

Primary Productivity of the Andaman Sea

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Received 15 December 1980; revised received 3 April 1981

The average surface and column primary productivity, chl *a* and particulate organic carbon, estimated at 24 stations during Feb. 1979, were respectively 5.3 mg C/m³/d and 273 mg C/m²/d; 0.03 mg/m³ and 3.64 mg/m²; and 132 mg/m³ and 4.59 g/m². The corresponding values during Jan. 1980 were 12.4 mg C/m³/d and 431 mg C/m²/d; 0.02 mg/m³ and 2.33 mg/m²; and 306 mg/m³ and 16.4 g/m². Chlorophyll *a* alone was greater in Feb. 1979 than in Jan. 1980. *Navicula* spp. *Peridinium* spp. *Trichodesmium thiebautii* and flagellates were abundant. Turnover rates of phytoplankton were estimated. Variations in the phytoplankton carbon, zooplankton carbon and detrital carbon were discussed.

Andaman Sea is one of the least explored regions of the Indian Ocean. Certain aspects of chemical, biological and physical oceanography were studied during the International Indian Ocean Expedition¹⁻⁴. This communication presents data obtained during 51 and 52 cruises (Feb. 1979) and 66 to 68 cruises (Jan. 1980) of *R V Gveshani*.

Materials and Methods

The stations from where observations were made are shown in Fig. 1 (A & B). Water samples were collected from surface and 4 other depths where the light levels were 60, 30, 16 and 1% of that at the surface. ¹⁴C incubations were carried out with 125 ml of sample to which 5 μCi of radioactive carbon was added. Samples in light were incubated for 24 hr under simulated *in situ* conditions using neutral density nylon filters⁵. Samples in dark bottles were filtered immediately after the addition of ¹⁴C. Samples were filtered onto a Sartorius membrane filter paper (0.45 μm porosity), dried and counted in a scintillation counting system using either 15 ml (during 1979) or 5 ml (during 1980) scintillation cocktail (NE 220). Chlorophyll *a* (chl *a*) was measured by fluorometry (during 1979) or spectrophotometry (during 1980). All values were corrected for phaeopigments. For the estimation of chl *a* from nanoplankton, samples were passed through a 20 μm net before filtration. Particulate organic carbon (POC) was measured by wet acid digestion and spectrophotometry⁶.

Results and Discussion

Primary productivity, chl *a* and POC values for Feb. 1979 and Jan. 1980 are given in Table 1. Variation in both surface and column productivity as well as POC was greater during the latter period. The average values were also higher. But chl *a* was less during Jan. 1980.

The phytoplankton population was mostly constituted by *Navicula* spp, *Peridinium* spp and *Trichodesmium thiebautii*. Flagellates dominated the population. Dinoflagellates formed an important constituent of phytoplankton in the Andaman Sea.

Environmental features—Salinity in the southern Andaman Sea (below 9°N) varied from 32 to 33‰ at the surface during Feb. 1979. Along 10°N channel salinity was about 32‰. On the eastern side of the north Andaman, salinity varied from 31.64 to 32‰ at the surface. It was higher on the western side as compared to eastern side. σ_t values in the upper 50 m were between 19.27 and 22.27. At 75 and 100 m depths of different stations σ_t values varied from 21.97 to 23.86 and 22.47 to 25.49 respectively.

