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Standardized PBF CPUE Series for Taiwanese Longline Fishery up to 2016

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Summary

PBF was an important seasonal target species to Taiwan offshore longline fishery, however, before 2010, only market landing data with small coverage of logbooks were available. Therefore, several alternative procedures have been adopted to estimate standardized PBF CPUE series, taking advantage of voyage data recorder (VDR) data and trip data (from the Coast Guard Administration) for estimating fishing effort, as well as landing data and CDS data for estimating catch (in number), using delta-generalized linear mix model (delta-GLMM). The current work is an update to the work of ISC/16/PBFWG-1/02 with a revision of 2015 data and an addition of 2016 data. Result of this analysis showed similar standardized CPUE trend as the previous work presented in the 2016 ISC PBFWG meeting. In general, the standardized CPUE declined continuously from 2001 to 2010, stayed at low level for two years, and then started to increase since 2013 through to 2016.

Introduction

Pacific bluefin tuna (PBF) is an import seasonal target species for Taiwanese longline fishery. The catch has been as high as 3,089 mt in 1999 but was continuously declined to the lowest record of 210 mt in 2012. Recently the catch has shown increasing sign to be 483 mt in 2014 and 577 mt in 2015. The 2016 catch is estimated to be lower than the 2015 level but by lower number of vessels. The catch was composed mainly of 150-200 kg median size fish (>60%) in the early 2000s, but following the decrease of available median size fish, large fish of >200kg became the majority. Recently, however, more median size fish was observed in the catch and its ratio has reached 50% since 2015.

The PBF logbook information for Taiwanese offshore longline fishery was considered incomplete and insufficient to conduct CPUE analyses. To enhance the management on PBF fishery, Taiwan implemented specific regulations (catch documentation scheme, CDS) on the fishery since 2010. Thereafter many catch and effort information were available and could be used to retrospectively construct catch and effort data for the years before 2010. Document ISC/15/PBFWG-2/10 (Chang et al., 2015) has performed four major works for estimating 2001-2014 Taiwanese standardized PBF CPUE series. Document ISC/16/PBFWG-1/02(revised) (Chang and Liu, 2016) further updated the CPUE series by adding 2015 data (2014 fishing year) and refining the algorithm for deriving fishing days from more complete VDR data. The 2016 work has also separated the standardization by region (south and north fishing grounds) and the CPUE series of the south fishing ground was recommended to be used for the 2016 PBF stock assessment. This study is to provide an update of CPUE series for the projection analysis on probability to achieve various rebuilding targets under various harvest scenarios, therefore, this study simply followed the previous work in 2016 and performed the same standardization on the same dataset with a revision of 2015 data and an addition of new 2016 data (2015 fishing season).

Materials and Methods

The data used in this study was the same as those in ISC/16/PBFWG-1/02(revised) (Chang and Liu, 2016) except that a new year data of 2016 was included.

The study followed the 2016 work and performed CPUE standardization on data of 2001 – 2016. The major procedures for the work are: (1) Estimating PBF catch in number from landing weight for 2001-2003 when the information of catch in number was incomplete, based on a Monte Carlo simulation; (2) Deriving fishing days for 2007-2009 from data of VDR based on a new developed algorithm taking advantage of the information of change of vessel direction calculated from VDR; (3) Deriving fishing days for 2001-2006 from vessel-trip information from the Coast Guard Administration, based on linear relationships between fishing days and at-sea days in a trip, by vessel size and fishing port; (4) Standardizing the CPUE for 2001-2016 using delta-generalized linear mix model (delta-GLMM) which separately estimates the proportion of positive PBF catches assuming a binomial error distribution (zero-proportion model), and the mean catch rate of positive catches by assuming a lognormal error distribution (positive-catch model). The standardized index is the product of these model estimated components.

Covariates considered in the GLMM included: year (2001 – 2016), month (May – July), fishing area (northern and southern fishing ground separated by 24.3°N), and vessel tonnage (CT1 – CT4). Since the number of explanatory variables considered in the study was small (due to limitation in available information), simpler backward (decreasing variables) and forward (increasing variables) methods were applied when determining the variables to be included in the model. All the explanatory variables were included initially in the model and were determined in the final models through backward method. First order interactions of the explanatory variables were also considered for the model and were determined through forward method. The interaction of year and the other categorical variables (month and vessel size) were treated as random variables. Two types of standardizations were performed: the area-combined standardization (fishing ground effect was treated as a covariate in the model) and the area-separate standardization (the standardizations were conducted separately by fishing ground). Coefficient of Variation (CV) series were calculated through bootstrap approach for 1000 times.

