The 20 questions in 40 min everything you wanted to know about toxic algae but were afraid to ask talk.

Greg Boyer

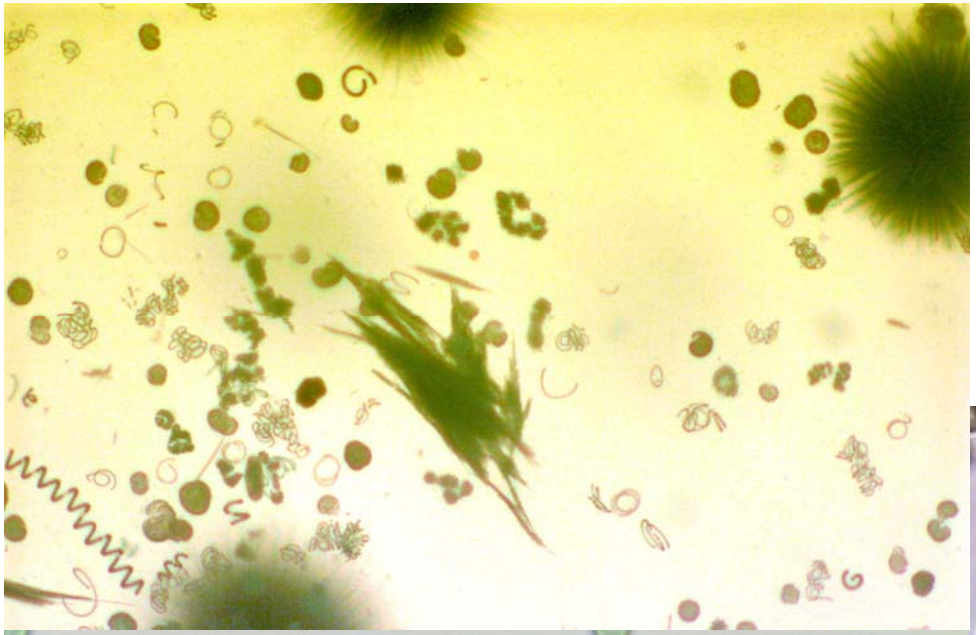
State University of New York
College of Environmental Science and Forestry, Syracuse, NY

Q1. Who am I?

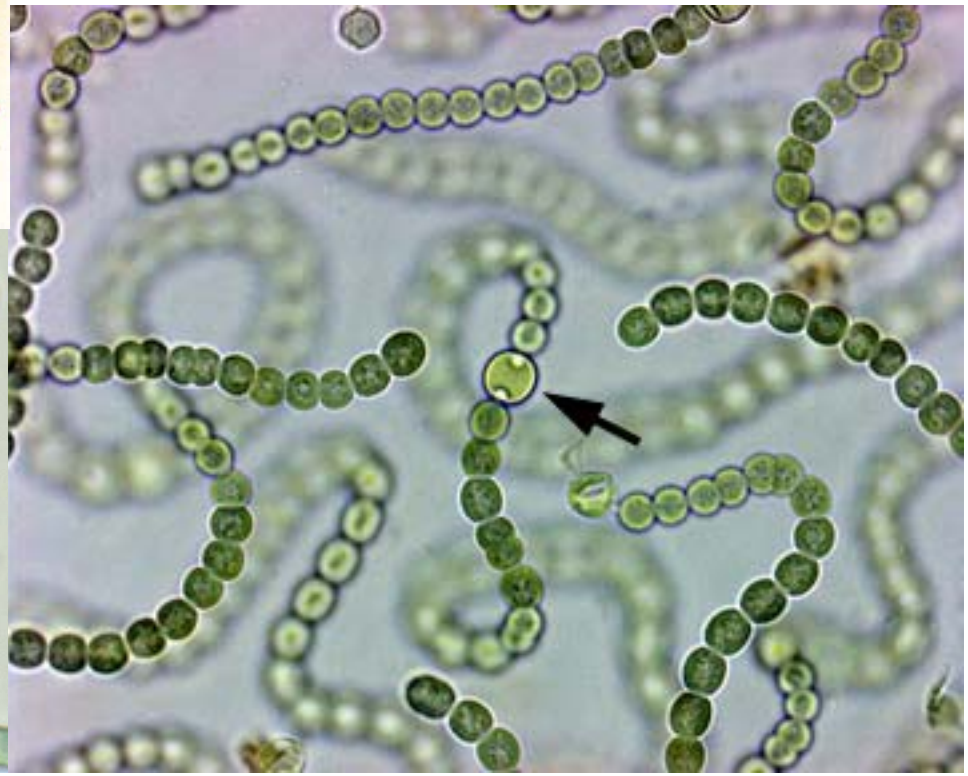
- Professor in Chemistry Department at SUNY-College of Environmental Science and Forestry (Syracuse)
  - Member water quality group
- Director of the Great Lakes Research Consortium (18 Universities)
- Research Scientist on Algal Toxins
  - 40 years experience (worldwide)
  - Analytical Chemist for CSLAP
  - NOAA Rapid Response Lab
  - Environment Canada toxins team
  - NYSDOH, WDOH, CDC, etc.

Interested in why algae produce toxins.

Q2. What are blue-green algae?



Specialized photosynthetic prokaryote (bacteria) called "Cyanobacteria"



Q3. What is a Harmful Algal Bloom (HAB) and can I recognize it?

Blue and white crust forming on bloom that is decaying

Lake Champlain

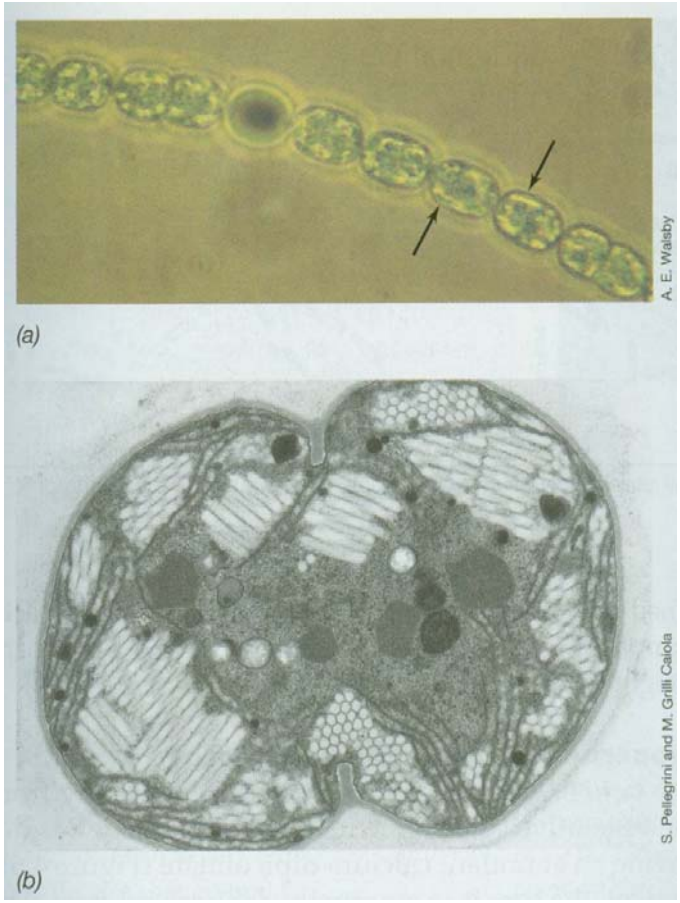
Blooms often concentrate at the shoreline or along docks.

Blue tint within algae bloom

Small cells spread throughout the water column

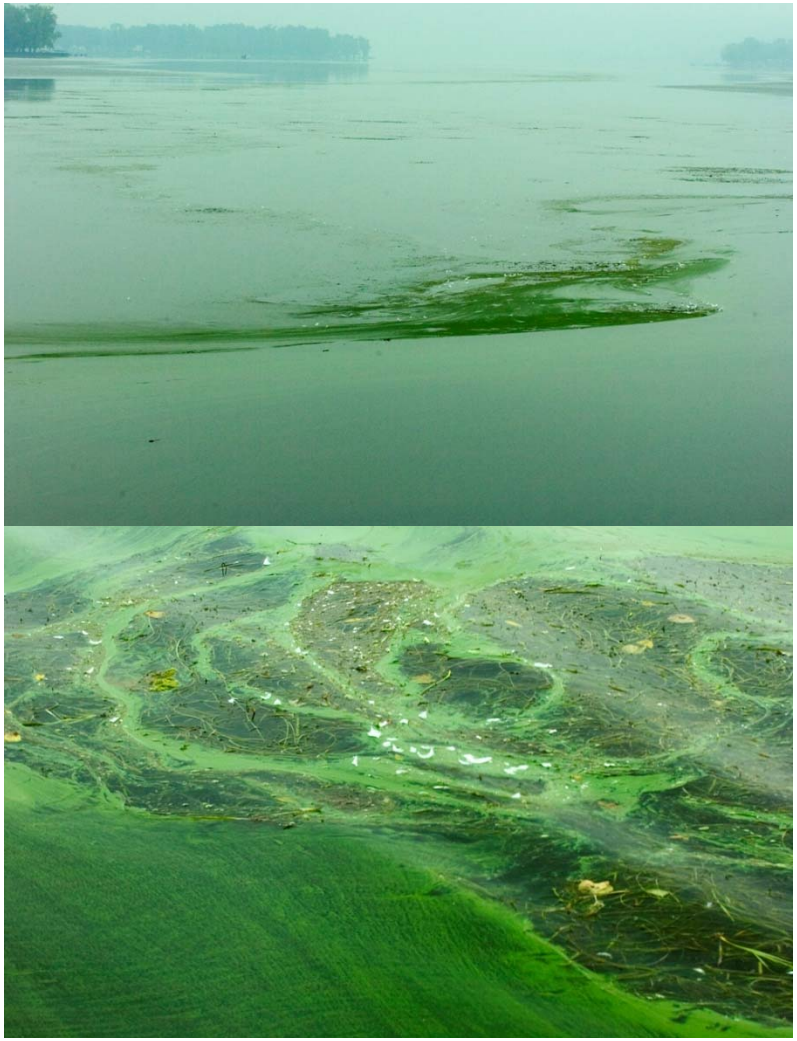

Lake Champlain

Blooms form surface accumulations



Gas vesicles in Anabaena and Aphanizomenon

Conesus Lake



Not every bloom or every scum is cyanobacteria. .

