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Standardized PBF CPUE Series and size frequency for Taiwanese longline fishery up to 2017 calendar year

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Summary

PBF was an important seasonal target species to Taiwan offshore longline fishery, however only market landing data with small coverage of logbooks were available before 2010. Several alternative procedures were thus used to reconstruct catch and effort data since 2001 for the fishery, 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). The CPUEs were then standardized separately by north and south fishing grounds using delta-generalized linear mix model (delta-GLMM). The current work is an update to the work of ISC/17/PBFWG-1/02 with a revision of 2015 and 2016 data and an addition of 2017 data. Standardized CPUE series for the southern fishing ground is recommended for representing the abundance index of PBF in this region. Result of this analysis showed similar standardized CPUE trend as the previous work presented in the 2017 ISC PBFWG meeting for the southern fishing ground. In general, the standardized CPUE declined continuously from 2001 to 2012 and then started to increase since 2014. The PBF catch were all large size fish (>225 cm) in general, however the proportion of medium sized fish (<225 cm) increased since 2014 and was over 50% since 2015 in the southern fishing ground.

Introduction

Pacific bluefin tuna (PBF) is an import seasonal target species for Taiwanese longline fishery. The longline 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, 552 mt in 2015 and 454 mt in 2016. The 2017 catch was estimated preliminarily to be 358 mt with about 60% of the catch harvested in the southern fishing ground, increased about 6% from 2016. PBF 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 during 2000 and 2014. However, since 2015, more median size fish was observed in the catch and its ratio has reached or over 50%.

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 information regarding PBF fishery were available and could be used as bases 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 approaches for estimating 2001-2014 Taiwanese standardized PBF CPUE series. The work was refined in 2016 and 2017 [ISC/16/PBFWG-1/02(revised) and ISC/17/PBFWG-1/02] (Chang and Liu, 2016, 2017) and published later in an academic journal (Chang et al., 2017). The refined work standardized the CPUE separately by the southern and the northern fishing grounds, and the CPUE index of the south fishing ground was recommended to be used for the PBF stock assessment from 2016 onwards.

This study is to provide an update of CPUE series for the 2018 PBFWG meeting. As agreed, no modification on standardization model was made from the 2017 work. Same datasets as in 2017 PBFWG meeting was used, with a revision of 2015 and 2016 data and an addition of new 2017 data (2016 fishing season).

Materials and Methods

The data used in this study was the same as those in ISC/16/PBFWG-1/02 (revised) and ISC/17/PBFWG-1/02 (Chang and Liu, 2017) with the following changes: (1) 2016 data (the last year data used in 2017 PBFWG) was updated due to more complete VDR data is available for the estimation of fishing effort. The 2015 data was also revised and finalized since the 2015 VDR data is completely processed at this stage. (2) New 2017 data is added to the dataset. The one-day trip data were excluded from the study (occurred mainly in 2014 and 2015) as explained in ISC/16/PBFWG-1/02 (revised), which has also been performed in producing the series for 2016 and 2017 PBFWG. Size of PBF were obtained from the CDS in which the length and weight of almost every PBF fish were measured by inspectors.

The study followed the 2016 and 2017 works and performed CPUE standardization on data of 2001 – 2017. The major procedures for the study are: (1) Estimating PBF catch in number from landing weight for 2001-2003, for which the catch number information was incomplete, based on a Monte Carlo simulation; (2) deriving fishing days for 2007-2009 from data of VDR based on an algorithm that 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; and finally (4) standardizing the CPUE calculated from the reconstructed data of 2001-2017 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. Akaike and Bayesian information criteria was used to determine the most favorable variable composition of standardization models,

Covariates considered in the GLMM included: year (2001 – 2017), 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. Three standardization runs were performed: (1) that on the area-combined data (fishing ground effect was treated as a covariate in the model); (2) that on the data from the southern fishing ground; and, (3) that on the data from the northern 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 – 2017. 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). As the works of previous years, vessel size variable does not have significant effect that was expected. The diagnostic residual plots for these GLMM runs in Fig. 2 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. 3.

