Implementation of Routine Cyanobacterial Toxicity Monitoring in Lakes Sammamish, Washington and Union

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Cyanobacteria
(a.k.a. blue-green algae)

- Found throughout the world in freshwater habitats
- Can produce a variety of toxins
- Increasing awareness of health risks from exposure to toxic blooms

That's Fit to Print"

The New York Times

VOL. CLVII . . . No. 54,097 © 2007 The New York Times SUNDAY, OCTOBER 14, 2007

SPEAKING OUT

An algae crisis in May confirmed the claims of a crusading peasant, Wu Lihong, who protested for more than a decade that factories were destroying Lake Tai.

ABOVE, REUTERS; BELOW, CHANG W. LEE/THE NEW YORK TIMES

In China, a Lake's Champion Imperils Himself

By JOSEPH KAHN

ZHOUTIE, China — Lake Tai, the center of China's ancient "land of fish and rice," succumbed this year to floods of industrial and agricultural waste.

Toxic cyanobacteria, commonly referred to as pond scum, turned the big lake fluorescent green. The stench of decay choked anyone who came within a mile of its shores. At least two million people who live amid the canals, rice paddies and chemical plants around the lake had to stop drinking or cooking with their main source of water.

The outbreak confirmed the claims of a crusading peasant, Wu Lihong, who protested for more than a decade that the region's thriving chemical industry, and its powerful friends in the local government, were destroying one of China's ecological treasures.

CHOKING ON GROWTH

This series, with extensive multimedia features, can be found at nytimes.com.

Mr. Wu, however, bore silent witness. Shortly before the algae crisis erupted in May, the authorities here in his hometown arrested him. In mid-August, with a fetid smell still wafting off the lake, a local court sentenced him to three years on an alchemy of charges that smacked of official retribution.

Pollution has reached epidemic proportions in China, in part because the ruling Communist Party still treats environmental advocates as bigger threats than the degradation of air, water and soil that prompts them to speak out.

Senior officials have tried to address environmental woes mostly through pulling the traditional levers of China's authoritarian system: issuing command quotas on energy efficiency and emissions reduction; punishing corrupt officials who shield polluters; planting billions of trees across the country to hold back deserts and absorb carbon dioxide.

But they do not dare to unleash individuals who want to make China cleaner. Grass-roots environmentalists arguably do more to expose abuses than any edict emanating from Beijing. But they face a political climate that varies from lukewarm tol-

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OVERWHELMED BY TOXINS

At least two million people near Lake Tai had to stop drinking and cooking with their main source of water.

Factors likely to contribute to toxin production

- **Bloom conditions** (e.g.,warmer temperatures, high nutrients, light)
- **Wind patterns creating surface scums**
- **Lake mixing/turnover in autumn**

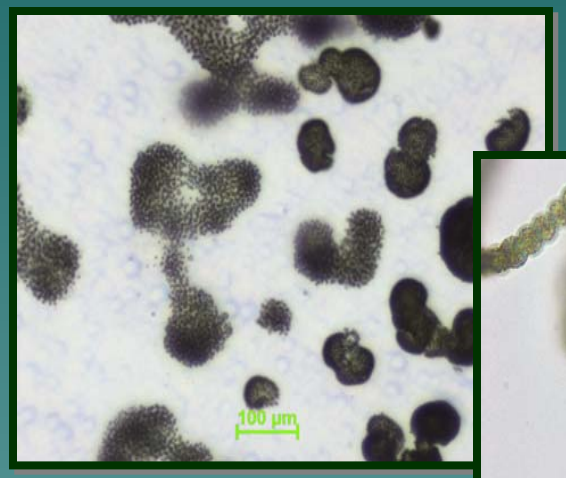
Green Lake bloom 2002

Cyanobacterial Toxins

Toxin Group	Primary target organ in mammals	Cyanobacterial genera
Microcystins	Liver	*Microcystis, Anabaena, Planktothrix (Oscillatoria), Nostoc, Hapalosiphon, Anabaenopsis*
Nodularin	Liver	*Nodularia*
Anatoxin-a	Nerve Synapse	*Anabaena, Planktothrix (Oscillatoria), Aphanizomenon*
Anatoxin-a (S)	Nerve Synapse	*Anabaena*
Aplysiatoxins	Skin	*Lyngbya, Schizothrix, Planktothrix (Oscillatoria)*
Cylindrospermopsins	Liver	*Cylindrospermopsis, Aphanizomenon, Umezakla*
Lyngbyatoxin-a	Skin, G.I. Tract	*Lyngbya*
Saxitoxins	Nerve Axons	*Anabaena, Aphanizomenon, Lyngbya, Cylindrospermopsis*
(LPS)	Potential irritant; affects any exposed tissue	ALL

Most Common Toxins

- **Microcystins**
  - liver
- **Anatoxin-a**
  - nerve
- **Saxitoxin**
  - nerve



Microcystis aeruginosa

Anabaena sp.

