## BACKGROUND

The Quantitative Fisheries Center (QFC) was established at Michigan State University (MSU) on 1 July 2005 to (1) build greater capacity within fishery management agencies in quantitative methods; (2) improve quantitative methods for assessing and managing fish stocks; (3) assist agencies in the use of model-based approaches to decision making; and (4) develop a better understanding of fish community and population dynamics. The QFC was created through joint funding by MSU, the Michigan Department of Natural Resources (now Michigan Department of Natural Resources and Environment), the Great Lakes Fishery Commission, and several Great Lakes Council of Lake Committee agencies. The QFC provides three main services to partner agencies: (1) innovative research on new approaches for quantitative science in support of fishery management; (2) outreach to assist in continued application of decision tools developed through partnerships with fishery agencies, and; (3) training opportunities in quantitative fishery techniques for graduate students and mid-career professionals in fishery management agencies.

## STATUS

### Staffing

The QFC is co-directed by Drs. James Bence and Michael Jones. Currently, QFC staff consists of an Associate Director, a Data Analyst/Computer Programmer, an Academic Specialist, three Post-Doctoral Research Associates/Visiting Assistant Professor, and eight Graduate Research Assistants (4 Ph.D. and 4 M.S. students). Except for 4 of the Graduate Research Assistants, all QFC staff members are at least partially supported through funding support provided by QFC partner agencies.

### Facilities

At the time the QFC was proposed, space needed for its operations was not available in allocations to the Department of Fisheries and Wildlife. Thus, the proposal to MSU that led to the creation of the QFC indicated that part of the MSU contribution would either be provision of such space or funds to rent needed space. QFC personnel moved into 1674 $ft^2$ of office and work space in Giltner Hall in June 2006. This space was reallocated from the Provost's office following approval of a QFC request by the Giltner Hall Space Committee in February 2006. The College of Agriculture and Natural Resources provided funds for renovating the space. These renovations, completed prior to the move of QFC personnel to this space, included installation of a drop-ceiling, kitchenette, air conditioners, and additional phone line and internet hook-ups, removal of a wall, and painting. Total cost of renovation was approximately $65,000. QFC personnel moved into the Giltner Hall space in June 2006.

### Advisory Board

Shortly after creation of the QFC, a Board of Advisors (BOA) was established to assist in providing oversight for QFC activities. The purpose of the BOA is to (1) make annual recommendations on the prioritization of QFC activities; (2) serve as liaison between the QFC and its contributing partners for identifying research, teaching, and outreach needs; (3) annually review and evaluate the accomplishments of the QFC and recommend changes to improve future performance; and (4) provide an annual review report and evaluation to the Council of Lake Committees and to the Chair of the Department of Fisheries and Wildlife at Michigan State University. The BOA consists of representatives from the four major supporting partners of the

QFC: Michigan State University, Michigan Department of Natural Resources and Environment, Great Lakes Fishery Commission, and the Council of Lake Committees. Current members of the BOA are

Mr. Roger Knight, Ohio Department of Natural Resources (representing the CLC) – Chair
Dr. Tammy Newcomb, Michigan Department of Natural Resources – Vice-Chair
Mr. David McLeish, Ontario Ministry of Natural Resources (representing the CLC) – Member
Dr. John Dettmers, Great Lakes Fishery Commission – Member
Dr. Roy Stein, Ohio State University (representing the GLFC) - Member
Dr. Kelley Smith, Michigan Department of Natural Resources – Member
Dr. John Baker, Michigan State University - Member
Dr. William Taylor, Michigan State University – Member

The BOA has met on five occasions: 27 January 2006, 29 September 2006, 1 May 2007, 6 May 2008, 5 May 2009. Terms of Reference for the BOA were adopted at the 29 September 2006 Board meeting and revised at the 1 May 2007 and 6 May 2008 BOA meetings. The next meeting of the QFC BOA is scheduled for 29 June 2010.

**ACTIVITY SUMMARY**

The activities and accomplishments of the QFC are summarized according to its three areas of focus: education, outreach, and research. A detailed listing of activities in each of these areas is presented in ensuing sections. In terms of educational activities, QFC personnel have taught 18 courses/short courses/workshops since the QFC was first created. In addition, several other courses are presently planned for 2010 and 2011. Courses taught by QFC personnel have been attended by staff and students from a wide variety of universities, agencies, and associations, including Michigan State University, Purdue University, Cornell University, University of Guelph, Trent University, University of Vermont, University of Minnesota-Duluth, University of Toronto, State University of New York – Oswego, Queen's University, University of Western Ontario, Grand Valley State University, Michigan Department of Natural Resources and Environment, Ohio Department of Natural Resources, Minnesota Department of Natural Resources, Ontario Ministry of Natural Resources, Pennsylvania Fish and Boat Commission, Wisconsin Department of Natural Resources, Ontario Commercial Fisheries Association, Bruce Power, U.S. Fish and Wildlife Service, U.S. Geological Survey, Wisconsin Department of Natural Resources, and Great Lakes Fishery Commission. Most courses for which evaluations were conducted received overall ratings ranging from good to excellent. In addition, the QFC has launched two non-credit online courses and one for-credit online course, and are in the process of developing content for two other online courses.

Since 2005, QFC personnel have provided outreach support on more than 25 projects. Requests for outreach support have come from a number of sources, including Michigan State University, Michigan Department of Natural Resources and Environment, Great Lakes Fishery Commission, Ohio Department of Natural Resources, Minnesota Department of Natural Resources, Illinois Department of Natural Resources, New York Department of Environmental Conservation, Indiana Department of Natural Resources, Ontario Ministry of Natural Resources, U.S. Geological Survey, 1836 Treaty Water Modeling Sub-Committee, Lake Erie Committee, Lake Huron Committee, Lake Michigan Committee, Lake Ontario Committee, and Lake Superior Committee. Many of these outreach activities have been heavily integrated with the

research activities of QFC personnel and several requests for outreach assistance have resulted in extramurally funded research projects. QFC support on outreach activities has directly impacted fishery management agency activities. Of particular note is that QFC outreach support has led to improvements in procedures used in stock assessments of lake whitefish and lake trout in lakes Superior, Huron, and Michigan, and for walleye and perch on Lake Erie. QFC outreach support has also led Great Lakes agencies to change their procedures and policies with regard to fish translocations in light of risks of moving pathogens.

