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Standardized skipjack CPUE of coastal troll fishery around Hachijo-Island from 1996 to 2013

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Abstract

Skipjack CPUE of coastal troll fishery around Hachijo-Island was standardized by Delta-Lognormal Model. Past data from 1996 to 2001 was newly included in the time series and recent data was added up to 2013. As for the implication of zero catch, the vessels staying at port without fishing operation was included in the consideration of effort. Both results from zero catch probability and lognormal standardization of CPUE without zero catch indicated declining trends in abundance. Delta-Lognormal result indicated that the recent (2006-2013) abundance of skipjack migrating to around Hachijo-Island would be reduced to nearly half of that in the past years (1996-2005).

Introduction

Troll is main fishery targeting on skipjack and other tuna species at the coastal region of Japan. Around Hachijo-Island of Tokyo metropolitan government (Fig. 1), skipjack is caught by this fishery, and the skipjack caught is mainly transported to around Tokyo as "Taru-Katsuo (meaning skipjack contained in barrel) brand". Troll fishery makes basically one day trip fishing at coastal water near from fishing port and can't shift its fishing ground broadly lake as that the pole and line fishery usually do. Therefore it is expected that the CPUE trend of troll fishery would be able to provide the information of abundance status of skipjack tuna coming over to Japanese coastal water. In the 7th Scientific Committee of WCPFC, as it was recognized as "However, there is concern that high catches in the equatorial region could result in range contractions of the stock, thus reducing skipjack availability to higher latitude (e.g. Japan, Australia, New Zealand and Hawaii) fisheries."(Anonymous, 2012), importance of monitoring the skipjack stock availability in Japanese coastal water has been increasing.

Kiyofuji et al. (2013) standardized skipjack CPUE of troll fishery in Wakayama and Hachijo-Island using GLM and indicated that the CPUE declined largely in 2004 and 2006 in Wakayama and Hachijo-Island, respectively. However as the analyzed period of the study was short from 2002 to 2012, it is not clear whether the declining trend observed is that to historical low level or that just in the historical fluctuation. In this study, skipjack CPUE of troll fishery in Hachijo-Island is analyzed using data back to 1996 with adding latest data up to 2013, and its trend is observed.

As the distance to fishing site for troll fishing is near from fishing port, if catch condition seems to be no good, it is common for the troll fishermen to stay at port without go fishing. Then CPUE using only unloading data can't reflect the effect of the staying vessel without fishing operation. In this study, potential active vessel which can fish but stay at port, is regarded as potential effort and applied in the analysis.

Materials and methods

Data used and data preparation

Data used in this study is unloading weight of skipjack, albacore, yellowfin and bluefin tunas by day and vessel from 1996 to 2013. Taking account the seasonality of troll fishery in Hachijo, unloading data from February to May was used.　Vessel which made at least one unloading in the period from February to May in one year, was regarded as potential active vessel of the year.　In the day when at least one vessel unloaded, potential active vessels without unloading were appended to the daily record as zero catch. Therefore, the day without any unloading was not included in the data although some fishing activity may have been made.

CPUE standardization

Troll CPUE was standardized using Delta-Lognormal Model (Lo et al., 1992) which consists of binomial model part and lognormal model part. All explanatory factors included in the model were categorical and interaction between them was not applied.

・Binomial model

The presence/absence of skipjack catches by vessel and fishing day. The dependent variables were modeled using a binomial error structure to estimate probability of non-zero skipjack catch for a fishing day. Zero catch consists of unloading without skipjack catch and no unloading by potential active vessel.　Explanatory variables included in the full model were Year, Month and Sea Surface Temperature (Table 1).　Another analyses in which potential active vessel without unloading is not included was also conducted for comparison.

・Lognormal model

Positive skipjack catch by vessel and fishing day excluding zero catch records. The dependent variable was modeled assuming a lognormal error structure. Explanatory variables included in the full model were Year, Month, Vessel ID, Sea Surface Temperature, and presence/absence of Albacore, Yellowfin and Bluefin tunas (Table 1).

