BOBP/REP/66

Promotion of small-scale shrimp and prawn hatcheries in India and Bangladesh

BOBP
For Fisheries Development
BAY OF BENGAL PROGRAMME

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by

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The shrimp and prawn culture industries in India and Bangladesh still depend on wild fry. However, expanding production and the trend towards intensification, especially in India, will require the development of hatchery industries in these countries. Since the private sector is likely to be the engine for this development, BOBP undertook activities to transfer small-scale hatchery technology as directly as possible to this sector.

In India, this took the form of training small-scale entrepreneurs in tiger shrimp hatchery technology and providing financial support to the Government of West Bengal for the construction of a demonstration hatchery. Of eight trainees in India, one has set up a shrimp hatchery. The shrimp/prawn hatchery in West Bengal was completed, but not put into production.

In Bangladesh, a small-scale demonstration freshwater prawn hatchery was set up in Chittagong District. A new hatchery technology, using brine and a simple recirculating biofilter, was found to be feasible. Both government and private sector participants were trained in the hatchery. Direct assistance in the form of training and equipment was given to four private groups. Three of them completed prawn hatchery construction by the end of 1993 and one of them went into production.

The Bay of Bengal Programme (BOBP) is a multiagency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Shri Lanka and Thailand. The programme plays a catalytic and consultative role: it develops, demonstrates and promotes new technologies, methodologies and ideas to help improve the conditions of small-scale fisherfolk communities in member countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, and also by UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

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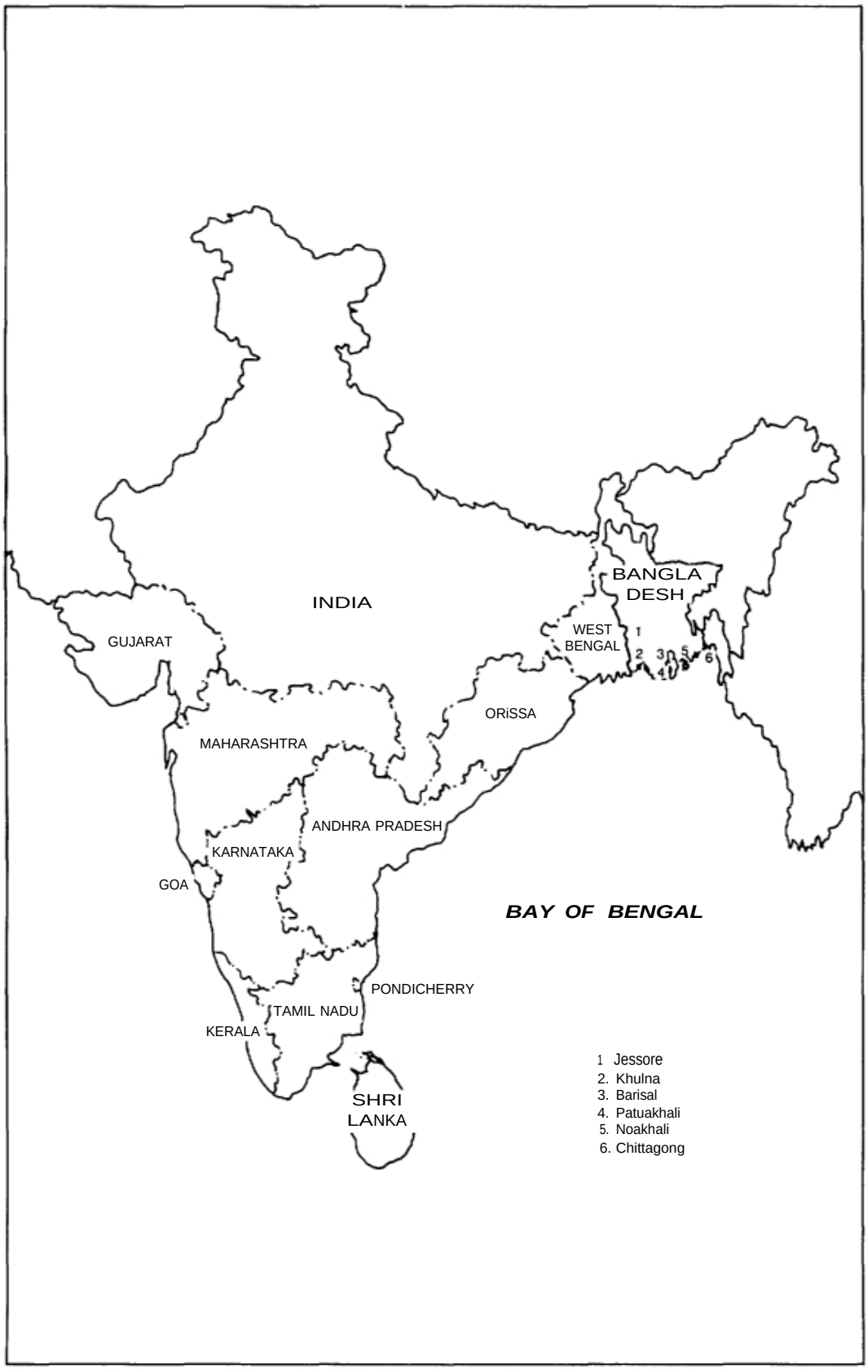
Fig. 1. Map of India and Bangladesh. showing the coastal states in India and the coastal districts in Bangladesh.



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1. INTRODUCTION

1.1 *Shrimp and prawn culture* *

Asia is the principal producer of farmed shrimp, accounting for 81 per cent of the total world production of about 600,000 t. Thailand is the largest exporter, with 150,000 t in 1992, followed by China, Indonesia, India, Viet Nam, the Philippines, and Bangladesh (see table below).

Asian shrimp culture production, 1992

	%	Head-on production (t)	Area in production (ha)	Production (kg/ha)	No. of farms
Thailand	25.4	150,000	60,000	2,500	14,000
China	23.7	140,000	150,000	933	3,000
Indonesia	22.0	130,000	200,000	650	15,000
India	76	45,000	70,000	643	1,500
Viet Nam	5.9	35,000	200,000	175	1,000
Taiwan	5.1	30,000	5,000	6,000	2,500
Philippines	4.2	25,000	40,000	625	3,000
Bangladesh	4.2	25,000	120,000	208	6,000
Malaysia	0.6	3,500	2,500	1,400	350
Japan	0.5	3,000	400	7,500	150
Others	0.8	5,000	8,300	602	440
Total	100	591,500			46,940

Source : Rosenberry, 1992.

The tiger shrimp, Penaeus monodon, predominates in Asian shrimp culture production because of its fast growth and adaptability to the pond environment and artificial feed. Thailand's output of cultured shrimp rose from 110 t in 1985 to 150,000 t in 1992. Indonesian production has grown similarly, from 12,000 t in 1985 to 130,000 t in 1992.

India's estimated farmed output in the 1992/93 season was 47,000 t, while Bangladesh produced 19,500 t (see tables below). Productivity remains low in these two countries. Although about 108,000 ha are devoted to shrimp culture in Bangladesh, the yield is only about 200 kg/ha. In India, with 70,700 ha in production, productivity is 665 kg/ha. Thai shrimp farmers average 2500 kg/ha.

Shrimp culture production by state and district in India and Bangladesh

INDIA. 1992 ' 1993

State	Estimated rackishwate area (ha)	Area under culture (ha)	Estimated production (t)
West Bengal	405,000	34,050	16,300
Orissa	31,600	7,760	4,300
Andhra Pradesh	150,000	9,500	12,800
Tamil Nadu	56,000	530	1,100
Pondicherry	800	-	-
Kerala	65,000	13,400	9,750
Karnataka	8,000	2,570	1,150
Goa	18,500	550	350
Maharashtra	80,000	1,980	1,050
Gujarat	376,000	360	200
Total	1,190,900	70,700	47,000

BANGLADESH. 1990- 1991

District	Area under culture (ha)	Estimated production (t)
Khulna	79,128	15,951
Chittagong	27,453	3,323
Jessore	6%	138
Patuakhali	326	65
Noakhali	61	7
Barisal	22	5
Total	108,280	19,489

*** According to FAO nomenclature, freshwater paleomonids are referred to as 'prawn'; marine penaeids, metapenaeids and paleomonids are called 'shrimp'.**

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However, as good culture sites become scarcer, the trend towards intensification will accelerate. Although various government sources in India have stated that about one million hectares of land is suitable for brackishwater culture, no detailed surveys have been made. Very rapid development is taking place where private land is available. Semi-intensive and intensive culture predominates in these areas. On the east coast, Nellore and East Godavari Districts are particularly noteworthy.

Interest in freshwater prawn culture began with the development of hatchery technology by S. W. Ling (1969). While there are about 125 species of ***Macrobrachium*** (Griessinger *et* ***al.,*** 1991.), only M. *rosenbergii* has proved suitable for commercial culture. The species is indigenous to tropical Asia, but has been introduced to many countries. The major farming countries are shown in the table alongside. Bangladesh is the leading producer from the capture fishery, while Thailand leads in cultured prawn production. Indian production is still low, but interest is high and a significant proportion of new hatchery construction is devoted to freshwater prawn fry production.

