Harmful Algal Blooms and Cyanotoxins in Maine

Linda Bacon, Biologist

Lake Assessment Section

Volunteer Lake Monitoring Program Annual Meeting
July 30, 2016

Overview

The Algae

The Toxins

The Standards

The Concentrations in Maine Lakes

Algae

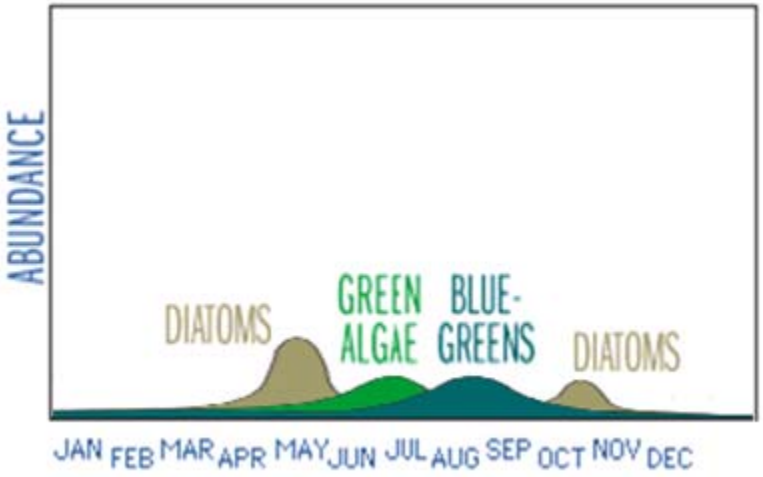
- **Primary producers**
- **Ubiquitous**
- **Pops controlled by nutrient availability**
- **Many forms: single cells, colonies, pelagic, benthic, attached, filaments, mats**

Image from Google Earth

In Maine, algal populations control lake transparency

Differences in Algae Populations

Jordan Pond



Sabattus Pond

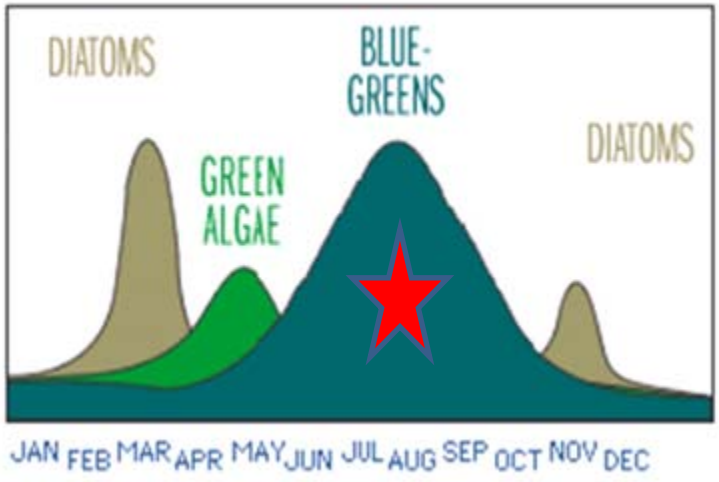


Photo taken by Brian Robertson, July 7, 2013 Jordan Pond, ANP (from Friends of Acadia Website) Jordon is the clearest lake in Maine (transparencies ~ 20 m)

Photo taken by Scott Williams, Sabattus Pond July 21, 2014 (transparency 1 meter)

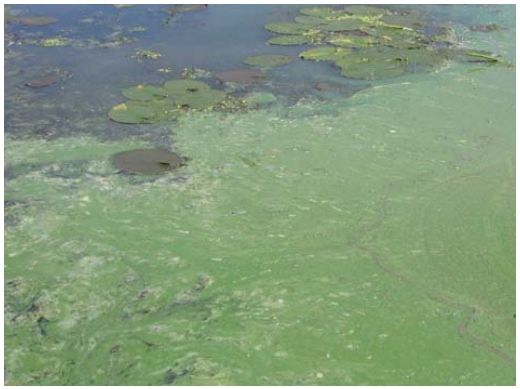
Blue-Greens - Fierce Competitors…

Growth favored when nutrients plentiful - P

Some accumulate P for use later – 'luxury consumption'

Use gas vesicles to control buoyancy

Not preferred by zooplankton as food



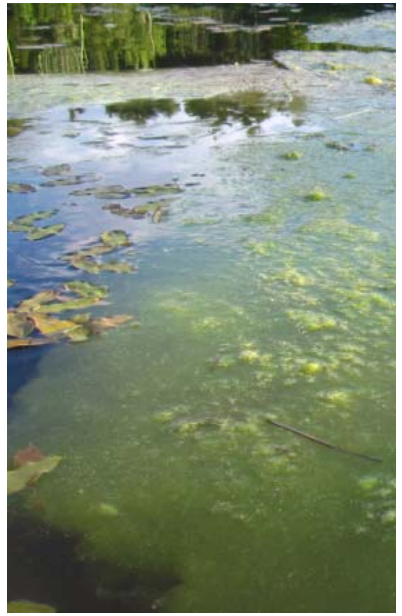
Extended warm temperatures

Some fix N via heterocysts

Some produce resting cells

Lots of sunlight

Periods of calm



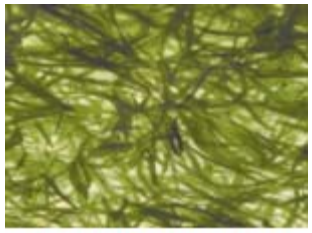
Promoted by longer growing season

Outcompete true algae

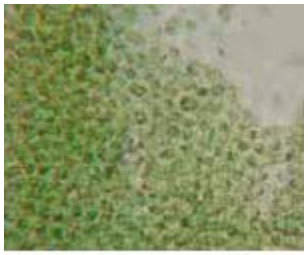
Algae? – No bacteria!

- Technically ‘blue greens’ are no longer considered algae, but photosynthetic bacteria
- Now classified as ‘Cyanobacteria’
- Toxins they produce - ‘Cyanotoxins’ -> HABs
- Annie, Fannie, Mike & Ozzy

