Harmful Algal Blooms and Cyanotoxins in Maine Lakes

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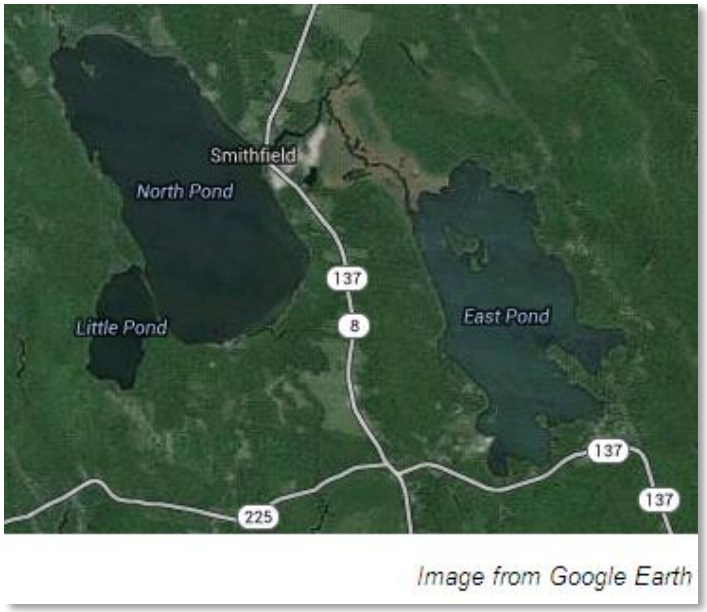
Presentation Overview

- Algae/Cyanobacteria
- Cyanotoxins
- Extent in Maine
- Recommendations

Algae

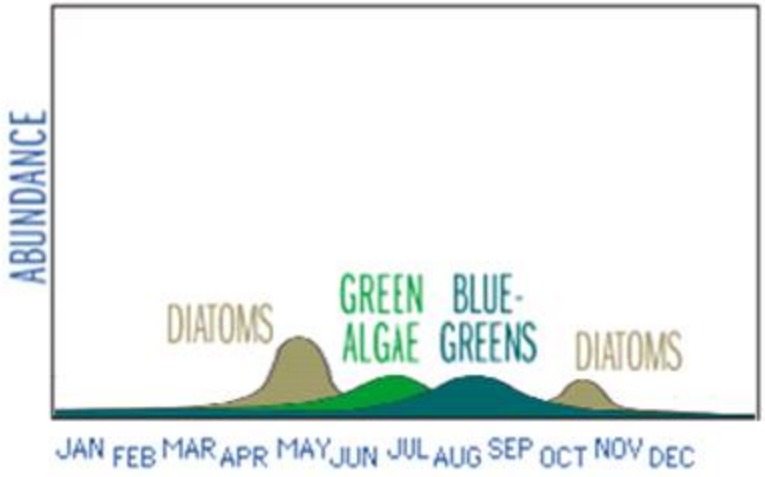
- Primary producers
- Ubiquitous
- Pops controlled by nutrient availability
- Many forms: single cells, colonies, pelagic, benthic, attached, filaments, mats



In Maine, algal populations control lake transparency

Differences in Algae Populations

Jordan Pond



Sabattus Pond

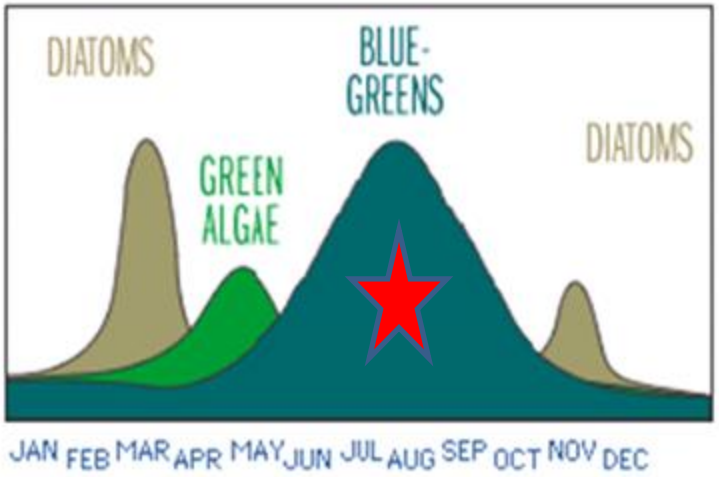
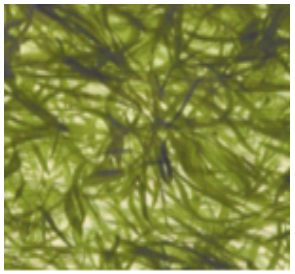


Photo taken by Brian Robertson, July 7, 2013 Jordan Pond, ANP (from Friends of Acadia Website) Jordon is the clearest lake in Maine (transparencies ~ 20 m)

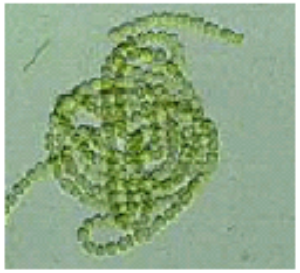
Photo taken by Scott Williams, Sabattus Pond July 21, 2014 (transparency 1 meter)

Blue-greens: algae or bacteria?

