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M. B. Raghunathan
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By

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INTRODUCTION

Estuaries form the nearest available biological habitats for the people, as most of the harbours and cities are situated on estuaries. Along the east coast of India several estuaries and lagoons like Ennore, Adayar, Cooum, Kovalam and Pulicat are found in and around Madras city of Tamil Nadu state. Here the Ennore estuary is taken up for detailed investigations.

The pioneering attempt of making qualitative study of the plankton of Ennore estuary was by Chacko and Rajagopal (1962). Then a few reports were published depicting the amplitude of seasonal changes of zooplankton of Ennore estuary (Evangeline and Subbiah, 1969., Srinivasan and Raghunathan 1977, 1978). Subsequently variation in relative proportions of specific groups such as chaetognaths (Srinivasan, 1976, 1978, 1980) and copepods (Raghunathan, 1980) were studied. The Gobioid fishes of this estuary were studided by Menon and Govindan (1976) and Menon and Rema Devi (1978). The pollution aspects of Ennore estuary were studied by Sreenivasan and Franklin (1975).

Despite the present knowledge of various zooplankton taxa accumulated through these reports, a complete picture on the different aspects of the zooplankton and hydrography of this estuary, that too after the dredging operations carried out by Ennore thermal station to keep the mouth of the estuary open throughout the year, is wanting. Hence this bioecological investigations extending over two years (1976-1978) were carried out with the view to study the zooplankton and hydrography.

ENVIRONMENT

Topography and related features of Ennore estuary have been described in some of the earlier publications (Chacko and Raja gopal, 1962 and Srinivasan and Raghunathan, 1978). The estuary is three

km. long, one km. wide and the depth varies from 1.5 to 2.5 M. Karatalayar river forms the main channel for this estuary besides Buckingham canal and Redhills surplus channel' The estuary is having a number of oyster beds and mussel beds. Prior to dredging the estuary was undisturbed and regular fishing operations were carried out and it did not attract the public attention. Now due to the establishment of Thermal station huge quantity of water is required for cooling purposes and the water is drawn from the estuary. To maintain a continuous flow of water throughout the year, the mouth of the estuary is kept open by dredging operations. Prior to dredging the sand bar at the mouth remains closed atleast for six months in an year and connected to the sea only during the north-east monsoon period (October-December).

Due to the mechanical dredging done by the Ennore thermal station the mouth of the estuary is kept open throughout the year resulting in the regular influx of seawater into the estuary during high tide and receding of the estuarine water into the sea during low tide.

DESCRIPTION OF STATIONS

Materials for the present study were collected from six stations (fig. 1) fixed both in the estuary and Koratalayar river. Of these six stations regular periodical samples were collected from the three stations situated in the estuary. The I station is near the bar mouth which is subjected to heavy tidal effect and it is half a km. away from the bar mouth. The bottom is sandy with hermitcrabs as the only bottom fauna. The II station is deeper than the first and it is 1.5 km. away from the I station. The tidal impact is comparatively less. The bottom is a mixture of mud and sand and the bottom fauna consisted of polychaetes, hermit crabs, bivalves and ostracods, Station III is near the south lock of the Buckingham canal and it is about 3 km. away from the bar mouth. The tidal impact is almost negligible and the bottom is muddy. The bottom fauna was poor and represented by bivalves and polychaetes. Also samples were collected from station IV, at a channel in Kariamkuppam near Manali which joins the estuary ; station V at Koratalayar river near Edayanchavadi and from station VI and Vallur dam where water will be seen only during the rainy months.

MATERIAL AND METHODS

As stated earlier, the materials for this investigation were mainly obtained from regular fortnightly zooplankton samples collected between 7 and 8 A.M. during the November 1976 to December 1978 at the three fixed stations in the estuary (plate 1). Samples were occasionally collected from station IV and V. As water is usually not found in Station VI (Vallurdam) sampling was not possible. For plankton collections a half M. nylon net (0.3 mm. mesh size) was towed horizontally for ten minutes from the Regional Station's fibreglass boat 'Matsya' Plankton samples were fixed in 5% formalin and the volume was determined by the displacement method. Then the plankton was diluted to 250 ml. and from which a subsample of 2 ml. was examined in a Sedgewick-rafter cell for enumeration of various planktonic organisms. For macroplanktonic organisms like *Lucifer*, Chaetognatha, medusae, *Pleurobrachia* and fish larvae the entire plankton sample was analysed.

Water samples collected from the different stations were analysed for salinity, dissolved Oxygen and pH. By using a Secchi disc transparency values were noted for all the stations. Further other parameters like depth, air temperature, water temperature, tide and weather conditions were noted. By using an Ekman dredge (15 × 15 cm.) benthic samples were collected from all the three stations. The collected bottom samples were filtered by using 500μ, 200μ, and 100μ sieves and the benthic forms were separated for enumeration and identification. General fish landings and the dominant fish groups were also recorded.

HYDROGRAPHIC FEATURES

(figs. 2, 3, 4 and 5)

Station I

Depth : The depth of this station was between 0.90 and 3.25 M. during the period of investigation and the depth was more during December 1976, January 1977 and less during August 1978. During the rest of the period the depth ranged between 1.0 and 2.5 M.

Transparency : The Secchi disc transparency values show that the water was always turbid and the possible and probably reasons for this are given in the ensuing discussion section. Maximum transparency

values were noted during April 1978 (1. 4 M.) and minimum during November 1977 (0.25 M.). The transparency values normally ranged between 0.25 and 0.75 M.

Temperature : The air temperature ranged between 25 to 31.5°C with maximum during July 1977 and minimum during December 1976 and November 1978. In this station the water temperature varied from 24 to 31°C with the maximum during November 1978. Water temperature was more than that of air-temperature on many occasions.

Salinity : The salinity at this station varied from 0.2‰ to 30‰. High salinity values were noted during January 1977 and low salinity conditions were generally observed during the north east monsoon periods (October-December). During the other seasons the salinity ranged between 22 to 24‰. The south west monsoon also plays a minor role in the fluctuations of the salinity.

Dissolved Oxygen : The dissolved Oxygen values at this station during the period of investigation fluctuated between 1.5 and 3.6 mg/1. The values were generally high during December 1976, January, August, September, October, November and December 1977.

pH value : The range of pH was between 7.30 and 8 30 with minimum during the monsoon months and maximum during April 1977. Wide fluctuations were not common but low values were noted during the monsoon months.

Station II

Depth : In this station the depth was always more and the average value was 2 M. The maximum depth (2.90) was noted during December 1976 and the minimum depth was recorded during March 1977 (1.60). Station II is comparatively deeper than the other two stations.

Transparency : As in Station I here also the transparency was low during the monsoon season (December 1976 and November 1977). More values were recorded during September 1977 and April 1978. The transparency values were comparatively more in this station.

Temperature : The range of air temperature was between 25.5 and 30.5°C with minimum during November 1978 and maximum during September 1977 and October 1978. Here always the air temperature was more than that of water temperature except on a few occasions. The range of water temperature was between 24.5 and 30.5°C with minimum during November 1978 and maximum during October 1977 and October 1978.

Salinity : Salinity values were similar as that of Station I with wide fluctuations during the monsoon months. The minimum value of 0.2‰ was noted during November 1977 and the maxinum value of 29‰ was recorded during January 1977.

Dissolved Oxygen : The Oxygen values were normally in the range of 1.5 to 4 mg/l. But during February, August, September, October and November 1977 more values were noted.

pH value : The range of pH was between 7.50 and 8.40 with minimum during the monsoon months and maximum during April 1977. As in Station I the values were low during the monsoon months.

Station III

Depth : Among the three stations, Station III is comparatively shallow with an average depth of 1.25 M. The minimum depth was noted during April 1978 (0.75 M) and maximum depth was noted during December 1976 (2.0 M). Since this station is near the south lock of Buckingham canal, the depth was also influenced by the south lock.

Transparency : The transparency values were generally low and varied between 0.25 and 0.90 M. Thr values were very low during the monsoon months and only during July 1978 the value was 0.90 M. This station is more turbid than the other two stations.

Temperature : Air temperature values were the same as in other two stations and the range was between 24 and 31°C with minimum during December 1978 and maximum during September, October and November 1977. Like Station II here also air temperature was generally more than that of water tenperature except on few occasions. Water temperature was between 25 and 30.5°C with minimum during November 1978 and maximum during October 1977.

Salinity : Salinity valves are similar to that of Station I and Station II with minimum values during the monsoon month (0.2‰) and maximum during January, 1977 (29‰). During the rest of the period normally the salinity values were in the range of 22 to 24‰.

Dissolved Oxygen : Compared with the other two stations the dissolved Oxygen values were tend to be more in this station. The range was between 1.7 and 7.5 mgl. with more values during February, July, August, September, October, November 1977 and August 1978.

pH value : The range of pH was between 7.60 and 8.60 with minimum during December 1978 and maximum during April 1977. Compared with the other two stations the pH values were slightly more here. During the monsoon months the pH values were low.

