Toxic Cyanobacteria in Washington State

May 22, 2013

Washington State Department of Health

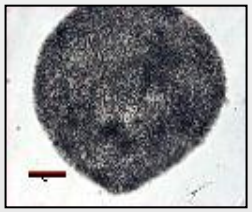
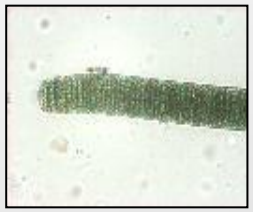
Public Health – Always Working for a Safer and Healthier Washington

Overview

- Cyanobacteria/Toxins
- History of FW Algae Control Program
- Human and Animal Incidents
- CDC Project
- Other Studies

Most Common Toxic Genera in WA

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

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Exposure Pathways

- Chronic ingestion – drinking water
- Sub-chronic ingestion or inhalation – recreation
- Dermal contact – recreation
  - Wading
  - Swimming
  - Skiing
- Consumption of fish, shellfish

Waughop Lake, Pierce County

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History

- Legislature established funding of a Freshwater Algae Control Program (2005)
- Ecology held workshops – feedback (2006)
  - DOH – Standards, Protocol
  - KCEL – Laboratory Tests
- Small grant program established (2007)

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Statewide Passive Surveillance Program

- Identify a bloom or developing bloom
- Call Ecology
- Take a sample
- Send sample to laboratory
- Results sent to LHJ, agencies, and posted on listserv

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"Provisional" Guidance Values – WA

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

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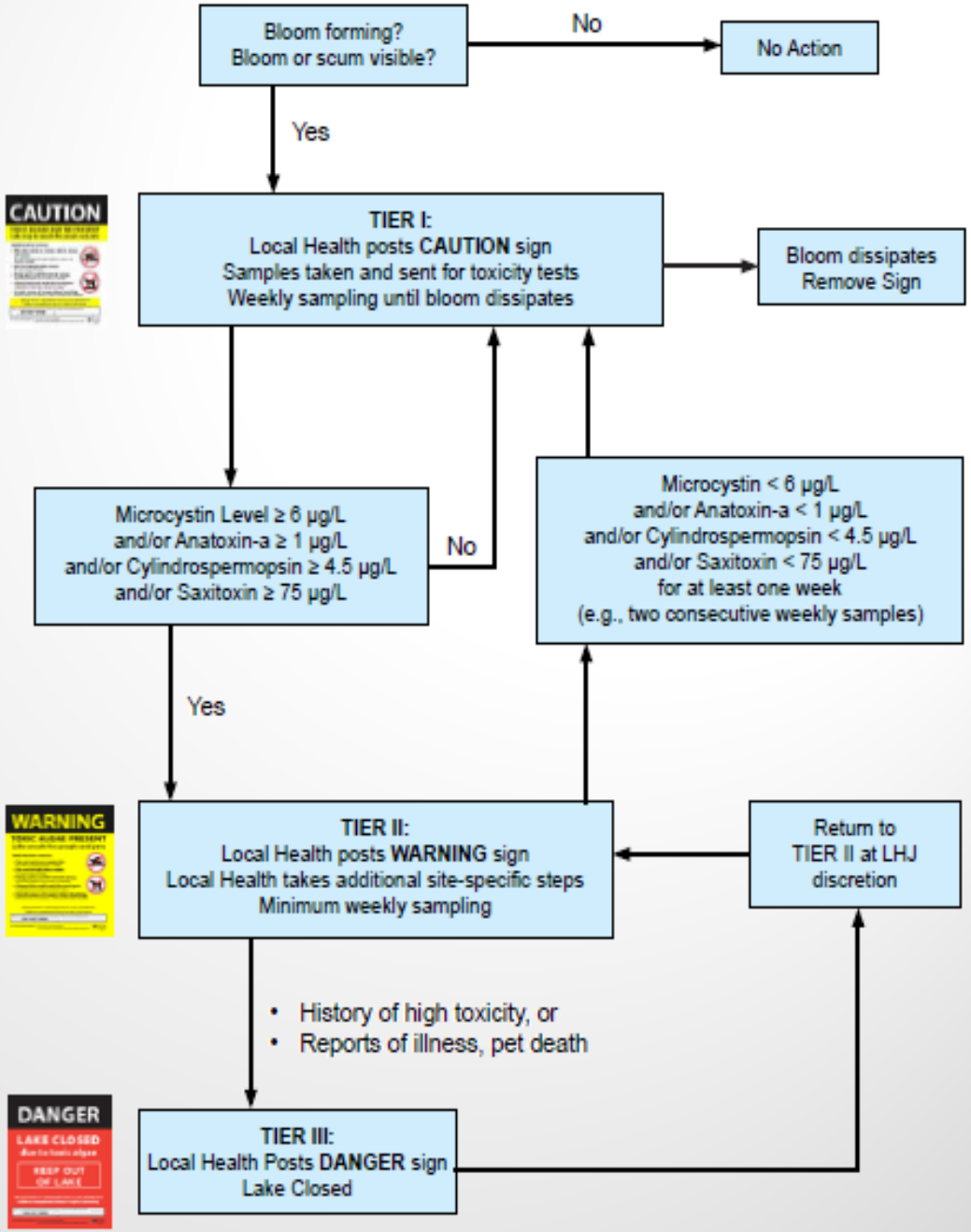
Lake Management Protocol



