Update of joint CPUE indices for albacore tunas in the Indian Ocean based on Japanese, Korean and Taiwanese longline fisheries data up to 2023

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ABSTRACT

Joint CPUE standardization was conducted for the Indian Ocean albacore tuna based on Japanese, Korean and Taiwanese longline fisheries data up to 2023 to provide the WPTmT with information on abundance indices for use in the 2025 stock assessment for this stock. The intention was to produce combined indices by increasing the spatial and temporal coverage of fishery data. To account for the inter-annual changes of the target in each fishery, information on clustering results was used in each region. For standardizing the catch-per-unit-effort data, the conventional linear models and delta-lognormal linear models were employed for the shared operational data in each region.

INTRODUCTION

Tuna-RFMOs, including the IOTC, have recommended the development of joint CPUE data from longline fisheries to enhance stock assessments for tropical and temperate 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 albacore tuna. This study was based on longline fisheries data from Japan, Korea, and Taiwan, up to 2023.

MATERIALS and METHODS

Figure 1 shows the definition of regions used in the analysis. The combined dataset for albacore 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) and clustering outcomes (see Fig 2) 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 data period for the three fisheries spans 1979-2023 for Japan and Korea, and 2005-2023 for Taiwan. Also we removed some data of Taiwanese vessels in 2021-2023 because of their sudden operational changes. Regarding vessel screening, only vessels with 20 or more data were included in the CPUE standardization. No subsampling was conducted.

A delta-lognormal model was tested to statistically account for “zero data,” as used in previous analyses (e.g. Hoyle et al. 2018; Kitakado et al. 2022). The first component, representing “zero” or “non-zero” catch, was modelled using a binomial distribution, with the probability of a non-zero catch expressed as a logistic function of

explanatory variables. The second component, for positive catch values, assumed a lognormal regression structure. The logarithm of the number of hooks was also included as a covariate in the binomial component. Data from clusters believed to represent oilfish and Southern bluefin tuna fisheries were excluded from the analyses (see Figure 2 and Table 2).

A traditional lognormal (LN) regression model with a constant adjustment was also applied to data from selected clusters that may have specifically targeted albacore. An overview of the models used in this study and information on selected clusters are provided in Tables 1 and 2 respectively.

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

Some comparisons of selected results were shown in Figure 3.

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Table 1. Summary of specification of models used in the analysis.

Model name	Probability distribution	Cluster selection	Delta VesselID	Delta ln(Effort)	Delta S-T interactions	Positive VesselID	Positive S-T interactions	Note
Delta_r0r0	Delta-LN	All but SBT/Oil	X	X		X		
Delta_r0r1		All but SBT/Oil		X		X	X	Continuation of 2022
Delta_r1r0		All but SBT/Oil		X	X	X		
Delta_r1r1		All but SBT/Oil	X	X	X	X	X	
LN_r0	LN	Selected				X		
Ln_r1		Selected				X	X	

Table 2. Summary of clusters selected in LN models

	Japanese fleet	Korean fleet	Taiwanese fleet
R1	2	4	4
R2	2	2	1
R3	1 -(4)	4 -(5)	3, 4 -(2)
R4	3 - (1,2)	3 -(1,4)	1,2

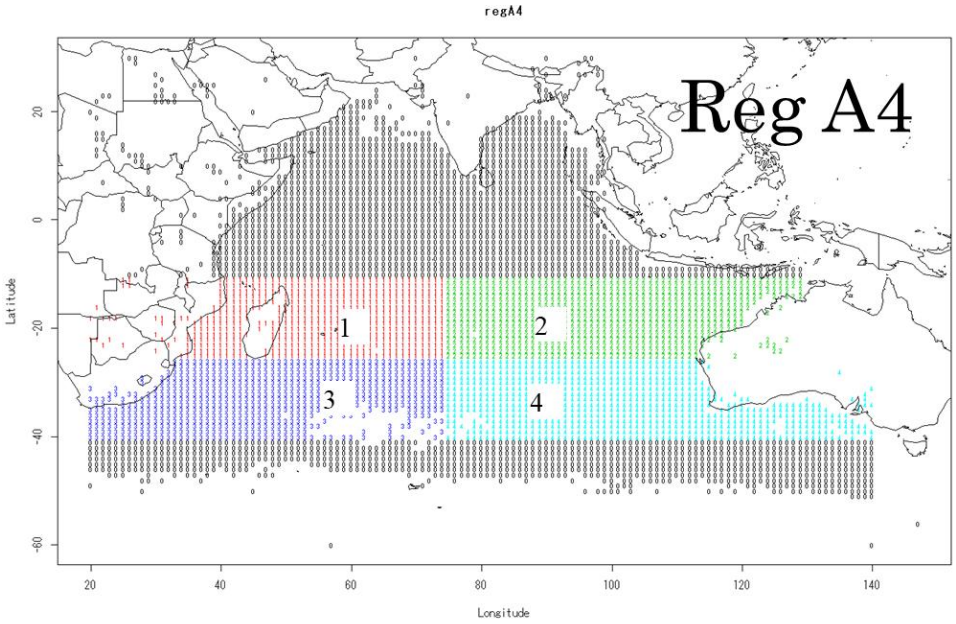


Figure 1. Definition of the regions used in the analysis.

