

## PRIMARY PRODUCTION IN THE BAY OF BENGAL DURING AUGUST 1977

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Primary production, chlorophyll *a*, phaeophytin, phytoplankton and particulate organic carbon (POC) were studied at 14 stations in the Bay of Bengal during August 1977. Column primary production, chlorophyll *a*, and phaeopigments varied from 0.14 to 5.59 g C/m<sup>2</sup>/day, 2.1 to 23.6 mg/m<sup>2</sup> and 1.9 to 15.73 mg/m<sup>2</sup> respectively. Column concentration of POC varied from 2.57 to 10.49 g/m<sup>2</sup>. A mixed diatom bloom located at station 657 comprised mainly of *Thalassiosira subtilis*, followed by *Skeletonema costatum*, *Thalassiothrix* sp., *Navicula* spp. and *Coscinodiscus* spp. The diatom concentrations at surface and 5 m were  $3.6 \times 10^5$  and  $4.5 \times 10^5$  cells/l, where *T. subtilis* contributed 3.3 and  $3.6 \times 10^5$  cells/l.

*Key-words* : Primary production, chlorophyll. Bay of Bengal, diatom bloom.

Primary production, chlorophyll *a*, phaeopigments and particulate organic carbon were measured during two cruises of RV *Gayeshani* during August 1977 in the Bay of Bengal. Information available on these aspects for this season is only from those studies of Chalapati Rao and Rao (1975), Radhakrishna (1978) and Radhakrishna, Bhattathiri and Devassy (1978). This communication presents studies on primary production and related parameters in 14 stations situated between 15° and 20°20' N and 80°45' and 89°00' E.

Water samples were collected from 5 depths of 100%, 60%, 30%, 16% and 1% of the incident light. Primary production was measured by <sup>14</sup>C method; and samples were incubated for 24 hours under simulated *in situ* conditions. Chlorophyll *a* was measured by a Turner Fluorometer and particulate organic carbon (POC) by wet acid digestion and colorimetry (Strickland and Parsons, 1968). Phaeophytin correction was applied to chlorophyll *a*.

At the head of the Bay, surface salinity was around 30‰, and about 18‰ at the river mouths of the Krishna and Godavari.

PO<sub>4</sub>-P varied from 0.16 to 0.63 µg at/l at the surface, while NO<sub>3</sub>-N was undetectable. NO<sub>2</sub>-N was either not detectable or almost zero and NH<sub>4</sub>-N varied from 0 to 3.83 µg at/l. At 50 m the corresponding values varied from 0.16 to 1.52, 0 to 11.37, 0 to 0.75 and 0 to 2.77 µg at/l.

The data on primary production, chlorophyll *a*, phaeopigments and POC at the surface and in the euphotic column are given in Table I. Primary production at the surface varied widely from 2.0 to 495.3 mg C/m<sup>3</sup>/day and in the column from 0.14 to 5.59 g C/m<sup>2</sup>/day. It is interesting to note that at 3 stations situated well offshore along 19° 31' N latitude, column productivity was high ( $\geq 1$  g C/m<sup>2</sup>/day). At the farthest station (657) along this

transect the column productivity reached a record high of 5.59 g C/m<sup>2</sup>/day. This is primarily due to a diatom bloom encountered there. As a result of this bloom, the productivity at the surface was 495.3 mg C/m<sup>3</sup>/day and at the 60% light depth 400.4 mg C/m<sup>3</sup>/day (Table II). At station 650 off False Point near the Mahanadi river mouth and at station 685 situated near the Godavari river mouth, production was high (Table I). Average values of primary production for the inshore, offshore and the entire region were 0.98, 0.57 and 0.64 g C/m<sup>2</sup>/day respectively. The values for corresponding regions during August 1976 (Radhakrishna, Bhattathiri and Devassy, 1978) were 0.295, 0.265 and 0.275 g C/m<sup>2</sup>/day respectively.

Chlorophyll *a* at the surface and in column varied from 0.03 to 1.04 mg/m<sup>3</sup> and 2.1 to 23.6 mg/m<sup>2</sup> respectively (Table I). In general, the values were low except at station 657 where chlorophyll *a* was very high due to the diatom bloom. At this station high chlorophyll *a* values > 1 mg/m<sup>3</sup> were observed upto the 60% light depth (Table II).

The mean phaeophytin concentrations from all stations showed a distinct increase with depth from 0.01 to 0.04 mg/m<sup>3</sup> from surface (upto 30% light depth). The mean concentration at the 16% light depth was 0.035 mg/m<sup>3</sup> and at the 1% light depth was 0.07 mg/m<sup>3</sup>. This would indicate that phaeopigment concentrations increased inversely proportional to the decrease in light intensity and that at the lower limit of euphotic zone the proportion of detrital chlorophyll was relatively higher than in the upper layers.

