Reducing uncertainty in a parameter critical for striped marlin (*Kajikia audax*) stock assessment in the Western Central North Pacific Ocean

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Abstract. Fish stock assessments, which estimate the abundance and productivity of fish populations, play a crucial role in managing fishery resources by providing reliable information on the status of fish populations and guiding policymakers in making informed management decisions. However, the results of the stock assessment for striped marlin in the Western Central-North Pacific Ocean critically depend on a parameter that had been estimated with high uncertainty. The parameter in question, the initial mortality multiplier (f), caused the 2023 stock assessment to estimate that the stock was overfished, while the 2022 assessment did not. The present study redid the 2023 stock assessment by removing the potentially unreliable Japanese drift-net dataset prior to 1994. The redone assessment found that the value of f was substantially smaller and the accompanying 95% confidence interval was substantially narrower compared to the 2023 assessment, indicating that the stock is within reference limits. These findings highlight the importance of ensuring the quality and reliability of datasets used in stock assessments to improve their accuracy, particularly by addressing inconsistencies in catch data, sampling methods, and modelling assumptions.

Introduction. The assessment of fish stocks is crucial for the sustainable management of fisheries, because it provides essential information on the status of the stocks and informs management decisions. However, it is not uncommon for the results of stock assessments to vary over time due to changes in the data or modelling approaches. In the case of the striped marlin stock assessment, the results of the 2022 assessment and its 2023 redo revealed a substantial difference, prompting an investigation into the causes of this disparity (Jusup and Ijima, 2023).

Through this investigation, it was found that the primary cause of the difference was a large uncertainty in the estimate of the initial mortality multiplier (f), which had a significant impact on the stock assessment results. Thus, there is an urgent need to reduce this uncertainty to enhance the accuracy of stock assessments.

To this end, the present working paper aims to contribute to the goal of reducing uncertainty in the estimate of the parameter f by identifying potential issues with the Japanese drift-net dataset prior to 1994. We suspect the reliability of this dataset due to scarce and unclear information on where the fish was caught and a possibility of misidentification of striped and blue marlin catches. Therefore, we redid the 2023 stock assessment without the Japanese drift-net dataset prior to 1994. Here, we present the results of this analysis and briefly discuss the potential ways to improve the consistency among the datasets used to estimate the model parameters.

Methods. In our attempt to reduce uncertainty in the estimate of the initial mortality multiplier (f) for the striped marlin stock assessment, we performed simulation runs in the Stock Synthesis 3 model starting from the year 1994. The model's initial setup was taken from input files from the sensitivity analysis performed for the 2023 stock assessment.

We proceeded to remove all time blocks and weights. The size of age 0 fish (i.e., at the time of recruitment) was assumed to be 10 cm. We also changed the Japanese drift-net selectivity profile in Japan's exclusive economic zone from logistic to double normal and added a time block for the Japanese drift-net (F1, F2) and the U.S. drift-net (F16) selectivities, which secured a better fit with size data.

After examining the R_0 profiles for the model with time blocks, the U.S. CPUE dataset was removed. Weights for Taiwan and U.S. size data were set to 0.5. Using the described setup, we re-estimated all parameters and re-ran the model for the period from 1994 to 2020. We finally compared the results of these re-runs primarily with the results of the 2023 stock assessments.

Results. The redone stock assessment produced significantly different results from the 2023 assessment, as shown in Figure 1a-c. Furthermore, the initial mortality multiplier (*f*) estimate was substantially smaller in the redone assessment, while the 95% confidence interval was much narrower compared to the 2023 assessment, indicating reduced (albeit not small) uncertainty about this estimate (Figure 1d). The point estimate of the equilibrium recruitment (R_0) parameter remained practically unchanged, with a narrow 95% confidence interval indicating little uncertainty about this estimate.

As a result of the smaller *f* value and the same R_0 value, the spawning stock biomass was substantially larger in the redone assessment, remaining above the reference limit throughout the simulation period from 1994 to 2020 (Figure 1a). The larger spawning stock also enabled the model to generate the same catches with less mortality, which remained below the reference limit throughout the same simulation period (Figure 1b).

The difference in recruitment between the two models was negligible (Figure 1c), likely due to the relatively high steepness parameter for striped marlin. High steepness makes recruitment numbers less sensitive to changes in the spawning stock biomass.

We examined model diagnostics in terms of the difference profile of the negative log-likelihood function for parameter R_0, which is shown in Figure 2. Specifically, Figure 2a contains profiles for the CPUE datasets, Figure 2b profiles for the size datasets, and Figure 2c aggregate profiles including that for recruitment deviations from the expected Beverton-Holt stock-recruitment relationship. Apart from the US long-line size data, there is high consistency among the datasets, all pointing to the R_0 value of approximately 6.

Discussion. Overall, these results highlight the importance of improving our estimate of the initial mortality multiplier (*f*) in future stock assessments of striped marlin. By removing the potentially unreliable Japanese drift-net dataset prior to 1994 and thus using mutually more consistent datasets, we were able to obtain a less uncertain estimate of this parameter. The point estimate of the parameter was substantially smaller than in the 2023 stock assessment, producing a larger spawning stock biomass that stayed above the reference limit throughout the simulation period. This outcome is more in line with the 2022 stock assessment than the subsequent 2023 assessment.

