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Occurrence of *Trichodesmium Erythraeum* (Cyanophyte) Bloom and Its Effects on the Fish Catch during April 2013, in the Andaman Sea

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Abstract

A highly intense bloom of the nitrogen fixing Cyanobacteria *Trichodesmium erythraeum* (~7,000 filaments l^{-1}) was observed during April 2013 (for a period of 5 days) in the Andaman Sea, at Lat.10°-13°N and Long. 93°-95°E. This is the first report of this bloom in the open waters of this region. Atmospheric temperature at the time ranged from 27 to 30.5 °C, sea surface temperature ranged from 29 to 34 °C, and salinity values ranged from 32.5 to 34 psu. However, there was no significant variation in pH (8.1-8.3), and DO concentrations ranged from 4.7 to 5.5 mg l^{-1} during the study period. Phosphate values ranged from 0.07 µmol l^{-1} to 0.57 µ mol l^{-1}, silicate values ranged from 1.7 to 2.7 µmol l^{-1}, nitrate levels were very low (0.3-0.57 µmol l^{-1}). At this time, the biomass of *Trichodesmium erythraeum* was high, indicating the bloom was in a growth phase. An upsurge in water temperature was found to explain the bloom, together with an increase in salinity. The hooking rate of fish ranged from 0 to 0.32%. However, in the study area with the highest density of the bloom, almost zero fish catch was recorded, clearly indicating the harmful impact of this algal bloom on fish populations and their distribution pattern.

Keywords: *Trichodesmium erythraeum*; algal bloom; marine cyanobacteria; Andaman Sea

Introduction

Trichodesmium, also known as sea sawdust, is a genus of filamentous cyanobacteria. Members of this genus are non-heterocystous colonial marine cyanobacteria found in nutrient-poor tropical and subtropical ocean waters [1]. *Trichodesmium* fixes atmospheric nitrogen into ammonium ions, which can be utilized by other organisms. The genus is being extensively studied for its role in nutrient cycling in the ocean, as it provides a substrate for many small oceanic organisms such as bacteria, diatoms, dinoflagellates, protozoa and copepods. The importance of *Trichodesmium* in fixing both atmospheric carbon and nitrogen has been well-studied [2-6]. Carpenter and Romans (1991) found that nitrogen fixation by *Trichodesmium* filaments represents an important input for new nitrogen into the euphotic zone, with daily fixation rates of approximately 30 mg^{-1} N m^{-2} d^{-1}. It is also a bloom-forming species, with *Trichodesmium* responsible for > 30% of the world's algal blooms [7]. Negri et al., (2004) reported the presence of *T. erythraeum* in the environment with harmful effects on the components of the marine biota [8].

Trichodesmium blooms causes many harmful effects, frequently causing damage to coastal fish and shellfish fauna [9]. It is also known to cause mortality of *Artemia salina* and also human lymphocytes *in vitro* [10]. Generally, the bloom of this filamentous alga occurs during warm weather with bright sunlight under conditions of stable high salinity levels [11-12]. Red tide phenomena by *Trichodesmium* blooms have been reported during the pre-monsoon months (March to May) in the exclusive economic zone (EEZ) of India by a number of researchers [1, 13-18]. This paper reports for the first time the occurrence of *Trichodesmium erythraeum* bloom in the open waters of the Andaman Sea.

Materials and Methods

1) Study Area

Sampling was done on board the survey vessel *M.F.V. Blue Marlin* (OAL-36.0m) a multi-filament tuna long-liner attached to the Fishery Survey of India, Port Blair Zonal Base during her April'2013 survey voyage. The survey used multifilament tuna long line gear with 5/7 hooks per basket. Ordinary 625 hooks were used and an average of 14 operations were made per voyage. Depth of sampling stations ranged from 1,320 m to 3,113 m. During the regular fishing survey, a highly intense *Trichodesmium* bloom was observed for five days, from 2 April to 25 April 2013 in the Andaman Sea (Figure 1).

