Update of joint CPUE indices for bigeye tunas in the Indian Ocean based on Japanese, Korean and Taiwanese longline fisheries data (up to 2024)

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ABSTRACT

Joint CPUE standardization for the Indian Ocean bigeye tuna was conducted using Japanese, Korean and Taiwanese fisheries data up to 2024. This effort aimed to provide the IOTC Scientific Committee with updated abundance indices for use in the stock assessment in 2025 for this stock. The collaboration sought to enhance the spatial and temporal coverage of fishery data, thereby producing combined indices. To account for inter-annual variations in the target species for each fishery, data on hooks between floats or clustering results were incorporated for each region. Conventional regression models were applied to standardize catch-per-unit-effort data, using shared operational data in each region. Overall, the trend in CPUE was broadly consistent with those used in previous stock assessments and MP applications.

INTRODUCTION

Tuna-RFMOs, including the IOTC, have recommended the development of joint CPUE data from longline fisheries to enhance stock assessments for tropical tunas. In response, the IOTC has been conducting collaborative efforts for several years to produce abundance indices by combining CPUE data from major longline fleets. An ensemble approach using fishery data from multiple longline fleets has been applied to tropical and temperate tuna species in their stock assessments. Following these established practices within the IOTC and other RFMOs, we conducted a collaborative study to develop abundance indices for the Indian Ocean bigeye tuna. This study was based on Japanese, Korean and Taiwanese longline fisheries data up to 2024.

Following these customary practices used in the IOTC and other RFMOs, we conducted a collaborative study for developing abundance indices for the Indian Ocean bigeye tuna based on Japanese, Korean and Taiwanese longline fisheries data up to 2024 by updating the analyses (Kitakado et al. 2022b) reported in the WPTT24(DP) meeting and those reported in the special session of SC in February 2025 (Kitakado et al. 2025).

MATERIALS

Data sharing protocol

The combined dataset for bigeye tuna CPUE standardization included operational data on catch numbers by species, with spatio-temporal information (daily; 1° latitude and longitude), vessel IDs, number of hooks (as effort), as well as HBF (for R1N, R1S and R2) and clustering outcomes (R3) to account for changes in the target species during fishing operations. For clustering, as outlined by Wang et al. (2021), the species were classified into albacore

(ALB), bigeye tuna (BET), yellowfin tuna (YFT), southern bluefin tuna (SBT), black marlin (BLM), blue marlin (BUM), swordfish (SWO), other billfishes (BIL), sharks (SKX), and others (OTH).

The available data cover the period 1979–2024 for the Japanese and Korean longline fisheries, and 2005–2024 for the Taiwanese longline fishery. Vessel ID data is available from 1975 for the Japanese data; however, for consistency with previous analyses, data from 1979 onward were used. For the Taiwanese data, data from 2005 onwards were used due to data quality issues discussed in previous IOTC meetings. Also, we also removed some data of Taiwanese vessels in 2021-2024 because of their sudden operational changes. Regarding vessel screening, only vessels with 20 or more data were included in the CPUE standardization.

For standardizing the catch-per-unit-effort data, the conventional delta-lognormal models were employed for operational data.

The covariates used in the analysis were shown below:

- Temporal component (Quarterly)
- Spatial component (5° squared longitudinal and latitudinal grid)
- Vessel ID
- Cluster category
- HBF averaged within aggregated data: Shallow (<=7), Medium (8<=HBF<=13) and Deep (14 <= HBF)

For the first component of "zero" or "non-zero" is expressed as a binomial distribution with a probability of "non-zero" catch as a logistic relationship with some explanatory variables, and the second component for positive catch assumed the same regression structures used in the LN regression models with a constant adjustment. All the covariates were used in the two components in delta-lognormal model. The logarithm of the number of hooks was also used in the delta-component of analysis.

Data screening

Vessels were screened as follows to save computational time and memory:

- Vessels ≥ 20 data
- Vessels ≥ 10 positive CPUE data
- 20% sub-sampling in each of spatio-temporal component defined above

Extracts of abundance indices from models with interactions

Once the model fitting was conducted, the final output of the abundance index is extracted through an exercise of quarterly effects from both the components. Note that binomial rescaling was conducted so that the average of predicted proportion of positive catch over time is equal to that of mean proportion of observed CPUE over time because of adjustment value in the logit space influence the predicted positive probabilities.

RESULTS and NOTES

Some comparisons of selected results were shown in Figures 3-5.

- **Figure 2** shows a comparison of CPUE series produced in 2019, 2022, and 2025 (this study). Operational-level data were used in the 2019 and 2025 analyses, while aggregated data were used in 2022 due to data access constraints caused by the COVID-19 pandemic. The overall CPUE trends are broadly similar across the overlapped years, but some differences are evident, as shown in **Figure 3(a)–(c)**. Note that the each CPUE was normalized so that the mean value is equal to 1, and therefore the early period of CPUE and recent slight increase may cause the difference even the most of CPUEs in the overlapped period is essentially similar.
- Although the magnitude differs, a slight increase in standardized CPUE was observed in each region.

  In the 2022 CPUE analysis, a common HBF effect was assumed across the three fleets in each region. However, the authors considered that fleet-specific HBF effects might be more appropriate and applied this approach in the 2025 analysis. **Figure 4** illustrates the differences in standardized CPUEs from the delta-lognormal model under the assumptions of common and fleet-specific HBF effects for the Japanese, Korean, and Taiwanese fleets in R1N, R1S, and R2. While the overall patterns were broadly similar, some spikes were observed in the common-effect case. Although not all effects were statistically significant (see the table below) and were not considered in previous analyses, these parameters are important for capturing fleet-specific characteristics. Therefore, they were ultimately included in the results.

Binomial	Estimate	Std. Error	t value	Pr(>|t|)	LN	Estimate	Std. Error	t value	Pr(>|t|)
JPN-Medium	0.515	0.453	1.135	0.256	JPN-Medium	0.269	0.073	3.683	0.000
JPN-Deep	0.673	0.499	1.347	0.178	JPN-Deep	0.144	0.083	1.733	0.083
KOR-Shallow	0.082	0.426	0.193	0.847	KOR-Shallow	-0.272	0.063	-4.319	0.000
KOR-Medium	-0.738	0.373	-1.980	0.048	KOR-Medium	-0.220	0.055	-3.974	0.000
TWN-Medium	-1.450	0.245	-5.908	0.000	TWN-Medium	-0.309	0.086	-3.601	0.000

- **Figure 5** presents a comparison between standardized CPUEs derived from the delta-lognormal model using data up to 2024 (this study) and those from the lognormal model using data up to 2023 (Kitakado et al. 2025), which was employed in the computation of the management procedure in February 2025. In both cases, HBF was used to account for targeting; however, the 2025 delta-lognormal model newly incorporated a fleet-specific assumption. While the results were not perfectly consistent, the overall trends were broadly similar.
- In relation to the above, the updated code used in the February 2025 workshop for the lognormal model contained a minor error: a small constant adjustment to avoid taking the logarithm of zero was not applied in the final computation of standardized CPUEs. However, as the outcomes from the four regions were ultimately normalized and combined into a single CPUE series for fitting the state-space production model, the effect on the resulting TAC should be minimal. Furthermore, **Figure 5** indicates that the CPUEs from the delta-lognormal model (assumed to be used in the MP) are also similar to those used in the management procedure.

ACKNOWLEDGEMENT

The authors are grateful to the experts — Simon Hoyle, Gorka Merino, Dan Fu, and Genevieve Phillips — for their helpful and constructive comments provided during the workshop and through subsequent email communications. The authors were advised to include background information on the fisheries for each fleet. However, due to time constraints, this version does not incorporate that advice. Basic information will be included in a future revision of this paper for upcoming WPTT meetings, including the one scheduled for October 2025.

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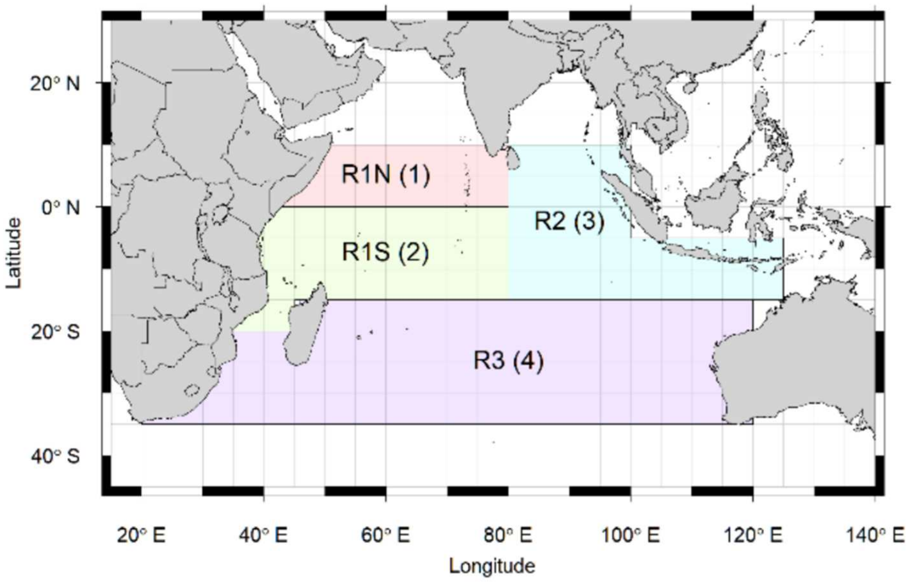


Figure 1. Definition of the regions used in the analysis.