When the QFC was initially proposed, one of its selling points was that its establishment would enhance the ability to secure extramural research funds to complement the science being conducted in support of agency needs. Since 2005, QFC personnel have been involved in 20 extramurally funded research projects, the majority of which started after initial establishment of the center.

**EDUCATION**

1) Online courses
    a. Advanced Topics: Likelihood Estimation for Natural Resources and Ecology (MSU for-credit course – 2 credits) (Launched – 15 May 2010)
    Instructor(s): Jim Bence, Matt Catalano, Travis Brenden, Angie Leslie
    Number of enrollees to date: 9
    b. R Essentials for Natural Resource Professionals online course (Launched – 15 January 2010)
    Developer(s): Ty Wagner, Matt Catalano, Travis Brenden
    Number of enrollees to date: 11
    c. Maximum Likelihood Estimation for Natural Resources and Ecology online course (Launched – 16 October 2007)
    Developer(s): Mike Wilberg
    Number of enrollees to date: 22
    d. Resampling Approaches to Data Analyses in Natural Resources and Ecology online course (In development)
    Developer(s): Travis Brenden
    e. Population Dynamics Primer online course (content to include modules on recruitment, mortality, growth, and an overview of dynamics and processes) (In development).
    Developer(s): Brian Irwin, Iyob Tsehaye, Matt Catalano, Jim Bence

2) Stock assessment training short courses
    Instructor(s): Jim Bence, Travis Brenden
    Location: East Lansing, Michigan
    Dates: 3 workshops planned for late 2010 through Spring 2011
    Number of Students: 10 (anticipated)

3) Introduction to R for Fisheries Scientists workshop [2010 AFS Annual Meeting]
    Instructor(s): Matt Catalano
    Location: Pittsburgh, Pennsylvania
    Dates: Planned for September 12
    Number of Students: 40 (maximum number of students allowes)

4) Introduction to R for Fisheries Scientists workshop [2010 IAGLR Annual Meeting]
   Instructor(s): Matt Catalano
   Location: Toronto, Ontario
   Dates: May 17, 2010
   Number of Students: 32

5) Fisheries Management [undergraduate course at MSU)
   Instructor(s): Brian Irwin
   Location: East Lansing, Michigan
   Dates: January 2010 – May 2010
   Number of Students: 20

6) MARK tutorial workshop
   Instructor(s): Aaron Berger
   Location: East Lansing, Michigan
   Dates: January 15, 2010
   Number of Students: 8

7) AD Model Builder Advanced Fishery Applications short course
   Instructor(s): Jim Bence, Brian Irwin, Travis Brenden
   Location: East Lansing, Michigan
   Dates: June 20-21, 2009
   Number of Students: 11
   Overall rating: Excellent/Good

8) AD Model Builder Basics short course
   Instructor(s): Jim Bence, Brian Irwin, Travis Brenden
   Location: East Lansing, Michigan
   Dates: June 18-19, 2009
   Number of Students: 11
   Overall rating: Excellent/Good

9) Introduction to R for Fisheries Scientists workshop [2009 AFS Annual Meeting]
   Instructor(s): Cheryl Murphy, Mike Jones
   Location: Nashville, Tennessee
   Dates: August 30, 2009
   Number of Students: 25

10) Introduction to R for Fisheries Scientists workshop [2008 AFS Annual Meeting]
    Instructor(s): Cheryl Murphy
    Location: Ottawa, Ontario
    Dates: August 17, 2008
    Number of Students: 23

11) Introduction to SAS Macros workshop

Instructor(s): Jim Bence
Location: East Lansing, Michigan
Dates: March 13, 2008
Number of Students: ≈40

12) Introduction to R short course
Instructor(s): Ty Wagner
Location: East Lansing, Michigan
Dates: February 28-29, 2008
Number of Students: 21 (including 5 gratis registrations to employees of QFC Supporting Partners)
Overall rating: Excellent

13) Resampling Approaches to Data Analysis workshop
Instructor: Travis Brenden
Location: East Lansing, Michigan
Dates: December 7, 2007
Number of Students: 40
Overall rating: Good/average

14) Introduction to AD Model Builder short course
Instructor: Travis Brenden
Location: Aitkin, Minnesota
Dates: October 22-24, 2007
Number of Students: 10
Overall rating: Good

15) AD Model Builder Advanced Fishery Applications short course
Instructor: Brian Linton
Location: East Lansing, Michigan
Dates: August 8-9, 2007
Number of Students: 3
Overall rating: Excellent

16) AD Model Builder Basics short course
Instructor: Brian Linton
Location: East Lansing, Michigan
Dates: August 6-7, 2007
Number of Students: 7
Overall rating: Good

17) Introduction to R Statistical Language and Software Environment short course
Instructor: Dr. Tyler Wagner
Location: East Lansing, Michigan
Dates: May 21-22, 2007
Number of Students: 18

Overall rating: Excellent/Good

18) Introduction to AD Model Builder and Emacs short course
Instructor: Dr. Brian Irwin
Location: Cornell Biological Field Station, New York
Dates: May 21, 2007
Number of Students: 6
Overall rating: Good

19) Introduction to R Statistical Language and Software Environment short course (Beta Test)
Instructor: Dr. Tyler Wagner
Location: East Lansing, Michigan
Dates: January 4-5, 2007
Number of Students: 12
Overall rating: Excellent/Good

20) AD Model Builder Advanced Fishery Applications short course
Instructor: Dr. James Bence and Brian Linton
Location: East Lansing, Michigan
Dates: June 12-13, 2006
Number of Students: 23
Overall rating: Excellent/Good

21) AD Model Builder Basics short course
Instructor: Dr. James Bence and Brian Linton
Location: East Lansing, Michigan
Dates: June 8-9, 2006
Number of Students: 21
Overall rating: Excellent/Good

**OUTREACH SERVICES**

1) LAKE ERIE PERCID STOCK ASSESSMENT AND MANAGEMENT
Requestor: Lake Erie Technical Committee
Description: QFC personnel have provided input on Lake Erie percid stock assessments and management approaches. QFC involvement has included the writing of a white paper on approaches to weighting data components, participating in and helping coordinate stock assessment and harvest policy workshops, and coding and interpretation of revised stock assessment models.
Products:
Bence, J.R. 2006. Approaches to Weighting Data Components and Addressing Concerns about Density-Dependent Catchability for Lake Erie Percid Assessments. Quantitative Fisheries Center Technical Report T2006-01.

