The Lady Bird Lake Harmful Proliferation

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March 2021

Agenda

- **Background on the Critter of Interest**
- **About CyanoToxins**
- **Environmental Drivers**
- **2019 Summary**
- **2020 Summary**
- **Hypotheses about why Lady Bird went Toxic**
- **Next Steps**

Poll Question #1

"Blue-Green Algae" are a type of:

A. Green Algae

B. Bacteria

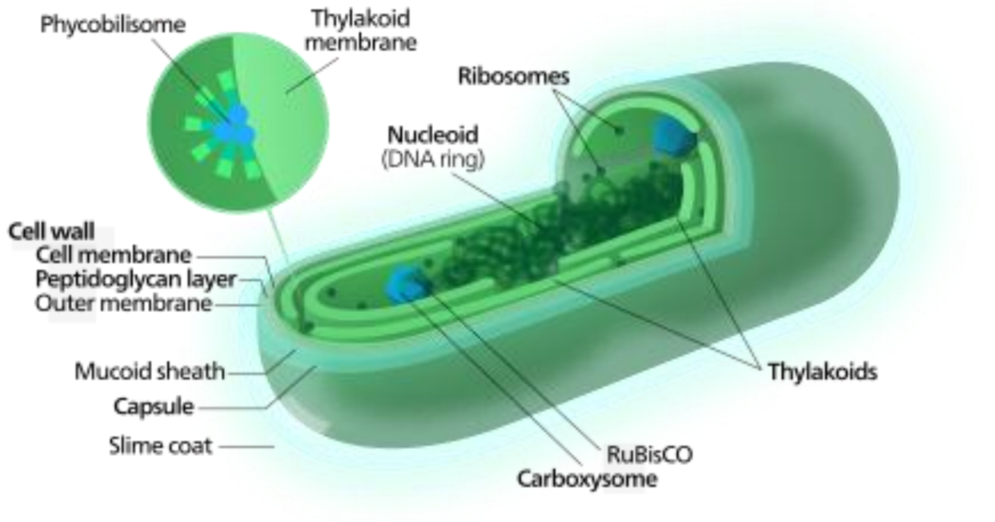
C. Fungi

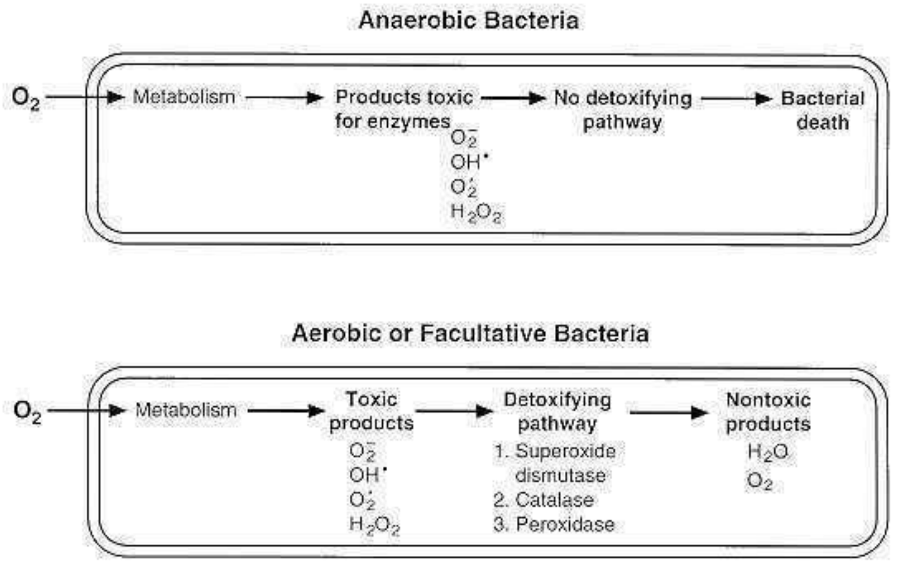
D. Diatom

About Cyanobacteria

- "Blue-green Algae" is a bit of misnomer – these organisms are photosynthetic *Bacteria*
    - Prokaryotic – loose nuclear material, organelles not bound
    - All other algae and land plants are derived from Cyanobacteria and still contain cyanobacteria genetic material within their chloroplasts!
- Primitive!
    - Over 3 *billion* years old
- First photosynthetic organisms; changed Earth's atmosphere leading to the first major extinction

  The GREAT OXYGENATION EVENT
- 6,000+ estimated species



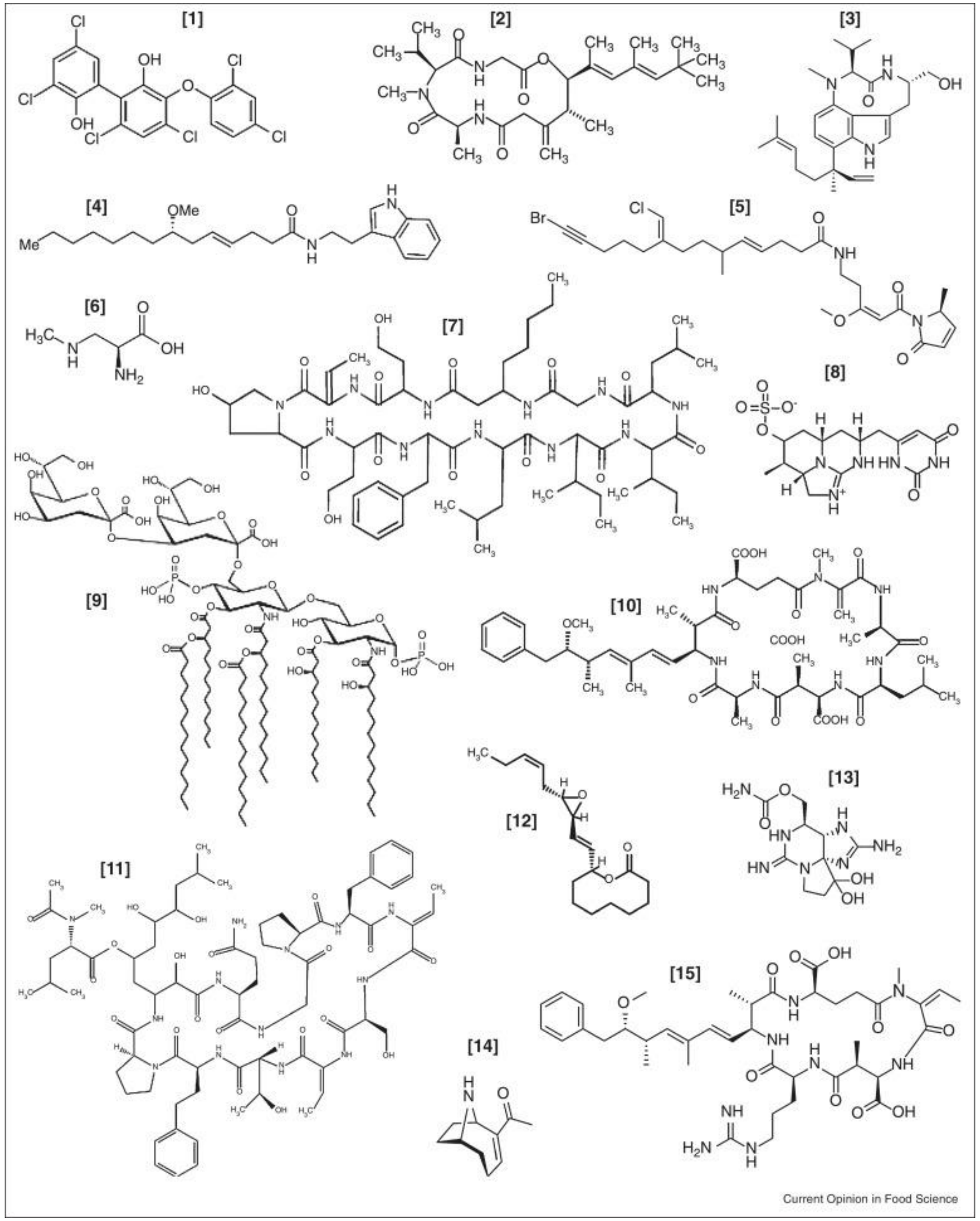


Growth Forms

- Planktonic – single cells in water column
- Cohesive mats – benthic and/or floating matrix of filaments
- Stromatolites – calcareous mounds of filaments

