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What caused the increase in retrospective pattern in the chub mackerel stock assessment in the Northwest Pacific?

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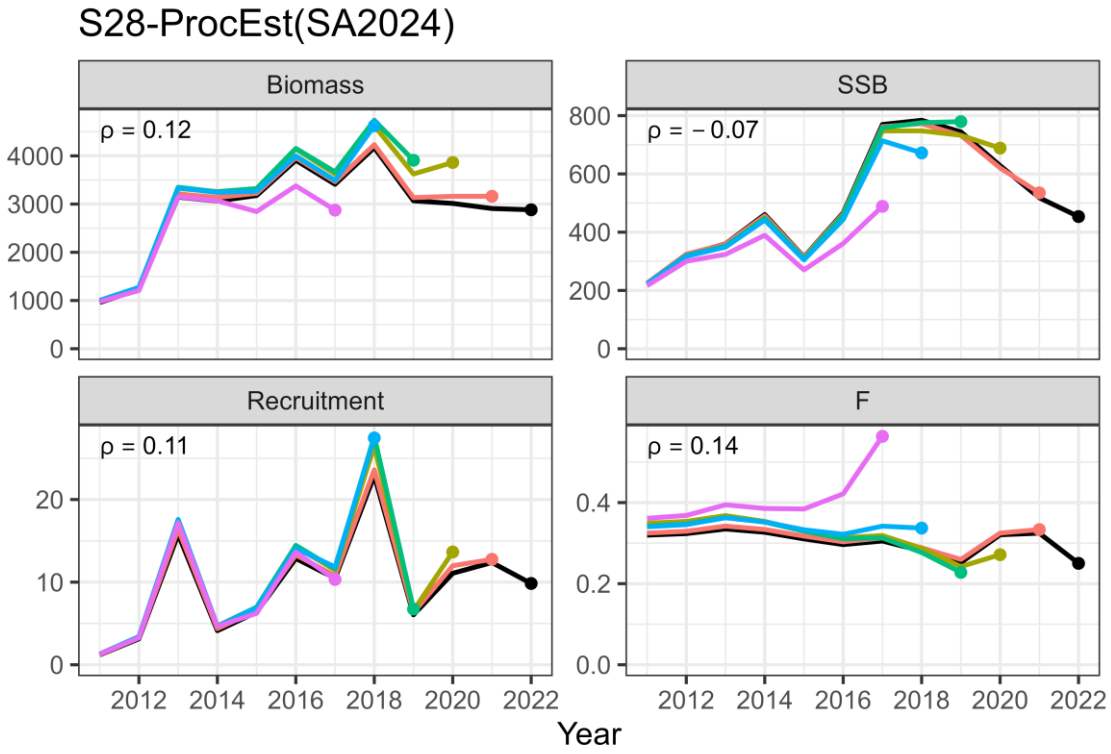
Summary

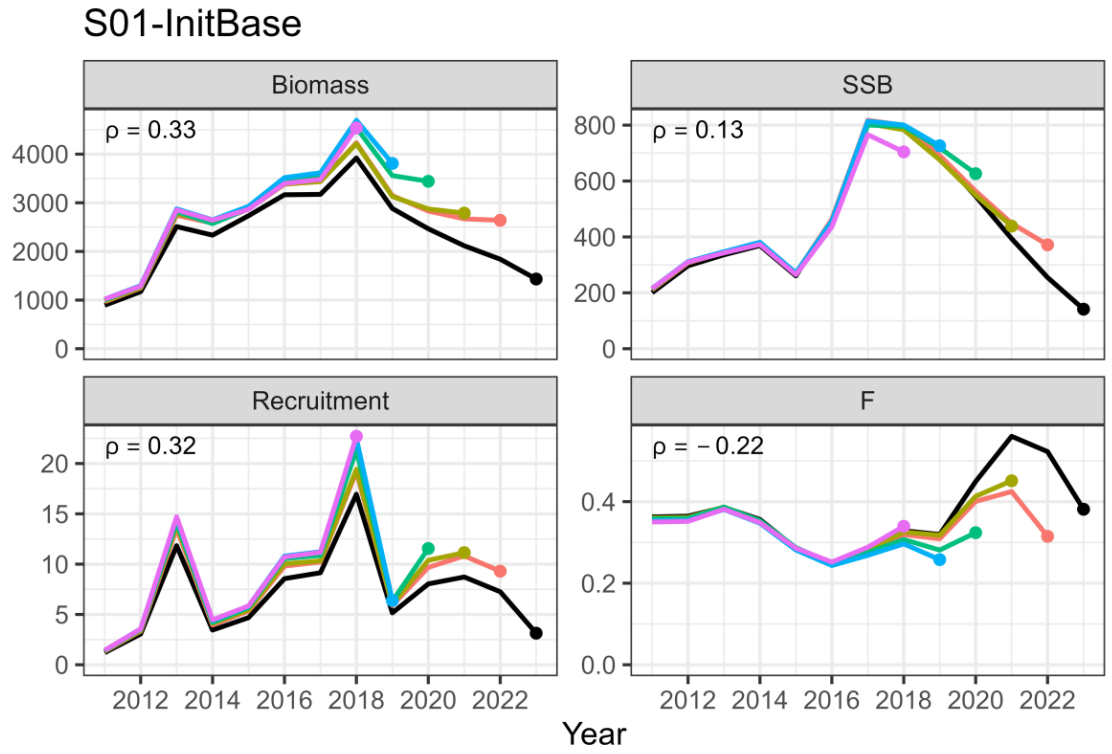
- In the 2025 provisional assessment of the Northwest Pacific stock of chub mackerel, retrospective patterns quantified by Mohn's rho for stock biomass and recruitment over the five-year retrospective analysis increased compared to the values in the previous year's assessment.
- An investigation into the cause revealed that the primary factor was that all index values for 2023 were lower than the predicted values of the model without 2023 indices, leading to a downward revision of recent stock biomass and recruitment when including the 2023 indices.
- The one-year shift in the reference period used to calculate Mohn's rho also contributed to the increase in the values.
- In contrast, changes in the stock assessment model settings had little effect.
- It was also found that revisions to catch-at-age data prior to 2022 contributed to a *reduction* of Mohn's rho.
- Retrospective pattens does not necessarily mean estimation bias and rather the update of estimates with new data is a crucial step in stock assessments.
- For the chub mackerel stock assessment, it is important to include the latest available abundance indices to mitigate future shifts in abundance estimates that would inevitably occur if the latest data were excluded.

