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An update of the standardized abundance index of skipjack by the Japanese pole-and-line fisheries in the WCPO

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Abstract
Catch per unit effort (CPUE) for skipjack were updated and evaluated for the skipjack stock assessment in 2014. The data were updated by two years and vessel ID was updated and corrected from the last assessment in 2011. The same methods were applied as proposed in the previous assessment (2010, 2011) and derived indices were compared between 2011 indices and 2014 indices. Compared to the 2011 indices, substantial changes were identified in overall indices from the last assessment. This is because of addition of new data set by three years and updated vesselID data.

Introduction

Skipjack catch per unit effort (CPUE) derived from the Japanese pole-and-line is an important index as representative of abundance and input data for skipjack stock assessment in the WCPO. Those indices was created by taking non-zero catch for a fishing day (binomial model and the non-zero skipjack catch for a fishing day (lognormal, non zero catch model) into account. Vessel ID effects were included to the model for considering ability of each vessel to explore fish schools. The delta-lognormal indices were calculated by multiplying the two sets of indices (Langley et al., 2010; Kiyofuji et al., 2011).

In this document, skipjack CPUE from the Japanese pole-and-line fisheries was update using same methodology as in 2010 and 2011 for stock assessment in 2014. Updated CPUE was also compared to CPUE in 2011.

Data and Methods

Fisheries Data
The operational level of catch and effort data for the Japanese pole and line (JPN PL) from 1972 to 2012 with noon positions in equidistant $1^\circ \times 1^\circ$ grid cells was used. Date, number of poles, catches in weight and vessel size in gross register tonnage (GRT) was employed. In this document, JPN PL was categorized by vessel size and their equipment. Vessel size between 20-199 GRT is defined as offshore PL (JPN PLOS) and larger than 200 GRT as distant-water PL (JPN PLDW).

Information on the fishing technology used by the fleet has been collected via interview, as described in Shono and Ogura (2000). Vessel specific information details the implementation of five important technological innovations only in the JPN PLDW: the low temperature live bait tank (LTLBT), onboard NOAA meteorological satellite image receiver (NOAA receiver), first and second generation bird radar, and sonar. The application of these components is described in detail in Ogura and Shono (1999).

License number was applied to identify individual vessel and these number has changed in every five years (1987, 1992, 1997 and 2007). For the distant-water pole and line fleet, a reference table has been created and updated that details the license number of an individual vessel in each year (Langley et al., 2010; Kiyofuji et al., 2011). Number of unique vessel in each year has been checked, since small number of unique vessel in 1987 was identified in the previous analysis (Kiyofuji et al., 2011). This is because license number in 1987 may not be updated appropriately due to year of license number update. As a result of updating license number in 1987, 1992 and 1997, number of unique vessel of PLOS increased approximately eight times (from 22 to 177) in 1987 and of PLDW increased a little (from 61 to 74 in 1987 and from 33 to 38 in 1992) from the previous research, respectively (Table 1 and Figure 1).

A generalized linear model was applied and the basic GLM model formulation applied in this study is shown as following equations for PLDW and PLOS, respectivley.

$$CPUE(PLDW) = YearQtr + VesselID + LatLong + NumPoles + Device + \mu$$

$$CPUE(PLOS) = YearQtr + VesselID + LatLong + NumPoles + \mu$$

Definitions of the predictor variables are shown in Table 2. Area stratification was changed mainly western tropical area (Fig.2). CPUE was also calculated accordingly. The model was implemented separately for each region and both binomial and lognormal models were applied. All major changes were summarized in Table 3.

1. The presence/absence of skipjack catches for a fishing day. The dependent variables were modeled using a binomial error structure to estimate probability of non-zero skipjack catch for a fishing day.

2. Non-zero skipjack catch for a fishing day after zero catch records have been excluded. The dependent variable was modeled assuming a lognormal error structure.

For the binomial model, the year/quarter indices indicating probability of capture (p) were derived using the inverse logit of the individual year/quarter factorial coefficients, with the average predicted value of p in the first 5 years constrained to equal t he observed average p for the same period. For the lognormal model, the year/quarter CPUE indices were derived by exponentiation of the individual year/quarter factorial coefficients. Delta-lognormal indices were derived by multiplying the binomial p values and the non-zero lognormal indices (Lo et al., 1992).

