STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-16

Study No.: 230522 **Title:** Quantitative stock assessments and assessment of predator-prey balance for Lake Huron fishery management.

Period Covered: October 1, 2014 to September 30, 2015

Study Objectives:

1. To compile annually collected diet data and conduct comparative analyses among major piscivores in the fish community of Lake Huron.

2. To maintain regular energy density monitoring and conduct comparative analyses among major fish species of Lake Huron.

3. To monitor variation and changes in life-history parameters, as indicators of ecosystem health and individual conditions, including comparative analyses among major fish species of Lake Huron.

4. To maintain, improve, and develop age-structured stock assessment models for major fish species and their fisheries in Lake Huron, assisting fishery managers with harvest regulation, including the development and evaluation of management strategies.

5. To update total prey consumption estimates at individual, population, and lake-wide levels, including the consumption of each major prey species, assisting fishery managers with management decisions.

Summary: This project met all job requirements for 2014–15. We published findings in the *Canadian Journal of Fisheries and Aquatic Sciences* documenting the first overall modeling synthesis about top-down influences on rapid changes in the Lake Huron food web. The second modeling synthesis, which used time-varying growth parameters and body condition to indicate ecosystem regime shift in the main basin of Lake Huron, is in review at the same journal. Model applications directly assisted stock assessments for multiple fish species in multiple management units, including those in 1836 Treaty ceded waters.

Findings: Jobs 1–5 were scheduled for 2014-15, and progress is reported below.

Job 1: Gather and organize data.–

1) We used a mixed-effect ANOVA model to analyze 2014 spring and summer survey data contributed by multiple agencies, and updated the fisheries-independent index of Lake Trout *Salvelinus namaycush* relative abundance from 2015 stock assessments for each of the three management units in the main basin of Lake Huron. We incorporated updates into 2015 stock assessment models.

2) We incorporated 2014 data contributed by multiple agencies into 2015 stock assessment models, and updated time-series for commercial and recreational fishing effort and catch for each of the three management units in the main basin of Lake Huron.

3) We incorporated 2014 data contributed by multiple agencies into 2015 stock assessment models, and updated time series of commercial, recreational, and survey age composition, including data weighting.

4) We collected more than 700 Lake Whitefish *Coregonus clupeaformis* samples from Michigan Lake Huron commercial fisheries, and started the age assignment process.

Job 2: Update life-history parameters.–

1) We incorporated 2014 data, and updated time-varying growth models and time-varying length-weight models for multiple Lake Whitefish management units of 1836 treaty waters.

2) A manuscript using time-varying asymptotic length and body condition of top piscivores to indicate ecosystem regime shift in the main basin of Lake Huron is in review with the Canadian Journal of Fisheries and Aquatic Sciences. This manuscript included updates of model structures for time-varying growth and length-weight models and their applications to Lake Trout, Chinook Salmon, and Walleye.

Job 3: Update stock assessment models.–

1) We conducted a comprehensive review of Lake Trout assessment models, and made major progress toward rebuilding the models as reported at the September 2000 Consent Decree Technical Fisheries Committee Modeling Subcommittee meeting.

2) We published a Michigan State University Quantitative Fisheries Center technical report documenting the update of the Chinook Salmon catch-at-age model.

3) We secured multiagency data collected through 2014 and began the process of updating the Walleye *Zander vitreus* catch-at-age model.

Job 4: Update ADMB fish bioenergetics models.–

1) We published the following article in the Canadian Journal of Fisheries and Aquatic Sciences documenting the model system for coupling age-structured stock assessment and fish bioenergetics models, including model applications to Lake Trout, Chinook Salmon *Oncorhynchus tshawytscha*, Walleye, and Lake Whitefish in multiple management units in the main basin of Lake Huron:

   He, J. X., J. R. Bence, C. P. Madenjian, S. A. Pothoven, N. E. Dobiesz, D. G. Fielder, J. E. Johnson, M. P. Ebener, R. A. Cottrill, L. C. Mohr, and S. R. Koproski. 2015. Coupling age-structured stock assessment and fish bioenergetics models: a system of time-varying models for quantifying piscivory patterns during the rapid trophic shift in the main basin of Lake Huron. Canadian Journal of Fisheries and Aquatic Sciences 72:7-23.

2) We submitted a project completion report to the Great Lakes Fishery Commission for the funded companion project: Quantifying new top-down influences on the rapidly changing food web in the main basin of Lake Huron.

