Summary of the Pacific saury SS3 assessment in 2025

NPFC SSC PS 16

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bluematter

Summary of modeling progress in 2025

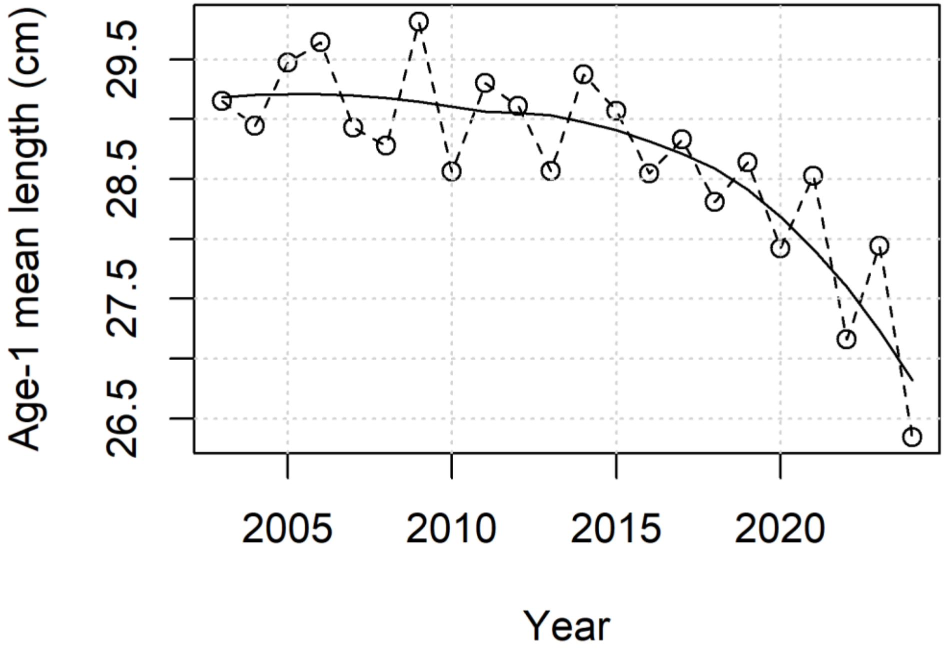
- WGNSAM 2 (May 2025): Converted annual model to seasonal model. Multiple spawning activity in calendar year (1st, 2nd, and 4th quarter) and sub-annual cohorts provided better description of biology and better fit to aggregate fishery length composition

- WGNSAM 3 (November 2025): Continued development of seasonal model with data update from September SSC PS 15, with final time step in 2025, season 4

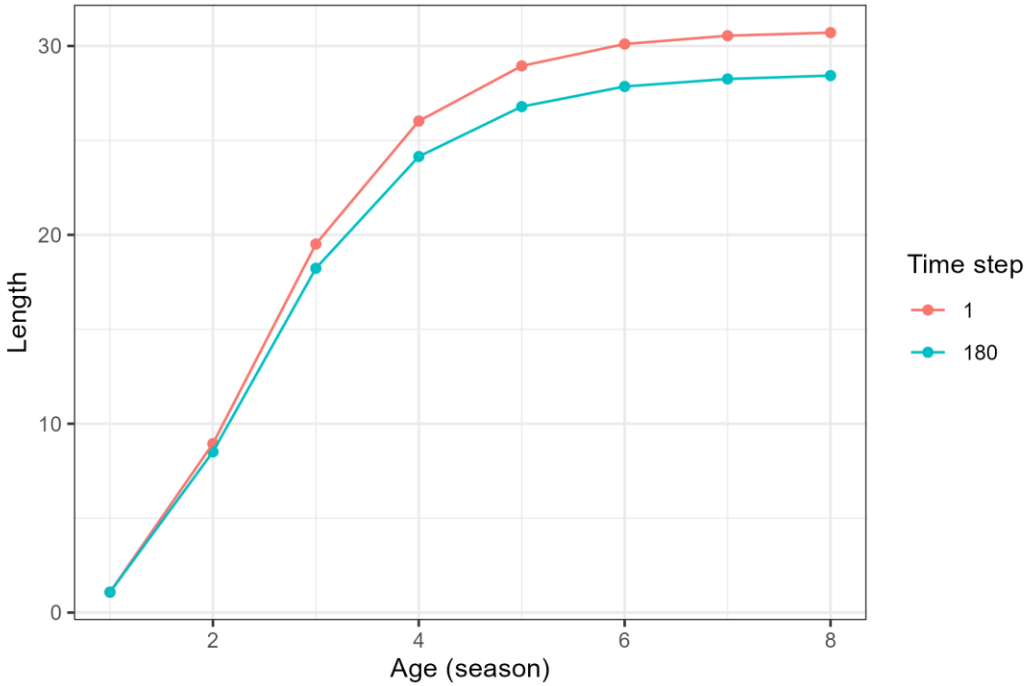
    - Empirical trends in length at age informs changes in growth
    - Update Members' fishery catch, length composition, and CPUE series (to 2024)
    - Age-aggregated survey index with length composition (to 2025)

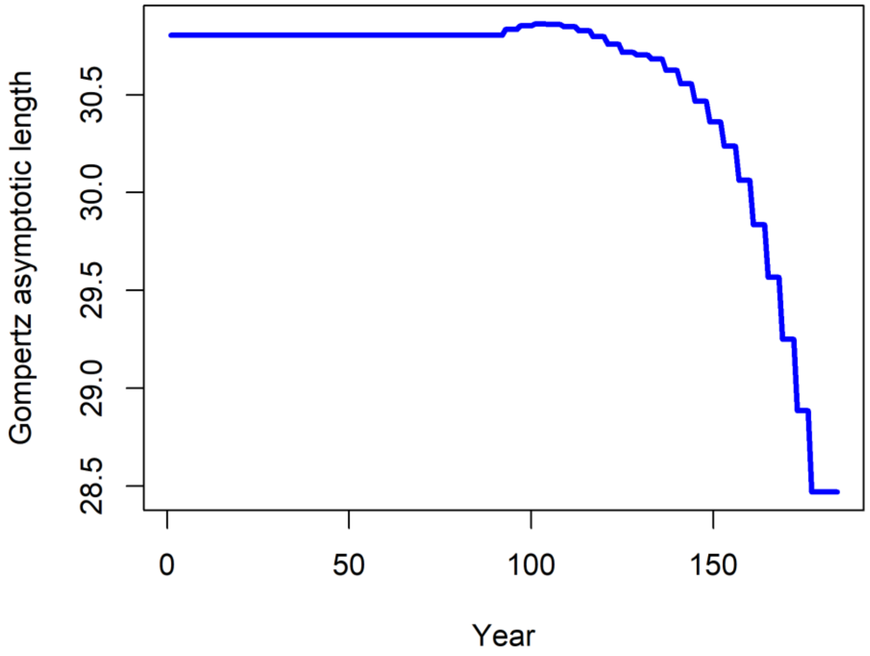
Evaluation of growth

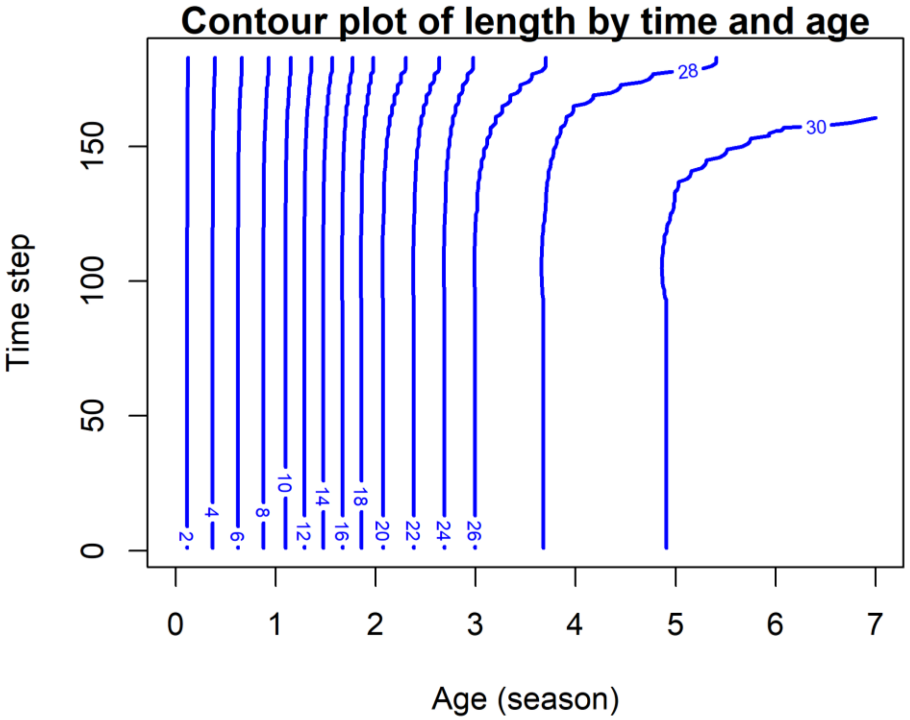
- Japanese size-at-age data indicates a recent decrease in age 1 Pacific saury
- This was incorporated in the model with a loess smoothed line in asymptotic length by calendar year



Evaluation of growth







**There are issues with the time-varying length-at-age calculation with the seasonal model in the current SS3 version.

I proposed a change in the source code to Rick Methot (SS3 developer) which solves the problem for Pacific saury, but awaiting final confirmation (my proposed solution does not work for annual models).