2) Sample collection and analysis

Plankton samples were collected using a plastic bucket and filtered through a plankton net (mesh size, 20µm) from the surface water. The plankton samples were fixed in 4% formaldehyde solution and fixed with Lugol's iodine solution immediately after collection. Surface water temperature was measured using a standard mercury Centigrade thermometer. Salinity was estimated using a hand-held refractometer (ATAGO), while pH was measured using a pH meter (OAKTON) from Eutech Instruments. Dissolved oxygen was estimated by the modified Winkler's method. Chlorophyll-a (90% acetone method) was measured spectrophotometrically in the laboratory [19] and expressed as mg l^{-1}. Surface water samples were collected separately in clean polyethylene bottles for analysis of nutrients, and were stored immediately in an ice box before transport to the laboratory. The collected water samples were filtered using a Millipore filtering system, then analyzed for dissolved inorganic nitrate, reactive silicate and inorganic phosphate, adopting the standard procedures described by Parsons, et al., (1972) and are expressed in µmol l^{-1}. 1 to 2 drops of the sample was put on a slide, covered with a cover slip and examined under an inverted microscope to identify the species. Species identification of the phytoplankton samples was done by referring the identification keys [20-22]. The phytoplankton cell counts were performed on a Sedgewick-Rafter Counting Slide [23].

$$N = n \times v \times 1000/V$$

Where N is the total number of phytoplankton filaments per liter of water filtered, n is the average number of phytoplankton filaments in 1mL of sample, v is the volume of phytoplankton concentrates and V is the volume of total water filtered.

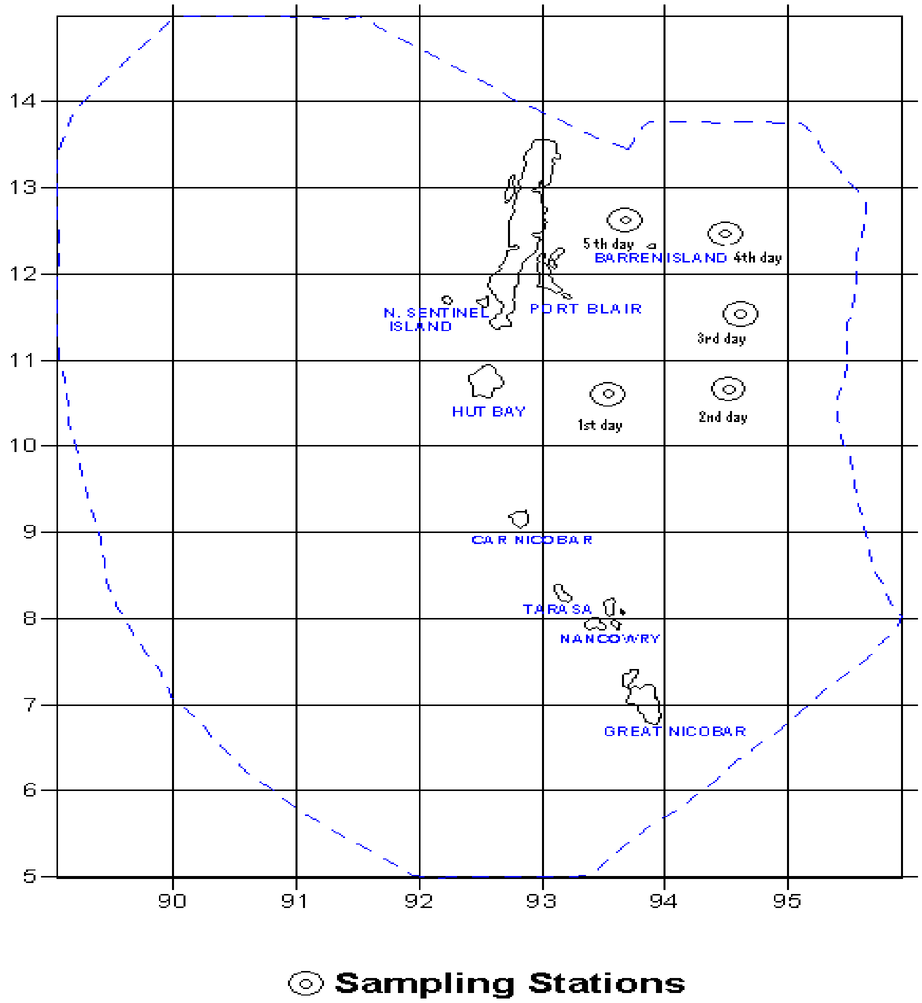

Figure 1 Map showing study area

Results and Discussion

1) Hydrography

The surface seawater temperature during this period ranged from 27 to 32 °C (Figure 2). Generally, blooms of this filamentous alga occur during hot weather as cyanobacteria require relatively high temperatures for optimum growth compared to other phytoplankton [11-12]. The relatively high temperature in this area was reported as a major factor contributing to the abundance of *Trichodesmium* [2, 28]. Similar observations were reported during *Trichodesmium* blooms in other areas in summer in both coastal [1, 14, 15, 18, 24-26] and in open waters [17, 27].

