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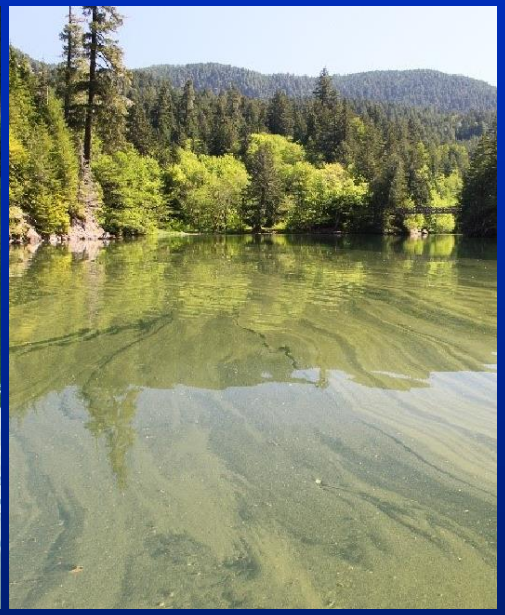
Enhanced Water-Quality Monitoring in Detroit Lake and the North Santiam River to Support Dam Operations and Drinking Water Management



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U.S. Geological Survey

9th Annual North Santiam Basin Summit
Basin Changes and Challenges
Salem, Oregon
May 15, 2019

Cyanobacterial Blooms Include..

Floating Phytoplankton and Benthic "Periphyton"

Timothy Lake

North Fork Reservoir

Phormidium
Fish Creek
Upper Clackamas Basin

Nostoc
Oak Grove Fork
Clackamas R.

Oscillatoria
Lower Clackamas River

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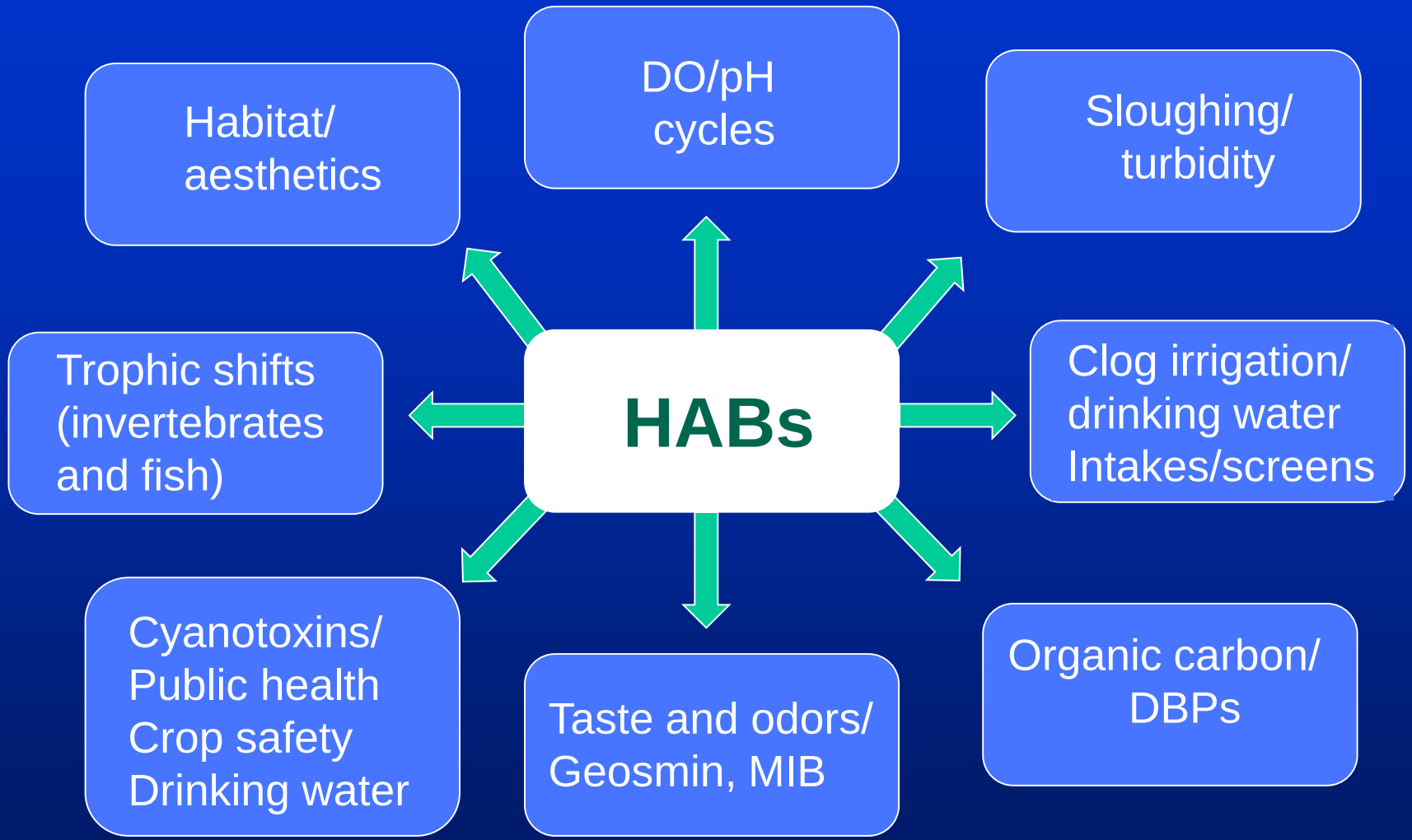
Some Impacts from HABs