Therefore, model results shown here use an unofficial update of SS3

Base and sensitivity model

At WGNSAM 3, the base model (Step22c) has the following parameters:

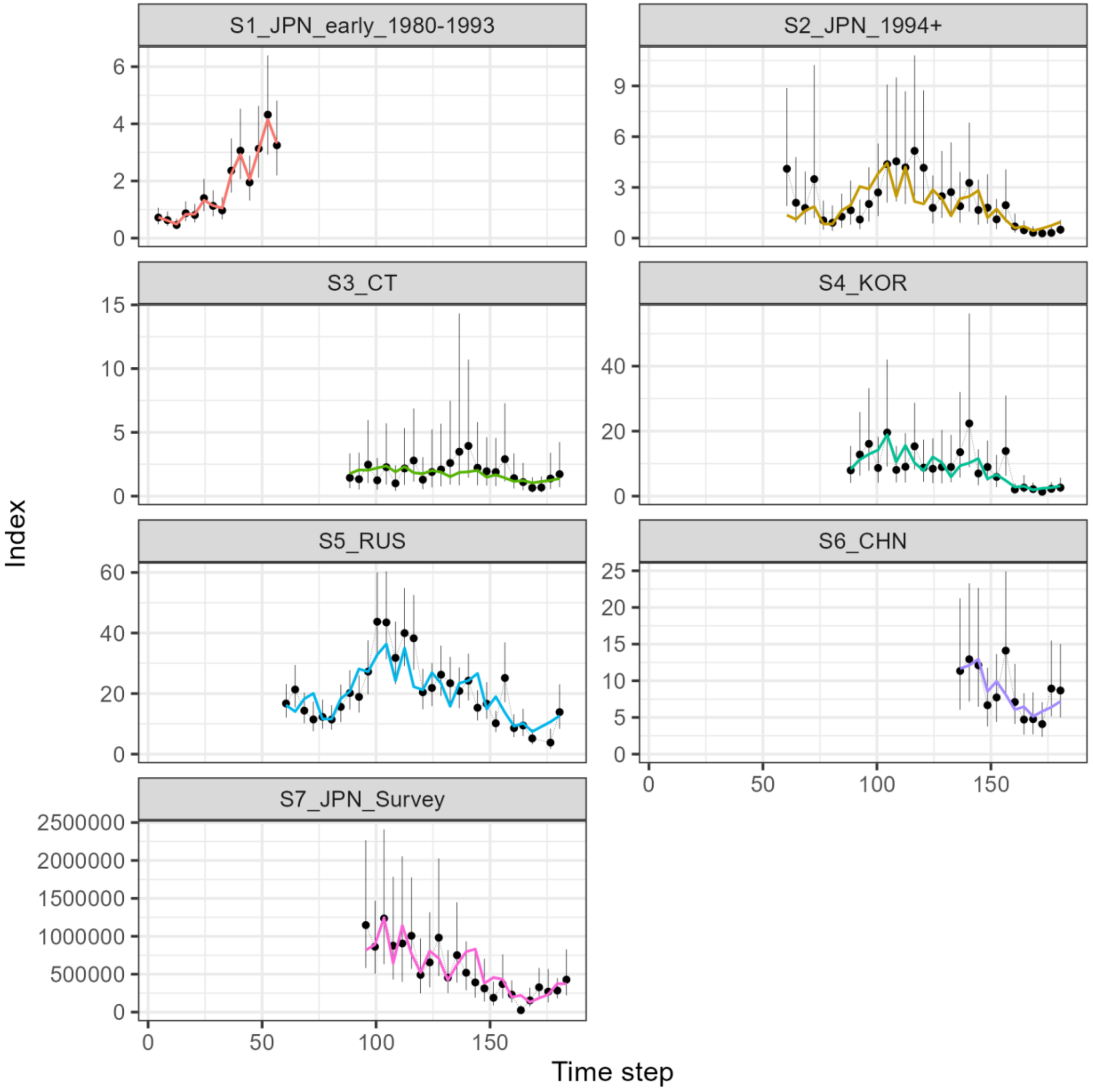
- Recent reduction in asymptotic size
- Fit to members' CPUE (with hyperstability parameters) and Japanese survey with length composition
- Stock-recruit steepness (h) = 0.82
- Natural mortality M = 2.18 per year
- Catchability prior for Japanese survey

Sensitivity models:

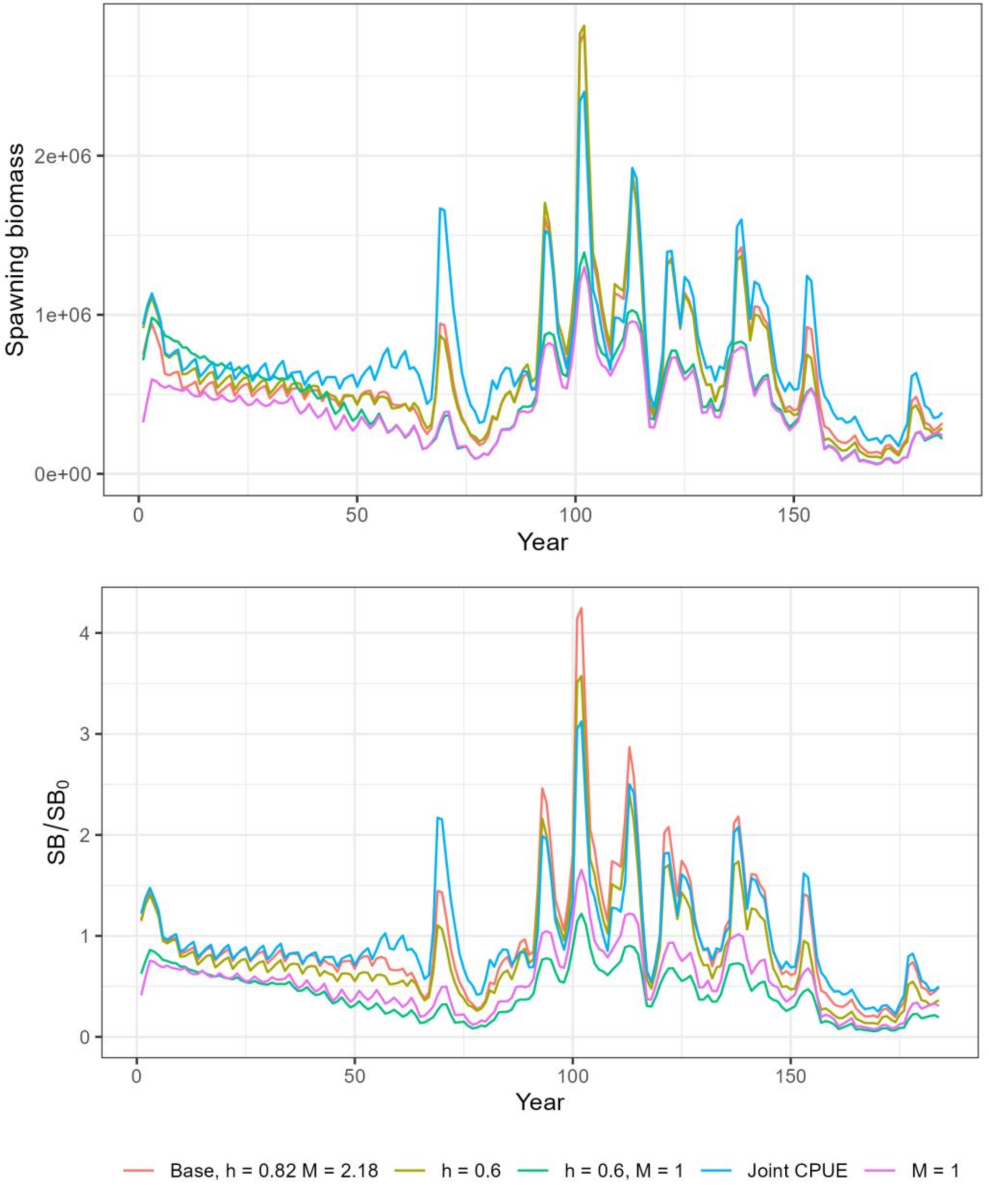
- Steepness = 0.6
- Replace member CPUE with joint CPUE
- M = 1
- M = 1 & h = 0.6