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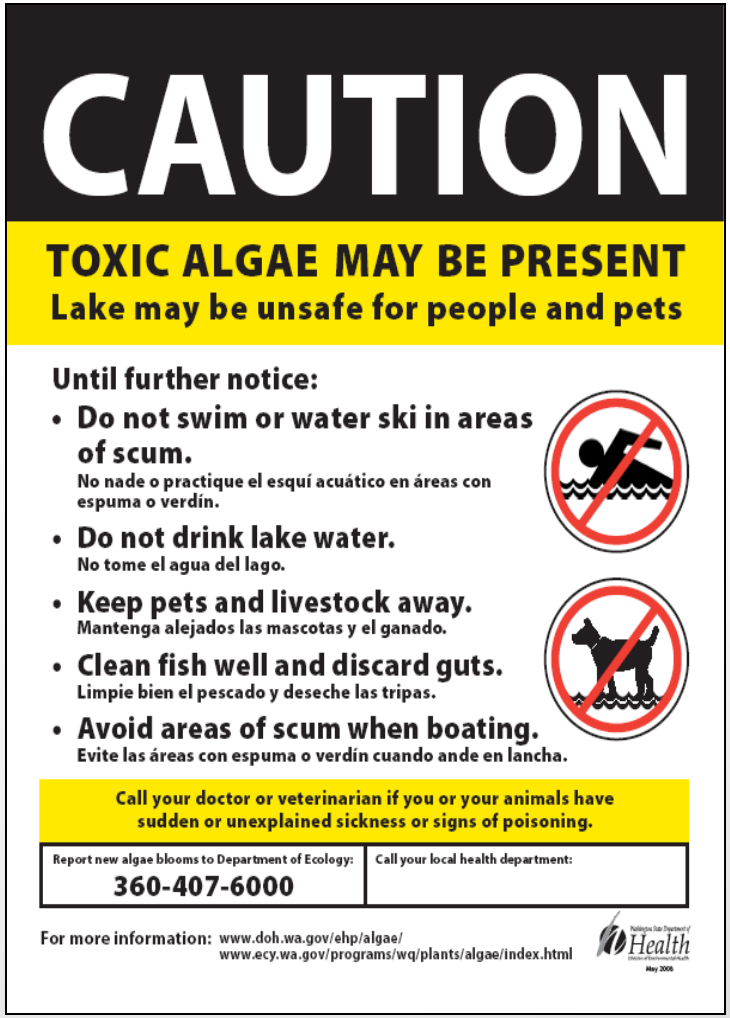
Tier I

- Bloom Forming
- Scum Visible
- Before results
- < 6 µg/L microcystin
- < 1 µg/L anatoxin-a
- < 4.5 µg/L cylindro
- < 75 µg/L saxitoxin



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Tier II

- >6 µg/L microcystin
- >1 µg/L anatoxin-a
- >4.5 µg/L cylindro
- >75 µg/L saxitoxin

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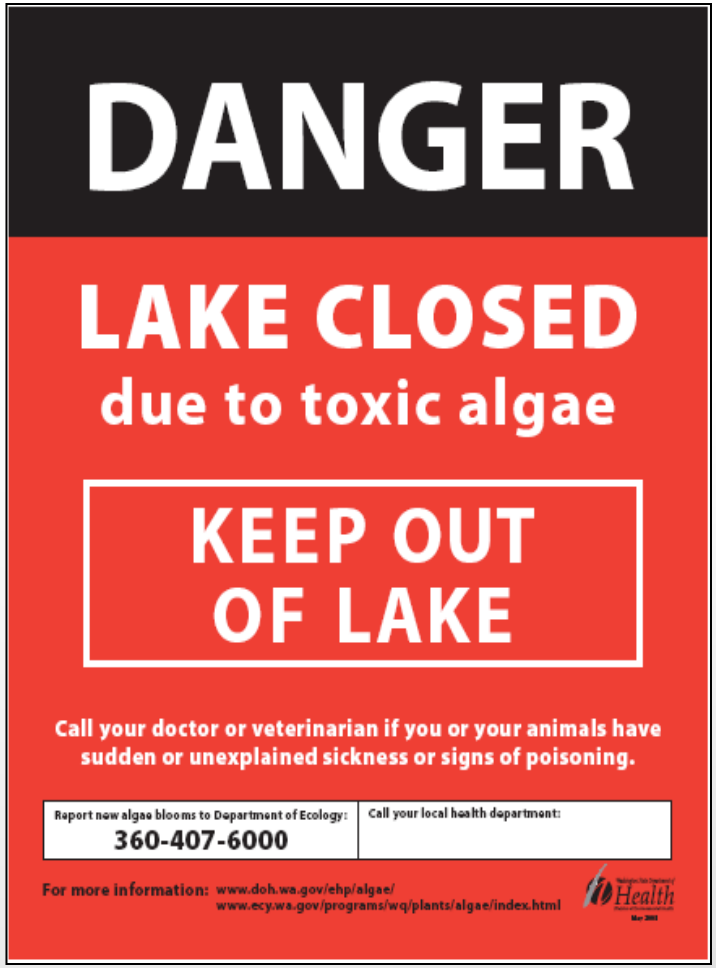
Tier III

172,640 µg/L anatoxin-a



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CDC HABISS Cooperative Agreement: 2009 – 2013

- Track human health and animal health incidents
- Add saxitoxin and cylindrospermopsin
- Monitor 30 Puget Sound lowland lakes
  - 3 Years – 6 months per year
  - Biweekly sampling
- Evaluate outreach efforts

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Lake Illness Investigations

Year	# Lakes	# Human Illnesses	# Animal Illnesses
2009	16	122	4
2010	2	2	1
2011	4	4	3
2012	2	2	2

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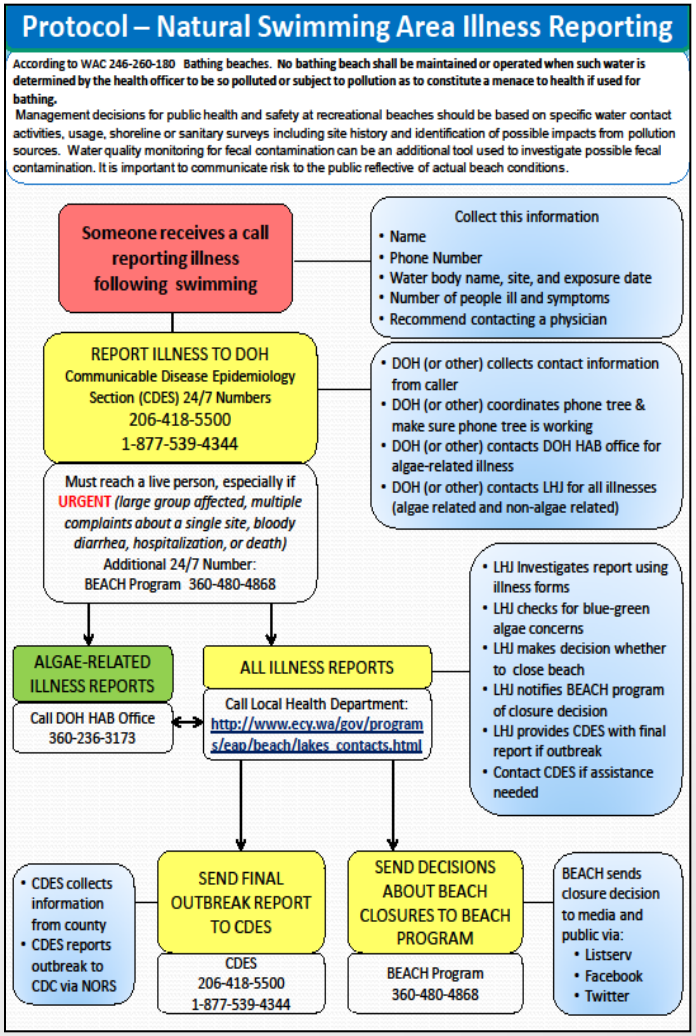
Recreational Waterborne Illness Outbreak Investigation and Reporting Protocol