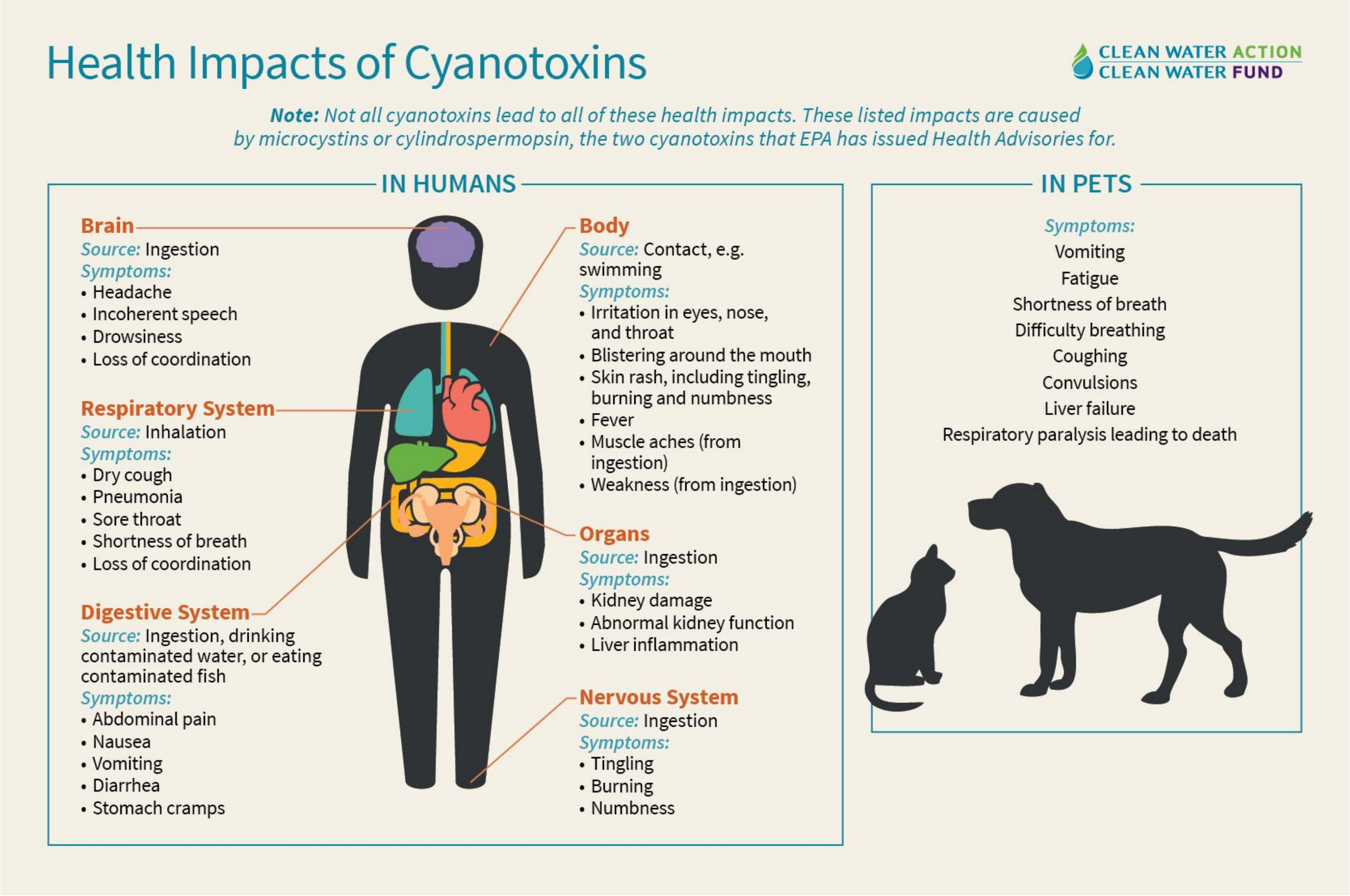
Secondary Metabolites

- Cyanobacteria have been around a long-time; full arsenal of compounds can be produced
- Most concerning – Cyanotoxins
  - Anatoxin-a (neurotoxin)
  - Cylindrospermopsin (cytotoxicity, liver/kidney toxicity)
  - Microcystin (hepatotoxin)
  - Saxitoxin (neurotoxin)
- Drinking water standards
  - EPA – microcystins 0.3 µg/L; Cylindrospermopsin 0.7 µg/L
  - States – Anatoxin-a 0.7 – 20 µg/L; Saxitoxin – 0.3 – 3 µg/L
- A lot of toxin variants!
  - For example, over 100 types of microcystin structurally ID'd



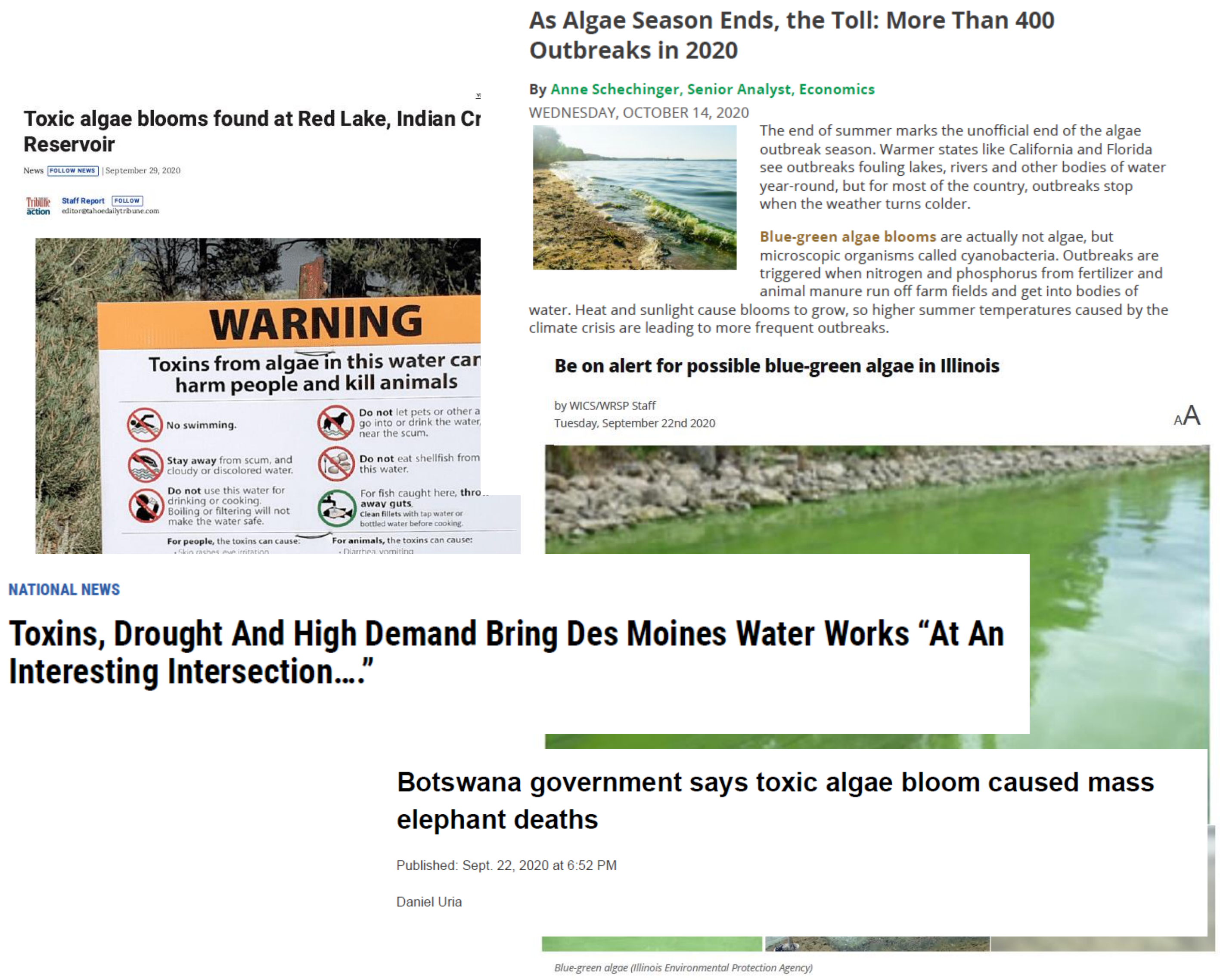
Cyanotoxin E(a)ffects

- Human and animal health
- Economic
- Perception
- Drinking water
  - EPA and State guidelines but they are Limited and Planktonic-focused



National and Global Impacts

- Drinking water utilities impacted by *Planktonic* blooms
- Recreation threatened by *Planktonic* and *Benthic* Proliferations
- Commercial fisheries threated by *Planktonic* blooms
- Costs….literally hundreds of millions a year (Sanseverino et al. 2016; Smith et al. 2019)


Toxic algae blooms found at Red Lake, Indian Cr Reservoir

News FOLLOW NEWS | September 29, 2020

Staff Report FOLLOW
editor@tahoedailytribune.com

As Algae Season Ends, the Toll: More Than 400 Outbreaks in 2020

By Anne Schechinger, Senior Analyst, Economics
WEDNESDAY, OCTOBER 14, 2020

The end of summer marks the unofficial end of the algae outbreak season. Warmer states like California and Florida see outbreaks fouling lakes, rivers and other bodies of water year-round, but for most of the country, outbreaks stop when the weather turns colder.

Blue-green algae blooms are actually not algae, but microscopic organisms called cyanobacteria. Outbreaks are triggered when nitrogen and phosphorus from fertilizer and animal manure run off farm fields and get into bodies of water. Heat and sunlight cause blooms to grow, so higher summer temperatures caused by the climate crisis are leading to more frequent outbreaks.

Be on alert for possible blue-green algae in Illinois

by WICS/WRSP Staff
Tuesday, September 22nd 2020

AA

NATIONAL NEWS

Toxins, Drought And High Demand Bring Des Moines Water Works "At An Interesting Intersection…."

Botswana government says toxic algae bloom caused mass elephant deaths

Published: Sept. 22, 2020 at 6:52 PM

Daniel Uria

Blue-green algae (Illinois Environmental Protection Agency)

Poll Question #2

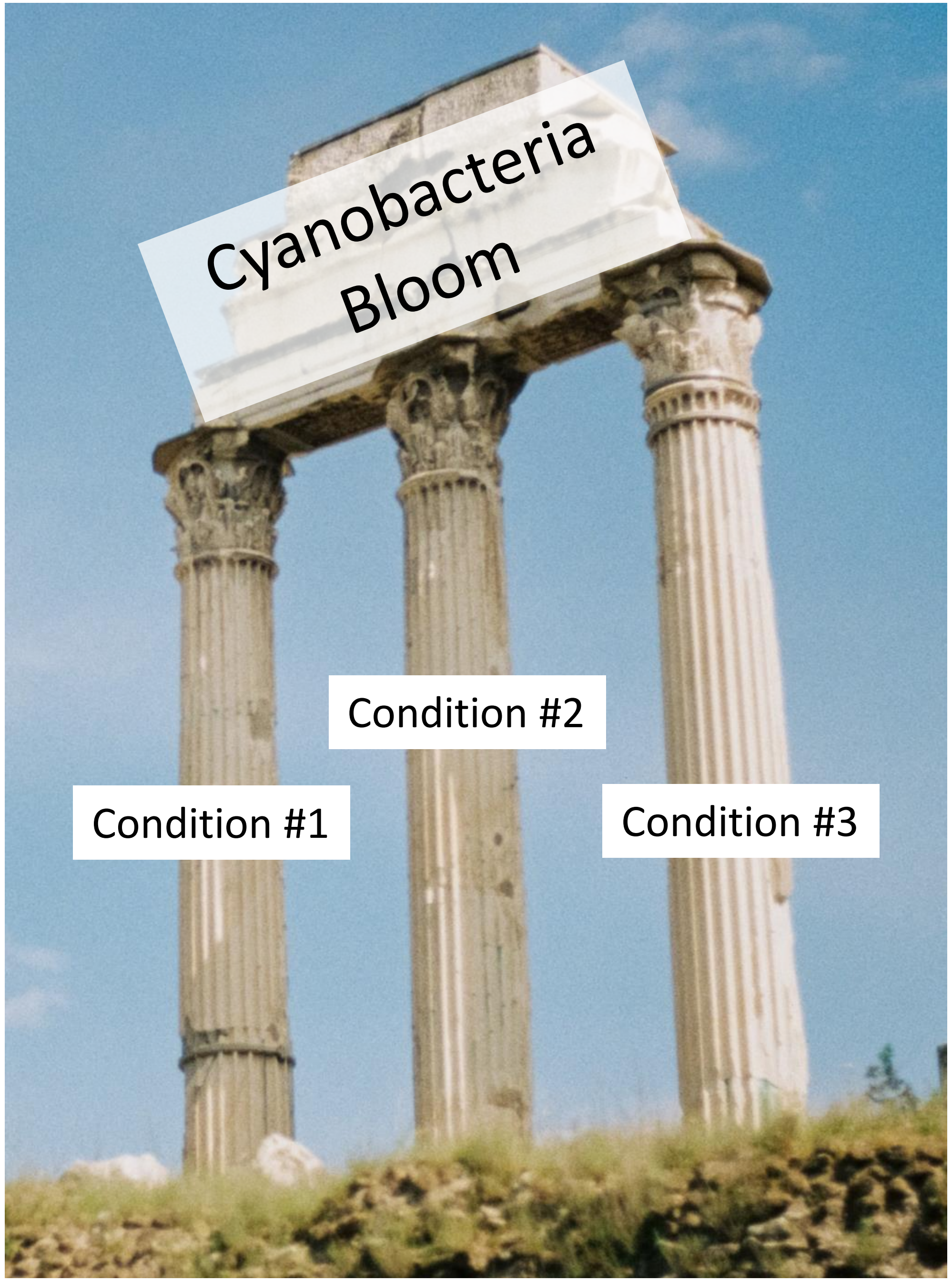
What are the 3 pillars of a cyanobacteria bloom?

