STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-6

Study No.: 230724 **Title:** The importance of trophic interactions for salmonine fisheries of the Great Lakes

Period Covered: October 1, 2004 - September 30, 2005

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 specifically addresses understanding uncertainty and variation in the 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, further modifications to and application of a decision model for stocking of salmon on Lake Michigan, review of the status of a fishery projection model for Lake Huron, calculation of preliminary economic injury levels for sea lamprey in Lakes Huron and Michigan, analyzing and synthesizing information on Chinook salmon energetics, and completion of a comparison of 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 2004-05, 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.–Dr. Bence continued to provide oversight on ongoing analyses of alewife and bloater dynamics. Part of this work led to revisions of a collaborative manuscript in response to reviews (with U.S.G.S. and University of Michigan scientists) in which an alewife stock-recruitment model was developed based directly on trawl survey data. This has now been published in the *Transactions of the American Fisheries Society*. We also did some new analyses to support ongoing revisions to our manuscript describing a detailed model based assessment of alewife and bloater dynamics, which we will resubmit to the *Canadian Journal of Fisheries and Aquatic Sciences*. As described in previous years, the results of this analysis provide critical information used in our decision analysis for salmonine stocking in Lake Michigan. Dr. Bence continued to participate as a member of a multi-investigator working group, which applied the stochastic simulation model we developed of the salmonine-prey fish community of Lake Michigan, to help evaluate alternative decisions about the numbers and species composition of hatchery-reared fish to be planted in Lake Michigan. This work provided part of the information on which the Lake Michigan Committee based their recommendation for a 25% cut in stocking of Chinook salmon in Lake Michigan for 2006. These results were presented at a September 24, 2005 conference for anglers and other stakeholders, where possible cuts in stocking were discussed. Dr. Bence participated in this conference.

Job 3. Title: Lake Huron projection model.–Work on the Lake Huron projection model was limited this year to discussions with Dr. Ji He (Michigan DNR Fisheries Division) on future changes and updating. Dr. He has been designated as the coordinator for future use of the model by the Lake Huron Technical Committee.

Job 4. Title: Sea lamprey lethality and functional response.–Dr. Bence worked collaboratively with a postdoctoral associate (Dr. Emily Szalai) and another professor (Dr. Michael Jones) to determine preliminary Economic Injury Levels (EILs) for lakes Michigan and Huron. EILs specify a level of investment in sea lamprey control above which costs of control exceed the economic value of increases in harvest, and below which further increases in control efforts can be justified solely on the basis of increased harvest. These EILs make use of attack lethality and functional response parameters for the parasitic sea lamprey phase and a model for sea lamprey recruitment and larval development. Our results indicate that on both lakes Huron and Michigan current sea lamprey control is less than could be justified based on EIL results.

Job 5. Title: Chinook salmon energetics.–Guidance was provided by Dr. Bence to collaborators (Dr. Michael Jones, Amber Peters, and others) on approaches to data analysis regarding Chinook salmon energetic status. Work to date in this collaborative project has emphasized three 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, (2) how might Chinook salmon energetic status be monitored as part of ongoing surveys, and (3) how Chinook energetic status varies among lakes Michigan, Ontario, and Huron. In the past year we have prepared a manuscript based on our results for area (1), which has now been submitted to the *Canadian Journal of Fisheries and Aquatic Sciences*. The results in this paper expand on and refine patterns reported on in the 2002-03 annual report, based on a total of 345 Chinook salmon that were collected during 6 sampling periods, beginning in the fall of 2000 and ending in the spring of 2003. Small fish (approximating yearlings) having significantly lower lipid levels than larger fish, were averaged over the spring and fall seasons and years. Lipid levels changed differently from spring to fall for different sizes of fish, however, and averaged over sizes of fish showed some variation in patterns among years. Lipid levels increased from spring to fall for small fish, and decreased for large fish (approximating ages 3 and older), and changed little for medium sized fish. Thus, although larger fish had higher lipid levels on average, large fish had the lowest lipid levels in the fall. This difference in seasonal patterns of lipids for different sizes of Chinook salmon was also seen in seasonal trends in other measures (e.g., water content). For larger fish similar patterns were seen throughout the lake. For small fish lipid levels were lower on the western side of Lake Michigan than on the eastern side. Overall, the lowest lipid levels were seen for small fish in the spring, especially on the western side of the lake. A draft manuscript on area (2) is now being revised for submission to the *Journal of Great Lakes Research*. The results continue to show that lipid levels seen in some Chinook salmon in Lake Michigan during 2000-2003 were low enough to be of concern, and that lipid levels can be efficiently indexed by water content from a dorsal muscle sample. We have recommended to the Lake Michigan Technical Committee that monitoring should focus on small Chinook salmon in the spring, and that both east and west sides of the lake should be monitored. Sampling and preliminary analysis is complete for area (3). Most samples available for comparisons among lakes Michigan, Huron, and Ontario were collected in the fall (2002-2004). Lake Huron salmon had the lowest lipid levels (7.8% in muscle plugs) and Lake Ontario the highest (18.1%). The very low levels in Lake Huron (7.8%), and nearly as low levels in Lake Michigan (9.1%) are of some concern. Lipid levels decreased with size, with the decline being greatest for Lake Ontario fish. This declining relationship with size contrasts with the overall average reported for Lake Michigan during 2000-2003, but this is because the samples for the cross lake comparison were from the fall. Although lipid levels fell more with size in Lake Ontario, lipid levels were still highest for all size classes in that lake. There were tight negative relationships between whole-fish lipid and whole-fish water

content, tight negative relationships between whole-fish lipid and water in muscle, and tight positive relationships between percent lipid in muscle and percent lipid in whole fish for each lake during 2002-2004. These relationships were consistent with our results for Lake Michigan during 2000-2003. The observation of very low lipid levels in Lake Huron and higher lipid levels in Lake Ontario are consistent with our *a priori* expectations based on the observations that (1) Chinook salmon growth rates vary in a similar fashion among the three lakes (highest growth in Lake Ontario) and (2) earlier work from 1997 identified high water and low energy content for Chinook salmon collected in Lake Huron. We worked with Dr. Ji He, Jim Johnson and other members of the Lake Huron Technical Committee to consider future needs to understand the low lipid levels and changing growth and maturation responses of Chinook salmon in Lake Huron.

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 Fishery Commission. Specific activities have been to provide analysis and review to support revisions to the Lake Huron case study paper, and to support completion of a paper comparing top down effects of salmonines (particularly emphasizing Chinook salmon). Both these papers represent multi-investigator collaborations. On the Lake Huron case study, Dr. Bence participated in writing and literature review. The Lake Huron case study paper has now been published in the *Canadian Journal of Fisheries and Aquatic Sciences* (CJFAS). This case study forms critical underpinnings for the cross-lake comparisons, and is an important repository for information on the system. Dr. Bence is the lead author on the cross-lake comparison of top down effects of salmonines in the Great Lakes paper. A revised manuscript was prepared based on comments by the guest editor for CJFAS and this has been submitted to CJFAS, where it is now undergoing peer-review. Results continue to 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 time.

Prepared by: James Bence
Date: September 30, 2005