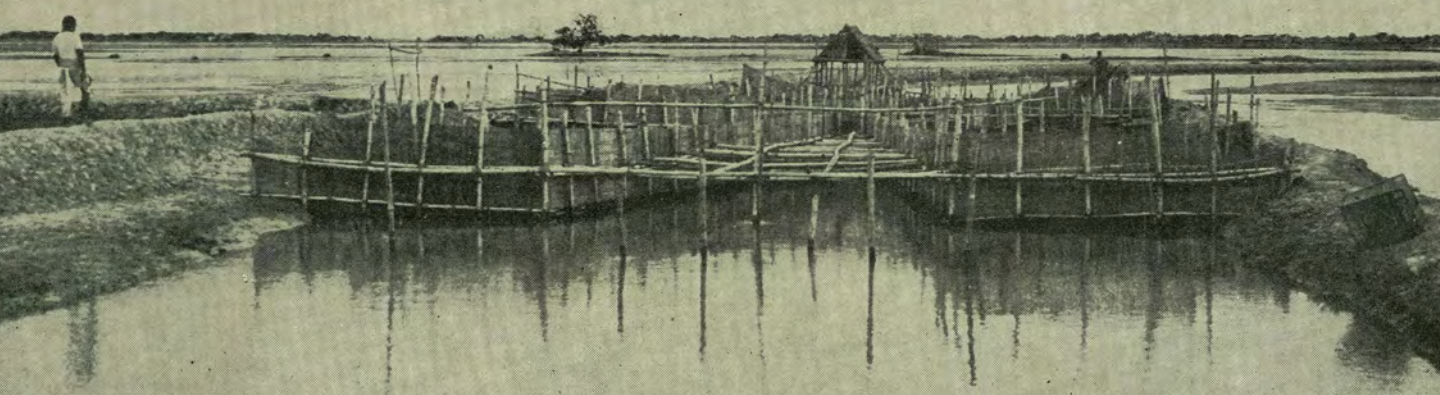
ECOLOGY AND FISHERY MANAGEMENT OF BRACKISHWATER BHERIES IN WEST BENGAL

BULLETIN No. 46
AUGUST 1986



CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
BARRACKPORE • WEST BENGAL

Produced by :
Information and Extension Division

Published by :
SRI D. D. HALDER
on behalf of The Director
Central Inland Fisheries Research Institute
Barrackpore

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FOREWORD

Bheries constitute one of the important fishery resources mainly in the estuarine wetlands of the Upper and Lower Sunderbans of West Bengal. With a waterspread area of about 33 000 ha and spanning across low, medium and high saline zones, bheries offer immense scope and potential for augmenting fish and shellfish production in these brackishwater impoundments through improvement of traditional practices.

This document is the outcome of detailed studies of the physico-chemical and biological environment of bheries undertaken by the Institute. It also attempts to synthesize, update and expand the widely scattered information available on the bheries of West Bengal. Laying due stress on the crucial components of the biological production system in bheries, this bulletin is intended to form a useful background paper on the assessment and management of these natural fishery resources.

A.G. Jhingran
Director

C O N T E N T

ECOLOGY AND FISHERY MANAGEMENT OF BRACKISHWATER BHERIES in WEST BENGAL

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1 INTRODUCTION

The fisheries developed through ages in brackish water tidal wet lands, namely mudflats, swamps, marshes, paddy fields, etc., are locally known as 'bhasabadha' or 'bheries' in the district of 24-Parganas, West Bengal. This traditional fishery is reported to have first developed in spill area of the Bidhyadhari river near Calcutta city, which was silted up due to sewage discharge in it. A portion of the river and spillway were embanked and converted into lucrative bheri fisheries. Later this fishery has been developed in the lower deltaic region of West Bengal known as the Sunderbans with the advancement of transport facilities. Since the effect of tides is felt far inland even in silted up rivers and also in tributaries, bheries in good numbers also exist in the upper low saline zone far away from the sea face. Main sources of water for bheri fishery are three major estuaries, viz. Saptamukhi, Thakuran, and Matla in the Hooghly - Matlah estuarine system and other minor estuaries like Gosaba, Murigganga, Harinbhanga, Kulti, Ichamati, Raimangal etc. with their tributaries.

Earlier some contributions on the development of bheri fishery have been made by Hora and Nair (1944), Naidu (1952), Pillay (1954), Pillay et al., (1962) and Pakrasi et al., (1964 and Pakrashi (1965). Available information on this vast fishery resources is meagre and not updated.

Over the passage of years bheri fisheries have assumed a new dimension in brackishwater aquaculture as these form very important productive units for raising both fresh and brackishwater fish and prawn to cater the protein needs of people of Calcutta Metropolis and as well as earning foreign exchange through export of valuable tiger prawn, (Penaeus monodon.)

With an objective to record comprehensive updated knowledge, studies have been made on bheri fishery relating to inventory survey, fertility status of soil, ecology, and management of bheries under different saline regimes and the details of which are presented in this technical bulletin.

2 LOCATION, AREA, AND SIZE OF BHERIES

Bheries are large shallow water bodies embanked by low earthen dykes allround and located in various mouzas under 22 police stations in the north, north-east, and south in the Sunderbans of the district of 24 - Parganas. Those exist above, 22°40'N latitude are low saline, below 22°20'N are high saline, and those fall in between are medium saline. Some are very close to the Calcutta city. Location of the bheries are shown in the map (Fig. 1).

Inventory survey made during 1982 - 84 by complete enumeration has revealed that total number of bheries is about 1334 covering a brackishwater area of about 32930 ha spread over three saline zones. The maximum area of bheri fishery recorded is in the medium saline zone (15613 ha) followed by low (9844 ha) and high saline zones (7472 ha).