Table I. Values of primary productivity (PP), Chlorophyll *a*, phaeopigments (Phaeo.) and particulate organic carbon (POC) at different stations in Bay of Bengal.

Stn. No.	Latitude N	Longitude E	Date	SURFACE				EUPHOTIC COLUMN			
				pp mgC/m <sup>3</sup> /day	chl- <i>a</i> mg/m <sup>3</sup>	Phaeo. mg/m <sup>3</sup>	POC mg/m <sup>3</sup>	pp gC/m <sup>2</sup> /day	chl <i>a</i> mg/m <sup>2</sup>	Phaeo mg/m <sup>2</sup>	POC g/m <sup>2</sup>
650	20°20'	87°36'	31.7.77	37.7	0.64	0.13	—	1.19	18.89	7.06	—
652	19°31'	87°00'	01.8.77	8.7	0.27	0.09	—	1.00	23.60	6.83	—
655	19°30'	87°38'	01.8.77	84.6	0.25	0.11	—	1.00	5.30	5.98	—
657	19°30'	89°00'	02.8.77	495.3	1.04	0.31	—	5.59	23.18	15.73	—
665	17°00'	83°02'	23.8.77	2.0	0.03	0.04	62	0.14	2.11	1.97	4.9
667	17°00'	84°00'	23.8.77	9.4	0.03	0.04	33	0.34	2.86	2.52	5.9
669	17°15'	84°58'	24.8.77	13.0	0.04	0.02	50	0.50	4.03	3.98	7.2
671	17°00'	86°00'	24.8.77	12.0	0.03	0.02	25	0.30	2.12	1.70	2.6
673	17°00'	87°00'	25.8.77	13.9	0.03	0.01	62	0.54	2.22	2.50	10.5
675	17°00'	88°00'	25.8.77	14.6	0.03	0.01	83	0.39	3.50	2.28	6.7
676	15°00'	86°00'	26.8.77	19.7	0.08	0.01	106	0.98	4.32	2.06	9.6
678	15°30'	81°00'	01.9.77	9.4	0.06	0.07	47	0.54	4.67	4.12	8.2
680	15°30'	80°45'	01.9.77	—	0.12	0.08	—	—	7.05	6.30	—
685	16°16'	81°57'	02.9.77	31.4	0.30	0.06	123	0.78	6.89	1.19	5.2

The distribution of particulate organic carbon at the surface varied from 25 to 123 mg/m<sup>3</sup> and for the column from 2.6 to 10.5 g/m<sup>2</sup>. The distribution of POC in the column did not show any marked trend although the concentration at the surface was low, at the subsurface it was higher, the highest being at 60% light depth. At 1% light depth the concentration varied from 33 to 187 mg/m<sup>3</sup> in the study area. The highest surface value of 123 mg/m<sup>3</sup> was discerned at station 685 near the Godavari river mouth. In the surface waters off Waltair (Bay of Bengal) Chalapati Rao and Rao (1975) observed high POC in August (144 mg/m<sup>3</sup>).

The horizontal and vertical distribution of these four parameters at 6 selected stations along 17° 03' N latitude are given in Table III. At station 665 closest to the shore, surface primary production was < 5 mg C/m<sup>3</sup>/day at all the depths. Primary production was found to be maximum at the 60% light depth at stations 665 and 667, below which it declines rapidly. POC was relatively low at the surface.

The present observation that primary production was maximum at 60% light depth at many stations and not at the surface is in contrast to the observations of Radhakrishna (1978). The lower primary production at the surface could be due to the fact that during the period under investigation the insolation at the surface was high enough to cause photo-inhibition and the optimum intensity was around 60% depth resulting in higher primary production at that depth.

A dense diatom bloom was observed at station 657. The various phytoplankton groups encountered here and the parameters recorded are given in Table II and the nutrient data in Table IV. The bloom was mainly concentrated at the upper 5 m column and consisted of *Thalassiosira subtilis*, *Skeletonema costatum*, *Thalassiothrix* sp., *Navicula* spp. and *Coscinodiscus* spp. *Thalassiosira subtilis* was the dominant organism which alone contributed 75.2%, 88.1%, 69%, 56% and 27% respectively to the total phytoplankton

Table II. Depthwise distribution of various parameters at station 657.

