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Skipjack Catch per unit effort (CPUE) in the WCPO from the Japanese pole-and-line fisheries

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Summary

Catch per unit effort (CPUE) of skipjack caught by Japanese pole and line (JPN PL) in two spatial structures (same as 2014 stock assessment and alternative spatial structure for 2016 stock assessment as sensitivity runs) were estimated from logbook data between 1972 and 2015. Three years data from 2013 and 2015 were added after the 2014 stock assessment and model configuration for estimating CPUE were same as in 2014. Standardized CPUEs for alternative spatial area definition in 2016 were also estimated by two cases using all available data and extracted data that vessel operated continuously for more than 30 years. Overall trend of standardized CPUEs by updated data in each area were similar results by 2014. As for alternative spatial structure, overall trends by core data decreased in each region. Standardized CPUEs by all data were lower than results the CPUE by core data before 1990 especially in area 2 (tropical) and area 6 (subtropical), and trend after 1990 were vice verse. This indicates that vessels operated before 1990 have some impacts for estimating CPUE.

Introduction

In this document, catch per unit effort (CPUE) of skipjack tuna caught by both of the Japanese offshore (PLOS) and distant water pole-and-line (PLDW) in the WCPO was updated based on logbook data between 1972 and 2015 as same model configuration as in 2014 stock assessment. JPN PL CPUE 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. The delta-lognormal indices were calculated by multiplying the two sets of indices (Langley et al., 2010; Kiyofuji et al., 2011; Kiyofuji and Okamoto, 2014). Standardized CPUE for the alternative spatial structure was also estimated by the similar model configuration but two data set (all available data and 30 years continuously operated data; core data) were applied.

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).

Recent spatial patterns of catch (tonnes) by aggregated in 1x1 degree both for PLOS and PLDW were shown in **Fig.2** and **Fig.3**. There was no significant spatial changes for both PLOS and PLDW. Fishing areas by PLOS in recent years were found within region 1. Two core fishing areas were identified for the PLDW. One is equatorial region between 140 ℃E and 160 ℃W and another of the same area as the PLOS core area but extended to 180 °E.

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 and 2014).

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 1** and **2**. The model was implemented separately for each region and both binomial and lognormal models were applied.

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.

In 2016 SKJ stock assessment, sensitivity run for alternative spatial structure are planed and CPUEs for this area also should be standardized as same manner. Standardized CPUE was estimated both for all regions of 2016 stock assessment and alternative spatial structure shown in **Fig.1**. Standardized CPUE for alternative spatial structure were estimated by two cases using all available data and extracted data that vessel operated continuously for more than 30 years during the study period as core data set. The reason why data were extracted was because vessel operated longer time period would have a consistency in terms of technological changes through the periods. **Fig.4** represents time distribution of each unique vessel in each region for alternative spatial structure and red line shows vessel operated more than 30 years during the study period. Number of core vessel was approximately 1/10 relative to number of vessel of all available data. Focusing simply on before 1990, approximately 50 - 60% of vessels closed fisheries. In 1980's, JPN PL was converted to the purse sein fisheries as policy change due to deterioration of PL management of each vessel. Hence, those data might have some impacts to standardization process and results.

Table 3 shows a list of final model configurations for 2014 and 2016 stock assessment area and 2016 alternative structure. As for alternative spatial structure, two data set were analysed in separately. PLOS were operated mainly in region 1 and 7, PLDW were in region 2, 3 and 6. Several vessels in region 7 operate differently around anchored FADs, so that data in west of 130°E was deleted in this analysis. Final model was determined with statistically significant explanatory variable after running all available variables.

Results and Discussion

2016 CPUE in 2014 SA area

Updated results of probability of catching skipjack, non zero catch and delta-lognormal are shown in **Fig.5** - **Fig.7** in red lines. Overall trends of each SKJ index were not significantly changed from the results in 2014 (black) with generally continue to be flat in region1, decreasing trend after 2000 and increased updated year in region2 and continuously decreasing after 1990 in region3.

The binomial model indicates that the probability of catching skipjack within region1 is between 0.7 and 0.9 during the analysis period and there were no any significant trends (**Fig.5**). The lognormal non zero model estimated the non zero daily catch of skipjack. There were also no particular trends derived from the model (**Fig.6**). The indices calculated by multiplying both binomial and lognormal non zero (delta-lognormal) shows annual trend that it did not change largely until 2000 but decreased until 2005. The indices increased gradually from 1990 to 2000 and then decreased until 2005 (**Fig.7**).

