Mid-Klamath River CHAB Monitoring

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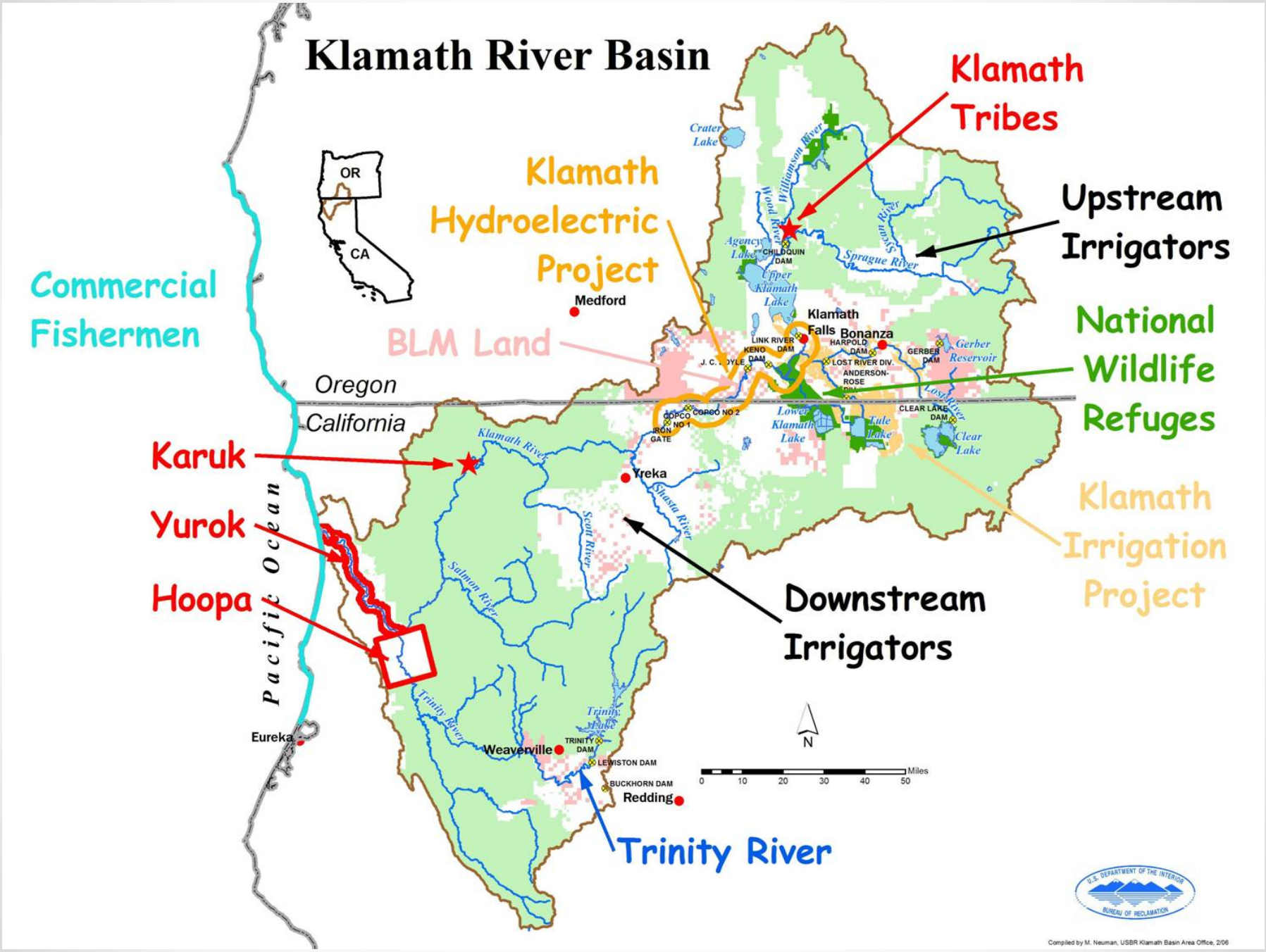
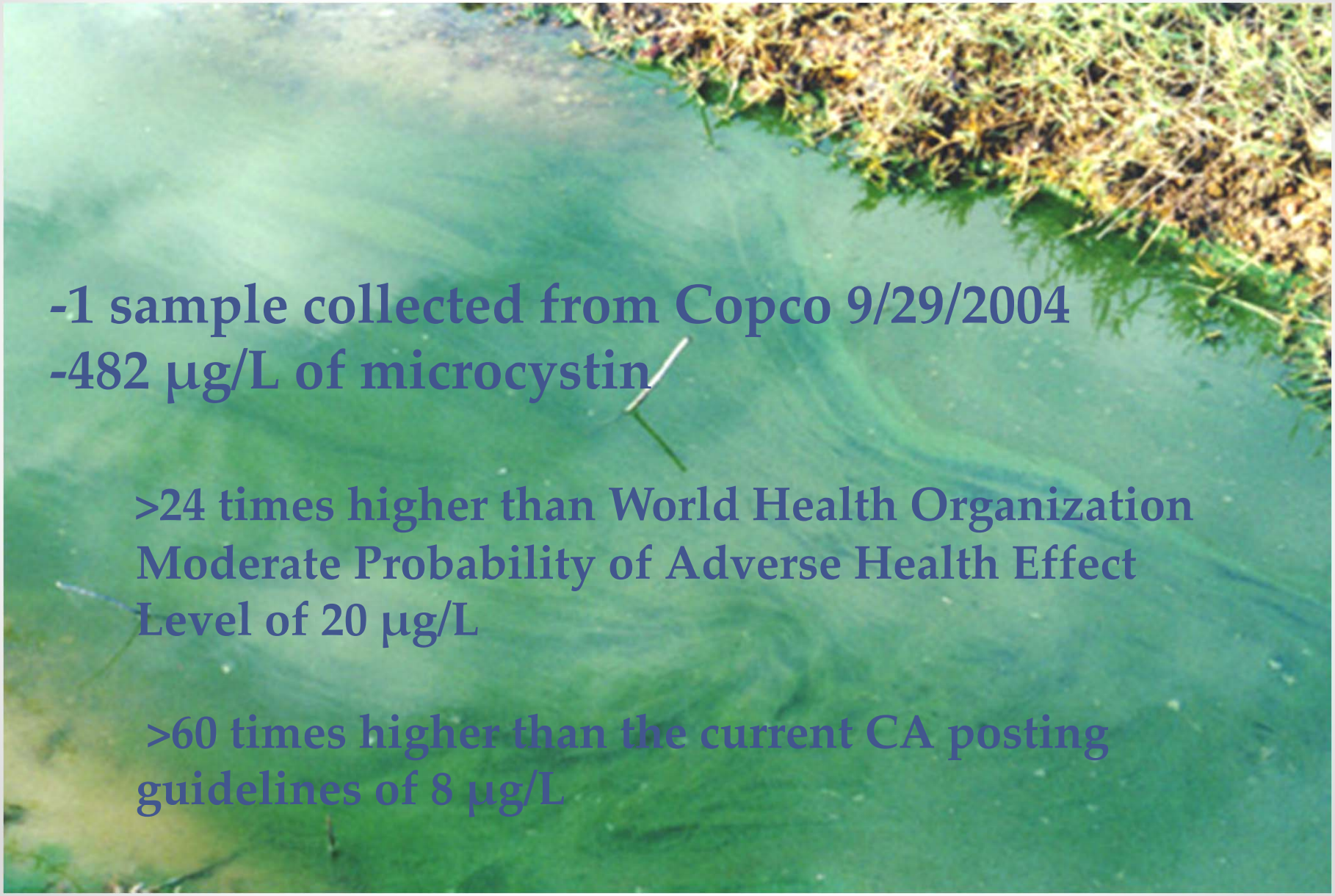
Special Thanks To:
Yurok Tribe Environmental Program
Ken Fetcho
Micah Gibson
Suzanne Fluharty


Klamath River Basin
Klamath Tribes
Upstream Irrigators
Klamath Hydroelectric Project
Commercial Fishermen
BLM Land
National Wildlife Refuges
Karuk
Yurok
Hoopa
Klamath Irrigation Project
Downstream Irrigators
Trinity River
OR
CA
Oregon
California
Pacific Ocean
Medford
Klamath Falls
Bonanza
Yreka
Weaverville
Redding
Eureka
Crater Lake
Williamson River
Wood River
Sprague River
Sycan River
Agency Lake
Upper Klamath Lake
CHILOQUIN DAM
LINK RIVER DAM
KENO DAM
J. C. BOYLE
HARPOLD DAM
LOST RIVER DIV.
ANDERSON-ROSE DIV.
GERBER DAM
Gerber Reservoir
Lost River
CLEAR LAKE DAM
Clear Lake
Tule Lake
Lower Klamath Lake
COPCO NO 1
COPCO NO 2
IRON GATE
Klamath River
Shasta River
Scott River
Salmon River
Trinity River
Trinity Lake
TRINITY DAM
LEWISTON DAM
BUCKHORN DAM
N
Miles
0 10 20 30 40 50
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Compiled by M. Neuman, USBR Klamath Basin Area Office, 2/06