Increase in retrospective bias

Base case in 2024 (S28-ProcEst)



A candidate base case in 2025 (S01-InitBase)



- Retrospective patterns quantified by Mohn's rho for stock biomass and recruitment over the five-year retrospective analysis increased from the base case assessment of previous year
- The data has been updated for one year (until 2022 in the 2024 base case assessment and until 2023 in the 2025 candidate base case).

Six hypotheses

- We examined the effects of individual changes made since last year's stock assessment on the retrospective pattern by setting the following six hypotheses

H01 Changes in model settings increased retrospective pattern.

H02 The inclusion of 2023 index values increased retrospective pattern.

H03 The inclusion of 2023 catch-at-age data increased retrospective pattern.

H04 Revisions to standardized index values prior to 2022 increased retrospective pattern.

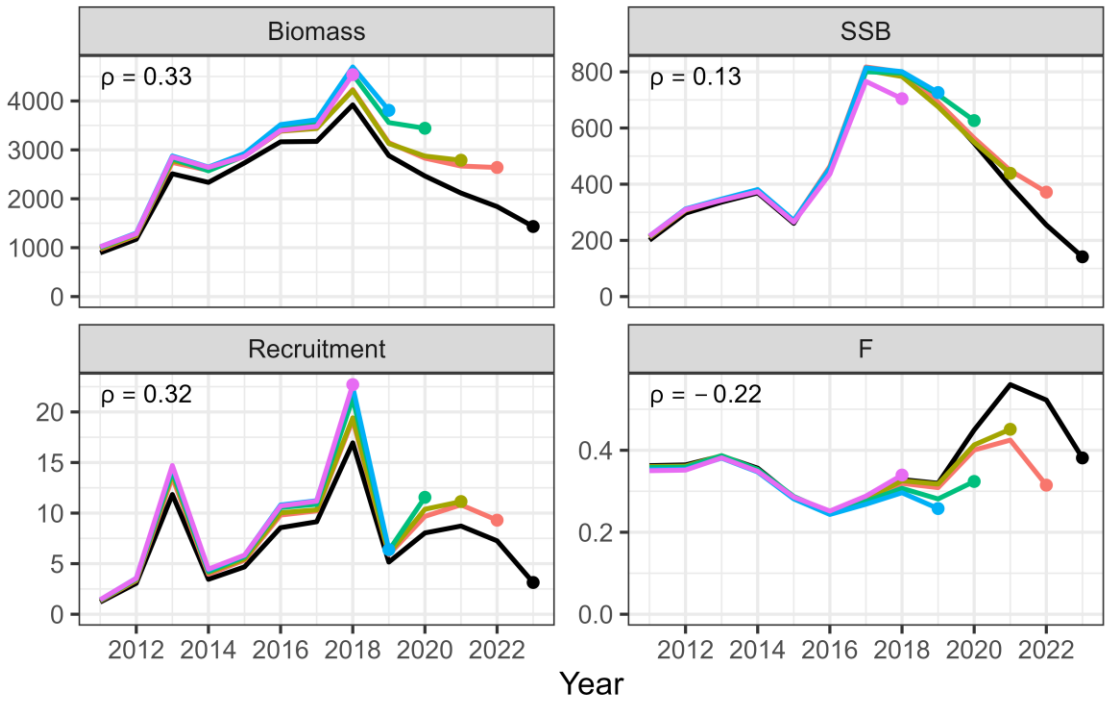
H05 Revisions to catch-at-age data prior to 2022 increased retrospective pattern.

H06 The one-year shift in the reference period used to calculate Mohn's rho increased retrospective pattern.

