# Toxic Cyanobacteria in Washington State

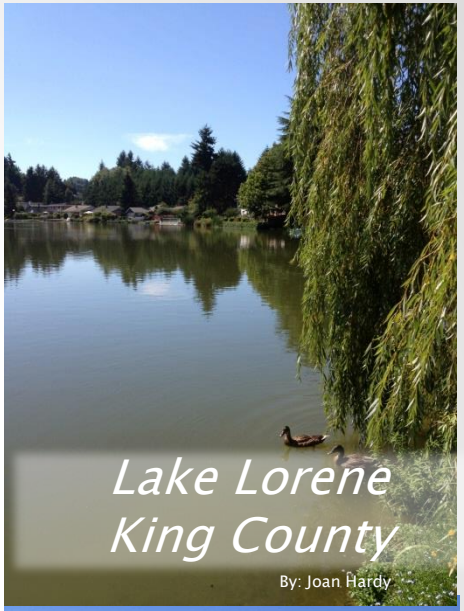
EPA Region 10
Harmful Algal Blooms Workshop
Seattle, Washington
March 2016

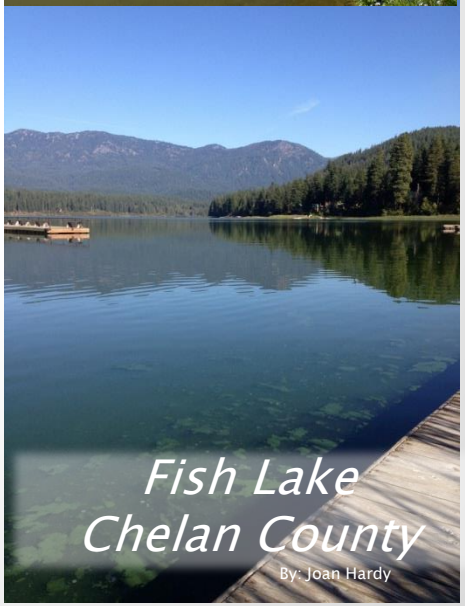
Washington State Department of Health

*Public Health – Always Working for a Safer and Healthier Washington*

# Overview

- WA Freshwater Algae Control Program
- CyanoHABs
  - MCs
  - Anatoxin-a, others
  - Predictors of MCs in 9 Lakes
- Update on Other Studies
  - Fish Consumption
  - *Anabaena*
  - FW Microcystin transfer to Marine Waters
- 303d Narrative Criteria

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# Statewide Passive Surveillance Program

- Funded by $1/boat license fee
- Staff or citizens identify a bloom or developing bloom
- Check www.nwtoxicalgae.org
- Send sample to laboratory
- Results sent to LHJ, agencies, and posted on listserv

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# Washington State Toxic Algae

Freshwater algae bloom monitoring program

Home | Find lake | Report a bloom | Health risks | About toxic algae | Summaries | Program

## Welcome to the freshwater algae site

The purpose of this site is to provide toxin data related to cyanobacteria blooms in Washington lakes, ponds and streams. Washington State Department of Ecology (Ecology) uses this site to share the data from their ongoing freshwater algae monitoring program.

Cyanobacteria (or blue-green algae) can produce toxins at levels that are harmful to humans, pets, domestic animals, and wildlife. There is no way to detect toxins in an algae bloom except through laboratory analysis. This website provides access to Ecology's results.

### Find your lake

Use our database to locate a lake and find out the most recent testing.
Or find your lake >

### Report a bloom

If you think that your lake has an algae bloom and you want to have the algae identified: Report a bloom.

### See lakes with algae bloom

Examples of local lakes experiencing algae blooms. View our gallery and descriptions.

### Health risks

Learn about the potential health risks to people and pets exposed to algae blooms through swimming or consuming the water.

**No lake is above guidelines**

### News and announcements

8/12/2015 MyNorthwest.com
Green Lake: When in doubt, stay out

7/10/2015 Seattle Times
High temperatures, sunny skies could aggravate algal bloom in lakes

4/24/2015 Kirkland Reporter
Waverly Beach open; Kirkland waterfront parks remain posted with algae alerts

Washington State Department of Health | Department of Ecology State of Washington | King County

# Report a Bloom: www.nwtoxicalgae.org

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### How to report and test a bloom

**Sampling a bloom event**

If you have not participated in this program before and think that your lake is experiencing an algae bloom, please refer to the automated sample number generator below. The Dept of Ecology will approve testing of the sample after submittal. If the sample is not approved, we will contact you to let you know.

Directions can be found here about how to collect the sample and how to send or deliver it to the laboratory. It is very important for you to carefully follow the directions.

When collecting the sample, be sure to fill out the data sheet and send it along with your sample to the King County Environmental Lab.

To start the sampling process please use the automated sample number generator and follow the instructions.

Toxic algae caution sign at Lake Hicks

Marisa Burghdoff – Lake Ketchum

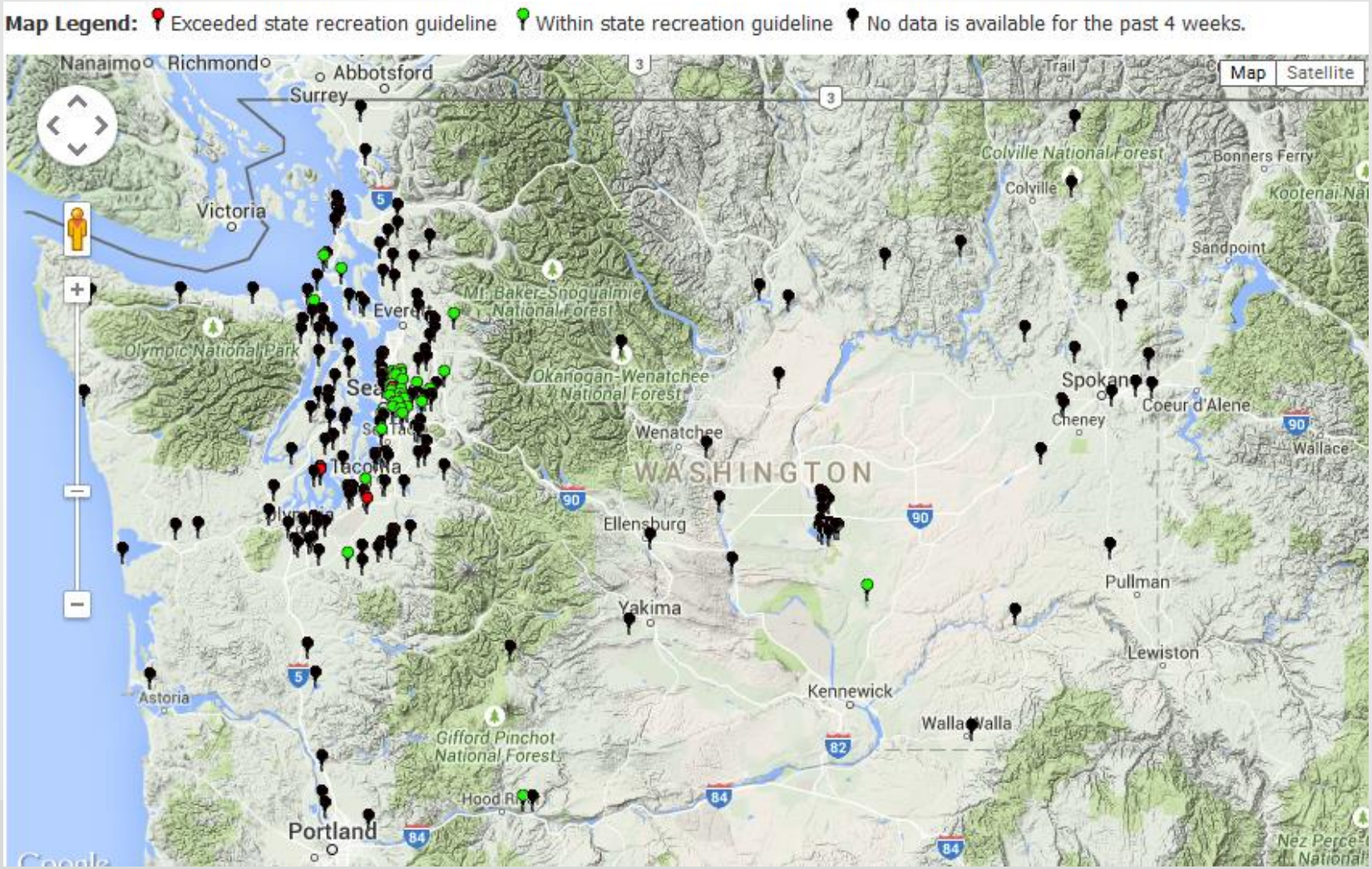
Once a sample is at the laboratory, specialists will identify the algae species. If the sample contains an algae known to produce toxins, the laboratory will run a toxin analysis on the sample and you may be asked to send in more samples. Be aware that Ecology cannot reimburse postage or delivery costs but does pay for laboratory analyses.