Process for:

- Receiving
- Reporting
- Investigating



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Microcystins

Year	# Lakes	# Samples above Std.	Maximum Conc. (µg/L)
2007	9	22	4,810
2008	18	88	4,620
2009	19	69	18,700
2010	14	78	1,330
2011	31	85	26,400
2012	23	68	2,700

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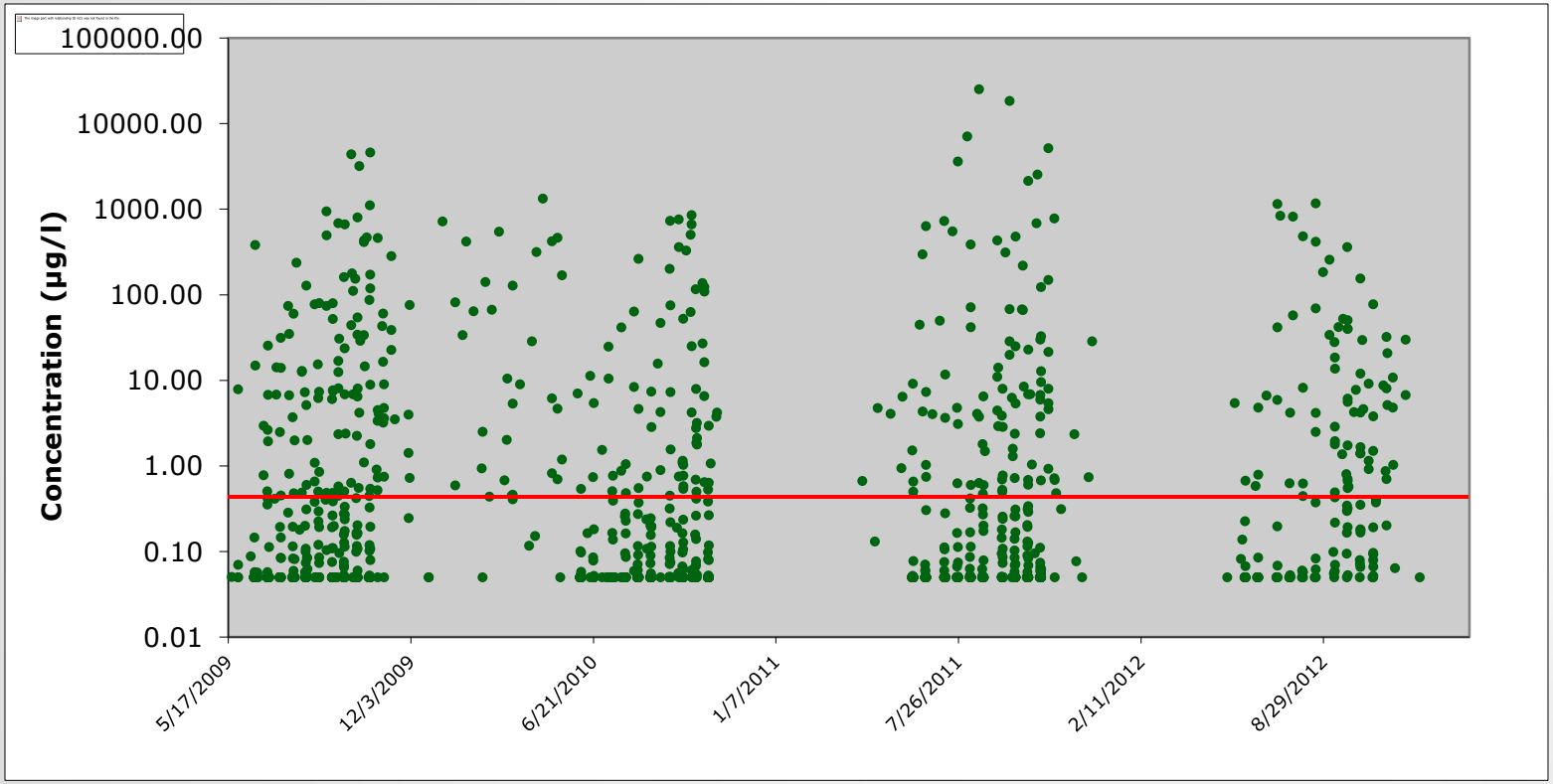
Seasonal Pattern of Microcystins (2009 – 2012)



