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SEASONAL VARIATIONS IN PLANKTON OF THE NEARSHORE WATERS OFF MANGALORE

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ABSTRACT

The present study relates to the observations on the plankton at nine stations in three sections near Mangalore along the south Kanara Coast during the period February 1976 to January 1977. The monthly and seasonal variations in the wet weight and dry weight of phyto and zooplankton and of the important constituents of zooplankton have been dealt with.

Both phytoplankton and zooplankton increased in quantity at the end of the south-west monsoon recording maximum values during September. Nearshore stations recorded more phytoplankton and zooplankton when compared with the offshore stations. The general pattern of fluctuations of various groups of zooplankton revealed a first peak in September controlled by copepods, cladocerans, fish eggs and larvae and a second peak in April and May influenced by lucifers, chaetognaths and oikopleurans.

INTRODUCTION

THE IMPORTANCE of plankton studies in understanding the productivity of the seas needs no emphasis. The South Kanara Coast supports rich fisheries of mackerel and oilsardine which feed mainly on plankton. However, there is no systematic study of plankton of this stretch of the west coast of India except the work of Menon *et al.* (1976) which is confined to a smaller area near the effluent discharge point of Mangalore Chemicals and Fertilizers. The present study deals with the monthly and seasonal fluctuations in the standing crop of phyto and zooplankton and the main groups constituting the zooplankton along a portion of the South Kanara Coast near Mangalore.

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MATERIAL AND METHODS

The area under investigation was divided into three sections perpendicular to the coast, one off Mangalore and one each to the north and south of Mangalore (Fig. 1). These sections were chosen to coincide with the fishing grounds off Mangalore where there is intense fishing activity. Along each section, three stations were selected at 6, 12 and 20 m depths. Plankton samples were collected at monthly intervals from these stations during the cruises of the fishing vessels, 32 ft. M. V. NEPTUNUS and 43.5 ft. M. V. DOLPHIN of the College of Fisheries. The collections were spread over the period, February 1976 to January 1977 excepting

the months of June and July, when collections could not be made due to unfavourable weather conditions. The plankton samples were collected by the Heron-Tranter net whose mouth area was 0.25 m^2. Only vertical hauls were made at all the stations. The phytoplankton was collected with the net having mesh size of 60 μ and the zooplankton with the net having mesh size of 200 μ. The plankton samples were fixed in 5% sea water formalin.

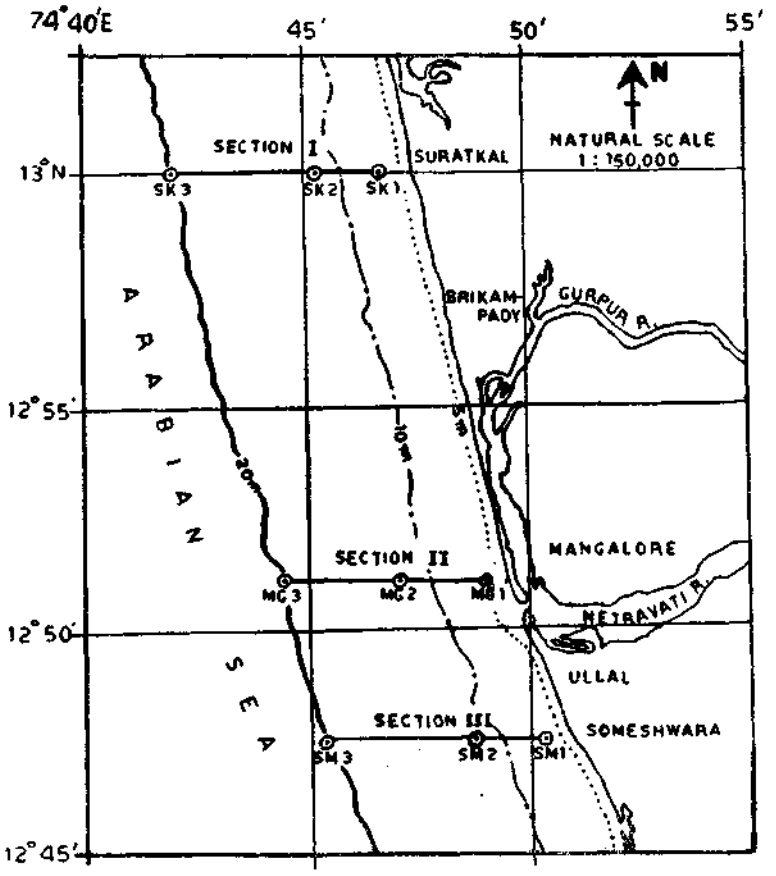

Fig. 1. Map showing the sections and station locations.

