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PRIMARY PRODUCTIVITY AND PLANKTON ABUNDANCE ALONG THE SHELF AND OCEANIC WATERS OFF SOUTHEAST COAST OF INDIA DURING AUGUST, 1987

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ABSTRACT

The study is based on the hydrobiological data collected on board FORV *Sagar Sampada* from the shelf and oceanic waters of Bay of Bengal between Lat. 10° - 14° N and Long. 80° - 83° E in August, 1987. Mean values of chlorophyll 'a', 'b', 'c' and plant carotenoid pigments in surface water were estimated as 2.180, 0.184, 1.616 and 1.651 mg/m³ in the shelf and 0.333, 0.088, 0.406 and 0.297 mg/m³ for the oceanic region respectively while primary productivity experiments (by oxygen method) showed mean values of 146 and 92 mg C/m³/day respectively in the upper euphotic zone.

Phytoplankton blooms and zooplankton swarms observed in the shallow shelf region between $10^{\circ}30'$ and $11^{\circ}30'N$ and along the continental shelf edge and adjacent oceanic waters between $12^{\circ}30'$ and $13^{\circ}30'N$ are reported. Wet volume of plankton biomass (soon after preservation) was found to vary from 0.88-10.6 cc/m³ of water in the shelf and 0.18-1.77 cc/m³ in the oceanic region with their mean volume estimated as 3.14 and 0.48 cc/m³ in the respective regions. The concentration of total suspended matter (dry weight) in the surface layer varied from 1.90-7.91 mg/l. Contribution of plankton biomass to total suspended matter, their distribution pattern and factors relating to their abundance are discussed.

INTRODUCTION

Fertility of the sea is determined by its bioproductivity. Phytoplankton, being the basic food in the marine food-chain, followed by zooplankton play a vital role of significance to our food resources from the sea. Hence, investigation on the distribution and abundance of plankton is necessary to assess the potential fishery resources. James *et al.* (1983) have briefed out the important works on the production and distribution of phytoplankton and zooplankton of the west and east coasts of India in relation to fisheries. Apart from the investigations made during the International Indian Ocean Expedition (IIOE), the information available on phytoplankton and zooplankton productivity of the east coast of India is very much limited, especially from the oceanic waters. The present paper is based on the hydrobiological data collected on board FORV *Sagar Sampada* during cruise 34 along the shelf and oceanic waters of the southeast coast of India in Bay of Bengal during August, 1987.

MATERIAL AND METHODS

The study is based on the collection and analysis of hydrographic and plankton samples,

primary productivity experiments, quantitative estimation of phytoplankton pigments and total suspended matter and the observations made at 9 stations from the shelf and 23 from the oceanic waters, commencing from stations 1124 to 1155 (Fig. 1) between Lat. 10° - 14° N and Long. 80° - 83° E, during 19-28 August, 1987.

Phytoplankton pigments were determined by the method given by Strickland and Parsons (1968) using Perkin-Elmer UV/VIS Spectrophotometer. Primary productivity experiments were conducted at all stations by oxygen (light & dark bottle) technique with uniform artificial light incubation for three hours; and the productivity values thus obtained were extrapolated for 12 hours of the day.

Salinity and dissolved oxygen were estimated for the water samples by the standard titration methods. Wet volume of plankton biomass, collected by Bongo-60 net in oblique hauls, were quantified in cc/m³ of water, soon after preservation in 5% formalin. Quantitative estimation of total suspended matter in dry weight was made for the surface water samples and expressed in mg/l of water.

OBSERVATIONS AND RESULTS

Chlorophyll 'a'

Concentration of chlorophyll 'a' in surface water varied from 0.734 to 6.305 mg/m³ in the shelf and 0.035 to 3.201 mg/m³ in the oceanic region with their mean values as 2.180 and 0.333 mg/m³ respectively. The stations at which maximum values recorded were 1125 in the shelf and 1151 in the oceanic waters (Fig.1) by the blooming of *Trichodesmium erythraeum* and *Rhizosolenia* sp. respectively. A very prominent low productive zone (<0.100 mg/m³) was observed in the oceanic realm between 11° and 12°N adjacent to the continental shelf edge (Fig. 2). Other least productive stations were 1128, 1129, 1130 and 1143. In general, the shelf region south of 12° N (south zone) and oceanic region north of 12° latitude (north zone) appeared to be fertile in chlorophyll 'a' pigment.