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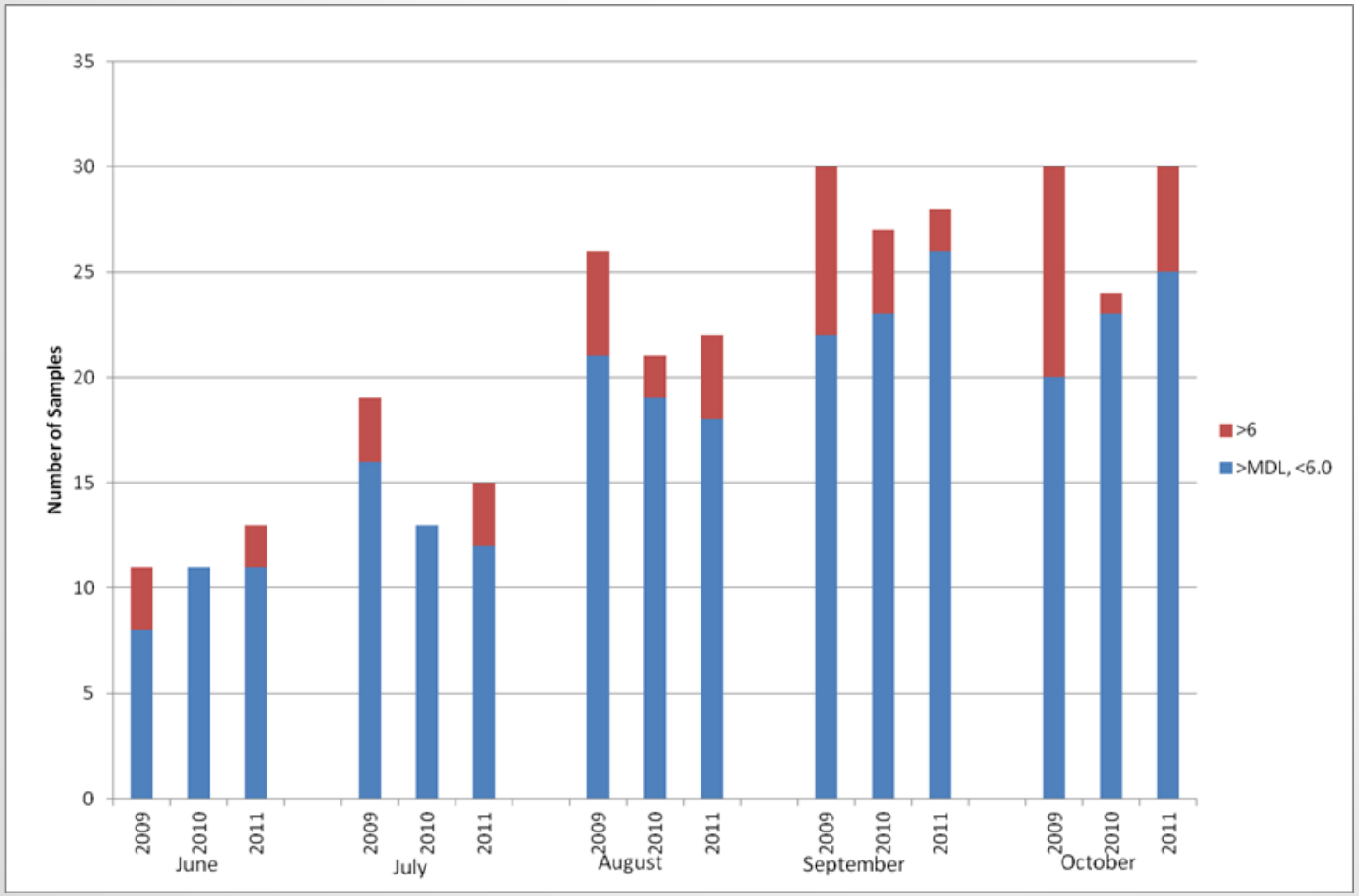
Microcystins June–October 2009, 2010, 2011



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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

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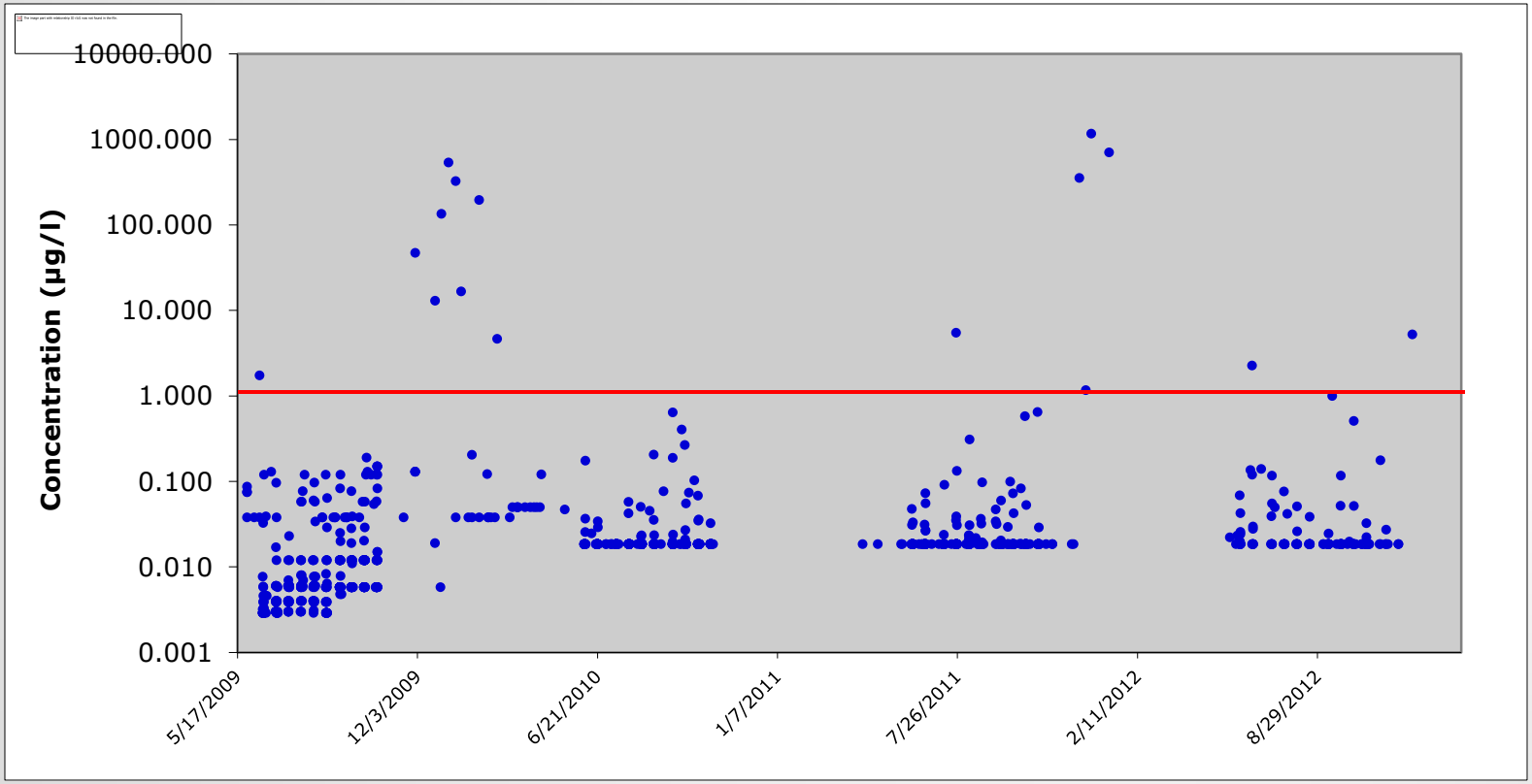
Seasonal Pattern of Anatoxin-a (2009 – 2012)



