri Lanka, we examined the technical aspects of the project, including feasibility, scope and logistics, and evaluated these in relation to the apparent capability of government to carry out its share to these activities, as well as their other responsibilities.

The total cost of the ADB Loan Project will be U.S. $21.62 million, with support services amounting to U.S. $18.64 million. Most of this money will support freshwater fish culture in inland areas; a smaller component will support brackish shrimp culture. The project is of six years' duration. The executing agency is the Ministry of Fisheries (MOF) and its Inland Fisheries Division (IFD), which is responsible for all aspects of aquaculture as well as of capture fisheries in fresh and brackishwater, will play the major role.

The brackishwater component of the ADB project is composed of the following activities.

- Shrimp hatchery. A shrimp hatchery will be built to supply postlarvae to stock ponds and to demonstrate hatchery techniques. The design capacity will be 20 million postlarvae per year, but the production goal is initially only 10 million per year. A consultant group will be hired for site selection, design, contracting and overseeing construction, equipment procurement, and initial operation of the hatchery and training of the IFD staff.

- Demonstration ponds. Twenty-five hectares of brackishwater ponds will be constructed. Pumps will be used to fill the ponds because of the small tidal amplitude. Management of the ponds calls for fertilization to encourage growth of natural feed. There is no provision for supplemental feed. Plans call for a stocking rate of 20,000 per hectare. Two crops will be grown each year. Survival is projected to be 60%, and size of shrimp at harvest 20 grams. The estimated yield is 400 kq/ha./crop. A brackishwater aquaculture consultant will be provided for 24 months.

- Demonstration pens. Twenty-five ha. of pens are to be built to demonstrate means of bringing brackishwater lagoons under cultivation. No information is given about management procedures or type of construction. Provision is made for a pen culture expert consultant to work for 12 months.

- Credit for 200 ha. of commercial ponds. This component is to provide funds to small-scale operators for construction of 200 ha. of ponds, purchase of pumps, and working capital. The average pond area is assumed to be 5 ha., and about 200 shrimp farmers are expected to be employed. The ponds are to be stocked with shrimp postlarvae from the hatchery and with milkfish from the wild. Annual yields from the 200 ha. are expected to be 160 tons of shrimp and 20 tons of milkfish. Scheduled development is: 20 ha. in year 3; 80 ha. in year 4; 140 ha. in year 5; 200 ha. in year 6.

- Training. Local training is to be provided for IFD personnel, initially at the Pitipana brackishwater aquaculture station and later at the hatchery after it is completed. A total of 39 staff are to be sent overseas for periods ranging from one to twelve months for technical training. Of these, an unspecified number are to receive training in subjects related to brackishwater aquaculture.

The shrimp aquaculture component manpower requirements are as follows:

	Skilled	Unskilled	Farmers
Hatchery	16	8	-
Demonstration ponds	8	40	-
Demonstration pens	12	10	-
Brackishwater ponds	-	-	200
TOTAL	36	58	200

COST SUMMARY - BRACKISHWATER COMPONENT

(US $ 1,000)

Activity	Foreign Exchange	Local Currency	Total
Brackishwater Culture	(517)	(704)	(1,221)
Shrimp hatchery	296	177	473
Demonstration ponds	64	164	228
Demonstration pens	57	39	96
Operation	100	324	424
Consulting Services	(1,150)	(243)	(1,393)
Shrimp hatchery development	760	130	890
Brackishwater aquaculturist (24 mo.)	240	-	240
Pen culture expert (12 mo.)	120	113	143
Brackishwater ponds (200 ha.)	-	(2,980)	(2,980)
TOTAL COST *	1,667	3,927	5,594

*Excluding project management, servicing costs and training costs.

The goal of the brackishwater component is to product 200 m.t. of shrimp for export with an ex-farm value of $1.2 million and a foreign exchange value of $1.8 million. In addition, 25 m.t. of milkfish are projected to be produced for domestic consumption.

The final project bears little resemblance to the FAO Investment Centre Mission proposal. The technical aspects of the brackishwater aquaculture component are now reasonable and feasible. Since shrimp hatchery technology in several parts of the world is fairly well developed, a company with experience in hatchery design and operation should be able to construct and successfully operate the modest hatchery called for in the project. Production goals for the demonstration ponds are reasonable and no major problems are foreseen in accomplishing them.

However, we are concerned that because the coastal soils in Sri Lanka are in general sandy, traditional pond construction with earthen dikes may not be satisfactory. A more detailed discussion of this is given later.

Pen enclosures for shrimp culture are included in the project but they are relegated to a research phase, and the success of the project does not rely much on them. No mention is made of the type of management to be employed for the pens. We assume that management practices will be similar to those given us in the FAO Investment Centre proposal. If so, there seems to be no provision for providing pelleted feeds. Developing 200 ha. of commercial ponds over a six-year period is a realistic goal.

Other External Assistance in Aquaculture

In addition to the ADB Loan assistance in aquaculture, there are several other on-going or planned activities supported by external aid agencies.

- FAO/UNDP Aquaculture Development and Training Project
  This project has a scheduled duration of 36 months and is expected to end in October 1984. The foreign financial contribution to the project is $750,301. The main objectives of the project are to increase production of freshwater fish fingerlings, train fishery personnel in aquaculture technology, and increase production of fish in seasonal tanks.

  This project is directly supportive of activities to be initiated under the ADB loan, especially the inland components.

  Even though FAO/UNDP participation in the project is ending, the national staff will probably form a core for the training under the ADB project. The staff seem well equipped to carry on most of the activities, although the amount of time the individuals spend on training activities will have to be greatly expanded.

- IDRC is supporting three aquaculture activities:

  1. Cage culture of freshwater fish. Initially, 24 cage culture units were established at Udawallawe for culture of *Sarotherodon nilotica*. The project has now been expanded to additional tanks and experiments are underway to test different stocking densities in polyculture with carps. Experiments to culture trout in cages is being carried out at Nuwara Eliya. This work is being done by the Inland Fisheries Division of the Ministry of Fisheries.

  2. Pen culture of milkfish. Research is being carried out in a 0.25 ha. pen in Puttalam lagoon and a 1 ha. pen with four partitions in Bolgoda Lake. This work is being done by the Inland Fisheries of the Ministry of Fisheries.

3. Raft culture of green mussels is being done at Trincomalee by NARA.

These projects do not appear to offer significant support to the ADB loan activities except in the training activities. Scholarships are provided for training in Integrated Fish Farming at Wuxi, China, and a senior aquaculturist was sponsored for one year at the NACA in the Philippines.

- FAO Bay of Bengal Programme is assisting with a project entitled Development and Demonstration of Coastal Aquaculture Techniques in Sri Lanka. This project, which started in January 1984, is to be of two year's duration. The foreign financial contribution to the project is US $ 21,350. The project has two components. One is pen culture of penaeid shrimp in monoculture or polyculture. The second is demonstration of basic shrimp hatchery techniques through establishment of interim makeshift hatchery facilities at the Pitipana station. Two possible sites for pens have been located in Negombo lagoon and sampling of hydrological and tidal parameters is underway.

