STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-1

Study No.: 496 **Title:** Develop computer models of lake trout and lake whitefish in 1836 Treaty-ceded waters of lakes Superior, Michigan, and Huron.

Period Covered: October 1, 1999 to September 30, 2000

Study Objective: To construct computer models of lake trout and lake whitefish populations and fisheries in 1836 Treaty-ceded waters of lakes Superior, Michigan, and Huron. Then, to utilize those models to assist with negotiating or litigating state/tribal-fishing agreements in the year 2000.

Summary: Data requirements for development of catch-at-age models have been determined, appropriate software has been selected, and assembly of all pertinent data into a common relational database is complete. Statistical catch-at-age (SCAA) models estimating population parameters of lake trout and lake whitefish populations and fisheries in the upper Great Lakes have been developed. Whitefish SCAA models have been used to estimate population parameters for State of Michigan and tribal whitefish management units. Development of a short-term simulation model used to predict total allowable catch and the effects of different fishery management scenarios has also been completed. This prediction tool uses Microsoft Excel as the software platform.

Job 1. Title: Inventory and assemble all available assessment data on lake trout and lake whitefish into relational databases by species and lake, and correct errors.

Findings: All assessment data on lake trout and lake whitefish dating back to at least 1981 has been inventoried and assembled into a database. This is includes data collected in collaboration with the tribes and all data available from the State.

Job 2. Title: Assemble all sport and commercial harvest data, including age compositions, into databases for each lake and correct errors.

Findings: Sport and commercial harvest data were assembled. Estimates of sport harvest prior to 1999 used in the models were those generated using software and algorithms in use at the time those surveys were done. These were deemed the best available estimates of harvest. Initially we considered the possibility of re-estimating harvest for all years using new formulae that provide more robust estimates of variance and potentially more reliable harvest estimates. Difficulties were encountered recovering all data and checking the many special cases. Initial re-estimates were sometimes far from the original values. In checks on a subset of cases this sometimes occurred because of unrecoverable data files needed to re-calculate these estimates. In other cases substantial differences were found that were generally resolvable as resulting from special aspects of the creel survey at a site that had not been accounted for in the programs being

used. However there were some differences in estimated values (generally not large for well-sampled sites) that arose from application of the new algorithm. Because initial checks indicated that re-calculated point estimates (where all data were available and there were no ambiguities) were similar to those calculated in the past, and because a fully verified set of new estimates could not be generated in the time available, the existing estimates were used. This is an area needing further examination. The State of Michigan commercial harvest data have been error checked, are complete, and have been put into a relational database in Lansing, Michigan. Tribal commercial fishery harvest data was also error checked, are also complete, and have been put into a relational database in Lansing, Michigan. Additional data may be requested from Chippewa Ottawa Resource Authority (CORA) Biological Services Division (BSD) to supplement this database as required for future model development.

Job 3. Title: Assemble all stocking data and correct errors.

Findings: Stocking data for lake trout are maintained by U.S. Fish and Wildlife Service and the Michigan Department of Natural Resources. Verification of data for all three of the upper Great Lakes has been completed, and those data have been put into a relational database in Lansing, Michigan.

Job 4. Title: Define geographical boundaries for models and migration.

Findings: Geographical boundaries were adjusted from last year to match data compilation used in the models for various management areas. Lake Superior geographic boundaries for models of lake trout populations and fisheries were defined as lake trout management units MI-5 - Marquette, MI-6 - Munising, MI-7 - Grand Marais, and MI-8 - Whitefish Bay. Lake Huron geographic boundaries were a northern area including the MH-1 statistical district and associated Ontario waters- Northern Lake Huron southward to Rogers City, and a north-central area encompassing MH-2 and associated Ontario waters- Rogers City to Sturgeon Point. Lake Michigan areas included a northern area encompassing MM-1, MM-2 and MM-3 (south to Norwood), MM-4 - Grand Traverse Bay, MM-5 - Leelanau Point to Arcadia, and MM-6 and MM-7 combined - Arcadia to Holland. Within the northern Lake Michigan and combined MM-7 and MM-8 areas, separate sub-areas encompassing the northern and mid-lake refuges (respectively) were modeled to account for the lack of fishing in those areas and evidence that the stocks in those refuges were not well mixed with the more nearshore stocks. Within Lake Superior lake trout were assumed to occur within the management unit they originally recruited to. In lakes Michigan and Huron transition matrices were developed to account for movement among areas, based on results of coded wire-tagging studies and other information on movements. A simple approach was adopted, whereby fish were moved immediately after stocking to a modeled area and were assumed to reside in this area of recruitment thereafter.

Lake Superior geographic boundaries for models of lake whitefish populations and fisheries were defined as lake whitefish management units WFS-04, WFS-05, WFS-06, WFS-07, and WFS-08. In northern Lake Huron boundaries included whitefish management units WFH-01, WFH-02, WFH-04, and WFH-05. Data were inadequate to model the refuge area (WFH-03) in Lake Huron. In Lake Michigan, geographic boundaries included whitefish management units WFM-01, WFM-02, WFM-03, WFM-04, WFM-05, WFM-06, and WFM-07.

