¿Qué tan graves son nuestros problemas con las cianobacterias?

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Imágenes

Cyanobacteria planctónicas

- Qué tienen de especial?
- Qué favorece su crecimiento?
- Qué consecuencias tienen las floraciones?

Las cianobacterias son únicas porque:

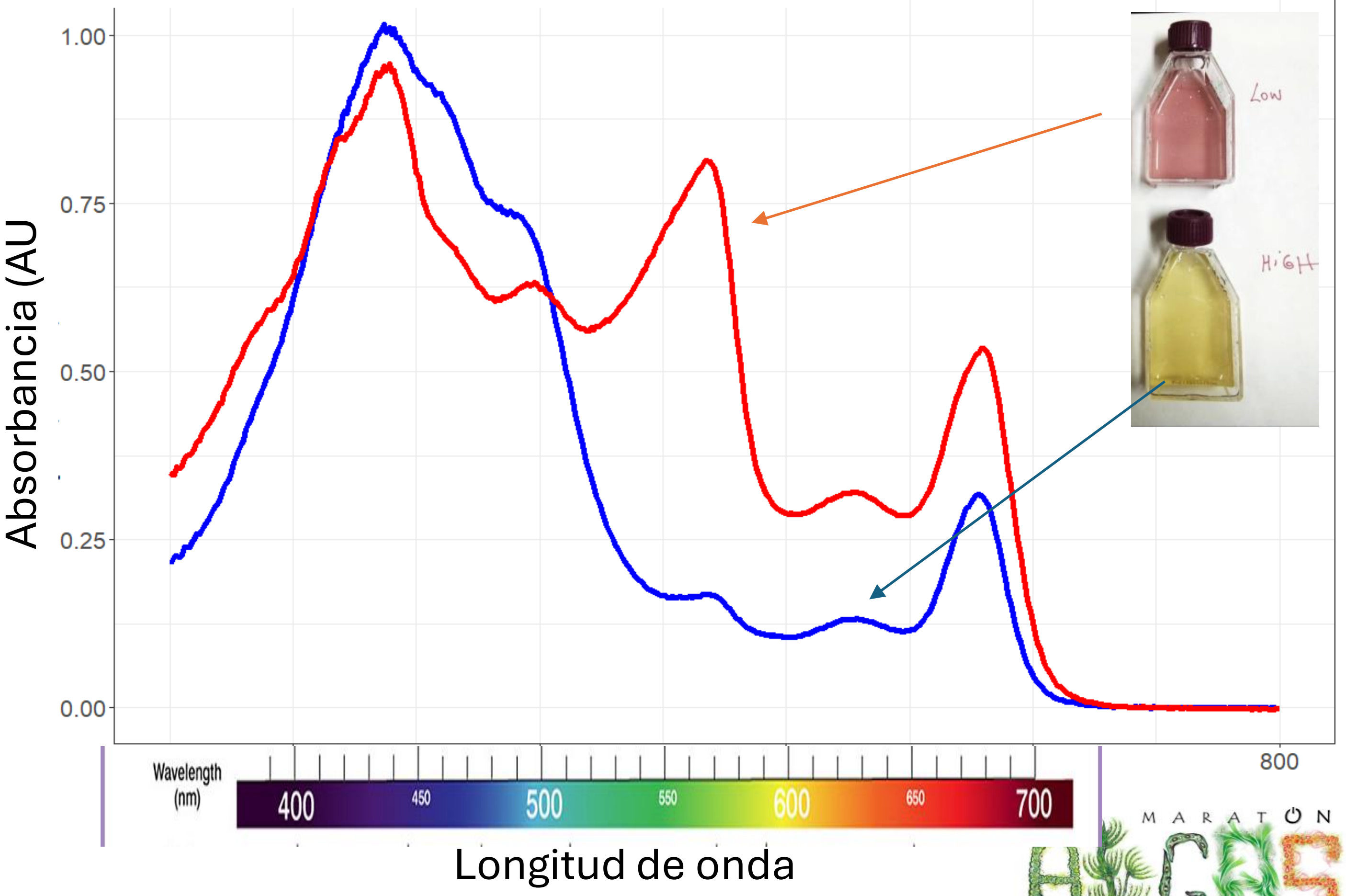
Utilizan los restos energéticos que nadie más puede usar (luz)

Ficobilinas

FICOCIANINA

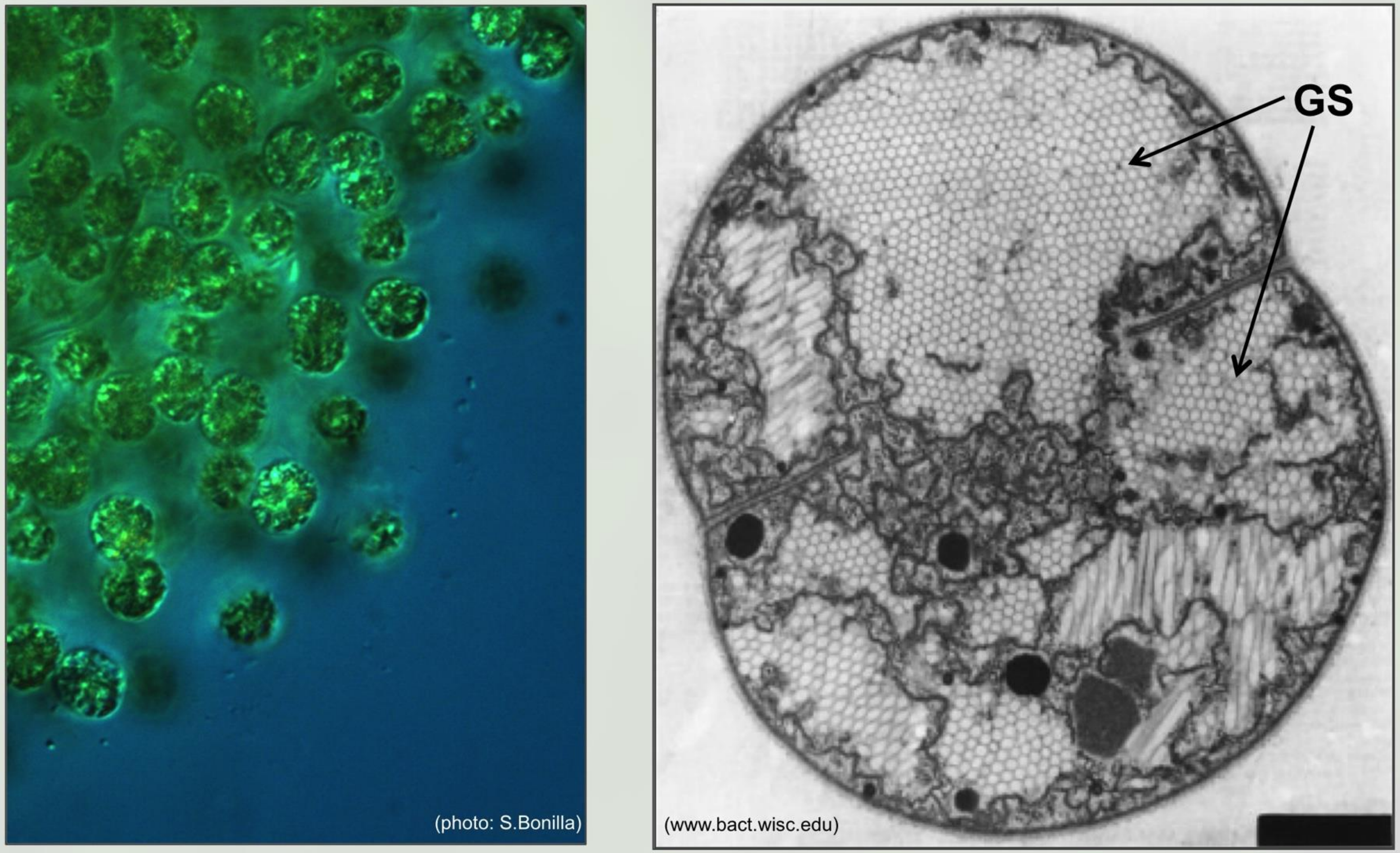
Espectros de absorción *in vivo* (aph)

FICOERITRINA



Bonilla et al (resultados preliminares)

Las cianobacterias son únicas porque:



Microcystis cells filled with vacuola (grouped gas vesicles) (x1000).

TEM image of a cyanobacterial cell full of gas vesicles (GS) (hexagonal structures). (From Walsby, 1974).

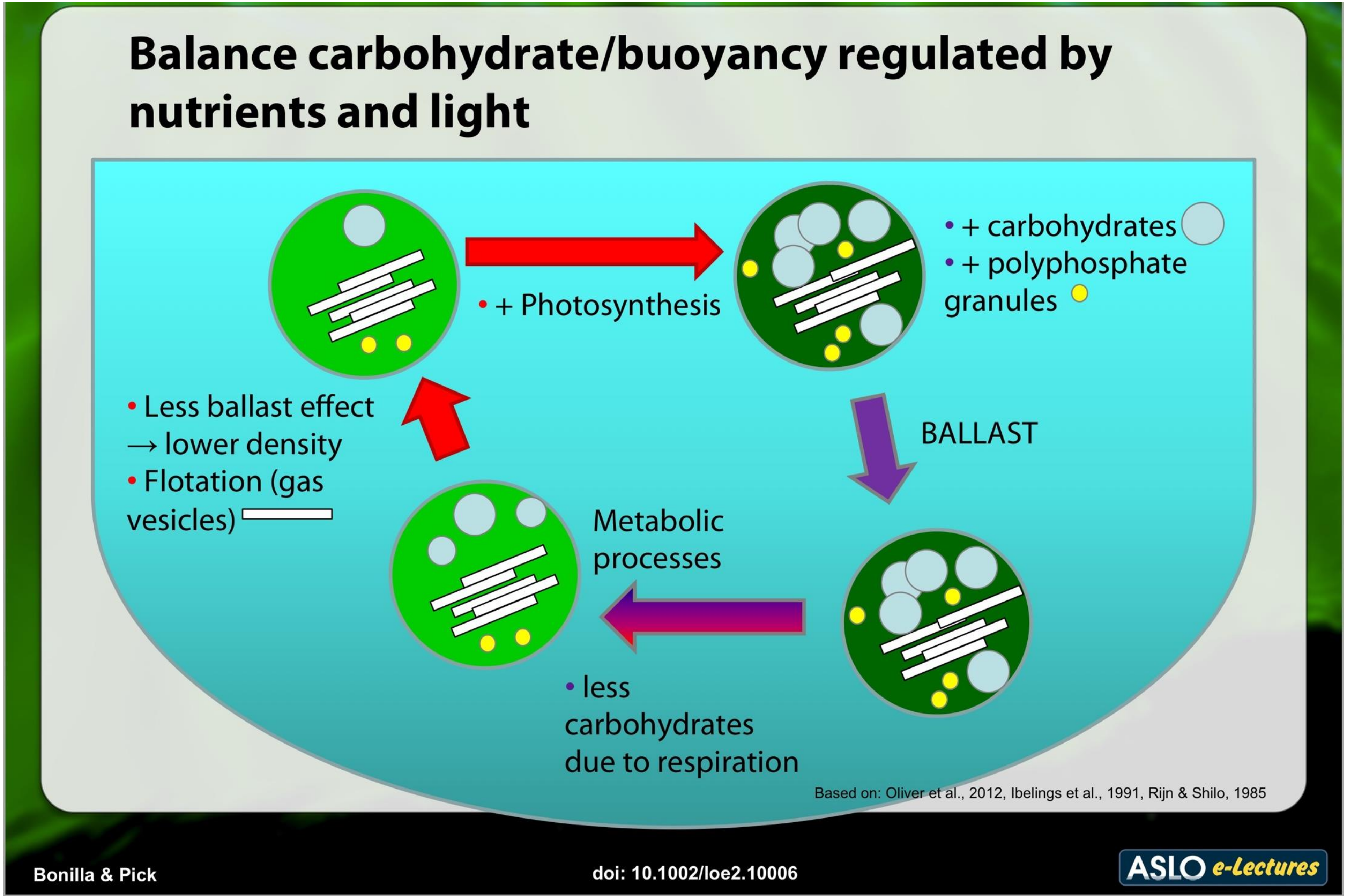
Bonilla & Pick

doi: 10.1002/loe2.10006

ASLO e-Lectures

Bonilla & Pick 2017

Las cianobacterias son únicas porque:

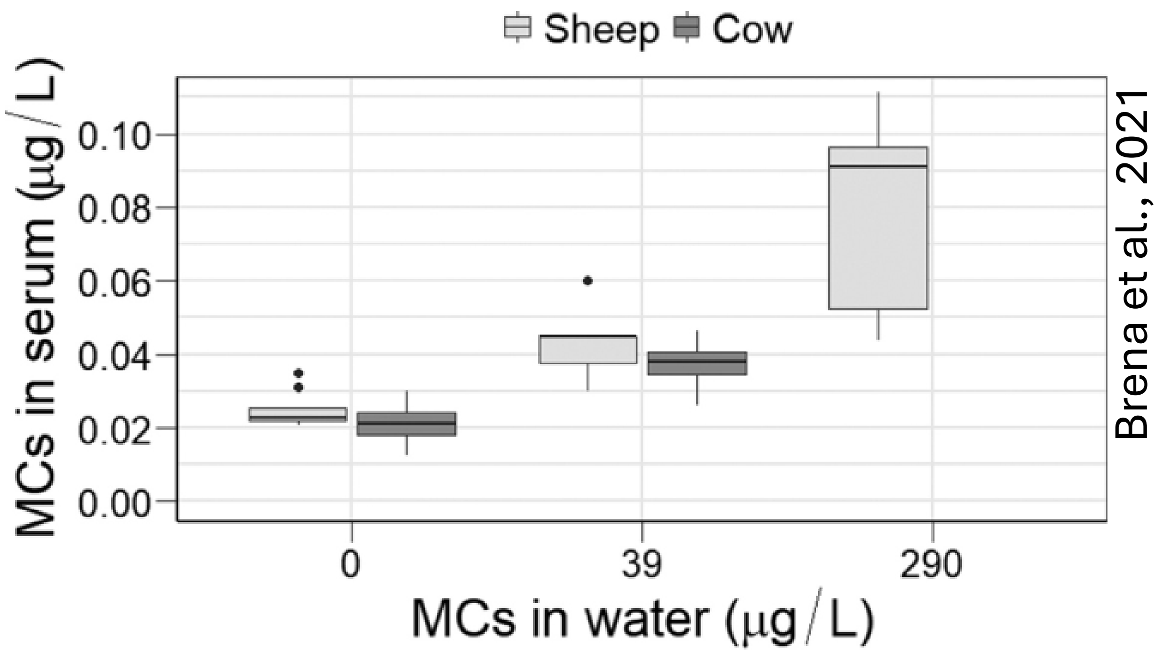


Bonilla & Pick 2017

Las cianobacterias son únicas porque:

Producen potentes toxinas para los animales y el ser humano

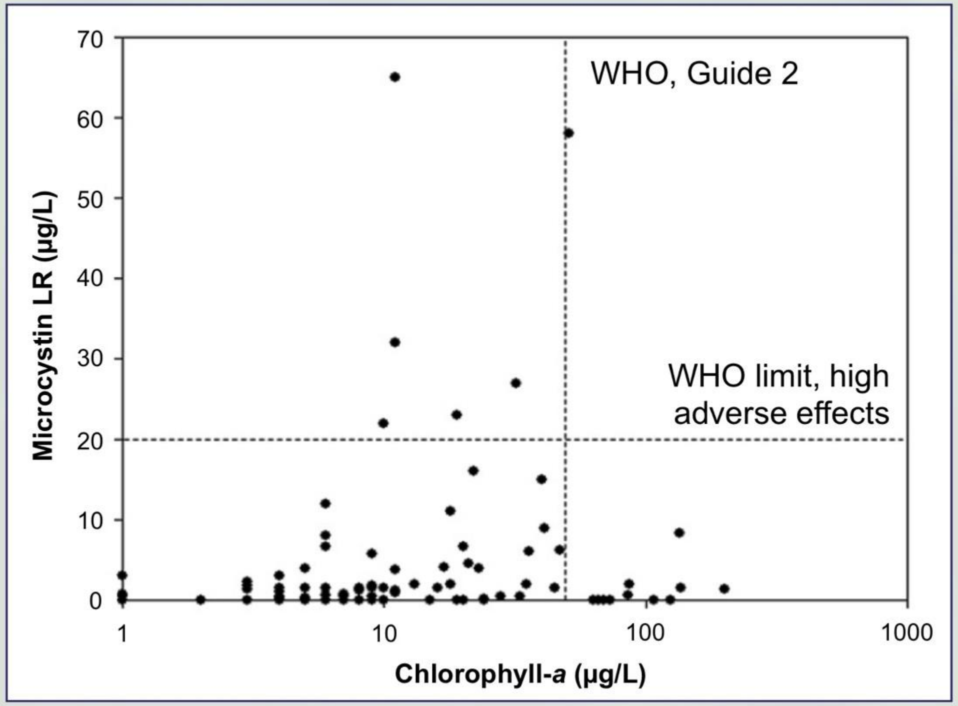
- Toxinas: diversos metabolitos (péptidos, alcaloides, organofosforados naturales)
- Acciones hepatotóxicas, neurotóxicas, dermatotóxicas o citotóxicas
- Gran número de variantes, se supone hay muchas aún sin caracterizar



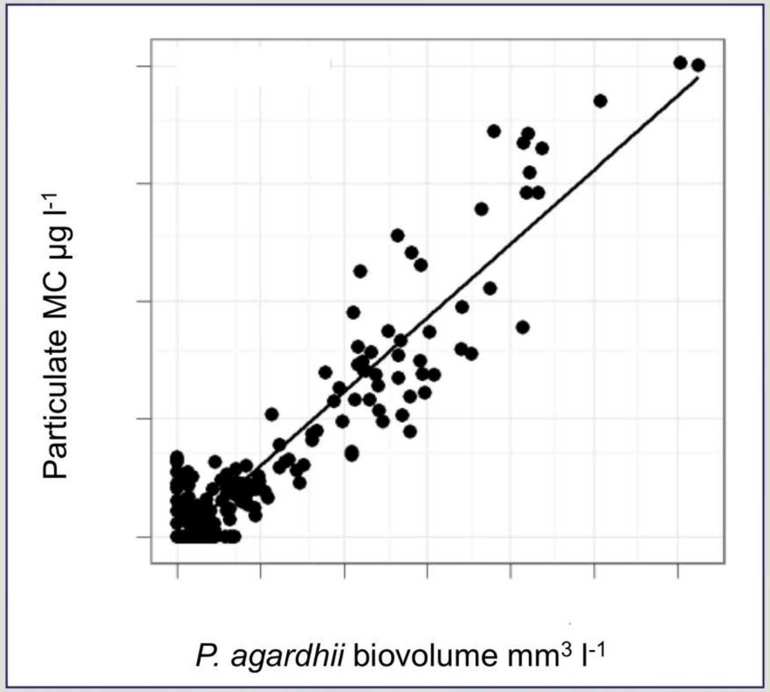
Presencia de MICROCISTINA en sangre de ganado (vacas y ovejas), Río Negro

MICROCISTINAS EN FLORACIONES DE CIANOBACTERIAS

Is this bloom toxic?



La Plata River, Uruguay.
(from Pírez et al., 2013)



Lakes of northern Germany.
(from Dolman et al., 2012)

doi: 10.1002/loe2.10006

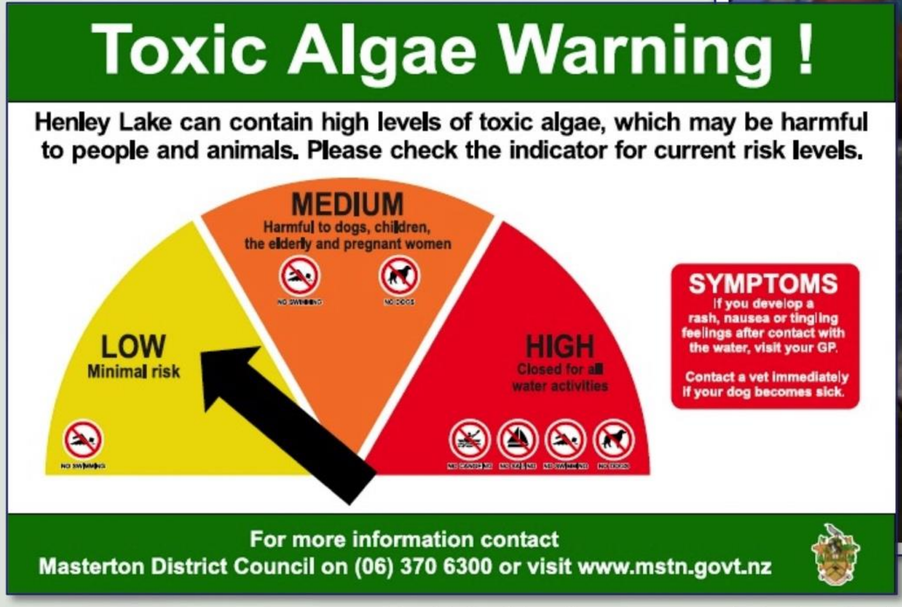
FLORACIONES TÓXICAS IMPIDEN EL USO DEL AGUA

Cyanotoxins:
Threaten or limit water use (e.g. drinking, recreation, livestock)

Toledo, Ohio, without safe tap water

Water treatment plant finds samples with microsystin, product of Lake Erie algae

The Associated Press Posted: Aug 03, 2014 8:39 AM ET | Last Updated: Aug 03, 2014 10:59 AM ET



New Zealand, http://www.gw.govt.nz/toxic-algae-faqs/

doi: 10.1002/loe2.10006

Qué fue lo que pasó?