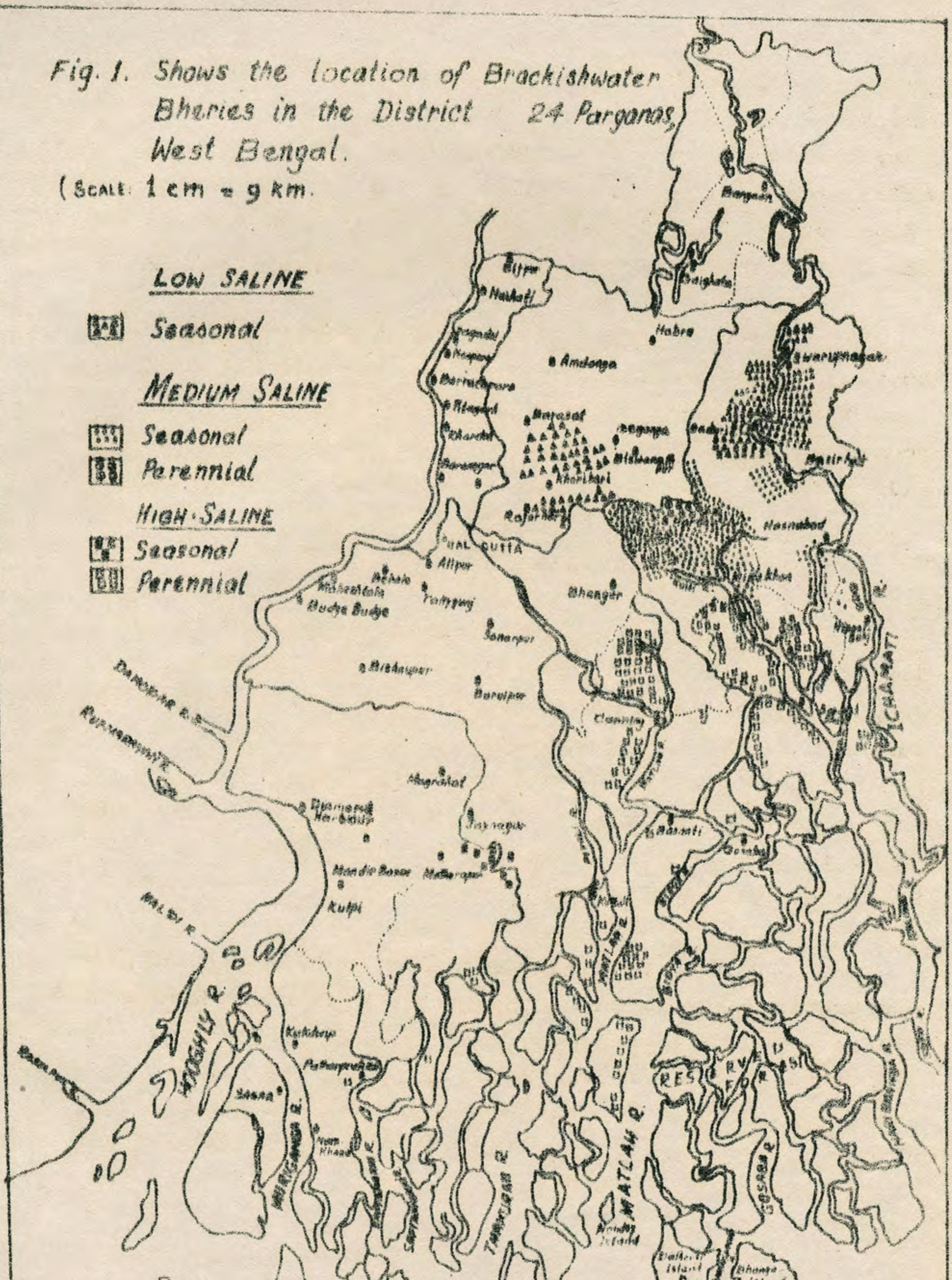

Fig. 1. Shows the location of Brackishwater Bheries in the District 24 Parganas, West Bengal.

The shape of bheries is very irregular and the size varies from a small (2 ha) to as big a water area as 267 ha. The average size of bheries ranges from 15 ha to 34 ha in the three saline zones. Bheries in high saline zone are smaller and those in medium saline zone (Table - I) are bigger.

Over the years the area under brackishwater bheries has increased considerably because this fishery is a profitable enterprise. However, a decrease in area in case of freshwater sewage-fed bheries to 1618 ha from 3239 ha has been reported due to utilization of erstwhile saline swampy area for construction of salt lake city.

3 TYPES OF BHERIES

Bheries in West Bengal may broadly be categorised into two types - freshwater sewage-fed and brackishwater bheries. The present study is restricted to brackishwater bheries only.

3.1 Freshwater bheries

These are erstwhile brackishwater bheries located very close to Calcutta Metropolis in plain viz., Saltlake, Tiljala, Jadavpur, Sonarpur, and Bhangar. The tidal effect in these bheries had since long ceased due to silting up of the Didhyadhari river and as a result these have been converted into sewage-fed fishery utilizing and recycling waste waters of the city. The species of Indian major carps, exotic carps, and tilapia are mainly cultured.

3.2 Brackishwater bheries

These bheries are categorised into low saline (below 10 ppt), medium saline (10 - 20 ppt) and high saline (above 20 ppt) water bodies varying in salinity depending on their distance from sea face. Tidal waters varying in salinity from low 1.00 ppt to as high as 32.0 ppt are being used during cultural period in bheries.

Estimated total production of fish and prawn from bheries is about 25518 t per annum. The average annual production is about 775 kg/ha from a bheri. The total production of prawn (P. monodon) is about 4664 t per annum with an average production of 142 kg/ha. P. monodon contributes about 18% of the total production. The data indicate the production in bheries is low. These bheries are of seasonal and perennial types.

Seasonal bheries are dried up during November - December and left exposed to sun for about a month till next season starts. Both fish and paddy are raised in the same unit in a sequential manner and also in conjunction. Such bheries mainly exist in low and medium saline zones and to a least extent in high saline zone.

Perennial bheries exist mainly in high saline in the south Sunderbans, but in small numbers in medium saline zone. Brackishwater prawn and fish are generally raised in these units almost throughout the year. The bed of such bheri is not generally dried and paddy crop is not grown due to high soil salinity. These bheries are locally called as 'tank fisheries' (Table I).

