

PHYTOPLANKTON PIGMENTS AND PRIMARY PRODUCTION AROUND THE OIL FIELDS OFF MAHARASHTRA

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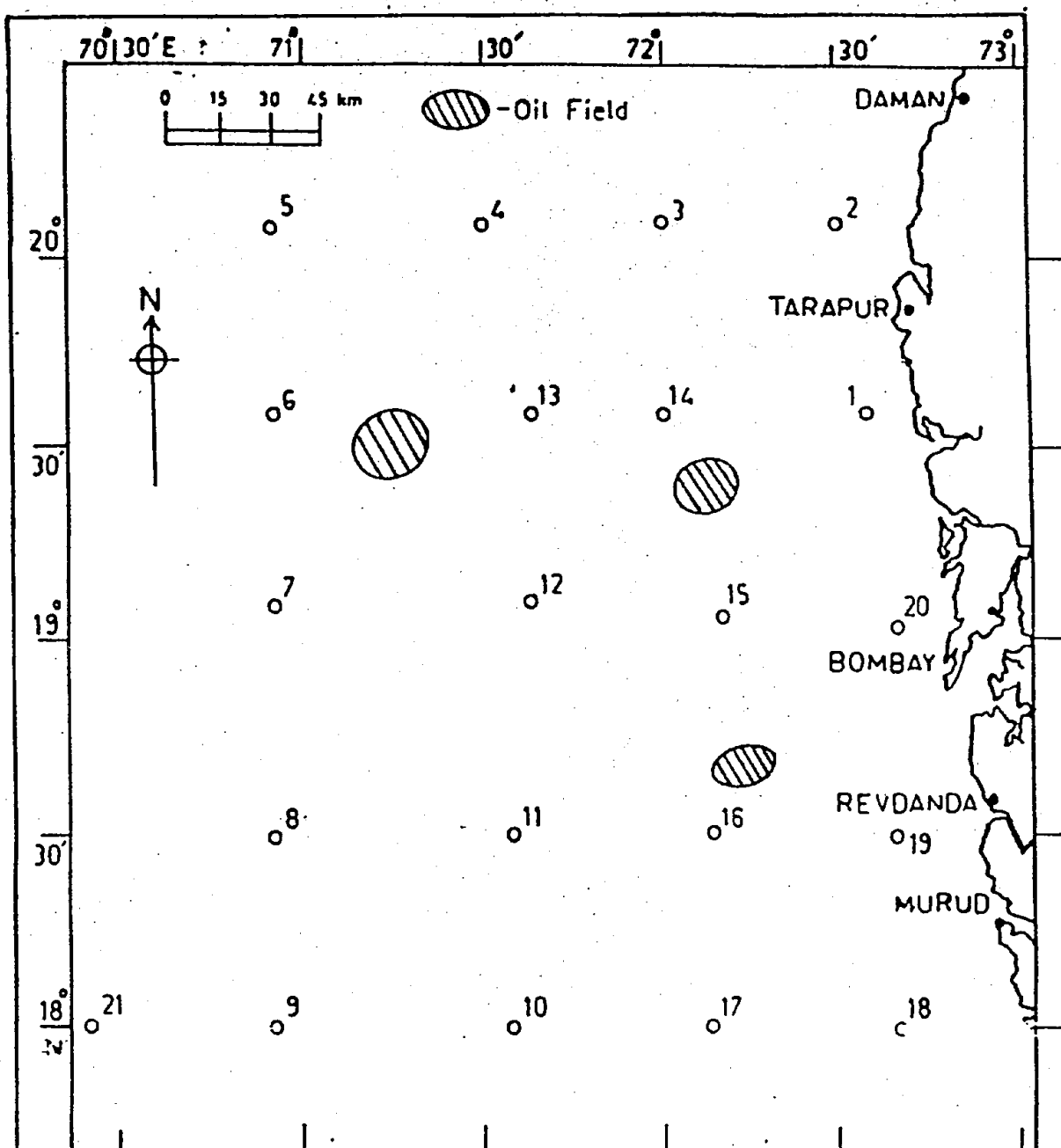
Studies on phytoplankton pigments, primary productivity and particulate organic carbon were made at 21 locations off Bombay and adjacent waters during the 48th cruise of ORV *Sagar Kanya* in December 1988 to January 1989. Variation in chlorophyll *a* at surface was from 0.3 to 48.6 mg m⁻³ whereas at the subsurface the range decreased to 0.3 - 9.1 mg m⁻³. The respective ranges in primary productivity at surface and subsurface were 0.4 - 146.9 and 0.04 - 16.4 mgC m⁻³ day⁻¹. Highest column production (276.8 mgC m⁻² day⁻¹) was recorded in the coastal water off Bombay while lowest rate (12.1 mgC m⁻² day⁻¹) was observed at the outer zone. Particulate organic carbon values were generally high towards the offshore area. The coastal zone was four times more productive than the outer zone and the average values of chlorophyll *a* and primary productivity in these zones were respectively 3.3 & 0.8 mg m⁻³ and 15.3 & 3.2 mgC m⁻³ day⁻¹. Latitudinal variation in primary production revealed decrease in production towards the northern part. The correlations between chlorophyll *a* and primary productivity and chlorophyll *a* and phaeophytin were significant ($P < 0.001$). The ratios of chlorophyll *a* to phaeophytin were fairly high at the stations located away from the oil fields whereas the same decreased noticeably at the stations around the oil fields and coastal waters of Bombay suggesting the unhealthy condition in these areas.