Results and Discussions

CPUE on trip basis were calculated for the whole series of 2001 – 2016. Three delta-GLMM runs were performed on data of southern area, northern area, and whole combined area. The best explanatory variable combinations were shown in Table 1. In general, all the best models include key variables of year, month, and year*month interaction (random variable). Vessel size variable does not have significant effect that was expected. The diagnostic residual plots for these GLMM runs in Fig. 1 indicated the appropriateness of the two-stage delta lognormal model for evaluation of the factors that influence the PBF catch rate. The resulted relative CPUEs are shown in Table 2 (along with their CVs) and Fig. 2. The new CPUE series for south fishing ground (S_2017) is very similar to the previous one (S_2016) with substantial increases in 2015 and 2016.

Although AICs and BICs of the southern and northern areas in Table 1 cannot be directly combined to compare with those of the combined whole area, from the large difference between them, the area-separated standardization with much smaller AIC/BIC was likely to be a statistically significant improvement. The PBF catch in the northern area historically have included an additional cohort of medium sized fish comparing to the southern area catch (Fig. 3) and so the average size of catch was smaller. Also, the northern area was basically a new fishing ground; historically this area composed less than 10% of the annual catch before 2008 and less than 30% before 2013. With these considerations and that the southern area was the traditional fishing ground with higher proportion of historical catch, this study recommended to use the series of the southern area as the representative of Taiwanese PBF CPUE series.

References

Chang, S.-K., H.I. Liu. and Y.-W. Fu. 2015. Estimation of standardized CPUE series on Pacific bluefin tuna for Taiwanese longline fishery under incomplete data. Pacific Bluefin Tuna Working Group Intersessional Workshop of the ISC, Kaohsiung, Taiwan, November 18-25, 2015. ISC/15/PBFWG-2/10.

Chang, S.-K. and H.I. Liu. 2016. Update of Standardized PBF CPUE Series for Taiwanese Longline Fishery. Pacific Bluefin Tuna Working Group Intersessional Workshop of the ISC, La jolla, USA, 29 February – 11 March, 2016. ISC/16/PBFWG-1/02 (revised).

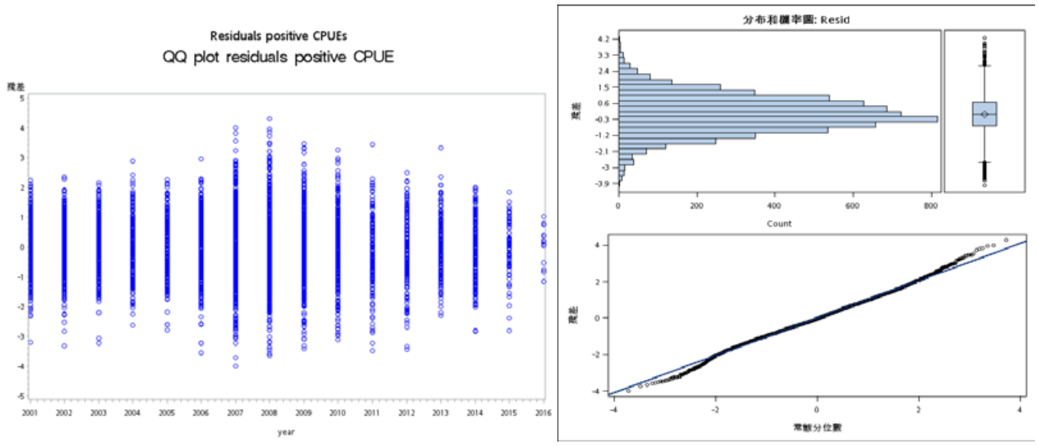
Table 1. Best variable combinations of the delta-lognormal mixed models and the Akaike information criterion (AIC) and Bayesian information criterion (BIC). (ZPM: zero-proportion model; PCM: positive-catch model)

Model type	Final model formulation	n	AIC	BIC
South fishing ground				
ZPM:	Year+Month+Year*Month	152	439.5	443.2
PCM:	Year+Month+Year*Month	6348	18562.2	18565.9
North fishing ground				
ZPM:	Year+Month+Vessel_size +Year*Month	115	376.2	379.7
PCM:	Year+Month+Year*Month	1970	5344.2	5347.3
Combined South and North fishing grounds				
ZPM:	Year+Month+Area+Year*Month	267	857.3	861.1
PCM:	Year+Month+Area+Year*Month	8318	24155.9	24159.6

