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BRACKISHWATER FISH AND SHRIMP CULTURE

PACKAGE OF PRACTICES FOR INCREASING PRODUCTION

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(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
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FOREWORD

The country's brackishwater aquaculture experience was by and large limited only to paddy-cum-fish culture system and bheries (impounded fisheries) in the coastal areas of Kerala and West Bengal until recent years. But culture of shrimps and fishes in brackishwater fish farm is of recent origin and gained momentum following country's efforts for augmenting export of marine products. CIFRI has been carrying out detailed culture experiments of brackishwater fishes and shrimp in the experimental fish farm at Kakdwip since 1966. These studies resulted in evolving a set of package and practices for optimum production of fish and shrimp. The technology being low cost is specially relevant to coastal farmers with poor economic base. The manual is designed to meet the requirements of extension workers, prospective entrepreneurs and progressive fish farmers. The country has extensive saline swamps, deltaic stretches and mud flats of the order of 9 lakh ha. But scientific culture of brackishwater shripms and fin fishes has made little headway. It is hoped the present manual would create awareness and generate necessary momentum in the transfer of technology to the users.

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PACKAGE OF PRACTICES FOR INCREASING PRODUCTION IN BRACKISHWATER FISH AND SHRIMP CULTURE

Apurba Ghosh, M. L. Bhowmik, G. N. Chattopadhyay & R. K. Chakraborty

1. INTRODUCTION

Along the 5,600 km coastline of India, about 1.42 m ha of saline tract is available for development of brackishwater aquaculture. Apart from the utilisation of this vast unproductive fallow swampy land for increasing fish production, the brackishwater aquaculture entails the culture and production of prawn, a high priced commodity having universal demand for earning foreign exchange. The production of prawns from the marine source is already showing declining trends. Therefore, to meet this high demand in the overseas markets, it is imperative to develop and exploit the huge potential of the brackishwater resources of the country. At present an estimated 50,000 ha of brackishwater area is under traditional system of fish farming in the maritime states. In the traditional trapping-holding-growing operation, the average yield of fish & prawn is 200 kg/ha/yr. Moreover, due to diverse ecological conditions and soil characteristics, yield from different places are highly variable.

To encounter all the limiting factors related to traditional culture system and suitably modulate the ecosystem for culture needs, selective stocking of compatible species having judicious choice of size and number, proper use of manures and fertilizers to enhance the fertility status, adoption of supplemental feeding for better growth and survival and maintenance of fish pond hygiene by periodic flushing of metabolities as devices of controlled farming were sought to be established and this ultimately came into being at an experimental fish farm in West Bengal at Kakdwip in 1968. With the encouraging results obtained from the experimental fish farm at Kakdwip and from the coordinated project centres established in the east and west coasts of the country, the brackishwater aquaculture techniques so far been developed for propagation are presented in the following chapters.

2. SELECTION OF SITE FOR BRACKISHWATER FISH AND SHRIMP FARMING

One of the important pre-requisite for undertaking brackishwater aquaculture is the selection of suitable site. The site has to be selected by taking into consideration topography, soil type, tidal fluctuation, wave action, flood drainage, cyclonic hazards, seed abundance and other ecological, biological and environmental factors.

Tidal mud flats, swamps, marshes and other low lying estuarine areas are generally suitable for brackishwater farm construction. The topography of the site should be flat or gently sloping towards the outlet. For construction of fish ponds, a site with slight depression may be ideal. For the entire farm, earth work in excavation should, as far as possible, balance with the earth work in filling for raising the peripheral and internal dykes. Water supply and drainage should preferably be accomplished by gravity.

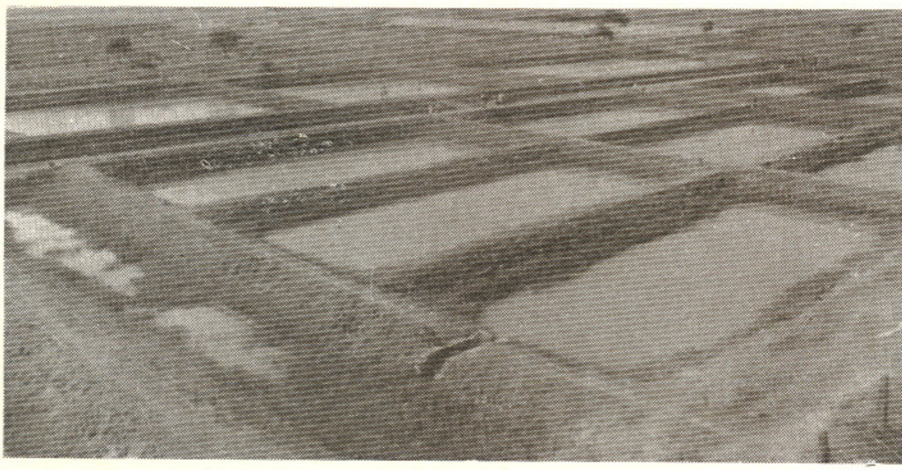
Soil types of salt affected areas occuring in the coastal tracts show variation in different maritime states. The soil of the prospective site must be water retentive. Porous soil should be avoided as such soils will neither retain water nor permit compaction. However, the coastal saline soils, in general, are of moderate to heavy texture which are likely to retain water for all practical purposes.

Primarily, a constant or atleast periodic supply of brackishwater in spring tides, must be available to the ponds throughout the year. This factor facilitates water exchange in fish ponds to replenish water loss through seepage and evaporation and also to maintain the hygiene of the pond bottom. The water flow pattern and direction, rise and fall of tidal amplitude at the selected site should be ascertained before designing a farm. Where heavy evaporation takes place, freshwater from ground source or any other perennial source, is required to be added in the fish pond for preventing ecalation of salinity. High rate of precipitation and freshwater run-off, on the other hand, may cause sudden fall in salinity in brackishwater pond leading to heavy mortality of penaeid prawns which needs due consideration in designing a brackishwater fish farm.