Karuk Tribe's 1st Look at Toxic Algae in the Klamath Hydroelectric Project



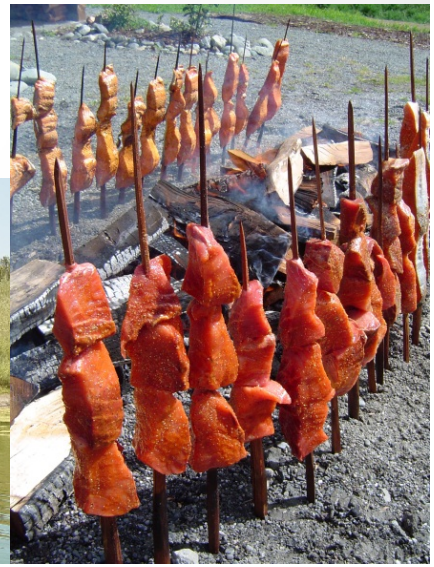
-1 sample collected from Copco 9/29/2004
-482 μg/L of microcystin

>24 times higher than World Health Organization Moderate Probability of Adverse Health Effect Level of 20 μg/L

>60 times higher than the current CA posting guidelines of 8 μg/L

Environmental and Public Health Concerns

- Recreators (swimming, water skiing, rafting)
- Subsistence fishing
- Ceremonial use
- Bioaccumulation in food chain (subsistence and recreational foods)
- Pets
- Wildlife
- Additional stressor on already stressed system



Thresholds and Guidance for BGA

The World Health Organization (WHO 1998; 2003) has set the following thresholds for *Microcystis*/microcystin concentrations in recreational waters:

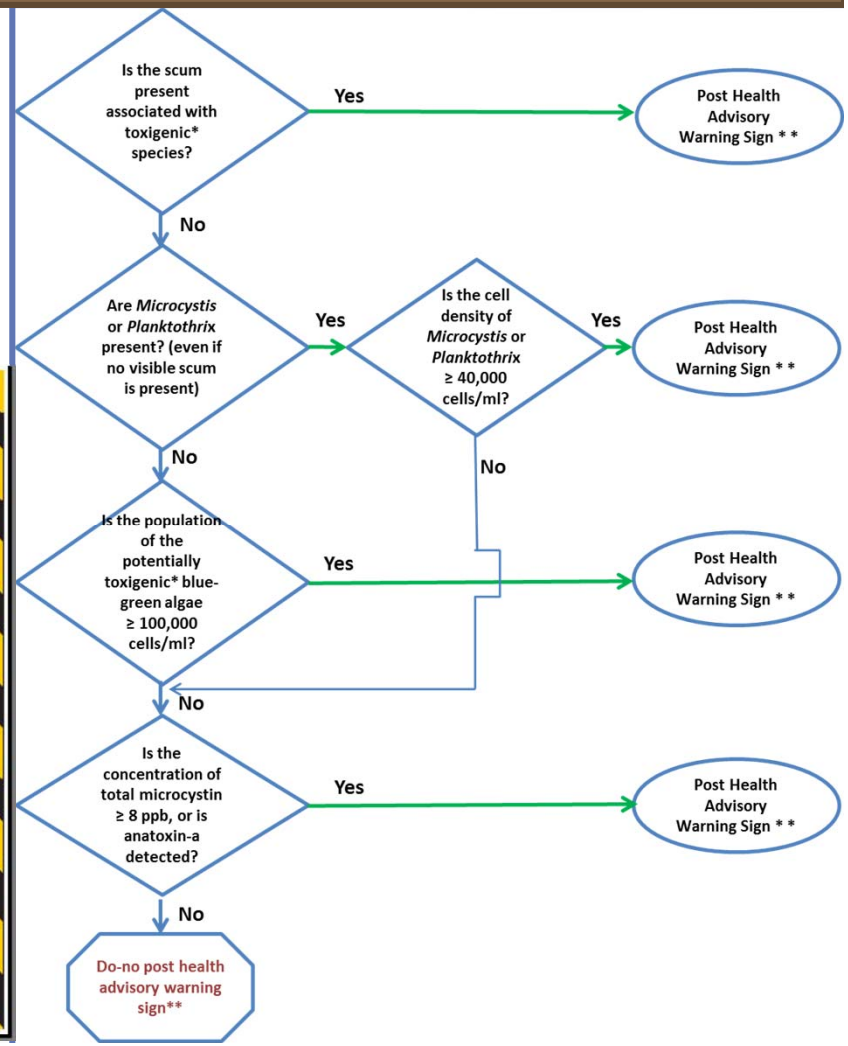
	cells/ml	µg/L
Low Risk:	20,000	4
Moderate Risk:	100,000	20
Severe Risk	visible scum	

Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms – July 2010

California voluntary guidelines for posting health advisories:
40,000 cells/ml
8 µg/L

Currently being updated

Figure 1. Decision tree for posting health advisory warnings:



Klamath River Hydroelectric Project Reservoir Water Quality Dynamics Study 2005-2008

Internal nutrient loading study in Klamath Hydroelectric Project for Copco and Iron Gate Reservoirs.

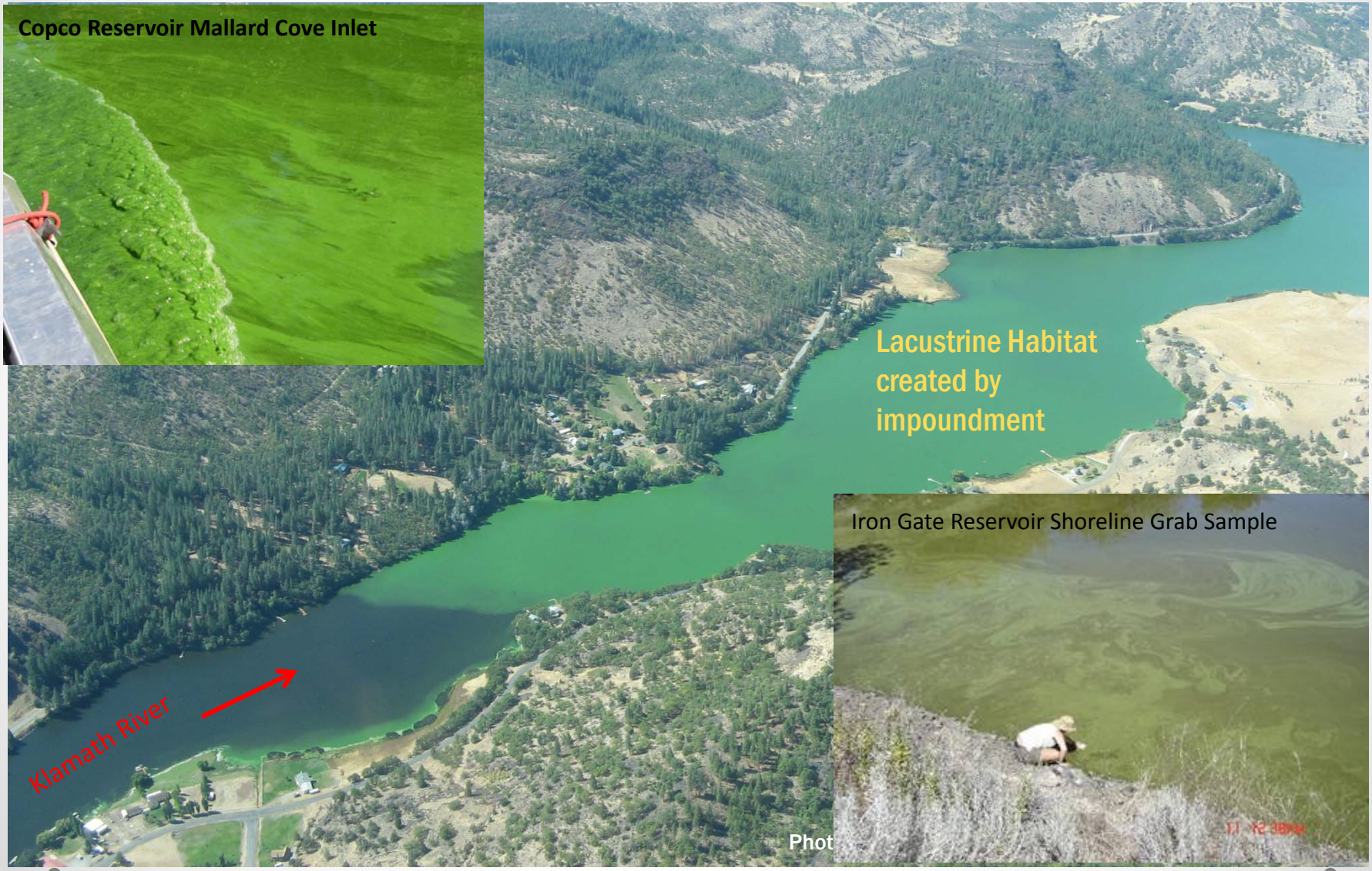
Biweekly Sampling for cell counts and toxin.

Nutrient Samples: Shipped over-night to Aquatic Ecosystems in Seattle, WA.

