GREAT LAKES FISHERY COMMISSION

2011 Project Completion Report

Enhancing Fishery Stock Assessment Modeling in the Great Lakes

by:

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July 2011

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ABSTRACT:

We developed and offered stock assessment training to a cohort of natural resource professionals. This training included an online course on maximum likelihood methods (MLE), two workshops following a short-course format on stock assessment methods and initial work on individual projects, and a third workshop intended to help participants finish projects and interact with other professionals about their work. Participants for the stock assessment training opportunity were identified through an e-mail that was distributed to Council of Lake Committee members, Lake Technical Committee chairs, and others involved in Great Lakes fishery science and management. We received a total of 12 applications during our application time-frame and all were accepted into program. The accepted participants represented Ontario, one federal agency (USGS), and four US states (WI, MN, MI, PA). One participant withdrew prior to the onset of the course and an additional participant withdrew after completing the online maximum likelihood training and the first workshop. Eight of the 10 who completed the program were working fishery biologists on the Great Lakes who expected to be engaged in fish stock assessment activities. The other two participants were wildlife biologists hoping to apply age-structured stock assessment methods to mammals. The ten students who completed the course worked on nine “capstone” projects as part of the training (the two wildlife professionals shared a common project). These projects all involved development or refinement of catch-at-age assessments. Stocks worked on included walleye, yellow perch, lake whitefish, lake trout, as well as mammals, and geographically spanned four Great Lakes (all but Ontario) and terrestrial habitat in Michigan. Feedback on the MLE online course was collected via surveys completed during the course, and in June 2011, participants in the stock assessment training program were asked to complete an anonymous online survey. The training program met its overall goals and thus was successful. We base this conclusion on the fact that all surveyed respondents strongly agreed or agreed that they learned new information on stock assessment and population dynamics and that they believed they would be able to apply this new information in the future. We further judge the training program to have been a success due to most students having made good progress on their capstone projects. Thus, as a result of this training, there are nine new or improved SCAA models upon which natural resource managers potentially could use to help manage fish and wildlife populations in the Laurentian Great Lakes region. While the training program was successful, our experiences and the surveys of participants suggest ways to improve similar training programs in the future.

INTRODUCTION:

Quantitative estimates of system dynamics are essential for rational natural resource management. In the field of fisheries science, these estimates are provided through the process of fishery stock assessment. Historically, fishery stock assessment has been viewed as a method of obtaining estimates of current stock size and, hence, the allowable harvest given a known target exploitation rate. The role of stock assessment has evolved and expanded substantially in recent years. While some have argued for simpler, non-model based approaches (e.g., based directly on fishery catch per unit effort) for use in annual assessment cycles (Walters and Martell 2002; Butterworth 2008), detailed models of underlying processes and estimates of their parameters are essential for testing management strategies, with the annual assessment approach (perhaps a simple non-model based approach) treated as part of the management strategy. A quantitative understanding of the magnitude of system components and how they interact is also essential for non-harvest based management [e.g., salmon stocking and sea lamprey control in the Great Lakes and for analyses supporting ecosystem level approaches to management (e.g., Ecosim modeling)].

The foundations of modern statistical approaches to fishery stock assessment have been in place since the 1980s (Fournier and Archibald 1982; Deriso et al. 1985; Methot 1989). Over the past 20 years, there has been increasing emphasis on Bayesian approaches to conducting assessments (Punt and Hilborn 1997; Peterman et al. 1998; Maunder 2008). The state of the art assessment is an age (and possibly sex and size) structured model that is simultaneously fit to a range of different data sources. Such assessments evolved from the statistical catch-at-age models of the 1980s and 1990s, but are sometimes referred to as integrated models to reflect their flexible and broader nature. A number of challenges faced by statistical approaches, such as how to weight different data components, how to allow for time-varying processes without over-parameterizing models, and how to assess uncertainty were recognized in the 1990s (NRC 1998). Significant progress has occurred on some of these issues,
although many challenges remain (Butterworth et al. 2003; Wilberg and Bence 2006, 2008; Linton and Bence 2008; Maunder 2008).

Statistical, model-based fishery assessment will undoubtedly remain an important task in support of fisheries management, and it is clear that to be skilled in this area requires specialized training due to increases in model sophistication. At both national and global scales, there is a recognized shortage of trained fishery stock assessment scientists (DOC and DOE 2008; Berkson et al. 2009). This shortage also applies to the Great Lakes. The foremost requested service at Michigan State University’s Quantitative Fisheries Center (QFC) is to conduct or support efforts to conduct a statistical catch-at-age stock assessment; the number of requests received for this type of service far surpasses the QFC’s capacity to conduct this work. It is thus evident that there is a need for a broader cadre of individuals with greater assessment background within the Great Lakes community. With knowledgeable individuals distributed through Great Lakes management agencies, with contacts among each other, and with experts at the QFC and other places, the assessment expertise and new research results in stock assessment available at the QFC could be better harnessed. We do not believe that each Great Lakes fishery agency can afford to duplicate the type of assessment expertise possible at a university center or federal agency. We do think, however, that a higher common level of expertise among a key group of individuals would allow these individuals to make more progress on their own and to request more targeted assistance when problems are encountered.

Long term global and national strategies for confronting the shortage of stock assessment scientists relate to mathematics and problem solving education in K-12 education, further infusion of quantitative problem solving into natural resource undergraduate programs, and support of quantitative graduate training in fisheries science (DOC and DOE 2008; Berkson et al. 2009). Similar solutions, including enhanced funding for stock assessment positions (perhaps shared among contributing agencies) would be useful within the Great Lakes. The focus of our project, however, was on producing shorter-term benefits for far less investment. In our experience, there are a number of fishery biologists with quantitative aptitude who could make major strides in their ability to work on stock assessment models independently if they could be educated about the conceptual underpinnings of the assessment methods and could receive assistance in their initial efforts to apply their newly-learned skills.