3.2.1 Low saline bheries

These bheries are located in the north of the district of 24-Parganas under Barasat, Swarupnagar, Deyganga, Rajarhat, and Baduria police stations. In these, the maximum water salinity does not generally rise above 10.0 ppt in summer months, while during monsoon the water salinity drops down to almost freshwater level. Both fresh and brackishwater fishes and prawn are cultured in these ecosystems together or separately. Paddy is grown from July to November along with freshwater fishes. P. monodon is extensively cultured along with L. parsia during January to the second week of June prior to onset of monsoon. Besides Indian major carps (L. rohita, C. catla, and C. mrigala). T. mossambica are extensively cultured. The average production of low saline bheri is about 878 kg/ha/yr of which P. monodon contributes about 70 kg/ha/yr. Estimated total annual production of fish and prawn in this zone is about 8641 t including that of P. monodon 690 t.

3.2.2 Medium saline bheries

These bheries exist in north - east region of the district of 24-Parganas under Haroa, Minakhan, Hashnabad, Basirhat and Hingalgunge Police Stations. The water salinity of these bheries does not generally rise above 20 ppt during summer while minimum value drops down to traces during monsoon. Estimated total annual production of this zone is about 11692 t of which P. monodon contributes about 3349 t (29.0%). The average production of fish and prawn is about 749 kg/ha/yr. The yield of prawn is higher in this zone (214 kg/ha/yr)

than in other two zones (70 - 84 kg/ha/yr). The cultured practices and types of fish and prawn grown in this zone are similar to that in low saline zone. This zone has saline sewage-fed bheries at Minakhan P.S.

3.2.3 High saline bheries

Highly saline bheries are located in south of the Sunderbans covering Police Stations *viz.*, Canning, Mathurapur, Joynagar, Patharpratima, Basanti, Kultali, Gosaba, Sandeshkhali, Kakdwip etc. The water salinity of bheries rises to as high as 30 - 37 ppt during summer while during monsoon it does not generally drop down to below 6 - 7 ppt. Estimated total annual production of this zone is about 5185 t of which *P. monodon* accounts for about 625 t (12%). The average production is 694 kg/ha/yr including *P. monodon* 84 kg/ha/yr. Brackishwater fishes like *L. parsia*, *L. tade*, *L. calcarifer*, *Mystus* sp., *E. tetradactylum*, etc., and prawn like *P. monodon*, *P. indicus* and *M. monoceros* are generally reared. Total production per ha in high saline zone is comparatively low because fast growing major carps can not be raised here as practised in other zones.

4 ECOLOGY OF BRACKISHWATER BHERIES

Ecological studies were made during 1983-84 in selected bheries at Kharibari (low saline), Haroa and Kulti (medium saline) and Golabari (high saline) to determine the extent of variations in water qualities and soil conditions and their impact on biological productivity of these ecosystems. The findings of the study are presented here-under.

4.1 Water qualities

The details of water qualities in respect of the range of fluctuations of important physico-chemical parameters with their annual average values are shown in Table II.

The parameters can be grouped into two on the basis of extent of variations in between the saline zones. One group comprising water depth, temperature, turbidity, pH, dissolved oxygen and nitrate nitrogen though showed wide variations in the respective zonal bheri but their average values when compared did not show significant variations in between the saline zones. The other group comprising electrical conductivity, salinity, total alkalinity, calcium, magnesium, and dissolved inorganic phosphate showed not only striking variations in water in the respective zonal bheri, but also in bheri water in between the saline zones. This feature was more marked in between low and high saline bheries. It is seen from the table II that annual average values of salinity (18.2 ppt), E.C. (23.0 mmhos/cm), calcium (186.0 ppm), magnesium (843.0 ppm) and phosphate (0.24 ppm) were recorded maximum in high saline bheri at Golabari. These were, however, recorded minimum excepting phosphate value in low saline bheri at Kharibari (3.8 ppt, 6.2 m.mhos/cm, 65.0 ppm, 153.0 ppm and 0.11 ppm respectively). The total alkalinity was recorded minimum in high saline bheri (111.0 ppm) as compared to that in medium and low saline bheries (145.0 and 138.0 ppm respectively). The water salinity ranged from 0.10 - 9.5 ppt., 0.27 - 15.8 ppt and 6.6 - 36.2 ppt. in low, medium and high saline bheries respectively. In both low and medium saline bheries, the water turned into fresh during monsoon, while salinity of high saline bheri declined to a low saline range

during that time. Due to transitional phase from brackish to fresh and vice versa, it has been possible to raise both brackish and fresh water fish and prawn in the above ecosystems. As expected, both calcium and magnesium values increased with the increasing salinity from low to high saline zones, the latter increased proportionately more.

Ecology of saline sewage-fed bheri at **Kulti** in medium saline zone is dealt separately because the ingress waters into bheries in this area and around are polluted due to sewage discharge of Calcutta city in Kulti river. Hence the dissolved oxygen level (2.8 - 5.3 ppm) in bheri water was found comparatively low while the water was rich in dissolved nutrient contents like phosphate (0.72 ppm) and nitrate nitrogen (0.56 ppm). The other chemical parameters were similar values as those recorded in other bheries in medium saline zone.

4.2 Soil characteristics

The brackishwater bheri soils are generally silty clay to silty clay loam in texture which have high water retentive capacity. As a management practice these soils are subjected to periodical inundation with tidal waters of varying salinity, nutrients and silt contents which influence the soil condition of bheries. Bheri soils adsorb a portion of dissolved nutrients from tidal ingress waters and encourage development of benthic algae - natural food organisms for fish and prawn.

Important soil chemical conditions which influence the productivity of bheries were determined and the data are presented in Table III.

It is discerned from the table that there was a striking difference in soil salinity in between the high and low saline zones. Average Electrical conductivity value of high saline bheri was much higher (15.4 m.mho^{s}/cm) than that of low and medium saline bheries (3.8 and 5.9 m.mho/cm respectively). The soil characteristics of high saline bheri remained distinctly saline throughout, while that of low and medium saline bheries during monsoon months turned into normal soils registering a drop in E.C. values from 7.5 to 0.9 and 12.1 to 1.1 m.mho^{s}/cm respectively. A change over from saline soil to normal soil condition and vice-versa is an important ecological phenomenon of these bheries. A direct correlation between soil and water salinity of bheries was discerned.