A. High Flows, Low Nutrients, Cold Waters

B. Low Flows, High Nutrients, Warm Waters

C. Moe Howard, Larry Fine, Curly Howard

D. High Winds, Blizzards, Cedar Fever



Cyanobacteria Bloom Drivers

- "Three pillars" to a bloom

  1. Low flows (general lack of turbulence related to hydrology, wind, rain)

  2. High Nutrients (N, P)

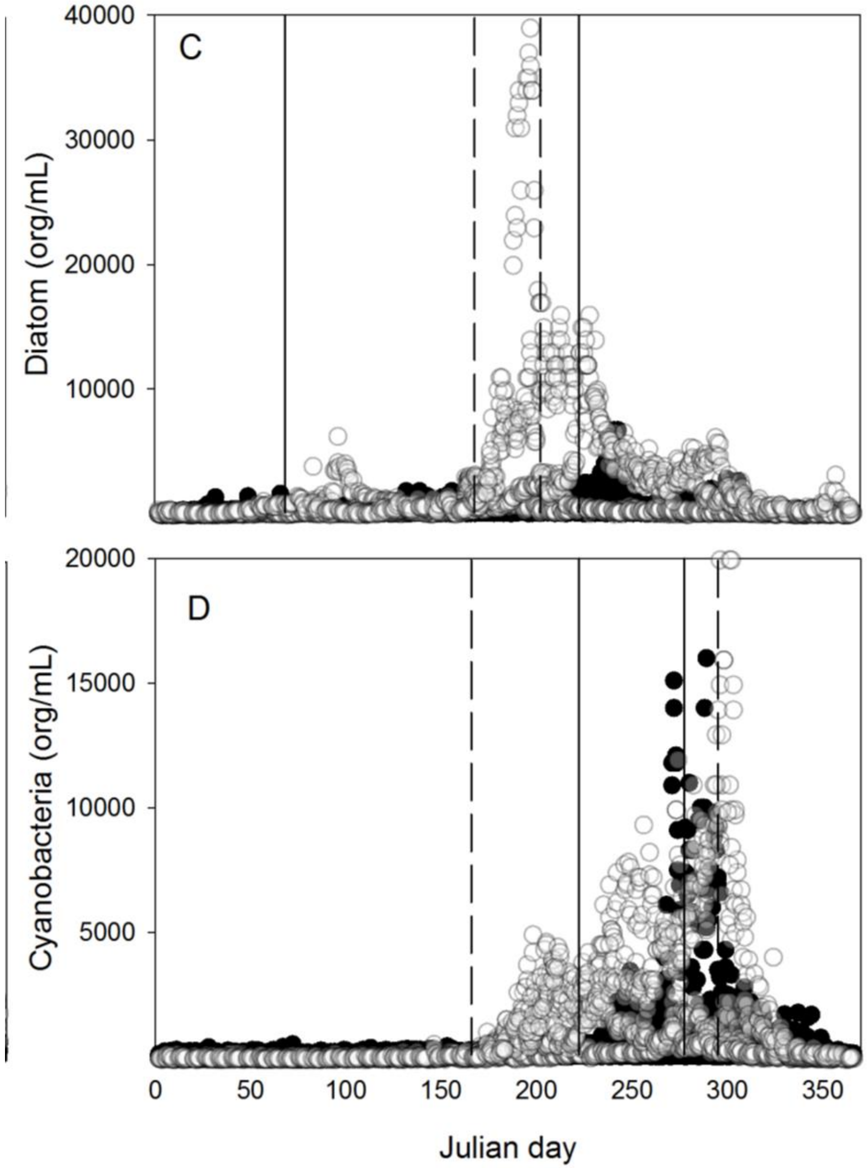
  3. Warm Waters

- Conditions Typically Come Together in Late Summer

  Data from Lake Austin at treatment plants; *no toxins measured*(!) despite abundant cyanobacteria in the phytoplankton

  Hypothesize that nutrient limitations are why L. Austin did not experience HABs during the recent drought

- *So what happened in Lady Bird Lake*?!?



Poll Question #3

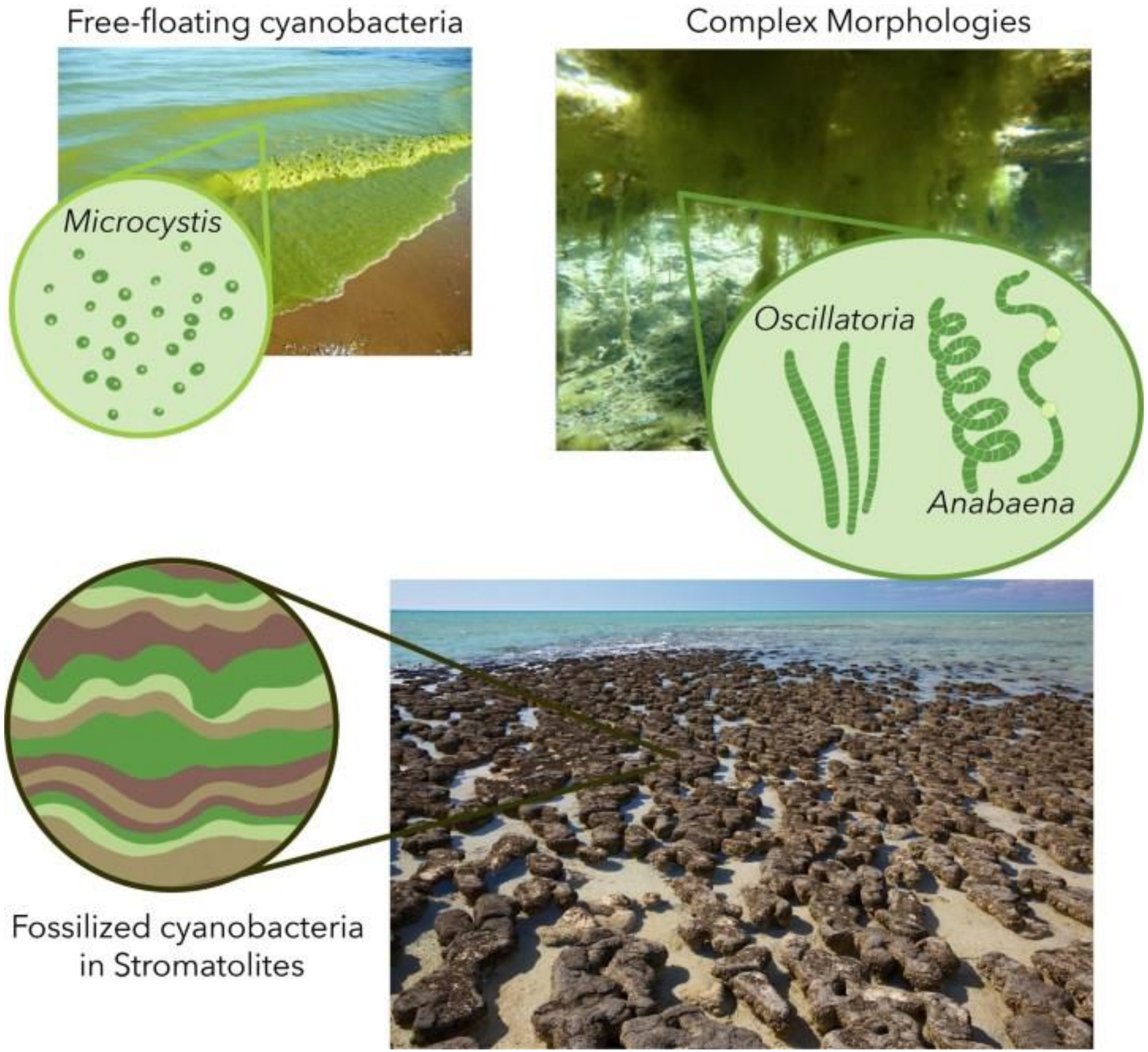
What type of toxic cyanobacterial growth form did we have in Lady Bird Lake?

