Bay of Bengal Programme

Development of Small-Scale Fisheries

EXPERIMENTAL SHRIMP FARMING IN PONDS IN POLEKURRU, ANDHRA PRADESH, INDIA

BOBP/WP/46

SWEDISH INTERNATIONAL DEVELOPMENT AUTHORITY

FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS

BAY OF BENGAL PROGRAMME BOBP/WP/46
Development of Small-Scale Fisheries GCP/RAS/040/SWE

EXPERIMENTAL SHRIMP FARMING IN PONDS IN POLEKURRU, ANDHRA PRADESH, INDIA

J.A.J. Janssen
Aquaculturist (Associate Professional Officer), Bay of Bengal Programme

T. Radhaknshna Murthy
Asst. Director of Fisheries, Andhra Pradesh & Team Leader, Polekurru project

B.V. Raghavulu
Inspector of Fisheries, Andhra Pradesh

V. Sree Krishna
Inspector of Fisheries, Andhra Pradesh

Executing Agency:

Food and Agriculture Organization
of the United Nations

Funding Agency:

Swedish International
Development Authority

Development of Small-Scale Fisheries in the Bay of Bengal. Madras, India, July 1986
Mailing Address: Post Bag No. 1054, Madras-600 018, India.
Street Address: 91 St. Mary's Road, Abhiramapuram, Madras-600 018, India
Cables: FOODAGRI. Telex: MS-311 FISH. Phones: 71294, 71296, 71587, 77760

This paper describes the establishment of a small farm complex of six ponds of different design for experimental brackishwater culture of shrimps and fish. It is located in Polekurru, near Kakinada, Andhra Pradesh, India. An account is given of two years of culture trials of penaeid shrimps. The purpose was to identify suitable pond configurations and appropriate water management practices.

In response to a request for assistance in coastal aquaculture from Andhra Pradesh, BOBP arranged for a three-member Indonesian mission to help identify suitable activities. Based on their recommendations, a pilot project, including the design of the pond complex, was prepared by Mr. Narasimha Rao, Technical Co-ordinator of the Directorate of Fisheries in Hyderabad and Dr. M. Karim, Aquaculturist of the BOBP. The latter also supervised the implementation of the project, and the authors wish to acknowledge his inspiring work.

At the end of the culture trials (September 1985) described in this paper, an assessment of the socio-economic feasibility of pond culture in the Polekurru area was undertaken. The findings of this assessment will be reported separately.

The Polekurru project, and this paper which describes it, are activities of the small-scale fisheries project of the Bay of Bengal Programme (BOBP). The project is funded by SIDA (Swedish International Development Authority) and executed by FAO (Food and Agriculture Organization of the United Nations), and covers five countries bordering the Bay of Bengal — Bangladesh, India, Malaysia, Sri Lanka and Thailand. The main goal of the project is to develop, demonstrate and promote appropriate technologies and methodologies to improve the conditions of small-scale fisherfolk in member countries.

CONTENTS *Page*

1. INTRODUCTION

A macro-level survey undertaken by the Directorate of Fisheries, Andhra Pradesh in 1980 indicated that an area of 17,000 ha was immediately suitable for coastal aquaculture; the total area having potential for brackishwater culture was likely to be substantially larger. The water quality in respect of year-round salinity distribution, chemical and physical nature of soil, vegetation, availability of seed for culturable shrimp and fish species, etc., appeared to be favourable for coastal aquaculture.

Despite many natural and socio-economic advantages, coastal aquaculture has not evolved as a rural farming practice in Andhra Pradesh as it did in West Bengal and Kerala in India and in some other neighbouring countries. Insufficient tidal fluctuations and relatively high land elevation may have been the most important factors which prevented the expansion of coastal aquaculture.

BOBP was requested in 1980 to support the Government's intention to develop coastal aquaculture, primarily for the small-scale sector. In order to identify suitable activities BOBP engaged a three-member mission from Indonesia under a TCDC (Technical Cooperation among Developing Countries) arrangement early in 1981 for a period of one month.

The mission suggested (BOBPIWPI1 7) that any large scale brackishwater culture should be preceded by pilot projects on sites typical for various districts in respect of land elevation and tidal amplitude. Shrimp farming is most economical if the location is such that it is possible to maintain a metre of water depth in the pond utilizing tidal rise and fall. To do so the tidal amplitude would have to be sufficiently high, say 1-2 m daily range with an absolute annual range of 2-3 m. The pond's bottom level would have to be above the mean low water neap tide level so that the pond can be completely drained at any low tide and filled at high tide. Such ideal conditions do not exist in Andhra Pradesh. The choice is to excavate ponds to depths that would allow tidal water exchange or to avoid excavation by putting a dyke around and use pumps for filling and water exchange. Both the processes introduce heavy cost elements and technical uncertainities, risking both the technical and economic viability. Thus, working out an appropriate pond design was a key to the future expansion of coastal aquaculture.