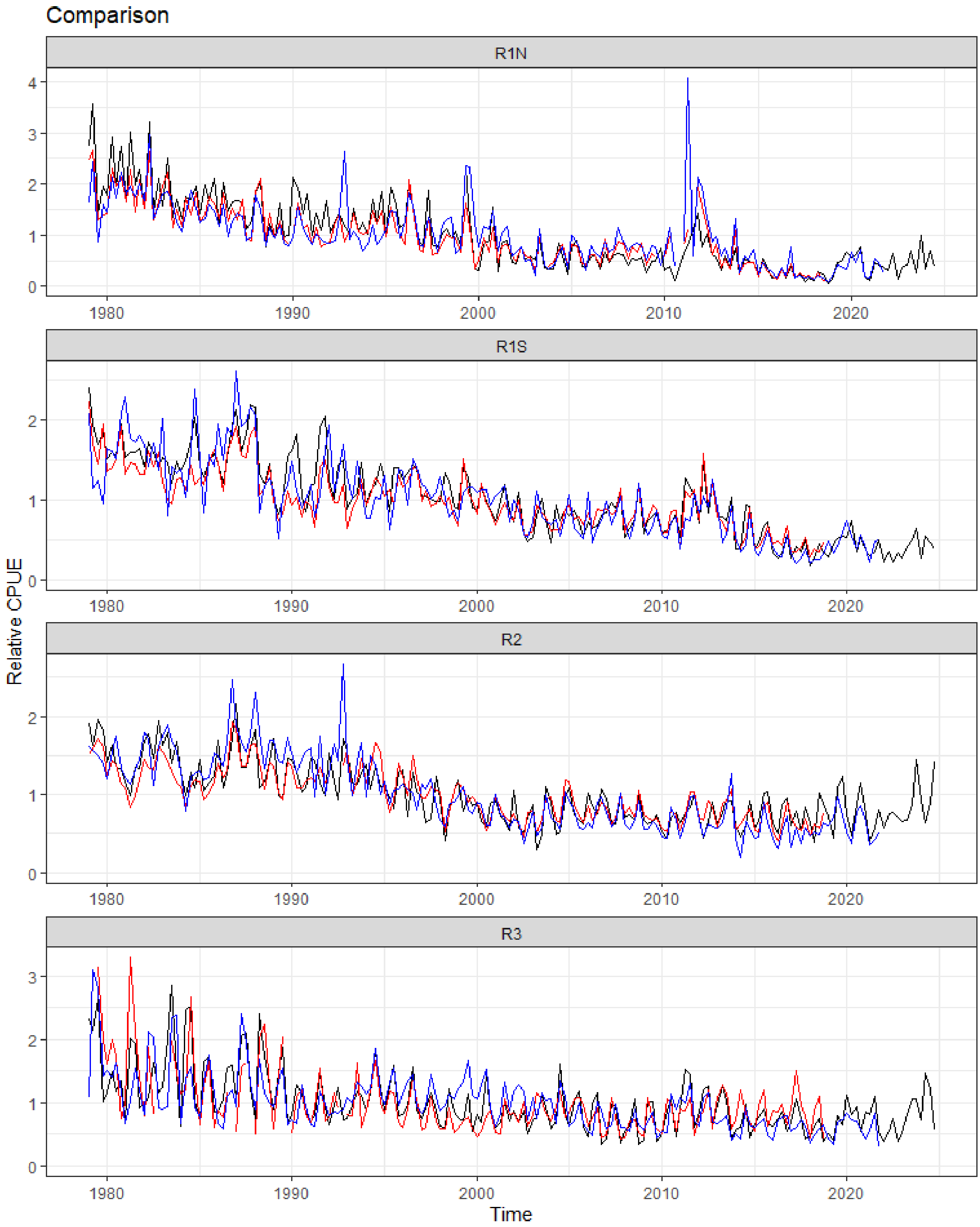


Figure 2. Standardized CPUE series produced in 2019 (red), 2022 (blue), and 2025 (black). Operational-level data were used in the 2019 and 2025 analyses, while aggregated data were used in 2022.

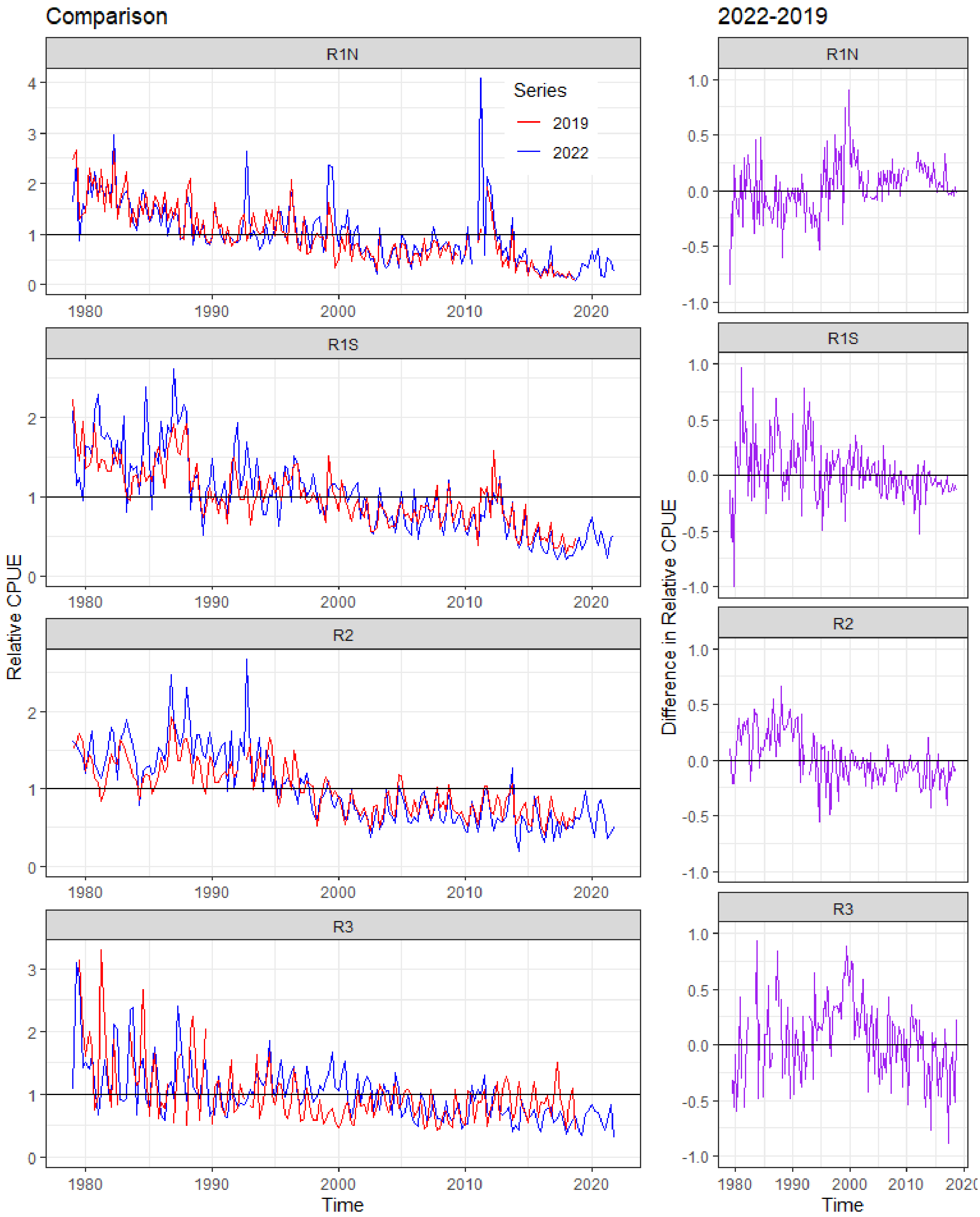


Figure 3(a). Comparison of standardized CPUE in 2019 (Hoyle et al. 2019) and 2022 (Kitakado et al. 2022).

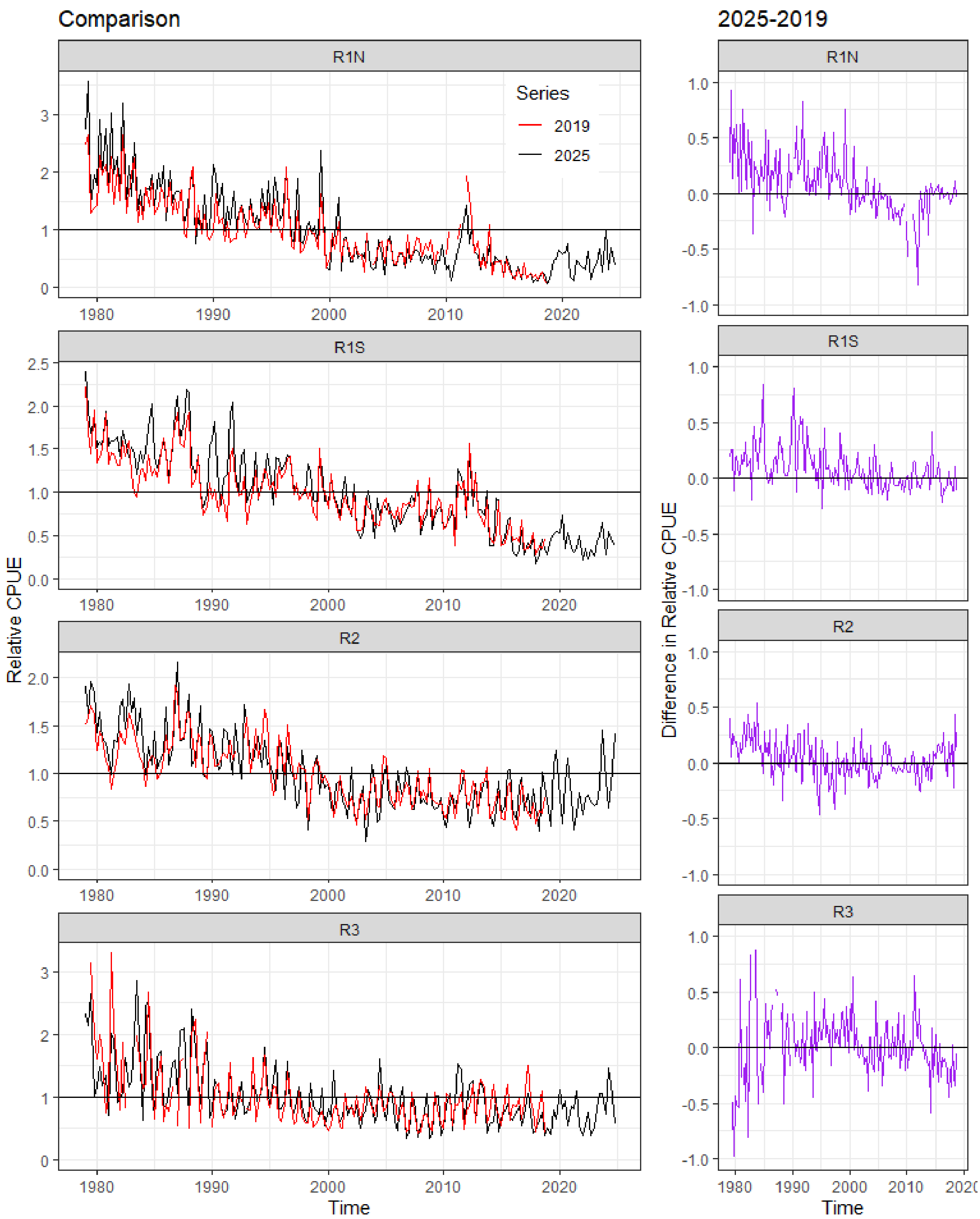


Figure 3(b). Comparison of standardized CPUE in 2019 (Hoyle et al. 2019) and 2025 (in this paper).