**Resampling a bloom event**

If you are submitting a follow-up sample for a lake that has already been tested in previous week (s), please follow the directions above. Please sample only one week after the toxin levels return below recreational levels. Samples will be approved by Ecology before testing.

Please work through Ecology. The laboratory will not accept outside samples through the Ecology program unless they have been approved by Ecology.

# www.nwtoxicalgae.org –July 2015



The pins on the map represent the center of small lakes, regardless of where the sample was taken. To find more precise location information, download the toxin data and click the "view scum info" link. That is where specific sampling location information will be if it was provided. On larger lakes, (such as Lake Washington, Moses Lake and Potholes) pins represent the location of the sample if provided.

County
--All Counties--

WRIA
--All WRIAs--

Site
--All sites--

Toxin
--All toxins--

Minimum Toxin Concentration

Maximum Toxin Concentration

Start Date (MM/DD/YYYY)

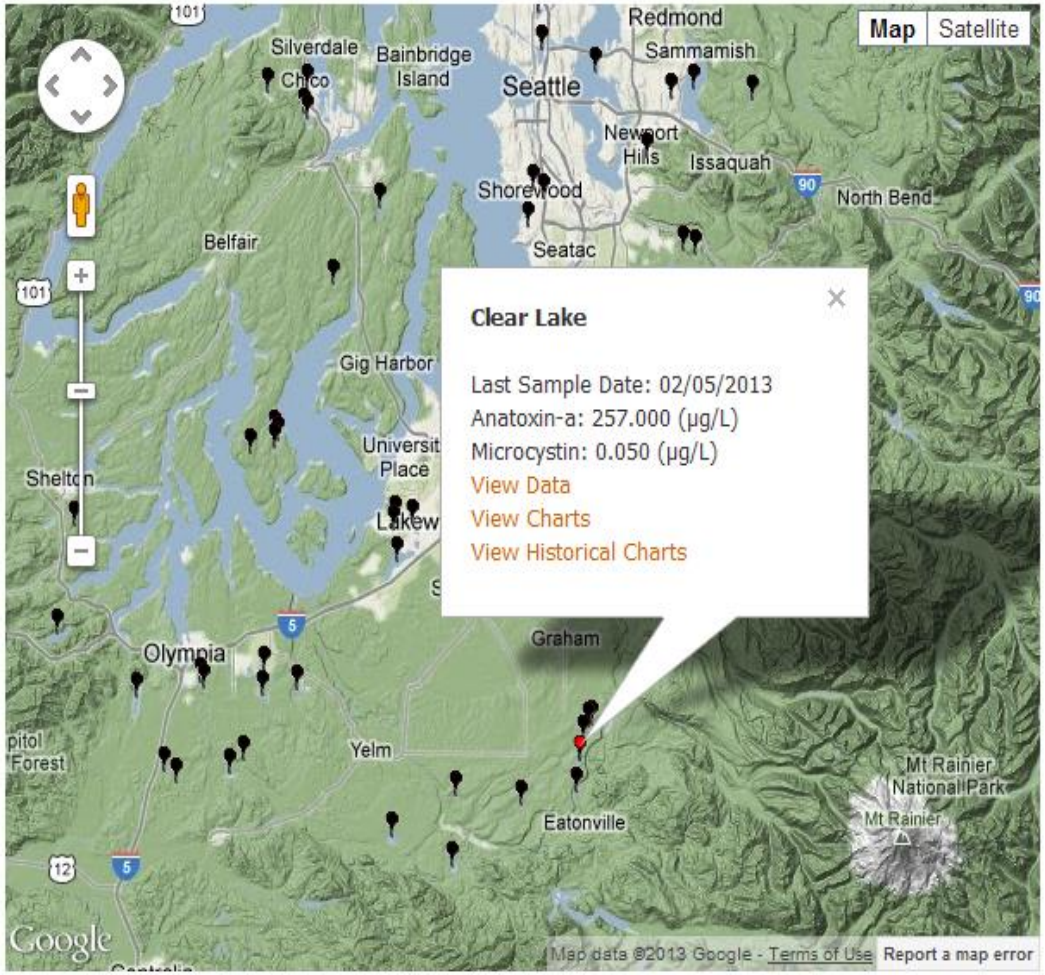
End Date (MM/DD/YYYY)

Lab Sample Number

Plot Map
Clear Selections

Hold **"shift" key** and drag a box around an area or **zoom in** using the slider on the left.

**Map Legend:** Exceeded state recreation guideline  Within state recreation guideline
No data is available for the past 4 weeks.



# Washington State Toxic Algae

Freshwater algae bloom monitoring program

Home | Find lake | Report a bloom | Health risks | About toxic algae | Summaries | Program

## Detailed search for your lake

This database contains the most current toxicity data available. Since there is a lag time from the date of sample to the date of analysis, be sure to check the sample date when looking at data or before you use the lake. Remember to use caution and avoid scums. "When in doubt, stay out!"

Your local jurisdiction may have more specific information about your lake. Questions? Contact Lizbeth Seebacher at Department of Ecology.

