Algae Monitoring and Response in the Clackamas River Watershed

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Clackamas River Water

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Clackamas River Water

Clackamas River Water Providers

Working together to protect and conserve our drinking water.

Why Are Algal Blooms a Concern to Drinking Water?

- Increased raw water turbidity and shorter filter run times
- Increased disinfection byproduct precursors
- Increased operational costs
- Odor, taste, and color problems in finished water
- Customer loss of confidence in the quality of drinking water
- Potential release of cyanotoxins in source water or through treatment process, can cause damage to the liver, nervous system, skin, and gastrointestinal system resulting in paralysis, organ damage, heart failure, and death.

Algae Blooms in the Clackamas River Watershed

- Toxic cyanobacterial blooms have been know to occur periodically in the upper reaches of the watershed where water can become stagnant and/or stratified- i.e. Timothy Lake and the North Fork Reservoir
- Taste and Odor events in finished drinking water downstream of the reservoirs occur almost every summer
- HABs in our region are difficult to predict and control.
  - What causes a HAB to form (or not) can be the result of many things and the tiniest changes in environment.

Goals of the CRWP Algae Monitoring Program

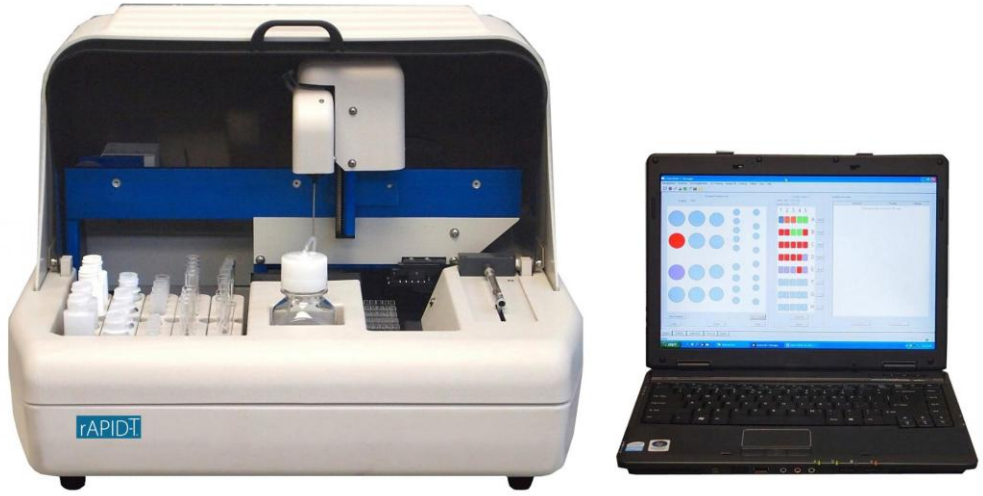
1. Be more proactive with water sampling.
2. Track conditions that lead to a bloom.
3. Employ preventative measures.

Hoping to be able to predict the onset of an algae bloom one day, but it all starts with monitoring and collecting data.


Monitoring Program

Monitoring Raw Water for Cyanobacteria

- The instruments used for algae monitoring allow for the rapid identification and quantification of algae and nutrients in the system.
- Samples are analyzed for dominant genera with a Fluid Imaging Technologies FlowCAM.
- Nutrient concentrations (ammonia, nitrate + nitrite, orthophosphate) with an Astoria-Pacific ChemWell-T AutoAnalyzer.



AutoAnalyzer

FlowCAM

- FlowCAM is an automated microscope for detailed morphological analysis (size, shape, etc.) of algal cells.
- Microscope + Camera + Flow Cytometer + Image Recognition Software.
- Rapid detection of potentially toxic cyanobcteria during bloom events.
- Ability to monitor intakes closely during toxic blooms to determine if these organisms are reaching the treatment plant.

FlowCAM operation at CRW

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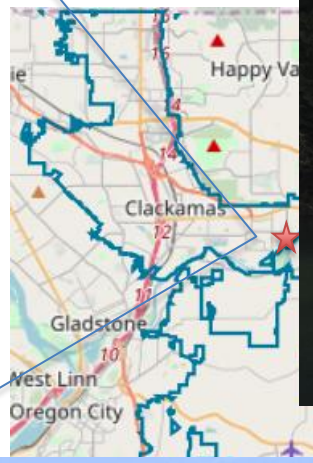
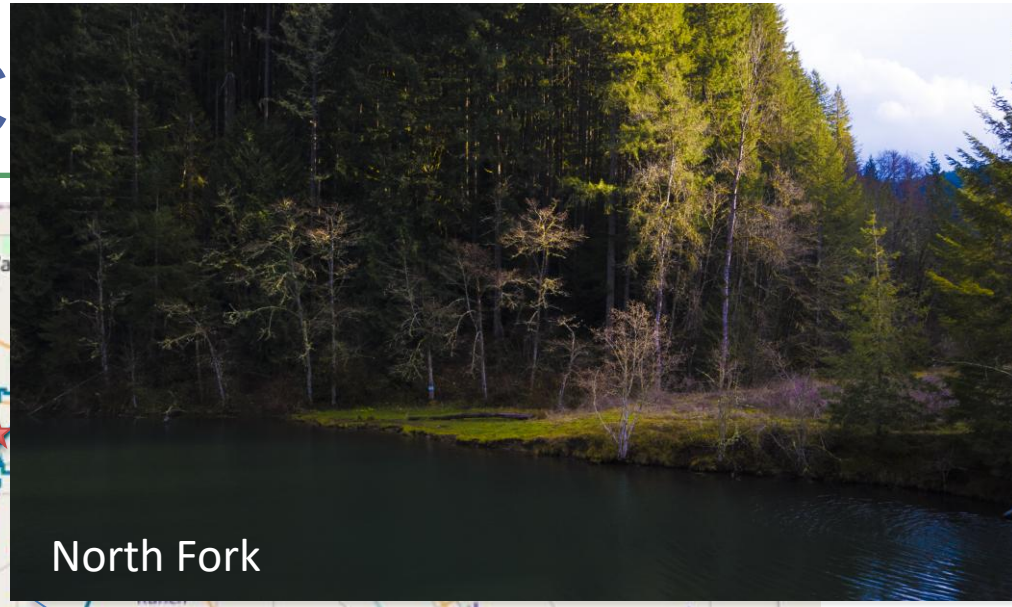
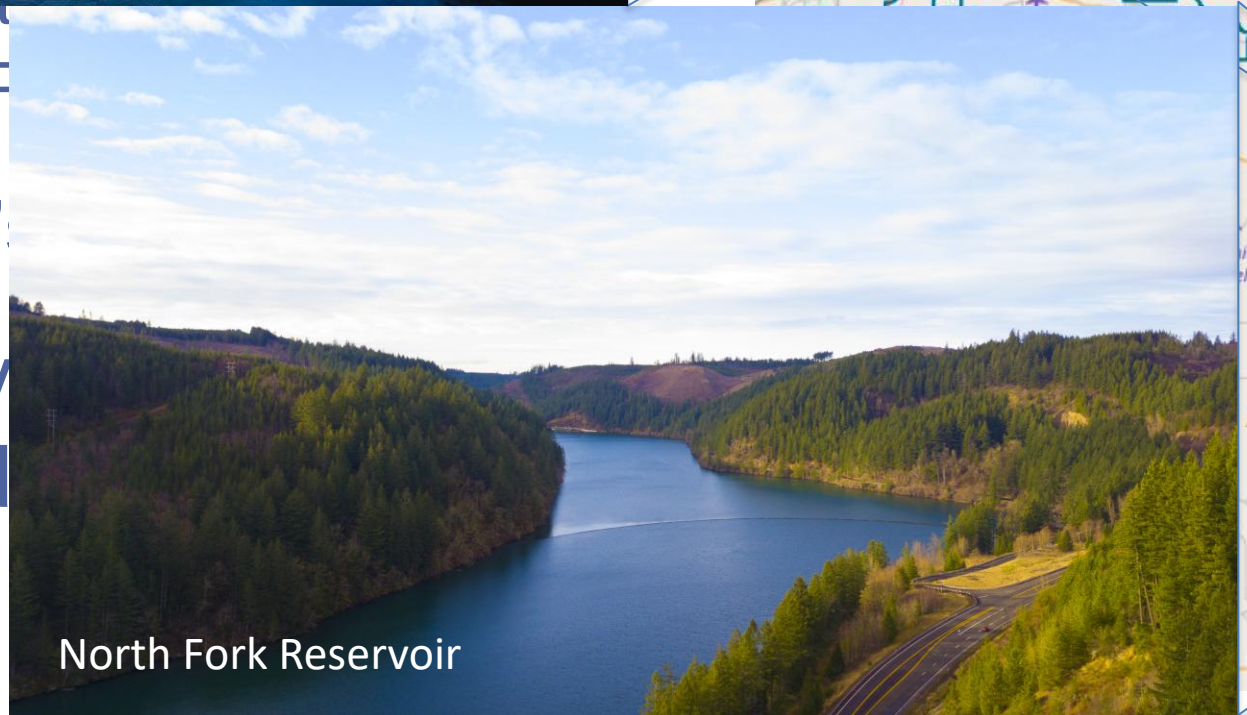
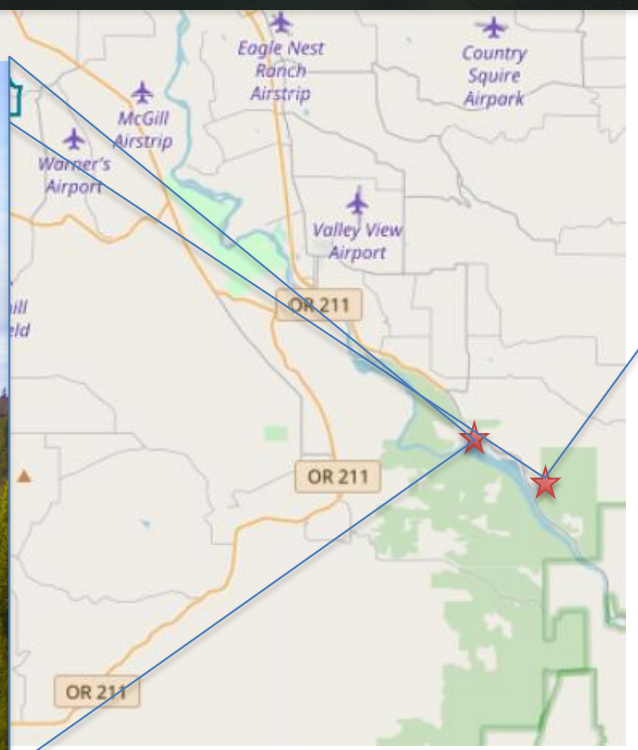