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. Chang et al. (2017) demonstrated using the overall R^2 calculated to compare fitting performance between area-separated and area-combined standardizations, that the area-separated one has better statistical performance. 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, as previous studies, this study recommended to use the series of the southern area as the representative of Taiwanese PBF CPUE series.

The resulting new CPUE series for southern fishing ground (TLS_2018) is similar to the previous one (TLS_2017) that used in the 2017 PBFWG meeting. In general, the standardized CPUE declined continuously from 2001 to 2012 and then started to increase since 2014. This series showed similar trend with that of Japanese longline fishery obtained and re-scaled from ISC/18/PBFWG-1/01 Table 1 (Fig. 4).

The PBF catch were all large size fish (>225 cm) in general for 2010–2013. However, the proportion of medium sized fish (<225 cm) increased since 2014 and was over 50% since 2014 in the northern fishing ground and since 2015 in the southern fishing ground. In terms of fish weight, proportional changes of different size cohorts were observed in the catch (Fig. 5). Based on the available CDS data of 2010–2017, the percentage of fish with weight <180 kg was low in the catch during 2010–2012, then increased continuously to 2015, but shown decreases in 2016 and 2017. On the other hand, percentage of 180–240 kg fish decreased since 2010 to a low level of 16% in 2014 and thereafter started to increase continuously to 50% in 2017. In the meantime, percentage of large fish >240 kg increased since 2010 to the highest level of 70% in 2012 and thereafter decreased continuously to 22% in 2017.

References

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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	168	485.0	488.9
PCM:	Year+Month+Year*Month	7567	20917.1	20925.0
North fishing ground				
ZPM:	Year+Month+Vessel_size +Year*Month	124	538.6	542.2
PCM:	Year+Month+Year*Month	2287	5560.4	5927.5
Combined South and North fishing grounds				
ZPM:	Year+Month+Area+Year*Month	292	954.1	958.0
PCM:	Year+Month+Area+Year*Month	9854	26628.0	27369.2

Table 2. Relative CPUE series from this study and from PBFWG-2017. '2017 est.' is the series that was used in 2017 stock assessment. 'This study' and 'CV' are the relative CPUEs and their CVs estimated from this study. The relative CPUEs and CVs are obtained from 200 bootstrap runs.

	South fishing ground			North fishing ground		All fishing ground	
Year	2017 est.	This study	CV	This study	CV	This study	CV
2001	2.445	2.562	0.028	0.525	0.124	2.528	2.528
2002	1.040	1.059	0.071	1.259	0.012	1.048	1.048
2003	1.742	1.862	0.037			1.935	1.935
2004	1.842	1.949	0.032			2.021	2.021
2005	1.319	1.366	0.040	1.163	0.129	1.351	1.351
2006	1.393	1.432	0.030	0.972	0.058	1.342	1.342
2007	1.126	1.022	0.046	0.480	0.021	0.848	0.848
2008	0.993	0.873	0.051	0.894	0.036	0.823	0.823
2009	0.771	0.820	0.035	0.972	0.040	0.805	0.805
2010	0.424	0.409	0.053	0.544	0.034	0.388	0.388
2011	0.440	0.395	0.047	0.610	0.056	0.396	0.396
2012	0.344	0.349	0.052	0.439	0.065	0.319	0.319
2013	0.345	0.363	0.072	0.758	0.039	0.381	0.381
2014	0.506	0.552	0.064	1.723	0.032	0.681	0.681
2015	0.578	0.625	0.043	1.478	0.020	0.712	0.712
2016	0.691	0.624	0.037	1.908	0.026	0.733	0.733
2017		0.738	0.033	1.275	0.027	0.690	0.690

