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HYDROBIOLOGICAL STUDIES IN THE COASTAL WATERS OF TUTICORIN, GULF OF MANNAR

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ABSTRACT

Hydrological and meteorological features in relation to the distribution of zooplankton of Tuticorin coast in the Gulf of Mannar are described. Seasonal variations in the surface temperature and salinity show similarity in general trends. A bimodal cycle in the distribution of these major factors was noticed. An increasing trend in the dissolved oxygen content was observed during postmonsoon months. The relation between pH and oxygen appeared to be inverse. The annual cycle of production of plankton in the region was found to be dicyclic. Copepods and chaetognaths reached their maximum when the salinity was low. Copepods and lucifer showed an inverse relationship when the latter dominated the plankton. Poor percentages of copepods and lucifer were noticed when molluscan larvae and fish eggs constituted high percentages. The bulk of the larval stock consisted with planktonic stages of decapods, lamellibranch, gastropod and fish. Maximum occurrence of larvae coincided with the rainfall. The seasonal variations and the inter-relationship of the planktonic organisms are discussed.

INTRODUCTION

IN COMPARISON with the considerable amount of knowledge available on the hydrology and planktonology of the southeast coast of India, practically little is known about the hydrobiological aspects off Tuticorin in the southern sector of the Gulf of Mannar. While relatively more information is available on the hydrography of the waters off Tuticorin (Chacko and Rajendran, 1959; Chacko and Malu Pillay, 1957; Malu Pillay, 1962) our knowledge of the plankton of this region is mostly confined to the preliminary account by Sambandamurthy (1962) The observations by Chidambaram *et al.* (1951) on the hydrobiological conditions of the pearl bank, Tholayiram Paar, off Tuticorin are based on a limited observation of samples taken over a very short duration of a month. Freda Chandrasekaran and Sudhakar (1968) had given a brief account on this aspect of study of this area. Thus, a scrutiny of the available literature indicates the paucity of bio-hydrographical studies of intensive nature, particularly for inshore waters of this region. There is an increasing need for accurate appraisal of the relative fertility of this area and the resultant seasonal variation in zooplankton stocks which directly or indirectly support pelagic populations. The work was carried out during 1973–74 and covered a stretch of 20 miles along the Tuticorin Coast.

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MATERIAL AND METHODS

The surface samples were collected at weekly intervals between 0600–0900 hours from fixed stations having a depth of 4–25 m (Fig. 1). The hydrological factors studied side by side with

plankton investigations are surface temperature, turbidity, salinity, dissolved oxygen and pH. The surface plankton was collected by towing a half metre ring diameter net of bolting silk No. 21 for ten minutes at a speed of one knot. The sample was immediately preserved in 5% formalin. The volume of plankton was measured by displacement method.

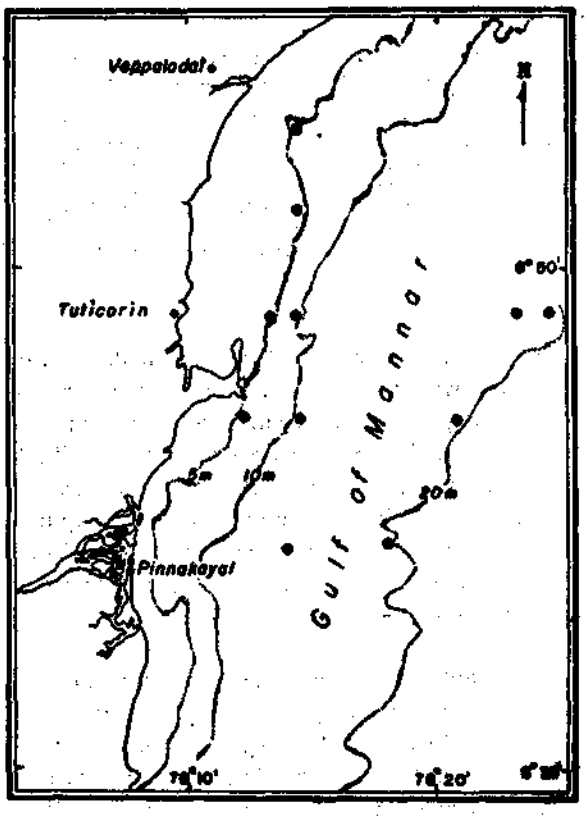

Fig. 1. Station positions in the area studied.

