Alternative input data bin format of length-composition from Japanese longline fishery for robust estimation of its selectivity

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Summary

This document discusses an alternative input data bin format for the length-composition from Japanese longline fishery used in PBF stock assessment model. In the alternative input data, the bin width was changed from the current one to 2 cm width for all bins, 16-290 cm FL. The uncertainty in selectivity parameters estimated by the Pacific bluefin tuna SS3 short model using this alternative input data showed results similar to the current base case in terms of standard deviations, and those were not sufficient improvements. The results in this document suggest that using input data with finer length bin can improve to fit the data, but more consideration is needed for optimal parameter estimation.

1. Introduction

The current stock assessment for Pacific bluefin tuna (PBF) uses Stock Synthesis 3 (SS3) (Methot and Wetzel, 2013) as the stock assessment model, and Japanese longline fishery operated from April to June is defined as Fleet1 (F1) in this model with catch amount and its length composition data. The length-composition data on this fishery are important because the estimated selectivity on this fleet is the representative size of abundance index for large PBF. Despite the importance of this selectivity, the resolution of length bin width for large fish (>110cm) is smaller than that for small fish to reduce the calculation time. And the estimation of the selectivity for Fleet 1 has not been well determined (ISC, 2021) due to the high uncertainty on the parameter estimation of descending ramp of dome shape.

In this document, the data length bin width for Fleet 1 was changed to give more information for parameter estimation of selectivity. The data bin width was revised to have higher resolution than that in the previous method, thereby increasing the number of observations at given width of the composition data to be provided for the selectivity estimation. The catch-at-size (CAS) was re-estimated with alternative length bin width and compared to that for current benchmark assessment. Finally, the several outputs by SS3 using alternative CAS were discussed to evaluate the effect of the finer resolution length data on the estimation of the Fleet 1 selectivity.

2. Materials and Methods

2.1. Data and data format

The CAS of PBF from Japanese longline for input of Fleet 1 was estimated using size-measurement and sales slip data which were obtained at 10 main landing ports in five prefectures, mainly collected by the "Research Project on Japanese bluefin tuna (RJB)" since 1993 FY. Some size-measurement data from other research projects such as observer data were also used (Tsukahara et al., 2021). Currently, this fishery is modeled as two separated fleets with CAS data from January to March (3rd

Fqt) and from April to June (4th Fqt). But Fleet 1 only uses data from April to June (4th Fqt), which is corresponding to the spawning season of PBF.

In recent years, the size composition of this fishery has been dominated by smaller fish (<150 cm FL), which were rarely observed until 2015. Because this change in the size composition was observed continuously and became more pronounced after 2017 FY, it was determined that the number of fish caught after 2017 FY should not be included in the likelihood component for the 2020 assessment, in favor of stability and consistency in the selectivity of this indicator. Therefore, in this document, the data preparation method was changed with finer data length bin width, with maintaining data period of the fleet 1 as April to June (4th Fqt) of the 1993-2016 FY same as in the current stock assessment.

In the stock assessment model, the data length bins of 2, 4, and 6 cm width were used for 16-58, 58-110, and 110-290 cm FL, respectively (Nishikawa, 2021). These bin widths are based on the growth rate of PBF, and the majority of PBF caught in the longline fishery are large fishes that are counted in 6 cm bin width. Instead of the current bin width, we made the alternative CAS only for Feet 1 which has the single length bins of 2 cm width for 16-290 cm FL. The number of data bins was changed from 65 to 138 bins. The increase of data points may help to estimate the selectivity parameters.

2.2. Estimation by Stock Synthesis model

The alternative CAS with 2 cm size bin was input to the SS3 ver. SS3.30.14.08 short model starting from 1983 (Fukuda et al., 2022). In this calculation by SS3, input data and settings other than input CAS of Fleet 1 were not changed at all including input sample size for Fleet 1 size data from previous assessment data.

The SS3 estimation results of length-composition of Fleet 1 and selectivity of Fleet 1 using each dataset were compared. In addition, other components, e.g., calculation time, SSB trajectory, were also investigated to see the positive and/or negative effects of the Fleet 1 CAS changes on overall assessment results.

