An alternative base-case model for the 2022 WCNPO MLS stock assessment

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This working paper was submitted to the ISC Billfish Working Group Workshop, 2-3 December 2022 held at Fisheries Resources Institute, Japan Fisheries Research and Education Agency.

Abstract

Based upon discussions of the ISC billfish working group and the ISC Plenary at their meeting in July 2022, the working group agreed to continue exploring the growth curves used in the 2022 western and central North Pacific Ocean striped marlin (WCNPO MLS) stock assessment. This document presents the alternative base-case model (2023 growth) using a refitted Von Bertalanffy curve that the working group agreed was the best information available from the original growth curve in Sun et. al, 2011. The growth curve uses the data in that paper as well as information on the range of sizes of fish caught in the WCNPO and southwest MLS fisheries to produce a new growth curve. In addition, a comparison is presented to show the result of the assessment using the growth curve from the 2019 WCNPO MLS assessment for comparison (2019 growth) and the growth curve used in the original 2022 base-case model (2022 growth).

Introduction

Based upon discussions of the ISC billfish working group and the ISC Plenary at their meeting in July 2022, the working group agreed to continue exploring the growth curves used in the 2022 western and central North Pacific Ocean striped marlin (WCNPO MLS) stock assessment. This document presents the alternative base-case model using a refitted Von Bertalanffy curve that the working group agreed was the best information available from the original growth curve in Sun *et. al*, 2011. The growth curve uses the data in that paper as well as information on the range of sizes of fish caught in the WCNPO and southwest MLS fisheries to produce a new growth curve. In addition, a model run is presented to show the result of the assessment using the growth curve from the 2019 WCNPO MLS assessment for comparison.

Methods

No changes were made to the model input data or parameters apart from the alternative growth models from the 2022 WCNPO MLS base-case model. Table 1 provides the growth parameters used in each model. Decisions on model weighting, data series to include, and time-blocks/selectivity patterns were made based upon the diagnostics of each model. A description of each model changes from the 2022 base-case model are as follows.

2019 Growth model

The 2019 growth model uses the growth curve from the 2019 base-case assessment. This growth curve uses an age at L1 of 0.3, L1 of 104 cm EFL, an L2 of 203 cm EFL, and K was set to 0.24. Other changes to the model from 2019 are the selection of CPUE indices based upon the log-likelihood, which resulted in dropping S1, S2, and S5 as well as setting the lambda for S3 to 0.5. Finally, the estimation of recruitment deviations are forced to sum to zero, as allowing the recruitment to be freely estimated resulted in a model that failed to converge and produce a positive definite Hessian.

2023 Growth Model

The 2023 growth model uses the re-estimated Von Bertalanffy by the working group members from the data used in the Sun *et al*., 2011 paper and prior knowledge of the size distribution of MLS caught in the Pacific. The age at L1 was set to 0.5, L1 was 110.9 cm EFL, L2 was 215 cm EFL, k was set to 0.2645 and the CV of old fish was increased from 0.08 to 0.10 to better fit the largest size classes. Similar to the 2019 growth model, the recruitment deviations were set to sum to zero. Finally, lambdas for S03 and S06 were set to zero,

Results

The change in the growth model from the 2022 growth to the 2019 and 2023 growth models resulted in an important change to the biomass estimate but had a smaller effect on fishing mortality. Overall, the 2019 growth and 2023 growth models have fairly similar results, indicating that the re-estimation of the growth curve by the working group had a minor effect on the assessment model results. Based upon the diagnostics of the 2023 growth model and the use of the improved growth model compared to 2022, we would propose that the 2023 growth model be considered for the base-case model for the 2022 WCNPO MLS stock assessment.

References

ISC (2022). Stock assessment of striped marlin in the Western and Central North Pacific Ocean in 2022, Report of the Billfish Working Group Stock Assessment Workshop. 11-18 July, 2022 Kona, Hawaii. ISC/SAR/MLS/2022.

Sun, C.L., Hsu, W.S., Chang, Y.J., Yeh, S.Z., Chiang, W.C., and Su, N.J. (2011). Age and growth of striped marlin (Kajikia audax) in waters off Taiwan: A revision. Working paper submitted to the ISC Billfish Working Group Meeting, 24 May-1 June 2011, Taipei, Taiwan. ISC/11/BILLWG-2/07: 12p.

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Tables

Table 1. Changes in the growth parameters and model settings between the three growth models.

Parameter	*2022 Growth model*	*2019 Growth Model*	*2023 Growth Model*
Age at L1	0.5	0.3	0.5
L1	110cm EFL	104cm EFL	110.9cm EFL
L2	203 cm EFL	203 cm EFL	215 cm EFL
K	0.34	0.24	0.2645
CV-young	0.14	0.14	0.14
CV-old	0.08	0.08	0.10
*Do_Recdevs**	2	1	1
Size comp DWT	F14, F16 lambda = 0.9	F16 Lambda = 0.9	No
Survey Index	Exclude S2, S3, and S4	S3 lambda=0.5, S4 lambda = 1 exclude S1, S2, and S6	Exclude S3, S6

*do-recdevs set to 1 forces recruitment deviations to sum to zero, do_recdevs set to 2 was used in the previous assessment, but models in this assessment did not converge with this setting.

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Figures

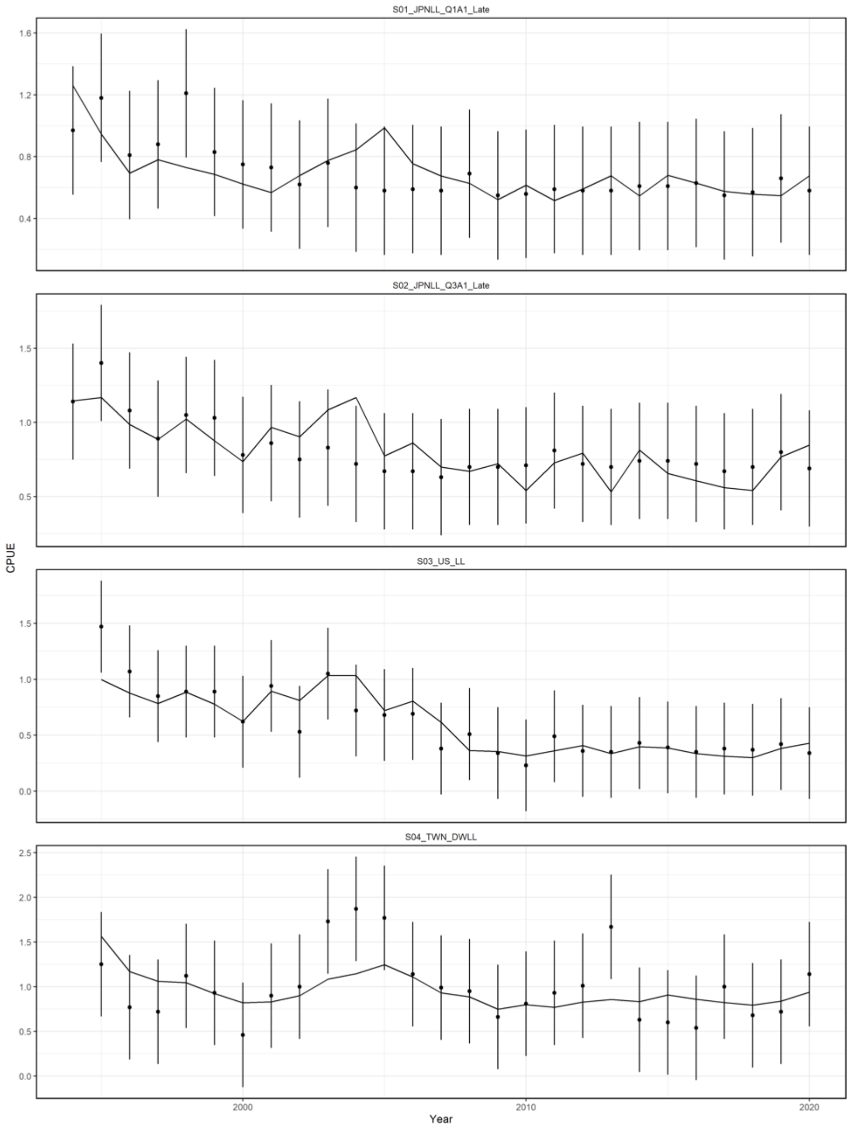

Figure 1. Fit to the CPUE for each survey (top to bottom, S1 through S6) in the 2023 growth base-case model.

