Further Considerations of the Use of SS3 ASPM-R as an Estimation Model in PBF MSE *

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Abstract

This short document is a discussion paper that briefly reports simple comparisons of performance between full Stock Synthesis (SS3) and SS3 ASPM-R (Age-Structured Production Model with Recruitment deviations) when using these models as the estimation model (EM) in PBF management strategy evaluation (MSE). Based on the previous examination (Takahashi et al 2023) and suggestions from the last PBFWG (ISC-PBFWG 2023), we further explored to determine what composition data needs to be included and what specifications of ASPM-R need to be improved. An ASPM-R specification with fixed selectivities for all fleets except Japanese F1 and Taiwanese F12 fleets, and also with log-likelihood functions of size frequency data included only for F1 and F12 (named 'ASPMR_F1F12') was used. The use of ASPMR_F1F12 as the EM was able to reduce computation time by 1/4 as compared to the full model EM. The trajectory of future TAC based on the result from ASPMR_F1F12 was almost same as those of full SS3, and the TACs appeared to be determined according to the SSB trend. For the explorative purpose of testing candidate management procedures, the use of ASPMR_F1F12 as a tentative EM merits consideration to reduce the computation time of PBF MSE simulations.

1. Introduction

Upon a request from the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC), the International Scientific Committee for tuna and tuna-like species in the North Pacific Ocean (ISC) Pacific Bluefin Tuna Working Group (PBFWG) is in charge of developing a management strategy evaluation (MSE) to test potential management procedures (MP) for PBF. The ISC-PBFWG has been setting up the management strategy evaluation (MSE) framework (Tommasi and Lee 2022). In the PBF MSE, the PBFWG plans to use the Stock Synthesis (SS3) software as the basis for the estimation model (EM). However, the EM based on the latest SS3 stock assessment requires substantial computation time for MSE simulations even when applying parallel computing. Consequently, this poses a time constraint for conducting a large number of simulation runs to evaluate candidate MPs under a wide array of uncertainty scenarios. As such, the PBFWG decided to consider the use of SS3 ASPM-R (Age-Structured Production Model with Recruitment deviations) as the EM alternative to the full assessment-like SS3 model (ISC-PBFWG 2022).

At the last PBFWG meeting (March 2023), we reported comparisons of performance between SS3 ASPM-R and full SS3 when using these models as the EM in PBF MSE (Takahashi et al. 2023). The PBFWG suggested that the ASPM-R fitting to composition data (with fixed selectivities) could be used as a computationally efficient representation of the full SS model to reduce run times (ISC-PBFWG 2023). This document briefly reports results of further exploration to determine what composition data needs to be included and what specifications of ASPM-R need to be considered.

2. Settings of MSE runs for this exploration

R function codes, input/data files, and SS3 (version 3.30.18) executable file available in the Github detommas/PBF_MSE repository were used. To use SS3 as ASPM-R for the EM, the relevant R function code, 'EM_fun_adj.R', was modified (added the ASPM-R switch). Related to

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this code modification, control.ss files modified from 'control_simple_1719_2021.ss' were added to the 'PBF_MSE/Condition/1/SAM' directory. When the ASPM-R switch is on, it prompts the function to read one of the control.ss files every time the EM function is called depending on choice of the option of ASPM-R specification (e.g., if the simple ASPM-R is selected, then the function reads data from 'control_simple_1719_2021_ASPMR.ss' in which phase values of selectivity and time-varying selectivity for all fleets were set to negative and values of like_comp=6 for all fleets were set to 0).

Takahashi et al. (2023) noted that there was some convergence problem found in results when full SS or SS ASPM-R were used as the EM (results for the EM had large final gradients). Through intersessional work, we figured out that the problem was caused by inappropriate algorithm of MSE simulation to generate sample size of length frequency for the input data for the EM ('EMdat.ss'). Tommasi fixed the algorithm and updated the R code file. The MSE runs for this exploration were conducted using the updated code.

The personal computer used for the MSE runs was Lenovo ThinkStation with a specifications: Intel(R) Core(TM) i9-9900 CPU @ 3.10GHz, 64.0 GB RAM, 64 bits Windows 11 Pro.