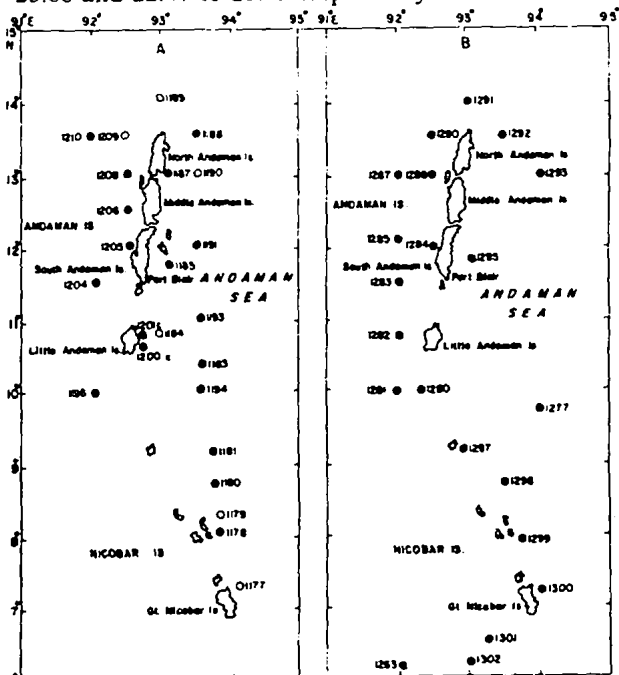


Fig. 1 - Location of stations [A, Feb. 1979 and B, Jan. 1980. ●, PP, chl *a* and POC; ○, chl *a* and POC]

Table 1—Primary Production (PP), Chlorophyll *a* and Particulate Organic Carbon (POC) of the Andaman Sea during Feb. 1979 and Jan. 1980

St No.	Surface			Column			
	PP (mg C/m ³ /day)	Chl <i>a</i> mg/m ³		PP (mg C/m ² /day)	Chl <i>a</i> mg/m ²		POC (g/m ²)
		Whole plankton	Nanno-plankton		Whole plankton	Nanno-plankton	
Feb. 1979							
1177		0.10			9.58		
1178	9.7	0.04		60	268	2.86	5.63
1179		0.05				11.00	
1180	8.0	0.01		90	445	0.43	0.77
1181	6.0	0		0	495	1.48	0
1183	4.9	0.02	0.02	0	242	3.64	2.36
1184		0.03	0.03	60		1.95	1.63
1185	9.3	0.06	0.05	30	183	2.11	0.98
1187	7.7	0.03	0.03	60	302	3.79	3.68
1188	3.1	0.02	0.02	0	167	2.67	2.18
1189		0.02	0.01	60		2.10	2.85
1190		0.04	0.03	465		8.63	8.44
1191	2.5	0.03	0.02	285	229	3.03	1.22
1193	3.7	0.02	0.01	90	188	1.95	5.03
1194	2.9	0.03	0.02	90	157	3.88	5.48
1196	5.1	0.05	0.04	180	359	3.62	13.19
1200C	3.6	0.03	0.02	120	309	5.26	2.60
1201C	5.4	0.05	0.05	120	140	2.71	3.33
1204	5.5	0.02	0.02	180	227	1.83	11.91
1205	7.4	0.02	0.02	240	291	3.76	5.10
1206	4.0	0.04	0.04	390	615	2.84	6.23
1208	4.9	0.05	0.03	150	192	4.05	3.98
1209		0.02	0.01	150		2.46	8.85
1210	1.3	0.03	0.01	90	120	1.62	5.48
Average	5.3	0.03		132	273	3.64	4.59
Jan. 1980							
1263	4.6	0		108	360	0	9.24
1277	6.3	0.02		192	232	3.32	14.05
1280	3.8	0		192	229	3.75	10.03
1281	7.0	0.08		468	433	2.30	19.69
1282	7.6	0.03		384	317	2.70	21.65
1283	3.3	0		336	196	4.71	21.14
1284	19.7	0.06		324	498	4.76	18.71
1285	4.5	0		384	242	2.15	19.88
1287	8.2	0.08		312	273	0.56	17.62
1288	67.0	0.07		372	1218	9.01	16.96
1290	7.3	0		324	338	0	16.25
1291	39.5	0		228	1044	3.60	16.25
1292	11.7	0		240	469	2.26	14.59
1293	11.3	0.03		408	368	2.38	25.69
1295	17.3	0		348	566	0.47	19.98
1297	4.3	0.04		336	252	0.48	15.20
1298	2.8	0.03		276	250	2.33	8.22
1299	11.7	0		216	526	0.95	8.53
1300	11.1	0		336	453	1.14	21.36
1301		0.01		384	431	2.01	19.34
1302		0.01		144	255	0.04	7.19
Average	12.4	0.02		306	431	2.33	16.40

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Table 2 gives the integral mean values of inorganic nutrients⁷. At most of the stations nitrite-nitrogen was zero at surface as well as subsurface levels.

