CPUE standardization of bigeye tuna caught by Korean tuna longline fishery in the Indian Ocean, 1979-2020

Sung Il Lee[1], Mi Kyung Lee[2], Youjung Kwon[2] and Junghyun Lim[2]

[1]Pukyong National University, Busan, Republic of Korea

[2]National Institute of Fisheries Science, Busan, Republic of Korea

Abstract

In this study the CPUE of bigeye tuna caught by Korean tuna longline fishery in the Indian Ocean was standardized using lognormal constant model and delta lognormal model with added cluster factor as a categorical variable for addressing target changes over time. The data used for the CPUE standardization were catch in number, hooks used, fishing location (5° cell), and vessel identifier by year, quarter, and region. The standardized CPUE for R1S decreased from 1979 to 2010, and after that it has shown an increasing trend. For R2, it also showed a decreasing trend until the early of 2000s, and then it has shown a slight increasing or stable trend. For R3, from 1979 to 1990 it decreased but after that showed a stable trend.

Introduction

The Korean tuna longline fishery in the Indian Ocean commenced in 1957, and from the beginning its target species were bigeye, yellowfin and albacore tunas. The catches of bigeye and yellowfin considerably increased from the mid-1960s, peaking at about 33 thousand tons in 1978 and 31 thousand tons in 1977, respectively, but decreasing to a few hundred tons by the early 2010s. After then bigeye catch has been remained under the 5 hundred tons up to now. This document provides results of CPUE (catch per unit effort) standardization of bigeye tuna caught by Korean tuna longline fishery in the Indian Ocean as well as clustering analysis for addressing target changes over time using methods developed by a trilateral collaborative study (Kitakado et al. 2021).

Data and Method

Catch and effort data used in this study were collected from logbooks filled out by captains onboard. The data were plotted to explore changes in geographical distributions of efforts and bigeye catch of Korean tuna longline fishery in the Indian Ocean.

To address target changes over time, a clustering approach was used as in the previous study (Hoyle et al. 2019) and the method is described in detail in Kitakado et al. (2021). Data used for clustering analysis contain vessel identifier (ID), operation date, operation location to 1°, number of hooks and floats used, and catch by species in number for albacore (ALB), bigeye (BET), yellowfin (YFT), southern bluefin tuna (SBT), swordfish (SWO), sharks (SKX) and others (OTH). Data are available from 1979 to 2020 because data prior to 1979 have no information of vessel ID.

We standardized CPUE of bigeye tuna using a lognormal constant model, and the details are described in Kitakado et al. (2021). The lognormal constant model is as follows.

$$ln(CPUE + c) \sim Year + Quarter + LatLon + Cluster + Vessel + Error$$

The definition of region for bigeye CPUE is based on the current regional structure used for BET stock assessment (R1N, R1S, R2, R3). However, CPUE standardization for R1N could not be carried out because there were not enough data to run it.

Results and Discussion

Figs. 1 and 2 show geographical distributions of fishing efforts (number of hooks used) and BET catch (in number) of Korean tuna longline fishery by decade from 1970s to 2020s in the Indian Ocean. The fishing efforts were concentrated in tropical areas between 10°N-15°S of the western Indian Ocean during the 1970s to 1990s, which targeted BET and YFT along with some ALB. Until the 1980s there was a little fishing effort in the south of 25°S, but since the 1990s some fishing vessels moved southward to fish for SBT in the western and eastern Indian Oceans within 35°S-45°S. In the 2010s, most of the fishing vessels were operated in the south of the equator and they operated mainly in the south of 20°S in the western and eastern Indian Oceans to fish for YFT, BET, SBT and sometimes ALB.

Regarding on result of cluster analysis of Korean tuna longline fishery, four to five clusters were chosen in each region to address target strategies (4 clusters for R1N; 4 clusters for R1S; 4 clusters for R2; 5 clusters for R3).

In region R1N, all clusters were dominant before 2000 and were prominent from February to June. Hooks were similar in all clusters, with clusters 2 higher. Cluster 4 was formed in at the northwest area compared to other clusters (Fig. 3(A)). The species composition of cluster 1 had similar amounts of BET, YFT and OTH. Cluster 2 showed more YFT along with BET. Cluster 3 and 4 were dominated by YFT and BET, respectively (Figs. 4(A) and 5(A)).

In region R1S, all clusters were dominant before 2000 and clusters 1 and 3 has shown some appearance in recent years. Clusters 1 and 3 had a high appearance in the first half of the year, and clusters 2 and 4 in the second half of the year. Hooks were similar in all clusters. Cluster 1 was formed in the southeast area, and clusters 4 in the northwest area, compared to other clusters (Fig. 3(B)). The species composition of cluster 1 was dominated by YFT along with some BET. Cluster 2 had more YFT along with BET, and cluster 3 had higher OTH along with some BET and YFT. Cluster 4 was dominated by BET, followed by YFT (Figs. 4(B) and 5(B)).