Anabaena



Aphanizomenon



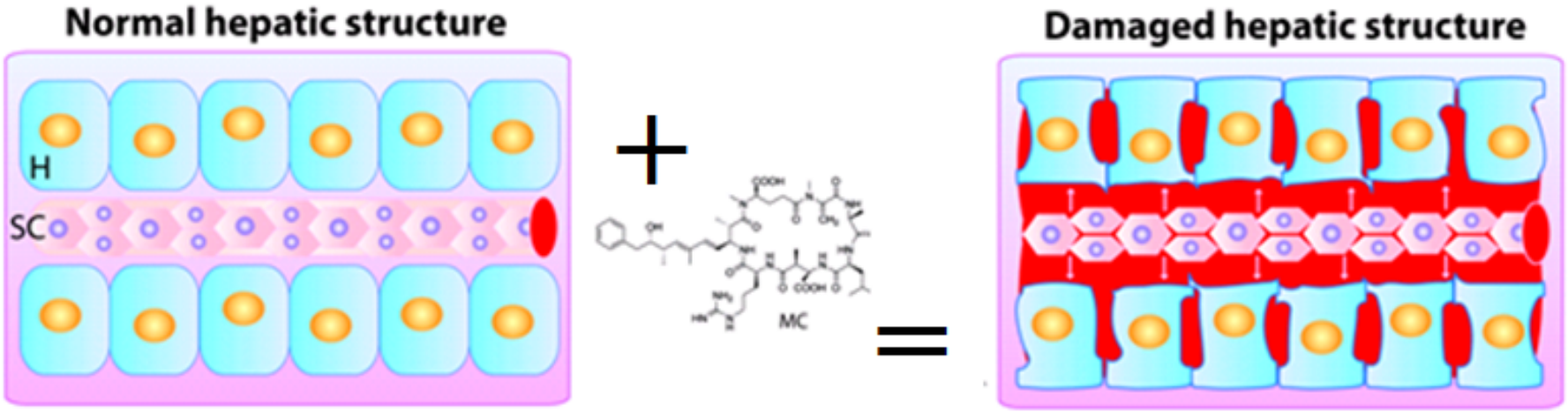
Microcystis

Oscillatoria

Cyanotoxins: *Hepatotoxins*

<u>Effects</u>: hours/days, acute/chronic

Microcystins Nodularians Cylindrospermopsin

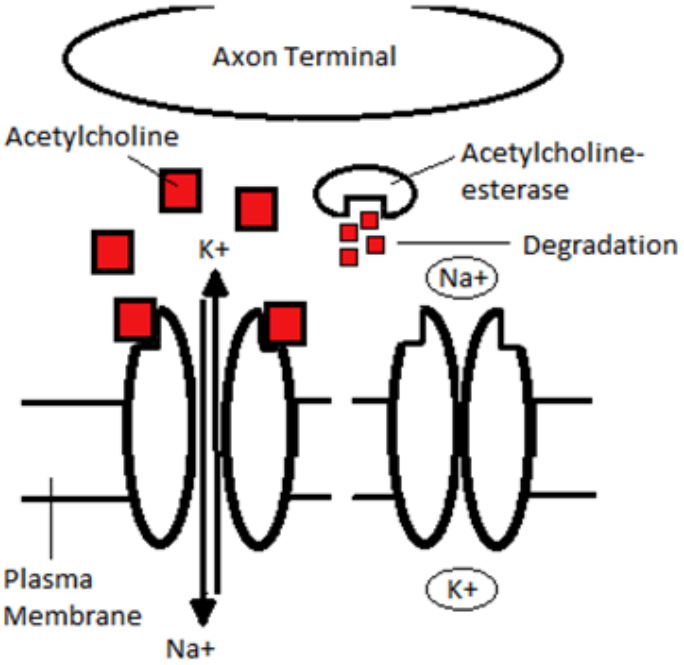


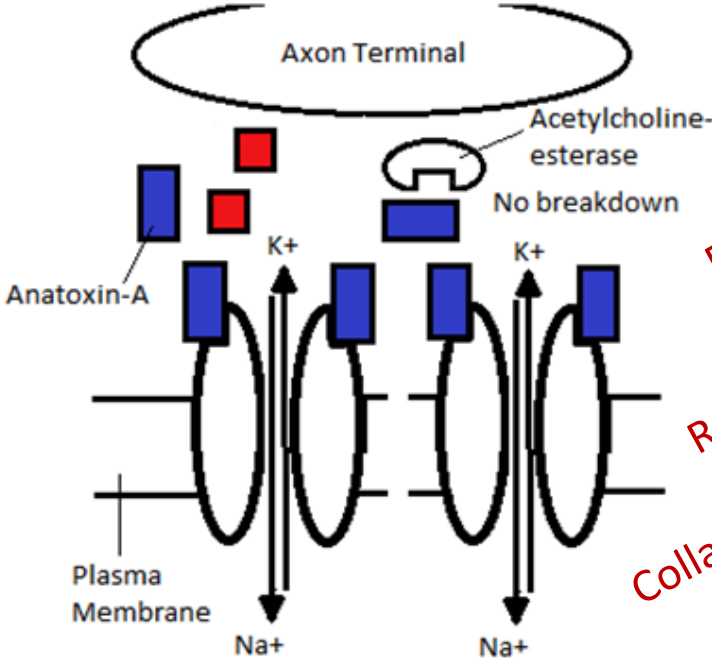
From: New Insights into Toxicity and Drug Testing, 1/23/2013

Cyanotoxins: Neurotoxins

Effects: minutes/long term*, acute/lifetime

Anatoxins **Saxitoxin** **BMAA***





Muscle Twitching

Decreased Movement

Rapid Breathing

Collapse Cyanosis

Convulsions

Death

Diagram from Wikipedia

"Very Fast Death Factor"

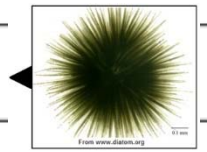
Cyanotoxins: Irritation

Effects: hours/days, relatively minor

- Skin rash
- Mucous membrane irritation
- Nuisance vs. fatal
- Relatively minor compared to hepatotoxic and neurotoxic effects

Algal Genera – Toxin Production

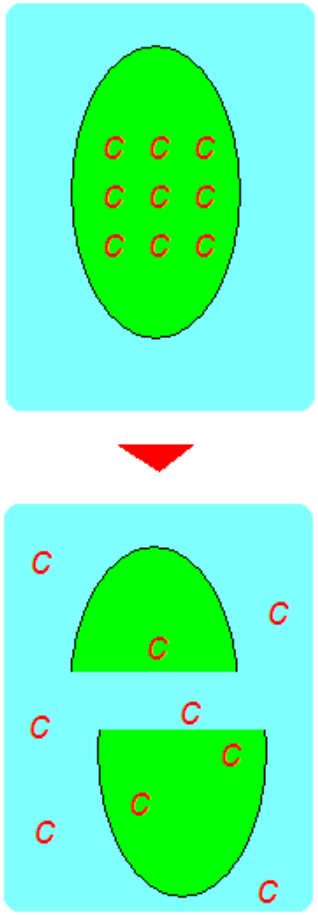
Genus of Algae	Toxin Produced	Type of Toxin
Anabaena	Anatoxin, Saxotoxin	Neurotoxin
	Microcystin, Cylindrospermopsin	Hepatotoxin
Aphanizomen	Anatoxin, Saxotoxin	Neurotoxin
	Cylindrospermopsin	Hepatotoxin
Planktothrix (Oscillatoria)	Anatoxin	Neurotoxin
	Cylindrospermopsin, Microcystin	Hepatotoxin
Cylindrospermopsis	Cylindrospermopsin	Hepatotoxin
Gloeotrichia	Microcystin	Hepatotoxin
Microcystis	Microcystin	Hepatotoxin



From Oregon Health Authority

Cyanotoxin Challenges

- **Spatial, temporal and environmental factors affecting cyanotoxin production are poorly understood**
- **May be related to concentration, age of the bloom, stage of bloom, climate/weather, or ???**
- **Cyanotoxins occur within cells and may not be measurable unless cells are lysed and the toxins are released**



Standards

Microcystin-LR is the most toxic and most prevalent cyanotoxin in Northeast.

- **World Health Organization (WHO) standards for microcystin-LR: Drinking Water = 1.0 ug/L**
  Recreation = 10 ug/L
- **EPA Drinking Water standards:**
  Non-school-age children = 0.3 ug/L
  School-age children & adults = 1.6 ug/L

New England states have a variety of responses to algal blooms w/r/t advisories, most based on other measures such as cell counts, transparency, pigments, taxonomy.

Standards (cont.)

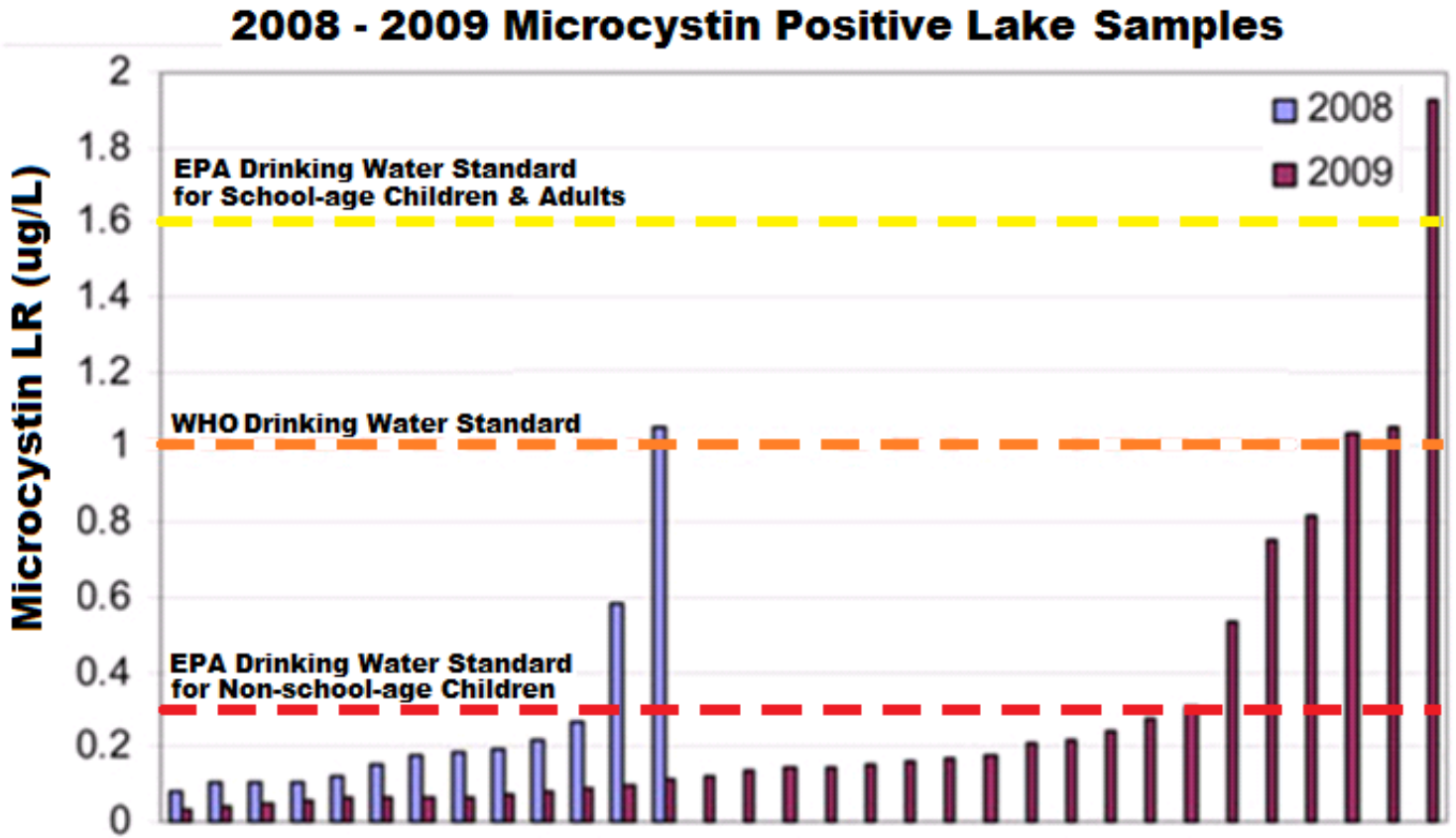
EPA Recreational Standards expected in autumn 2016.