Job 5: Write annual performance report.–This progress report was prepared on schedule. In addition, a project summary was completed (Attachment 1).

Prepared by: Ji X. He and David G. Fielder
Date: September 30, 2015

Quantitative Stock Assessments and Assessment of Predator-Prey Balance for Lake Huron Fishery Management

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Background

The past 15 years have seen dramatic changes in the food web of Lake Huron. The collapse of Alewives in 2003, following changes in nutrient availability due to invasive mussels, caused a crash of the Chinook Salmon fishery and allowed resurgence of native Lake Trout and Walleye. Prior to this change, large amounts of field survey data were collected every year in the main basin of Lake Huron and summarized to assist fisheries management decisions. Since the food web has greatly changed, the typical data analysis and summaries of the abundance, growth, and survival of recreationally and economically important fish species were no longer sufficient for examining Lake Huron's fisheries. Separate analyses of each data source, as done in the past, often suggested different fisheries management directions, and left information gaps to manage this fishery. This study is designed to provide the needed information synthesis by using a group of models to describe populations of major predator species and how they have responded and will continue to respond to food web changes.

There are no field or laboratory components specific to this study; rather, it uses data collected from many existing surveys, including the assessment of lake trout stocks in Lake Huron, the description of the fish community in Saginaw Bay, walleye tagging in Saginaw Bay, and the creel survey program. Data from surveys conducted by other fisheries agencies are also used. The models use all measurements from major predator species in the main basin of Lake Huron, including Saginaw Bay. Current models have included Chinook Salmon (one management unit), Walleye (one management unit), Lake Trout (three management units), and Lake Whitefish (six management units). Age-structured population (also known as stocks) assessments are used to estimate abundance and mortality, and models that vary over time are used to evaluate growth and condition changes over a range of years. These models are coupled with diet information using fish bioenergetics models to assess fish production and prey consumption. Future efforts will include development of similar models for Yellow Perch as well as additional trout and salmon species, and existing models will be updated and improved as needed.

What are the key recent results?

In the past year, we estimated the predator fish influences on the recent and ongoing changes in the food web, which can be used to predict and explain future diverse fishing opportunities in Lake Huron. Some of the key findings are:

- During 1995–2002, changes were already underway that ultimately led to the collapse of Alewives, and dramatic decline in Chinook Salmon abundance.
- Lake Trout responded to the early declines in prey supply by reducing body length, but maintaining their body condition. In contrast, Chinook Salmon and Walleye maintained their growth in body length but became thinner.

- Relative to Lake Trout, the contribution of Chinook Salmon to total predator biomass and total consumption of prey fish decreased during the pre-collapse period.
- Unlike Chinook Salmon, both Walleye and Lake Trout effectively switched to feeding on alternative preys such as Round Goby after the collapse of Alewives. They were able to enhance young fish survival once Alewives became scarce, and were able rapidly increase natural reproduction and recruitment.
- Before and after the Alewife collapse, total biomass of major predator fish species combined were relatively stable, although there were major changes in the relative contribution of each species, reflecting differences in life histories and feeding ecology.
- The combination of a general preference for Alewives by all the major fish predators and a relative stable total fish predator biomass supported by other prey species, contributed to the initial declines and final collapse of alewives in Lake Huron. This combination has continued to date and Alewives are still nearly absent from Lake Huron.

Where can I find the detailed results?

Data and analysis from this study have been published in several peer-reviewed journal articles, which are available from the lead biologists. In addition, project updates are presented at many different venues each year, including the annual Michigan Sea Grant Lake Huron fishery workshops and the Great Lakes Fisheries Commission's annual Lake Committee meetings. Additional information on this study can be found at http://www.michigan.gov/dnr/0,4570,7-153-10364_52259_19056-333302--,00.html.

What does this project do for fisheries managers and anglers?

The models generated and maintained by this study are critical to Fisheries Division's ability to track, predict, and advise management of both recreational and commercial fisheries in Lake Huron. Fisheries managers use the information from this project to set fishing regulations, such as minimum size limits and daily bag limits, which specify the size and number of fish that an angler can harvest in one day. Fisheries regulations for Lake Huron can be found by clicking "Rules & Regs" on the Michigan Department of Natural Resources' Fisheries Division website at http://www.michigan.gov/dnr/dnrfishing.