STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-4

Study No.: 681 **Title:** Development of multi-lake management strategies for Michigan's inland lakes

Period Covered: October 1, 2002 - September 30, 2003

Study Objective: Develop a classification system for management of Michigan's inland lakes by determining how and why fish communities - and their response to management practices - vary among lakes (i.e., intersystem variability), along abiotic (e.g., longitudinal) and biotic (e.g., productivity) gradients, as well as across years (i.e., interannual variability).

Summary: Significant progress was made with respect to augmenting the historic fish growth database. Historic fish growth data from a subset of lakes were integrated with landscape context data (developed previously as part of job 2) and macrophyte cover data to investigate the relationship between macrophyte cover and fish growth rates. Plans regarding integration of fish growth data and landscape context data on a statewide scale were refined and analysis is underway. Additional research in Michigan lakes investigated the effects of human development of lake shorelines on features of littoral zone habitat, and on habitat use and growth of littoral zone species.

Findings: Jobs 3, 4, 5, and 8 were scheduled for 2002-03, and progress is reported below.

Job 3. Title: Determine the extent of interannual and intersystem variability in fish population parameters.–Supplemental data acquisition and data entry of MDNR historic growth summaries for the Upper Peninsula occurred during the summer of 2003 after it was determined that there were large gaps in the records for that region. New records from the Fish Collection system were obtained during the summer of 2003 and are in the process of being integrated into the existing fish growth database. During our efforts (including data from the Fish Collection System, the Institute for Fisheries Research in Ann Arbor, and recently collected data from the Upper Peninsula), we have obtained more than 2,950 fish growth surveys spanning the years from 1952 to the present and representing approximately 920 lakes. A final summary of the total number of lakes and surveys will be available upon completion of ongoing data entry. We will use these growth data in future analyses to better understand spatial and temporal variability in fish growth rates in Michigan inland lakes.

In many cases, the historic mean length-at-age summaries represent an analysis of aged fish that comprise a sub-sample of all captured fish. During the past year, we completed analyses to evaluate the assumption that growth estimates from the sub-sample of aged fish adequately characterize the average growth condition or potential of lakes. Using recent data from the Fish Collection System, comparisons were made between estimates derived directly from the sub-sample to estimates derived by extrapolating the subsample to the full sample, using the size distribution of captured fish. The analysis will be summarized in the following manuscript, currently in partial draft form:

Evaluation of fish growth parameter estimates obtained from the sample of all fish collected and the sub-sample of fish collected for age information:

Data: *Fish variables (RESPONSE variable)*– von Bertalanffy growth parameters (ω and L_{∞}).

Data analysis: Growth parameters (ω and L_{∞}) were estimated for bluegill, smallmouth bass, largemouth bass, northern pike, walleye, and yellow perch using non-linear regression for the sub-sample of fish that were aged, considering only those surveys in the MDNR-Fisheries Division "Fish Collection System" where age-length keys may be constructed. Comparison of growth parameter estimates from the sub-sample to estimates obtained by extrapolating ages from the sub-sample to the full sample (using an age-length key) indicated no differentiable bias in using the sub-sample information. Growth parameter estimates varied greatly depending on the range of ages included in the estimation procedure. Work is ongoing to define comparable ranges of ages to include in the estimates for each species.

With the diagnostic work regarding the fish growth data base nearing completion, preliminary analysis of historic growth summaries has begun. Von Bertalanffy growth parameters have been estimated for walleye, yellow perch, bluegill, and largemouth bass. Growth parameters were estimated for all surveys conducted during 1960-1999 where walleye, yellow perch, largemouth bass, northern pike, or bluegill were collected. See Figure 1 for a summary of the number of surveys available per species (note: the numbers in Figure 1 represent the number of surveys to date and will increase with completion of data entry). Findings to date have revealed interesting patterns, and have informed Fisheries Division's ongoing evaluation of statewide fishing regulations.

Job. 4. Combine historic fisheries data with abiotic and biotic data.–Historic fish growth data from a subset of lakes has been used to evaluate the relationship between fish growth rates and macrophyte cover in lakes. Many foodweb interactions among fish are mediated by macrophytes. Since the influential paper by Crowder and Cooper in 1982, the idea accepted by fisheries managers has been that there is an optimal intermediate macrophyte cover for fish growth and foraging in lakes. However, surprisingly few field tests of this idea have been conducted, and those that have been conducted do not yield strong consistent support for the hypothesis. Therefore, Kendra Spence Cheruvelil (a PhD student at MSU) performed a field test of this idea using 39 lakes in Michigan, U.S. Ms. Cheruvelil sampled macrophyte cover at the whole-lake scale in 2001 and 2002 (range of cover = 18-84%). Nancy Nate assessed fish growth in these lakes by calculating length at age for largemouth bass and bluegill using the historic fish growth database and extracting information from the 1990s. Relationships between fish growth for each age class and macrophyte cover were analyzed for the 39 lakes using nonlinear and linear regression. Strong evidence to support the idea of an optimal intermediate macrophyte cover for largemouth bass or bluegill growth rates was lacking. However, for bluegill ages 5-8, there were significant negative relationships between growth and macrophyte cover.

