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Preliminary analysis of the Chinese albacore fishery and CPUE standardization in the Indian Ocean

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Abstract

Based on logbook data from the Chinese longline fishery, this study conducted a preliminary analysis of fishery and CPUE standardization for the Indian Ocean albacore (*Thunnus alalunga*). The temporal and spatial variations of fishing effort, albacore catch and individuals' mean weight were examined from 2014 to 2018. According to the basic setting used in the existing joint CPUE standardization and stock assessment for albacore in 2016 WPTmT, this study estimated the standardized CPUE of albacore in year-quarter scale. This is a good beginning to derive albacore CPUE from the logbook of Chinese longline fishery. More effort will be spent in the future for further exploring the Chinese albacore fishery data.

1. Introduction

Albacore (*Thunnus alalunga*) is a commercially important tuna species in all three oceans, and has been one of the two target species of Chinese longline fishery in the Indian Ocean. In recent years, albacore fishery supports the highest catch for Chinese longline fishery in Indian Ocean, followed by bigeye tuna (*Thunnus obesus*).

The logbook data for Chinese longline fishery is partially available since 2003. However, high resolution data (1° by 1° degree) for detailed statistics analysis is only available from 2014 to 2018. China would like to provide more effort not only in data collection, but also in data statistics, CPUE (catch per unit effort) standardization and stock assessment for Indian Ocean tuna fishery.

The objectives of this study are, 1) to prepare Chinese logbook data and summarize albacore fishery from 2014 to 2018; 2) to conduct preliminary standardization for Chinese albacore CPUE. Results of this paper could provide Chinese albacore fishery information and data to be used in Working Party on Temperate Tuna (WPTmT) and bases for joint CPUE standardization and stock assessment for albacore in Indian Ocean.

2. Data sources

The logbook data used in this study was from 2014 to 2018, covered the main fishery ground for albacore in Indian Ocean (Figure 1) (F. Rochman, *et al*. 2016). Observations of each set include year, month, number of hooks, longitude and latitude, catch in weight and number, etc. The sea surface temperature (SST) by 1° × 1°, used in CPUE standardization, was derived from KNMI Climate Explorer (http://climexp.knmi.nl/).

Based on the A3 regional structure used in the joint analysis for CPUE standardization (Hoyle *et al.* 2016), the spatial structure was considered to be consistent with that used in the previous CPUE standardization and stock assessment (Langley and Hoyle, 2016). Regions were divided by 25°S and 75°E, in which Region 1 (R1) represented the north west part, Region 2 (R2) for the north east, Region 3 (R3) for the south west, and Region 4 (R4) for the south east (Figure 1). Additionally, the catch and effort (number of hooks) were aggregated by 5°(latitude)×5°(longitude). Year-quarter was used as the temporal interval, in order to be consistent and to extend the temporal scale, meaning that Quarter 1 (Q1) includes January, February and March; Quarter 2 (Q2) includes April, May and June; Quarter 3 (Q3) includes July, August and September; Quarter 4 (Q4) includes October, November and December.

3. Review of Albacore Fishery

3.1 Fishing effort

The fishing effort for albacore in Indian Ocean increased from 2014 to 2015 by two times, but decreased in 2016, with high effort to albacore fishery in 2017 and 2018. The main fishing season is quarter 3 and 4 (Q3&4), with relatively low effort in Q1 (Figure 2). In recent 3 years, fishing effort in Q2 was also high, similar to Q4. In 2016, there was no big different fishing effort among 4 quarters. The spatial variations of fishing effort indicate that there was limited effort in the north east part (R2), while more than half effort was conducted in the R1 (Figures 3 and 4). Fishing effort in R3 was stable, while effort in R4 has been increasing in recent years.

3.2 Albacore catch

Catch of albacore was relative stable during the period 2014 to 2016, but increased much in 2017 and 2018 in both weight and numbers. Temporal variations among quarters and months varied among different years, with the highest values in Q4 for 2016, 2017 and 2018 but in Q4 for 2014 and 2015 (Figure 5). The catch in both weight and number of albacores showed relative consistent spatial variations with the fishing effort (Figures 6-8). Catch in R2 was the lowest among 4 regions in all five years. Catch in R1 and R3 were high, with catch in R4 increased much from 2016 to 2018.

