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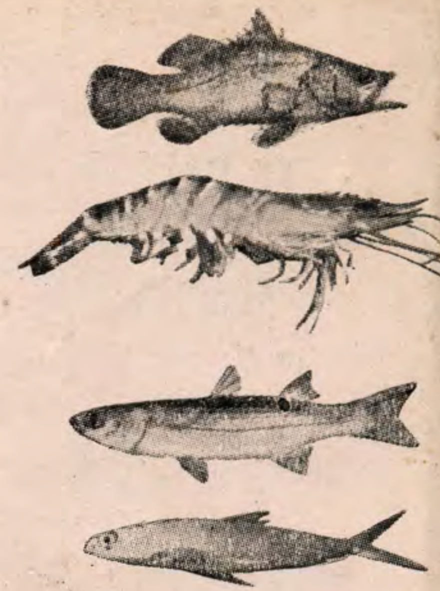

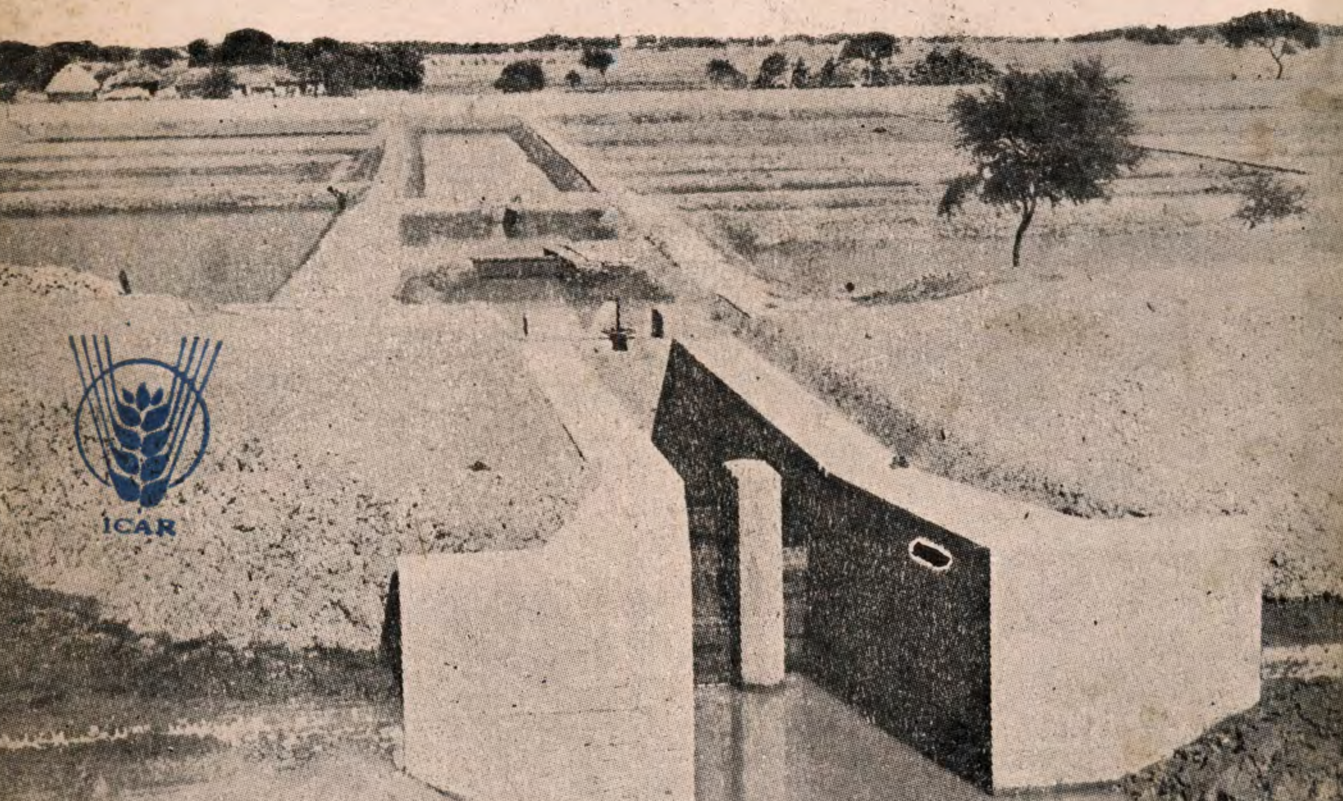

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BRACKISHWATER AQUACULTURE IN INDIA

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MANUAL
BRACKISHWATER AQUACULTURE IN INDIA

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FOREWORD

Brackishwater Aquaculture in India has a hoary past especially in the State of West Bengal and Kerala and the traditional system is largely based upon trapping the natural seed, holding and fattening them in impounded tidal swamps or in paddy fields adjoining the backwater areas. Though the annual production of prawns and fish from this system of culture is well over 10,000 tonnes, the unit yield rate is both low and is subject to large scale fluctuations. The country has an estimated 1.5 million ha area under saline swamps which could be reclaimed for brackishwater aquaculture. But improvement in productivity and increased and sustained yield per unit area imply adoption of scientific brackishwater aquaculture tecnnology relevant to this country. The need for a manual on scientific brackishwater aquaculture which takes into consideration site factors, the tidal amplitude, farm lay out, sclective stocking, scientific fertilisation and feed, nursery management and stock pond management, etc is keenly felt by practising farmers, prospective enterpreneurs and other involved in the industry and it is hoped that the present manual being brought out on the occasion of the Summer institute on Brackishwater Capture and Culture Fisheries would serve bridge this gap.

31.7.80

A. V Natarajan
DIRECTOR

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PREFACE

Because of the shrimp boom the world over, at the present point of time, people from many walks of life being motivated by earning quick profits, are now getting interested in brackishwater aquaculture. Queries seeking information on this type of farming, its technical know-how, its practicability its capacity for finance turn out, where and how to construct a farm and get quick monetary returns, and its constraints and pitfalls are pouring in at the Central Inland Fisheries Research Institute (CIFRI) by dozens.

This manual on brackishwater fish and prawn farming is prepared with a view to communicate the existing information on the subject to interested parties and to answer at least some of the more important questions on brackishwater aquaculture.

Most of the information given in this manual is relevant to India and is based on know-how developed at the Central Inland Fisheries Research Institute at its Brackishwater Experimental Fish Farm, Kakdwip (South 24-parganas) in West Bengal with a mention, in selected topics, of the techniques developed elsewhere in the country and abroad.

Research is the key to growth in knowledge in technology and this is being pursued vigorously in the CIFRI and the five centres of the Co-ordinated Project on Brackiswater Fish Farming which are located at Keshpur in Chilka in Orissa, at Kakinada in Andhra Pradesh, at Madras in Tamil Nadu, at Vytilla in Kerala and at Goa. Research is also being pursued on brackishwater aquaculture at the Central Marine Fisheries Research Institute, Cochin and Central Institute of Fisheries Education, Bombay, and some of the Agricultural Universities especially the Konkan Krishi Vidyapeeth in Maharashtra.

Our country has a wide variety of climates in coastal areas, a vast seed resource of cultivable fin fish and shell fish, and tidal amplitudes ranging from a few cm to 5 or 6 metres. Cost of land in coastal and backwater areas is low and labour not very expensive. These are the prime requisites for brackishwater aquaculture.

The projections in this manual are restricted to the terrains that fall within the coastal areas, estuaries, mangroves, inlets, and bays where most of the potential for brackishwater farming exists.

PART I

ENGINEERING FACTORS

Chapter 1

SELECTION OF SITE

Three principal criteria for site selection are : 1. Topography, 2. water availablility and supply, and 3. Type of soil.

1.1 TOPOGRAPHY

Important considerations here are terrain *i. e.*, the type of area available, elevation of land in relation to that of water source and economic considerations.

1.1.1 TERRAIN

When digging a pond, embankments are given prime consideration. Therefore, terrain is considered most important for site selection. Normally, pond embankments may be constructed on a wide variety of terrains provided slopes can be maintained easily at least on one but preferably on both sides. This implies that rocky and sandy terrains are highly unsuitable. Sandy soils cannot be compacted, cause severe slides and are biologically unproductive too. Undulating terrain should be only moderately so as to enable smoothening out when constructing the farm. Terrains thickly forested would cause heavy outlays of expenditure. Contour surveys may be considered essential before farm construction.

1.1.2 TYPES OF BRACKISHWATER AREAS

Several categories of land found useful for brackishwater farming are variously called :

1.1.2.a Tidal mud-flates :

which get covered with water during high tides but are exposed in low tides. Tidal flats along streams are most desirable for location of fish pond to ensure a supply of fresh water when the pond water becomes hypersaline and is to be made brackish.

The tidal mud-flats often do not require any excavation ; construction of a peripheral dyke with a master sluice would convert the area into a farm.

Farm ponds constructed on mangrove areas or tidal mud-flats must be cleared of all vegetation.

1.1.2.b Swamps and marshes :

Areas with low shrubs and other vegetation partially covered with water, water table being high. Subsoil is always under standing water, which could be stagnant or rising and falling with tide. Such areas are usually located very close to coast. The areas are sinks for sediments because of the action of plants in slowing water flow. They also absorb nutrients from water thus improving water quality in areas where sewage effluents are a problem (Valiela and Teal, 1972).

1.1.2. c Estuarine areas :

The water zone lying between the riverine stretch and open sea with distinct zonation of tides, salinities and water flows.

In an estuary carrying high silt load, the latter gets deposited in high tides along low lying banks (eg. the Hooghly Estuarine System). In course of time such areas harden despite being covered by tidal waters twice in a day. In the Hooghly estuarine system, such areas occur nearly 60-70 km up from the river mouth.

Estuarine areas are broadly classified into five zones ;

(1) HEAD ZONE : Entry of freshwater ; salt penetration range may be 5% ; River flow dominates the currents.

(2) UPPER ZONE : Salinity range 5-18% ; muddy bottom deposite ; current negligible.

(3) GRADIENT ZONE : Salinity 18-25%. Mud and sand present. Higher tidal levels with faster current.

(4) LOWER ZONE : Salinity 25-30%. Dominating sand with some mud present. Fast current prevails.

(5) MOUTH OF THE RIVER : Salinities virtually equal that of adjacent sea ; maximum sand content. Topography sometimes rocky. Strong tides prevail.

The picture of estuarine areas varies within small limits according to the region in which the estuary is located. The location of the brackishwater farm should ordinarily be within Zones 3 and 4 *i.e.*, in the gradient and lower zones.

1.1.2 d Swamps :

Land lying between highly interlacing creeks branching off from the lowermost zones of the estuary. Often, these areas are swampy, rich in organic detritus. Some sections of this ecosystem could be suitable for construction of a farm.

1.1.2.e Inlets :

Inlets from the sea and coastal areas lying on the margin of bays, either covered by scrub or bars. Those which are partially enclosed by natural shores can be made into farms by construction of artificial dykes. Only short gates enclosing narrow outlets are needed.

1. 1. 2. f Salt pans :

Disused salt pans are also found very suitable especially for prawn culture. Quite often the salt farms maintain a series of small and large reservoirs to 1.5m in depth. These can be used for culture provided the salinity does not exceed 40 ppt. In monsoon, the salinity declines to 10-15 ppt. Which makes the salt pans highly suitable areas for prawn culture.

1. 1. 3 ELEVATION OF LAND

1. 1. 3. a Contour surveys :

Contour surveys are to be undertaken in order to make out the size and shape of the land, especially in relation to the water source. This information would help in layout and designing of the farm. Lower contour zones should be primarily selected for the construction of the ponds. The contour survey in relation to the water source is necessary since water supply is the main consideration of the farm construction, the water being taken in (i) either by gravitation flow or (ii) by way of pumping-in.

1. 1. 3. b Higher elevation :

If the land is at a very high elevation relative to the water source considerable expenditure would be involved in excavation of the ponds to the level of supply channel. It is better to choose lower contour zones of this area for pond excavation and leave the higher contour zones for construction of other building which form part of the infrastructure. Because of the high elevation of the land the peripheral and secondary dykes need not be high.

1. 1. 3. c Land below the level of supply :

If, on the other hand, the land is below the level of supply channel, water logging would form a main hinderance although considerable saving can be made on easy excavation. Embankments will have to be high to prevent flooding.

1. 1. 3. d Engineering considerations :

If the land is sloping away from the the water source or of uneven nature, engineering considerations can be applied by having a pond at an elevation (say 3′ to 4′ above the general farm) which would act as a reservoir receiving water at every high tide ; lead channels can take water from there to the rest of the farm by gravitational flow.

Maximum advantage is to be taken of the natural contours of the land, existing canals and creeks.

1. 1. 4 ECONOMIC CONSIDERATIONS

1. 1. 4. a Vegetation, erosion characteristics of the region and siltation :

If the site chosen is thickly forested or otherwise has too much vegetation, clearnce of the land of roots and stumps would involve considerable expenditure ; similarly an area with high erosion or siltation problems would pose recurring problems of preventive and protective measures involving heavy capital outlay. Heavily silt-laden waters, when they enter confined farm ponds deposit silt very rapidly thus reducing the efficiency of the farm. Along the Hooghly estuarine system near Kakdwip, Raidighi, Bidyadhari and several such areas 'bheris' (low lying impoumdments with tidal influence) are constructed and are used for wild culture practices These 'bheris' take in highly silt-laden Hooghly waters. Desiltation of the farm is undertaken from time to time to keep the required depth in ponds.

1.1.4.b Distance from water source :

Other economic considerations would involve distance of the water supply source to the farm location, whether the inlet channel has to be dug, the depth required and the distance and maintenance of the channel. If water is taken by pumping, considerations such as a channel to receive the water in case the water cannot be pumped directly into the farm ponds or reservoir ponds, would have to be made. The greater the distance of the water supply source, the greater the capital outlay on pumps, pipes or channels.

1.1.4.c Roads and transport and sources of nearest outlet for marketing :

A passable road for a cart or tractor or a vehicle is an important consideration. Under Indian monsoon conditions, most of the areas where brackishwater farms can be located become impassable. An outlay on road to the nearest transportation network in case such is not available would be required. Availability of a market nearby is a part of this consideration.

1.2 WATER AVAILABILITY AND SUPPLY

1.2.1 AVAILABILITY

1.2.1.a Water source :

Basically, a constant supply of brackishwater must be available to the ponds throughout the year. This serves to exchange water from the confined pond, to replace water lost through seepage, evaporation, and generally acts as a buffer to all fouling propensities in high density rearing systems.

A preliminary survey of the water source; its flow patterns and directions; rise and fall in tides; silt carrying capacity, etc., should have to be conducted. Conditions prevailing during all the seasons of the year *viz.*, summer, monsoon and winter must be known alongwith information on rate of evaporation.

1.2.1.b Tidal range and elevation :

Tidal inflow and outflow of the available source should be such that water can be taken in at every high tide and drained out at low tide. Such a situation is, however, neigther always feasible nor is essential due to the following reasons :

i) Biologically speaking, daily exchange of water is not needed. Supply at 10-15 day intervals would suffice to keep the ponds fit for aquaculture.

ii) Supplemental feeding schedules and effective action of artificial fertilization to increase the natural fertility of the ponds would be adversely affected.

iii) Daily harvesting, for which mainly draining out would be required, is not possible because such fast daily growth is not possible.

iv) This constant rate of exchange may harm some animals and bring in unwanted predators.

v) Economically speaking, this is impractical and unprofitable causing enormous expenditure on operation of sluices, use of nets, man-power, etc.

vi) Physically, the high tides may not be high enough on all days to reach the farm site and the highest point of tide may not last long enough to supply the entire farm.

In such cases, spring tides should be fully utilised for exchange.

*Tidal levels along Indian coast line rapidly decline from north to south (See Chapter-II). While on the North-east and North-west along 22°N latitude, the highest high tide reaches about 4.86 m, at a latitude, of 17°N this height is only 2 m and at a latitude of 13°N the same is further reduced to 1 m only. At a latitude of 10°N (Cochin) the spring tide level is 0.63 m.

The time lag between spring tides is 13-15 days and the height of water level during this period in each month should be known. The spring tides should be tapped for water supply to the farm. In the Hooghly estuary, the narrow funnel type mouth of the estuary creates, what are commonly termed as bore tides, reaching maximum heights of 5 m. This level helps to replenish the entire farm area located along this region.

1.2.2 WATER SUPPLY

Supply of water to the farm could be, as far as possible through natural creeks which connect to the main river, channel or the bay itself;

*Note : A brackishwater farmer is advised to buy yearly a copy of the Indian Tide Tables published by the Govt. of India at printing group of Survey of India, Dehradun ; this will enable him to keep a time table of high tides which will reach his farm site in a fortnight/month, etc.

or a suitable supply channel should be dug from the main source to the farm.

The direction of the channel and its flow patterns are important. The water entry point should be from the most adjacent point of main source to the main or master sluicc of the farm. The lesser the meanderings of the channel the better the supply.

1.2.2.a Quality of the water

1.2.2.a.1 POLLUTANTS

The supply water should be free from organic and chemical pollutants. It is a prime consideration in location of farms.

A preliminary physical survey would enable the farmer to know what industries/factories exist in and around the region selected by him and the location of their effluent channels, the periodicity of release of effluents, etc.

1.2.2.a.2 FRESHWATER RUN OFF

Heavy freswater run off could be drastic to the well-being of the cultured animals. Sudden fall in salinity, change in pH and specific density would cause heavy kills.

1.2.2.a.3 SILT

Heavily silt laden waters are generally detrimental to the brackishwater both physically and biologically. Physically, the silt load helps to deposit silt quickly in farm ponds, rapidly raising the level of pond beds relative to the water inflow level.

Biologically, the turbidity caused by the silt hampers productivity of the water ; causes respritatory problems to the cultivated animals. Prawns, particularly, show heavy mortalities with high silt deposition. Silt also brings in large quantities of organic detritus, the further decay of which producces anaerobic conditions in pond bottom.

However, engineering considerations can be applied here : By constructing a reservoir pond where water can be taken in first ; the supernatant water can then be channelled to the rest of the farm. Such a break in the through-flow system would help to deposit the heavy silt particles first ; the reservoir alone might be desilted as and when required.

1.2.2.a.4 SALINITY PROFILE

Salinity is the measure of salt content in the water (salts include sodium, and chloride ions plus smaller quantities of potassium, magnesium, calcium and sulphate ions and several others in minute quantities). It might be expressed as grams of salt per kilograms of sea water. The symbol is °/oo (parts per mille ; or per thousand).

Knowledge of the salinity profils of the water source at the site to be selected is essential. Classification of brackishwaters based on salinity (*Arch. Oceanog. Limnol.* Vol. 11, 1959) is :

ZONE	SALINITY (°/oo Nacl)
Hyperhaline	>40
Euhaline	40 to 30
Mixohaline	(40) 30 to 0·5
—euhaline	>30 but <adjucent euhaline sea
—polyhaline	30 to 18
—Mesohaline	18 to 5
—Oligohaline	5 to 0.5
Limnetic (freshwater)	<0·5

Salinity profile can be understood by repeated sampling of water in the area both during high and low tides, during spring tides, during different months, etc.

Salinity profile is usually effected by the freshwater inflows either from the river itself or from the surrounding rain water catchment areas. Therefore, the salinity profile plays an important role in site location. Water sources with the nearest saline water inflows are the best areas, to avoid any rapid changes in salinity from season to season.

1.2.2 a.5 ELECTRICAL CONDUCTIVITY

Since most of the salts exist as ions in water and ions are charged, they conduct a electrical current. The greater the ionisations, the greater the conductivity. The total amount of dissolved salts in water can be approximately measured by measuring the electrical conductivity of the water. The result are depicted as Micromhos per centimeter at 25°C since temperature affects the conductivity of the water.

1.2.2 a 6 TEMPERATURE PROFILE

Other qualities of water useful in brackishwater aquaculture are temperature, pH, oxygen saturation and chemical characteristics.

Temperature has an important role to play in growth. Under Indian climatic conditions, the difference in the temperature range during different seasons from north to south coastal regions of India varies between 5-6°C (Table 1).

Table 1 : Average water temperatures at different latitutes.

LAT °N (Nearest degree)	REGION OF INDIA		AVERAGE TEMP. (°C)	
	East coast	West coast	Min. (December)	Max. (May)
21.5	Hooghly mouths	Porbander	18·0	
19	Chilka	Bombay	21.4	30·7
16	Godavari mouths	Ratnagiri	25·2	33·2
9.5	Tuticorin	Cochin		

Normally in coastal regions, the difference between day and night temperature in any season is less than in upland areas. However, variation would occur between surface waters exposed to atmospheric changes and bottom waters. In the shallow (1—1.1m) pond waters these changes are felt rapidly. In flow-in systems, like the brackishwater farms, temperature variations could be controlled to the extent that waters constantly show slow wind or tide-generated movement or current. Winter temperature in higher latitudes could be detrimental to growth and survival so also extremes of high temperatures in summer. Exchange of water by way of pumping in could equalize conditions throughout the pond.

1.2.2 a 7 DISSOLVED NUTRIENTS/GASES

The composition and abundance of nutrients determine the productivity of water. Further, a knowledge on this aspect would also determine the amount and type of artificial fertilization required to enhance its productivity in confined ponds. The concentration of these minerals are determined by run offs from other soil sources adjacent to the estuary. The important nutrients are the phosphorus, potassium and nitrogen. Other elements such as carbon, magnesium, calcium and sulphur have an important role to play even if they occur in small quantities. Therefore, an estimate of these chemicals in the water at the site must be made and be known.

Dissolved gases that are important are oxygen and carbondioxide which control the biochemical processes like uptake of nutrients, photosynthesis, respiration, etc.

Dissolved Oxygen

The dissolved oxygen content of water depends on the water temprature and salinity. Its solubility decreases with increasing temperature and salinity. At saturation of 15°C, a litre of sea water (at 36°/oo salinity) contains 5.8 cc oxygen. Fluctuations in the oxygen saturation in water taken into the farm occur associated with flood seasons, inflow of other freshwaters or, with the dry winter and summer season when tidal flow of sea water dominates. Vertical stratification in salinity also results in conspicuous differences in dissolved oxygen content in deep and in surface waters.

Analysis of surface and bottom waters, at different times of the day or night would give a good picture of the DO content at any given period.

Carbon-di-oxide system and pH

The solubility of carbondiozide is determined by the amount of sea water mixed with fresh water and also by the temperature. The solubility depends on salinity. The pH of sea water usually differs in a range from 8.1 to 8.3. The pH values generally vary inversely to the free carbondioxide content and directly with dissolved oxygen concentration.

1.2.3 LOCATION RELATIVE TO THE COAST

As stated in the foregoing pages, the basic premise on which brackishwater farm system operates is on the assured supply of brackish or sea water from a nearby channel of the estuary, creek, or bay during high tides. Since the development of brackishwater aquaculture practices is to utilize the thus-far unused intertidal zone, the farm should be located as near the water supply as possible.

If the farm is located (refer to section 1.1.2 for type of land areas of culture) up the estuary say at 30—40 km (e. g. Kakdwip farm in West Bengal), salinity variations would commonly occur from season to season. This variation, within certain limits, is still productive since most species of fish and prawns have wide tolerance limits. However, their growth may not be optimal. If the salinity shows constant fall due to water flow from adjacent areas, in course of time some species would get eliminated from the system.

1.2.4 PUMPING

Another method of supply of water is by pumping in. This is less expensive than it may appear. If the pump is operated at a time when the tide is on the rise large volumes can be obtained quickly. Diesel pumps should be used since diesel is cheaper. Where electric power can be obtained this can be used depending on its cost. A pump must be maintained in the farm anyway for dewatering the ponds and for general emergencies.

1.2.4.1 Pumping through borewells

Usefulness of the pump is more emphasized in cultures conducted in salt pans. The salinity level declines sharply in monsoon in these pans. The salinity of the sub-soil water, however, would be very high ranging from 20—60 ppt and above. This water can be pumped through a borewell to maintain required salinity.

1.3 TYPE OF SOIL

1.3.1 SOIL QUALITY

Soil type, its texture and properties, is the third very important factor in the selection of a site for brackishwater farming. A general term—'swamp' is often mentioned as a suitable area for this farming. However, not all swamps are suitable. The type of soil present in the swamp forms the basis for its characterisation. Too porous a soil permits water logging, creating conditions of oozing. Animals being cultured in such an area would find no shelter at the bottom.

A clayey soil provides a hard bottom. An admixture of sand and organic detritus keeps it porous enough to enable animals such as shrimp to hide by burrowing. Too soft and porous bottom materials are to be avoided. This causes constant erosion.

Soil having 70 to 80% sand content will not have stability despite its good bearing capacity. Similarly newly formed islands near estuaries are also not stable since they would not have become compact in a short time and thus have poor bearing capacity. Elevated lands are good but expenditure on excavation would be high. The soil profile suitable is :

Clay	...	8% to 15% by weight
Sand	...	60% to 80% by weight
Silt	...	12% to 25% by weight

1.3.2 SOIL PRODUCTIVITY

1.3.2.a Nutrients*

To test soil productivity, soil water extract analysis must be done. Air dry soil must be collected for this purpose. In general, silty loam with more than 60% of silt content are found to be favourable for brackishwater aquaculture since the estuarine silt can trap a large part of the high concentration of phosphates in the water during the freshwater run off periods. The phosphate is released into water phase for biological utilization. Atmospheric nitrogen in different forms is the main source of soil nitrogen and it is present in organic form. Nitrogen availability is however a problem, as the high pH of both soil and water of brackish areas leads to a gaseous loss of ammonical nitrogen. Salinity plays an important role in the transformation of soil nitrogen, available nitrogen increasing at salinities ranging from 10 to 20 ppt. Organic matter in the soil is another important character of productivity. It controls the character of the water body, reduces seepage loss and increases the aerability of the bed soil. Further, it is the main source of nitrogen and organic phosphorus. In excess it would act as a pollutant but sometimes may act also as an antitoxicant. Organic matter is essential in a pond soil-water interface to regulate the food chain cycle.

1.3.2.b pH

pH is a very important character of soil profile as also the alkalinity. Both these factors need to be analysed. In brackishwater ponds. the soil type should favour the growth of benthic algae. For this a pH between 6.5 and 7.5 is found to be the best. Generally, the soil is said to be highly responsive to the release of nutrients at this level of pH.

The soil pH, like that of water, depends on oxygen supply. A low oxygen supply results in slow decomposition of organic matter. This produces mainly reduced or partially oxidised compounds like H_2S, CH_4, and short chain fatty acids. The soil becomes acidic and may lead to low production.

* **NOTE** : The nearest soil testing laboratory or mobile soil testing labs may be approached for this test.

Chapter 2

FARM DESIGN AND CONSTRUCTION

2.1 INTRODUCTION

A brackishwater farm is composed of four main constituents : 1. A peripheral dyke (to protect the farm from strong tidal action and wind action), 2. Secondary dykes inside the farm separating the ponds with secondary sluices for inlet and outlet of water, 3. A master sluice which controls the water flow-in system of the entire farm, and 4. A feeder channel leading from the master sluice ; it takes in water and acts as a reservoir ; secondary feeder channels branch off from here depending on the layout and design of the farm.

The following section describes the general principles to be followed in designing and construction of a brackishwater farm. Other considerations in the fundamental planning of a brackishwater farm are shown in table 2.

2.2 DESIGN AND STRUCTURES

The layout of the farm and its design are directly related to the water source and the contour of the land. A typical layout of a brackishwater farm and the existing farm at Kakdwip (West Bengal) are shown in figs. 1 & 2 respectively.

2.2.1 THE PERIPHERAL DYKE OR THE MAIN DYKE

The peripheral or main dyke goes round the farm. It protects the farm from the influx of high water from the adjacent estuary or creek. It also acts as a wind breaker.

2.2.1.1 Height

The dyke height would depend on the farm location. The tide levels at the site vary from Northern to Southern regions of India. At a latitute of 22°E, for instance in the gradient regions of the Hooghly estuary, the tide levels fall and rise on an average of 2m in normal daily tidal rhythm or 4—5m, during

Table 2 : Considerations in the fundamental planning of a Brackishwater Farm

Biology						Engineering			Management, Economics & Others	
Life history of the species	Habitat Preferences	Main stocking densities to be used	Harvesting types	Environmental		Water quality	Soil profile	Hydraulics	Biology	Economics
				Temp.	Wind. velocity	Salinity			Plankton	—Cost of reclamation of land
				D.O.	& direction.	pH	Sandy		Benthos	—Of material and of transporation
				Salinity		turbidity	clayey gravel humus	—Direction & movement of tides & waves		
				Productivity	Precipitation	DO BOD	Organic	—Water replacement during a tide	Productivity	—Adjacent region partially developed or undeveloped
Seed availability (a) from nature (b) from hatcheries				Bottom biota	Daily record of temp.	Phosphates			Growth & breeding Diseases	--Marketing supply and demand
				Type of feeding		Calcium				
						Ammonia				
						Carbonates				
						Others				

LAY·OUT OF A BRACKISHWATER FARM (5 ha WATER AREA)
(NOT TO SCALE)

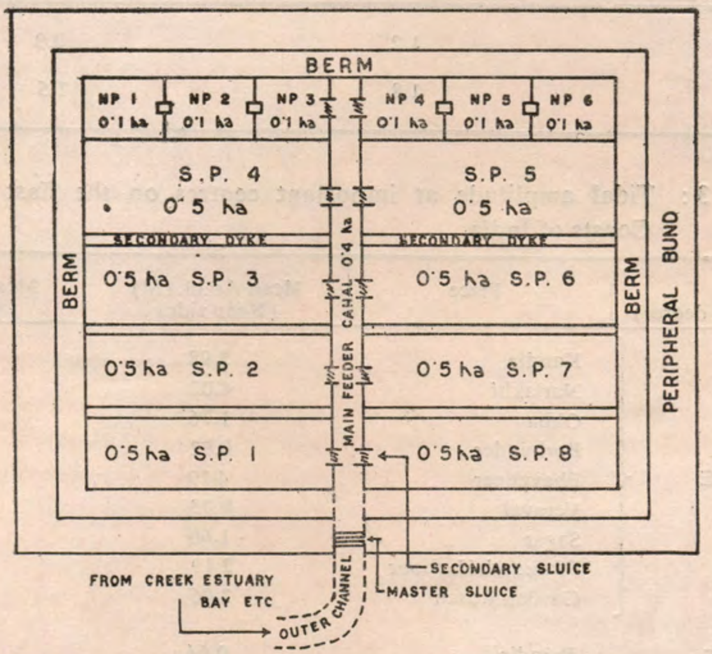


Figure 1.

the spring tides, once in 15 days. The mean amplitude (Table 3 and Fig. 3) at Kakinada and Visakhapatanam regions, at a latitude of 16—18°E is 0.38—0.54 m in neap tide and 1.23 to 1.43m in spring tide.