Japanese offshore pole-and-line fishing activity near Japanese water mainly occurs during April - October, targeting both of skipjack and albacore. The absence of skipjack in the catch from targeting albacore trips is unlikely to be suitable for representing the relative abundance of skipjack. This is also a critical issue for derivation of relative abundance of albacore (e.g. Kiyofuji and Uosaki, 2010). To exclude such data from the analysis, those fishing trips that skipjack represented 75% of the combined skipjack and albacore were removed. The data set was limited to individual vessels that completed a minimum of 10 days fishing each year for a minimum of five years.

Time series of available data for standardization were summarized to figure 3 (region1, PLOS), figure 4 (region2, PLDW) and figure 5 (region 3, PLDW). Note that there are not enough data for standardization in region 4 and region5.

Results and Discussion

Trend of standardized CPUE in 2011 and 2014

In this document, CPUE indices for skipjack were evaluated and updated. Data were updated by three years from 2011 assessment and vessel ID list was updated. We implemented a generalized linear model (GLM) as suggested by Langley et al. (2010) and updated by Kiyofuji et al. (2011) to produce standardized time series for the full data set. This analysis was similar to analyses for the last stock assessment in 2011 but vessel id information was updated and the definition of area stratification was changed. Some changes were apparent in the CPUE trends to those seen in 2011, in the lognormal indices in region2 and binomial in region 1 (**Figure 6 - 9**). But trend in all area were likely similar to the trend in 2011.

Figure 9 shows three indices in each region and each model configuration were plotted together (Black circle: 2011, red circle: 2014, blue triangle: drop final year from the 2014 configuration. Note that green triangle in region2 is 2014 data in OLD region 2.). Overall, trend of each indices were similar but levels of indices were changed. 2014 indices in all regions by binomial model were lower than that in 2011. One possible reason is that vesselID was updated both PLOS and PLDW, data is more consistency through the period. Conversely, lognormal positive 2011 indices in region 2 were lower than 2014.

Figure 10 is another representation to examine any changes between indices. No remarkable but substantial changes were identified between 2014 and drop final year from the 2014 in each region (Fig10; blue), and between 2014 in NEW region2 and 2014 in OLD region2 (green). Therefore results using data in 2014 is consistent because of small changes in each sensitivity analysis. However, clear differences between 2011 indices and 2014 indices (Fig.10; red) were confirmed in all regions. Number of unique vessel increased especially in 1987 would give a consistent data set due to updated vessel ID data (Table 2), which could be one possible reason for changes from 2011 in all regions. Although further investigation for clarification of these changes are necessarily, there still remains some issues to extend back to check vessel ID. This should be left for further investigation in future.

Followings are summary of this document.

- Skipjack abundance indices by the Japanese pole-and-line fisheries in the WCPO were undated until 2012.
- Vessel ID was corrected along with updating license number especially in 1987, 1992 and 1997. As results, number of unique vessel of PLOS increased from 22 to 177 in 1987, number of PLDW slitely increased in 1982 and 1992.
- Compared to the 2011 indices, substantial changes were identified from the last assessment throughout the period. This is because of addition of new data set and updated

vesselID data.

Reference

Kiyofuji, H., Uosaki, K. and Hoyle, S. (2011) Updata CPUE for skipjack caught by Japanese offshore pole and line fishery in the northern region of western and central Pacific Ocean. *WCPFC-SC7/SA-IP-13*.

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Lo, N. C., L. D. Jacobson and J. L. Squire (1992). Indices of Relative Abundance from Fish Spotter Data based on Delta-Lognormal Models. *Can. J. Fish. Aqu. Sci.*, **49:**(12) 2515-2526.

Ogura, M. and Shono, H. (1999) Factors affecting the fishing effort of the Japanese distant water pole and line vessel and the standardization of that skipjack CPUE. Part A; Description of the fishery and the data. Standing Committee on Tuna and Billfish., SCTB12 SKJ-4, 1-12.

Shono and Ogura (2000) The standardized skipjack CPUE, including the effect of searching device, of the Japanese distant water pole and line fishery in the western central Pacific Ocean. *Col. Vol. Sci. Pap. ICCAT*, 51: 312-328.

Table 2. Definition of the predictor variables included in the model.

