

DIURNAL VARIATION OF PHYTOPLANKTON PIGMENTS AND POPULATION IN THE NEARSHORE WATERS OFF THAL (MAHARASHTRA)

M. JIYALAL RAM, B.N. DESAI AND S.A.H. ABIDI
Regional Centre of National Institute of Oceanography,
Seven Bungalows, Versova, Bombay - 400 061

ABSTRACT

Variations in phytoplankton species and pigments at three stations off Thal were studied for a period of 24 hrs in March and October, 1980. Phytoplankton cell counts and pigment values were maximum around mid-day and mid-night which coincided with high tide. The number of phytoplankton species was maximum during day time at the offshore station whereas minimum number of species was obtained at the nearshore station. *Pleurosigma*, *Coscinodiscus*, *Nitzschia*, *Navicula*, *Thalassionema*, *Thalassiothrix*, *Thalassiosira*, *Rhizosolenia*, *Amphora* and *Asterionella* were commonly found in the collections. A bloom of *Ceratium* was observed in October.

Key-words : Phytoplankton pigments, nearshore waters. Thal.

INTRODUCTION

Even though there are quite a number of investigation on phytoplankton from the West Coast of India (Qasim and Reddy, 1967; Shah, 1968; Bhattathiri and Devassy, 1977; Devassy and Bhargava, 1978; Gajbhiye, Ram, Nair and Desai, 1981; Varshney, Nair and Abidi, 1982), information pertaining to Maharashtra Coast is limited to a few studies (Krishnamoorthy, 1968; Bhattathiri and Devassy, 1977 and NIO, 1981).

MATERIALS AND METHODS

Diurnal variation of phytoplankton and pigments were studied at 3 stations (M_1 -close to shore, M_2 -4 km away towards offshore and S-2.5 km away from the above stations towards south) off Thal (Fig. 1) in order to evaluate the tidal effect and day-night variation. Sampling at M_1 was done on 25/26 March, at M_2 on 27/28 March and at S on 24/25 October, 1980. Surface samples were collected from all the stations at four hourly intervals using Niskin water sampler.

Phytoplankton samples were preserved in Lugol's solution and analysed as per standard methods (Anon., 1975). Phytoplankton pigments were analysed following Strickland and Parsons (1971). Some of the physico-chemical parameters are given in Table I.

RESULTS AND DISCUSSION

Station M_1

Results of diurnal variation of chl. *a*, *b*, *c* and carotenoids are shown in Table II. Highest concentration (7.45 mg/m³) of chl. *a* was observed at

2000 hrs during high tide whereas lowest concentration (2 mg/m^3) of chl. *a* was recorded at 1600 hrs during low to high tide. Chl. *a* was always more than chl. *b* but the values were invariably lower than chl. *c*. The ratios of chlorophyll *a*: *b*, *a*: *c* and *a*: carotenoids were always fluctuating. Generally the ratios of chl. *a* to *c* and chl. *a* to carotenoids were less than 1.

Highest number of cells ($7.2 \times 10^4/l$) of phytoplankton was observed at 2000 hrs during high tide whereas lowest number of cells ($1.28 \times 10^4/l$) was recorded at 0800 hrs also during high tide. There were two peaks of phytoplankton population, one at 2000 hrs during high tide and another at 1200 hrs during high to low tide.

28 species belonging to 13 genera of phytoplankton were recorded at this station. Only *Pleurosigma* and *Coscinodiscus* were recorded during all the 24 hrs. *Anabaena* contributed the highest percentage composition (45.96%) at this station. Diversity of phytoplankton was maximum during high to low whereas lowest was during the high tide.

Station M_2

A wide fluctuation was observed in the concentration of phytoplankton pigments. The range of chl. *a* and carotenoids varied between $1.02\text{--}8.70 \text{ mg/m}^3$ and $1.22\text{--}22.73 \text{ m-SPU/m}^3$ respectively. Two peaks in chl. *a* and carotenoids, one at 2400 hrs and other at 1200 hrs both during high to low tide

