# US EPA BENTHIC HABS DISCUSSION GROUP WEBINAR

## DECEMBER 7, 2021, 8:30-10:00 Pacific Standard Time

### Webinar registration:

https://zoom.us/webinar/register/WN_ZPS21a-aQa6XlrMI7W7oZQ




**GUEST SPEAKERS:**

**MARGARET SMIGO, WATERBORNE HAZARDS PROGRAM COORDINATOR, VIRGINIA DEPT. OF HEALTH**

**JESSICA TROUT-HANEY, POSTDOCTORAL-RESEARCHER DARTMOUTH COLLEGE**

# I. AGENDA

I **Welcome, Agenda Overview, Announcements, and Introductions**
*Keith Bouma-Gregson & Margaret Spoo-Chupka*

II **Presentation: 2021 Cyanobacteria Bloom and Recreational Advisory for the North Fork Shenandoah River, Virginia, USA**
*Guest Speaker – Margaret Smigo*

III **Presentation: Microcystins in Benthic Food Webs of Greenlandic Lakes and Ponds**
*Guest Speaker – Jessica Trout-Haney*

IV **2022 Schedule, Wrap Up & Next Steps**
*Facilitators & Benthic HAB members*

# I. INTRODUCTIONS

Webpage: https://www.epa.gov/cyanohabs/epa-newsletter-and-collaboration-and-outreach-habs#benthic

| Name | Affiliation | Contact Information |
|---|---|---|
| Margaret Spoo-Chupka | Metropolitan Water District of Southern CA | Phone: 909-392-5127<br>Email: MSpoo-Chupka@mwdh2o.com |
| Keith Bouma-Gregson | United States Geological Survey | Phone: 510-230-3691<br>Email: kbouma-gregson@usgs.gov |
| Dr. Lesley D'Anglada | US EPA, Washington, DC | Phone: 202-566-1125<br>Email: Danglada.Lesley@epa.gov |

# I. ANNOUNCEMENTS

- Upcoming US EPA Benthic HAB Discussion Group Webinar – February 8, 2022, 10:00am-11:30 Pacific Time
  - Guest Presenter – Hwee Sze Tee
- **ITRC Benthic HCB Report** – Spring 2022
- **Joint Aquatic Sciences Meeting** – May 14-20, 2022, Grand Rapids, MI
  - Abstracts due January 10, 2022
- **International Toxic Cyanobacteria Conf.** – May 22-27, 2022, Bowling Green, OH
  - Abstracts due January 15, 2022
- **US HABs Symposium** – October 23-28, 2022, Albany, NY
  - Abstracts due May 6, 2022

# ITEM II
# GUEST PRESENTATION:
# 2021 Cyanobacteria Bloom and Recreational Advisory for the North Fork Shenandoah River, Virginia, USA

*Margaret Smigo, Waterborne Hazards Program Coordinator, Virginia Department of Health*

# ITEM III

# Guest Presentation: Microcystins in Benthic Food Webs of Greenlandic Lakes and Ponds

*Jessica Trout-Haney, Postdoctoral-researcher Dartmouth College*

# ITEM IV

# 2022 Schedule, Wrap Up & Next Steps

*Facilitators & Benthic HAB members*

SAVE THE DATE: next US EPA Benthic HAB Discussion Group Webinar – February 8, 2022, 10:00am-11:30 Pacific Time

Guest Presenter – Hwee Sze Tee

Contact us if you have suggestions for topics or presenters in future webinars.

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Webpage: https://www.epa.gov/cyanohabs/epa-newsletter-and-collaboration-and-outreach-habs#benthic

# 2021 Cyanobacteria Bloom and Recreational Advisory for the North Fork Shenandoah River Virginia, USA

Tuesday December 7, 2021

Benthic Workgroup Meeting

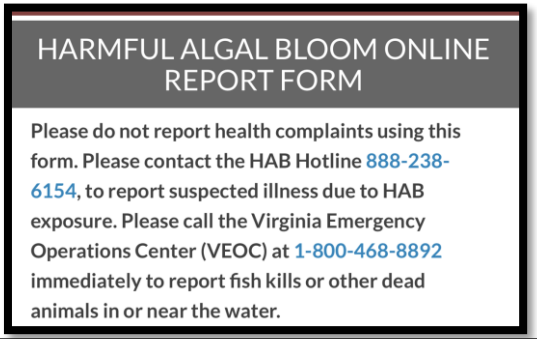
Margaret Smigo
Waterborne Hazards Program Coordinator
Virginia Department of Health (VDH)

VDH VIRGINIA DEPARTMENT OF HEALTH
*To protect the health and promote the well-being of all people in Virginia.*

North Fork Shenandoah River Bethel Rd. 7/12/21: by DEQ

# Background: Harmful Algae Blooms (HABs) and Advisory Management in Virginia

- Historically the HAB program (VA HAB Task Force) focused on planktonic marine bloom toxin-producers capable of impacting seafood and public health along the VA coast
- Expansion in the 2010s to include response for planktonic freshwater blooms primarily in lakes and reservoirs, and ponds, which posed a health risk to recreational water users and drinking water intakes
- HAB hotline for illness complaints, online HAB report form, HAB toolkit, HAB response plan document (2018), Advisory guidance (2011, 2021)



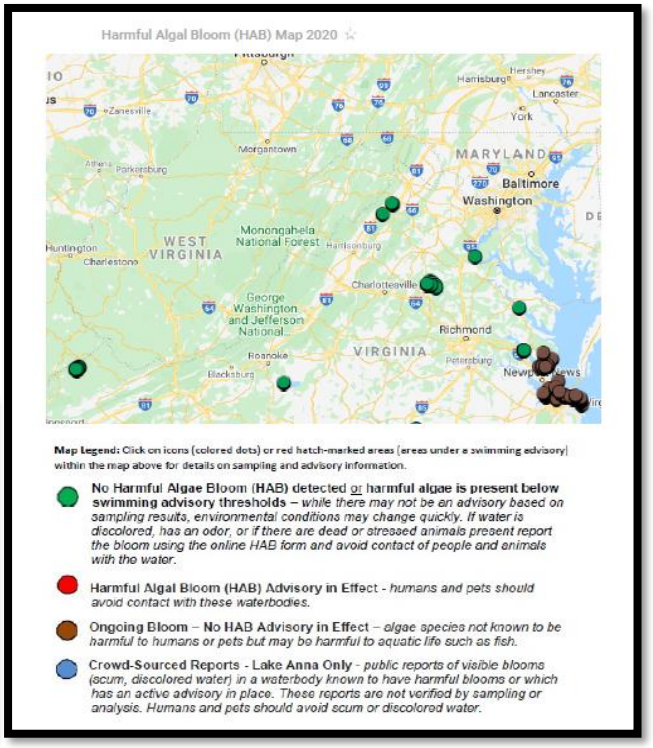
HARMFUL ALGAL BLOOM ONLINE REPORT FORM

Please do not report health complaints using this form. Please contact the HAB Hotline 888-238-6154, to report suspected illness due to HAB exposure. Please call the Virginia Emergency Operations Center (VEOC) at 1-800-468-8892 immediately to report fish kills or other dead animals in or near the water.

Is your report concerning a public or private body of water? *

Public

The HAB Task Force does not currently have the resources to respond to reports of possible algae blooms in private bodies of water. Please contact a private consultant for assistance with private waterbodies. The Department of Game and Inland Fisheries maintains a consultant list for such services at: https://www.dgif.virginia.gov/fishing/private-pond-management/private-consultants/




www.SwimHealthyVA.com

# Guidance for Cyanobacteria Bloom Recreational Advisory Management: 2021

Water column thresholds for cell count densities and toxins:

**Table 1: Hybrid advisory approach:** Cyanobacteria bloom recreational advisory thresholds using cell densities and toxin concentrations for targeted cyanotoxins.

| Metric | Concentration |
|---|---|
| *Microcystis* species | ≥40,000 (total cells/mL) |
| total potentially toxigenic (PTOX) cyanobacteria taxa* | ≥100,000 (total cells/mL) |
| microcystin toxin | ≥8 µg/L |
| cylindrospermopsin toxin | ≥15 µg/L |
| anatoxin-a toxin | ≥8 µg/L |
| saxitoxin toxin | ≥4 µg/L |

**PTOX taxa list is subject to change based on most recent research and is available upon request. Current list is included in Appendix B.*

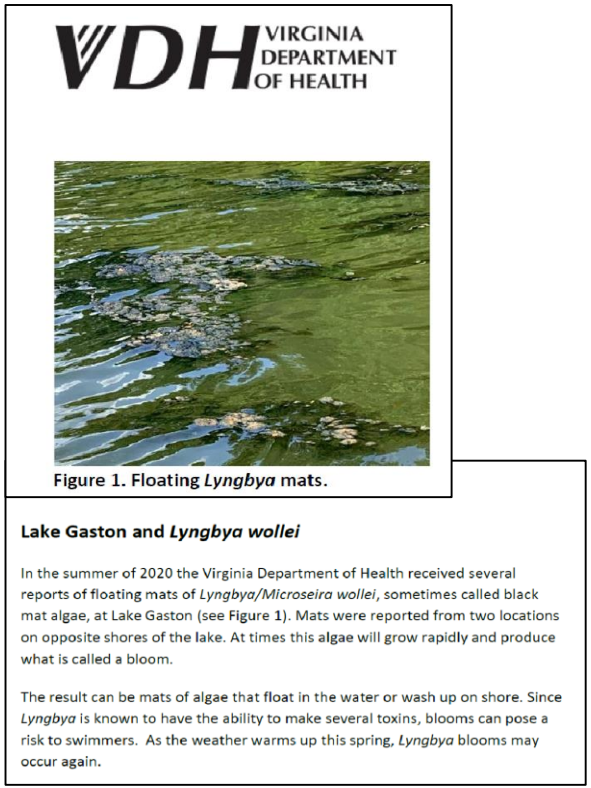
**Assessing Cyanobacteria Exposure Risk of Scums or Floating/Benthic Mats** Should field staff judge that conditions warrant, investigations may also include collection of "solid material" samples (i.e. algal scums or mats that are suspended in the water column, on the surface, or on the bottom). Sampling of solid material is warranted when algal growth at the surface or on the bottom is spatially extensive, such that it cannot easily be avoided when accessing a water body for recreation. When warranted, samples containing solid material that does not disperse into the water column sample will be collected to provide supplemental information to the public and stakeholders on the bloom compositions. These samples will be evaluated in the laboratory to determine if algal toxins are detectable or not and to determine the proportion of potentially toxic cyanobacteria present in the sample, relative to non-toxigenic algae. Neither cell densities (algal cells per unit volume) nor toxin concentrations (mass toxin per unit volume) will be reported from solid material samples. Because there are currently no accepted nor published advisory thresholds for solid materials for Virginia waters, information from solid materials will not be used as grounds alone for issuance of advisories. Exceptions to this are cases where water column thresholds are exceeded, or when solid material at the surface with confirmed toxins and/or potentially toxigenic species is extensive and widespread in the waterbody, such that it cannot be avoided during water recreation activities and is therefore likely to result in accidental ingestion.

https://www.vdh.virginia.gov/content/uploads/sites/178/2021/03/Guidance_for_Cyanobacteria_Recreational_Advisory_Mgt.pdf

# Benthic/Mat-forming Cyanobacteria - VA experience

- VA/NC - Lake Gaston - 2020 *Microseira wollei* (Lyngbya) Investigation
    - *M. wollei* is a mat-forming algae capable of producing toxins
    - Aug 2020 - VA collab with NC partners due to public health concerns → brochure produced
    - First VA cyanobacteria “benthic mat” investigation
    - Inspired the method development for toxin testing of benthic mat samples by ODU Phytoplankton Analysis Lab
    - No health complaints received by VA to-date for Lake Gaston

https://www.vdh.virginia.gov/content/uploads/sites/178/2021/04/Lake-Gaston-and-Lyngbya-wollei-Factsheet-210222.pdf



VDH VIRGINIA DEPARTMENT OF HEALTH

Figure 1. Floating *Lyngbya* mats.

**Lake Gaston and *Lyngbya wollei***

In the summer of 2020 the Virginia Department of Health received several reports of floating mats of *Lyngbya/Microseira wollei*, sometimes called black mat algae, at Lake Gaston (see Figure 1). Mats were reported from two locations on opposite shores of the lake. At times this algae will grow rapidly and produce what is called a bloom.

The result can be mats of algae that float in the water or wash up on shore. Since *Lyngbya* is known to have the ability to make several toxins, blooms can pose a risk to swimmers. As the weather warms up this spring, *Lyngbya* blooms may occur again.