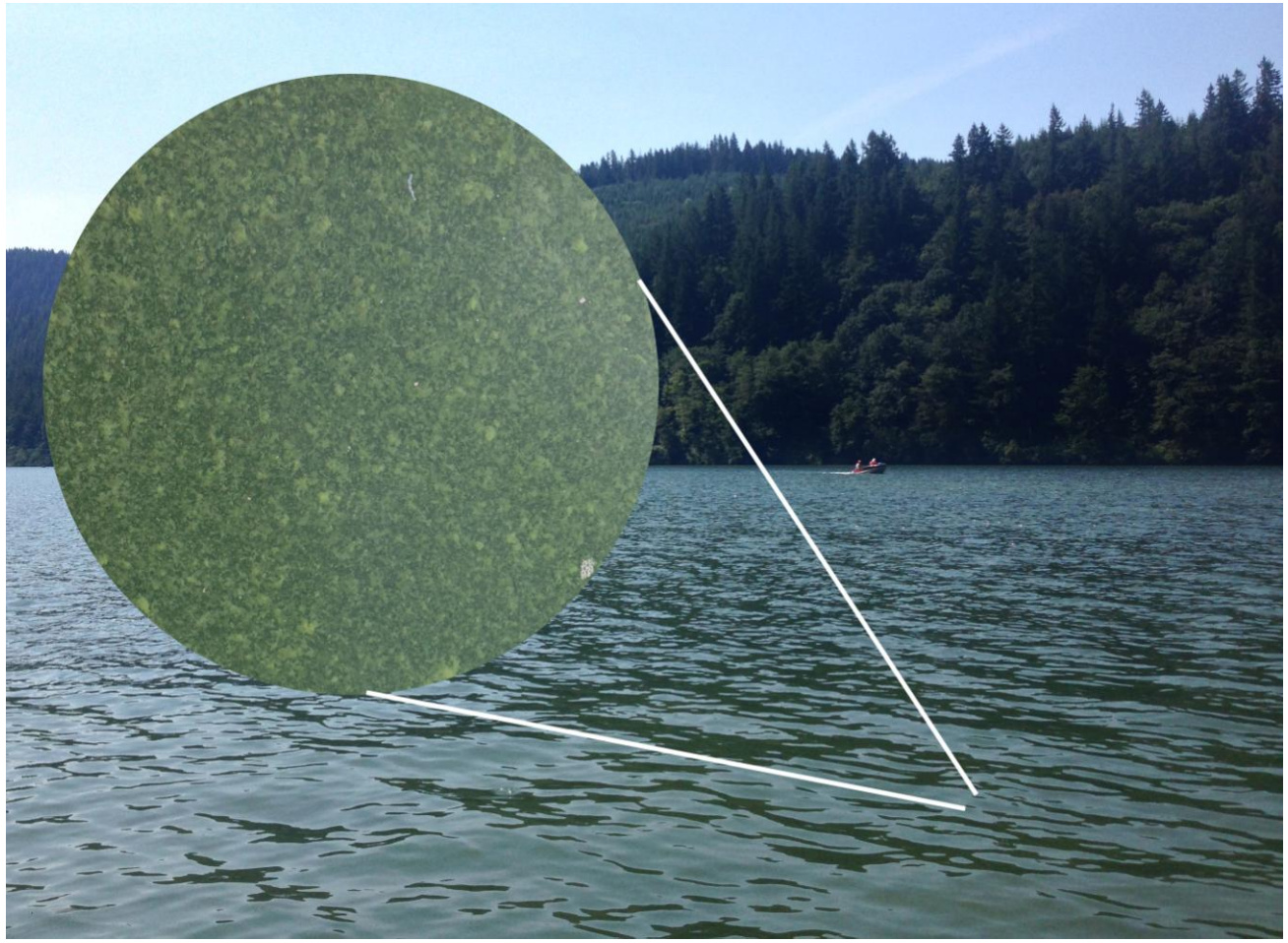






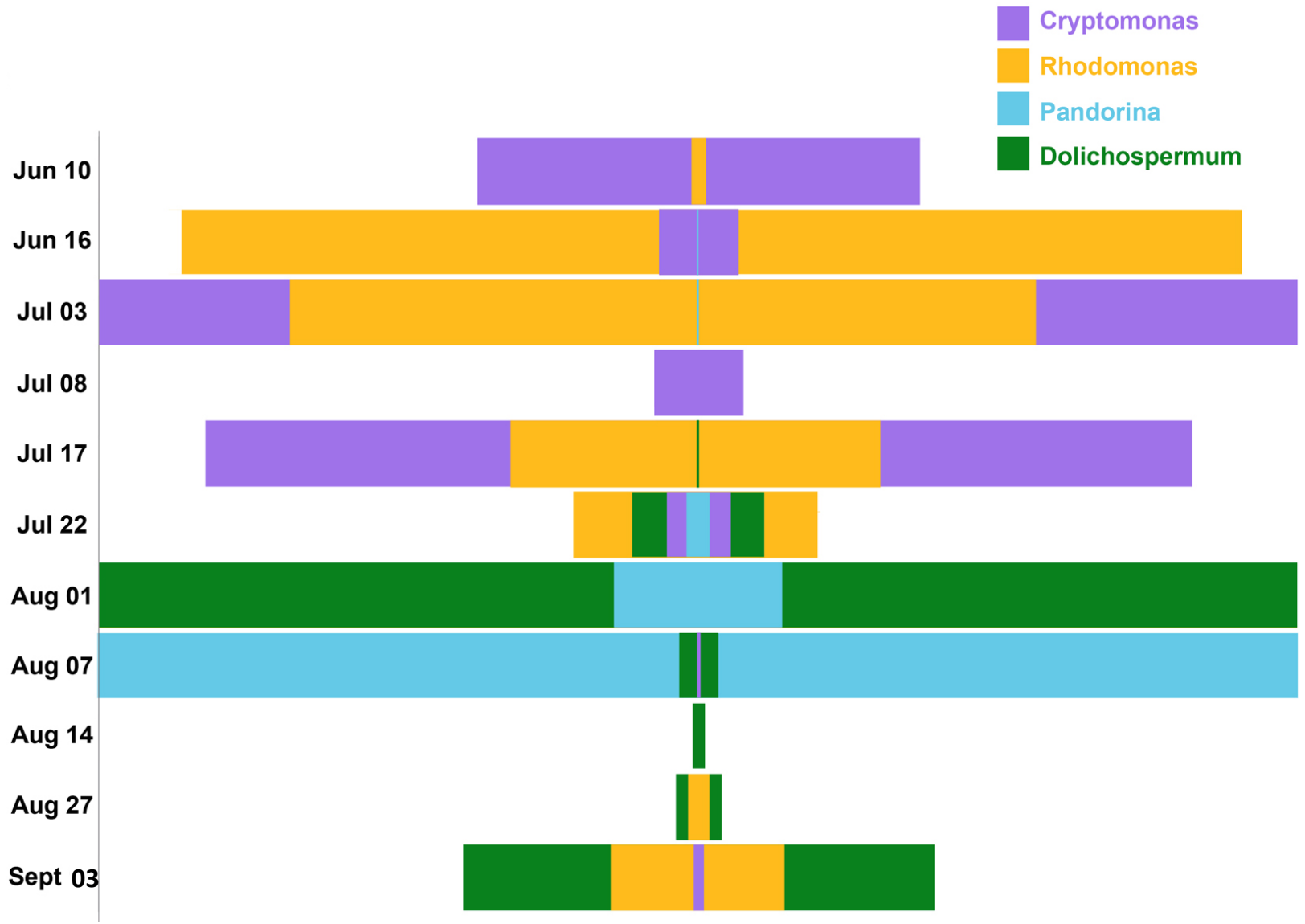
Scenario #1- 2014 Bloom Perfection

- Late July into early August 2014 the North Fork Reservoir experienced a large algae bloom.