OBJECTIVES:

1. Provide training to a cohort of fishery professionals in the Great Lakes on likelihood theory and related estimation methods.
2. Provide training/review to a cohort of fishery professionals in the Great Lakes regarding modern statistical approaches to stock assessment.
3. Provide hands on training to a cohort of fishery professionals in the Great Lakes in using AD Model Builder in an assessment context.
4. Assist the individuals in the cohort to complete assessment tasks of interest to them and their agencies, and facilitate communication among the cohort with a vision of promoting their long term-interactions and mutual assistance.
5. Determine whether participants view the individual components and total training program to be effective and identify ways to improve similar future training exercises.

METHODS:

Participants in the stock assessment training opportunity were identified through an e-mail that was distributed to Council of Lake Committee members, Lake Technical Committee chairs, and others involved in Great Lakes fishery science and management (Table 1). The e-mail included an attachment letter that described the training opportunity (Appendix 1) and noted that between 8 and 12 individuals would be selected to participate in the training program. Those who received the announcement were asked to forward the e-mail to individuals that they thought might be interested in participating in the program. Applicants were asked to e-mail a copy of their CV and a letter of application addressing their reasons for wishing to participate, the benefits that would derive to themselves, their agencies, and more broadly, and a brief description of the capstone application to which they intend to apply the learned stock assessment procedures by 19 May 2010. A process was put in place for
choosing who would participate in the training program in the event that interest in participating in the training exceeded workshop capacity; however, this selection process was not needed (see Results section).

Table 1. List of individuals to whom the announcement for the stock assessment training opportunity was sent.

<table>
<thead>
<tr>
<th>Name</th>
<th>Agency</th>
<th>Name</th>
<th>Agency</th>
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<tbody>
<tr>
<td>Don Pereira</td>
<td>Minnesota DNR</td>
<td>Ed Roseman</td>
<td>US Geological Survey</td>
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<tr>
<td>David McLeish</td>
<td>Ontario MNR</td>
<td>Jana Lantry</td>
<td>New York DEC</td>
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<tr>
<td>Bill Mattes</td>
<td>Great Lakes Indian Fish and</td>
<td>Mark Ebener</td>
<td>Chippewa Ottawa Resource</td>
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<td></td>
<td>Wildlife Commission</td>
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<td>Authority</td>
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<tr>
<td>Tom Gorenflo</td>
<td>Chippewa Ottawa Resource</td>
<td>Dan Makauskas</td>
<td>Illinois DNR</td>
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<tr>
<td>Steve Scott</td>
<td>Michigan DNR</td>
<td>Chuck Krueger</td>
<td>Great Lakes Fishery Commission</td>
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<tr>
<td>Bill Horns</td>
<td>Wisconsin DNR</td>
<td>John Dettmers</td>
<td>Great Lakes Fishery Commission</td>
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<td>Steve Robillard</td>
<td>Illinois DNR</td>
<td>Kelley Smith</td>
<td>Michigan DNR</td>
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<tr>
<td>Stu Shipman</td>
<td>Indiana DNR</td>
<td>Erie Boysen</td>
<td>Ontario MNR</td>
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<tr>
<td>Brad Eggold</td>
<td>Wisconsin DNR</td>
<td>Steve Pallo</td>
<td>Illinois DNR</td>
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<tr>
<td>Jim Dexter</td>
<td>Michigan DNR</td>
<td>Ray Petering</td>
<td>Ohio DNR</td>
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<tr>
<td>Steve Hewett</td>
<td>Michigan DNR</td>
<td>Doug Stang</td>
<td>New York DEC</td>
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<td>Don Einhouse</td>
<td>New York DEC</td>
<td>Dirk Peterson</td>
<td>Minnesota DNR</td>
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<tr>
<td>Dave Miko</td>
<td>Pennsylvania FBC</td>
<td>Bill Culligan</td>
<td>New York DEC</td>
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<tr>
<td>Brian Locke</td>
<td>Ontario MNR</td>
<td>Tammy Newcomb</td>
<td>Michigan DNR</td>
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<tr>
<td>Roger Knight</td>
<td>Ohio DNR</td>
<td>Kurt Newman</td>
<td>US Geological Survey</td>
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<tr>
<td>Steve LaPan</td>
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<td>Roy Stein</td>
<td>Ohio State University</td>
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<tr>
<td>Andy Todd</td>
<td>Ontario MNR</td>
<td>Bill Taylor</td>
<td>Michigan State University</td>
</tr>
<tr>
<td>Jim Markham</td>
<td>New York DEC</td>
<td>Jon Baker</td>
<td>Michigan State University</td>
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The training program consisted of the following activities:

1) Completion of Maximum Likelihood Estimation for Natural Resource Professionals online course: Students in the stock assessment program were given access to the maximum likelihood estimation online course between 1 September 2010 through 31 January 2011. This online course provided material roughly equivalent to the content of a two-credit graduate course on essential mathematical statistical background related to likelihood-based estimation. The course was video based and consisted of 8 units (Overview, Introduction to R, Model Specification and Model Fitting, Introduction to Probability, Introduction to Maximum Likelihood Parameter Estimation, More About Fitting Models Using Maximum Likelihood, Assessing Uncertainty in Parameter Estimates, and Model Selection and Averaging). The course also included quizzes at the end of most units along with a mid-term and final exam to assess student learning.

2) First Short Course - Basics of Statistically-Based Stock Assessments. This first short course was held 13 December 2010 through 16 December 2010 on the Michigan State University Campus. The agenda for the workshop was the following:

Day 1
- ADMB Intro
- Theory of fishing
- Catch curve as SLR example
- Looping and conditional statements
- Multinomial distribution and likelihood
- Survival estimation part 1 (S and f)
- Survival solution
- Survival estimation part 2 (F and M)

Day 2
- ADMB report files
- ADMB function
- Modify survival ADMB code to include functions
- Standard error review plus Delta method
- Modify previous example to include standard error on derived variables
- Process and observation error
- Intro discussion concerning weighting of data sources
- Surplus production illustration (use simulated data to make sure well behaved)
- Time varying components and random walks
- Surplus production modification to use random walks

Day 3
- Introduction to age structured assessment
- Virtual Population Analysis (VPA)
- VPA example in R or Excel
- Backwards recursion estimation

Day 4
- Statistical Catch at Age (SCAA) Introduction
- SCAA Coding

Some modifications of the agenda were necessary to accommodate actual progress. By the end of day 4, students had been exposed to the basics of statistical catch at age modeling.

