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Exploration of time-varying age-based selectivity options in Stock Synthesis in preparation for the albacore benchmark assessment

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Abstract
This working paper evaluated the potential of estimating time-varying selectivity with the two-dimensional autoregressive (2dAR) option in Stock Synthesis (Xu et al. 2019). Exploration was motivated by estimated selectivities that did not fit length composition data well for some fleets and years in the 2023 benchmark stock assessment. The recent assessment estimated time-varying age-based selectivity with the time block option in Stock Synthesis. The 2dAR seemed to result in slightly better fits to the length composition data for some of the years of concern and seemed to result in model convergence. There were slight changes to the scale of spawning stock biomass and biomass ratio values, although the trends were the same. Selectivity estimated with the 2dAR feature will likely be included in the 2026 benchmark, and a more thorough comparison and justification will be presented at the upcoming data preparation meeting.

The 2023 albacore benchmark stock assessment model contained data from 37 fishing fleets, but the data from Japanese fleets had the highest catch amounts and were considered to be most representative of albacore in the north Pacific. The Japanese Longline, area 2, quarter 2 fleet (Fleet 12) was the index of abundance in the base case assessment. The Japanese pole-and-line, areas 3 and 5, quarter 2 (Fleet 22) and quarter 3 (Fleet 23) length composition data have some years for which the fits have been poor. For example, fits in 1994, 2001, and 2003 for Fleet 22 (Figure 1) and fits in 1994, 2001 and 2009 for Fleet 23 (Figure 2) were poor.

The assessment model was not able to fit length compositions for some years despite estimation of time-varying age-based selectivity for these fleets. The time-invariant length-based selectivities used the double normal option (Figure 3), and the age-based selectivity used a flexible form for which a selectivity parameter was estimated for each age (Figure 4). The motivation behind these parameterizations was that selectivity is the result of two processes. Gear selectivity, modeled as length-based selectivity, was the process by which fish are sampled by fishing gear. For example, an explanation for the pattern in Figure 3 might be that the pole-and-line hooks were only able to catch of a certain size. Smaller fish are not able to be hooked by the gear and larger fish may be able to break free from the hooks. Availability, modeled as age-based selectivity, represents fish that are able to be caught by fishing gear at a specific time and place. Availability can be representative of fish movements and distributions. The age-based selectivities were modeled with time blocking, in which the user specifies the duration of specific blocks. The age-based selectivities for the benchmark assessment had one time block for data from 1994-2015 and another for 2016-2021.

Stock Synthesis contains a range of flexible selectivity options, and this working group paper explores inclusion of time-varying age-based selectivity with alternative parameterizations in preparation for the 2026 benchmark stock assessment. The two-

dimensional auto-regressive (2dAR) option was designed to account for autocorrelation in selectivity deviations (Xu et al. 2019) although autocorrelation was not the focus of this working group paper. Rather, selectivity parameters for Fleet 22 were estimated as deviations (similar to the method of estimating recruitment deviations) with the goal of improving fits to data from Fleet 22. There have not been studies recommending model selection protocols for the 2dAR configurations, thus a full range of configurations were not explored here.

The 2dAR option was added to Fleet 22 with a sigma value of 1 (higher sigma allows more variability in deviations) with no autocorrelation. The fits to the length composition data are shown in Figure 5, and were overall fairly similar to those estimated in the base model. The largest visual improvements were for years including 2006, 2007, 2010, and 2013 (Figure 5). Later years such as 2019 and 2020 seemed to have worse fits with the 2dAR option (Figure 5). Additionally, there were minor changes in the fit to the index of abundance (Figure 6) and small changes in the scale of SSB estimates and biomass ratios (Figure 7). Increasing values of sigma had diminishing improvements to the length composition fits and changes to the management quantities.

There are a number of next steps to identify the potential benefits of the 2dAR option. The non-autocorrelated 2dAR option functioned to constrain the variability in selectivity estimates (similar to constraining recruitment deviations). Time blocking involved a number of decisions regarding the relationship between time blocks and the duration of the time blocks. Model convergence is sensitive to the specification of the time block relationships (e.g. additive or multiplicative), and the 2dAR option may require fewer assumptions. The 2dAR settings, including application to both Fleets 22 and 23, will continue to be explored for the data preparation ALBWG meeting.