Salinity values ranged from 32.5 to 34 psu during the study period. Stable salinity condition close to typical value of 32 psu and above supported further the growth and abundance of *Trichodesmium* as this cyanobacterium is a stenohaline form with optimum growth at >33 psu; it cannot survive in low salinity condititons [15, 25]. There was no significant variation in pH (8.1-8.3) and hence no correlation with the appearance of the bloom. DO concentrations ranged from 4.7 to 5.5 mg l^{-1}. Higher DO values during bloom were attributed to photosynthetic discharge of oxygen by the highly dense algal biomass and this has also been reported elsewhere [3].

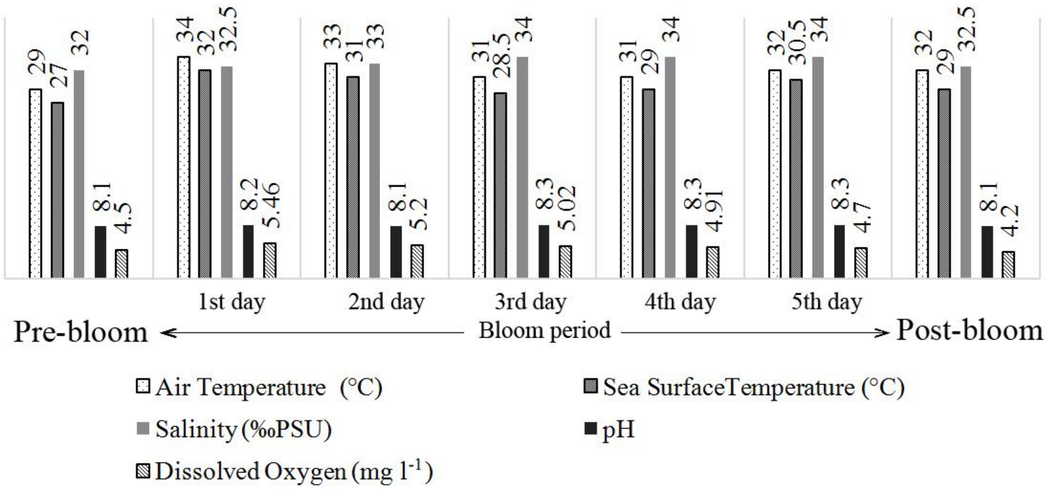

Figure 2 Environmental parameters during the study

2) Nutrients

Phosphate is the most important inorganic nutrient that can limit phytoplankton production in tropical coastal marine ecosystems [29] and thereby the overall ecological balance. In the present study, an abrupt increase in phosphate content was recorded during the bloom, compared to pre- and post-bloom periods. Phosphate values ranged from 0.017 µmol l^{-1} to 0.07 µmol l^{-1} on the day of the bloom (Figure 3), the peak coincided with the day of highest cell density observation. The increase in phosphate level during the bloom period could be due to decomposition of dead plankton, resulting in release of phosphate. Very low levels of phosphate during pre- and post-bloom periods could be due to its rapid uptake by phytoplankton. The relatively high phosphate levels on the day of the bloom could be attributed to the drifting of phosphate-rich oceanic water from the central Indian Ocean into coastal waters during current reversal [30-31]. Santhanam et al. (1994), have also reported similar increases in phosphate content during the blooms of *Trichodesmium* in the coastal waters of Tuticorin off the southeast coast of India.

