Atlantic States Marine Fisheries Commission

Retrospective Pattern Advice Document

Background

The retrospective patterns working group met over the summer of 2023 to draft advice for evaluating when and how to address retrospective patterns in stock assessments of ASMFC-managed species. The need for the group arose following recent assessments when guidelines from different fisheries science/management organizations (NEFSC and ICES) led to different and opposite advice about whether to adjust the terminal year estimate for these assessments. The WG drafted a flow chart to aid stock assessment subgroups in decision-making. The aim of this document is to provide a transparent procedure for determining whether a retrospective adjustment is necessary, while allowing the individual assessment subcommittees to use their species- and fishery-specific expertise and best judgment to make decisions when the need is less clear.

Using the Decision Tree

Begin with standard stock assessment retrospective analysis/diagnostic tools; you will need them as you work your way through the decision tree. Each of the shaded boxes specifies a recommended action to take (to apply or not to apply an adjustment). Some steps refer to tables of reference values, which currently supply generic values for short-lived (maximum age less than 15 years;) and long-lived species (maximum age greater than 15 years); age-cutoffs are based on the simulation work of Hurtado-Ferro et al. (2015). However, species-specific values may be added in the future. Note that, as with all elements of this document, the cut-off for short-lived species is a suggested guideline, but the Assessment Science Committee encourages analysts to use their discretion with respect to whether the species at hand has a life history more fitting to a short-lived or long-lived species (e.g., fast-growing, small-bodied, high natural mortality vs. slow-growing, large-bodied, low natural mortality). Questions can be answered objectively with a simple yes or no, with the exception of Question 4, which is a bit more complex. Further explanation/examples of “additional considerations” are given below.

In Question 4, the assessment team is asked to consider other aspects of the stock, its fishery, and the assessment methods that may give the analyst(s) additional information on which to base the adjustment decision. Such considerations include, but are not limited to:

- Biological characteristics:
    - Does the stock have a history of boom-and-bust cycles?
    - Is productivity and/or recruitment below average and seem to be driven by non-fishing factors?
    - Has the stock’s spatial distribution shifted offshore/out of the survey or management area?
- Fishery characteristics:
    - Have there been management-based changes to effort that were not well-reflected in the model?

    - Are there market-based effort changes that are unaccounted for?
    - Has fishing effort shifted spatially or temporally?
- Assessment & management characteristics:
    - Are there model-based uncertainties that are plausible and important to consider in setting management advice?
    - Historically, is the management of this stock effective, overly precautionary, or risk prone?

The assessment team should consider whether the observed retrospective pattern will continue into the future and whether stock status and stock projections adequately capture the assessment uncertainty when evaluating the risk of overfishing or being overfished. It is difficult to know for certain what is causing a retrospective pattern in the assessment, but things like changes in M, changes in survey catchability, and underestimated/missing catch can contribute to the pattern. If there is evidence for any of those factors occurring, then the likelihood of the retrospective pattern persisting in future assessments is increased, and adjusting for the pattern is more warranted. The probability of being overfished or experiencing overfishing in the terminal year of the assessment and of the projections incorporates uncertainty from the base run of the model, but not the uncertainty from the retrospective pattern.

The initial question of whether the retrospectively-adjusted values are within the uncertainty bounds of the base model estimates attempts to evaluate whether the retrospective pattern is significant enough to warrant an adjustment, or if it is minor compared to other sources of uncertainty that are included in the stock status determination and projections. Different assessments use different methods to calculate those uncertainty bounds, such as the asymptotic standard errors estimated from the Hessian, MCMC runs from the fitted model, and Monte Carlo bootstrapping approaches for important fixed input parameters.

Retrospectively-adjusted values could be outside the confidence intervals from one method, but not the other. The comparison should be made on the basis of the methods that are used to inform the projections and the probabilities of being overfished and experiencing overfishing, as those are the bounds of uncertainty that inform catch advice and stock status. However, those uncertainty bounds may not fully capture the model uncertainty observed in sensitivity runs or other model diagnostics; if those sources of uncertainty are consistent with the retrospective pattern (e.g., sensitivity runs and retrospective pattern both suggest a lower SSB and higher F than the base model), then adjusting for the pattern is more warranted. Similarly, if management has historically been less effective or less precautionary, the risk of overfishing or being overfished in the terminal year of the projections is higher and an adjustment may be more warranted.