In region R2, all clusters were also dominant before 2000, and were prominent in the second half of the year. Hooks were similar in all clusters, with cluster 2 higher (Fig. 3(C)). Cluster 1 was formed in the west area and cluster 3 in the north area, compared to other clusters. The species composition of cluster 1 showed higher BET along with ALB and YFT. Cluster 2 was dominated by BET along with some YFT. Cluster 3 showed higher YFT along with BET, and cluster 4 showed higher BET along with YFT (Figs. 4(C) and 5(C)).

In region R3, all clusters were apparent after 2000 except for cluster 3. Clusters 1, 2 and 5 were prominent in the first half of the year and clusters 3 and 4 in the second half of the year. Hooks were similar in all clusters, with cluster 1 higher. Clusters 1 and 2 were formed in the northeast area, clusters 3 and 4 in the south area, and cluster 5 in the southeast area (Fig. 3(D)). The species composition of cluster 1 was dominated by YFT, cluster 2 was comprised of mainly YFT along with some OTH. Cluster 3 was dominated by BET, followed by ALB, and cluster 4 was dominated by ALB. Cluster 5 also had higher ALB along with some YFT and OTH (Figs. 4(D) and 5(D)).

Fig. 6 represents BET CPUE indices standardized by the lognormal constant model and the delta lognormal model, along with the nominal CPUEs for each region. The standardized CPUE for R1S decreased from 1979 to 2010, and after that it has shown an increasing trend. For R2, it also showed a decreasing trend until the early of 2000s, and then it has shown a slight increasing or stable trend. For R3, from 1979 to 1990 it decreased but after that showed a stable trend. Diagnostic frequency distributions of standardized residuals and Q-Q plot indicate that data fitted the GLM well (Fig. 7).

The influence plots for cluster effect by region by the lognormal constant model are shown in Fig. 8. The pattern of the parameter estimates is shown at the top of each plot, and the influence of each parameter on the year effect on the right side of each plot.

References

Hoyle S, Chang ST, Fu D, Kim DN, Lee SI, Matsumoto T, Chassot E and Yeh YM. 2019. Collaborative study of bigeye and yellowfin tuna CPUE from multiple Indian Ocean longline fleets in 2019, with consideration of discarding. IOTC-2019-WPM10-16.

Kitakado T, Wang S-P, Satoh K, Lee SI, Tsai W-P, Matsumoto T, Yokoi H, Okamoto K, Lee MK, Lim J-H, Kwon Y, Su N-J, Chang S-T and Chang F-C. 2021. Report of trilateral collaborative study among Japan, Korea and Taiwan for producing joint abundance indices for yellowfin tuna in the Indian Ocean using longline fisheries data up to 2019. IOTC-2021-WPTT23(DP)-14.