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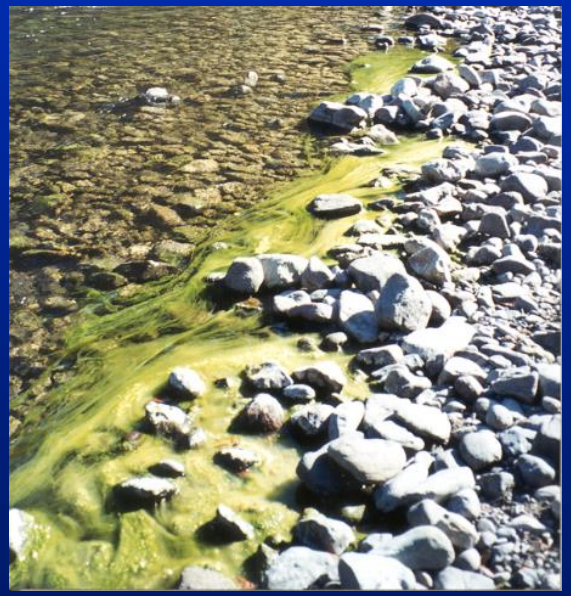
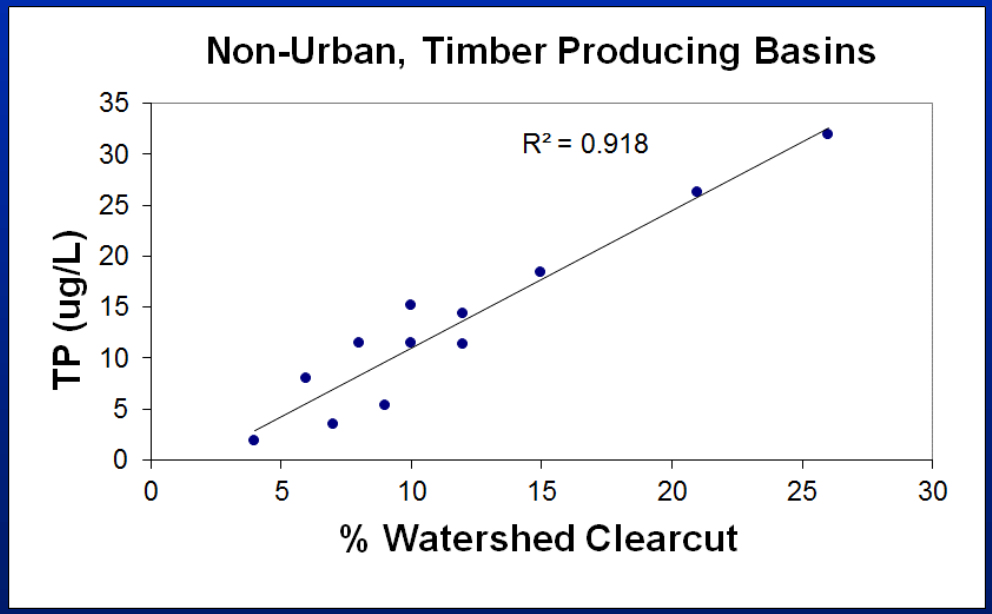
Cyanobacterial Blooms

- Have a long history of causing humans problems
- Cascade Range rivers are prone to blooms
- Naturally occurring phosphorus
- Steep topography causes landslides
- Timber harvesting and roads can cause erosion





