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BLOOM OF *Noctiluca scintillans* (MACARTNEY) KOFOID & SWEZY (DINOPHYCEAE) IN SOUTHERN BRAZIL

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The dinoflagellate *Noctiluca scintillans* (Macartney) Kofoid & Swezy, commonly called sea sparkle, can aggregate into a bloom, and sometimes produces substances that are potentially toxic to marine life. *Noctiluca scintillans* is a large (up to 1200 μm), oblong, luminescent heterotrophic dinoflagellate, and is frequently associated with bloom events (ELBRACHTER; QI, 1998). The species is considered non-toxic, but is sometimes responsible for the mortality of fish and benthic fauna, associated with anoxia. More recently, it has been reported that *N. scintillans* may act as a vector of phycotoxins to higher trophic levels, by feeding on toxigenic microalgae (ESCALERA et al., 2007).

Noctiluca scintillans is widely distributed in temperate to tropical regions, where it commonly causes blooms (SRIWOON et al., 2008). The mechanism of bloom formation of *N. scintillans* has been examined in many parts of the world, e.g., in the German Bight (UHLIG; SAHLING, 1990), Dapeng Bay, South China Sea (HUANG; QI, 1997; WANG et al., 2008), Minnie Bay, Andaman Islands (EASHWAR et al., 2001; DHARANI et al., 2004), Sagami Bay, Japan (MIYAGUCHI et al., 2006), Thailand (SRIWOON et al., 2008), Gulf of Mannar, India (GOPAKUMAR et al., 2009), Red Sea off Saudi Arabia (MOHAMED; MESAAD, 2007), northern Adriatic Sea (UMANI et al., 2004), and several parts of the Australian coast (AJANI et al., 2001, MURRAY; SUTHERS, 1999, DELA-CRUZ et al., 2002).

Blooms by *N. scintillans* appear either pinkish-red or greenish. The former coloration has been reported in various temperate and subtropical waters, but the latter occurs only in tropical waters of the western Pacific and Indian oceans (ELBRACHTER; QI, 1998, SAITO; FURUYA, 2006). The majority of blooms are harmless water discolorations, predominantly caused by *N. scintillans* (AJANI et al., 2001). Hereafter, *N. scintillans* that lacks the symbiont is referred to as red *Noctiluca* (SRIWOON et al., 2008).

On the coast of the state of Rio Grande do Sul (RS), most blooms are formed by diatoms (*Asterionellopsis glacialis*). However, high concentrations of dinoflagellates are occasionally found, associated with low wave energy and high light intensity (ODEBRECHT et al., 1995). On the southern coast of Brazil, four mortality events have been recorded for the benthic fauna, associated with the presence of potentially toxic dinoflagellates (MACHADO, 1979; ROSA; BUSELATO, 1981; GARCIA et al., 1994, ODEBRECHT et al., 1995, MENDEZ, 1995). In this region, dinoflagellate blooms are irregular and seem to be more a response to the vagaries of unpredictable shifts in climatic factors, than to a deterministic mechanism. Nocturnal bioluminescence of *Noctiluca scintillans* was observed in northern RS in summer 2005, but was recorded only by a local newspaper (Zero Hora).

The northern coast of Rio Grande do Sul extends for 120 km from Torres Beach at the border with the state of Santa Catarina, southward to Pinhal Beach. During three days in December 2008, a red color on the sea was visible from the beach [1]. On the first day (17 December), the bloom was visible at Capão da Canoa Beach (nearly 70 km from Torres Beach) and moved southward to Cidreira and Pinhal beaches by the third day (19 December), after which it vanished. The present report describes the first recorded reddish bloom of *Noctiluca scintillans* on the northern coast of Rio Grande do Sul, Brazil.

The area off the RS continental margin is influenced by several water masses, including the Tropical Water (TW) of the Brazil Current; the South Atlantic Central Water (SACW), also called Subtropical Water (STW); and the coastal branch of the Falklands Current, which transports Sub-Antarctic Water (SAW). The thermohaline properties of water on the continental shelf vary as a result of the volume of fresh water discharged by the plume of the Plate River (RPP) and the Patos Lagoon, and the degree of influence of the TW and SAW. More locally, four water masses influence the northern coast: Subtropical Water of the continental shelf (STWP), Sub-Antarctic Water of the continental shelf (SAWP), Tropical Water (TW), and the South Atlantic Central Water (SACW). Only the TW (≥18.5°C; ≥36‰) and SACW

(≤18.5°C; ≥35.3‰) show temperature and salinity patterns independent of the seasons (MÖLLER et al., 2008). The discharge from Tramandaí Lagoon influences, to different degrees, the thermohaline properties of the water on the northern coast, mainly during the winter rains, but to a lesser degree than the larger Patos Lagoon and the Plate River.

During the morning of day 2 (December 18 2008) of the bloom, surface-water samples were collected from a PETROBRAS vessel, 800 m from Tramandaí Beach. The samples were collected following standard sampling procedure (APHA, 1995), using Van Dorn bottles (two, 1-L samples for quantitative analysis) and a plankton net with 63 µm mesh (one 1-L sample for qualitative analysis) in the same area of the bloom. The temperature was taken simultaneously, with a manual thermometer.

Noctiluca cell numbers were estimated from the mean counts in 1-mL and 5-mL water samples; cells were counted in the entire volume of a Sedgwick-Rafter chamber, using a Zeiss inverted microscope. The density was calculated in cells per liter (APHA, 1995).

A single species of *N. scintillans* formed a broad streak about 3 m wide and 50 m long, with a thick soup-like consistency. During the bloom period, the coastal waters were colored reddish, which was attributed to the bloom of *Noctiluca*. This is the first record of a red tide with this characteristic color on the northern coast of RS; all previous records refer to the southern coast of RS, bordering Uruguay (MACHADO, 1979; ROSA; BUSELATO, 1981, GARCIA et al., 1994, ODEBRECHT et al., 1995, MENDEZ, 1995).

