First Record of a *Rhizosolenia debyana* Bloom in the Gulf of California, México[1]

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Abstract: A bloom of the diatom *Rhizosolenia debyana* H. Peragallo was observed in the southwestern Gulf of California. This bloom was estimated to be about 22 km long and represents the first record of this species for the area. Total abundance of *R. debyana* ranged from 2,576,000 to 3,684,000 cells liter^{-1}. Chlorophyll *a* concentrations ranged from 17.15 to 41.45 mg/m^3. *Rhizosolenia debyana* has a tropical and subtropical distribution.

The diatom genus *Rhizosolenia* is one of the most important genera of marine phytoplankton and sometimes dominates the phytoplankton biomass in highly productive areas of the ocean (Sundström 1986). In addition to solitary forms and chain-forming growth modes, *Rhizosolenia* species also grow in aggregate forms. These aggregates or plankton blooms dominated by large and attenuate *Rhizosolenia* species have been referred to as "styliplankton" (Smayda and Reynolds 2001).

Round (1967) observed that marine diatoms develop important blooms in the Gulf of California. However, in spite of *Rhizosolenia* being one of the most abundant and common taxa in the gulf (Gárate-Lizárraga et al. 1990, Hernández-Becerril 1995), no blooms have been recorded previously in the area. According to Hallegraeff (1993), a worldwide increase of algal blooms has occurred in the last three decades. In the Gulf of California such an increase has also been observed, and blooming species of dinoflagellates such as *Cochlodinium polykrikoides* and *Alexandrium affine* have been recorded for the first time in Mexican coastal waters (Gárate-Lizárraga et al. 2000, 2001*a*). Here we report blooming by the diatom *Rhizosolenia debyana* H. Peragallo in the Gulf of California.

MATERIALS AND METHODS

Two surface samples were collected from a golden brown patch observed on 27 June 2001 in the San Lorenzo Channel (24° 23.2′ N, 110° 17.0′ W and 24° 24′ N, 110° 15.0′ W), in the southwestern Gulf of California (Figure 1). Samples for identification and cell counting were fixed and preserved with Lugol and 3% formalin. Samples were analyzed in 5-ml settling chambers and observed using a phase-contrast inverted microscope (Hasle 1978). Total abundance was estimated at the same time as the species composition determination. Surface water temperatures were recorded using a Kalhlsico thermometer. To determine the photosynthetic pigments, 100 ml of water was passed through Whatman GF/F filters, which were frozen at −20°C until further analyses in the laboratory. Chlorophyll content was measured following the technique of Jeffrey and Humprey (1975).

