Floating Treatment Wetlands to Mitigate Lake Eutrophication: Enhanced Circulation and Nutrient Uptake Expand Fish Habitat

Project Location: Research Lake near Shepherd, MT, USA

Simple, cost-effective water treatment strategies show the ability to transform agricultural effluent into world-class fish habitat. This case study discusses an ongoing experiment to monitor the efficacy of a floating treatment wetland (FTW) that incorporates air diffuser technology to lift and circulate water through floating stream beds within the FTW. This combination of FTW and efficient water circulation/aeration is trade-named Leviathan™, a model of BioHaven floating island, and represents a novel approach to address nutrient loading.

Overview:

Determining whether biofilm-based microbes can set the stage for high fish productivity along with nutrient removal was a primary objective of this test.

Shepherd Research Lake, August 2010

Wetland areas have been reduced worldwide while human-caused nutrient loading has expanded with growing human populations. Mass-production agriculture as practiced in many developed nations has contributed to numerous cases of hyper-eutrophication in bodies of water that were previously low in nutrient concentrations. In fresh water, partly as a result of normal seasonal stratification, nutrient loading can deplete oxygen levels within the livable temperature zone for cold-water fish species.

Floating Island International (FII) is a private research and development-focused business. Over the last 11 years, FII has developed the BioHaven FTW technology, which mimics the ability of natural peat-based wetlands to purify water. The Leviathan maximizes surface area and circulation, which are key components of wetland effectiveness. The islands are also designed to provide optimal perennial plant habitat. The Montana Board of Research and Commercialization, along with FII, funded the work described in this case study.

System Background:

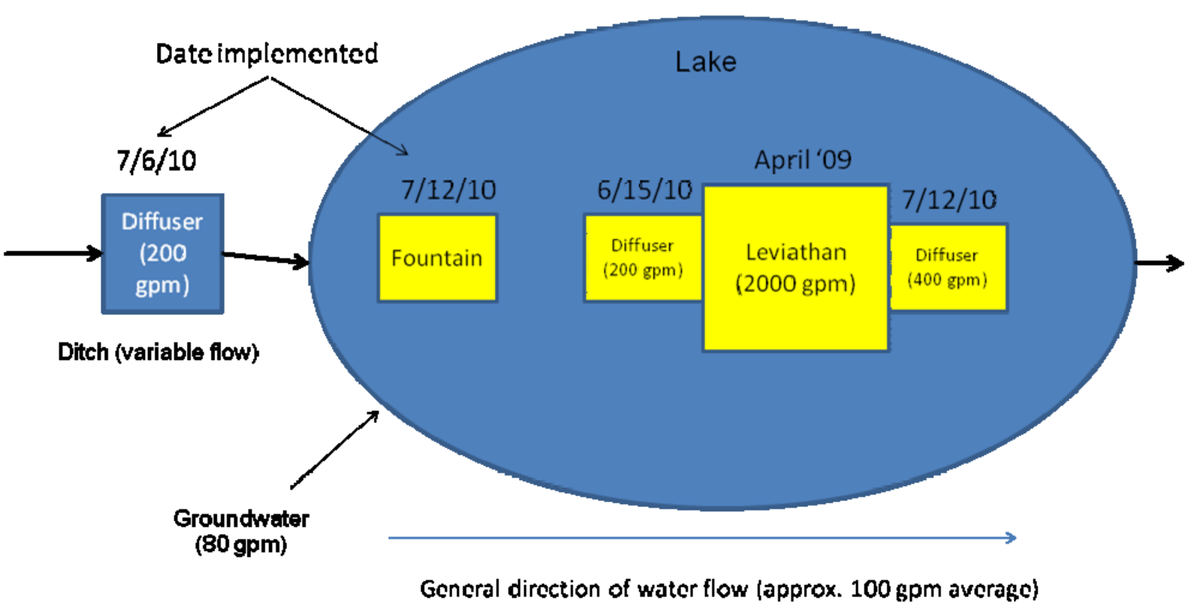
Dissolved oxygen and temperature measurements taken on FII's 6.5-acre lake outside of Shepherd, Montana in 2008/2009 indicated that stratified water near the surface was too warm to sustain a trout fishery. While temperatures below the stratified warm water layer were sufficiently cool for trout, that zone contained low dissolved oxygen (DO) levels. During late summer at this south-central Montana lake, no strata of water could consistently provide the cool-water, high-DO environment demanded by fish such as rainbow, brown and, especially, Yellowstone cutthroat trout.