WHO Recreational Standard is ten times greater than their Drinking Water Standard, thus the EPA Standard likely to be similar.

Maine

- No State Standards or Criteria…yet
- No Recent Precipitating acute event (death)
- Ecological factors vague
- Links to chronic issues still fuzzy (ALS, etc.)
- Gathering information since 2008
  http://www.maine.gov/dep/water/lakes/cyanobacteria.htm
- ‘Team Maine’ includes CDC, DW & DEP
- Regional effort in NE since 2014

Pilot Study Maine



Note: Six surface scum samples ranged to ~12,000 ug/L

Precautions

- Avoid contact with water where algae are visible (e.g., pea soup, floating mats, scum, etc.)
- Do not let pets or livestock swim or drink where you see foam, scum, or mats of algae on the water
- If you or a pet swims or wades in water that has dense algae present - rinse off with fresh water and soap, if available, ASAP
- Do not drink lake water during a bloom. Take short showers to avoid breathing aerosols in lake water.
  (Domestic water treatment systems are not guaranteed to remove algal toxins.)

Regional Effort – 2014 & 2015

- EPA Workshop to compare state programs
- Identified how to establish regional dataset
- Tiered approach
  - Agencies
  - Volunteers
- EPA supplies & equipment
- State added analyses

FluoroQuick Fluorometer (phycocyanin & chlorophyll)

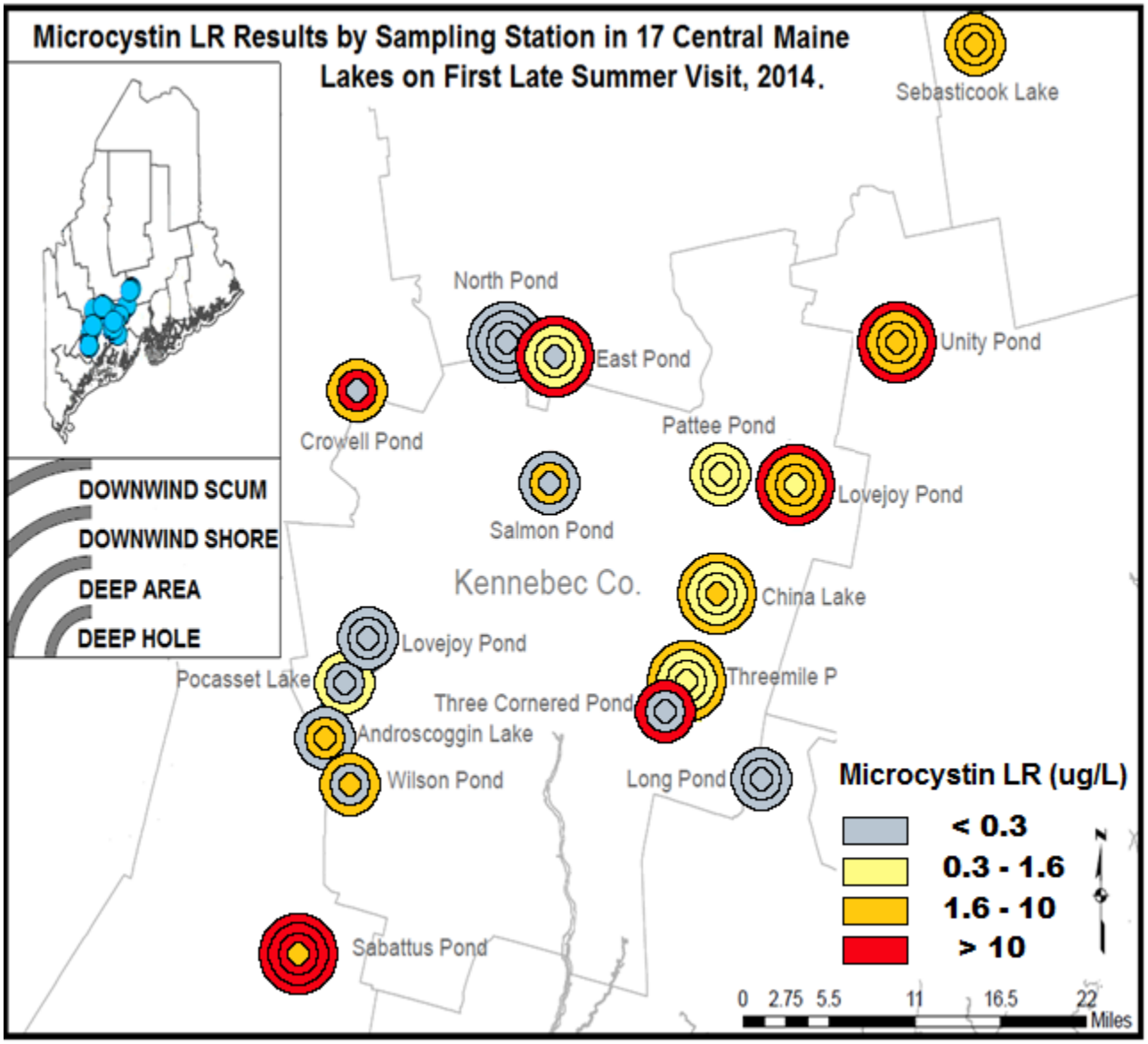
Maine Cyanotoxin Monitoring 2014/2015

- **Randomly chosen lakes > 150 acres in Kennebec, Androscoggin, Lincoln, Knox & Waldo counties**
- **Multiple visits to 4-5 lakes that bloom**
- **In addition to routine parameters (transp, DO/temp, TP, chl, chemistry), collected samples to measure phycocyanin and chlorophyll on Fluorometer from monitoring station and downwind shore and froze samples for algal toxin analysis**

