NOTA

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 °C y 33.13, respectivamente durante la proliferación que estuvo relacionada con altas concentraciones de nutrientes, particularmente de amonio y nitratos.

Gárate-Lizárraga, I.[1], G. Sevilla-Torres[3], M. Álvarez-Añorve[3], F. Aguirre-Bahena[2], J. Violante-González[4] & A. Rojas-Herrera[4]. [1]Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas, Departamento de Plancton y Ecología Marina, [2]Departamento de Oceanología, Apartado postal 592, La Paz, Baja California Sur, 23096, México. [3]Universidad Autónoma de Guerrero Unidad Académica Preparatoria 2 y Unidad Académica de Enfermería 2, Av. de la Cañada s/n, Col. Alta Progreso Acapulco de Juárez Guerrero, 39350, México. [4]Unidad Académica de Ecología Marina, Universidad Autónoma de Guerrero, Gran Vía Tropical No. 20, Fraccionamiento Las Playas, Acapulco de Juárez, Guerrero, 39390, México. email: igarate@ipn.mx

Gárate-Lizárraga, I., G. Sevilla-Torres, M. Álvarez-Añorve, F. Aguirre-Bahena, J. Violante-González & A. Rojas-Herrera. 2013. First record of a red tide caused by *Gyrodinium instriatum* (Dinophyceae: Gymnodiniales) in Bahía de Acapulco, Guerrero. *CICIMAR Oceánides*, 28(1): 43-47.

Red tides along the coasts of the State of Guerrero, particularly in Bahía de Acapulco, have been monitored over the last two decades (Saldate-Castañeda *et al*., 1991; Orellana-Cepeda *et al*., 1998; Gárate-Lizárraga *et al*., 2008; 2009a; 2011; 2012; Diaz-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 (Autoanalyzer 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 × 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 °C in 19 June and 26.3 °C in 27 June (Fig. 7). Average temperature and salinity (*in situ*) were 24.4 °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 μM PO_4, 1.04–2.2

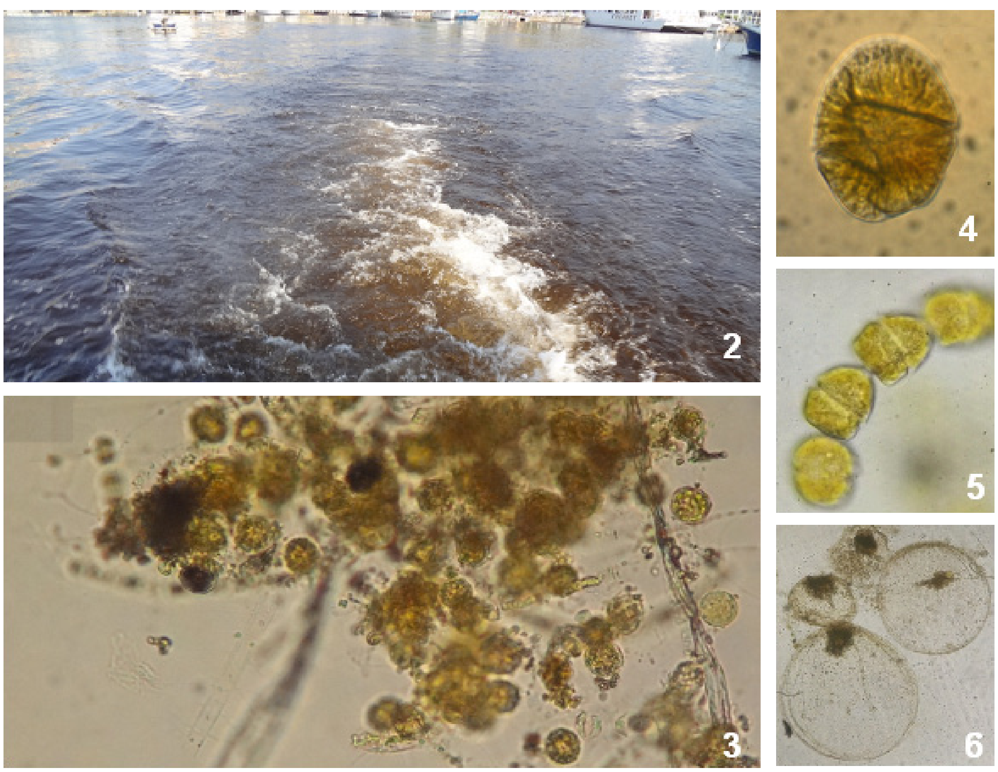
Figure 1. Location of sampling stations (1–3) in Bahía de Acapulco, Guerrero, surveyed on 26 January 2012.