The index estimated by the binomial model suggests that the probability of catching skipjack in region2 decreased from 1970 ' to 2010 (**Fig.5**) and slightly increased recently. The index estimated by the lognormal non zero model are likely decreased after 1995 (**Fig.6**). Indices by delta-lognormal also decreased constantly especially after 1990 (**Fig.7**).

Skipjack catch rates in region3 were between 0.8 and 1.0 and decreased after 2000 (**Fig.5**). The index estimated by the lognormal non zero model fluctuated largely after 1990, with an overall declining trend on average (**Fig.6**). As in region 2, there appears to be a step change in about 1984. The delta-lognormal index shows similar variability to the lognormal non zero model with decreasing trend after 1990 (**Fig.7**).

Alternative Spatial Structure in 2016

Results of probability of catching skipjack, non zero catch and delta-lognormal in alternative spatial structure for all data and core data are shown in **Fig.8** - **Fig.10** in black and red lines, respectively. The binomial model indicates that the probability of skipjack in region 1 is between 0.4 and 0.8 with flat, but recent year after 2010 shows decreased trend. The probability in region2, region3 (tropical area) and region6 (subtropical area) shows gradually decreasing trends, but in region7 were slightly increased trend. The index estimated by the lognormal non zero model both all and core data show similar trend in region1, region3 and region7, but different trend were identified in region2 and region6 among the data set before and after end of 1980'.

Overall trends of delta-lognormal by core data likely decreased in all regions but in region7. It is worth noting that trends in region2 (tropical) and 6 (subtropical) shows different trends between all and core data before and after 1990. This indicates that vessels operated before 1990 have some impacts for estimating CPUE because JPN PL was converted to the purse sein fisheries as policy change due to deterioration of each vessel

PL management, so that not only lower ranked vessel changed or stopped fisheries but also higher ranked vessel as well.

Followings are summary of this document.

- Skipjack abundance indices by the Japanese pole-and-line fisheries in the WCPO were undated until 2015 in same area definition in 2014 stock assessment.
- CPUE for alternative spatial structure was also estimated using all data and core data that vessel operated for more than 30 years.
- Compared to 2014 indices, no significant changes were identified from updated CPUE.
- Different trends were identified between CPUEs by all and core data in alternative spatial structure. CPUE by all data before 1990 was larger than CPUE by core data in especially region 2 and 6, and trends after 1990 were vice verse. This indicates that vessels operated before 1990 have some impacts for estimating CPUE.
- Estimating CPUE by the JPNPL by core data should be used in the assessment because clearer data have exceptional prospects for stock assessment inputs.
- Recent effort declines in region3 should also be addressed as representativeness of abundance index in this region.

Reference

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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.

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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 1. Definition of the predictor variables included in the model. JPPL offshore (PLOS; fleet size ≤ 200). Region1 for 2014 SA area and Region1 and 7 for 2016 alternative spatial structure.

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

Table 2. Definition of the predictor variables included in the model. JPPL distant water (PLDW; fleet size $>$ 200). Region2 and 3 for 2014 SA area and Region 2, 3 and 6 for 2016 alternative spatial structure.

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 the final model configurations of JPN PL CPUE estimations in 2014 and 2016.