As for the both models, some combinations of experimental variables included in the model were tested, and the model which have the smallest Bayesian information criterion (BIC) was adopted as the final model.

For the binomial model, the year indices indicating probability of capture (*p*) were derived using the inverse logit of the individual year factorial coefficients. As for the lognormal model, the year CPUE indices were derived from exponentiation of lsmeans of the year factor. Delta-lognormal indices were derived by multiplying the binomial *p* values and the non-zero lognormal indices (Lo et al., 1992).

Sea Surface Temperature

Since the monthly one degree grid NOAA Optimum Interpolation (OI) Sea Surface Temperature (SST) was applied in Kiyofuji et al. (2013), SST at fixed station at Kaminato-port in Hachijo recorded by Tokyo Metropolitan Island Area Research and Development Center for Agriculture , Forestry and Fisheries was applied in this study as this SST is supposed to reflect the environmental condition of Hachijo troll fishing area more closely than NOAA data.

Results

Basic observation of troll fishing data

Skipjack catch of Hachijo troll fishery from February to May has fluctuated largely by year.　Before around 2006, the skipjack catch was fluctuated largely with average of about 600mt、after when its level has decreased to about 200mt（Fig. 2）.The number of potential active vessel which made at least one unloading of troll catch in February through May in the year which was about 130-140 in 1996-1997 decreased steadily to about half, 70 vessels in 2013. Decrease in catch should partly be attributed to this declining trend of active vessels (Fig. 2). The total number of unloading has also decreased from 4000-5000 in 1996-1997 to around 1500 in 2013 (Fig. 3). Percentage of the number of unloading including skipjack catch in all unloading was higher than 90% though it became somewhat low about 85% in the latest two years (Fig. 4).

CPUE standardization

For the both analyses of Binomial and Lognormal models, full models had the least BIC values and were adopted as the final model (Table 2). In both final models, effects of all explanatory variables included in the model were significant as shown in ANOVA (Table 3).

In Fig. 5, results of two cases of binomial model analyses, including and excluding potential active vessel without unloading, are shown. As for the case including potential active vessel without unloading into zero catch, possibility of positive catch which was around 1.2 in relative scale fluctuating between 0.9 and 1.5 until 2006 decreased to around 0.8 fluctuating between 0.7 and 1.0 thereafter, and average of recent (2006-2013) was 76.1% to that in the past (1996-2005). In the case of analysis excluding potential active vessel without unloading, possibility of positive catch was almost constant with slight decline after 2006, and average of recent was 93% to that in the past.

Results of analysis using lognormal model in which CPUE was expressed as skipjack catch by vessel and day using only positive catch data was shown in Fig. 6. CPUE fluctuated largely between 0.5 and 2.5 with average 1.15 until 2005, after when it fluctuated between 0.5 and 1.0 with average 0.64. Average in recent years (2006-2013) is 55.4% to that in the past years (1996-2005), indicating 45% reduction in recent years. However, as there was extreme high jump of CPUE in 2000, this high value should affect on the level of the past average, to some extent. If past average is calculated excluding 2000 value, average ratio of recent to past become 63.9%, still indicates 36% of recent reduction.

Probability of positive catch derived from binomial analysis (including potential active vessel without unloading) and CPUE of positive catch derived from lognormal analysis was multiplied and CPUE of skipjack catch with zero catch was estimated (Fig. 7). Ratio of recent average to past average including and excluding 2000 value is 40.8% and 51.2%, respectively, which indicates that recent CPUE decreased to about half of past CPUE. In the case of that the CPUE calculated using the result of binomial analysis applying only unloading data, ratio of recent average to past average including and excluding 2000 data becomes 50.7% and 59.4%, respectively, which is about 10% higher than the analysis including potential active vessel without unloading.