Statiou IV

To study the quality of channel joining the estuary in Kariamkuppam near Manali, the important parameters were studied. The parameters like temperature and transparency were the same as in other stations. But the salinity values of this channel were quite low with maximum only being 15.6‰ during September 1977. During the same period the salinity value in the estuary was 23‰. Hence this channel is one of the media of freshwater supply to the estuary. The pH values were between 7.50 and 8.20. The dissolved Oxygen values were quite low and varied from 1.2 to 3.12 mg/l with maximum during 1977.

Station V

To study the water quality of Koratalayar river, water samples were analysed from the Koratalayar river near Edayanchavadi bridge beyond the estuary. Here the salinity, pH and dissolved Oxygen values were similar to that of Ennore estuary. The salinity values were between 0.2‰ and 24‰ with minimum value during November 1977 and maximum during July, 1977. The pH values were between 7.70 and 8.15. The dissolved Oxygen values were in the range of 0.9 to 2.8 mg/l with minimum during December 1977 and maximum during September 1977. In Koratalayar river beyond Edayanchavadi, Vallurdam was also visited to examine the water quality. But generally during most of the seasons the river was completely dried

up except during the monsoon months. Hence regular samples could not be collected from this station.

BIOLOGICAL FACTORS

Phytoplankton production : Along with the zooplankton samples certain important diatoms like *Coscinodiscus* sp. and *Thallasiothrix* sp. were also seen in large numbers. They also have been studied for their seasonal fluctuation in abundence. *Thallasiothrix* sp. showed major peak during November and December 1976. *Coscinodiscus* sp. was also present during these two months. Dinoflagellates were represented by *Noctiluca* sp. showing abundance during July 1978.

Zooplankton volume : A general picture of the seasonal variation of zooplankton volume in Ennore estuary shows that it is relatively high during the later part of the monsoon and the postmonsoon period and low during the monsoon months with relatively minor secondary peak during the premonsoon period. (fig. 6). During the monsoon period the main constituents were the larval copepods and fish eggs. During the postmonsoon period the main constituents were the copepods, cladocerans, fish eggs and fish larvae. In the premonsoon period hydromedusae, ctenophores, copepods, mysids, decapod larvae, chaetognaths, bivalve larvae and fish eggs were the dominant forms.

HOLOPLANKTERS

Medusae and ctenophores : In Ennore estuary medusae were totally absent during the major part of the year and seen in abundance only during June, July, August. *Pleurobrachia* sp. also showed more or less the same pattern of fluctuation in the samples collected. They were present only during June and July 1977 with a maximum in July 1977. During the rest of the period very few specimens were only recorded. More number of medusae were found in Station I than the other two stations during the period of investigation.

Siphonophores : Stray occurrence of very few specimens of siphonopheres were recorded during January and April 1978 and during the rest of the period they completely absent.

Cladocerans : *Evadne* sp. and *Penilia* sp. were recorded for the first time from Ennore estuary. During April, May and June 1978 the

plankton samples were completely represented by these two cladocerans. During the rest of the period they were not seen in the samples (fig. 8, B). The volume of the zooplankton also is greatly influenced due to the sudden blooming of these two cladocerans. Among the two, maximum number of *Penilia* sp. was noted during April 1978. *Evadne* sp. also showed the same type of distribution with a maximum during April 1978. But during May and June 1978 the number of *Evadne* sp. was more than that of *Penilia* sp.

Copepoda : Copepoda constitutes the most predominant component of zooplankotn in Ennore estuary. Among the copepods, adult calanoids belonging to the genera *Acartia* and *Pseudodiaptomus* were noted during December 1976, 1977, July, August, November 1977 and January 1978. Herpecticoid copepods were poorly represented in the samples and found only during February and August 1977. Cyclopoid copepods were recorded during February, July and August 1977. In station I the major peaks were noted for copepodites during December 1976, February and August 1977 (fig. 9). In station II also during the same periods the peaks were noted. But in station III only one peak was noted during February 1977. Among three stations copepods were more in both station I and station II. In station I they were uniformly represented in less numbers during most of the periods except during the extremely low salinity values. On the whole only copepodites were the dominant representatives than the adult forms in the samples.

Mysids : More number of mysids were recorded during August 1977 and during the rest of the periods only few forms were recorded.

Adult decapods : *Lucifer* sp. was noted throughout the period of observation in the samples but was dominant during July 1977 and 1978.

Chaetognatha : During the period of present investigation the following species of chaetognaths namely *Sagitta bedoti* Beraneck, *Sagitta enflata* Grassi and *Sagitta pulchra* Doncaster were recorded and they were abundant during December 1976, November 1977, January, June, July and August 1978 with a maximum during July 1978. In all the three stations they were found in large numbers.

MEROPLANKTERS

Polychaete larvae : Polychaete larvae were poorly represented in

the collections and found only during December 1976, February, December 1977 and May 1978.

Decapod larvae : Decapod larvae represented in most of the plankton samples collected during the present investigation with maximum during August 1977 (fig. 8 A).

Molluscan larvae : Among the molluscan larvae more number of bivalve larvae were recorded than the gastropod larvae. Bivalve larvae were represented in the plankton samples during December 1976, February, August 1977, January and June 1978 with a maximum during August 1977.

Fish eggs : Fish eggs were seen throughout the period of observations with peaks during December 1976, June and December 1977 (fig. 10), Among the three stations fish eggs were found in large numbers in station II. During December 1976 in both station I and in station II more number of fish eggs werc noted. On the other hand during July and December 1977 they were noted in abundance at station II.

Fish larvae : Compared with the fisheggs, fish larvae were sparsely represented in the samples. Fish larvae were recorded during February, July, August, November 1977 and February, June and July 1978. Maximum number of fish larvae were recorded during February 1978.

FISHERIES

In Ennore estuary the fish landings were mainly represented by mullets and prawns. Among the mullets, *Mugil cephalus*, *M. cunnesius*, *M. macrolepis* and *M. tada* were found with *Mugil cephalus* as the dominant species in the catches. Also other groups of fishes like perches, clupeids and catfishes were seen in the catches but they are negligible in quantity. Further the following species of the gobioid fishes were collected by us from the Buckingham canal after the south lock by operating a drag net (kondu valai). *Acentogobius cannius* (C. & V.), *A. globiceps* (Hora), *A. viridipunctatus* (C. & V.), *ctenogobius criniger* (C. & V.), *Glossogobius biocellatus* (C. & V.), *G. giuris* (Ham.), *Oxyurichthys jaarmani* (Weber), *O. tentacularis* (C. & V.), *Boleopthalmus boddarti* (Pallas), *Periopthalmus variablis* Eggert, *Pseudapocryptes lanceolatus* (Bloch & Schn.).

In addition to fishes the following prawns were also noted in the dragnet collections. *Penaeus indicus* was noted more frequently with occasional representation of the following species namely *Penaeus monodon, P. semisulcatus, Metapenaeus monoceros* and *M. dobsoni.*

Oyster beds were exposed and seen above the water level near the third station during the low tides and the main species was *Crassostrea madrasensis* (Preston). The oyster shells are utilised for the preparation of lime and poultry feed. The other important molluscs represented are *Mytilus viridix* and *Meretrix casta.* Among the gears used for fishing the following are important namely stake net (suthu valai), shore seine (badivalai), dragnet (kondu valai), stake net (kattu valai) and castnet.

POLLUTION ASPECTS

The effect of disposal of effluents from the petrochemical complex on Ennore estuary were studied by Sreenivasan and Franklin (1975) The Madras Refiniries Ltd. discharge their treated effluents through the Buckingham canal and the Madras Fertlisers Ltd., through the Redhills surplus channel, both reaching Ennore estuary. It was found that the treated effluents had a nutritive effect and Ennore estuary does not seem to be affected by the effluents from the two factories.

Regarding flyash pollution on Ennore coastal waters Ramanathan and Rama Rao (1976) have stated that out of 100% of coal 30% becomes flyash when used as per the process devised at Ennore thermal station, Madras. The flyash is mixed with the sea water taken in, roughly in proportion of 1 : 10 and discharged into the sea. The studies on the movement of flash was investigated by the isotope division of Bhabha Atomic Research Centre, Trombay (Bombay) and it was found that flyash occupies approximately six KM2 along the Ennore coast. So far no detailed investigation on the flyash pollution in Ennore estuary was made.

DISCUSSION

Estuarine environment is recognised as a complex ecosystem with widely varying physico-chemical influences and characteristic biota. Among the important physico-chemical parameters, the depth in Ennore estusry is mainly influenced by the north-east and south west monsoon rains, tides and dredging. During the monsoon months, in all the three stations the depth was more due to freshwater influx. But at station I

General pattern of the occurrence and abundance of various zooplankton groups in Ennore estuary during different seasons.

GROUP	SEASONS		
Holoplankters	Premonsoon	Monsoon	Postmonsoon
1. Hydromedusae	XX	A	R
2. Siphonophores	R	A	X
3. Ctenophores	XX	A	AA
4. Polychaetus annelids	R	A	R
5. Cladocerans	R	A	XX
6. Copepods	X	XX	XX
7. Ostracods	R	A	X
8. Adult decapods	XX	R	X
9. Decapod larvae	X	R	X
10. Mysids	XX	R	X
11. Chaetognaths	XX	X	XX
12. Isopods	A	A	A
13. Amphipods	A	A	A
14. Fish eggs	XX	XX	XX
15. Fish larvae	X	R	X
Meroplankters			
16. Polychaete larvae	R	X	R
17. Oligochaete larvae	R	R	R
18. Gastrapod larvae	R	X	R
19. Lamellibranch larvae	XX	X	X

XX--Abundant, X—Common, R—Rare, AA—Apparently absent, A—Absent,

tides also influence the depth. On the other hand at station II normally the depth range was more consistent and the influence of other factors is comparatively less. At station III the depth is shallower than the other two stations and the depth is also influenced by the presence of south lock of Buckingham canal besides other factors.

