

Seasonal variations in physico-chemical characteristics of Tuticorin coastal waters, southeast coast of India

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Abstract Physico-chemical parameters were determined along the Vellapatti, Tharuvaikulam and Threspuram coastal waters, southeast coast of India. All the physico-chemical parameters such as sea surface temperature, salinity, pH, total alkalinity, total suspended solids, dissolved oxygen and nutrients like nitrate, nitrite, inorganic phosphate and reactive silicate were studied for a period of 12 months (June 2014–May 2015). Sea surface temperature varied from 26.4 to 29.7 °C. Salinity varied from 26.1 and 36.2 ‰, hydrogen ion concentration ranged between 8.0 and 8.5. Variation in dissolved oxygen content was from 4.125 to 4.963 mg l⁻¹. Total alkalinity ranged from 64 to 99 mg/l. Total suspended solids ranged from 24 to 97 mg/l. Concentrations of nutrients, viz. nitrates (2.047–4.007 μM/l), nitrites (0.215–0.840 μM/l), phosphates (0.167–0.904 μM/l), total phosphorus (1.039–3.479 μM/l), reactive silicates (3.737–8.876 μM/l) ammonia (0.078–0.526 μM/l) and also varied independently.

Keywords Physico-chemical parameters · Nutrients · Southeast coast · Bay of Bengal

Introduction

Studies of pollution in natural ecosystem have many aspects, physical, chemical and biological. The physical aspects include the distribution of potential contaminants within the ecosystem. The chemical aspects include the level and chemical form of contaminants found within both the biotic and the abiotic components of ecosystem. But, it is recognition of the biological effects of contamination that defines the true significance of the physical and chemical contamination. Chemical analyses of water provide a good indication of the chemical quality of the aquatic systems, but do not integrate ecological factors such as altered riparian vegetation or altered flow regime, and therefore, do not necessarily reflect the ecological state of the system (Karr et al. 2000). The aquatic ecosystems are affected by some health stressors that extensively deplete biodiversity, the loss of biodiversity and its effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems (Sala et al. 2000). To review the potentialities of any aquatic system, hydrobiological studies are very essential. Physico-chemical parameters are responsible for the spatio-temporal variations of all aquatic organisms. The investigations on meteorological and hydrographical features are necessary for assessing the fertility and productivity of any ecosystem (Rajasegar 2003). A number of researchers have studied the physical and chemical characteristics of some Indian estuaries (Anilkumar and Dineshkumar 2002; Thillai Rajasekar et al. 2005; Perumal et al. 1999). Though, considerable attention has been paid in the recent years to study the physico-chemical parameters of the coastal waters around India in order to ascertain the water quality and productivity, very little information is available on these aspects of the Palk Bay. The present study was made to obtain the present status of hydrographical parameters Vellapatti, Tharuvaikulam

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and Threspuram coastal waters, southeast of India. This information would be helpful in the ecological monitoring of this ecosystem.

Materials and methods

Description of study area

Tuticorin coast is located in the southeast coast of Bay of Bengal, Tamil Nadu. Three sampling stations were fixed, viz. Vellapatti (Lat. 08°11'N; Long. 78°41'E), Tharuvaikulam (Lat. 08°09'N; Long. 78°16'E) and Threspuram (Lat. 08°48'N; Long. 78°04'E) coastal region is having harbour with lot of fishing activities and a number of industries are situated along the coast discharging many effluents (Fig. 1). Further it is an important tourism centre with related activities. These stations were selected as they represent the north and central part of the southwest Bay of Bengal leaving the southern part intentionally as it is covered under the Gulf of Mannar National Park area with coral distribution where the environmental variables behave differently.

Several environmental variables were monitored and water samples were examined from over a period of 12 months during June 2014–May 2015. Sea surface temperature (SST) was measured using a digital multi-stem thermometer of 0.1 °C accuracy. Salinity was estimated using a hand-held refractometer (Atago hand refractometer,

Japan) and the pH (hydrogen ion concentration) was measured using a pH pen (pH tester, Malaysia) with the accuracy of ± 0.1 . Dissolved oxygen (DO) was estimated by the modified Winkler's Method (Strickland and Parsons 1972). Nutrients such as the nitrite (NO_2) was measured by a colorimetric method using sulfanilamide, nitrate (NO_3) by the cadmium reduction method, inorganic phosphorus (IP) and total phosphorus (TP) by the ascorbic acid method and reactive silicate by the molybdate method using a PC-based double-beam spectrophotometer (Systronics-2202).