Statewide analyses linking fish growth rates to landscape features and climate will be conducted upon completion of data entry (Job 3). In the meantime, we have made substantial progress detailing our plans for analyses, including exploratory data analyses and database summaries. Water quality and landscape-context databases have been combined in exploratory data analysis efforts (see Job 1 in Project 714, Managing Michigan Lakes: Evaluating Effects of Watershed and Habitat Perturbation on Lake Resources). Below, planned manuscripts and analyses are summarized:

(1) Predicting lake water quality from multi-scaled landscape features.

Data: *Landscape features (PREDICTOR variable)* – Local, subregional, and regional landscape variables (such as: *watershed area, lake area, lake mean depth, ecoregion, lake order/landscape position, groundwater input, lake connectivity to streams, etc.*).

Water quality variables (RESPONSE variable) – Variables such as: *total phosphorus, chlorophyll, Secchi depth, and alkalinity.*

Analysis: Hierarchical linear modeling (multiple landscape features as predictor variables; individual water quality variables as response variables). Each water quality response variable will have its own model developed. Hopefully, an overall model can be determined, but individual models must be analyzed first.

(2) Predicting fish growth rates using landscape and water quality variables.

Data: *Landscape features (PREDICTOR variable)* – Local, subregional, and regional landscape variables (such as: *watershed area, lake area, lake mean depth, ecoregion, lake order/landscape position, groundwater input, lake connectivity to stream, etc.*).

Water quality variables (PREDICTOR variable) – Variables such as: *total phosphorus, chlorophyll, Secchi depth, and alkalinity.*

Fish variables (RESPONSE variable)– Von Bertalanffy growth parameters.

Analysis: Hierarchical linear modeling (multiple landscape features and water quality parameters as predictor variables), and separate models for each fish species-specific growth parameter. The analysis will also be conducted using only landscape variables as predictors to determine if landscape alone can predict fish growth. Then, water quality parameters will be added as additional predictor variables, allowing us to compare the relative ability of landscape versus select internal lake features to predict fish growth.

(3) Predicting fish growth rates (for Michigan and Wisconsin lakes) using an existing lake classification scheme for northern Wisconsin lakes.

Data: *Fish variables (RESPONSE variable)*– Von Bertalanffy growth parameters.

Landscape features (PREDICTOR variable) – Local and regional landscape variables (such as: watershed area, lake area, lake mean depth, ecoregion).

Water quality variables (PREDICTOR variable) – Variables to include: alkalinity, magnesium, N:P ratio, and phosphorus.

Analysis: Michigan and Wisconsin lakes will be assigned to Emmons et al. (1999) lake classes. Species-specific growth curves will be estimated for individual lakes, lake classes, ecoregions, and statewide. Comparisons among growth curves will be made using likelihood ratio tests.

Job 5. Title: Conduct research to assess bluegill recruitment.–Development of lake shorelines by riparian land-owners has the potential to negatively affect littoral habitat by removing or reducing plants and coarse woody material (CWM), and altering substrate composition. In small amounts, shoreline development may benefit aquatic organisms by diversifying the littoral habitat. Extensive and uniform development along shorelines, however, may be detrimental to aquatic organisms. In particular, the response of littoral fishes (such as largemouth bass, bluegill, and northern pike) to such habitat alterations is not fully understood.

In order to quantify the extent to which residential shoreline development adversely affects littoral fishes and habitat, we selected 15 lakes within the Huron River Watershed to conduct among and within-lake comparisons. The 15 study lakes have roughly equivalent land cover proportions within the 500m buffer, but vary with degree of shoreline development (Figure 2.). Shoreline sites were selected in a subset of six lakes (two high, two medium, and two low development lakes) based on shoreline features such as development type (developed seawall/riprap, developed maintained, undeveloped) and natural features such as terrestrial slope in riparian area and wind exposure.