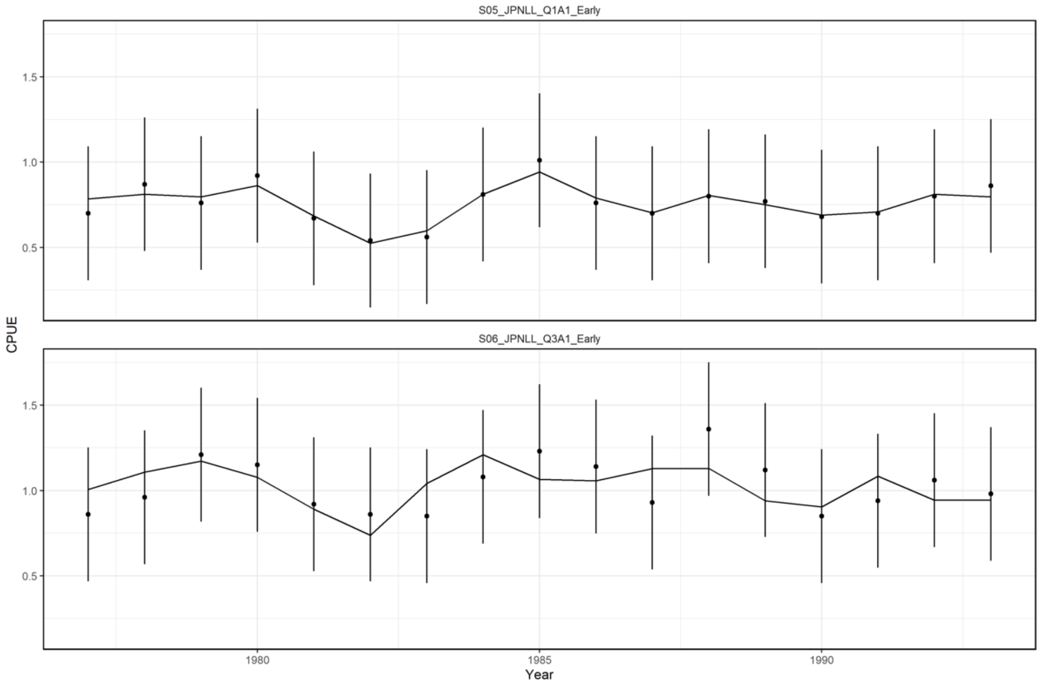

Figure 1 (continued).

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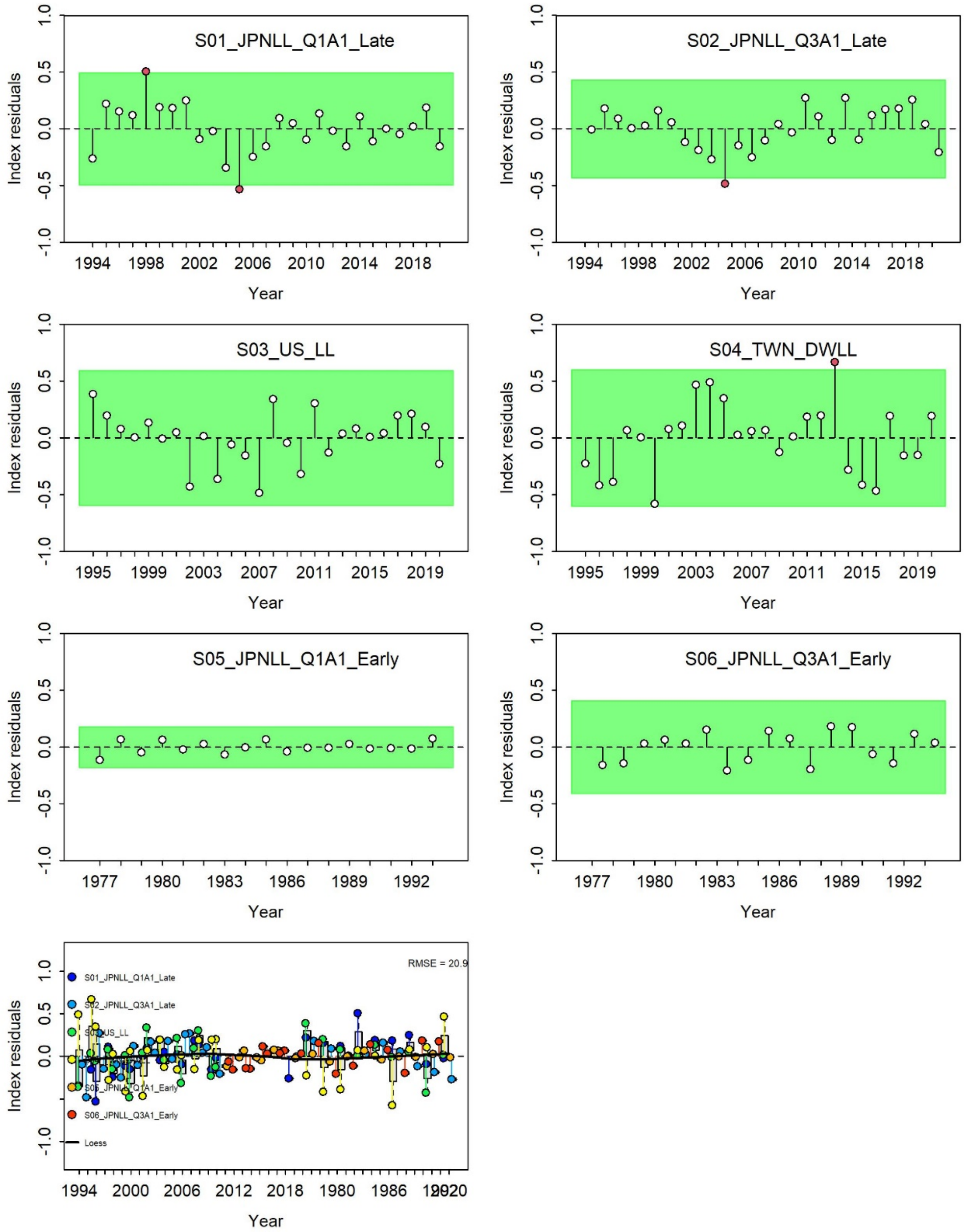

Figure 2. Results of a runs test on the residuals of the CPUE fits from the 2023 growth base-case model.

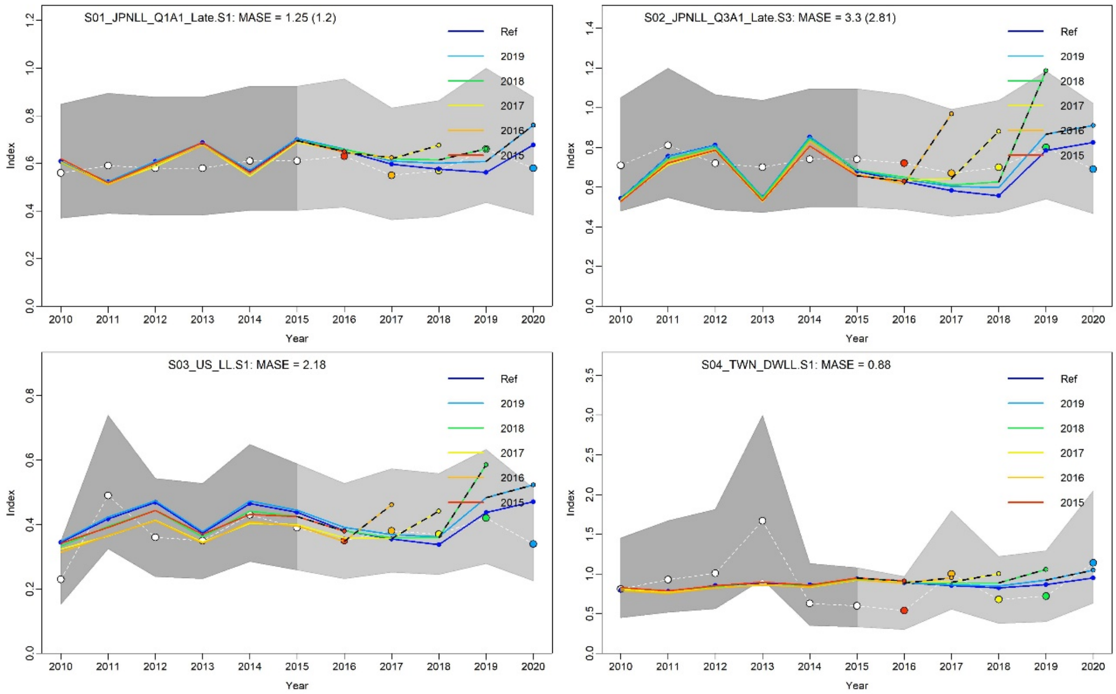

Figure 3. Hind-cast cross-validation results for S1 through S4, which evaluates the predictive ability of the model for the next year. MASE scores less than 1 indicate good predictive ability, MASE scores above 1 indicate poor predictive ability.

