Oneida Lake – An Introduction to Harmful Algal Blooms

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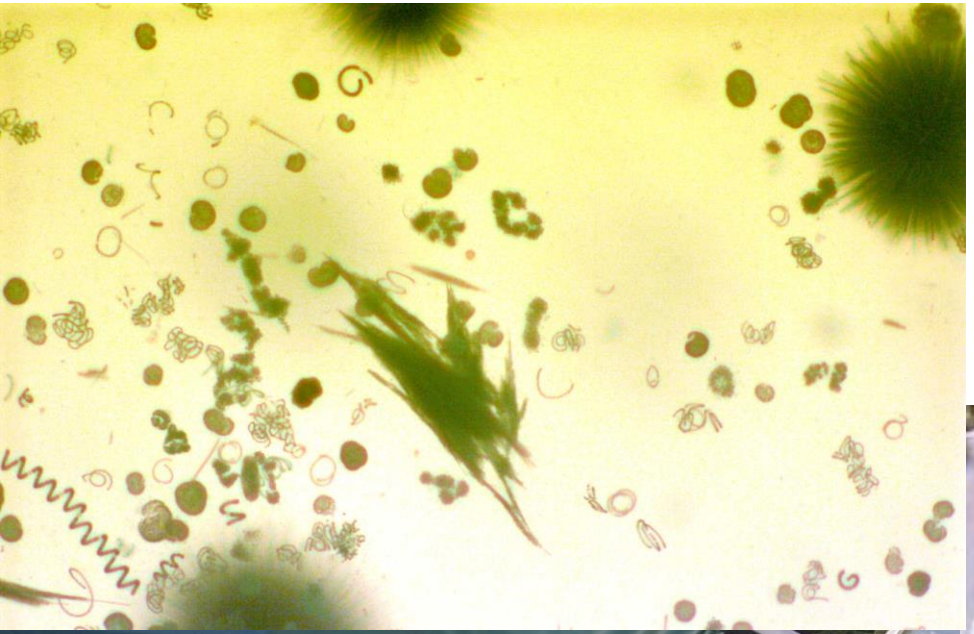
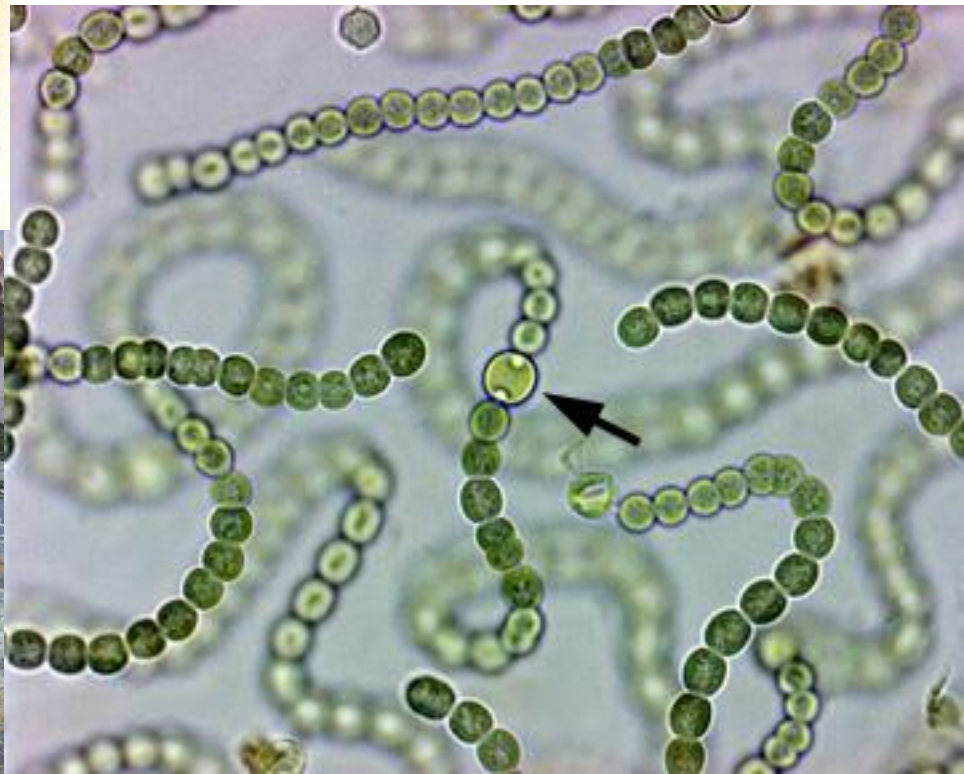
What are blue-green algae?



Specialized plant-like bacterium called Cyanobacteria

- 8000 species
- 3 billion years of evolution
- not all are bad….



Blooms often concentrate at the shoreline or along docks.

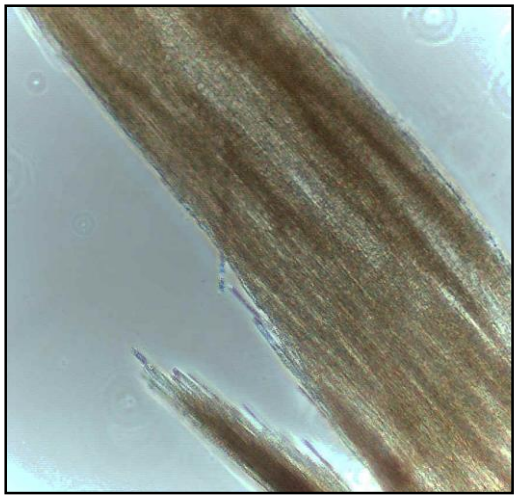
Not every bloom or every scum is cyanobacteria. .