A. Planktonic

B. Cohesive Mat

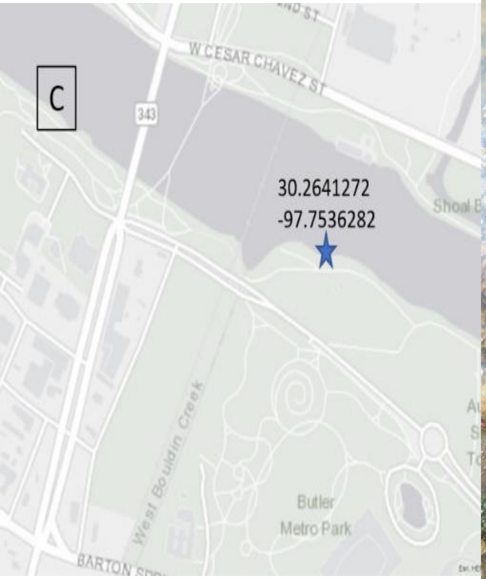
C. Fusiform

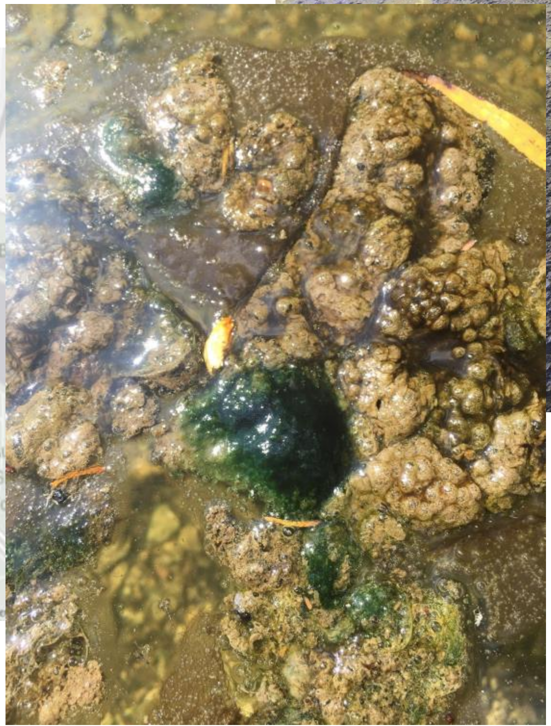
D. Stromatolite



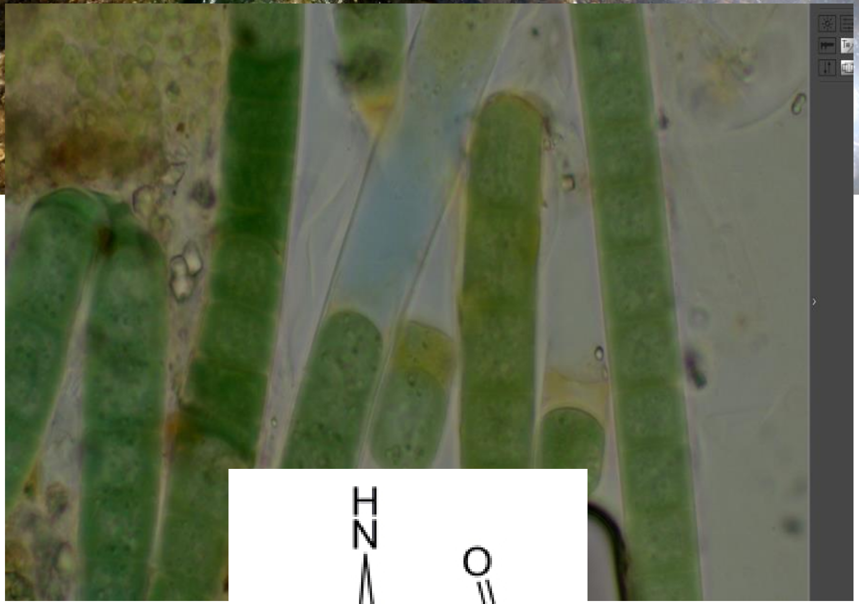
2019 Lady Bird Lake Event

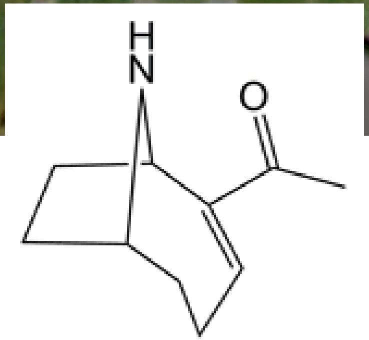
- In July, a number of dogs became sick and a few died at Red Bud and Auditorium Shores from toxic *Cohesive Mats*





What We Found





Species in the Order Oscillatorialles

- Many known toxin producers in this group

Within algae mats dihydroanatoxin (dhATX) dominant

- Anatoxin-a (ATX) potent neurotoxin “fast acting death factor”
- dhATX possibly 4x more toxic than ATX ?!?! (Puddick et al. 2018)

Contents = <1 – 5.3 mg/kg wet weight mat

Field Observations – Temperature and Nutrients

- Water Temps
  - >30°C weekend of dog deaths
- Nutrients
  - Abundant Nitrogen (esp NH_3??) and Phosphorus
  - Distinct water quality @RB compared to previous years

Toxic Sites

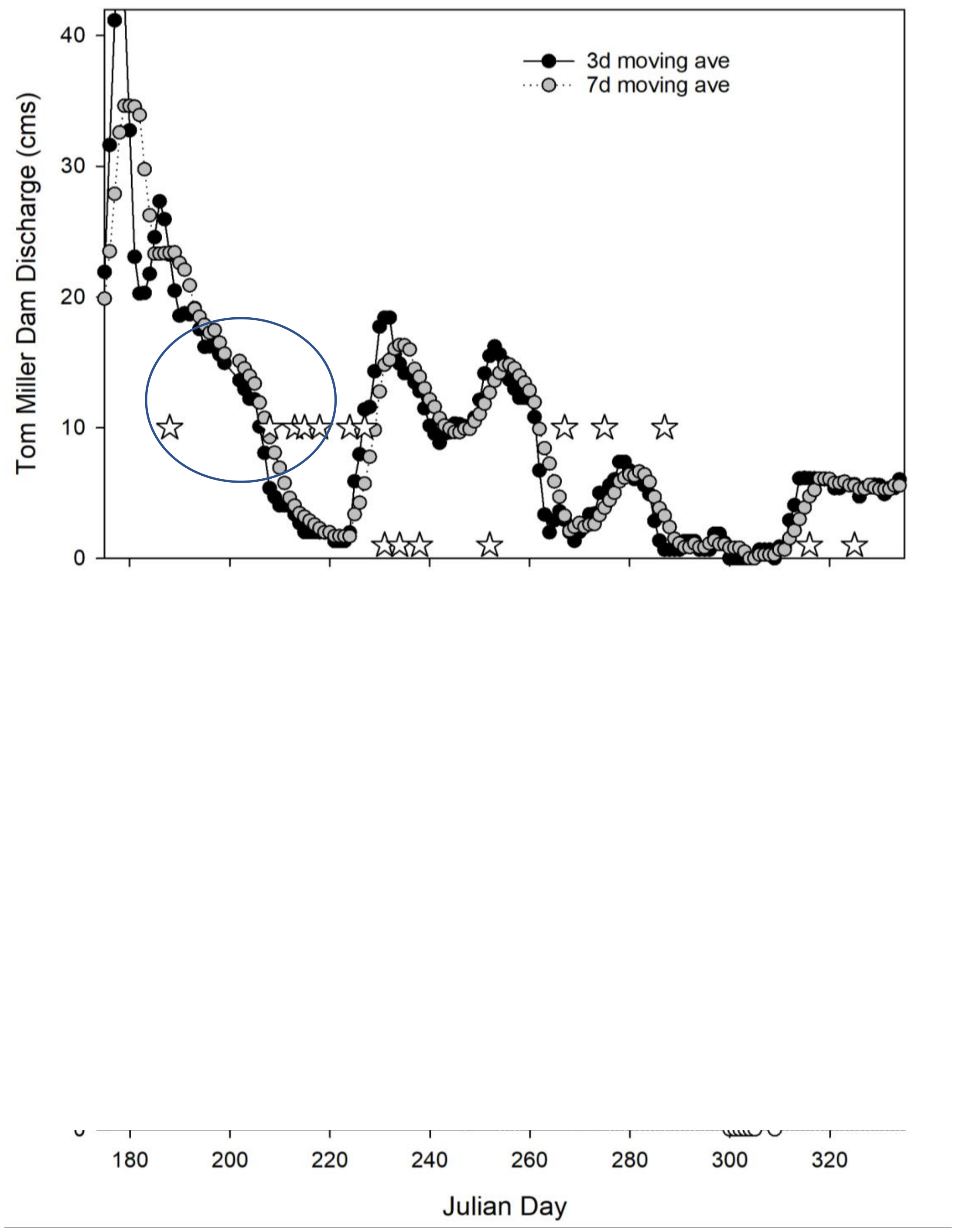
Data period	Site name and ID (n)	TSS (mg/L)	NH3 (ug/L)	Nox (ug/L)	TKN (ug/L)	TN (ug/L)	TP (ug/L)	N:P
2019	Red Bud West 1996 (4)	n/a	41.1 ± 7.7	111.0 ± 42.2	401.0 ± 28.7	513.5 ± 40.6	26.0 ± 20.8	87.1 ± 72.7
	Auditorium Shores 1252 (4)	n/a	24.1 ± 20.3	396.0 ± 148.0	404.5 ± 56.5	798.3 ± 200.9	17.7 ± 6.5	119.1 ± 74.3
2016-2018	Red Bud 5 (9)	2.6 ± 0.9	10.8 ± 8.3	130.8 ± 81.5	424.6 ± 133.6	555.4 ± 119.2	12.6 ± 9.3	125.4 ± 47.0
2019	Red Bud 5 (5)	2.1 ± 1.1	21.5 ± 22.0	477.9 ± 622.0	370.8 ± 56.1	848.7 ± 621.2	29.6 ± 17.2	81.3 ± 66.6
2016-2018	1st St. 2 (9)	3.7 ± 2.0	20.4 ± 37.3	247.1 ± 208.5	485.9 ± 206.0	733.0 ± 275.5	13.4 ± 8.2	153.5 ± 83.4
2019	1st St. 2 (5)	1.9 ± 0.4	16.1 ± 11.1	434.6 ± 184.0	388.4 ± 33.2	823.0 ± 213.2	15.7 ± 11.7	160.1 ± 75.5

Long-term Monitoring Sites

Discharges

- Discharge rates
  - Late July drop in discharge coincided with bloom and toxins event

