STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-3

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

Period Covered: October 1, 2001 - September 30, 2002

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: Having completed assembly of the historic fish population assessment database, we continued to quantify growth rates of key fish species and assemble GIS databases characterizing lake watersheds at several spatial scales. Additional research in Michigan lakes continued to investigate the effects of artificial structures on fish populations and impoundments along the Au Sable River. Participation in several Fisheries Division committees continued and laid the groundwork for new research assessing Fisheries Division's program for resource inventory and assessment.

Findings: Jobs 2, 3, 4, 5, 6, 7, and 8 were scheduled for 2001-02, and progress is reported below.

Job 2. Title: Assemble abiotic, biotic, and meteorological data.–Our progress in this component of the research has received additional support from USGS and MSU-MAES and is directed by Dr. Pat Soranno, MSU. Our goal is to quantify the spatial attributes of land adjacent to Michigan inland lakes. We are using Dr. Jim Breck's (MDNR Fisheries Division) comprehensive digital lake map (vector format) as our lake base map and are coordinating our efforts with him. The majority of the spatial analyses have been done using ESRI's ArcView GIS and/or ArcGIS software packages.

Overall, the following databases have been compiled, representing the efforts of Drs. Soranno, Breck, and Bremigan, as well as the graduate students and personnel within their laboratories, and Ralph Bednarz, Michigan Department of Environmental Quality.

Michigan Lakes GIS data coverage:
All lakes have been given a Humphreys-Green code (new-key code). Includes the lake coverage, lake area, and location information.

Landscape-context GIS data coverage: For the above lakes, various landscape context variables have been collected and added to a new table (ecoregion, watershed area, land use, % wetland, groundwater input, landscape position, etc.).

Historic fish database:
The database includes mean length at age estimates for a number of fish species from ~598 (of the ~700 STORET) lakes collected during ~1960-2001. The source was MIDNR Fisheries Division historical fish mean length at age summaries that have been entered electronically from records at the IFR or obtained from the MIDNR Fisheries Division Fish Collection System.

Water quality data from the STORET database:
Public lakes that were sampled by the DEQ in the 1970-1980's as part of their lakes monitoring program. About 700 lakes >20ha (all public) were sampled at some point in this time period. Data include total phosphorus, total nitrogen, alkalinity, chlorophyll, Secchi, average depth.

54-Lake macrophyte field database from 2001-2002:
Lakes were chosen in a stratified-random design based on Secchi depth, mean depth and lake size.

Remotely-sensed Secchi and plants from 2001:
Using Landsat images from 2001, Secchi depth and plant cover will be estimated in as many lakes as possible from Landsat images. Only lakes within 3 Landsat images in a single path can be used (this results in many of the lakes of the lower peninsula, but not all).

Citizen Lake Monitoring Secchi data (historical): (work in progress)
About 70 lakes throughout the state have Secchi data from this program with > 8 years of data. Laura is currently compiling these data into an Access database.

Citizen Lake Monitoring Secchi data (2001):
About 140 lakes for which we have Secchi data from 2001 measured weekly during summer.

Job 3. Title: Determine the extent of interannual and intersystem variability in fish population paramters.–Data entry of MDNR historic fish growth summaries began during the summer of 2000, was completed in August 2001, and updated in September 2002. We are planning to use these growth data in several future analyses to represent the average fish growth condition for 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 initiated analysis 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 are being made between estimates derived directly from the sub-sample to estimates derived by extrapolating the ages to the full sample of captured fish. This analysis will be summarized in the following manuscript:

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)– Variables such as age-specific mean length and/or von Bertalanffy growth parameters.

Data analysis: Estimate growth parameters (ω and L_∞) 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 can be constructed (estimated 373 lakes). Compare 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). Determine whether there is a bias in using the sub-sample of aged fish. Determine whether the bias differs among species

In addition, analysis of historic growth summaries is ongoing. Von Bertalanffy growth parameters have been estimated for walleye populations on approximately 50 lakes. Growth parameters will be estimated for all surveys conducted during 1960-1999 where walleye, yellow perch, largemouth bass, northern pike, bluegill or lake trout were collected.

Job. 4. Title: Combine historic fisheries data with abiotic and biotic data.–This analysis will be conducted upon completion of Job 3. In the meantime, we have made substantial progress detailing our plans for analysis. Below, planned manuscripts and analysis are summarized:

(1) Predicting lake water quality and macrophyte cover 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.

Macrophyte variables (RESPONSE variable) – Variables such as percent cover.

Analysis: Hierarchical linear modeling (multiple landscape features as predictor variables; individual water quality and macrophyte variables as response variables). Each water quality/macrophyte 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, water quality, and macrophyte 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.

Macrophyte variables (RESPONSE variable) – Variables such as percent cover.

Fish variables (RESPONSE variable)– Variables such as age-specific growth rates and/or von Bertalanffy growth parameters.

