Report from the Bayesian Surplus Production model (BSP) workshop: Yokohama, Japan – November 2012[1]

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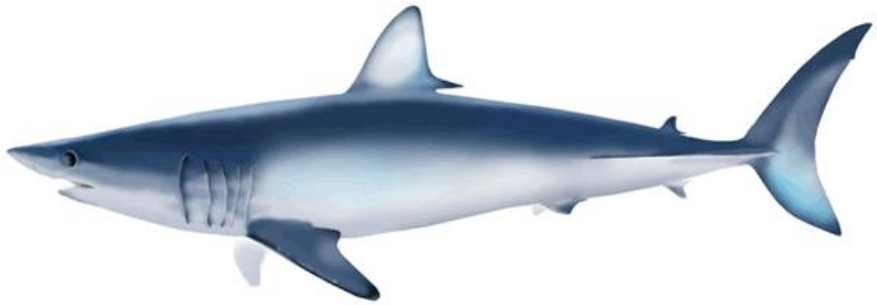

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Workshop Dates: 18-20 November 2012

Workshop Attendees: University of British Columbia Murdoch McAllister (workshop instructor); Japan delegates: Minoru Kanaiwa, Ai Kimoto, Norio Takahashi, Yuko Hiraoka, Kotaro Yokawa; USA: Tim Sippel

The ISC Shark Working Group (SHARKWG) decided a Surplus Production (SP) model would be constructed as the base-case for its initial North Pacific blue shark assessment. Given the variable quality of fishery and biological data available for the assessment, it was decided this would be an appropriate starting point from which supplemental analyses and future assessments could be constructed from. A state-space Bayesian Surplus Production (BSP) model has been developed by Prof. Murdoch McAllister at University of British Columbia and colleagues. The software is referred to as BSP2 and is considered an appropriate application for the needs of this assessment.

BSP2 is implemented in Visual Basic 6.0 (VB6) and the software was distributed to the workshop attendees. BSP2 fits either a Schaefer or Fletcher/Schaefer model to time-series of catch and indices of abundance (CPUE), with CV's if available. The parameters that can be fit include carrying capacity (K), intrinsic rate of increase (r), biomass in the first modeled year defined as a ratio of K (alpha.b0), the shape parameter for the surplus production function for the Fletcher/Schaefer fit (n), the average annual catch for years prior to recorded catch data (cat0), catchability for each CPUE series (q). Priors can be used for all parameters. The biomass trajectory can be projected under any catch or harvest policy, with confidence bounds. Decision tables with policy performance at given time horizons, such as stock rebuilding are included in the outputs. Bayesian approaches can make use of a variety of algorithms to sample probability distributions, including Markov-chain Monte-Carlo (MCMC) which is one of the most common implementations, or alternatively the Sampling Importance Resampling (SIR) algorithm. Through much research, Prof. McAllister has found that SIR consistently outperforms alternatives in terms of accuracy of results and speed, and this underpins why the software is implemented in VB, as opposed to WinBUGS or JAGS which have hard-wired MCMC or Metropolis-Hastings probability sampling methods.

The first day of the workshop started with discussion of basic theory and assumptions of SP models, as well as an introduction to SIR and why it has been chosen for the BSP2 implementation. Subsequent to that discussion, catch data from 1975-2002 taken from the Kleiber et al 2009 blue shark stock assessment and preliminary abundance indices from the Japanese longline fleet for the pending 2013 ISC assessment were compiled. At the time of the workshop, the abundance indices had not been formally adopted by the SHARKWG and were provided only as a relevant working example. Using these data, deterministic as well as state-space implementations of SP models were developed and tested using 'Solver' to estimate parameters within Microsoft Excel. This demonstrated the basic principles of major SP model implementations (with and without process error), and demonstrated that the blue shark data available at the time was of sufficient quality to fit simple and reliable models to the data.

The second day of the workshop focused on development of priors for BSP parameters (r, K, etc.), likelihood functions, and computation of relative model weights for alternative fits to the same data.

VB6 and BSP2 were installed on workshop attendee computers and the directory and file structure of BSP2 was explored. Implementation of the model requires some specific manipulation of files and directories, including within the source code itself, that would not be straight-forward to understand without expert training. Previously, existing catch and abundance index data from the Canadian Boccaccio stock were used to begin exploring use of BSP2. Subsequently, blue shark data were prepared for BSP2 on Day 3.

The third and final day focused on running BSP2 with the provisional blue shark data from Day 1. Development of priors for BSP2 using parameter estimates from the Day 1 spreadsheet exercise was discussed. Once the model was running, time was spent understanding how to fine tune it and to explore the diagnostics and outputs, before considering how to fit blue shark data. In addition to model fit and performance diagnostics, approaches to sensitivity analysis, stock status and policy projections were briefly introduced. A key aspect of BSP2 is assessing different model scenarios and determining criteria for objectively selecting and rejecting different models. The primary diagnostic for comparing model fits is calculating and comparing Bayes factors amongst different model likelihoods. Amongst a suite of alternatives, the model with the highest Bayes factor has the greatest support, but alternatives can not be objectively rejected unless its Bayes factor is 1/100 or less than an alternative. The ability to calculate Bayes factor as an objective metric of model fit relative to alternatives is a primary advantage of SIR algorithm.

The workshop covered a lot of ground, ranging from theory of SIR which underpins how parameter space is estimated in BSP2, to running SP models in spreadsheets, to developing a provisional version of BSP2 on sample blue shark data. An important outcome was learning that the provisional, but representative blue shark data used to develop a provisional BSP2 model was of good quality, relative to other assessments Prof. McAllister has conducted. The workshop was productive and a good primer to using the model on the pending blue shark assessment, however the software is currently implemented such that specific knowledge of its file structure requirements, directory structure, and some general knowledge of its source code is necessary to use it. There are ongoing plans to continue refining the software, including possible implementation in R as a stand-alone package.