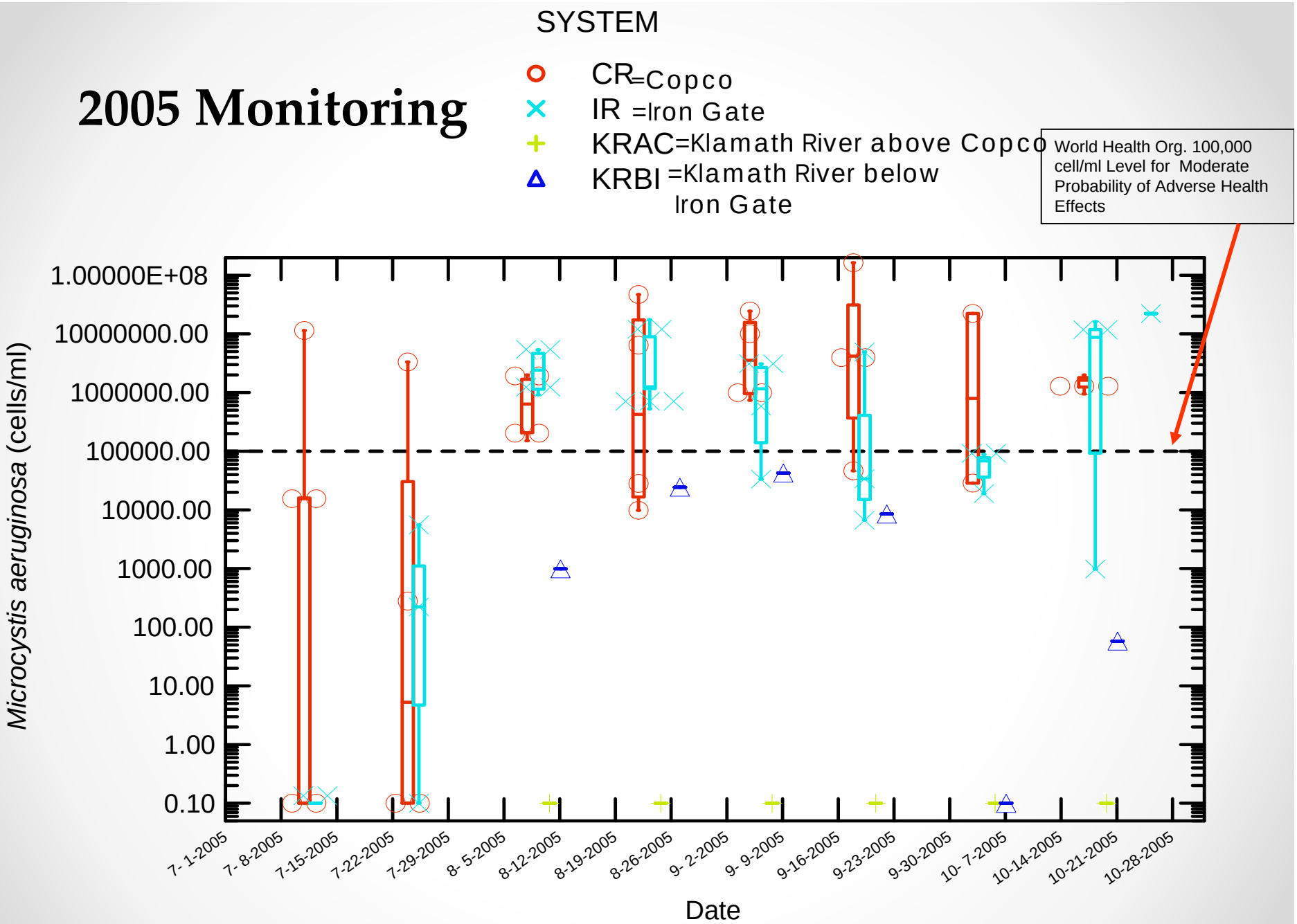
Cell counts: Samples preserved in Lugol's Iodine and Microscopic Analysis performed by Jim Sweet, Aquatic Analysts, White Salmon Washington

Microcystin Toxin Analysis: samples shipped Wright State University (2005) and then frozen (over-night) air to USEPA Region 9 Laboratory for ELISA test for microcystin concentration.

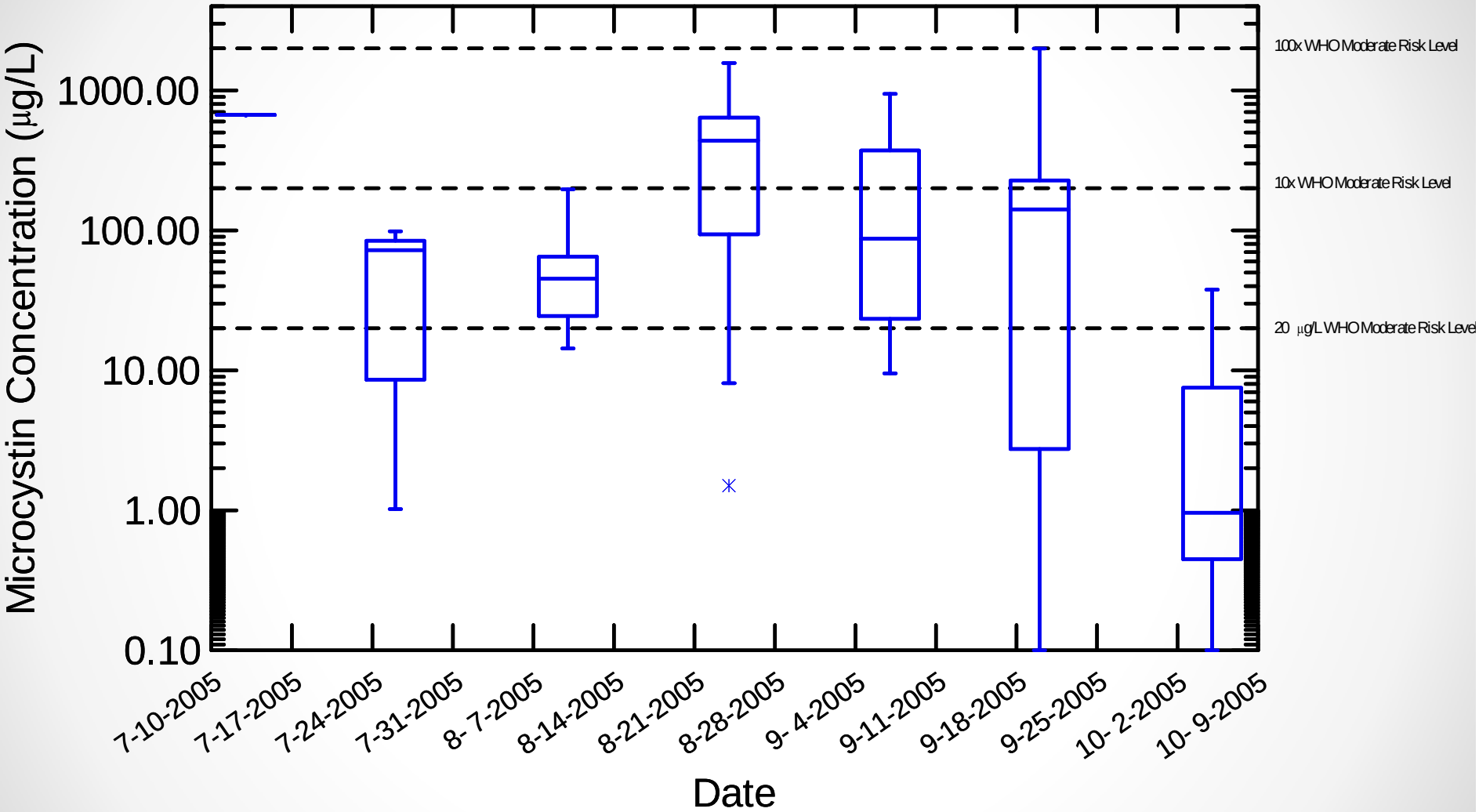
Toxic Algae Sampling 2005



2005 Monitoring

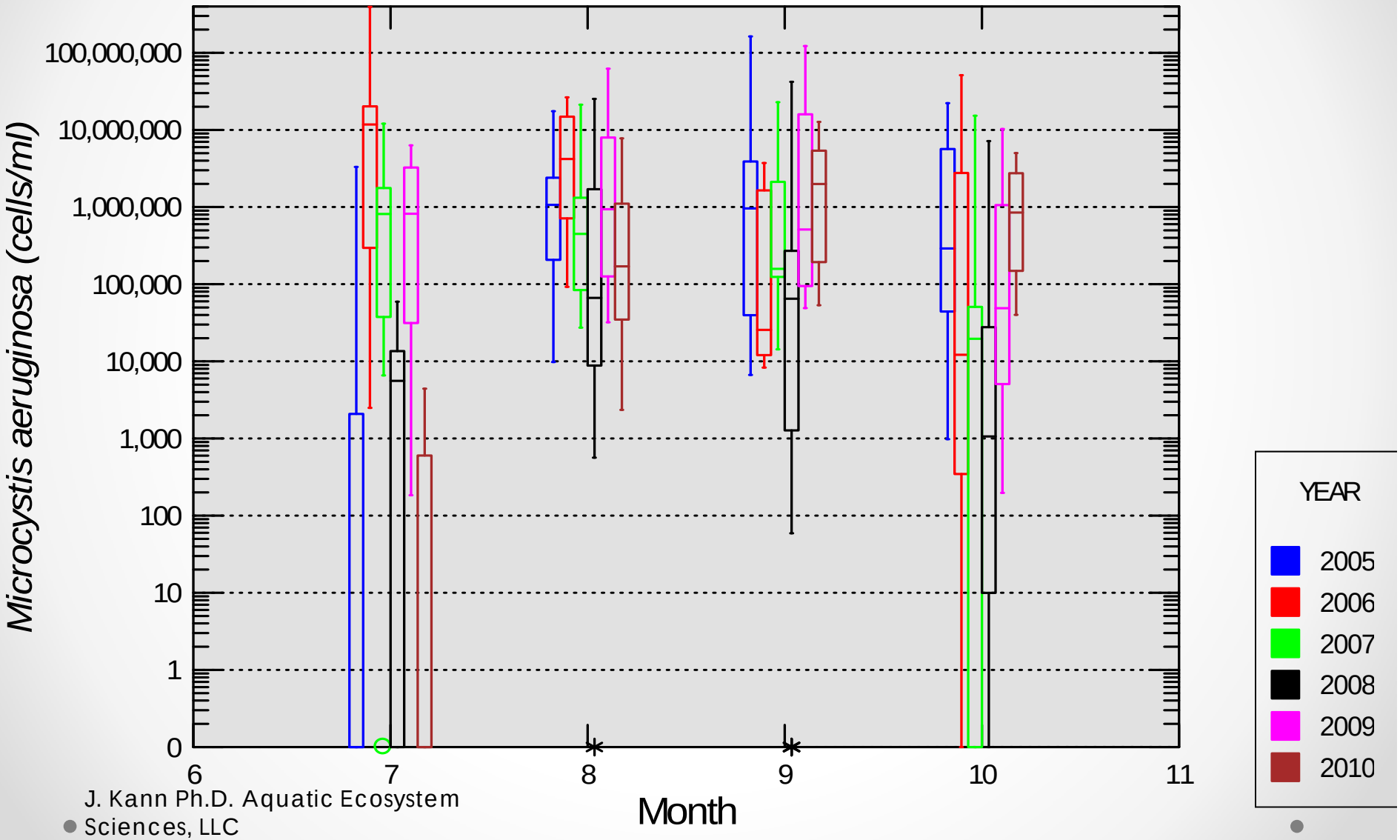


2005 Monitoring



Microcystin concentration time-series in Copco and Irongate Reservoirs, 2005.