(a) JPPL offshore (PLOS) in region 1 (fleet size ≤ 200)

Variable	Data Type	Description
YrQtr	Categorical	Unique year and quarter (2 and 3)
latlong	Categorical	5° of latitude and longitude spatial strata (midday position)
VesselID	Categorical	Unique vessel identifier
NumPoles	Continuous	Number of Poles

(a) JPPL distant water (PLDW) in region 2 and 3 (fleet size > 200)

Variable	Data Type	Description
YrQtr	Categorical	Unique year and quarter
latlong	Categorical	5° of latitude and longitude spatial strata (midday position)
VesselID	Categorical	Unique vessel identifier
NumPoles	Continuous	Number of Poles
Bait Tank (BT)	Categorical (2)	1. Vessel does not have bait tank
		2. Vessel has bait tank
NOAA (NOA)	Categorical (2)	1. Vessel does not have NOAA receiver
		2. Vessel has NOAA receiver
Sonar (SN)	Categorical (2)	1. Vessel does not have sonar
		2. Vessel has sonar
Bird Radar (BR)	Categorical (3)	1. Vessel does not have any bird radars
		2. Vessel has 1^{st} or 2^{nd} generation bird radar

Table 3. Summary of differences of JPN PL data between 2011 and 2014 stock assessment.

	2011 assessment	**2014 assessment**
Data period	1972 - 2009	1972 - 2012
Vessel ID	updated from 2010 (see Kiyofuji et al., 2011)	**updated** (see Table 1 and Fig.1)
region	OLD region 2 (NEW 2+4+5)	**New region 2** (see Fig.2)
Model	delta-lognormal	delta-lognormal
variable	see Table 2	same as 2011
final model	Kiyofuji et al. (2011)	same as 2011

Figure 1. Number of unique vessel used in 2011 stock assessment (black) and updated in this study (red) for (a) PLOS and (b) PLDW.

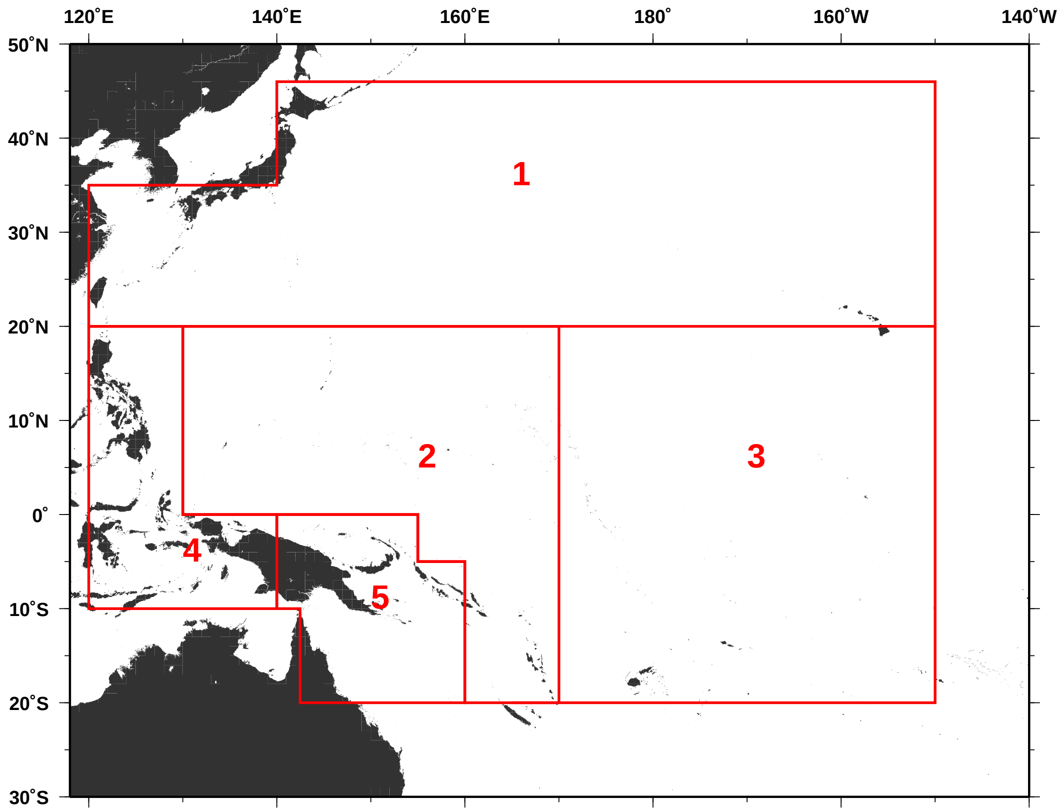

Figure 2. Area and subarea definition for CPUE standardization of the JapanesePL fisheries.

