Impact of the Falls Lake Impaired Water Quality Classification on the Reservoir's Fish Populations

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Introduction

Falls of the Neuse Reservoir (Falls Lake) is a 12,410 acre impoundment of the Neuse River located in Wake, Durham, and Granville counties in North Carolina. The project was designed to provide water supply, flood control, recreation and wildlife benefits. After completion of the dam in 1981, the lake quickly established a reputation as an excellent place to fish. The largemouth bass population especially was recognized as outstanding both by scientific collecting conducted by the North Carolina Wildlife Resources Commission (NCWRC) (NCWRC, unpublished) and in the popular sport fishing industry magazines both regionally and nationally. However, the reservoir's close proximity to the heavily urbanized Raleigh/Durham area was recognized early as a threat to the lake's water quality and its water supply mission. Changes in the lake's water quality in the decades since the dam was completed are well documented and justify those early concerns. The North Carolina Environmental Management Commission classified the lake as Nutrient Sensitive Waters in 1983 to limit phosphorus inputs and listed the reservoir as impaired for chlorophyll a in 2008. The North Carolina General Assembly intervened in 2005 and again in 2009 directing the Environmental Management Commission to make improvements in the reservoir's water quality. The lake's current water quality condition and status as a drinking water supply are updated by Dr. Burkholder elsewhere in these Proceedings.

As concern over reversing the long term water quality decline in Falls Lake intensifies, there is little information suggesting a concurrent decline in resident fish populations. Recent NC Wildlife Resources Commission studies (Rundle, pers. com. and NCWRC 2007) suggest quality largemouth bass and crappie populations are still present in the reservoir. Craig Holt (2012) with Game and Fish Magazine includes Falls Lake in his article entitled "7 North Carolina bass hotspots you don't want to miss" and Hall, Jones, and Blitz (2012) rank Falls Lake 44th in the nation in their Bassmaster Magazine article "100 best bass lakes". The purpose of this paper is to review some broad concepts relating water quality and fish population health in reservoirs in generally and Falls of the Neuse particularly.

What does a classification of "impaired waters" mean in North Carolina?

North Carolina state government's Division of Water Quality uses a surface water classification system that is based on a best use principal. Water supply, swimming, and fishing are examples of best uses. The system recognizes that the water quality characteristics that best support drinking water uses may be different from the water quality standards which best support fish populations and those differences are reflected in the state standards (http://portal.ncdenr.org/web/wq/ps/csu/swstandards). Most of the public concern about water quality at Falls Lake is driven by public health issues related to drinking water supply and water contact activities like swimming or water skiing.

A water body is declared "impaired" when the appropriate water quality standards as determined by best use classification are violated. For example, Class C waters are designed to protect aquatic life (among other things) and by definition include a limited amount of exposure to human skin. The dissolved oxygen standard for lakes is 5 ppm. If urban runoff and sewage effluent inputs (to name a few possibilities) dropped dissolved oxygen levels to 3 ppm, the stream would be classified impaired. Water bodies classified for water supply for humans generally have more protective standards. Failure to meet some of the more restrictive standards for water supply waters at Falls Lake may not impair aquatic life.

Nutrients and fish production in reservoirs

Much of the basis for fish production in southeastern United States reservoirs is related to population levels of green algae and diatoms found in lake water. Green algae and diatoms are found at the bottom of a reservoir food chain that eventually supports popular sport fish like largemouth bass and other top predators. In a principal directly demonstrated by farmers applying fertilizer to corn crops to increase the size of the harvest, single celled green algae may respond to those same nutrients (usually nitrogen or phosphorus) added to a reservoir from sources within the lake's watershed.

Rodriguez and Olmsted (1993) found the absolute abundance of most fish species in North Carolina and South Carolina reservoirs increased with increasing nutrient loading, especially phosphates. Yurk and Ney (1989) were looking at southern Appalachian reservoirs and found the same phosphorus based links to fish production and speculated water pollution abatement programs may sometimes hurt fish populations. Finally, Siler et al. (1986) found a gradient of nutrients in Lake Norman that was highest in the upstream end of the reservoir and lowest near the dam. This is a common occurrence and predictable since the primary source of nutrients in most reservoirs is the upstream river. The more significant finding was fish production varied along the same gradient, highest up lake where the nutrients were high and lowest

down lake where the nutrients were most scarce. These studies suggest a rationale for the simultaneous presence of healthy fish populations and water quality concerns in Falls Lake. It happens when nutrient loading increases to a point that threatens drinking water quality but not fish health.

How can reservoir fish populations thrive as nutrient levels increase? The answers are complex, but one factor is the scale of nutrient input. In the study reservoirs cited above, nutrient levels had not reached levels catastrophic to fish populations, but there are upper limits. Nutrient loading can increase until undesirable algae like blue green algae and their fish toxins or filamentous algae that modify habitat become more predominant. At high enough densities even the normally beneficial green single cell algae can affect water temperatures and dissolved oxygen, limit visibility for fish that are visual predators, and modify habitats in other undesirable ways. Until those upper limits of nutrient inputs are met, little change may be observed in fish populations.

Selection for more pollution tolerant fish in reservoirs

Fish species also vary in their tolerance to the threats excessively high nutrients and other pollutants can pose in reservoirs. In a river free of dams, the native fish have adapted over long periods of time to successfully use the variety of habitats available. Some are ecological specialists like darters (Etheostoma sp. or Percina sp.) that live in a very narrowly defined habitat within a certain kind of riffle and have limited mobility and very specific diet and reproductive requirements. Others are generalists like largemouth bass or channel catfish that can live in a wide variety of river habitats both deep and shallow, quiet water or flowing, over many types of river bottom. Generalists are usually highly mobile, can exploit many food sources, and can reproduce successfully in a variety of habitats. Dam construction selects for ecological generalists that are often also hardy and pollution tolerant.