World production of freshwater prawns (t)

Country	*Culture*	*Capture*
Thailand	15,000	4,000
Bangladesh	5,000	43,000
Taiwan	4,300	N.A.
Brazil	450	10,340
Mexico	360	3,220
France *	200	N.A.
Viet Nam	200	5,000
Dominican Republic	150	N.A.
Puerto Rico	90	N.A
Malaysia	70	N.A.
Japan	55	N.A.
USA	50	N.A.
Mauritius	45	N.A.

Source : Griessinger et al, 1991

* Overseas territories

N.A. : Not available or not applicable

1.2 *Fry requirement and state* ***of*** *hatchery development*

Management practices vary widely. Most operations are extensive and stock 5,000 to 15,000 post-larvae (PL) per ha. If the higher value is taken as maximum, the total demand in India would **be** about one billion PL, while in Bangladesh 1.8 billion PL would be required, at present acreages! As farming intensifies, severe pressure will be put on natural sources. Stocking densities in semi-intensive farms range from 50,000 to 100,000 PL/ha. Intensive operations may stock up to 300,000 PL/ha, although it is thought that few intensive farms will be established in India and Bangladesh due to high investment and operating costs together with increased risks due to diseases. In view of the increasing frequency of fry shortages, the hatchery industry will have to develop as the process of intensification continues.

Shrimp and prawn farming in India and Bangladesh are based on wild fry and will probably continue to be so for the foreseeable future. However, increasingly common fry shortages and high prices are stimulating the expansion of the hatchery industry, particularly in India.

Until the late 1980s, Indian hatcheries were experimental and confined to the government sector. In 1990, the Marine Products Export Development Authority (MPEDA) of the Ministry of Commerce, Government of India, established two commercial prototypes with the collaboration of France Aquaculture and Aquatic Farms of Hawaii. These facilities introduced commercially viable shrimp hatchery technology and have served as models for investors and developers.

There are now commercial freshwater prawn hatcheries operating in India in the states of Kerala, Andhra Pradesh and Orissa in addition to several public sector units. Entrepreneurial interest is increasing and rapid growth in the sector can be anticipated.

Hatchery development has been much slower in Bangladesh. Several factors account for this situation:

- Sites are largely limited to the far southeastern coast, from Cox's Bazar to Teknaf;
- Marketing arrangements are poor, because of the relatively remote location in relation to major farming areas;
- Foreign investment in the culture industry is still extremely limited;
- While there is a small cadre of trained hatchery technicians, it is very difficult to finance hatchery construction, despite World Bank funds to this sector being available.

A notable exception in Bangladesh is the establishment of Pioneer Hatchery at Cox's Bazar with external financing and technical assistance. Besides this unique private hatchery, there are several public sector hatcheries, but these are, for all practical purposes, nonproductive.

2. PROJECT ACTIVITIES

The Bay of Bengal Programme (BOBP) was requested in 1988 to undertake a project in India and Bangladesh that would enhance fry production by means of hatcheries. The project activities fell into three areas: training, demonstration and technical assistance. Six components evolved during the course of the project:

- Hatchery training, India.
- Assistance to the Government of West Bengal for shrimp and prawn hatchery demonstration.
- Prawn hatchery demonstration, Bangladesh.
- Prawn hatchery training, Bangladesh.
- Technical assistance to the private sector for freshwater prawn hatchery development.
- Study tours.

2.1 Hatchery training, India

Shrimp hatchery technology development in the Indian private sector has been slow. Inappropriate models and concentration of effort in the public sector were two reasons. It has been recognized that hatchery seed supply will only increase proportionally to the degree of private investment in the industry. Therefore, BOBP's training programme targeted the small-scale business community.

Advertisements placed in local and regional newspapers during November 1991 offered training in shrimp and prawn hatchery technology. Over 300 applications were received. Of these, 22 were interviewed and ten selected, eight of them for shrimp hatchery training and two for freshwater prawn hatchery training. Of the successful applicants, two had some experience in shrimp culture, while the others were small business persons, including one woman. Geographically, most applications were received from Tamil Nadu, followed by Andhra Pradesh, Orissa and West Bengal. Of the successful applicants, six were from Tamil Nadu, two from Andhra Pradesh and one each from Orissa and West Bengal. The candidates from Orissa and West Bengal were selected for freshwater training.

The National Prawn Fry Production and Research Center (NAPFRE), Pulau Sayak, Malaysia, was selected as the training site for the eight shrimp hatchery participants. NAPFRE regularly conducts international training courses, has a well trained and experienced staff and has good accommodation facilities. The curriculum included all aspects of tiger shrimp hatchery operation. The training period was for 31 days, June 7 - July 7 1992, and included field visits to small scale commercial hatcheries (see Appendix I for curriculum).

The participants from Orissa and West Bengal were trained in freshwater prawn hatchery technology for 35 days during 1993. In addition, two biologists from the Department of Fisheries (DOF) hatchery in Cuttack, Orissa, completed a 10-day short course in June 1993 (see Appendix II for curriculum).

2.2 Technical and financial support, West Bengal

A consultancy, study tours and financial support led to the construction of a small-scale hatchery in Digha, West Bengal. The facility was designed by the Assistant Director of Fisheries, Brackishwater, and financed by BOBP, which also supplied the equipment.

The objectives of the consultancy were to assess the technical and economic viability of a shrimp hatchery in West Bengal. A Thai firm, International Aquaculture and Resources Management (INARM), undertook a survey and prepared economic and technical studies during October and November, 1989. The consultants concluded that a tiger shrimp hatchery would be viable in West Bengal and proposed a facility at Ramnagar with an annual production capacity of 5-10 million PL/year. But the plan prepared by INARM was not implemented. Several major constraints to hatchery development had not been addressed in the report. Furthermore, the technical manpower capacity of the DOF in West Bengal would have been severely challenged had such a large facility been built.

Based on a plan presented by the Assistant Director, Brackishwater, DOF, BOBP provided financial support for the construction of a demonstration hatchery at Digha. BOBP also supplied basic equipment and ten cases of *Artemia* cysts.

The hatchery was constructed next to an existing laboratory building in Digha. It had six 4.5 t rearing tanks, algae culture tanks, a 25 t brine storage tank and a pump house. Brackish groundwater could be used, as well as brine. Tanks were provided with individual covers, rather than being housed in an expensive building.

Unfortunately, the hatchery could not be put into operation by the DOF.

2.3 Prawn hatchery demonstration, Bangladesh

The DOF requested assistance from BOBP for the development of small-scale prawn hatchery technology, in spite of the existence of several hatcheries at the time the request was made. Since these hatcheries were sited on the sea coast or tidal river banks, BOBP felt that it would be appropriate to introduce inland hatcheries along the lines of the Thai model. Modifications were made to accommodate the technology to conditions in Bangladesh.

The DOF Fish Seed Multiplication centre at Potiya, just south of Chittagong, was selected as the hatchery site. The following criteria determined the choice of Potiya :

- Market access: Previous studies had shown that there was a well organized market in Chittagong District for freshwater prawn fry.
- Availability of brine: Many salt farms are located in Cox's Bazar, four hours by paved road from Potiya.
- Motivated staff: At the time Potiya was selected, the farm manager had demonstrated skill in fish hatchery management and was very interested in prawn hatchery development.

Views of the DOF shrimp/prawn hatchery, Digha, West Bengal, India.

Exterior and interior views of Potiya demonstration hatchery, Chittagong, Bangladesh.

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– Access to electricity: 440 volt service was available at the site.

– Free of flood threats.

– Adequate drainage for waste water discharge.

The hatchery was designed by BOBP staff and constructed by a local contractor during the latter half of 1990.

The design used brine collected from solar sea-salt pans, but, in a departure from the Thai model, employed biofilters in a recirculating system. The purpose of a biofilter is to remove ammonia and nitrites which are toxic. These are removed by the bacteria which grow on the biofilter medium as the water flows through it. The substrata on which bacteria grows can be gravel, clean shells or inert plastic materials. For further reference see BOBP/MAG/13 - ***A Manual for*** *Operating a Small-scale Recirculation Freshwater Prawn Hatchery.* Brine is available in Bangladesh only during the dry season, from January through April. Sufficient brine must be stored to last the season. The design and operation of the hatchery are described by Chowdhury *et al. (1993).*

The first year of operation, 1991, was devoted to 'breaking in' the system. Very high larva1 mortality limited overall survival to about 6 per cent. Mid-cycle disease was the major cause of larval mortality. Improved rearing techniques implemented during 1992 increased overall survival to 27 per cent and PL production to 18 per litre (see table below). Eight batches of larvae were reared in two cycles. Broodstock became scarce in June, thereby preventing the anticipated three cycles from being completed. No significant disease problems were encountered during the 1992 season.