Cyanobacteria Bloom in the North Fork Reservoir

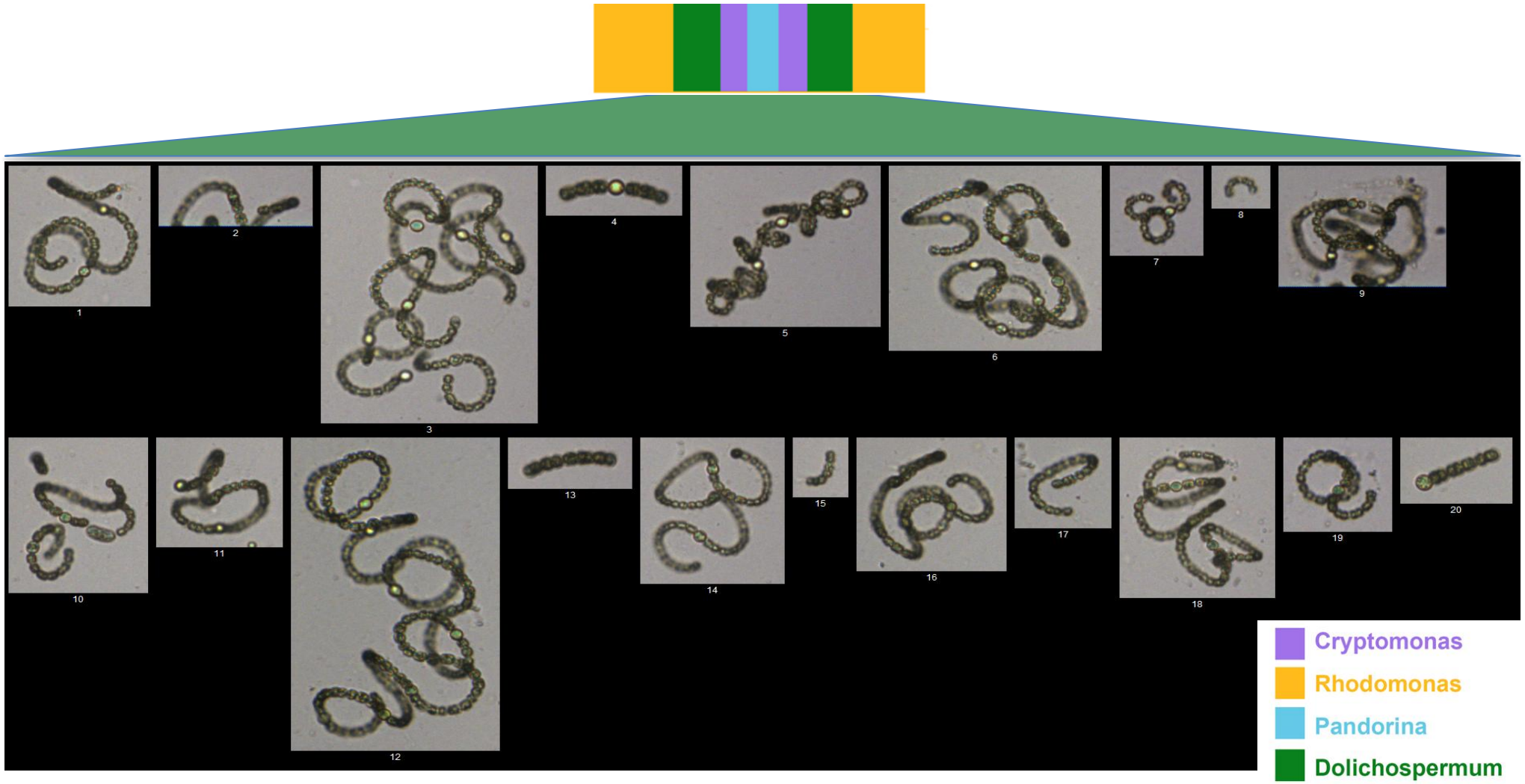
Population Dynamics of Top 4 Genera



The Rise of Dolichospermum

The Rise of Dolichospermum

Jul 22



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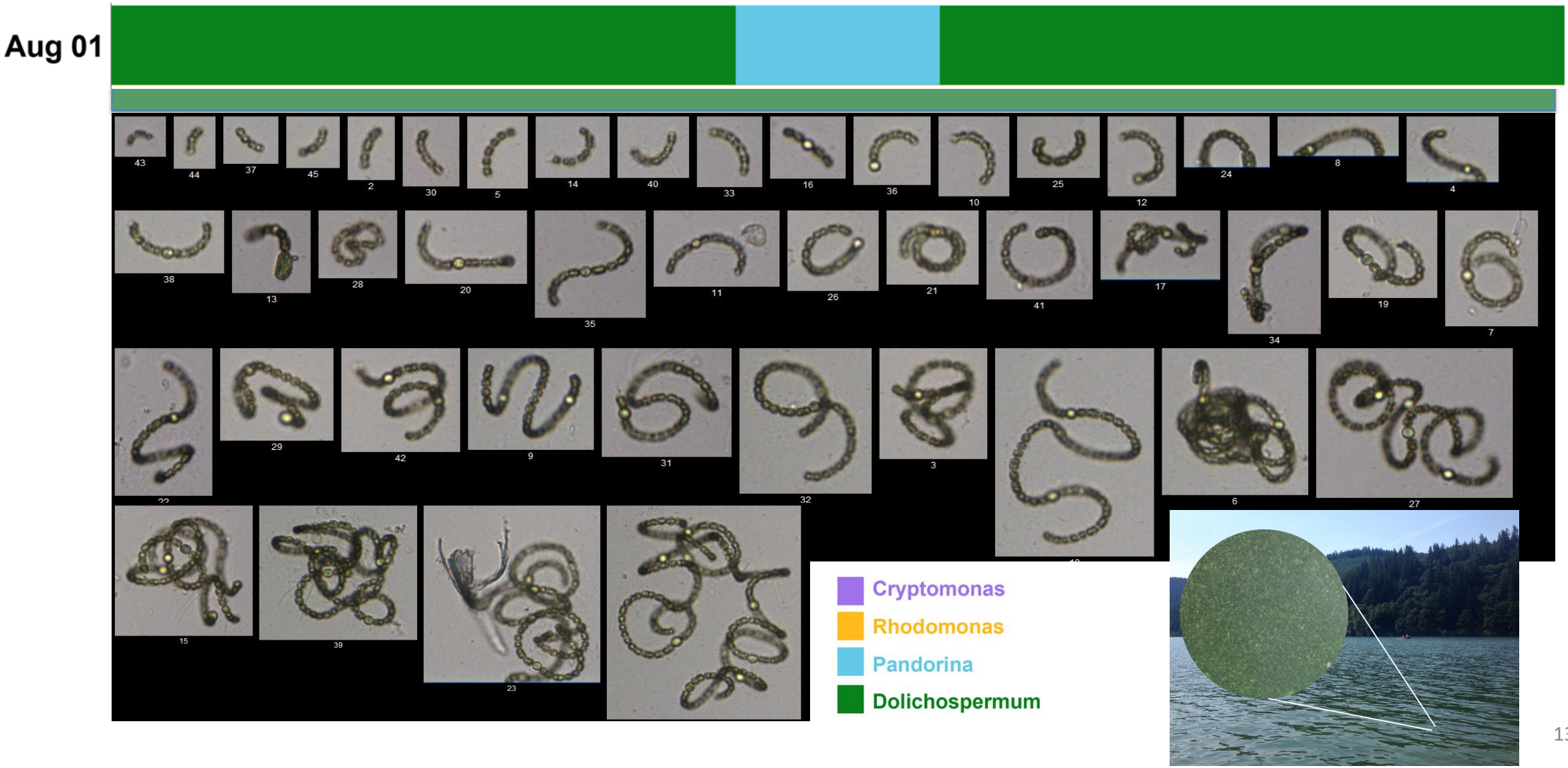
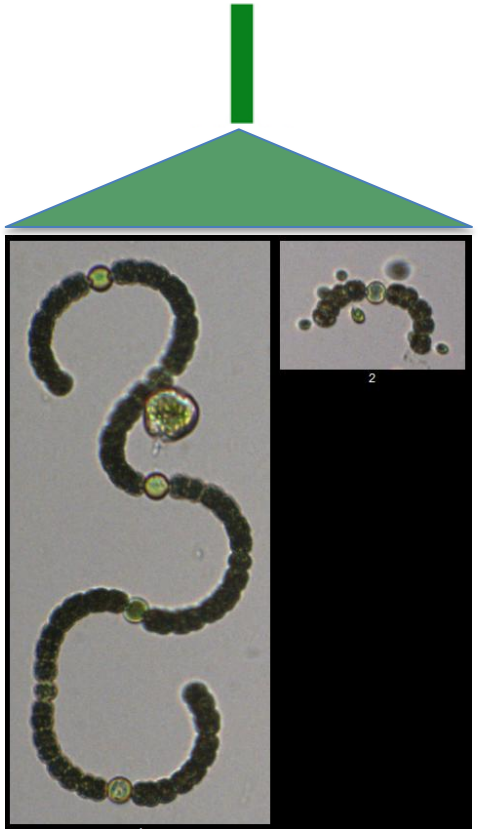


The Dem e of Dolichospermum

...and the Pandorina EXPLOSION!