3) Second Short Course - Advanced Stock Assessment using AD Model Builder. This second short course was held 24 January 2011 through 27 January 2011 on the Michigan State University Campus. The agenda for this second workshop was the following.

Day 1
- ADMB review and debugging
- SCAA review
- Review of process/observation error, lambdas, random walk
- Incorporation of a survey data series to SCAA model
- Explore different lambdas
- Catchability random walk
- Estimate annual fishing intensity as a parameter
- Approaches to parameterize recruitment
- Incorporating absolute estimators of abundance

Day 2
- Multiple fisheries
- Selectivity as a function
- Time varying selectivity
- Aging error
- Different aggregations of data (young, old; length groups)

Day 3
- Bayesian estimation in ADMB (maybe likelihood profiling)
- Control program/exploring assumptions

Day 4
- Individual help on capstone projects.
4) Workshop designed to solve common problems and individual support on capstone projects. Because of scheduling difficulties, we were unable to find a block of time where all participants were able to travel to the MSU campus for support on capstone projects. Instead, one group of students came to MSU from 13 April 2011 to 15 April 2011 and another group came from 17 May 2011 to 19 May 2011. Each participant gave a brief presentation to the others in attendance about their capstone project, including why the models were needed, what data went into the models, the structure of the models, and the reasoning behind the structure choices.

Feedback on the MLE online course was collected via surveys completed at the middle (Appendix 2) and end (Appendix 3) of the course. In June 2011, participants in the stock assessment training program were asked to complete an anonymous online survey to gain feedback as to how well the overall training program met participant needs, advanced their understanding of stock assessment, and their opinion as to the overall structure of the training program (Appendix 4).

RESULTS:

We received a total of 12 applications for the stock assessment training program. Because the number that applied was within the range of what we felt we were able to accommodate for the training and most applicants indicated only minimal need for travel support, all of those that applied were accepted into the program and no selection process was implemented. An additional application to the training program was received approximately 2 months after the application deadline; the applicant was told that the training program was full. The accepted participants represented Ontario, one federal agency (USGS), and four US states (WI, MN, MI, PA). One participant had to withdraw prior to the onset of the course because of family illness and one participant withdrew after completing the online maximum likelihood training and the first (December 2010), workshop due to a reassignment of job duties. The 10 remaining participants represented four US states and the province of Ontario. Eight of the 10 were working fishery biologists on the Great Lakes who expected to be engaged in fish stock assessment activities. The other two participants were wildlife biologists hoping to apply age-structured stock assessment methods to mammals.

Seven participants in the stock assessment training program completed the midterm evaluation for the maximum likelihood estimation online course. When asked about presentation of the online course material, 14.3% strongly agreed and 71.3% agreed that presentation of the material made it easy to learn on their own while 14.3% disagreed. When asked whether the online course was boring, 14.3% strongly disagreed and 85.7% disagreed that the course was boring. When asked about understanding of the material even though an instructor was not nearby, 100% agreed that they were understanding the material. When asked about the number of practice exercises, 71.4% disagreed that more exercises were needed while 28.6% strongly agreed. When asked whether there were times that help was needed but the participant did not ask for help, 71.4% agreed while 28.6% disagreed. When asked whether they were surprised at how much they were learning in the class, 85.7% agreed that they were surprised while 14.3% disagreed. When asked about course organization, 28.6% strongly agreed and 57.1% agreed that the course was well organized while 14.3% disagreed. When asked whether they knew what needed to be done for the course, 14.3% strongly agreed and 51.4% agreed that they knew exactly what to do in the course while 14.3% disagreed. When asked about the directions provided for the different tasks in the course, 14.3% strongly disagreed and 57.1% disagreed that the direction were confusing while 28.1% neither agreed nor disagreed. When asked about their overall opinion of the course, 85.7% responded that the course was great and that they were learning what they needed while 14.3% indicated that the course was okay and they were learning some new material. The items that respondents indicated were the most useful during the course were the practice exercises (7 of 7 respondents), the lecture videos (5 of 7 respondents), the printable answers to the practice exercises (5 of 7 respondents), printable handouts of videos (4 of 7 respondents), the practice questions/codes in the videos (3 of 7 respondents), and other printable handouts (3 of 7 respondents). As for comments or suggestions regarding the course, the following responses were received:

Comment 1 - Generally I think this format is working well. I've noticed a few places where there are some glitches, but they are generally minor and easy to ignore or work around. I probably should have made notes of what they were, but I haven't.
Comment 2 - I recognize that I am mathematically challenged, and in spite of that, I'm still not drowning yet.
Comment 3 - I don’t think some of the test questions were displayed correctly. For example the question with a table of mail per day and probabilities, had no probabilities and mail per day appeared wrong too. I have received a message about my internet explorer being an older version and some things may not display correctly. It had not been an apparent issue throughout the course so far until the midterm questions.

Comment 4 - My only suggestion would be to provide feedback for all wrong answers submitted in quizzes and exams that would clearly explain why my choice and the other incorrect choices were wrong.

