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Standardized CPUE of shortfin mako shark (Isurus oxyrinchus) caught by Japanese longliners in the Indian Ocean in the period between 1994 and 2010

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Summary

Japanese log-book system for distant-water longliners started to collect shortfin mako data in 1994. Because part of Japanese longliners released/discarded their shortfin mako catch and Japanese log-book system does not request to report them in regular base, the filtered catch and effort data by the reporting rate of the sum of catch of all shark species, which were supposed to report all their catch, used to analyze the CPUE. The annual trend of the standardized CPUE, however, became moderate when the easier filtering criteria are used, its overall trend does not affected largely by the change of filtering criteria. This indicated that the standardized CPUE estimated in this study is roughly reflecting the trend of fishable abundance of shortfin mako shark in the Indian Ocean .

Introduction

Japanese log-book system for distant-water longliners started to collect shortfin mako data in 1994 because it is one of the commercially important by-catch sharks for the Japanese longliners. In the present study, abundance indices of shortfin mako were estimated using GLM model. Because part of Japanese longliners released/discarded their shortfin mako catch and Japanese log-book system does not request to report them in regular base, the catch and effort data of shortfin mako, which were supposed to report all their catch of commercially important shark species, used to analyze the CPUE. The method has been improved by introducing statistically decided area stratification using the “GLM-tree” method developed by Ichinokawa and Brodziak (2010).

Materials and Methods

The Japanese distant water longline fishery catch and effort data (set by set data) were obtained from the logbook by the National Research Institute of Far Seas Fisheries. CPUE standardization was conducted for the period from 1994 to 2009, since shark catches were recorded by species. The data contains the information of catch number, number of hooks, and the number of branch lines between floats (hooks par baskets: HPB). The analysis was only applied on the data which HPB is between 4 and 24.

Selection of data (filtering) was conducted based on the assumption that all the catch of major shark species was reported in the log-book when catch of any sharks were reported in the more than 80% of sets per cruise. This assumption was initially addressed by Nakano and Honma (1997) and used in the analysis of CPUE of the Atlantic blue shark by Matsunaga (2009). In the present study, this assumption was applied on the set by set data in the period between 1994 and 2010 to obtain the data for CPUE analysis. For this filtering process, effects of the length of cruise as well as the effects of seasons and areas were ignored.

In the CPUE standardization, GLM-tree method (Ichinokawa & Brodziak 2010) was used to get optimal area stratification to standardize CPUE with fishery data after 1975. The GLM tree method estimates the optimal area separation which has the minimum AIC with a particular number of the splits. The optimal area designation were obtained when the analyzed region was separated into 2 to 9 areas, and further separation of area did not have much gain for the reduction of AIC values and also it caused the shortage of data coverage (avoiding to have missing data points in each separated area). Thus, the stratification with 9 areas was selected arbitrarily for the analysis of CPUE. The resolution of data was changed from original 1x1 degree block to 5x5 degree block to simplify the calculation.

The effect of the number of hooks between float (as the proxy of set depth of gear) was introduced as the form of the spline equation into the GLM model. In the previous study by Matsunaga (2009) introduced the effect of the number of hooks as the categorical valuables, but the spline equation could adjust finer differences of the number of hooks used in each operation.

The following GLM model with nominal error was applied to the both stocks in this study:

log(CPUE + const.) ~ year+quarter+area+s(hpb)+quarter *area +nominal error

, where s(hpb) means spline equation using GAM library in R 2.12.2, and const. was set to 1/10 of minimum nominal CPUE (CPUE>0). The estimated CPUE series were weighted mean of CPUE at each area by approximate size of area. All calculations of GLM in this study were conducted using R 2.12.2.