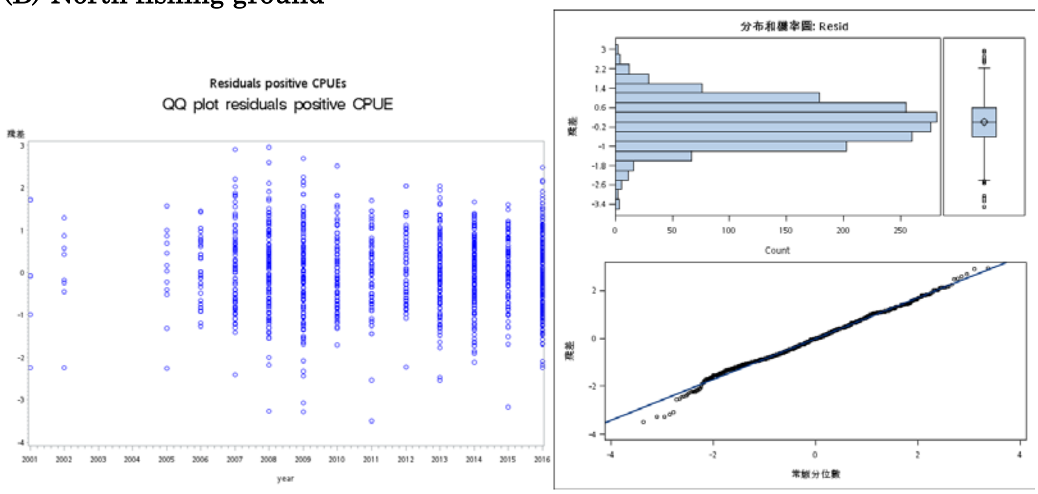
Table 2. Relative CPUE series from this study and from PBFWG-2016. '2016 est.' is the series that was used in 2016 stock assessment. 'Point estimate' is the relative CPUE estimated from delta-GLMM. 'Mean' and 'CV' are the mean estimates and their CVs obtained from 1000 bootstrap runs.

	South fishing ground			North fishing ground		All fishing ground	
Year	2016 est.	This study	CV	This study	CV	This study	CV
2001	2.399	2.445	0.030	1.057	0.119	2.390	0.031
2002	0.969	1.040	0.068	1.318	0.019	1.008	0.064
2003	1.773	1.742	0.042			1.749	0.040
2004	1.823	1.842	0.035			1.845	0.033
2005	1.292	1.319	0.043	1.323	0.143	1.282	0.042
2006	1.452	1.393	0.031	1.213	0.059	1.314	0.029
2007	1.107	1.126	0.046	0.562	0.053	0.878	0.039
2008	0.954	0.993	0.066	1.008	0.051	0.884	0.063
2009	0.759	0.771	0.035	0.920	0.049	0.724	0.031
2010	0.424	0.424	0.058	0.601	0.040	0.389	0.053
2011	0.422	0.440	0.048	0.681	0.064	0.452	0.039
2012	0.298	0.344	0.056	0.505	0.059	0.315	0.044
2013	0.347	0.345	0.085	0.777	0.046	0.392	0.072
2014	0.502	0.506	0.051	1.532	0.034	0.633	0.043
2015	0.395	0.578	0.090	1.280	0.047	0.899	0.042
2016		0.691	0.108	1.221	0.051	0.847	0.047

(A) South fishing ground



(B) North fishing ground



(C) Whole fishing ground

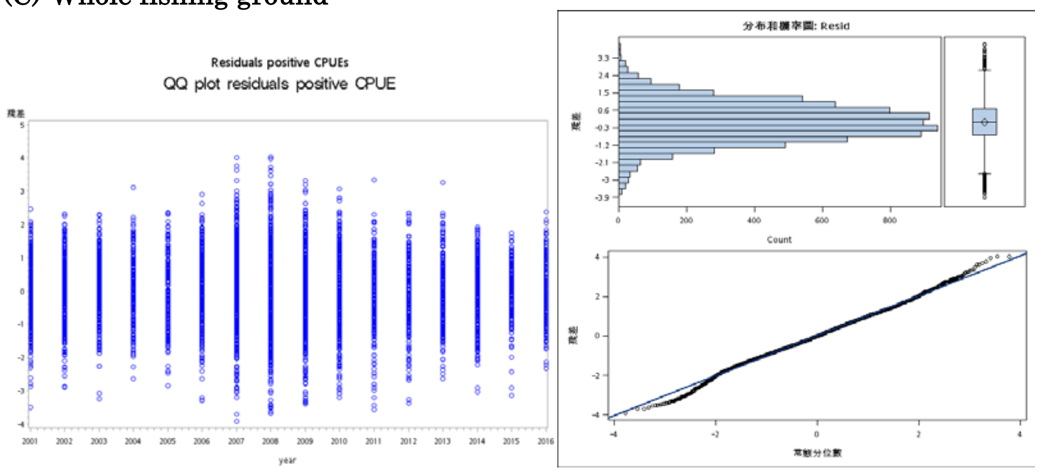


Fig. 1. Diagnostic residual plots for the delta-GLMM for PBF CPUE standardizations, for the three model runs.