INTRODUCTION

The possible built up of pollutants around the oil fields off the west coast of India has become a matter of great concern. Any change in water quality will have its impact initially on primary productivity and later will be passed on to the successive trophic levels. Contemplating on this assumption an extensive survey on the primary production potential around the oil fields of Heera and Tarapur were conducted during the 48th Cruise of R.V. *Sagar Kanya*. The findings on the primary productivity, phytoplankton pigments along with the particulate organic carbon, are presented in this communication. Apart from the earlier report on the distribution of phytoplankton pigments along the northern Arabian sea (Radhakrishna *et al.*, 1978) covering a few locations off Bombay there is no other information on the subject for the concerned area. Being baseline information on primary production potential around the oil fields the data are useful for future comparison and ecological assessment.

MATERIALS AND METHODS

Sampling was done at 21 locations around the oil fields including the coastal waters off Bombay (Fig. 1). Water samples from 100%, 30% and 1% penetration of light, based on secchi disc reading, were collected from all stations, using a Niskin water sampler, for the estimation of primary productivity, phytoplankton pigments and particulate organic carbon. For the estimation of primary productivity, the samples were collected in black and white D.O. bottles in duplicate. The samples were incubated for 24 hours after injecting 5 μ Ci of $\text{NaH}^{14}\text{CO}_3$ to each samples. Samples were filtered immediately using millipore nitro paper (45 mm diameter & 0.45 μ pore size) and productivity were estimated as per the methods of Vollen Weider (1969) and APHA (1985). Activity was counted on a Rackbeta liquid scintillation counter and primary productivity was calculated in $\text{mg Cm}^{-3} \text{ day}^{-1}$. For the determination of phytoplankton pigments, 500 ml water sample was filtered using Millipore filter paper (47 mm. dia., 0.45 μ pore size). Pigments were estimated in 90% acetone following standard methods (APHA, 1985; Strickland and Parsons 1976). 5 litre water sample was collected for the determination of particulate organic carbon (POC) and estimation was carried out as per the method of Strickland and Parsons (1976).



For interpretation of the results the area of study is divided into coastal zone (long. 72° 30' E to 73°OE), middle zone (long. 71° 30' to 72° 30' E) and outer zone (long. 70° 30' to 71° 30' E) The oil fields are confined mainly in middle zone.

RESULTS AND DISCUSSION

The depth of euphotic zone varied from 9 to 17 m (av. 12.4 m)

Table 1: Levels of particulate organic carbon (average) at different stations

Station	Surface (mg m ⁻³)	Column (g m ⁻²)	IMC* (µg l ⁻¹)	Depth (m)
2	469.01	373.7	373.7	0-20
3	419.33	14.36	478.67	0-30
4	652.84	5.80	483.42	0-12
5	526.15	26.4	528.04	0-30
7	425.79	19.94	375.66	0-60
9	481.43	19.89	284.26	0-70
10	306.84	126.53	335.95	0-250
11	378.59	29.06	484.33	0-60
12	514.22	20.59	411.70	0-50
15	538.32	10.89	476.32	0-30
17	314.49	18.64	266.28	0-70
18	460.56	10.42	347.08	0-30
19	284.19	6.32	315.79	0-20
20	315.94	4.16	346.54	0-12

*Integrated mean concentrations.

along the coastal zone with highest penetration of light at St. 2. Euphotic zone was slightly deeper (9-42 m; av. 15 m) at the middle zone as compared to the coastal zone. The euphotic depth for outer zone ranged between 10 and 28 m. The average euphotic depth (21 m) for this zone indicated the maximum penetration of light might be due to relatively lower suspended load.