EL OBSERVADOR

NACIONAL > POR ACUMULACIÓN DE ALGAS

Sigue el mal olor y sabor en el agua

El problema que apareció este jueves se espera solucionar en las próximas horas, indicaron desde el ente

Tiempo de lectura: 1'

08 de marzo de 2013 a las 11:30

A+ A-

Uruguay Presidencia

Institucional Políticas y Gestión Comu

Inicio » Comunicación » Audios » Breves » OSE invirtió US$ 300 mil extra en mitigar mal olor y sabor de agua de Laguna del Sauce

OSE invirtió US$ 300 mil extra en mitigar mal olor y sabor de agua de Laguna del Sauce

07/04/2015

Compartir

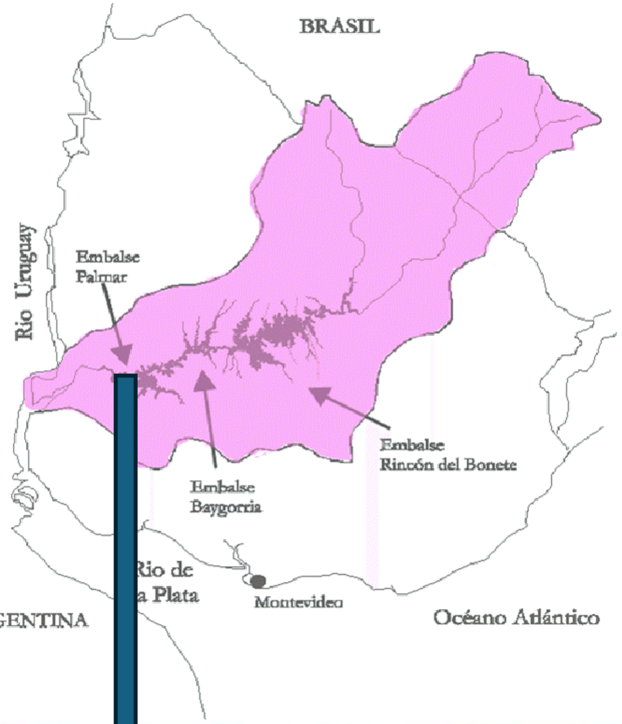
OSE invirtió US$ 300 mil extra para mitigar el evento de mal olor y sabor en el agua de Laguna del Sauce. El presidente del ente, Milton Machado, recordó que la empresa invirtió millones de dólares en el control y monitoreo científico del agua potable que se distribuye en el país. Dijo que no es sustentable financiar la contaminación porque cuanto peor venga la fuente de agua bruta más exigencia tiene OSE para potabilizar.

Evento de 2013: agua potable con fuerte olor y sabor

Factores

Factores combinados: nutrientes y tiempo de residencia

Mapa: González-Piana

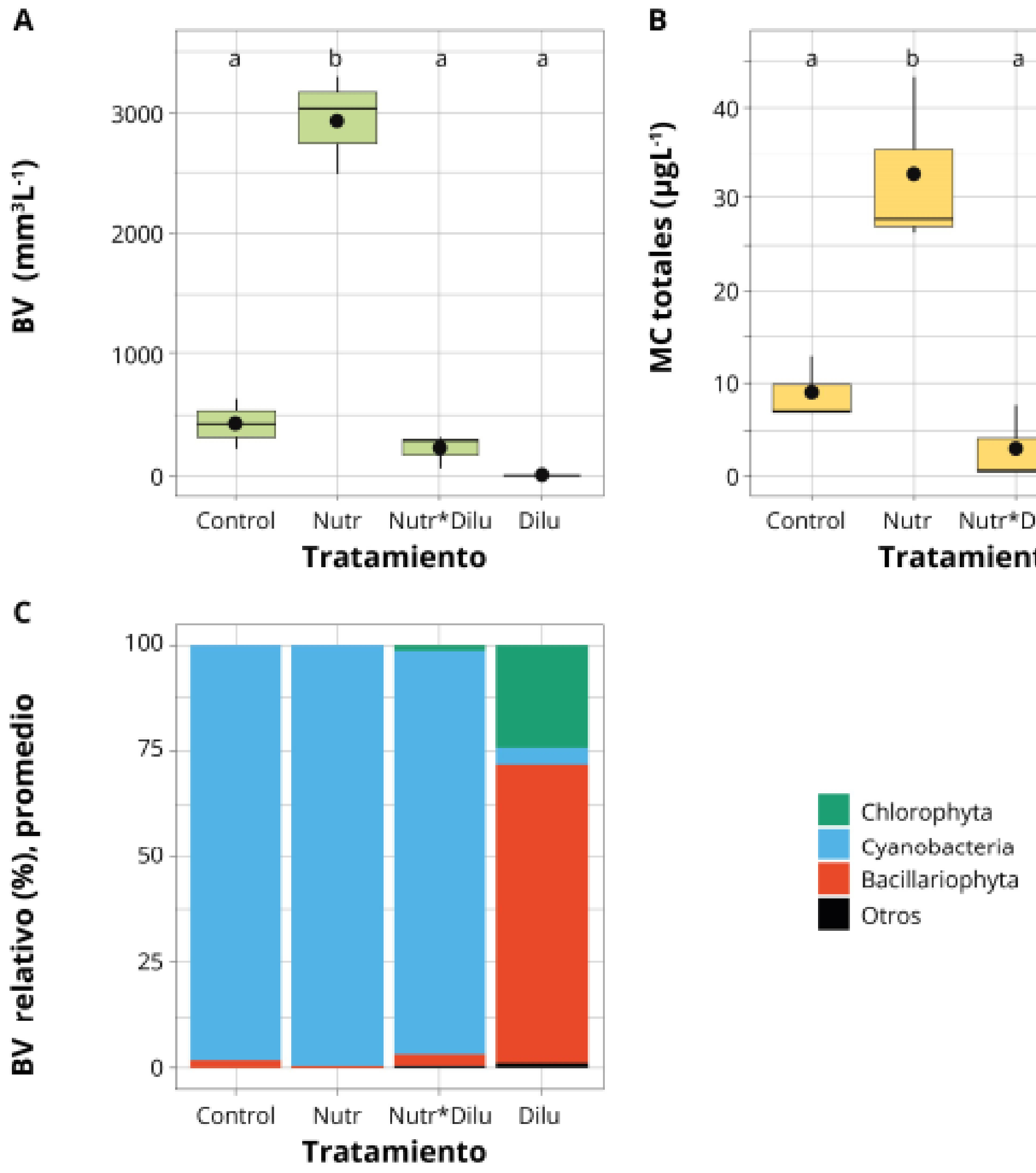


- 10 días
- Unidades experimentales: 600 mL
- Dosis diaria: 133 μgL^{-1} y 1,02 mgL^{-1} (fosfato y nitrato, respectivamente), TOTAL= 1,1 mg**P**L^{-1} y 8,2 mg**N**L^{-1}
- TR bajo: recambio diario de 175 mL con agua de río filtrada.
- n = 3
- 25 ± 2 °C
- 110 – 115 μmol fotón $m_{-2}s_{-1}$
- fotoperíodo 16:8, luz:oscuridad

Tiempo de residencia (TR)	Agregado de Nutrientes	
Bajo 3-4 días (dilución diaria)	No	+NP
Alto (muestra sin dilución, 10 días)	No	+NP

Bonilla et al., 2021

Factores combinados: nutrientes y tiempo de residencia



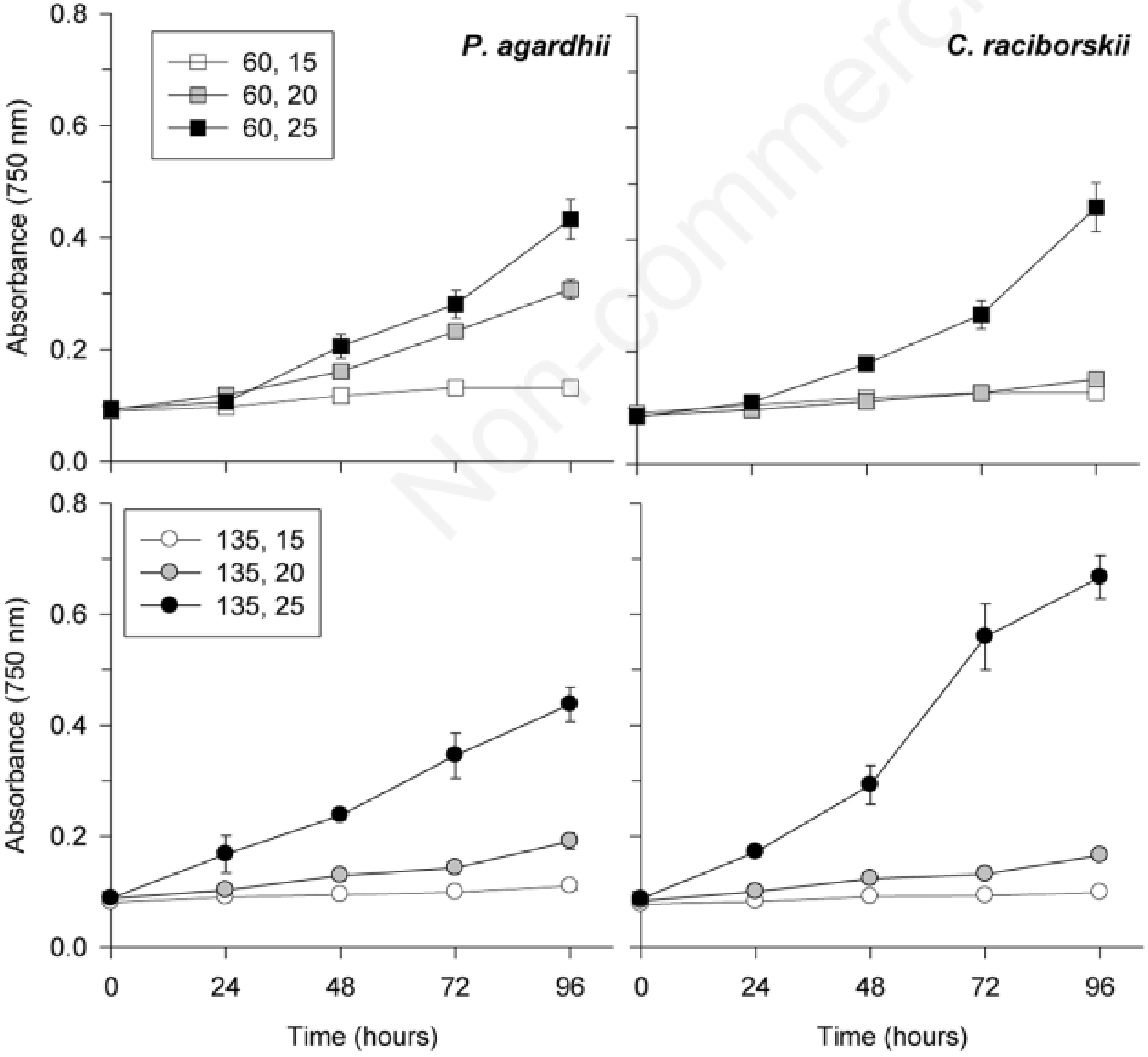
Experimento con agua de embalse Palmar, Río Negro

BV: biovolumen, MC: microcistinas totales
A: biovolumen total de fitoplancton,
B: microcistinas totales (MC), y
C: contribución relativa de los diferentes grupos en el total del biovolumen.

Las letras indican diferencias significativas entre tratamientos (p <0,05).