Results

Physico-chemical parameters are considered as one of the most important features that are capable of influencing the marine environment and have showed wide temporal and spatial differences. All the physico-chemical parameters showed clear seasonal patterns, which are very typical to the tropical marine environment. Sea surface temperature recorded at three different stations ranged from 26.4 to 29.7 °C. The minimum SST was observed during October 2014 and the maximum was registered during May 2015 at station-III (Fig. 2a). The observed salinity values ranged between 26.1 and 36.2 ‰. The minimum salinity was observed during November 2014 at station II and the maximum was registered during May 2015 at station III (Fig. 2b). Hydrogen ion concentration ranged from 8.0

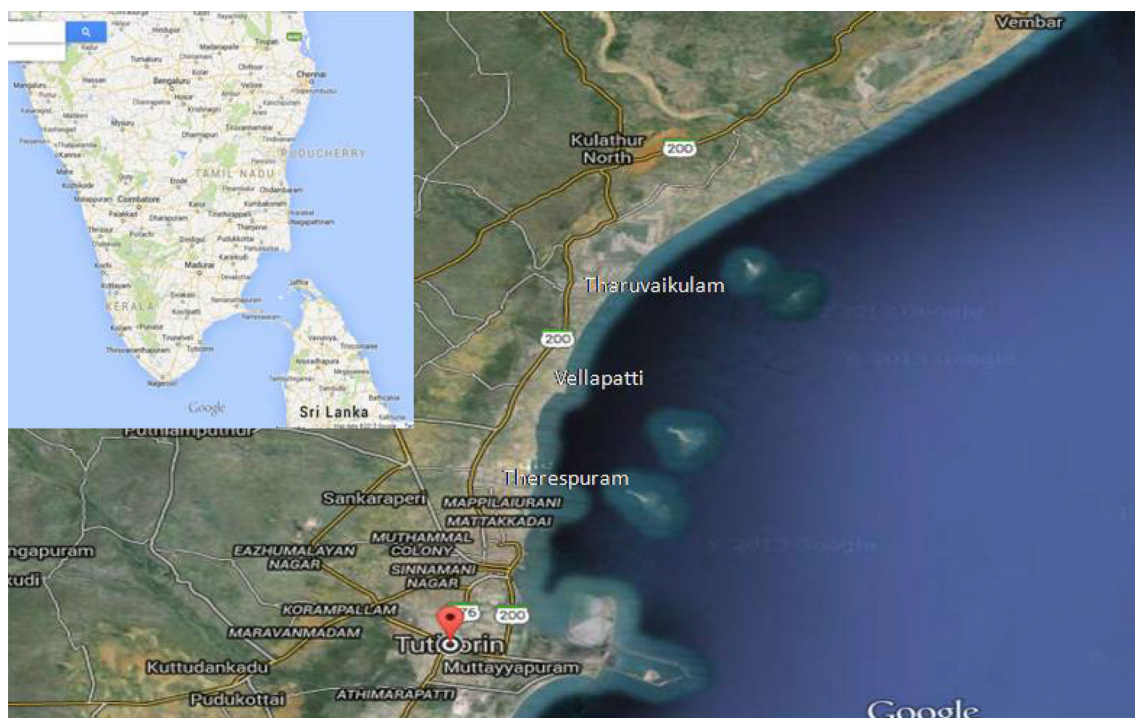


Fig. 1 Map showing the study area



(station-I during June 2014) to 8.5 (station-III during May 2015)(Fig. 2c). The DO concentration varied between 4.125 and 4.963 mg l⁻¹, registering maximum during December 2014 at station-I and minimum at station-II during August 2014 (Fig. 2d). Total alkalinity ranged from 64 to 99 mg/l with the maximum during April 2015 at station-II and minimum during June 2014 at station-I (Fig. 2e). Total suspended solids (TSS) ranged from 24 to 97 mg/l with the maximum during October 2014 at station-II and minimum during June 2014 at station-I (Fig. 2f). The nitrite concentration varied from 0.215 (February 2014 at station-III) to 0.840 μM/l (August 2014 at station-II) (Fig. 2g). The nitrate concentration ranged from 2.047 to 4.007 μM/l. The minimum NO₃ was observed during November 2014 and maximum was observed during May 2015 at station-III (Fig. 2h). The minimum inorganic phosphate concentration (0.167 μM/l) was recorded during September 2014 at station-III and the maximum concentration (0.904 μM/l) was registered during December 2014 at station-II (Fig. 2i). The total phosphorus was maximum (1.039 μM/l) during December 2014 and minimum concentration 3.479 μM/l was noticed at station-II during February 2015 (Fig. 2j). The reactive silicate concentration ranged from 3.737 to 8.876 μM/l with the higher value during November 2014 at station I and the lowest during June 2014 at station-II (Fig. 2k). The ammonia (NH₄) concentration ranged 0.078–0.526 μM/l with the maximum during October 2014 and minimum during July 2014 at station-II (Fig. 2l).