In the laboratory, each phytoplankton sample was split into two equal aliquots of 50% each by Folsom plankton splitter. One half was taken for quantitative analyses. The wet weight was determined by pressing the plankton sample between two filter papers to remove the superficial water and then weighed in an electrical balance (Metronex, type WA 31). The dry weight was determined after drying this sample in an oven at 60°C. The weights are expressed in mg/m^3. The zooplankton sample was spilt into two equal aliquots of 50% each, one of which was used for quantitative analyses as above and the other 50% was used for qualitative analysis. Larger organisms were sorted out from aliquot. After this the aliquot was made upto 100 ml from which 1 ml was utilized to record the number of smaller organisms. All numbers are represented as No/m^3.

PHYTOPLANKTON : QUANTITATIVE DISTRIBUTION

Wet weight

The wet weight of phytoplankton ranged from 0.31 mg/m³ to 46.17 mg/m³ in the area under investigation (Fig. 2).

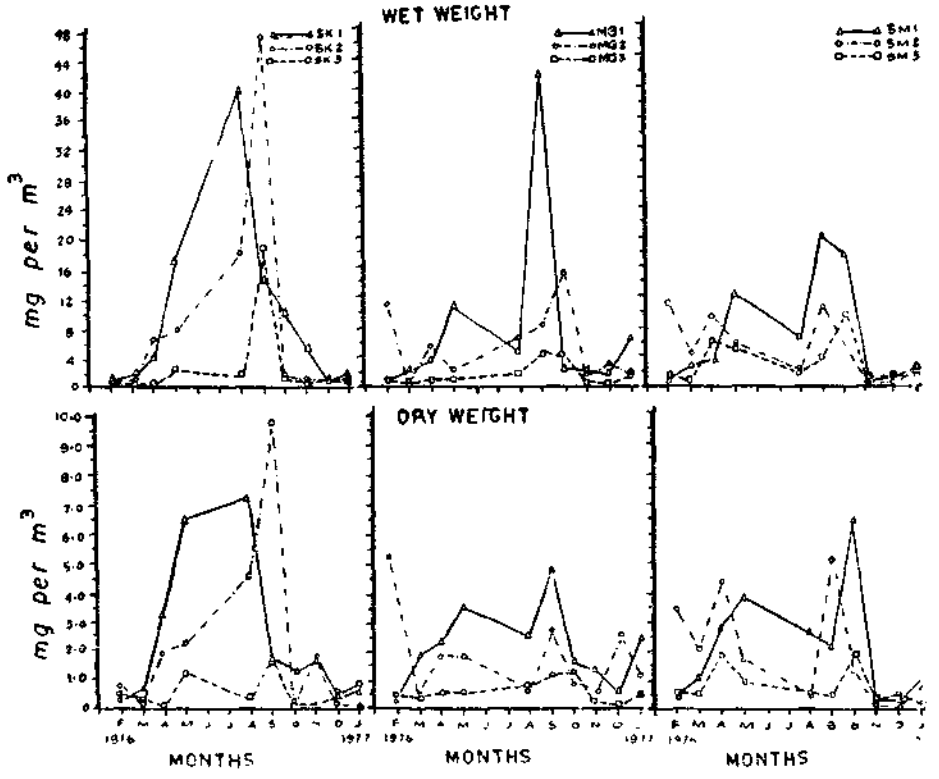

Fig. 2. Quantitative distribution of phytoplankton in the sections I, II and III.