If a lake is not listed, it has not been tested for toxic algae through the Ecology program.

The pins on the map represent the center of small lakes, regardless of where the sample was taken. To find more precise location information, download the toxin data and click the "view scum info" link. That is where specific sampling location information will be if it was provided. On larger lakes, (such as Lake Washington, Moses Lake and Potholes) pins represent the location of the sample if provided.

Toxin:

| County | WRIA Number | Site | Lab Sample Number | Collect Date | Parameter | Toxin Conc. (µg/L) | MDL (µg/L) | Above State Guideline | Scum |
|---|---|---|---|---|---|---|---|---|---|
| Pierce | 11 | Clear Lake | L57212-1 | 01/03/2013 | Anatoxin-a | 125.000 | 0.019 | Yes | No |
| Pierce | 11 | Clear Lake | L57212-1 | 01/03/2013 | Microcystin | 0.052 | 0.050 | No | No |
| Pierce | 11 | Clear Lake | L57389-1 | 02/05/2013 | Anatoxin-a | 257.000 | 0.019 | Yes | No |
| Pierce | 11 | Clear Lake | L57389-1 | 02/05/2013 | Microcystin | <MDL | 0.050 | No | No |
| Pierce | 11 | Clear Lake | L57389-2 | 02/05/2013 | Microcystin | <MDL | 0.050 | No | No |
| Pierce | 11 | Clear Lake | L57439-1 | 02/14/2013 | Anatoxin-a | 124.000 | 0.019 | Yes | No |
| Pierce | 11 | Clear Lake | L57439-1 | 02/14/2013 | Microcystin | <MDL | 0.050 | No | No |

Plot Map

Clear Selections

### Get data

Get Toxins

Get Phytoplankton

### Export data

Export Toxin Data

Export Phyto Data

# Washington State Toxic Algae

Freshwater algae bloom monitoring program

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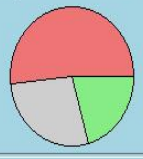
## View Chart

Pick the lake you are interested in to view charts about each toxin tested for the history of the lake: Clear Lake, Pierce

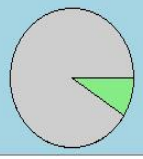
Start Date (mm/dd/yyyy) End Date (mm/dd/yyyy) View Charts View Data

Anatoxin-a total samples: 29 from 11/17/2009 to 02/14/2013



15 Exceeded state recreation guideline
8 Not detected
6 Detected - below recreation guideline

Microcystin total samples: 11 from 12/22/2009 to 02/14/2013



0 Exceeded state recreation guideline
10 Not detected
1 Detected - below recreation guideline

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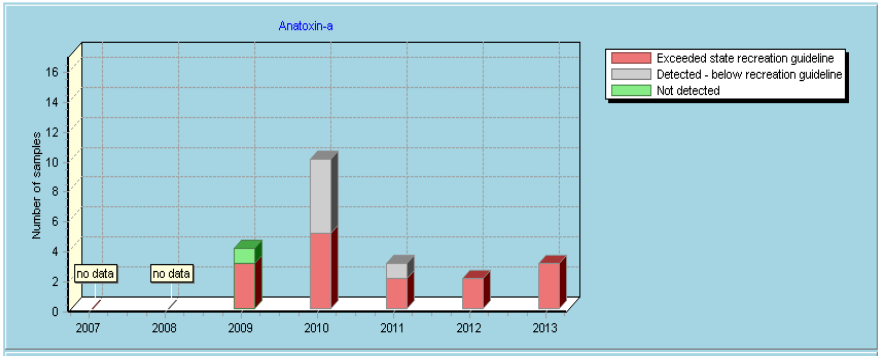
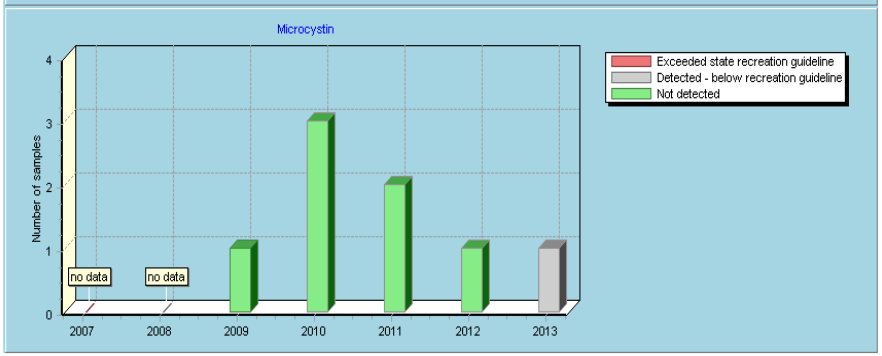
## Historical summary of your lake

Pick the lake you are interested in to view charts about each toxin tested for the history of the lake: Clear Lake, Pierce

View Data

Note: Charts are based on number of samples taken for analysis of each toxin. Please pay attention to the y-axis when interpreting these charts.

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# "Provisional" WA Recreational Guidance Values

| HABs | Guidance Value (GV) |
|---|---|
| Microcystins | 6 µg/L |
| Anatoxin-a | 1 µg/L |
| Cylindrospermopsin | 4.5 µg/L |
| Saxitoxins | 75 µg/L |

GVs will be updated when an acute RfD/TDI is available for each toxin or when a national guidance value is adopted