Silt load of the water source to be used for farming, should be kept in mind before site selection as heavy silt laden water are detrimental to brackishwater fish farming, both from physical and biological point of view. When silt laden tidal water enters into the confined area of the pond, the silt gets deposited at the pond. If a site is found otherwise suitable, except for siltation problem, it is recommended to provide a silt trap of special design inside the farm near the main sluice gate and the silt thus trapped may be removed periodically. If cyclone and flood prone areas are selected for farm construction, necessary precaution has to be taken by raising stronger peripheral dykes and providing bypass channels for excess flood discharge.

3. POND CONSTRUCTION

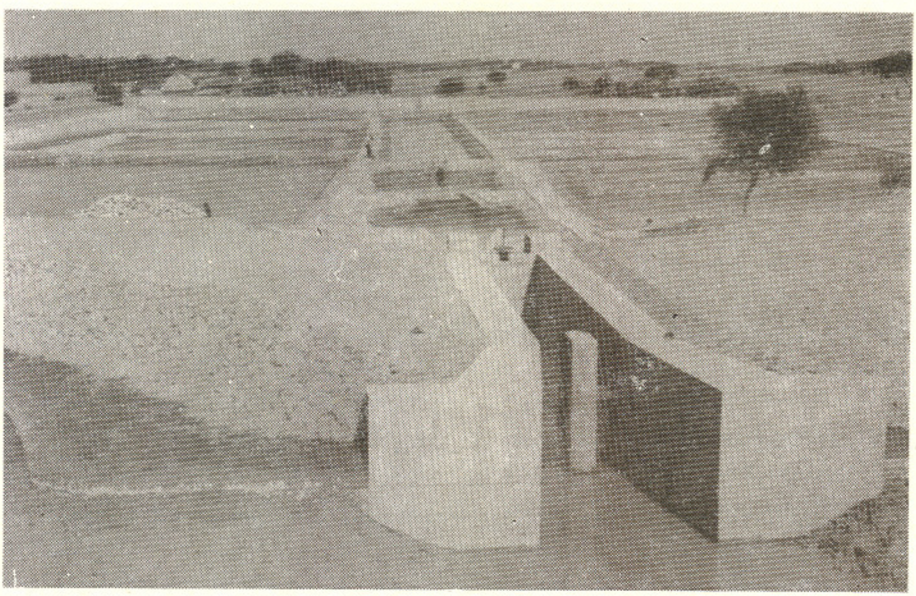
In the selected sites, pond, areas from 0.5 ha and above are to be excavated to hold a water depth of 80-180 cm. Peripheral dykes are to be constructed with compact soil to withstand external tidal pressure during spring tide period.



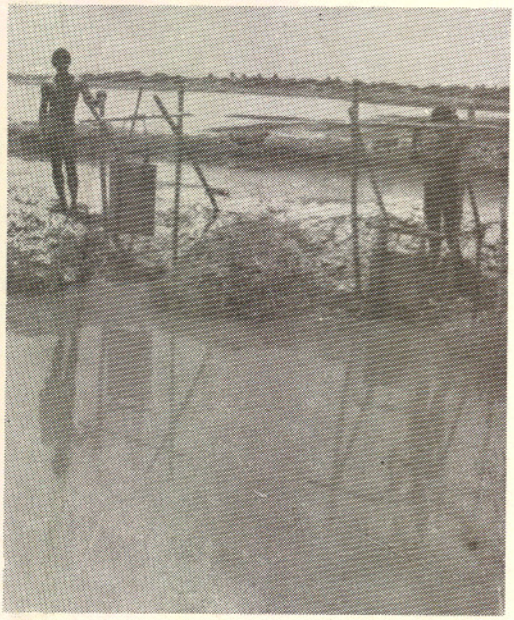
A view of CIFRI'S brackishwater fish farm at Kakdwip (West Bengal) showing ponds and dykes.

Basically there is difference in tidal amplitudes in higher latitudes compared to lower latitudes, showing a declining trend from north to south. In the gradient zone of the Hooghly estuary, the high water tide reaches more than 5 m during spring tides whereas at Kakinada coast line, the tide reaches upto 1.43 m height only. Therefore, the height and width of the dyke should be finalized after taking into consideration the tidal amplitude at the farm site.