Biomass, depletion, and indices

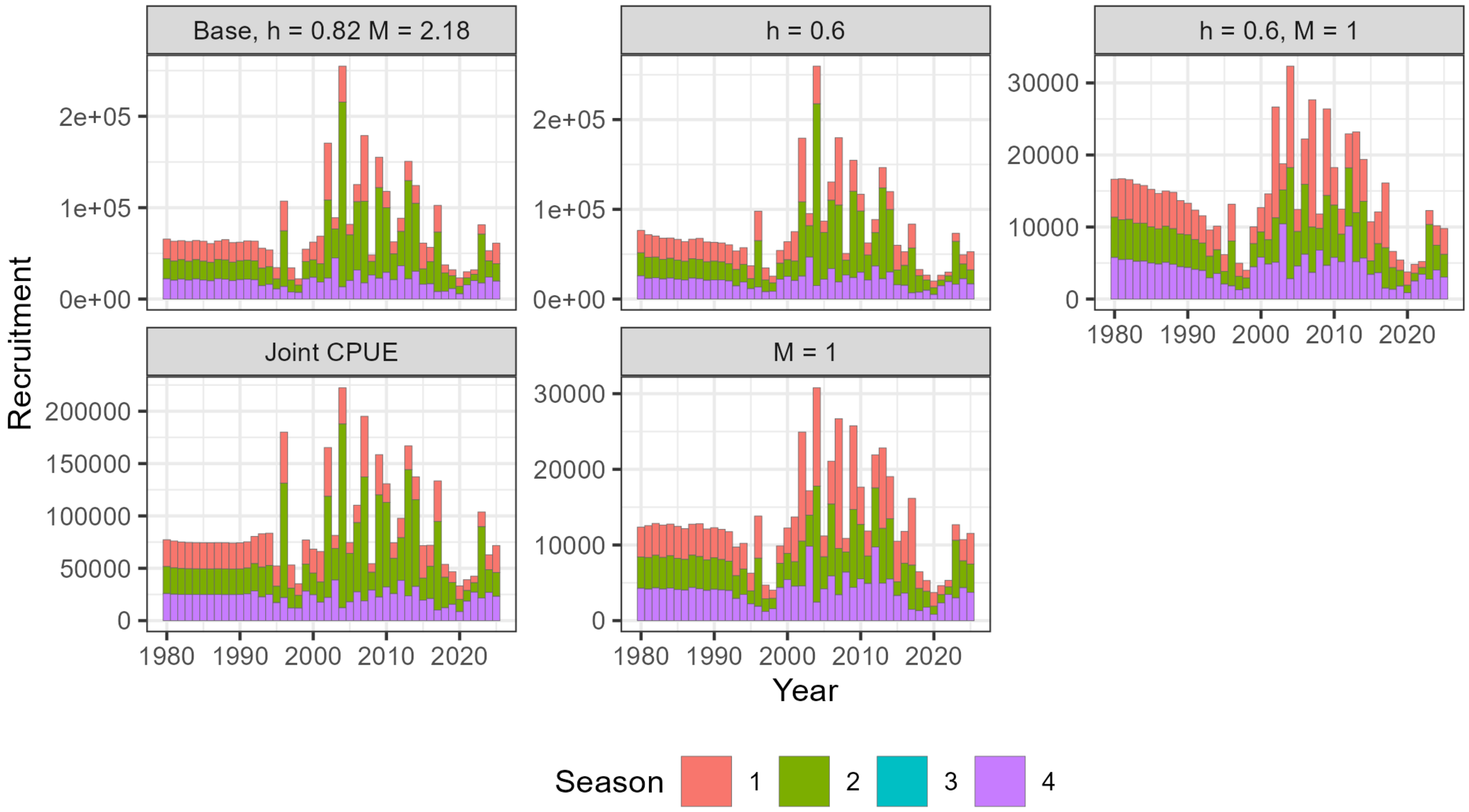
Fit in base model:



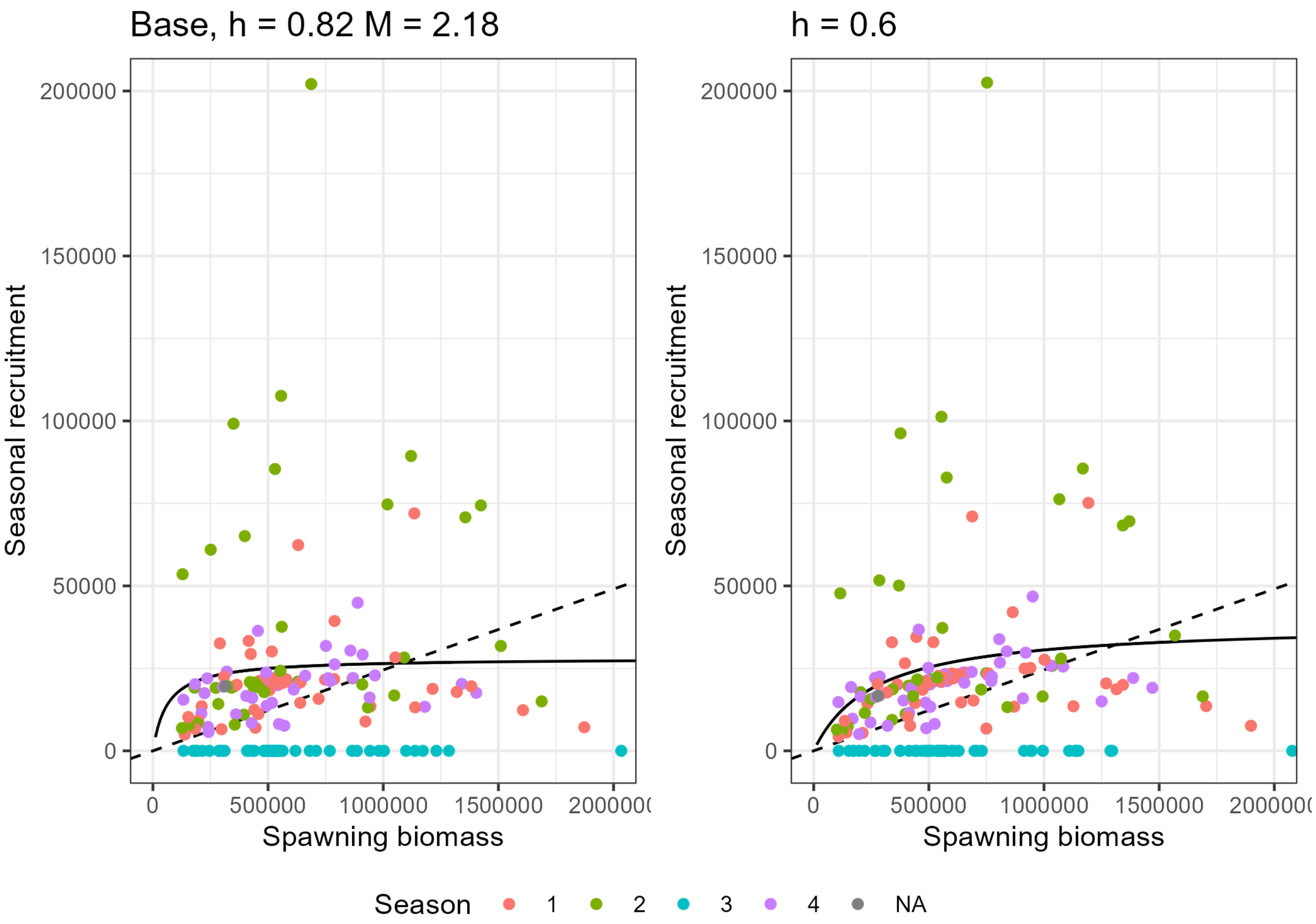
Comparison of base + sensitivity:



Recruitment time series



Stock-recruit relationship



Diagnostics for acceptance of assessment models

1. Does the model fit the data well?

2. Can the model reliably estimate parameters?

3. Does the model have good predictive ability?

Diagnostics for acceptance of assessment models

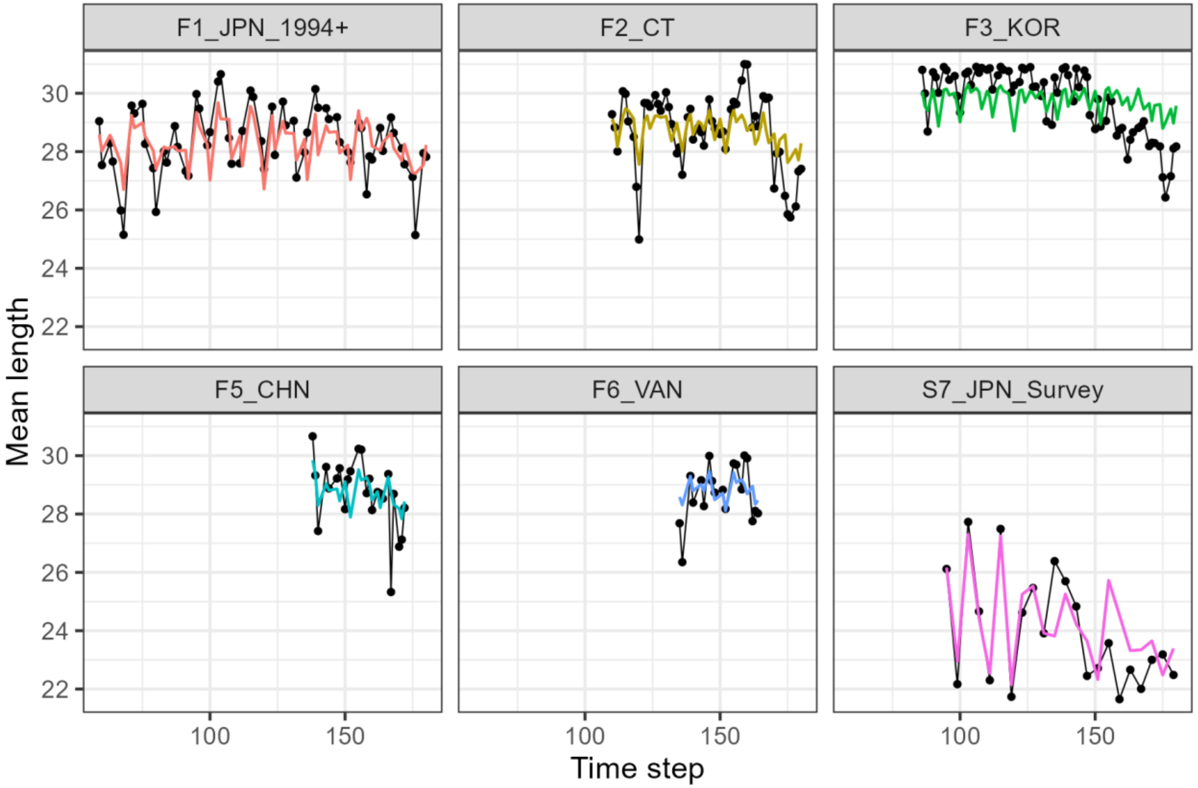
1. **Does the model fit the data well?**

- Improved fits to the length composition and mean length trends with time-varying asymptotic length

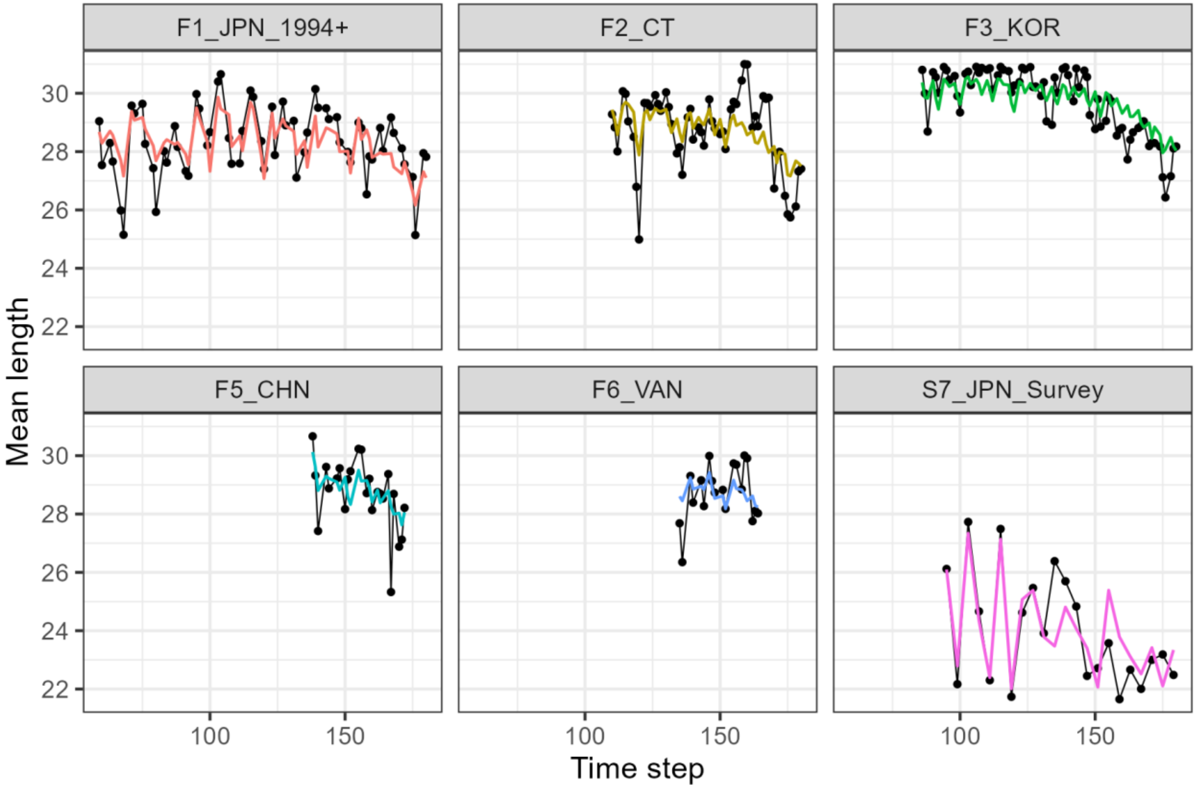
Fit to length composition

- The decrease in asymptotic length improves fit to fishery length composition, particularly for KOR fleet
- Indirect evaluation with observed vs. predicted mean length time series