Results and Discussion

Figure 1 shows the optimal area separations and its AIC value with 1 to 8 splits (2 to 9 areas) by the GLM tree method for the period between 1994 and 2010. Analysis was conducted using filtered data by 80 % reporting rate criteria. The AIC values was continuously decreased with the number of separated area from two areas to nine areas (right-bottom panel in Figure 1), but one large area remained in the eastern Indian Ocean which is separated from the western Indian Ocean at the first split of GLM-tree analysis. This indicates that trend of CPUE of shortfin mako shark is different between the east and west Indian Ocean, and thus it suggests a possibility of different two stock.

The general trend of the standardized CPUE of shortfin mako in the period between 1994 and 2010 does not affected by the number of area stratification in the range between 2 areas and 9 areas (Figure 2). The standardized CPUE by the number of hooks per basket changed by the number of area stratification and lower number of area produced higher CPUE of shortfin mako. This would be due to the fact that Japanese longliners use more uniform gear type in the smaller area.

The trend of CPUE of shortfin mako shows gradual decreasing trend with some unnatural up and down from 1994 to 2005 when it turns into steady increase (Figure 4). This general trend does not affected by the change of the filtering criteria except for the case that data selected by the 10% reporting rate which produce rather flat trend (Figure 5), and lower level of criteria tend to produce more moderate trend. Figure 6 shows the reported catch of shortfin mako shark by the different filtering criteria. The 80% criterion, which is recommended by Mastunaga (2009) at the Atlantic, reduce catch of shortfin mako from 35% to 90% (average 60%) of the total reported annual catch. In the present study, uniform filtering criterion was applied on all areas and season, but different filtering criteria on different area and season would produce better results of CPUE analysis as shortfin mako is mostly distribute in the subtropical and temperate zone and its CPUE of longline is generally not high as blue shark.

Conclusion

This study is the first trial of the CPUE standardization of shortfin mako shark in the Indian Ocean using log-book data of Japanese longliners operated in the Indian Ocean in 1994 – 2010. Because Japanese longliners do not retain all their shark catches, and parts of them are discarded/released (Nakano and Honma, 1997), the method to select non-biased log-book data, which is developed and verified by the studies in the Atlantic and Pacific Oceans (e.g., Matsunaga (2009)), was applied on the data in the Indian Ocean.

There are observed some unnaturally large ups and downs in the annual trend of standardized CPUE and this tendency become more apparent when the higher level of filtering criteria are used. This is supposed to be caused at least partially by the non-uniform distribution pattern by area and season of shark species recorded in the log-book. Mastunaga (2009) recommended to use 80% reporting rate as the filtering criteria to extract data of cruise which has records of all shark catch (not release and discard), but actual criteria may change by area and season. Further improvement of the filtering criteria should produce more reliable result.

The estimated general trend of standardized CPUE of shortfin mako sharks was robust to the change of area stratification as well as the change of the criteria to select data for the

CPUE standardization. This indicates that the estimated trend of the standardized CPUEs reflects the trend of the abundance of shortfin mako shark fishable to Japanese longliners. Because Japanese longliners have caught shortfin mako shark in the wide range of the Indian Ocean, the standardized CPUE obtained in this study can be used as an abundance index in the stock assessment of shortfin mako shark in the Indian Ocean.

