Final Report

Assessing Lake Michigan Salmonine Stocking Policies Using Decision Analysis

Project number: 2007.950

PROJECT ABSTRACT

Assessing Lake Michigan Salmonine Stocking Policies Using Decision Analysis

Lake Michigan's multi-billion dollar salmon fishery was developed through an aggressive stocking program beginning in the mid 1960s. Since the late 1980s, Lake Michigan fishery managers have faced critical questions concerning the ideal rate of salmon stocking to use to sustain this fishery. Two key factors that have influenced this issue are (1) evidence of a sharp increase in natural production of Chinook salmon from Lake Michigan tributaries since 1990, and (2) uncertainty about the salmonine predation rates that their primary prey species, the alewife, can support. The primary goal of this project was to inform management decisions about stocking levels. We collaborated with state agencies to collect tails of Chinook salmon and examine them for oxytetracycline marks that would indicate a hatchery origin for the fish. For the 2006-2009 year classes we found consistently high (> 50%) proportions of un-marked (i.e., naturally-produced) Chinook salmon, providing strong evidence that wild Chinook salmon are a large and important component of the overall predatory demand for alewife in Lake Michigan. Using federal and state agency data sets on salmon stocking, catch rates, growth rates, and prey fish abundance indices over time, we developed assessment models to reconstruct the estimated past history of salmonine and prey fish abundance and production in Lake Michigan. We used this retrospective analysis to develop a decision analysis model that forecasted the range of possible outcomes from alternative stocking strategies, measured in terms of important management objectives such as Chinook salmon catch rates, and alewife biomass. We developed this model through an engaged process that involved salmon fishery stakeholders (managers and fishers). The model indicated that current stocking levels resulted in unacceptably high risks of excessive predation – from the point of view of stakeholders – and ultimately played a central role in a collective decision of Lake Michigan fishery management agencies to substantially reduce Chinook salmon stocking in 2013. The combination of sophisticated population assessment tools and a process for engagement with stakeholders, including decision-makers, proved extremely effective at informing management decisions that enjoyed broad stakeholder support.

Final Narrative Report

Project Title: Assessing Lake Michigan Salmonine Stocking Policies Using Decision Analysis

Grantee: Quantitative Fisheries Center, Michigan State University

Project Team: Michael Jones, Iyob Tsehaye, Jim Bence, Travis Brenden, Mart Williams (Michigan State University); Randall Claramunt (Michigan DNR); David Warner (USGS Great Lakes Science Center)

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Grant Amount: $369,139

Start and End Dates: 11/1/2008 – 5/1/2014

Key Search Words: Decision analysis, Chinook salmon, Lake Michigan, alewife, stocking, fishery management

Background/Overview

1. Briefly summarize the project description as outlined in the original proposal.

A central management question faced each year by Lake Michigan fishery managers is how many and what species of salmonine fishes to stock. Although natural production of some salmonine species, especially Chinook salmon *Oncorhynchus tshawytscha*, is believed to be substantial (exceeding 50% of all recreational harvest for Chinook salmon), the economically valuable recreational salmon fishery in Lake Michigan continues to depend on hatchery production. The challenge is to avoid stocking too many fish, leading to an excess of predators relative to the supply of prey and consequently a decline in prey abundance. Such declines could lead to nutritional stresses that trigger elevated predator mortality. On the other hand stocking too few fish limits fishing opportunities (or at least catch rates), and may allow prey fish (primarily alewife *Alosa pseudoharengus*) to increase in abundance to levels where their predatory or competitive effects on native species are unacceptably great. In the early years of the Lake Michigan salmonine program (1970s and 80s) stocking rates increased as production capacity increased, with little attention given to forage availability. In the late 1980s, however, an outbreak of Bacterial Kidney Disease in Chinook salmon led to a sharp decline in salmon numbers and harvest prompting managers to carefully consider predator-prey balance in the ensuing years.

In this project we updated and refined a decision analysis model that integrated knowledge about the Lake Michigan salmonine predator prey system, and used this model as a key tool to inform discussions about management of the Lake Michigan salmonine stocking program. We completed a retrospective analysis of assessment data for salmonine predators and key prey species, and used these results to build a stochastic simulation of future salmonine dynamics that incorporated key sources of uncertainty identified and quantified in the retrospective analysis and allowed evaluation of alternative future stocking strategies. As well, we collaborated with state agencies to collect and examine Chinook salmon for the presence of an oxytetracycline mark that was indicative of hatchery origin, thereby allowing estimate of the contribution of naturally-produced Chinook salmon to the fishery. Using an amendment to the original project grant, we extended this empirical study to include all five Chinook salmon year classes (2006-2010) that were marked with OTC in hatcheries.