Anabaena and Aphanizomenon

Symptoms of Exposure to Liver Toxins

- Acute Effects - vomiting, diarrhea, pain
- Chronic Effects - include liver tumors

King County Cyanotoxin Monitoring Program

- 1997 and 1999 Toxic blooms measured in Lake Sammamish and Green Lake
- 2002 - began routine sampling at Major Lakes sites
- 2005 - added Swimming Beach sites

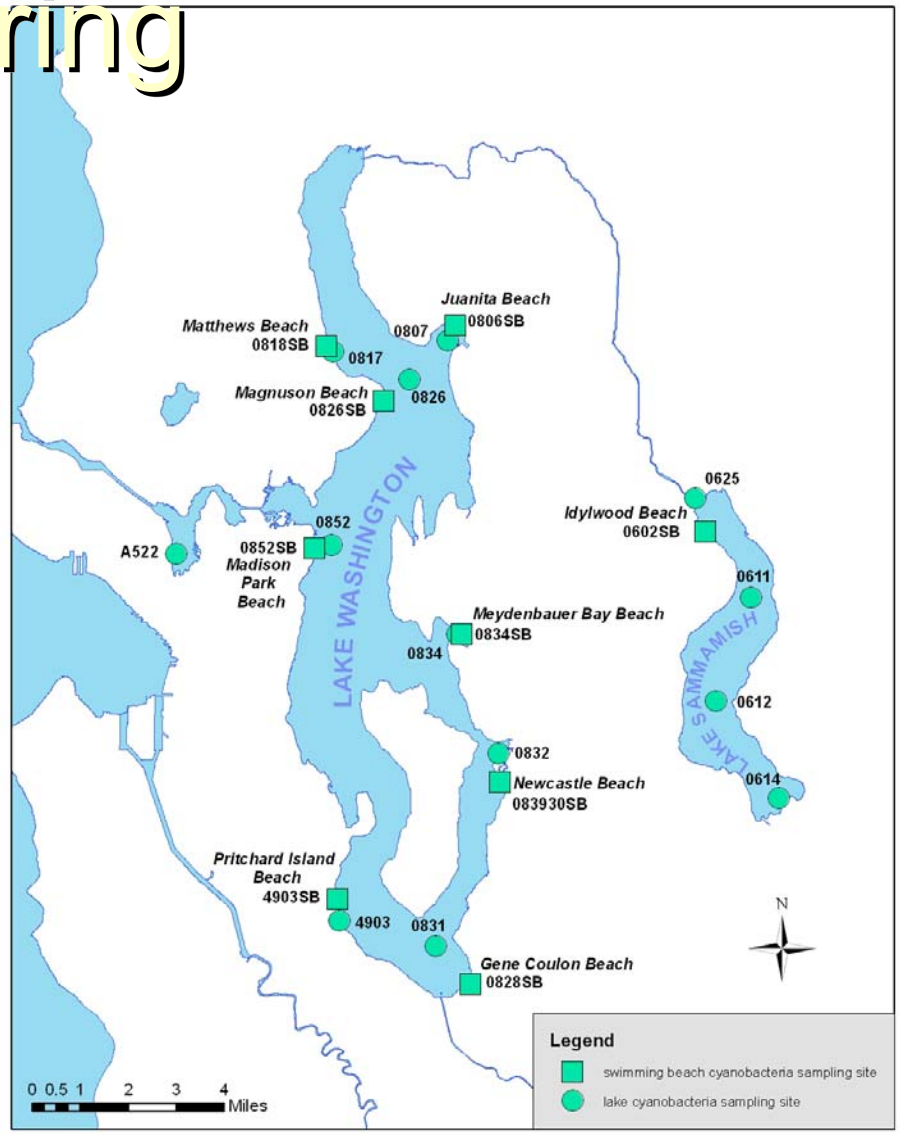
Lake Sammamish bloom 1997

Objectives

- Evaluate the presence of microcystin, a hepatotoxin (liver toxin), to protect human health.
- Estimate concentrations and geographic extent of the toxicity, should it be present.
- Establish relationships between microcystin and cyanobacteria species/abundance.
- Evaluate environmental conditions leading to toxin production in cyanobacteria.

Current Monitoring

- 13 Major Lakes sites
- 11 Swimming Beach sites
- Samples collected weekly Mar - Oct
- Alternating between Major Lake and Swimming Beach programs



2007 Cyanobacteria Toxicity Monitoring

Sampling

Discrete sub-surface
or
Integrated composite

Microcystins
Phytoplankton
Chlorophyll
Nutrients

In situ measurements

Physical/Chemical Parameters
(Major Lakes only)


FIELD DATA
SBE


HYDROLAB

Laboratory Methods

- **Extraction**:

  Microcystins are extracted by cell lysing (freezing and sonication)

- **Analysis**:

  Particulate and dissolved microcystins are measured using two types of laboratory analysis

Microcystin Tests

- **ELISA**

  (Enzyme linked immunosorbent Assay)

  – commercial, antibody-based

  – Measures predominantly Microcystin-LR

- **PPIA**

  (Protein Phosphatase Inhibition Assay)