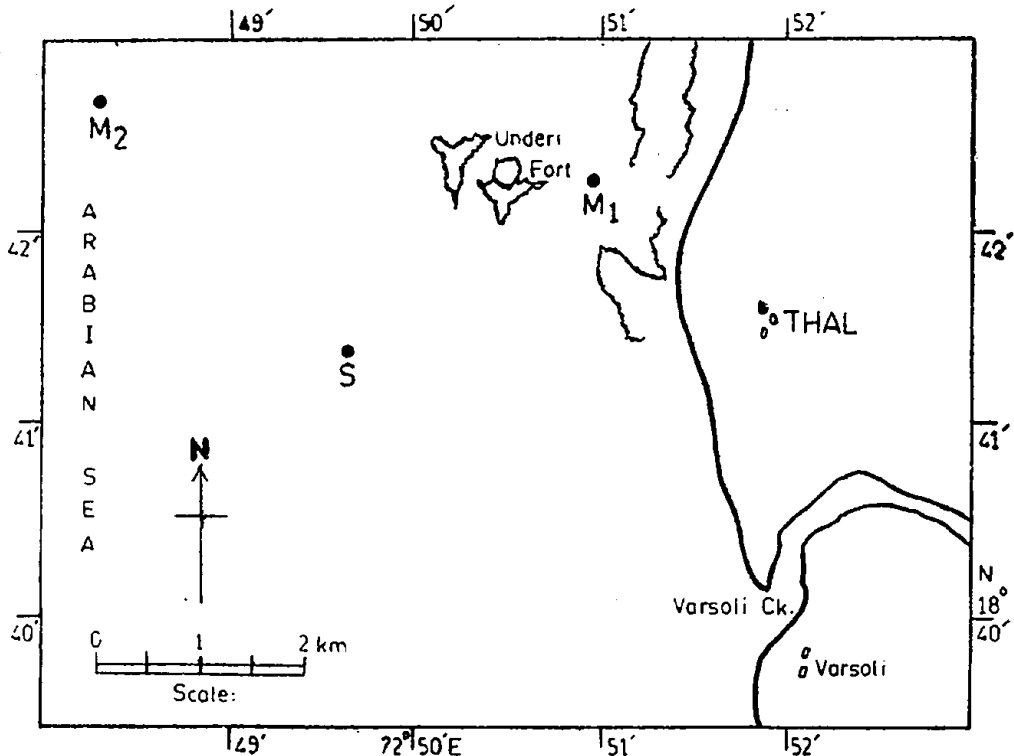


Fig. 1. Location of stations.

were observed. Lowest concentration of chl. *a* was recorded at 0400 hrs during low tide. Values for chl. *a* were higher than chl. *b*. The ratios of chl. *a* to chl. *b* and chl. *a* to chl. *c* were found fluctuating. The ratio of chl. *a* to carotenoid was always less than 1.

Phytoplankton cells showed two peaks, one at 2400 hrs and another at 1200 hrs. Highest population of phytoplankton was recorded during ebb tide, whereas lowest was during the high tide.

26 species belonging to 17 genera of phytoplankton were observed in the collections. *Pleurosigma* and *Coscinodiscus* were recorded in all the collections. *Navicula* was recorded in all the collections except at 2000 hrs. Maximum diversity of phytoplankton species was recorded during high to low tide (1200 hrs) and minimum was observed during low tide period (0400 hrs).

Table I. Diurnal variation of some physico-chemical parameters at stations M₁, M₂ and S during 1980.

Time hrs	Tide	Temp. (C°)		pH	Salinity ‰	Dissolved oxygen mg/l	PO ₄ -P	NO ₃ -N	NO ₂ -N	NH ₄ -N
		Air	Water (sur)							
Station M ₁										
1200	Eb	27.0	28.75	7.9	35.91	5.8	5.09	11.4	19.85	1.07
1600	Eb to Fl	27.25	29.50	7.9	36.29	6.1	2.16	12	1.85	—
2000	Fl	27.3	29.0	7.9	36.47	6.1	2.80	10.28	5.35	1.42
2400	Eb	27.0	28.0	8.0	36.23	5.8	0.67	13	—	—
0400	Eb to Fl	27.0	28.5	7.9	36.93	6.1	2.25	7.78	3.78	0.64
0800	Fl	27.25	28.5	7.9	36.67	6.1	1.87	—	20.42	0.35
1200	Fl to Eb	27.0	28	7.55	36.51	6.5	1.61	22.35	2	—
Station M ₂										
0800	Fl to Eb	27.0	26.8	8.05	37.05	6.8	0.54	0.92	0.42	7.14
1200	Fl to Eb	28.8	28.6	7.95	36.71	6.8	5.64	36.92	0.21	—
1600	Eb to Fl	28.4	28.3	8.00	36.33	6.8	0.83	3.28	1.85	2
2000	Fl	27.8	28.0	8.00	36.47	7.1	1.16	2.28	1.42	1.21
2400	Fl to Eb	27.1	28.1	7.95	—	6.1	7.90	14.78	3.21	0
0400	Eb	27.0	27.8	7.95	36.49	6.5	1.16	2.21	3.14	2.28
0800	Eb to Fl	27.6	28.0	8.1	36.65	7.1	1.06	4.28	0.92	2.07
Station S										
1730	Eb	29.25	29.0	8.18	34.99	5.54	4.19	—	7.42	1.71
2130	Eb to Fl	28.00	28.25	7.79	34.81	6.15	2.32	—	0.35	3.07
0130	Fl	26.25	28.25	7.93	22.58	5.23	1.45	—	1.21	1.07
0530	Eb	25.5	27.75	7.90	35.17	5.85	1.48	—	0.07	0
0930	Eb to Fl	28.8	28.8	7.91	35.73	5.23	2.64	—	0.78	3.92
1330	Fl	29.8	30.0	—	35.73	7.38	2.25	—	—	10.14
1730	Fl to Eb	32.0	29.8	7.6	35.55	7.08	1.25	—	—	0.28