  - Ave was lower than previous 3-year period

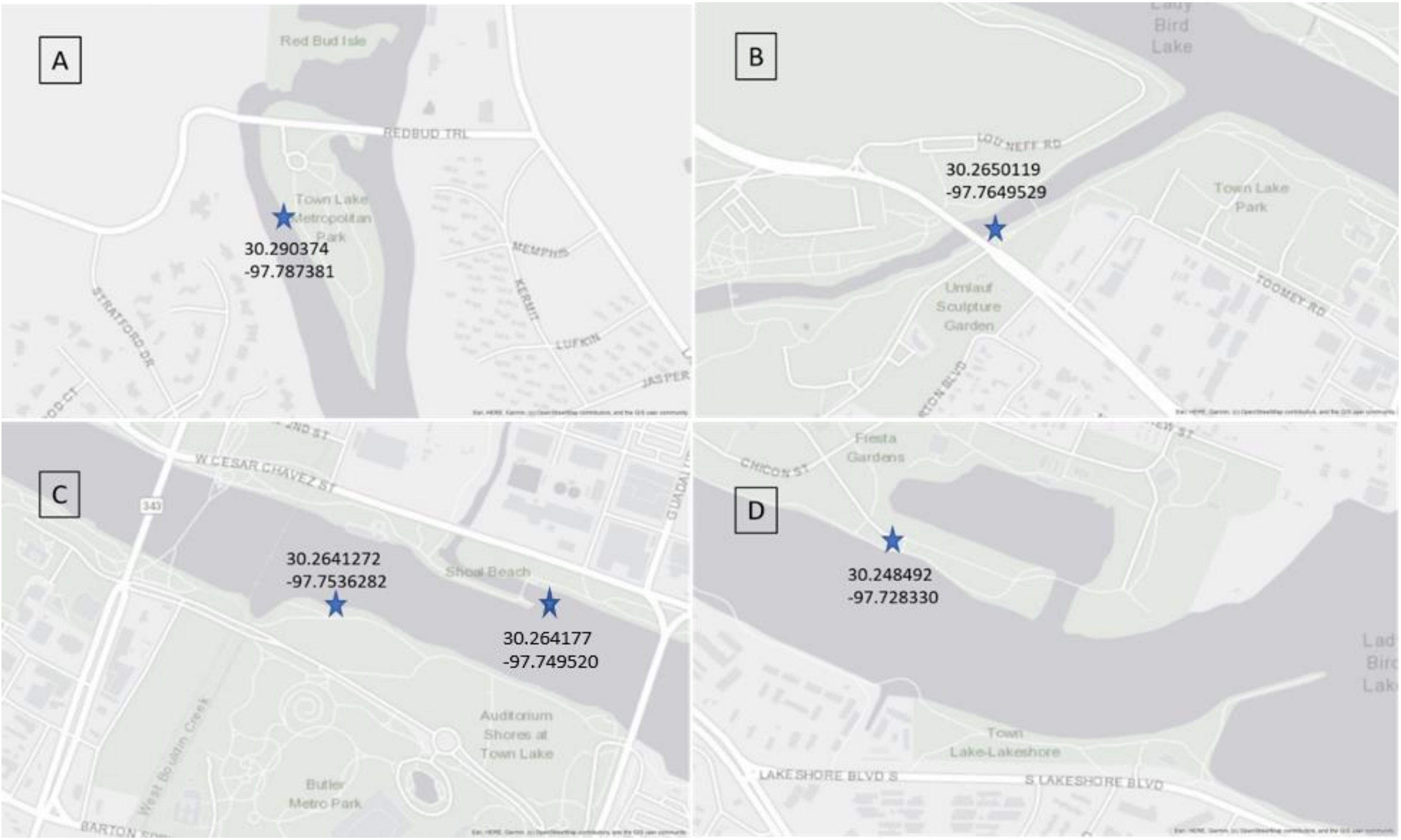


The 2020 Monitoring Plan

- Continue Routine Monitoring
  - 9x/yr at 3 fixed sites for water chemistry
  - Elucidate long-term trends

- HAB Monitoring
  - Began in June at 4 sites (added 5th in July)
  - Collaboration with UT
    - DNA fingerprinting, toxin ID and content
  - Water quality
    - Nutrients, water temp, pH
  - Tracking discharge velocities through LBL

Site Locations



Poll Question #4

Which site had the highest cyanotoxin contents in 2020?

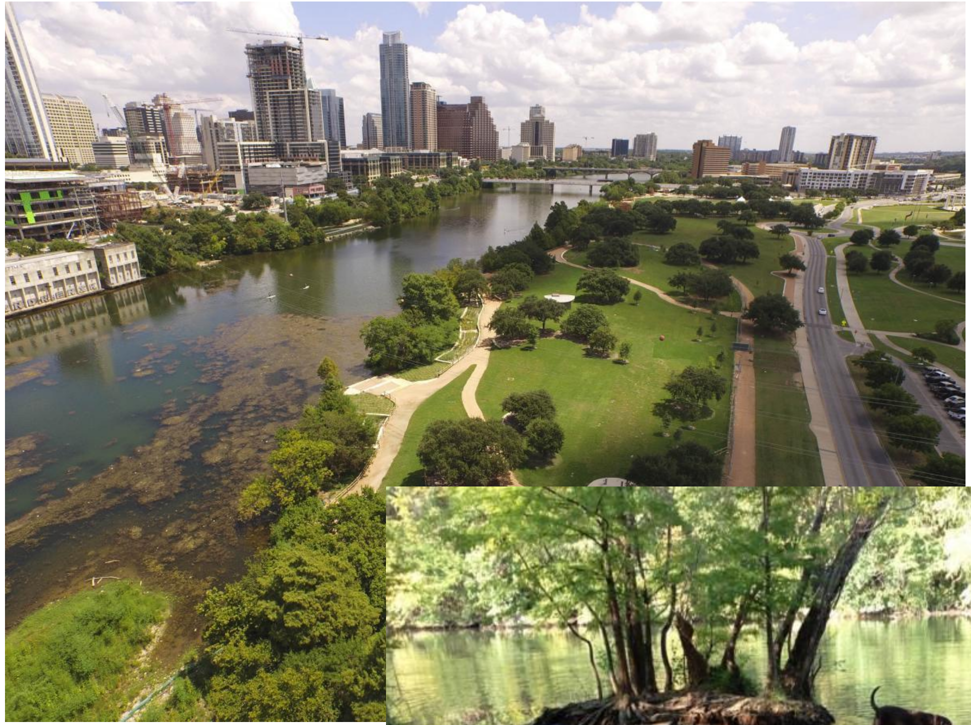
A. Auditorium Shores

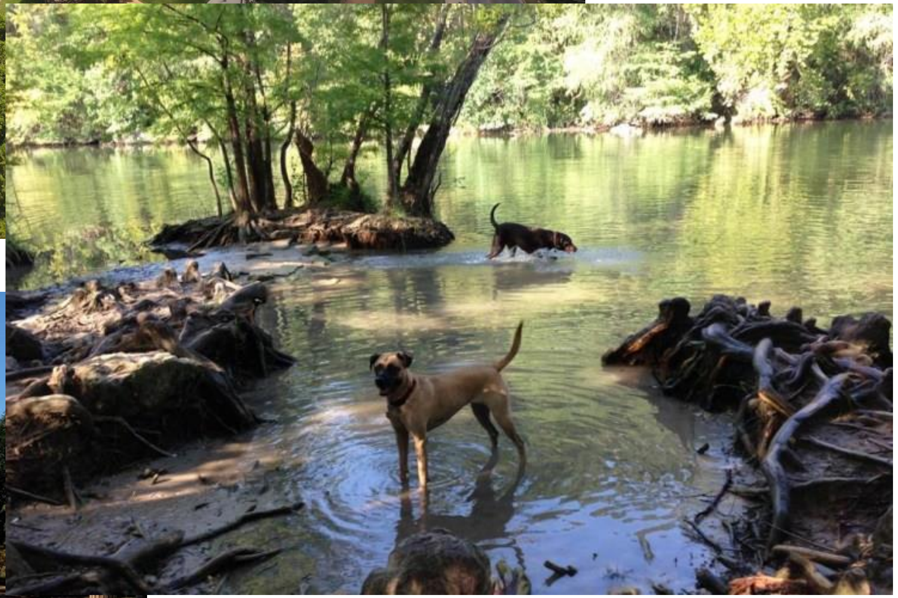
B. Red Bud

C. Shoal Creek

D. Torchy's

E. Festival Ramp





TORCHY'S
DAMN GOOD
TACOS

Data Summary - Toxins

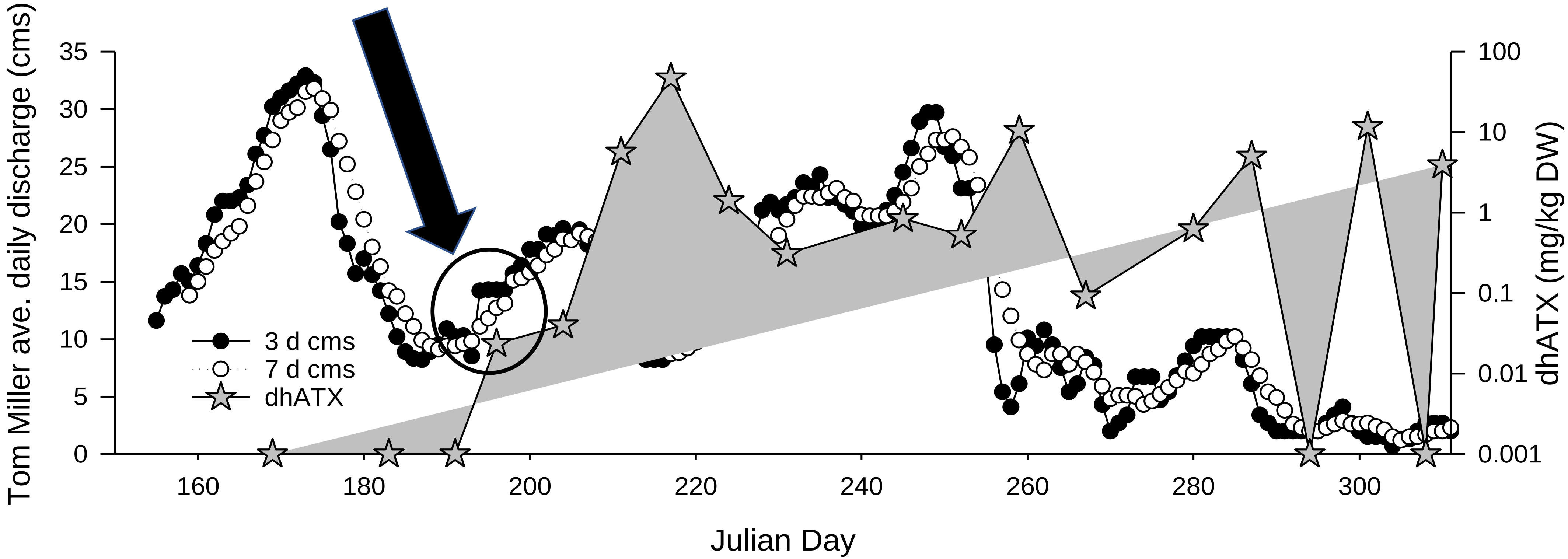
- *Red Bud* w/highest contents
- Orders of magnitude above what was reported in 2019*
- However, visually, extent and biomass appeared lower in 2020 than 2019

Site	Range dhATX (mg/kg DW)	Mean ± Std Dev dhATX (mg/kg)
Red Bud	0.0 – 132.7	15.1 ± 34.9
Auditorium Shores	0.0 – 5.7	1.2 ± 2.2
Mouth Shoal Creek	0.01 – 4.1	0.9 ± 1.8
Festival Ramp	0.0 – 3.2	0.3 ± 0.9

