

## Distribution of chlorophyll 'a' and 'b' in the eastern Arabian Sea (west coast of India) in relation to nutrients during post monsoon

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### Abstract

The distribution of chlorophyll 'a' and 'b' in the Arabian Sea along the west coast of India from Cape Comorin to Veraval in the 40-200m depth contour, in a single cruise of FORV *Sagar Sampada* (Cruise no. 177) was studied, covering 58 stations during the post monsoon period of October-November, 1999. Data on nitrates and phosphates were also collected along with chlorophylls. The results indicated that the coastal waters along the south west coast of India are more productive than the waters along the north west coast during the post monsoon period. Earlier observations on chlorophylls and nutrients from eastern Arabian Sea are also briefly discussed.

### Introduction

It is well known that photosynthetic pigments are the index of primary production of an area and playing a significant role in the ecological characteristics of an ecosystem. The biological productivity of the coastal and oceanic regions of the Indian seas in general are dependent on the complex physico-chemical and biological processes, especially the distribution and abundance of photosynthetic pigments in the euphotic zone.

While considerable informations are available on the physico-chemical and biological characteristics of the eastern Arabian Sea along the west coast of India (Ramamirtham and Jayaraman, 1960; Patil and Ramamirtham, 1963; Sharma, 1966; Radhakrishna, 1969; Qasim, 1977, 1982; Qasim *et al.*, 1972; Bhattathiri and Devassy, 1979; Pant, 1992; Pillai, 1983, Pillai *et al.*, 2000), information on the

distribution of chlorophyll 'a' and 'b' during the post monsoon period is limited. Banse (1968) reported some information on chlorophyll 'a' and nutrients during the south west monsoon period in the coastal waters of Arabian Sea while, Krey and Babernad (1976) and Sumitra Vijayaraghavan and Krishnakumari (1989) have given a general picture of the distribution of chlorophylls along the west coast. Balachandran *et al* (1989, 1997) studied the distribution and profile of chlorophyll 'a' in the inshore waters off Cochin and Laccadive Sea during the monsoon season. Recently Pillai *et al.* (2000) gave a comprehensive account on the seasonal variations of the physico-chemical and biological characteristics of the eastern Arabian Sea and Madhupratap *et al.* (2001) reviewed the oceanographic features of the Arabian Sea with special reference to fisheries.

In this account, an attempt is made to study the chlorophyll 'a' and 'b' in relation to nitrates and phosphates in the euphotic zone within the 40-200 m depth zone of the west coast from Cape Comorin to Veraval, during the post monsoon period of October - November 1999.

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### Material and methods

The entire area along the west coast of India between Cape Comorin and Veraval, in the depth zone of 40-200 m in the coastal and oceanic regions were covered in a single cruise of *FORV Sagar Sampada* (Cruise no. 177) during the post monsoon period of October-November 1999 (Fig. 1). The samples for the estimation of chlorophylls and nutrients were collected from 58 stations; 37 stations in the south eastern and 21 stations in the north eastern Arabian Sea. Data on chlorophylls and nutrients were collected at every station (representing one degree square) from surface to maximum depth of 75 m using Rosette samplers. For the estimation of chlorophylls and nutrients such as nitrates and phosphates, the methodology of Strickland and Parsons (1972) was fol-

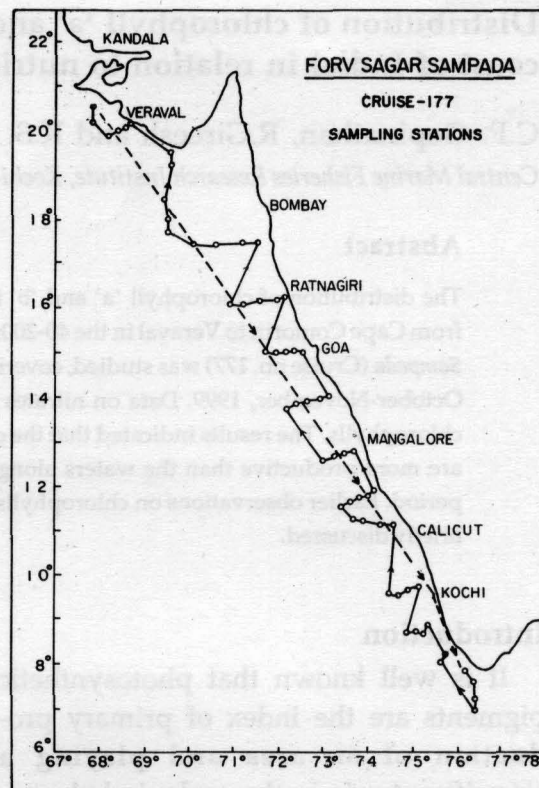


Fig. 1. Sampling stations

lowed. Quantitative and qualitative studies on phytoplankton were also made.