# HAB response NF Shenandoah River prior to 2021:

Filamentous algae reports to DEQ and the HAB report form

- NF Shenandoah River complaints submitted via the HAB report form ~20% of all complaints (2018-2020)
- Investigations for these complaints were - PTOX in water samples

NFSR Seven Bends State Park 7/7/21: by Shenandoah Riverkeeper

# Cyanobacteria mat cyanotoxin analysis method: (2021)

ODU Phytoplankton Analysis Laboratory

- Preparation of material
  - Analyses: Eurofins/Abraxis ELISA kits (microcystin, cylindrospermopsin, anatoxin-a, saxitoxin)
- Summary of toxin extraction method
  - Centrifuge excess water from algae mat
  - Weigh aliquot of algae mat (~50cc)
  - Freeze/lyse in -80 freezer
  - Thaw, combine Milli-Q water (1ml:1g of mat)
  - Homogenate mixture w/ mini-food processor
  - Freeze/thaw lyse 2 more times (3x total)
  - Centrifuge
  - ELISA analyses on supernatant
- PPE
  - Fume hood, gloves, lab coat, face shield

*In Spring of 2021 method for mat collection & analysis was developed with colocated water column samples →mat analysis includes PTOX ID and enumeration as well as toxin assays (MCY, CYL, ATX-A, SAX)*

# Timeline Highlights – Recreational Water Response

- **7/8/21:** Co-located report to DEQ nuisance algae complaint and VDH online HAB report forms - @ NFSR near Seven Bends State Park
- **7/12/21:** DEQ investigates HAB/nuisance algae @ Seven Bends (Lupton Rd.)
  - Water and Mat sample: **no potentially toxic (PTOX) cyanobacteria present**
- **7/12/21**: DEQ observation of dense blue green algae growth covering 10-20% of area-in NFSR near Bethel Rd;
- **7/13/21:** DEQ collects samples at Bethel Rd.
  - Water sample: **no PTOX cells, toxins BDL**
  - Mat sample: **PTOX species detected but** toxins could not be analyzed
- **7/14/21:** Reports of benthic algae mats at multiple locations near Strasburg
- **7/16/21:** VDH Local Health District issues social media public notice and advisory to avoid swimming in the Bethel Rd. area due to ongoing investigation on Friday *ahead of the weekend*
- **7/19/21:** DEQ investigates HAB reports @ Strasburg & collects @ Bethel Rd.
  - Water sample: **PTOX absent or minimal, toxins BDL**
  - Bethel Rd. mat sample: **anatoxin-a and microcystin detected**
- **7/23/21:** VDH issues formal recreational advisory
  - Harmful Algae Bloom Advisory Issued for North Fork of the Shenandoah River (~5 miles)



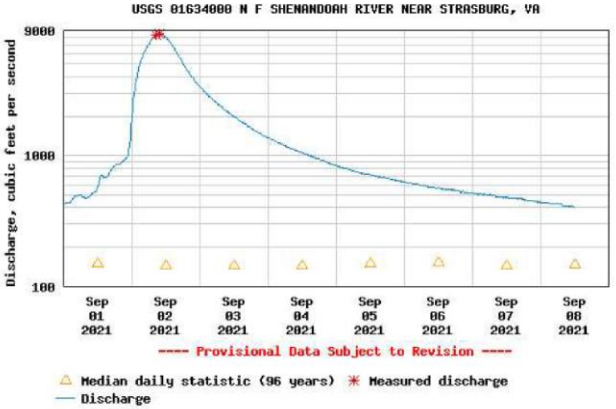

# Timeline - Recreational Water Response (cont)

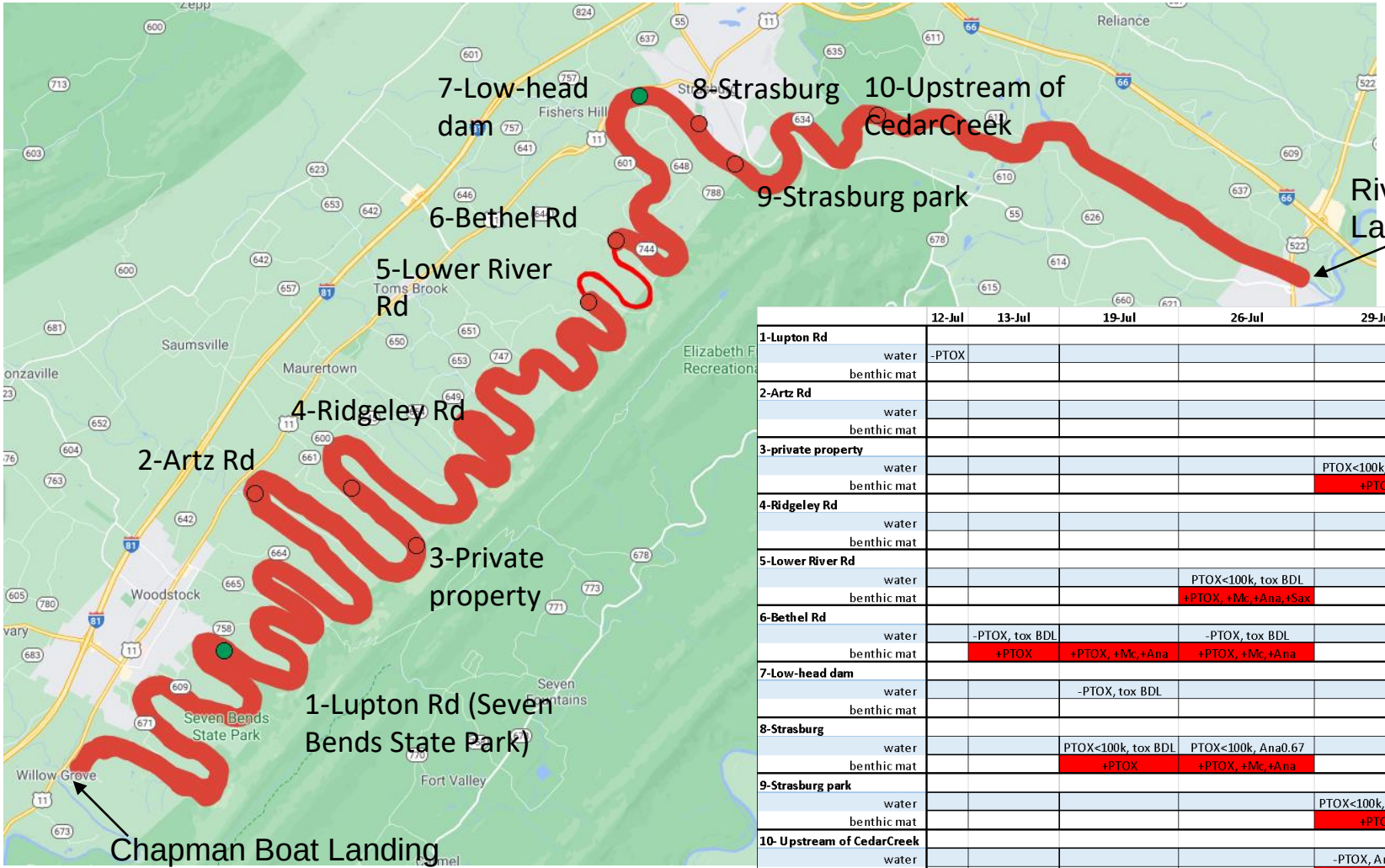
- **7/25/21:** HAB report: Lower River Rd.
- **7/26/21:** DEQ response to HAB complaint and follow-up sampling @Strasburg
  - **Water samples: PTOX species and anatoxin-a detected @ Lower River Rd and Strasburg**
  - **Mat samples: Mats contained potentially toxic cyanobacteria species in addition to toxins (including anatoxin-a, microcystin and saxitoxin detected at Lower River Road, Bethel Road and Strasburg)**
- **7/30/21:** VDH extends advisory ~8mi; from Lower River Road to Strasburg

  ***TOTAL OF 16 HAB reports submitted in month of July in NFSR***
- **8/3/21:** ODU Phytoplankton lab indicates 3 staff members experienced possible HAB related health effects – analysis for water samples only moving forward
- **8/11/21:** DEQ resources limited; response available for new mat sites only *along with the weekly set sites for nuisance algae observations*
- **8/11/21:** VDH extends advisory to ~52 miles from Chapman's Boat Landing to Riverton; due to samples above and below the prior 8 mile advisory stretch which contained PTOX species
- **9/2/21:** Tropical Storm Ida – scouring event suspected of ending the bloom by dispersing mats down-river
  - **ICPRB study using the Emergency Spill Model and storm sampling to evaluate high storm flow impacts to down-river drinking water intakes** *(found no impacts to DW intakes)*

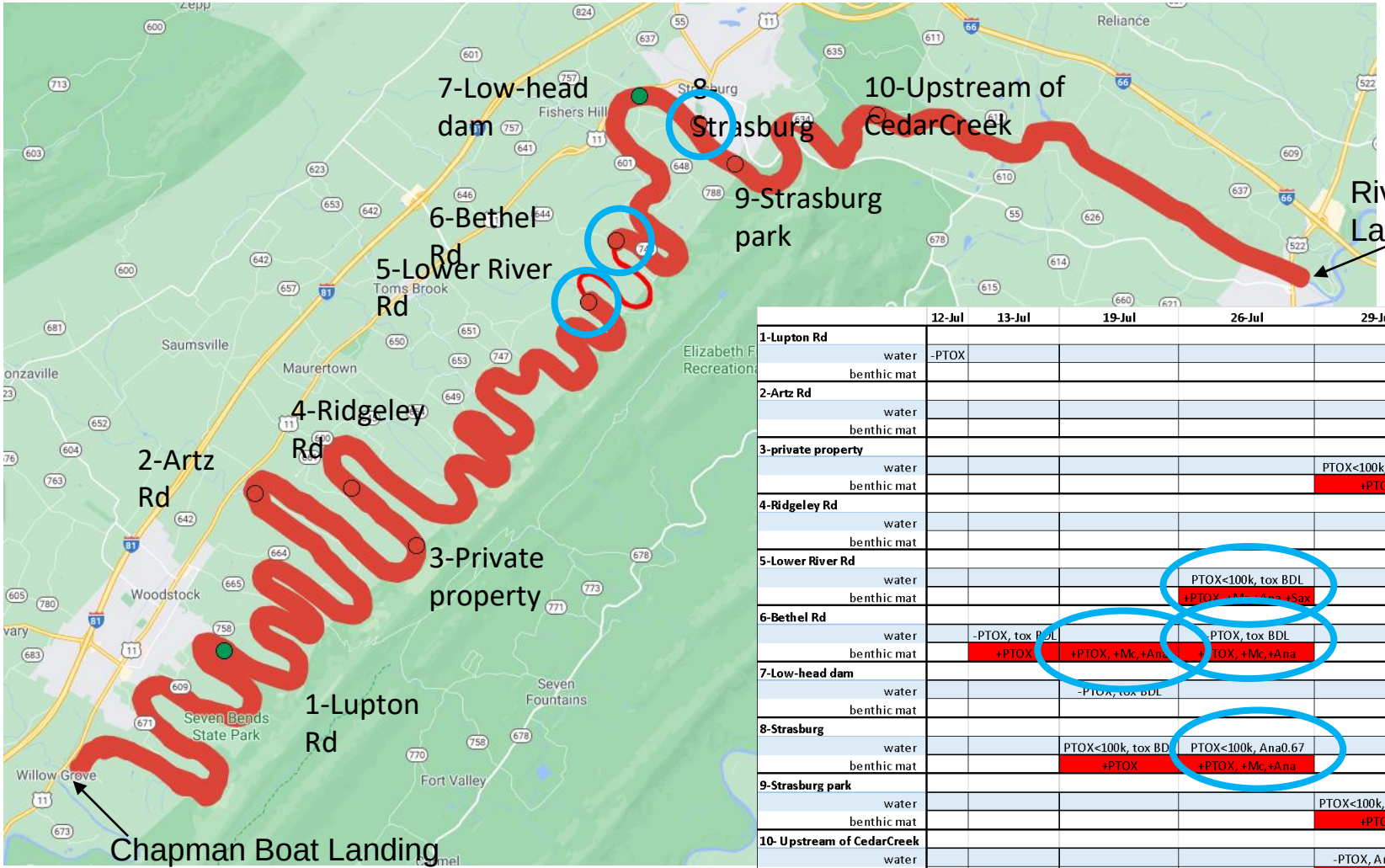
https://www.potomacriver.org/publications/rapid-response-survey-of-cyanobacteria-toxin-levels-downstream-of-north-fork-shenandoah-river-algal-bloom-after-tropical-storm-ida-2021/

- **9/16/21:** VDH lifts ~52 mile advisory on NF Shenandoah River based on absence of benthic mats at weekly DEQ observation sites in addition to absence of PTOX cells/toxins at select sites capturing the advisory area




| | 12-Jul | 13-Jul | 19-Jul | 26-Jul | 29-Jul | 2-Aug |
|---|---|---|---|---|---|---|
| **1-Lupton Rd** | | | | | | |
| water | -PTOX | | | | | |
| benthic mat | | | | | | |
| **2-Artz Rd** | | | | | | |
| water | | | | | | -PTOX, Ana 0.16 |
| benthic mat | | | | | | +PTOX |
| **3-private property** | | | | | | |
| water | | | | | PTOX<100k, tox BDL | |
| benthic mat | | | | | +PTOX | |
| **4-Ridgeley Rd** | | | | | | |
| water | | | | | | -PTOX, tox BDL |
| benthic mat | | | | | | +PTOX |
| **5-Lower River Rd** | | | | | | |
| water | | | | PTOX<100k, tox BDL | | |
| benthic mat | | | | +PTOX, +Mc,+Ana,+Sax | | |
| **6-Bethel Rd** | | | | | | |
| water | | -PTOX, tox BDL | | -PTOX, tox BDL | | |
| benthic mat | | +PTOX | +PTOX, +Mc,+Ana | +PTOX, +Mc,+Ana | | |
| **7-Low-head dam** | | | | | | |
| water | | | -PTOX, tox BDL | | | |
| benthic mat | | | | | | |
| **8-Strasburg** | | | | | | |
| water | | | PTOX<100k, tox BDL | PTOX<100k, Ana0.67 | | |
| benthic mat | | | +PTOX | +PTOX, +Mc,+Ana | | |
| **9-Strasburg park** | | | | | | |
| water | | | | | PTOX<100k, Ana 1.11 | |
| benthic mat | | | | | +PTOX | |
| **10- Upstream of CedarCreek** | | | | | | |
| water | | | | | -PTOX, Ana 1.77 | |
| benthic mat | | | | | +PTOX | |