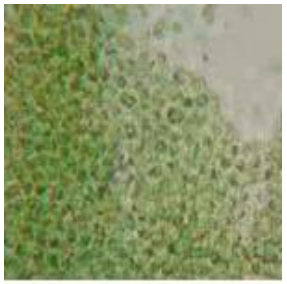
- Technically ‘blue-green’ algae, the group of algae responsible for blooms, are no longer considered algae, but photosynthetic bacteria
- Now classified as ‘Cyanobacteria’
- Both terms are still used



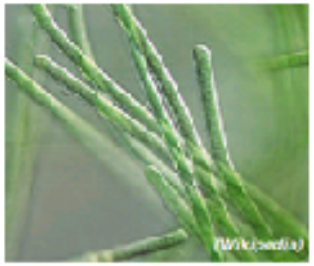
Aphanizomenon



Dolichospermum



Microcystis



Planktothrix

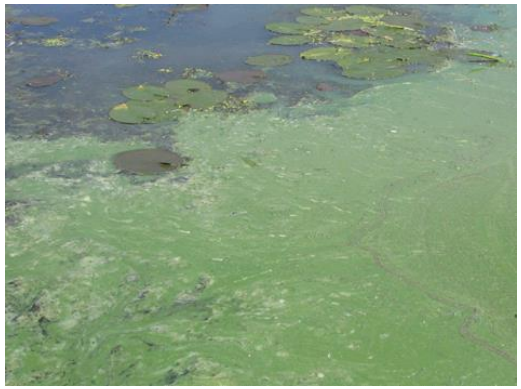
Blue-Greens are Fierce Competitors

Growth favored when nutrients plentiful - P

Some accumulate P for use later – 'luxury consumption'

Use gas vesicles to control buoyancy

Not preferred as food by zooplankton



Extended warm temperatures

Some fix N via heterocysts

Some produce resting cells

Lots of sunlight

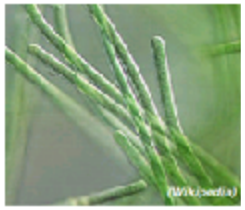
Periods of calm

Promoted by longer growing season

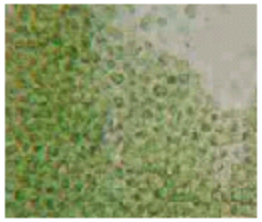
Outcompete true algae

Cyanotoxins

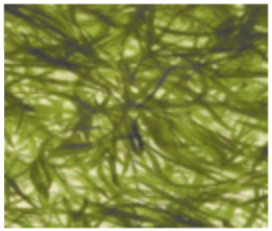
- Freshwater – from cyanobacteria
- Typically produced during severe blooms
- Blooms occur in nutrient-rich lakes
- Some blooms produce toxins – known as Harmful Algal Blooms or HABS
- Toxins
  - *Hepatotoxins*
  - *Neurotoxins*
  - *Dermatoxins*



Planktothrix



Microcystis



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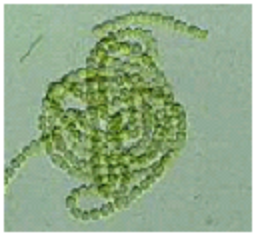


