Toxic Cyanobacterial Blooms in the Klamath River System, 2005

Presented by:
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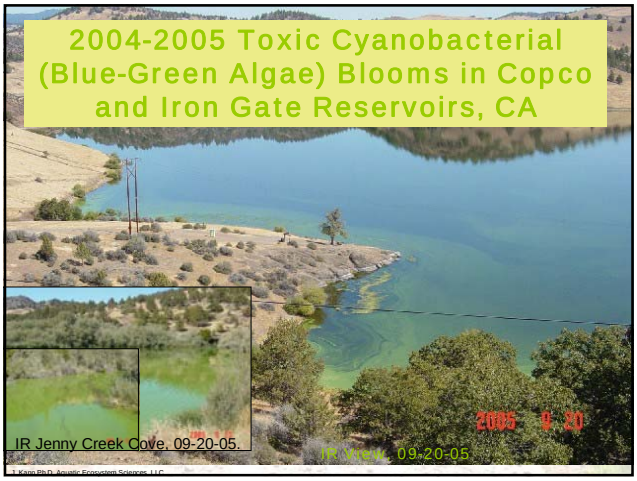
Data collected by:
Karuk Tribe
Yurok Tribe
USFWS
CA DHS
PacifiCorp

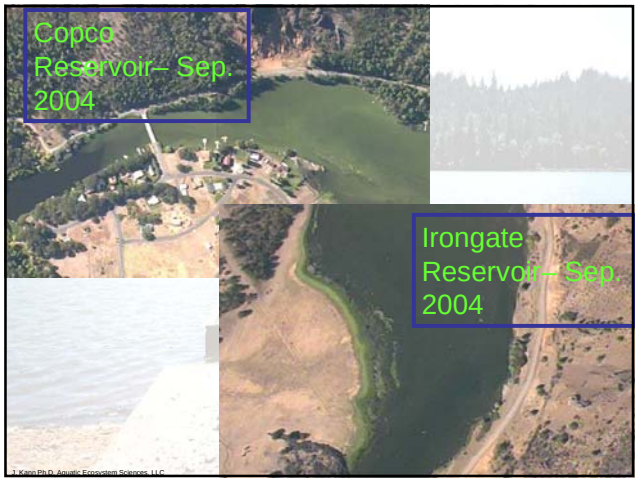
11/08/05

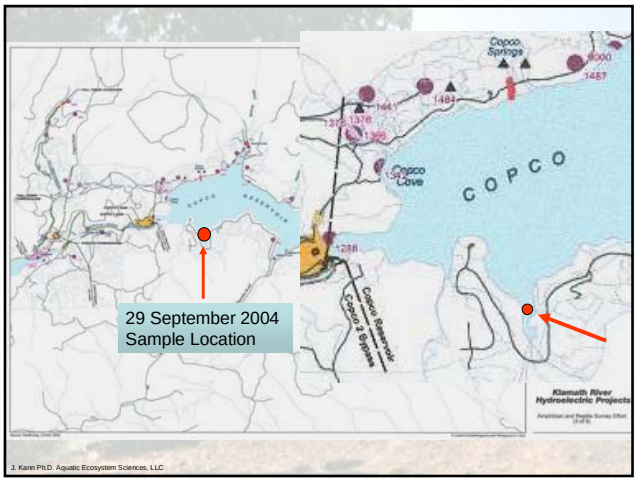
2004-2005 Toxic Cyanobacterial (Blue-Green Algae) Blooms in Copco and Iron Gate Reservoirs, CA



Copco Reservoir– Sep. 2004

Irongate Reservoir– Sep. 2004





Phytoplankton Sample Analysis

Sample: Copco Res
Sample Station: JSH
Sample Depth:
Sample Date: 29-Sep-04
Total Density (#/mL): 132,794
Total Biovolume (um³/mL): 45,273,384

Species	Density Colonies #/mL	Density Percent	Biovol. um³/mL	Biovol. Percent
Nitzschia palea	120,267	90.6	21,648,000	47.8
Microcystis aeruginosa	6,514	4.9	15,269,858	33.7
Aphanizomenon flos-aquae	4,009	3.0	2,886,400	6.4
Melosira ambigua	501	0.4	4,722,471	10.4
Cryptomonas erosa	501	0.4	260,578	0.6
Nitzschia frustulum	501	0.4	60,133	0.1
Gomphonema ventricosum	501	0.4	425,944	0.9

Microcystis aeruginosa cells/mL =1,908,732

Aquatic Analysts
Sample ID: GW95

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Toxins Found in Copco Reservoir Sample- Sep 2004

-Microcystin toxin level:

482 micrograms/L

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

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2005 Sampling

Biweekly Sampling for cell counts and toxin

Grab samples of surface algal material.

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 on ice (over-night) air to Dr. Wayne Carmichael at WSU for ELISA test for microcystin concentration.