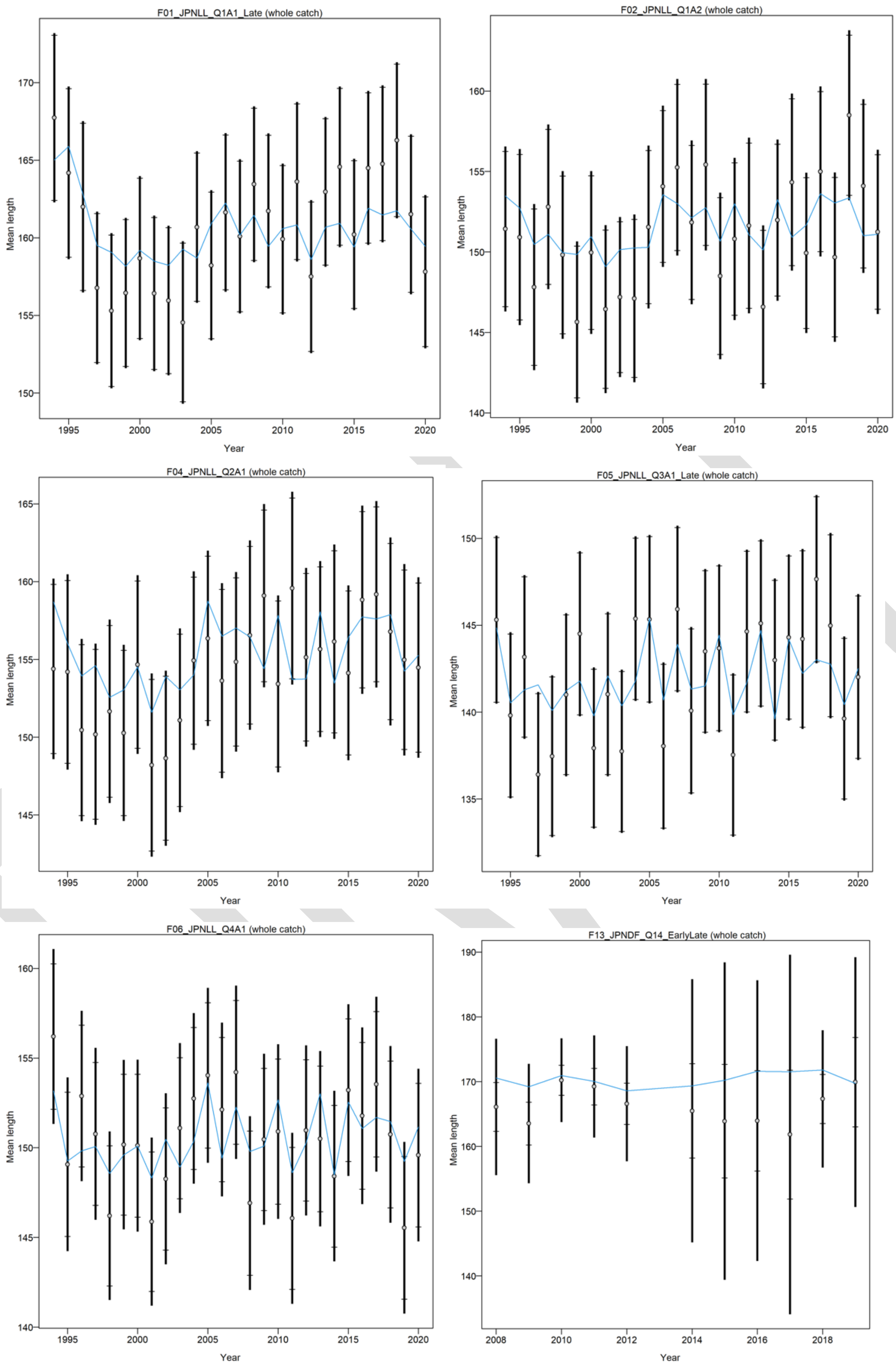

Figure 4. Fits to the mean length for each fleet in the 2023 growth base-case model for each size composition time series.

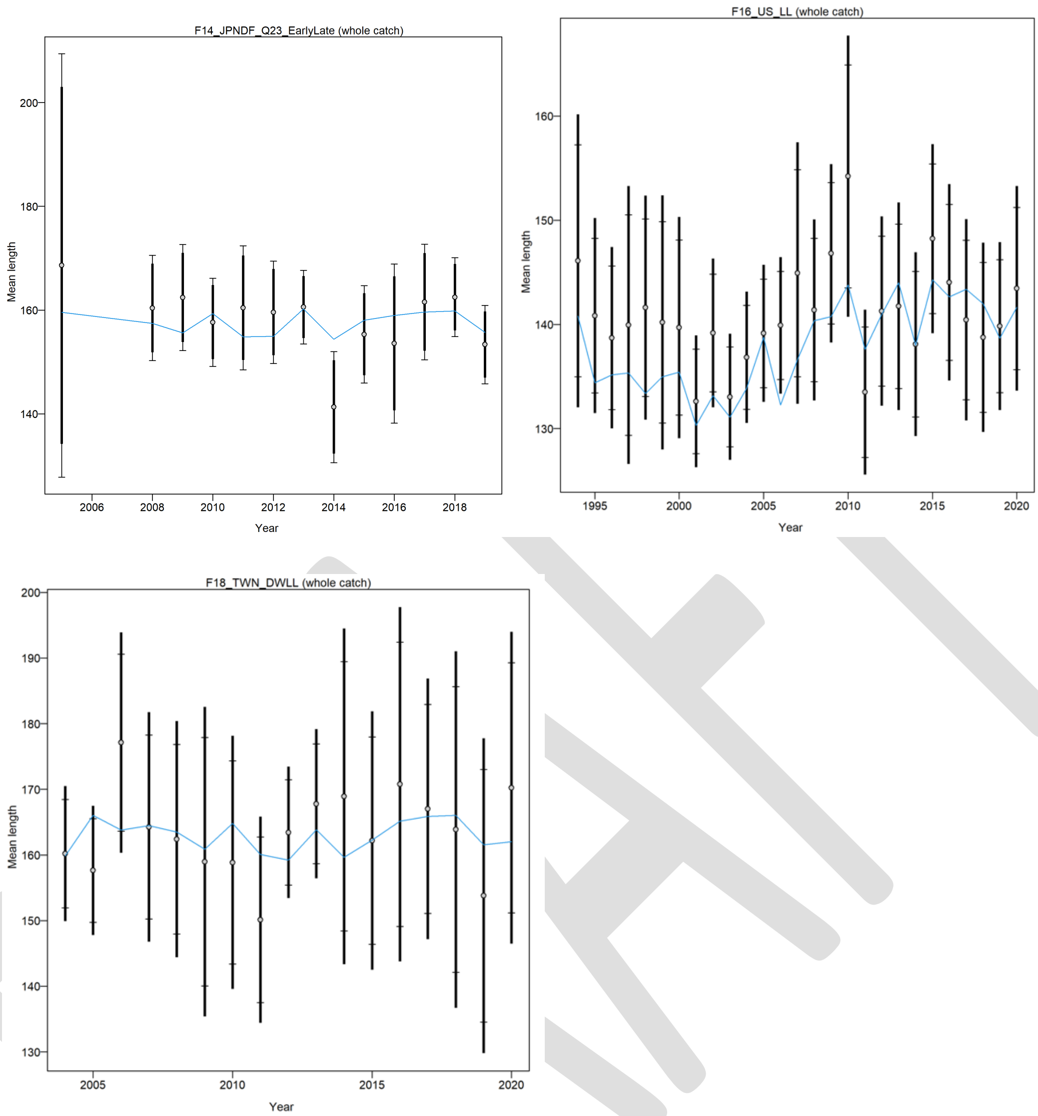

Figure 4. (Continued)