REFERENCES

Xu, H., Thorson, J.T., Methot, R.D. and Taylor, I.G., 2019. A new semi-parametric method for autocorrelated age-and time-varying selectivity in age-structured assessment models. Canadian Journal of Fisheries and Aquatic Sciences, 76(2), pp.268-285.

FIGURES

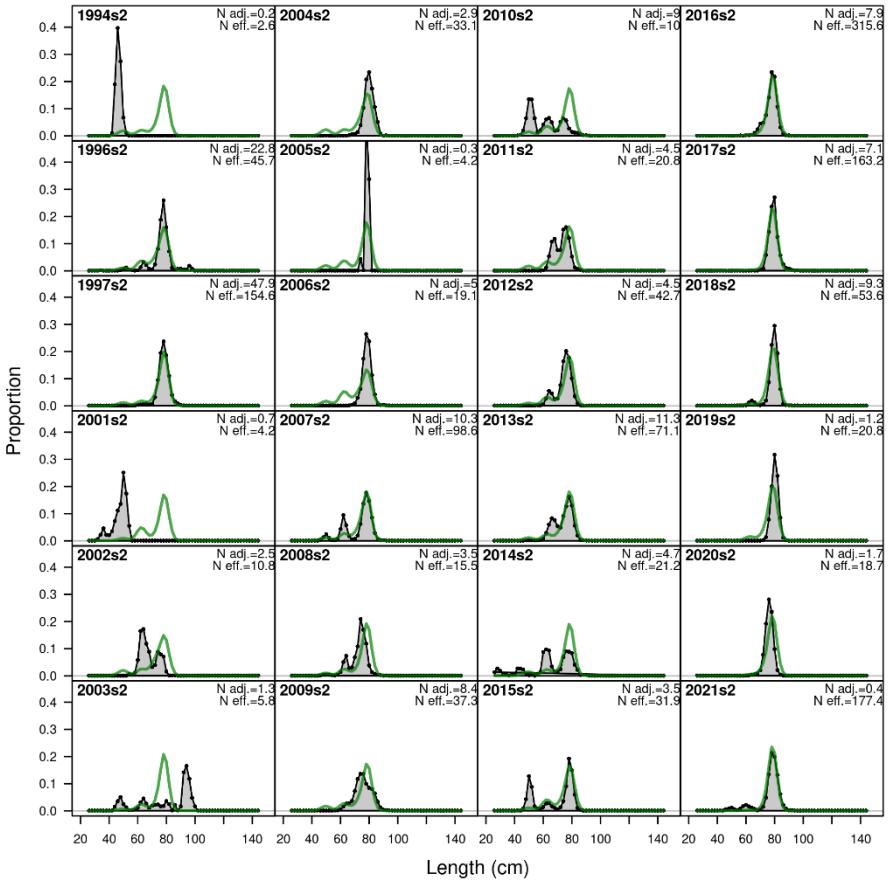

Figure 1: Length composition fits for Japanese pole-and-line, areas 3 and 5, quarter 2 (Fleet 22) data.