2) DATABASE SUPPORT SERVICE FOR MICHIGAN DNR CREEL PROGRAM
Requestor: Michigan Department of Natural Resources

Description: QFC personnel developed a Microsoft Access macro that would facilitate the appending of several hundred creel count and interview tables to a single master database.
Products:
MS Access macro

3) LAKE MICHIGAN STOCKING DECISION ANALYSIS
Requestor: Lake Michigan Technical Committee
Description: QFC personnel were requested to update a Lake Michigan salmonid stocking decision analysis model to include new data collected from the lake and to allow for a wided range of state dependent stocking strategies (e.g., stocking that depends on how fast salmon are growing).
Products:
Jones, M.L., J.R. Bence, E.B. Szalai, and Wenjing Dai. 2008. Assessing stocking policies for Lake Michigan salmonine fisheries using decision analysis. The State of Lake Michigan in 2005. Great Lakes Fish. Comm. Spec. Pub. In The state of Lake Michigan in 2005. Edited by D.F. Clapp and W. Horns. Great Lakes Fish. Comm. Spec. Pub. 08-02. pp. 81-88.

Jones, M.L. and J.R. Bence. 2009. Uncertainty and fishery management in the North American Great Lakes: lessons from applications of decision analysis. Pages 1059-1082 *in* C.C. Krueger and C. E. Zimmerman. Pacific salmon: ecology and management of western Alaska populations. American Fisheries Society, Bethesda, Maryland.

4) MAKING WISE DECISIONS ABOUT MOVING FISH IN THE GREAT LAKES BASIN
Requestor: Great Lakes Fishery Commission
Description: QFC personnel have periodically consulted with CLC agencies on balancing the risks and benefits of moving fish among lakes in the Great Lakes basin.
Products:
Fenichel, E.P., Tsao, J.I., Jones, M., and Hickling, G.J. 2008. Fish pathogen screening and its influence on the likelihood of accidental pathogen introduction during fish translocations. Journal of Aquatic Animal Health 20: 19-28.

Jones, M.L. and J.M. Dettmers. 2007. Making wise decisions about transferring fish among lakes within the Great Lakes basin. Journal of Great Lakes Research 33: 930-934.

5) RIVER VALLEY SEGMENT DELINEATION AND CLASSIFICATION FOR GREAT LAKES STATES
Requestor: Michigan Department of Natural Resources, Illinois Department of Natural Resources, Wisconsin Department of Natural Resources, U.S. Geological Survey
Description: QFC personnel have periodically consulted with fishery biologists from several CLC agencies regarding the delineation of river valley segments for state stream databases.
Products:

Brenden, T.O., L. Wang, and P.W. Seelbach. 2008. A river valley segment classification of Michigan streams based on fish and physical attributes. Transactions of the American Fisheries Society 137:1621-1636.

Brenden, T.O., L. Wang, P.W. Seelbach, R.D. Clark, Jr., M.J. Wiley, and B.L. Sparks-Jackson. 2008. A spatially-constrained clustering program for river valley segment delineation from GIS digital river networks. Environmental Modelling and Software 23:638-649.

6) INDIANA CREEL ASSISTANCE
Requestor: Indiana Department of Natural Resources
Description: QFC personnel provided input on the calculations for a redesigned creel sampling method for Lake Michigan by Indiana DNR. Calculations were reviewed and input provided.

7) MINNESOTA MILLE LACS WALLEYE STATISTICAL CATCH AT AGE MODELS
Requestor: Minnesota Department of Natural Resources
Description: QFC personnel provided input on developing an operating model for the statistical catch at age models used for the Mille Lacs walleye assessment. Input and AD Model Builder code was provided.

8) ONTARIO MNR SURPLUS PRODUCTION MODELS
Requestor: Ontario Ministry of Natural Resources
Description: QFC personnel provided input on a paper describing a method for understanding risks associated with different management decisions within the context of surplus production models (Hatton et al. 2005. A dynamical approach to evaluate risk in resource management. Ecological Applications 16:1238-148). A review was conducted and input provided.

9) VHS SCREENING FOR THE GREAT LAKES
Requestor: Great Lakes Fishery Commission
Description: QFC personnel participated in a meeting convened by Great Lakes Fish Health Committee on 31 Jan 2007, with the goal of helping to inform the VHS screening and management plan. QFC personnel presented results from their Real Options Research and discussed how it could apply to VHS screening.

10) 1836 TREATY WATERS STOCK ASSESSMENT AND FISHERY MANAGEMENT
Requestor: 1836 Treaty Waters Modeling Subcommittee (MSC)
Description: QFC personnel have interacted substantially with the 1836 Treaty Waters Modeling Subcommittee to provide their expertise on stock assessment work and harvest policies. This has included regular participation in their semi-annual meetings, presentations to the group on research results, and active participation in meetings on issues related to their current stock assessments. Additionally, QFC personnel have explored the efficiency in constructing model-based indices using different statistical software packages, and have provided the MSC code for automated sensitivity analyses, and variants of their existing stock assessment models.

Products:
R, SAS code, C++ code for stock assessment procedures.

