

## Short Communication

# *Noctiluca Scintillans* (Dinophyceae) in Central Coastal Waters of Tanzania: A New Phytoplankton Record for the Area

Charles Lugomela

Department of Fisheries Science and Aquaculture, Faculty of Aquatic Sciences and Technology, University of Dar es Salaam, P.O. Box 35064 Dar es Salaam, Tanzania

**Key words:** *Noctiluca scintillans*, ballast waters, Western Indian Ocean

**Abstract**—A one-year study (July 2003 – June 2004) to explore the spatial and temporal variability of potentially harmful dinoflagellates was carried out in the central coastal waters of Tanzania. During the course of the study a green dinoflagellate, *Noctiluca scintillans*, which has cosmopolitan distribution, was encountered for the first time in the coastal waters of Tanzania. It demonstrated a clear temporal distribution with high biomass (up to 30 cells/l) during the northern monsoon period and showed significant negative correlation with temperature and salinity. *Noctiluca scintillans* was possibly introduced by ballast waters or currents and became established for at least one season, but later disappeared due to the physical-chemical environment and/or competition or predation from other organisms in the water column. The need for a monitoring programme for potentially harmful micro-algae, and introduced alien species in Tanzanian coastal waters, is justified.

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## INTRODUCTION

The dinoflagellate *Noctiluca scintillans* (MacCartney) Ehrenb. is characterized by having large, up to 2,000  $\mu\text{m}$ , bladder shaped vegetative cells associated with an oral pouch in which are located the tentacle and one emergent flagellum (Lucas, 1982). Vertical movements of *Noctiluca* in the water column are due to active ionic regulation of the specific gravity. Potassium ions are accumulated in the cell sap relative to its concentration in seawater, whereas the concentrations of the heavier ions calcium and magnesium are reduced (see Elbrächter and Qi, 1998 and references therein). *Noctiluca* has no chloroplast, but may form symbiotic association with a photosynthetic green flagellate, *Pedinomonas noctilucae* (Sweeney, 1976). When the endosymbiont is present, *Noctiluca* can apparently thrive photosynthetically without the need for phagotrophic food uptake.

*Noctiluca scintillans* is known to have a cosmopolitan distribution and is found in all temperate, subtropical and tropical coastal waters (Elbrächter and Qi, 1998). In the Indian Ocean, blooms of *Noctiluca scintillans* have been reported from Indian waters (e.g. Subrahmanian, 1985; Devassy, 1989), in Hong Kong waters (Ho and Hodglist, 1992), far offshore from the equatorial Indian Ocean (Taylor 1976), and more recently in the Indian waters again (Eashwar *et al.*, 2001; Dharani *et al.*, 2004). Adnan (1989) provided a review of the green *Noctiluca* blooms in Jakarta Bay, Indonesia.

In some cases fish kills have been associated with blooms of *Noctiluca* (e.g. Subrahmanian, 1985; Ho and Hodglist, 1992). The fish kill may be caused by different mechanisms. In many cases oxygen depletion is proposed as the causative agent for fish kill (Subrahmanian, 1985; Ho and Hodglist, 1992; Xie *et al.* 1993). Another possible mechanism

of fish kill by *Noctiluca* may be through the release of ammonia (Okaichi and Nishio, 1976). This is particularly the case at the end of the blooms when *Noctiluca* no longer feed and accumulate ammonia in their cells before lysing.

Several studies (e.g. Bryceson, 1977; Lyimo, 1995; Lugomela, 1996; Wallberg *et al.*, 1999; Lugomela *et al.*, 2001) have reported on phytoplankton species composition in Tanzania coastal waters but did not report on the existence of *Noctiluca scintillans* in the area. This paper represents the first reported observation of this nuisance dinoflagellate in the coastal waters of Tanzania and presents its temporal distribution

in the area in relation to some physical chemical environmental parameters.

