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The fitting results of BSSPM to pseudo data with performance measures for Chub mackerel operating model

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Summary

This document showed the results of BSSPM (Bayesian State-Space Production Model) fitting to pseudo data (total catch and four abundance indices), with its performance measures. Almost BSSPM converged (2395 of 2400 basic runs and 467 of 480 retrospective analysis), with good model fitting and lower Mohn's ρ values. Compare with BSSPM based on real data, results from pseudo data have lower biomass (TB and B_{MSY}), higher exploitation rate (E and E_{MSY}), close depletion, higher relative fishing impact, without extremely large uncertainties or unrealistic estimates. Due to different model structure and assumption, how to evaluate the performance of BSSPM and to compare with other models, would be a complex and difficult issue for the TWG CMSA.

Introduction

To select the best model(s) used for Chub mackerel stock assessment, the operating model has been conducted. As one key step of operating model construction, those five stock assessment model candidates (ASAP, SAM, VPA, BSSPM and KAFKA) should be fitted to the pseudo data simulated based on PopSim by Dr. Joel Rice. The performance measures are also required to be calculated and compared. This document showed the results of BSSPM (Bayesian State-Space Production Model) fitting to pseudo data.

Materials and Methods

The data derived from pseudo data to be used for BSSPM, includes:

1) the total catch (catMtTot, 1970-2019)
2) four abundance indices (MTtotal for fleet 3,4,5,6), i.e.
    a) The Japanese fishery-independent egg survey for biomass estimates (2005-2019),
    b) Japanese dip-net fishery CPUE (2003-2019),
    c) Chinese fishery CPUE (2015-2019)
    d) Russian fishery CPUE (2016-2019)

The abundance index was scaled by mean, to be consistent. All other model structure, settings, initial default were same as the BSSPM based on the real data.

The pseudo data has 6 scenarios (A, B, C, D, E and F), with 400 iterations for each scenario. To save time, retrospective analysis was not conducted for all those 400*6 iterations. According to the agreement of SWG OM03, 80 iterations from each scenario, were provided by Dr. Joel Rice and conducted for retrospective analysis by each candidate model.

The performance measures were calculated, including state (total biomass *TB* and exploitation rate *E* of whole years), depletion (the max and median biomass of each decade), biological reference points (B_{MSY} and E_{MSY}), relative fishing impact ($F_{2016\text{-}2018}/F_{MSY}$ and $F_{2017\text{-}2019}/F_{MSY}$), and retrospective analysis (Mohn's ρ of *B* and *E*). The assumptions, methods, and equations of performance measures are referred to the agreed file, i.e., *Detailed configurations for calculating performance measures*.

Only results from the converged iterations were summarized, and compared with those from the BSSPM based on real data. Since natural mortality, weight-at-age, and maturity-at-age data were used in production model, BSSPM based on real data does not have 6 scenarios, with single stock assessment result and performance measure.

Results and Discussion

Among those 400*6 iterations, only 5 iterations (<0.1%) were not fitted converged by BSSPM basic run, while 13 iterations (<0.1%) from scenarios C, D, E and F of 80*6 iterations were not converged in the retrospective analysis (Table 1). Iterations of scenario A were all converged for basic run and retrospective analysis. The median estimates of Mohn's ρ values of exploitation rate are close to the real data, around zero (from -0.12 to 0.11). Compared with the Mohn's ρ of total biomass from real data, estimates from pseudo data were higher and closer to zero (from -0.14 to -0.02) (Figure 1). Therefore, BSSPM fitted well to the pseudo data, with better model fitting and projections.

Compare with BSSPM based on real data, results of BSSPM based on pseudo data had lower biomass (*TB*) and higher exploitation rate (*E*), particularly in recent years. Similar trend was indicated for the biological reference points, *i.e.* biomass and exploitation rate at the maximum sustainable yield MSY (Figures 2 and 3). The estimates *TB* and *E* during 1970~2005, were much close with results from real data, especially for scenarios CDEF.

