

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 such as low-pressure pumping and directional air diffusers show the ability to transform agricultural effluent into world-class fish habitat. This case study tracks 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:

The need to reduce nutrient levels in wastewater is increasingly critical as rivers, lakes and coastal waters become more nutrient-loaded worldwide due to pervasive human activity around water. This creates a niche for cutting-edge, “green” technologies such as FTW. 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; hyper-eutrophied waterways occur more and more frequently across the world. Developed countries are not immune to this phenomenon; severe nutrient loading associated with 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 (“oligotrophic”). 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 an embodiment of FTW technology called BioHaven floating islands, which mimic the ability of natural peat-based wetlands to purify water. The BioHaven variation called 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:

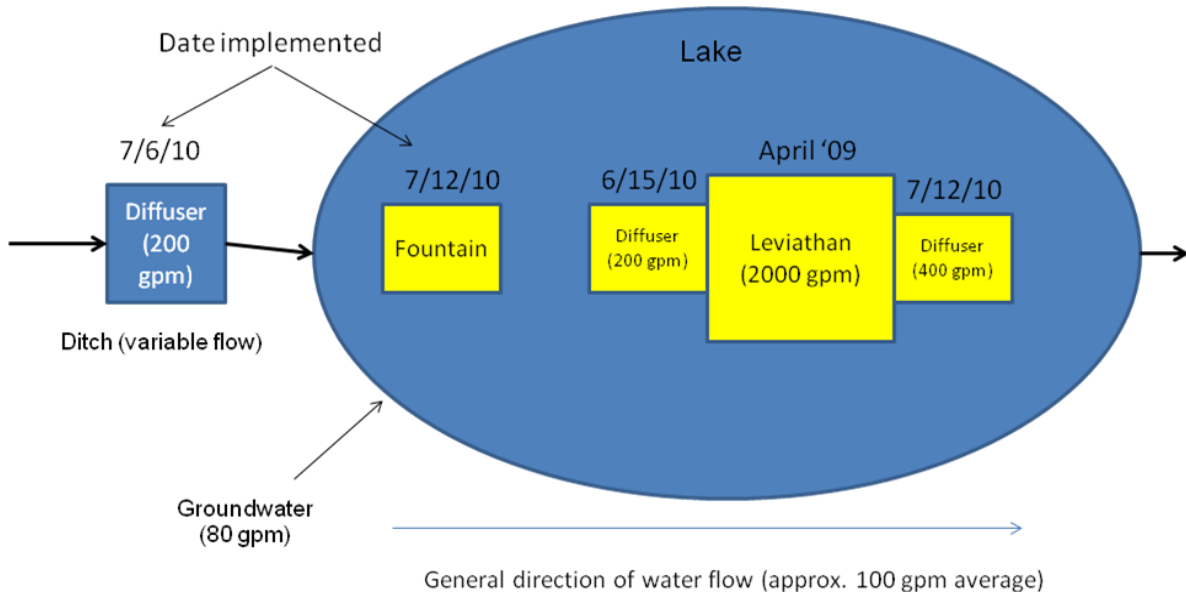
Dissolved oxygen and temperature measurements taken on a 6.5-acre lake outside of Shepherd, Montana indicated that stratified water near the surface was too warm to sustain a trout fishery. While a temperature zone below the stratified warm water was sufficiently cool for trout, that zone contained low dissolved oxygen (DO) levels. During late summer at this lake in south-central Montana, 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

Groundwater, which contains variable nutrient concentrations associated with agricultural activity, enters the lake at an average rate of 80 gpm. Additional surface water, which also occasionally experiences agricultural-based nutrient loading, enters the waterway in random volumes. Evaporative loss and outflow are manipulated to maintain the lake level at full pool, which ranges between 29 and 30 feet of depth.