The harvest control rule, HCR1a #15 (HCR15, Fig. 1), was used as an example. Settings for simulation runs (time horizon, assessment cycle, etc.) were all the same as in ones defined in the codes in the current PBF_MSE repository except for turning on the "do stock assessment" switch (set sa=1). We fixed simulation iteration to specific one (specific only 1 iteration) and ran the PBF MSE code using both full SS3 (w/ no selectivity deviation) and SS3 ASPM-R (with fixed selectivities for all fleets except Japanese F1 and Taiwanese F12 fleets, and also with log-likelihood functions of size frequency data included only for F1 and F12, named 'ASPMR_F1F12') as the EM, and compared the results.

Prior to the MSE runs, we ran ASPMR_F1F12 using the current data (for the short time base model) and checked whether ASPMR_F1F12 specification gave a reasonable assessment result similar to the current assessment based on SS3. The assessment result of ASPMR_F1F12 was almost identical to that of the short time base model (Fig. 2).

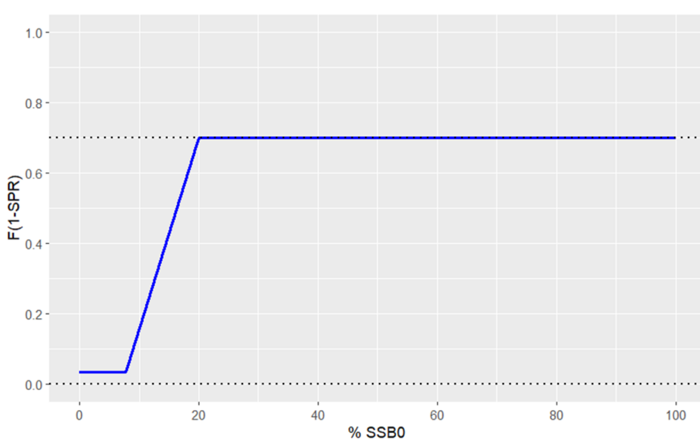

Fig. 1. Illustration of harvest control rule, HCR1a #15 (HCR15). HCR15 is characterized by: limit reference point = 7.7%$SSB_{F=0}$, threshold reference point = 20%$SSB_{F=0}$, target reference point = $F_{SPR30\%}$, minimum F = 5%F_{target}.

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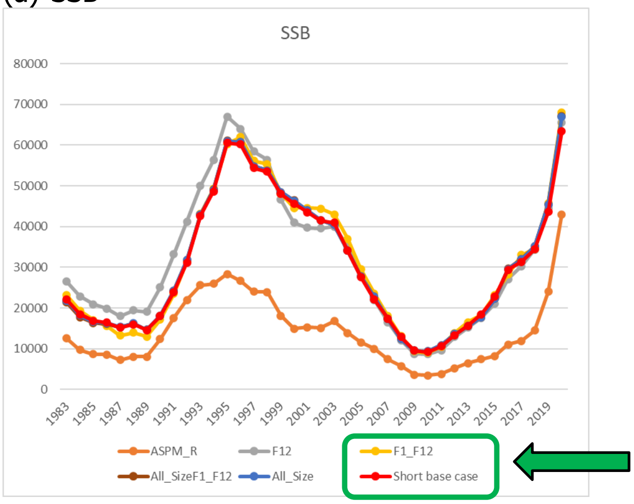
(a) SSB



