NOTA

BLOOMS OF *Trichodesmium erythraeum* AND *T. thiebautii* (CYANOBACTERIA, OSCILLATORIALES) IN THE BAHÍA DE LA PAZ, GULF OF CALIFORNIA

Florecimientos de *Trichodesmium erythraeum* y *T. thiebautii* (Cyanobacteria, Oscillatoriales) en la Bahía de La Paz, Golfo de California

RESUMEN. Se hicieron muestreos de siete florecimientos de *Trichodesmium* en la Bahía de La Paz entre 2005 y 2011. *Trichodesmium erythraeum* y *T. thiebautii* fueron las especies responsables; esta ultima especie es registrada por primera vez en el Golfo de California. Los florecimientos de *T. erythraeum* presentaron concentraciones entre 0.75 y 4.5 × 10^6 céls L^{-1} mientras que *Trichodesmium thiebautii* alcanzó densidades entre 1.86 y 2.34 × 10^6 céls L^{-1}. Los florecimientos ocurrieron dentro de un intervalo de temperatura de 20 y 30 °C y no causaron ningún efecto negativo sobre la biota marina de la zona.

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Microalgae blooms (also named “red tides”) are common seasonal events occurring throughout the littoral of the Baja California Peninsula (Gárate-Lizárraga, 2011). Bahía de La Paz is a large bay where blooms have been sighted since 1984. More than 40 blooms and more than 25 bloom-forming taxa have been recorded, including the lagoon called the Ensenada de La Paz located in its southern-most extension (Gárate-Lizárraga *et al*., 2001; 2006). The most reported bloom-forming species at the southern end of the bay are dinoflagellates and diatoms, and the ciliate *Myrionecta rubra* (Lohmann, 1908) Jankowski, 1976. Other phytoplankton groups, such as raphidophytes, silicoflagellates, and cyanobacteria have been rarely reported (Band-Schmidt *et al*., 2005; Gárate-Lizárraga *et al*., 2006; 2009). Blooms of oscillatorial cyanobacteria are a potential source of toxins in the ciguatera food chain and have been previously reported to contain certain types of paralyzing toxins (Kerbrat *et al*., 2010). An important component of the phytoplankton community during blooms in tropical and subtropical seas are species of *Trichodesmium* Ehrenberg ex Gomont, 1892 which comprise around 10 species of filamentous organisms that are mainly distributed in warm-temperate and tropical seas (Cronberg & Annadotter, 2006). *Trichodesmium* are ecologically important because they are non-heterocystous nitrogen-fixing species that contribute nitrogen in oligotrophic (Holl *et al*., 2007) and eutrophic waters (White *et al*., 2007). Blooms of *Trichodesmium* are rarely reported in the Gulf of California (Cortés-Altamirano, 1988) and particularly in the Bahía de La Paz (García-Pámanes & Gárate-Lizárraga, 1984; Ochoa *et al*., 1997; Muciño-Márquez, 2010). In this his study we describe recent blooms of *Trichodesmium erytraeum* Ehrenberg ex Gomont, 1892 and *Trichodesmium thiebautii* Gomont ex Gomont, 1892 in the Bahía de La Paz.

Samples from six surface blooms were collected at different sites in the Bahía de La Paz (Fig. 1). Also, samples of a bloom detected in September 2006 were collected at three depths (0, 15, and 30 m). Sea surface temperature was measured with a bucket thermometer. In all cases, cell counts were made in a Sedgewick-Rafter chamber or in 5 and 25 mL sedimentation chambers under an inverted phase-contrast Zeiss microscope. Cells of each trichome were counted to estimate abundance of *Trichodesmium* species. A compound microscope (model CH2, Olympus, Japan) was used to measure cells. A digital Konus camera and SONY Cyber-shot camera (8.1 MP) were used to record images.