3.3 Individual weight

The mean individual weight (in kg) was estimated by the catch in weight divided by catch in number. The mean weight of albacore was 16.59 kg caught during 2014-2018. Mostly, albacores caught in autumn and winter have a little higher weight than those in spring and summer. Since its distribution is in the south hemisphere of Indian Ocean, albacore gains more weight in warm seasons than in cold seasons. Albacores caught in different regions or years do not show obvious variations, with complex trends.

4. CPUE Standardization

CPUE standardization was explored in this study for albacore caught in Chinese longline fishery. Nominal CPUE is the number of albacores captured per 1000 hooks. Generalized Linear Model (GLM) with log-normal distribution for error structure was used to model the relationships of the nominal CPUE with multiple variables, including temporal variable (year or year-quarter), spatial variable (latitude by 5°and longitude by 5°, or LA5LN5, i.e. grid by 5° ×5°), vessel name and sea surface temperature (SST). A total of 12 models with different variables combinations were constructed (Table 1). The year-quarter was used as the time lag, in order to be consistent with the previous joint analysis of CPUE. The effects of temporal variable were assumed to be the standardized CPUE.

Ln(Nominal CPUE) ~ intercept + explanatory variables+ ε, where $\varepsilon \sim N(0, \sigma^2)$

Different combinations of explanatory variables were explored during the CPUE standardization modelling (Table 1). AIC, proportion of deviance explained, Q-Q plot and residuals were estimated to diagnose the model performance (Table1 and Figure 10).

Results of model diagnostic indicated that 4 models (M1, M5, M7 and M11) have better performance than others. All these 4 models included vessel name and LA5LN5 with different temporal variables. The effect of SST for CPUE was not obvious, since results of these models with or without SST as explanatory variable were similar. For example, M11 removed SST based on the same model configuration with M7,while M11 has same proportion of deviance explained and coincide standardized CPUE with M7 but lower AIC value (Table1 and Figure 11).

The standardized CPUE has similar trend with the nominal CPUE in the both year scale and year-quarter scale, but has lower values in most of the period (Figure 11). The standardized CPUE decreased from 2014-Q3, then kept at lower values in the following 6 quarters, and then fluctuated largely during recent years. Generally, the standardized CPUE was lower in Q4 and Q1, with much higher values in Q2 and Q3. The temporal trends of standardized CPUE were consistent in both the year scale and year-quarter scale.

5. Discussion and conclusions

The GLM model diagnostics suggested that the model M1 (Table 1) performed best, which means the effect of vessel should be considered during CPUE standardization. The latitude-longitude grid (5° × 5°) can reflect the spatial influence to CPUE better than latitude and longitude separately (in one-dimensional scale). Compared with year scale, CPUE in year-quarter scale can reveal more information about the population dynamics, which has already been used in the existing stock assessment for albacore. The effects of SST on CPUE is not significant as reflected by these 12 models, but the quarter variation of CPUE can still reveal its relationships with temperature.

This study aimed to explore information for understanding the Chinese longline fishery for albacore in the Indian Ocean. The logbook data used in this study comprised only data sets with good quality (i.e. not the whole logbook data sets). The methodology used in this study needs further improvement, e.g. may consider spatial modeling in the future. However, this is a well beginning and we are planning to explore more studies and join the cooperation within WPTmT.

6. References

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F. Rochman, *et al*. 2016 The potential fishing ground and spatial distribution pattern of albacore (*Thunnus alalunga*) in Eastern Indian Ocean. IOTC–2016–WPTmT06–12

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7. Tables

Table 1. Model configuration for CPUE standardization for Chinese albacore longline fishery