(b) Differences from Base case in SSB

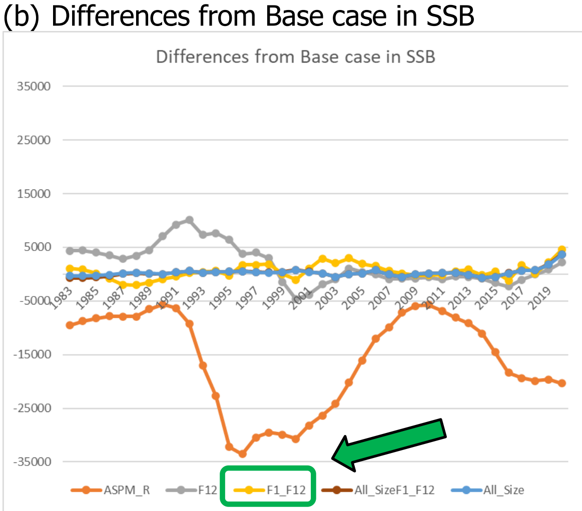


Fig. 2. The result of the stock assessment using 'ASPMR_F1F12' (SS3 ASPM-R with fixed selectivities for all fleets except Japanese F1 and Taiwanese F12 fleets, and also with log-likelihood functions of size frequency data included only for F1 and F12) and current input data for the short time base model (yellow solid lines with points). The result of the short time base model based on SS3 is also shown for comparison (a red solid line with points).

3. Results

The results reported below were of the case of iteration #1 (set itr=1). We tried other iteration number cases (e.g., itr=5). Results from these other cases also had similar tendencies to the iteration #1 case.

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Run times of MSE simulation were approximately 4.8 hr for full SS3, 1.3 hr for ASPMR_F1F12. As expected beforehand, the use of this ASPM-R specification substantially saved run times (approximately 1/4 computation time reduction).

As the time step advanced in simulations, computation time in each time step tended to become longer (Fig. 3). This may be because the models need more time for parameter estimation in future time steps (maybe due to increase of data).

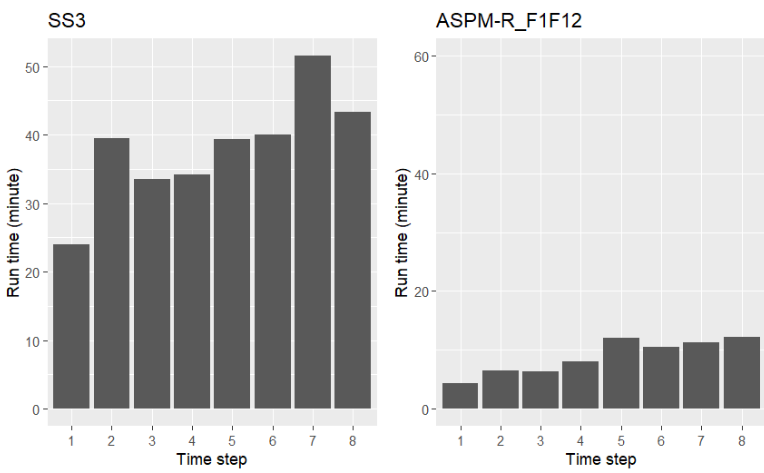

Fig. 3. Approximate computation time taken in each time step in MSE simulation (iteration #1 case, itr=1).

Trajectories of future TAC by using full SS3 and ASPMR_F1F12 as EMs were almost identical (Fig. 4). Accordingly, trajectories of future SSB were also very similar. Overall trajectories of TAC determined by HCR15 based on results from full SS3 and ASPMR_F1F12 appeared to follow the trends of SSB.

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Fig. 4. Comparisons of future TAC and SSB trajectories resulted from MSE simulations (iteration #1 case, itr=1) using HCR15 and full SS3 and ASPMR_F1F12 as EMs.

4. Consideration points and a proposal for future PBF MSE work

Based on the results above, we summarize consideration points and a proposal for future PBF MSE work:

- The use of ASPMR_F1F12 is able to reduce computation time (1/4), which allows to conduct a larger number of simulation tests necessary for evaluating candidate MPs under a variety of uncertainty scenarios in MSE.
- The convergence problem of when using full SS3 or ASPMR_F1F12 as the EM was resolved.
- The trajectory of future TAC based on the result from the EM of ASPMR_F1F12 was almost same as those of full SS3, and the TACs appeared to be determined according to the SSB trend.
- The use of ASPMR_F1F12 as a tentative EM merits consideration to reduce computation time of PBF MSE simulation. For example, during the exploring phase of the MSE process, ASPMR_F1F12 can be used as a tentative EM and a large number of simulation runs can be done to test candidate MPs. Then, in the final evaluation/selection phase, definitive MSE is implemented by switching the tentative EM to the full SS3 EM.

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