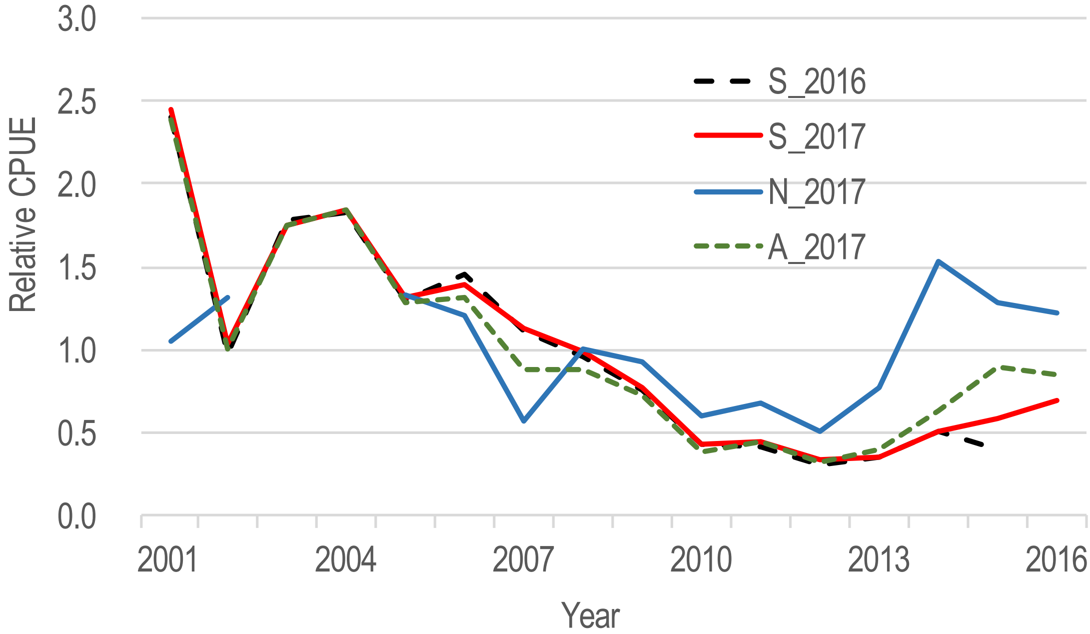


Fig. 2. Standardized CPUE series for Taiwanese PBF longline fishery. S_2016 is for south fishing ground adopted from ISC/16/PBFWG-1/02(revised). S_, N_ and A_2017 are CPUE series of the south, north and all fishing grounds obtained from this study.

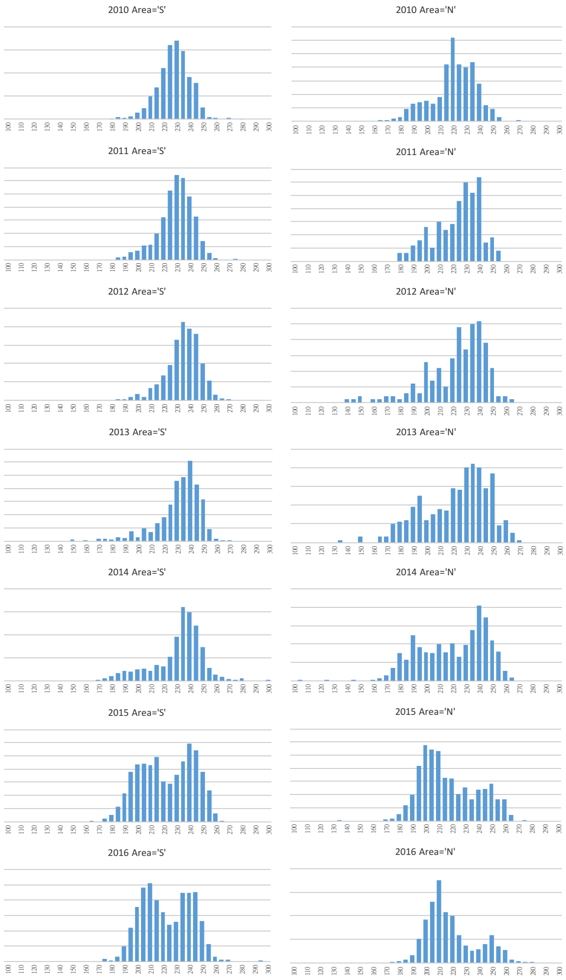


Fig. 3. PBF length distribution of Taiwanese longline fishery, by area (South in the left panels and North in the right panels) and by year (2010–2016).