The mission further suggested that two types of ponds should be tested, i.e., a completely tide fed pond in areas of medium tidal fluctuation (1 .2-1 .6 m) and pump-cum-tide fed ponds in areas of low tidal fluctuation (0.8-0.9 m). To reduce construction costs it was suggested that the ponds should have central platforms and peripheral trenches.

The mission's recommendations constituted the basis for a pilot project which was formulated during 1981. The site selected was Polekurru island, 25 km south of Kakinada in east Godavari district. (See map in Appendix 1).

The project was planned for a two-and-a-half year period in which time the technical feasibility, water management and production in ponds of different engineering design was to be studied. The following specific outputs were expected:

a) An experimental farm complex of five ponds of three different designs and a field laboratory.
b) Information on technical and economic feasibility of culture in different types of ponds.
c) Year-round data on hydro-biological parameters relevant to brackishwater culture in the area.
d) At least three trained fisheries officers with practical exposure to various aspects of brackish-water culture including pond design, construction and water management.
e) Socio-economic information about the population in and around the project area.
f) Information about the suitability of a windmill for pumping water.

The work and results of (a) — (d) are described in this report while that of (e) will be reported separately. Item (f) was not attempted.

The Government of Andhra Pradesh provided three full time scientific officers, 15 ha of land, supporting staff and office furniture. BOBP contributed technical expertise, pond construction, equipment, a laboratory, a car, a motorized boat, materials and operating costs.

The project become operational in May 1982 and the sequence of the project activities is summarized in Appendix 2.

2. FARM COMPLEX

2.1 Lay out

The farm complex is located on Polekurru island, which covers an area of 800 ha of which 15 ha was allotted by the government of Andhra Pradesh to the Directorate of Fisheries for the construction of the experimental farm. It consists of six ponds, rectangular in shape, each about 60 by 125 m, and covering 0.6-0.75 ha of water area (Appendix 3). Four ponds (1-4) are tide fed. Water enters the central supply-cum-drainage canal through a main sluice gate which supplies the water via wooden or masonry sluice gates to these ponds. Ponds 5 and 6 are pump fed from the supply-cum-drainage canal.

Polekurru island has a more or less uniform ground elevation of 1.2 m above lowest low water level (+ 1.2 m). The tidal amplitude in Kakinada (which is 25 km north of the farm site) is 0.9 m based on a mean low water level (MLWL) of 0.34 m and mean high water level (MHWL) of 1.25 m. It was assumed that Kakinada's tidal amplitude would reflect the one near Polekurru, for which no reliable data was available. To have a minimum water level of 0.9 m in the tide fed ponds excavation till +0.3 m would be required.

The main peripheral dykes are 5 m wide at the top, 1.8 rn high above ground level (+ 3 m) and the side slopes are 1: 1.5 (the dyke faIls 1 m over a distance of 1.5 m). The secondary dykes are 2.5 mat the top, 1.1 m high (+ 2.2 m) and have side slopes of 1 :1.5. The height of the dykes is more than what is actually required; it was necessary to absorb the excavated soil to reduce the cost of removal of surplus soil to a distant place. The height of the peripheral dyke is more than 1 m higher than the highest flood level ever recorded (+ 1.8 m). The supply-cum-drainage canal is 5 m wide at the bottom at a level of + 0.1 m. The canal is gently sloped towards the main sluice gate for better drainage of water.

2.2 Pond design

The ponds have platforms and trenches in common — the idea being to reduce costs by minimizing excavation. The higher platforms also facilitate better light penetration and growth of natural feed for the shrimps under culture. The trenches provide shelter to the shrimps during day time, during the moulting period and against land predators. The level of the platforms and the trenches in the different ponds is as follows (in m).

	1	2	3	4	5	6
Platform	+0.6	+0.6	+0.6	+0.5	+1.2	+1.2
Trench	+0.3	+0.3	+0.3	+0.2	+0.9	+0.8

The bottom of the trenches in ponds 1, 2 and 3 is gently sloped with a slightly lower level (0.1 m) at the outlet than at the opposite side of the pond.

Cross sections of the ponds are shown in Appendix 4 and specific characteristics are given below.

Pond I has a central trench along the longitudinal axis and shallower platforms on either side of the trench; the trench is 20 m wide. The inlet is a masonry sluice gate. The outlet at the other end of the pond consists of a wooden sluice gate. It was originally a concrete pipe of 40 cm diameter which did not work due to construction defects.

Pond 2 has a U-shaped trench, 10 m wide at the bottom. There is an inlet sluice gate of masonry at one end and an outlet sluice gate of wood at the other end – both connected with the supply-cum-drainage canal. The central ridge is 95 m long and is about 1 m wide at the top level (+ 1.5 m).