Therefore, in planning a dyke *i.e* , its height, depth and width, this tidal amplitude in the adjacent water source should be taken into consideration. A heavy water load at a spring tide level of 3m could exert heavy pressure.

Free board is allowed at the determined height of the dyke to prevent overtopping of it by a highest high wave. A metre of free board is considered a state height. As per the recommendation of American Society of Civil Engineers (A water resources technical publication 1973 as quoted by

A. Sengupta, 1977*) the free board required for small dams is :

Fetch, Miles less than 1	Normal free board (m)	Minimum free board (m)
1	1.2	0.9
2.5	1.8	1.5

Table 3 : Tidal amplitude at important centres on the East and West Coasts of India.

Lat. (to the nearest degree)	Place	Mean Ampl. (M) (Neap tide)	Mean Ampl. (M) (Spring tide)
21—23°E	Kandla	3.98	5.89
	Narlakhi	4.02	6.43
	Okha	1.76	3.06
	Porbunder	0.92	1.89
	Bhavnagar	4.79	8.76
	Veraval	0.73	1.61
	Sagar	1.60	4.30
	Diamond Harbour	2.19	4.86
	Garden Reach	2.06	4.16
20—21°E	Paradip	0.64	1.72
17—19°E	Bombay	1.44	3.66
	Visakhapatanam	0.54	1.43
	Kakinada	0.38	1.23
13—16°E	Marmagoa	0.76	1.64
	Karwar	0.70	1.56
	Mangalore	0.50	1.15
	Madras	0.41	1.01
9—11°E	Magapattinam	0.27	0.62
	Cochin	0.23	0.63
	Tuticorin	0.16	0.70
	Pamban	0.16	0.60

* *Construction and maintenance of shrimp farms for commercial production* by A. Sen Gupta.

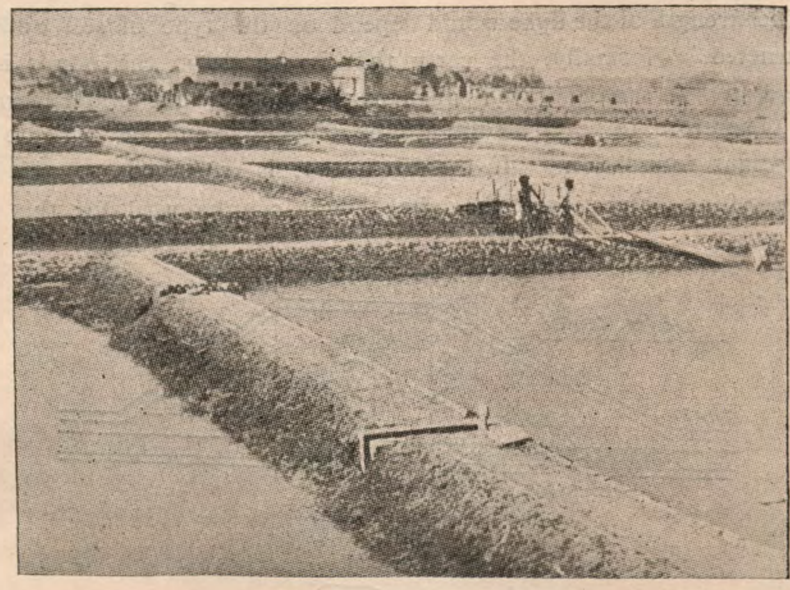
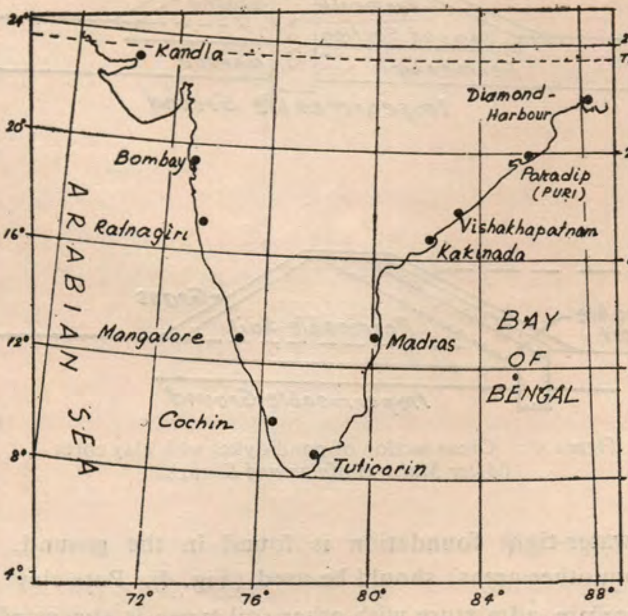


Figure 2 : Existing Brackishwater Fish Farm at Kakdwip, West Bengal



Kandla : N-3.98; S-5.89/ Bombay : N-1.44; S-3.66
Mangalore : N-0.50, S-1.15/ Cochin : N-0.23; S-0.63
Tuticorin : N 0.16; S-0.70/ Madras : N-0.41; S—1.01

D. Harbour : N-2.19; S-4.86/ Paradip : N-0.64; S-1.72
Vizag : N-0.54; S-1.43 Kakinada : N-0.38; S-1.23

Figure 3 : Showing tidal amplitudes at different coastal areas of India
(N=neap tide; S=Spring tide)

2.2.1.2 Strength

The strength of the dyke would depend on the type of soil on which it is constructed. Normally, the earth that is dug from the ponds is used to raise the dyke. In sandy, gravelly or marshy grounds, the water permeability is high. Therefore, to get to a solid ground, digging should be done to a depth of water-tight foundation. If the earth that is removed at this level is satisfactory for construction of the dyke, then it can be used for this purpose.

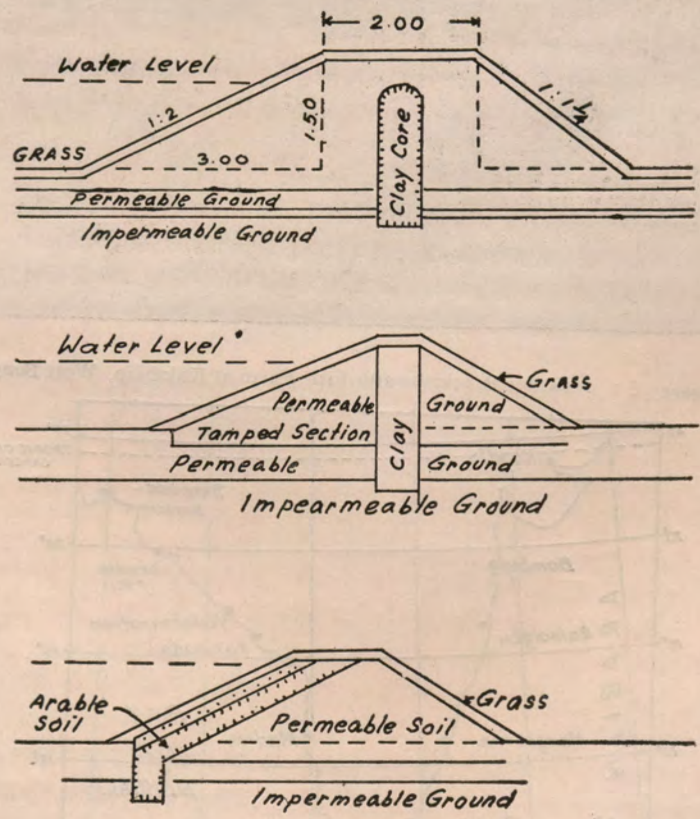


Figure 4 : Cross section of pond dykes with clay cores (*After Maier-Hoffman and Kaeuz*)

In case no such water-tight foundation is found in the ground, then a clay core (obtained from other areas) should be used (Fig. 4). Pure clay would crack when dry and, therefore, admixture with other soil types is suggested. Width of the dyke at the bottom should be doubled when the soil condition is unsatisfactory.

2.2.1.3 Width

Width of the dyke at the top should equal its height for solidity. The dyke would also serve then as a road-way for transportation work in the farm.

2.2.1.4 Slope

It is generally suggested that the side of the dyke, facing the pond, should be atleast a foot above water surface in the pond to allow for sudden subsidences, water additions by rain or seepages.

The slope of the dyke on the outside could be gentle = 3 : 1 and towards the inside it may vary from 1 : 1 to 1 : 2 depending on the height. The safe side slopes recommended in all engineering practices are :

NATURE OF SOIL	UPTO 8' HEIGHT	8—15' HEIGHT
Ordinary earth Soft clay, dry sand	1½ : 1	2 : 1
Loose earth	2 : 1	3 : 1
Loose sandy loam Wet sand	2½ : 1	4 : 1

2.2.2 *SECONDARY DYKES*

The construction of secondary dykes is for the purpose of partitioning off the farm into several or a few ponds. The earth dug from the ponds can be used to construct the secondary dykes, using the same basic principles as applied in the construction of the peripheral dyke. The height of the secondary dykes, however need not, in normal cases exceed 1 to 1.5 feet above the surface water level.

In the case of the main feeder canal, the dykes ought to be atleast 2′ above the expected high water level because this canal is directly in the path of the water flow through the master sluice.

2.2.3 THE MASTER SLUICE

The sluice, whether the master sluice or the secondary one, is an integral part of the dyke system. It could be a simple opening in the dyke at the point nearest to the entry of the outer channel into the farm ; such as the sluice used in a freshwater pond system. However, in a dynamic tidal system with diurnal changes in tides and current patterns a simple opening could collapse the dyke or erode it. Therefore, in the brackishwater farm complex of India, which is based on gravitational flows, a master sluice of strong design and construction is necessary. This would be the controlling centre for the water management of the farm. It could be pre-fabricated and placed in the dyke wall with a strong tow wall and other reinforcements.

2.2.3.1 Design

Sluice width

Preliminarily a provisional width is taken and the inflow and outflow of water in a given unit of time are measured ; this is in relation to the tide and elevation of the foundation. Then the volume of water required inside the farm is tested and compared at different tide levels and time intervals. If the water that is entering the farm cannot fill all the ponds to the required level within a specified time (the duration the tide lasts) then another width is tested. Thus, the passage is determined on the basis of flow velocity.

Sluice gate

A master sluice is generally designed to provide a gate. The sill level of it should be above the low water level. The purpose of the master sluice being to control the inflow of water as well as its outflow, the structure should be movable. In order to permit this movement, a strong reinforcement wall of concrete could help, especially in the areas of high tidal amplitudes. A flat board movable vertically on grooves will help. If a single flat board is cumbersome for a single man to operate, a series of boards placed one above the other on the principle of shutters, could be used. This gate could be placed 2—3′ behind the point of entry of the outer channel at the dyke to permit a gradual entry of water. When water is to be taken or let out, only the required number of boards can be opened from the top.

If a single gate is provided, it can be operated by a radial wheel and gear rod lifting device at the top.

Leakages at the grooves, in between boards could occur and care should be taken as per the requirement.

2.2.3.2 Secondary sluices

Secondary sluices are provided at the point of entry of the main feeder canal into the farm complex into different secondary feeder canals, or ponds. Thus, these are provided to control the water flows inside the farm and, therefore, are much simpler structures as compared to the master sluice and less expensive. An example of closed box design (Mukherjee, 1975) has been presented in figure 5.

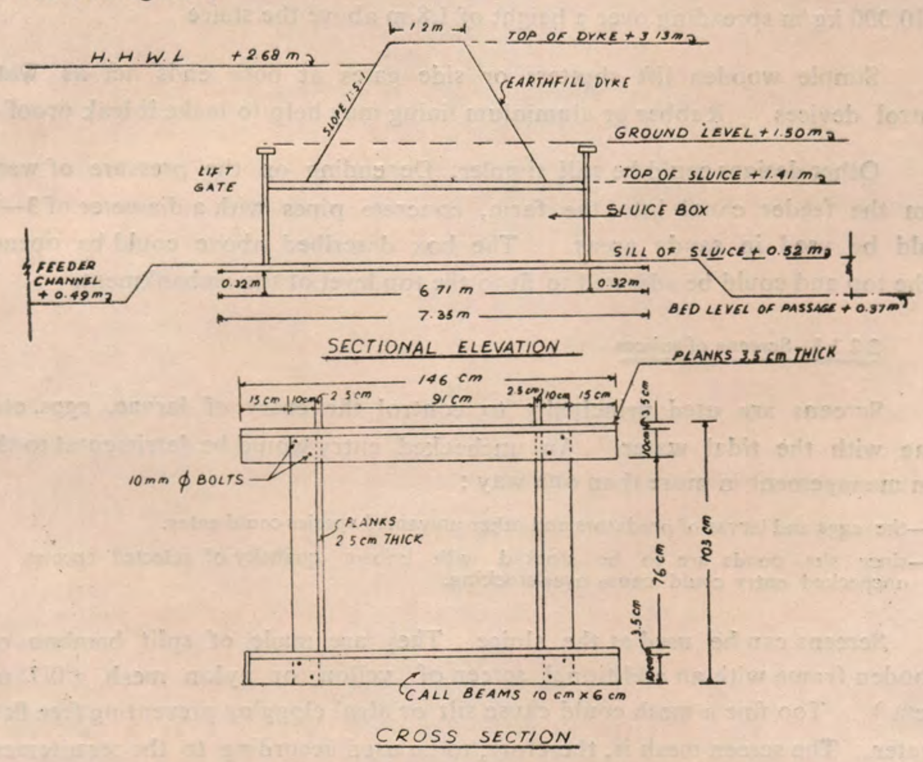


Figure 5 : Master Sluice : Closed box Type

The slucice is a rectangular wooden box, four sides covered by wooden planks. This structure is fitted into the earthern embankment or dyke. As this box remains within the embankment it has to support the vertical earth boards of the embankment on its top. Both sides of the box have to resist the horizontal thrust exerted from the full width of the wooden embankment. The base of the box which is beneath the water level and hence always submerged, is subject to uplift by the subsoil water level. The specifications are :

Thickness of the top planks	:	3.5 cm
,, ,, side ,,	:	2.5 cm
,, ,, base ,,	:	3.5 cm

Frames are placed 65 cm apart. The sluice sustains a vertical earth board of 10,000 kg/m spreading over a height of 1.8 m above the sluice.

Simple wooden lift shutters or side gates at both ends act as water control devices. Rubber or aluminium lining may help to make it leak proof.

Other designs could be still simpler. Depending on the pressure of water from the feeder canal into the farm, concrete pipes with a diameter of 3—5″ could be used in sandy areas. The box described above could be opened at the top and could be adjusted to fit to the top level of the embankment.

2.2.3.3 Screens of sulices

Screens are used principally to control the entry of larvae, eggs, etc., along with the tidal water. An unchecked entry would be detrimental to the farm management in more than one way :

—the eggs and larvae of predators and other unwanted species could enter.

—since the ponds are to be stocked with known quantity of selected species, unchecked entry could cause over-stocking.

Screens can be used at the sluice. They are made of split bamboo on a wooden frame with an additional screen of vellon or nylon mesh (0.1 to 0.2 cm). Too fine a mesh could cause silt or algal clogging preventing free flow of water. The screen mesh is, therefore, to be used according to the requirement of the moment.

The screens are not permanent structures. They should be movable, replaceable and easily constructed. A conical or V-net of nylon with large meshes at the main sluice would prevent entry of larger predators or escape of fish from inside the farm.

2.2.4 THE OUTER CHANNEL, THE MAIN FEEDER CANAL OF THE FARM AND SECONDARY FEEDER CANALS

2.2.4.1 The main outer channel

The flow condition, its velocity, flow direction, depth. etc., determine the main outer channel, which is the water resource for the farm. The high siltation prevalent, for example in some estuaries and creeks, accelerates the degradation of the channel exposing it to erosion or siltation. In such a case, a level should be considered after a model test. The design of the main channel or level should be on the basis of the tidal energy supplied from the main water source.

The maintenance of this channel is part of the management of the brackish watar farm although it lies outside the farm area. If this resource dries up, or is eroded or silted the entrepreneur must incur heavy outlay on another channel.

The channal also serves to take the drainage from the farm and should be at a lower level than the general farm level.

2.2.4.2 The main feeder canal

The outer channel can continue into the farm controlled by the master sluice, as the main feeder canal of the farm.

Layout of ponds could be in a row on either side of this canal in which case a direct flow is available to the ponds through the secondary sluices. Expenditure on extensive secondary canals can be avoided.

Often, in silt laden waters such a direct inlet could, however, be detrimental. The silt gets deposited quickly raising the pond level above the level of the feeder canal. A direct flow brake by way of secondary canals could reduce this load either of silt or sand. Once again, the tide levels at the site chosen are important considerations when laying out a single feeder canal or several. Medium tide levels would mean that at a given spring tide the entire water requirement of the farm could be through this single canal. Therefore, sufficient consideration for this factor is required.

Outlet canal

An outlet canal is not a *'Must'* in a brackishwater farm because the same feeder canal acts as both outlet and inlet. However, when a farm is located in such a way that the natural contours would permit outflow at another point in the farm, then separate outlet is advocated.

2.2.5 *THE PONDS*

The farm extent would determine the number and disposition of the ponds. The second consideration is the expenditure. While digging the top soil which is generally more fertile could be kept aside in order to spread it over the pond bottom after the ponds are ready for use.

Increase in the number of ponds would mean increase in the number of secondary dykes, secondary sluices and increase in the management measures. The total expenditure would increase. Thirdly, the water area would decrease.

Therefore, a general formula given below can be used and modified, if necessary, to suit the individual case :

i) Minimum water area of a pond considered suitable for economic management and production is 0.5 ha.

ii) If larger ponds are dug general drainage of the pond, harvesting. etc., would involve increase in labour and general management problems.

iii) Often sufficient water might not reach the entire pond in one tidal incursion and the tail ends might be left shallow or dry.

iv) Two types of ponds are to be dug : (a) stock ponds, and (b) nursary ponds. The nursary ponds can be of smaller dimensions—0.05 to 0.1 ha are easy to manage These should be adjacent to stock ponds. Outlet and inlet are not necessary adjuncts. Pumping of water from the feeder canal could be done. Water screening is absolutely essential.

Stock Pond

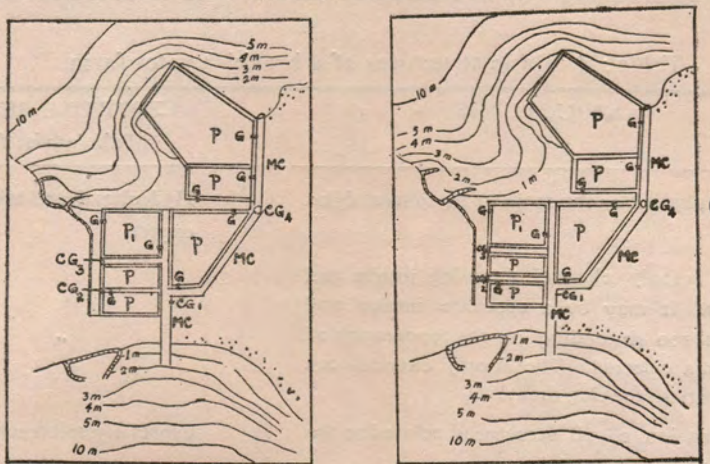
The stock pond is the production unit in a brackishwater farm. The shape of the pond is to be determined on the basis of the configuration of the whole farm. No norms are determined but an elongated or rectangular shape is thought to be suitable for some of the fish such as *Chanos*. These fish move or run fast and hence a longer pond length is advocated. A rectangular shape also helps easier netting of the ponds.

However, when the stock pond is large, considerations of shape of the pond might be of secondary importance while the best utilization of available farm space is of primary consideration.

The depth of the pond under normal conditions is taken to be 1.8 m with a minimum of 1.0 m. Once this depth is determined on the basis of available water, the surface area should be calculated.

In Japanese prawn ponds, it is stated "If the sluice and vertical gate is given a width of 3.4 m under a condition determined from the relationship between the sea level and the elevation of the foundation, it is possible to fill water to a level of 1.8 m with an area of 15 ha and discharge completely within the tides" (Kato, 1975—Fig. 6).

(*b*)



(*a*)

Figure 6 : Hime Jima Prawn Farm (Japan) showing layout of pond and water system—

(*a*) water being taken into pond P_1 ; Gates CG_2 & CG_3 closed and CG_1 opened ;

(*b*) water being discharged from pond P_1 ; gates CG_1 closed and CG_2 opened.

(MC=main channel ; CG=gate to canal, G=gate to pond, and P=fish pond)

Water flow in the pond

It is better to employ a flowing water system with some device inside the pond area. This will increase aeration inside the ponds, especially in the days when no tidal water is available, and keeps the pond clean. It is known that such circulation would increase the production levels.

A device being increasingly advocated is the wind directed wheels or wind mill using cheap indigenous material. A pump operation for a few hours in a day could also be done, water being sprayed back into the same pond.

An outlet channel in the design of the farm, as mentioned earlier, could also be adopted as a aeration/flow method. The outlet should be located diagonally across the inlet with rounded corners of the pond, the jet of tidal water which enters through the inlet and flows out would thus serve to create additional aeration and circulation.

The following table summarises the basic structures of the farm and the expertise required and help in seeking advice from the correct sources.

Table : 4 Basic structures of a brackishwater farm.

	STRUCTURES	EXPERTISE REQUIRED (Take advise from)
1.	Embankment or the main or peripheral dyke.	Hydrulics & soil mechanics expert.
2.	Main supply channel (serving intake and outlet. It may be a separate intake and outlet too depending on the topography of the area selected. The supply channel can also act as stocking area).	,,
3.	Foundation of all structures related to the soil profile.	Especially soil mechanics.
4.	Sluices (related to water levels, gravitational flows, discharge and adjustment, diversion flows, etc.).	,,
5.	Aeration system	Biological as well as engineering.
6.	Screening	,,
7.	Structures for management	,,
8.	Flood control	Hydraulics

2.3 CONSTRUCTION

The foregoing general principles of design and layout of peripheral dykes, secondary dykes, sluices and feeder canals and ponds could help to determine the construction of the farm, materials to be used and the expenditure involved. The height of the peripheral dyke should be based on the known levels of the highest high tides in a calender year in the first instance. However, an average of the past decade, if available, would yield reliable information on which to base the specifications.

In India, use of manual labour is the cheapest and possibly the easiest way of raising the peripheral dykes and digging the ponds especially since most of the brackishwater farms would be located in swampy, mangrove type location with soft clayey soils.

Clay from the area dug for ponds is used for raising the dyke. By this method, two purposes are served : i) Often the dug earth cannot be dispose off nearby and disposal elsewhere would involve enormous cartage charges, and ii) The earth can be used inside the farm for raising the dyke levels, for maintenance of dykes and so on. In course of time, this earth would become less and less saline and then can be used for raising coconut and other crops on the dykes.

In construction of a dyke, the advocated procedure is as follows :—

> Slabs of 30 cm × 75 cm × 10 cm thick are loosened and laid in rows. Each layer is exposed to the sun before a second layer is added on the top. By this method, compaction can be done layer by layer so that the earth does not fall apart at the first rain fall ; subsidence rate also would be slower.

2.3.1 MATERIALS

Materials used in construction are very important. The materials are exposed to the saline waters, constant wear and tear of the constant flow water system. They would need care or replacement much faster than in fresh or standing waters.

2.3.1.1 Pumps

Heavy duty pumps of S—10hp. are to be maintatined for water supply or pump-out in emergencies and water pump-out at the time of harvesting.

2.3.1.2 Material used in construction

Wood

Where available wood is the cheapest material used for structures ; wood can be used for the frame of the sluice screens ; wooden board can be used as sluice boards or shutters. Bamboo takes care of much of the requirements of secondary sluice screens ; to form a screen at points of erosion or subsidence of soil. Wood, however, requires pre-treatment to guard against mollusc and other worm-infestations. Coal tar could be used to protect the wood.

Iron

In case of iron structures, exposure to salty spray could quickly rust the surfaces and in no time it becomes useless. It is advisable to avoid the use of iron in brackishwater structures.

PVC

Use of PVC and fibre-glass is just coming into force in India. Wherever possible PVC fittings are advised in place of iron. Use of fibre-glass is subject to high cost. In the long run, its use in sluice boards might be more economically feasible than wood.

Concrete

Use of concrete pipes (humepipes) at the main supply channel and sluice gate can be hampered by quick accumulation of silt in it. In course of time the silt hardens into thick mud choking off the pipe. It becomes immovable and being beneath the water, very difficult to clean. Concrete is advised only as reinforcing material at the main sluice gates.

Bricks

Use of brick, partly burnt can be done. In some areas of India brick is less expensive than wood. It can be built as a wall near sluice gates for reinforcement of the outer slopes of the dyke, etc. ; It can be easily dismantled when required and it cannot be cut into by crabs.

2.3.1.3 Use of boulder lining

In the farms constructed in sandy soils, soil erosion is a problem. Often boulder lining is done in irrigation canals and drainage channels in the sandy terrian. Such boulder lining of dykes could be done in brackishwater farms when erosion poses a major problem.

2.3.2 EXTENT OF THE FARM

A farm extent would basically depend on only one main factor *viz.*, the economical viability.

2.3.2.1 Economically viable unit

Experience gathered from the exisiting government farms or the wild culture system like *bheries* of West Bengal indicates that a farm to be economicially viable should have a minimum water area of 5 hectares. Economic viability could be defined as follows:

—to be operated by a single *entrepreneur* ; the manager and operator being himself, and the watch and ward being himself or his family members.

—the turn-over or net profits from the farm should help in meeting the committments to the bank (both interest on capital and repayment of loan).

On this basis an economically viable unit can be a 5 ha of water area. It can increase to any large extent provided that unit could be of defined and controllable on the basis of a minimum unit mentioned above.

2.3.2.2 Operational unit

In this case, the viable unit of 5—10 ha extent can be defined as operational unit of 0.5 to 1 h of minimum extent, for a single farmer engaging labour only when required. Starting from 0.5—1 ha minimum extent this operational unit can extend to 5—10 ha or more.

2.3.2.3 Advantages & disadvantages

Small or large operational units have both advantages and disadvantages. The small units are easy to operate or manipulate the water exchange, in case of emergencies such as large scale mortalities. On the other hand, in the case of larger units,, even if partial mortality occurs in an area, the remaining fish can escape to other environmental niches and thus the farmar saves part of the crop.

Larger operational units would require increasing labour, watch and ward. Despite good flow water system, water supply may not reach the tail end of the farm unless separate outlets are present.

In smaller units, with small ponds, two many dykes sluices have to be maintained increasing the labour of the manager, plus costs of maintenance of all the structures.

In a generalized way 50—100 ha farm may have 1—2 ha compartments ; in bigger farms of hundreds of hectares the smallest unit may not exceed 5 ha for the purpose of management.

PART II

BIOLOGICAL FACTORS

Chapter 3

CRITERIA FOR SELECTION OF PRAWNS AND FISH SUITABLE FOR BRACKISHWATER CULTURE : THE SYSTEMATICS OF SELECTED SPECIES

3.1. CRITERIA FOR SELECTION

3.1.1 INTRODUCTION

In this chapter, among other aspects, are described the criteria for selection of species that can be profitably used in brackishwater aquaculture. Systematics of selected forms that might help in their indentification in field are also outlined. Currently, India's brackishwater aquaculture practices are, dependent on the seed abundantly available in the coastal waters of the country. Their diagnostic characters and methods of collection are also described in this chapter.

3.1.2 CRITERIA FOR SELECTION OF SPECIES

The identification of criteria itself is based on knowledge obtained through culture practices followed in India empirically in the 'Bheri' or 'Bhasa-bhada' fisheries of West Bengal and the 'Pokkali' field culture followed in the Kerala coastal regimes as well as traditional knowledge of aquaculture existing in South, South-Eastern , Far-Eastern countries.

