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INVESTIGATIONS ON PRIMARY PRODUCTION AND RELATED PARAMETERS IN THE INSHORE WATERS OF TUTICORIN*

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ABSTRACT

Primary production and related parameters were studied in the inshore waters of Tuticorin during 1985-87. The annual cycle of primary production indicated three peak periods, first during March-April, second during July and the third during September-October. Production was low in the winter months of November-January. The average primary production was estimated as 350 mgC/m³/day with relatively higher values of 1600 mgC/m³/day in April and low values of 114 mgC/m³/day observed in November. The chlorophyll *a* values showed a direct relation with the primary production. The hydrological parameters including nutrients of the water column showed definite seasonal fluctuations. The nutrients, especially phosphates and silicates showed an inverse relationship with primary production while nitrates indicated a positive correlation. Blooming of *Trichodesmium theibautii* during summer (April-June) and of dinoflagellates during northeast monsoon (October-December) were observed to be of regular phenomenon. The important dominant group of phytoplankton encountered in the study belonging to the species of diatoms *Chaetoceros, Skeletonema* and *Thalassiosira* and phytoflagellates such as *Isochrysis, Pavlova, Chromulina* and *Dicrateria*. The role of environmental factors in the production of organic matter and the observations of earlier workers are briefly discussed.

INTRODUCTION

CONSIDERABLE knowledge has been gained in recent years in the productivity parameters such as chlorophylls, solar radiation and nutrients of the coastal waters of the Indian Seas in general (Prasad, 1958 ; Prasad and Nair, 1960, 1963 ; Nair, 1974 ; Nair *et al.*, 1968, 1975 ; Qasim, 1979 ; Qasim *et al.*, 1969, 1978 ; Radhakrishna, 1969, 1975 ; Radhakrishna *et al.*, 1978 ; Nair and Gopinathan, 1981 ; Nair and Pillai, 1983). Relatively more information is available on the plankton and hydrography of the Gulf of Mannar (Chacko and Malu Pillay, 1957 ; Chacko and Rajendran, 1959 ; Chidambaram *et al.*, 1951 ; Prasad, 1954, 1956 ; Marichamy and Pon. Siraimeetan, 1979). However, informations on the primary and secondary production of the inshore area off Tuticorin are restricted to the recent account of Marichamy *et al.* (1985). Prasad and Nair (1963) has stated that the waters of the inshore area off Tuticorin, especially at 10 m depth, was remarkably productive and these authors have made an estimate of potential resources from primary production in the Gulf of Mannar. In the present account an attempt has been made to study the productivity parameters responsible for the production of phytoplankton in the inshore area off Tuticorin for a period of 2 years during 1985-87.

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Material and Methods

Fortnightly collections were made on board the research vessels *Cadalmin-IV* and *M. L. Chippy* of the Institute. Water samples were collected from surface and bottom (10-15 m depth during 1986-87) between 0630 and 0900 hrs from the inshore area. Although 2 stations in the inshore area (Fig. 1) were sampled, the data showed similar trend and hence only pooled values for these stations

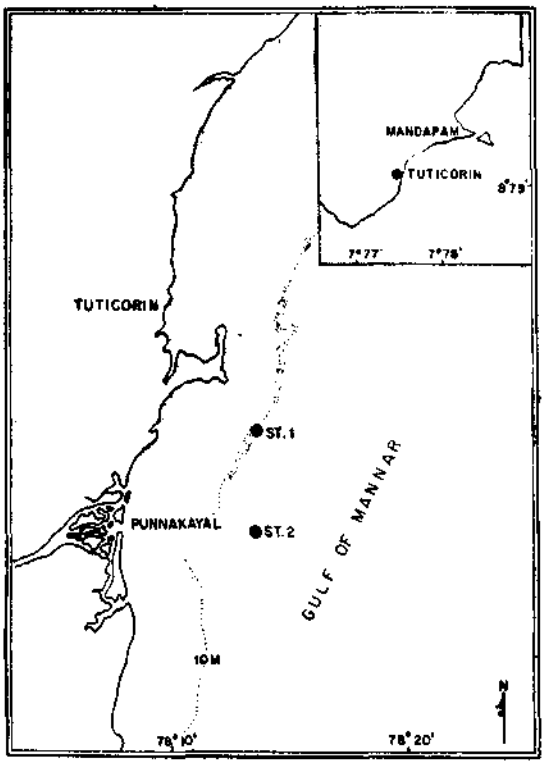

Fig. 1. Sampling stations in the inshore waters of Tuticorin.

are presented here. Light and dark bottle oxygen technique (Gaarder and Gran, 1927) was employed for measuring the primary production on board the research vessel. After uniform exposure of light, the samples were fixed by Winkler's method for the estimation of oxygen. The values were converted to carbon equivalent using a PQ of 1.25 for obtaining the gross production.

