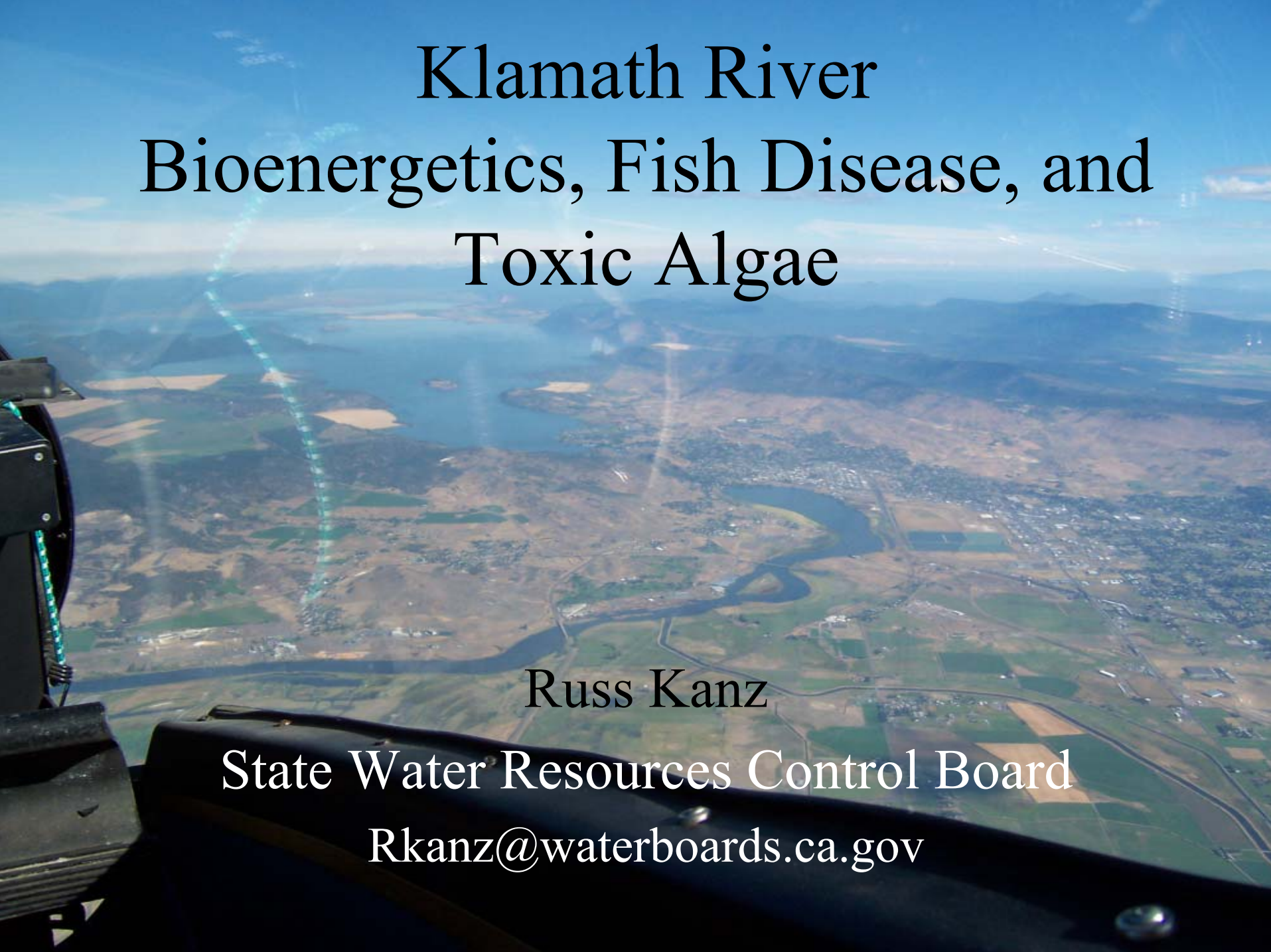

# Klamath River Bioenergetics, Fish Disease, and Toxic Algae

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State Water Resources Control Board