The transparency values were very low during the monsoon months in Ennore estuary. This may mainly be due to the abundance of

organic detritus drained into the estuary from the surrounding areas. The dredging operations near the mouth of the estuary also influence the transparency to some extent at station I and it is evident from the low values (0.25—0.75 m.). As the depth at the station II is alwas more and less inffuenced by other external factors, the transparency values were also comparatively more than the other two stations. The transparency values were very low at station III because of shallow nature and the flow of water from the Buckingham canal. Normally high transparency values were noted during the calm weather when there is no wind action. In this estuary the transparency values are mainly influenced by the factors like monsoon rains, dredging operation, depth and wind action.

A wide fluctuation in annual water temperature of about 7°C was encountered in this estuary at the surface level and it is largely due to the changes in atmospheric temperature. The interesting factor at station I is the occurrence of higher water temperatures than air temparature indicating the sea water influence. Besides the normal factors, the pumping of used flyash mixed warm water into the coast of Ennore estuary might also have played a role in raising the water temperature at this station. The occurrence of maximum and minimum temperatures coincides with the seasonal changes such as monsoon and summer. Prior to dredging the temperature fluctuation was very high and extreme temperature was noted during the summer months because of the closure of the bar mouth (Evangeline and Subbiah, 1969). Where as, during the present study such extreme conditions were not noted in view of the dredging operations resulting in free flow of water into the estuary and vice versa.

The salinity values of the estuary were mainly influenced by the monsoon rains and dredging operations. Extremely low values are recorded only during the monsoon months and the values ranged between 22‰ and 24‰ during the other seasons. This estuary has only very few channels for freshwater inflow. Only at station IV, the salinity values were quite low indicating that it is one of the freshwater influenced station. In Koratalayar river beyond the estuary, at station V, the salinity values were similar to that of the estuary indicating that only estuarine water is extending into the river during most of the seasons except during the monsoon months. Koratalayar river is flooded with freshwater during the monsoon and during the other

seasons the river is dried up. The water extends normally only upto Edayanchavadi (V). In Vallurdam (station VI) most of the time the water was absent. Prior to dredging the maximum salinity value recorded in the estuary was 46.7‰ (Chacko and Rajagopal, 1962). Then evoporation was playing a prominant role in controlling the salinity values. After the initiation of dredging, the estuary is kept open throughout the year resulting in the absence of extreme salinity values. In nearby Pulicat lake extreme (57‰) salinity values were recorded (50.5‰ average) during the premonsoon months because of evoporation (Menon and Raman, 1977). All these facts indicate the prolonged period of salt water dominance in this estuary during major part of the year and the absence of extreme salinity values.

The seasonal changes in the Oxygen concentration indicate that the range of fluctuation is moderate. The trend of variation shows that the monsoon rains influence the dissolved oxygen and it is evident from the higher values noted during January, August, September, October, November and December. Among the three stations the values were comparatively more at station III indicating the running water influence. But in station IV the oxygen values were low. Sreenivasan and Franklin (1975) have stated that dissolved oxygen values in Ennore estuary were between 4.8 and 10.6mg/l. However during the period of observation the dissolved oxygen values in the estuary were in the range of 1.5 to 7.5 mg/l.

The pH values varied between 7.30 and 8.60 with fluctuations during the monsoon months. During monsoon months the values tend to be more neutral. During December 1978 in all the three stations low pH values were noted depicting the monsoon influence. The same phenomena have been recorded for the estuaries of Ramanathapuram district Tamil Nadu by Evangeline (1975). In these estuaries at Ramanathapuram district pH values were neutral during the monsoon months. Comparing the three stations in Ennore estuary, at station III the pH values were more as in the case of dissolved oxygen. In station IV the values were between 7.50 and 8.20.

An apprisal of the distribution of different groups of zooplankton reveals that the majority of them show an increase in abundance during the high salinity periods. After the monsoon a decline in number and biomass of different groups were recorded and during the period of

rapidly increasing salinity both the number and biomass of the plankton were increased. Thus of all the environmental factors that control the estuary, the most significant appears to be the salinity variation which exerts considerable influence on the fauna found in the estuary. Next to salinity, dissolved oxygen and transparency also play important roles in controlling the flluctuation and abundance of different planktonic organisms.

Several interesting features were observed during the investigation and one of the notable finding is the presence of medusae and *Pleurobrachia* sp. in large numbers during the premonsoon period (June, July and August). Both these organisms were totally absent in the samples collected during the other months. The occurrence of these organisms in Ennore estuary during the premonsoon period in large numbers coincides with the higher salinity and dissolved oxygen conditions. Among the three stations studied, these were found in abundance at the I station near the bar mouth. Similar to this at Cochin backwaters also Santhakumari and Vanucci (1971) have observed the presence of these organisms in more numbers near the mouth of the estuary during the premonsoon period (South West monsoon) when the salinity was at its peak. So in Ennore estuary, as in other estuaries a close relationship has been found between the abundance of medusae, *Pleurobrachia* and salinity. The low salinity conditions are not favourable for these organisms and this fact is evident from the complete absence of these organisms during the monsoon and post-monsoon periods.

The presence of siphonophores in the estuary during January and April 1978 shows that these organisms are also controlled by salinity. During these months the salinity was 22 to 25‰. While examining the siphonophores of the Cochin backwater, Rengarajan (1974) has observed that the influx of these organisms into the backwater was mainly during the high salinity conditions. Such low salinity conditions are not favourable for the siphonophores and this may be the reason for the absence of these organisms during several months in Ennore estuary.

Another interesting feature observed was the presence of cladocerans during the summer months of 1978. Throughout the period of twenty six months observations these organisms were noted only during the four months (April May, June and July) of 1978 when the salinity was between 22 to 24‰. As observed by Pillai and Pillai (1975) at

Cochin backwaters, the distribution pattern of cladocerans in Ennore estuary is that, the commencement of their swarming is as abrubt as their tapering off. Wickstead (1965) has opined for greater part of the year they will be absent. Then when the resting eggs hatch one or two will be caught. After this the number will increase rapidly. Within six months or so *Penilia* can range from being comletely absent to being present in numbers like $2500/m_3$. forming over fifty percent of the plankton in number. In Ennore estuary also during April, May and June 1978 the plankton samples were completely represented by only *Penilia* sp. and *Evadne* sp. Especially in April both were at their maximum numbers and responsible for the maximum plankton volume during 1978. Similar to our findings at Portonovo waters also the maximum number of *Penilia* sp. was recorded during April with the population lasting for three manths (Vijayalakshmi and Venugopalan, 1972). According to these authors the occurrence of *Penilia* sp. in maximum numbers at Portonovo waters coincided with the abundance of diatoms. But in Ennore, our collections do not have any diatom bloom along with the cladocerans. However, we have come across the diatoms in large numbers during November and December 1976. These two organisms of cladocerans are recorded for the first time in such abundance from the estuary.

Among the copepods collected from the estuary the copepodites dominated in the samples than the adult copepods. As pointed out earlier by Raghunathan (1980) among the adult copepods, calanoids of the genera *Acartia* and *Pseudodiaptomus* were seen in more number than cyclopoid and herpecticoids. The copepods have formed the important constituent of the plankton. For instance three peaks in the plankton volume were noted during the period of observation and of these three peaks, copepods were solely responsible for two peaks (during December 1976 and February 1977). During July 1977, large number of calanoids with egg sacs were observed. Among the three stations investigated more copepods were collected from the I station followed by II station. A coincidence of phytoplankton maxima and breeding of copepods has been noted earlier by Krishnaswamy (1950) and he has stated that the diatom outburst has resulted in the abundance of food and this may be responsible for the abundance of larvae in July, September, December and March along the Madras coast. Ramamurthy (1953) has also found the abundance of copepod nauplii during April, May, November and December coincided with the

abundance of diatoms in Madras coast. Further recently Raghunathan (1980) has noted the relationship in abundance between diatoms and copepods in Ennore estuary. The present investigation at Ennore also shows a clear positive relationship in the abundance between diatoms and copepodites. During December 1976, the diatom *Thallasiothrix* sp. was recorded in large numbers in the plankton along with large number of copepodites.