Discussion

This short time series data may allow us to understand the effects of short time variations in the biological and physico-chemical conditions on the eutrophication in the coastal waters, southeast coast of India. Bay of Bengal is considered to be relatively less productive compared to its western counterpart Arabian Sea (Qasim 1977; Radhakrishna and Bhargava 1978; Prasanna Kumar et al. 2002); whereas, in monsoon seasons (southwest and northeast monsoon) the nutrient inputs from river runoff trigger primary production of the coastal waters of the Bay of Bengal (Gomes et al. 2000; Madhu et al. 2002; Madhupratap et al. 2003). Hence, the present study investigated the seasonal change in primary production in the southeast coast of India with respect to the prevailing hydrographical environment through planned systematic new data collections.

Generally, surface water temperature has been influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix-up with ebb and flow from adjoining neritic waters. Influence of temperature in phytoplankton community dynamics has been

investigated for different species and certain phytoplankton species have been observed to have a unique temperature range for growth (Eppley 1972). Change in SST tend to alter biological, physical and chemical reactions within an organism, thus affecting community structure by selecting those best suited to survive (Dupuis and Hann 2009). The surface water temperature varied from 26.4 to 29.7 °C mainly with changes in monthly variations. Higher surface water temperature recorded during the May 2015 at station-III might be due to the increased solar radiation (Satpathy and Nair 1990; Richardson et al. 2000). Though the SST is capable of altering the reproduction, growth, metabolism, microbial processes and especially photosynthesis rates, the observed ranges are not alarming and are within the optimal range (18.3–37.8 °C) for production of plankton in tropical waters (Hossain et al. 2007; Shah et al. 2008).

Salinity did not fluctuate much between the seasons registering the maximum (36.2 ‰) during May 2015 at station III, coinciding with the low amount of rainfall and higher rate of evaporation (Govindasamy et al. 2000) prevailing in the region during this season. The salinity is the main physical parameter that can be attributed to the plankton diversity which acts as a limiting factor and influences the distribution of planktonic community (Kouwenberg 1994; Neelam and Nair 1997; Chandramohan and Sreenivas 1998; Balasubramanian and Kannan 2005; Sridhar et al. 2006). pH was maximum in March 2011 at station I due to the influence of daily photosynthetic activity by phytoplanktons (Das et al. 1997) which removes dissolved carbon dioxide in the water column thereby increasing the pH level. Generally, fluctuations in pH values during different seasons of the year can be attributed to factors like removal of CO₂ by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter as stated by Upadhyay (1998), Rajasegar (2003), and Paramasivam and Kannan (2005). The observed high pH values might be due to the influence of seawater inundation and the high density of phytoplankton (Das et al. 1997; Subramanian and Mahadevan 1999).

The DO level varied between 4.125 mg l⁻¹ (August 2014) and 4.963 mg l⁻¹ (December 2014). Salinity and SST show negative relationship with phytoplankton biomass, whereas DO represent the balance between photosynthesis and respiration and showed a positive relationship. The increased DO (4.963 mg l⁻¹) level during December 2014 can be attributed to comparatively less SST and salinity recorded during this season and above all the turbulent nature of the sea during this season triggers vertical mixing of water column. Present findings are contradictory to the earlier reports (Satpathy et al. 2009)

that recorded increased DO level from August 2014 to December 2014 in this part of Bay of Bengal.

The silicate content was higher than that of all other nutrients except the total nitrogen registering maximum during November 2014 (8.876 $\mu\text{M/l}$). This could be largely

due to the heavy inflow of monsoon inputs. In coastal waters, apart from the physical mixing of seawater with freshwater, factors like adsorption of reactive silicate from suspended sedimentary particles, chemical interaction with clay minerals, co-precipitation with humid substances and