In order to compare the result derived from Delta-lognormal model in this study with previous analysis used in Kiyofuji et al. (2013), CPUE was analyzed by previous method, that is, lognormal model with unloading data including zero skipjack catch (Fig. 8). Both results showed similar trend though the declining trend of this study is slightly steeper than that estimated using previous method.

Discussion

Kiyofuji et al. (2013) indicated that the skipjack CPUE of Hachijo troll fishery which was relatively high until 2005 decreased largely in 2006 and has been kept in low level. However, it was difficult to know whether the drop of CPUE observed since 2006 can be regarded as historically remarkable decrease or just a common change in the range of the historical fluctuation. Therefore one of the main purposes of this study was to know more certain trend of CPUE using longer time series of data back to 1996. Resulted CPUE trend standardized by Delta-lognormal model using data from 1996 to 2013 showed that the CPUE in the few years (2003-2005) before the large drop in 2006 was relatively high, and the CPUE levels in 1999, 2001 and 2002 were as low as that in recent level. Nevertheless, in ten years until 2005

CPUE of six years exceeded the average of all analyzed period, while CPUE of any year since 2006 has not exceeded the average level. These results would indicate that although the level of low CPUE has not changed so much throughout the analyzed period, high CPUE level which observed before 2006 has disappeared thereafter and would suggest that the abundance of skipjack coming over around Hachijo-Island has decreased in recent years.

Unlike pole and line fishery, troll fishery can't shift largely its fishing ground depending on the catch condition. Therefore, when enough catch is not expected, it is common for troll fishermen to stay at the fishing port without making operation or conduct other fishing like a hand lining targeting on non-tuna species. Then, it is supposed that the information of going or not going troll fishing may include the information on abundance around the fishing site of troll fishery. The results of analysis considering "not going troll fishing" as the potential active vessel without unloading, estimated the declining trend of CPUE to be 5-8% steeper than previous analysis without considering it. However, going or not going fishing is not determined only by catch condition but also affected by other factors such as fish price and fuel price. It would be needed to apply these information into the model for further realistic estimation of CPUE as abundance index.

References

Anonymouns (2012). Summary Report of the Seventh Regular Session of the Scientific Committee.

Kiyofuji, H., Okamoto, H., Ashida H., Horii, Y. and Hoshikawa, A. (2013). Comparison of CPUE trends for skipjack tuna between two coastal troll fisheries around Hachijo-Island and south off Wakayama prefecture. WCPFC-SC9-2013/ SA-WP-13. 15pp.

Lo, N. Chyan-huei, Larry D. Jacobson, James L. Squire, (1992). Indices of Relative Abundance from Fish Spotter Data based on Delta-Lognormal Models. Canadian Journal of Fisheries and Aquatic Sciences, 1992, 49:(12) 2515-2526.

Table 1. Description of explanatory factors included in the model.

(a) Binomial model

Variable	Data type	Description
Year	Categorical	1996-2013
Month	Categorical	February -May
SST	Categorical	Sea surface temperature

(b) Lognormal model

Variable	Data type	Description
Year	Categorical	1996-2013
Month	Categorical	February -May
Vessel ID	Categorical	Vessel name
SST	Categorical	Sea surface temperature
ALB 0/1	Categorical	Presence or absence of albacore in the catch
YFT 0/1	Categorical	Presence or absence of albacore in the catch
BFT 0/1	Categorical	Presence or absence of albacore in the catch

Table 2. AIC, BIC for each model

(a) Binomial model.