Spirogyra and *Mougeotia*

Green (and Slimy) Algae

Duckweed (higher plant)

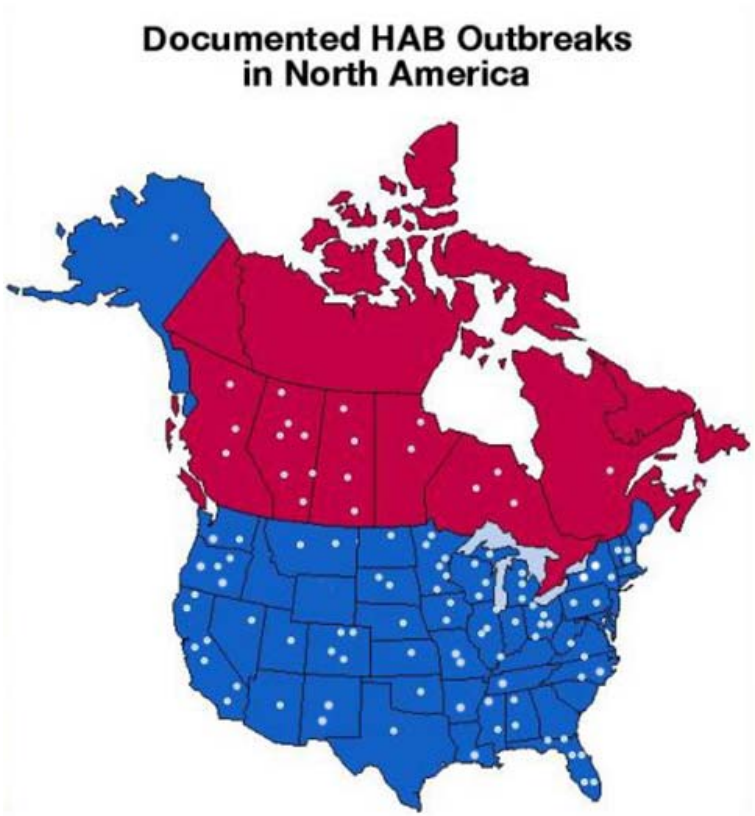
Pollen
(higher plants)

Probably not cyanobacteria if…

- Material is bright green in color
- Consists of long cohesive strands
- Is attached to rocks, debris or the sediment surface rather than free-floating
- Has leaves or other “structures”

Point – Can not be sure it is cyanobacteria without looking under a microscopic.

Q4. Are harmful algal blooms (HAB) unique to our area?



Modified from USEPA, Adv. Exp. Med. Biol. 2008

No!

"And all the waters that were in the river turned to blood. And the fish that were in the rivers died; and the river stank, and the Egyptians could not drink the water of the river, . . ."

Exodus 7:20-21

Hamilton Reservoir, Platte River Power Authority, Fort Collins, CO

Q5. Why do algae grow?

NUTRIENTS

Nutrients (N,P) usually come from the land as run-off.

LIGHT

Algal GROWTH

GRAZING ↑↓

WARM TEMPERATURE

Water > 60 C

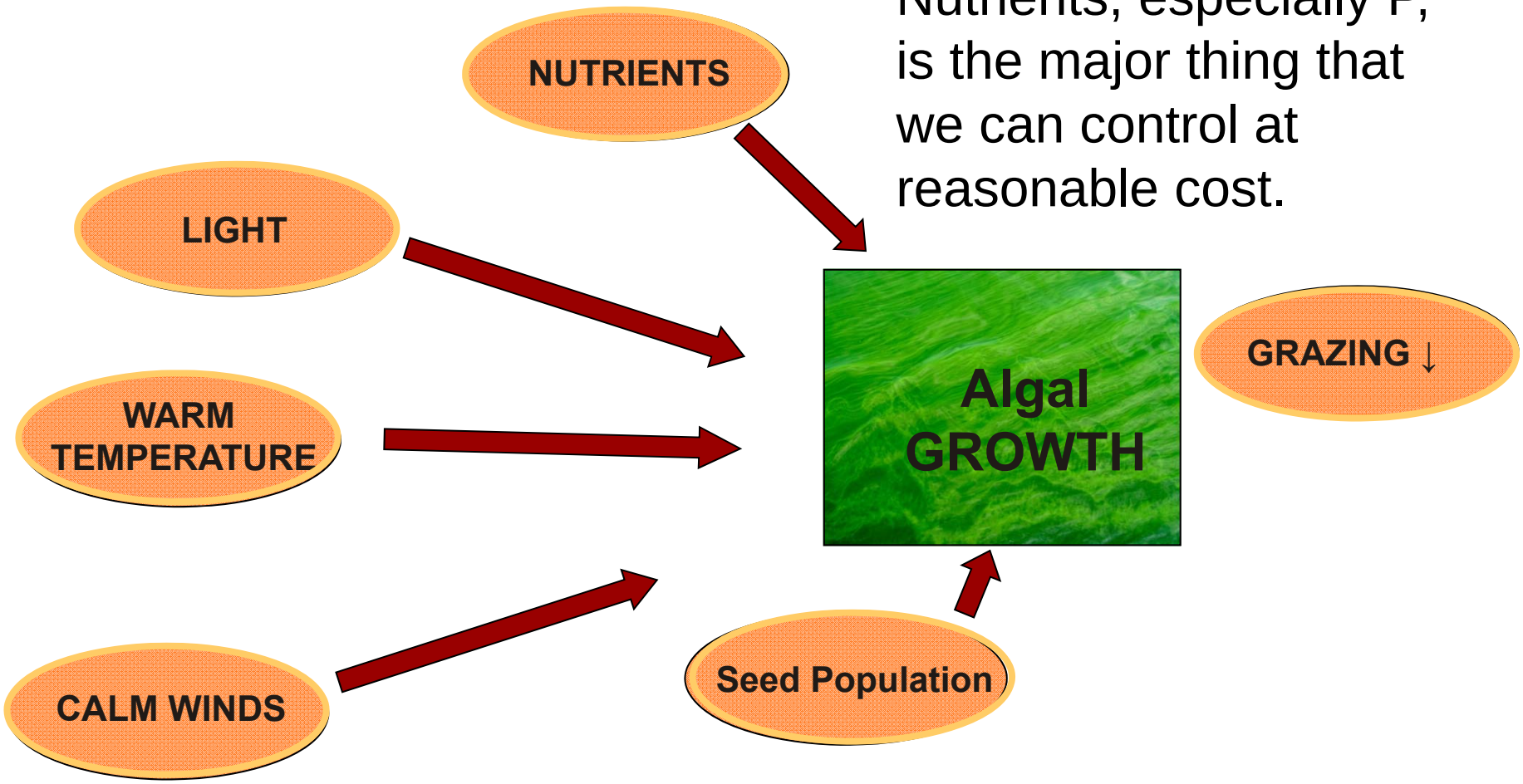
CALM WINDS

Seed Population

Many of these factors will increase in current climate change models.

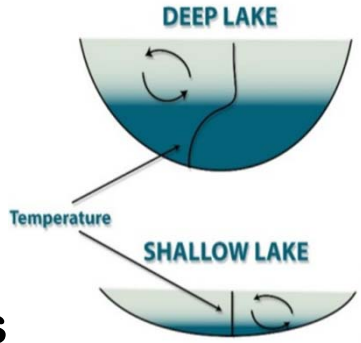
Q6. What can we do about it?

Nutrients, especially P, is the major thing that we can control at reasonable cost.



Q7. Why are they called Harmful?

- Cyanobacteria are a common member of the aquatic flora!
- <u>Some</u> (not all) produce:
  - liver toxins (heptotoxin).
  - Neurotoxins
  - Other nasty compounds
  - Swimmers itch
  - Alzheimer's-like agents.
- When they die – it uses up oxygen.



Especially important in stratified lakes

Q8. Has anyone ever died from these toxins?

Not in the US. Most affects are with animals:

…….associated with the *Anabaena Flos-aquae* bloom were estimated deaths of 5000-7000 gulls, 560 ducks, 400 coots, 200 pheasants, 50 squirrels, 18 muskrats, 15 dogs, 4 cats, 2 hogs, 2 hawks, 1 skunk, 1 mink, plus numerous song birds.

Storm Lake, Iowa, 1952

Q9. Has anyone ever gotten sick in the US from blue-green algae?

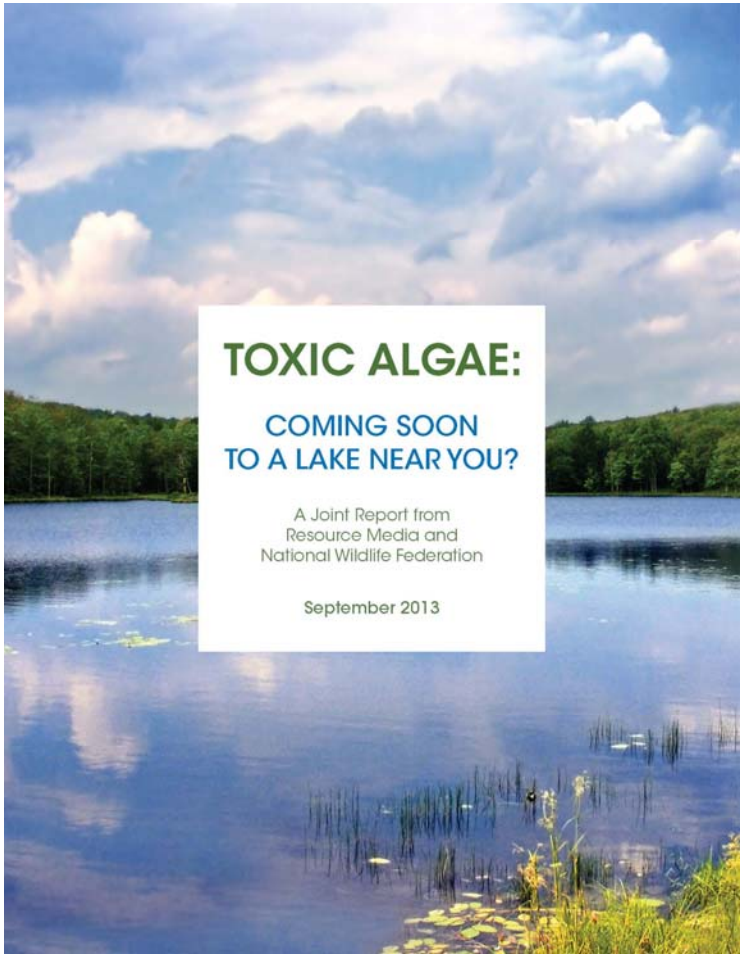
Coroner Cites Algae in Teen's Death . . . Experts are Uncertain About Toxin's Role

September 2003, After a yearlong investigation, the Dane County, WI coroner has concluded that the….

Absolutely!