The B_{max_1970} and B_{max_2000} were close to the estimates from real data, while B_{max} in other decades were higher. B_{median} were higher among 1970 and 1980, but lower in recent three decades (Figure 4). The relative fishing impact were higher than those estimates from real data. The median values of $F_{2016\text{-}2018}/F_{MSY}$ and $F_{2017\text{-}2019}/F_{MSY}$ were lower than 1, indicating that the recent fishing mortality was lower than F_{MSY}, with same stock status estimated from real data (Figure 5).

The pseudo data were simulated based on the stock assessment results of four age-structure models (ASAP, KAFKA, SAM and VPA), which have different model structures and assumptions. Additionally, BSSPM based on real data only has one single scenario, while the pseudo data have 6 different scenarios. This might lead to the difference among the results and performance measures between the BSSPMs based on real data and pseudo data. However, there is no extremely large uncertainties or unrealistic results from BSSPM based on pseudo data. How to evaluate the performance

of BSSPM and to compare with other models, would be a complex and difficult issue for the group.

Acknowledgement

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References

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Mangel Marc, MacCall Alec D., Brodziak Jon, Dick E.J., Forrest Robyn E., Pourzand Roxanna, and Ralston Stephen. 2013. A perspective on steepness, reference points, and stock assessment. Canadian Journal of Fisheries and Aquatic Sciences. 70(6): 930-940.

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Tables

Table 1 The iterations that didn’t converge during BSSPM fitting to the pseudo data

Scenario	Iteration of pseudo data	Basic run not converge	Retrospective analysis not converge
B	16	N	
C	4		N
C	123		N
C	150		N
C	379		N
C	394		N
D	126		N
D	388	N	
E	39	N	
E	40	N	
E	233	N	
E	290		N
E	293		N
F	32		N
F	105		N
F	286		N
F	334		N
F	368		N

Figures

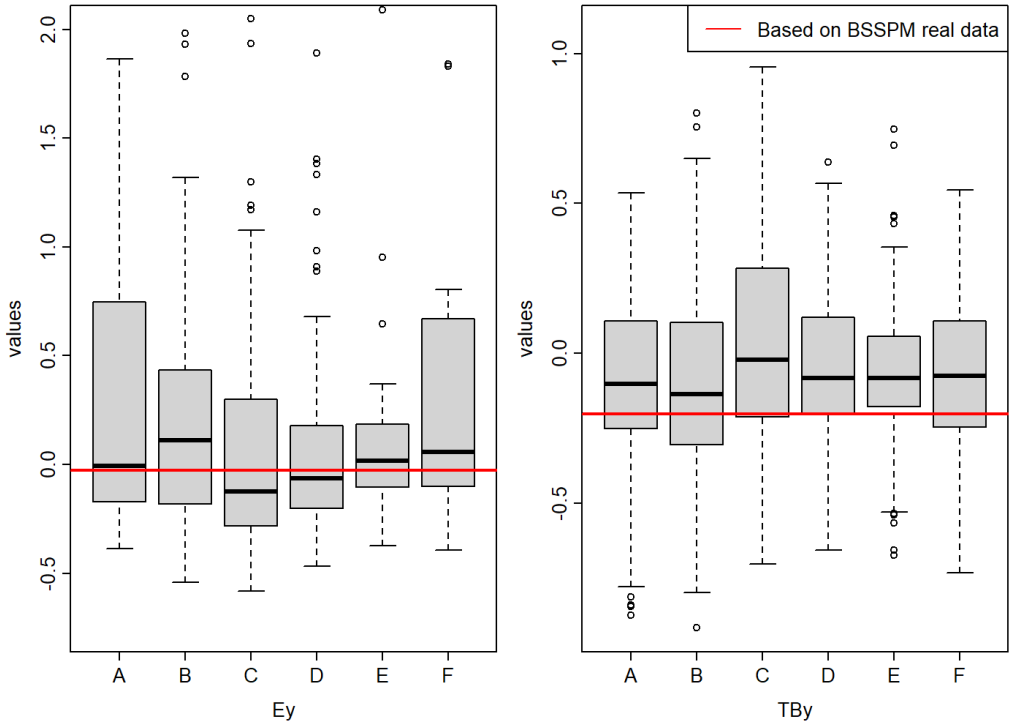

Figure 1 The Mohn's *ρ* values of exploitation rate *E*y and total biomass TBy from retrospective analysis of BSSPM 6 scenarios (A:F) fitting to the pseudo data