Models	**Explanatory variables**	**AIC**	**Proportion of deviance explained**
M1	YearQuarter+Name_Ship+LA5LN5+SST	**24796**	**47.9%**
M2	YearQuarter+Name_Ship+Lat_5+Lon_5+SST	26446	38.8%
M3	YearQuarter+LA5LN5+SST	25440	44.3%
M4	YearQuarter+Lat_5+Lon_5+SST	27491	32.1%
M5	YearQuarter+Name_Ship+LA5LN5	**24821**	**47.8%**
M6	YearQuarter+Name_Ship+Lat_5+Lon_5	26604	37.9%
M7	Year+Month+Name_Ship+LA5LN5+SST	**24650**	**48.6%**
M8	Year+Month+Name_Ship+Lat_5+Lon_5+SST	26435	38.9%
M9	Year+Month+LA5LN5+SST	25287	45.1%
M10	Year+Month+Lat_5+Lon_5+SST	27468	32.3%
M11	Year+Month+Name_Ship+LA5LN5	**24648**	**48.6%**
M12	Year+Month+Name_Ship+Lat_5+Lon_5	26551	38.3%

8. Figures

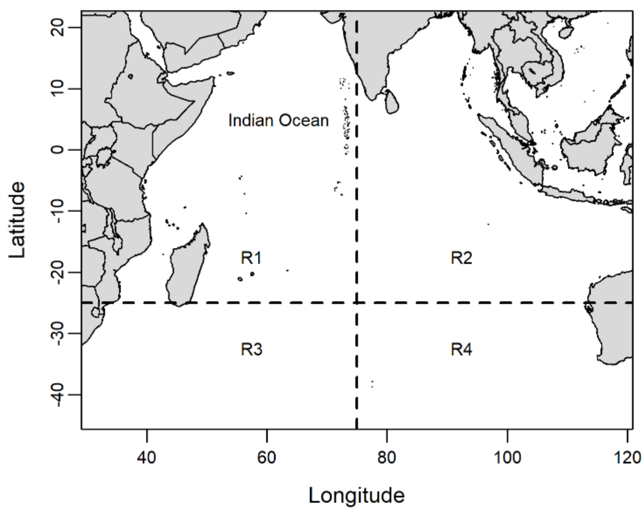


Figure 1. The A3 regional structure (4 regions: R1-R4) for Chinese albacore longline fishery from 2014 to 2018

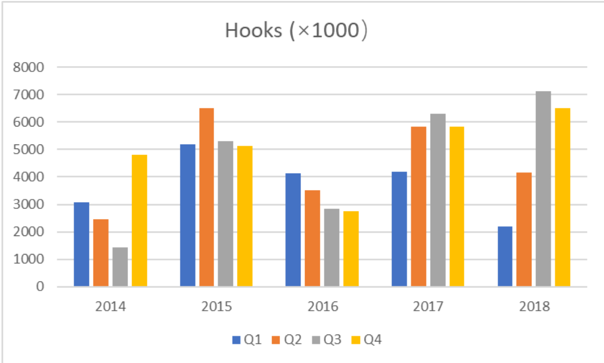


Figure 2. The temporal variations of effort (thousands of hooks) in Chinese albacore longline fishery from 2014 to 2018. Q1-4 represent different quarters.