Deroba, J.J., and J.R. Bence. *In press.* Assessing model-based indices of lake trout abundance in 1836 Treaty waters of Lakes Huron, Michigan, and Superior. Research report prepared for the Michigan Department of Natural Resources.

Deroba, J.J., and J.R. Bence. 2008. A review of harvest policies: understanding relative performance of control rules. Fisheries Research 94: 210-223.

Linton, B.C., and J.R. Bence. 2008. Evaluating methods for estimating process and observation error variances in statistical catch-at-age analysis. Fisheries Research 94:26-35

Wilberg, M.J., and J.R. Bence. 2008. Performance of deviance information criterion model selection in statistical catch-at-age analysis. Fisheries Research 93:212-221.

Wilberg, M.J., and J.R. Bence. 2006. Performance of time-varying catchability estimators in statistical catch-at-age analysis. Canadian Journal of Fisheries and Aquatic Sciences

Sitar, S.P., Bence, J.R., and Woldt, A.P. 2007. Stock assessment models, pages 8-16 in Woldt, A.P., and Sitar, S.P. (eds.). Technical Fisheries Committee Administrative Report 2006: Status of lake trout and lake whitefish populations in the 1836 treaty-ceded waters of Lakes Superior, Huron and Michigan in 2005, with recommended yield and effort levels for 2006.

Woldt, A.P., Bence, J.R., and Ebener, M.P. 2007. Recommendations and future directions to improve assessments, pages 17-22 in Woldt, A.P., and Sitar, S.P. (eds.). Technical Fisheries Committee Administrative Report 2006: Status of lake trout and lake whitefish populations in the 1836 treaty-ceded waters of Lakes Superior, Huron and Michigan in 2005, with recommended yield and effort levels for 2006.

Woldt, A.P., Bence, J.R., and Ebener, M.P. 2007. Executive Summary, pages 4-7 in Woldt, A.P., and Sitar, S.P. (eds.). Technical Fisheries Committee Administrative Report 2006: Status of lake trout and lake whitefish populations in the 1836 treaty-ceded waters of Lakes Superior, Huron and Michigan in 2005, with recommended yield and effort levels for 2006.

Woldt, A.P., S.P. Sitar, J.R. Bence, and M.P. Ebener. 2006. Summary Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan in 2004, with recommended yield and effort levels for 2005. Technical Fisheries Committee, 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan.

11) APPRAISAL OF SEA LAMPREY WOUNDING RATE ANALYSIS FOR NON-1836 TREATY WATERS OF THE GREAT LAKES

Requestor: Lake Michigan Committee
Description: QFC personnel reviewed a proposed approach for quantifying sea lamprey wounding rate analysis for non-1836 treaty waters of the Great Lakes and suggested alternative approaches that might be used.

12) POWER TO DETECT TEMPORAL TRENDS IN CATCH PER UNIT EFFORT FROM ANNUAL GILLNET SURVEYS FOR WALLEYE IN LAKE ERIE
Requestor: Ohio Department of Natural Resources
Description: QFC personnel provided assistance to Ohio DNR researchers concerning a power analysis of the gill net survey design used to index walleye population levels in Lake Erie. Center personnel used mixed modeling to estimate variance components for the existing gillnet dataset. These variance components were then incorporated in a simulation study to evaluate power to detect temporal trends based on differing levels of sampling intensity (duration, number of sampled sites).
Products:
Wagner, T., C.S. Vandergoot, J. Tyson. 2009. Evaluating the power to detect temporal trends in fishery-independent surveys: a case study based on gillnets set in the Ohio waters of Lake Erie for walleye. North American Journal of Fisheries Management.

Wagner, T. 2007. The statistical power to detect temporal trends in catch per unit effort from annual gillnet surveys for walleye in Lake Erie. Technical report prepared for the Ohio Department of Natural Resources, Division of Wildlife, Lake Erie Fisheries Unit, Sandusky Fisheries Research Unit. QFC Technical Report T2007-01.

Wagner, T. 2007. The statistical power to detect temporal trends in catch per unit effort from annual gillnet surveys for walleye in Lake Erie. Supplement I. Technical report prepared for the Ohio Department of Natural Resources, Division of Wildlife, Lake Erie Fisheries Unit, Sandusky Fisheries Research Unit. QFC Technical Report T2007-02.

13) COMPARISON OF METHODS FOR IDENTIFYING ENVIRONMENTAL THRESHOLDS
Requestor: Michigan Department of Natural Resources
Description: QFC personnel provided guidance on methods for identifying environmental thresholds based on differences in data-threshold relationships.
Products:
Brenden, T.O., L. Wang, and Z. Su. 2008. Quantitative identification of disturbance thresholds in support of aquatic resource management. Environmental Management 42:821-832.

14) EVALUATION OF METHODS FOR PREDICTING STREAM TEMPERATURES
Requestor: Michigan Department of Natural Resources
Description: QFC personnel provided assistance in evaluating methods for predicting stream temperature across the state of Michigan.
Products:

Wehrly, K.E., T.O. Brenden, and L. Wang. 2009. A comparison of statistical approaches for predicting stream temperatures across heterogenous landscapes. Journal of the American Water Resources Association 45:986-997.

15) A DECISION ANALYSIS FOR MULTISPECIES HARVEST MANAGEMENT OF LAKE HURON COMMERCIAL FISHERIES
Requestor: Lake Huron Committee
Description: QFC personnel were requested to develop a research project to apply decision analysis techniques for management of a multi-species commercial fishery in Lake Huron.

16) EVALUATION OF AGING ERROR CONSEQUENCES IN LAKE WHITEFISH STOCK ASSESSMENT
Requestor: Lake Huron Committee
Description: QFC personnel are presently conducting evaluations to determine in the context of stock assessment modeling "how much does it matter if age determination is incorrect.

17) REVIEW AND UPDATE OF EXISTING STATISTICAL CATCH-AT-AGE MODELS FOR LAKE SUPERIOR LAKE TROUT
Requestor: Lake Superior Committee
Description: QFC personnel have provided assistance to the Lake Superior Committee in finalizing, evaluating, and improving various management unit lake trout SCAA models. A mid- to late-July workshop is planned for this year.