## MATERIALS AND METHODS

Samples for dinoflagellate identification and quantification were collected twice per month in Dar es Salaam station and once per month in Zanzibar station, between July 2004 and June 2005, from an outboard engine boat. Dar es Salaam station is located in the open waters near Mbudya Island while Zanzibar station is located in the open waters near Bawe Island (Fig. 1 & 2). Samples were taken by concentrating 20 l of surface seawater through a

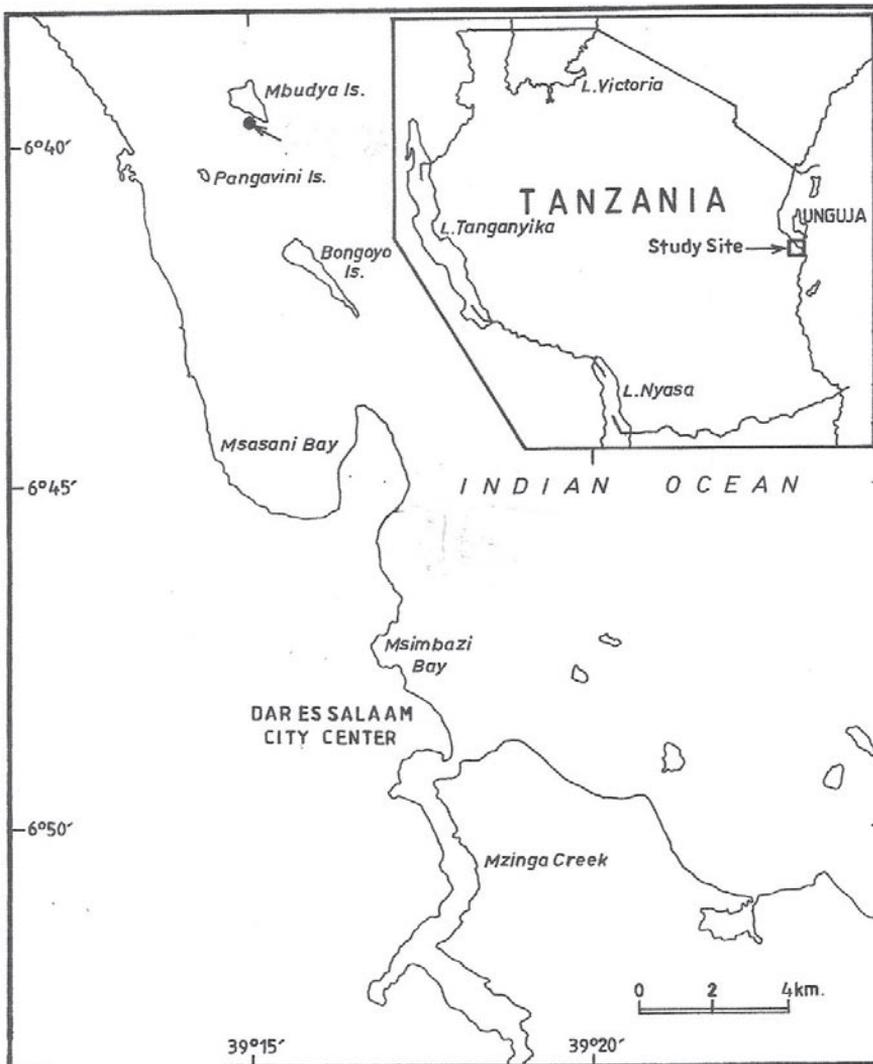


Fig. 1. Map of Dar es Salaam showing the sampling site (arrows) at Mbudya

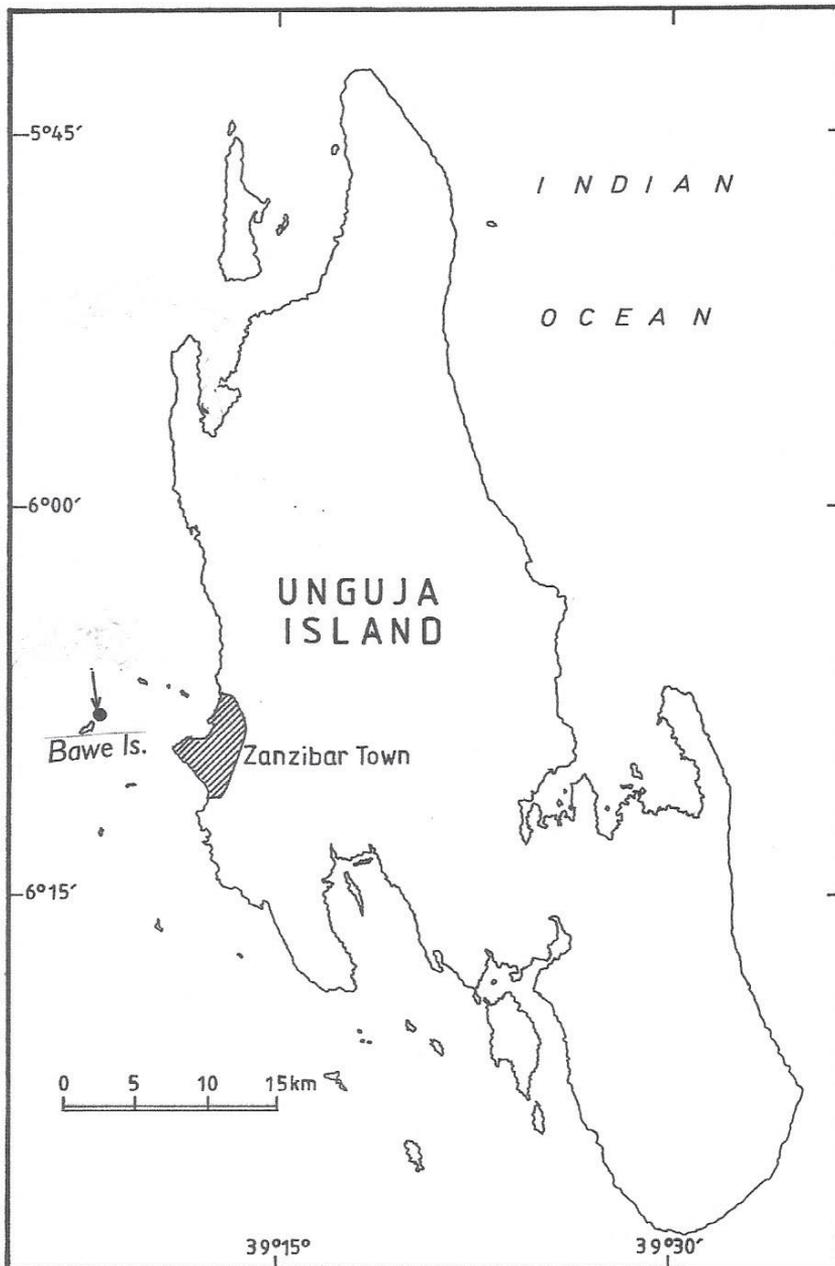


Fig. 2: Map of Zanzibar showing the sampling site (arrows) at Bawe.

20  $\mu\text{m}$  mesh size plankton net into a 100 ml volume dark glass sample bottle. The samples were then immediately fixed using acid Lugol's solution and brought to the laboratory. The dinoflagellated were counted in a Sedgewick-Rafter cell (Woelkerling *et al.*, 1976).

Water samples were collected from each sampling site for nutrients ( $\text{NO}_3^-$ , and  $\text{PO}_4^+$ )

determination. The collected water was filtered through 0.22  $\mu\text{m}$  pore sized Millex-GS Millipore filters (France). The filtered water samples were kept in 50 ml acid cleaned plastic vials and stored on ice for transport to a deep-freezing facility ( $-20^\circ\text{C}$ ) to await analysis. Analyses for nitrate ( $\text{NO}_3^-$ ), and phosphate ( $\text{PO}_4^+$ ) were undertaken using the methodology of Parsons *et al.* (1984). Two

other environmental parameters, water temperature and salinity, were measured in the field using a thermometer and refractometer (ATAGO, Japan).

