STUDY PERFORMANCE REPORT

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

Study No.: 724 **Title:** The importance of trophic interactions for salmonine fisheries of the Great Lakes.

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

Study Objective: The overarching objective of this study is to gain an improved understanding of trophic interactions that influence the salmonine communities of the Great Lakes and how these interactions influence sport fisheries. Research will specifically address understanding uncertainty and variation in response of the salmonine-prey community to management actions, developing an improved understanding (in the form of a feeding model) of sea lamprey-host interactions, and developing new information on the energy dynamics of chinook salmon.

Summary: Activities have included literature review, development and application of a decision model for stocking of salmon on Lake Michigan, expansion and further development of a fishery projection model for Lake Huron, work toward parameterizing a functional response for sea lamprey, collecting and synthesizing information on chinook salmon energetics, and comparing top down effects of salmonines across the Great Lakes. Substantial progress has been made in each of these diverse areas. The improved information provides incremental progress that will help make a system-based approach to managing salmonines practical.

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

Job 1. Title: Literature review.–Literature review was done on topics related to decision analysis, top-down and bottom-up effects, Great Lakes fisheries and systems, sea lamprey biology, chinook salmon biology, bioenergetics, and fish energy dynamics. This literature review supported active research and communication of results.

Job 2. Title: Lake Michigan decision analysis.–Existing approaches used to summarize alewife and bloater trawl survey data collected by the Great Lakes Science Center and generate age-specific indices of abundance are based on general linear models that allow for correlated errors. A single "best" model was selected that included fixed class effects due to year and lake region, and a fixed polynomial relationship with bottom depth. These models assumed that the relationship between catch per unit effort and bottom depth was constant over time, so that estimated year-effects could be used as relative indices of abundance. During the past year we have explored approaches that allow depth effects to vary and index abundance as a weighted average (across depths) of year specific predictions of abundance. We have also explored the possibility of using model averaging approaches rather than picking a single best model. Results suggest we can improve on existing methods but require further examination.

Oversight was provided on ongoing analyses of alewife and bloater dynamics. This analysis combined age-specific indices of alewife and bloater abundance from bottom trawl and hydroacoustic surveys, and estimates of predation calculated on the basis of predator stock assessments and bioenergetics calculations. The results of this analysis provided estimates of alewife and bloater recruitment over time, stock sizes over time, alewife and bloater stock recruitment functions, and parameters of the functional response for chinook salmon. In addition to point estimates, posterior distributions for these parameters were calculated. This work formed

a chapter in the completed Ph.D. dissertation of Emily Szalai, and work is proceeding toward producing a manuscript for submission to a peer-reviewed journal.

Supplementing the work on prey fish dynamics, the relationship between chinook salmon natural mortality rates estimated in a stock assessment were related to estimates of chinook salmon size-at-age. The idea here was that past observations suggest that mortality may be related to low growth and associated stress. The result of this analysis was posterior distributions for parameters of a simple function relating chinook mortality rates to size at age.

Dr. Bence participated as a member of a multi-investigator working group, which developed a stochastic simulation model of the salmonine-prey fish community of Lake Michigan. The resulting stochastic simulation model follows age-structured populations of the major predator species and alewife over time. Important process errors include the variation about the alewife stock-recruitment function. The major control variables are stocking rates of chinook salmon and lake trout. Uncertainty is incorporating by making use of the posterior probability distributions for key parameters, which were developed as described above. Key uncertainties allowed for in the modeling included parameters of the alewife stock-recruitment function, the overall effective search rate parameter for the predator functional response, and the connection between chinook salmon mortality and their amount of food intake. Repeated runs of the simulation model produce probability distributions for key quantities such as alewife biomass, chinook salmon mortality, and chinook salmon harvest rates for a given stocking policy.

The stochastic simulation model was developed with technical and non-technical input from natural resource agencies and stakeholders associated with the Lake Michigan system. A preliminary simulation model was presented to a technical working group (including Lake Michigan Technical Committee members and other experts suggested by the Lake Michigan Committee) in December 2002. Based on this input the simulation model was revised during the winter of 2003 and preliminary simulation results were presented to the Lake Michigan Committee in March of 2003. Additional input was received from the technical working group in March and further revisions to the model ensued during spring and early summer of 2003. To date we have used the model to evaluate the outcome of different stocking rates and of "feed-back" approaches where stocking rate depends upon the size chinook salmon reach by age-3. These results formed a chapter in Emily Szalai's dissertation, and a manuscript is being prepared for submission to a peer-reviewed journal.

Job 3. Title: **Lake Huron projection model.**–An existing software program contains information needed to describe current abundance at age and consumption of prey fish by key predators in the main basin of Lake Huron, and allows for projections of those populations and their predation given assumptions about future recruitment, growth, and mortality. We have worked to expand this projection program so that it incorporates stocks in Georgian Bay and the North Channel, and so that lake whitefish and sucker populations are also included. These changes are desirable because the Lake Huron Committee and the Lake Huron Technical Committee supports use of this information for management purposes, and they need summary status over a wider geographic range and for species that are important to fisheries (lake whitefish) or potentially serve as important alternative prey for sea lamprey (suckers). Dr. Bence has overseen the work of a postdoctoral researcher on this topic (Norine Dobiesz). To date she has added modules to the program for whitefish in the main basin, and for lake trout in Georgian Bay and the North Channel. The necessary information has been obtained to "populate" these modules with the needed inputs. In some cases reformatting is needed so the inputs are in the form expected by the program. We note that the lake whitefish information does not contain all the inputs currently used for top predators (e.g., gross conversion efficiency, diet, etc.) in the model. This is not critical since the reason for the inclusion of this species is not to account for their predation, but