Fecha de recepción: 05 de junio de 2012

Fecha de aceptación: 22 de octubre de 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 ($\mu M\ PO4)_3^-$	Ammonium ($\mu M\ NH_4^+$)	Nitrates ($\mu M\ NO_2^-$)
E1 - Club de Yates 16°50'40.16"N, 99°54'7.01"W							
Gyrodinium instriatum	2120	24.5	33.09	4	0.27	1.04	2.9
Gymnodinium catenatum	8						
Noctiluca scintillans	392						
Total Abundance	2520						
E2 - Casa Díaz Ordaz 16°49'35.42"N, 99°52'21.42"W							
Gyrodinium instriatum	1194	24.4	33.16	5	0.56	1.8	6
Gymnodinium catenatum	20						
Noctiluca scintillans	307						
Guinardia delicatula	83						
Total Abundance	1604						
E3 - Estación Palmita 16°49'26.67"N, 99°54'51.02"W							
Gyrodinium instriatum	796	24.3	33.14	3	0.7	2.2	Not detected
Gymnodinium catenatum	197						
Noctiluca scintillans	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).

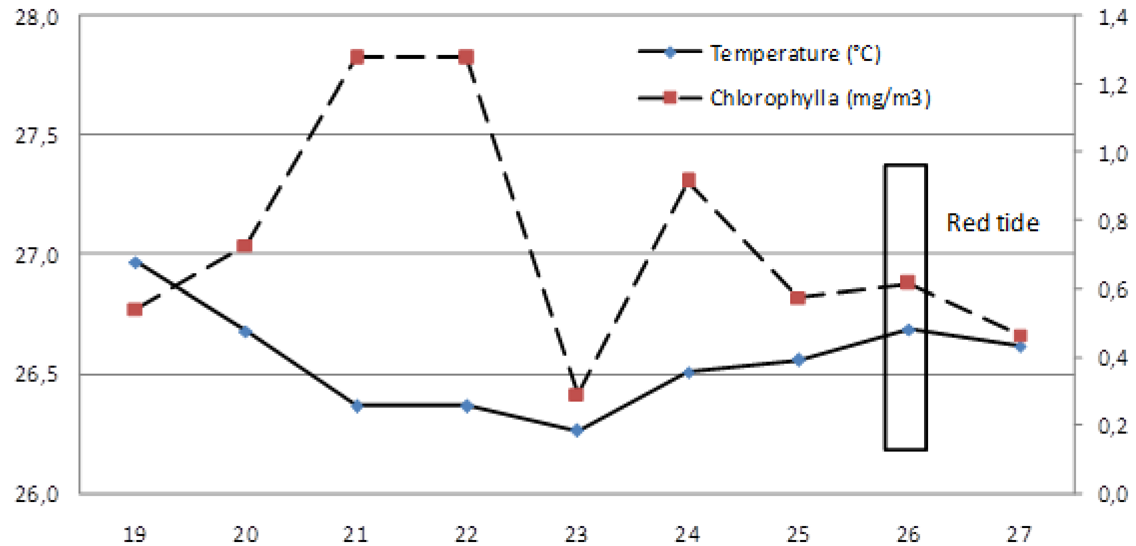


Figure 7. Sea surface temperature and chlorophyll *a* variation from 19 to 27 January 2012 in Bahía de Acapulco, Guerrero, downloaded from MODIS-OCEAN satellite database.

µM NH_4, 2.9–6 µM 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* (796–2120 × 10^3 cells L^{-1}) found in this study are in the range reported by Gárate-Lizárraga *et al.* (2009b) (702–3680 × 10^3 cells L^{-1}) in Bahía de La Paz and Mejía-Maya *et al.* (2011) (1973 × 10^3 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; Diaz-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 × 10^3 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.