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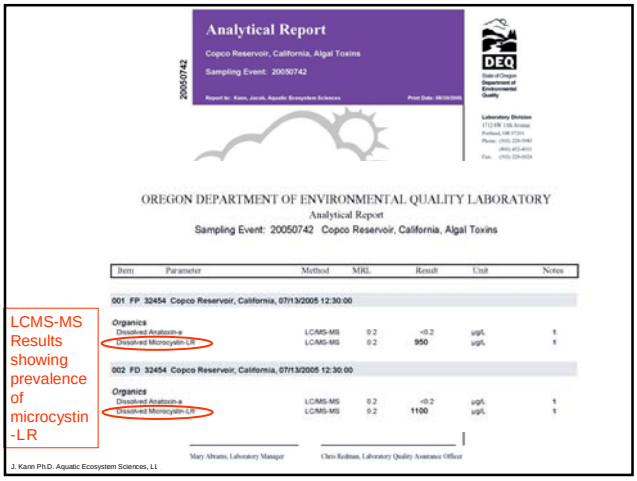

LCMS-MS Results showing prevalence of microcystin -LR

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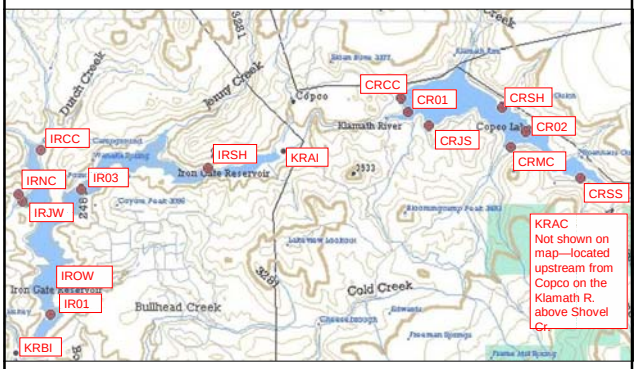
Copco and Iron Gate Reservoir Sampling Locations



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Copco shoreline from road (~12 ft above water level) 7-13-05

Copco shoreline standing on shoreline 7-13-05

Copco shoreline close up 7-13-05

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CRMC; 8-10-05

1,427,215 cells/ml *Microcystis*

CRCC; 8-10-05

283,963 cells/ml *Microcystis*

IRNC; 8-11-05

5,350,847 cells/ml *Microcystis*

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August 24-25 2005

IRJW-sample: 17,458,065

IRJW

IROW-8,944,366 cells/ml

IronGate Water Skier 8-25-05

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September 7-8 2005

CRSS 24,415,038 cells/ml

Siskiyou County Algae Information Sign

CRMC; 737,617cells/ml

CRCC; 10,022,222 cells/ml

IR03; 2,307,442 cells/ml

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CRCC Sample Bottle, 09-20-05

CRCC Shoreline, 09-20-05

IR View, 09-20-05

IR Jenny Creek Cove, 09-20-05.

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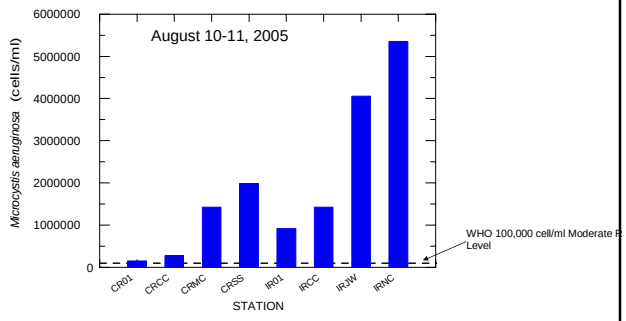

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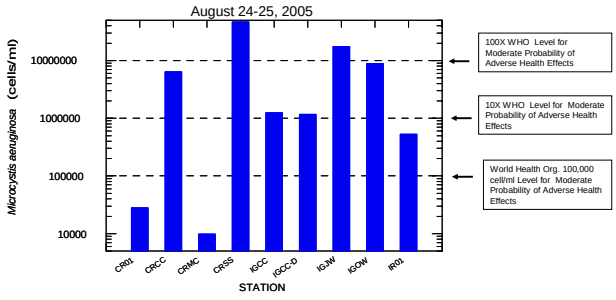

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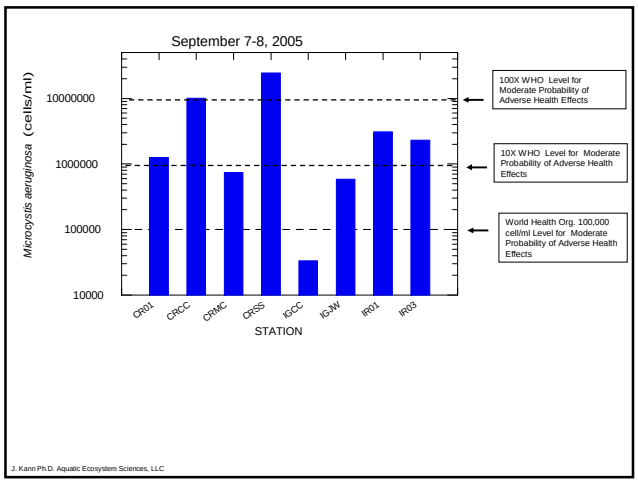
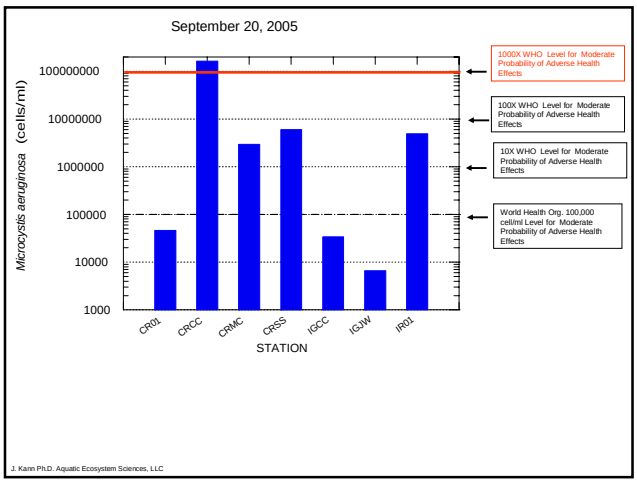