Phytoplankton pigments

The observed variation in chlorophyll *a* and phaeophytin were respectively 0.53-24.27 (av 4.49 mg m⁻³) and 0.05-4.64 mg m⁻³ in the coastal zone. Surface chlorophyll *a* at all locations showed higher concentration in the coastal zone off Bombay, Revadanda and Murud, than the outer zone and the trend continued at 30% and 1% of light penetration (Fig. 2 a-c).

Medium level of chlorophyll *a* (0.53-48.59, av. 2.77 mg m⁻³) and phaeophytin (0.04-4.64 mg m⁻³) was confined mostly to the middle zone

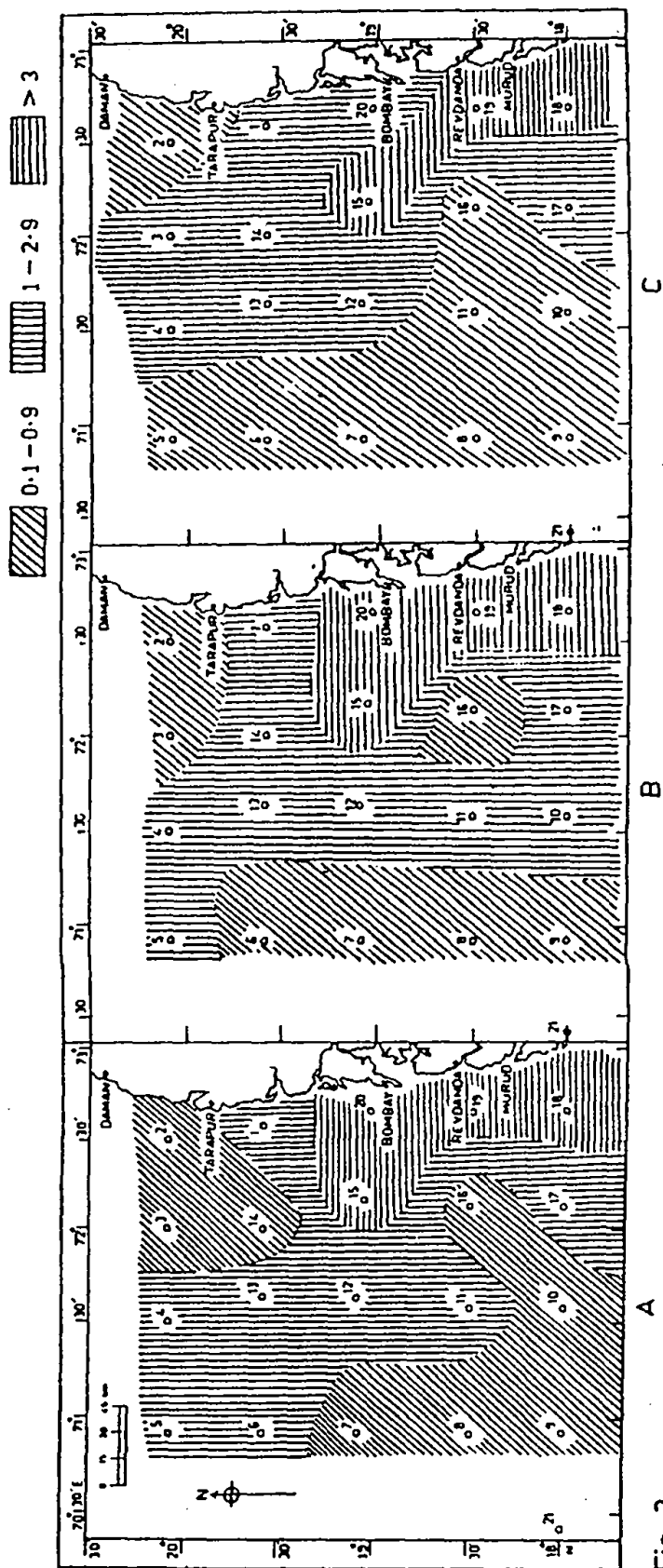


Fig. 2

Table 2: Ratio of chlorophyll *a* to phaeophytin at different light intensities for various locations.