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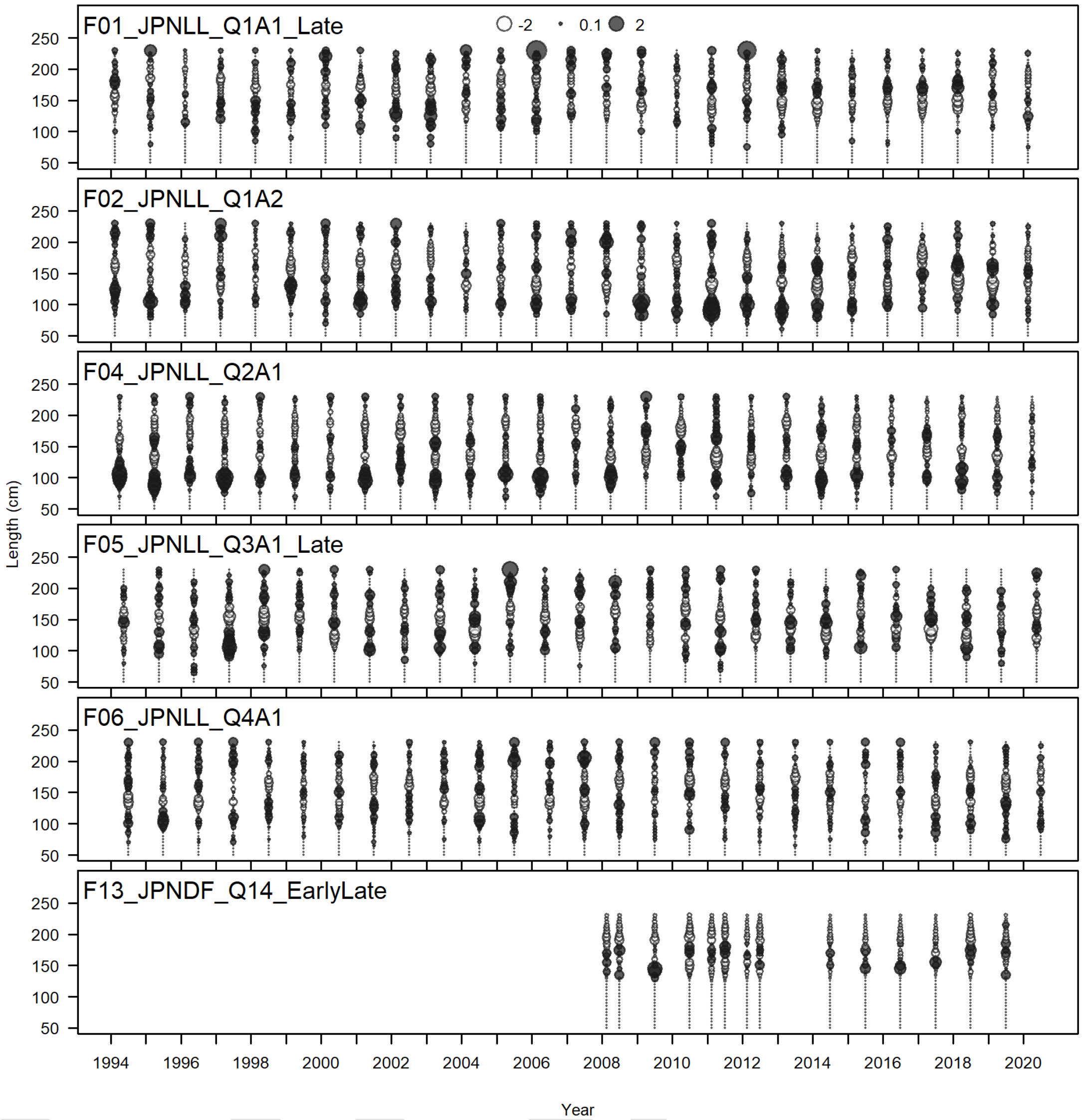

Figure 5. Quarterly size composition residuals by fleet for the 2023 growth base-case model.

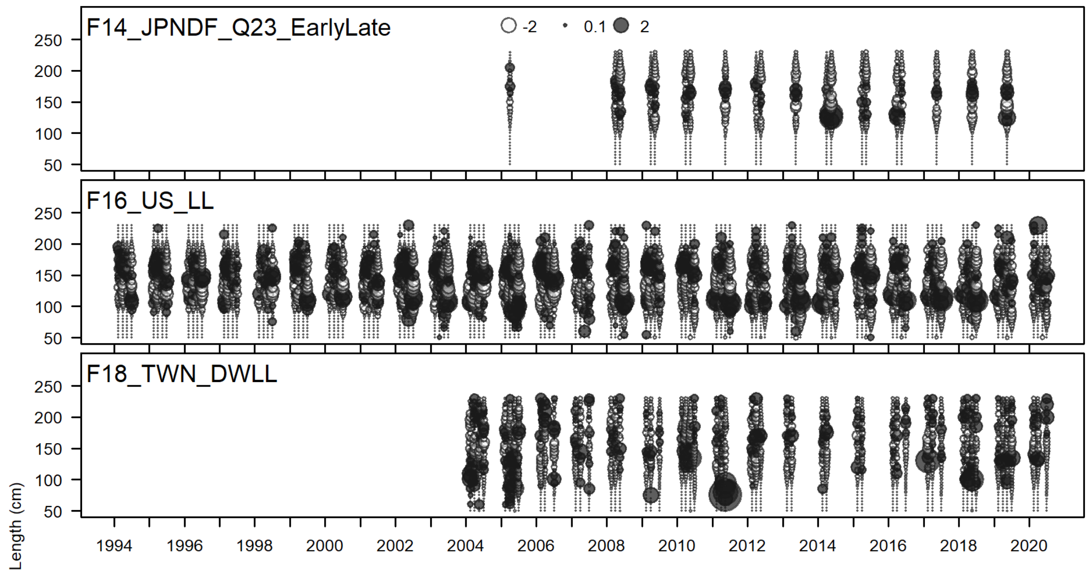

Figure 5. (continued)

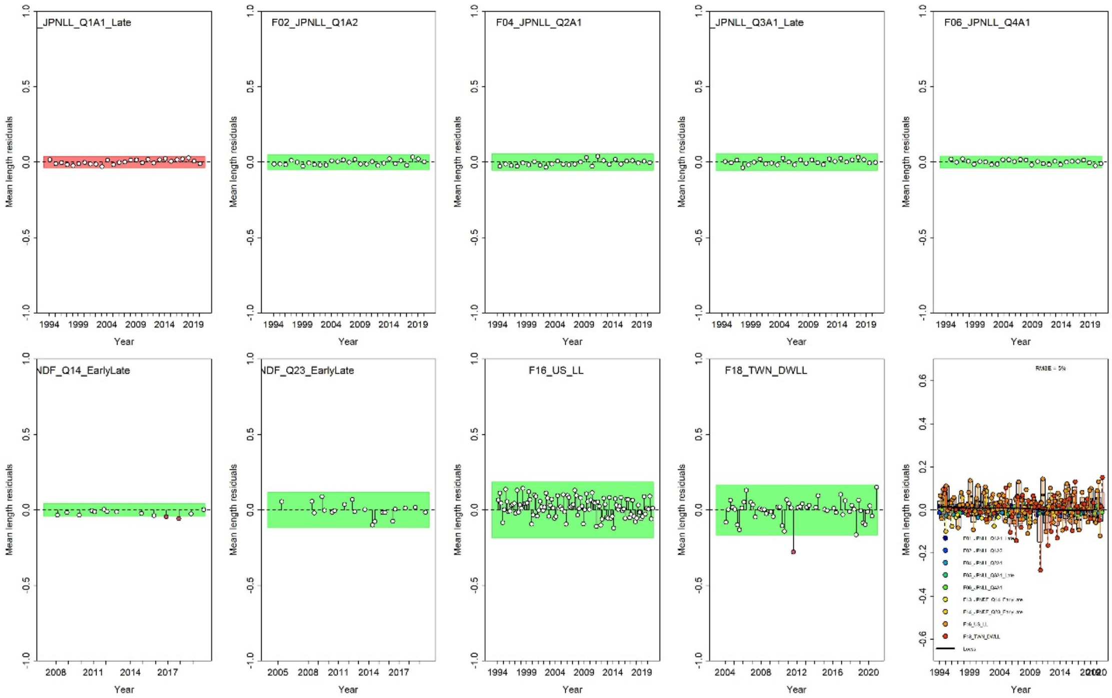

Figure 6. Runs test results on the residuals from the size composition data by fleet for the 2023 growth base-case model. Green indicates a fleet has passed the runs test, red indicate the fleet fails the runs test.