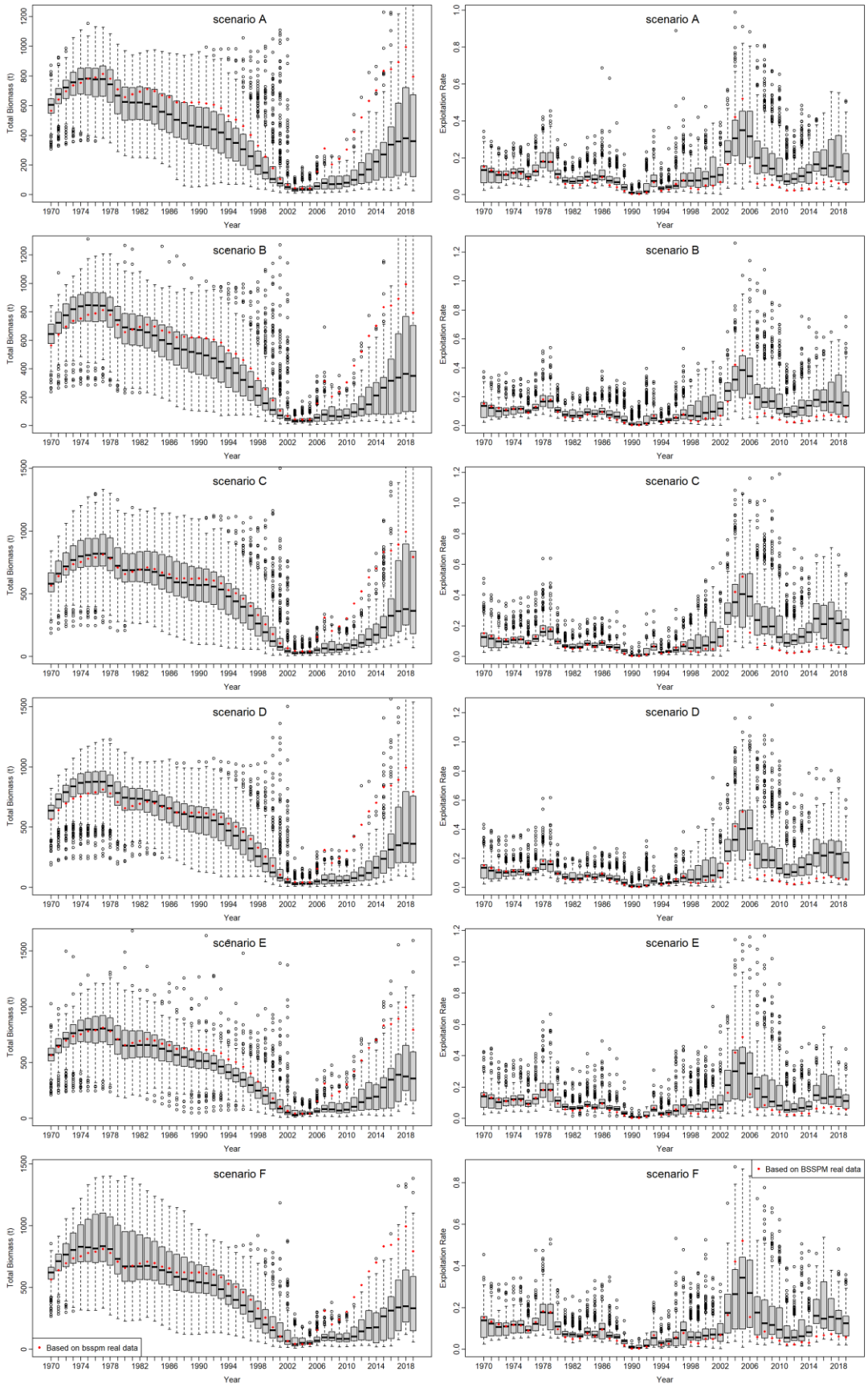

Figure 2 The total biomass and exploitation rate estimated from BSSPM 6 scenarios (A:F) fitting to the pseudo data