Comment 5 - 1. Still having a difficult time determining when to use a Poisson or negative binomial distribution as opposed to others. Could use a summary table or key to help guide us toward which distribution to use for a given scenario. 2. Course would be very difficult without exercises and handouts. Exercises and questions are important for keeping me on track. It's not always clear from exercise directions what is desired, and a quick peek at completed exercise helps to clarify. Otherwise, having to contact instructors with clarification questions would have greatly slowed things down and added to frustration. 3. Could use more direction use of R-editor for script and R-console for storing output. Or, maybe it was just me that didn't get this? Luckily, a couple folks in my office use R a bit. 4. Glitches and typos scattered here and there in materials. Probably normal, but would be good to at least double-check exercises, quizzes, and exams. Otherwise, so far so good!! :)

Five participants in the stock assessment training program completed the final evaluation for the maximum likelihood estimation online course. When asked about gains in knowledge, 60% strongly agreed and 40% agreed that the course had improved their knowledge of model building. When asked about presentation of the course material, 100% agreed that presentation of the course materials facilitated learning on their own. When asked whether the online course was boring, 40% strongly disagreed and 60% disagreed that the course was boring. When asked about understanding of the material even though an instructor was not nearby, 100% agreed that they were able to understand the material. When asked about the amount of practice exercises, 20% strongly disagreed and 40% disagreed that more exercises were needed while 40% agreed. When asked whether there were times that help was needed but the participant did not ask for help, 80% agreed while 20% disagreed. When asked whether they were surprised at how much they were learning in the class, 20% strongly agreed and 60% agreed that they were surprised while 20% disagreed. When asked about course organization, 40% strongly agreed and 60% agreed that the course was organized well. When asked whether participants knew exactly what they needed to do for the course, 80% agreed while 20% disagreed. When asked whether the course was worth the investment of their time, 20% strongly agreed and 80% agreed. When asked whether they would be able to apply what they learned from this course in the future, 40% strongly agreed and 60% agreed. When asked about their level of knowledge of maximum likelihood estimation at the end of the course, 60% of respondents rated their knowledge as good while 40% rated it as average. When asked about their overall opinion of the course, 80% responded that the course was great and that they were learning what they needed while 20% indicated that the course was okay and they were learning some new material. The items that respondents indicated were the most useful during the course were the practice exercises (5 of 5 respondents), the printable answers to the practice exercises (5 of 5 respondents), printable handouts of videos (5 of 5 respondents), the lecture videos (2 of 5 respondents), the practice questions/codes in the videos (2 of 5 respondents), and other printable handouts (2 of 5 respondents).

When asked what was most liked about the course, the following comments were received:

Comment 1 – I liked that I could proceed at my own pace and that all of the lecture notes were so readily available.

Comment 2 - The video lectures were very well done. I didn't do well in this course, but I believe this a function of my mathematical ability, not a reflection of the course design.

Comment 3 - Instructors were available and helpful. Materials were good. Technology worked well (easy to use).

Comment 4 - The well-documented worked examples provided for all the topics. The usage of the R software program as the basis for the course

When asked how future courses could be improved, the following suggestions were received:

Comment 1 - In general, the lectures, exercises, assignments, etc were fine. My biggest problems were really more annoyances - links that didn't work, typos in answer keys, quiz questions that did not specify the required number of decimal places, etc. I would also recommend either providing starting values for all parameters in the exercises and assignments, or providing more explanation of the role of the parameters in the model so reasonable starting can be intuited.
Seven participants completed the survey for the overall stock assessment training program. When asked about presenter preparation, 14.3% strongly agreed and 85.7% agreed that presenters were well prepared. When asked about the size of the group, 42.9% strongly agreed and 57.1% agreed that the size of the group was appropriate. When asked about prepared materials, 57.1% strongly agreed and 42.1% agreed that materials were helpful. When asked about understandability of the prepared materials, 100% agreed that materials were understandable. When asked whether they learned new information about stock assessment, 85.7% strongly agreed and 14.3% agreed that new information had been learned during the training program. When asked whether the training was worth their investment in time, 85.7% strongly agreed and 14.3% agreed that the training was worth their investment. When asked about application of the information in the future, 71.4% strongly agreed and 28.6% agreed that they would be able to apply this information. When asked about gains in knowledge of population dynamics and stock assessment, 57.1% strongly agreed and 42.9% agreed that their knowledge level increased as a result of this training program. Prior to the training opportunity, 71.4% of respondents characterized their knowledge in stock assessment as average, while 28.6% characterized it as either good or poor. Following the course, 100% of respondents characterize their knowledge as good. Overall, 71.4% of respondents characterized the training program as excellent, while 28.6% characterized it as good. When asked why they participated in the training program, 85.7% of respondents indicated it was to use or potentially use as part of their work while 14.3% indicated it was to understand methods that others are using. When asked about how the online maximum likelihood estimation course prepared them for the rest of the training program, 28.6% strongly agreed and 57.1% agreed that the course provided valuable preparation, while 14.3% neither agreed nor disagreed. When asked about the amount of time spent on the online course, 14.3% strongly agreed and 71.4% agreed that there were able to devote sufficient time to the course while 14.3% disagreed. When asked about skills learned during the two training short courses, 42.9% strongly agreed and 57.1% agreed that valuable skills were learned that they would be able to apply to their project. When asked how important the individual project was to the overall training program, 50% strongly agreed and 50% agreed that the individual projects were critical to the training program. When asked about the amount of time spent working on individual projects between the January and April/May meetings, 42.9% agreed that they were able to spend enough time while 28.6% disagreed, 14.3% strongly disagreed, and 14.3% neither agreed nor disagreed. When asked whether more could have been gained if more had been accomplished on individual projects if more time had spent working on the projects after the January workshop, 16.7% strongly agreed and 50% agreed that more could have been gained while 33.3% disagreed. Overall, 71.4% of respondents felt that an adequate amount of time was spent at MSU while 28.6% felt that not enough time was spent. When asked to provide ideas for how future stock assessment training could be structured differently to meet the needs of working professionals, the following comments were received:

Comment 1 - Could start with a perspectives and status of the art.
Comment 2 - I can't suggest any way to improve the program.
Comment 3 - Perhaps a few more working examples of how stock assessment techniques are being applied directly to some relevant Great Lakes fisheries issues. In some situations, it would have been more beneficial to work through a coding example as a class versus giving some background and then, in some cases, quick instructions before working independently. There clearly are cases where "muddling" through a model is a good way to learn. That said, if it results in too much "wheel spinning", then valuable time is lost.
Comment 4 - I thought the structure of this course worked very well, no suggestions for improvement.
Comment 5 - I honestly think this course could be a yearlong, but with a similar format. Add more classroom materials to assist those that are in need of it...perhaps some of the stock assessment principles (key population dynamics) could be another online course? Have multiple sessions for individual work sessions, though I may be living in a fantasy world with travel budgets and such. I just thought the course was great and despite having just completed it would do it again if offered tomorrow!
Comment 6 - On the whole, it was tailored about right. The suggestions above are just tweaks that might be considered. Taking care of lodging, meals and transportation really helped make this not only possible, but more enjoyable.
Comment 7 - The online MLE class was useful, but a bit tedious. I would have liked quiz and exam questions to be a bit more challenging so I knew I was learning something for all the time I spent.