Spirogyra and *Mougeotia*

Green (and Slimy) Algae

Pretty easy to tell under a microscope…

Anabaena



Aphanizomenon

Microcystis

Known to a generation of scientists as Anni, Fanni and Mike
(3 most common bloom-forming species)
NOT the three most common toxic species!

Why do the algae grow?

NUTRIENTS

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

LIGHT

WARM TEMPERATURE

Algal GROWTH

Water > 60 F

GRAZING ↑↓

CALM WINDS

Seed Population

How do we prevent blooms?

- We know the seed population is there
- Zebra mussels may promote blooms or “harvest blooms”, best bet is to keep them out of the system.

How do we prevent blooms?

Not much we can do about light, temperature and winds

LIGHT

WARM TEMPERATURE

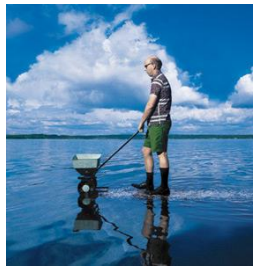
Water > 60 F

CALM WINDS

Algal GROWTH

If anything – climate changes predicts we will have more calm days and warm falls (aka a longer growing season

How do we prevent blooms?



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

NUTRIENTS

That brings us to nutrients……..

It is not the only thing important, it is the only thing we can control.

Algal GROWTH

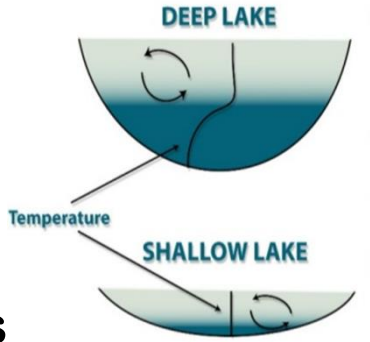
Blue-green algae don't care what is the source of nutrients.

control both episodic and continual inputs

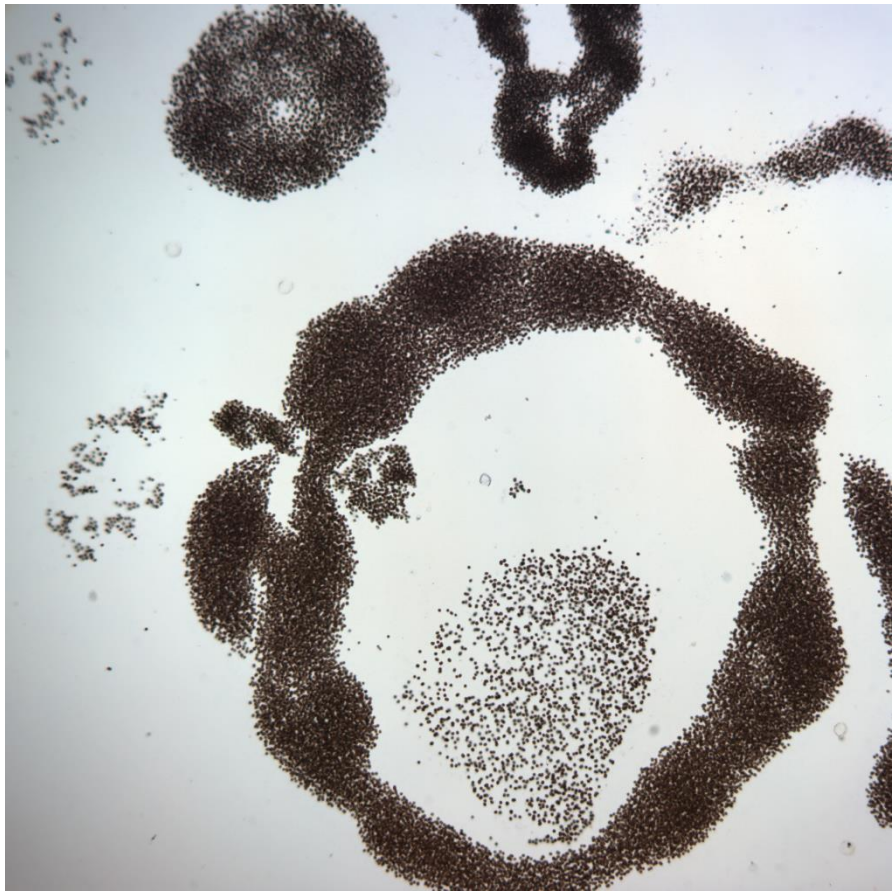
Why are they called Harmful?

- 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.

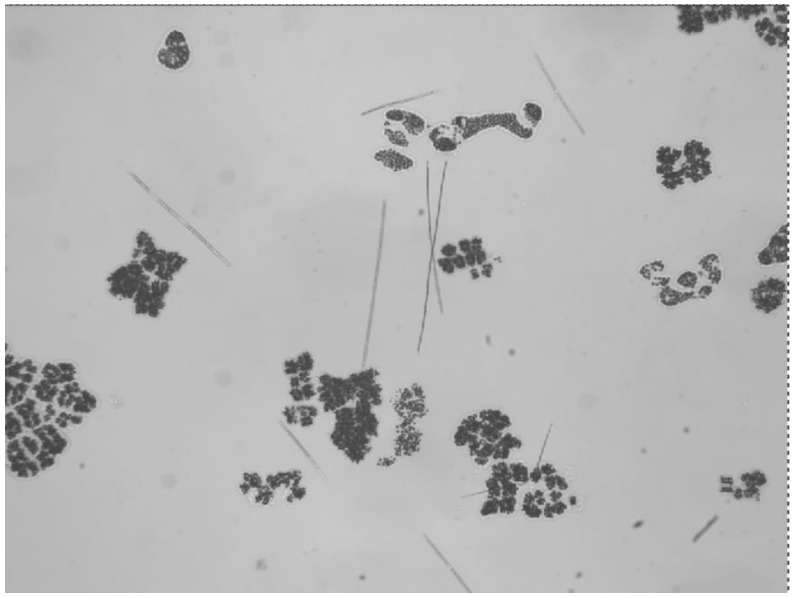
Especially important in stratified lakes



What is the difference between *Microcystis* and microcystins?