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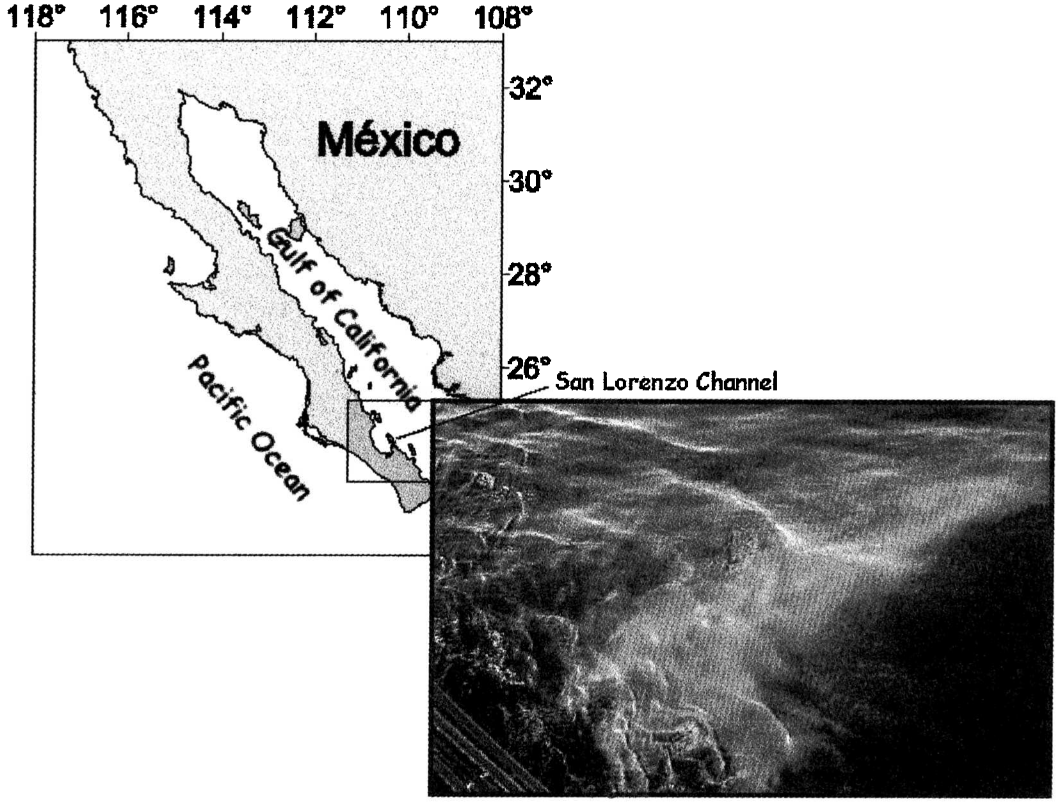

FIGURE 1. Location of the study area and bloom of *Rhizosolenia debyana*.

RESULTS AND DISCUSSION

The golden brown patch was estimated at about 22 km long. Phytoplankton composition in samples was mainly *Rhizosolenia debyana* (≈95–99%). A bloom of similar magnitude (tentatively identified as *R. castracanei*) was recorded in a frontal system at 2° N, 140° W (Yoder et al. 1994). Other taxa, such as *R. formosa* and *R. temperei*, were observed in low concentrations in our samples. These two large species of *Rhizosolenia* were also recorded by Gárate-Lizárraga (1989) and Hernández-Becerril (1995). These species and *R. debyana* have a tropical and subtropical distribution (Sundström 1986).

Rhizosolenia debyana occurs as solitary cells or in chains of two and three cells. Cells are cylindrical, hyaline, with conical valves ending in a sharp process (Figure 2*a*). The otaria is detectable only on the valve. The cingulum bands are arranged in columns (Figure 2*b*). From 19 to 22 band areolae occur in 10 µm. There are distinct claspers in the contiguous area. The length of the frustules along the pervalvar axis varied from 320 to 970 µm ($n = 15$). Diameter of the valves varied from 160 to 278 µm ($n = 15$). The valve is similar in shape to that of *Rhizosolenia castracanei* var. *castracanei*, but the band areolae are smaller. Total abundance of *R. debyana* ranged from 2,576,000 to 3,684,000 cells liter^{-1}. *Rhizosolenia debyana* had been recorded previously by Hernández-Becerril (1995) in extremely low numbers, in only one sampling station located in the outer part of the Gulf of California.

The *R. debyana* bloom occurred at a surface water temperature of 26°C. Nutrient concentrations recorded in this area were as follows: 0.44 µM $NO_2 + NO_3$, 0.71 µM PO_4,