*different labs carried out analyses between years

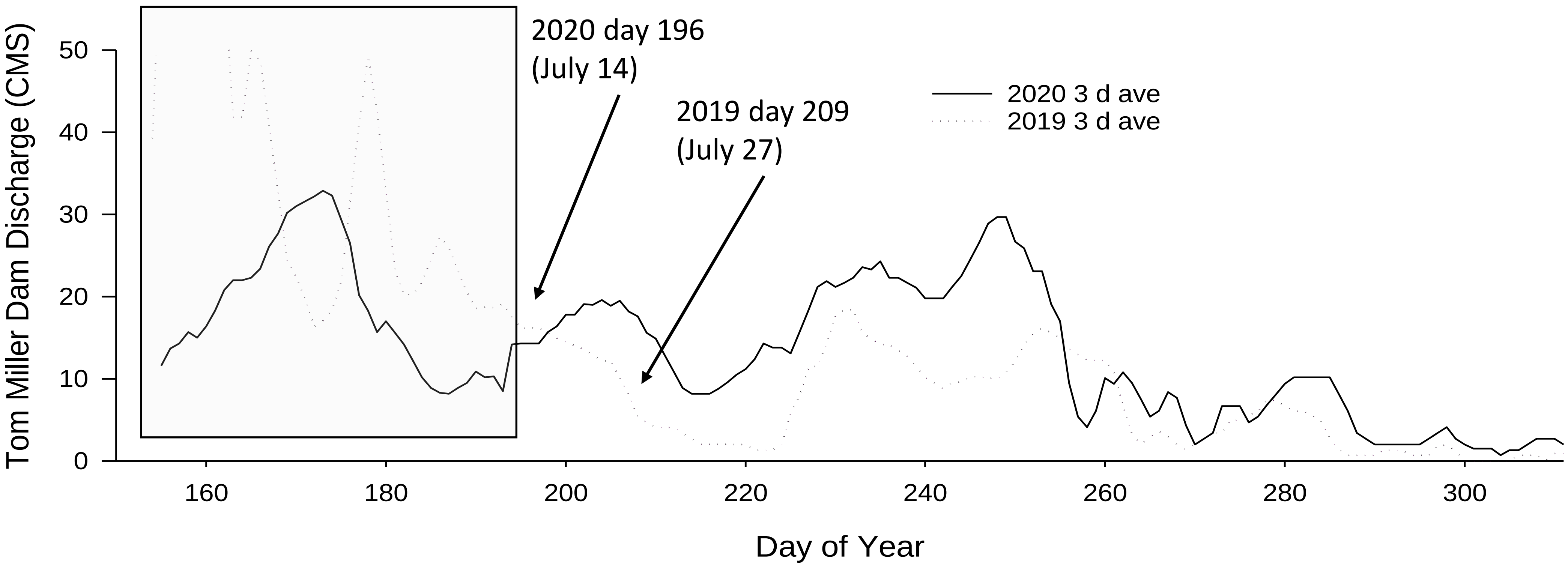
Discharge

- First toxin hit on 7/14/2020 following decline in daily average discharges
- Last mat sample collected 11/10/2020



2019 vs. 2020

- Lower June and early July discharges in 2020 than 2019
- Earlier toxin detection in 2020 then first reported dog fatality in 2019



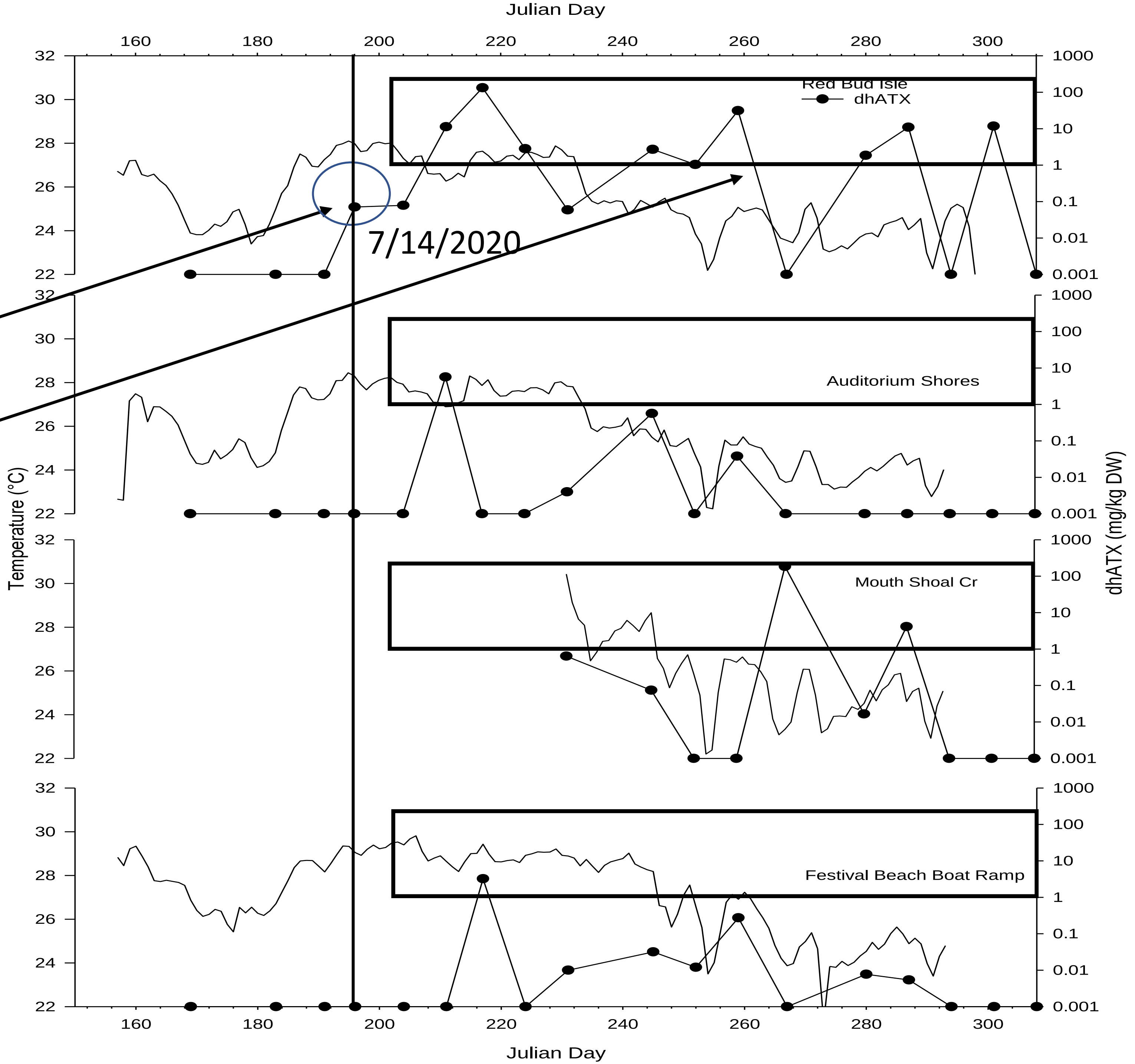
Temperature

- All sites have daily ave. temps > 27°C in July
- Festival Ramp with highest temps being furthest from large inputs

	June	July	August	September	October
Red Bud	25.1 ± 1.3	27.2 ± 0.9	26.6 ± 1.1	24.3 ± 1.0	22.8 ± 2.4
Auditorium Shores	25.5 ± 1.2	27.5 ± 0.8	27.1 ± 1.0	24.5 ± 1.1	22.9 ± 2.2
Shoal Creek			27.9 ± 1.4	25.3 ± 2.0	23.2 ± 3.4
Festival Ramp	27.2 ± 1.4	28.8 ± 1.2	28.8 ± 1.2	25.6 ± 1.9	23.7 ± 2.0

Temporal Temps

- Red Bud:
  - First site toxins detected
  - Most frequent detections
  - Highest contents
- Toxic mats persisted even after water temps declined below 25°C



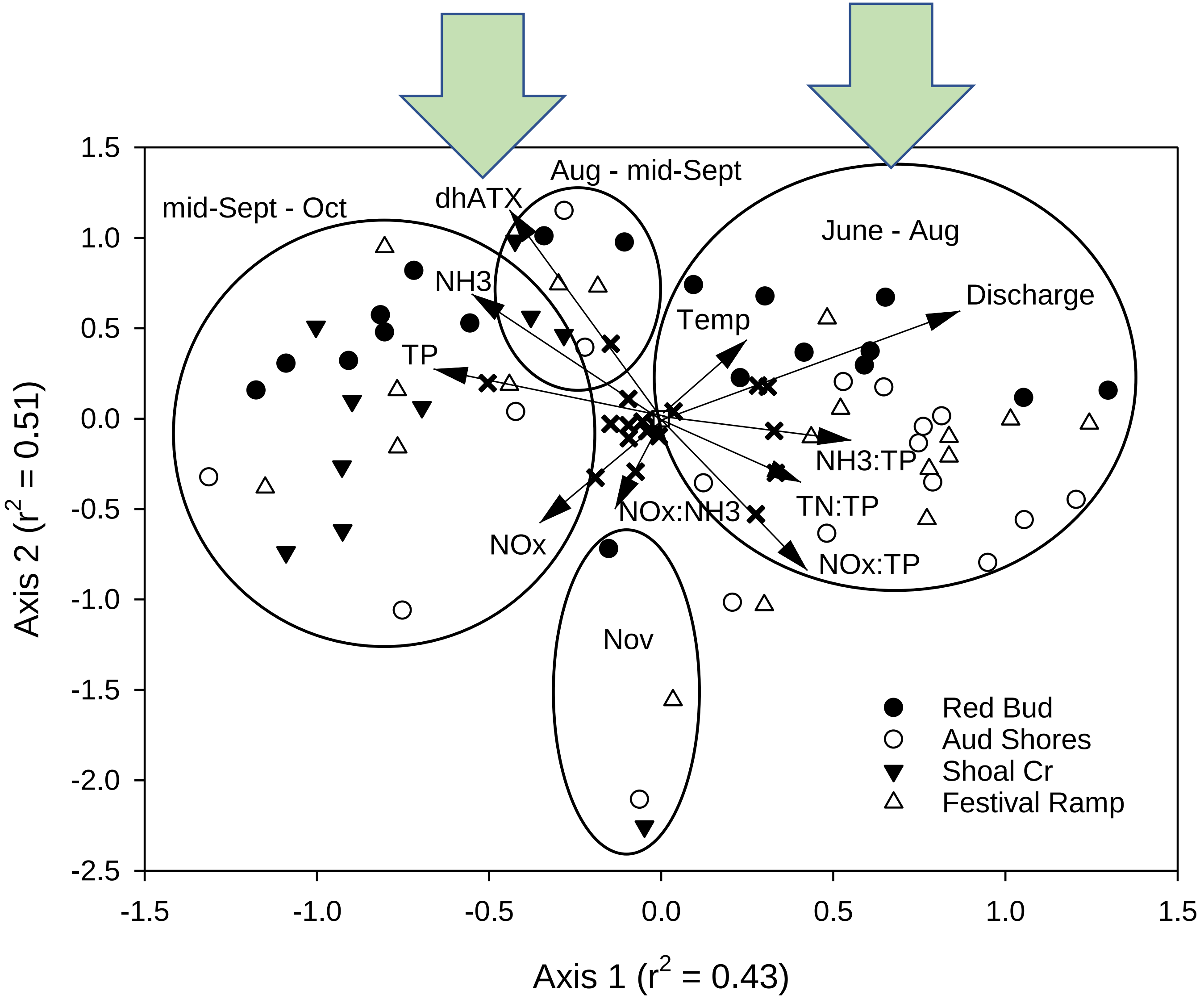
Nutrients

- Red Bud highest ammonia, lowest nitrate, 2nd lowest TN:TP
- Shoal Creek also elevated nutrients, low TN:TP