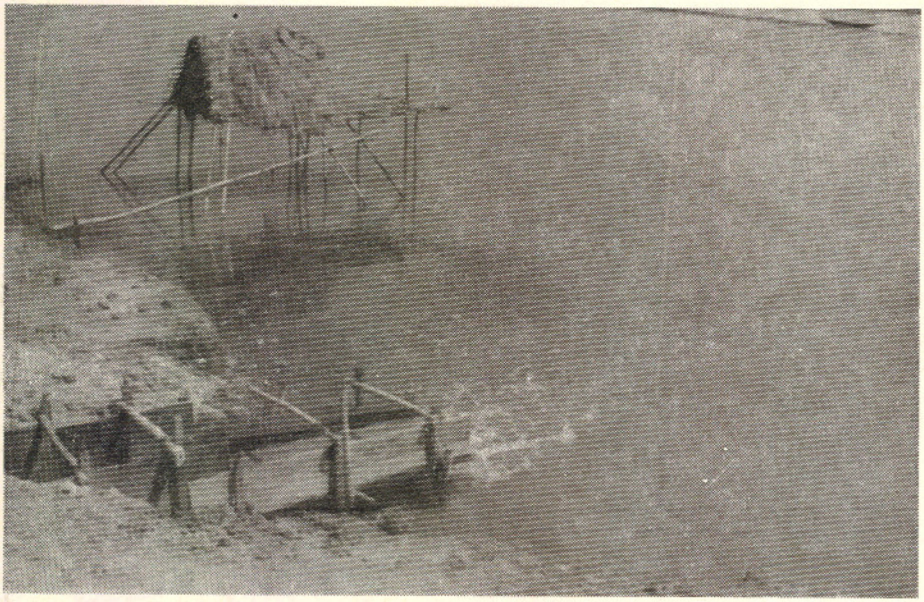
The sluice is an integral part of the dyke system of a brackishwater farm. In the dynamic tidal system with diurnal changes in tides and current pattern, a master sluice of strong design and construction, is necessary. This would be the controlling centre for the water management of all the farm ponds fed through feeder channels. Volume of water required to pass through the sluice in a specified time (i. e. duration of the tide) will determine the width of the sluice. Material and type of the sluice will depend mainly upon the nature of the soil. In view of low consistency of the soil, light wooden structures are preferred. The wooden sluice with open top is preferred over closed box as heavy column of silt which usually gets deposited by intake of tidal water, can easily be cleared from the open top type. The subsidiary sluice of individual fish pond of the farm should be provided with adjustable shutters so that by adjusting the shutters, water from different levels can be taken into the fish pond and drained out as well to prevent excessive siltation. The sluice should be placed over the mud bottom strengthened by wooden pins.



The sluice gate leading to the main feeder canal of the brackishwater fish farm at Kakdwip.



Wooden shutters for closing and opening the wooden sluice gate for controlling the intake of tidal water.



Wooden box type sluice gate commonly used by the fish farmers of West Bengal.

4. POND MANAGEMENT

4.1 Culture pond preparation

Newly excavated brackishwater pond bottom is generally hard and low in organic matter. To such bottom initially a heavy dose of decomposed cowdung manure (@ 5000 kg/ha) is to be applied and ploughed thoroughly to make the bottom suitable for culture of prawns and fishes. Ponds already under culture are prepared by draining out water after total harvest and drying the bed to eradicate unwanted and harmful organisms. The drying also helps in enriching the pond soil by oxidation of metabolic wastes and decaying organic matters accumulated in the bottom mud. When complete drying is not practicable, the water level is kept as low as possible to apply either mohua oil cake @ 200-250 ppm or tobacco waste @ 100-150 kg/ha or tea seed cake @ 500-1000 kg/ha for eradication of predatory fishes and other unwanted organisms. Repeated raking of the bottom and application of lime @ 300 kg or more/ha, depending on the soil pH, will help to remove obnoxious gases and accumulated metabolites.

After initial fertilization, tidal water is drawn into the pond and allowed to stand at a depth of 10-15 cm for a few days till the formation of thick layer of benthic algae and associated micro organisms. The water level is then increased to 60-80 cm by intake of fresh tidal water and stocking is accomplished.

4.2 Fertilization and manuring schedule

Benthos being the chief food constituents of cultured brackishwater fin-fish and shell-fish, soil fertilization instead of water fertilization is more effective in coastal aquaculture.

Initial analysis of the pond soil reflects the nutrient deficiencies in the soil. Application of deficient nutrients correct the soil for better productivity. However, it is often safe to apply both organic manure and inorganic fertilizer at the same site since the combined action generally produce advantageous results. In saline soils response to phosphatic fertilizer is generally not well pronounced. However, in alkaline pH, frequent application of super phosphate at low doses and in acidic soils, rock phosphate at 600 kg/ha/yr is likely to enhance the productivity. When nitrogenous fertilizers are to be applied, ammonium forms should be used to increase productivity of fish ponds. As organic manure, well decomposed chicken manure is preferable because of its potential value. If chicken manure is not available, well decomposed cattle dung at a dose 3 times more than the chicken manure may be used. The following fertilization schedule may be followed for optimum results. However, depending on the basic properties of vergin soil of a particular farming site, the fertilization schedule prescribed hereunder may be modified particularly in respect to inorganic fertilizers.

Item	*Quantity kg / ha* *Initial dose*	*Subsequent monthly dose*	*Remarks*
Poultry manure	250	50	
Cowdung	750	150	As a substitute when poultry manure is not available.
Urea	50	20	
Super Phosphate	50	20	
Rock Phosphate	120	50	As a substitute for super phosphate in acidic soil.

Brackishwater fish pond is a highly dynamic system involving fortnightly or monthly water exchange. Hence fertilization should be done in such a manner that nutrient rich water is not flushed out before it is utilised by the crop. In case of persistant algal bloom, fertilization may be discontinued till the bloom subsides.

5. SEED PROCUREMENT

During the last two decades investigations were undertaken to assess brackishwater seed resources along the east and west coast of the country. Though breakthrough has been achieved in producing hatchery bred *P. monodon* and *P. indicus* seeds, it is yet to be commercialised. Even when hatchery bred prawn and fish seed will be available in millions, dependence on natural seed for development of brackishwater aquaculture will still continue. It is, therefore, necessary to lay greater emphasis on seed prospecting to meet the demand of cultivable species as an essential prerequisite to promote brackishwater aquafarming.