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|---|---|---|---|---|---|---|
| **1-Lupton Rd** | | | | | | |
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| benthic mat | | | | | | |
| **2-Artz Rd** | | | | | | |
| water | | | | | | -PTOX, Ana 0.16 |
| benthic mat | | | | | | +PTOX |
| **3-private property** | | | | | | |
| water | | | | | PTOX<100k, tox BDL | |
| benthic mat | | | | | +PTOX | |
| **4-Ridgeley Rd** | | | | | | |
| water | | | | | | -PTOX, tox BDL |
| benthic mat | | | | | | +PTOX |
| **5-Lower River Rd** | | | | | | |
| water | | | | PTOX<100k, tox BDL | | |
| benthic mat | | | | +PTOX, +Mc, +Ana, +Sax | | |
| **6-Bethel Rd** | | | | | | |
| water | | -PTOX, tox BDL | | PTOX, tox BDL | | |
| benthic mat | | +PTOX | +PTOX, +Mc, +Ana | +PTOX, +Mc, +Ana | | |
| **7-Low-head dam** | | | | | | |
| water | | | -PTOX, tox BDL | | | |
| benthic mat | | | | | | |
| **8-Strasburg** | | | | | | |
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| **9-Strasburg park** | | | | | | |
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| **10- Upstream of CedarCreek** | | | | | | |
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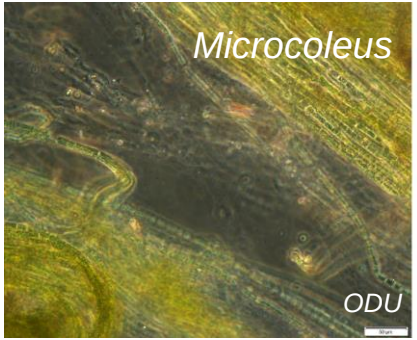
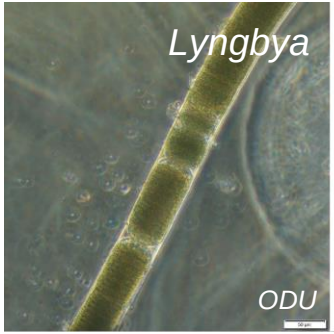
| benthic mat | | | | | +PTOX | |

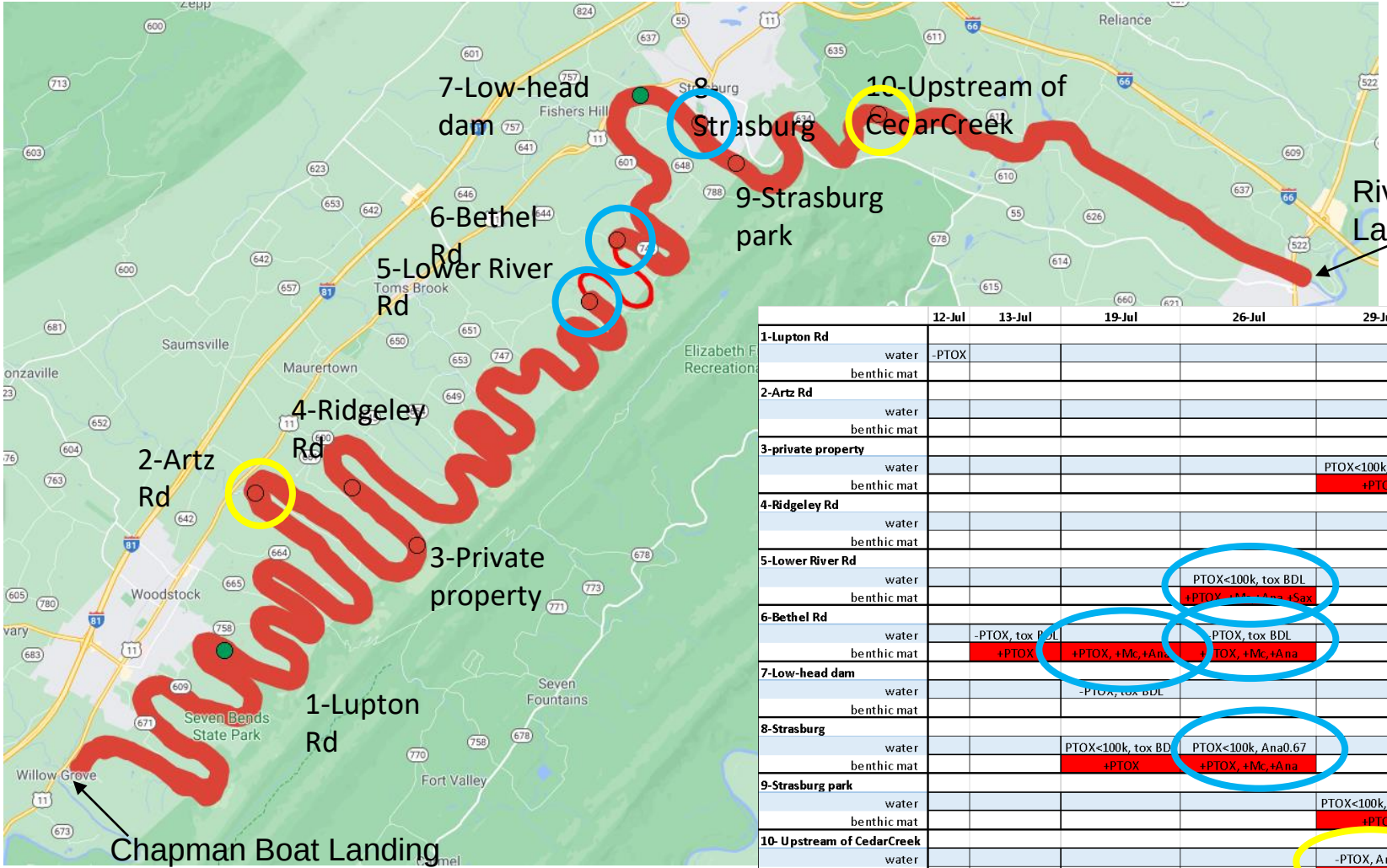
# Cyanotoxin results summary

| | Water samples | Cyanobacteria mats |
|---|---|---|
| microcystin | BDL (<0.15) | 1.69 - 4.31 |
| cylindrospermopsin | <0.05 - 0.05 | 0.07 - 0.15 |
| saxitoxin | <0.02 - 0.02 | 0.01 - 2.45 |
| anatoxin-a | <0.02 - 1.77 | 64.45 - 2804 |
| | | |
| | quantitative<br>ppb (µg/L) toxin within water | presence/absence; semi-quantitative<br>ppb within lab sample |

Cyanobacteria mats
- *Microcoleus*
- *Planktothrix*
- *Phormidium*
- *Oscillatoria*
- *Lyngbya*



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| benthic mat | | | | | | +PTOX |
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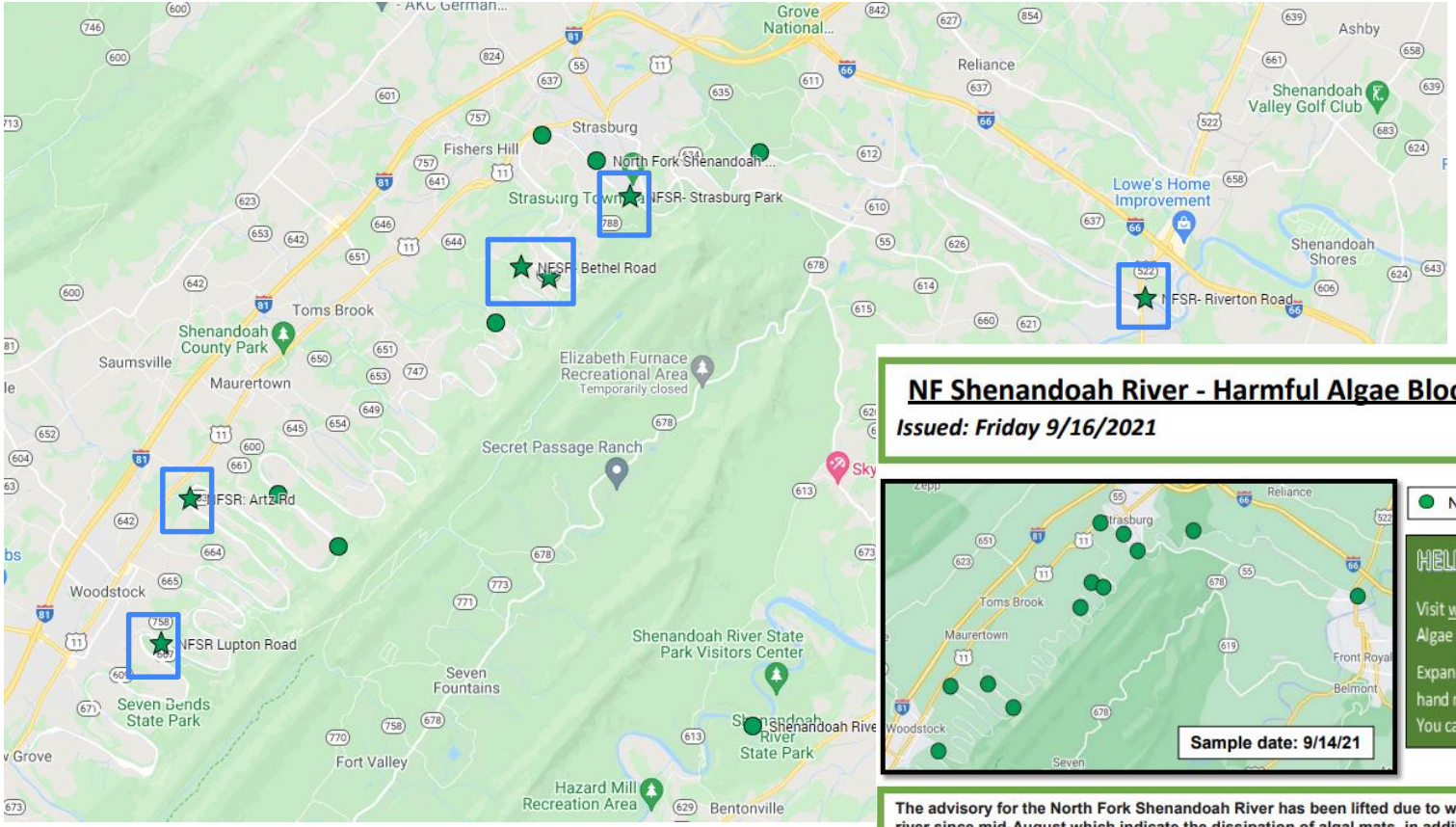
| **5-Lower River Rd** | | | | | | |
| water | | | | PTOX<100k, tox BDL | | |
| benthic mat | | | | +PTOX, +Mc, +Ana, +Sax | | |
| **6-Bethel Rd** | | | | | | |
| water | | -PTOX, tox BDL | | PTOX, tox BDL | | |
| benthic mat | | +PTOX | +PTOX, +Mc, +Ana | +PTOX, +Mc, +Ana | | |
| **7-Low-head dam** | | | | | | |
| water | | | -PTOX, tox BDL | | | |
| benthic mat | | | | | | |
| **8-Strasburg** | | | | | | |
| water | | | PTOX<100k, tox BDL | PTOX<100k, Ana0.67 | | |
| benthic mat | | | +PTOX | +PTOX, +Mc, +Ana | | |
| **9-Strasburg park** | | | | | | |
| water | | | | | PTOX<100k, Ana 1.11 | |
| benthic mat | | | | | +PTOX | |
| **10- Upstream of CedarCreek** | | | | | | |
| water | | | | | -PTOX, Ana 1.77 | |
| benthic mat | | | | | +PTOX | |




## NF Shenandoah River - Harmful Algae Bloom (HAB) Status Report

***Issued: Friday 9/16/2021***




No harmful algal mats detected

**HELPFUL TIP:**

Visit www.SwimHealthyVa.com and click on the Harmful Algae Bloom Map to review sample results near you!

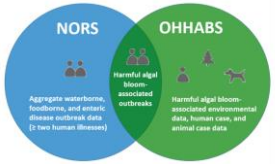
Expand the map using the symbol in the upper right hand map title bar, then click on the magnifying glass. You can search my location name or address!