MODEL	AIC	BIC
Year	199511.9	199691.4
Year + Month	190265.6	190475.0
Year + Month + SST	**188264.1**	**188583.1**

(b) Lognormal positive model

MODEL	AIC	BIC
Year	171441.5	171601.5
Year + Month	168303.6	168490.2
Year + Month + Vessel ID	162053.7	164195.2
Year + Month + SST	167754.7	168039.1
Year + Month + + ALB 0/1	168285.6	168481.1
Year + Month + + YFT 0/1	168175.0	168370.4
Year + Month + + BFT 0/1	168301.3	168496.8
Year + Month + + ALB 0/1 + YFT 0/1 + BFT 0/1	168154.4	168367.7
Year + Month + Vessel ID +SST	161351.3	163590.6
Year + Month + Vessel ID +SST + ALB 0/1 + YFT 0/1 + BFT 0/1	**161041.0**	**163306.9**

Table 3. Type 3 ANOVA for final model selected.

(a) TYPE 3 ANOVA for selected binomial model

Factor	DF	ChiSq	Pr > ChiSq
yr	17	2270.02	<.0001
mn	3	6295.08	<.0001
SST	11	1731.72	<.0001

(b) TYPE 3 ANOVA for selected lognormal positive model

Factor	DF	TYPE III SS	F	Pr (>F)
Year	17	9654.78	478.11	<.0001
Month	3	4088.88	1147.41	<.0001
Vessel ID	220	8874.91	33.96	<.0001
SST	11	814.84	62.36	<.0001
ALB 0/1	1	21.28	17.91	<.0001
YFT 0/1	1	320.04	269.42	<.0001
BFT 0/1	1	6.62	5.58	0.0182

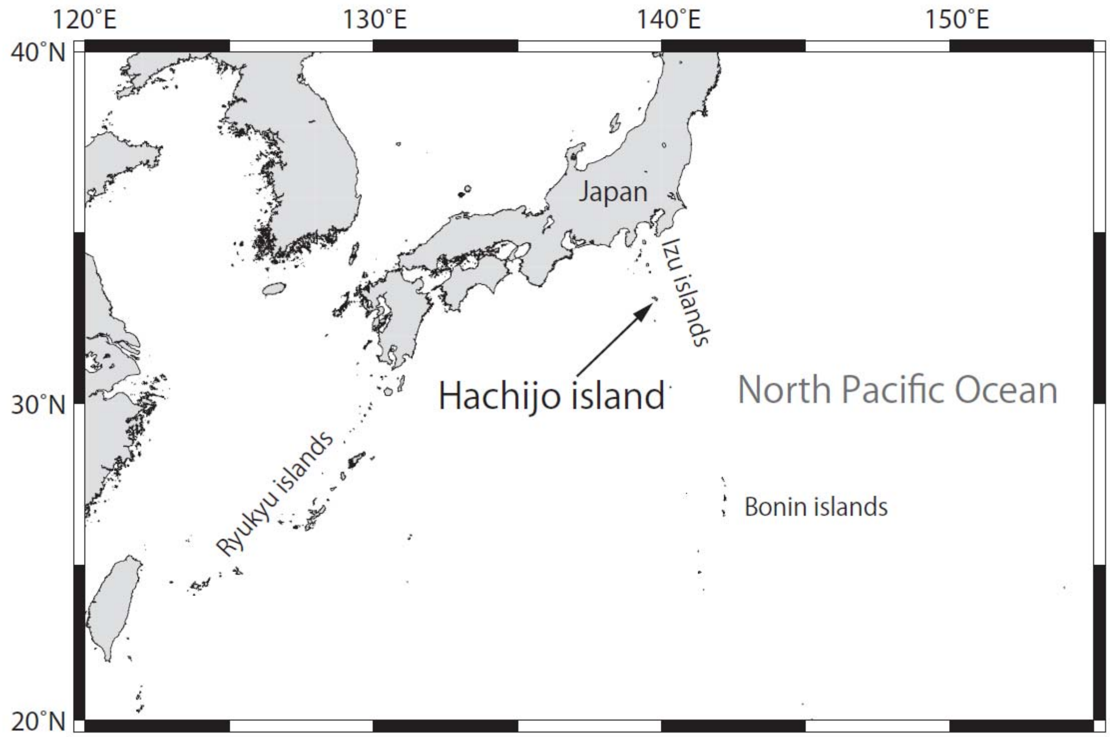

Fig. 1. Map indicating location of Hachijo-Island.