CRITERIA

BIOLOGICAL	ECONOMICS
—Environmental adaptability	—Degree of possible market volume and price
—Compatability with other economic species	—Other considerations such as competition with other natural supplies, other areas/regions, etc., which may adversely affect the price.
—Adaptability to intensive culture	

3 1.2.1. Biological criteria

3.1.2.1.1 ENVIRONMENTAL ADAPTABILITY

For the purpose of culture under controlled conditions, we should consider temperature first *viz.*, the range of ambient temperature suitable for production. For maturation of adults, etc., temperature manipulation can be achieved only in the laboratory.

Under pond conditions, optimal growth and survival are important. Other environmental factors are the salinity limitations, turbidity of water and type of bottom soils. The last factor is particularly applicable to prawns. One example of salinity limitation is the Indian white prawn, *Penaeus indicus*, in which case optimal survival and growth cannot be achieved under low or highly fluctuating salinity regime. On the other hand, species of Metapenaeid prawns are highly suitable for culture even in low or fluctuating salinities despite their smaller sizes and lower growth rates.

Mass mortality, especially of prawn, is noticed in brackishwater regimes following sudden rainfall in the hot summer months or storms or at the onset of monsoon usually. Mullets, on the other hand, adapt themselves both to falling salinity as well as sudden environmental changes.

3.1.2.1.2. COMPATABILITY OF SPECIES

This denotes mutual dependence, tolerance, symbiotic relationships or elimination. A good example of species grown together are *Chanos* and *Penaeus monodon* in Philippine waters. There is not only the utilization of different nitches by different type of feeders (a principle adapted in freshwater composite culture practices) but also a factor indicating favourable conditions for growth when these two are grown togather. *Penaeus monodon* and mullets also show this relationship, however, the same studies indicate better growth in combination with *Chanos*.

The basis of polyculture practices is this relationship. In many cases, the studies in this direction are still of a preliminary nature but different combinations of fish and prawns need to be attempted.

A negative relationship is that of the predator, *Lates calcarifer* or a Polynamid like *Eleutheronema tetradactylum* to prawns. The growth of *Lates*, which is fast growing fish, is greatly dependent on fast supply of live feed, fish or prawns. An accidental entry of *Lates* into *Penaeus monodon* ponds might result in total loss of the prawn.

3.1 2.1.3 ADAPTABILITY TO INTENSIVE CULTURE

Intensive culture can be applied to two different phases of aquaculture : 1. the early larval phase, and 2. the production phase to raise table-sized fish when intensive applications of technical nature are made.

Characters in animals which are important to intensive commercial culture are :

- —the ability of the species to reproduce in captivity ;
- —hardiness of eggs and larvae ;
- —food requirements that are readily satisfied ;
- —Acceptance of artificial feed and high conversion value ; and
- —relatively fast rate of growth.

[Not all species meet all these requirements]

Presently, the seed supply of *Penaeus monodon* is from nature ; their post-larvae are easy to segregate, they are amenable to intensive nursery practices given 90% survival ; feed requirements are met with ease using low cost powdered feeds. It is now known that the species does breed in confined conditions in the laboratory and can also be induced-bred under laboratory conditions.

In the case of the fish *Mugil cephalus* there is plentiful natural seed supply, easily satisfied feed requirements ; high survival ; successful induced breeding makes it a candidate species fulfilling conditions of adaptability to intensive culture practices.

The carbs, *Neptunus* and *Scylla*, grow to considerable sizes but their candidature is barred by their tunnelling propensity which is destructive to bunds and embankment ; high rate of cannibalism ; still-to be-developed breeding techniques. Similarly, the candidature of any molluscs in brackishwater cultures are yet in-determinate.

3.1.2.2 Economic criteria

All the foregoing criteria are not fully worthy of consideration unless the economic criteria are also applied to their selection. Species selection is based on consumer preference which in turn control the unit price of the species.

Competition from regional and inter-regional markets also has an effect on the unit price. The main criterion, presently upholding the prawn production, is its international market.

Therefore, from time to time, such factors as fluctuating market prices, changing technologies, variation in consumer preferences should be analysed in selecting a species for culture at a given time in the time series of culture practices to protect the unit price and volume.

Regional and seasonal predominances should also be marked. Local markets are solely governed by seasonality in production from natural supplies, and intra-and inter-regional trade. Good storage and transport system are also to be maintained to maintain the value and volume.

3.1.3 *SPECIES SELECTED FOR CULTURE AND OUTLINES OF THEIR BIOLOGY*

On the basis of the foregoing criteria, a few species ideally suitable for brackishwater culture and some important aspects of their biology are given below. The selection does not preclude any other species of local importance or species for which technology might be developed in future.

3.1.3.1 PRAWNS

The species of prawns selected for culture are :

Penaeus monodon Tiger shrimp or Jumbo tiger prawn
Penaeus indicus Indian white shrimp
Penaeus merguiensis Banana prawn
Penaeus semisulcatus Banded prawn or Green tiger prawn
Metapenaeus monoceros
Metapenaeus brevicornis Yellow prawn
Metapeneus dobsonii

Taking *P. monodon* as an example, the characters which make this prawn a suitable species for culture are :

1. The larvae are abundantly available in nature and quantitatively they dominate the collections in certain months of the year ; they are easy to collect ; easy to transport ; easy to segregate ; techniques for post-larval rearing are known with high percentage of survival.
2. The species is highly responsive to manipulation of temperature and salinity fluctuations.

3. High food conversion efficiency ; many feeds are found to be acceptable.
4. Quick growth rate reaching 30 g average size within 100 days from post-nursery stage whenever optimum temperature and salinity regimes are maintained.
5. The species is found to be amenable to laboratory breeding ; mature specimens brought directly from sea can be used ; recently techniques of ablation have also been proved to be successful [In short, the existing technology is favourable for producing the prawn in commercial quantites].

Characters still to be established are :

1. Low cost and indigenously available synthetic dry food.
2. Techniques of cultivation under raceway systems, under recirculating water systems ; the economic feasibility of conservation of water and space resources which would take the technology to areas other than coastal areas also.
3. Prevention of mortality at sudden rainfalls ; mass kills at certain seasons.

The supply and demand position are presented for each species separately.

3.1.3.1.1 PENAÆUS MONODON

Extensive production of *P. monodon* (Fig. 7) currently is from *bheris* and from capture fisheries of backwaters, brackishwater lakes such as Chilka, Kakinada Bay, Godavari estuarine complex, besides the offshore catches. Same areas are rich seed producing centres too. The species grows to a maximum size of 330 mm.

At the existing price the species commands, *viz.*, Rs. 50-70/kg (heads-on), a weight of 30-35 numbers per kilogram in 90-100 days of production period; the aquaculture of this species is economically viable even in small holdings of 1-2 hactares. For the second size group, 60-100 prawns per kilogram, Rs. 10-15 per kg demand is quite high even in local markets, both in fresh and dry fish markets.

Reproduction and seed supply

Under pond conditions, *P. monodon* does not mature. Ablation has given a successful maturation technique, mature prawns from nature are also amenable to laboratory breeding; sharp temperature rise (28-35°C), salinity increase (28-30 ppt) and dissolved oxygen (5-8 ml/l), high feeding are useful in inducing maturity and spawning.

Developmental stages (applicable to all Penaeids)

The fertilized egg is released directly into the water and further development follows as presented in table 5 and Fig. 8.

Table 5 : Principal larval stages, their duration and feed requirements

STAGE OF DEVELOPMENT	DURATION (in days)	No. of stage	FOOD UTILIZED
Fartilized egg Nauplius	14—16 hours	6	—
Protozoea	3—4 days	4—5	
Zoea (Mysis)	6—8 days	3	Unicellular algae or diatoms rotifers, emulsions of small prawns & *Artemia* nauplii.
Post larve	15—20 days	6—7	Algal powder+yeast+fish or shrimp meal, soyabean cake, mollusc meat, etc.
Juvenile	25—45 days	Reaches table size in 90 days	,, ,,

The rearing of larvae to the post-larval stage can be done in hatcheries ; its success depends on availability pre-filtered, toxicity free sea water supply of required salinity and temperature ; upon aeration ; upon adequate amounts of suitable species of algal diatom or rotifer food and nauplii of *Artemia salina*.

Natural seed supply

Seed of *P. monodon* occurs mostly in the coastal esturaine regions on the eastern coast of India from West Pengal down to Madras coast diminishing in intensity from north to south.

Nursery rearing practices can be followed in earthern ponds, in plastic pools or in recirculating water systems. The post-larvae grow very fast and within 15 days are ready for stocking in earthern ponds. Stocking densities can vary from 0.1 to 0.3 million/ha in the first 30 days and later reduced to 50,000/ha. Juveniles can be collected from inter-tidal pits for direct stocking.

Growth and production

There is no differential growth in sexes. Stocked at a size of 20-30 mm/6 mg, *P. monodon* attains 150 mm/30g on an average in 90-100 days, in summer. Growth is generally temperaturs-dependent simultaneously corresponding to a period of higher salinities, fastest growth being in summer (March to May), medium in monsoon and poor in winter.

Food and feeding

Generally, they are detritus feeders and also omnivorous with strong scavenging tendancies indicating non-selectivity. However, each species does show preferences for selective feeds in confined conditions.

A rational food formula has to be developed. Feed which contains atleast 40-60% protein is found to give fast conversion value. Dietic substances include rice bran, soyabean meal, trash-fish meal, prawn or *Acetes* meal, algal powder, yeast and slaughter house waste, vitamin mix and salts in different combinations. Efficiancy of food intake is greater when the animal is small.

It has been suggested that feeds having an essential amino-acid composition similar to the animal that is being fed will result in better conversion efficiency. Therefore, the type of essential amino-acids should be known.

3.1.3.1.2. PENÆUS INDICUS

Size attained in nature is about 8″. Maximum size attained is 175 mm/38g in an year under culture conditions. In 90 days, the growth is about 110mm/

Figure 7 : Penaeus monodon (Tiger shrimp or Jumbo tiger prawn)

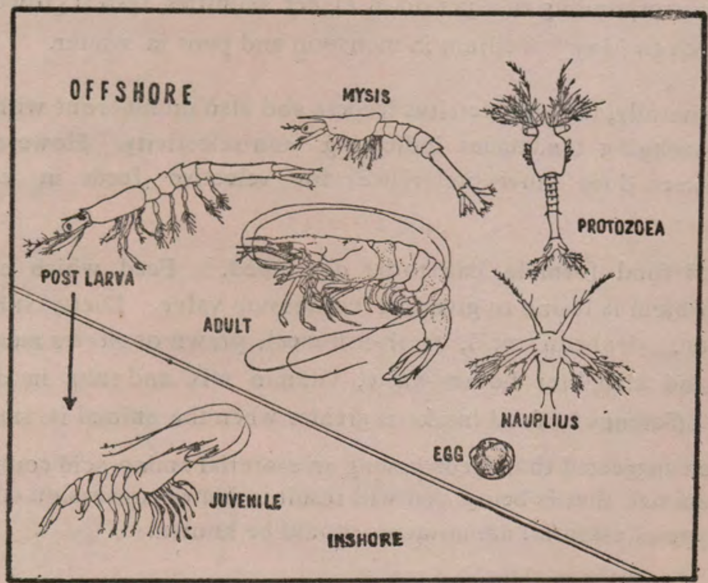


Figure 8 : Showing developmental stages of Penaeid prawns

7.5g. In perennial fields, growth of 135-150mm/15-20g has been recorded in a period of 70-85 days (Fig. 9).

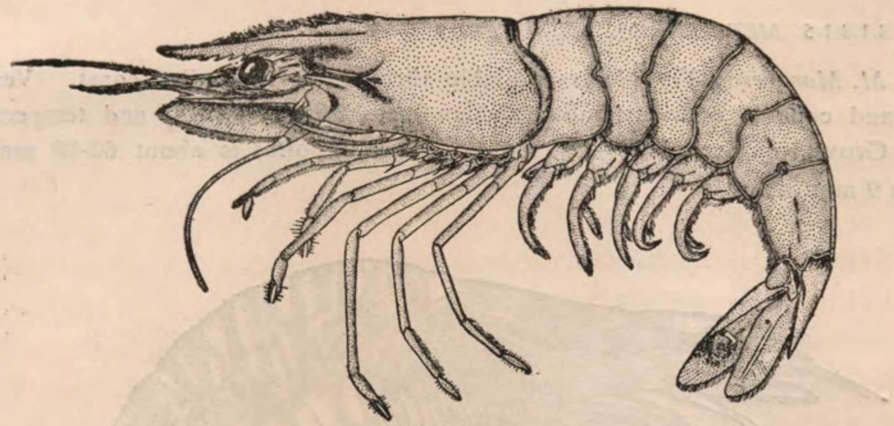


Figure 9 : *Penaeus indicus* (Indian white shrimps)

3.1.3.1.3 *PENAEUS MERGUIENSIS*

Attains a size of over 8″ in nature. Comparable to *P. monodon* in other characterstics of growth and production under culture practices.

3.1.3.1.4 *PENASUS SAMISULCATUS*

The species attains maximum size of 12″ in nature (Fig. 10). Resembles

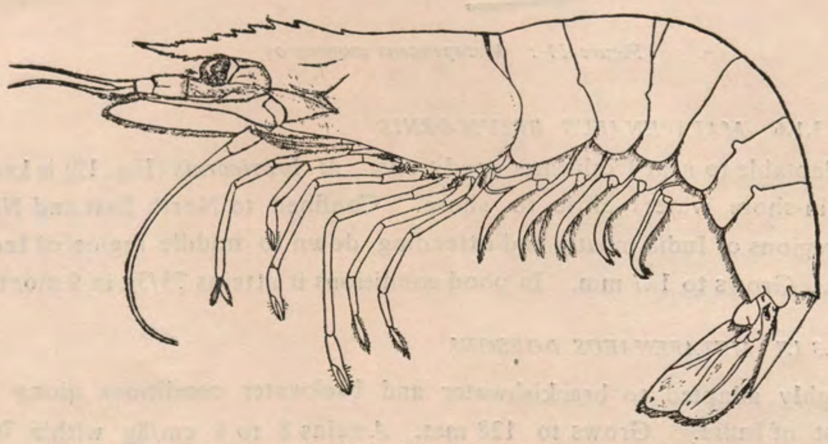


Figure 10 : ***Penaeus semisulcatus*** **(Banded prawn or Green tiger prawn)**

P. monodon in several of characteristics, besides its higher salinity preferences Commands as good a market as *P. monodon*.

3.1.3.1.5 *METAPENAEUS MONOCEROS*

M. Monoceros (Fig. 11) is available throughout the Indian coast. Very hardy and capable of withstanding sudden fluctuations in salinity and temperature. Grows to a size of 170—180 mm. Growth in ponds is about 60-80 mm/ 3.5g in 9 months.

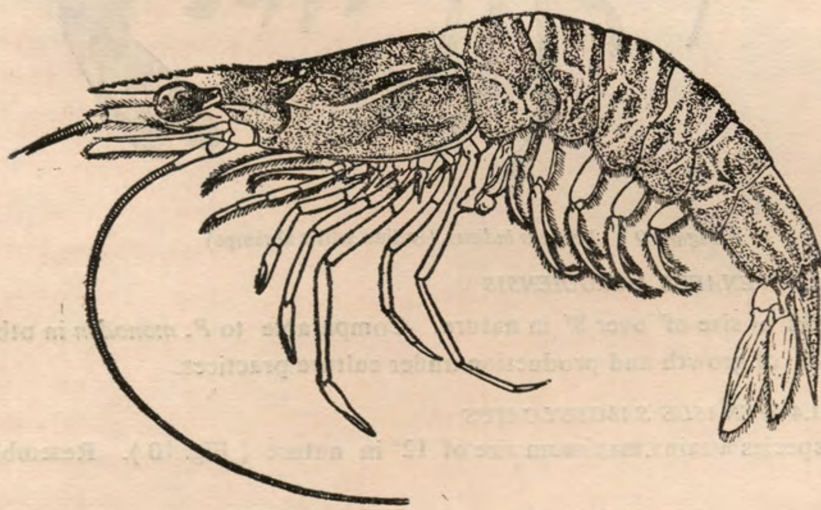


Figure 11 : Metapenaeus monoceros

3.1.3.1.6 *MATAPENAEUS BREVICORNIS*

Adaptable to near freshwater conditions. *M. brevicornis* (Fig. 12) is known to breed in-shore waters close to shore. Confined to North East and North Western regions of India mostly and extending down to middle region of Indian coast line. Grows to 127 mm. In pond conditions it attains 75/3g in 9 months.

3.1.3.1.7 *METAPENAEUS DOBSONI*

Highly adapted to brackishwater and backwater conditions along the west coast of India. Grows to 128 mm. Attains 8 to 9 cm/8g within 70-85 days in perennial waters.

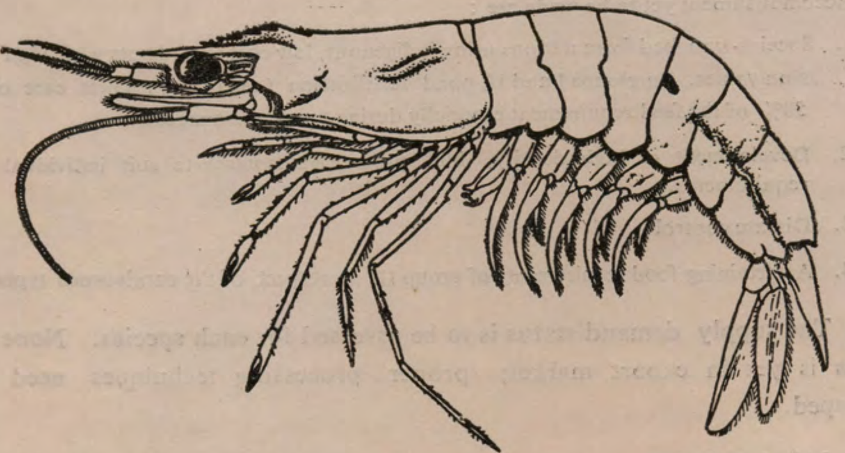


Figure 12 : M. brevicornis

3.1.3.2 FISHES

The species of fish selected for brackishwater aquaculture on the basis of the criteia mentioned earlier are group-wise indicated below :

		Group I
Grey Mullets	:	*Liza parsia; Liza tade; Liza macrolepis, Mugil cephalus; Rhinomugil corsula.*
		Group II
Other fish	:	*Chanos chanos; Etroplus suratensis; Scatophagus argus*
		Group III
Carnivorous types	:	*Lates calcarifer; Elops saurus, Megalops cyprinoides; Eleutheronema tetradactylum*

Progress of research in respect of different groups is as under :

1. *Among group I* : techniques for obtaining eggs and rearing larvae and fry have been developed. Experiments are underway to establish similar techniques for all the species chosen in groups I and III.
2. The natural occurrence of seed, diagnostic characters helpful in identification, methods of collection and segregation, seasons and location of low, medium and high abundance have been established.
3. All the species display high adaptability to temperature and salinity fluctuations.
4. Groups I and II show high food conversion efficiency. A conversion of 1.5 to 2 has been established using dry, powdered and pelleted feeds.
5. Fast growth in captivity is established.

Accomplishment yet to be made are :

1. Species-wise feed formulations using indigenous, low cost ingredients with high conversion values. In groups I and II, pond fertilization (manuring) takes care of atleast 50% of the feed requirement especially during nursery management.

2. Development of high density, high productive systems to suit individual species requirements.

3. Disease control

4. Ascertaining food requirements of group III in respect of the carnivorous types.

The supply demand status is to be assessed for each species. None of the species is yet in export market; proper processing techniques need to be developed.

3.1.3.2.1 MULLETS

Mullets are one of the most desirable groups of fishes from the consumer point of view as Penaeid prawns are among shell fish. Even in regions where predominantly freshwater fish are sought after, mullets command high market preference.

Another point in favour is that one or other of the species of mullets occurs along both coast lines of India, thus saving seed import cost. All species are hardy; low in food chain being herbivores; high tolerance to salinity fluctuations (0-38 ppt was recorded); accept supplemental feeds ; high percentage survival. Although maturation does take place in estuaries, breeding occurs only in offshore areas of the sea. Recently artificial spawning has been successful in *M. cephalus*. But routine spawning is not yet practiced.

The similarity of their habits makes it possible to substitute species within the same rearing systems when such necassity occurs.

LIZA PARSIA

The species (Fig. 13) attains 150-190 mm/30-50g under pond conditions in one year. However, it is more economical to harvest it at a size of 20-25g in about 6-8 months grow-out time because growth slows down after this time. At a stocking density of 2-3 lakhs/ha of fry of 17-20 mm, 75-90% survival is possible within a rearing period of 30 days. Beyond this period, the stocking density could be reduced to 1 lakh to 50,000/ha.

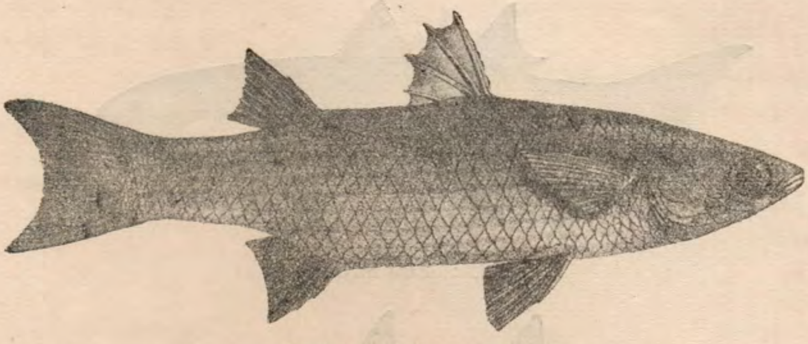


Figure 13 : Liza parsia

LIZA TADE The species attains an average size of 200mm/100g in one year under pond conditions. The growth in 2nd year of life is faster when it could attain a size of 350-500mm/300-500g. For profitable productions, therefore, two biological years are advised starting from the fry stage. At a stocking density of 2-3 lakhs, 60-75% survival is possible in 30 days rearing time. After thinning to 50,000 to 1 lakh/ha the fry grow to a size of 75 mm in 3 months. *L. tade* (Fig. 14) reaches a length of 70 cm in nature.

Figure 14 : Liza tade

LIZA MACROLEPIS The species resembles *L. parsia* in growth and production potential. *L. Macrolepis* (Fig.15) grows to about 225mm in the first year.

MUGIL CEPHALUS In one year the species attains a size of 400mm/800g. Supplemental feeds consist of rice bran, maize powder or wheat powder and fish meal. However, in all the mullet ponds, artificial fertilization is done with organic or inorganic fertilizers. *M. cephalus* (fig. 16) attains a size of 50-55cm/1.2 to 2 kg in 4-6 years in nature.

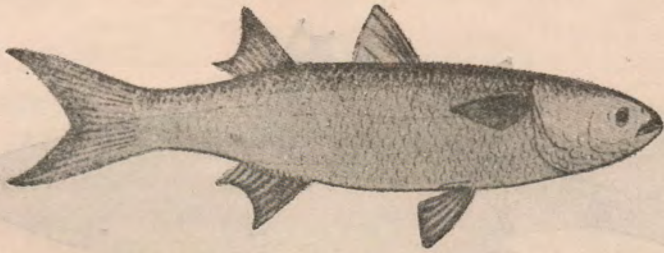


Figure 15 : *Liza macrolepis*

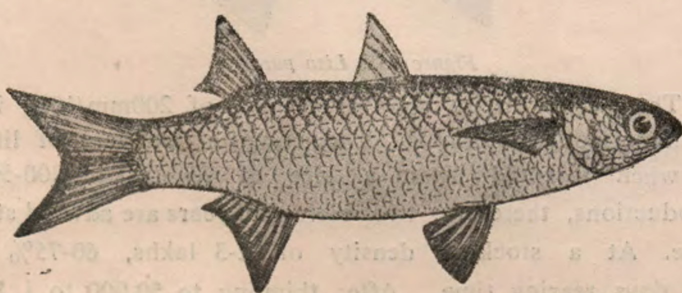


Figure 16 : ***Mugil cephalus***

RHINOMUGIL CORSULA Adapts even to freshwater conditions. Fry of this species prefer copepods and insects.

3.1.3.2.2 CARNIVOROUS TYPES

LATES CALCARIFER The species (Fig. 17) commands high consumer preference and high unit price all along the eastern States. Its food preferences are mainly predatory. Therefore, individual pond space and special live feeds are required for monoculture. Live fishes, snails, prawns especially ***P. monodon***, worms and Mysids are preferred.

Because of this high predatory tendencies, all brackishwater farms might not accommodate this species. Also the fast growth rate noticed in this species is possible only when such live food preferences are met with at daily frequency. A kilogram growth under such conditions is possible in one year.

ELEUTHERONEMA TETRADACTYLUM Another common predator, can be grown together with *Lates calcarifer*. However, this species is less hardy. *E. teradactylum* (Fig. 18) grows to amaximum size of 180 cm.

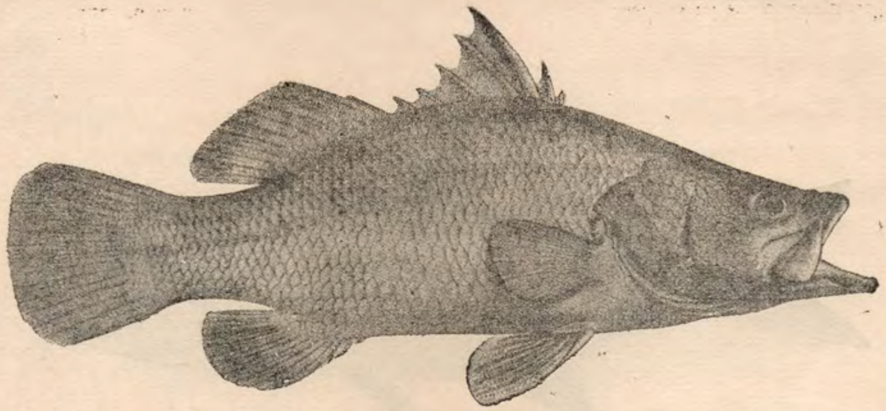


Figure 17 : Lates calcarifer [redacted]

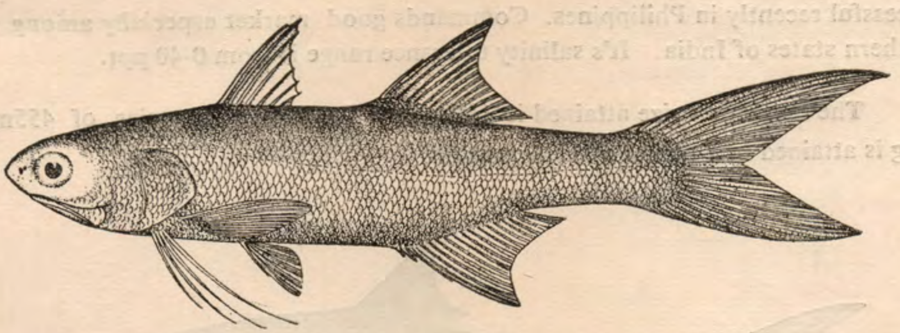


Figure 18 : Eleutheronema tetradactylum

ELOPS SAURUS It grows to a size of 600 mm. Under pond conditions the size attained is 400 mm in one year.

MEGALOPS CYPRINOIDES It grows to size of 600 mm and under pond conditions 400 mm in one year. Highly adaptable to fluctuation in salinities (Fig. 19).

3.1 3.2.3. OTHER FISH

CHANOS CHANOS The milk fish (Fig. 20) is the most common species in the brackishwater systems in South-east Asia. In India, it commands a next place only to the mullets. It is found to grow fast either in monoculture or in combination with *P. monodon*. A type of food commonly called *lab-lab* is especially grown on the pond bottom to fulfill its food requirements. The species is very hardy. Grows fast. Attempts of breeding in captivity have been

Figure 19 : Megalops cyprinoides

successful recently in Philippines. Commands good market especially among the southern states of India. It's salinity tolerance range is from 0-40 ppt.

The maximum size attained is 150 cm. In polyculture size of 455mm/ 550g is attained in a period of 15th months.

Figure 20 : Chanos chanos

ETROPLUS SURATENSIS Highly adapted to brackishwater systems. It is hardy, breeds in impoundments, shows parental care ; can be easily acclimatized to freshwaters even. Commands high market preferences. The species (Fig. 21) attains a size of 190mm in nature.

