Joint standardisation of Japanese pole-and-line and regional purse-seine CPUE for skipjack tuna in the equatorial WCPO

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Introduction

- The SKJ MP was adopted in 2022, with the estimation method using JPPL CPUE as regional abundance indices.
- However, the continued spatial contraction of the JPPL fishery has reduced data coverage and may affect the representativeness of its CPUE index in the equatorial region.
- SC20 therefore recommended “the further development of alternative indices in advance of the third implementation of the MP”, through the skipjack monitoring strategy.

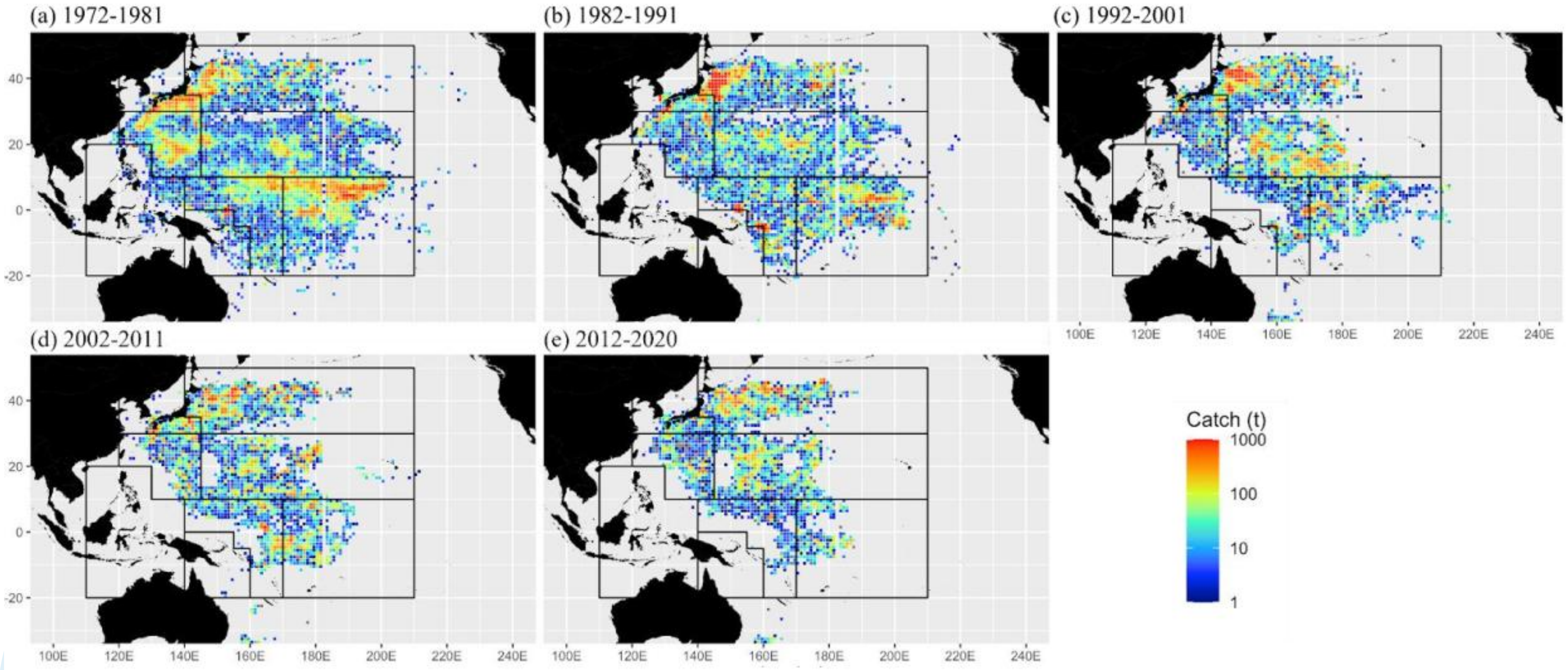
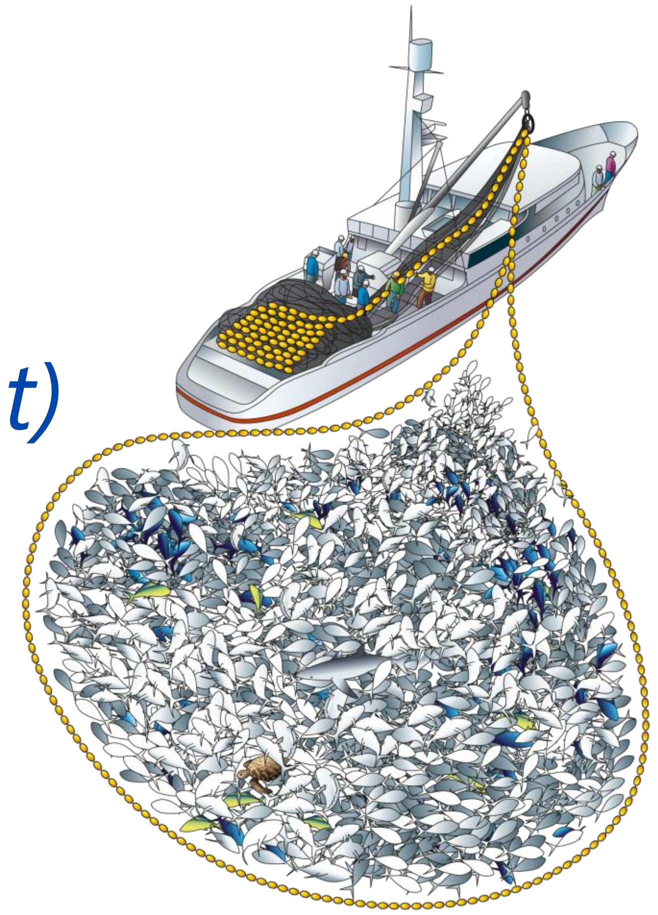
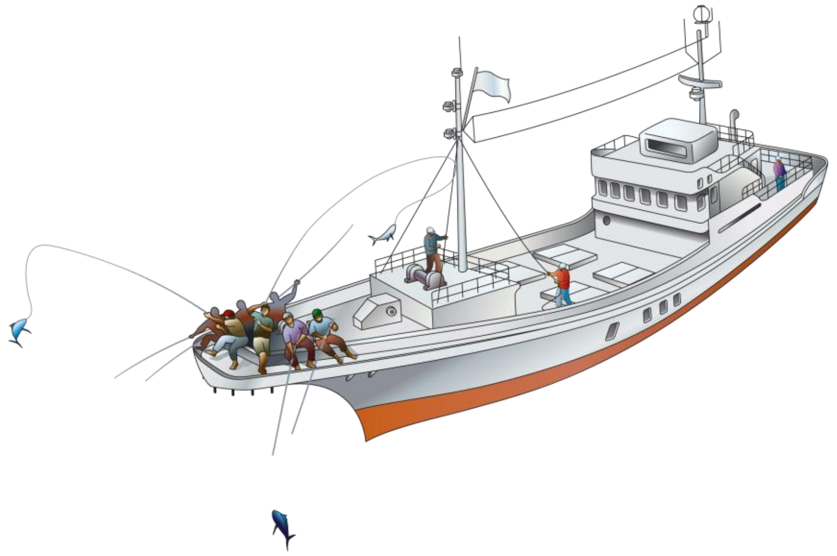