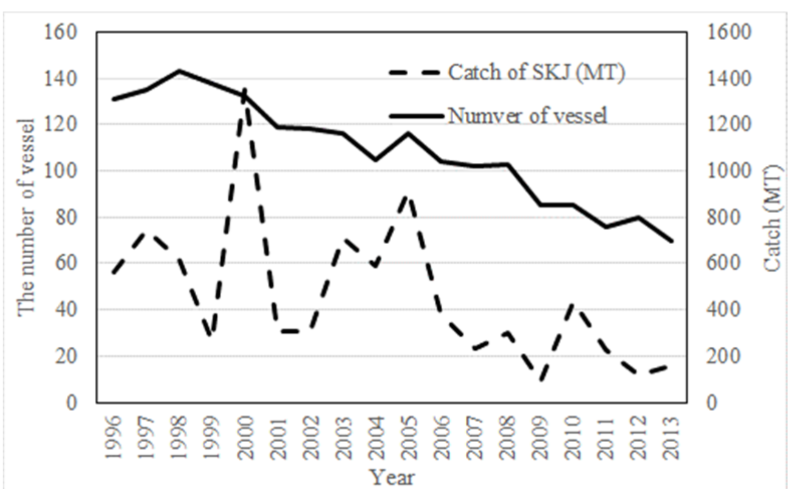

Fig. 2. Annual change in skipjack catch of Hachijo troll fishery and the number of potential active vessel.

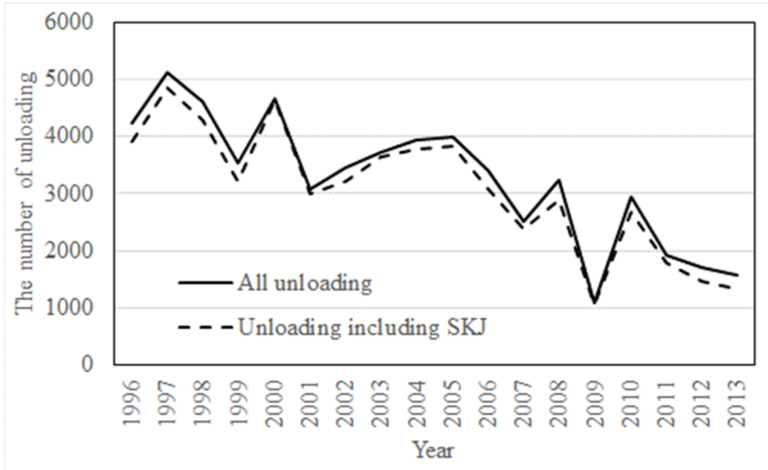

Fig. 3. Change in the number of all unloading (solid line) and that including skipjack catch (dashed line)

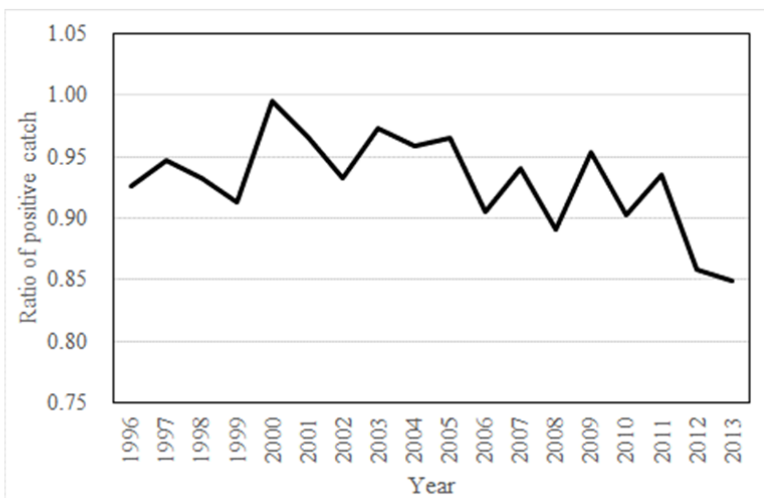

Fig. 4. Change in the ratio of unloading including skipjack catch in the all unloading.