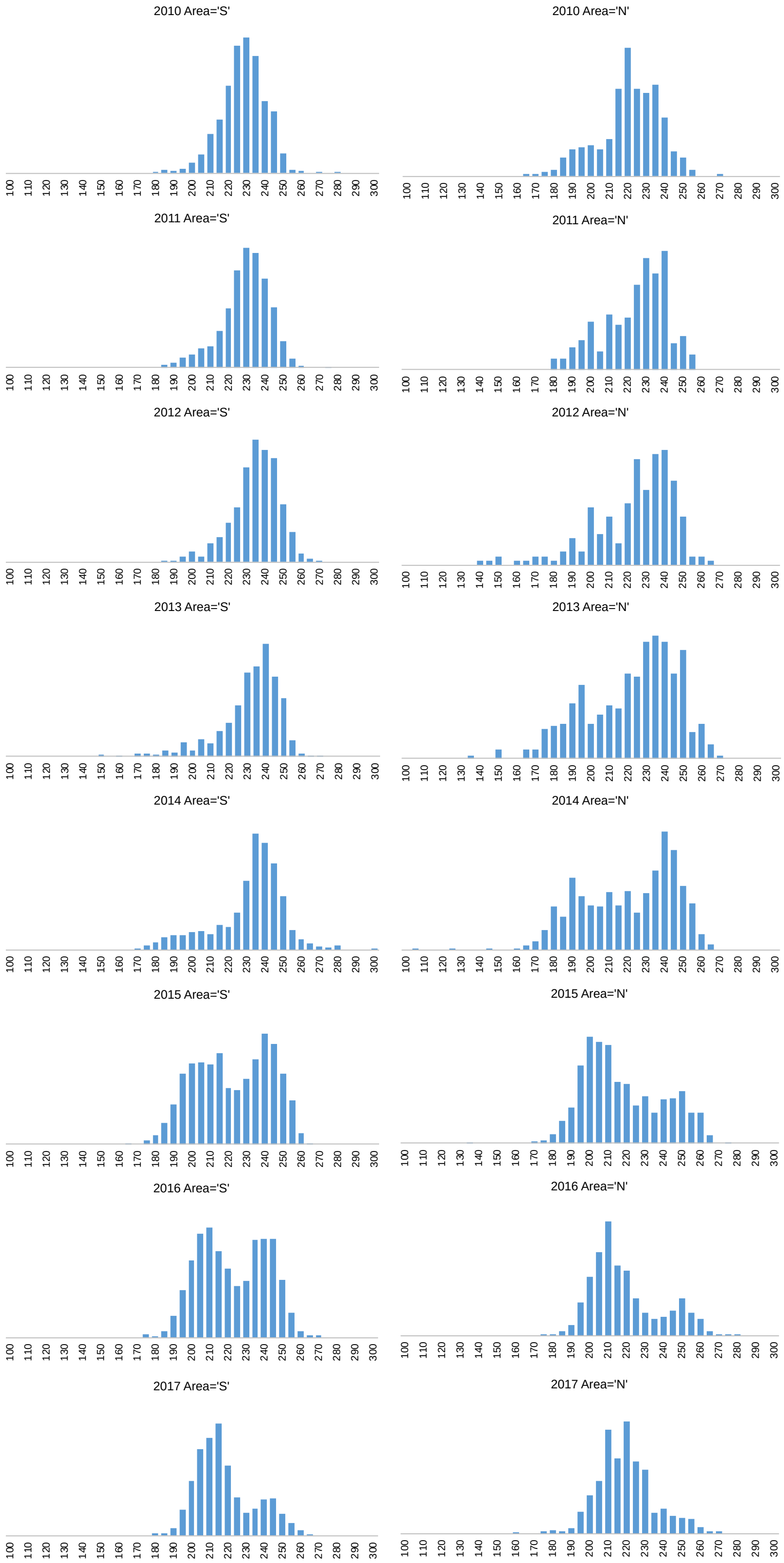

Fig. 1. PBF length distribution of Taiwanese longline fishery, by area (South in the left panels and North in the right panels) and by year (2010–2017).