5.1 Calender of availability

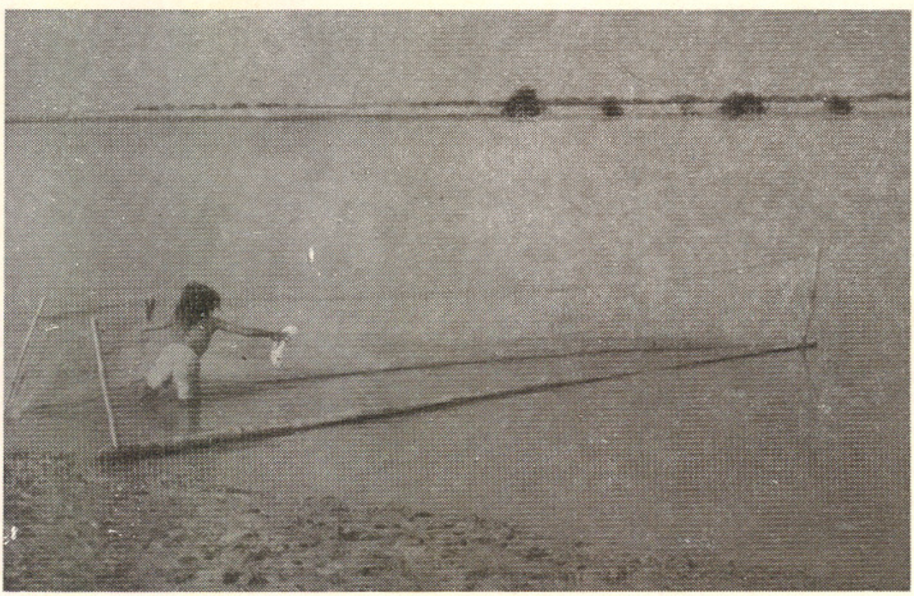
The distribution of cultivable commercial species of fishes and prawns in time and space has been charted out and the calender (Table-1) prepared for procurement of seed along the coasts of six maritime states of the country may be considered as a guide line.

5.2 **Collection methods of brackishwater prawn and fish seed**

All culturable brackishwater species of fish and prawns in the country, except *Etroplus* spp. are not known to breed normally in confined waters. Generally breeding ground of fish and prawn is restricted within the foreshore and offshore areas of the sea. During the season of abundance, the brackishwater prawn and fish seed, in nektonic form, oscillate with the tides in estuarine and coastal areas in search of shelter and nursery ground. To negotiate with these prawn and fish seed, several types of gears are generally operated for collecting the stocking materials for brackishwater aquaculture.

5.2.1 **Gears for collection of prawn seed**

The most important gear used for prawn collection is shooting net. It is a funnel shapped bag net with 4-6 m length and 4-6 m width at the mouth and gradually tappering at the cod end where a detachable tail piece is tied. Synthetic net cloth having 1/2 inch or 1/16 inch mesh size is used for stiching such nets which are found to be very effective for prawn seed collection in tidal streams. The prawn seeds collected in the tail piece is hauled every 20-30 minutes. In West Bengal, *P. monodon* is the dominant penaeid prawn collected by such net.



Spawn collection net commonly used for collection of *Penaeus monodon* post larvae in tidal estuaries of West Bengal.

Along Northern Circars, Coromondal and Malabar coasts, where tidal amplitudes and current velocities are not sufficient enough for operation of shooting nets, locally fabricated scoop nets and hand nets may be used in the shallow marginal sheltered areas along the coast line for collection of postlarvae and juveniles of Penaeid prawns i. e. *P. monodon* and *P. indicus*.

5.2.2 Gear for collection of fish seed

Cultivable fish seeds of importance like, *L. calcarifer*, mullets and *C. chanos* when entrapped in shooting net may escape from the tail piece when the current is feebale. Such fish seeds are known to harbour in shallow sheltered waters infested with weeds or mangrove vegetation and also in natural depression and irrigation pits where from the juveniles may be scooped out with the help of a rectangular sac-like cloth piece popularly known as hapa.

Enclosure net is generally used in mudflats in tidal zone inundated during high tide and completely exposed in the receding phase of the tide. During high tide the area is encircled by drag net cloth with the help of bamboo props. When the encircled area is completely exposed during low tide, the entrapped fish seed, both fry and fingerlings, are handpicked and transported for stocking in fish ponds. Drag net with scare lines of palmyra leaves is commonly used along the Northern Circars and Coromondal coasts for collection of *C. chanos* fry. The gear is operated by two persons by encircling shallow coastal area. The scare line of leave is shaken at times over a cloth net and *C. chanos* fry is collected.

5.3 Seed transport

5.3.1 Transportation of prawn and fish seed

For carrying out successful brackishwater aquaculture throughout the year, the required quantity and quality of cultivable prawn seed may not be always available in the vicinity of farm site. While some sites are surplus in respect of some particular species of seed, others are deficient. Moreover, zoo-geographical pattern of fish seed distribution is not uniform in the east and west coasts. Therefore, it would be necessary to transport seed from collection sites of abundance to fish farms situated at a distance. To maintain adequate supply of seed at places of deficiency, improved methods of seed transportation has been evolved. The following techniques developed so far in this direction may be adopted.

5.3.2 Transport of penaeid prawn under oxygen packing

After collection and segregation of economic varieties of prawn from the net, the seed is kept in small containers in settled estuarine water for a duration of 2-3 hours. The seed is then transferred to plastic bags having 4-5 litres of water. Packing at a density of 500 to 2500 per litre of post larvae (10-12 mm) of *P. monodon* is done depending on the duration of transport. From 500 to 2500 seeds/litre can be packed under oxygen for transport durations of 36 to 12 hours respectively with survival of 85-90%

5.3.3 Transport without oxygen packing

Taking into consideration of the dissolved oxygen concentration, temperature, etc. of the ambient water and the rate of oxygen consumption by the postlarvae per unit time, penaeid seed can be transported for short distance of 4-6 hours journey without oxygen packing. In aluminium containers of 20 to 30 litre capacity, 500 seeds/litre can be transported with less mortality.