The soil reaction of bheries was found in the near neutral range (pH 6.5 - 7.5). Though variations were observed in the respective saline bheries, the average values (pH 7.1-7.3) did not vary appreciably in between the saline zones. In general bheri soils were poor in available nitrogen (14.0 - 17.8 mg N/100 g) but rich in phosphorus (8.1 - 12.4 mg P_2O_5/ 100 g). Organic carbon content of bheri was in the medium productive range (0.53 - 0.69% C). In sewage polluted saline bheri at Kulti pH ranged from acid (6.2) to neutral (7.4) while both organic carbon (0.89%) and available nitrogen (19.0 mg N/100 g) were higher because of higher organic loads.

4.2.1 Fertility status of bheri soils

Besides studying soil conditions of selected bheries, 120 soil samples collected at random during survey from bheries under different saline zones were analysed to assess

fertility level of these ecosystems. The data on this are given in Table IV. It is evinced from the table that E.C. values of soils indicated a salinity gradient - low, medium and high saline zones (below 8.0, 8.0 - 13.0 and above 13.0 m.mho/cm respectively). Both organic matter and available nitrogen status of bheri soils were low, but available phosphorus content was high. Bheri soils are generally fertile as these contain more of phosphorus, a most essential nutrient necessary for fish production. Interestingly, soils of high saline bheri were found to contain a higher level of available P but lower level of available N, and organic carbon while this was just reverse in case of low saline bheries in general.

4.3 Biological features

Biological observations made in different saline bheries in respect of plankton, primary production, benthic algae, worms and molluscs abundance are described below.

4.3.1 Plankton

The net plankton density greatly varied in bheries under three saline zones. Total plankton was recorded (Table V) maximum (721 u/l) in low saline bheri at Kharibari while minimum (352 u/l) in medium saline bheri at Haroa. Plankton density was also fairly high 552 u/l in high saline bheri at Golabari. In sewage polluted bheri at Kulti though the water was rich in nutrients, the plankton density was comparatively low (381 u/l) due to pollution effect. It revealed that zooplankters dominated total plankton population by many

times more than phytoplankton in all the three zones, maximum being in low saline bheri (644 u/l) and minimum in medium saline bheri (239 u/l). Phytoplankton was, however, more in high saline bheri than in other bheries.

In high saline bheri phytoplankton was dominated mainly by marine forms like Gyrosioma sp., Bidulphia sp. and Coscinodiscus sp., and zooplankton by Brachionus Plicatelis, Mysid, and Acarticlla sp. In low and medium saline bheries, the former was dominated by. Melosira sp., Spirulina sp., and Spirogyra sp. while the latter by Brachionus plicatelis, Diaptomus sp., Nauplii and Cyclops sp.

4.3.2 Primary production

Primary production of bheri waters under different saline zones was assessed by the light and dark bottle technique and the values expressed as milligram of carbon synthesised in a definite time. Among the bheries, the maximum primary production was recorded in high saline bheri at Golabari (324 mg $C/m^2/hr$) while minimum being in medium saline bheri at Haroa (126 mg/ $C/m^3/hr$). It ranged from 110 - 720 mg $C/m^3/hr$ in the former and from 28.2 - 330.0 mg $C/m^3/hr$ in the latter. The average production of carbon was about two times more in high saline bheri than that in the low saline bheries (146 mg $C/m^3/hr$).

4.3.3 Bottom biota

It comprises benthic algae and fauna in bheries.

Benthic algae : The abundance of benthic algae varied widely in bheri soil under different salinities. The maximum density

was recorded in high saline bheri (2200 g/m^2) and minimum being in medium saline bheri (110 g/m^2). The dominant forms of benthic algae recorded were Lingbya sp. and Oscillatoria sp. in Myxophyceae, Spirogyra sp. and Scenedesmus sp. in Chlorophycae and Gyrosigma sp. and Navicula sp. in Diatomaceae in high saline bheri. In low saline bheri dominant forms were represented by Nostoc sp., Anabaena sp. , Oscillatoria sp. and Lyngbya sp. Among the filamentous benthic algae, Lyngbya sp., Oscillatoria sp. and Spirogyra sp. were major occurrence in bheries. The occurence of Enteromorpha sp. was poor and irregular.

In saline sewage polluted bheri at Kulti, the benthic algae density was also rich (1406 g/m^2) next to high saline bheri. Dominant forms of filamentous algae were Spirogyra sp., Lyngbya sp., and Oscillatoria sp.

Benthic fauna : These include worms and molluscs. Their abundance varied with salinity. Both worms (2403 u/sq.m) and molluscs (1600 u/sq.m) were recorded, maximum in medium saline bheri while minimum being 790 and 982 u/sq.m respectively in high saline bheri. Among worms dominant forms were found Gammarus sp., Tenedes and Polychaetes. The density of Gammarus sp. was highest in low saline bheri while that of Gammarus sp. and Tenedes in medium and high saline bheris respectively. Molluscs population was mainly represented by Bella-mya sp. and Diagoniostoma sp.

In the sewage-fed saline bheri at Kulti both worms (2300 u/sq.m) and molluscs (1025 u/sq.m) were found rich. The forms identified were the same as recorded in other saline bheries (Table VI).

5 MANAGEMENT OF BHERIES

Bheri management includes construction and maintenance of bheries and raising fish and prawn production.

5.1 Construction of maintenance

5.1.1 Construction

Before constructing bheries a contour survey of the site is to be made. A gentle gradient is provided in bheri bed towards the sluice so as to facilitate egress of tidal waters. The boundary of bheri is embanked by earthen dykes all round by burrowing soils from the toe line of dykes resulting in a channel along the dyke inside the bheri. The height and breadth of dykes vary on the shape and size of the bheri. The dykes are made stronger in height and breadth on the river or canal side from where tidal water enters the bheri to withstand the thrust of water. The height of dyke generally varies from 1.5 m to 2.0 m and the crest width is given as 60 - 80 cm. A dyked channel inside the bheri of 4 - 6 m in length, about 1 m deep and 2 m width following sluice box is excavated in bheri bed for management of water and harvesting of fish. In this channel bamboo screens known as 'Pattas' are fixed vertically in V or W shape to prevent escape of fish and prawn from the bheri. In addition some shallow depressions and trenches are kept in fringe areas of bheri in which fish and prawn can take shelter during a drop in water level in bheri and rise in water temperature during summer.