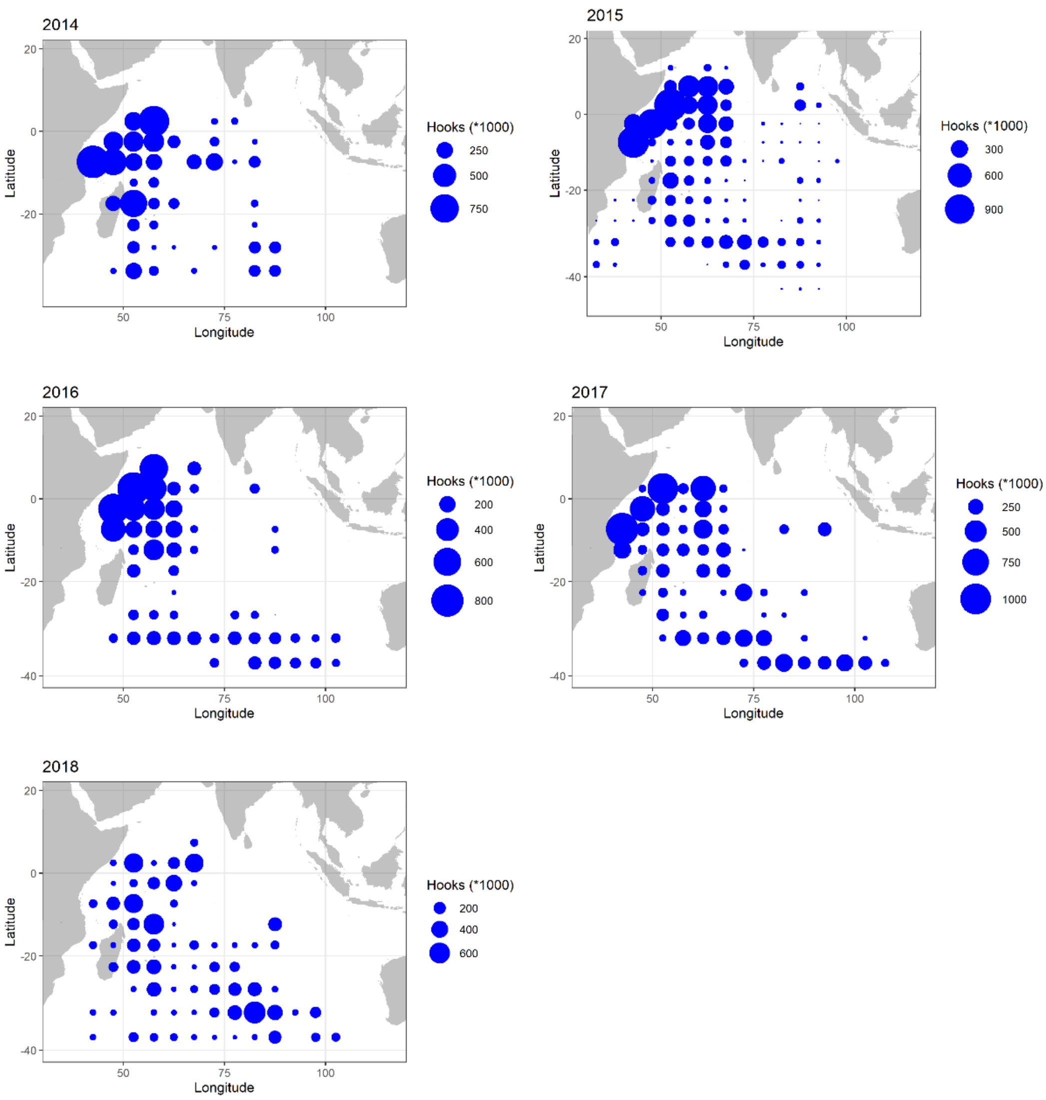


Figure 3. The spatial variations of effort (thousands of hooks) in Chinese albacore longline fishery from 2014 to 2018

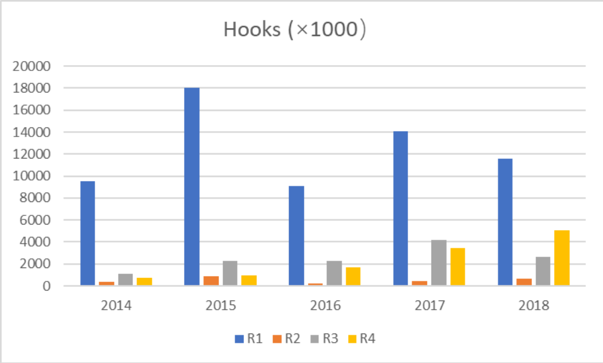
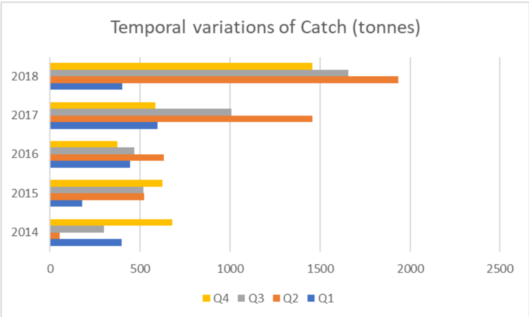


Figure 4. Variations of effort (thousands of hooks) in Chinese albacore longline fishery among regions (R) from 2014 to 2018.