3. Results and Discussion

The results of the CAS comparison between the CAS used in the current assessment and that with alternative length bin width are shown in Fig. 1. The overall shape of the CAS data are similar to each other. On the other hand, the CAS with alternative bins was not smooth with a lot of small spikes in the surface. Although the alternative CAS has small spikes, the size distribution showed the same trend, and there were no remarkable changes in F1 input data. This suggested that the number and resolution of measurement were enough to construct the composition data in finer resolution.

The estimated selectivity results are shown in Fig. 2, and the parameter estimation results are shown in Fig. 3 and Table 1. Changing the input data with alternative size bin made little changes in the shape of selectivity. The several estimated parameters, i.e., peak (P1) and top of plateau (P2), had smaller standard deviations. The peak (P1) parameter showed improvements in terms of the estimation uncertainty, although the standard deviation was still large for most of them. However, the descend (P4) and end (P5) parameters had larger standard deviations in this study than the current base case. Parameter estimation results changed only slightly from previous results and did not show the expected improvement (Fig. 3).

The expected length-composition in each year by SS3 showed slight differences in some years, such as 2003 (Fig. 4), but the estimated population dynamics results were similar to the previous ones in general. This is due to the wider full selection in estimated selectivity, but not due to the change of stock dynamics (Fig. 6). Aggregating the length-composition across data periods, there were also no large differences in the expected Fleet 1 length-composition (Fig. 5). Although the results confirmed that the alternative size bin settings impaired the smoothness of the data, it provided a smaller RMSE and better fits to the data than the current bin settings for the length-compositions estimated by SS3 (Table 2).

The fit to the abundance index of Japanese longline fishery (Fleet 21), which is highly related to the estimation of F1 selectivity, is unchanged in terms of RMSE. There was some minor worsening of likelihood or RMSE for other sizes and indices data, but neither was a major worsening (Table 2). The results of SSB and recruitment trajectory were also unchanged (Fig. 6), indicating that changes in the Fleet 1 input data did not affect the overall stock assessment results, while some parameter uncertainties and fit to the Fleet 1 size were improved.

4. Conclusion

As a result of using the alternative input data with finer bin definition in the short assessment model, the expected length-composition and shape of selectivity showed little changes, while fitting to size data was improved. In addition, although there was a potential concern that calculation time increases due to the larger data amount of the input data, the actual calculation time was unchanged. The results in this document suggested that using input data with finer length bin width can reduce some of the uncertainty of selectivity estimation for Fleet 1, but the contribution of this modification to the overall model performance needs to be examined more in detail. The PBFWG is welcomed to discuss about the utility of the finer length bin for this fleet or others for the 2024 stock assessment.

References

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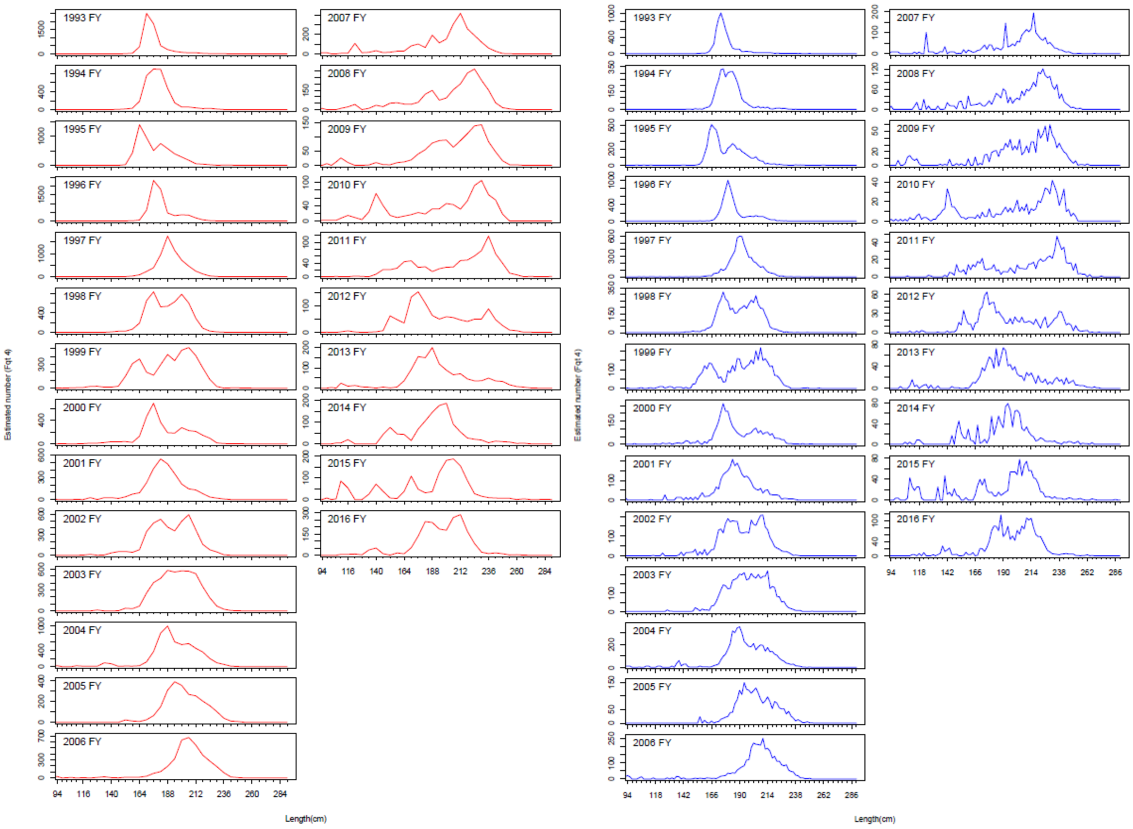