Carpenter 2003 (USGS WRIR 02-4189)

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Cyanobacterial Blooms

- Nearly all major reservoirs in the Willamette Basin have experienced blooms of cyanobacteria
- 1990's - Cyanobacteria blooms caused tastes and odors in the Clackamas water supply
  - Cyanobacteria (*Dolichospermum*) was found in two primary reservoirs
  - Later, toxin (microcystin) was detected in North Fork Reservoir
- Cyanobacteria blooms in Detroit Lake – has been a recurring issue for at least 15+ years, likely longer

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Factors Contributing to HABs

- Warm water temperatures – stratification favors cyanobacteria, and expands window for HABs
- Nutrient inputs from forestry, agriculture, rural, and urban areas
- Clear water is good for light penetration
- Reservoir releases (hypolimnetic and epilimnetic) may enrich downstream rivers
- Erosion of P-rich soils (High Cascades) can exacerbate HABs
- Once infected, a waterbody is prone to worsening HABs due to sediment bank of akinetes

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Ecological Strategies: internal structures for optimizing placement in the water column

Gas Vesicles: Buoyancy regulation and vertical migration

Low light ↑

↓ $(C_6H_{12}O_6)n$

Nutrients scavenged near lake sediments or at thermocline

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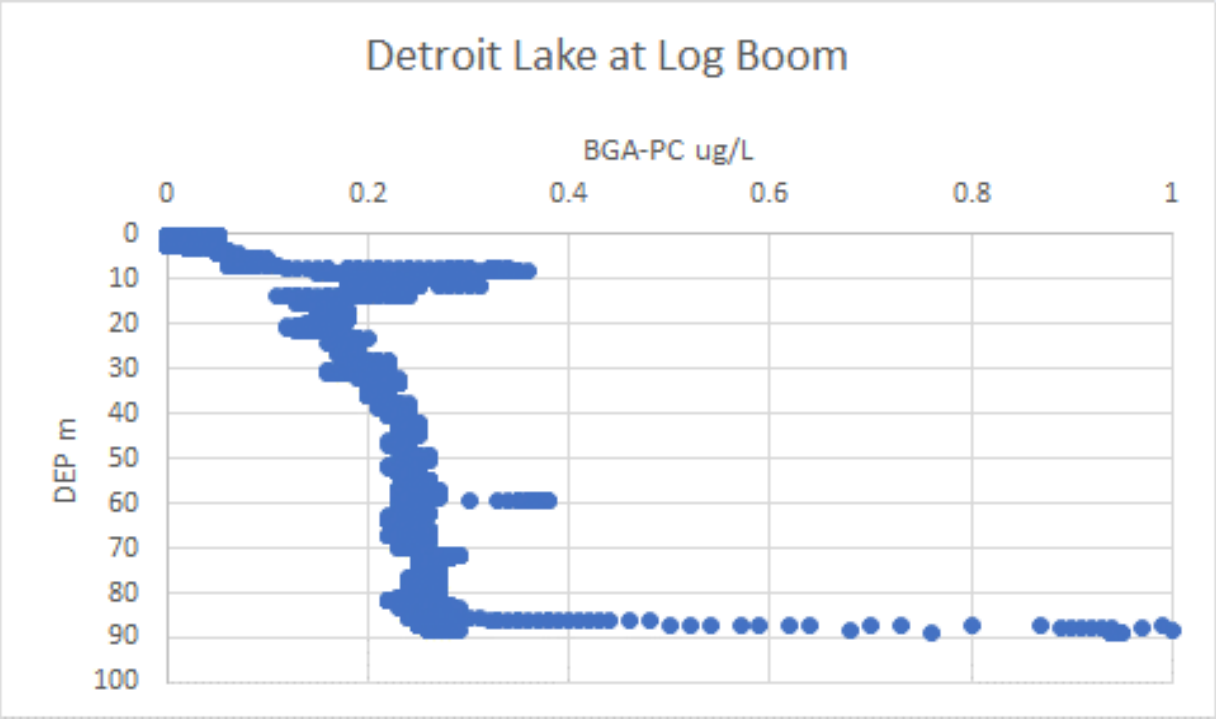
Slide courtesy of Barry Rosen/USGS