September 7-8, 2005
Microcystis aeruginosa (cells/ml)
10000000
1000000
100000
10000
CR01
CRCC
CRMC
CRSS
IGCC
IGJW
IR01
IR03
STATION
100X WHO Level for Moderate Probability of Adverse Health Effects
10X WHO Level for Moderate Probability of Adverse Health Effects
World Health Org. 100,000 cell/ml Level for Moderate Probability of Adverse Health Effects
J. Kann Ph.D. Aquatic Ecosystem Sciences, LLC


September 20, 2005
Microcystis aeruginosa (cells/ml)
100000000
10000000
1000000
100000
10000
1000
CR01
CRCC
CRMC
CRSS
IGCC
IGJW
IR01
STATION
1000X WHO Level for Moderate Probability of Adverse Health Effects
100X WHO Level for Moderate Probability of Adverse Health Effects
10X WHO Level for Moderate Probability of Adverse Health Effects
World Health Org. 100,000 cell/ml Level for Moderate Probability of Adverse Health Effects
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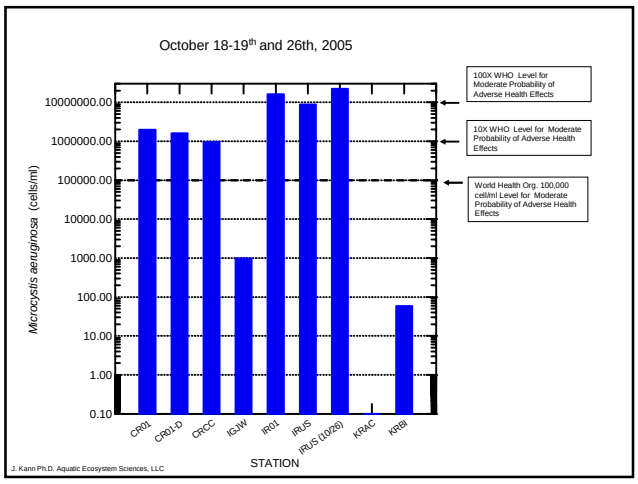
October 18-19th and 26th, 2005
Microcystis aeruginosa (cells/ml)
10000000.00
1000000.00
100000.00
10000.00
1000.00
100.00
10.00
1.00
0.10
CR01
CR01-D
CRCC
IGJW
IR01
IRUS
IRUS (10/26)
KRAC
KRBI
STATION
100X WHO Level for Moderate Probability of Adverse Health Effects
10X WHO Level for Moderate Probability of Adverse Health Effects
World Health Org. 100,000 cell/ml Level for Moderate Probability of Adverse Health Effects
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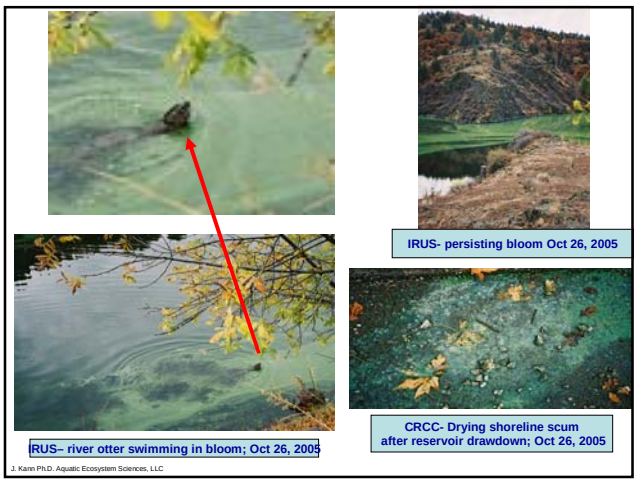
IRUS- persisting bloom Oct 26, 2005
IRUS– river otter swimming in bloom; Oct 26, 2005
CRCC- Drying shoreline scum after reservoir drawdown; Oct 26, 2005
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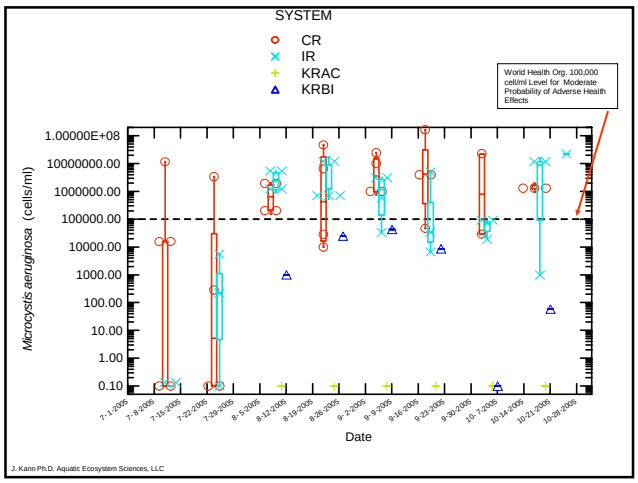