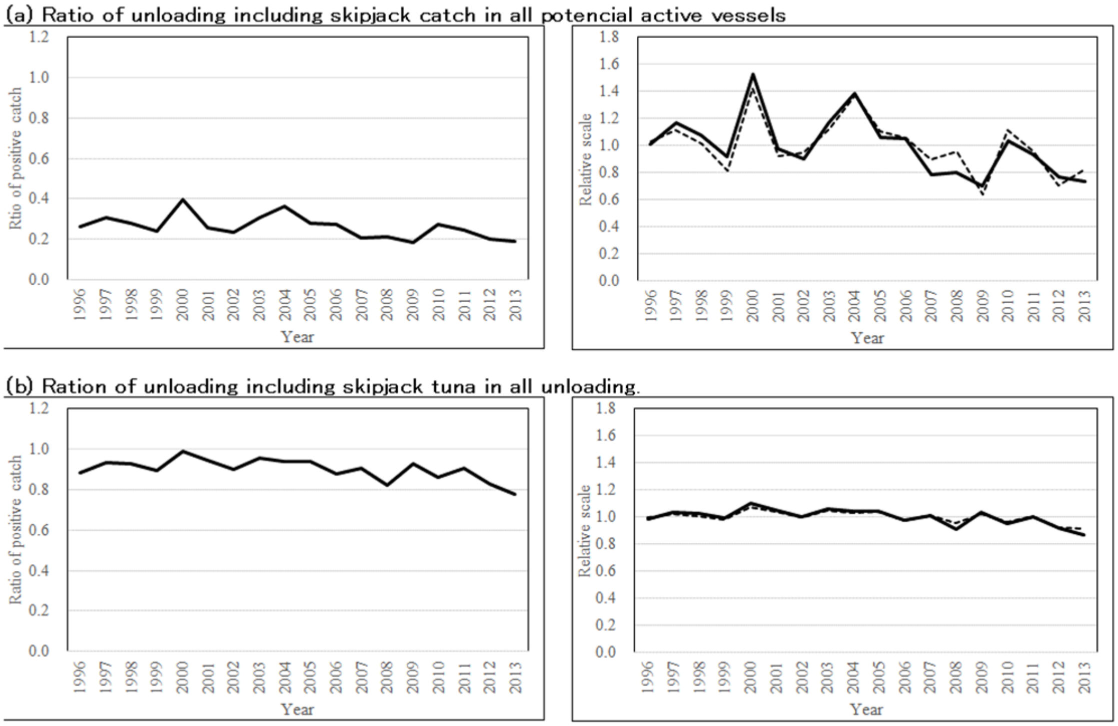

Fig. 5. Result of binomial model analyses on the ratio of unloading including skipjack catch in all potential active vessels (a) and in all unloading (b), in real scale (left) and relative scale (right) in which all year average is set to 1.0, with nominal value (dashed line).

