The Role of Fish in Lake Management

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Do Fish Matter?

Are fish an important component of lakes? The quick answer is that it depends on your perspective, if you are an angler the answer is an unqualified yes. If you are a lake visitor or resident who doesn't fish, the answer might be no. If you are a lake manager, the answer might have been maybe historically but these days most lake managers would say that the answer is yes.

Traditionally, fisheries managers looked at lakes as a place to store an inventory of fish, the goal being to keep the inventory steady through natural reproduction or stocking as anglers take fish out or to create new "products" for anglers by introducing new fish species that anglers might like to catch (Figure 1). Limnologists and lake managers often looked at lakes from another perspective, as mixing bowls of water and nutrients, where what goes in must balance what accumulates plus what goes out. Out of this soup grew some algae and aquatic plants and maybe a few zooplankton or bugs. Fish had water quality requirements for temperature and oxygen but were of little consequence in terms of their influence on lakes.

Over the past several decades, the fisheries and water quality folks have gotten together to figure out how water quality might influence fish and how fish might influence water quality. This led to some interesting research suggesting that the nature of the lake dictates the type and number of fish present and the type and number of fish present can dictate the nature of the lake. In other words, we now know that fish are a critical part of the living system of lakes.

Figure 1: A stringer of piscivores from the past. Today many more anglers release large fish which helps keep fish populations in balance.

Types and Roles of Fish in Lakes

Despite the experiences of some anglers, nearly all lakes have some fish. There are a few exceptions but they are rare and are special cases that warrant their own article. Fish in lakes can be divided into a few general groups that roughly match up with where they live, where they feed, what they eat, and ultimately, what their role is in the lake ecosystem. Benthivores dine predominantly on insects and insect larvae in the sediments, on sediment directly, or on plants rooted to the sediment. Bullhead, sucker, and carp are all examples of benthivorous fish. Herbivorous fish, such as grass carp, eat aquatic plants. Planktivores feed primarily on free swimming zooplankton in the water column. Often these fish are found in the middle of the water column (pelagic) and are not associated with the bottom or shallow water near the shore. Examples of planktivores include alewife, threadfin and gizzard shad, and golden shiner (Figure 2). Piscivores are the top predators. They feed on other fish including planktivores, benthivores and young piscivores. Examples include bass, pike, walleye, and musky (Figure 3). Many piscivores will even eat their young if the opportunity arises. In some work I

Figure 2: The golden shiner, a common planktivore in many lakes and ponds. Note the small mouth that is adapted for eating small prey.

did in graduate school in Peter and Paul Lakes on the upper peninsula of Michigan it was common to find young-of-the-year largemouth bass in the stomachs of juvenile bass and juvenile and young-of-the-year bass in the stomachs of adult bass. We never found the "trifecta" of a bass in a bass in a bass but I'm sure it occurs.

It is important to note that fish often take on different roles in a lake as they grow: early life stages may be planktivores, middle life stages may be benthivores, while adults may be piscivores (Figure 4). Even among these groups there are few fish who dine exclusively in one area or on one type of food (like humans) although the early life stages may eat almost all one staple item like zooplankton, the chicken nugget of the young fish diet (Figure 5). A simplified food chain in lakes is shown in Figure 6. The simplified food chain in lakes links fish with nutrients through a series of "middlemen" or mid-trophic levels. It makes sense that changes in one level in the chain can cause changes to cascade through to other levels in the chain. In general, the closer the levels are to each other in the chain, the stronger the influence of a change. We know that an increase in nutrients leads to more algal growth at one end of the chain in lakes. We also know that an abundance of planktivores (think bait) can grow some large piscivores (think dinner) at the other end of the chain. But does one end of the chain influence the other? The answer is that "it depends."

Figure 3: Smallmouth bass are a critical piscivore in many northern lakes.

Are Fish a Result of Management or the Tool?

Traditional lake management has focused on nutrient management to control unwanted aquatic plants and excessive algal growth. Along the way, some of these nutrient control measures have lead to changes in upper trophic levels, all the way to fish. This is called "bottom-up" management of lakes and associated fish populations where management is focused on the bottom of the food chain, the supply of nutrients. The connection between nutrients and fish is bolstered by the observation that the best "fishing" lakes are not necessarily the clearest or nutrient poor but rather, are those lakes that have a moderate or high level of nutrients. The effect does not continue forever; ever-increasing nutrients does not equal ever increasing numbers and size of fish; there is a limit. Once nutrients get very high in a lake, other factors related to eutrophication such as

Figure 4: An introduced rainbow trout that acts as both as a planktivore and a piscivore at times depending on what food is available.

Figure 5: Smaller members of the sunfish family, commonly called "panfish" include rock bass (red eyes) and bluegill. These fish are primarily planktivores and benthivores when young but will eat fish when they get large.

low dissolved oxygen, high ammonia, and water clarity start to negatively influence fish abundance (Figure 7).

