EVALUATING MANAGEMENT NEEDS OF LAKE BLACKSHEAR, GEORGIA

M. E. Lebo[1], H. E. Cofer[2], W. L. Tietjen[3], P. Y. Williams[4], D. Partridge[5]

AUTHORS: [1]Aquatic Scientist, Weyerhaeuser Company, New Bern, North Carolina; [2]Emeritus Professor, Department of Geology; [3]Emeritus Professor, Department of Biology; [4]Lab Technician, Department of Biology, Georgia Southwestern State University, Americus, Georgia; [5]Senior Fisheries Biologist, Georgia Department of Natural Resources, Dawson, Georgia.
REFERENCE: Proceedings of the 2005 Georgia Water Resources Conference, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Lake Blackshear has been characterized for three decades as eutrophic due to high nutrients and low light penetration (i.e. Secchi depth). However, algal biomass and diversity metrics in the reservoir indicate a lower trophic status. In terms of bottom-dwelling macroinvertebrates, annual surveys since the mid-1980s have shown a relatively consistent distribution among major taxonomic groups over time, with individual species that exhibit a broad sensitivity to pollution. Evaluation of limited data on recreational fishery productivity in the reservoir supports lower overall primary and secondary production in Lake Blackshear compared with two other reservoirs in the region. At present, the reservoir appears to be in good ecological health. Future management efforts for the reservoir should balance the potentially competing needs of maintaining current ecological condition of the reservoir and of recreational benefits that may result from enhanced overall productivity.

INTRODUCTION

Lake Blackshear, a hydroelectric reservoir created in 1929 on the Flint River in central Georgia, serves area needs for fishing and other recreational activities. There has also been extensive residential development around the reservoir in recent decades. Since the 1970s, the reservoir has been classified as eutrophic based on high nutrients and low transparency. However, levels of chlorophyll *a* (Chl*a*) in the reservoir are low compared with potential algal production suggested by total phosphorus (TP) concentrations.

This paper utilizes data on water quality, benthic macroinvertebrates, and fisheries collected over the past two decades to evaluate the overall ecological condition of Lake Blackshear. Condition is evaluated in the context of general water quality, ecological health, and the capability of the reservoir to support recreational activities important to the region (e.g. sportfish fishery). This study is of significance to the understanding of the interrelationships among water quality, trophic state, ecological condition, and a strong sportfish fishery.

BACKGROUND AND RELATED WORK

Lake Blackshear is a run-of-the-river reservoir on the Flint River formed by a hydroelectric power station at Warwick, Georgia. Normal operations maintain lake elevation at full pool. In 1992, Crisp County Power Commission estimated annual recreational lake use to be 750,000 person-days. There also are approximately 1800 residences located around the reservoir.

Lake Blackshear was classified as eutrophic in 1973 as part of the National Eutrophication Survey (USEPA, 1975). Of the lakes surveyed in Georgia (n=14), Lake Blackshear had the lowest Secchi disc transparency but also the lowest Chl*a* values. Georgia Environmental Protection Division (GA EPD) in 1981 initiated lake surveys, including calculation of a total trophic state index (TTSI) based on indices of Carlson (1977) for Chl*a*, Secchi depth, and TP. Growing season TTSI values for Lake Blackshear for 1980 to 1993 ranked in the top three (of 27 lakes) for eight of the twelve years sampled (GA EPD, 1994). In these surveys, TSI values for TP and Secchi depth were consistently higher than values derived from Chl*a*. Algal growth control by factors other than nutrients has been suggested in recent years as potential causes for discrepancies among indicators of trophic status (e.g. Kennedy, 2001).

An extensive ecological study of the Flint River / Lake Blackshear ecosystem was conducted in 1983 by the Academy of Natural Sciences of Philadelphia following the 1981 startup of an upstream pulp mill (ANSP, 1984). Results from this study indicated diverse populations at all trophic levels (bacteria to fish), indicative of a healthy ecosystem. *Lyngbya wollei*, a cyanobacterium, was found in several embayments and was noted to have been present for at least 20 years.

EPA, in cooperation with GA EPD, sponsored a Clean Lakes study in 1992-93 to address general concerns about water quality. The study evaluated patterns in dissolved oxygen (DO), temperature, pH, conductivity, Secchi depth, Chl*a*, and nutrients throughout Lake Blackshear and its embayments (LBWA and GSSU, 2000). Water sampling was done as a photic zone composite at each station. Profiles of DO, pH, conductivity and temperature were taken using a Hydrolab Surveyor 3 at one meter depth intervals from surface to bottom. In addition to the monitoring program, special studies were conducted on the diurnal DO pattern, sediment oxygen demand (SOD), algal growth potential (AGP), and the algal community present (see LBWA and GSSU, 2000).