The blooms of *T. erythraeum* and *T. thiebautii* were observed at different sites at the southern end of the Bahía de La Paz. The surface water color during the blooms varied from pale brown to pinkish red. A bloom detected on 10 December 2011 was yellow pale. Here, *Trichodesmium* cells were forming a single filament (Fig. 2) of more than 90 trichomes (Fig. 3). Surface blooms of *T. erythraeum* reached densities from 0.75–4.5 × 10^6 cells L^{-1} and *T. thiebautii* reached densities from 1.86–2.34 × 10^6 cells L^{-1} (Table 1). *T. erythraeum* had a well-marked vertical distribution on 25 June 2006. The highest concentrations occurred at the surface and the lowest at 30 m (Table 1). Blooms of *Trichodesmium* species occurred in a range of 20–30 °C. *Trichodesmium* specimens fit well within the diagnosis and descriptions of Desikachary (1959). Morphological differences between these two species seem to be related to the diameter:height ratio of cells in the trichome, higher in *T. erythraeum* than in *T. thiebautii*. The filaments of *T. erythraeum* are usually attenuated with a calyptra at the end; calyptrae are not found in *T. thiebautii* (Desikachary, 1959). Both species occur in solitary trichomes or in colonies of aggregated filaments. *Trichodesmium* can oc-

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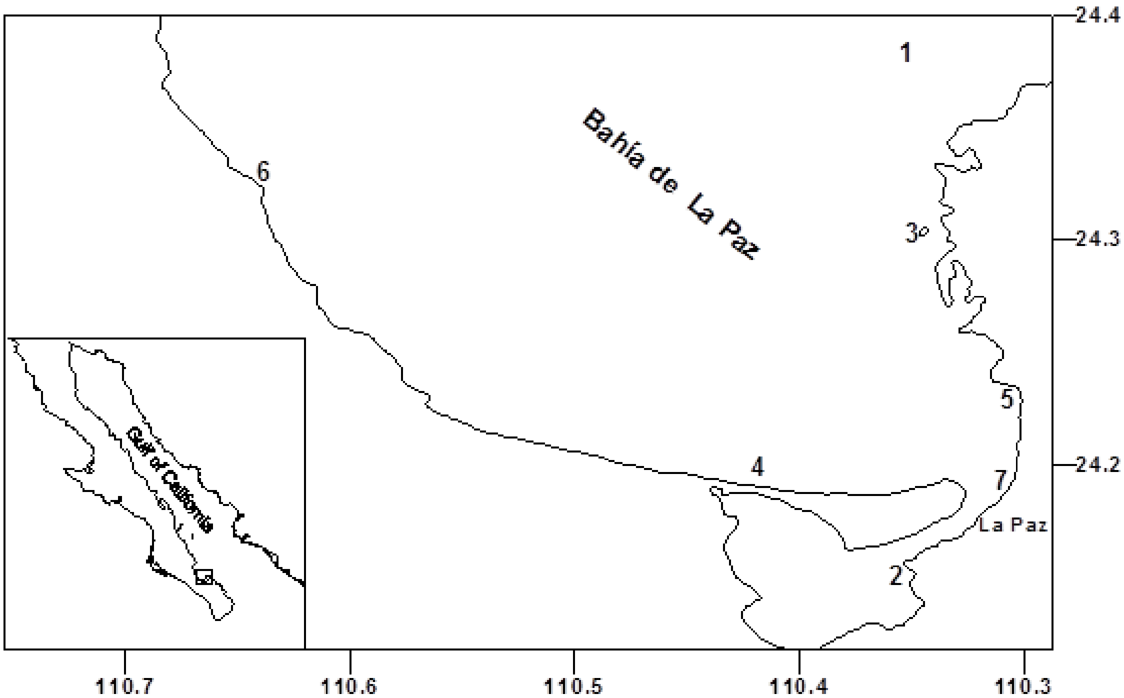


Figure 1. Locations where blooms of *Trichodesmium* species were observed in the Bahía de La Paz, Gulf of California, between 2005 and 2011.