<table>
<tr><th></th><th>2014 SA</th><th>2016 SA (2014 SA area)</th><th>2016 alternative SA</th></tr>
<tr><td>Region1 (PLOS)</td><td></td><td></td><td></td></tr>
<tr><td>[all data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td colspan="3">$yrqtr + latlon + vID + poles$</td></tr>
<tr><td>positive logn</td><td colspan="3">$yrqtr + latlon + vID + poles$</td></tr>
<tr><td>[core data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID$</td></tr>
<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID$</td></tr>
<tr><td>Region2 (PLDW)</td><td></td><td></td><td></td></tr>
<tr><td>[all data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>$yrqtr + latlon + vID + SN + BR$</td><td colspan="2">$yrqtr + latlon + vID + SN$</td></tr>
<tr><td>positive logn</td><td colspan="3">$yrqtr + latlon + vID + poles + BT + BR$</td></tr>
<tr><td>[core data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles$</td></tr>
<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles + BT$</td></tr>
<tr><td>Region3 (PLDW)</td><td></td><td></td><td></td></tr>
<tr><td>[all data]</td><td></td><td></td><td></td></tr>
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<tr><td>positive logn</td><td>$yrqtr + latlon + vID + poles + BT + BR$</td><td colspan="2">$yrqtr + latlon + vID + poles + BR$</td></tr>
<tr><td>[core data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + BT$</td></tr>
<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles + BT + BR$</td></tr>
<tr><td>Region6 (PLDW)</td><td></td><td></td><td></td></tr>
<tr><td>[all data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID$</td></tr>
<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles + BR$</td></tr>
<tr><td>[core data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles$</td></tr>
<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles + BT + BR$</td></tr>
<tr><td>Region7 (PLOS)</td><td></td><td></td><td></td></tr>
<tr><td>[all data]</td><td></td><td></td><td></td></tr>
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<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles$</td></tr>
<tr><td>[core data]</td><td></td><td></td><td></td></tr>
<tr><td>binominal</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID$</td></tr>
<tr><td>positive logn</td><td>-</td><td>-</td><td>$yrqtr + latlon + vID + poles$</td></tr>
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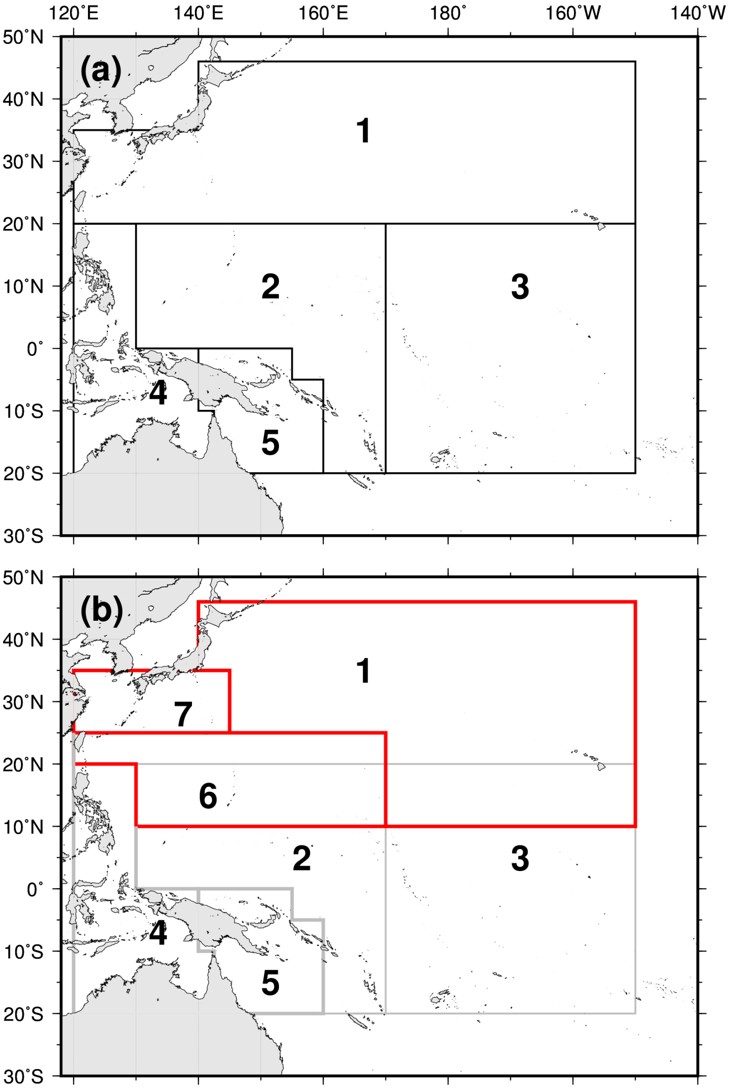

Figure 1. (a) Area definition used for the 2014 SKJ stock assessment and (b) New area definitions for the 2016 SKJ stock assessment as sensitivity analysis.