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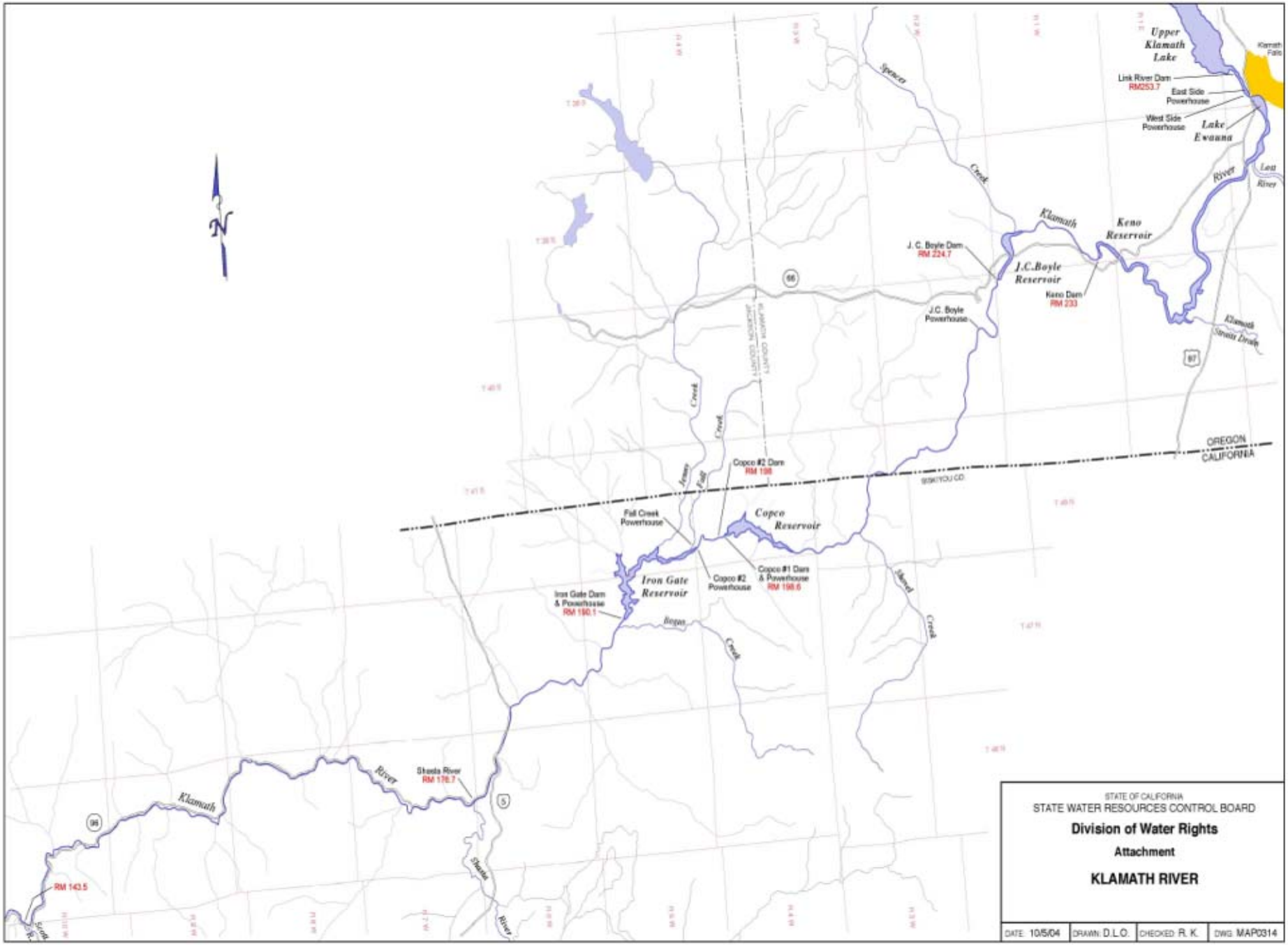
# Klamath Hydroelectric Project Relicensing

- The Federal Energy Regulatory Commission (FERC) issues licenses for hydroelectric facilities for periods of 30 to 50 years
- PacifiCorp Energy began relicensing the Klamath Hydroelectric Project in 2001
- PacifiCorp must obtain water quality certification under section 401 of the CWA from the State Water Resources Control Board before FERC can issue a new license
- Conditions are mandatory in the FERC license