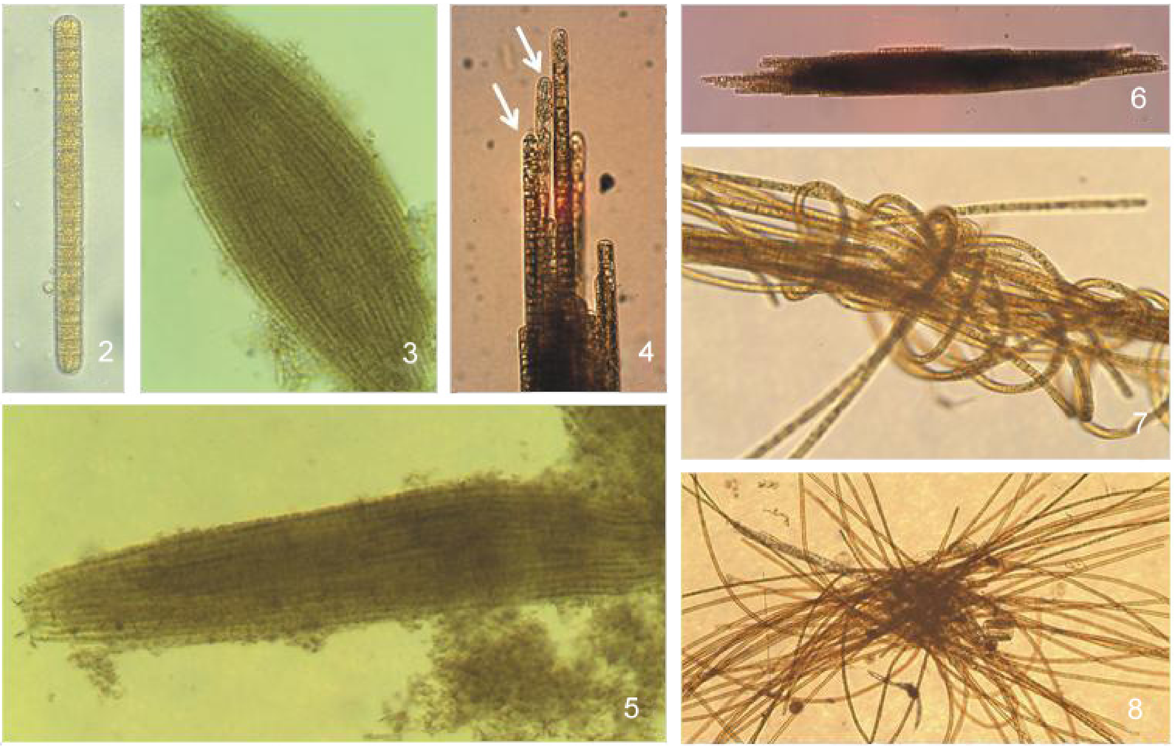
cur as tufts formed by parallel arrays of filaments (*T. erythraeum,* Figs. 3–6) or radial puff arrays of filaments (*T. thiebautii*, Figs. 7 and 8). The latter species can form fusiform (Fig. 7) and puff aggregates (Fig. 8), according to Carpenter *et al*. (2004). Trichomes had approximately 6–80 cells. The *T. erythraeum* cells width is 7-15 µm and the cells length is 5-10 µm. *T. thiebautii* cells were not measured.

Blooms of *T. erythraeum* have rarely been reported along the Pacific coast of Mexico (Cortés-Altamirano, 1988; Figueroa-Torres, 1994; Gárate-Lizárraga & Siqueiros-Beltrones, 1998; White *et al*., 2007) and Mexican coast of the Gulf of Mexico (Aldeco *et al*., 2009; Aké-Castillo, 2011). Blooms of *T. thiebautii* have not been reported until now. This finding is a new record for this species that caused a bloom in Bahia de La Paz. Massive blooms of *T. erythraeum* were reported in the Ensenada de La Paz during 1981 (García-Pámanes & Gárate-Lizárraga, 1984). These blooms were attributed to municipal discharges into the shallow coastal lagoon. When discharges stopped, blooms of *T. erythraeum* were not observed for a long time.