Japanese fleet

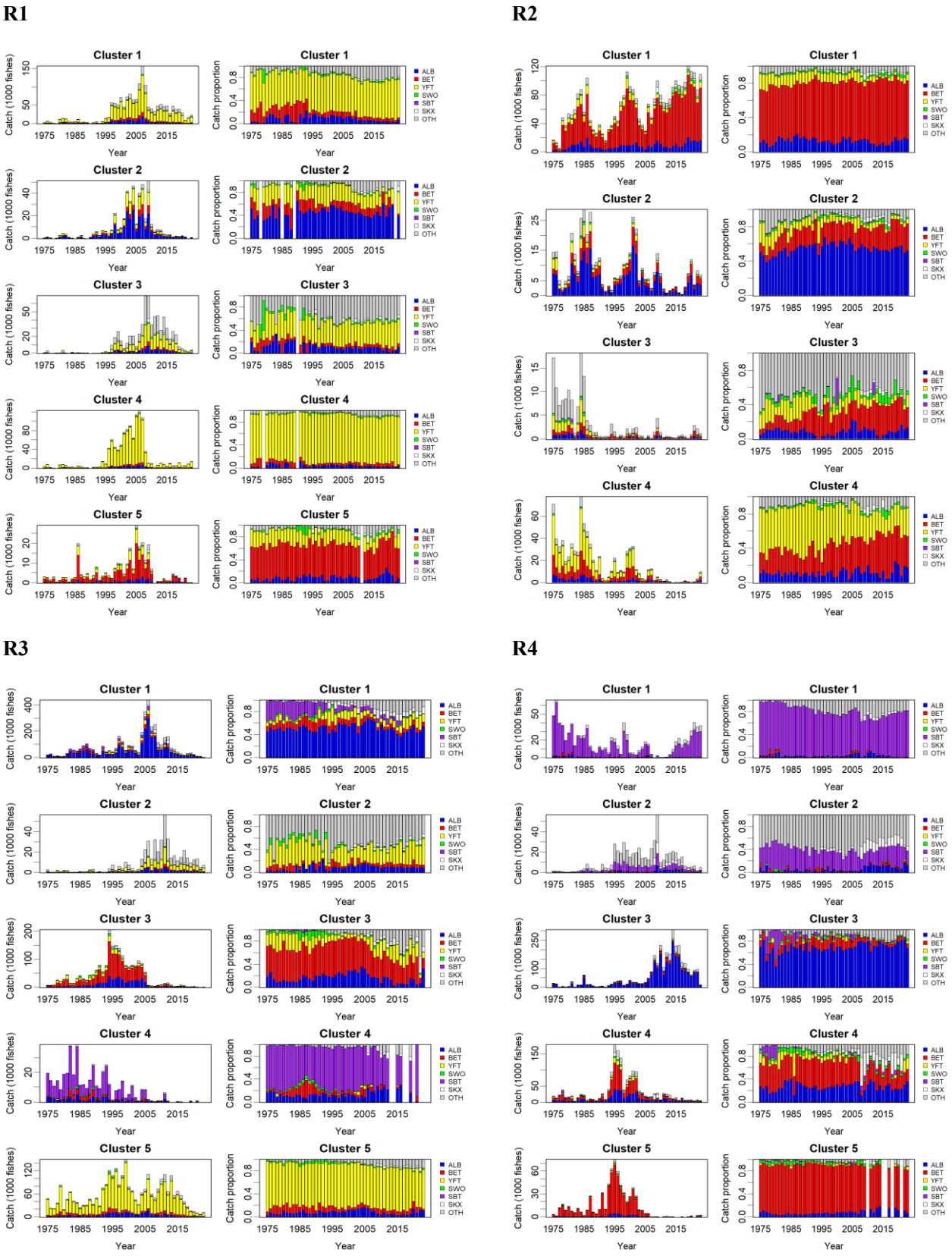


Figure 2 (a): Species composition for each cluster in Japanese fisheries.

Korean fleet

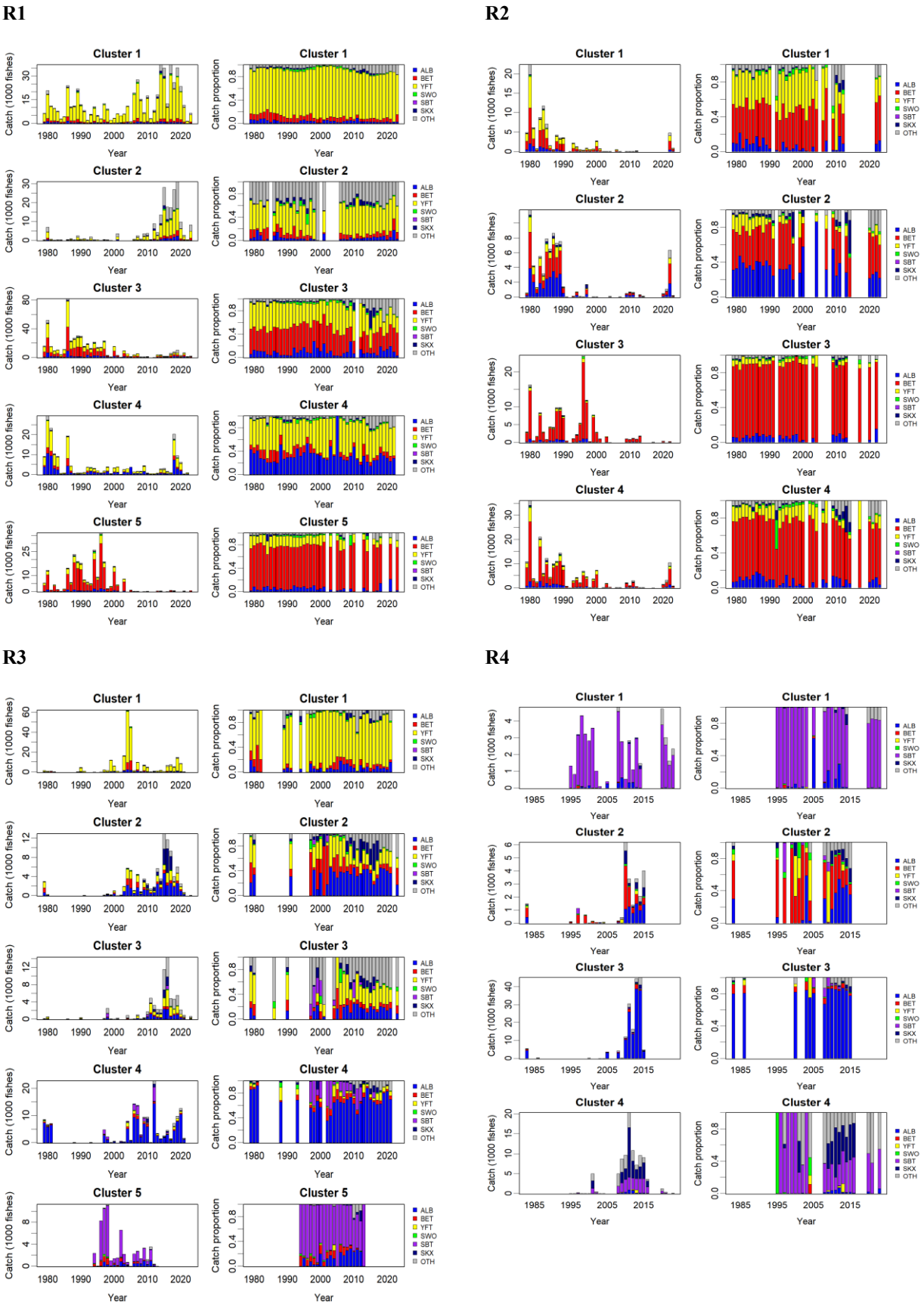


Figure 2 (b): Species composition for each cluster in Korean fisheries.