**The advisory for the North Fork Shenandoah River has been lifted due to weekly observations at sites along the river since mid-August which indicate the dissipation of algal mats, in addition to water samples at 6 sites (Deer Rapids, Lupton Rd, Artz Rd Strasburg Park, and Riverton Rd) on Sept 14 which indicated cyanobacteria and toxins were at acceptable contact levels. Weather and other environmental factors can cause rapid changes in the water quality and algal mats which have dissipated can return if conditions are favorable to support algal growth. People and pets should avoid contact and accidental ingestion of algal mats (should they reappear) within this area of the river.**

**Drinking water remains safe to drink and use in Woodstock, Strasburg, and Winchester.**

★ NF Shenandoah River sites sampled to lift advisory

# Health Complaints





- 8/2/21 person reported suspected health effects from multiple exposures while recreating along ~1 mile stretch of the NF Shenandoah River at Seven Bends State Park between 6/29 – 7/8/21
  - Exposure = inhalation & skin contact; taught fly fishing ~6hrs day (no waders)
  - Symptom onset = 7/9/21
  - Symptoms = cough, congestion, sore throat, and post nasal drip
  - Skin rash onset was 20 days after the last exposure

- 8/3/21 ODU reports 3 lab staff members experienced health effects while processing HAB samples (*2 participated in epi-interview*)
  - Exposure = inhalation and skin contact *(occupational)*
  - Duration of exposure ranged from 30 min to ~ 7 hours
  - Symptom onset varied from 15 minutes to 4 hours after exposure
  - Symptoms = neurologic and respiratory
    - Dizzy, oral & tongue numbness, muscle weakness, headache, and generalized numbness
    - Respiratory symptoms = wheezing and shortness of breath
    - Nausea and skin irritation also reported

*Symptoms disappeared within 15 minutes after staff left the area where mat samples were located*

# Recreational Water – Lessons learned and 2022 ideas:

- Improve coordination/communication with local health and TF partners - continue developing our stakeholder lists, get feedback on how we can more effectively communicate risks and advisory information
- Utilize existing resources to enhance surveillance (for example) Friends of Shenandoah River Algae Watch Map, DEQ weekly surveys for filamentous algae – ***additional discussions necessary based on staff availability***
- Identify and establish relationships with additional labs to process benthic mat material if necessary
- Raise public awareness for the potential of cyanobacteria benthic mats
    - Social media ads to include benthic mat visuals, HSSW campaign, permanent signage (Be Aware of Algae Blooms) at public access points where prior bloom events have occurred ***(i.e. Seven Bends State Park – coordination with DCR required)***
    - Share (Virtual HAB Toolkit) more broadly with watershed groups (HOAs, community bulletins, libraries

# Timeline - Drinking Water HAB Response:

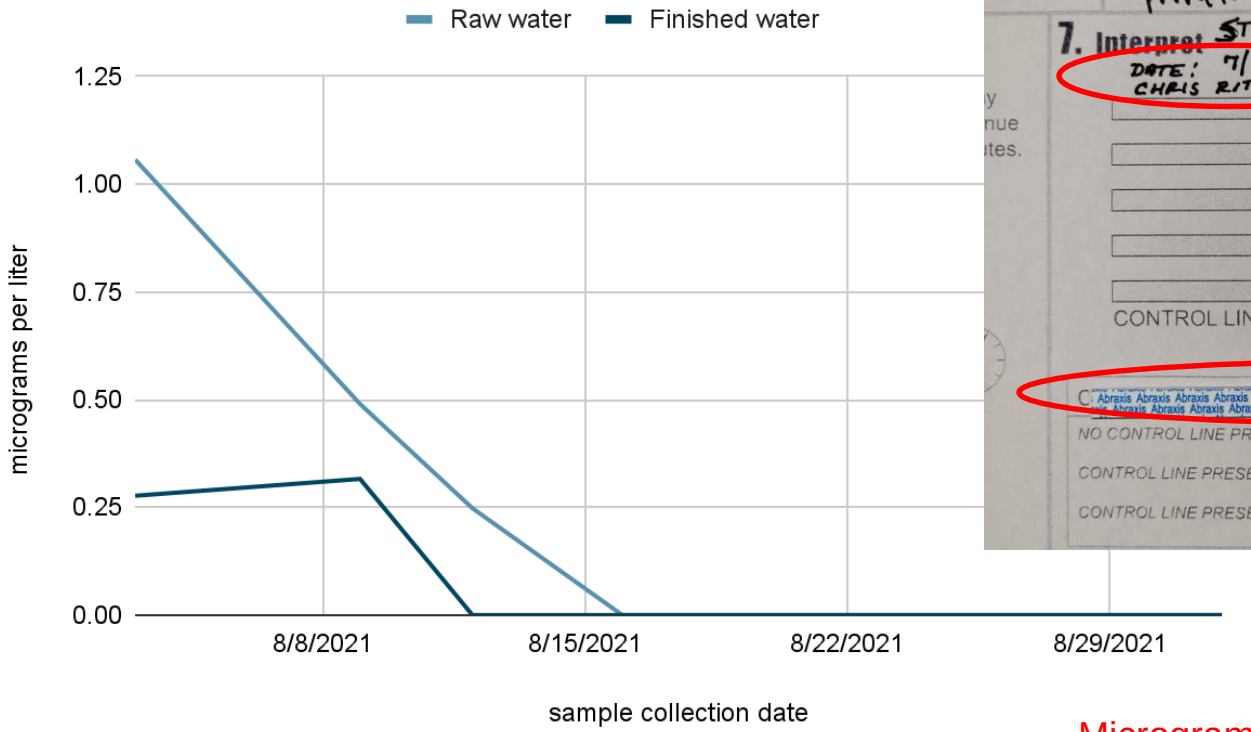
- **July 30** - Town of Strasburg detects anatoxin-a in raw and finished water using Abraxis test strips (not definitive; qualitative in nature).
- **August 3** - Town of Strasburg collects first sample for ELISA testing - anatoxin-a detected in raw and finished water (quantitative, but can over-report).
- **August 5** - Town of Strasburg, Town of Woodstock, and City of Winchester met with EPA to discuss optimizing water treatment processes.
- **August 16** - Town of Strasburg's sample results indicated anatoxin-a was below detectable levels.
- **September 1** - Town of Strasburg performs final sample collection for ELISA testing, indicating anatoxin-a was below detectable levels.

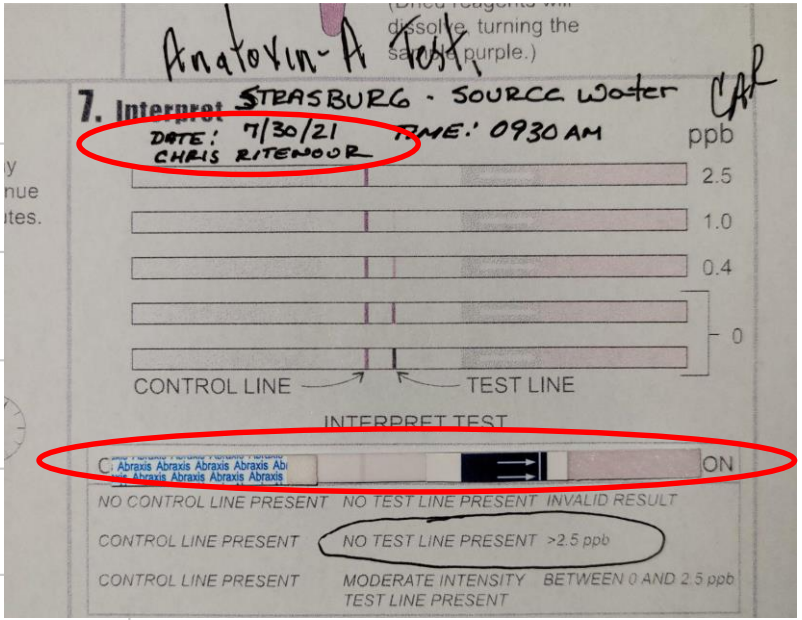
Began twice-weekly ELISA testing.

Began preparing for possible boil water advisory.

Conducted a few more weeks of monitoring using Abraxis test strips, then discontinued monitoring.

# Anatoxin-a detection in Town of Strasburg (Drinking Water)




Micrograms per liter = ppb (parts per billion)

# Drinking Water Notifications:

- Public
  - Weekly press releases sharing results of cyanotoxin testing in all three localities.
- Federal Government
  - Regular meeting with Environmental Protection Agency to discuss plans, ongoing actions, and needed resources.
- State and Local Government
  - Regular conversations to share test results and discuss contingency planning for a potential boil water advisory.
- Water Treatment Plants
  - Daily conversations with lead operators to discuss testing, planning, and needed resources.

# Drinking Water Lessons learned and Plans for 2022:

- HAB Plan
  - Testing frequency
  - Testing type
  - Monitoring strategy
- Procurement and Funding
  - Procurement turnaround time
  - HAB monitoring funding sources need to be identified
- Ongoing or Pre-detection Monitoring
  - No decisions made - a discussion is warranted

# Thank you for the opportunity to share this information!

**www.SwimHealthyVa.com**

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# Cyanobacteria in benthic food webs of Greenlandic lakes and ponds

Jessica Trout-Haney
Postdoc at Dartmouth College
Benthic HABs Discussion, 7 Dec 2021

# Concerns associated with cyanotoxins

## Human health

- Threats to freshwater for drinking and recreation
- IPCC & EPA regulations




# Concerns associated with cyanotoxins

## Human health

- Threats to freshwater for drinking and recreation
- IPCC & EPA regulations

## Health and behavior of other organisms

- Lethal and sublethal effects


Reduced clutch sizes,
Impaired growth
Reduced filtering rates

Morphological changes in competing phytoplankton

# Concerns associated with cyanotoxins

## Human health

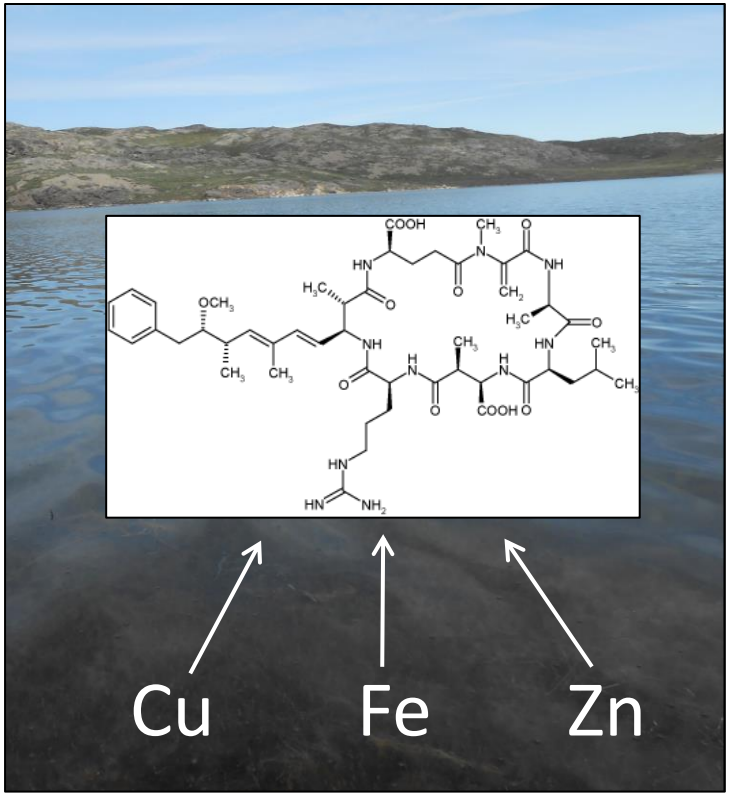
- Threats to freshwater for drinking and recreation
- IPCC & EPA regulations

## Health and behavior of other organisms

- Lethal and sublethal effects

## Affect ecosystem scale processes

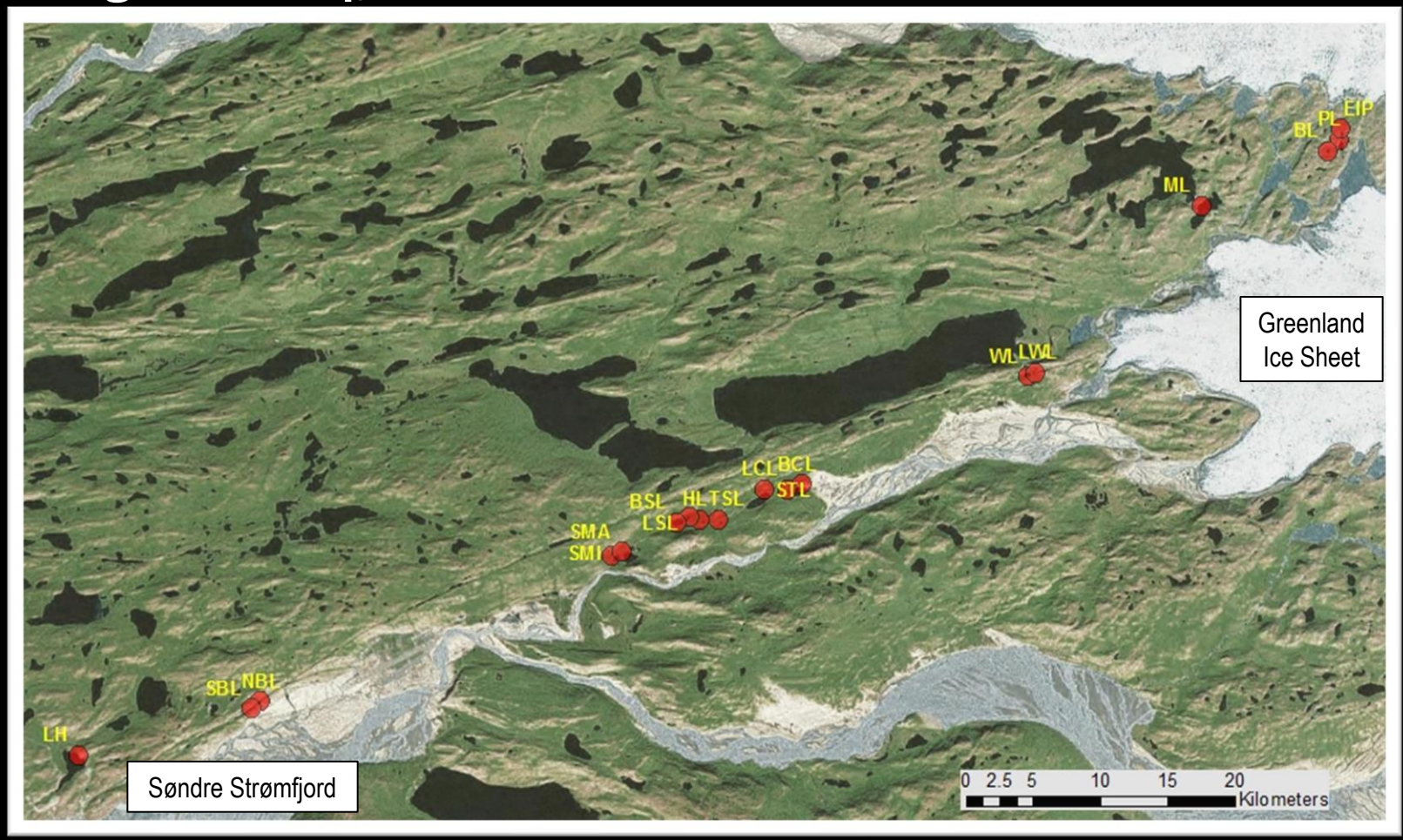
- Chelate metal ions
- Nutrient cycling & energy flow



Surface bloom biased?