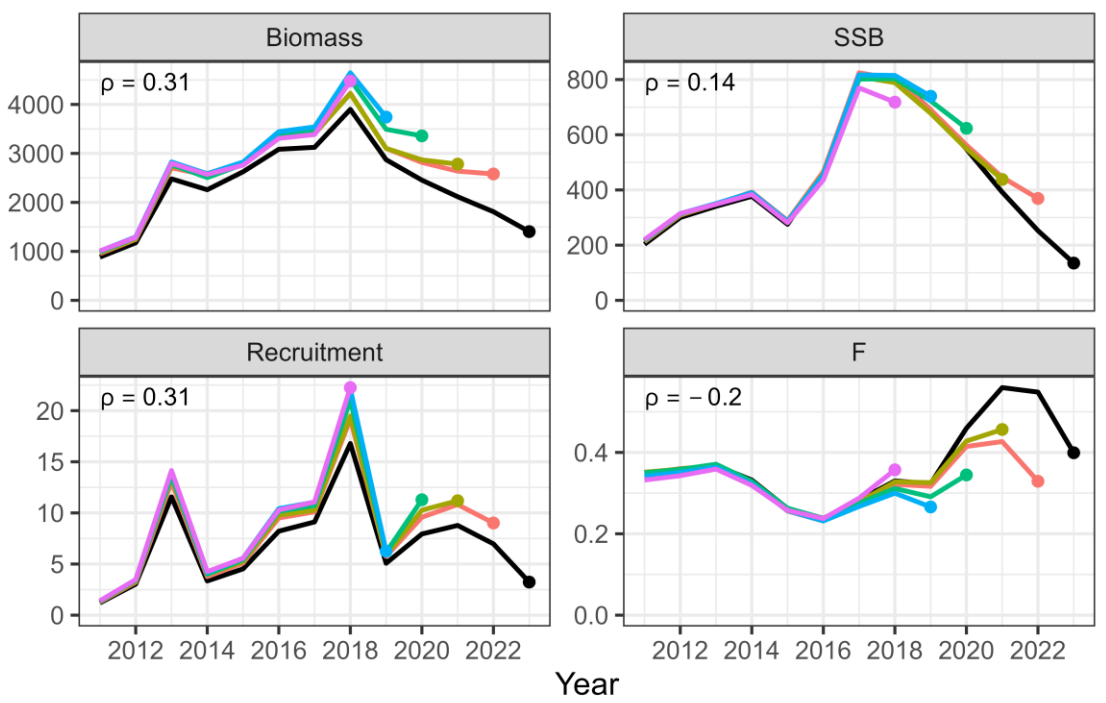
H01: Effects of the changes in model settings

- A different model setting on process errors in numbers-at-age and F-at-age and observation errors in catch-at-age were used as a result of model selection
- Analyzed a model in which the process and observation error structures were set to match that of last year's base case (H01-Modconfig)