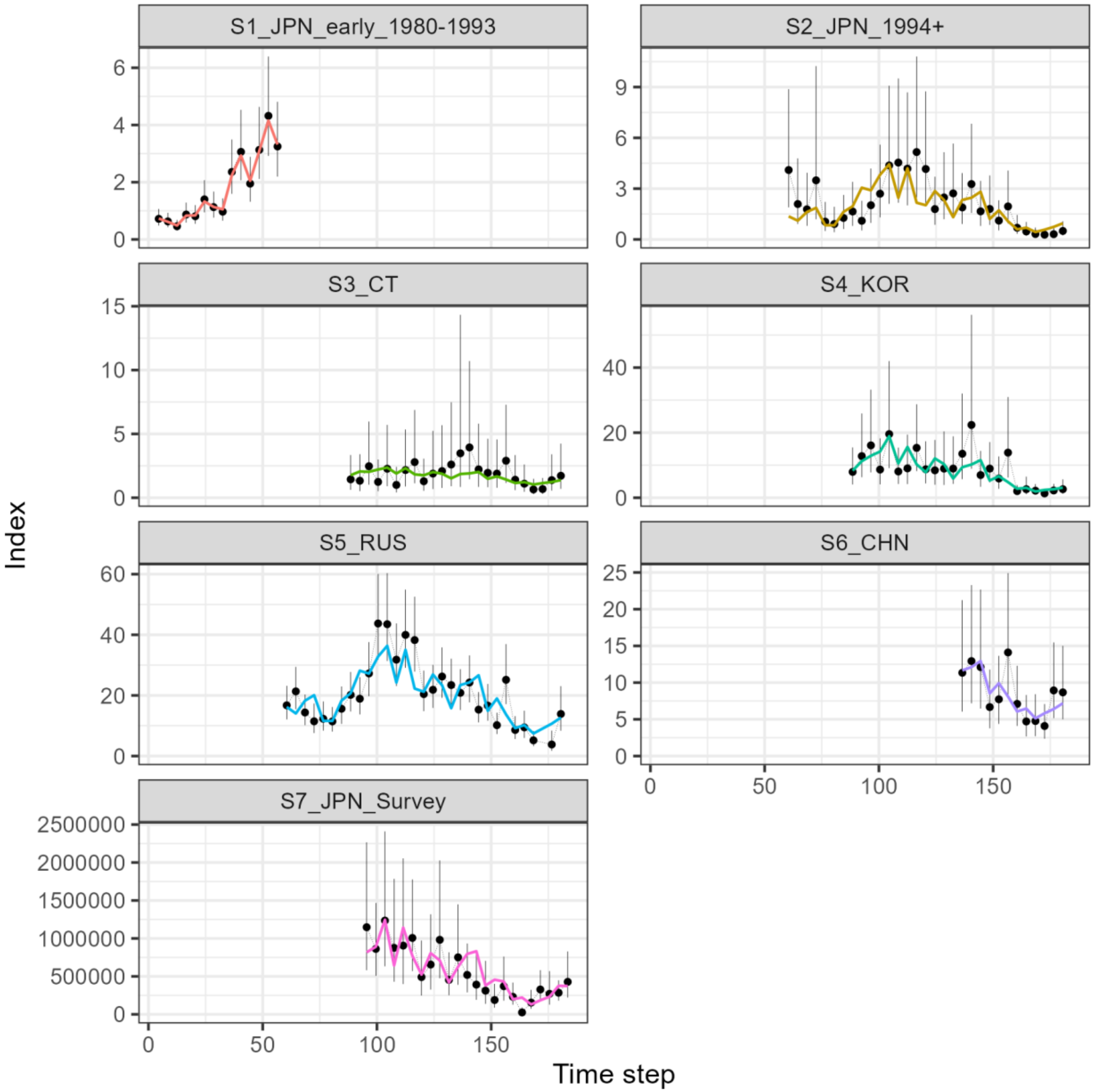
Model with constant growth (Step 22)



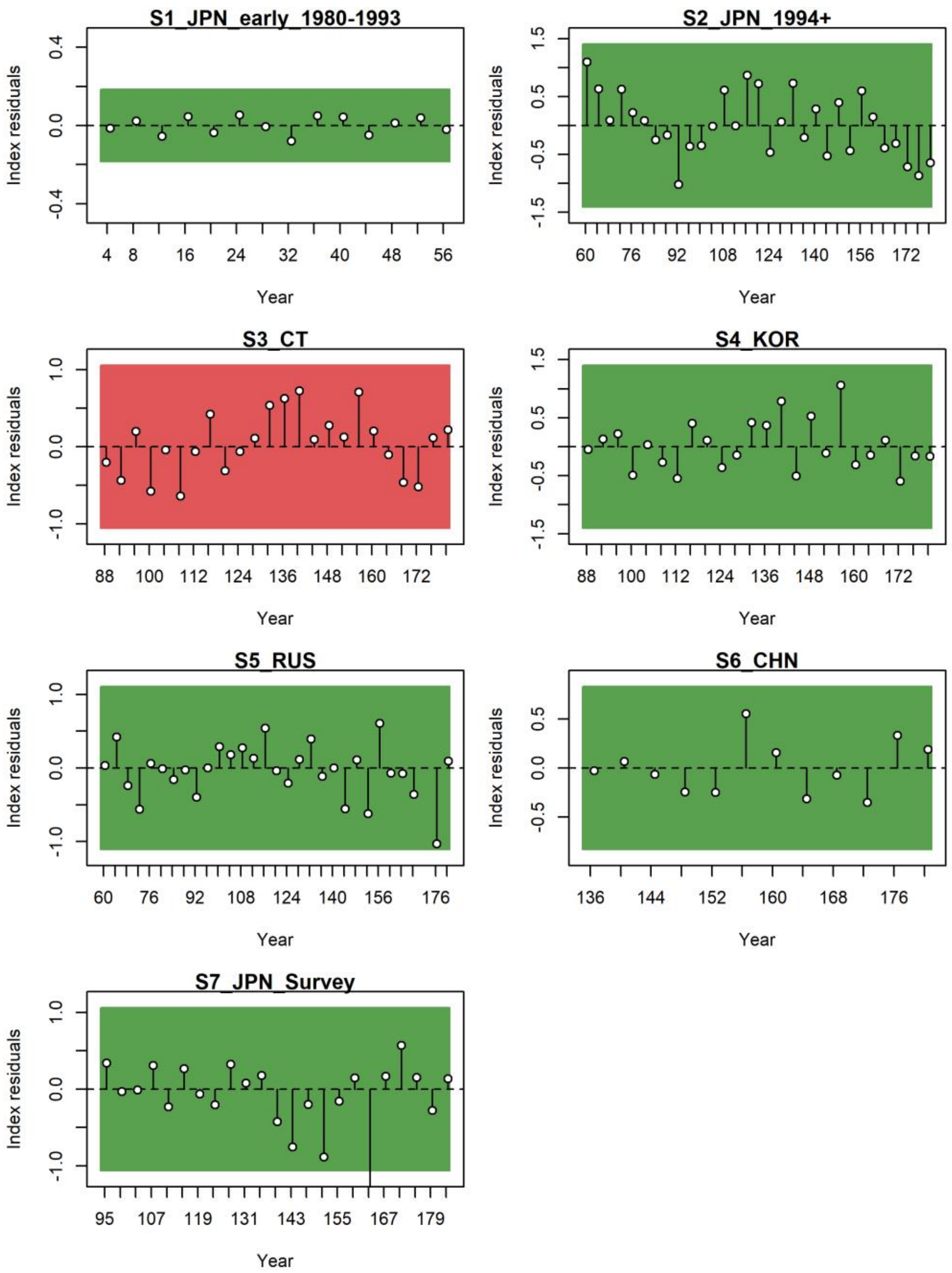
Model with declining growth (Step 22c)



Fit to index



ss3diags residuals runs test



Diagnostics for acceptance of assessment models

1. **Does the model fit the data well?**

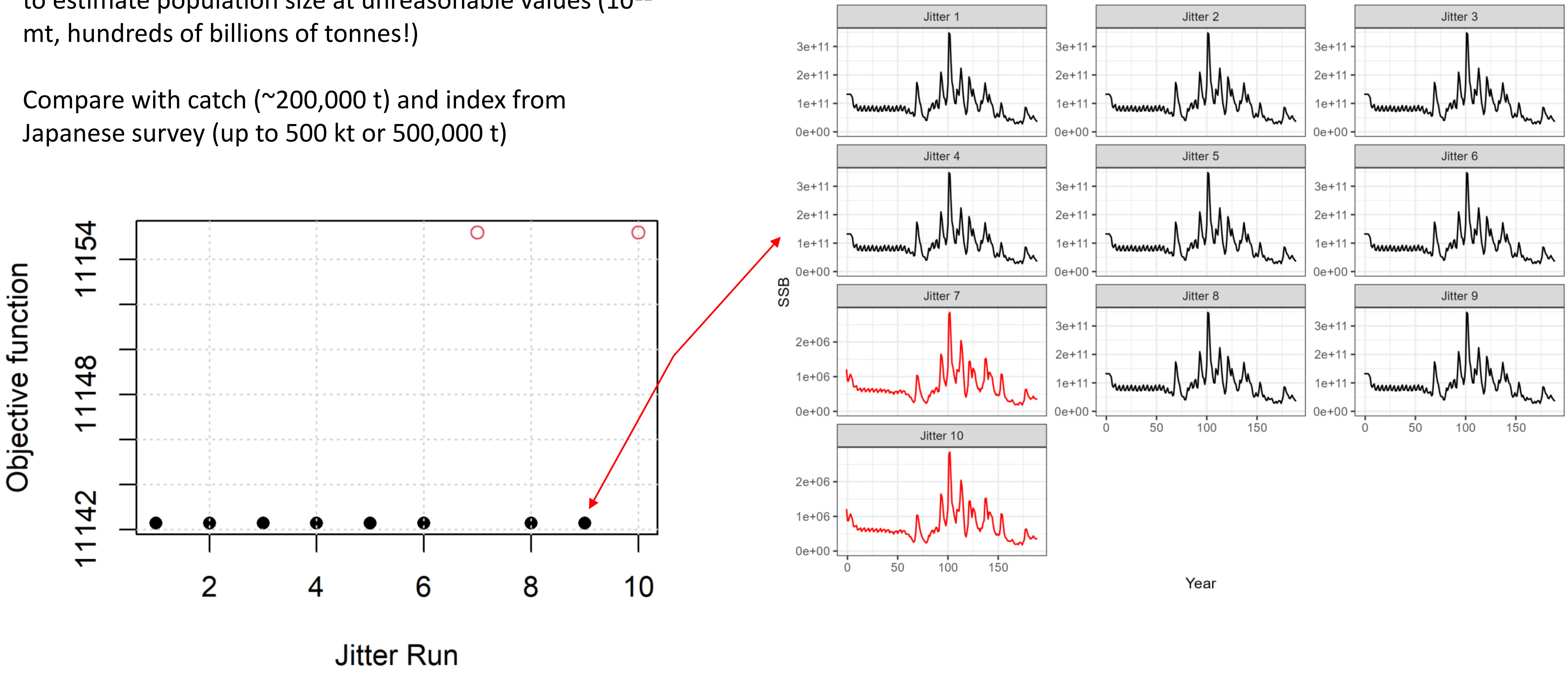
- Improved fits to the length composition and mean length trends with time-varying asymptotic length