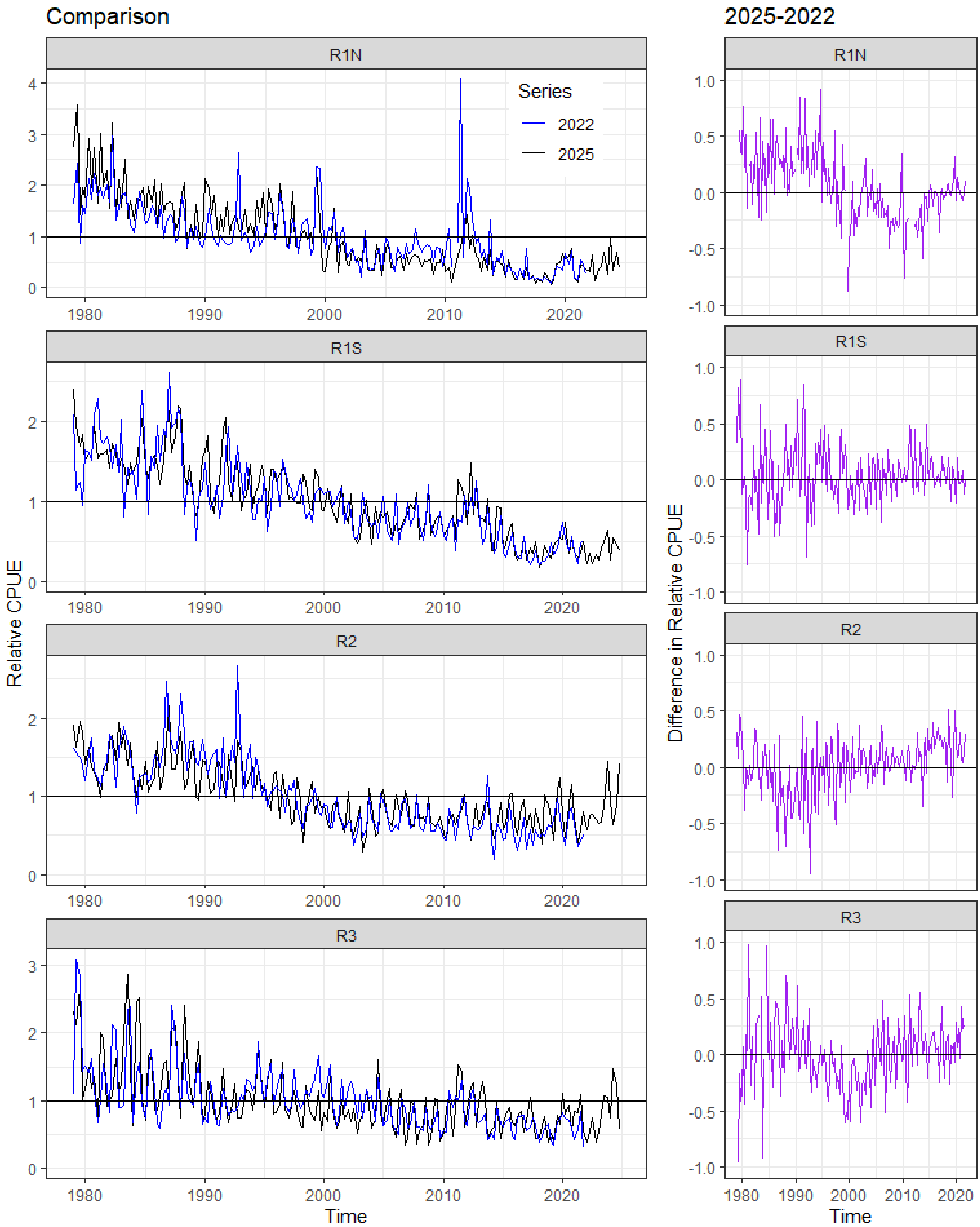


Figure 3(c). Comparison of standardized CPUE in 2022 (Kitakado et al. 2022) and 2025 (in this paper).

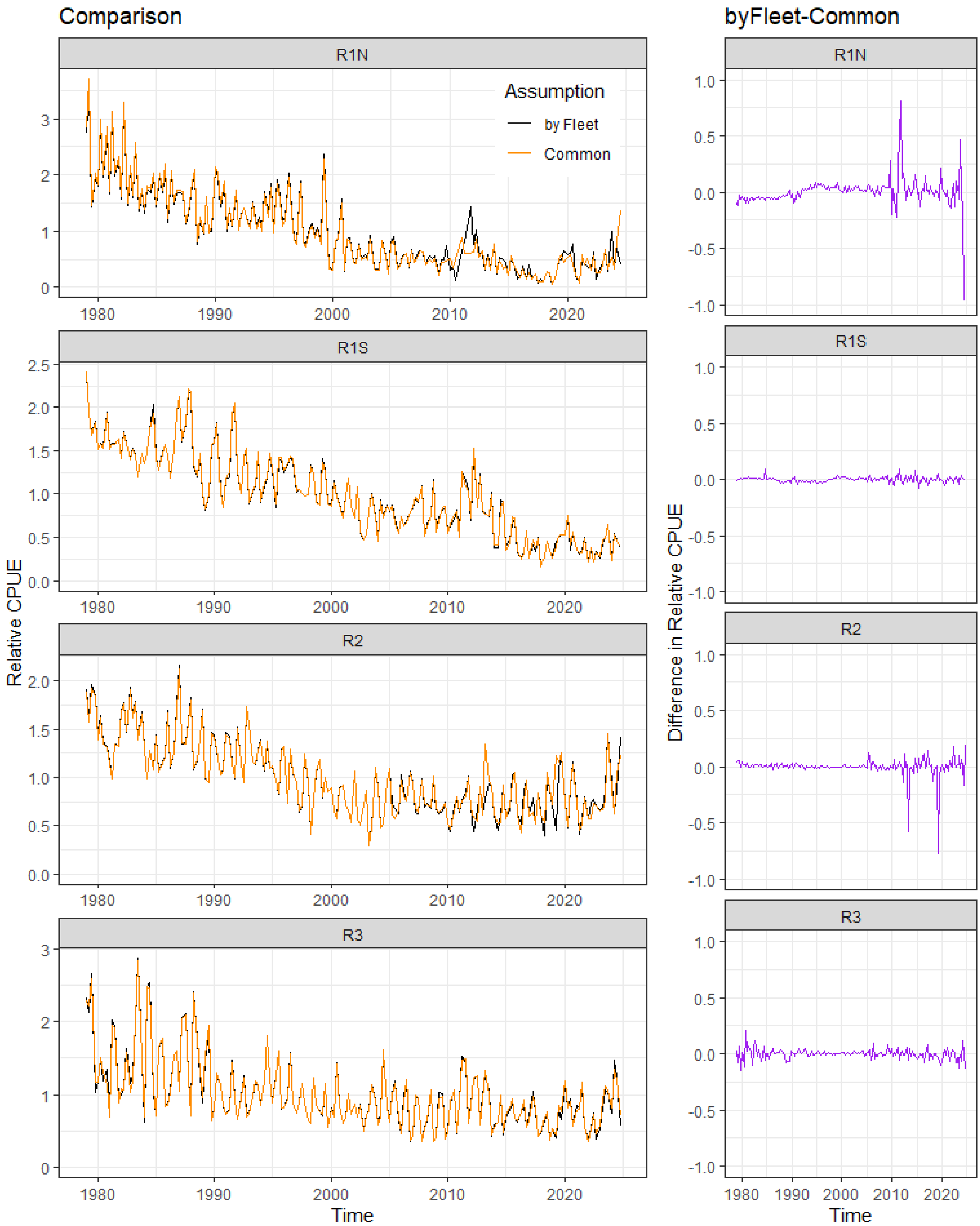


Figure 4. Comparison of standardized CPUE from the delta-lognormal model assuming **common** and **fleet-specific** HBF effects across Japanese, Korean, and Taiwanese fleets (in R1N, R1S and R2). Difference in R3 due to 20% sub-sampling.

