Benthic Sources of Cyanotoxins in Three Oregon Rivers Used for Municipal Drinking-Water Supply

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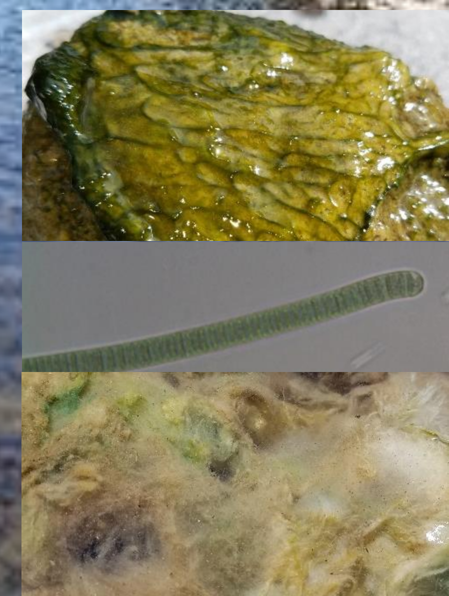


Photo: Barry Rosen/USGS Emeritus/FGFU

HABs May Involve..

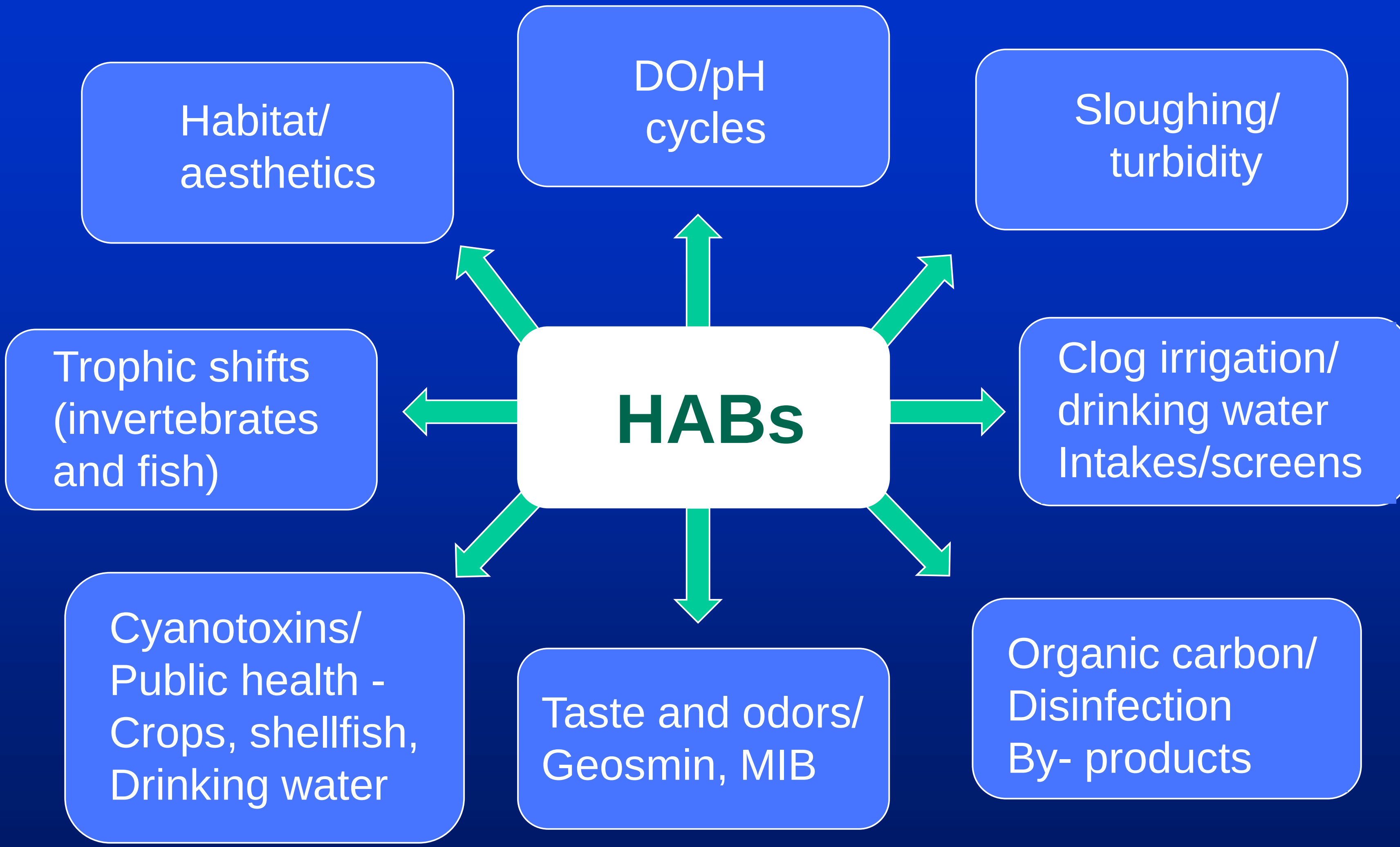
Phytoplankton **AND** **Benthic “Periphyton”**