Field work conducted: In May 2003, study lake shorelines and their features were mapped using a Trimble GeoExplorer differentiated GPS unit and downloaded to ArcView GIS software. This information was used to randomly select 40m sites within the subset of 6 lakes. In May and June 2003, CWM relative abundance and substrate composition at each site were determined. To determine fish response to shoreline development, growth rates will be back-calculated using scales from bluegills and largemouth bass that were collected by nighttime electroshocking during July-September 2003. Dorsal spines were taken from northern pike for use in age analysis. Sites examined for CWM and substrate composition were re-visited in August to determine vegetation abundance and Eurasian watermilfoil presence/absence. Whole-lake plant surveys were conducted on all 15 study lakes in August 2003. Alkalinity, total phosphorus/total nitrogen, and chlorophyll samples were also taken from all study lakes in the same time period. Secchi depth, temperature, and dissolved oxygen profiles at the deep station of each lake were also recorded. Zooplankton samples of each lake were collected in August-September 2003.

Future work: Analysis of CWM, substrate, and plant survey data will begin in fall 2003. Age of scales collected from bluegills and largemouth bass will be determined using Optimas software beginning in November 2003.

Job 8. Prepare annual reports and publications.–The following documents have been prepared and are included with this report.

Hayes, D., E. Baker, R. Bednarz, D. Borgeson, Jr., J. Braunscheidel, et al. 2003. Developing a Standardized Sampling Program: The Michigan Experience. Fisheries 28(7):18-74.

Valley, R. D. and M. T. Bremigan. 2002. Effects of herbicide control of Eurasian watermilfoil on age-0 largemouth bass piscivory and growth. Journal of Aquatic Plant Management 40:79-87.

Wills, T.C., M.T. Bremigan, and D.B. Hayes. In press. Variable effects of habitat enhancement structures across species and habitats in Michigan reservoirs. Transactions of the American Fisheries Society

Literature Cited

Crowder, L.B. and W.E. Cooper. 1982. Habitat structural complexity and the interaction between bluegills and their prey. Ecology 63:1802-1813.

Emmons, E.E., M.J. Jennings, and C. Edwards. 1999. An alternative classification method for northern Wisconsin lakes. Canadian Journal of Fisheries and Aquatic Sciences 56: 661-669.

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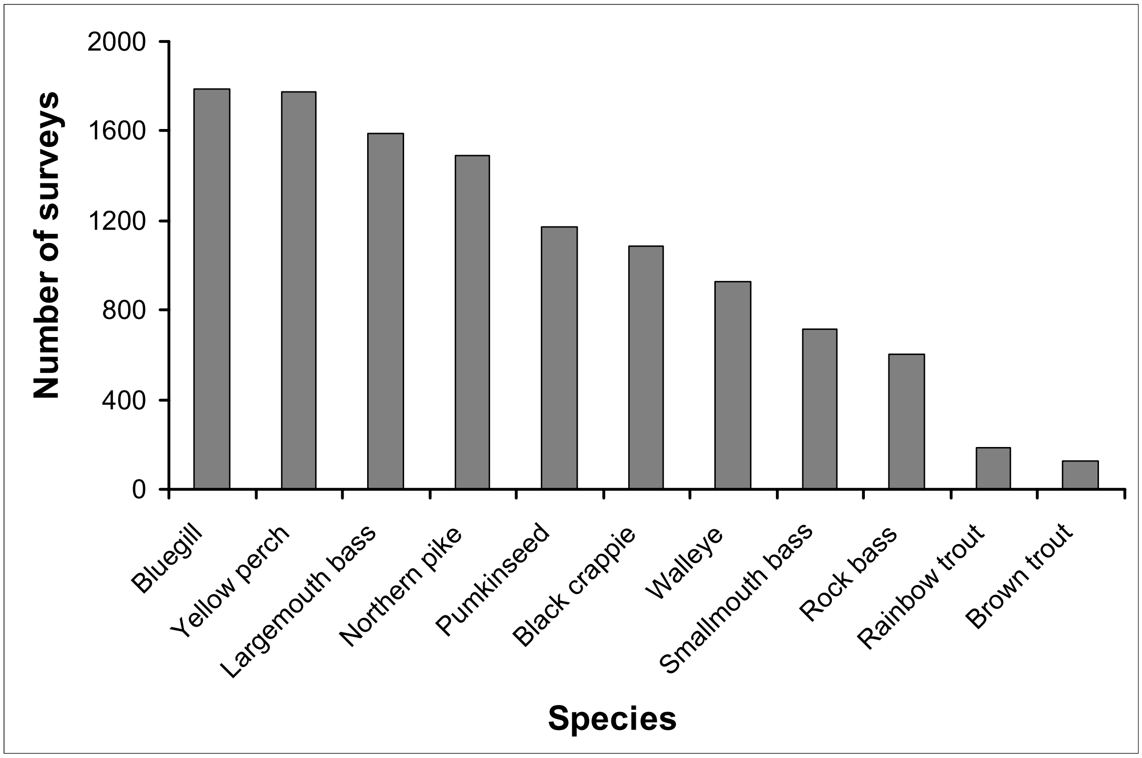

Figure 1.–Total number of fish growth surveys by species. Surveys are annual fish growth summaries collected by the Fisheries Division of the Michigan Department of Natural Resources.

