STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-4

Study No.: 714

Title: Managing Michigan lakes: evaluating effects of watersheds and habitat perturbation on lake resources.

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

Study Objectives:

1) To evaluate the ability of the Fisheries Division Status and Trends Program to actually detect changes in the status of Michigan lakes over time.

2) To investigate the effects of habitat perturbation on lake biota.

3) To conduct workshops designed to improve dialog within the Division regarding implementation of the Status and Trends program, and integration of the program with research and management efforts.

Summary: Analysis of existing data sets is underway. Lakes across the state can be distinguished according to total nutrient concentrations (phosphorus and nitrogen) and conductivity levels. In turn, differences in nutrient and turbidity levels are related, in part, to lake hydrology. Efforts are also underway to transfer findings to the Division in the form of interactive workshops.

Findings: Jobs 1, 5, and 7 were scheduled for 2002-03, and progress is reported below.

Job 1. Title: Analyze existing data sets.–To date, exploratory data analysis (EDA) has been conducted to elucidate spatial relationships between water quality and landscape-context GIS variables. In addition, EDA allowed for detection of outliers, and evaluation of potential multicollinearity and the distribution (i.e., multivariate normal) of predictor variables. With the diagnostics complete, these data will be used in subsequent analyses, such as the development of landscape-based classification systems for Michigan inland lakes, power analyses to compare and evaluate lake classification systems, and prediction of fish growth rates using landscape and water quality variables.

Water quality database summary:

Water quality data were obtained from the U.S. Environmental Protection Agency's (EPA) data storage and retrieval system (STORET). All data were collected by the Michigan Department of Environmental Quality. The database was summarized to contain summer (July, August, and September) values collected from the epilimnion. The final database consists of 577 unique records (lakes >50 ha); however, the number of lakes varies for each water quality variable. For example, 248 lakes contain data for specific conductance, whereas 575 lakes contain data for total phosphorus, nitrate-N, and total ammonium.

Exploratory data analysis:

As an example of EDA, principal component analysis (PCA) was performed to ordinate lakes by ecoregion and hydrologic connectivity (Table 1) with respect to selected water quality variables. Principal component analysis produces a new set of latent variables (linear combinations of the original variables) which are linearly independent of each other (Johnson 1998). Because water quality variables are not measured in similar units, PCA was conducted on the correlation matrix, which is equivalent to performing the analysis on standardized data (*Z* scores). For example, Table 2 shows the results from a PCA using selected water quality variables. The first two principal components accounted for 77% of the variance in the original water quality data. The interpretation of the components is not clearly defined; however, principal component 1 is associated with nutrients (total phosphorus and total nitrogen) and principal component 2 is associated with alkalinity and conductivity. Secchi depth is not strongly associated with either vector; although Secchi depth is negatively associated with nutrients, as would be expected. The principal component scores (values of the latent variables) are then plotted by lake hydrology category and ecoregion to visually examine differences between lake types and to asses spatial heterogeneity (based on ecoregions) in nutrients (principal component 1) and conductivity and alkalinity (principal component 2) in Michigan lakes (Figure 1). For instance, Figure 1 illustrates that lakes in Michigan's Upper Peninsula, regardless of hydrologic connectivity, have lower nutrient concentrations and lower alkalinity and conductivity compared to lakes in the Lower Peninsula (principal component scores 1 and 2 are significantly lower in ecoregion 9 compared to ecoregion 6 and 7, ANOVA $P < 0.05$). Furthermore, there are differences among hydrological categories within an ecoregion, with seepage lakes often having lower nutrient levels compared to other lake types. Upon completion of the fish growth database, similar EDA will be performed on these data in preparation for future analyses.

Job 5. Title: Conduct Division-wide workshops.–Research approach and findings have been communicated to the Division primarily through presentations at Basin Team meetings. This interaction is quite helpful for planning of larger scale workshops to discuss Division research and application to management activities and decisions. Planning for the workshops has progressed, and opportunities for collaboration with other Division personnel are being explored.

Job 7. Title: Prepare annual reports, final report, and manuscripts.–This report was prepared and submitted on schedule.

Literature Cited:

Johnson, D. E. 1998. Applied multivariate methods for data analysts. Duxbury Press, CA

Martin, S. 2003. The role of spatial and hydrological connectivity in measuring lake landscape position. Michigan State University, Masters thesis proposal.

Prepared by: Mary Bremigan
Date: 9/30/03

Table 1.−Definitions of lake hydrology (hydrologic connectivity) categories as defined by Martin (2003). S = seepage, I = inflow, IO = inflow/outflow, RIO = inflow/outflow with upstream tributary lake, H = headwater, IH = inflow headwater, RH = headwater lake with upstream tributary lake, F = flow-through, RF = flow-through lake with upstream tributary lake, T = terminal (modified from Martin 2003).