rather to provide a summary of their abundance for fishery purposes and as one source of alternative prey for sea lamprey. We have examined some catch per unit effort data for sucker provided by Mark Ebener (Chippewa/Ottawa Resource Authority), but at this point we are uncertain about how or whether these data can be converted into age specific estimates of absolute abundance. Dave Fielder (Michigan Department of Natural Resources) provided us with all of the data needed to update the Saginaw Bay walleye population model, and worked with us to update the parameters of that model. Except for testing this is now up to date and complete. We have obtained some raw diet information for salmonines in the main basin of Lake Huron but have not made final decisions on how to update the diet information. Given sample sizes and variability it is not clear these should be updated annually based on each year's data, especially since changes in diets have ramifications for gross conversion efficiencies. Time was spent with both Llyod Mohr (Ontario Ministry of Natural Resources) and Dave Fielder at the January 2003 Lake Huron Technical Committee meeting discussing the program, the data it used, and what needed to be done.

Job 4. Title: **Sea lamprey lethality and functional response.**–Minor modifications at the copy editing and page-proofs stage were made to a number of "in press" manuscripts that came out of the Sea Lamprey International Symposium, which are being published in *The Journal of Great Lakes Research*.

Bence, J. R, R. Bergstedt, G Christie, P. Cochran, M Ebener, et al. 2003. Sea Lamprey Parasite-Host Interactions in the Great Lakes. Journal of Great Lakes Research 29 (Supplement 1): In press.

Ebener, M. P., J. R. Bence, R. A. Bergstedt, and K. M. Mullett. 2003. Classifying sea lamprey marks on Great Lakes lake trout: observer agreement, evidence on healing times between classes and recommendations for reporting of marking statistics. Journal of Great Lakes Research 29 (Supplement 1): In press.

Rutter, M. A., and J. R. Bence. 2003. An improved method to estimate sea lamprey wounding rate on hosts with application to lake trout in Lake Huron. Journal of Great Lakes Research 29 (Supplement 1): In press.

Stewart, T. J., J. R. Bence, R. Bergstedt, M. Ebener, F. Lupi, and M. Rutter. 2003. Recommendations for assessing sea lamprey damages: toward optimizing the control program in the Great Lakes. Journal of Great Lakes Research 29 (Supplement 1): In press.

Oversight was provided on work attempting to develop a joint sea lamprey functional response and lake trout assessment for the main basin of Lake Huron. This analysis is essentially complete and rough draft descriptions of results have been prepared. The description of results needs to be further refined to support a student dissertation and peer-reviewed publications.

Job 5. Title: **Chinook salmon energetics.**–Guidance was provided by Dr. Bence toward the design of sample collection and approaches to data analysis regarding chinook salmon energetic status. Work to date has emphasized two areas: (1) how chinook salmon lipid levels and associated measures in Lake Michigan vary spatially and temporally as well as with age, size, or other characteristics, and (2) how might chinook salmon energetic status be monitored as part of ongoing surveys. Results show strong seasonal patterns over several years with higher lipid levels in the fall, differences among years and categories of fish, but relatively little spatial differences among locations within the lake. Based on these results samples are now being collected in the fall to compare lipid levels and other measures among lakes Michigan, Huron, and Ontario. Lipid levels are low enough in Lake Michigan that some chinook salmon could be experiencing negative health consequences. Improved understanding of chinook salmon

energetics seems essential, and comparisons between the Great Lakes and Oceanic populations within their native range, as well as among the Great Lakes, may facilitate this. Comparisons of lipid levels (whole body and from various tissues), whole body energy density and water content affirm results from previous investigations that water content may be a cheap and effective approach to monitoring energetic status.

Job 6 Title: **Top down effects and cross-lake comparisons.**–Work in this area has focused on contributions to the Salmonid Communities of Oligotrophic Lakes (SCOL) initiative of the Great Lakes Fisheries Commission. Specific activities have been work to bring the Lake Huron case study paper to fruition, as an article to be submitted to the Canadian Journal of Fisheries and Aquatic Sciences (CJFAS), and to prepare a paper comparing top down effects of salmonines (particularly emphasizing chinook salmon) also for submission to the CJFAS. The Lake Huron paper is a critical underpinning to the cross-lake comparisons. In this area Dr. Bence has participated in writing and literature review as well as overseeing the work of a postdoctoral researcher (Norine Dobiesz). A nearly complete draft will soon be distributed to all co-authors. Dr. Bence is the lead author on a cross-lake comparison of top down effects of salmonines in the Great Lakes. A rough draft manuscript was prepared and a presentation on the manuscript was given at a SCOL meeting held in August 2003. Results indicate marked differences among lakes, especially when comparing Lake Ontario with lakes Michigan and Huron. Lake Ontario appears to have higher growth rates of chinook salmon, more abundant alewife, higher planktivory, and lower growth rates of alewife.

Job 7 Title: **Prepare annual reports.**–This report was prepared on schedule.

Prepared by: James Bence
Date: September 30, 2003