Basic Ecological Information on Harmful Algal Blooms in New Jersey.

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Rowan College, Mt. Laurel, New Jersey

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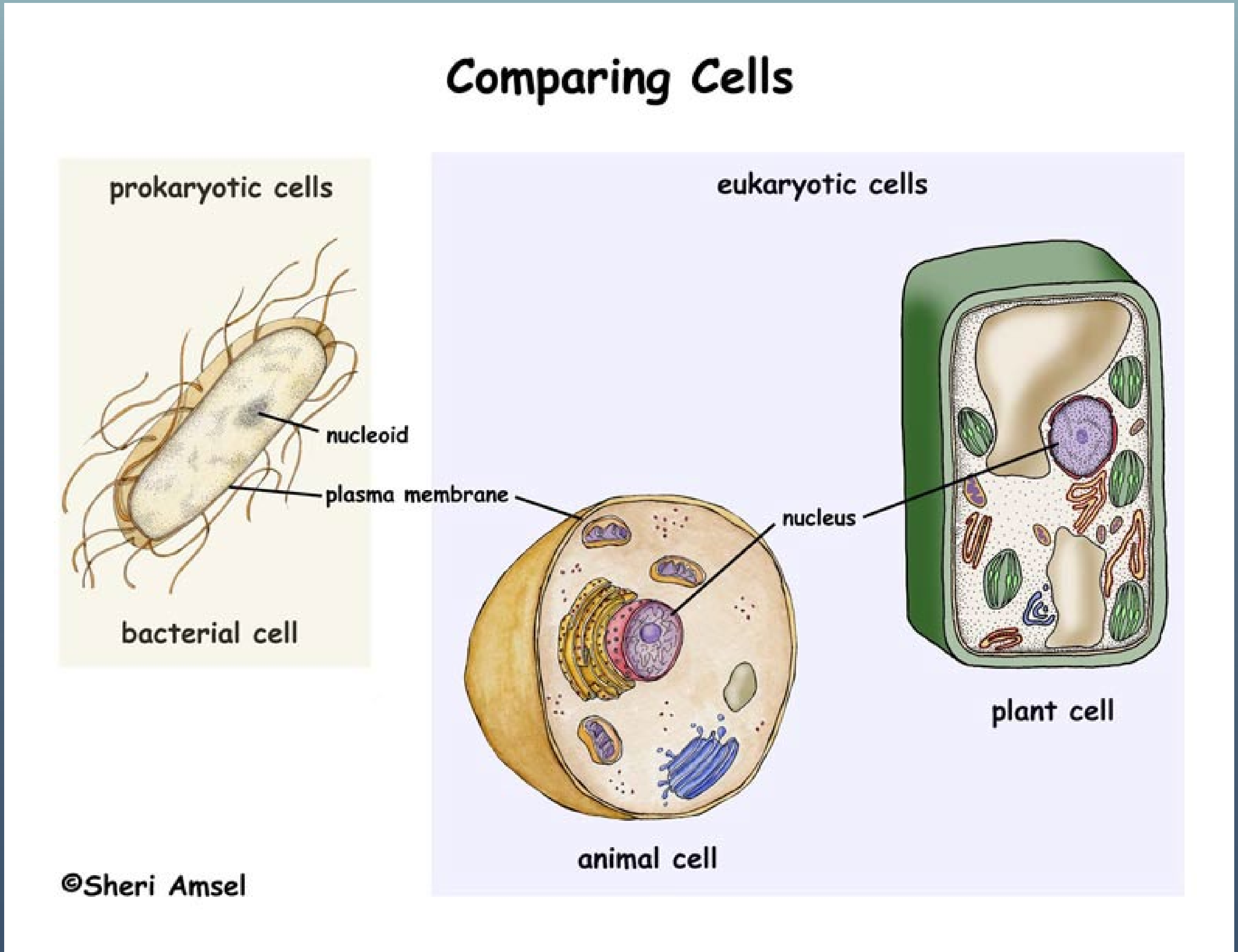
The term "Algae"

- ✓ More of an ecological term than a taxonomic one since algae include both eukaryotes and prokaryotes (blue-green algae, also known as cyanobacteria).
- ✓ Most algae provide valuable ecosystem services.
- ✓ Base of the food web; primary productivity.
- ✓ Contribute toward oxygenating the water.
- ✓ Sequester carbon.
- ✓ May be a source of biofuel and have some pharmacological values.
- ✓ However, some algae can be problematic.



Comparing Cells
prokaryotic cells
eukaryotic cells
nucleoid
plasma membrane
nucleus
bacterial cell
plant cell
animal cell
©Sheri Amsel

Eukaryotes

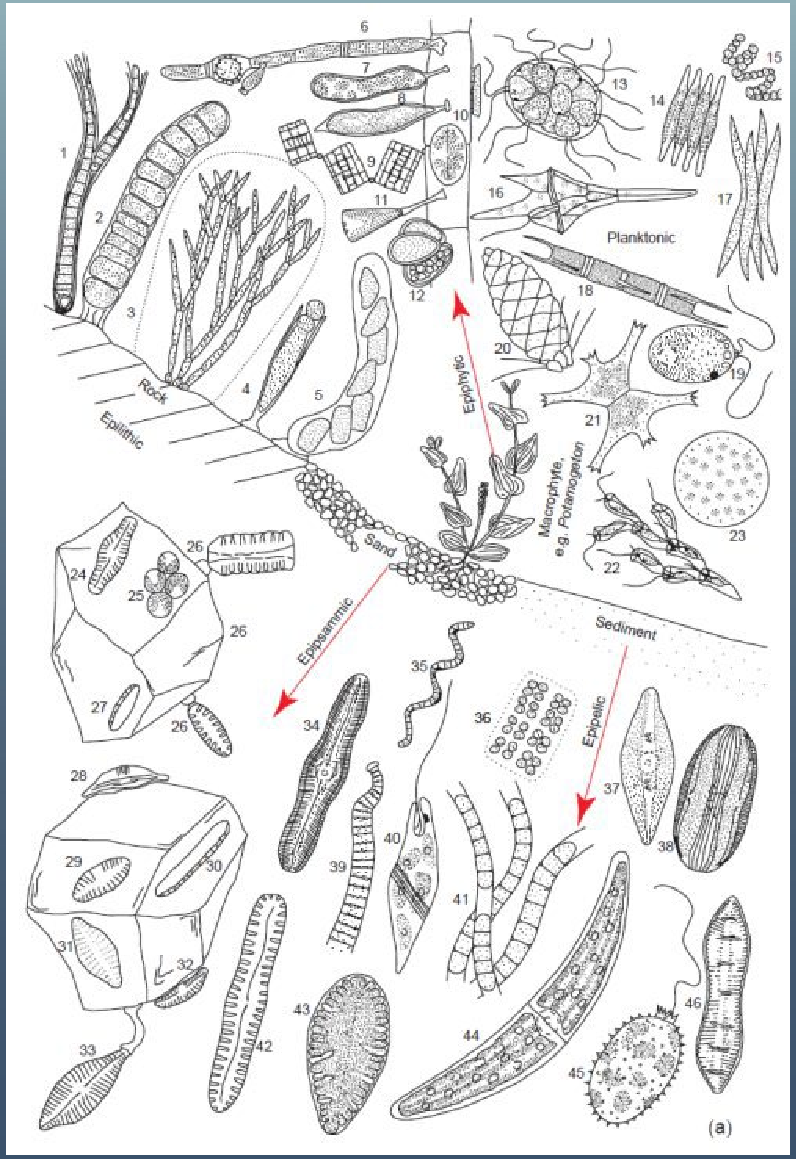
Prokaryotes

Anabaena (blue-green alga) Bloom

Euglena Bloom

Algal groups

Green algae
Chrysophytes
Diatoms
Dinoflagellates
Euglenoids
Cyanobacteria
Others



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Phytoplankton

- ✓ Phytoplankton are essentially, “free floating” algae.
- ✓ There are approximately 5,000 known species of phytoplankton.
- ✓ Of those, about 300 species (6%) are known to form Harmful Algal Blooms (HABs).
- ✓ About 80 of those species are known to be toxin producers.

Harmful Algae Blooms (HABs)

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Impacts of Marine HABs

- ✓ Algal Toxins - Health impacts on human and animal health. Neurological impairment, gastrointestinal distress, respiratory irritation; even severe illness and death.
- ✓ Deaths tend to be associated with eating shellfish and/or fish contaminated with marine algal toxins.
- ✓ Fish kills but other animals (birds, sea turtles, mammals) have been attributed to these toxins.
- ✓ Shading out desirable seagrasses, depletion of dissolved oxygen (DO).
- ✓ Aesthetic, recreational and economic impacts.

Red Tide (dinoflagellates)

- ✓ *Dinophysis*
- ✓ *Alexandrium*
- ✓ *Karenia*

Photo Credit: NJDEP

Dinophysis sp: an organism that can produce okadaic acid and dinophysistoxins which are linked to diarrhetic shellfish poisoning (DSP).

Karenia brevis: produces potent nelurotoxins that cause gastrointestinal and neurological problems in other organisms.

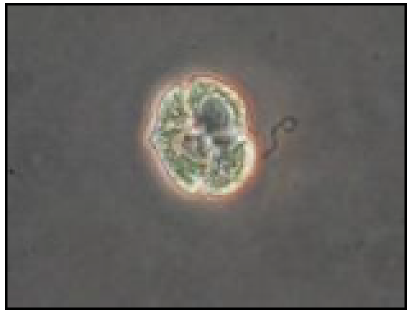


Photo Credit: Mote Marine Laboratory

Photo Credit: David Patterson & Bob Andersen

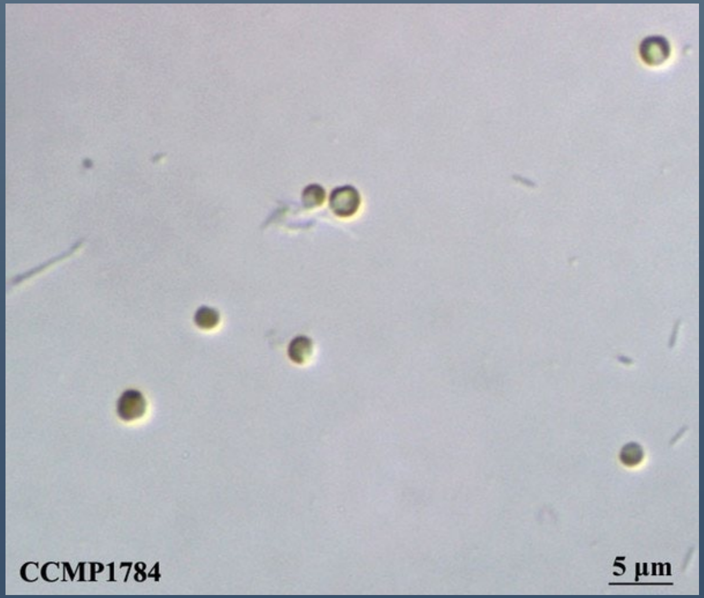
Alexandrium sp.: a saxitoxin producing organism that causes paralytic shellfish poisoning.