The entire sample was fractioned by means of a sub-sampler and the total number of organisms in one such sub-sample was counted and estimated for the whole sample. Fish eggs and fish larvae were counted numerically in the whole sample throughout the period of observation. The fluctuations in the plankton and physico-chemical conditions are discussed in terms of monthly averages. Data relating to the rainfall, were collected from the Meteorological Centre, Tuticorin Harbour Project.

Results and Analysis

Temperature

The atmospheric temperature was recorded regularly along with the surface water temperature. The monthly average values of these two are shown in Fig. 2 to indicate their relationship. The similarity in the curves reveal that the surface temperature is considerably influenced by the atmospheric temperature. This is in confirmity with the earlier findings of Chacko *et al.* (1954) and Prasad (1957). As pointed out by Prasad (1957) the observed decrease in the surface temperature during August may be due to the strong, south-west winds, resulting in rapid evaporation of the surface waters. It can be seen from the figure that atmospheric temperature was above the surface temperature continuously from April/May to September/October. The temperature of the surface water was well above the air temperature during November to March and this trend reveals a more or less close similarity to an earlier record made by Prasad (1957) in the Gulf of Mannar, in Mandapam area. Both the atmospheric temperature and sea temperature steadily increased from the winter low level upto April when it reached the peak. The temperature declined gradually thereafter till August, when the Southwest wind is active. A secondary rise in temperature was noticed in September and afterwards registered another fall during December-January when cooler weather prevailed. The general trend of temperatures exhibited a clear bimodal oscillation in the course of the year. Two maxima were noticed one in April and the other in September, corresponding to the two dry seasons and the two minima in August and January.

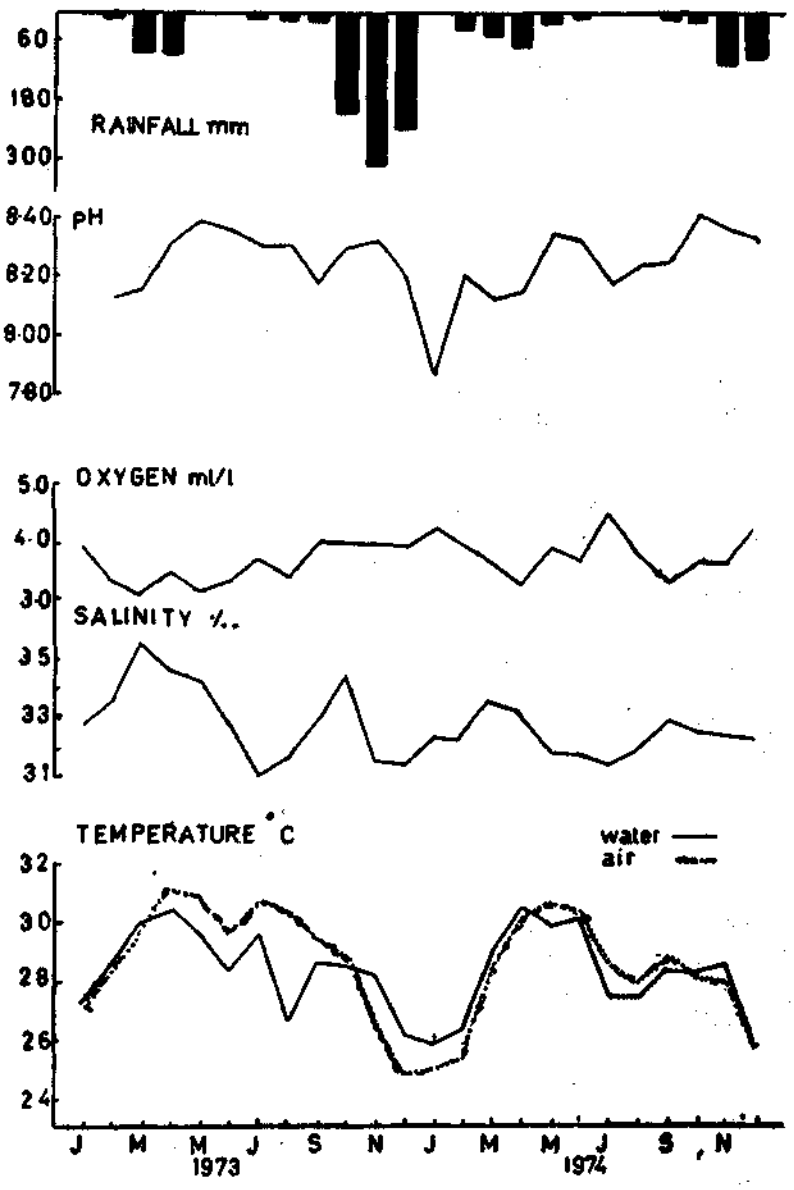

Fig. 2. Seasonal changes in hydrological parameters.