S01-InitBase



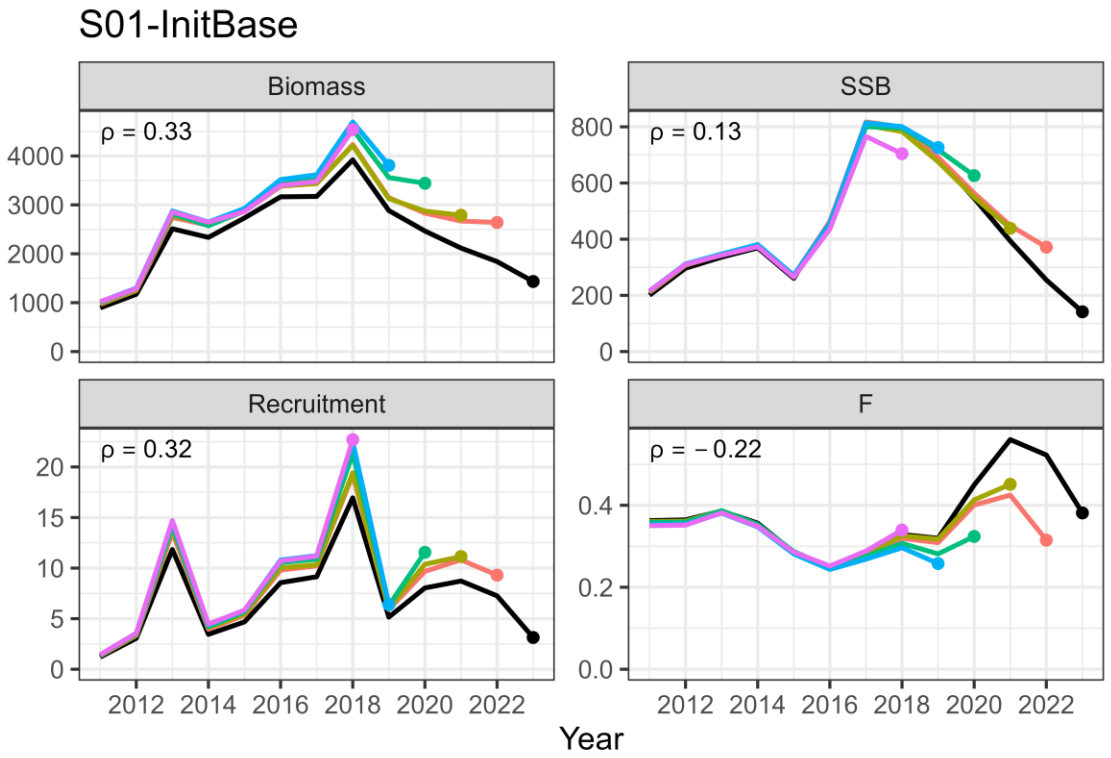
H01-ModConfig

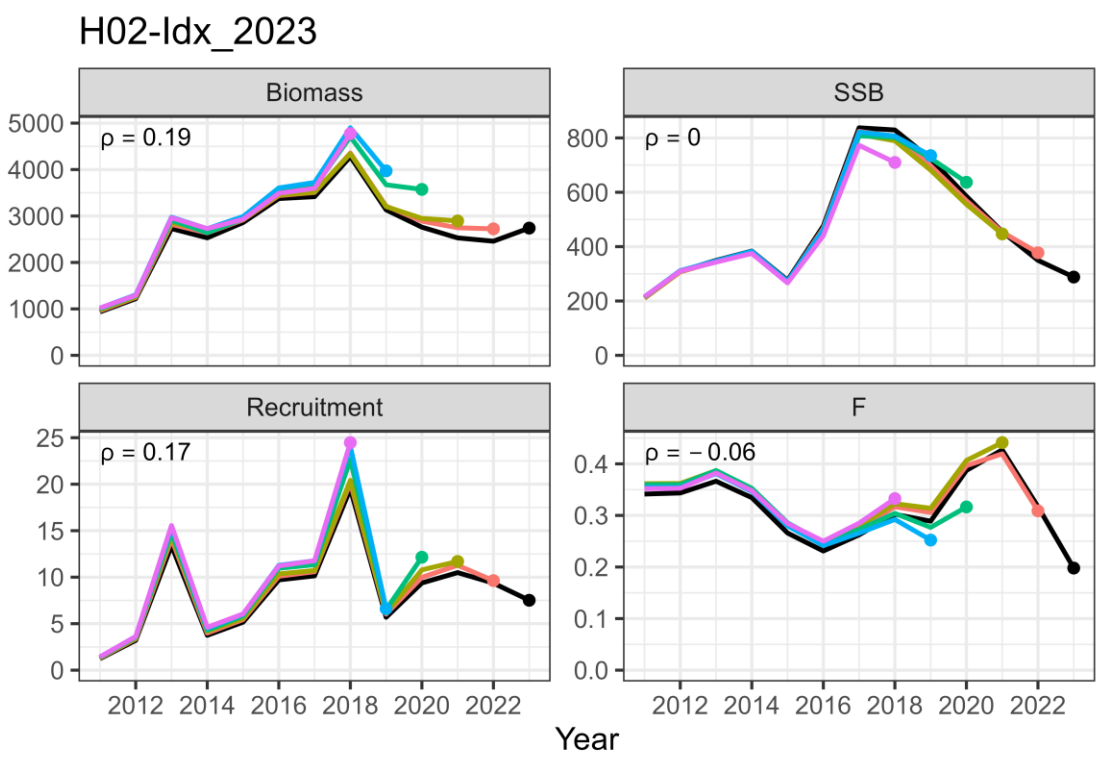


The values of Mohn's rho were almost identical to those of S01-InitBase (Fig. 1), leading us to reject the hypothesis that the change in model settings increased the retrospective pattern

H02: Effects of the inclusion of 2023 index values

- To test this hypothesis, parameter estimation was first conducted using the model configuration of S01-InitBase without the 2023 index values.
- The expected values of the 2023 indices from this model were then used as pseudo-observations in SAM