Brown Tide (diatoms)

- ✓ *Amphora*
- ✓ *Pseudo-nitzschia*
- ✓ *Nitzschia*
- ✓ *Aureococcus* (a pelagophyte) – very small cells, produces a "mucopolysaccharide" that clogs the gills of filter feeders (photo from www.ncma.bigelow.org)

Pseudontizschia sp: known to produce domoic acid which is the marine biotoxin related to amnesic shellfish poisoning (ASP).

Photo Credit: NJDEP



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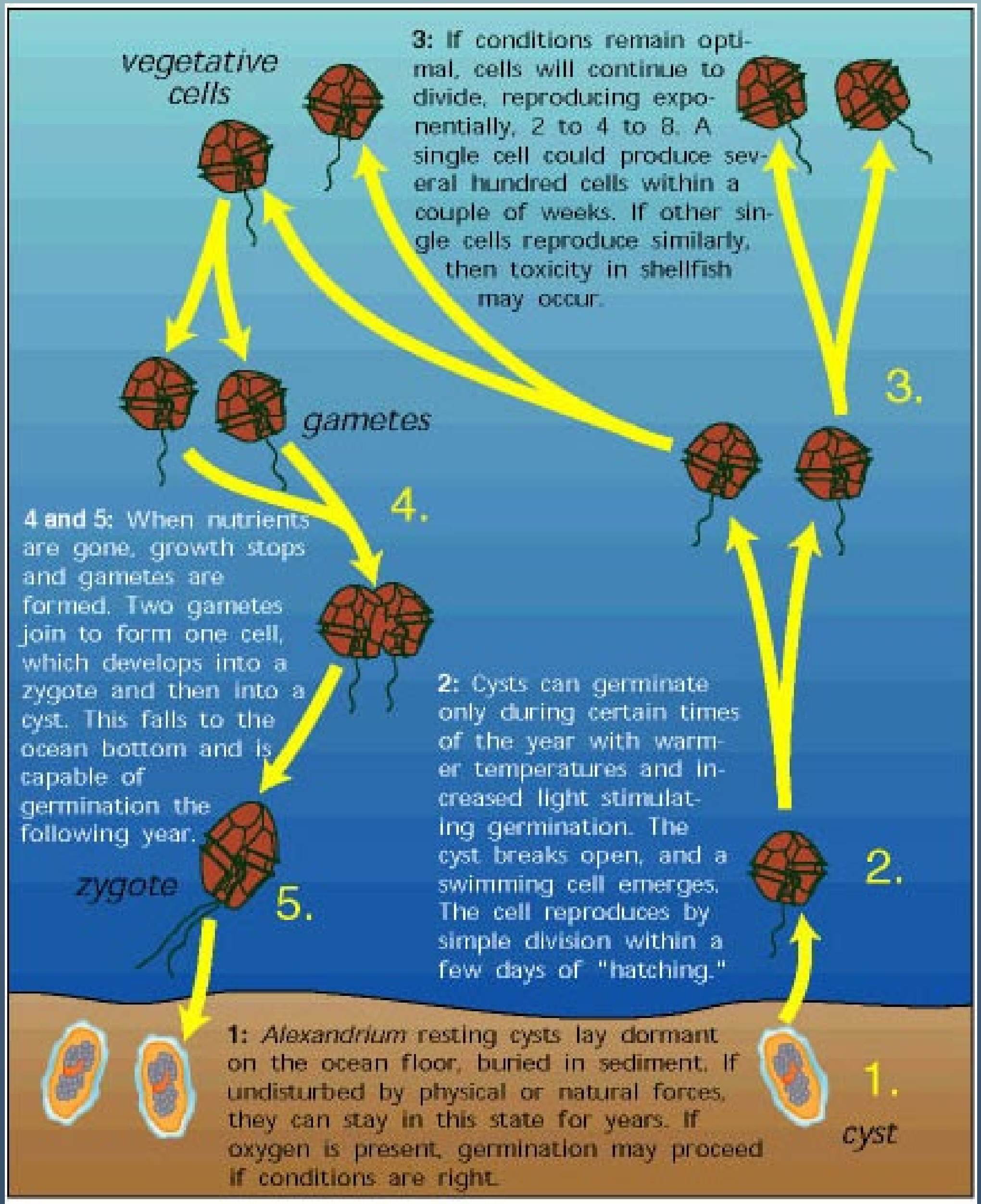
What Triggers a Red / Brown Tide?

- ✓ Increased temperature / light
- ✓ Reduced estuarine flushing rates
- ✓ Mixing of the water
- ✓ Elevated salinities
- ✓ Mild winters / dry springs
- ✓ Inorganic nutrients (for many red / brown tides but not all)
- ✓ Iron and organic nutrients

Simplified life cycle of a dinoflagellate. Credit: Woods Hole Oceanographic Institute / NOAA



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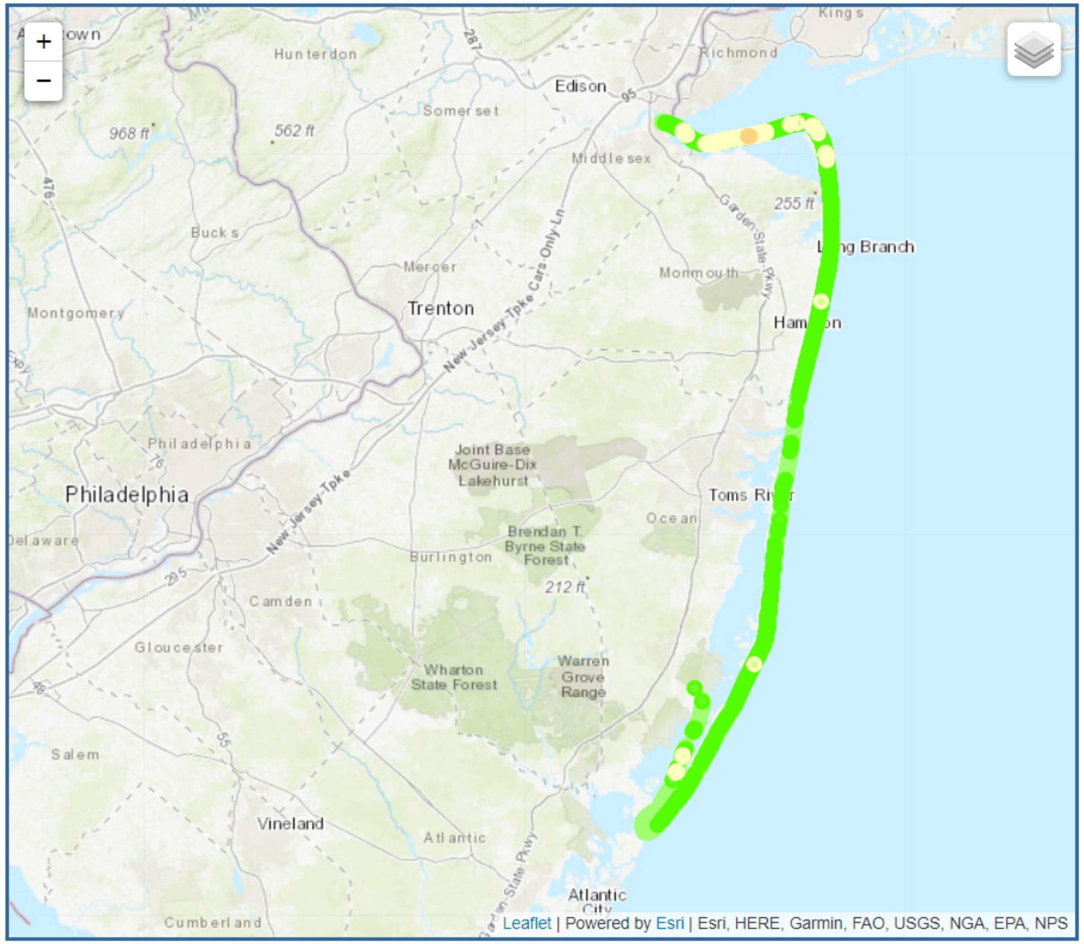
Chlorophyll Remote Sensing

NJDEP's Bureau of Marine Water Monitoring, in cooperation with the NJ Forest Fire Service, Rutgers University and US EPA Region 2, conducts aircraft remote sensing for estimating chlorophyll levels in NJ's coastal waters. Since chlorophyll is a plant pigment, high levels of chlorophyl in the water are typically associated with an algal bloom. To detect potential blooms, the plane flies 6 days a week during the summe months, in favorable weather conditions, over the coastal waters of New Jersey. These flights provide a valuable perspective on wate conditions and trends that enable the Bureau to target boat sampling in locations where algal blooms may be occurring.



Year 2024 **Month** 8 **Day** 27

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Est. Chlorophyll a (ug/L)		
☑		0-3
☑		3-6
☑		6-12
☑		12-24
☑		24-35
☑		35-50
☑		>50

Continuous Monitoring

Marine HAB Monitoring (NJDEP)

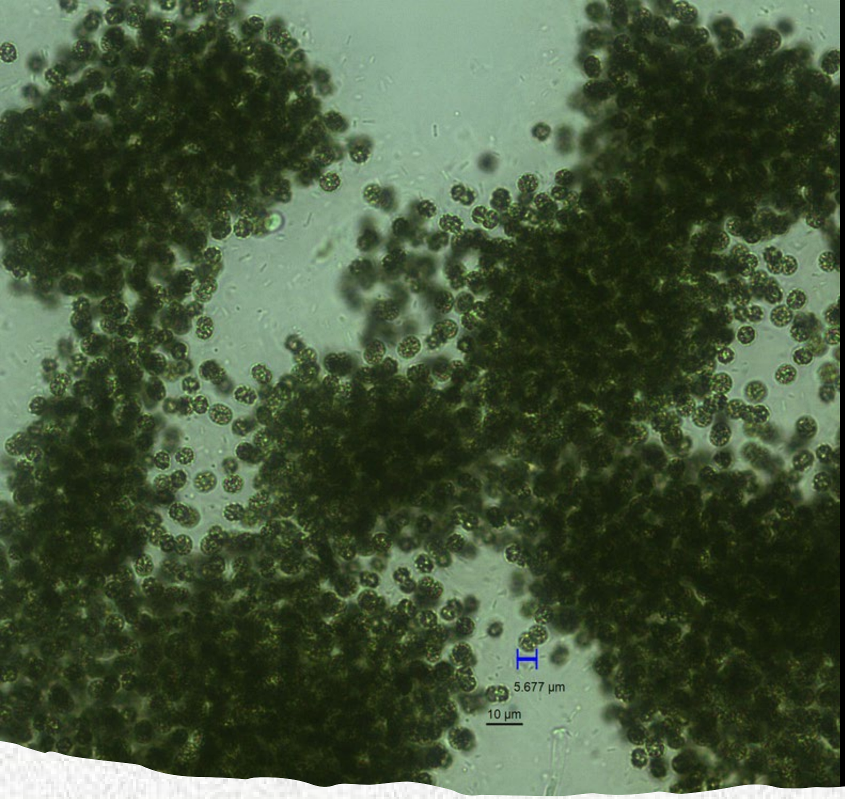
- ✓ Googled: NJDEP and Rutgers university chlorophyll remote sensing.
- ✓ Routine Sampling of 48 marine phytoplankton stations. Sampled between 5 and 10 times per year.
- ✓ Analyzed for chlorophyll-a (all algae possess chlorophyll-a).
- ✓ Identify toxin-producing species / dominate species and conduct cell counts (cells / mLs).