# Kangerlussuaq, Greenland

# Kangerlussuaq, Greenland

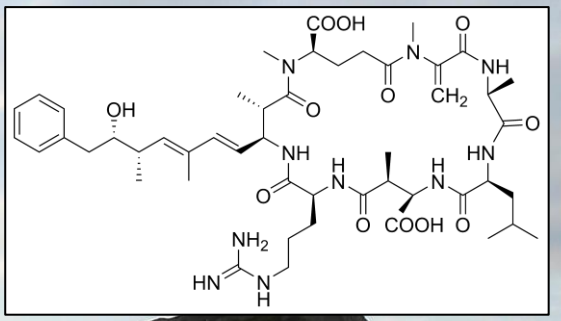


# Kangerlussuaq, Greenland

# Kangerlussuaq, Greenland

# Are Arctic cyanobacteria producing cyanotoxins?

Cyanotoxin of interest:
**Microcystin (MC)**



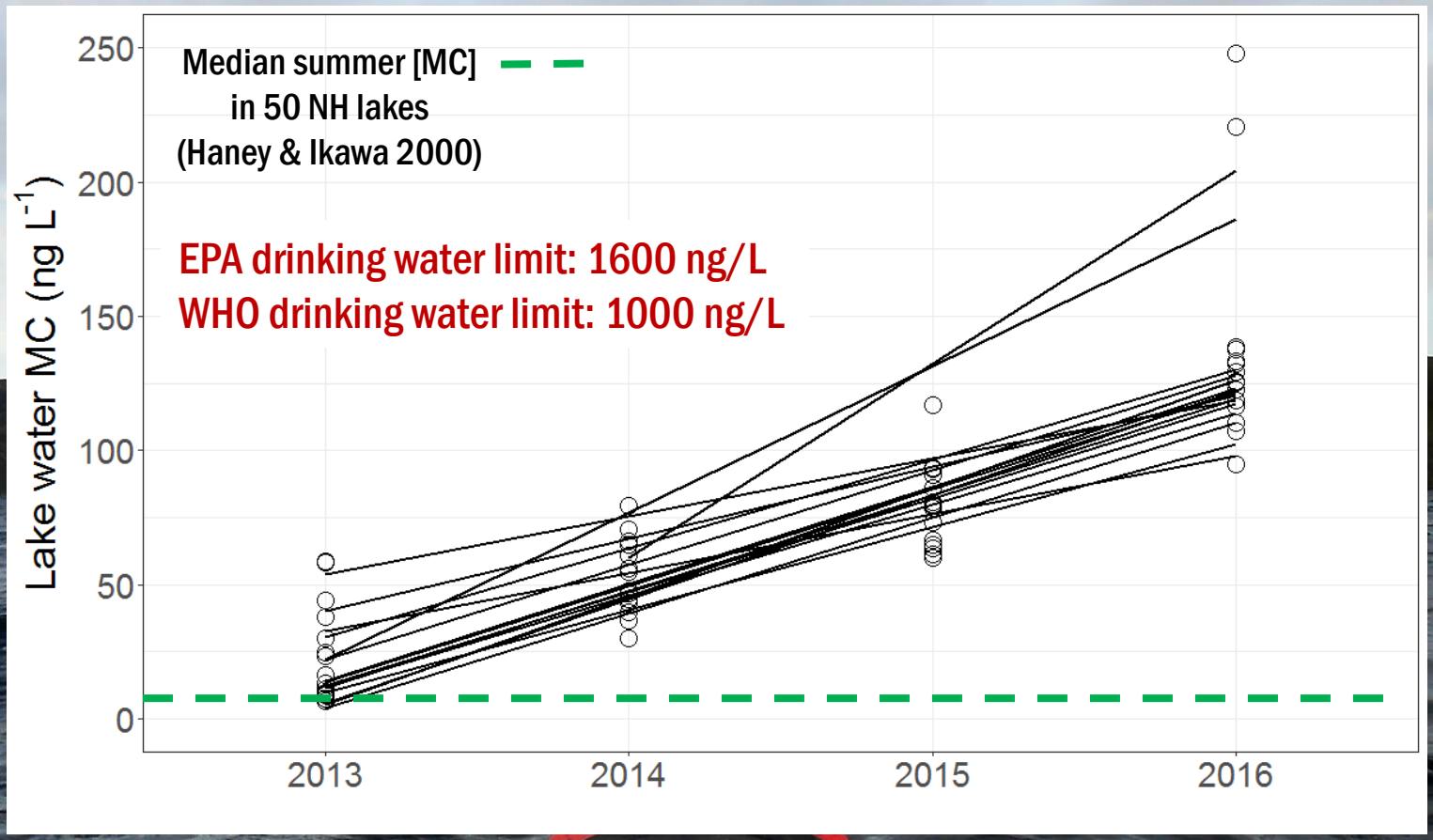

## MC is a widespread cyanotoxin

- Most widely detected cyanotoxin globally
- Liver toxin, tumor promoter
- Blocks protein phosphatases 1 & 2a

## Detection method

**a.** Extract: triplicate freeze-thaw, sonication, vortex
**b.** Freeze-dry to concentrate, when below detection
**c.** ELISA (enzyme-linked immunosorbent assay)

