

ESTUARINE ECOSYSTEM SERIES



PART-I

RUSHIKULYA ESTUARY
ORISSA

ZOOLOGICAL SURVEY OF INDIA
1992



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PART 1

RUSHIKULYA ESTUARY, ORISSA

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FOREWORD

Estuaries play a vital role in socio-economic development in any country. India with a large number of rivers offer an array of estuaries presenting a distinctive ecosystem. The Zoological Survey of India can take pride as an institution initiating survey of estuaries (Hugli-Matlah) as far back in early twenties. Now a programme has been initiated to survey five major estuaries of Indian region between 1985 to 2000 A.D. This department has already completed resurvey of Hugli-Matlah estuary in West Bengal and survey of Rushikulya estuary in Orissa and the present document forms the first in the series of publication on the subject. I am sure that the data presented in this document will add to our knowledge of Indian estuaries and I would like to record my deep sense of appreciation for all the participating scientists and other members of the staff connected with the project.

21st August, 1992
Calcutta

A. K. Ghosh
Director
Zoological Survey of India

ESTUARINE ECOSYSTEM IN INDIA AND FAUNAL RESOURCES

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INTRODUCTION

The estuary is defined as an area along the coast where the river joins the sea. Estuarine region provides an admixture of freshwater with salt water and are often characterised by wetlands - marshes and swamps, often with mangroves vegetation submerged in water for a greater period of the day (Odum, 1988). The riverine inflow include inorganic material in the form of clay turbidity (T), nutrient including Co₂, organic material (G), and sand and gravel (R). The tidal influx also bring (T) (N) (G) components along with salt (S) and larvae of marine biota (L). The reaction provides the kinetic energy added by the wind blown waves as the tidal waves flow in, mix with fresh water and flow out. The kinetic energy increases the biological productivity of the estuary by circulating nutrients, food, plankton (phytoplankton and zooplankton) eggs and larvae of various animals (Odum 1983). The phytoplankton remain suspended by the motion and are eaten by zooplankton, which in turn are eaten by small fish. On the other hand, dead organic matter and micro-organism forming detritus, which provide food for benthic organism, like worms, molluscs, crustaceans and bottom feeding fishes. The marsh edging the estuaries often provide mudflats, an ideal habitat for invertebrates.

Table 1 : Major Rivers and their estuaries in eastern – and western part of India

1. Indus Sutlej	Arabian Sea
2. Ganga	Bay of Bengal
3. Bramhaputra	Bay of Bengal
4. Sabarmati	Gulf of Kambhat
5. Mahi	Gulf of Kambhat
6. Narmada	Gulf of Kambhat
7. Tapi	Gulf of Kambhat
8. Subarnarekha	Bay of Bengal
9. Brahmani	Bay of Bengal
10. Mahanadi	Bay of Bengal
11. Godavari	Bay of Bengal
12. Krishna	Bay of Bengal
13. Pennar	Bay of Bengal
14. Cauvery	Bay of Bengal

The riverine system of India is composed of 14 major (Table 1) 44 medium and 55 minor rivers and the network of river system either flow to eastern coast or to the western coast meeting Bay of Bengal or Arabian sea. The estuarine region of India thus form a substantial part of ecosystem.

Of the major estuaries of India, some studies have been conducted on Hugli, Matla, Mahanadi, Godavari, Krishna, Kaveri Pennar (Major estuaries) and Subarnarekha, Cooum, Vellar (medium & minor estuaries). On the west coast, Mandovi-Zuari estuary has also been studied from biological point of view.

During 1985, an attempt was made to estimate the biological resources Indian estuaries and the data presented by scientists working in different animal groups is revealing.

SURVEY OF ESTUARY

In order to have better understanding of Indian estuaries a programme has now been initiated by Zoological Survey of India, Ministry of Environment & Forests, Government of India, to survey selected estuaries during the coming time (Table 2) in the eastern coast.

Table 2

River	States
1. Hugli-Matlah	West Bengal
2. Rustikulya	Orissa
3. Mahanadi	Orissa
4. Godavari	Andhra Pradesh
5. Krishna	Andhra Pradesh

The results of the survey of Rushikulya estuary presented in the present document, provide data of only two years study but indicate the potential of even a minor-river estuary in Indian region. The survey of Hugli-Matlah estuary, perhaps the most productive of all the estuaries in India acting as the base for south Bengal fisheries, has also been completed and the results are being compiled for publication. At present (from 1990 onward) the work on Mahanadi estuary is being continued. Simultaneously re-survey (after 60 years) of fauna of Chilka lagoon (1,14,000 ha) fed by one of the distributory of Mahanadi has also been completed and the data show an amazing range of biological diversity; these will be published in separate volume. The Pulicat Lake in Nellore district of Andhra Pradesh and Chingaputtu district in Tamil Nadu is connected with Bay of Bengal at the southern tip and receive fresh water from Arani river in the south and Kalayni river in the North; the total wetland area of 4,405 sq. km., has a rich base of phytoplankton and invertebrate and vertebrate fauna of with 60% of fishery catches being prawns, besides clupeoids, cat fishes, crabs etc. But all these large lake system in eastern coast are receiving a heavy sedimentation load from the riverine system and hydrological features are changing drastically from mainly brackishwater to more freshwater feature (as in Chilka).

The same phenomenon of sediment load has been noted in many of the Indian estuaries. The changes in the hydrological characteristic and water quality is also ascribed to impact of human

activities in upstream areas, largely originating from industrial effluent and domestic discharges from human settlements. As such the biota in the downstream estuarine region has undergone drastic changes, which need to be quantified and monitored (ecological effects) and work on which are being conducted by NEERI, Dept. of Ocean Development, Central Pollution Control Board, National Institute of Oceanography, Industrial Toxicology Research Institute, Lucknow, and a number of universities.

Another problem of estuaries is connected with shipping industry and refinery which originate from oil or oil by-products from ships and refineries. Oil is frequently discharged into the estuary from barges, tankers, dredgers and ship. It spreads as a thin film on the water surface tending to prevent diffusion of oxygen into the water. Oil pollution often lead to respiratory problem in fishes. By large scale dredging to maintain or improve upon navigational channel, deeper pockets of saline water traps can be created with poorer concentration of dissolved oxygen. The spoil disposal within the estuary can create an incalculated hostile turbidity cloud and disrupt common preying ground of fish shoals. Man made pollution of estuaries can lead to depletion of D.O. or fall in exchange coefficient, formation of sulphides, corrosion, destruction of habitat, non availability of potable water and bacteriological pollution etc. and water authorities of developed countries recommend monitoring of estuarine environment by a set of tests to measure, viz., C.O.D., BOD (5 day at 30 c), D.O. level. Temperature, pH value, suspended & dissolved solid, organic cation, turbidity, sulphide, soluble iron, etc. (Biswas & Bandopadhyaya, 1991).

The population pressure in the estuary region of India is another phenomenon to be reckoned with. The Hugli-Matlah estuary can be cited as an example. The terminal zone of this estuary called "Sundarbans" region above has 2.5 million population (1981) spread of 1060 villages, and three towns, 89% of the population still being dependant in agriculture (part on the reclaimed land); a high percentage (57%) of mechanical boat owners suffer from indebtedness and nearly 40% of indigenous boat owners suffer from the same condition (Bose, A.N. 1991).

The Survey of estuary is therefore a multidisciplinary exercise. It involves (i) physical, chemical, biological survey of water area (ii) survey of land use and changing pattern, (iii) survey of socioeconomic condition of the population of the estuary area.

These data-set can help to draw up an appropriate management plan for any estuary along the coast zone in India.

FAUNAL RESOURCES

The faunal resources as can be analysed from the Table 3. shows a high index of biological diversity. The estuarine fauna presents a significant part of endemic faunal component specially in two of the major aquatic groups viz. Mollusca and Fishes. Details of the faunal resources are being separately published in the form of State of Art Report by ZSI.