Cyanobacteria are Dynamic

- Cyanobacteria optimize placement in the water column using gas vesicles
- Akinetes germinate in sediments and enter the water column
- Gas vesicles cause filaments to rise up to obtain light
- Lenses of cyanobacteria colonies can occur at the surface, mid-depth, and off the bottom
- Knowledge of where cyanobacteria reside in the water column can inform dam operations and drinking-water treatment plant operators



Detroit Lake profile 7/27/2018 - USGS Preliminary Data Subject to Revision

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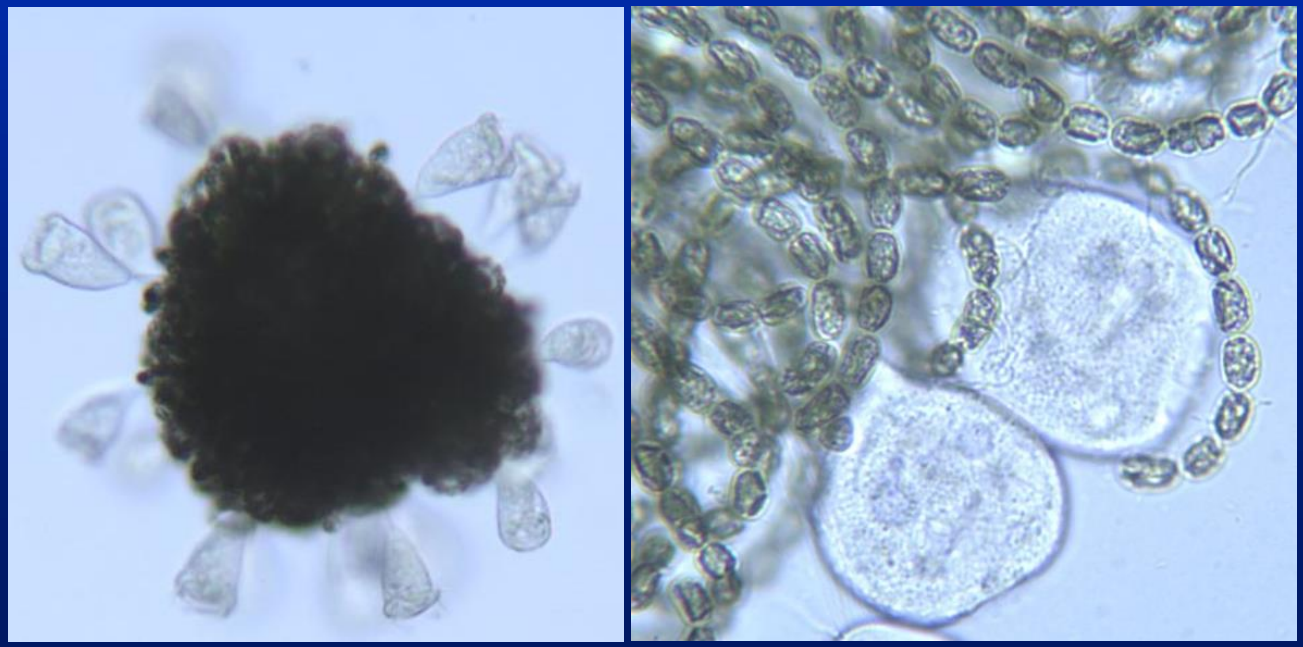
2018 Cyanobacteria Bloom in Detroit Reservoir

- May 2018 - A bloom of *Dolichospermum* occurred in Detroit Reservoir
- May 23 - Recreational advisory issued
- May 23 - Cylindrospermopsin and Microcystins detected in drinking water
- Health advisory for vulnerable populations recurred intermittently until July 3

- Late July - The bloom resurfaced; > 5 µg/L microcystins were detected
- July 27 - August 16 - Recreational advisory issued for Detroit Reservoir

***Dolichospermum* blooms are common in Detroit Reservoir, dating back to at least 2005**



Detroit Reservoir at log boom 9/20/2005

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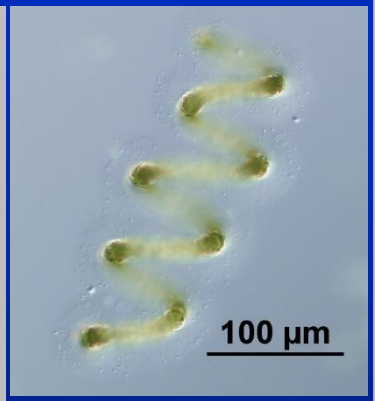
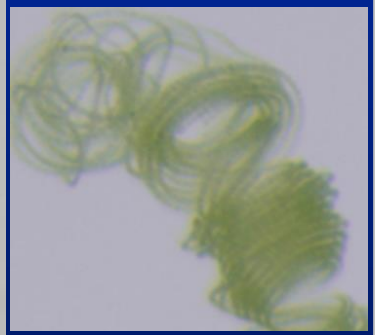
Dolichospermum spp.