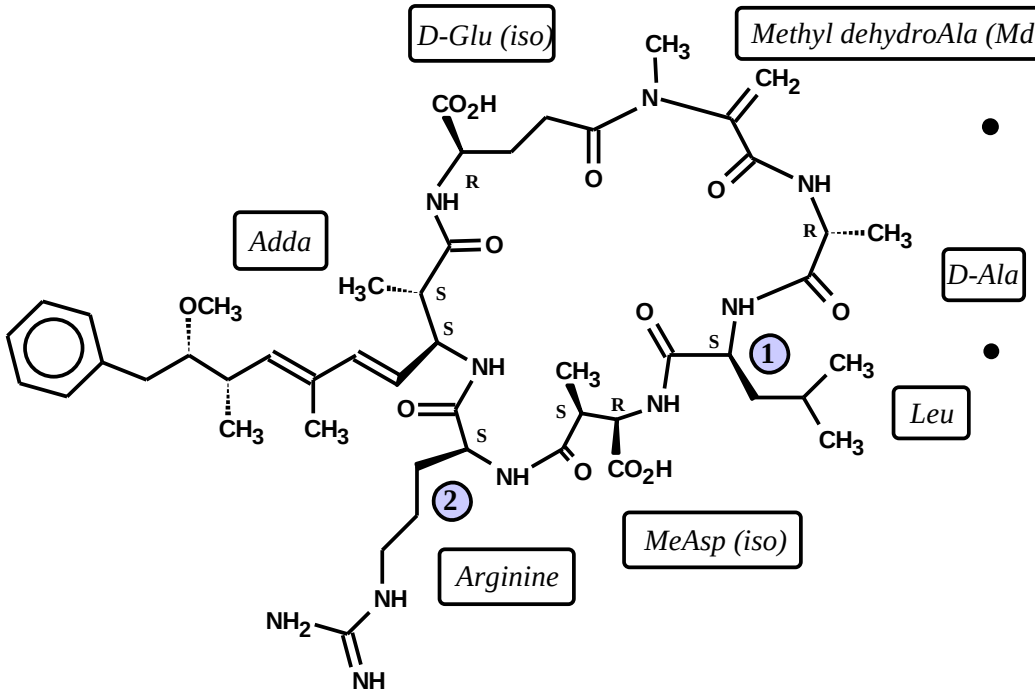


- *Microcystis aeruginosa*
  - non-N fixer.
  - Likes organic N
  - forms surface blooms
- Very common genera
  - Found in every water body
- Can exist in toxic, non-toxic and potentially toxic forms.
  - Liver toxin called microcystins
  - Cell wall may be allergenic to some.



Microcystins

- Family of toxins made by
  - *Microcystis species*
  - *Anabaena* species
  - *Planktothrix* species.
  - *Nodularia* species (halophytes)