**RESULTS**

Water temperature at the sampling points ranged from 25.5°C in March 2004 at Mbudya station to 29.5°C during January 2004 at Mbudya (Fig. 3). Salinity varied only slightly ranging from 34.5 ppt

in March at Bawe to the highest value of 36 ppt in September and October at Bawe and in November at Mbudya (Fig. 4).  $PO_4^{+}$  concentration in the water column ranged from 0.21 nMol  $PO_4^{+}$ /l at Mbudya during October and November 2003 to 26.4 nMol  $PO_4^{+}$ /l at Bawe in January 2004 (Fig. 5).  $NO_3^-$  concentration ranged from 23.2 nMol  $NO_3^-$ /l at Bawe in July 2003 to 81.9 nMol  $NO_3^-$ /l at Mbudya in February 2004 (Fig. 6). Significantly high nitrate concentration ( $t = 3.02, p = 0.016$ ) was observed

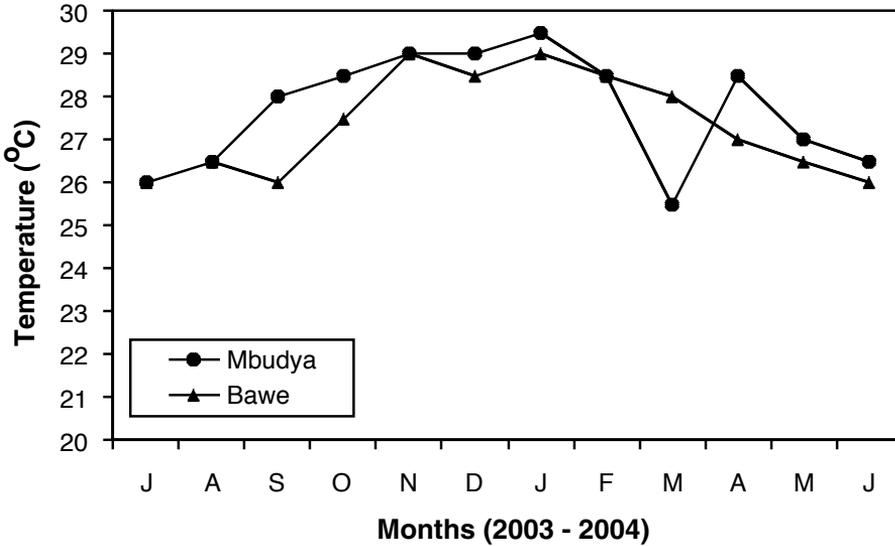


Fig. 3. Temperature variations in the water column during the study period

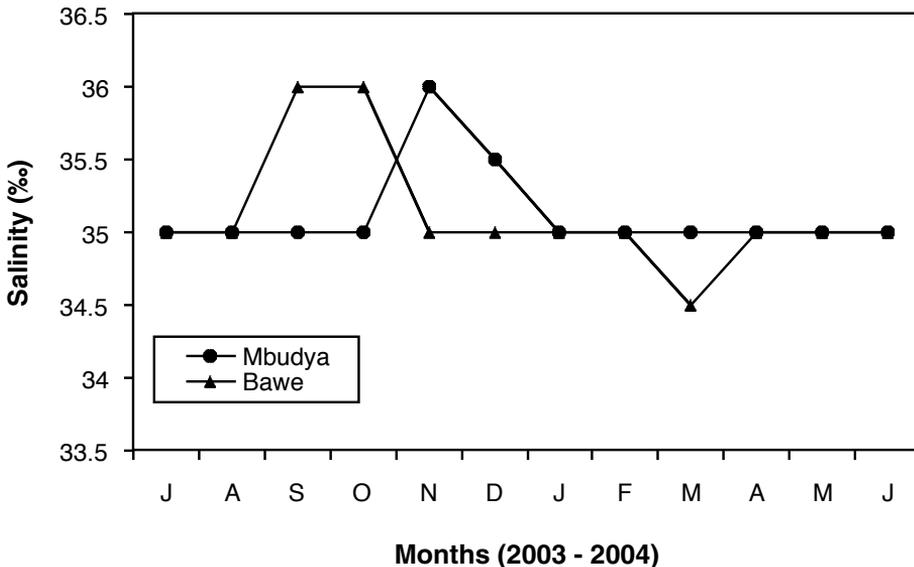


Fig. 4. Salinity variations in the water column during the study period

