Update Report

Period 6/1/2013 - 2/28/2014

Project 2013-E/I-21 - NMFS Population Dynamics Sea Grant Graduate Fellowship Optimizing Bayesian analysis in data-rich stock assessments and management resources in data-limited fisheries. Trevor Branch in support of Cole Monnahan

STUDENTS SUPPORTED

No Students Reported This Period

CONFERENCES / PRESENTATIONS

Monnahan CC (2013) ss3sim An R package for stock assessment simulation with SS3. Presentation at the Stock Synthesis Development Workshop, Seattle, WA. December 10., public/profession presentation, 15 attendees, 2013-12-10

Monnahan CC (2014) ss3sim An R package for stock assessment simulation with SS3. Presentation at the "Think Tank" workshop put on by the University of Washington and NOAA Fisheries. Seattle, WA, February 26., public/profession presentation, 20 attendees, 2014-02-26

ADDITIONAL METRICS

K-12 Students Reached	Acres of degraded ecosystems restored as a result of Sea Grant activities
Curricula Developed	Resource Managers who use Ecosystem-Based Approaches to Management
Volunteer Hours	HACCP - Number of people with new certifications
Cumulative Clean Marina Program - certifications	

PATENTS AND ECONOMIC BENEFITS

No Benefits Reported This Period

TOOLS, TECH, AND INFORMATION SERVICES

Description		Developed	Used	Names of Managers	Number of Managers
ss3sim An R	Actual (6/1/2013 -	1	0		0

package for sheries stock assessment simulation with Stock Synthesis	2/28/2014) Anticipated (6/1/2014 - 2/28/2015)	0	0

HAZARD RESILIENCE IN COASTAL COMMUNITIES

No Communities Reported This Period

ADDITIONAL MEASURES

Safe and sustainable seafood

Number of stakeholders modifying practices
Actual (6/1/2013 - 2/28/2014)
Anticipated (6/1/2014 - 2/28/2015)

Number of fishers using new techniques
Actual (6/1/2013 - 2/28/2014)
Anticipated (6/1/2014 - 2/28/2015)

Sustainable Coastal Development
Actual (6/1/2013 - 2/28/2014)
Anticipated (6/1/2014 - 2/28/2015)

Coastal Ecosystems
Actual (6/1/2013 - 2/28/2014)
Anticipated (6/1/2014 - 2/28/2015)

PARTNERS

Partner Name Northwest Fisheries Science Center (US DOC, NOAA, NMFS, NWFSC)

IMPACTS AND ACCOMPLISHMENTS

Title Washington Sea Grant investigates common fishery stock-assessment methods that may bias managers' fishery catch decisions

Type accomplishment

Description Relevance Most fishery models used to assess fish stocks assume that the natural mortality of fish remains the same but in reality it is rarely constant and, as in human populations, can be affected by a variety of factors. The methods to estimate this "constant" natural mortality for a fish stock are often unreliable, and may require information that is not available. Unfortunately, using the wrong natural mortality or estimating it inaccurately can bias calculations of catch limits and other parameters for sustainably managing fisheries. Response Under a Washington Sea Grant-sponsored fellowship, a researcher used computer simulations to evaluate the ability of assessment models to estimate key parameters of fish stocks and fisheries, like catch limits, when natural mortality varies in time. The fellow also evaluated the effects of setting natural mortality at high, medium and low levels in assessment models and of using an actual estimate of mortality. Results Preliminary results indicate that in the absence of information about natural mortality, but when it is presumed to vary across time, using an actual estimate was the approach that introduced the least error. Most problematic for many of the scenarios examined was to set natural mortality at a high value. This means that it is better to assume natural mortality is lower than it actually is than that it is higher. This asymmetry suggests that when an assessment must be conducted but

natural mortality is unknown and not enough data are available to estimate it, it is wise to set it at the low end of possible values.

Recap A Washington Sea Grant-supported fellow evaluated the conditions under which stock assessment models can accurately estimate natural mortality and provided guidance on how to set the value when it cannot be estimated.

Comments Primary Focus Area LME (SSSS) State Goals Support conservation and sustainable use of living marine resources through effective and responsible approaches, tools, models and information for harvesting wild and cultured stocks and preserving protected species (SSSS Supply).

Related Partners Northwest Fisheries Science Center (US DOC, NOAA, NMFS, NWFSC)

PUBLICATIONS

Title ss3sim Fisheries stock assessment simulation testing with Stock Synthesis

Type Computer software Publication Year 2014 Uploaded File none URL http //cran.r-project.org/web/packages/ss3sim/index.html

Abstract The ss3sim package develops a framework for fisheries stock assessment simulation testing with Stock Synthesis 3 (SS3).