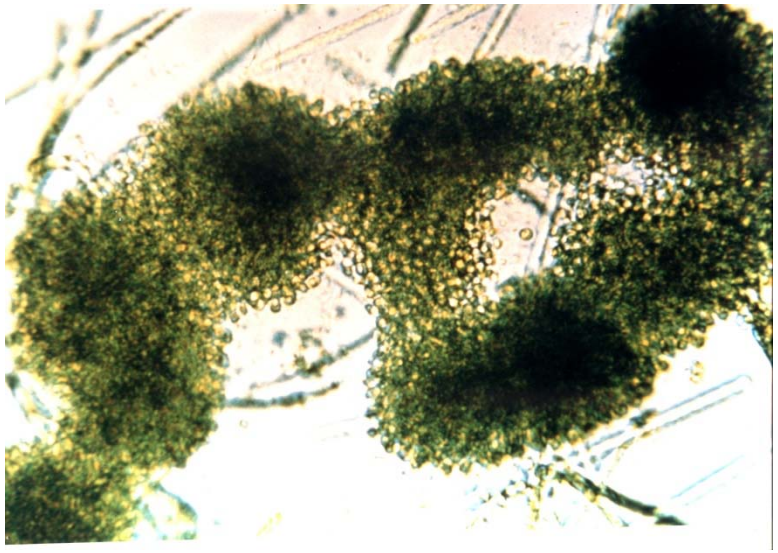
- 1930: *Microcystis* bloom on Ohio and Potomac Rivers caused intestinal illness in 5,000-8,000 people.
- 1980: Several cases of illness in Pennsylvania following a bloom.
- 2004: Approximately 50 people reported illness following exposure to toxic cyanobacterial blooms in Nebraska lakes and reservoirs.
- 2010: Seven people ended up in the Toledo hospital following exposure to toxic cyanobacteria in Grant Lake St. Marys (Ohio).
- 2014: Toledo – hundreds of people called into the hospital due to BGA toxins even though the levels where well below any health effects

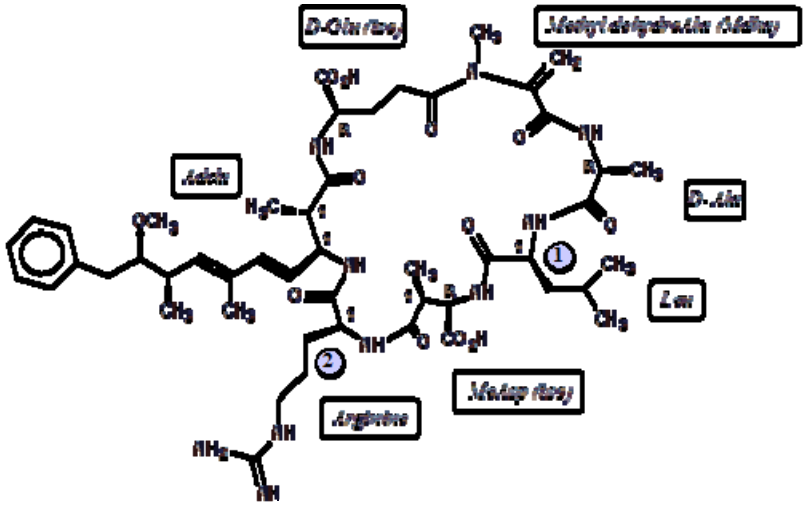
10. How widely recognized is the threat from cyanobacteria blooms?



- A 2013 Joint Report from Resource Media and the National Wildlife Federation reports that HABs strike all areas of the US.
- **National Lake Assessment** in 2007 included microcystin testing for the first time.
  - Microcystins found in 30% of Lakes.
- AWWRF study (1998) found MC in 80% of drinking water supplies tested.

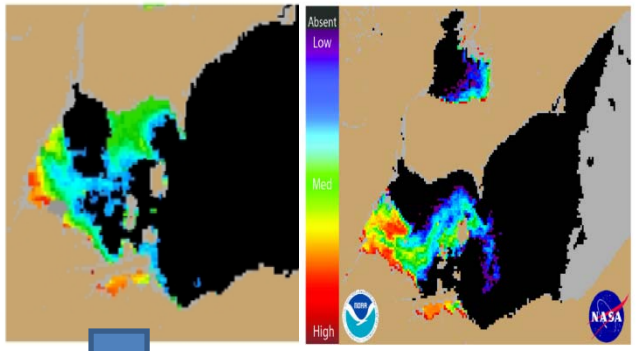
Q11. Tell me more about the *Microcystis* and microcystins





- *Microcystis aeruginosa*
  - non-N fixer.
  - Likes organic N
  - forms surface blooms
- Very common genera
  - Toxin also produced by a number of other species.
- Large variation in toxins
  - 100+ structural variants + 500 toxin-like peptides
- Microcystins are liver toxins (LD_{50}: 25-60 $\mu g\ kg^{-1}$)
- Toxin is very stable to boiling

12. So what happened in Toledo in August 2014?



State of emergency declared in Lucas County after toxins found in Toledo water - Toledo Blade#o1BSAaAKupv3UuW0.03

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Print Story

Published: Saturday, 8/2/2014 - Updated: 2 seconds ago

State of emergency declared in Lucas County after toxins found in Toledo water

Microcystin found in samples; boiling not recommended

BLADE STAFF

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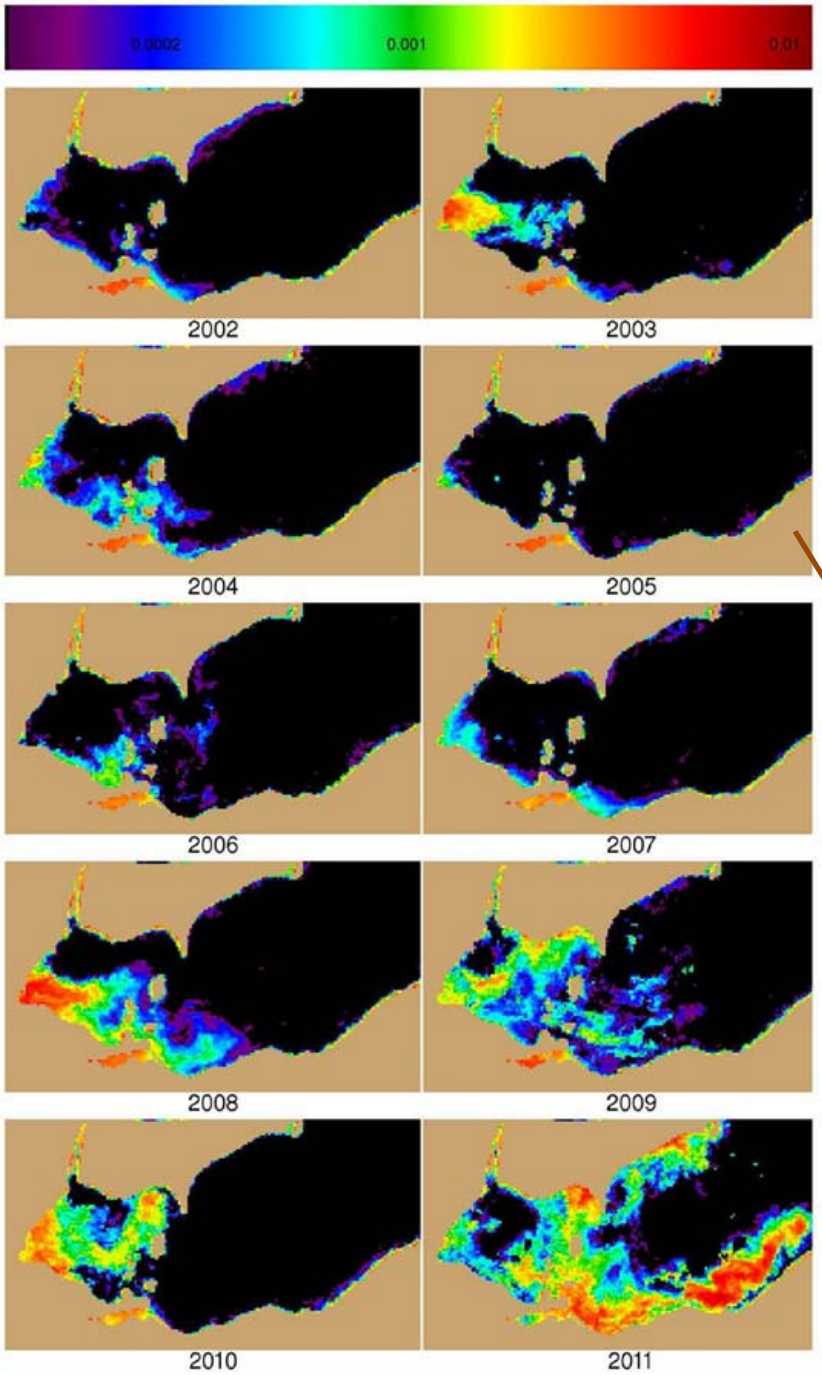
Scenes like this were common this morning as area residents traveled all over in search of bottled water.
THE BLADE/ JETTA FRASER Enlarge | Buy This Photo

A state of emergency was declared today in Lucas County and the greater Toledo area after tests at the Collins Park water-treatment plant in East Toledo produced two toxin sample readings.

Chemists testing water at Collins Park plant found two sample readings for microcystin that exceeded the recommended "do not drink" standard of one microgram per liter standard.

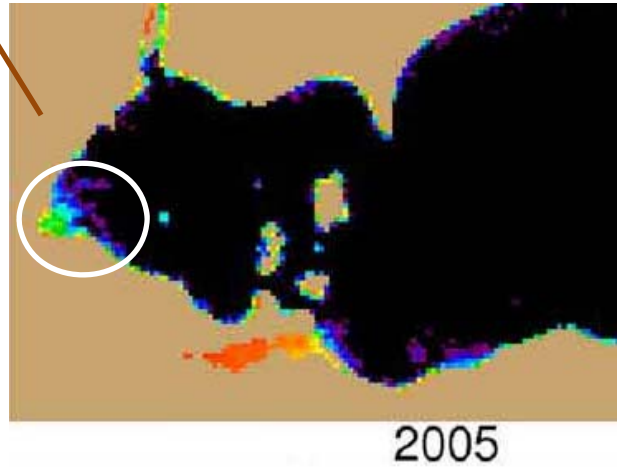
Toledo Mayor D. Michael Collins and health leaders asked residents to remain calm and said they may have answers later today on when Toledo-area water supply will be safe to drink again.