Fig. 1 The CAS of PBF caught by Japanese longline based on size-measurement and sales slip in 1993-2016 FY (4th Fqt). Red plots are current CAS with 2, 4, and 6 cm size bin for 16-58, 58-110, and 110-290 cm FL, respectively. Blue plots are alternative CAS with 2 cm size bin for 16-290 cm FL.

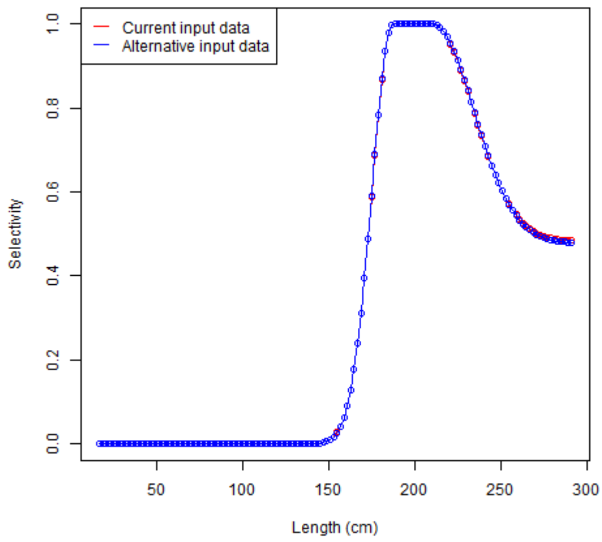

Fig. 2 Comparison plot of selectivity estimated in F1

Table 1 Estimated parameter values and their standard deviations (SD)

Parameter	Current input data		Alternative input data	
	Value	SD	Value	SD
F1JLL_peak (P1)	187.43	3.85	187.36	3.82
F1JLL_top (P2)	-1.29	1.38	-1.27	1.30
F1JLL_ascend (P3)	5.67	0.32	5.67	0.32
F1JLL_descend (P4)	7.01	5.72	7.02	5.92
F1JLL_end (P5)	-0.06	5.81	-0.08	6.24