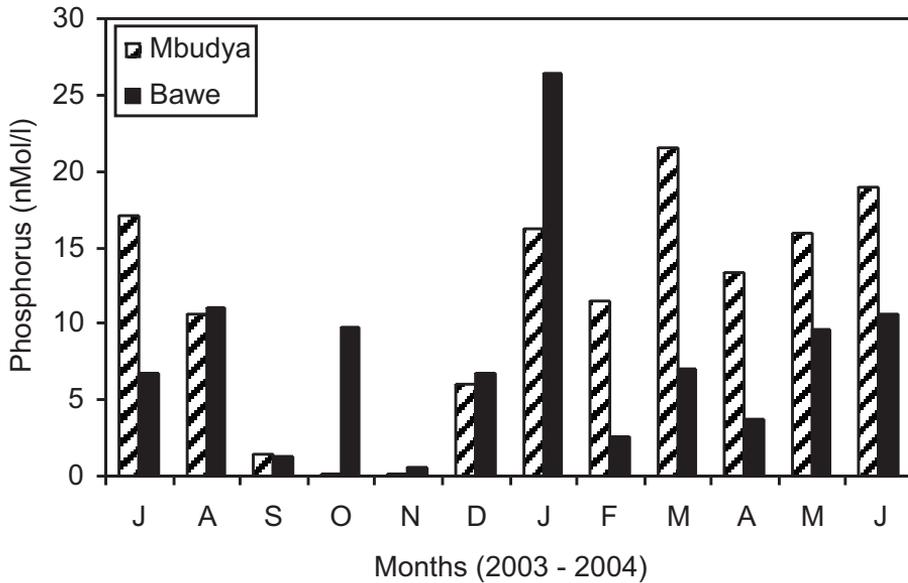


Fig. 5. Variations in soluble reactive phosphorus concentration in the water column during the study period

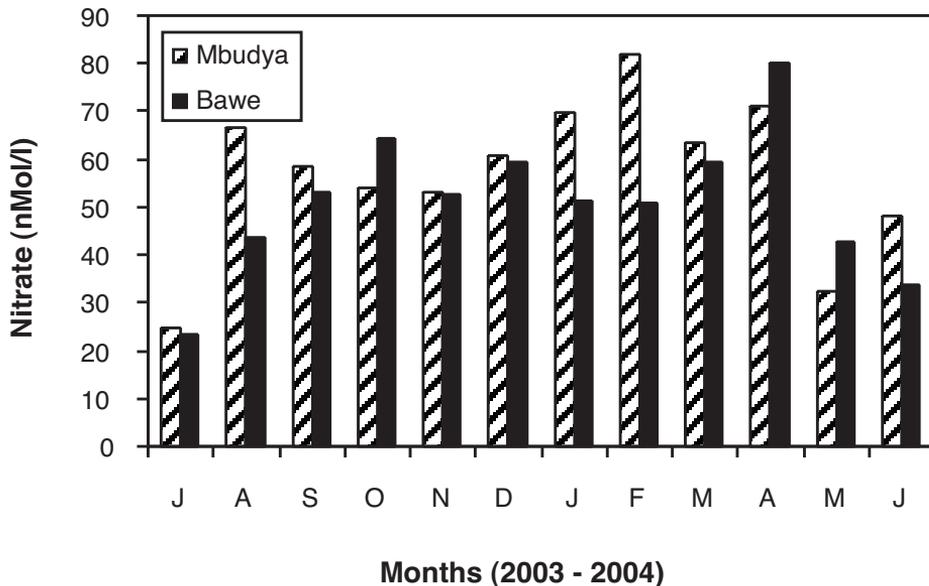


Fig. 6. Variations in nitrate concentration in the water column during the study period

during the northeast monsoon period (October-March) compared to the southern monsoon period (June-September).

Green *Noctiluca scintillans* with turbid cell contents (Plate 1) were encountered among plankton from both Mbudya and Bawe stations. The dinoflagellate showed a clear seasonal distribution appearing among the plankton during the northern

monsoon period. The species reached a peak value of 30 cells per litre at Mbudya during March 2004 (Fig. 7). However, no *Noctiluca scintillans* was encountered in the study sites during the months of July to November (2003) and May to June (2004). Correlations between the biomass of *Noctiluca scintillans* and the various environmental parameters are given in Table 1.