Staff at the Flint River Pulp Mill have conducted regular monitoring of DO and temperature at several locations in the upper portion of Lake Blackshear. The Mill since 1986 has also sponsored annual surveys of benthic macroinvertebrates along four transects in the upstream portion of the lake. Sediment samples were collected along each transect with a petite ponar grab sampler and preserved in the field. Samples were sorted in the laboratory and identified to species or family, depending on taxonomic group (see SWRC, 2001).

Additional water quality monitoring was done in April-August 2001 following Hurricane Alberto (July 1994) and its associated impacts on Lake Blackshear (see SWRC, 2001). Reservoir stations were sampled for general water quality (temperature and DO profiles), collection of a water sample at a depth of 3.3 ft (1.0 m) (for Chl*a*), and measurement of Secchi depth.

Threadfin and gizzard shad estimated biomass from cove rotenone sampling and largemouth bass growth rates from Blackshear and Walter F. George are from Georgia Department of Natural Resources unpublished data. Largemouth bass growth estimates for Seminole are from Brown and Maceina (2002). Black bass catch statistics were obtained from the Georgia B.A.S.S Chapter Federation 2003 Tournament Creel Report compiled by Dr. Carl Quertermus (Univ. West Georgia).

RESULTS

Lake Blackshear, as is typical for southern reservoirs, exhibits seasonal thermal and DO stratification during summer months. Data from 1992-93 showed a vertical temperature gradient of 2-4°C in May through September but well-mixed conditions the remainder of the year. During periods of thermal stratification, DO concentration in bottom waters decreased below values near the surface. Monitoring from 1997 to 2001 showed that deep off-channel sites demonstrated a temporal pattern of DO depletion in bottom waters. Bottom waters in shallow off-channel regions remained 1.5 to 2.0 mg/L higher than in the deeper portions of the reservoir, indicating maintenance of adequate habitat for bottom-dwelling invertebrates despite episodic periods of low DO.

Nutrient concentrations observed in 1992-93 were consistent with prior studies. The growing season average trophic state calculated for TP was >56 (eutrophic range) for all stations (Fig. 1). Algal growth potential (AGP) tests with *Selenastrum capricornutum* were conducted on three dates (7/6/92, 9/13/92, 1/9/93) to evaluate the potential for nutrient limitation of algal growth in the Flint River (L1), two reservoir stations (L3 and L6), and four embayments (Limestone, Spring, Gum, and Swift Creeks). Concentrations of N and P in Lake Blackshear were typically (18 of 21 tests) above levels that may cause nuisance algal blooms (dry weight >5 mg/l). However, TSI values based on either Chl*a* or phytoplankton biovolume (not shown) were more consistent with a mesotrophic classification.

The bottom-dwelling macroinvertebrate community of Lake Blackshear has shown, exclusive of disturbance affected years (1995-97), relatively constant proportions among the major taxonomic groups and total biomass (Fig. 2). In annual samplings, chironomids, *Chaoborus*, oligochaetes and the mayfly *Hexagenia* accounted for a large fraction of the community. The species present in Lake Blackshear exhibit a broad sensitivity to pollution. Several species, including the predominant chironomid (*Coleotanypus*), *Chaoborus*, and oligochaete worms, have high tolerance values and are generally considered indicative of organic enrichment. However, other common taxa are considered sensitive to pollution. Included are the chironomids *Cryptochironomus*, *Pseudochironomus*, and *Tanytarsus* with intermediate tolerance values of 5.4 to 6.8 and *Cladopelma* and *Cladotanytarsus* with low tolerance values of 3.5 and 4.1. Further, the tolerance value of *Hexagenia*, which represents a large fraction of total biomass and abundance is 4.9. Therefore, the community as a whole indicates habitat conditions in the lake promote a diverse assemblage of macroinvertebrates.

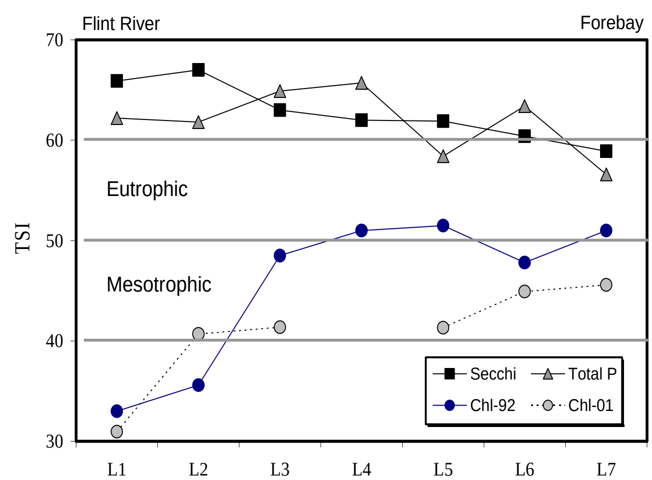

Figure 1. Trophic state index values according to Carlson (1977) based on average values from May-October in 1992. Chlorophyll values are also included for data collected in 2001.