Copco and Iron Gate Reservoirs



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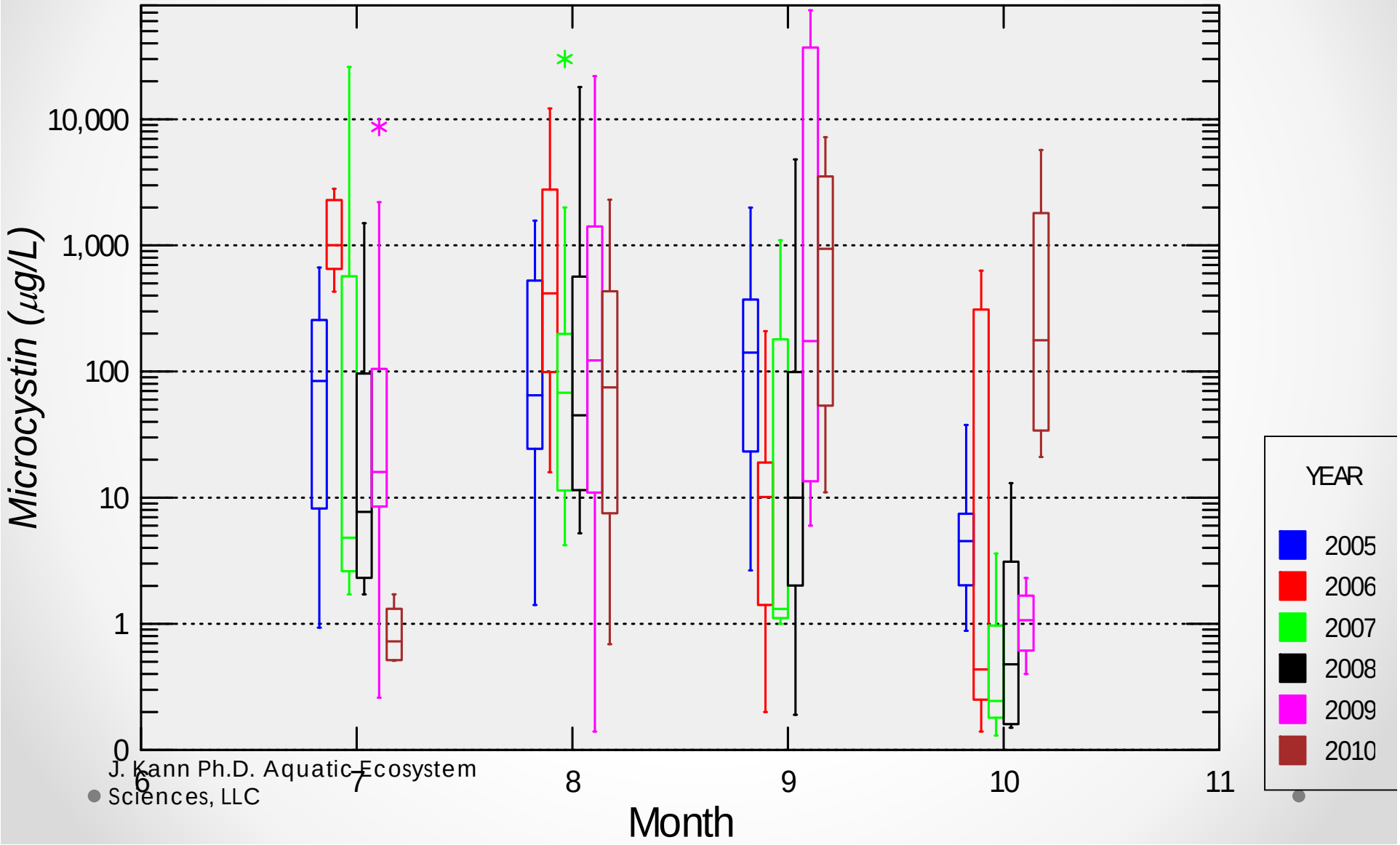
Copco and Iron Gate Reservoirs (July-October)



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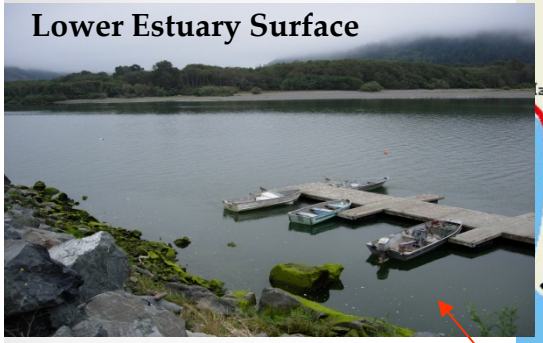
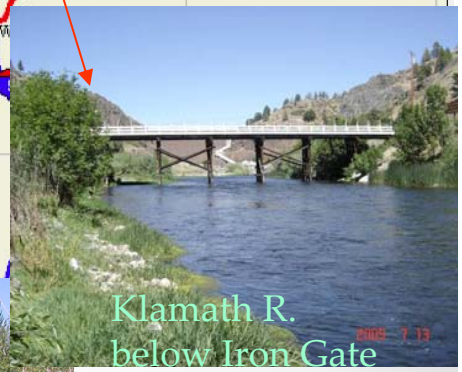

Lower Estuary Surface


Klamath River at Turwar Gage


Klamath R. above Copco


California
Link River Dam
Altamont
Keno
Midland
Bel. Keno Dam
Worden
Merrill
Abv. Copco
Bel. Iron Gate
Abv. Scott
Abv. Shasta
Siead Gage
Happy Camp
Hamburg
Shasta R.
Scott R.
Happy Camp
Coon Cr.
Coon Cr. BW
Turwar Gage
Estuary
Blue Cr.
Salmon R.
Orleans
Bel Weitchpec
Weitchpec
Trinity R.
Fort Dick
Gasquet
Crescent City
Orick
Fort Jones
Etna
Callahan
Forks of Salmon
Grenada
Gazelle
Macdoel
Mount Hebron
Copco/ Iron Gate Reservoir Area
River Sample Stations