Salinity

The monthly average of salinity varied from 35.50‰ in March 1973 to 31‰ in July 1973. The surface salinity steadily increased from January to March. From the peak of March–April, the salinity declined considerably in the following months. The decline continued from May to July coinciding with the south-west monsoon. The salinity increased again

to a definite secondary peak in September/ October. With the onset of the rain bearing northeast monsoon, a marked change in the conditions was observed. For a second time the salinity declined abruptly to a minimum value in November and thus a period of low salinity with little difference in monthly average was noticed during November–January, due to the effect of rainfall. After the secondary fall, the salinity steadily increased until it fell again at the commencement of the Southwest monsoon season. Due to the failure of NE monsoon in 1974 the monthly average values of salinity was well above 32‰ during November–December.

A unimodal fluctuation in salinity, the peak being in October has been observed by previous workers (Jayaraman, 1954; Bapat, 1955; Chacko *et al.*, 1954) at the head of the Gulf of Mannar. The present observation clearly revealed a bimodal fluctuation in salinity with two maxima and two minima in the course of the year. Generally, the low and high values closely followed the trend of double oscillation of temperature.

Oxygen

The dissolved oxygen registered a fall generally during March–April. The highest and lowest values recorded during this study along the coast were 4.4 ml/l in July 1974 and 3.1 ml/l in March 1973 respectively.

pH

Similar to the temperature the variations in pH exhibited a bimodal variation. The two maxima were recorded during May and October corresponding to the pre-monsoon.

Zooplankton

The plankton of Tuticorin coast is rich in quantity and variety exhibiting regular seasonal variations. The morphometric features of the area as well as the dynamic factors like currents and monsoon winds have a definite bearing on the productivity of the region. The pattern of fluctuation and the general trend of occurrence of zooplankton exhibited a similarity in the years under review. A rise in the volume of plankton was noticed during January, April and August–September (Fig. 3). A reduction in volume of zooplankton was noticed in May. After this decline in the summer the volume steadily increased reaching a prominent maximum in September 1974.

The total volume of plankton was rather erratic during the latter half of 1974. The studies on the seasonal distribution of the various planktonic groups revealed a quick and marked change in the composition of the plankton with the onset of rains although the volume of plankton did not bear any direct relationship. The high standing crop during August/September was constituted largely by copepods and lucifer. The seasonal occurrence of the dominant forms did not appreciably change but the intensity has been observed to vary in the same groups.

The zooplankton consisted mainly of hydromedusae, scyphomedusae, siphonophores, chaetognaths, copepods, lucifer, planktonic decapods, lamellibranchs, gastropods and stomatopods besides fish eggs and larvae which occurred round the year in varying numbers. Among the common forms, copepods, lucifers, fish eggs and larvae particularly of decapods, molluscs and fish were the most dominant, occurring almost throughout the year. The seasonal variations of the common zooplankters which occurred in the plankton almost round the year are presented in Table 1. Several other groups such as foraminifers, siphonophores, chaetognaths and tunicates were sporadic in appearance and are categorised as 'other forms'. Foraminifers were noticed in the

samples for a brief period during January–March 1974. Siphonophores occurred in April and August–January and showed a well defined periodicity. Polychaetes and amphipods though negligible in proportions were noticed almost round the year. Chaetognaths dominated in the samples collected during May 1974. Their numbers varied to a great extent in the rest of the period. Among the species of chaetognaths *Sagitta enflata* appeared to be common in this area often noticed at intervals from May to September. According to Prasad (1954a) the species of *Sagitta* were taken in great numbers during February–March. Among the pteropods, the occurrence of *Creseis* sp. was more pronounced during October to December. It was also noticed in the samples collected during February–April but in poor numbers. They showed a distinct periodicity in their occurrence in the years 1973 and 1974. The most common tunicate that occurred in this zone was Appendicularians during October 1973–January 1974. *Salpa* sp. was present in June–August 1973 in small numbers but in the following year they were poorly represented in the collections. *Doliolum* sp. occurred only in September 1974 in negligible percentage. The two common ctenophores were the *Pleurobrachia* sp. and *Beroe* sp. but no distinct pattern of occurrence was noticed. Cladocerans appeared in varying numbers at different seasons of the year. *Evadne* sp. were noticed during July–August 1974 but swarmed during April 1974 only.