Citizen Scientists / Volunteers

- ✓ Check out the Aircraft Remote Sensing website - NJDEP New Jersey Department of Environmental Protection - Aircraft (rutgers.edu)
- ✓ Visual observations (photos, color, turbidity, etc.)
- ✓ Measure chlorophyll-a with a meter
- ✓ Measure water clarity with a Secchi disk
- ✓ Report an environmental incident / situation to NJDEP (1-877-WARNDEP)

Impacts of Freshwater HABs

- ✓ Cyanotoxins - Health impacts on human and animal health. Neurological impairment, gastrointestinal distress, respiratory irritation; even severe illness and death.
- ✓ Direct impact on the quality of potable water supplies.
- ✓ Deaths tend to be associated pets.
- ✓ Direct health impacts on livestock and wildlife as well.
- ✓ Shading out desirable submerged aquatic vegetation, depletion of dissolved oxygen (DO).
- ✓ Aesthetic, recreational and economic impacts.

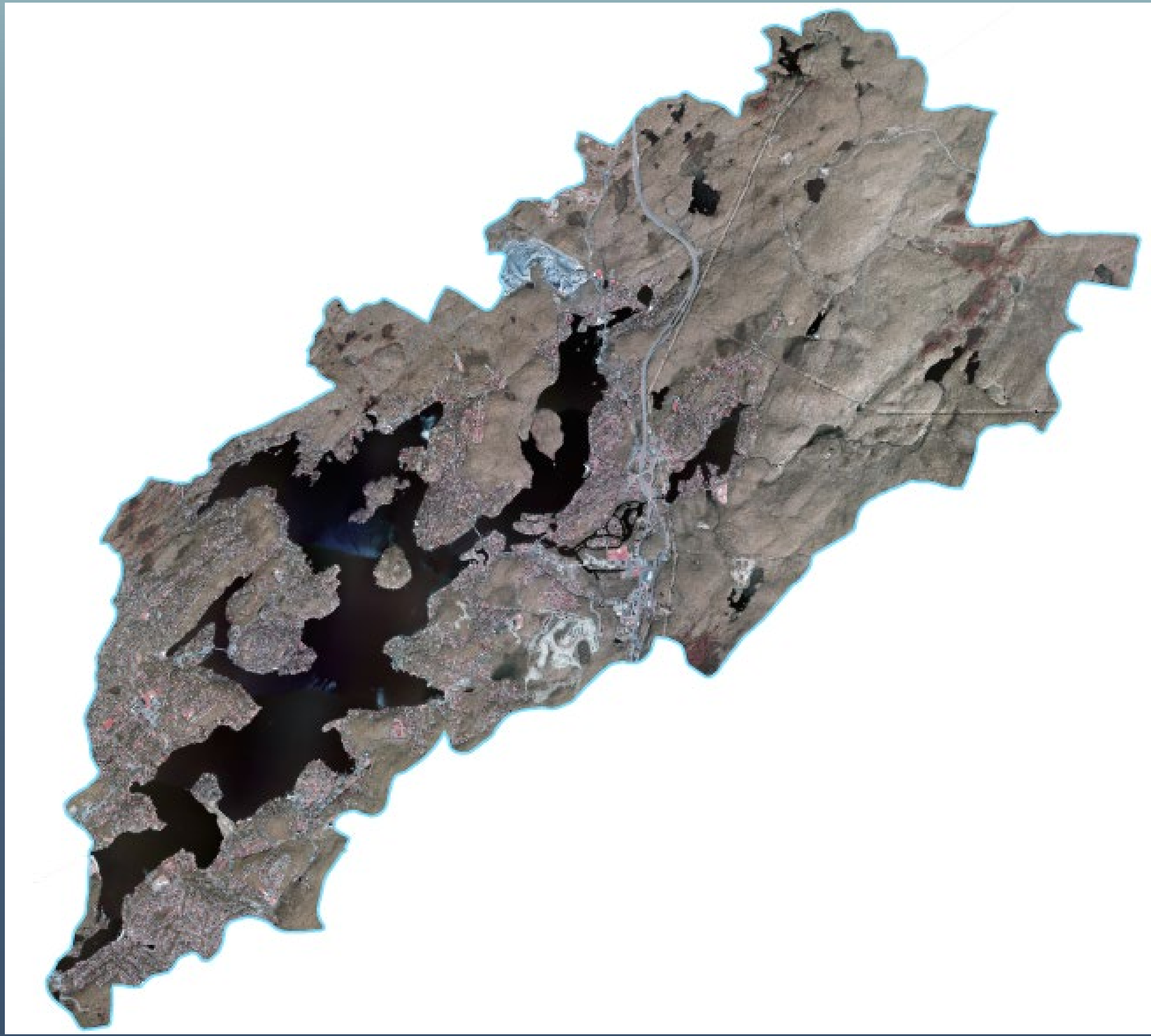


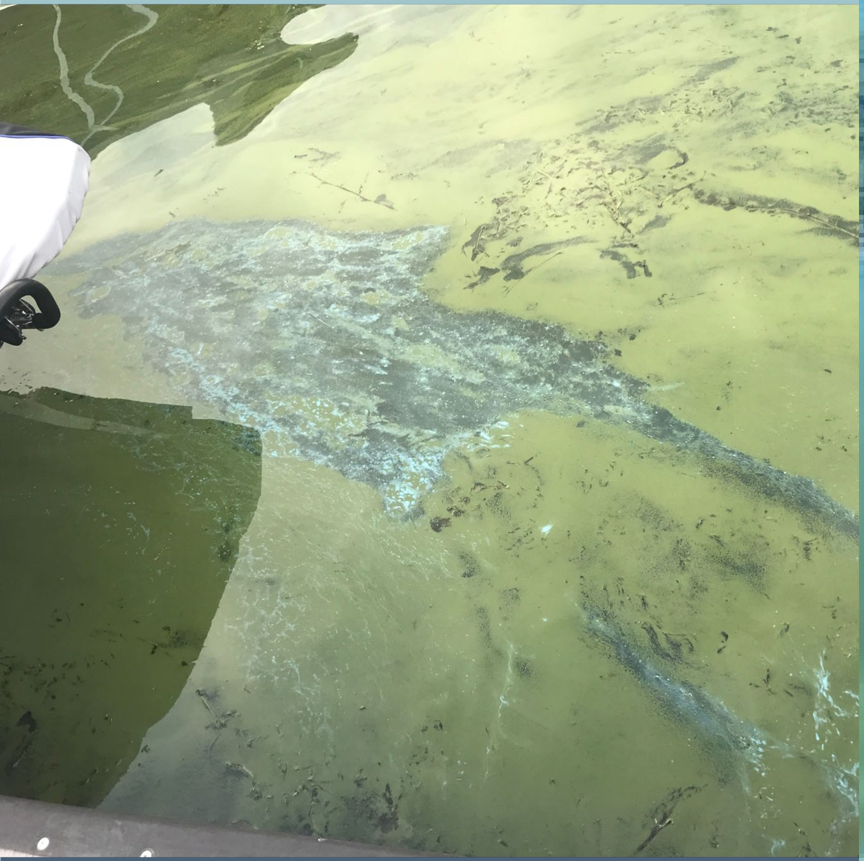
Cyanobacteria

- *Microcystis*
- *Dolichospermum (Anabaena)*
- *Aphanizomenon*

Lake Hopatcong, Morris and Sussex Counties, NJ

- ✓ Largest lake in New Jersey (2,686 acres; 1,087 ha).
- ✓ Five municipalities in watershed (13,548 acres; 5,482.7 ha).
- ✓ More than 500,000 people visit the lake or live in the watershed.





Blooms at Lake Hopatcong, New Jersey (June 2019)