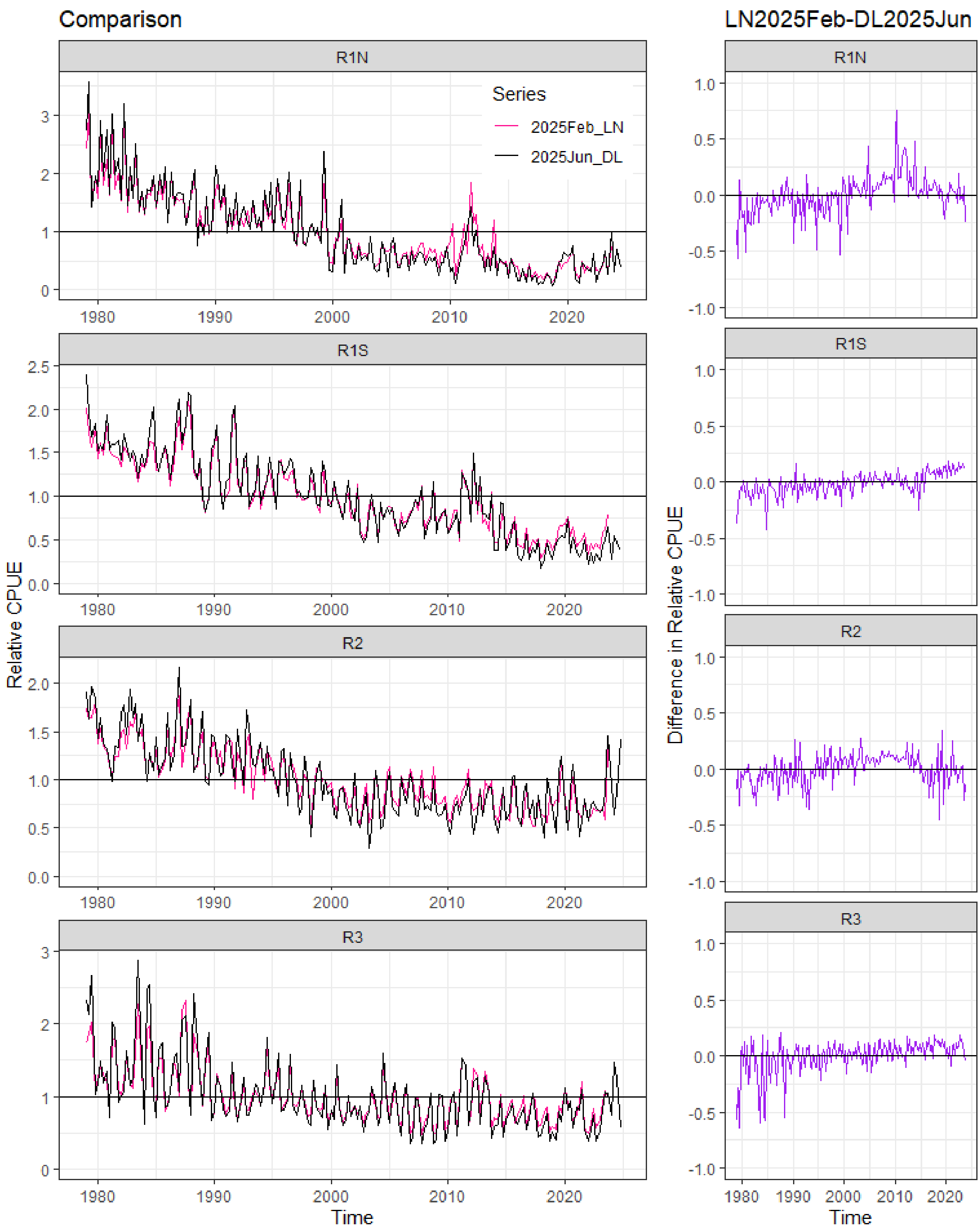
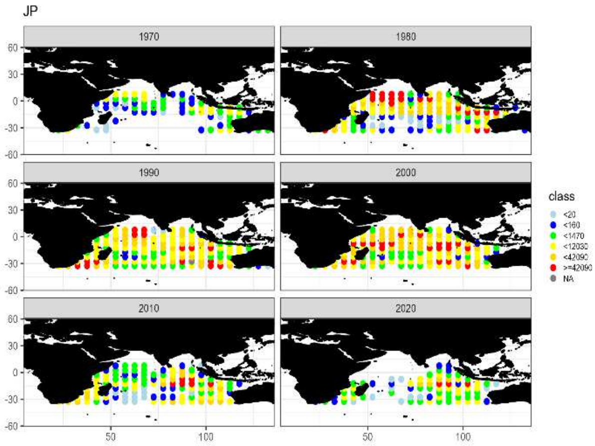


Figure 5. Comparison of standardized CPUEs from the delta-lognormal model using data up to 2024 (this study) and the lognormal model using data up to 2023 (Kitakado et al. 2025), which was employed in the computation of the management procedure in February 2025. In both cases, HBF was used to account for targeting; however, the 2025 delta-lognormal model newly incorporated a fleet-specific assumption.

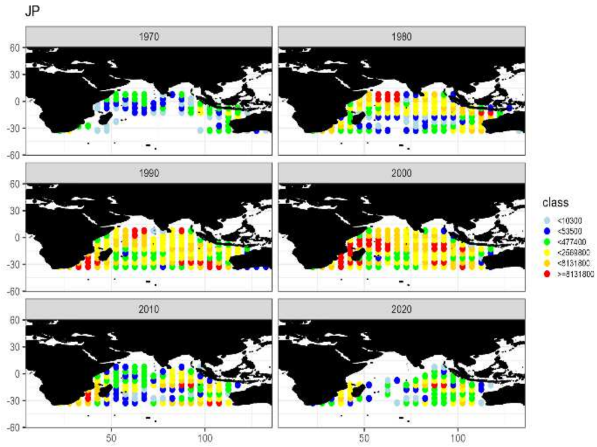
Appendix 1. Map of catch, effort, and CPUE

a) Japanese fisheries

Catch



Effort



CPUE

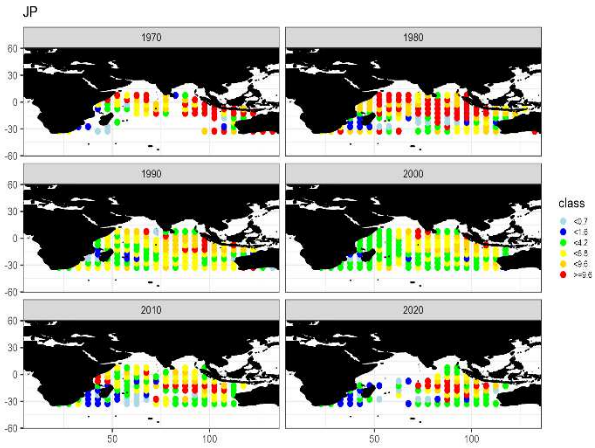
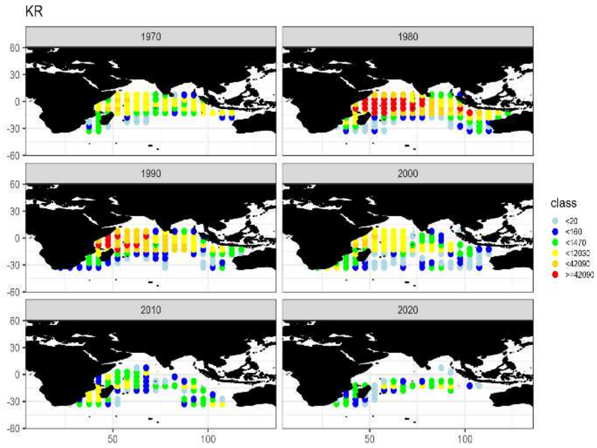


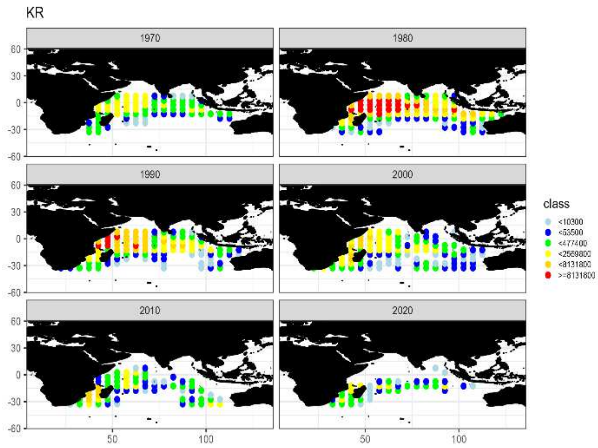
Figure A1(a). Map of catch, effort, and CPUE in Japanese fisheries.

b) Korean fisheries

Catch



Effort



CPUE

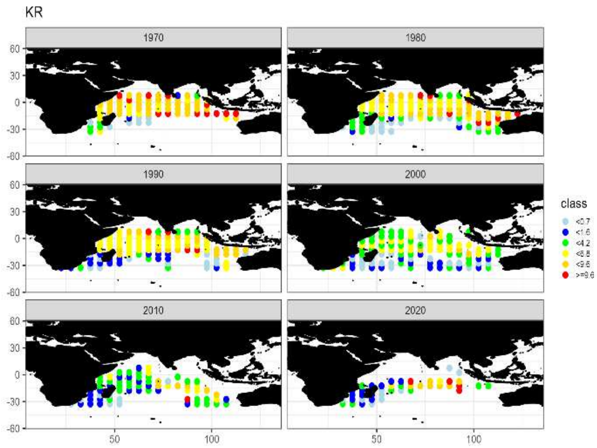
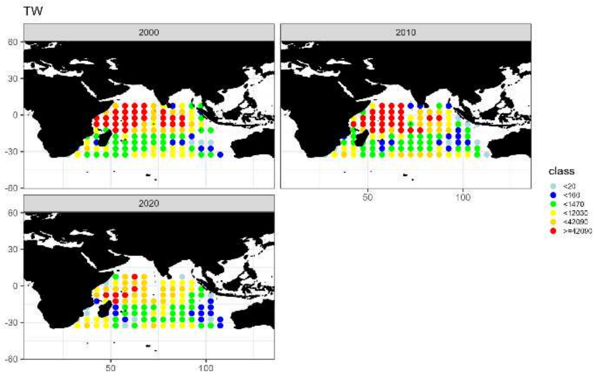


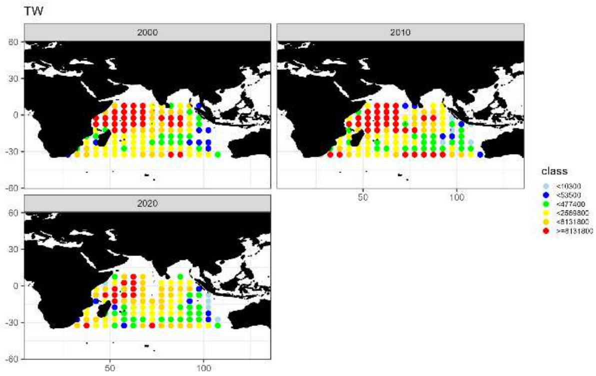
Figure A1(b). Map of catch, effort, and CPUE in Korean fisheries.

c) Taiwanese fisheries

Catch



Effort



CPUE

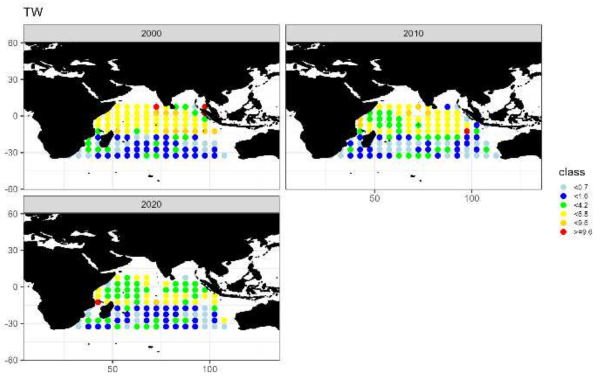


Figure A1(c). Map of catch, effort, and CPUE in Taiwanese fisheries.

