

DISCOLOURATION OF WATER AND ITS EFFECT ON FISHERIES ALONG THE GOA COAST

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ABSTRACT

During February-April, 1987 an intense bloom of *Noctiluca miliaris* Suriray was observed in the lower reaches of the Mandovi and Zuari estuaries and the coastal waters of Goa. The bloom also extended from Mangalore to Malvan. During the bloom period chlorophyll *a* concentration was as high as 16.70 mg m⁻³ and *N. miliaris* contributed to 91.3% of the total phytoplankton (51,360 counts l⁻¹). The bloom imparted green colouration due to the presence of a flagellate *Pedinomonas noctilucae* (Subr.) Sweeney in large numbers. Midwater trawl catch during the period showed substantial fall in fish catch. The prevailing environmental conditions and possible impact on local fisheries during such blooms are discussed.

Key-words: Discolouration, bloom, *Noctiluca miliaris* *Pedinomonas noctilucae*.
fisheries.

There are several reports on toxic and non-toxic red tides occurring in the world oceans (Slobodkin, 1953; Brongersma-Sanders, 1957; Devassy, Bhattathiri and Qasim, 1978 and Okaichi, 1984). One of such blooms occurred during February 1987, in the coastal waters of Goa including the lower reaches of the Mandovi and Zuari estuaries which appeared as a thick slimy green soup. This feature was also observed from Mangalore in the south to Malvan in the north during this period (Reddy, personal communication). Dinoflagellate mainly *Noctiluca miliaris* Suriray was found to be responsible for such slimy water, and the innumerable motile flagellates harboured in this organism was responsible for imparting deep green colouration.

N. miliaris, though by and large known as a harmless bloom forming organism, multiplies rapidly during certain periods and by its sheer number form thick soup-like water and which on death and decay causes the mortality of fish and other organisms (Aiyar, 1936; Bhimachar and George, 1950; Prasad, 1953; Prasad and Jayaraman, 1954 and Subrahmanyam, 1954). Subrahmanyam (1954) identified the flagellate contained in *N. miliaris* as *Protoeuglena noctilucae*. Later Sweeney (1976) identified it as a prasinomonad, *Pedinomonas noctilucae* (Subr.) Sweeney.

Surface water samples were collected during February 1987 from 5 stations (73° 48'E & 15° 24.5'-15° 26'N) from the Zuari mouth region. Although periodic samplings were carried out only from Zuari estuarine mouth, visual observations were made in the Mandovi estuary and coastal waters of Goa. The samples were analysed to estimate physico-chemical features and phytoplankton counts. Samples for chl *a* were collected during the peak and the decay phase of the discolouration and analysed fluorometrically. The chemical analyses were effected following the methods of Strickland and Parsons (1968). Phytoplankton samples were fixed in 1% Lugol's iodine and preserved in 3% formaldehyde and counted in a Sedgwick rafter counting chamber.

During the first week of February 1987 a thick slimy green material was noticed in the lower reaches of the estuaries and in the coastal waters. The concentration was relatively higher in the estuarine mouth region as compared to that of coastal region. The discolouration in the Zuari estuary temporarily declined by February end, but reappeared during the last week of March to persist through April. Similar observation was also made by Subrahmanyam (1954) off Calicut. According to his observation the discolouration initially appeared in December 1952, and reappeared in March 1953 indicating its existence even after a gap of two months.

Salinity at midstream (stn. 3) was around 33.8‰, dissolved oxygen 3 ml l⁻¹, PO₄-P 2.4 µg at l⁻¹, NO₂-N 0.3 µg at l⁻¹ and NO₃-N 9.4 µg at l⁻¹ during the course of this *Noctiluca* bloom (Rajagopal, unpublished). During the premonsoon period nutrient concentration is generally low in the Zuari estuary and adjoining coastal waters (Devassy, 1983). However, the PO₄-P and NO₃-N values obtained during the present investigation were higher and could be attributed to the presence of *Noctiluca* bloom as well. A similar increase in phosphate and nitrate was reported by Prasad and Jayaraman (1954). During the peak discolouration, chl *a* concentration attained a high value of 16.70 mg m⁻³ (Phaeophytin 1.90 mg m⁻³), while during the decay phase chl *a* concentration was lower (10.12 mg m⁻³) but phaeophytin value higher (4.76 mg m⁻³).