When asked what they liked most about the training, the following comments were received:

Comment 1 - Comprehension.
Comment 2 - Working through the in-class examples with Travis and Jim there to show me where I screwed up my code.
Comment 3 - The accessibility and responsiveness of the instructors when I had questions was very impressive. I think that is critical to the success of a course of this level.
Comment 4 - Working through examples with the help of instructors and classmates. I learned the most from attempting to write the code and then having instructors work through the code or work through completed code myself later.
Comment 5 - The small class size was great. Personalizing it by having it on site was nice, requiring us to concentrate on it while we were there. The final session was extremely helpful - I think I could waste weeks of Jim's and Travis's time :)
Comment 6 - For me, it was just the right content at the right time. I think the success of this workshop series is selection of students who are ripe for this sort of training. Everyone there seemed to be at the same approximate stage or level of learning and each had data they might bring and understand the application to their work. I really enjoyed the other students and conversations and networking with them.
Comment 7 - The willingness of the instructors to help students with their personal projects.

When asked how future stock assessment training opportunities could be improved, the following comments were received:

Comment 1 - A session of case studies before individual project. Why and how particular methods or options were selected in a particular case.
Comment 2 - No suggestions.
Comment 3 - Beyond what I've mentioned, I don't feel there were any serious issues that I feel could have been improved upon.
Comment 4 - More supplemental information for student so read/study prior to workshops might help in trying to cover more information in the current format. For example, I would like more background on some topics covered, but there was not enough time to ask questions or discuss as a group.
Comment 5 - Make it longer.
Comment 6 - Maybe some way to facilitate collaboration with instructors once back home. Maybe something as simple as an FTP site with assigned folders for each student that they could upload their model files to so that instructors might be able to follow progress, try their own runs and readily have materials to examine so as to accommodate and promote question asking.
Comment 7 - Online introduction to ADMB to reduce time spent on campus just learning about the software.

Additional comments received included the following:

Comment 1 - I only wish I was able to dedicate more time to the training outside of the course. It seemed like I was really catching on to things just about the time the sessions at MSU were coming to an end.
Comment 2 - During the first two workshops, the presentation material seemed to skip back and forth some over certain topics. I'm not sure if that was intentional or not. Particularly the treatment of SCAA. Not a big detraction, just something noticed. Also there seemed to be some confusion over the files and folders to be copied over, some confusion over versions. It would have been nice if all the handouts and files were fully organized in advanced and exactly uniform between students. Just cuts down on the confusion.
Comment 3 - I was in particular need of a better working understanding of ADMB and this workshop series suited that very well.
Comment 4 - With regard to the Max Likelihood course, although I feel it was valuable, I would rank it between the "Agree" and "Neither". To be clear, for the questions regarding time spent on the online course and between workshops, my responses were the result of work obligations not allowing me enough time to devote to the course/project. I feel there probably was adequate time.
Comment 5 - Again, I wish I could have dedicated more time to the project outside of class, however the April session was fantastic! The individual time with the instructors was extremely valuable.
Comment 6 - There were many occasions where I had further questions about the concepts and materials presented in the online course and first two workshops once I started in on my own project. I often wished I could have heard again the explanations and lectures on things like effort deviations and random walk once I was not in the project. Put another way, those didn't mean as much to me at the time they were presented. I could have probably asked more questions but I really wished I could have "replayed" some of the discussion. I made use of my notes a fair amount.

Comment 7 – Regarding amount of in residence time at MSU, I think it may have bordered a little on too much but adequate in general. However, because the scope of origin of the participants was so great, a certain amount of time needs to be set aside.

Comment 8 - In my opinion we could not have spent enough time with the instructors at MSU. The individualized time was tremendously valuable. Time with the other students was good, too as it provided peers with which to discuss problems/ideas. Classroom work seemed rushed at times, but there is just so much information, seems hard to distill it to the necessary "classroom" information.

Comment 9 - I think the online material could be strengthened by at least one or two days in person to "gel" some of the concepts. More importantly, working on the project actively in the presence of the instructors really helped to make progress so more of that time would have been nice (like the last workshop). Not sure if that's possible or realistic but would help ensure progress. It’s hard to "get help" on a model remotely.

Comment 10 - Although I only participated in the December workshop at MSU, I thought that the preparation by the instructors was excellent and the course content and pace was challenging, but not unrealistic. I regret that I could not continue through the rest of the workshops and the individual project.

Comment 11 - Overall, I feel that this was a great program and very beneficial to those with Great Lakes management responsibilities. I feel that, if the course should be offered again, candidates should be clear that a fairly substantial amount of time should be reserved in order to meet the goals and intent of the training. Thanks very much for the opportunity to participate, I am impressed by the knowledge of the instructors and their willingness to pass along their expertise.

Comment 12 - Thank you very much for the opportunity. I hope the communication/relationship does not end with the course.

Comment 13 - It might be nice if there was some recognition of the investment these student/professionals made in terms of time and effort-perhaps MSU continuing education credits, or even a certificate or something. Not so much for the ego, but to demonstrate to others (like agency administrators) that there was some significant value and accomplishment to these efforts. Of course, ultimately it’s the knowledge they are taking back with them.

Comment 14 - Nametags for all of the students would be helpful.