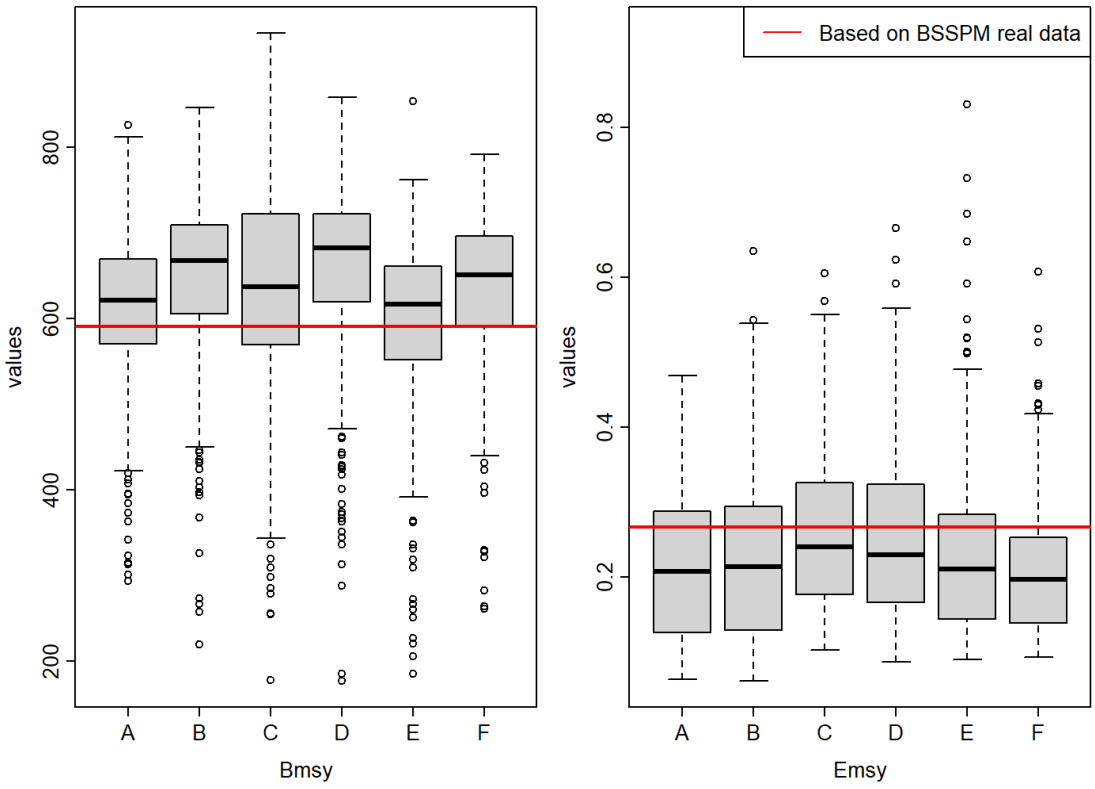

Figure 3 The biological reference points (B_{MSY} and E_{MSY}) estimated from BSSPM 6 scenarios (A:F) fitting to the pseudo data