Bonilla et al., 2021

Factores combinados: luz y temperatura



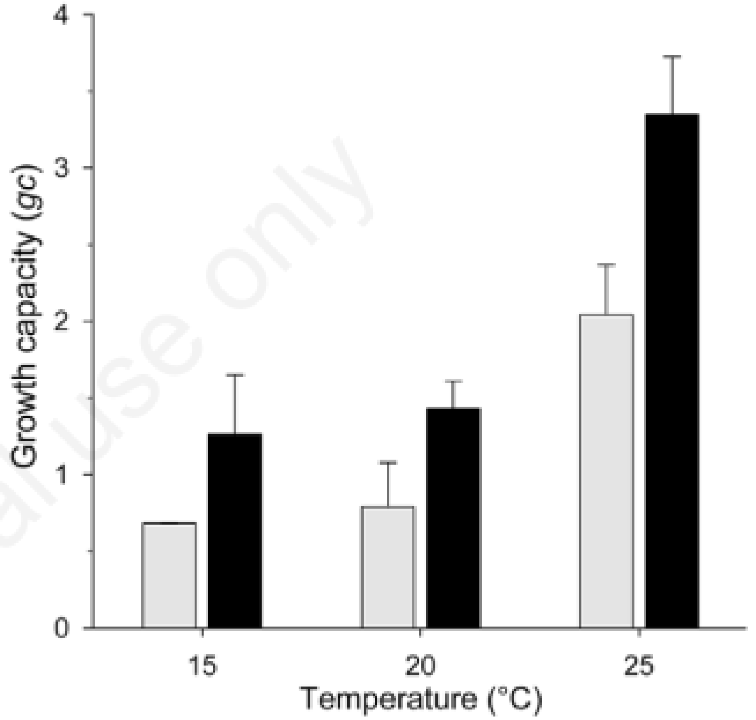


Fig. 3. Growth capacity index for *C. raciborskii* at two light intensities (60 and 135 µmol photons m^{-2} s^{-1}) and three temperatures in mix cultures with *P. agardhii*. Data are averages with standard deviations (vertical lines, grey and black bars, respectively), n=3.

Bonilla et al., 2016

Temperatura (?)

CLIMATE

Blooms Like It Hot

Hans W. Paerl[1] and Jef Huisman[2]

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

Nutrient overenrichment of waters by urban, agricultural, and industrial development has promoted the growth of cyanobacteria as harmful algal blooms (see the figure) (*1*, *2*). These blooms increase the turbidity of aquatic ecosystems, smothering aquatic plants and thereby suppressing important invertebrate and fish habitats. Die-off of blooms may deplete oxygen, killing fish. Some cyanobacteria produce toxins, which can cause serious and occasionally fatal human liver, digestive, neurological, and skin diseases (*1*–*4*). Cyanobacterial blooms thus threaten many aquatic ecosystems, including Lake Victoria in Africa, Lake Erie in North America, Lake Taihu in China, and the Baltic Sea in Europe (*3*–*6*). Climate change is a potent catalyst for the further expansion of these blooms.

Rising temperatures favor cyanobacteria in several ways. Cyanobacteria generally grow better at higher temperatures (often above 25°C) than do other phytoplankton species such as diatoms and green algae (*7*, *8*). This gives cyanobacteria a competitive advantage at elevated temperatures (*8*, *9*). Warming of surface waters also strengthens the vertical stratification of lakes, reducing vertical mixing. Furthermore, global warming causes lakes to stratify earlier in spring and destratify later in autumn, which lengthens optimal growth periods. Many cyanobacteria exploit these stratified conditions by forming intracellular gas vesicles, which make the cells buoyant. Buoyant cyanobacteria float upward when mixing is weak and accumulate in dense surface blooms (*1*, *2*, *7*) (see the figure). These surface blooms shade underlying nonbuoyant phytoplankton, thus suppressing their opponents through competition for light (*8*).

Cyanobacterial blooms may even locally increase water temperatures through the intense absorption of light. The temperatures of surface blooms in the Baltic Sea and in Lake IJsselmeer, Netherlands, can be at least 1.5°C above those of ambient waters (*10*, *11*). This positive feedback provides additional competitive dominance of buoyant cyanobacteria over nonbuoyant phytoplankton.

Global warming also affects patterns of precipitation and drought. These changes in the hydrological cycle could further enhance cyanobacterial dominance. For example, more intense precipitation will increase surface and groundwater nutrient discharge into water bodies. In the short term, freshwater discharge may prevent blooms by flushing. However, as the discharge subsides and water residence time increases as a result of drought, nutrient loads will be captured, eventually promoting blooms. This scenario takes place when elevated winter-spring rainfall and flushing events are followed by protracted periods of summer drought. This sequence of

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Undesired blooms. Examples of large water bodies covered by cyanobacterial blooms include the Neuse River Estuary, North Carolina, USA (top) and Lake Victoria, Africa (bottom).

CREDITS: (TOP) HANS PAERL/UNIVERSITY OF NORTH CAROLINA; (BOTTOM) SATELLITE PHOTO, DIGITALGLOBE

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Canadian Science Publishing NOTE

Evidence of eutrophication in Arctic lakes[1]

Paola Ayala-Borda, Connie Lovejoy, Michael Power, and Milla Rautio

Abstract: Lakes and ponds are dominant components of Arctic landscapes and provide food and water for northern communities. In the Greiner Lake watershed, in Cambridge Bay (Nunavut, Canada), water bodies are small (84% <5 ha) and shallow (99% <4 m deep). Such characteristics make them vulnerable to eutrophication as temperatures rise and nutrient concentrations from the greening landscape increase. Here, we investigated and compared 35 lakes and ponds in the Greiner watershed in August 2018 and 2019 to determine their current trophic states based on their chemical composition and phytoplankton communities. The ponds had higher trophic status than the lakes, but overall, most sites were oligotrophic. Lake ERA5, located upstream of any direct human influence was classified as eutrophic due to high total phosphorus (32.3 $\mu g \cdot L^{-1}$) and a high proportion of Cyanobacteria (42.9% of total phytoplankton biovolume). Satellite imagery suggests the lake may have been eutrophic for the last 30 years. We hypothesize that the coupled effects of catchment characteristics and elevated local snow accumulation patterns promote higher nutrient leaching rates from the soils. We recommend further analysis and monitoring as eutrophication could become more widespread with ongoing climate change and the associated increases in temperature, precipitation, and catchment–lake coupling.

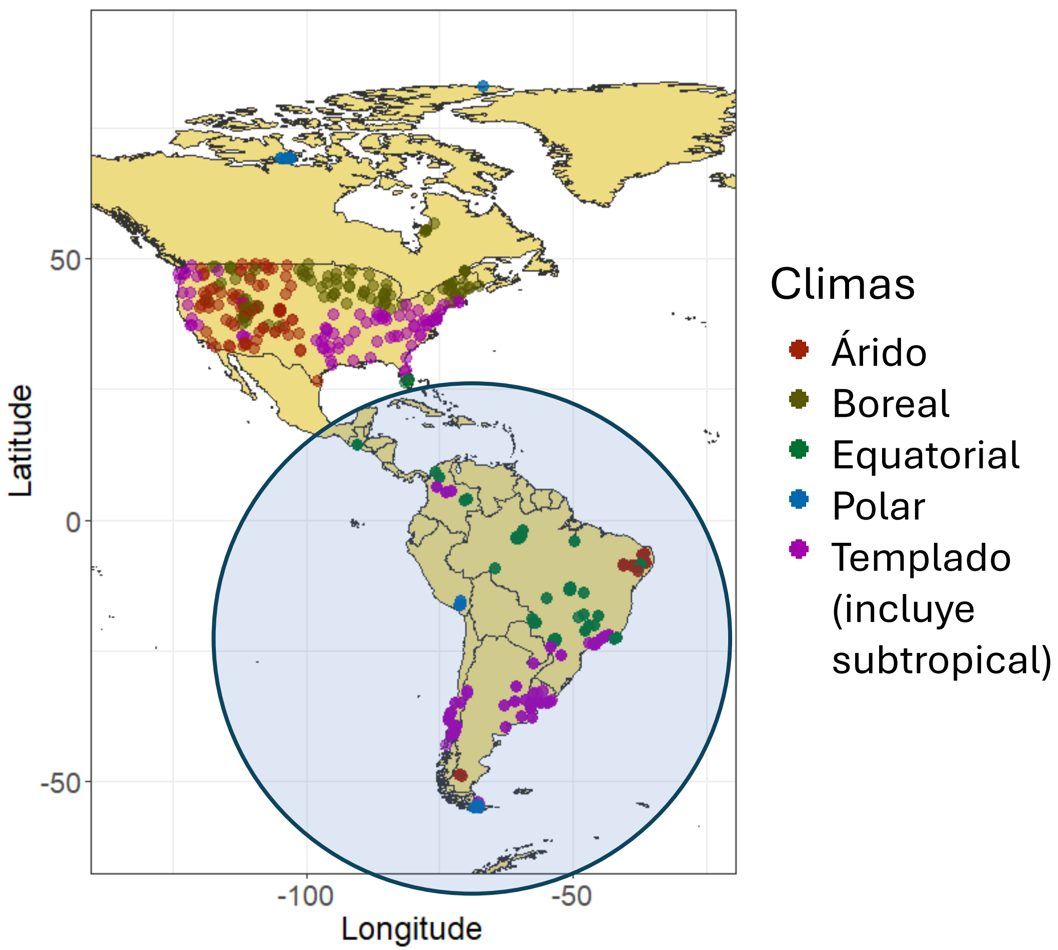
Key words: eutrophication, Arctic lakes, climate change, nutrients, cyanobacteria.

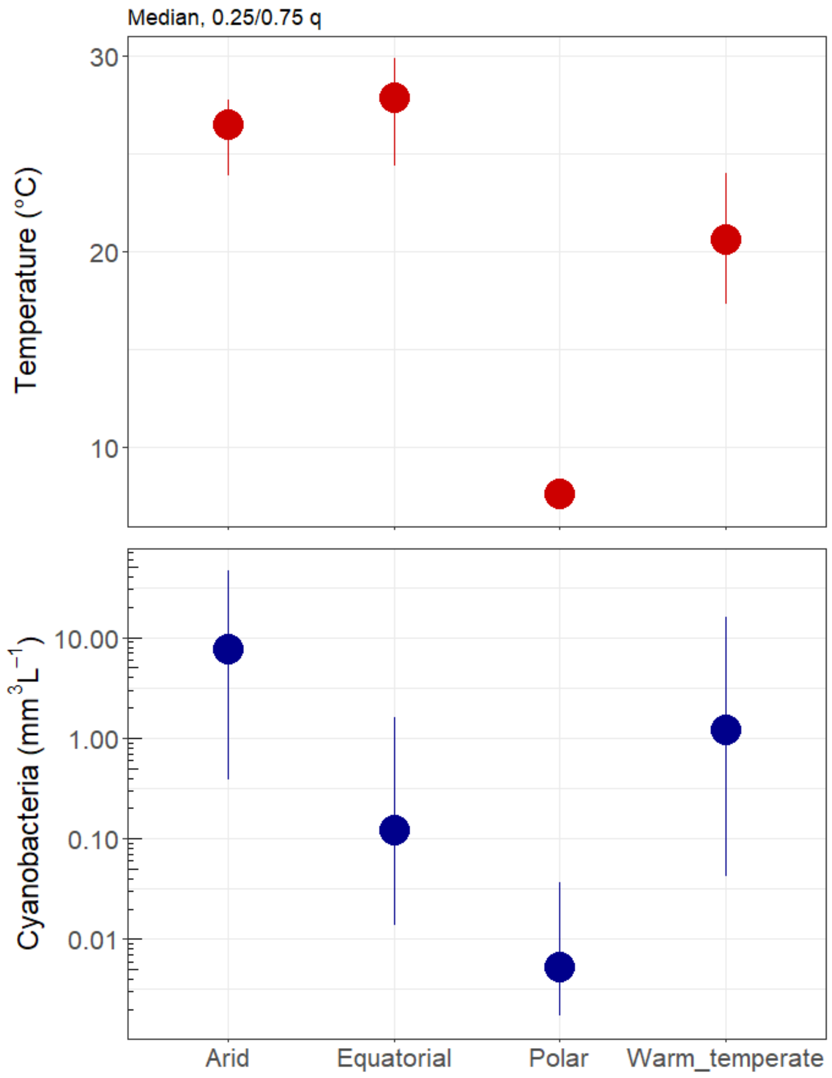
Table 1. Limnological characteristics of lakes, ponds, and Lake ERA5. Area is the range of category for surface area of the pond or lake. Other values are mean ± standard deviation of 23 lakes and 12 ponds.