2. **Can the model reliably estimate parameters?**

- Jitter analysis indicates catchability prior is needed to provide population scale
- MCMC can better characterize high correlation in parameters, may be preferred estimation approach, similar to current assessment (NPFC-2025-SSC PS16 WP07)
- Uncertainty in important productivity parameters (steepness and M) can be explored in sensitivity scenarios

Jitter analysis

- In the absence of information on scale, the model wants to estimate population size at unreasonable values (10^{11} mt, hundreds of billions of tonnes!)
- Compare with catch (~200,000 t) and index from Japanese survey (up to 500 kt or 500,000 t)

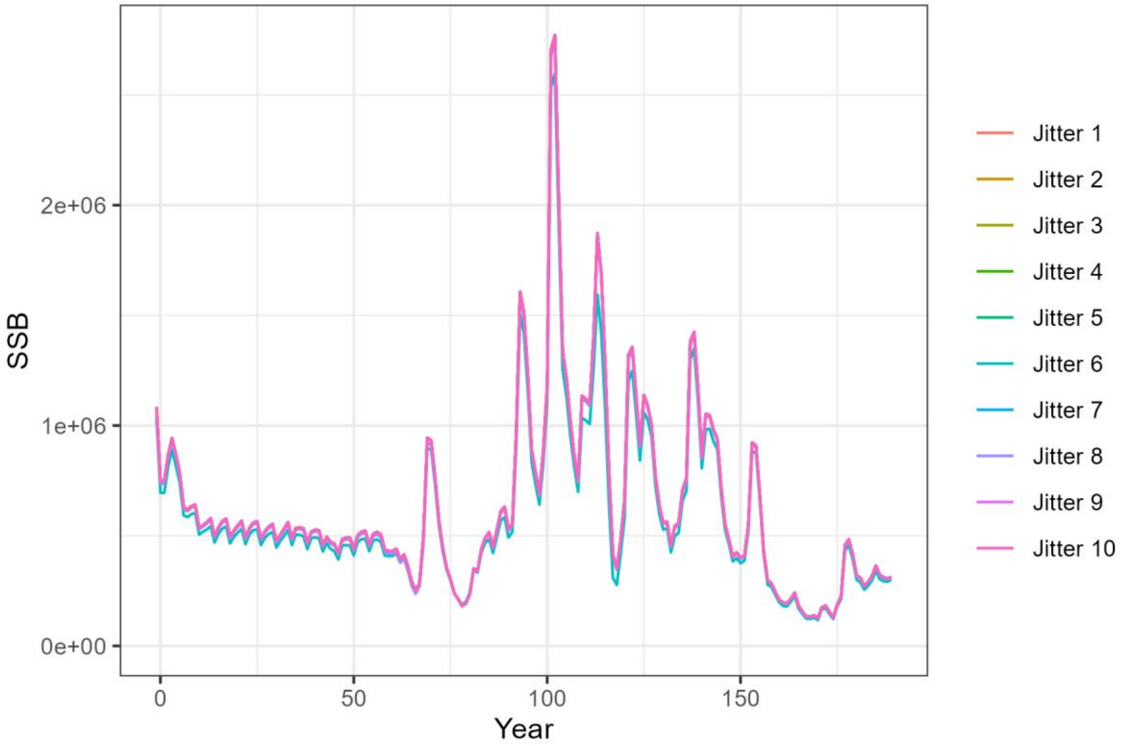


Jitter analysis

A catchability (q) prior on the survey index is best practice to stabilize model with respect to population scale (Thorson and Cope 2017)

$$\log(q) \sim N(\log(1) - 0.5\sigma^2, \sigma = 0.2)$$

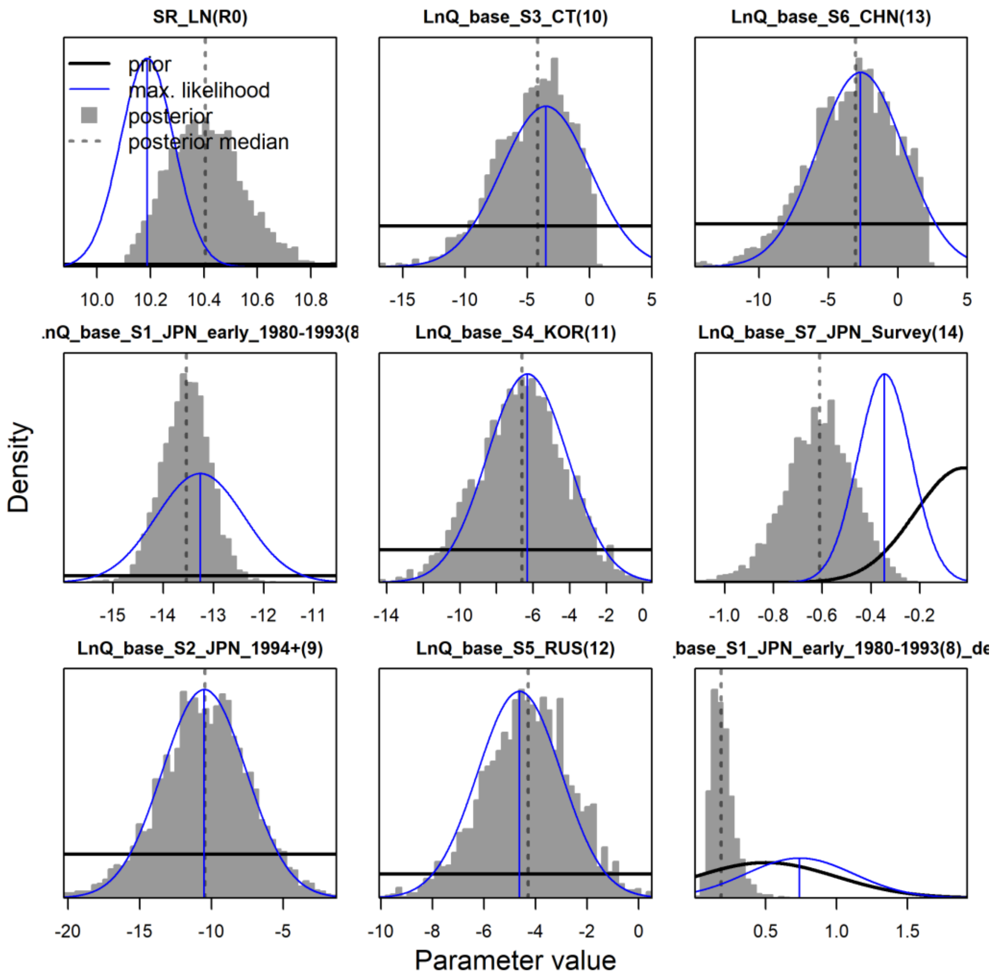
- Population scale prior informed area-weighted expansion of survey catch with VAST model
- Posterior estimate of survey q is 0.54
- Previous empirical estimates of q = 0.179, although with low precision (Naya et al. 2010)