Decision Tree Support Tables

Table 1: Bounds of ρ for short-lived and long-lived species bounds

Species	lower bound on ρ	upper bound on ρ
short-lived (max age ≤ 15 years)	-0.22	0.3
long-lived (max age > 15 years)	-0.15	0.2

Table 2: Peels outside of CIs for short-lived and long-lived species

Species	Peels outside of confidence interval
short-lived (max age ≤ 15 years)	2 out of 3 most recent
long-lived (max age > 15 years)	3 out of 5 most recent

Applying a Retrospective Adjustment

The first decision in exploring whether and how to apply a retrospective adjustment is the question of how many peels to do to calculate Mohn's rho. The ICES standard is 5 peels and the NEFSC standard is 7 peels, and Miller and Legault (2017) found the value of Mohn's rho often stabilized after 5 peels. The choice between 5 and 7 peels is left to the discretion of the TC/SAS on the basis of species life history and model formulation.

If the TC/SAS determines that an adjustment is warranted, the next decision is how to apply that adjustment. There are a number of different ways to adjust for a retrospective pattern. Currently, the NEFSC adjusts the terminal year estimates of F and SSB for status determination and the terminal year plus one estimates of population abundance at age for catch projections using the rho-values from the base model of the assessment, when an adjustment is deemed necessary (Legault 2020). The F and SSB values for stock status are adjusted using the F and SSB rho values, and the abundance estimates for the projections are adjusted either using the rho for SSB applied to all ages in the population or the age-specific rho values applied to each age. Legault (2020) suggested an alternative approach where the base model was rerun with alternate time series of catch, M, or other adjustments designed to minimize Mohn's rho and then using the average of this ensemble of models to provide status and catch advice. This approach is labor-intensive and requires significant expert judgment to capture potential causes and corrections for the retrospective patterns, and has not been simulation tested yet, but is an example of an alternative adjustment approach.

Identifying the best method to use to adjust for a retrospective pattern is beyond the current scope of this document, and would require extensive simulation testing. The current approach used by the NEFSC is straightforward, has passed peer review multiple times, and has been studied with simulation testing (e.g., Brooks and Legault 2016), and so is considered suitable for ASMFC use, but the assessment team may consider alternative approaches such as approaches used for ICES species, which may be better suited to individual species if deemed appropriate.