ACKNOWLEDGMENTS

This project was funded by Universidad Autónoma de Guerrero (Project: Variables fisicoquímicas que determinan las floraciones algales en la Bahía de Acapulco) and the Instituto Politécnico Nacional (Project: SIP-20121153). I.G.L. is a COFAA and EDI fellow.

REFERENCES

Alonso-Rodríguez, R., F. Páez-Osuna & I. Gárate-Lizárraga. 2004. El fitoplancton en la camaronicultura y larvicultura: importancia de un buen manejo. Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México y Comité Estatal de Sanidad Acuícola de Sinaloa, México. 147 p.

Anderson, D.M., S.W. Chisholm & C.J. Watras. 1983. Importance of life cycle events in the population dynamics of *Gonyaulax tamarensis*. *Mar*. *Biol*., 76:179–189.

Díaz-Ortiz, J.A., B. Pérez-Cruz, R. Valdovinos-Sánchez, M.A. Alarcón-Romero, S. López-Silva, L. Chávez–Almazán & J.L. García-Barboza. 2010. Registro histórico de marea roja en la Bahía de Acapulco de 1992 a 2010. *Red Sanitaria*, 7(2):1–4.

Gárate-Lizárraga, I., M. L. Hernández-Orozco, C. Band-Schmidt & G. Serrano-Casillas. 2001. Red tides along the coasts of Baja California Sur, México (1984 to 2001). *Oceánides*, 16(2):127–134.

Gárate-Lizárraga, I., B. Pérez-Cruz, J.A. Díaz-Ortíz & C.J. Band-Schmidt. 2008. Microalgas y biotoxinas marinas en las costas mexicanas. *Conversus*, 9: 22–26.

Gárate-Lizárraga, I., J.A. Díaz-Ortiz, B. Pérez-Cruz, M. Alarcón-Tacuba, A. Torres-Jaramillo, M.A. Alarcón-Romero & S. López-Silva. 2009a. *Cochlodinium polykrikoides* and *Gymnodinium catenatum* in Bahía de Acapulco, Mexico (2005–2008). *Harmful Algae News,* 40: 8–9.

Gárate-Lizárraga, I., C.J. Band-Schmidt, F. Aguirre-Bahena & T. Grayeb del Alamo. 2009b. A multi-species microalgae bloom in Bahía de La Paz, Gulf of California, Mexico (June 2008). *CICIMAR Oceánides*, 24 (1):15–29.

Gárate-Lizárraga, I., J.A. Díaz-Ortiz, B. Pérez-Cruz, M.A. Alarcón-Romero, L.A. Chávez-Almazán, J.L. García-Barbosa & S. López-Silva. 2011. A multi-species dinoflagellate bloom and shellfish toxicity in Costa Grande, Guerrero, Mexico (December, 2010). *CICIMAR Oceánides*, 26(1): 67–71.

Gárate-Lizárraga, I., B. Pérez-Cruz, J.A. Díaz-Ortiz, M. Alarcón-Tacuba, L. Chávez-Almazán, M.A. Alarcón-Romero, S. López-Silva, J.J. Bustillos-Guzmán & S. Licea-Durán. 2012. Toxicity and paralytic toxin profile in *Pyrodinium bahamense* var. *compressum* and violet oyster in Bahía de Acapulco, Guerrero, Mexico. *Harmful Algae News*, (45): 2–3.

Hasle, G.R. 1978. The inverted microscope method. 88–96. *In*: Sournia, A. (Ed.). *Phytoplankton Manual*. UNESCO, Paris.

Jimenez, R. 1993. Ecological factors related to *Gyrodinium instriatum* bloom in the inner estuary of the Gulf of Guayaquil. 257–262, *In:* Smayda, T.J. & Y. Shimizu (Eds.) *Toxic Phytoplankton Blooms in the Sea*. Elsevier, New York.

Matsuoka, K. & Y. Fukuyo. 2000. *Guía Técnica para el Estudio de Quistes de Dinoflagelados Actuales*. HAB/WESTPAC/IOC, Japan. 30 p.