In section I, the stations SK_2 and SK_3 recorded the peak in September, while station SK_1 had the peak in August. The lowest values were found in February, March and April for stations SK_1, SK_2 and SK_3 respectively. In section II, the major peak was found in September for stations MG_1 and MG_3, whereas it was in October for station MG_2. The lowest value was in February for station MG_1, in March for station MG_2 and in December for station MG_3. The major peak was found in September for station SM_1, and in October for station SM_3 in section III. For station SM_2, eventhough the value was high in September, the maximum value was in February. Lower values were recorded in November for the three stations.

Dry weight

Dry weight values of phytoplankton followed the same trend as that of wet weight (Fig. 2). The dry weight ranged from 0.13 to 9.74 mg/m³. From an analysis of variance of phytoplankton dry weight (mg/m³), it was found that at 5%

level of significance, there was no significant difference between sections while there was significant difference between stations and months (Table 1).

TABLE 1. *Analysis of variance table-phytoplankton (dry weight)*

Source of variation	Df	Sum of squares	Mean sum of squares	'F' ratio
Between sections	2	1.599	0.799	0.884
Between months	9	47.602	5.289	5.849*
Between stations	2	81.887	40.943	45.281*
Error	76	68.719	0.9042	
Total	89	199.808		

*Significant at 5% level

ZOOPLANKTON : QUANTITATIVE DISTRIBUTION

Wet Weight

The wet weight of zooplankton in the year ranged from 12.80 to 1731.70 mg/m³ (Fig. 3). In section I, the major peak was found in September at stations SK_2 and SK_3 although station SK_1 showed this in August. The wet weight gradually decreased after September. The minimum values were obtained during March,

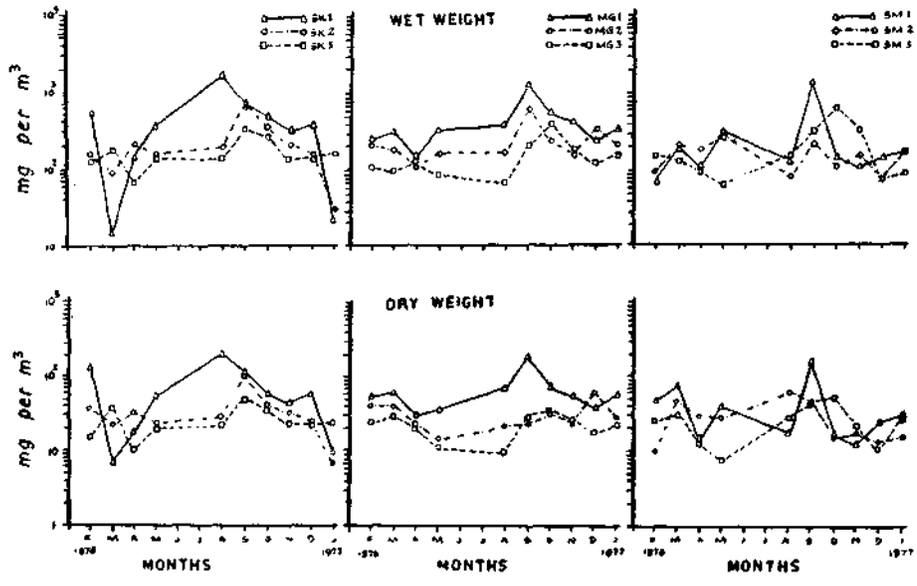

Fig. 3. Quantitative distribution of zooplankton in the sections I, II and III.

April and January for stations SK_1, SK_3 and SK_2 respectively. In section II, stations MG_1 and MG_2 recorded maximum values in September, whereas station MG_3 had highest value in October. The lowest values were found in April for

stations MG_1 and MG_2 and in August for station MG_3. The major peak was in September for station SM_1, in May for station SM_2 and during October for station SM_3 in section III. The lowest values were found in February, December and May for stations SM_1, SM_2 and SM_3 respectively.

Dry weight

The trend in the dry weight variation was very similar to that of wet weight (Fig. 3). Analysis of variance of zooplankton dry weight revealed that there was no significant difference between sections (Table 2). However, there was significant difference between months and stations.