The estimation of chlorophyll *a* was made by filtering one litre of seawater using Millipore HA filters, then dissolving the same in 90% acetone. The optical wavelength (665) of the solution was measured by a Spectrophotometer.

The hydrological factors studied simultaneously with the primary production were surface temperature, turbidity, salinity, pH and nutrients such as nitrites, nitrates, phosphates and silicates. The estimation of the chemical properties of the water was done following the method same by Strickland and Parsons (1968). The Secchi disc was employed for the measurement of turbidity of the water.

The fluctuations in the primary production and chlorophyll *a* and the physico-chemical conditions are discussed in terms of monthly averages.

Observations and Results

Water visibility

The clarity of water as evidenced by secchi disc visibility of the waters of the inshore region ranged from 1.5 to 8.5 m in different months (Fig. 2 a). The secchi disc visibility was low during January to August. The clarity of the water was very high during the months of September - December and the maximum clarity was observed during October (8.5 m).

Temperature

The atmospheric temperature was recorded regularly along with the surface water temperature. The monthly average values of surface and bottom waters along with the atmospheric temperature are shown in Fig. 2 b, c to indicate their relationship. The close similarity in the curves reveal that the surface

temperature is considerably influenced by the atmospheric temperature. Both the atmospheric and surface temperature indicated low values during the winter months of November - February and maximum during the summer months of March - May. A secondary rise in temperature was noticed in July - September and afterwards registered another fall in December - February when cooler conditions prevailed in the inshore area.

Oxygen

The dissolved oxygen content at the surface and bottom waters were represented in Fig. 2 d,

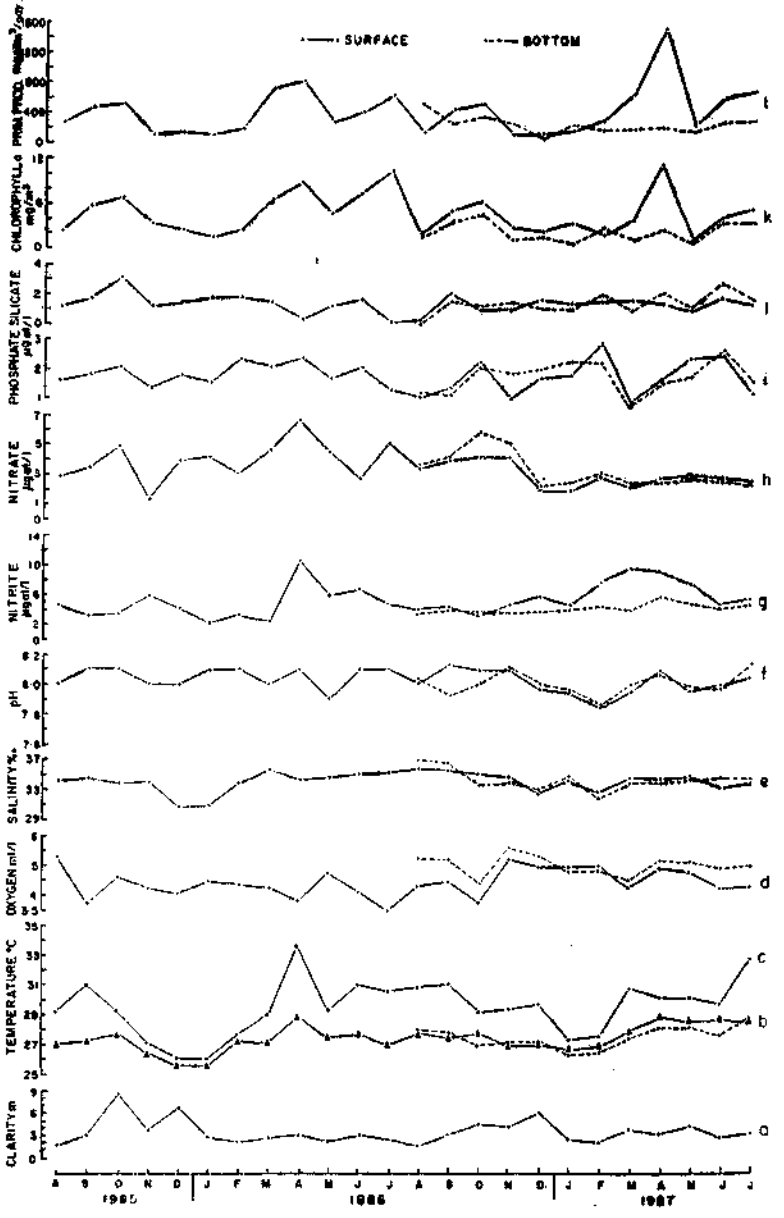

Fig. 2. Seasonal variations of hydrobiological parameters in the inshore waters of Tuticorin.

which showed slight fluctuations. High values of oxygen content were noticed at the surface during May, August and November. However, the bottom water showed high values during August - September and November '86 and April - July '87 periods. The lowest values of oxygen content noted during July and October months.