SHEPHERD LAKE WATER FLOW AND AERATION/CIRCULATION



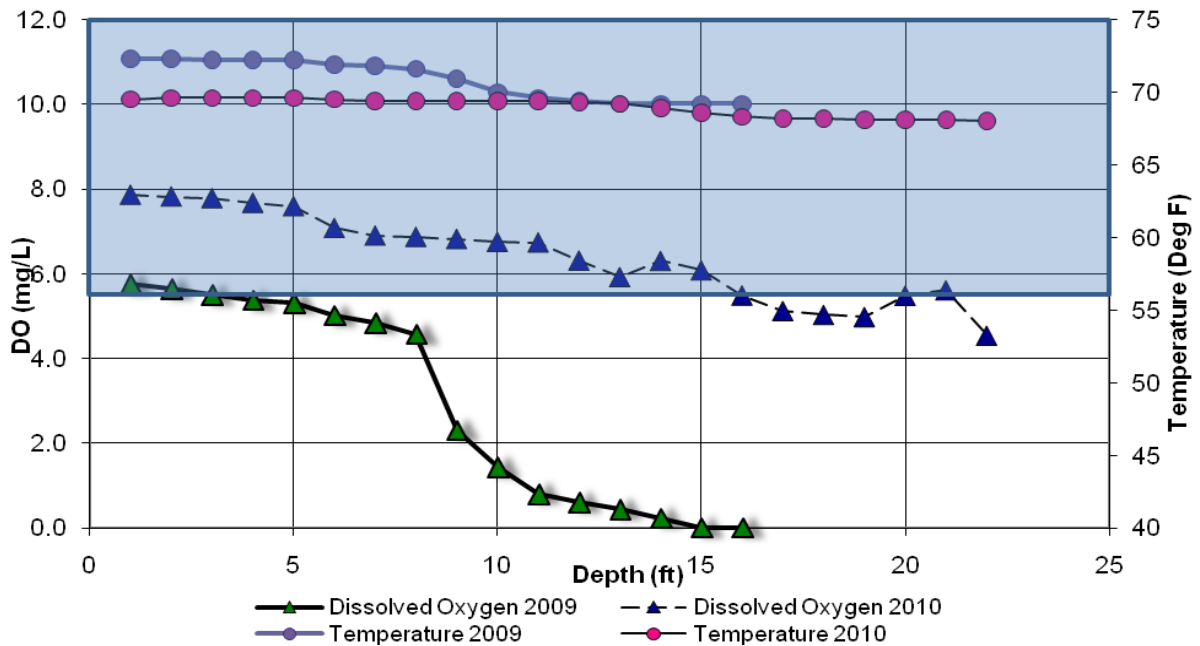
As the lake was filled, a series of BioHaven floating islands covering 5200 square feet of lake area and providing over one million square feet of saturated surface area was installed. A number of these islands were positioned next to the inflow to maximize exposure to the highest nutrient concentrations.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

Results:

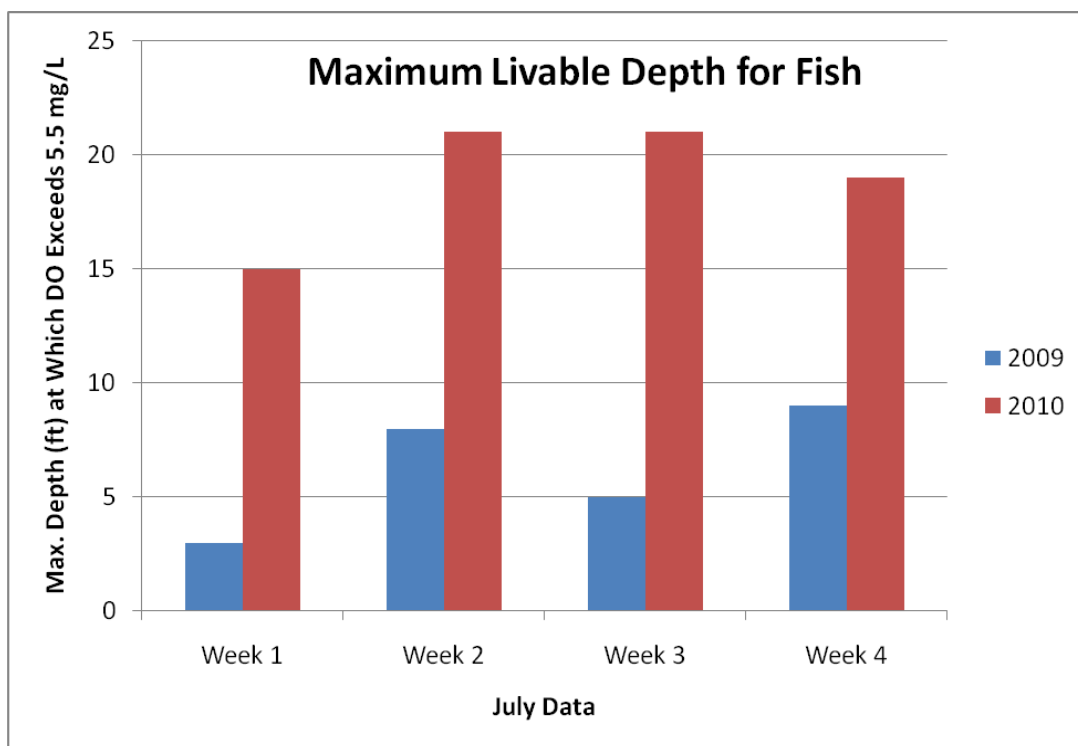
The Leviathan system, incorporating floating stream beds and grid-powered water circulation, was installed in the lake in April 2009. This system circulates up to 2000 gallons per minute (gpm) through the stream channels within the island. The 1250-square-foot Leviathan was constructed of post-consumer 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 habitat for the cutthroat. One-year-old and two-year-old black crappie 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.

Shepherd Lake -- Dissolved Oxygen and Temperature



The chart above shows the shaded area that provides favorable conditions (DO and temperature) for cold-water fish, with much better results in 2010 after the Leviathan design was enhanced and additional aeration was installed. The following chart shows that a much larger zone of cool, high-DO water 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 been unsuccessful in two attempts at introducing cutthroat fish populations in the adjacent stretch of Yellowstone River, which is located a half-mile away from the research lake.

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.