  This project seems to be duplicative of work planned under the ADB loan. Selection of sites for pen culture might prove useful, but it is difficult to see any positive aspects of attempts to do hatchery work at the Pitipana station since the site is not well suited for this work.

- Indian Technical and Economic Cooperation (ITEC). Under this program, the government of India is providing the services of three aquaculturists. One is assigned to the Inland Fisheries Division at the D.O.F. to advise on Culture of Fish in Ponds and Small Tanks. Two are working at various aquaculture-related tasks at NARA, one of which is studying production of brine shrimp from local sources.
  The personnel provided under this plan will give good support for the ADB loan program.

- Government of China. There is a sub-contract with China for a nine-month program to design a research orientated program for breeding Chinese carps and to train technical staff in the methodology.

  This activity provides direct support to the ADB loan.

- UNDP/UNESCO. As part of a US $ 750,000 three-year project, this is to provide institutional support for NARA. Some research on seawood culture would be done at Trincomalee.

  This activity provides no support for the ADB loan. USAID is considering providing assistance to the Coastal Conservation Division for preparation of a resource inventory, i.e. mapping wetlands, which would be of considerable help to those considering the establishment of shrimp farms.

RELATIONSHIP BETWEEN SHRIMP CULTURE AND ENVIRONMENTAL FACTORS

Among the considerations this mission was asked to include in its observations was activity of the Government in environmental protection of the shoreline environment, since the integrity of this area is vital to a successful shrimp farming industry. It seems apparent from our short experience in the country and from the documents we had access to, that Sri Lanka is well aware of the necessity of protecting the near-shore environment, and is taking intelligent action to maintain this kind of area, and to repair damage already done.

To reinforce the necessity of this kind of action, we provide below short statements of the inter-relationship between shrimp and fish populations and the ecology of coral and sand regions in shallow waters, and of mangrove and other vegetated areas.

Role of Shallow Sea and Estuarine Vegetated Areas in Supporting Fishery Stocks, and the Ecological and Profitability Aspects of Building Shrimp Farms in these Areas

Shallow sea vegetated areas, including mangrove forests and other wetlands, have been recognized for many years by ecologists to be richly productive regions supporting much higher populations of commercially valuable fishes and invertebrates (especially shrimp) than would exist in the absence of the vegetation. The general public and government officials have been slower to realize the close and important relationship between the size of commercial fish populations and the existance of wetlands, and a common belief is that these areas are wastelands where better use can be made of the areas than to leave them intact. But in recent years, better scientific information and wider dissemination of this information has resulted in greater protection of estuaries and wetlands. Moreover, the once common destruction of grass and mangrove areas to build shrimp ponds has diminished sharply in many parts of the world (especially in Central and South America) as it has been discovered that the production of such ponds declines after a few years. Thus, for example, the initial costs of building in mangrove areas and the management problems encountered reduce profitability - sometimes so that shrimp farms built in these areas are abandoned.

The high biological productivity of a mangrove forest is based on the conversion of fallen leaves into protein-rich protoplasm by micro-organisms. This film of micro-organisms is grazed by a large variety of small animals - crustaceans, worms and others - and these are eaten by larger animals. Many species of fish and invertebrates consume the grazers, and in many cases these larger animals move from the mangrove shallows into the adjacent sea, where they often support valuable commercial fisheries. Grassy areas have similar food chains. There is good evidence that grass areas and mangroves are necessary for the existence of many fishery stocks; the best of such evidence relates to marine shrimp (penaeids). For example, one study of 27 locations in the tropics found a positive mathematical correlation between the amount of inter-tidal vegetation and commercial catches of shrimp; in Indonesia similar results were reported; in Australia 90% of the food of shrimp

came from mangrove regions; a biologist reported to the Indian Ocean Fisheries Commission the flat statement, "no mangroves, no shrimp". Fish, too, depend on wetland areas with near-shore vegetation. An estimated 80% of fishery production in the United States is from animals using estuaries and other shallow areas at some time in their lives; in Fiji, 60% of fish of commercial importance are either caught in mangrove areas or use such areas at some time; 67% of all the commercial catch in Eastern Australia is mangrove-related.

There are other ecological values of grass beds and mangroves in addition to the food they provide to fish invertebrates. The grass areas and the aerial roots of mangrove trees provide shelter for many species, especially during their juvenile and highly predator-prone stages. Then, these regions provide a buffer zone, trapping land sediments which could otherwise ruin offshore areas; coral reefs are especially vulnerable to destruction by turbid water and coating by sediment. Finally, grass areas and especially mangrove forests, reduce current and wave action and reduce shoreline erosion.

Wetlands can be inadvertantly destroyed by certain human activities including release of sediment from land and agriculture or building construction. The sediment can clog the aerial roots of mangroves through which the trees obtain the oxygen for their root systems. Pollution - herbicides, oil, sewage - can destroy vegetation, as can long-term freshwater flooding.

Deliberate destruction of estuaries and mangroves occurs in order to use the land for housing or industrial building sites, or - of special relevance here - for shrimp ponds. The latter practice may in some places and circumstances be appropriate, but there is a growing realization that both ecological and monetary costs are often too high to justify building shrimp ponds in mangrove areas.

The ecological effects of clearing mangroves to build shrimp ponds can be implied from the above discussion of their ecology - destruction of primary productivity and consequent reduction in the size of valuable fishery stocks inside the vegetated areas and in the sea beyond, shelter for animal populations, increased sediment loads, possible introduction of pollutants, alteration of circulation and tidal flushing, possible changes in freshwater inputs and in salinity regimes.

The likelihood of lowered profitability from shrimp ponds built in mangrove areas relates to the high cost of clearing the forest, building ponds, controlling the acid-suphate soils, and building water exchange systems. Harvest efficiency is usually greatly reduced and water quality is lower.

The ecological and profitability considerations have led shrimp farmers in many parts of the world to build ponds on shore, above the mangrove areas. The environmental considerations should weigh heavily with policy makers, and cause them to consider possible consequences before issuing permits for construction of shrimp farms in mangrove areas. There may be circumstances where this practice is justified, but these will probably be rare and will be in the absence of other options.

Ecology of Coral Reefs and Sand Flats in Relation to Coastal Resources Including Fisheries

Coral reefs provide shelter for populations of plants and animals, some of which are commercially valuable and support fisheries. Coral reefs also serve the function of providing protection for the shoreline against wave action and long-shore currents, and thus help control erosion.

Coral reefs exist in delicate balance with the ocean environment and small changes can be damaging and sometimes fatal to the reef community. Corals must have warm water, high light intensity, no silt or other turbidity, ocean level salinities, moderately high water exchange by waves and currents and relatively low water nutrient levels. Moreover, corals are extremely slow-growing, so that rehabilitation of a damaged reef may take years or decades.

Coral reefs can be damaged or destroyed inadvertantly through natural or human actions, or deliberately through removal of reef material. Inadvertant damage can be caused by siltation of the reef or an increase in turbidity caused by runoff from land of water bearing sediment from agriculture land or from construction activities. Sand dredging may have the same effect. Salinity decreased from above-average freshwater runoff can kill reefs. Pollution from agricultural runoff, industrial wastes, oil spills or thermal rises is a potential threat.