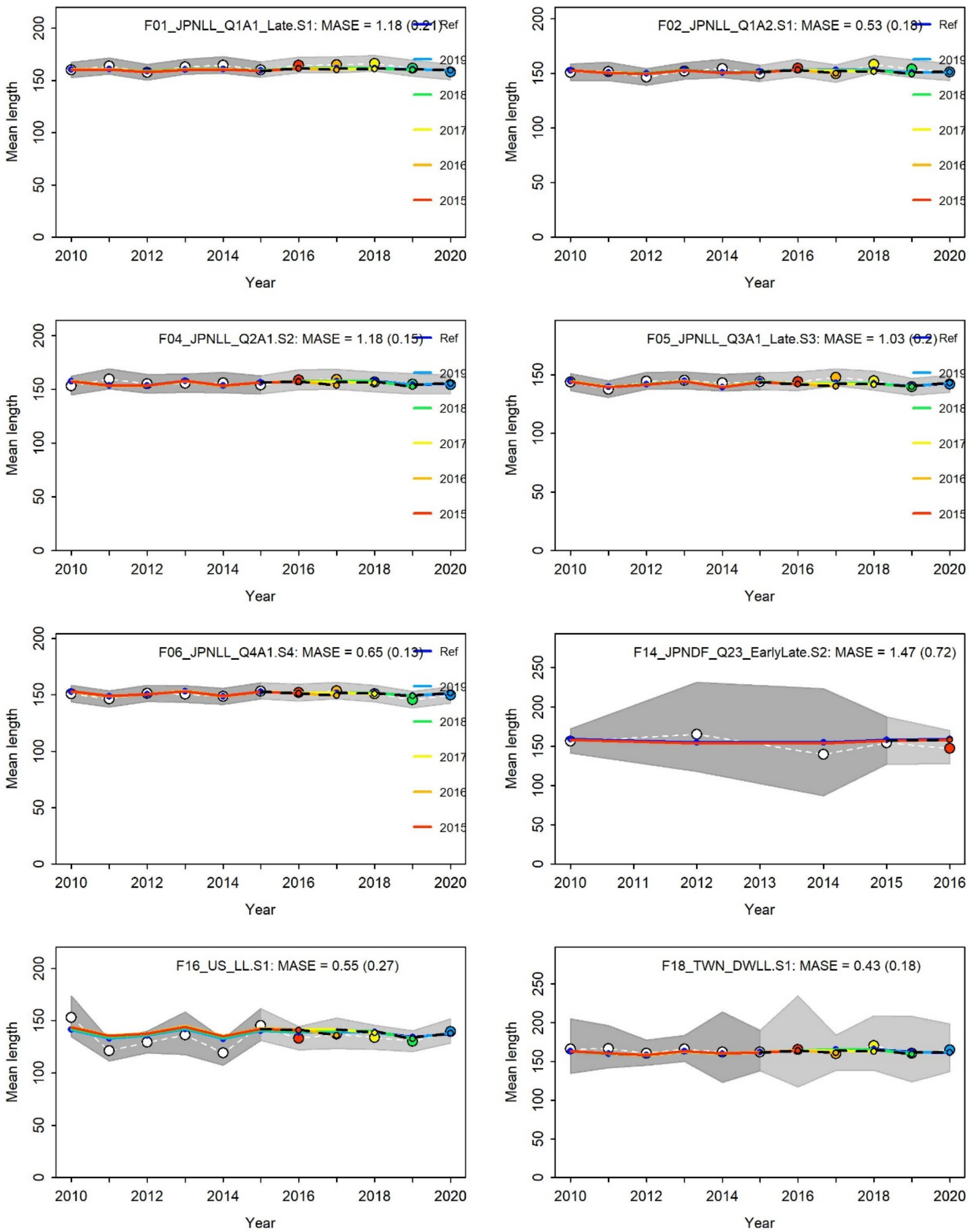

Figure 7. Hind-cast cross-validation results for size composition data in the 2023 growth base-case model, which evaluates the predictive ability of the model for the next year. MASE scores less than 1 indicate good predictive ability, MASE scores above 1 indicate poor predictive ability.

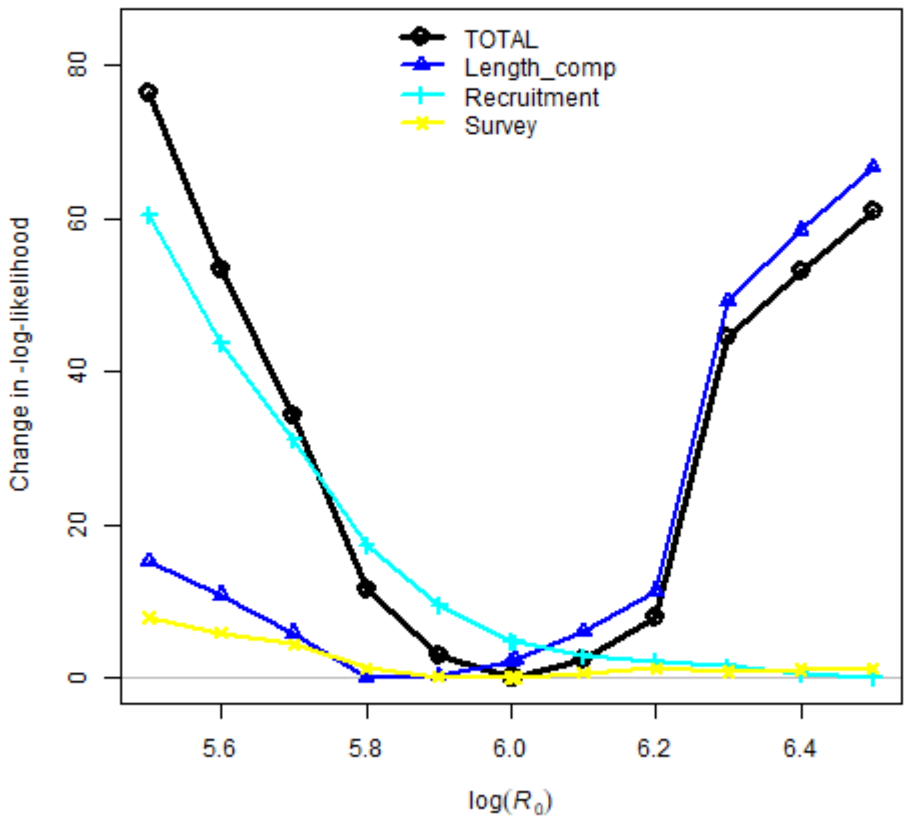

Figure 8. Overall likelihood profile on virgin recruitment (R_0) for the 2023 growth base-case model. The maximum likelihood estimate for ln(R_0) was 5.99.

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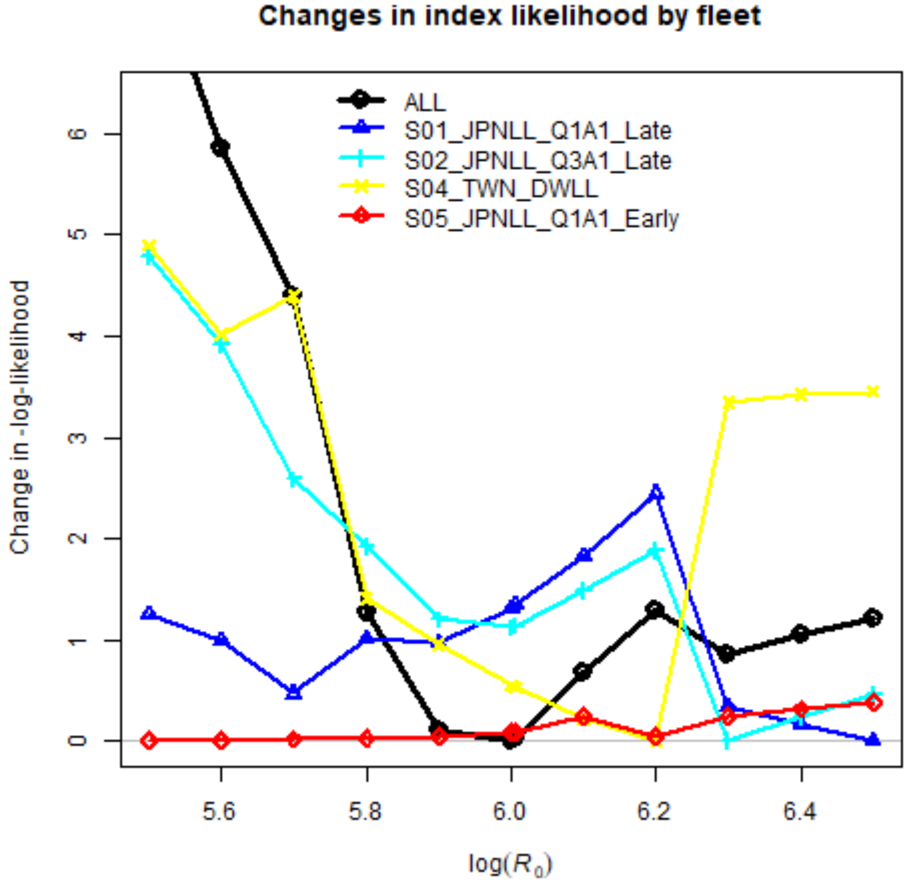

Figure 9. Likelihood profile on virgin recruitment (R_0) by CPUE fleet for the 2023 growth base-case model. The maximum likelihood estimate for ln(R_0) was 5.99.

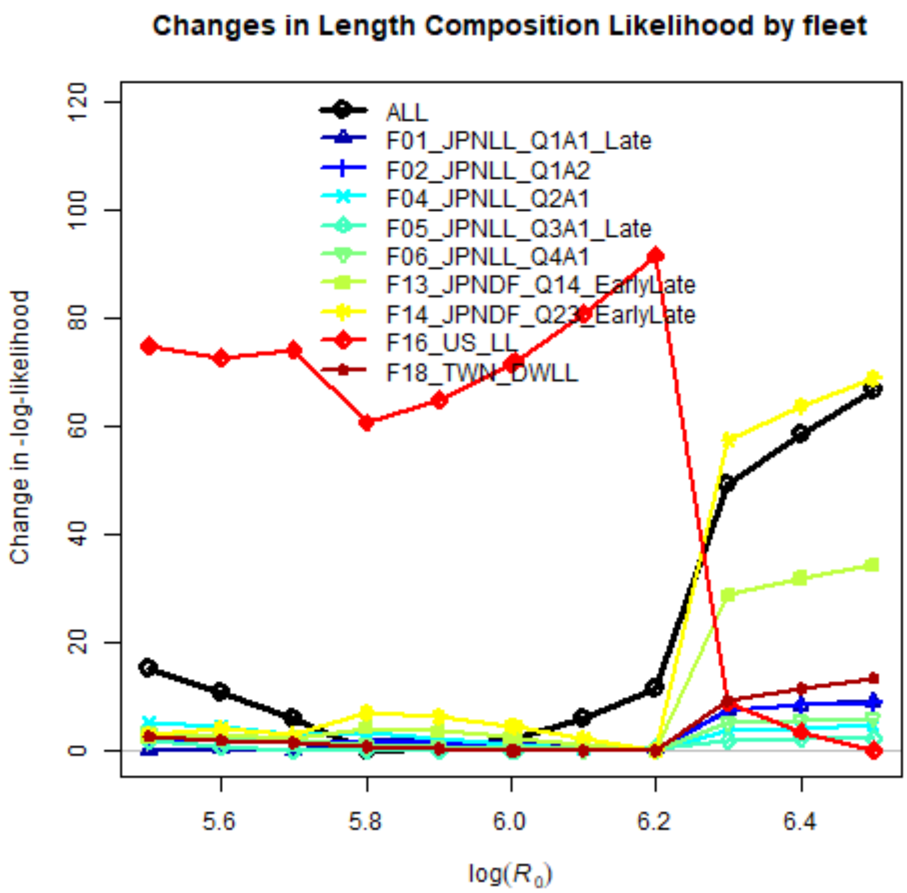

Figure 10. Likelihood profile on virgin recruitment (R_0) by size composition fleet for the 2023 growth base-case model. The maximum likelihood estimate for $\ln(R_0)$ was 5.99.