Figure 3: Decadal shifts in spatial distribution of Japanese pole-and-line (JPPL) fishery skipjack catch (metric tons) from 1972 to 2020.

Joint CPUE Method

$CPUE_1(s,t) = q_1 * B(s,t)$



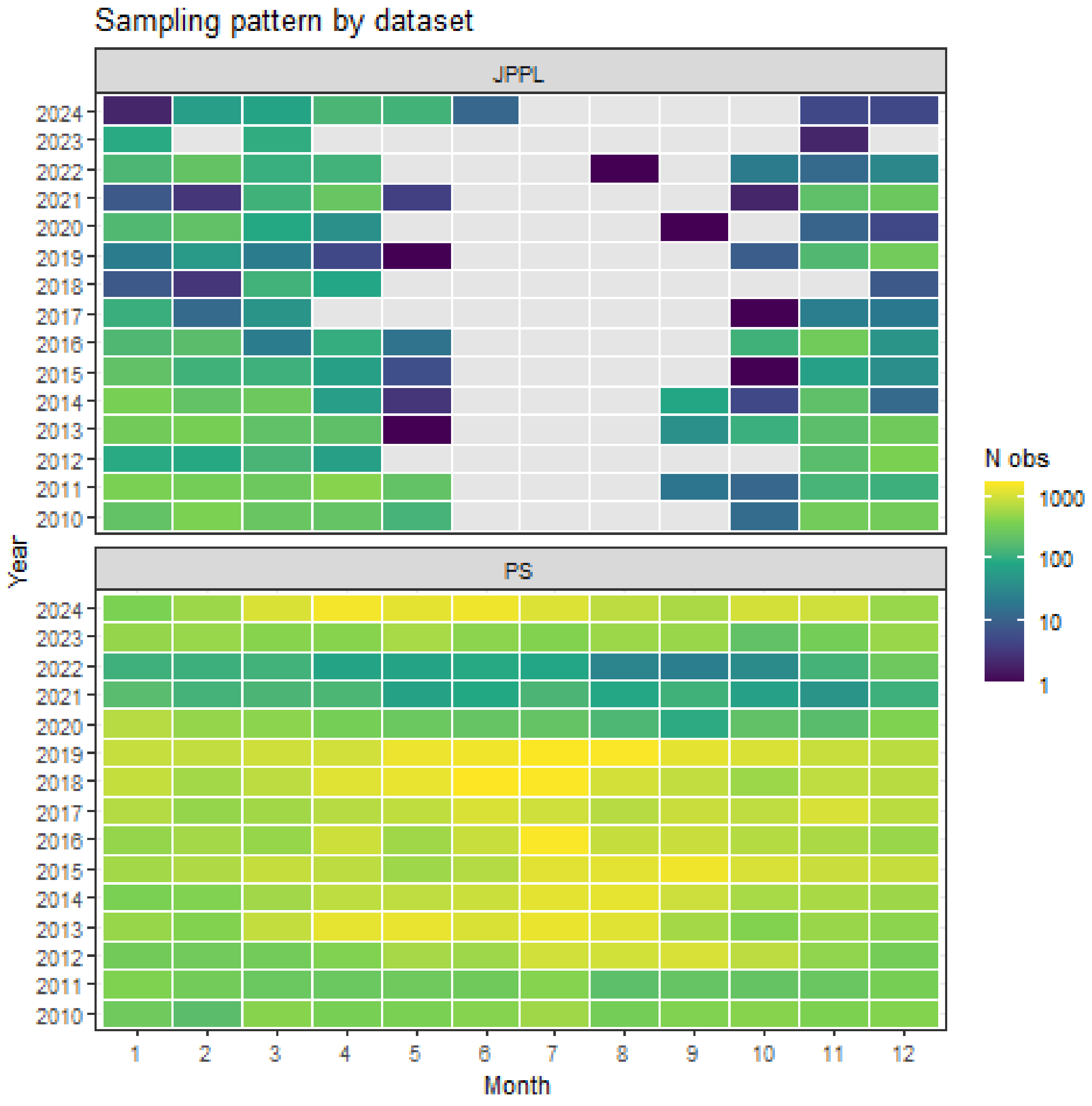


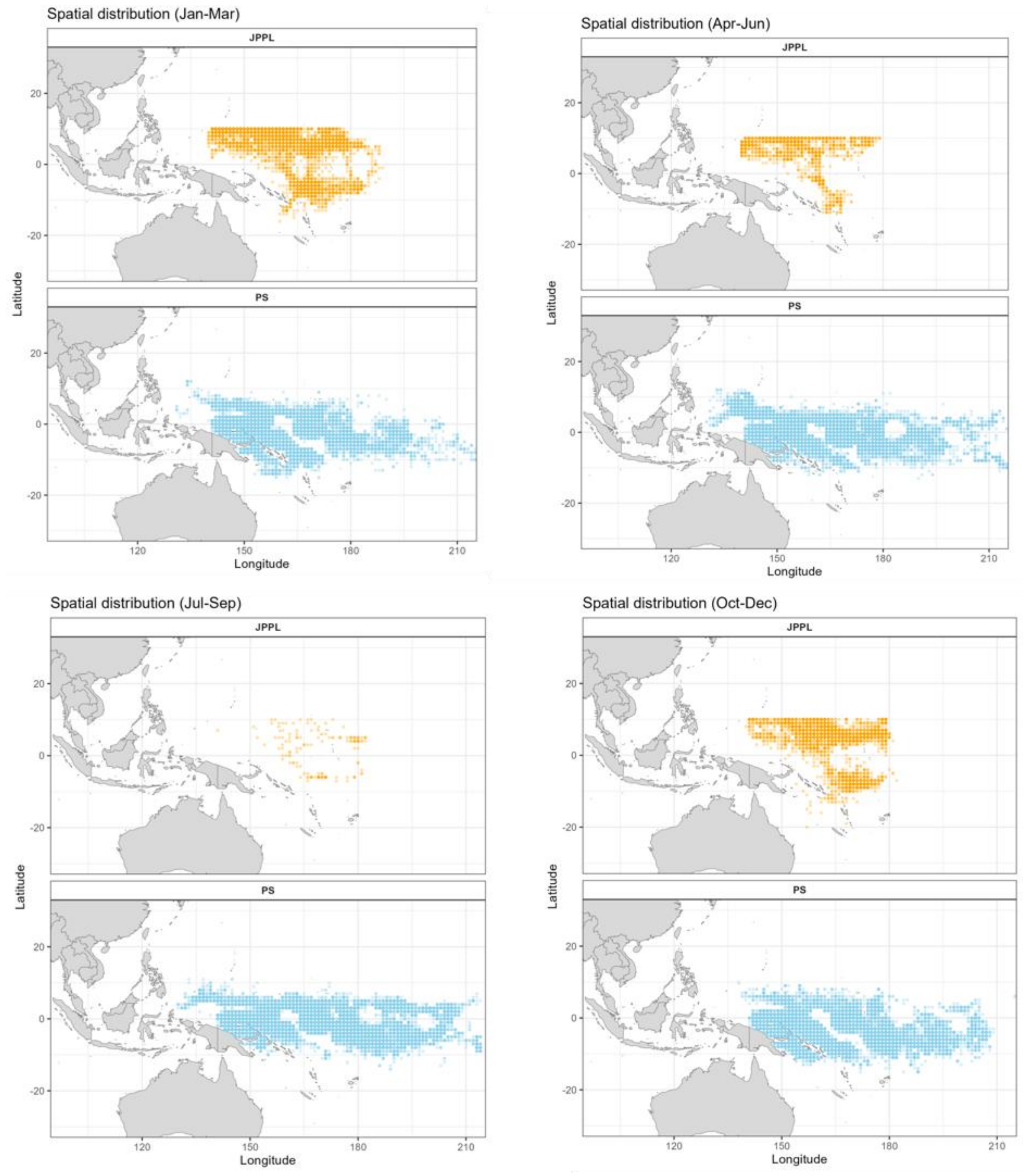
$CPUE_2(s,t) = q_2 * B(s,t)$

- Fisheries observe a **shared biomass** $B(s,t)$, scaled by gear-specific q_k; separate standardisation can bias $\hat{B}$ under sparse coverage.
- A joint spatiotemporal model estimates a common biomass surface $B(s,t)$ with **gear-specific** $\boldsymbol{q_k}$.
- When one fishery is sparse in a period or space, other fisheries inform $B(s,t)$, and thus reducing bias.
- This approach mitigates JPPL spatial contraction by borrowing information from purse seine data in the equatorial region.

Characteristics of the JPPL and PS Data

2010 onwards and equatorial region only





	Number of Records	Percentage	No. of 0 Records
JPPL	10,517	9%	2,622
PS	106,181	91%	0
Total	116,698		

Model Structure

Shared population process

$$CPUE(f; s_i, t_i) = q(f) \times B(s_i, t_i)$$

- $B(s_i, t_i)$: shared latent relative biomass.
- $q(f)$: fishery-specific catchability.