- In *Dolichospermum* (formerly *Anabaena*), short chains develop into filaments and spiraling/tangled colonies of alternating vegetative and nitrogen-fixing cells, with occasional spores (akinetes)
- *D. lemmermanii* (shown below) is from Detroit Reservoir (2017) producer of cyanotoxins including microcystin, cylindrospermopsin, and anatoxin-*a*





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Microscope photographs by Barry Rosen/USGS

Cyanotoxins

- Potent Liver, Kidney, and Neurologic Toxins
- UCMR4 (2018-2021): Includes Microcystins/Nodularins, Anatoxin-*a*, and Cylindrospermopsin
- EPA's Cyanotoxins Toxicity Assessment and Proposed Drinking Water Criteria

Toxin	10-day Health Advisory	
	Bottle-fed infants and pre-school children	School-age children and adults
Microcystins	0.3 µg/L	1.6 µg/L
Cylindrospermopsin	0.7 µg/L	3 µg/L

- Microcystins Detected in 30% of Lakes during National Lakes Assessment
- Similar Detection Rate in Pacific Northwest Streams during 2015

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New Project at Detroit and Cougar Reservoirs

- Five New Continuous Water Quality Monitoring Stations

  North Santiam River Basin
  - Detroit Lake (profiling pontoon system, 100-meters)
  - North Santiam River at Niagara

  McKenzie River Basin
  - Cougar Reservoir (profiling pontoon system, 100-meters)
  - South Fork McKenzie River downstream from Cougar
  - Blue River downstream from Blue River Reservoir

- Fully loaded 8-parameter EXO2 Sondes

- Project is collaboration including the U.S. Army Corp of Engineers, USGS, City of Salem, and Eugene Water and Electric Board