Although *Trichodesmium* blooms are a good

Table 1. Data from seven locations during *Trichodesmium* blooms in the Bahía de La Paz.

Bloom	Date		Species	Abundance (cells L^{-1})	T °C
1	28/06/2005	(Sample 1)	*T. erythraeum*	1.89×10^6	26.5
	29/06/2005	(Sample 2)	*T. erythraeum*	1.23×10^6	26
2	9/12/2006	(Sample 1)	*T. erythraeum*	2.74×10^6	21
3	25/09/2006	(Sample at 0 m)	*T. erythraeum*	1.6×10^6	30
	25/09/2006	(Sample at 15 m)	*T. erythraeum*	45.8×10^3	28
	25/09/2006	(Sample at 30 m)	*T. erythraeum*	20.6×10^3	26.5
4	17/05/2009	(Sample 1)	*T. erythraeum*	0.75×10^6	25.5
5	12/05/2010	(Sample 1)	*T. erythraeum*	4.5×10^6	24
	12/05/2010	(Sample 2)	*T. erythraeum*	3.63×10^6	24
	12/05/2010	(Sample 3)	*T. erythraeum*	3.41×10^6	24
	13/05/2010	(Sample 1)	*T. erythraeum*	1.91×10^6	24.5
	13/05/2010	(Sample 2)	*T. erythraeum*	1.27×10^6	24.5
6	13/12/2010	(Sample 1)	*T. thiebautii*	1.86×10^6	20
	14/12/2010	(Sample 2)	*T. thiebautii*	2.34×10^6	22
7	10/12/2011	(Sample 1)	*T. erythraeum*	0.82×10^6	20
	10/12/2011	(Sample 2)	*T. erythraeum*	0.33×10^6	20



Figures 2–8. Solitary trichome of *Trichodesmium erythraeum* (Fig. 2). Different tufts of *T. erythraeum* blooms (Figs. 3, 4, 5, and 6), arrows indicate the calyptra at the end of the trichomes. Tuft (Fig. 7) and Puff (Fig. 8) colonies of *T. thiebautii* in the Bahía de La Paz.

source of newly fixed carbon and nitrogen, they serve as a food source only for a selected group of copepods because others organisms are deterred by a toxin produced by these cyanobacteria (Hawser *et al*., 1992; Capone 1997). Occasionally, *T. erythraeum* and *T*. *thiebautii* have been implicated in die-offs and negatively affect public human health (Sato *et al*., 1963) and marine life (Landsberg, 2002). Toxicity of *Trichodesmium* has been recorded mainly in marine grazers (Hawser *et al*., 1992; Preston *et al*., 1998); public health records exist (Sato *et al*., 1963). Strains can produce neurotoxins and hepatotoxins (Hawser *et al*., 1991, 1992; Cronberg & Annadotter, 2006); Lipid-soluble toxins (CTXs-like toxins) and water-soluble paralyzing toxins were recently detected in *T*. *erythraeum* and *T*. *thiebautii* (Kerbrat *et al*., 2010), showing the contribution of these pelagic cyanobacteria to the ciguatera food chain. Blooms of *T. erythraeum* and *T*. *thiebautii* were found in small patches (10–30 m long and 3–16 m wide), which accumulated along the shore by wind forcing or during rising tides (Gárate-Lizárraga *et al*., 2006). They were observed for one or two days. These small blooms were not implicated in die-off events that cause negative effects to marine biota. To prevent future public health and aquaculture problems by these toxic species, a monitoring program in the Bahía de La Paz and other coastal areas of the State of Baja California Sur is an on-going activity.

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