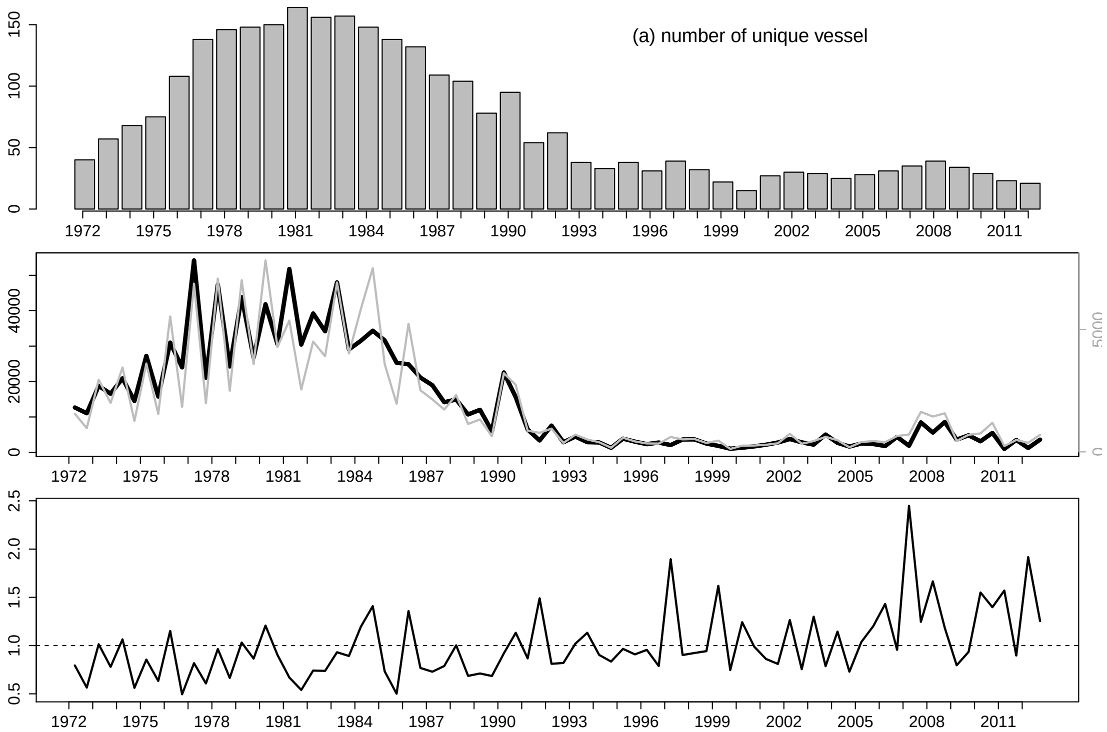

Figure 3. (a) number of unique vessel, (b) catch (gray) and effort (number of poles), (c) nominal CPUE (scaled by average) in year quarter by PLOS in region 1.