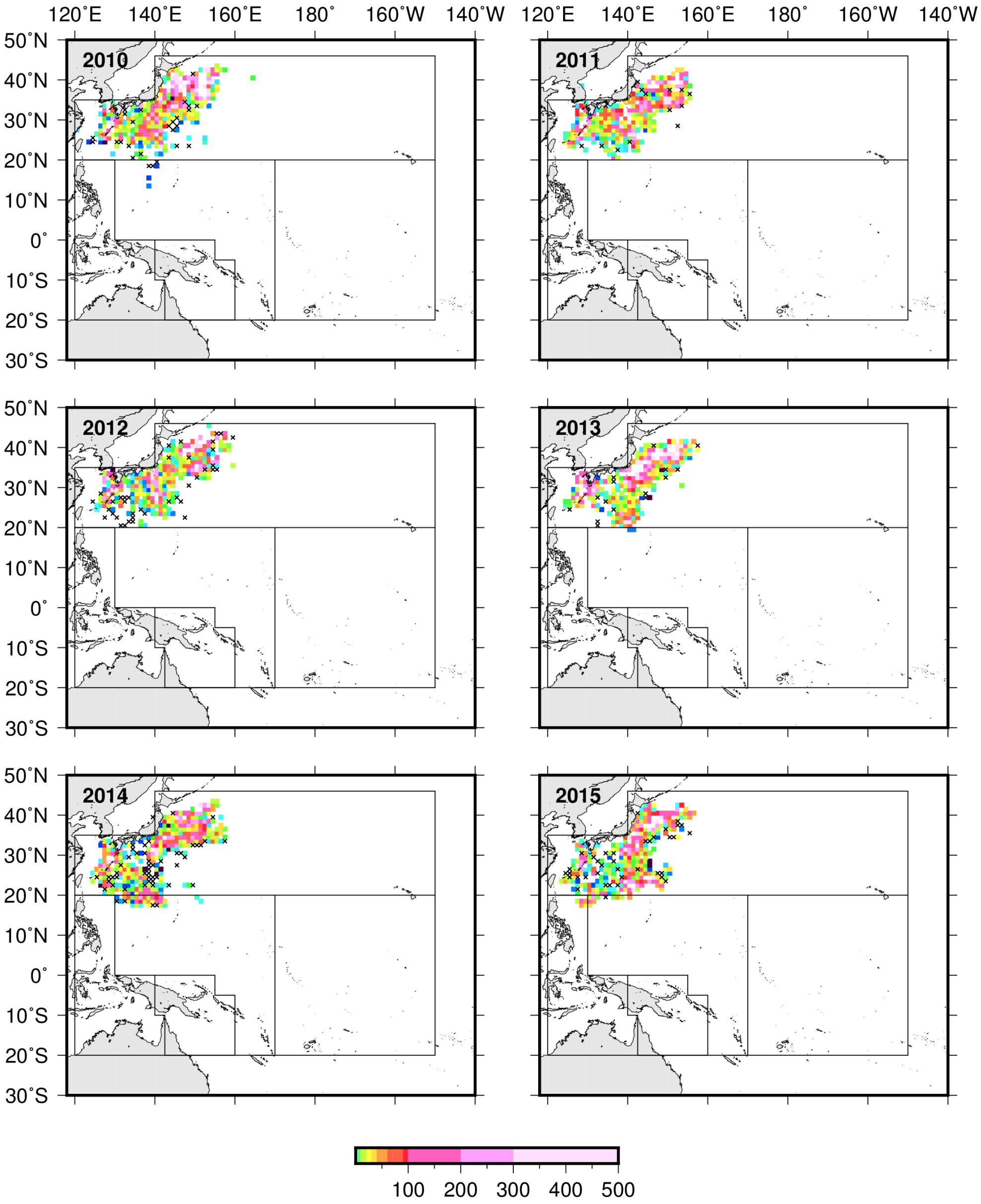

Figure 2. Catch distribution by JPN PLOS (< 200grt) in recent 6 years.