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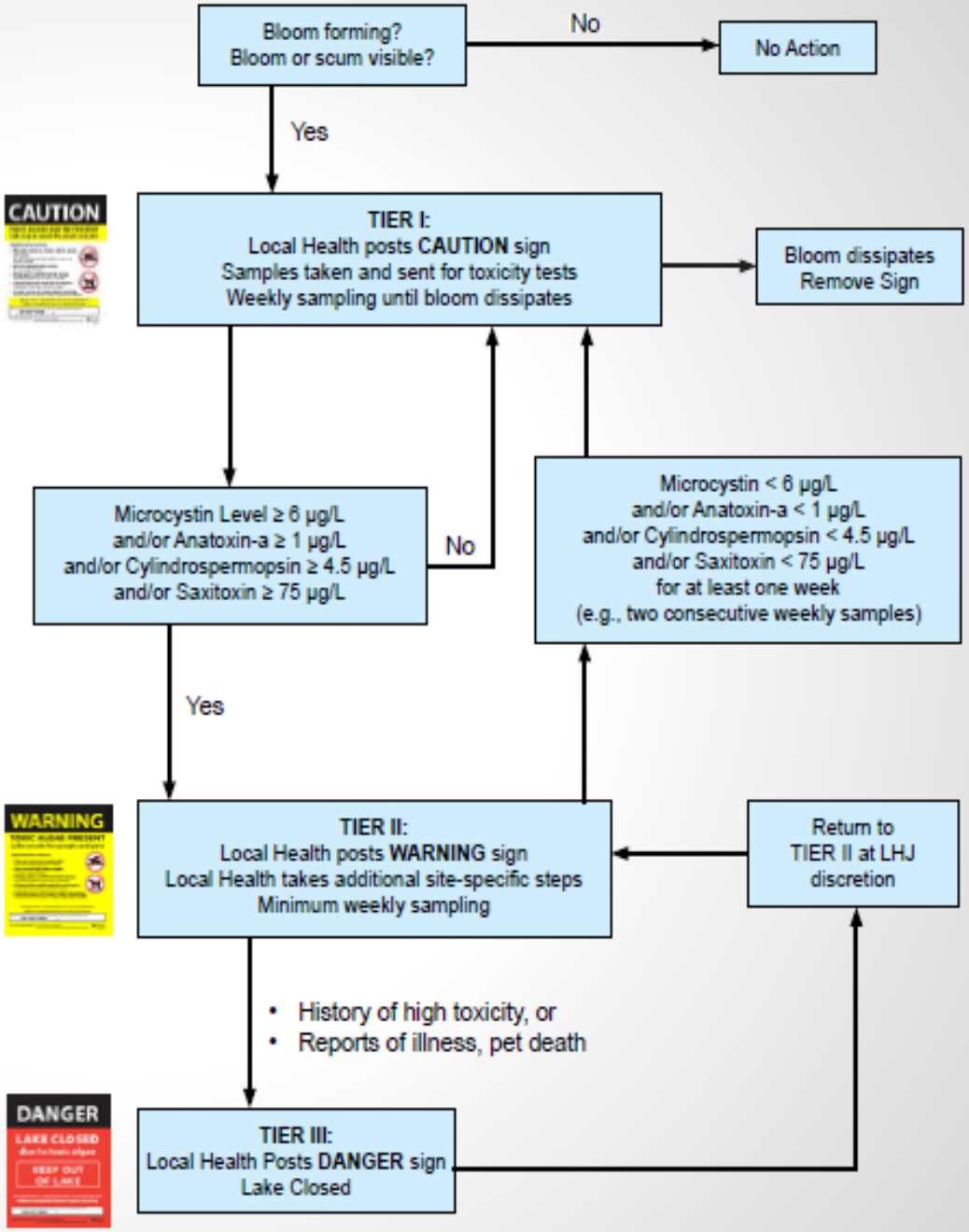
# Lake Management Protocol

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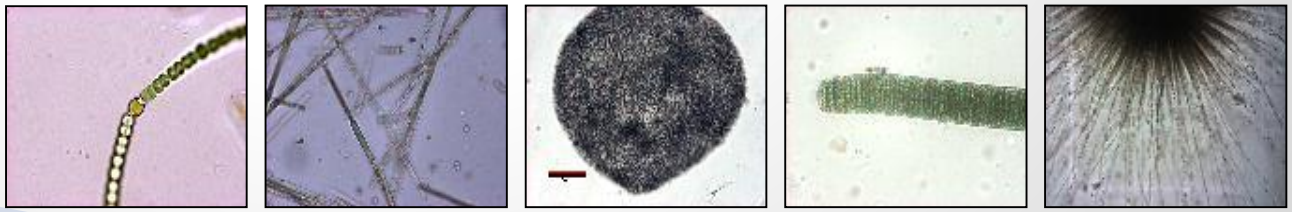
# Most Common Toxic Genera in WA

- *Anabaena (Dolichospermum)* – anatoxin-a, microcystins, saxitoxins
- *Aphanizomenon* – anatoxin-a, saxitoxins, cylindrospermopsin
- *Microcystis* – microcystins
- *Oscillatoria* – microcystins, anatoxin-a, aplysiatoxins
- *Gloeotrichia* – microcystins



By: Robin Matthews

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# Cyanotoxins: FWACP and HABISS

- All Cyanotoxins:
  - MCs>Anatoxin-a>Saxitoxin or Cylindrospermopsins
- CDC HABISS Cooperative Agreement
  - Sampled 30 lakes for 3 years
  - Biweekly June – October
- Seasonal Results
- Monitoring Type
- Outreach Implications

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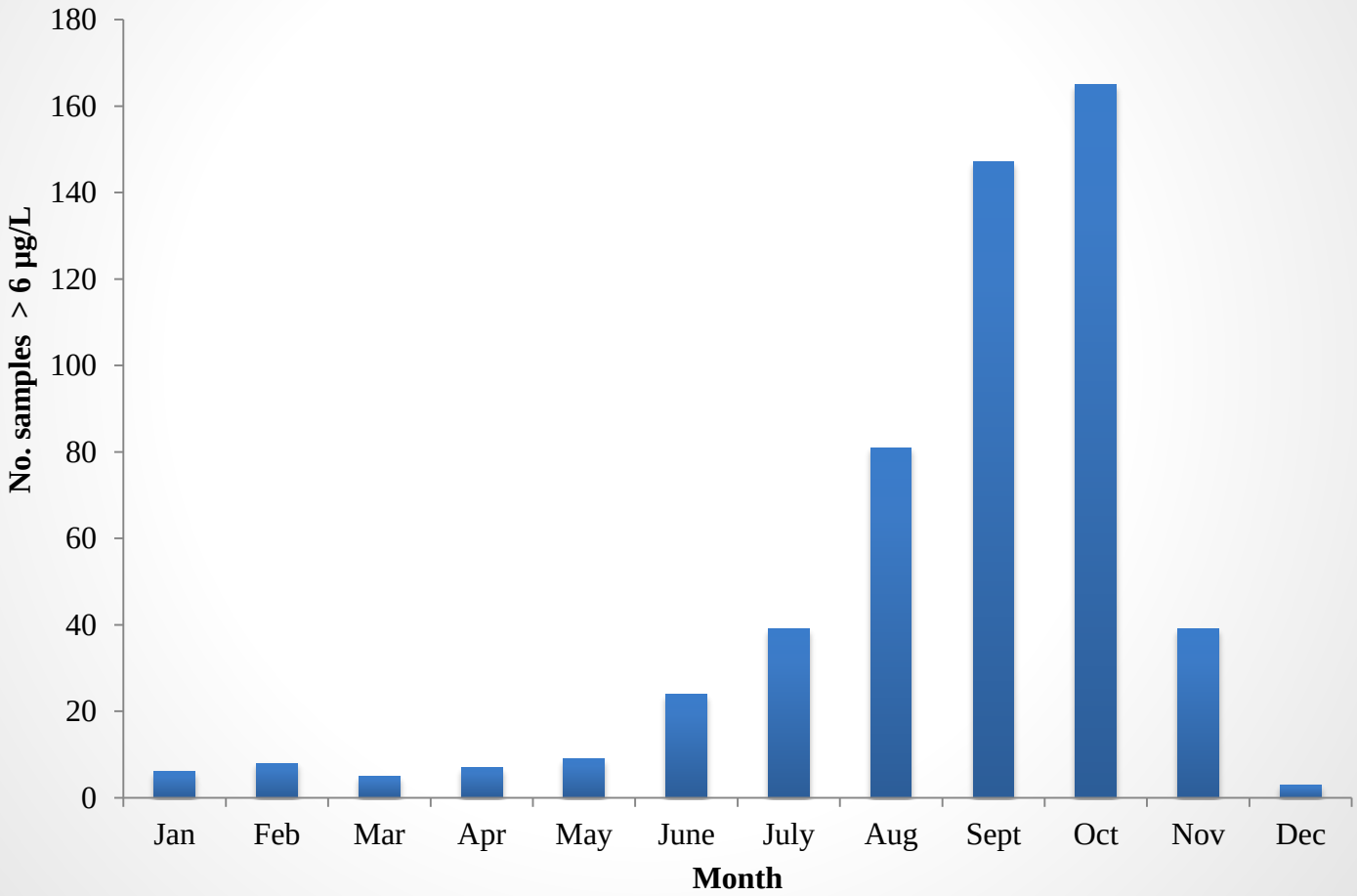
# MC Samples > 6 µg/L by Month




Trainer, V. and FJ Hardy. 2015. Integrative Monitoring of Marine and Freshwater Harmful Algae in Washington State for Public Health Protection. Toxins 7, 1206-1234.