  - Measures combined toxicity of all congeners

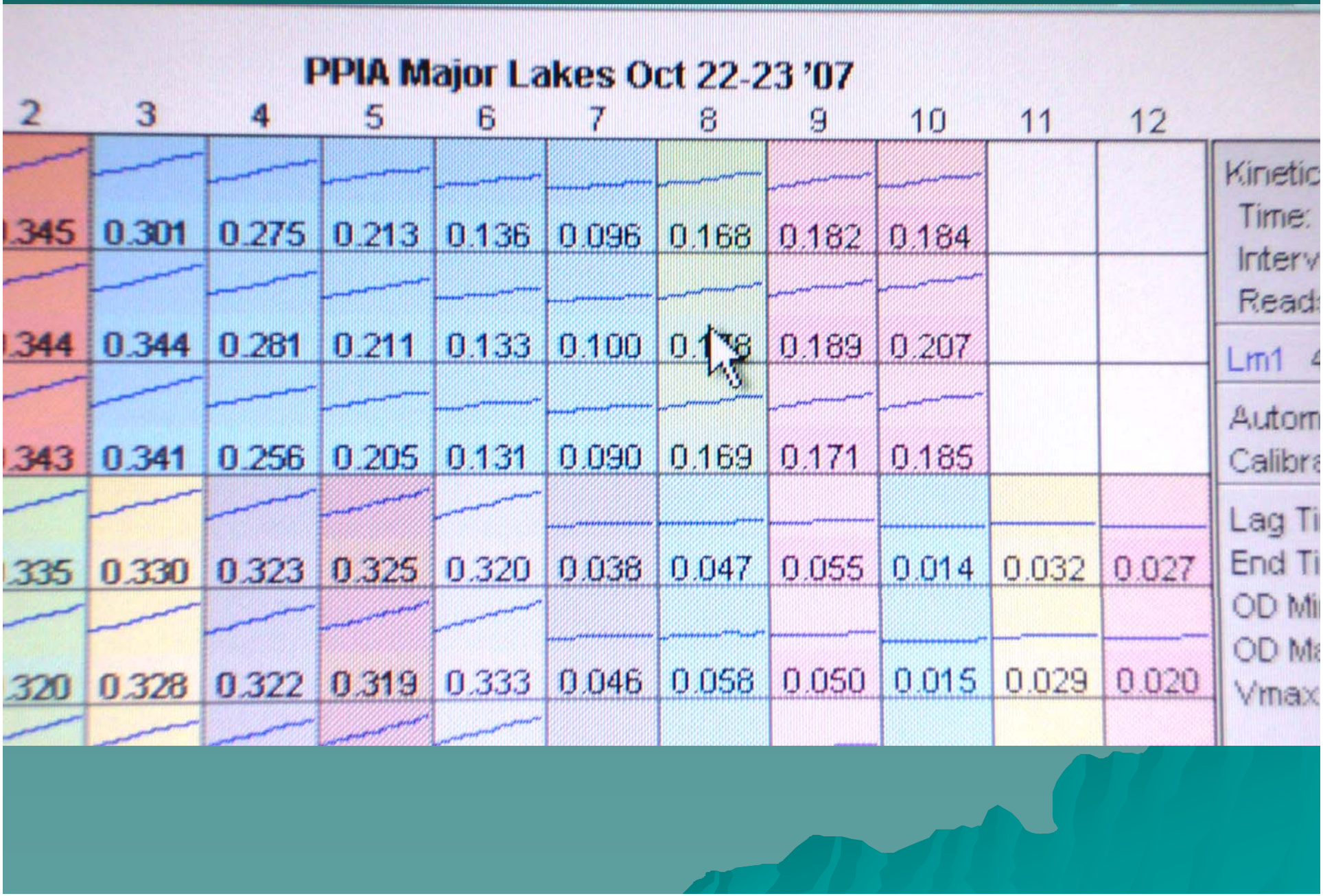
ELISA

Microcystin molecule binds to antibody

PPIA

Substrate + Enzyme = Yellow End Product

All Microcystins inhibit enzyme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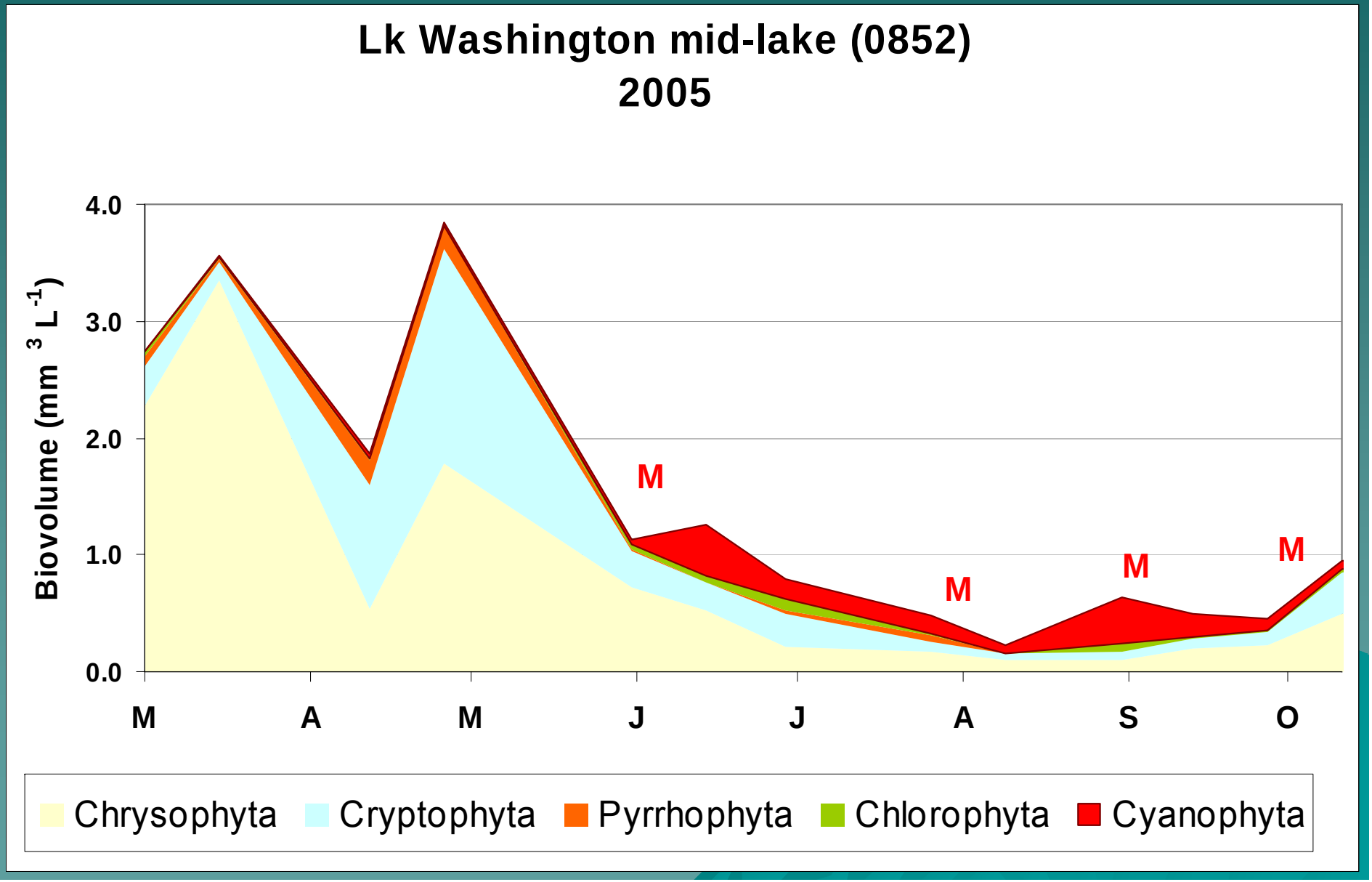
.345 0.301 0.275 0.213 0.136 0.096 0.168 0.182 0.184
.344 0.344 0.281 0.211 0.133 0.100 0.189 0.207
.343 0.341 0.256 0.205 0.131 0.090 0.169 0.171 0.185
.335 0.330 0.323 0.325 0.320 0.038 0.047 0.055 0.014 0.032 0.027
.320 0.328 0.322 0.319 0.333 0.046 0.058 0.050 0.015 0.029 0.020
Kinetic
Time:
Interv
Read
Lm1
Autom
Calibra
Lag Ti
End Ti
OD Mi
OD Ma
Vmax