TABLE 1. *The percentage composition of important zooplankton in the coastal waters of Tuticorin during* 1973–74

Months	Copepods	Lucifers	Fish eggs	Chaetognaths	Siphonophores	Amphipods	Decapods	Lamellibranchs	Gastropods	Fish larvae	Stomatopods	Polychaetes	other forms
Jan. '73	42.5	25.9	2.4	2.8	0.5	0.5	7.1	5.2	3.4	4.8	0.0	0.0	4.9
Feb.	68.6	5.1	10.9	0.3	0.0	0.1	1.2	0.2	0.2	12.9	0.1	0.0	0.4
March	3.3	0.6	5.7	0.0	0.0	0.0	0.1	89.5	0.0	0.8	0.0	0.0	0.0
April	48.7	16.1	27.4	0.3	3.1	0.0	1.0	0.7	0.7	1.5	0.2	0.0	0.3
May	66.7	17.8	12.4	0.0	0.0	0.0	0.5	0.4	0.3	1.9	0.0	0.0	0.0
June	41.9	15.3	27.8	3.5	2.1	0.0	6.7	0.2	0.2	0.8	0.7	0.0	0.8
July	23.5	3.0	62.9	0.8	3.8	0.0	2.5	0.7	0.7	1.0	0.4	0.2	0.5
August	77.7	8.2	7.3	1.2	0.3	0.1	3.5	0.0	0.0	0.1	0.1	0.0	1.5
Sept.	73.1	14.7	4.2	3.2	0.3	0.0	2.0	0.0	0.3	0.1	0.1	0.0	2.0
Oct.	16.0	63.5	1.8	0.9	1.2	0.0	11.2	0.3	0.7	0.1	0.0	0.0	4.3
Nov.	3.9	0.9	0.4	0.1	0.1	0.1	1.5	0.1	91.8	0.1	0.0	0.0	1.0
Dec.	61.4	19.9	7.1	0.6	1.8	0.4	7.1	0.2	0.4	0.3	0.0	0.2	0.6
Jan. '74	54.2	30.0	1.3	0.1	0.2	0.3	6.3	1.1	0.7	3.8	0.0	0.1	1.9
Feb.	28.5	32.6	28.5	0.5	0.0	0.4	3.9	0.3	0.1	4.1	0.4	0.2	0.5
March	18.0	9.0	63.3	0.1	0.4	0.1	6.0	0.4	0.4	1.3	0.3	0.4	0.3
April	60.8	0.6	1.6	6.1	0.1	0.0	0.3	0.1	0.0	0.0	0.0	0.0	30.4
May	18.5	3.3	15.4	42.7	0.3	0.4	16.0	0.0	0.0	0.1	0.1	0.8	2.4
June	73.3	12.8	3.3	4.4	1.7	0.0	2.2	0.7	0.8	0.3	0.0	0.1	0.4
July	67.2	0.1	15.0	2.9	0.4	1.0	2.6	0.1	0.2	0.7	0.0	0.1	10.7
August	84.4	0.4	0.8	1.9	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.3	11.5
Sept.	32.6	55.7	0.2	2.2	0.1	0.0	2.7	0.2	5.2	0.0	0.0	0.1	0.5
Oct.	65.7	4.9	12.7	0.5	0.1	0.1	5.8	6.9	2.1	0.7	0.0	0.0	0.5
Nov.	55.3	20.8	10.5	0.1	0.0	0.0	6.0	3.9	2.2	0.8	0.0	0.0	0.4
Dec.	77.9	4.9	3.3	0.6	0.0	0.8	2.9	1.8	2.0	0.0	0.0	0.0	5.8

Copepods

The distribution pattern of most of the common zooplankton groups and their relative percentage composition in the total collection has been depicted in Fig. 3. Copepods rank first among the crustacean zooplankton and present throughout the year in the samples. Their number and species vary very widely.