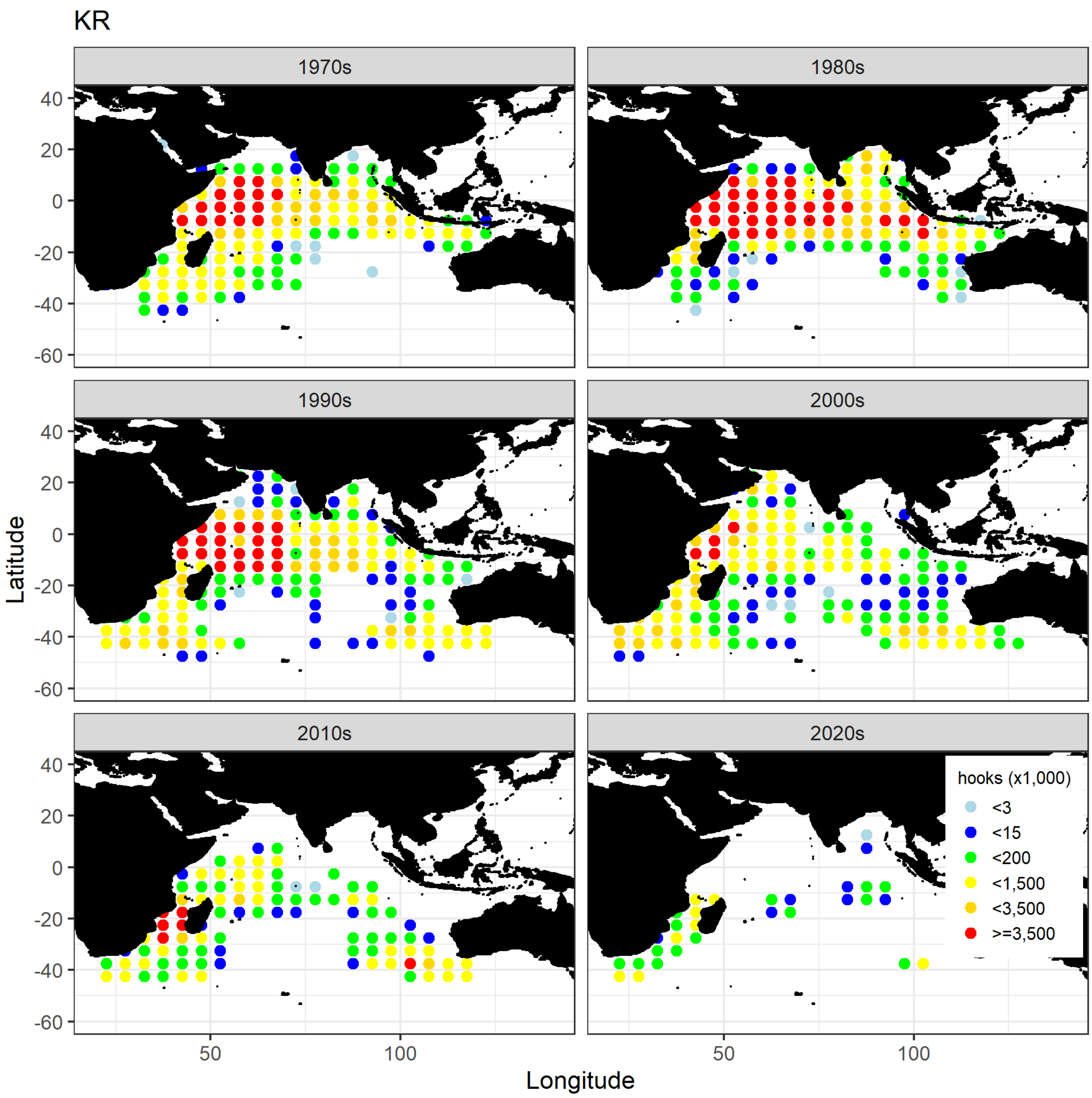


Fig. 1. The geographical distributions of total effort (number of hooks) of Korean tuna longline fishery in the Indian