18) DESIGNING SAMPLING STRATEGIES AND ANALYSES TO TAKE ADVANTAGE OF MASS MARKING OF STOCKED SALMONIDS IN LAKE ONTARIO
Requestor: Lake Ontario Commitee
Description: QFC personnel were requested to provide assistance to the Lake Ontario Committee in convening a workshop to develop sampling strategies and analytical approaches for mass marking of salmonids in Lake Ontario. The workshop was held in early 2009 and QFC personnel gave a presentation on statistical aspects of tagging studies.

19) LAKE TROUT EARLY MORTALITY COORDINATION WORKSHOPS
Requestor: None
Description: QFC personnel organized two workshops to convene experts from around the Great Lakes basin to address some of the major uncertainties associated with early survival of lake trout, and why some lakes have been better able to transition to supporting wild reproduction of lake trout.

20) VARIANCE DERIVATION REVIEW FOR CREEL HARVEST EXPANSION VALUES
Requestor: Michigan DNRE
Description: QFC personnel were requested to review the variance derivations for creel harvest expansion values

21) PROVIDE ASSISTANCE IN CONSOLIDATING PIT AND JAW TAGGING WORK ON LAKE ERIE
Requestor: Lake Erie Committee
Description: QFC personnel are providing assistance in combining information collected from a recent PIT tag study with a long-term jaw tagging dataset to develop estimates of walleye natural mortality, tag shedding, and tag reporting rates

22) EFFECTS OF A SISCOWET FISHERY ON THE LAKE SUPERIOR ECOSYSTEM
Requestor: Lake Superior Committee
Description: QFC personnel are providing assistance in attempting to describe the direction and magnitude of changes in abundance of various fish species as siscowet populations are reduced as a consequence of commercial fishing.

23) LAKE ONTARIO LAKE TROUT STATISTICAL CATCH AT MODEL
Requestor: Lake Ontario Committee
Description: QFC personnel provided assistance in the development of a lake trout catch at age model to assist in quantifying and examining trends in abundance and population dynamics of the species and to better understand what factors may be inhibiting efforts to re-establish a self-sustaining and dominant lake trout populations.
Products:
AD Model Builder assessment model

Brenden, T.O., J.R. Bence, B.F. Lantry, J.R. Lantry, and T. Schaner. In prep. Population dynamics of Lake Ontario lake trout during 1985-2007. Target Journal: North American Journal of Fisheries Management

24) PERCID SURVEY GEAR BIAS ON LAKE ERIE
Requestor: Lake Erie Committee
Description: QFC personnel have assisted in the evaluation of selectivity for walleye of two experimental gill net configurations. As part of this assistance, a simulation tool was created to assess accuracy of gill nets in predicting age composition of at-large populations.
Products:
MS Excel VBA simulation tool

Vandergoot, C.S., P.M. Kocovsky, T.O. Brenden, and W. Liu. In prep. Comparison of two experimental gillnet configurations for assessing Lake Erie walleye stocks. Target Journal: Fisheries Research or North American Journal of Fisheries Management

25) EVALUATION OF REGRESSION APPROACHES FOR PREDICTING LAKE ERIE YELLOW PERCH RECREATIONAL HARVEST
Requestor: Ohio DNR
Description: QFC personnel were requested to evaluate regression approaches for predicting yellow perch recreational for the purpose of setting commercial fishery harvest limits in Ohio waters of Lake Erie.

Products:
MS Excel VBA macro for calculating confidence intervals for new observations in a multiple linear regression context.

Brenden, T.O., and W. Liu. 2010. Evaluation of regression approaches for predicting yellow perch (*Perca flavescens*) recreational harvest in Ohio Waters of Lake Erie.

26) REVIEW OF ONTARIO MNR LAKE HURON LAKE TROUT REHABILITATION PLAN
Requestor: Ontario MNR
Description: QFC personnel reviewed and provided comments on Ontario's lake trout rehabilitation plan for Lake Huron.

27) NATURAL RESOURCE MODELING/EXPERIMENTAL DESIGN/DATA ANALYSIS CONSULTING
Requestor: Michigan State University
Description: QFC personnel periodically consult with colleagues at Michigan State University on issues related to modeling/experimental design/data analyses in the field of natural resources. Examples of such consultation include:
   a. Consultation on the design of an experiment for evaluating resistance to viral hemorrhagic septicemia infection in fish previously exposed to the virus.
   b. Consultation on the use and estimation of zero-inflated Poisson and negative binomial regression models.
   c. Consultation on the use of logistic regression for heavily skewed data.
   d. Consultation and assistance in analyzing *Renibacterium salmoninarum* and *Cystidicola fontinalis* infection of lake whitefish stocks in northern lakes Huron and Michigan.
   e. Consultation on performing varimax rotation as part of a principal components analysis.
   f. Consultation on proposed multivariate analyses for the National Fish Habitat Action Plan.
   g. Consultation on piecewise growth modeling
   h. Consultation on building an R script for data conversion.