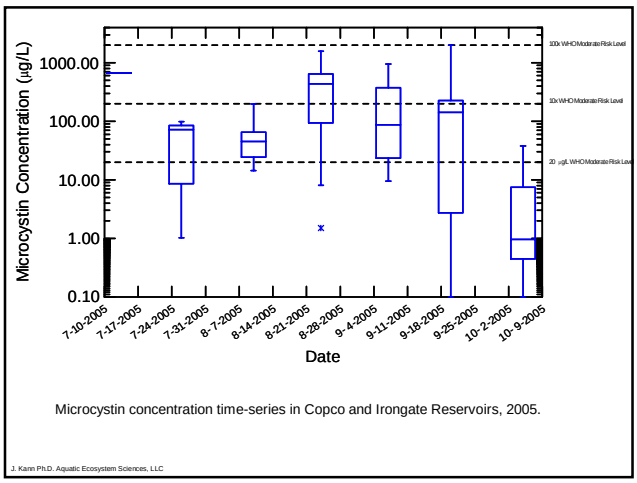

Microcystin concentration time-series in Copco and Irongate Reservoirs, 2005.

DATE	STATION NAME	DEPTH	*Microcystis aeruginosa* (cells/ml)	Microcystin Total (µg/L)	Exceedance of moderate risk level of 100,000 cells/ml *Microcystis* (x greater than 10^5 cells/ml)	Exceedance of moderate risk level of 20 ug/L microcystin (x greater than 20 µg/L)	Exceedance of TDI of 0.04 µg/kg/day for a 40 lb (18kg) child ingesting 100 mls (x greater than TDI)
9/29/04	CRJS	0	1,908,732	482	19	24	67
7/13/05	CRSH	0	11,402,943	667	114	33	92
7/26/05	CRCC	0	3,316,176	72.16	33	3.6	10.0
7/27/05	IR03	0	5,534	0.92	0	0.05	0.13
7/27/05	IRSH	0	NA	98.38	NA	4.9	13.6
8/10/05	CR01	0	151,004	90.35	2	4.5	12.5
8/10/05	CRCC	0	283,963	196.36	3	9.8	27.1
8/10/05	CRMC	0	1,427,215	36.58	14	1.8	5.1
8/10/05	CRSS	0	1,985,035	44.22	20	2.2	6.1
8/11/05	IR01	0	916,548	16.23	9	0.8	2.2
8/11/05	IRCC	0	1,423,430	14.23	14	0.7	2.0
8/11/05	IRJW	0	4,059,000	46.55	41	2.3	6.4
8/11/05	IRNC	0	5,350,847	46.02	54	2.3	6.4
8/24/05	CRCC	0	6,413,303	640.2	64	32.0	88.4
8/24/05	CRMC	0	9,826	1.4	0	0.1	0.2
8/24/05	CRSS	0	46,834,615	1571.7	468	78.6	217.1
8/24/05	CR01	0	28,188	8	0	0.4	1.1
8/25/05	IR01	0	528,759	645.4	5	32.3	89.1
8/25/05	IGCC	0	1,251,525	93.6	13	4.7	12.9
8/25/05	IGCC-D	0	1,164,467	94.6	12	4.7	13.1
8/25/05	IGJW	0	17,458,065	632.2	175	31.6	87.3
8/25/05	IGOW	0	8,944,366	436.9	89	21.8	60.3

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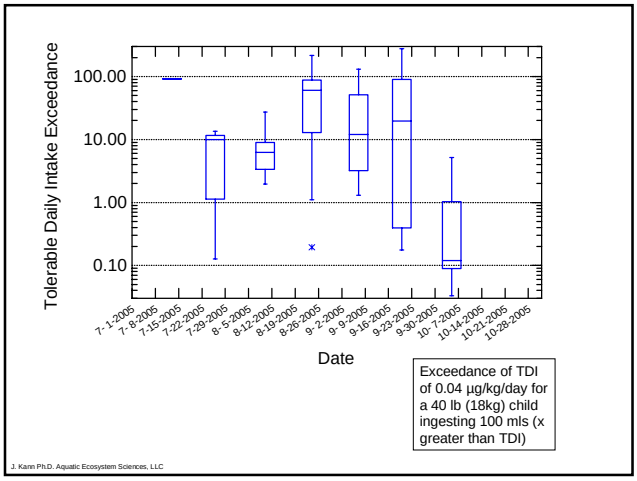
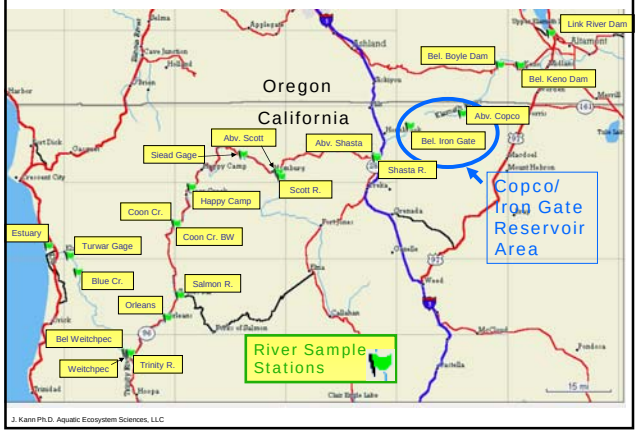
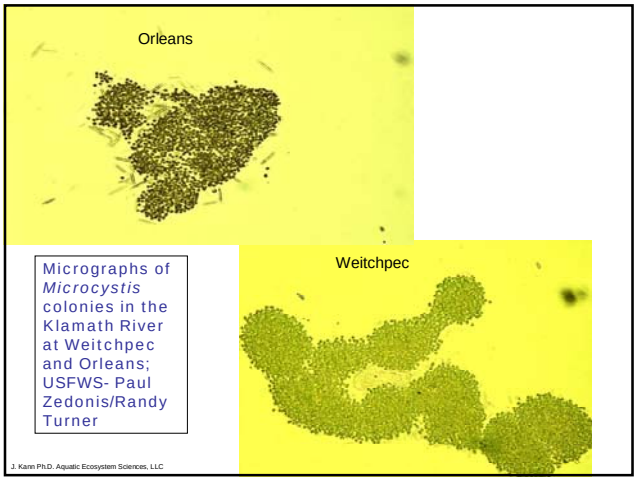