Citation Anderson SC, Monnahan CC, Johnson KF, Ono K, Valero JL, Cunningham CJ, Hurtado-Ferro F, Licandeo R, McGilliard CR, Szuwalski CS, Vert-pre KA, Whitten AR (2014) ss3sim Fisheries stock assessment simulation testing with Stock Synthesis. R package version 0.8.0.

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Journal Title CRAN The comprehensive R archive network

Title The importance of length and age composition data in statistical age-structured models for marine species

Type Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year 2014 Uploaded File Ono_et_al_2014__Import....a.pdf URL http //icesjms.oxfordjournals.org/content/early/2014/02/20/icesjms.fsu007.abstract?sid=6c860438-43ab-4231-99fb-4f448f7bb2aa

Abstract Management of marine resources depends on the assessment of stock status in relation to established reference points. However, many factors contribute to uncertainty in stock assessment outcomes, including data type and availability, life history, and exploitation history. A simulation–estimation framework was used to examine the level of bias and accuracy in assessment model estimates related to the quality and quantity of length and age composition data across three life-history types (cod-, flatfish-, and sardine-like species) and three fishing scenarios. All models were implemented in Stock Synthesis, a statistical age-

structured stock assessment framework. In general, the value of age composition data in informing estimates of virgin recruitment (R0), relative spawning-stock biomass (SSB100/SSB0), and terminal year fishing mortality rate (F100), decreased as the coefficient of variation of the relationship between length and age became greater. For this reason, length data were more informative than age data for the cod and sardine life histories in this study, whereas both sources of information were important for the flatfish life history. Historical composition data were more important for short-lived, fast-growing species such as sardine. Infrequent survey sampling covering a longer period was more informative than frequent surveys covering a shorter period.

Citation Ono K, Licandeo R, Muradian ML, Cunningham CJ, Anderson SC, Hurtado-Ferro F, Johnson KF, McGilliard CR, Monnahan CC, Szuwalski CS, Valero JL, Vert-pre KA, Whitten AR, Punt AE (2014) The importance of length and age composition data in statistical age-structured models for marine species. ICES Journal of Marine Science, doi 10.1093/icesjms/fsu007.

Journal Title ICES Journal of Marine Science

Title Time-varying natural mortality in fisheries stock assessment models Identifying a default approach

Type Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year 2014 Uploaded File ICESJMS-2013-347_Johns....l.pdf URL none

Abstract A typical assumption used in most age- and size-structured fishery stock assessments is that natural mortality (M) is constant across time, sex, and age. However, M is rarely constant in reality as a result of the combined impacts of exploitation history, predation, environmental factors, and physiological trade-offs. Methods to estimate even an age- and time-invariant (i.e., constant) M within age-structured assessment models rely on informative length- and age-composition data, which are often not available. Misspecification or poor estimation of M can lead to bias in quantities estimated using stock assessment methods, potentially resulting in biased estimates of fishery reference points and catch limits, with the magnitude of bias being influenced by life history and trends in fishing mortality. Monte Carlo simulations were used to evaluate the ability of statistical age-structured population models to estimate spawning stock biomass, fishing mortality, and total allowable catch when the true M was age-invariant, but time-varying. Configurations of the stock assessment method, implemented in Stock Synthesis, included a single age- and time-invariant M parameter, specified at one of three levels (high, medium, and low) or an estimated M. The min-max approach to specifying M (i.e., finding the stock assessment configuration for which the analyst could go least wrong about terminal spawning stock biomass and total allowable catch, given no information about M) when it is thought to vary across time was to estimate M. The least robust approach for the majority of scenarios examined was to fix M at a high value, suggesting that the consequences of misspecifying M are asymmetric.

Citation Johnson, KF, Monnahan, CC, McGilliard, CR, Vert-Pre, KA, Anderson, SC, Cunningham, CJ, Hurtado-Ferro, F, Licandeo, R, Muradian, ML, Ono, K, Szuwalski, CS, Valero, JL, Whitten, AR, and Punt, AE. (In press). Time-varying natural mortality in fisheries stock assessment models identifying a default approach. – ICES Journal of Marine Science, doi 10.1093/icesjms/fsu055.