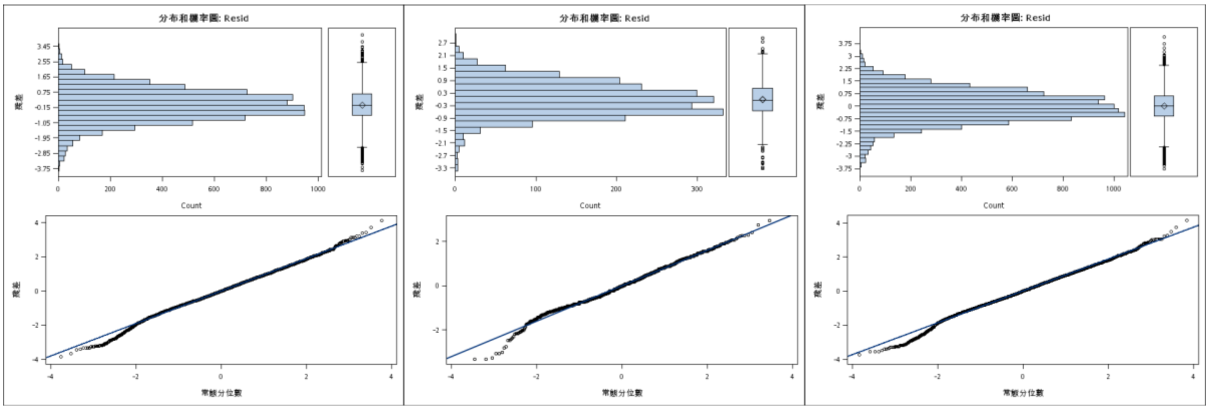

Fig. 2. Diagnostic residual plots for the delta-GLMM for PBF CPUE standardizations, for the three model runs: from left to right respectively, residual plot for the model on the southern, the northern and the whole fishing grounds.

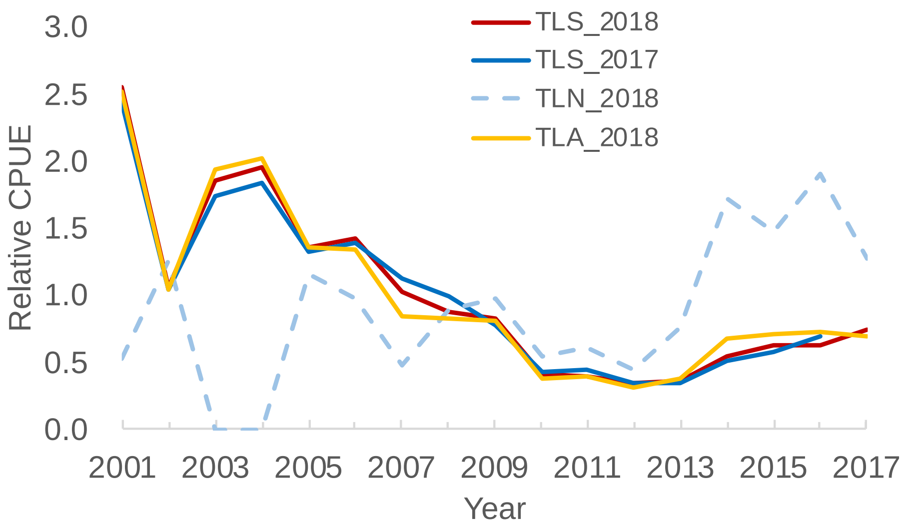

Fig. 3. Standardized CPUE series for Taiwanese PBF longline fishery. TLS_2017 is for south fishing ground adopted from ISC/17/PBFWG-1/02. TLS_, TLN_ and TLA_2018 are the standardized CPUE series of the south, north and all fishing grounds obtained from this study.

