

Yesterday Carl and Jeannette joined us for a dinner of frog legs and green beans, with tart pie cherries in cream for dessert. Just this morning Anne and I did the walking tour of a local farmers' market, and I noticed tart pie cherries, not as nice as our home-grown, unpitted, selling for \$8/lb. Who can guess what price frog legs would have commanded? Last night after dinner the four of us flailed away with small wet flies, and caught 42 bluegill, crappie and a couple perch, mostly on a red and yellow #16 wet fly pattern Carl had thrown together. This was Anne's first time with a fly rod, and she caught several fish. She's an accomplished spin fisher person so no one was unduly surprised.

Two days ago Pat, our research assistant, photographed a big buck mink downstream from the outflow of dry pond, moving through a cattail patch where the week before, half a dozen magnum bullfrogs were in the habit of basking. We hadn't seen the frogs for a few days and were guessing that some predator was vectoring with that spot. Mink as effective frog predator makes perfect sense. Bullfrogs are an invasive here in Montana and as is normal around invasives, they've been enjoying a free ride until the last several years, where between humans and our bedazzling ten volt spotlights combined with super sharp gigs, and blue herons, raccoons, bull snakes, leather back turtles, and even yard-long garter snakes, some predation is evolving around this new species.

Dry Pond is a section of our spiral wetland, and represents our effort to duplicate Brush Park Aquaculture, as described in Azim's Periphyton compendium. Today, literally anywhere on the pond, any open water is crowded with five-prong stickleback or fathead minnow fry. I've never seen such concentrations of fish before. The nutrient source driving this productivity is non-point nutrient laden water...from farms upstream. Pat, with some help from Frank Stewart and Mark Reinsel, consultant engineers, actually tracks nutrient inflow and outflow, and now we can see that the ratio of phosphorus to nitrogen is out of balance. This means that unless we respond by correcting the imbalance we will bias the waterway



towards the several life forms that can maintain productivity in the face of nutrient imbalance...like a cyano bacteria form of blue green algae. We can see this unfolding in front of us daily as a carpet of algae builds along the perimeter of Dry Pond, only held in abeyance by a baby Leviathan, just 120 square feet of floating streambed driven by a one hp air blower. Within two days of turning the Leviathan off, based on grim past experience, every minnow in Dry Pond would be dead and mouldering, and adding to the organic accretion on the pond's bottom. With the Leviathan and additional inflow/circulation via another water source, we have backup in

case of breakdown...we have redundancy of a sort. Unlike last year. This year our Brush Park appears to be coming to fruition, and in a way, for me, represents a breakthrough in my personal understanding of how to fix water in the face of human-induced nutrient pollution. Literally, we intend to grow and harvest as much fish as we have excess nutrients with which



to do so. The trick is to grow fish instead of some form of toxic algae.

Four days ago John Green, a retired professor of Biology from New



Zealand was visiting with his wife, Rita, who is a choral and orchestral conductor. Rita and Anne have a long and rich history around classical music.

John also is an accomplished oboe player. When the three of them were not talking, performing music, or playing ping-pong, John was with me exploring Fish Fry Lake. At one point we were flat on our bellies, lying on a BioDock adjacent to the underwater viewing tank watching clouds of water fleas, a cousin of daphnia, swarming in and out of the tangle of roots protruding from BioHavens positioned against the walkway. Or we were in the viewing tank observing schools of bluegill and crappie, with the crappie undulating in and around BioCoral, with its newest form of biota in display, a tawny colored form of freshwater sponge, renowned for two things...remarkably high levels of built-in circulation associated with its life strategy, and high water quality. John noted that the sponge, which is actually a very basic form of animal life, is even more adept at water filtration than oysters or other shellfish.



This sponge is another lesson for me. It's saying that our stewardship efforts are not going unnoticed...by the natives...so to speak. We have taken Fish Fry Lake from a water clarity of fourteen inches to as much as nineteen feet. We have maintained dissolved oxygen at high levels, top to bottom in this thirty foot deep pond. We have engendered an incredibly productive wild fish fishery, with no artificial feeding. In