Station	100%	30%	1%
1	0.92	14.54	0.99
2	0.26	2.5	2.5
3	0.31	0.55	21.4
4	66.75	19.45	33.38
5	5.93	1.34	1.34
6	1.95	1.00	1.82
7	1.86	1.43	1.18
8	3.31	3.31	3.31
9	0.77	1.51	1.31
10	3.31	5.33	2.52
11	16.75	20.0	3.38
12	0.99	1.13	0.92
13	1.44	2.28	0.78
14	0.90	2.49	0.94
15	9.06	4.97	5.60
16	2.52	2.52	2.52
17	53.4	8.34	53.4
18	8.92	11.70	6.50
19	8.34	15.24	4.69
20	1.32	1.74	0.41
21	1.44	1.19	0.81

while the lowest concentration of these pigments (0.53-1.6, av. 0.85 mg m⁻³ and 0.16-0.69 mg m⁻³ was seen in the outer zone, might be due to the low level of nutrients at this zone.

The overall average of chlorophyll *a* was 12.32 mg m⁻³ in the coastal waters off Bombay and the average standing crop was estimated to be 825 mg m⁻³ which was around 2 times higher than that of Murud, 7 times higher than Revadanda and 20 times higher than the standing crop recorded for Tarapur coastal waters. Such an excellent concentration of standing crop recorded in the coastal waters off Bombay could be due to the high level of nutrients available into the region. This might be possibly due to the input through wastes disposal and land drainage into the coastal waters off Bombay, though there was no direct correlation between chlorophyll *a* and nutrients.