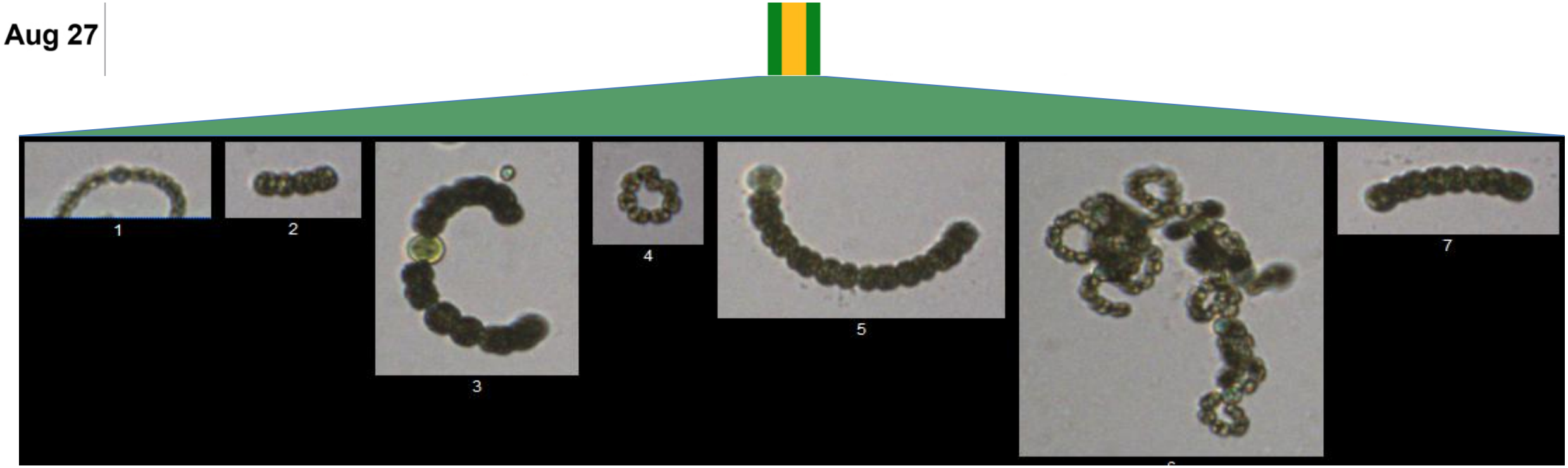
The Demise of Dolichospermum

Aug 14



Cryptomonas
Rhodomonas
Pandorina
Dolichospermum

The Resurgence of Dolichospermum



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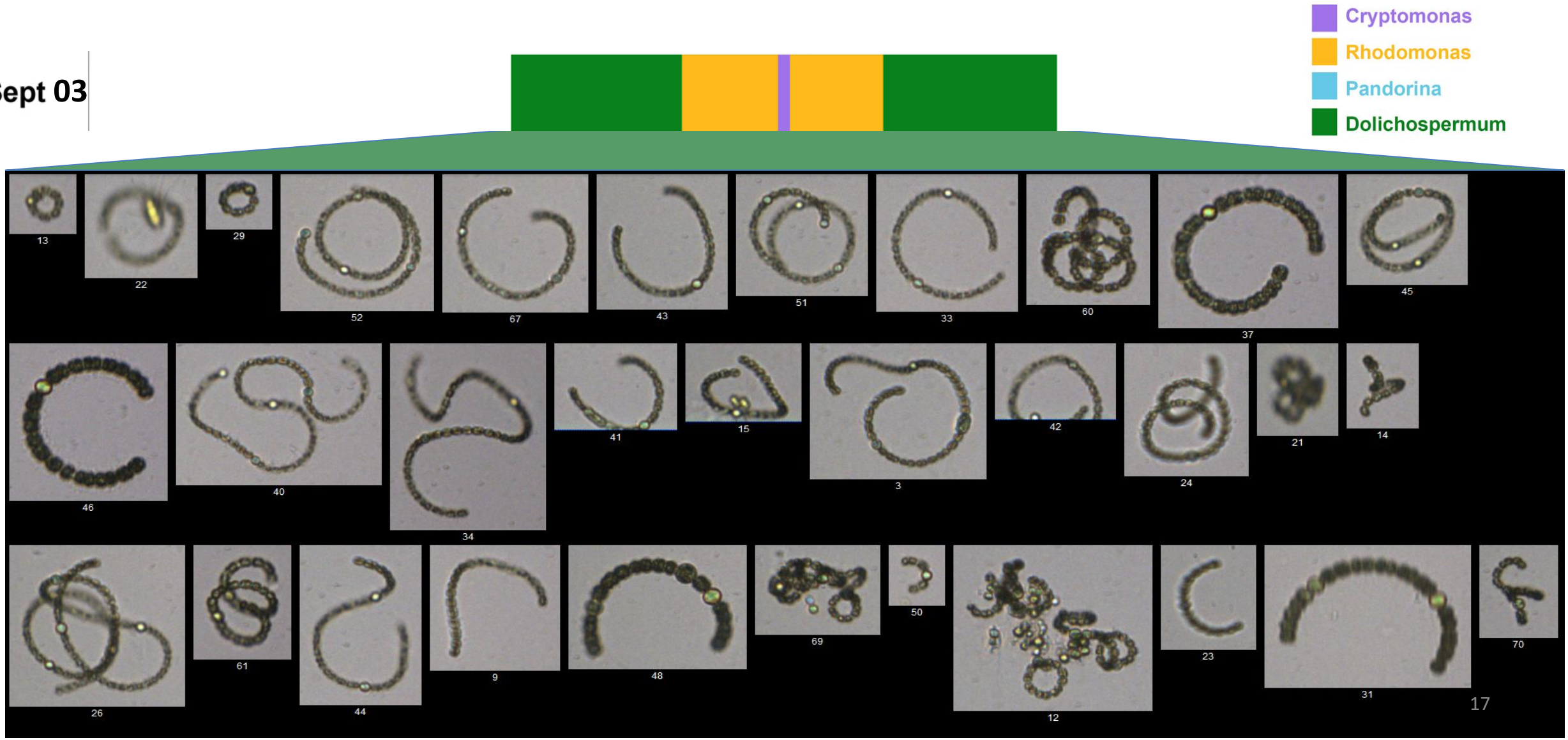
The Resurgence of Dolichospermum



Scenario #1- Drinking Water Impacts

- Taste and Odor issues were reported in finished drinking water.
- Were Dolichospermum detected at the drinking water intakes during the bloom period?
  - **No.**

Dolichospermum Bloom August 2016

- August 2016 PGE reported a small Dolichospermum bloom in the North Fork Reservoir
  - Triggered toxin sampling at North Fork Reservoir, Estacada, and Lake Oswego
  - Toxins detected at North Fork Reservoir and Lake Oswego
- Anabaena never detected at CRW intakes
- Highlighted the need to leverage monitoring with our watershed partners