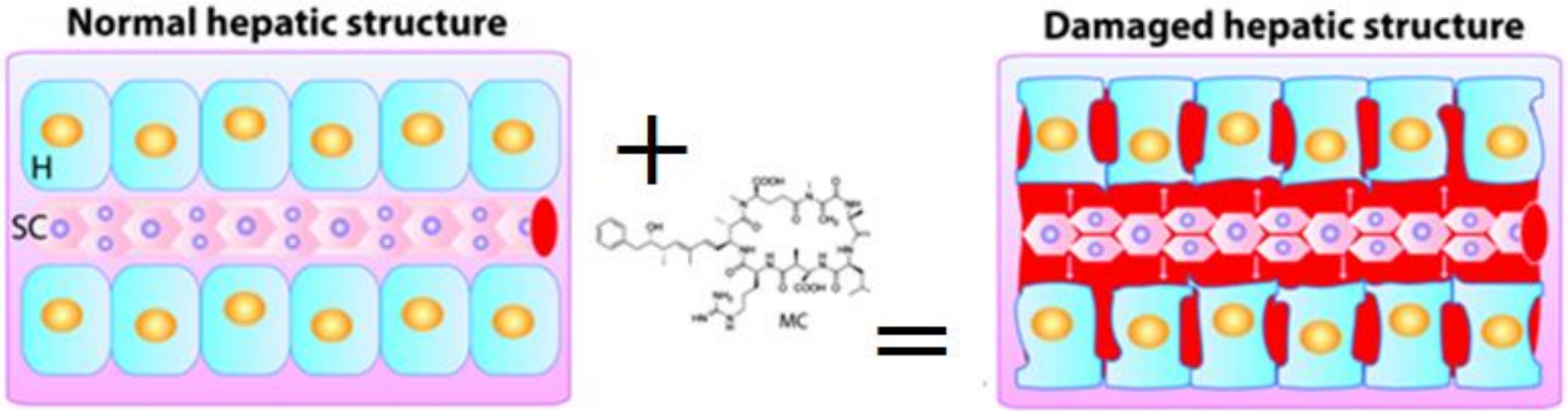
Dolichospermum

Hepatotoxins *(liver toxins)*

Effects:

- **Hours/days**
- **Acute/chronic**

- **Microcystins**
- **Nodularians**
- **Cylindrospermopsin**



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

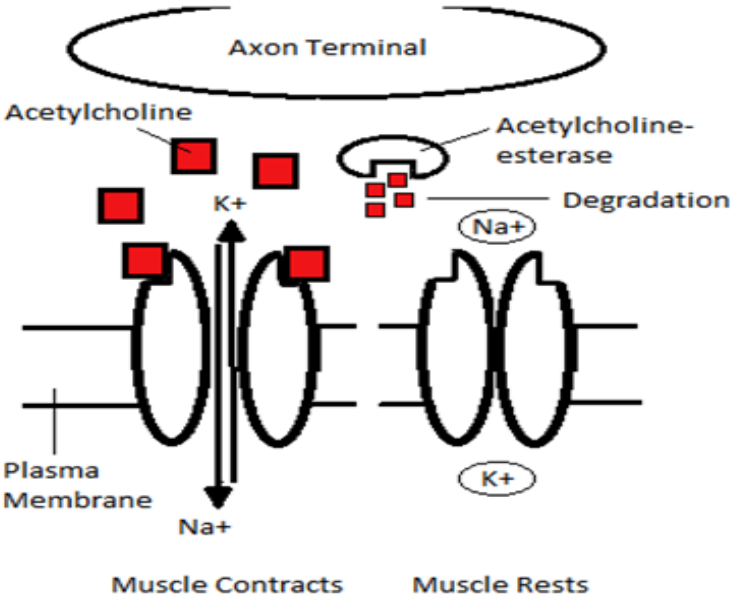
Neurotoxins *(nerve toxins)*

Effects:

- **Acute** (minutes)
  "Very Fast Death Factor"
- **Long term***

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

Muscle Twitching
Decreased Movement
Rapid Breathing
Collapse Cyanosis
Convulsions
Death



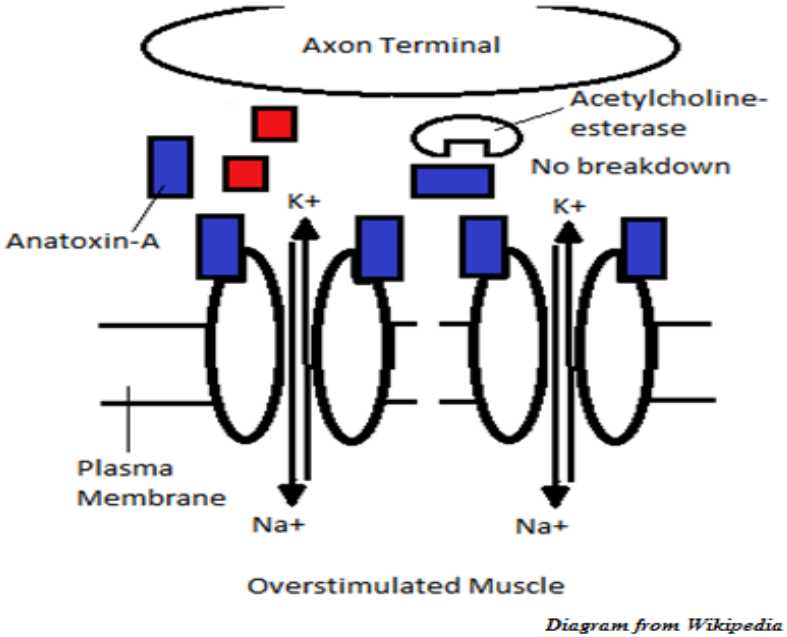


Diagram from Wikipedia

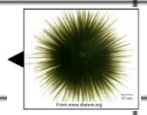
Dermatoxins *(skin irritants)*

Effects:

- **Hours/days**
- **Acute/chronic**

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

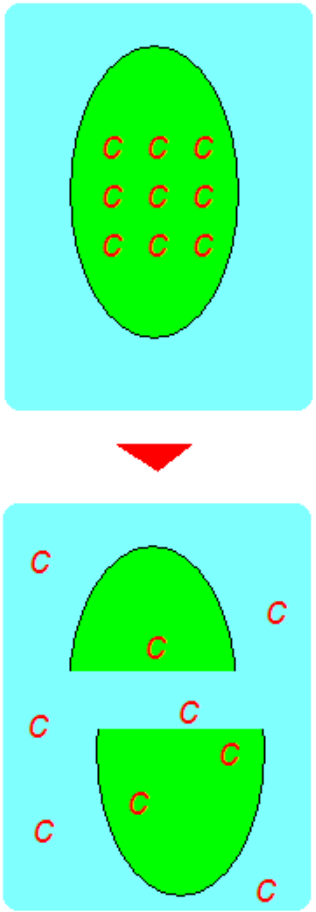
Algal Genera – Toxin Production

Genus of Algae	Toxin Produced	Type of Toxin
Dolichospermum (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

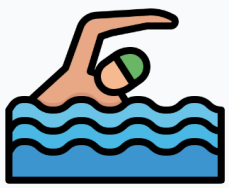
From Oregon Health Authority

Cyanotoxin Evaluation Challenges

- Spatial, temporal, & environmental factors affecting cyanotoxin production are poorly understood
- May be related to concentration, age of the bloom, years a lake has bloomed, stage of bloom, climate & /weather…
- Cyanotoxins occur within cells and may not be measurable unless cells are lysed and the toxins are released



EPA & World Health Organization exposure levels

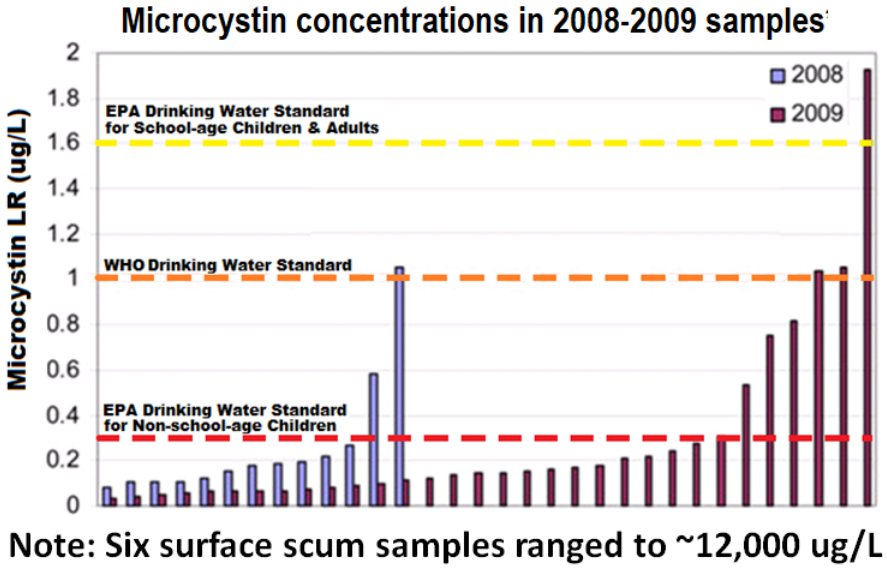


EPA microcystin health advisory levels (*10-day)	
Exposure Category	**Exposure Level**
Drinking water for infants & small children	<0.3ug/L*
Drinking water for adults & school-age children	<1.6 ug/L*
Recreation	<8 ug/L

WHO 2021 microcystin-LR provisional guideline values		
Exposure Duration	**Exposure Category**	**Exposure Level**
Chronic (long-term) term	Lifetime Guideline	0.96 µg/L (~1 µg/L)
	Tolerable Daily Intake	0.04 µg/kg/day
Short-term	Drinking Water Guideline	12 µg/L
	Recreation Guideline Value	24 µg/L

Microcystin Study

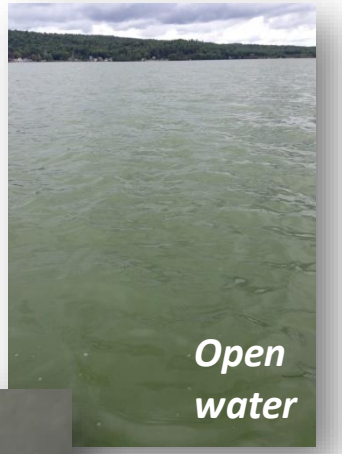
- 2008-2009 – Pilot
  - Targeted blooming lakes
    - *Which toxins?*
    - *Concentrations?*
- 2014-2019
  - Probabilistic
  - Targeted - *time series*
  - Opportunistic
- 2020 - Revisits