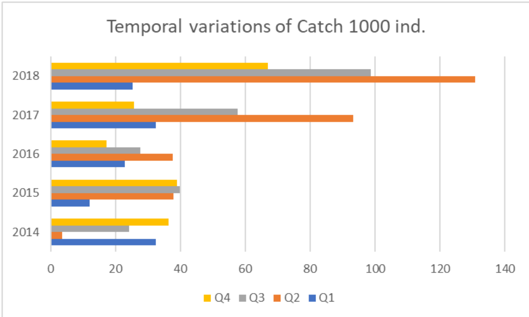
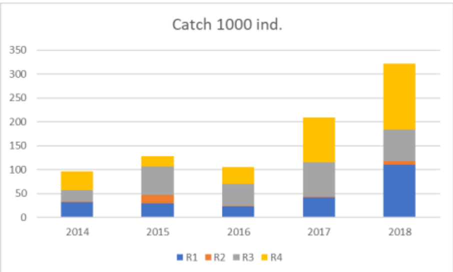


Figure 5. The temporal variations of albacore catch (in tonnes and 1000 individuals) from 2014 to 2018. Q1-4 represent different quarters.



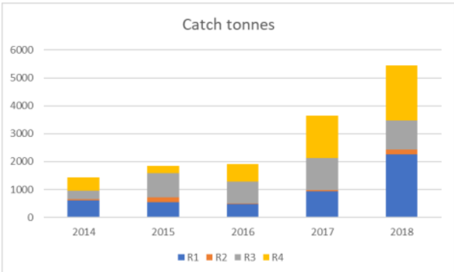


Figure 6. Variations of Chinese albacore catch (in tonnes and 1000 individuals) among regions from 2014 to 2018.