	Unit	Lakes	Ponds	ERA5
Area	ha	4.31 – 3873.72	0.07 – 7.31	141.32
Depth	m	8.5 ± 7.6	0.5 ± 0.1	1.2
Chl *a*	$\mu g \cdot L^{-1}$	1.86 ± 1.08	2.30 ± 2.22	4.29
Temperature	°C	10.0 ± 1.0	10.0 ± 2.1	8.7
Conductivity	$\mu S \cdot cm^{-1}$	378.0 ± 185.3	549.3 ± 250.6	682.7
TN	$\mu g \cdot L^{-1}$	425.8 ± 163.7	1128.8 ± 216.4	940.0
TP	$\mu g \cdot L^{-1}$	8.4 ± 5.5	10.4 ± 2.6	32.3
TDP	$\mu g \cdot L^{-1}$	5.8 ± 1.3	8.4 ± 1.7	9.8
DOC	$mg \cdot L^{-1}$	5.0 ± 1.6	16.0 ± 2.8	9.9
Bacterial Production	$\mu g\ C \cdot L^{-1}\ d^{-1}$	31.7 ± 19.8	48.2 ± 31.6	112.1
Total phytoplankton biovolume	$mm^3 \cdot L^{-1}$	0.65 ± 0.61	1.11 ± 1.91	0.59
Chlorophyta biovolume	$mm^3 \cdot L^{-1}$	0.04 ± 0.04	0.12 ± 0.14	0.19
Cyanobacteria biovolume	$mm^3 \cdot L^{-1}$	0.02 ± 0.05	0.04 ± 0.09	0.25

Note: Chl *a*, chlorophyll *a*; TN, total nitrogen; TP, total phosphorus; TDP, total dissolved phosphorus; DOC, dissolved organic carbon.

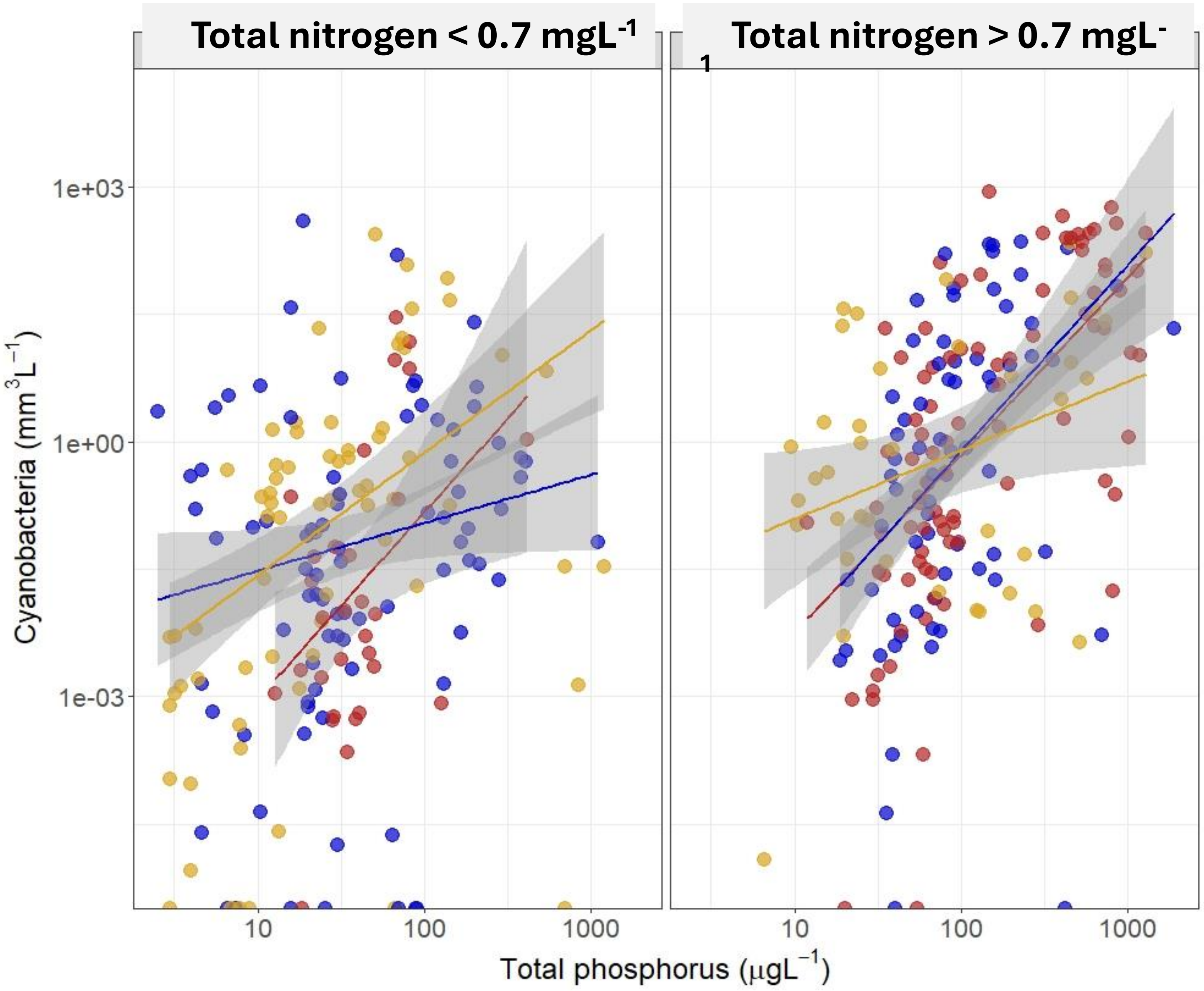
Cianobacterias en ecosistemas lénticos

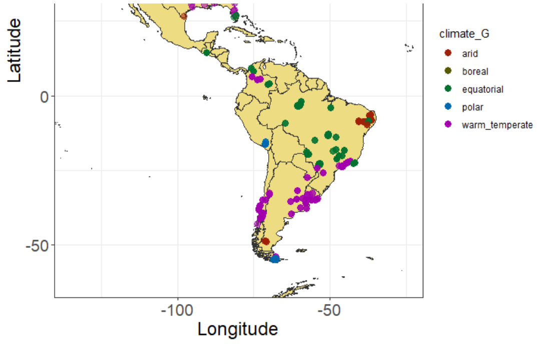




Modelos: la temperatura NO es un factor significativo para explicar la biomasa de cianobacterias