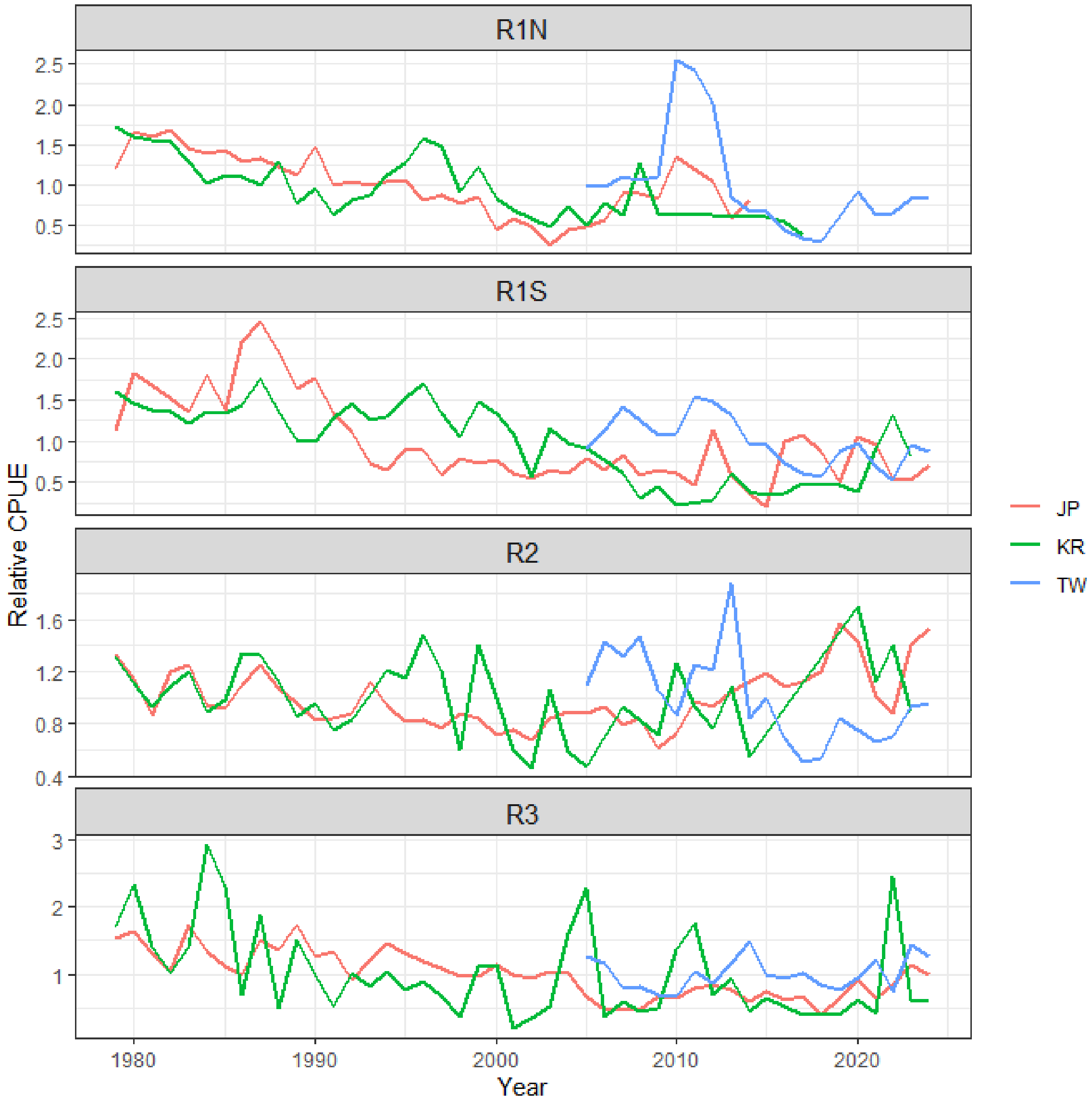
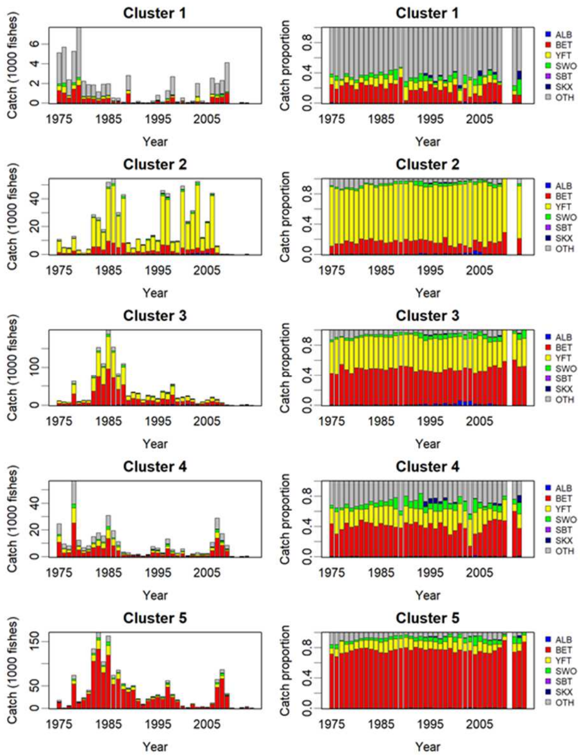


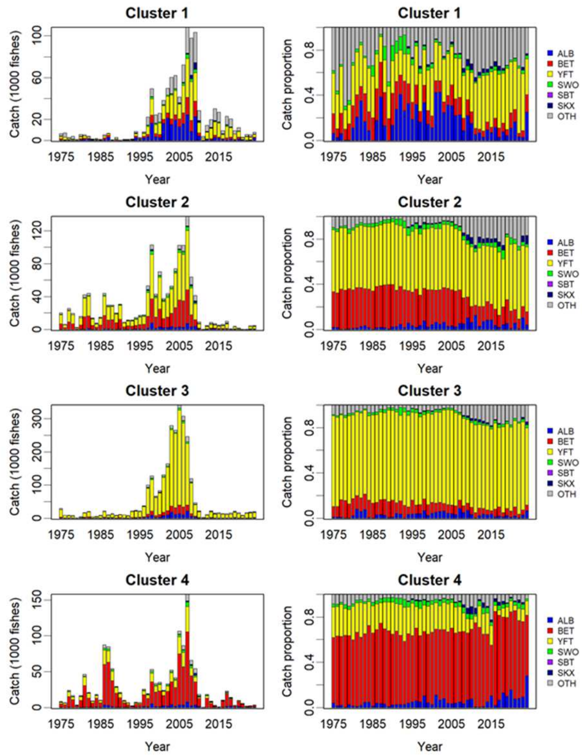
Figure A2. Annual time series of nominal CPUE by region.

a) Japanese fisheries

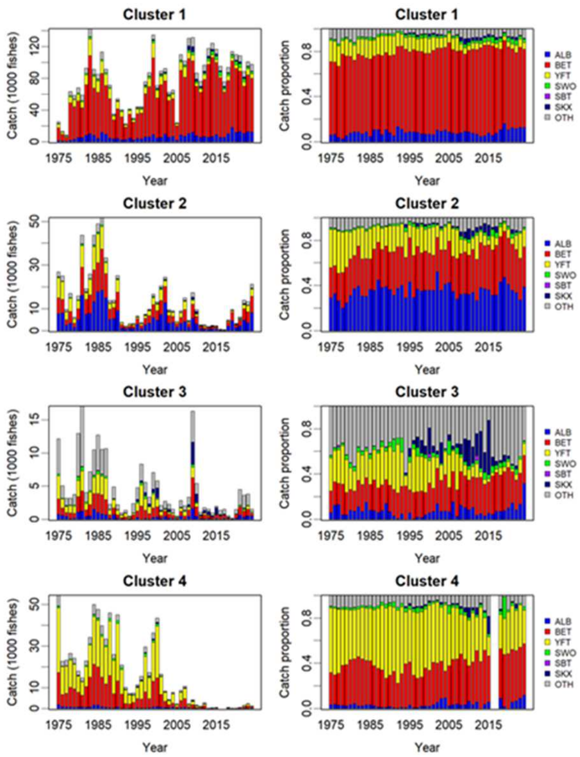
R1N



R1S



R2



R3

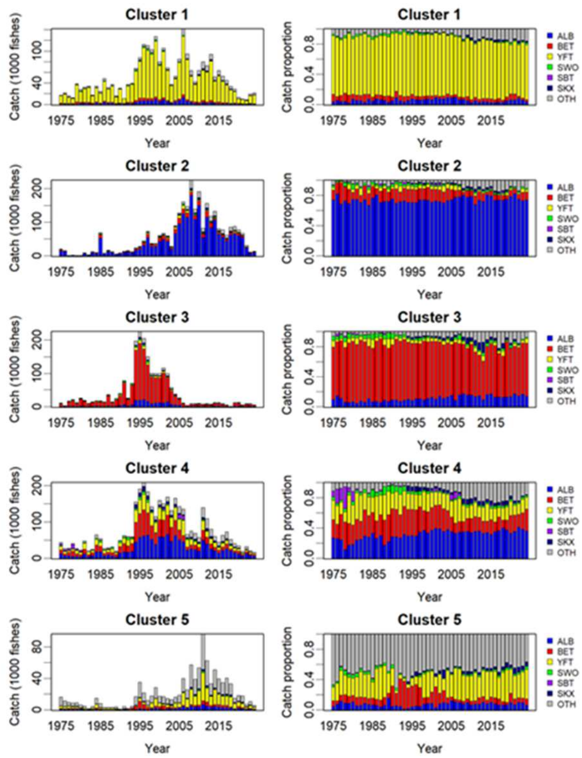
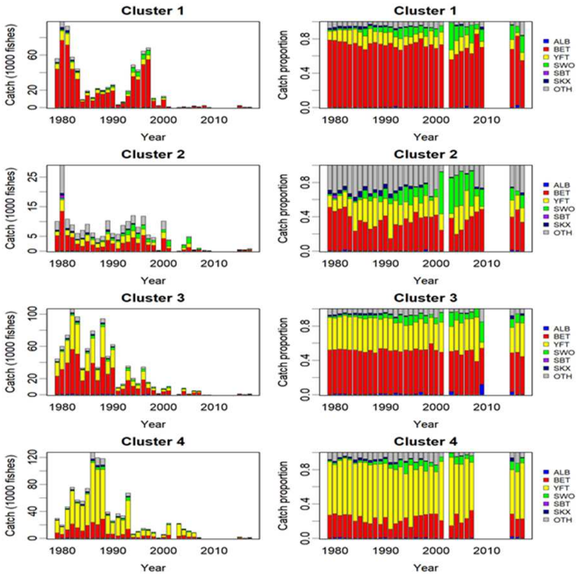