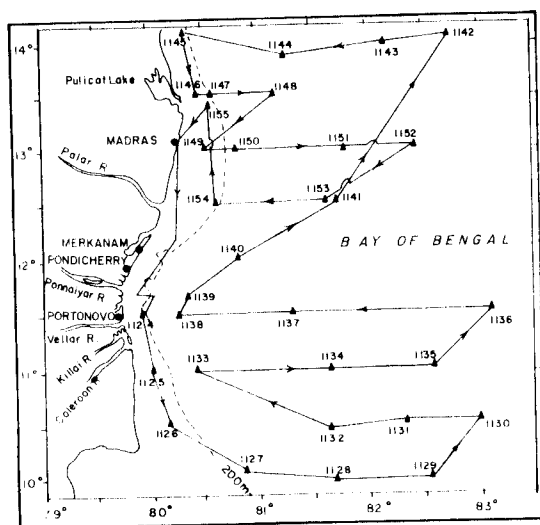


Fig. 1. Map showing station position and cruise route.

Chlorophyll 'b'

Its concentration varied from nil to 0.857 mg/m³ in the shelf and from nil to 0.610 mg/m³ in the oceanic region with their mean values as 0.184 and 0.088 mg/m³ respectively. Maximum values were recorded at stations 1126 in the shelf and 1127 along the slope region in the south zone. In the north zone, higher values of 0.406 and 0.460 mg/m³ were recorded in the oceanic region at stations 1153 & 1154 respectively. Other than these, all stations in the shelf and oceanic regions had 'b' pigments less than 0.150 mg/m³ only (Fig. 3). In general, higher concentration of chlorophyll 'b' was found distributed in areas little south of blooming zones of

Trichodesmium and *Rhizosolenia* (Figs. 2 & 3), indicating watermass of different characteristics from the blooming zone.

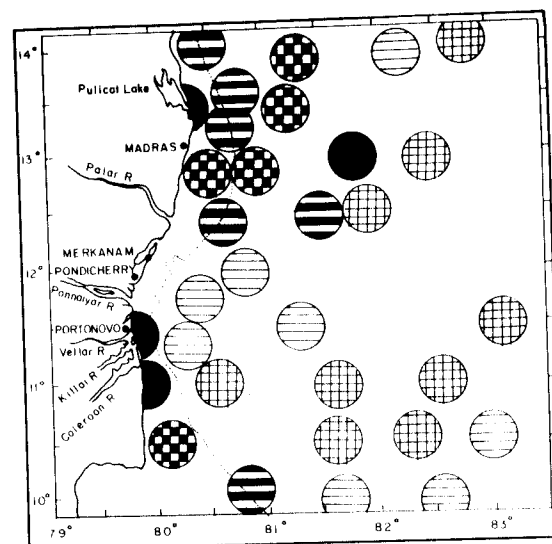


Fig. 2. Chl. 'a' (mg/m³)

| | |
|--|--------------------------|
| | 0.250-1.000 (mean 0.705) |
| | < 0.100 (mean 0.050) |
| | 1.000-3.000 (mean 1.457) |
| | 0.100-0.250 (mean 0.140) |
| | > 3.000 (mean 4.366) |

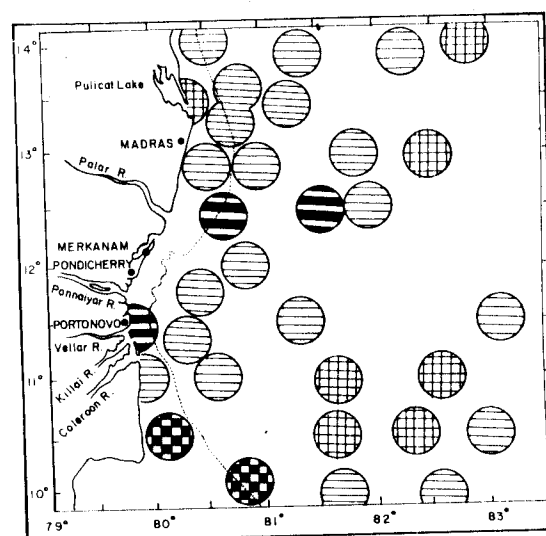
Fig. 2. Distribution of chlorophyll 'a' pigment (mg/m³).