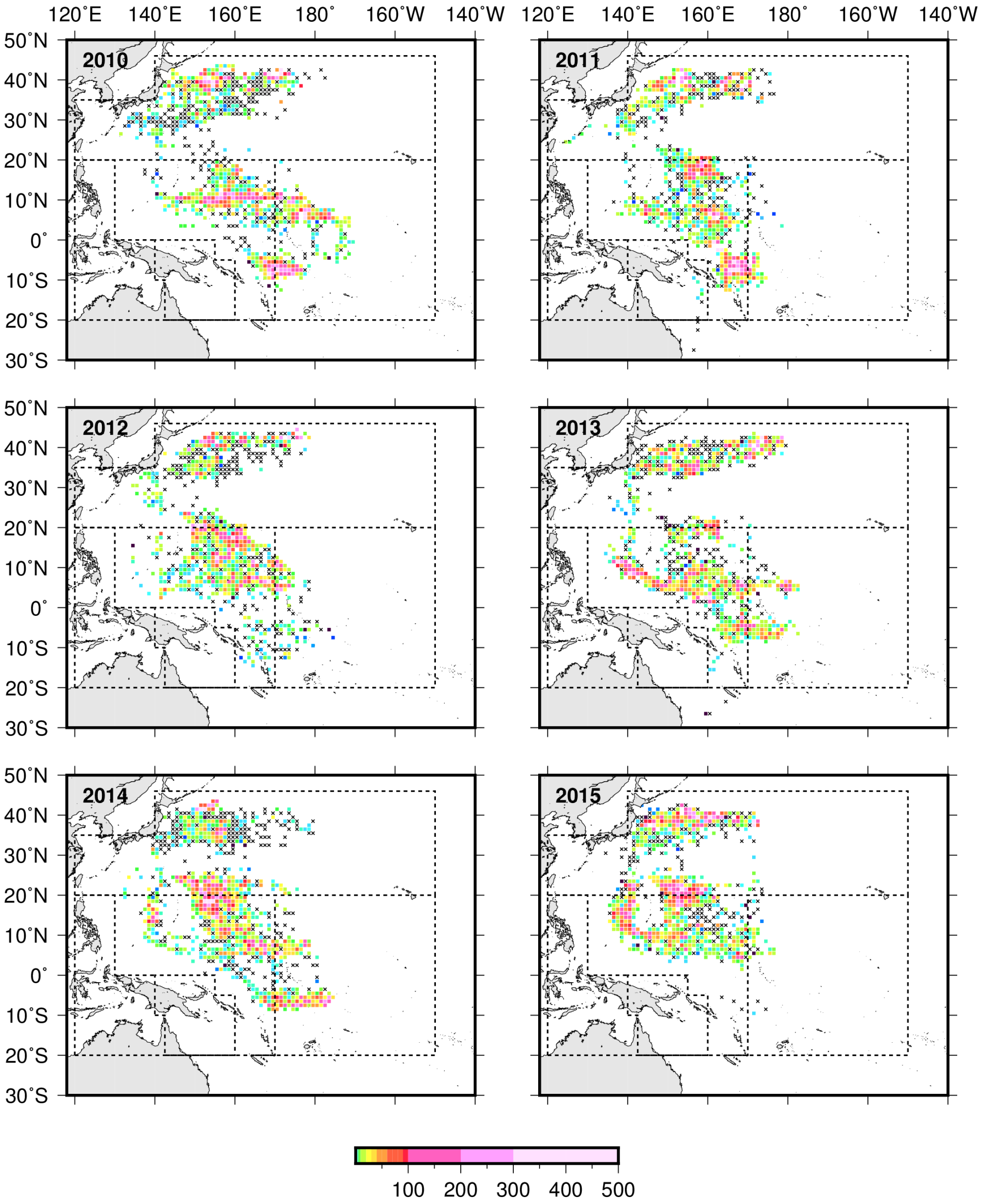

Figure 3. Catch distribution by JPN PLDW (>= 200grt) in recent 6 years.

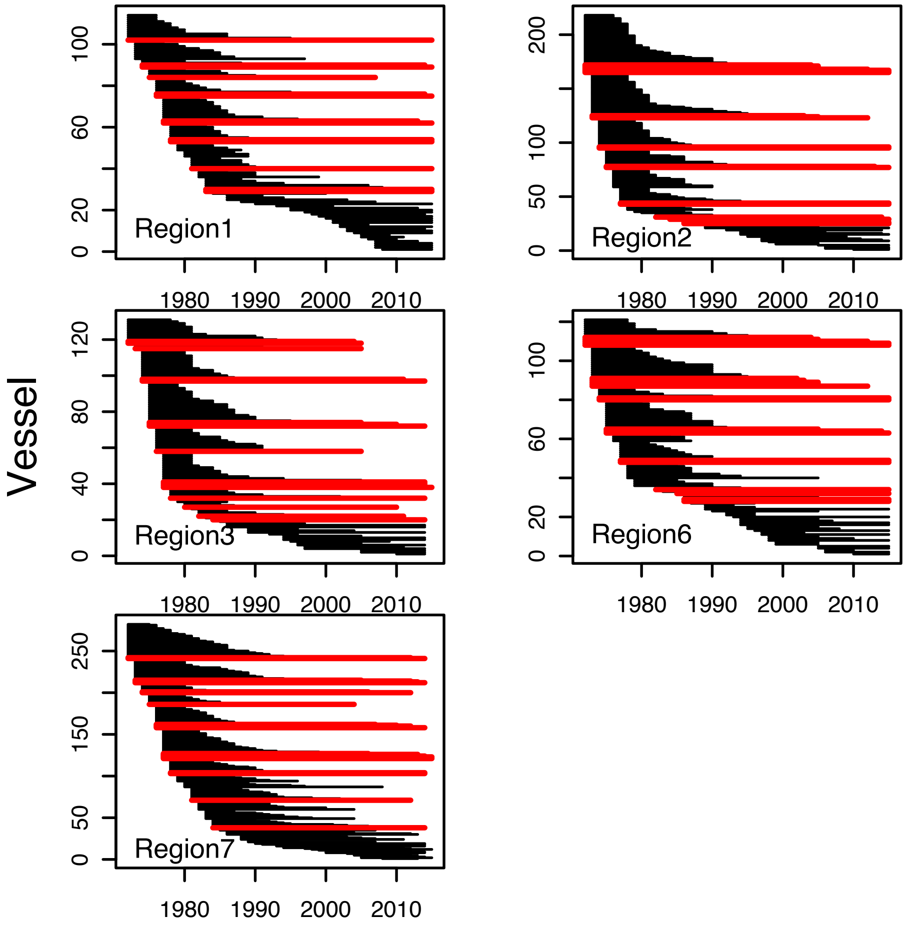

Figure 4. Time distribution of each unique vessel in each region. Red lines represent that vessel operated more than 30 years during the study period.