Site	NH_3-N (µg/L)	NO_3^--N (µg/L)	TN (µg/L)	TP (µg/L)	TN:TP
Red Bud	53.3 ± 35.4	124.7 ± 126.8	544.8 ± 171.1	19.8 ± 14.3	91.3 ± 52.1
Barton Creek	26.3 ± 28.6	1,135.9 ± 457.9	1,538.1 ± 224.9	31.2 ± 34.9	229.3 ± 167.8
Auditorium Shores	29.4 ± 11.3	230.7 ± 120.8	688.5 ± 185.8	15.5 ± 12.5	140.6 ± 67.2
Mouth Shoal Creek	46.7 ± 21.9	383.8 ± 336.5	963.8 ± 400.8	49.1 ± 52.1	85.9 ± 84.4
Festival Ramp	33.4 ± 30.9	160.0 ± 76.9	630.9 ± 135.8	15.7 ± 11.3	127.5 ± 65.2

Put all that data together!

- Non-metric multidimensional scaling
  - Ordination technique based on site data dissimilarity
  - Closer together = more similar
- Sampling events tended to cluster by month
- June through July → warmer waters, but higher discharges, lower TP, lower dhATX
- Aug through Sept → TP, NH_3, and dhATX were highest, flows lowest



Summarizing Last Two Years

- The 2020 bloom extent appeared to be longer than in 2019
  - But 2019 bloom “start” based on reported dog illness, not empirical observation

- Toxin contents in 2020 appeared to be greater than in 2019, notably at Red Bud Isle

- However, visually, surface extent of the mats was lower than observed in 2019
  - Same-day average discharges a bit higher in 2020 than 2019, possible influence on reduced biomass?

Poll Question #5

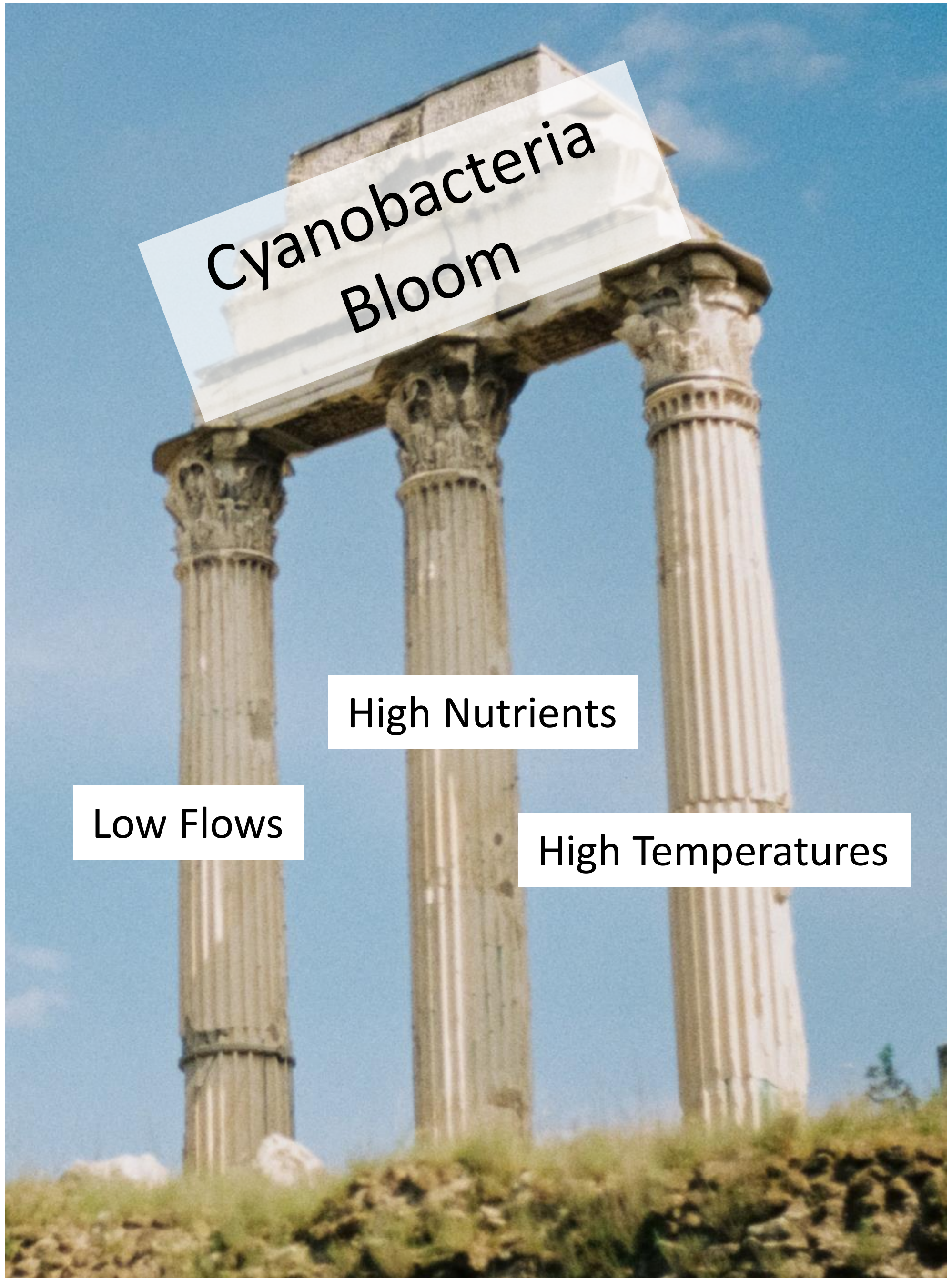
Which of the 3 Pillars is *Probably* the Most Important?

A. Cedar Fever

B. High Nutrients

C. Low Flows

D. High Temperatures



What Caused the Apparent Change in Lady Bird?

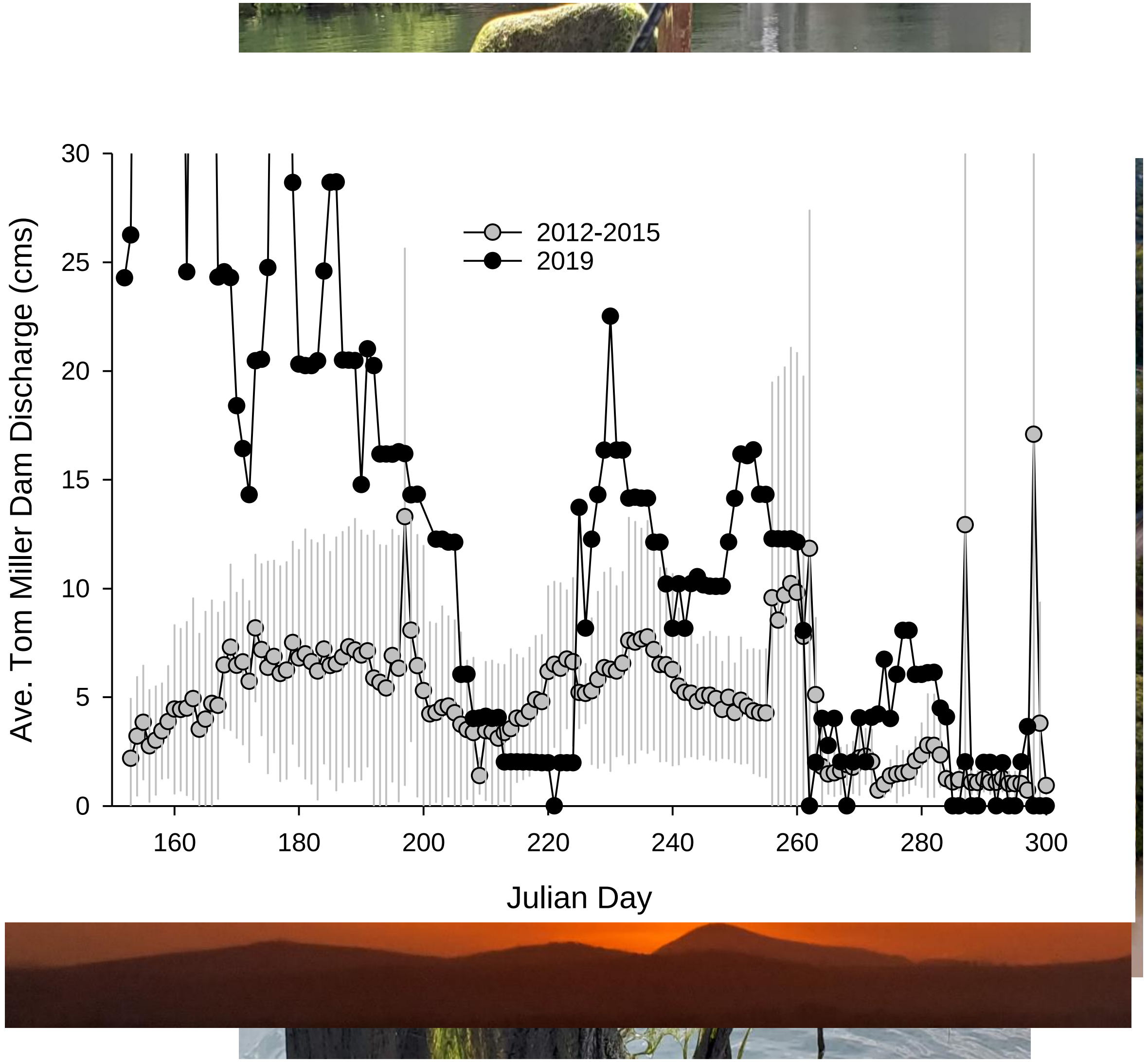
- Among the drivers, Austin is always hot in the summer, flows are always (relatively) low in July/August

- So, it must be the *Nutrients!*
  - But not just the concentration (which were elevated) but also types; i.e., more NH_3 and Phosphorus which cyanobacteria really like

- How or Why do you have more of those nutrients in Lady Bird Lake now?

