Update of Standardized PBF CPUE Series for Taiwanese Longline Fishery

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Summary

PBF was an important seasonal target species to Taiwan offshore longline fishery. Before 2010, only market landing data with small coverage of logbooks were available. Therefore, several non-traditional procedures have been performed to estimate standardized PBF CPUE series for 2001-2014 in the paper submitted to the second intersessional PBFWG in 2015 (ISC/15/PBFWG-2/10), taking advantage of voyage data recorder (VDR) data, as well as landing data from fish markets and trip information data from the Coast Guard, using generalized linear models with delta lognormal and zero-inflated negative binomial assumptions. This working paper provides an update of the standardized CPUE series with 2015 data (2014 fishing season data) included. Result of the updated analyses shows similar trend as the previous: declining from 2001 to 2010 with annual fluctuations and starting to increase since 2013 after two years' low status, with a further increasing sign of 2015.

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 542 mt (preliminary value) in 2015. 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% in 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: (1) Estimating PBF catch in number from landing weight for 2001-2003 of which years the information was incomplete, based on an MCMC simulation; (2) Deriving fishing days for 2007-2009 from data of vessel monitoring system (VMS) and voyage data recorder (VDR) based on a new developed algorithm; (3) Deriving fishing days for 2001-2006 from vessels trip information based on linear relationships between fishing days and at-sea days for a trip, by vessel size and fishing port, during 2007-2014; (4) Standardizing the CPUE for 2001-2014 using generalized linear models (GLMs) with delta lognormal and zero-inflated negative binomial assumptions.

This paper provides an update of the work by (1) including the PBF data of 2015 (2014 fishing year) and (2) refining the algorithm for deriving fishing days from more complete VDR data. VDR data was in the interval of 3 minutes therefore VMS data was not necessary in this study.

Materials and Methods

The data used in this study was the same as those in ISC/15/PBFWG-2/10 (Chang et al., 2015) except that a new year data of 2015 was included. In addition, the trip data with only one fishing day were deleted for 2013 – 2015 to avoid the bias caused by vessels acting as carriers to bring back the PBF for landing that caught by other fishing vessels. Also, when developing the optimum criteria for deriving fishing days from VDR data for the second PBFWG in 2015, only a subset of the big VDR dataset was tested due to time constraint. In this study, more complete VDR data was used to find the optimum criteria (with best performance) for identifying fishing days. Logbooks that were used to judge the fishing status were firstly cross-checked with CDS and landing data from markets and trip information from Coast Guard Administration. Logbooks that were not totally matched were excluded from the study.

The algorithm for deriving fishing days from VDR/VMS data for 2007-2009 was similar to that in ISC/15/PBFWG-2/10 with some modifications. The same three approaches were tested but with finer scale of intervals for two of them.

(1) Vessel-speed approach: vessel speed was considered to be comparatively lower while fishing, especially when retrieving hooks and processing fish. This study tested the performances of the following criteria: a day with at least an instance of vessel speed at x knots is defined as a fishing day; x is 1 – 7 knots per one knot.

(2) Within-day-distance approach: Longliners move in shorter distance in a day while conducting fishing operation. The study tested the performance of criteria that defining a day as a fishing day if the within-day-distance if below x km; x is 70 – 190 km per 10 km.

(3) Direction-change approach: This approach has been chosen as the optimal one in ISC/15/PBFWG-2/10. Change of vessel direction has been observed in fishing operation while the vessel completed the hook deployment and returning to either the start or the end positions of deployment after some time preparing for retrieval operation. With this observation, the study tested the performance of criteria that defining a day as a fishing day if the angle of direction change is within x degree; x is 5° – 180° degree per 5°. In the test, the VDR/VMS data was firstly aggregated into one record per 1 – 6 hours, respectively, to show clear trend of direction change.

The performance of the criterion was assessed based on the ability to maximize agreement between the predicted fishing-day/non-fishing-day distribution from the VDR data and the observed distribution from available actual fishing-day information (logbooks and CDS). The criterion maximizing the sum of sensitivity and specificity (SSS = true positive rate (sensitivity) + true negative rate (specificity)) and minimizing the differences (DSS) was considered as the optimal (Jiménez-Valverde and Lobo, 2007; Chang and Yuan, 2014). Detail information please see ISC/15/PBFWG-2/10.