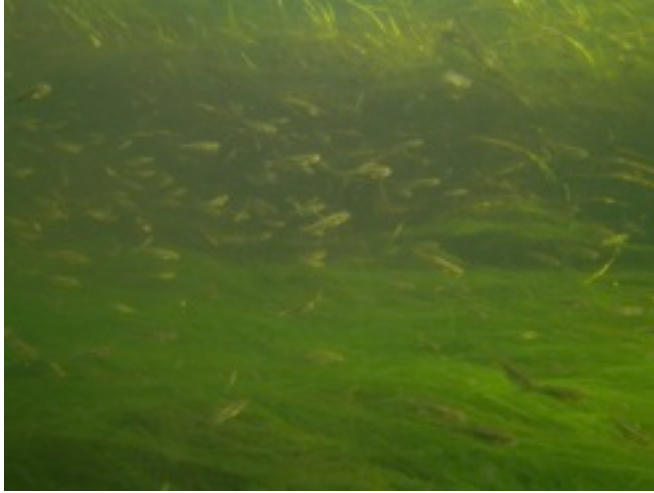
fact, last year the 6.5 acre lake yielded over thirteen hundred pounds of fish, and this year it's on track to exceed that number by another eight hundred pounds. And the sponge, which is colonizing our islands and BioCoral, is one more marker that we are in an upward spiral.



Six days ago Pat and Rob harvested fish. They were lent a hand by Leela O'Dea, a visiting water ecologist from England. They gathered up 228 fish between two funnel nets and fish retained in a live well. The live well fish had been caught via hook and line as part of a nature experience for kids that happened earlier that day. Pat and Rob released eleven large breeders, and gutted, scaled and dried the rest. The guts are also dried in advance of being aerobically digested and then incorporated into a fish tea concept we are

developing. The fish, which represent our primary means by which to harvest phosphorus, are also being developed into a canine treat. This fish harvest system happens twice a week, and we are averaging a bit over four hundred fish a week currently. We purposefully harvest fish between one and two years old, because they represent the easiest way to harvest phosphorus.

At the beginning of last week, what with this being about midway through the growing season here in Montana, we reviewed our nutrient cycling strategy for the water that flows through this property...about 134 million gallons per year. The science indicates that we are on track to cycle about 28 pounds of phosphorus out of our water, against an inflow volume of 11 pounds. What's harder to track is the inventory of phosphorus that's accumulated in the bottom of Fish Fry over the years. Unlike nitrogen, which ultimately gasifies and becomes the largest component of earth's atmosphere along the way, the primary way phosphorus cycles out of water is in the form of a living cell. And fish, especially the bony fraction of their bodies, represent by far and away the most concentrated form of phosphorus. Per John, fish bones can have as much as 25 times as much phosphorus in them as does fish flesh. Last year for example, 1320 pounds of human-harvested fish came out of Fish Fry, which yielded 13 pounds of phosphorus. We also harvested 38,700 pounds of algae, northern milfoil, and chara, as in plant material, which yielded 5.5 pounds of phosphorus. Accordingly, this year we are focussed on the concentrated phosphorus opportunity, as in fish, which has the added benefit of being a lot more fun than weed harvest.



Yes, we are in an upward spiral. But even with all our measurements, it's guessey to predict how many years of excess phosphorus harvest are ahead of us. But there are other paybacks along the way. I don't know of anywhere in Montana where wild fish are caught so readily. Everyone catches fish, even three year olds! And because of our slot limit/age class harvest strategy, there are some monster perch and black crappie to be had, with bluegills coming on strong. Bob Lusk asked me at one point why I didn't introduce a serious predator fish...to help with harvest of small fish.

Well, there's largemouth bass present, so they are coming. We have seen the occasional small bass, and suspect they found their way here along with bluegill, probably in irrigation runoff water. It will be extremely interesting to track whether we can maintain our phosphorus uptake numbers in the presence of other large predators like largemouth, if and when they take hold. The science suggests that it will be harder to do so, as every time you move up a trophic level, efficiency of nutrient cycling reduces. This means that bass, their manure, their natural mortality, essentially their lack of efficiency relative to nutrient conversion, may reduce our ability to cycle phosphorus out of Fish Fry.



I also snorkel and dive the water frequently...and the clarity means I can become part of the waterscape and see what's happening. It's to the point that the bluegill (which have to be closely related to piranha!) have actually taken to at first just nibbling, but lately actually biting me, usually when I'm vertical in the water and they can approach from behind. In fairness maybe they justifiably suspect I'm the guy behind this "fish harvest" program?

Maybe the best feature of being in this upward spiral is that I'm beginning to understand how the dots fit together. Between hundreds of experts, people like Jim Bays, Chris Tanner, Al Cunningham, Terry Wearmouth, John and Leela, most recently, not to mention Bob, our own esteemed Pond Boss, along with lessons direct from the source, direct from the natural systems that happen here at Shepherd like the sponge, a person can't help but learn by convection.