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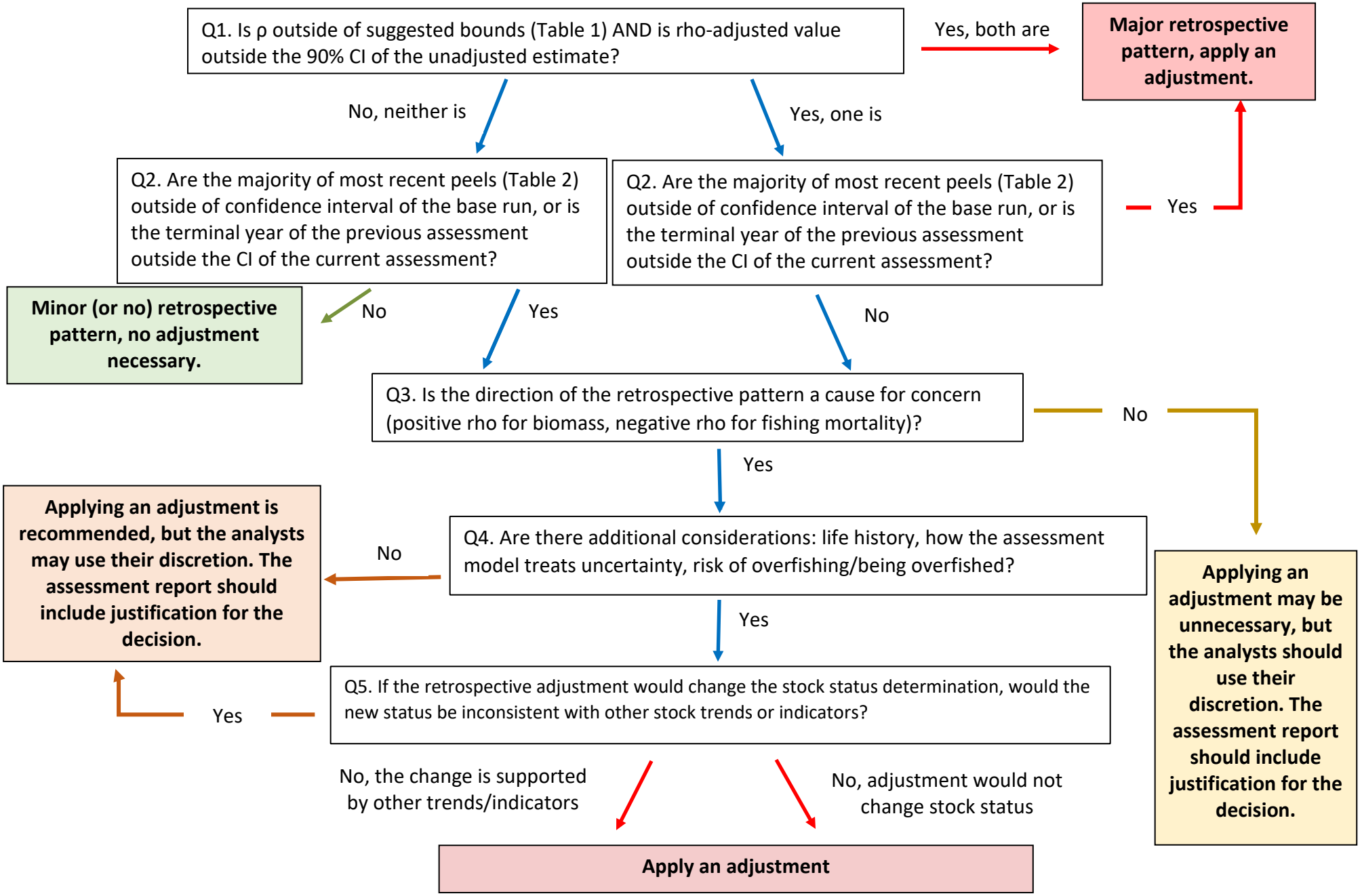


Appendix A: Applying the decision tree to an example species (Species A)

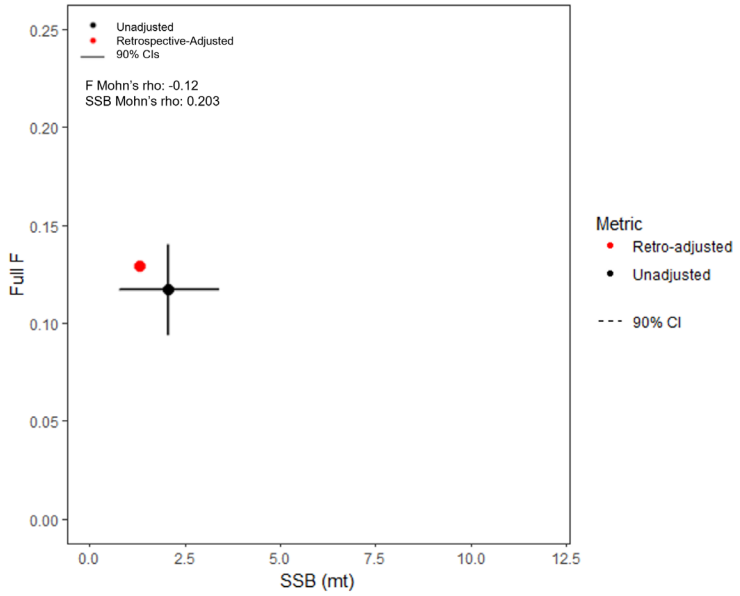
Q1. Is ρ outside of suggested bounds (Table 1) AND is rho-adjusted value outside the 90% CI of the unadjusted estimate?