Taiwan fleet

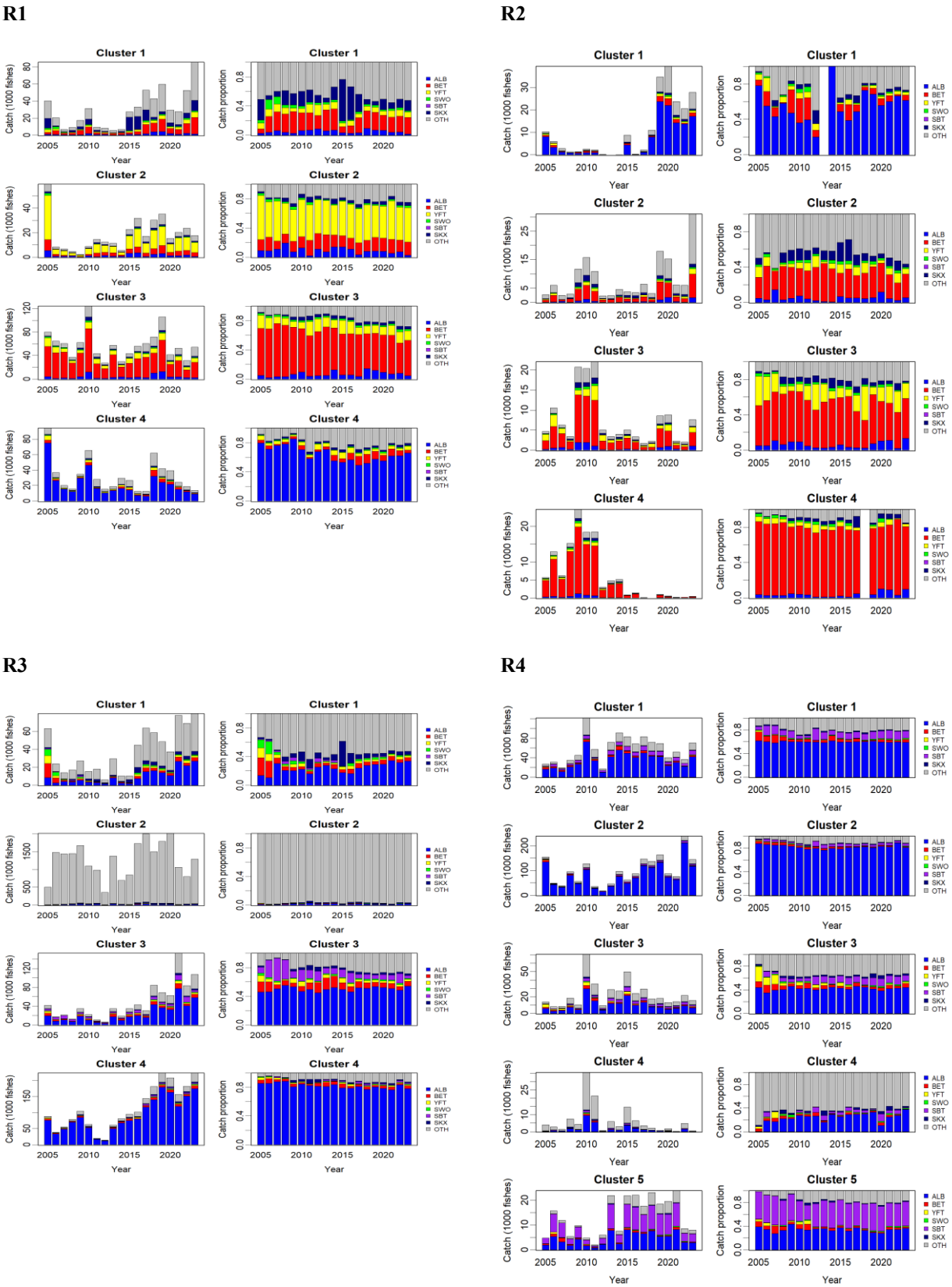


Figure 2 (c): Species composition for each cluster in Taiwanese fisheries.