Timothy Lake

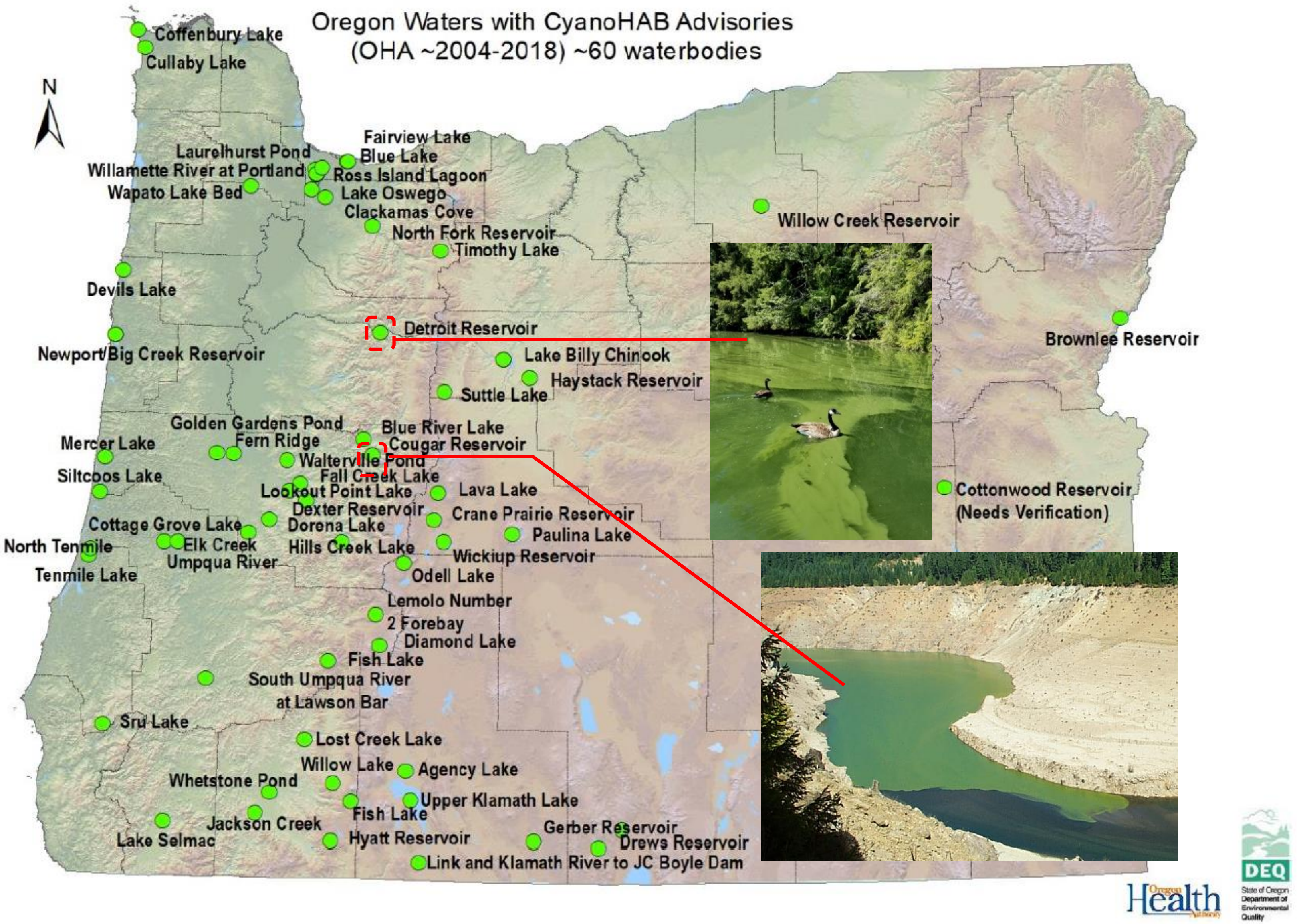
North Fork Reservoir

Clackamas River Basin streams