Fl — Flood, Eb — Ebb, PO₄-P — Phosphate phosphorus,
 NO₃-N — Nitrate nitrogen, NO₂-N — Nitrite nitrogen,
 NH₄-N — Ammonical nitrogen.

Table II. Diurnal variation of phytoplankton pigments and cell counts at st. M₁, M₂ and S during 1980.

Time hrs	Tide	Chl. a	Chl. b mg/m ³	Chl. c	Carote- noids m-SPU/m	Phytoplankton cell counts x 10 ³ /ℓ
Station M ₁						
1200	Eb	2.17	0.77	2.94	1.54	15.12
1600	Eb to Fl	2.00	0.19	1.49	3.91	29.04
2000	Fl	7.45	4.27	16.75	7.89	72.00
2400	Eb	4.47	0.84	5.42	2.8	33.20
0400	Eb to Fl	2.20	0.43	2.17	2.59	19.20
0800	Fl	2.60	1.23	3.18	4.11	12.80
1200	Fl to Eb	3.10	2.96	8.70	7.16	35.80
Station M ₂						
0800	Fl to Eb	1.10	0.22	1.08	2.76	4.00
1200	Fl to Eb	4.20	3.14	9.75	5.64	32.60
1600	Eb to Fl	2.55	1.65	3.97	4.42	22.40
2000	Fl	2.18	0.93	0.74	3.96	6.00
2400	Fl to Eb	8.70	3.03	11.74	22.73	42.40
0400	Eb	1.02	1.19	3.41	1.22	7.60
0800	Eb to Fl	3.19	2.12	4.15	3.20	12.80
Station S						
1730	Eb	5.28	2.44	8.32	6.70	132.40
2130	Eb to Fl	4.36	1.78	2.54	6.04	73.20
0130	Fl	1.56	0.04	0.90	3.06	22.00
0530	Eb	4.30	1.52	5.88	5.79	97.8
0930	Eb to Fl	6.68	0.64	4.96	8.22	130.20
1330	Fl	28.44	9.06	23.38	28.94	581.8
1730	Fl to Eb	5.52	1.26	3.22	7.46	85.4

Pleurosigma (28.08%) was the dominant genus among all the phytoplankton genera at this station. *Rhizosolenia* contributed the minimum (0.32%).

Station S

The recorded chlorophyll values were highly fluctuating. The values of chl. *a* and carotenoids varied in the range of 1.56–28.44 mg/m³ and 3.06–28.94 m-SPU/m³ respectively. Chl. *a* was always more than chl. *b*. Generally the concentration of chl. *c* was more than chl. *a*. Highest phytoplankton pigments were observed at 1330 hrs during high tide and lowest were at 0130 hrs during ebb tide. The ratios of chl. *a* to *b* and chl. *a* to *c* fluctuated. Chl. *a* to carotenoids ratios were less than one.

Maximum phytoplankton counts (581.8 × 10³/ℓ) was recorded during high tide (1330 hrs) whereas minimum (2.2 × 10³/ℓ) was observed during high tide (0130 hrs).

21 species belonging to 11 genera were recorded during the period of study. *Pleurosigma*, *Coscinodiscus* and *Ceratium* were observed in all the

collections whereas *Thalassiosira*, *Striatella*, *Biddulphia* and *Asterionella* were recorded in a few collections. *Coscinodiscus*, *Ceratium* sp. and *C. hirudinella* were observed in all the collections and contributed the highest composition (92.55%) of total counts. *Ceratium* was observed in a very high numbers in all the collections at stn. S representing the bloom.