Post-larvae production from two cycles in 1992 of the Potiya freshwater prawn hatchery

Tank & cycle	*Larvae stocked (no.)*	*PL production (no.)*	*Waler volume (litre)*	*Survival (%)*	*Production (PL/litre)*
CYCLE 1					
R1	402,000	82,400	4,200	20.5	19.6
R2	235,066	68,600	4,200	29.2	16.3
R3	244,000	76,700	4,200	31.4	18.3
R4	294,800	77,500	4,200	26.3	18.5
ST1	168,000	57,500	1,500	34.2	38.3
ST2	126,000	48,300	1,500	38.3	32.2
CYCLE 2					
R1 R4 combined	1,000,000	411,000	19,800	29.3	16.3

Note : 1 Due to several transfers of larvae from tank to tank during the rearing period, it has not been possible to estimate the production for each tank during the second rearing cycle. The objective of the transfers was to control larval density within optimal limits, reduce cannibalism etc.

2. RI- R4 are rearing tanks and ST1 · ST2 are spawning tanks

High post-larval mortality resulted from limited holding space. Total production of PL was 733,000. Sales were only about 350,000, as a result of high mortality in the PL-holding tanks. The selling price ranged from 350-500 Tk*/thousand, depending on the quantity purchased. There were about 50 buyers from the area surrounding Potiya.

* US $ 1 = **Tk 38** (appx.)

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Production improved during the 1993 season (see table below). Overall survival was 39 per cent with an average production of 21 PL/litre. Ferrocement tanks performed better than RCC rearing tanks because of persistent algal blooms which improved water quality. These tanks were adjacent to the main hatchery building and received enough sunlight to initiate the bloom of Navicula-like diatoms.

Post-larvae production, Potiya freshwater prawn hatchery, 1993

Tank & cycle	Larvae stocked (no.)	PL production (no.)	Water volume (litre)	Survival (%)	Production (PL / litre}
R3 / C1	180,000	52,000	4,200	28.89	12.38
R4 / C1	105,000	36,000	4,200	34.28	8.58
FCT1 / C1	140,000	56,000	1,800	40.00	31.00
R1 / C2	98,000	25,000	4,200	25.51	5.95
R2/C2	160,000	48,000	4,200	30.00	11.43
R3 / C2	244,000	105,000	4,200	42.00	25.00
R4 / C2	232,000	107,000	4,200	46.12	25.47
FCT1 / C2	115,000	55,000	1,800	47.82	30.55
FCT2 / C2	120,000	50,000	2,200	41.67	22.73
R2/C3	285,000	140,000	4,200	49.12	33.33
R3/C3	205,000	95,000	4,200	46.34	22.62
Total	1,884,000	769,000			

Note : RI - R4 = Rearing Tanks 1 -4

RCT1 - RCT2 = Fenocement Tanks I and 2

CI C3 = cycles 1 3

Total PL production was 769,000 and sales 431,300 (56 per cent PL survival). Mortality during holding was high in May, but improved coordination with buyers minimized holding time in the outdoor tanks to a few days. Consequently, survival was increased. Sales amounted to Tk 170,080. Several experiments were directed at reducing operating costs. Crude solar sea-salt replaced brine in the preparation of hatching water for *Artemia* cysts. There was no detectable difference in hatching rates. Since brine used for hatching *Artemia* constituted 33 per cent of the hatchery's requirement, a considerable saving was realized. Furthermore, it was found that mixing brine and sea-salt to prepare the larval rearing water was effective, as shown in the table below. Half the salinity, that is, 6 ppt, was made with brine and the remainder with sea-salt. However, when the brine component was reduced to 25 per cent and sea-salt increased to 75 per cent, total larval mortality occurred within several hours of hatching. Overall, using sea-salt to hatch *Artemia* and combining brine and sea-salt for larval rearing resulted in a reduction of brine consumption of *56* per cent.

Results of mixed brine/sea salt trials at Potiya freshwater prawn hatchery

Dare	Duration (days)	Tank No.	Larvae stocked (no.)	PL produtin (no.)	Wter volue (litre)	Surviva (/)	Productio (PL/litre)
26.07.93 to 09.09.93	45-46	R 2	285,000	140,000	4,200	49.12	33.33
27.0693 to 17.08.93	53-54	R 3	205,000	95,000	4,.200	46.34	22.62

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Limited trials were conducted using recycled rearing water. After all the PL were harvested, the used rearing water was returned to the mixing tank, chlorinated, filtered and used as a rearing medium in small buckets. There was no difference between recycled rearing water and controls. Time did not permit full-scale trials, but recycling appeared to be effective. Brine usage could be reduced by another 50 per cent.

There are several reports in the literature of freshwater prawn larval-rearing using artificial seawater. If successful, hatcheries could become completely independent of the sea. Unfortunately, in three trials using two different recipes, all larvae died within a few days.

The motivations and interest of the farm manager was of paramount importance in selecting the Fish Seed Multiplication Centre at Potiya for the hatchery. The individual in question was subsequently trained by BOBP. But after his training had been completed, he was transferred to another post! His successor demonstrated little interest in the prawn hatchery and did not actively participate or allow any of his staff to do so. Hatchery operation depended entirely on local staff recruited by BOBP.

The electricity supply at Potiya proved unreliable, but since auxiliary power was provided for the air blower, no serious consequences of prolonged power cuts were experienced. But the situation did occasion increased maintenance of the auxiliary power unit.

The Potiya hatchery is located adjacent to the Chittagong-Cox's Bazar highway. It was anticipated that the spoils ditch parallel to the highway would serve as the waste water drain. However, rice is planted in the ditch during the rainy season, even though the land is government-owned. Objections to the discharge of brine were raised by the farmer using the ditch adjacent to the hatchery. To placate him, a waste water receiving sump had to be constructed inside the hatchery complex.

MARKETING

Most PL sales were made to buyers in the area immediately surrounding the hatchery. There are many carp nursery ponds whose owners recognized the benefits of freshwater prawn nursing either as a single species crop or in combination with Indian major carps. The availability of PLs from the hatchery was advertised through local newspapers. Word of mouth was also effective in promoting sale of PLs.

Price depended on quantity, with less than 10,000 selling at Tk 500/1000 and larger quantities priced at TK 350/1000. More than 50 buyers patronized the hatchery. Many of the buyers in 1991 returned in '92 and '93.

Production was very limited in 1991, but in 1992 poor coordination with buyers led to high PL mortality while the PL awaited delivery in outdoor holding tanks. The holding facilities at the hatchery site were too cramped to permit keeping PLs more than a few days. Mortality increased rapidly in PL holding tanks, primarily as a result of cannibalism.

A concerted effort was made to improve coordination and speed delivery in 1993. Holding time was reduced to not more than a few days, significantly improving PL survival.

VIABILITY

The financial viability of a small-scale hatchery in Bangladesh was examined by evaluating the internal rate of return (IRR) of the model under various operating conditions. Construction costs were based on estimates by local contractors. Operating costs and production drew on the experience with the Potiya hatchery.

The model differs slightly from the Potiya hatchery in having six 5 t rearing tanks as opposed to four. It is assumed that only 50 per cent of the target production would be reached during the first year, rising to 75 per cent the second and that full production would be reached in the third year.

Schedule of investment costs for a model prawn hatchery, Bangladesh

BUILDING & FIXTURES	*TAKA*
Hatchery building	193,000
Rearing tanks, 5 t, 6 nos.	120,000
Furniture for office, laboratory and storage room.	15,000
Electrical installation, including junction fuse box, meter, wiring, sockets etc.	45,000
Outdoor holding tanks, including floor preparation (45' x 24')	79,000
Carrying charges, with some miscellaneous items	*20,000*
Tube well	100,000
Miscellaneous (transport, fittings etc.)	20,000
Subtotal	*592,000*
EQUIPMENT	***TAKA***
1 Refrigerator	15,000
1 Stereo microscope	40,000
1 Compound microscope	12,000
1 Desiccator	3,000
1 pH meter	3000
2 Refractometer	30,000
Assorted glassware	10,000
1 Blender	3,000
1 Balance	2,000
Assorted utensils/tools	5,000
8 Titanium immersion heaters	56,000
Assorted air stones	7,000
Nitex screen cloth	8,000
Assorted plastic buckets/tubs	3,000
1 Air blower	21,000
A 5 hp electric motor	5,000
A 7.5 hp diesel engine	12,000
2 Submersible pumps	14,000
1 Plastic hand brine pump	6,000
25 Plastic drums, 200 l	24,000
Subtotal	279,000
Total investment cost	871.008

1 US $ = 38 Tk. appx.

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Schedules of investment and operating costs are presented in the table on the facing page and alongside. The base case assumes a production of 20 PL/litre, three cycles per season and a selling price of 500 Tk/1000. Under these conditions, the IRR is 41 per cent (see table below).

The IRR for a project can be judged against low risk investments, such as savings deposit rates or government bonds. The savings deposit rate in Bangladesh in 1993 was 11.75 per cent. The Executive Committee of the National Economic Council (ECNEC) uses 25 per cent as a bench mark for investment projects.

Although PL can be sold for 500 Tk/1000, the required production in the base case is above the average experienced at Potiya. Three cycles at a production of 20 PLs/litre should be the minimum objective of the operator, with a target price of 500 Tk/1000. This can be achieved, provided brood stock is sufficiently available during the rainy season (normally June and July).

