STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-2

Study No.: 480

Title: Development of Decision Models for the Great Lakes' fisheries

Period Covered: October 1, 2000 - September 30, 2001

Study Objective: Develop decision models for Great Lakes salmonine fisheries that incorporate stocking, harvest, and other management actions as control variables; and predict the likely outcomes such as harvest rates in different locations and other measures of ecosystem performance relevant to achieving a valuable and sustainable fishery.

Summary: Statistical catch-age models were refined or updated for some of the major predators in lakes Michigan and Huron. Substantial progress was made in applying similar methods to alewife and bloater in Lake Michigan. The species-specific stock assessment results are being linked together to estimate consumption of forage fish and to model fish community dynamics. The research program also addressed the issue of sea lamprey mortality on lake trout in Lake Huron, the assessment of yellow perch in Lake Michigan, and basic questions about performance of the stock assessment methods. Results were reported extensively through presentations and submission of manuscripts for publication.

Job 4. Title: Tropho-dynamic and predator models.

Findings: We continued to refine existing predator population models for the main basin of Lake Huron and used these in combination with a gross production approach to estimate predator consumption of forage fish. This work is forming the basis of a Ph.D. dissertation (Norine Dobiesz). The predators we considered were determined through consultation with the Lake Huron Technical Committee and included: three populations of lake trout (north, central, south), two distinct populations of walleye (Saginaw Bay and southern main basin), chinook salmon (entire main basin), and burbot (entire main basin). Details of model structure were described in previous reports. Over the past year, we have largely completed the task of migrating our model to a Visual Basic program from a spreadsheet implementation. We have also updated predator models, with the most extensive updates being for lake trout. More detail on this work is reported in the Study 689 Performance Report.

Overall, our results continued to suggest that total consumption may be near the productive capacity of Lake Huron, although there is still great uncertainty. Current estimates of consumption are above estimates of historical consumption by lake trout and are substantial relative to estimates of forage abundance. Model projections, however, continue to indicate that large reductions in stocking would be required to substantially reduce predator demand for prey, due to major contributions of self-sustaining native and naturalized predator populations. Model projections also suggest that successful control of sea lamprey will produce a modest increase in consumption of prey fish by piscivores.

On Lake Michigan, the chinook salmon model has been refined to better model changes in maturity and growth. Otherwise, the predator models for that lake were not updated.

On Lake Michigan, our focus in the past year was on developing a parameter estimation model to estimate stock-recruitment dynamics of key forage fish species, while accounting for mortality due to predator consumption. This approach treats predator abundances as a forcing function (estimated externally in separate analyses), and parameters are estimated to determine a recruitment time-series and the functional response linking predators to prey. With recruitment and stock sizes of the forage fish then in hand, a stock-recruitment function can be estimated. Because this approach relies on both forage fish survey data and predator abundance estimates, this work is tightly linked to our earlier work on forage fish data and predator stock assessments.

This work was implemented in the AD Model Builder environment, and our current model attempts to estimate alewife and bloater recruitment patterns, while treating predators and the abundance of other forage fish as "known". We continued to address two main challenges in this work. First, initially our model (based on the existing SIMPLE model) for bloater assumed constant size-at-age. However, the observed change in size-at-age over time has been substantial. We have addressed changes in bloater size-at-age through a separate estimation model. This model fits observed size-at-age data over time by allowing growth rates to change dynamically. Incremental growth follows a von Bertalanffy model, and the parameters of the model are allowed to change gradually over time. This modeling work is complete and a draft manuscript is in preparation.

The second and larger challenge has to do with the observed patterns in alewife age and length compositions. The prevailing view is that predator consumption of alewife has been substantial and the major cause of the observed decline in alewife abundance. However, observed age and length compositions for alewife do not show substantial trends over time. Given the pre-existing estimates of size selection by the predators, the model could not fit the full observed age composition without estimating very low levels of predator-induced mortality and extremely high alewife abundance. This is not a reasonable result. Over the past year we explored whether different assumptions regarding size selection of prey fish might account for the observed patterns. Our results demonstrated that any reasonable assumption regarding size selection cannot reproduce the observed patterns. We are uncertain regarding the cause, but now believe that observed changes in age composition of the survey catch may not be completely reflective of the age composition of the population. One possibility stems from a switch from scale to otolith aging in 1984. Other studies have demonstrated that when alewife growth is slow, use of scales can underestimate age. The switch in methodology occurred more or less coincident with a large change in alewife abundance. Hence, changes in methodology and growth might be part of the reason the expected patterns in the full age and size composition are not apparent. Because of potential problems with aging, we now pool ages 3 and above as one group and use only this group and age-0 abundance from the trawl survey when fitting the model. With this modification, fitting the model to the observed data produces overall prey abundance and consumption estimates that make sense in light of direct estimates of prey abundance, and current estimates of predator abundance and consumption rates. This model is still in development. Although overall estimates of predator consumption seem reasonable, the current model showed an unreasonable drop in predator consumption during the 1980s. The modeled level of consumption would not support the growth of chinook salmon that was observed. We suspect this can be resolved by making use of observed growth data to adjust the effective search rate parameter in the functional response. The model also does not fit recent trawl survey indices of age-0 alewife abundance. We are exploring whether this pattern might result from changing catchability of the survey for age-0 alewife that can be adjusted for.