Leviathan Water Circulation System, August 2010
(5000 ft^2 of FTW surface area = 29 acres of effective surface area)

Groundwater containing variable nutrient concentrations enters the lake at an average rate of 80 gallons per minute (gpm). Surface water also flows into the lake at variable nutrient concentrations and flow rates. Evaporative loss and outflow are balanced to maintain the lake level at full pool, which ranges between 29 and 30 feet of depth.

As the lake was filled, a series of BioHaven floating islands covering 5200 square feet of lake area and providing over one million square feet of saturated surface area was installed. Several islands were positioned next to the inflow to maximize exposure to the highest nutrient concentrations. These islands, in combination with the Leviathan system, were designed to maximize biofilm production and move nutrients into and through the food web as organisms attached to underwater surfaces ("periphyton").

SHEPHERD LAKE WATER FLOW AND AERATION/CIRCULATION

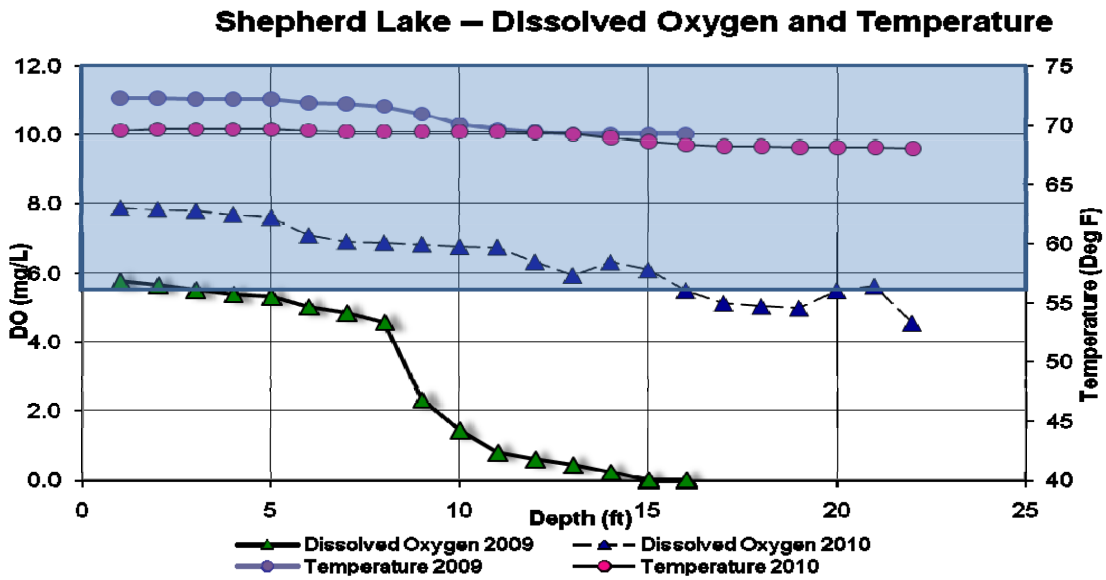


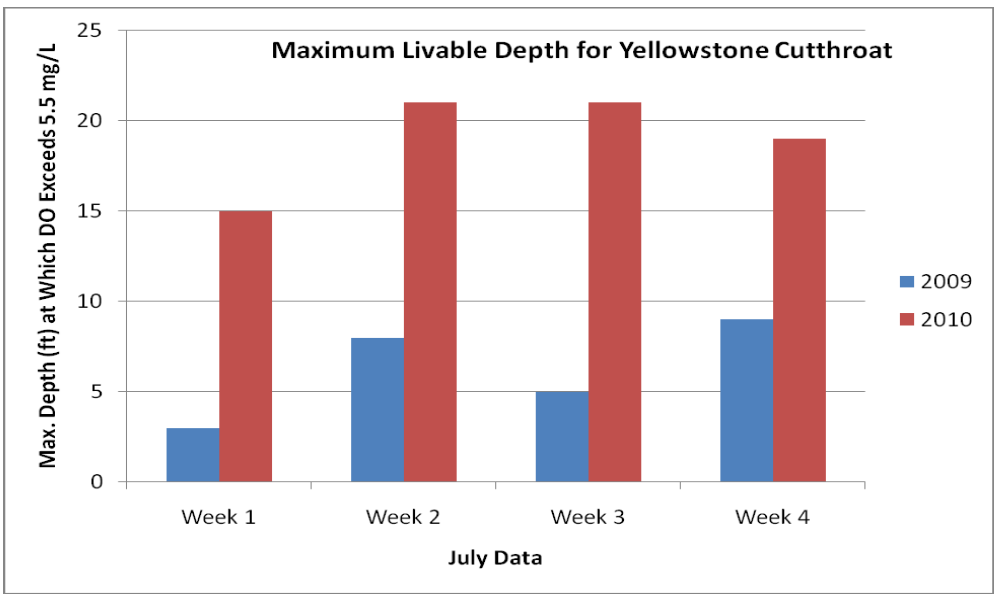
Results:

A 1250-square-foot Leviathan system, incorporating floating stream beds and grid-powered water circulation, was installed in the lake in April 2009. This system circulates up to 2000 gpm through the stream channels within the island. The Leviathan was constructed of post-consumer polymer "matrix," averaging 25 inches in thickness, with each cubic foot of matrix providing 375 square feet of surface area. The Leviathan pump enabled personnel to pull water from any depth and move it through the stream channels, exposing it to the concentrated surface area (containing a microbial biofilm) and atmospheric oxygen.