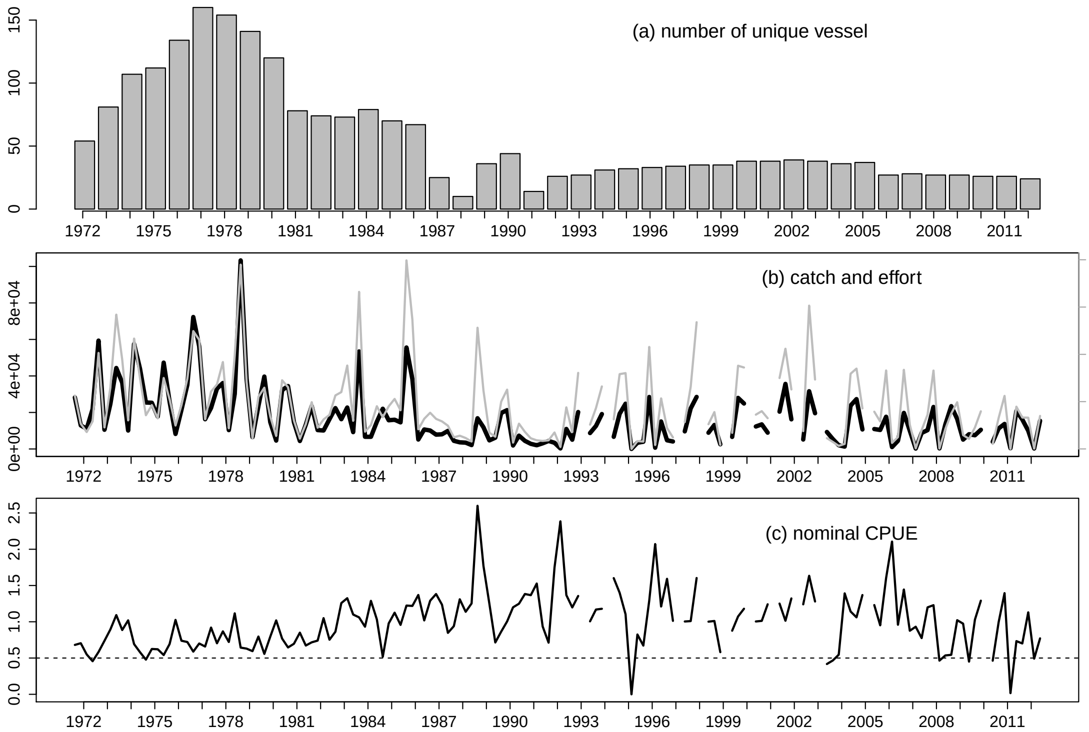

Figure 4. (a) number of unique vessel, (b) catch (gray) and effort (number of poles), (c) nominal CPUE (scaled by average) in year quarter by PLDW in new region 2.

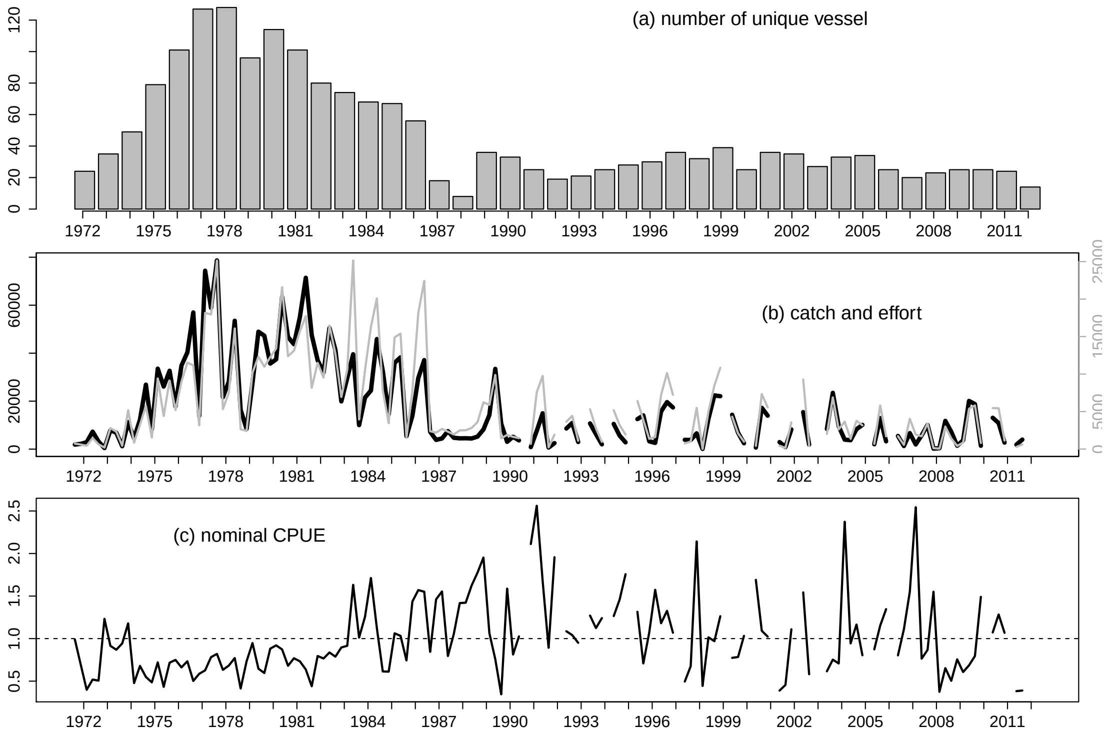

Figure 5. (a) number of unique vessel, (b) catch (gray) and effort (number of poles), (c) nominal CPUE (scaled by average) in year quarter by PLDW in new region 3.