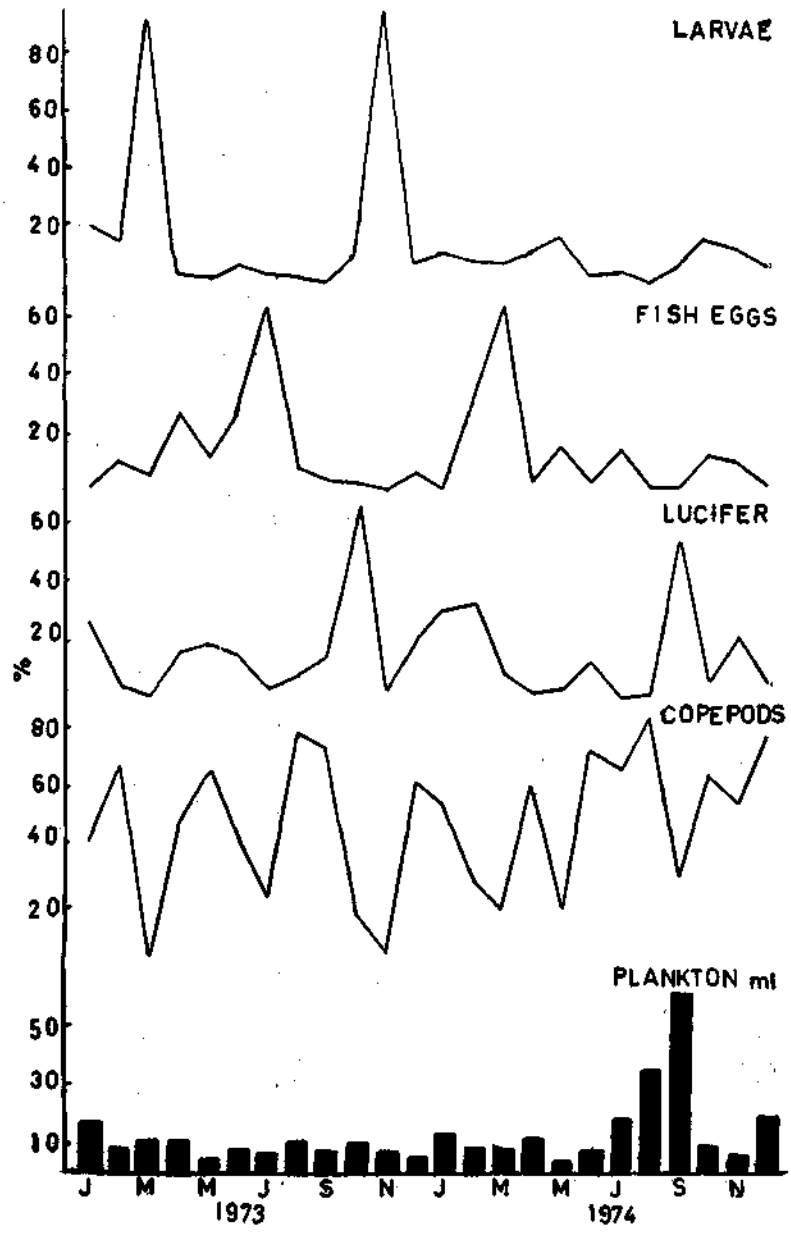

Fig. 3. Percentage composition of major zooplankters.

But the bulk of the population was constituted of calanoids. The common genera were the *Calanopia, Paracalanus, Eucalanus, Acrocalanus, Acartia, Labidocera, Centropages, Euterpina, Oithona, Corycaeus and Microsetella.* The distribution pattern of copepods in the year 1973 and 1974 revealed two distinct peaks. The trends were almost alike in August and

December. Besides this, relatively higher population of copepods was also observed during April 1974 and May 1973. This sudden increase was noticed after its lowest ebb in March. A second prominent fall in the quantity in copepods was observed during September–November.

Lucifer

Lucifers constituted an important adult planktonic decapod and encountered in varying percentages in a year. During the early part of the year they occurred in 25–30%. Their number dwindled considerably in March. Following this there was an increase upto June and a sharp fall in the next month, again followed by an increase to a maximum 52–62% in September or October. The inter-relationship of common zooplankters can be seen on the rare occurrence of copepods or lucifer coinciding with the enriched numbers of either molluscan larvae or fish eggs as seen in March, July and November.