Ocean during the 1970s-2020s.

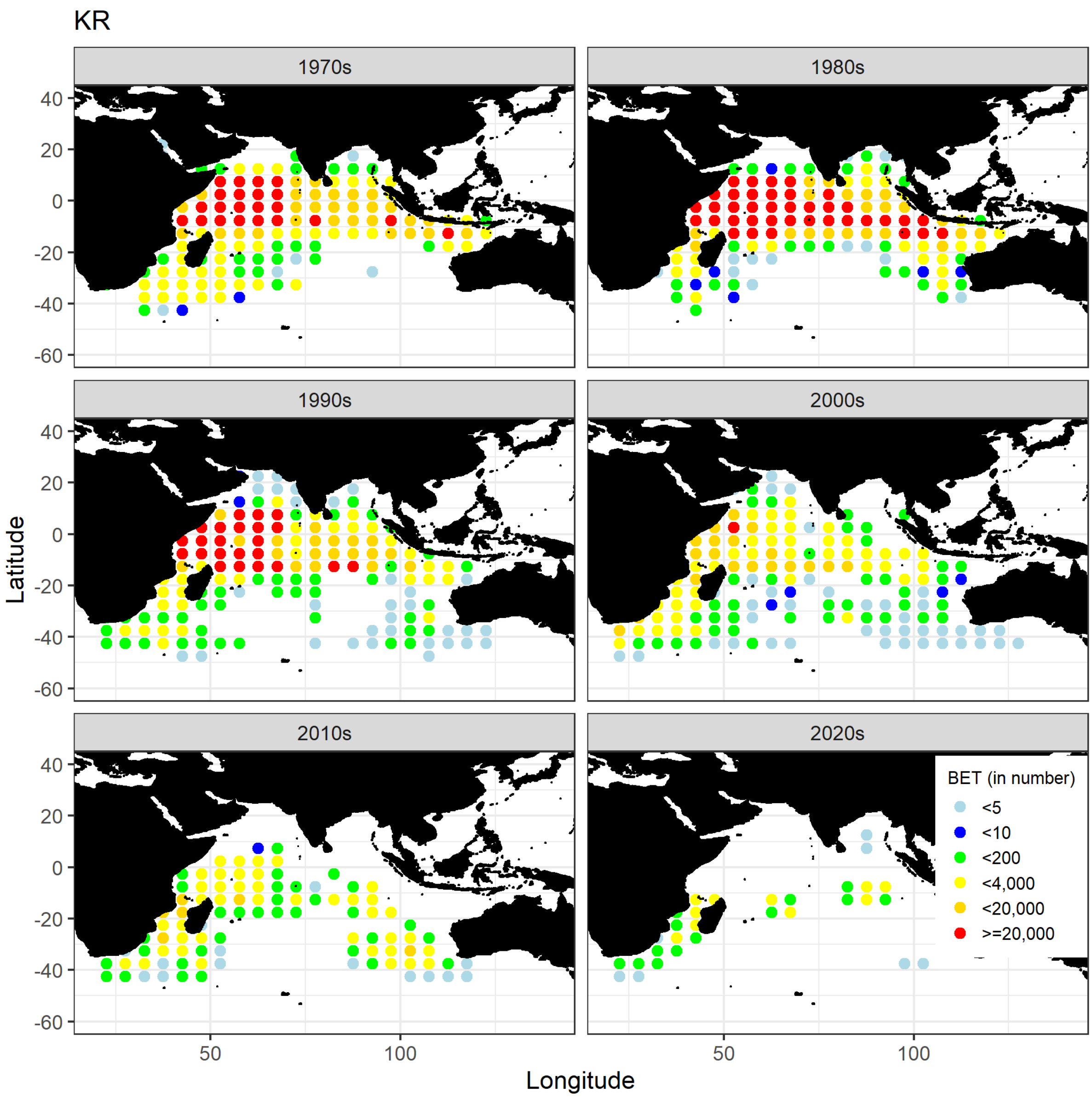
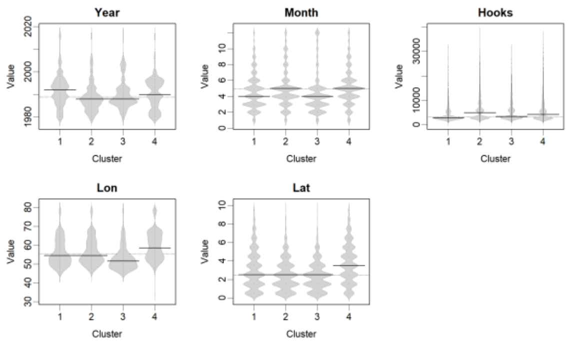
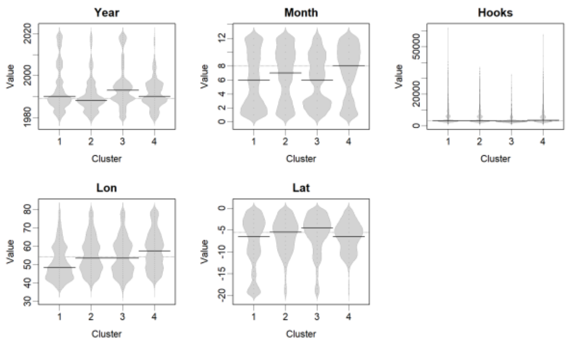