Physical removal of parts of a reef by mining of either dead coral or live can remove natural breakwaters and lead to damage by storm waves through erosion, and to structural damage of harbors, breakwaters, roads and villages. And since in the tropics as much sand may be derived from corals as from land sources, destruction of reefs may in the long run alter the sand budget adversely.

Sand dredging near shore may also be damaging to the biological populations and to current and wave patterns, leading to undesirable changes. Hence, sand mining, whether for trace minerals, to create channels or harbors, for construction purposes, for beach enhancement, or as fill for new land can be damaging, costly and potentially disasterous. One irony is that sand mining for fill to repair eroded beaches may lead to further and even more damaging erosion as current patterns are altered and sand sources once available for natural beach nourishment are removed. Removal of sand and coral reefs can be seriously damaging to the shallow water ocean environment including the commercially valuable fishery populations. This is especially true if the sand areas have vegetation. Removal of such sand or the deposition of sand on vegetated areas from mining operations nearby can destroy significant proportions of the biological productivity of an area. This is because shallow areas, especially grass flats, among the most productive regions of the ocean, are especially vital in maintaining shrimp populations. Coral reefs are directly linked to fish production for certain species, through the food and shelter provided by the reef.

The reefs are less directly linked to shrimp production, but reef destruction or degradation will affect the overall productivity of an ocean ecosystem, with adverse impacts of shrimp populations that may occupy such a system. Moreover, if removal of reefs eliminates protection of the shoreline from the erosion effects of waves and currents, inshore shrimp habitat or shrimp farm structures and facilities may be destroyed.

Coral mining in Sri Lanka is known to have been damaging to shorelines and to have reduced biological productivity of ocean waters. The removal of dead or living coral from reefs is forbidden in Sri Lanka, but due to social problems related to the difficulty of providing alternative means of livelihood for those traditionally engaged in harvesting coral and manufacturing lime, the law is sometimes hard to enforce. But once corals are removed, rehabilitation of a living reef is very difficult or even impossible. If it can be done at all, it may take decades. Some corals grow only six centimeters a year, and others as little as one centimeter a year. If alternative means of livelihood for those engaged in this activity cannot be found, progressively more serious ecological and economic consequences are certain. The cost to the country of loss of reefs threatens to be very high.

Sand mining is an acceptable practice if it is done with careful planning and control. Unplanned and unmonitored sand removal can result in heavy economic loss through coastal erosion and environmental damage. A national sand budget should be prepared which takes into account expected removal rates. Usually near-shore mining should be replaced by operations far enough offshore to reduce effects on living populations and shore processes. Mining techniques such as suction probes, which cause less turbidity than many common methods, may be useful.

In summary, coral reefs and sandy areas, especially those with vegetation, are of highly significant importance in maintaining fish, shrimp and other living populations, and their destruction can be far more costly in monetary terms than the reduction of income caused by stopping the removal of coral or the banning of sand mining in certain near-shore areas.

RELATIONSHIP OF SHRIMP CULTURE PROGRAMS AND ECONOMIC AND SOCIAL ACTIVITIES AND VALUES

It is apparent that potential social problems have already surfaced with the initiation of some aquaculture programs in Sri Lanka and elsewhere. Fishermen are understandably nervous about any disruption of their traditional activities, especially any appropriation for other uses of fishing, landing or beach areas. Any threat of reduced catches by capture of fry or brood animals for culture purposes, whether justified or not, causes resentment. Already, the planned use of part of the Negombo Lagoon for shrimp cages has caused unrest in the fishing community. Experience in other countries makes it certain that more of this kind of problem will arise in Sri Lanka.

These problems can be reduced by planning, by socio-economic studies of the fishermen's groups to be affected, and by involvement of the local communities in the design and conduct of the fish culture programs. In particular, if the local people can share in the monetary rewards of the new activity, by new roles or direct share in profits, tension and conflict can be lessened. NARA is conducting a study of this sort of problem in connection with the Puttalam Lagoon study, and this should be repeated for other areas in the future.

Shrimp culture programs should provide significant employment for coastal-dwelling populations. If the ADB project comes to the full level contemplated, some 200 ha. of small shrimp ponds will be created involving some 200 shrimp farmers. The large-scale commercial shrimp farm projects will employ an unknown but probably large number of local people.

Since shrimp is a high-priced item on the world market, and since this market is very strong, the production of farms can be exported and yield large amounts of foreign currency, to the great advantage of the nation's balance of trade. Japan is now and will likely continue to be the major customer for Sri Lankan shrimp, with the United States and Europe buying considerably less. In a recent year, fishery product exports brought in Rs. 400 million and fully 65% of this was from shrimp. The projected large-scale shrimp culture projects, which are in advanced stages of development, could double exports of this commodity in a few years.

SUGGESTIONS AND RECOMMENDATIONS FOR ACTIONS TO ACCELERATE THE DEVELOPMENT OF COMMERCIAL SHRIMP CULTURE IN SRI LANKA

1. The Government should make certain policy decisions.

The Government, and in particular the Ministry of Fisheries, is pursuing generally appropriate and helpful policies for the encouragement of aquaculture (including shrimp culture). Significantly, this appears to be the perception of the private sector, insofar as we have been able to determine. But is is our feeling, shared by those we have talked to in the private sector, that the development of shrimp culture in this country has reached a turning point -- a critical stage where the future development of this activity can either be significantly accelerated or can be constrained by wrong policy decisions or by a failure to make decisions.

Policy areas where decisions require to be made, or strengthened or made more explicit, include the following:

Land use policy

Government policy in respect to the use of land for shrimp farming has already been partially formed and expressed. Overall, this policy is to give encouragement to anyone, local citizens or foreigners, who want to enter the business of shrimp farming. In pursuit of this policy, crown land has been made available to certain entrepreneurs on easy terms, and other concessions and help have been provided. What is still lacking in Government land use policy is a clear signal or statement concerning the relative encouragement to be given to large-scale highly capitalized enterprises versus small individual farmers. Among the issues which should be addressed in this aspect of shrimp culture policy is how many large-scale permits are to be issued, involving how much total land. Unlike the case in some other countries, the amount of coastal brackish water land area available in Sri Lanka for effective shrimp culture is relatively small. By no means are all the coastal areas suitable for this purpose, either because they are already used for other purposes, the soil or water conditions are unfavorable, or a substantial number of other conditions make the areas unsuitable for shrimp culture. Already the demand for large tracts of land is heavy, and when the first farms are successful (as it seems likely that they will be), this demand may become much larger. At that time it may be discovered that no additional suitable land is available for small-scale farmers. Some guiding policies are therefore needed to develop requirements to be imposed on applicants for land/water areas to be used for shrimp farming. A plan is suggested elsewhere in this report for surveying potential shrimp farming areas of the coast and deciding which of these should be set aside exclusively for small-scale farmers. Policies might also include requirements on the part of those given concessions on crown land to protect the environment, to train a certain number of local people in the techniques to be used (on the case of large-scale operations), and perhaps other rules. While care should be taken not to change the present desirable climate of encouragement for potential shrimp farmers, the time may have come to sit back and examine the

probable effects of uncontrolled access to crown lands for this kind of purpose.