TABLE 2. *Analysis of variance table-zooplankton (dry weight)*

Source of variation	Df	Sum of squares	Mean sum of squares	'F' ratio
Between sections	2	1840.965	920.483	1.959
Between months	9	29224.743	3247.194	6.910*
Between stations	2	41177.075	20588.538	43.809*
Error	76	35717.096	469.962	
Total	89	107959.879		

*Significant at 5% level

QUALITATIVE DISTRIBUTION

Larval copepods

This formed the major bulk of the zooplankton collection. Although this component was found in abundance during August, the peak varied from section to section. The number of larval copepods was more in the nearshore stations than in the deeper stations (Fig. 4). In section I, stations SK_1 and SK_2 registered the major peak in August while the station SK_3 showed this in September. Lower values were found in October, March and February at stations SK_1, SK_2 and SK_3 respectively. Section II depicted a different picture. Station MG_1 had a peak in November while stations MG_2 attained a peak in March and station MG_3 in May. October registered lowest values for the three stations of this section. In section III, the peak for station SM_1 occurred in September, while at station SM_2 it was in April and at station SM_3 it occurred in October. The minimum values for these three stations were recorded in February.

Copepods

This group formed the major constituent of the zooplankton throughout the year. Only during February, the number of copepods was found to be less in general. The nearshore stations had higher number of copepods than the deep water ones. In section I, stations SK_1 and SK_3 registered the peak in August and stations SK_2 in November. Lowest values for stations SK_1 and SK_2 were recorded in March, while for station SK_3 it was in February (Fig. 4). In section II, the major peak was in November at station MG_1, while it was during October at stations MG_2 and in August at station MG_3. All the three stations registered

lesser number of this group during February. For stations in section III, the maximum was in October at stations SM_1, while the maximum occurred during September at station SM_2 and in August at station SM_3. February registered lowest values for these three stations.

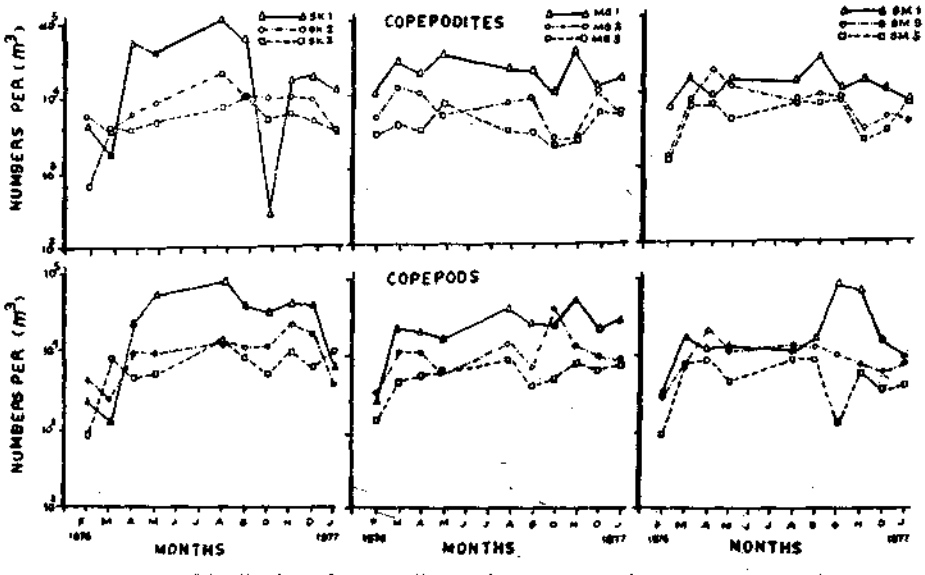

Fig. 4. Distribution of copepodites and copepods in the sections I, II and III.