The capstone projects that participants worked on as part of the stock assessment training opportunity varied in their nature. Some of the projects involved development of new SCAA models, while others involved refinement (inclusion of new data sources, change in model structure) of existing SCAA models. Below is a list of the projects that participants worked on:

- Project 1 – Estimating catchability, selectivity, and natural mortality in Lake Huron lake trout SCAA models
- Project 2 – Incorporation of fall spawning survey and recreational ice fishery data sources into the North/Moonlight Bay lake whitefish SCAA model
- Project 3 – Development of an SCAA model for lake whitefish in Thunder Bay, Lake Superior
- Project 4 – AD Model Builder coding an existing fisher and marten integrated assessment model; Development of an integrated assessment model for bobcat (2 participants worked on this project together)
- Project 5 – Development of an SCAA for lake whitefish in Apostle Islands, Lake Superior
- Project 6 – Incorporation of recreational fishery length composition in the lake trout SCAA model for Minnesota waters of Lake Superior
- Project 7 – Development of an SCAA model for walleye in Big Bay de Noc, Lake Michigan
- Project 8 – Development of an SCAA model for Lake Huron walleye
- Project 9 – Incorporation of an alternative approach to estimate gillnet survey selectivities and inclusion of OMNR Long Point Bay Index Gillnet Survey in the MU4 Lake Erie yellow perch SCAA model
While most participants have made good progress on their projects, none of the projects have been finalized. We therefore anticipate that we will continue providing support to the workshop participants on their projects past the official completion date of the project. We are happy to provide such support and consider it to be part of the regular operation of the QFC.

DISCUSSION:

Based on student evaluations of both the overall training program and the maximum likelihood estimation online course, we consider this training program to have met its overall goal and to have been successful. We base this conclusion on the fact that all surveyed respondents strongly agreed or agreed that they learned new information on stock assessment and population dynamics and that they believed they would be able to apply this new information in the future. We further judge the training program to have been a success due to most students having made good progress on their capstone projects. Thus, as a result of this training, there are nine new or improved SCAA models upon which natural resource managers potentially could use to help manage fish and wildlife populations in the Laurentian Great Lakes region.

Although we consider the training program to have been a success, there were nevertheless several areas of the training that were somewhat problematic, which we would likely address if we offered a similar training opportunity in the future. First, some participants appeared to focus their learning on the use of the R statistical software package during the maximum likelihood estimation online course, rather than on the concepts that were the focus of the course (e.g., probability distributions, likelihoods, characterizing uncertainty in parameter estimates). Even by the end of the second workshop, some participants were still having difficulties in adding additional components (e.g., log-normal, multinomial components) to objective functions of models even though this had been a major focus of the online course and the first workshop. In the past, when we have taught AD Model Builder short courses, students in those courses also struggled with the concepts related to maximum likelihood estimation. For those past courses, we generally attributed this to our only being able to spend maybe half a day at most discussing this topic. We had hoped that by having participants complete an online course roughly equivalent to a two-credit graduate course, that they would have entered into the stock assessment part of our training with a firmer grasp on the statistical background related to likelihood-based estimation needed for this type of stock assessment modeling. Unfortunately, this was not the case. In discussions with some of the participants in the training, it was clear that most had little experience with the R statistical software package prior to taking the online course. It thus seems conceivable that many students focused their learning efforts on how to use R in order to be able to complete exercises and assignments. At this point, we are uncertain as to how exactly we would change the training opportunity to rectify this problem in future offerings, as no matter what package is used to illustrate likelihood-based estimation techniques, some students will struggle with it. We still do recognize it as an area to be improved upon. Possible approaches might include either a first course on using the R language in addition to the course on maximum likelihood itself, or presenting the likelihood theory using the same software used for the more complex stock assessment applications (AD Model Builder).

Another possible change to future training opportunities would be to try and shorten the length between the first two workshops. For this training opportunity, the first workshop occurred December 13-17, and the second workshop occurred January 24-27. Although there was only a 5-week separation of the workshops, a substantial amount of material covered during the first workshop needed to be reviewed during the second workshop. It is possible that the need to review material was heightened as a result of the holidays between the two workshops. Regardless, in future offering we may consider reducing the separation of the workshops to two or three weeks.

One other change to future training opportunities would be to enact steps to ensure that participants consistently worked on their capstone projects prior to the final meeting at MSU. Although we feel most participants indeed made good progress on their capstone projects, their time at MSU during the third workshop in most cases could have been more productive if prior to arriving they had ensured all data were read-in correctly to AD Model Builder and if they had a simple, albeit functioning, SCAA model. This would have resulted in their being to devote more time with the instructors incorporating additional complexity and processes into their models, rather than helping troubleshoot basic code structure. We envision that this could be accomplished by scheduling times to meet with each participant remotely to assess project progress, answer questions, and help troubleshoot coding.
As stated previously, there is a documented national and global shortage of appropriately trained fishery stock assessment scientists, and this shortage is perhaps exacerbated in the Great Lakes region as state fishery management agencies do not have the resources to staff fulltime stock assessment personnel. The ultimate goals for this training opportunity were to increase familiarity in stock assessment methodologies for a cadre of fishery biologists in the Great Lakes region and to facilitate networking among these biologists and with personnel at the Quantitative Fisheries Center. We believe we accomplished this goal, although there still remains a broad need for appropriate trained stock assessment scientists at regional, national, and global scales.