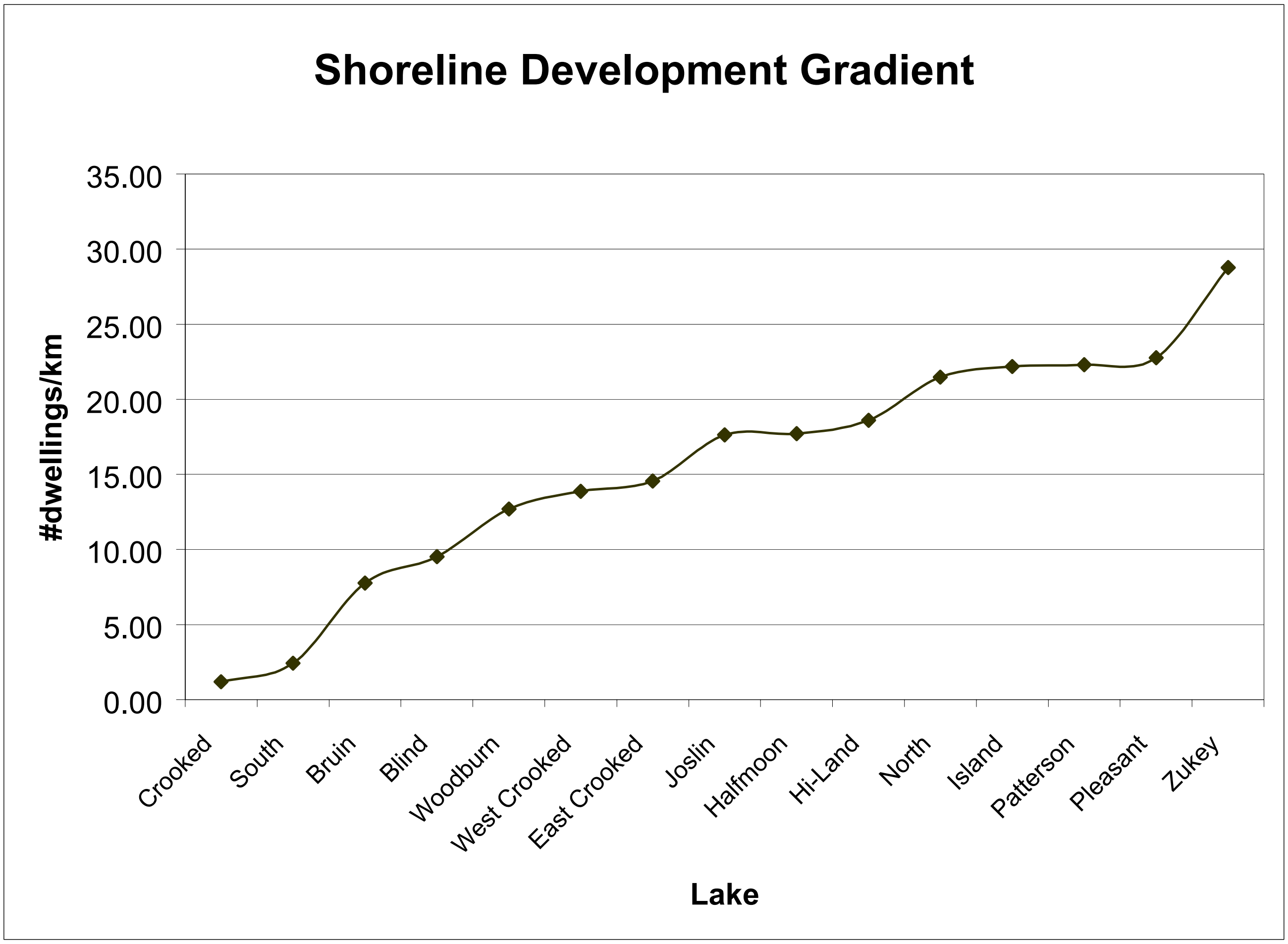

Figure 2.–Graph indicating shoreline development for 15 study lakes in Huron River watershed.