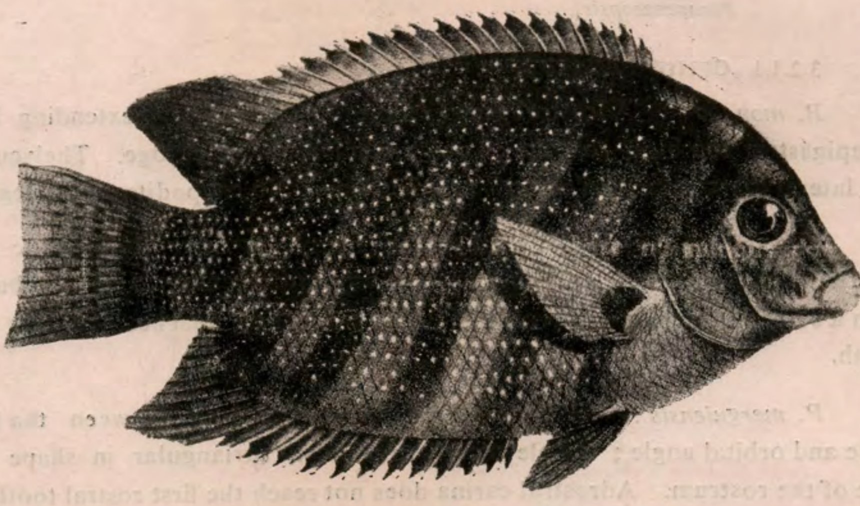


Figure 21 : *Etroplus suratensis*

3.2 GENERAL SYSTEMATIC POSITION OF THE CULTIVABLE PRAWN AND FISHES OF INDIA

3.2.1. *BRACKISHWATER PRAWNS*

Phylum : ARTHROPODA	Order : DECOPODA
Class : *CRUSTACEA*	Suborder : Natantia
Sub-class : Malacostraca	Section : Penaeidea
Series : Eumalacostraca	Family : PENAEIDAE
Superorder : Eucarida	Subfamily : Penaeinae

1. Rostrum serrated on both edges; a pleurobranch on the last thoracic somite (xiv); exopodite on all, or all but the last pair of thoracic legs

First pair of chelipeds short and slender in both sexes :

[Genus : *Penaeus*]

2. Rostrum serrated on its dorsal edge only

i. A pleurobrach on somite xiii. but not on somite xiv. Exopodites on all, or all but the last pair of the thoracic legs : [Genus : *Metapenaeus*]

ii. No pleurobranchiae on somites xiii and xiv ; all the thoracic legs with exopodites

Exopodite absent from atleast the last three pairs of thoracic legs. [Genus *Parapenaeopsis*] . . . . . .

3.2.1.1 GENUS *PENAEUS*

P. monodon : Adrostral groove present ; shallow not extending beyond 1st epigastric tooth on rostrum ; a longitudinal hepatic ridge. Thelycum with two lateral lobes meeting along with median line. No exopodite on 5th leg.

P. indicus : Gastero-orbital carina present, proximal to hapatic spine ; rostrum slender extending straight without any prominent crest at its base but with a somewhat triangular profile. Adrostral carina reaches the first rostral tooth.

P. merguiensis : Gastero-orbital carina present between tha hepatic spine and orbital angle ; an elevated rostral crest, triangular in shape at the base of the rostrum. Adrostral carina does not reach the first rostral tooth.

P. semisulcatus : Adrostral carina goes beyond the epigastric tooth, the post rostral distinctly grooved ; hepatic inclined downward anteriorly. A small exopodite on 5th leg.

3.2.1.2 GENUS *METAPENAEUS*

M. monoceros : Rostrum generally short. Rostrum straight without rostral crest ; it extends beyond the second segment of the antennular peduncle ; a carinated first abdominal segment.

M. brevicornis : Rostrum curved with a marked crest ; it does not extend beyond the second segment of the antennular peduncle ; first abdominal segment not carinated.

M. dobsoni : Rostrum curved with a basal crest ; last pair of thoracic legs fall short of the middle of the antennal scale.

3.2.1.3 GENUS *PARAPENAEOPSIS*

P. styliferus : Rostrum highly curved at the tip. Hepatic carina continues to the branchioptegal spine strong telson spines present.

P. sculptilis : Rostrum moderately curved at the tip. Hepatic carina does not continue to branchioptegal spine ; dark transverse bands on the body.

3.2.2. BRACKISHWATER FISHES

Class : TELEOSTOMI

Subclass : *ACTINOPTERYGII*

3 2.2.1 **Order** : MUGILIFORMES

Suborder : *MUGILOIDAE*

Family : **MUGILIDAE**

Interdorsal spaced wide, about $1\frac{1}{2}$/-2 times base of spinous dorsal ; snout rounded ; pectoral high ; no socketted teeth in mouth. No detached finlets behind anal and 2nd dorsal fins.

GENUS : *Liza*

L. parsia

L. tade

M. cephalus

L. macrolepis

GENUS : *Rhinomugil*

R. corsula

3.2.2.2. **Order** : CLUPEIFORMES

suborder : *CLUPEOIDEI*

Mouth large ; not terminal gill membrances entirely free below ; accessory branchial organ absent.

Family ; **ELOPIDAE**

Abdomen smooth, non-keeled ; Gular plate present ; Scales small (L l abɔve 90) ; anal fin short (less than 20 rays).

GENUS : *Elops*

E. sauras

Family : **MEGALOPIDAE**

Scales large (L.1. below 50) ; anal fin moderate (more than 20 rays).

GENUS : *Megalops*

M. cyprinoides

Suborder : *CHANOIDAE*

Family : **CHANIDAE**

Doral fin situated in trunk region of body ; mouth small, terminal ; gill membrane entirely united belew ; accessory branchial organ present.

GENUS : *Chanos*

C. chanos

3.2.2.3 **Order : PERCIFORMES**

Suborder : *PERCOIDEI*

Family : **CENTROPOMIDAE**

Inter-dorsal space narrow (or absent), less than spinous dorsal ; head not depressed, without spines and bony ridges ; no protuberant spine before dorsal ; caudal fin rounded, scales ctenoid.

GENUS : *Lates*

L. calcarifer

Family : **CICHLIDAE**

Operculum smooth ; anal spines 12-16 ; accessory branchial organ absent.

GENUS : *Etroplus*

E. suratensis

Family : **SCATOPHAGIDAE**

Preoperculum smooth and unarmed Anal with spines.

GENUS : *Scatophagus*

S. argus

3.2.2.4. **Order : POLYNEMIFORMES**

Family : **POLYNEMIDAE**

Lower pectroal rays free and filamentous with 4 free pectroral filaments.

GENUS : *Eleutheronema*

E. tetradactylum

Chapter 4

FIELD IDENTIFICATION CHARACTERS OF PRAWN AND FISH SEED

4.1. FIELD IDENTIFICATION CHARACTERS OF SEED PRAWN AND SEED FISH SELECTED FOR CULTURE

Seed in fresh collections yield characters of identification based on :

i) Colour : Distribution of pigments on the various parts of the body;
ii) Swimming behaviour;
iii) Orientation of body in relation to light, to the depth of water in the container, etc.

Immediate segregation is advisable for easy identification and also to avoid mortality.

4.1.1. CHARACTERS OF IDENTIFICATION BETWEEN PENAEID AND CARIDEAN GROUPS OF PRAWNS

Species of *Penaeus*, *Metapenaeus* and *Parapenaeopsis* can be distinguished from the Caridean group of prawns by three important characters :

i) Three pairs of chelate thoracic legs against two pairs in Caridean prawns; no noticeable difference in size of 2nd pair of legs.
ii) The second abdominal segment overlaps the first and third in the Caridean prawns.
iii) In the first group, the tail is more slender and elongated; The 'head' portion is unusually prominent and the tail more rounded in Caridean prawns.

(See fig. 22 A and B).

4.1.2 CHARACTERS OF BREEDING AND MAIN DEVELOPMENTAL STAGES OF PENAEID PRAWNS

All Penaeid prawns breed offshore, in the sea at different depths. The fertilized eggs are released in to the water. The larval and post-larval forms enter the lagoons, creeks, estuaries and backwaters along the coast as part of the planktonic mass migrations.

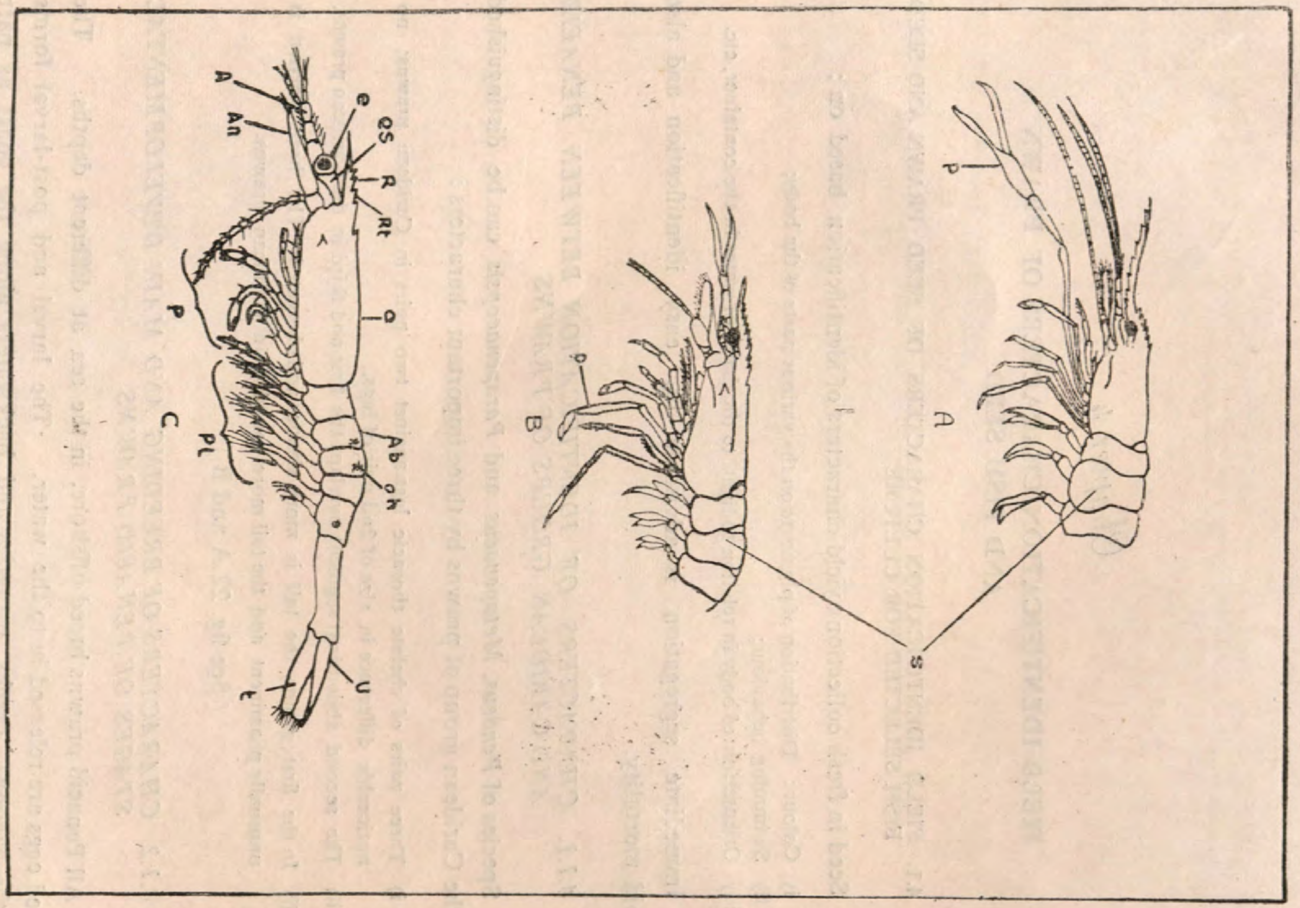


Figure 22 : Showing distinguishable characters of Caridean (A) and Penæid (B) prawns. A typical post-larva (C) of a Penaeid is also presented [R : rostrum, C : carapace, Ab : abdomen, e : eye, es : eye-stalk, A : antennule, An : antenna, P : periopods, t : telson, U : uropod, ch : chromatophore, S : 2nd abominal segment].

Generally, the penaeid eggs hatch and metamorphose through four distinct stages :

Stages and Number :	Nauplius	Zoea	Mysis	Post-larva
	4—5	3	3	6—7
Duration in time :	3—4 days		Upto 6—8 days	Upto 15—20 days

In post-larval stage (Fig. 22C), in fresh collections the colouration on the body (chromatophore distribution), the size and shape of rostrum and dentation on the same and other characters of the size and shape of the body can be used, by practice, to distinguish from species to species.

For nursery rearing, post-larval stage is the best or optimal phase both in terms of field collection, identification and, rearing through various stages to juvenile phase when it can be directly transferred into the production ponds.

The first post-larva can be distinguished by the following characters :

i) Pleopods (the swimming legs present on the 'tail' or abdomen) act as functional locomotory organs, the fine hair like setae developed on all pleopods help in this function.

ii) Other changes occur on body such as loss of spines on the dorsal part of the abdominal segments

4.1.3. FIELD IDENTIFICATION CHARACTERISTICS OF POST-LARVAE AND JUVENILES OF PENAEID PRAWNS SELECTED FOR CULTURE.

The description pertains to the early post-larvae. Advancing stages of post-larvae and juveniles would show increase in length and increase in teeth on rostrum.

4.1.3.1 *Penaeus monodon* (Fig. 23 A, B, C)

Size range of the post-larvae is from 6 to 14 mm in total length. Body very slender and elongated. Very difficult to distinguish in shooting net collections in turbid waters unless transferred to a tray with white background.

Rostrum : Just reaches beyond the eye stalk. Eyes are smaller and eye-stalk shorter than in *P. indicus*.

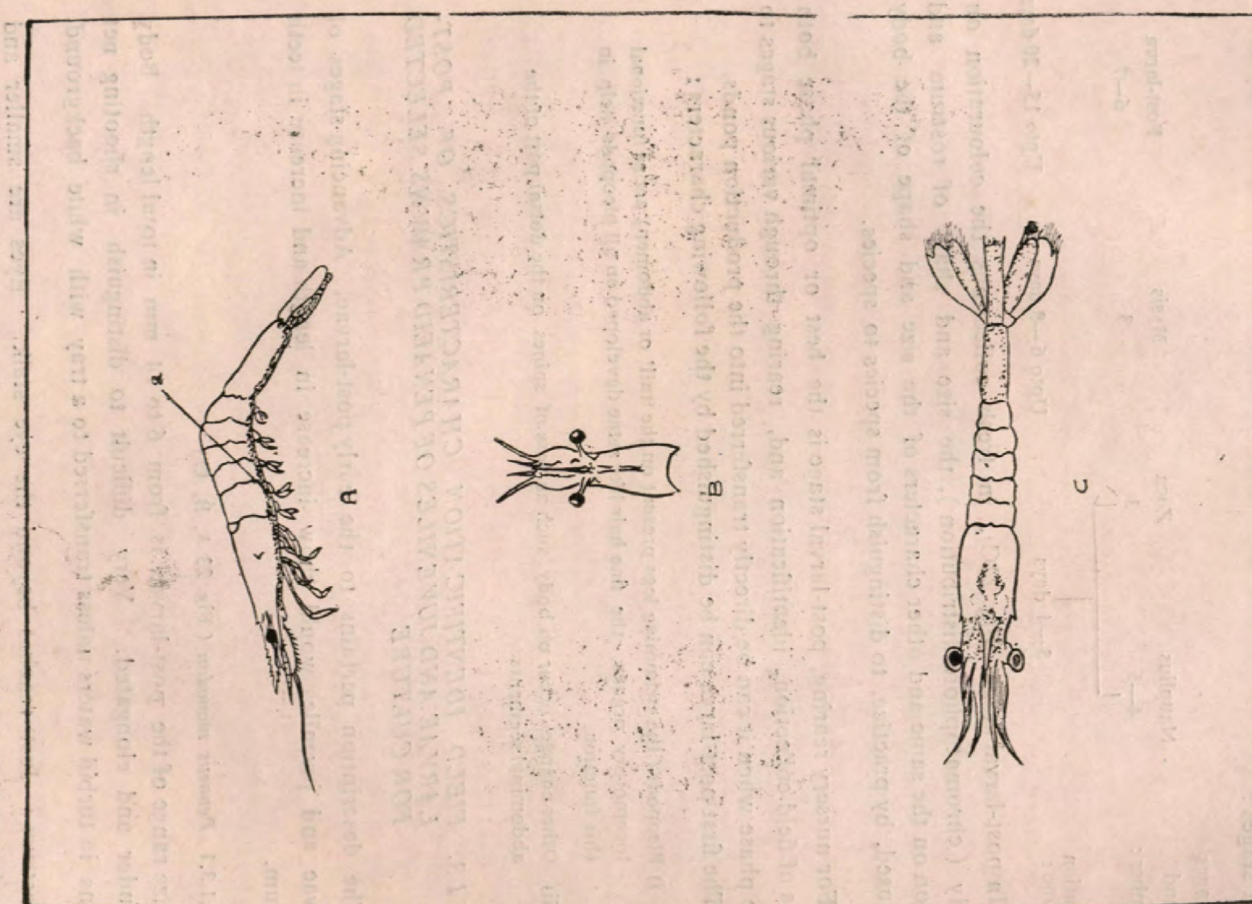


Figure 23 : Showing advanced post-larvae of ***Penaeus monodon*** : (A) ventral longitudinal band of pigmentation (a) ; (B) head region showing relative size of eyes and stalk ; and (C) dorsal view of early post-larva.

Colouration : A red streak is present along the entire ventral side of the abdomen. On closer look, 14-19 reddish brown chromatophores are visible on the ventral side of the sixth abdominal segment. In larger specimens, over 15 mm, reddish streak turns pink and then green.

Swimming behaviour : Very rapid straight movement along the edges of the container. Tend to attach themselves to any resting twigs or algal masses. In containers the larvae tend to congregate in schools.

Juveniles : In juveniles, beyond 20 mm size considered as early juveniles, the green colour spreads to the entire body with a prominent streak on the ventral side of the body. As the size increases the entire body becomes dark green.

The rostrum has now teeth on the dorsal side and on ventral side. It reaches quite beyond the tip of the antennules.

4.1.3.2 *Penaeus indicus* (Fig. 24 A, B, C, D) :

Size : The size range is from 5.00 to 10.00 mm in total length.

Colouration ; To the naked eye the post-larvae is, in general, transparent white in colour excepting for pink colouration at the tip of the rostrum and the tip of the telson.

Antennular peduncle tipped by light reddish colouration. Light yellowish colour on eye-stalks. A few branched brownish chromatophores tinged with yellow present on the mid-carapace and on few of the mid-abdominal segments and telson.

A single dorsal tooth is present on the rostrum. The rostrum extends very slightly beyond the eye in the first post-larvae. A well-defined super-orbital hepatic spine. A median dorsal and lateral spine is present on the 5th and 6th abdominal segments. Anal spine is also present.

Swimming behaviour : Post-larvae swim fast, moving along edges and surface of the container. When disturbed they try to jump out. In swimming position, a prominent mid-dorsal abdominal bend is very characteristic.

Juveniles : Body remains transparent white upto a length of 25mm. Red spot at the tip of the rostrum continues to be present. On the uropod and telson a few dark reddish brown spots occur. Rostral formula is $\frac{8}{7}$; the length of the rostrum is about 6-8mm.

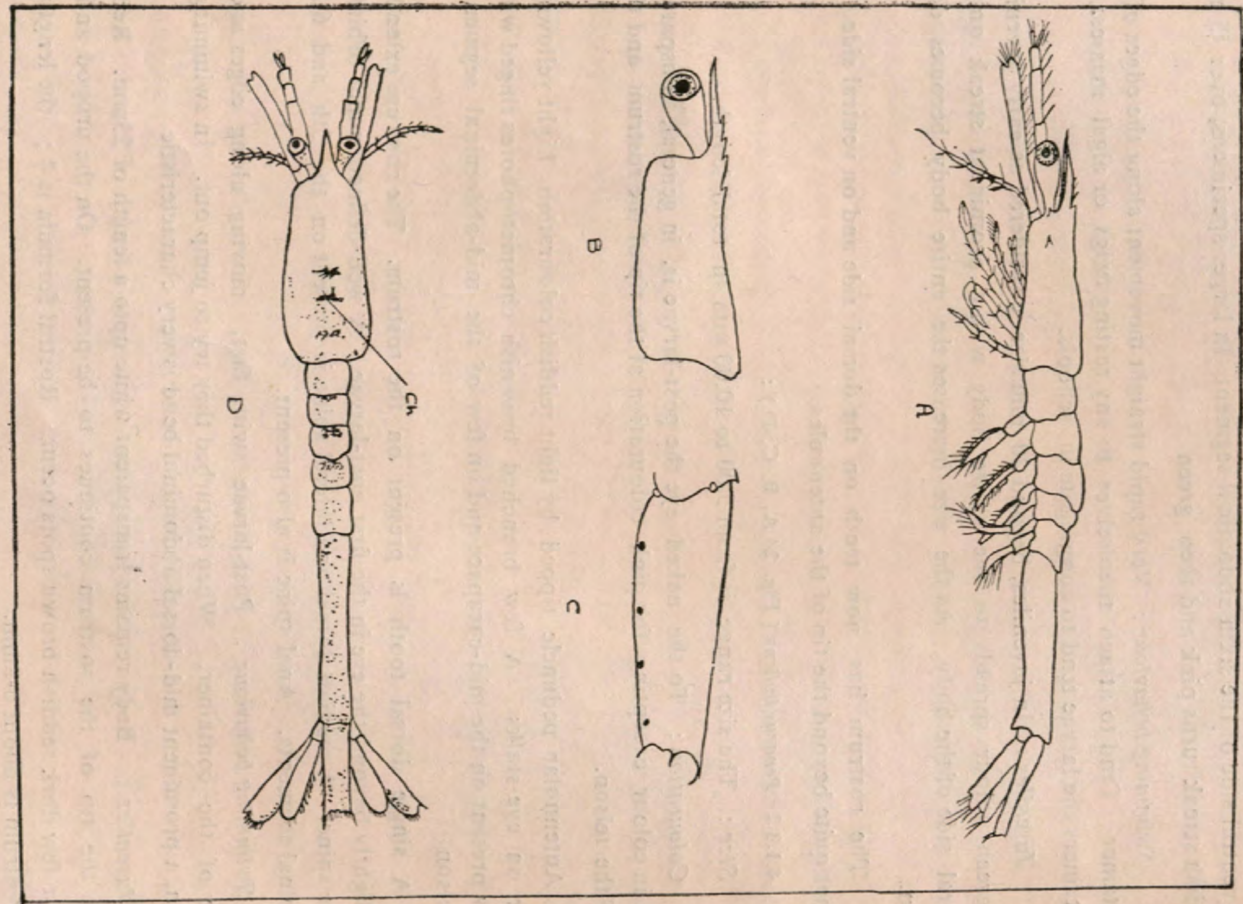


Figure 24 : Showing (A) early post-larvae of *P. indicus*. Teeth of rostrum not developed, (B) carapace of advanced post-larva, (C) 6th aqdominal segment showing pigmentation, and (D) dorsal view showing chromatophores (ch).

The elongated selender rostrum is the principal identifying character.

4 1.3.3 : *Penaeus merguiensis* (Fig. 25 A and B) :

Penaeus indicus and *P. merguiensis* show very close resemblance. Therefore, greater care and attention to detail is required in distinguishing them.

Rostrum : In *P. merguiensis* also the rostrum is slender and elongated as in *P. indicus*. However, the elevation at the basal region of rostrum is not so-well defined in *P merguiensis*, extending only slightly on to carapace.

Colouration : Deeper colouration on the entire surface on antennular and antennal flagellae, usually reddish. The general body colour is whitish instead of transparent.

Juveniles : The juveniles differ greatly from adult and are likely to be mistaken for another species. The rostral formula is $\frac{8}{6}$ with five of the dorsal teeth behind the cornea. The rostrum is long, curving upward anteriorly. Its crest is low. The body is pigmented. The dark granules distributed over the body gives it a spotted appearance, the tail being darker. Banded antenna.

4.1.3.4 *P. semisulcatus* (Fig. 26 A & B) :

The post-larvae are more or less identical to *P. monodon.*

Rostrum/Colouration : 8—11 reddish brown extends beyound the eye spots on the underside of sixth abdominal segment.

Genus *Metapenaeus* :

Post-larvae in general are shorter in total length and rounder in appearance as compared to Penaeus post-larvae at similar stages of development. Secondly there is greater pigmentation all over the body clearly distinguishing them.

4.1.3.5 *Metapenaeus monoceros* (Fig. 27 A, B, C, D)

Often late mysis stages and post-larvae occur together in field collections. The size range of post-larvae is 3 75-4.00 mm in total length. The late mysis measures about 3—3.5 mm.

Rostrum : Rostrum is very small falling short of the middle of the eye-stalk. The tip of rostrum is acutely pointed. Two principal teeth are borne at the base of rostrum and one smaller tooth in front of the first principal one. A dorsal spine on 6th abdominal segment only.

Figure 25 : —>
Carapace showing rostrum and teeth of (A) *P. merguiensis*, and (B) *P. indicus*.

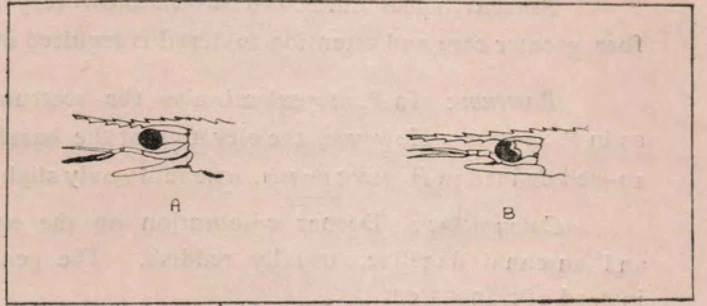
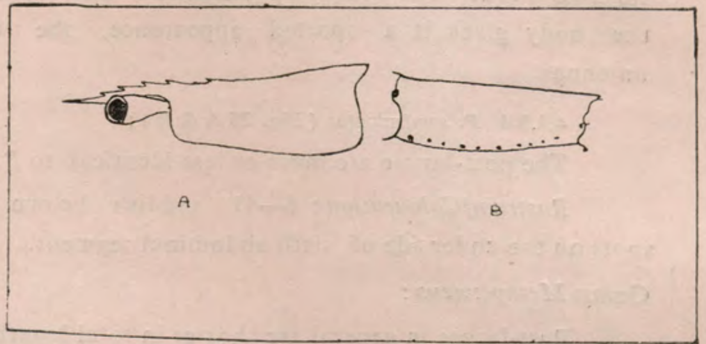


Figure 26 : —>
P. semisulcatus: (A) Carapace showing rostrum, teeth and eye, and (B) distribution of pigment spots on 6th abdominal segment.



Colouration: The colouration is the most characteristic feature. The post-larvae can be identified with naked eye by the characteristic brown colouration. Reddish pigmentation on antennular peduncles, profuse reddish chromatophores on the ventral side of abdomen and on entire telson gives total dark brownish appearance. Most of these are branched chromatophores as can be seen under microscopic examination. In later post-larvae on the sides of the carapace bluish brown spots concentrate to form a band. A 'M' shaped bluish black patch is also seen on the dorsal side of abdomen at this stage.

Swimming behaviour: Show movements in one straight line direction. No jerky motions. These larvae usually rest at the sides of the containers.

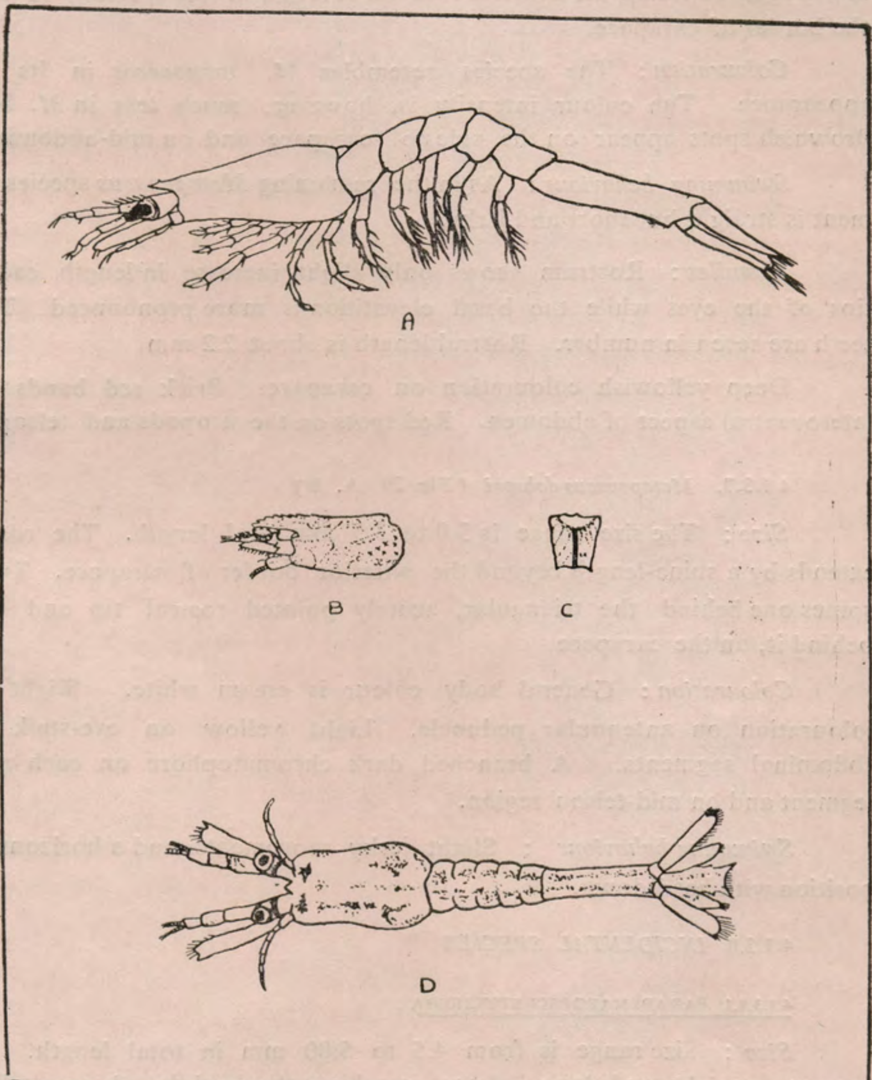


Figure 27 ; *Metapenaeus monoceros* : (A) early post-larva, (B) carapace grouped rostral teeth., (C) back of abdomen showing the 'M' like pigment patch, and (D) dorsal view of early post-larva showing chromatophore distribution.