5.3.4 Transport of fish seed

Seed of mullets, *Etroplus* sp., *Chanos* sp., *Lates* sp., etc. can be transported for long distance under oxygen packing by careful manipulation of seed density and fry size in the container.

6. CULTURE MANAGEMENT

6.1 Species mix and culture sequence

Based on scientific farming principles, production systems which have attained the status of technology and are suitable for large scale adoption in the country are :- (a) monoculture of penaeid prawn, (b) monoculture of mullets, *Chanos* sp., *Lates* sp. and *Etroplus* sp., (c) biculture of penaeid prawns with mullets or *Chanos* sp., *Etroplus* sp., (d) biculture of fishes and (e) triculture of prawns and fishes of aforesaid species. Based on ecological consideration and availability of stocking materials, a suitable species mix and culture sequence have been formulated for different coastal stretches along the east and west coasts of the country as shown in Table-2

In pond under monoculture of prawn algal bloom develop during summer season due to fertilization and supplementary feeding. To control this excessive algal concentration and to keep the pond ecology congenial for prawn grcwth, herbivorous species i. e. mullets or milkfish may be introduced in prawn ponds at a low stocking density of 500 to 1000 nos./ha. This method is not only found to be effective in biological control of algae but also contributes substantially to enhance overall production of the pond.

In biculture of fish and prawn, two crops of prawn and one crop of fish is usually obtained during a culture period of one year. Combinations other than that given in the table-2 can also be adopted considering the compatibility of the species, availability of stocking materials and other ecological factors.

6.2 Stock manipulation and stocking densities

By proper manipulation of stocking densities and cropping pattern, there are three methods of achieving high production *viz.*, (a) single stocking and single harvesting : In this method, fish and prawn of uniform sizes are stocked at a time and reared till they attain marketable size. (b) single stocking and multiple harvesting : In this system different size groups are stocked together and specimens both, fish and prawn, which attain marketable sizes are harvested and the rest are allowed to grow further. (c) multiple stocking and multiple havesting : In this system, fish seed of different size groups are stocked together and after a period of growth the species which attain marketable size are harvested and replenished by equal numbers of seed of the same species of smaller size groups so as to maintain uniform stocking density as planned at initial stage of culture.

6.2.1 Monoculture of prawn/fish

In monoculture of *P. monodon*, the stocking density of 50,000/ha in case of postlarvae (12-24 mm) and 15,000-25,000/ha in case of juveniles (40-50 mm) may be adopted. In case of *P. monodon*, the suitable stocking rate is 40,000 to 70,000/ha for 15-20 mm seed which is available in natural collection. In both the cases normal culture duration of 100-150 days will yield marketable prawns. But depending on natural fertility of the prawn pond, much shorter or slightly longer duration of culture may also be tried for obtaining desired yield (Table-3).

A haul of *Penaeus monodon* from a monoculture pond of Kakdwip fish farm.

A haul of *Lates calcalifer* from monoculture experimental pond at Kakdwip fish farm.

For monoculture of fishes i. e. *C. chanos*, *M. cephalus* & *L. tade*, a stocking density between 3000 and 5000/ha with fry size of 60 to 80 mm may be cultured for a duration of 10-12 months for raising marketable crops. If desired size is not attained in the first year, the culture duration may be extended to the second year.

In monoculture of *L. calcarifer*, a stocking density of 3000/ha is to be practised in slightly bigger impoundments with frequent flushing facilities so that sufficient forage fishes are allowed to enter into the pond along with tidal waters which serves as food for the grwoing Bhetki. If the desired size is not attained within a year, the culture operation may be extended to the second year.

6.2.2 Production rates

In monoculture of penaeid prawn, a net production of 250-350 kg/crop can easily be obtained within 100-150 days. In three short term crops a year, a total production of 1185 kg/ha of *P. monodon* has already been achieved at the experimental brackishwater fish farm of the Institute at Kakdwip. In monoculture of fishes i. e. *C. chanos*, *M. cephalus*, or *L. tade*, a net production of 1000-1200 kg/ha/yr can be achieved. Production from monoculture of *L. calcarifer* is still better and varies within 2000-2500 kg/ha/yr.

6.3 Biculture and triculture production systems

Besides usual monoculture of prawns, biculture of prawns, prawn and fish, triculture of prawns and fishes may be undertaken. In biculture of prawns, only two penaeid prawns namely, *P. monodon*, and *P. indicus* are generally used and a production upto 500 kg/ha/120 days may be obtained.

In biculture of prawn and fish, a fast growing non-predatory and basically harbivorous fish may be stocked either with *P. monodon* or *P. indicus*. Most important combination may be *P. monodon* or *P. indicus* with *Chanos chanos*. Since *C. chanos* requires nearly 6 months to attain marketable size, the culture duration may vary from 140 to 180 days. A production range from 1000-1200 kg/ha may be obtained.

In triculture, one fish and two prawns or vice versa may be used and a production ranging from 500 kg/ha to 1900 kg/ha may be obtained. In triculture of fishes, 3 fast growing fishes may be selected depending on the availability of fish seed at the particular place of culture. Most common combination may be *Chanos chanos*, *M. cephalus* and *Etroplus suratensis*. Other combination is *Liza parsia*, *L. tade* and *C. Chanos*. In such culture, production upto 1400 kg/ha may be obtained (Table-4).

7. SUPPLEMENTARY FEED AND FEED SCHEDULE

Supplementary feeding is one of the important and essential part of the brackish-water aquaculture technology for maintaining the growth of the stocked fish and prawn. The quantity of feed to be provided and its utilization by the stock is dependent upon ambient salinity and temperature.