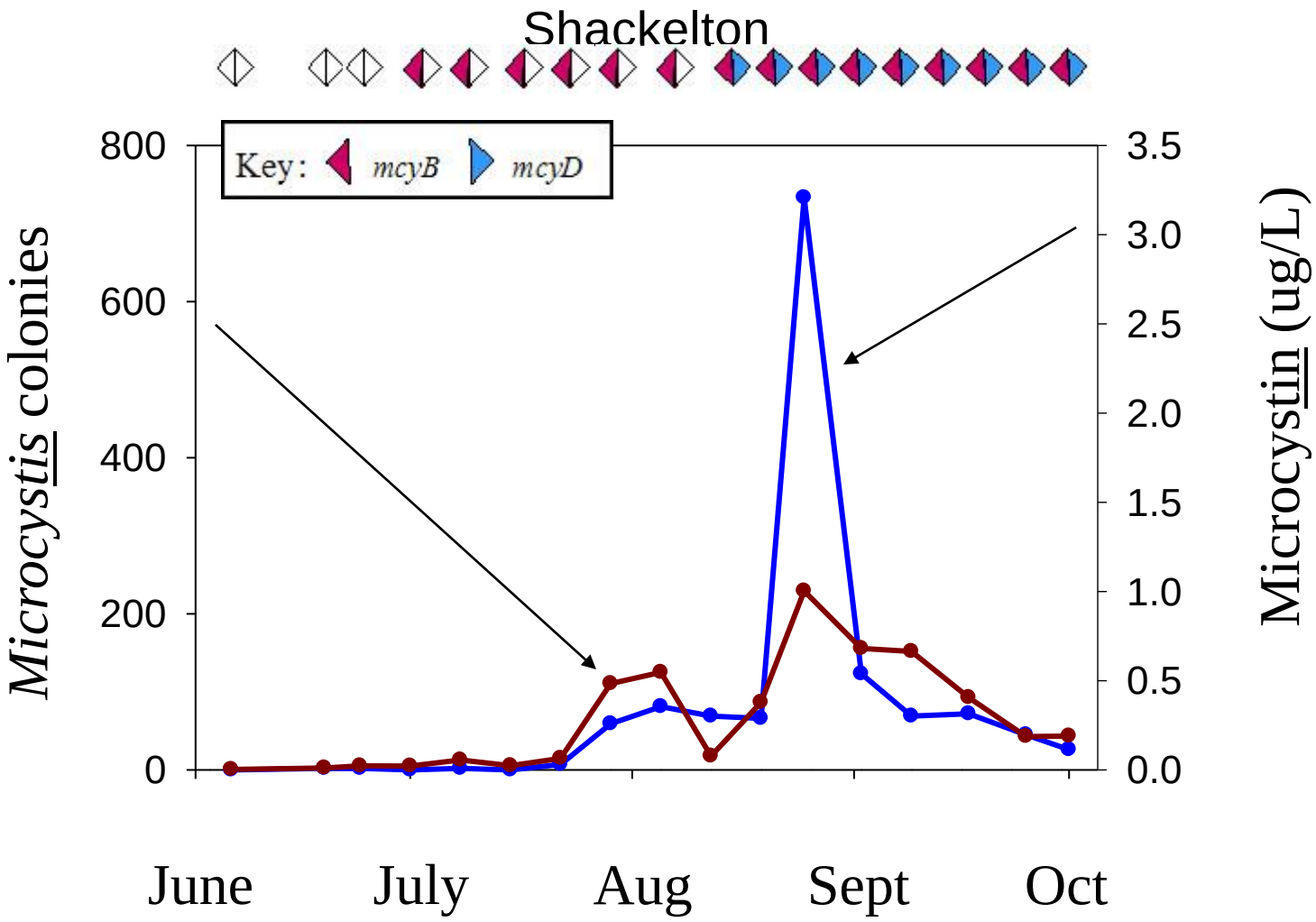


- Toxic and non-toxic species a morphologically indistinct
  - DNA tools can tell them apart.
- Liver Toxin

  0.3 -1.6 ug/L (ppb) in DW
  4 ug/L in recreational water

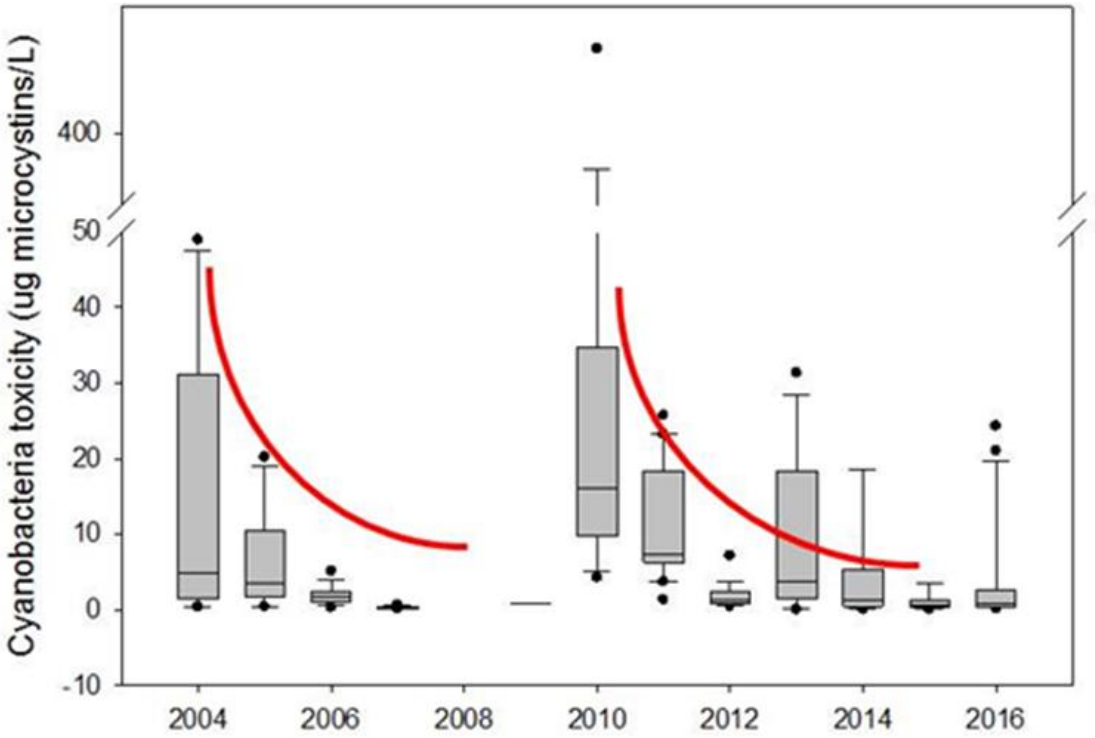
NOT Bio-accumulated
Rapidly metabolized

Toxin Production in Oneida Lake, 2003



Hotto et al, Environ. Toxicol 2005

Phosphorus is important for algae, but other factors are important for toxicity.