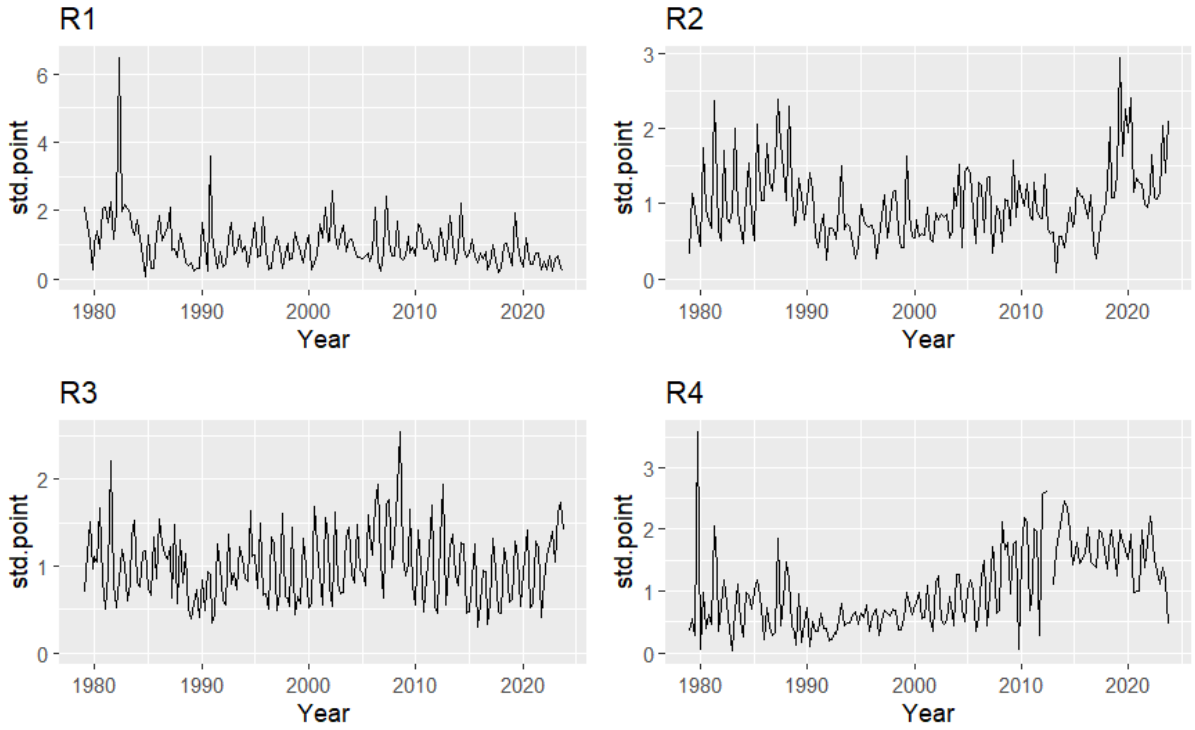


Figure 3 (a) Extracted results for Delta_r0r0

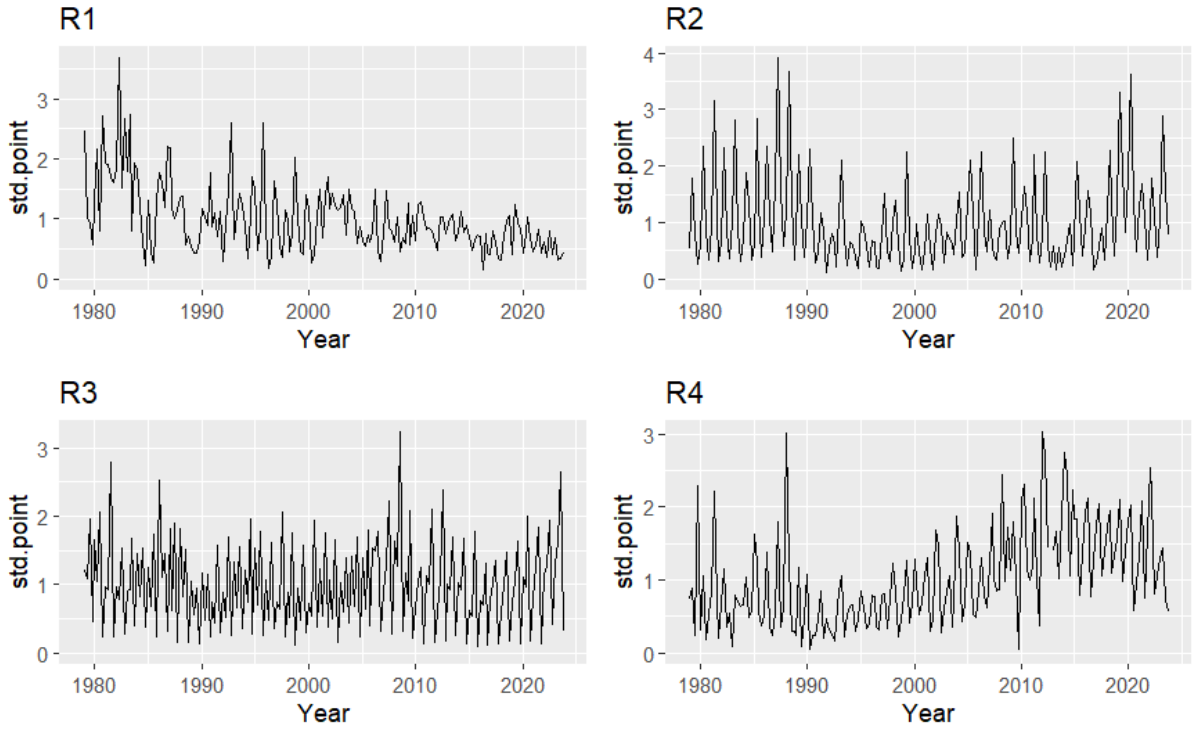


Figure 3 (b) Extracted results for Delta_r0r1

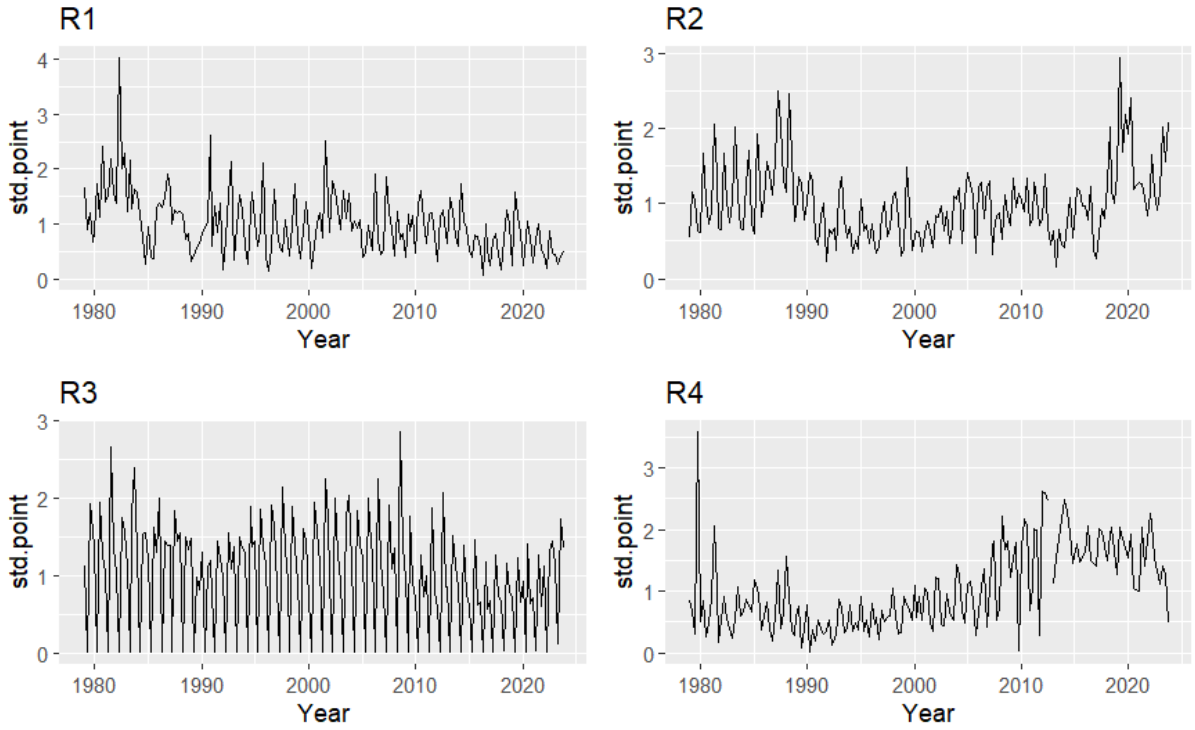


Figure 3 (c) Extracted results for Delta_r1r0

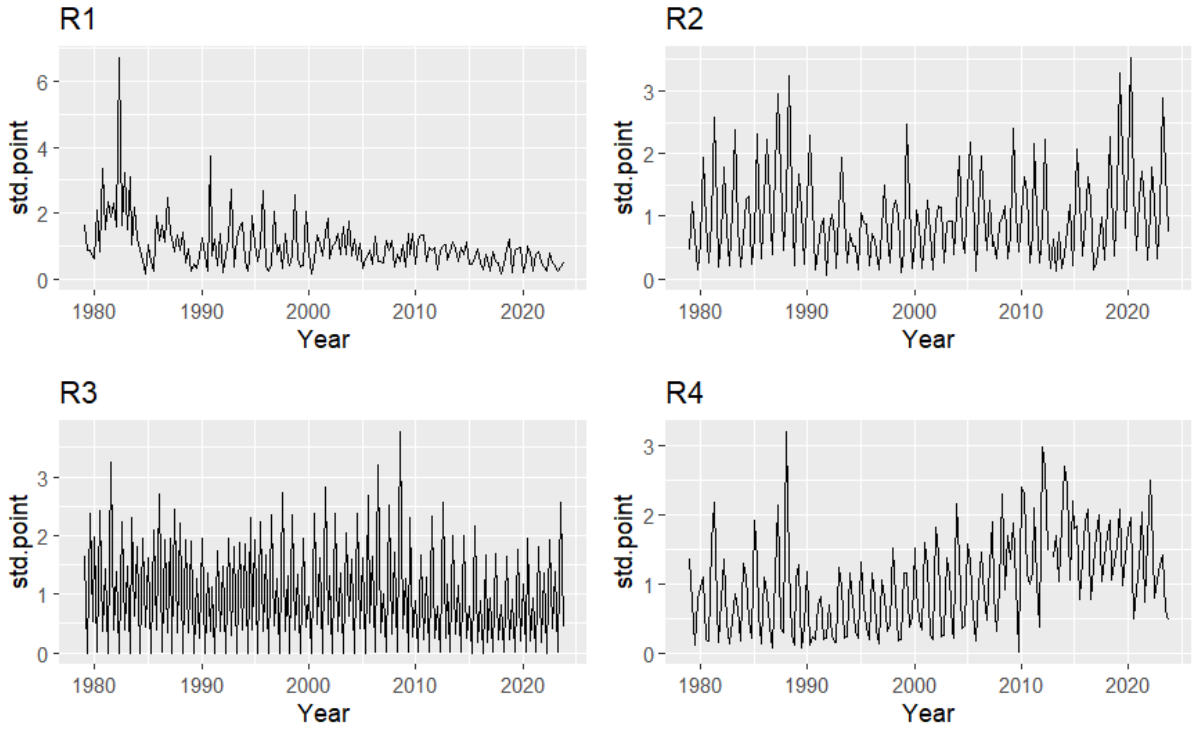


Figure 3 (d) Extracted results for Delta_r1r1

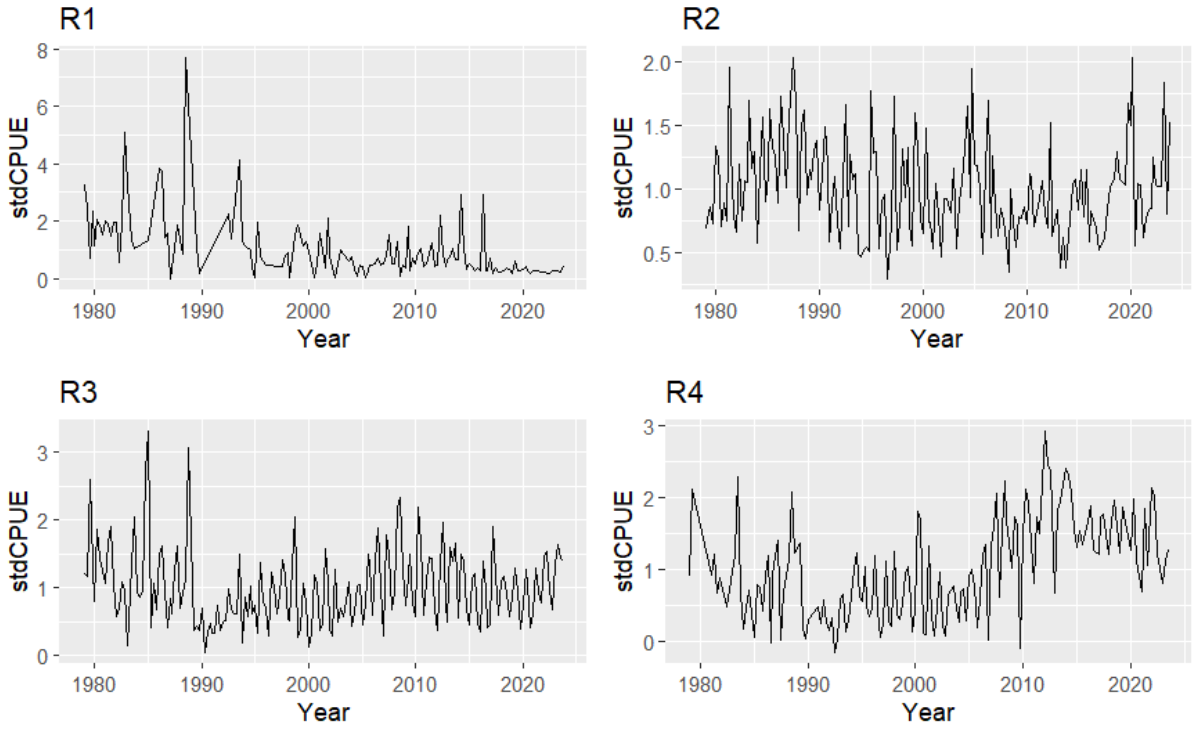