Needless to emphasise that this resource area in the estuary *per-se* and in the adjacent coastal lakes of India (Chilka in Orissa, Pulicat in Andhra etc.) provide an economic base for social development of coastal population in India. The fishery development programme has put emphasis on brackishwater aquaculture in estuarine region and prawn-shrimp fishery, shell- fish fishery and other fishery culture can also be augmented in the vast estuarine region located along 600 km

coastal line. It is stated that West Bengal alone has 615,000 ha of brackishwater area of which only 6 percent is being utilised at present. The fishery productivity of Chilka lagoon and Pulicat lakes support major market structure both locally and on trans-regional basis. The biological survey of estuary can provide necessary input data on the present status and future strategy.

	Groups	Genera	Species	Genera
1.	Sponges	5	7	
2.	Sea anemonia	12	15	
3.	Monogenia	23	31	
4.	Digenia	28	40	
5.	Cestoda	60	N.A.	
6.	Nematoda			Data not for available
7.	Eichura	3	6	
8.	Siphuncula	2	2	
9.	Cladocera (Crustacea)	2	2	
10.	Cirrepedia (Crustacea)	14	30	
11.	Cumacea (Crustacea)	5	5	
12.	Macrura (Crustacea)	3	10	
13.	Brachyura (Crustacea)	12 (+)	100	* 20 family
14.	Anomura : (Crustacea)	5	8	
15.	Mollusca	136	317 *	* 137 species described from Indian region
16.	Brachipoda	1	Indet spp.	
17.	Chaetognatha	1	9	70 from the world
18.	Echinodormata	14	21	
19.	Protochordata	2	2	
20.	Fishes	275	402	197 species described from Indian estuaries
21.	Amphibia	1	2	
22.	Reptilia	11	12	
23.	Birds			No comprehensive data available; Chilka lagoon in Orissa Coast has records of 150 species of birds
24.	Mammalia	7	8	

Source : State of Art Report : Estuarine Biology ZSI, 1985

DISCUSSION

The estuarine ecosystem is facing a serious warning in recent time due to the mean sea-level rise phenomenon. The prediction has been variable but it is calculated that throughout 20th century, sea level has risen by 10-20 cm. The rate of rise can be expected to increase if the global temperature continue to climb and by 2100 AD, it may be 65 cm higher than at the beginning of this century. It will be worsened by frequency and severity of storms, which will drive wave further inland in to the deeper estuarine zone. Salt water regime may invade tens of kilometers further inland uprivers. Vast areas of estuarine region may go under submergence and fertile land may turn into saline desert. Coastal wetlands, a part of estuaries may disappear thereby affecting the essential nursery for many species of fish, shrimp and birds. (UNEP Report June, 1991 : Climate change and Sea-level rise).

This phenomenon, besides the factors discussed earlier call for an urgent plan to collect data in a systematic, time targeted manner and also implement a system of monitoring of major estuaries. Recent exercise in understanding coast-zone problems in India (Dwivedi et. al. 1989) or in a state (Bose et. al. 1989) are indicative of the efforts but no complete status report on any single major estuarine area of India is available.

The programme of Zoological Survey of India will be able to cater to the need of providing basic faunal data of the selected estuaries but only with other needed exercises a comprehensive state of art report of major estuarine region and management plan can be drawn.

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**STUDIES ON THE ECOLOGY AND FAUNA OF THE
RUSHIKULYA ESTUARY, (GANJAM), ORISSA.**

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INTRODUCTION

Estuaries have long been important to mankind both for reasons of navigation and providing locations on their banks for towns and cities. These are under constant pressure as repositories for the effluents of industrial and domestic waste. The estuaries are also interesting biologically as well due to their periodical changing environment with an admixture of marine and fresh water fauna. Estuaries are typical in having mudflats formed by fine sedimentary material carried from the rivers. These mudflats provide an excellent habitat for a variety of animals.

Several major and minor rivers passing through the state of Orissa and joining the Bay of Bengal thus forming many estuaries along the coast. Of these the major are Mahanadi estuarine complex, Brahmini and Bitarani estuary etc., further many smaller estuaries are also present among which Rushikulya estuary is situated in the southern part of Orissa. This estuary being nearer to the Estuarine Biological Station, Zoological Survey of India, Berhampur, regular investigations were carried out for understanding its bioecology.

Fauna of the Chilka lagoon by Annandale & Kemp (1915) is the first information on ecology and fauna from estuarine and brackish areas of Orissa. The available literature on estuaries of Orissa and its fauna mainly deals with fish & Fisheries, (Shetty et al. 1965, 1967, 1969; Rao N.G.C. 1964, 1967 and Mohapatra, 1966); wood boring mollusca of Mahanadi estuary were reported by Subba Rao, (1968); Polychaetes of the Mahanadi and Bitarani estuary by Rao and Julka, (1977) and Rao, C.A.N. (1981), studies on the milk fish larvae and phytoplankton of the Rushikulya estuary by Patnaik, (1984) and Rajshree Gouda & Panigrahi, (1989) respectively. However, no detailed studies on the estuaries of Orissa and its fauna are available.

With a view to have more information on Indian estuaries in general and Orissa in particular, studies on Rushikulya estuary were conducted during 1985-86 by collecting fauna and its ecological parameters at regular intervals.

GENERAL FEATURES OF THE ESTUARY

River Rushikulya originates from the Rushimala mountains of eastern ghats and flows through the Ganjam District and meets the Bay of Bengal at Ganjam thus forming an estuary. This is a minor river with less water flow during most part of the year except monsoon period. Most of the water of this river is being utilised for agriculture and other domestic purposes thus further reducing the flow

of water into the sea. The tidal effect in the river extends for about 4 to 5 Kms. upstream forming a small estuarine complex. This estuarine part of the river is less than one Km. in width and very shallow, with depth of less than one metre at the upper reaches and gradually the depth increases towards lower reaches. Before joining the sea the river divides into three branches thus exposing the land masses in between the river branches and meets again to open into the sea. A narrow canal (Palur or Chilka canal) was dug out west of the mouth of the estuary parallel to the coast line connected to the southern part of the Chilka lake to facilitate incursion of sea water during high tides into the lake for enriching the fishery resources. The fresh water inflow through this channel to the estuary is very negligible except during monsoon. The slopes of the river banks are very less as the river reaches towards the mouth, and there are no bunds on either side, thereby causing submersion of vast areas of land during the monsoon.

The tidal range varies from 0.5 to 1.0 mt. in height, however the water spreads during high tide to about 20 to 25 mts. On either side of the river, as the slopes of the banks are very less. The water spread during high tides is profound in the middle areas and near the mouth of the estuary. The inter-tidal area near the mouth is sandy while adjacent coastline towards the river course for about 2 Kms. is muddy with less sand composition.

MATERIALS AND METHODS

Sampling and data collections were made at three stations during 1985-1986, fixed along the estuary starting from its mouth on one side (Sta. I) and a point about 4 Kms. upstream of river (Sta. III) and in between these two stations a middle station (Sta. II) was also selected (Fig. 1). The Ist station was near the river mouth which is subjected to regular tidal effect and at this point the Palur (Chilka) canal is opening into the river. The IInd station is about 2 Kms. from the first station, where also the tidal influence is noticed and vast areas submerged during high tide. The IIIrd station was fixed near the bridge area, which is about 1.5 Kms. from the IInd station, where the tidal influence is negligible.

Fortnightly samplings were made at all the three stations both at high and low tides during the period 1985-86. Physico-chemical parameters like temperature, pH, depth, transparency, etc. were collected in the field by using instruments while salinity, dissolved oxygen, total solids were analysed in the laboratory following standard methods. Plankton sampling was made at three stations through plankton net for quantitative and qualitative studies. The other groups of animals were collected by hand picking, sieving the sediment collected from inter-tidal areas and through grab sapling. Fish larvae were collected at mouth region by operating standard Midnapore shooting net during high tides and through hand net at other stations. The adult fishes were collected from fish landing centres and from fishermen while they were fishing in the estuary.