A1. Species A is a long-lived species (maximum age ~30 years), so the bounds on ρ are -0.15 and 0.20.

Species A ρ for F = -0.12

Species A ρ for SSB = 0.203

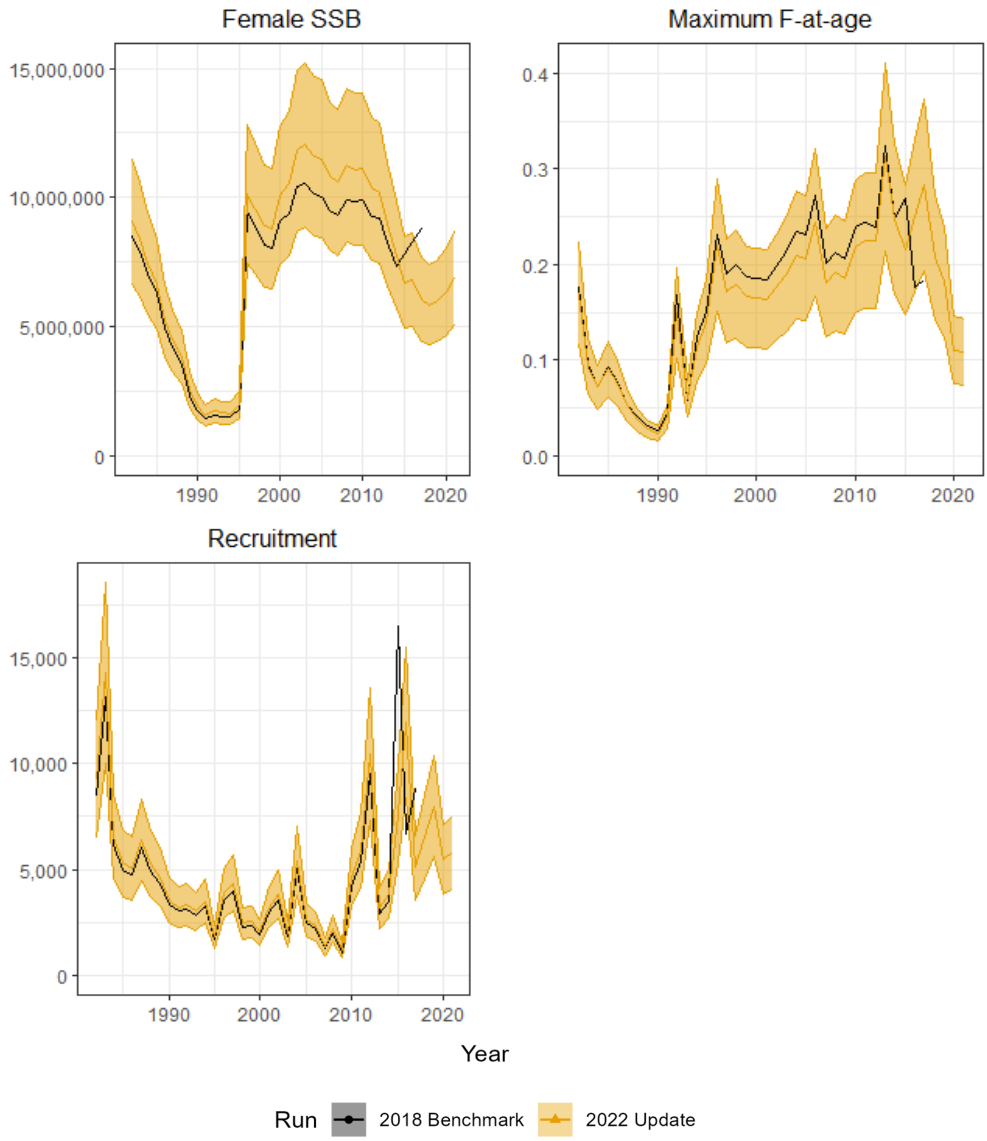
- ρ is NOT outside the suggested bounds for F or SSB
- The rho-adjusted values of F and SSB are NOT outside the 90% confidence intervals of the unadjusted values.