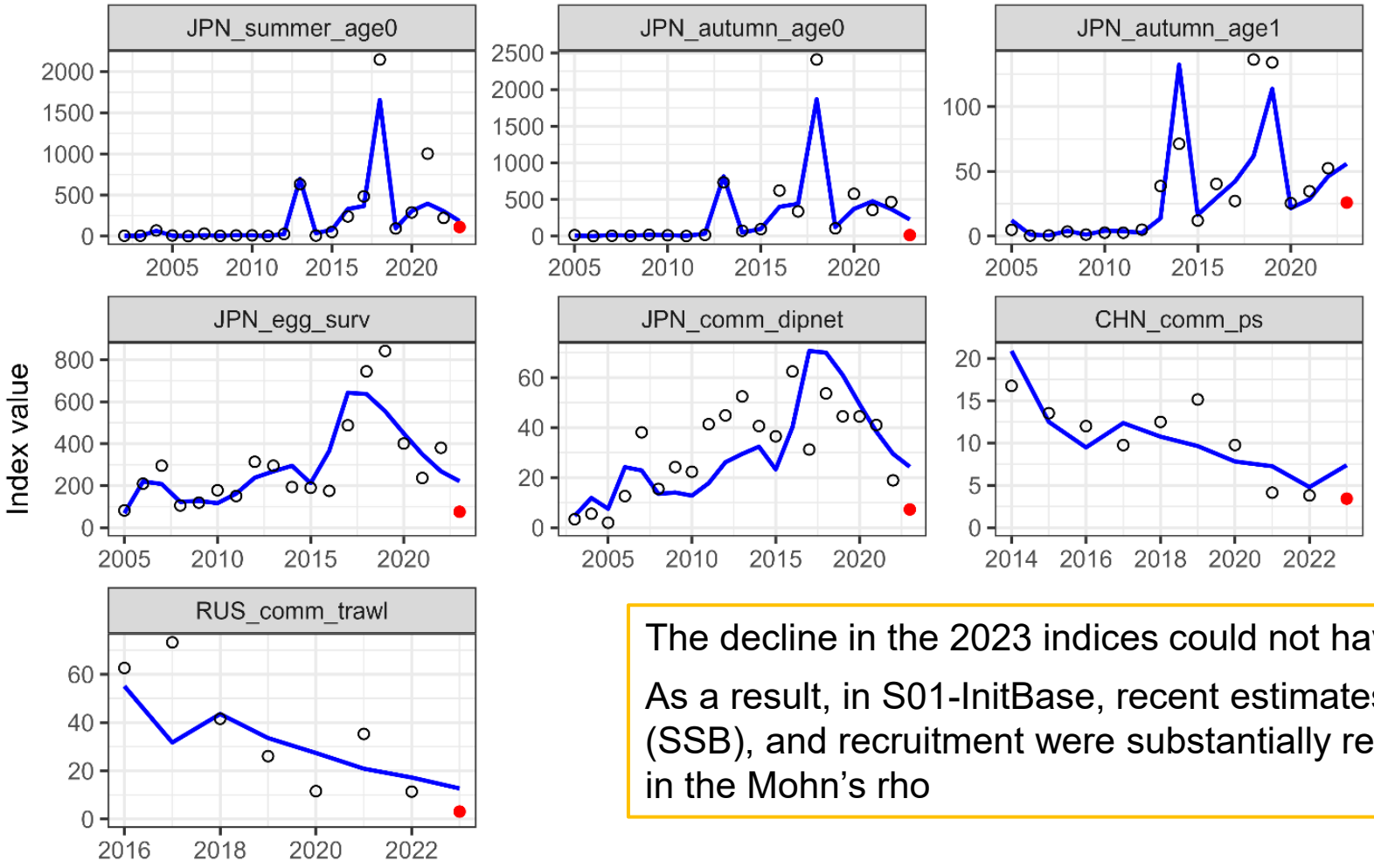




A retrospective analysis using this model (H02-Idx_2023) showed that the absolute values of Mohn's rho decreased by 0.13–0.16 compared to S01-InitBase

All 2023 abundance indices are lower than predicted

The predicted index values (blue lines) in the model without indices in 2023 (H02-Idx_2023) and the actual indices in 2023 (red dots). Circles represent indices through 2022.

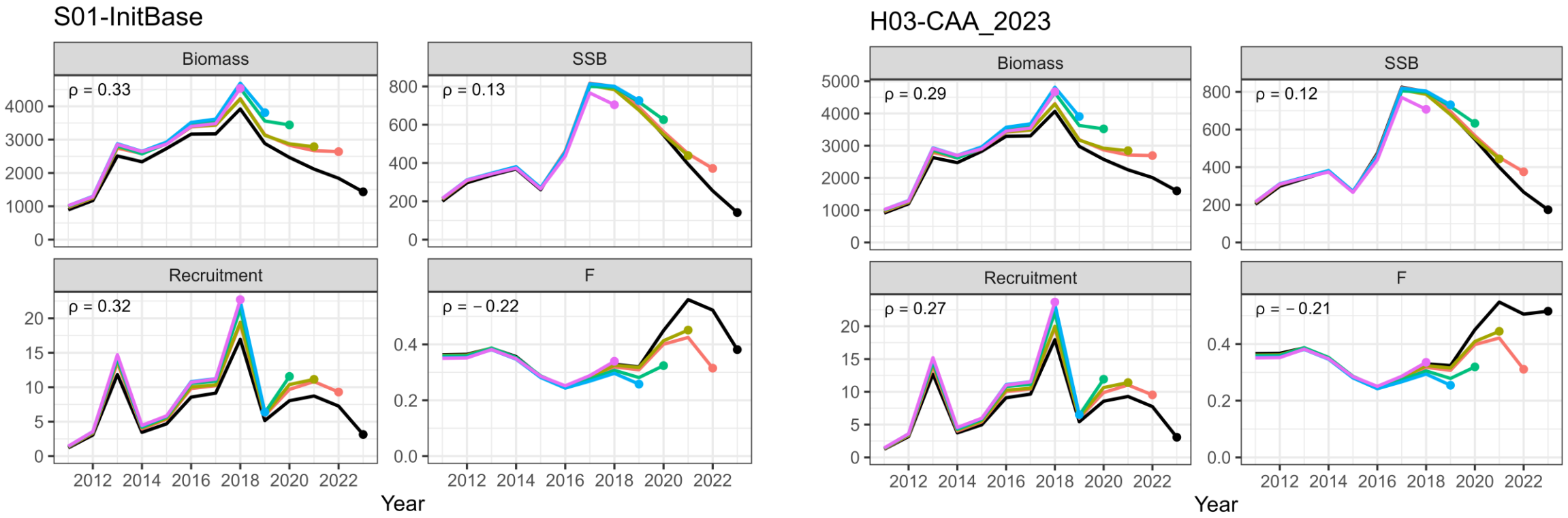


The decline in the 2023 indices could not have been predicted from data up to 2022.

As a result, in S01-InitBase, recent estimates of stock biomass, spawning stock biomass (SSB), and recruitment were substantially revised downward, which led to the increase in the Mohn's rho

H03: Effects of the inclusion of 2023 catch-at-age

- Similar to H02, parameter estimation was first conducted using the model configuration of S01-InitBase without the 2023 catch-at-age.
- The predicted values of the 2023 catch-at-age from this model were used as pseudo-observations in SAM