HYDROGRAPHIC FEATURES

Depth : The depth near the mouth of the river was between 0.5 to 3.5 mts. and increase in its depth was noticed during monsoon period. At the middle of the estuary (Station II) the depth pattern is similar to that of the mouth area, and a marginal increase in depth was noticed here also during monsoon. In the upper reaches of the estuary (Station III) the depth is very less, not even

exceeding one metre during most part of the year, and appreciable increase in depth was noticed at this region also during monsoon.

Temperature : The atmospheric temperature was between 24.5 to 35°C the three stations during the different months of the year. The lowest temperature noticed December and highest during September. Differences between air and water temperature were found to be less at the mouth. While higher water temperature was noticed than the air temperature at the middle and upper reaches of the estuary (IIInd & IIIrd stations) during February, March, April, July, August and September (fig. 2).

pH : At the mouth of the river the pH values varied from 9.05 to 7.6 and the maximum during November and minimum in July. At the middle area (Station-II) maximum was about 8.9 in November and 7.5 during January. While in the upper reaches maximum 9.5 in the month of November and minimum of 7.5 in July recorded (Fig. 3).

Salinity : At the mouth of the river the salinity ranging from 35.37 to 33.71 ppt. during the March to August, and during September complete fresh water conditions with salinity of 0.07 ppt. and during October-March salinity ranging between 19.63 to 25 ppt. were noticed. The mixing of freshwater with sea water is very high at middle area of the estuary, thus varying the salinity between 25.21 to 5.77 ppt. during most part of the year except a high salinity of 35.05 during May and very low salinity (1.5 to 0.07 ppt.) during September-October were found. At the upper reaches of the estuary salinities ranging between 23.17 to 14.75 ppt. during March to June and in the remaining months ranging between 5.05 to 0.14 ppt. and during July and September fresh water conditions were noticed (Fig. 5).

Dissolved Oxygen : The Dissolved Oxygen quantity ranging from 21.0 to 5.8 mg./lt were noticed at the three stations during the period of study. At the middle and upper reaches of the estuary more Dissolved Oxygen quantities were noticed than at the mouth area. At all the three stations maximum Dissolved Oxygen quantities were noticed during May-October and minimum during November-April (Fig. 6).

ZOOPLANKTON

Though the Zooplankton was found consisting several groups of organisms, fish eggs and larvae, copepoda, cladocerans and chaetognaths are found to be dominant groups. However, larval invertebrates were seen in most of the samples also.

i) **Fish eggs and larvae** : Fish eggs and larvae were found in almost all the zooplankton samples collected from the mouth and middle areas of the estuary but their number and frequency of occurrence is very less in the upper reaches (Station III). During the monsoon months of July and August fish eggs and larvae were not found in any of the samples.

ii) **Copepods** : Copepods were found to be the major component of the Zooplankton. Abundance of copepods throughout the estuary is noticed during March-May and Sept.-Oct., while very less number were seen during June, Nov.-Jan. Generally at the mouth of the estuary more copepods were seen that at the remaining two stations except during July.

iii) **Chaetognaths** : Chaetognaths were found more in the mouth and middle areas of the estuary

during the period from May to October, but their occurrence is almost nil at the upper reaches. More number of Chaetognaths were found in the mouth area during the month of October.

Table 1 : Physico-Chemical Parameters, Station-I (Mouth of the River) During 1985-86.

Month	Temperature °C		pH	Salinity (ppt.)	D.O. (mg./Lt.)
	Air	Water (Subsurface)			
Jul.	29.0	28.2	7.6	33.64	16.5
Aug.	27.8	28.5	7.9	33.71	13.0
Sep.	31.2	31.7	7.7	0.07	13.8
Oct.	29.1	29.1	8.52	19.63	17.4
Nov.	27.0	27.2	9.05	25.0	5.8
Dec.	24.5	24.0	7.83	23.46	9.9
Jan.	27.0	26.9	7.76	18.59	8.4
Feb.	28.7	27.9	8.3	21.51	7.3
Mar.	29.9	29.1	8.0	35.37	13.9
Apr.	30.5	30.8	7.91	34.72	8.8
May	30.5	29.75	8.09	35.05	18.0
Jun.	28.5	29.5	8.0	34.6	11.3

Table 2 : Physico-Chemical Parameters, Station-II (Middle of the River) During 1985-86.

Month	Temperature °C		pH	Salinity (ppt.)	D.O. (mg./Lt.)
	Air	Water (Subsurface)			
Jul.	28.2	28.4	7.9	10.46	15.3
Aug.	26.7	28.4	8.2	20.21	16.0
Sep.	35.0	35.0	8.57	0.07	13.6
Oct.	31.3	28.0	8.88	1.5	20.4
Nov.	28.7	25.2	8.9	8.5	7.8
Dec.	26.0	24.5	8.45	23.10	11.4
Jan.	28.4	25.9	7.52	5.77	8.8
Feb.	29.0	30.0	8.10	10.46	8.1
Mar.	28.1	29.9	8.3	25.21	12.4
Apr.	29.3	30.4	7.83	19.24	6.2
May	30.5	29.0	8.2	35.05	15.0
Jun.	31.0	29.25	8.0	18.03	16.6

iv) *Cladocera* : Cladocerans are seen during all the months except in the month of December in the estuarine waters. However they were more in the samples collected from middle and upper reaches of the estuary. These were also present in the samples collected from mouth area during the months of January to April, and surprisingly their number is very high during March-April. The minimum number of cladocerans were seen in the months of May, August and October.

v) *Meroplankters* : The microplankters viz. crustacea, ploycheata and mollusca larvae were seen in all the samples throughout the year. However these are seen in more numbers during March, April, May and September.

Table 3 : Physico-Chemical Parameters, Station-III, (Bridge Area) During 1985-86

Month	Temperature °C		pH	Salinity (ppt.)	D.O. (mg./Lt.)
	Air	Water (Subsurface)			
Jul.	28.0	27.0	2.51	0.0	16.0
Aug.	26.5	28.2	8.4	5.05	16.0
Sep.	34.7	35.2	8.82	0.0	13.0
Oct.	32.6	28.7	8.93	0.33	21.0
Nov.	26.0	25.8	9.5	0.14	8.8
Dec.	26.0	25.5	8.46	2.31	4.6
Jan.	28.0	26.7	7.8	2.59	9.4
Feb.	28.9	30.7	7.9	2.16	9.4
Mar.	28.7	30.5	8.0	14.75	13.00
Apr.	31.5	32.5	7.96	23.17	7.3
May	31.0	29.5	8.45	22.7	10.0
Jun.	29.5	28.5	8.5	19.13	16.5

Table 4 : Zooplanktoon Quantity ml/200 lt.