Upper Klamath Lake
Link River Dam RM253.7
East Side Powerhouse
West Side Powerhouse
Lake Ewauna
Spencer Creek
Klamath River
Lost River
Keno Reservoir
J. C. Boyle Dam RM 224.7
J.C.Boyle Reservoir
Keno Dam RM 233
J.C. Boyle Powerhouse
Klamath Forest Drain
97
66
OREGON
CALIFORNIA
Jenny Creek
Fall Creek
Copco #2 Dam RM 198
Fall Creek Powerhouse
Copco Reservoir
Iron Gate Reservoir
Copco #2 Powerhouse
Copco #1 Dam & Powerhouse RM 198.6
Iron Gate Dam & Powerhouse RM 190.1
Shovel Creek
Bogus Creek
Shasta River RM 176.7
Klamath River
5
96
Shasta River
RM 143.5
N
STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD
Division of Water Rights
Attachment
KLAMATH RIVER
DATE: 10/5/04
DRAWN: D.L.O.
CHECKED: R. K.
DWG: MAP0314

# Studies, Studies, Studies

- FERC and agencies require studies to evaluate the impacts of the proposed project and to develop license/permit conditions
- PacifiCorp conducted a large number of studies covering a range of resources areas
- Tribes, agencies and NGOs also conducted studies

# Bioenergetics Study, Bugs Beyond CSBP

- The J.C. Boyle Powerhouse is operated as a peaking operation
- 100 cfs is released into the bypass reach
- About 225 cfs of spring flow at about 11° C
- Flows in the peaking reach vary from about 325 to 1400 cfs daily

# Why Bioenergetics?

- Fish in the Keno Reach grow more slowly, however, fish in the by-pass and peaking reaches grew significantly slower after age 3 compared to fish in the Keno Reach
- Experience has shown that CSBP is not a good tool for evaluating peaking impacts

# Bioenergetics Study

- Conducted by Utah State University
- Objective of the study was to assess bioenergetics and trout growth over a range of flow, food, and temperature conditions, and predict how trout growth under existing conditions may differ from steady flow and without project conditions