Fig. 3. Chl. 'b' (mg/m³)

| | | | |
|--|--------------------------|--|--------------------------|
| | < 0.050 (mean 0.016) | | 0.100-0.500 (mean 0.333) |
| | 0.050-0.100 (mean 0.077) | | 0.500-1.000 (mean 0.733) |

Fig. 3. Distribution of chlorophyll 'b' pigment (mg/m³).

Chlorophyll 'c'

The distribution pattern of chlorophyll 'c' pigment was found almost similar to that of chlorophyll 'a' except in the level of concentration (Figs. 2 & 4). The values ranged from 0.271 to 3.231 mg/m^3 in the shelf and trace to 1.989 mg/m^3 in the oceanic waters with their mean values as 1.616 and 0.406 mg/m^3 respectively. The stations at which maximum values ($>3.000 \text{ mg}/\text{m}^3$) recorded were 1125 & 1126 in the shelf and at 1151 in the oceanic region. As in the case of chlorophyll 'a', a well demarcated low productive area of chlorophyll 'c' was observed in the same oceanic region between 11° and 12°N (Figs. 2 & 4). The surface water along the continental shelf and slope south of 12° latitude (south zone) was found to be highly fertile with values ranging between 1.921 and 3.231 mg/m^3 with an average of 2.732 mg/m^3 , while along the northern shelf zone (north of 12° latitude), the values ranged from 0.271-2.454 with an average of 0.922 mg/m^3 only. The south and north zones of oceanic region recorded mean values of 0.292 and 0.616 mg/m^3 respectively.

Total chlorophylls

Combined data of chlorophyll 'a', 'b' and 'c' pigments showed the distribution pattern almost

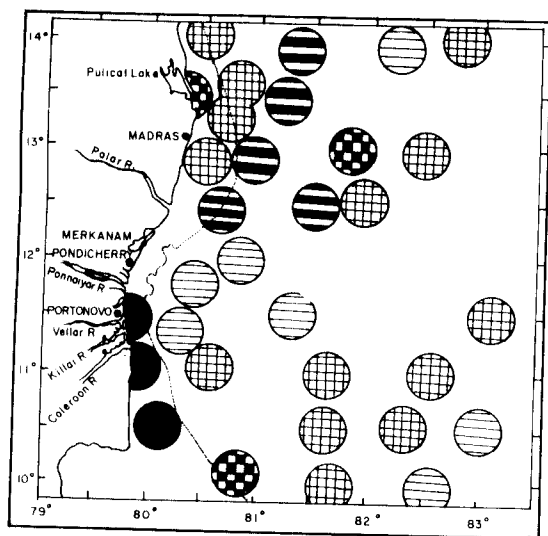


Fig. 4. Chl. 'c' (mg/m^3)

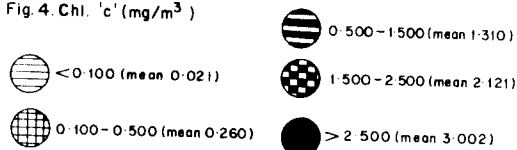


Fig. 4. Distribution of chlorophyll 'c' pigment (mg/m^3).

similar to that of chlorophyll 'a' and 'c' (Figs. 2, 4 & 5). The total values ranged from 1.041 to 9.425 mg/m^3 in the shelf region and from trace to 5.233 mg/m^3 in the oceanic region with their mean as 3.980 and 0.781 mg/m^3 and their maximum values recorded at stations 1125 and 1151 in the shelf and oceanic waters respectively. In general, the shelf region south of 12°N latitude proved to be highly fertile with phytoplankton pigments when compared to the shelf and adjacent oceanic waters of north zone and the central oceanic region adjacent to the concave edge of continental shelf between 11° and 12°N proved to be least productive zone in the surveyed sector.