These blooms occur every year:

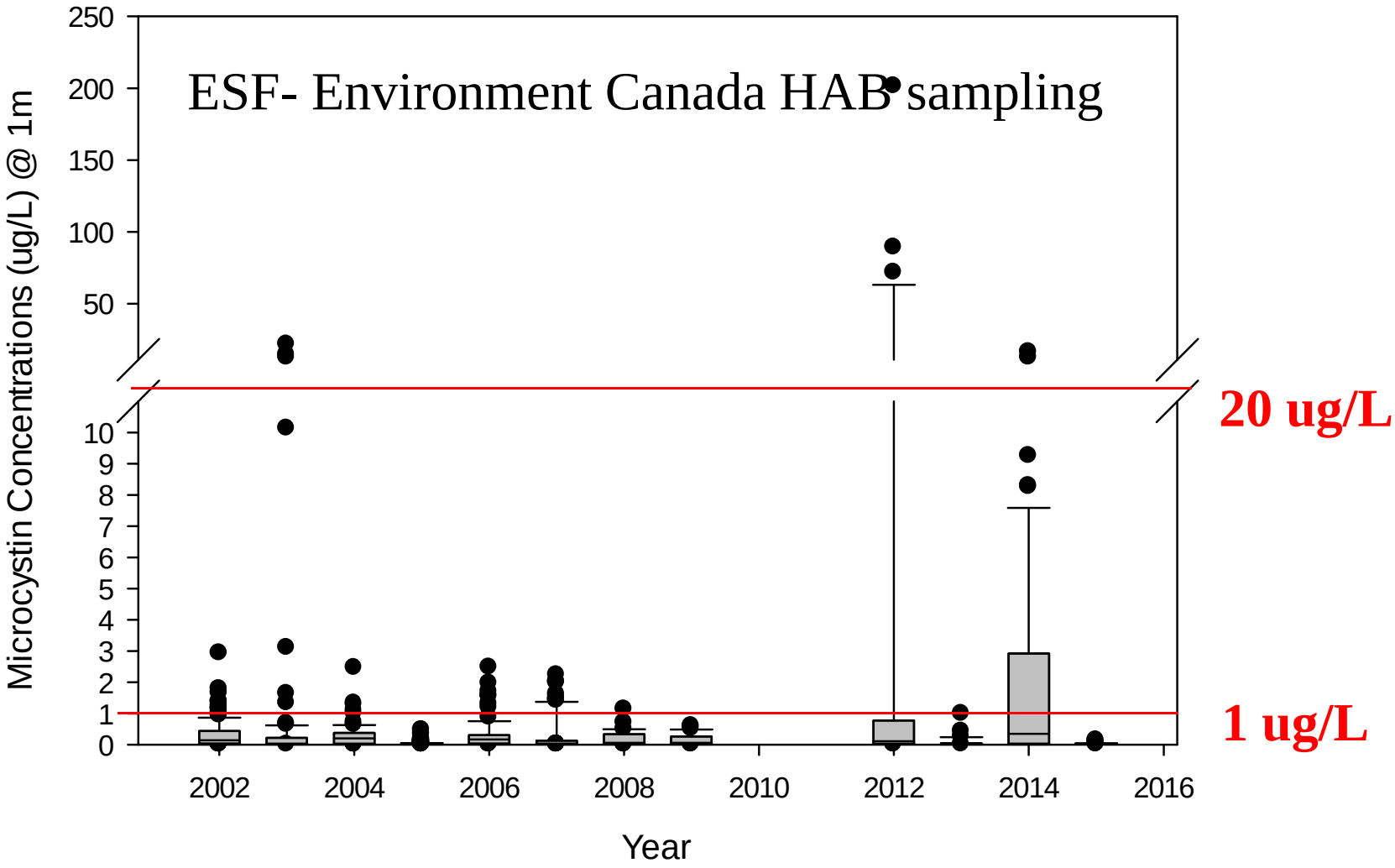
- MERIS Imagery, cyanobacteria index
- Blooms generally peak in August

- Generally associated with the appearance of dreissenids in the Lake in the late 1990. Fed by phosphorus coming out of the Maumee River.



Stumpf et al. (2012). Interannual variability of cyanobacterial blooms in Lake Erie. *PLoS ONE*, *7*(8).

In the Lake Erie – it is not a matter of if it is toxic, but simply how much….



Let's start in 2013…….

Carroll Township's scare with toxin a 'wake-up call'

Water plant shut over lethal microcystin from algae

BY TOM HENRY
BLADE STAFF WRITER

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Henry Biggert is confident he 'made the right call' to shut down the Carroll Township Water Plant when he detected microcystin, a potentially lethal toxin.
THE BLADE/JETTA FRASER
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OAK HARBOR, Ohio — They got lucky.

The 2,000 residents of Ottawa County's Carroll Township who were told to avoid their tap water last weekend can thank one person — not any one of America's thousands of state and federal health laws — for sparing them from sickness, possibly even death.

Henry Biggert, the township's water plant superintendent since it went online in 1998, knew he had to act fast when he saw microcystin, the potentially lethal toxin in Lake Erie's harmful, blue-green algae known as microcystis, spike to a level beyond plant capability Sept. 5.

Fall 2013

- *Microcystis* HAB in the western basin of Lake Erie
- Carroll Township WTP's intake, 1000m offshore sucks up Bloom.
- Levels of microcystins in <u>finished</u> water reach 3.6 ug/L.
- Few outside of Ohio heard about it.

Initial Conditions, 2014

Published: 7/26/2014 - Updated: 1 day ago

LAKE ERIE

Algae season starting now, will continue into October

BY TOM HENRY
BLADE STAFF WRITER

Algae is expected to be seen on Lake Erie through October.

Western Lake Erie's 2014 algae season is upon us.

From now through October, residents need to avoid swimming or r
has a distinctive pea-green hue to it, as well as green water they r
the Maumee River, the Tiffin River, and the Sandusky River.

They need to be careful not to accidentally ingest it or let their dog

The lake's most prevalent form of algae, microcystis, is a neurotox
fatal in large enough doses. Scientists have found in recent years

Residents are advised to keep their distance in general, because r
inhaled, especially when water is agitated. The aerosol can make
coming in contact with the water or ingesting it.

The state of Ohio put out its first algae advisories of 2014 along La
Lake Erie beach at Maumee Bay State Park.

Toledo Blade
July 27th

- High spring run-off and nutrients from the Maumee River enter the western basin.

HOME → NEWS → LOCAL

Print Story

Published: Thursday, 7/24/2014 - Updated: 5 days ago

Toxin level found in area water not harmful to residents

But EPA director says standard should be set

BY TOM HENRY
BLADE STAFF WRITER

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Brian Boberg, construction supervisor with ARCADIS, talks about the Oakdale Miami storage basin site to, from left, Bob Stevenson, resource manager at ARCADIS; Alan Ruffell, Toledo manager of operations; Edward A. Moore, director of Toledo Public Utilities, and Chris McGibbeny, Division of Water.
THE BLADE/AMY E. VOIGT Enlarge | Buy This Photo

Ohio Environmental Protection Agency Director Craig Butler got a whirlwind tour of Toledo-area water projects Wednesday, five months after Gov. John Kasich appointed him to be the state's top environmental cop.

Mr. Butler, an Ohio EPA employee for 25 years, served under six state EPA directors before Mr. Kasich picked him in January as the interim director. The governor elevated Mr. Butler from interim to permanent status on Feb. 21.

Mr. Butler saw laboratory evidence documenting the return of a toxic form of algae, microcystis, which has plagued western Lake Erie nearly every summer since 1995.

Doug Wagner, Oregon water superintendent, ran tests on Oregon's raw water and that of other systems, including the Port Clinton-based Ottawa County

- Low levels of toxins are found off-shore, but not at levels of concern

Initial Conditions

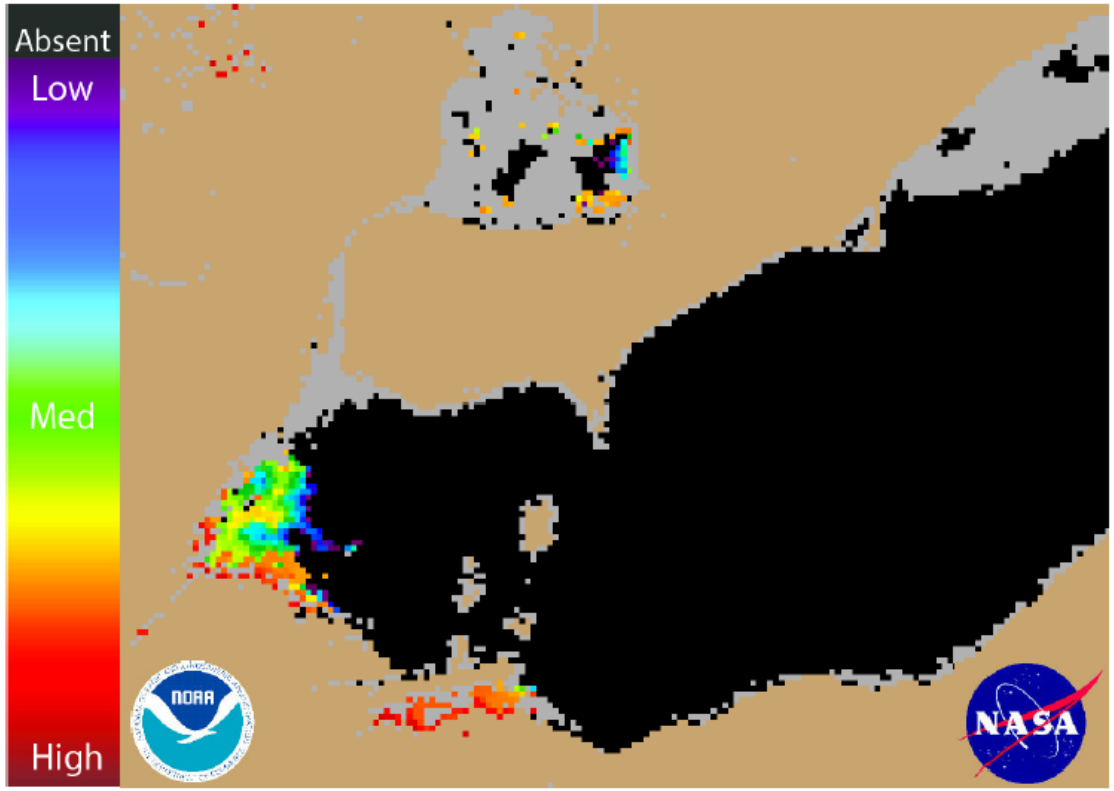
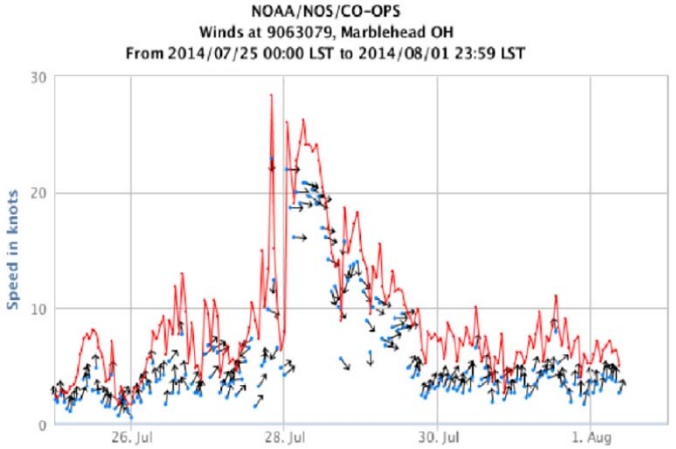


Figure 1. Cyanobacterial Index from NASA's MODIS-Aqua data collected 31 July 2014 at 2:30 pm.