4.1.3.6. *Metapenaeus brevicornis* (Fig. 28 A, B, C) :

Size : The size range of the post-larvae is 3.0-3.5 mm. Of all the *Metapenaeus* species, the shortest rostrum is found in this species. It just touches the border of carapace.

Colouration : The species resembles *M. monoceros* in its brownish appearance. The colour intensity is, however, much less in *M. brevicornis.* Brownish spots appear on the sides of carapace and on mid-abdominal region.

Swimming behaviour : As in the remaining *Metapenaeus* species the movement is straight but short and jerky.

Juveniles : Rostrum shows only slight increase in length exceeding the tips of the eyes while the basal elevatinon is more pronounced. The dorsal teeth are seven in number. Rostral length is about 2.2 mm.

Deep yellowish colouration on carapace. Brick red bands along the lateroventral aspect of abdomen. Red spots on the uropods and telson.

4.1.3.7. *Metapenaeus dobsoni* (Fig. 29, A, B)

Size : The size range is 3.0 to 3.5 mm total length. The rostrum just extends by a spine-length beyond the anterior border of carapace. Two dorsal spines one behind the triangular, acutely pointed rostral tip and the other behind it, on the carapace.

Colouration : General body colour is cream white. Slight brownish colouration on antennular peduncle. Light yellow on eye-stalk and on abdominal segments. A branched dark chromatophore on each abdominal segment and on mid-telson region.

Swimming behaviour : Slight jerky movements and a horizontal resting position with head down.

4.1.3.8 *INCIDENTAL SPECIES*

4.1.3.8.1 PARAPENAEOPSIS STYLIFERA

Size : Size range is from 4.5 to 5.00 mm in total length. Rostrum narrow, straight and long, almost reaching the middle of eye-stalk. Two dorsal rostral spines, the posterior one being at the level of frontal margin of carapace. No dorsal or lateral spines on the abdominal segments.

Colouration : Light brownish on antennular peduncles. Yellowish

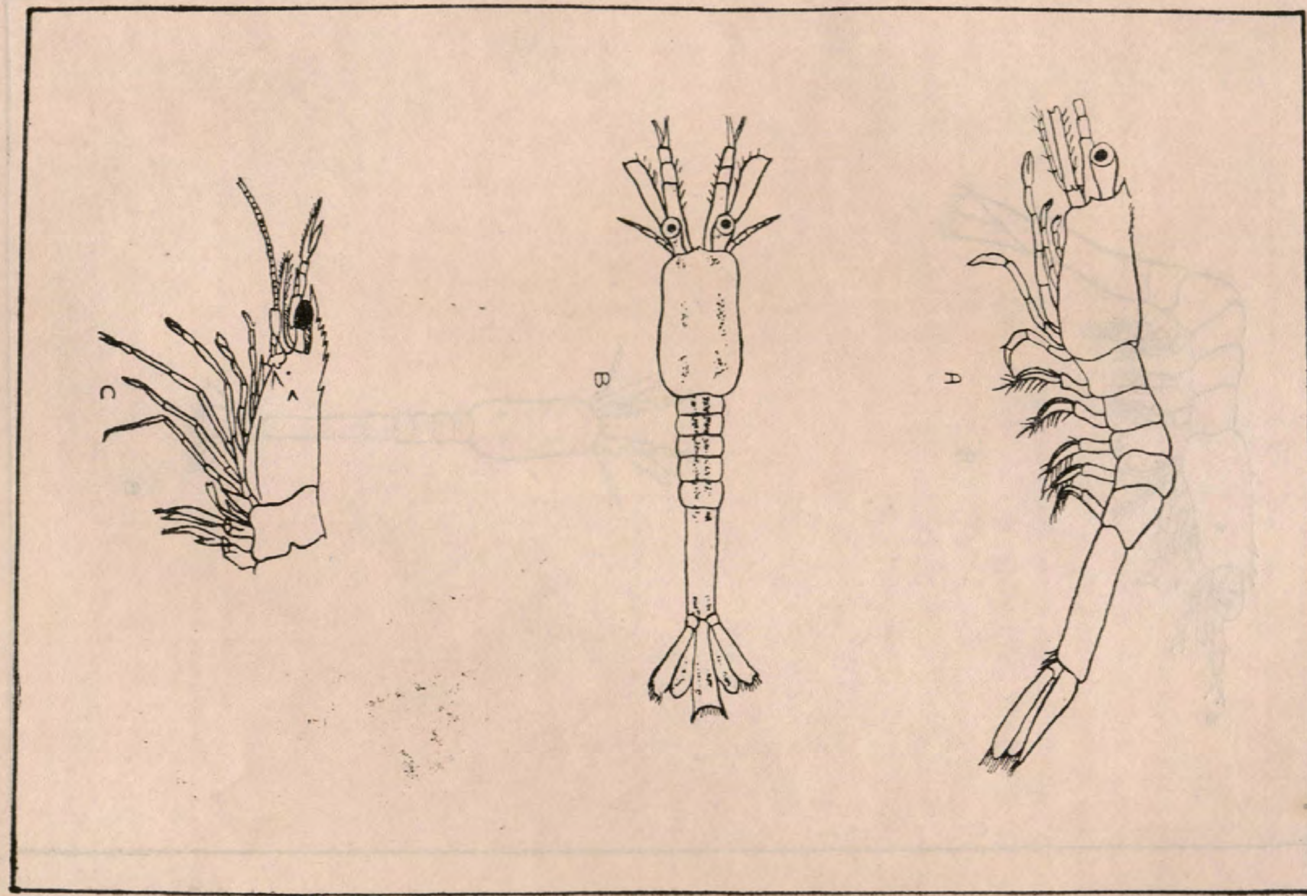


Figure 28 : *M. brevicornis* : (A) early post-larva showing short but elevated rostrum, (B) dorsal view of early post-larva to show chromatophore distribution, (C) head region of juvenile showing carapace with dorsal teeth and other appendages.

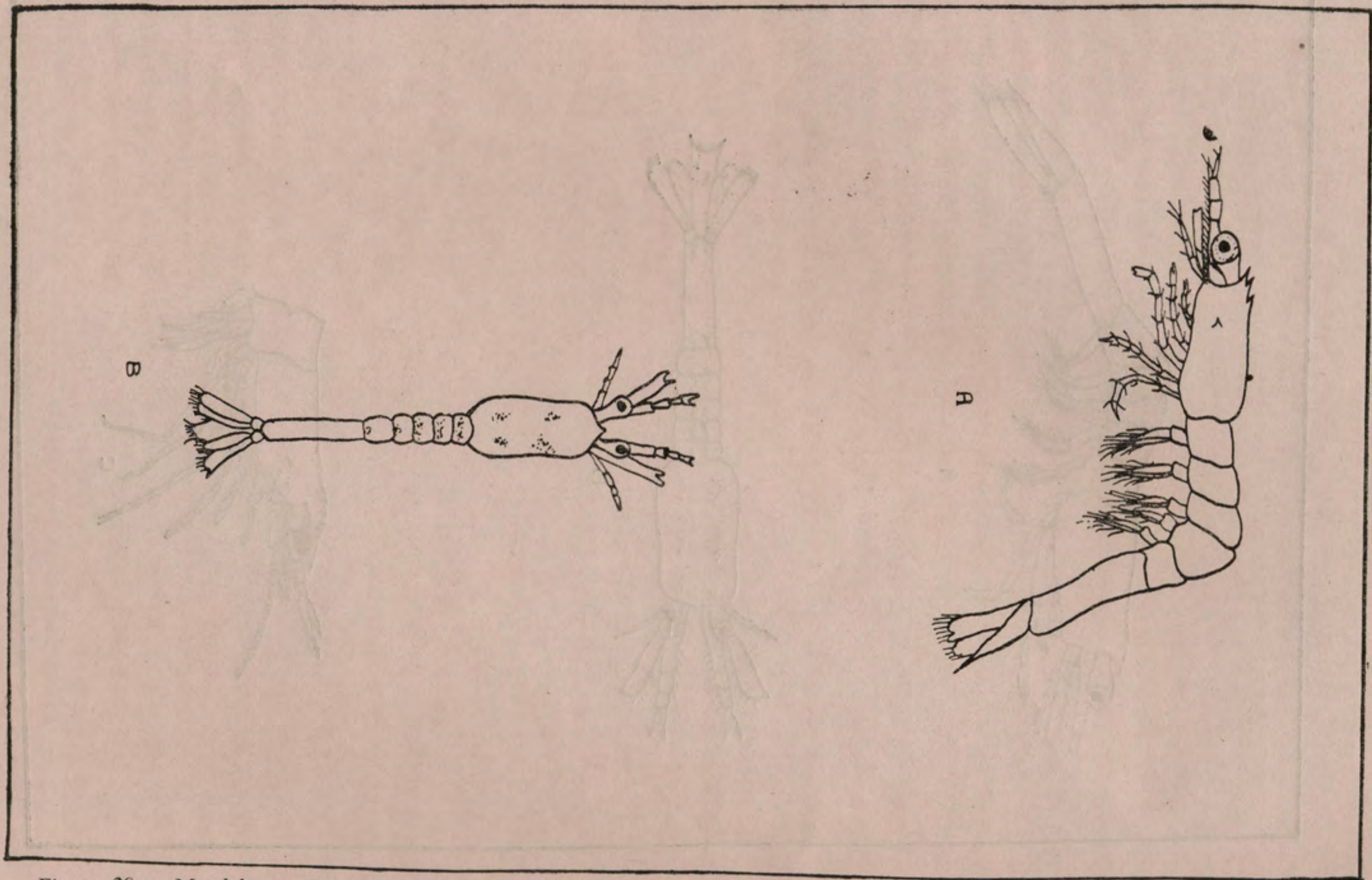


Figure 29 : *M. dobsoni* ; (A) early post-larva, and (B) dorsal view of abdominal segment showing fewer chromatophores.

on eye-stalks. Mid carapace with a few branched brownish chromatophores ; abdomen yellowish ; tinged with brown at the region of telson.

4.1.3 8.2 P. SCULPTILIS

An oblique elevated line on carapace does not meet the antennal spine. Pink colour with bluish bands on abdomen.

In 20 mm juveniles rostrum slightly exceeds the base of the eye. It shows a slight downward bent. 6 drosal teeth. Its length is about 3.25 mm. The body continues to show intensified reddish colouration.

4.1.3.8.3 PALAEMON STYLIFERUS

General body shape rounder than in the *Penaeus* species giving it a plumper appearance. Head looks prominent as compared to the rest of the body. The second pair of chelate thoracic legs gives an appearance of pincers, short and upcurved.

Rostrum long even at early stages and its base is elevated. 5 – 7 teeth occur on dorsal side and 6—10 teeth on the ventral side of the rostrum.

Colouration : Generally cream white as in all *Palaemon* species.

Juveniles : At 10 – 13 mm juvenile stage rostrum is further elongated extending upto the antennular peduncle in the smaller group and beyond the antennular peduncle in the larger group. It is not curved but shows a strong basal portion. Rostral formula is $\frac{6+1}{3}$, its length about 3.25 to 3.50mm. The body is white in colour with only slight yellowish tinge on the carapace. The 2nd pair of thoracic legs begins to show distinct faster growth with slight swelling on their last penultimate segment.

4.1.4 FIELD IDENTIFICATION CHARACTERS OF FRY AND YOUNG ONES OF FISH SELECTED FOR CULTURE

4.1.4.1 Mullets

4 1.4.1.1 LIZA PARSIA (Fig. 30 A)

Length of the head is less than that of maximum width of the body (at first dorsal). Dorsal and ventral profiles are equally convex. The spinous dorsal commences midway between the snout and the caudal base. Body colour is silvery white. A black straight lateral line is present extending from the opercle to the base of the caudal fin.

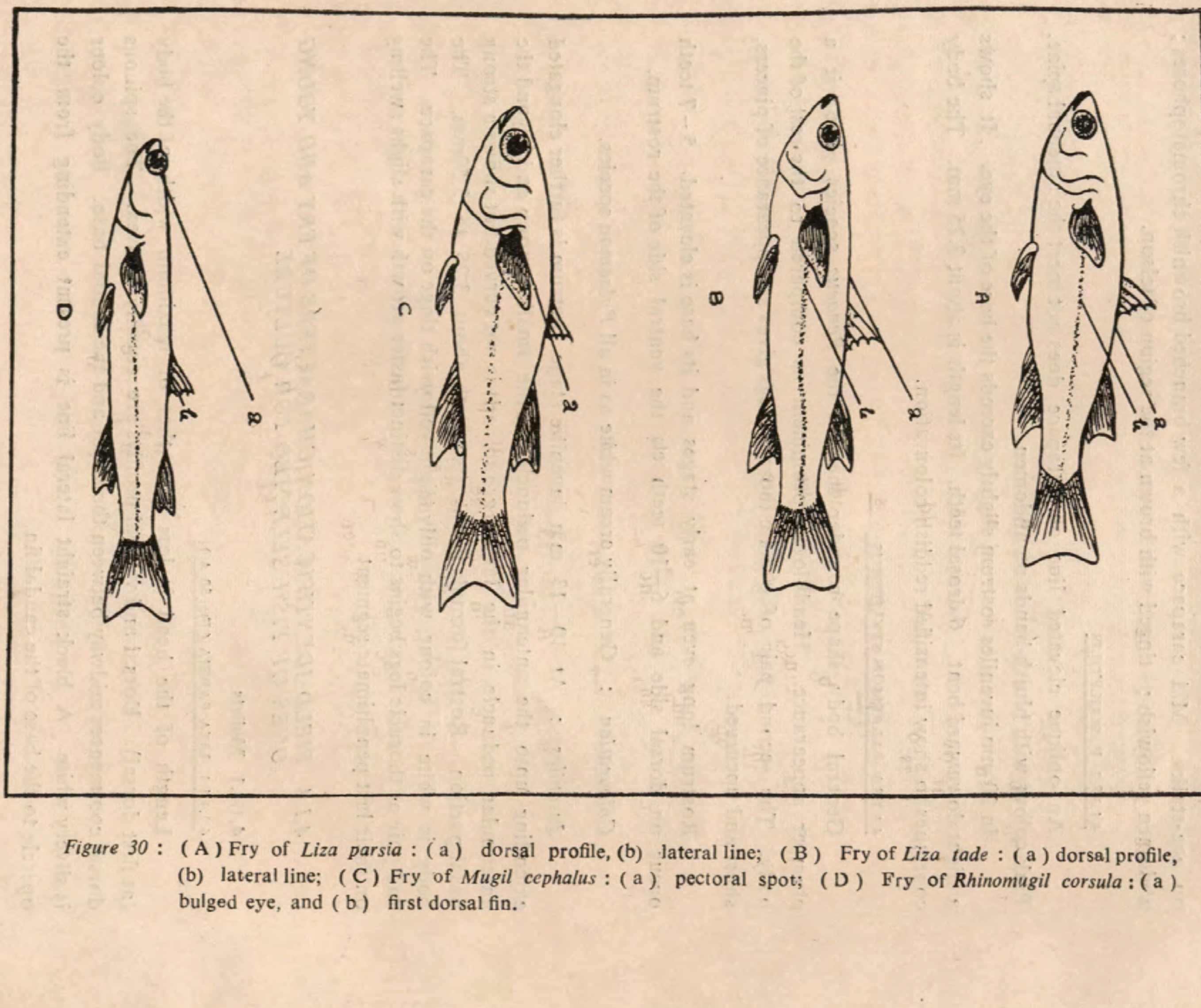


Figure 30 : (A) Fry of *Liza parsia* : (a) dorsal profile, (b) lateral line; (B) Fry of *Liza tade* : (a) dorsal profile, (b) lateral line; (C) Fry of *Mugil cephalus* : (a) pectoral spot; (D) Fry of *Rhinomugil corsula* : (a) bulged eye, and (b) first dorsal fin.

4.1.4.1.2 LIZA TADE (Fig. 30 B)

Length of the head is equal to the maximum width of the body (at 1st dorsal). The dorsal profile is less convex than the ventral. The spinous dorsal commences slightly posterior to the midway between the snout and the caudal base. The dorsal side of the body is darker than the ventral. A closed black lateral line slightly concave behind the he ad region is present extending from opercle to caudal base.

4.1.4.1.3 LIZA MACROLE

Length of head 1/5th of total length. Eye without adipose lids. Inter orbital space nearly flat. Upper lip moderately thick and forming the end of the snout. Spinous dorsal arises midway between the front edge of the eye and the base of the caudal fin. Caudal fin lunated.

4.1.4.1.4. MUGIL CEPHALUS (Fig. 30 C)

The head is bigger in comparison to other mullets and in relation to its body length. The dark black spot on the pectoral base is developed in this stage which is the characteristic feature of the adult.

4.1.4.1.5 RHINOMUGIL CORSULA (Fig. 30 D)

The fry of this species can be easily distinguished by the bulged eyes turned upwards projecting from the head. Head depressed. Dorsal profile nearly horizontal. Mouth angular, the upper jaw is longer and over hung by the snout. These fish swim with their eyes just above the surface of water.

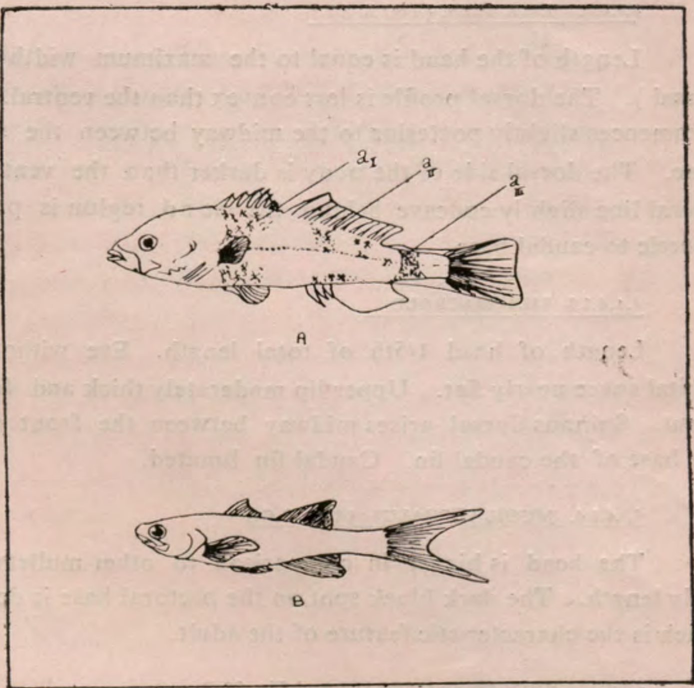
4.1.4.2. Carnivorous Types

4.1.4.2.1 LATES CALCARIFER (Fig. 31 A)

At 10.0 mm size, the general features of the adult appear. The lower jaw is longer than the upper. The 1st dorsal is with 5 spines and the rayed dorsal with 11 rays. The pectoral has 14 rays. Pre-opercle with four angular spines. Characteristic ventral bands of chromatophores are developed.

4.1.4.2.2 ELUTHERONEMA TETRADACTYLUM (Fig. 31 B)

Body colour is silvery green becoming yellowish-white in the sides and base of the fin. The unpaired fins are greyish with nearly black at the edges. Ventral fin pale orange and pectoral filaments white. On the head, slightly behind the eye, a patch of black pigments is present. Pectoral rays undivided, the four



Figuer 31 : (A) Fry of *Lates calcarifer* (15 mm size) - a_I a_{II} and a_{III} vertical bands; (B) Fry of *Eleutheronema tetradactylum* (8 mm).

free rays reach the end of ventral fin. The caudal fin is deeply forked with lower lobs longer than the upper.

4.1.4.2.3. ELOPS SAURUS (Fig. 32 A and B)

In *Elops* and *Megalops*, the larva is the leptocephalus form, transparent white, flat and leaf-like with distinct myomeres (muscle segements) which can be counted. In fact, the disposition and number of myomeres is one of the important characters of identification of these Clupeid larvae.

One more important character to be noted in these species is that in the post-leptocephalus stage or the transition stage from larval to adulthood there is an actual reduction in size which is likely to cause confusion to field collectors.

In *Elops saurus*, the leptocephalus stage is about 35-38 mm length, transparent, ribbon shaped. 62 myotomes can be counted from head to caudal and. Head is very small and pointed anteriroly. The dorsal and anal fins are highly backward in position. Dorsal fin is anteriorly continuous with dorsal embryonic finfold. Anal fin is separate from caudal. Fin rays not distinct. Caudal fin has 19 rays. Air bladder rudimentary and is vertically disposed or bending forward opposite the 27-28 myotome.

Post-leptocephalus stage now shrunk to 20-25 mm size, are less transparent and leaf-like but become slightly linear with a row of chromatophores along mid-dorsal line. Dorsal fin with 23-26 rays nearer to caudal base than to snout commencing from opposite 35th myotome and extends upto 50th. Anal fin opposite the hind end of the dorsal. Small rudiments of ventral fin. Air bladder elongates; shifting of dorsal fin forward. Cleft of mouth oblique with comparatively wide opening. Lower jaw shorter than the upper. Colour silvery, fin yellowish with greenish tinge.

4.1.4.2.4 MEGALOPS CYPRINOIDES (Fig. 32 C and D)

At a 21 mm stage, when the leptocephalus is collected in coastal waters, it is still flat, band like and almost transparent. Definite pigmentation occurs only along the mid-line of the body, with one dark spot on every myomere and between pectorals and ventrals. There are a total of 67 myomeres, 45 from the head to the anterior dorsal fin and 27 from the the head to the ventral fins. The pectorals are large and flap-like. Ventrals are very small and approximately midway between the snout and caudal. The dorsal fin is posterior in position and immediately anterior to the caudal peduncle. Relatively large air bladder bending backwards unlike in *Elops saurus*.

A 15 mm transitional larva is still flat but less band-like and less transparent. More pigmentation, general increase all over the body; 65 myomeres, 40 from head to dorsal fin and 23 from the head to ventral fin. Dorsal fin moves forward, caudal peduncle elongates and deeply lobed.

In juveniles, body oblong and compressed. Single closed fin with 26—21 rays, origin midway between snout and base of caudal. Last ray of dorsal fin prolonged into a filament. Caudal deeply lobed. Wide mouth opening with prominent lower jaw.

Colour black bluish green, abdomen silvery with bluish markings.

4.1.4.3 Other Fish

4.1.4.3.1 CHANOS CHANOS (Fig. 32 E and F)

No leptocephalus stage in development. Post larvae of 12—14 mm are

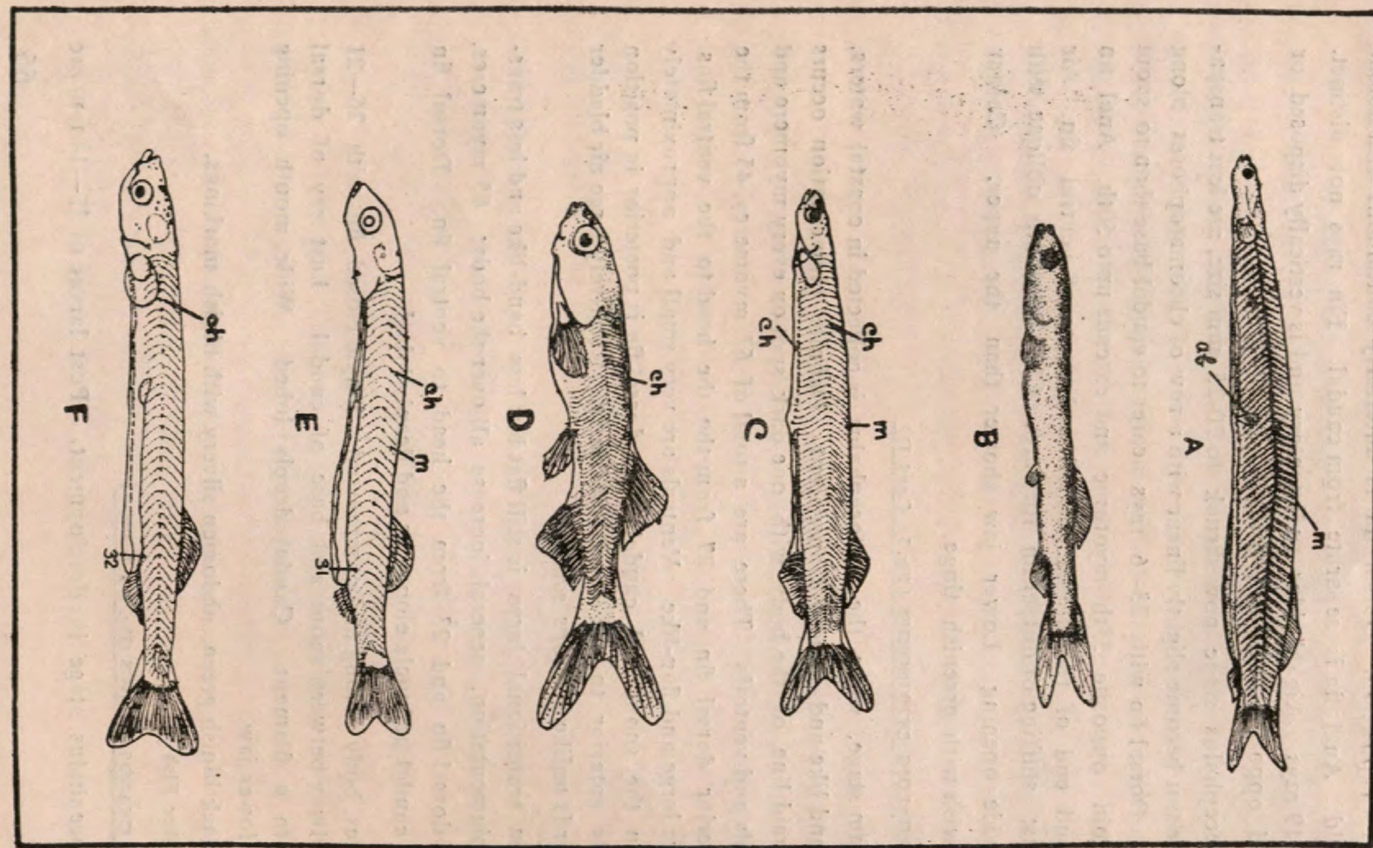


Figure 32: Leptocephalus of *Elops saurus* (*m* myotomes ; Ab : Air bladder ; ch : chromatophores) ; (B) Post-leptocephalus of *Elops saurus ;* (C) Leptocephalus of *Megalops cypriniodes* (m : myotomes ; ch : chromatophores); (D) Post-leptocephalus of *Megalops cyprinoides* (ch : chromatophores) ; (E) Larva of *Chanos chanos* (m : myotomes ; ch : chromatophores) ; and (F) Larva of *Chanos chonos* (ch : chromalophores)

transparent with one prominent black spot over the air bladder. Juveniles of 16-17 mm with elongated compressed body with single dorsal fin of 13—16 rays. Mouth small, terminal and transverse. .Upper jaw overhanging the lower law. Number of myomeres are 30+11-12, 30 in front of the anus. Chromatophores in a row from the dorsal edge of the myomeres to lateral line. Cadudal fin deeply lobed. Colour bluish grey above ; sides and abdomen silvery and whitish. In the transparent larvae, the muscle fibres in *Chanos* larvae are parellel to the longitudinal axis of the body diverging slightly at dorsal and ventral edges. In the *Elops* and *Megalops* larvae the muscle fibres show crossed arangement.

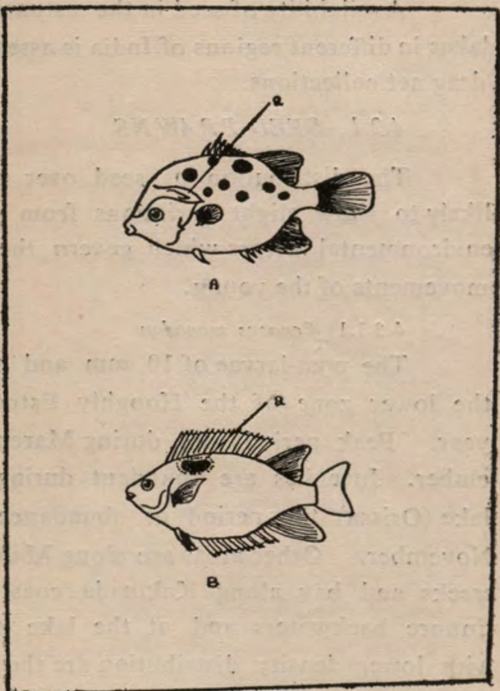


Figure 33: (A) Fry of *Scatophagus argus* ;- (a) Pectoral spine ; (B) Fry of *Etrcplus suratenis*- (a) Black spot surrounded by white ring.

4.1.4.3.2 SCATOPHAGUS ARGUS (Fig. 33A)

Body compressed and somewhat quadrangular. Few very fine teeth at the angle of the pre-opercle and along its lower limb. Fry purplish in colour with orange and greenish spots on the body. A bony ridge ending in spine passes from the eye above the opercle to the shoulder.