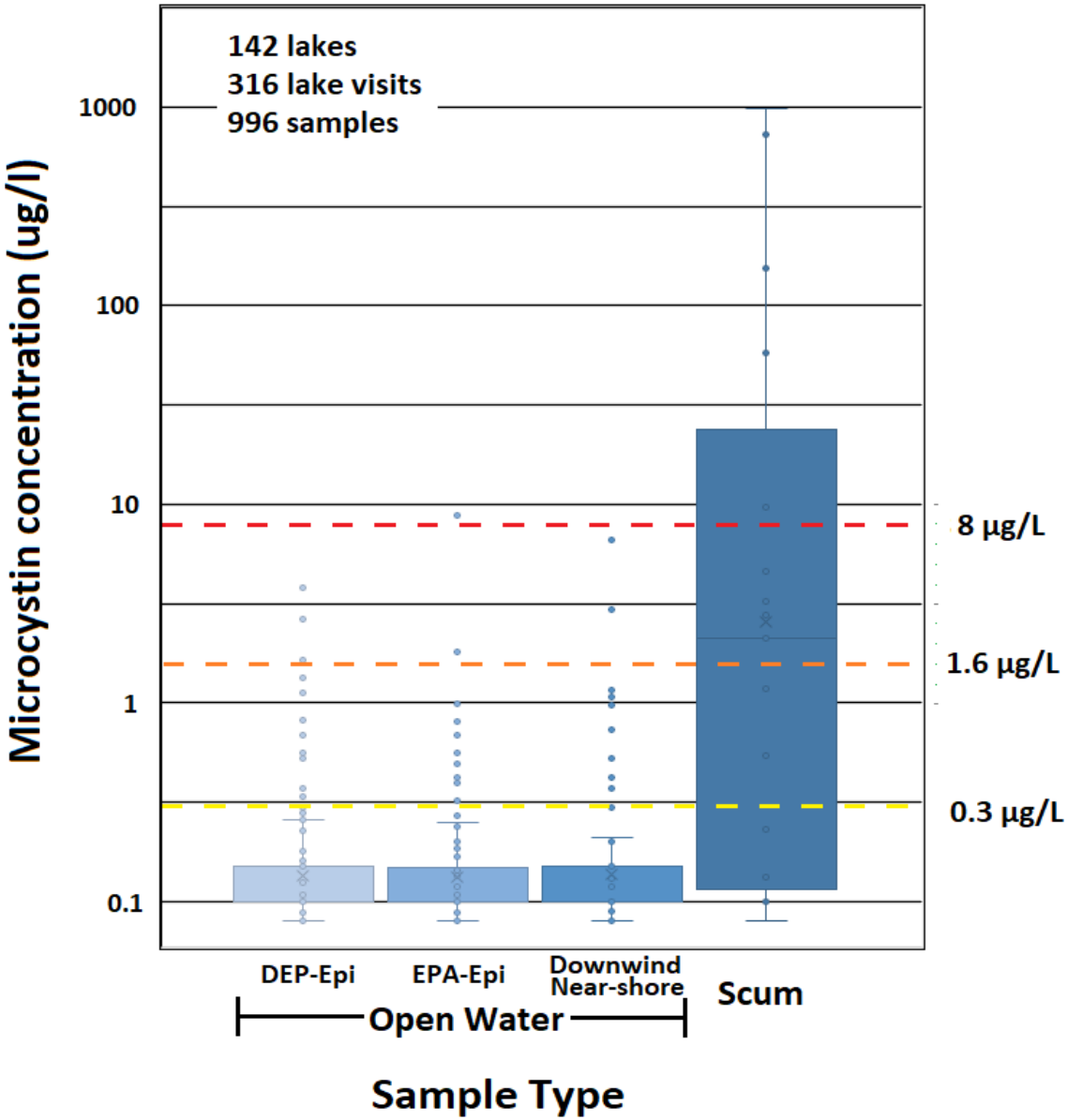


Note: Six surface scum samples ranged to ~12,000 ug/L

2014-2020 Monitoring

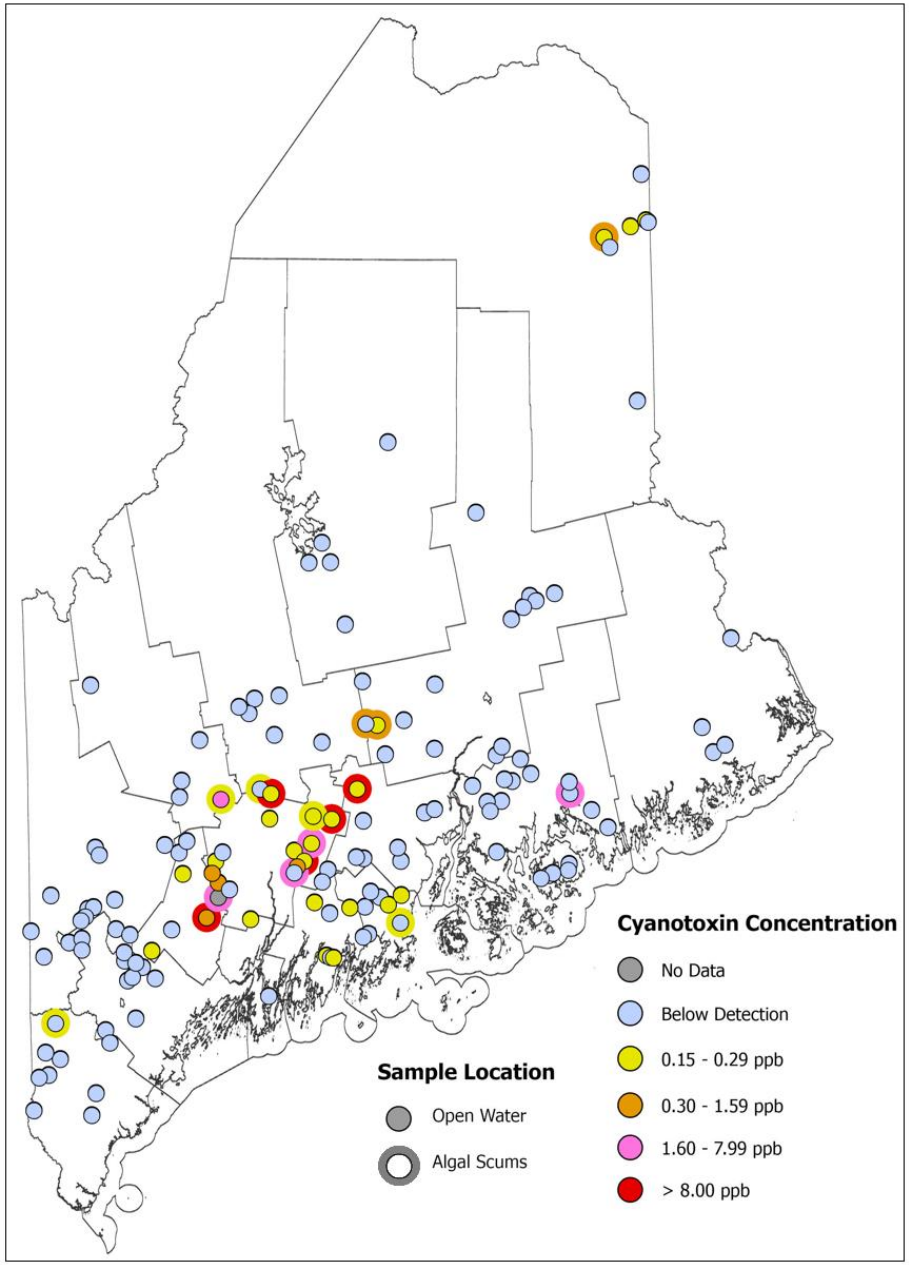
- Late summer baseline period
- Open water
  - Deep hole epilimnetic core samples
    - *(DEP & EPA protocols)*
  - Downwind shore samples
- Downwind scum samples
- 60 mL samples – *frozen until analyzed*
- Phytoplankton (& SDT, DO, Chl-a, TP)