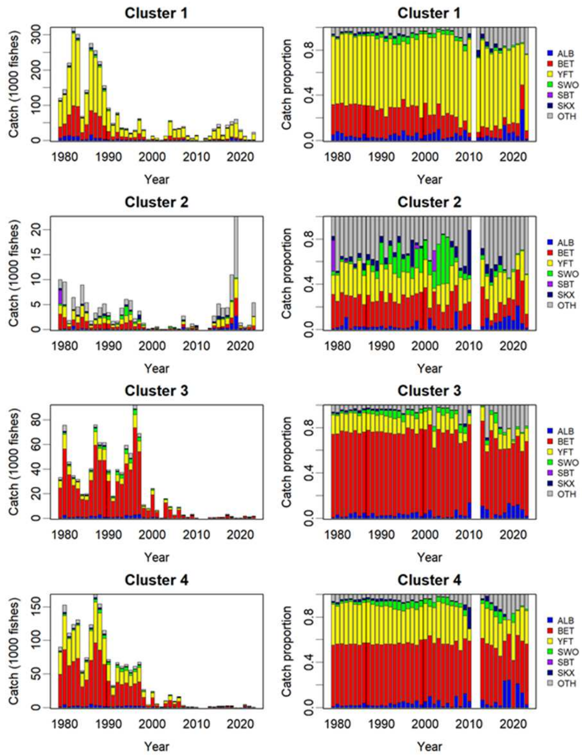
Figure A3(a). Species composition for each cluster in Japanese fisheries.

b) Korean fisheries

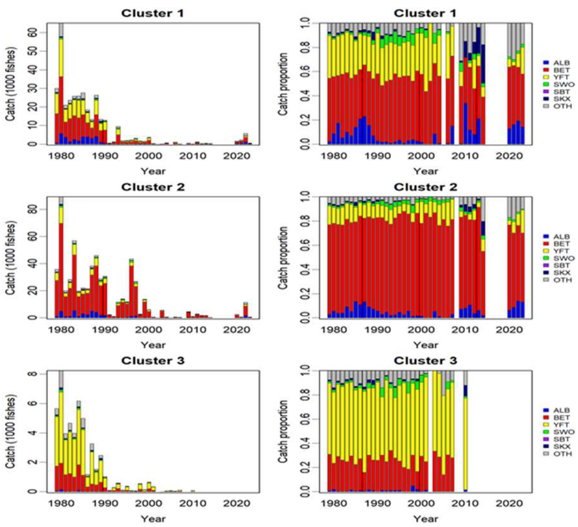
R1N



R1S



R2



R3

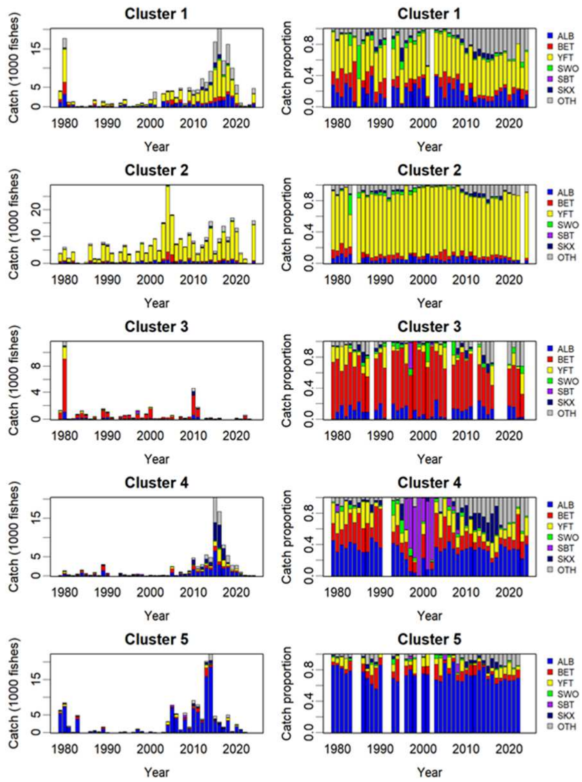
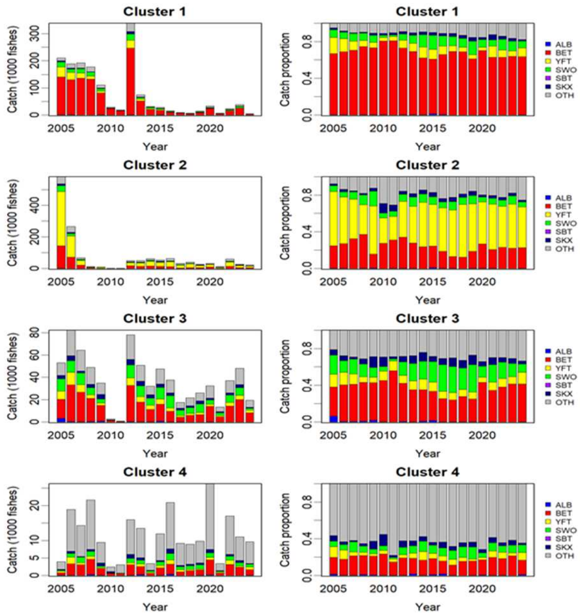


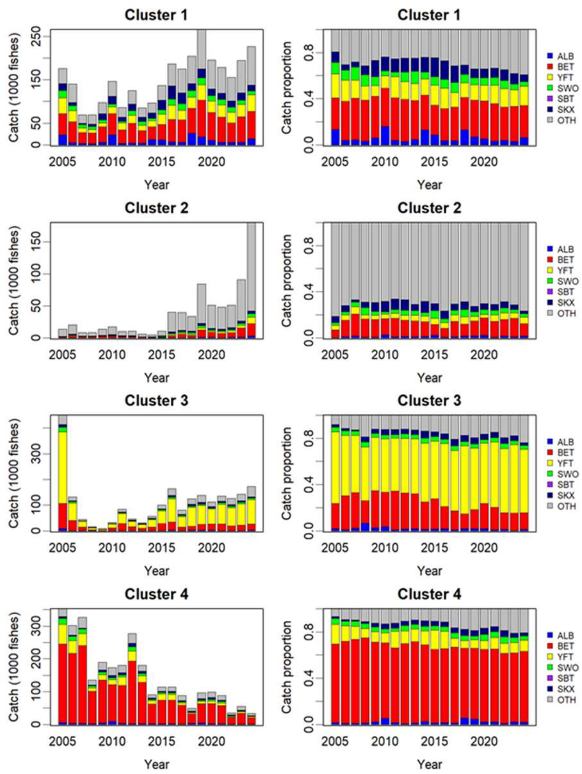
Figure A3(b). Species composition for each cluster in Korean fisheries.

c) Taiwanese fisheries

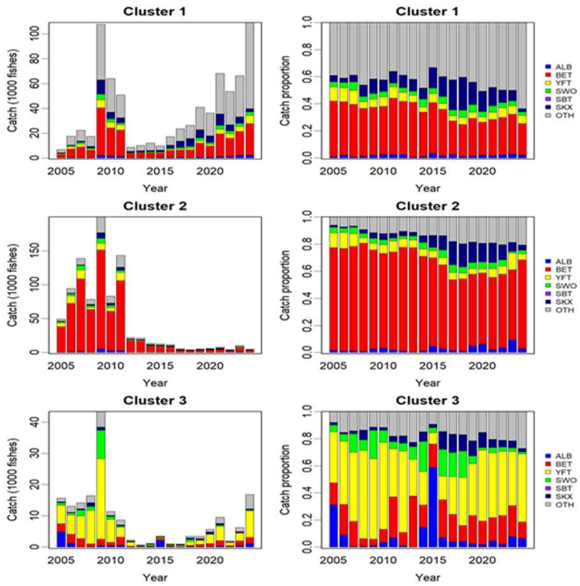
R1N



R1S



R2



R3

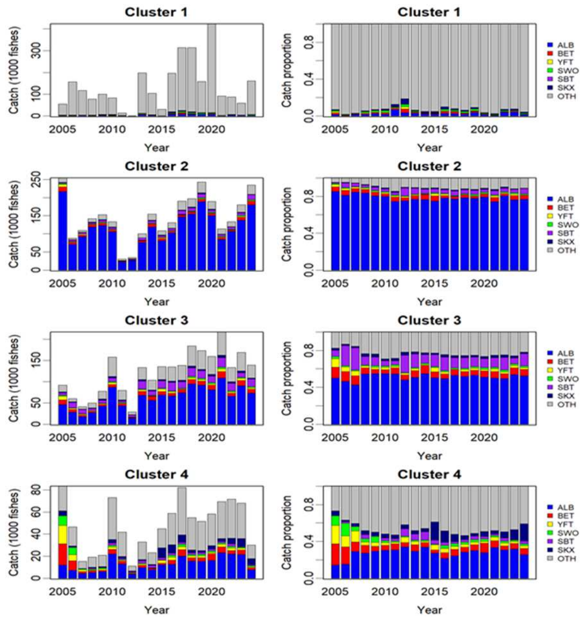


Figure A3(c). Species composition for each cluster in Taiwanese fisheries.