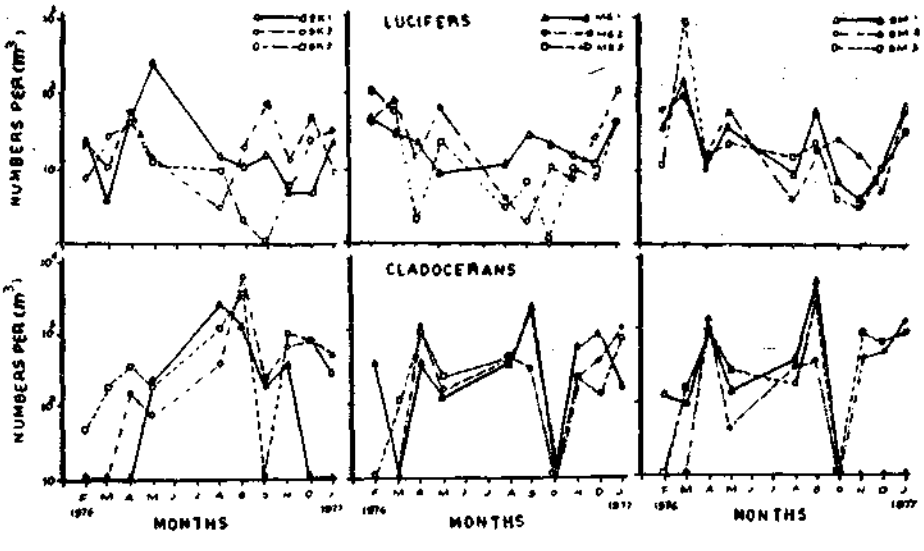

Fig. 5. Distribution of lucifers and cladocerans in the sections I, II and III.

Cladocerans

This group was also an important component of the zooplankton. In general, they were found in deeper stations almost throughout the year except in February

and October. Cladocerans dominated the plankton during September. In section I, station SK_1 registered the peak in August followed by stations SK_2 and SK_3 in September (Fig. 5). Cladocerans were totally absent at stations SK_1 during February, March, April, December and January (1977). Only this section showed the presence of cladocerans in October. At station SK_2, cladocerans were absent in February and March, while at station SK_3 cladocerans were present throughout the year except in October. Both stations MG_1 and MG_3 registered peaks of cladocerans during September while station MG_2 recorded the peak during April in section II. This group was absent in March and October at station MG_1, while at station MG_2 this was absent from February to March and in October. The cladocerans were absent at station MG_3 during February and October. In section III, the peak occurrence of cladocerans was evident during September at stations SM_1, SM_3 and in April at station SM_2. Station SM_1 showed complete absence of cladocerans from October to January, while station SM_2 showed complete absence in February, March and October. At station SM_3 this group was not present only during February and October.

Lucifers

This group was recorded throughout the year in the area under study. On a few occasions, very low numbers were encountered. Contrary to what has been observed in the case of copepods, this group flourished in good quantities at the offshore stations. The peak of abundance was registered in May for station SK_1, in October for station SK_2 and in April for station SK_3 in section I (Fig. 5). March, August and October recorded lowest numbers of Lucifers at stations SK_1, SK_2 and SK_3 respectively. In section II, major peak was observed either in January or February for the three stations. Minimum number was recorded in May, September and October for stations MG_1, MG_2 and MG_3 respectively. March registered the peak at all the three stations in section III. The lowest number occurred during August for stations SM_2 and in November for stations SM_1 and SM_3.

Chaetognaths

A distinct and clear bimodal abundance of chaetognaths was found to occur in general. In section I, two major peaks were evidenced one in May and the other in October at all the stations (Fig. 6). Chaetognaths were not present at stations SK_1 and SK_2 during February whereas at station SK_3, the lowest number was present in this month. Depicting similarity in distribution, section II also followed section I in general abundance. No chaetognaths were recorded at station MG_1 during February while the other two stations had less number of this group in this month. Maximum quantity was recorded during December at station SM_1 and in October at stations SM_2 and SM_3 in section III. Chaetognaths were absent at station SM_1 during February and least at stations SM_2 and SM_3 during September.

Oikopleurans

In numercial abundance, this group was next to copepods. August recorded peak for station SK_1, while October was the month of abundance for station SK_2 and April for station SK_3 in section I (Fig. 6). This group was absent during February and March for all the stations in this section except at station SK_3 during March. In section II, at station MG_2 peak was observed in October, whereas stations MG_2 and MG_3 recorded the peak in the month of April. Oikopleurans

were completely absent during February and March in this section. All the stations in section III recorded the major peak in April. This group was absent at all the stations in this section during February and at stations SM_1 and SM_2 during March.