Month	Station-I (Mouth area)	Station-II (Middle area,)	Station-III (Bridge area)
Jul.	0.1	0.2	0.3
Aug.	0.1	0.1	0.1
Sep.	0.2	0.5	0.5
Oct.	1.9	0.1	1.05
Nov.	0.1	0.2	0.2
Dec.	0.3	—	0.2
Jan.	0.1	0.1	0.1
Feb.	0.15	0.1	0.3
Mar.	1.5	0.9	0.1
Apr.	1.3	0.5	0.5
May	0.8	0.2	0.5
Jun.	0.3	0.1	0.1

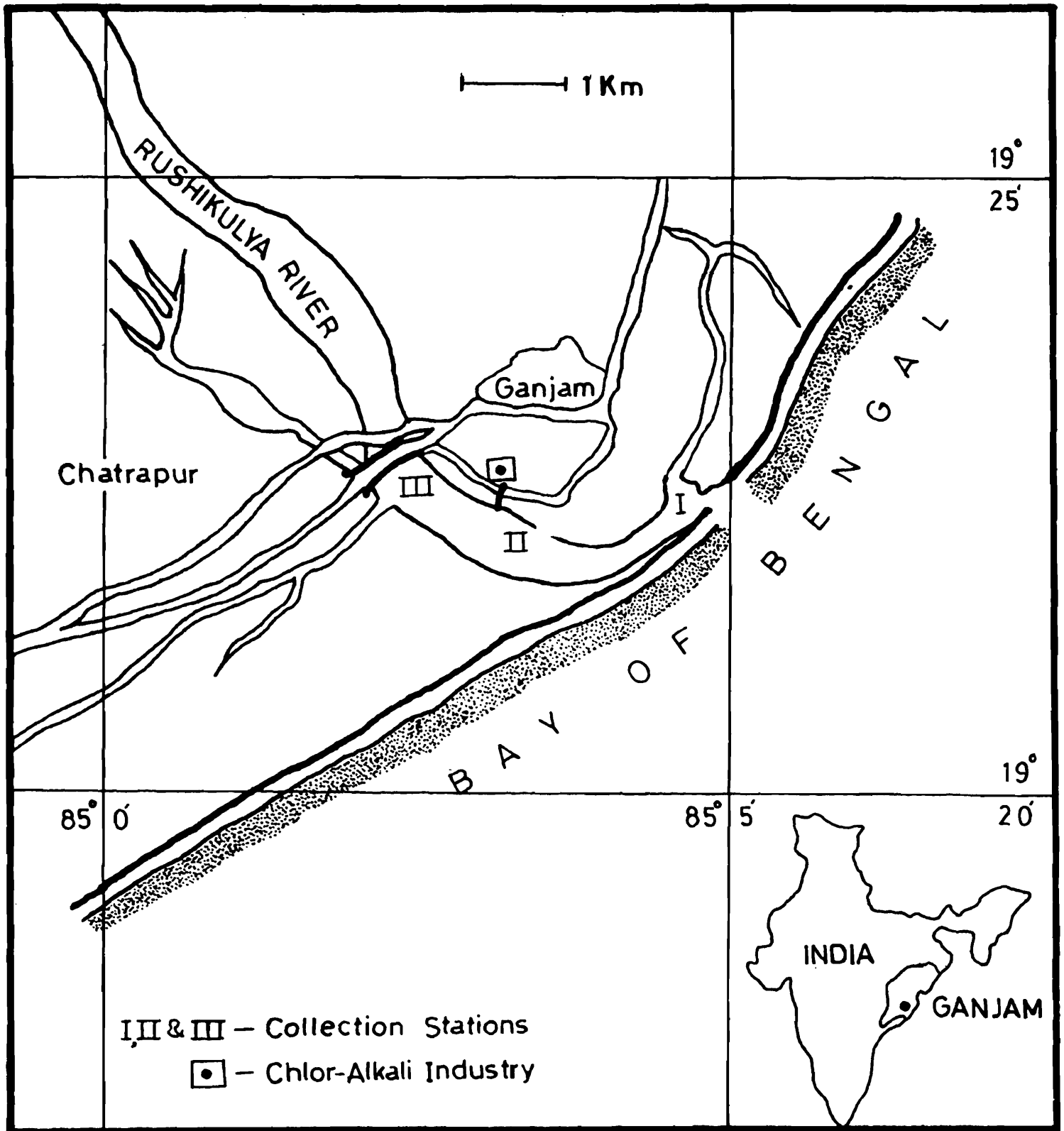


Fig. 1 Map of Rushikulya estuary showing collection stations

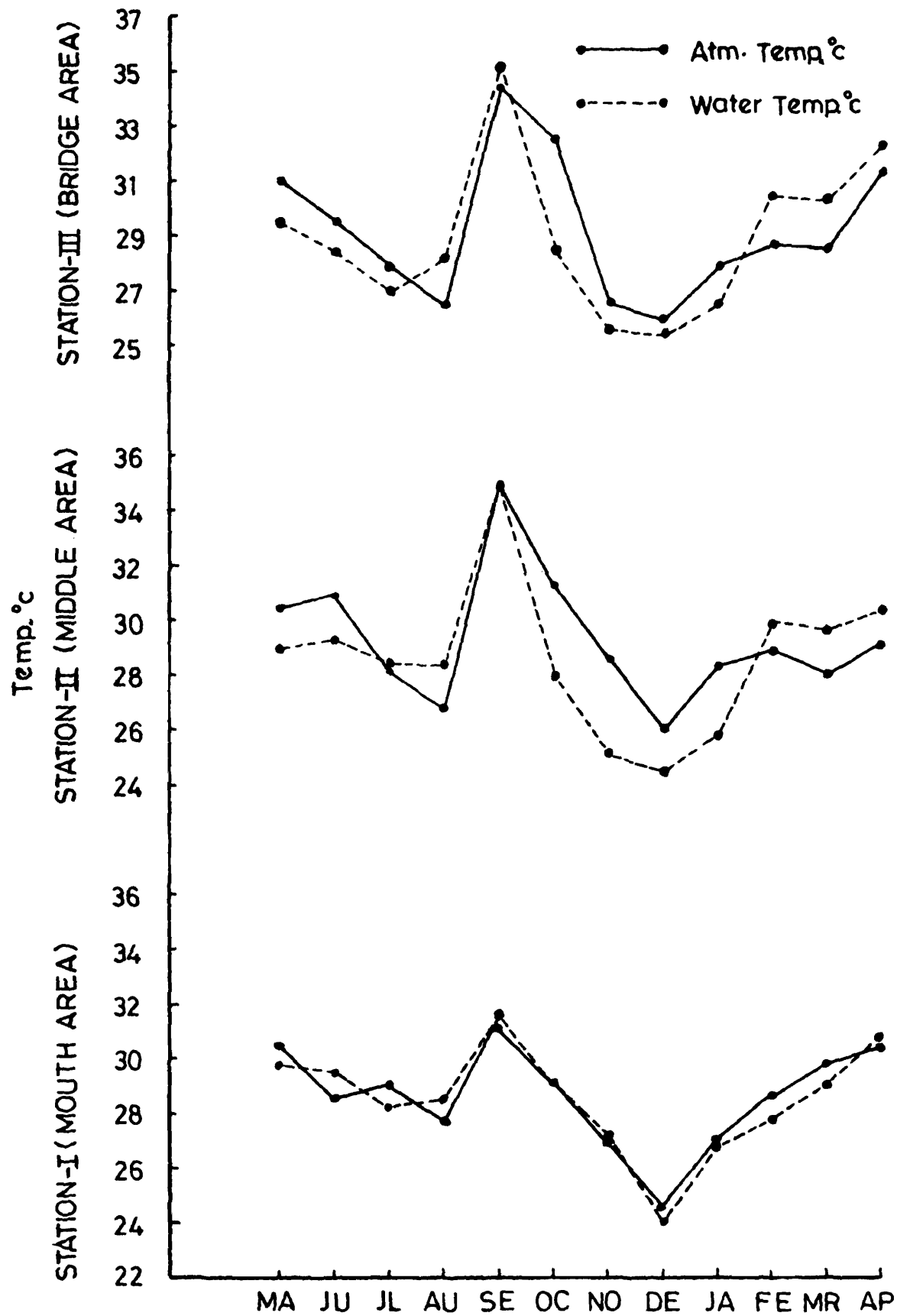


Fig. 2 Air and water temperature at stations I, II & III during 1985-86

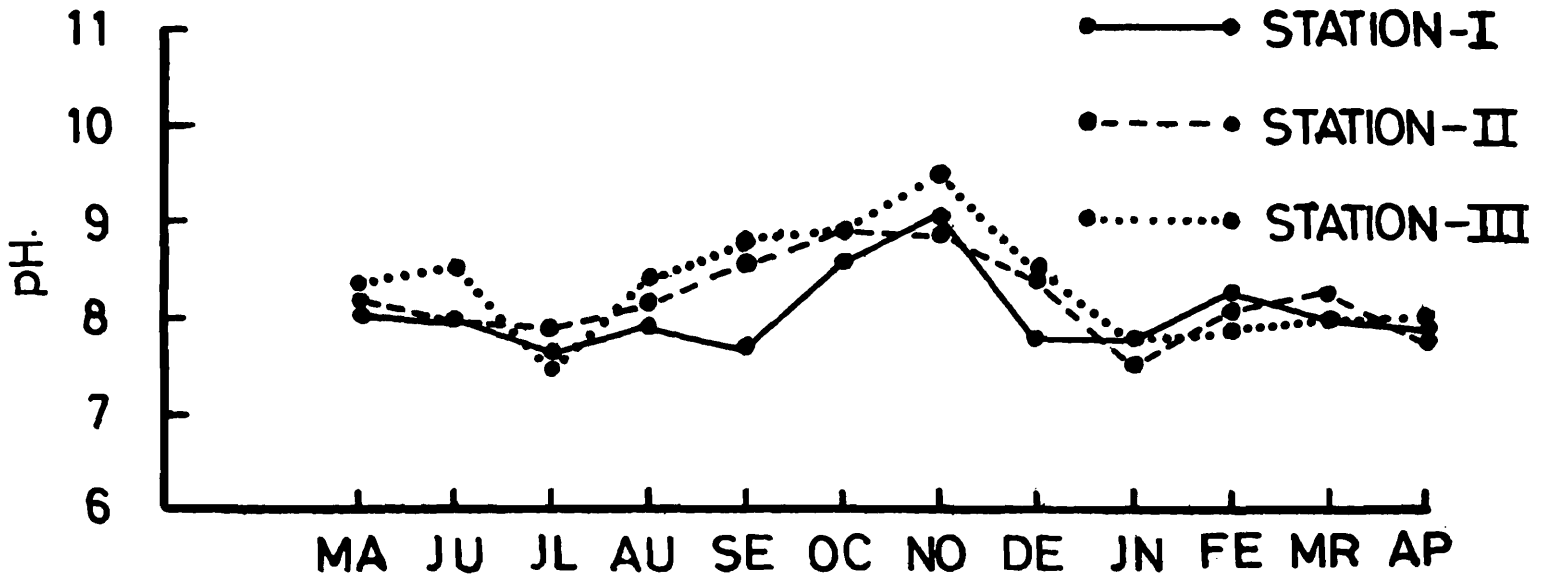


Fig. 3 pH of water at stations I, II & III during 1985-86

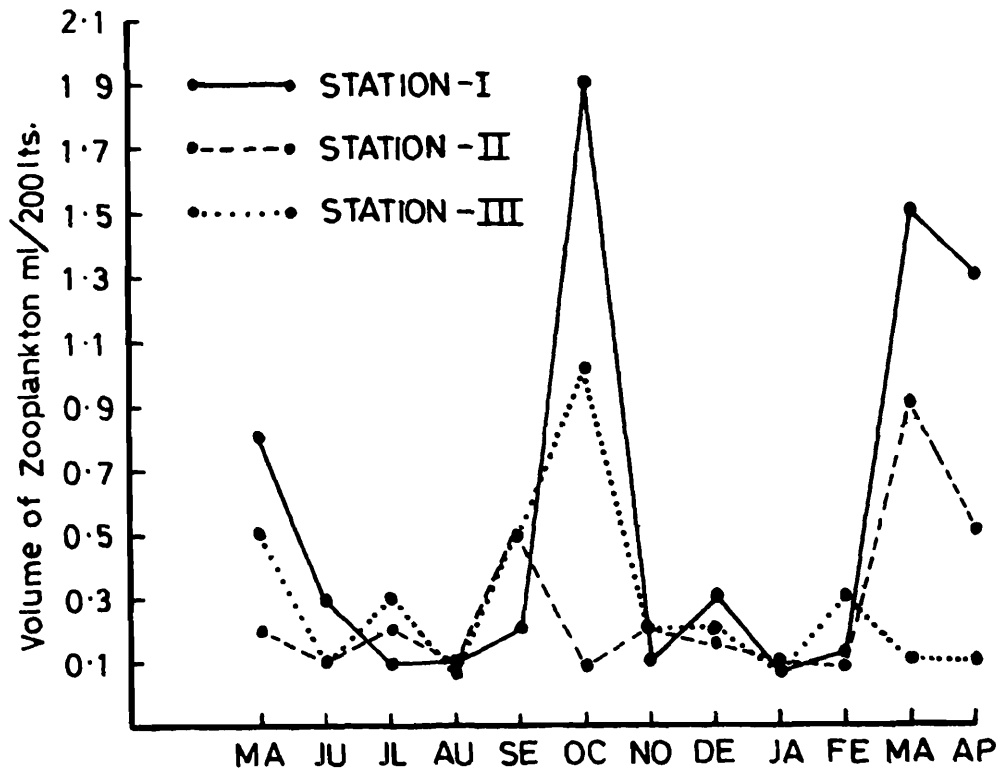


Fig. 4 Volume of Zooplankton at stations I, II & III

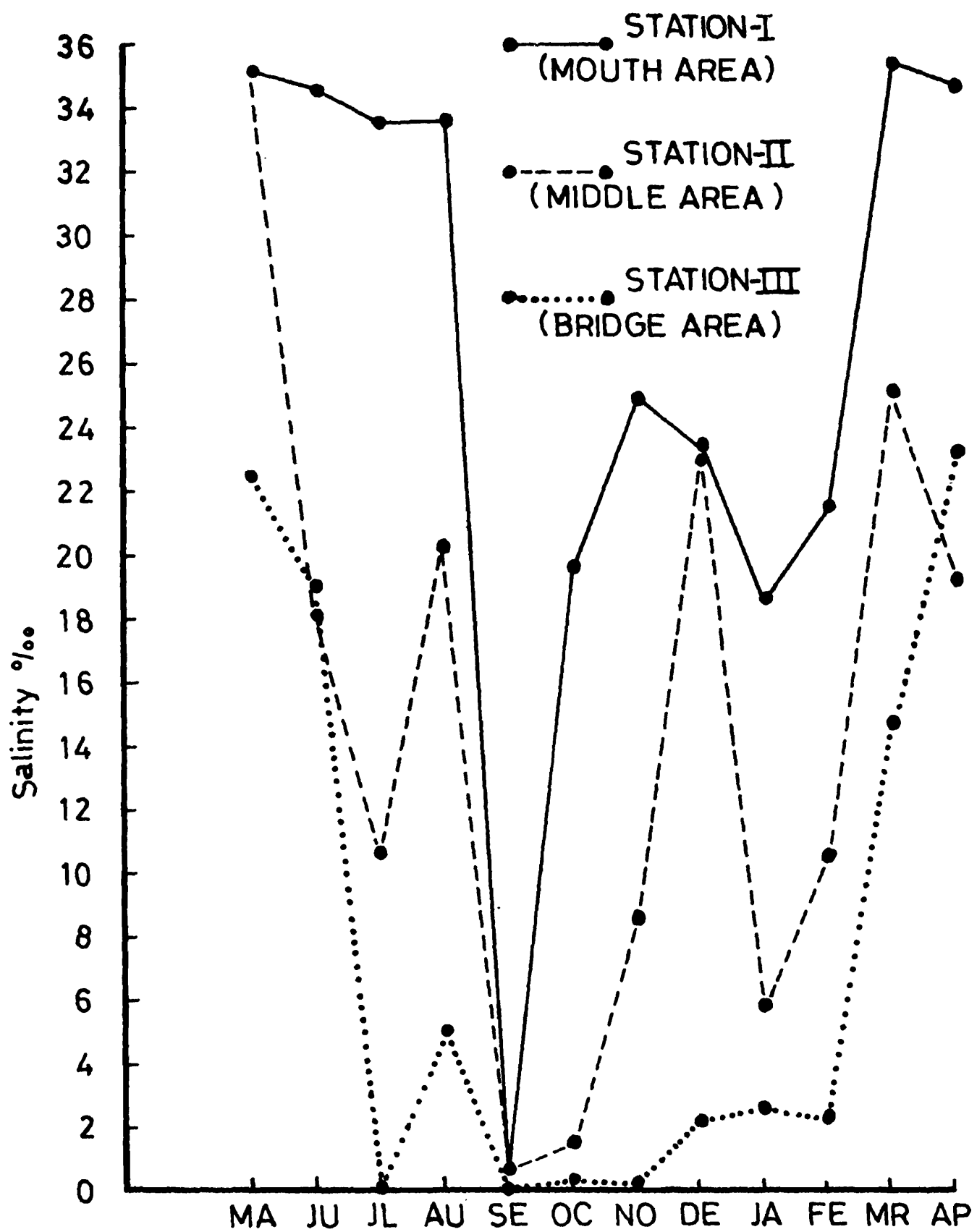


Fig. 5 Salinity at stations, I, II & III during 1985-86

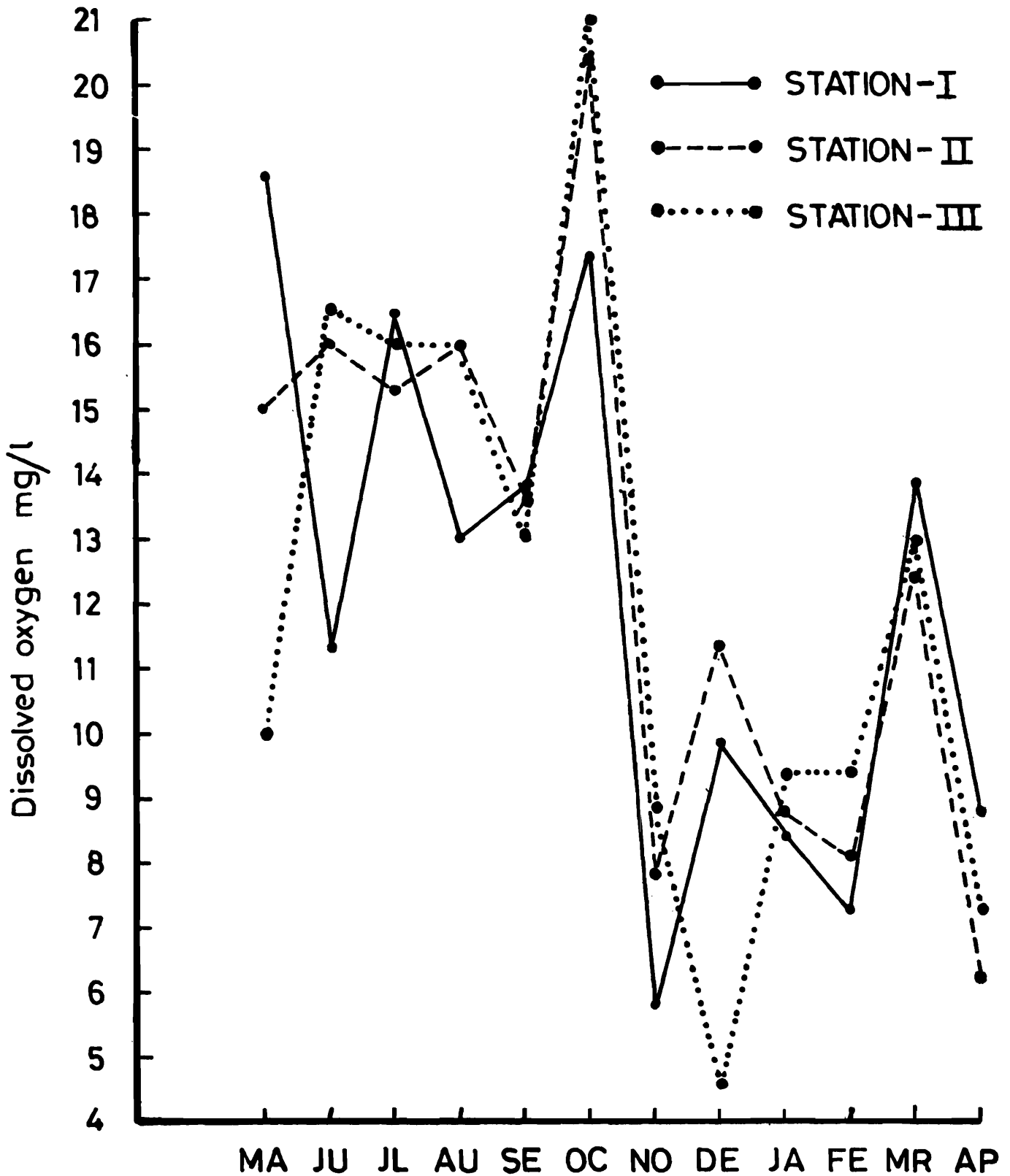


Fig. 6 Dissolved Oxygen at stations, I, II & III during 1985-86

Quantitative studies : The volume of Zooplankton shows seasonal fluctuations with two peaks in a year (fig. 4). The first peak is in the month of March and the other in the month of October i.e. premonsoon and post monsoon. During the monsoon period low quantities of Zooplankton were noticed. The above situation occurs in all the three stations. However the Zooplankton volumes at the middle and upper regions were lower than in the mouth area. In the middle area the