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element

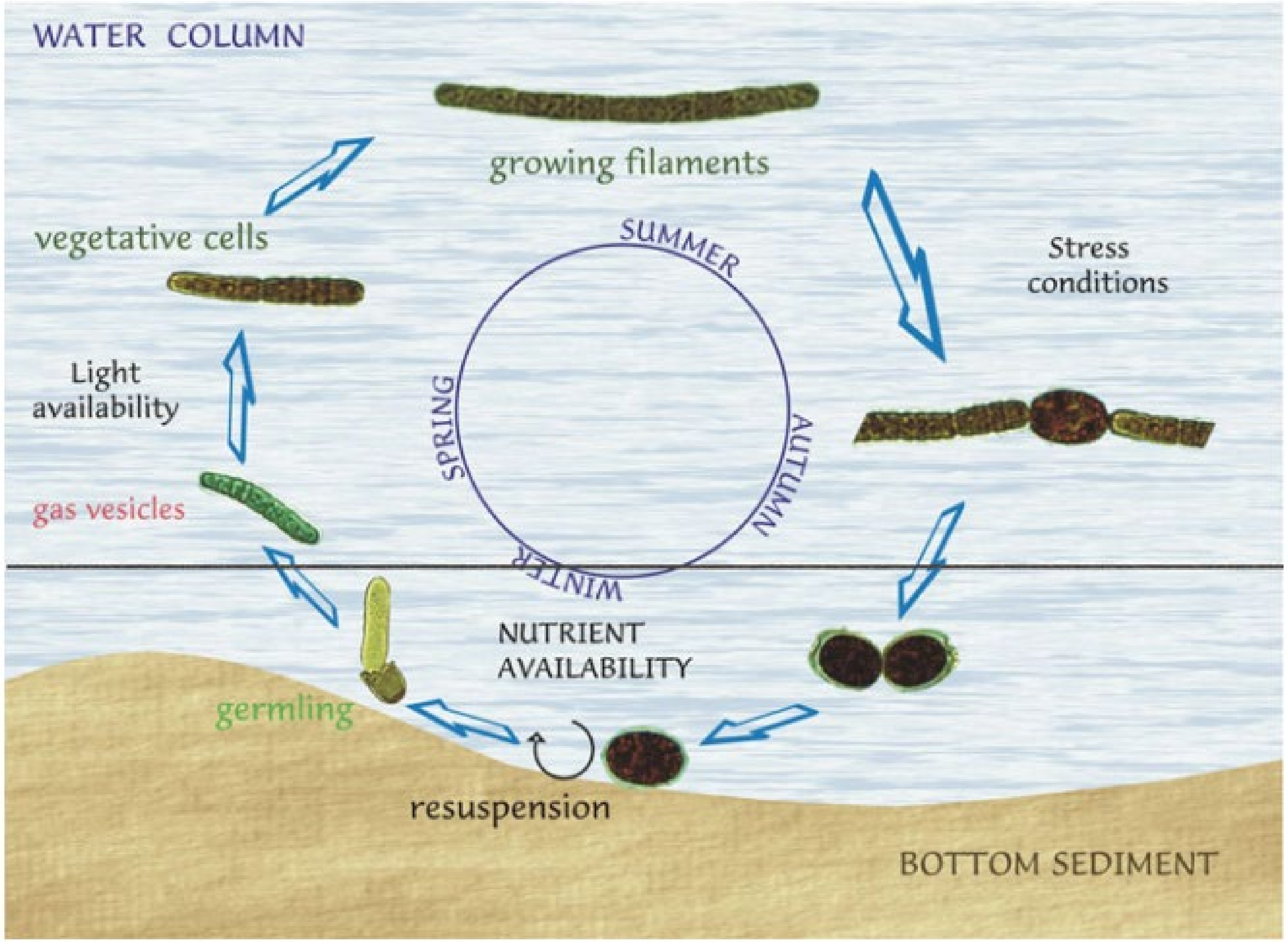
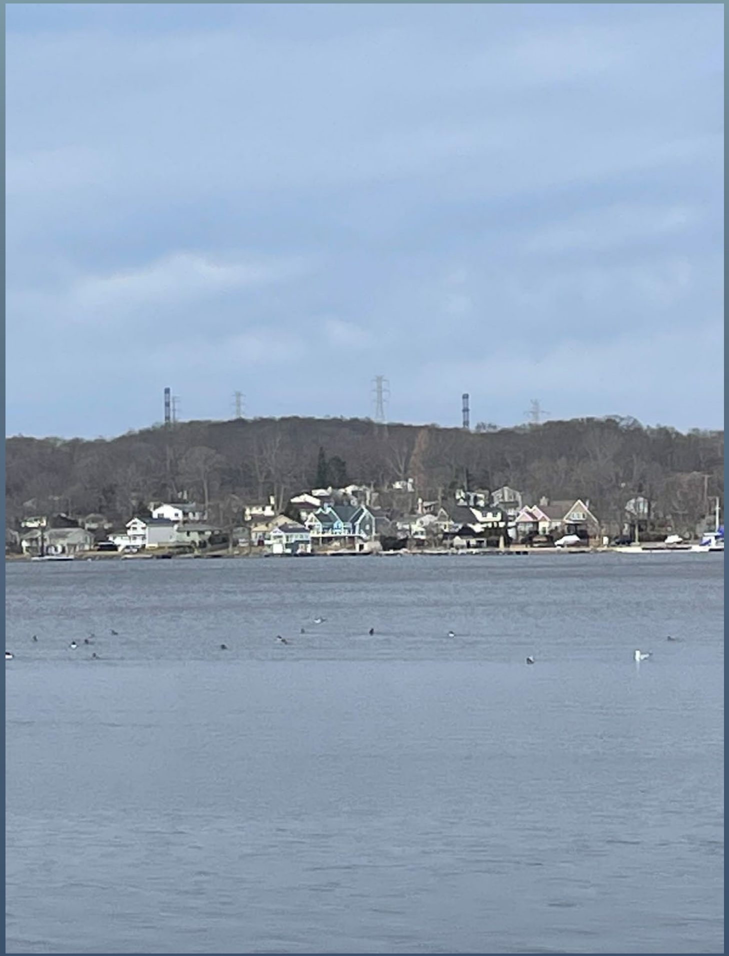


Fig. 2.1 Life cycle of the cyanobacterium *Aphanizomenon ovalisporum* (Nostocales). Adopted from Hense and Beckmann (2006)

What Triggers a CyanoHAB?

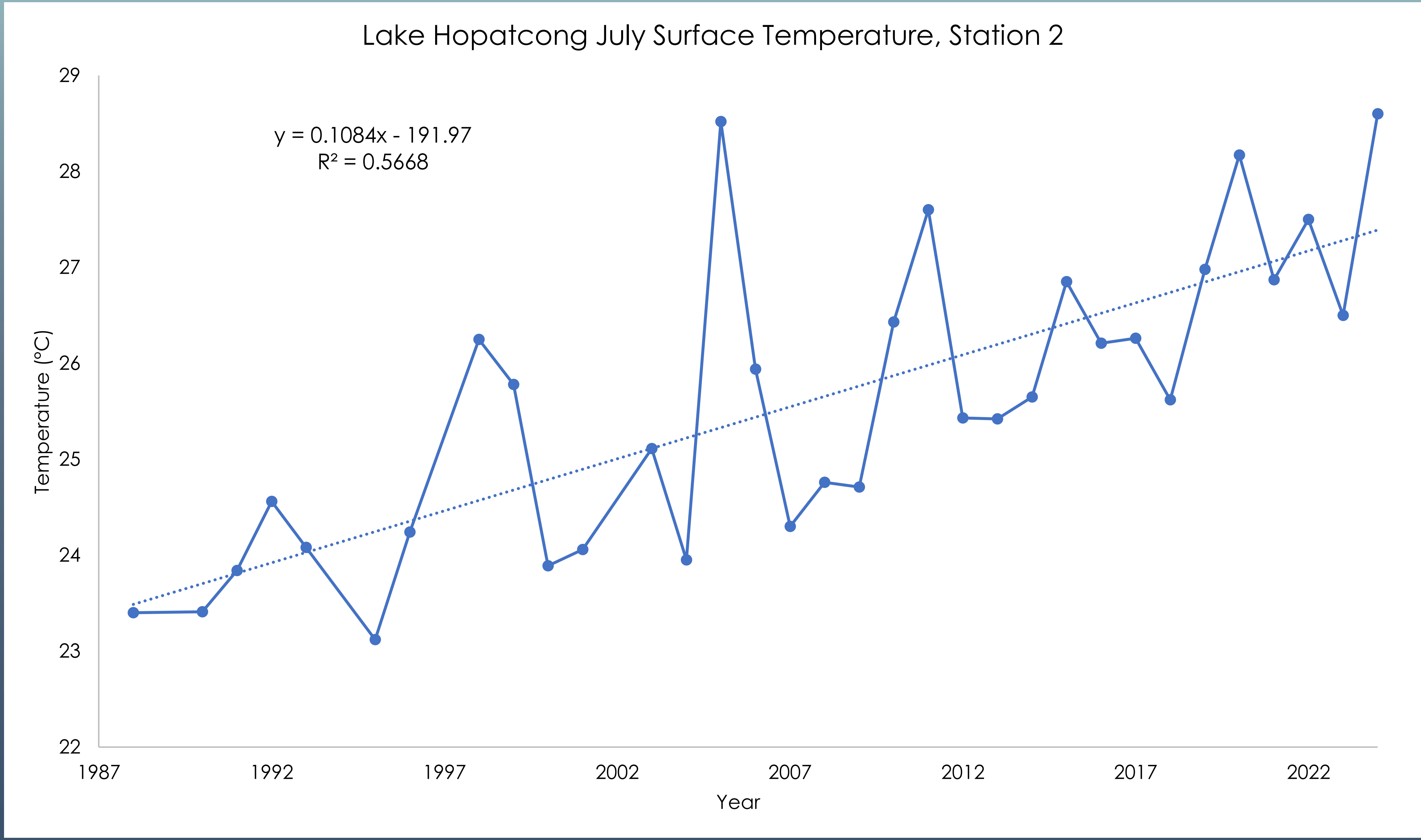
- ✓ Increased temperatures
- ✓ Lower flushing rates
- ✓ Increased stabilization / thermal stratification
- ✓ Increased phosphorus availability (increase in algal biomass)
- ✓ Increased availability of inorganic nitrogen (will trigger the production of cyanotoxins such as microcystins)

Lake Hopatcong – Early 2023



- Further to the left was taken on 11th January 2023
- Photos on right was taken 19th February 2023 (just starting to get a thin layer of ice as of 26th February 2023)


Lake Hopatcong – 27th February 2024


Lake Hopatcong July Surface Temperature, Station 2
y = 0.1084x - 191.97
R² = 0.5668
Temperature (°C)
29
28
27
26
25
24
23
22
1987
1992
1997
2002
2007
2012
2017
2022
Year

