Unprecedented bloom of the cyanobacteria *Aphanizomenon* in a coastal bay of El Salvador

Cyanobacteria bloom in marine, freshwater and estuarine ecosystems [1]. It is widely recognized that increased nutrient inputs in waterbodies may enhance cyanobacterial growth, resulting in harmful algal blooms [2-3]. In estuarine systems, blooms are enhanced by factors such as excessive nutrient loading, increased surface water temperature, persistent water column stratification, long water residence time, organic matter enrichment, and hydrodynamic and salinity anomalies [4].

Several cyanobacterial species produce toxins, such as microcystins, nodularins, cylindrospermopsin, anatoxin-a, saxitoxins, LPS, aplysiatoxins, and lyngbyatoxins, which can affect humans and animals. [5]. In El Salvador, cyanobacterial blooms have only been reported in freshwater ecosystems, and blooms in estuarine environments are more commonly caused by diatoms or dinoflagellates.

In February 2019, green water discoloration, possibly caused by an intense microalgal bloom, was reported in western Bahía de Jiquilisco, particularly around La Pirraya island (Fig. 1A-B; Supplementary material 1). According to the locals, this potential bloom had started on February 16th and dead clams belonging to the genus *Anadara* were found along the coast of La Pirraya Island during the bloom period (Supplementary material 2). Concern about the impacts from this bloom increased when four piglets, less than one year old, showed signs of dizziness, disorientation and pupil dilation after eating these dead clams washed ashore La Pirraya island at low tide. These piglets subsequently died as they were not able to walk or swim when the tide rose (Supplementary material 3).

In response to this event, five sites in Bahía de Jiquilisco (Fig. 1A) were sampled on 19th by LABTOX-UES staff using a Van Dorn bottle and 20 µm phytoplankton net. Phytoplankton species were quantified using the Utermöhl method or a Sedgewick-Rafter chamber (depending on cell abundance). An additional water sample from February 18th sampled by staff from the Ministry of the Environment and Natural Resources (MARN) offshore from La Pirraya island was also available for analysis.

Samples from February 18th revealed the presence of a high density population (127 x 10^3 colonies L^{-1}) of the cyanobacteria *Aphanizomenon* (Fig. 2). Colonies were counted since cells were moderately disintegrated and difficult to indentify individually. This species of *Aphanizomenon* presented filaments forming fascicle-like colonies that ranged from 99 to 698 µm in length and 46 to 257 µm in width.

Water temperature ranged from 30.4 to 31.1°C, pH from 7.0 to 8.1 and Secchi disk depth from 2.0 to 2.3m.

Aphanizomenon is one of the most common bloom-forming cyanobacteria reported to form blooms in brackish environments [3]and more recently anthropogenic modifications of aquatic environments. However, this genus has not been previously reported in the brackish environments of El Salvador. The genera *Dolichospermum, Pseudanabaena, Lyngbya,* and *Oscillatoria* have been recorded in Bahía de Jiquilisco, [8]. This event is the first first report of an *Aphanizomenon* bloom in the brackish environments of El Salvador.

Despite of the high concentration of *Aphanizomenon* in the sample of February 18th, the genus was not detected

