DETERMINING IMPACTS TO AQUATIC BIOTA FROM RESERVOIR RELEASES

Colleen Cunningham[1], E. Aylin Lewallen[2], and James F. Renner[3]

AUTHORS: [1]Environmental Scientist, [3]Geologist, Golder Associates Inc. 3730 Chamblee Tucker Road, Atlanta, GA 30341. 770-496-1893. Ccunningham@golder.com, [2]ENTRIX, Inc. 621 North Avenue, NE, Suite A-125, Atlanta, GA 30308. 404-881-5355. Alewallen@entrix.com.
REFERENCE: Proceedings of the 2003 Georgia Water Resources Conference, held April 23-24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Golder Associates Inc. (Golder) monitored the biological community in the Conasauga River in northwest Georgia for seven years to determine if it was adversely affected by releases from Dalton Utilities' River Road Reservoir. Twelve Federally protected mussel and fish species inhabit the Conasauga River, and identifying and quantifying impacts to rare aquatic species has been extremely challenging.

Review of the data collected throughout the seven-year study showed that there were no impacts to the aquatic biota as a result of reservoir releases into the river. In addition, our review showed that some data sets were more useful than others in assessing impacts and that some methods did not produce useful data. For similar projects in the future, Golder recommends intensive monitoring at fewer locations, collecting physiological data (length-weight) in addition to population numbers for fishes, careful habitat affinity correlation, and quantitative habitat mapping when attempting to identify impacts to extremely rare aquatic species.

BACKGROUND

In 1992 Dalton Utilities received a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers (USACE) to build an off-stream impoundment that would discharge into the Conasauga River during periods of low flow to allow for withdrawal for public water supply 11 miles downstream. Because of concerns raised by the United States Fish and Wildlife Service (USFWS) during the permitting process, a special provision was included in the permit for monitoring of the Federally protected species and associated habitat in the Conasauga River.

Golder has monitored the biological community in the Conasauga River since 1995, but intensive monitoring did not begin until 1997. During this period, there were reservoir releases in 1999 and 2000. It was assumed that if there were any impacts to the protected fish species, the affects would be apparent within one life cycle (approximately 2-5 years for the protected fish species in the Conasauga River. Therefore, Golder analyzed data collected from the 1995-2001 to assess any trends over time in the water quality, aquatic community, and habitat conditions in the Conasauga River.

METHODS

Thirteen sampling stations were set up along an 18-mile section of the Conasauga River in northwest Georgia (Figure 1). Six of these stations were located upstream of the reservoir discharge point and seven were located downstream. Stations were located in areas with riffles that could provide potential habitat for protected fish species. Fish, water quality and quantity, and habitat conditions were sampled at each of the thirteen stations. Benthic macroinvertebrates and algae were sampled at selected stations, while mussel surveys occurred along the entire 18-mile reach.

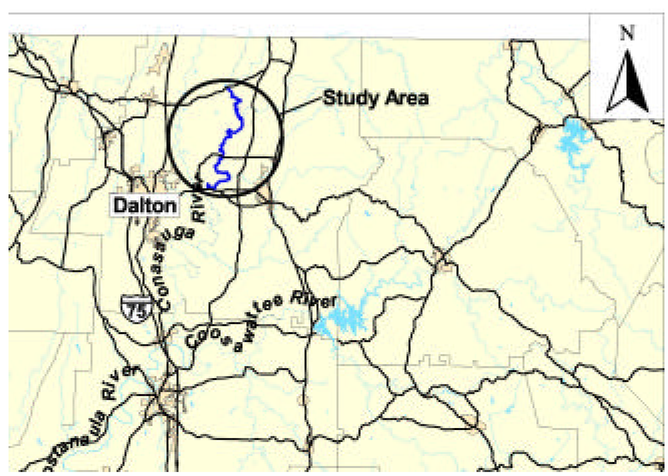

Figure 1. Conasauga River Study Area.

Fish were sampled by seine netting and identified to species. All amber darters (*Percina antesella;* Federally Endangered) and Conasauga logperch (*Percina* *jenkinsi*; Federally Endangered) were weighed, measured, and released. Starting in 1998, length and weight measurements were taken in the field on all darters to gain information on the overall condition of the population. Snorkel surveys were also added in 1998 in an effort to sample Conasauga logperch habitat that was too deep to seine.

Fish habitat was monitored using a variety of techniques. A habitat code was assigned to each seine attempt to show trends in species diversity or abundance associated with habitat type. The codes were designed to capture information on water depth and velocity, substrate size, bed sediment mobility, and aquatic vegetation. Flow velocity was also measured at each shoal. Sketches were made of each survey station every year and photographs were taken at specific locations at each station every year. Water quality parameters were measured at every fish survey shoal and grab samples were collected for laboratory analysis. In addition, algae samples were collected at about half the stations for ash–free dry mass (AFDM) analysis. The survey protocol was changed in 1998 to include survey of the stations using a Wild® Total Station to catalog reach features and to determine the size, amounts, and shifts in movable gravel at each station.