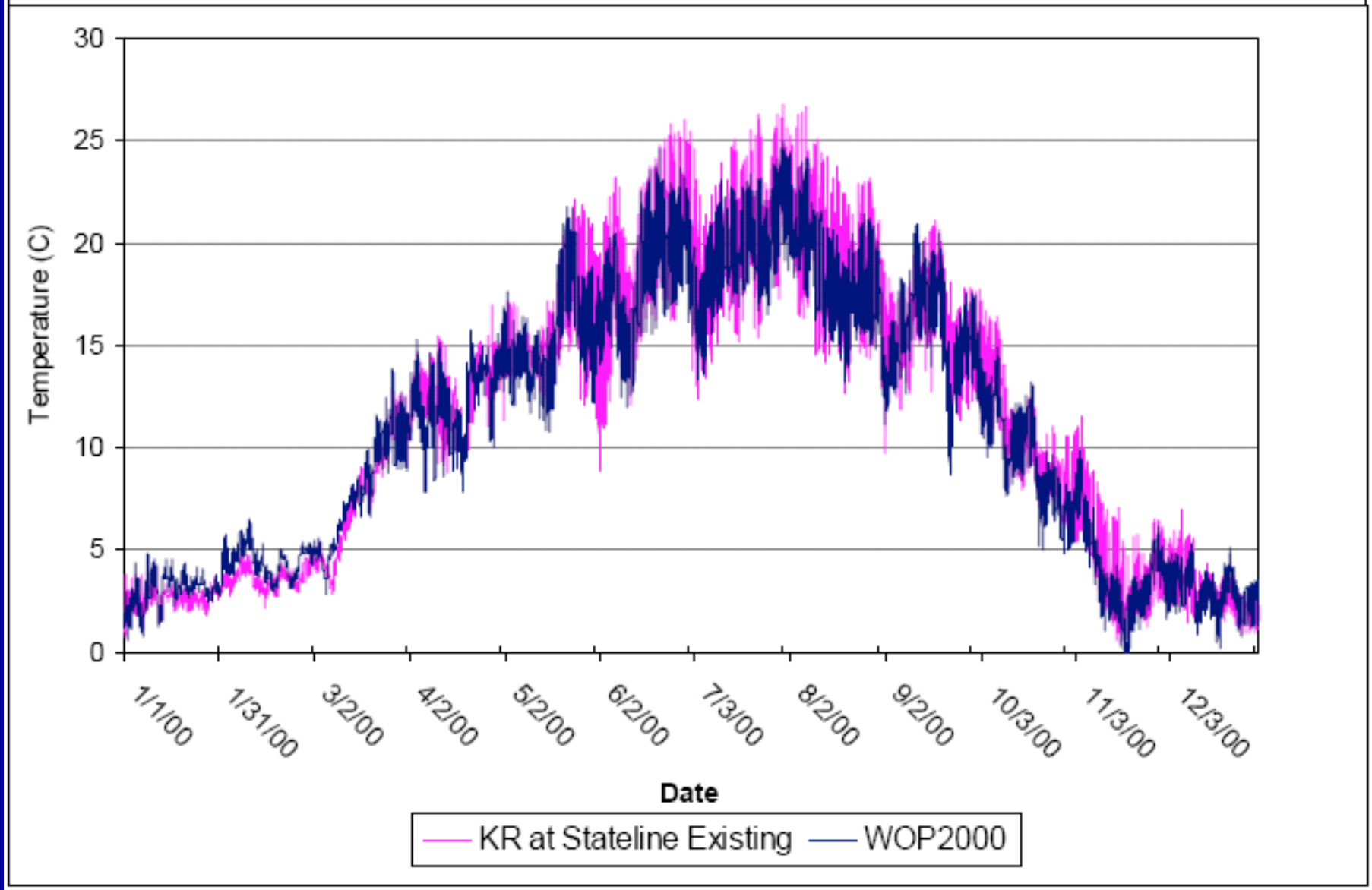
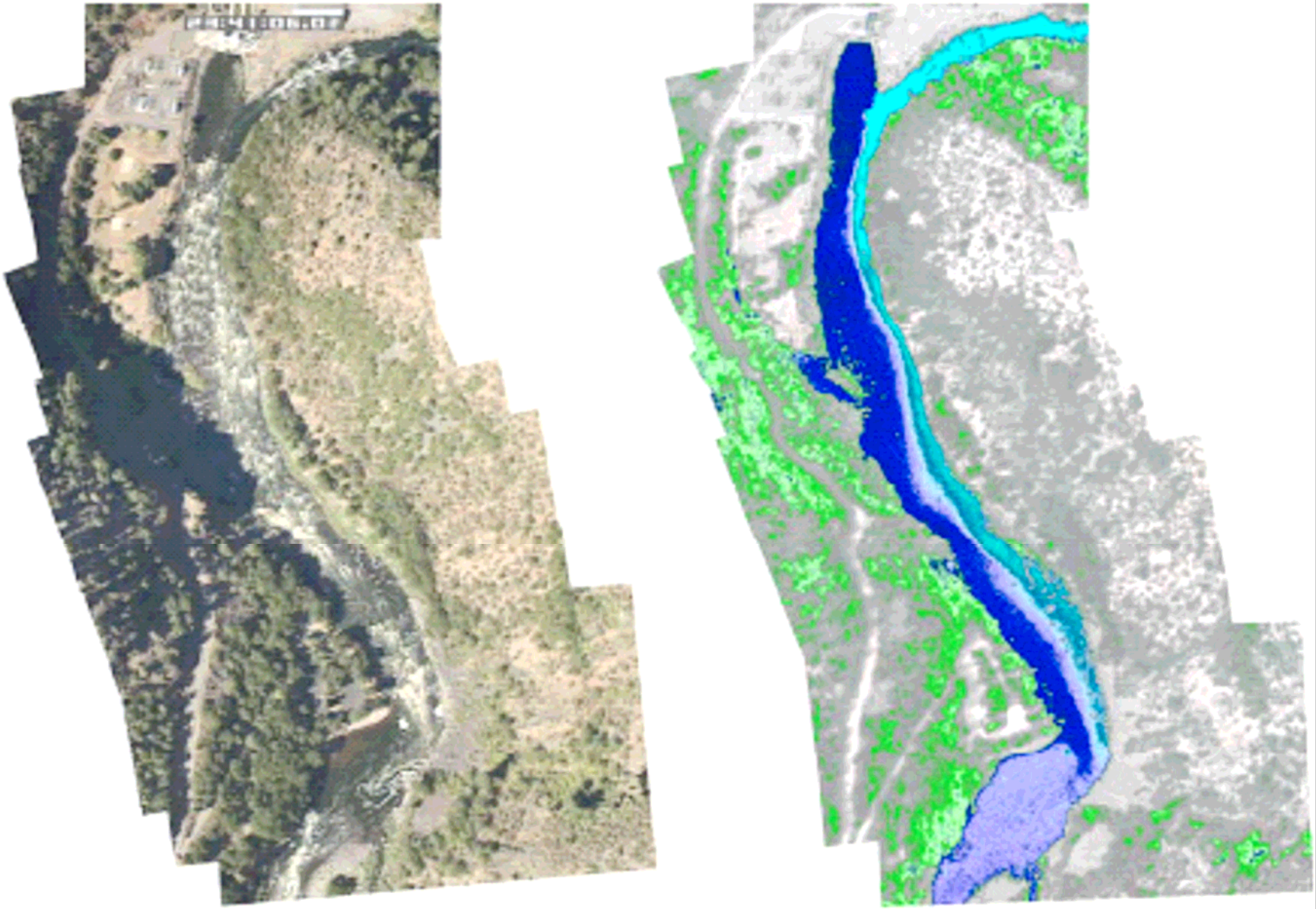



