Growing Fish

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In a 75-gallon aquarium, not far from my desk, we have a fathead minnow that is easily twice as large as any other fathead I've ever seen. That's saying a lot, since I grow this species of minnow in volume. Last year for example, we engendered, grew and harvested some 145-thousand of them.

The average life span of fatheads is two years, but this individual is now at least five and a half years old. It weighs 29 grams or about seven times the average weight of a fathead.

Fish are unlike mammals in that they continue to grow as long as they live, barring health or adverse environmental conditions. So right away, to grow terrific fish they must be allowed to live well for an extended time. Now combine this with good genetics, low stress, and lots of optimal food and minerals, and you are on the right path. With fish, Omega 3 content of their feed is particularly vital. Fortunately, their natural food is normally high in this vital fatty acid, so, as long as their natural food is plentiful and is not manipulated away from Omega 3 content, we are right in the middle of the right path.

Good genetics are fundamental, and represent a huge potential. Think of the advances around many forms of animal husbandry, like whitetail deer for example. Today there are whitetail that can grow racks greater than 250 inches… in their second year. The average buck experiencing its second autumn in northern Wisconsin might have been a forked horn, or frequently just a spike, with eight or nine inches of horn, in those far away days of my youth. Now with selective breeding some whitetail bucks are exceeding trophy horn status - I've even heard of 300-plus inches happening - in their second year!

Five year old, one pound 11 ounce northern yellow perch. Deep coloration and extremely high growth rate demonstrates health connected with biodiversity in Fish Fry Lake."

Here at Floating Island International's headquarters, which is also my home, we have several test site water bodies. Fish Fry Lake and Minnow Pond are focused on demonstrating how many pounds of fish we can engender, grow and harvest, without commercial feed or fertilizer. Today Fish Fry Lake is probably the most productive wild fishery in the state, based on water bodies over 50 acre feet. The lake is 6.5 acres and averages between 8 and 9 feet in depth, so contains about 54 acre feet of water. We average a harvest of 8,000 fish. The harvest also serves as a crude form of genetic selection. It's based on a slot limit, where small fish are kept and larger fish are released. This results in an average weight of harvested fish of a little less than 3 ounces each, and works out to a harvest between 26 and 27 pounds per acre foot of water. The genetic selection process could be improved If all of our fish were from the same hatch, the very same age class. But this isn't achievable in the wild, natural setting of Fish Fry… not without a real-time age identification ability. But even allowing for the happenstance strategy of our genetic selection system, we are gaining. Older age-class fish are beauties. Wonderful, chunky, brilliantly colored specimens, with excellent growth rates.

We can't find any lakes or ponds in Montana of over 50 acre feet that produce a harvest of even ten pounds. In fact, we can't find any that do five pounds per acre foot of water.

A young, deeply-colored, chunky largemouth destined to change the panfish demographics of Fish Fry Lake

On Fish Fry Lake we can grow fish biomass at what appears to be a high level. But we are talking about growing terrific, trophy fish. So what else has to happen here? Basically, we want to maintain that growth volume but reduce the numbers of fish. In other words, maintain or expand our slot limit harvest system.

Here are other components of our management, call it stewardship, that we employ on Fish Fry Lake. These relate to the "low stress, optimal food and minerals, and high Omega 3 level" component of our management system:

- As noted with the fathead, we allow fish to live long and prosper, to borrow a phrase from Mr. Spock. This factor has many nuances. For example, we attempt to limit predation on the large, presumably older age class fish. An example of this is that apex predator fish, like northern pike or musky, have not been introduced into FFL. And good security cover for fish against cormorant or pelicans or mergansers or mink or otter is provided by floating islands and specific forms of aquatic vegetation.

- To prosper, the fish should have an optimal environment. My sense is that this can vary, but will always include biodiversity, which spells numerous natural food sources, excellent security cover, as well as excellent conditions for our specific types of fish to acquire food, like ambush cover for largemouth bass, or a chara understory for northern yellow perch, or fresh water sponge colonized BioHaven floating island matrix for red ear sunfish, or suspended brush for yellow perch spawning structure. The list goes on and on…

Fresh water sponge, a filter feeder, has colonized this thick island on Fish Fry Lake. Eventually plant roots will add to the habitat biodiversity.

- As many grow-days as possible, as in days within a temperature zone that is ideal for health and growth of that fish. Floating streambed embodiments of floating islands are used to homogenize our water's temperature. The system is an extremely efficient way to pull water from any depth, to de-stratify it, and maintain it at the surface for a designable period, and in the process extend grow days within that optimal temperature zone. The system also insures for optimal aeration in both late winter and late summer, and in the process reduces stress.
- Optimal dissolved oxygen levels, to induce consistent high level feeding activity and growth. The key location at which dissolved oxygen is critical is the lake bottom. A diatom-based food web, particularly diatom-based periphyton, provides this. So Fish Fry Lake is productive from top to bottom, unlike standard eutrophic waterways that can go anoxic or even anaerobic in their stratified bottom zone.