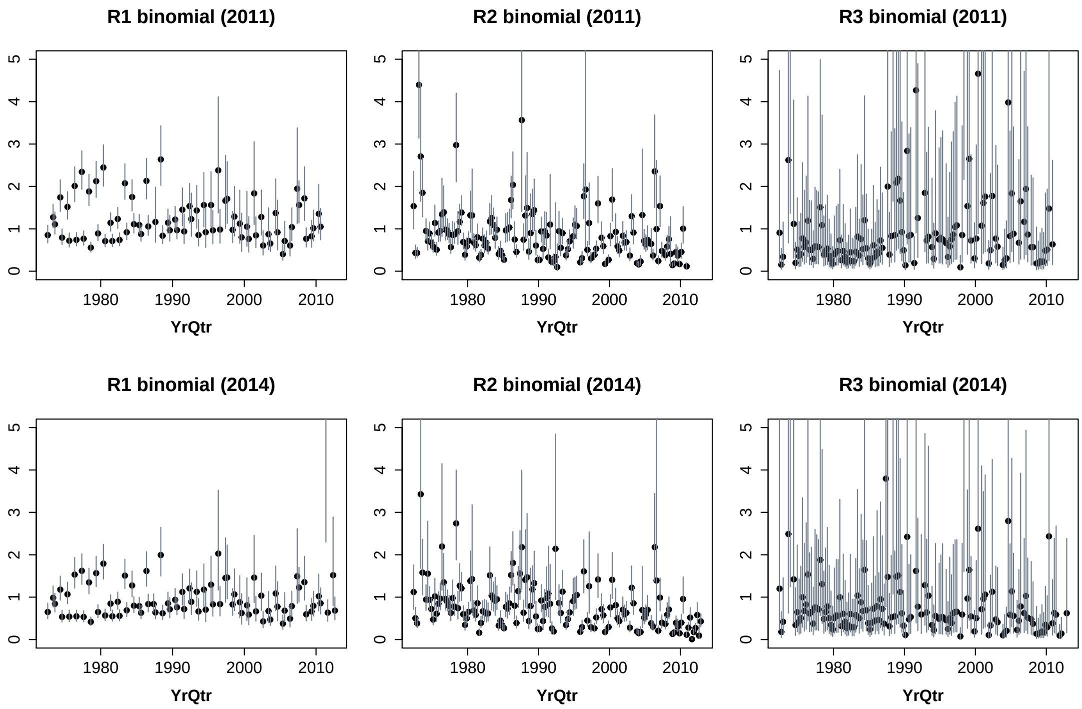

Figure 6. Comparison between indices by binomial in 2011 (upper) and in 2014 (lower) for each region. Region1 (left), **NEW** region2 (middle) and region3 (right).

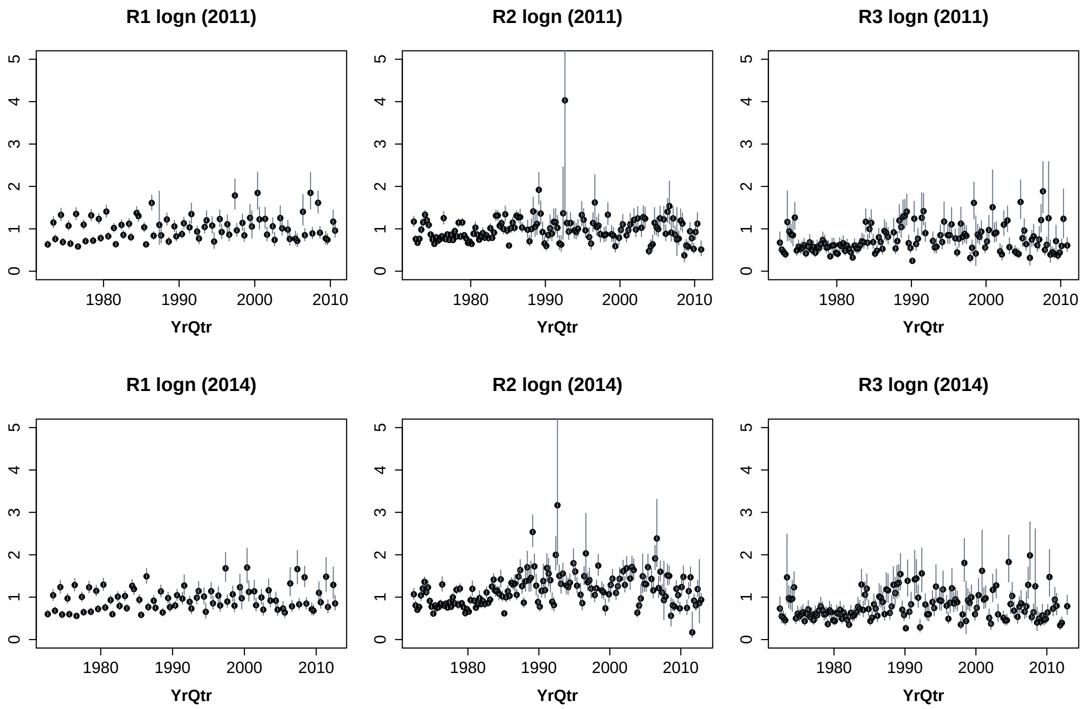

Figure 7. Comparison between indices by lognormal positive in 2011 (upper) and in 2014 (lower)for each region. Region1 (left), **NEW** region2 (middle) and region3 (right).