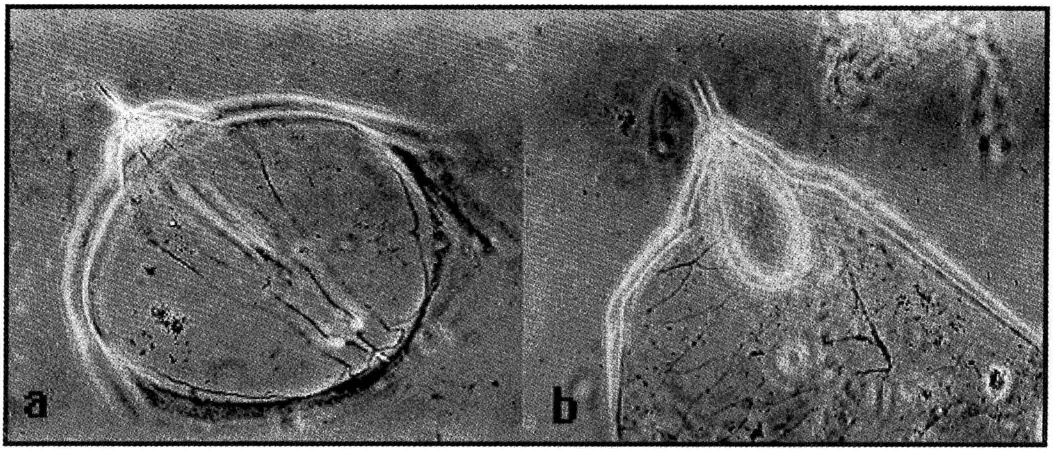

FIGURE 2. *Rhizosolenia debyana* (light microscopy): *a*, cell in valve view. *b*, lateral view.

and 4.71 μM SiO_4. Chlorophyll *a* concentrations were high and ranged from 17.15 to 41.45 mg/m^3. Highest values of chlorophyll *a* in this area have been related to blooms of *Mesodinium rubrum* (10 mg/m^3) (Martínez-López et al. 2001) and *Cochlodinium polykrikoides* (2.7–56.8 mg/m^3), which are responsible for local increases in the concentrations of chlorophyll *a* and seem to be very important in terms of the fertility of this coastal zone (Gárate-Lizárraga et al. 2000, 2001*b*). Chlorophyll *a* concentrations of the patches of *R. castracanei* reported by Yoder et al. (1994) were also high and ranged from 5 to 29 mg/m^3. Villareal and Carpenter (1989) pointed out that *Rhizosolenia* aggregations or mats may account for ≈2–30% of chlorophyll *a* in surface waters. However, the bloom reported here may have accounted for up to 90% of the chlorophyll *a* measured. Although algal blooms are common events along both coasts of the Gulf of California (Cortés-Altamirano et al. 1996, Gárate-Lizárraga et al. 2001*b*), records of diatom blooms are scarce (Round 1967, Gárate-Lizárraga et al. 1990, Molina et al. 1997). This *R. debyana* bloom represents not only the first record for this area but worldwide.

Villareal (1988) recorded *R. debyana* off Miami, the Bahamas, and in the Sargasso Sea. Villareal mentioned that this species is capable of positive buoyancy, which represents a key mechanism for explaining the survival of extremely large diatom cells in oligotrophic waters. Positive buoyancy by diatoms can be achieved via density regulation and provides a clear advantage to cells in a stratified, stable water column where turbulence may be insufficient to keep negatively buoyant cells suspended (Smayda 1970). A thermal stratification of the water column has been observed during summer in the San Lorenzo Channel (De Silva-Dávila 1997, Lavaniegos and López-Cortés 1997). Similar hydrographic conditions and the lack of winds could have favored the occurrence and persistence of the *R. debyana* bloom.

The transitional nature of the study area poses an ideal environment for the growth of this highly opportunistic species. San Lorenzo Channel water temperatures vary from 16.5°C in February to 29°C in August (Lavaniegos and López-Cortés 1997). Seasonal variations of hydrographic conditions combined with El Niño–La Niña events may allow formation of diatom blooms such as this one more frequently than previously suspected. During the sampling, though, normal conditions characterized the study area (Durazo et al. 2001).

The monitoring programs directed toward detection of harmful algal blooms (HABs) may yield further observations of diatom blooms in the area. This will lead to a better understanding of phytoplankton blooming under various conditions and of the mechanisms that trigger and sustain a particular algal bloom.

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