### Results

#### Chlorophyll 'a' :

Figs. 2-7 indicate the distribution of chlorophyll 'a' in the eastern Arabian Sea at various depth regions (surface, 10m, 20m, 30m, 50m and 75m) of the euphotic zone.

In the surface waters, the highest chlorophyll 'a' values of  $8.28 \text{ mg/m}^3$  was observed off Cape Comorin at lat.  $8^\circ 27.58' \text{ N}$  and long.  $76^\circ 42.72' \text{ E}$ . Higher values ( $5.60 \text{ mg/m}^3$ ) were also observed off Goa (lat.  $15^\circ 24.94' \text{ N}$  and long.  $73^\circ 39' 09' \text{ E}$ ).

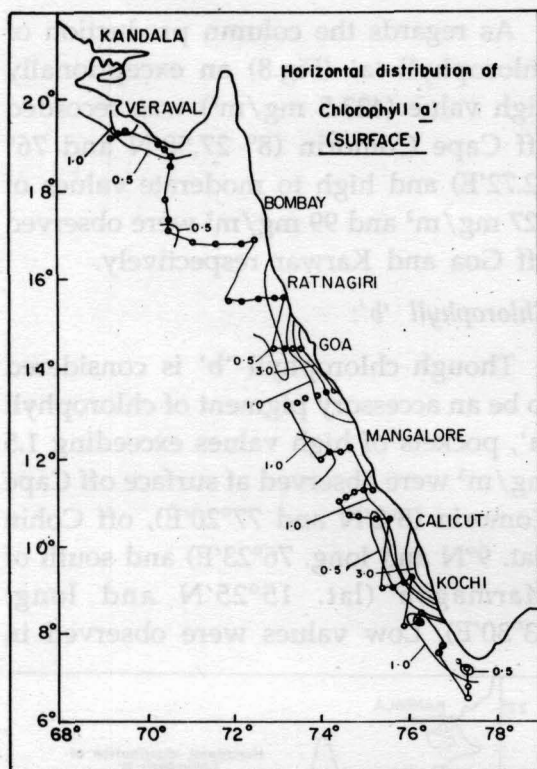


Fig. 2. Distribution of chlorophyll 'a' at surface

Moderate values of more than  $2.0 \text{ mg/m}^3$  were noticed in the coastal waters south and north of Cape Comorin and Mumbai (Fig.2).

A very high value of  $15.72 \text{ mg/m}^3$  of chlorophyll 'a' was noted at 10 m depth off Cape Comorin at lat.  $8^\circ 27.58' \text{N}$  and long.  $76^\circ 42.72' \text{E}$ . Further at the Wadge Bank area (lat.  $9^\circ 57.02' \text{N}$  and long.  $76^\circ 00.01' \text{E}$ ) a high value of  $8.01 \text{ mg/m}^3$  was noticed. Again pockets of high values were observed off Karwar ( $7.47 \text{ mg/m}^3$ ), off Wadge Bank ( $5.87 \text{ mg/m}^3$ ) and off Cape Comorin ( $5.07 \text{ mg/m}^3$ ). Moderate to high values of more than  $3 \text{ mg/m}^3$  were observed at stations off Goa and Mumbai. (Fig.3).

At 20m-depth zone, the highest chlorophyll 'a' value of  $21.36 \text{ mg/m}^3$  was observed off Karwar ( $11^\circ 28.12' \text{N}$  and  $75^\circ 21.47' \text{E}$ ) and next highest values of  $15.22 \text{ mg/m}^3$ , was again off Karwar. Pockets of high values were observed off Karwar ( $15.22 \text{ mg/m}^3$ ). Cape Comorin ( $11.48 \text{ mg/m}^3$ ); Goa ( $6.67 \text{ mg/m}^3$ ) and moderate value of  $3\text{--}4 \text{ mg/m}^3$  of chlorophyll 'a' recorded off Cape Comorin and off Ratnagiri (Fig.4).

