

Red tide of *Noctiluca miliaris* off south of Thiruvananthapuram subsequent to the ‘stench event’ at the southern Kerala coast

‘Red tides’ refer to the discoloration of the ocean surface caused by the blooming of some planktonic organisms. A few species of dinoflagellates (a group of protists) periodically form red tides along the west coast of India and *Noctiluca miliaris* is the most frequent one^{1,2}. *Noctiluca* red tide observed on 29 September 2004, seems to be significant since the phenomenon has occurred within a fortnight of the stench event that had created panic among people living along the southern Kerala coast. Mass fish kill was noticed on 17 September 2004 along the Trivandrum coast, with foul smell coming from the sea³. Many people, especially children, who got exposed to the stench, were hospitalized due to vomiting and nausea. Initial reports indicated that the causative organisms for the stench and fish kill were *Cochlodinium* sp. and *Gonyaulax diegensis*⁴. Later, detailed study on samples collected from all along the southern Malabar coast reported it was due to a holococcolithophore bloom⁵. In the present communication, we describe the favourable environmental conditions that prevailed in the region of the *Noctiluca* red tide.

During the 229 cruise of FORV *Sagar Sampada*, we witnessed large patches of *Noctiluca* bloom centred about 25 nautical miles off south of Trivandrum (off Thumba – lat. 8°19’N, long. 76°30’E). On the calm sea surface, the bloom mostly existed as large patches, with a length of 9–11 km and a width of 2–4 km (Figure 1a). The bloom was located along the continental slope and rarely found uniformly spread on the sea surface (Figure 1b). We sampled the bloom region for many relevant hydrographical and biological parameters. The conductivity temperature depth (CTD) profiler recorded the temperature and salinity of the water column. Nutrient (nitrate, phosphate and silicate) concentration of the study area was analysed by a SKALAR SAN PLUS autoanalyser. Primary productivity⁶, chlorophyll *a*⁷, phytoplankton composition⁷ and microzooplankton⁷ were analysed following standard procedure. Mesozooplankton samples were collected from the mixed layer with a multiple plankton net. Surface samples collected using a plastic bucket were examined microscopically for counting the *Noctiluca* cells.

Horizontal distribution of temperature, salinity and dissolved oxygen showed some interesting features in the bloom area (Figure 2). Relatively low temperature and high salinity, known to be favourable for the proliferation of *Noctiluca*, prevailed in the bloom area. Relatively lower concentrations of dissolved oxygen found in the bloom area were apparently due to the large-scale respiration by *Noctiluca*⁸. Low nutrient concentration observed in the southernmost part of the west coast (bloom region) indicates the retreating phase (weakening phase) of upwelling in the area (Figure 2). Upwelling weakens in the southernmost part of the west coast of India by October and as a result, the high concentrations of nutrients initially available at the surface waters get exhausted due to autotrophic production. As *Noctiluca* is a total heterotroph, it is unlikely that the reduced nutrient concentrations were due to its proliferation. The weather was calm during the cruise with clear sky and the wind was southwesterly and moderate, with a speed of 3.92 ms⁻¹.

Abundance of *Noctiluca* cells in the bloom patches exceeded $9 \times 10^5 \text{ l}^{-1}$. Phyto-

plankton in the bloom area was relatively lower in abundance (4250 cells l⁻¹) compared with other coastal stations (av. 5000 cells l⁻¹). Major components of the phytoplankton community of the bloom area were *Thalassiosira* sp. (1160 cells l⁻¹), *Coscinodiscus* sp. (480 cells l⁻¹), *Rhizosolenia* sp. (360 cells l⁻¹), *Nitzschia* sp. (320 cells l⁻¹), *Peridinium* sp. (360 cells l⁻¹), *Gymnodinium* sp. (140 cells l⁻¹) and *Ceratium* sp. (100 cells l⁻¹). Chlorophyll *a* concentration was 0.6 mg m⁻³ in the bloom region, which was relatively less compared to the other coastal stations (av. 0.9 mg m⁻³). Primary production was also lower in the bloom area (217 mgC m⁻² d⁻¹) compared with other coastal stations (av. 350 mgC m⁻² d⁻¹). Relatively low chlorophyll *a* and primary production may be due to the low availability of nutrients in the region. Abundance of microzooplankton (ciliates) in the bloom region was low (19 l⁻¹) compared to the other coastal stations (30 l⁻¹). Interestingly, mesozooplankton biomass was higher in the bloom area (1052 ml 1000 m⁻³) compared with the adjacent stations (756 ml 1000 m⁻³). Zooplankton community was



Figure 1. Bloom of *Noctiluca miliaris* as (a) a large patch and (b) spread evenly. (c) Photomicrograph of *N. miliaris*.