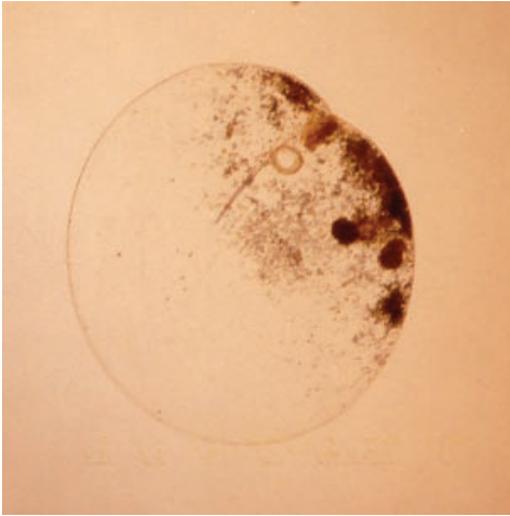


Plate 1: Photomicrograph of *Noctiluca scintillans* collected among plankton in the study area

is similar to previous records in the area (e.g. Bryceson, 1977). Nutrient concentrations were also similar to previous records reported by Bryceson (1977) and Lugomela and Semesi (1996). Significantly higher nitrate concentrations in the water column were encountered during the northern monsoon period confirming earlier observations in the study areas (e.g. Bryceson, 1977; Lugomela and Semesi, 1996). Elevated nitrate concentration during the northern monsoon has been linked to nitrogen fixation by the planktonic colony forming cyanobacterium *Trichodesmium* spp., which is in high abundance during that period (Bryceson, 1977; Lyimo, 1995; Lugomela *et al.*, 2002). In addition, the East Africa coastal current slows during the northern monsoon compared to the southern monsoon and increases the residence period of the water in the shelf and shallow environments,

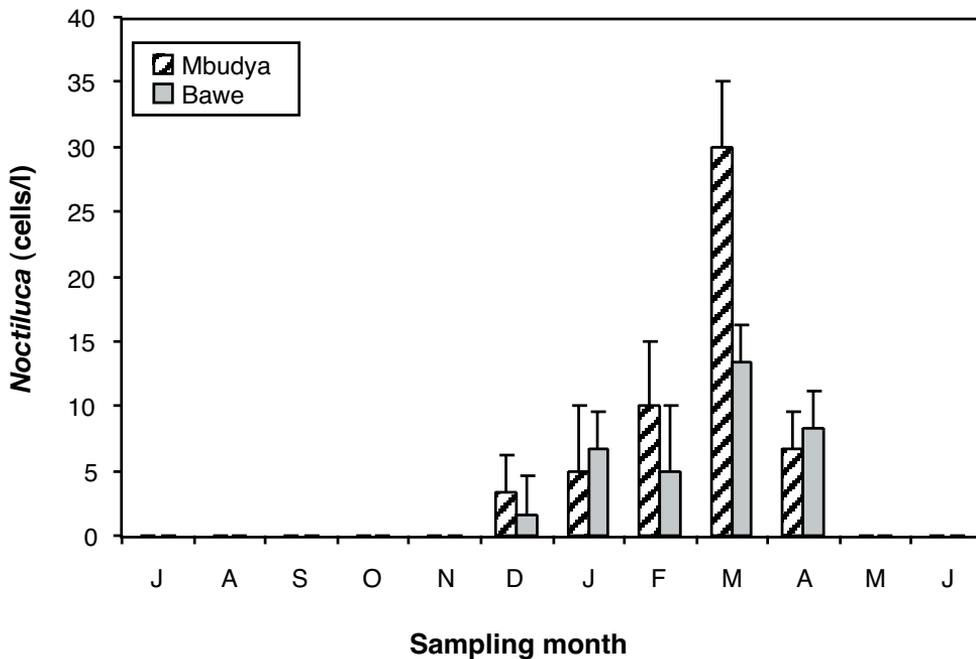


Fig. 7. Biomass of *Noctiluca scintillans* in the water column at Mbudya and Bawe during the study period (error bars = standard deviation,  $n = 3$ )

## DISCUSSION

In general, low temperature values were recorded during the southern monsoon period (May to September) as compared to the northern monsoon period (November to March). This observation

therefore waters acquire more neritic characteristics with increased nutrients (Bryceson, 1977). In general, nutrient values along the Tanzanian coast are low as a result phytoplankton blooms, apart from those of the nitrogen fixing cyanobacterium *Trichodesmium* species, have not been documented.

