Project details

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Project number: E/I-21, award number: NA13OAR4170109

Project title:

Optimizing Bayesian analysis in data-rich stock assessments and management resources in data-limited fisheries

Project update:

My work since June 2015 falls into three categories: (1) Incorporating Hamiltonian samplers into TMB and ADMB, (2) coauthoring the assessment for Pacific halibut, and (3) taking general exam and writing chapters for publication.

Hamiltonian algorithms

I have concluded my review of algorithms that will be used to optimize Bayesian analysis. The most promising algorithm for use in a wide variety of fisheries models, including stock assessments, is the “no-U-turn” sampler by Hoffman and Gelman (2014). This algorithm is quickly gaining traction in other fields, and is considered state of the art for Bayesian models. The performance gains by using this algorithm over what is currently used has the potential to open up Bayesian inference on data-rich stock assessment models that are simply too slow. Currently, the no-U-turn sampler is only available in the software platform Stan (Stan Development Team 2015). However, I have incorporated it into the R package TMB, which is quickly becoming a powerful and useful tool for many fisheries models. Figure 1 below shows example behavior of a Hamiltonian sampler.

The next step will be to incorporate it into ADMB so that all stock assessments have this option available. I have made plans to work toward this goal in June of 2016 when the ADMB development team is meeting in Seattle. I will prototype the algorithm for them, and then with their help incorporate it directly into the source code. After this is accomplished, I can recompile Stock Synthesis (or other ADMB models) and directly quantify the improvements of the new algorithm, as well as comparing frequentist and Bayesian estimates of uncertainty, which was the largest hurdle for one of my chapters.

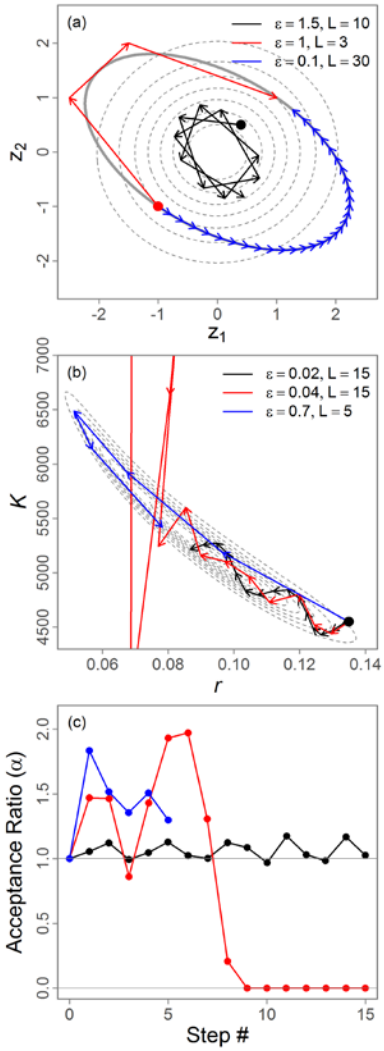

Figure 1. Approximate trajectories of a Hamiltonian system. (a) Effect of different step sizes (ε) and number of steps (L). The blue trajectory has the same initial position but negative momentum compared to the red trajectory, but both are approximations of the same true contour (solid gray line), and have the same path length (ε*L). The blue trajectory has much less approximation error (deviation from true contour) than the red one. The black trajectory would continue to cycle, despite the large step size, demonstrating the stability of the Leapfrog integrator. (b) Approximate trajectories on a logistic posterior surface. All three trajectories have the same initial position and momentum. The red trajectory shows accumulating approximation errors, causing it to diverge off of the true contour. The blue trajectory results from utilizing an appropriate mass matrix which transforms the surface to be closer to a bivariate standard normal which makes the surface easier to approximate (see text). Note this trajectory has a longer path length than the black line, despite having only one third the steps. (c) The acceptance ratios of the trajectories in (b), calculated as $\alpha = \exp(H_0 - H_t)$. The corresponding acceptance probability is min(1, α).