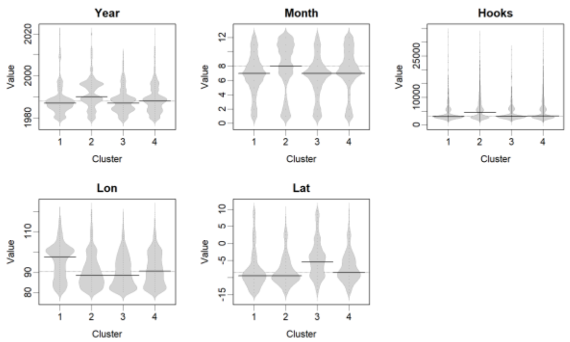
Fig. 2. The geographical distributions of bigeye tuna caught by Korean tuna longline fishery in the Indian Ocean during the 1970s-2020s.



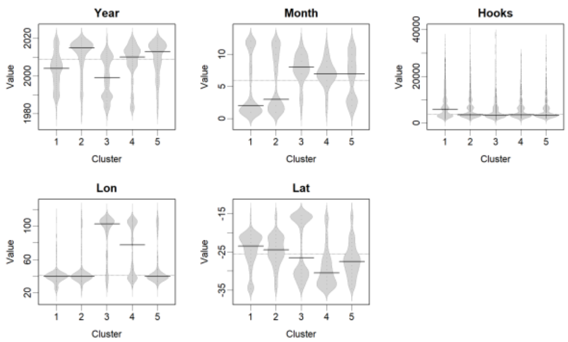
(A) R1N



(B) R1S

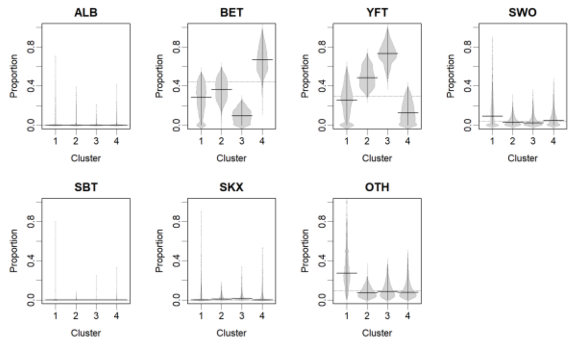


(C) R2

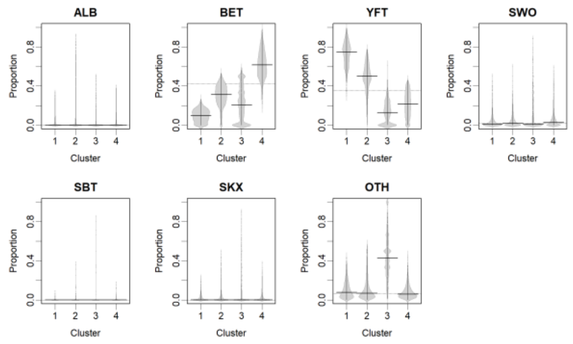


(D) R3

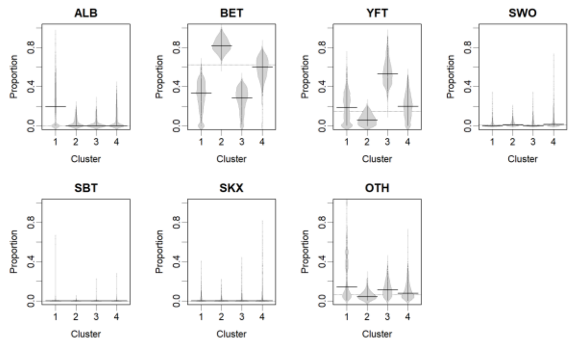
Fig. 3. Beanplots showing the number of sets versus covariate by cluster for each region. The horizontal bar indicates the median.



