Mid-Klamath River CHAB Monitoring

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Susan Corum
Department of Natural Resources
Karuk Tribe

Jacob Kann, Ph.D.
Aquatic Ecosystem Sciences, LLC

Special Thanks To:
Yurok Tribe Environmental Program
Ken Fetcho
Micah Gibson
Suzanne Fluharty
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
The World Health Organization (WHO 1998; 2003) has set the following thresholds for Microcystis/microcystin concentrations in recreational waters:

- **Low Risk:** 20,000 cells/ml, 4 µg/L
- **Moderate Risk:** 100,000 cells/ml, 20 µg/L
- **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
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

Copco Reservoir Mallard Cove Inlet

Lacustrine Habitat created by impoundment

Iron Gate Reservoir Shoreline Grab Sample
2005 Monitoring

SYSTEM

- CR = Copco
- IR = Iron Gate
- KRAC = Klamath River above Copco
- KRBI = Klamath River below Iron Gate

World Health Org. 100,000 cell/ml Level for Moderate Probability of Adverse Health Effects
Microcystin concentration time-series in Copco and Irongate Reservoirs, 2005.
Copco and Iron Gate Reservoirs (July-October)

![Graph showing Microcystin concentrations in Copco and Iron Gate Reservoirs from July to October. The graph includes data from various years: 2005, 2006, 2007, 2008, 2009, and 2010. The x-axis represents months from July to October, and the y-axis represents Microcystin concentrations in μg/L.]
Lower Estuary Surface

Klamath River at Turwar Gage

Klamath River edgewater below mouth of Blue Creek

Klamath River at Weitchpec

Klamath R. above Copco

Klamath R. above Iron Gate

Trinity River at Weitchpec

J. Kann Ph.D. Aquatic Sciences, LLC
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.
2013 ISCO Deployment for Measurement of Diel Microcystin Concentrations below Iron Gate Dam

Microcystin Concentration

IG July 30-31

IG September 17-18

IG October 26-27

Date-Time

Midnight

Microcystin (µg/L)

8 µg/L Public Health Threshold

- 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.
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

Thomas Dunklin 8-26-2007

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

<table>
<thead>
<tr>
<th>Temporal pattern of exposure and ensuing Tolerable Intake (TI)</th>
<th>Assumptions</th>
<th>Tolerable Intake per kg</th>
<th>Tolerable Intake for a 10 kg child</th>
<th>Tolerable Intake for a 75 kg adult</th>
<th>Guideline value for food (μg kg^{-1})</th>
<th>AF = 1</th>
<th>AF = 0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute TI</td>
<td>NOAEL¹ of 250 μg/kg and day, extrapolation factors of 100</td>
<td>2.5 μg per kg and single exposure</td>
<td>25 μg per single exposure</td>
<td>190 μg per single exposure</td>
<td>Adult: 1900, <strong>Child: 250</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adult: 380, Child: 50</td>
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<td></td>
</tr>
<tr>
<td>Seasonal TI</td>
<td>NOAEL of 0.4 μg/kg and day, extrapolation factors of 100 (Chorus and Bartram, 1999, adapted)</td>
<td>0.4 μg per kg and day</td>
<td>4 μg per day</td>
<td>30 μg per day</td>
<td>Adult: 300, <strong>Child: 40</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Adult: 60, Child: 8</td>
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</tr>
<tr>
<td>Lifetime TI</td>
<td>NOAEL of 0.4 μg/kg and day, extrapolation factors of 100 and uncertainty factor of 10 (Chorus and Bartram, 1999)</td>
<td>0.04 μg per kg and day</td>
<td>0.4 μg per day</td>
<td>3 μg per day</td>
<td>Adult: 30, <strong>Child: 4.0²</strong></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>Adult: 6, Child: 0.8²</td>
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</tbody>
</table>

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
<table>
<thead>
<tr>
<th>Weitchpec Steelhead Liver - Adult</th>
<th>TRACE; 0.17 ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weitchpec Steelhead Liver - Half-Pounder</td>
<td>0.54 ppm or μg/g</td>
</tr>
</tbody>
</table>

**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.
Microcystin (ng/g or ppb)

- Lifetime TDI for Child; 4 ppb
- Seasonal TDI for Child; 40 ppb
- Acute TDI for Child; 250 ppb

ORGANISM
- mussel
- perch_fillet

Acute TDI for Child; 250 ppb
Seasonal TDI for Child; 40 ppb
Lifetime TDI for Child; 4 ppb
Total MCYST in FW Mussels 2009

Microcystin (ppb)

Location

IB BB SV HC OR KA

Acute TDI for Child; 250 ppb
Seasonal TDI for Child; 40 ppb
Lifetime TDI for Child; 4 ppb
Ambient Concentration All Data

Public Health Monitoring & CDFG Data

Total Microcystin (ppb)

Location

IB BB SV HC OR KA TG

0.0 0.1 1.0 10.0 100.0 1,000.0

10x California Health Threshold

SWRCB/OEHHA 8 μg/L Public Health Threshold

Klamath River Below Iron Gate Dam: Microcystis collecting on periphytic algae, 9-24-07
## Anatoxin

<table>
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<tr>
<th>Date</th>
<th>Station</th>
<th>Type</th>
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<tbody>
<tr>
<td>6/10/2015</td>
<td>IB</td>
<td>SG</td>
<td>&lt;10</td>
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<tr>
<td>7/8/2015</td>
<td>IB</td>
<td>SG</td>
<td>128</td>
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<tr>
<td>7/22/2015</td>
<td>IB</td>
<td>SG</td>
<td>&lt;10</td>
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<tr>
<td>8/5/2015</td>
<td>IB</td>
<td>SG</td>
<td>19.1</td>
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<tr>
<td>8/5/2015</td>
<td>WA</td>
<td>OC</td>
<td>20.4</td>
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- 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?
Susan Corum
Karuk Tribe
scorum@karuk.us
(530) 469-3456