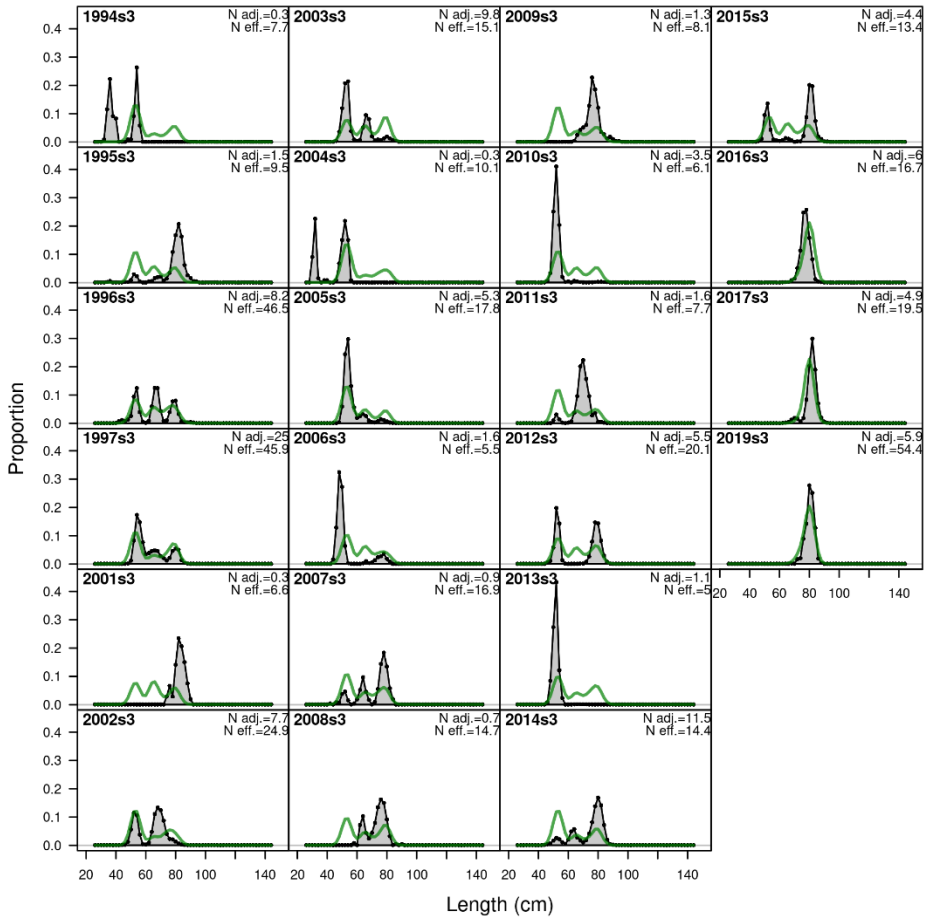

Figure 2: Length composition fits for Japanese pole-and-line, areas 3 and 5, quarter 3 (Fleet 23) data.

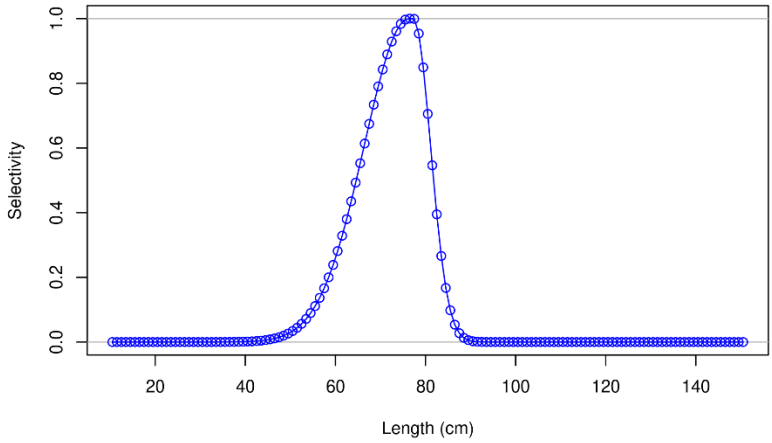

Figure 3: Length-based selectivity (estimated with the double-normal option in Stock Synthesis) for Fleet 22, females. The curves for Fleets 22 and 23, both males and females look similar to this curve.