Washington State Department of Health

# Top 15 MC Concentrations 2008 – 2015

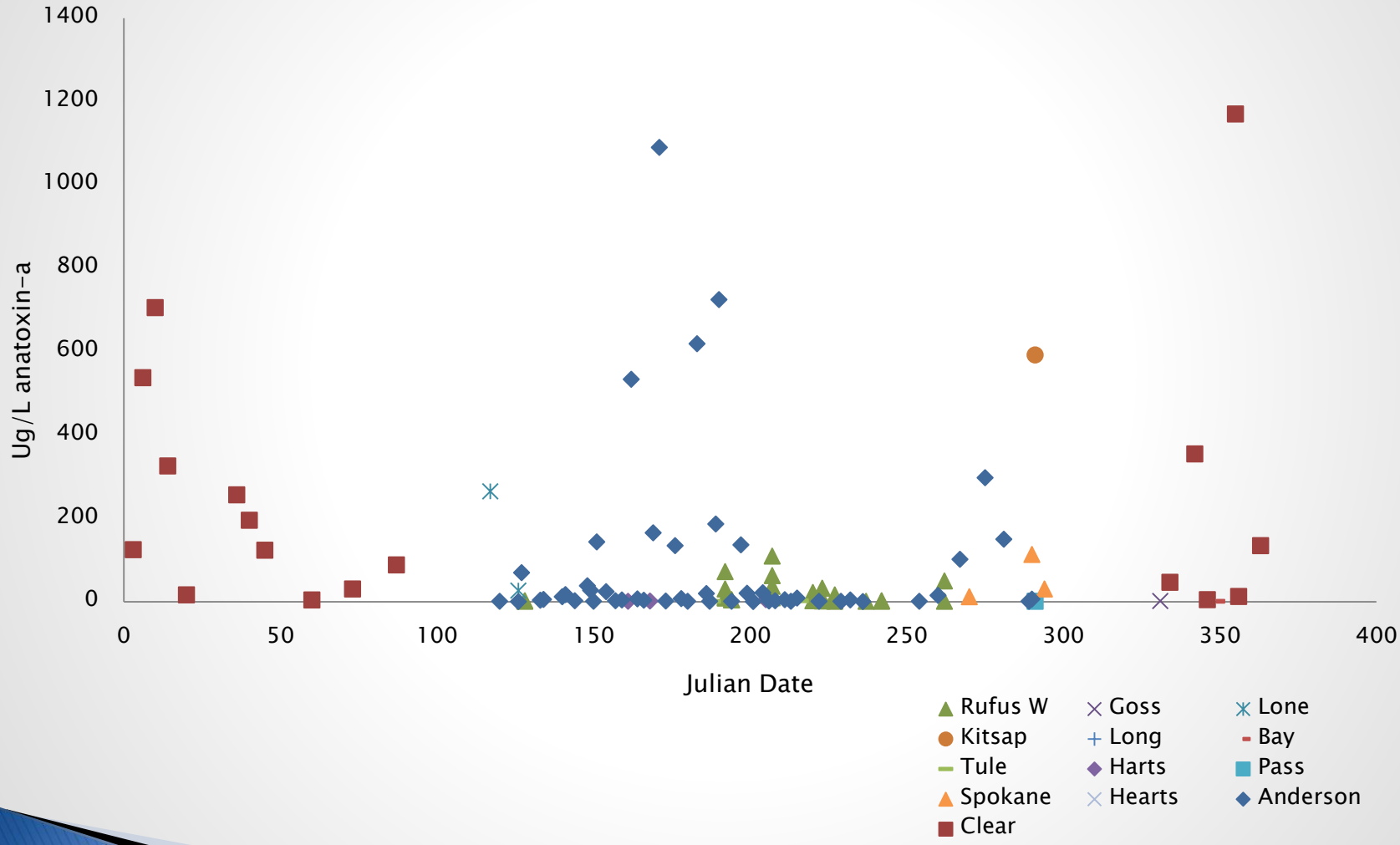
| | | | | |
|---|---|---|---|---|
| 1 | Spokane | Lake Spokane | 10/17/2011 | 26400 |
| 2 | Pierce | Waughop Lake | 8/17/2011 | 25200 |
| 3 | King | Green Lake | 9/11/2014 | 25000 |
| 4 | King | Green Lake | 9/9/2014 | 23800 |
| 5 | Spokane | Lake Spokane | 9/23/2009 | 18700 |
| 6 | Snohomish | Lake Cassidy | 9/20/2011 | 18400 |
| 7 | Spokane | Lake Spokane | 10/5/2011 | 18400 |
| 8 | King | Green Lake | 9/12/2014 | 13753 |
| 9 | King | Green Lake | 11/12/2014 | 13500 |
| 10 | Pierce | Silver Lake | 9/22/2015 | 12300 |
| 11 | King | Green Lake | 9/12/2014 | 10513 |
| 12 | Kitsap | Kitsap Lake | 10/6/2009 | 8230 |
| 13 | Pierce | Waughop Lake | 8/4/2011 | 7080 |
| 14 | Pierce | Bay Lake | 10/5/2015 | 6410 |
| 15 | King | Green Lake | 10/22/2014 | 6298 |

# Anatoxin-a

| Year | # Lakes | # Samples above Std. | Maximum Conc. (µg/L) |
|---|---|---|---|
| 2007 | 1 | 1 | 4,000* |
| 2008 | 8 | 25 | 172,640* |
| 2009 | 4 | 21 | 144,000* |
| 2010 | 5 | 14 | 538 |
| 2011 | 8 | 32 | 1,170 |
| 2012 | 7 | 40 | 706 |
| 2013 | 6 | 25 | 257 |
| 2014 | 5 | 15 | 991 |
| 2015 | 9 | 27 | 7,951 |