Go to Q2

Q2. Are the majority of most recent peels (Table 2) outside of their respective confidence intervals from the base run, or is the terminal year of the previous assessment outside the CI of the current assessment?

A2. For Species A, all 5 of the F and SSB peels are within the confidence intervals of the base run estimates, but the terminal year estimate of SSB from the last benchmark is just outside the 95% confidence intervals of that same year in the current update.



Go to Q3

Q3. Is the direction of the retrospective pattern a cause for concern (positive rho for biomass, negative rho for fishing mortality)?

A3. Yes, rho is positive for SSB and negative for F, suggesting the assessment overestimates SSB and underestimates F in the terminal year.

Go to Q4

Q4. Are there additional considerations: life history, how the assessment model treats uncertainty, risk of overfishing/being overfished?

A4. No. In general, the retrospective pattern is minimal, and the only estimate that was outside the confidence bounds was the 2017 SSB from the last assessment, and the estimate was only marginally outside of the bounds. Species A is a long-lived, relatively slow to mature species, and the fishery is operating mainly on older ages for which the estimates of recruitment are more robust – the most recent estimates of recruitment are less influential on estimates of exploitable biomass and SSB in the short term management. Recruitment has been below average for a number of years now, but this low recruitment regime is incorporated into the current F reference points and the projections. The stock was overfished in 2021 but not experiencing overfishing, and adjusting for the retrospective pattern would not change the stock status. Sensitivity runs from the last assessment update did not diverge significantly from the base run.

Recommendation:

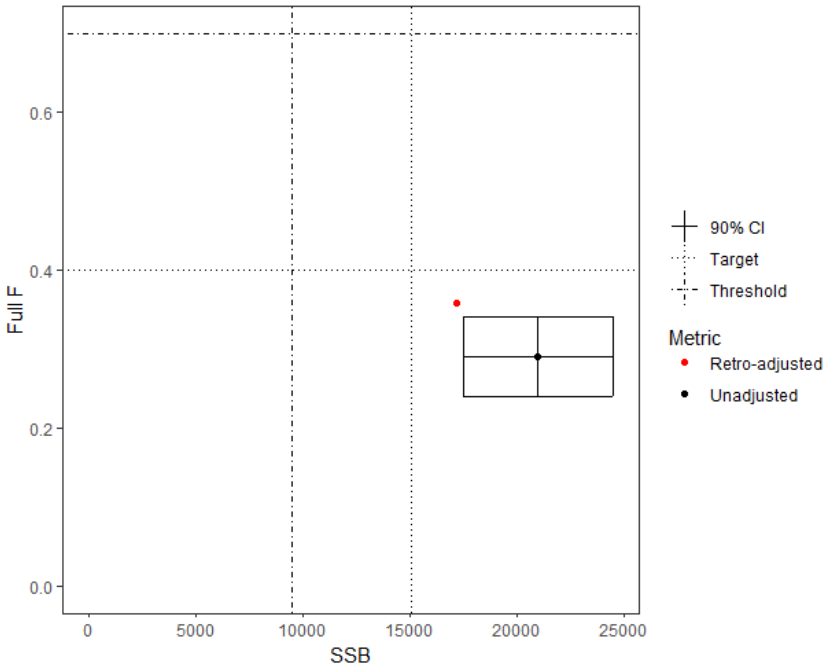
Applying an adjustment is recommended, but the analysts may use their discretion. The assessment report should include justification for the decision.

Appendix B: Applying the decision tree to an example species (Species B)

Q1. Is ρ outside of suggested bounds (Table 1) AND is rho-adjusted value outside the 90% CI of the unadjusted estimate?

