STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-7

Study No.: 230713

Title: Improving fishery stock assessments in the Great Lakes

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

Study Objective: Work with Michigan DNR researchers and managers, the modeling subcommittee of the Technical Fisheries Committee for 1836 Treaty waters, the Lake Michigan yellow perch task group, and Lake committees and Lake 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 provision of maximum benefits from the resource. Study amendments in 2004-05 and 2005-06 indicate that the study will apply results broadly including outside the Great Lakes, and encourage the use of state of the art approaches by others.

Summary: Activities during the past year included: literature review (primarily in support of the research efforts of two graduate students); modeling work aimed at evaluation of fishery policies including harvest of yellow perch in Lake Michigan; preparation of a general review paper on harvest policies in support of design work on a harvest policy analysis for lake whitefish in the Great Lakes; simulations evaluating alternative approaches to how to model time varying catchability, our ability to distinguish among catchability models, and to estimate the relative importance of observation and process error (a critical concern regarding stock assessment applications); and further development of indices of abundance for Great Lakes lake whitefish. We also prepared workshop materials and presented them, targeting working fishery professionals, and worked to communicate results through presentations to professional groups and by preparing and submitting written work to peer-reviewed outlets. 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, worked toward model-based decision support, and provided input to improve specific suites of stock assessments.

Findings: Jobs 1, 4, 8, 9, 10, and 12 were scheduled for 2005-06, and progress is reported below.

Job 1. Title: <u>Literature review.</u>–We have continued the literature search and review of articles pertaining to the Great Lakes, harvest policies, and assessment approaches. This ongoing work reflects the need to stay abreast of ongoing developments and for training of graduate students participating in this project. This included a fourth year student (Brian Linton) and a second year student (Jon Deroba). In the arena of stock assessment, articles examined this year have dealt primarily with approaches to allowing selectivity and catchability to vary over time, approaches to summarizing fishery or survey catch per effort based on ANOVA-like models, and approaches to setting the relative variances of process and observation error when fitting assessment models. We continued to review harvest policy literature in support of preparing a written review of this literature and conducting harvest policy analyses.

Job 4. Title: Evaluate policies.–Work on this job included the preparation of a partial rough draft of a review paper describing the existing literature on harvest policies, some design work in preparation of a harvest policy analysis for lake whitefish in 1836 treaty waters of the Great Lakes, and development and refinement of a simulation model for evaluating harvest policies of yellow perch in Lake Michigan.

Our review of the harvest policy literature has shown that although there was a substantial amount of previous work, this literature is splintered and in some cases apparently contradictory. Our review has emphasized that the major policies of constant catch, constant fishing rate, biomass based fishing rate, and constant escapement involve different tradeoffs between maximizing and stabilizing yield, and that these tradeoffs are altered when uncertainty in stock size or in dynamic processes is acknowledged. This review has helped us refine the appropriate range of harvest policies to consider in our lake whitefish analysis and emphasized the importance of appropriately incorporating uncertainty.

The complex life history of lake whitefish, with growth and maturity schedules varying over time and among locations has provided a challenge to developing an appropriate simulation model for this species, and this has slowed our progress. Our current plans in this regard are to incorporate density dependent growth as well as a stock-recruitment relationship. One possible path forward is to tie maturity schedules to growth through a reactive norm, which presumes that feasible age/length combinations that lead to a given proportion of the population maturing fall along a single species (or possibly lake specific) curve.

Our work on harvest policy analysis for yellow perch and determining economic injury levels for sea lamprey control has been done collaboratively with postdoctoral research associates supported through other funding sources at the Quantitative Fisheries Center at Michigan State University. In part, this study allowed for the participation of Dr. Bence in these important policy analyses. Historically, yellow perch have been economically important throughout most of the Great Lakes region by supporting both recreational and commercial fisheries, yet there is no established harvest policy for their management. Using a decision analysis framework, we are constructing a stochastic forecasting model to evaluate harvest scenarios for yellow perch in Lake Michigan. We have developed a working simulation model, and have revised it using input from the Lake Michigan Yellow Perch task group. We expect that some additional revisions will be made both before a planned meeting for next January with the same group and then in response to interactions at that time. Our simulations track the age-, sex-, and size-structure of the yellow perch population through time in four management areas of southern Lake Michigan. The model we developed allows for simulations with different decision options, which represent alternative management actions. Repeated simulations need to be done for each decision option because the model is stochastic, incorporating both process errors and uncertainty about parameter values (or states of nature). Thus each individual simulation uses different parameter values and also has different process errors that influence system dynamics. This approach and the structure of our model allows us to explicitly incorporate uncertainty about population processes (e.g. stock-recruitment relationships, maximum recruitment potential, migration among areas) and propagate this through to produce a distribution of outcomes associated with any given harvest policy. Our model framework will allow selected management policies to be evaluated based on the distribution of outcomes and pre-determined measures of performance (e.g., annual catch, size composition of population). Ultimately, this effort aims to aid Lake Michigan managers in determining harvest regulation strategies that are robust to critical uncertainties about yellow perch fisheries.