4.1.4.3.3 ETROPLUS SURATENSIS (Fig. 33B)

Bacause of the parental care exhibited in this species, larvae are not collected in nature. In young ones of 18mm and above, the body is oblong, elevated and compressed. Single dorsal with 18-19 strong spines and 14-15 soft rays. Caudal fin emarginate. 8 vertical blackish slate coloured bands on the body. Scales above the lateral line with a central pearly spot (Ocellus). Abdomen with irregular black spots. A distinct ocellus on the soft rays of the dorsal fin.

4.2 REGIONAL AND SEASONAL AVAILABILITY OF SEED PRAWNS AND SEED FISH SELECTED FOR CULTURE

Availability of seed in the estuaries, lagoons, creeks and brackishwater lakes in different regions of India is assessed from the tow net, shooting net and drag net collections.

4.2.1 SEED PRAWNS

The distribution of seed over months recorded in the following pages is likely to show slight variations from year to year depending on changes in environmental factors which govern the maturity and breeding of adults and movements of the young.

4.2.1.1 *Penaeus monodon*

The post-larvae of 10 mm and above and juveniles are recorded from the lower zone of the Hooghly Estuary (West Bengal) almost throughout the year. Peak periods are during March to June and a smaller peak in November. Juveniles are abundent during June—September. Along the Chilka lake (Orissa) the period of abundance is during January to April and August to November. Other areas are along Mahanadi estuary (Orissa), Godavari estuary, creeks and bay along Kakinada coast (Andhra Pradesh). in Adyar estuary, Ennore backwaters and at the lake mouth of Pulicat (Tamil Nadu). Areas with lower density distribution are the backwaters of Kerala and Goa.

4.2.1.2. *Penaeus indicus*

Abundant occurrence throught the year is reported in Hooghly-Matlah estuarine system and Pulicat Lake with peak in January, March and August. In Chilka lake also it occurs almost throughout the year. Other areas of intense distribution are Kakinada Bay and creeks, backwaters of Kerala and Collair lake. General distributional range is along both coastal regions of India.

4.2.1.3. *Penaeus merguiensis*

This species is reported from Kakinada Bay, in the backwaters and creeks of this region generally mixed with the catches of *Penaeus indicus*. other areas of distribution are the Chilka Lake and Bombay regions.

4.2.1.4. *Penaeus semisulcatus*

Seed of this species is more abundant in the estuaries and lagoons of coastal Andhra Pradesh and Tamil Nadu (Kovalam), recorded round the year in Pulicat lake and Chilka lake.

4.2.1.5. *Metapenaeus monoceros*

This species is one of the most abundant species of prawns reported to occur in coastal lagoons, creeks and coastal lakes throughout India. The seed is available throughout the year in Adyar estuary, Pulicat lake, Gautami-Godavari estuary and creeks and in Collair lake. Occurrence in lower magnitude is reported from the Hooghly estuary, the backwaters of Kerala and Chilka lake.

4.2.1.6. *Metapenaeus brevicornis*

This species is one of the most abundant commercial species in Hooghly estuary in its juvenile phase. Both mysis and post larval stages of this species occur throughout the year, except in July and October. It is also available in Chilka lake and along the mouths of the Godavari river and in the creeks along the Kakinada Bay. The next abundant distributional range is along the Gulf of Kutch on West coast.

4.2.1.7. *Metapenaeus dobsoni*

This is the most abundant species in the backwaters and lagoons along Kerala coast. The seed is by far the most abundant of all the prawns in this region and occur almost throughout the year. It is also reported from Chilka and Pulicat lakes and to a lesser extent in the Godavari estuary. Seed is available over a major part of the year with peaks during January—June and in October.

4.2 1.8. *INCIDENTAL SPECIES*

Juveniles of *Parapenaeopsis sculptilis* are available throughout the year in the lower zones of Hooghly-Matlah estuarine system. The peak periods for collections are during March to June and again in November. Another area of abundance is along the Godavari estuary and creeks along Kakinada Bay. The period of abundance is November to January.

Seed of *Parapenaeopsis styliferus* is fairly abundant in the marine plankton of Kerala coast during the monsoon months.

Palaemon styliferus occurs in Hooghly-Matlah estuarine system, Chilka lake and to a minor extnet in Godavari estuary. The peak period of abundance of seed is in August, September and November.

4.2.2. SEED FISH

4.2.2.1. Mullet

4.2.2.1.1 LIZA PARSIA

Fry of *Liza parsia* are the most dominınt in the shooting net collections of Hooghly estuary, in its lower riches, in and around Kakdwip area.

These appear in the estuaries from December to April. During this period, the young ones in the length of 15-10 mm move in waves. Dragging a net along the edges of the creek with the rising tide yields thousands of fry. Often in a peak period pure, unmixed seed can be collected in this manner.

4 2.2.1.2 LIZA TADE

Next to *L. parsia*, *Liza tade* occur in considerable abundance in the Hooghly estuarine system around Sunderbans and in Chilka lake. Peak seed availability is in the post-monsoon months of August—October. Early fry can be collected from June onwards. The time gap in the occurrence of the two principal species of Mugils, in the Hooghly estuaries, particularly, helps in their easy segregation.

90—95% of shooting net and drag-net collections in the peak season contains 20—25mm seed of *Mugil tade*.

42214 MUGIL CEPHALUS.

The distribution of *Mugil cephalus* is chiefly oriented to Eastern and South-Eastern parts of India.

There is very sparse distribution in the Hooghly estuaries, limited to lower Sundarbans near Bakkhali. The collection period here is limited to March—May when they occur along with seed of *L. parsia* at the end of *L. parsia* collection season.

M. cephalus seed are available in considerable abundace in Mahanadi estuary during January, March—May (Peak) and December. In Chilka lake, the period of availability is longer commencing from September and lasts upto January.

Along the estuaries of Godavari, the mouths of the river and creeks along Kakinada Bay the collection period is during January—May.

Along the creeks at Mandapam region, fry and fingerlings are available throughout the year with peak in June to December.

4.2.2.1.4 LIZA MACROLEPIS

Fry and fingerlings of *Liza macrolepis* occur in limited quantities in the Hooghly estuary near Kakdwip in March, May and along the mouth of the Chilka lake during December-January. 13—15 cm size group constitute a good percentage of catches in the Mandapam lagoon during most part of the year.

4.2.2.2. *CARNIVOROUS TYPES*

4.2.2.2.1 LATES CALCARIFER

Fry of the species occur in the Hooghly-Matlah estuarine system during May to September. In Mahanadi estuary, they are reported to occur during the same period. Availability is also reported from the Godavari estuaries.

4.2.2.2.2 ELEUTHERONEMA TETRADACTYLUM

Fry of the species 4-6 mm in size are available throughout the year in the Hooghly estuary and in Chilka. They are also reported from Madras and Bombay waters. Young ones beyond 6 mm size are available in all sizes in any season of the year. However, peak periods of abundance are from January to June and July to September.

4.2.2.2.3. ELOPS SAURUS

Along Madras coast, the larvae are available during April, October and November. In the outer channel of the Chilka lake, they are available during April to September. They occur throughout the year at the mouth of the

Pulicat lake with peaks in August. In the lower zones of Hooghly estuary the larvae and early juveniles occur during April-August. From the Kerala coast the presence of larval forms is reported during December-January.

4.2.2.2.4 MEGALOPS CYPRINOIDES

The seed of the species is available throughout the year on the Bombay coast with a peak during June to October. In Mahanadi, Matlab and Hooghly estuaries during April-August with peak in May. In Pulicat lake the larvae are available throughout the year with peak during April. Along Madras coast availability during April and September-October and along Trivandrum Coast (South-west Coast) the larvae are found in December.

4.2.2.3. *OTHER FISH*

4.2.2.3.1. CHANOS CHANOS (Milk fish)

The tiny transparent fry of this species 12—14 mm in size occur in considerable abundance in the estuaries of Godavari, along the Kakinada Bay, Pulicat lake and Gulf of Mannar along the southern coastal belt. The eastern part of Chilka lake is also a good source of collection. More limited occurrence is recorded in Hooghly near Bakkhali creak. Fingerlings of 40—60mm occur in limited quantaties near Kakdwip. The highest potential source, however, is the coast of Tamil Nadu.

4.2.2.3.2. ETROPLUS SURATENSIS

Fry and fingerlings of 25-75 mm in length occur in abundance in Chilka lake from April to July, and September to November. At Madras, the fry occur during November to February and in Adyar throughout the year.

4.3. METHODS OF COLLECTION OF FISH AND PRAWN SEED :

Generally, the tiny seed remain in shallow waters where the current is very mild and the region is rich in required food organisms. These move to and fro in the estuary along the marginal waters during the tidal rise and fall. As the inflow increases the estnary expands and inundates the shallow or deep depressions and burrow pits in the inter-tidal regions. Some of the moving fry find shelter in these depressions.

Therefore, for better collection of the fish and prawn seed, it is necessary that both these environments should be exploited. The procedures for collection are :

4.3.1 *SHOOTING NET*

This is a funnel shaped net of finely woven netting, generally used for carp spawn collection from rivers (Fig. 34). This net could be operated in shallow margins of the estuary, creeks and canals with the mouth facing the tidal current. At the cod end of the net, there is usually a stitched in ring of split bamboo or cane and to this is attached the tail piece in which the spawn get collected. To operate the net within the intertidal zones 6 bamboo poles, 2 at the mouth region, 2 at the ring, 1 at the tail end of tail piece, and 1 to keep the mouth open are required. The minimum period for collections is 2 hours per tide.

The standard Midnapore type shooting net is of the following dimensions :

> Length-320 cm, width at mouth-310 cm, height at mouth-66 cm, and ring diameter-25 cm, with a gamcha of handloom square netting cloth size : length170 cm, height-60 cm and width at rear and-45 cm.

Under estuarine conditons, it would be seen that once the fry begin to get collected in the tail piece, crabs can be a menace by destroying the cloth. This difficulty can be overcome to a certain extent by using synthetic netting for the net as well as the tail piece. The collections from the tail piece are to be taken out at short intervals, say 5-10 minutes for segregation and oxygenation whenever the density is high.

The maximum number of nets as far as possible may be operated simultaneously at each centre. It has been found by experience that in most estuarine conditons it may not be possible to operate more than 3 nets at a time at a centre by a team of 2 to 4 workers.

Frequency of operations : 2 hours per tide on the days when the currents and velocity conditions are favourable. Generally 6-8 days collections around

Figure 34 : A Midnapore type standard shooting net in operation.

each full moon and new moon phase may be possible, at regions where tidal fluctuations are appreciable.

Catch per unit of effort : The catch (numbers) may be expressed species-wise per unit of time (eg. per hour) per standard net, separately for high and low tides, and day and night collections.

4.3.2. *ENCLOSURE NET*

This type of net is generally operated in places having large tidal amplitudes inundating the slopes and mud flats of the estuarine system at high tides and completely exposing the same areas at the end of the receding phase of the tide. The nets are either made of cotton or nylon (maximum mesh size : 6.4 mm stretched, total height about 1.80-2.15 meters) or made of closely set bamboo splits (1.50-1.80 metres approx in height), interwoven with string popularly known as "Patta". The length of the net may vary according to the area to be enclosed. During highest of high tides, when the tidal current is very weak, the net is fixed in position (first by putting the vertical poles and then attaching the net or bamboo screen). During the low tide phase water will gradually recede from the enclosure made and finally the entrapped fry and fingerlings may be collected. They generally get stuck to the mud and hence have to be hand picked. However, it would be preferable to operate some small meshed drag nets when the water is receding so that the fry (or fingerlings) may be collected without physical damage.

Frequency : As already mentioned the net is to be operated from the time of highest water level to the time when water recedes from the area enclosed. Number of days on which the net may be operated depends on the tidal amplitude and elevation of the site selected for collections.

4.3.3 *FYKE NET*

This is usually a shallow water gear and if made of fine mesh material, could be used advantageously in the collection of brackishwater fish seed, in narrow creeks and canals having moderate current velocity. Use of such nets have been tried successfully at the Kakdwip Fish Farm of the Central

Inland Fisheries Research Institute. Fry of mullets, which may not be caught effectively in the shooting net under unfavourable current conditions, have been found to appear in appreciable quantities in fyke net collections. The dimensions of the net now being used at the Institute for experimental purposes are :

Total length : 3 60m, dia of rings 1st—0.90m ; 2nd—0.75m, and 3rd—0.60m. Two side wings, each 1.80 m in length.

The rings serve a double purpose in keeping the net in stretched condition and also form attachment for the base of net funnels, which prevent the fry or fingerlings from escaping. The collections are removed from the last packet. The first ring is to be attached to two vertical wings set obliquely on either side of the mouth.

Frequency of operations : Generally same as for shooting net, collections may be removed according to quantity accumulated, at intervals.

Catch per unit of effort : Catch per net per hour (species-wise) can be calculated and recorded, separately for each tidal phase.

4.3.4 HAPA NET

This may be a simple rectangular cloth piece through which water can pass easily or a rectangular bag (mouth 1m $\times$ 1/2 m and, length 1 m) made of beehive type mosquito netting. This type of net may be used conveniently in shallow inundated estuarine areas and slopes.

The *hapa* nets may be operated in inundated areas during the period when high waters are available. The total period, number of hauls and duration of each haul may be recorded.

4.3.5 DIP NETS

Small dip nets, which may be either triangular or circular may be used successfully in shallow waters, specially for collecting mullet fry. The cloth used should be fine meshed (1/16″) and the frame made of split bamboo or cane. The triangular net may be of base 40 cm and each side, 75 cm. The circular net may be of 50 cm. The number of dip operations, and duration may be recorded.

4.3.6 MISCELLANEOUS NETS

Two types of nets operated commercially for collection of fry and fingerlings from brackishwater, *viz* ; fine meshed drag nets and cast nets are also be used in several areas of India.

The method generally adopted in South India to collect *Chanos chanos* (milk fish) fry, is to keep a piece of cloth 3m × 1.2m closely in water, in sandy regions. A scare line 3 metres in length and with palmyra leave tied to it at short intervals is draged by two fishermen in a semicircular manner, in front of the cloth, thereby frightening the fry which jump into the cloth. Sometimes a close meshed drag net is also used to collect the fry after using the scare line.

In another method called "bush method" used for collecting *Chanos* fry and fingerlings, small plants and/or tree branches are tied together and kept in the water, in which the young fish take shelter. The fishermen slowly drag the branches to the shore, take them out of water and shake them. The fish sticking to the branches thus fall on the ground and are immediately collected.

Fine meshed pouch or purse nets are used for the collection of mullet fry from swamps near some brackishwater fish farms in Kerala. The net is rectangular in shape (12m × 6m × 1m deep) and the mesh size gradually diminished from 2.5cm at the mouth to 6mm at the posterior end. The net is set in shallow water with the mouth kept open by two fishermen standing at the wings, the upper margin buoyed with wooden floats, tied about 60 cm apart and the lower kept down by the men standing on it. A scare line 30 to 60 metres long, with palm leaves strung all over, is operated in front of the net and as soon as the same is brought to the net, the mouth is closed, by bringing the two wings together, thus enclosing the fry (Hora and Pillay, 1962).

The above method could be tried if feasible and necessary for making fry collections and qualitative estimations.

Chapter 5

CULTURE SYSTEMS

5.1. MONO-SPECIES CULTURE

Culture of a single species of either fish or prawn is known as monoculture. After nursery rearing, the prawn or fish is transferred to the stocking pond with no admixture of any other species to take advantage of a particular set of optimal conditions or a optimal season.

5.1.1. *SINGLE STOCKING AND SINGLE HARVESTING*

The process followed is to stock advanced fry or fingerling-size of a particular fish or prawn at a time and rear them till they attain marketable size when harvesting is done. This process is known as single stocking and single harvesting and may last for varying periods depending on the size that is expected for marketing [*Example : P. monodon* culture from February to June].

5.1.2. *SINGLE STOCKING AND REPEATED HARVESTING*

In a second category, advanced fry or fingerlings or 4-6″ young fish are stocked together for growth. Larger individuals are harvested earlier and the smaller ones are allowed to grow for successive periods of time before harvesting. This is known as single stocking and multiple harvesting.

5.1.3. *REPAETED STOCKING AND REPEATED PARTIAL HARVESTING*

In other methods, a single size group or different size groups are stocked heavily, and partially harvested after a specified period of rearing, restocked with smaller size groups and this process is repeated. This is known as repeated stocking and repeated partial harvesting. Depending on the availability of stocking material, any of these methods can be followed in seasons when monoculture is not advisable. For a continuous harvest and utilization of the pond area, these three methods must be judicially managed by stock manipulation and other measures.

In the case of mullet farming, this type of manipulation can be followed. The third method of repeated partial harvesting has been found to be very efficient in case of mono-species culture. In the case of *Liza parsia*, a stocking density of 15,000—20,000/ha can be done in the post nursery rearing phase. This density can be maintained throughout the culture period with partial harvesting of better grown forms in every 3-4 months. Replenishing the same quantity by smaller size group must be done, if such stock is available In the case of *Liza tade*, a starting stocking density of 10,000/ha of fingerlings must be thinned out after a growing period of 3-4 months because the species grows faster and attains lager sizes. However, the stock that has been removed must be transferred to another pond for better growth. It is to be mentioned that *L. tade* and *M. cephalus* exhibit faster growth rate in the 2nd year of rearing. Supplementary feeding and fertilization procedures must be maintained.

In prawn farming particularly that of *Penaeus monodon*, single stocking and single harvesting with short culture period of a maximum 90 days is desirable in summer months of February to June. The rate of stocking should be around 30,000/ha of juveniles ranging between 40-60mm. Within the growth period of 90 days, those weighing more than 25 grams could be harvested. In monsoon and winter months, mixed culture of prawns or polyculture with fish is advocated.

5.2 POLYCULTURE

The raising of two or more species with compatibility in feeding habits in the same pond is termed as polyculture and is the best means of increasing production. With prawn as the main species reared in brackishwater ponds, there are a number of other desirable species of fin fish that can be stocked together. Normally in brackishwaters they include grey mullets, milkfish (*Chanos chanos*) and *Etroplus* sp. which are all non-predatory and non-carnivorus in feeding habits. In addition, it may even be advisable to maintain balance of the pond stock by stocking a small number of carnivorous species such as catfishes to take care of undesirable small forage species (minnows, mosquito fish, etc.) which may accidentally enter the pond and multiply rapidly. This is ususlly done after the main cultivated species have grown to a good size and would not fall victim of this predator.

5.2.1. *POLYCULTURE OF MULLETS*

In polyculture of different species of mullets, the stocking density should be reduced to have a total stocking density of 10,000/ha at any moment of time because these species have varying growth rates. Stocking density of 6,000 of *Liza parsia* which attains small size, 4,000 of *Liza tade* or *Mugil cephalus* which grow to larger sizes can be tried. A method of multiple stocking and repeated harvesting must be followed for such polyculture to harvest the fast growing forms. Supplementary feeding and fertilization of the ponds must be done.

5.2.2 *POLYCULTURE OF DIFFERENT SPECIES OF PENAEID PRAWNS*

For polyculture of different species of penaeid Prawns, the total stocking density may be around 50,000/ha. The stocking ratio of *Panaeus monodon* to other species *viz.*; *P. indicus, P. merguiensis* and Metapenaeids being more on the basis of seed availability of the species used. The stocking ratio of larger Penaeids should be more.

When the stock have grown to sizes of 70-80 mm, the stocking density can be reduced to 30,000/ha and are to be transferred to bigger ponds (minimum 0.1. ha) with the same facility of letting in tidal water which carries in food material. An average depth of 120 mm can be maintained. The tidal ingress may be frequently permitted as per the tidal level.

5.2.3 *POLYCULTURE OF PRAWN AND FISH*

In brackishwater environment, the concept of different ecological niches is related to the compatibility of habitat preference of different species mainly and food preferences follow. Prawns generally move on the bed of the pond and feed on organic detritus including the flesh of dead organisms. Mullets are mainly zooplankton feeders and inhabit the mid-surface layer of water. They can easily adapt themselves to supplementary feed. Thus in polyculture, prawn and fish both are benefitted. Stocking densities would depend on the size of the prawn and fish fry used. The pattern of stock manipulation can be on the basis of repeated stocking and repeated partial harvesting for fishes and that of prawn can be based on single stocking and single harvesting with short rearing period.

5.3. EXAMPLES OF NURSERY REARING OF SEED

Nursery rearing has not formed into an organised practice in India for brackishwatater farming due to the traditional practice of culturing stocks by trapping. Now it is recognized that nursery rearing is a vary important primary step for higher production. The important steps for nursery rearing are :-

1) Preparation of nursery ponds of the land based nurseries to receive the stocking material ; and

2) Conditioning the seed collected from nature to the conditions prevailing in the nursery ponds.

5.3.1. PREPARATION OF NURSERY POND

The pond may be drained off, completely dried and exposed to the sun. When sufficiently dry and the bottom soil cracks, it may be tilled or manually turned over for the lower layers to be exposed. When complete drying is not possible, the water level should be lowered to the minimum possible level (10-15 cm). The bottom should then be thoroughly raked with hand rakes operated by two men. This will facilitate escape of obnoxious gases, oxygenation, and killing of predators hidden below. Raking should be undertaken at regular intervals and the sunrays allowed to penetrate to the bottom. Generally, a minimum of 15 days time is required for this operation. Then the nursery pond is to be filled up with fresh tidal water.

5.3.2. *CONDITIONING OF THE STOCKING MATERIAL*

5.3.2.1. Conditioning to salinity :

The stocking material, after collection may be transferred to cement cisterns or plastic pools containing water of the same pond in which it is proposed to be cultured. If the salinity variation is wide between the site of collection and the nursery pond, the collected material is to be acclimatised in graded doses of salinity (75%, 25% and pond salinity). Acclimatisation for a period of 3 hours at each grade appears to be sufficient.

5.3.2.2. Conditioning to supplementary feeding

After being conditioned to the ambient salinity for 24 hours, the stocking material is conditioned to supplementary feeding through small doses. Feed can be provided at regular intervals at morning, noon and night, and is observed whether they are coming up for feeding. When almost all of the stocked material come up to the surface immediately on application of the feed, it may be construed that they have been properly conditioned to the type of food and action is to be taken to stock them in nursery ponds. Generally, the entire process of conditioning may last for a period of a week During this period, care should be taken either to partly replenish the cistern/plastic pool water with fresh pond water to keep the bottom clean by siphoning out the waste materials from the bottom regularly at short intervals. If arrangement for aeration (Air blowers or compressors) is available in the farm, a slow aeration may be created through air diffusers in the land-based nurseries.

5.3 3. *SELECTION OF STOCKING MATERIAL :*

Only such of the conditioned specimens should be selected which are robust, agile and have shown a fast growth by acceptance of the supplementary feed provided to them. Different size groups present in the conditioned stocks be segregated and uniform size group (size within 10 mm range) be stocked together.

5.3.4. *SPECIFIC REQUIREMENTS OF INDIVIDUAL SPECIES*

The specific requirements of cultured organisms in the nurseries vary. Therefore, while preparing the nurseries care should be taken to provide the particular requirement of the cultured organisms. Principal steps to be taken for the preparation of individual types of nurseries are :-

5.3.4 1. Nursery ponds for prawn postlarvae :

After preparation of the pond in the manner suggested earlier marginal grass with long stalks should be encouraged to spread over the water surface. However, grass may take sometime to grow. Therefore, in addition to this measures, palm leaves and dried twigs of locally available mangrove plants or date palm leaves be bundled and kept submerged in the pond at different points. These will encourgage the growth of periphyic organisms on them as additional source of food for the stocked post-larvae and also as a substratum to rest on. During the moulting period such a device will also provide shelter and save the post-larvae from predation.

5.3.4 2 Nursery ponds for fin fish

Basic requirements in respect of food for the fry of individual species of fin fish like mullets, milk fish and pearlspot are different. Mullets prefer zooplankton in capativity while milkfish depend on benthic algae and other associated organisms and the pearlspot young ones feed on aquatic insect larvae, filamentous algae and phytoplankton. Therefore, while preparing the nurseries for mullet fry, after basic preparation of the pond as suggested earlier, water fertilisation with urea and superphosphate will help the growth of desired food organisms. The rate of fertilisation will depend on the nutrient level of the pond. However, 25 kg/ha of nitrogen and 50 kg/ha of phosphorus will be sufficient to give desired effect.

Benthos grow better at a depth of 60-90 cm. Therefore, in milk fish nursery the water level should be so regulated that a steady depth within this range is maintained. In addition, if and when necessary, manuring with either poultry manure or cattle dung may be undertaken to enhance production of benthic organisms. This will be done only when the organic content of the soil is very low.

The requirements of pearlspot, *Etroplus* sp. are different from both mullet and milk fish. In these nurseries both filamentous algae and other phytoplankton are to be grown by both soil and water fertilisation. For this purpose fertilizing the soil with organic manure, nitrogenous and phosphatic fertilisers at 50kg/ha each should be used.

5.4 EXAMPLES OF CULTURE SYSTEMS

5.4.1 *EXAMPLE OF PRAWN CULTURE SYSTEM*

P. MONODON :

Soil type is important for *P. monodon* culture. Sandy clay is good because it is useful for constructing compact dyke when it is taken out from the pond. Stuitable type of algal growth occurs on which young prawn feed ; and the animals find such soil easy to burrow and take shelter. Clay loam also is acceptable as a second choice.

Normally acceptable level of water in *P. monodon* pond is about 3′. Water exchange is possible at every spring tide. But temperature and salinity regimes are to be protected keeping an average of 25°C and 20—25 ppt respectively. Even a fall in salnity to 5 ppt is not going to harm *P. monodon* growth as much as a fall in temperature.

In Philippines, elaborate ponds are constructed (Fig 35). A 10 ha pond has an outer sluice gate opens into a catch pond, a little deeper than the rest of the pond. The culture pond bottom slopes towards this catch pond

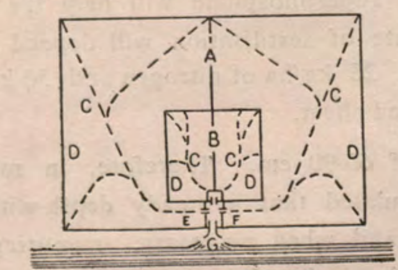


Figure : 35

and sluice gates. A nylon mesh screen filters out predators, etc. The drainage ditches serve mainly to facilitate harvest. Twigs and bush clumps are provided for attachment of young prawns.

In the pond preparation process, drying of pond bed is for 2 to 6 weeks ; agricultural lime is applied at this time @ 400 kg/ha to help absorb excess carbon and supply calcium required for the moulting shrimp. Then water is let in to a level of 370 cm. This permits the growth of the benthic algal complex called *lab lab* on which the young prawn feed and flourish well. In about a month, the pond is ready for stocking.

In India, a similar preparation of pond is followed, however, using poultry manure plus NPK mixtures before the first level water is let in. Secondly, pond preparation period is shorter because normally in low-lying areas total sun-drying is practically impossible ; despite all care, pests like frogs and snakes do enter. Sudden rainfalls prevent longer drying. Therefore, earth is raked or turned over and preparation commences.

Stocking at a rate of 3,00,000-5,00,000/ha for nursery rearing is done after preliminary acclimatization for 10 days in similarly prepared (in regard to fertilizers) plastic pools with or without aeration. This gives 80-90% survival and the larvae are in better state to be transferred to earthern nurseries.

Some rules to be followed are :

—disperse the larvae all over the pond so that in the first stage of transfer they remain grouped and weaklings in process of moulting will not be killed (most of the initial mortality occurs in transfer and stocking),

—this scattering helps to prevent competition for food and individuals would find their own materials to cling,

—*P. monodon* ponds should have a submerged grass edging for the larvae to cling and to graze on the benthos,

—predators to be eliminated on sight,

—do not disturb the pond by any mechanical means for atleast 30 days after stocking so that the fragile bodies are not torn,

—plant clumps of bushes, bunches of twigs of both as shelters and grazing grounds, and

—prevent growth of filmentous algae (it can be done by proper control of fertilizers used qualitatively and quantiatively).

When the juveniles are to be transferred to production ponds, these twig bunches would help in easy capture besides other methods such as netting, dralning the water and hand picking.

Preparation and operation of production ponds are similar to nursery ponds. The *P. monodon* rearing period lasts from 3 months (after nursery) to 1 year. Presently, 3 crops in an year are advocated. Supplemented feeding enhances growth. However, average size at harvest should be determined. Average size attained ranges from 20—30g in this period. This is a harvestable size either for direct rearing or for stocking, to other freshly prepared ponds for further growth. A production of 1200 kg/ha/yr could be achieved through three crops.

Three growth periods have been demarcated under our cultural practices :

Summer growth	:	Fast pick up of growth by mid-February which lasts up to mid-May, when prawns weighing 30g can be harvested.
Monsoon growth	:	Tempo of growth lessens, liklihood of heavy mortality at onset of rains ; frequent exchange of water could help to lessen this factor. From February to September the growth may be 45—50g.
Winter growth	;	Growth almost at a stand still at North-eastern part of India under temperatures ranging between 15—17°C

from November to February. Larger prawns may attain 60g. Smaller groups do not show much growth.

Between March and June, new batch of young are entering the estuary ; therefore, sufficient preparation are to be planned to cope with on going production programme and preparation for nursery programmes.