Pond 3 is identical to pond 1 except that the inlet sluice gate is also used for drainage.

Pond 4 is actually a small complex with a grow out pond 60 x 110 m, a catch basin 15 x 17 m and two nursery ponds also 15 x 17 m each. This type of pond is used in Indonesia (BOBP/WP/1 7). The peripheral trench in the grow out pond is 6 m wide. The catch pond bottom lies at the same level as the trench (+ 0.20 m), the two nursery ponds lie at a higher level (+ 0.50 m). The grow out pond is filled and drained through the catch pond which connects the grow out pond and two nurseries with three wooden sluice gates; the catch pond opens to the supply-cum-drainage canal through a masonry sluice gate.

Pond 5 has been constructed by excavating a 20 m wide central trench and executing dykes with the removed soil. The soil on the platform (+ 1 .2 m) therefore remains undisturbed. The pond's only sluice gate, made of wood, is meant mainly for drainage. The designed water level is + 1 .8 m. The pond is pump-fed.

Pond 6, also pump-fed, is similar to pond 5. It has a platform at ground level with a peripheral trench on three sides of the platform. The trench is 10 m wide. A small masonry sluice gate is used as the outlet.

2.3 Sluice gates

The *main sluice gate* is constructed on a concrete and sand foundation. It has two vents, each 1 .5 m wide, and is open up to the deck slab which is at + 3.00 m. The deck slab made of M 150 (1 part cement: 2 parts sand: 4 parts small stones) has been provided for passage across the gate. The sluice gale shutters are 1 .5 m wide and 1 .80 m high and are of the screw rod type which are operated in guiding channels fixed in the abutment and the pier. The screw rod (5 cm thick) is operated by a U type rotating bow from the deck slab. Each shutter is made of seasoned teak wood planks (5 cm thick) contained in a flat iron frame (6 mm thick). The bottom and the two vertical sides of each shutter are fitted with rubber linings (Appendix 5).

There are 11 *pond sluice gates* of which 5 are of masonry and the rest of wood. All the slUice gates are of an open type with wooden fall board shutters. The bottom levels of the inlet sluice gates in ponds 1 and 2 are placed at + 0.35 m and those of outlet sluice gates at + 0.25 m. In ponds 3 and 4, the same sluice gate is used for both supply and drainage; the bottom level of the gate in pond 3 is + 0.25 m, and that in pond 4 is + 0.20 m.In ponds 5 and 6, the two sluice gates are placed at + 0.90 m.

Four *masonry sluice gates* in the tide fed ponds are each 12m long, 0.9 m high and 0.9m wide with wooden fall board shutters. For free flow of water, a raft foundation of 0.15 m thick concrete and a base of 20 mm blue metal stones over a 0.20 m thick sand filling, were provided. For masonry and plastering of the wall, cement mortar 1:4 was used; plaster was 20 mm thick.

On the canal side, 4 sets and on the pond side 3 sets of grooves each 3 cm wide and 2 cm deep were provided for using fall boards and screens. The grooves are 17-18 cm apart from each other. In the sluice gate of pond 6, 3 grooves were made, one in the middle and one at each end.

The fall board shutters are 20-25 cm wide and 2-3 cm thick made of locally available wood (Nallamaddi). This wood was later replaced with teak since the former, though it worked well under water, warped and cracked when exposed to the sun.

A small masonry sluice gate was constructed in the pump fed pond 6. This sluice gate is 3.7 m long, 0.6 m wide and 0.9 m deep. It has 3 grooves and board shutters of teak wood (see Appendix 6). The construction cost of this sluice gate was Rs. 3,000 while the long masonry sluice gate cost Rs. 9,000.

The *wooden sluice gates* are 5 to 10 m long, 0.9 m high and 0.6 m wide; 2.0-2.5 cm thick and 20-25 cm wide planks of Nallamaddi wood *(Terminal/a tomentosa)* were fixed inside a wooden frame constructed with 5 x 7 cm vertical and horizontal reepers at 0.6 m intervals (Appendix 7). The planks were fixed with butt and joints, initially without caulking. Heavy leakage of water through the joints was noted and subsequently the joints were thoroughly caulked and tar coated. This stopped the water leakage satisfactorily.

Each wooden sluice gate had at each end one set of wooden shutters and one screen. Later, an additional set of shutters was provided in the middle of the sluice gate in pond 2 in order to test if a shutter in the middle of the sluice gate had any operational advantage. It appeared not to have any advantage.