Sea water was supersaturated with O₂ at the surface and few metres below at most of the stations on the eastern Andaman Sea. But on the western side supersaturation with O₂ was observed even up to 50 m.

The surface temperature of the Andaman Sea remains near 28°C throughout the year. Mixed layer is shallowest during Jan/Feb and varies from 25 - 30 m⁸. Since the Andaman Sea is a confined physiographic basin, flow to open-ocean areas of Bay of Bengal occurs through the channels around and between Andaman and Nicobar Islands. During January to April the flow through Malacca Strait is northwestern and the strongest. The surface circulation is controlled by the monsoon system of the northern Indian Ocean. During January to April anticyclonic circulation is established in Bay of Bengal and Andaman Sea. Circulation pattern reported earlier indicated the flow of water from Bay of Bengal to Andaman Sea through the Preparis Channel⁸. This southward flow leaves the Andaman Sea near 10°N channel. The flow is increased further due to the westerly current originating from Malacca Strait. Ramesh Babu and Sastry⁴ have reported that basically the flow consists of cells (cyclonic and anticyclonic of 100 - 200 km size) which eventually lead to upwelling and sinking. Maslennikov³ has earlier reported the occurrence of cyclonic and anticyclonic cells in the Andaman Sea.

The surface primary productivity varied from 1.3 to 9.7 and 2.8 to 67 mg C/m³/day during Feb. 1979 and Jan. 1980. Similar measurements during March/April 1963 showed that productivity (mg/C/m³/day) varied from 0 to 3.40⁹. The values of productivity during 1963 were probably low due to the fact that dark bottles were incubated for 24 hr before filtration. The average productivity values during the 3 periods were 5.3, 12.4 and 2.4 mg C/m³/day respectively. The column productivity values varied from 120 to 615 and 196 to 1218 mg C/m²/day during 1979 and 1980. During 1963 the values were between 10 and 270 mg C/m²/day. Thus the respective average productivity was 273, 431 and 135 mg C/m²/day. The above values indicate that the productivity was maximum during 1980. Kabanova¹⁰ has found productivity at 2 stations (33rd cruise of *Vityaz*, sts 4964 and 4979) in central Andaman Sea to be 114 and 177 mg C/m²/day when the phosphate-phosphorus was zero and nitrate-nitrogen was between 1.5 and 2 µg-at/litre in the euphotic column. Table 3 gives the variation in the productivity of Andaman Sea and that of Arabian Sea and Bay of Bengal for comparison.

The values of chl *a* at the surface during 1979 and 1980 were in the same range as found during an earlier observation in 1963⁹. The variation in column chl *a* was similar to those (2 - 14 mg/m²) reported⁹. During 1963 chl *a* values would have been still lower if correction for phaeopigments would have been applied.

Table 2—Integral Mean Concentrations of Nutrients in the Andaman Sea during Feb. 1979 and Jan. 1980

[Values are given in µg-at/litre]

Column depth (m)	PO ₄ -P		NO ₃ -N		NH ₄ -N	
	Feb.	Jan.	Feb.	Jan.	Feb.	Jan.
50	0.17-0.54	0.03-0.40	0	0-0.76	0.39-3.82	0-3.6
75	0.20-1.45	0.09-0.39	0.41-6.51	0.03-1.15	0.49-3.64	0-3.2
100	0.38-1.63	0.19-0.88	2.32-9.53	0.19-6.62	0.41-4.52	0-2.6

Table 3—Primary Productivity (mg C/m²/day) of the Andaman Sea

[For comparison values reported for other areas of Arabian Sea and Bay of Bengal are included]