**Figure 35.** Comparison of hourly temperatures (year 2000) at the Stateline node for Existing Conditions (magenta), Steady Flow (blue line, top), and Without Project scenarios (blue line, bottom).



Frame: klm0660-0672 – The confluence of the Klamath River (16.6°C) and the outlet of the John C. Boyle power plant at river mile 24.9. The Klamath River flows in from the right top of the image. The power plant outlet has a dramatic influence on downstream temperatures.

**Table 4.** 2004 drift data collected in the Klamath River in the Keno Reach, J.C. Boyle Bypass Reach, J.C. Boyle Upper Peaking Reach and Lower Peaking Reach.

| | Late June/ Early July 2004 | | | | Early September 2004 | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Upper | Lower | | | Upper | Lower |
| | Keno | Bypass | Peaking | Peaking | Keno | Bypass | Peaking | Peaking |
| **Avg # / ft^3** | 0.629 | 0.068 | 0.183 | 0.059 | 0.139 | 0.059 | 0.025 | 0.018 |
| **# Samples** | 18 | 12 | 12 | 18 | 18 | 12 | 12 | 12 |
| **Std Dev.** | 0.497 | 0.035 | 0.223 | 0.019 | 0.085 | 0.027 | 0.011 | 0.009 |
| **Avg Size mm** | 3.444 | 2.746 | 3.336 | 3.230 | 3.207 | 2.956 | 3.246 | 3.359 |

# Conclusions

- The model predicted that due to the greater energy requirement of large fish, particularly at high summer temperatures, fish in the 400+ mm size range could not obtain a positive energy intake feeding at existing drift densities
- Confirmed by empirical data