- Bloom of *Microcystis* in the Western basin continues to grow.
- Wind events mix bloom throughout the water column



Experimental Lake Erie Harmful Algal Bloom Bulletin 2014:009

August 1st, 2014 (Friday)

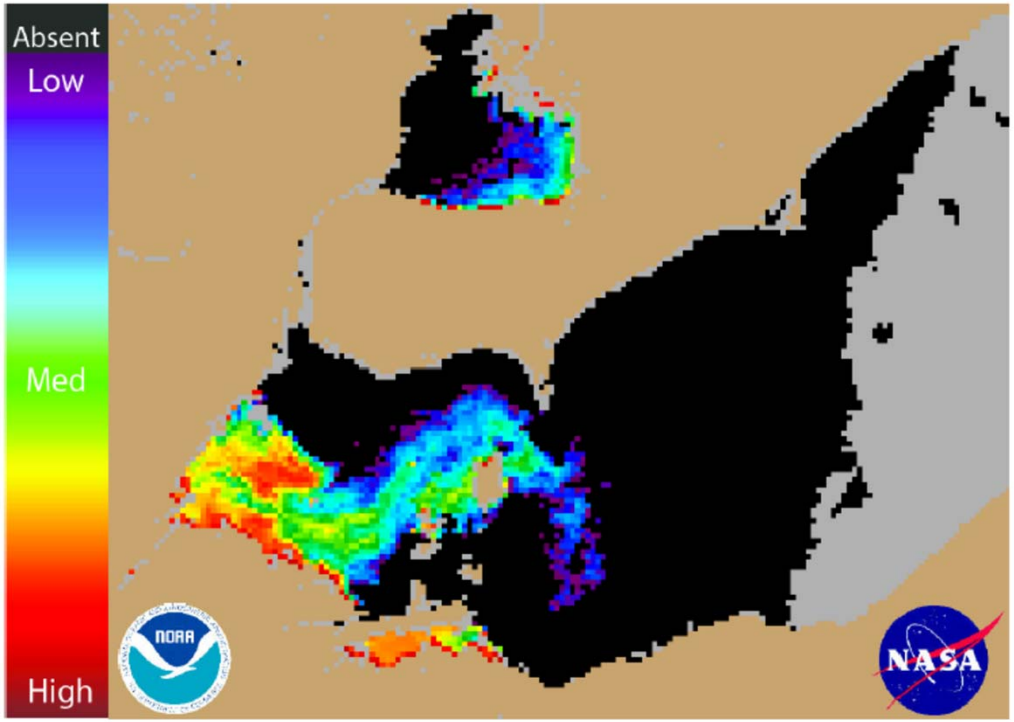


Figure 1. Cyanobacterial Index from NASA's MODIS-Aqua data collected 3 August 2014 at 1:10 pm.

- Strong winds Northeast pin the bloom to the Southern Shore near the water intake
- Initial readings show MC values >5.5 in raw water (top of standard curve) in raw water.
- Measurable levels 0.6 µg/L in the finished water.
- Prompts notification of Ohio EPA.

Experimental Lake Erie Harmful Algal Bloom Bulletin 2014:010

Mechanics of the Collins Park WTP

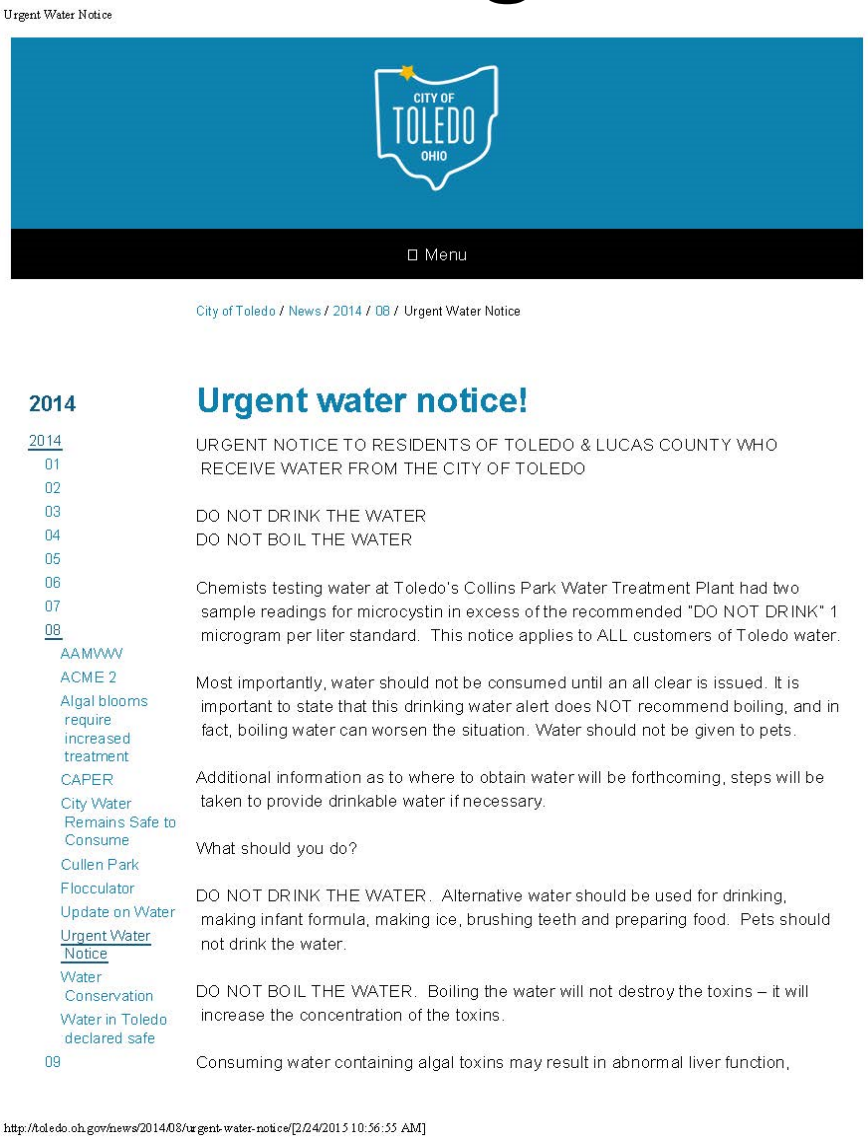
Intake is located about 3 mi offshore in 24 ft water

Feed KMnO4 (0.5 mg/L) before low pumping station

Time to the Collins Park WTP takes about 12-16 hr

Clear-well to distribution system: 18-24 hr

August 2nd (Saturday)



Urgent Water Notice

CITY OF TOLEDO OHIO

Menu

City of Toledo / News / 2014 / 08 / Urgent Water Notice

2014

2014
01
02
03
04
05
06
07
08
AAMWW
ACME 2
Algal blooms require increased treatment
CAPER
City Water Remains Safe to Consume
Cullen Park
Flocculator
Update on Water
Urgent Water Notice
Water Conservation
Water in Toledo declared safe
09

Urgent water notice!

URGENT NOTICE TO RESIDENTS OF TOLEDO & LUCAS COUNTY WHO RECEIVE WATER FROM THE CITY OF TOLEDO

DO NOT DRINK THE WATER
DO NOT BOIL THE WATER

Chemists testing water at Toledo's Collins Park Water Treatment Plant had two sample readings for microcystin in excess of the recommended "DO NOT DRINK" 1 microgram per liter standard. This notice applies to ALL customers of Toledo water.

Most importantly, water should not be consumed until an all clear is issued. It is important to state that this drinking water alert does NOT recommend boiling, and in fact, boiling water can worsen the situation. Water should not be given to pets.

Additional information as to where to obtain water will be forthcoming, steps will be taken to provide drinkable water if necessary.

What should you do?

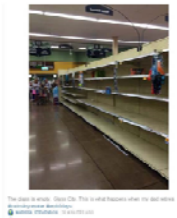
DO NOT DRINK THE WATER. Alternative water should be used for drinking, making infant formula, making ice, brushing teeth and preparing food. Pets should not drink the water.

DO NOT BOIL THE WATER. Boiling the water will not destroy the toxins – it will increase the concentration of the toxins.

Consuming water containing algal toxins may result in abnormal liver function,

http://toledo.oh.gov/news/2014/08/urgent-water-notice/[2/24/2015 10:56:55 AM]

- Microcystin levels in the Collings Park WTP as measured by Toledo Health Department reach 2.6 µg/L.
- City of Toledo issues a Do not drink and do not boil water advisory.
- WTP increasing the activated carbon from 3 ppm to 15 ppm.



August 3rd (Sunday)

- Governor John Kasich declares State of Emergency
- Local brewery discards 50,000 gallons of product
- >9,000 cases of bottled water delivered through distribution centers
- 1300 meals served to emergency providers by August 3
- Microcystin levels: ~5 ppm raw water and ~0.3 in tap.

August 4th (Monday)

- Raw water samples remain above 1 ppb
- Finished water samples drop below 1 ppm in response to increased activated carbon and flushing the system.

Breaking: From ToledoNewsNow.com:

"During a US EPA conference call this afternoon Congresswoman Marcy Kaptur complained that the Ohio EPA is withholding water test results taken from Toledo's water system. And she urged the USEPA pressure the Ohio EPA to provide those results. ……

August 5th (Tuesday)

- Finished water remains below the 1 µg/L threshold for second 2nd day.
- Water advisory lifted.
- Water service returned to 500,000 people.

13. What did we learn from Toledo?

Lesson #1:

Blooms always happen on the Friday just before the weekend or just before vacation.

Need contingency plans for staffing, extra sampling, etc.

Lesson #2

You need to “Control” the Message

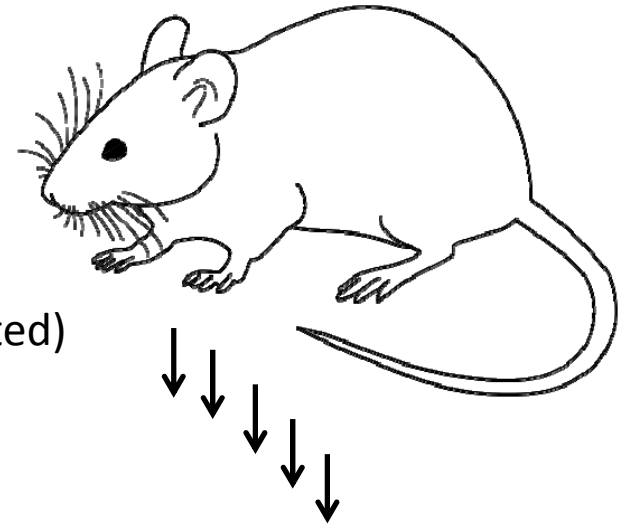
- Toxin levels exceed 1 ppm in finished drinking water.
- Residents should drain their swimming pools.
- Industries using live steam should shut down to avoid exposure to the toxins.
- No amount of toxin is safe to drink.
- It was unsafe to shower {flush the toilet} with the water.
- A million people are without water for another day, many without food, businesses closed, an entire section of the United States shut down largely because of illegal pollution and a governor owned by organized crime who is punishing his political enemies. People are dying.