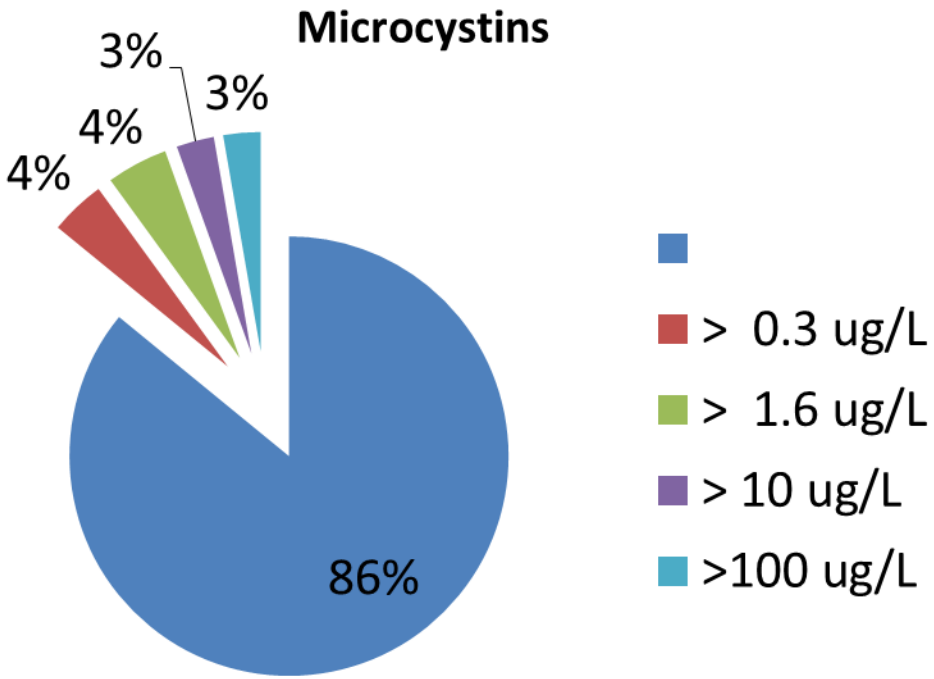


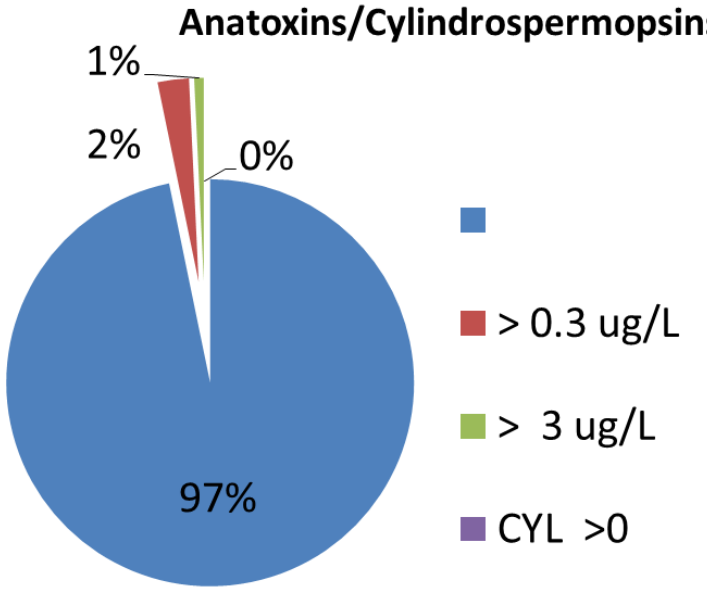
Factors that affect toxicity include:

- Algal species
- Nitrogen, Iron
- Light
- Competition
- Bacteria

Big Picture Overview of New York Lakes

Microcystins in about 14% of our samples

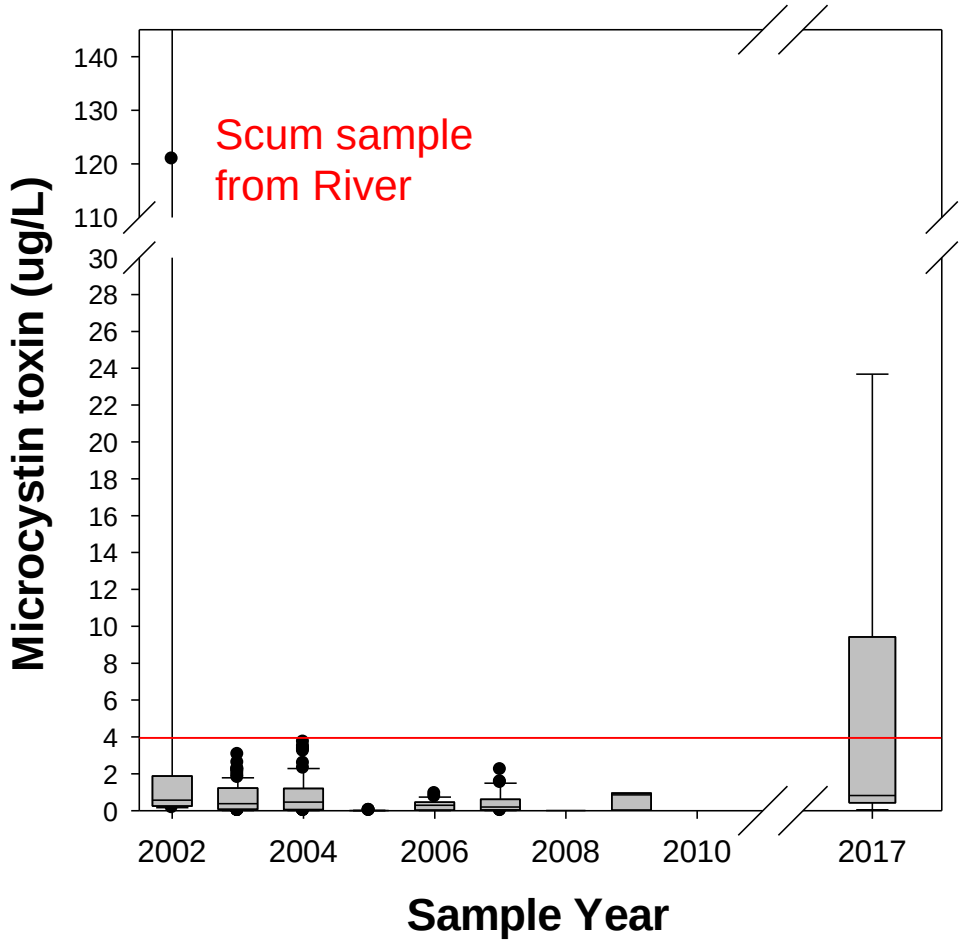




Anatoxin-a in about 3-4% of our samples

2015-2017 data; n ~ 4800

What about Oneida Lake?



