Experiments from Shepherd's Pond

by Bruce Kania

Picture farm ground in Montana. Pine buttes off in the distance. Yellowstone River bordering the south side. Mountains to the west, just on the horizon. This is reasonably flat ground where agriculture, mostly sugar beets, corn, wheat, barley, alfalfa and cattle are raised. The soil profile averages about three feet of clay loam which lapses into sandy cobble for about another twelve feet. Then it transitions to Bear Paw shale, which happens to hold water up pretty well. Of course, any water that perks that deep tends to pick up a salt load along the way, since this whole region was once an inland sea. But the salt's not too bad, maybe 1500 parts per million. Cutthroat trout, perch and crappie don't mind it a bit!

I remember reading a Pond Boss article, maybe it was a "pondmeister to Bob" query, suggesting that it would be great if he could organize his pond so that every depth zone in the pond held fish that appreciated the corresponding temperature zone. Cold, oxygen-rich water on the bottom for cold water fish. Warm water on top for warm water species. Then when the seasonal transition happens the fish adjust accordingly. This way the pondmeister's entire pond produces fish. Sounded like a reasonable idea to me!

It was about this time I was filling a 6.5 acre pond here at the farm, near Shepherd, Montana. We had filled it and flushed it twice already with available irrigation water. Why flush it? It seems that our intense regional farming practices can result in surges of nutrients. The Bear Paw shale probably contributes to the problem by preventing these nutrients from perking deep into the ground. Nutrients can be a good thing, but not when they combine with carbon and, in the process, use up too much dissolved oxygen. When we filled the pond the first time, the top six feet had as much as 6.4 parts per million dissolved oxygen, which wasn't too bad. The problem was the temperature of this water that August was 88 degrees. The trout I was hoping to stock won't tolerate water over 80 degrees. Yellowstone Cutthroat are even more demanding and require water no warmer than 75 degrees. The water below six feet was much cooler at 59 degrees, but only held slightly over 3 parts per million of dissolved oxygen. Cutthroat cutoff is 6.5.

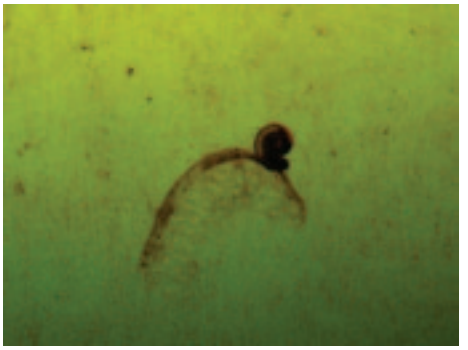
So you can see the problem. Plenty of cool water but it's stratified, just like almost every other pond in the nation. Trout would cook on top, suffocate below.

This is the observation blind with a window toward the bottom of it in 11 feet of water.

Why flush it?

What's a pondmeister to do?

I tried aeration first. Vertical aerators didn't seem to touch the problem. There must have been some mixing, but I couldn't measure it. I also tried stretching out horizontal aerators. Same thing. Barely noticeable mixing. So I flushed the pond a second time, thinking that these nutrients must have built up an inventory and maybe I could flush them out. I've heard new ponds are normally very productive at first, and then taper off over time. Maybe this nutrient build-up happens elsewhere, too? But with repeated measurement, it turned out that nutrients were still present. They occur in surges, probably connected with farm fertilization schedules. And yes, the nutrient overloading problem does happen lots of other places too. It can result in the premature aging of a lake, otherwise known as eutrophication,



Periphyton and algae grows on the observation window 11 feet deep. Here, a snail makes its way across the window, feeding.

or even hyper-eutrophication in extreme cases. When enough of these nutrients hit the ocean, a dead zone can result. Currently over 390 of these dead zones have been identified in marine settings, but you can bet there's lots of dead fresh water - water devoid of enough dissolved oxygen to sustain fish - upstream from these oceanic sites as well.

About this time, I had the honor of hosting guru pondmeister Bob Lusk. He was here to check out our floating islands and offer some thoughts on how they might work for fish. We spent some time brainstorming about what was

1) The Yellowstone River borders our land on the south. 2) The 6.5 acre research pond is connected to a wetland and provides some fun recreation.

going on with excess nutrients in the 6.5 acre pond. I remember being with Bob in a canoe on our 2.5 acre wetland that drains into this bigger pond, getting a lesson in underwater macrophyte identification. And maybe it was some of Bob's Irish luck rubbing off, but since then that pond has been producing northern yellow perch pushing two pounds! Anyway, I expressed to Bob that "wouldn't it be great if a pond could generate good numbers of desirable, fast growing fish without a feeding program. And wouldn't it be great if the water was clear! Think swimming, snorkeling, diving, and actually being able to see where you're going!" Bob was cautiously optimistic. This little wetland had clear water, with over eight feet of visibility based on a Secchi disk reading. Perch had gotten into the pond through a pump with a one eighth inch screen in front of it so they were either eggs or fry. Since the pond was only five years old when we started catching perch, the age group with fish weighing up to 1 lb, 11 oz had been growing at a good clip, something like a half ounce per month. This little wetland was the inspiration for the concept of growing fish in clear water!