Results

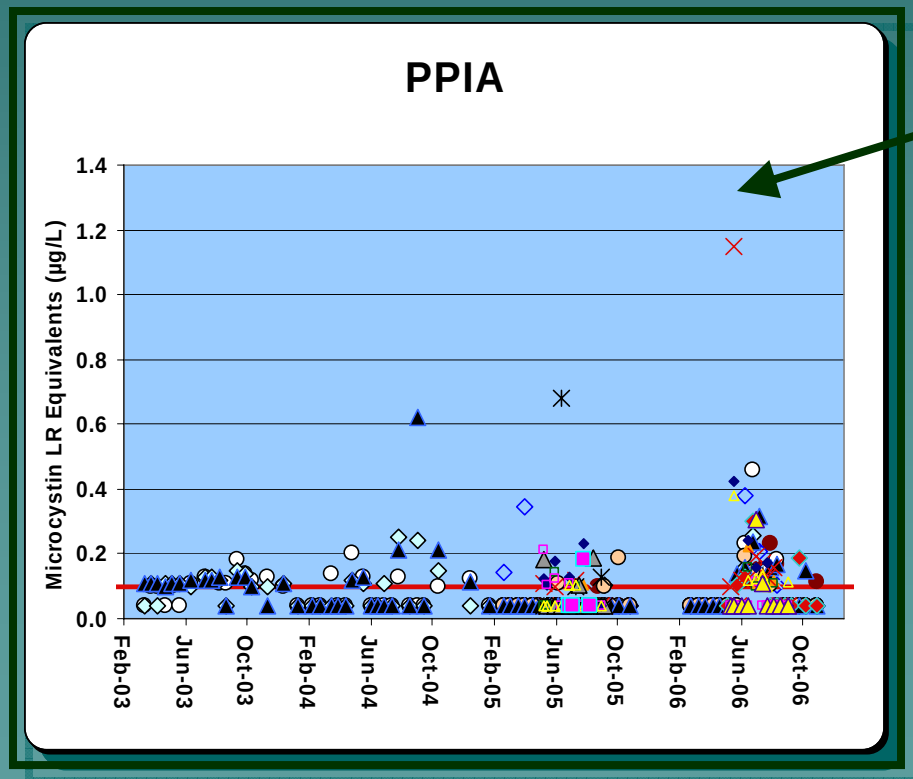
Phytoplankton

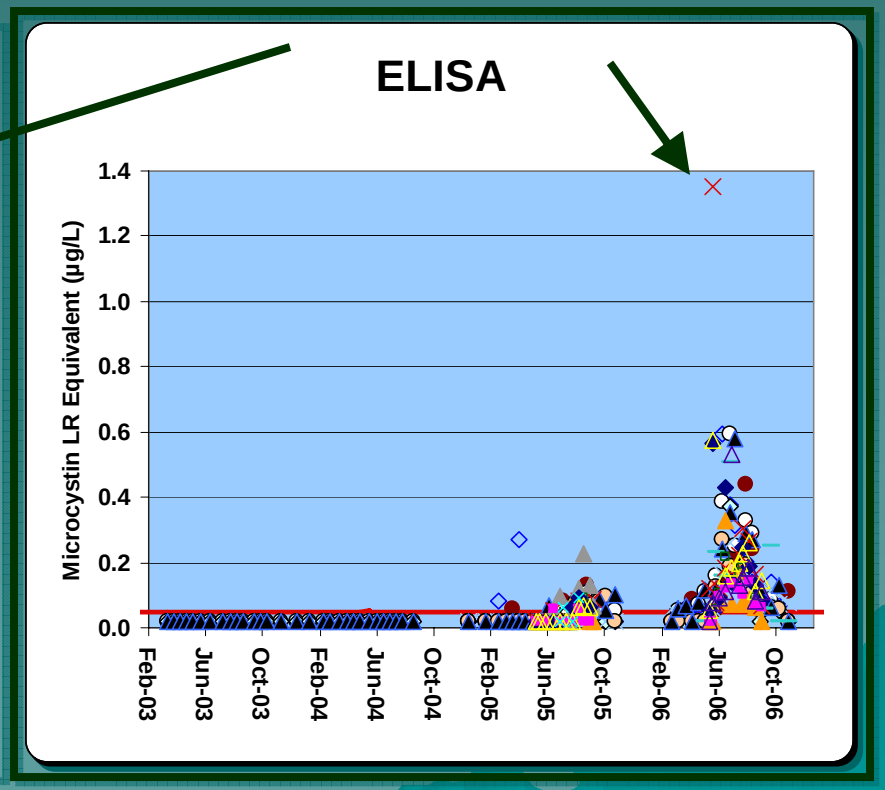


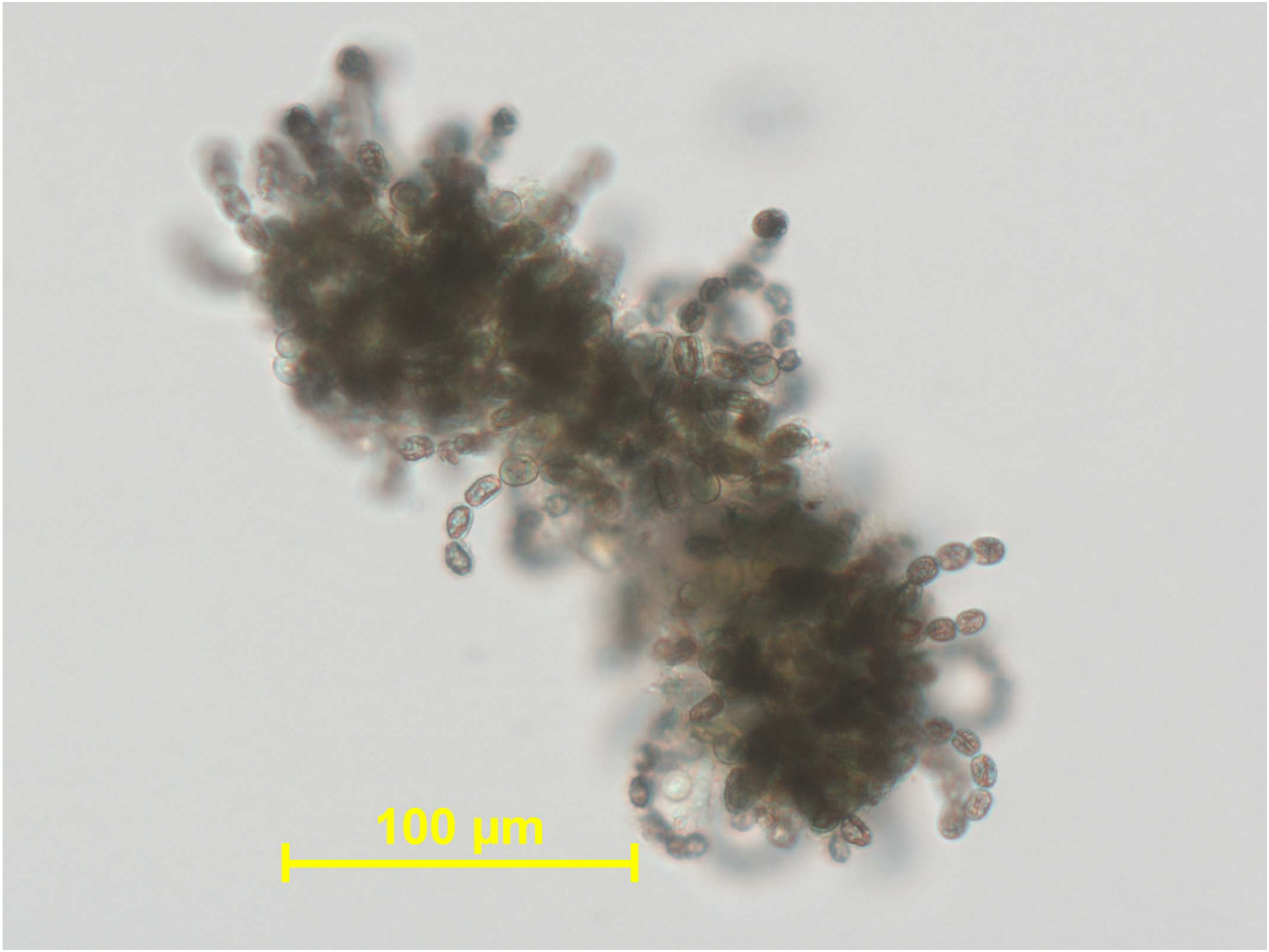
Lake Washington

2003 – 2006

- **World Health Drinking Standard Guideline = 1.0 ug/L**
- May 30, 2006 Bloom at Matthews Beach = 52 ug/L or 47.1 ug/L