Job 5. Title: Construct age-structured lake trout population models and debug.

Findings: Lake trout population models were constructed for management areas as shown in Table 1. Model parameters for use in the construction of the lake trout models are similar to those used by Sitar (1996).

Shawn Sitar (Marquette Fisheries Station) and Dr. James Bence (Michigan State University) developed a comprehensive lake trout model, which took into account sea lamprey induced mortality. Models were developed using the software AD Model Builder (Otter Research Ltd. 1993). AD Model Builder allows the rapid development and fitting of general nonlinear statistical models similar to the catch-at-age models of lake trout and lake whitefish developed here. AD Model Builder achieves its high performance levels by employing the AUTODIF C++ class library. AUTODIF combines an array language with the reverse mode of automatic differentiation supplemented with precompiled code for derivatives of common array and matrix operations. In short, AD Model Builder is able to quickly compute exact solutions to difficult nonlinear problems thus making it state-of-the-art in this type of model development.

Actual compilation of needed data, and fitting and evaluation of lake trout models for all areas, is complete and has been a team effort including substantial contributions by many Michigan DNR, tribal, and federal biologists.

Job 6. Title: Construct age-structured lake whitefish population models and debug.

Findings: Lake whitefish population models were constructed for management areas as shown in Table 1. Model parameters for use in construction of lake whitefish models were similar to those used by Sitar (1996). Recreational fishing intensity was not high enough to include in these models. Sea lamprey induced mortality was included for Lake Huron whitefish models.

As in Job 5 above, AD Model Builder was used to develop comprehensive models of lake whitefish populations and fisheries. Kurt Newman worked with Dr. James Bence in development of these models. The basic model included two fisheries, trap and gill net. Development of the basic model was done with a time series of the necessary data compiled by Mark Ebener (Chippewa Ottawa Tribal Fishery Management Authority (COTFMA) from whitefish management unit WFM-03. Models have been developed for all whitefish management units. As with lake trout models, the stock assessment and modeling for lake whitefish completed this year for all management units was done cooperatively with state and tribal biologists making substantial contributions.

Job 7. Title: Run catch-at-age analysis and estimate the optimum suite of parameters that best describe the population dynamics of lake trout and lake whitefish.

Findings: Fisheries catch-at-age models are used to try and estimate exploitation rates, population size-at-age, and recruitment to the fishery in exploited fish populations. Results from the models described above, which make use of the full time series of data inputs compiled last year, were evaluated. Consensus among the modeling group was that the basic results are complete and the development of final reports is underway.

Job 8. Title: Run model simulations according to various management options to estimate future population dynamics.

Findings: This modeling effort is a three-part process. It begins with parameter estimation, which leads to short-term projections of total allowable catches (TAC's), and long-term projections under different management scenarios (gaming). Parameter estimation for all management units was completed this year and a short-term projection model was developed utilizing Microsoft Excel software as the platform.

Job 9. Title: Update models as data become available and recalibrate if necessary.

Findings: Updates to models will continue as new data are collected. However, at this time the modeling group is in agreement that the parameter estimation phase of this modeling effort has been completed with the best and most appropriate time series data by management unit available.

Job 10. Title: Assist the negotiating or litigating parties in predicting how differing settlement scenarios will effect lake trout and whitefish populations.

Findings: Assistance to the implementation team is ongoing.

Job 11. Title: Write annual Federal Aid reports and reports documenting construction of the models, how they were used in the negotiation or litigation process, and how well any settlements conformed to the model outputs.

Findings: Final reports/stock assessments are in development. This annual progress report was completed as scheduled.

Literature Cited:

Otter Research Ltd. 1993. AD Model Builder software. Box 265, Station A, Nanaimo, B.C. V9R 5K9 CANADA.

Sitar, S. P. 1996. Estimation of lake trout (*Salvelinus namaycush*) abundance and mortality due to sea lampreys (*Petromyzon marinus*) and fishing in the main basin of Lake Huron, 1984–93. Michigan Department of Natural Resources, Fisheries Research Report 2030, Ann Arbor.

Smith, S.H., H.J. Buettner, and R. Hile. 1961. Fishery statistical districts of the Great Lakes. Great Lakes Fishery Commission, Technical Report 2, Ann Arbor, MI.

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Table 1.–Lakes Michigan, Superior, and Huron management units[a] requiring modeling efforts (x) for lake trout, whitefish, or both species.

Management	Michigan		Superior		Huron	
Unit	Lake trout	Whitefish	Lake trout	Whitefish	Lake trout	Whitefish
M-1	x	x			x	x
M-2	x	x			x	x
M-3	x	x				
M-4	x	x		x		x
M-5	x	x	x	x		x
M-6	x	x	x	x		
M-7	x		x	x		
M-8		x	x	x		

[a] Lake trout management units in Lake Superior are subdivisions of statistical districts and lakes Michigan and Huron are statistical districts as described by Smith et al. (1961). Lake whitefish were modeled by lake whitefish management units (WFMU) for each of the lakes.