

FIRST RECORD OF A RED TIDE CAUSED BY *Gyrodinium instriatum* (DINOPHYCEAE: GYMNODINIALES) IN BAHÍA DE ACAPULCO, GUERRERO

Primer registro de una marea roja ocasionada por *Gyrodinium instriatum* (Dinophyceae: Gymnodiniales) en Bahía de Acapulco, Guerrero

RESUMEN. El 26 de Enero de 2012 se observó en la Bahía de Acapulco una marea roja causada por el dinoflagelado desnudo *Gyrodinium instriatum*, cuya abundancia varió entre 796 y 2120×10^3 céls L^{-1} . Otros dinoflagelados abundantes fueron *Noctiluca scintillans* y *Gymnodinium catenatum*. Los valores promedio de temperatura y salinidad (*in situ*) fueron de $24.4^\circ C$ y 33.13 , respectivamente durante la proliferación que estuvo relacionada con altas concentraciones de nutrientes, particularmente de amonio y nitratos.

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Red tides along the coasts of the State of Guerrero, particularly in Bahía de Acapulco, have been monitored over the last two decades (Saldade-Castañeda *et al.*, 1991; Orellana-Cepeda *et al.*, 1998; Gárate-Lizárraga *et al.*, 2008; 2009a; 2011; 2012; Díaz-Ortiz *et al.*, 2010). In most cases, these blooms resulted from the proliferation of dinoflagellates such as *Gymnodinium catenatum*, *Pyrodinium bahamense* var. *compressum*, and *Cochlodinium polykrikoides*. Sometimes, these three toxic species occur simultaneously (Gárate-Lizárraga *et al.*, 2011). Red tides often have negative impacts on marine fauna through poisoning, mechanical damage, or by other media (Gárate-Lizárraga *et al.*, 2001). However, other causative organisms, such as *Noctiluca scintillans*, *Neoceratium balechii*, and *Takayama* sp., have proven innocuous to the marine biota in Bahía

de Acapulco (Gárate-Lizárraga *et al.*, 2008). This report describes the first proliferation of *Gyrodinium instriatum* in Bahía de Acapulco during the winter of 2012 and its connections to physicochemical variables.

Samples were collected at three stations in Bahía de Acapulco, Guerrero (Fig. 1) during the onset of a red tide on 26 January 2012. Discolored (reddish) water was observed at different sites in Bahía de Acapulco (Fig. 2; Table 1). Samples for cell counting, temperature, salinity, and nutrients were collected at 1 m using a 3 L van Dorn bottle. Samples were fixed with Lugol solution. Cells were counted in a Sedgewick-Rafter chamber (1 mL), using a compound Zeiss microscope (Hasle, 1978). Water transparency was measured with a Secchi disk. Water temperature and salinity were measured *in situ* with an YSI probe. Nutrient concentrations (phosphates, ammonium, nitrates, and nitrites) were determined in each sample following a standard method (Auto-analyzer C200). Sea surface temperature (SST) and chlorophyll *a* images with a 4 km resolution (3-day composites) from 19 to 27 January 2012 were used (www.oceancolor.gsfc.nasa.gov). The data were limited to the area of the Bahía de Acapulco.