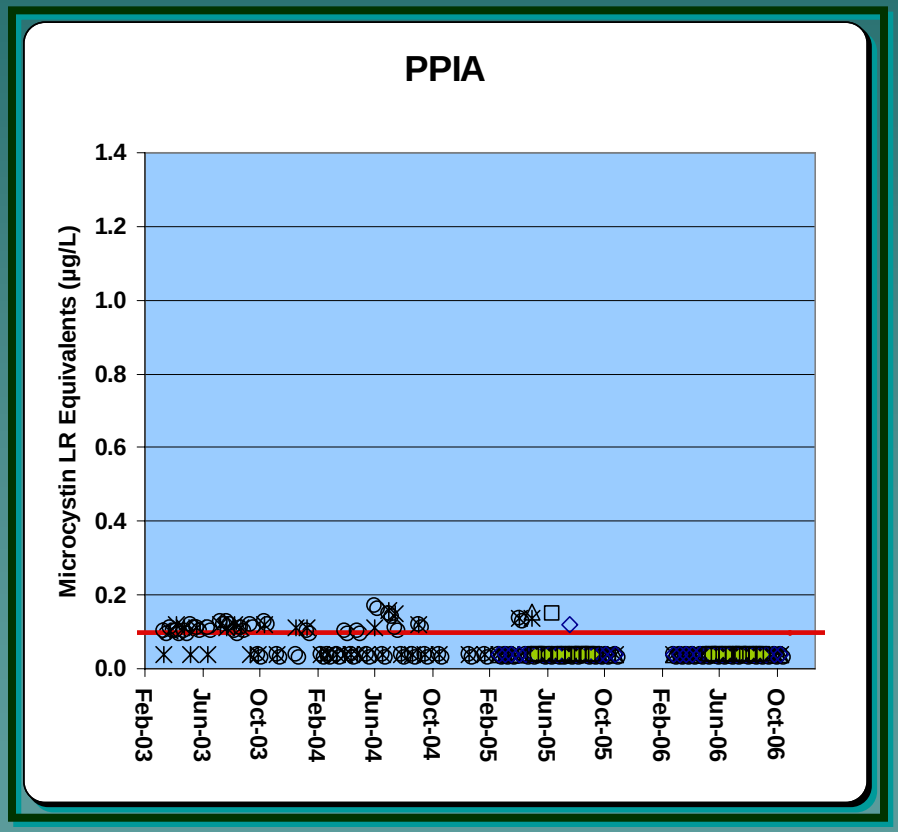


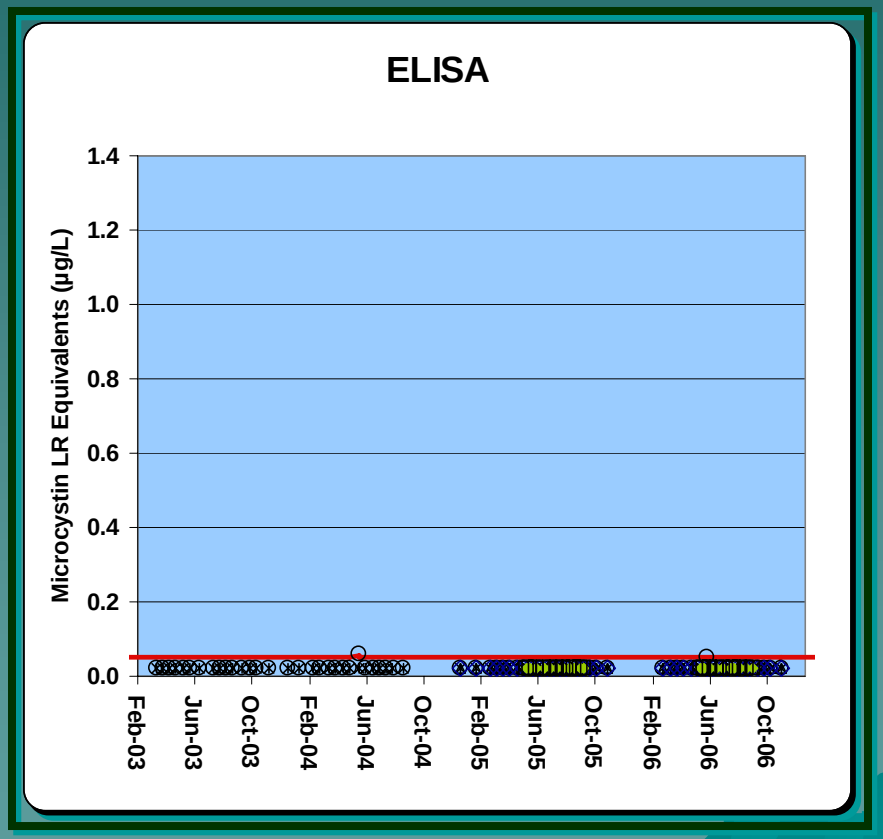



100 µm

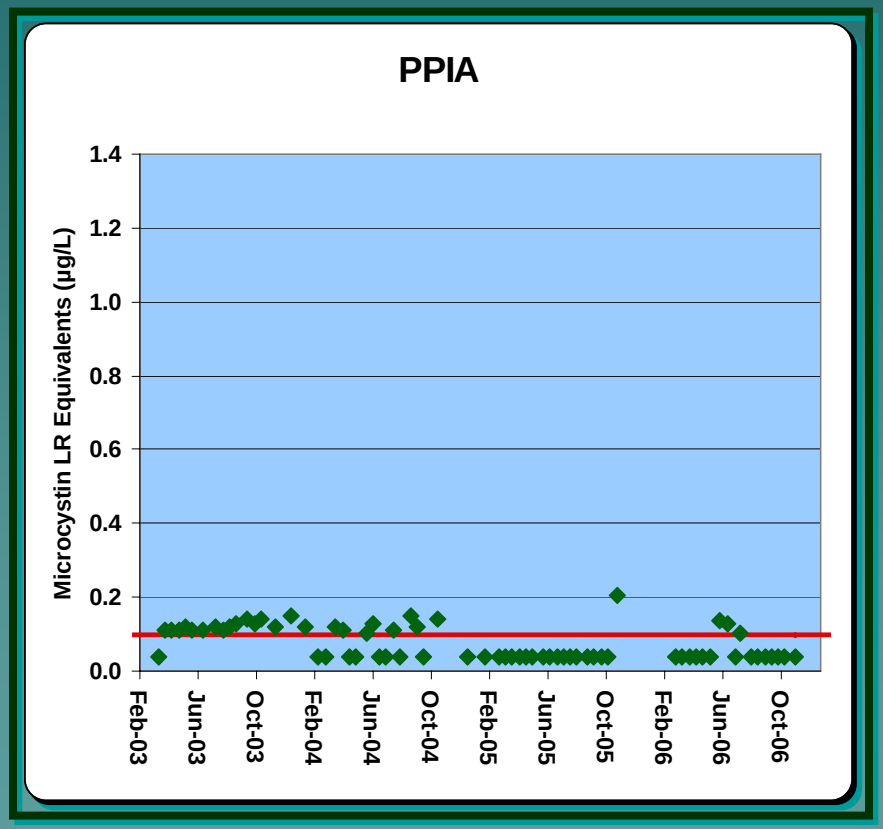
Lake Sammamish

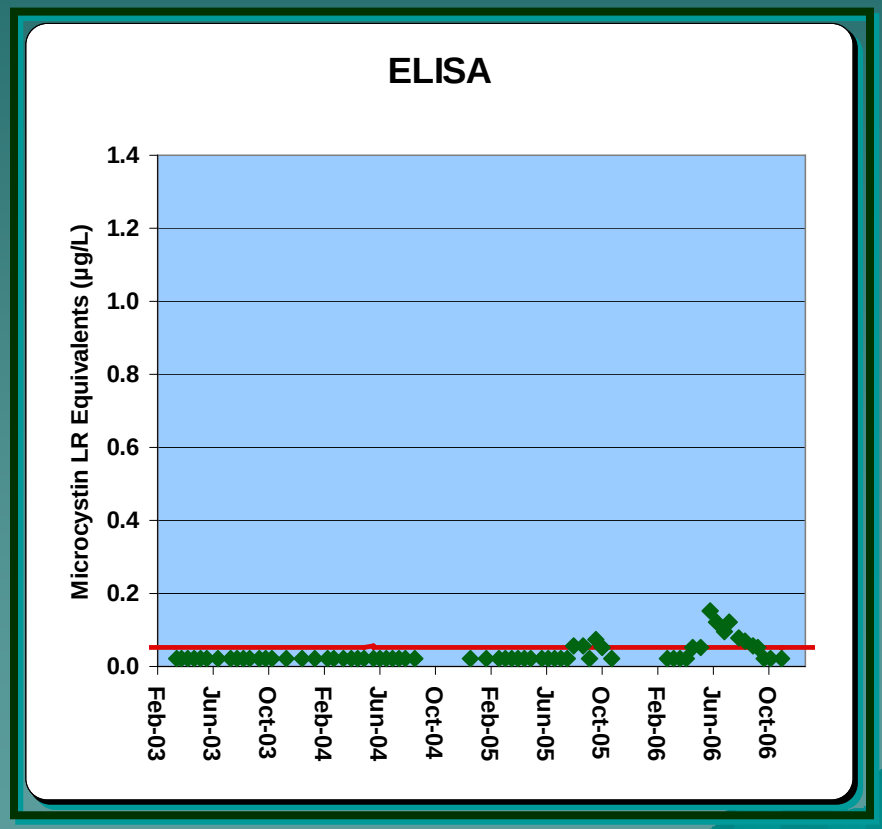
2003 – 2006





Lake Union
2003 – 2006



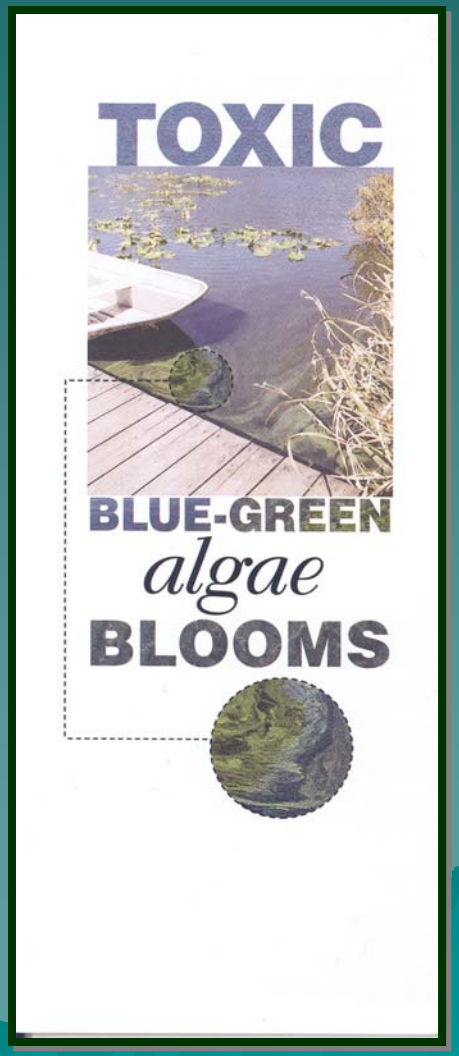


Conclusions

- **Microcystins detected in all lakes**
- **Concentrations well below WHO guideline for drinking water** (except one bloom at Matthews Beach)
- **No significant correlation with other water quality parameters**

Ecology's Fresh Water Algae Control Program

- **Freshwater algae identification**
- **Toxicity testing**
- **Utilizes the King County Environmental Lab**




Palmer Lake (Okanogan Co.)
June 2007

Other Toxic Blooms

Pierce Co.	Wapato	4,810	µg/L
	Steilacoom	221	µg/L
	Spanaway	121	µg/L
Snohomish Co.	Cassidy	1,374	µg/L
Island Co.	Lone	92	µg/L
Kittitas Co.	Fiorito	55	µg/L
Grant Co.	Potholes Res.	41	µg/L

2008 Toxin Analysis

- **Microcystins** (hepatotoxins)

NEW!!

- **Anatoxin-a** (neurotoxin)

Our new HPLC