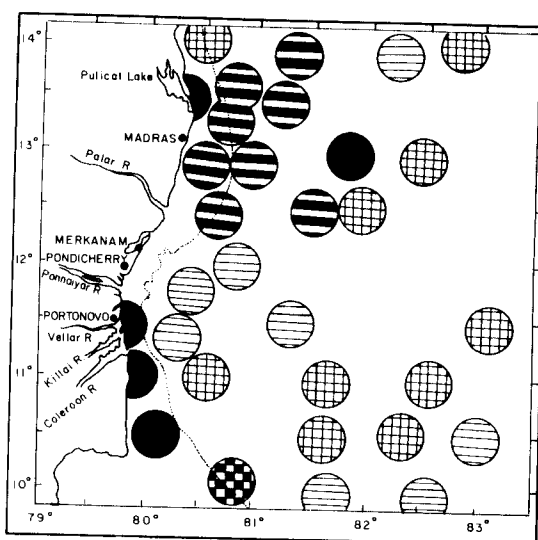


Fig. 5. Total chls. (a+b+c) in mg/m^3

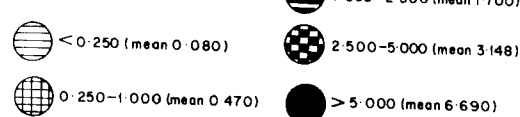
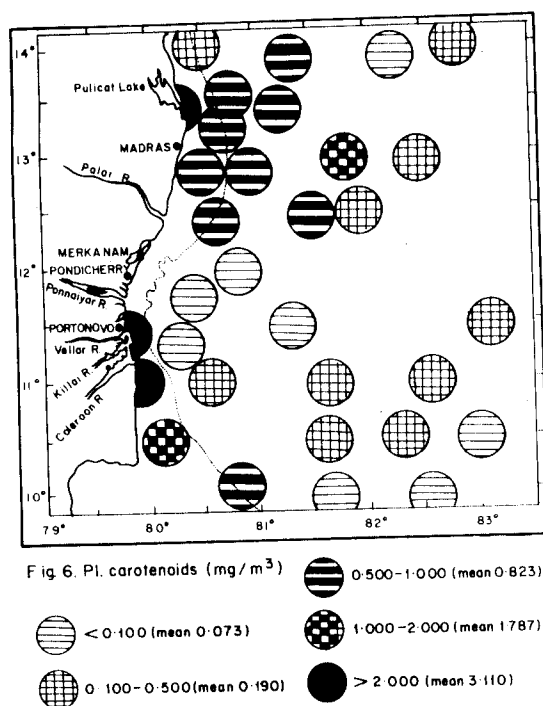


Fig. 5. Distribution of total chlorophylls ('a' + 'b' + 'c') in mg/m^3 .

Plant carotenoids

In the shelf waters, the concentration ranged from 0.500 to 4.146 mg/m^3 with a mean of 1.651 mg/m^3 while in the oceanic waters, it varied from 0.010 to 1.769 with an average of 0.297 mg/m^3 . The distribution of plant carotenoids showed the same pattern and trend as in the case of total chlorophylls. The concentration was found more in the blooming areas of *Trichodesmium* and *Rhizosolenia*, showing more affinity towards chlorophyll 'a' and 'c' pigments (Figs. 2-6).

Fig. 6. Distribution of plant carotenoids in mg/m^3 .

Primary productivity

Along the shelf region, the rate of production per day ranged from 12 to 812 $\text{mg C}/\text{m}^3$ with a mean value of 146 $\text{mg C}/\text{m}^3$ while in the oceanic euphotic zone the range and mean were 17-223 and 92 $\text{mg C}/\text{m}^3$ respectively.