Delta model

$$z_i = \begin{cases} 1, & Postive\ catch \\ 0, & Zero\ catch \end{cases} \qquad z_i \sim Bernoulli(p_i)$$

- Models catch occurrence and positive catch separately.

Positive-only model

$$\log(C_i) \sim Normal\ (\eta_i, \delta^2(f_i))$$

- Positive catch only.

Linear predictor

$$\eta_i = \gamma_{ti} + \log\left(q_{fi}\right) + \omega(s_i, t_i) + x_{q,i}^{\top}\beta_q + x_{E,i}^{\top}\beta_E + \nu_{v_i}$$

- Shared process: temporal and spatiotemporal effects.
- Random effect: vessel.
- Fishery-specific catchability covariates: gear–month, number of poles, GRT and detection method.
- Population covariate: SST.

- Alternative spatial and spatiotemporal structures are also included in the testing phase.

Candidate Model Comparison

Model	Model type	Catchability covariates	Population covariates	Spatial effect	Temporal effect	Observation SD
M1	Positive-only	Gear × month + detection code + npoles + GRT	SST	Off	Quarterly RW	Fishery-specific
M2	Positive-only	Gear × month + detection code + npoles	SST	Off	Quarterly RW	Fishery-specific
M3	Positive-only	Gear × month + detection code	SST	Off	Quarterly RW	Fishery-specific
M4	Positive-only	Gear × month + npoles	SST	Off	Quarterly RW	Fishery-specific
M5	Positive-only	Gear × month	SST	Off	Quarterly RW	Shared
M6	Positive-only	Gear × month + detection code + npoles + GRT	SST	On	Quarterly RW	Fishery-specific
M7	Delta	Gear × month + detection code + npoles + GRT	SST	Off	Quarterly RW	Fishery-specific

Model Selections

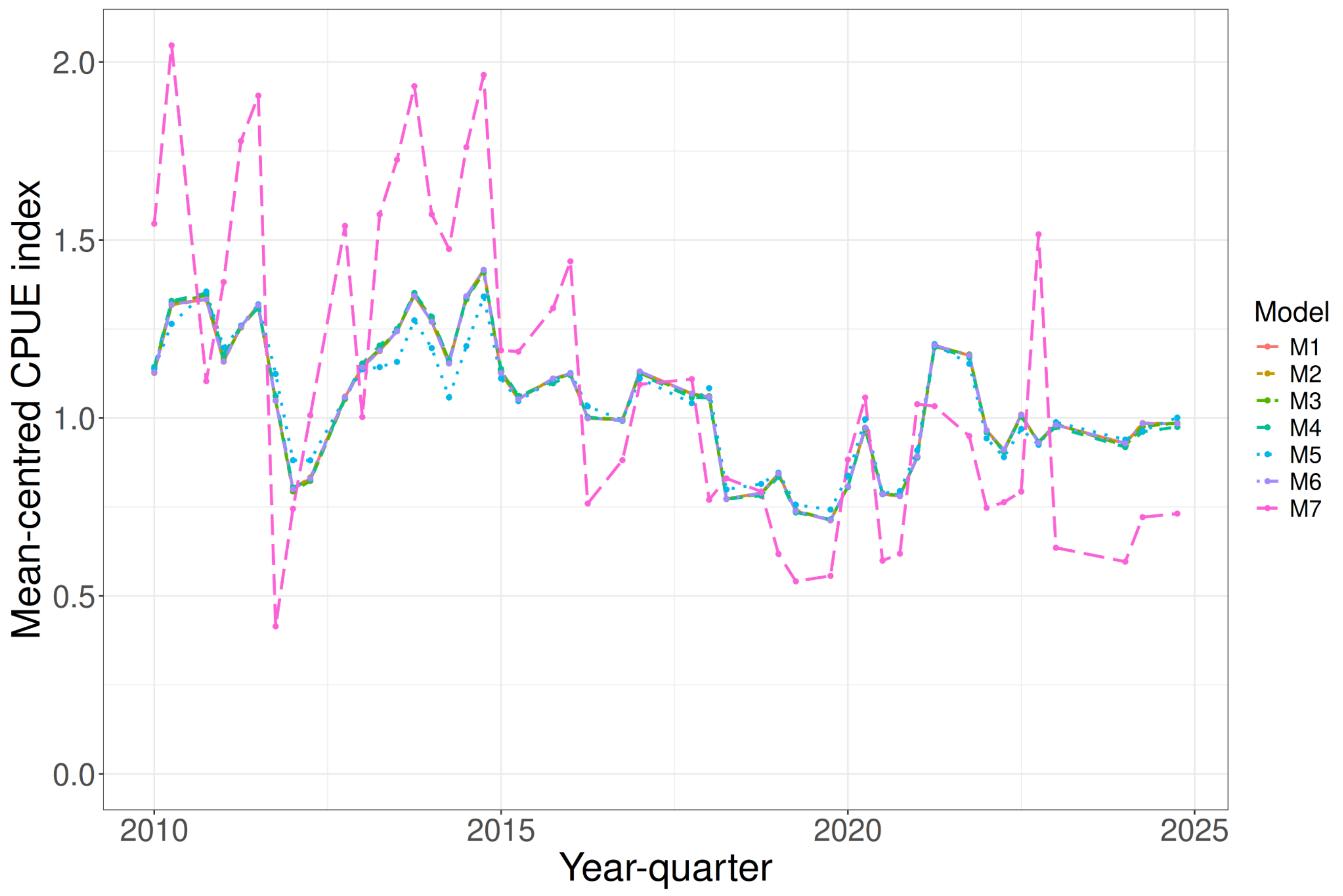
Candidate models were evaluated using:

- Optimizer convergence.
- Positive-definite Hessian.
- Maximum absolute gradient.
- Akaike information criterion (AIC).
- Model complexity.
- Mean and median CVs of the standardised quarterly index.