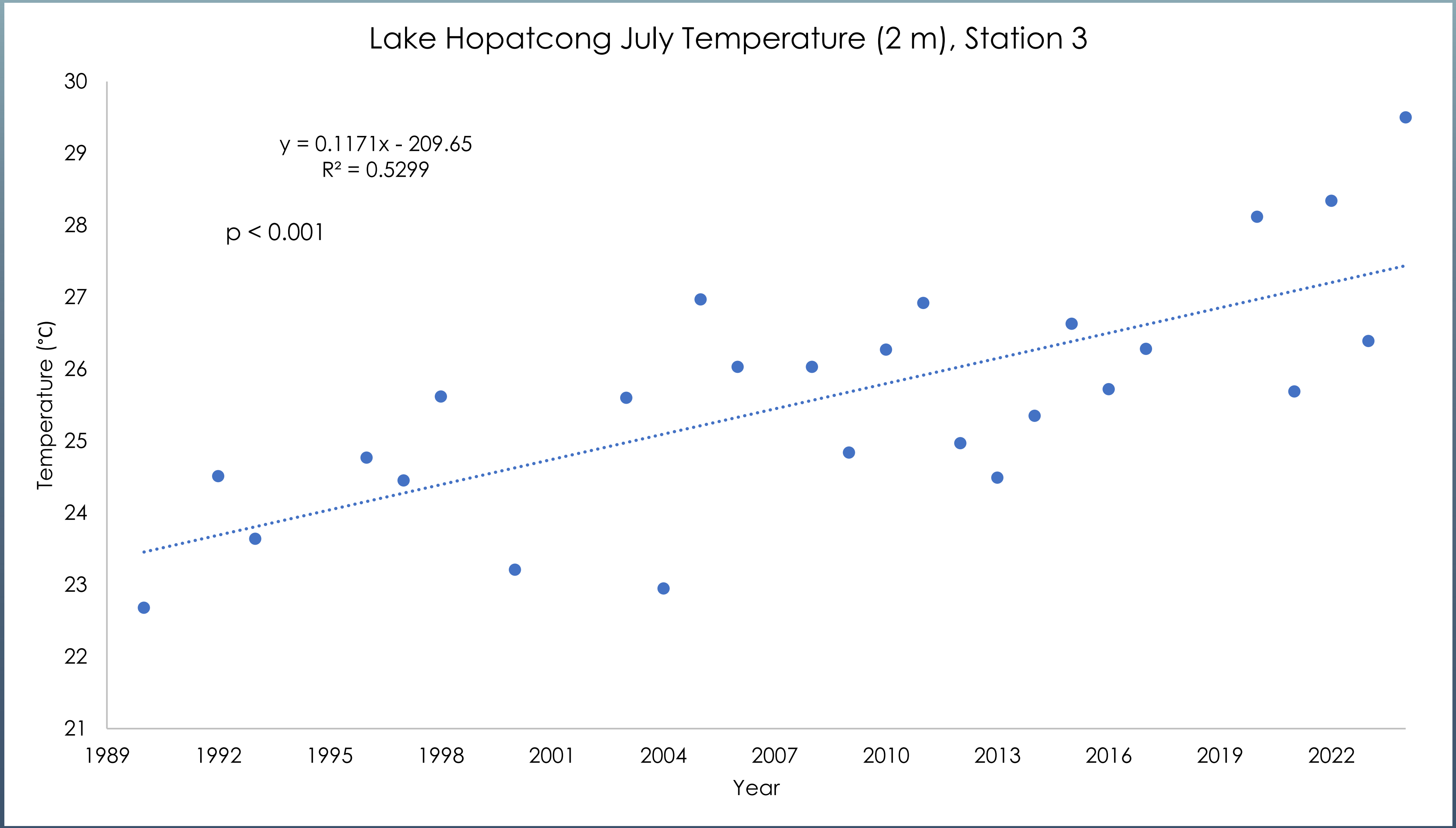


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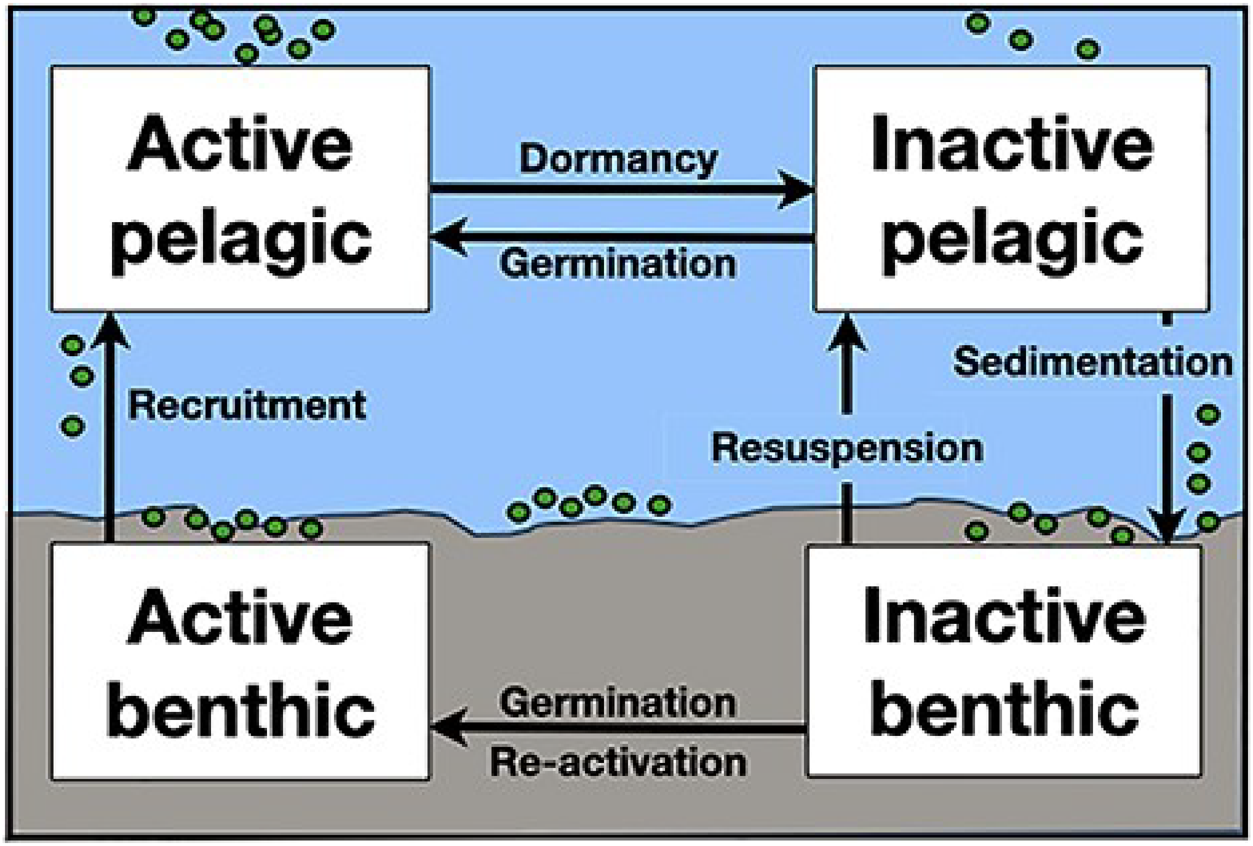
Fig. 1 Schematic for a generalized cyanobacterial life cycle; details vary among taxa.



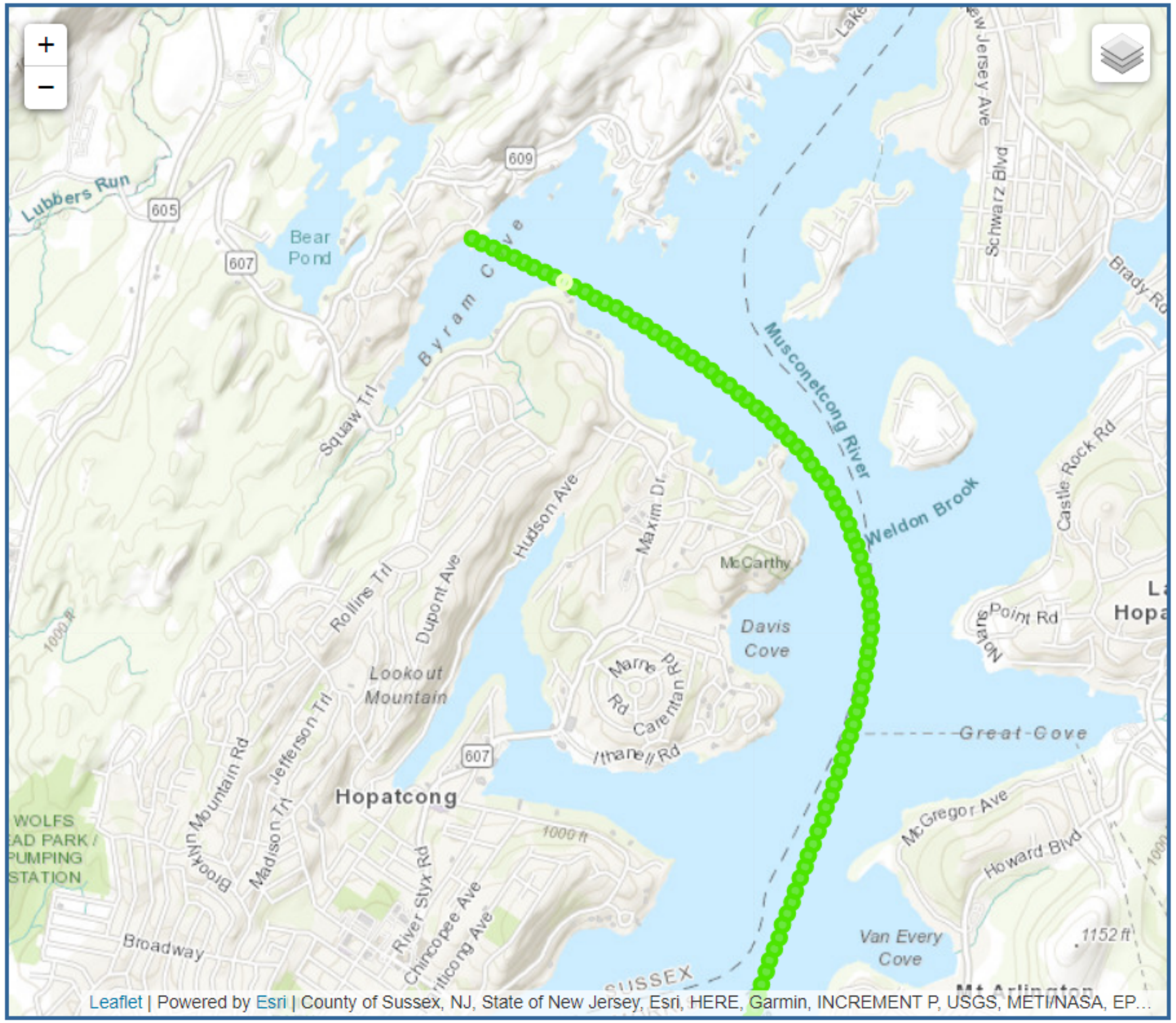
J Plankton Res, Volume 43, Issue 1, January/February 2021, Pages 10–19, https://doi.org/10.1093/plankt/fbaa059

Volunteer / Citizen Monitoring for Cyanobacteria

- ✓ Check out the Aircraft Remote Sensing website - NJDEP New Jersey Department of Environmental Protection - Algal Bloom Remote Sensing (rutgers.edu)
- ✓ Visual observations (photos, color, turbidity, etc.)
- ✓ Measure chlorophyll-a and **phycocyanin** with a meter
- ✓ Conducting cell counts (cells / mLs)
- ✓ Measure water clarity with a Secchi disk
- ✓ Report an environmental incident / situation to NJDEP (1-877-WARNDEP)

Algal Bloom Remote Sensing

NJDEP's Water Monitoring, Standards and Pesticide Control (WMSPC), in cooperation with the NJ Forest Fire Service and Rutgers University conduct aircraft remote sensing using phycocyanin measurements for estimating the presence of cyanobacteria Harmful Algal Blooms (HABs in select NJ lakes. Phycocyanin measurements are used to estimate the cell density and the spatial extent of cyanobacteria. This informatio is used by WMSPC to strategically deploy staff to collect HAB samples for laboratory analysis. Laboratory analysis of cell density, species an cyanotoxins are used to confirm the presence of HABs and to determine if a recreational Alert level is triggered. To detect potential bloom and assess the status of previously confirmed HABs, the plane flies one day a week (generally on Tuesday) or as needed over lakes with known history of HABs. Other lakes may be considered and added, however the flight path and phycocyanin sensor resolution is limited t larger lakes. Other screening and status monitoring is performed on smaller lakes via on-site surveys. The overall goal is to inform respons actions for public health and safety of NJ residents. To learn more about cyanobacteria and the potential threat to health they may cause, visi DEP's HAB Page. Alert Postings and laboratory analysis results can be found on the HAB Interactive Map.