**EXTRAMURAL FUNDED RESEARCH PROJECTS**

1) EVALUATING INTEGRATED PEST MANAGEMENT IN THE ST. MARY'S RIVER
Funding Agency: Great Lakes Fishery Commission
Project Dates: 4/1/2010 to 3/31/2011
Funded Amount: $34,940
Princ. Investigator(s): Mike Jones

2) EFFECTS OF TEMPERATURE ON FUNCTIONAL RELATIONSHIPS AMONG MICHIGAN'S FLUVIAL FISH ASSEMBLAGES: IDENTIFYING MANAGEMENT OPPORTUNITITES IN THE FACE OF ENVIRONMENTAL CHANGES
Funding Agency: Michigan Department of Natural Resources and Environment
Project Dates: 9/1/2009 to 9/30/2011

Funded Amount: $46,900
Princ. Investigator(s): Dana Infante, Ashley Moerke, Casey Huckins, Travis Brenden

3) SIMULATENOUS ANALYSIS OF GENETIC AND LENGTH-AT-AGE DATA TO ESTIMATE STOCK CONTRIBUTION FOR MIXED-STOCK AND STRAIN OPEN-WATER FISHERIES IN THE GREAT LAKES
Funding Agency: Great Lakes Fishery Trust
Project Dates: 8/1/2009 to 10/31/2013
Funded Amount: $338,425
Princ. Investigator(s): Travis Brenden, Jim Bence, Kim Scribner

4) AYK-SSI EXPERT PANEL ON ESCAPEMENT GOALS
Funding Agency: Bering Sea Fishermen's Association
Project Dates: 5/1/2009 to 3/15/2011
Funded Amount: $200,000
Princ. Investigator(s): Mike Jones

5) SPATIAL AND TEMPORAL COMPONENTS OF VARIATION IN GREAT LAKE PERCID POPULATIONS: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT
Funding Agency: U.S. Fish and Wildlife Service
Project Dates: 4/1/2009 to 12/31/2010
Funded Amount: $67,878
Princ. Investigator(s): Dan Hayes, Ty Wagner, Jim Bence, Brian Irwin, Nigel Lester

6) ASSESSING LAKE MICHIGAN STOCKING POLICIES USING DECISION ANALYSIS
Funding Agency: Great Lakes Fishery Trust
Project Dates: 11/1/2008 to 11/1/2011
Funded Amount: $326,139
Princ. Investigator(s): Mike Jones, Jim Bence, Travis Brenden

7) THE IMPORTANCE OF THE LARVAL STAGE TO CISCO RECRUITMENT VARIATION IN THE GREAT LAKES
Funding Agency: U.S. Fish and Wildlife Service
Project Dates: 9/1/2008 to 8/31/2012
Funded Amount: $122,192
Princ. Investigator(s): Mike Jones

8) REAL OPTIONS ANALYSIS OF LAKE ONTARIO STERILE SEA LAMPREY TRANSFERS
Funding Agency: Great Lakes Fishery Commission
Project Dates: 2008-2010
Funded Amount: $66,418
Princ. Investigator(s): Jean Tsao, Eli Fenichel, Michael Jones, and Graham Hickling

9) DEVELOPMENT OF HABITAT TRADING PROGRAMS FOR MILITARY INSTALLATIONS AND THEIR NEIGHBORS THROUGH ADAPTIVE MANAGEMENT
Funding Agency: U.S. Department of Defense
Project Dates: 4/15/2008 to 4/14/2012
Funded Amount: $ 1,822,958
Princ. Investigator(s): Doug Bruggeman, Mike Jones

10) ESTIMATING THE RELATIONSHIP BETWEEN SEA-LAMPREY INDUCED MORTALITY OF LAKE TROUT AND OBSERVED MARKING RATES
Funding Agency: Great Lakes Fishery Commission
Project Dates: 2007-2008
Funded Amount: $36,296
Princ. Investigator(s): James Bence and Travis Brenden
Products:
Irwin, B.J., T.O. Brenden, W. Liu, and J.R. Bence. 2009. Estimating the relationship between sea lamprey-induced mortality on lake trout and observed marking rates. Great Lakes Fishery Commission, Project Completion Report, Ann Arbor, Michigan.

11) DEFINING TARGETS FOR SEA LAMPREY CONTROL IN THE GREAT LAKES: ECONOMIC INJURY LEVEL ANALYSIS AND FISH COMMUNITY GOAL-BASED TARGETS
Funding Agency: Great Lakes Fishery Commission
Project Dates: 2006-2008
Funded Amount: $43,267
Princ. Investigator(s): James Bence and Michael Jones
Products:
Irwin, B. J., J. R. Bence, M. L. Jones, and W. Liu. In prep. Defining economic injury levels as targets for sea lamprey control in the Great Lakes. Target Journal: North American Journal of Fisheries Management

Jones, M. L., B. J. Irwin, G. J. A. Hansen, H. A. Dawson, A. J. Treble, W. Liu, W. Dai, and J. R. Bence. 2009. An operating model for the integrated pest management of Great Lakes sea lampreys. The Open Fish Science Journal 2:59-73.

Irwin, B. J., J. R. Bence, M. L. Jones, and W. Liu. 2008. Defining targets for sea lamprey control in the Great Lakes: economic injury levels and fish community goal-based targets. Great Lakes Fishery Commission Project Completion Report.

12) SEA LAMPREY POPULATION DYNAMICS: UPDATING DEMOGRAPHIC MODELS AND APPLICATION TO A NOVEL CONTROL STRATEGY
Funding Agency: Great Lakes Fishery Commission
Project Dates: 2006-2007
Funded Amount: $93,500
Princ. Investigator(s): Michael Jones
Products:

Fenichel, E.P., and G.J.A. Hansen. 2010. The opportunity cost of information: an economic framework for understanding the balance between assessment and control in sea lamprey (*Petromyzon marinus*) management. Canadian Journal of Fisheries and Aquatic Sciences 67:209-216.

Hansen, G.J.A., and M.L. Jones. 2009. Variation in larval sea lamprey demographics among Great Lakes tributaries: A mixed-effects model analysis of historical survey data. Journal of Great Lakes Research 35:591-602.

Dawson, H.A., and M.L. Jones. 2009. Factors affecting recruitment dynamics of Great Lakes sea lamprey (*Petromyzon marinus*) populations. Journal of Great Lakes Research 35:353-360.

Dawson, H.A., M.L. Jones, K.T. Scribner, and S.A. Gilmore. 2009. An assessment of age determinations methods for Great Lakes larval sea lampreys. North American Journal of Fisheries Management 29:914-927.

Hansen, G.J.A. and M.L. Jones. 2008. The value of information in fishery management. Fisheries 33: 340-348.