Yurok Tribe/USFWS River Sampling



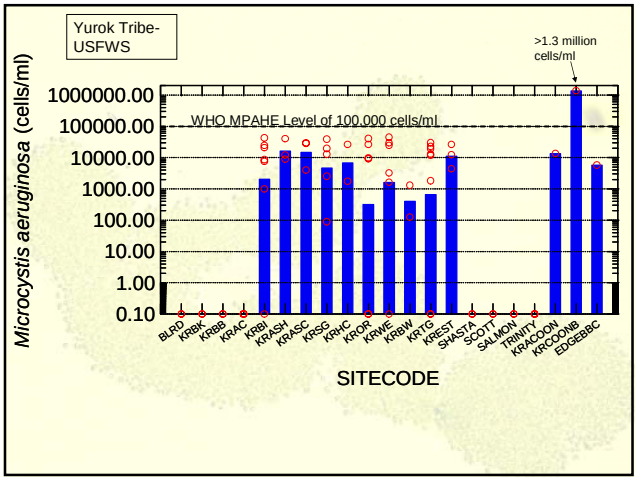


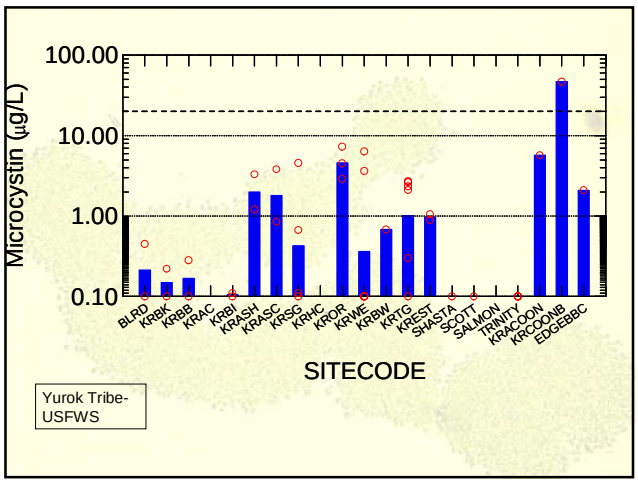
Station Codes

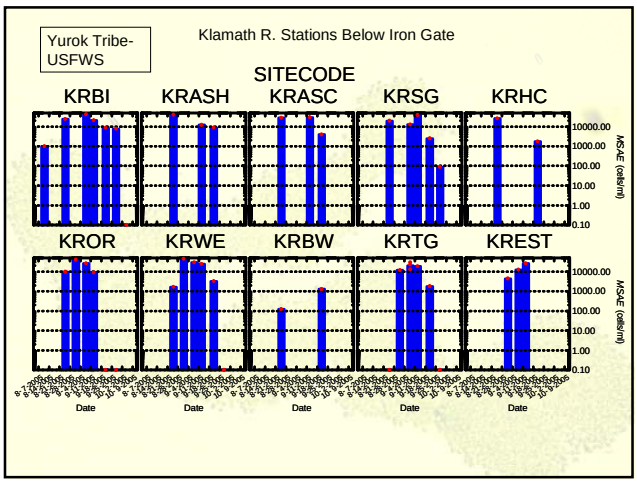
Below Link River Dam	BLRD
Below Keno Dam	KRBK
Below JC Boyle Dam	KRBB
KRAC	KRAC
KR @ Below IG	KRBI
Abv Shasta R.	KRASH
Abv Scott R.	KRASC
Siead Gage	KRSG
Happy Camp	KRHC
Orleans	KROR

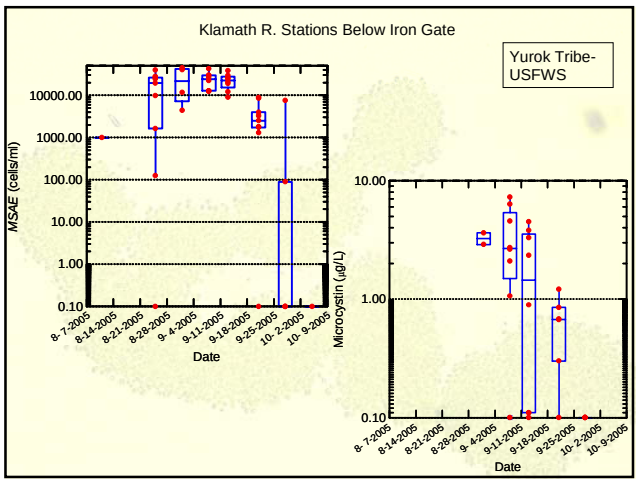
Cont.