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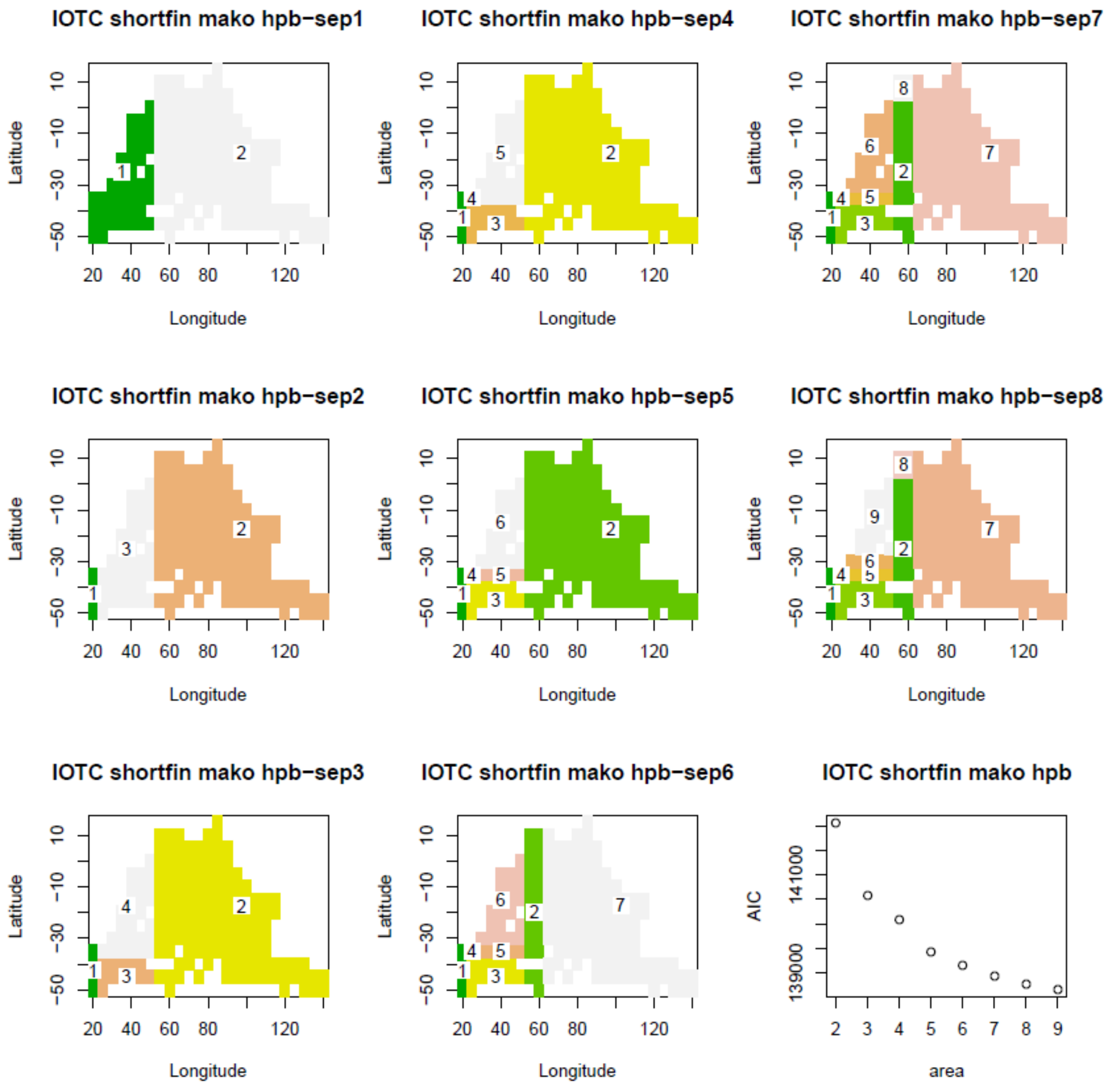

Figure 1. Area separations with 1 to 8 splits (2 to 9 areas) by GLM-tree and its AIC value (right-bottom panel) on shortfin mako in the Indian Ocean for the period between 1994-2010. Analysis was conducted using filtered data by 80 % reporting rate criteria.