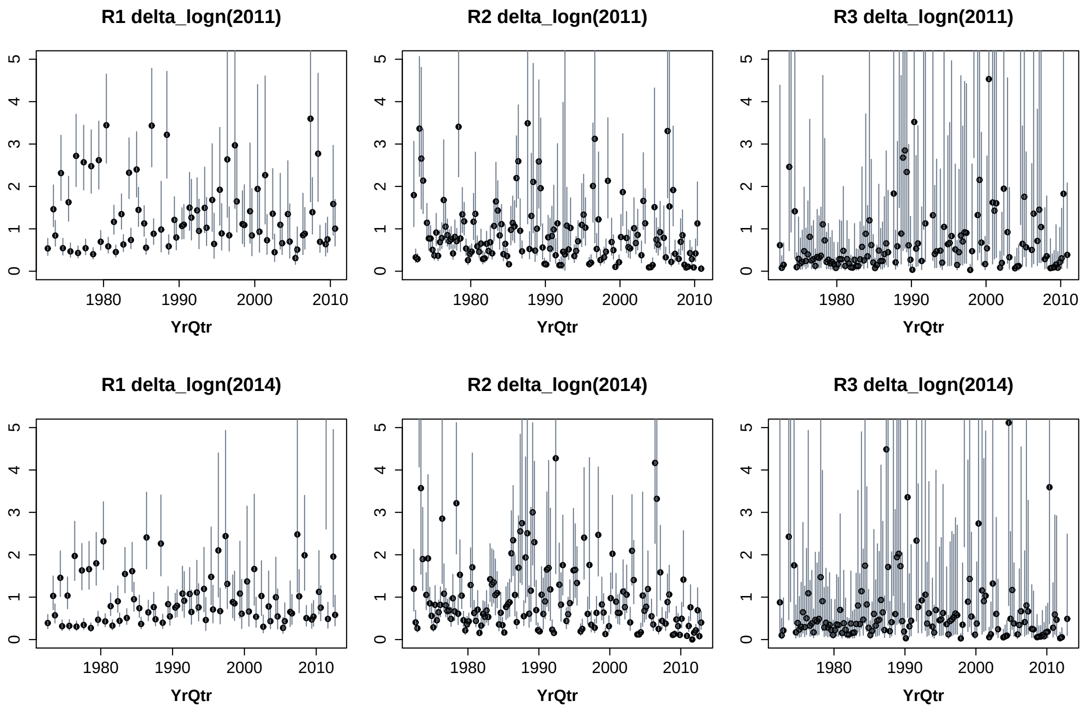

Figure 8. Comparison between indices by delta-lognormal in 2011 (upper) and in 2014 (lower)for each region. Region1 (left), **NEW** region2 (middle) and region3 (right).