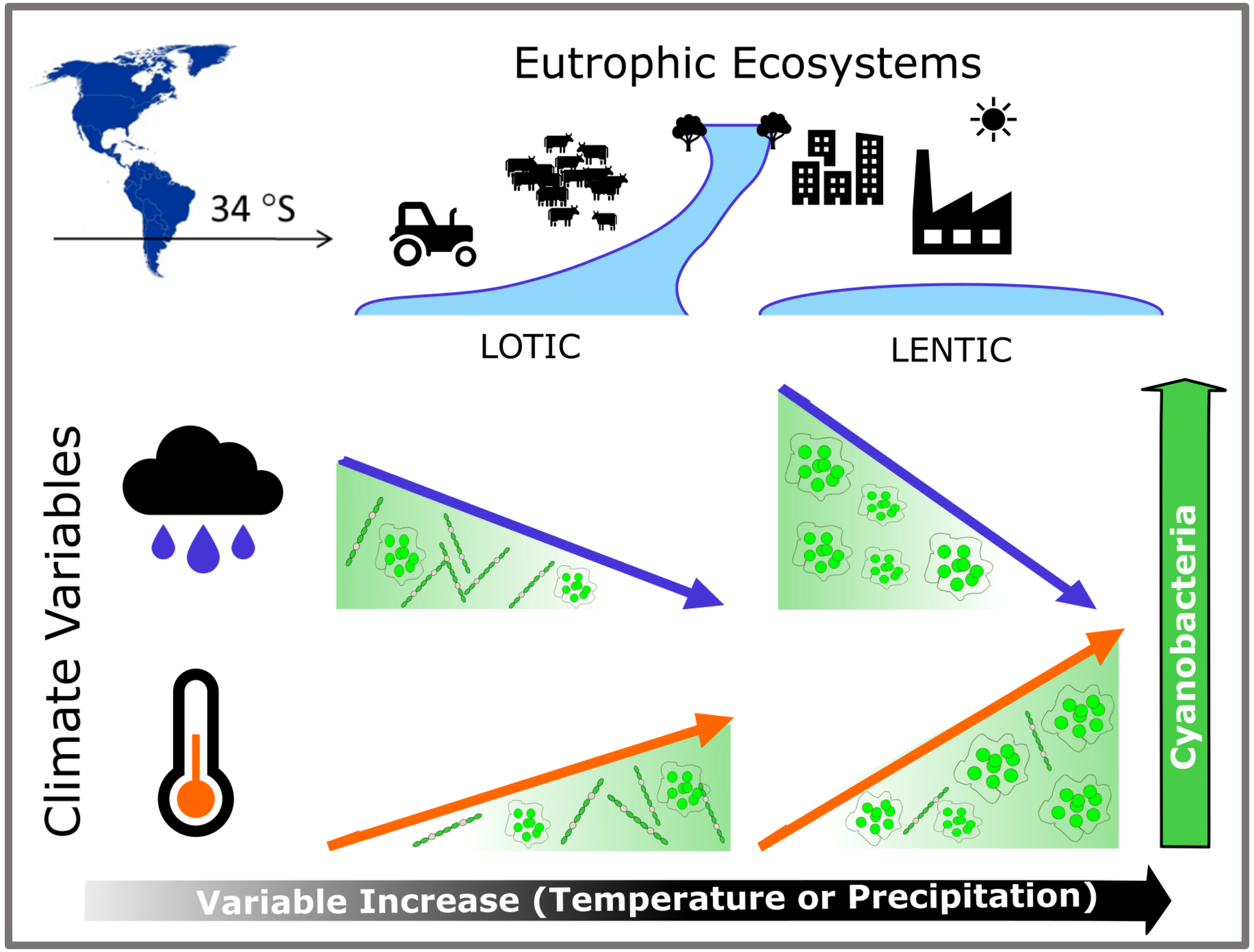
Factores más significativos

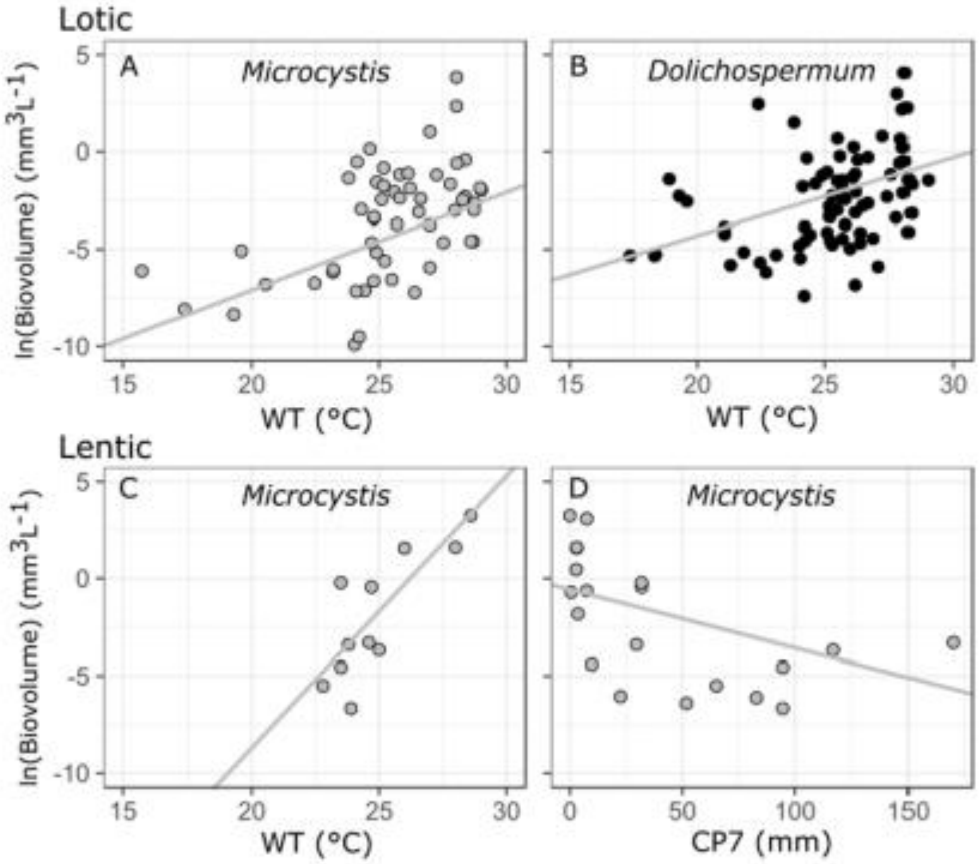




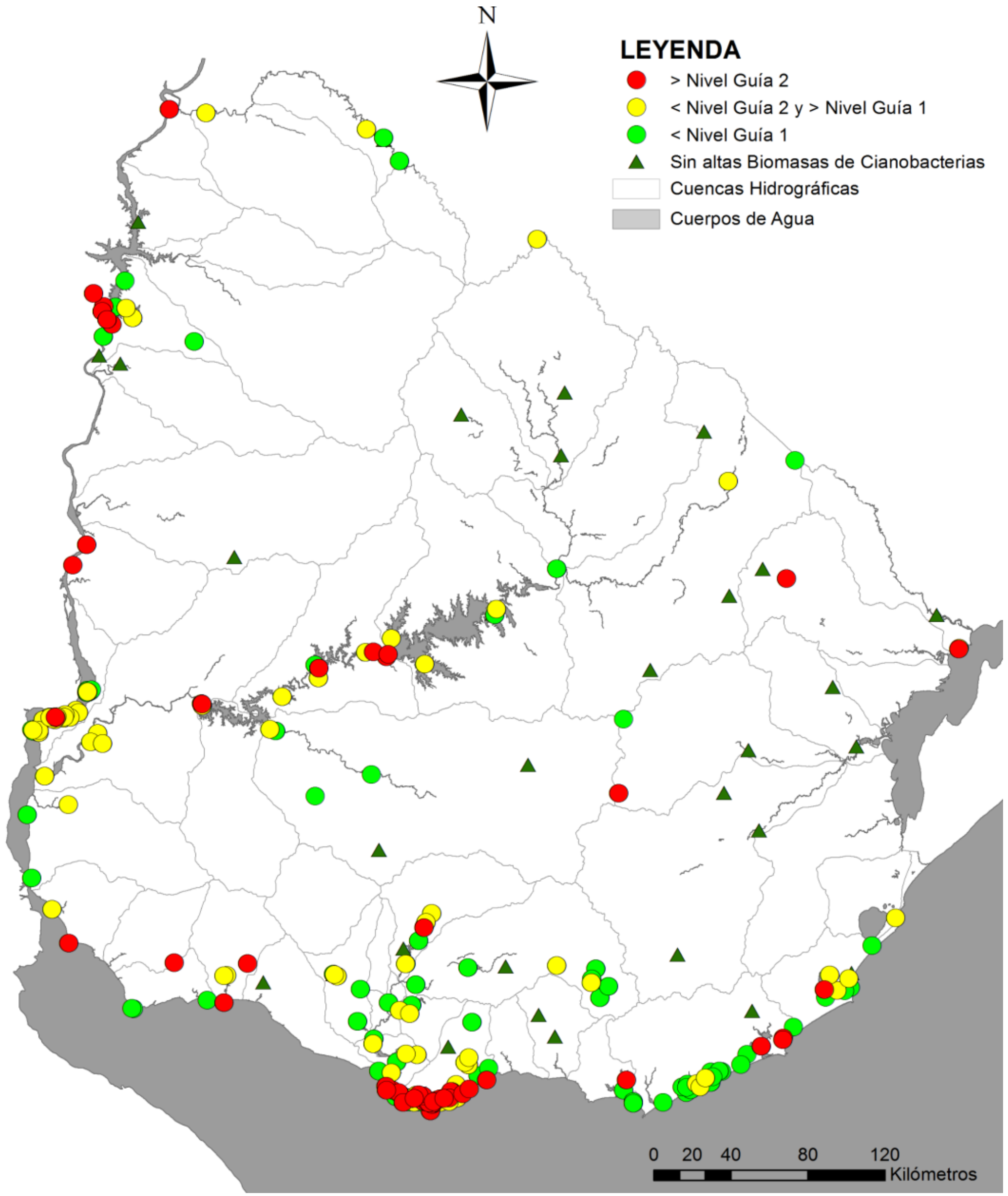
- Nutrientes son el factor más importante, en especial el FÓSFORO
- En lagos someros el NITRÓGENO es relevante

Cuando los ecosistemas YA son eutróficos....

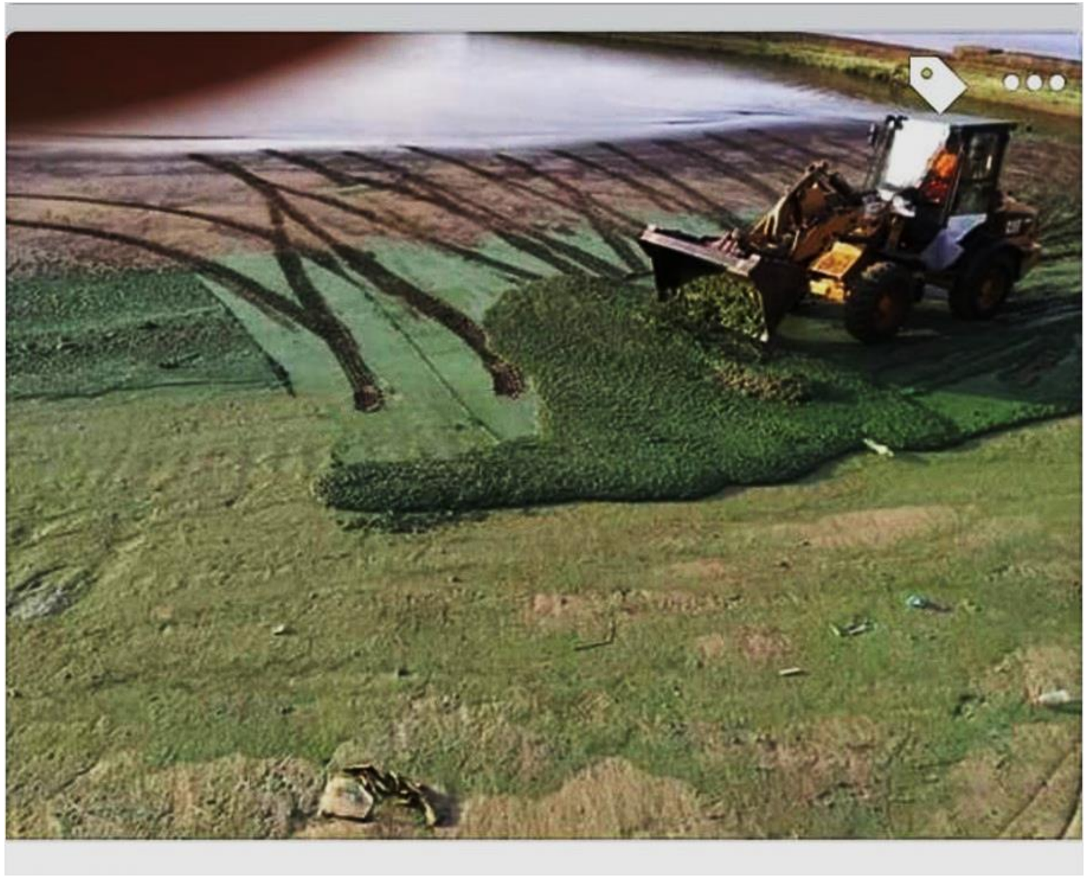




¿Qué tan mal estamos?



Bonilla et al., 2015



Playa Ramírez, Montevideo, 2019

¿Qué tan mal estamos?