Chaetognaths were seen more or less in all the samples and found in abundance during July, August. The previous studies at Ennore by Srinivasan and Raghunathan (1978) have also shown that the chaetognaths were abundant during August. As observed earlier, the present study also confirms that among the available three species of *Sagitta* at Ennore estuary, *S. enflata* dominates followed by *S. bedoti* and *S. pulchra*. Among the three species of chaetognaths found in the present study at Ennore *S. enflata* and *S. bedoti* were seen in large numbers including a graded series of specimens belonging to various maturity stages. This study has confirmed the earlier findings that both *S. enflata* and *S. bedoti* are continuous breeders with two or three intensive broods in an year followed by normal broods. Specimens of fully matured forms of both the species were generally not found in the samples suggesting the possiblity of migration of these forms into the sea for spawning. Further the specimens of both the species of *Sagitta* are generally smaller in size compared to the specimens of the marine habitat. *S. enflata* of the coastal waters will be usually between 5 and 20 mm. or more in total length and *S. bedoti* will be between 7 and 13 mm. Whereas the specimens present in these collections measured between 3.6 and 9.2 mm. (*S. enflata*) and 3 and 5 mm. (*S. bedoti*). As pointed out by Kinne (1964) these are smaller in size because of the habitat in which they are living is controlled by a wide fluctuation of salinity conditions.

Another interesting observation noted during the present study was the presence of decapod larvae and bivalve larvae in abundance during December 1976, February, August 1977, January and June 1978 when the dissolved oxygen and salinity were more. During August 1977, the dissolved oxygen was high and these larvae were also seen in large numbers. During the other periods of the present investigation both these organisms were not seen in the collections.

The present study has also revealed the occurrence of fish eggs in large numbers during December 1976, December 1977 and July 1978 when the salinity was about 18‰. It is interesting to note that the eggs were abundant during the monsoon months and it is a known fact that the fishes generally spawn during the monsoon months. In Ennore estuary *Mugil cephalus* is the dominant fish and the breeding behaviour of this shows that the spawning season extends from September to February with a peak during October to December (Rangaswami, 1975). All these facts lead one to conclude the spawning of *M. cephalus* during October-December may be one of the possible reasons for the presence of eggs in abundance during December. The occurrence of fish eggs in large numbers at Ennore esruary during certain seasons clearly indicate that this is one of the important nursing ground for fishes.

Compared with the fish eggs, fish larvae were sparsely represented in the samples and they were abundant during the post-monsoon period (February, 1978). This study has also revealed the abundance of copepodities and fish larvae in large numbers during the same month. As it is a known fact that copepodites form the main food of fish larvae, the coincidence observed here between the copepodites and fish larvae suggests a probable food and feed relationship. Thus our investigations have shown that this is a complex fertile ecosystem, wherein several organisms live and silently interact with one another.

In view of the mechanical dredging, Ennore estuary is basically different from the other nearby estuaries like Pulicat, Adayar, Cooum and Kovelong. The dredging operations in the estuary help in the following factors such as the free mixing of waters and organisms between the sea and estuary, absence of extreme temperature values, absence of extreme salinity values and absence of foul smell. On the other hand the mechanical dredging operations also have some adverse effect like silt generation. From the recent investigations it is evident that transparency values are affected to some extent by the dredging operations. But exactly to what extent the dredging operations affect the transparency values as well as the other orgrnisms in this estuary requires further detailed investigations. While considering the management of coastal ecosystems, Menon and Raman (1977) have suggested that one of the ways of effective management is to keep open the mouth of the estuary by mechanical means. But in India, so far no

authentic studies have been made on the exact nature of the impact of these man made changes. It is a known fact that small habitat modifications result in drastic changes in the structure, stability and productivity of that habitat. Also, it is a fact that what may constitute a small habitat modification in one ecosystem may represent a substantial modification in another. These small modifications produce additional and potentially adverse stresses on those mechanisms which maintain the integrity and stability of the ecosystem. Hence, further investigations on these lines will reveal the exact nature of the impact felt in the Ennore estuary.

SUMMARY

Ennore estuary was investigated from 1976-1978 with special reference to hydrobiology and zooplankton contents. The estuary is characterised by very few channels of freshwater inflow and prolonged period of salt water domination. Among the zooplankton, copepods, decapod larvae, cladocerans, medusae and fish eggs constitute the main component. Majority of zooplankton show maximum occurance and abundance during the high salinity period. The fish landing were mainly represented by mullets and prawns. Several interesting findings like the presence of *Evadne* sp. and *Penilia* sp., occurrence of chaetognaths, medusae and fish eggs in abundance during a particular season have been noted down during the investigation.

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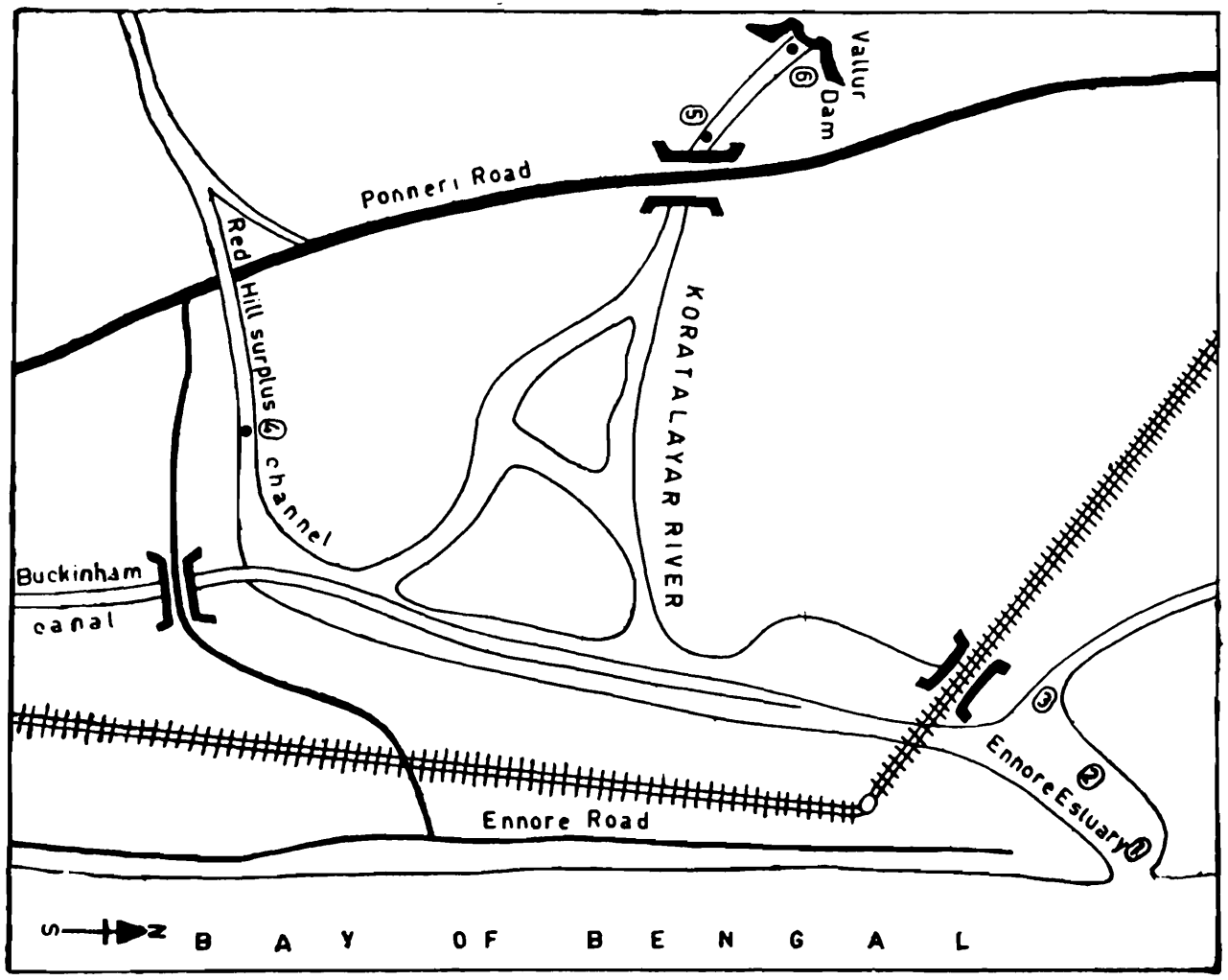


Fig. 1. Map of Ennore estuary, Koratalayar river and surplus channel, showing all the six stations.