Mejía-Maya, A., Y. Ahuja-Jiménez, D. U. Hernández-Becerril, G. Ceballos-Corona & A. Morales-Blake. 2011. Análisis de marea roja ocurrida el 5 de mayo de 2010 frente a La Bahía de Maruata, Michoacán (Crucero oceanográfico MAREAR-II). 1er Congreso Nacional de la Sociedad Mexicana para el estudio de los Florecimientos Algales Nocivos A.C. Mazatlán, Sin., 16-18 de Noviembre de 2011. 10 p.

Morales-Blake, A., A. Tintos-Gómez, I. González-Chavarín, H. Ortíz-Lira, J.C. Chávez-Comparán, C. Lezama-Cervantes Carlos & D.H. Hernández-Becerril. 2009. Las mareas rojas en las Bahías de Manzanillo, Colima, (2007-2009). III Taller sobre Florecimientos Algales Nocivos, Acapulco, Gro., 6-9 de Noviembre de 2009. 29 p.

Morales-Blake, A., S. Barón-Campis, Sofía, D.U. Hernández-Becerril, M. Rodríguez-Palacio & G. Ceballos-Corona. 2011. Factores oceanográficos antes y durante eventos de marea roja en el Océano Pacífico Central Mexicano. 1er Congreso Nacional de la Sociedad Mexicana para el estudio de los Florecimientos Algales Nocivos A.C. Mazatlán, Sin., 16-18 de Noviembre de 2011. 13 p.

Nagasoe, S., D.I. Kim, Y. Shimasaki, Y. Oshima, M. Yamaguchi & T. Honjo. 2006. Effects of temperature, salinity and irradiance on the growth of the red tide dinoflagellates *Gyrodinium instriatum* Freudenthal et Lee. *Harmful Algae*, 5: 20–25.

Nagasoe, S., T. Shikata, Y. Yamasaki, T. Matsubara, Y. Shimasaki, Y. Oshima & T. Honjo. 2010. Effects of nutrients on growth of the red-tide dinoflagellates *Gyrodinium instriatum* Freudenthal et Lee and a possible link to blooms of this species. *Hydrobiologia*, 651:225–238.

Orellana-Cepeda, E., E. Martínez-Romero, L. Muñoz-Cabrera, P. López- Ramírez, E. Cabrera-Mancilla & C. Ramírez-Camarena. 1998. Toxicity associated with blooms of *Pyrodinium bahamense* var. *compressum* in southwestern Mexico, 60, *In*: Reguera, B., J. Blanco, M.L.

Fernández &T. Wyatt (Eds.) *Harmful Algae*. Proceedings of the 8th International Conference on Harmful Algae. Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Vigo, Spain.

Orlova, T. Yu., M.S. Selina & O.G. Shevchenko. 2003. Morphology of cysts and vegetative cells of *Gyrodinium instriatum* (Dinophyta): A new species of dinoflagellates for the Seas of Russia. *Russ. J. Mar. Biol*., 29: 138–140.

Rojas-Herrera, A.A., J. Violante-González, S. García-Ibáñez, V.M.G. Sevilla-Torres, J.S. Gil-Guerrero & P. Flores-Rodríguez. 2011. Temporal variation in the phytoplankton community of Acapulco Bay, Mexico. *Microbiol. Res*., 3: 13–19.

Saldate-Castañeda, O., J.L. Vázquez-Castellanos, J. Galván, A. Sánchez-Anguiano & A. Nazar. 1991. Poisoning from paralytic shellfish toxins in Oaxaca, México. *Sal. Pub. Méx*., 33: 240–247.

Tomas, C.R., L.A. Zimmermann, & M.D. Smith. 2004. *Gyrodinium instriatum*. North Carolina Sea Grant. Marine Phytoplankton Identification Series. UNC-SG-00-0X.

Toriumi, S., 1990. *Gyrodinium instriatum.* III Dinophyceae, 63, *In*: Fukuyo Y., H. Takano, M. Chihara & K. Matsuoka. *Red tide organisms in Japan. An illustrated taxonomic guide*, Uchida Rokakuho, Tokyo.

Wang, Z., Y. Qi, Y. Yin, T. Jiang, & L. Xie. 2001. Studies on the cause and the occurrence reasons of a *Gyrodinium instriatum* red tide in Shenzhen Bay in spring of 1998. *Marine Science*, 25(5):47–50.