Region and Season	Primary productivity		Region and Season	Primary productivity	
	Range	Av.		Range	Av.
Andaman Sea ⁹			Arabian Sea ^{15,16}		
March/April 1963	10-270	135	Northern/Dec. 1973 to May 1974	109-2666	698
Feb. 1979	120-615	273	North-eastern Nov. 1976	100-312	216
Jan. 1980	196-1218	431			
Bay of Bengal ¹⁷⁻¹⁹			Laccadive Sea ¹⁴		
Aug./Sept. 1976	49-606	275	Oct. 1976	22-359	134
Aug. 1977	139-1138	641	Dec. 1976	45-1167	358
Aug./Sept. 1978	116-3408	983	March/April 1978	254-829	372

Table 4—Particulate Organic Carbon (POC), Phytoplankton Carbon, Zooplankton Carbon and Detrital Carbon in the Andaman and Laccadive Sea

[Average values are given in parenthesis. Values are expressed in mg/m²]

	POC	Phytoplankton carbon	Zooplankton carbon	Detrital carbon
Andaman Sea				
Feb. 1979	975-17535 (7302)	30-432 (225)	108-648 (290)	761-17137 (6787)
Jan. 1980	7190-25690 (16400)	0-451 (127)	360-1440 (905)	6285-24610 (15368)
Laccadive Sea ¹⁴				
Oct. 1976	2045-33200 (17425)	45-605 (308)	104-871 (365)	1900-32400 (16752)
Dec. 1976	1969-14754 (7194)	192-943 (530)	60-2040 (376)	1145-13945 (6288)
March/April 1978	1546-6155 (3603)	83-770 (303)	75-672 (368)	984-5704 (2932)

POC values observed during Jan. 1980 were higher than those found during Feb. 1979 both at the surface and column. Rao and Rao¹¹ have reported that POC values at the surface varied from 24 to 120 mg/m³ except few higher values near the Burmese coast. Along this coast POC values vary from 35 to 238 mg/m³.

During Jan. 1980 the zooplankton biomass (ml/m²) was much higher (av. 30) than that during Feb. 1979 (av. 9.1). During March/April 1963 the zooplankton biomass was between 2 and 25 ml/m² (av. 10.7)¹². Zooplankton biomass values found during 6th cruise of *INS Kistna* (Feb/March 1963) were between 0.5 and 4 ml/m² (av. 2.5). But during April 1964 the biomass was within 7.5 and 41 ml/m² (av. 19.1)¹². From the above it becomes clear that the higher average zooplankton biomass was found during Jan. 1980.

In general, the oxygen level on the eastern side of Andaman Sea was less than that of the western side. On the eastern side O₂ concentration at 50 m was less than 4 ml/litre near the islands but was between 4.5 and 4.7 ml/litre along long. 93°30'E. Garg *et al.*¹ found that in a section along long. 95°E and between lat. 09°30'N and 15°N, O₂ concentration in the upper layers during Feb/March 1963 was above 4.5 ml/litre. It was also found that the thickness of the layer with O₂ concentration >4 ml/litre increased from 35m in the northern end to 80 m at 11°N and then decreased southwards. Ramesh Babu and Sastry found similar results by analysing the O₂ data collected during Feb/March 1963 on board *R V Semano*⁴.

It is known that the particulate material in the sea consists of living and nonliving materials. Hence it is possible to estimate the detrital carbon in POC using appropriate factor for converting chl *a* and the zooplankton biomass into carbon equivalents; 1 mg

chl *a* is considered equivalent to 50 mg C and 1 g wet weight of zooplankton to 30 mg C¹³. Both chl *a* and POC have been computed for 100 m column and zooplankton for 200 m column. In shallow waters the entire column was considered. Table 4 shows the variation in POC, phytoplankton carbon, zooplankton carbon and the detrital carbon along with the respective averages. For comparison similar values obtained from Laccadive region have also been included¹⁴. Except phytoplankton carbon, all other carbon values were higher during Jan. 1980. However, these values were within the same range as found in the Laccadive region for different seasons. The percentage of detrital carbon in POC showed variation from 64 to 98 (av. 87) in 1979 and 91 to 97 (av. 94) in 1980. In the Laccadive Sea similar values varied from 81 to 96% at different seasons.

Acknowledgement

The authors are grateful to Dr S Z Qasim, former Director, NIO, and Dr T S S Rao, Head, Biological Oceanography Division, for criticism.

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