Year Month Day

2024 9 10

Download

Estimated Cells per ml		
☑	0 - 10,000	
☑	10,000 - 20,000	
☑	20,000 - 40,000	
☑	40,000 - 60,000	
☑	60,000 - 80,000	
☑	80,000 - 100,000	
☑	> 100,000	

Continuous Monitoring

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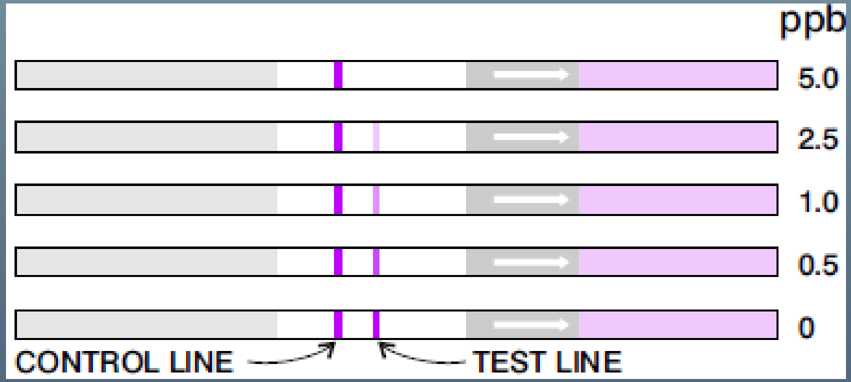
General Observations

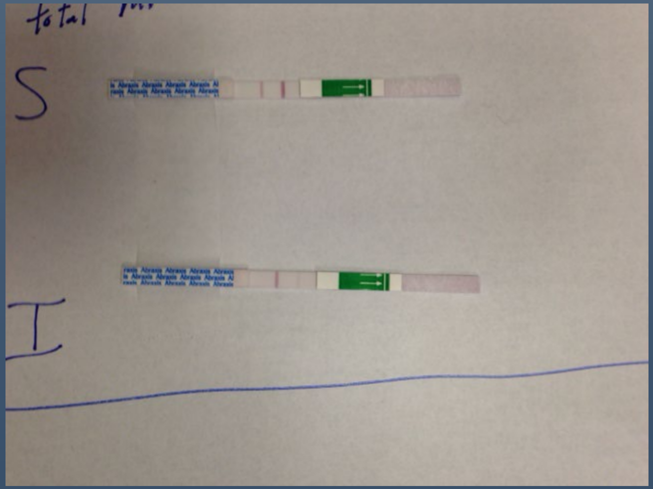
- ✓ Changes in plant operations (decline in filter runs, increase product use, increase in pH)
- ✓ Color / turbidity of water
- ✓ Surface scums / mat algae
- ✓ Tastes or odors
- ✓ Decline in water clarity

Cyanotoxins are NOT Taste and Odor Compounds

- ✓ Cyanotoxins are colorless, tasteless and odorless compounds
- ✓ Taste and odor (T&O) compounds such as Geosmin and MIB can be produced by cyanobacteria (blue-green algae) and some actinobacteria
- ✓ Cyanobacteria can produce T&O compounds and not produce cyanotoxins
- ✓ They can also produce cyanotoxins and no T&O compounds

Field Testing for Cyanotoxins





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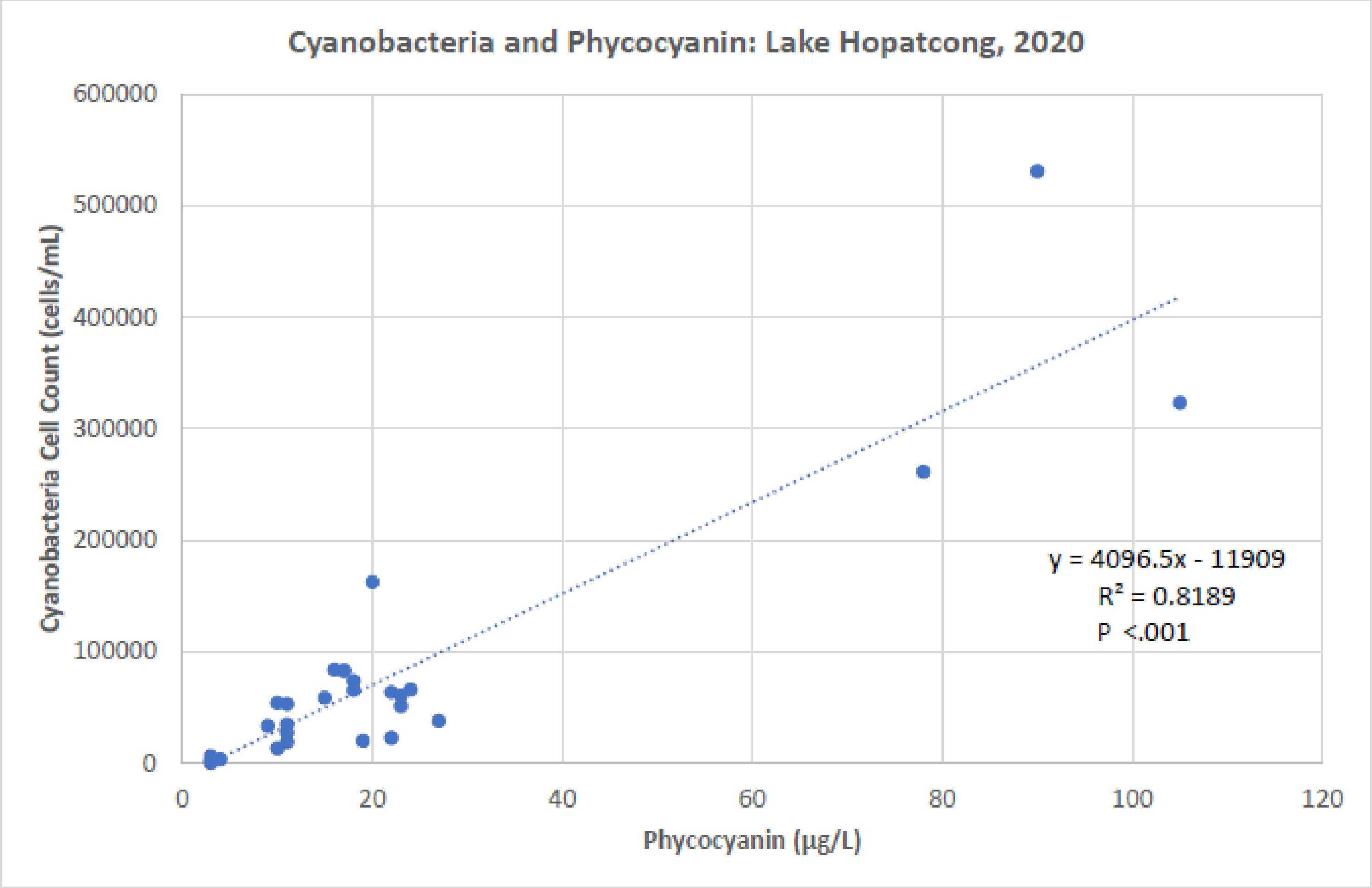
Measuring phycocyanin as a surrogate to cyanobacteria cell counts

Phycocyanin – what is it?

- ✓ One of several phycobiliproteins that are accessory pigments that aid in photosynthesis, particularly in low light level environments.
- ✓ Gives the cyanobacteria their bluish-green color.
- ✓ All algae (and plants) use chlorophyll-*a* in photosynthesis, which is why measuring chlorophyll-*a* concentrations is a way of quantifying algae biomass.
- ✓ Thus, phycocyanin can be used to quantify cyanobacteria biomass.

Lake Hopatcong



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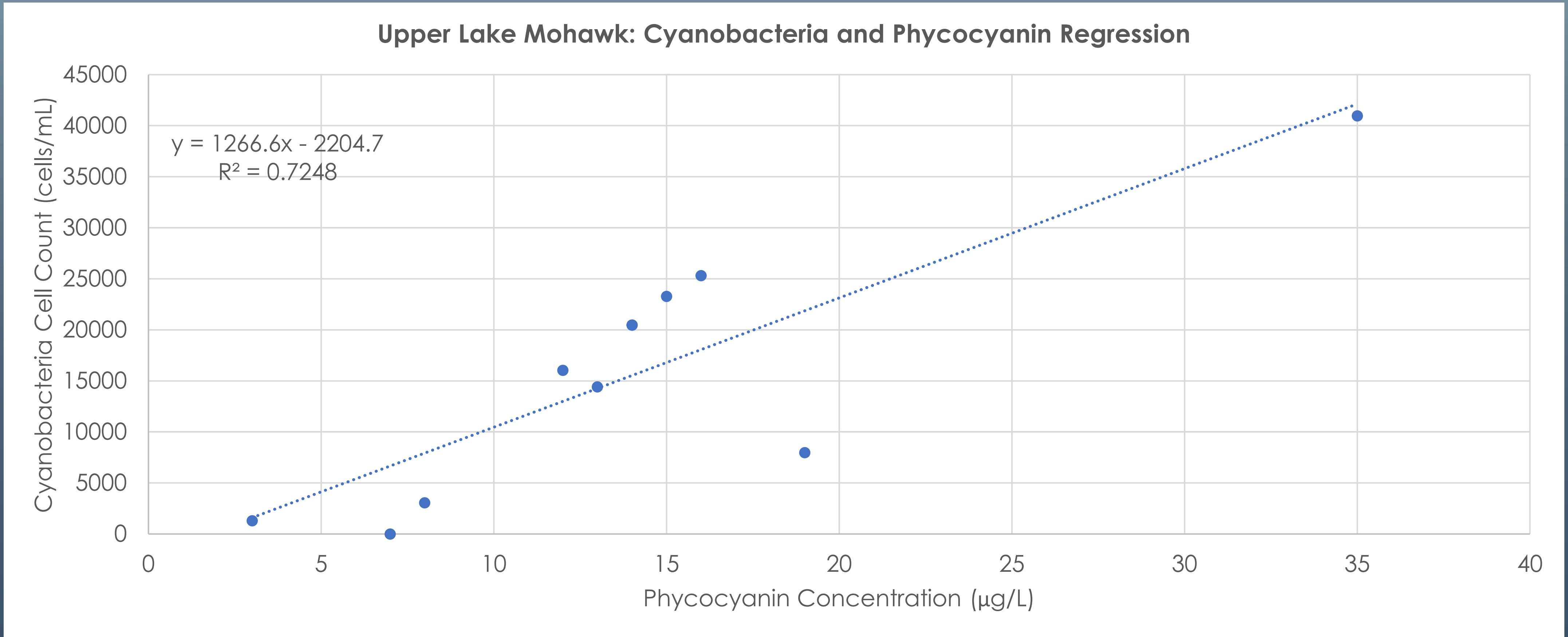
Upper Mohawk Lake