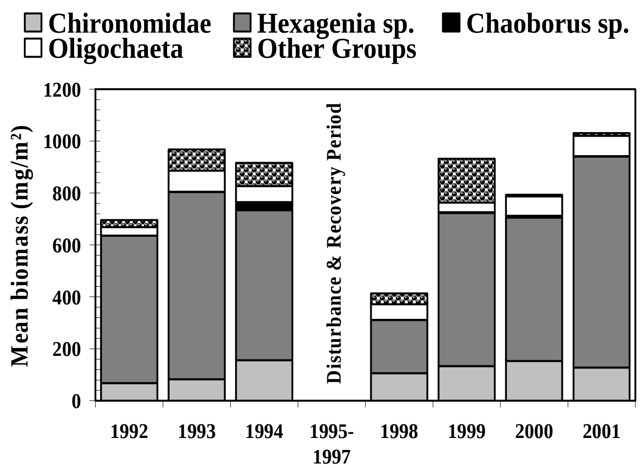

Figure 2. Biomass of benthic macroinvertebrate taxonomic groups in Lake Blackshear by year.

Evaluation of fishery productivity data for Lake Blackshear showed lower biomass of threadfin and gizzard shad than Walter F. George located on the Chattahoochee River and Lake Seminole located downstream at the confluence of the Flint and Chattahoochee rivers (Table 1). In addition, Lake Blackshear had slower growth rates for largemouth bass than Walter F. George and Seminole, and catch statistics in bass fishing tournaments reflected poorer fishing for black bass in Blackshear compared to these other two reservoirs. Average Chl*a* values for each of the reservoirs generally followed the pattern of metrics estimating fish productivity; average growing season Chla was 15.4, 7.5, and 5.4 µg/L, respectively, in Walter F. George, Lake Seminole, and Lake Blackshear based on this study and data collected by GA EPD.

DISCUSSION

The ecological integrity of the Lake Blackshear ecosystem, as a productive southern reservoir, is influenced by both its physical environment and water quality conditions. During the winter-spring months, flow in the Flint River is typically high, which limits algal growth in the system due to short residence time and a well-mixed water column. As inflow to the reservoir decreases in the late spring, algal abundance typically increases, with peaks in Chl*a* >20 µg/l (LBWA and GSSU, 2000). Longer residence time and regular thermal stratification of the water column during summer months are likely key factors in this seasonal algal cycle. The correspondence in Lake Blackshear between peak algal production and warm, stratified conditions can lead to depleted bottom water DO. Monitoring data for the lake over the past several years confirm the episodic occurrence of low bottom water DO concentrations, primarily in drowned river and tributary channels. The duration of hypoxic conditions appears to be controlled by irregular mixing events associated with storms.

Lake Blackshear has been classified primarily through the use of trophic state indices. Carlson (1977) strongly cautioned against using Secchi depth or TP TSIs as predictors for algal biomass in water bodies where there are discrepancies among the different parameters, but rather, he encouraged investigation of causes behind the divergences. For Lake Blackshear, divergence in the different parameters has been consistently observed (e.g. Fig. 1). A classification of trophic status based on algal biomass would show the lake to be mesotrophic. Algal growth potential test data for Lake Blackshear provide support that more than adequate P is present, although not efficiently utilized by algae. Kennedy (2001) and Knowlton and Jones (2000) note algal growth often fails to reach its potential in reservoirs due to short hydraulic retention times and limitation by non-algal turbidity.

Available data on fishery productivity in Lake Blackshear indicate overall fish stocks and largemouth bass growth reflect moderate productivity. When compared to Walter F. George and Lake Seminole, Lake Blackshear has slower largemouth bass growth rates and smaller bass in fishing tournaments (Table 1). Forage fish stocks of threadfin and gizzard shad are also much lower in Lake Blackshear. These differences in the fish populations in the three reservoirs support a conclusion that fishery productivity in Lake Blackshear is lower than in Walter F. George and downstream in Lake Seminole.

Table 1. South Georgia Reservoir Fishery Data.