The internet is a vast source of information, Some of it is even true. (Anonymous)

14. Was the water unsafe?

NO EPA guidance so how did WHO determine safe levels of toxin in water?

- Start with a mouse
- Measure the highest level that has no effect.
  - No Observed Adverse Effect Level (NOAEL)
  - 40 µg/kg body weight for microcystins
- Include safety factors
  - 10x (mice are not people)
  - 10x (not every mouse is the same)
  - 10x (limited number of studies)
- Average body weight of adult (60 kg or 132 lb)
- Consume 2 L water per day <u>for life</u> (80% is contaminated)
- Does not consider infant/child or at risk populations



World Health Organization Guideline value:

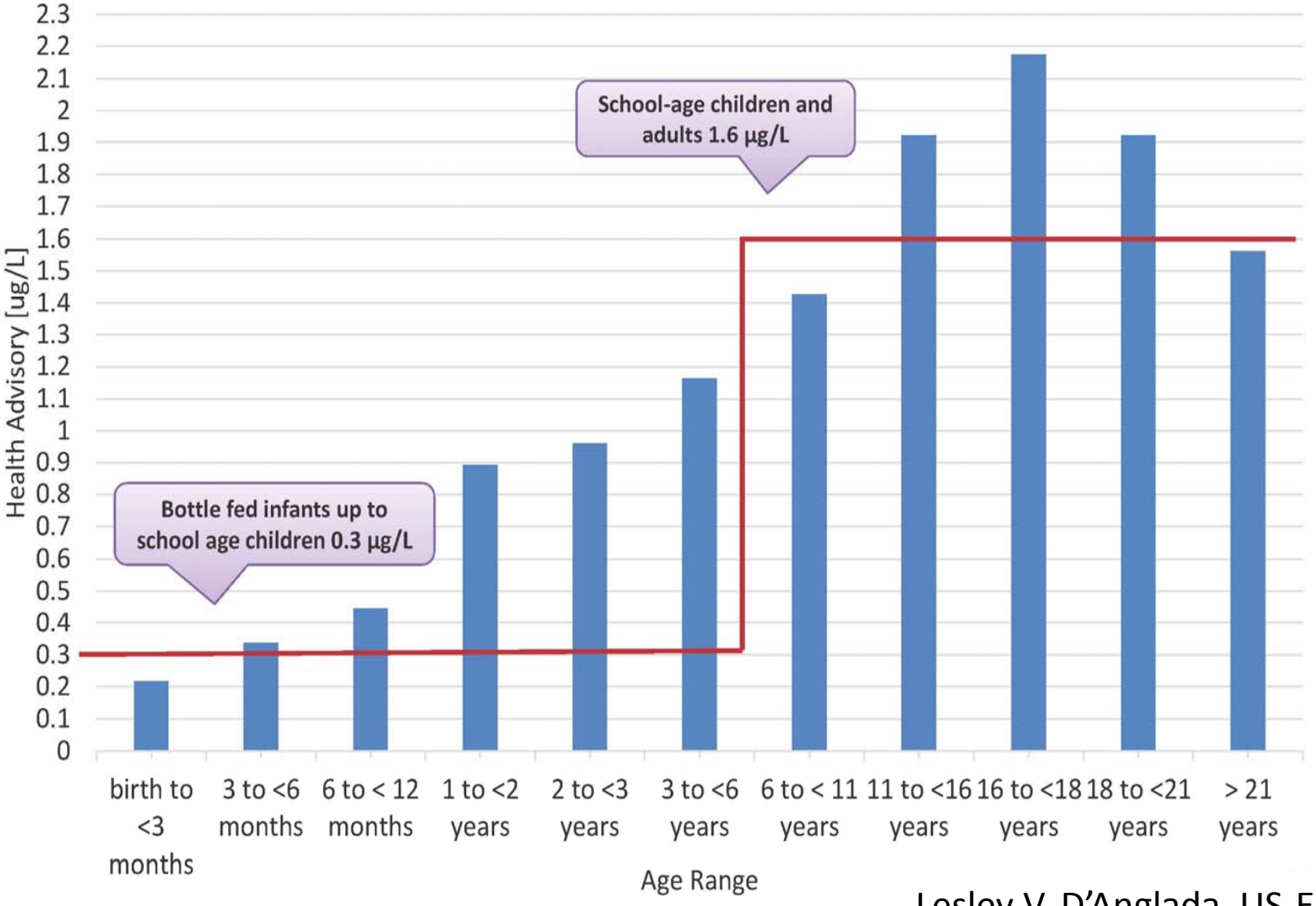
= 1 ug / L (ppb)

(guideline value – not regulatory)

(At the time, EPA had no guidelines for microcystins in drinking water so most states used the WHO values if anything. Canada adopted 1.6 ug/L in 2002)