MONOCULTURE: In monoculture practices, probably a vast ecological niche is left unutilized in *P. monodon* ponds. However, the price of the reared animal offsets this loss. However, the best growing period is summer for monoculture to take advantage of the fast growth. In other seasons polyculture practices can also be adopted.

POLYCULTURE : In polyculture, *P. monodon* has been grown with the following combinations :

P. monodon : milk fish

P. monodon : other *Penaeid* prawns and *Palaemon* group (incidental catch)

P. monodon : mullets

The pond preparation and nursery rearing techniques are similar in all the systems. *P. monodon* is usually introduced into the polyculture systems at a size of 40-60 mm/2-3g (juveniles).

*In polyculture with other prawns, *P. indicus*, *Metapenaeus brevicornis*, *M. monoceros* and *Palaemon styliferus* are the common forms. In this a production of 850 kg/ha/270 days is possible at 2 lakhs/ha.

*With *Chanos* or mullets the production is 997.0 kg/ha and 891 kg/ha of prawns and fish together in 270 days of cutture.

*With mullets, milk fish, other penaeids and metapenaeids the production achieved is 2,670 kg/ha/yr at 50,000/ha.

In Japan in the kuruma (*Penaeus japonicus*) culture methods, the culturist grows his larvae from egg to larval stages thus giving him a dependable supply of shrimp. The yields attained are 2,000 to 6,000 kg/ha depending chiefly on whether running water can be supplied. Pond sizes vary from 0.01 to 10 ha or more. A combination of large and small ponds are tried. The pond depths are 1—2 m with sand bottom. The food used for rearing larvae is : *Skeletonema* : *a* diatom ; *Isochrysis galbana* and *Monochrysis lutheri* : flagellates.

* Figures relate to experiments conducted at CIFRI, Barrackpore.

The kuruma (*P. japonicus*) culturist expect to produce 1 kg of shrimp for 10-15 kg of feed at 25°C.

Comparatively the extension culture practices of Japan yield 0.25 kg/m^2 in the tidal ponds, 0.070 kg/m^2 in the ponds constructed in marsh areas in USA, 0.028 kg/m^2 in netted off portions in the bay in USA.

5.4.2 EXAMPLES OF FINFISH CULTURE SYSTEMS

CHANOS CHANOS

Milk fish (*Chanos chanos*) feeds near the bottom of the food chain. Algae being the main food such that the primary source of feed and nutrition is catered to by use of fertilization which gives rise to a complex mass of benthic algae, protozoa and detritus (*lab lab*).

Converted salt pans seem to be very suitable for milk fish culture. In Indonesia, the ponds are constructed in a region transitional between mangrove swamps and agricultural land ; to guard against erosion, a dense population of mengrove is planted along the dykes. Salinity averages 10—35 ppt. Best soils for milk fish culture are found to be soft jelly like, hydrophilic and biologically active mud containing about 4% humus and large amounts of clay. Such mud encourages growth of blue green algae eaten by milk fish.

The size of nursery ponds varies from 200-500 m^2 and the depth of water does not exceed 30 cm. The stocking rate is 30—50 numbers/m^2. *Chanos* are extremely fast growers with 1 mm growth per day attaining sizes of 5 to 7 cm/1.4 to 3.7 g. Latest production figures from Philippines and Taiwan and Indonesia indicate a production of 600 to 800 kg/ha (Taiwan) with improved practices. In Philippines, the average yield is 300—500 kg/ha but it was raised to 1000 kg/ha also. The fishes are harvested at 300 to 800g size.

In India, the species is yet to be utilized fully. It is found compatible to grow along with prawns—*Penaeus monodon, P. semisulcatus, P. indicus, Metapenaeus* species and *Palaemon styliferus*. Incidental species are *Lates calcarifer, Elops* sp., *Megalops cyprinoides*, etc. In Philippines, the prawn culture in milk fish ponds is secondary or incidental.

Pond preparation

The Philippines system offers good example of pond preparation. It involves draining in November for the first growing season ; drying for about 15 days exposure to sun to allow cracking. Then poultry manure (2000 kg/ha) and tobacco waste (400 kg/ha) are spread over the bottom. The tobacco was to serve the dual purpose of fertilizing as well as natural pesticide. Saponia 15 to 18 kg/ha or quick lime 1000 kg/ha are also equally effective. For lighter soils 25% more chicken manure is recommended. Actual fertilization is by 400 kg/ha of rice bran and inorganic manures applied in December or January. After this water is filled in to 15 cm level.

Repeated stocking and harvesting are done by these methods. Milk fish grown this way attained 450 g in 6-9 months.

Lab lab

The biological layer thus formed by micro-organisms, known as "lab lab" in the Philippines, contains mainly of algae and includes bacteria, uni-or multicellular blue-green algae (Myxophyceae), *Oscillatoria* in particular, fragments of filamentous green algae and diatoms. It also includes animals such as protozoans, entomostracans (Cladocera and Copepoda), worms and also detritus and mineral particles. Sometimes this mass rises to surface in small or large fragments due to oxygen bubbles. They are eaten either at the bottom on the mat or on the surface floating mat or in planktonic form.

MULLETS: Mullets are fragile in handling and, hence care is to be applied in transportation as well as stocking.

So far mullets in India, as elsewhere, are used in polyculture systems and also in mixed cultures using all mullets together *viz* ; *M. cephalus*, *R. corsula*, *L. tade*, *L. parsia* and *L. macrolepis*. The only other extraneous species used is *P. monodon*. Two species combination, such as the fast growing *L. tade* and slow growing *L. parsia* are also commonly tried.

Mullet nurseries are prepared in the same way as *Chanos* nurseries. Fry of 20-23 mm are stocked at rates of 3-5 lakhs/ha for 30-40 days rearing period. Supplemental feed of rice bran plus oilcake is used at a daily rate of 5—10% of stock weight. 80—90% survival is possible in this intensive system. At the end of 40 days, the new juveniles can be transferred to production ponds.

Mullets accept dry, powdered feeds as well as pellets. If two different size groups of the same species or different species are reared together the larger ones move fast to take the feed when broadcast. So, natural feed must always be maintained in ponds by way of application of poultry manure or NPK mixtures. Supplementary feeding and fertilization help to augment production. Fuller utilization of the pond could be done by polyculture practices. An example of trend of age and growth of mullets is also presented (Table 6).

Table 6 : Age and growth of mullets cultured in India*

Species	Age years	Average length (cm)	Average wt. (kg)
Mugil cephalus	1	14	—
	2	24	—
	3	33	—
	4	39	—
	6 7	50	1.3
Mugil corsula	3	35	—
	3	45 (maximum)	—
Mugil dussumieri	1	15-9	—
	—	25 (maximum in culture ; wild fish attains 40 cm)	
Mugil tade	1	24-25	
	2	34-36	1.4-1.8
	—	70 (maximum)	

*(from Bardach *et al*, 1972)

The growth pattern of three species of grey mullets in specific culture experiments carried out at the Kakdwip and Bakkhali Fish Farm of CIFRI is also given in table 7.

Table 7 : Age and growth of cultured grey mullets

Species	Age	Average length (mm)	Average weight (g)
Mugil cephalus	One year	426.6	873.8
Liza tade	6 months	267.0	211.0
Liza parsia	3 months	121.2	27.3

LATES CALCARIFER

Nursery management :

a) Cut stems of dried mangrove plants or of *Acacia avabica* be interspersed in the nursery ponds having an average water depth of 35 cm to 105 cm ; b) early fry of *Lates calcarifer* (size group 8 mm to 15 mm) be stocked at a total density of 50,000/ha and allowed to grow upto an average size of 40 mm.

At this size, reduce the stocking density to 10,000/ha and transfer them to ponds provided with special inlet structure to allow inflow of tidal water with small fish and prawn.

Rearing

In India for the first time this highly marketable species is being cultured in the elongated feeder canals of the farm system. The fish is a predator preferring live fish/prawn feed. To enable it to feed naturally, the canals are also fertilized in natural food such as small shrimp, mysids and small molluscs.

Therefore, currently no intensive care is followed either in feeding or pond maintenance.

Lates requires lot of running space in the ponds. Ponds with length wise extension or the channels supplying water to ponds are best preferred. At the Kakdwip Fish Farm (W. B.), the production obtained for *L. calcarifer* is 3350.00 kg/ha/yr and their growth pattern is presented in table 8.

Table 8 : Growth and production of *L. calcarifer*

Duration	Stocking density	Stocking size	Size attained	Production
One year (January to December 1977)	2500/ha	315.1/mm/375.50g	572.5 mm/1900g	3350.00kg/ha/yr.
		251.95 mm/168.23g	442.0 mm/800g	

Chapter 6

(I) MANAGEMENT PRACTICES

6.1. POND PREPARATION AND MANAGEMENT

6.1.1. *INTRODUCTION*

Managent is an important tool in fish farming activities to augment the yield from unit area/volume of work and to maximise the production from a given water body.

Brackishwater aquaculture has been broadly classified into two categories (i) extensive, and (ii) controlled. The extensive culture is carried out in very big waterbodies with little or no control over the environmental variables and where the production is largely dependent on natural fertility. In contrast, the controlled culture is undertaken in man-made artificial water-bodies like raceways, ponds tanks, etc , where a high stocking density is maintained and most of the prominent variables like predators, salinity, temperature, water level, etc., are kept under control. In this type of culture, the soil fertility is improved through fertilisation and manuring and the production is substantially increased through supplementary feeding and maintenance of hygeinic condition in the pond environment.

6.1.2. *TYPES OF MANAGEMENT PRACTICES*

Management activities in a brackishwater farm generally centre round :-

a) Preparation of ponds.

b) Water management to maintain water qaality congenial to the growth of organisms being cultured.

c) Feeding schedules.

6.1.2.1. Pond Preparation :

As mentioned earlier, pond preparation is the most important stage before stocking in fish farm management. Pond preparation can be divided into two parts: a) Pre-fertilisation treatment, and b) Fertilisation and manuring.

Pre-fertilisation Treatment : After the stock is harvested, the water is drained out and the pond bed is exposed to the sun for drying (Chapter 5). This eliminates the predators and competitors from the farm pond on one hand and allows the pond bed to be aerated and oxygenated for quick mineralisation. When the pond bed is dried, levelling and cultivating the pond bottom, the removal of all stumps, roots and excessive amount of decaying organic matters are also carried out. This procedure is a must for extensive culture where one depends on natural productivity only.

In controlled culture after the pond bed is dried allowing the atmospheric oxygen to penetrate in to the subsoil, some toxicant (for example Mahua oil cake) should be used to remove bottom dwelling and other burrowing organisms. Generally, organic toxicants are used for the purpose since after initial toxic effect the same acts as an organic manure to enrich the bottom productivity. In brackish water fish farm such organic toxicants should be used where the lignin content is rather low so that mineralisation on waterlogging may not pose any problem. The amount of organic toxicant to be used depends on the incidence of the burrowing organisms as mentioned earlier. Then water is let into flood the pond to an approximate depth of 10-20 cm which enables the toxic ingredients to enter into the cracks along with water to kill unwanted bottom fauna. For a better result the pond should be kept water logged for a period of at least three days after which the supernatant water may be drained out and the pond bed is flushed with fresh tidal water to remove the toxic effects and make it ready to receive fertilizers

Fertilization and Manuring : Majority of the brackishwater fin-fish prefer benthic organisms as their food and, therefore, soil fertilization instead of water fertilization is more effective in brackishwater fish farm. Depending on the quantum of organic contents in the bottom soil, the amount of organic manure to be administered is determined. Generally it ranges from 2000-5000 kg/ha. High dosage of organic manure in a single instalment is discouraged since the rate of mineralisation is rather slow in brackishwater ponds and as such application at a very high dose may result in bottom pollution. Therefore fortnightly or monthly doses are advised. In addition to the organic, inorganic fertilizer like urea & superphosphate at the rate of 200-500 kg/ha/yr are applied to help rapid organic production. In this case also the application should be fortnightly or monthly depending on the productivity of the pond.

This fertilization scheme presupposes that the environment is alkaline in nature, if it is not, adequate liming (200-250 kg/ha) may have to be done to improve the soil towards alkalinity. The lime should be mixed with the soil before the fertilization, as detailed above, may be carried out.

6.1.3 CARE FOR THE GROWING STOCK

6.1.3.1 Stocking size and density

Preference should always be given to the locally important species of fish or prawn which can adapt themselves to the lentic environment of the fish farm, euryhaline in nature, whose growth rate is fast, can adopt to supplementary feeding easily, can be induced to breed under captivity (optional) and has a ready market acceptance (see Chapter 3). Other suitable cultivable species from elsewhere can also be considered (for example : transplanting of *P. monodon* seed from Hooghly to Cochin region). It has been customary to calculate the stock, for convenience by the number of fry or fingerlings stocked per unit area of pond and their total weight. In this way, the maximum stocking rate (density) that the pond with a given standing crop of natural food can support, without danger of loosing its capacity to regenerate more food, can be assessed.

The stocking size ranges from post-larvae to fingerling in nursery ponds. In stocking ponds, stock manipulation has to be done depending on culture systems as discussed earlier. Post-stocking management is done through refertilization at required intervals, supplementary feeding, partial harvesting and restocking. In this way, the production per unit area is augmented to achieve maximum.

6.1.4 WATER MANAGEMENT

6.1.4.1 Flow water system

Gravitional flow

Dynamic changes take place in the environment of brackishwater ponds being fed from the estuary by the tidal waters. The temperature, salinity and pH tend to vary constantly. Normally the "spring tides" are now used in the flow-in and flow-out systems. 'Spring tides" are those which occur at the time of a full moon or new moon. They follow a pattern of slow rise at first 2-3 days before the full or new moon day, then rise fast to reach a peak on that day and decline in the same manner (see Chapter-1). The tidal amplitude during normal spring tide has been shown in figure 36.

FIG. DIAGRAMMATIC REPRESETATION OF TIDAL AMPLITUDE AT NORMAL SPRING TIDE.

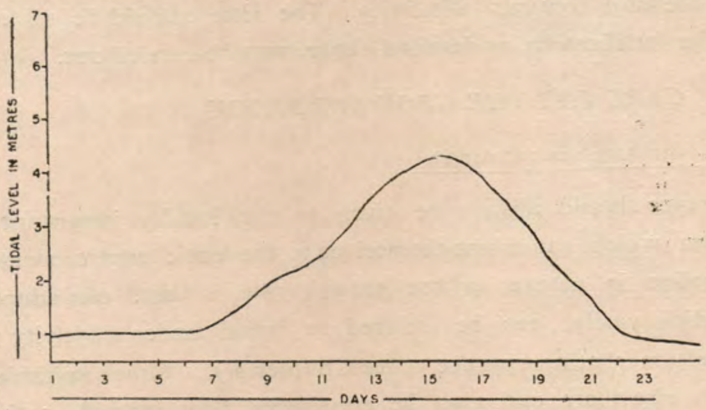


Figure : 36

The spring tide rise of water is in addition to the daily rise (high tide) and fall (low tide) in tidal waters of an estuary or coastal waters. When a farm location is considered, the level to which water rises in any normal spring tide is also reckoned with a view to taking in fresh tidal waters at this time. When no such variations in tidal amplitude occur to enable a flow-in system by way of gravitational flow, then a heavy-duty pump comes into the picture.

Use of pump

Pumping in water is common especially in the Philippine ponds, (1) where ponds are located on elevated areas, or (2) water intake point is rather far away from the farm location, or (3) waters close to inshore have to be avoided because of industrial or other pollution.

Action of flow-system

The flow system whether by gravity or by pumping acts to flush out accumulated matabolites in the closed environment with a high standing stock. It brings in "fresh" water with high dissolved oxygen, changed salinity, temperature and pH. In addition, despite fine gauze scrcens considerable plankton biomass is brought in which acts as food for the standing crop. One disadvantage is the intrusion of larvae of unwanted species, especially predators.

Removal of metabolites

The flow-system is also a "*must*" when unusual mortality occurs in pond. At the first sight of a dead fish in the pond flushing should be done. This would eradicate any adverse effects caused by low dissolved oxygen, fall in temperature, fall in salinity, change in pH value and pollution due to unutilized feeds, etc.

Utility of slow current

Almost all species of prawns thrive well when some low current previls in the ponds. The current keeps the gills washed, food moving and geneally maintains a healthy environment to the bottom where these animals commonly rest.

Other methods of aeration of ponds could be tried where water from tidal flushing is not possible by pumps.

6.1.5. *SEED SUPPLY*

Earlier it was mentioned (Chapter-3) that one of the criteria for location of brackishwater farms is the seed source. Animals selected or found suitable for brackishwater farming include those species which can be raised from egg to adult (eg. *Mugil cephalus* and most of the prawns) and those the young of which must be collected from nature. Presently for all the species seed collection is from nature.

The "*critical*" period is when the seed occurs in nature in varying magnitudes, the farmer should be prepared in every sense of the word. Every seed carrying tide should be "tapped" for seed till his target is met and a stand by stock position is also attained. Estuarine environment is subjected to several storms, failure in expected rain fall or such ; or breeding itself could be adversely affected in the sea. In other case, the seed may not turn up at the expected time or its abundance may be of the low order.

The magnitude of migrations of larvae, when to collect, what level of tide is suitable for operation of seed collection nets, identification of the larvae, segregation, requirements of their early rearing must be known (Chapter 3).

In case the seed is being purchased from other sources all the management would centre round its transportation and pre-prepared nursery for receiving the transported seed and its future care.

6.1.6. *HATCHERY AND HATCHERY MANAGEMENT*

The second method of obtaining seed without the involvemnt of collection and segregation is rearing them from egg to post larval stages and then to marketable sizes.

This procedure involves considerable expenditure and know-how. However, when such a method can be adopted, the farmer is assured of a steady supply of young ones and need not depend on vagaries of nature. Possibly a year-round supply of seed is assured when 2-3 crops of marketable sizes of prawn or fish are to be raised in an year.

6.1.6.1. Methods of breeding :

This method involves (1) capturing mature adults from nature, at a time close to the natural spawning time, their care and rearing in closed pens or tank till they spawn, (2) induced breeding by eye-stalk ablation,

The first method is very easy in regard to prawns since both sexes can often be obtained in ripe condition. Further, since fertilised females are collected from nature collection and care of males is eliminated. In the second method, removal of eye-stalks in prawn induces maturation and spawning.

6.1.6.1.1. ABLATION :

Two methods of ablation are advocated : (1) Quick removal of eye-stalk by cutting at its base with a sharp blade or fine but strong thread, (2) by slitting the eye-ball with a blade and squeezing out the contents of the eye-stalk progressively to the distal part and through incision. (Liao and Haung , 1970).

The prawns used for ablation should be over 60 g in weight. Males need not be ablated. Both males and females must be reared in a common pen. Care should be taken to properly feed the animals. Actual ablation should be done only during intermoult period.*

Within 5-20 days of ablation, provided all other environmental conditions are maintained at required level *viz.*, salinity 26-30 ppt, temperature 28-32°C, and the prawns are in healthy condition.

* Moulting—periodical shedding of the skin immediately after which the prawn is very soft and should not be handled. Intermoult period starts immediately after.

6.1.6.2 Care of the eggs and larvae :

Proper care of eggs and larvae must be taken as follows :

—Clean, filtered sea water of required salinity (26-30 ppt).

—Containers made of fibre-glass or marine plywood have been found to be most suitable. the shape cylindrical with bottom conical or inclining at 30° to drain out water and metabolites (Fig. 37).

DIAGRAM OF A TYPICAL FIBRE GLASS HATCHERY TANK WITH ACCESSORIES

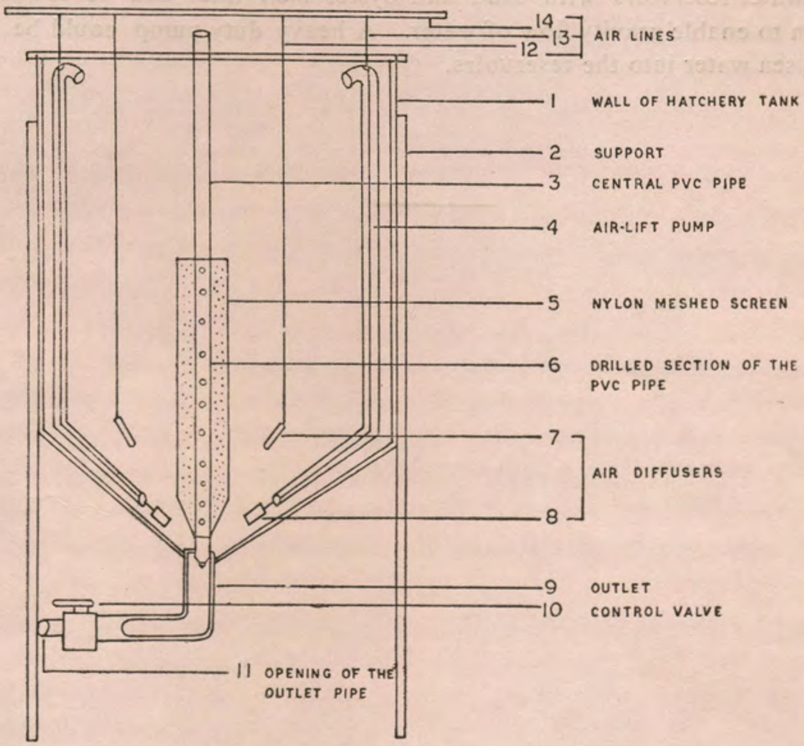


Figure : 37

—Oil free supply of air either through air-pipes or air-blowers with air-stones to help in diffusion.

—Suitable uni-cellular algal food, diatoms and rotifers, nauplii of the brine-shrimp, *Artemia salina* at each individual later stage of development (see Chapter 3, table 5) such as zoea, mysis, etc.

—Pipes, tanks and all fitting should be chemically inert ; P. V. C. should be suitable.

—Monitering of pollution ; check on salinity, temperature, pH and ammonia.

—Constant attention.

6.1.6.3. Location of hatchery

—A hatchery should be normally located under shelter so that extraneous factors could be eliminated. A closed shed with corrugated sheet can be constructed to locate required number of 2000-3000 litre cylindrial tank with inclined bottom, with all water and air supply fittings.

Sea water reservoirs with sand and oyster-shell filter can be located at an elevation to enable gravity flow of water. A heavy duty pump could be used to pump in sea water into the reservoirs.

(II) FOOD AND FEEDING PRACTICES

6.2.1. *FEEDING*

As the grouping in chapter 3 suggests some fish are harbivores, some are carnivores, while prawns are exclusively detritivores and, or omnivores. However, under intensive culture conditions, the aim of the culturist is to provide specific feeds to specific fish or prawns which would result in fast growth, better utilization of resources used and a conversion ratio of atleast 2.5.

It is now very well recognized that the feed supplied cater to three important requirements : proteins, carbohydrate and lipids. A single item by itself would be ineffective. All three in proportionate ratio on the basis of individual requirements must be given as feeds,

6.2. .1. Feeding the young

The young of fish or prawns feed on plankton. Hence, a farmer rearing the young stocks should also have facilities for mass culture of plankton to feed the fish.

Algae, yeast, rotifers and the brine-shrimp (*Artemia salina*) larvae take care of these food requirements. Temperature, light, oxygen, salinity and nutrients must be controlled closely for large scale production,

6.2.2. *FERTILIZERS TO PRODUCE PLANKTON*

In nursery rearing of most of the brackishwater species, the best means of producing plankton and maintaining it at the required time is by fertilization.

A prior analysis of the water used in the rearing pond would help in determination of the nutrients required. Addition of nutrients already present in the water might result in increasing the pH and killing the plankton Some ponds function well with inorganic and others with organic fertilizers. In either case the production of a bloom, time taken to produce, and its composition are the best indicators of successful fertilization treatment. Production of "lab lab" (Chapter 5) a mixture of phyto- and zooplankton mass produced on the bottom of *P. monodon-Chanos* ponds in Philippines has been found very effective for the young larvae of *Chanos* and mullets. This is a plankton biomass produced just off the bottom by addition of the required nutrients. The normal constituents of plankton are rotifers, cladocera, copepods, worms, algae diatoms and larvae of insects and molluscs, etc.

Inorganic fertilizers have accurately known amount of futilizirg element so that required quantities can be added. These should be broadcast over the pond for even distribution. Organic fertilizers, cow-dung, poultry and pig droppings, etc. are sometimes carriers of diseases. Hence dosage should be less, used in one corner of the pond or in heaps at distinct intervals. If undesirable algae result then the ferlilization should be suspended till another water test is made.

6.2.2. *FEEDS*

6.2.2.1. Type of feeds

As the animal grows, its feed requirements often differ from younger stages. Structures of the mouth parts tend to change resulting in differing feeding habits as well.

The feeds commonly used now are in powdered form, broadcast over the water acting both as feeds and fertilizers. In this case the feed may not reach all the fish. The stronger fish rush to swallow the food as it falls into water while the weaker fish are pushed out of the way. This way some food is "lost" to the bottom of the water where it may, within limits, tends to act a fertilizer, or act, when in larger quantities, as a pollutant.

Pelletized feed is the current method of feed supply to fish. Required feed ratios can be formulated, compounded and made into pellets. Loss of feed by way of dissipation is minimized and pollution is less. Such a pellet should be refrigerated. This being an expensive arrangement, the feeds could be prepared few days before their use.

Use of raw flesh, either the viscera of other animals, slaughter house wastes, or dead fish, rotten vegetables, fruits, etc. is not desirab!e in a clean pond water. Boiling the feeds, drying and powdering before use is a cleaner and disease-free method.

6.2.2.2. Feed conversion ratio :

This is a method of obtaining a gross estimation of the usefulness of the feeds used. This means calculation of "food quotient" or the weight of food required to obtain a given weight of the cultured fish flesh. For example, if one kilogram of food is required to produce one kilogram of fish weight then it is the most ideal situation. Normally such "conversion ratio" is not possible. However, a quotient as close to '1' as possible gives the best conversion. Secondly, such search for feeds also includes the "cost" of the ingredients. Ultimately, the cost of any food formulated is somewhat secondary if the conversion is as closer to '1' as possible and does not use any ingredients directly used in human feeds. One such example is soyabean meal. It is directly used in producing human feeds, oil and powder. The factory waste of soyabeen, however, still contains enough protein to make it selective feed ingredient in prawn diets. Composition of selected ingredients extensively tried is given in table 9.

Table 9 : Proximate composition of selected feed ingredients*

INGREDIENTS	Crude protein	Fat	Carbo-hydrate	Fibre	Ash
Ground-nut cake	36	10	32	—	19
Musturd oilcake	31	10	29	—	30
Soyabean cake	44-50	8-11	33	6	6
Rice bran	13-16	4-18	43-47	6-9	13-15
Wheat flour (white)	12	1	87	<1	<1
Maize	7-12	5-6	81	2	2
Crustacean (Mysis)	74	15	—	—	—
Small shrimps	66	7	5	—	—
Mixed zooplankton	46	6	23	—	25

**After Bardach et al, (1972) ; Aquaculture*

6.2.2.3. An example of a formulated feed

Table 10 : Composition, and protein content of a formulated prawn feed

INGREDIE T	Analysed protein%	% in feed
Fish meal		5
Shrimp meal		6
Sodium hexa-metaphophease	51.5	1
Rice bran		25
Soy flour		58.5
Vitamin and mineral mix		4.5

It is well known that fish feeds do require, as poultry or cattle feeds, additives such as vitamins and minerals also to prevent dietary deficiencies. Such feeds would also prevent disease and mortality due to deficient feeds.

In a diet constituting 98% of fish meal, it was observed that the prawns *Penaeus monodon* assimilated 76.2% protein, *P. semisulcatus* 80.7%, and *Metapenaeus monoceros* 81.4%. This is one example of nutritive value of feeds among different species of one group of animals, namely prawns. Therefore, until such time a feed formula is developed seperately, a generalized feed formula should consist of 40-60% of protein (fishes at 40% and prawns at 40-60%) and the remaining of carbohydrate and lipids.

6.2.2.4. Diet ingredients

A few commonly tested and used items and unused so far are listed in table 11.

Table 11 : Some ingredients available for feed mixes in India

Ingredients of animal origin		Ingredients of plant origin	
Slaughter house waste	(used)	Rice bran	(used)
Fish, shrimp meal	(used)	Soyabean powder,	(used)
Squid meal	(used)	Cake, factory waste	(used)
Bone meal	(to be tried)	Maize powder	(used)
Meat meal	(used)	Wheat powder	(used)
Snail and other molluscan meat	used)	Oilcakes	(used)
Artemia salina	(used)	Legumes (leaf, stem & fruits)	(to be tried)
Swuitra	(used)	Mangrove leaves	(to be tried)
		Detritus	(used)

6.2.3 USE OF SUPPLEMENTAL FEED, ITS RATE OF USE

Supplemental feeds such as rice bran, oilcake mixtures are being extensively used in freshwatar ecosystems now. Use of similar type of feed in brackishwater systems is yet new.

If a pond is fertilized resulting thick blooms, then normally the need for supplemental feed is minimized. However, density dependent factors are to be taken into consideration as also differential growth in same species in monoculture practices and the several species in polyculture practices. Sampling at specific interval is one way of assessing the growth and thereby determining the need for supplemental feeding. A judicious use of artificial fertilization and supplemental feed could be followed in the controlled culture practices.