After 17 months of operation, water clarity had improved from a low of 14 inches of visibility to as much as 131 inches. Simultaneously, the water temperature gradient was reduced, creating a larger zone of "livable" water for fish. Two age classes of Yellowstone cutthroat trout were introduced 13 and 14 months into the test. Through the summer of 2010, a favorable temperature/dissolved oxygen strata ranging from the water surface down to a depth of at least 12 feet was maintained as potential cutthroat habitat. One-year-old and two-year-old black crappies were also introduced two months into the test, and naturally-occurring northern yellow perch were present in the lake when it was filled. All three species have flourished.

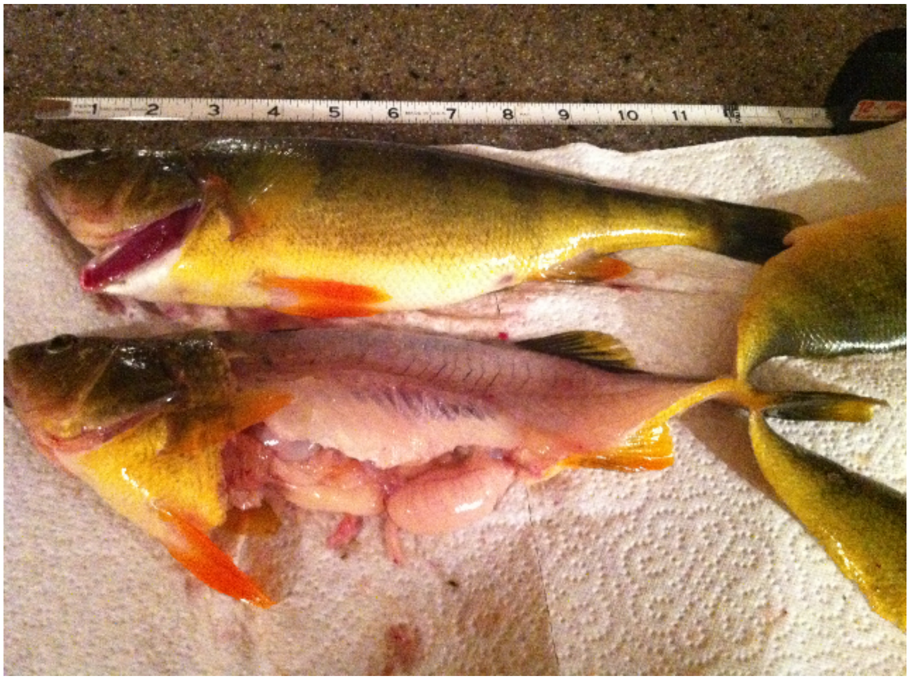
The shaded area in the first chart below contains favorable conditions (DO and temperature) for cold-water fish, with a much larger zone of favorable habitat in 2010 after the Leviathan design was enhanced and additional aeration was installed. The second chart shows the extent of the larger zone of cool, high-DO water that was available for fish in 2010.





Fish catch rates and growth rates are now being monitored at the lake. Initial data show that experienced fishermen can catch up to one perch per minute. Visual observations from diving and an underwater viewing station indicate that perch approaching or exceeding the Montana state record of 2 pounds 2 ounces now inhabit the lake.

The research lake is relatively unique in that it supports fish accustomed to cold water (Yellowstone cutthroat trout), temperate water (perch) and warm water (crappies). Montana officials have made two unsuccessful attempts at sustaining cutthroat populations in an adjacent stretch of the Yellowstone River, which is located a half-mile away from the research lake.



Large northern yellow perch heavy with eggs, September 2010

The new aeration scheme in the lake improves water quality by incorporating dissolved phosphorus and nitrogen into the aquatic food web, in the form of periphyton, while limiting the growth of deleterious algae. Total phosphate concentrations are reduced from about 0.6 mg/L to 0.2 mg/L, while total nitrogen concentrations decrease from about 0.5 mg/L to 0.1 mg/L.