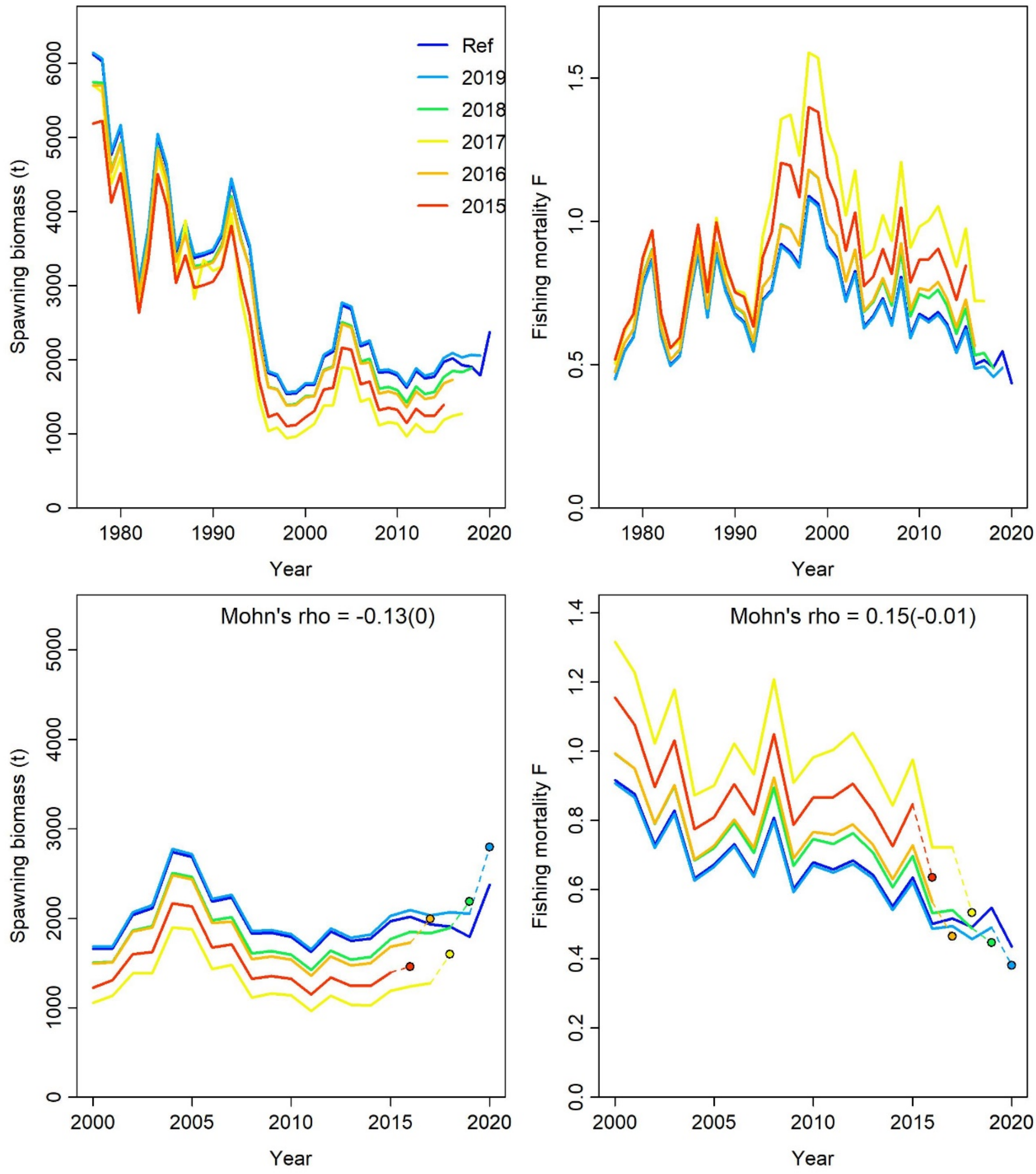

Figure 11. Retrospective analysis for spawning biomass (left) and fishing mortality (right) for the 2023 growth base-case model with a 5-year peel. Mohns rho between -0.15 and 0.2 indicate little to no retrospective pattern.

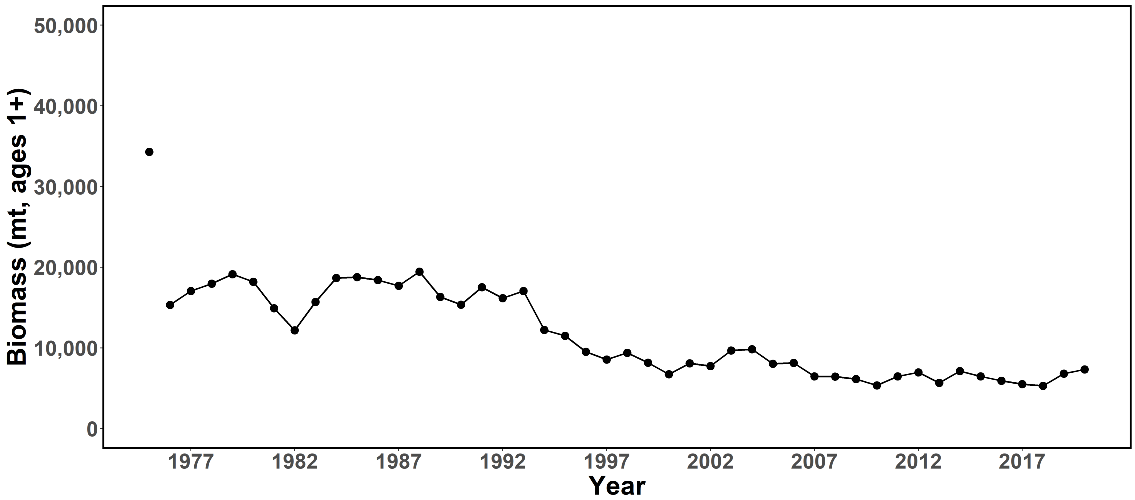

Figure 12. Annual total biomass of fish age 1+ estimated from the 2023 growth base-case model.

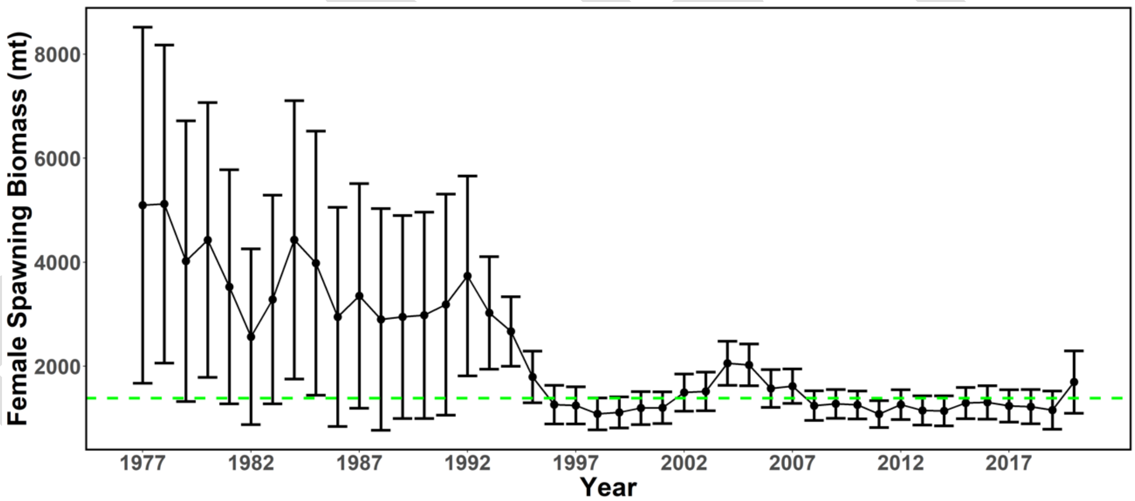

Figure 13. Female Spawning Stock biomass from the 2023 growth base-case model. Green line is 20%$SSB_{F=0}$ reference point.