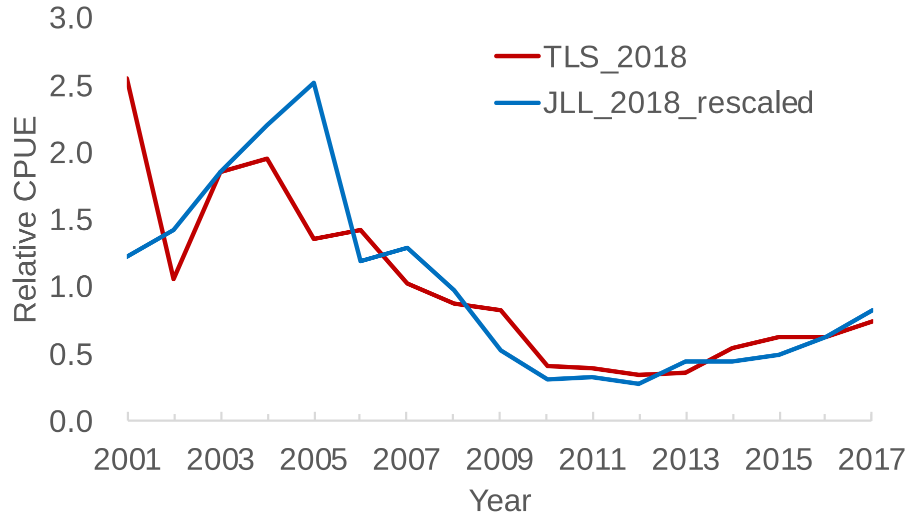

Fig. 4. Comparison of standardized CPUE series of Taiwanese PBF longline fishery in the southern fishing ground (TLS_2018) and that of Japanese longline fishery obtained and re-scaled from table 1 of the ISC/18/PBFWG-1/01.

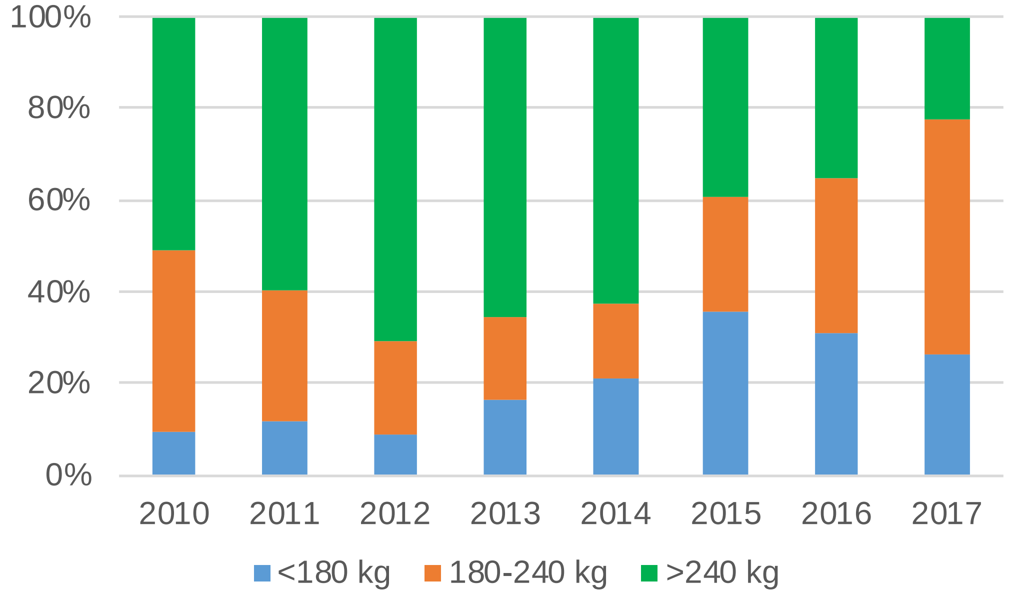

Fig. 5. PBF catch composition of 2010–2017 by weight category: <180 kg, 180–240 kg and > 240 kg.