# Are Arctic cyanobacteria producing cyanotoxins?

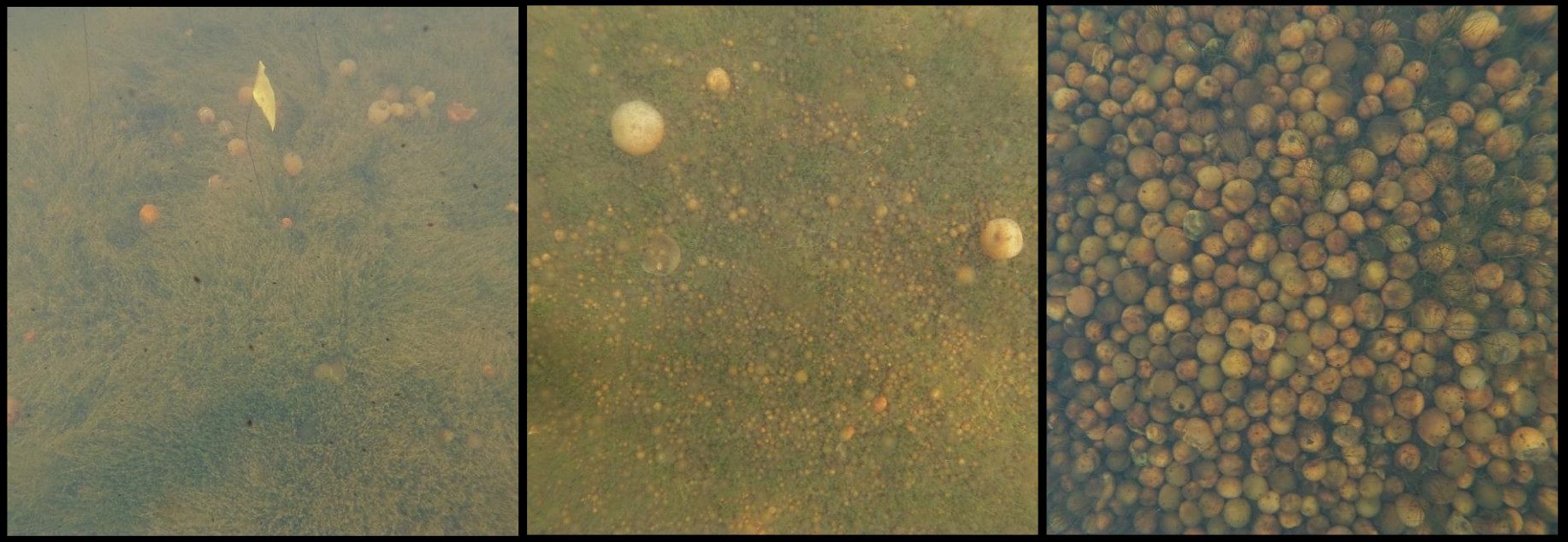



Benthic cyanobacteria
"Sea Tomato"
Genus *Nostoc*

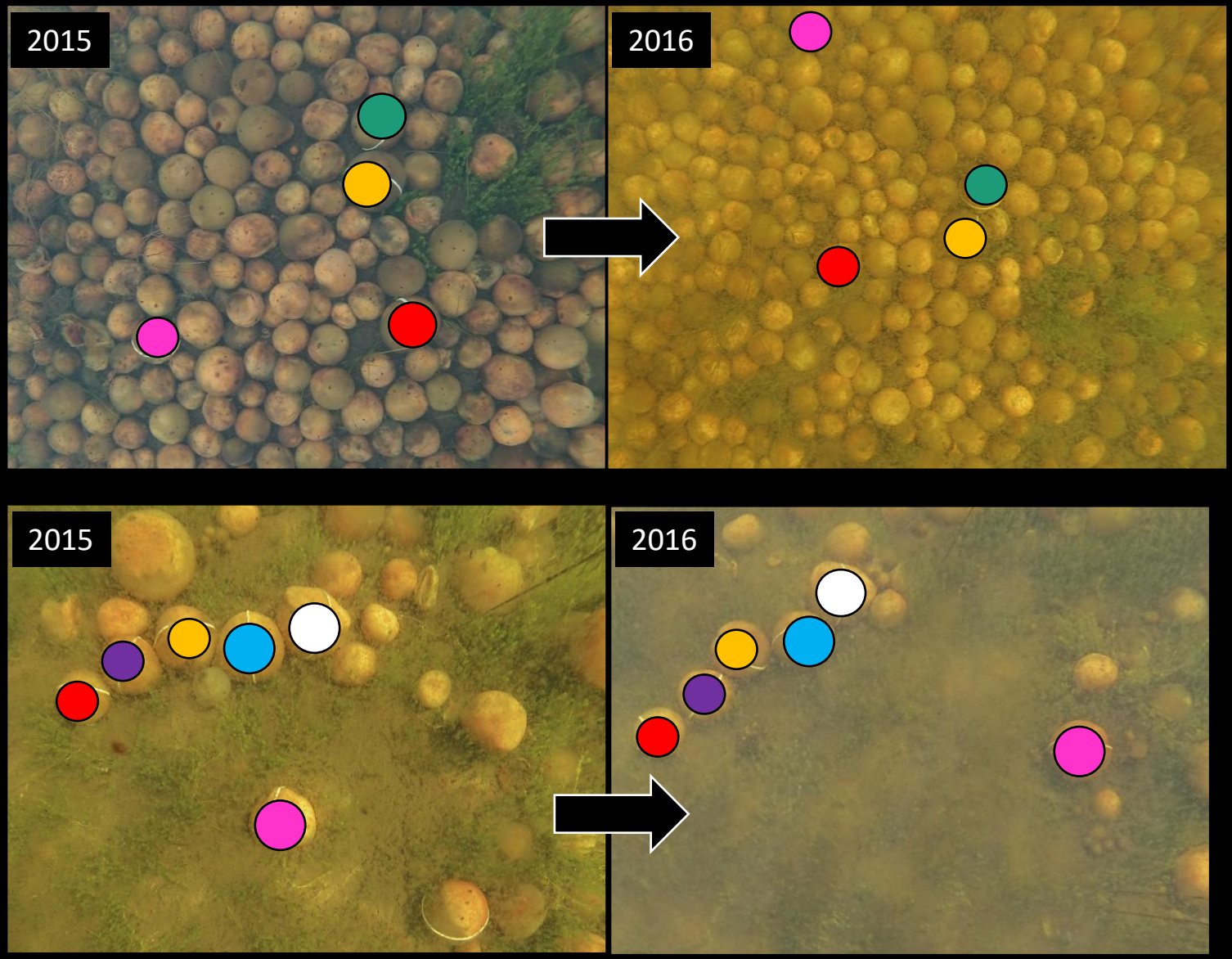


Several morphologies and species

Provide microhabitat for aquatic invertebrates

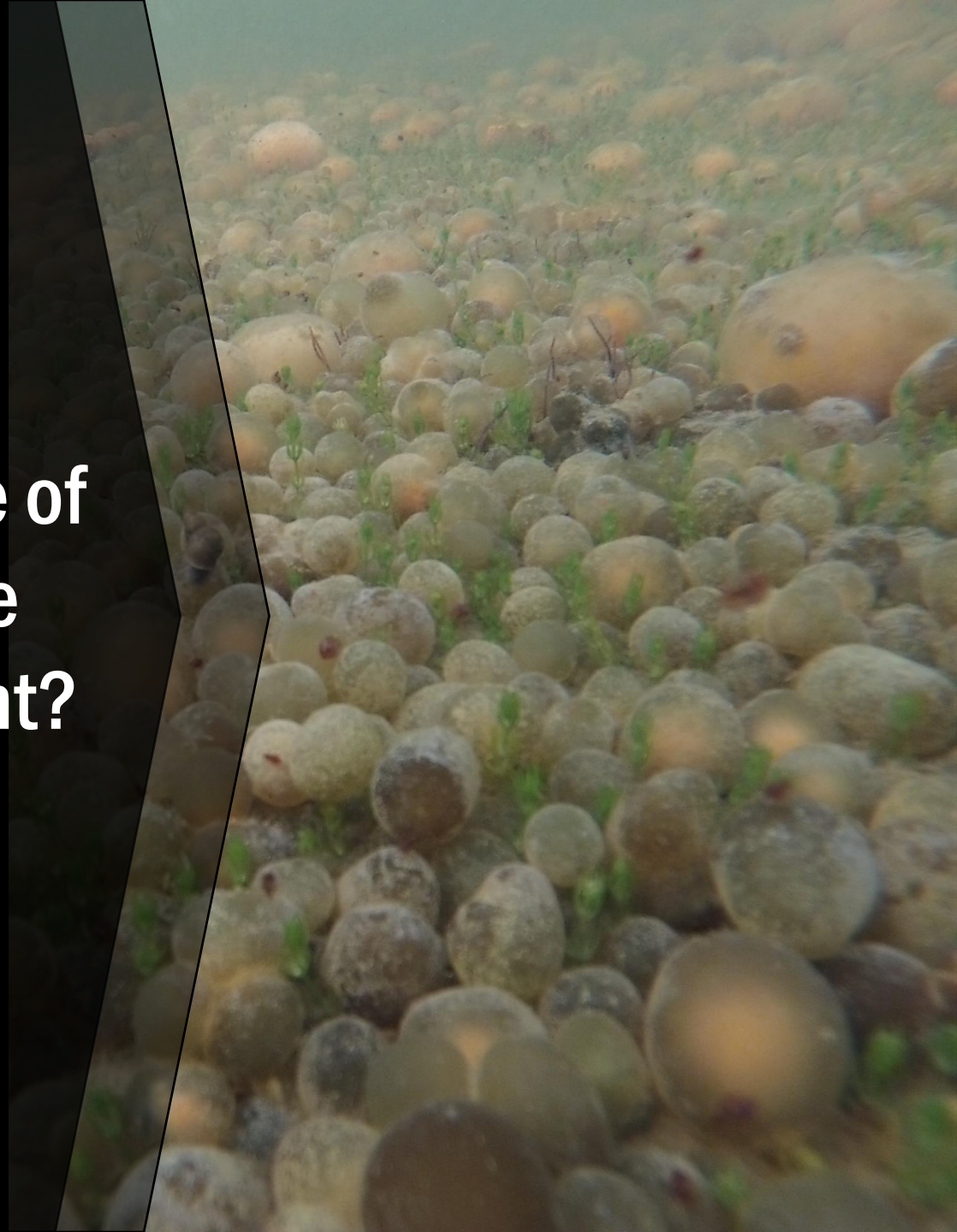


Range of colony sizes (proxy for age)



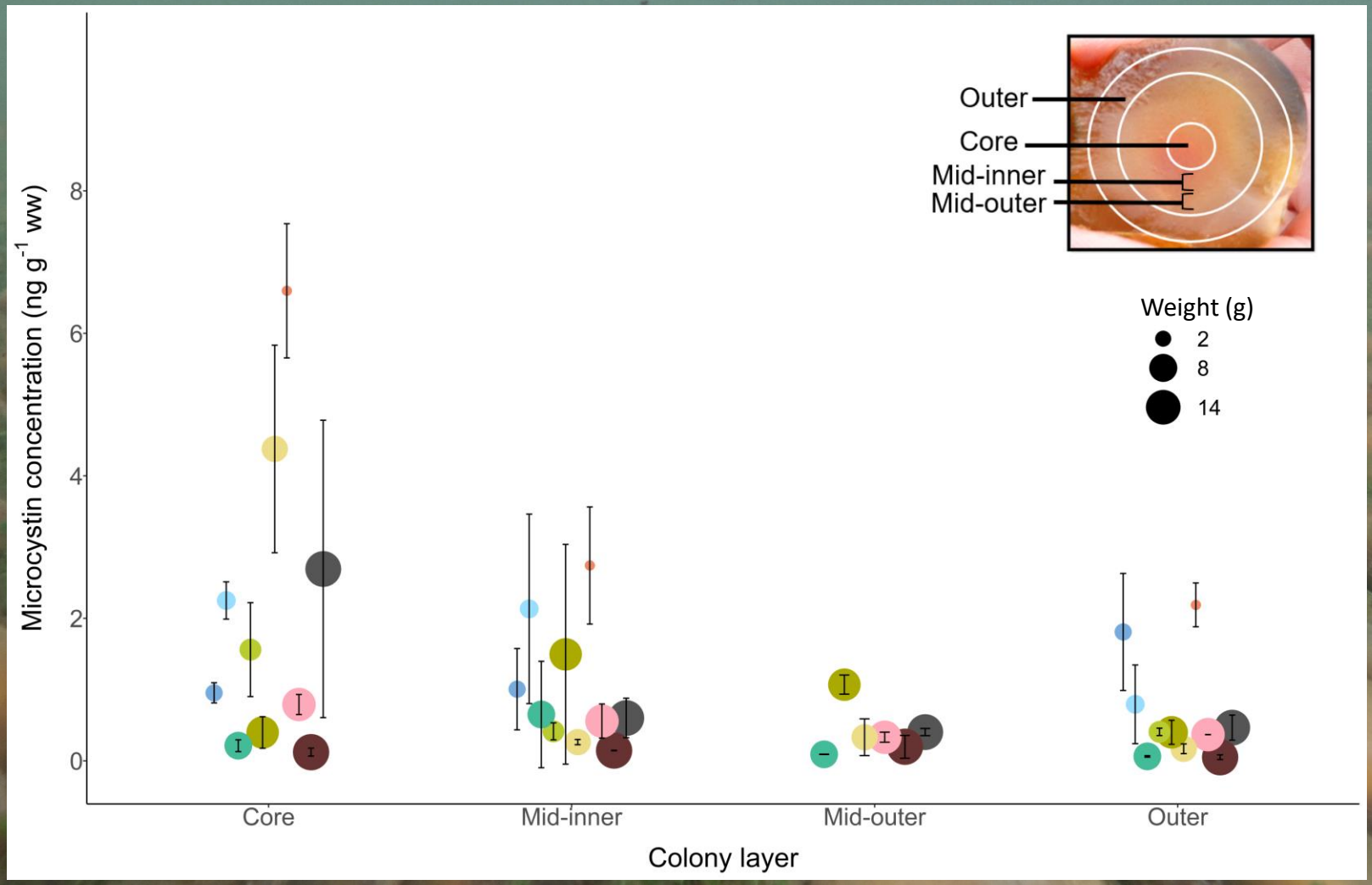

Colonies hold relatively stable positions on the benthos, even over years

Are *Nostoc* a source of cyanotoxins to the aquatic environment?



# Do *Nostoc* colonies produce toxins?

- Yes, Nostoc contain MCs throughout the colony ☑

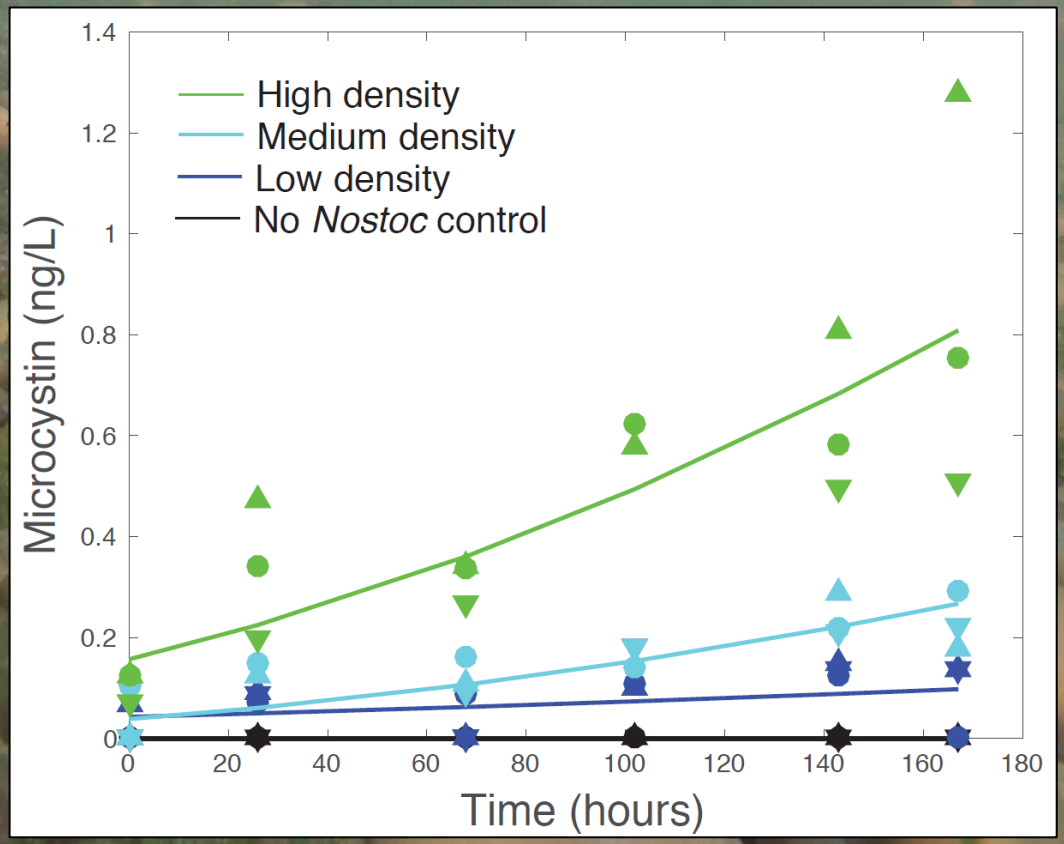


# Do *Nostoc* colonies produce toxins?

- Yes, Nostoc contain MCs throughout the colony ☑

## Can colonies release toxins into the environment?

- Yes, colonies are capable of releasing/leaking MCs ☑
- Higher densities release increasingly more MC through time