Silicate values ranged from 1.02 to 1.27 µmol l^{-1}. Though not supporting the cyanobacteria bloom, it supports other siliceous frustules of diatoms, and constitutes one of the most important nutrients regulating phytoplankton growth and proliferation, and in extreme, its blooming [23]. Observations similar to this have also been reported by several authors during the appearance of non-diatom blooms [18, 33- 34]. Nitrate concentration was low, varying from 0.1 to 0.48 µmol l^{-1}, with maximum value recorded during post-bloom, and the lowest during pre-bloom. Nitrate is considered to be the most stable nitrogenous nutrient responsible for the metabolism and growth of phytoplankton, but in the case of cyanobacterial bloom the contribution of nitrate is low because cyanobacteria themselves fix atmospheric nitrogen [2-5, 35-36]. This corresponds with similar earlier reports of low nitrate concentrations during *Trichodesmium* bloom [1, 15, 17-18] from different regions in Indian waters. Chlorophyll *a* concentration ranged between

0.02-0.1 mg m^{-3}, the maximum concentration was found during the bloom when compared to pre- and post-bloom, indicating the meagre pro-ductivity of this region, compared with coastal waters (Figure 4). Similar observations have been reported earlier [1, 13-15, 17-18, 25].

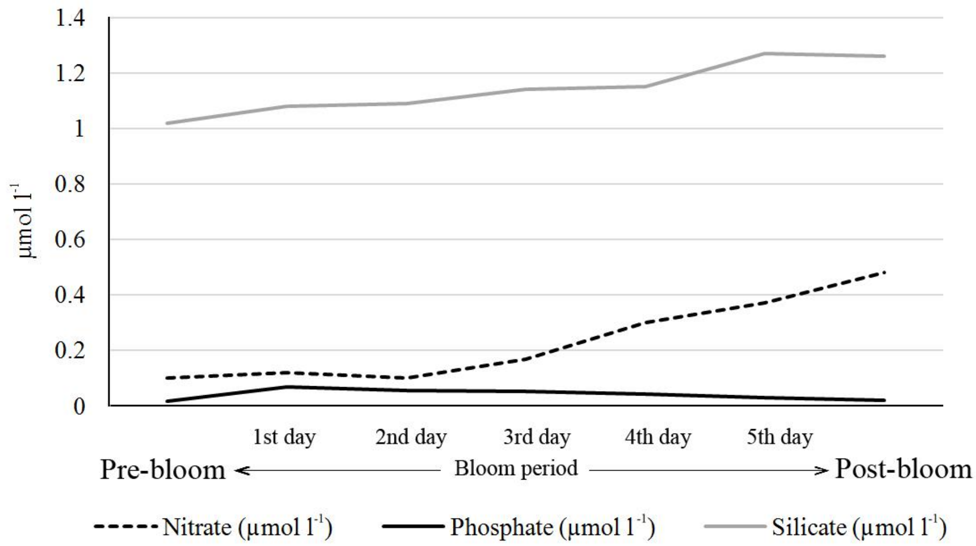

Figure 3 Variations in nutrients during the study

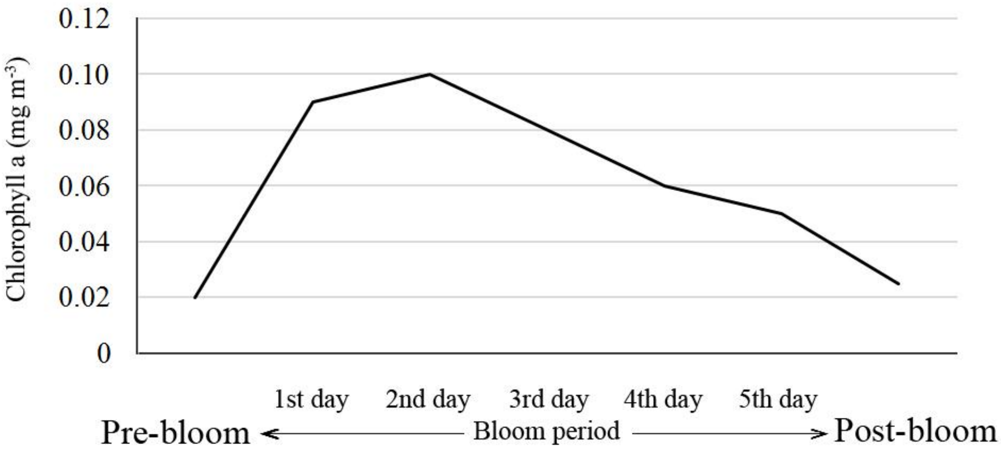

Figure 4 Variations in Chlorophyll a concentration during the study

A bloom of the cyanobacterium *Trichodesmium erythraeum* was observed near the off-shore waters of 'Hut Bay' to Barren Island (Lat. 10°-13°N and Long. 93°-95°E) in the Andaman Sea during April 2013, (Figure 5); this species dominated (96-99%) the total phyto-plankton biomass. Hence, *T. erythraeum* was considered as the bloom-forming species with a population density of ~7,000 filaments l^{-1}. The population density of *T. erythraeum*, kept de-pleting day by day and finally (on Day 5) the density reached 1,300 filaments l^{-1} (Figure 6).

