Minnow Pond: A Brush Park Aquaculture Study

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Introduction

Investigating the novel application of BioHaven floating island technology to improve fishery productivity, through enhancing the habitat, cycling surplus nutrients into higher fish populations and improving the water quality to tackle eutrophication.

Over the last few decades the application of inorganic phosphorus as a fertiliser has had a significant effect on our rivers and lakes. Skipping a tropic level it is 10 times more impactful than organic phosphorus directly contributing to nutrient enrichment and the dominance of algae and cyanobacteria species in our freshwaters.

Whilst it should always be our ambition to prevent phosphorus from entering our water it will require long-term change. According to the most recent Environment Agency data only 17% of England's rivers are deemed to be healthy and this is a similar representation across the globe. At the floating island international (FII) research centre in Shepard, Montana the situation is no different.

The idea of increasing the bio-complexity of the water comes from mimicking the design of nature, amassing surface area to resurrect the food web so that nutrients may be cycled up the trophic levels as a food source.

It is not a new concept. Brush park aquaculture is practiced throughout the world as a simple and low-cost means of enhancing fisheries. The practice involves the use of dried brush or other substrata in water to grow periphyton communities, a primary food source for many species and life stages of fish. Periphyton is a complex mixture of organisms particularly bacteria, algae, cyanobacteria, heterotrophs and other microbes that grow on submerged surfaces and develop into three-dimensional communities. The potential for periphyton to support enhanced fisheries derives from its ability to provide a nutrient-rich food source for grazers. The only required inputs being surface area and available nutrients (Azim 2005).

BioHaven floating islands and streambeds imitate this practice offering a place for microbes to live, in the same way as brush, cobbles and sand, providing an enhanced surface area for colonisation.

FII theorised that increasing the Nitrogen:Phosphorus (N:P) molar ratio (typically less than 10) to the Redfield ratio of 16:1 through the addition of fertiliser would foster biomass growth (Cleveland and Liptzin, 2007) and allow higher P removal rates. This hypothesis was confirmed in a series of tank tests, which reduced P levels by 84% versus 43% in the control, using a nitrogen-based fertiliser.

N can be removed from waterways through nitrification and denitrification processes enhanced by the presence bacteria within the periphyton, the most effective means of P removal may be to grow and harvest biomass, i.e. physically removing it from the aquatic environment. It could be possible that achieving a higher N:P ratio may not only reduce P levels and therefore eutrophication, but may also

increase the integrity of a system by favoring for or against certain communities. Cyanobacteria are known to fix atmospheric N, so are unaffected by a low N:P ratio in water and can outcompete other species. Cyanobacteria blooms can be toxic as well as contribute to low DO levels as the blooms die off both of which are extremely detrimental to fish populations.

The study area focused on Minnow Pond and Fish Fry Lake. Minnow Pond has an area of 500m2 with an average depth of 1.2m. The northern edge of the pond is shallow and dominated by an expanse of cattail and bulrush species. Feed water for Minnow Pond comes from two sources; Irrigation Spiral, a 60-mile irrigation canal off the Yellowstone River, and South Creek, a surface flow stream that meanders through agricultural lands pumped from a collection basin through the Boxcar Ditch (figure 1). Both feed waters have high nutrient concentrations and would be considered eutrophic. South Creek is consistently rich in N, while the irrigation spiral is high in P. Both the waters suffered from low dissolved oxygen levels and high algal growth.

The goal of this study was to:
1. Increase dissolved oxygen (DO) levels in both waters,
2. Determine if the addition of N fertiliser reduced P levels,
3. Reduce phosphorus concentrations by cycling it into minnow biomass, and
4. Note changes in the ecological community.