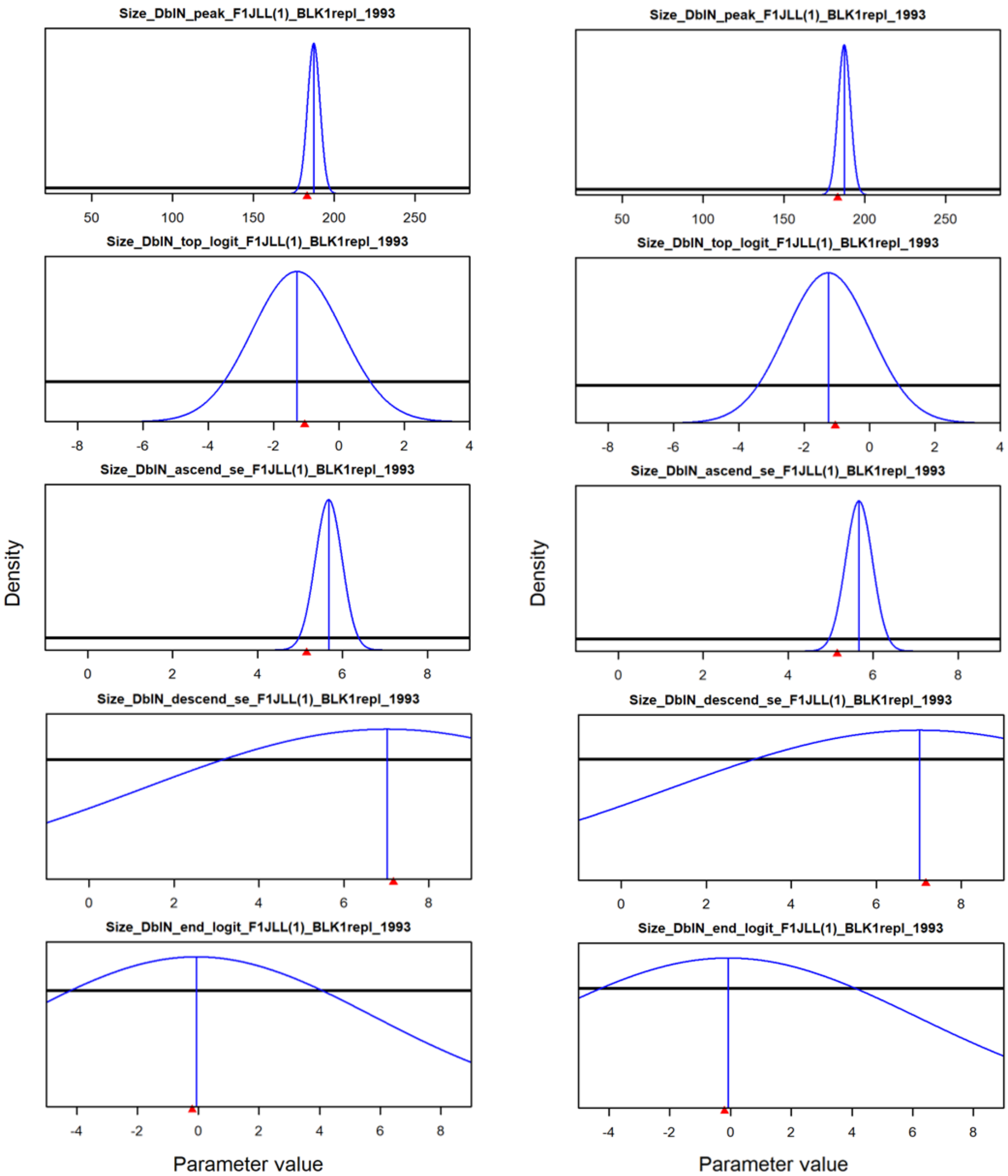

Fig. 3 Estimation results of five parameters based on table 4 (From top to bottom: peak, top of plateau, ascend, descend, end). Left is using current input data, and right is using alternative input data.