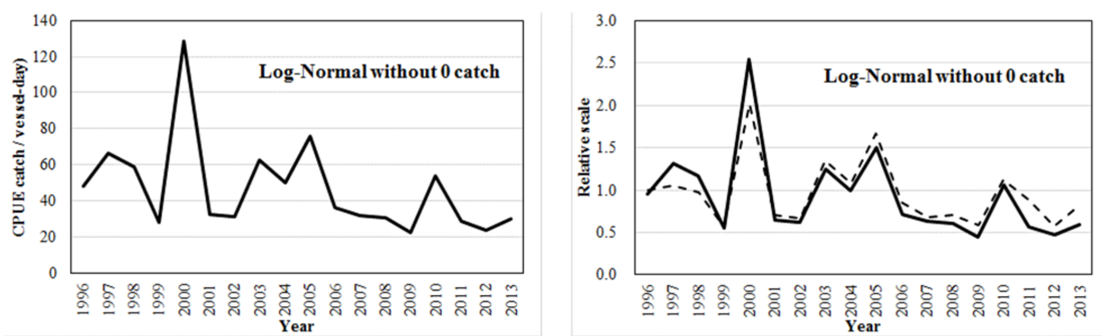

Fig. 6. Skipjack CPUE standardized lognormal model using unloading data including skipjack catch in real scale (left) and relative scale (right) in which all year average is set to 1.0, with nominal value (dashed line).

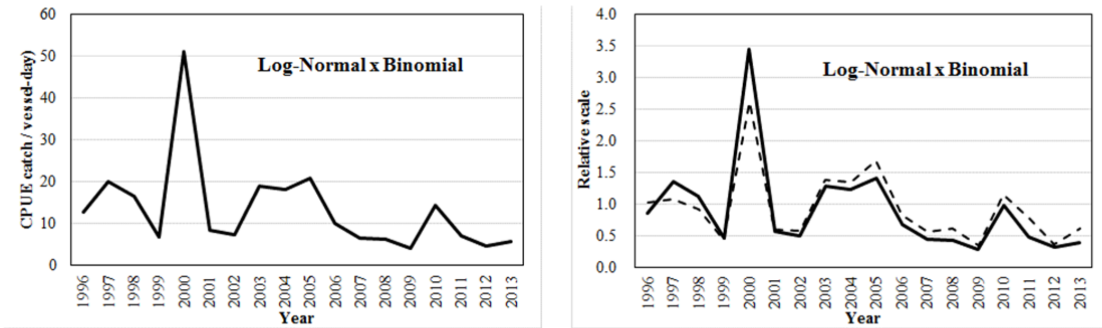

Fig. 7. Result Delta-Lognormal analysis. Result of binomial (analysis applying potential active vessel) and lognormal positive catch analysis was multiplied to estimate CPUE with zero catch, in real scale (left) and relative scale (right) in which all year average is set to 1.0, with nominal value (dashed line).

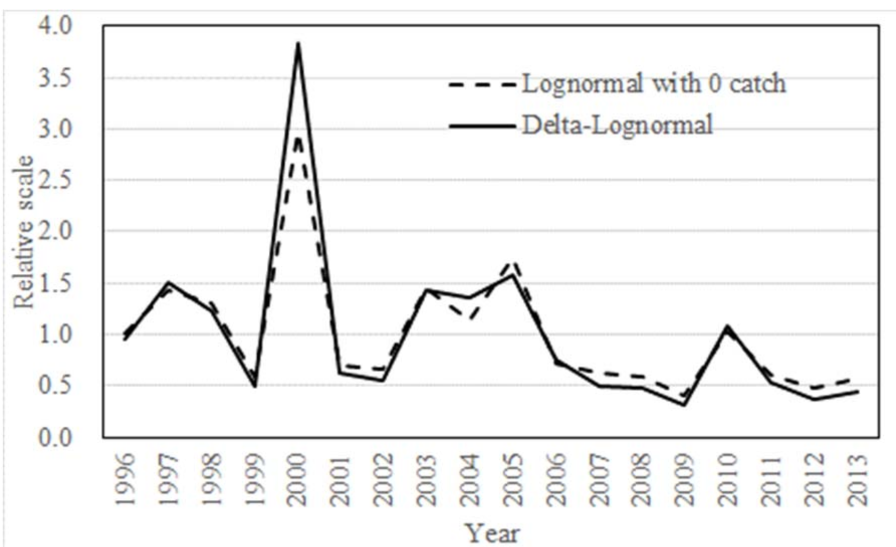

Fig. 8. Comparison of results from Delta-Lognormal analysis (this study) and Lognormal with zero cach analyses which was used in Kiyofuji et.al. (2013).