Weitchpec (abv TR)	KRWE
Below Weitchpec	KRBW
Turwar Gage	KRTG
KR Estuary	KREST
Shasta R.	SHASTA
Scott R.	SCOTT
Salmon R.	SALMON
Trinity R.	TRINITY
KR Above Coon Creek River Access	KRACOON
Backwater pool at Coon Creek River Access	KRCOONB
Edgewater Below Blue Creek	EDGEBBC









Fish Tissue Analyses - Yurok Tribe Environmental and Fisheries Program

Site Location Information	13-Sep	14-Sep	30-Sep	3-Oct
Site Name	Microcystin Concentration (ppm or µg/g)	Microcystin Concentration (ppm or µg/g)	Microcystin Concentration (ppm or µg/g)	Microcystin Concentration (ppm or µg/g)
Weitchpec Adult Salmon Liver	0.00 (BDL)[1]	0.00 (BDL)		
Weitchpec Adult Salmon Liver		0.00 (BDL)		
Weitchpec Adult Salmon Muscle		0.00 (BDL)		
Weitchpec Adult Salmon Muscle		0.00 (BDL)		
Iron Gate Hatchery Adult Salmon Tissue - Male			0.00 (BDL)	
Iron Gate Hatchery Adult Salmon Tissue - Female			0.00 (BDL)	
Iron Gate Hatchery Adult Salmon Liver - Male			0.00 (BDL)	
Iron Gate Hatchery Adult Salmon Liver - Female			0.00 (BDL)	
Weitchpec Steelhead Tissue - Adult				0.00 (BDL)
Weitchpec Steelhead Tissue - Half-Pounder				0.00 (BDL)
Weitchpec Steelhead Liver - Adult				TRACE: 0.17 ppb[2]
Weitchpec Steelhead Liver - Half-Pounder				0.54

[1]BDL= below detection limit of 0.147 ppb; [2]Limit of quantification=0.175 ppb

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Fish Tissue Analyses - 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 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.

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New Zealand Ecological Society Annual Conference
28 August – 1 September 2005

Talk: **Accumulation of microcystins (a toxin produced by cyanobacteria) in freshwater organisms**

Susie Wood1, L. R. Briggs2, J. Sprosen2, J. R. Ruck3, R. G. Wear4, P. T. Holland5, and M. Bloxham6

1 Cawthron Institute, Nelson
2 Toxinology, AgResearch, Ruakura
3 Institute of Food, Nutrition and Human Health, Massey University at Wellington
4 School of Biological Sciences, Victoria University of Wellington
5 Cawthron Institute, Nelson
6 Environment Bay of Plenty, Whakatane

Abstract: Microcystins are hepatotoxins produced by some cyanobacteria (blue-green algae) species. Microcystins inhibit protein phosphatase types 1 and 2A in affected organisms and have been implicated in human, bird, wild animal and livestock fatalities. Accumulation of microcystins in rainbow trout (Oncorhynchus mykiss) and freshwater mussels (Hyridella menziesi) in Lakes Rotoiti and Rotoehu (Rotorua) were investigated. Hatchery rainbow trout were added to an enclosure in Lake Rotoiti where levels of microcystins in the water could be closely monitored, and trout that were free to roam in th entire area of each lake were also included in the study. Freshwater mussels were suspended sub-surface in cages in the enclosure. Rainbow trout liver and muscle tissue and the tissues of mussels were analyzed for microcystins using the ADDA-ELISA method and selected samples were analysed using LC-MS. **ELISA results confirmed the presence of microcystin immunoreactivity in rainbow trout liver and muscle tissue, and in freshwater mussels at levels of 12 79 g kg-1**. The microcystin congeners: LR, YR RR, AR, FR, LA and WR were detected by LC-MS in the freshwater mussels but were not detected by in either the trout muscle or liver. The Daily Tolerable Intake limit of microcystins for human consumption recommended by the World Health Organisation is 0.04 g kg-1 day-1. Modelling was carried out for the human intakes of microcystin compounds from trout muscle and the potential health risks estimated, assuming the ADDA-ELISA was determining compounds of equivalent toxicity to microcystin-LR.

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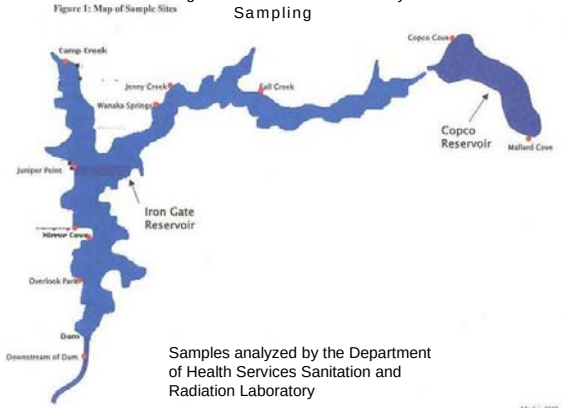
CA Dept. of Health Services, Division of Drinking Water and Environmental Management: 9/3/2005 Microcystin/Anatoxin-a Sampling

Figure 1: Map of Sample Sites



Samples analyzed by the Department of Health Services Sanitation and Radiation Laboratory