142 lakes
316 lake visits
996 samples
Microcystin concentration (ug/l)
1000
100
10
1
0.1
8 µg/L
1.6 µg/L
0.3 µg/L
DEP-Epi
EPA-Epi
Downwind Near-shore
Scum
Open Water
Sample Type

Microcystin Results from 142 Maine Lakes

- 142 lakes
- 316 lake visits
- 996 samples



Microcystin in 376 open-water samples from 126 probability-draw lakes

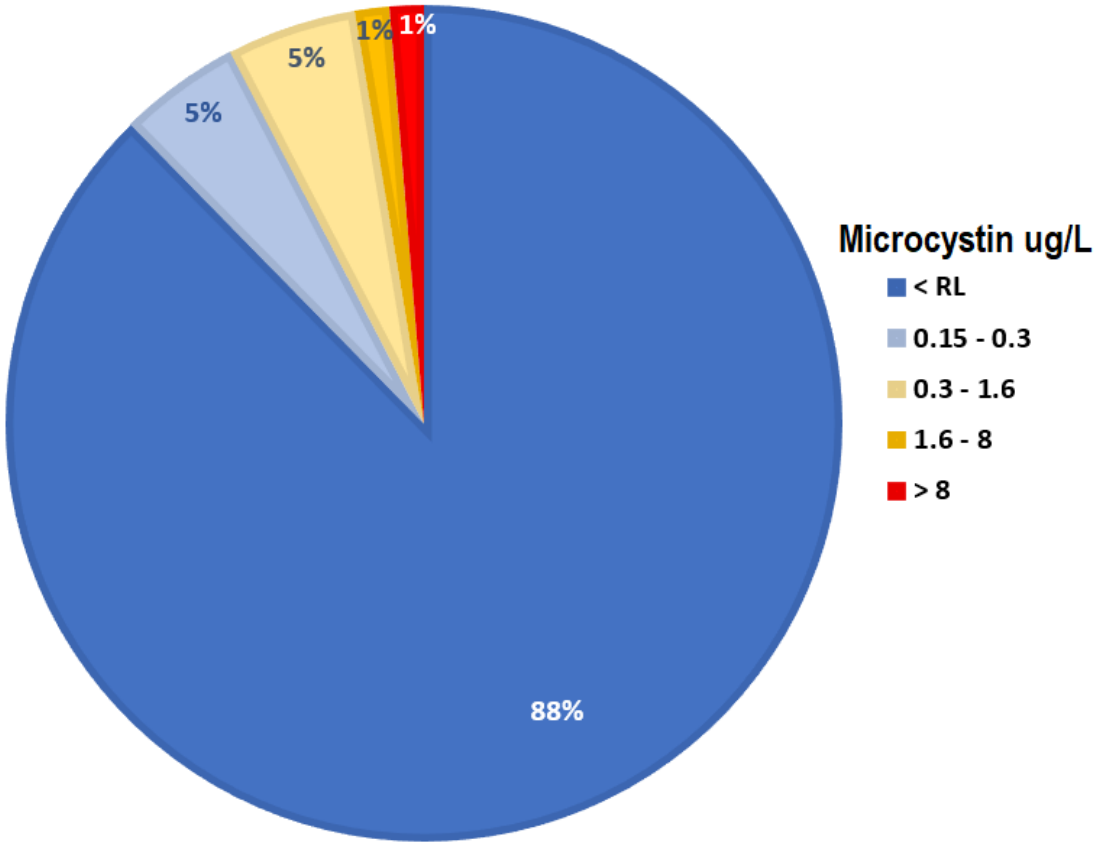
EPA health advisory levels:

<0.3ug/L* Drinking water for infants & small children

<1.6 ug/L* Drinking water for adults & school-age children

<8 ug/l Recreation

*10-day



Microcystin in 6 scum samples from 126 probability-draw lakes

EPA health advisory levels:

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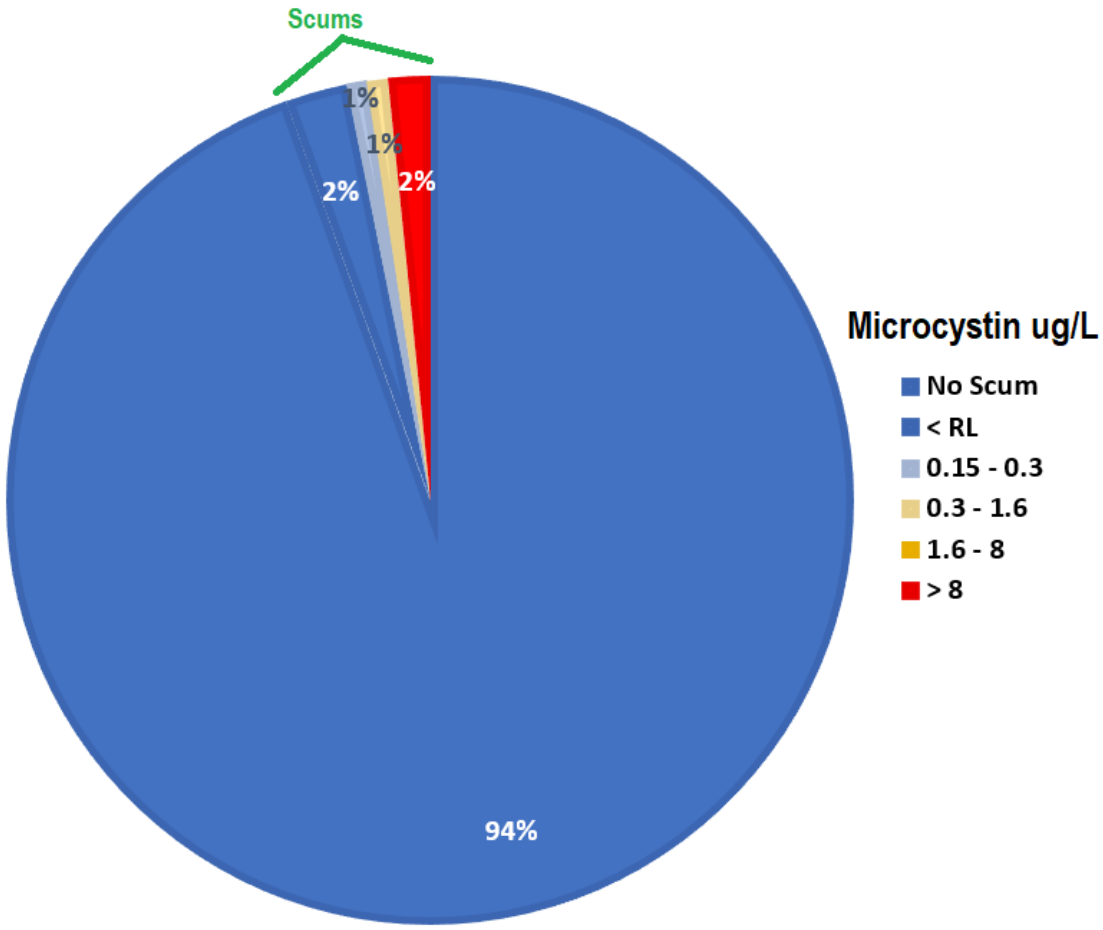
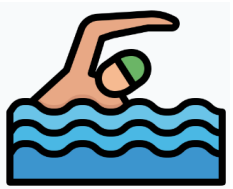