*Original method

# Anatoxin-a: Seasonal Distribution

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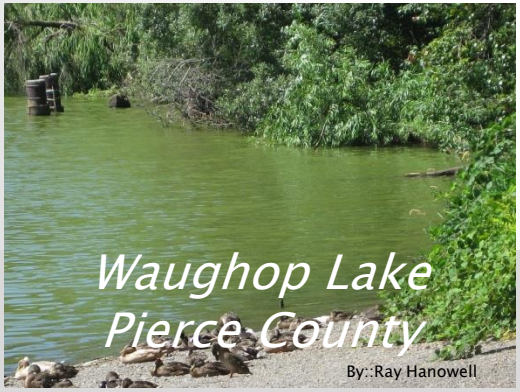
# Saxitoxin and Cylindrospermopsin in WA Lakes

| Saxitoxin Total N = 836 | Cylindrospermopsin Total N = 914 |
|---|---|
| 1 sample > 75 µg/L | 0 samples > 4.5 µg/L |
| 6 samples < 75 µg/L and > 1 µg/L | 4 samples < 4.5 µg/L and > MDL |
| 65 samples < 1 µg/L and > MDL | 910 samples < MDL |
| 765 samples < MDL | |
| * 75 µg/L WA saxitoxin recreational GV | * 4.5 µg/L WA cylindro recreational GV |



By: Gene Williams

# "Dominant factors associated with microcystins in nine midlatitude, maritime lakes"

- Jacoby et al. 2015. Inland Waters 5(2): 187–202.
- 9 lakes sampled biweekly, 2012
- Identified factors most closely associated with 4 cyanotoxins
- Best predictors of MC:
  - When TN:TP ratios $\leq$ **25.7**
  - MC was generally absent when TN:TP ratios >25.7
- Poster

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# Clinic Posters

- Helps clients identify:
  - Toxic Blooms
  - Poisoning Signs
  - What to do if pet is sick
  - Who to call

Washington State Department of Health

# Vet Reference Card

**Blue-Green Algae Exposure and Clinical Information** - There are no antidotes to these toxins. Medical care is supportive.

| Exposure Route | Likely Signs | Onset to Signs | Differential Diagnosis | Possible Laboratory or Other Findings |
|---|---|---|---|---|
| **Swallowing** water with toxic blue-green algae (cyanobacteria) or other toxins<br><br>**Licking fur or hair** contaminated with toxic blue-green algae | **Hepatotoxins**<br>- Acute depression<br>- Weakness & incoordination<br>- Loss of appetite<br>- Excess drooling<br>- Vomiting and diarrhea<br>- Abdominal tenderness<br>- Jaundice<br>- Dark urine | One or two hours, or more | Acetaminophen, nonsteroidal anti-inflammatories, aflatoxin, mushrooms, copper, zinc, iron, xylitol, sago palm | - Elevated bile acids & liver enzymes<br>- Hypoglycemia<br>- Prolonged clotting times<br>- Proteinuria<br>- Presence of toxin in clinical specimens (liver, gastrointestinal contents) collected from animals |
| | **Neurotoxins**<br>- Excess drooling<br>- Apprehension & anxiousness<br>- Vomiting<br>- Muscle twitching<br>- Seizures<br>- Respiratory failure | Minutes to hours | Organophosphate and carbamate insecticides, strychnine, metaldehyde, pyrethrins, moldy foods, chlorinated hydrocarbon pesticides, bromethalin, mushrooms | - Presence of toxin in clinical specimens from stomach contents taken from animals that became ill |
| **Skin contact** with toxic blue-green algae or other toxin(s) | **Dermal Toxins**<br>- Rash, hives, allergic reaction | Minutes to hours | Other dermal allergens | - Blue-green staining of fur or hair |

Monogastric animals appear less sensitive than ruminants or birds; however, the dose-response curve is very steep in dogs – up to 90% of a lethal dose may elicit no clinical signs. Surviving animals have a good chance for recovery. While therapies for cyanobacterial poisonings have not been investigated in detail, activated charcoal slurry is likely to be of benefit. Health effects from exposure are derived from reports of animal poisonings. For more information see Department of Health (www.doh.wa.gov/algae) or the Merck Veterinary Manual (www.vetmanual.com).

## Veterinarian Reference Card

**Algal poisoning is often an acute, fatal condition.**

**This card provides clinical information to help veterinarians identify blue-green algae (cyanobacteria) exposure and poisoning signs.**

Fatalities and severe illness of livestock, pets, and wildlife occur among animals drinking or swimming in algal infested freshwater. Dogs may exhibit severe signs such as collapse and death within minutes to hours after swallowing contaminated water. Poisoning usually occurs during warm seasons but can occur year round.

**There are no antidotes to these toxins.**
Medical care is supportive. Activated charcoal may be useful within the first hour, and atropine has efficacy with saxitoxin exposure.

**What are blue-green algae?**
Blue-green algae (cyanobacteria) are literally blue-green bacteria that contain specific photosynthetic pigment. Three genera of cyanobacteria account for a majority of blooms: *Microcystis*, *Anabaena*, and *Aphanizomenon*. **A bloom can consist of one or a mixture of two or more genera and may contain liver and nervous system toxins.**

**What is a toxic bloom?**
When algae grow quickly, they may rise to the surface of the water and form a surface scum. If conditions are favorable for a bloom, a lake or pond can change from clear to turbid within a few days. As cells die, toxins are released into the water. Sometimes blue-green algae produce toxins that can affect the liver and central nervous system. Not all blooms are toxic and only laboratory tests can confirm whether a bloom is toxic or not. Since cyanobacterial toxins can be lethal to animals in relatively small amounts, caution should always be taken when a bloom occurs. Advise your clients "***When in doubt, stay out.***"

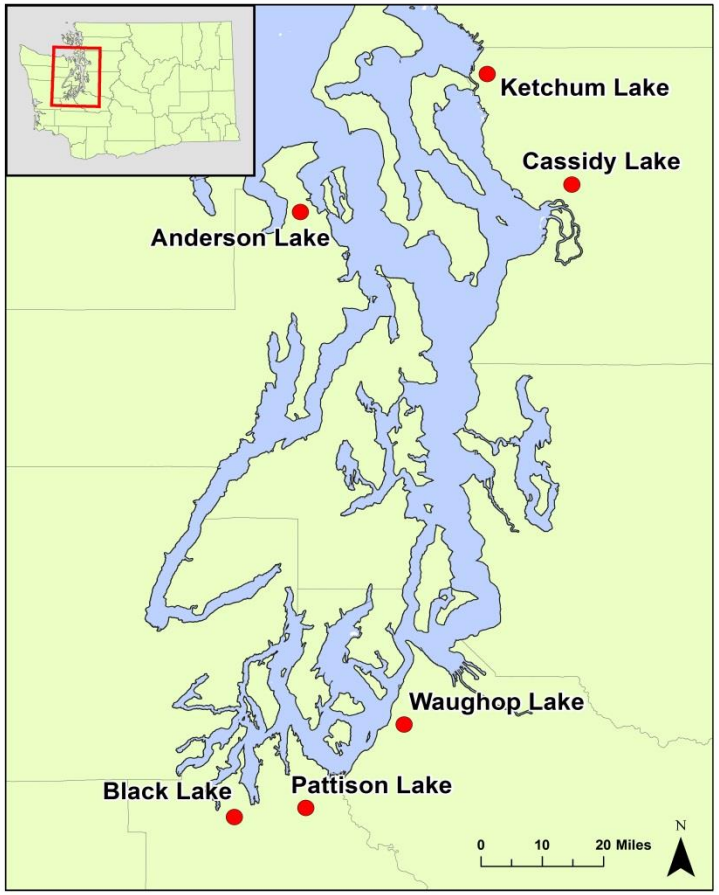
**What causes a bloom?**
No individual environmental condition causes blooms to be toxic. Factors such as light, temperature, percent oxygen saturation, nutrient availability and depletion, wind patterns, internal lake mixing, growth stage, and zooplankton predation may play a role in bloom formation.