Is the toxin free floating? Is the toxin coming from something other than the reservoir bloom?

Scenario #2- NFR Bloom September 2016

On Sep 28, 2016, at 2:07 PM, Dan Cramer <Dan.Cramer@pgn.com> wrote:

Hello,

A blue green algae bloom was observed in the forebay of North Fork Reservoir today. Samples were collected at noon and sent overnight for toxin analysis. We will likely know the results of the analysis sometime early next week and I will pass these results along to the group as soon as I receive them.

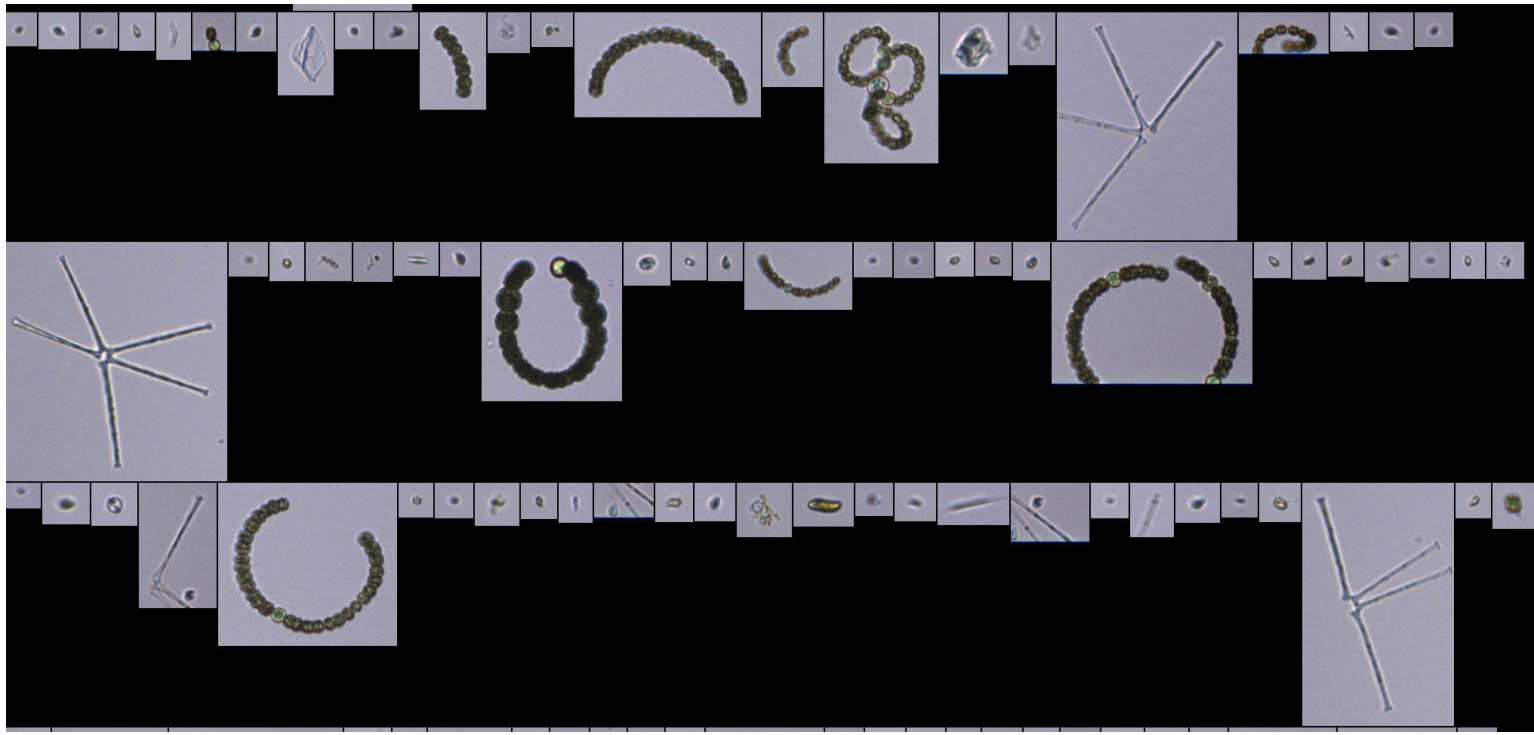
Monitoring at Timothy Lake for 2016 is complete. The bloom noted today extends PGE's monitoring at North Fork Reservoir into October and will conclude when there is no longer visual evidence of a bloom.

Please contact me with any questions.