The use of supplemental feed also would vary with seasons and salinity regimes in the ponds. Metabolic activity of fish varies with temperatures and salinity. Feed intake is, therefore, a dependent factor.

Use of fresh and dry food in combination, use of proteins of animals and vegetable origin in combination are found to yield better results and the farmer is advised to use this method.

In prawn ponds, the pellet dissolves and disperses more quickly than in fin fish ponds because the prawn picks the food by using its chelate legs. The prawns do not swallow the food immediately, instead they move off in quick movements losing the food. Therefore, a binding material of good quality should be used.

The basic premise of binding the food in pellets is that feed cemprising all basic requirements is available quickly to the animal at any given feeding moment.

6.2.4 IMPORTANCE OF BENTHIC ORGANISMS AS FEED

The importance of natural food such as small crustaceans among zooplankton should be repeatedly emphasised. Especially benthic diatoms play a major role as feeds to young prawns and fish. Other small animals such as copepods, polychaete grow along with benthic diatoms and these are consumed by prawns and the grazing fish.

Table 12: Showing important considerations in supplemental feeds and feeding

1. Management	:	i. Rates of feeding and frequency of feeding. ii. Feeding in relation to environmenttal factors such as temperature, salinity. iii. Way of feeding: broadcasting; strategic locations; feeding trays. iv. Accumulation of unutilized feeds; detritus formation; pollution.
2. Feeds	:	i. Type of ingredients that could be available locally. ii. Considerations of cost. iii. Considerations of priority uses of these ingredients: human, poultry cattle or fish feeds. iv. Sewage and detritus. v. Natural food from artificial fertilization.
3. Nutritional values of feeds.	:	i. Basic feed requirements, protein, carbohydrates, lipids. ii. Their percentage requirements in formulated feeds. iii Other supplements, specific amino-acids, minerals, vitamins. iv. Requirements according to growth.
4. Conversion values	:	i. Conversion with specific feeds. ii. In combination with other additions. iii. Species-specificity. iv. Digestibility, caloric value, etc.
5. Pelletizing	:	i. Dissolving rate. ii. Binding materials iii Retention of nutrients on storage and handling. iv. Use of appetizing odours, etc. v. Form and size of pellets
6. Cost	:	i. Of all the above factors. ii. In the total economic evaluation of the brackishwater farming venture. iii. Cost of labour for preparation of feeds, daily feeding, collecting unused feeds, etc.

6.2.5. *IMPORTANCE OF DETRITUS AS FEED*

Investigations have suggested that detritus is the basic "food" substance or diet especially of prawns. The term "detritus" denotes a conglomeration of substances, dead and decaying organic matter derived from plankton, vegetation, fecal matter of the standing stock, dead animals plus the live micro-organisms that thrive on this matter. When organic or inorganic fertilizer is used or when material like rice bran or maize powder is broadcast over the pond, detritus is created in a short course of time. Prawn especially and other bottom feeders thrive on this.

6.2.6. *RATES OF FEED*

Use of supplemental feed is dependant on growth of the standing stock. Therefore, rate of feed is the key factor. As mentioned earlier, wastage of feed can cause two adverse effects ; i) increase the feed costs of the farming venture ; ii) pollution of the environment often leading to anaerobic conditions of the bottom of the pond.

Food is commonly distributed in traps at strategic areas of the pond or large food balls or pellets are released at specific points. A farmer can ascertain by visual observation how much food is unutilized and accordingly regulate it.

In nursery rearing, a level of 10-15% of body weight per day has been found to be a suitable rate, the body weight varying between 0.2-3.0g. As the animal grows, this rate is reduced to 2-5% at bi-weekly intervals or per necessity when artificial fertilization is used. It is reiterated that a combination of artificial fertilization and supplemental feed is the recommended way of manipulation of feed system. The method of evaluating feed system of prawn or fish cultured in confined ponds has been presented in table 12.

(III) BIO-ENVIRONMENTAL MAINTENANCE

6.3.1 INTRODUCTION

The relationships between temperature, salinity and dissolved oxygen values are discussed. The inter-relationship between the three factors would make it clear how these can affect the survival and growth of brackishwater organisms.

6.3.1.1 Temperature/oxygen relationship

Temeperature and solubility of oxygen are invesely related. As the temperature rises oxygen content of the water declines. Normal temperature in Indian coastal waters ranges from 17-40°C. At a temperature ranging from 28-30°C, the disolved oxygen ranges from 6.79 to 6.85 ppm at a chlorinity of 12‰. At a temperature of 17-19°C, the oxygen is 8.47 to 8.15 ppm at the same chlorinity of 12‰.

Salinity

Salinity and solubility of oxygen are also inversely related. That means any increase in salinity reduces the oxygen dissolved in the water. Thus, both high temperature and high salinity can reduce the oxygen present in the water which in turn affects the metabolic activities of the organism. Salinity and specific gravity could be measured by a refractomater, salinometer or hydrometer*. It is better to keep a specific gravity level of 1.027 in brackishwater system. Salinity$=0.03+1.805\times$chlorinity.

6.3.1.2 Dissolved oxygen **

Besides the relationship of oxygen to temperature and salinity, normal wind action can keep high dissolved oxygen levels at the surface of the water because of diffusion.

To keep oxygen levels high, agitation is created at lower levels of hatchery tanks by way of air diffusers with air blown in through air blowers or

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* Suitable hydrometers can be purchased to measure density of water directly, read specific gravity and then convert to salinity.

** Dissoved oxygen can be measured in laboratory by titratration method or directly with a portable electronic meter.

compressors. In large ponds water flow to create bottom current or constant in-flow and out-flow system would raise the dissolved oxygen at tha tlevels. The turnover created by the disturbance brings more water in contact with the atmosphere.

Dissolved oxygen is very important in warm water because the animals under culture have higher oxygen requirements, especially since the high temperatures keep the oxygen level low. And the bottom organisms would also be competing with the cultured animals for oxygen.

6.3 1.3 Temperature

Temperature is the most important factor in the culture practices. Although, in tropics, temperature is not a limiting factor still adequate care is to be taken to prevent sudden changes.

Temperature affects respiration by way of the relationship with dissolved oxygen level in waters and thus affects the metabolic activities of the animal. The animals that are being cultured, the fish and crustaceans, are all cold-blooded forms and they get acclimatized to certain range of temperatures in their normal hibitat. The respiration rates increase with increasing temperature. Thus, when required level of dissolved oxygen is not available for respiration at high temperatures heavy mortality occurs.

Normally brackishwater ponds maintain a level of 3-4' of water. When the fish constantly raise-up showing distress, quick water exchange should be adopted. Since this flow-in takes slow time, the water inside the pond and that flowing-in would intermingle and equalize at a slow rate preventing any distress to the animals.

6 3.1 4 pH

pH is the increase of hydrogen-ion concentration resulting from changes in alkalinity. Water with a pH of more than 7 is basic. When inorganic fertilizers are added to the pond, addition of any one element which is already present in the water in considerable quantities would adversely affect the pH of the water. The acceptable pH range in brackishwater is 7.5—8 3 If the decline in pH happens to be gradual then the effect on cultured animals would be insignificant. However, threshold limit should be maintained at 7.5.

6 3.2 METABOLITES

Metabolites are the wastes accruing to the pond system from the high density standing stock in the water. The metabolites settle down to the water and decompose. Accumulation beyond a certain level result in toxic concentrations generated by the mineralization of organic substences by heterotrophic bacteria. Ammonia is the predominant form of nitrogen excreted by aquatic animals and this applies to brackishwater forms too. Ammonia is also the main excretory product of aquatic invertebrates including crustaceans

6.3.2.1 Ammonia

Ammonia is acutely toxic to the animals in confined environments. Normal concentration in waters should not be allowed to exceed 0.1 ppm and usually it should be limited to even less than that.

Dissolved oxygen level in the water and pH affect ammonia toxicity. pH is found to be important here because only the un-ionized form of ammonia (NH_3) affects the animals adversely by crossing the tissue barrier. The level of pH of water, (the medium) and the pH inside tissue barrier (of the animal) show even slight shift in values ; the concentration of un-ionized ammonia on either side of the barrier shifts.

As the pH increases a decline occurs in the hydrogenion concentration, and there occurs rise in un-ionized ammonia concentrrtion. A reduction in the pH from 8 to 7 results in decrease in the quantity of un-ionized ammonia.

Un-ionized ammonia concentration affect the fish in confined rearing ponds by reducing growth rate, loss in physical stamina and decrease in disease resistance. Whether in mono- or polyculture systems presence of ammonia concentration is thus detrimental.

An increase in dissolved oxygen reduces the toxicity of un-ionized ammonia. High turnover rates also help in filteration, remove ammonia and increase the dissolved oxygen.

(IV) HARVESTING

6.4.1. *INTRODUCTION*

One of the principal problems faced by shrimp culturist is harvesting; Netting and trapping are only partially effective. Partial draining is to be done first before the first netting. After the entire pond is drained, hand picking is done and also search for burried prawns. The entire operation is time consuming and operation of pumps increases fuel costs

Mullets gather at sluice mouths when tidal water is let in. Harvesting by cast nets is possible at this site or a bag net can be attached to sluice gate and the gate opened when the fish enter along with the gushing water.

6.4.2. *HARVESTING BY DRAINING*

To harvest or for removal of the total population of a pond, draining remains the only effective method. However, it should be remembered that the unit size of the pond determines its total draining capacity. A small pond less than 0.1 ha can be drained out quickly, if the size increases more time is consumed. In such cases partial harvesting is possible as the water level falls, by operation of cast nets. Total draining itself may sometimes takes two to three days.

The draining can be done by gravity flow through sluices when the water level outside the pond/tank is out at low tide. At certain level, the pond bed might be lower than outer water level in which case pumping out is the only choice left.

6.4.2.1. Season and Time

Draining is somentimes not possible in monsoon in India because there is standing water on all sides. Harvesting seasons/times should, therefore, be timed properly to allow total drainage. Under warm temperature draining out is inadviceable. Therefore, early morning or evenings should be chosen for harvesting.

6.4.2.2. Mode

Fast draining is deterimental to the fish. Slow and regular flow would allow the fish to follow the flow-out and can be captured at the mouth of the sluice. Fast flow would cause fast fish movement, sluices and screens may injure the fish or they get entangled in surface vegetation or bury in mud

Before draining, all materials that hamper water movement inside the ponds such as bunches of twigs placed in prawn ponds should be removed. Screen mesh size can be enlarged to enable easy flow.

6.4.2.3. Personnel

Nets, scoops, containers such as baskets, tubs, scales, etc , can be kept ready at the pond to be harvested. Only experienced fishermen should be allowed to take part in the operation, he only wade into the pond when completely drained to hand pick the remaining organisms.

6.4.2 4. Storage

If fish harvested cannot be transported to market immediately or sorting is required in order to give more growth time to one species, then a net enclosure in an adjacent pond could be used for releasing the fish alive. This is only temporary storage. If the density is high several such enclosures can be made.

6.4.3. *CATCHING FISH BEHIND SLUICES*

When only partial harvesting is done or in small holdings this method can be followed. Mullets move against current and when water is let in catching them at sluice mouths is easy.

In box type sluices, the first shutter or board can be removed till the fish gather inside the box. Then the board is put back in place ; a net can be kept suspended inside and the gathered fish can be lifted out.

6.4.4. *CATCHING FISH WITHOUT DRAINING*

Traps : Use of traps is common in catching prawns and crabs. Several traps can be placed in a row or group. This would be useful in large operational units of more than 1 ha in extent, in deeper waters and when partial harvesting or thinning has to be done.

NETS : Cast nets are used regularly in large holdings or when draining is not possible or not required. Mesh size should be proportional to the size of the fish to be taken out.

In large holdings or operational units, seines, bamboo screens, trap, nets etc., can be used. Other methods such as disturbing the fish in order to drive them into fixed nets can also be followed.

It is essential that some form of net is maintained by the farmer himself depending on the size of his farm.

6.4.5. *ECONOMIC CONSIDERATIONS*

Harvesting again is an economic consideration. If a single farmer cannot maintain a pump or large nets, he must be able to take them on short term loan from other sources. He can engage labour for short terms for the period of harvesting, for pump operation, netting, and later, for preparation of ponds for next season.

(V) FARM MAINTENANCE

6.5.1. *INTRODUCTION*

Any culture, whether in aquatic or terrestrial, environment has an element of risk and has to face certain hazards during the management operations. The risks and problems which are generally encountered in brackishwater fish and prawn farming are listed below.

6.5.2. *MECHANICAL PROBLEMS* :

Structural failures

Due to constructional defects, use of substandard materials, unequal subsidence of the base soil (due to characteristically low bearing capacity, tunneling beneath the gate platform due to unequal water pressure on either side of the gate and low consistency of the soil, ete.) the structures may become ineffective and consequently water management would pose a problem. If the structures are made of hume pipe, it is very often seen that the pipes are silted up rapidly with the water laden silt because the outlet flow from the farm is not strong enough to dislodge the settled silt. Cumulative silt deposition not only reduces the water supply into the farm ponds but at times make the structures completely inoperative.

Land slides from dykes

Saline soils, on which brackishwater farms are made, are generally of low consistency When dry they contract and on being wet they change into a quagmire. Since it is difficult to grow vegetation on saline soil, cracks very often develop in the dykes during dry months which at times assume huge proportions. With the break of monsoon, rain water passes through these cracks, develop internal tunnel and result in large scale sliding of the earth from the dykes, often jeopardising the very existence of the dyke if suitable corrective measures are not taken in time.

Erosion and silting up of farm ponds

The high concentration of exchangeable sodium in saline soil results in dispersion and fluffyness of surface soil and, hence aids in erosion of the soil. The rate of erosion is accelerated by strong wind and heavy rains and the soil thus eroded from the dykes and embankments are deposited in the farm ponds and feeder canals resulting in silting up of their beds. If timely action is not taken the pond beds may be silted up.

Over flooding of ponds

Torrential rains or heavy downpour considerably stows up the water level beyond the free board of the pond. If this happens during the spring tide phase and concides with the rising tide the position becomes all the more grave. The tidal thrust and pressure on the water gate is so strong that the gate has to be opened to save it from collapsing. Once the gate is opened the incoming tidal water exposes the farm ponds to over flooding. At such times lowering the water level in farm ponds with the beginning of inclement weather or to drain out the excess rain water to the estuary during low tide can be tried.

(VI) PROBLEMS

6.6.1. *PREDATORS, PESTS DISEASE AND COMPETITION*

Pests : Growth rate of cultured animals would depress in the ponds if other food competition are present. Small fish, frogs, snakes, eels and crabs can all act as competitors. Intenmittant netting should help in eliminating these. The presence of carbs and eels is otherwise harmful too in that they create tunnels in the ponds which act as escape routes both for water as well as the animals. A constant watch should be maintained to check this.

Parasites Parasites are not harmful as long as they use the host for obtaining food. But disease causing parasite could mean trouble in a large way *viz.*, heavy mortality. In confined water like ponds where high density standing stock are hold, disease of one fish could spread quickly.

Generally, the longer we keep a stock of fish the greater the problems of disease. Since the basic aim of culture in confined environment is to produce maximum fish by weight in the shortest time possible, the harvesting at correct times would partly offset the loss due to such factors.

ypes of parasites Tand diseases : Not much information is available at present on the types of parasites and diseases common in brackishwater system probably because the flushing effect of tidal waters would keep this problem low. However, some commenly known parastes in brackish water fish and prawn are given below . There are two types of parasites, the ectoparasites and the endoparasites. The ectoparasites are those which attach themselves to the outer regions of the body and the endoparasites reside inside the animal. The latter are more dangerous because their presence is unknown till deaths occur. In the case of ectoparasites prophylactic measures such as use of chemicals, dips in potassium permanganate, etc., would prevent fungal and bacterial attacks.

Parasite/disease	Host animal	Remarks
Gregarine	In stomach of prawns.	
Milky condition (cotton prawn) caused by a Microsporidean.	All over the body or restricted to some organs and musculature; The prawns turn white, cottony soft, loose some parts slowly. In musculature and liver and sotmach.	No serious harm reported. Incidence not so high so far; If it occurs however, the animals are not marketable.
Larval trematodes and tape worms and round worms. External flatworms.	In *Chanos chanos*, and Crustaceans; Attach themselves on the surface of the body. Milky condition and fin rot reported here also.	

Some corrective or prophylactic measures are :

—Keep the ponds clean and well aerated.

—Change water as soon as a single dead fish with unknown reason is found.

—Segregate pale, emaciated or dull fish or prawns.

—Apply some lime in low quantities.

—Reduce salinity.

—Do not release fish handled by any person directly into water without first diping it in dilute (1-2 ppm) potassiam permaganate solution.

—Avoid use of too much putrefied organic fertilizers.

—For fin rot, dip in 1 part copper sulphate in 200 parts water for 1-2 minutes.

—For fungal attack, dip in malachite green of 1 parts in 15,000 parts water. for a short time.

—For any swallings on body, dip in 1 part formalin (40% formaldehyde) in 4000 parts of water daily for an hour.

—If large scale mortality occurs the entire pond should be drained, emptied, dried and dug up afresh.

Molluses are carriers of parasites. Certain phases of life of these parasites cycle pass through the snails. Reduction of snail fauna in the ponds would be advisable. Similarly use of raw snail flesh as a food ingredient could also be avoided unless they are free of any cysts or parasites.

Competition

Competition would often exist in polyculture systems unless proper knowledge of the feeding habits and ecological niches of different species is well established. Competition could be for space, for feed ; between young and adults of the same species or different species ; between different size groups of the same age groups. This is one reason that compatability criterion is used when lecting species for polycultue is brackishwater system. A few known examples of competition and compabaility are :

Spcc:es	Predators	Competitors	Compatability
Prawns	*Lates* *Eleutheronema* *Elops* *Megalops* Frogs snails	Same species of prawn at the time of moulting (cannibalism) or interspecies like frogs and carbs	*Chauos chanos* Mullets
Chanos chanos	Fish snakes frogs	Mullets *Lates*	prawns *P. monodon*
Mullets	*Lates* & other fishes	Other species of mullets *Chanos*	Prawns *Etroplus* *suratensis*

Control of environ mental factors

Acute sensitivity of brackishwater animals to changes in temperature, salinity, dissolved oxygen and pH are brought out earlier. This sensitivity is intensified under the confined conditions of ponds. Most of the external diseases are brought about by bacteria and protozoans. Quality control of water is the best prophylactic method. Internal parasites and Helminths, Arthropod parasites are not that easy to dislodge despite environmental control.

PART III

ECONOMIC FACTORS

Chapter 7

ECONOMIC FEASIBILITY OF FARMING

7.1 ECONOMIC FEASIBILLITY OF BRACKISHWATER CULTURE PRACTICES

The economic viability is largely governed by favourable factor-product price relationship. Current high prices of shrimps particularly of exportable variety *viz.*, *Panaeus monodon* do offer a potent incentive to inventors. The success of the brackishwater venture depends largely on the wise exploitation of certain natural factors elaborated in the foregoing pages. Briefly, therefore, wise selection of site, conservation and utilization of natural resources while digging the ponds and easy access to seed are the conditions precedent for its success.

A venture of this type is also :

1. Profit-oriented, therefore, all efforts are concentrated in raising currently the highly valued Penaeid prawns.
2. These operations can be combined with fin fish production that has a local market.

The owner can also, depending on his own initiative may make many innovations in his farm to improve production. He may explore individual marketing channels, ways and means of capturing market at correct moment and of facilities for storage and freezing. This means, in other words, the expertise possessed by the manager (farmer) himself is to be properly utilized unless he would engage a trained farmer.

Price sensitivity

Taking one example of price sensitivity, mullets are now generally grown only in brackishwater operations, processing technology is not so much advanced so as to make fillets which can find a a market in cities. The exportability of the fish in live condition in intra-regional transport is not yet tested. Therefore, marketing is confined to local areas at a price ranging between Rs. 3/- to Rs 6/- per kg in various States. The price sensitivity of the prawn viz. *Penaeus monodon* on the other hand was imilar to that of mullets a decade or two ago. Changes in consumer preferences elsewhere in the world, introduced an inflated unit value on the prawn. The price level is at a peak now ranging from Rs. 50-75 per kg (head-on) at any small local market. Generally, the A-grade prawns are out of local market.

A farmer should, therefore, balance between these two extreme examples, in choosing his culture cropping operations.

Apart from these economic considerations based on biologic requirements and markets; economic considerations involve two major costs : fixed and variable :

1. FIXED COSTS :
Site selectlon and cost of land (outright purchase or lease).

2. CONSTRUCTION COSTS :
i) Main sluice gate (Iron/wood material).
ii) Strengthening of main sluice gate (earth work, pitching, tow-wall).
iii) Digging the ponds to a depth of 4-5' depending on tide level in the locality chosen.
iv) Strengthening the dykes (mud levelling and compacting.)
v) Secondary sluice gates (mud/brick).
vi) One make intake channel from the main slujce (digging, embankment).

3. WATER PUMP (Stand by)
(Can be taken on loan also).

4. INTEREST ON AMORTIZED CAPITAL

Generally, a purely economic analysis would have to consider the costs of diverting the capital to (alternative use), from otherwise, a profitable use. Say for e.g., : on poultry, interest in keeping it in bank. on paddy field or any other industry. In short return on rupees investment is the guiding principle at in any oteer investment.

CASE STUDY* An example of expenditure/return expectancy for a typical 5 ha farm at Kakdwip village in West Bengal (location : latitude approximately 88°.15' E and 22° E ; having a tidal range of 5.15 m) is presented in table 13.

*All costs/prices are as applcable to 1978 and the State of West Bengal, India.

Table 13 : Expenditure/return expectancy of a typical 5 *ha* brackishwater farm located at Kakdwip, West Bengal.

Fixed Costs (initial)	Initial cost (Rs)	Annual costs (Rs)
Land at the rate of Rs. 8000/ha 20 years payment	40.000	2,000
Construction of dykes and ponds, installation of sluice gate 25 year amortization	1,00,000	4,000
Buildings :		
20 year amortization	20,000	1.000
Boats and nets 5 year amortization	5,000	1,000
Interest on amortized capital funds at the rate of 15%	—	12,495
Total :	1,65,000	20,495
Say :	1,65,000	20,500
Capital costs per ha	33,000	4,100

5. A shed to store implements or residence for the watchman :
   Watchman is essential when the owner himself is not on the spot both to take precautions against natural hazards as well as against animal and human poaching.

6. Nets, implements :
   Nets for harvesting and sampling have to be maintained. Implements required for maintenance of farm are also to be kept.

Variable costs (*Recurring*) *:* Cost of seed (fry or fingerlings) ; including labour and net costs if seed is colleted by farmer himself, time spent on operation, transport and segregation.

Cost of production : Chemicals/fertilizers ; Supplemental feed ; Labour (to maintain ponds, take in water, etc) ; Water pumping ; Fuel ; Harvesting ; Net maintenance and cages (if used) ; Maintenance (general) ; Taxes and depreciation ; Interest on capital.

Income and profit before taxes : An example of the economic feasiblity is presented in table 14.

The stocking rates, fertilize rates, production rates applicable to a case study are presented in the table.

Table 14 : Production costs and income (5 ha unit)

Production costs (Annual)	Prawns (Rs)	Fish (Rs)
A SEED (cost of purcease and/or of collection and transport 1000 nos prawns or fish	750	750
Fertilizers		
Organic manures	500	500
Inorganic	2,000	2,000
Feed (Ground-nut oilcake price bran, Maize powder yeast, soyabean and wheat powder)	15,000	3,500
Salaries and wages (Manager Rs. 500/-P.M. 4 Labour (Watchman) Rs. 200/- P.M. x 4)	15,C00	15,600
Transport	1,000	1,000
Farm maintenance & repair	2,000	2,000
Misc. expanses 5% or production costs	1,542	968
Interest on operational funds 15% Per annum, 3 months	1,215	762
Tatal :	39,607	27,080
Say :	39,600	27,100
Production costs per ha	7,920	5,420
B. SALES :		
prawns 1000 kg/ha/yr (3 short-terms crops)		
Fish : 2000 kg/ha/yr.		
Sale Price		
(Modest) Prawn Rs. 35/kg		
(Average) Fish Rs. 6/kg.	35,000	12,000
C TOTAL ANNUAL COSTS (annual capital costs and production costs)	60,100	47,600
D. TOTAL ANNUAL C~ST PER HA.	12,020	9 520
Profitability (Gross return)	1,14,900	12,400
Profitability per ha	22,980	2,480
F. RATE OF PROFITABILITY ON CAPITAL (%) (After deducting amortization costs and interest on operating capital)	69.6	7.5

The above case study applies to one region where because the tides are at 15′ level, concomitant rise in dyke and sluice levels are needed.

Therefore, a generalised evaluation given above must be applied by each individual farmer to assess the feasibility of his venture.

7.2 FRY INDUSTRY

Fry industry with its base on naturally occurring seed in coastal waters in India is another instance where economic potential might exist. This has not been studied yet.

The only area where even small village or house-hold level industry exists in India is West Bengal for the penaeid prawn ; *Penacus monodon.* Fry industry also exists for *Lates calcarifer.* Seed of *Macrobrachiun malcolmsoni,* at River Godavari are also sold/transported by the Government of Andhra Pradesh (Department of Fisheries) at nominal prices.

Recently State Fisheries Corporation of West Bengal and Marine Products Export Development Authority has taken up *Penaeus monodon* fry transport.

7.2.1 AN EXAMPLE OF FRY INDUSTRY IN PHILIPPINES

Chonos chanos : The milk fish fry industry is highly developed in Philippines. The fry catch is estimated to be 1.35 billion, sufficient to meet the country's requirements. Monthlv fry prices indicated that the system responded to supply and demand changes and other stimuli (Bardach *et. al.,* 1972).

7.2.2 DOMESTIC LEVEL FRY INDUSTRY INDIA

Penaeus monodon : The penaeid (*P. manodon*) fry industry is still at a house-hold level industry in West Bengal and has not received much attention so far. It has been purely intra-ragional at lower Sunderban region. Prices vary between Rs. 12-16/1000 fry in abundant season and Rs. 25-30 in non-season (1980 figures). The costs involved are 7-8 man-hours in operation per day, one Midnapore spawn collection net and 2-4 man-hours in transportation.

Consignments air-lifted by MPEDA recently from Calcutta to Cochin in 18 hours showed survival rates as shown in the following table varying from 48-96%, lowered density increasing the percentage survial.

Table 15 : Survival of air-lifted fry from Mammen *et al.*, 1975.*

Times despatched	Size of fry	No of fry in each tin	No received at Cochin	Survival rate
1	12-15 mm	2,000	955	48%
2	,,	2,000	904	45%
3	,,	1,500	870	58%
4	,,	1,500	870	58%
5	,,	1,500	835	58%
6	25-30 mm	250	240	96%
		8,750	4,682	53.5%

Transportation cost worked out to Rs. 160/- and Rs, 107/-respectively per thousand live fry.

* Procurement of prawn fry by MPEDA by T.A. Mammen & others. The short term fry programme in Management of brackishweter farmers ; 4-14 December, 1970 by CIFE, Bombay.

Chapter 8

INSTITUTIONAL SERVICE/BANKING SERVICES

8.1 INTRODUCTION

Any well conceived strategy for brackishwater aquaculture development may open avenues for wage—paid employment either of seasonal or regular nature in areas where large-scale investment is envisaged. Besides augmenting domestic availabilatities of protein food increased foreign exchange earnings may contribute to the overall economic development of the country.

The brackishwater farmer might be benifitted by the knowledge on the type of help he could obtain from Research Institutions and Banking Services. A short account is given here.

8.2 INSTITUTIONAL SERVICES

Government and Indian Council of Agricultural Research Institute's services are doing considerable research, development, extension and training. All these institutes will meet the demands of the industries or private entrepreneurs for practical solutions to their problems. However, it is the responsibility of these people/industries to bring their problems to the notice of the research institutes.

An important line between the field and the institute is the extension service. Technical advice or help can be obtained from this service.

State Govts., and Krishi Vigyan Kendra's are maintaining mobile soil testing laboratories. State-wide soil and water testing labs offer sevices to agriculturists regularly. Every geographical area has this help.

The third way is to take part in the training programmes offered by the ICAR research institutes. Details of technology and methodology are offered in these training programmes which last from 10 days to 5 weeks. Teaching is offered in the local language to help the non-English knowing participants It is necessary that the participants should be receptive listeners. For instence, a manual of this type is necessarily broad based. Individual geographical, socioeconomic limitations, detailed inputs vary and cannot be covered. It is necessary that individual limitations be actively brought to the attention of the training authorities.

8.3. HELP FROM BANKING INSTITUTIONS

Brackishwater farming is a new field. However, despite the involvement of risks, the high potential for foreign exchange earnings and employment potential are enough reasons for development of brackishwater culture systems. Banking institutions are coming forward to participate by way of advancing capital loans of long-term nature.

8.4 SUBSIDIES FROM STATE GOVERNMENT OF FISHERIES

Coastal State Governments have also been implementing schemes to subsidise, 25% to 100% in some cases to the brackishwater farming enterprise. This help is going to the poorer sections of the farmers *viz.*, the marginal farmers provided they form a co-operative society. This subsidy would cover cost of land, construction of farm and implements and nets.

For details, the Fisheries Department of State Governments may be approached.

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