A changed and Changing System

- Zebra mussels (new)
  - Alter water chemistry (notably NH_3 and Phosphorus)
  - Promote dense benthic growth
- Large flooding, runoff, depositional event (Fall 2018) (new)
  - Altered sediment and water chemistry?
- Climate change (new)
- Dog waste (old)
- Low flows (old)
  - But now coupled with new drivers!



Next Steps

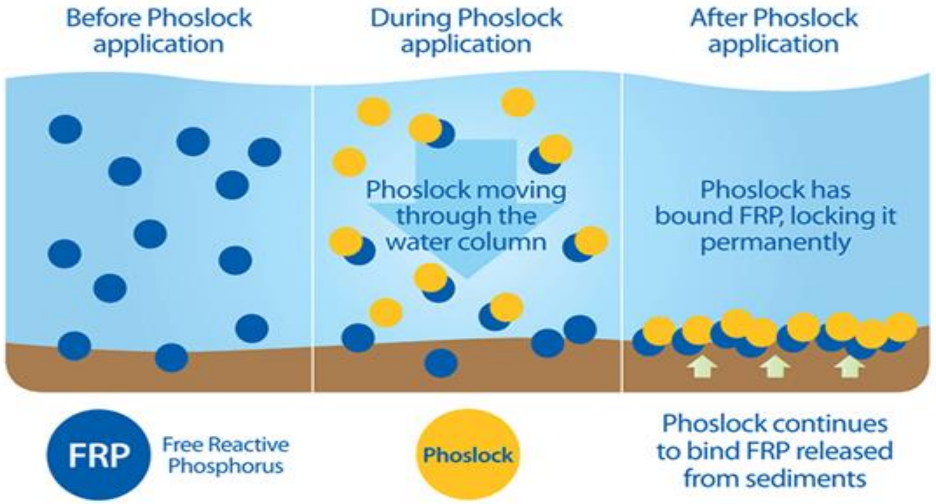
- “HABs cannot easily be eliminated or prevented, but they can be monitored and predicted, and the potentially negative consequences can be managed and mitigated. Changes in human activities and behaviour could also contribute to prevent or minimize certain HABS and their deleterious effects.” Kudela et al. (2015) IOC/UNESCO Report

- Need to know why a bloom is occurring, when, and what is causing it – then can try and control it

Models being developed based on data collected in 2020

Treatment options are also going to be tested this summer to “starve” cyanobacteria of Phosphorus:

- “Phoslock” – lanthanum-modified bentonite
- Biochar



Unclear how effective any of these treatments would be in reservoir (typically applied to ponds and where inflows can be managed)

What About Lake Austin?

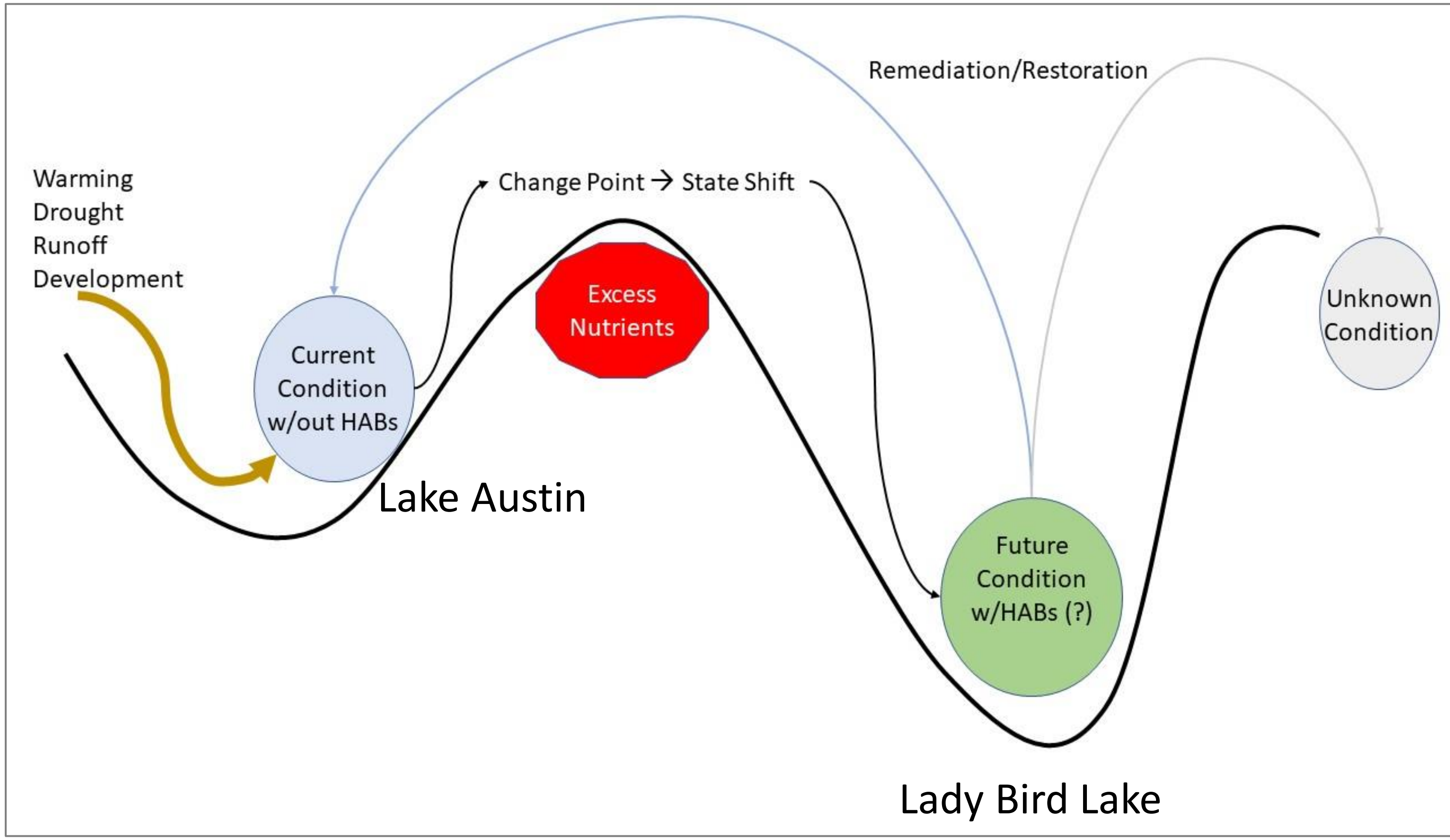
- No Toxic events *YET*

  Best Option – PREVENTION

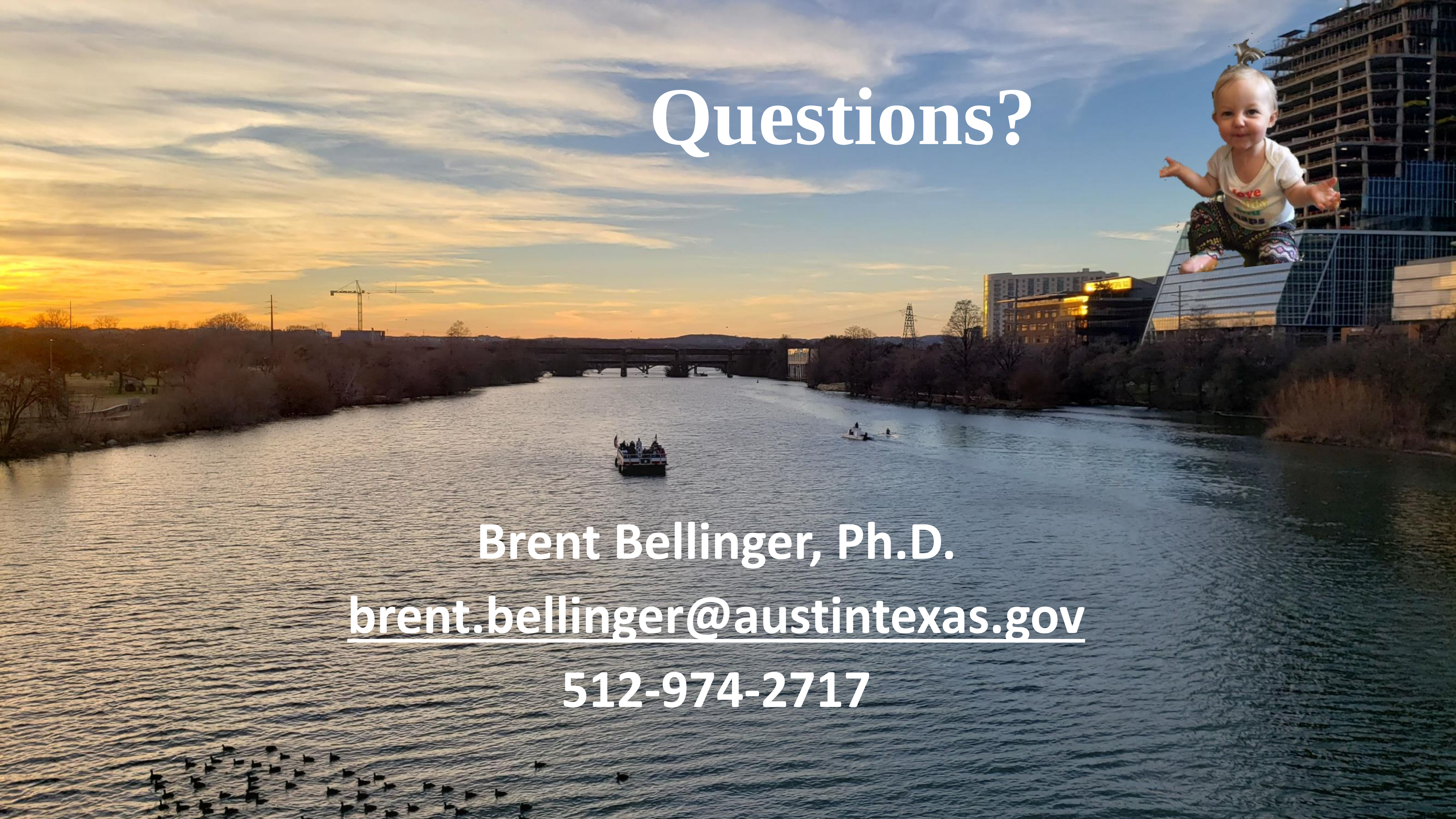
<u>Nutrient Management</u>

- Keep nutrient loading and concentrations in the reservoir low
- Still time for Lake Austin; task will be more difficult for Lady Bird due to hysteresis

Need to prevent Lake Austin from "tipping over the edge"



"Alternative Stable State" Theory



Questions?

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