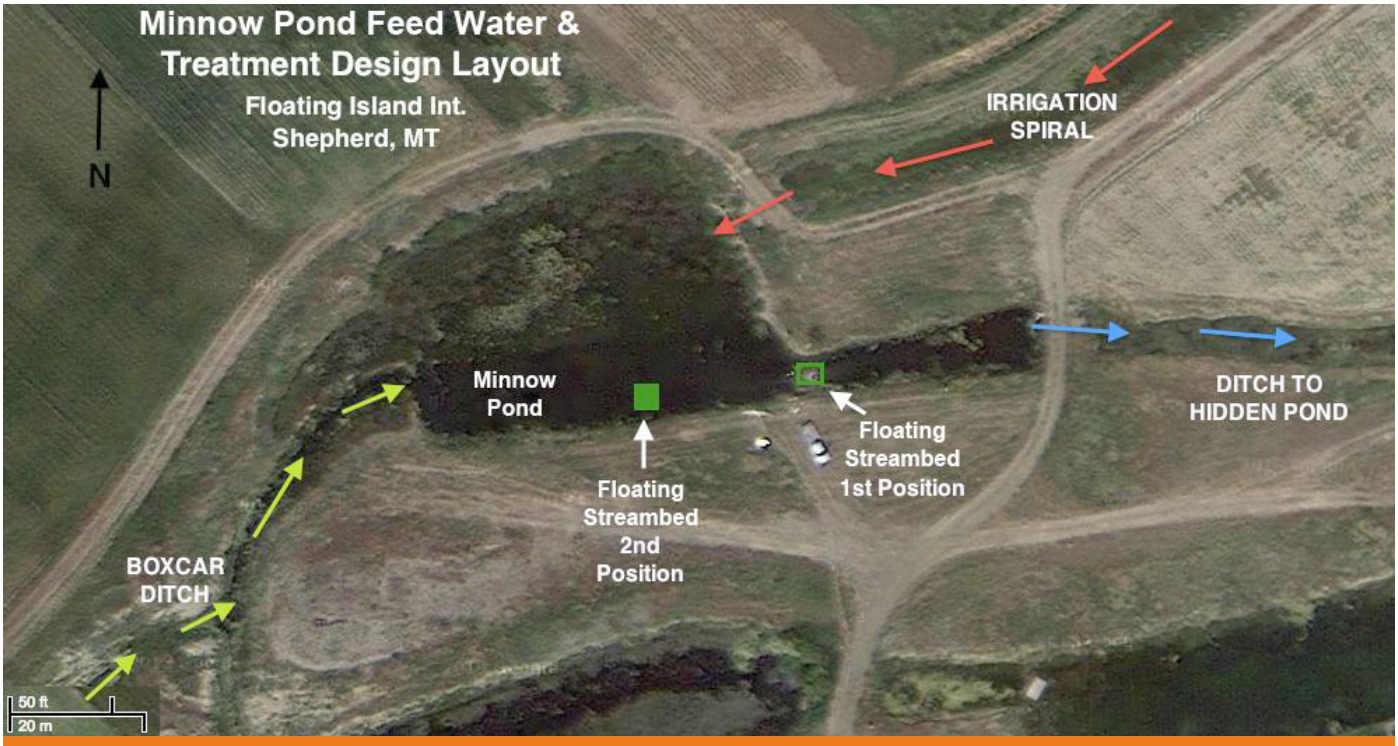

Figure 1. Aerial view of Minnow Pond and feed water sources.

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Method

A small floating streambed, including a newly designed air diffuser, blower unit and deflector plate, was installed at a narrow area on the east side, where the water flows out of Minnow Pond, however the location was changed to the middle of the pond to promote aeration and circulation in the brush park, and to reduce the chance of a potentially harmful anoxic or anaerobic zone being created.

A brush park was installed using approximately 1,000lbs of black cottonwood (90%) and Russian olive (10%) brush and branch material positioned in the deeper, open water section in the middle of Minnow Pond.

Minnows were chosen for the study because they feed upon periphyton, they spawn frequently and prolifically. Minnows were collected in traps and quantity measured in a bucket (Figure 2). These were then transferred to nearby Fish Fry Lake.

On August 1st, addition of granular urea fertilizer (46-0-0 N:P:K) began via the floating streambed.

DO, N and P were measured every weekday. N and P were measured with a Hach spectrophotometer.

Figure 2. Minnows captured in Minnow Pond.

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Results

After installing a floating streambed in Minnow Pond, higher dissolved oxygen (DO) concentrations were maintained than previously observed. Average DO levels exceeded 4 mg/L and levels did not drop below 2 mg/L.

Fertiliser addition did not consistently increase N levels or decrease P levels.

In less than six months, in excess of 54,000 minnows equating to 520 pounds of minnows and 4.7 pounds of P (based on an estimated 0.9% P content in minnow biomass) were harvested between June and November 2013, a 6 month period.

The brush park and floating streambed created a much more active ecosystem in Minnow Pond, in terms of vegetation, insects, minnows and invertebrates. The floating streambed stabilised the oxygen content of the pond, allowing more complex ecological relationships to develop and increasing the diversity of the system.

The minnows were transferred to fish fry lake to feed larger predatory fish including yellow perch, crappie and bluegill as well as used as live bait, permanently removing nutrients from Minnow Pond. These larger fish were also recreationally harvested cycling P out the water as the fish were processed as dog food and the offal processed into fertiliser.

References

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Cleveland, C.C. and D. Liptzin, 2007. C:N:P stoichiometry in soil: Is there a “Redfield ratio” for the microbial biomass? Biogeochemistry, 85:235-252.

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