Salinity

The monthly average values of salinity of the inshore waters varied from 29.5 to 37‰ during the period of observations (Fig. 2 e). Slight variations were noticed from surface to bottom. High values of salinity noticed during the summer months of March - April and low values, with the onset of northeast monsoon, during November - January. The bottom water showed slightly higher values of salinity during June - September months.

pH

The values of pH at the surface and bottom are shown in Fig. 2 f. Similar to the variations of dissolved oxygen content, the pH of the water column ranged from 7.8 to 8.15. In general the trend of fluctuations of pH in the surface and bottom waters did not show much difference.

Nitrite

The monthly values of nitrite content of the water is shown in Fig. 2 g. The surface values of nitrite showed wide fluctuations when compared to the rather steady values of bottom during the 2nd year of observations. During April - June '86 and Feb. - May '87, the values at the surface showed 'slight increase while in other months when the rate of primary production was high, the nitrite values were low or negligible indicating that nitrite-N has been utilized by the phytoplankton.

Nitrate

The monthly values of nitrate-N (Fig. 2 h) of the water showed wide fluctuations during 1985-86 than '87 when the values remained steady without fluctuations. The nitrate-N values were more during March - May, July and October, coinciding with the 3 peaks of primary production, suggesting that the nitrogenous products were not fully used by the phytoplankton for its growth and multiplication.

Phosphate

The inorganic phosphate values at the surface and bottom are represented in Fig. 2 i. The values showed wide fluctuations of phosphate during the period of study. The bottom values were slightly on the higher level during November - January period. A unimodal variation in the values of phosphate was observed with high values during October '86, February and May - June '87 and a minimum of low or negligible values during August, November and March periods.

Silicate

The values of silicate showed less fluctuations when compared to other nutrients, which is represented in Fig. 2 j. Slightly higher values were noted during September - October, suggesting that the silicates were not utilized fully during this period for the diatom production. In other months, negligible values were recorded. In other words, the silicates indicated an inverse relationship with the primary production.

Chlorophyll a

Since chlorophyll *a* is one of the major indices of the standing crop of phytoplankton, the estimation of this pigment along with that of the primary production is expected to give a general idea of the variation in the magnitude of production. Fig. 2 k gives the average values of chlorophyll *a* at the surface for one year and surface and bottom for the second year. However, the bottom values were very low when compared to the surface. The chlorophyll *a* ranged from 2-12 mg/m³ during the

entire period of observation. Chlorophyll *a* values showed distinct seasonal variations and direct relationship with the primary production. Three peak periods have been observed, one during March-April, second during June - July and the third during September - October, similar to the peak periods of primary production.

Primary production

The rate of gross primary production estimated by oxygen technique at the surface and bottom waters are presented in Fig. 2 I. Wide range of fluctuations were noticed between the values of surface and bottom. The primary production indicated three seasonal peak periods, the first one during March - April, second during July and the third during September - October. Production was found to be low in the winter months of November - January. However, the magnitude of production was very high during March - April when compared to July and September - October periods. Except one or two months, the surface production was higher than the bottom. The average primary production for the inshore waters is estimated as 350 mgC/m^3/day, with relatively higher values of 1,600 mgC/m^3/day observed during April '87 and very low values of 114 mgC/m^3/day during November '86.

Qualitative studies on phytoplankton

The phytoplankton of the inshore area of Tuticorin is rich in biomass and variety, exhibiting regular seasonal variations during the study. The maximum number of phytoplankters dominated by diatoms occurred in April, coinciding with the first peak of primary production.

The presence of large quantities of *Trichodesmium theibautii* during summer (April - June) as brown patches in the surface waters of the inshore area is of common feature here. Blooming of this blue-green alga during summer causes substantial reduction of nitrogen compounds in the surface waters.

The proportion of Dinophyceae in the water samples was extremely low when compared to the diatom. However, the abundance of this diversified group of phytoplankton was noticed during the period October - December. The season of abundance somewhat coincided with the 3rd maxima of primary production. The most important species belonged to the genera *Ceratium*, *Peridinium*, *Ornithocercus*, *Prorocentrum*, *Dinophysis*, *Podolampas*, *Ceratocorys* and *Amphisolenia*. Blooming of *Noctiluca miliaris* was also observed during November '86.

