

Spread the Word...NOT the Tui Chub

Restoring Diamond Lake's Water Quality and Trout Fishery Through Invasive Species Removal and Education

The introduction of rainbow trout to the naturally fishless Diamond Lake attracted both wanted and unwanted visitors, resulting in significant changes to the health of the lake and lake-based recreational tourism. Fishing enthusiasts visiting Diamond Lake brought an invasive fish species, the tui chub, to use as live trout bait. (Live bait is illegal in Oregon.) Over time, the exploding tui chub population not only took its toll on the rainbow trout fishery, but also on the overall water quality of the lake. The tui chub fed on larger herbivorous zooplankton—the microscopic organisms in the lake responsible for controlling algae growth—throwing the lake's nutrient cycling processes off balance. As a result, Diamond Lake suffered from excessive growth of toxic algae blooms that increased pH levels and reduced dissolved oxygen (DO) levels. Diamond Lake could no longer support its aquatic life designated use and was often closed for recreation during summer months due to potential health risks.

The Oregon Department of Environmental Quality (ODEQ) initiated the development of a TMDL to help Diamond Lake restore its aquatic life designated use. The TMDL analysis predicted that removing the tui chub from Diamond Lake would restore the lake's nutrient cycling processes and support the aquatic life designated use. Based on the TMDL recommendations, multiple stakeholders from the federal, state, and local levels collaborated to develop and implement a plan to remove the tui chub and restore the trout fishery. The biology and chemistry of Diamond Lake have shown significant improvement due to the removal of the tui chub. As a result, Diamond Lake is now both fishable and swimmable. Currently, Diamond Lake is meeting Oregon's water quality standards and ODEQ expects to remove Diamond Lake from the state's list of impaired waters in the next assessment cycle in 2010.

How are TMDLs at work in Diamond Lake?

Through the technical analysis, the Diamond Lake pH and DO TMDL provided stakeholders with a clearer understanding of the external and internal loads of nutrients affecting the levels of pH, DO, and algal blooms in the lake. The final TMDL report provided an explanation of how changes to the biological community found in Diamond Lake due to the tui chub population changed how efficiently the lake cycled nutrients, resulting in excessive algal blooms. The computer model tailored to Diamond Lake used in the TMDL analysis estimated the percentage of tui chub that stakeholders would need to remove from the

TMDL at a Glance

Diamond Lake TMDLs- pH and Dissolved Oxygen

(approved April 2007)

www.deq.state.or.us/wq/tmdls/umpqua.htm

Factors causing impairment

Aesthetics, fishing, and water contact recreation designated uses impaired due to elevated pH levels and reduced dissolved oxygen levels from excessive algal blooms

Sources contributing to impairment

Introduction of the tui chub, an invasive fish species, resulting in the removal of native aquatic organisms that typically control algae growth

Restoration options

Tui chub removal and educational efforts to prevent introduction of invasive species

Stakeholder involvement

Umpqua National Forest, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Partners for Umpqua Watersheds, Oregon Wildlife Heritage Foundation, Oregon Division of State Lands, Oregon Department of Agriculture, Douglas County, PacifiCorp, watershed residents, local businesses, and several other state and federal agencies

Status of waterbody

Restoration of aquatic life designated use after removal of tui chub; anticipated attainment of other water quality standards with potential delisting by 2010

Benefits to stakeholders

Improved water quality, recreational opportunities (fishing, boating, and swimming), and lake aesthetics, as well as increased tourism

What is a total maximum daily load (TMDL)?

It is a study or analysis that calculates the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. The TMDL establishes a pollutant budget and then allocates portions of the overall budget to the pollutant's sources. For more information on TMDLs, visit EPA's website at www.epa.gov/owow/tmdl.

lake to improve the lake's nutrient cycling and restore water quality. In addition, the TMDL analysis revealed that changes in trout stocking densities would also be necessary to attain water quality standards.

What is the current status of Diamond Lake as a result of the TMDL process?

In 2005, partners mechanically and chemically removed approximately 103,000 pounds of tui chub from Diamond Lake. Monitoring data collected in Diamond Lake after the removal of the tui chub demonstrate that the lake now supports its aquatic life designated use. To monitor the health of Diamond Lake after the removal of the tui chub, the Oregon Department of Fish and Wildlife (ODFW) assessed the lake in 2007 and compiled the 2008 Lake Conditions Index Report. This report uses metrics related to water chemistry and biology to measure changes in the lake's condition. The 2008 report states that Diamond Lake's pH levels are near or below the 8.5 water quality criteria value and DO levels meet the water quality criteria appropriate for Diamond Lake on most days. In addition, the 2008 report states that chlorophyll *a* values decreased from a high of 50 µg/L before the rotenone treatment to less than 10 µg/L (the numeric water quality criterion associated with aquatic weeds and algae) after treatment. Figure 1 illustrates the changes in chlorophyll *a* values in Diamond Lake before and after tui chub removal.