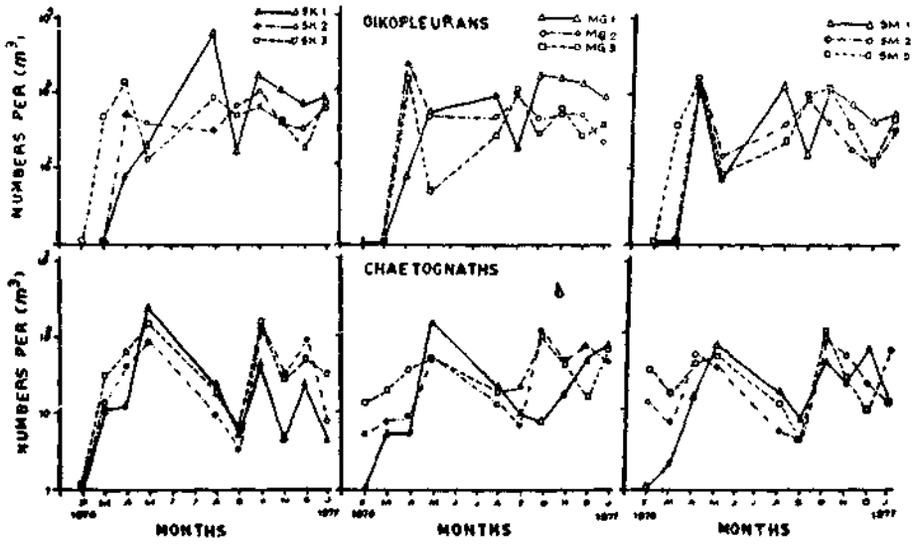

Fig. 6. Distribution of oikopleurans and chaetognaths sections I, II and III.

Fish eggs

In section I, station SK_1 recorded the maximum number of fish eggs in January, station SK_2 depicted the peak in October and station SK_3 recorded highest in August (Fig. 7). Station SK_1 failed to reveal fish eggs during March, while station SK_2 in March and September and station SK_3 in April, November and December did not show any fish eggs. Appearing in good numbers during March and August at station MG_1 and in August at station MG_3, fish eggs were completely absent during April and October at all stations in section II. The maximum number of fish eggs were recorded in November at station SM_1, in August at station SM_2 and during December at station SM_3 in section III. During the month of March, April and May fish eggs were totally absent at station SM_1 whereas only during November station SM_3 failed to reveal this fraction in zooplankton. Station SM_2 recorded this group throughout the year.

Fish larvae

In section I, while the peak occurrence of fish larvae was observed during October at station SK_1, this happened during August at stations SK_2 and SK_3 (Fig. 7). This group was absent at stations SK_1 and SK_2 in March. November and December did not register fish larvae at stations SK_3. The nearshore stations MG_1 and MG_2 in section II showed increased quantity of fish larvae during March and January respectively, while station MG_3 depicted the peak in August. Complete absence of fish larvae was found during April and October in this section. August was the period of peak occurrence for stations SM_2 and SM_3, while the incidence of fish

larvae in good numbers occurred during March at station SM_1 in section III. In general May, August and November to January registered total absence of fish larvae at station SM_1. However, such a distribution did not occur at stations SM_2 and SM_3.