At 30m-depth zone, high values of  $9.6 \text{ mg/m}^3$  and  $8.81 \text{ mg/m}^3$  of chlorophyll 'a' were observed off Cape Comorin and Goa respectively. Moderate to high values of  $3\text{--}4.5 \text{ mg/m}^3$  of chlorophyll 'a' were re-

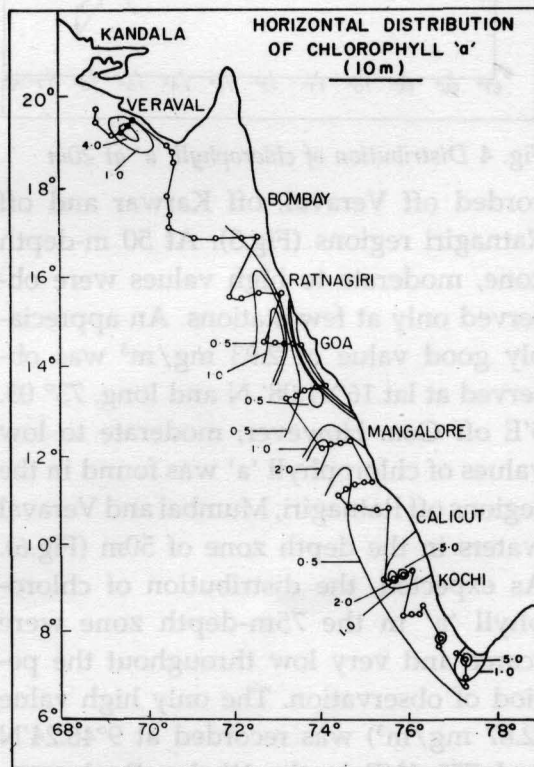


Fig. 3. Distribution of chlorophyll 'a' at 10m



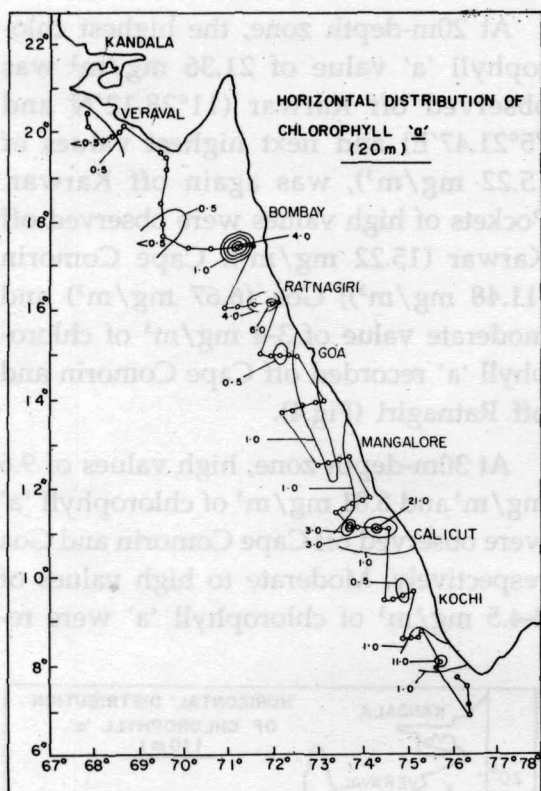


Fig. 4 Distribution of chlorophyll 'a' at 20m  
 corded off Veraval, off Karwar and off Ratnagiri regions (Fig.5). At 50 m-depth zone, moderate to high values were observed only at few stations. An appreciably good value of 2.93 mg/m<sup>3</sup> was observed at lat.16°41.08' N and long. 73° 03. 5'E off Goa. However, moderate to low values of chlorophyll 'a' was found in the regions off Ratnagiri, Mumbai and Veraval waters in the depth zone of 50m (Fig.6). As expected, the distribution of chlorophyll 'a' in the 75m-depth zone were scarce and very low throughout the period of observation. The only high value (2.67 mg/m<sup>3</sup>) was recorded at 9°46.24'N and 75° 41'E in the Wadge Bank area. (Fig.7).