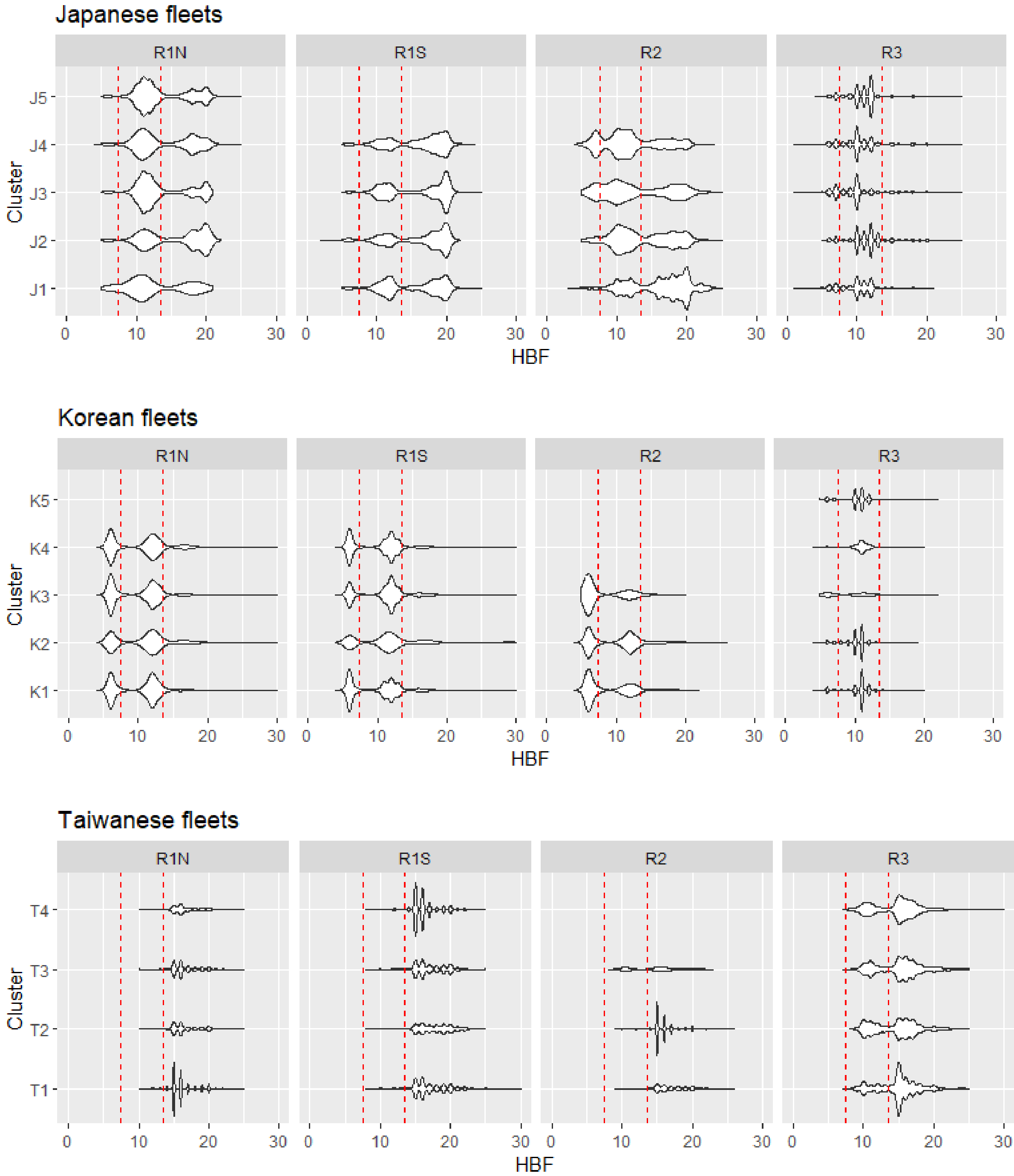
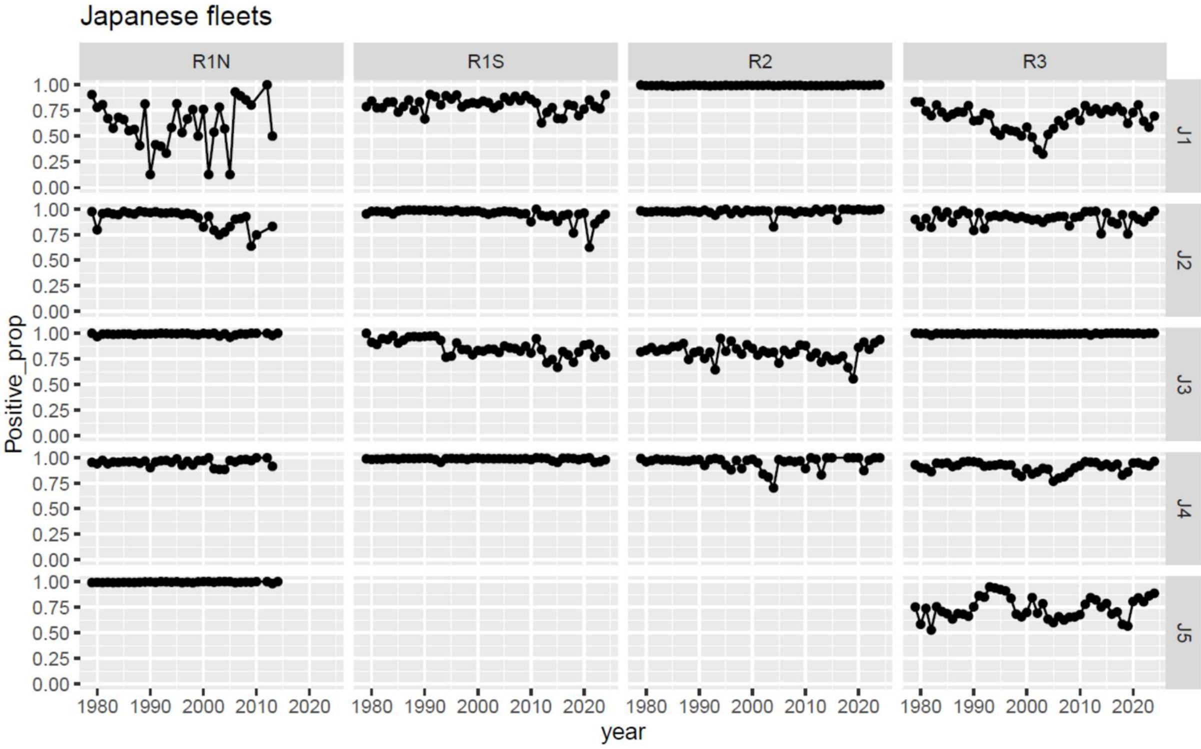


Figure A4. Relationship between HBF and Cluster in each region.

a) Japan

Cluster



HBF

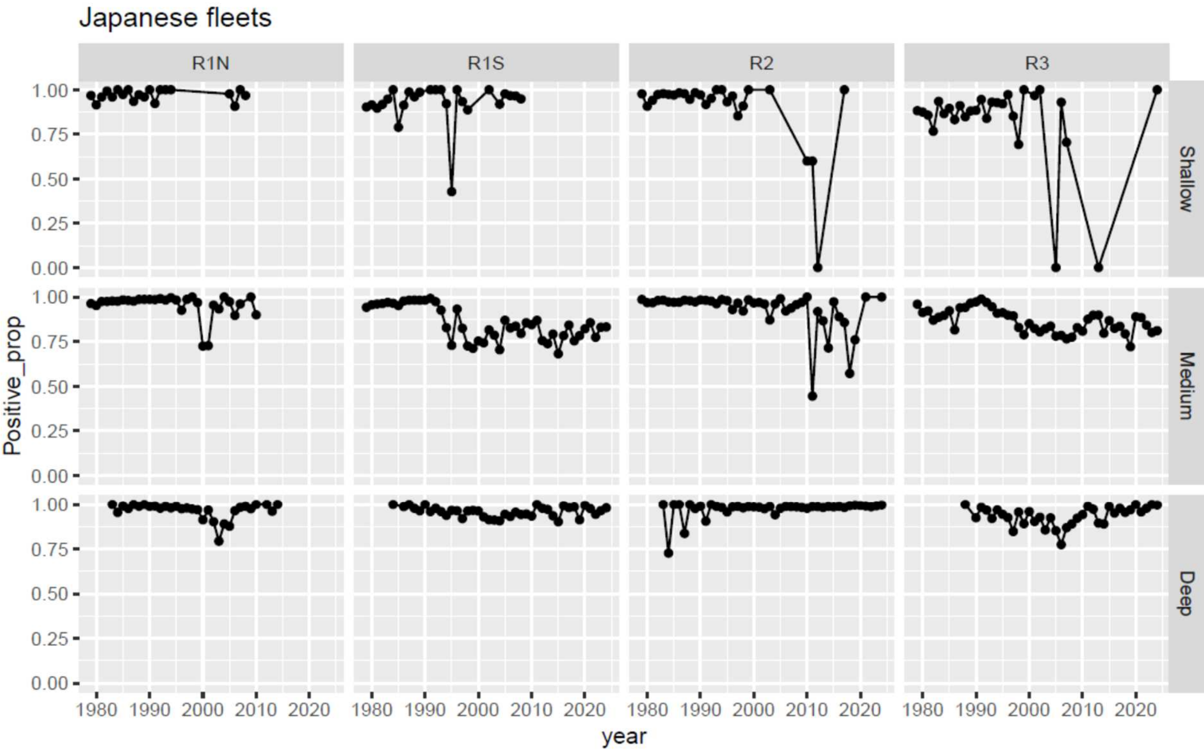
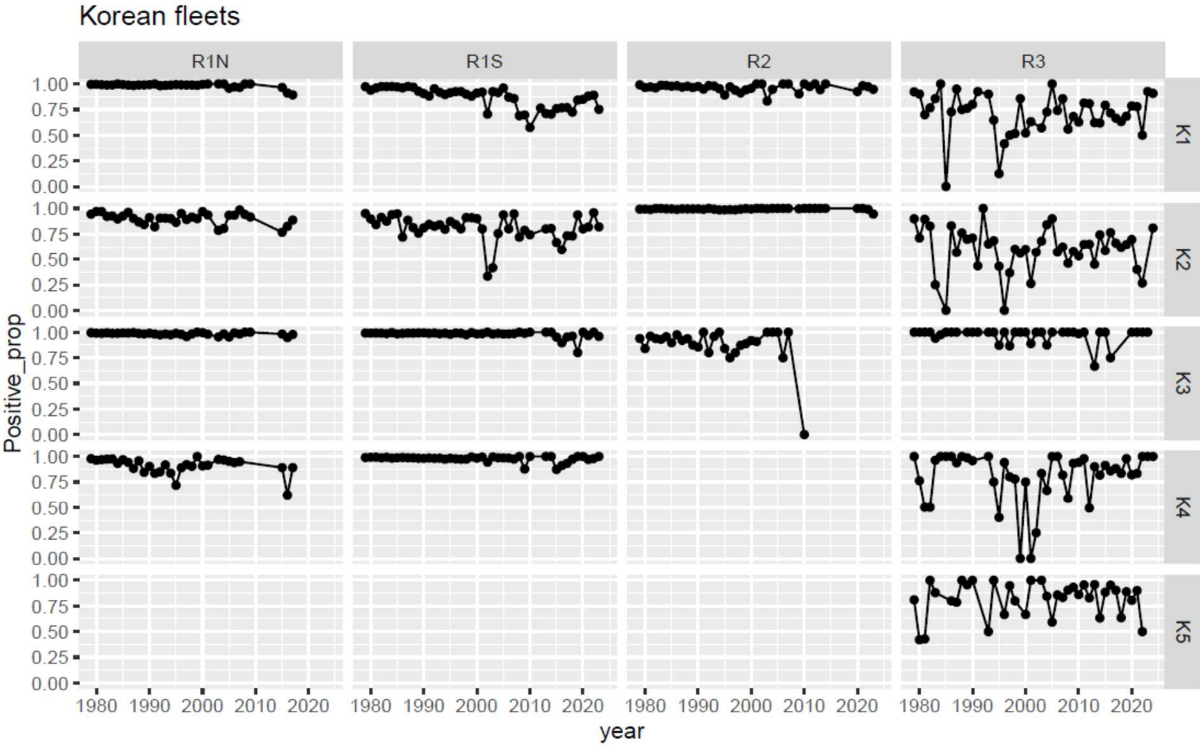