REFERENCES:


ACKNOWLEDGEMENTS:

We wish to thank all who participated in the stock assessment training program for the time and effort they devoted to the training. We also thank Angie Leslie for helping develop AD Model Builder training videos and for administering the maximum likelihood estimation online course and course survey, and Weihai Liu for assistance in troubleshooting AD Model Builder code. Finally, we thank the Great Lakes Fishery Commission Science Transfer Program for providing the funding that made this training possible. This is publication 2011-03 of the Michigan State University Quantitative Fisheries Center.
DELIVERABLES:

2. Completion report submitted 1 July 2011.

PRESS RELEASE:

Title: Quantitative Fisheries Center at Michigan State University Provides Valuable Training Opportunity in Fishery Stock Assessment to Great Lakes Natural Resource Biologists

Throughout the last year, a cohort of natural resources biologists from management agencies in the Great Lakes region have traveled to Michigan State University (MSU) to participate in a training program offered by the Quantitative Fisheries Center (QFC). This training program, which was led by Dr. James Bence, QFC co-Director and a Professor in the MSU Department of Fisheries and Wildlife, and Dr. Travis Brenden, QFC Associate Director and an Assistant Professor in the MSU Department of Fisheries and Wildlife, was funded by a grant from the Great Lakes Fishery Commission Science Transfer Program. The purpose of the training program was to increase the number of biologists with familiarity in stock assessment methodologies in the Great Lakes region and to facilitate networking among these biologists and with personnel at the QFC to help confront stock assessment needs. Biologists that participated in this training program included personnel from four US states (MI, WI, MN, PA) and the province of Ontario. As part of the training, participants completed an online course on likelihood-based estimation techniques and traveled to MSU in December 2010 and January 2011 for population dynamic and stock assessment methodology training. Participants also received training in the use of AD Model Builder, an extremely powerful and versatile software package for statistical modeling. Each participant additionally identified a stock assessment project that they worked on during the training program. Participants traveled to MSU in late spring 2011 to discuss progress and receive assistance on projects. Examples of stock assessment projects that participants worked on included development of a statistical catch at age (SCAA) model for lake whitefish around the Apostle Islands of Lake Superior, incorporation of recreational fishery length composition in the lake trout SCAA model for Minnesota waters of Lake Superior, and development of an SCAA model for walleye in Lake Michigan’s Big Bay de Noc. All participants that responded to a survey about the training program, agreed that they had learned new information on stock assessment and population dynamics as a result of this training and that they would be able to apply this new information in the future. Comments on the course included the following.

“In my opinion we could not have spent enough time with the instructors at MSU. The individualized time was tremendously valuable. Time with the other students was good, too as it provided peers with which to discuss problems/ideas.” (Anonymous comment received from course participant)

“Overall, I feel that this was a great program and very beneficial to those with Great Lakes management responsibilities. I feel that, if the course should be offered again, candidates should be clear that a fairly substantial amount of time should be reserved in order to meet the goals and intent of the training. Thanks very much for the opportunity to participate, I am impressed by the knowledge of the instructors and their willingness to pass along their expertise.” (Anonymous comment received from course participant)

Contact: Dr. James R. Bence, Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources, East Lansing, MI 48824; 517-432-3812; bence@msu.edu

APPENDICES:
Appendix 1 – Application Solicitation Letter for Stock Assessment Training

05 May 2010

Solicitation for Applicants
Stock Assessment Training at the Quantitative Fisheries Center
Application deadline:  May 19, 2010

The Quantitative Fisheries Center (QFC) at Michigan State University (MSU) is soliciting applicants for a series of stock assessment training short courses that it will be hosting on the MSU campus throughout the coming year. Costs associated with enrolling in the courses will be covered as part of funding from the GLFC for this training program. Accepted individuals will be provided free housing (likely at the residence of a QFC member). We have some funds to cover additional travel costs and those accepted into the program who indicate a need will be considered for this support. The intent of these training workshops is to broaden the cadre of scientists in the Great Lakes region with training and expertise in advanced stock assessment methods. Dr. Jim Bence, co-Director of the QFC and a Professor in the MSU Department of Fisheries and Wildlife, will be the lead instructor for these workshops.

We anticipate that between 8 and 12 individuals will be selected for the training program. Those selected will receive training in likelihood theory and related estimation methods, modern statistical approaches to stock assessment, and in the use of AD Model Builder in an assessment context. As part of the training, students must self-identify and work on a stock assessment project of interest to themselves and their affiliated agency. The final training workshop will involve participants coming together as a group to discuss their applications and along with the instructors jointly work to solve encountered problems.

Agenda:
The overall training program will consist of:
1) Completion of Maximum Likelihood Estimation Online Course. This online course provides material roughly equivalent to the content of a two-credit graduate course providing essential mathematical statistical background related to likelihood-based estimation. This course has already been developed and tested. Cohort members have the option of taking this standard not for credit course (with costs covered by project funding), taking a for-credit version (additional costs borne by individual or their agency), or opting out of this course with our (Bence and Brenden) approval on the grounds of prior experience and background.

2) Basics of Statistically-Based Stock Assessments - first short course. This four day short-course will cover basic model components (e.g., Baranov catch equation, exponential mortality, separable fishing mortality), statistical concepts of fitting models, exercises to build a statistical surplus production and catch-at-age assessment models, diagnostics, and coverage of important complicating issues (weighting data sources, allowing parameters to change over time).

3) Advanced Assessment using AD Model Builder - second short course. This four day short course will walk students through the process of coding statistical catch-at-age models in AD Model Builder. Additionally, the course will address the range of choices and complexity faced in real world assessments, and will provide theory and practice of assessing uncertainty, including via Bayesian estimation.

4) Workshop Designed to Solve Common Problems and Provide Individualized Support. This culminating or capstone experience will occur approximately three months after the second stock assessment short course. It is expected that participants will have worked on applications of interest to them and their agencies based on material covered in the previous short courses. Each
participant will give a brief presentation to the group describing their application, progress, and difficulties. Presentations will be followed by hands on programming and debugging work with instructors to solve remaining problems and further explore results.

**Additional Detail on Costs:**
Each individual accepted into the training program will automatically be given a scholarship to cover costs of the online maximum likelihood estimation course, and all other short courses will be free of charge. Students can indicate in their application whether they need assistance with travel costs. Acceptance into the program will not depend on this need, although the total number accepted will depend upon actual costs (i.e., applications will be ranked and accepted starting from the highest ranked until the budgeted funds are used). Travel costs will be restricted to mileage or plane fare, and standard per diem costs for meals during travel, and dinners during the workshop (continental breakfast and lunch will be provided). Gratis lodging will be available for all the workshops. This is likely to be at the residence of a QFC staff member. You are free to make other housing arrangements at your own expense. Our intent is for this training to be as small of an expense burden as possible for individuals and/or agencies sending students to the program.