Dan Cramer
Portland General Electric
Fish Biologist

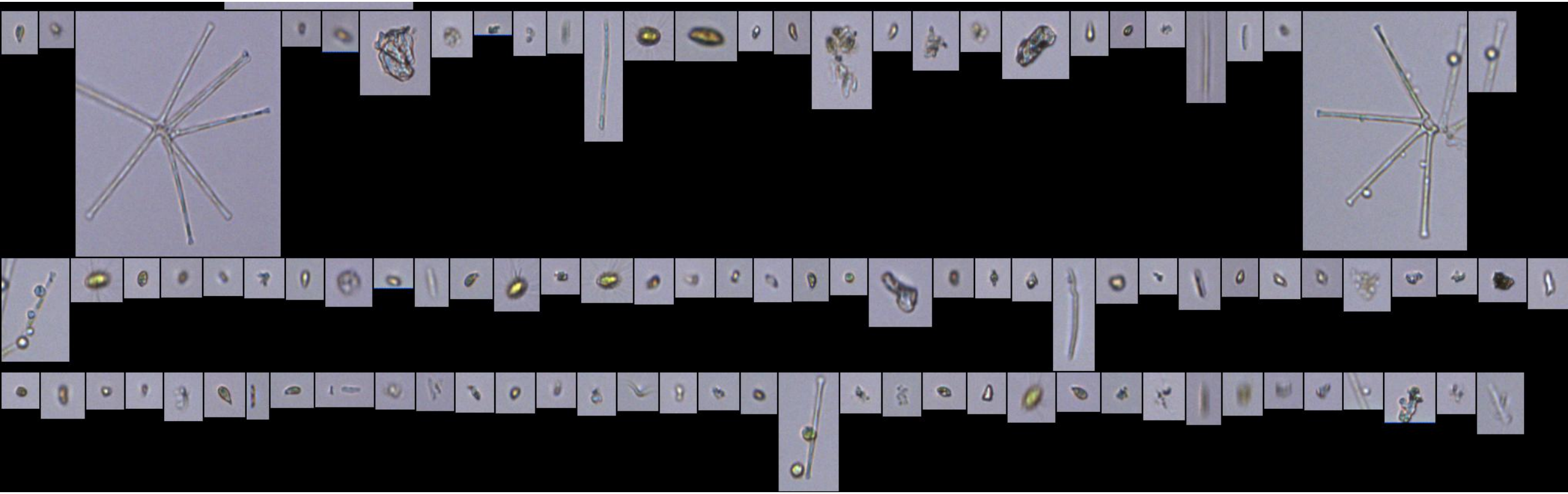
Scenario #2- NFR Bloom September 2016

- Responded to PGE on September 28, 2016 at 3:41pm.
  - Non-uniform bloom.
  - Potential toxin producing cyanobacteria Dolichospermum present.



Scenario #2- NFR Bloom September 2016

- October 11, 2016- while still visible, the bloom had largely dissipated and Dolichospermum was negligible.



What we've learned from monitoring so far…

Collecting baseline data since 2014

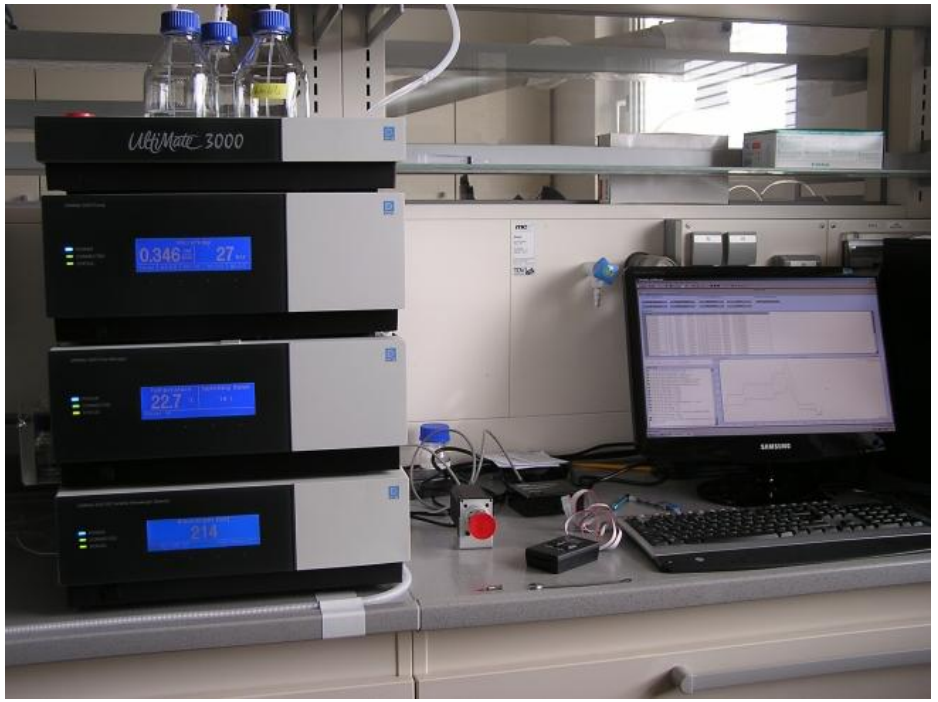
- Shifts in algal communities in the North Fork Reservoir can be observed within days
  - Primary potential toxin producer is Dolichospermum
  - Weekly monitoring shows that, in most cases, dominant cyanobacterial species will be observed at low levels prior to the blooms.
- At the CRW intakes changes are observed over longer time frames
  - Primarily diatoms in the main stem of the river
  - Rarely see cyanobacteria
  - Benthic species are occasionally observed
  - Winter communities are primarily Cymbella and Navicula
  - Summer communities exhibit more diversity

Cyanotoxin Analysis

Toxin Analysis by High-Performance Liquid Chromatography (HPLC)

In collaboration with Clackamas Community College.

- HPLC is a technique in analytical chemistry used to separate, identify, and quantify each component in a mixture.
- Pumps pass a pressurized liquid solvent containing the sample mixture through a column filled with a solid adsorbent material.

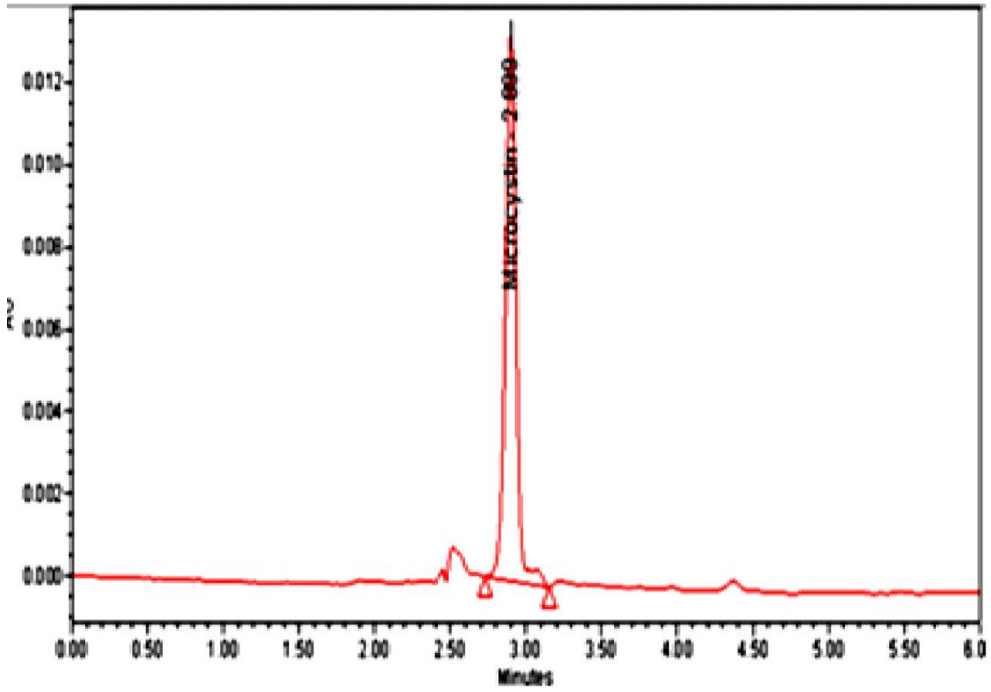


High Performance Liquid Chromatography (HPLC) at Clackamas Community College

- Each component in the sample interacts differently with the adsorbent material, causing different flow rates for the different components and leading to the separation of the components as they flow out the column.