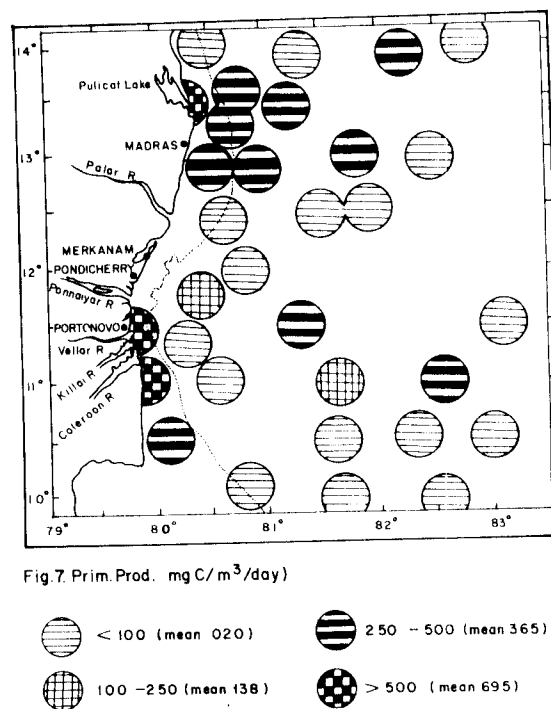
Relatively higher productivity values were obtained at stations 1125, 1124 and 1146 in the order along the shelf region. The rate of production was found to increase at station 1137 where phytoplankton pigments were found in very low concentration; and the productivity was found low at stations 1153 and 1154 where chlorophyll 'b' concentration was relatively higher. These observations indicated that the rate of production increased in patches and did not show any definite relation with the concentration of phytoplankton pigments (Fig. 7). In general, the northern oceanic zone indicated relatively higher productivity when compared to the south oceanic zone during August, 1987.

Plankton biomass

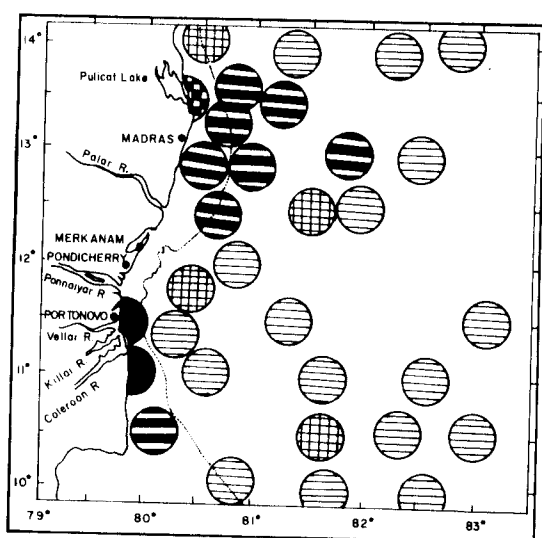
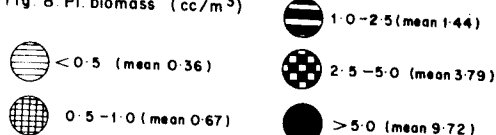
Wet volume of plankton biomass, determined soon after preservation, was found to vary from 0.88 (stn. 1145) to 10.6 cc/m^3 (stn. 1125) in the shelf and from 0.18 (stations 1142, 1152) to 1.77 $\text{cc}/$

m^3 (stn. 1148) in the oceanic waters, while the mean values were estimated as 3.14 and 0.48 cc/m^3 for the respective regions.

Along the southern shelf region, the mean volume was found to be 5.90 cc/m^3 while it was 1.63 cc/m^3 in the northern shelf region. The biomass volume was found to boost up from 8.83 to 10.6 cc/m^3 at stations 1124 and 1125 respectively in the southern shelf region. The northern oceanic zone appeared to be more productive than the oceanic waters of south zone (Fig. 8).

Fig. 7. Primary productivity in $\text{mg C}/\text{m}^3/\text{day}$.