**Table 1. Correlations between the biomass of *Noctiluca scintillans* and the various environmental parameters in the water column at Mbudya and Bawe stations (r = Pearson's product-moment correlation coefficient, p = probability of making type one error, \* = significant)**

Station	Parameter	r values	p values
Mbudya	Temperature	- 0.9926	0.001*
	Salinity	- 0.3429	0.0104*
	Phosphate	0.9166	0.001*
	Nitrate	- 0.6397	0.001*
Bawe	Temperature	- 0.3199	0.05*
	Salinity	- 0.9058	0.001*
	Phosphate	- 0.185	0.287
	Nitrate	0.1442	0.4087

However, with the apparent increase in pollution and eutrophication in the coastal waters of Tanzania (Mohammed, 2002), it is likely that such blooms may occur in the future.

The biomass of *Noctiluca scintillans* was low compared to that reported by Dharani *et al.* (2004) from Minnie Bay, India, and there were no signs of a bloom nor fish kills in this case. However, a significant negative correlation was observed between the biomass of *Noctiluca scintillans* and water temperature and salinity at both Mbudya and Bawe stations (Table 1) suggesting that this dinoflagellate does not perform well in waters with high temperatures and salinity. This is similar to the report by Huang and Qi (1997) in Dapeng Bay, South China Sea, from where these authors reported that the seasonal occurrence of *Noctiluca* occurred at water temperatures between 15.8°C to 28.6°C, with that mass development at temperatures between 19 to 22°C. This could explain why *Noctiluca* is not common in inshore waters, where temperature and salinity fluctuations are usually higher than those of oceanic water masses. There was also a significant negative correlation between the biomass of *Noctiluca scintillans* and concentrations of nitrate in the water column at Mbudya station. However, a significant positive correlation (Table 1) was observed between the biomass of *Noctiluca* and the concentration of phosphate in the water column at Mbudya station suggesting that phosphorus may also be a limiting factor for growth.

*Noctiluca* is regarded as one of the most common red-tide organism (Elbrächter and Qi, 1998), though it has never been reported before from the coastal waters of Tanzania (see e.g. Bryceson, 1977; Lyimo, 1995; Lugomela, 1996). The possibility exists that *Noctiluca* is not a native phytoplankton species in the area, but was introduced perhaps through ballast waters or ocean currents. Being mixotrophic, *Noctiluca* can remain viable in the dark ballast waters for long period and therefore easily transported over great distances (e.g. Hallegraeff, 1993, 1998). It disappeared with the onset of the southern monsoon and was not encountered again in subsequent phytoplankton samples from the area (Personal Observ.). That the dinoflagellate managed to establish for at least one season supports the introduction hypothesis, but the evidence also suggests that it might have been later out-competed by other organisms or eliminated due to inhospitable physical-chemical conditions. The occurrence of this potentially harmful dinoflagellate in Tanzanian waters supports the need for the establishment of a monitoring programme for this and other potentially harmful algal alien species.

*Acknowledgement*—I wish to express my sincere gratitude to the Western Indian Ocean Marine Sciences Association (WIOMSA) for providing the financial support that made this study a reality. Dr. Julius Francis, Mr. Hamad Chani and Mr. Seif Abdallah (WIOMSA) are strongly acknowledged for their useful correspondence and logistical support during the whole process of this study. I am indebted to the Faculty of Aquatic Sciences and Technology, University of Dar es Salaam for availing time to me to conduct this study. Thanks to the Department of Zoology and Wildlife Conservation and the Institute of Marine Sciences (IMS), Zanzibar for providing laboratory space and some logistical support. Mr. Augustine Mwandya, Juma Kangwe, Muhidin Abdallah and Idd Hamis (IMS, Zanzibar) are strongly acknowledged for their field assistance in Zanzibar. My thanks are also due to Mr. Yukundus P. Mhonda and Shelard Mukama for their assistance in the field whilst in Dar es Salaam. I also acknowledge the reviewers for their constructive comments.

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