Figure 3 (e) Extracted results for LN_r0

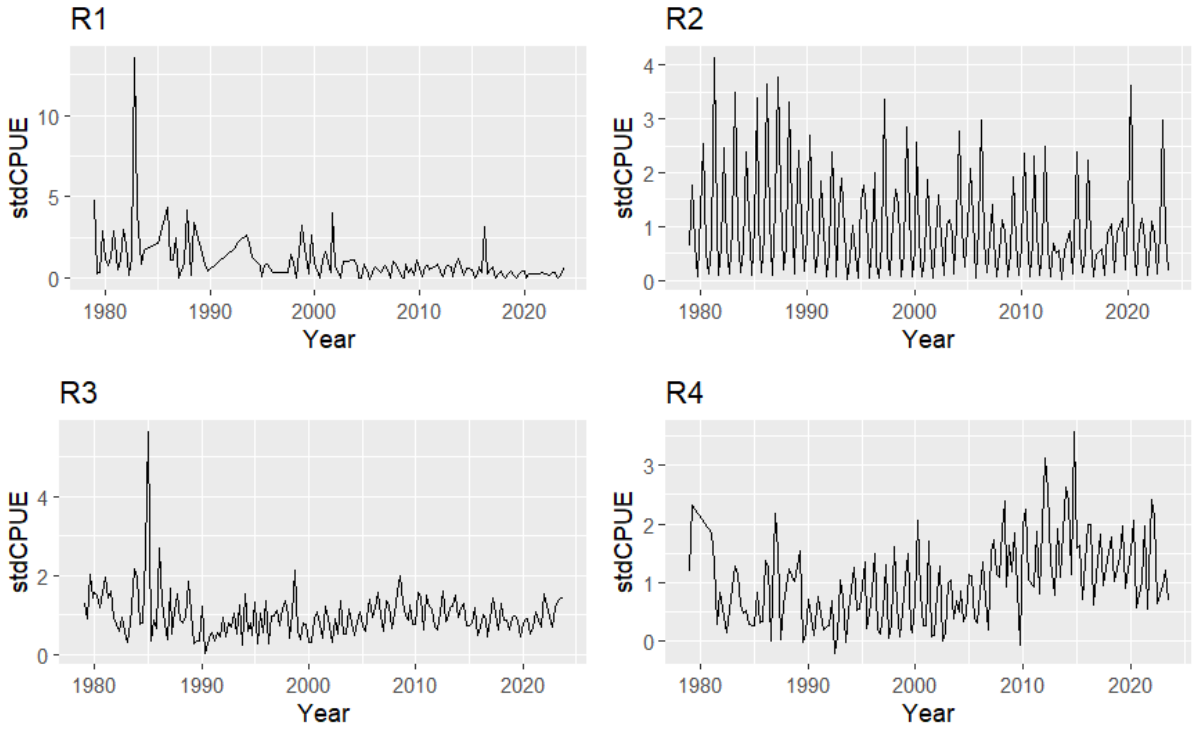
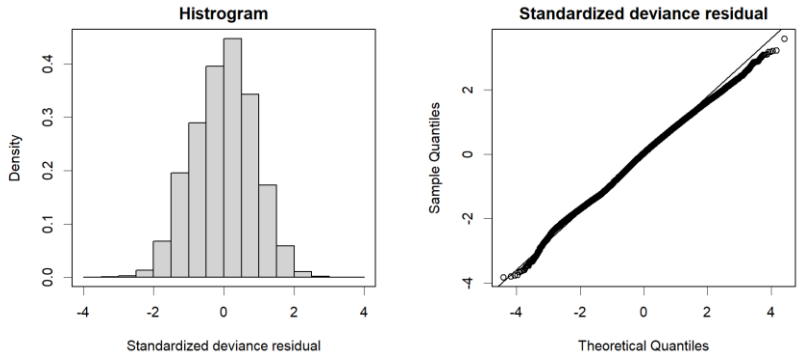
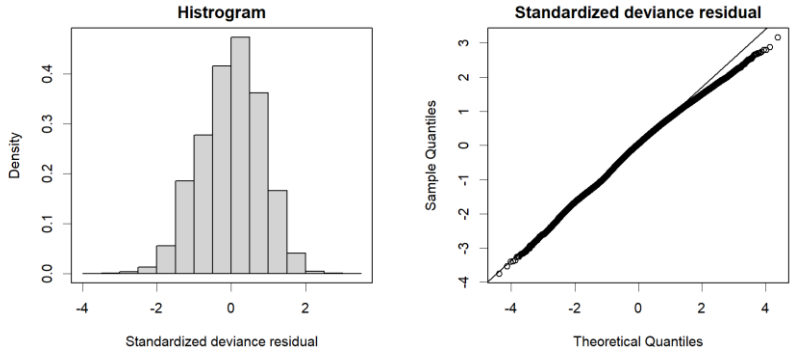


Figure 3 (f) Extracted results for LN_r1

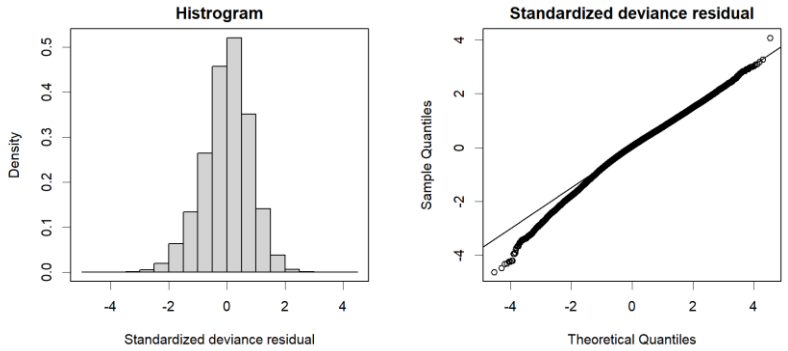
R1



R2



R3



R4

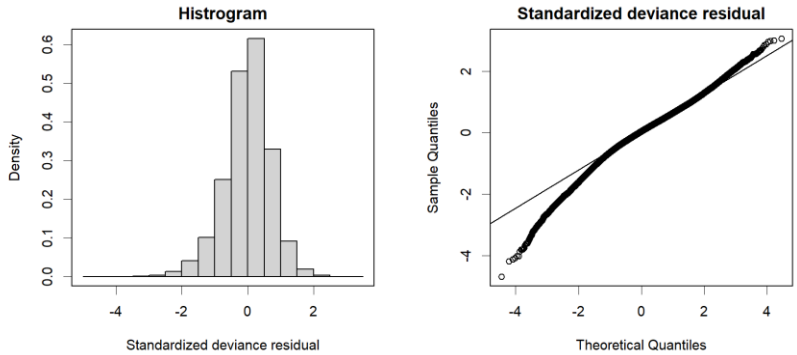
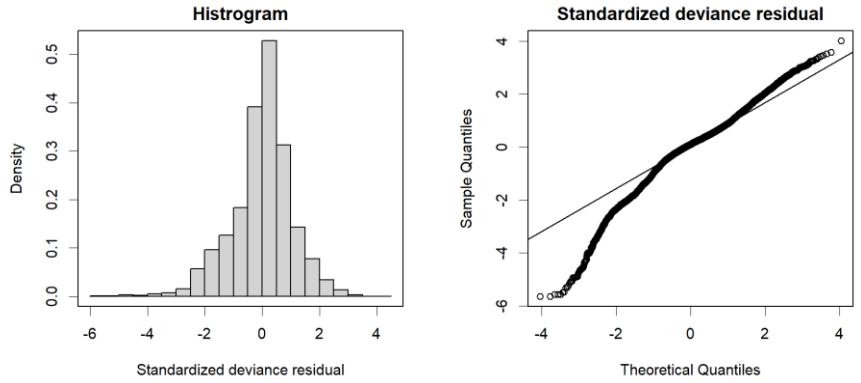
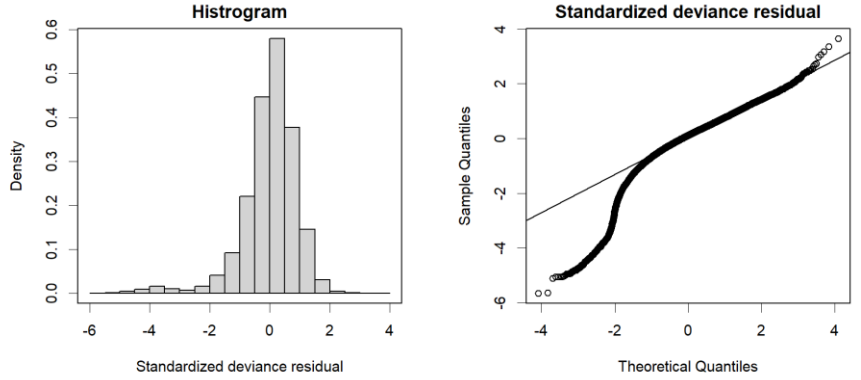