**To report an animal poisoning call the Washington Department of Health at 360-236-3330 or visit www.doh.wa.gov/algae**

Washington State Department of Health
DOH 332-115 June 2012

Washington State Department of Health

# ECY Collected 10 Fish Species



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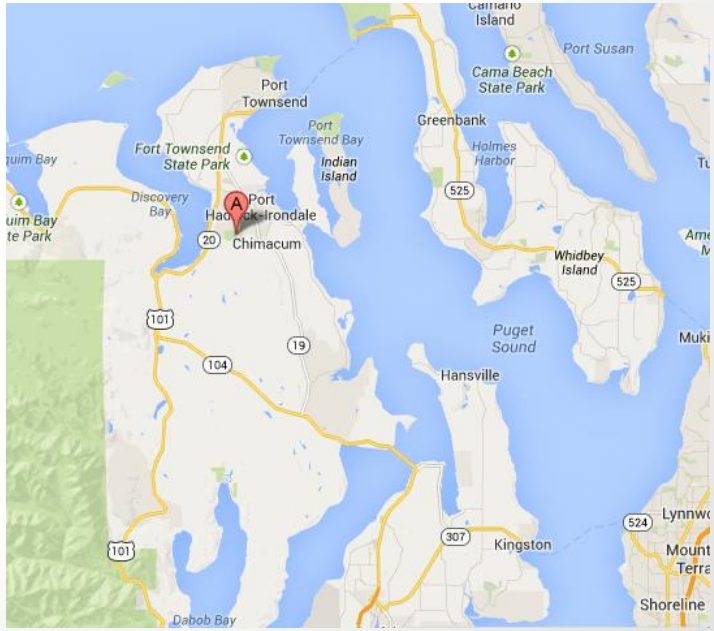
# Confirmed MC in WA Fish

- Used two types of ELISA and LC-MS/MS
- Higher concentrations in the liver (X=50, 64 ug/Kg, wet) than in the gut or muscle tissue (X=5.6, 14 ug/Kg, wet)
- Recommend that ELISA be used only to screen fish tissue
- Recommend that LC-MS/MS be used in conjunction with ELISA to confirm results of screening

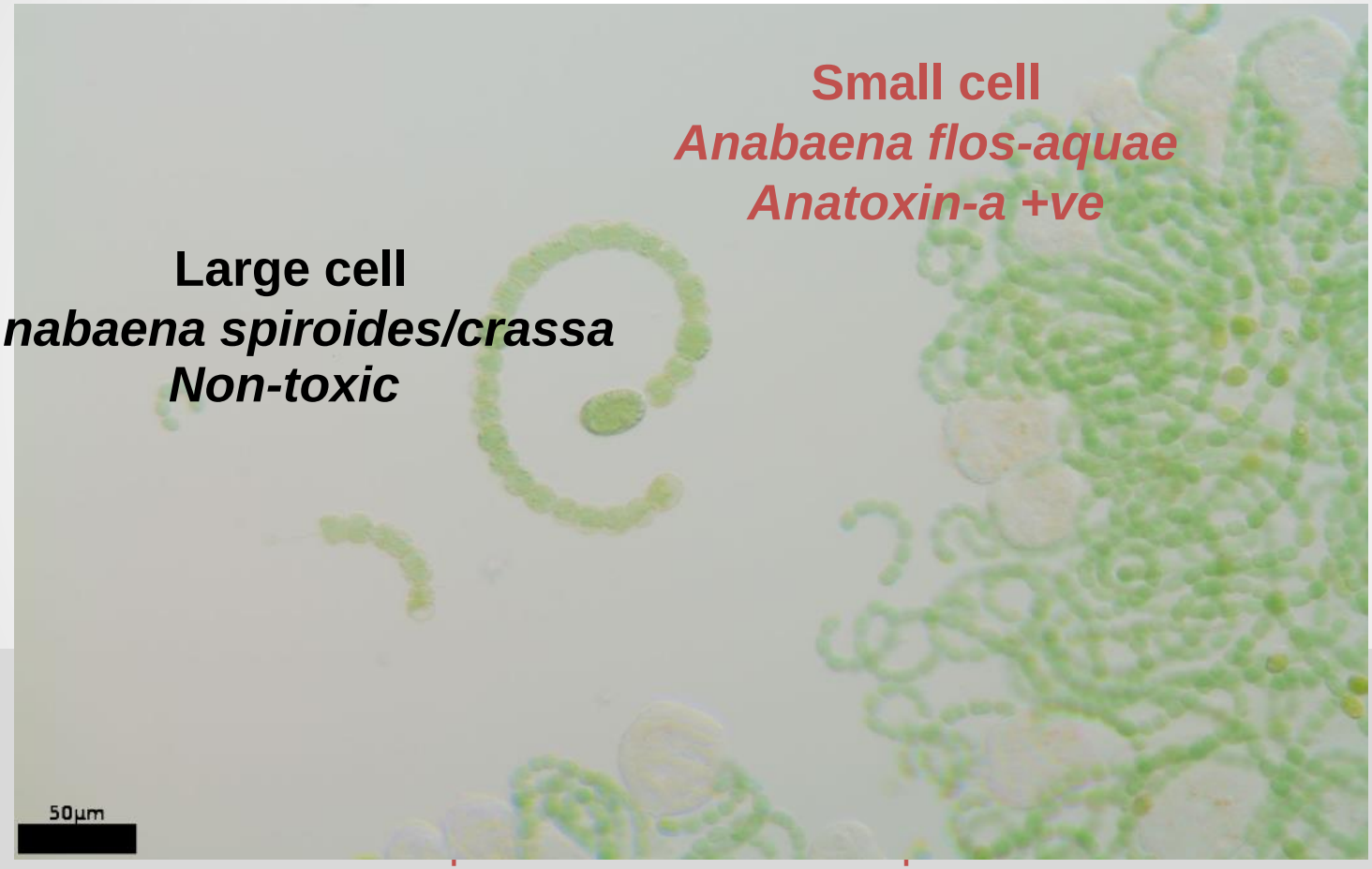
Hardy, FJ, A Johnson, K Hamel, E Preece. 2015. Cyanotoxin bioaccumulation in freshwater fish, Washington State, USA. Environ Monit Assess (2015) 187: 667

# Toxic Gene Presence

- Puget Sound Lowland Lakes (2012 season)
- Anderson Lake, Jefferson County
  - Very high anatoxin-a concentrations