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Saxitoxin and Cylindrospermopsin (2009–2012)

Toxin	# Counties	# Lakes	Maximum Conc.	Lake(s) with Maximum Conc.
Saxitoxin	3	5	193	Waughop
Cylindrospermopsin	3	7	1.123	Long, Black

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Animal Deaths in Washington

- 1976 – Four dogs in Spokane County died after drinking water during a toxic *Anabaena* bloom
- 1982 – Two hunting dogs died, Moses Lake
- 1989 – Five cats died, American Lake, Pierce County
- 2006 – Two dogs died, Anderson Lake, Jefferson County
- 2007 – Two hunting dogs died, Potholes Reservoir

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Differential Diagnosis: Hepatotoxins

- Acetaminophen
- Nonsteroidal anti-inflammatories
- Aflatoxin
- Mushrooms
- Copper, Zinc, Iron
- Xylitol
- Sago Palm

Differential Diagnosis: Neurotoxins

- Organophosphate and carbamate insecticides
- Strychnine
- Metaldehyde
- Pyrethrins
- Moldy foods
- Chlorinated hydrocarbon pesticides
- Bromethalin
- Mushrooms

Treatment Review

- There are no antidotes to these toxins
- Medical care is supportive
- Activated charcoal slurry may be of benefit

Clinic Posters

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

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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 **Licking fur or hair** contaminated with toxic blue-green algae	**Hepatotoxins** - Acute depression - Weakness & incoordination - Loss of appetite - Excess drooling - Vomiting and diarrhea - Abdominal tenderness - Jaundice - 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 - Hypoglycemia - Prolonged clotting times - Proteinuria - Presence of toxin in clinical specimens (liver, gastrointestinal contents) collected from animals
	Neurotoxins - Excess drooling - Apprehension & anxiousness - Vomiting - Muscle twitching - Seizures - 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** - 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

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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.

Did you know?

Most cyanobacterial blooms occur during warm summer and early fall months. However, toxic blooms can also occur during the colder winter months.

News and announcements

July 21, 2012 - wenatcheeworld.com
Officals post warnings to avoid toxic algae bloom

March 28, 2012 - NPR
Battling 'Red Tide,' Scientists Map Toxic Algae To Prevent Shellfish Poisoning

August 20, 2011 - seattletimes.com
Algae bloom pops up at Potholes Reservoir in Eastern Washington

July 20, 2011 - seattletimes.com
Heat wave fosters toxic algae in touristy lakes

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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)

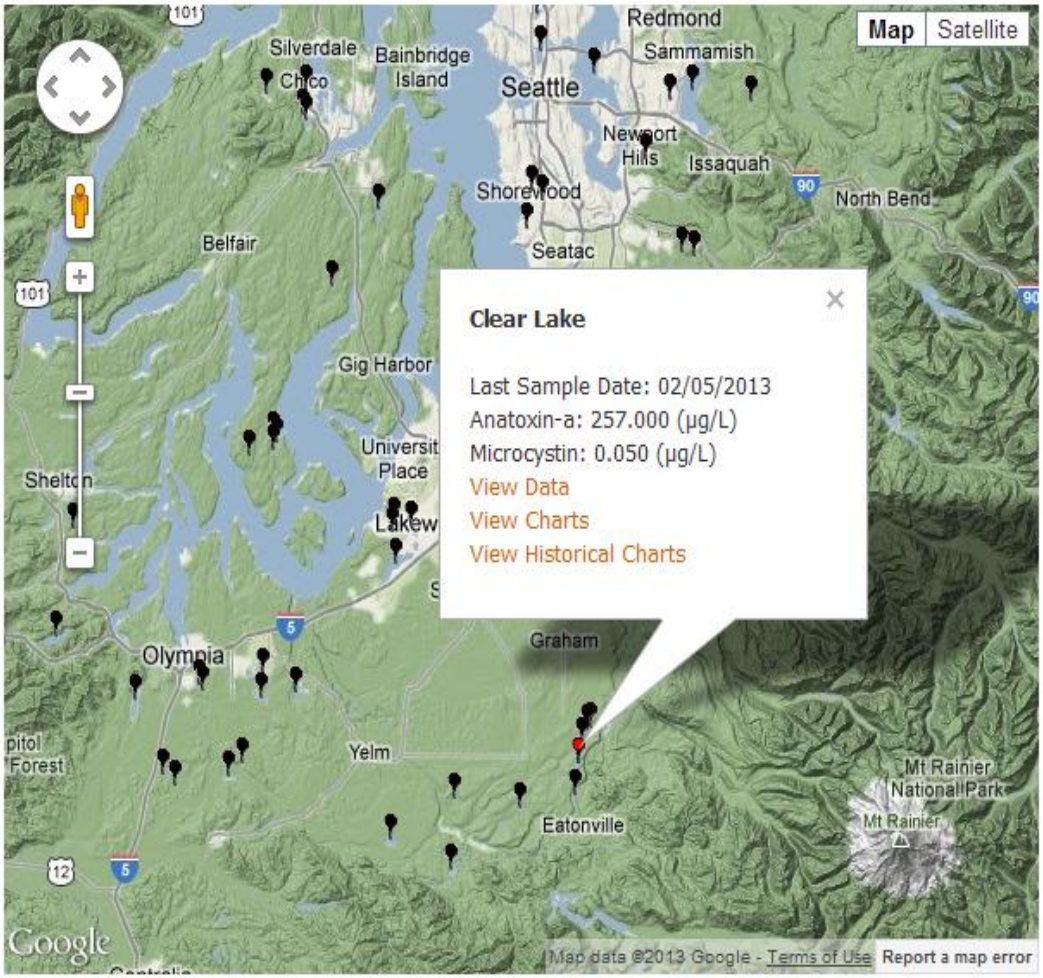
End Date (MM/DD/YYYY)

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.