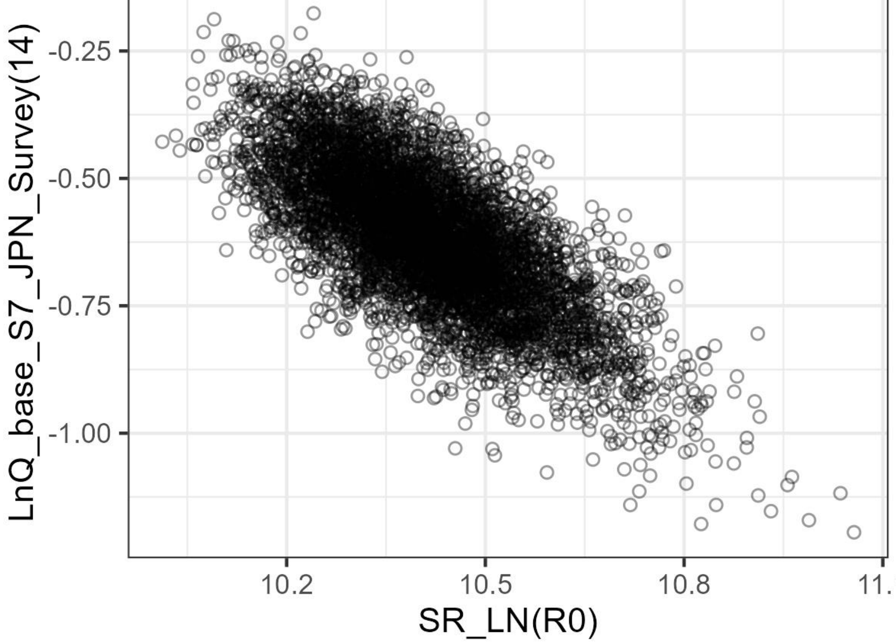


MCMC

Blue: maximum likelihood estimate + Hessian uncertainty
Grey: MCMC posterior distribution

MLE and MCMC diverge for R0 and survey q due to high correlation between parameters (MCMC samples below)





Diagnostics for acceptance of assessment models

1. Does the model fit the data well?

2. Can the model reliably estimate parameters?

3. **Does the model have good predictive ability?**

- Improved retrospective and hindcasting behaviour in latest model
- Short-term projection will remain challenging for short-lived species

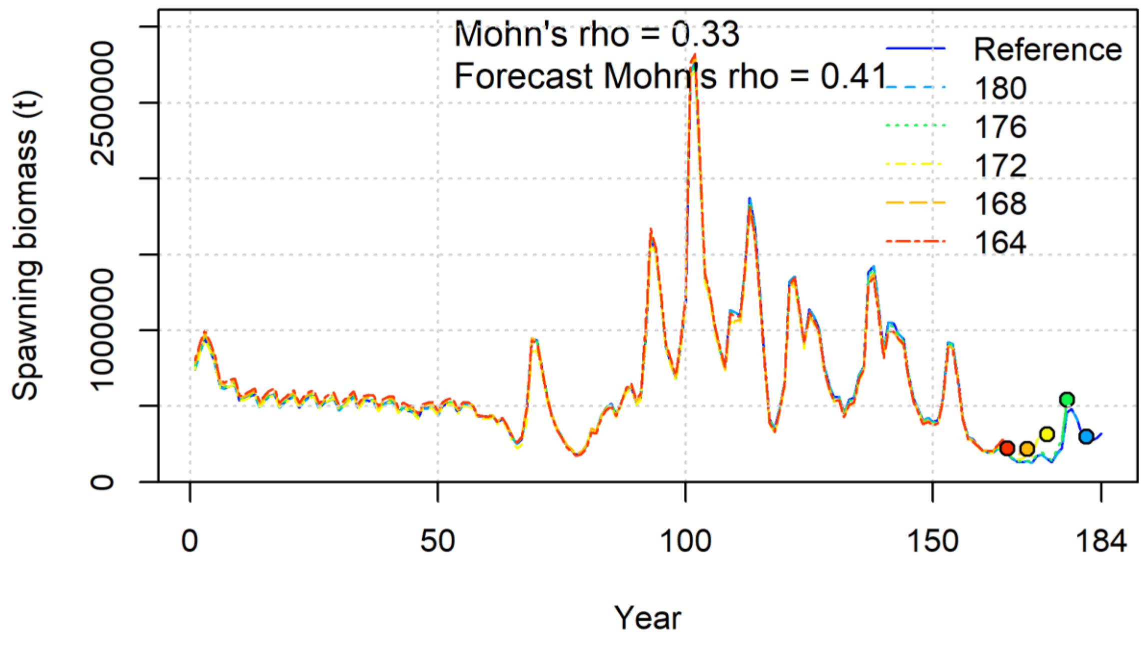
- Why? Short-term projection requires assumption on strength of current cohorts (typically stable and reliable because estimated from data) and new cohort (not observed).

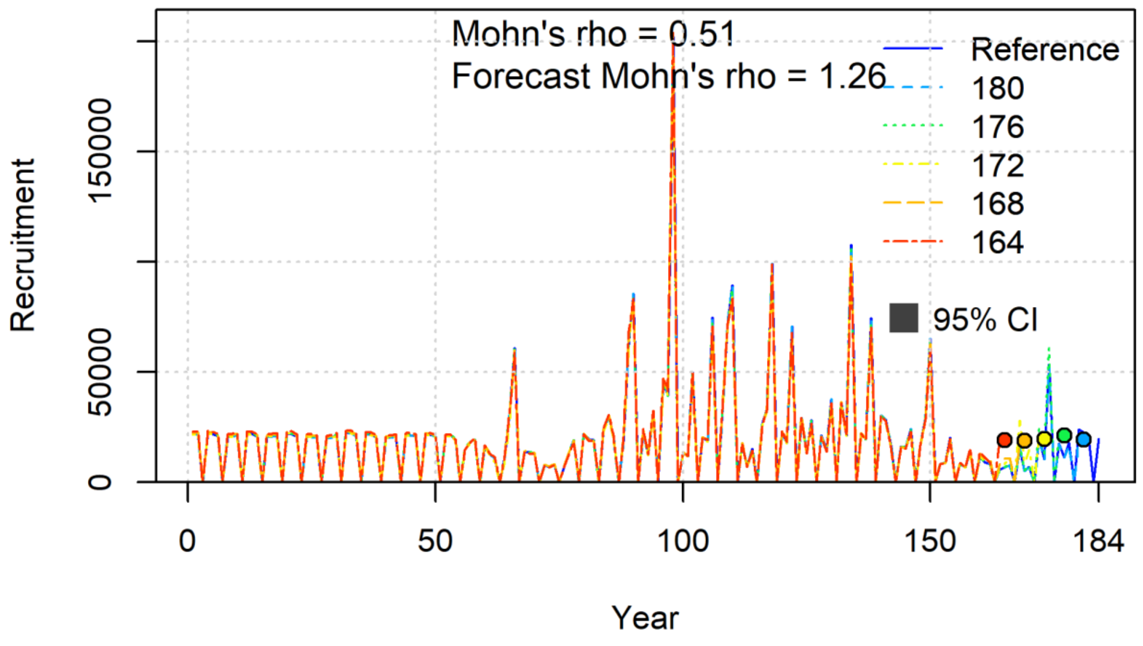
- Pacific saury only has 2 annual cohorts. Estimation error of new cohort has a stronger impact on advice compared to longer-lived species (one of many cohorts)