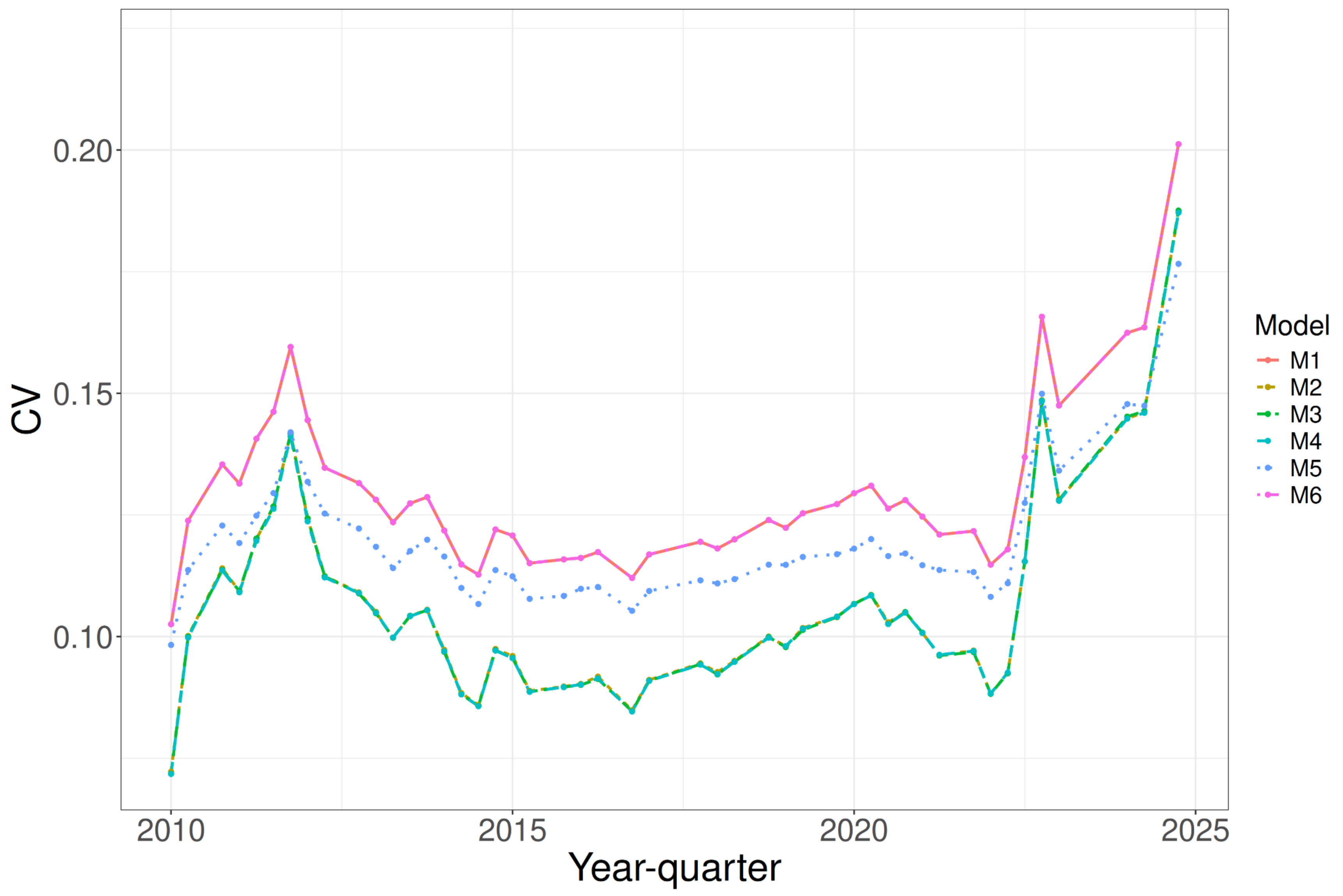
Results

Model	Converged	Max. gradient	Positive-definite Hessian	Parameters	AIC	ΔAIC	Mean CV	Median CV
M1	Yes	0.0424	Yes	75	**362,066.4**	**0.0**	0.137	0.128
M2	Yes	0.0587	Yes	74	362,069.5	3.1	**0.115**	**0.105**
M3	Yes	0.0314	Yes	72	362,087.4	21.0	**0.115**	**0.105**
M4	Yes	0.0628	Yes	71	362,342.2	275.8	**0.115**	**0.105**
M5	Yes	0.0487	Yes	74	363,918.2	1,851.8	0.126	0.118
M6	Yes	0.0817	Yes	76	362,068.4	2.0	0.137	0.128
M7	**Yes**	**0.2227**	**No**	**143**	**373,350.2**	**—**	**—**	**—**

