STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-4

Study No.: 713 **Title:** Improving fishery stock assessments in the Great Lakes

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

Study Objective: Work with Michigan DNR researchers and managers, the modeling subcommittee (MSC) of the Technical Fisheries Committee for 1836 Treaty waters, the Lake Michigan yellow perch task group, lake committees, and technical committees to evaluate the reliability of current and potential alternative approaches to quantitative fish stock assessment, and to evaluate current and alternative harvest or other management policies (e.g., allowable total mortality rates) with regard to their sustainability (e.g., avoiding stock collapses) and providing maximum benefits from the resource.

Summary: Activities during the past year included literature review (primarily in support of the research efforts of a graduate student), development of a general sensitivity analysis for statistical catch-at-age models and a preliminary application of that approach to assessments for two lake whitefish management units, simulations evaluating different approaches to allowing fishery catchability to vary over time in statistical catch-at-age models, holding of two short courses on statistical catch-at-age methods for fishery professionals, and development of statistical catch-at-age assessments for yellow perch in Lake Michigan. All these activities achieved their primary goals and led to improved capacity for stock assessment in the Great Lakes and more broadly. These activities improved the science of statistical catch at age assessments, helped develop greater capacity among fishery professionals to use these methods, provided tools to improve specific suites of stock assessments, and directly led to improved stock assessments for yellow perch in Lake Michigan.

Findings: Jobs 1, 2, 7, 9, 10, 11, and 12 were scheduled for 2002-03, and progress is reported below.

Job 1. Title: Literature review.–A literature search has been conducted to find articles pertaining to the Great Lakes, harvest policies and assessment approaches. The articles collected this year have dealt primarily with stock assessment approaches and sensitivity analyses used to evaluate stock assessment models in areas related to the doctoral research of graduate student Brian Linton who is working on this project.

Job 2. Title: Sensitivity analysis.–A general evaluation of sensitivity of assumptions of existing lake trout and lake whitefish stock assessment models is currently in progress. The analysis evaluates sensitivity of the stock assessment models to variations in model inputs, such as starting values and bounds for model parameters, as well as, to variation in model structure, such as the method used to estimate recruitment and the likelihood function used to fit model predictions to observed data. Sensitivity of the stock assessment models is evaluated by measuring changes in selected model outputs, which include: the predicted fully selected fishing mortalities for the active fisheries, predicted population biomass, predicted current spawning stock biomass per recruit (SSBR), predicted SSBR of the unfished population, predicted SSBR at target mortality levels, predicted spawning potential reduction (SPR) at target mortality levels, and the estimated yield calculated for target mortality rates for the projected population. This sensitivity analysis

has been completed for whitefish stock assessments for two management units on Lake Huron. Preliminary results suggest that these two stock assessment models are most sensitive to changes in the probability distributions used in the likelihood function, gear selectivity parameters, and assumed standard deviations in fishery catch and effort. Predicted SSBR values are also sensitive to changes in the average proportion of females in the population and the maturity schedule. A new projection model, used to estimate fishery yield and SSBR values for the projected fish population, was developed during the sensitivity analysis. The new projection model should reduce the time and effort needed to run population projections, because the new model can read in data directly from the stock assessment model. The new projection model has been presented to the MSC.

Job 7. Title: Evaluate catchability approaches.–Oversight was provided by Dr. Bence for a series of simulations that evaluated different approaches to estimating catchability in a "generic" statistical catch-at-age assessment model. A set of assumptions were made in the form of a generating model to produce simulated data and for each simulated dataset a suite of different estimating models were applied. The estimating models were evaluated on the basis of how well they reproduced known quantities of interest (e.g., overall exploitation). The basic age-structured model used in both the generating and estimating models started from an initial age-structured population and accounted for recruitment and mortality each year. Total mortality rate (Z) was a sum of a constant natural mortality rate (M) and a fishing mortality rate (F) that varied by age and year using a separability assumption. Fishing mortality (on fully selected ages) was then was assumed to be in some sense "proportional" to effort (i.e., $F = q \bullet$ Effort). Generating and estimating models differed in how they allowed "q" (catchability) to vary over time. Generating models included ones that modeled catchability as white noise, as an autoregressive process, as changing abruptly in the middle of the modeled period, as trending over time, and as being density dependent (a power function of density). Estimating models included modeling catchability as white noise, random walk, or density dependent. Preliminary results (presented at the annual meeting of the American Fisheries Society) showed that all the estimating models performed reasonably well and without large differences when there was no trend or abrupt change to the underlying catchability. When catchability did have such a change, the random-walk approach performed much better than other methods in terms of having less bias and/or lower root mean square error for key quantities such as exploitation. Our simulation results have provided guidance to our approach to modeling catchability in our yellow perch stock assessments for Lake Michigan.

We are developing an approach to evaluate current and alternative methods for modeling catchability for lake trout and lake whitefish assessments in 1836 treaty waters. These assessment models currently assume a white noise pattern (average catchability is constant). Simulation models will be used to evaluate how different approaches to catchability estimation affect model output. The different estimation approaches that we are considering include: a single (mean) catchability for each fishery, time-varying catchability using a random walk function, and density-dependent catchability. Diagnostic techniques for evaluating the different estimation approaches will be developed for use by stock assessment biologists.