- Opportunities for collaboration with other researchers

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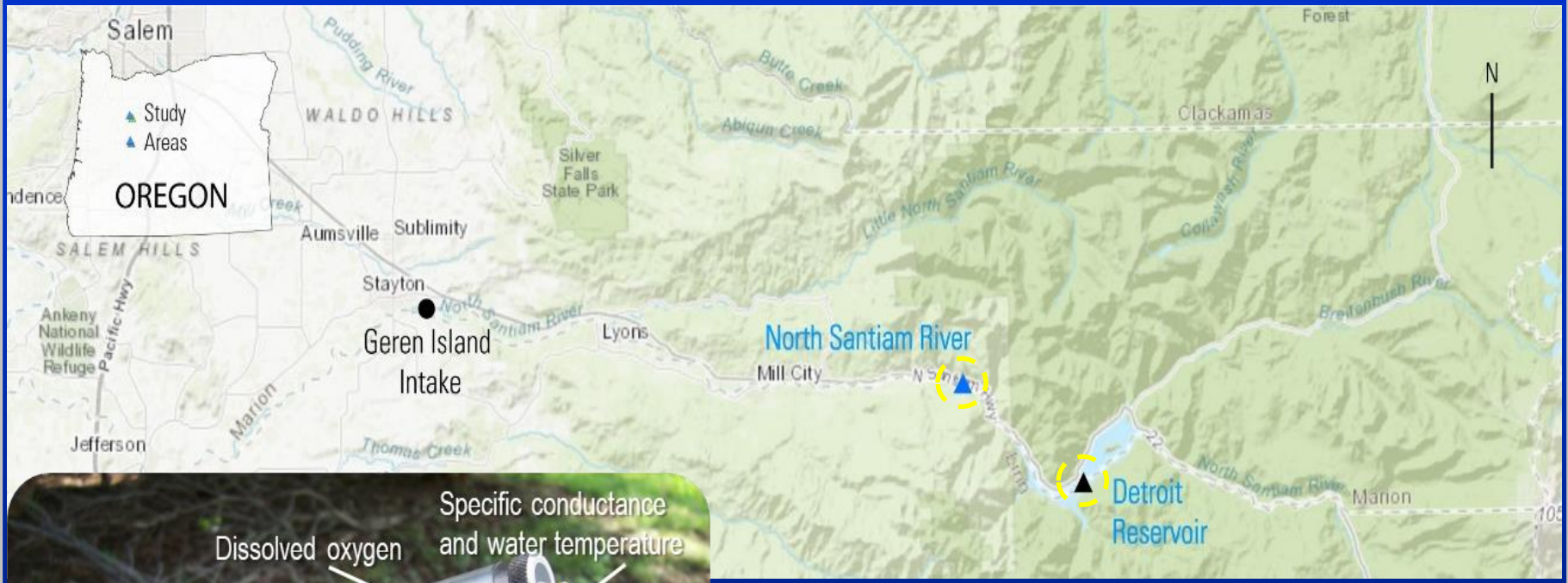
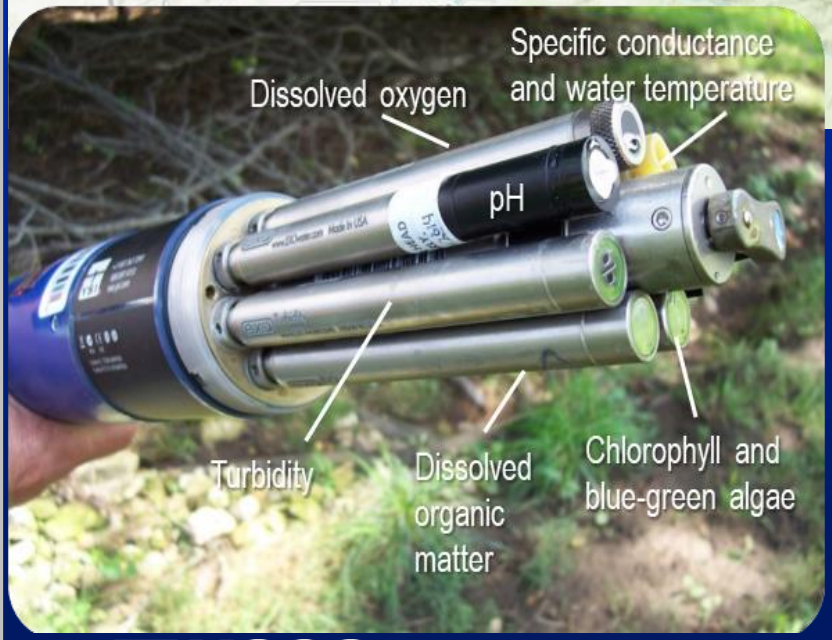
Two New Continuous WQ Monitoring Stations





- **8 Water-Quality Parameters**
  - Water temperature
  - Dissolved oxygen
  - pH
  - Specific conductance
  - Total chlorophyll
  - Phycocyanin (blue green algae pigment)
  - Turbidity
  - Fluorescing dissolved organic matter (fDOM)

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Project Objectives

Objective 1. Provide real-time monitoring data to understand HAB development in Detroit Lake and Cougar Reservoirs and the transport of cyanobacteria and potential cyanotoxins downstream

Objective 2. Provide an early warning system for downstream water treatment plant operators and dam operators, about the presence of cyanobacteria and algae in the river

