STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-7

Study No.: 230701 **Title:** Decision-support tools for managing fisheries of inland lakes

Period Covered: October 1, 2005 to September 30, 2006

Study Objective: To prepare reviews of the characteristics of Michigan's inland lakes and of fisheries management of selected species in inland lakes, and to develop decision-support tools to help manage fisheries on inland lakes. One critical set of tools to be developed is methods for allocating fish among multiple fisheries that occur in the same lake, given a safe harvest level. Another objective of this study is to develop tools that help fisheries managers compare the status and potential of specific lakes and fisheries.

Summary: Several activities occurred under Job 4 in the development of decision-support tools. Work continued on editing and linking database tables and geographic information system (GIS) files that will be used to build decision-support tools for natural resource managers. Data analysis programs were developed and used to prepare 4,018 graphs to assist in the analysis of temperature profiles from inland lakes. Collaborations continued with university faculty and graduate students to prepare a database of lake attributes and to classify inland lakes. A manuscript on models for fish proximate composition and energy density was provisionally accepted and is being revised. Work is underway on a model for fish population dynamics incorporating life history information in order to better understand factors influencing age at maturity and timing of juvenile transitions between habitats. A talk on this subject was given at the 2006 annual meeting of the American Fisheries Society.

Findings: Jobs 4 and 5 were scheduled for 2005-06, and progress is reported below.

Job 4. Title: Develop additional decision-support tools.–Development continued on several database tables and geographic information system (GIS) files that will be used to build decision-support tools for natural resource managers.

In this reporting period I prepared summaries and graphs of historical temperature profiles to assist in determination of lake stratification. In the previous reporting period we completed the entry into electronic form of temperature and dissolved oxygen profiles for inland lakes from limnology cards in the lake files at the Institute for Fisheries Research. These 4,194 profiles (a total of 36,398 measurement records) had been entered into Excel and converted into Access database tables. In this reporting period we assigned unique lake codes to these profiles so that other lake characteristics (such as geographic location, area, and volume) could be linked to these profiles for further analysis and so that summaries could be prepared. We also added temperature profiles collected by the Michigan Department of Environmental Quality, representing 723 lakes, 1,893 profiles, and 11,110 temperature-depth measurements. A data analysis program was written in Python to identify usable temperature profiles, to estimate the top and bottom of the metalimnion (the depth range in which water temperature is decreasing by at least 1°C/m) and to estimate the plane of the thermocline (the depth at which the rate of decrease of temperature with depth is greatest and at least 1°C/m). A program was written in R (2004) to produce a graph in a pdf image for each of 4,018 acceptable temperature profiles. Each graph shows temperature versus depth, the estimated top and bottom of the metalimnion (if present), the plane of the

thermocline (if present) and a title containing the lake name, county and the date of profile collection. Information on temperature and dissolved oxygen is important for classifying lakes and for making decisions about fish stocking and other management actions.

Collaborations are continuing with faculty and graduate students at Michigan State University to prepare a database of lake attributes and to classify Michigan lakes.

A manuscript describing new models for proximate body composition and energy density in fishes was provisionally accepted for publication and is being revised. These models should help in developing bioenergetics models with a more realistic treatment of starvation conditions as well as allocation of new biomass to growth in condition and length. One purpose of such bioenergetics models is to give fish biologists a tool for interpreting differences in fish body condition between lakes or over time.

Work continues on a model for fish population dynamics incorporating life history information. A talk was presented at the 2006 annual meeting of the American Fisheries Society on a model explaining variation in timing of maturation among individual steelhead *Oncorhynchus mykiss* in Lake Michigan. An individual decision rule for maturation was developed based on comparing current and future reproductive value. For the case of big-bang reproduction, the decision criterion (D_{crit}) simplifies to the following, where r is the per capita rate of population growth, b is the slope in a log-log plot of fecundity versus length, and s is the probability of surviving one more year in the lake.

$$D_{crit} = \left(\frac{e^{r}}{s} \right)^{1/b}$$

An individual female in the Great Lakes (or ocean) should delay maturation one more year if the ratio of her estimated length next year (L_{t+1}) to her length this year (L_t) exceeds the decision criterion (D_{crit}). The goal of this modeling and analysis is to improve management decisions on stocking and fishing regulations.

Job 5. Title: <u>Write progress report.</u>–This progress report has been prepared as scheduled.

Literature Cited:

R Development Core Team. 2004. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-00-3, URL http://www.R-project.org.

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