Outcomes

3. To what extent and how (if at all) did this research project advance scientific knowledge of the issue?

This project has, to date, resulted in two peer-reviewed publications describing our retrospective analyses, and a Masters thesis describing the results of the first three years of the OTC study. We are continuing to analyze the OTC data to include all five years, and anticipate publishing the results of this work. We will also prepare and seek to publish a paper summarizing our decision analysis work.

4. To what extent and how (if at all) did this project contribute to the education and advancement of graduate or undergraduate students focused on Great Lakes fishery issues?

The OTC study formed the basis of a Masters thesis research project for Mart Williams. We also employed four undergraduate students to assist with the processing of samples. One of those student conducted an MSU Undergraduate Research Project working with the OTC data and presented his findings at a student research forum on campus. Another undergraduate student is currently assisting with the analysis of the full OTC data set, and will use this to form the basis of a second Undergraduate Research Project, and contribute (as a co-author) to the publication of the results. Finally, the post-doctoral research associate (Iyob Tseheye), while not a student, used this project to considerably advance his skills with stock assessment and modeling, leading to him being the lead author on publications that have results, and preparing him for a successful career in quantitative fisheries science.

5. To what extent and how (if at all) did this work help you or others on your team build new relationships with others in the research or management communities?

During this project technical staff at the QFC worked closely with management agency staff on the analysis, and in stakeholder-centered discussions of the decision analysis model. These interactions enhanced our already strong working relationship with Lake Michigan fishery management agencies.

6. To what extent and how (if at all) do the findings have action implications for fishery

managers? If the research has direct management implications, do you have any knowledge of use of the findings by managers? If the research does not have direct management implications at this stage, to what extent did the research advance the process of identifying management responses to critical issues?

The work supported by this project directly influenced the key management decision by Lake Michigan fishery agencies to substantially reduce Chinook salmon stocking. To be candid, it is difficult to imagine a project that had more direct management implications. We were in fact urged by the Lake Michigan managers to seek funds to carry out this project, as part of their ongoing partnership relationship with the QFC.

7. Considering the above or other factors not listed, what do you consider to be the most important benefits or outcomes of the project?

Undoubtedly, the most important benefit of this project, from a broad perspective, is that it provided an objective, scientifically sound basis for determining the risks associated with alternative stocking policies. This, coupled with our deliberate efforts to engage managers and stakeholders in the analysis, allowed our efforts to have a substantive impact on policy.

Related Efforts

8. Was this project a stand-alone effort, or was there a broader effort beyond the part funded by the GLFT? Have other funders been involved, either during the time of your GLFT grant or subsequently?

This project was a stand-alone effort.

9. Has there been any spin-off work or follow-up work related to this project? Did this work inspire subsequent, related research involving you or others?

This project informed two more recent projects, one funded by the Great Lakes Fishery Commission to examine and revise the "Red Flags" approach used by the Lake Michigan Technical Committee to assess the status of the salmonine fishery, and a second funded by the Great Lakes Fishery Trust to assess the magnitude of movement of Chinook salmon from Lake Huron into Lake Michigan.

Communication/Publication of Findings

10. List publications, presentations, websites, and other forms of formal dissemination of the project deliverables, tools, or results, including those that are planned or in process.

Tsehaye, I., Jones, M. L., Brenden, T. O., Bence, J. R., and Claramunt, R. M. 2013. Changes in the salmonine community of Lake Michigan and their implications for predator-prey balance. 56th Annual Conference of the International Association for Great Lakes Research (IAGLR), Purdue University, West Lafayette, IN, June 2–6, 2013.

Jones, M.L. and I. Tsehaye. 2011. Examining stocking options for Lake Michigan salmonines using Decision Analysis. Lake Michigan Committee Meeting, Ypsilanti, MI, March 23, 2011

Tsehaye, I. and Jones, M. L., Assessing changes in alewife and rainbow smelt abundance in relation to salmonine consumption in Lake Michigan. AFS Annual Conference, Seattle, WA, September 4–11, 2011.

Tsehaye, I.W., M.L. Jones, T.O Brenden, J.R. Bence, C.P. Madenjian, and D.M. Warner. 2014. A multispecies statistical age-structured model to assess predator–prey balance: application to an intensively managed Lake Michigan pelagic fish community. Canadian Journal of Fisheries and Aquatic Sciences 71(4): 627-644.

Tsehaye, I.W., M.L. Jones, T.O Brenden, J.R. Bence, and R. Claramunt. 2014. Changes in the salmonine community of Lake Michigan and their implications for predator-prey balance. Transactions of the American Fisheries Society 143:420-437.