Schedule of operating costs for a model prawn hatchery, Bangladesh, for three cycles/year

	Taka
Brine	18,100
Salt	3,300
Broodstock	4,320
Artemia	42,840
Chemicals	55,530
Prepared feed	3,000
Electricity	81,000
Technical labour	36,000
Land rent	1,000
Opportunity cost of management	84,000
Watch and ward	12,000
Total	341,090

Cash flow (in Taka) for a model prawn hatchery, Bangladesh, with production of 20 PL/litre and a sales price of 500 Tk/thousand, operating three cycles per season

	Year 0	1	2	3	4	5	6 - 10
Fixed costs	(871,000)			17,000		127,800	
Variable costs		341,100	341,100	341,100	341,100	341,100	341,100
Revenue		450,000	675,000	900,000	900,000	900,000	900,000
Cash flow	(871,000)	108,9000	333,900	541,900	558,900	431,100	558,900
IRR = 41%							

Variables affecting the profitability of a freshwater prawn hatchery include price, PL production per litre and the number of cycles per season. A matrix may be constructed to show the effect of changes in these variables on the internal rate of return (see table below).

Effect of price, PL production and cycles per season on the IRR — sensitivity matrix in a model prawn hatchery, Bangladesh

	Production PL/1			
	15	20	25	30
Price Tk/1000		IRR %		
		4 cycles		
250	-12	10	25	37
350	13	32	48	63
500	37	59	79	98
		3 cycles		
250	-167	-4	11	22
350	-1	18	32	44
500	22	41	57	73
		2 cycles		
250		-136	- 10	2
350	-33	-2	12	22
500	2	19	33	45

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The prevailing market price for PLs in 1993 ranged from *350-500* Tk/thousand, depending on quantity purchased. Below 350 Tk/thousand, the IRR would be inadequate. Demand for juveniles to stock grow-out ponds is high and growing, so it is unlikely that the price of hatchery FL will decline in the near future. Wild juveniles ready for stocking fetch Tk 1-2 each, so the scope for nursery culture using hatchery PL is great. The IRR is sensitive to decreases in production per litre, as well as the number of cycles run per season.

Increasing investment costs would have little effect on the IRR. An increase of, say, 20 per cent would reduce the IRR by only 6 per cent. Thus, the risk to profitability from inflated investment costs is not high in the present economic situation in Bangladesh.

2.4 *Prawn hatchery training. Bangladesh*

Training courses were sponsored by BOBP from 1990 to 1993. The first course was held at a private hatchery in Cox's Bazar, while succeeding courses took place at the Potiya hatchery.

Both long- and short-term courses were given. The curriculum emphasized practical, hands-on experience. All aspects of hatchery operation were covered in both classroom and hatchery. At the conclusion of the courses, participants were given a written test and also asked to evaluate the course.

The first four formal training courses in 1992 were of ten days each and were completed by six managers of fish seed production centres nominated by the Director, DOF.

Training in 1993 was directed exclusively at the private sector. Four participants selected for the hatchery development activity (see Section *2.5* below) completed a 35-day course at Potiya, followed by a brief field trip to hatcheries in Cox's Bazar. Four 10-day courses were offered to those candidates interviewed but not selected for the long-term course (see table alongside).

Summary of prawn hatchery training activities, Bangladesh

Year	Number of courses		Number of participants	
	Short	Long	Short	Long
1990		1		4 DOF staff 3 private
1991		1		2 private
1992	4		6 DOF staff	
1993	4	1	18 private 2 DOF staff	6 private 1 NGO staff

Note: Short-It days; Long-35 days

2.5 *Assistance to the private sector, Bangladesh*

The private sector was directly targeted in Bangladesh to promote the establishment of inland freshwater prawn hatcheries. There were two aspects, training and technical support. Technical support consisted of provision of essential equipment and one year's supply of *Artemia* cysts.

There were 163 respondents to newspaper advertisements in the national vernacular media. Eighteen of them were interviewed and four selected for the programme. Successful candidates promised to construct the hatchery building on their own land in return for training and equipment. Each one provided documents supporting land ownership and his financial condition.

One of the four participants was operating a successful carp hatchery, one was an NGO with an aquaculture development programme, one a relatively large manufacturing firm with a fish farm and the fourth a newly-formed company.

The selected candidates were provided training at Potiya for 35 days and supplied with essential equipment for hatchery operations (see Appendix III). One year's supply of *Artemia* cysts was also given to each of the four participants. BOBP staff gave technical assistance during hatchery construction and to the one hatchery which started operation during 1993.

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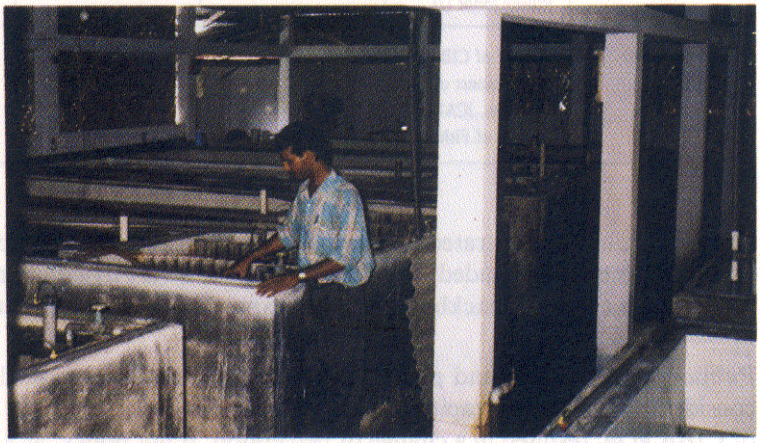
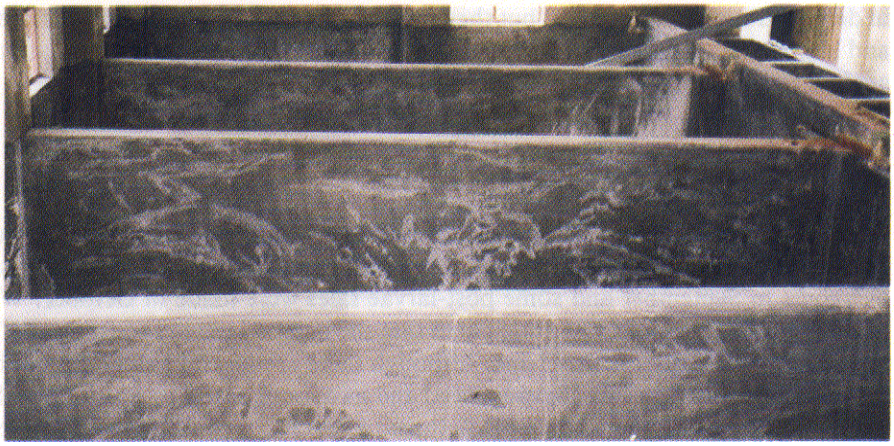


Exterior and interior views of Jalak Prawn Hatchery, Gozipur, Mymensingh, Bangladesh.



Crescent Fish Farms under construction, Jhodipur, Bangladesh.

2.6 *Study tours*

Study tours were organized in conjunction with training courses, to familiarize high-level officials with technology in more advanced countries, or to provide background for state officials (see table below). Study tours were also incorporated into training programmes, generally undertaken at the conclusion of the practical work.

Study **tour summary**

Dates	*Participants*	*Country of origin*	*Destination*	*PWpose*	*Subject*
28.8.89- 11.9.89	Dept. of Fisheries (6) Private sector (2)	West Bengal, India	Thailand	Observation	Small-scale shrimp and prawn hatcheries
16.7.90 - 22.7.90	Dept. of Fisheries *(5),* Private sector (2)	Bangladesh	Thailand	Training	Small-scale shrimp and prawn hatcheries
February 1991	Director of CIBA; Commissioner of Fisheries, ICAR; Director of Fisheries.	India	Thailand, Philippines	Observation	Finfish culture and breeding, small-scale shrimp and prawn hatcheries

The study tours concentrated on small-scale shrimp and prawn hatcheries in Thailand. In one case, the Philippines was included. Both countries have a very dynamic small-scale ('backyard') hatchery industry which is the backbone of their expansion and intensification of shrimp culture.

Public-funded shrimp and prawn hatcheries in India have tended to be large facilities requiring considerable investment capital. There are indications that the study tour undertaken by the Director of CIBA *et* a!. resulted in a change of perception, if not policy, as a result of first-hand observation of the thriving hatchery industries in Thailand and the Philippines.

Conversely, much of the effort spent on participants from West Bengal and Bangladesh appears to have been wasted. Only three of the Bangladeshis and none of the West Bengal staffers have been involved in prawn hatcheries since their return. It should be noted, however, that the Digha hatchery was designed by one of the West Bengal study tour participants. This hatchery, although never put into production, attracted considerable interest from local entrepreneurs and several small prawn hatcheries were under construction in late 1993.