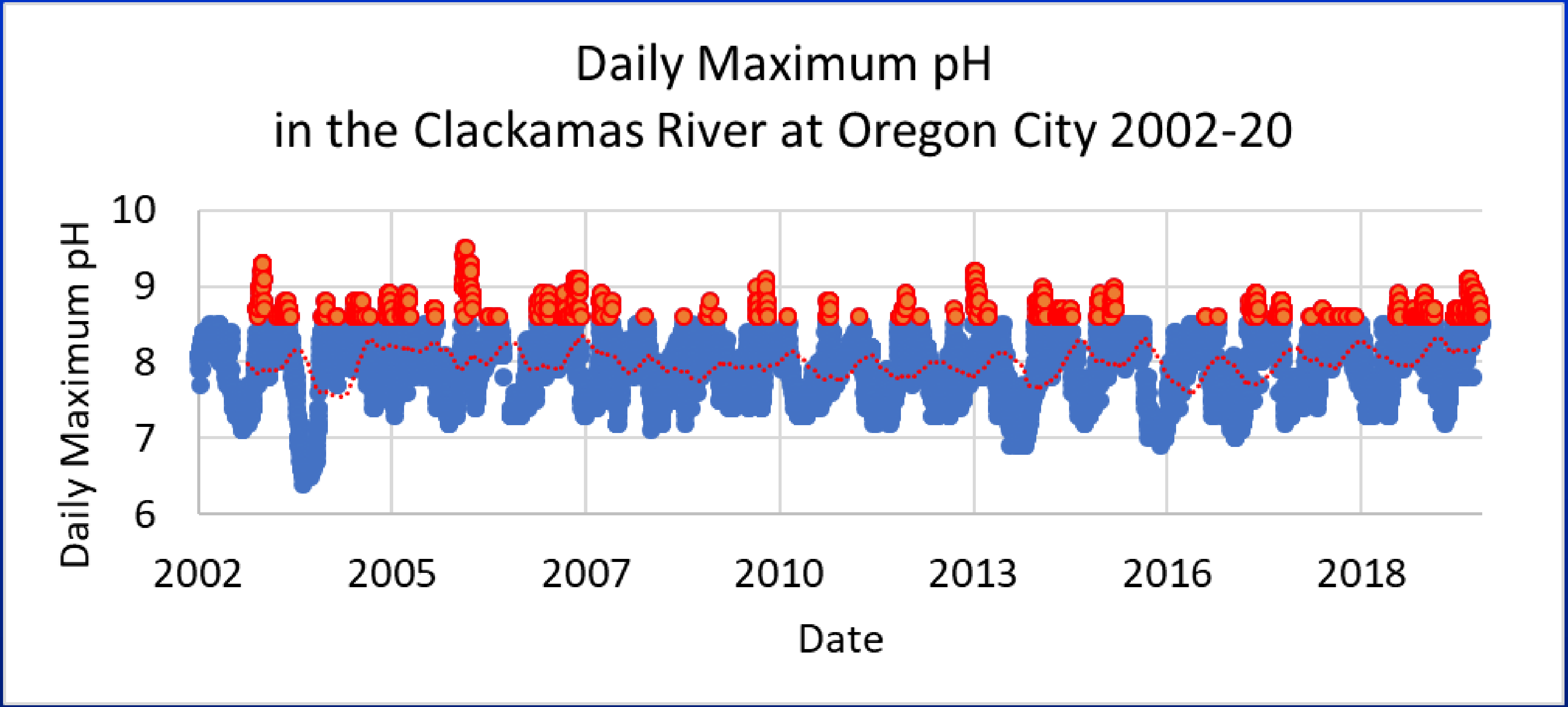
Impacts from HABs



Where have CyanoHABs occurred?