Now I need to provide just a little background on what we do here at Shepherd. Our job is to research and develop around a few different

concepts. The main idea we work with is technically called Floating Treatment Wetlands. For short, we call them floating islands. Sort of as a perk connected with this research, we have lots of scientific measurements happening around these islands. For instance, we have an underwater viewing window, the bottom of which sits eleven feet deep. If you read the notebooks stacked in this viewing tank you can pretty much chart my thinking about what it is that kicks off the food web in this Montana setting. Here are a few bullet points out of "lessons from the window":

1. Every minnow species in our pond - fatheads, creek chub, lake chub, stickleback and brassies - graze periphyton off the acrylic window. Perch up to eight or nine inches also eat periphyton regularly. Periphyton is a blend of biofilm, which is microbes and their residue, and whatever sticks to it, like phytoplankton. It's the scum you see on rocks, and which we tend to slip on when we set foot. The window grows a diatom-based periphyton and trust me, it is meat and potatoes for these minnows. Incidentally, diatoms are sort of a crossover life form...actually a phytoplankton that, unlike regular algae, doesn't need sunlight. We have a floating island growing pumpkins, of all things, positioned above the viewing tank that blocks any light that would otherwise make it down eleven feet. But the point is that almost everything eats this periphyton, with the exception of crappie and trout. But then, they eat the minnows that eat the periphyton.

2. Snails are a constant on the window, also eating trails through the periphyton. Three different varieties of them, and it doesn't take a shellcracker to eat them...our perch eat them too. In a nearby lake upstream, one of these varieties of snails is associated with waterfowl disease, so the idea of something that can provide at least some predation on the snails is certainly welcome!

3. Here in Montana we don't seem to have any native fish that can filter-feed on floating algae. We don't have Tilapia, and I'm trying to keep carp out. So without something, hopefully something big, to graze phytoplankton, it can monoculture into a huge bloom with the corresponding impact on dissolved oxygen. From the window, the green of phytoplankton is there all the time. We aren't going to stop it, and we don't want to. We just want to make sure that it's not getting a free ride, that it's competing with periphyton. So the idea of filtering the green water through islands and other forms of surface area provides a way to catch this algae and connect it in a form that allows it to be eaten...periphyton again. Incidentally, when this happens near the surface, like on an island, it's a veritable scud factory. When you look at the critters that grow in this periphyton and their concentration, you can see the food web unfolding.

4. The window makes it clear, pun intended, that phytoplankton is a primary cause of low visibility in the pond water. By moving some of this phytoplankton right along the bus to become periphyton, we improve water clarity.

The research pond at Shepherd is also a place of enjoyment.

Floating islands are designed to take their share of excess nutrients from our water at the research center.

Over the last fifteen months, water clarity has gone from 14 inches to nearly 11 feet. Incidentally, this means that solar energy can now make its way far deeper into the pond, and cause even more growth to happen. Of course, as many pondmeisters know, this needs to be stewarded. We don't want a monoculture of algae, or a monoculture of any other form of plant life.

5. Fish growth in the pond over the last fifteen months has been measured. It looks like the same high rates are happening as occurred in the upper wetland. Another way of saying this is that we appear to be converting the free nutrients supplied from local farmers into fish.

Recognizing that this is an experiment in progress, we are optimistic. But, by now you're probably wondering just what we've done? And no, this is not an advertisement for floating islands. In truth, they are a component of the plan, but that's it, they are just one of the tools. What we did, in a nutshell, and thank you Bob for being a cog in this wheel, is that we have figured out how to airlift nutrient rich, cool water from a targeted depth into and through concentrated surface area, which is a primary limiting variable for periphyton. In the process we accomplish three things...we add some dissolved oxygen, we homogenize water temperatures, and we position these latent nutrients to move through the food chain. So, getting back to the beginning of this story...the pond that at one time could not sustain even brown trout, is growing Yellowstone Cutthroat. Even at the peak of summer, we had at least twelve feet of water that was concurrently below 75 degrees Fahrenheit and above 6.5 parts per million of dissolved oxygen. In addition, the pond is growing crappie and perch at a ferocious rate. Three year old crappie spawned successfully this year and average over six inches. Growth rate on perch looks good. Some of the oldest age group from the 2.5 acre wetland just upstream have made their way into this pond and, based on nothing other than eyeball estimation, again through the viewing window, appear to be in the neighborhood of 2½ pounds. This fall we are doing formal fish aging and growth measurement on all three species, including the trout.

There has been one other development that has me scratching my head. Literally, since the day we introduced a thousand 7-9" cutthroat into the pond, no minnows of less than three inches in length appear in the window. Before that they were regulars, even in the face of the big perch. I've heard that brassies tend to disappear in the presence of game fish...I mean they just look tasty, sort of like a 9F gold Rapala. But their remarkable and complete apparent departure has me amazed. There are huge numbers of lake chub and creek chub, mostly near shore or weed beds. But, with minnow traps positioned all around the pond, we just aren't finding the stickleback or any brassies, except in an inflow culvert and the outflow culvert. Just sticklebacks there. It's really hard to imagine that a few hundred 9 inch trout could make such a difference. My theory is that they may not have been consumed, but they may have simply exited stage left through the outflow culvert which was partially open at the time. Another theory is that they are still here, just hidden in some of the more dense weed beds. Maybe other pondmeisters have experienced this sort of thing in the past and solved the mystery?

Doggone it, pen's running out of ink! Those details about just how we destratify the bottom water and perch it on top so it gets aerated, and in the process move those wonderful nutrients through the food web, I guess I'll just have to go out and buy a new pen. Will probably get that done about the time we have those fish growth measurements in hand this fall.

Bruce Kania is a scientist and inventor with a passion to help figure out what to do with nutrient-laden waters. He's the inventor of floating islands produced by Floating Island International. He's also a darn good table tennis player. He can be reached at bruce@floatingislandinternational.com