Results

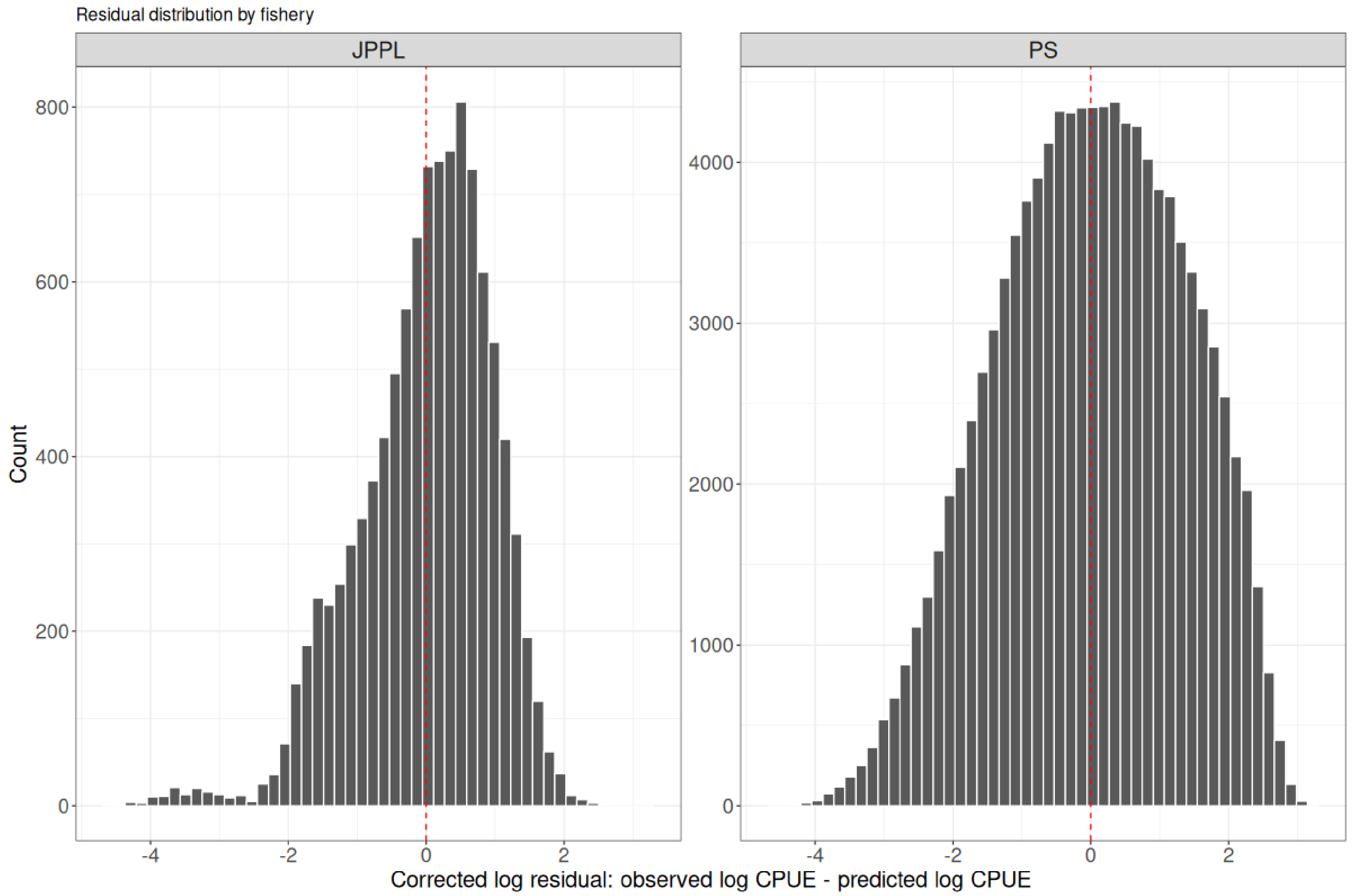


Mean-centred CPUE index
2.0
1.5
1.0
0.5
0.0
2010
2015
2020
2025
Year-quarter
Model
M1
M2
M3
M4
M5
M6
M7