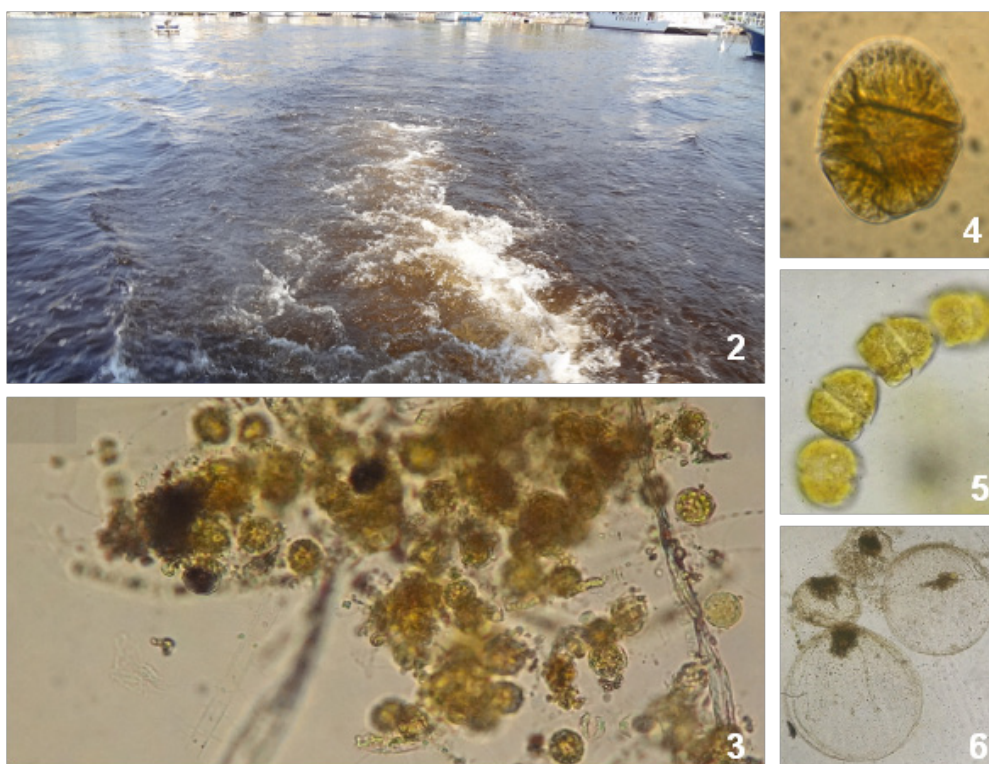
Total abundance and the contribution of each microalgae species during the red tide are summarized in Table 1. The predominant species was *Gyrodinium instriatum* (2120×10^3 cells L^{-1} ; Figs. 3-4), followed by other dinoflagellates such as *Gymnodinium catenatum* (197×10^3 cells L^{-1} ; Fig. 5), *Noctiluca scintillans* (613×10^3 cells L^{-1} ; Fig. 6), and the diatom *Guinardia delicatula* (83×10^3 cells L^{-1}). Seawater temperature varied from $27^\circ C$ in 19 June and $26.3^\circ C$ in 27 June (Fig. 7). Average temperature and salinity (*in situ*) were $24.4^\circ C$ and 33.13 , respectively. Turbidity, measured with a Secchi disc, ranged from 3–5 m (Table 1). Concentrations of nutrients during the bloom ranged from 0.27 – $0.7 \mu M PO_4$, 1.04 – 2.2



Figure 1. Location of sampling stations (1–3) in Bahía de Acapulco, Guerrero, surveyed on 26 January 2012.

Table 1. Data collected at three sampling sites, location, abundance of microalgae species (cells L⁻¹) and physicochemical variables in Bahía de Acapulco during the red tide on 26 January 2012.

	Abundance ($\times 10^3$)	Temperature (°C)	Salinity	Secchi disk (m)	Phosphates ($\mu\text{M PO}_4^{3-}$)	Ammonium ($\mu\text{M NH}_4^+$)	Nitrates ($\mu\text{M NO}_2^-$)
E1 - Club de Yates 16°50'40.16"N, 99°54'7.01"W							
<i>Gyrodinium instriatum</i>	2120	24.5	33.09	4	0.27	1.04	2.9
<i>Gymnodinium catenatum</i>	8						
<i>Noctiluca scintillans</i>	392						
Total Abundance	2520						
E2 - Casa Díaz Ordaz 16°49'35.42"N, 99°52'21.42"W							
<i>Gyrodinium instriatum</i>	1194	24.4	33.16	5	0.56	1.8	6
<i>Gymnodinium catenatum</i>	20						
<i>Noctiluca scintillans</i>	307						
<i>Guinardia delicatula</i>	83						
Total Abundance	1604						
E3 - Estación Palmita 16°49'26.67"N, 99°54'51.02"W							
<i>Gyrodinium instriatum</i>	796	24.3	33.14	3	0.7	2.2	Not detected
<i>Gymnodinium catenatum</i>	197						
<i>Noctiluca scintillans</i>	613						
Total Abundance	1606						



Figures 2–6. A general view of the bloom at Club de Yates (Fig. 2); characteristic phytoplankton in the bloom observed at 200X (Fig. 3); ventral view of a live cell of *Gyrodinium instriatum* (Fig. 4); a four-celled chain of *Gymnodinium catenatum* (Fig. 5); cells of *Noctiluca scintillans* (Fig. 6).