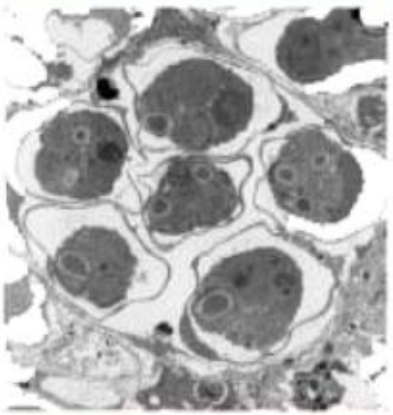
# *Ceratomyxa shasta*

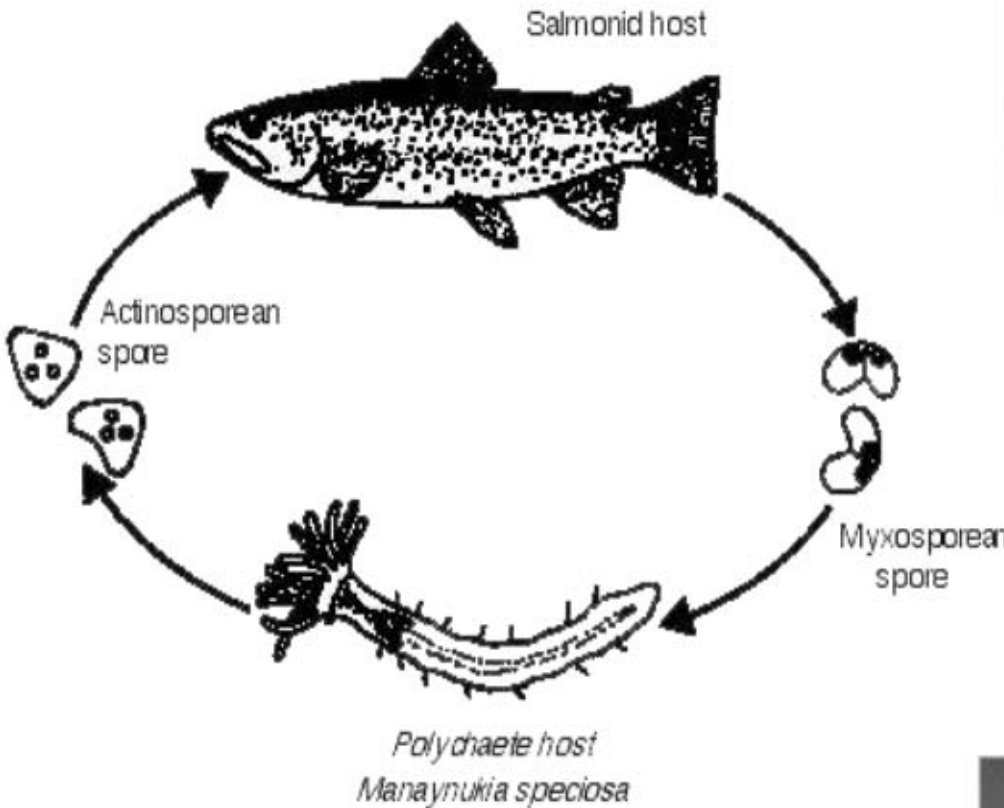
- *Ceratomyxa shasta* is a microscopic myxosporean protozoan parasite that afflicts salmonid fish of the Pacific northwest (Bartholomew et al. 1989)
- Distribution in Pacific Northwest (Idaho, Oregon, Washington, Northern California, British Columbia, Alaska)

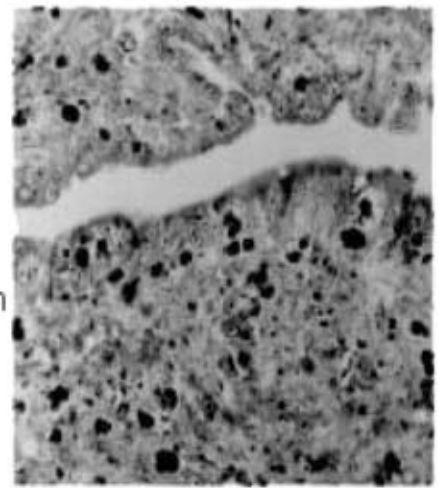
# The Evil Worm

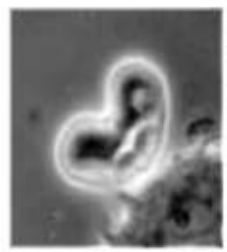
- Intermediate host is a freshwater polychaete; *Manayunkia speciosa*
- Infection through contact with infectious stage (actinospore) found in water column
- Neither horizontal (fish to fish), or vertical (fish to egg) transmissions have been documented in laboratory testing
- Spore size 14-23µm long 6-8µm wide
- QPCR analysis can detect very low numbers of parasites

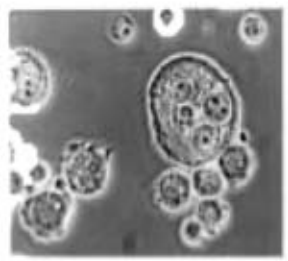
# Life Cycle of *Ceratomyxa shasta*









# *Ceratomyxa shasta*

- Progression of infection and mortality is temperature dependent (higher temperature yields increased disease progression / quicker mortality)
- Rainbow trout temperature related mortality (Udey et al. 1975) - Mortality – 155 days at 6.7º C; 14 days at 23.3 º C

# *Ceratomyxa shasta*

- *C. shasta* is the most significant disease issue for outmigrating juvenile chinook and steelhead in the Klamath Basin
- 50% of smolts sampled in the Lower Klamath River in 2001 were infected with *C. Shasta*