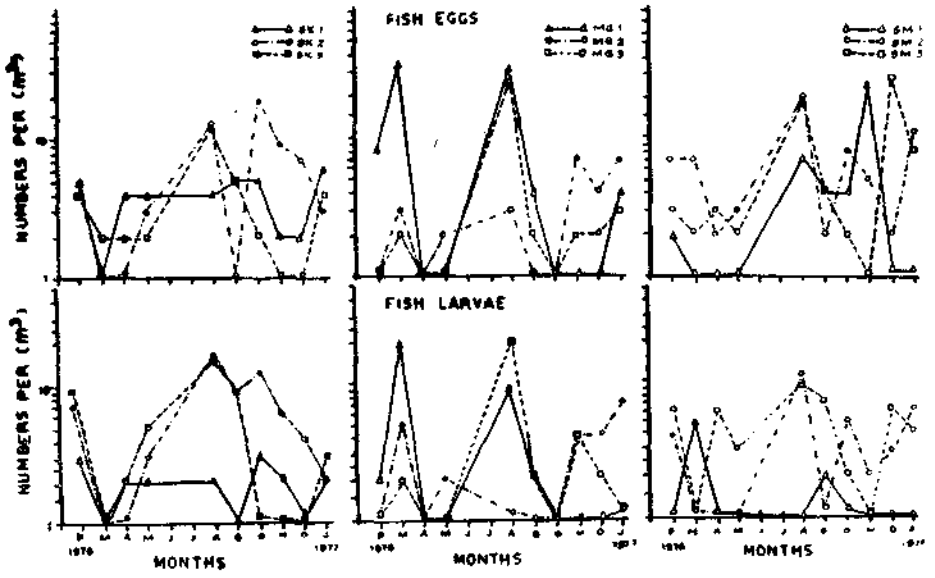

Fig. 7. *Distribution of fish eggs and larvae in the sections I, II and III.*

Discussion

The quantitative distribution of phytoplankton in general depicts a bimodal oscillation with a primary peak in September and a secondary peak in April to May. The minimum phytoplankton was recorded in November falling in the post monsoon period. Strikingly enough, the phytoplankton peak succeeded the nutrients peak which occurred in August (Suresh and Reddy, MS). Perhaps the changes that take place in the hydrological characteristics of the coastal waters *viz.*, lowering of temperature and enrichment of the plant nutrients appear to be responsible for the peak production of phytoplankton in September. Enlightening on the primary production of the Indian Ocean, Krey (1973) categorized the northern Arabian Sea as a highly productive section due to upwelling caused during the south-west monsoon. Aruga (1973) also supported this idea. Along the west coast of India, George (1953) found that the plankton peak was during the south-west monsoon period, while Subrahmanyan (1959 a) observed phytoplankton maxima in June to July and a minimum during November. A certain amount of spatial difference in phytoplankton distribution was discernable in the present investigation.

Ramamurthy (1965) discussing the abundance of zooplankton along the north Kanara Coast, remarked that the months of April to November represent periods of zooplankton abundance. He observed that this abundance may be due to the effects of upwelling. Mukundan's findings (1967) based on observations extended over a period of nine years clearly indicate that yearly and seasonal variations could occur in the zooplankton standing crop. The zooplankton increases in quantity

and attains the peak during September coinciding with the phytoplankton peak in the present study. The general pattern of fluctuations showed the following trend: The first peak in September was controlled by copepods, cladocerans, fish eggs and larvae and the second peak in April to May was influenced by lucifers, cheatognaths and oikopleurans.

Kasturirangan *et al.* (1973) divided the Indian Ocean based on number of copepods present in the plankton, collected from one standard haul, into four zones of relative abundance. According to them, south west coast of India occupies second largest rank in distribution. The presence of developing stages of copepods throughout the year in the nearshore waters off Mangalore supports the assumption of Prasad (1954) that reproduction is continuous in this group. Cladocerans are known to be an important component of zooplankton of coastal waters during late monsoon and post monsoon months. However, at some instances this group was found to be present throughout the year although the peaks were found to occur during the above periods. Pillai (1968) working on the plankton of Bombay Coast observed that the high standing crop of this group results during October to November period. The present findings are nearly in conformity with these results.

Nair and Rao (1973) studied extensively the distribution of chaetognaths. These authors observed a distinct peak during the southwest monsoon period although they remarked that even during the northeast monsoon, the coast of India is rich in most of the chaetognath species. The present findings clearly show that the postmonsoon months and the month of May had large number of chaetognaths. Referring to the appendicularians of the Indian Ocean, Fenaux (1973) discussed in length on the distribution of a few species of *Oikopleurans*. This group was present off Mangalore throughout the year except in February and also to a considerable extent in March. However, Menon *et al.* (1976) did not record this during April and September. For the north Kanara Coast, Ramamurthy (1965) delineated the months of September to November as the period of abundance of this group. Fish eggs and larvae, although present throughout the year, were found in good numbers from August to November in the nearshore waters of Mangalore. Nellen (1973) suggested that similarities occur in the quality of fish larvae appearing at different places along the west coast of India.

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