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Estimation of coefficient of variances in standardized CPUE of Pacific bluefin tuna caught by Japanese coastal longline with a nonparametric method

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Abstract

CPUE of Pacific bluefin tuna caught by Japanese coastal longliners was standardized by delta-lognormal method for the use of next stock assessment (Ichinokawa and Takeuchi 2012, ISCPBFWG/12-1/8). In ISCPBFWG/12-1/8, standard errors of the standardized CPUE were calculated by the method presented by Shono (2008), where standard errors are analytically derived from variances of estimated parameters by using Taylor expansion and delta-method. This document provides alternative estimates of standard errors (equivalent to CVs in normal scale) of the standardized CPUE by using non-parametric bootstrap method. CVs estimated from non-parametric method are about 3 times higher than those by the analytical method, and increased in early and late time periods. The discrepancy of the estimated CVs between parametric and non-parametric methods would be caused by heterogeneous spatiotemporal distribution of fishing efforts and CPUE, which were not fully explained by the standardization model.

Introduction

CPUE of Pacific bluefin tuna caught by Japanese coastal longliners was standardized by delta-lognormal method for the use of next stock assessment (Ichinokawa and Takeuchi 2012, ISCPBFWG/12-1/8). In ISCPBFWG/12-1/8, standard errors of the standardized CPUE were calculated by the method presented by Shono (2008), where standard errors are analytically derived from variances of estimated parameters by using Taylor expansion and delta-method. ISCPBFWG/12-1/8 provided 95% confidence intervals of the standardized CPUE only graphically, which was estimated by an equation presented by Shono (2008). The estimated standard errors that were not shown by table in the original document are presented in Table 1. Because all of the values are significantly smaller than 0.2, 0.2 of CV for all years was inputted to the preliminary stock assessment model.

However, we found difficulty on interpretation of the estimated standard errors in the document and underlying assumption by Shono (2008). When sample size is sufficiently large, error distribution of the standardized CPUE derived from delta-lognormal model is expected to be product of normal distributions in errors of parameters estimated in 1st and 2nd steps, which can't be expressed by parametric probability function. Shono (2008) provides two equations; one assumes normal error distribution of the standardized CPUE by eq. 12, and another assumes normal error structure of log-CPUE by eq. 13. In ISCPBFWG/12-1/8, appropriateness of the assumption in error distribution of estimated CPUE should not have checked before applying the equations, and might be better to use eq. 13 for estimating CV of CPUE (Table 1). Otherwise, nonparametric bootstrapping method would be robust for evaluating standard errors of derived CPUE.

This document provides alternative estimates of standard errors of standardized CPUE by using non-parametric bootstrap method to compare estimates from the analytical method by Shono (2008). Because non-parametric method doesn't need any assumption of probability functions for error distribution of estimated statistics, CV of Japanese coastal longline CPUE derived from the method can more reflect actual uncertainty of the estimated index. In discussion, annual trends of CV estimated by the bootstrap method are examined for the use of next stock assessment.

Method

Non-parametric bootstrapping was conducted by resampling data used for standardizing CPUE with replication. Standardized CPUE was calculated with data produced by each bootstrap replication in order to estimate standard errors (equivalent to CV in normal scale CPUE) of the standardized CPUE. The bootstrap samplings were conducted with stratification of fixed effects used in standardizing CPUE (year, 10 days interval, shiptype and hooks per basket). In addition, bootstrap samplings without any stratification were conducted to check sensitivity of resampling method on estimated standard errors. The bootstrap resampling was repeated 970 times. The replication time was determined by limitation of available computer resources and calculation time. The fishery data and standardization model were exactly same as those used in ISCPBFWG/12-1/8.

Results

Table and Figure show estimated CVs from various methods of analytical estimation by using Shono (2008) and bootstrap estimation with and without stratification. The CVs estimated with non-parametric methods are approximately 2-3 times higher than analytical estimation. This is probably caused by poor predictability of the standardization model (Table 4 in ISCPBFWG/12-1/8) and skewed residual distribution (Fig. 6 in ISCPBFWG/12-1/8), although exact reason is still unclear.

The estimated CV by using bootstrapping methods (boot CV) ranges from 0.032 to 0.101 when conducting stratified samplings and from 0.033 to 0.085 when conducting non-stratified sampling. Both CVs are approximately similar except for estimates of 1994, sensitivity of bootstrapping methods on estimation of CV is minor. The boot CVs are different among years. The boot CV of stratified sampling decreased from 0.101 of 1994 to 0.033 in 2005, and increased to 0.082 of 2011.

Discussion and conclusion

This document shows that CVs estimated by analytical method by Shono (2008) and non-parametric bootstrap methods are not equivalent. The discrepancy suggests parametric assumption of error estimation of the analytical method is inadequate in the case of standardized CPUE of Pacific bluefin tuna by Japanese coastal longliners. Because non-parametric method doesn’t need any assumption of error distribution, CV estimated with non-parametric method could be appropriate to evaluate uncertainty of model estimation in this case.

Boot CV suggested that CVs in early and late period are higher than those in mid-period. The annual changes of boot CV may be caused by historical changes of effort distribution: efforts were rarely distributed in the southern and northern part of fishing grounds for standardization in early period, while efforts tended to concentrate particular area in late period (see Fig. 3 in ISCPBF/12-1/8). The uneven spatial distribution of efforts would degrade predictability of the model, because current area stratification is not enough to explain heterogeneous distribution of the CPUE (see Oshima document). Therefore, the boot CV estimated in this document may represent different amount of uncertainty among years in estimates of standardized CPUE, which is caused by heterogamous distribution of fishing efforts through the time period. The potential change of CV should be incorporated into the stock assessment, as input CV.