Fish eggs

A higher concentration of fish eggs was observed in July 1973 but in the succeeding year the bulk was noticed in March itself, although a minor peak appeared in July 1974. From August onwards the eggs were relatively scarce except to a slight increase in their number during October–December. The general trend of distribution was not exactly identical in the two years. However, based on the presence of fish eggs of one kind or another, with slight variations the maximum spawning period may be marked as March–July.

Fish larvae

Definite peak seasons were plotted for the occurrence of larvae of a variety of marine animals. Prominent dicyclic pattern was noticed in 1973. A maximum number of larval forms was enumerated in March and November. In the later months of the year more or less the same trend was maintained, but the fluctuations further suggest variation from year to year and changes in intensity of population. The bulk of the larval population consisted of planktonic stages of decapods, lamellibranchs, gastropods and fish. An inverse relationship was exhibited between the occurrence of larval forms and other major zooplanktonic organisms.

The concentration of larval stock observed in March 1973 was entirely due to the occurrence of lamellibranch larvae in swarms. Similarly, gastropod larvae with 91.8% in the plankton during November 1973 accounted for the peak in the total larvae. The distribution was somewhat different in 1974. Decapod larvae mainly constituted the first peak of total larvae recorded in May 1974 while the secondary peak noticed in October 1974 was due to the presence of decapods and lamellibranch larvae in equal numbers. The percentage of lamellibranch larvae occurring in different months varied from nil in August 1973 to 89.5% in March 1973. Gastropod larvae were comparatively high during September–January. They fluctuated from 91.8% in November to 0.03% in April 1974.

The distribution and fluctuations of the dominant larvae which form the major constituents of the planktonic larval population were treated separately and their percentage occurrence in different months during 1973–74 is presented in Fig. 4.

Decapod was the most important single group of planktonic larvae. Decapod larvae especially zoeae of different groups, megalopae, cirripede nauplii and nauplii of copepods were found in varying numbers round the year, the lowest being 2.5% in March 1973 and the highest 96.0% in May 1974. The fluctuation was rather irregular during November to May.