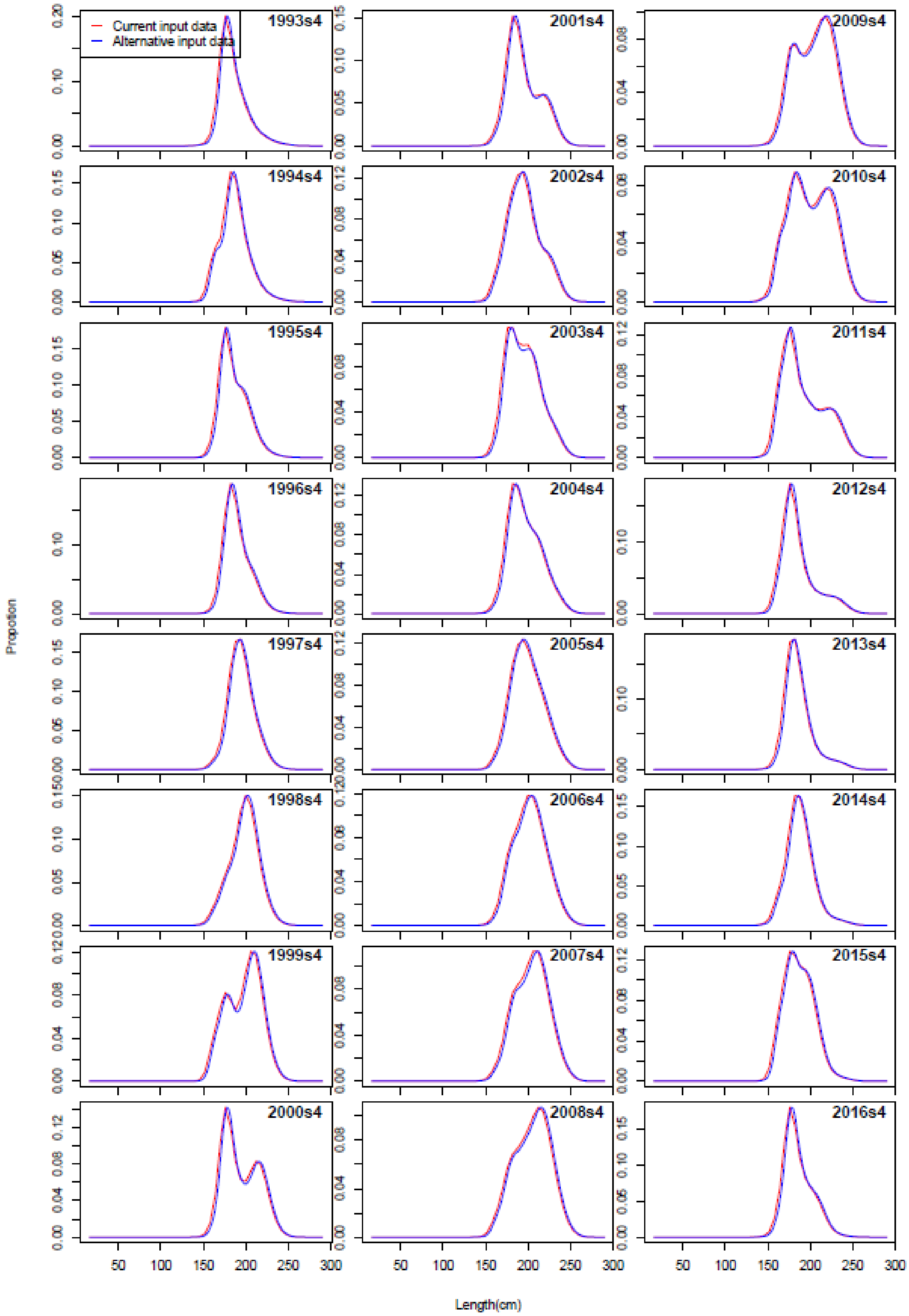

Fig. 4 Comparison plot of length-composition by fishing year estimated by SS3

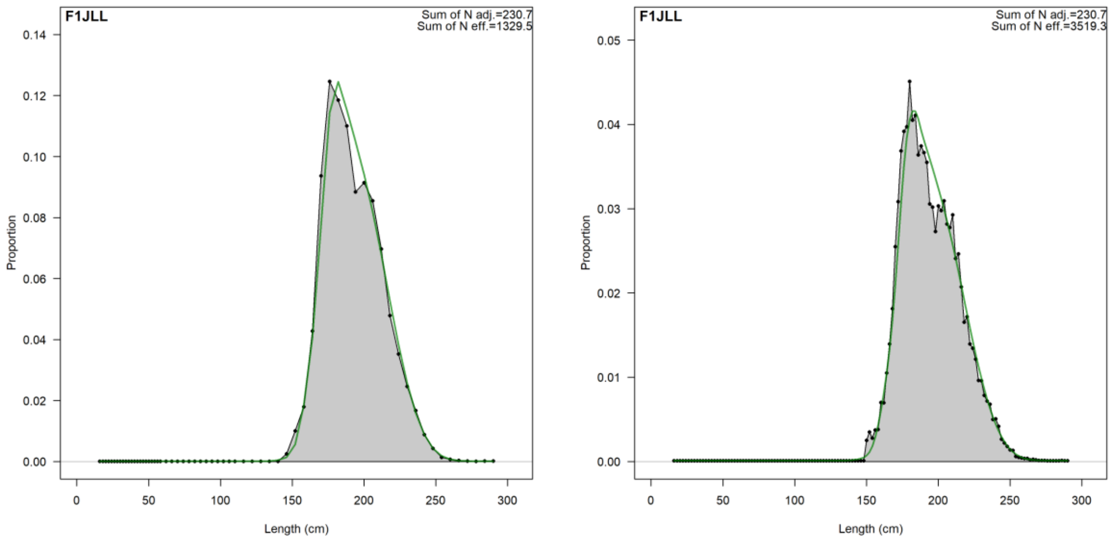

Fig. 5 The length-composition of F1 based on CAS (black dots with gray fill) and the estimated length-composition by SS3 (green line). Left is using current input data, and right is using alternative input data.