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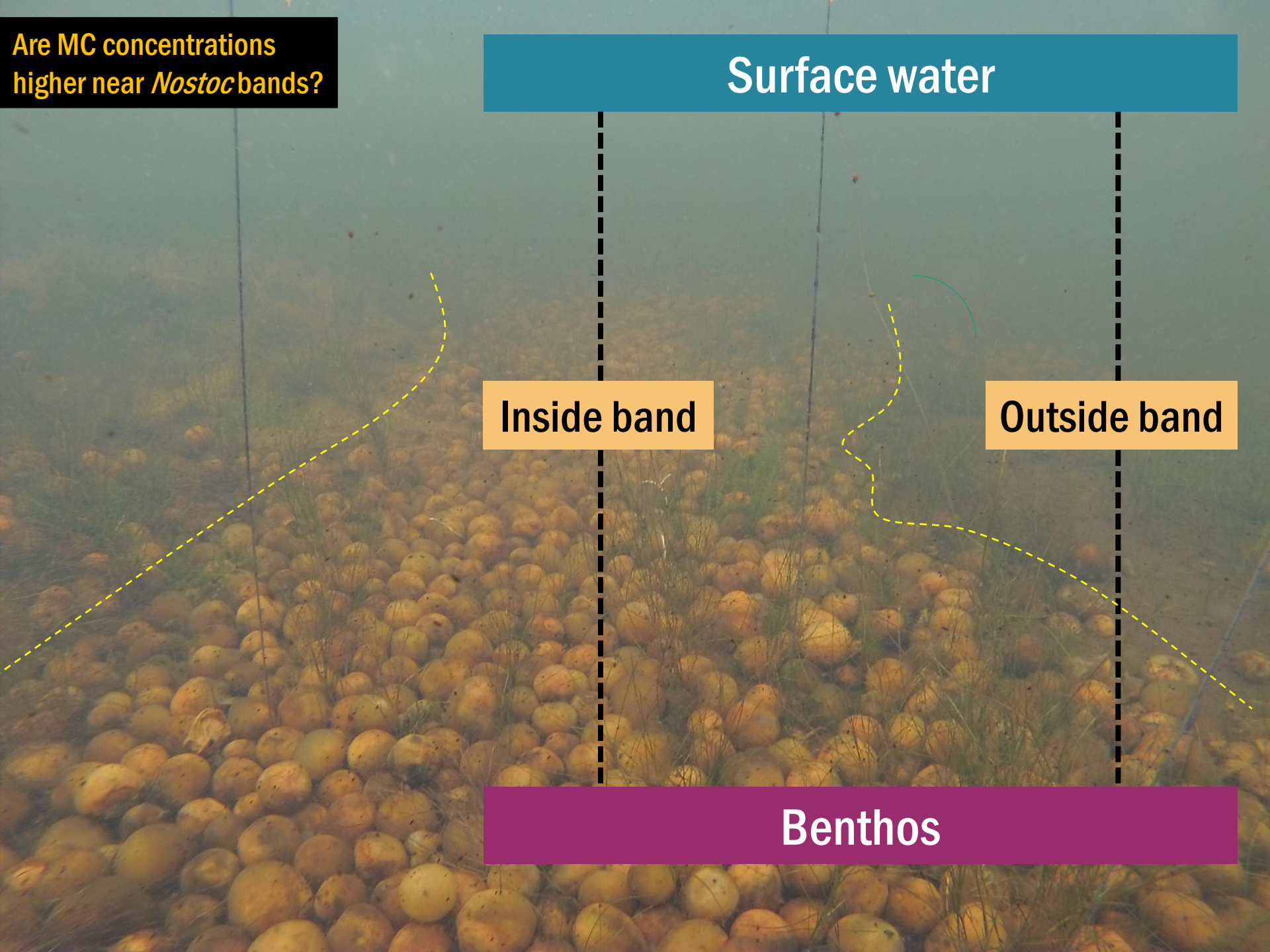
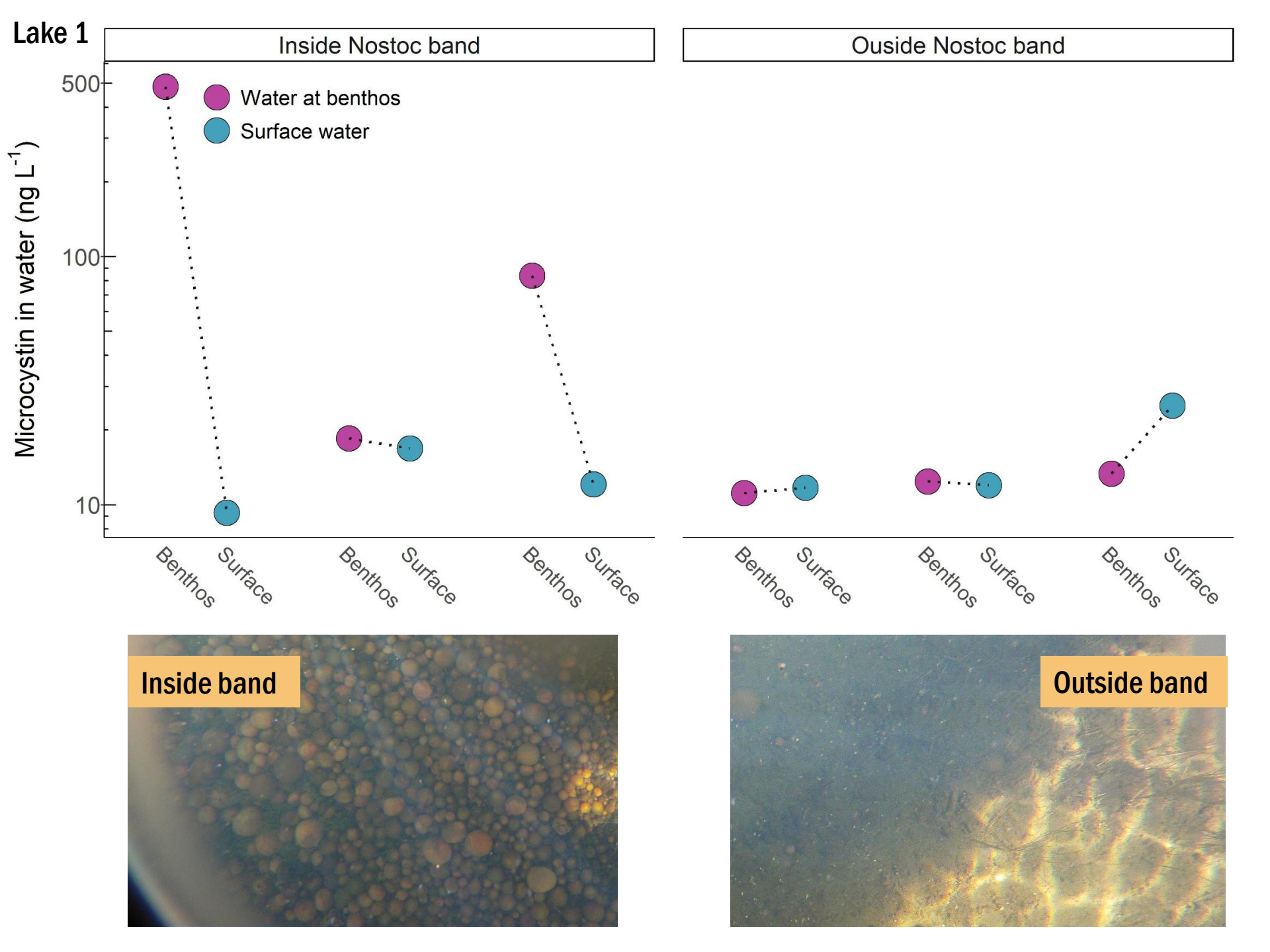
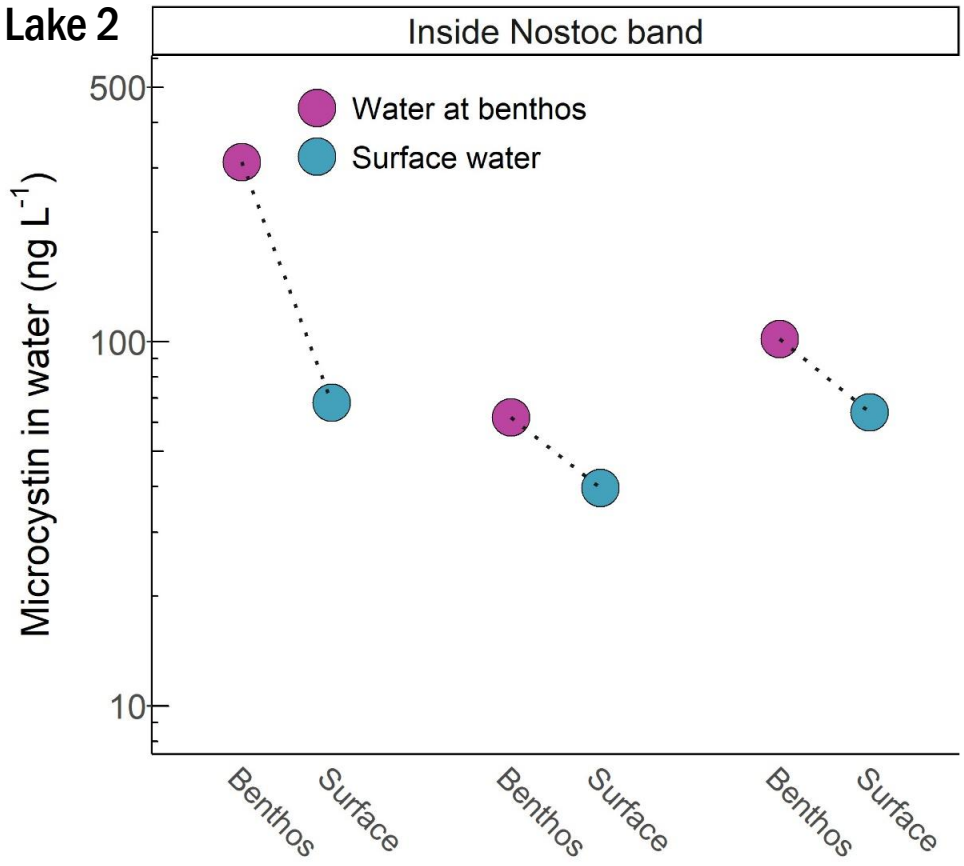
**Is the spatial variability of MCs in water influenced by the density of *Nostoc*?**

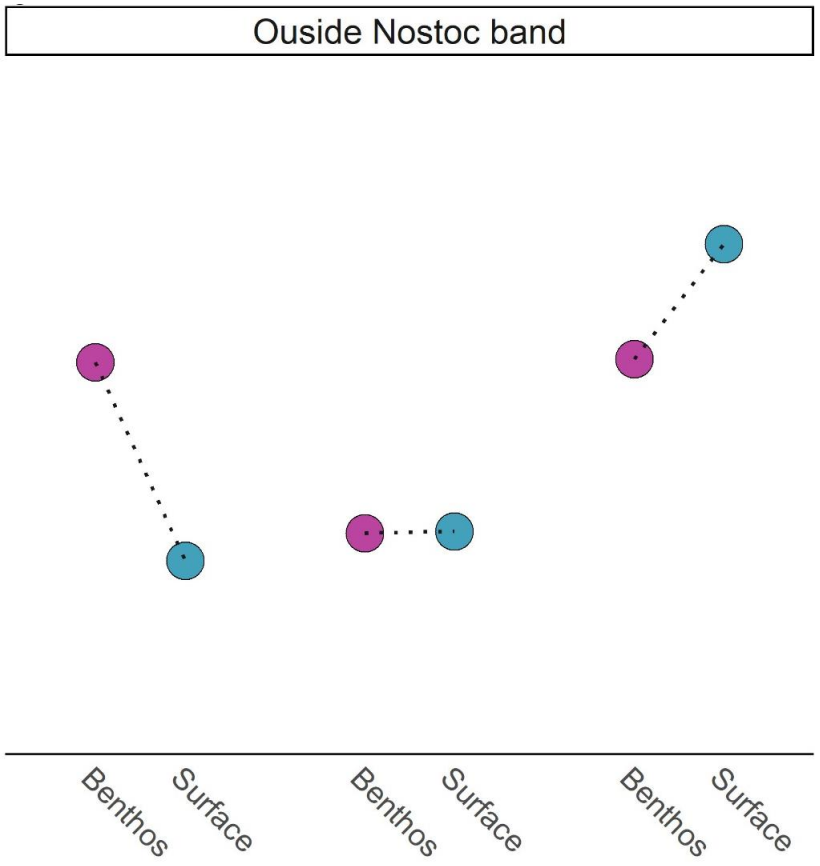

Are MC concentrations
higher near *Nostoc* bands?


Are MC concentrations higher near *Nostoc* bands?
Surface water
Inside band
Outside band
Benthos


Lake 1
Inside Nostoc band
Ouside Nostoc band
Water at benthos
Surface water
Microcystin in water (ng L-1)
500
100
10
Benthos
Surface
Inside band
Outside band

Lake 2


Inside Nostoc band
Water at benthos
Surface water
Microcystin in water (ng L-1)
500
100
10
Benthos
Surface
Benthos
Surface
Benthos
Surface