2.4 Other construction work

A bridge was built over the supply-cum-drainage canal. To increase accessibility from the main road to the project site (500 m away), a footpath, small bridges over creeks and two jetties in the main creek (Vadalanali creek) were also built. A boat was used for transportation across the creek. In May 1984 a building (4.5 X 11 .5 m) was constructed which contains a laboratory (4.5 x 9 m) for chemical and biological analyses, a toilet (2 x 2.5 m) and kitchen (2.5 x 2.5 m). The laboratory room was converted to a lecture room during training courses.

2.5 Construction costs

The actual cost of establishing the farm, excluding BOBP and Government personnel, but including an assumed cost of land, was Rs. 31 7,000 (about US $ 25,000). The major items of expenditure were:

Earthwork	As. 112,000
Main sluice gate	Rs. 42,000
Sluice gates for ponds	Rs. 71,000
Lab building	As. 66,000

The total cost (As.) per pond was as follows:

1	2	3	4	5	6
49,000	45,000	41,000	56,000	33,000	26,000

These figures include all costs except those for the lab building, since those were much higher than they would be for a commercial farm. Costs of feeder canal, main sluice gate, jetty and bridges are distributed equally over the six ponds. The details are given in Appendix 8.

3 CULTURE TRIALS

The culture trials started in August 1983 and continued uninterrupted till the first half of 1985; the tide-fed ponds then had to be desilted. The schedule of stocking, harvest and desiltation is given in Appendix 2. Each cycle had a minimum duration of 60 days and a maximum 208 days with an average of 148 days. This allowed four cycles in two years but the fourth cycle in three of the ponds was still in progress at the beginning of the third year. Records of the culture cycles completed by September 1985 are presented in this report (Appendix 9 a-d). The cultured species were *P. monodon* and *P. indicus.* The usual stocking density was about 30,000 per ha but in a couple of the trials it was much higher, i.e., 60,000 per ha.

3.1 Production

The overall average yield of *P. indicus* and *P. monodon* attained in 20 crops is 250 kg/ha. The minimum is 81 kg/ha and maximum 378 kg/ha. The highest pond average is 335 kg/ha for pond 2 and the lowest is 193 kg/ha for pond 3. The yields in kg/ha/crop are given in the table below:


Sluice under construction


iwo-vent main sluice


Aeration in pond 6 by pumped water

 

Left above: Shrimp seed collector with bucket, handnet and bike
Right: Pushnet with wooden frame   Below: Catching tiger shrimp juveniles

Pond Cycle	1	2	3	4	5	6	Average
1	170	378	284	284	143	—	252
2	190	325	215	305	151	273'	243
3	261	302	81	90	300'	333	228
4	—	—	—	260'	318'	3201	299
Average	207	335	193	235	228	309	249

Large seeds (2-8 g)

It was anticipated that the yield would be low in the first crop and then gradually increase as the ponds stabilized. But, on the contrary, the first crop turned out to be the best-yielding (if the fourth crop is disregarded since it was based on larger seeds). The siltation (of about 30 cm in a year) reducing depth and causing poor exchange of water may well be the reason for the poor performance of the tide fed ponds.

In *Pond 1* during the first culture cycle it was observed that the outlet made of hume pipes did not work properly. It silted up and draining of the pond was not possible. The water was not flowing through the pond from inlet to outlet as planned but entered and returned through the inlet masonry sluice gate.

The bottom of the inlet sluice was designed to be located at + 0.35 m, but the actual level was found to be + 0.70 m. The higher location of the sluice limited the quantity of water that could be taken in during high tide to about 500 m3/h against the expected 800 m3/h, which hampered the water exchange.

During the first cycle shrimp seed were stocked in a nursery pen. After a rearing period, the net was lifted and shi imp entered the pond. No counting was done of the actual number stocked. So, the actual survival rate might be higher than the recorded 35%.

The silt deposits reduced the water depth from 90 cm to 60 cm in about a year.

Pond 2 was designed to facilitate a good exchange of water with the flow aided by the U-shaped trench with separate inlet and outlet sluice gates. However, after some time it was felt that the water exchange was too slow and that it could be enhanced by operating both sluice gates at the same time either as inlet or as outlet gates. This increased the exchange capacity from 500 to 900 m3/h.

The highest yield was attained in the first cycle during the last months in which clam meat and mammalian intestines were supplemented with the ordinary feed (see 3.4 below).

Large numbers of metapenaeid shrimps entered the pond during the third cycle despite the 0.8mm nylon screens through which the water was filtered; 155 kg of them were harvested.

Pond 3 was badly affected by siltation, which reduced the water depth to 60 cm in the trench and to 25 cm on the platform in the third cycle.

Notable are the large quantities (100 kg) of metapenaeid shrimps harvested in the second and third cycles.

The reason for the failure of the third cycle (81 kg/ha) is not known.

Pond 4 too was badly affected by siltation; even the wooden sluice was partly blocked during the third cycle. Poor water exchange might have been the main reason for the failure of the third cycle (90 kg/ha).