The biomass was dominated by *Trichodesmium*, *Rhizosolenia*, *Chaetoceros*, and *Ceratium* among phytoplankton and by copepods, chaetognaths, small medusae and doliolids among zooplankton in the order of abundance. Other groups encountered in the samples were *Planktoniella*, *Bacteriastrum*, *Thalassiosira*, *Thalassionema*, *Coscinodiscus*, *Hemidiscus* and *Ditylum* among phytoplankton, and lucifers, polychaetes, euphausiids, decapod larvae, gastropod larvae, fish eggs and larvae and radiolarians among the zooplankton. The rare planktonic branchiostoma was recorded in the oceanic stations 1129, 1131 and 1140 where the depth to bottom varied from 2100 to 3660 m. Leptocephali were found abundant at station 1142.

Fig. 8. Pl. biomass (cc/m³)Fig. 8. Distribution of plankton biomass (wet volume in cc/m³ of water).

Dense blooms of *Trichodesmium erythraeum* observed in the shelf waters between 10°30' and 11°30'N at stations 1124 and 1125 on 19.8.1987 and of *Rhizosolenia* sp. observed during 25-28 August, 1987 in the northern zone between 12°30' and 13°30'N, predominantly distributed at stations 1144, 1146, 1148, 1150 and 1151 along the shelf and adjacent oceanic waters, gave an indistinct smell causing severe vomiting sensation to the participants onboard. Apart from this, a very long and broad stretch of natural slick of silvery shining observed in the surface waters off Madras quite parallel and close to the shelf edge and the route between stations 1154 and 1155 (Fig. 1) on 28.8.1987 was confirmed to be due to *Rhizosolenia* bloom.

Suspended particulate matter

Dry weight of total suspended matter in surface water constituted by plankton biomass and other suspended organic and inorganic inert materials, showed a different trend in distribution pattern when compared to the distribution pattern of phytoplankton pigments and plankton biomass (Figs. 2-6, 8 & 9). The total dry weight varied from 2.35 (stn. 1126) to 7.91 mg/l (stn. 1145) in the continental shelf region and from 1.90 (stn. 1127) to 5.17

mg/l (stn. 1151) in the oceanic region, with their mean values estimated as 5.05 and 3.07 mg/l for the respective regions. The coastal region north of Pulicat Lake (stn. 1145) showed the highest value (7.91 mg/l) with moderate plankton production. In general, the northern zone appeared to be more in total suspended matter (Fig. 9) with an average of 4.58 mg/l as against 3.09 mg/l in the south zone.

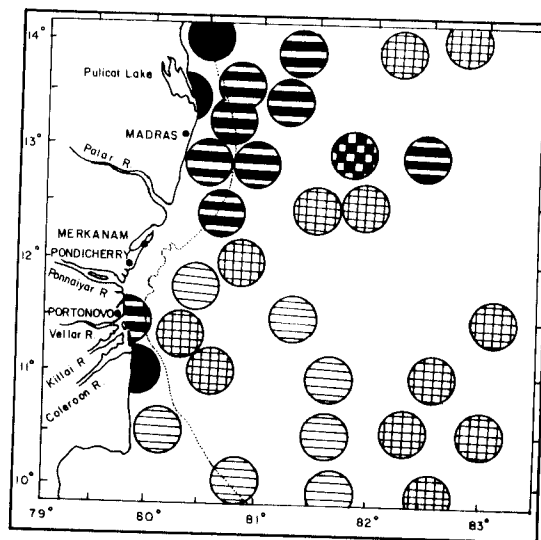


Fig. 9. Susp. matter (dry wt. in mg/l)

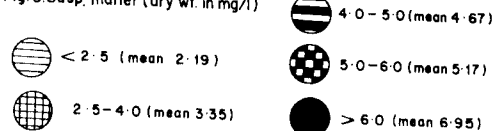


Fig. 9. Distribution of suspended particulate matter (dry weight in mg/l of water).

Hydrography

Surface water had temperature ranging from 27.0 to 29.5°C with its minimum recorded at station 1125 and maximum at 1145. The range in salinity was 34.75 - 36.00‰. Dissolved oxygen varied from 4.17 to 5.31 ml/l with its maximum recorded at stations 1124 and 1125 in the shelf and at 1151 in the oceanic waters indicating the areas of highest primary production. The oceanic waters at station 1137 recorded relatively low oxygen and temperature and higher salinity than the surrounding waters.