Mussel surveys were conducted in 1995 through 1998 by inspecting potential habitat while wading or canoeing. In 1999 the survey protocol was changed to allow for a more thorough investigation of potential habitat via snorkeling and wading with viewing boxes. Collected mussels were placed in the following categories: 1) live mussels; 2) fresh dead mussels; and 3) relict shells of long dead mussels. Live mussels were identified, measured, and released. The locations of mussels collected were referenced to river miles.

Benthic macroinvertebrates were quantitatively sampled using Surber samplers (1995-1996) and Hess samplers (1997-2001). Collected specimens were identified to the lowest level possible.

DATA ANALYSIS

Fall fish survey data from 1996-2001 were analyzed to detect the impacts of discharges that initiated in August 1999. Three approaches were used to test for impacts on species abundance. First, the data were analyzed using a BACI (Before After Control Impact) design approach (Green 1993). The before impact data (B) from 1996 through 1998 were separated from the after impact data (A) from 1999 through 2001. The six upstream locations were control sites (C) and the seven downstream locations were the impact sites (I). An analysis of variance model was constructed (PROC GLM in SAS version 8.02 software, SAS Institute, Inc.) to test the four main effects: Before/After (BA), Control/Impact (CI), river mile (location), and year. The second approach contrasted abundance of species collected downstream of the outlet after 1999 with samples collected upstream of the outlet during the same period or prior to discharge. The third approach modeled trends in fish abundance at each river mile over the six years and compared average slopes of these trends for BACI effects.

Potential impacts on fish growth and condition were examined using length-weight analyses for selected species of minnows (Cyprinidae) and darters (Percidae). SAS was used to determine if year (before or after discharge) and river mile (upstream or downstream of discharge point) had a significant impact on the length and weight of fishes collected.

Percentage of available habitat was summarized by station and by year. Analysis consisted of determining the diversity of habitat and the presence of habitat preferred by the amber darter, Conasauga logperch, and blue shiner (*Cyprinella caerulea*, Federally threatened). Wild® Total Station data were overlaid by year to show how movable gravel was shifting or aggrading/degrading over time. Water quality data was summarized by year and upstream vs. downstream of the reservoir. The AFDM data were not analyzed in the comprehensive report because of the variability in the data and the lack of complimentary data. Discharge at each sampling station was calculated using field velocity measurements. Reservoir release data were compared to daily discharge data from the Eton gauge to determine the percentage of river discharge attributable to the reservoir release.

Mussel diversity and abundance data were examined separately for the pre-1999 and post-1999 monitoring periods because different survey methods resulted in substantially different results over the monitoring period. Size and frequency data were compiled for the most commonly sampled species and were evaluated separately, both above and below the reservoir.

Benthic macroinvertebrate sampling stations were grouped by location (upstream vs. downstream) and temporally (pre-release vs. post-release) for analysis. Benthic community metrics utilized for comparison include taxa richness, density, species diversity, EPT taxa[1], and the North Carolina Biotic Index (NCBI).

[1] Sum of taxa representing the orders Ephemeroptera, Plecoptera, and Trichoptera.

RESULTS

High variability exists in the fish survey data due to natural variation, such as variable river stage during sampling events. No definitive trends between pre-release (1995-98) and post-release (1998-2001) were evident. Habitat data analysis indicates that habitat is extremely variable for depth and flow regime, vegetation, and streambed mobility. This can be attributed to natural diversity at each station and subjectivity of habitat interpretation. However, the data indicates that habitat for the Federally protected fish species continues to persist at each station.

There were no differences in water quality between pre and post release years and upstream and downstream stations. Discharge data showed high variability, mostly likely due to climactic variability. During reservoir releases into the river, 0 - 52 percent of the river discharge was attributed to the releases. Releases were during the summer and early fall months when the river discharge was typically at the lowest for the year.

Mussel abundance and diversity remained consistent across sampling intervals, and above and below the reservoir. However, mean abundance and combined species diversity above and below the reservoir was greater during the 1999-2001 sampling period than the 1995-1998 period due to changes in collection methods. Differences in diversity and abundance data collected over the sampling periods precluded direct comparison of the data. Sampling results show that mussel diversity and abundance increases dramatically below the reservoir, most likely due to improved habitat condition. Size distribution analysis for 1999-2001 indicates recent recruitment of *Tritigonia verrucosa*, but there are no definitive trends of recruitment of other mussel species.

No significant differences were observed when comparing the number, density, or composition of benthic macroinvertebrate taxa before and after the release, or upstream and downstream of the outfall. This is indicative of the overall biological health and stability of the system.

DISCUSSION

After performing BACI analysis on fish and macroinvertebrate data, analyzing mussel data, and summarizing water quality and habitat data, it is evident that releases from the River Road Reservoir in 1999 and 2000 have not adversely impacted Federally protected species in the Conasauga River or the biological community as a whole. Overall, species abundance and diversity appears influenced by other environmental conditions (i.e., drought conditions since 1998, land use impacts, etc.), which have affected the aquatic community throughout the study area.