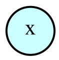
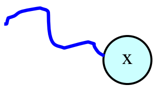
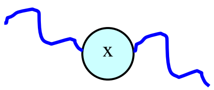
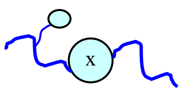
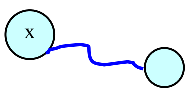
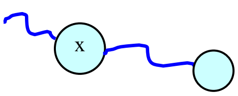
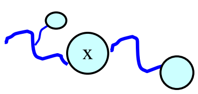
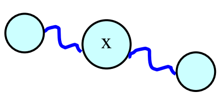
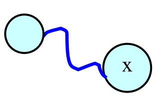
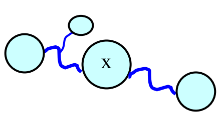
Lake hydrology category		River connections		Upstream	Mainstem lake	
		Upstream	Downstream	tributary lake	Upstream	Downstream
S		no	no	no	no	no
I		yes/no	yes/no	no	no	no
IO		yes	yes	no	no	no
RIO		yes	yes	yes	no	no
H		no	yes	no	no	yes
IH		yes	yes	no	no	yes
RH		yes	yes	yes	no	yes
F		yes	yes	no	yes	yes
RF		yes	yes	yes	yes	yes
T		yes	yes/no	yes/no	yes	no

Table 2.−Eigenvectors for principal component analysis using selected STORET water quality variables. Variables with strong relationships to one another (shown in bold) have elements in the eigenvector (column) that tend to be larger in absolute value than others in the eigenvector.

Water quality variable	Principal component 1	Principal component 2
Total phosphorus	**0.48**	-0.29
Total nitrogen	**0.48**	-0.34
Conductivity	0.46	**0.50**
Secchi	-0.42	0.39
Alkalinity	0.38	**0.62**

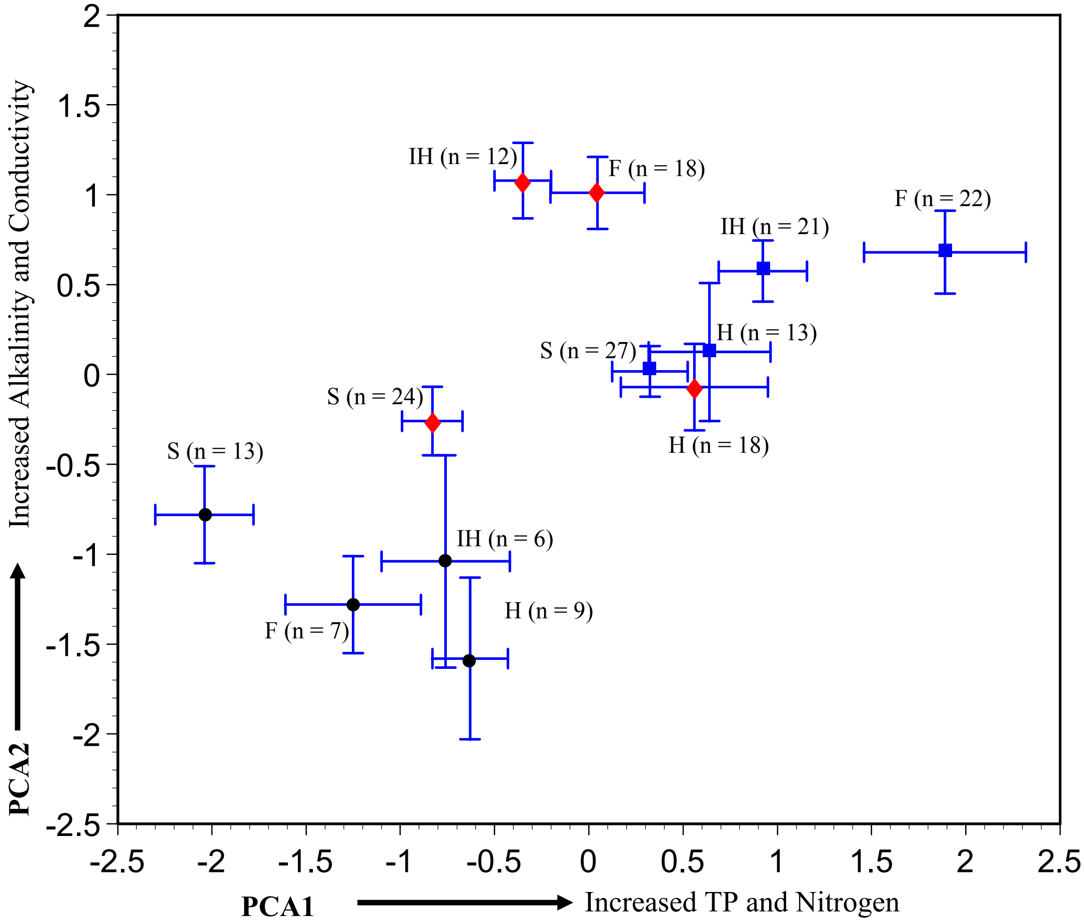


Figure 1.–Scatter plot of mean principal component scores for seepage (S), flow through (F), inflow headwater (IH), and headwater lakes (H). Ecoregions are as follows: circles = ecoregion 9, diamonds = ecoregion 7 and squares = ecoregion 6. Ecoregion 8 and other lake hydrology categories did not have adequate sample sizes for each lake type to plot. Error bars are ± 1 standard error. Sample sizes (n) are shown in parentheses.