Figure 4(a). Examples of diagnostics in the residuals in LN component in Delta_r0r1 model.

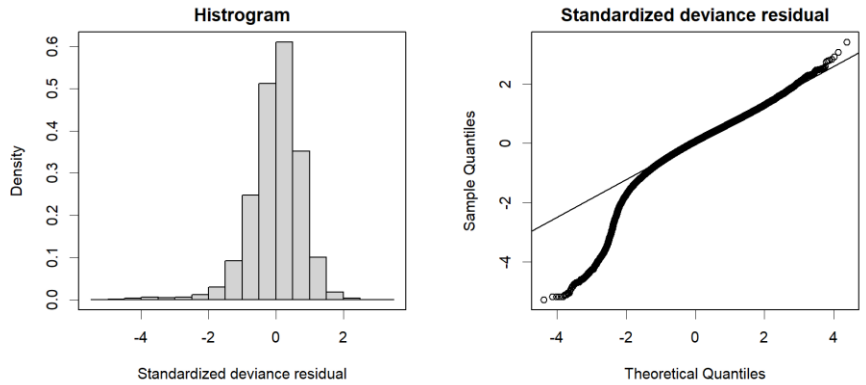
R1



R2



R3



R4

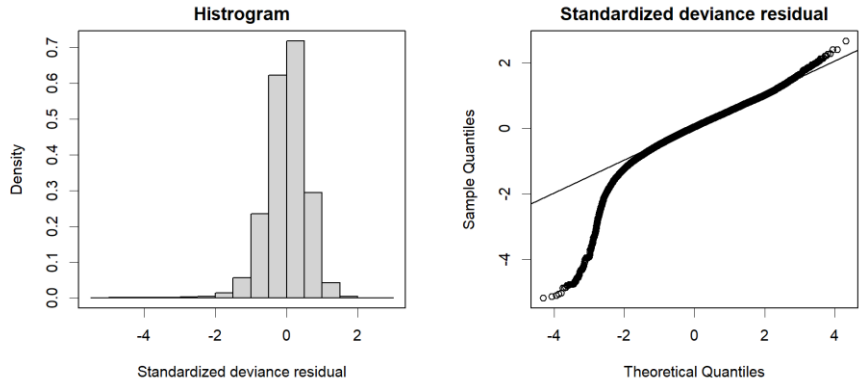


Figure 4(b). Examples of diagnostics in the residuals in LN_r0 model.

Appendix 1.

a) Japanese fisheries

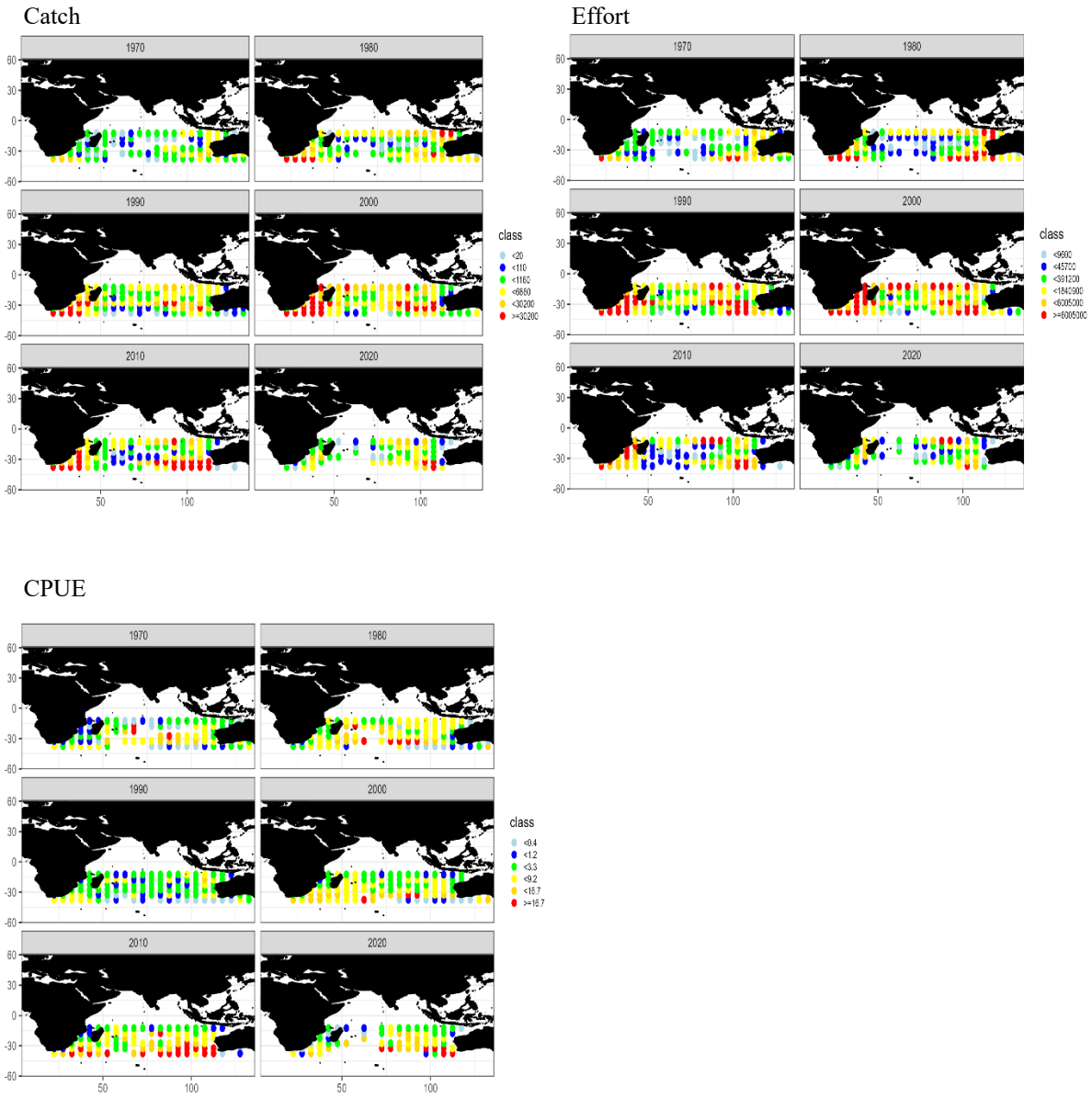


Fig A1(a). Map of catch, effort, and CPUE in Japanese fisheries.