An aspect of land use policy would be to make certain that no development is permitted near a shrimp farm area that would pollute or otherwise be detrimental to the culture activity.

License and lease policy

Present license and lease policies for aquaculture endeavor are liberal, perhaps too liberal. Leases are very long, taking away other possible uses if farming operations are unsuccessful. There should be some performance requirements for a lease which ensure that the land is used for the purpose for which the lease was granted and that the land is not tied up for low yield purposes. There should be regulations as to whether and how leases can be transferred, renewed or inherited. There should be regulations providing the amount of space to be permitted between pens, ponds and other structures.

Subsidies and other support for small-scale shrimp farmers

The encouragement of small-scale shrimp farmers might well involve some special concessions and subsidies by the Government, and the implications of this kind of policy should be examined. Subsidies may encourage the entry of under-capitalized persons and those with insufficient skills and energy to make a success of shrimp farming. This could lead to business failure that would be damaging to the Government and the program itself. Thus, active encouragement of small-scale farming carries with it a requirement that the Government provide a good extension service to provide the small farmer with techniques necessary for him to make a profit. This policy of supporting the small farmer should also be followed by a quality control program for the product to be exported that ensures that no Sri Lankan shrimp farmer, large or small, is allowed to sell a product below the quality which gives the whole country a good reputation in the market place.

Coordinating council

The Government might consider whether it would be useful to create some coordinating body with representation from the various ministries having jurisdiction and authority over activities in the coastal zone. We were informed that some confusion, duplication and contradiction prevails among these authorities. Leadership of such a coordination body might be assigned to the Ministry of Fisheries since it has a dominant role in this area. Care should be exercised to impose as little bureaucratic control and expense to persons wishing to make appropriate and socially acceptable commercial or other use of the coastal zone, while still protecting public natural interest.

2. A substantially longer training program involving supervising aquaculturists, farm managers, extension agents and farmers should be carried out.

Of concern is the ability of the Inland Fisheries Division to carry out the numerous activities needed for implementation of the ADB loan. The IFD has a staff of 275, including 84 professional officers. Only nine of these work in brackishwater aquaculture, although the ADB project calls for 39 technical staff to be engaged in such activities. Many professionals will therefore have to be trained in the new technology. In addition, the 200 farmers expected to be engaged in shrimp farming must be trained and so must the extension workers who will advise them.

Establishment of a viable shrimp culture industry will thus involve training on several levels. The first step is to train national technical staff. This will be accomplished by on-the-job training with expert consultants and by sending local staff abroad for training. The next step is to train extension workers and farmers. This will require development of specialized courses for which syllabi, lecture notes and training aids must be prepared. Ponds suitable for demonstration of management techniques and actual production are essential. This will require greater input of professional time than is provided under the ADB loan agreement, and a project proposal for foreign assistance to supply this need is attached.

The ADB loan document proposed that training in brackishwater aquaculture be conducted at the Pitipana station initially, and later at the shrimp hatchery provided under the project. If so, the Pitipana station must be upgraded significantly. There are now no ponds suitable for shrimp culture. Some training could be done at the new hatchery but it is not clear that it will have the proper ponds for training in pond management. In any case, it is only in rare instances that a site suitable for a hatchery also proves suitable for demonstration ponds. Plans should be made to build at least a few ponds at the Pitipana station suitable for demonstrating shrimp grow-out technology as soon as possible.

The training expert is due to start only on month 27. He probably will spend most of his time organizing training activities for the larger, more important freshwater component. It would be useful to have another training advisor arrive earlier and work with the brackishwater aquaculturist and pen culturist to develop syllabi and lecture notes for brackishwater training.

In addition to the substantial effort required to provide training for the brackishwater activities of the ADB loan project (39 skilled people), a total of 339 skilled, 170 unskilled personnel and a large number of farmers will have to be trained for freshwater aquaculture. A one-year consultancy by a training advisor for months 27 - 39 seems inadequate for this. The national staff of the FAO/UNDP training project has acquired sufficient knowledge of the technical aspects of fish culture to provide training, but we were informed that they have never been taught any teaching or training skills. Neither they nor the

foreign experts have prepared any manuals or teaching aids. Preparation of manuals is planned for the end of the project, but this appears a backwards way of operation. The national staff also lacks the skills needed to teach extension methodology. The local staff is also performing its training duties on a part-time basis, being expected to carry on its normal professional tasks as well. The training is of such fundamental importance that it appears to us to require the full-time efforts of professionals, and we suggest that future training programs be staffed by professionals assigned to this duty alone.

Two projects which might be assisted by external aid are suggested later in this report to strengthen the training component of the Ministry of Fisheries' activities in aquaculture.

3. A program of applied research in support of aquaculture should be initiated.

The efficiency and profitability of agriculture is sustained to a critical degree by continued research and demonstration activities, usually by Government. Aquaculture, being technologically far behind land farming, needs this backing even more and will continue to need it indefinitely. The Sri Lankan Government should plan a carefully designed and appropriately staffed and financed shrimp culture research and development facility and program.

It is uncertain whether the production techniques used by large-scale shrimp enterprises will be suitable for use by small holders. It will be the responsibliity of Government to develop the technology required for small-holder development.

A strengthened program of research is therefore needed to develop a technology appropriate to Sri Lanka. Many details of pond management must be worked out, including the best types of fertilizers for use in local waters and their rates of application, the length of the growing period, stocking densities, etc. Staff must be trained in the recognition and treatment of disease and the poor pond conditions which bring on disease.

The type of management using fertilizers to provide natural food is a good way to initiate development, but it will be necessary for long-term success to work toward intensive culture involving feeding. This will require the use of processed feeds and possible aeration. Research in development of shrimp feeds using local ingredients is required.

There is not provision for ensuring a supply of feed under the ADB loan; and as far as the Mission could determine, none of the commercial ventures is planning to market feed to others. Additional research is needed.

The hatcheries will require brine shrimp nauplii to feed the larvae. These should be produced locally instead of being imported. A plan for technical assistance to do that is attached. Nutritional requirements of the species of shrimp to be cultured are known, but specified feed formulations based on locally available ingredients must be developed.

4. To overcome the handicaps created by the low tide amplitude and the nature of the local soils, engineering tests should be conducted on various types of pond design and construction.

The ADB project provides for demonstration ponds to be built, but it does not specify the method of construction or location in relation to the tide. The accepted location for pond construction in Sri Lanka now is in coastal wetlands. But due to the slight tidal variation here, it is not possible to situate a pond so that its bottom is at an elevation high enough to be drained and also to allow exchange of water by tidal action. Ponds at the two Government brackishwater stations and at least at one private farm are excavated to below the mean low water mark. This allows only a portion of the water to be exchanged by tide. Even with pumping, the pond bottoms at the brackishwater research stations cannot be drained because seepage is so high. The ponds are harvested by using pumps to lower the water level in the pond, concentrating the fish and shrimp so that they can be captured. Pumps are used for water exchange only to augment tidal exchange.