In *Pond 5* the growth and survival of *P. indicus* was very poor during the first cycle. There were several contributing factors; the water level was low and the exchange poor since the pump also had to be used to feed the supply-cum-drainage canal during the low tide period; shortly before harvest the salinity was 46 ppt and the water temperature 35°C; the rotting of the vegetation left on the platform might have reduced the oxygen, which is detrimental to the survival of juveniles.

Even without the effect of the above mentioned factors the second cycle produced a poor yield.

For the third and fourth cyc1es the stocking material was obtained from non-marketable sizes (5.8-9.8 9) of the harvest in Ponds 1 and 3 plus large juveniles (2.1-4.3 g) from the wild.

In *Pond* 6 the topsoil on the platform was not removed, but the vegetation was. By not disturbing the soil, nutrients were available for the growth of phytoplanktons which formed a green mat of lab lab over the platform. The lab lab was hardly noticeable in any of the other ponds.

The yield did not vary much during the three cycles (273-333 kg/ha). The second cycle produced a good yield from 0.5 g seeds while larger seeds (2.0-4.1 g) were used in the other cycles.

3.2 Pond preparation

An analysis of carbon, phosphorus and potassium done in August 1982 before The pond excavation started showed that the soil was not rich in carbon and phosphorus. To increase these in order to facilitate phytoplankton growth manuring was needed.

The pond bottom was first dried till it cracked to eradicate predator animals. Lime was added (150-200 kg/ha) to improve the response of the bottom to inorganic fertilisers. The water level was then kept at about 10 cm. After one week, cattle dung (2 t/ha), urea and single super-phosphate (50-100 kg/ha) were applied. The water level was increased up on 60-75 cm within a week.

After each full and new moon when the water exchange period was over, 5-7 kg/ha of urea and superphosphate were applied. Cattle dung (250-500 kg/month) was applied if the development of phytoplankton was low. Fertilizers were not applied during summer months because phytoplankton is abundant due to high temperature (30-34°C).

Several phytb and zoo-plankton species were identified:

Phytoplankton: *Ni(zschia, Mesidion, Amphora, Achanthes, Dip/oneis, Rhizosobenia, Melosira* and others.

Zooplankton: *Cyclopa, Daphnia, Brachionus, Fillinia, Stentor* and *Lacrymaria.*

Several methods were developed to frighten or to.prevent pests entering the pond. To frighten sea otters, wild cats, foxes, cattle and birds, crackers were fired, drums were beaten and whistling sounds were made whenever these pests were found entering the pond complex during the day or night. Snakes, fish and crabs were removed whenever found.

To prevent the entry of large wild fish, split bamboo screens (8 to 10 mm) were placed before and after the main sluice gate. Nylon screens were placed in the pond sluice gates to prevent the entry of egg and larval stages of shrimp and fish. Various mesh sizes were tried, i.e., P16 (16 meshes per inch), P24, P30 and P40.

Whenever P16-24 or 30 were used as screening material, competitors like *Metapenaeus monoceros* and *M. dobsoni* and *Po/ynemus* (a fish species) and the predator fish *Lates calcarifer* (seabass) entered the ponds. *Metapenaeus* entered in large quantities in October-December and seabass in May and June shortly after the fish breeding season. The only reliable screen was the one made of P40 mesh. To increase the surface area and the water flow a bag type screen was used.

3.3 Seed

All shrimp seed were collected from the wild by the project staff or by shrimp seed collectors, who sold them to the project. Three good seed collection sites were identified i.e., Pedavalasala village opposite the project site, Chollangi 20 km north and Vakalapuda 30 km north of the project site, both close to Kakinada. The sites are characterized by small hamlets, creeks, shallow areas and the land which is submerged frequently. Different collection gears such as pushnet with metal or wooden frames, hand and dragnet were used to estimate the seed availability of *P. monodon.* The pushnet with wooden frame (net opening 0.54 m^2), and with metal frame (0.3 m^2) and dragnet (1 m^2) were used in open water areas and gave more or less the same catch results for *P. indicus* and *P. monodon.* The hand net (net opening 0.14 m^2) appears to be the most suitable gear for collection of *P. monodon* seed. They are caught in high densities in the submerged vegetation near the edge of the creeks where the other gear cannot be used effectively. *P. indicus* is caught with all tested gears at a rate of 100-200 per half hour all the year round. *P. monodon* catches varied from a few to 2400 caught by hand net in a half hour operation by one man (see Appendix 10). Metapenaeid species were caught in large numbers (200-2600) with push and drag nets.

The catch results of *P. monodon* and *P. indicus* show that these shrimps can be collected all the year round. But the availability pattern is not the same every year.