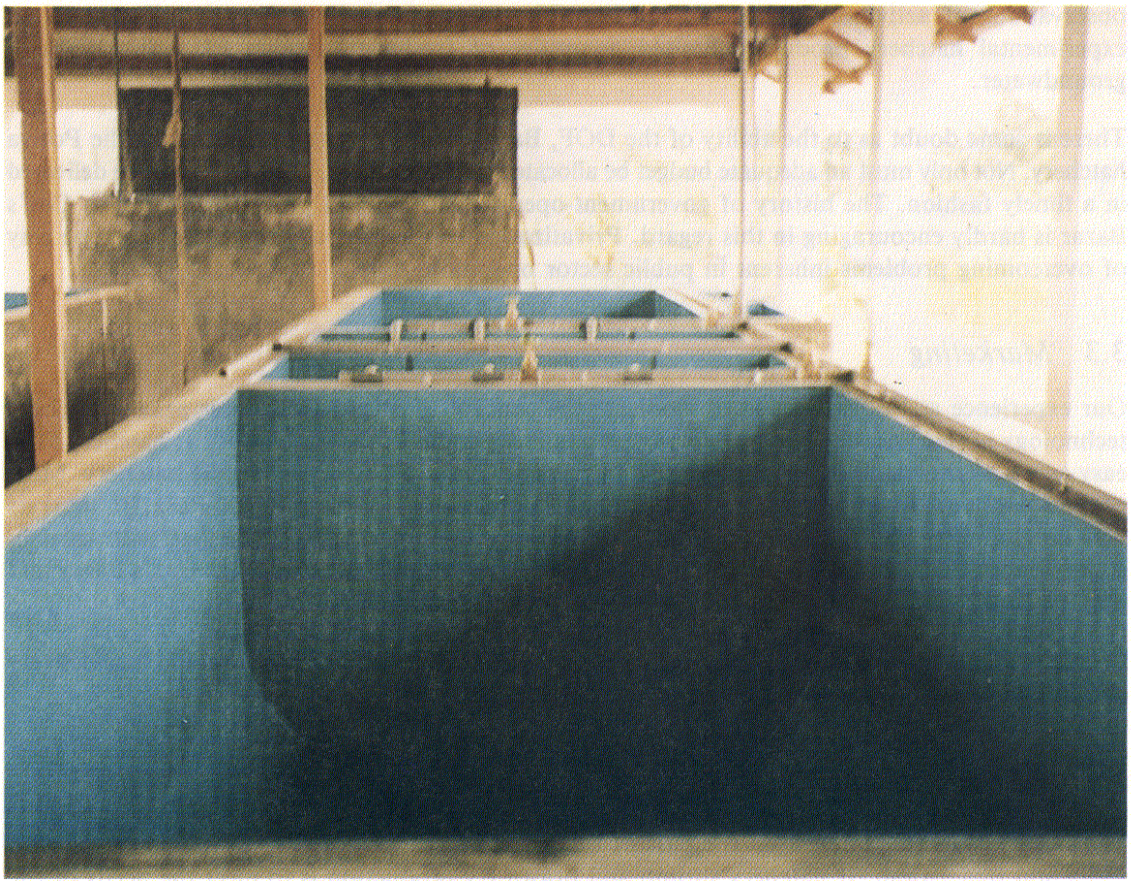
3. *CONCLUSIONS*

In general, small-scale shrimp and prawn hatchery technology appears to be viable in India and Bangladesh. The most effective approach will be direct assistance to the private sector, rather than government operated, centralized facilities. However, Departments of Fisheries have a role to play in demonstration and training, but they must ensure that facilities and staff are adequately funded and supported. Unfortunately, bureaucratic procedures, controls and staffing policies mitigate against the successful operation of such facilities.

3.1 *Assistance to the private sector*

Of the four private sector participants in Bangladesh, three had completed their hatchery construction by the end of 1993. One of these went into production in July 1993. Serious disease problems were overcome in September and some post-larvae sales were made in October. With the termination of the BOBP subproject, it is anticipated that the hatcheries will face some difficulties overcoming water quality and disease problems. Although there are several hatcheries established by other aid programmes, their staff are inexperienced and have poor access to scientific and technical literature which would enable them to find solutions to specific technical and biological problems.

Exterior and interior views of Proshika prawn hatchery, Koittia, Bangladesh.



Overall, the programme was very effective as a method of introducing freshwater prawn hatchery technology to the private sector. The four participants made a significant financial commitment in return for training and equipment. The NGO Proshika will incorporate hatchery production into its fish culture development programme, which has 800 participating farmers. The farmers will obtain loans from local offices of Proshika to purchase fry.

It is anticipated that the establishment of the other three hatcheries will stimulate freshwater prawn farming in areas adjacent to the hatcheries. Nursery rearing of freshwater prawn fry could also be encouraged through the increased availability of hatchery-produced prawn fry.

Of the eight Indian trainees sent to Malaysia, only one has constructed a hatchery. The design and scale will serve as an appropriate model for the small-scale sector. Another of the trainees is presently working in a hatchery. However, the impact in the private sector was less than hoped for. Although candidates may have suitable paper credentials, it is difficult to ascertain their determination to undertake such a risky business.

One of the two participants from India in freshwater prawn hatchery technology used his training to improve production in his pre-existing hatchery in Orissa.

3.2 Technology transfer

One of the functions of the Potiya hatchery was to demonstrate the economic viability of the technology. A financial model has been constructed using the production data from the hatchery, which shows that small-scale hatcheries can be profitable in Bangladesh. Continued close collaboration and support of the small scale private sector will be required to ensure that the hatchery industry in Bangladesh continues to expand.

The failure of the Department of Fisheries in West Bengal, India, to put the Digha hatchery into operation illustrates the difficulties of government institutions operating under financial and bureaucratic constraints. However, the facility may have encouraged small-scale entrepreneurs to set up hatcheries. Construction of several facilities has started in Digha, based on the owners' observations of activities at the DOF facility. The BOBP-funded hatchery is adjacent to an experimental hatchery producing limited quantities of freshwater prawn PL using brackish groundwater.

There is some doubt as to the ability of the DOF, Bangladesh, to continue to operate the Potiya hatchery. Not only must an adequate budget be allocated to the hatchery, but funds must be delivered in a timely fashion. The history of government-operated shrimp and prawn hatcheries in Cox's Bazar is hardly encouraging in this regard. Privatization of the Potiya facility might be one way of overcoming problems inherent in public sector operation.

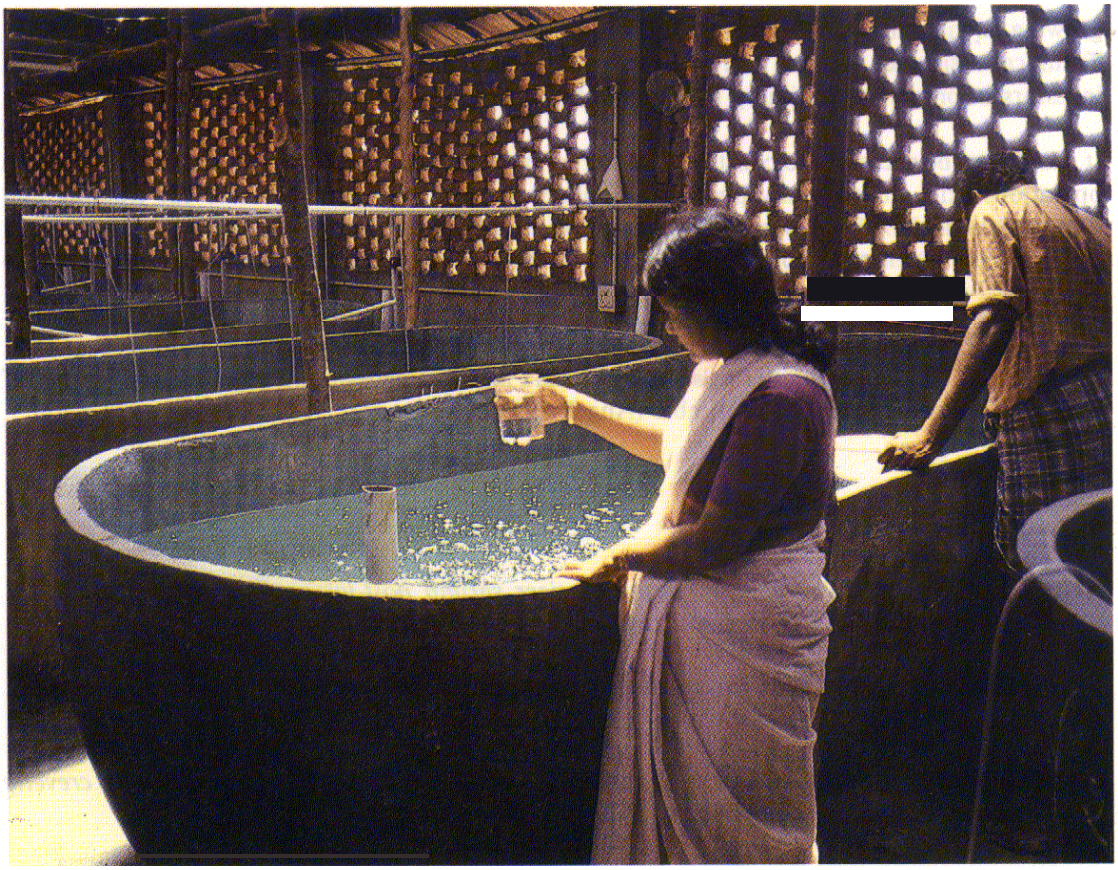
3.3 Marketing

Our experience at Potiya seemed to vindicate the concept of inland freshwater prawn hatchery technology in Bangladesh. There are many carp nursery ponds in the vicinity of the hatchery. The easy access to the hatchery encouraged fish farmers to try the PL produced in the hatchery. Most of these ponds are small, so most buyers made small purchases of less than 10,000 PL's. PL markets will develop with the growing popularity of freshwater prawn culture together with carp in southwestern Bangladesh. The region is accessible by road from brine sources in Cox's Bazar and may be considered for future inland prawn hatchery development.