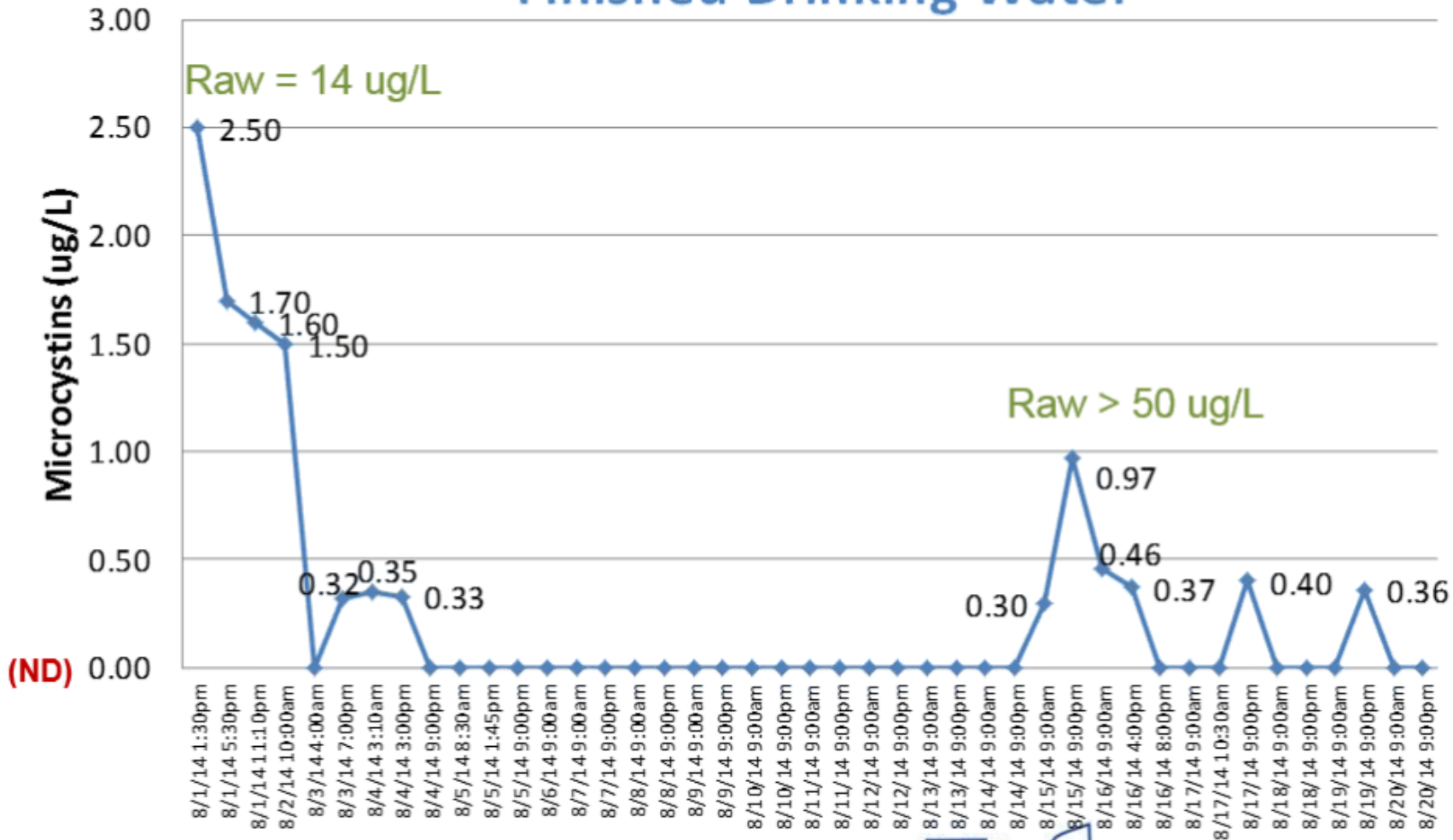
US-EPA issues drinking water guidelines

10 day average



Lesley V. D'Anglada, US-EPA

Microcystins Concentrations in Toledo's Finished Drinking Water

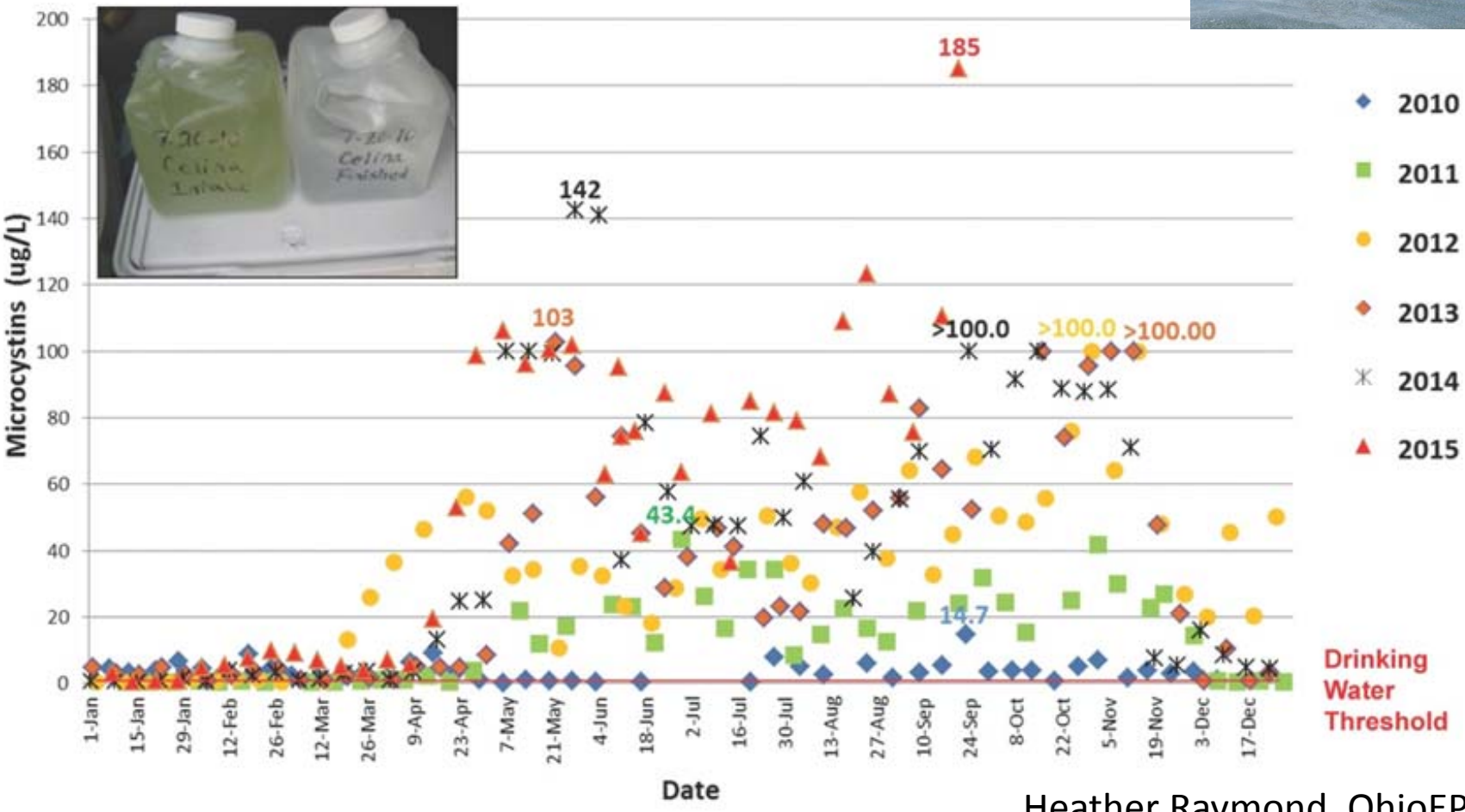


OhioEPA

ND= Not Detected (Concentration <0.25)

Data Source: Toledo PWS

WTPs have excellent capabilities to remove microcystins if used:



Heather Raymond, OhioEPA

15. So why do animals die?

- LD_{50} microcystin LR = 50µg/kg
- 40 lb lab (18kg)
- 1 ppb toxin in water
- = 900 µg (almost 1 mg)
- Dog must drink 900 liters of water to consume enough toxin for acute toxicity

Take home message:
Dogs do not die from drinking the water
They die from contacting the scums….

16. So what is the difference between a scum and water?

Indian River Florida
(aka St Lucie River)

- Nutrient input (aka Lake Okeechobee)
- High growth of cells
- Buoyant cells float to the surface and accumulate against a stationary object.

- St. Lucie River

  Water concentrations ~10 ug/L

  Scum toxic ~ 100-10,000 ug/L

A few more pictures of Florida

Most of the severe bloom accumulated against piers or in backwaters

Open waters were clear…..

Q17. What is New York State doing to protect us?

New York State Citizens-based lake Assessment Program (CSLAP)

- **Started in 1985:**

  "I propose creating a program within the Department of Environmental Conservation to use trained volunteers to collect information on the State's water bodies. With this information, the Department can more effectively manage and protect our invaluable water resources."

- **Collect high quality lake data**
- **Identify problems and water quality trends**
- **Educate the public about lake stewardship**
- **Train volunteers to collect water samples**
- **25 Lakes chosen from lake associations**
  - **expanded to include 1500 volunteers, 125 Lakes**
- **Expanded again in 2011 to include HABs.**

HAB samples come in two forms

200 ml open water sample filtered in the field and frozen => Sent to nutrient lab

Bloom samples

SUNY ESF Shoreline Bloom Sample Data Sheet

Which of the following best describes and looks like the location of the lake where you collected the bloom samples you have submitted for HAB analysis? **Circle the letter that best describes the bloom.**

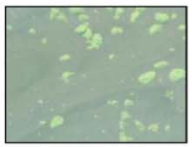
Lake Name: _____ County: _____
Sample ID Number: _____ Date: _____
Location of Bloom Site: _____
Description of bloom conditions (if applicable): _____
Sampler Name: _____

Bloom Site Description
(skim sample)

A. Spilled paint appearance on surface
(probably cyanobacteria)

B. Pea soup appearance within the water
(probably cyanobacteria)

C. Streaks (usually green) on the water
(probably cyanobacteria)



D. Green dots or clumps on/in the water
(may be cyanobacteria)

Bloom Site Description
(skim sample)

E. Bubbling scums on the lake surface
(probably not cyanobacteria)

F. Slight greenish or brownish tint to the water (probably not cyanobacteria)

G. Duckweed or watermeal (don't collect):

H. Other: _____

I. No evidence of bloom (do not collect shoreline sample)

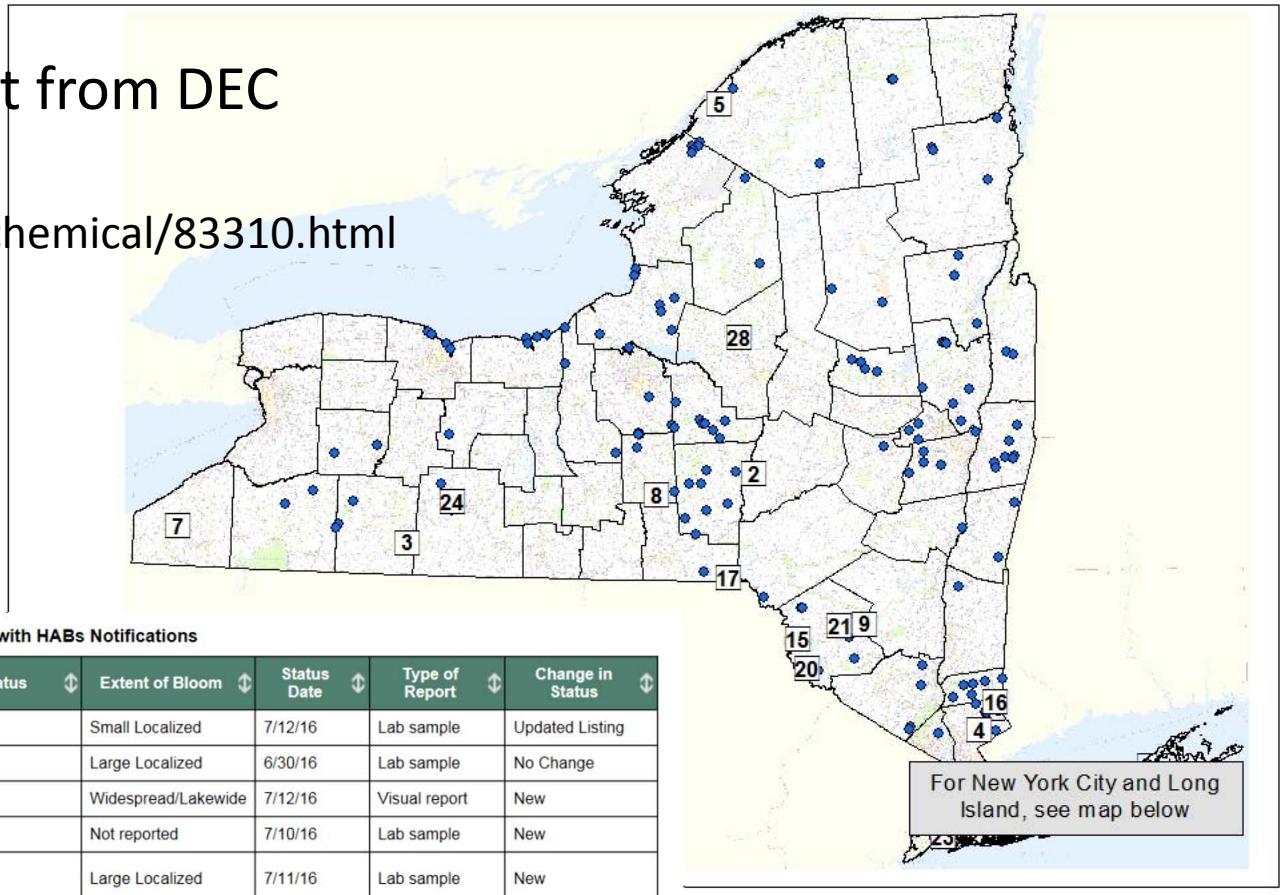
SHORELINE BLOOM SAMPLE

Bloom samples are sent directly to ESF

18. How is this reported to the public?

- Weekly Email blast from DEC
- DEC website:
  http://www.dec.ny.gov/chemical/83310.html

Map comes with link to “Lake Notices”