At stns. M_1 and M_2 two peaks of pigments and phytoplankton were observed one around mid-day and the another at mid-night. Similar observation was also reported in East Sound water by Yentsch and Scagel (1958). However, at stn. S the values for phytoplankton pigments and cell counts were maximum around mid-day and lowest during mid-night similar to the findings of Shah (1968) from the Laccadive Sea. This appears to be due to the optimum intensity of light and tidal changes. Peaks in phytoplankton pigments and cell counts were usually coinciding with the highest values of nutrients.

Maximum concentration of phytoplankton pigments and cell counts were recorded during high tide which could be due to the intrusion of phytoplankton cells from offshore area during flood period. Similar trend have already been reported by Bhargava (1973) and Bhargava and Dwivedi (1974).

In general, diversity of phytoplankton species was more during flood period. However, in the present study the diversity of phytoplankton species showed irregular pattern. Vijayalakshmi and Venugopalan (1973) have observed more diversity of phytoplankton during high tide in Vellar estuary.

A bloom of *Ceratium* (*Ceratium* sp. and *C. hirudinella*) was observed in the month of October at station S contributing 92.55% of the total organisms. The observed highest population of *Ceratium* (5.418×10^5 /l cells) was associated with highest surface water temperature (30.0°C), dissolved oxygen (7.38 mg/l) and ammonical nitrogen (10.14 μ g-at/l).

Several reports on blooms of *Trichodesmium*, *Chaetoceros* and *Noctiluca* were recorded along the Indian Coast (Devassy, Bhattathiri and Qasim, 1979; Venugopalan, Haridas, Madhupratap and Rao, 1979; Madhupratap, Devassy and Rao, 1980). But this is the first record of the bloom of *Ceratium* along the west coast of India.

No regular trend in the relationship between chl. *a*, *b*, *c* and carotenoids was observed. Similar observations were made by Humphrey (1960); Qasim and Reddy (1967); and Shah (1967). This may lead one to believe that any light induced chlorosis would have resulted in differential loss of chl. *a* compared to carotenoids giving rise to varying ratios (Shah, 1968; Bhargava, 1973; Bhattathiri and Devassy, 1978). Lower ratios of chl. *a* to carotenoids indicated an unhealthy and chlorotic phytoplankton population (Bhargava, 1973).

The intensity of light is one of the limiting factors for phytoplankton pigments (Shah, 1968). Diurnal variation of net phytoplankton and nanoplankton could be attributed to the factors like variation in nutrient concentration and light (Subramanian and Venugopalan, 1978). According to Qasim and Gopinathan (1969); Bhargava (1973) and Bhargava and Dwivedi (1974), tidal

condition affects the concentration of phytoplankton population resulting in the variation of chlorophyll pigments. However, diurnal variation in phytoplankton can also be affected by cellular characteristics or physiological state or mode of behaviour of phytoplankton (Yentsch and Ryther, 1957; Bhargava and Dwivedi, 1974; Smayda, 1973). Smayda (1973) observed a bloom of *Skeletonema costatum* in Narragansett Bay during winter and spring season and indicated that the bloom could be related to temperature, light, nutrients, grazers, possible species interactions and hydrographic disturbances.

The diurnal variations in phytoplankton and pigments were not decided by any single factor as peak values were observed either during mid-day or mid-night or during high tide or at the time of high concentration or nutrients. In fact the combination of the above factors have resulted in the higher abundance of phytoplankton at stn. S at 1330 hrs.

The above results clearly indicate that the combination of factors like tidal changes, light intensity and availability of nutrients have influenced the diurnal variation of phytoplankton and pigments in the nearshore waters of Thal.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. S.Z. Qasim, Secretary to Government of India, Department of Ocean Development, New Delhi (formerly Director, National Institute of Oceanography, Goa) and to Dr. V.V.R. Varadachari, Director, National Institute of Oceanography, Goa, for facilities and encouragement. Thanks are also due to Dr. Vijayalakshmi R. Nair, Dr. M.D. Zingde and Dr. K. Govindan, Scientists, Regional Centre of National Institute of Oceanography, Bombay, for their assistance during the period of this study.