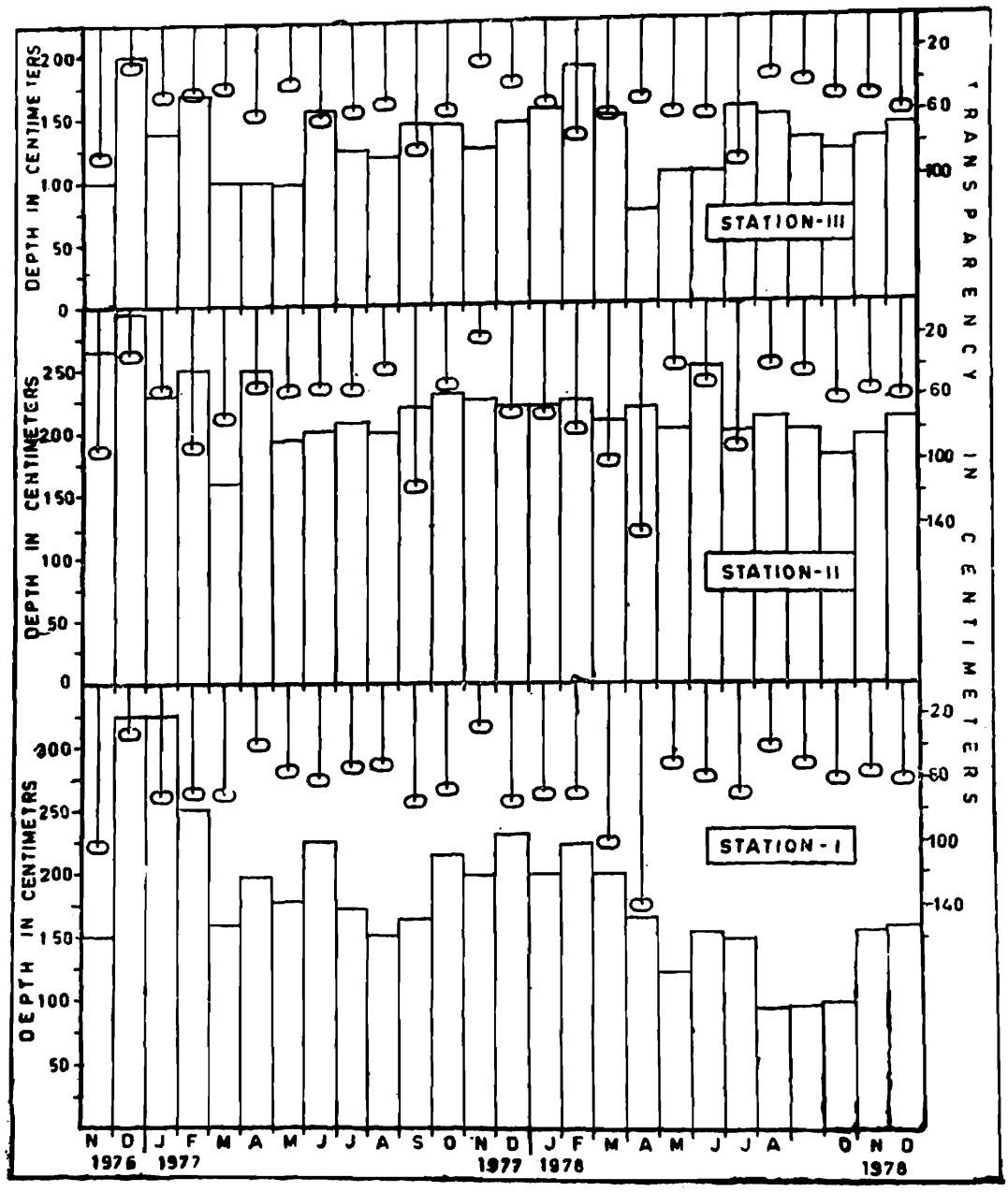


Fig. 2. Depth and transparencies at stations 1, 2 and 3.

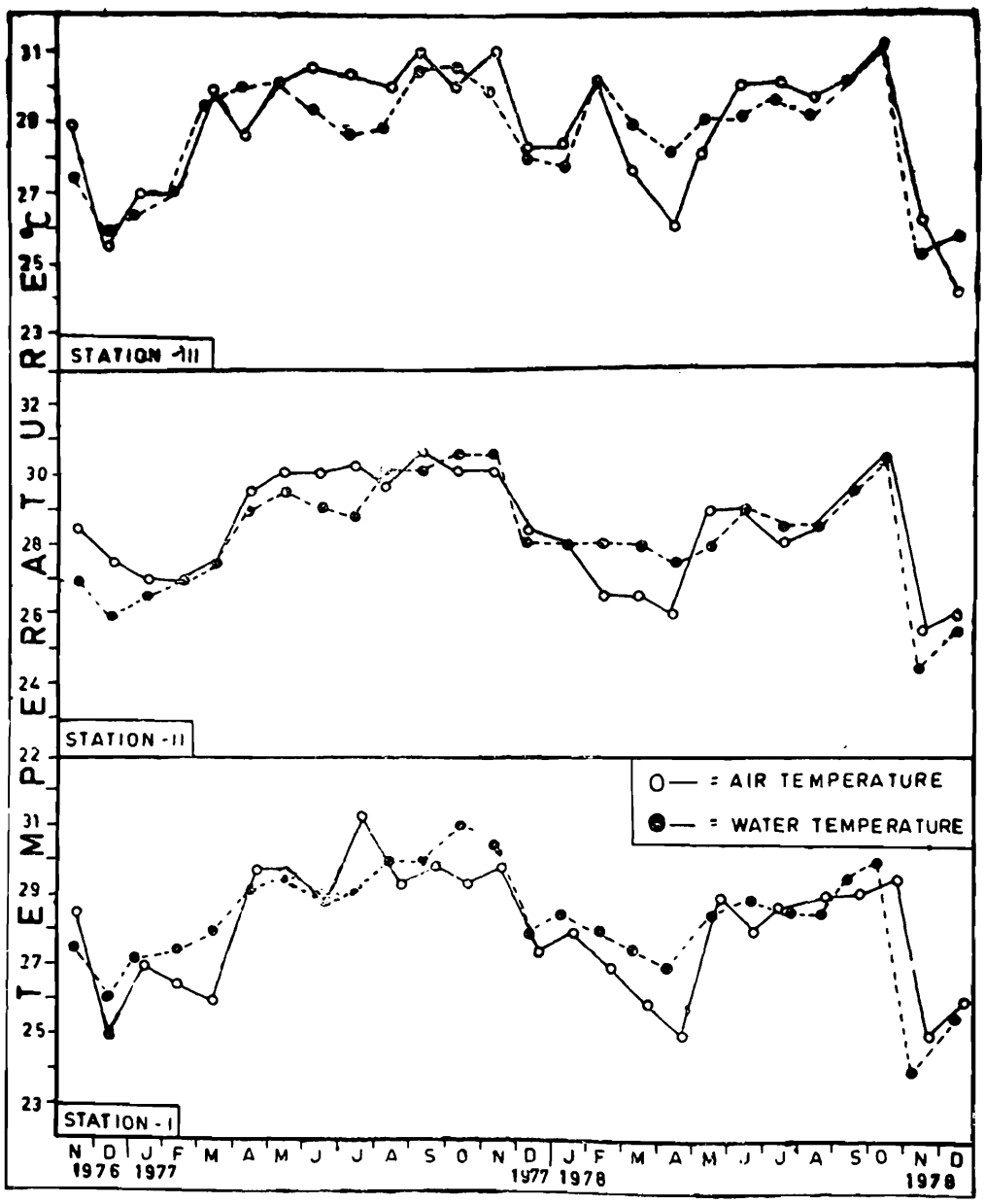


Fig. 3. Air and water temperature at stations 1, 2 and 3.

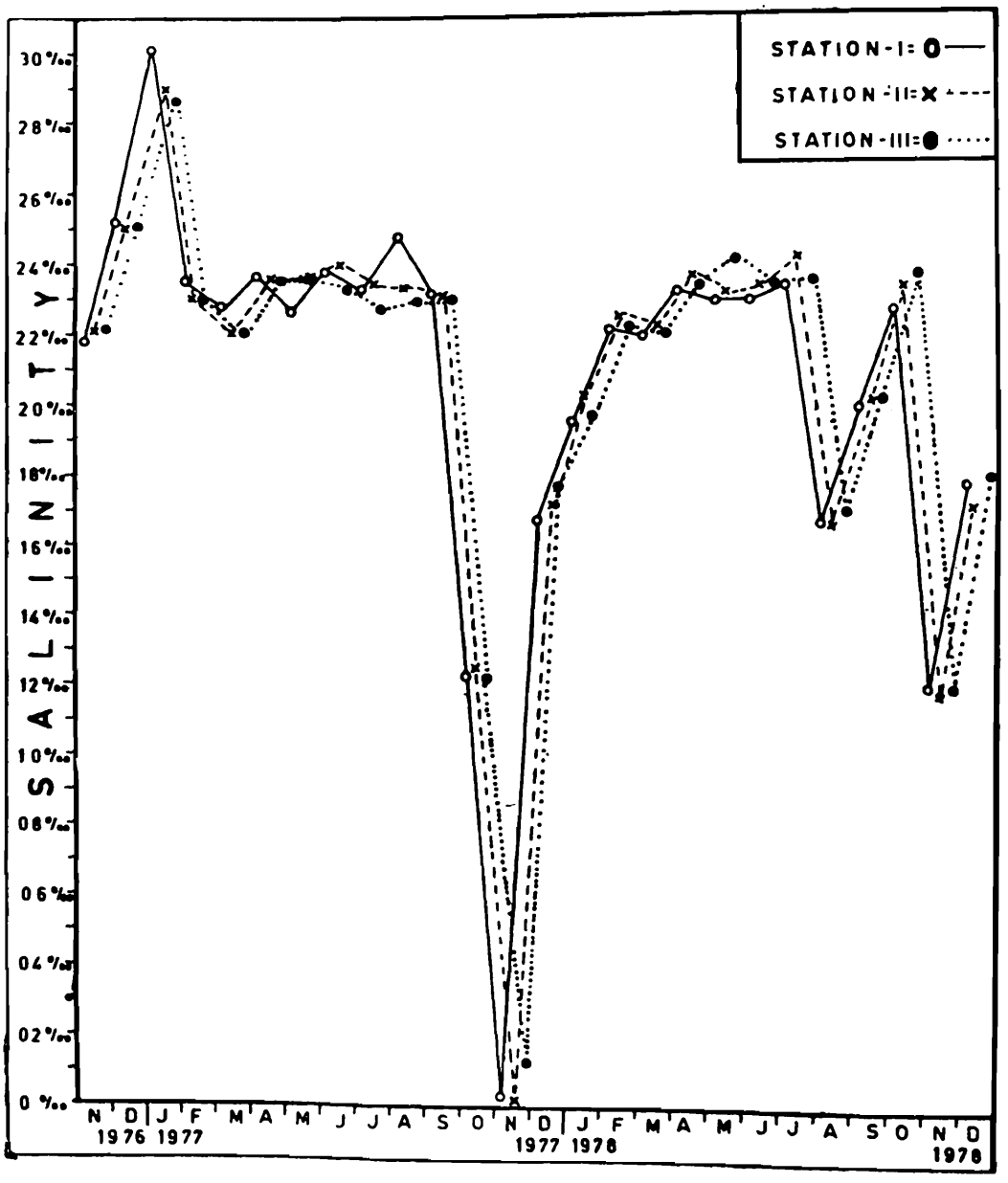


Fig. 4. Salinity at stations 1, 2 and 3.