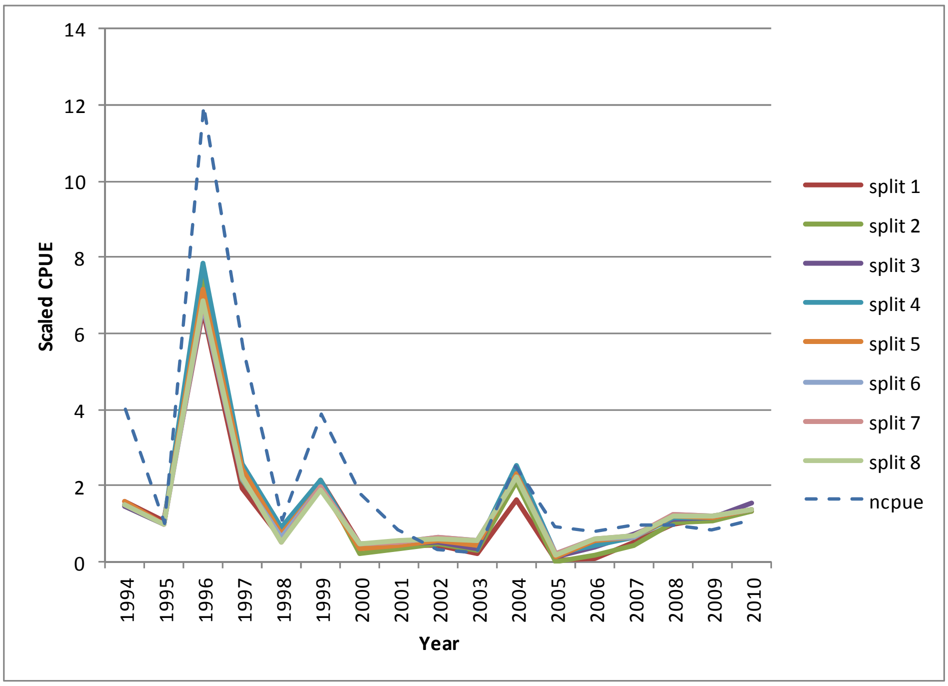

Figure 2. Scaled standardized CPUE of shrotfin mako by area separation (1 to 8 splits) and the nominal CPUE in the Indian Ocean. All values were scaled to the median of values in the period analyzed, which was set to 1.0. Split 1 – Split 8 denote the 1st to 8th split of area, and ncpue shows the nominal CPUE.

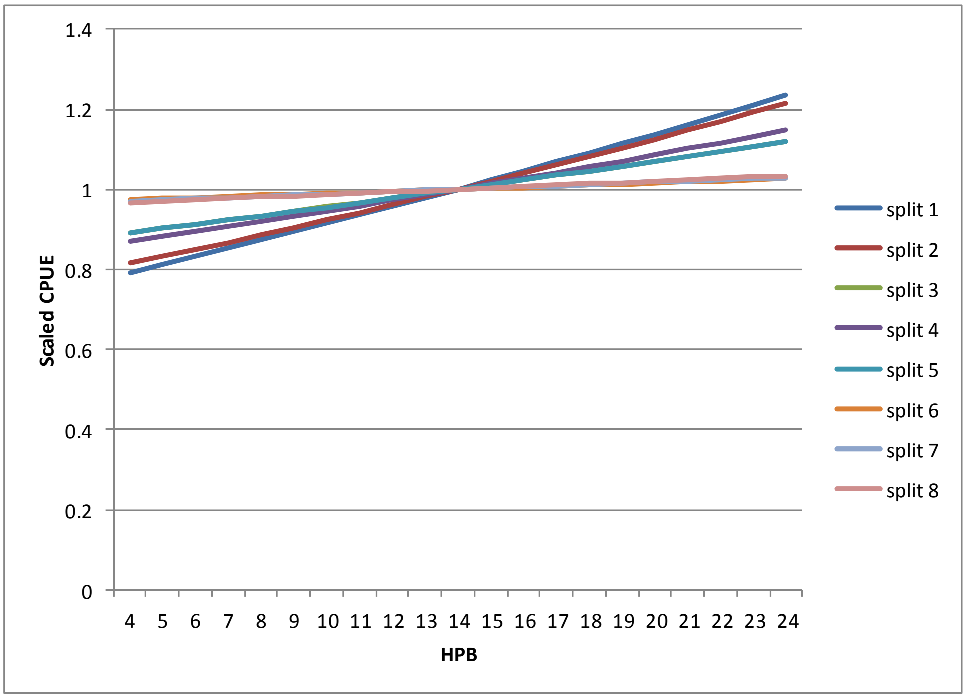

Figure 3. HPB effects by area separation (1 to 8 splits) in the Indian Ocean. All values were scaled to the median of each whole period which was set to 1.0. Split 1 – Split 8 denote the 1st to 8th split of area.