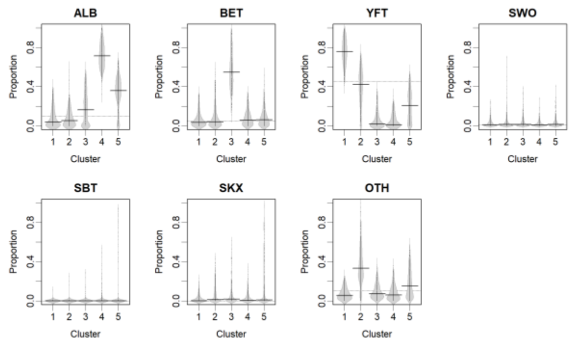
(A) R1N



(B) R1S

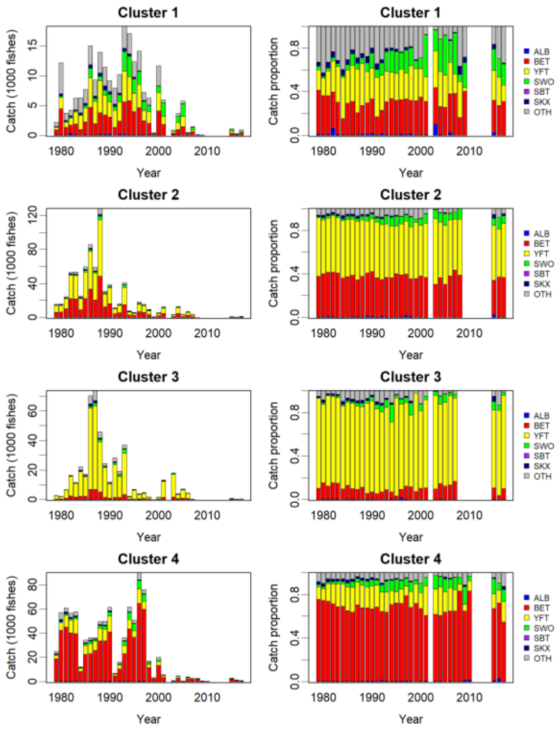


(C) R2

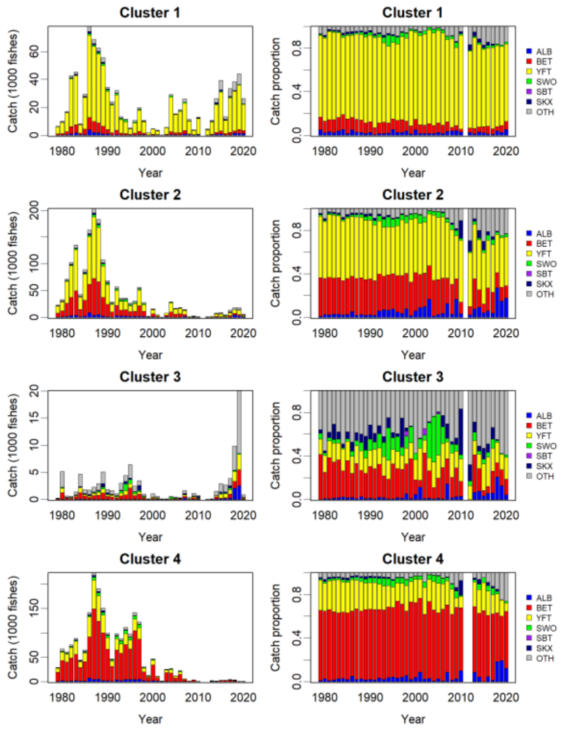


(D) R3

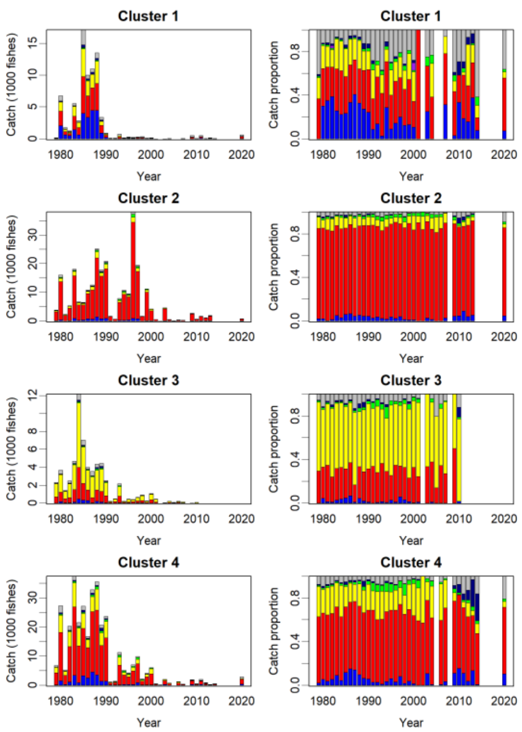
Fig. 4. Beanplots showing species composition by cluster for each region (ALB: albacore tuna, BET: bigeye tuna, YFT: yellowfin tuna, SWO: swordfish, SBT: southern bluefin tuna, SKX: sharks, and OTH: other fishes). The horizontal bar indicates the median.



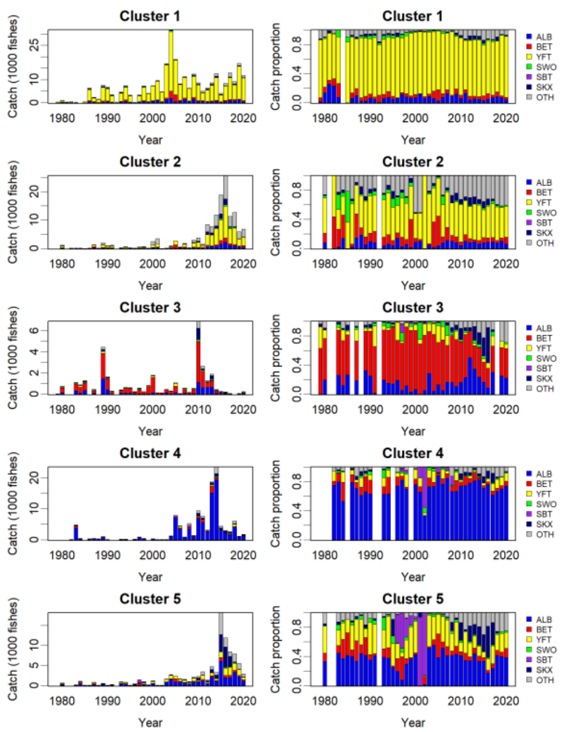
(A) R1N



(B) R1S



(C) R2



(D) R3

Fig. 5. Annual change in catch and species composition by cluster for each region.