The abundance of planktonic diatoms in the waters of the inshore area noticed during the summer months of February-May and again during the period July - September, coincided with the primary and secondary peaks of primary production. Another interesting features of the diatom abundance was that the Centrales dominated during the February - May period and Pennales contributed substantially during July - September months. The predominent ones which constituted the bulk in many months of the year were species of *Chaetoceros* spp., *Skeletonema costatum*, *Thalassiosira subtilis*, *T. gravida*, *Coscinodiscus* spp., *Stephanopyxis palmariana*, *Rhizosolenia* spp., *Bacteriastrum hyalinum*, *Biddulphia mobiliensis*, *B. sinensis*, *Ditylum brightwelli* and *Climacodium frauenfeldianum* among Centrales and *Nitzschia* spp., *Navicula* spp., *Thalassionema nitzschioides*, *Thalassiothrix frauenfeldii*, *Asterionella japonica*, *Pleurosigma normanii* and *Synedra* spp. among the Pennales.

The phytoflagellates, most of them are nannoplankters were represented by the members of Chlorophyceae, Chrysophyceae and Haptophyceae. They are species of *Isochrysis*, *Pavlova*, *Chromulina*, *Dicrateria*,

Tetraselmis, *Platymonas* and *Dunaliella*. The nannoplankton flagellates were found to be abundant during June - July and September - October periods, coinciding with the second and third peak of primary production.

Discussion

The seasonal variation of the nutrients of the water in the inshore area of Tuticorin revealed that phosphates and silicates were significantly utilized by the phytoplankton showing an inverse relationship during the peak periods of primary production. The nitrites and nitrates of the water indicated a single peak during May to September, coinciding with the second peak of primary production. In other months, very low values of nitrates were noted. These suggest that nitrogen compounds of the water column of the inshore area is utilized by the phytoplankton much faster than the phosphates and silicates. The gradual fall in the silicate during July - August was due to the utilization of these compounds by the diatoms and this coincided with the high values of primary production during these months.

It has been observed by Prasad and Nair (1963) that the inshore waters off Tuticorin is remarkably productive due to the extensive photosynthetic zone. According to these authors, the productivity zone extends over 40 m and the rate of production at 10 m depth would be exceptionally high. Using oxygen technique, Prasad and Nair (1960) observed a column production of 3.4 gC/m²/day which is very high and this rate of production in the inshore regions of the Gulf of Mannar is a regular phenomenon, typical of tropical shallow areas of high productivity. Similar high productivity values were observed in the present investigations also. Prasad (1954) observed in the Gulf of Mannar, more than one maxima of phytoplankton production, a summer peak in May with others in February - March and August to November, more or less a similar trend was noticed in the present investigations.

Generally, the southwest monsoon is not active along the Tuticorin Coast and hence its influence on the productivity and hydrological conditions are negligible. The northeast monsoon which starts in late September or early October is observed to exert influence on the environmental conditions of the coastal waters. According to Steemann Nielsen and Jensen (1957), extensive investigations during different seasons are necessary in order to give a true picture of the productivity of the Bay of Bengal as the monsoon shift has considerable influence on the productivity there. They have also pointed out that the productivity of the Bay of Bengal is due to the high run off from various river systems which discharge high quantity of terregenous organic matter which affects light penetration. Radhakrishna (1975) has suggested that mixing process being weak, on account of greater degree of stratification due to the river discharge, lessens the transfer of subsurface nutrients to the euphotic zone. He also reported from the Bay of Bengal, during the southwest post-monsoon (August - September) period a production of 0.22 gC/m²/day in general, 0.29 on the shelf and 0.32 at the slope and pointed out that the southwest post-monsoon period is more productive compared to the pre-monsoon period.

Qasim *et al.* (1978) determined the biological productivity of coastal waters of India from Dabhol to Tuticorin and arrived at a figure of 330 mgC/m³/day. After making a thorough comparative study of the six different tropical environments in the Indian seas, Qasim (1973) has come to the conclusion that the rate of production near the shore is greater than in regions away from the coast and high instantaneous rates of production are generally recorded in upwelling areas during the monsoon period.

Generally speaking, the results obtained on the trend of seasonal progression of the standing crop of phytoplankton during the present studies are comparable to those of Prasad (1954) for the Gulf of Mannar. Although there had been variations within and between the months and shifts in the period of seasonal maxima, the close similarity of the production for the two years of study present a reasonably true picture of the magnitude of production in this area.

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