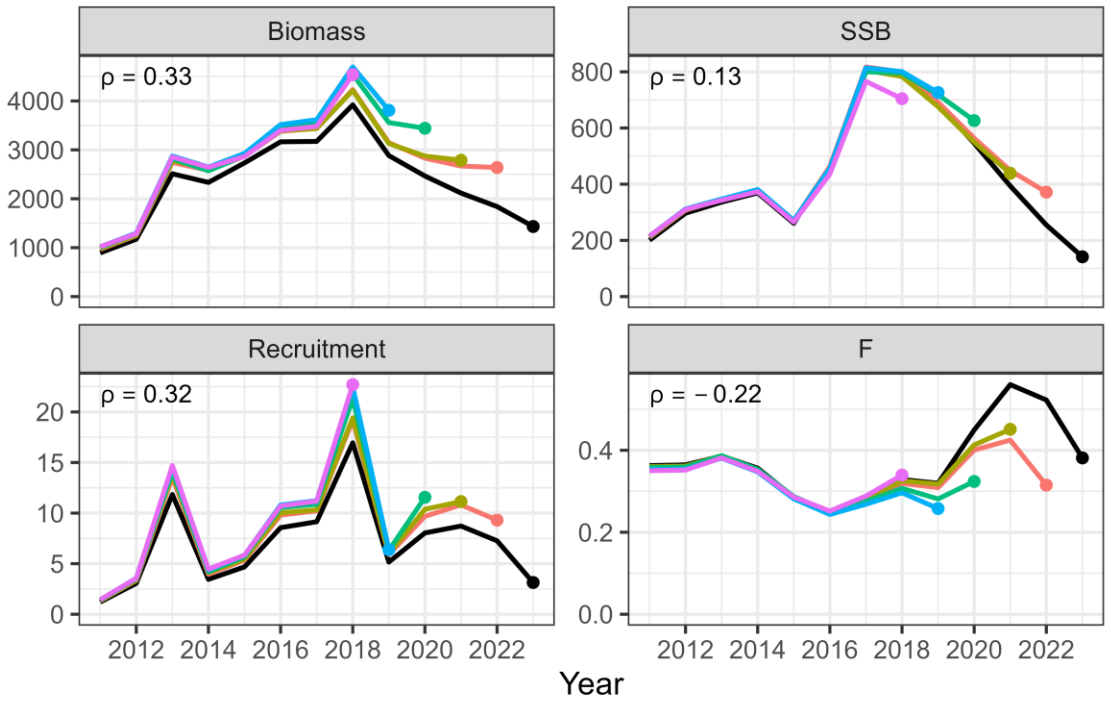
The absolute values of Mohn's rho decreased by 0.01–0.05 compared to S01-InitBase

The 2023 catch-at-age data may have contributed slightly to the increase in retrospective pattern.

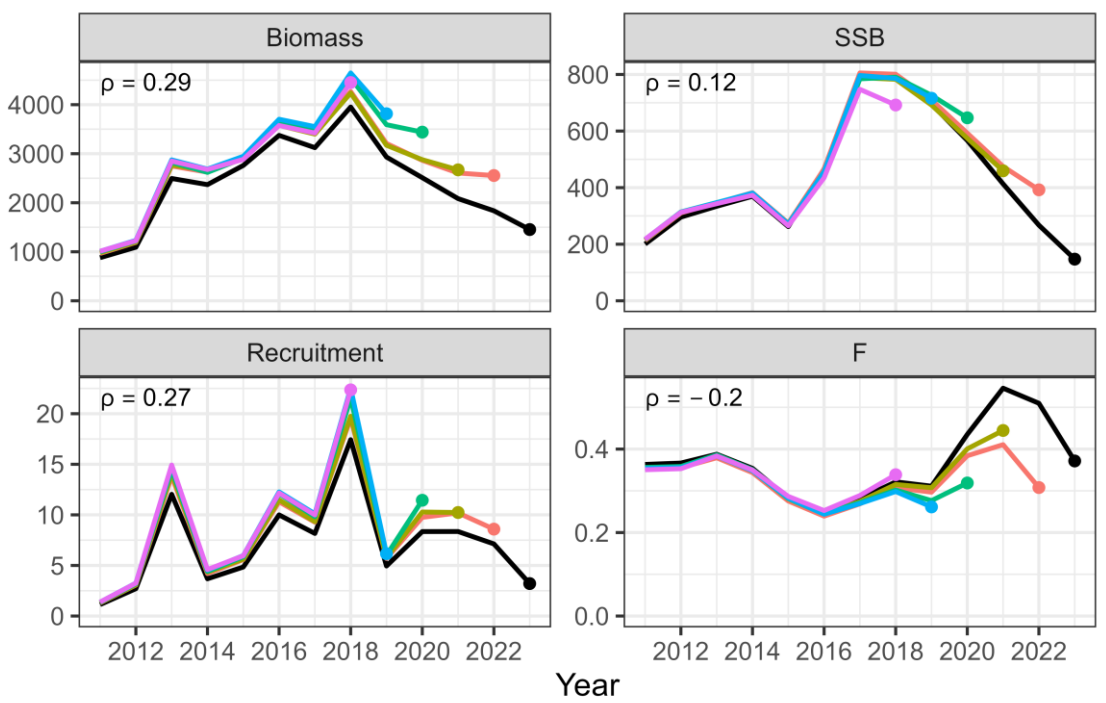
H04: Effects of revisions to standardized index values prior to 2022

- Pseudo-data were created by replacing the data up to 2022 for six indices (excluding the Russian CPUE) with the values used in last year's assessment
- The replacement was made by multiplying last year's index values by the ratio of the mean values of the indices up to 2022 between this year and last year