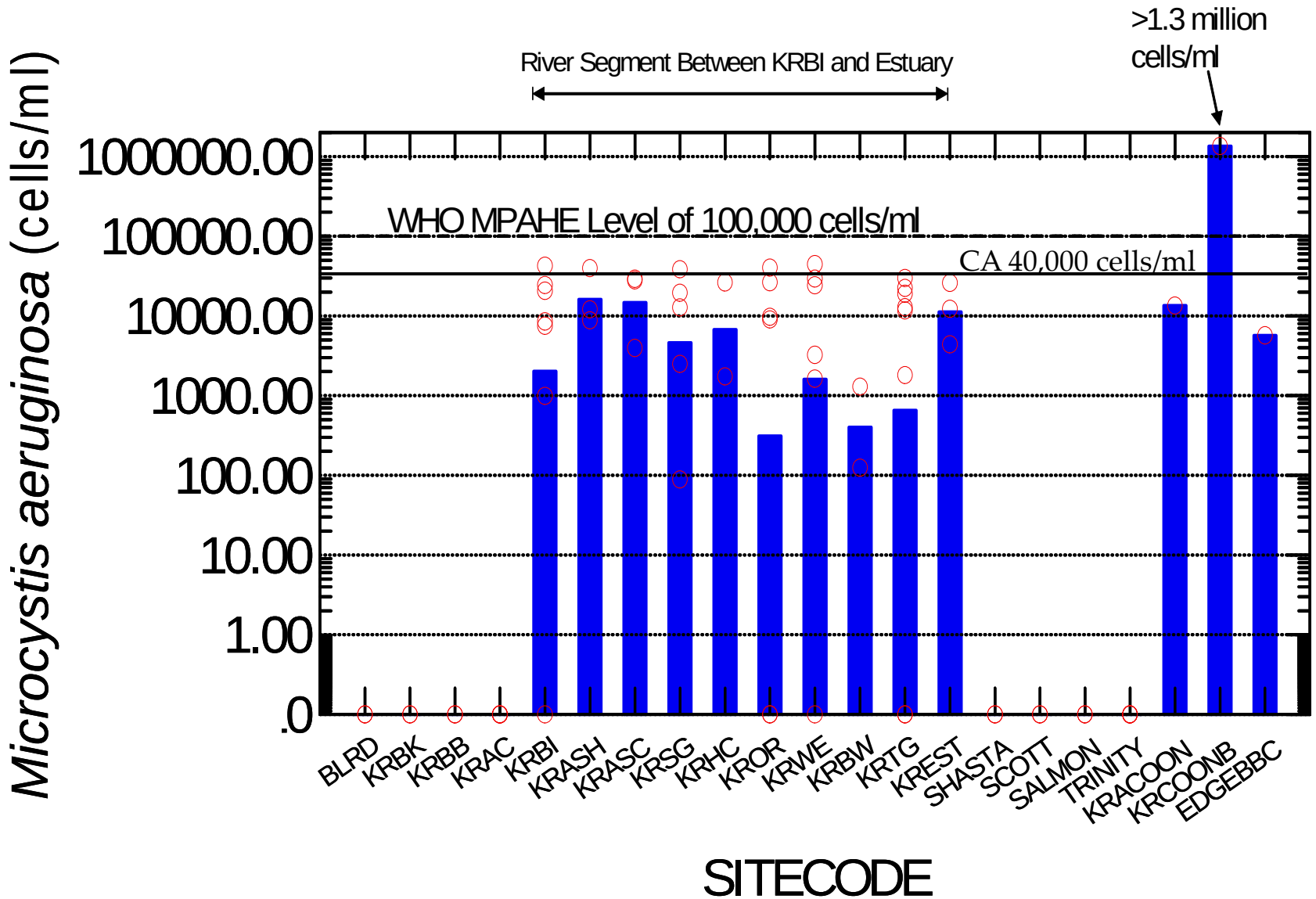

Klamath River edgewater below mouth of Blue Creek

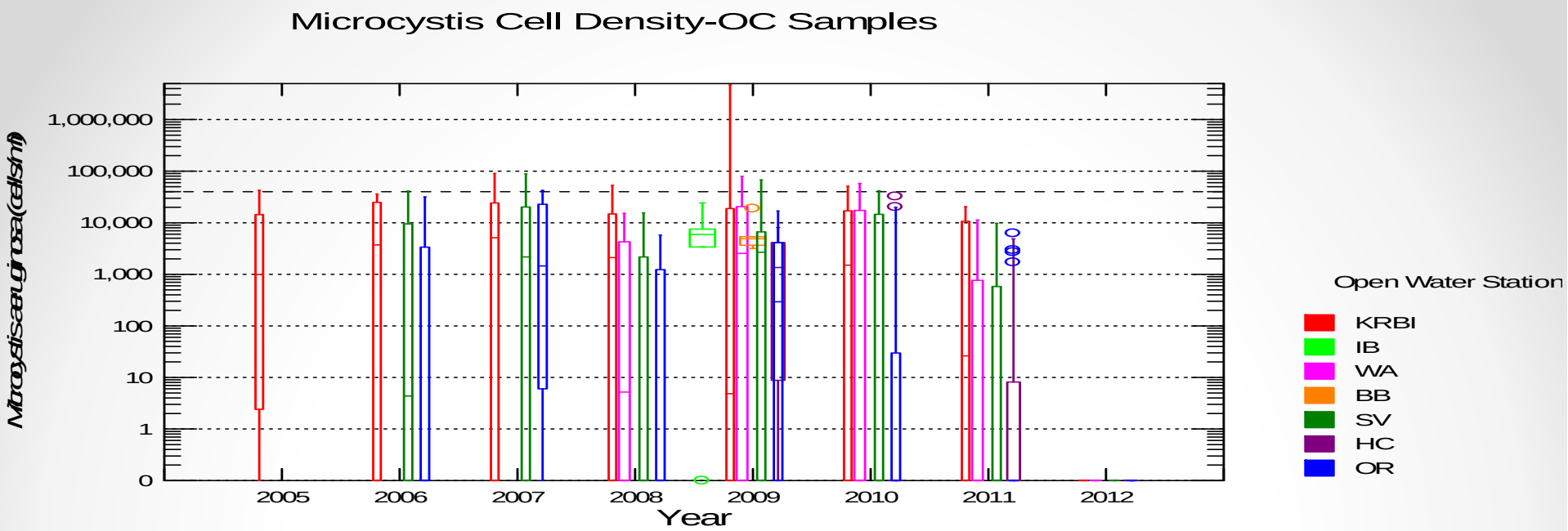

Klamath R. below Iron Gate

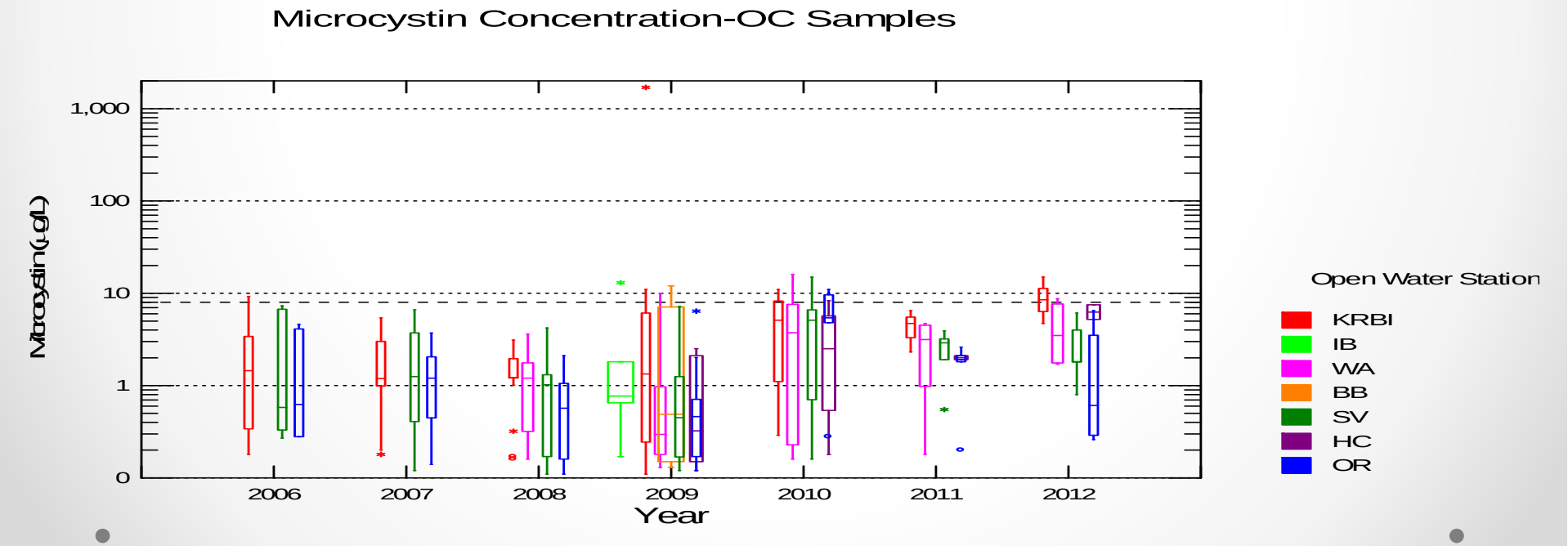

Klamath River at Weitchpec


Trinity River at Weitchpec

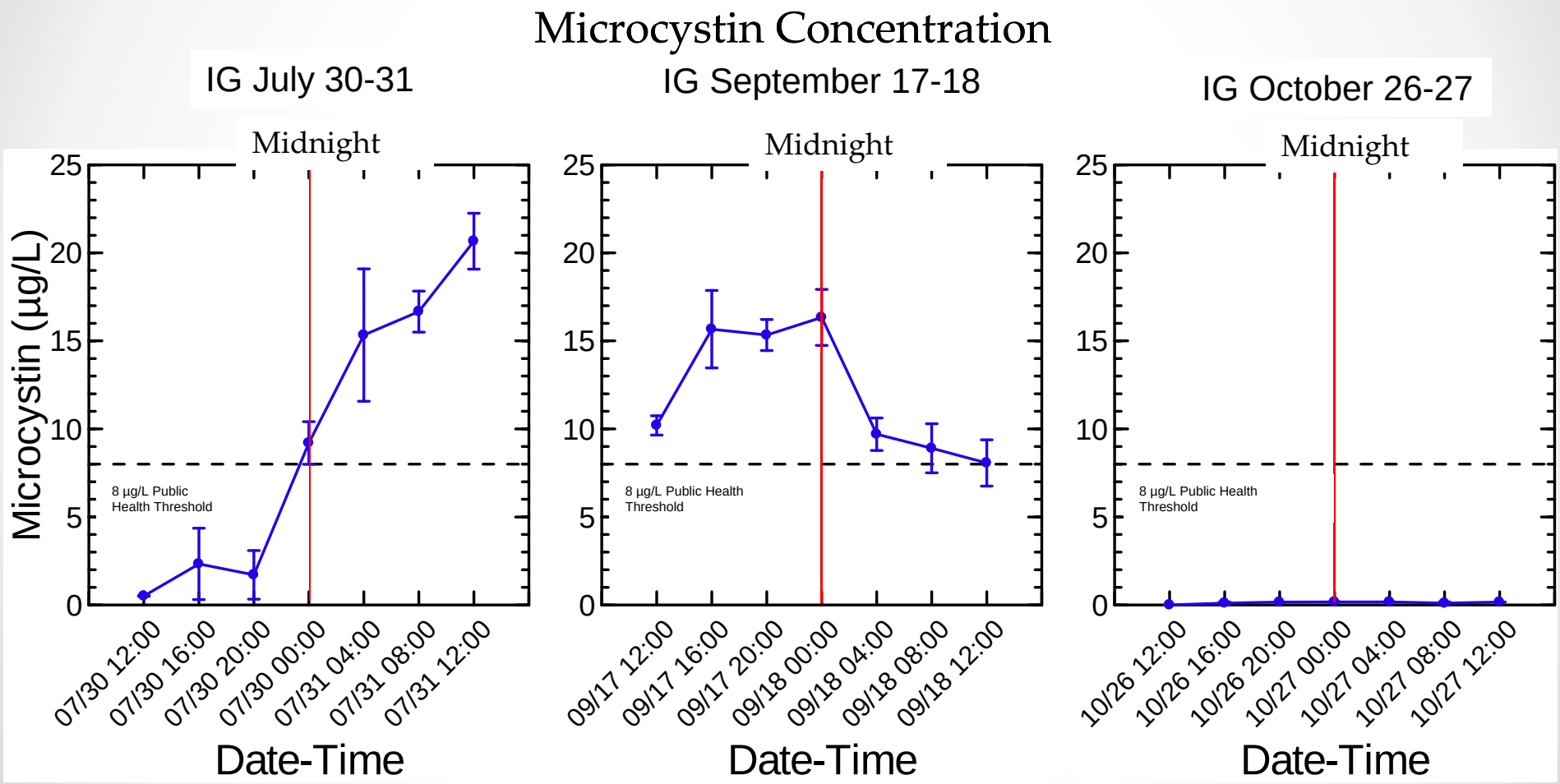
Figure 13. Yurok Tribe/USFWS MSAE cell density trends in the Klamath River system, 2005. Stations from KRBI to KREST are ordered from upstream on the left to downstream on the right. Blue bars are station means and red circles are individual data points.