post monsoon increase was very less in comparison to the mouth area. In the upper reaches of the estuary the increase in Zooplankton quantity during premonsoon period is very less compared to the lower reaches of the estuary (Fig. 4).

MACROFAUNA

The important constituents of the estuarine macrofauna comprises polychaetes, crustaceans, molluscs and fishes. However other groups such as coelenterates, sipunculids, echiuroids etc. also occur in less numbers. As the major groups, viz. polychaetes crustaceans, mollusca and fishes, are abundant and commercially important, regular collections of these were made from different localities of the estuary and studied in detail.

Polychaetes : Polychaetes are one of the important constituents of the benthic fauna of the estuary as these are the most abundant of all the invertebrates. Although polychaetes were seen all along the estuary their presence is very less at the upper reaches of the estuary where freshwater conditions are seen during most part of the year except few months. In the middle region, the vastly exposed intertidal mud flats were found inhabited by large populations of polychaetes of different families. At the mouth are also, sediments of the intertidal region mixed with sand and mud harboured good number of polychaetes.

About 18 species belonging to 11 families of polychaetes were collected, of which majority of them belong to the Families, Nereidae, Eunicidae, Spionidae, Capitellidae and Sabellidae. At the upper reaches of the estuary except few Spionids, no other polychaetes were seen. The following is the list of the polychaete fauna of the Rushikulya estuary.

1. Family : Pilargiidae
 1. *Ancistrosyllis constricta* Southern
2. Family : Phyllodocidae
 2. *Eulalia viridis* (Muller)
3. Family : Pisionidae
 3. *Pisionidens indica* (Aiyar and Alikunhi)
4. Family : Nereidae
 4. *Nereis (Ceratoneris) burmensis* Munro
 5. *Nereis (Neanthes) reducta* Southern
5. Family : Glyceridae
 6. *Glycera alba* Rathke
 7. *Glycera lancadivae* Schmarda
6. Family : Eunicidae

8. *Lumbrineris notocirrata* Fauvel
9. *Diopatra neapolitana* Delle Chiaje
7. Family : Trochochaetidae
 10. *Poecilochaetus serpens* Allen
8. Family : Spionidae
 11. *Malacoceros indicus* (Fauvel)
 12. *Prionospio cirrifera* Wiren
 13. *Scolelepis squamata* (Muller)
9. Family : Sebellidae
 14. *Laonome indica* Southern
10. Family : Capitellidae
 15. *Heteromastus similis* Southern
 16. *Paraheteromastus tenuis* (Munro)
 17. *Branchiocapitella singularis* Fauvel
11. Family : Terebellidae
 18. *Loimia medusa* (Savigny)

Of the above *Glycera*, *Pisionidens*, *Eulalia*, and *Poecilochaetus* occur in few numbers and the remaining are abundant during most part of the year except in August and September.