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Washington State Toxic Algae

Freshwater algae bloom monitoring program

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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

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Washington State Toxic Algae

Freshwater algae bloom monitoring program

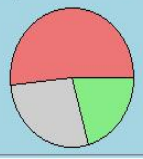
Home | Find lake | Report a bloom | Health risks | About toxic algae | Summaries | Program

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

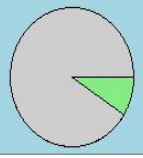
Start Date (mm/dd/yyyy) End Date (mm/dd/yyyy) View Charts View Data

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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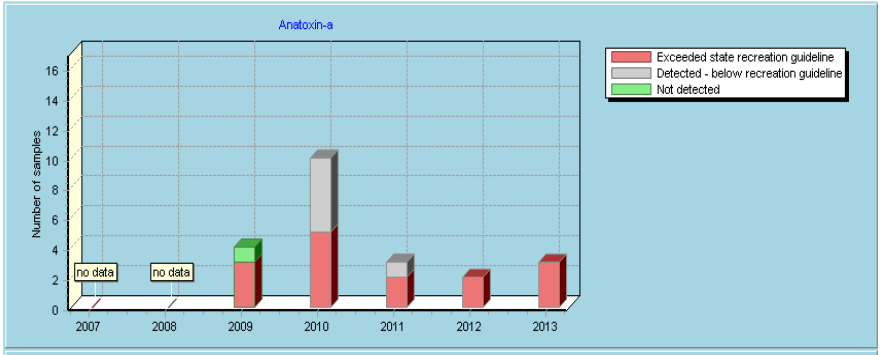
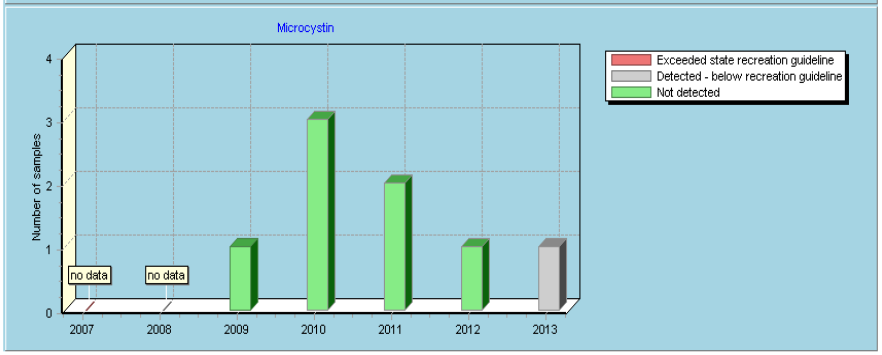
Historical summary of your lake

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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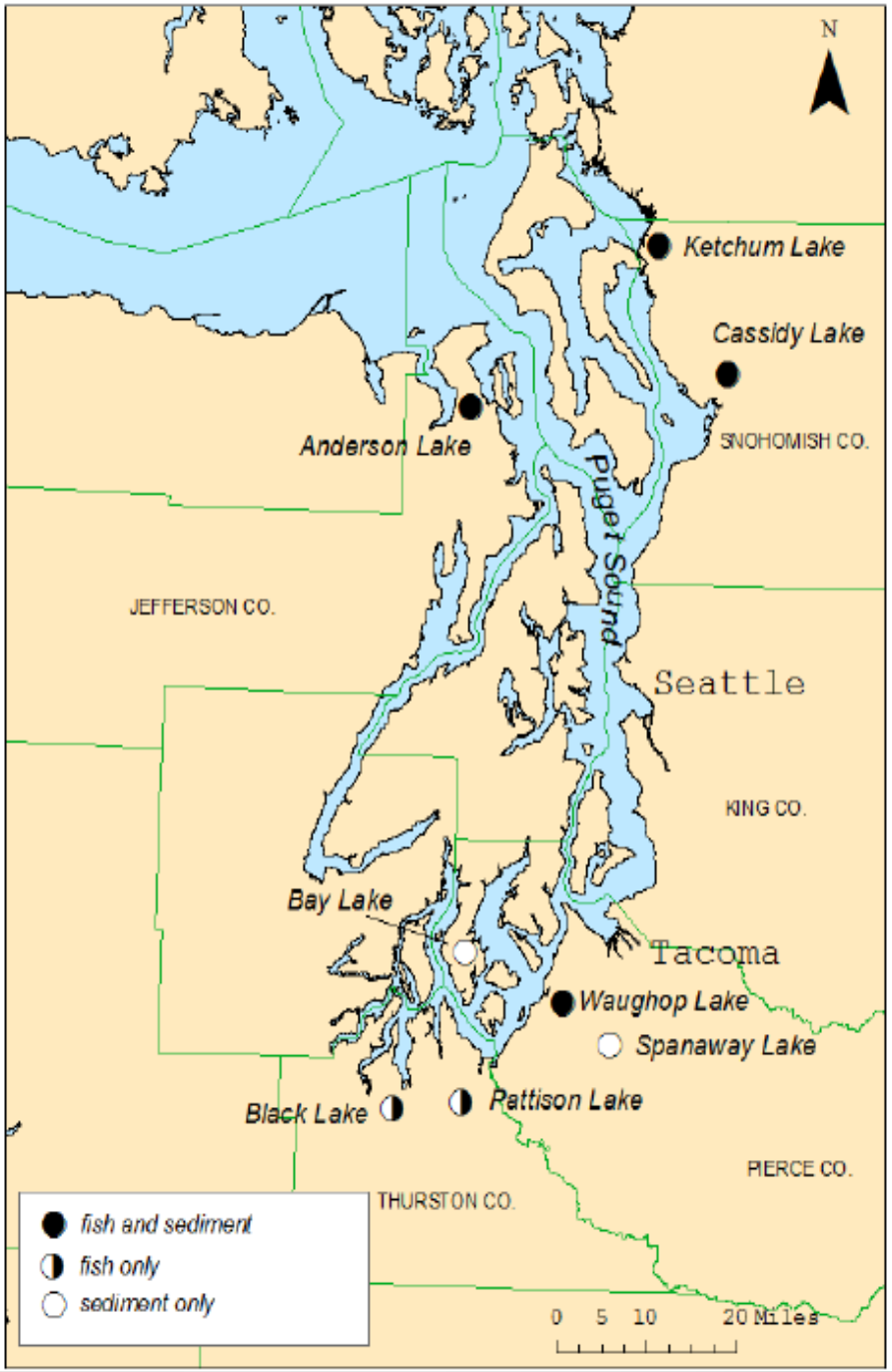
Fish and Sediment Samples from Western WA