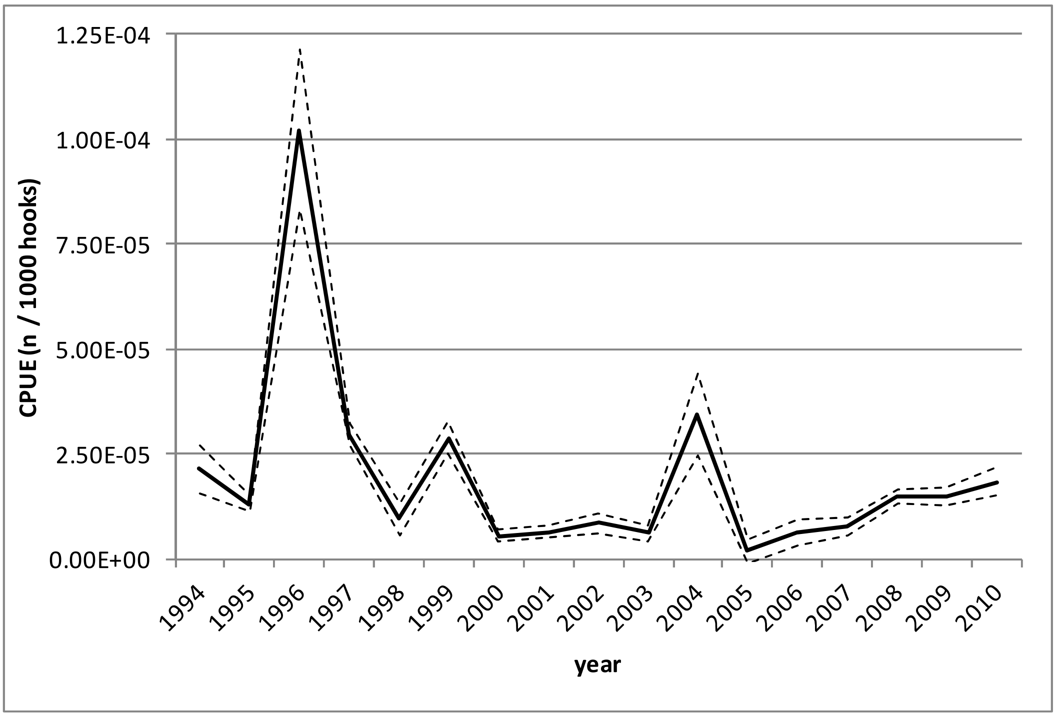

Figure 4. Standardized CPUE (n/1000 hooks) and its confidence interval. CPUE calculated using filtered data by 80 % reporting rate criteria and 9 subareas.