Crustacea : Though this group comprises prawns, crabs, hermit crabs, amphipods and Isopods etc., only the commercially important crabs and prawns were collected and studied. The taxonomic list of the crabs and prawns is given below.

1. Family : Penaeidae
 1. *Penaeus monodon* (Fabricius)
 2. *Penaeus semisulcatus* (De Hann)
 3. *Parapenaeus rectacuta* Bata
 4. *Matapenaeus* sp.
2. Family : Ocypodidae
 5. *Macrophthalmus depressus* Rupell
 6. *Ocypoda macrocera* M. Edwards
 7. *Ocypoda* sp.
 8. *Uca annulipes* Later,
 9. *Uca triangularis* M. Edwards
 10. *Dotilla brevitarsis* De Hann
3. Family : Grapsidae
 11. *Varuna littrata* (Fabricius)
4. Family : Portunidae

12. *Scylla serrata* (Forsk.)
13. *Thelamita crenata* (Later)
14. *Charybdis affinis* Dana

Among the crabs, decapoda crabs were seen abundant in the intertidal areas at the middle and mouth areas of the estuary. The intertidal mud flats at the middle region of the estuary is dotted with thick populations of *Uca* sp. while at the mouth and middle areas the mud crab *Scylla serrata* were found caught in large numbers by fishermen. Though large number of prawn larvae and juveniles were observed in the estuary, only few species of prawns were encountered. However, good catches of prawn were also noticed during the fishing activities in the estuary.

Mollusca : Molluscan shells both living and dead ones were found abundant at the mouth and middle areas of the estuary but very less in numbers at the upper reaches. In the intertidal mud flats at the middle region, many bivalves viz. *Solen*, *Crassostrea*, *Macra*, *Corbicula* were found buried along with other benthic fauna. At the mouth region dead shells were seen washed ashore of which many are probably of marine origin. However all the shells found in the estuary upto the mouth region were collected and the list of the molluscan fauna given below.

Class : GASTROPODA

Order : MESOGASTROPODA

1. Family : Turritellidae
 1. *Turritella columanaris* Kiener
2. Family : Thiaridae
 2. *Thiara (Tarebia) lineata* (Gray)
 3. *Thiara (Tarebia) granifera* (Lamarck)
 4. *Thiara (Stenomelania) torulosa* (Bruguiere)
3. Family : Architectonicidae
 5. *Architectonica laevigata* (Lamarck)
4. Family : Potamididae
 6. *Telescopium (Telescopium) telescopium* (Linnaeus)
 7. *Cerithidea (Cerithideopsis) cingulata* (Gmelin)
5. Family : Cypraeidae
 8. *Mauritia arabica* (Linnaeus)
 9. *Erosaria ocellata* (Linnaeus)
6. Family : Cymatiidae
 10. *Cymatium tripus* (Lamarck)
 11. *Distorsio reticulata* Roeding
7. Family : Viviparidae
 12. *Bellamyia bengalensis* f. *typica* (Lamarck)
 13. *Bellamyia dissimilis* (Mueller)

8. Family : Pilidae

14. *Pila globosa* (Swainson)

9. Family : Naticidae

15. *Natica gualteriana* Recluz

Order : NEOGASTROPODA

10. Family : Muricidae

16. *Murex tribulus* Linnaeus

11. Family : Olividae

17. *Oliva oliva* (Linnaeus)

12. Family : Turridae

18. *Lophiotoma (Lophioturris) indica* (Roeding)

13. Family : Buccinidae

19. *Babylonia spirata* (Linnaeus)

Order : Basommatophora

14. Family : Planorbidae

20. *Indoplanorbis exustus* (Deshayes)

Class : BIVALVIA

Order : ARCOIDA

15. Family : Arcidae

21. *Anadara* sp.22. *Anadara (Anadara) granosa* (Linnaeus)23. *Anadara (Tegillarca) rhombea* (Born)24. *Scapharca deyrollei* Jousseaume

16. Family : Glycymerididae

25. *Glycymeris tenuicostata* (Reeve)

Order : Veneroidea

17. Family : Carditidae

26. *Cardites antiquata* (Linnaeus)

18. Family : Cardiidae

27. *Cardium* sp.28. *Acanthocardia coronata* (Schroeter)29. *Acanthocardia lata* (Born)

19. Family : Mactridae

30. *Mactra luzonica* Deshayes31. *Mactra mera* Deshayes32. *Mactra cuneata* (Gmelin)

20. Family : Donacidae
 33. *Donax scortum* Linnaeus
21. Family : Corbiculidae
 34. *Corbicula striatella* Deshayes
22. Family : Veneridae
 35. *Marcia pinguis* (Schroeter)
 36. *Meretrix meretrix* (Linnaeus)
 37. *Meretrix casta* (Gmelin)
 38. *Timoclea imbricata* (Sowerby)
 39. *Sunetta effosa* (Hanley)
 40. *Sunetta donacina* (Gmelin)
 41. *Sunetta* sp.
 42. *Sunetta scripta* (Linnaeus)
 43. *Sunetta meroe* (Linnaeus)
23. Family : Solenidae
 44. *Solen truncatus* Wood

Order : PTERIOIDA
24. Family : Anomiidae
 45. *Anomia achaeus* Gray
25. Family : Ostreidae
 46. *Crassostrea cuttackensis* (Smith and Newton)

Order : Unionoida
26. Family : Amblemidae
 47. *Parreysia (Parreysia) corrugata* (Mueller)

Order : MYTILOIDA
27. Family : Mytilidae
 48. *Perna viridis* (Linnaeus)

Fish and fish larvae : Fishing operations in the estuary were seen during most part of the year. The fish fauna of the estuary is very rich both quantitatively and qualitatively. Different types of gear were found operated in the estuary and near the mouth area by the fishermen. The adult fish fauna of the estuary will not give the total fish potential of the estuary as the estuaries are considered to be the nurseries and breeding grounds for a variety of fishes. Hence the abundance and taxonomy of the fish larvae and juveniles were also studied. The fish larvae and juveniles were collected during high and low tides by using Midnapore shooting net and were identified up to generic level. The fish samples were collected from fish landing centres and from the fishermen while fishing in the estuary. The details of the fish fauna is given below.

Fish fauna of the estuary :

1. Family : Ophichthidae
 1. *Callechelys longipinnis* (Knar and Steidachner)
2. Family : Clupeidae
 2. *Hilsa ilisha* Hamilton
 3. *Sardinella fimbriata* Valenciennes
3. Family : Engraulidae
 4. *Stolephorus indicus* (Van Hasselt)
 5. *Stolephorus commersonii* Lacepede
4. Family : Bagridae
 6. *Mystus gulio* (Hamilton-Buchanan)
5. Family : Ariidae
 7. *Arius arius* (Hamilton-Buchanan)
 8. *Arius caelatus* Valenciennes
6. Family : Syngnathidae
 9. *Microphis brachyurus* Bleeker
7. Family : Platycephalidae
 10. *Platycephalus indicus* (Linnaeus)
8. Family : Ambassidae
 11. *Ambassis urotaenia* Bleeker
9. Family : Theraponidae
 12. *Therpon jarbua* Forskal
10. Family : Sillaginidae
 13. *Sillago sihama* (Forskal)
11. Family : Carangidae
 14. *Caranx carangus* (Bloch)
12. Family : Lutjanidae
 15. *Lutjanus jhonii* (Bloch)
13. Family : Gerridae
 16. *Gerres filamentosus* Cuvier
14. Family : Mullidae
 17. *Upeneus tragula* Richardson
15. Family : Scatophagidae
 18. *Scatophagus argus* (Linnaeus)
16. Family : Mugilidae