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ELISA Results for Microcystins in Fish Muscle Tissue, Washington

Site/Lake	Species	Date	Abraxis ADDA	Envirologix
Arlington Hatchery	Rainbow Trout	19-Apr	7.0	1.0
Cassidy	Pumpkinseed	26-Aug	8.7	0.31
	Yellow Perch	26 Aug	7.7	0.76
		21-Sep	8.0	0.47
Pattison	Largemouth Bass	8-Sep	8.2	0.25
Anderson	Rainbow Trout	27-Aug	6.3	2.2
	Rainbow Trout (dup)		11	2.4
	Rainbow Trout	28-Aug	9.6	0.38

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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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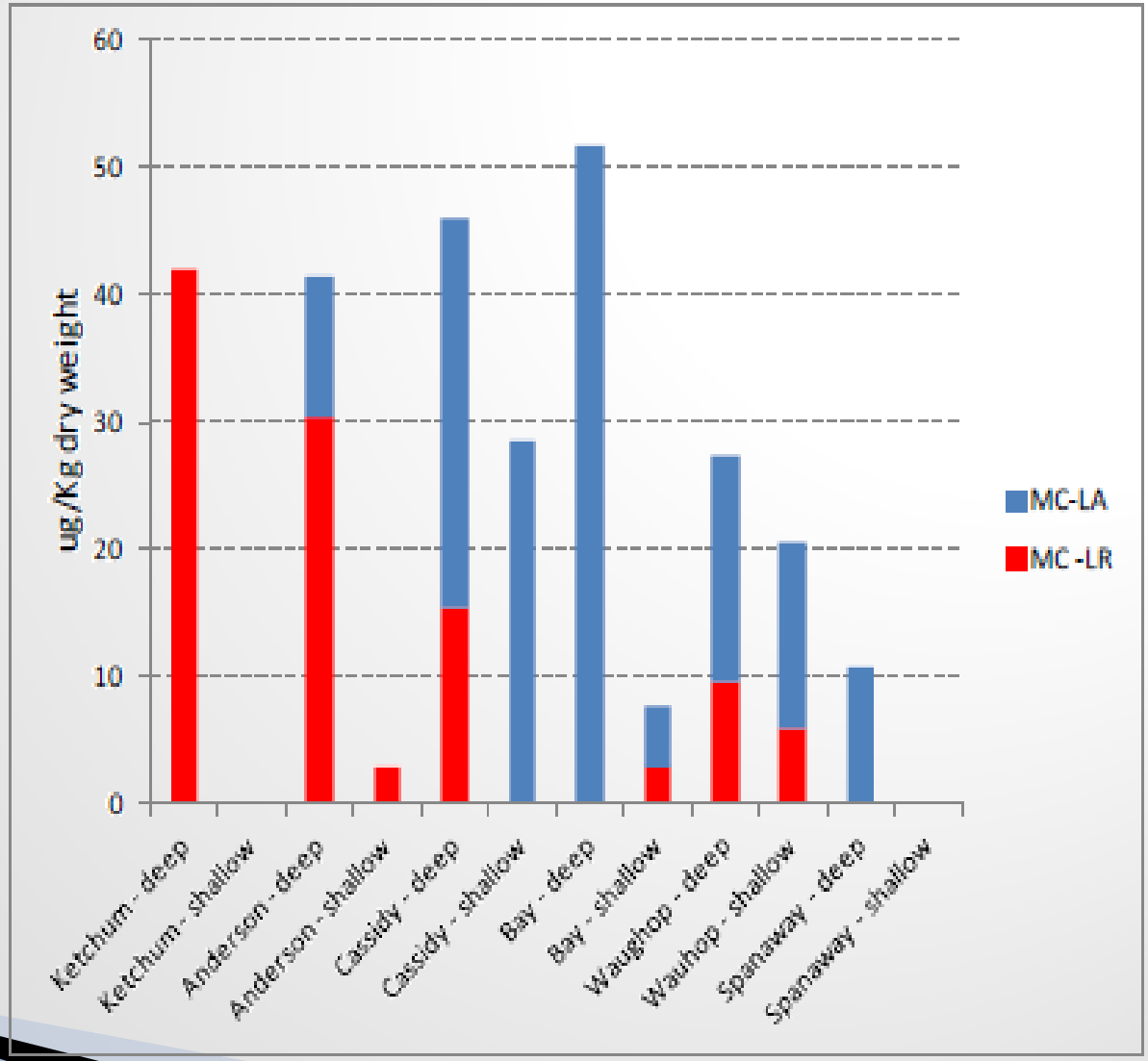
Microcystins in Lake Sediments