5.1.2 Sluice

The sluice is a most important mechanical device in bheri system through which tidal water is taken in and out of the bheri druing spring and neap tides. The sluice box is of rectangular shape made of 'sal' woods. In some bheries single tier type and in others two tier types of sluice boxes are fixed. The upper sluice for ingrees of water and the lower one for egress of water in 2 tier system, while both the purposes are served in a 1-tier sluice. The sluice box is provided with wooden draw shutters on either end of it which move freely in the groves made in margin of the box. The size of sluice box varies with size of the bheri. The sluice box is fixed on the dyke facing the tidal water by cutting a portion of the dyke and is held securely by earth compaction at a height which facilitate maximum entry of tidal water. In larger bheries besides sluice box sluice gates and hume pipe are also fixed at different places on the dyke for faster filling in and draining out water from bheri from safety of the dykes.

5.1.3 Maintenance of bheri

During November - December the dykes all round the bheri is thoroughly repaired and secured after dewatering seasonal bheries in low and medium saline zones. The soil from the periphery is dug out and put on the dyke to strengthen it in order to withstand the tidal water thrust and prevent escape of fish. The other work like sluice box repairing and removing silt from the inside channel and mending ('pattas' and 'traps' are also attended to during the off-season period.

5.2 Soil management

The bed soil of bheri must be brought in proper condition before drawing in water. The bed of bheri, after dewatering, is well exposed to sun during November - December so as to accelerate decomposition of accumulated organic matter and control of fish pathogens. Some farmers prefer to plough the soil for better aeration and mixing weeds and algal matter intimately with soil for faster release of nutrients resulting in rich production of benthic algae - cheap natural food items for fish and prawn. Bheri bed is sometimes limed after dewatering.

5.3 Water management

The water management in the bheri is most vital for fish culture operations and highly technical. The success of bheri fishery depends largely on efficient manipulation of ingress and egress of tidal water impounding an optimal water depth 0.8 - 1.2 m in the bheri. The tidal water from rivers or tributaries are drawn in the bheri during lunar phase (fullmoon and new moon) in the months of January - February when spring tide amplitude reaches high. Excess water from bheri is let out through the sluice box during low phase of neap tide in order to reduce water pressure on the dyke inside the bheri. Water management in bheri is not only for replenishment of water but also for recruiting fish and prawn seed along with ingress water. Besides, it helps in improving the environment by aerating stagnant bheri water, flushing the bheri beds of toxic metabolites and supplementing natural food and nutrients periodically.

5.4 Culture operations

Fish culture practices in bheries have changed with time due to lessavailability of seed along with tidal waters. Since the availability of young ones of fish and prawn at the upper reaches of estuaries has been affected adversely because of Calcutta Sewage discharge in Kulti river and also due to extensive catch at the lower estuaries, a selective stocking of fish and prawn is followed presently in bheries under low and medium saline zones with seeds purchased from market/traders. While in high saline bheries in the lower Sunderbans, the traditional practices of auto-stocking of bheries through tidal ingress, water carrying seed of predatory, commercial, and non-commercial species of fish and prawn is being continued. Besides, in this zone too, prawn (P. monodon) and mullets (L. parsia and L. tade) are purchased and stocked in bheries, because the abundance of seed in tidal water has gone down considerably as these are captured in large scale from the rivers and are marketed to upper reaches in lower saline zones.

5.4.1 Nursery practices

Direct stocking of fish and prawn in bheries, a traditional practice, is followed. Nursery rearing of seed prior to stocking in bheri does not exist. This results in poor survival of prawn seed. Recently, however, farmers have developed a device for nursery rearing of prawn seed in order to achieve better survival of prawn seed. A small area inside the bheri is embanked and the water salinity which is low (2 - 3 ppt) is raised by adding common salts @ 3000 - 4000 kg/ha. Prawn seed (P. monodon) stocked @ 5 - 8 lakhs/ha in

the enclosure is reared for 15 - 20 days, when they grow a little bigger and hardy are released in the main bheri by cutting the bundhs. In general artificial food is not used for rearing purpose. In some bheries, shallow small ponds and channels are made inside the bheri for the purpose of nursery grounds. In these some dried twigs of date palm leaves are fixed in soil and kept under water to serve as support for development of periphyton which form ideal natural food for prawn post larvae.

5.4.2 Stock management in bheries

Low and medium saline zones : Prior to stocking bheri with prawn, natural food organisms, namely benthic algae and periphyton, are allowed to develop in the bheri bed by maintaining a lower depth of water (25 - 30 cm) for about a fortnight, After development of natural food items, P. monodon post-larvae @ 40,000 - 50,000/ha is stocked in the bheri during January and February. After about a month or two L. parsia, major carp and tilapia fry are also stocked in the low saline bheri @ 1000 - 1500, 4000 - 5000, and 5000 - 6000/ha respectively. A true polyculture system of growing brackishwater and freshwater fish and prawn together in the low saline bheri has been developed. Some farmers of this zone however, prefer to raise brackishwater fish and prawn crop first in bheries followed by freshwater fishes during monsoon season.

In medium saline bheries, farmers grow only prawn and mullet till June before monsoon sets in and thereafter when salinity drops down due to rain they rear freshwater fishes from July onward in the same bheri. A crop of Kharif paddy is also raised from July-August to November-December in low and medium saline bheries.

High saline bheri : Brackishwater fishes and prawn are only raised here and paddy crop is not generally grown due to high salinity.

Besides auto-stocking of bheri with tidal water, selective stocking of fish and prawn like L. parsia @ 700 - 1000/ha, L. tade @ 700 - 1000/ha and P. monodon @ 30,000 - 40,000/ha is followed. L. calcarifer enters the bheri through ingress water is also reared with other fishes. Their entry is, however, restricted by putting nylon net at the mouth of the sluice box. The fish culture operation continues in these bheries almost throughout the year.

5.4.3 Fertilization and feeding

Fertilizers and artificial feed are not generally used in bheri management for production of fish and prawn. The entire production system is based on manipulation of natural fertility of the ecosystem. Therefore, the production of prawn and fish from these vast resources remains low. Recently, some affluent farmers are using organic manures like rice bran and mustard oil cake @ 500 - 780 kg/ha in the ratio 3 : 1 and a low dose of urea (25 - 50 kg/ha). Liming is done at a very low rate 100 - 200 kg/ha, as prophylactic measure, for better growth of prawn.