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Journal Title ICES Journal of Marine Science

Title ss3sim An R package for fisheries stock assessment simulation with Stock Synthesis

Type Reprints from Peer-Reviewed Journals, Books, Proceedings and Other Documents Publication Year 2014 Uploaded File Anderson_et_al_2014_ss3sim.pdf URL http //arxiv.org/abs/1312.6450

Abstract Simulation testing is an important approach to evaluating fishery stock assessment methods. In the last decade, the fisheries stock assessment modeling framework Stock Synthesis (SS3) has become widely used around the world. However, there lacks a generalized and scriptable framework for SS3 simulation testing. Here, we introduce ss3sim, an R package that facilitates reproducible, flexible, and rapid end-to-end simulation testing with SS3. ss3sim requires an existing SS3 model configuration along with plain-text control files describing alternative population dynamics, fishery properties, sampling scenarios, and assessment approaches. ss3sim then generates an underlying 'truth' from a specified operating model, samples from that truth, modifies and runs an estimation model, and synthesizes the results. The simulations can be run in parallel, reducing runtime, and the source code is free to be modified under an open-source MIT license. ss3sim is designed to explore structural differences between the underlying truth and assumptions of an estimation model, or between multiple estimation model configurations. For example, ss3sim can be used to answer questions about model misspecification, retrospective patterns, and the relative importance of different types of fisheries data. We demonstrate the software with an example, discuss how ss3sim complements other simulation software, and outline specific research questions that ss3sim could address.

Citation Anderson SC, Monnahan CC, Johnson KF, Ono K, Valero JL (2014) ss3sim an R package for fisheries stock assessment simulation with Stock Synthesis. PLoS ONE, In press. doi 10.1371/journal.pone.0092725

Copyright Restrictions + Other Notes

Journal Title PLOS One

OTHER DOCUMENTS

No Documents Reported This Period

LEVERAGED FUNDS

No Leveraged Funds Reported This Period

UPDATE NARRATIVE

Uploaded File Monnahan_3502_update_n....3.pdf

Project details

Cole Monnahan, monnahc@uw.edu

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 2013 falls into two categories: (1) a collaborative student project doing simulation work with Stock Synthesis and (2) preparing for simulation of algorithms to a variety of fisheries models.

Simulation project

I participated in a large student project (labeled 'FISH600') at the University of Washington under the auspices of Prof. Andre Punt (UW, SAFS) and Drs. Rick Methot and Jim Ianelli (NOAA). The focus of the project was to do a simulation project and present it at the World Conference on Stock Assessment Methods.

As a group we developed and implemented three distinct stock assessment simulation studies investigating: (1) the influence of data, (2) the impact of ignoring time-varying natural mortality, and (3) the causes of retrospective patterns. These three topics were all presented at the conference, and two have since been published in a special issue of the ICES Journal of Marine Science. I spent much of the last 6 months helping to plan, execute, interpret, and publish these studies.

I was also an integral part in developing an R package ('ss3sim') which we used to implement the three FISH600 simulation studies. We originally developed this code to solely be used for our studies, but subsequently decided to publish it for use by the broader stock assessment community. This end-to-end simulation software is available on CRAN, and there is an accompanying publication describing the functionality and philosophy of the package. I contributed in a variety of ways to the package. We started from scratch, so there were many discussions on the best design and structure of the software and stock assessment simulation studies in general. I also authored three sets of R functions included in the package. The first sample from SS operating model output and create data inputs for the SS estimation model, including indices from scientific surveys or fisheries, as well as length- and age-compositions (with optional over-dispersion). The second set extract SS output from simulation runs (e.g., model fits, convergence diagnostics, meta-data) and organize it into a cohesive, consistent format for easy analysis. The last set is plotting functions which are specifically designed for ss3sim simulation output, and make it straightforward to quickly examine and explore model results. Lastly, I contributed to individual R function documentation, the package documentation ('vignette') as well as the published manuscript.

I presented ss3sim twice to help disseminate the package: once at the Stock Synthesis Development Workshop (NWFSC, December 2013) as well as the “Think Tank” workshop series (February 2014) which is a collaboration between NOAA Fisheries and the University of Washington. Allan Hicks (NFMS, NWFSC) is currently adapting his hake assessment model into our framework to facilitate research on growth for that stock.

Although these simulation studies and package were not originally in my proposal, they are directly related to the work I propose to do. First and foremost, I learned about SS, whereas I had previously never used it. A major component of the simulation studies was to convert functional SS models used for assessments to ones that would be suitable for generic life history simulation models (i.e. operating and estimating models). This required going through the input files and carefully and turning on/off certain features, depending on the model. In that process I learned about the different input files, (some of) the options available, how to run a model, and examine and interpret the output files. In doing so I greatly increased my understanding of SS, which will be instrumental when I begin testing Bayesian algorithm efficiency on actual stock assessment models written in SS. Second, I gained valuable experience in how to organize, develop, execute, and interpret large, complex simulation studies. Much of my proposed work requires such simulations, and the lessons learned from this project will surely carry over. Lastly, I will be able to use ss3sim directly for some of my proposed simulation work. Because I am so familiar with the package already, it will greatly minimize the time needed to implement my future simulations.