Shrimp larvae collected at places far away from the project site were transported in half-filled plastic bags. About 1000 larvae of 20-30 mm or 500 larvae of 30-40 mm can be put in a 20 litre bag. To provide larvae some substratum to attach to, twigs, long grass and tiny branches were placed inside. For transportation of shrimp larvae collected at sites close to the project, buckets were used.

P. monodon and *P. indicus* larvae collected from the three seed collection sites ranged from 10 to 30mm. The large sizes were stocked directly in the grow out ponds but the smaller ones were nursed in the nursery ponds (No. 4) in pens and in happas.

3.4 Feeding

The shrimp in all ponds were given supplementary feed, with the following approximate composition:

60% trash fish (silver belly, ribbon fish, squilla, sciaenids, small shrimp), clam meat.
30% rice bran, ground nut oil cake, broken rice.

10% tapioca, maida as feed binder.

Initially the required quantum of trash fish was washed thoroughly and cleaned. It was then minced in hand mincers and mixed with rice bran, broken rice and soaked ground nut oil cake. The binding agent was boiled till it became sticky and was thoroughly mixed with the prepared food material until the whole mass turned into a sticky dough. This was divided into smaller lumps and distributed to various ponds as per the determined feeding rate.

The feed was given in mud plates. The plates were placed at a margin of 30 cm depth of the pond bottom at places marked with long sticks. It was observed that such feed remained intact under water for nearly two hours.

At times the feed consisted of vegetable ingredients only since animal flesh was not available for certain periods either during cyclones or local festivals or during the non-fishing season.

Feed was served in the evening hours at 8-10% of the body weight of shrimp in ponds during the first trial and 5-8% during the other trials.

The feed conversion ratio, i.e., total feed supplied into the pond divided by the net production (harvest mass minus stocking mass) of shrimp and fish showed an average of 8.6 during the first cycle and 5.6 during the other cycles (discarding cycle 4 in Pond 4). Details are in Appendix 9, It is to be noted that the feed was wet and the conversion ratio is therefore not directly comparable with dried pellet feeding.

3.5 Water management

From February 1983 the tide levels were registered daily. Appendix 11 shows the daily low and high tide levels for one year from May 1983 to April 1984. The low tide varies between 5 and 110 cm and the high tide between 30 and 150 cm. Based on recordings of 590 days in 1983 and 1984 the mean low and high tide levels were calculated at 66 and 110 cm respectively.

The aim was to exchange two-thirds of the water quantity in the ponds during the full moon or new moon days. The pump-fed ponds were drained during these days through their sluice gates but filled again by pumping. In Appendix 12 the tide levels and the water management schedule for one month are given.

The tide-fed ponds are designed to have a minimum water depth of 90 cm in the deeper areas (trench) and 60 cm on the platforms. To do so the water level in the creek should be + 120 cm at least during the full moon and new moon periods. Appendix 12 shows that this occurred on 4 days in November 1983. Appendix 11 covering the period May 1983 to April 1984 shows that a water level of + 120 cm did not occur (regularly) from January to May. The best period when one can rely on tidal water levels for water exchange is from May to December.

During the rainy season from June to November, the water in the creek contains a lot of silt. After one year the siltation in the trenches varied from 25 to 33 cm. When this occurred, it was a real problem to maintain a water depth of 90 cm. At the pond complex all tide-fed ponds were desilted 1 Y2 years after the first trials started.

3.6 Hydrological parameters

Parameters like pH, dissolved oxygen, free carbon dioxide were measured during full and new moon periods and on the 7th day after full and new moon. Salinity and temperature were recorded every day.

The water temperature of the Vadalanali creek varied from 24.0°C in November to 30.0°C in May. The temperature at the pond complex ranged from 22.0°C in November to 35.0°C in April. The maximum temperature of 35°C was recorded in Pond 5 when the water depth on the platform was only 30 cm (Appendix 13).

During the peak of the rainy season (July-August) the salinity in the creek came down to trace level due to dilution with rain water. The salinity increased during the summer months (May/June) to 36 ppt. The salinity in the ponds varied from trace level in August and September to 39-44 ppt in May and June. Pond 5 recorded in May 1984 a salinity level of 46 ppt due to the low water depth on the platforms (30 cm) (Appendix 12).

The pH in the creek varied from 6.9 to 8.1 and in the pond complex from 7.0 to 7.8. The top soil pH varied from 7.0 to 8.7.

The dissolved oxygen of creek water ranged from 2.6 ppm (in May) to 9.9 ppm (in June) whereas in the pond complex the dissolved oxygen content varied from 3.3 (in March) to 14.7 (in June). It was observed that during fertilization (i.e. 30 kg/ha of both urea and superphosphate) the dissolved oxygen content value came down to lethal levels (below 2 ppm) particularly during the night. During that period the shrimp came to the surface and shores and became inactive. To increase the dissolved oxygen value the water level was decreased and fresh water pumped into the pond.