Figure A5(a). Time series of positive catch probabilities in Japanese fisheries.

b) Korea

Cluster



HBF

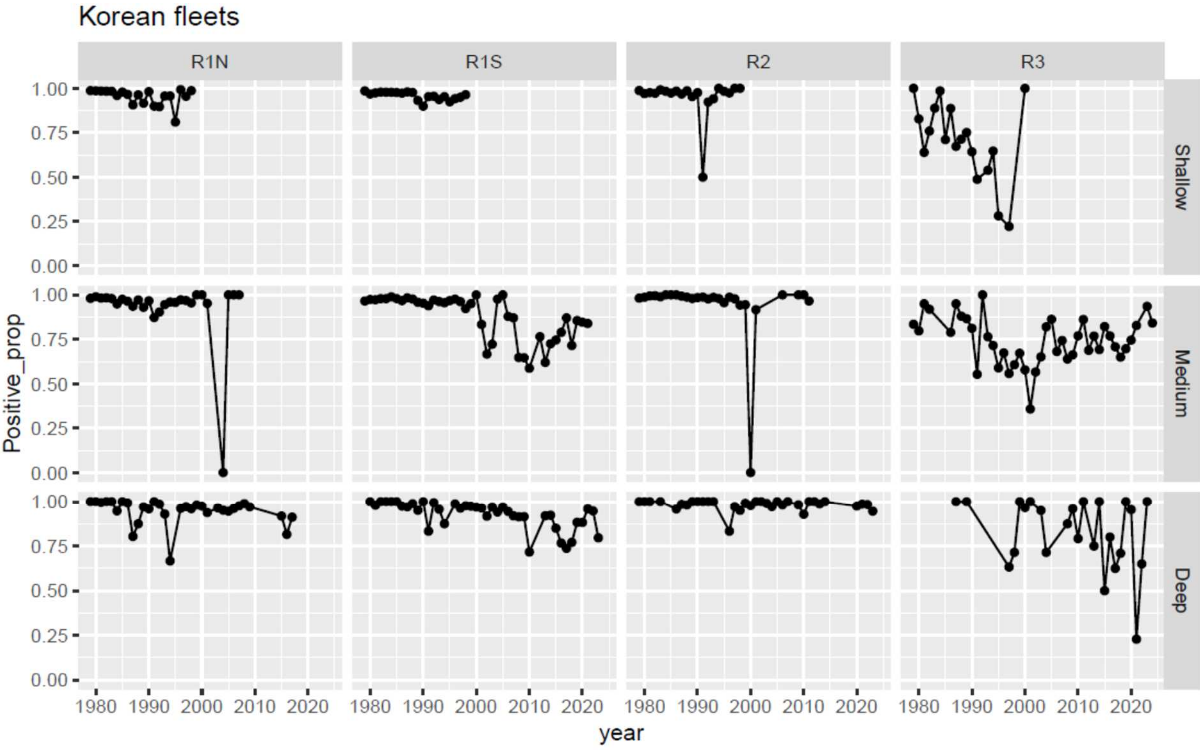
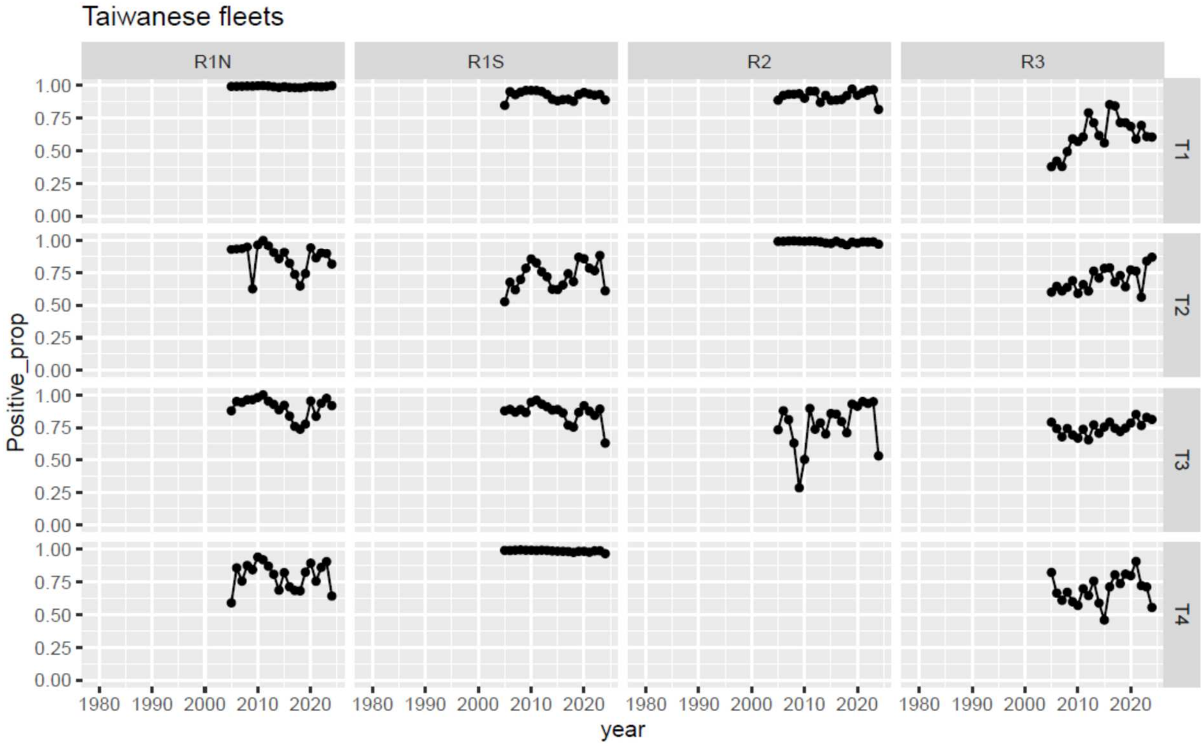


Figure A5(b). Time series of positive catch probabilities in Korean fisheries.

c) Taiwan

Cluster



HBF

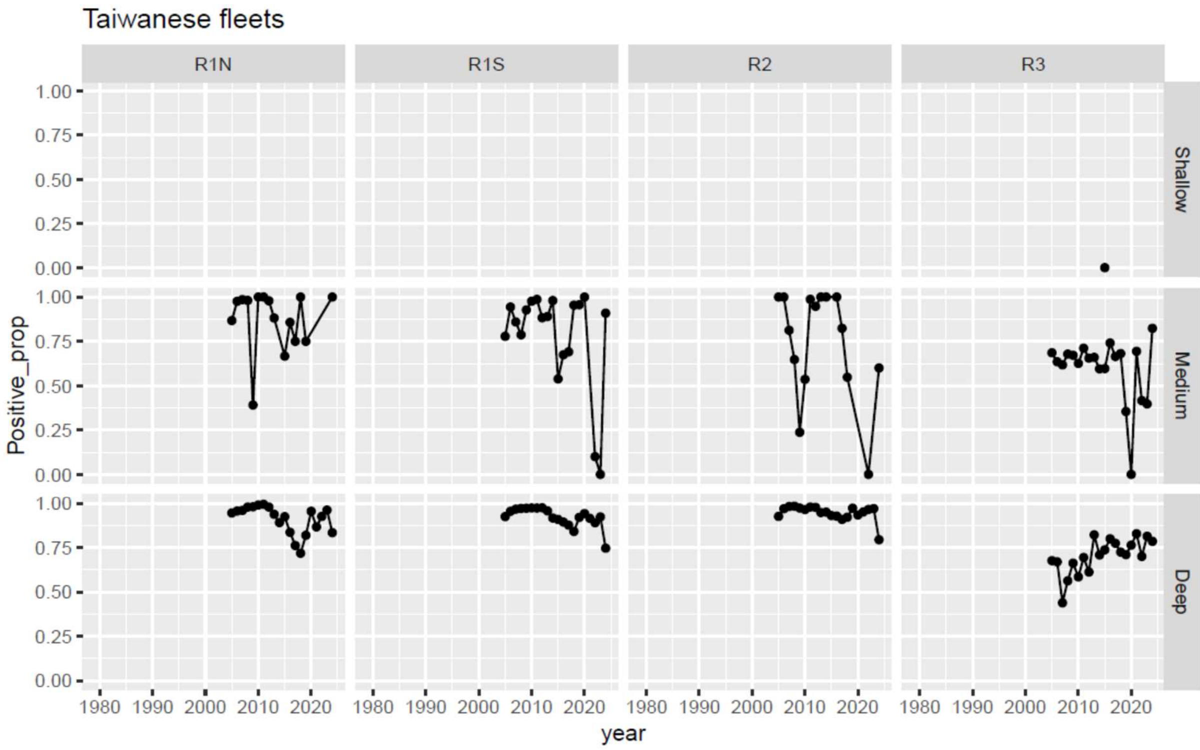


Figure A5(c). Time series of positive catch probabilities in Taiwanese fisheries.