Mackie 2005

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CA DHS-DDWEM

Collector		Source Note: Water System No 47100007 Serves the City of Montague Near Lake Shastina	Anatoxin -a	MCLR	
4741	T. Wiedemann	System No. 4710007 Treated (PAC filtrate)	<RL	<RL	
4742	T. Wiedemann	System No. 4710007 Influent	<RL	<RL	
4743	T. Wiedemann	Raw Water Pond	20	<RL	
4743	T. Wiedemann	Raw Water Pond	19	<RL	
4768	T. Wiedemann	System No. 4710007 Treated (PAC filtrate)	<RL	<RL	
4769	T. Wiedemann	System No. 4710007 Treated (PAC filtrate)	<RL	<RL	
4770	T. Wiedemann	System No. 4710007 Treated (PAC filtrate)	<RL	<RL	
4771	T. Wiedemann	System No. 4710007 Influent	<RL	<RL	
4772	T. Wiedemann	System No. 4710007 Influent	<RL	<RL	
4773	T. Wiedemann	System No. 4710007 Influent	<RL	<RL	
4628	T. Mackie	Klamath River (just downstream of Iron Gate Dam)	<RL	6.8	
5501	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	<RL	7.9	
5502	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	<RL	26	
5502	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	<RL	30	
5503	T. Mackie	Copco Reservoir - Copco Cove	<RL	33	
5503	T. Mackie	Copco Reservoir - Copco Cove	<RL	21	
5508	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	34	99	
5508	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	33	111	
5508	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	30	136	
5509	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	25	153	
5509	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	24	146	
5509	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	22	221	

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CA DHS-DDWEM

Toxin Conc. µg/L

Exceedance of TDI of 0.04 µg/kg/day for a 40 lb (18kg) child ingesting 100 mls (x greater than TDI)

Collector		Source	Anatoxi n-a	MCLR	
4628	T. Mackie	Klamath River (just downstream of Iron Gate Dam)	<RL	6.8	1
5501	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	<RL	7.9	1
5502	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	<RL	26	4
5502	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	<RL	30	4
5503	T. Mackie	Copco Reservoir - Copco Cove	<RL	33	5
5503	T. Mackie	Copco Reservoir - Copco Cove	<RL	21	3
5508	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	34	99	14
5508	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	33	111	15
5508	T. Mackie	Iron Gate Reservoir - Overlook Park (South point 1)	30	136	19
5509	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	25	153	21
5509	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	24	146	20
5509	T. Mackie	Iron Gate Reservoir - Overlook Park (North point 2)	22	221	31

Anatoxin-a RL = 2 µg/L (ppb)

Microcystin LR RL = 0.3 ug/L (ppb)

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PacifiCorp Klamath River Phytoplankton Sampling 2001-2004

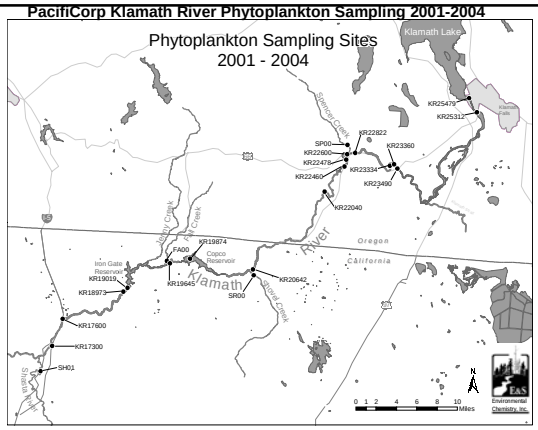

Figure 1. Location of phytoplankton collection sites in the vicinity of the Klamath Hydroelectric Project, 2001-2004.

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Table 1. Phytoplankton sample sites in the vicinity of the Klamath Hydroelectric Project, 2001-2004.

Site ID[1]	River Mile	Latitude	Longitude	Site Name
KR17300	173.00	41.8362	-122.5825	Klamath River above Shasta River
KR17600	176.00	41.8301	-122.5937	Klamath River at I-5 Rest Area
KR18973	189.73	41.9310	-122.4423	Iron Gate dam Outflow
KR19019	190.19	41.9342	-122.4350	Iron Gate reservoir near dam
KR19645	196.45	41.9731	-122.3652	Copco 2 dam Outflow
KR19874	198.74	41.9794	-122.3333	Copco reservoir
KR20642	206.42	41.9721	-122.2016	Klamath River upstream of Shovel Creek
KR22040	220.40	42.0932	-122.0713	Klamath River upstream, of J.C. Boyle Powerhouse
KR22460	224.60	42.1217	-122.0494	Klamath River below J.C. Boyle dam
KR22478	224.78	42.1228	-122.0470	J.C. Boyle reservoir at Log Boom
KR22600	226.00	42.1351	-122.0313	J.C. Boyle reservoir at Hwy 66 Bridge
KR22822	228.22	42.1499	-122.0154	Klamath River above J.C. Boyle reservoir
KR23334	233.34	42.1353	-121.9489	Keno dam Outflow
KR23360	233.60	42.1345	-121.9482	Keno reservoir at Log Boom
KR23490	234.90	42.1222	-121.9194	Klamath River at Keno Bridge (Hwy 66)
KR25312	253.12	42.2188	-121.7884	Link River at Mouth
KR25479	254.79	42.2383	-121.8053	Upper Klamath Lake at Fremont St Bridge
SP00	0	42.1528	-122.0325	Spencer Creek near Mouth
SR00	0	41.9724	-122.2027	Shovel Creek near Mouth
FA00	0	41.9681	-122.3653	Fall Creek near Mouth
SH01	1	41.8231	-122.5944	Shasta River near Mouth

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Abudance of *Microcystis aeruginosa* and *Aphanizomenon flos-aquae*

in Samples Collected from Copco and Iron Gate Reservoirs on August 23, 2005.