Nauplii were abundant in the net sample. No dead animals were seen in the ocean during the three days of the bloom, or during seven days of observation of the sample in the laboratory. Unfortunately, the state Environmental Protection Agency does not monitor HAB along the coast, but only water quality along the beaches (by coliform bacteria counts). Although in this case the bloom was not harmful, another bloom of this species in the Gulf of Mannar (India) caused mortality of marine organisms and also formed a thick mucus-like layer that settled on the seaweeds, corals and the bottom sediment. This led to the death of almost all the local marine fauna and flora, by asphyxiation (GOPAKUMAR et al., 2009). Because of the potential for harm, a HAB monitoring program must be implemented in RS, especially during summer when the beaches are crowded.

Microscopic examination of living *Noctiluca* cells showed a weakly twisted flagellum. The density of *N. scintillans* on day 2 of the bloom (December 18 2008) was 144 x 10^3 cells.L^{-1}; the population consisted of large-diameter cells (600-1000 µm). The water temperature was 18 °C, which is characteristic of the South Atlantic Central Water (SACW) according to Möller et al. (2008). The cell density of *N. scintillans* was similar to those reported by previous observers around the world (Table 1). Unfortunately neither nutrients nor chlorophyll *a* were measured during this bloom.

Noctiluca scintillans is distributed globally in cold and warm waters (KIØRBOE, 2003). Under laboratory conditions, *N. scintillans* reproduced actively at low temperatures, showing similar growth rates in two experiments (k = 0.2 day^{-1}), close to the growth rates reported in the literature for higher temperatures (UMANI et al., 2004). In the case of *N. scintillans*, a temperature change is thought to be the dominant factor in triggering the onset of a bloom (UHLIG; SAHLING, 1990).

Table 1. Some blooms of *Noctiluca* around the world.

Study sites	**density (cells. L^{-1})**	**Reference**	**Obs**
Tramandai beach, Southern Brazil	144 x 10^3	this study	
Dapeng Bay, the South China Sea	surface10^4 to 10^5	Huang & Qi, 1997; Wang et al., 2008	summer and fall
subsurface10^3 to 10^4	Huang & Qi, 1997		
Minnie Bay, Port Blair	1.5 to 2.3 x10^4	Eashwar et al., 2001	
Minnie Bay, Port Blair	17 x 10^3	Dharani et al., 2004	bloom 48h
Sagami Bay, Japan	Miyaguchi et al., 2006		
Thailand	18.7 x 10^3	Sriwoon et al., 2008	maximum in June 2003 during monsoon periods
Gulf of Mannar (southeast coast of India)	5.1x10^5 to 13.5 x10^5	Gopakumar et al., 2009	intense bloom 2 to 13/October/2008
South-eastern Australia	0.1 to 1 x10^4	Murray & Suthers, 1999	spring and late summer

[1]Photographs of the bloom are available at http://www.lei.furg.br/taxonomia/site/index.php and http://www.clicrbs.com.br/busca/rs?q=mare vermelha&c=004339507562457011598:slvytw1qlpm&t=local

The recent increased frequency of algal blooms worldwide has led some scientists to believe that a change in marine planktonic ecosystems on a global scale is being caused by human alterations to the coastal zone (DHARANI et al., 2004). It is well understood that the outbreak of an algal bloom is a result of a complex interplay among temperature, currents, wind and nutrients (GOPAKUMAR et al., 2009). A rich food supply is necessary for *Noctiluca* to reproduce massively, but a suitable temperature and stable humid weather without heavy rain are also considered to be important factors (HUANG; QI, 1997).

Several factors are proposed as affecting the population dynamics of red *Noctiluca* in temperate waters, as summarized by Elbrachter and QI (1998); these factors include temperature, salinity, light, food supply, cellular buoyancy, and physical processes that determine the spatial distribution of the organism. Because of its heterotrophic nature, prey availability is essential for the growth of red *Noctiluca* (SRIWOON et al., 2008). Red *Noctiluca* is a voracious predator, with a diverse diet ranging from phytoplankton to copepods and fish eggs (HATTORI, 1962; KIMOR, 1979; SCHAUMANN et al., 1988; NAKAMURA, 1998). A suggested link between increasing bloom events of red *Noctiluca* and the eutrophication of coastal waters is enhanced prey availability due to eutrophication. Various factors other than food supply also play a role in the population dynamics of red *Noctiluca*, the relative importance of which probably changes according to the locality, phase of bloom formation, and environmental conditions (UHLIG; SAHLING, 1995; ELBRACHTER; QI, 1998). The present case is the first reported instance of a red *Noctiluca* bloom in RS, and the coastal waters in this region, as in other parts of the world, are becoming increasingly eutrophic. Without a HAB monitoring program, it is difficult to assess the specific cause of this red bloom. However, it is often very difficult to determine the specific cause of an algal bloom. In extensively studied areas such as Port Blair Bay, the origin of *Noctiluca* blooms is not always concurrent with nutrient inputs (EASHWAR et al., 2001), although it has been suggested that local enrichment of nutrients by terrigenous and allochthonous inputs to the coastal waters of Port Blair Bay may be one of the important causative factors (DHARANI et al., 2004).

Although the precise cause of the present bloom is unclear, we suggest that probably the short period of the bloom (three days) was a result of freshwater output from the Tramandaí Lagoon channel, because *Noctiluca* requires high salinity and is more often found in cool water (e.g., in neighboring Uruguay). In the net sample, nauplii were abundant, which contributed to the food supply and may have been one of the important causative factors of this red *Noctiluca* bloom.

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