Depth m	chl a mg/m <sup>3</sup>	Phaeo. mg/m <sup>3</sup>	PP mg C/m <sup>3</sup> /day	Diatoms	Dino- flagel- lates	Flagel- lates (Cells per litre)	Silico- flagel- lates	Total phyto- plankton	<i>T. subtilis</i>
0	1.04	0.31	495.3	448400	6300	25900	350	480950	361900
5	1.00	0.43	400.4	361200	1800	15000	0	378000	333000
15	—	—	53.8	60600	900	7200	0	68700	47400
30	0.11	0.20	15.6	8700	1200	1800	0	11700	6600
70	0.10	0.10	12.4	3900	1500	1200	0	6600	1800
	mg/m <sup>2</sup>		gC m <sup>2</sup> /day						
Column	23.18	15.73	5.59						

Table III. Vertical distribution of primary production ( $\text{mgC}/\text{m}^3/\text{d}$ ), chlorophyll *a* ( $\text{mg}/\text{m}^3$ ), phaeopigments ( $\text{mg}/\text{m}^3$ ) and particulate organic carbon ( $\text{mg}/\text{m}^3$ ) at various light depths on a section along  $17^\circ 00' \text{N}$  latitude.

Stn.	Light depth %	PP.	Chl. a	Phaeo.	P.O.C.
665	100	2.04	0.031	0.04	62
	60	4.45	0.032	0.04	112
	30	2.29	0.042	0.03	94
	16	3.66	0.037	0.04	75
	1	2.20	0.071	0.06	168
667	100	9.37	0.027	0.04	33
	60	15.0	0.031	0.06	116
	30	8.79	0.035	0.03	66
	16	7.53	0.044	0.03	198
	1	3.15	0.128	0.11	99
669	100	13.0	0.035	0.02	50
	60	12.23	0.025	0.03	116
	30	9.72	0.035	0.03	116
	16	7.46	0.085	0.07	132
	1	2.46	0.039	0.07	33
671	100	11.99	0.032	0.02	25
	60	11.65	0.026	0.02	158
	30	8.16	0.020	0.02	83
	16	5.28	0.048	0.04	17
	1	3.19	0.048	0.04	50
673	100	13.88	0.032	0.01	62
	60	9.06	0.025	0.03	176
	30	9.73	0.034	0.04	141
	16	8.70	0.026	0.02	132
	1	3.78	0.037	0.06	187
675	100	14.57	0.029	0.01	83
	60	10.46	0.032	0.02	231
	30	10.31	0.032	0.02	198
	16	6.52	0.037	0.01	116
	1	6.28	0.152	0.12	99

Table IV. Concentration of different nutrients ( $\mu\text{g at/l}$ ) with depth at station 657 where a mixed diatom bloom was observed.

Depth m	$\text{PO}_4\text{-P}$	$\text{NO}_3\text{-N}$	$\text{NO}_2\text{-N}$	$\text{NH}_4\text{-N}$
0	0.31	0.23	0.22	3.86
10	0.16	0.76	0.31	0.19
20	0.21	0.66	0.55	0.06
30	0.31	0	0.06	5.02
50	0.52	5.95	0.44	1.83
75	1.52	16.45	0.40	2.99

at the corresponding light depths of 100, 60, 30, 16 and 1%. Flagellates were second in the order of abundance followed by dinoflagellates. Below 5 m level the effect of the bloom was not felt. Although *T. subtilis* was maximum at the surface it made up only 75.2% of the total phytoplankton. This was due to the presence of other diatoms also at the surface. At 60% light depth *T. subtilis* contributed 88.1% of the total phytoplankton though their number was less than that at the 100% light level. Relatively higher column primary production (5.59 g C/m<sup>2</sup>/day) and chlorophyll *a* (23.18 mg/m<sup>2</sup>) were recorded at this station (Table I).

The physiological state of the bloom as evidenced by the phaeophytin values showed active phase. Observation of a phytoplankton bloom associated with zooplankton swarm from Bay of Bengal was reported by Madhupratap, Devassy, Sreekumaran Nair and Rao (1980). During this bloom the dominant organisms were again diatoms, viz., *Chaetoceros lorenzianus*, *Chaetoceros* spp., *Nitzschia seriata*, *Rhizosolenia styliformis*, *Rhizosolenia* spp. which was of the magnitude of 1–3 × 10<sup>5</sup> cells/l at various light depths in contrast to the 3.6–4.5 × 10<sup>5</sup> cells/l reported here. Earlier, Subba Rao (1969) working on a diatom bloom from Bay of Bengal recorded a maximum concentration of 93.2 × 10<sup>6</sup> cells/l of *Asterionella japonica* which was concentrated in the upper 10 m column.

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