The process of impoundment selecting for more hardy species is certainly true for Falls Lake. The NC Division of Water Quality (2006) stream fish community assessment ranks many of the fishes of North Carolina as pollution intolerant, intermediately tolerant, and tolerant. Most of the Centrarchidae species in Falls Lake (including several species of sunfish, black and white crappie, and largemouth bass), the white bass and white perch, blue and channel catfish, and gizzard and threadfin shad classified as intermediately pollution tolerant. Longnose gar, bowfin, grass carp and common carp, white catfish and several species of bullhead catfish, and green sunfish are categorized as pollution tolerant. None of the Falls Lake fish are on the pollution intolerant list. Also, the NC Wildlife Action Plan (2005) identifies 25 fish species and 17

kinds of freshwater mussels as species of conservation concern in the Neuse River basin. None of those species are found in Falls Lake.

Pollution "buffering" in reservoir systems

Reservoirs generally provide more stable environments for fish than rivers and streams. Short term variations in flows can create extreme water quality and fish habitat availability fluctuations in streams that are then muted in large downstream reservoirs by the sheer volume of water impounded. In reservoirs, dilution can be the solution to some forms of pollution. Silt that is so devastating to aquatic biota in upstream rivers often settles out of the water column when it reaches slower moving impounded waters, filling in shallow upstream reservoir locations to the benefit of down lake locations. Chemical contaminants like heavy metals can be bound in the silt in streams then lost to the substrate in reservoirs. Again, down reservoir locations are protected from contamination.

While these examples of mitigating characteristics of reservoirs may reduce the impacts of pollution on reservoir fish communities, they are not fail-proof systems. Raise the pollution inputs ever higher and all reservoirs will eventually experience physical and/or chemical changes in fish habitat. While there is currently little evidence of degraded fish populations in Falls Lake, the possibility remains that worsening conditions could cross a threshold and create unwanted changes in fish populations. The key to good water quality and healthy reservoir fish populations is good upstream basin land management that keeps pollution inputs at levels that can be assimilated.

Are we sure Falls Lake fish populations are unaffected to date?

Earlier, we cited recent fisheries data collected by the NCWRC and anecdotal from outdoor writers to contend that largemouth bass and crappie populations in Falls Lake are healthy. The NCWRC conducts spring electrofishing for largemouth bass mid-fall trap netting to sample crappie. Samples have been conducted at least once every three years since the reservoir reached full pool. Sampling locations are distributed throughout the reservoir. Biologists measure the length and weight of all fish collected before they are released back into the reservoir. The data provide size distributions and a surrogate index of fish health created by the ratio of a fish's length and weight. A small sample is sacrificed to provide an age distribution for both species with each sample. Age and length data specific to each fish are combined to determine fish growth rates. The number of fish caught each year is sometimes used as an estimate of fish abundance.

There are a multitude of factors that affect fish abundance, size distributions, body condition (length/weight), and age distributions and they vary annually. Healthy populations of fish are characterized by length distributions that indicate fish are present from the smallest to the larger sizes common to older fish. The age distribution should demonstrate all year classes from young fish to older fish are present. That affirms successful annual reproduction. Starved, sick or diseased fish will have poor body condition while healthy well fed fish will have higher body conditions. NCWRC biologists have looked at the period of record data for crappie and largemouth and concluded that these criteria were met in recent samples and no undesirable trends are evident or confirmable.

Fish often respond to changing dissolved oxygen concentrations and pollution concentrations in an all or nothing fashion. There will be little change in fish health over a large range of concentrations until just before a lethal threshold concentration is passed. At that point, sub-lethal responses like weight loss, reproductive failure, or poor growth rates might occur. When the lethal threshold is passed death for most members of the population will follow quickly.

If declining trends in water quality are causing recent subtle changes in crappie and largemouth bass populations it is unlikely those changes could be identified and positively assigned to water quality degradation and not other more usual sources of variation in the data. Burkholder (in press) stated that the current water quality issues are worse in the upper half of the reservoir and moving downstream. It is even less likely that subtle negative changes in the fish study parameters up lake and down lake could be detected and assigned with conviction to the recent water quality history.

Neither sampling effort examines the contribution of bass and crappie to the larger fish community. If there are shifts in the relative abundance of the different fish species in the lake, it would go undetected.

Conclusion

Water quality declines in Falls Lake are threatening the City of Raleigh with the necessity of developing a more expensive raw water treatment process to obtain its drinking water. Fish populations are buffered from these declines because Falls Lake is populated by hardy pollution tolerant fish species and water quality degradation has not yet threatened lethal threshold concentrations for fishes for any of the water quality parameters. Existing NCWRC data and recent anecdotal stories from outdoor writers indicate that largemouth bass and crappie populations in Falls Lake are in good condition. Those data are not comprehensive and are incapable of measuring short

term subtle changes in fish populations in specific regions of the lake from water quality should they exist or attribute those changes to water quality degradation or other causes. Good land management in the Neuse Basin above and around the reservoir is necessary to reverse the declining water quality trend. Successful restoration of Falls Lake water quality to meet its designated uses will more than safeguard the reservoir's fish community.

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