19. *Mugil cephalus* Linnaeus
20. *Liza parsia* (Hamilton-Buchanan)
21. *Valmugil seheli* (Forsk.)
22. *Valmugil speidleri* (Bleeker)
17. Family : Callionymidae
 23. *Callionymus sagitta* Pallas
18. Family : Gobiidae
 24. *Glossogobius giuris* (Hamilton)
 25. *Glossogobius biocellatus* (Valenciennes)
 26. *Oxyurichthys microlepis* (Bleeker)
19. Family : Siganidae
 27. *Siganus canaliculatus* (Park)
20. Family : Cynoglossidae
 28. *Cynoglossus semifaciatu*s Day
21. Family : Tetraodontidae
 29. *Chelenodon patoca* (Hamilton-Buchanan)

Fish larvae : The fish larvae were collected by using standard Midnapore shooting net at mouth area during high and low tides for a period of 12 months to know the composition of the fish larvae as the fishery of the estuary is dependent on successful recruitment of larvae and juveniles from the sea. Nearly 60% to 70% of the fishery is constituted by these recruits which migrate to the upper reaches of the estuary and grow to larger sizes. This estuary is ideal for collection of seeds of culturable species of brackish water fishes viz. *Chanos*, *Mugil*, *Elops*, *Megalops*, etc.

In all, 38 species belonging to 19 families were encountered in the present collections of which 8 families of fish are commercially important viz. Mugilidae, Chanidae, Leiognathidae, Cynoglossidae, Engraulidae, Theraponidae, Elopidae and Megalopidae.

The occurrence and abundance of these larvae varies during different periods of the year. In the month of March, June and December the larval representation is almost nil and during August and October very few fish larvae were seen represented by only Gobiidae and Elopidae larvae. But in the remaining months (January, February, April, May, July, September and November) fish larvae and juveniles belonging to many families were encountered. Along with the fish larvae many species of post larvae and juveniles of Prawns and Crabs were also encountered round the year in the Midnapore net collections. The following are the various groups of fish larvae of the Rushikulya estuary.

1. **Elopid**s : The transparent leptocephalus like post larvae of *Elops saurus* Linn. Measuring 26 to 36 mm occur in the months of January, February, April and May in lesser numbers and occur in large numbers during July–August.

2. **Megalopid**s : Transparent leptocephalus like post larvae of *Megalops cyprinoides* (Brouss.) ranging 22 to 28 mm. in length occur in stray numbers and found only in the month of May. No single specimen was found during the remaining period.

3. *Eel leptcephali* : Four species of transparent ribbon-like leptocephalus larvae of eels belonging to the families Muraenidae and Ophichthidae were found in large numbers in the month of January, May and July. Usually these eel larvae are seen entering the estuaries during high tides only.

4. *Engraulids* : Large number of larvae and post larvae of two species of engraulids viz. *Stolephorus* and *Thryssa* sp. measuring 8 to 25 mm. in length occur in the collections made in the month of January, February, July and November.

5. *Milk fish* : Large number of post larvae and juveniles of *Chanos chanos* in the size range of 13.5 to 15 mm. were found during high tides before the on-set of monsoon i.e. in May. The larvae and juveniles of *Chanos chanos* usually found along with the larvae of *Elops*, *Megalops* and *Mugils*.

6. *Mulletts* : Two species of mullet larvae and juveniles of the *Liza* ranging 11 to 17.5 mm. in length were seen in large numbers during the month of May and in very less numbers during October - November, i.e. post monsoon period.

7. *Cyprinids* : Few species of cyprinid fish larvae were collected during October - November. A single juvenile specimen of *Esomus danricus* (Ham.) and larvae of different species of *Puntius* measuring 15 to 20 mm. were found.

8. *Leiognathids* : Large number of post larvae and juvenile leiognathids belonging to *Leiogonathus leniolatus* (Cuv. & Val.) and other species of *Leiogonathus* ranging from 7.5 to 18 mm. in length were found during the month of January, February, July and September.

9. *Theraponids* : Post larvae and juveniles of *Therapon jarbua* (Forsk.) ranging 10 to 15 mm. in length occurred in the month of April, May June and July i.e. during premonsoon and monsoon periods. During remaining months no specimen was encountered.

10. *Gobiids* : Large number of juveniles of Gobiid fishes were collected during premonsoon and post monsoon (i.e. in January, February, April, September, October and November) of which nine larvae belong to *Gobius* sp., two *Gobioides* sp. and one species of *Boleophthalmus* were identified.

11. *Cynoglossids* : Metamorphosed larvae of two species of *Cynoglossus* sp. measuring 4.6 to 7.8 in length were found in small numbers during only January and May.

12. *Ambassids* : Post larvae and juveniles of *Ambassis* sp. measuring 7.5 to 23 mm. in length were recorded in large numbers during post monsoon period of September, October and November months.

13. *Tetraodontids* : Post larvae and juveniles of *Chelonodon Patoca* (Ham. & Buch.) ranging 9 to 17 mm. were found in stray number during the months of January, February and July.

In addition, larvae and juveniles of some fishes of other families in smaller numbers were seen of which post larvae and juveniles of *Scatophagus argus* (Linn.), *Vespicula* sp., *Platycephalus* sp., and *Macrognathus aculeatus* are noteworthy.

DISCUSSION

Estuarines provide a dynamic ecosystem with constantly changing physico-chemical conditions and its fauna during different periods of the year and different regions within the estuary due to floods, monsoon, tides, etc. At the Station-I and II increase in depth was noticed due to tidal

influence. However appreciable increase in depth is noticed at all the stations during monsoon periods. Marked difference in the air and water temperature was not noticed in the estuary except at Station-III where the depth is very less. Due to tidal influence, at Station-I and II, less differences in the air and subsurface water temperature was noticed. Nearly sea water conditions are seen at the Ist Station during the most part of the year except during September-October. Very high volume of sea water enters the estuary during high tide, and the river water flow is very less compared to the sea water inflow. This observation was also made by Murthy *et al.* (1988). However real estuarine conditions exists at Station-II as mixing of fresh water with sea water takes place. At the IIIrd Station very less salinities are noticed throughout the year except summer months of March - June and during this period negligible amount of fresh water flow is seen in the river and thereby maximum sea water inflow to this station. Marked seasonal difference in the dissolved oxygen values are seen. The dissolved oxygen content in the estuarine waters is more during summer and monsoon months in comparison to post monsoon period at all the stations. Generally more dissolved oxygen quantities are seen at Station-III, probably due to the running water conditions at this place. The dissolved oxygen values observed in this estuary were found to be higher in comparison to Ennore estuary (Raghunathan and Srinivasan, 1983) where in 1.5-7.5 mg./lt. dissolved oxygen values are reported. The high values of dissolved oxygen seen in Rushikulya estuarine water might be due to less depth.

pH values did not show any marked seasonal fluctuations except at Station-I where nearly neutral values are seen during monsoon months. pH ranging between 7.5 to 9.5 was recorded in the estuary during the study; slightly more alkaline conditions are noticed at Station-III, in comparison to the other two stations. Similar observations are noticed in the estuaries of Ramanathapuram. (Evangeline, 1975) and Ennore (Raghunathan and Srinivasan, 1983). Generally two peaks in Zooplankton quantities are found one in summer and the other during post monsoon period. Zooplankton at Station-I is found to be rich both quantitatively and qualitatively as higher salinities influence in Zooplankton production. Peaks in Zooplankton in general, and copepoda in particular after phytoplankton blooms are reported by Ramamurthy (1953) and Krishnaswamy (1950). Raghunathan (1980) also reported the relationship between the abundance of Diatoms and Copepods in Ennore estuary. Quantitative studies on Phytoplankton of the Rushikulya estuary enables us to understand the Zooplankton distribution pattern.

The occurrence of rich macrofauna viz. polychaetes, crustaceans, mollusca along with high Zooplankton quantities at Station-I in general shows the important role of salinity in the abundance of fauna and its variety.

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