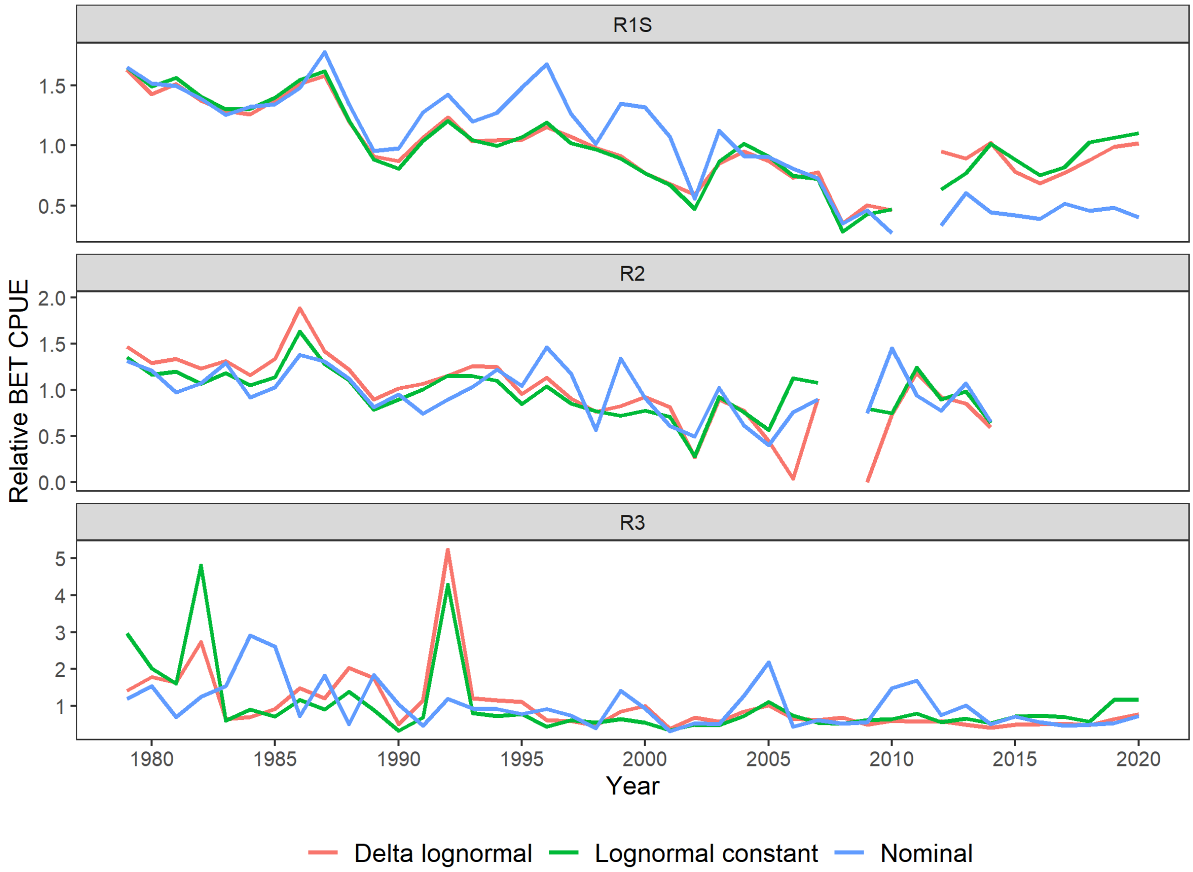
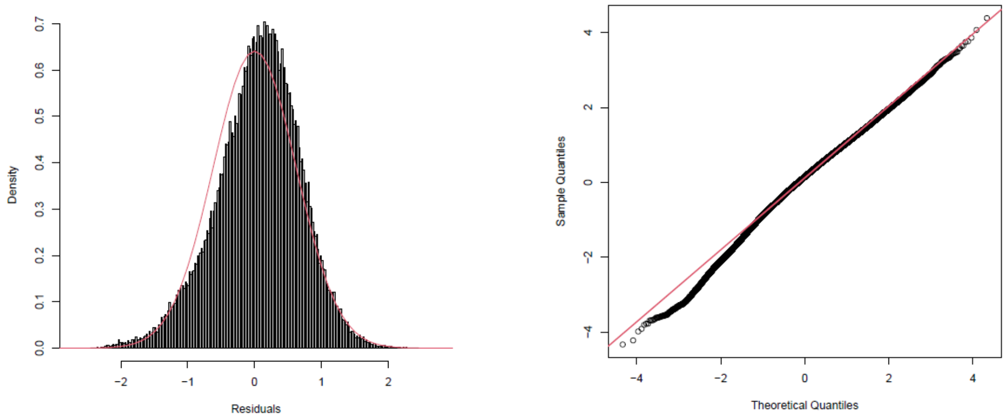
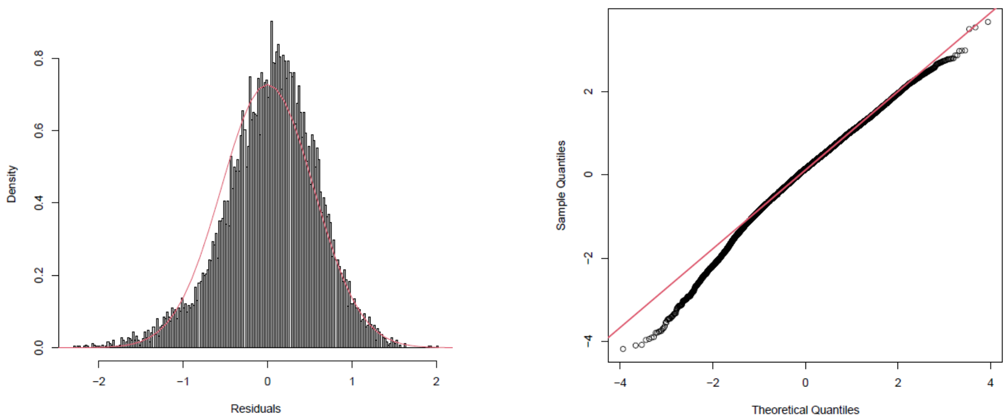