As regards the column production of chlorophyll 'a' (Fig.8) an exceptionally high value (423.5 mg/m<sup>2</sup>) was recorded off Cape Comorin (8° 27.58'N and 76° 42.72'E) and high to moderate values of 127 mg/m<sup>2</sup> and 99 mg/m<sup>2</sup> were observed off Goa and Karwar respectively.

#### Chlorophyll 'b':

Though chlorophyll 'b' is considered to be an accessory pigment of chlorophyll 'a', pockets of high values exceeding 1.5 mg/m<sup>3</sup> were observed at surface off Cape Comorin (8°2'N and 77°20'E), off Cohin (lat. 9°N and long. 76°23'E) and south of Marmagoa (lat. 15°25'N and long. 73°30'E). Low values were observed in

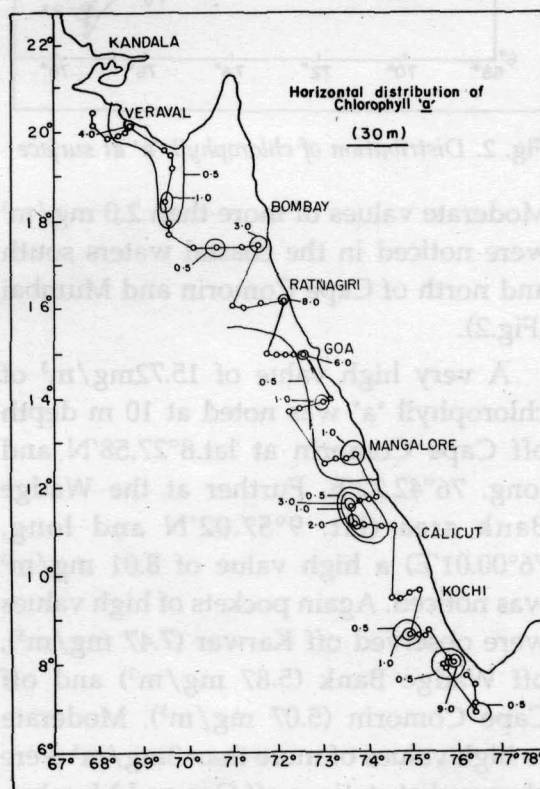


Fig. 5. Distribution of chlorophyll 'a' at 30m

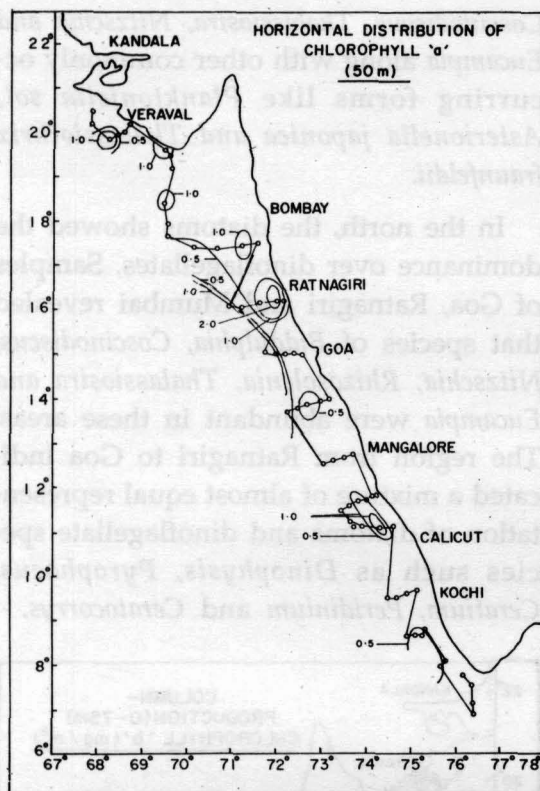


Fig. 6. Distribution of chlorophyll 'a' at 50m

the northern region when compared to southern region. Chlorophyll 'b' concentrations at 10m, 20m, 30m, 50m and 75m depths ranged from 0.1 - 1.4; 0.04-1.5; 0.05-1.2; 0.04-1.05; 0.07-1.2 mg/m<sup>3</sup> respectively. Moderately high values were observed (0.5-1.0 mg/m<sup>3</sup>) in the area between Marmagoa and Veraval.

Column production of chlorophyll 'b' (Fig 9) indicated high values in the southern region; off Calicut and Marmagoa (>90 mg/m<sup>2</sup>) when compared to the northern region (>70mg/m<sup>2</sup>). Moderate values (25-45 mg/m<sup>2</sup>) were noted frequently in the south and moderate to low values (20-25 mg/m<sup>2</sup>) in the north.