Source: Oregon Department of Environmental Quality


Daily Maximum pH
in the Clackamas River at Oregon City 2002-20
Daily Maximum pH
10
9
8
7
6
2002
2005
2007
2010
2013
2016
2018
Date

Benthic Cyanobacteria in the Clackamas River Basin

Algal Genera	Reservoirs (n=2)	Mainstem (n=8)	Tributaries (n=15)
Schizothrix	2	8	14
Oscillatoria	0	8	13
Nostoc	0	8	5
Lyngbya	0	6	7
Tolypothrix	0	3	2
Dolichospermum[1]	2	0	0
Microcystis	1	0	0

[1] Formerly *Anabaena*

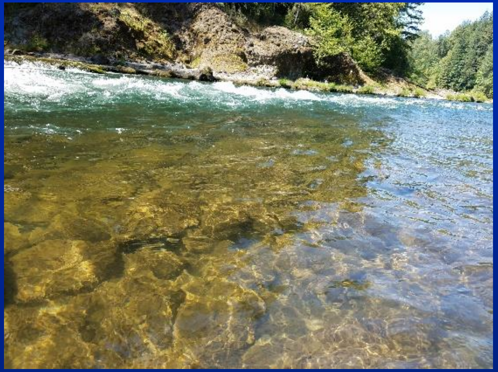
USGS Water Resources Investigations Report 02-4189 (Carpenter 2003)