Usually, the locally available food substances with a high conversion ratio are preferred. The composition of the feed is determined keeping in view the nutritional requirements of the species stocked.

Several experiments were carried out in formulating a suitable feed of *P. monodon* for application in culture ponds during the last few years. It was found that indegenous materials comprising of deoiled rice-bran (29 g) + soyabean meal (29 g) + marine trash fish (40 g) + vitaminised mineral mixture (2 g) gave better growth when applied @ 5% of the body weight/day. Recently after a number of trials, the following two formulae, using readily available cheap ingredients, have been worked out for feeding the juvenile prawns. In these formulations, complete nutritional requirement of prawns has been considered as the main basis.

FORMULA OF DIET I

Molluscan meal and shrimp meal (1 : 1)	326.8 g each
High gluten wheat starch & corn waste (1 : 1)	1332.2 ,,
Molasses + Palm oil + cod liver oil + vitamin mineral mixture.	20.0 ,,

FORMULA OF DIET II

Algal powder and shrimp meal (1 : 1)	311.75 „
High gluten wheat starch & corn waste (1: 1)	148.25 „
Molasses + Palm oil + cod liver oil + vitamin mineral mixture.	20.0 „

Diet I contains 46.3 % protein and diet II 46.7% protein, Both the feeds are stable in water for more than three hours. The starchy content is gelatinised by cooking in hot water in which other ingredients are added. The whole mash could be converted into a dough and pellets be prepared with it.

Depending upon the consumption and conversion, the feed is given from 2 to 10% of the body weight of the stocked animals. The required daily ration may be given in instalments either by broadcasting or by serving it in trays kept submerged in the pond.

For biculture and triculture of fish and prawn, a powdered mixture of rice bran (60%), fish or prawn meal (25%) and oil cake (15%) is prepared. The feed mixture is spread over the pond water @ 2 to 5% of estimated biomass of fish pond. The time of broadcasting should be during early morning or late evening hours. In mixed culture of fishes i. e. *M. cephalus*, *C. chanos* and *L. parsia*, supplemental feeding comprising groundnut oil cake and wheat-bran at 1 : 1 ratio gave favourable growth when applied @ 5% of the body weight/day.

8. MANAGEMENT OF THE STOCK POND

The physical, chemical and biological factors of brackishwater fish pond have individual as well as synergic effect on the dynamics of brackishwater aquaculture. Unlike freshwater system, the ecology of a brackishwater pond is subjected to abrupt changes primarily due to changes in salinity at the onset of monsoon. Fish food organisms, benthic flora and fauna are also observed to keep pace with the changed conditions and thereby directly affect the stocked polulation. Factors like, temperature, depth, turbidity and organic matters have direct bearing on the productive process of the system. Regular monitoring of the physico-chemical parameters like salinity, pH, dissolved oxygen, turbidity etc. of the stocked pond is very much essential, since abrupt change in any of these parameters may lead to large scale fish mortality, Secondly, accumulated unused feed and other waste products may create unfavourable conditions. Strees and strain of which reduce the resistance power of the stocks and they become prone to the attack of diseases and pests.

The best method to overcome all such problems is to flush the pond water at regular intervals with fresh tidal water. At the time of flushing the pond, care should be taken to see that neither unwanted organism enters the fish pond nor the stocked materials escape out. In cases where tidal exchange is not possible, the circulation and aeration of the pond water may be effected by pumping in water from outside or by some other mechanical means.

Depth of water column in brackishwater impoundements is a limiting factor for the growth of benthos and zoophyto matrix. To ensure maximum photosynthesis and also to provide a congenial ecological environment at the pond bottom, a depth varying from 30 to 80 cm should be maintained.

Salinity plays a vital role on the brackishwater organisms but its monitoring is very difficult. Salinity in the range of 10 to 30 ppt, particularly in its raising phase is suitable for optimum growth of penaeid prawns and fishes. Hense immediately after monsoon is over, aquaculture practices should be initiated for better yield of prawns.

Dissolved oxygen is a vital factor effecting culture of *P. monodon*. Survival of prawns are greatly influenced by dissolved oxygen concentration. Judicious application of feed and fertilizers, timely removal of metabolities through water exchange method and application of lime for decomposition of organic matter to maintain positive oxygen level over 4 ppm at early morning hours will help to keep the system congenial for prawn culture. Crawling of prawns at the edge of fish pond during morning hours is an indication of oxygen depletion.

Growth of *P. monodon* is more or less uniform during the first two months attaining 110-120 mm in length. At this time utmost care is necessary to obviate sudden fluctuation in physico-chemical parameters of stock ponds by suitable management measures. Shifting prawn at this stage to another well prepared pond generally gives very encouraging growth.

9. FISH DISEASE

In brackishwater aquaculture fish diseases are not so commonly encountered as in fresh water aquaculture. Diseases of fin and shell-fishes recorded from brackishwater impoundments are as follows :

9.1 Vibriosis

Causative organism of the disease is *Vibrio parahaemolyticus*. The disease is generally recorded in shrimps. The symptoms of the disease are expansion of chromatophores and excessive opaqueness of abdominal muscles. Predisposing factors for the disease are over stocking and capture.

9.2 Brown-spot disease

Causative organisms of the disease are *Vibrio* sp. and *Pseudomonas* sp. The common symptoms of the disease are brown spots on the exoskeleton, often with white margine and necrosis of the underlying tissue. The disease is encountered mostly from *Penaeus* spp.