Cyanotoxin Analysis by HPLC

- Development of cyanotoxin analysis
  - **Microcystin- LR**
  - Anatoxin A
  - Cylindrospermopsin
  - Saxitoxin
- Rapid detection of toxins in raw water if a bloom is identified
  - Currently samples are shipped to Lake Superior State University in Michigan
- Provide the ability to test for toxins in finished drinking water



HPLC Chromatogram of Microcystin LR Standard

Regulations for cyanotoxins are coming down the pipeline.

We will be testing for cyanotoxins in the EPA's Unregulated Contaminant Monitoring Rule 4. (2018)

Tying it together- CRW's Algae Monitoring and Response Plan

Tier 1

Sampling, Testing, and Treatment Response

Tier 1- Initiating Condition: Reports of taste and odor issues in finished drinking water; or
Visual bloom reported in watershed boundaries

CRW Response- increased algae monitoring at established sampling sites and intake

Potential toxin producer detected?

yes: Collect samples for toxin analysis at all locations

Toxin detected?

yes

no

no: Continue monitoring species until bloom subsides

Public Outreach Response

Tier 1- Initiating Condition: Reports of taste and odor issues in finished drinking water; or
Visual bloom reported in watershed boundaries

1. Notify Customer Service Department
   Provide Fact Sheet and/or talking points
   Provide CRWP taste and odor tracking
2. Update social media to direct users to fact sheet

Tier 2

Sampling, Testing, and Treatment Response

Tier 2- Initiating Condition: Toxic bloom event

CRW Response- continued monitoring at established sampling sites dictated in Tier 1
HPLC analysis of cyanotoxins throughout duration of bloom as needed

Toxin detected at intake?

yes: Test finished water for toxins

Toxins detected?

yes

no

no: Continue sampling and toxin analysis at intakes daily until bloom subsides

Public Outreach Response

Tier 2- Initiating Condition: Toxic bloom event

1. Provide talking points to Customer Service Department
2. Post information on line about recreating in waterbodies experiencing toxic blooms online
   Post links and updates on social media
   Provide information on any adjustments made to treatment
   Provide updates weekly (at minimum)

Tier 3

Sampling, Testing, and Treatment Response

Tier 3- Finished water cyanotoxin event

CRW Response- continued monitoring at established sampling sites dictated in Tier 2

Is the toxin potentially intracellular?
Based on FlowCAM data.

yes: Adjust Treatment Processes
Pre-Treatment
Discontinue pre-chlorination
Use PAC
Coagulation/Sedimentation
Focus on the removal of intact cells
Keep pH above 6.5
Filtration
CRW's direct filtration should be effective at removing cells but NOT cyanotoxins
Do not recycle filter backwash

no: Is the toxin Anatoxin-A?

yes: Chlorine treatment ineffective

Focus on pre-treament

no: Chlorine disinfection effective. Optimized dosage based on pH and temperature. Compliment with PAC.

Public Outreach Response

Tier 3- Finished water cyanotoxin event

CRW will respond at levels for EPA guidelines values for children under 6

1. Consult with OHA
2. Notify CRW Management and Staff of intent to issue DO NOT DRINK
3. Provide Customer Service Department with talking points
4. Issue DO NOT DRINK order (template)
5. Notify media (template)
6. Notify dialysis centers/at risk populations
7. Activate autodialer or reverse 911
   Deploy reader boards as needed
8. Provide notification via social media (templates)
   Provide updates 1-2x's/day during event

Next Steps

1. Continue the development of toxin analysis by HPLC.
   - Toxin analysis via HPLC remains the biggest challenge moving forward.
   - Spiked sample analyses are required before finalizing microcystin protocol.
2. Evaluate feasibility of treatment process adjustments in response to a potential toxin event.
3. Continue the collection of baseline data at established sites.


Questions?

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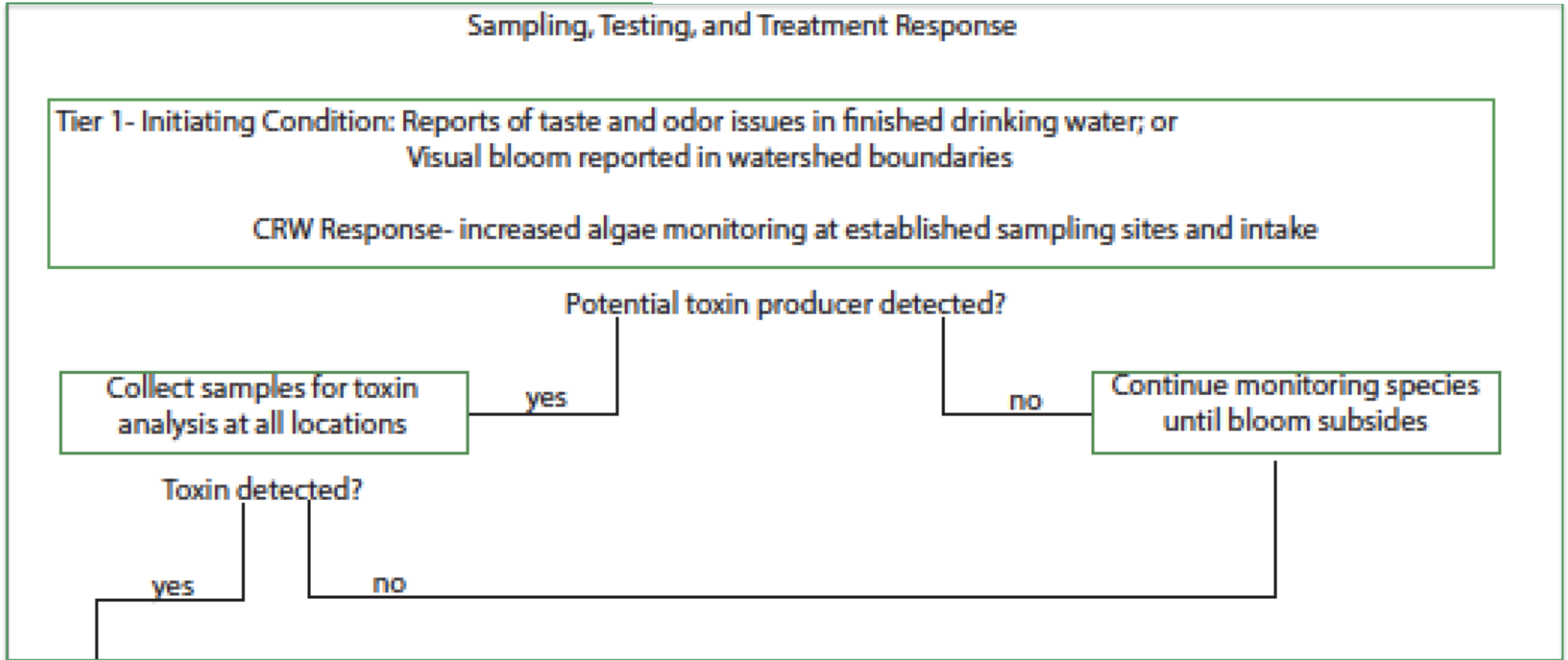
Sampling, Testing, and Treatment Response