Dolichospermum bloom, Cougar Reservoir
Photograph by Chauncey Anderson/USGS

Microscope photograph by Barry Rosen/USGS

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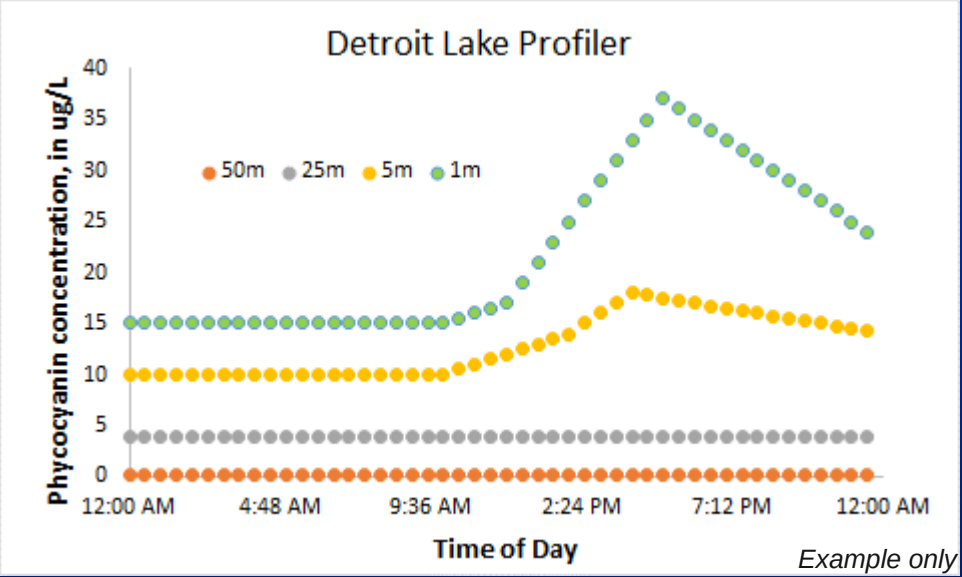
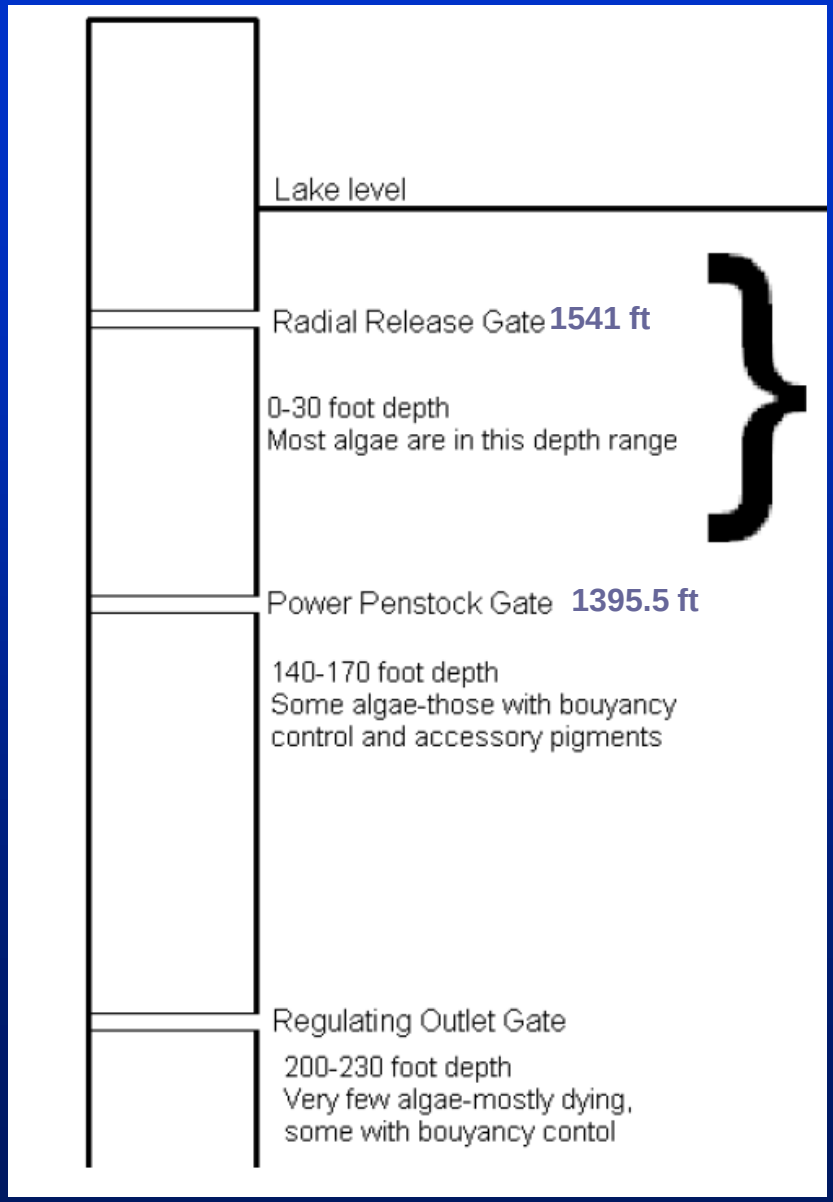
Profile Analysis Tool

NWIS Web tool will be developed to depict real-time water-quality conditions at specific depths in the water column down to 100 meters





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Project Timelines

	FY 2019									FY 2020												FY 2021											
Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Construction			x	x																													
Water Quality Monitoring				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x												
Tool Development				x	x	x	x																										
Interpretive Report																					x	x	x	x	x	x	x	x	x	x	x	x	x