2014 SA area definition

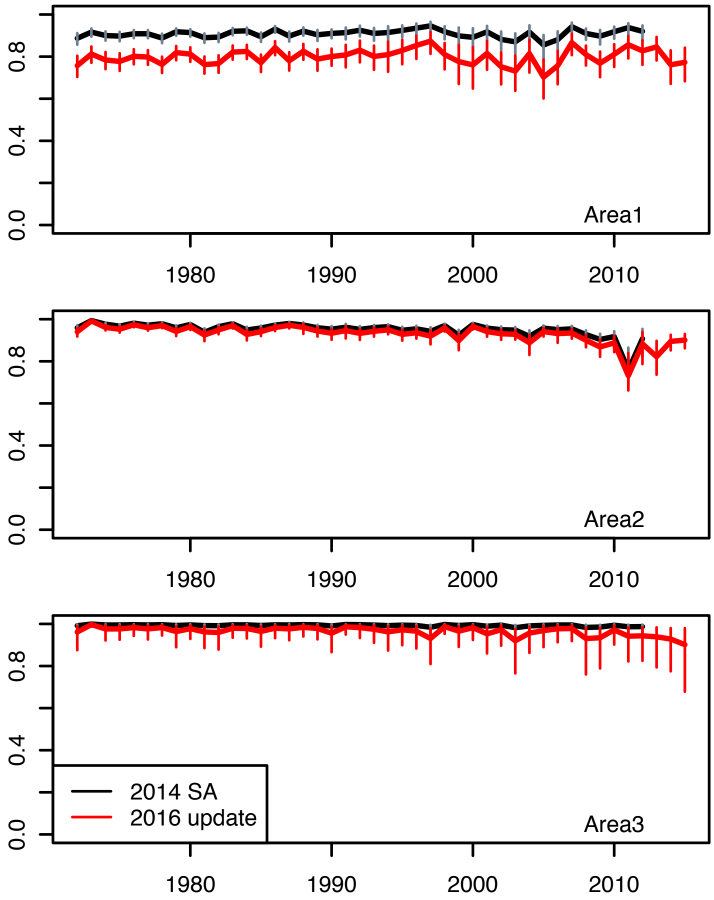

Figure 5. Probability of non zero catch in each area for data for 2014 (black) and 2016 (red).

2014 SA area definition

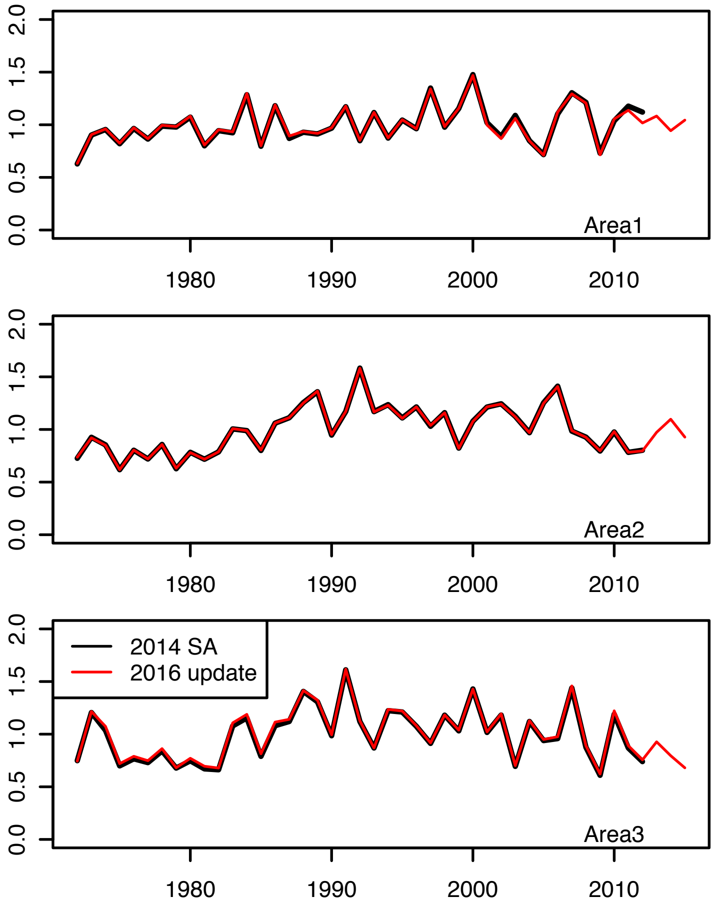

Figure 6. Indices for positive catch by JPN PL in each area for data for 2014 (black) and 2016 (red).