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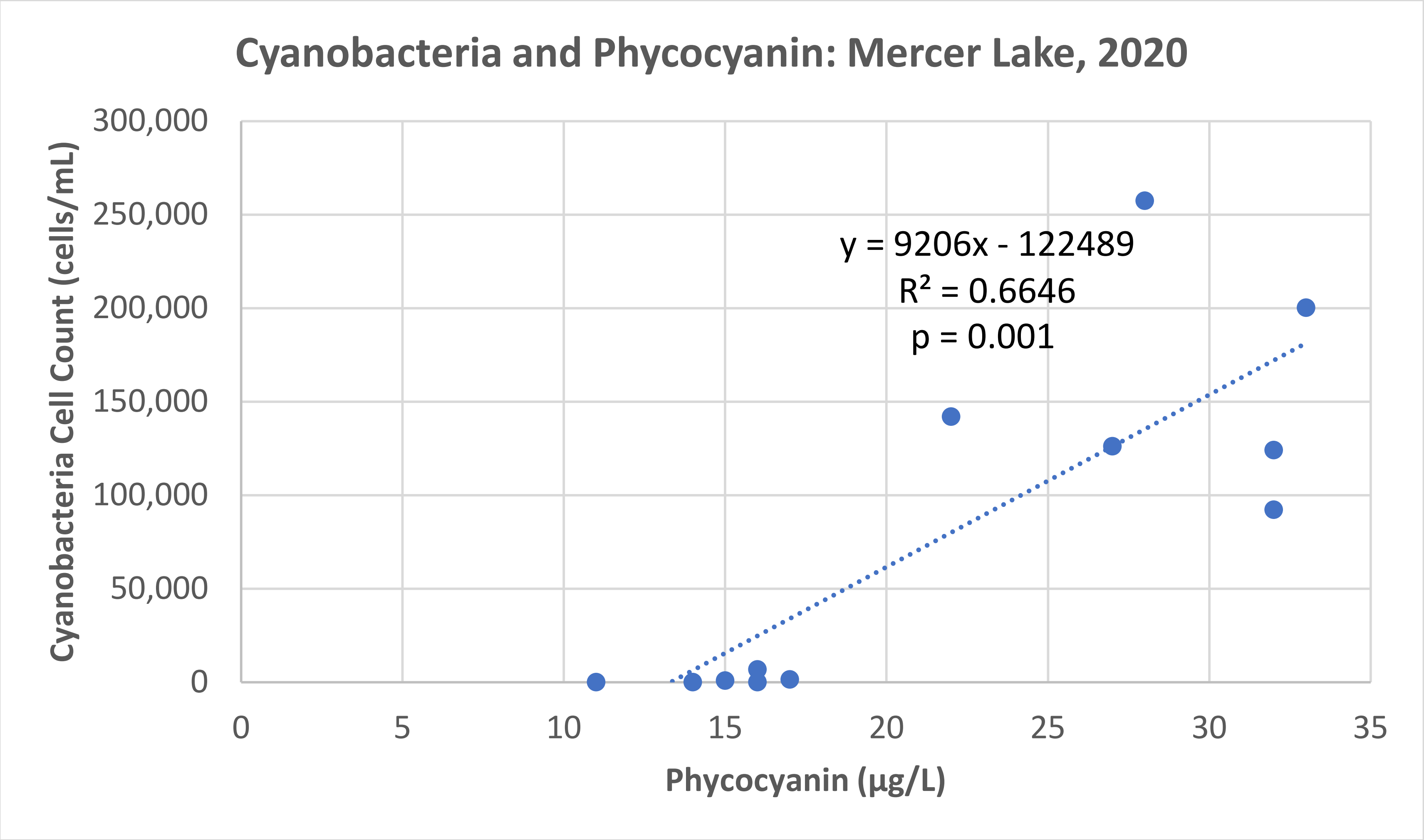
Mercer Lake



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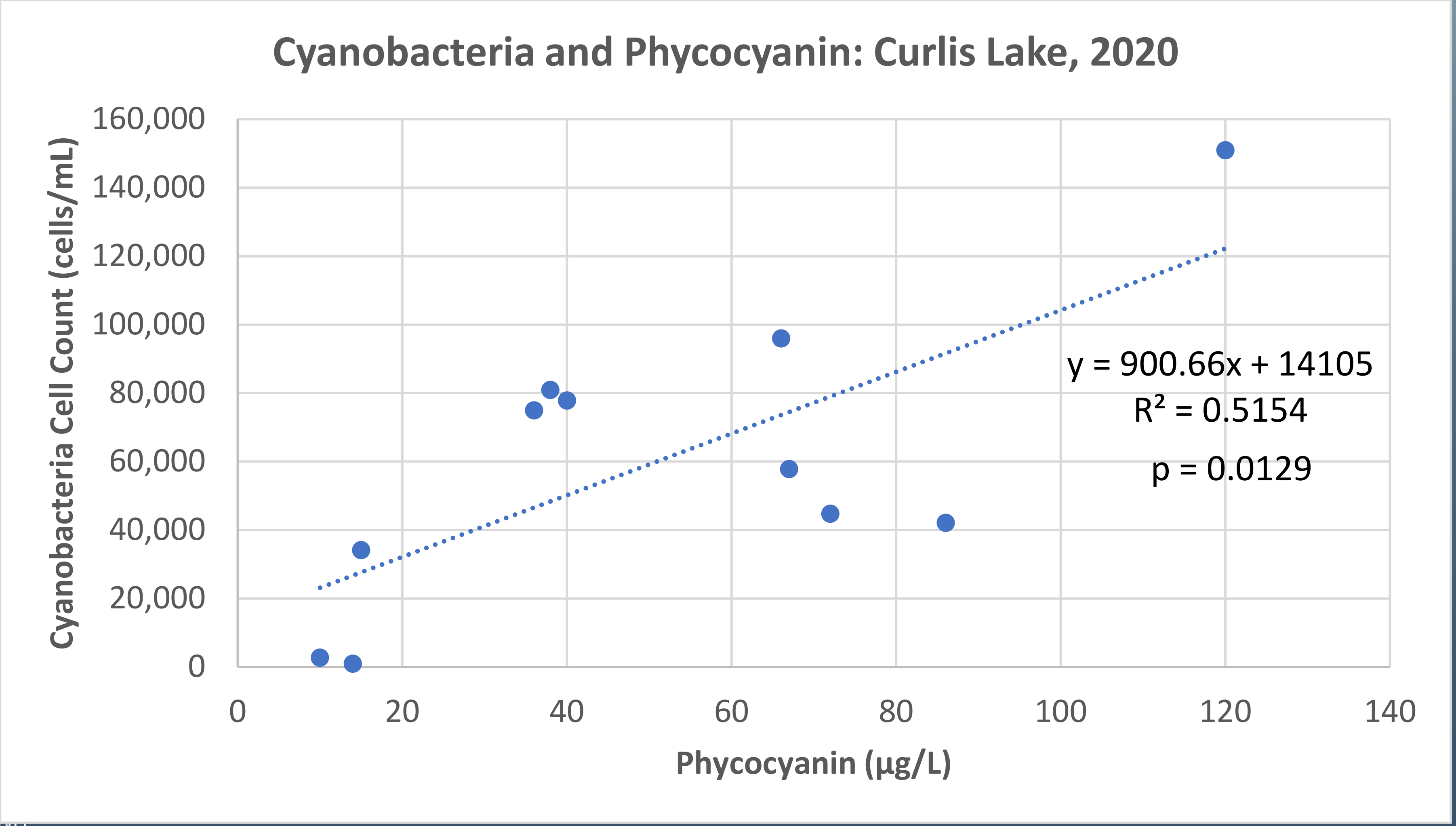
Curlis Lake