Tier 2

Public Outreach and Response

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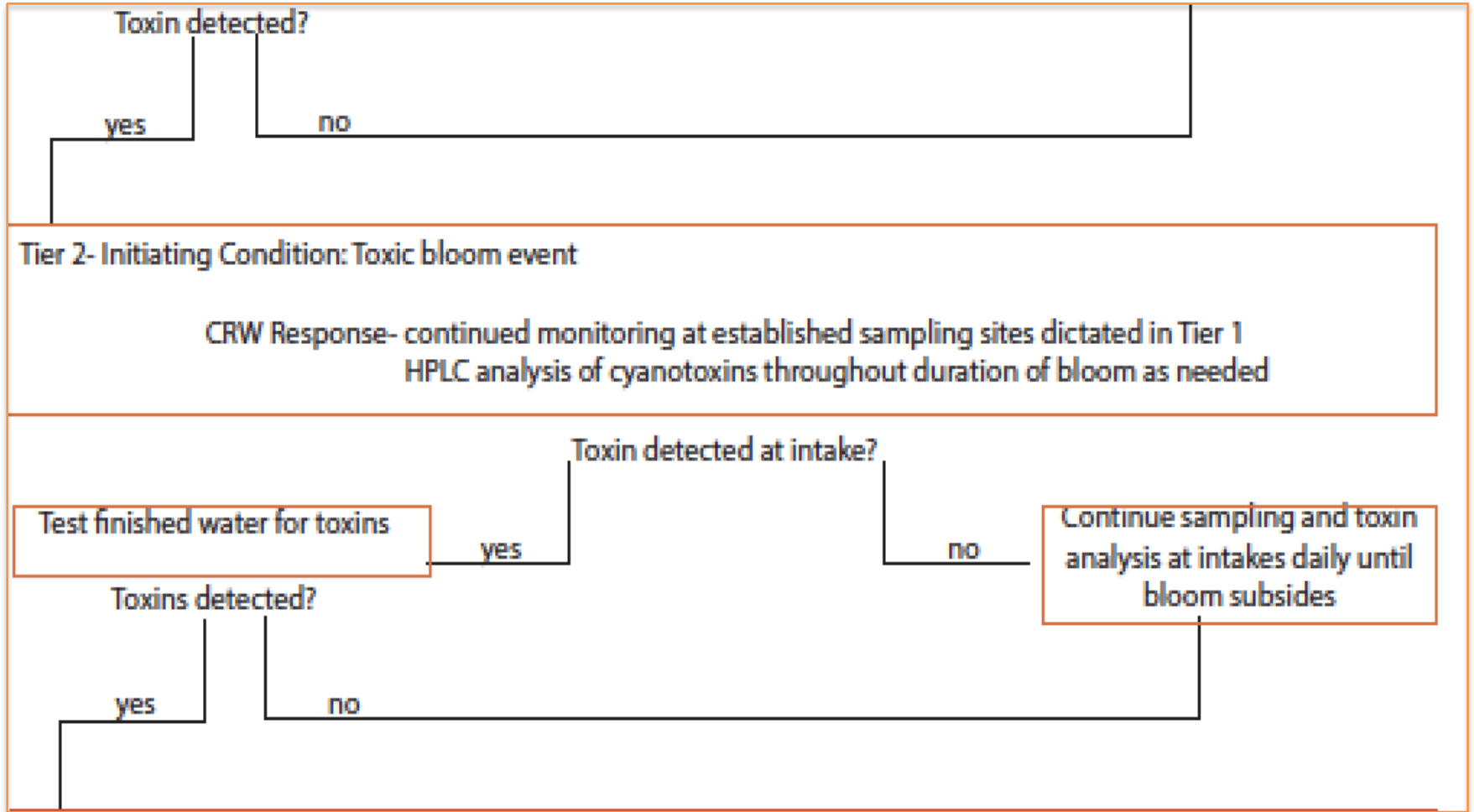
Sampling, Testing, and Treatment Response



Tier 3

Sampling, Testing, and Treatment Response

yes

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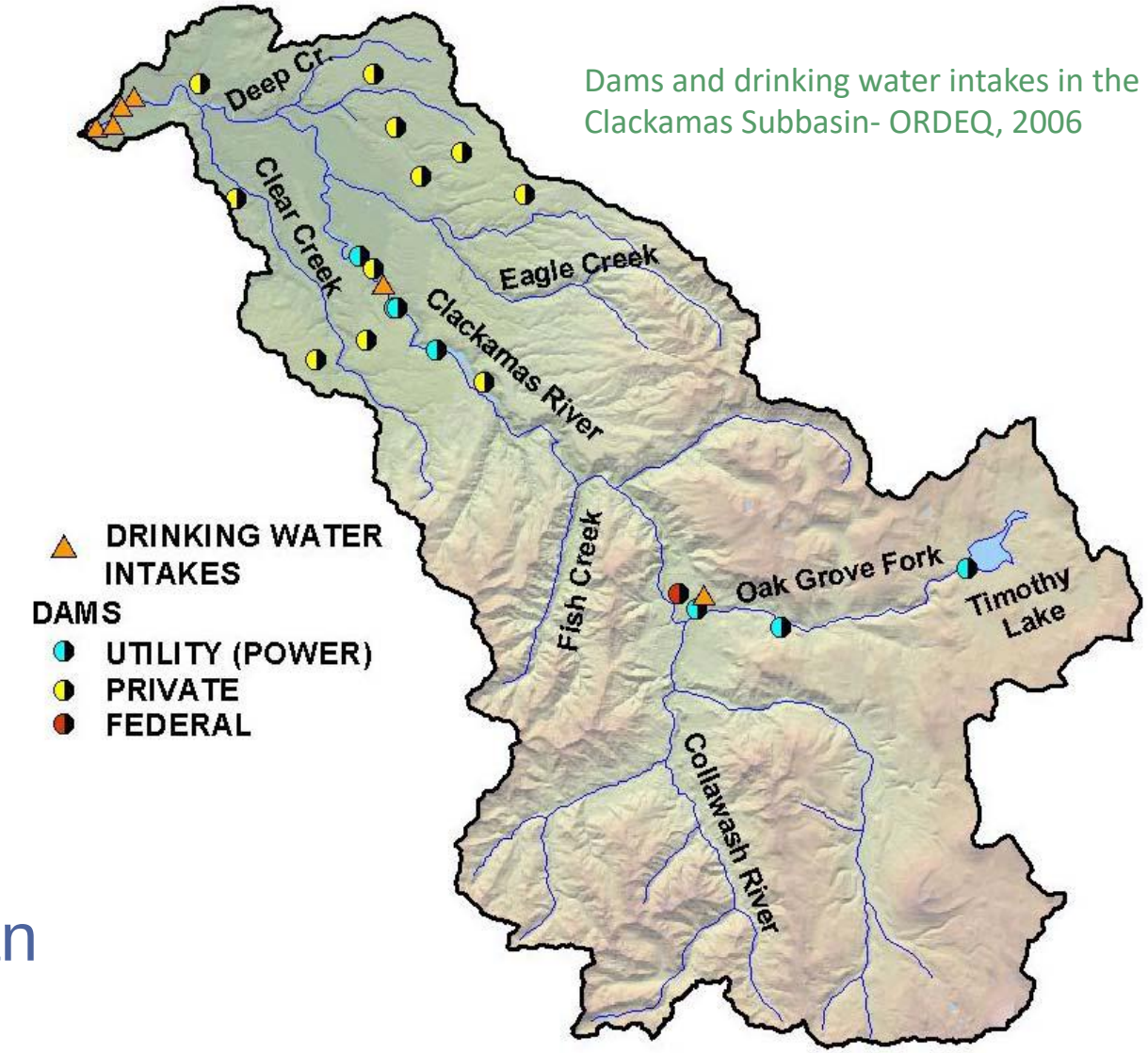
The Clackamas River

Background

The Clackamas River Watershed

- Clackamas River is an approximately 83-mile tributary of the Willamette River
- Drains approx. 940 mi^2
  - Forests
  - Agricultural land
  - Residential
  - Light industrial
- Hydroelectric power
- Drinking water for more than 300,000 people



Dams and drinking water intakes in the Clackamas Subbasin- ORDEQ, 2006

Water Quality

- Water quality in the Clackamas River is consid-ered very good.
- The largest inputs of contaminants introduced by human development occur in the lower basin.
- Water-quality problems, such as high levels of turbidity, occasionally occur from soil erosion.

History of Algae Blooms in the Clackamas River

- In September 1994 foul tastes and odors appeared in drinking water supplied by the Clackamas River.
  - A survey of the watershed for a potential cause of this problem indicated that an algal bloom had developed in North Fork Reservoir.
  - Water samples collected from the reservoir contained Anabaena and were positive for geosmin.
- Seasonal blooms have occurred intermittently since 1994.
- Taste and Odor events occur almost every summer.