Locating the pond bottoms in this way below mean low tide is not a good practice for several reasons. The main one is that organic debris builds up in the pond bottom; and because the pond cannot be completely flushed or sun dried, a high content of organic matter makes the bottom turn anaerobic. The result is that most of the food organisms living in the bottom die, greatly reducing the natural food for the shrimp whose diet is composed mainly of meiofauna (bottom-living organisms). Also of importance, when pond bottoms are not dried, harmful products of anaerobic action such as hydrogen sulphide enter the pond water and consume oxygen. The only really effective way of treating the pond bottom is to dry it and mineralize the organic waste built up in the soil. Acid sulphate soils occur commonly in Sri Lanka and pond management experience shows that excavation in these soils should be as shallow as possible because acidity increases with soil depth. Construction should, therfore, involve excavating from a shallow burrow ditch adjacent to the dike. The interior of the pond should only be levelled and shaped so that drainage is into the graded peripheral canal.

It is thus a matter of great importance that pond bottoms be located high enough so that they can be drained and sun-dried. This will require the use of pumps to fill the ponds. Many people consider the cost of pumping to be prohibitive, but that is not true in many cases when the long-term profitability of well-managed ponds is calculated. Pumping is the common practice in Taiwan, Thailand and Ecuador where shrimp farming is practiced most successfully and profitably. The San Miguel Corporation in the Philippines pumps water into ponds located above the high-tide line. They produce three to

eight tons per ha. per 120 day crop, and water exchange during that time only amounts to about seven times the pond volume. Furthermore, the practice of pumping water into ponds built with their bottoms high enough to be drained by gravity causes less adverse environmental impact on the important and sensitive wetlands during pond construction. Ponds can be constructed on the least productive, higher areas, or better yet out of the tidal zone completely on higher ground adjacent to the water source.

Construction of ponds with a pumped water supply in high ground area means that the dikes will have to be higher than otherwise. The sandy soils which prevail in Sri Lanka are not well suited for making traditional earthen dikes. They are subject to severe erosion from rain and wind-driven waves, and require high maintenance. Special methods of construction will be needed. A project to assist in the development of appropriate construction methods is presented later in this report.

This emphasis on the necessity to construct shrimp ponds on land high enough for the bottoms to be above the high tide levels may seem exaggerated and unnecessary to some prospective Sri Lankan shrimp farmers, even some who have experience elsewhere. This is especially the case because land costs and contruction costs are often lower if the ponds are built on lower land that cannot be completely drained. Yet we are confident of the strong advantage to be gained by the use of ponds on higher land using pumps to fill them and being able to drain and dry the pond bottoms completely. Experience in other parts of the world is now enough to show that ponds that cannot be completely drained may show good production at first and show promise of reasonable return or investment, but that after a few years the productivity of these ponds declines to money-losing levels and capital and operating investment is lost. On the long-term, and this should be the time span planned for, the higher costs of land and of pumping to fill the ponds will significantly increase the chance of receiving a profit from a shrimp farm.

5. The Government should encourage both the Ministry of Fisheries and private sector activities to develop hatchery and farming techniques for shrimp culture suitable for Sri Lankan conditions.

Activities to be carried out under the ADB loan are a good start toward development of small-scale commercial shrimp culture in Sri Lanka. Developments by the private sector which have been encouraged by government will complement the activities under the ADB loan. Development of hatcheries of different locations by the Government and private companies with different technologies is to be encouraged. This will ensure more than one source of supply for farmers in case one of the hatcheries experiences problems due to disease or other difficulties. While hatchery technology itself is fairly well known, maturation of *P. monodon* in captivity is not, and it will be beneficial to have more than one group working on this problem. Likewise, the various methods planned by private companies for growing shrimp in ponds will accelerate development of the method best suited for Sri Lankan conditions. The joint ventures will bring new and different technology into the country.

6. Economic and social tensions which are likely to arise from the development of shrimp farming activities should be anticipated, and plans made ahead of time based on appropriate studies.

The concept of growing shrimp in pens is fairly new and as yet of unproven economic success. Efforts to assess its suitability under Sri Lankan conditions should continue, but because of possible social problems which can arise, commercial development should proceed cautiously even if culture trials do show it to be economic. Some 93% of fishery production in Sri Lanka comes from the small-scale coastal fishery. Tensions have arisen between purse seiners and small-scale fishermen over shared use of the coastal fish resources. The same type of problem is likely to occur if water areas in the lagoons - which are popularly considered to be community property - are assigned to private ownership. This has created severe problems in cage culture trials in India. In Sri Lanka, the Inland Fisheries Department has already experienced problems with poaching of milkfish from pens in Pittalam Lagoon, and in selecting sites for pens in Negombo Lagoon. It is important that the feelings and needs of both the local fishing communities and migrant fishermen be ascertained before any large-scale development is undertaken.

7. A study should be made of the feasibility of creating "shrimp farm estates" as a possible way of encouraging small-holder activities.

As part of the Government's program to encourage establishment of commercial shrimp farms, long-term leases are being given for large tracts of crown land. Land suitable for development into shrimp farms is a finite resource. Care should be taken to make allocations so that sufficient areas are set aside for development by small holders. Several people interviewed by us expressed concern that if applications for crown land continue, most of the most suitable land may be tied up by large investors. In order to prevent this from happening, the Mission recommends that several large tracts of land be set aside for future development by small holders. To facilitate selection of sites suitable for development by small holders in a few predetermined lagoon areas, technical assistance in the form of a short consultancy by a shrimp culturist is proposed.

The Mission does not feel it necessary to make a detailed survey to assess suitable sites or seed resources throughout the country. Once areas for small holders are identified and set aside, larger commercial firms will be able to select their own sites and IFD extension workers can determine their suitability on a case-by-case basis.

Entry of landless fishermen into shrimp culture as small holders will present special problems. These people do not have sufficient capital to qualify for loans, and they have no experience managing relatively large sums of money. One of the less risky methods of encouraging their entry into shrimp farming is through participation in a "shrimp farm estate", such as is being planned by the Malaysian government.

In the estate concept, government builds all the facilities, ponds, canals, pump stations, roads, housing, etc. These can then be leased to small holders on either a group or individual basis. An important aspect of this is that there is no need for the poor farmers to have collatoral prior to entry, and in an estate they only have to manage small amounts of money under the close supervision of an extension worker. Costs are generally less in the estate. There is no need for individual water pumps since centrally located pumps and the canal system are maintained on a cooperative basis. Bulk purchasing of inputs lowers costs and ensures availability of such things as screening materials, which may have to be imported. Likewise, unified marketing ensures that a fair price is obtained for the harvested shrimp.

A very important point is that it is easier to provide extension and training support for the farmers under the estate system. The importance of too little supervision is demonstrated by the experience with seasonal tanks in Sri Lanka. Initially, when the number of tanks stocked was small, production was high. Later, when the number of tanks managed was increased, the unit production decreased. This was related to difficulties in overseeing management in the increased number of tanks at separate sites. The same thing will probably happen with small-holder shrimp farms located in different places. In an estate, however, the farmers are all close together and it is easy for extension workers to have daily contact with all the farmers. Thus, the number of extension workers needed will be fewer and they will be more effective.