b) Korean fisheries

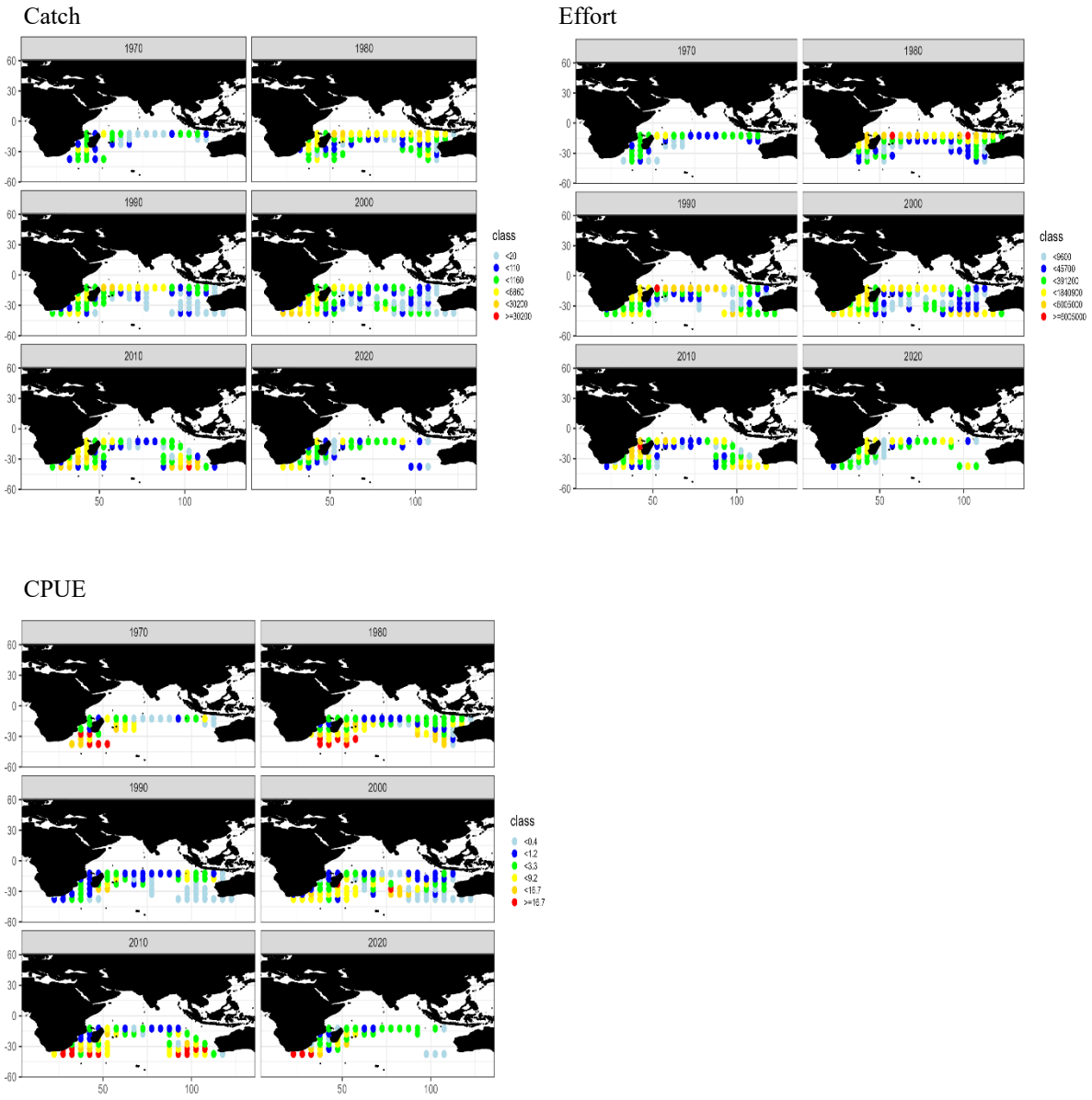
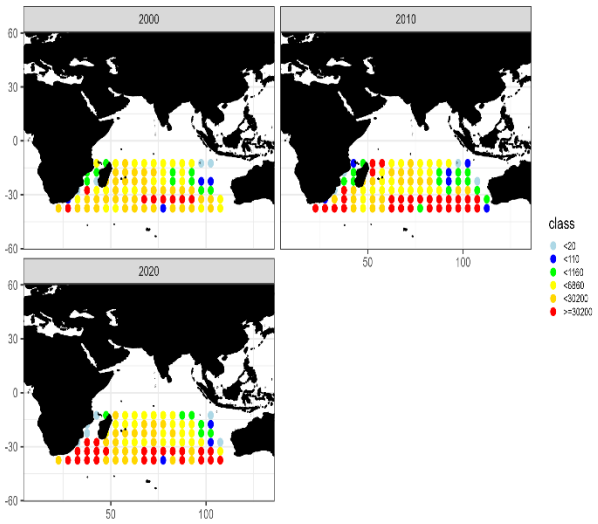


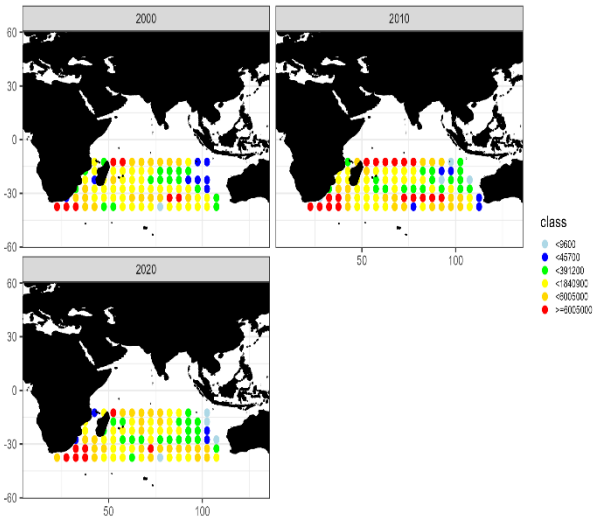
Fig A1(b). Map of catch, effort, and CPUE in Korean fisheries.

c) Taiwanese fisheries

Catch



Effort



CPUE

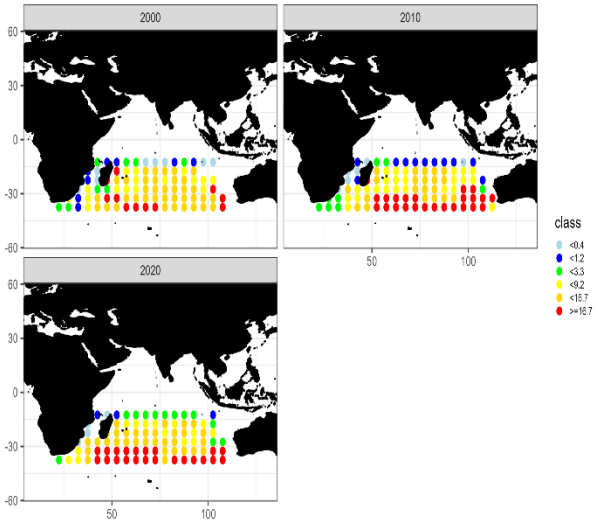


Fig A1(c). Map of catch, effort, and CPUE in Taiwanese fisheries.