Hansen, G.J.A., and M. L. Jones. 2008. A rapid assessment approach to prioritizing streams for control of Great Lakes sea lampreys (*Petromyzon marinus*): a case study in adaptive management. Canadian Journal of Fisheries and Aquatic Sciences 65 (11): 2471-2484.

Jones, M.L. and G.J.A. Hansen. 2008. Evaluation of an alternative model of stream selection of lampricide treatment. Great Lakes Fishery Commission Project Completion Report and QFC Technical Report T2008-04.

Jones, M. L., G. J. A. Hansen, W. Liu, B. Irwin, A. J. Treble, and H. A. Dawson. 2008. Sea lamprey population dynamics: updating demographic models and application to a novel control strategy. Great Lakes Fishery Commission Project Completion Report.

13) EVALUATING HARVEST POLICIES FOR YELLOW PERCH IN LAKE MICHIGAN

Funding Agency: Michigan Sea Grant College Program
Project Dates: 2005-2008
Funded Amount: $139,998
Princ. Investigator(s): James Bence and Michael Jones
Products:

Irwin, B. J., M. J. Wilberg, J. R. Bence, and M. L. Jones. 2008. Evaluating alternative harvest policies for yellow perch in southern Lake Michigan. Fisheries Research 94:267-281.

Wilberg, M.J., J.R. Bence, B.T. Eggold, D. Makauskas, and D.F. Clapp. 2005. Yellow perch dynamics in southwestern Lake Michigan during 1986-2002. North American Journal of Fisheries Management 25: 1130-1152.

Wilberg, M. J., B. J. Irwin, M. L. Jones, and J. R. Bence. 2008. Effects of source-sink dynamics on harvest policy performance for yellow perch in southern Lake Michigan. Fisheries Research 94:282-289.

14) A MODEL-BASED EVALUATION OF HOW STOCKING ONCORHYNCHUS INFLUENCES THE FISH COMMUNITIES OF LAKES HURON AND ONTARIO
Funding Agency: Great Lakes Fishery Commission
Project Dates: 2005-2008
Funded Amount: $110,000
Princ. Investigator(s): James Bence
Products:
Brenden, T.O., and J.R. Bence. 2009. A model-based evaluation of how stocking Pacific salmonids influences the fish communities of lakes Huron and Ontario. Great Lakes Fishery Commission, Project Completion Report, Ann Arbor, Michigan.

15) RESPONSES OF LAKE TROUT AND CHINOOK SALMON TO UNPRECEDENTED DECLINES IN MAJOR PREY FISH ABUNDANCE IN LAKE HURON
Funding Agency: U.S. Fish & Wildlife Service
Project Dates: 2005-2008
Funded Amount: $142,000
Princ. Investigator(s): James Bence
Products:
Bence, J.R. and J.X. He. Temporal patterns of growth and condition of lake trout and Chinook salmon in the Main Basin of Lake Huron. Appendix A to: Responses of lake trout and Chinook salmon to unprecedented declines in major prey fish abundance in Lake Huron, completion report submitted to the U.S.F.W.S. Restoration Act Program.

Bence, J.R. and N. Nye, and W. Liu. Changing patterns of maturity schedules of lake trout and Chinook salmon in Lake Huron. Appendix B to: Responses of lake trout and Chinook salmon to unprecedented declines in major prey fish abundance in Lake Huron, completion report submitted to the U.S.F.W.S. Restoration Act Program.

Bence, J.R., N. Nye, and J.X. He. Patterns in energy density, lipids and related energetics variables in lake trout and Chinook salmon during 2005-2007 and comparison with observations from Lake Huron and Lake Michigan during 2000-2004. Appendix C to: Responses of lake trout and Chinook salmon to unprecedented declines in major prey fish abundance in Lake Huron, completion report submitted to the U.S.F.W.S. Restoration Act Program.

Bence, J.R., J.X. He, and N.J. Nye. Bioenergetics modeling of Chinook salmon and lake trout in Lake Huron: methods and results. Appendix D to: Responses of lake trout and Chinook salmon to unprecedented declines in major prey fish abundance in Lake Huron, completion report submitted to the U.S.F.W.S. Restoration Act Program.

He, J.X., N.J. Nye, and J.R. Bence. Ecological and life-history dynamics of energetic status: lake trout in the main basin of Lake Huron, 2006-2008. Appendix E to: Responses of lake trout and Chinook salmon to unprecedented declines in major prey fish abundance in Lake Huron, completion report submitted to the U.S.F.W.S. Restoration Act Program.

16) DEVELOPING AND TESTING MODELS OF LAKE HERRING POPULATION DYNAMICS IN LAKE SUPERIOR
Funding Agency: U.S. Fish & Wildlife Service
Project Dates: 2005-2008
Funded Amount: $95,996
Princ. Investigator(s): Michael Jones
Products:
Myers, J.T., M.L. Jones, J.D. Stockwell, and D.L. Yule. 2009. Re-assessment of the predatory effects of rainbow smelt on ciscoes in Lake Superior. Transactions of the American Fisheries Society 138:1352-1368.

Myers, J.T., Stockwell, J.D., Yule, D.L., and Black, J.A. 2008. Evaluating sampling strategies for larval cisco (Coregonus artedi). Journal of Great Lakes Research 34(2):245-252.

17) MODELING *RENIBACTERIUM SALMONINARUM* DYNAMICS IN MULTIPLE HOSTS
Funding Agency: Great Lakes Fishery Trust
Project Dates: 2005-2007
Funded Amount: $43,287
Princ. Investigator(s): Jean Tsao and Michael Jones
Products:
Fenichel, E., J.I. Tsao, and M.L. Jones. 2009. Modeling fish health to inform research and management: *Renibacterium salmoninarum* dynamics in Lake Michigan. Ecological Applications 19:747-760.

18) DYNAMICS AND BIOLOGY OF SISCOWET LAKE TROUT IN LAKE SUPERIOR
Funding Agency: U.S. Fish & Wildlife Service
Project Dates: 2004-2007
Funded Amount: $81,498
Princ. Investigator(s): James Bence
Products:
Bence, J.R., M. Mata, and J. Nieland. 2009. Dynamics and biology of siscowet lake trout in Lake Superior. Great Lakes Fish and Wildlife Restoration Act Project Completion Report.