Close coordination with buyers is required to minimize PL holding time. Buyers should take delivery within one or two days of PLs being removed from the larval rearing tanks.

3.4 Future directions

There is considerable interest on the part of the private sector in hatchery development in both India and Bangladesh. If hatchery shrimp and prawn fry production is to meet the needs of the



Povithra Hatcheries' shrimp hatchery, Madras, India, under construction.

growing aquaculture industry, assistance programmes should directly address the private sector. Technical assistance projects can provide training, operate demonstration hatcheries and assist investors in preparing feasibility studies and financing proposals.

It should not be necessary to construct hatcheries in the public sector where successful commercial operations exist. It is usually possible to collaborate with the private sector for training and demonstrations. BOBP's cooperation with a private Bangladeshi hatchery for training is an example. Public sector hatcheries should only be established if they can plough back their revenues into operating funds.

Freshwater prawn nursery rearing in cages and ponds should be encouraged to stimulate the market for hatchery PL. Opportunities exist in both India and Bangladesh and cage nursery rearing of freshwater prawn fry can be profitable (Angel1 1993).

4. REFERENCES

ANGELL, C. L. (1993). *Nursery rearing of tiger shrimp post-larvae in West Bengal, India.* BOBP/WP/86. Bay of Bengal Programme, FAO, Madras. 24 p.

LING, S.W. (1969). Methods for rearing and culturing *Macrobrachium rosenbergii* (de Man). FAO *Fish. Rep. 57(3):* 607-619.

GRIESSENGER, J.M., LACROIX, D. and GONDOUIN, P. (1991). *L'elevage de la crevette tropical d'eau douce.* IFREMER. 372 p. ISBN 2-905434-3 l-7.

CHOWDHURY, R., BHATTACHARJEE, H. and ANGELL, C.L. (1993). *A manualfor operating a small-scale recirculation freshwater prawn hatchery.* BOBP/MAG/13. Bay of Bengal Programme, FAO, Madras, India. 36 p.

NEW, M. (1990). Freshwater prawn culture: a review. *Aquaculture, 88:* 99-143.

ROSENBERRY, B. (1992). World shrimp farming 1992. *Aquaculture Digest.* San Diego, California.

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APPENDIX I

Curriculum of NAPFRE training

Day	0815-1015 hrs.	1045-1245 hrs,	1408-1600 hrs
1	Arriv al		
2	Opening ceremony	General briefing	Lecture I Introduction to Malaysian aquaculture
3.	Lecture 2 Shrimp biology	Lecture 3: Water supply and treatment	Lecture 4: Site selection and hatchery design
4	Lecture 5: Diatom culture	Practical 1 Estimation of algal cell density and pteparation of stock solution.	Practical 2: Isolation of diatom preparation of algal culture
		Ptactical 3: Algal growth monitoring	
6		Practical 4: Algal growth monitoring	
		Practical 5: Algal growth monitoring	
8	Lecture 6: Biology and the use of artemia	Practical 6: Laboratory determination of hatching quality of *artemia*	Practical 7 Algal culture in tanks. Artemia preparation
9	Lecture 7 Artificial feed and preparation	Practical 8: Artificial feed preparation	Practical 9: Algal culture in tanks. Artemia preparation
10	Lecture 8: Broodstock maintenance, maturation and selection	Practical 10: Broodstock selection	Practical 11: Algal culture in tanks. Artemia preparation
11	Lectute 9: Shrimp larviculture	Practical 12: Eye-stalk ablation	Practical 13: Lar tank preparation.
12	Practical 14: Egg collection and determination of total eggs and their qualits	Practical 15: Stocking and monitoring larval stages	
13		Practical 16: Shrimp larviculture (Routine monitoring)	
14	Practical 7: Shrimp larviculture Monitoring larval stages and feeding)	Practical 18 Determination of water quality	Practical 19: Shrimp larviculture (Monitoring larval stages and feeding)
15	Practical 20: Shrimp larvicultare (Monitoring larval stages and fending)	Lecture 10: Shrimp disease and prevention	Practical 21 Shrimp larsicalture (Monitoring larval stages and feeding)
16	Shrimp larviculture (Monitoring larval stages and feeding)	Practical 23: Shrimp disease identification and treatment	Practical 24: Shrimp larvicultare (Monitoring larval stages and feeding)
17	Shrimp larviculture (Monitoring larval stages and feeding)	Practical 23: Shrimp fry nursery management	Practical 26: Shrimp larviculture (Monitoring larval stages and feeding)
8	Shrimp larviculture (Monitoring urea) stages and feeding)	Practical 28: Collection, counting and packing of shrimp fry	Practical 29: Shrimp larviculture (Monitoring larval stages and feeding)
9	Practical 30 Shrimp larviculture Routine monitoring, partial water change and feeding)		
20	Practical 31 Shrimp larviculture (Routine monitoring, partial water chattgc and feeding)		
21	Practical 32 Shrimp arviculture (Routine monitoring, complete water change and feeding)		
22	Practical 33 Shrimp larvicultute (Routine monitoring, complete water change and feeding)		
23	Practical 34 Shrimp larviculture (Routine monitoring, complete water change and feeding)		
24	Practical 35 Shrimp larviculture (Routine monitoring, complete water change and feeding)		
25	Practical 36 Shrimp larviculture (Routine monitoring, complete water change and feeding)		
26	Practical 37 Harvesting post-larsae		
	Leave for Lumat : Visit Bay Beach Hatchery, Butterworth, and PPUG, kg. Acheh, Perak Darul Ridzuan		
28	Visit aquaculture projects in Lumut, Perak Darn Ridzuan Lease for NAPFRE		
29	Visit to aquacuhure projects in Kedah Daralaman		
30	Report presentation and discussion		
31	Coarse evaluation and closing ceremony		
32	Departure of participants		

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APPENDIX II

Curriculum of 10-day freshwater prawn hatchery training

Day	Activity	
	0830-1300 *hrs*	1430-1730 *hrs*
1	Introduction to hatchery tacilities and equipment Dimension of measurements excrexercises	Application of refractometer. Brackishwater preparation. Theoretical exercises — Measurements, Salinity Sal. Calc
2	Routine tests salinity, temperature Larval and Artemia counting. Artemia requirement estimation, Tank cleaning.	*Artemia* decapsulation and hatching demonstration. Theoretical exercises — Temp Artemia, Artemia CaIc.
3	Routine check. *Artemia* feeding, PF feeding.	Preparation of larval feed (PF). Water quality tests. Theoretical exercises — *Artemia* feeding, Water quality.
4	Routine check. Protocol keeping. Brackishwater treatment/preparation.	Larval stage determination. Diseases, predation-treatment. Theoretical exercises.
5	Post-larval acclimatization. PL holding and packing.	Theoretical exercises.
6	Slide lecture on salt production and brine collection.	Visit to sites for spawner collection.
7	All daily operations performed by trainees under supervision of hatchery biologists.	
8	All daily operations performed by trainees under supervision of hatchery biologists.	
9	All daily operations performed by trainees under supervision of biologists.	Economic considerations of hatchery operation/management.
10	Exercises	Evaluation

Curriculum of 35-day freshwater shrimp hatchery operation and management

Lectures : 0830 - 1730 hrs,

Practicals : 1330 - 1730 hrs, starting from 3rd day

Week I

Introduction to coarse

Purpose of training course.
Material to be covered,
Schedule of lectures and practical work.
Tour of Potiya hatchery.

2. General biology of ***Macrobrachium rosenbergii.***

Geographical distribution.
Taxonomic classification.
General description of life cycle.
Morphology.

3. Life cycle

Identifying characteristics of males and females.
Mating and gonad maturation.
Spawning and egg development.
Identification of larval stages.

Week 2

1. Brine.

Definition of brine.
Sources of brine.
How to measure salinity of brine.
How to calculate hatchery brine requirement.
Collection, transport and storage of brine,

2. Fresh water supply

Water quality parameters.
Sources of freshwater,
Surface water treatment,
- Sand filter design.
- Flocculation.
- Filtration.
- Storage.

3. Rearing water preparation

Mixing tank design.
Calculating amount of brine to be added.
Water treatment methods
- Formalin
- Chlorination
- Principles of chlorination
- Use of bleaching powder
- Measuring free chlorine
- Neutralizing free chlorine
- Sand filtration

4. Principles of recirculating systems

Toxic byproducts of metabolism in ammonia and nitrate
Biofl lter design.
Chemical reactions of biofiltration
How to measure ammonia and nitrite.
How to start up biofilters.