**Schedule:**
Scheduling of the training program will be decided upon among the applicants chosen to participate in the workshop. Two scenarios are envisioned. The scenario chosen will depend on what allows the greatest level of attendance.

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLE Online Training</td>
<td>June – Oct., 2010</td>
<td>Sep. – Dec., 2010</td>
</tr>
<tr>
<td>Short Course 1</td>
<td>Oct. 2010</td>
<td>Dec. 2010</td>
</tr>
<tr>
<td>Short Course 2</td>
<td>Nov. 2010</td>
<td>Jan. 2011</td>
</tr>
<tr>
<td>Capstone Experience</td>
<td>Feb. 2011</td>
<td>May 2011</td>
</tr>
</tbody>
</table>

**To Apply:**
Those interested in attending the stock assessment training should provide by e-mail a copy of their CV and a letter of application addressing their reasons for wishing to participate, the benefits that would derive to themselves, their agencies, and more broadly, and a brief description of the capstone application to which they intend to apply the learned stock assessment procedures. Applicants should also indicate their scheduling preference (Scenario 1 or Scenario 2) and whether they will require travel assistance. Applicants will be judged by a selection committee consisting of the instructors for this training and at least two other members from agencies working on two different Great Lakes, not intending to participate themselves, and with broad familiarity with Great Lakes stock assessment issues. Please submit application materials via e-mail attachment by **May 19, 2010** to Angie Leslie (lesliea@msu.edu) with a message subject line of “Stock Assessment Training Application Materials”.

Questions regarding this training opportunity should be directed to Dr. Jim Bence (bence@msu.edu).

James R. Bence
Travis O. Brenden
Appendix 2 – MLE Online Course Midterm Evaluation

<table>
<thead>
<tr>
<th>Please rate the following</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The material was presented in a way that it was easy for me to learn on my own.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. I find the course to be boring.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I find myself to be understanding the material even though I did not have an instructor near by.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I want more practice exercises.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. There were times when I needed help and I did not ask for it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. I am pleasantly surprised at much am I am learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. The course is organized well. I know where to find everything I need.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. I know exactly what I need to do. I don't feel lost and I know what I need to do and what is expected of me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

9. Select the option that best describes your experience with the course
   - Is not living up to my expectations so far.
   - Is ok. I am learning some material.
   - Is great. I am enjoying it and learning what I need.
   - Is exceeding my expectations.

10. Select the items that are most useful to you.
- The lecture videos.
- The practice questions/codes in the videos so you can follow along and test your knowledge.
- The practice exercises.
- The printable answers to practice exercises.
- Printable handouts of videos.
- Other printable handouts (at-a-glance)

Please select the response that best describes what you think of the procedures guiding the course and the instructor's expectations of you.

<table>
<thead>
<tr>
<th>11. The directions for completing assigned tasks are confusing</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

12. What comments or suggestions do you have for us?
Appendix 3 – MLE Online Course Final Evaluation

<table>
<thead>
<tr>
<th>Please rate the following.</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. This course improved my knowledge of model building.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. The material was presented in a way that it was easy for me to learn on my own.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I find the course to be boring.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I find myself to be understanding the material even though I did not have an instructor near by.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. I want more practice exercises.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. There were times when I needed help and I did not ask for it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I am pleasantly surprised at much am I am learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. The course is organized well. I know where to find everything I need.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. I know exactly what I need to do. I don’t feel lost and I know what I need to do and what is expected of me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. This course was worth the investment of my time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. I will be able to apply what I learned from this course in the future.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Please select the appropriate response.</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
<th>Very Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. After this course my knowledge of maximum likelihood estimation is.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

13. Select the option that best describes your experience with the course

- Is not living up to my expectations so far.
- Is ok. I am learning some material.
- Is great. I am enjoying it and learning what I need.
- Is exceeding my expectations.

14. Select the items that are most useful to you.

- The lecture videos.
- The practice questions/codes in the videos so you can follow along and test your knowledge.
- The practice exercises.
- The printable answers to practice exercises.
- Printable handouts of videos.
- Other printable handouts (at-a-glance)
15. What did you like most about this only course?

16. How would you improve future courses?
### Appendix 4 – Evaluation Questions for Overall Stock Assessment Training Program

We are interested in knowing how well this training opportunity met your needs.

<table>
<thead>
<tr>
<th>Please circle your response.</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Presenters were well prepared.</td>
<td>1</td>
<td>2</td>
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<td>5</td>
</tr>
<tr>
<td>2. The size of the group was just right.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Prepared materials were helpful.</td>
<td>1</td>
<td>2</td>
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<td>5</td>
</tr>
<tr>
<td>4. Materials were understandable.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I learned new information about stock assessment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. The training was worth the investment of my time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. I will be able to apply this information in the future.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. This course increased my knowledge of population dynamics and stock assessment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please think about your level of knowledge of stock assessment before and after this training.

<table>
<thead>
<tr>
<th>Please circle your response.</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
<th>Very Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Before this course, my knowledge was:</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. After this course, my knowledge is:</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. Overall, how do you rate this training?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

12. Which best describes your purpose in attending this training?
   A. To use or potentially use it as part of my work.
   B. To understand methods that others are using.
   C. Develop a general background in quantitative fisheries.
   D. Other:

We are interested in your thoughts about the overall structure of the training program

<table>
<thead>
<tr>
<th>Please circle your response.</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. The online Max Likelihood course provided valuable preparation for the rest of the training program.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. I was able to devote the time needed to the online Max Likelihood course.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. I learned valuable skills during the December and January workshops that I was able to apply to my project and/or other work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. The work on an individual project was a critical part of the training program.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
17. I was able to spend enough time between the January workshop and the April/May workshop on my project.

18. I could have gained much more from the April/May workshop if I had done more on my project before the workshops.

19. Was the amount of in residence time at MSU adequate, not enough, or too much?

20. Please provide us any ideas about how a stock assessment training program could be structured differently to better meet the needs of working professionals.

21. What did you like most about this training?

22. How would you improve future training beyond what you have already told us?