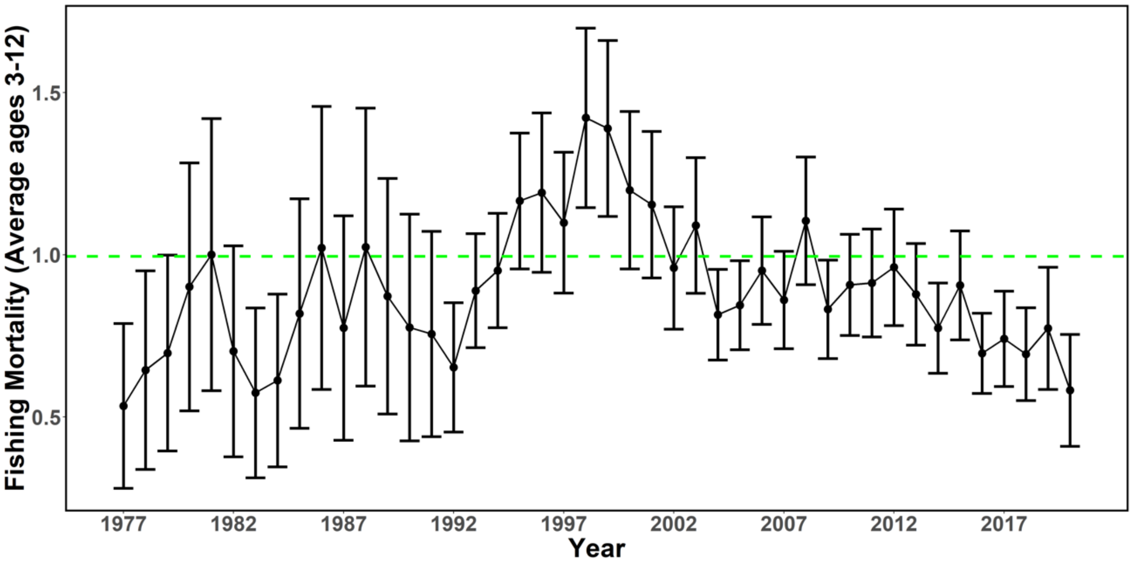

Figure 14. Annual fishing mortality estimated from the 2023 Growth base-case model. The F to reach 20%$SSB_{F=0}$ is indicated by the green dashed line.

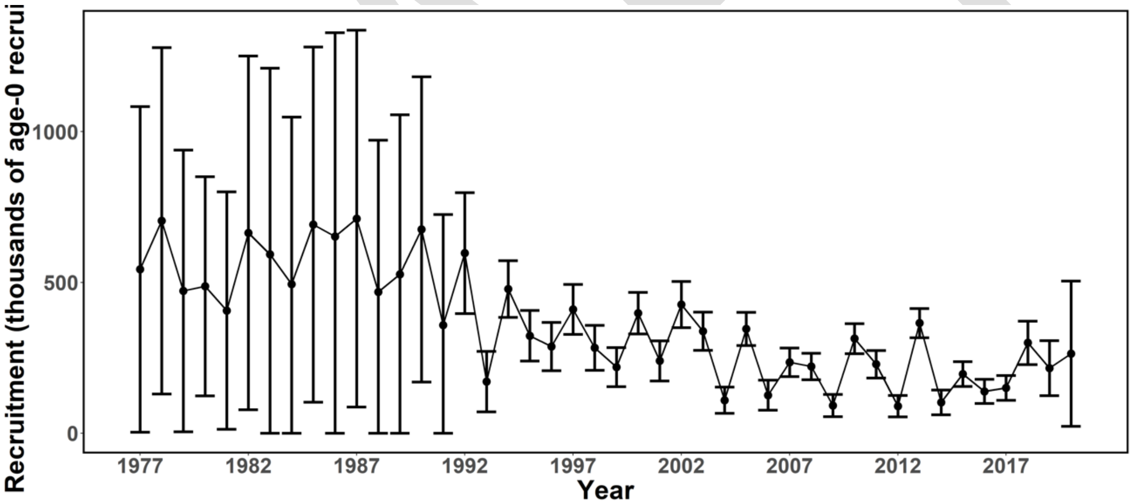

Figure 15. Annual recruitment (thousands of age-0 fish) for the 2023 growth base-case model.

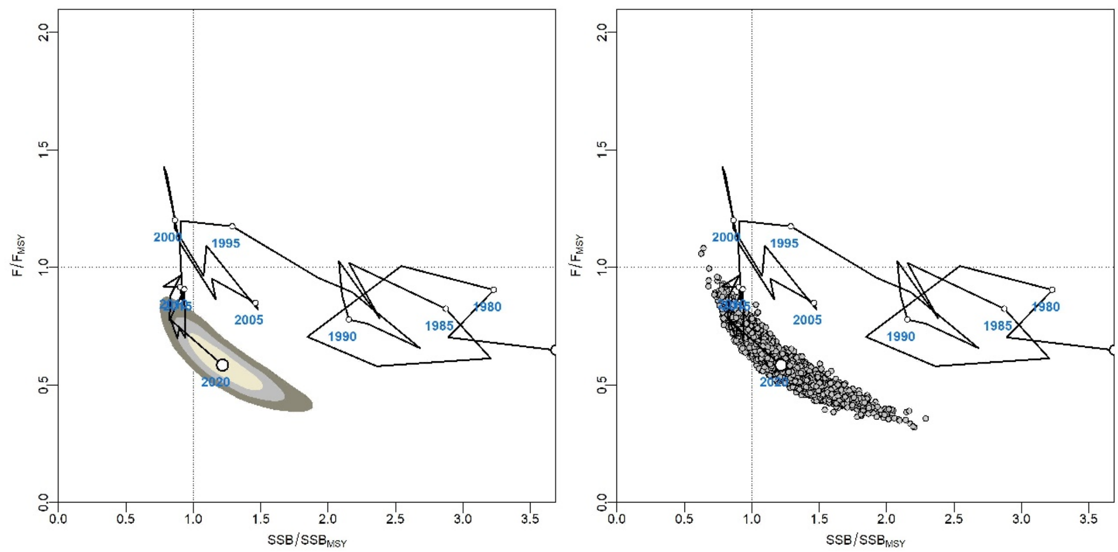

Figure 16. Kobe plot for the 2023 growth base-case model, note that the axis labels are wrong, stock status is measured relative to $20\%SSB_{F=0}$ dynamic B0 reference point not MSY. The probabilities for being in each quadrant: 85.7% green ($F_{2022}<F_{20\%SSBF=0}$, $SSB_{2020}>20\%SSB_{F=0}$); 14.26% yellow ($F_{2022}<F_{20\%SSBF=0}$, $SSB_{2020}<20\%SSB_{F=0}$); 0.04% red ($F_{2022}>F_{20\%SSBF=0}$, $SSB_{2020}<20\%SSB_{F=0}$); and 0% orange ($F_{2022}>F_{20\%SSBF=0}$, $SSB_{2020}>20\%SSB_{F=0}$).

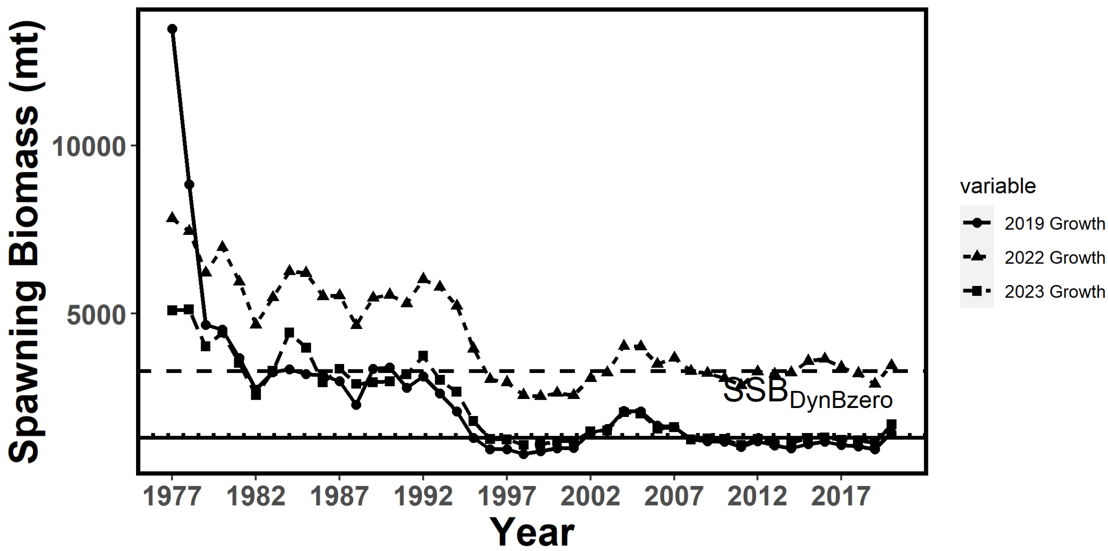

Figure 17. Plot of spawning stock biomass for each growth model: 2019 growth, 2022 growth, and 2023 growth. Horizontal lines indicate the $20\%SSB_{F=0}$ reference point for each model.