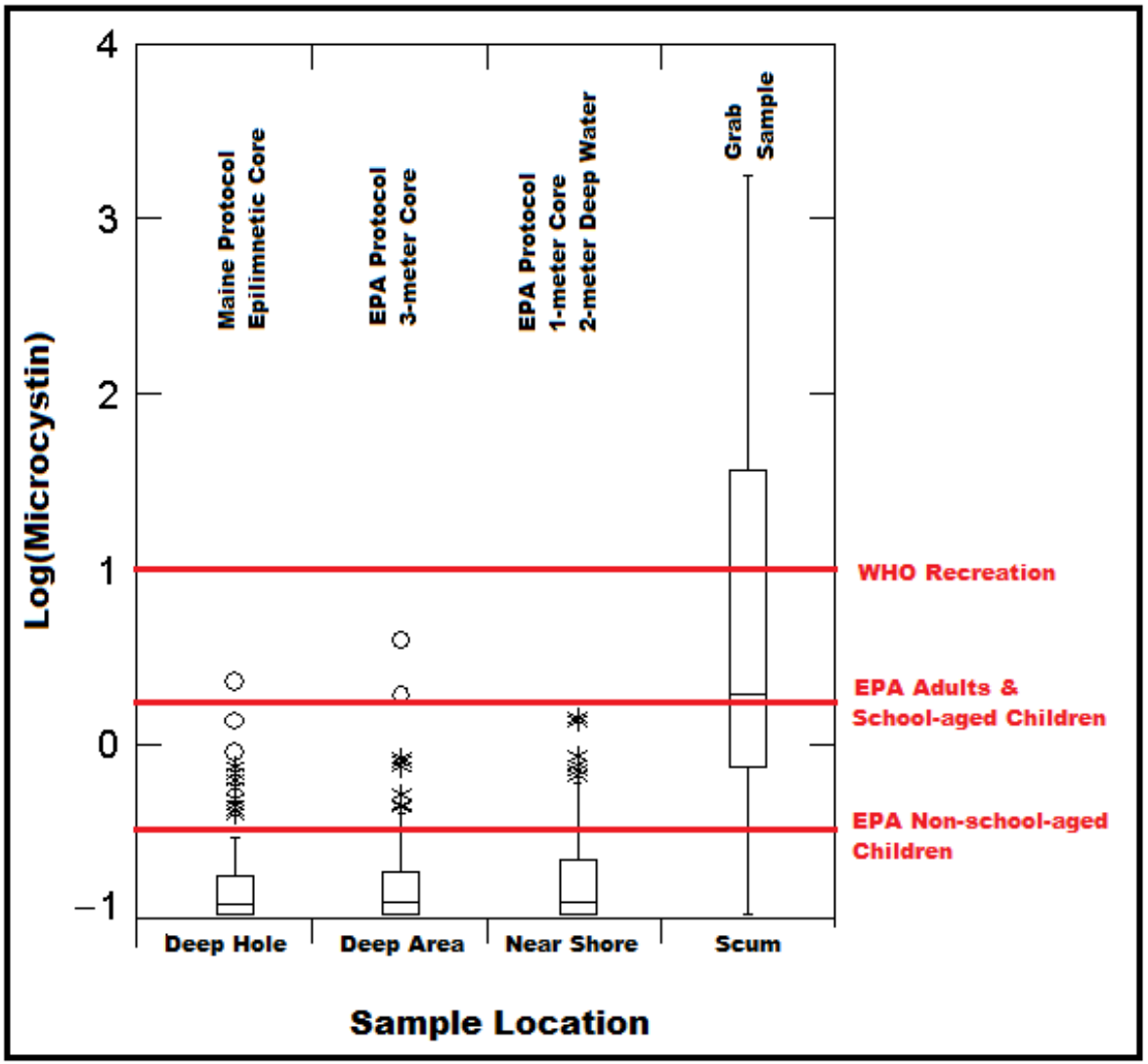

Open water


Near shore


Scum


Microcystin LR Results by Sampling Station in 17 Central Maine Lakes on First Late Summer Visit, 2014.
DOWNWIND SCUM
DOWNWIND SHORE
DEEP AREA
DEEP HOLE
Sebasticook Lake
North Pond
East Pond
Unity Pond
Crowell Pond
Pattee Pond
Lovejoy Pond
Salmon Pond
Kennebec Co.
China Lake
Lovejoy Pond
Pocasset Lake
Threemile P
Three Cornered Pond
Androscoggin Lake
Wilson Pond
Long Pond
Sabattus Pond
Microcystin LR (ug/L)
< 0.3
0.3 - 1.6
1.6 - 10
> 10
0 2.75 5.5 11 16.5 22
Miles

Distribution of microcystin concentrations by sample location (2014 & 2015).



Microcystin LR Concentrations (ug/L) in Four Maine Lakes from which Time Series Data were Collected during 2014 & 2015.

	Location	Late August	Early Sept	Late Sept	Early Oct	Late August	Early Sept	Late Sept	Early Oct	Late Oct	Early Nov	Late Nov
	Deep Hole	3.46	21.47	1.60	4.67	0.24	0.66	1.16	0.54	0.49	0.08	0.08
	Deep Area	37.84	3.34	1.82	7.35	0.36	0.86	0.73	0.59	0.84	0.23	0.33
	Near Shore	12.39	5.60	4.46	4.44	0.28	0.57	0.34	1.19	0.6	0.4	0.26
Sabattus: 3796	Surface Scum	619	10605	1674		35.78	3.51	10.21		1.67	4.02	
	Deep Hole	3.16	7.88	3.14	6.42	0.27	0.28	0.58	0.33	0.21	0.08	
	Deep Area	2.43	1.74	6.44	6.96	0.39	0.6	0.49	0.32	0.08	0.08	
	Near Shore	3.20	2.13	7.44	4.97	0.23	0.26	0.08	0.44	0.31	0.08	
Unity: 5172	Surface Scum	22.53	273				30.9	4.14	1146			
	Deep Hole	1.38	5.70	3.00	1.19	0.08	0.08	0.08	0.22	0.3	0.18	0.08
	Deep Area	1.83	2.94	1.81	1.68	0.08	0.08	0.08	0.08	0.26	0.23	0.29
	Near Shore	2.48	2.81	1.63	1.68	0.15	0.21	0.23	0.22	0.08	0.48	0.08
Lovejoy: 5176	Surface Scum	491	17696	1948	18.46	15.4	17.86	8.55	3.34			60.3
	Deep Hole	0.64	1.68	0.33	0.30	5.12	3.49	1.4	0.59			
	Deep Area	1.02	1.51	0.70	0.33	3.43	4.14	1.59	0.53			
	Near Shore	1.48	2.31	0.61	0.27	6.61	5.6	4.9	0.39			
Threemile: 5416	Surface Scum	9.26	2.70	56.90		17.63	724	710				
	Deep Hole	0.08	0.08	0.08	0.08							
	Deep Area	0.08	0.08	0.08	0.08							
	Near Shore	0.08		0.08	0.08							
North: 5344	Surface Scum	0.08										
	Deep Hole	0.08	12.37	0.08	0.08							
	Deep Area	0.08	1.05	0.08	0.48							
	Near Shore	0.08	0.48	0.08	0.42							
East: 5349	Surface Scum		9.67									
	Deep Hole	0.63	0.08	0.35	0.35							
	Deep Area	0.18	1.89	0.08	0.08							
	Near Shore	0.99	0.08	0.27	0.20							
Salmon: 5352	Surface Scum											

Microcystin Concentration (ug/L) Color Key
<0.3
0.3 - 1.6
1.6 - 10
>10

Deep Hole Samples

- DEP Protocol – Epilimnetic core

  Chl-a (fluorometric)

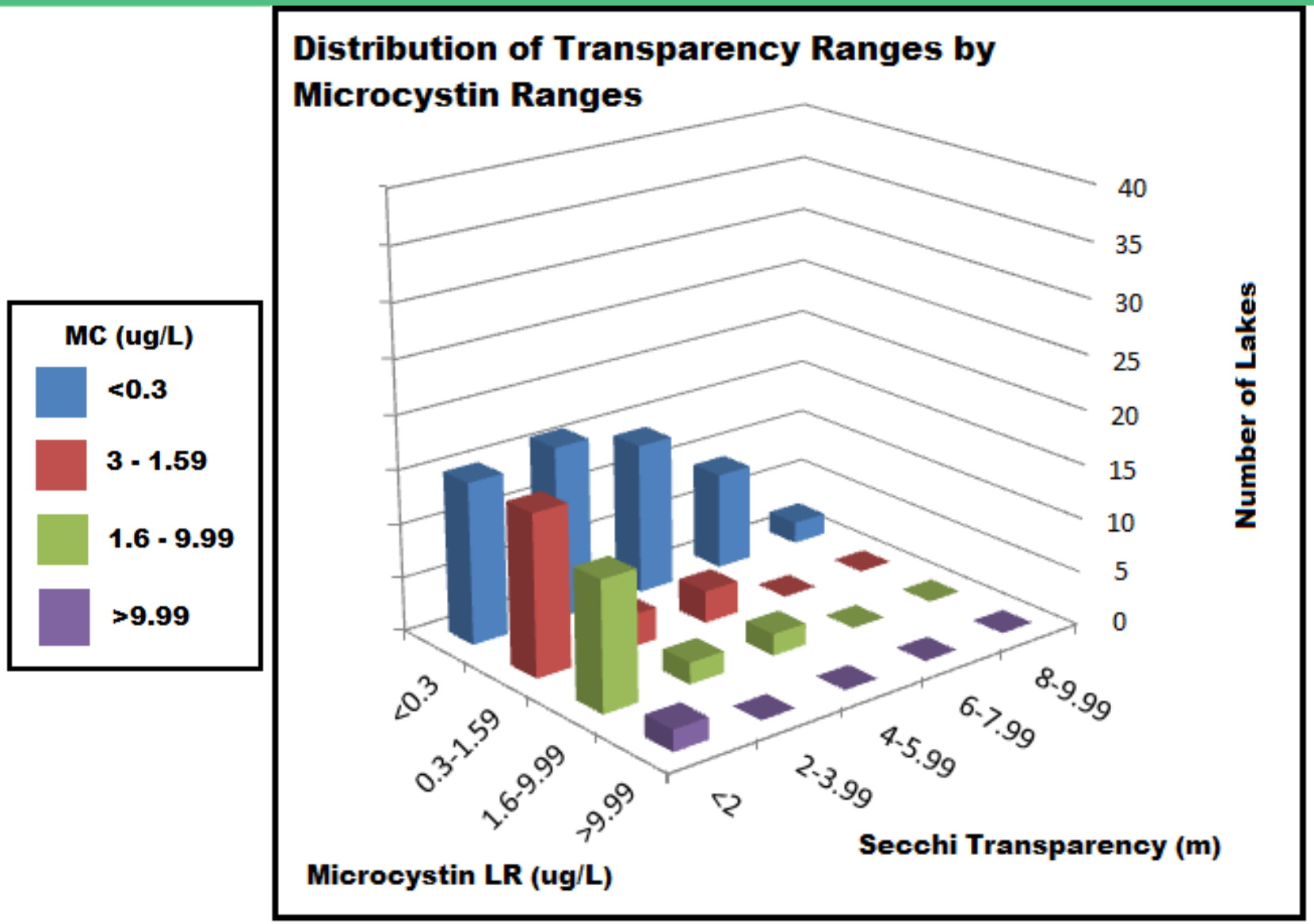
  Phaeophytin (fluorometric)