Location	Sample ID	Species	Abundance (cells/mL)
Copco (KR19874)	KR5128	*Microcystis aeruginosa*	130,871
1 m grab sample		*Aphanizomenon flos-aquae*	100,670
Iron Gate (KR19019)	KR5129	*Microcystis aeruginosa*	39,711
10m integrated		*Aphanizomenon flos-aquae*	23,259
Iron Gate (KR19019)	IGSURF	*Microcystis aeruginosa*	6,687,729 (see note below)
Surface grab sample		*Aphanizomenon flos-aquae*	Not observed*
Iron Gate (KR19019)	KR5133	*Microcystis aeruginosa*	1,318
1 m grab sample		*Aphanizomenon flos-aquae*	Not observed
Iron Gate (KR19019)	KR5134	*Microcystis aeruginosa*	68,428
10 m integrated		*Aphanizomenon flos-aquae*	Not observed
Below Iron Gate Dam	KR5126	*Microcystis aeruginosa*	33,063
(KR19873)		*Aphanizomenon flos-aquae*	51

*Present at less than 1 percent of the total sample biovolume

Note: This data (Iron Gate KR 19019, IGSURF) is from an additional (non-routine) sample that was taken from the most concentrated area of a localized algal bloom at the surface of the water based on observed conditions present at the time of sampling.

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PacifiCorp: 2001-2002

DATE	STATION	RM	DEPTH	SLIDE	DENS
17-Oct-01	KR22478	224.78	8.0	FY88	5
14-Aug-02	KR19019	190.19	12	GI41	1
14-Aug-02	KR19645	196.45	0.5	GI40	5
10-Sep-02	KR18973	189.73	0.5	GI66	18
10-Sep-02	KR19019	190.19	0.5	GI65	67
10-Sep-02	KR19645	196.45	0.5	GI72	9
10-Sep-02	KR19874	198.74	10 INT	GI70	17
10-Sep-02	KR20642	206.42	0.5	GI62	30
9-Oct-02	KR19645	196.45	0.5	GI97	52
9-Oct-02	KR19874	198.74	0.5	GI94	155

Note: Density (DENS) is reported in colonies/ml not as cells/ml

PacifiCorp - 2003

DATE	STATION	RM	DEPTH	SLIDE	DENS
16-Jul-03	KR19019	190.19	10 INT	GL76	3
16-Jul-03	KR19874	198.74	0.1	GL68	38
19-Aug-03	KR19019	190.19	10 INT	GL80	27
19-Aug-03	KR19874	198.74	10 INT	GL78	498
19-Aug-03	KR19874	198.74	0.1	GL77	22,550
20-Aug-03	Lake Ewauna			GU25	24
20-Aug-03	Lake Ewauna			GU08	171
20-Aug-03	Lake Ewauna			GU09	131
20-Aug-03	Lake Ewauna			GU13	96
20-Aug-03	Lake Ewauna			GU15	102
20-Aug-03	Lake Ewauna			GU16	17
20-Aug-03	Lake Ewauna			GU21	11
20-Aug-03	Lake Ewauna			GU23	53
21-Aug-03	KR18973	189.73	0.5	GL89	69
21-Aug-03	KR19645	196.45	0.5	GL88	1,113
21-Aug-03	KR20642	206.42	0.5	GL87	9
21-Aug-03	KR23490	234.9	0.5	GL83	49
17-Sep-03	KR18973	189.73	0.5	GL00	31
17-Sep-03	KR19019	190.19	0.1	GU04	12
17-Sep-03	KR19019	190.19	10 INT	GU05	22
17-Sep-03	KR19645	196.45	0.5	GU03	54
17-Sep-03	KR19874	198.74	0.1	GU01	29
17-Sep-03	KR19874	198.74	10 INT	GU02	19
14-Oct-03	KR19874	198.74	10 INT	GU46	5

PacifiCorp - 2004

DATE	STATION	RM	DEPTH	SLIDE	DENS
20-Jul-04	KR18973	189.73	0.5	HF38	3
21-Jul-04	KR19019	190.19	0.5	HF43	7
21-Jul-04	KR19019	190.19	8	HF44	1
21-Jul-04	KR19019	190.19	10 INT	HF46	5
21-Jul-04	KR19874	198.74	0.5	HF41	5
10-Aug-04	KR22040	220.4	0.5	HF48P	105
17-Aug-04	KR17600	176	0.5	HF75P	18
17-Aug-04	KR18973	189.73	0.5	HF74P	75
17-Aug-04	KR19645	196.45	0.5	HF73P	223
17-Aug-04	KR22460	224.6	0.5	HF69P	458
20-Aug-04	KR19019	190.19	0.5	HF79P	105
20-Aug-04	KR19019	190.19	10 INT	HF80P	117
20-Aug-04	KR19874	198.74	0.5	HF76	220
20-Aug-04	KR19874	198.74	10 INT	HF77P	312
21-Sep-04	KR18973	189.73	0.5	HF84P	18
22-Sep-04	KR19019	190.19	10 INT	HF97P	28
22-Sep-04	KR22460	224.6	0.5	HF93P	12
13-Oct-04	KR19645	196.45	0.5	HP01P	17
14-Oct-04	KR19874	198.74	0.5	HP02P	246
14-Oct-04	KR19874	198.74	8	HP03P	42

Discussion