Job 6. Title: Expand research into other areas.

Findings: Research was expanded through funding obtained from other agencies and by partnership with other Projects. Additional support was obtained from the Great Lakes Fishery Commission (GLFC) and Michigan Sea Grant (MSG) to sponsor research on salmonine stock assessment and modeling in the Great Lakes. Sea Grant and GLFC supported graduate students and staff who participated in modeling and data analysis of predator and forage fish in Lake Michigan. Currently a Ph.D. student (Emily Smith) is working in this area. Details on this work are described in other Jobs.

Additional MSG funding was obtained to support research on stock assessment modeling methods, and funding was arranged through the GLFC to support specific stock assessment work on yellow perch in Lake Michigan. A new Ph.D. student was recruited and started in the fall of 2000 (Michael Wilberg) to participate on these projects. An initial statistical catch-age model for yellow perch in Lake Michigan is now in development. The student has become familiar with statistical catch-age methods, simulation approaches, and available software. Trial programs have been developed to simulate data and fit statistical catch-age models to them, as a means for evaluating estimator performance.

GLFC funding has supported work by a pH student (Mike Rutter) on sea lamprey-lake trout interactions. This research included a new method for summarizing sea lamprey wounding, which is described in a manuscript that has been submitted for publication (see Job 7). Research has continued to integrate these results with data informative on sea lamprey and lake trout abundance. The approach here is to integrate a functional response for sea lamprey into a statistical catch-age model for lake trout. This has been implemented in an AD Model Builder environment and performance of the method is being evaluated. This sea lamprey work was extended to include active participation in the sea lamprey international symposium (Dr. Bence co-chaired a session) sponsored by the GLFC in August 2000 and as a result a number of manuscripts have subsequently been submitted for publication (see Job 7).

Tropho-dynamic work described in Job 4 was expanded to make comparisons across the Great Lakes with regard to plankton communities, prey standing stocks, predator standing stocks and consumption rates by predators. As part of this work, a preliminary statistical catch-age model was developed for chinook salmon in Lake Ontario, in Collaboration with the Ontario Ministry of Natural Resources and their partners. These comparisons suggest that consumption of prey fish per unit area is highest in Lake Michigan, but reaches comparable levels in Lake Ontario. Somewhat lower consumption of prey fish occurs in Lake Huron. Much lower prey fish standing stocks and predator consumption of prey fish occurs in Lake Superior, although the top down effect may be large there. Lake Ontario appears to stand out in having much higher standing stocks of alewife. This appears to be a long-standing difference stemming from higher recruitment of alewife in that lake. The smaller average zooplankton size in that lake is consistent with the higher alewife abundance. Similarly, chinook salmon have generally grown faster in Lake Ontario, as might be expected if the dominant prey is more available there. Results from this comparison were presented at a special GLFC workshop, as the second phase of the Salmonid Communities of Oligotrophic Lakes-2 process. Contrast across the Great Lakes in prey fish density and growth of chinook salmon may aid in parameterizing the functional response for this predator.

Dr. Bence expanded his impact on stock assessment in the Great Lakes by acting as an external reviewer of statistical catch-age assessments of walleye and yellow perch in Lake Erie during 2001. This review process was supported by the GLFC within the Lake Committee structure.

Job 7. Title: Publish results and prepare annual reports.

Findings: This annual report was prepared. Two manuscripts were accepted for publication:

Krause, A.E., D.B. Hayes, J.R. Bence, C.P. Madenjian, and R.M. Stedman. In press. Measurement variability in nine Lake Michigan fish species. Journal of Great Lakes Research.

Wilberg, M., J.R. Bence, and J.E. Johnson. In press. Survival of juvenile lake trout stocked in western Lake Huron during 1974-1992. North American Journal of Fisheries Management.

Eight manuscripts were submitted for publication:

Madenjian, C.P., G.L. Fahnenstiel, T.H. Johengen, T.F. Nalepa, H.A. Vanderploeg, G.W. Fleischer, P.J. Schneeberger, D.M. Benjamin, E.B. Smith, J.R. Bence, E.S. Rutherford, D.S. Lavis, D.M. Robertson, D.J. Jude, and M.P. Ebener. Submitted. Dynamics of the Lake Michigan food web, 1970-2000. Canadian Journal of Fisheries and Aquatic Sciences.