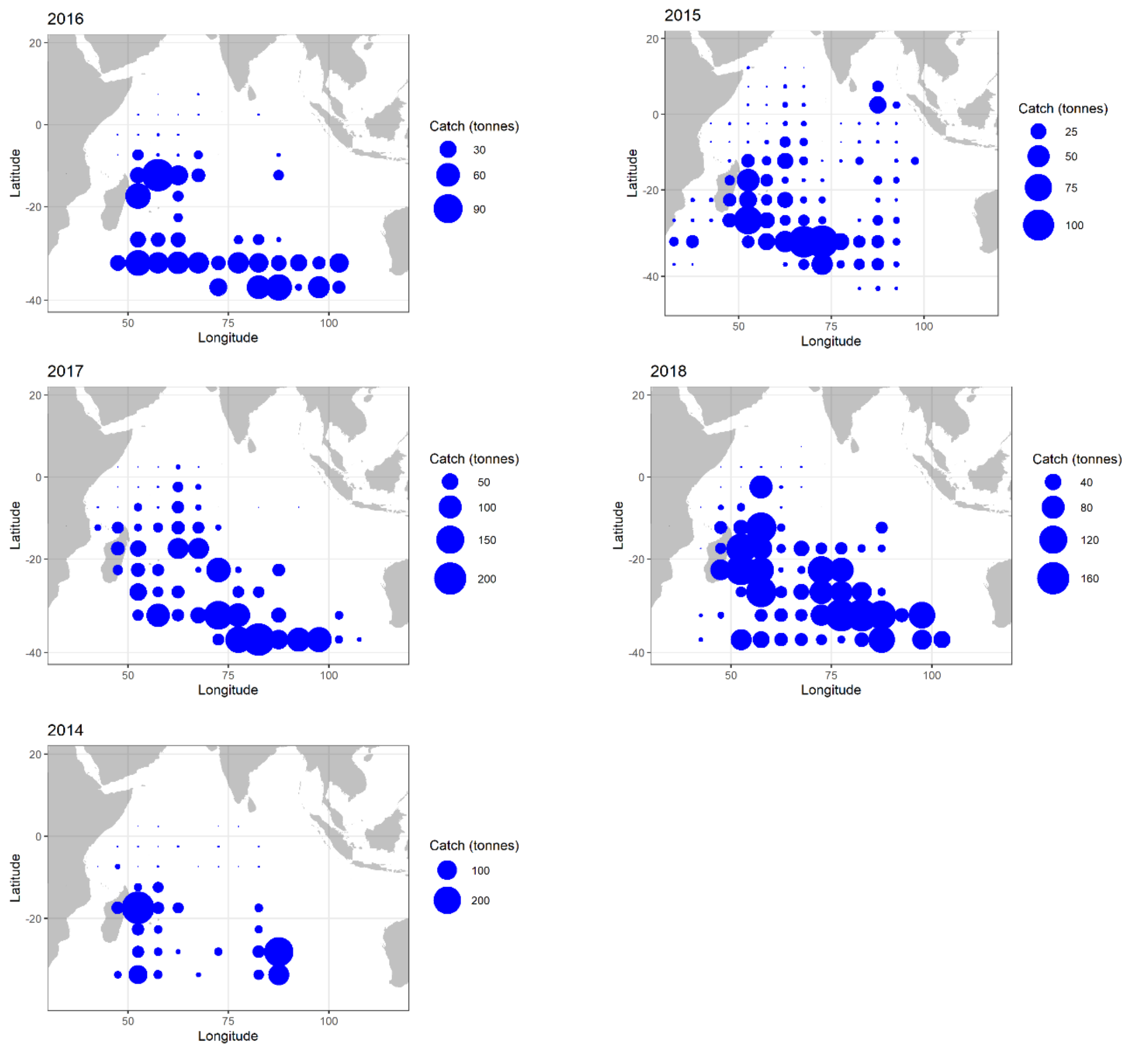


Figure 7. The spatial variations of albacore catch (tonnes) in Chinese longline fishery from 2014 to 2018