9.3 Other infections

Following parasites have also been recorded from the brackishwater fishes :—

Fishes	*Parasites*
Liza parsia	*Trichodina sp.*
Lates calcarifer	*Ergasilus sp.*
Lates calcarifer	*Trichodina sp.*
Mystus gulio	*Echinorhynchus sp.*

9.4 Non-parasitic diseases

Non-parasitic diseases can be controlled by thining out the population and providing supplementary feed. Soft shell and muscle opaqueness of *P. monodon* also occur due to sudden fluctuation of temperature (due to hail storm) and salinity of water (due to rains) or repeated netting. However, soft shell diseases can be controlled by repeated liming. More emphasis should be laid in maintaining general hygiene of fish pond.

10. HARVESTING

Harvesting procedure of brackishwater fish and prawn is different from that of freshwater fishes. Partial draining of fish pond is to be done before netting. Netting and trapping are only partially effective in removing the stocked fishes and prawns. For total harvest, draining or pumping out of all pond water is essential. After complete drainage, hand picking has to be done mainly to recover the burried prawns.

11. ECONOMICS

Economics of brackishwater aquaculture will vary from place to place depending on land price, cost of labour and farm construction materials and transportation of the stockable materials to the working site, since many of the suitable sites are located in desolate areas without proper communication facilities.

General economics of brackishwater shrimp culture of a farm having 12.5 ha (water area 10.0 ha) is given in Table-5, Investment and return functions have been calculated on the basis of land price and cost of other construction materials prevalent in the state of West Bengal.

12. CONSTRAINTS

Brackishwater fish farming involves high capital investment and maintainance of these farms pose many problems. Area development, communication and infrastructure developments entail heavy capital expenditure. Unfavourable tidal amplitude, high rate of siltation, cyclone, pollution, soil acidity, etc. are some of the factors that deserve special consideration.

Table-1 : Brackishwater prawn and fish seed calender

Species	*Coast/species*	*Sunderban (West Bengal)*	*Kalinga (Orissa)*	*Northern circars (A.P.)*	*Coromondel (Madras)*	*Malabar (Kerala)*	*Konkan (Goa)*
Prawn	*P. monodon*	Throughout the year, peak during March-July	Throughout the year, peak during March-July	Throughout the year, peak during Nov.-Jan.	Oct-Feb in moderate numbers.	May-June in moderate numbers.	—
	P. indicus	Poor	May-June.	—	Throughout the year, excepting March-May. Peak during Dec-Feb & July-Sept.	Throughout the year, peak in Apr.	Mar-April.
Mullets	*L. tade*	July-Spet.	—	—	—	—	—
	L. parsia	Feb-April.	—	—	Oct-Jan.	Throughout the year in moderate numbers with peak in Aug.	—
	M. cephalus	—	Dec-Feb.	Nov-Jan.	—	—	—
	L. macrolepis	—	Dec-Jan.	April-May in moderate nos.	Oct-Jan.	—	—
	M. dussumieri	—	—	—	—	April-May.	In moderate nos. during Mar-April.
Other fishes	*Chanos chanos*	—	—	Feb-Oct, peak during April-May.	April-Oct, peak in Sept.	April-May in moderate nos.	March-June, peak during April-May.
	L. calcarifer	April-June.	June-August.	—	—	—	—
	E. suratensis	—	—	—	Nov-Dec.	April-June	Mar-April.

Table—2 : Species mix and culture sequence suitable for different coasts

Culture system	*Mono culture*									*Biculture*			*Triculture*	
Species and Coasts	*P. monodon*	*P. indicus*	*C. Chanos*	*M. dussumieri*	*L. macrolepis*	*L. calcarifer*	*L. tade*	*E. suratensis*	*M. cephalus*	*P. monodon +M. cephalus*	*P. monodon +Ccephalus*	*P. indicus +C. chanos*	*P. monodon +L. tade+ L. parsia*	*C. chanos+ E. suratensis+ M. dussumieri*
Sunderban (W.B.)	Feb.-June July-Jan.	—	—	—	—	Apr.-Mar.	July-June	—	—	—	—	—	Feb.-Jan.	—
Kalinga (Orissa)	Feb.-June July-Jan.	—	—	—	—	Jul.-June	—	—	—	Feb-Jan	—	—	—	—
Northern Circars (A. P.)	May-Sept. Oct.-April.	—	—	—	May-Oct.	—	—	—	Nov-April	May-April	May-April	—	—	—
Coromandel (T. N.)	—	Jan-May June-Dec.	March-Feb.	—	—	—	—	Dec-Nov.	—	—	—	July-June	—	—
Malabar (Kerala)	—	Jan-May	May-Dec.	June-Dec	—	—	—	June-Dec	—	—	—	—	—	Aug-Sept. 6 months to 1 yr.
Konkan (Goa)	—	April-Sept.	Oct.-Sept.	—	—	—	—	—	—	—	—	Oct-Sept.	—	April-March.

Table-3 : Monoculture of penaeid prawns

Name of the Stretch (Centre)	*Species cultured*	*Density per ha (No.)*	*Period of culture (days) for each crop.*	*Fertilization (F) and feed (Fe).*	*Production rate kg./ha.*
West Bengal (Kakdwip)	*Penaeus monodon*	20,000	149	F + Fe	499
—do—	—do—	,,	147	,,	332.5
—do—	—do—	25,000	63	,,	343.5
—do—	—do—	20,000	180	,,	1054.81 (2 crops)
—do—	—do—	50,000 (Post larvae)	320	,,	871.75
Kalinga (Keshpur)	—do—	20,000	120	,,	232.1
Northern Circars (Kakinada)	—do—	15,000	120	Fe	286.5
Coromandel (Madras)	*P. indicus*	25,000	100	Fe	295.0
Malabar (Vytilla)	—do—	40,000	63	F	362.7
Konkan (Ela Dauji)	—do—	25,000	85	F + Fe	218.0