Our findings emphasise the importance of ensuring the quality and reliability of the datasets used in stock assessments, even if it means sacrificing the quantity of data available. The quality of datasets is paramount in reducing uncertainty and ensuring that the models used to assess stock status are reliable. Our results suggest that there may be particular datasets that are inconsistent with other datasets, which can impact the reliability of the models used in stock assessments. Future research should focus on identifying and resolving these inconsistencies to improve the accuracy of stock assessments.

Looking forward, we plan to revisit the Japanese drift-net dataset, using the methods of machine learning, to re-estimate catches in a manner that would make the dataset more consistent with other observations. We hope that doing so will represent a step in the right direction to reduce uncertainty around the initial mortality multiplier (*f*) and improve the accuracy of future striped-marlin stock assessments.

References

Jusup M, Ijima H (2023) Impact of parameter uncertainty on striped marlin stock assessment in the Western-Central North Pacific Ocean. Working paper ISC/23/BILLWG-01/01.

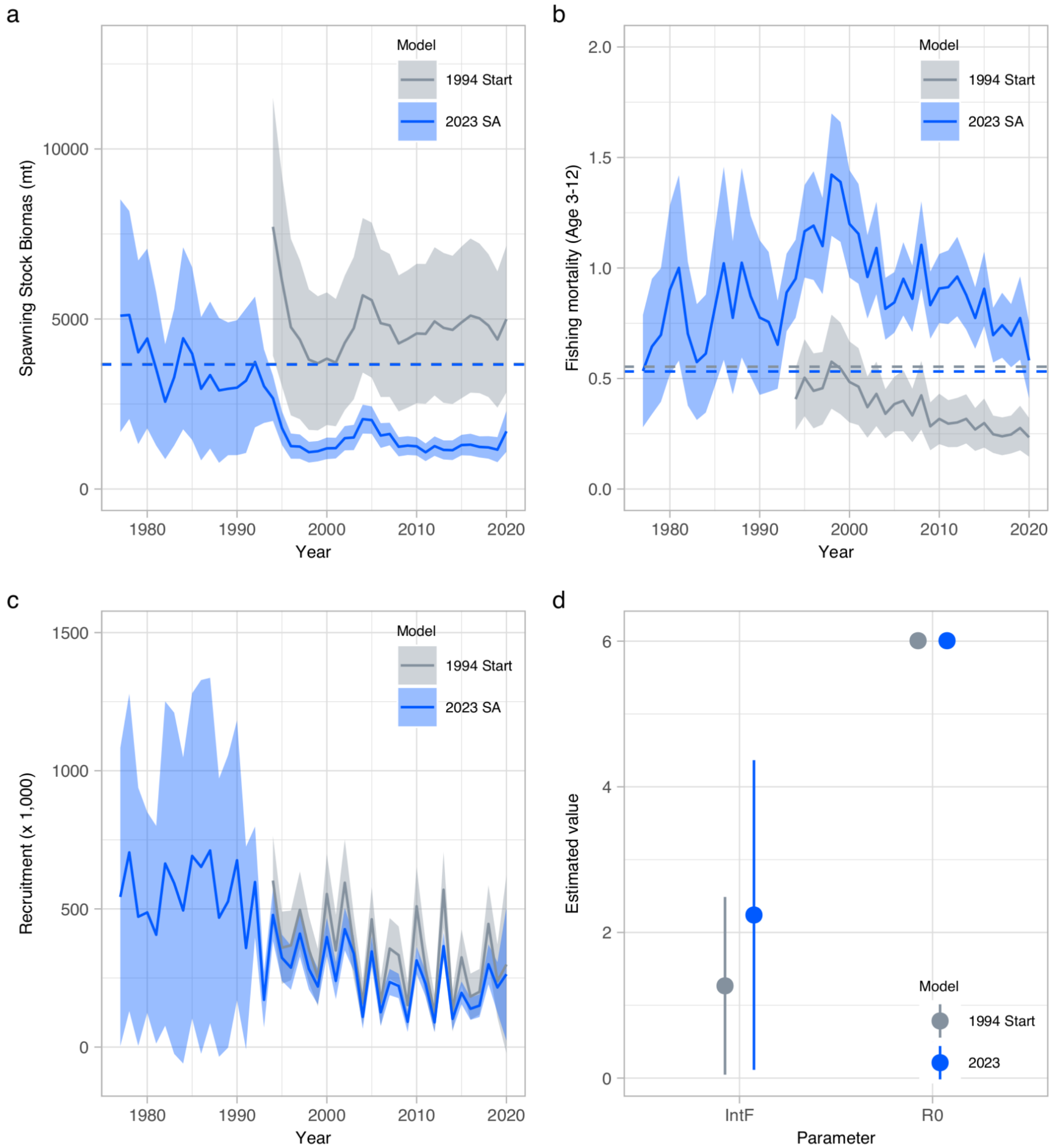

Figure 1. Comparison of results from the 2023 stock assessment and the shortened-data model run. **a**, Estimated spawning stock biomass through time. Dashed horizontal lines indicate the management objective in the form of 20%$SSB_{F=0}$ for the period from 2001 to 2020. **b**, Estimated fishing mortality through time. Dashed horizontal lines indicate the management objective in the form of F_{MSY}. **c**, Estimated recruitment through time. **d**, Point estimates and the 95% confidence intervals for initial mortality multiplier (*f*) and equilibrium recruitment (R_0).