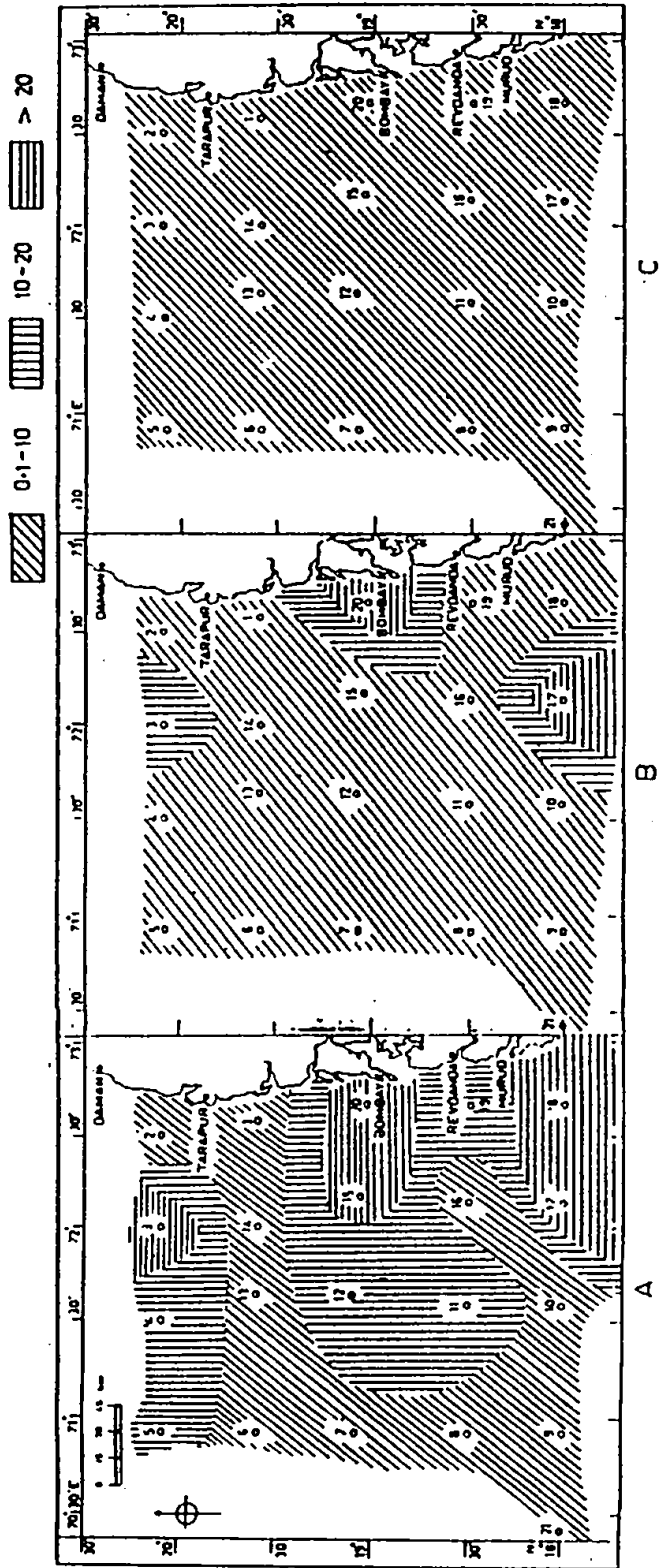


Fig. 3

Earlier reports indicate that in Australian waters relatively high nutrient content did not cause proportionate increases in pigment (Humprey, 1960) while in Indian waters the high population of phytoplankton caused decrease in the level of nutrient salts (Radhakrishna *et al.*, 1978). In the coastal water of Tarapur very low concentration of chlorophyll *a* (0.27 mg m^{-3}) was recorded at St. 2 as compared to the value (1.6 mg m^{-3}) observed towards offshore at St. 5. The concentration of nutrients showed a reverse trend at these stations indicating the utilisation of nutrients as evidenced by the negative correlation between chlorophyll *a* and NO_3 and chlorophyll *a* and PO_4 (Table 3). The present result was similar to the findings of Bhattathiri and Radhakrishna (1980) for Bay of Bengal and Jacob *et al.* (1980) for Kuwaiti waters.

However, very low values (av. 0.53 mg m^{-3}) of chlorophyll *a* recorded near oil fields (Stns 14 and 16) could be due to unfavourable environmental conditions.

In general, the values of phaeophytin were higher at subsurface than the values of surface at all stations. This could be due to the fact that dead cells and cell debris settle down at the bottom resulting on higher level of phaeophytin. The ratios of chlorophyll *a*/phaeophytin were almost higher than 1 except at the stations near Tarapur coastal waters (Sts. 1, 2, 3, 14). These stations exhibited higher level of phaeophytin than chlorophyll *a* indicating an unhealthy condition of phytoplankton cells. These ratios of two pigments were comparatively lower in the coastal zone than outer zone which can be associated with the high suspended load in the coastal water zone. Same trend was also recorded by Ram (1985) and Jacob & Zarba (1981). Very often high values of chlorophyll *a*/phaeophytin recorded at 1% light penetration, associated with low column values of particulate organic carbon and vice versa (Table - 1 & 2) can be attributed to the accumulation of dead cells. Fairly high values (16.75 - 66.75) of the ratios of these pigments recorded in the middle zone at Sts. 4, 11 & 17 in the entire water column indicated much higher concentration of chlorophyll *a*, than phaeophytin.

Particulate organic carbon

The distribution pattern of particulate organic carbon (POC) at the

surface indicated limited variations between stations (Table 1). However, outer zone and off Bombay exhibited relatively higher level of POC than other area. Column level of POC showed wide variations (Table -1). Highest column value (373.7 g m^{-2}) of POC was observed in the coastal waters of Tarapur whereas highest surface POC value (652.84 mg m^{-3}) was recorded in the offshore waters of Tarapur. The observed concentration of POC was much higher than that recorded for Bay of Bengal (Bhattathiri *et al.*, 1980).

Primary productivity

The wide variations in primary productivity observed at the surface ($0.18\text{-}146.91 \text{ mg C m}^{-3} \text{ day}^{-1}$) was much higher than that noticed at 1% light penetration ($0.05\text{-}16.35 \text{ mg C m}^{-3} \text{ day}^{-1}$, Fig 3). This clearly indicated that light energy was one of the main responsible factors controlling the primary productivity. There was well defined difference in production at different zones. Coastal zone revealed comparatively much higher concentration (av. $30.82 \text{ mg C m}^{-3} \text{ day}^{-1}$) of primary productivity at surface compared to middle zone) av. $17.93 \text{ mg C m}^{-3}$) and outer zone ($7.06 \text{ mg C m}^{-3} \text{ day}^{-1}$, (Fig. 3a). The relatively higher level of nutrients available in the coastal zone which might have promoted the growth of phytoplankton resulting higher level of primary productivity in the coastal zone.