5.5 Harvesting and marketing

Harvesting of prawn is done from April - July in low and medium saline bheries. Mullets and other fishes are harvested in September to November. In high saline bheri prawn is harvested maximum in May - June. Later L. parsia, L. tade, and L. calcarifer are harvested during October-November which continues till next season.

Cage traps made of split bamboo sticks (locally known as 'bitti' or 'atol') are fixed in between the bamboo 'patta' fences in the inlet channel for harvesting of prawn. During ingress of tidal water prawn move against the water current towards the sluice box and are caught in the traps. This is a major mode of harvesting prawn. Besides seine, cast and scoop nets are operated in bheries for harvesting fish. In harvesting of tilapia from bheries using set gill nets, fishermen beat water from a distance by bamboo trands to drive fishes towards the net to be gilled and thus caught.

There are well developed local marketing centres under different saline zones, namely Kharibari, Rajarhat, Malancha, Haroa, Barasat, Hashnabad, Nazat, Raidighi, Canning, etc. After harvest, farmers bring their produce to marketing centres and hand them over to 'Aratdars' (fish dealers) for disposal. The mode of disposal is mainly by auction. Fishes and non-exportable prawn are sent to Calcutta city for sale in local markets, while exportable prawn are beheaded at the fish marketing centres, preserved with ice and transported to companies in Calcutta who after further processing ship the produce to foreign countries.

6 E C O N O M I C S

Economics of bheri fishery have been worked out based on data of two representative samples - one bheri in low saline zone and another in high saline zone. The details are presented in Tables VII and VIII. Net profit per hectare is about Rs. 10,713.00 with a capital turn over a of about 174% in the low saline bheri while those are Rs. 5,250.00 and

152% respectively in a high saline bheri. Return from investment is much more in a low saline bheri than that in a high saline bheri. This also holds good in case of medium saline bheries. Because a crop of paddy is also raised in the lower saline bheri system besides growing both fresh and brackish-water fish and prawn which accounts for a higher profitability in the above system.

7 CONSTRAINTS

There are many constraints which adversely affect fish and prawn production in bheri fishery resources. These may be classified into following groups:

A Environmental

i) Floods and draught during culture operation, (ii) silting up of feeder canals, creeks, etc., (iii) pollution of water sources through discharge of sewage effluent, and (iv) excessive growth of filamentous algae and weeds.

Floods caused due to excessive rain, inundate this fishery resulting in heavy damage to dykes and also loss of fish crop. Draught also affect availability of seed of fish and prawn due to change in hydrobiological conditions of water restricting their breeding. It becomes difficult to maintain optimum depth of water in bheri due to low tidal amplitude. Silted up feeder canal affect the sufficient water flow into the bheri resulting in water management problem.

Sewage effluent of Calcutta city discharged in Kulti river has already affected this fishery adversely. Seed availability in the tidal water for bheries at upper reaches have been dwindled completely due to pollution of Kulti river. Presently, the bheri fisheries in low and medium saline zones are facing pollution problem affecting production of P. monodon Excessive growth of filamentous algae, namely Spirogyra sp. and weeds causes problem when these decompose fast during summer months resulting in depletion of oxygen and production of poisonous gases.

B Managerial

i) Procurement of seed materials for stocking bheries, (ii) maintenance of watch and ward to check poaching, (iii) lack of cold-storage, ice plant, transport facilities in remote areas, and (iv) lack of scientific technology for bheri management.

Seed availability at reasonable price is a major constraint for bheries at upper reaches. Since the collection of young ones of fish and prawn are made from rivers at lower reaches and transported it accounted for higher cost.

Non-availability of well developed transport facilities, ice plant for preserving prawn and marketing centres in remote areas are impediment to this fisheries. The watch and ward is a problem and also expensive for bigger water area. Last but not the least that a scientific technology for management of bheri fisheries needs to be developed in enhancing fish and prawn production from this vast resources.

C Socio-economical

i) distress condition of fishermen engaged in this industry, (ii) legal aspect of owning bheri, and (iii) availability of bank loan. In bheri management both casual and regular labours are engaged, the former @ Rs. 8 - 10/day without food and the latter @ Rs. 200 - 250/month with food. They are low paid and their welfare needs to be looked into by the bheri owners.

Legal aspect in regard to ownership of bheri is a major constraint affecting production system. A number of bheries are left unmanaged due to pending of legal disputs in court regarding ownership of bheri. Rich enterpreneurs are leasing out their bheries splitting them into smaller units for fear of forcible occupation of bheri. Leasee of the same bheri may change from year to year which also affect the fish production.

In management of bheri of say 10 ha in area an investment of about 100,000 - 120,000 of rupees needs to be made in a year. To mobilize resources to the above extent is a main constraint for small farmer or Fisheries Cooperatives unless bank advances loan for this fishery.

8 AREAS FOR IMPROVING BHERI FISHERY

The Government of West Bengal should take necessary steps to forestall forcible occupation of bheries by people in order to safeguard the interest of the bheri owners. This measure will result not only in increased production of fish and prawn for the people of West Bengal but also in enlarging

scope for earning foreign exchange through export of P. monodon.

If the ownership of bheries vests with the Government those may be leased to the Fisheries Cooperative Societies for their management on reasonable terms and conditions.

The monitoring of natural seed resources is necessary to estimate seed availability in quantity and quality during the season. Besides, induced breeding of commercially important brackishwater fish and prawn should be attempted to meet the demand of quality seed for bheri fisheries.

Better transport technique needs to be developed for transporting fish and prawn seed from collection centres at the lower estuaries to the bheries at upper reaches where selective stocking is practised.

For scientific management of bheri fishery, laboratory facilities should be developed for analyses of samples like soil, water and benthic biota.

More importance should be given to nursery management of bheri fishery to achieve higher survival of costly post-larvae of P. monodon, since their survival is very poor due to direct stocking in bheries (large water bodies).

Investigation may be made on the extent of damage caused to bheri fishery due to sewage discharge in the Kulti river and its remedial measures to safeguard this fishery should be developed.