Table 2 Likelihood and RMSE for each fleet obtained by SS3.
* The values became worse by using alternative input data.

Fleet	Likelihood		RMSE	
	Current input data	Alternative input data	Current input data	Alternative input data
1	–	–	0.021	0.009
2	149.48	149.51*	–	–
3	56.39	56.38	–	–
4	82.65	82.67*	–	–
5	50.42	50.42	–	–
6	177.93	177.94*	–	–
7	44.94	44.93	–	–
8	368.83	368.84*	–	–
9	102.82	102.84*	–	–
10	44.76	44.82*	–	–
11	102.12	102.16*	–	–
12	36.51	36.48	–	–
13	0.33	0.34*	–	–
14	40.64	40.64	–	–
15	90.19	90.19	–	–
16	3.49	3.49	–	–
17	3.78	3.78	–	–
18	64.85	64.94*	–	–
19	56.52	56.52	–	–
20	29.66	29.66	–	–
21	–	–	0.294	0.294
22	–	–	0.000	0.000
23	–	–	0.099	0.100*
24	–	–	0.216	0.216
25	–	–	0.245	0.245
31	–	–	0.239	0.238
32	–	–	0.593	0.594*
33	–	–	0.245	0.245
34	–	–	0.574	0.575*
35	–	–	0.578	0.578
36	–	–	0.266	0.266
37	–	–	0.484	0.483

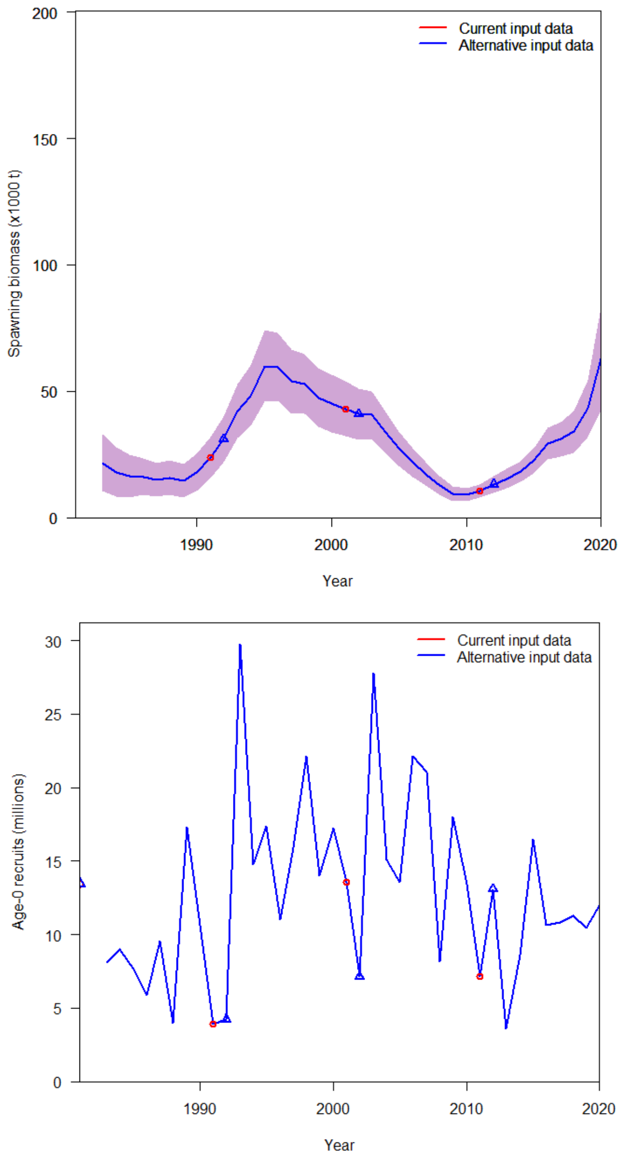

Fig. 2　Comparison plots of SSB (top) and recruitment trajectory (bottom)