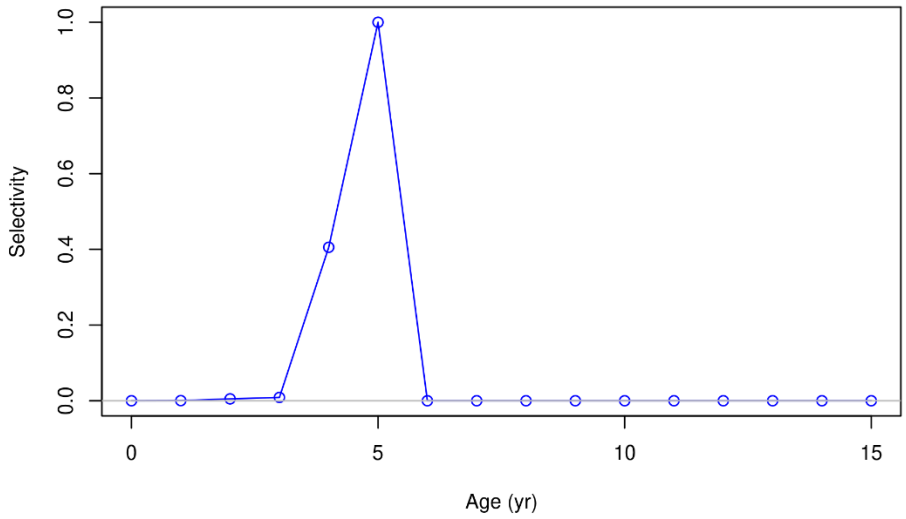

Figure 4: Age-based selectivity for Fleet 22, females. The curves for Fleets 22 and 23, both males and females look similar to this curve.