REFERENCES

- Anon., 1975. *Standard Methods for Examination of Water and Wastewater*, American Public Health Association, 14th Edition, 1194 pp.
- Bhargava, R.M.S., 1973. Diurnal variation in phytoplankton pigments of Mandovi estuary, Goa. *Indian Journal of Marine Sciences*, **2**: 27-31.
- Bhargava, R.M.S. and S.N. Dwivedi, 1974. Diurnal variation in phytoplankton pigments in Zuari estuary, Goa. *Indian Journal of Marine Sciences*, **3**: 142-145.
- Bhattathiri, P.M.A. and V.P. Devassy, 1977. Diurnal variation in phytoplankton pigments and primary production off Bombay. *Indian Journal of Marine Sciences*, **6**: 96-99.
- Bhattathiri, P.M.A. and V.P. Devassy, 1978. Diel variation in phytoplankton pigments and primary production. *Indian Journal of Marine Sciences*, **7**: 191-193.
- Devassy, V.P., P.M.A. Bhattathiri and S.Z. Qasim, 1979. Succession of organisms following *Trichodesmium* phenomenon. *Indian Journal of Marine Sciences* **8**: 89-93.
- Devassy, V.P. and R.M.S. Bhargava, 1978. Diel changes in phytoplankton population in the Mandovi and Zuari estuaries of Goa. *Mahasagar — Bulletin of the National Institute of Oceanography*, **11**: 195-199.

- Gajbhiye, S.N., M. Jiyalal Ram, R.V. Nair and B.N. Desai, 1981. Plankton of the Narmada Estuary and adjacent creeks. *Mahasagar—Bulletin of the National Institute of Oceanography*, **14**: 23–31.
- Humphrey, G.H., 1960. The concentration of plankton pigments in Australian waters. *Division of Fisheries and Oceanography Technical Paper*, C.S.I.R.O., Australia, **9**: 27 pp.
- Krishnamoorthy, T.M. and R. Vishvanathan, 1968. Primary productivity studies in Bombay Harbour bay using ¹⁴C. *Indian Journal of Experimental Biology*, **6**: 115–116.
- Madhuratap, M., V.P. Devassy and T.S.S. Rao, 1980. Swarming of pelagic tunicates associated with phytoplankton bloom in the Bay of Bengal. *Indian Journal of Marine Sciences*, **9**: 69–71.
- NIO, 1981. Selection of the site for waste disposal and unloading facility for the fertilizer plant at Thal. *Technical Report*, National Institute of Oceanography, Regional Centre Bombay.
- Qasim, S.Z. and C.V.G. Reddy, 1967. The estimation of plant pigments of Cochin backwaters during the monsoon months. *Bulletin of Marine Sciences*, Gulf. Carribb., **17**: 95–110.
- Shah, N.M., 1967. Certain features of diurnal variation of phytoplankton in the Arabian Sea of Cochin. *Proceeding of the Symposium on "Indian Ocean"*, *Bulletin of National Institute of Sciences of India*, **30**: 727–732.
- Shah, N.M., 1968. Certain features of diel variation of phytoplankton pigments and associated hydrographic conditions in Laccadive sea off Cochin. A comparison of two seasons. *Bulletin of Department of Marine Biology Oceanography*, University of Kerala, **4**: 167–174.
- Strickland, J.D.H. and T.R. Parsons, 1971. A practical handbook of sea water analysis. *Bulletin of the Fisheries Research Board of Canada* **177**: 310 pp.
- Smayda, T.J., 1973. The growth of *Skeletonema costatum* during winter spring bloom in Narragansett Bay, Rhode Island. *Norwegian Journal of Botany*, **20**: 219–247.
- Subramanian, B.R. and U.K. Venugopalan, 1978. Diurnal variation in net phytoplankton, nanoplankton, primary production and chlorophyll *a* in the Vellar estuary. *Indian Journal of Marine Sciences*, **7**: 191–193.
- Varshney, P.K., R.V. Nair and S.A.H. Abidi, 1982. Primary productivity in nearshore waters of Thal, Maharashtra Coast. *Indian Journal of Marine Sciences*, **12**: 27–30.
- Venugopalan, P., P. Haridas, M. Madhuratap and T.B. Rao, 1979. Incidence of red water along South Kerala Coast. *Indian Journal of Marine Sciences*, **8**: 94–97.
- Vijayalakshmi, G.S. and V.K. Venugopalan, 1973. Diurnal variation in physico-chemical and biological properties in Vellar estuary. *Indiane Journal of Marine Sciences*, **2**: 19–22.
- Yentsch, C.S. and J.H. Ryther, 1957. Short-term variations in phytoplankton chlorophyll and their significance. *Limnology and Oceanography*, **2**: 140–142.
- Yentsch, C.S. and R.F. Scagel, 1958. Diurnal variation of phytoplankton pigments. An *in situ* study in East Sound Washington, Sears Foundation. *Journal of Marine Research*, **17**: 567–584.