Pacific halibut assessment

I collaborated with my committee member, Dr. Ian Stewart, to conduct the annual assessment done by the International Pacific Halibut Commission (IPHC). In doing this work I learned valuable skills for the rest of my dissertation. Namely, how to utilize the R package r4ss (I

contributed new functionality to it) for data-rich stock assessments in Stock Synthesis. This includes the Bayesian functionality, which will need to be improved and updated for the no-U-turn sampler. Having this functionality available to all users of Stock Synthesis will greatly improve the practical reach of my work.

I also learned how different model structures can be used for the same stock, as the assessment actually has four models: combinations of coast wide vs areas and long vs short time series (Stewart and Martell 2015). I thus learned how to model a specific stock using Stock Synthesis.

One issue that arose was how data weighting and process error interact. This is of particular interest for the IPHC because of the complex, time-varying selectivity patterns. What effect such complex process error has on typical ways to tune the data weights so they are “correct” is an open question. Dr. Stewart and I therefore conducted a simulation study to investigate this and are in the process of writing it up for publication in the special issue of *Fisheries Research* on this topic.

Writing chapters

My PhD committee has approved my dissertation proposal and I have passed my general exam. Therefore, I have begun writing up two of my dissertation chapters. The first is on the no-U-turn sampler, illustrating the algorithm and then simulation testing demonstrating when it should be preferred. The target journal is *Methods in Ecology and Evolution*. The second is the effect of hook spacing on catch rates of halibut. The target journal is *Canadian Journal of Fisheries and Aquatic Sciences*.

After June when the no-U-turn sampler is available for ADMB models, I will be able to initiate that analysis. My last chapter, a review of Bayesian inference for stock assessment, will follow naturally from the previous chapters as most of the literature review will be done.

Summary of progress

My committee has approved my PhD dissertation and I have passed my general exam to become a candidate. For the most part I now know what I need to do and how to do it. At this point I am mostly working on writing up and publishing my PhD chapters. I expect a year from now to be close to defending, and having several manuscripts in prep or review.

REPORT
E/I-21
03/01/2015 - 02/29/2016
Submitted On: 03/22/2016 08:42:34 PM

METRICS & MEASURES

Acres of coastal habitat

Metric/Measure	Value	Note
Acres of coastal habitat	0	

Fishermen and seafood industry personnel

Metric/Measure	Value	Note
Fishermen and seafood industry personnel	0	

Communities - economic and environmental development

Metric/Measure	Value	Note
Communities - economic and environmental development	0	

Stakeholders - sustainable approaches

Metric/Measure	Value	Note
Stakeholders - sustainable approaches	0	

Informal education programs

Metric/Measure	Value	Note
Informal education programs	0	

Stakeholders who receive information

Metric/Measure	Value	Note
Stakeholders who receive information	0	

Volunteer hours

Metric/Measure	Value	Note
Volunteer hours	0	

P-12 students reached

Metric/Measure	Value	Note
P-12 students reached	0	

P-12 educators

Metric/Measure	Value	Note
P-12 educators	0	

REQUESTED INFORMATION

Publications

The effect of length bin width on growth estimation in integrated age-structured stock assessments.
Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other Documents
Publication Year: 2016
Publication Authors:
Publisher Info:
Notes:
Related URLs:
Keywords:
Publication URLs: http://www.sciencedirect.com/science/article/pii/S0165783615301259
Abstract:
Citation: Monnahan, K. Ono, S. C. Anderson, M. B. Rudd, A. C. Hicks, F. Hurtado-Ferro, K. F. Johnson, P. T. Kuriyama, R. R. Licandeo, C. C. Stawitz, I. G. Taylor, and J. L. Valero (In press). The effect of length bin width on growth estimation in integrated age-structured stock assessments. Fisheries Research. doi: http://dx.doi.org/10.1016/j.fishres.2015.11.002
Citation for Coverpage:
SG can post PDF online?:
Uploaded File: Monnahan_et_al_2015_The_effect_of_length_bin_width.pdf

An empirical weight-at-age approach reduces estimation bias compared to modeling parametric growth in integrated, statistical st
Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other Documents
Publication Year: 2016
Publication Authors:
Publisher Info:
Notes:
Related URLs:
Keywords:
Publication URLs: http://www.sciencedirect.com/science/article/pii/S0165783615300837
Abstract:

Citation: Kuriyama, P. T., K. Ono, F. Hurtado-Ferro, A. C. Hicks, I. G. Taylor, R. R. Licandeo, K. F. Johnson, S. C. Anderson, C. C. Monnahan, M. B. Rudd, C. C. Stawitz, and J. L. Valero (In press). A empirical weight-at-age approach reduces estimation bias compared to modeling parametric growth i integrated, statistical stock assessment models when growth is time varying. Fisheries Research. do http://dx.doi.org/10.1016/j.fishres.2015.09.007
Citation for Coverpage:
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The potential impact of time-variation in vital rates on fisheries management targets for marine fishes
Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other Documents
Publication Year: 2015
Publication Authors:
Publisher Info:
Notes:
Related URLs:
Keywords:
Publication URLs:
Abstract:
Citation: Thorson, J. T., C. C. Monnahan, et al. (2015). The potential impact of time-variation in vita rates on fisheries management targets for marine fishes. Fisheries Research 169(0): 8-17.
Citation for Coverpage:
SG can post PDF online?:
Uploaded File: Thorson_et_al_2015_The_potential_impact_of_time-variation.pdf

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Assessment of the Pacific halibut stock at the end of 2015
Publication Type: Technical Reports (non-peer-reviewed)
Publication Year: 2015
Publication Authors:
Publisher Info:
Notes:
Related URLs:
Keywords:
Publication URLs: http://iphc.int/publications/rara/2015/RARA2015_12Assessment.pdf
Abstract:
Citation: Stewart, I. J., Monnahan, C.C., Martell, S. (2016). Assessment of the Pacific halibut stock at the end of 2015. IPHC Report of Assessment and Research Activities 2015. p. 188-209. (http://www.iphc.int/publications/rara/2015/RARA2015_12Assessment.pdf)
Citation for Coverpage:
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Stewart_et_al_2015_Assessment_of_the_Pacific_halibut_stock_at_the_end_of_2015.pdf

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Overview of data sources for the Pacific halibut stock assessment and related analyses
Publication Type: Technical Reports (non-peer-reviewed)
Publication Year: 2016
Publication Authors:
Publisher Info:
Notes:
Related URLs:
Keywords:
Publication URLs:
Abstract:
Citation: Stewart, I.J., and Monnahan, C.C. 2016. Overview of data sources for the Pacific halibut stock assessment and related analyses. IPHC Report of Assessment and Research Activities 2015. p. 99-187. (http://www.iphc.int/publications/rara/2015/RARA2015_11Assessmenddatasources.pdf)
Citation for Coverpage:

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Students Supported

No **Students Supported** information reported

Narratives

Hamiltonian MCMC for stock assessments
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Partners This Period

No **Partners This Period** information reported

STANDARD QUESTIONS

Economic Impacts

(1)

For each economic impact: (provide a description and numbers in all relevant categories)	
Description	NA
Market Impacts ($)	0
Non-market Impacts ($)	0
Businesses Created	0
Businesses Sustained	0
Jobs Created	0
Jobs Sustained	0
Patents	0

Tools, Technologies, Information Services / Sea Grant Products

(1)

Description	None in this period,
Developed (in the reporting period)?	No
Used (in the reporting period)?	No
Used for EBM?	No
ELWD product?	No

Number of managers	0
Description/Names of managers	

Community Hazard Resilience

(1)

Name of Community	NA
County	NA
Number of trainings/technical assistance services provided	0
Description	NA
Was hazard resilience improved?	No

Meetings, Workshops, Presentations

(1)

Type of Event	Public or professional presentation
Description	Presented work at the UW School of Fisheries and Aquatic Sciences Quantitative Seminar. Title: Advantages of gradient-based MCMC algorithms for difficult-to-fit Bayesian models in fisheries and ecology.
Event Date	12-04-2015
Number of Attendees	40

(2)

Type of Event	Public or professional presentation
Description	Gave a workshop demonstration of ss3sim, an R package for simulation testing of fisheries stock assessment models I helped develop, at the CAPAM workshop on data conflict and weighting, likelihood functions, and process error.
Event Date	10-19-2015
Number of Attendees	100

Leveraged Funds

No **Leveraged Funds** information reported

Impacts and Accomlishments

No **Impacts and Accomlishments** information reported