This was still discernible in the coastal waters off Bombay where highest level of primary productivity (av. $78.43 \text{ mg C m}^{-3} \text{ day}^{-1}$) was recorded at stn. 20, and second maximum ($53.9 \text{ mg C m}^{-3} \text{ day}^{-1}$) was towards south of Murud at Stn. 18. However, off Bombay maintained maximum production level even at 30% light intensity as observed at Stn. 20 (Fig. 3b) and second peak at Stn. 17 towards south of Murud. Other zones showed low level of production. At 1% intensity of light, maximum production was observed again at Stn. 17 (Fig 3c). Though there was no direct correlation between primary productivity and nutrients, the overall higher level of nutrients recorded in the coastal waters of Bombay and Murud could be the reason for high production. Comparatively much lesser production recorded along the offshore waters could be due to the lower level of nutrients available, (NIO, 1990). The results in the present study are comparable to the findings of Bhattathiri and Radhakrishna (1980) for the Bay of Bengal. Column production also revealed wide variation from $7.62 \text{ mg C m}^{-2} \text{ day}^{-1}$ to $276.8 \text{ mg C m}^{-2} \text{ day}^{-1}$ at stns 12, 15 & 20 in the coastal waters off Bombay and stns

Table 3: Correlation between chlorophyll *a*, phaeophytin and various environmental parameters.

	Chloro- phyll <i>a</i>	DO	NH ₄	NO ₂	NO ₃	pH	Phaeo- phytin	PO ₄	Primary Production	S% _∞
Chlorophyll <i>a</i>	1.0000									
DO	0.2079	1.0000								
NH ₄	0.0408	-0.0333	1.0000							
NO ₂	0.1593	-0.1284	0.4623*	1.0000						
NO ₃	-0.0649	-0.1988	0.3106	0.5290**	1.0000					
pH	0.0340	-0.0201	-0.3156	-0.3894	-0.4558*	1.0000				
Phaeophytin	0.6226**	0.0397	-0.0849	0.0868	0.0530	-0.0263	1.0000			
PO ₄	-0.0499	-0.0781	0.4429*	0.5507**	0.8954***	-0.5874**	0.0918	1.0000		
Primary Production	0.8620***	0.2064	0.1821	0.3250	-0.0124	-0.1341	0.6233**	0.0157	1.0000	
S% _∞	-0.2037	-0.2273	0.0891	-0.1304	0.3715	0.0637	-0.0757	0.2050	-0.2651	1.0000

* P .05

** P .01

*** P .001

17 & 18 in the coastal waters towards south of Murud; and indicated fairly high values of column production in the entire water column for this region.

Invariably productivity was high in the coastal zone as compared to the middle zone and outer zone (Fig. 3 a-c) and the observed ratio of production in the respective order of these zones was 5:3:1. The standing crop in terms of chlorophyll *a* showed comparable ratio of 4:3:1 - for the coastal, middle and outer zones. There was well defined decrease in production from day south of lat 19° (av. 9.95 mgC m⁻³ day⁻¹) to north of lat. 19° (av. 6.12 mgC m⁻³ day⁻¹). The correlation between phytoplankton pigments, primary productivity and nutrients (Table 3), did not indicate significant correlation between phytoplankton pigments, primary productivity and nutrients (Table 3), did not indicate significant correlation between primary productivity and nutrients, and between chlorophyll and nutrients. Highly significant correlation between primary productivity and chlorophyll *a* was recorded at .001 level and the correlation between primary productivity and phaeophytin was significant at level of .01.

Even though there was no distinct variability between zones around the oil fields and other areas the ratios of chlorophyll *a* to phaeophytin showed differences. The observed ratio around the oil field was relatively low (av. 1.47) as compared to that of other zone (av. 10.33). Increase in phaeophytin leading to proportionate low ratios of chlorophyll *a* to phaeophytin indicated an unhealthy situation. Probably repeated monitoring of the area and comparison with the present baseline data may provide more authentic information.

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