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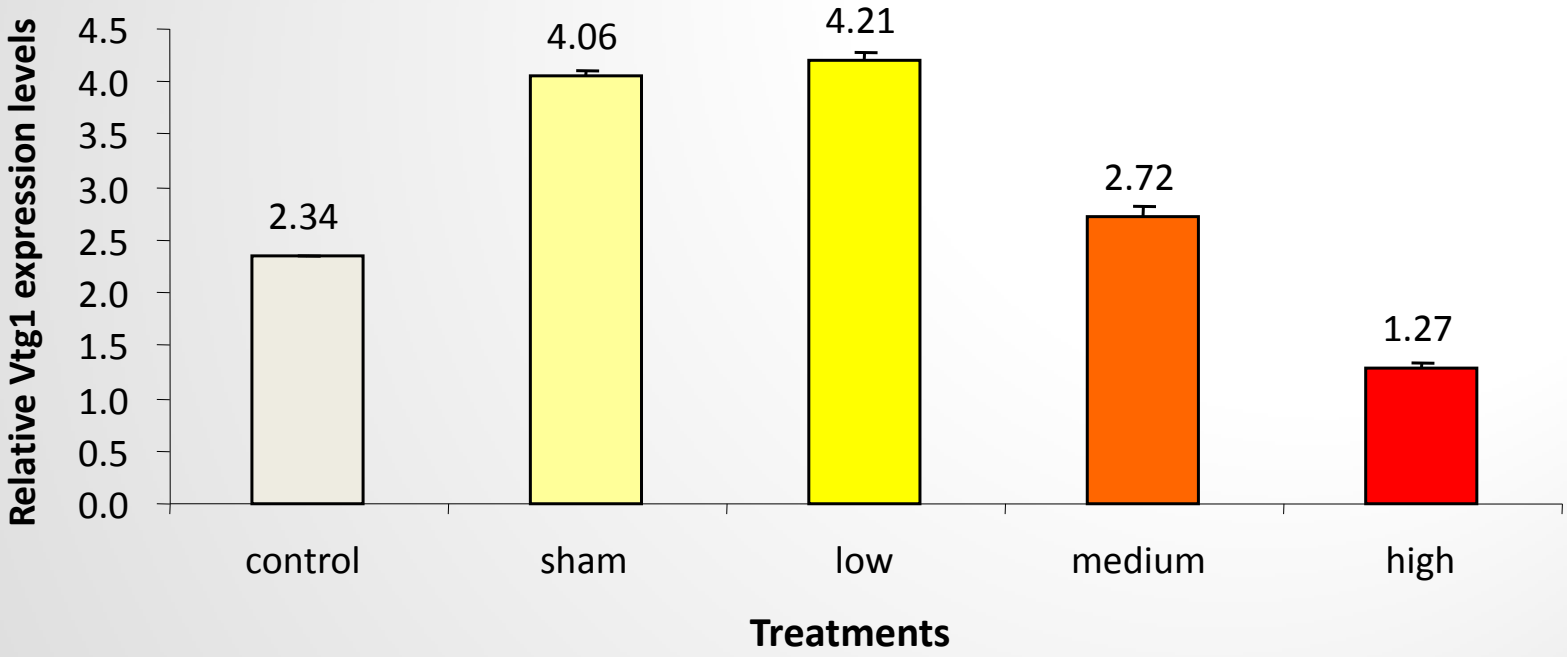
Gene Expression in Rainbow Trout



Fold-change in hepatic vitellogenin 1 (Vtg1) expression in fish fed on diets containing inactivated algae extract (sham) or increasing concentration of active algae extract (low, medium, high).

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Toxic Gene Presence – Waughop Lake

Date	Cyano genus	# Colonies	*anaC* PCR	*mcyE* PCR
4 June	*Aphanizomenon*	3	-ve	+
		7	-ve	-ve
18 June	*Gloeotrichia*	2	-ve	-ve
	Microcystis	6	-ve	+
		2	+	+
9 July	*Anabaena*	1	+	+
		1	-ve	+
		1	-ve	-ve
	Gloeotrichia	2	-ve	-ve
		1	-ve	+
	Woronichinia	1	-ve	-ve
	Microcystis	17	-ve	+
		1	+	+

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Mussels in Puget Sound

Pilot Project

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

WSU analyzing microcystins

- Preliminary results show bioaccumulation at levels of potential human health concern

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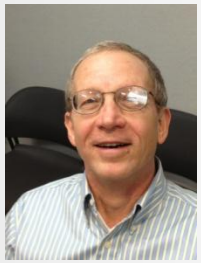
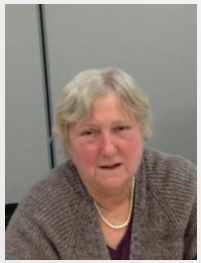
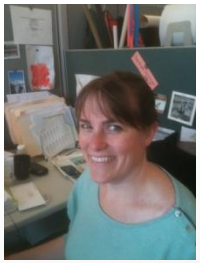
Summary

- Cooperative approach – partners working together
- State funded testing: 4 cyanotoxins
- State recreational guidance values
- FW biotoxin online database
- Many public health questions left to answer
- Climate change?

Regional Examination of HABs Team







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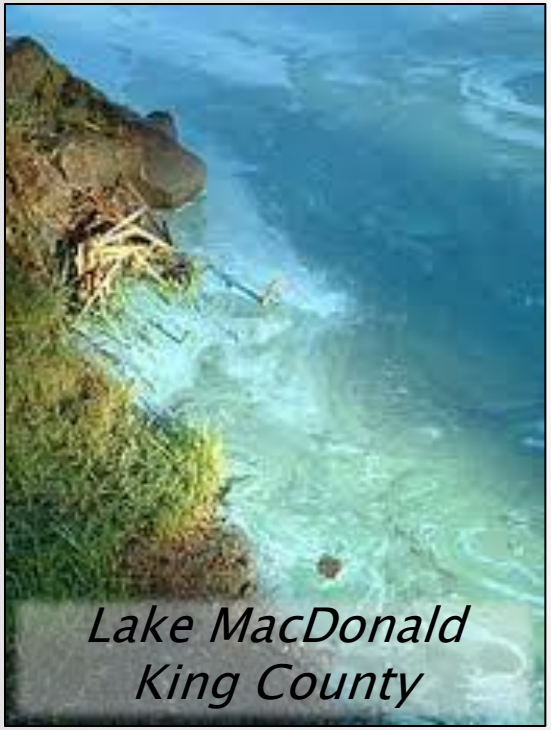

Questions?

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