The other approach to lake management is called, interestingly enough, "top-down" management. Carpenter et al. (1987) demonstrated the influence of top- down control of planktivores by piscivores and associated changes throughout the food chain in nutrient-poor north temperate lakes. Changes in the balance between piscivores and planktivores resulted in cascading effects down through the food chain to nutrients and algae. The basic premise is that the piscivores eat the planktivores, leaving less of them to eat the zooplankton. The increased zooplankton population eats more algae, which changes the way nutrients are transported and stored throughout the food chain. The trophic cascade hypothesis was then tested in more nutrient rich temperate lakes (Kitchell 1992; Mills, Forney and Wagner 1987; Dettmers and Stein,1996). Sometimes an effect could be seen, sometimes it could not. The bottom line from this later research is that the more productive the lake, the more difficult it is to see an effect all the way down through the food chain by changing the fish population. The cascading effect is generally not seen when certain resilient species of fish like gizzard shad are present (Dettmers and Stein 1996).

So how do we apply some of these concepts to lake management? In lakes and reservoirs, the goal of influencing water quality can theoretically be accomplished by manipulating nutrients or any of the components of the food web; however, the farther the trophic level is removed from the component or trophic level to be managed the stronger the manipulation must be to effect change. Likewise, the higher the nutrient concentration, the bigger the fisheries manipulation needs to be. In other words, you need a big stick. Traditional lake and reservoir algal management has focused on "bottom up" approaches that seek to influence algae and other primary producers through the management of sources of limiting nutrients (Cooke et al 2005). These approaches remain as essential parts of management plans aimed at problems associated with excessive growth of rooted plants, attached algae, and phytoplankton. These approaches should still form the basis and the primary focus of management plans for most lakes.

Control of nutrients still represents the best opportunity to reduce the frequency, intensity, and duration of periods with excessive algal growth. The techniques of biomanipulation (changing the food chain as Shapiro [1975] first called it), which serve to change the amount of biomass at various levels of the food chain by changing the fish community, may be helpful in keeping lakes "in balance" or accelerating recovery from excessive nutrient loading. It is possible that a carefully conceived biomanipulation project may result in a