Microcystis Cell Density-OC Samples
1,000,000
100,000
10,000
1,000
100
10
1
0
2005
2006
2007
2008
2009
2010
2011
2012
Year
Open Water Station
KRBI
IB
WA
BB
SV
HC
OR

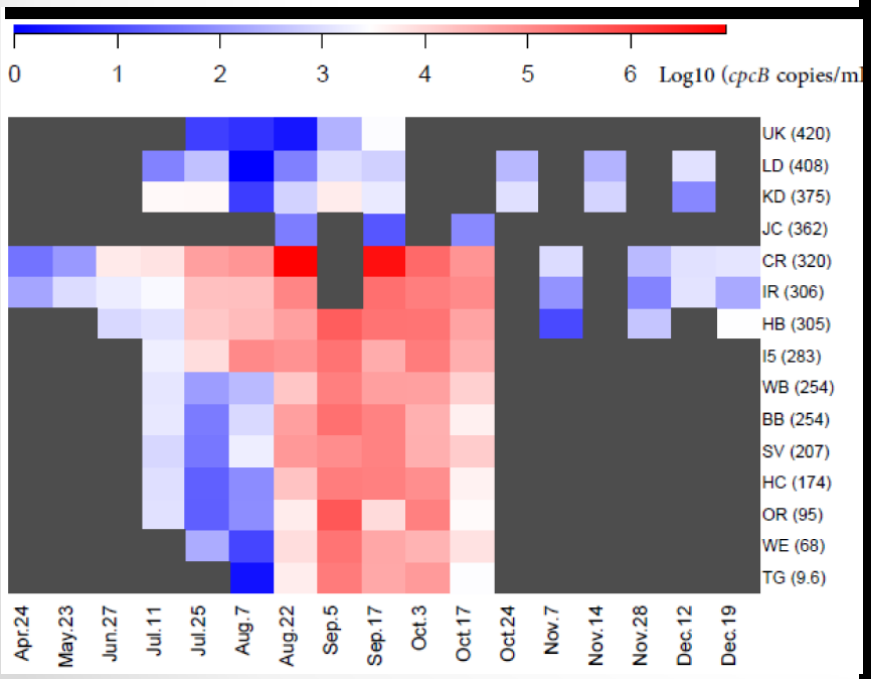

Microcystin Concentration-OC Samples
1,000
100
10
1
0
2006
2007
2008
2009
2010
2011
2012
Year
Open Water Station
KRBI
IB
WA
BB
SV
HC
OR

2013 ISCO Deployment for Measurement of Diel Microcystin Concentrations below Iron Gate Dam

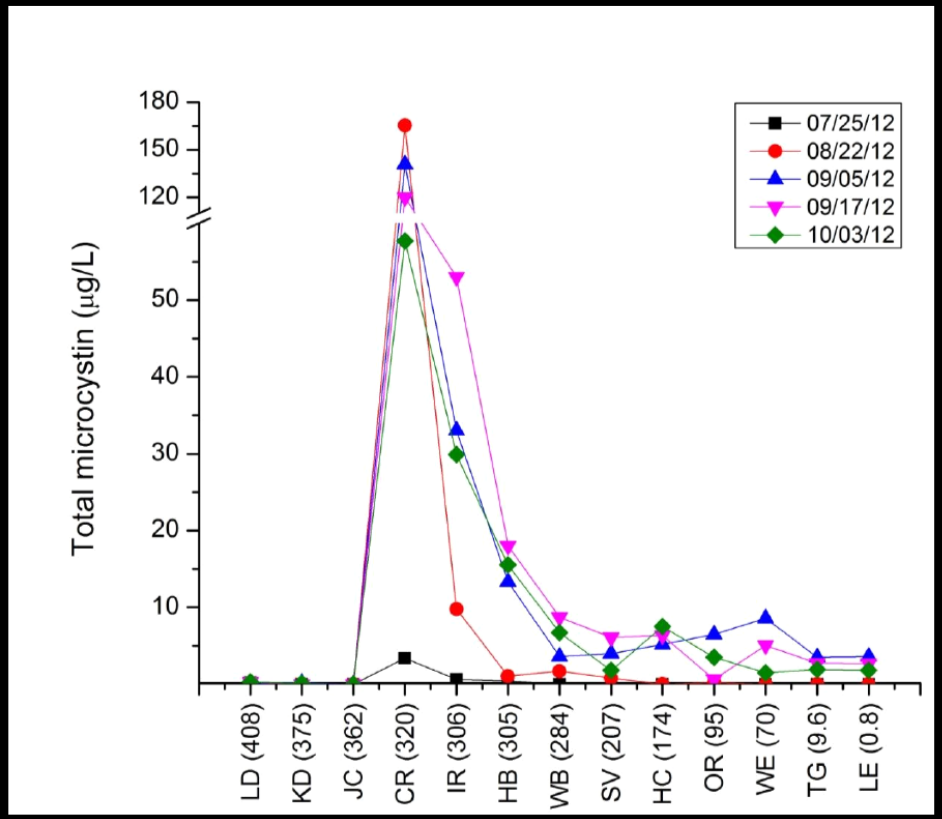


Otten, et al. 2015. Application of molecular tools for microbial source tracking and public health risk assessment of a *Microcystis* bloom traversing 300 km of the Klamath River. Harmful Algae.

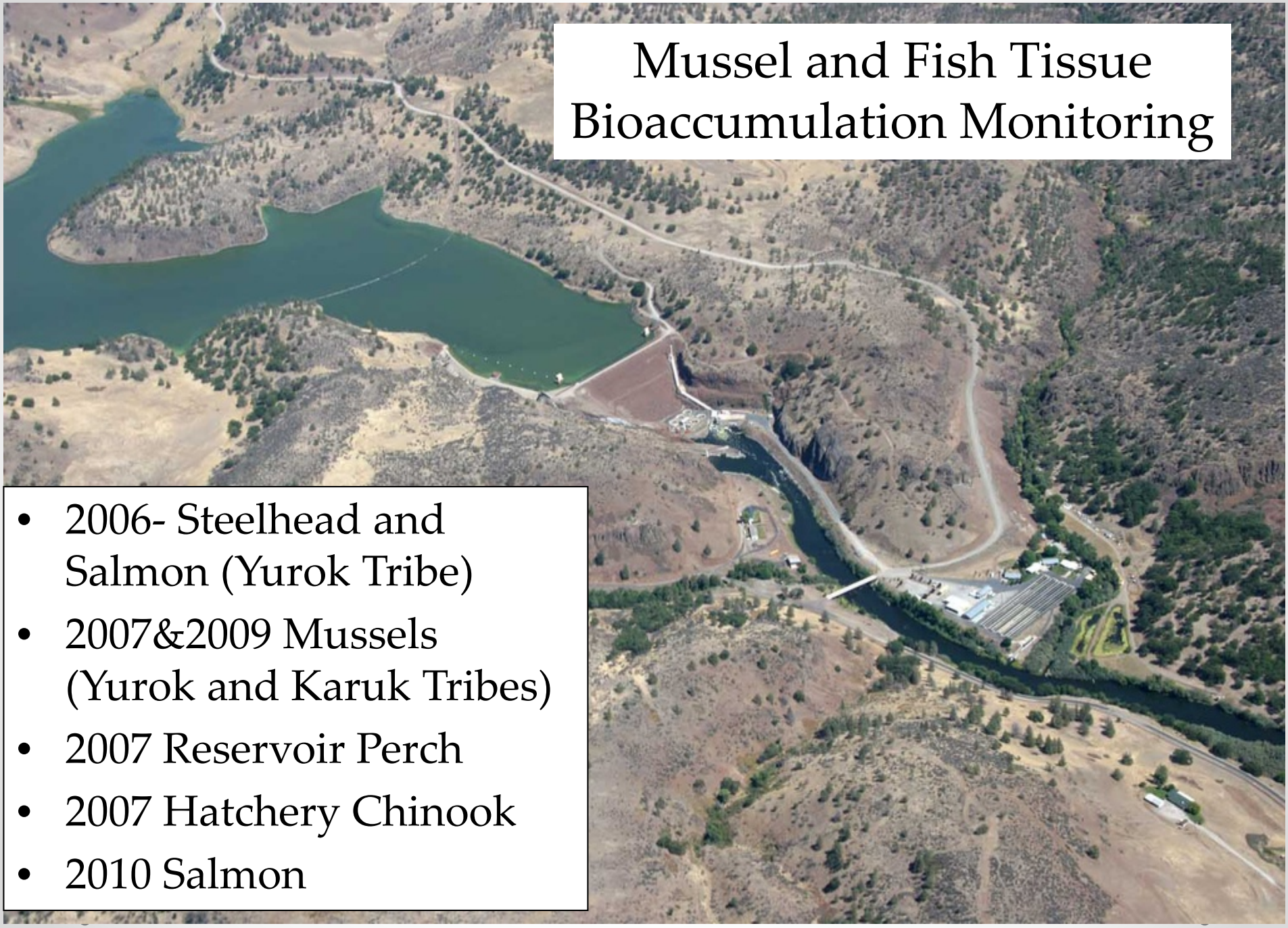
- Large quantities of intact and toxic *Microcystis* cells through hydroelectric facilities and transport distances exceeding 300 km.
- CHAB blooms that originate in distant upstream locations should be included in public health risk assessments.