8. The Government may be over-extended beyond its ability to supervise and promote aquaculture, and it should consider consolidation of present activities rather than undertaking additional tasks.

The mission believes that for the present, activities of the IFD in brackishwater aquaculture should be limited to penaeid shrimp culture. This is due to the tremendous strain already imposed on the division's manpower to fulfill commitments of the ADB loan and other responsiblities already incurred. Developmental research for fresh-water shrimp, *Macrobrachium rosenbergii*, and other species should be done by NARA.

In addition, it is not sure how much potential there is for the development of large-scale *Macrobrachium* farms. One of the local persons who has been involved in trying to develop commercial operations in this field informed us that it is not a good venture for large-scale development here because most land with access to dependable supplies of fresh water is already in use for traditional agriculture. In Sri Lanka, *Macrobrachium* is probably more suited for polyculture with fish in small holder ponds.

In the same way, proposals for additional development activities in fresh or brackishwater aquaculture development should be critically reviewed to ensure that their adoption would not jeopardize the ability to carry out activities already committed.

PROJECTS WHICH MIGHT BE SUPPORTED BY EXTERNAL AID AGENCIES

1. Training in shrimp culture.

Technical personnel of the IFD have very little knowledge of shrimp culture although a few of the aquaculturists have been exposed to the shrimp culture practices as part of other training. If small holders are to become involved in shrimp culture, they will have to be guided by government officers. This means that these officers must become knowledgeable enough to train extension workers and farmers. A formal training program is the best way to accomplish this.

The first requirement is for facilities in which management techniques and actual production can be demonstrated. Neither of the brackishwater stations now has suitable ponds. It is recommended that either a new station be built on that government land next to the Pitipana station be used to build new ponds. Four 0.5 ha. ponds and four 0.25 ha. ponds should be sufficient for training purposes.

A shrimp culture consultant should be provided to teach the trainers shrimp production techniques and to assist in developing lecture notes and a manual for extension workers and farmers.

A training advisor consultant should be provided to teach the trainers teaching skills and extension methodology. He should develop a course syllabus, lecture notes and training aids for a course in shrimp culture for extension workers and farmers. Training aids should include a manual to serve as a continuing reference for those who have attended the course, visual aids for lectures, and slide shows or video tapes for extension use. The training advisor should evaluate at least two courses, one for extension workers and one for farmers, and recommend improvements as necessary.

The project should be for two years. The inputs required are as follows:

Staffing

Shrimp consultant (2 years)
Training advisor (2 years)
Illustrator/draftsman - local recruitment
Typist - local recruitment

Equipment and Supplies

Construction of demontration ponds	- US $ 30,000
Operation of demonstration ponds	- US $ 12,000
Preparation of training aids	- US $ 10,000

2. Assistance to determine training requirements to ensure timely implementation of Government plans to expand freshwater aquaculture.

The Government of Sri Lanka has embarked on an ambitious plan to develop an aquaculture industry in the country. The most serious constraint is the lack of trained manpower to carry out the many activities which are essential to the success of the program. The ADB loan program alone calls for recruitment of 375 new personnel. There are other programs which also require personnel: the IDRC pen and cage culture project; the FAO/BOBP Pen Culture of Shrimp Project; the Chinese joint venture. In addition to the government officers, a large number of individual farmers must receive training, and there is a need for direct and continuing guidance of small aquaculturists at the village level by locally recruited extension workers, a considerable number of which must be trained.

At the same time, the Government is encouraging foreign participation in shrimp culture through joint ventures. These companies will require local counterparts, and it is only to be expected that there will be some loss of experienced government personnel to the private sector.

A number of government officers have already received training in various aspects of aquaculture, but their number is small. They now occupy key positions, and if they are moved up or into new positions, there is no experienced staff to take their place. An FAO/UNDP project has initiated training in brackishwater aquaculture but appears to be undermanned by national staff. The instructors have to carry on their former regular duties in addition to their training tasks. This project is to end in October 1984 and at this writing no course syllabi or lecture notes have been prepared. While the national staff of the FAO/UNDP project have acquired considerable technical expertise in freshwater fish culture, they have not had adequate training in teaching methodology, extension methodology or the preparation of training aids. The ADB loan agreement has provision for training. A National Inland Fisheries Development Centre (NIFDC), to be operating by month 30 of the project, will have facilities for training and applied research. In the meantime, training is to be conducted at the Udawallawe station. There is provision for a training advisor for 12 months during the third year of the project. There is provision for training equipment.

We believe that there is a need for additional training, including some in the areas of teaching methodology, extension methodology, and preparation of training materials for trainees at different levels. We did not have the time or the expertise to formulate a detailed plan for assistance and recommend that a training advisor be recruited for a period of two months to study the training needs of the IFD and formulate a proposal for technical assistance for a training in fresh water fish culture.

3. Assistance in engineering for brackishwater pond construction.

In general, the coastal areas in Sri Lanka are not suitable for traditional brackishwater pond construction. The soils are generally sandy, with clay content only up to about 35%. This type of soil packs hard but is very susceptible to erosion. There have been several instances in Sri Lanka where ponds built with traditional type earthen dikes have been almost completely destroyed during storms. Seasonal rains are heavy, and rain-caused erosion requires almost continuous maintenance to repair damaged dikes. Also, tidal conditions are not suitable for filling and draining ponds by tidal action, so that pumps must be used. Little information is available here on the types of pumps which are best suited for pumping salt water at low heads or on the cost of operating such pumps.

Expert assistance to design and test methods of construction and the type of pump best suited for Sri Lankan conditions are clearly needed.

There are several examples of non-conventional pond design which could be examined. In Taiwan, pond walls are made from brick or concrete. In Singapore, a free-standing wall of asbestos/concrete (A/C) roofing sheets is used for shallow ponds. In the U.S., a research station on Grande Terre Island, Louisiana, has pond walls constructed of two rows of A/C sheets with the space between filled with sand. This farm has been in operation more than fifteen years with no major maintenance required even though several hurricanes have occurred.

In addition to durability, hard vertical pond walls have other advantages for shrimp culture: (1) One of the major problems is predation by birds wading at the edge of the pond. In some cases estimates of crop loss have been substantial. This problem is eliminated in ponds with vertical walls. (2) A major cause of dike damage and possible failure are holes caused by burrowing crabs; some crabs can burrow through ten-foot dikes. In ponds with a pumped water supply, the constant positive head can result in even more damage than in tidal ponds. Pond walls with a hard surface eliminate this problem.

There are several types of pumps which can be used. Most would have to be imported at a cost in foreign exchange, and these pumps would be hard to maintain because local technicians would be unfamiliar with them and spare parts would have to be provided. Shrimp farmers in Thailand have devised a simple type of propellor push pump which should have applicability in Sri Lanka due to the low head required. The pump is simple and can be constructed on the site with locally available materials. Maintenance should be no problem for local people. An engineering consultant to an FAO project in Malaysia visited Thailand and examined these pumps. He reported that their efficiency could be improved greatly if a few simple modifications could be made. These would include the pitch of the propellor, the distance between the propellor and the pump casing, the speed and the slope of the casing. Experiments would have to be carried out to arrive at a proper design for Sri Lanka.