Table-4 : Production rates in bi- and triculture system

Culture system	*Species*	*Stocking density*	*Yield (kg/ha)*	*Culture period (days)*	*Fertilizer (F) and Feed (Fe)*
Biculture (only prawns)	Pm + Pi (2 : 9)	55,000	504.0	120	F + Fe
Biculture (Prawn+Fish)	Pm+CC (10 : 1)	44,000	1125.0	140	F + Fe
—do—	Pi+CC (6 : 1)	43,000	2196.0	180	F + Fe
Triculture (1 prawn+2 fishes)	Pm+Lp+Lt (4 : 1 : 1)	25,000	1915.6	420	F + Fe
—do— (2 prawns+1 fish)	Mm+Pi+Mdu (8 : 2 : 1)	132,000	508.0	180	F + Fe
—do— (only fishes)	Cc+Mdu+Es (5 : 2 : 3)	10,000	1493.75	320	F + Fe

Abbreviation : Pm = *P. monodon*, Mm = *M. monoceros*, Mdu = *M. dussumeiri*, Pi = *P. indicus*, Lp = *L. parsia*, Es = *E. suratensis*, Cc = *C. chanos*, Lt = *L. tade*

Table - 5 : Financial evaluation of brackishwater shrimp culture (3 crops/yr) for a 12.5 ha farm (water area 10 ha) for commercial venture.

Cost structure

1. CAPITAL COSTS ON ASSETS

Item	*Expenditure range* (Rs.)	*Charged per ha water area basis* (Rs.)	*Total per crop* (Rs.)	*Total* (Rs.)
FARM CONSTRUCTION				
Sluice, bund, dyke, ponds, farm house, farm shed & tube well (expected life 20 yrs.)	10,000 40,000/ha	25,000ha	—	250,000
EQUIPMENT				
Push carts, nets, containers, cycle, pump set etc. (expected life 10 yrs.)	10,000 30,000/ha	20,000/ha	—	200,000
	TOTAL CAPITAL COST			450,000

2. VARIABLE COSTS

Pond preparation	*Input Rate*	*Expenditure (Rs.)*	*Total expenditure (for 3 crops in 10 ha)*
Lime 300 kg/ha/yr	Rs. 60/qntl.	4600/crop	13,800
Poultry manure 100 kg/ha/yr	Rs. 20/qntl.		
Urea 250 kg/ha/yr	Rs. 250/qntl.		
Super phosphate 250 kg/ha/yr	Rs. 150/qntl.		

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Seed 20,000/ha/crop	Rs. 37.50/thousand	750/ha/crop	22,500
Feed 1200 kg/ha/crop @ 5% of body weight.	Rs. 2.50/kg.	3000/ha/crop	90,000
Labour 200 man-days/ha/crop	Rs. 10/man-day	2000/ha/crop	60,000
Maintenance cost	Rs. 1500/ha		15,000
	Total..................Rs.		2,01,300
(b) Contingent expenditure @ 10% of total.		Rs.	20,130
	Grand total ....Rs.		2,21,430

Total approximate cost—Rs. 2.214 lakh

3. FIXED COSTS

	Rate	*Total for the year*
a) *Staff*		
(i) Farm Manager	1 @ Rs. 1500/m.	Rs. 18,000
(ii) Farm Technician	1 @ Rs. 800/m.	Rs. 9,600
(iii) Farm skilled hands	15 @ Rs. 500/m.	Rs. 90,000
b) *Services*		
(i) Taxes, Telecommunications, water charge, insurance, electricity etc.	Rs. 2000/p.m.	Rs. 24,000
(ii) Land lease rent (12.5 ha)	Rs. 800/ha/annum	Rs. 10,000
Total fixed annual cost		Rs. 1,51,600

4. To interest @ 15% per annum of 6.0 lakh capital borrowing Rs. 90,000

5. To depreciation (Rs. 20,000/yr per equipment of 10 yr life and 12,500 / yr for farm of 20 yr. life).
(20,000 + 12,500) Rs. 32,500

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4 INCOME

Product sale	Production from experimental pond (600-1200 kg/ha/yr)	Total (for 3 crops from 10 ha) per yr.
		Rs.
(i) Shrimp (20-30 count)	200 kg/ha/crop @ Rs. 100/kg.	6,00,000
(ii) Shrimp (30-50 counts)	50 kg/ha/crop @ Rs. 40/kg.	60,000
(iii) Small shrimp	50 kg/ha/crop @ Rs. 10/kg.	15,000
	Total	6,75,000
Less 10% due to hazards		67,500
	GROSS INCOME	6,07,500

5 CASH FLOW

1. To assets ..	Rs. 4,500 lakhs
2. To variable cost ..	Rs. 2,214 ,,
3. To fixed cost ..	Rs. 1,516 ,,
4. To interest ..	Rs. 0,900 ,,
5. To depreciation ..	Rs. 0,325 ,,
Total	Rs. 9,455 lakhs

Gross income ..	Rs. 6,075 lakhs
Less variable cost ..	Rs. 2,214 ,,
Gross profit ..	Rs. 3,861 ,,
Less fixed cost ..	Rs. 1,516 ,,
Net income ..	Rs. 2,345 ,,
Less (interest + depreciation) ..	Rs. 1,225 ,,
Net Profit ..	Rs. 1,120 lakhs

..Contd.

6 ECONOMIC INDICATIONS

1. Capital turnover (%) $= \frac{6.075}{6.0} \times 100 = 101.25\%$

2. Return rate

   (a) On variable cost $= \frac{2.345}{2.214} \times 100 = 105.92\%$

   (b) On Investment $= \frac{2.345}{6.0} \times 100 = 39.08\%$

Cost of production/kg. of prawn on variable cost only—Rs. 8.20

□