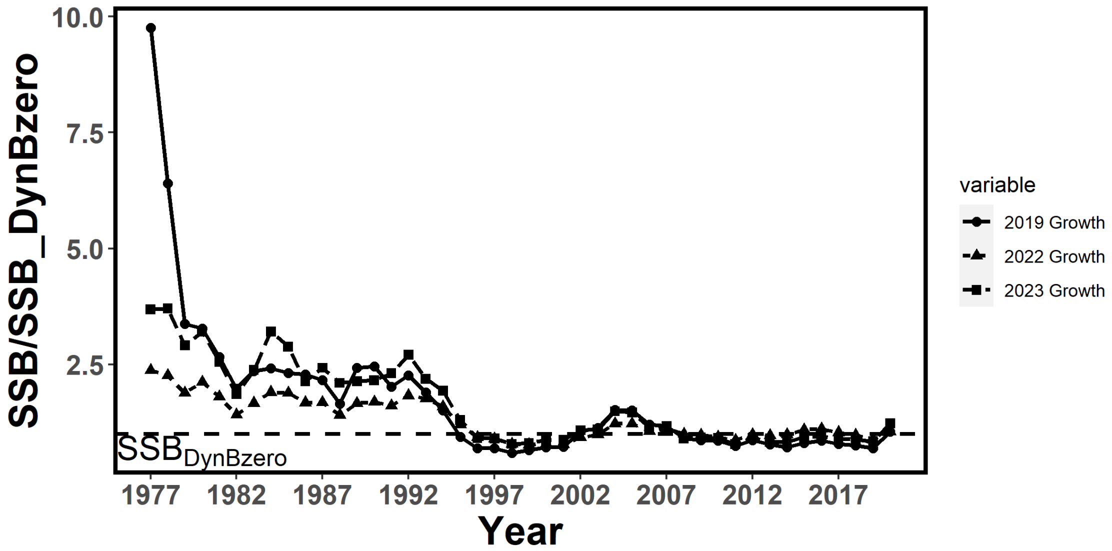

Figure 18. Plot of relative spawning stock biomass for each growth model: 2019 growth, 2022 growth, and 2023 growth. Horizontal line indicate the 20%$SSB_{F=0}$ reference point for each model.

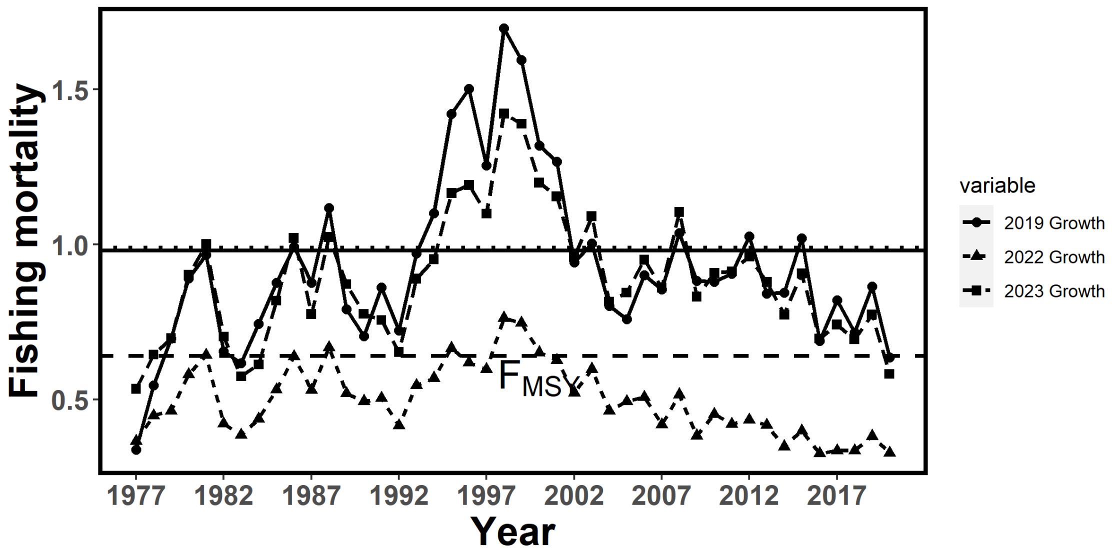

Figure 19. Plot of annual fishing mortality for each growth model: 2019 growth, 2022 growth, and 2023 growth. Horizontal lines indicate the F to reach 20%$SSB_{F=0}$ reference point for each model.

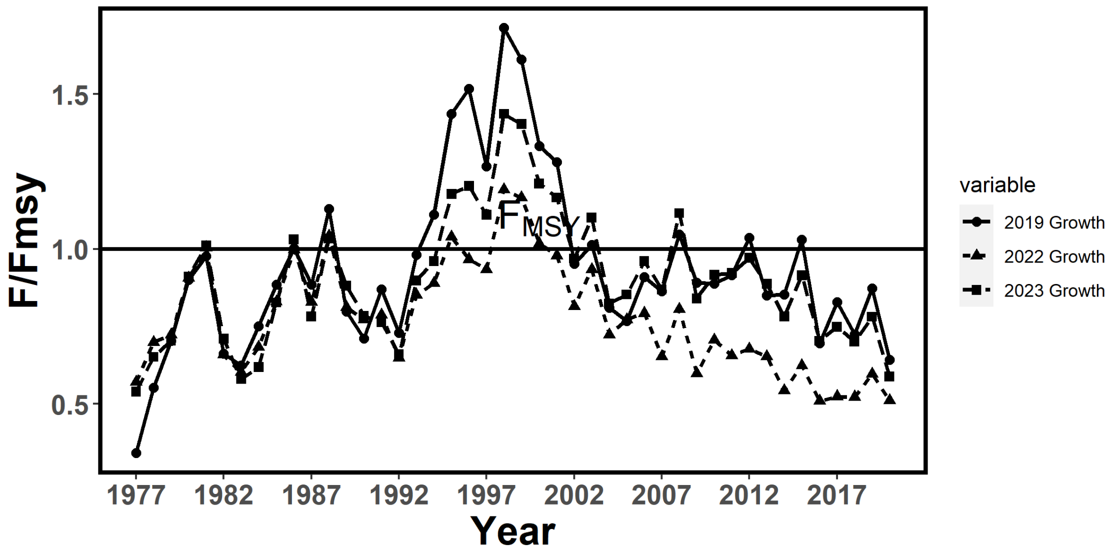

Figure 20. Plot of relative fishing mortality for each growth curve: 2019 growth, 2022 growth, and 2023 growth. Horizontal lines indicate the F to reach 20%$SSB_{F=0}$ reference point for each model.

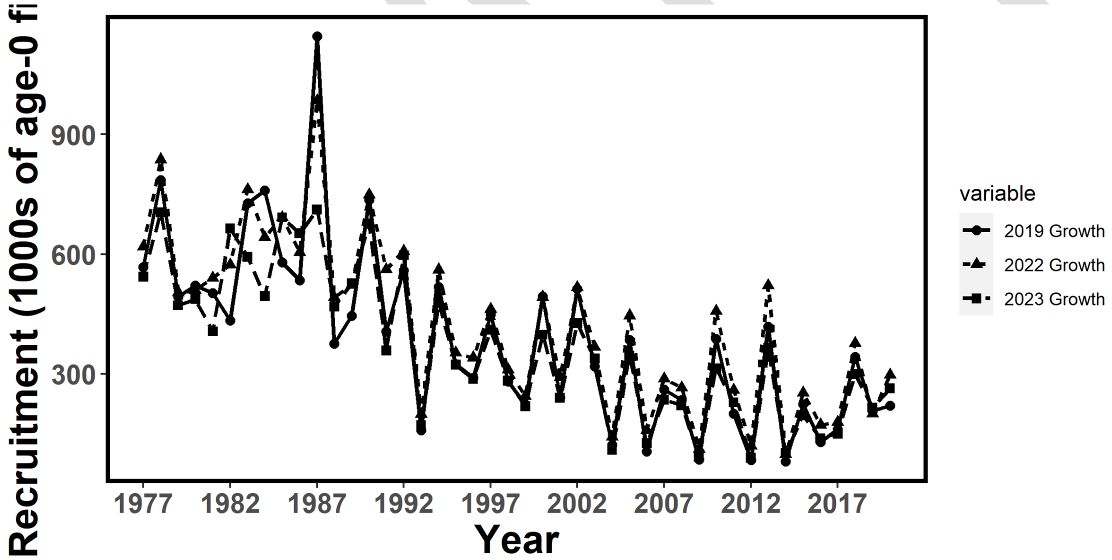

Figure 21. Recruitment in 1000s of age 0 fish for each growth model: 2019 growth, 2022 growth, and 2023 growth.