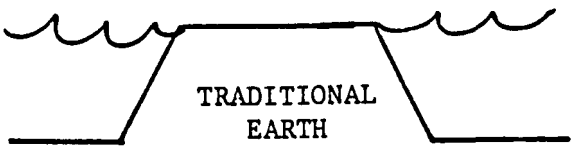
It is proposed that engineering assistance be provided to design pond walls suitable for use under the sandy Sri Lankan conditions. An engineer should visit ponds at Grande Terre, La., USA, Taiwan and Singapore to observe non-conventional types of construction. In Sri Lanka an inventory of available building materials and their cost should be made. The consultant engineer could design several types of pond walls which could be incorporated in the initial ponds to be constructed under the ADB loan or at the Pitipana station. After they have been field tested, a final design could be selected. Some ideas for pond walls are attached.

In the past, personnel of the Thai Department of Fisheries have expressed a willingness to work with a consultant engineer to perform the tests needed to obtain design criteria to improve the efficiency of the push pumps. An engineer should spend about two months in Thailand working with Thai fishery officers to develop an improved pump design and observe construction techniques. During this time, he would advise the Sri Lanka Department of Fisheries as to equipment requirements to construct a pump here. This material could then be ordered. When the work in Thailand was completed, the engineer would proceed to Sri Lanka where a pump would be constructed. Department of Fishery officers would receive on-the-job training in its manufacture and operation.

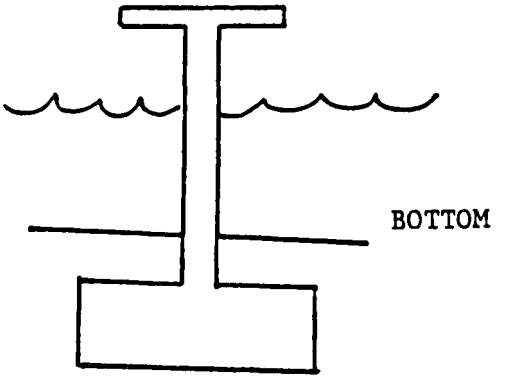
As part of the process of evaluating the engineering improvements recommended, an aquaculture economist would conduct a two-week analysis of the recommended procedures to verify their cost effectiveness.

TYPES OF POND WALLS

1.



2.

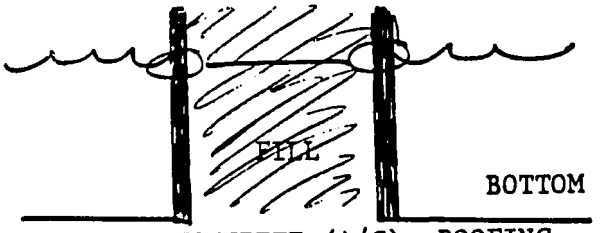


REINFORCED CONCRETE

3.

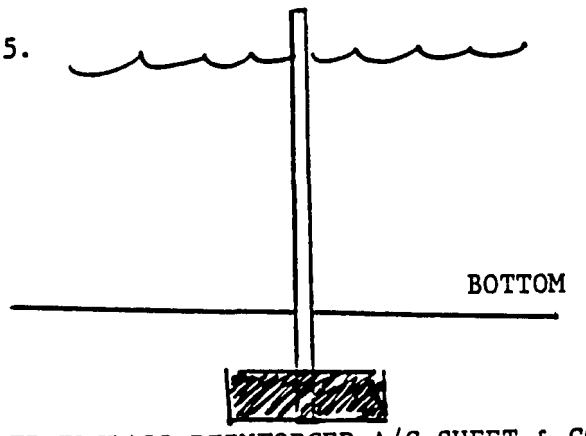
BRICK WITH SOIL FILL

4.



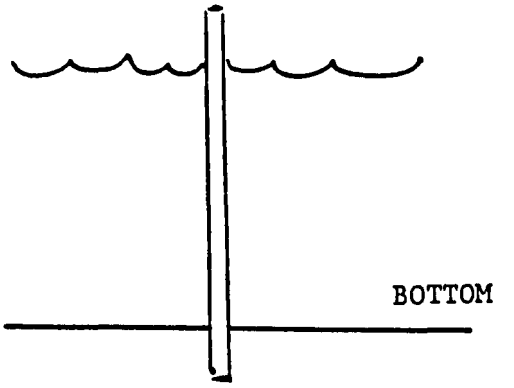
ASBESTOS CONCRETE (A/C), ROOFING,
MANGROVE - POSTS & CABLE W/SOIL FILL

5.



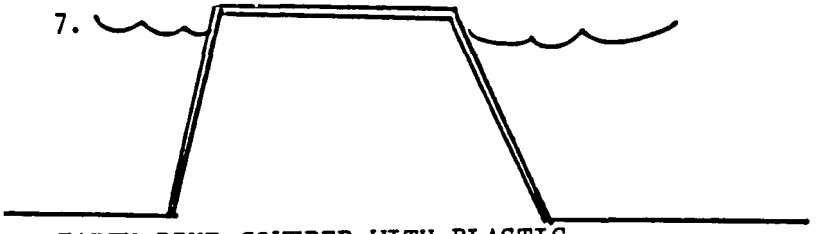
FIBERGLASS REINFORCED A/C SHEET & CONCRETE BASE

6.



FIBERGLASS REINFORCED A/C SHEETS
WITHOUT CONCRETE BASE

7.



EARTH DIKE COVERED WITH PLASTIC
SHEET

8. For #5 and #6, other materials available locally might be tried. A 24 mm thick sheet of concrete and rubber tree fibers is available in Singapore.

Manpower Requirements

Aquaculture engineer - dike construction	3 months
Aquaculture engineer - pumps	4 months
Economist	2 weeks

Equipment and Suppliers

Dike construction	$10,000
Pump evaluation and construction	$ 6,000

4. Shrimp culture research

This proposal is for establishing a program of research to adapt technology developed elsewhere to Sri Lankan conditions, and to provide a research base to support commercial development. Almost without fail, attempts to adapt directly a method of aquaculture developed in another country have encountered problems. The climate may be slightly different, the cost of inputs is different, or there may be unexpected problems like a new predator. Adaptive research is almost always required. That is, the aquaculture system must be tested on a small scale and modified to meet local conditions. Once this is done and a suitable system is developed and put into practice by farmers, there is a continuing need for research to support the new industry. Methods must be improved and new techniques integrated so that profitability increases. Backstopping is necessary to identify, treat and prevent future outbreaks of disease.

At least one brackishwater station should be built or modified and equipped for use as a research and development center. The station at Pitipana might be suitable for this since government land for construction of new ponds is available adjacent to the station. The supply of freshwater and electricity is good and buildings for test facilities are already in place. It would cost much less to modify this station than to build a new one, but it should be emphasized that it is not suitable in its present form. At least six 0.5 ha. ponds and ten 0.25 ha. ponds should be built. They should be constructed so that their bottoms are high enough to drain and dry, and that they are not influenced by acid sulfate soils. This will require the use of a pump to fill them. The existing nursery tanks can be modified by partially filling them in with soil so that their bottoms are above the tide level.