S01-InitBase



H04-Idx_to2022



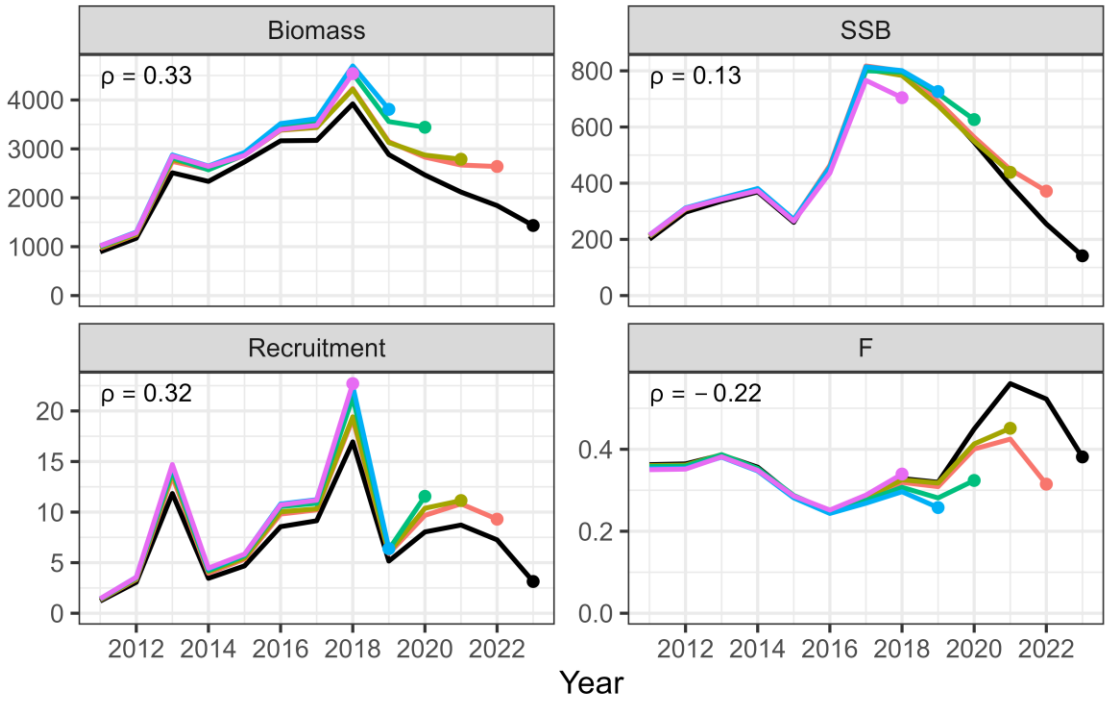
The absolute values of Mohn's rho decreased by 0.01–0.05 compared to S01-InitBase,

Revisions to the pre-2022 indices may also have been a minor contributing factor to the increase in retrospective pattern.

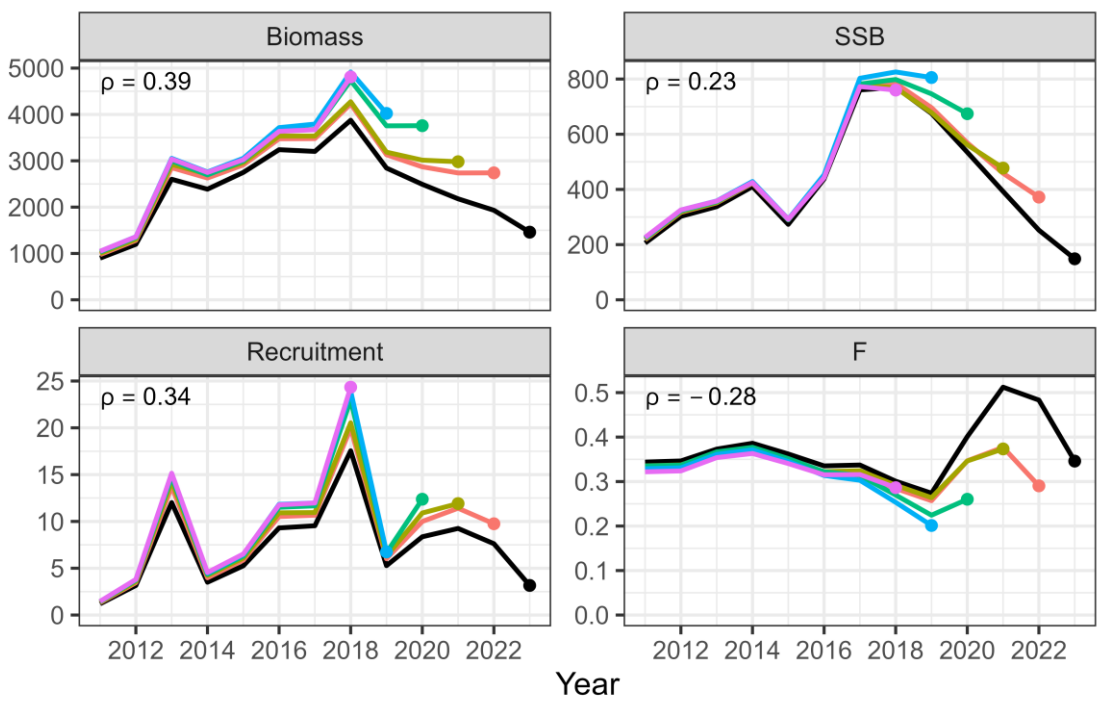
H05: Effects of revisions to catch-at-age data prior to 2022

- The catch-at-age data prior to 2022 were revised from last year to resolve discrepancies between the NPFC Annual Summary Footprint and the data used in the stock assessment
- A model (H05-CAA_to2022) was analyzed in which the catch-at-age data prior to 2022 were replaced with those used in last year's assessment, and a retrospective analysis was conducted.

S01-InitBase



H05-CAA_to2022



Retrospective pattern as measured by Mohn's rho increased by 0.02–0.10 compared to S01-InitBase.

This suggests that the revision of the catch-at-age data prior to 2022 contributed to a *reduction* in retrospective pattern.