Lastly, a scientific technology for management of bheries needs to be developed to boost fish and prawn production in these large water bodies through application of inputs, like feeds, fertilizers, and manures and manipulation of stocking density.

TABLE - I

BASIC INFORMATION ON BRACKISHWATER BHERI FISHERIES
IN THE DISTRICT OF 24 - PARGANAS, WEST BENGAL

Bheri Fisheries	No. of bheri	Area (ha)	Size range and av. (ha)	TYPE OF BHERI		Fish and prawn cultured	Estimated annual production				% of P. monodon to the total production
				Seasonal % Area	Perennial % Area		Fish and Prawn		Prawn (P. monodon)		
							Total (tons.)	Catch/ ha (kg.)	Total (tons)	Catch/ ha (kg)	
LOW SALINE ZONE	387	9844.11	2 - 200 (25.44)	94.12	5.88	*Brackish & *Fresh water fishes and Prawn	8641.16	877.80	689.78	70.07	7.98
MEDIUM SALINE ZONE	458	15613.25	2 - 267 (34.09)	92.00	8.00	-do-	11691.67	748.83	3348.73	214.48	28.64
HIGH SALINE ZONE	489	7472.20	2 - 120 (15.28)	5.78	94.22	Brackish water & Prawn fishes	5184.74	693.87	625.20	83.67	12.06
T O T A L	1334	32929.56	--	--	--	--	25517.57	--	4663.71	--	--
ZONAL AVERAGE	--	--	24.68	73.07	26.93	--	--	774.91	--	141.63	18.78

	Fishes	Prawns
*Brackishwater	L. parsia, L. tade, L. calcarifer, P. monodon and R. corsula etc.	P. indicus and M. monoceros
*Freshwater	L. rohita, C. catla, C. mrigala, L. bata, C. carpio, M. gulio, T. mossambica and H. molitrix etc.	M. rosenbergii

TABLE - II

RANGES AND AVERAGE ANNUAL VALUES OF PHYSICO-CHEMICAL PARAMETERS OF SELECTED BHERI WATERS UNDER DIFFERENT SALINE ZONES

Saline zones	Places	Water Depth (m)	Temp. (°C)	Turbidity (ppm)	pH	E.C. m.mho/cm	Salinity (ppt.)	Total alkalinity	P_2O_5	NO_3-N	Calcium (Ca)	Magnesium (Mg)	Dissolved O_2
										(ppm)			
Low	Kharibari	0.24-1.61	21.0-32.0	72-360	6.8-7.8	0.9-11.4	0.1-9.5	84-212	Tr.-0.32	0.04-0.30	25-230	25-650	4.0-6.8
		(0.81)	(28.8)	(115)	(7.4)	(6.2)	(3.8)	(138)	(0.11)	(0.08)	(65)	(153)	(5.8
Medium	Haroa	0.25-1.55	23.1-32.0	63-350	7.0-8.2	1.1-28.2	0.27-15.8	90-196	Tr.-0.24	0.02-0.48	24-220	36-880	4.2-6.2
		(0.82)	(29.1)	(112.0)	(7.5)	(9.8)	(6.3)	(145)	(0.09)	(0.13)	(94)	(250)	(5.6
High	Golabari	0.25-1.6	20.0-30.6	57-240	7.0-8.3	11.8-51.7	6.6-36.2	88-155	0.03-0.66	0.03-0.32	70-350	280-1640	4.8-6.2
		(0.62)	(28.2)	(135)	(7.6)	(23.0)	(18.2)	(111)	(0.24)	(0.10)	(186)	(843)	(5.(
		——— SALINE SEWAGE-FED BHERI ———											
Medium	Kulti	0.27-1.57	26.0-32.3	62-360	6.6-8.2	0.9-28.1	0.54-15.6	76-220	0.08-3.0	0.05-1.2	30-220	52-960	2.8-5.3
		(0.63)	(29.3)	(105)	(7.4)	(10.2)	(5.9)	(146)	(0.72)	(0.56)	(98)	(339)	(4.2

* Average values in parenthesis.

TABLE - III

SOIL CHARACTERISTICS OF SELECTED BHERIES IN DIFFERENT SALINE ZONES

Saline zones	Places	pH	E.C. m.mho/cm	Available Nutrients N (mg/100g)	P_2O_5	Organic Carbon (%)
Low	Kharibari	6.9-7.5 (7.3)	0.9-7.5 (3.8)	9.8-23.2 (16.1)	5.2-22.0 (10.4)	0.60-0.92 (0.69)
Medium	Haroa	6.5-7.4 (7.1)	1.1-12.1 (5.9)	14.1-22.9 (17.8)	6.0-18.0 (8.1)	0.48-0.88 (0.68)
High	Golabari	7.0-7.4 (7.1)	9.8-23.2 (15.4)	10.6-22.2 (14.0)	6.0-24.0 (12.4)	0.41-0.62 (0.53)
		SALINE SEWAGE-FED BHERI				
Medium	Kulti	6.2-7.4 (6.8)	0.7-12.5 (6.1)	14.9-29.3 (19.0)	4.8-48.0 (26.8)	0.70-1.2 (0.89)

* Avg. values in parenthesis.

_T_A_B_L_E_-_IV_

SOIL FERTILITY STATUS OF BHERIES IN DIFFERENT SALINE ZONES

Bheries	E.C. m.mhos/cm	pH	Available Phosphorus (P_2O_5) (mg/100 g soil)	Available Nitrogen (N) (mg/100 g soil)	Organic Carbon (%)
Low saline	1.2-8.0 (3.0)	7.2-7.6 (7.5)	3.2-28.0 (10.81)	17.6-33.32 (25.5)	0.36-1.56 (0.90)
Medium saline	4.5-13.0 (6.19)	6.4-7.8 (7.1)	2.4-60.0 (12.2)	9.3-32.32 (18.59)	0.18.1.23 (0.57)
High saline	8.0-24.0 (11.91)	7.0-7.5 (7.2)	2.4-60.0 (16.17)	10.6-21.2 (15.11)	0.12-0.87 (0.42)