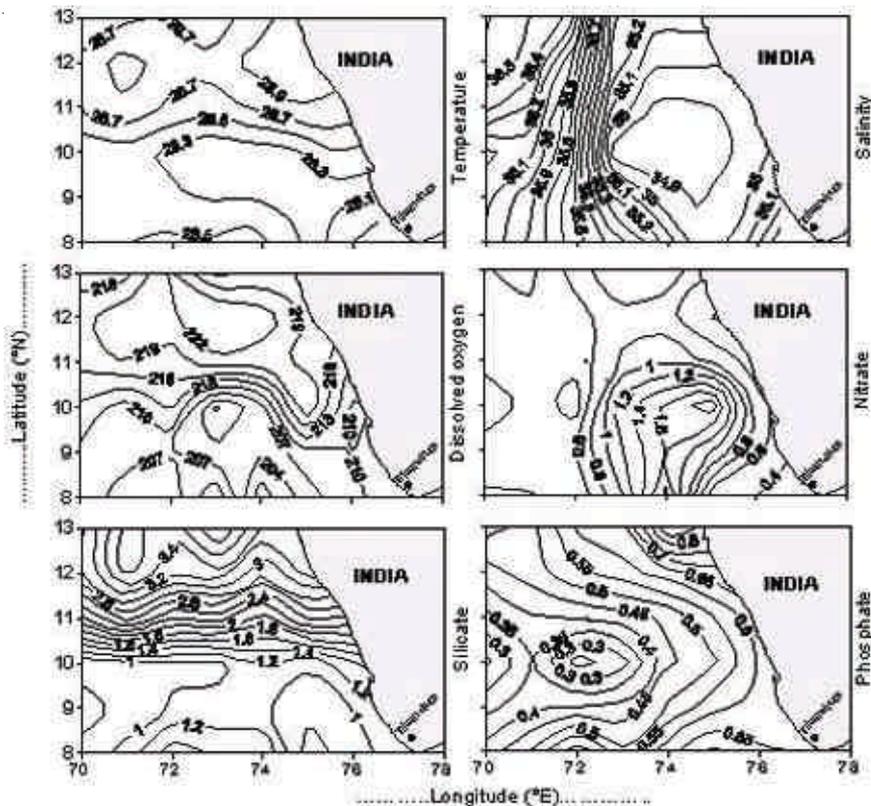


Figure 2. Horizontal distribution of temperature ($^{\circ}\text{C}$), salinity (psu), dissolved oxygen (μM), nitrate (μM), silicate (μM) and phosphate (μM).

dominated by copepods (68%) followed by decapods (17%) and copelates (8%).

Literature suggests that *Noctiluca* bloom occurs in nutrient-enriched waters during the course of plankton succession. High concentration of macronutrients (nitrate, phosphate and silicate) in the surface layers during intense upwelling initially favours the proliferation of smaller diatoms^{9,10}. When the nutrient concentrations decrease due to assimilation and weakening of upwelling, larger diatoms and dinoflagellates start to dominate and their low growth rate enables them to survive in such conditions⁹. Relatively low nitrate and silicate concentration observed in the bloom area during the present study implies that the conditions were favourable for larger diatoms such as *Thalassiosira* sp., *Coscinodiscus* sp., *Rhizosolenia*, *Nitzschia* and dinoflagellates (*Peridinium* sp., *Gymnodinium* sp. and *Ceratium* sp.). Another interesting feature in the composition of phytoplankton was the dominance of *Thalassiosira* sp., the most preferred diatom by *N. miliaris* for feeding.

In recent years, the frequency of *Noctiluca* red tides has increased considerably in many countries and is believed to be linked with the eutrophication of coastal waters¹¹. In India, an operational mechanism to record the frequency of *Noctiluca* blooms is currently lacking. Continuous and long term monitoring of this organism seems to be significant in Indian coastal waters, since many recent studies depict *Noctiluca* bloom as a biological indicator of eutrophication¹².

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