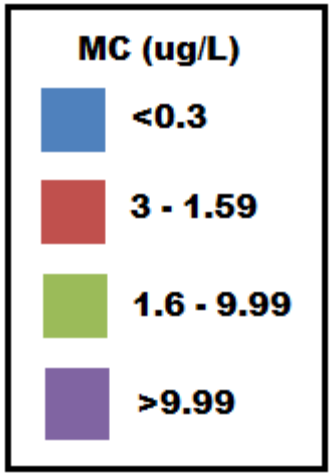
  &

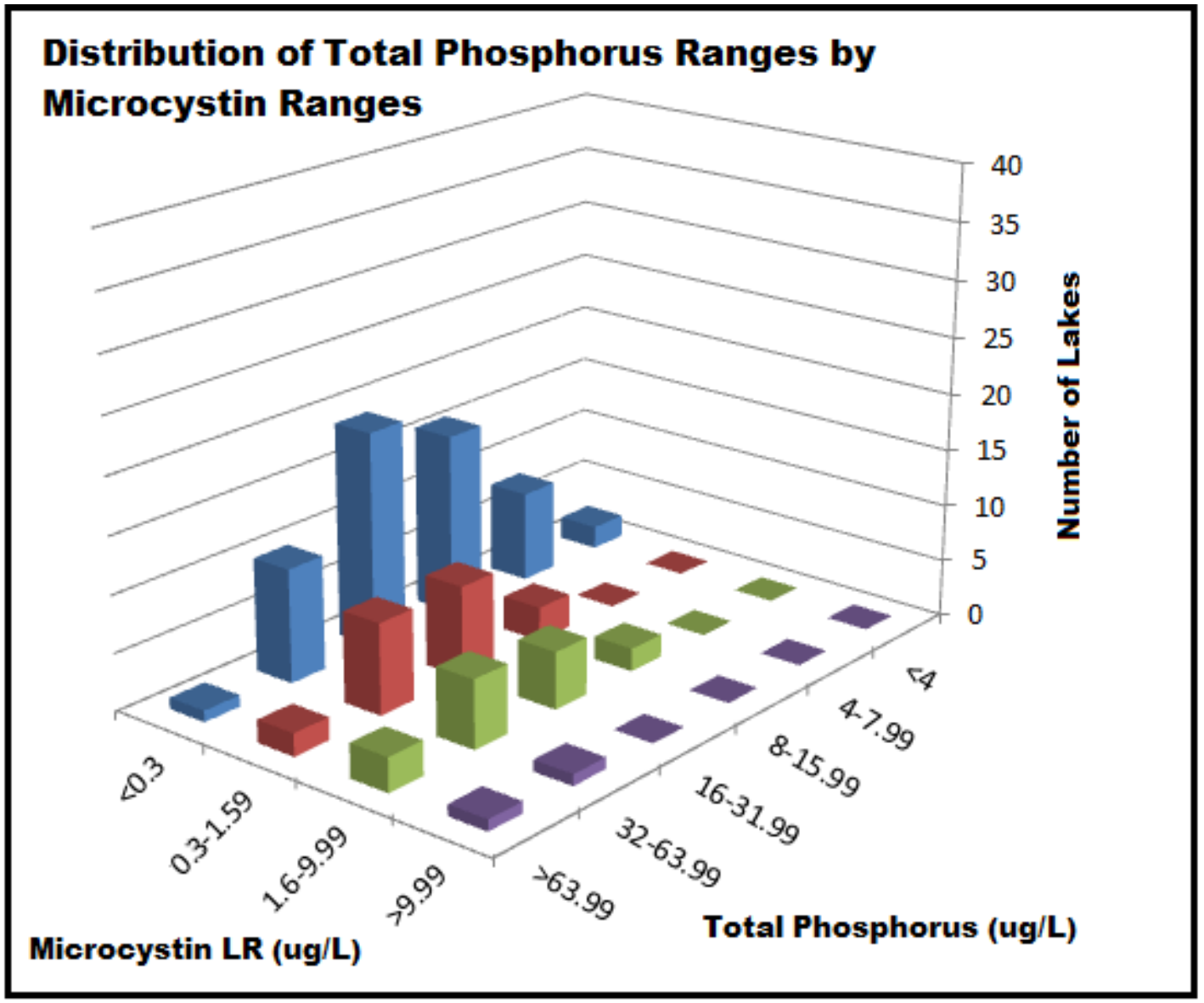
  Chl-a (trichromatic)