Covariates considered in the GLM model for CPUE standardization included: year (2001 – 2015), month (May – July), fishing area (northern and southern fishing ground), and vessel tonnage (CT1 – CT4). In ISC/15/PBFWG-2/10, two model assumptions were investigated to address the high percentage of zero catch in the data: delta lognormal assumption and zero-inflated negative binomial (ZINB) assumption. Both of the models have resulted in similar relative CPUE trends with similar good diagnostic performances. However, the ZINB model could converge only when vessel tonnage covariate was excluded from the model which was considered influential in PBF catch rate. Therefore, this study conducted the standardization only with delta lognormal model. Coefficient of Variation (CV) series were calculated through bootstrap approach for 1000 times.

Results and Discussions

The performance statistics of the criteria for deriving fishing days with highest SSS (Table 1) shows that an instance of 3 knots vessel speed in a day was the optimal criterion for the vessel-speed approach (Fig. 1A), a daily movement distance of 130 km was the optimal choice for the within-day-distance approach (Fig. 1B), and a change of vessel direction of 90° occurred in a day for per 5-hour data was the optimal choice for the direction-change approach (Fig. 2). Among them, the direction-change approach has the highest SSS and lowest DSS and therefore was recommended to be used as the optimal criterion for deriving fishing days from VDR data.

The SSS contour plot at different per-hour data (1 – 6 hours) and different direction change angle (5° – 180°) (Fig. 2) indicates that the highest SSS was occurred at 5-hour and 90° cross zone; which means the optimal criterion was to identify a day as a fishing day when there was a 90° change of vessel direction in a per 5-hour VDR data (starting from the first VDR record in that day). This criterion was a little different from the one in ISC/15/PBFWG-2/10, therefore the linear relationships between the at-sea days calculated from vessel trips data and the fishing days estimated from VDR were recalculated by vessel size and by port for 2007 – 2014 (Table 2). Since no at-sea days should have no fishing days, no intercept was assumed for all the linear relationships. The relationships were all statistically significant at 1% level with $R^2 > 90\%$[1]. The coefficients were applied to the vessel trips data of 2001 – 2006 to estimate the fishing days from at-sea days by the category.

From the above works, CPUE on trip basis were calculated for the whole series of 2001 – 2015. Performing GLM on the data, the best explanatory variable combinations under delta-lognormal assumption were year, month, fishing area, vessel tonnage and interaction between year and month for positive catch model and year, month and fishing area for proportion model. The diagnostic residual plots for this GLM run in Fig. 3 indicated the appropriateness of the two-stage delta lognormal model for evaluation of the factors that influence the PBF catch rate. The resulted relative CPUE is shown in Table 3 and Fig. 4. The new series has very similar trend with the one in ISC/15/PBFWG-2/10.

References

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[1] The R^2 were calculated by SAS v9.4 under the condition of no-intercept which may cause over-estimation of the values. The table was just for reference of the suitability of the applying these equations to deriving fishing days from at-sea days from vessel trips data. Please refer to the following links: "R-square for regression without intercept?" http://onbiostatistics.blogspot.tw/2010/08/r-square-for-regression-without.html and "FAQ: Why are R^2 and F so large for models without a constant?" http://www.ats.ucla.edu/stat/mult_pkg/faq/general/noconstant.htm.

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Table 1. Performance statistics of fishing-day versus non-fishing-day binary classification criteria, based on (A) vessel-speed approach, (B) within-day-distance approach, and (C) direction-change approach. Only the optimal criterion with highest SSS of each approach was shown.

	TP	FN	FP	TN	TPR	TNR	SSS	DSS
A. Vessel-speed approach								
3 knots	2731	96	1031	136	0.966	0.117	1.083	0.850
B. Within-day-distance approach								
130 km	2482	343	690	474	0.879	0.407	1.286	0.471
C. Direction-change approach								
90° per 5h	2687	202	342	841	0.930	0.711	1.641	0.219

Note: The table shows true positive (TP), false negative (FN), false positive (FP), true negative (TN), true positive ratio (TPR, sensitivity), and true negative ratio (TNR, specificity). Sum of sensitivity and specificity (SSS) and absolute difference of sensitivity and specificity (DSS) are performance measures for the criteria.