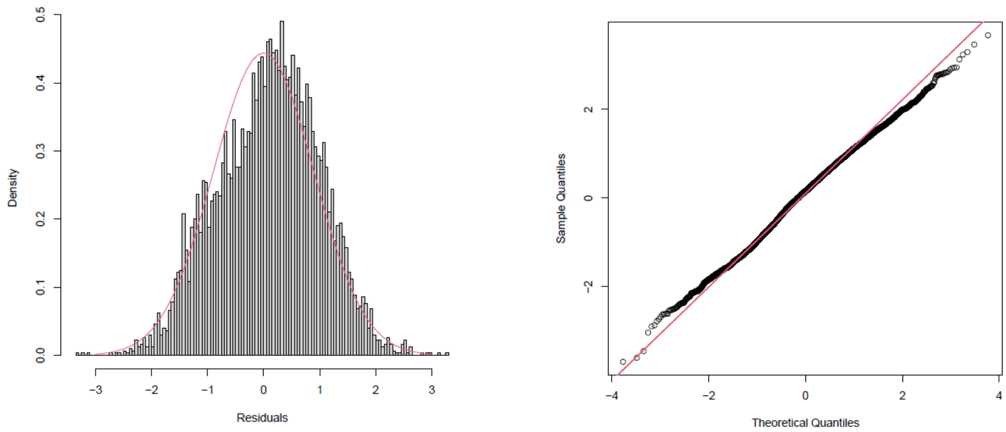
Fig. 6. Standardized bigeye CPUE indices from Korean longline fishery by region based on the lognormal constant and delta lognormal models.



(A) R1S

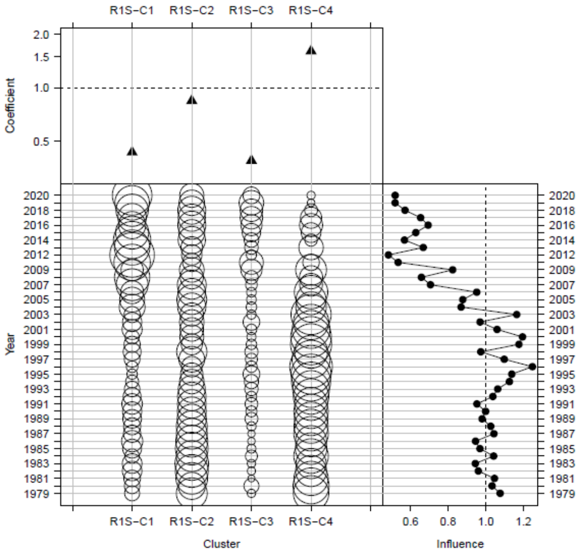


(B) R2

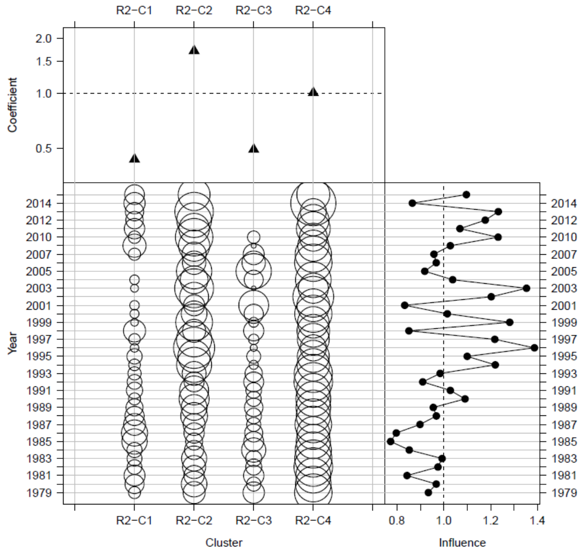


(C) R3

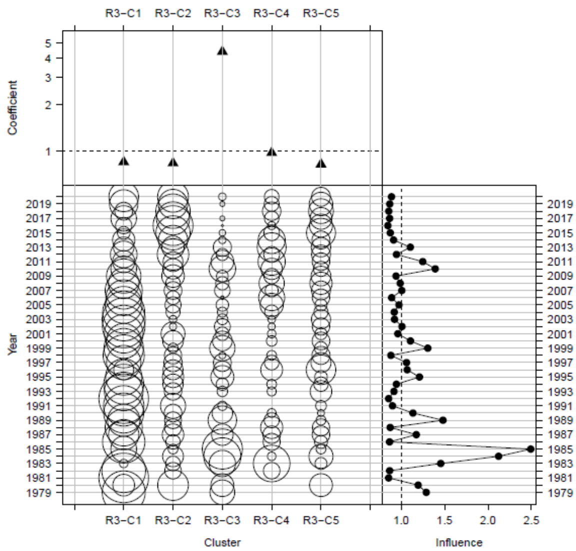
Fig. 7. Frequency distributions of standardized residuals and Q-Q plot of bigeye CPUE standardization for each region.



(A) R1S



(B) R2



(C) R3

Fig. 8. Influence plots for cluster effect by region.