Environmental factors, especially tempera-ture, play a major role in the control of this bloom. Since the open waters are generally oligo-trophic in nature, any slightest sudden change in environmental factors, including nutrient pro-file, can trigger a bloom. Though blooms could be a common occurrence at this time of the year due to the nutrient profile changes, this has not been reported here so far, although it is known to occur in other regions [1, 18]. There is also a possibility that some kind of dormant resting stage may prevail during non-bloom conditions, which goes unnoticed or is misidentified during analyses; alternatively, the organism in the non-bloom season remains distributed throughout the mixed-layer such that sampling at the surface under these conditions will show only a few filaments, and then, at the onset of favourable conditions the filaments become buoyant and rise to the surface to form blooms [27].

Apart from *Trichodesmium erythraeum*, other dominant phytoplankton species recorded were *Asterionella glacialis, Nitzschia spp., Rhizosolenia spp., Thallasiothrix longissima,* and *Thalasiossira decipiens*. Similar results have been reported from the west and east coast of India [25], where very low number of other phytoplankton species were encountered, along with *Trichodesmium* bloom. The bloom was observed only for five days in the eastern Andaman Sea.

The diversity indices of *Trichodesmium* bloom in the study area are shown in Figure 7. Noticeable variation in phytoplankton species diversity during the time of bloom was observed in the present investigation. Mean number of species was found to be the same (14) throughout the bloom, while the mean diversity values (H') were relatively higher during the late bloom (0.25) period as compared with the early days of the bloom. Also, the mean species richness values (D) was found to be higher during late bloom (0.07) than in early bloom. The mean dominance indices were higher in early bloom. Evenness values showed no significant change throughout the bloom. The significant decrease in diversity and evenness values during the intense bloom could be attributed to the complete dominance of *Trichodesmium*, out-competing other phytoplankton species (Figure 7).

The hooking rate of fish (Nos. of fish hooked/ Nos. of hooks operated x 100) from this area was very low in the bloom-forming area, ranging from 0 to 0.32%. With the highest density of the bloom, almost nil fish catch was recorded. At 12°N/ 94°E, the hooking rate was only 0.32% and 0.16% at 11°N/94°E. An earlier survey from this area (during April'2011) also reported low hooking rates (0.32%-1.28%), indicating the harmful effect of this algal bloom on fish populations and their distribution patterns.