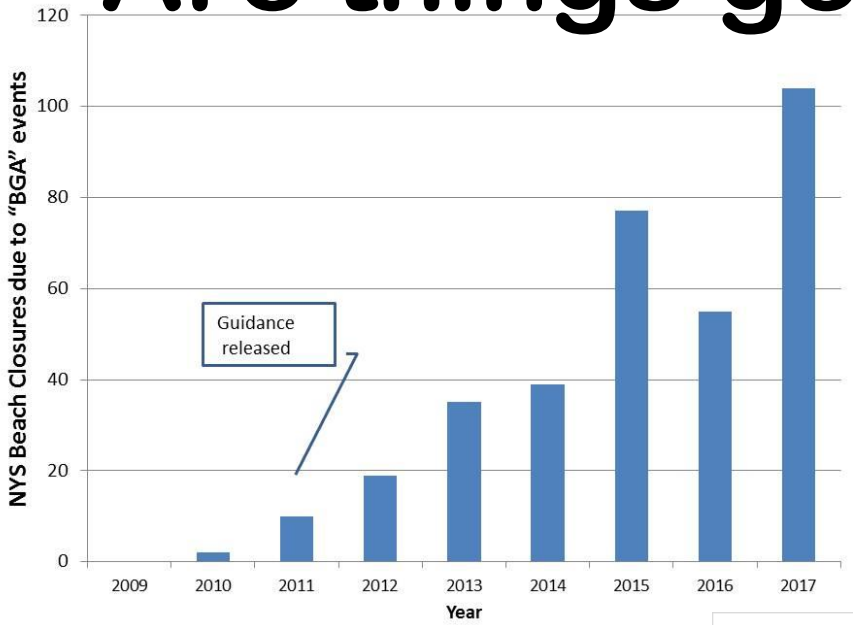
Other Lakes:

Skaneateles Lake: 200 ug/L
Seneca Lake: 400 ug/L
Owasco Lake: 1800 ug/L

All 11 Finger Lakes experienced HAB events in 2017

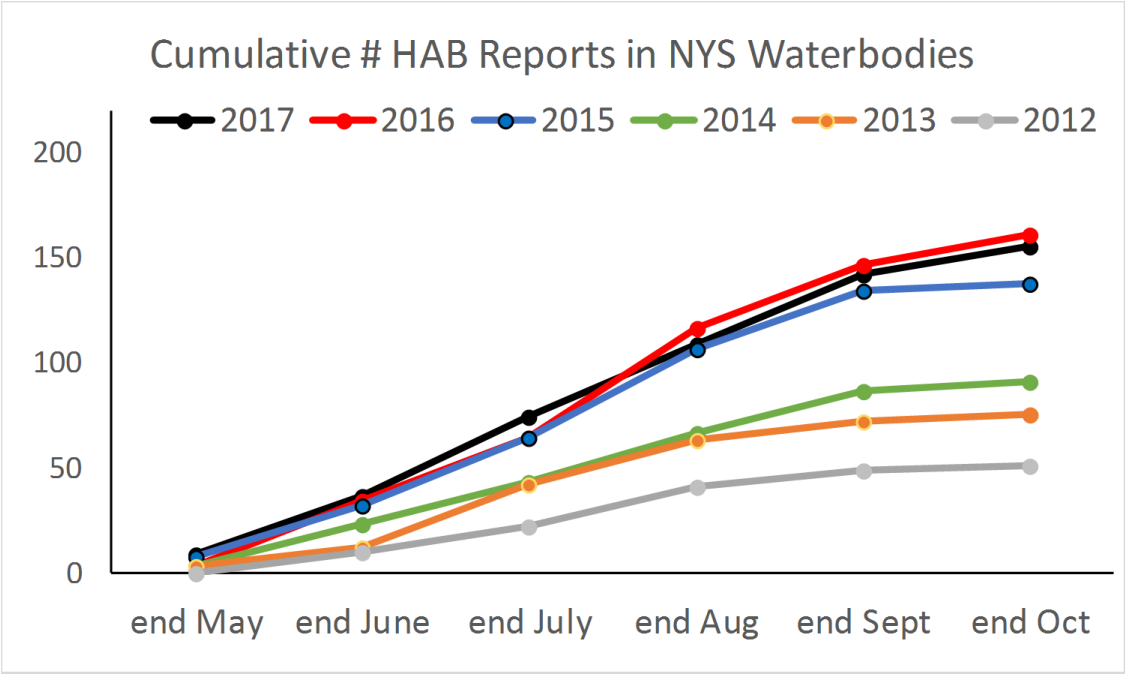
Avoid recreational contact

Are things getting worse? …..



Beach closures at NYS parks reported to the DOH have steadily increased;

Over 160 water bodies were reported to the DEC HAB network last year;

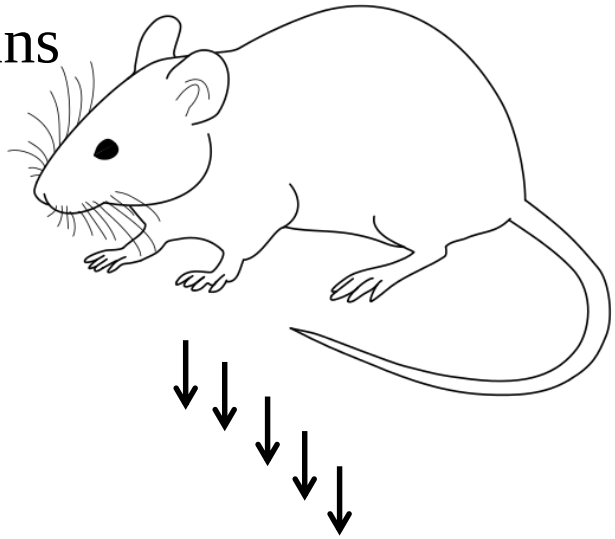


So lets talk about fish…….

What do we know about eating fish caught in a bloom?

How do you determine safe levels of toxin in Food?