#### Nutrients:

The high and low concentrations of nitrates and phosphates in the southern and northern regions are presented in Table 1 and 2. In the southern region, high values of nitrates (1.3 and 1.5 µg atN/l) were observed off Karwar and Calicut and low values were noted at Cape Comorin and Wadge Bank area (0.2-0.8 µg at./l). Similarly, high phosphate values were observed at Calicut - Kannur region (1.77-2.62 µg at. P/l) and low values off Quilon and Cape Comorin (0.7-0.8 µg at P/l).

In the north, high values of nitrates were noted off Goa and Mumbai (0.56 - 0.6 µg at. N/l) and low values were re-

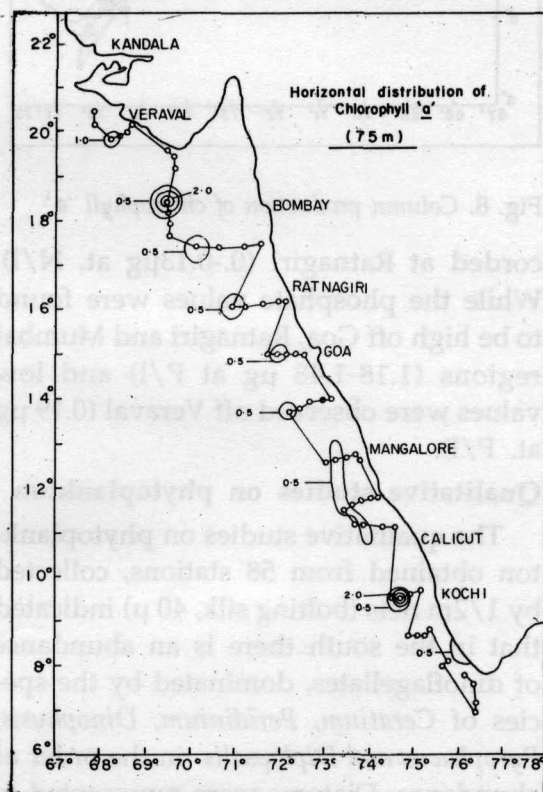


Fig. 7. Distribution of chlorophyll 'a' at 75m

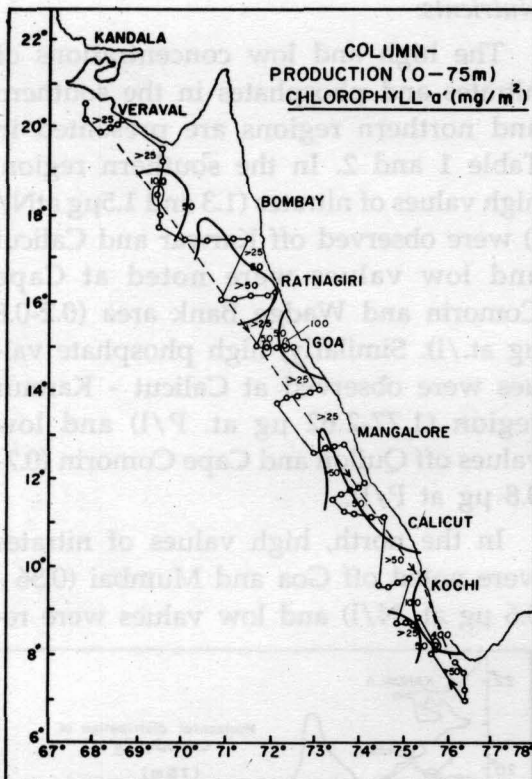


Fig. 8. Column production of chlorophyll 'a'

recorded at Ratnagiri ( $0.0\text{--}0.13\mu\text{g}$  at. N/l). While the phosphate values were found to be high off Goa, Ratnagiri and Mumbai regions ( $1.18\text{--}1.48\mu\text{g}$  at P/l) and low values were observed off Veraval ( $0.19\mu\text{g}$  at. P/l).