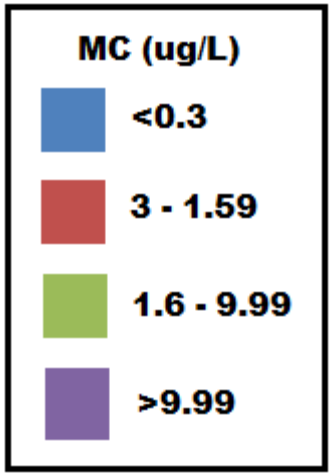
  TP

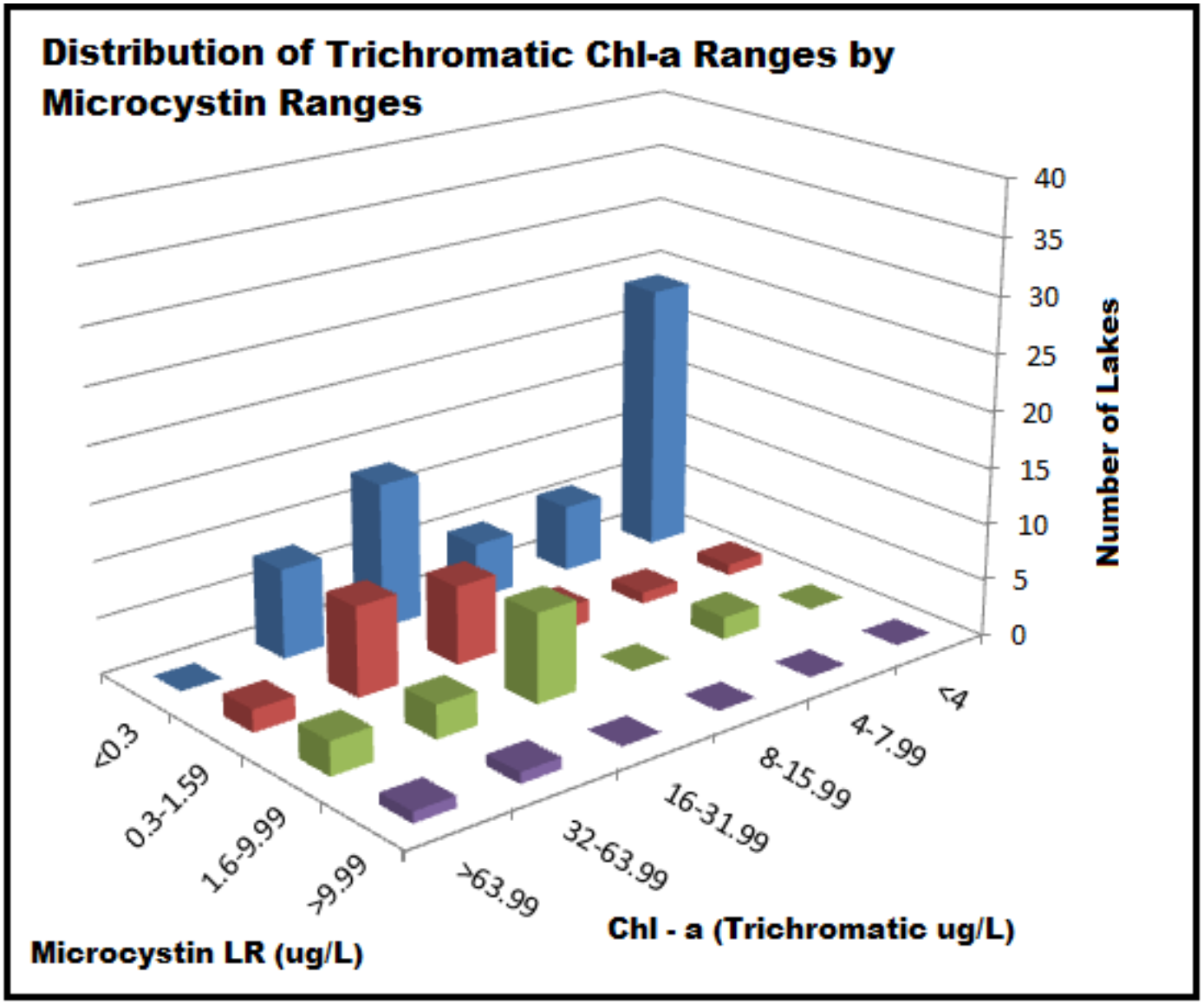
  Secchi Transparency

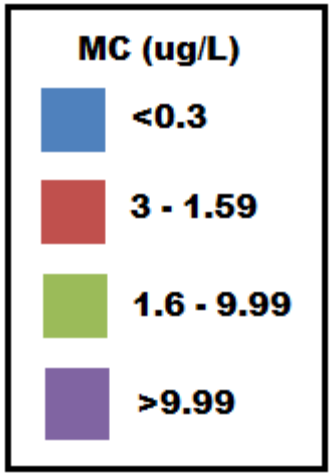

Distribution of Transparency Ranges by Microcystin Ranges
MC (ug/L)
<0.3
3 - 1.59
1.6 - 9.99
>9.99
40
35
30
25
20
15
10
5
0
Number of Lakes
<0.3
0.3-1.59
1.6-9.99
>9.99
<2
2-3.99
4-5.99
6-7.99
8-9.99
Secchi Transparency (m)
Microcystin LR (ug/L)

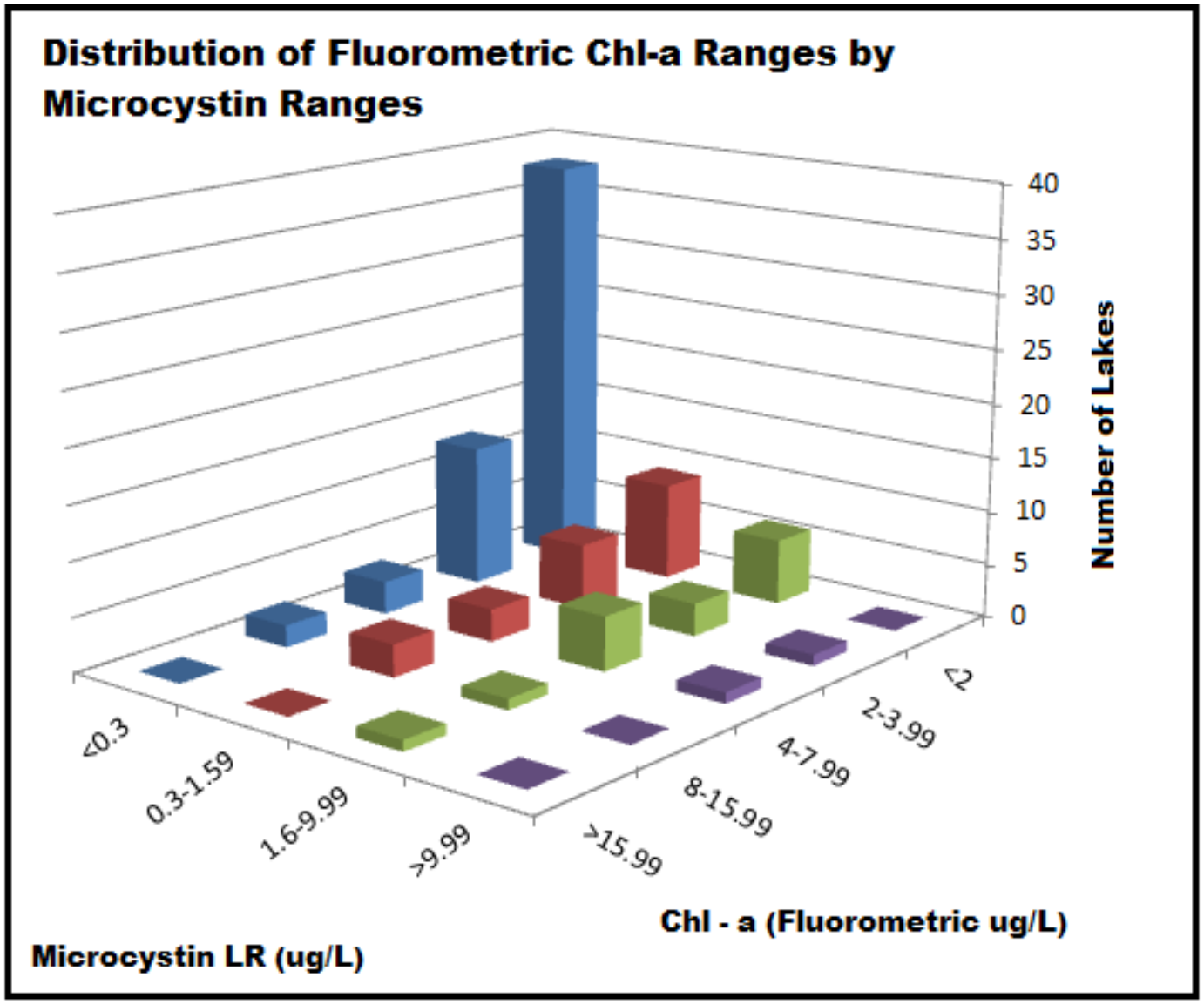

MC (ug/L)
<0.3
3 - 1.59
1.6 - 9.99
>9.99


Distribution of Total Phosphorus Ranges by Microcystin Ranges
40
35
30
25
20
15
10
5
0
Number of Lakes
<0.3
0.3-1.59
1.6-9.99
>9.99
Microcystin LR (ug/L)
<4
4-7.99
8-15.99
16-31.99
32-63.99
>63.99
Total Phosphorus (ug/L)