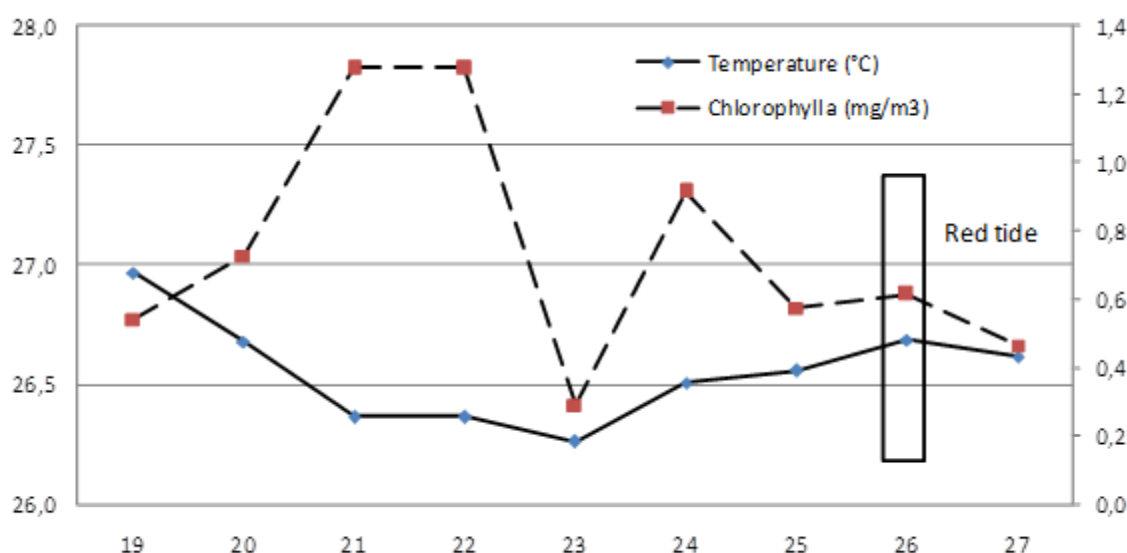


Figure 7. Sea surface temperature and chlorophyll a variation from 19 to 27 January 2012 in Bahía de Acapulco, Guerrero, downloaded from MODIS-OCEAN satellite database.

$\mu\text{M NH}_4$, 2.9–6 $\mu\text{M NO}_2$ nitrites were not detected (Table 1). Chlorophyll a content was 1.3 mg m^{-3} previous to the microalgal bloom and 0.61 mg m^{-3} during the red tide (Fig. 7). Highest values of chlorophyll a recorded previous to the bloom could mean that this began before it was surveyed.

Densities of *G. instriatum* ($796\text{--}2120 \times 10^3 \text{ cells L}^{-1}$) found in this study are in the range reported by Gárate-Lizárraga *et al.* (2009b) ($702\text{--}3680 \times 10^3 \text{ cells L}^{-1}$) in Bahía de La Paz and Mejía-Maya *et al.* (2011) ($1973 \times 10^3 \text{ cells L}^{-1}$) in Bahía de Maruata, Michoacán. No densities of *G. instriatum* were reported for Bahía de Mazatlán, Sinaloa and Bahía de Manzanillo, Colima. Although red tides are frequent and periodic throughout the year in Bahía de Acapulco (Gárate-Lizárraga *et al.*, 2008, 2009a; Díaz-Ortiz *et al.*, 2010; Gárate-Lizárraga *et al.*, 2011, 2012), this finding represents the first proliferation of *G. instriatum* in Bahía de Acapulco. It is also the southernmost record along the Pacific coast of Mexico for this species.

Red tides by *G. instriatum* are common in Japan (Toriumi, 1990), in the Gulf of Guayaquil in Ecuador (Jimenez, 1993), and along the east coast of the United States and estuaries leading into the Gulf of Mexico (Tomas *et al.*, 2004). Red tides by *G. instriatum* have been rarely reported in the Gulf of California (Alonso-Rodríguez *et al.*, 2004; Gárate-Lizárraga *et al.*, 2009b, 2011) and along the central Pacific coast of Mexico (Morales-Blake *et al.*, 2009; Mejía-Maya *et al.*, 2011).

Optimum growth rates (>0.5 divisions/day) for *G. instriatum* were observed at temperatures ranging from 20 to 30 °C and at salinities from 10 to 35 (Nagasoe *et al.*, 2006). The proliferation of *G. instriatum* during the event in Bahía de Acapulco lies in the range of these two variables reported by Nagasoe

et al. (2006). High turbidity (3–5 m) resulted from the high density of microalgae at each sampling station (1604 to $2520 \times 10^3 \text{ cells L}^{-1}$). Concentrations of nutrients were higher than reported for this bay in a previous study (Rojas-Herrera *et al.*, 2011), particularly ammonium and nitrates. Nagasoe *et al.* (2010) believes that a continuous supply of inorganic nitrogen would be essential for *G. instriatum* blooms. This species has a resting cyst stage in its life cycle (Matsuoka & Fukuyo, 2000; Orlova *et al.*, 2003). Resting cysts of dinoflagellates are significant in initiating blooms (Anderson *et al.*, 1983). The combination of environmental factors and the presence of cysts in the bay could eventually lead to other blooms of *G. instriatum* in Bahía de Acapulco.

At present no specific toxin has been identified for *G. instriatum*, although red tides of this species can have noxious effects (Tomas *et al.*, 2004). Mass mortality in shrimp farms caused by *G. instriatum* in the Gulf of Guayaquil in Ecuador could be the result of anoxic bottom water following the outbreak of this dinoflagellate (Jimenez, 1993). However, during a red tide of *G. instriatum* in Shenzhen Bay, China in spring 1998 no fish kills were recorded (Wang *et al.*, 2001). In our study, no mortality or deleterious damage was observed among the local marine biota. Monitoring of blooms and toxin-producing microalgae species in Bahía de Acapulco is an on-going activity.

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