Distribution of microcystins



Mussel and Fish Tissue Bioaccumulation Monitoring



- 2006- Steelhead and Salmon (Yurok Tribe)
- 2007&2009 Mussels (Yurok and Karuk Tribes)
- 2007 Reservoir Perch
- 2007 Hatchery Chinook
- 2010 Salmon

Ibelings, B.W., and I. Chorus. 2007. Accumulation of cyanobacterial toxins in freshwater "seafood" and its consequences for public health: A review. *Environ. Pollut*. 150: 177-192.

Table 2 from Ibelings and Chorus (2007) entitled *"Tolerable doses to microcystin-LR in relation to frequency and duration of exposure"*

Temporal pattern of exposure and ensuing Tolerable Intake (TI)	**Assumptions**	**Tolerable Intake per kg**	**Tolerable Intake for a 10 kg child**	**Tolerable Intake for a 75 kg adult**	**Guideline value for food (μg kg^{-1})**	
					AF = 1	**AF = 0.2**
Acute TI	NOAEL[1] of 250 μg/kg and day, extrapolation factors of 100	2.5 μg per kg and single exposure	25 μg per single exposure	190 μg per single exposure	Adult: 1900, **Child: 250**	Adult: 380, Child: 50
Seasonal TI	NOAEL of 0.4 μg/kg and day, extrapolation factors of 100 (Chorus and Bartram, 1999, adapted)	0.4 μg per kg and day	4 μg per day	30 μg per day	Adult: 300, **Child: 40**	Adult: 60, Child: 8
Lifetime TI	NOAEL of 0.4 μg/kg and day, extrapolation factors of 100 and uncertainty factor of 10 (Chorus and Bartram, 1999)	0.04 μg per kg and day	0.4 μg per day	3 μg per day	Adult: 30, **Child: 4.0[2]**	Adult: 6, Child: 0.8[2]

OEHHA. 2012. Toxicological summary and suggested action levels to reduce potential adverse health effects of six cyanotoxins.

- Action Level is 10 ng/g of microcystin for wet weight

Fish Tissue Analyses – Fetcho 2006: Yurok Tribe Environmental and Fisheries Programs

Weitchpec Steelhead Liver - Adult	TRACE; 0.17 ppb
Weitchpec Steelhead Liver - Half-Pounder	0.54 ppm or μg/g

Fish Summary:

- Of 9 adult salmon liver and muscle samples from Weitchpec and Iron Gate Hatchery all were below the detection limit of 0.147 ppb.
- Of 2 Steelhead (one adult and one ½ pounder) tissue samples from Weitchpec both were below the detection limit of 0.147 ppb.
- Of 2 Steelhead (one adult and one half-pounder) liver samples from Weitchpec the adult had a trace amount of 0.17 ppb and the ½ pounder had 0.54 ppm (μg/g).

Conclusion: Low to trace quantities of microcystin in Steelhead livers in the lower Klamath River show that these fish were likely exposed to toxin levels in the river environment, and indicate the potential for toxin uptake to occur.

Note: Steelhead residing in the Klamath River at the time of sampling would have increased exposure time relative to salmon.