Haakonsson et al., 2017

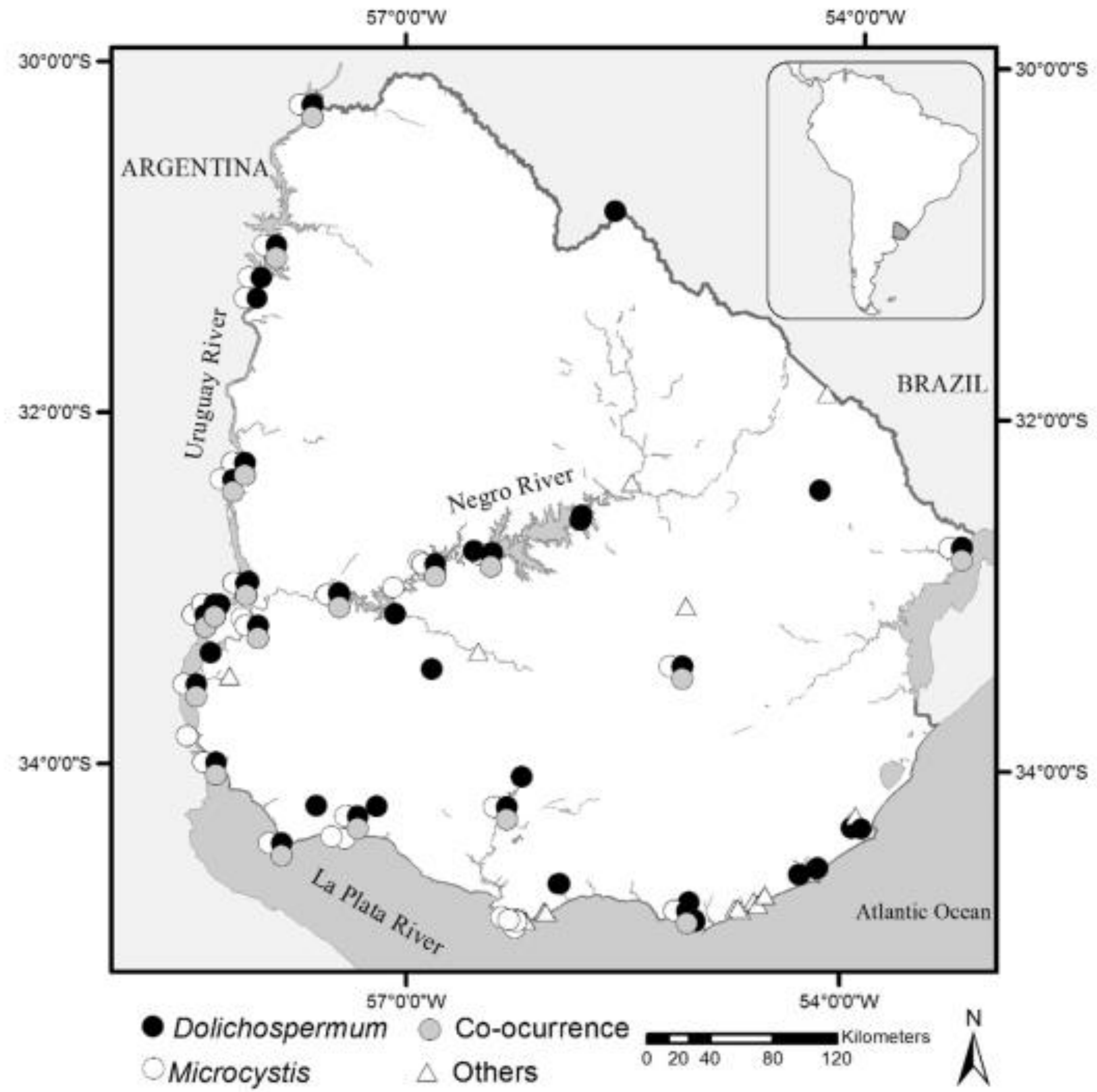
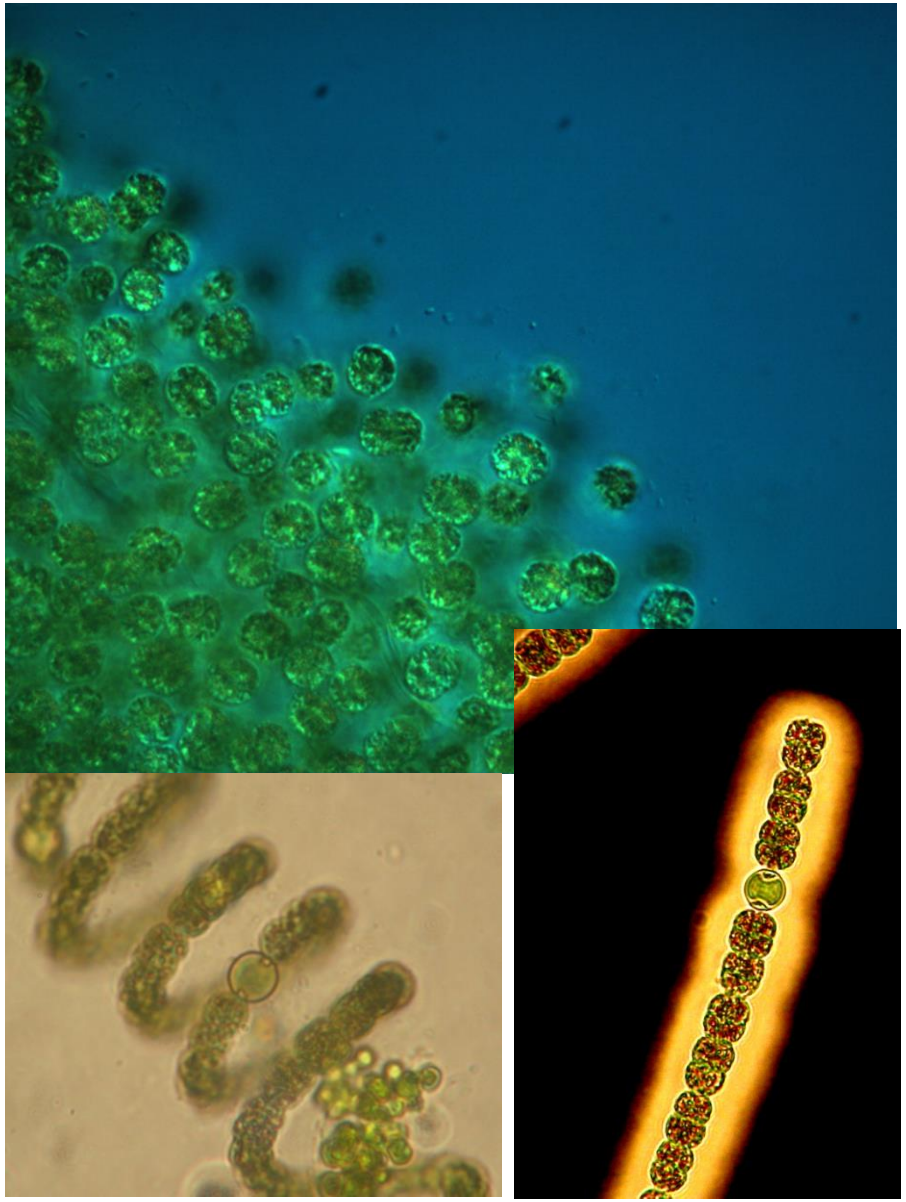


Fig. 2. Distribution of *Dolichospermum* (black circles), *Microcystis* (white circles) and co-occurrence of both (grey circles) across Uruguay. "Others" (white triangles) represent other cyanobacterial genera, shown only when none of the two most frequent genera has been recorded.



« Mega » floraciones

mas del día: Robo, persecución y muerte en La Unión • Edificios granteados • Vienen varios días de lluvia • Podc

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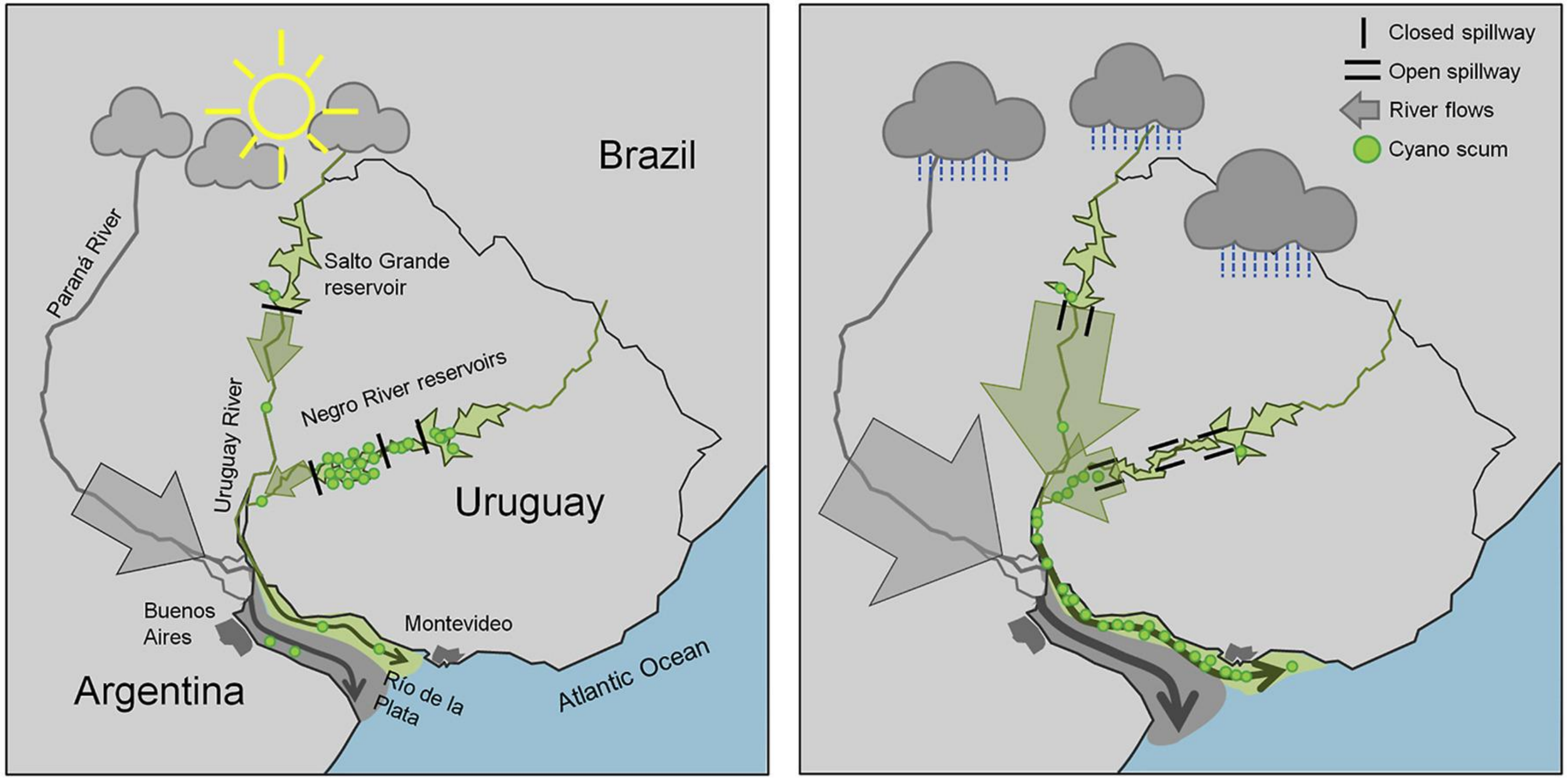
PROBLEMA AMBIENTAL

El intenso fenómeno de cianobacterias que afectó a casi toda la costa uruguaya en el verano de 2019 se generó en la cuenca del río Negro, según un estudio de la Facultad de Ciencias.