Job 8. Title: Evaluate alternative stock assessment approaches.–We have previously reported on results of two simulation experiments evaluating the performance of assessments when fishery catchability is varying over time. In the past year we have further interpreted the results of one simulation experiment and refined and repeated the second simulation experiment, substantially increasing the sample size for that experiment. Detailed results from the first experiment are now in press at the Canadian Journal of Fisheries and Aquatic Sciences and details of the second are in a manuscript that will soon be submitted to the same journal. Our first simulation experiment showed that the most common approaches to using fishery effort and catch data, which assume that catchability is constant except for white noise variation, are sensitive to violations of this assumption. An alternative approach, where catchability was allowed to vary gradually by following a random walk process produced better estimates of stock size and mortality rates when catchability actually did vary. Our second simulation experiment followed up the first by evaluating whether an appropriate model for time-varying catchability could be chosen from among competing alternatives using the Deviance Information Criterion. This work demonstrated that often the data could point the direction toward a more appropriate model of the process, but for the particular conditions of our experiment estimates of stock size and mortality were not much improved.

Working with the 1836 treaty waters statistical catch at age models, we previously conducted a broad sensitivity analysis of both assumed constants and model structure. Results suggest that these stock assessment models are most sensitive to changes in recruitment and gear selectivity parameters. During the past year these results were further synthesized and submitted for publication as a Michigan DNR research report. This work, as well as experiences of the fishery biologists doing the actual assessments, has identified evaluating the approach to modeling time-varying selectivity as a key area for future work. We are working toward a simulation study to evaluate alternative approaches to modeling selectivity and how to select among them. However, as a preliminary to this work we chose to first address to what extent the relative magnitude of process and observation error could be estimated. Credible competitors among the viable models use process error as a way to allow selectivity parameters to vary over time. Standard practice is to assume, *a priori*, the ratio of process error and measurement error. Simulations we did during the past year showed that information on the relative magnitude of process and measurement error can be obtained through the process of fitting a statistical catch at age model, although prior information on the magnitude of observation error is required. This is a very important result. The National Research Council had indicated that the issue of setting variances was crucial and an open research question, and this issue has been a major source of concern in every actual age structured stock assessment we have experience with. This is not just an issue when one wants to allow time varying selectivity, as most models already include both process and observation error. Results from this simulation study were presented at the American Fisheries Society meeting in Lake Placid in September and we are working toward a journal paper based on this simulation experiment.

Although some changes in catchability can be handled through appropriate modeling, assessments perform better with a reliable index of abundance, either based on surveys or fishery catch and effort data. In 1836 treaty waters, lake trout models rely on gill net survey indices of abundance derived from fitting general linear mixed models that adjust for site and depth effects. We previously evaluated alternative approaches to building these models and found that approaches already in place were satisfactory. We are in the final stages of preparing a report on this work to be published as a Michigan DNR research report. The 1836 treaty waters lake whitefish models used fishery catch and effort in a way that presumes that the ratio of aggregate catch to aggregate effort can index abundance. We had previously applied a general linear mixed model approach to the whitefish fishery data, and in the past year have considered a broader range of models that incorporate more types of random effects. Our qualitative conclusions, however, have not changed. In this case the current practice can be substantially improved. We found that factors associated with who fished (operator), as well as where and when fishing took place during the year could explain a substantial amount of variation in most lake whitefish management units. Accounting for these factors often changed our perception of how relative abundance was changing over time. We expect to prepare a journal paper on this work.

Job 9. Title: Develop workshop materials.–Jim Bence continued supervising efforts of a Visiting Assistant Professor funded from other sources, as part of the Quantitative Fisheries Center at Michigan State University, and this led to near completion of the development of online materials for a course on approaches to estimation of parameters of nonlinear models. All seven primary units have been drafted and most have been revised based on reviews. Jim Bence and graduate student Brian Linton prepared materials for two short courses on the use of AD Model builder, a software package widely used in fishery stock assessment work.

Job 10. Title: Conduct workshops.–In June 2006, Jim Bence and Brian Linton taught two short courses on the use of AD Model Builder software, which is a powerful tool for estimating model parameters and is widely used in the fitting of fishery stock assessment models. Their efforts as part of this study were facilitated by logistical support from the Quantitative Fisheries Center. The first short course (AD Model Builder Basics) was an introduction to AD Model Builder and was held on June 8th and 9th. The AD Model Builder Basics course was attended by 21 participants from the following agencies and institutions: Michigan State University (8), Purdue University (1), University of Guelph (1), Michigan Department of Natural Resources (2), Ohio Department of Natural Resources (3), Ontario Commercial Fisheries Association (2), Ontario Ministry of Natural Resources (1), U.S. Fish and Wildlife Service (1), U.S. Geological Survey (1), and Wisconsin Department of Natural Resources (1). The second short course (AD Model Builder Advanced Fishery Applications) was held on June 12th and 13th. Twenty-three participants attended the second short course from the following agencies and institutions: Michigan State University (9), University of Guelph (1), Michigan Department of Natural Resources (2), Ohio Department of Natural Resources (2), Ontario Commercial Fisheries Association (1), Ontario Ministry of Natural Resources (4), U.S. Geological Survey (1), U.S. Fish and Wildlife Survey (2), and Wisconsin Department of Natural Resources (1). Both short courses received overall ratings of excellent/good by course participants.

Job 12. Title: Prepare annual performance report.–This Performance Report was completed as scheduled. In addition project personnel have worked toward publication of work in the primary literature as described in other jobs. Furthermore, Brian Linton presented simulation results at the American Fisheries Society Annual Meeting in Lake Placid in September 2006 and Jon Deroba presented his analyses of lake whitefish abundance indices at the Midwest Fish and Wildlife Conference in Grand Rapids, Michigan in December 2005.

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