Table I shows the distribution of *N. miliaris* and other organisms during the occurrence of this discolouration. It can be seen that the highest *N. miliaris* population was on 11th February when it contributed to 91.3% of the total phytoplankton at stn. 3 (51,360 counts l⁻¹). In the other stations it showed declining trend though it contributed to 68.3% at stn. 1, 88.3% at stn. 2, 55.8% at stn. 4 and 81.2% at stn. 5 on the same date. Venugopal, Haridas, Madhuratap and Rao (1979) observed a *Noctiluca* red tide along the south Kerala coast where *N. miliaris* contributed to 90% of the total number. Another dinoflagellate frequently occurring with *N. miliaris* was *Ceratium* spp. Earlier when a *Noctiluca* bloom occurred off Goa (free from the flagellates), *N. miliaris* contributed to 57% of the total phytoplankton (Devassy, Bhattathiri and Qasim,

1979). Other common dinoflagellates were *Peridinium* spp, *Prorocentrum* spp, *Gymnodinium* sp., *Dinophysis miles* and *Ceratocorys* sp. and green algae. During various occasions a diatom bloom preceded the dinoflagellate bloom or in other words some kind of preconditioning of water was done before dinoflagellate bloom appeared (Brongersma-Sanders, 1957). During another *Noctiluca* bloom which occurred in September 1973, off Goa coast, the population reached a high intensity of 1002×10^8 cells l^{-1} (Parulekar and Selvakumar, unpublished). Venugopal, Haridas, Madhupratap and Rao (1979) observed *N. miliaris* counts from 3.01×10^5 to 7.71×10^6 m^{-3} , where samples were collected using a fine meshed HT net. Bhimachar and George (1950) observed a maximum number of 525×10^3 cells l^{-1} during their investigations in the Malabar and Kanara coasts.

It is interesting to note that other than the dinoflagellates mentioned above diatoms such as *Rhizosolenia* spp always occurred along with *N. miliaris* (Table I). *N. miliaris* and *Rhizosolenia* spp cohabited constantly during the period of observations. However, when the *N. miliaris* population increased there was a decline in the *Rhizosolenia* population and vice versa (Table I). The size of *N. miliaris* collected, ranged between 650 and 760 μm (Fig. 1a).

Bhimachar and George (1950) further observed that the decaying *N. miliaris* constitute a good culture medium for euglenoids and ciliates. They also found that fish avoids putrefying *Noctiluca* rather than the abundance of the euglenoids. Also, euglenoids constitute only a link in the chain of succession and cannot be regarded as the primary cause for the setback to the fishery or to fish mortality. In this bloom also the green colouration of the water was due to thousands of the flagellate *Pedinomonas noctilucae* (Subr.) Sweeney (Fig. 1) contained in *Noctiluca* and the surrounding waters. The cells measured from 5 to 9.5 μm in length and 4.4 to 7.8 μm in breadth (Fig. 1b), whereas Subrahmanyam (1954) measured the length as 5-6 μm and breadth 4.45 μm . Sweeney (1976) measured the length of this flagellate as 2-6 μm .

Fishing operations in the estuarine lower reaches and coastal regions of Goa were severely affected during the bloom period. Observations made on mid-water trawls during the months of January and February revealed the following trend. In the month of January, when there was no discolouration in the coastal waters of Goa the catch varied from 60 to 200 kg per hour. In February, when the bloom was at its peak, the catch declined to 0 to 22 kg per hour which is a substantial reduction from the previous month. Bhimachar and George (1950) reported on the abrupt setback to fishery in the Malabar and Kanara coasts due

Table 1 - Phytoplankton population (counts 1-1) observed during *Noctiluca miliaris* discoloration.
(Absence is indicated by —)

Organisms	Date	Stn. 1			Stn. 2			Stn. 3			Stn. 4			Stn. 5		
		11	12	13	11	12	13	11	12	13	11	12	13	11	12	13
<i>Noctiluca miliaris</i>	13200	9490	4884	32250	8260	3705	51360	4324	1908	4902	2880	5848	5264	9504	6110	
<i>Ceratium furca</i>	2880	—	—	—	600	—	—	—	—	—	—	—	—	—	—	
<i>C. macroceros</i>	—	—	—	600	—	—	—	—	—	—	—	—	—	—	—	
<i>Ceratium</i> spp	—	584	1188	2250	—	190	2140	94	106	2280	990	344	376	1056	—	
<i>Peridinium</i> spp	—	—	—	—	—	—	—	—	—	—	90	—	—	—	130	
Undertified	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
dinoflagellates	—	—	—	—	—	—	—	—	—	114	—	—	—	—	—	
<i>Euglena</i> sp.	1920	730	—	—	—	—	856	—	—	114	90	—	—	—	—	
<i>Dictyocha</i> sp.	—	—	—	—	—	—	—	—	—	—	3870	—	—	—	—	
<i>Rhizosolenia</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>syliformis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>R. faroensis</i>	—	—	1452	—	—	—	—	—	318	342	180	—	—	—	910	
<i>Rhizosolenia</i> spp	1320	3942	7788	2850	4200	4560	1712	3478	4346	912	—	5590	846	4092	11310	
<i>Nitzschia pungens</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Nitzschia</i> spp	—	—	—	—	140	950	214	—	212	114	—	344	—	396	650	
<i>Coscinodiscus</i> spp	—	—	132	150	—	—	—	—	—	—	180	1032	—	396	2990	
<i>Chaetoceros</i> spp	—	—	—	—	—	—	—	—	318	—	—	—	—	—	—	
<i>Pleurosigma</i> spp	—	—	—	—	420	190	—	—	—	—	—	—	—	—	130	
<i>Gyrosigma</i> spp	—	—	—	—	—	285	—	—	424	—	—	86	—	—	390	
<i>Gracilaria paradoxo</i>	—	—	—	—	—	1615	—	—	—	—	—	—	—	—	—	
<i>Fragilaria oceanica</i>	—	—	—	—	—	855	—	—	—	—	—	708	—	—	—	
<i>Hemidiscus</i> sp.	—	—	—	—	—	95	—	—	—	—	—	—	—	—	—	
<i>Lauderia</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	940	
<i>Diploneis</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100	
Total	19320	14746	15444	38700	13020	13445	56282	7632	7632	8778	8280	13952	6486	15576	23660	