#### Qualitative studies on phytoplankton

The qualitative studies on phytoplankton obtained from 58 stations, collected by  $1/2\text{m}$  nets (bolting silk,  $40\mu$ ) indicated that in the south there is an abundance of dinoflagellates, dominated by the species of *Ceratium*, *Peridinium*, *Dinophysis*, *Pyrophacus* and *Diplopsalis* in the order of abundance. Diatoms were represented in lesser numbers, comprising of species of

*Coscinodiscus*, *Thalassiosira*, *Nitzschia* and *Eucampia* along with other commonly occurring forms like *Planktoniella sol*, *Asterionella japonica* and *Thalassiothrix fraunfeldii*.

In the north, the diatoms showed the dominance over dinoflagellates. Samples of Goa, Ratnagiri and Mumbai revealed that species of *Biddulphia*, *Coscinodiscus*, *Nitzschia*, *Rhizosolenia*, *Thalassiosira* and *Eucampia* were abundant in these areas. The region from Ratnagiri to Goa indicated a mixture of almost equal representation of diatoms and dinoflagellate species such as *Dinophysis*, *Pyrophacus*, *Ceratium*, *Peridinium* and *Ceratocorys*.

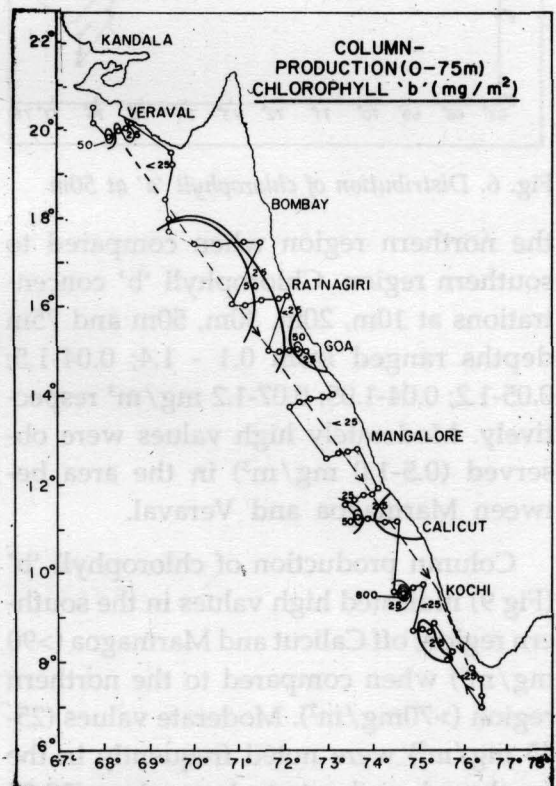


Fig. 9. Column production of chlorophyll 'b'



**Table 1.** Values of nitrate and phosphate in the south eastern Arabian Sea

Latitude	Location Longitude	Area	µg at./l (0-30m average)
High values (NO <sub>3</sub> )			
14° 08 05'	74° 04 86'	Off Karwar	1.59
11° 48 99'	74° 52 10'	Off Calicut	1.30
11° 20 12'	75° 21 47'	Off Calicut	0.9
Low values (NO <sub>3</sub> )			
8° 00 02'	77° 20 59'	Off Cape	0.02
11° 44 95'	74° 40 02'	Off Calicut	0.02
7° 54 29'	77° 21 59'	Wadge Bank	0.08
High values (PO <sub>4</sub> )			
11° 59 72'	75° 04 35'	Off Calicut	2.62
12° 44 47'	74° 14 78'	Off Kannur	2.38
12° 43 69'	73° 06 59'	Off Kannur	1.77
Low values (PO <sub>4</sub> )			
9° 00 27'	76° 23 93'	Wadge Bank	0.07
7° 11 20'	77° 20 09'	Off Cape	0.08
9° 46 26'	75° 41 42'	Wadge Bank	0.08

**Table 2 :** Values of nitrate and phosphate in the north eastern Arabian Sea

Latitude	Location Longitude	Area	µg at./l (0-30 m average)
High values (NO <sub>3</sub> )			
20°42 72	69°16 46	NW Mumbai	0.62
20°34 42	70°43 25	NW Mumbai	0.6
16°38 18	72°39 14	NW Goa	0.57
16°41 33	73°03 05	NW Goa	0.56
Low values (NO <sub>3</sub> )			
18°49 75	70°48 32	Off Ratnagiri	0.13
20°26 66	70°46 53	NW Mumbai	0.13
20°57 50	60°47 84	NW Mumbai	0.13
High values (PO <sub>4</sub> )			
16°43 53	73°12 42	Off Goa & Ratnagiri	1.48
16°41 33	73°03 05	Off Goa & Ratnagiri	1.48
15°25 56	72°53 04	Off Goa	1.43
18°00 13	72°47 15	Off Ratnagiri	1.43
19°18 57	70°46 93	Off Miumbai	1.19
Low values (PO <sub>4</sub> )			
21°04 02	69°59 59	Off Veraval	0.19