Stewart, T., J.R. Bence, R.A. Bergstedt, M.P. Ebener, F. Lupi, and M. Rutter. Submitted. Recommendations for assessing sea lamprey damages: toward optimizing the control program in the Great Lakes. Journal of Great Lakes Research.

Ebener, M.P., J.R. Bence, R.A. Bergstedt, and K.M. Mullett. Submitted. 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.

Hayes, D.B., B. Thompson, J.R. Bence and T. Kwak. Submitted to editors. Biomass, Density and Yield Estimators. Chapter 8 *in* M. Brown and C. Guy, editors, Analysis and Interpretation of Freshwater Fisheries Data. American Fisheries Society Special Publication.

Haeseker, S., M. Jones and J.R. Bence. Submitted. Estimating uncertainty in the stock-recruit relationship for St. Marys River sea lamprey. Journal of Great Lakes Research.

McCleish, D.A., L.C. Mohr, B.A. Henderson, R.L. Eshenroder, M.P. Ebener, T.F. Nalepa, A.P. Woldt, J.E. Johnson, R.L. Argyle, G.L. Curtis, N. Dobiesz, J.R. Bence, and J.C. Markarewicz. Ecology of the Lake Huron Fish Community 1970-1999. Submitted. Special report of the Great Lakes Fishery Commission.

Rutter, M.A. and J.R. Bence. Submitted. Summarizing sea lamprey wounds on lake trout in Lake Huron: a length based approach. Journal of Great Lakes Research.

Bence, J.R, M.A. Rutter, R. Bergstedt, W. Swink, G. Christie, P. Cochran, M. Ebener, J. Koonce. Submitted. Sea Lamprey Parasite-Host Interactions in the Great Lakes. Journal of Great Lakes Research.

Nine oral platform presentations or poster presentations:

Madenjian, C.P., G.L. Fahnenstiel, T.H. Johengen, T.F. Nalepa, H.A. Vanderploeg, G.W. Fleischer, P.J. Schneeberger, D.M. Benjamin, E.B. Smith, J.R. Bence, E.S. Rutherford, D.S. Lavis, D.M. Robertson, D.J. Jude, and M.P. Ebener. Dynamics of the Lake Michigan food web, 1970-2000. Ecological Society of America, August 2001.

Smith, E.B., G. Fleischer, and J.R. Bence. Modeling time-varying growth for bloater in Lake Michigan. American Fisheries Society Meeting, August 21, 2001, Madison, Wisconsin.

Madenjian, C.P., D.M. Benjamin, E.B. Smith, J.R. Bence, E.S. Rutherford, and P.J. Schneeberger. Dynamics of salmonine, lake whitefish, burbot, and yellow perch populations in Lake Michigan, 1970-2000. International Association for Great Lakes Research, June 10-14, 2001, University of Wisconsin - Green Bay. Abstract published by IAGLR, 2205 Commonwealth Blvd, Ann Arbor, MI 48105.

Dobiesz, N.E. and J.R. Bence. Prey fish biomass eaten by predators in the main basin of Lake Huron. International Association for Great Lakes Research, June 10-14, 2001, University of Wisconsin - Green Bay. Abstract published by IAGLR, 2205 Commonwealth Blvd, Ann Arbor, MI 48105.

Schrouder, J.R., J.R. Bence (presenter), and M.P. Ebener. Evaluating Fish Community Objectives for Lake Huron. International Association for Great Lakes Research, June 10-14, 2001, University of Wisconsin - Green Bay. Abstract published by IAGLR, 2205 Commonwealth Blvd, Ann Arbor, MI 48105.

Woldt, A.P., S.P. Sitar, J.R. Bence, and M.P. Ebener. Status of lake trout in Lake Huron: partitioning mortality using statistical catch at age modeling. International Association for Great Lakes Research, June 10-14, 2001, University of Wisconsin - Green Bay. Abstract published by IAGLR, 2205 Commonwealth Blvd, Ann Arbor, MI 48105.

Dobiesz, N.E. and J.R. Bence. Consumption by key predators in the Lake Huron main basin. Poster presented at Michigan DNR Fisheries Division In Service meeting, March 1, 2001.

Dobiesz, N.E. and J.R. Bence. Predator-prey interactions: prey consumption by key predators in Lake Huron. State of Lake Huron Symposium, Upper Lake Meetings, March 22, 2001, Sault Ste. Marie, Canada.

Ebener, M.P., J.R. Bence, R. Bergstedt, and K. Mullet. Sea lamprey marking assessment. Common Session, Upper Lake Meetings, March 22, 2001, Sault Ste. Marie, Canada.

Prepared by: James Bence
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