Stocked trout health has also improved since the eradication of the tui chub, according to ODFW assessment data. Before the removal of the tui chub, stocked trout had a growth rate and a survival rate of

nearly zero. During the summer of 2007, stocked trout grew an average of two inches per month. ODFW states that trout growth rates are now similar to the growth rates observed in the 1970s and 1980s—the decades known as the *hey days* for fishing in Diamond Lake.

Data from two years after tui chub eradication and trout restocking have shown signs of water quality improvements in Diamond Lake. Benthic organisms, an important food source for mature trout, increased from less than 25 pounds per acre (lbs/ac) in 2004–2006 to 200.6 lbs/ac in 2007 and 168 lbs/ac in 2008. Before treatment of Diamond Lake in 2006, the bio-volume of cyanobacteria was 24,407 cells per milliliter (cells/ml), or 25.7 percent of the bio-volume. Two years after treatment of the lake, the bio-volume of cyanobacteria decreased to 49 cells/ml or 4.9 percent of the bio-volume. ODEQ will use this information and other required data inputs to run the model used in the TMDL analysis to determine how these decreases translate into annual cyanobacteria biomass (i.e., kilograms/year) reductions—the numeric target established in the TMDL. The pH of Diamond Lake also decreased from 8.5 to less than 7.8 during this two year period.

How did local stakeholders benefit from the TMDL process?

Removal of the tui chub from Diamond Lake provided the lake's natural nutrient cycling processes to regain its balance. As a result, both water quality and the lake's biological communities showed improvement. It is anticipated that these improvements will lead to Diamond Lake's removal from the state's list of impaired waters in 2010.

In addition to water quality benefits, the restoration of Diamond Lake has benefitted stakeholders in several ways. Additional benefits that followed the restoration of Diamond Lake include:

- **Decreased human health risks.** Before treatment of Diamond Lake to remove the tui chub, state officials closed the lake for recreation during summer months when the toxic blue-green algae dominated the lake. Blue-green algae blooms produce toxins that are harmful to humans and animals. After implementation, blue-green algae went from the dominant algae type in Diamond Lake to only a small percentage of the algal community.
- **Revived tourism to boost local economy.** Diamond Lake recreational enthusiasts contribute approximately \$3.5 million to the local economy each year. Restoring water quality and aquatic communities have helped to also restore Diamond Lake's reputation as a favorite destination for trout anglers. According to ODFW,

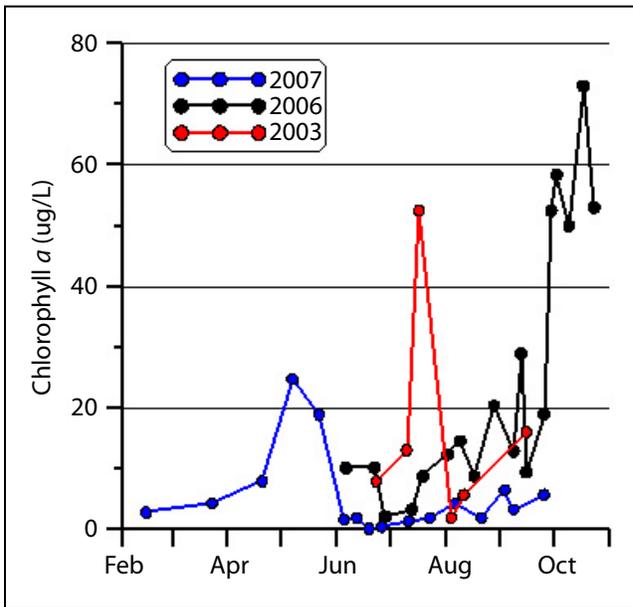


Figure 1. Reduction in algal blooms, as represented by chlorophyll *a*, before and after chub removal.

there were 72,085 angler trips in 2007. These trips generated an estimated \$3.76 million in sales and \$2.57 million in labor income in the area (based on the 2006 value of the dollar). The Diamond Lake Resort, the third largest employer in the area, had a staff of 80 when tourism was suffering most and has since increased the staff by over 60 percent due to the boost in lake-based tourism.

- **Improved aesthetics.** Significant reductions in nuisance algae occurred and the lake increased from a visible depth of 10 feet to almost 50 feet after implementation.
- **Increased educational awareness to prevent spread of invasive species.**

It is illegal to use live bait for fishing anywhere in Oregon. The educational effort for Diamond Lake reminds visitors of that law through educational brochures and signage around the lake. In addition, partners conducted a boater survey to better understand boaters' habits and perceptions relating to the spread of invasive species. Educational efforts remind boaters and recreational enthusiasts of the simple steps they can take, such as washing boats and fishing equipment, to avoid giving *aquatic hitchhikers* a free ride to Diamond Lake.

■ Stakeholders Say...

"Anyone working in recreation does it for the satisfaction, not for the money, but it is our livelihood. When your lake has a problem, you get involved to find a solution. Getting involved answered a lot of questions for us about the area. We found a solution that had a huge ripple effect both on the lake's ecosystem and on our local economy."

—Rick Rockholts, Manager
Diamond Lake Resort

For more information on the Diamond Lake TMDL, contact
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For more information on the Oregon TMDL Program, visit www.deq.state.or.us/WQ/TMDLs/TMDLs.htm



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