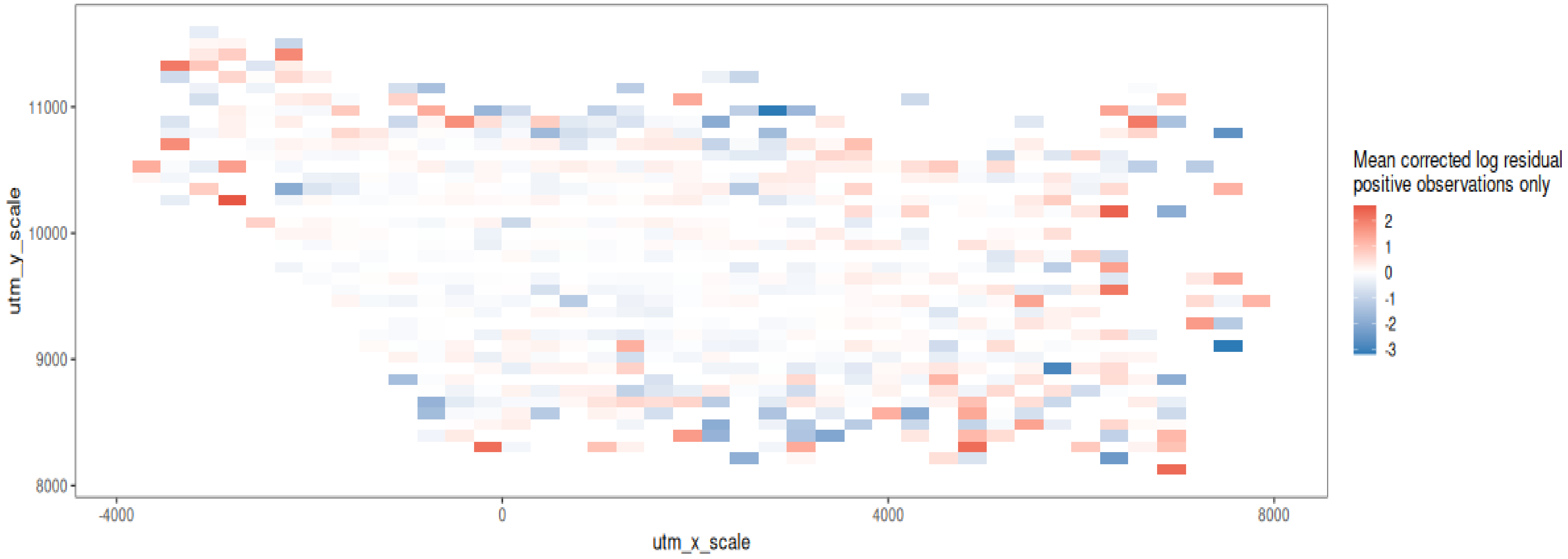


CV
0.20
0.15
0.10
2010
2015
2020
2025
Year-quarter
Model
M1
M2
M3
M4
M5
M6

Results

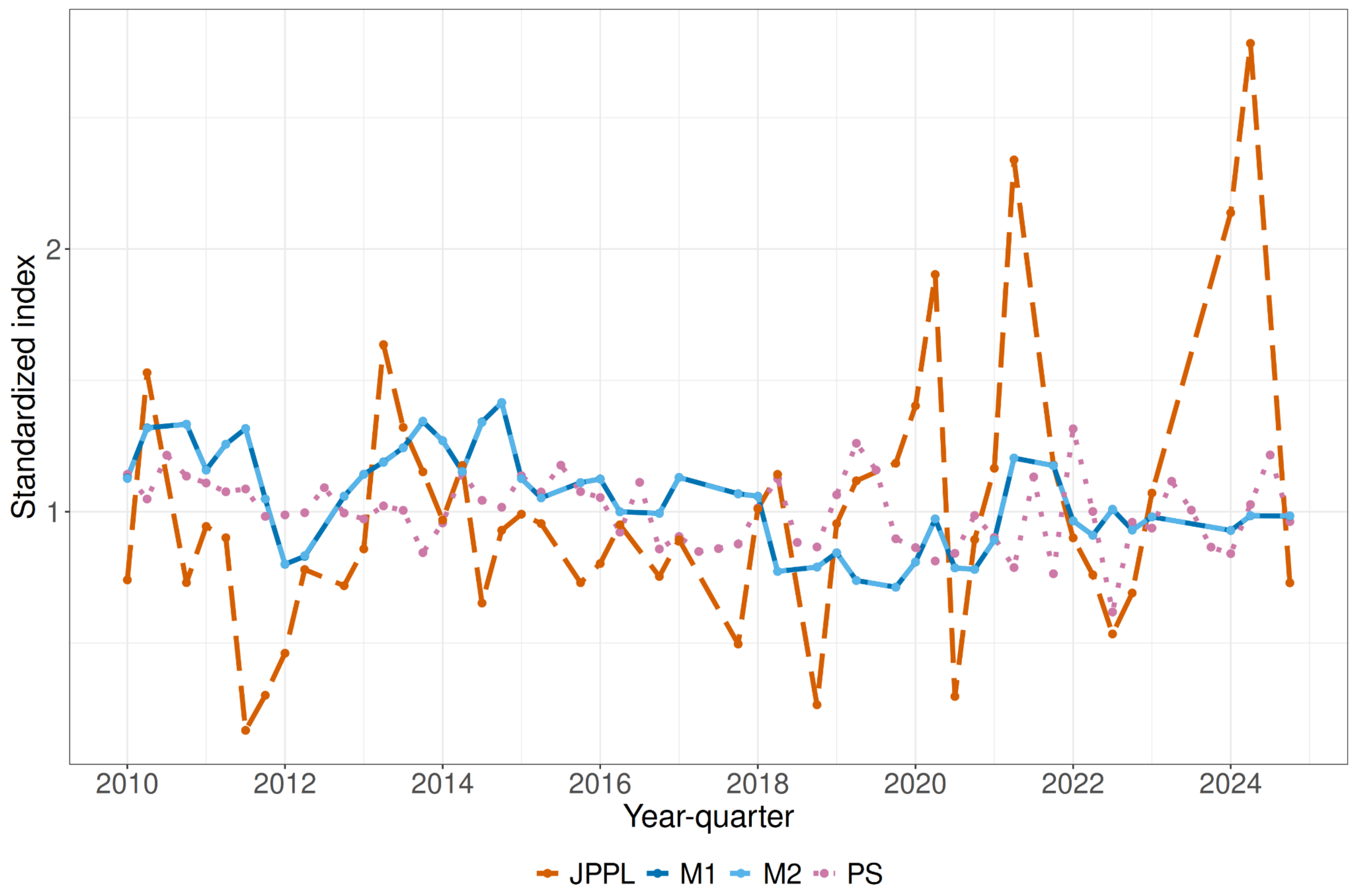


Residual distribution by fishery
JPPL
PS
Count
800
600
400
200
0
4000
3000
2000
1000
-4
-2
0
2
Corrected log residual: observed log CPUE - predicted log CPUE