During most of the months the free carbon dioxide value was nil in the Vadalanali creek and in the ponds. The maximum value recorded was 16 ppm.

Water in the Fklekurru area is alkaline in nature. The total alkalinity of creek water ranged from 60 ppm (in August) to 264 ppm (in December) while in the poild complex the value varied between 66 (in September) and 230 ppm (in April).

4. ECONOMICS

Detailed accounts were kept of the direct expenditure incurred during the culture activities under the headings of feed, fertilizer, seed, fuel and labour. The labour costs were based on three workers for the whole complex and extra labour engaged for the harvests. The costs not included were those for management/supervision and for the desiltation undertaken at the end of the third culture cycle. All the cost details together with proceeds of sales are given in Appendix 14.

Even though the farm was set up as an experimental unit and not as a commercial pilot project, attempts were made to maximize production during the trials. The economic data therefore might be of some relevance. The revenue from sales just about covered the operational costs over the entire trial period. It can also be seen from Appendix 14 that the return increased with each cycle. It should be noted though that this was primarily because of less expenditure on feed and seed and not due to increased yields.

Looking at the economics of each pond, losses were incurred in Ponds 1 and 3. There was not much of a profit margin in Ponds 4 and 5, considering that large seeds, already reared in other ponds at a certain cost, were used as stocking material during the 4th cycle.

Ponds 2 and 6, however, show clear positive returns. If we estimate the cost of desiltation at Rs.1,122 in Pond 2 and of desiltation and pump maintenance at Rs.924 in Pond 6, the return per pond is Rs.6,000 over 3 cycles or Rs4,000 in one year. This should be compared with the investment cost which is as follows:

	Pond 3	Pond 6
Investment (section 2.5)	45,000	26,000
Add half pumpset		7,500
Deduct for cheaper sluice gate	6,000	
Add for miscellaneous equipment	2,000	1,500
Investment (adjusted)	41 000	35,000
Annuity (10% - 10 years)	6,600	5,600

The annual deficit would thus be Rs.2,600 and Rs.1 600 respectively. This means that the revenue needs to be increased by 13% in Pond 2 and by 9% on Pond 6 to reach a breakeven point. It therefore seems that economic viability could be reached. However, the data is only indicative and, as stated above, costs of management/supervision, which will vary with form of ownership, have not been taken into account.

5. TRAINING

Three scientific officers were assigned to the project almost from the inception and they remained throughout the culture period. They therefore took part in all aspects of the project including design and construction of the farm complex in addition to the culture work which was supervised by them under guidance of BOBP. Their exposure to brackishwater culture was thorough. Besides the in-service training the following specific training events were organized.

During the design work, an engineer of the Directorate of Fisheries in Hyderabad visited Bangalore to study the engineering aspects of sluice gates and ponds used for aquaculture. His experiences were applied at the project.

Study tours for the three scientific officers of the Polekurru project were organized to Tamil Nadu and West Bengal. The team leader visited the Santhome fish farm in Madras, several other shrimp farms and the BOBP-supported pen culture project in Killal in Tamil Nadu for a week. The two other scientific officers visited various aquaculture projects in the coastal area of West Bengal for a week. They observed extensive culture practices, paddy-cum-shrimp culture, disease of shrimp due to malnutrition, low production due to poor exchange of water or improper methods for screening water, etc.

During the culture trials several scientists from other projects and institutions visited Polekurru for periods up to a week to observe the work. Among them were two scientific officers from Bangladesh, three scientific officers from the Killai pen culture project, Tamil Nadu and twenty-two scientific officers from the Fisheries Training Institute, Kakinada, Andhra PradesFi.

During 1985 two training programmes were organized. one for ten fishermen (17-24 June) and one for high-level officials (22-27 July).

The fishermen, selected to be owners of one hectare ponds in a 16 ha government-supported shrimp farm, were trained in all the practical aspects of shrimp culture. They manured a pond with cowdung, collected a large number of seed and did the complete harvest of a pond. At the end of the training course fishermen were given buckets, pushnets and handnets for their own seed collection.

The participants of the training course for high-level officers came from the Department of Fisheries (8) and Andhra Pradesh Fisheries Corporation (2). Two private entrepreneurs also attended this course. The training covered all aspects of pond culture of shrimp and included shrimp seed collection, segregation, rearing and nursery stocking, shrimp feed preparation and harvesting. Lectures about pond engineering, oit soil, fertilization and feed components were given. Background papers were given to the trainees on status of prawn farming in Andhra Pradesh in 1985, desirable soil quality for coastai ponds, seasonal availability of shrimp post larvae, shrimp pests and their control and harvesting techniques.