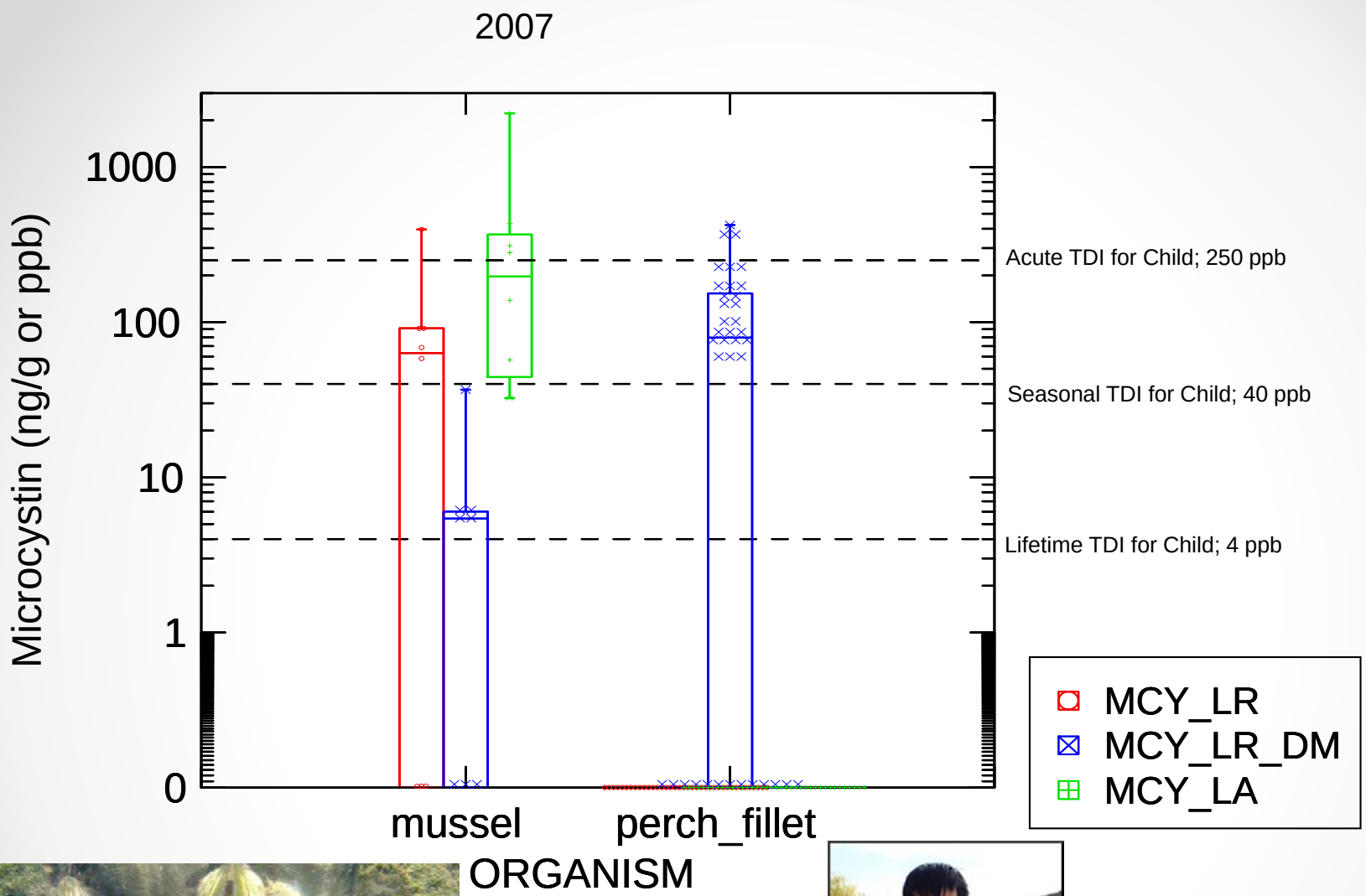
Salmonid Tissue Sampling

Iron Gate Hatchery Yearling Chinook

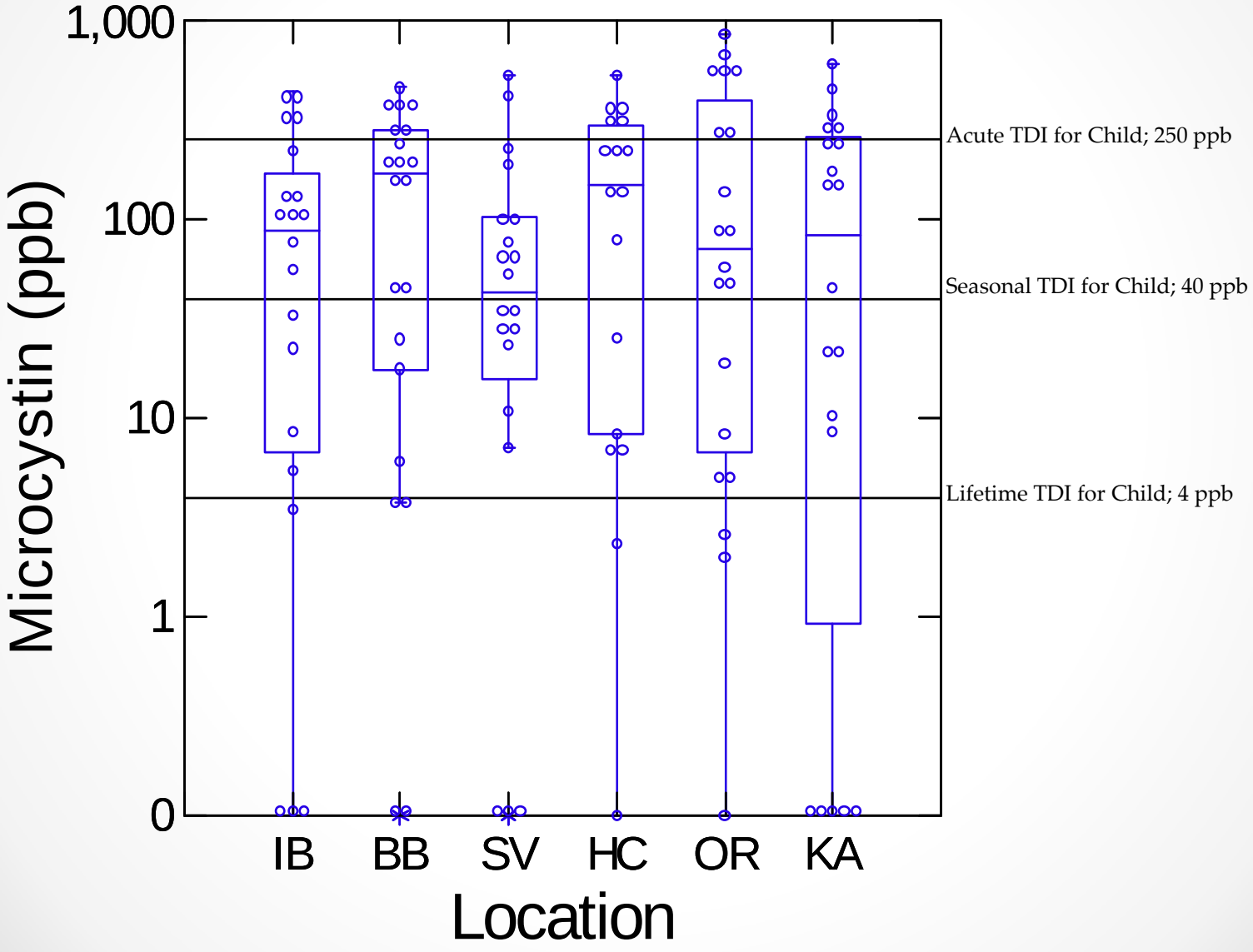
- July 2007 composite samples of stomach, fillet, and liver
- Liver samples had 301 ppb microcystin LA

Chinook at Ishi Pishi Falls

- September 2010-3 of 7 Chinook livers collected had detectable levels
- October 2010-1 of 7 Chinook livers had a high level of microcystin-RR (121 ppb), and 1 of 15 steelhead livers had a high level of microcystin-LR (152 ppb), both exceeding public health guideline levels.

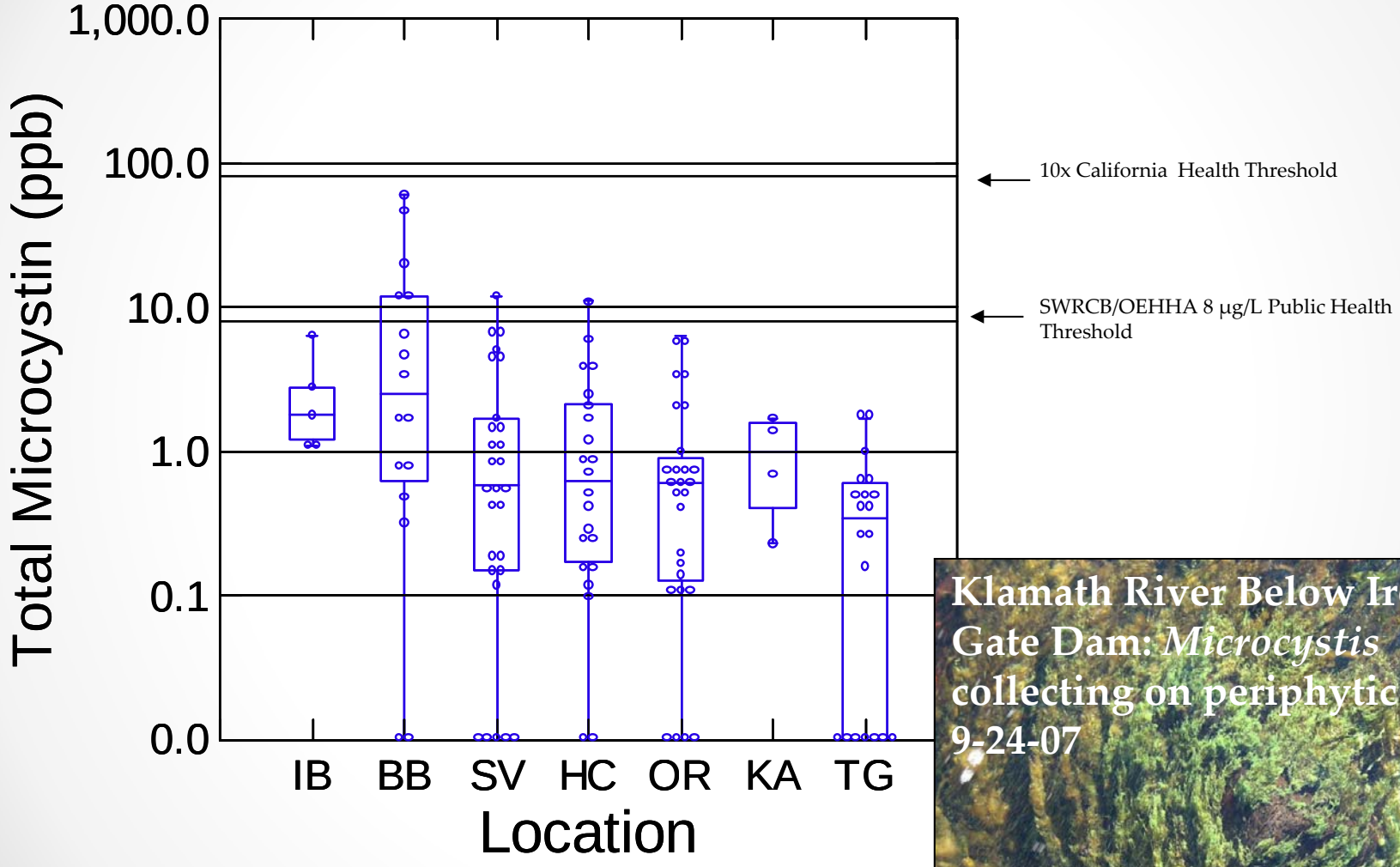

2007
Microcystin (ng/g or ppb)
1000
100
10
1
0
Acute TDI for Child; 250 ppb
Seasonal TDI for Child; 40 ppb
Lifetime TDI for Child; 4 ppb
MCY_LR
MCY_LR_DM
MCY_LA
mussel
perch_fillet
ORGANISM

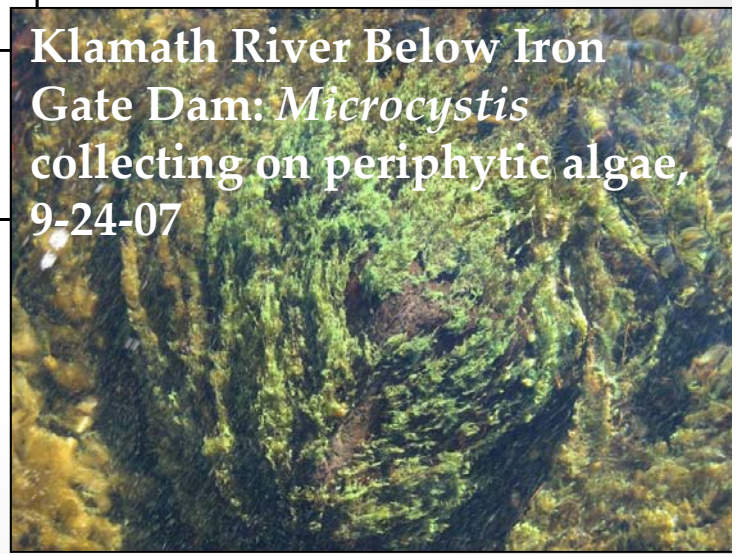
Total MCYST in FW Mussels 2009



Ambient Concentration All Data

Public Health Monitoring & CDFG Data





Anatoxin

Date	Station	Type	Anatoxin
6/10/2015	IB	SG	<10
7/8/2015	IB	SG	128
7/22/2015	IB	SG	<10
8/5/2015	IB	SG	19.1
8/5/2015	WA	OC	20.4

- Public health concern
- Sampling for 6 years and just caught it
- Results from CDFW lab in Rancho Cordova
- Long turn-around time (not good for public health)
- Switching labs for 2016

Next Steps and Lessons Learned

Dam Removal

- KBRA done after 12/15
- AIP signed by CA, OR, Feds, Pacificorp for dam removal

Future Research

- Impacts of low levels of cyanotoxins on rearing salmonids below dam
- Depuration of cyanotoxins from freshwater mussels

Lessons Learned

- Toxicity of blooms can be variable and can change quickly (genetic shifts? smoke? air temperatures?)
- Long-term data sets are wonderful, wonderful things

Questions?

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