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Week 3

Brood stock collection

Sources of broodstock,
Transport methods.
Selection.
Disinfection.
Broodstock tank managetlient.
Gravid female tank management.

2. Hatching tank management

Salinity control.
Use of EDTA
Collecting Stage I larvae.
Counting Stage I larvae

3. Rearing tank management

Application of EDTA.
Stocking State I larvae
Monitoring water quality
Partial water changes.
Cleaning.

4. Larval rearing

Staging larvae.
Estimating *Artemia* density.
Preparation of artisicical teed and feeding techniques.
How to count larvae.

5. *Artemia* hatching

General biology of .4rtemru
Estimating number of cysts.
Decapsulation procedures
Where to obtain *Artentta*

Week 4

Disease aad its prevention

Characteristics of healthy larvae,
Mid-cycle disease.
Bacterial necrosis.
Exuv ia entrapment disease
Microscopic epibiont diseases

2. Harvesting post-larve

Acclimation to freshwater
Nursing post-larvae
— Stocking rates in tanks and *happas*
— Use of shelters to improve surv iv al
— Feeds and feeding
Packing and transport.
Causes of transport mortality

3. Principles of hatchery design

Site selection
What should be the production capacity?
Basic componeirts and layout.
Design principles.
Equipment selection,
Estimating operating costs.

Week 5

I. Independent operation of larral rearing tank

2. Hatchery management

APPENDIX III

Shrimp hatchery equipment transferred to each entrepreneur

Particulars	Qty.	*Price US $*
Imported Items	I	**1,832**
Air blower with intake filter, silencer, pressure relief salve, pressure gauge		
Portable manual brine	I	38
Refractometer	I	396
Stereozoom	I	964
pH meter, pen type	I	43
Airsiones assorted	36	24
Niten screen, 150 micron	4 5 yds	82
Water test kit	1	160
Reagents refills	1	50
Iron test kit	1	55
Iron reagent refills	1	11
Chlorine test tablets	1	66
Titanium immersion heater	3	875
Beakers assorted, plastic	6	122
Cylinder, grad., assorted	3	44
Brine shrimp cysts	10 cases	1000
Total		5.985

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Those marked with an asterisk (*) are out of stock but photocopies can be supplied.

Reports (BOBP/REP/...)

32.* Bank Credit for Artisanal Marine Fisherfolk of Orissa, India. U. Tietze. (Madras, 1987.)

33. Nonformal Primary Education for Children of Marine Fisherfolk in Orissa, India. U. Tietze, N. Ray. (Madras, 1987.)

34. The Coastal Set Bagnet Fishery of Bangladesh — Fishing Trials and Investigations. S. E. Akerman. (Madras, 1986.)

35. Brackishwater Shrimp Culture Demonstration in Bangladesh. M. Karim. (Madras, 1986.)

36. Hilsa Investigations in Bangladesh. (Colombo, 1987.)

37. High-Opening Bottom Trawling in Tamil Nadu, Gujarat and Orissa, India : A Summary of Effort and Impact. (Madras, 1987.)

38. Report of the Eleventh Meeting of the Advisory Committee, Bangkok, Thailand, 26-28 March, 1987. (Madras, 1987.)

39. Investigations on the Mackerel and Send Resources of the Malacca Straits. (Colombo, 1987.)

40. Tuna in the Andaman Sea. (Colombo, 1987.)

41. Studies of the Tuna Resource in the EEZs of Sri Lanka and Maldives. (Colombo, 1988.)

42. Report of the Twelfth Meeting of the Advisory Committee. Bhubaneswar, India, 12-15 January 1988. (Madras, 1988.)

43. Report of the Thirteenth Meeting of the Advisory Committee. Penang, Malaysia, 26-28 January 1988. (Madras, 1989.)

44. Report of the Fourteenth Meeting of the Advisory Committee. Medan, Indonesia, 22-25 January, 1990. (Madras, 1990.)

45. Gracilaria Production and Utilization in the Bay of Bengal Region: Report of a seminar held in Songkhla, Thailand, 23-27 October 1989. (Madras, 1990.)

46. Exploratory Fishing for Large Pelagic Species in the Maldives. R.C.Anderson, A.Waheed, (Madras, 1990.)

47. Exploratory Fishing for Large Pelagic Species in Sri Lanka. R Maldeniya, S. L. Suraweera. (Madras, 1991.)

48. Report of the Fifteenth Meeting of the Advisory Committee. Colombo, Sri Lanka, 28-30 January 1991. (Madras, 1991.)

49. Introduction of New Small Fishing Croft in Kerala, India. 0. Gulbrandsen and M. R. bnderson. (Madras, 1992.)

50. Report of the Sixteenth Meeting of the Advisory Committee. Phuket, Thailand, 20-23 January 1992. (Madras, 1992.)

51. Report of the Seminar on the Mud Crab Culture and Trade in the Bay of Bengal Region, November 5-8, Surat Thani, Thailand. Ed by C.A. Angell. (Madras, 1992.)

52. Feeds for Artisanal Shrimp Culture in India — Their development and evaluation. J F Wood et al. (Madras, 1992.)

53. A Radio Programme for Fisherfolk in Sri Lanka. R N Roy. (Madras, 1992.)

54. Developing and Introducing a Beachlanding Craft on the East Coast of India. V L C Pietersz. (Madras, 1993.)

55. A Shri Lanka Credit Project to Provide Banking Services to Fisherfolk. C. Fernando, D. Attanayake. (Madras, 1992.)

56. A Study on Dolphin Catches in Shri Lanka. L Joseph. (Madras, 1993.)

57. Introduction of New Outrigger Canoes in Indonesia. G Pajot,O Gulbrandsen. {Madras, 1993.)

58. Report of the Seventeenth Meeting of the Advisory Committee. Dhaka, Bangladesh, 6-8 April 1993. (Madras, 1993.)

59. Report on Development of Canoes in Shri Lanka. G Pajot, O Gulbrandsen. (Madras, 1993.)

60. Improving Fisherfolk Incomes through Group Formation and Enterprise Development in Indonesia. R N Roy. (Madras, 1993.)

61. Small Offshore Fishing Boats in Shri Lanka. G Pajot. (Madras, 1993.)

62. Fisheries Extension Services in the Maldives. A M H Heelas. (Madras, 1994.)

63. Small-scale Oyster Culture on the West Coast of Peninsular Malaysia. D Nair, R Hall, C Angell. (Madras. 1993.)

64. Chandi Boat Motorization Projects and Their Impacts. R Hall, A Kashem. (Madras, 1994.)

65. Learning by Doing in Bangladesh: Extension Systems Development for Coastal and Estuorine Fisherfolk Communities. R N Roy. (Madras, 1994.)

66. promotion of Small-sale Shrimp and Prawn Hatcheries in India and Bangladesh. C Angell. (Madras, 1994.)

67. The [mpact of the Environment on the Fisheries of the Bay of Bengal. Ed. by S Holmgren. Swedish Centre for Coastal Development and Management of Aquatic Resources, SWEDMAR/BOBP. (Madras, 1994.)

<<

Working Papers (BOBP/WP/...)