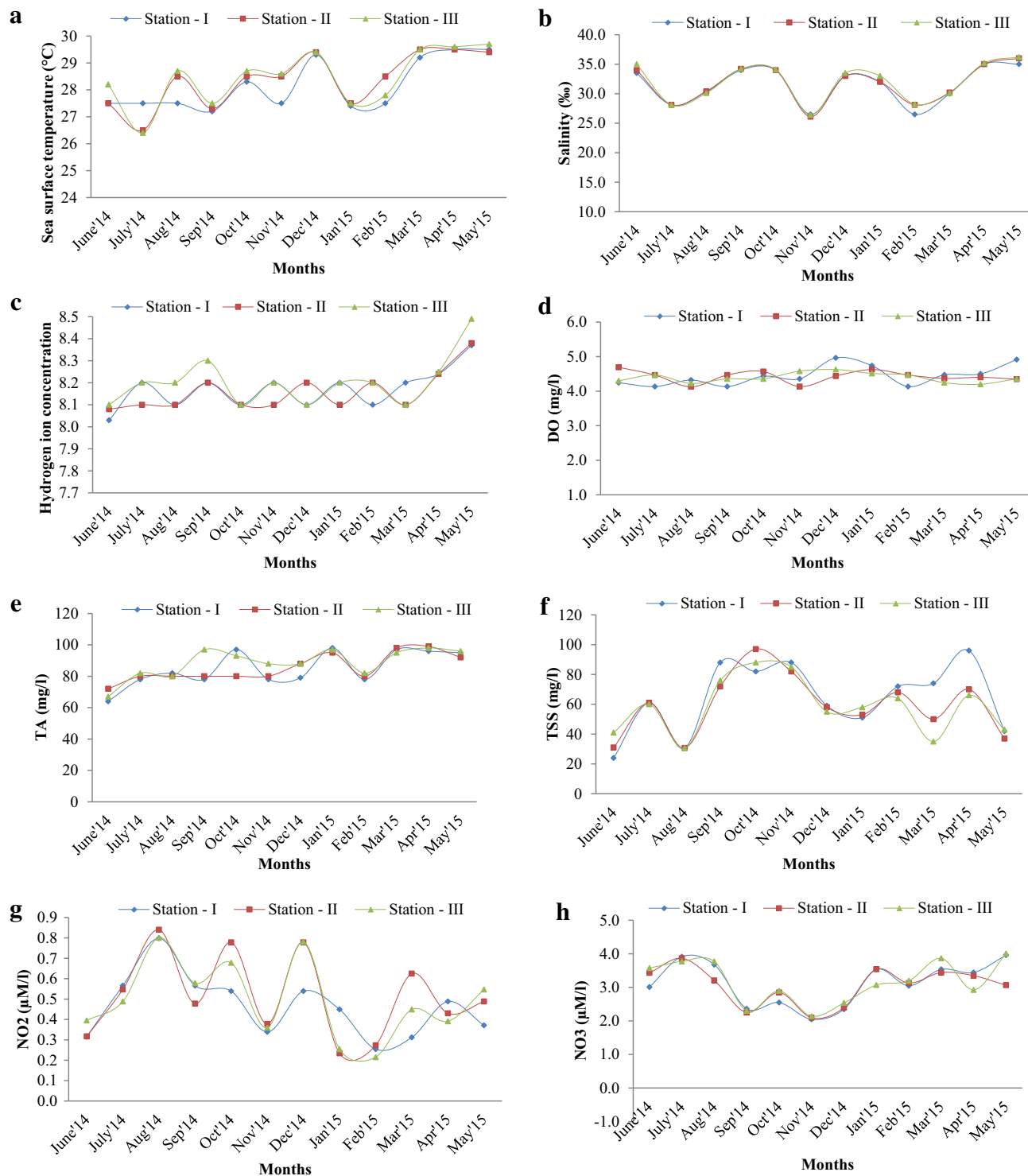


Fig. 2 Physico-Chemical characteristics of Tuticorin coastal waters during June 2014 to May 2015