Exploring algorithm efficiency

Most of my focus has been on the previous task, but I have made progress on the specifics of my proposed project. I have been examining the AD Model Builder (ADMB) source code to better understand the underlying algorithms, as well as the options available. I have been documenting the features of Bayesian analysis in ADMB which I expected will replace the current ADMB manual chapter on the subject. I am also developing a set of R functions that facilitate expansive simulation in R but using ADMB models. These functions make it quick, transparent, and reproducible to run factorial designs of different algorithms on arbitrary ADMB models. I used these functions to optimize the jump function correlation of a model used in my MS thesis, and got the Bayesian posteriors to converge in a fraction of the time. Preliminary results suggest that this method is most successful when a parameter is estimated near a bound, because the covariance estimated at the point is not reflective of the shape of the posterior through the parameter space (see Fig. 1 for an example).

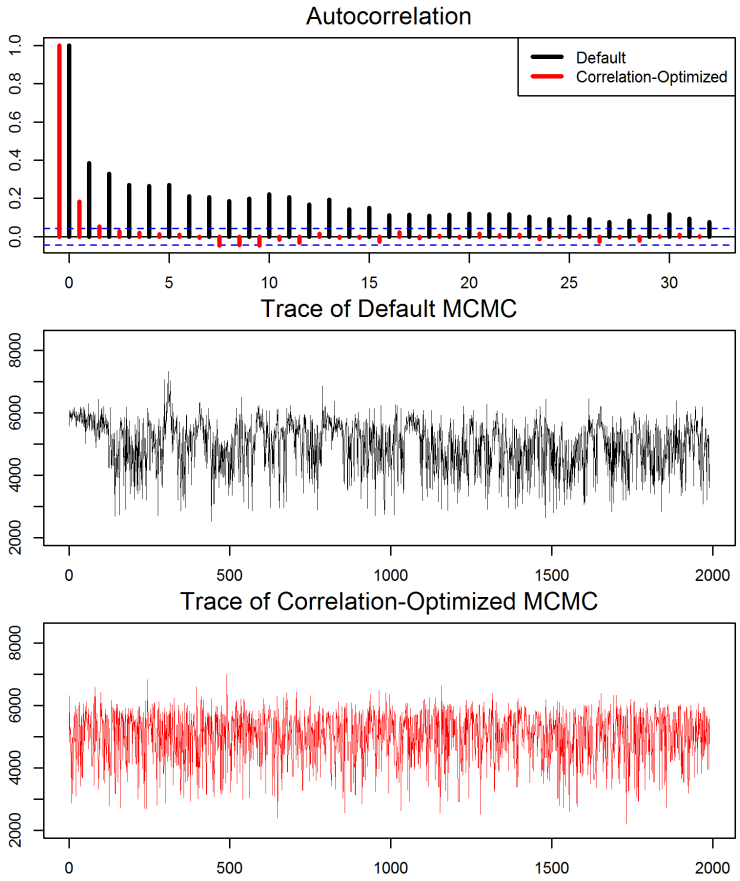

Figure 1. Example of performance increase by optimizing the algorithm. Default ADMB is shown with a version with an optimized correlation. The optimized version (in red) converges much faster (i.e. has to be thinned less) than the default version. In this case the optimized version was around 15-30 times faster, so that a simulation which normally takes a month can be reduced to a day by making a small change to one correlation.

Further, I have been in contact with Jason Cope (NWFSC) and Carolina Minte-Vera (IATTC) and they have provided me with data-moderate stock assessment models that exhibit extremely slow Bayesian convergence. Moving forward, I will use these simpler models to develop a simulation framework and use the knowledge gained from the results to on my work with data-rich SS stock assessments.

A recently published package, “Template Model Builder” (https://github.com/kaskr/adcomp) has similar capabilities to ADMB but is implemented directly in R. This framework may be ideal for my purposes since I can develop arbitrary models in R and use all of the cutting-edge algorithms already implemented in other R packages. By building and testing TMB models, I can identify the algorithms that are optimal for fisheries stock assessment models (from data-moderate to data-rich). If any algorithms are particularly efficient, I could work with ADMB developers to include them into a future version of ADMB, such that they would be available to all assessment models currently implemented in ADMB.

My next steps are to (1) proceed with literature review on Bayesian algorithms, (2) get models working using both ADMB and TMB, and (3) begin simulation testing the algorithms under a variety of model conditions and assumptions (i.e. posterior shapes).