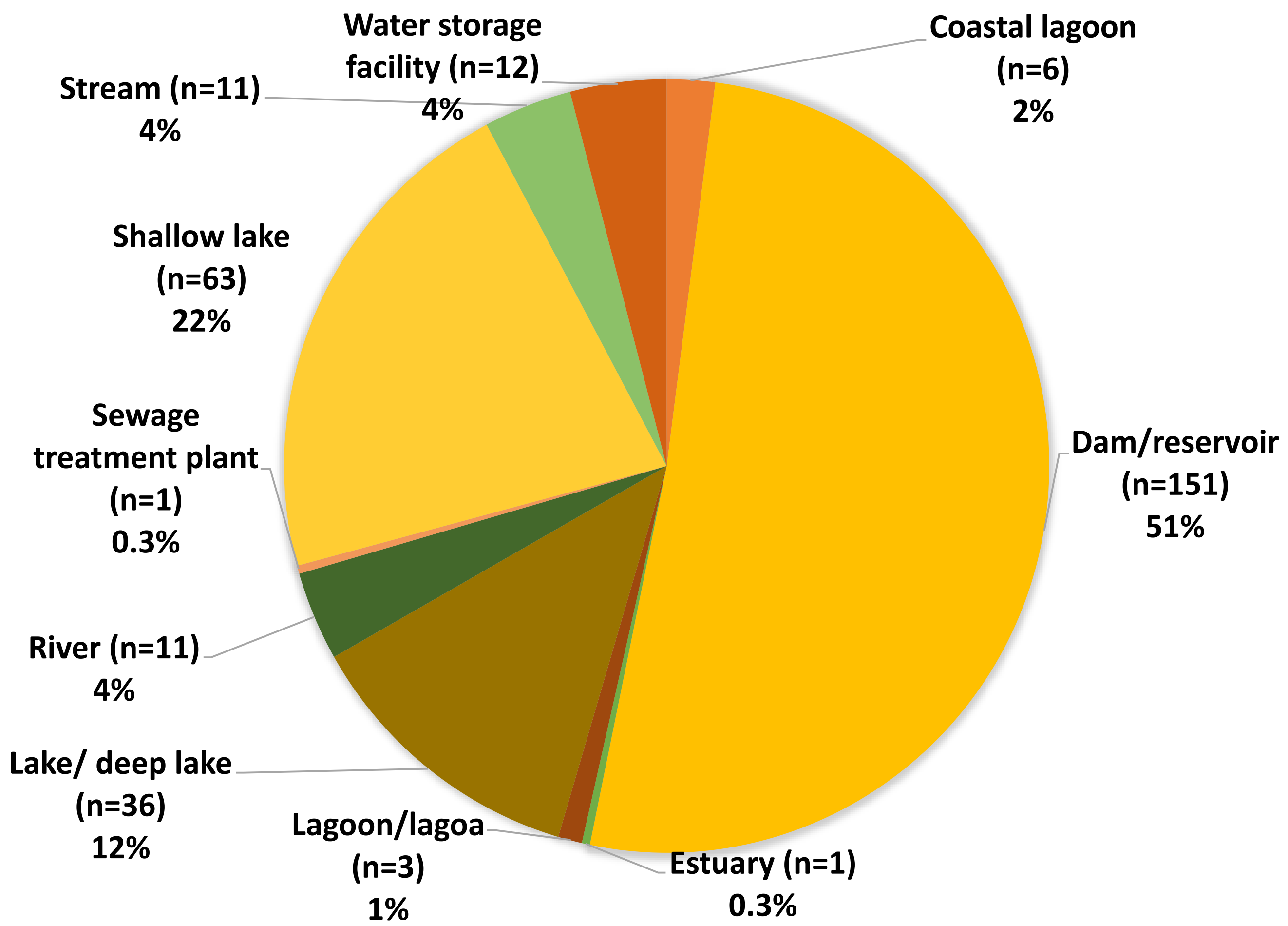
Superficie: 100.000 canchas de fútbol!

Encuesta !

La realidad en la región

Dónde ocurren las floraciones de cianobacterias en el continente?

Tipo de cuerpo de agua



Embalses> lagos someros> lagos

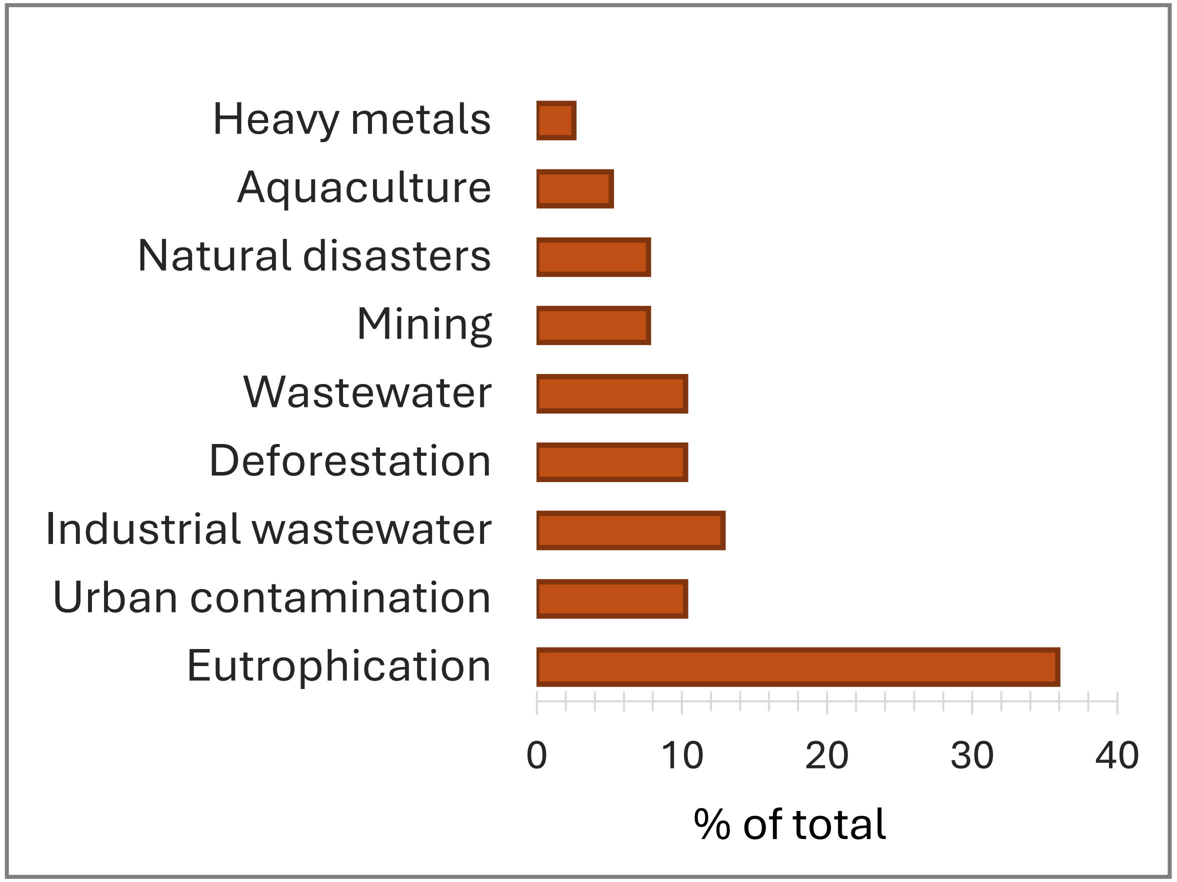
Uso: para suministro de agua potable (21%)

(Aguilera et al., 2023)

Total n= 295

Eutrofización en América Latina

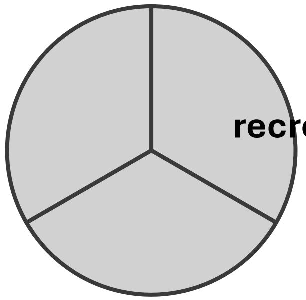
Threats to freshwaters in South America (and Caribbean)

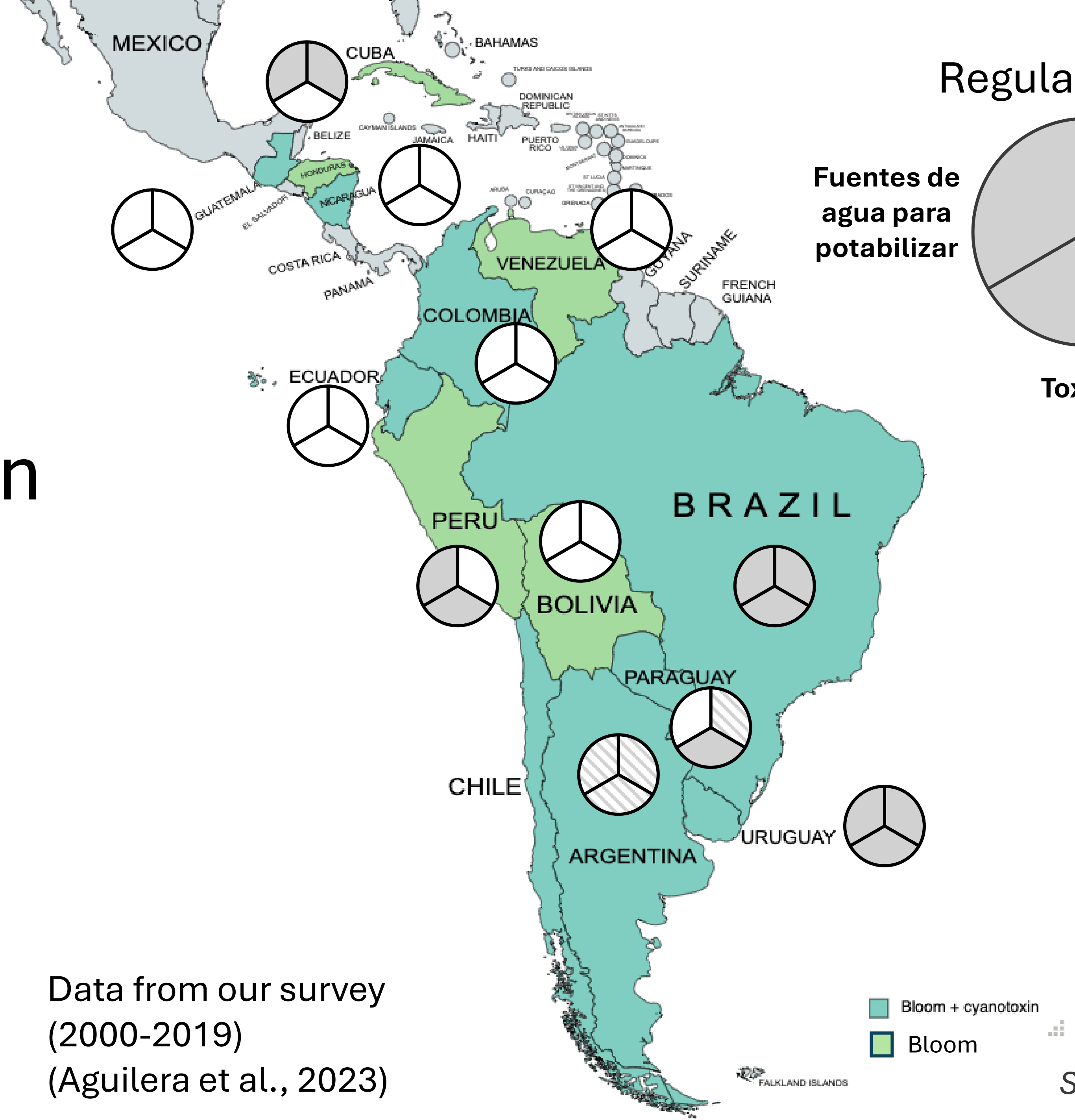


Aguilera et al., 2023

Sería possible controlar (algunos de) estos factores?

Monitoreo de cianobacterias en América del Sur





Data from our survey
(2000-2019)
(Aguilera et al., 2023)

S. Bonilla

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Finalmente, podemos responder la pregunta inicial? Y hacia dónde se debería avanzar?

- ¿Qué tan graves son nuestros problemas con las cianobacterias?