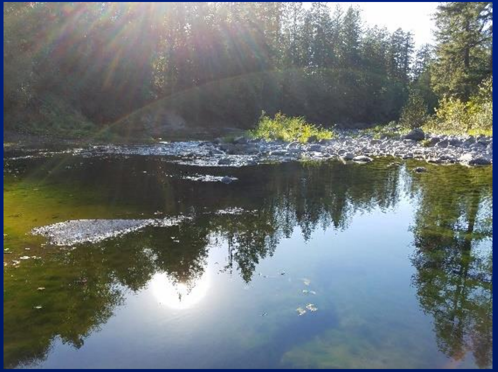
USGS



2016-18 Study of Drinking Water Sources

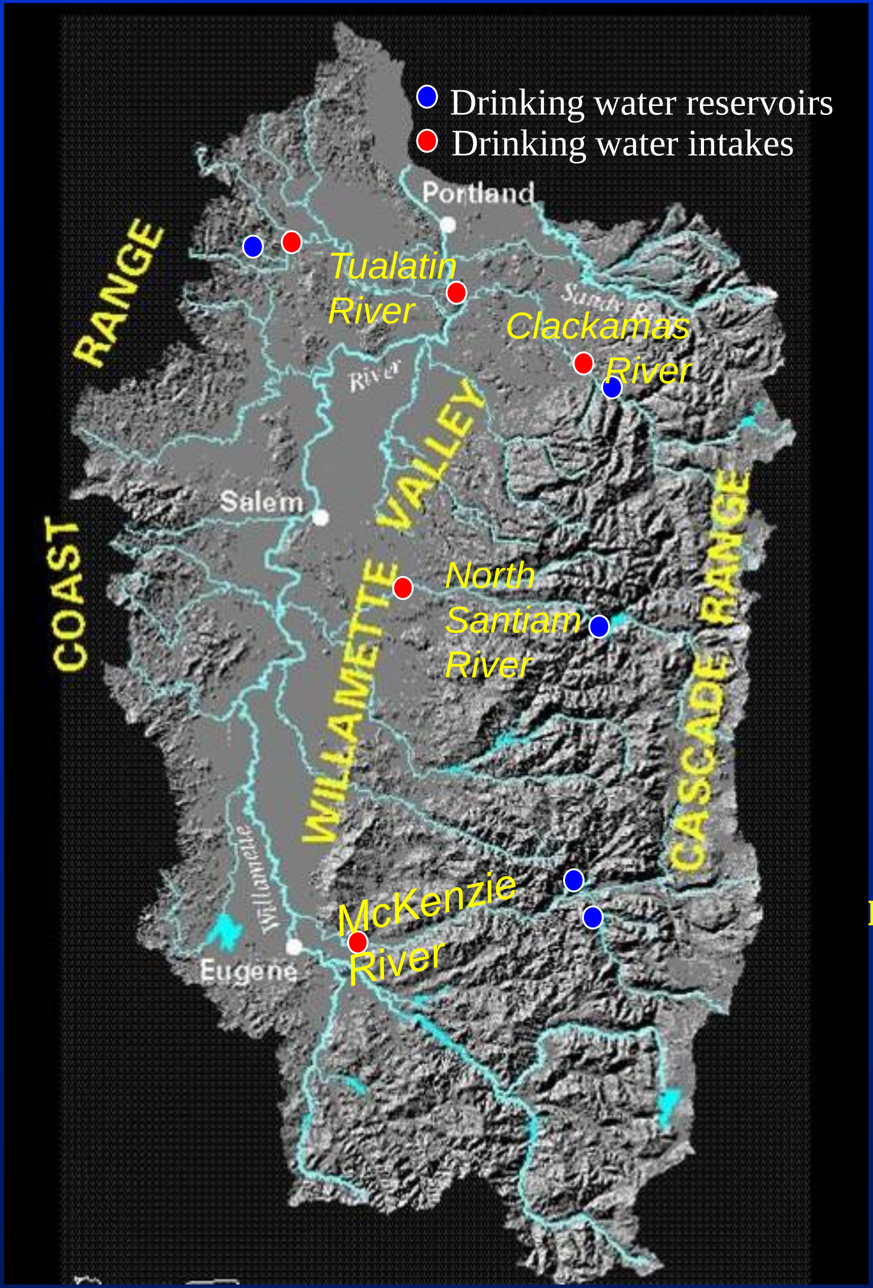




Study Areas

- Clackamas River/ Tributaries
- North Santiam River / intake
- McKenzie River / intake



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"Multiple Lines of Detection" Sampling Approach





- ***Cyanobacteria colonies and mats*** **(n=78) hand-picked during visual surveys**
- ***Plankton net tows*** **(n=84) from reservoirs and riverine sites to identify cyanobacteria and cyanotoxins in transport to downstream DWTP intakes**
- ***SPATTs*** **(n=122) Deployment of solid-phase adsorbent toxin trackers in drinking-water intakes, tributaries, main-stem sites, and a few reservoirs**

Cyanotoxin Analyses

- Cyanobacteria - 3 freeze-thaw cycles to release toxins
- SPATTs extracted with MeOH, concentrated
- Filtered - 1.2 µm glass fiber filters
- Analyze with Enzyme-Linked Immunosorbent Assays (ELISA) for 4 cyanotoxins

- Positive detection when extract concentration exceeded the lowest standard (0.15 µg/L for MC and ANX, 0.05 µg/L for CYL, and 0.02 µg/L for SAX)

Results

- **Seven benthic samples of cyanobacteria—all from the Clackamas Basin—contained detectable levels of all 4 measured cyanotoxins. These included two samples of *Nostoc parmeloides* (ears) and five samples of *Microcoleus***

Nostoc parmeloides (*“Ears”*)

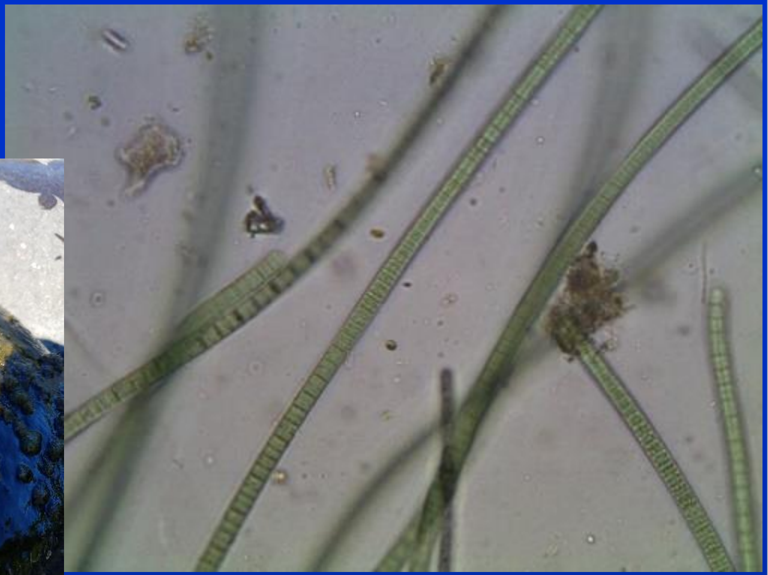
<u>Tested Positive</u>:

Cylindrospermopsins
Microcystins
Anatoxins
Saxitoxins

Microcoleus **("Mats")**

Clackamas River at McIver Park

Cymbelloid stalked diatoms



<u>Tested Positive</u>:

Cylindrospermopsins
Microcystins
Saxitoxins
Anatoxins

USGS Unpublished Data Subject to Revision

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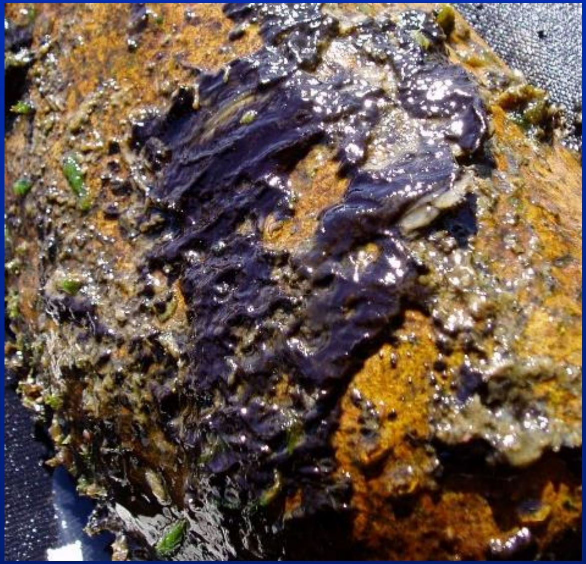
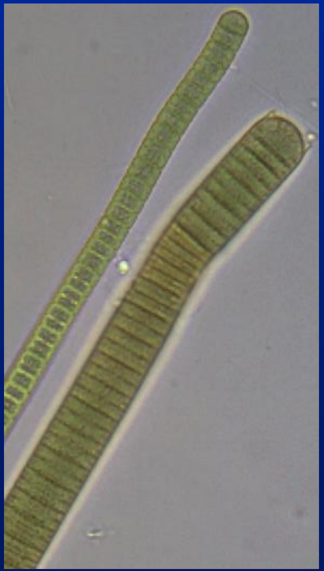
Oscillatoria (“Mats”)

Common in many habitats and rivers, streams, and wetlands





<u>Tested Positive</u>:

Cylindrospermopsins
Microcystins
Anatoxins

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Wollea

Upper Clackamas River, in mats of stalked diatoms (*Cymbella janischii*)

Photo: Barry Rosen/USGS Emeritus, FGSU

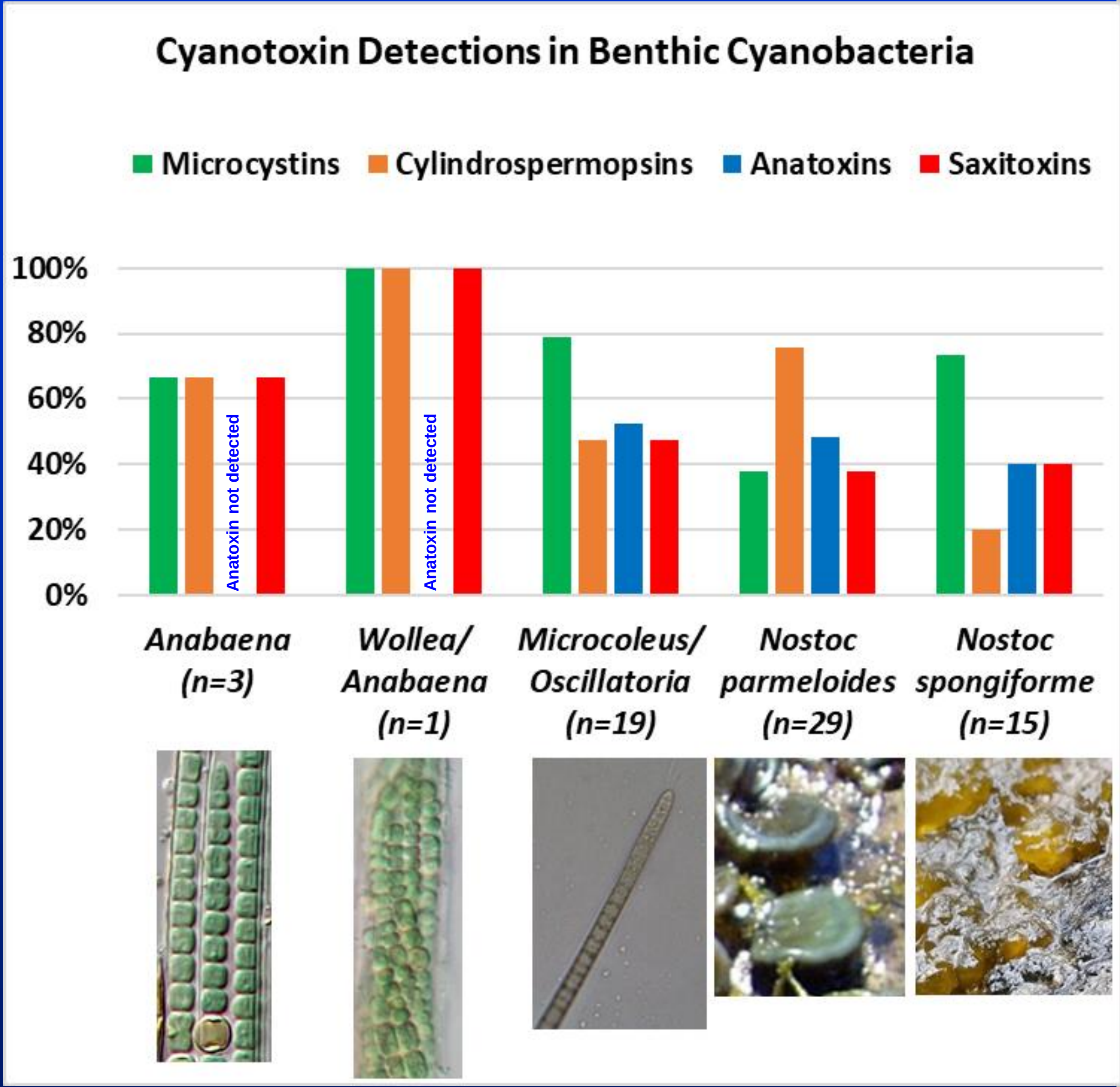
Tested Positive:

Cylindrospermopsins
Microcystins
Saxitoxins

USGS Unpublished Data Subject to Revision

Results

- **94% of 67 samples tested positive for one or more cyanotoxins**
- **Only 4 samples tested negative for all 4 toxins**
- ***Microcoleus, Oscillatoria* and *Nostoc* were the most common toxic benthic taxa**
- **Genes often present along with toxins**



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Cyanotoxin Genes - qPCR (n=12)

- 12 multiple-toxin specimens tested
- CYL and SAX genes and toxins - mostly agree
- One case of toxin gene detected, but no toxin found - not unexpected

	Sample extract cyanotoxin concentrations (ug/L)			
Cyanobacteria present	**MC**	**CYL**	**SAX**	**ANX**
Nostoc	0.48	**0.12**	<	0.29
Microcoelus	0.33	<	**3.33**	0.17
Nostoc	1.15	**0.14**	**0.17**	0.23
Wollea saccata, Anabaena, Nostoc spongiforme, Tolypothrix	**8.54**	**0.65**	**0.53**	<
Dolichospermum, etc	0.23	**0.35**	<	0.26
Dolichospermum, Nostoc, Tolypothrix	**4.89**	**2.67**	**0.18**	<
Dolichospermum, Oscillatoria, Tolypothrix	4.77	**3.40**	**0.20**	0.16
Dolichospermum, Oscillatoria, Tolypothrix	2.74	**2.67**	**0.16**	0.16
Dolichospermum, Oscillatoria, Tolypothrix, Rivularia	144	<	**0.06**	<
Dolichospermum spp., possibly other cyanos	**30.5**	**0.11**	<	0.17
Dolichospermum, Nostoc	2.51	**0.07**	**0.08**	<
Oscillatoria, Tolypothrix, Rivularia	<	**0.07**	**3.67**	0.26
	Yellow highlight = Toxin Gene Present			

USGS ELISA/CRW Phytoxigene Data Unpublished - Subject to Revision

- MC genes sometimes not detected in lowest concentration samples
- Several labs are working on primers for anatoxins

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Conclusions

- Presence of all 4 primary cyanotoxins confirmed in numerous samples of benthic cyanobacteria
- Plankton net tow samples contained cyanobacteria, including Nostoc (especially) in transport to drinking water intakes
- Since toxins are intracellular, risk is unknown but frequent detection in SPATTs indicates that some toxin is dissolved
- Toxins might also be transported downstream associated with <u>sediments</u> or <u>organic carbon</u>

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Considerations and Next Steps

- *Samples were natural collections, not unialgal cultures, so multiple strains may be present*
- *Culturing is ongoing to isolate and identify toxin production, spectral reflectance*
- *Draft journal paper, abstract submitted for 2020 ASLO-SFS Conference*
- *Focus efforts this summer on Detroit Lake, Cougar Reservoir (continuous profiling, SPATT deployments, samples for culturing and further evaluation)*

Thank You!

Acknowledgements

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