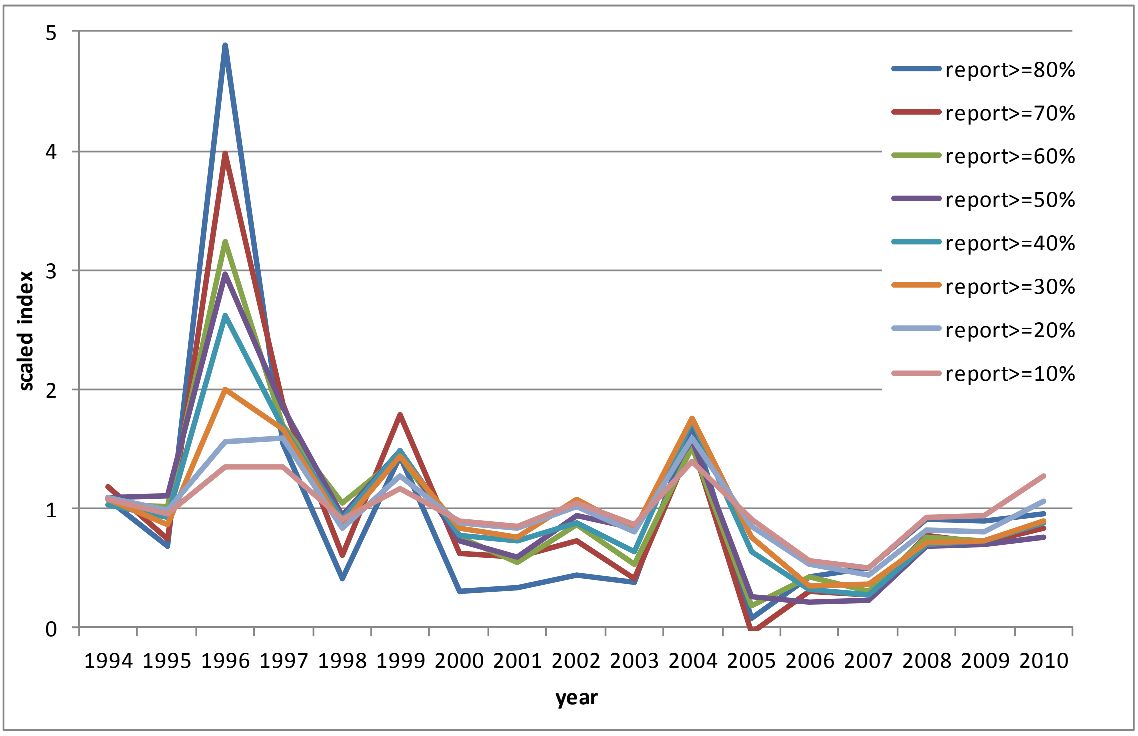

Figure 5. The trend of standardize CPUE by different data filtering criteria. The criteria changed arbitrarily. All the CPUE values was scaled to its mean which set at 1.0.

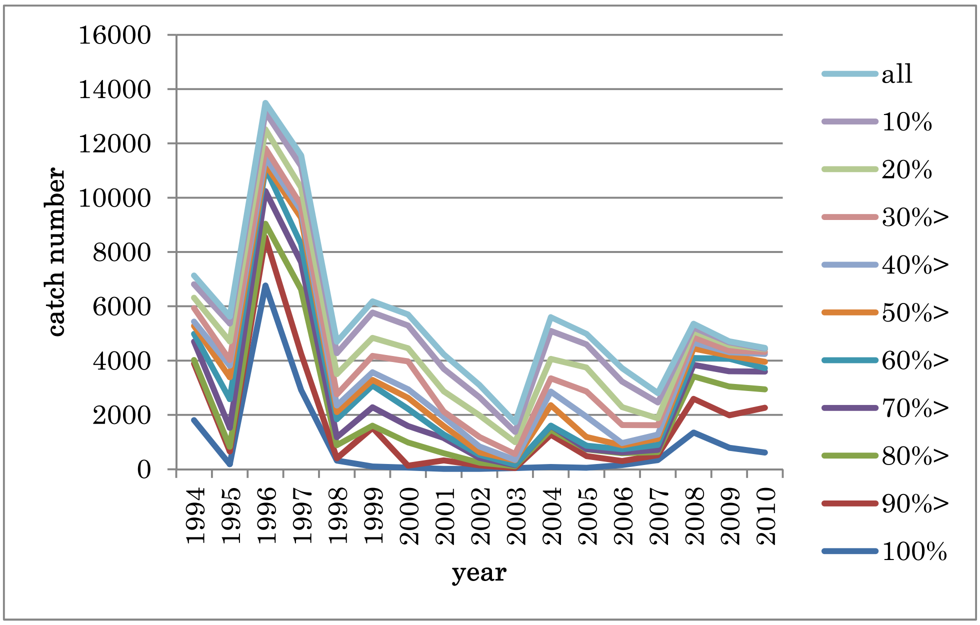

Figure 6. Reported catch number of shortfin mako shark by the different filtering criteria.