2014 SA area definition

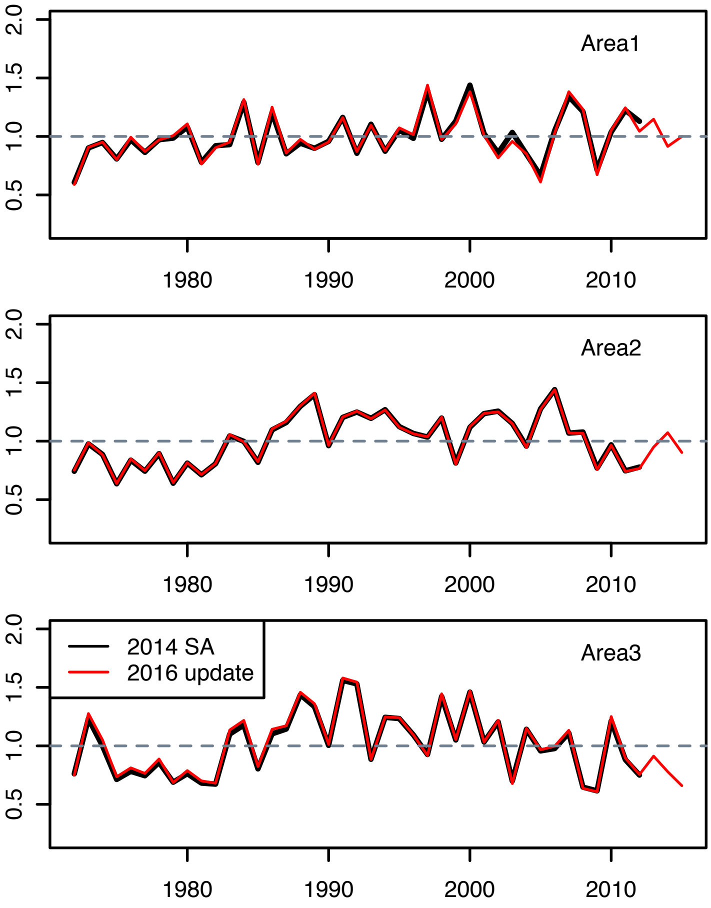

Figure 7. Abundance Indices of skipjack by JPN PL in each area for data for 2014 (black) and 2016 (red).