DISCUSSION

The results of the present investigation reveal the occurrence of higher concentrations of phytoplankton pigments, plankton biomass and suspended particulate matter in patches along the shelf

and adjacent oceanic waters off the southeast coast of India during August, 1987. Subrahmanyam (1960; 1967) has pointed out that on the east coast, maximum primary production occurs during the southwest monsoon months, followed by one or more peaks of production of a lesser magnitude during the northeast monsoon months. Although southwest monsoon rainfall has not much of direct effect along the southeast coast, the surface layers of shelf and adjacent oceanic waters are influenced partly by the outflow of river systems of this coast bringing monsoon waters from interior places of southern India and partly by the drift of the coastal waters from the west coast towards the southeast coast bringing nutrient-rich water to this region resulting in considerable increase in phytoplankton production during this period.

Apart from these, the local mixing up of nutrient-rich deeper water with surface column may also play a significant role in the distribution and abundance of planktonic communities. The very long and broad stretch of natural slick due to the bloom of *Rhizosolenia* sp. observed in the surface water between 12°30' and 13°30'N quite parallel and close to the shelf edge, with relatively higher salinity recorded in the surface water along its shelf edge and slope and simultaneous abundance of zooplankton communities around this region may be related to such mixing processes during this period. Further, the continuity in the distribution and abundance of *Rhizosolenia* sp. and zooplankton biomass from the oceanic region towards the shelf region off Madras coast (between 12°30' and 13°30'N) indicates the distribution of water mass of same hydrographic characteristics towards the coast.

In this connection, the article by Radhakrishnan *et al.* (1989) on the unusual upwelling-like phenomenon and subsequent congregation of deep water organisms along the north Tamilnadu coast observed during the same period (August-September, 1987) and the observations of Vivekanandan *et al.* (1983) close to this period of 1982 should be of interest. The shoreward drift of upwelled water, from the shelf edge and the adjacent oceanic waters, might be attributed to the observations of Radhakrishnan *et al.* (1989) on the appearance of "Vandal Thanneer" (local name) or turbid water with low temperature (24.5-27.0°C) and low dissolved oxygen (2.37-3.22 ml/l) recorded close to the shore during 26th August to 4th September, 1987 in and around Kovalam Bay near

Madras. As per local enquiry, it seems that it is a regular phenomenon every year particularly during August-September period. The wind generated turbulence of water in relation to the topography of the shelf edge of this region (Fig.1) and perhaps the change in pattern and direction of the ocean current system in Bay of Bengal close to August-September period might have significant role in such mixing processes. However, further studies on the hydrodynamics of this region during this period are required to substantiate the actual causes of such phenomenon.

Blooms of phytoplankton and abundance of zooplankton are known to occur generally in the inshore regions while it has been rarely reported from the oceanic waters. Mathew *et al.* (1988) have enlisted in detail the occurrence of phytoplankton blooms at different centres of the east and west coasts of India during the period 1982-'87. However, the present occurrence of blooms of *Rhizosolenia* sp. from the shelf and oceanic regions off Madras coast and of *Trichodesmium erythraeum* along the shelf region south of Portonovo form the record of this season. Simultaneous abundance of phytoplankton and zooplankton groups along with high dissolved oxygen content in the water indicates that phytoplankton production might be much higher than the grazing level by zooplankton.

Although the distribution of total suspended matter (dry weight) showed a different picture from that of phytoplankton pigments, plankton biomass concentration and primary productivity, it revealed some relation with the abundance of plankton biomass (wet volume) in the regions where the biomass was found abundant. However, the data indicated that the composition of plankton groups in the biomass and distribution of other suspended inert materials brought by the estuarine discharges and by other sources may have significant role in it. The abundance of phytoplankton and zooplankton and the availability of high dissolved oxygen level in the surface waters, along the shelf and adjacent oceanic regions of north zone extending to about 82° E and along the shelf region of the south zone of the surveyed sector indicate the areas of highly productive zones for potential fishery resources close to this season.

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