Job 9. Title: Develop workshop materials.–Dr. Bence was the primary author of materials that were developed for two short courses on statistical catch at age methods and provided guidance to a graduate student assisting in the development of course materials. These materials included Power Point slide presentations, written course notes, and example files in Excel and code for AD Model Builder applications. An ftp site was with these materials was also made available to course participants.

Job 10. Title: Hold workshops.–Dr. Bence oversaw two short courses on statistical catch at age methods. These short courses were designed for practicing fishery scientists/managers who were involved in or expected to be involved in the development of age-structured stock assessments. The first short course was held December 17-20, 2002 in the Natural Resources Building at Michigan State University in East Lansing. The first short course was designed for experienced fishery professionals, who had some understanding of fish population dynamics and fishery data, but had limited prior experience with age-structured stock assessment models. This short course included a refresher on relevant fishery models and theory. This short course included lectures and hands on (Excel-based) computer work. The second short-course was held at the Kellogg Center of Michigan State University during January 6-10, 2003. This second course provided more advanced coverage of statistical catch-age models. Participants were expected to have background understanding equivalent to that covered in the first workshop. This course also included both lectures and computer applications. Computer applications made use of AD Model Builder software, with some processing of results using spreadsheets.

A total of 25 students registered and attended most of the first short course, although only 19 students attended the last half-day session. All 19 students who attended the final half-day session submitted an evaluation form. The students had a variety of purposes for attending the course ranging from immediate need to implement catch-age models as part of their jobs to a desire to improve their general understanding of fishery population dynamic theory. The attendees represented a total of 13 different agencies including agencies of 5 state/provincial governments (Michigan, Wisconsin, Illinois, Minnesota, and Ontario), agencies of both the U.S. and Canadian Federal Governments, and 4 different tribal resource agencies. Ninety-five percent of the respondents agreed highly with the statement that the instructors understood the material they were presenting. Nearly 80% highly agreed with the statement that the course was well thought out, and 95% of the respondents classified the course as either excellent or very good. In general students thought the course had the correct mix of theory and application, while two students thought the course was too applied and one thought the course was too theoretical. Based on narrative comments and our conversations with attendees, we believe that most attendees were pleased with the overall content and format of the first short course.

Participants did suggest some changes for any future iterations of the course. One common theme was that more discussion of an application when it was complete would have been useful, and that a greater diversity of case history applications would have been useful. Some participants thought that an instructor led development of spreadsheet models would have been better than letting students puzzle things out, whereas some thought this "puzzling out" process was an essential part of the class. A few students thought that some of the theoretical presentations could have been shortened or left out in order to enhance the discussion of applications.

There were a total of 27 registered students that attended the second short course. The attendees represented a total of 13 different agencies/organizations (two new groups sent a representative and two that sent a representative to the first workshop did not for the second). The students were largely professional fishery scientists and biologists, along with several Michigan State University staff and graduate students. In contrast with the first course, the attendees at this course were more focused on developing stock assessment expertise they would use directly as part of their work. The attendees represented 4 state/provincial governments (Michigan, Wisconsin, Illinois, and Ontario), agencies of both the U.S. and Canadian Federal Governments, and 4 different tribal resource agencies. Of the attendees, 22 provided an evaluation. Of those 22 who evaluated the course 16 had attended the first short course. Of those 16, 14 thought that the first course was very important in helping them understand the material covered in the second course and two thought the first course was moderately important to their understanding. All but

one respondent highly agreed with the statement that the instructors understood the material being presented. Most (82%) of the respondents thought the course was well thought out, and over 95% rated the course as very good or excellent. Based on our observations, narrative comments, and one-on-one interactions with students it was clear that nearly all attendees were more comfortable at the end of the course in using AD model builder software, the standard software now being used by many resource agencies for stock assessment modeling.

Again students did provide some suggestions for changes, but no consensus for a different course format emerged.

Job 11. Title: Lake Michigan yellow perch assessments.–Separate assessment models were completed for Wisconsin and Illinois waters of Lake Michigan, and these were updated to incorporate results through 2002. As part of this job, Dr. Bence provided oversight and technical input during the development of these stock assessments. Results from these stock assessments have been presented to the Lake Michigan Yellow Perch Task Group and the Lake Michigan Committee has been briefed on these results. Results indicate that total mortality rates were quite high (sometimes Z>2.0 on the most highly selected categories) during the period of less restricted fishing (prior to the 1990s). Available evidence strongly suggests these high mortality rates were largely due to commercial (Wisconsin) and recreational (Illinois) fishing, and in general fishing mortality rates were higher in Wisconsin than in Illinois. After closures of commercial fisheries and greater restrictions on recreational fishing, mortality rates declined. Under current conditions (recreational) fishing mortality rates on highly selected ages are on the order of F=0.1. Efforts to construct similar assessment models and obtain reliable estimates of mortality and stock size for Indiana and Michigan waters were less successful. This is primarily a consequence of data limitations. During the period of high mortality and unrestricted fishing critical data on total yields and composition of fishery harvest are missing. Current recreational effort in Michigan waters is about equal to the sum of the effort in Illinois and Wisconsin, over an area about equal to that of those two states. Assuming similar relationships between effort and fishing mortality suggests that fishing mortality is likely to be moderate in Michigan's waters.

Job 12. Title: Prepare publications/reports.–This report was prepared on time.

Prepared by: James Bence
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