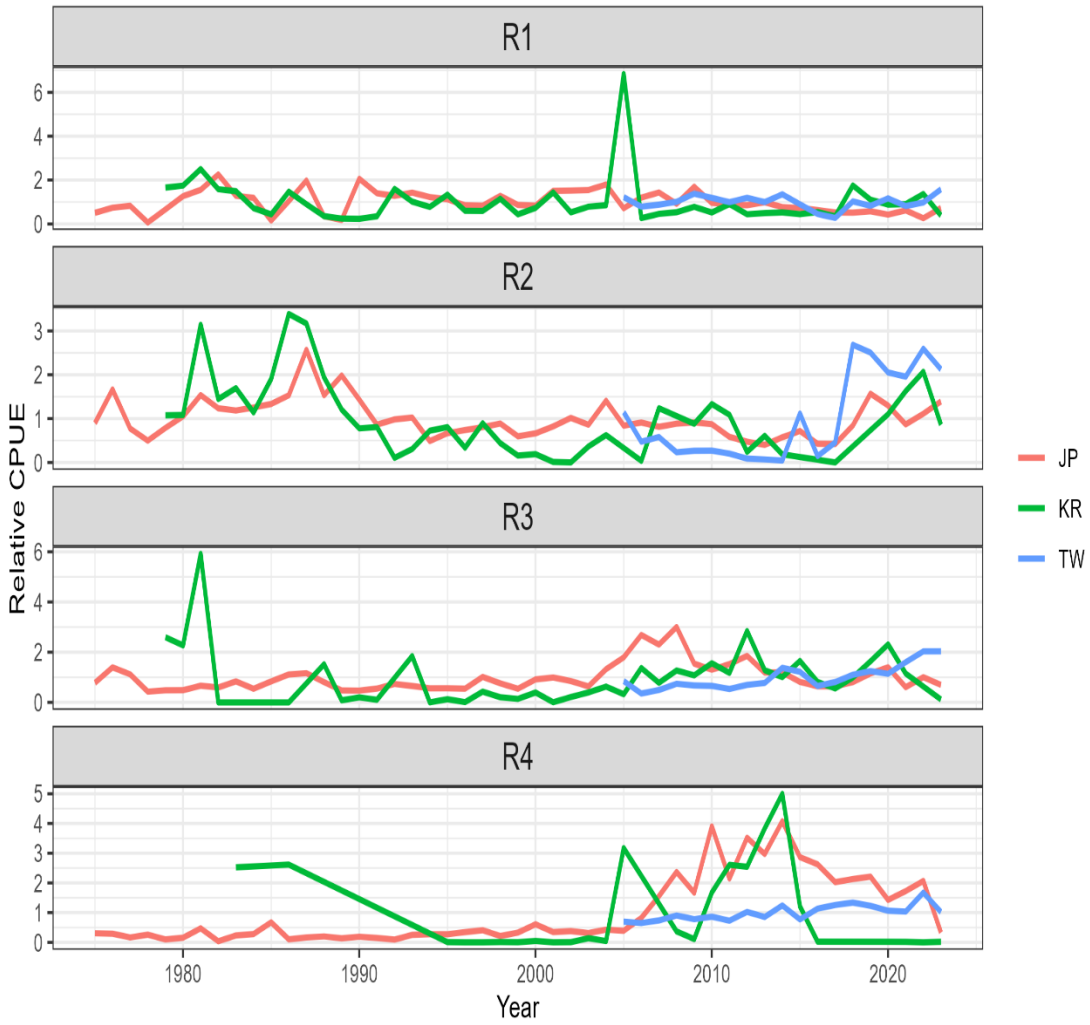
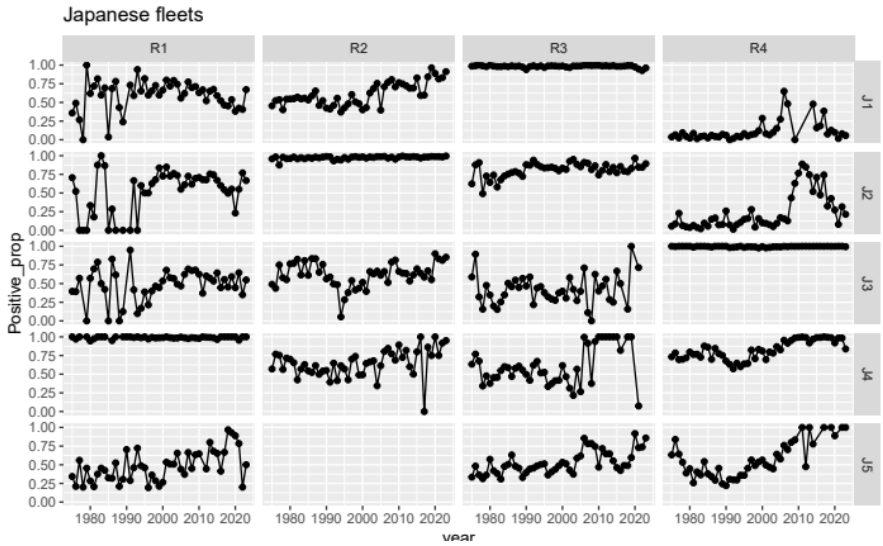
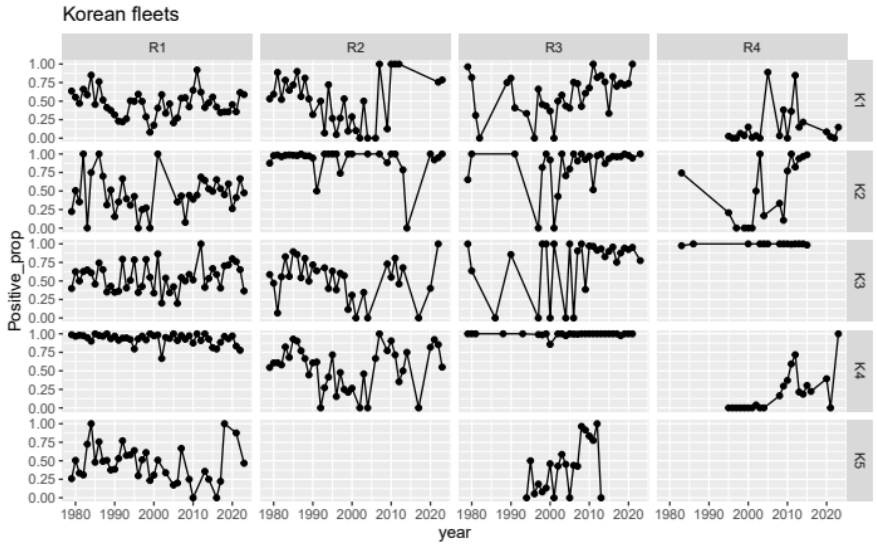


Fig A2. Time series of nominal CPUE by region.

A. Japanese fleets



B. Korean fleets



C. Taiwanese fleets

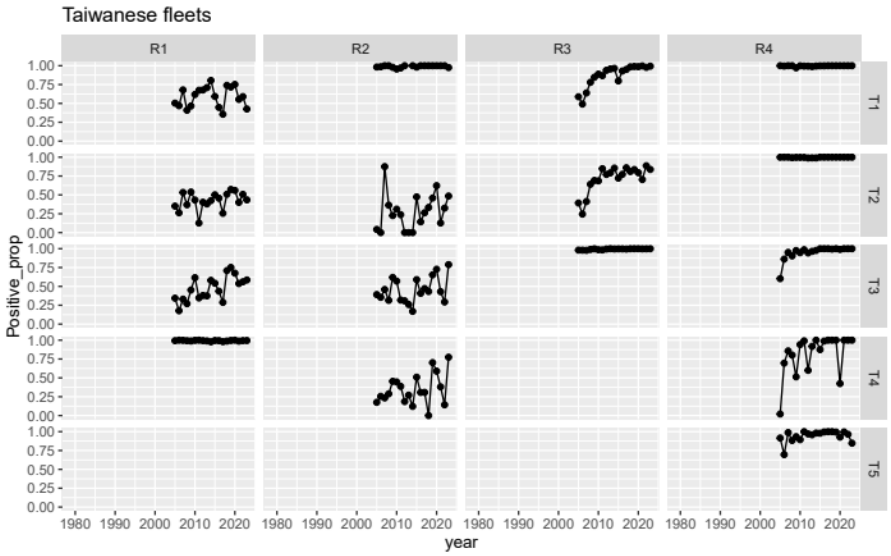


Fig A4. Time series of positive probability time series (A: Japanese, B: Korean, C: Taiwanese fleets).