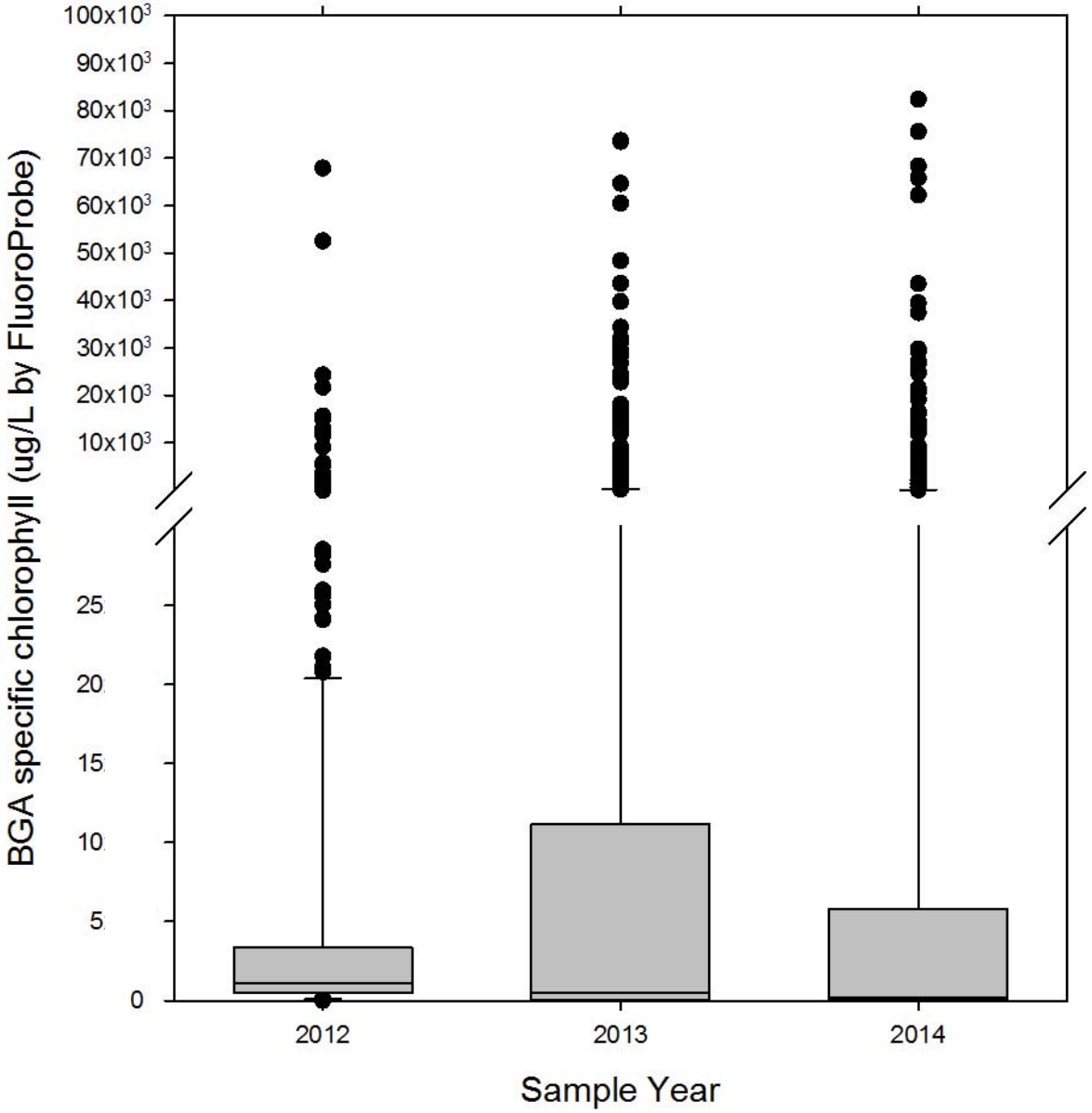


Waterbodies with HABs Notifications

Map Number	Waterbody Name	County	Bloom Status	Extent of Bloom	Status Date	Type of Report	Change in Status
1	Agawam Lake	Suffolk	Confirmed	Small Localized	7/12/16	Lab sample	Updated Listing
2	Allen Pond	Otsego	Confirmed	Large Localized	6/30/16	Lab sample	No Change
3	Andover Pond	Allegany	Suspicious	Widespread/Lakewide	7/12/16	Visual report	New
4	Bedford Lake	Westchester	Confirmed	Not reported	7/10/16	Lab sample	New
5	Black Lake	St. Lawrence	Confirmed	Large Localized	7/11/16	Lab sample	New
6	Bowne Pond	Queens	Confirmed	Not reported	7/11/16	Lab sample	Updated Listing
7	Chautauqua Lake*	Chautauqua	Confirmed	Large Localized	7/11/16	Lab sample	New
8	Deans Pond	Cortland	Confirmed	Widespread/Lakewide	7/3/16	Lab sample	No Change
9	Evens Lake	Sullivan	Confirmed with High Toxins	Large Localized	6/28/16	Visual report	No Change
10	Forge Pond/Peconic Lake	Suffolk	Confirmed	Small Localized	7/6/16	Lab sample	No Change
11	Georgica Pond	Suffolk	Confirmed	Widespread/Lakewide	7/14/16	Lab sample	Updated Listing

Go out every Friday

Cyanobacteria abundance



Most samples have low levels of BGA:

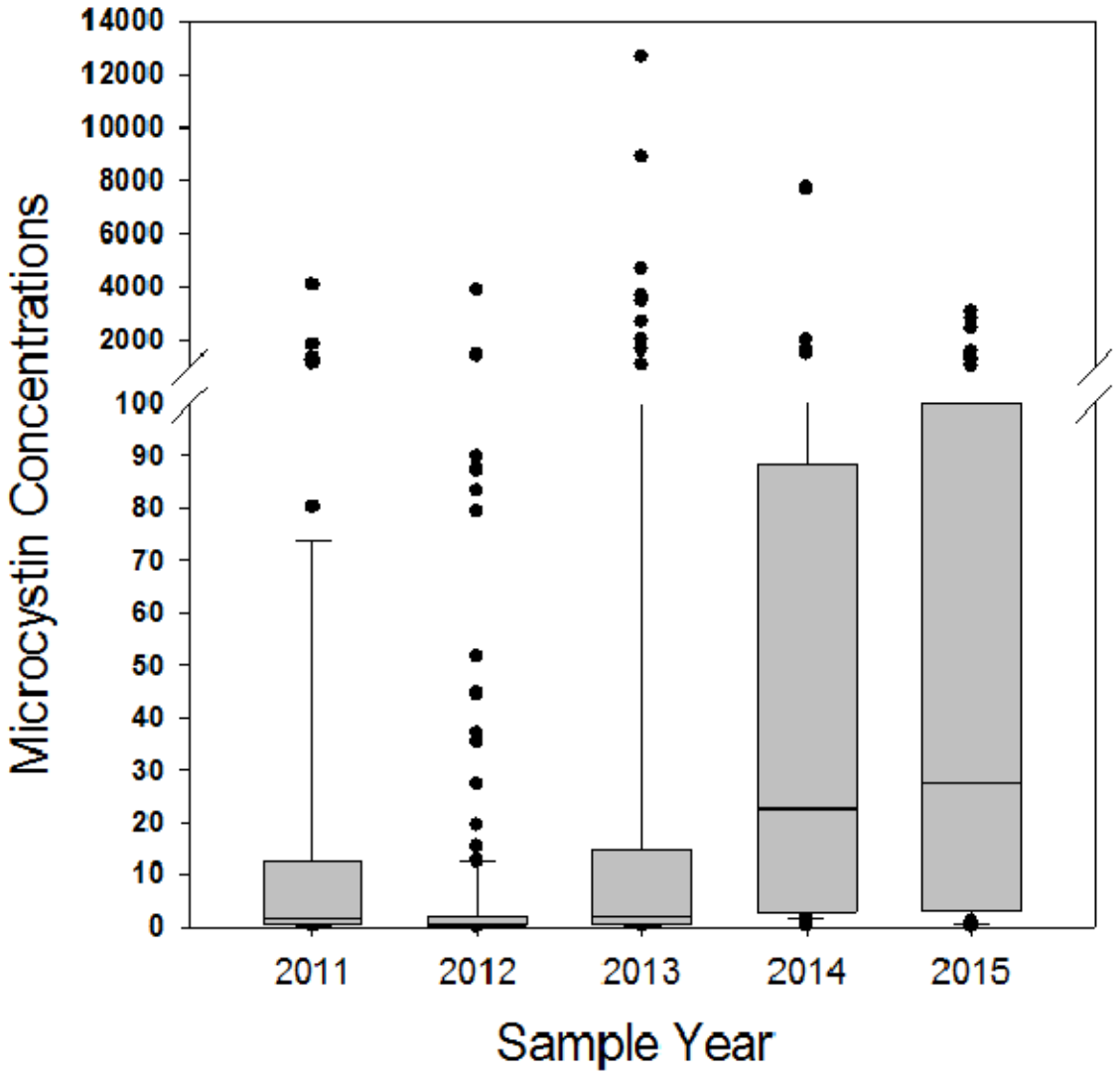
BGA specific Chl-a ranges from 0-100% of total Chl-a.

Scum levels can be very high:

- 600,000 ug/L chl-a

Visual exams show: *Microcystis, Anabaena, Aphanizomenon*, diatoms fish, duckweed, etc.

Microcystin abundance in NY



Most samples are non-toxic:

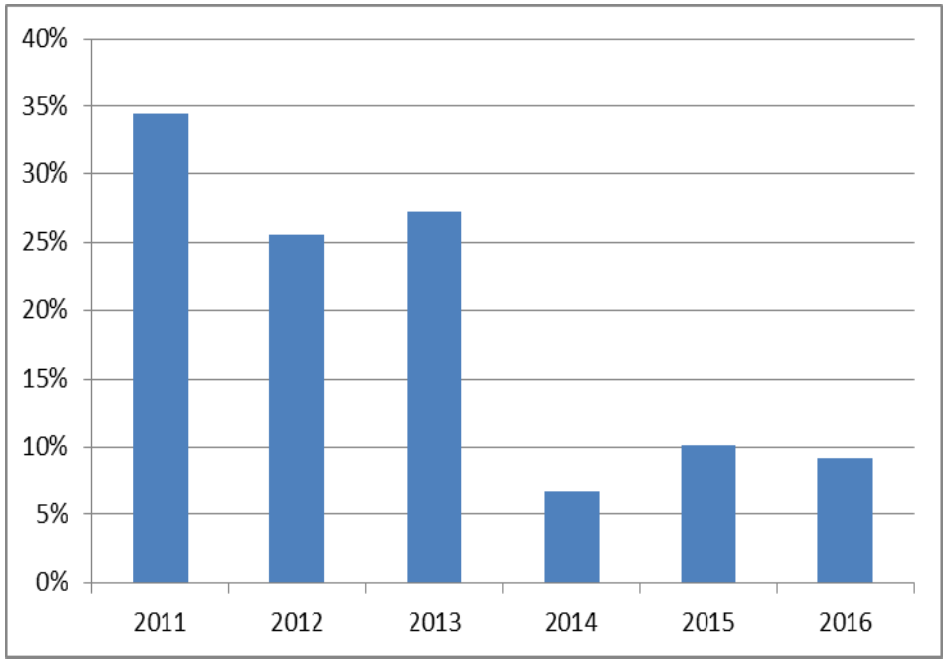
- 65-75% by PPIA
- 90% by LCMS

Toxin levels range:
0.3 ug/L (MDL)
12,300 ug/L (scum)

WHO Recreational levels of <20 ug/L include 50% of the samples

Other toxins:
Anatoxin-a (yes)
CYL, BMAA (no)

19. So what will 2016 bring?



Percent of CSLAP+ lakes with measureable MC toxicity

- Drier year,
  - less spring rains
  - Fewer nutrients
- Warmer sooner
  - Blooms have longer to grow
- Probably balance out and be about the same.

Q20. What do I do if I see a bloom?

1. Remember not all blooms are toxic.
2. If it is a bloom, don't drink the water. Avoid contact with scums.
3. Be very careful of surface accumulations where the algae may pile up on the beach.

   Be careful that young children don't "eat" the seaweed.

4. If you pet gets into the water, wash them off with clean water from a hose.

Bonus Question: Do you have questions for me?

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