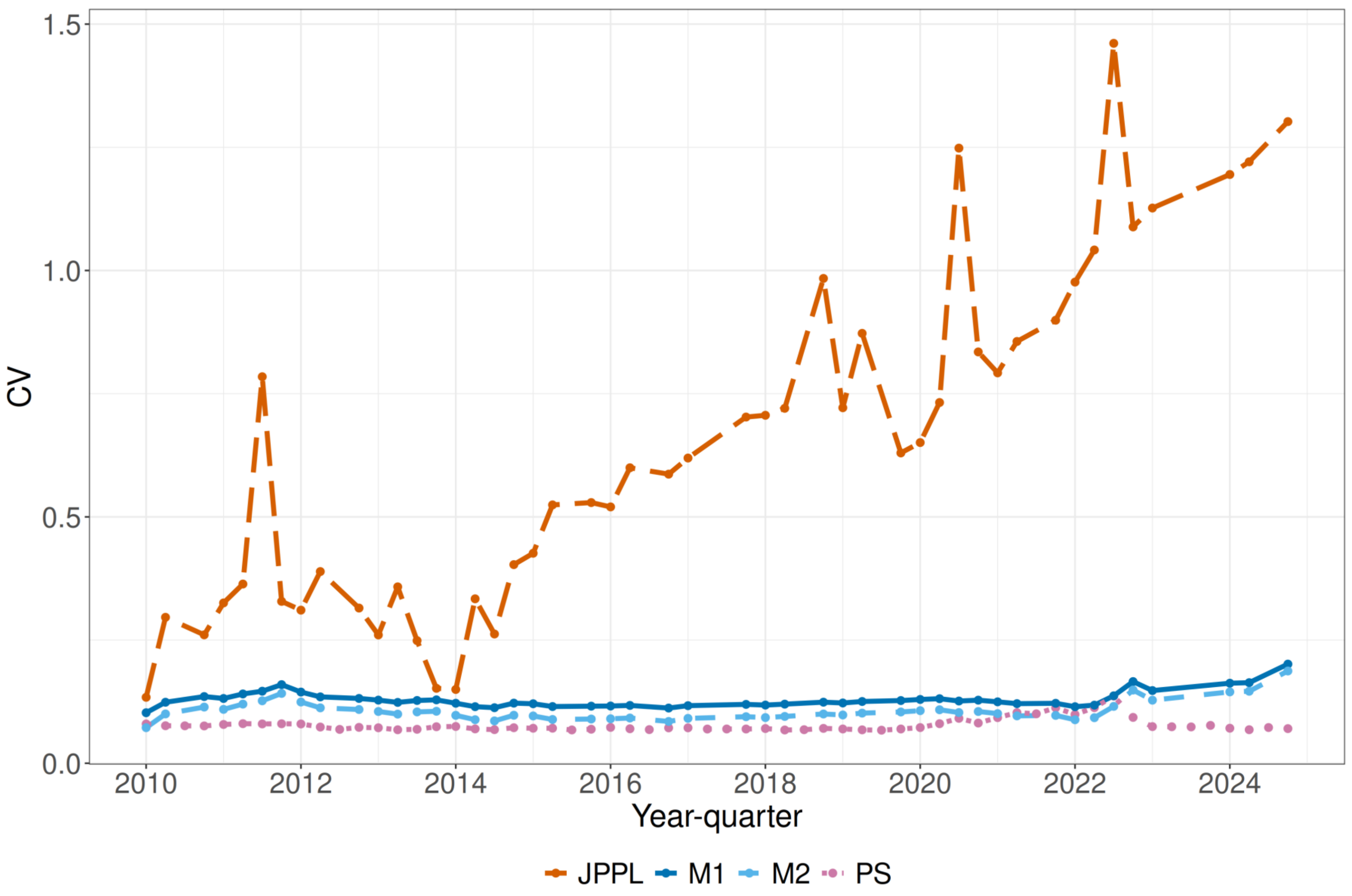


utm_y_scale
11000
10000
9000
8000
-4000
0
4000
8000
utm_x_scale
Mean corrected log residual
positive observations only
2
1
0
-1
-2
-3

Results



Standardized index
2
1
2010
2012
2014
2016
2018
2020
2022
2024
Year-quarter
JPPL
M1
M2
PS



CV
1.5
1.0
0.5
0.0
2010
2012
2014
2016
2018
2020
2022
2024
Year-quarter
JPPL
M1
M2
PS

Discussion and Conclusions

- The joint JPPL–PS framework is feasible and improves spatial coverage and precision relative to the JPPL-only analysis.
- The preferred model was well supported by model comparisons and showed no strong broad-scale spatial residual bias.
- The joint index broadly follows the PS-only trend, reflecting the much larger number of PS observations.
- Unequal sample sizes and fishery-specific selectivity require further evaluation.
- Longer time series, sensitivity analyses, and testing within the skipjack MP are needed before operational use.

Discussion and Conclusions

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SC22 is invited to:

- Provide feedback on the proposed joint modelling framework.
- Consider prioritising its further development before the third skipjack MP implementation cycle.

Acknowledgement

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Thank you

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Size Distribution