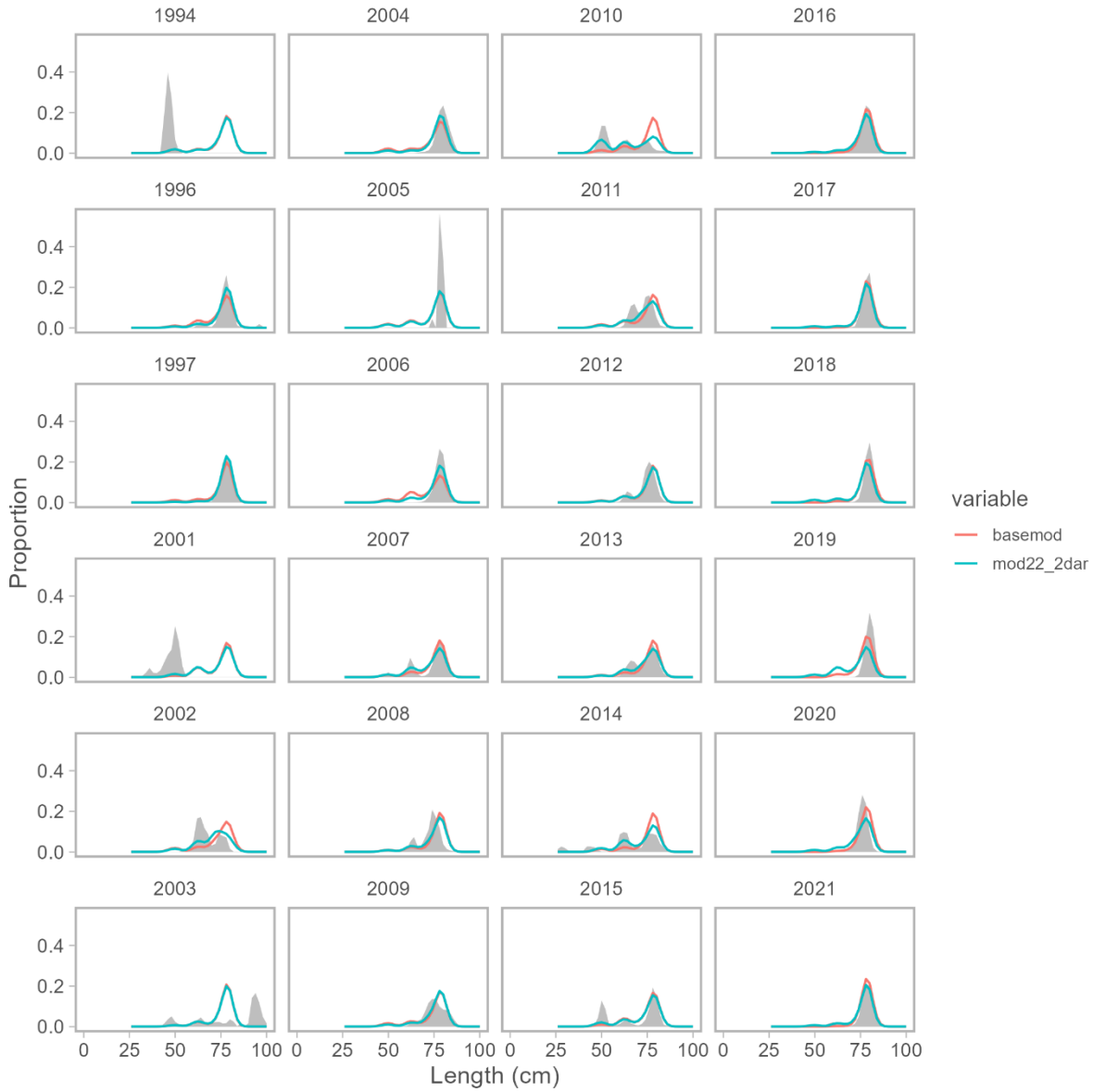

Figure 5: Length composition data from Fleet 22 (gray shading) and model fits from the base model (red) and Fleet 22-2dAR model (blue).

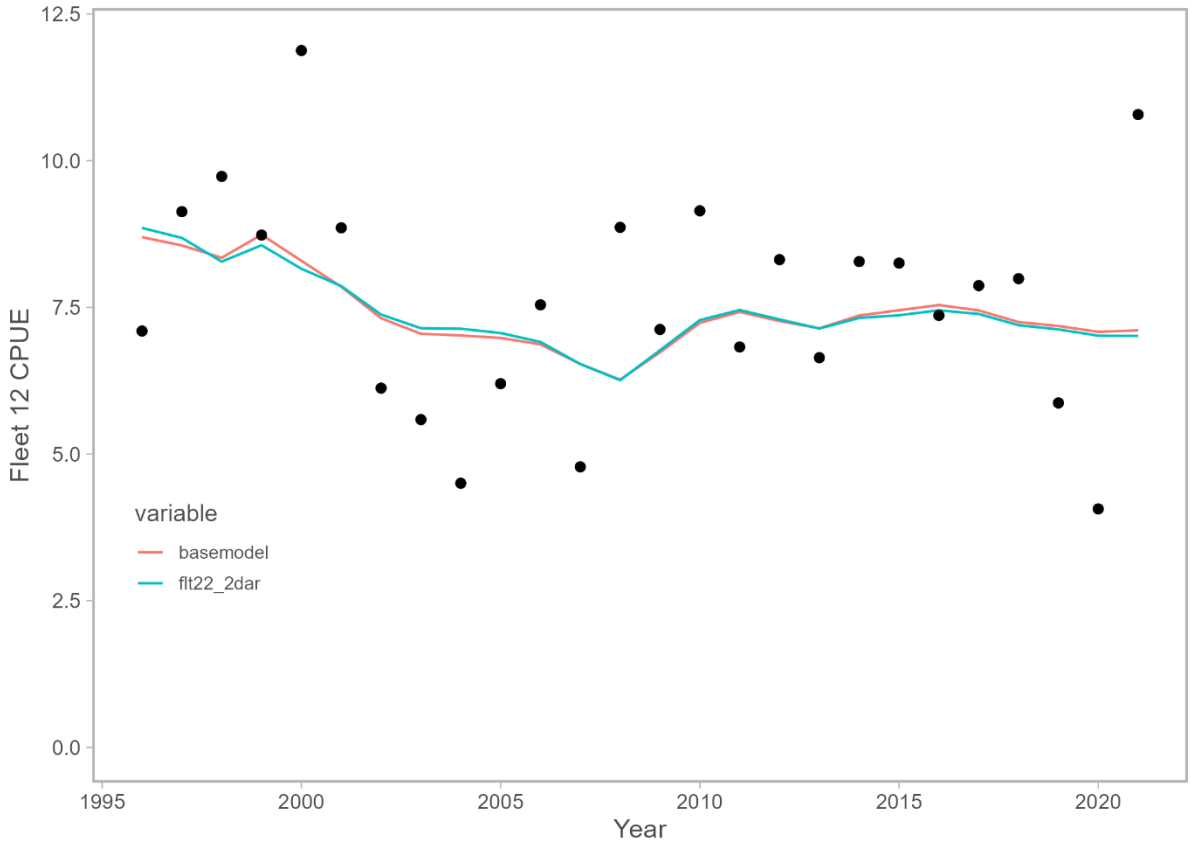

Figure 6: Fleet 12 CPUE values (points) and fits (lines) for the base model (red) and Fleet 22-2dAR model (blue).