6. LESSONS LEARNED

The objectives of the shrimp culture project were to identify a suitable pond design, develop proper water management schedules, and compare tide and pump-fed ponds. In the process of working towards these objectives, a number of lessons were learned, some of which should contribute to more efficient shrimp culture practices in Andhra Pradesh. The most important of these were:

1. The tide-fed ponds were constructed at Polekurru using tidal data collected at Kakinada. Actual tidal data collected at site showed considerable variation and this resulted in water management problems. Should one desire tide fed ponds, the levels of the pond should be determined on the basis of tidal data collected at the spot for a period of at least one year.
2. While constructing the tide-fed ponds, top soil was removed. This may have reduced the natural productivity of the ponds; and the better performance of the pump-fed ponds, where two-thirds of the top soil was left intact, supports the hypothesis. While an attempt was made in some of the ponds to keep aside the top soil during excavation and replace it, the characteristic lab-lab mat on which the juvenile shrimp graze was not observed.
3. Siltation during the rainy season was a major problem with the tide-fed ponds. Over a period of a year and a half, siltation ranged from 25 to 30 cm and had to be excavated, adding to operating costs. The vertical distribution of silt in the creek throughout the tidal cycle needs to be determined to see if it is possible to draw off less silt laden surface water with appropriately designed sluice gates.
4. In medium and low tidal amplitude areas, there is a need to do some careful thinking and comparing of tide-fed and pump-fed ponds, for as the Polekurru experience shows, due to lesser excavations (the pump-fed ponds had only trenches cut and left two-thirds of the top soil intact) the capital cost of the pump fed ponds was much lower than that of tide-fed ponds, in spite of the cost of the pump.

   Further, the culture costs did not differ much between the pond types. Overall, the pump-fed ponds seemed to have done better in production. There could have been several reasons for this better performance.

   a. The pump-fed ponds had at least two-thirds of their top soil intact leading to better natural productivity. There is a need to give careful attention to fertilization and manuring to enhance natural productivity. Organic manure seemed to perform better than inorganic fertilizers.There is a need to avoid inorganic chemical fertilizerswhen there is excessive phytoplankton growth. Water exchange should be avoided immediately after manuring and fertilization.
   b. The pumping action aerated the water, increasing dissolved oxygen.

      In summary, pump-fed ponds were found to be better than tide-fed ponds in the Polekurru conditions.
5. For tide-fed ponds, the best pond configuration would be one with a U-shaped trench in it, with two inlet sluice cages and one outlet sluice gate at the opposite end in the curve of the U. The opposing sluice gates increase flushing and water exchange, and avoid stagnation.

   For pump-fed ponds the best pond configuration would be one with either a central trench along the length of the pond or a peripheral trench, with a sluice gate at either end and one pump. The configuration should leave at least two-thirds of the top soil intact.

   For both tide-fed and pump-fed ponds, the dyke levels may be less than the worst case conditions of the region.

6. Wooden sluice gates were unsuitable and long, expensive masonry gates were not necessary. Instead, low cost 3-4 m long masonry sluice gates are recommended.

7. Bag type screens made of P40 mesh are far superior to flat screens at the sluice gates and allow for better and more efficient water exchange.

8. Pumps designed for agricultural use are not suitable for brackishwater ponds. Axial pumps, designed for high volume and low head, are preferred. They are easily fabricated if not available as an "off-the-shelf" item. If powered by diesel, the engine must be able to withstand the rigorous conditions of brackishwater pond culture.

9. Pumping additionally aerates the pond, and can be used to tide over oxygen crisis but there is a need to design low-cost aerators.

10. A simple hand net was found most effective for seed collection. Shrimp seed was available throughout the year but species composition and quantity varied. Stocking large juveniles (30-45 mm) increases survival and reduces grow-out time. Therefore nursery management is seen as an important aspect of culture.

11. Large-scale expansion of culture operations may make feed availability a problem. There is a need for appropriate low-cost feed formulation, particularly of the type that the farmer can mix on location. Fish protein tends to be available seasonally and there is a need to develop a pelletized feed with increased shelf-life to overcome supply fluctuations.

12. A production rate of 300 kg/ha/crop of penaeid shrimp is achievable in $4\frac{1}{2}$ to 5 months using wild seed stock. With nursery management providing larger juveniles the survival rate can be increased and the grow out period reduced to three months to achieve the same 300 kg/ha/crop output. This would make possible three crops a year.

    However, alternative management systems should be considered which would increase revenue through the production of larger shrimp. Through phased stocking and multiple cropping, a trade-off would be made between higher yields and higher revenue.

    Phased stocking may also enable continuous production during periods of seed scarcity.

    The key to profitability is a combination of increasing revenue through production of lower count shrimp and reducing capital investment. Larger ponds will reduce construction and equipment costs, but further studies are required to determine an optimum pond size, keeping in mind that larger ponds are more difficult to manage.