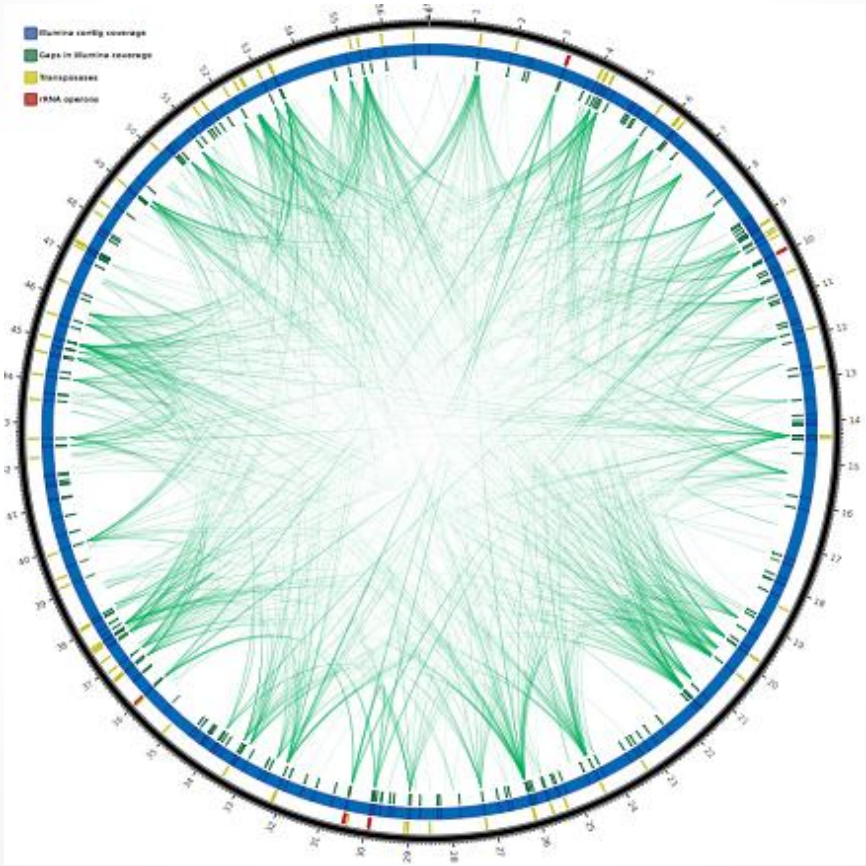


# *Anabaena flos-aquae*-like morphotype is a major anatoxin-a producer in Anderson Lake




(9 July 2012 and 24 June 2013)

# *Anabaena sp.* WA102




Tested positive for anatoxin-a production

Culture from 5/20/2013

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Oregon State University OSU

# Mussels in Puget Sound

Pilot Project – 2012

- Bay Lake – Mayo Cove
- Lake Steilacoom – Chambers Creek
- Kitsap Lake – Chico Creek

Repeated in 2013, 2014

WSU analyzed MCs (E. Preece)

- Found MCs present in mussels associated with lake blooms

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# MC in Puget Sound Mussels

- Method development
  - Identifying best methods for routine ELISA detection of microcystin in seafood. 2015. Preece et al. Environ Monit Assess 187:12
- Detected MC in mussels
  - First detection of microcystin in Puget Sound, Washington, mussels (*Mytilus trossulus*). 2015. Preece et al. Lake and Reservoir Management, 31:1, 50-54.
- ID'd MC in lake, stream, and mussels
  - Transfer of Microcystin from Freshwater Lakes to Puget Sound, WA and Toxin Accumulation in Marine Mussels (*Mytilus trossulus*). Preece et al. Ecotoxicol Environ Saf 122-98-105.

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# Future

- EPA working on national recreational guidance values
- Animal illnesses can act as sentinels – vets
- FW/Marine interface
- Historic satellite imagery
- Biomarker work
- Sediments, periphyton
- Potential for increased HABs with climate change

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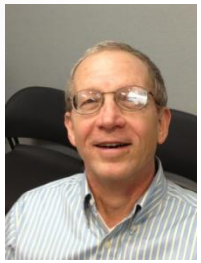
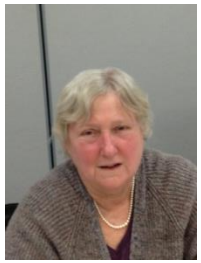
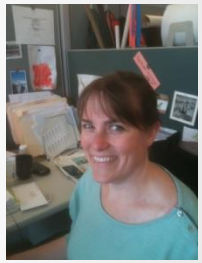
# Regional Examination of HABs Team







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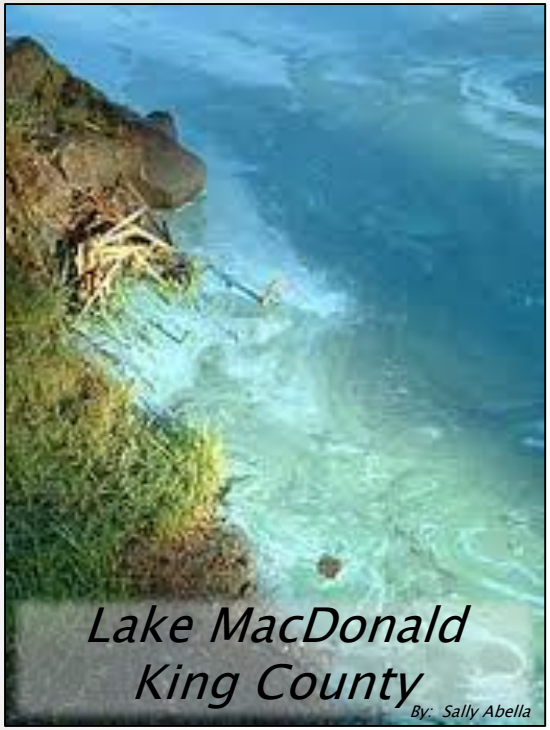


# Questions?

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*Public Health – Always Working for a Safer and Healthier Washington*

# Microcystins in Fish (ADDA ELISA)

| Waterbody | Species | Tissue | N = | Microcystins (ug/Kg, wet) | Reference |
|---|---|---|---|---|---|
| Western Wash. lakes (5) | 4 species | muscle | 14 | 5.6 | Present study |
| | | liver | 16 | 50 | |
| Western Wash. lakes (6) | 6 species | muscle | 20 | 14 | Johnson (2010) |
| | | liver | 11 | 64 | |
| Lago de Patzcuero, Mexico | Carp | muscle | ? | 5.0 | Berry et al. (2011) |
| | | liver | ? | 94 | |
| Lake Albufera, Spain | Mullet | muscle | 103 | 5.0 | Romo et al. (2012) |
| | | liver | 103 | 200 | |
| Greek Lakes (13) | Carp | muscle | 130 | 7.1 | Papadimitriou et al. (2010) |
| | | liver | 130 | 124 | |
| Lake Ontario and Lake Erie | 17 species | muscle | 57 | 7.8 | Poste et al. (2011) |

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