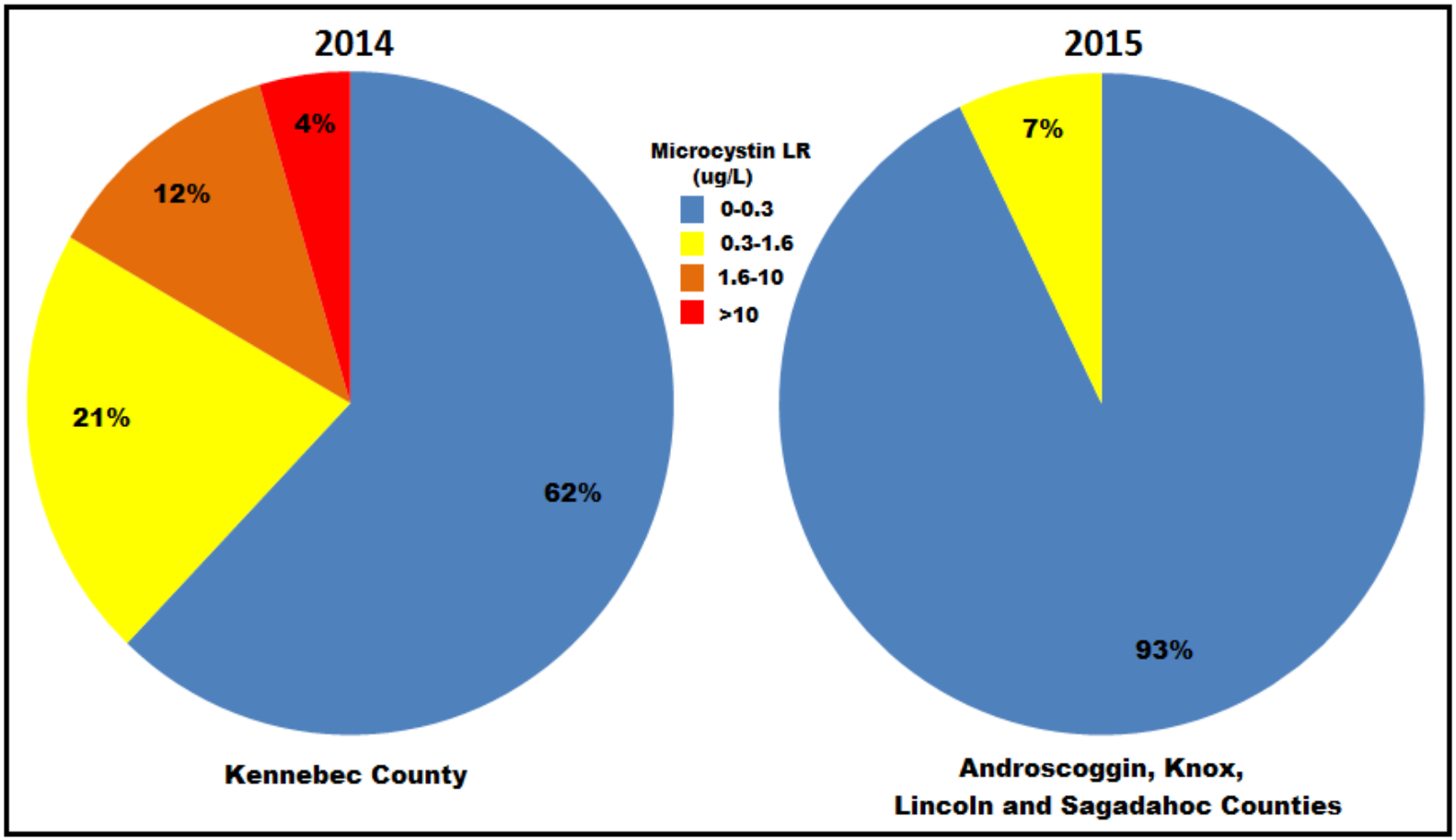

MC (ug/L)
<0.3
3 - 1.59
1.6 - 9.99
>9.99


Distribution of Trichromatic Chl-a Ranges by Microcystin Ranges
40
35
30
25
20
15
10
5
0
Number of Lakes
<0.3
0.3-1.59
1.6-9.99
>9.99
Microcystin LR (ug/L)
>63.99
32-63.99
16-31.99
8-15.99
4-7.99
<4
Chl - a (Trichromatic ug/L)


MC (ug/L)
<0.3
3 - 1.59
1.6 - 9.99
>9.99


Distribution of Fluorometric Chl-a Ranges by Microcystin Ranges
40
35
30
25
20
15
10
5
0
Number of Lakes
<0.3
0.3-1.59
1.6-9.99
>9.99
>15.99
8-15.99
4-7.99
2-3.99
<2
Chl - a (Fluorometric ug/L)
Microcystin LR (ug/L)

County Comparisons



Next Steps

- Plenty of further data analysis
- Pool with data for regional results
- Continue evaluating with CDC
- Develop Statewide Advisory
- Conduct 2016 monitoring

Feedback

Risk communication is a challenge.

If the language used is too technical, people stop listening and ignore.

If too simple, people may not perceive a risk is being conveyed.

Ideally we'd like to people to have adequate guidance on how to make their own decisions about drinking the water, letting pets and livestock drink the water, swim in the water, etc.

What guidance would you suggest???

Feedback (continued)

For example:

Don’t use the lake for drinking water if…

…you can’t see the bottom at the end of your dock…

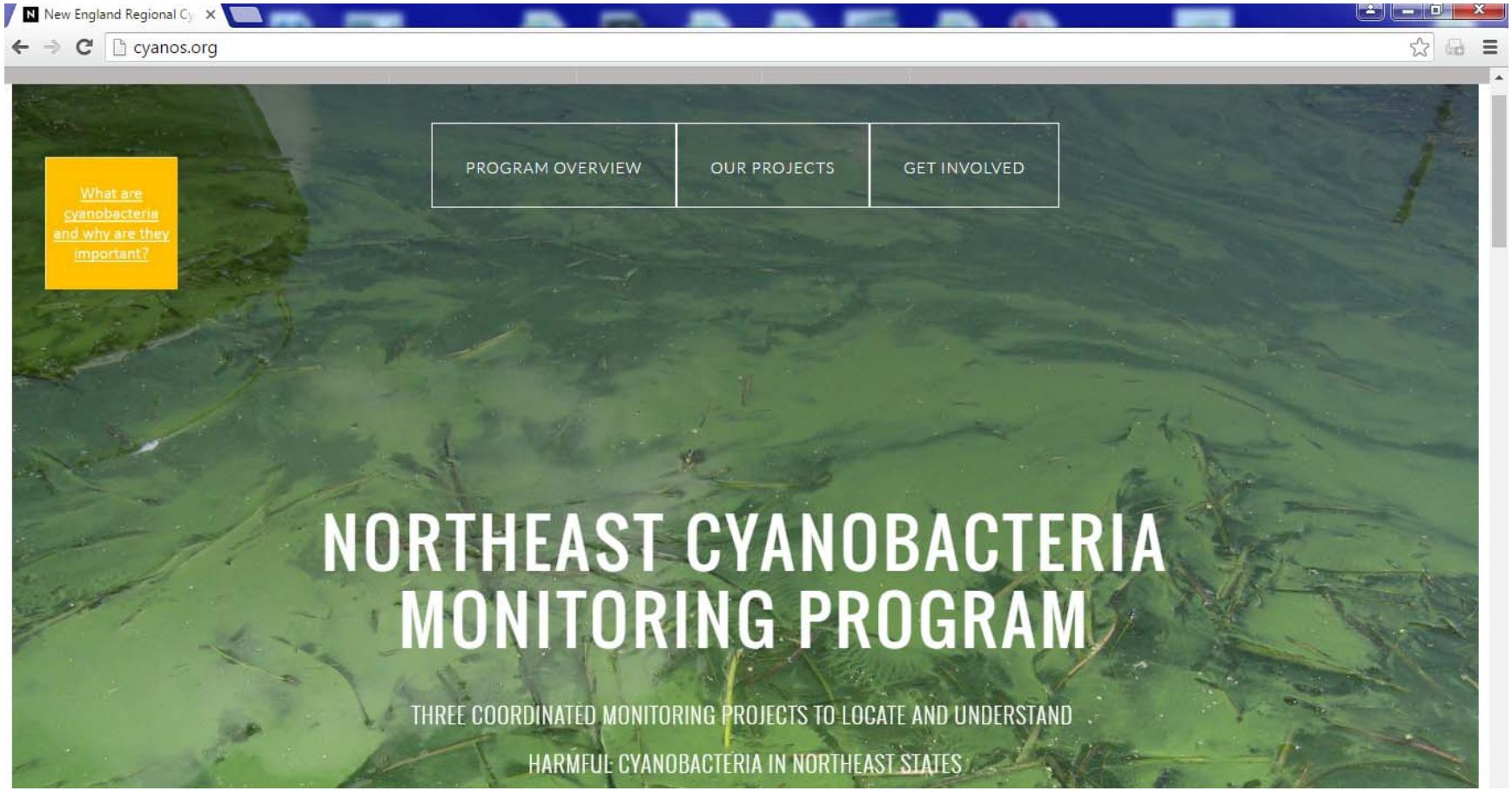
…you can’t see your toes when in water up to your waist…

…the water is thick and green like pea soup…

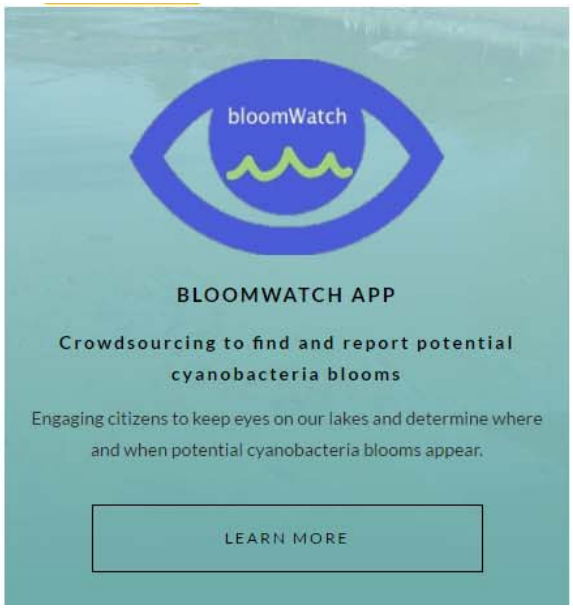
…the Secchi reading is less than 1 meter…or 3 feet…

