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Preface

Stock Synthesis: Advancing stock assessment application and research through the use of a general stock assessment computer program

The pressure toward global improvement in the management of fish stocks has led to the need for more and better stock assessments. General software programs have been developed to implement stock assessments for a wide range of situations (e.g. MULTFAN-CL – Fournier et al., 1998; Hampton and Fournier, 2001; CASAL – Bull et al., 2005; Coleraine – Hilborn et al., 2000). The most flexible and widely used general stock assessment program is currently Stock Synthesis (SS), developed by Richard Methot of the US National Marine Fisheries Service (see Methot and Wetzel, in this issue). Initially developed to assess coastal pelagic species off the west coast of the US, it is now used for many US fish stock assessments. SS is also used outside of the US, currently in Australia, Japan, Spain, and Chile, and by international organizations such as the Inter-American Tropical Tuna Commission, the International Commission for the Conservation of Atlantic Tunas, and the Indian Ocean Tuna Commission. SS has been applied to assess a wide range of species including tunas, billfish, small pelagics, flatfish, ground fish, rockfish, skates, clams, and sharks (Appendix B of Methot and Wetzel, in this issue).

General stock assessment programs such as SS not only facilitate the production of stock assessments, but the consistency they bring also aids review processes and the dissemination of results. SS epitomizes the contemporary integrated approach to stock assessment (see Maunder and Punt, in this issue); it is very flexible and allows the inclusion of a variety of data types and modeling assumptions. It supports a general parameter structure, allowing most model parameters to have priors, environmental covariates, vary temporally, and other factors. This flexibility accommodates a variety of life history and fishery characteristics, and allows the user to test various assumptions and hypotheses. SS is based on AD Model Builder (ADMB) and therefore inherits ADMBs efficient and stable parameter estimation, uncertainty estimation, Bayesian capabilities, and a variety of other functionality (Fournier et al., 2012). In addition, SS has built-in simulation capabilities that can be used to calculate bootstrap confidence intervals and conduct simulation testing.

This special issue features two core papers, one describing integrated analysis (Maunder and Punt, in this issue), which forms the basis for Stock Synthesis, and the other that describes Stock Synthesis (Methot and Wetzel, in this issue). The remaining papers contributed by internationally renowned leaders and up-and-coming researchers focus on recent developments in aspects of stock assessment methodology as implemented using SS.

Traditional stock assessments assume that the fishery operates on a single homogenous population in which the dynamics of the population are driven only by the fishery and that parameters are stationary. SS accommodates spatial structure, time-varying parameters, and environmental drivers of biological processes. Whitten et al. (in this issue) evaluate methods implemented in SS to account for temporal change in mean length-at-age in the assessment for the largest fishery by volume off southeast Australia.

SS is a tool that is used to develop and test new methodology. The special issue includes four papers which outline advances in stock assessment methodology which have been developed using SS. Taylor et al. (in this issue) outline the Maunder–Taylor–Methot (M–T–M) stock-recruitment model for low fecundity species, which was developed specifically to make SS more applicable to species such as shark, and apply it to spiny dogfish shark in the Northeast Pacific Ocean. Taylor and Methot (in this issue) show how the platoon concept in SS can be used to allow size-specific selectivity to alter size-at-age in simulated populations, a phenomenon that may be common in nature, but not in contemporary stock assessment models. They use simulations to compare this phenomenon to dome-shaped selectivity, an alternative explanation for observing fewer than expected large fish in sampled data, but with very different implications for population productivity. MacCall and Teo (in this issue) show that SS can be configured in a manner which is a hybrid between traditional Virtual Population Analysis (VPA) and contemporary statistical separable models to deal with high temporal variability in selectivity and availability of young individuals. Finally, Cope (in this issue) investigates suitability of SS for data-limited situations, including how SS can be configured to mimic the Depletion-Based Stock Reduction Analysis (DB-SRA) (Dick and MacCall, 2011) estimation of overfishing limits.

The estimation and presentation of uncertainty in stock assessment results is important because managers need to take this into consideration when making management decisions. Development of effective methods to quantify uncertainty has hence become a key feature of contemporary fisheries science. SS has several approaches that can be used to estimate uncertainty (asymptotic approximation based on the Hessian matrix, profile likelihood, Bayesian integration, and bootstrap). Stewart et al. (in this issue) use SS to compare Bayesian integration and the asymptotic approximation for estimating uncertainty intervals based on the Hessian matrix and conclude that the differences in catch advice may be important. MacCall (in this issue) illustrates an approach using the delta method, in which the partial derivatives of the model outputs with respect to all of the parameters are obtained numerically using likelihood profiling, can be used to provide estimates of precision for model outputs when some key parameters are fixed. Ultimately,

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the impact of SS on management decisions is how it performs in combination with a harvest control rule. Wayte (in this issue) uses management strategy evaluation to examine the consequences of using incorrect recruitment assumptions in the assessment that is used in the harvest control rule for a fishery off southeastern Australia.

The special issue contributes to the knowledge base of stock assessment, provides guidance for stock assessment practitioners on using SS and contemporary stock assessment methods in general, and identifies future research needs for stock assessment model development. We hope that it will stimulate further development of stock assessment methodology and introduce new users to the SS community, and ultimately contribute to an increase in the number of peer-reviewed stock assessments and hence in the quality of fisheries management advice generally.

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André E. Punt [a,*]
Mark N. Maunder [b]
[a] *University of Washington, School of Aquatic and Fishery Sciences, P.O. Box 355020, Seattle, WA 98195, United States*
[b] *Inter-American Tropical Tuna Commission, 8604 La Jolla Shores Drive, La Jolla, CA, 92037-1508, USA*

[*] Corresponding author. Tel.: +1 206 221 6319; fax: +1 206 685 7471.
E-mail addresses: aepunt@u.washington.edu, aepunt@uw.edu (A.E. Punt)