	Lake Blackshear	Walter F. George	Lake Seminole
Forage fish stocks (kg/ha±SE)			
Samples	4	16	6
Threadfin shad	11.5 ± 3.9	59.5 ±12.9	336 ±256
Gizzard shad	27.5 ±8.4	109 ±14.4	212 ±118
Predicted largemouth bass ages (yr) at length (mm)			
Age at 304 mm	2.59	2.48	2.53
Age at 356 mm	3.81	3.30	3.34
Age at 406 mm	5.33	4.25	4.41
Tournament bass creel mean values (lbs)			
Bass weight	2.02	2.30	2.18
Largest bass	3.92	4.83	4.52
Winning weight	8.13	14.2	10.4

Average Chl*a* values for the three reservoirs generally support this conclusion of lower overall productivity in Lake Blackshear.

A gap in our current understanding of Lake Blackshear is why available nutrients are not effectively utilized. Light availability is certainly a constraining factor, but nutrients are not effectively depleted even in surface waters during periods of thermal stratification. Residual nutrients have been measured in surface waters during summer months despite laboratory assays with reservoir waters that indicated a high potential for algal growth. At the same time, several embayments of tributaries experience extensive growth of the cyanobacterium *L. wollei*. Better understanding the availability of nutrients and factors limiting overall algal productivity in the reservoir are essential to forecasting how future watershed changes may affect the ecology of Lake Blackshear.

SIGNIFICANCE TO WATER MANAGEMENT

Future management efforts for portions of the Flint River Basin draining to Lake Blackshear should consider how the overall productivity of the lake may be affected. Ecological benefits associated with potential actions should be evaluated in the context of maintenance of diverse invertebrate and fish communities while achieving the recreational uses which are an important public benefit from the project. Reduction of nutrient loading to the lake would decrease the potential for development of eutrophic conditions. However, examination of the current algal, macroinvertebrate, and fish communities indicates the potential eutrophic trophic state indicated by measured TP concentrations is not achieved. Further, the absence of reported fish kills and the presence of a healthy benthic macroinvertebrate fauna suggest that excessive DO depletion in bottom waters is of limited importance. Benefits to the Lake Blackshear ecosystem through nutrient controls would most likely be limited to local embayments experiencing *L. wollei* growth and should probably be focused on those tributary drainage areas. At the same time, improved light penetration through watershed erosion controls may lead to higher algal productivity. Evaluation of potential future enhancements to reservoir productivity should be done balancing the likely benefit to sport fishery production and possible changes in the diversity of flora and fauna in Lake Blackshear. Both ecological and recreational needs should be taken into account when developing management objectives for the system.

ACKNOWLEDGEMENTS

Financial support provided for the Clean Lakes study was provided through the U. S. Environmental Protection Agency, the Georgia Environmental Protection Division, the Proctor and Gamble Corporation, and the supporters of the Lake Blackshear Watershed Association. Support from Weyerhaeuser Company and Georgia Southwestern State University is also gratefully acknowledged. Our technicians and student research assistants endured much to make the study successful. Views expressed in this paper are those of the authors and do not represent positions of their respective organizations.

LITERATURE CITED

Academy of Natural Sciences of Philadelphia. 1984. Ecosystem Studies of the Flint River and Lake Blackshear - 1983. Div. Environ. Res., Acad.Nat. Sci. Phil., Philadelphia, PA.

Brown, S.J., and M. J. Maceina, 2002. The influence of disparate levels of submersed aquatic vegetation on largemouth bass population characteristic in a Georgia reservoir. Journal of Aquatic Plant Management 40:28-35.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography. 22:361-369.

GA EPD 1994. Georgia Department of Natural Resources. 1994. Water Quality in Georgia, 1992-1993: Atlanta, GA Georgia Department of Natural Resources, Environmental Protection Division. 99p.

Kennedy, R.H. 2001. Considerations for establishing nutrient criteria for reservoirs. Lake and Reservoir Management. 17(3):175-187.

Knowlton, M.F. and J.R. Jones. 2000. Non-algal seston, light, nutrients and chlorophyll in Missouri reservoirs. Lake and Reservoir Management. 16(4): 322-332.

LBWA and GSSU 2000. Water Quality Conditions in Lake Blackshear, Georgia Prior to the Flood of 1994: The Results of a 1992 Study. Lake Blackshear Watershed Association and Georgia Southwestern State University.

Stroud Water Research Center. 2001. Environmental Monitoring Studies on the Flint River at Lake Blackshear: Population Dynamics of Hexagenia and Other Macroinvertebrates. Stroud Water Research Center, Avondale, PA.

U.S. EPA. 1975. Report on Lake Blackshear, Georgia. EPA Region IV, Working Paper No. 283.