A1. Species B is a short-lived species (maximum age = 9 years), so the bounds on ρ are -0.22 and 0.30.
Species B ρ for F = -0.19
Species B ρ for SSB = 0.22

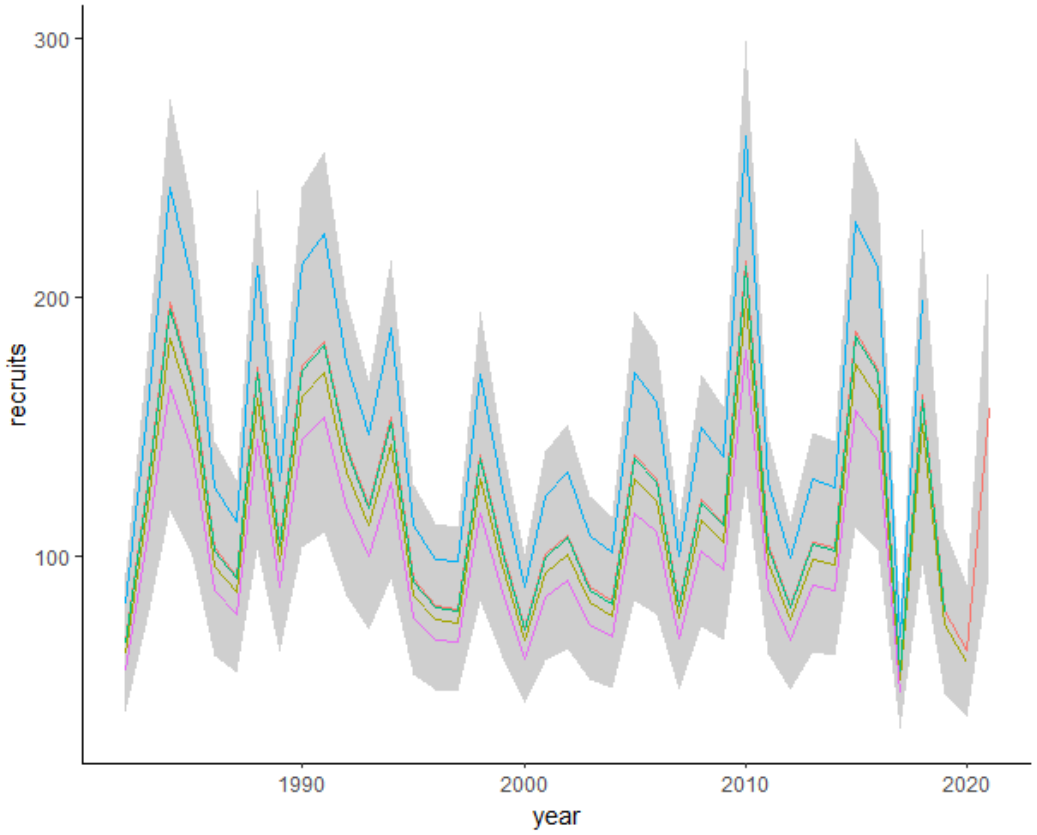
- ρ is NOT outside the suggested bounds for F or fecundity
- The rho-adjusted values of F and fecundity ARE outside the 90% confidence intervals of the unadjusted values.



Go to Q2

Q2. Are the majority of most recent peels (Table 2) outside of the confidence interval of the base run, or is the terminal year of the previous assessment outside the CI of the current assessment?

A2. For Species B, all 3 of the F and SSB peels are within the confidence intervals of the base run estimates (2 of the last 3 peels for recruitment are outside the confidence intervals). The estimates of F and fecundity from the 2019 benchmark are within the confidence intervals of the 2022 assessment update.



Go to Q3

Q3. Is the direction of the retrospective pattern a cause for concern (positive rho for biomass, negative rho for fishing mortality)?