- ✓ Construction of new riverine sites complete
- • Pontoon system procurement is underway, will install asap
- ✓ North Santiam River at Niagara continuous real-time water-quality monitoring site re-activated on 4/23/19
- ✓ McKenzie River stations (Blue River and South Fork) went in this week – real-time data immanent
- ✓ Real time data available at https://waterdata.usgs.gov/nwis/
- ✓ And on the Data Grapher https://or.water.usgs.gov/grapher/

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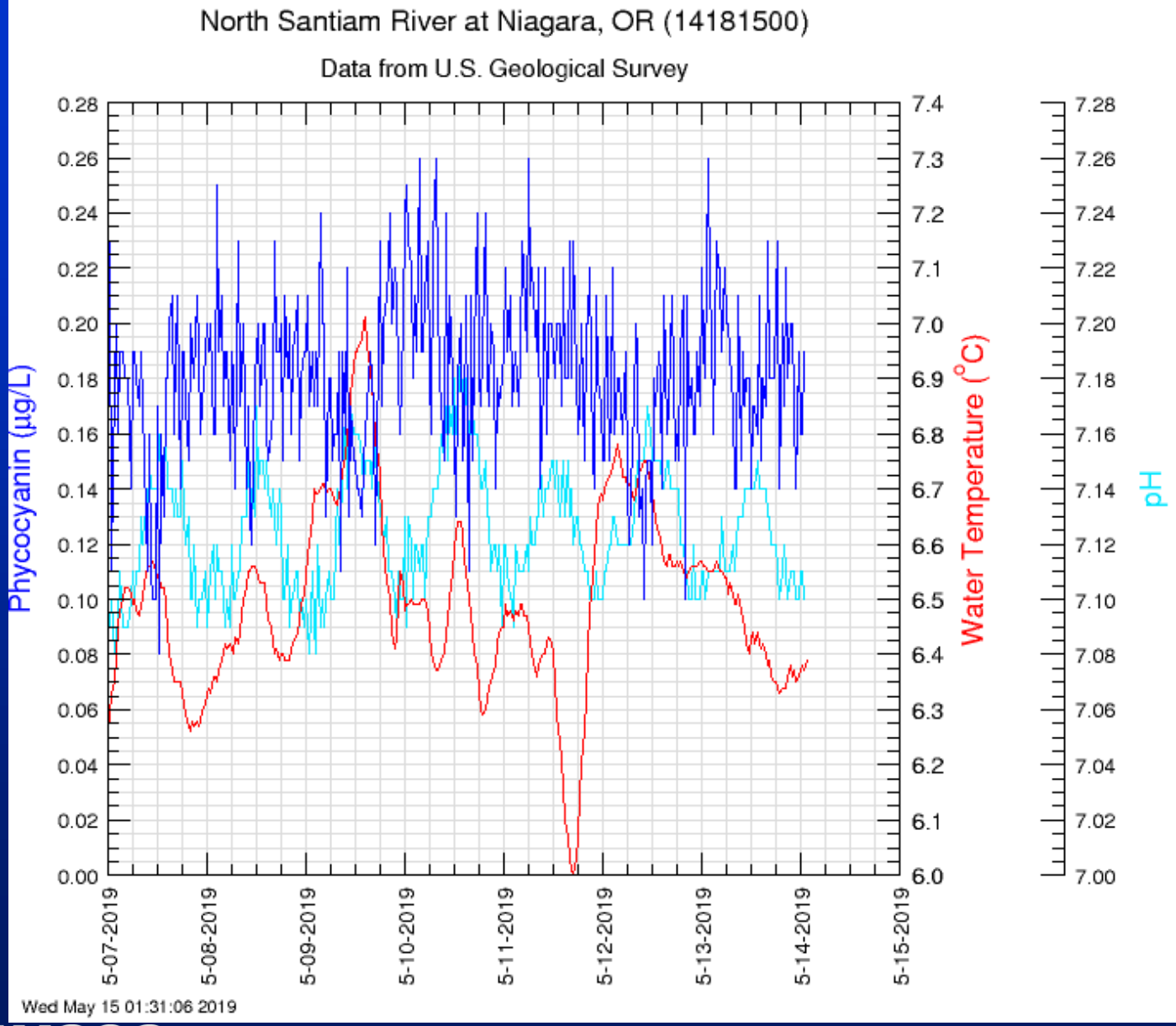
https://or.water.usgs.gov/cgi-bin/grapher/grapher_3site.pl



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