- Surface area and targeted circulation to enhance for biofilm and ultimately diatom based periphyton dominance in the lake. This is vastly better than designing for green or other forms of phytoplankton. The target is a waterway that is not short-circuiting. All nutrients are cycling into appropriate biota. The stacking up of any nutrient in the lake's bottom sediment would eventually spell disaster, as could a massive algae bloom. And note that every layer of biofilm provides all three of the microbial forms required to complete nature's nitrogen cycle.
- Elimination of limiting variables or conditions. This might include pH modification, for example. I'm not certain about this one, but it feels right. On the other hand, the world record muskellunge came from Chippewa Falls Flowage, with a pH of around 5. That's low, but it did not prevent a world record fish. Another key limiting variable is sunlight in deep water. At least low light at depth allows for those diatoms, a form of phytoplankton. And this form of phytoplankton is much less stressful than the green and blue-green forms, primarily because it transitions, it lives and dies over time, instead of in an extreme, short, boom/bust cycle.
- Supplementation of the lake's forage fish population with native species of minnow… from Minnow Pond. Similarly, excess aquatic vegetation is cycled into worms and night crawlers, autotroph to heterotroph, which are also fed back into the fish population.

We can tell when our strategy is working two ways. First, we do this by tracking the concentration of nitrogen and phosphorus in our inflow and outflow water. (1. We also track what form the phosphorus is in, which is super critical. Phosphorus in mineral form must cycle into an autotrophic form of life, ie. Plant life. We target diatoms here. While phosphorus in an organic wrapper must cycle into a heterotrophic life form, like biofilm generating microbes, or zooplankton or invertebrates or fish. These forms of life are highly appropriate, but require circulation/aeration.) When the outflow water is at low or non-detect levels, against high inflow rates, this means that nutrients coming in on the inflow side are staying in the lake. It also means that we are doing right by our downstream neighbors, and not gifting them with nutrient polluted water.

The second way is obvious… we can sample and measure growth rates of our fish. We do both of these things on FFL.

Minnow pond is uphill from FFL. And here we amp up the experiment. The pond is only about 5,400 square feet, and averages about four feet in depth. We engender and grow fathead and brook stickleback minnows here. Last year, for example, we harvested a bit over 420 pounds of minnows from this half acre foot of water. That translates to a rate of 840 pounds of forage fish per acre foot of water, a much higher rate of production than FFL. There are two explanations for this.

First, the minnows and sticklebacks are at least one full trophic level below the game fish species in FFL. Every time a nutrient and its organic wrapper cycles through a trophic level, 90% of the energy, the carbon, associated with it stays behind. And the reverse is true. So what we believe this boils down to is that you can grow at least nine times more biomass by operating with a lower trophic level species. Another way of saying this is that your water should grow nine pounds of bluegill, for one pound of largemouth.

There is another component to our thinking going on here too. Our inflow nutrients, the ones we are being gifted with by our up-watershed agricultural neighbors, can be very high - so high that if left unchecked, they'd result in massive algae blooms. So we want to turn this nutrient pollution into "lemonade", and lots of it, in the form of forage fish that will become mosquito control agents, because they voraciously consume mosquito larvae, and also can be fed into FFL, where they supplement the existing population while also cycling into game fish.


The periphyton growth on deciduous brush is key to growing high volumes of minnows…. Minnow Pond in background.

The second means by which we achieve this massive cycling of nutrients out of Minnow Pond's inflow water is by employing what's called Brush Park aquaculture. This is not the stacking of dead Christmas trees that we've all heard about or seen, or done for that matter. What we do is position aged deciduous brush, usually willow in our case, horizontally in stacks along Minnow Pond's shoreline and intermittently in open water. Biofilm grows on this brush, and biofilm is sticky. Suspended solids present in the nutrient-rich pond water stick to the biofilm and form periphyton. And the minnows, as well as a host of other critters, graze the periphyton. They also consume some of the host of invertebrates that make periphyton their home. Meat and potatoes. The deciduous brush will break down over time, and adds to the periphyton growth. Ultimately it adds to fish volume, as long as the other fundamental parameters are maintained, like dissolved oxygen levels, which are critical in this high oxygen demand setting.

When you combine high levels of nutrients with lots of carbon in a shallow water setting, there will be terrific demand for dissolved oxygen. Regular run-of-the-mill aeration isn't enough to keep dissolved oxygen levels in their optimal range, even for tolerant species like fatheads. We know this because we've

The circulation generated by this small floating streambed's airlift system provides critical aeration in Minnow Pond's high oxygen demand environment

tried it. We've tested and experimented. Today we circulate Minnow Pond's water with a floating streambed. Given the same horsepower of vertical aeration, the unique floating streambed performs admirably, while vertical aeration fails consistently.

In Minnow Pond we do everything else noted in the seven bullet points above, but we've added the Brush Park/forage fish combination. And the result is massive minnow production, some of which will supplement FFL's game fish production. And again, note that we add no feed to either Minnow Pond or FFL. We simply steward nature's food web, and those free inflow nutrients from up watershed. The result is the water that leaves Minnow Pond and FFL is progressively cleaner than inflow water.