Experiments in pond management should be supervised by a shrimp culture consultant. Experiments should include trying different types of fertilizers at different rates to see which work best in local waters, testing the frequency of water exchange, testing stocking rates, testing the length of culture period. An economic analysis should be made of the different types of management to determine what is a suitable economic unit for a small-holder shrimp farm.

A consultant familiar with the nutritional requirements of penaeid shrimp should devise a food formula based on locally available ingredients. This should be used to fabricate a feed locally. The feed will then have to be tested. This will require about twenty tanks each with a bottom area of 2 m^2. After an initial feed is developed, experiments should continue to improve it and to work out rates of feeding required for different sizes of shrimp. A Sri Lankan scientist should be sent to the University of Arizona for one year to study shrimp nutrition.

A laboratory with equipment for disease diagnosis should be established. An expert on shrimp disease could do this on two short-term consultancies; one to advise on the physical facilities required and specify equipment, and a second to install the equipment and demonstrate its use. A Sri Lankan scientist should be sent to study shrimp disease at the University of Arizona for six months.

Inputs

Shrimp culturist	2 years
Feed technologist (shrimp)	6 months
Aquaculture economist	2 months
Shrimp disease specialist	2 months

Equipment

Ponds	55,000
Facilities - tanks, aquaria, disease room, water supply system	15,000
Equipment	30,000
Supplies	20,000

5. Project to culture brine shrimp

One of the items which will be required in large amounts for crustaceans and marine fish hatcheries is brine shrimp, to feed larval stages of cultured animals. These are imported as dry cysts and are relatively expensive. The cysts are hatched and the small nauplii larvae obtained are used as food for the larger shrimp, prawn and fish larvae. The use of these live larvae is required because they swim up in the water column and remain available to the hatchery-reared larvae. Attempts have been made to fabricate special rations to replace brine shrimp, but none has been used successfully on a large scale. The major problem is that these foods settle to the bottom of the hatchery tank where the larval shrimp and fish cannot eat them. When they accumulate at the bottom, they rot and cause water in the hatchery tank to become foul.

Brine shrimp occur naturally in the salinas (salt evaporation pens) of Sri Lanka, but they are not now utilized commercially. Scientists at NARA have identified sites where the brine shrimp occur. There is need now to teach the operators of the salinas how to collect the cysts and process them. Processing entails separating the live viable cysts from dead cysts and debris, and then packaging them in containers suitable for storage. It is possible to increase greatly the production of cysts by manipulating pond conditions to control salinity, temperature, oxygen content and phytoplankton food. Good success in doing this has been achieved in Thailand and the Philippines where local farmers are now growing brine shrimp and harvesting the cysts for use in local hatcheries. It is proposed that a project be carried out to introduce culture of brine shrimp to Sri Lanka. Doing so would result in considerable savings in foreign exchange over the years.

The project would be for one year. An expert in pond culture of brine shrimp would be recruited from Thailand or Belgium. The expert would work with the operators of some of the local salternes, advising them on how to modify their ponds and management procedures for the ponds. He would specify equipment needed to process the cysts and demonstrate its use. As a part of his duties, he would also teach methods for decapsulating the eggs so that they can be used without the cysts contaminating the water with bacteria and other diseases.

The executing agency would be NARA. The funding requirements are estimated as follows in US dollars:

	US $
Brine shrimp culture expert - 12 months	65,000
Fertilizers	1,000
Pond monitoring equipment	2,000
Cyst processing equipment	13,000
Transportation (vehicle and fuel)	20,000
TOTAL	$ 101,000

6. Technical assistance to local sites suitable for development of small-holder brackishwater shrimp farms.

Sri Lanka has only a limited number of sites suitable for establishment of brackishwater ponds for culturing penaeid shrimp. As part of its effort to encourage commercial development of shrimp culture, the Government is granting long-term leases for large tracts of land on concessionary terms. There is concern that after these initial ventures are shown to be profitable, there will be a rush of applicants for the available land by commercial interests. Part of the ADB loan activities are designed to encourage development of small-holder shrimp farms. This will undoubtedly take longer to develop than the large commercial farms due to problems inherent in working with landless, poorly educated people. To ensure that sufficient land is kept available for small-holder farms, it is recommended that suitable sites be located and set aside as reserves in which no large-scale commercial development will be considered.

To accomplish this, foreign assistance is suggested to help in determining which areas should be set aside. The services of a shrimp culturist and an aquaculture engineer for a period of two months each is proposed. In cooperation with the IFD and CCD, they would visit selected areas of government land along the coast and determine their suitability for small-scale shrimp farms. They would take soil and water samples for analysis and review available data on hydrobiological factors.

Foreign Exchange Component

Shrimp aquaculturist - 2 months	
Aquaculture engineer - 2 months	
Equipment - soil auger	$ 500
Supplies - sample bottles	500
Transportation	3,000
Laboratory analysis	2,000
TOTAL	$ 6,000

APPENDIX

Persons Contacted

Colombo, Sri Lanka

Government Officials -

Anura Weeraratne
Secretary, Ministry of Fisheries

K. Thayaparan
Director, Inland Fisheries Development Division
Ministry of Fisheries

R.A.D.B. Samaranayake
Acting Officer in Charge, Brackishwater Aquaculture
Ministry of Fisheries

R. D. Chakrabarty
Expert Fish Farming and Farm Management
Ministry of Fisheries

Sunil N. Siriwardena
Officer in Charge, Pen Culture Project
Ministry of Fisheries

Naton R. Attapattu
Director of Fisheries (Marine)
Ministry of Fisheries

K. S. B. Tennakoon
Asst. Director (Inland Fisheries)
National Project Manager
FAO/UNDP Aquaculture Development & Training Project
Ministry of Fisheries

S. K. Onil Perera
Director, General
National Aquatic Resources Agency
Ministry of Fisheries

S. Subasinghe
Consultant
National Aquatic Resources Agency
Ministry of Fisheries

Thurairajaha
Director (Planning and Programs)
Ministry of Fisheries

J. A. J. Jayasuriya
Senior Deputy Director (Designs)
Irrigation Department

H. J. M. Wickremeratne
Manager (Development)
Coast Conservation Division

US AID Mission

Bill Schoux
Acting Director
US AID

Mike Korin
Chief, Agriculture and Rural Development
US AID

Tissa de Souya
Agriculture Marketing Specialist
US AID

Eric R. Loken
Energy & Environmental Engineering Officer
US AID

N. H. Bowdaich
Private Sector Development Advisor
US AID

Seneka Abeyratone
US AID

Anne Dammarell
US AID Program Office

Rolando Jiron
Advisor, National Planning
US AID

FAO

R. M. Bhowmick
FAO Senior Advisor, Aquaculture

Private Sector

R. L. Ferdinando
Project Manager
Lever Aquaproducts, Ltd.

David Milton
Chairman & Managing Director
Serandib Seafoods, Ltd.

Manila

Richard Neal
Director
International Center for Living Aquatic Resources Management
(ICLARM)

Ian Smith
Economist
ICLARM

Y. K. Shin
Senior Fisheries Specialist
Asian Development Bank

Edward J. Rice
Chief, Agricultural Operations Division
US AID