Statistical Analysis

A lake is more likely to produce microcystin when:

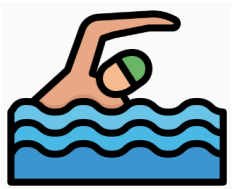
- It has supported algal blooms for many years
- Water samples have elevated chlorophyll and phosphorus
- And Secchi disk transparency (water clarity) is low

Maine's approach



- No waterbody-specific advisories at this time
- Most open-water samples below EPA's DW health advisory & Rec standard
- Maine CDC already discourages folks from drinking any untreated surface waters
- Exceedance of rec standards occurs mostly in scum samples covered by the general HABs advice to avoid scums
- EPA's rec standards are based on incidental ingestion of water from a young child swimming and thus is an extremely conservative estimate of actual exposure (e.g., someone boating or fishing out in the open water should really have much incidental ingestion)

Maine's approach (cont.)



- A lake-rich state like Maine and the temporal nature of HABs, managing waterbody specific advisories would be extremely challenging
- General HABs guidance, possibly including information about waterbodies that are known bloomers, is going to be a more workable approach (similar to what is posted on DEP website)
- If municipalities or lake associations want to issue their own advisories or post lakes that are blooming and are known to have elevated microcystin results, they have that option

per Maine CDC

Challenges

- Media hype & panic over any algae
- Clear, consistent messaging
  - In 2017 DEP posted a list of lakes that have ever bloomed, which was misinterpreted by the press and public
- Populations that don't speak English

DEP Phones…

…begin to ring mid-summer…

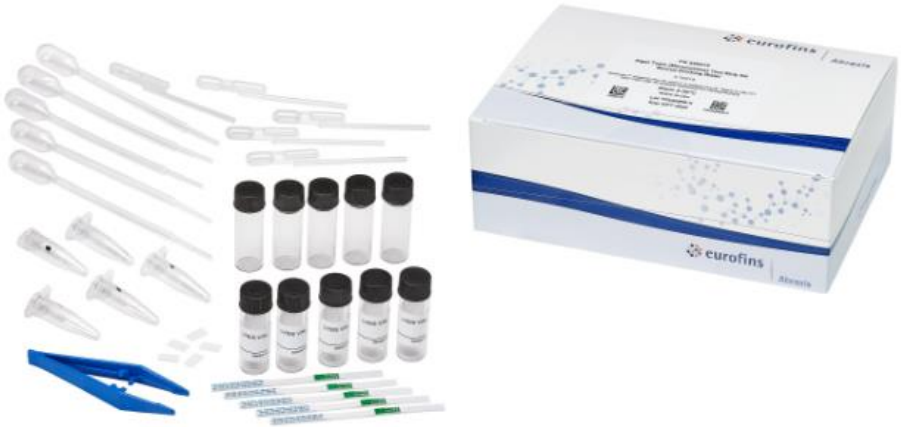
- Is my lake safe to swim in?
- My dog got sick
- My dog died *(cyanotoxins OR Leptospirosis OR water intoxication OR THC ingestion OR…)*
- Which lakes are safe?
- How often is testing done?
- I just bought a house on ……

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. (NOTE: Domestic water treatment systems are not guaranteed to remove algal toxins, but filtration and activated charcoal filters may reduce risk.)

https://www.maine.gov/dep/water/lakes/algalbloom.html

Abraxis Tests and Strip Reader



ABRAXIS® Dipstick with QuikLyse® Feature

Microcystin

- **Source Water**
  - 0-5 ppb
  - Increments of 0, 0.5, 1, 2.5, and 5 ppb
- **Recreational Water**
  - 0-10 ppb
  - Increments of 0, 1, 2.5, 5, and 10

Anatoxin

- **Source Water**
  - 0-5 ppb
  - Increments of 0, 0.4, 1, and 2.5 ppb

Available in quantities of 5 or 20

Pros and Cons of Abraxis Dipsticks

- **Pros**
  - Fast results
  - Simple procedure
  - Portable
- **Cons**
  - Discrete measurement
  - Ranges may be too broad
  - Shelf life
  - $$$
  - Analyst detail-oriented

Climate Change + Land Use Change = Pressure on Maine's Aquatic Resources

- Extreme weather
- Warmer air –> warmer water
- Ice phenology
- Longer growing season
- Browning of waters
- Pred/prey asynchrony
- Invasive species
- Climate migration
- Development pressure
- Inadequate infrastructure
- Antiquated ordinances/laws/regs

Adaptation includes increased protection!

Contact:

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www.maine.gov/dep