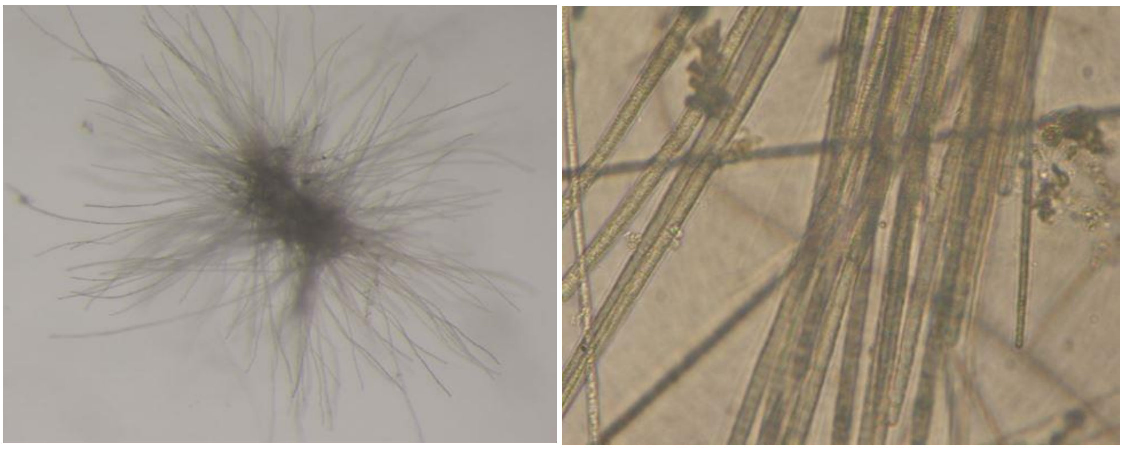

Figure 5 Bloom forming cyanobacteria *Trichodesmium erythraeum*

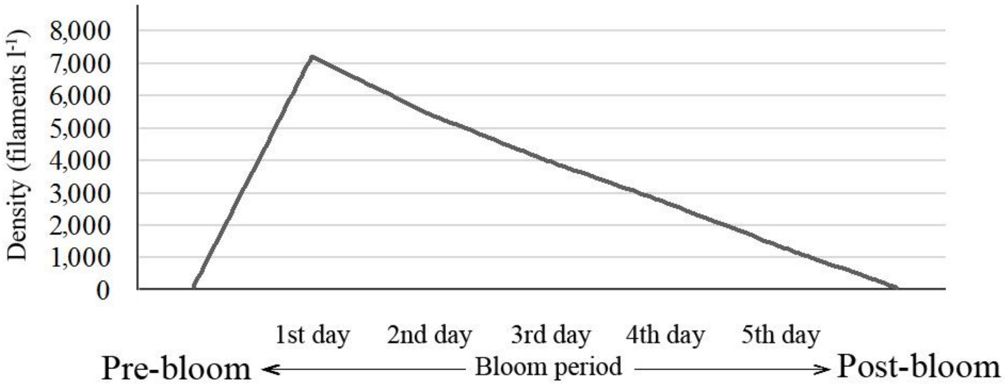

Figure 6 Variations in the density of *Trichodesmium erythraeum* during the study

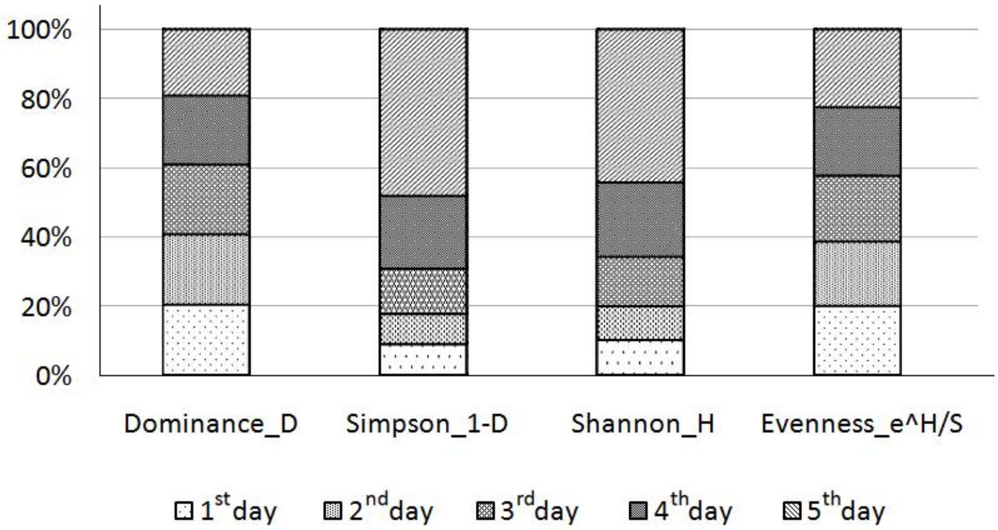

Figure 7 Diversity indices of Phytoplankton during the study

Conclusion

The present study reveals that the high intensity bloom of *Trichodesmium erythraeum* observed in the Andaman Sea was caused by an upsurge in water temperature, which in turn led to an increase in salinity. This species is already reported to cause fish mortality. Since fishing is an active occupation for the people of these islands the major adverse impact of the bloom on fishes and their landing is to be considered. Such types of bloom require continuous monitoring of coastal and open waters to understand the triggering mechanism behind bloom events. It is recommended that further work is done on the effects of such blooms on fish populations in this region.

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