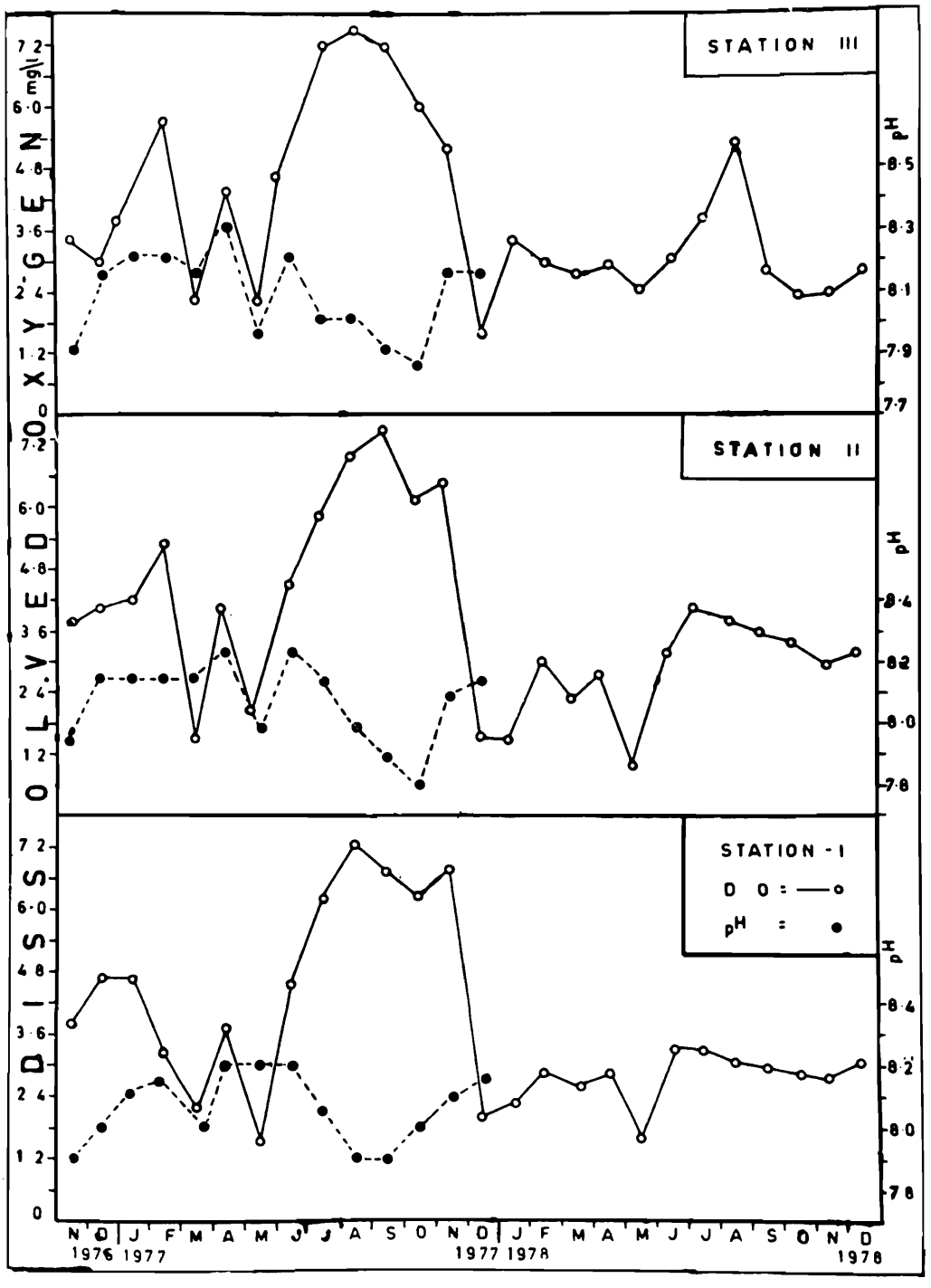


Fig. 5. Dissolved Oxygen and pH, at stations 1, 2 and 3.

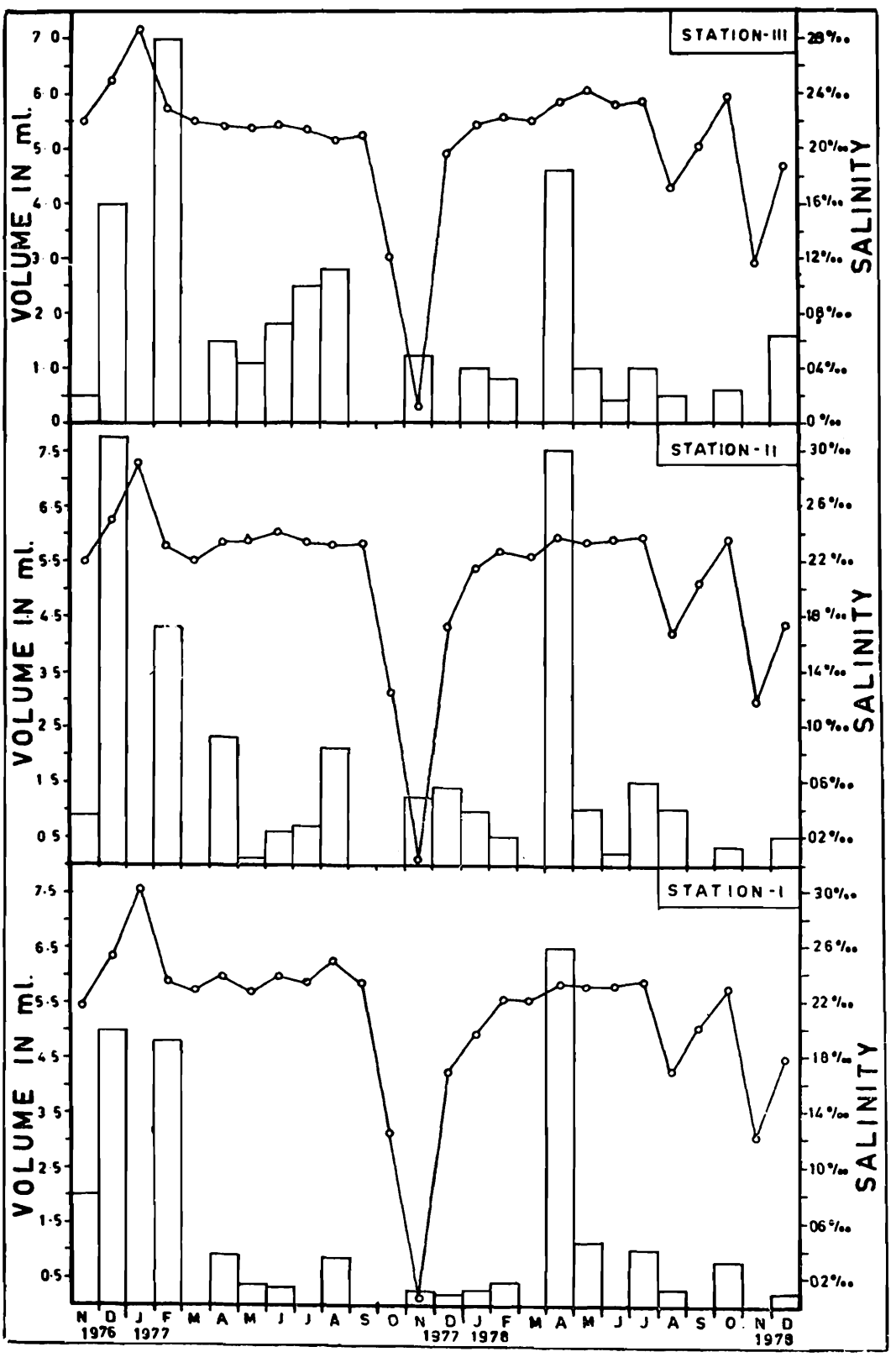


Fig. 6. Volume of zooplanktons and salinity at stations 1, 2 and 3 during November 1976 to December 1978.