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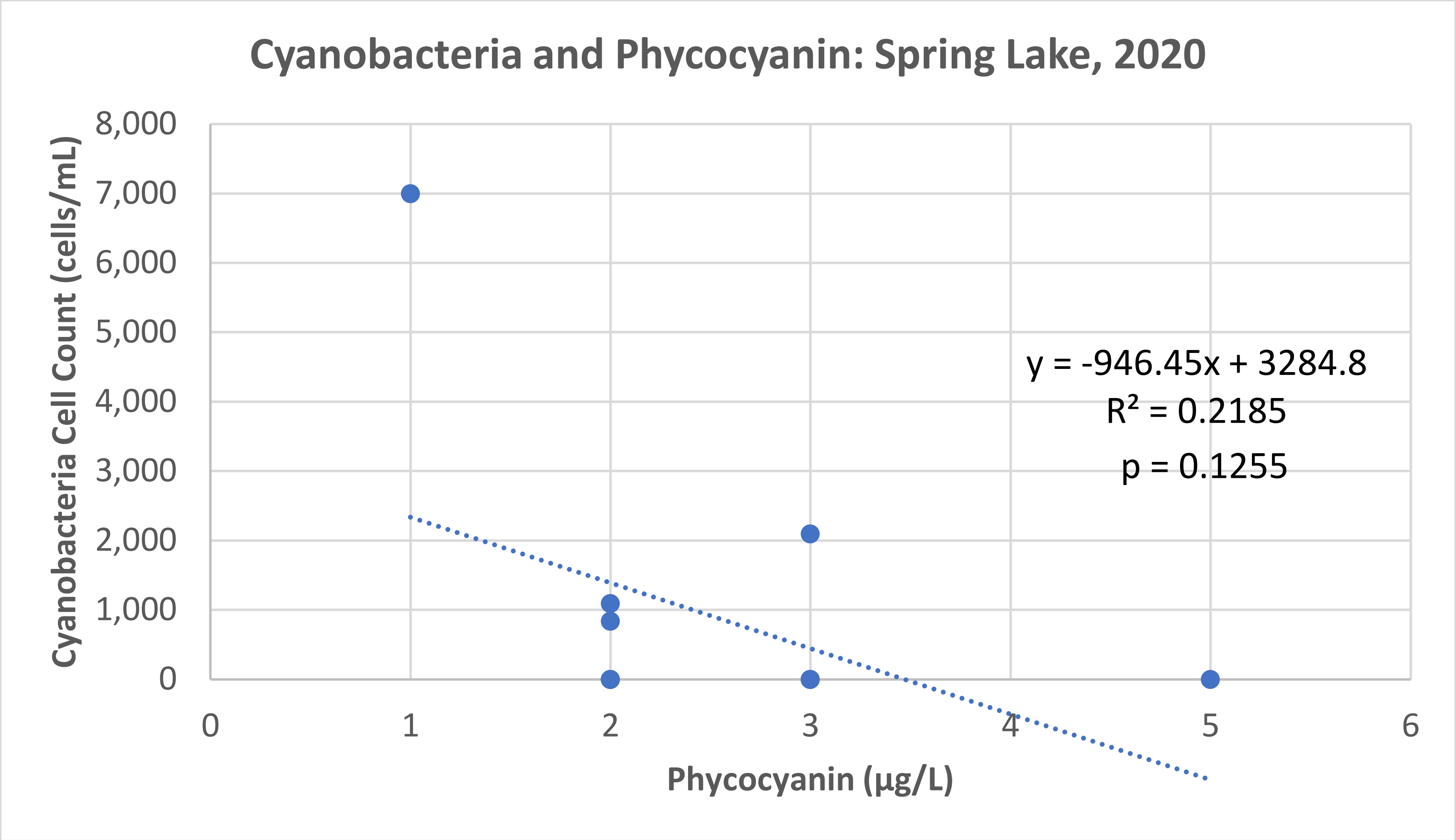
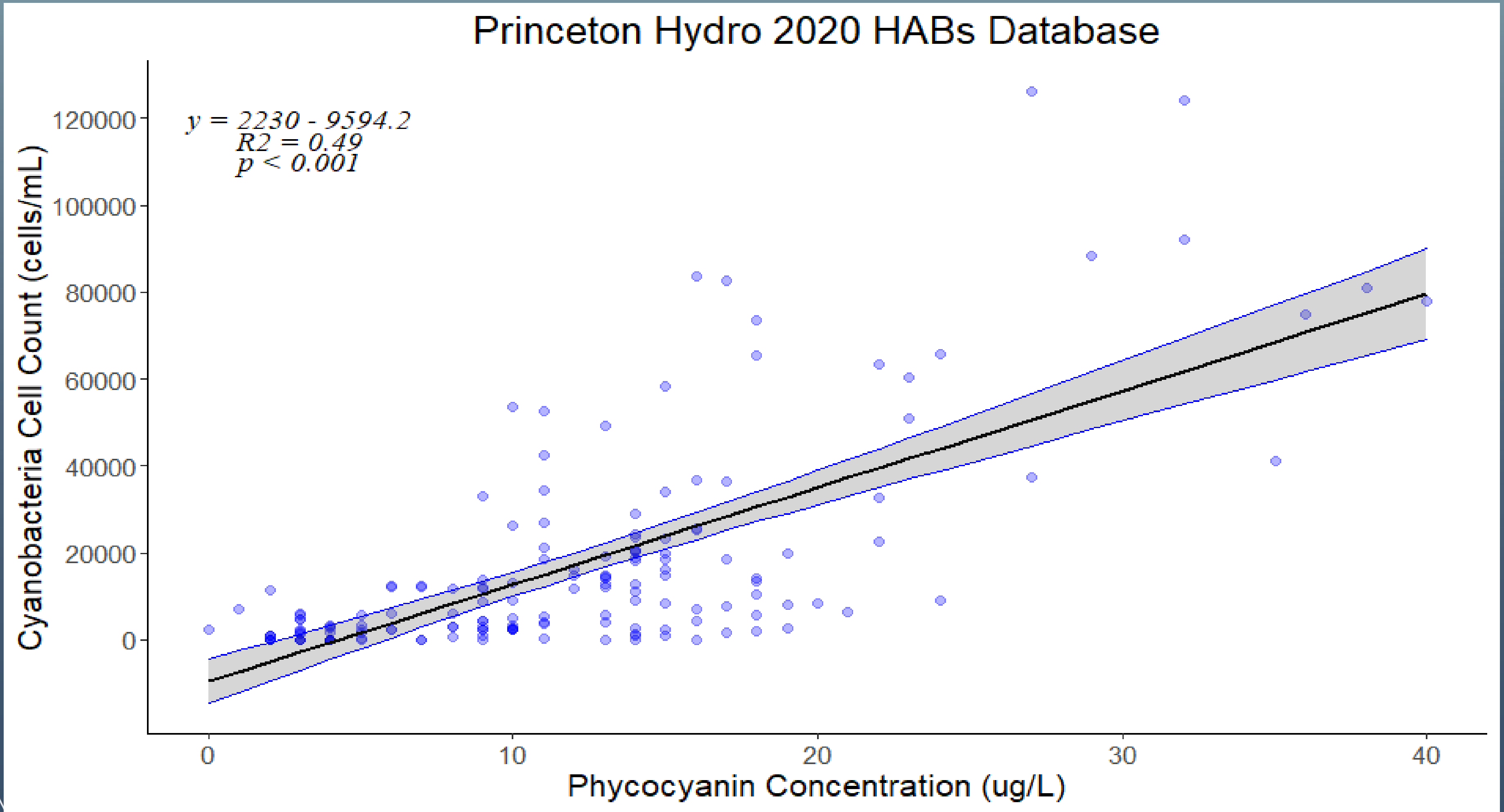
Spring Lake



Cyanobacteria and Phycocyanin: Spring Lake, 2020
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Cyanobacteria Cell Count (cells/mL)
y = -946.45x + 3284.8
R² = 0.2185
p = 0.1255
0
1
2
3
4
5
6
Phycocyanin (µg/L)

Spring Lake

Entire 2020 PH Database



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NJDEP HAB Alert Level	
Cell Count	Level
0 - 20,000	None
20,000 - 40,000	Watch
40,000 - 80,000	Alert
80,000 +	Advisory

Phycocyanin and Cyanobacteria Regression Equations		
	Princeton Hydro	NJDEP
Phycocyanin (ug/L)	Predicted Cyanobacteria (Cells/mL)	Predicted Cyanobacteria (Cells/mL)
3	-	3,154
4	-	5,034
5	1,556	6,914
6	3,786	8,794
7	6,016	10,674
8	8,246	12,554
9	10,476	14,434
10	12,706	16,314
11	14,936	18,194
12	17,166	20,074
13	19,396	21,954
14	21,626	23,834
15	23,856	25,714
16	26,086	27,594
17	28,316	29,474
18	30,546	31,354
19	32,776	33,234
20	35,006	35,114
21	37,236	36,994
22	39,466	38,874
23	41,696	40,754
24	43,926	42,634
25	46,156	44,514
26	48,386	46,394
27	50,616	48,274
28	52,846	50,154
29	55,076	52,034
30	57,306	53,914
31	59,536	55,794
32	61,766	57,674
33	63,996	59,554
34	66,226	61,434
35	68,456	63,314
36	70,686	65,194
37	72,916	67,074
38	75,146	68,954
39	77,376	70,834
40	79,606	72,714
41	81,836	74,594
42	84,066	76,474
43	86,296	78,354
44	88,526	80,234
45	90,756	82,114
46	92,986	83,994
47	95,216	85,874
48	97,446	87,754
49	99,676	89,634
50	101,906	91,514

Princeton Hydro Equation: $y = 2230 – 9594.1$, $R^2 = 0.49$; NJDEP Equation: $y = 1880x – 2468$

*Note: NJDEP equation is from the 2021 NJDEP HABs Summit presentation.

Algal Bloom Remote Sensing

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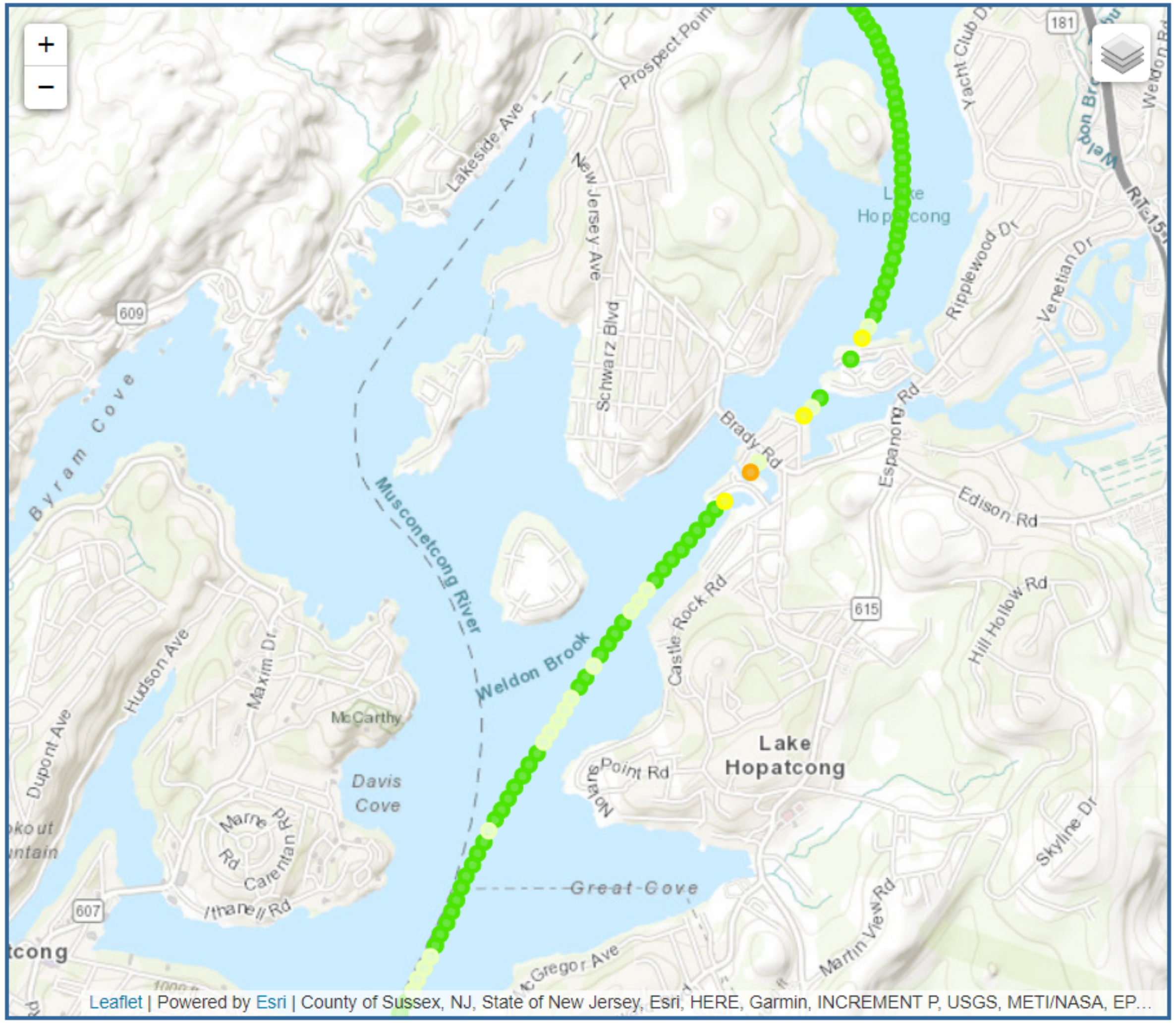

Year **Month** **Day**

2024 | 8 | 20

Download

Estimated Cells per ml
0 - 10,000
10,000 - 20,000
20,000 - 40,000
40,000 - 60,000
60,000 - 80,000
80,000 - 100,000
> 100,000

Continuous Monitoring

Limitations Associated with Using Phycocyanin

- ✓ A few other algae produce phycocyanin such as red algae and cryptomonads.
- ✓ In addition, there are some benthic forms of filamentous cyanobacteria (i.e., *Oscillatoria*, *Spirulina*, *Anabaena*) that do not produce large amounts of phycocyanin but instead produce phycoerythrin.
- ✓ Need to develop a lake-specific database of **cell counts (not colonies; not filaments ; not units)** and phycocyanin.

Cryptomonads

- *Cryptomonas* (to the left)
- *Rhodomonas* (to the right)

Curlis Lake

- August 2021 had phycocyanin value of > 100 ug/L
- While the lake had very low cyanobacteria cell counts, the cryptomonad cell counts were extremely high.

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