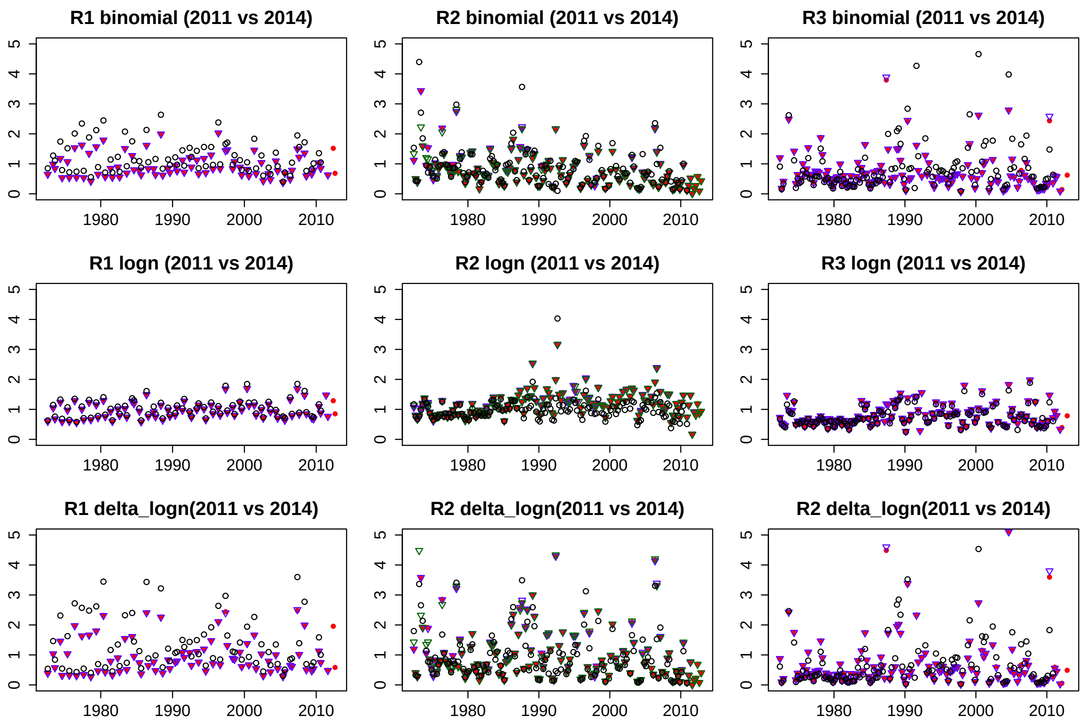

Figure 9. All indices in 2011 (black circle), drop final year from the 2014 model (blue triangle), in 2014 (red circle) and 2014 in **OLD** region2. Region1:left, region2: middle and region3: right.

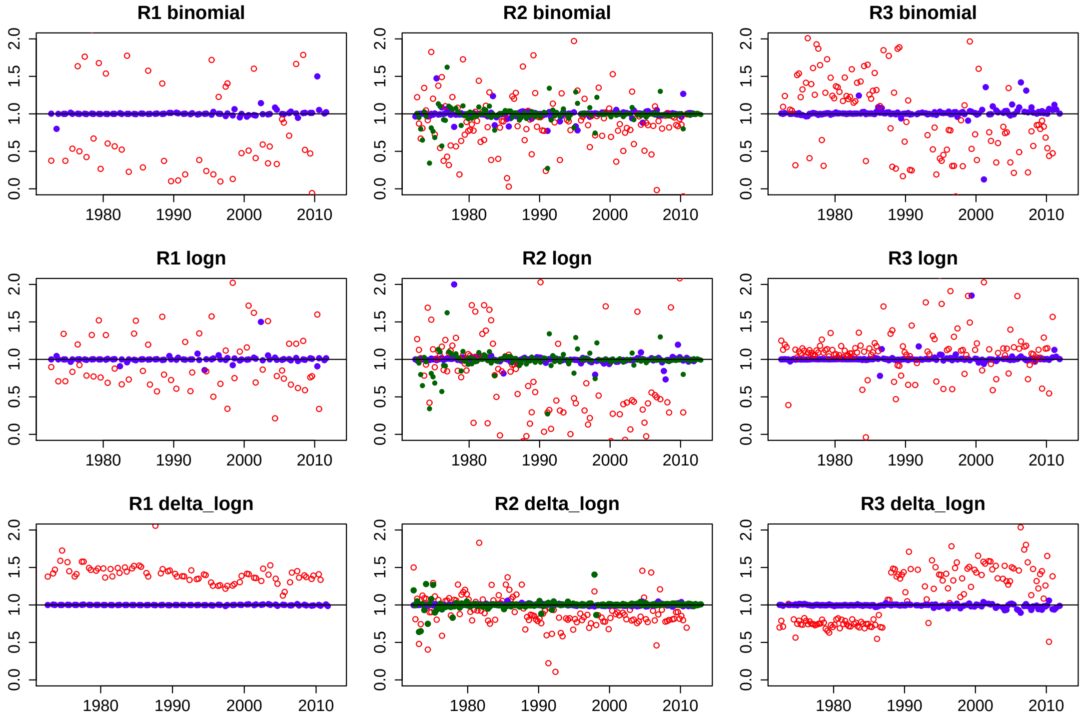

Figure 10. Ratio of coefficients between 2014 and 2011 (red); drop final year from the 2014 model (blue) and 2014 in **OLD** region2. Note that ratio equals to 1 indicate no changes between each index.