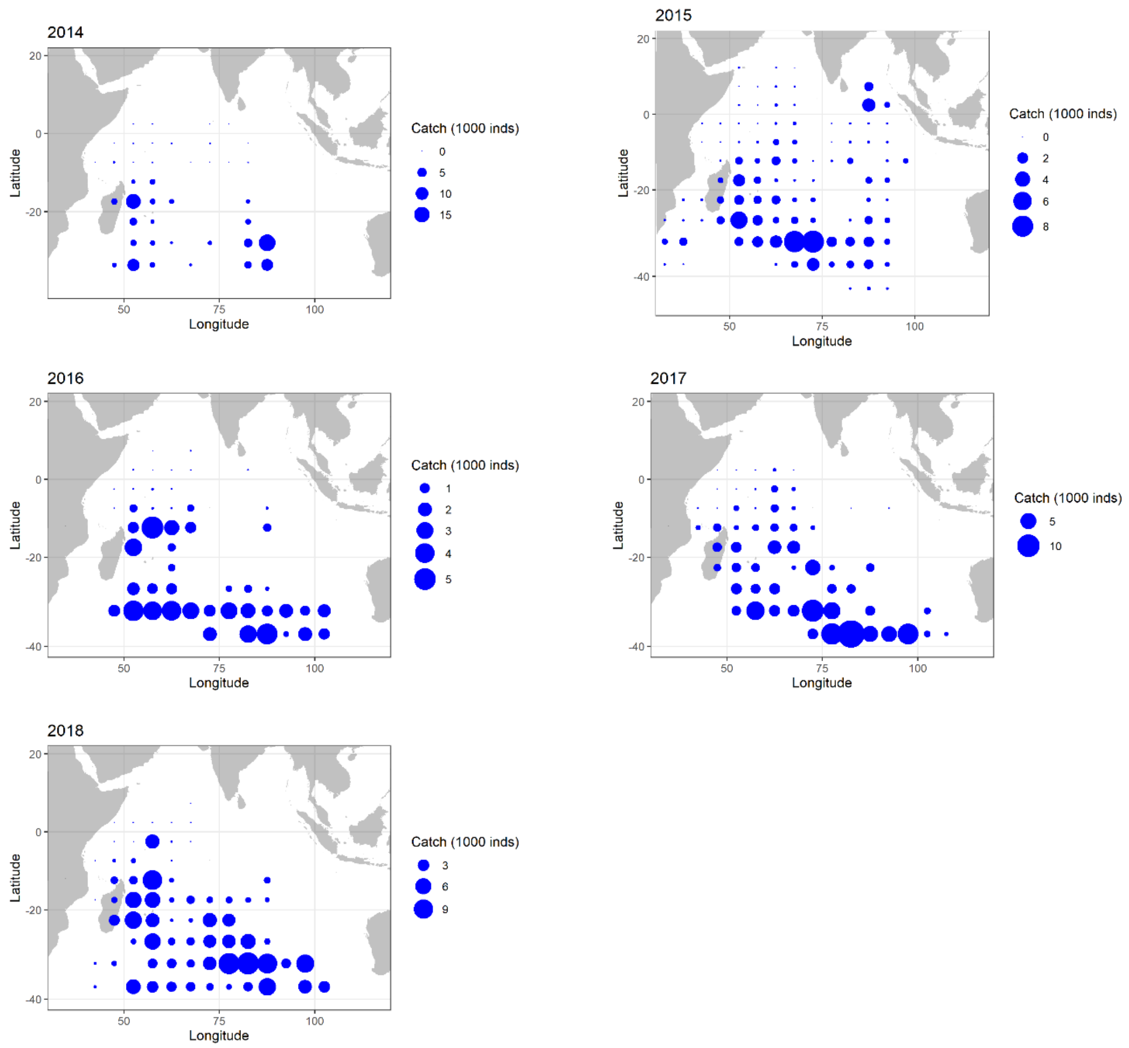


Figure 8. The spatial variations of albacore catch (1000 individuals) in Chinese longline fishery from 2014 to 2018

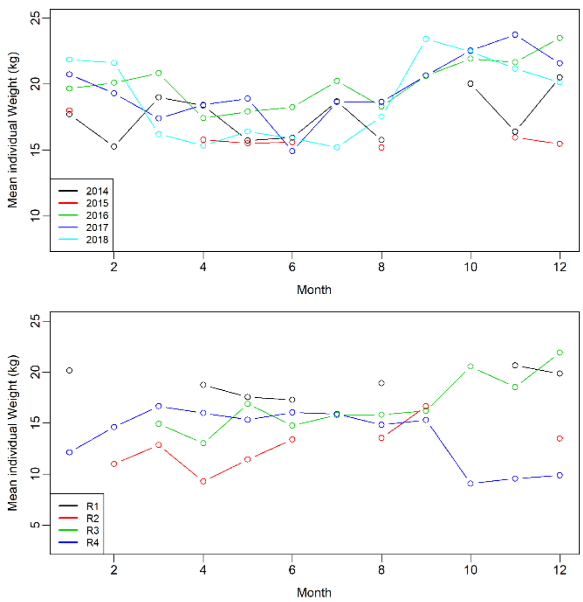


Figure 9. The temporal and spatial variations of albacore weight from in Chinese longline fishery from 2014 to 2018