Table 2. Statistics of linear relationships between at-sea days and fishing days established from data of 2007 – 2014. The relationships were all statistically significant at 1% level.

Ports	Vessel size	Coefficient	R^{2*}
Suao	CT2	0.828	0.967
	CT3	0.824	0.975
	CT4	0.797	0.962
Singang	CT1	0.818	0.955
	CT2	0.816	0.952
	CT3	0.831	0.963
	CT4	0.791	0.963
Tungkang	CT1	0.750	0.974
	CT2	0.810	0.970
	CT3	0.752	0.968
	CT4	0.693	0.934

* R^2 in this table were calculated by SAS v9.4 under the condition of no-intercept which may result in over-estimation of R^2. Please refer to the notes in the text.

Table 3. Relative CPUE series from this study (and its CV) and from PBFWG-2015.

Year	CPUE_2016	CV	CPUE_2015
2001	2.398	0.040	2.070
2002	0.991	0.075	0.926
2003	1.795	0.063	1.641
2004	1.870	0.062	1.688
2005	1.281	0.073	1.180
2006	1.311	0.042	1.154
2007	0.887	0.062	0.991
2008	0.894	0.063	0.863
2009	0.730	0.048	0.797
2010	0.390	0.065	0.435
2011	0.454	0.096	0.475
2012	0.311	0.066	0.399
2013	0.423	0.038	0.528
2014	0.642	0.073	0.852
2015	0.623	0.071	

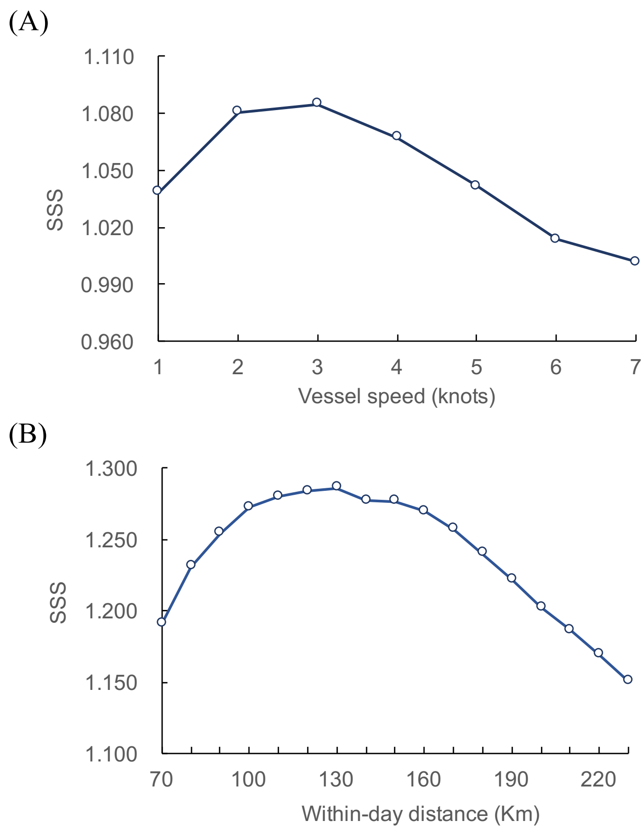

Fig. 1. Distribution of sum of sensitivity and specificity (SSS) by (A) vessel speed and (B) within-day distance.