49. Pen Culture of Shrimp by Fisherfolk : The BOBP Experience in Killai, Tamil Nadu, India. E. Drewes, G. Rajappan. (Madras, 1987.)
50. Experiences with a Manually Operated Net-Braiding Machine in Bangladesh. B.C. Gillgren, A. Kashem. (Madras, 1986.)
51. Hauling Devices for Beachlanding Craft. A. Overa. P.A. Hemminghyth. (Madras, 1986.)
52. Experimental Culture of Seaweeds (Gracilaria Sp.) in Penang, Malaysia. (Based on a report by M. Doty and J. Fisher). (Madras, 1981.)
53. Atlas of Deep Water Demersal Fishery Resources in the Bay of Bengal. T. Nishida. K. Sivasubramaniam. (Colombo, 1986.)
54. Experiences with Fish Aggregating Devices in Sri Lanka. K.T. Weerasooriya. (Madras, 1987.)
55. Study of Income, Indebtedness and Savings among Fisherfolk of Orissa, India. T. Mammo. (Madras, 1987.)
56. Fishing Trials with Beachlanding Craft at Uppada, Andhra Pradesh, India. L. Nyberg. (Madras, 1987.)
57. Identifying Extension Activities for Fisherwomen in Vishakhapatnam District, Andhra Pradesh, India. D. Tempelman. (Madras, 1987.)
58. Shrimp Fisheries in the Bay of Bengal. M. Van der Knaap. (Madras, 1989.)
59. Fishery Statistics in the Bay of Bengal. T. Nishida, (Madras, 1988.)
60. Pen Culture of Shrimp in Chilaw, Sri Lanka. D. Reyntjens. (Madras, 1989.)
61. Development of Outrigger Canoes in Sri Lanka. 0. Gulbrandsen, (Madras, 1990.)
62. Silvi-Pisciculture Project in Sunderbans, West Bengal : A Summary Report of BOBP's assistance. CL. Angell, J. Muir, (Madras, 1990.)
63. Shrimp Seed Collectors of Bangladesh. (Based on a study by UBINIG.) (Madras, 1990.)
64. Reef Fish Resources Survey in the Maldives. M. Van Der Knaap et al. (Madras, 1991.)
65. Seaweed (Gracilaria Edulis) Farming in Vedalai and Chinnapalam, India. I. Kalkman, I. Rajendran, C. L.Angell. (Madras, 1991.)
66. Improving Marketing Conditions for Women Fish Vendors in Besant Nagar, Madras. K. Menezes. (Madras, 1991.)
67. Design and Trial of Ice Boxes for Use on Fishing Boats in Kakinada, India. I.J. Clucas. (Madras, 1991.)
68. The By-catch from Indian Shrimp Trawlers in the Bay of Bengal: The potential for its improved utilization. A. Gordon. (Madras, 1991.)
69. Agar and Alginate Production from Seaweed in India. J. J. W. Coopen, P. Nambiar. (Madras, 1991.)
70. The Kattumaram of Kothapatnam-Pallipalem, Andhra Pradesh, India — A survey of the fisheries and fisherfolk. K. Sivasubramaniam. (Madras, 1991.)
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72. Giant Clams in the Maldives -A stock assessment and study of their potential for culture. J. R. Barker. (Madras, 1991.)
73. Small-scale Culture of the Flat Oyster (Ostrea folium) in Pulau Langkawi, Kedah, Malaysia. D. Nair, B. Lindeblad. (Madras, 1991.)
74. A Study of the Performance of Selected Small Fishing Craft on the East Coast of India. G. El Gendy. (Madras, 1992.)
75. Fishing Trials with Beachlanding Craft at Thirumullaivasal, Tamil Nadu, India, 1989-1992. G. Pajot (Madras, 1992.)
76. A View from the Beach — Understanding the status and needs of fisherfolk in the Meemu. Vaavu and Faafu Atolls of the Republic of Maldives. The Extension and Projects Section of the Ministry of Fisheries and Agriculture, The Republic of Maldives. (Madras, 1991.)
17. Development of Canoe Fisheries in Sumatera, Indonesia. O. Gulbrandsen, G. Pajot. (Madras, 1992.)
18. The Fisheries and Fisherfolk of Nias Island, Indonesia. A description of the fisheries and a socio-economic appraisal of the fisherfolk. Based on reports by G. Pajot, P. Townsley. (Madras, 1991.)
19. Review of the Beche De Mer (Sea Cucumber) Fishery in the Maldives. L. Joseph. (Madras, 1992.)
80. Reef Fish Resources Survey in the Maldives — Phase Two. R. C. Anderson, Z. Waheed, A. Arif. (Madras, 1992.)
81. Exploratory Fishing for Large Pelagic Species in South Indian Water. J. Gallene, R. Hall. (Madras, 1992.)
82. Cleaner Fishery Harbours in the Bay of Bengal. Comp. by R. Ravikumar (Madras, 1992.)
83. Survey of Fish Consumption in Madras. Marketing and Research Group, Madras, India. (Madras, 1992.)
84. Flyingfish Fishing on the Coromandel Coast. G. Pajot, C. R. Prabhakaradu. (Madras, 1993.)
85. The Processing and Marketing of Anchovy in the Kanniyakumari District of South India: Scope for development. T. W. Bostock, M. H. Kalavathy, R. Vijaynidhi. (Madras, 1992.)
86. Nursery Rearing of Tiger Shrimp Post-larvae in West Bengal, India. H Nielsen, R Hall. (Madras, 1993.)
87. Market Study of Tiger Shrimp Fry in West Bengal, India. M M Raj, R Hall. (Madras, 1993.)
88. The Shrimp Fry By-catch in West Bengal. B K Banerjee, H Singh. (Madras, 1993.)
89. Studies of Interactive Marine Fisheries of Bangladesh. Management and Development Project, Department of Fisheries, Chittagong, Bangladesh. (Madras, 1993.)
90. Socioeconomic Conditions of Estuarine Set Bagnet Fisherfolk in Bangladesh. K.T. Thomson, Sk. Md. Dilbar Jahan, Md. Syed Hussain. (Madras, 1993.)
91. Further Exploratory Fishing for Large Pelagic Species in South Indian Waters. G Pajot. (Madras, 1993.)
92. Cage Nursery Rearing of Shrimp and Prawn Fry in Bangladesh. C Angell. (Madras, 1994.)
93. Dealing with Fishery Harbour Pollution — The Phuket Experience. R Ravikumar. (Madras, 1994.)

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Manuals and Guides (BOBP/MAG/...)

1. Towards Shared Learning : Non-formal Adult Education for Marine Fisherfolk. Trainers' Manual. (Madras, June 1985.)
2. Towards Shared Learning : Non-formal Adult Education for Marine Fisherfolk. Animators' Guide. (Madras, June 1985.)
3. Fishery Statistics on the Microcomputer : A BASIC Version of Hasselblad's NORMSEP Program. D. Pauly, N. David, J. Hertel-Wulff. (Colombo, 1986.)
4. Separating Mixtures of Normal Distributions : Basic programs for Bhattacharya's Method and Their Application for ***Fish Population Analysis.*** H. Goonetilleke, K. Sivasubramaniam. (Madras, 1987.)
5. Bay of Bengal Fisheries Information System (BOBFINS): User's Manual. (Colombo, 1987.)
6. A Manual on Rapid Appraisal Methods for Coastal Communities. P. Townsley. (Madras, 1993.)
7. Guidelines for Extension Workers in Group Management, Savings Promorion and Selection of Enterprise. H. Setyawati, P. Limawan. Directorate General of Fisheries, Ministry of Agriculture, Government of Indonesia, Jakarta and Bay of Bengal Programme. (In Indonesian). (Madras, 1992).
8. Extension Approaches to Coastal Fisherfolk Development in Bangladesh: Guidelines for Trainers and Field Level Fishery Extension Workers. Department of Fisheries, Ministry of Fisheries and. Livestock, Government of Bangladesh and Bay of Bengal Programme. (In Bangla). (Bangladesh, 1992.)
9. Guidelines on Fisheries Extension in the Bay of Bengal Region. I Jungeling. (Madras, 1993.)
10. ***Our Fish, Our Wealth.*** A guide to fisherfolk on resources management — In 'comic book' style (English/Tamil/Telugu). K. Chandrakanth with K. Sivasubramaniam, R. Roy. (Madras, 1991.)
11. Our Shrimp, Their Lives. A guide to fisherfolk on resources management — In 'comic book' style (English/Tamil). K. Chandrakanth with K. Sivasubramaniam, R. Roy. (Madras, 1993.)
12. ***How to Build a Timber Outrigger Canoe.*** O Gulbrandsen. (Madras, 1993.)
13. A Manual for Operating a Small-scale Recirculation Freshwater Prawn Hatchery. R. Chowdhury, H. Bhattacharjee, C. Angell. (Madras, 1993.)
14. Building a Liftable Propulsion System for Small Fishing Craft — The BOB Drive. O Gulbrandsen, M R Andersen. (Madras, 1993.)
15. Guidelines for Fisheries Extension in the Coastal Provinces of Thailand. Fisheries Extension Division, Department of Fisheries, Ministry of Agriculture and Cooperatives, Bangkok, Thailand and the Bay of Bengal Programme. (Thailand, 1993.)
16. Safety at Sea — A safety guide for small offshore fishing boats. O Gulbrandsen, G. Pajot. (Madras, 1993.)
17. Guidelines for Cleaner Fishery Harbours. R. Ravikumar. (Madras, 1993.)
18. A Handbook of Oyster Culture. H. Nawawi. (In English/Malay). (Madras, 1993.)
19. Management of Fisherfolk Microenterprises - A manual for training of trainers. V. Muthu, P.S.A. Kunchitha Padam, Bhatnagar. (Madras, 1993.)
20. Life on Our Reefs - A colouring book. Ministry of Fisheries and Agriculture, Male, Republic of Maldives and the Bay of Bengal Programme. (Madras, 1993.)

Information Documents (BOBP/INF/...)

10. Bibliography on Gracilaria — Production and Utilization in the Bay of Bengal. (Madras, 1990.)
11. Marine Small-Scale Fisheries of West Bengal : An Introduction. (Madras, 1990.)
12. The Fisherfolk of Puttalam, Chilaw, Galle and Matara -A study of the economic status of the fisherfolk offourfisheries ***districts in Sri Lunka. (Madras,*** 1991.)
13. Bibliography on the Mud Crab Culture and Trade .in the Bay of Bengal Region. (Madras, 1992.)

Newsletters (Bay of Bengal News)

Quarterly, from 1981

Other Publications

1. Helping Fisherfolk to Help Themselves : A Study in People's Participation, (Madras, 1990.).
2. The Shark Fisheries of the Maldives. R C Andersen, H Ahmed. Ministry of Fisheries and Agriculture, Maldives. (Madras, 1993).

NOTE: Apart from these publications, the BOBP has brought out several folders, leaflets, posters etc., as part of its extension activities. These include Post-Harvest Fisheries folders in English and in some South Indian languages on anchovy drying, insulated fish boxes, fish containers, ice boxes, the use of ice etc. Several unpublished reports connected with BOBP's activities over the years are also available in its Library.

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