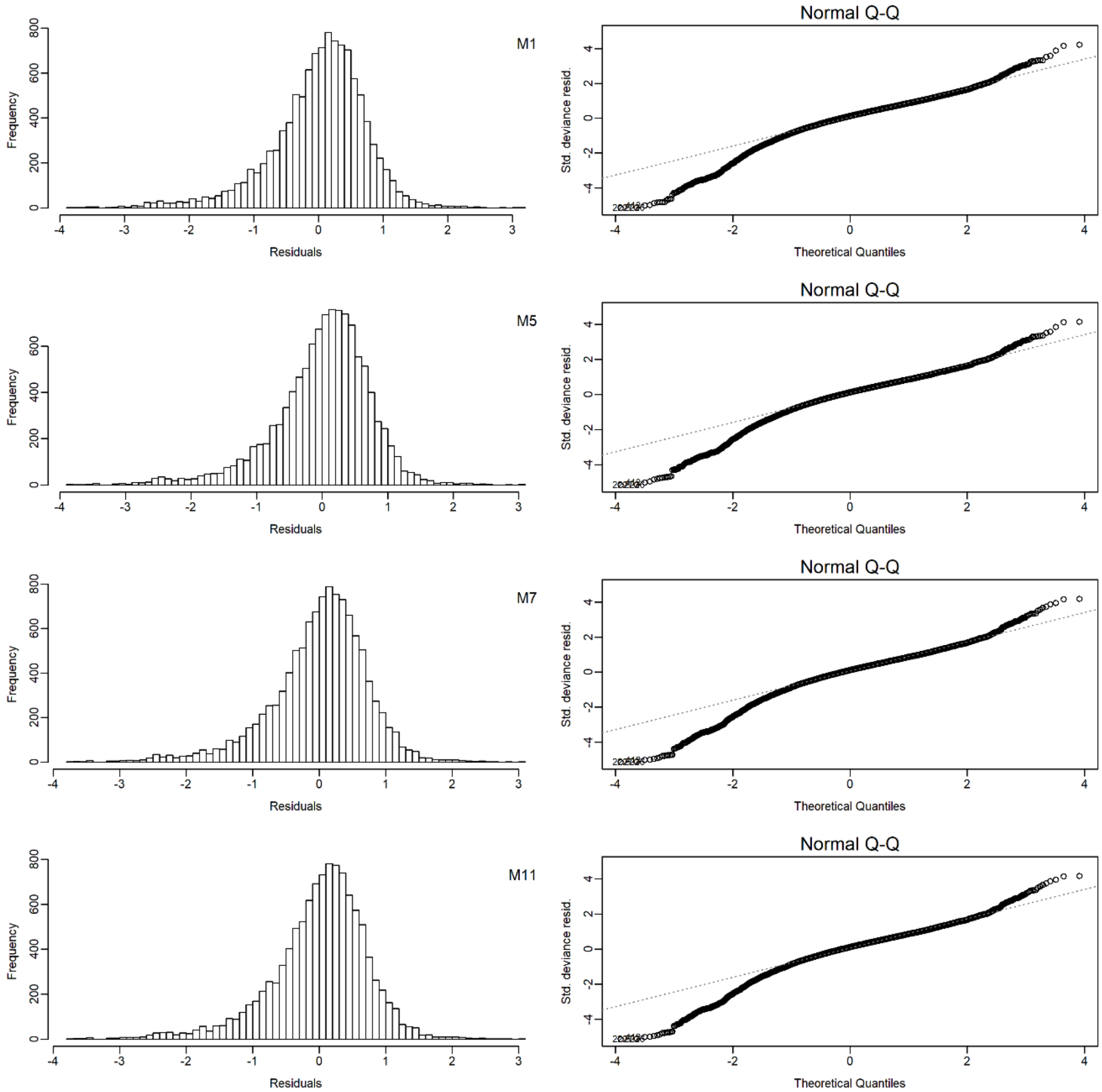


Figure 10. Residuals and Q-Q plot for the 4 selected models (M1, M5, M7 and M11) for albacore CPUE standardization

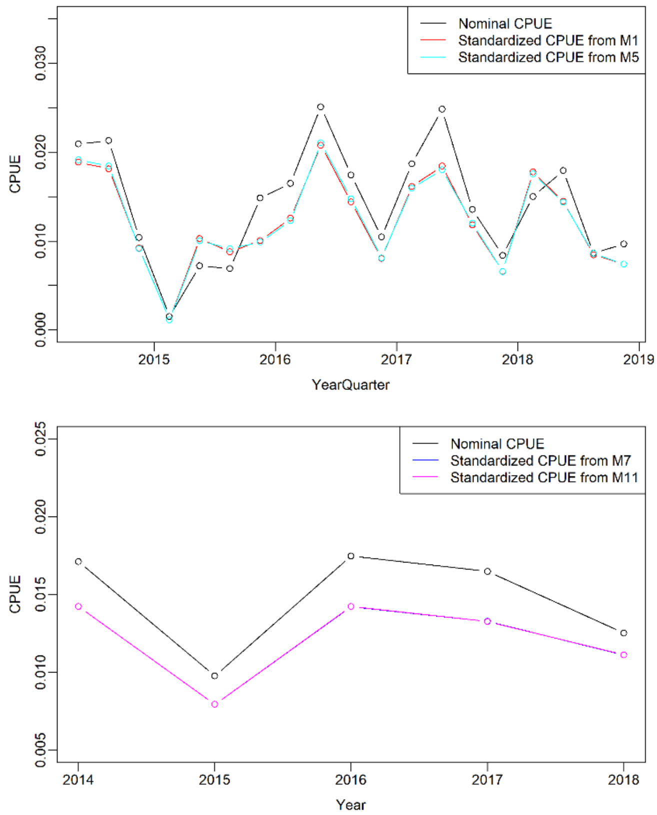


Figure 11. Nominal and standardized CPUE of albacore from 4 selected models (M1, M5, M7 and M11)