H06: Effects of one-year shift in the reference period

- Five-year reference period shifted one year (2017-2021 in last year and 2018-2022 in this year)
- In last year, the Mohn's rho values in 2017 were negative for stock biomass, SSB, and recruitment
- In this year, the Mohn's rho values in 2018 were positive for stock biomass, SSB, and recruitment
- When the reference period was aligned to the common years (2018–2021) between the two analyses, these differences decreased from 0.21 to 0.11 for stock biomass, 0.20 to 0.04 for SSB, 0.20 to 0.18 for recruitment, and 0.36 to 0.14 for F

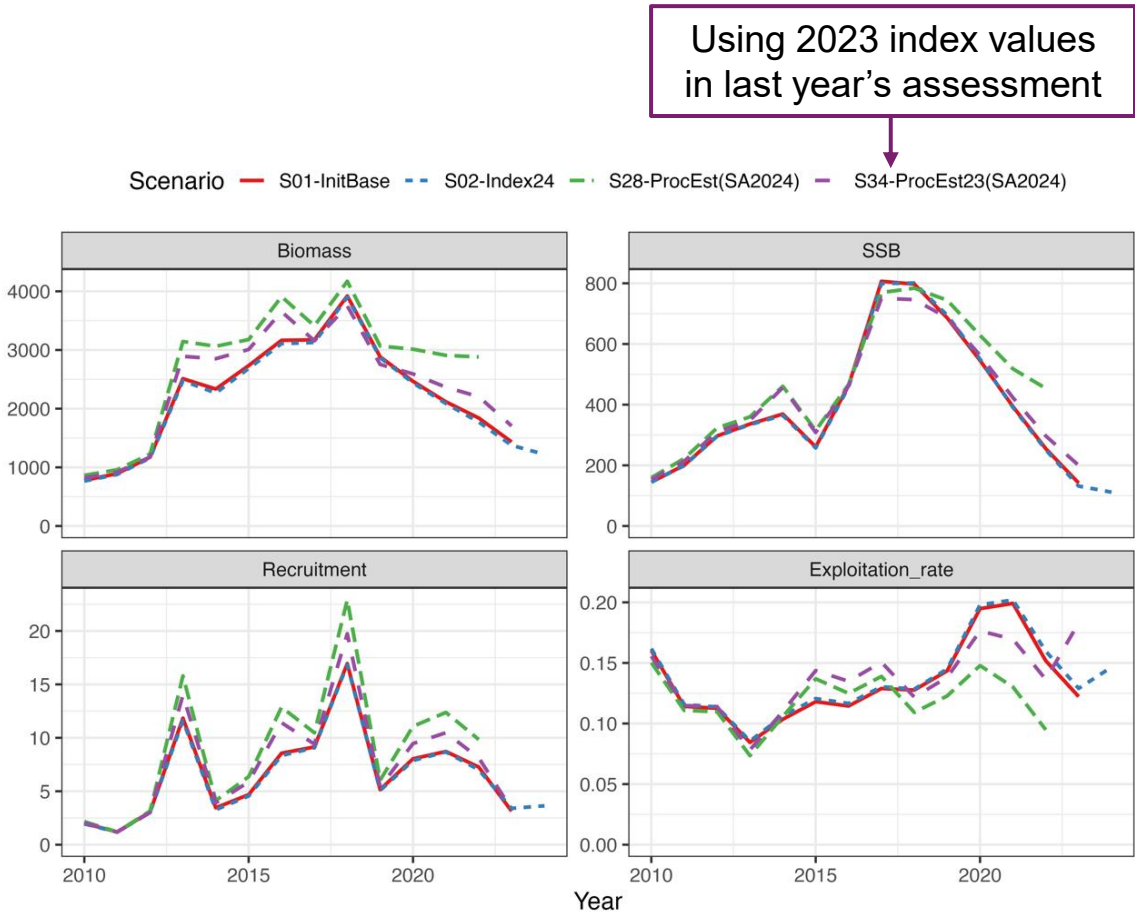
	Biomass		SSB		Recruitment		F	
Year	S01	S28	S01	S28	S01	S28	S01	S28
2022	0.434	-	0.458	-	0.281	-	−0.410	-
2021	0.317	0.087	0.114	0.032	0.277	0.031	−0.208	0.012
2020	0.396	0.282	0.148	0.095	0.438	0.233	−0.294	−0.185
2019	0.321	0.274	0.059	0.047	0.239	0.116	−0.202	−0.124
2018	0.158	0.109	−0.117	−0.143	0.340	0.199	0.035	0.179
2017	−0.108	−0.157	−0.319	−0.365	−0.095	−0.014	0.445	0.837
Ave2018–2022 or Ave2017–2021*	0.325	0.119	0.132	−0.067	0.315	0.113	−0.216	0.144
Ave2018–2021	0.298	0.188	0.051	0.008	0.323	0.145	−0.167	−0.029

The shift in the reference period accounted for 0.02–0.22 of the change in Mohn's rho and was a major factor in reversing the direction of retrospective pattern for SSB and F.

Conclusions

- The main factors contributing to the increase in retrospective pattens represented by 5-years Mohn's rho were:
  1. the substantial downward revision of estimated stock biomass due to uniformly low abundance indices in 2023
  2. the one-year shift in the reference period used to calculate Mohn's rho.
- Retrospective analysis is a classical diagnostic tool that has been used to evaluate model robustness (Carvalho et al., 2021; Kell et al., 2021), and the presence of retrospective pattern does not necessarily indicate model misspecification or bias in the estimates (Breivik et al., 2023; Cadrin, 2025).
- Although the 2023 index values were not included in last year's base-case assessment, all but the Chinese CPUE were already available at the time.
- It has been shown that if these index values had been used explicitly at that time, the degree of downward revision accompanying this year's data update would have been smaller

Fig. 32 in NPFC-2025-TWG CMSA11-WP06



- To improve both the accuracy and robustness of stock biomass estimates, it is recommended that the most recent abundance indices (i.e., 2024 in this year's case) be included in the chub mackerel stock assessment.