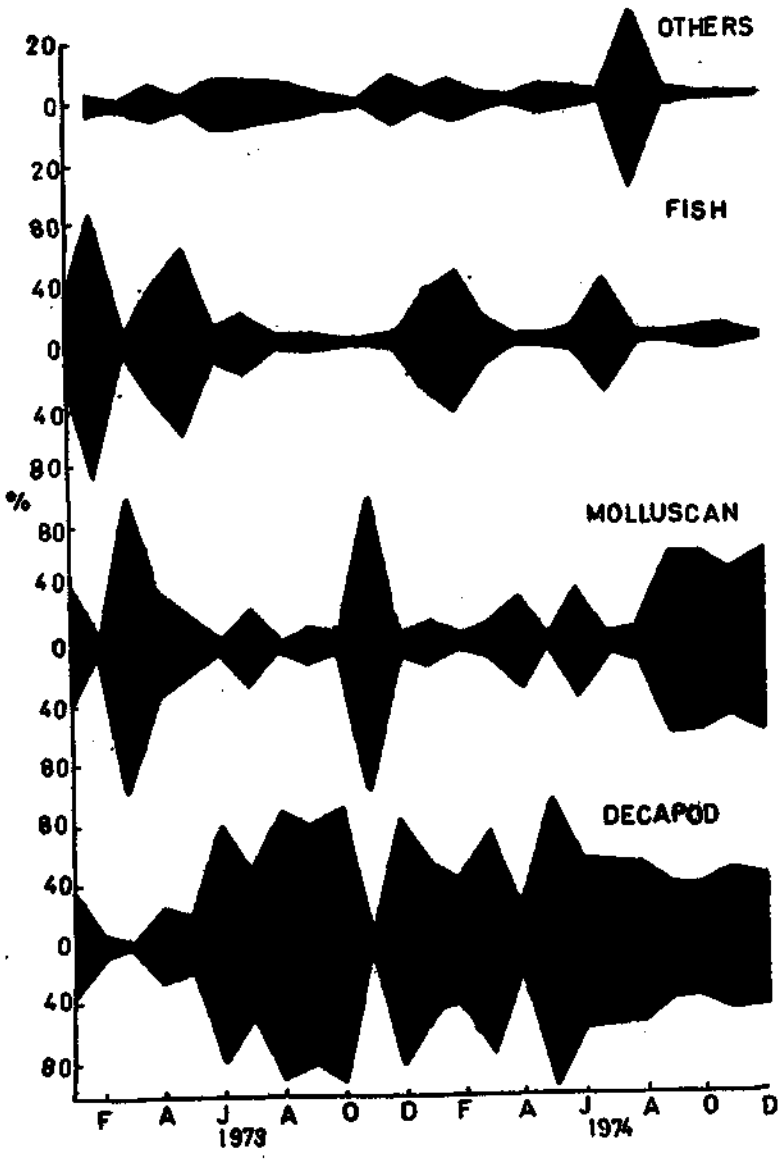

Fig. 4. Relative percentage of important larval stock.

Decapods remained high in the plankton from May or June to October without any abrupt changes except to a fall seen in July 1973. These larvae were extremely poor during March and November 1973. Significantly molluscan larvae were present in abundance in these corresponding months. An inverse relationship can be noticed with the poor percentage of molluscan larvae and high occurrence of decapod larvae as seen in most of the months. In 1973, two distinct peaks of molluscan larvae were seen in March and November. The pattern of distribution in the following year was altogether different. They were rich in June and again a concentration appeared from September to December.

Among larval forms the presence of fish larvae exhibited a marked periodicity. They were abundant in the plankton during the early part of the year as well as in July. The fish larvae were recorded in high numbers in 1973. During other seasons they were recorded in low percentages and on such intervals molluscan larvae dominated in the plankton. Larvae of minor groups such as nemerteans, stomatopods, brachiopods, echinoderms and polychaetes were pooled together for the purpose of computing their percentage. The monthly percentage composition of these 'other larvae' varied from 0 to 30.0 in the total larval composition with a propensity in August 1974.

Discussion

The surface temperature and salinity exhibited a clear double oscillation in the course of the year, the maxima corresponding to the two dry hot seasons and two minima during the periods of southwest and northeast monsoons. Prasad (1954a) has stated that the Gulf of Mannar is wide open at the southern end and is subjected to incursions of water masses from the Indian Ocean and Arabian Sea. As the south-west monsoon is negligible, the primary fall in salinity during June–August could be attributed to the effect of the coastal current from the southern part of Arabian Sea around the peninsula and flowing on the south-east coast to some extent. The course of this current off the Tinnevelly coast in the Gulf was made use of by the local fishermen in their fishing activity (Silas, 1962).

The retreat of the southwest monsoon, the changed pattern of temperature and the prevalence of highwinds as well as increased rate of evaporation, probably accounted for the increase in salinity to 34.41‰ in October. The secondary fall noticed in the salinity from November onwards may be associated with the onset of northeast monsoon and the current flowing from north to south as recorded by Sewell (1929).

The relation between salinity and oxygen has been observed to be inverse in most months. As Prasad (1958) stated, the dissolved oxygen in the surface waters of Gulf of Mannar is generally high and attributed to the greater existence of coral reefs in the shallow region along the coast. The relation between pH and oxygen appeared to be inverse.

The northeast monsoon which starts in late September was observed to exert influence on the environmental conditions of the coastal waters. Prasad (1956) observed an inverse relationship with salinity and copepods as well as zooplankton in general in Mandapam area. In the present observation it appears that the salinity may not be the only contributing factor for the concentration of copepods. Lucifers appear in plenty while the major environmental factors reach their maximum. Sudden drop in salinity coincided with the poor composition of lucifer and decapod larvae.

Bapat (1955) recorded a bimodal occurrence of fish eggs, the primary peak falling in March and the secondary in September or October associating with the low surface salinity–temperature period. The results of the present studies indicated a slight difference in the occurrence of secondary maxima. The occurrence of fish larvae showed two peaks in their distribution, the primary one falling in January–February and the secondary one in June or July. The salinity and temperature in the corresponding periods were low and suggested that these factors influence spawning.

Panikkar and Aiyar (1939) observed breeding restricted to two or more seasons of the year in relation to the rainfall. Based on the observations on larvae the breeding habits of the important groups are broadly classified into two (1) continuous breeding all the year round

but more active during a certain part, (2) discontinuous breeding, the larvae appearing at irregular intervals.

The hydrobiological studies of Tuticorin Coast show similarities as well as distinct differences when compared to the Mandapam area, the northern part of Gulf of Mannar.

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