Ouside Nostoc band
Benthos
Surface
Benthos
Surface
Benthos
Surface


Inside band


Outside band

## Do *Nostoc* colonies produce toxins?

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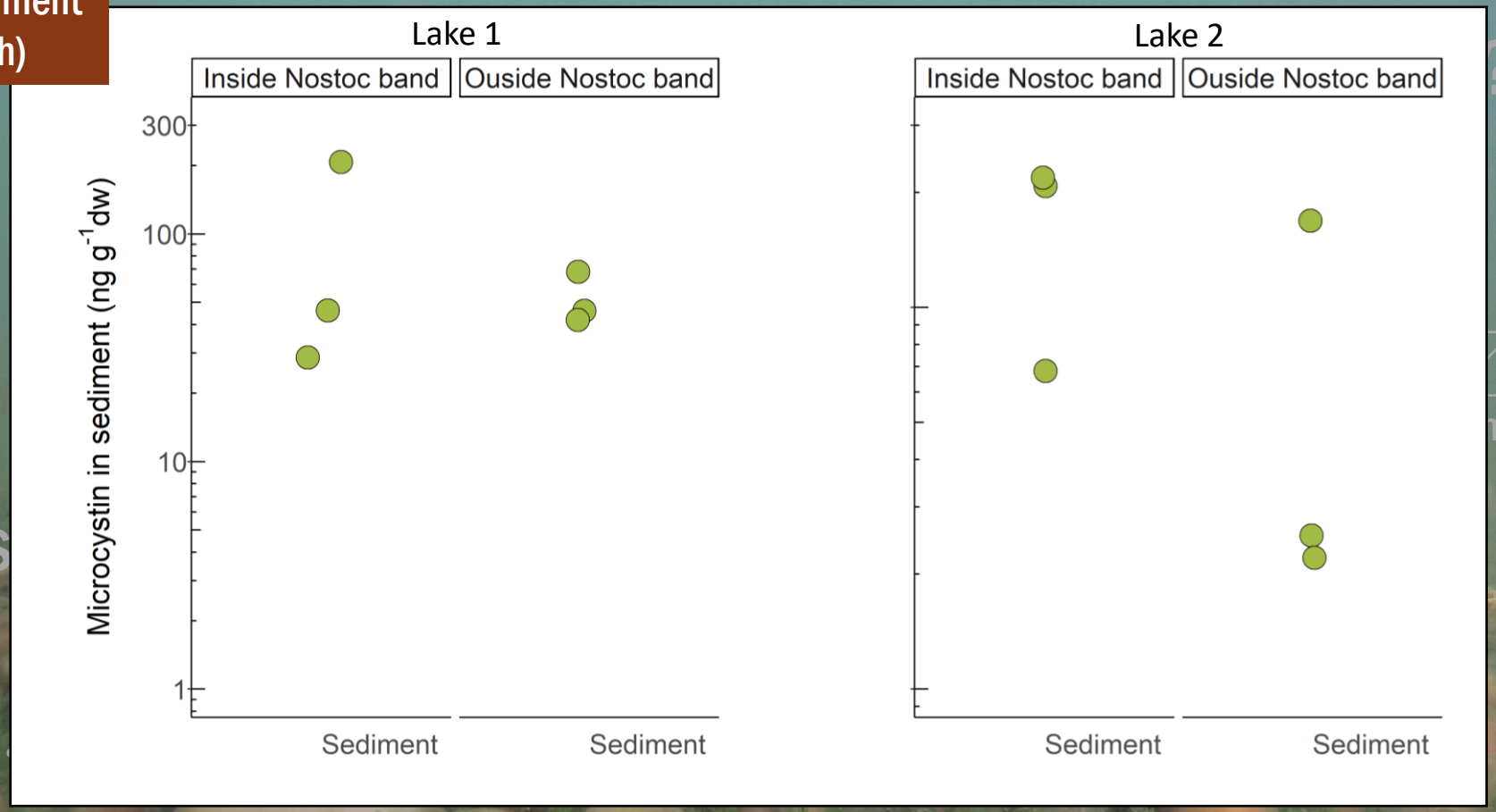
## Can colonies release toxins into the environment?

- Yes, colonies are capable of releasing/leaking MCs ☑
- Higher densities release increasingly more MC through time

# Is the spatial variability of MCs in water influenced by the density of *Nostoc*?

- Yes, water directly above *Nostoc* bands contained higher MCs than above bare sediment ☑
- MCs are spatially variable within the lake at the scale of a few meters
- Many other lake processes also likely play in important role in this within-lake variability
  - e.g., wind-drive mixing, movement of invertebrates, settling of plankton

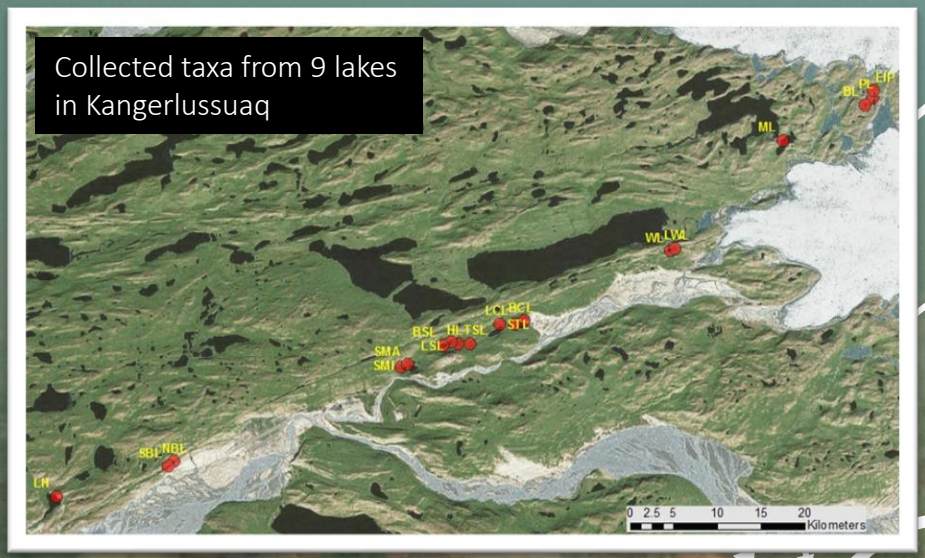
Within sediment (5 cm depth)




# Are MCs contained in sediment under *Nostoc* bands?

- Yes, MCs were found in the upper layer of sediment from all sites ☑
- But, no differences in sediment MCs from under *Nostoc* bands ⊗

# Finally, are MCs transferred within the lake food web?

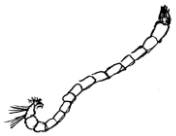




Pelagic cyanobacteria


Zooplankton

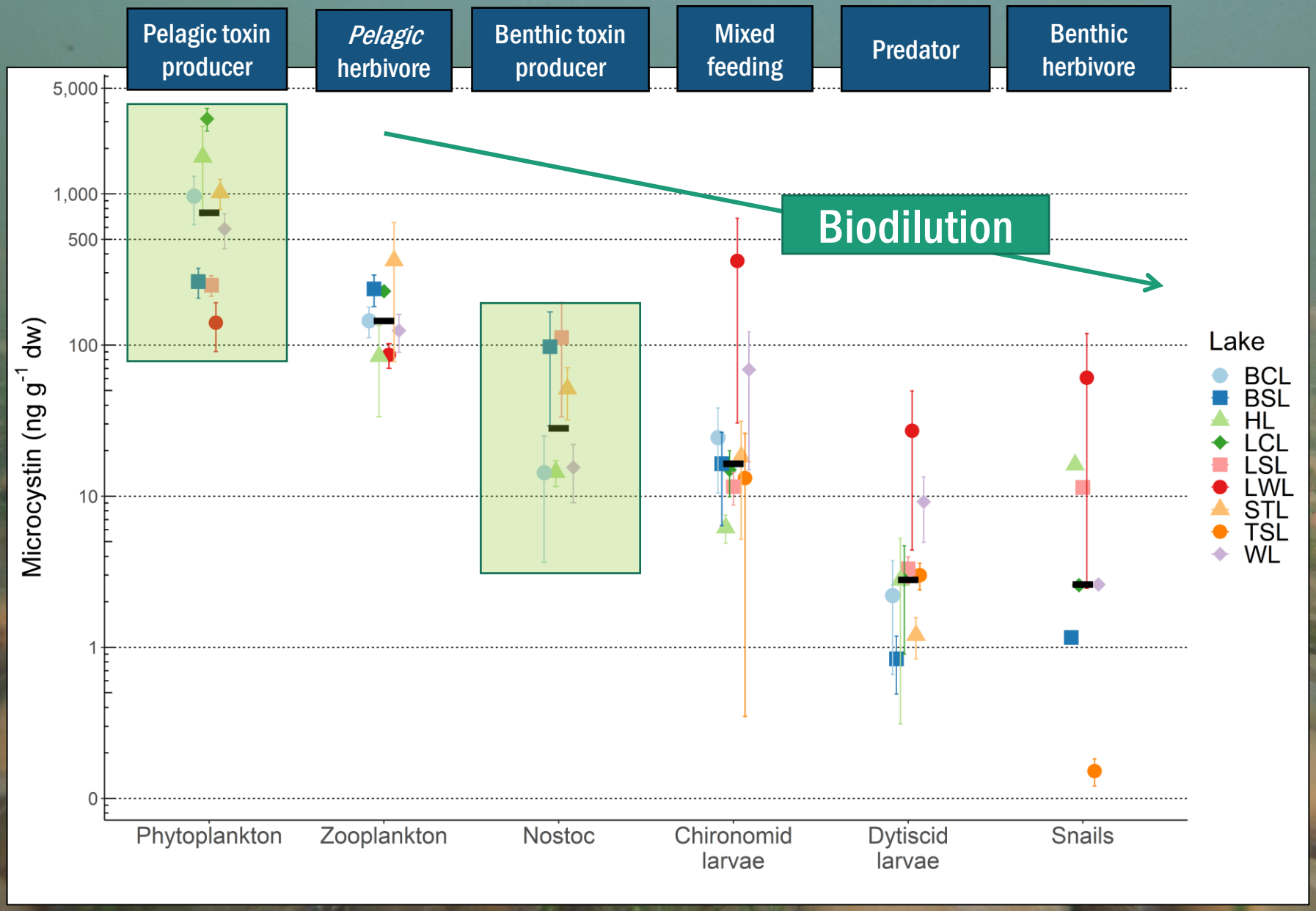
Toxin in water


Midge larvae


Beetle larvae

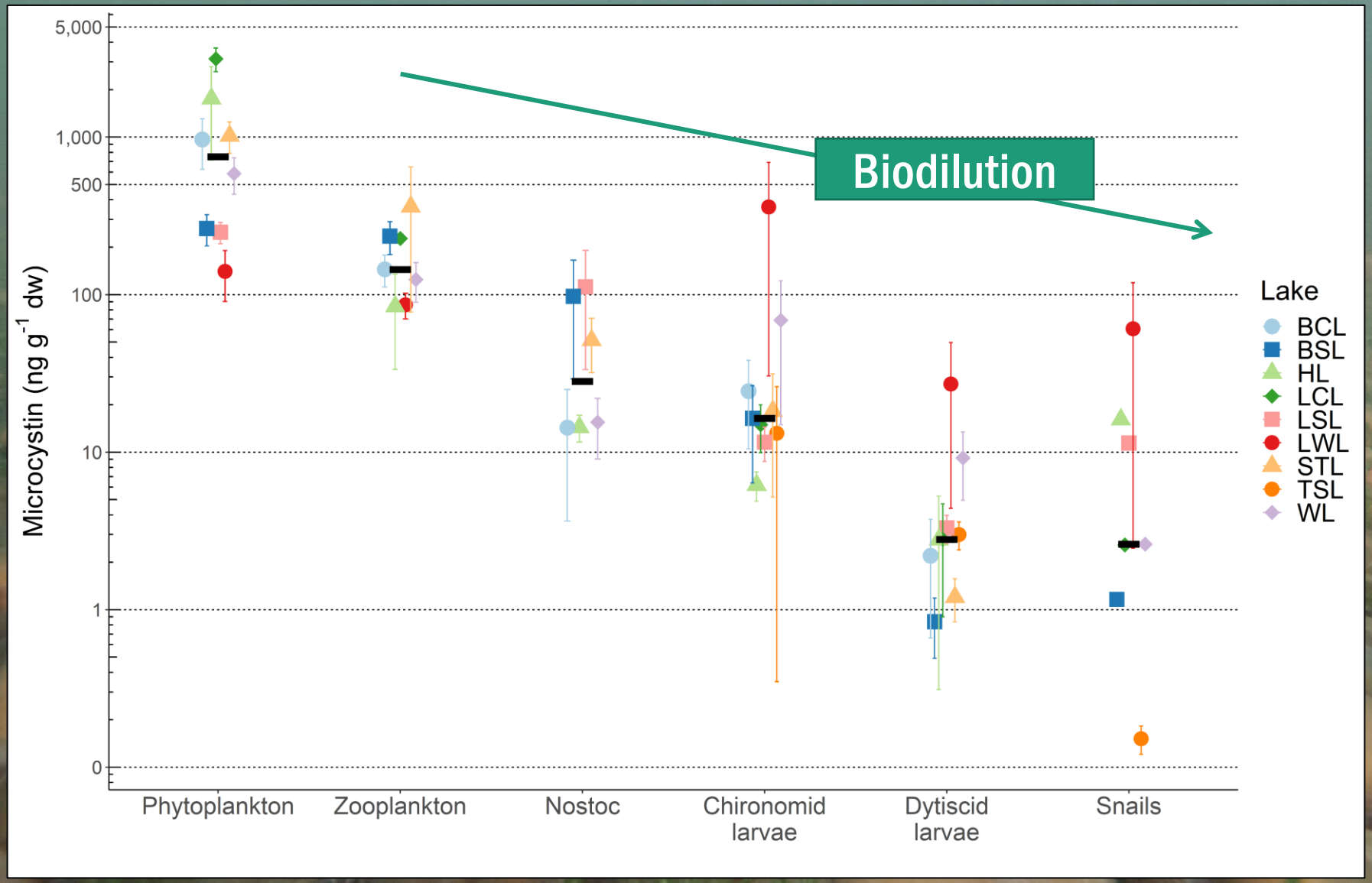

Snail


Benthic cyanobacteria


Pelagic toxin producer
Pelagic herbivore
Benthic toxin producer
Mixed feeding
Predator
Benthic herbivore
Biodilution
Microcystin (ng g-1 dw)
5,000
1,000
500
100
10
1
0
Phytoplankton
Zooplankton
Nostoc
Chironomid larvae
Dytiscid larvae
Snails
Lake
BCL
BSL
HL
LCL
LSL
LWL
STL
TSL
WL

# Are MCs transferred within the lake food web?

- Yes, MCs are contained in multiple trophic levels ✓
- Concentrations are highly variable across lakes and taxonomic groups
- Both benthic and pelagic cyanobacteria could be important sources of cyanotoxins



# Questions?


## Acknowledgements:

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