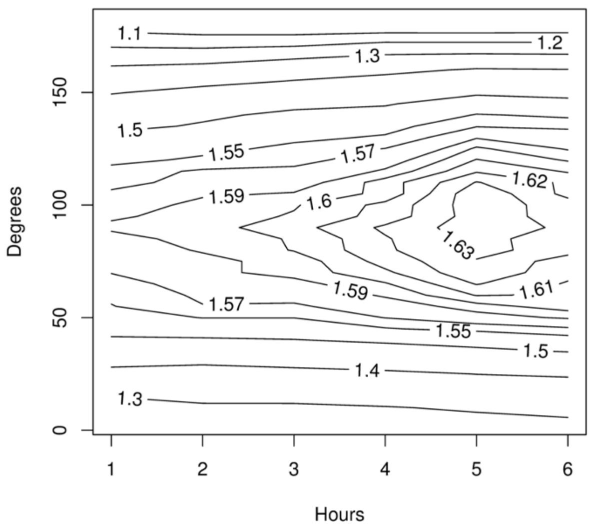

Fig. 2. Sum of sensitivity and specificity (SSS) contour plot at different per-hour data (1 – 6 hours) and direction change angle (5° – 180°).

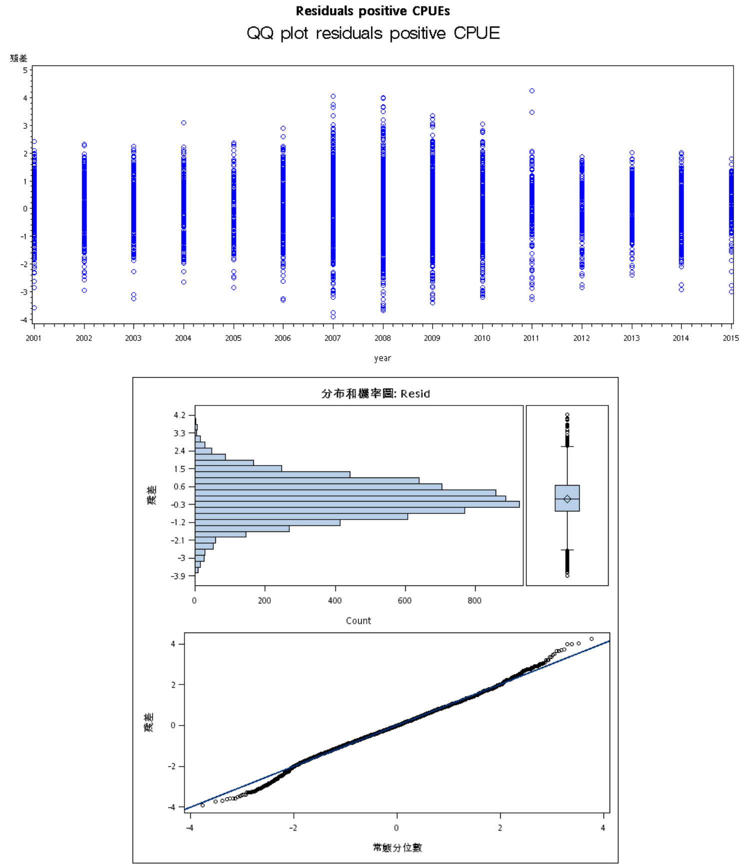

Fig. 3. Diagnostic residual plots for the GLM run with delta lognormal assumption for standardization of PBF CPUE.

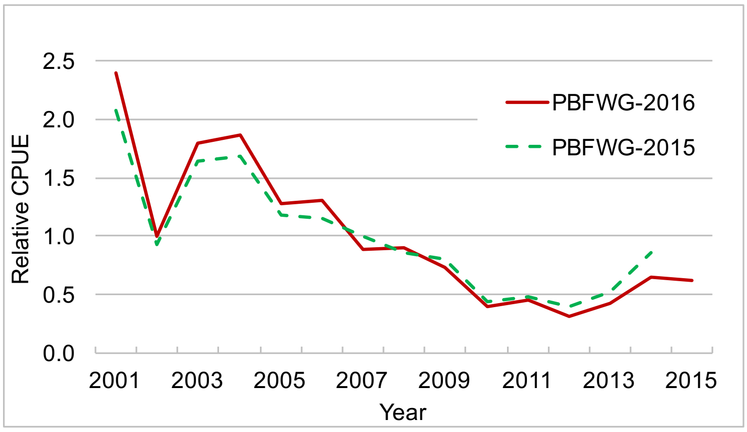

Fig. 4. Standardized CPUE series for Taiwanese PBF longline fishery by GLM with delta-lognormal assumption.