# *Ceratomyxa shasta*

- "Polychaetes require fine particulate organic material for construction of their living tubes. This material may be trapped in periphytic *Cladophera* sp. and freshwater sponges, which provide a protected substrate for tube construction and can support high polychaete densities. Diatoms are found consistently in the gut, suggesting this may constitute a major portion of their diet". (Bartholomew, 2004)

# *Ceratomyxa shasta*

- Infection prevalence in polychaete populations collected at locations in the upper and lower river was highest directly downstream of Iron Gate dam (8 and 12% for *C. shasta* and *P. minibicornis*, respectively; elsewhere it was typically below 2%). Thus, the area below the dam, which is a major spawning ground for adult Chinook salmon, may be the primary source of infectious spores for the entire lower Klamath River.

# Polychaete Habitat

- "These preliminary analyses indicate that for the Copco/Iron Gate Reservoir system, the April-November period is characterized by periods of positive and negative retention for both phosphorus and nitrogen (net positive values denote a sink and net negative values denote a source). Despite acting as net sinks for P and N over the entire Apr-Nov period, both Copco and Iron Gate Reservoirs can act as a nutrient source during critical periods (e.g., June through September), making nutrients available at such periods for downstream growth of algae and macrophytes". Kann, J., and E. Asarian, 2005.

# Closing the Loop

- Reservoirs create nutrients – promotes the growth of cladophora that has a competitive advantage
- Reservoirs may also increase FPOM that supports high populations of polychaetes
- Altered geomorphology and hydrology may prevent scouring of the bed
- Conditions allow polychaetes to grow in greater numbers
- Hydro project reservoirs increase water temperature
- Increased rate of disease infection
- May be other factors – Parvicapsula minibicornis

# Blue Green Algae in the Klamath River

- Upper Klamath Lake is hypereutrophic, rich in phosphorus
- Assimilative capacity is impacted by peaking operations and reservoirs
- Iron Gate and Copco Reservoirs create the perfect environment for the growth of blue-green algae; warm, stratified, internal nutrient cycling, eutrophic
- Large bloom of Aphanizomenon flos-aquae add nitrogen to the system

# Toxic Algae

- Aquatic Ecosystem Sciences obtained a sample of algae from a single location on the south side of the Copco Reservoir near Patricia Avenue. The sample was analyzed by Wright State University who reported 1.9 million cells per milliliter of *Microcystis aeruginosa* and a microcystin level of 482 micrograms per liter. This level is 482 times greater than the World Health Organization recommended level for drinking water.

# Microcystin Toxicity

- The mechanism of toxicity of microcystins is the inhibition of protein phosphatases, which can cause internal hemorrhaging of the liver. Exposure to microcystins has the potential to cause acute and chronic injury, depending on the dose and duration of duration of exposure. Sub-acute damage to the liver is likely to go unnoticed up to levels that are near severe acute damage (Chorus et al., 2000).

# Microcystin Toxicity

- Two aspects of chronic damage include progressive injury to the liver and tumor-promoting capacity. Microcystins alone have not been classified as carcinogenic. However, microcystins are considered to be tumor promoters based on studies in mice that were initiated with a known carcinogen (Falconer and Buckley, 1989).

# Microcystin Toxin

- On August 9, 2006, "Microcystin levels exceeded the WHO guideline by as much as 608.8x at station CRCC and a 40 lb child accidentally ingesting 100 mls at this station would exceed the Tolerable Daily Intake (TDI) by over 1,681x (Table 1). Microcystin concentration at other reservoir stations (including open water locations) exceeded the TDI level by between 12 and 522x. The microcystin levels of 3779 µg/L at CRMC and 12,176 µg/L at CRCC are the highest yet recorded in these reservoirs and are among the highest recorded in the world". Jacob Kann, Ph.D.

# HEALTH ADVISORY

## AVOID WATER CONTACT IN IRON GATE AND COPCO RESERVOIRS

Due to high levels of blue-green algae
that can produce harmful toxins.

- Do not use this water for drinking or cooking.
- Do not consume fish livers or digestive organs, and wash fillets with drinking water.

**Children and pets are at greatest risk.**

For more information contact:

North Coast Regional Water Quality Control Board

(707) 576-2220