Analysis: Hierarchical linear modeling (multiple landscape features, water quality and macrophytes as predictor variables), and separate models for each fish species-specific growth parameter. Will also do the analysis just using landscape variables to see if landscape alone can predict fish growth. Then, water quality and plants will be added as additional predictor variables, allowing us to compare the relative ability of landscape versus 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)– Variables such as age-specific growth rates and/or 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' 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.–Research on bluegill recruitment represents a portion of a larger research project evaluating the indirect effects of selective removal of Eurasian watermilfoil (using the herbicide Sonar®) on largemouth bass and bluegill populations. Two MS graduate students (Ray Valley and Steve Hanson) on this project have successfully completed their degrees. We have continued to publish the findings of this collaborative project (see Job 8).

Todd Wills, an MS student in my laboratory successfully completed his research, evaluating the effects of structures (half logs and aqua cribs) on fish populations in impoundments of the Au Sable River. Through a combination of snorkeling observations, sampling, and angling, we compared fish presence, diet, vulnerability to angling, and nesting success between areas with and without the artificial structures. Because our study impoundments span a range of habitat conditions (in terms of macrophyte abundance, turbidity, etc.), we were able to evaluate the extent to which the effects of artificial structures depend on "background habitat". Overall, the habitat enhancement structures had relatively few effects. Most notably, nesting abundance and nesting success of smallmouth bass were positively affected by the presence of half logs, particularly in gravel areas with relatively little macrophyte cover. Mr. Wills graduated in summer 2002; in September 2002 we submitted a manuscript summarizing his research (see Job 8).

Job 6. Title: Participate in assessment and inventory committee.–I continued to participate in the Resource Inventory and Assessment Committee, served as a member on a job interview committee for Fisheries Division, and presented research findings at the annual Fisheries Division research review meetings in June 2002, Saline, Michigan. I received additional funding (see Job 7) to integrate my research program with the Resource Inventory and Assessment process. Specifically, analyses that are planned include:

(1) Power analysis to determine RIP ability to detect status and trends

Data: Historic fish database, Water quality data from STORET, Remote sensing Secchi and Plants from 2001

Analysis: The purpose of this manuscript is to determine the power of lake groups, based on lake size and depth, to detect differences among lake groups, and trends over time. Statistical power will depend, in large part, on three characteristics: inherent variability among lakes within groups, the magnitude of differences that occur among groups or over time, and the number of lakes sampled per year. We will evaluate these characteristics using existing data sets that characterize fish growth rates, water quality, and macrophyte cover. This will allow us to estimate the statistical power the RIP program will have to detect differences among lakes groups and changes over time within lake groups.

(2) Comparison of lake size/depth and landscape context to group lakes

Analysis: We will compare the ability of lake groups based on (1) size and depth, and (2) landscape context to explain variability among lakes in terms of fish growth, water quality, and macrophyte cover.

Job 7. Title: Expand research into related areas.

Proposals:

Bremigan, M.T. and P.A. Soranno. Fisheries Division, MDNR: "Managing Michigan lakes: evaluating effects of watersheds and habitat perturbation on lake resources." Funded.

Bremigan, M.T. Fisheries Division, MDNR: "Developing decision tools for inland lake management through field sampling and statistical models linking lakes to landscape context". Funded.

Job 8. Title: Prepare annual reports and publications.

Manuscripts published:

Valley, R. D., and M. T. Bremigan. 2002. Effects of macrophyte bed architecture on largemouth bass foraging: implications of exotic macrophyte invasions. Transactions of the American Fisheries Society 131:234-244.

Manuscripts in press:

Valley, R. D., and M. T. Bremigan. In press. Effects of herbicide control of Eurasian watermilfoil on age-0 largemouth bass piscivory and growth. Submitted to the Journal of Aquatic Plant Management.

Garvey, J.E., R.A. Stein, R.A. Wright, and M.T. Bremigan. in press. Largemouth bass recruitment in North America: quantifying underlying ecological mechanisms along environmental gradients. Proceedings of the Black Bass Symposium 2000, American Fisheries Society.

Presentations:

Wills, T.C., M.T. Bremigan, and D. B. Hayes. 2002. Does natural habitat mediate smallmouth bass (Micropterus dolomieu) use of half-log habitat enhancement structures? American Fisheries Society, Baltimore, MD.

Wills, T.C., M.T. Bremigan, and D. B. Hayes. 2002. Does natural habitat mediate smallmouth bass (Micropterus dolomieu) use of half-log habitat enhancement structures? Michigan Chapter, American Fisheries Society, Muskegon, MI.

Wills, T.C., M.T. Bremigan, and D. B. Hayes. 2001. Effects of half-log habitat enhancement structures on smallmouth bass (Micropterus dolomieu) in two Michigan reservoirs. Midwest Fisheries and Wildlife Conference, Des Moines, IA.

Chiotti, J.A., and M.T. Bremigan. 2001. Predicting characteristics of gizzard shad populations along a productivity gradient. Midwest Fisheries and Wildlife Conference, Des Moines, IA.

Soranno, P.A., M.T. Bremigan, K.S. Cheruvelil, S.M. Hanson, K.L. Rogers, R.D. Valley, and J.D. Madsen. 2001. The role of macrophytes in mediating pelagic and littoral zone foodweb interactions: implications for shallow lake management. North American Lake Management Society, Madison, WI.

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