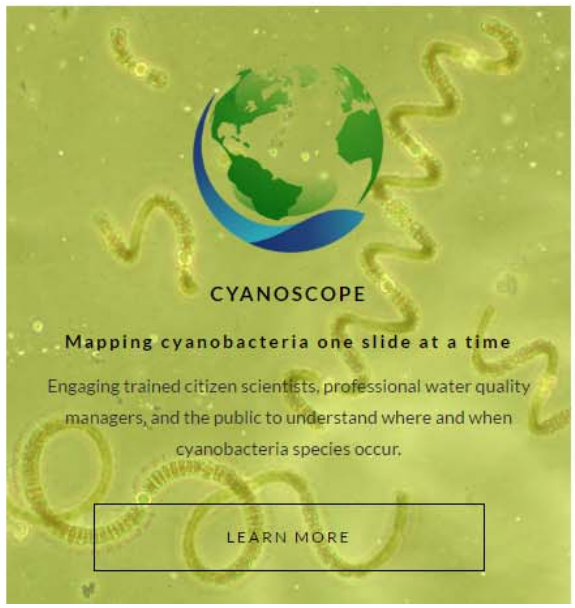
YOUR SUGGESTIONS HERE:

Regional Effort – EPA Region I



Regional Effort – EPA Region I





Regional Effort – EPA Region I

PROJECT OVERVIEW: BLOOMWATCH APP

Help track cyanobacteria blooms using your smartphone

bloomWatch

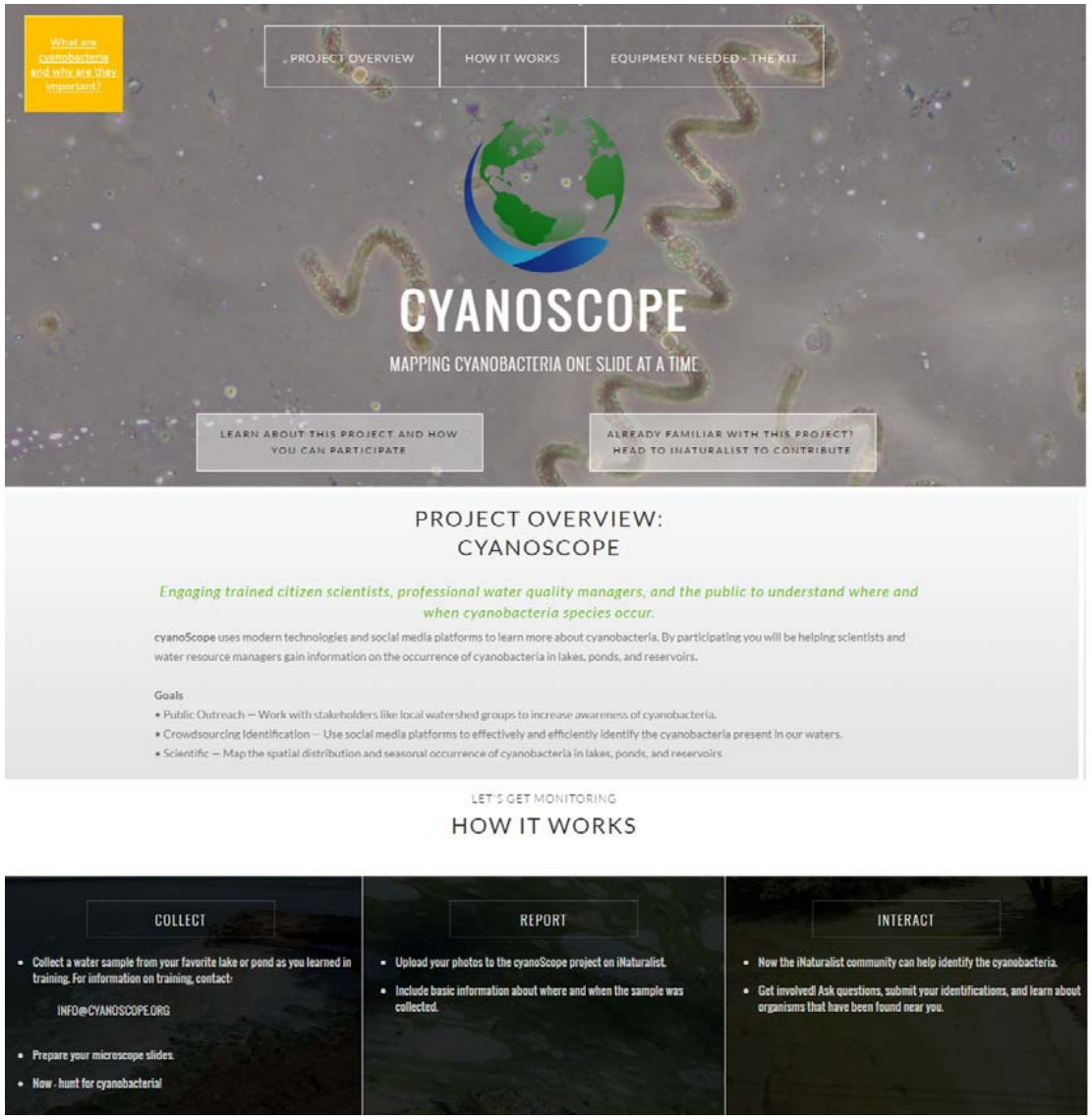
Are you seeing a normally-clear lake that has suddenly turned the color of pea soup or a blue-green paint spill? It may be a bloom of cyanobacteria, which have the potential to produce toxins that affect humans, pets, and our ecosystems.

State and local officials can't be watching every lake at all times. With you and your smartphone helping us out, we want to improve our ability to understand where, how, and when these organisms may be proliferating and causing issues.

APPLE PHONE USERS:
GET BLOOMWATCH ON THE APP STORE

ANDROID PHONE USERS:
GET BLOOMWATCH ON GOOGLE PLAY

Regional Effort – EPA Region I



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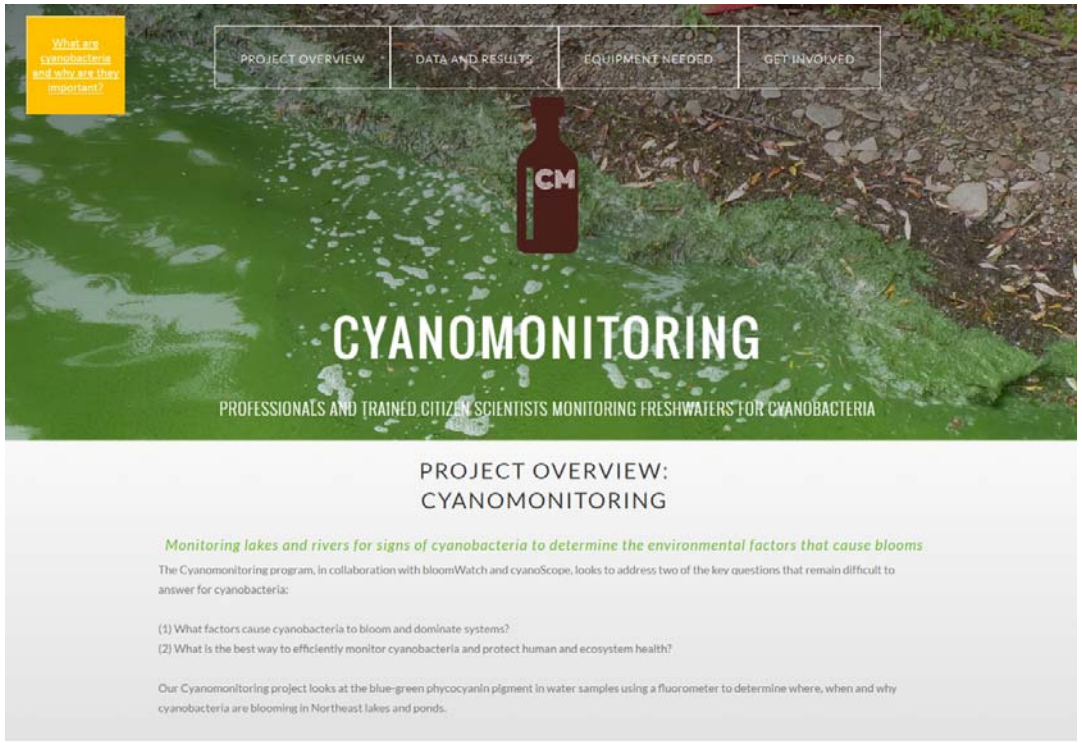

Questions?

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