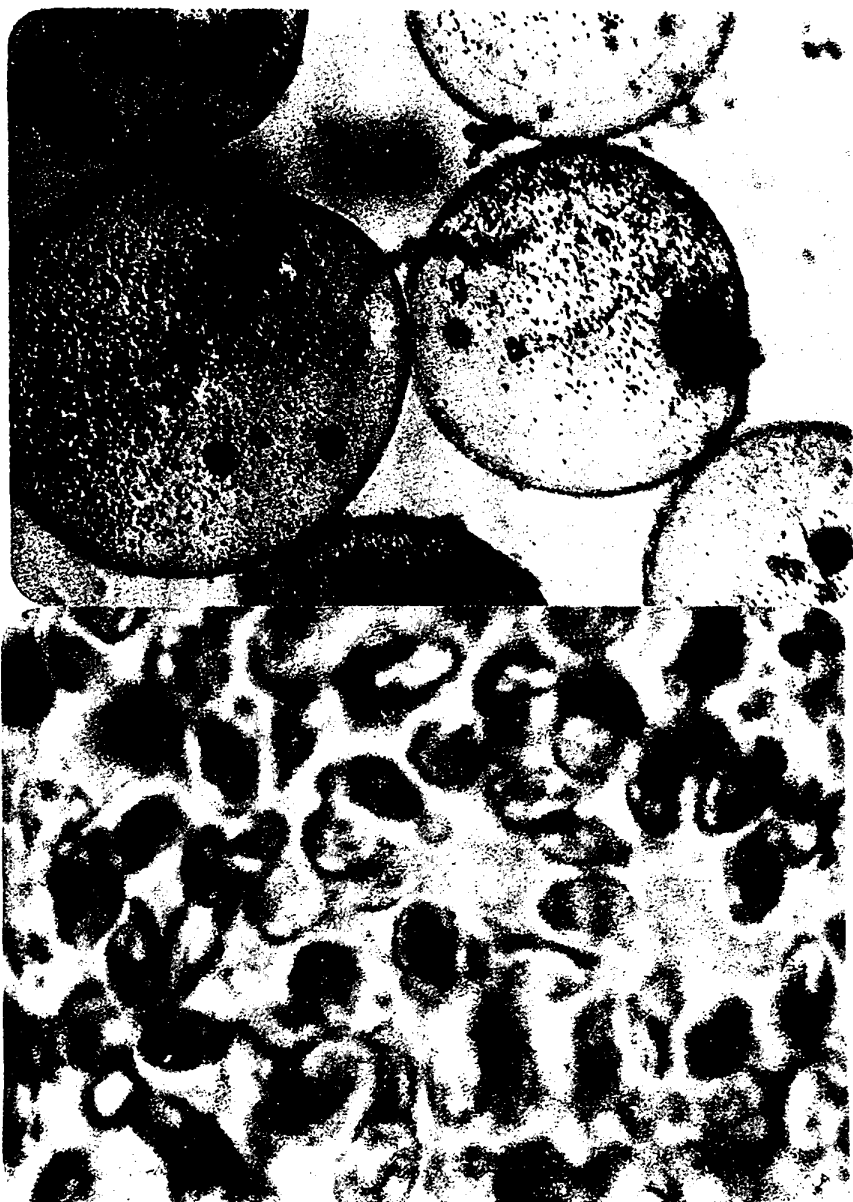


Fig. 1 a *Noctiluca miliaris* Surry containing innumerable *Pedinomonas noctilucae* (Subr.) Sweeney (X20), b *Pedinomonas noctilucae* (X 500)

to the abundance of *N. miliaris* red water. They reported steep fall in fish catch especially shoaling commercial population. Prasad and Jayaraman (1954) were of the opinion that commercial fishes particularly the shoaling fishes avoid *Noctiluca* bloom, which they observed while studying the phenomenon in Palk Bay and Gulf of Mannar. Prasad (1953) suggested that *Noctiluca* can be considered as an indicator species of a poor 'Choodai' fishery in the Palk Bay. In addition, fish mortality particularly that of *Mugil* spp was observed in Canacona coastal region (South Goa) during this *Noctiluca* bloom period (Doiphode. Personal Communication). Thus, *Noctiluca* blooms, alongwith other red tide occurrences, which are said to be on the increase due to more industrialization and introduction of more effluents (Holmes and Lam. 1985), assume greater significance in the fishery of coastal waters of India.

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