A study was run at Mississippi State University by a student of Dr. Wes Neal. The study tracked fish production in a controlled setting. All ponds were fertilized. The pond with the largest floating streambed, which covered 2.3% of its surface, generated 19.9% more fish biomass. The study concluded that this was a significant growth differential, but was expensive relative to cost.

The floating stream bed on Minnow Pond covers 2.4% of the pond's surface area. One third of the minnows harvested from this pond last year were sold to a single retail account, and paid for the pond's floating streambed, the power it used all year, and a handful of floating islands employed as spawning habitat (fatheads attach their eggs to the underside of floating islands) in the pond.

FFL has two floating stream beds operating on it. They combine to cover just 0.8% of the lake's surface area. And recall the relative fish production in both of these waterways. But note that we do have some small floating islands operating on Minnow Pond, and a variety of floating island designs on FFL. They provide key spawning and security habitat, as well as ambush structure for largemouth bass, as well as shade cover. In Minnow Pond the islands only add another 0.1% of coverage of the pond's surface area, while in FFL islands cover an additional 2.5%.

There is another component to our fish growth strategy. This one is really exciting and fun. What we do is search out both existing and new environmental parameters that can influence fish growth, in both directions: what can cause optimal fish growth, and what can stifle fish growth.

Here's what this looks like: tracking optimal fish production in oligotrophic lakes in the Beartooth Wilderness, where over 300 lakes with fish occur. Or diving and sampling along the edge and underneath naturally-occurring floating islands in Chippewa Flowage, where that world-record musky was taken. Or interviewing fisherman on that same flowage, to determine why 72% of them spent 90% of their time fishing the perimeter of these floating islands, as compared to open water.

We want to build on this data set. That's why I've written this article, and shared some of the specialized information we've gleaned from our research. I hope that those of you who have read to this point will consider sharing your information, anecdotal or otherwise. Let's call it the Fish Fry Lake Challenge. Let's look at mesotrophic and eutrophic, and even hyper-eutrophic ponds and lakes, and find out where the optimal fish production is happening. Let's compare the environmental parameters connected with all of these. Maybe… MAYBE… we can glean some new insights into fishery enhancement. Please don't be put off by our emphasis on wild fish. Feeding or other manipulation of the food web is simply another environmental parameter to consider.

At a Fish-a-Thon held on Fish Fry Lake in September 2016, fifteen kids caught 879 fish in five hours from a wide range of age classes.

In late September of 2016 we held a Fish-a-thon on Fish Fry Lake. Fifteen kids from a local academy oriented around learning challenges fished for five hours. They raised nearly $10,000. They caught 879 fish, from a multitude of age classes. Some of the fish would have been considered trophies by any of us.

There's something else going on here. For the last 50 years, we have been steered away from our water. We have learned to fear it. We don't trust that our fish can be safely eaten. And we've been told that catch and release is what sportsmen, and women, do.

Here's a different message…we can and will and must clean up our water. And catch and keep, especially these young fish that are safer to eat than older ones in which toxins can bio-accumulate, is a natural and wonderful component, or tool to remove those pollution causing nutrients. Many of us must learn to come back to fish in our diet, because harvest of fish is among the best ways to fix nutrient impaired water.

Montana is now experiencing zebra mussels. Yellow perch and some forms of sunfish prey on mussels. Enhancing for such fish where the mussels are invading, and up watershed from where the mussels are happening, could be another form of lemonade. Remember that maxim…that biodiversity results in health.

There's another factor too. As I review the "footprint" of our efforts here at Shepherd, it's clear that our input energy is dramatically less than when this property was farmed conventionally. There is a lot less tractor time on this 340 acre property than in the past. Yet our protein production is actually higher now than when the property was growing sugar beets and corn. This bears examination. Let's ask the question…how do we sustain on this planet in the face of burgeoning population growth? My sense is that healthy fish populations can serve as a marker, a canary of sorts, that help us track our success as stewards. After all, what is the relationship between healthy fish and healthy water? Consider this statement…"you don't fix water in hopes of resurrecting the food web…you resurrect the food web in order to fix water." (2. Provide surface area and circulation to engender biofilm, and launch nature's wetland effect.)

Indian Paintbrush is a very specialized form of perennial flower. There will be a variety of insects that vector with this broadleaf plant, resulting in added biodiversity.

These are truly exciting times. Our quality of life hinges on water, and we have the science. We can steward for clean, clear, hyper productive water. Water with the pristine qualities we associate with oligotrophic, and yet the productivity associated with eutrophic. (3. Transition Water, cite the TEDX talk) We can go well beyond simply enjoying our water again!

I know there are many other experimental strategies going on across the country, targeting new, world record fish, particularly oriented around largemouth bass. I know of a lake in Wisconsin oriented around extreme walleye enhancement too. My request to all of you is that you reach out to me. Let's share what we know, anecdotal and science based. I welcome opportunities to share what we have learned and continue to learn, and I hope that you do too. So reach out.