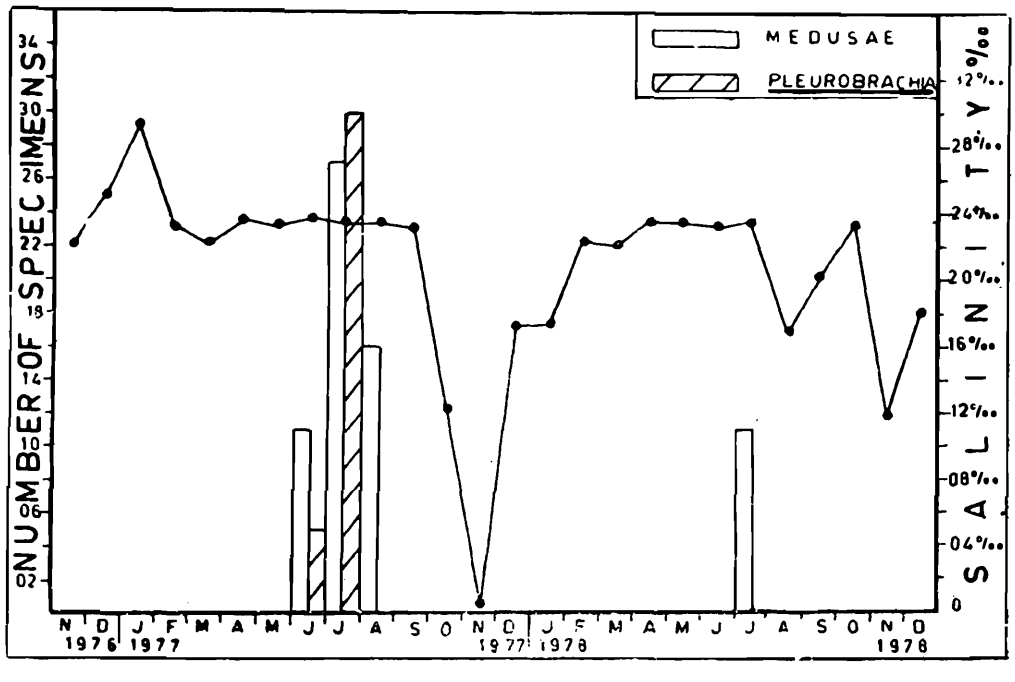


Fig. 7. Fluctuations of medusae and Ctenophores with salinity during November 1976 to December 1978.

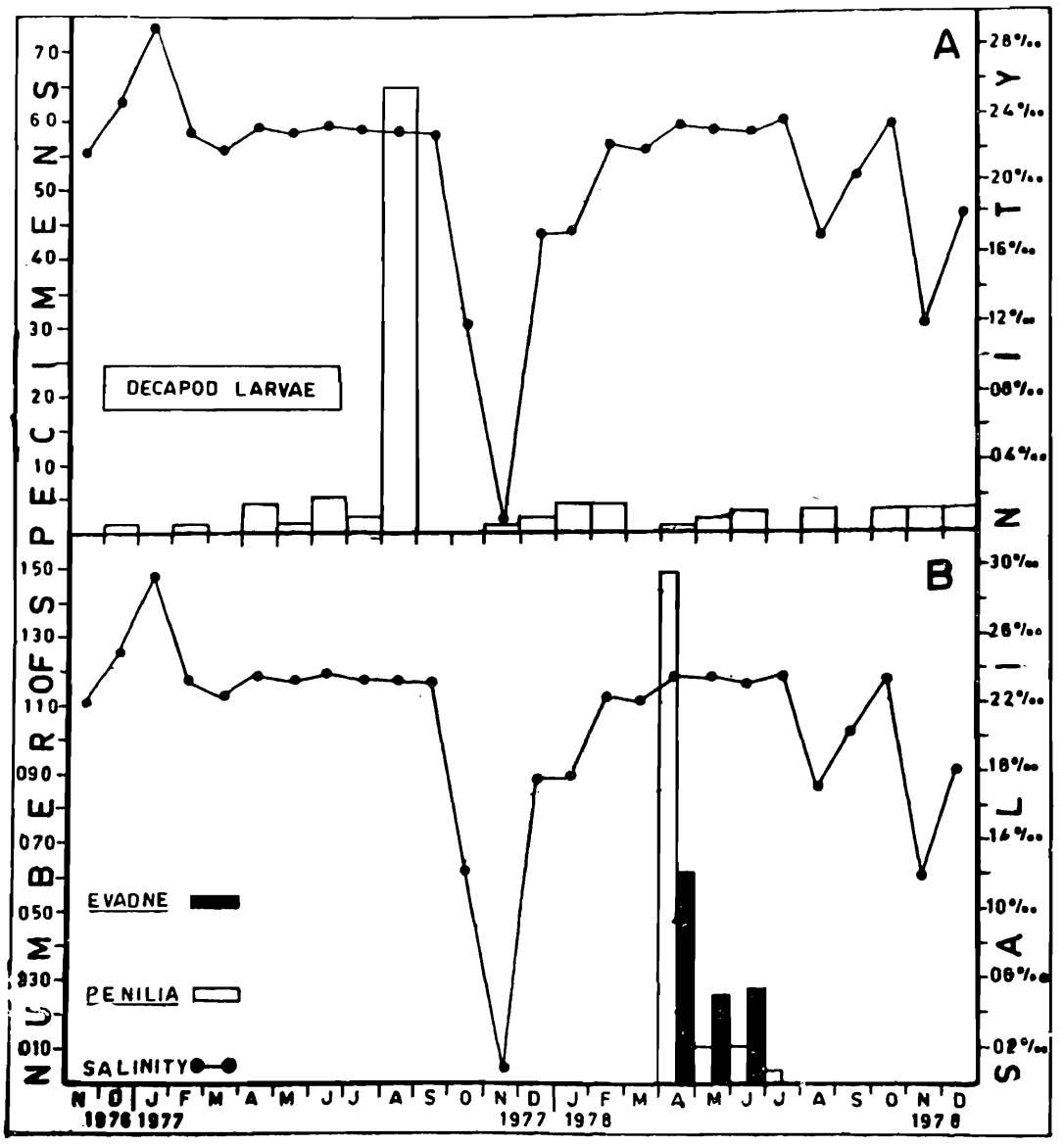


Fig. 8. A. Fluctuations of Decapod larvae in relation to salinity.
B. Fluctuation of *Penilia* sp. and *Evadne* sp. against the salinity.

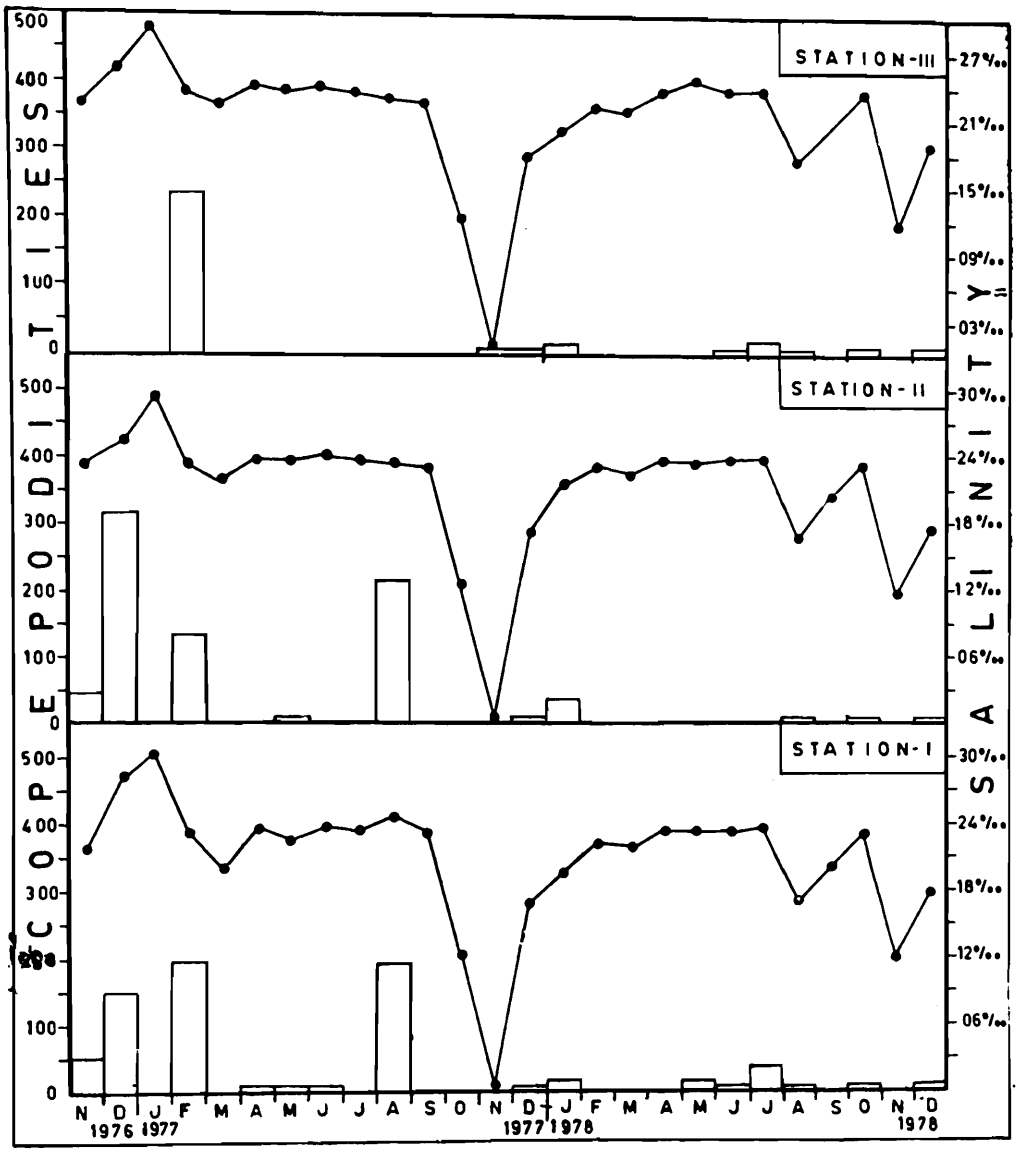


Fig. 9. Fluctuation of Copepodites and salinity at stations 1, 2 and 3 during November 1976 to December 1978.