- 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 same safety factors
  - 10x (mice are not people)
  - 10x (not every mouse is the same)
  - 10x (limited number of studies)
- Average body weight of adult

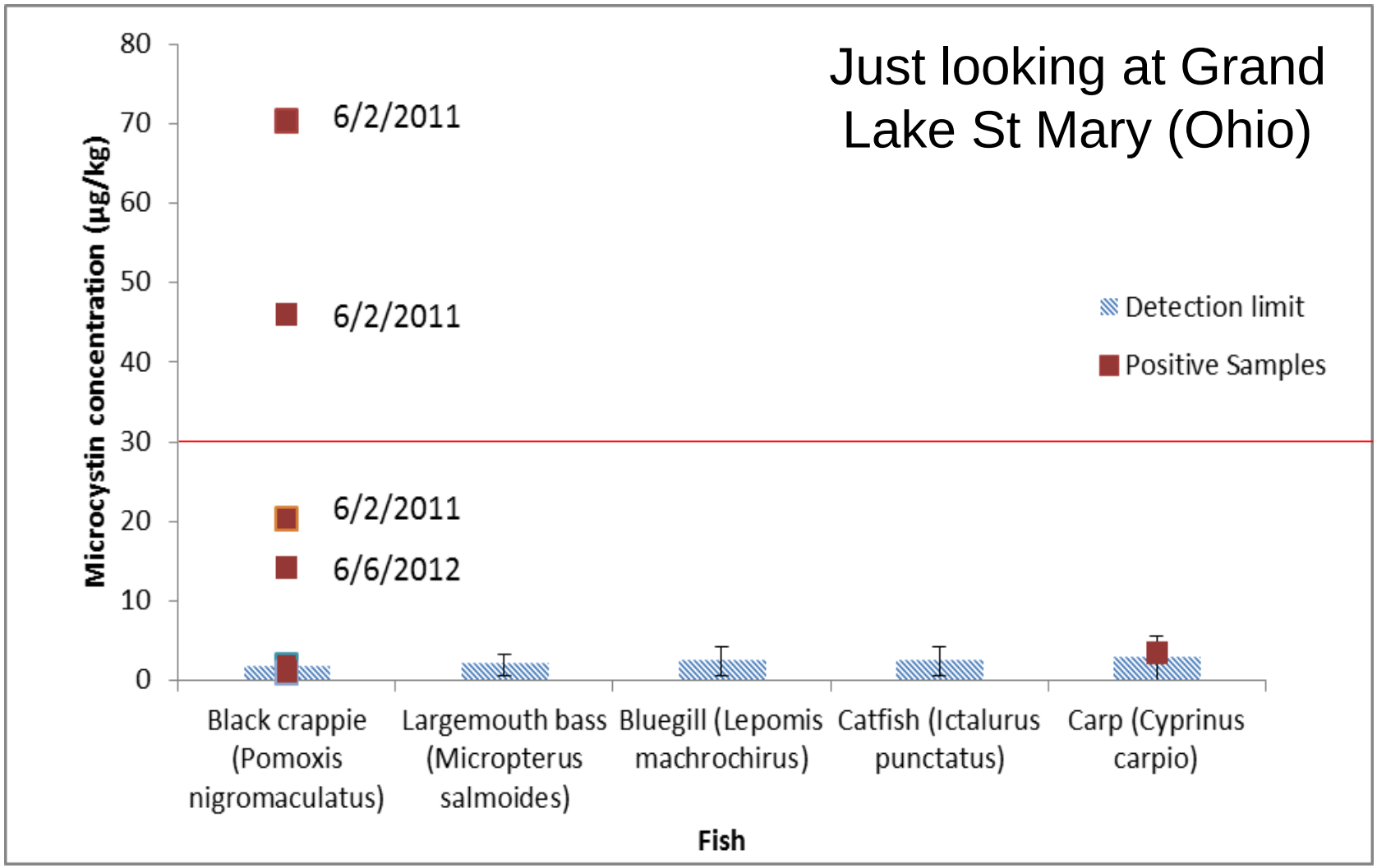
- 100 g fish/meal/day (*Ibelings & Chorus 2007)*
  - Daily: 3 ug/kg fish (adults)
  - Seasonal: 30 ug/kg (adults)
  - kids are 5-8 fold less

So what are levels in fish?

Lake & Sample Year	Species	Tissue	#	Bloom Present	Technique	MC Concentrations
Lake Champlain, NY	Smallmouth bass	Liver and muscle	34	small bloom, non-toxic	LC-MS/MS	Non-detect
2016	Bullhead catfish	Liver and muscle	1			Non-detect
Slodysko, SUNY-ESF	Yellow perch	Liver and muscle	35			Non-detect
	Largemouth bass	Liver and muscle	1			Non-detect
	Sheephead	Liver and muscle	10			Non-detect
Lake Neatahwanta, NY	Carp	Liver	29	bloom, low toxins	LC-MS/MS	Non-detect
2006	White Sucker	Liver	2			Non-detect
Slodysko, SUNY-ESF	Freshwater drum	Liver	1			Non-detect
	Brown Bullhead Catfish	Liver	5			Non-detect
	Northern Pike	Liver	1			Non-detect
Grand Lake Saint Marys, OH	Black Crappie	Muscle	69	bloom, low-high toxins	LC-MS/MS	1.0 - 70 µg/kg ww
2011/2012	Bluegill sunfish	Muscle	15			Non-detect
Schmidt et al. 2013	Channel Catfish	Muscle	15			Non-detect
	Common carp	Muscle	15			3.5 µg/kg ww
	Largemouth Bass	Muscle	15			Non-detect
St. Mary's River, Stony Creek Lake, Saginaw Bay,	White bass	Muscle	10	not indicated	ELISA,LC-MS/MS	0.052 - 0.658 µg/kg w
2014	Walleye	Muscle	9			0.092 - 0.417 µg/kg w
Synder et al. (unpublished)	Channel Catfish	Muscle	7			0.047 - 0.336 µg/kg w
	Rock bass	Muscle	5			0.018 - 0.055 µg/kg w
	Common carp	Muscle	4			0.164 - 0.236 µg/kg w
	Northern Pike	Muscle	12			0.052 - 0.129 µg/kg w
	White perch	Muscle	9			0.039 - 0.188 µg/kg w
Lake Erie, OH	Walleye	Muscle or Belly flap	29	bloom, low - high toxins	ELISA	<17.9 – 303 ug/kg ww
2013	White Perch	Muscle	52			<7.83 – 91.8 ug/kg ww
Wituszynski et al. 2017	Yellow Perch	Muscle	55			<7.51 – 73.3 ug/kg ww