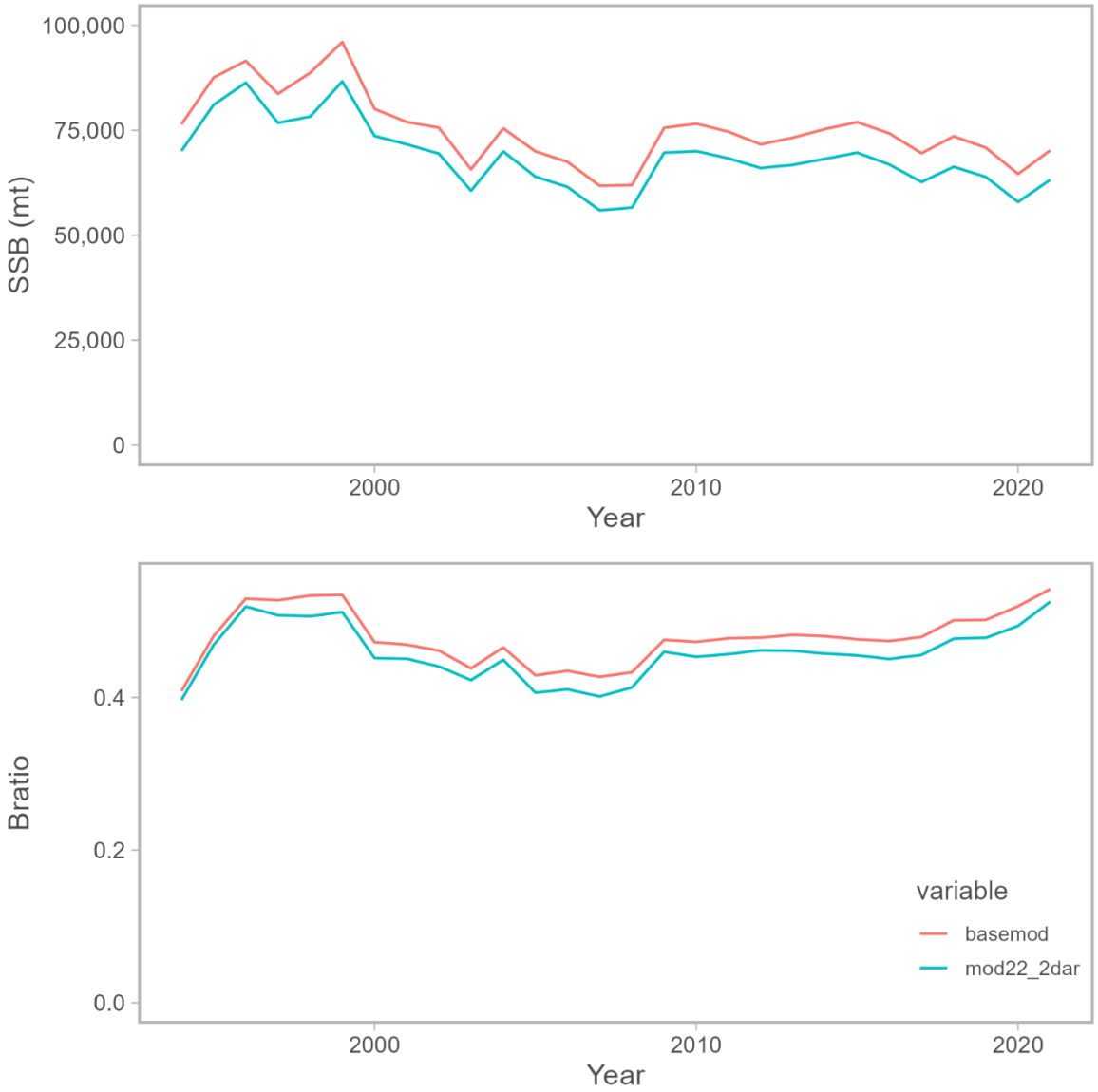

Figure 7: SSB and biomass ratio values for the base model (red) and Fleet 22-2dAR model (blue).