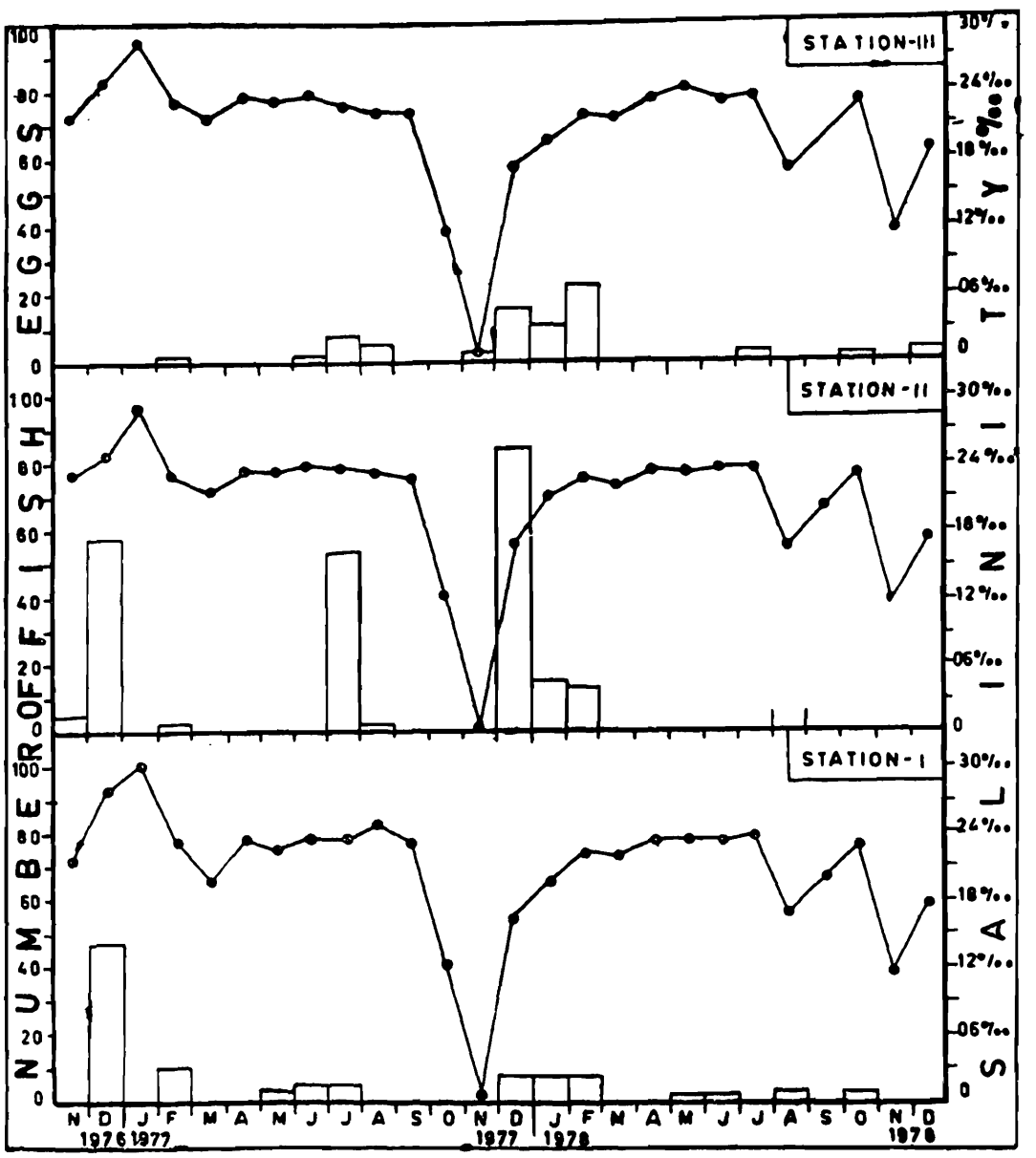
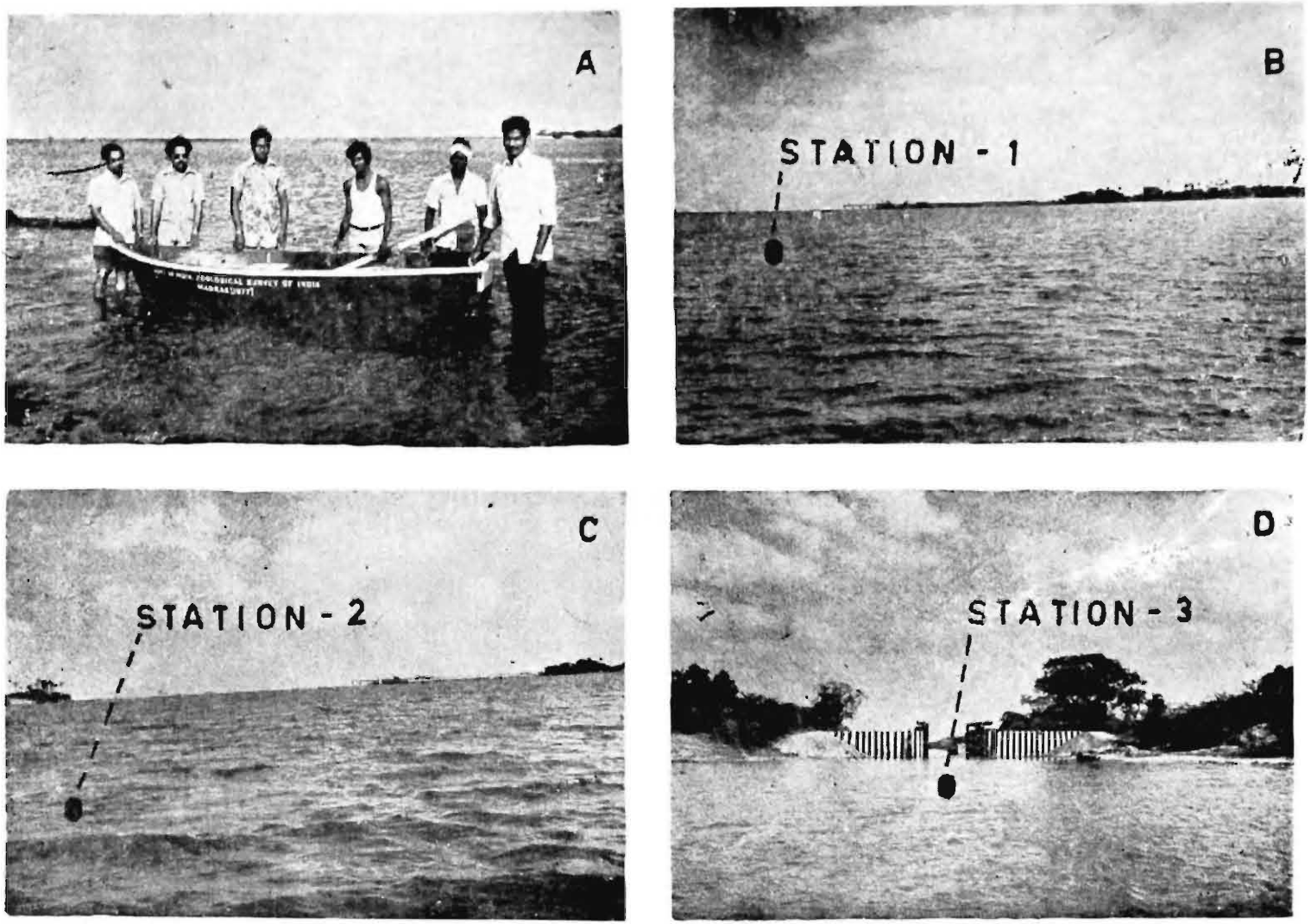


Fig. 10. Fluctuation of fish eggs and salinity at stations 1, 2 and 3.



A. Departmental boat with the members of the team. B. Ennore estuary showing the position of Station 1 ; C. Station 2 ; D. Station 3.