Base model retrospective

Better predictive ability in retrospective compared to previous models

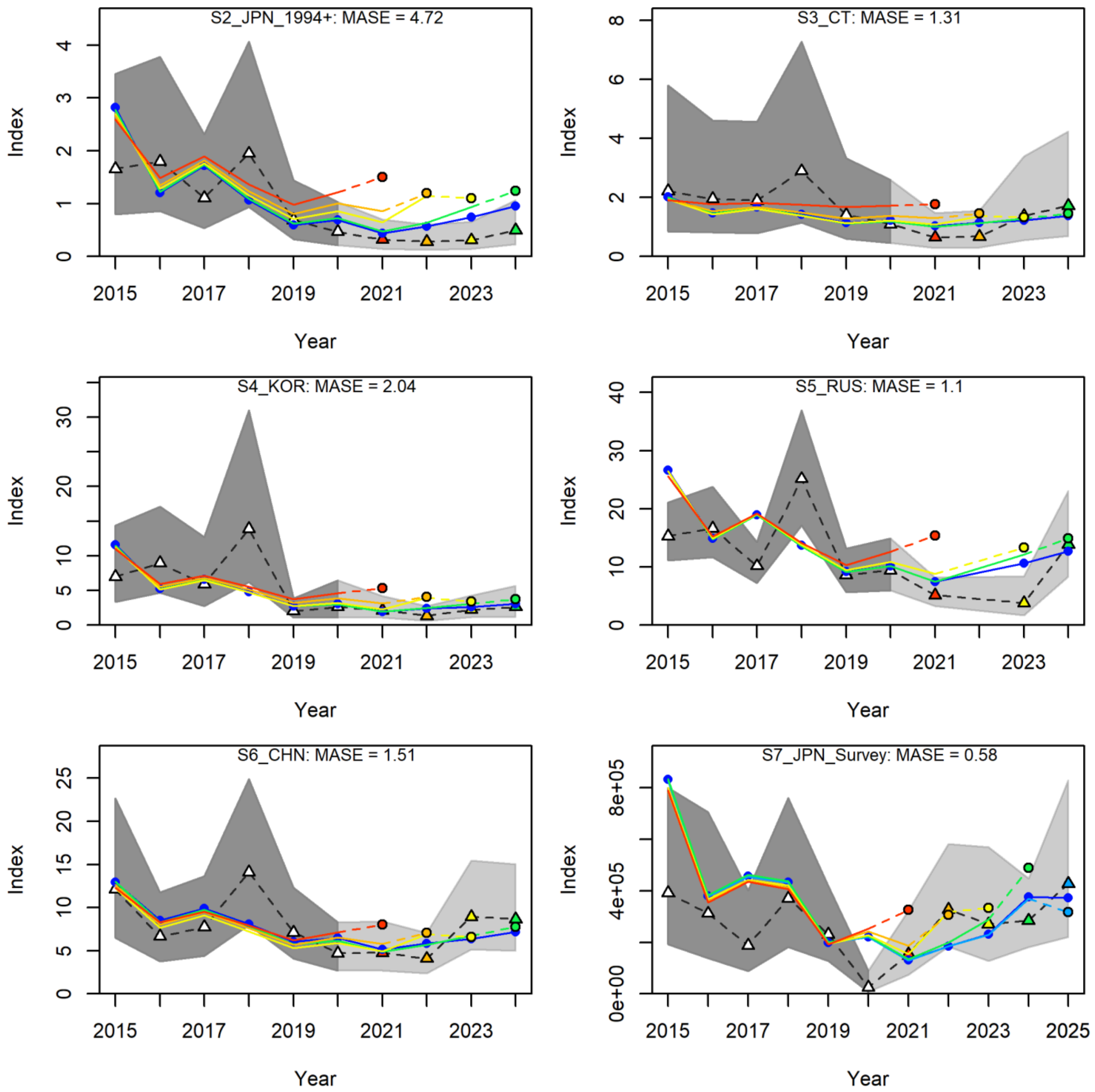
I believe the model with growth decline has partially addressed the retrospective issue





Base model hindcast

- White + grey are data
- Colour lines are index/CPUE predictions from retrospective runs
- Colour points are first projection year prediction from retrospective runs. Good prediction skill when coloured points closer to data points
- We have better prediction skill with survey than with CPUE



Challenges and next steps

- Review and update biological parameters

- Re-visit choice of natural mortality (M)
- Model with base value does not provide practical management advice
  - Low impact of fishery on historical stock dynamics
  - Yield-curve not defined, no reliable MSY estimates
  - Data supports lower value of M (likelihood profile)

- If MSY is not well-estimated, consider proxy units for reference points (B0 instead of BMSY, spawning potential ratio instead of FMSY)

Table 2: Biological parameters for the Pacific saury SS3 base case model. Rate parameters (natural mortality and growth rate) are in instantaneous units per year.

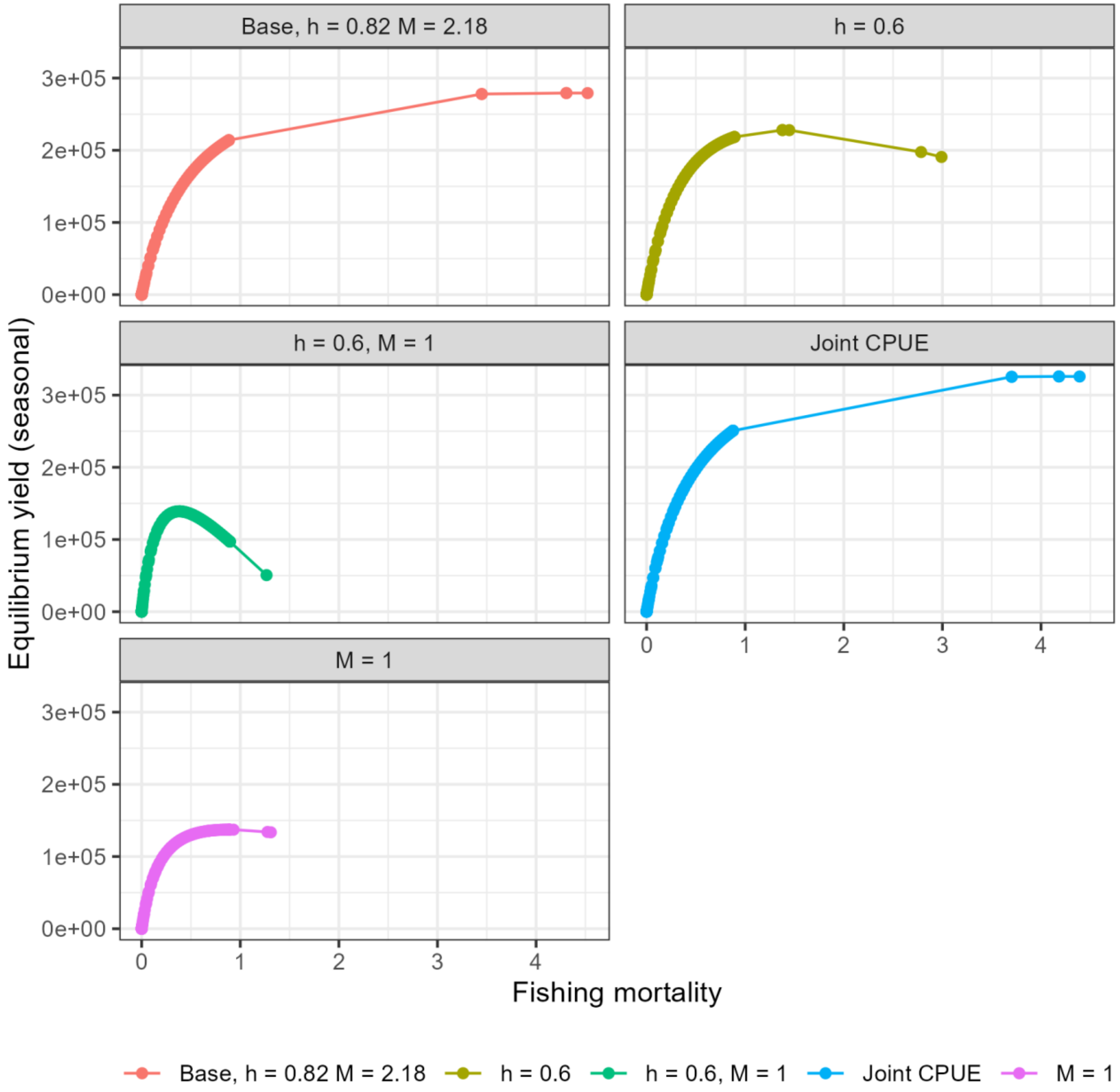
Parameter	Value	Reference
Natural mortality	2.18	Meta-analysis by Hsu et al. (2022)
Richard asymptotic length	30.84	Nakayama et al. (2019); NPFC (2024)
Growth rate K	3.99	Nakayama et al. (2019); NPFC (2024)
Richard power function	0.0001	Simplifies to Gompertz function
Length at age zero	1.028	Derived from Gompertz function
Length of 50% maturity	25.8	Hsu and Chang (2023); Suyama et al. (2006)
Length of 95% maturity	30.2	Hsu and Chang (2023); Suyama et al. (2006)
Length-weight a	0.0015	Fuji et al. (2019); Kosaka (2000)
Length-weight b	3.33	Fuji et al. (2019); Kosaka (2000)
Fecundity	Proportional to weight-at-age	
Stock-recruit steepness	0.82	Hsu et al. (2024)
Recruitment variability	0.6	Fixed assumption

Yield curve

- With base M = 2.18, there is difficulty finding the clear optimum of yield curve

- Implied long-term yields is very large compared to historical catches, therefore the historical biomass is explained by natural environmental variability

- High M → unfished age structure already declines very rapidly. No limit to yield curve because additional fishing mortality has little impact age structure



Thank you