* Avg. values in parenthesis

** Soil samples collected at random.

TABLE - V

PLANKTON ABUNDANCE IN BHERIES UNDER DIFFERENT SALINE ZONES

PLANKTON/LITRE WATER

Saline zone	Places	Total Plankton Range	Total Plankton Average	Phytoplankton Range	Phytoplankton Average	Phytoplankton Dominant forms	Zooplankton Range	Zooplankton Average	Zooplankton Dominant forms
Low	Kharibari	78-2770	721	18-178	77	Melosira sp. Spirulina sp. Synedra sp. Spirogyra sp. Coscinodicus sp.	60-2722	644	Brachionus plicatilis Mysid
Medium	Haroa	90-1542	352	30-198	81	Oedogonium sp. Spirogyra sp. Melosira sp.	40-1155	239	Diaptomus sp. Brachionus plicatilis Cyclops sp. Mysid
High	Golabari	94-2548	552	34-400	116	Gyrosioma sp. Bidulphia sp. Coscinodicus sp. Amphora sp.	50-2140	433	Mysid Acartiella sp.
Medium	Kulti	78-2189	381	28-134	61	Melosira sp. Spirogyra sp. Oedogonium sp.	18-2121	320	Brachionus sp. Nauplii Diaptomus sp. Cyclops sp.

TABLE - VI

ABUNDANCE OF BENTHIC ALGAE AND FAUNA IN BHERIES LOCATED IN DIFFERENT SALINE ZONES

Saline zone	Places	Benthic Algae			Benthic Fauna					
					Worms/m^2			Molluscs/m^2		
		Range (g/m^2) (wet wt.)	Average (g/m^2)	Dominant forms	Range	Average	Dominant forms	Range	Average	Dominant forms
Low	Kharibari	180-1170	675	Nostoc sp. Anabaena sp. Oscillatoria sp.	10-6375	1071	Gammarus sp. Tenedes Polychaetes	675-3601	1008	Bellamya sp. Diagoniostoma sp. Planobides sp.
Medium	Haroa	89-131	110	Oscillatoria sp.	135-6400	2403	Gammarus sp. Polychaetes	550-5945	1600	Bellamya sp. Diagoniostoma sp. Thiara sp.
High	Golabari	1100-4300	2700	Lyngbya sp. Oscillatoria sp. Spirogyra sp.	5-6160	790	Tenedes Polychaetes Gammarus sp. Oligochactes	135-2145	982	Bellamya sp. Diagoniostoma sp. Unio sp.
SALINE SEWAGE-FED BHERI										
Medium	Kulti	900-2230	1406	Spirogyra sp. Lyngbya sp. Oscillatoria sp.	20-8950	2300	Tenedes Polychaetes Gammarus sp.	475-4815	1025	Bellamya sp. Diagoniostoma sp. Unio sp. Lymnaea sp.

T A B L E - VII

ECONOMICS OF BRACKISHWATER SEASONAL BHERI (WATER AREA 30 HA) IN LOW SALINE ZONE

EXPENDITURE

	Rs. Total P.
A. Variable costs :	
i) Seed prawn : Rs. 126,000.00p Fish : Rs. 34,425.00p Paddy : Rs. 5,500.00p	1,65,925.00
ii) Labour	21,900.00
iii) Others (Fertilizer, Contingent, etc.)	30,500.00
	2,18,325.00
B. Fixed costs :	
i) Staff salary	93,600.00
ii) Tax, Legal exp., etc.	6,000.00
iii) Annual lease	1,80,000.00
	2,79,000.00
C. Interest on Capital	82,500.00
D. Depreciation	52,608.33

INCOME

Prawn	5,40,000.00
Fish	2,73,000.00
Paddy	1,07,730.00
Straw	33,696.00
Gross Income	9,54,426.00
Less A+B+C+D	6,33,033.33
Net Profit :	3,21,392.67

Net profit per ha : Rs. 10,713.09p

Capital : Rs. 5.5 lakh

Capital turnover = $\frac{\text{Gross income}}{\text{Capital}}$ X 100 = 173.53

T A B L E - VIII

ECONOMICS OF BRACKISHWATER PERENNIAL BHERI (WATER AREA 15 HA) IN HIGH SALINE ZONE

	Total Rs. P.
EXPENDITURE	
A. Variable Costs	
i) Seed Prawn : Rs. 15,750.00p Fish : Rs. 1,740.00p	17,490.00
ii) Labour	19,200.00
iii) Others (Fertilizer, Contingent, etc.)	11,400.00
	48,090.00
B. Fixed costs :	
i) Staff salary	86,400.00
ii) Tax, Legal exp, etc.	2,250.00
iii) Annual lease	56,250.00
	1,44,900.00
C. Interest on Capital :	33,000.00
D. Depreciation :	30,890.00
INCOME	
Prawn :	2,36,250.00
Fish :	99,375.00
Gross Income :	3,35,625.00
Less A+B+C+D :	2,56,880.00
Net Profit :	78,745.00
Net Profit per ha	Rs. 5,249.67p
Capital	Rs. 2.2 lakh
Capital turnover = $\frac{\text{Gross Income}}{\text{Capital}} \times 100 =$	152.56

A LIST OF FISHES AND PRAWNS COMMONLY AVAILABLE IN BRACKISHWATER

B H E R I

	Scientific name	Local name
1	Lates calcarifer	Bhetki
2	Liza parsia	Parse
3	Liza tade	Bhangon
4	Rhinomugil corsula	Khorsula
5	Eleutheronema tetradactylum	Gurjaoli
6	Mystus gulio	Tengra
7	Odontomblyopus rubicundus	Gulo
8	Glossogobius giuris	Bele
9	Labeo bata	Bata
10	Catla catla	Catla
11	Labeo rohita	Rui
12	Cirrhinus mrigala	Mrigal
13	Cyprinus carpio	Cyprinus/American Rui
14	Hypophthalmichthys molitrix	Rupali Rui
15	Ctenopharyngodon idella	Gheso Rui
16	Tilapia mossambica	Thilapia/American Koi

P R A W N S

1	Penaeus monodon	Bagda chingri
2	Penaeus indicus	Chapra chingri
3	Metapenaeus monoceros	Honye chingri
4	Metapenaeus brevicornis	Chamne chingri
5	Macrobrachium rosenbergii	Golda Chingri
6	Leander styliferus	Ghora chingri