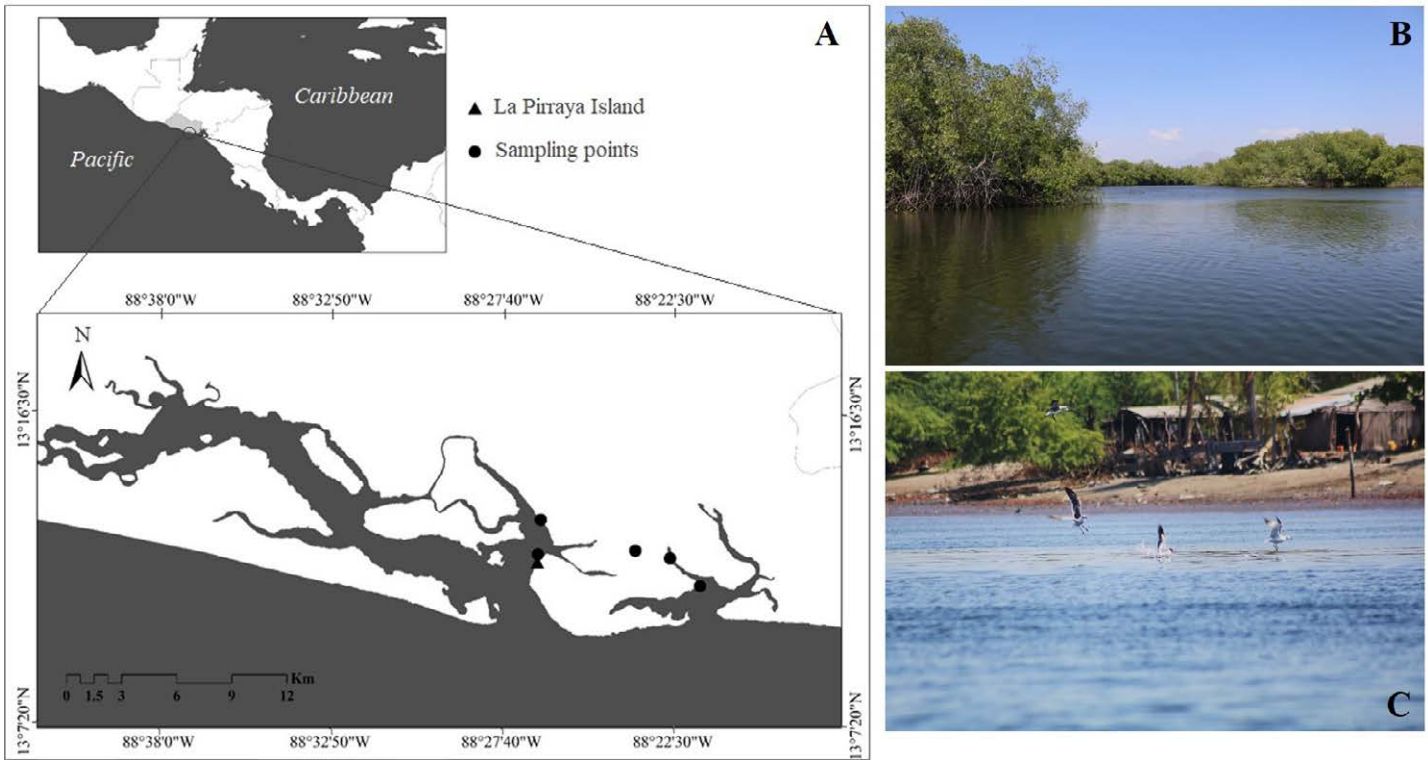

Fig. 1. A. Location of La Pirraya Island and sampling point in Bahía de Jiquilisco, El Salvador. B. Sampling location in Bahía de Jiquilisco. C. Shore of La Pirraya Island, where four pigs died.

Fig. 2. Aphanizomenon fascicles found in Bahía de Jiquilisco observed using an inverted microscope.

Table 1. Most abundant phytoplankton genera and species found in Bahía de Jiquilisco,February 19th, 2019.

Taxa	Cell abundance (cells L^{-1})
Coscinodiscus spp.	54,429
Skeletonema costatum	44,363
Pseudo-nitzschia spp.	18,148
Prorocentrum micans	672
Tripos fusus	672
Prorocentrum c.f. *compressum*	336
Tripos furca	336
Dinophysis caudata	20

in the samples collected during February 19th; suggesting the bloom lasted around three days. Table 1 shows the most abundant phytoplankton genera and species found at the five sampling sites on February 19th. These species were found in similar abundances in previous reports from this area.

It is most likely that the spring high tides that occurred during the night of February 18th washed away the bloom, since local inhabitants reported that after high tide they no longer saw water discoloration. Locals of La Pirraya also expressed they had never seen such type of bloom in the area before.

Although toxicity was not measured in tissues from the dead piglets, it is suspected that the *Aphanizomenon* bloom was linked to their intoxication, since this genus has been reported to produce toxins such as cylindrospermopsin, anatoxin-a, and saxitoxins than can cause hepatic and neurologic effects on mammals [5, 9]. Although four piglets died, there were several other pigs (1.5 years old) nearby that ate dead molluscs but did not die, and signs of dizziness and disorientation they had exhibited disappeared with time.

This event highlights the need to monitor cyanobacteria blooms in El Salvador and the toxins produced by species within this group, since the current national capability to study these blooms is low.

Acknowledgements

We thank the NGO ProCosta for their support for the sampling campaign and providing video material, the Secretary of Scientific Research from the University of El Salvador for logistic support, and the Ministry of Environment and Natural Resources (MARN) for providing water samples. This work was funded by IAEA Project RLA7022 and by the "Network for the Investigation of marine coastal stressors in Latin America and the Caribbean (REMARCO)"

Supplementary material

This material was provided by NGO ProCosta and can be accessed in the following links:
https://drive.google.com/drive/folders/1HLgwp_d9JNhzQQYedVsQVCWOoYQONvn4?usp=sharing

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