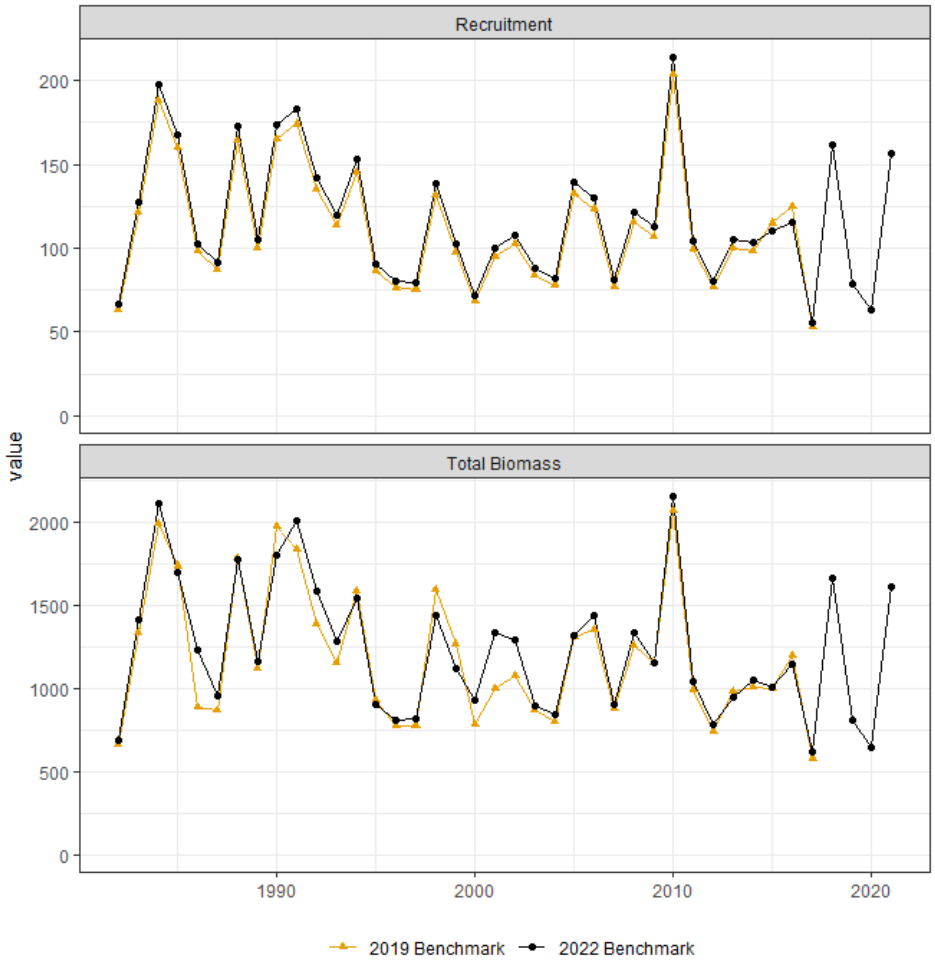
A3. Yes, rho is positive for SSB and negative for F, suggesting the assessment overestimates SSB and underestimates F in the terminal year.

Go to Q4

Q4. Are there additional considerations: life history, how the assessment model treats uncertainty, risk of overfishing/being overfished?

A4. Yes. The last few years of the update show a similar pattern to the last few years of the benchmark assessment: two unusually high years of recruitment before the terminal year, which translates into a sharp increase in biomass in the last two years of the assessment. However, those high estimates in the benchmark were revised downward in the assessment update, suggesting that the high estimates in the assessment update may be overestimates. The fishery operates mainly on ages 2-4, so the quota recommendations for the next 3 years of

the fishery are strongly influenced by the scale of biomass in the most recent years, increasing the risk of exceeding the F target in subsequent years if recruitment and biomass are overestimated in the last two to three years of the assessment. In addition, the retrospectively-adjusted values of F and SSBare outside the confidence intervals of the terminal year values, suggesting the projections are not adequately capturing the uncertainty from the retrospective pattern.



Go to Q5

Q5. If the retrospective adjustment would change the stock status determination, would the new status be inconsistent with other stock trends or indicators?

A5. Adjustment would not change stock status.

Recommendation
Apply an adjustment