Schmidt et al, Toxins, 2013

Fish results are highly variable – mostly zero

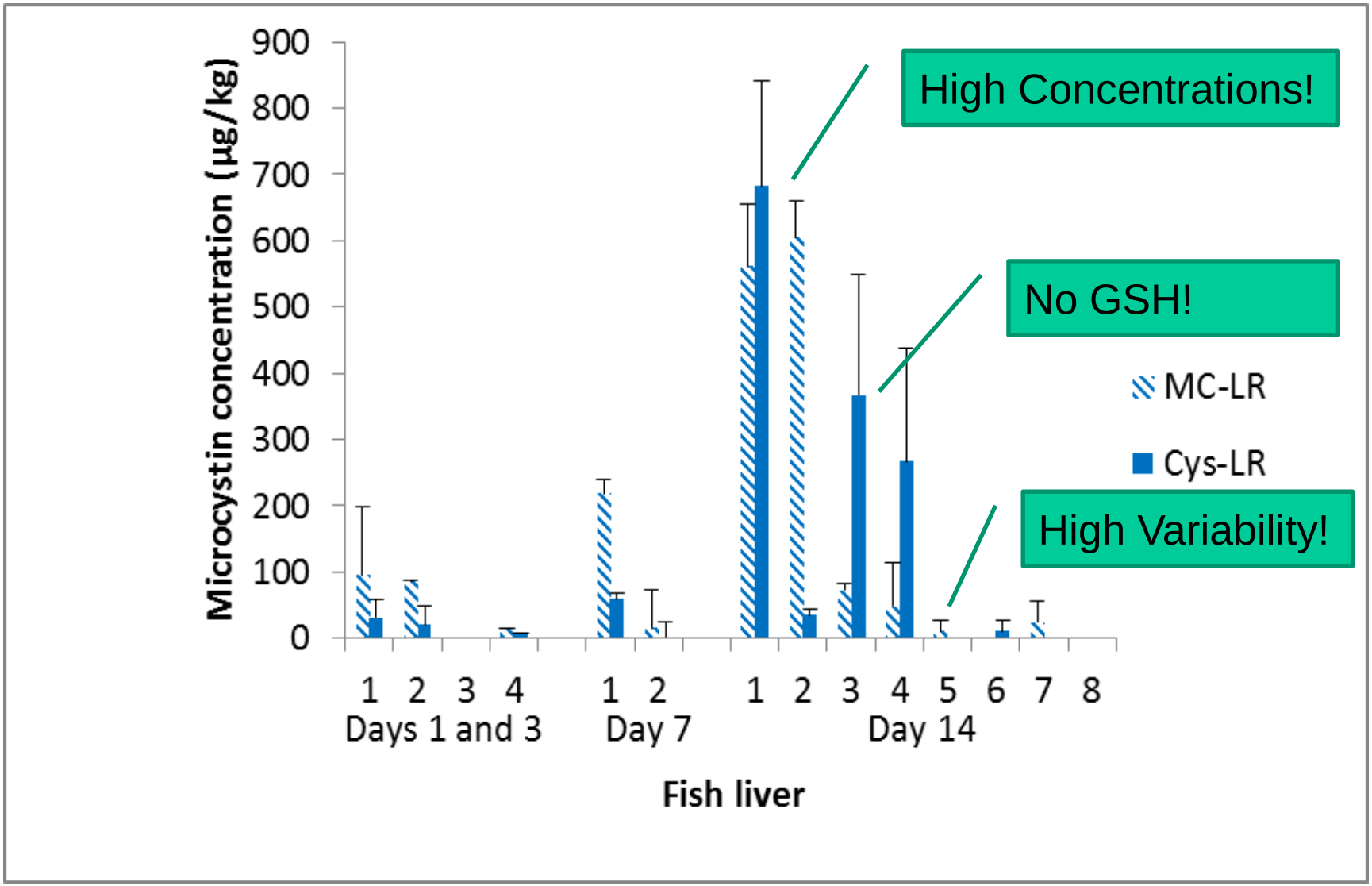


Why are the fish be so variable?

- Artifact (# fish too small)

- True species differences between fish
- Difference in fish diet (foodweb effect)
- Fish finding refuge from blooms
  - Differential exposure
- Fish metabolizing the toxins

Cultured catfish fed toxin-chow



SUMMARY

- Toxin accumulation in fish is highly variable
  - Accumulate toxin if the fish is given enough.
    - Does not kill the fish (low dissolved oxygen)
  - Levels are not explained by exposure.
    - No blooms – no toxin in fish
  - Large differences between species
    - Pan fish seem to be higher
- Toxins are rapidly metabolized in the liver and leaves the fish in ~2 weeks
- Not bio-accumulated in fatty tissue like Hg.

Lets keep things in perspective

"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

- Blooms are not new.
- Long term solution is by nutrient control.
- Avoid contact as you cannot separate good from bad by looking.
- Happy fishing (outside of the bloom)

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