Review of the data collected throughout the seven-year study showed that some data sets were more useful than others in assessing the impact of reservoir releases. Habitat affinity and collection effort data helped to understand the natural variation in fish species populations. Length and weight measurements for protected species and key common species, although time-consuming, were felt to be an important indicator of system health. Monitoring surrogate species with characteristics similar to the protected was important because of the low frequency with which protected species were collected. After analysis of the data from 1995-2001, length and weight measurements were added for key endemic minnows in order to provide additional surrogate species data. Blue shiners (*Cyprinella caerulea*; Federally Threatened), although present in the survey collections, were not measured because they are extremely susceptible to scale loss.

General environmental data (stage, discharge, water quality) provided a basis for understanding factors influencing natural variation in populations.

Some methods did not produce useful data. Raw numbers of collected individuals, while obviously required, were not particularly useful for identifying impacts because some species are so rare that they cannot be collected in statistically significant numbers, this is particularly true of the protected mussel species. Snorkel surveys proved to be very time intensive and provide little additional information on habitat preferences because very few individuals were observed. Algae collected for ash free dry mass analysis (AFDM) failed to provide additional information on nutrient dynamics above what was obtained from water quality analysis due to variability in the data and a lack of complimentary data. Extensive surveying was conducted at each station every year; however, precise surveying was never completed for the whole reach and data on channel changes could not easily be compared from year to year. Pebble counts and cross-section surveys were added to the 2002 survey protocol to provide another quantitative method for monitoring channel changes.

The usefulness of mussel data was severely limited because 1) small populations make it difficult to obtain the sample size needed to for statistical analysis; 2) the monitoring period, while sufficient for fish, may not be sufficient for mussels given their longer life span; and

3) direct comparison of post-release data to pre-release data was precluded because of changes in protocol that made it possible to collect more individuals.

RECOMMENDATIONS

When working on projects that have annual sampling events covering a large reach over several years, there will be natural variability in conditions and it will be difficult to set up a sampling design to remove this variability. For similar projects in the future Golder recommends intensive monitoring at fewer locations to provide more detailed information. Physiological data (such as length-weight data for fish) should be collected in addition to population numbers to show potential impacts on growth and condition. The use of common species (with similar characteristics and preferences as the protected species of interest) as surrogates for analysis is recommended in situations where the target species are extremely rare and cannot be collected in significant numbers. Careful habitat affinity correlation and quantitative habitat mapping are essential for monitoring habitat usage and condition. It is also important to consider how changes in protocol during the life of the project will affect your ability to utilize the data.

ACKNOWLEDGEMENTS

The authors would like to thank: Susan Davis and Dalton Utilities; Dr. Byron Freeman, University of Georgia, Institute of Ecology; Dr. Paul Johnson, Tennessee Aquarium, Southeast Aquatic Research Institute; and Wendell Pennington, Pennington and Associates.

SELECTED REFERENCES

Anderson, P.G., B.G.H. Browne. M.H. Hughes, B.J. Freeman and Z.E. Kovats. 1997. Conasauga River Baseline Monitoring Pre-Operation of the River Road Reservoir, Dalton, Georgia. Volumes 1 and 2. Prepared for the U.S. Army Corps of Engineers, Atlanta, Georgia by Golder Associates, Inc.

Freeman, B.J. 1989. Biological Assessment of Endangered Species at Dalton Utilities River Road Reservoir. Prepared for the Department of the Army, Corps of Engineers, Savannah District.

Freeman, B.J. and M.C. Freeman. 1994. Habitat Use by an Endangered Riverine Fish and Implications for Species Protection. Ecology of Freshwater Fish. 3:49-58.

Golder Associates Inc. 1998. Environmental Monitoring Plan for Operation of the River Road Reservoir Including Modifications of September 1998. Prepared for the U.S. Army Corps of Engineers, Atlanta, Georgia.

Green, R.H. 1993. Application of repeated measures designs in environmental impact and monitoring studies. Austral. J. Ecol. 18:81-98.

Kleinbaum, D. G. and L. L. Kupper. 1978. Applied regression analysis and other multivariable methods. Duxbury Press, North Scituate, MA, USA 556p.

Lewallen, E. A., Freeman, B.J. and Johnson, P. 2002. Evaluation of the Biological Community of the Conasauga River from 1995 to 2001. Prepared by Golder Associates for the United States Fish and Wildlife Service.

Scott, M.C., and G.S. Helfman. 2001. Native invasions, homogenization, and the mismeasure of integrity of fish assemblages. Fisheries 26(11):6-15.

Underwood, A.J. 1991. Beyond BACI: Experimental Designs for Detecting Human Environmental Impacts on Temporal Variations in Natural Populations. Australian Journal of Marine and Freshwater Resources 42: 569-587.

U.S Fish and Wildlife Service (USFWS). 1986. Conasauga Logperch and Amber Darter Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 34pp.

U.S Fish and Wildlife Service. 1990. Biological Opinion for the River Road Water Supply Reservoir, Dalton, Georgia, Permit 074 OYN 006911. U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1993. Final Rule: Endangered Status for Eight Freshwater Mussels and Threatened Status for Three Freshwater Mussels in the Mobile River Drainage. 50 CFR, Part 17.