However, because of potential process errors relating to fishing activities such as shift of targeting (Oshima document), the absolute scale of CV would be still underestimated. It is recommended that the boot CV will be used to represent relative accuracy of estimated CPUE after scaling by traditional value such as 0.2.

References

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Table. CVs estimated with various methods of Shono (2008), and bootstrapping. All figures except for the last row named by ‘This document, CV (bootstrap)’ have been submitted to this WG in ISCPBWG/12-1.

		ISC/12-1/PBFWG/8						This document		
		CPUE				Variance estimation		Variance estimation		
Clendar year	Fishing year	Nominal	Nominal (normalized)	Standar-dized	Standar-dized (normalized)	SD (Shono2008) in normal scale (graphically shown in ISC/12-1/PBFWG/8)	CV calculated from the left column	SD (Shono 2008) in lognormal scale (equivalent to CV in normal scale)	CV in normal scale (bootstrap with stratification, n=970)	CV in normal scale (bootstrap without stratificaion, n=970)
1994	1993	0.549	1.510	0.301	1.769	0.021	0.069	0.035	0.101	0.085
1995	1994	0.357	0.984	0.218	1.280	0.017	0.077	0.029	0.059	0.062
1996	1995	0.503	1.384	0.271	1.596	0.019	0.070	0.034	0.072	0.078
1997	1996	0.466	1.283	0.281	1.654	0.018	0.065	0.028	0.049	0.051
1998	1997	0.482	1.326	0.248	1.460	0.017	0.067	0.025	0.051	0.057
1999	1998	0.415	1.143	0.177	1.041	0.013	0.073	0.019	0.045	0.044
2000	1999	0.272	0.749	0.135	0.797	0.012	0.092	0.019	0.051	0.050
2001	2000	0.196	0.540	0.106	0.621	0.011	0.100	0.018	0.046	0.046
2002	2001	0.233	0.642	0.121	0.711	0.011	0.094	0.019	0.056	0.057
2003	2002	0.337	0.928	0.201	1.182	0.013	0.067	0.021	0.042	0.043
2004	2003	0.376	1.035	0.216	1.272	0.011	0.053	0.020	0.032	0.034
2005	2004	0.441	1.214	0.256	1.508	0.013	0.050	0.021	0.032	0.033
2006	2005	0.240	0.660	0.126	0.741	0.012	0.094	0.019	0.043	0.046
2007	2006	0.398	1.096	0.180	1.056	0.012	0.068	0.019	0.039	0.041
2008	2007	0.183	0.505	0.098	0.578	0.011	0.108	0.019	0.045	0.047
2009	2008	0.151	0.416	0.063	0.370	0.013	0.214	0.021	0.054	0.056
2010	2009	0.090	0.248	0.033	0.194	0.013	0.402	0.023	0.074	0.077
2011	2010	0.071	0.196	0.029	0.172	0.018	0.604	0.029	0.082	0.087

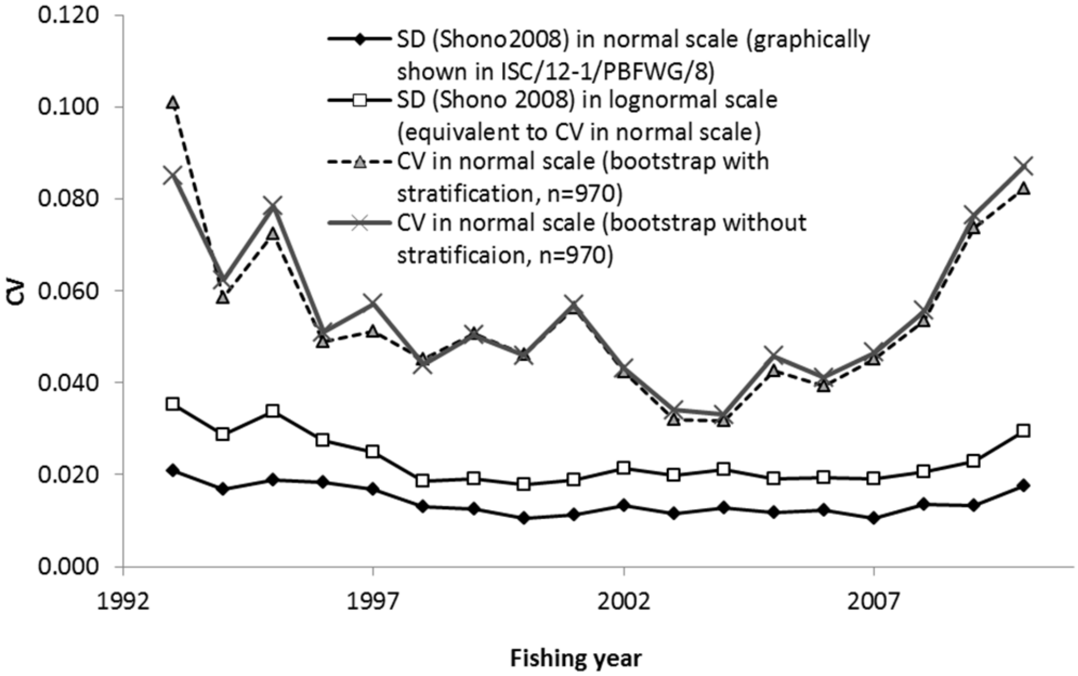

Fig. Estimated CVs of standardized CPUE of Pacific bluefin tuna caught by Japanese longliners with various methods.