19) A BIOPHYSICAL MODEL OF LAKE ERIE WALLEYE RECRUITMENT: EXPLAINING HISTORICAL RECRUITMENTS AND ANTICIPATING CONSEQUENCES OF CLIMATE CHANGE
Funding Agency: U.S. Fish & Wildlife Service
Project Dates: 2004-2007

Funded Amount: $97,272
Princ. Investigator(s): Michael Jones
Products:
Zhao, Y., M.L. Jones, B.J. Shuter, and E.F. Roseman. 2009. A biophysical model of Lake Erie walleye (*Sander vitreus*) explains interannual variations in recruitment. Canadian Journal of Fisheries and Aquatic Sciences 66:114-125.

20) MAGNITUDE AND POTENTIAL CAUSES OF MORTALITY IN LAKE WHITEFISH
Funding Agency: Great Lakes Fishery Trust
Project Dates: 2003-2008
Funded Amount: $399,298
Princ. Investigator(s): Michael Jones
Products:
Brenden, T.O., M.P. Ebener, and T.M. Sutton. 2010. Assessing the health of lake whitefish populations in the Laurentian Great Lakes: foreword. Journal of Great Lakes Research 36(Suppl. 1):1-5.

Brenden, T.O., M.P. Ebener, T.M. Sutton, M.L. Jones, M.T. Arts, T.B. Johnson, M.A. Koops, G.M. Wright, and M. Faisal. 2010. Assessing the health of lake whitefish populations in the Laurentian Great Lakes: lessons learned and research recommendations. Journal of Great Lakes Research 36(Suppl. 1):137-141.

Brenden, T.O., M.L. Jones, and M.P. Ebener. 2010. Sensitivity of tag recovery mortality estimates to tag shedding, handling mortality, and reporting rate inaccuracies. Journal of Great Lakes Research 36(Suppl. 1):102-111.

Ebener, M.P., T.O. Brenden, and M.L. Jones. 2010. Estimates of fishing and natural mortality rates for four lake whitefish stocks in northern lakes Huron and Michigan. Journal of Great Lakes Research 36(Suppl. 1):112-122.

Ebener, M.P., T.O. Brenden, G.M. Wright, M.L. Jones, and M. Faisal. 2010. Spatial and temporal distributions of lake whitefish spawning stocks in northern lakes Michigan and Huron, 2003-2008. Journal of Great Lakes Research 36(Suppl. 1):38-51.

Faisal, M., W. Fayed, T.O. Brenden, A. Noor, M.P. Ebener, G.M. Wright, and M.L. Jones. 2010. Widespread infection of lake whitefish *Coregonus clupeaformis* with the swimbladder nematode *Cystidicola farionis* in northern lakes Michigan and Huron. Journal of Great Lakes Research 36(Suppl. 1):18-28.

Faisal, M., T.P. Loch, T.O. Brenden, A.A. Easa, M.P. Ebener, G.M. Wright, and M.L. Jones. 2010. Assessment of *Renibacterium salmoninarum* infection in four lake whitefish (*Coregonus clupeaformis*) stocks from northern lakes Huron and Michigan. Journal of Great Lakes Research 36(Suppl. 1):29-37.

Loch, T.P., and M. Faisal. 2010. Infection of lake whitefish (*Coregonus clupeaformis*) with motile *Aeromonas* spp. in the Laurentian Great Lakes. Journal of Great Lakes Research 36(Suppl. 1):6-12.

Loch, T.P., and M. Faisal. 2010. Isolation of Aeromonas salmonicida subspecies salmonicida from lake whitefish (*Coregonus clupeaformis*) inhabiting lakes Michigan and Huron.. Journal of Great Lakes Research 36(Suppl. 1):13-17.

Wagner, T., M.L. Jones, M.P. Ebener, M.T. Arts, M. Faisal, T.O. Brenden, D. Honeyfield, and G. Wright. 2010. Spatial and temporal dynamics of lake whitefish health measures: linking individual-based indicators to a management-relevant endpoint. Journal of Great Lakes Research 36(Suppl. 1):123-136.

21) IMPROVING FISHERY STOCK ASSESSMENTS IN THE GREAT LAKES
Funding Agency: Michigan Department of Natural Resources and
Project Dates: 2005-2010
Funded Amount: ≈$50,000 to $70,000 per year
Princ. Investigator(s): Jim Bence

Products:
Deroba, J.J., and J.R. Bence. In press. Assessing model-based indices of lake trout abundance in 1836 Treaty waters of Lakes Huron, Michigan, and Superior. Michigan Department of Natural Resources, Fisheries Division, Fisheries Research Report.

Deroba, J.J., and J.R. Bence. 2008. A review of harvest policies: understanding relative performance of control rules. Fisheries Research 94: 210-223.

Linton, B.C., and J.R. Bence. 2008. Evaluating methods for estimating process and observation error variances in statistical catch-at-age analysis. Fisheries Research 94:26-35

Linton, B. and J.R. Bence. In press. Sensitivity analysis of lake whitefish stock assessment models used in the 1836 treaty waters of Lake Huron. Michigan Department of Natural Resources, Fisheries Division, Fisheries Research Report.

Radomski, P., J.R. Bence, and T.J. Quinn II. 2005. Comparison of virtual population analysis and statistical kill-at-age analysis for a recreational, kill-dominated fishery. Canadian Journal of Fisheries and Aquatic Sciences 62: 436-452.

Wilberg, M.J., and J.R. Bence. 2008. Performance of deviance information criterion model selection in statistical catch-at-age analysis. Fisheries Research 93:212-221.

Wilberg, M.J., and J.R. Bence. 2006. Performance of time-varying catchability estimators in statistical catch-at-age analysis. Canadian Journal of Fisheries and Aquatic Sciences