## Discussion

It is well known that abundance of chlorophylls and nutrients in the water column are of paramount importance for determining the biological productivity and potential resources. Light penetration decides the depth of the euphotic zone while the nutrients especially the nitrates and phosphates indicate the fertility of the water to promote productivity and the availability of photosynthetic pigments reveal the production at the primary level.

It is quite interesting to note that there is a positive correlation between chlorophyll 'a' and 'b' noticed in most of the regions of the present study. High values of chlorophyll 'b' observed at Calicut and Wadge Bank area of the south west coast and off Goa and Mumbai coincided with high concentrations of chlorophyll 'a'. Though chlorophyll 'b' is considered to be an accessory photosynthetic pigment of chlorophyll 'a', its concentration in these regions are significant for assessing the fertility of the area.

The availability of nitrates and phosphates in the surface to 75m in the eastern Arabian Sea is largely due to upwelling and river run off and also drainage from the land. Very often, these nutrients available in the water column are not fully utilized by the phytoplankton and high concentrations are detected in the surface and column regions (Table 1 and 2). A negative correlation between chlorophyll 'a' concentration and nutrient distribution is observed in the south. High concentra-

tion of chlorophyll 'a' was noted off Cape and Wadge Bank area and low values of nitrates and phosphates were recorded from these areas during the post monsoon period. In the north a close positive correlation existed between chlorophylls and nutrients. The high values of chlorophyll 'a' noted in the coastal waters off Goa and Mumbai and high to moderate value of nutrient concentrations observed in these areas clearly revealed the positive correlation. These observations have indicated that in the south, the nutrients were fully utilized by the phytoplankton for its growth and development while in the north the nutrients were partially utilized by the planktonic algae. The negative correlation especially with the phosphates in the south indicated that phytoplankton is able to meet the requirements for growth and multiplication through inorganic phosphate sources. A positive correlation between chlorophyll 'a' and phosphates has been reported by Balachandran *et al* (1989) from the inshore waters of Cochin while negative correlation was reported between these parameters from the Laccadive Sea during the south west monsoon season (Balachandran *et al.* 1997)

In the present investigation, the highest values of phosphates (1.77 to 2.62  $\mu\text{g}$  at P/l) recorded off Calicut and Kannur, coincided with the low to moderate values of chlorophyll 'a' observed from these regions. The integrated values for column production (0-30m) of chlorophyll 'a' indicated that the pigments are localized in pockets between 10-30m depth contours.



It is also observed that at the edge of the continental shelf, in the Wadge Bank area, there is a zone of high chlorophyll 'a' productivity ( $423 \text{ mg/m}^2$ ) which could probably be due to localized phytoplankton abundance, a common phenomenon found during the post monsoon in the south eastern Arabian Sea.

It was observed that the regions of high concentrations of chlorophyll 'a' are the coastal waters off Goa and Mumbai in the north and Wadge Bank and Cape Comorin area in the south. Integrated values of chlorophyll 'a' (0-75m) indicated that much of the photosynthetic pigments occur below the surface in the southern region. Comparatively higher concentrations of chlorophyll 'a' and 'b' were found to exist between 10 to 30m. Column production of chlorophyll 'a' and 'b' in the entire eastern Arabian Sea during the post monsoon period indicated that the southern region has higher production than the northern region. Recent findings of Pillai *et al.* (2000) also revealed this fact. The findings of Madhupratap *et al.* (2001) further revealed that there is a clear tendency for carnivorous fishes to dominate the Northern region and planktonivorous forms in the southern region. However, according to Radhakrishna *et al.* (1978), the average production in the north eastern Arabian Sea is higher than region is by and large more fertile than the southern region. Recent studies by Balachandran *et al.* (1989, 1997) in the inshore waters of Cochin and Laccadive Sea pointed out the role of photosynthetic pigments as indices of biological productivity in the

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