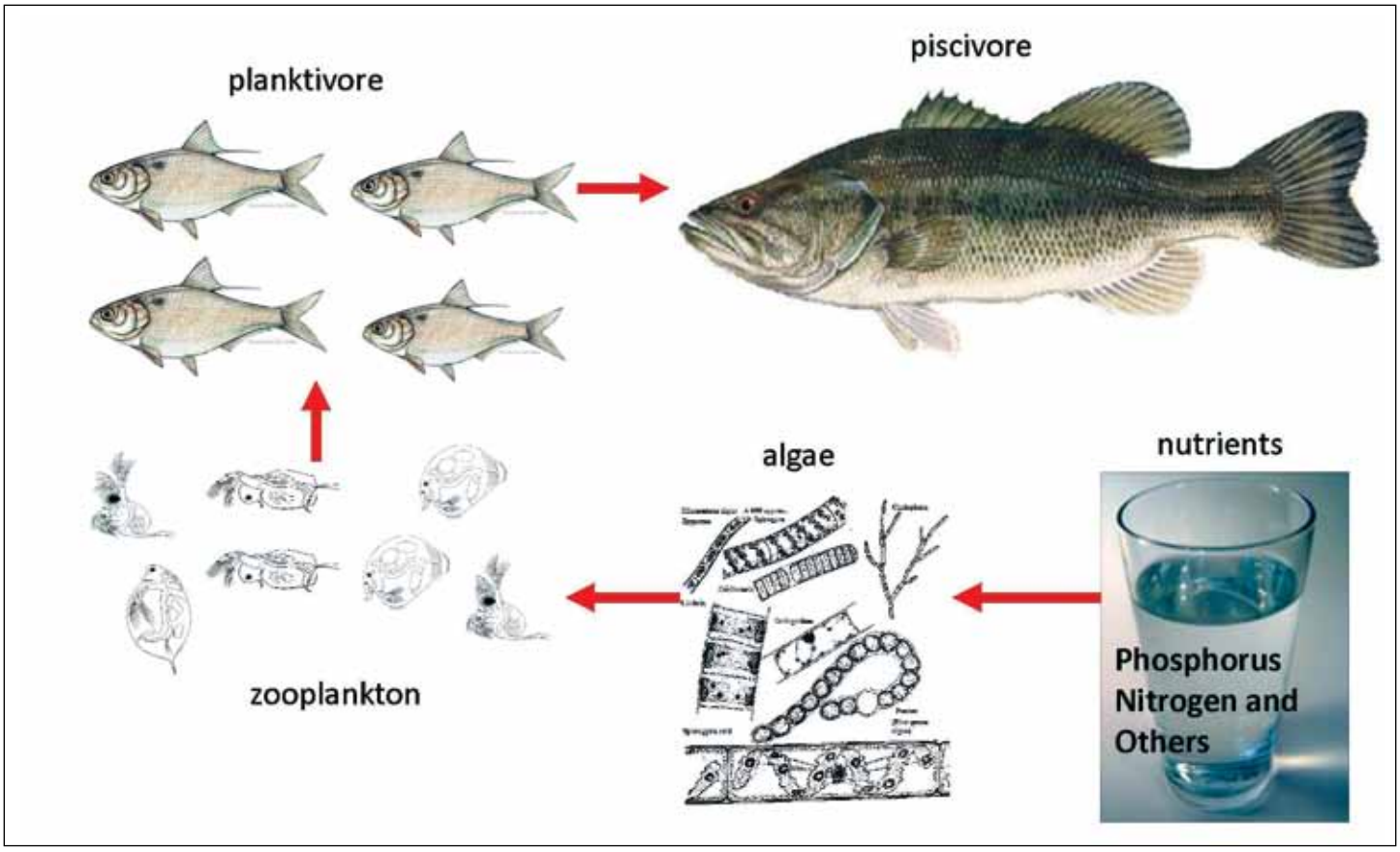

Figure 6. A simplified food chain in a lake.

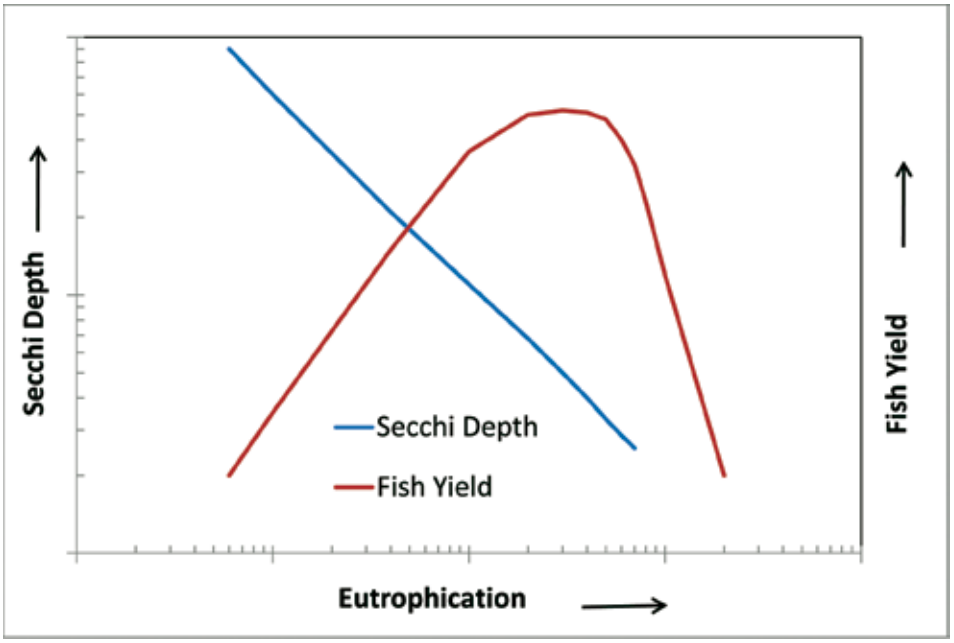

Figure 7. The influence of increased eutrophication on Secchi disk transparency and fish yield (adapted from Holdren et al. 2001).

lake that grows fewer algae per unit of nutrient loading. The most commonly used manipulation designed to control algae involves a reduction in the biomass of planktivorous fish. Control of planktivores is typically done either by selective removal of the planktivores or by increasing the abundance of piscivores either by stocking or through regulation of fish harvest. A side effect of biomanipulation is that the fishing for large fish may get better, so everybody wins.

Final Thought

Many people look at lakes with little thought as to what is below the water's surface. The fact that most award-winning photos of lakes include a reflection of the sky in the lake surface reinforce the notion that a lake is defined by its surface and not what is below. One thing anglers always knew and lake managers now appreciate is that there are fish down there…and they matter. Fish are not only nice to have in lakes but are essential to the healthy functioning of our lakes, and can play an important role in lake management.

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Don Kretchmer asked his father one day while fishing on a lake in central Ontario if he could ever make a living doing this sort of thing. His father replied, "Absolutely not!" So began his pursuit of a career working on and messing around in lakes. Don is a Certified Lake Manager with over 25 years of experience in watershed, nutrient, aquatic ecology and fisheries issues in lakes and rivers. He works for AECOM from an office in Wolfeboro, NH. In his spare time he is very active in the Lake Wentworth Association and is an avid sailor, skier, and fisherman. He can be reached at donald.kretchmer@aecom.com.