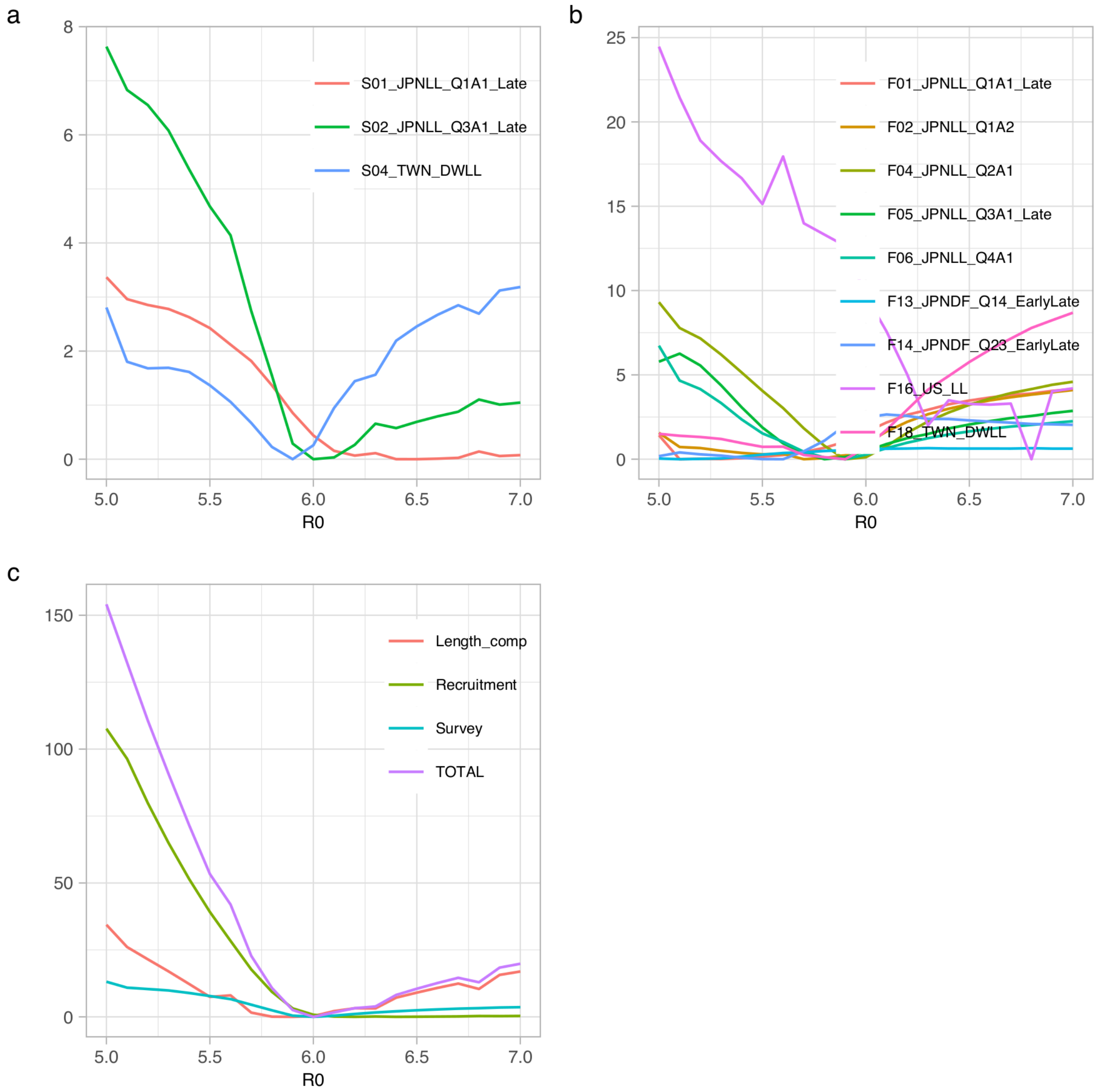

Figure 2. Examination of conflicts between datasets used to fit the stock-assessment model. The vertical axis displays the difference between the negative log-likelihood function for the R_0 value on the horizontal axis and the negative log-likelihood function's minimum. Contributions to the negative log-likelihood of mutually consistent datasets reach zero for the same R_0. **a**, CPUE datasets used for model fitting. **b**, Length-composition datasets used for model fitting. **c**, Aggregate negative log-likelihood difference profile for the CPUE datasets (cyan), length-composition datasets (red), and recruitment deviations from the expected Beverton-Holt stock-recruitment relationship (green). Also shown is the total negative log-likelihood difference profile (purple).