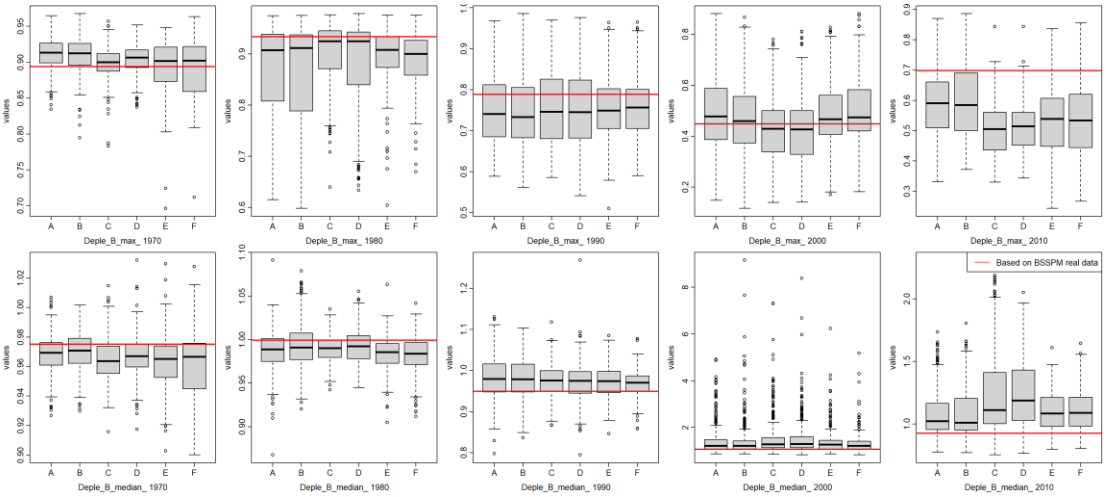

Figure 4 The depletion (B_{max} and B_{median} of different decades) estimated from BSSPM 6 scenarios (A:F) fitting to the pseudo data

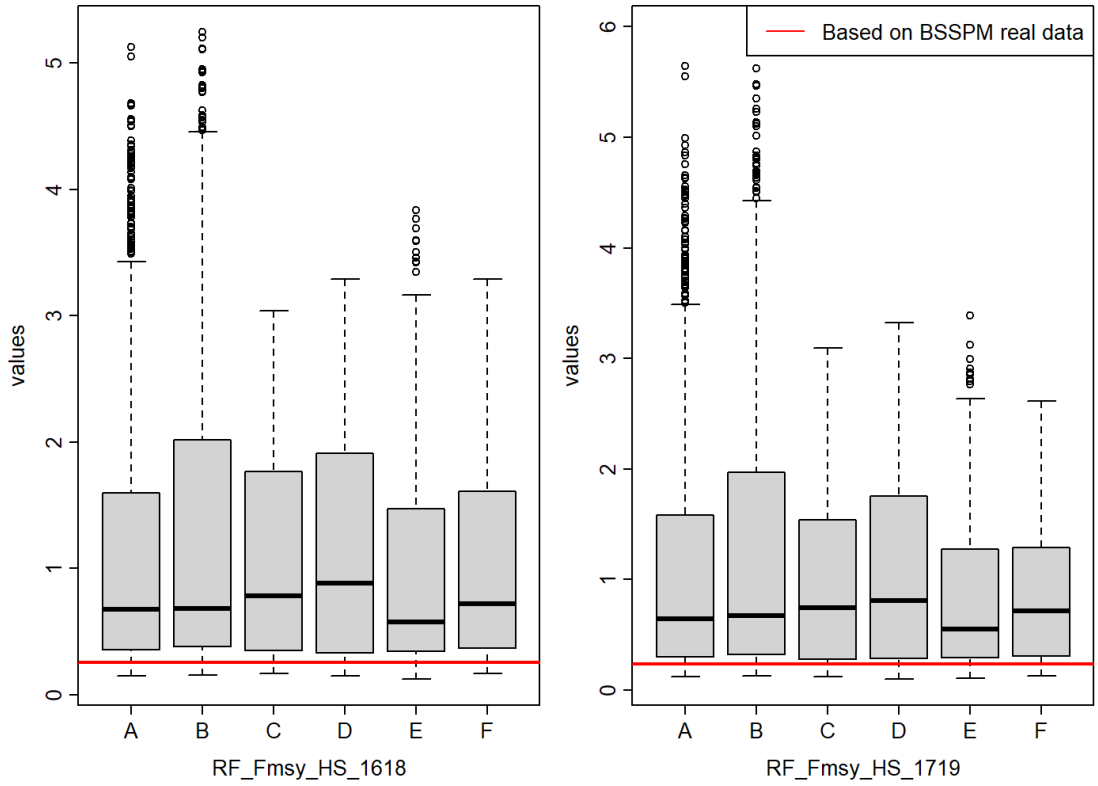

Figure 5 The relative fishing impact ($F_{2016\text{-}2018}/F_{MSY}$ and $F_{2017\text{-}2019}/F_{MSY}$) estimated from BSSPM 6 scenarios (A:F) fitting to the pseudo data