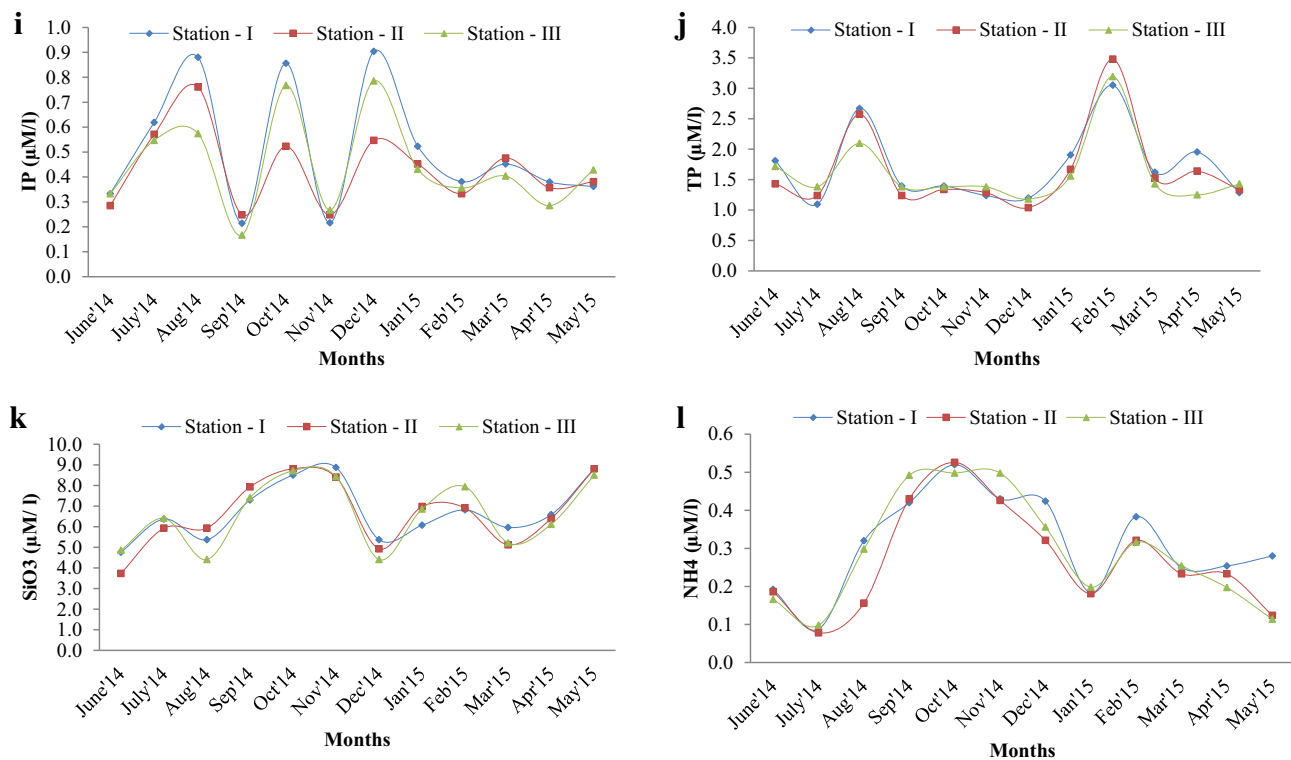


Fig. 2 continued

biological removal by phytoplankton (diatoms and silico-flagellates) can significantly influence the spatio-temporal variation of silicate (Satpathy et al. 2010). Phosphate concentration in coastal waters was influenced by the mixing of the freshwater with the seawater in the land–sea interaction zone, addition through localized upwelling and uptake of phytoplankton (Satpathy et al. 2010). Maximum inorganic phosphate ($0.904 \mu\text{M/l}$) concentration was recorded during December 2014 while low concentration ($0.167 \mu\text{M/l}$) was observed during September 2014. This might be possibly due to the utilization of phosphate by the increased phytoplankton population during the season. The maximum level ($3.479 \mu\text{M/l}$) of total phosphorous (TP) was recorded during December 2014 and the minimum ($1.039 \mu\text{M/l}$) was recorded during February 2015 which also support the above fact. The limiting nutrient concentrations vary with season, location and phytoplankton community structure (Fisher et al. 1992), and phosphate is one of the important organic nutrients that can limit the phytoplankton population in tropical waters.

The present study showed the abundance of nutrients at the southern Bay that might have resulted due to the discharge of nutrient-rich water from the rivers at the southeast coast of India to the Bay of Bengal during southwest monsoon season.

Salinity and nitrate concentration was low and reactive silicate, and inorganic phosphates are moderate. Silicate,

nitrate and phosphate ratios are therefore useful for predicting the phytoplankton abundance and assemblages in the tropical coastal waters. The ability to identify limiting nutrients has thus become of considerable importance for our understanding of the plankton ecology (Havens 2000). However, such limiting nutrient factors vary for closed water bodies and water bodies influenced by the external discharges.

Conclusion

The present study attempted to record the seasonal variations of hydrographical parameters along the southeast coast of India. Analyses of our data sets revealed that the southwest of Bay of Bengal does not exhibit a large-scale spatial variability. All the hydrographical parameters showed clear seasonal patterns, and are typical to the tropical marine environment without any marked variation between the stations. Increased thermal stratification especially on surface waters and utilization of essential nutrients by phytoplankton makes the Bay of Bengal oligotrophic during summer when there is no external input. Tuticorin coastal water is subjected to seasonal fluctuations in physico-chemical parameters depending upon the seasonal tidal amplitude and freshwater influx resulting in a continuous exchange of organic, inorganic, plant and animal matters.

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