Bunnell, D.B., Barbiero, R., Ludsin, S.A., Madenjian, C.P., Croley, I.I., Thomas, E., Warren, G.J., Dolan, D.D., Brenden, T.O., Briland, R., Gorman, O.T., He, J.X., Johengen, T.H., Lantry, B.F., Lesht, B.M., Nalepa, T.F., Riley, S.C., Riseng, C.M., Treska, T.J., Tsehaye, I., Warner, D.M., Walsh, M.G., and Weidel, B.C. 2014. Changing ecosystem dynamics in the Laurentian Great Lakes: bottom-up and top-down regulation. *BioScience* 64: 26–39.

Madenjian, C.P., Bunnell, D.B., Warner, D.M., Pothoven, S.A., Fahnenstiel, G.L., Nalepa, T.F., Vanderploeg, H.A., Tsehaye, I.W., Claramunt, R.M., and Clark, R. D., *To be resubmitted July 15*. 2014. Changes in the Lake Michigan food web following dreissenid mussel invasions. *Journal of Great Lakes Research*.

Williams, M.C. 2012. Spatial, temporal, and cohort-related patterns in the contribution of wild chinook salmon (Oncorhynchus tshawytscha) to total Chinook harvest in Lake Michigan. MS Thesis. Michigan State University.

An additional manuscript is planned to present the complete results of the OTC study.

11. Please characterize your efforts to share the findings of this research with state, federal, Tribal, and interjurisdictional (e.g., Great Lakes Fishery Commission) agencies charged with management responsibilities for the Great Lakes fishery. If other audiences were priority for this research, please characterize your outreach efforts to those audiences as well. (Please note: You may wish to consult midterm reports in which specific audiences for the findings, and means of outreach to these audiences, were identified.)

We attended Lake Michigan Technical Committee meetings on numerous occasions during the project period to update biologists and managers on our progress. Also, as noted earlier, we organized separate meetings with stakeholders and experts to discuss and inform model development. We worked with Michigan Sea Grant to contribute to outreach events with presentations of our research.

12. Please identify technical reports and materials attached to this report by name and indicate for each whether you are requesting that GLFT restrict access to the materials while you seek publication. (Please note that the maximum amount of time during which GLFT will restrict access to the results of funded research is six months, unless notified that more time is needed.)

None

13. Manuscripts. Grantees submitting one or more publications or pending publications in lieu of a stand-alone technical report must submit a cover memo that confirms that all aspects of the funded research are incorporated in the published work, and, in cases of multiple publications, identifies or crosswalks the grant-funded objectives to the published article containing results.

Two published manuscripts are attached.

14. Compilation reports. Grantees working on several related sub-projects under a single grant may submit a series of sub-project reports rather than a single, integrated report. However, grantees must submit a cover sheet or introduction that outlines and crosswalks grant objectives with the location of the results in the compilation document.

Does not apply

Discussion

As noted earlier, this GLFT-funded project has, in our view, made a significant contribution to advancing the scientific basis for decision making regarding salmonine stocking in Lake Michigan. Our work has made use of a wide range of information sources, and integrated them into a synthetic model that allows objective forecasts of the risks associated with alternative stocking strategies. The success of the project is largely due to a strong collaborative effort among experts with relevant knowledge and information about salmonine-prey fish dynamics in Lake Michigan, and to engagement of key decision-makers and stakeholders in the analytical-deliberative sequence that guided model development and use. Our analysis of the OTC data set we gathered during this project is ongoing, and promises to yield valuable insights into the dynamics of wild Chinook salmon production from Lake Michigan tributaries. Additionally, the project stimulated a new set of critical research questions that has motivated (1) a new study on hatchery Chinook salmon movement between Lakes Michigan and Huron, funded in 2013 by the GLFT, and (2) a research proposal submitted to the GLFC in 2014 to utilize otolith microchemical signatures from Chinook salmon to estimate contributions of wild Chinook salmon from various sources, including Lake Huron, to the Lake Michigan Chinook fishery. These two studies will address a key uncertainty that emerged from this project, namely the degree to which immigration of Lake Huron salmon into Lake Michigan is an important driver of both catch rates, and predatory demand. Finally the retrospective analyses conducted as part of this project have led to the identification of a potentially powerful indicator to help guide future management of this fishery: a ratio of predator biomass to prey biomass that uses outputs from our now published assessment models and that appears to reliably indicate when risks of excessive predation are sufficient to warrant serious consideration of a stocking cut. The Lake Michigan Committee is currently considering adopting this metric as a primary indicator to guide future management of this extremely valuable fishery.