2016 alternative area definition

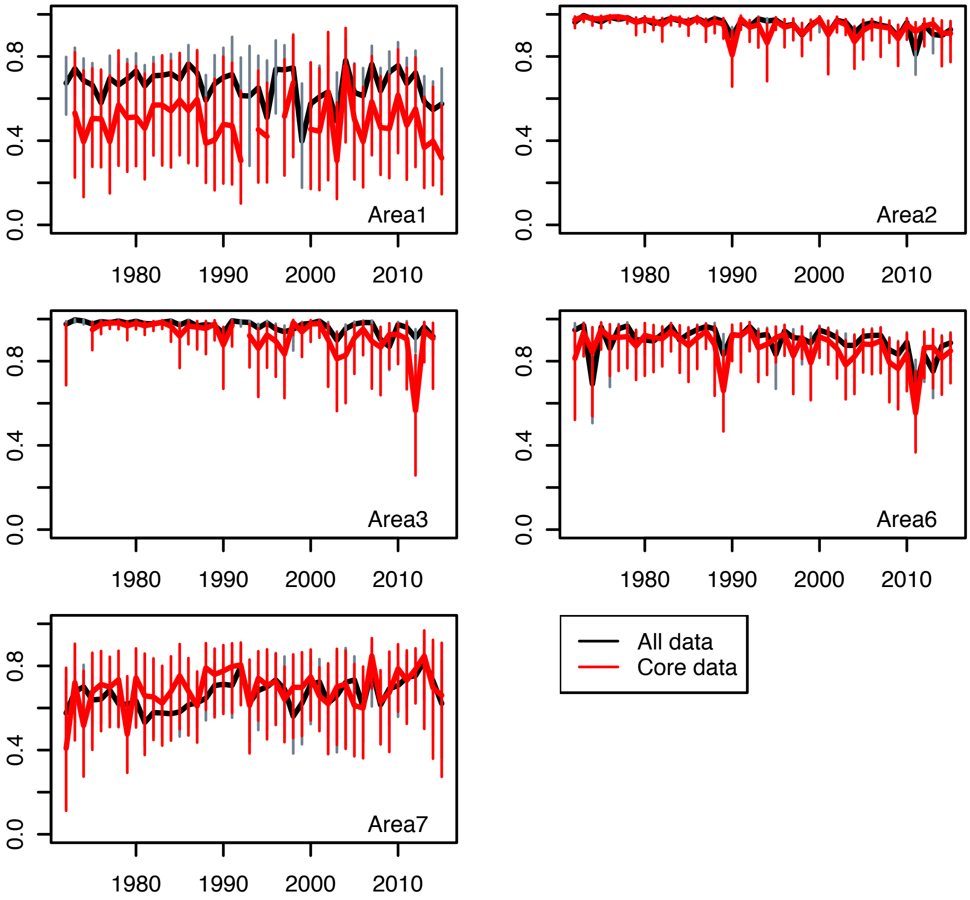

Figure 8. Probability of non zero catch by PLOS (1 and 7) and PLDW (2, 3 and 6) in each region for alternative area definition. (Black and red represents that all and extracted data, respectively.)

2016 alternative area definition

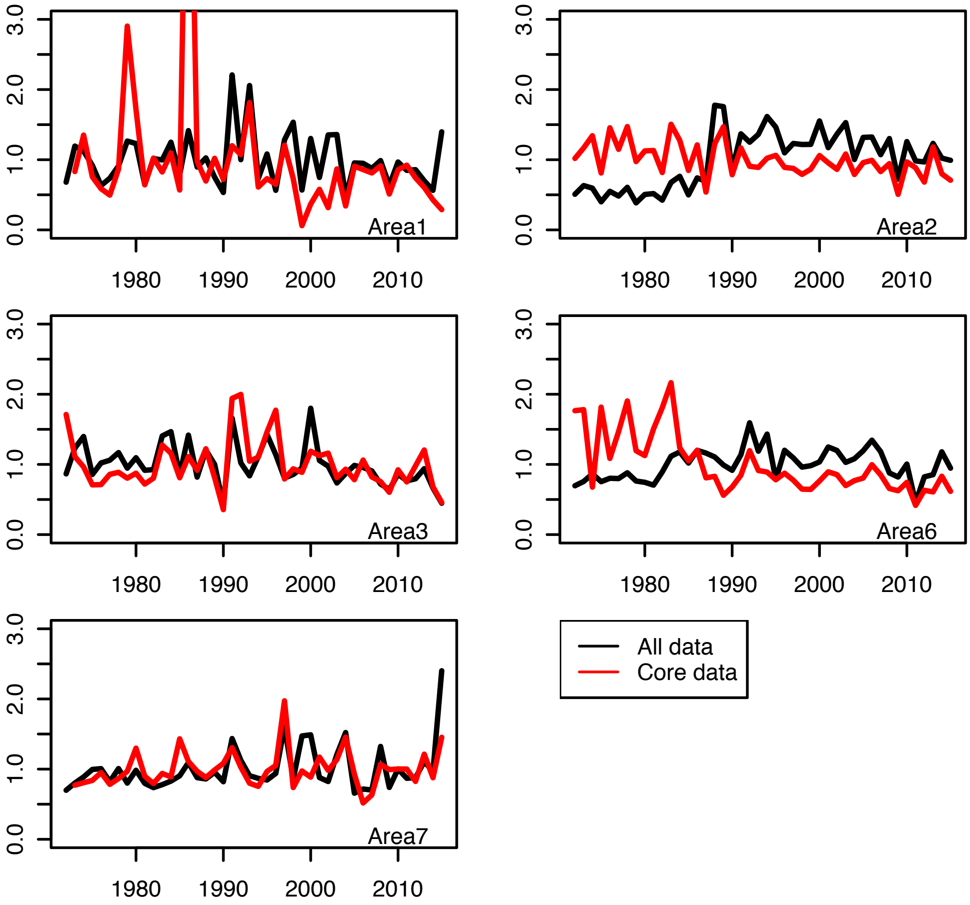

Figure 9. Indices for positive catch by PLOS (1 and 7) and PLDW (2, 3 and 6) in each region for alternative area definition. (Black and red represents that all and extracted data, respectively.)

2016 alternative area definition

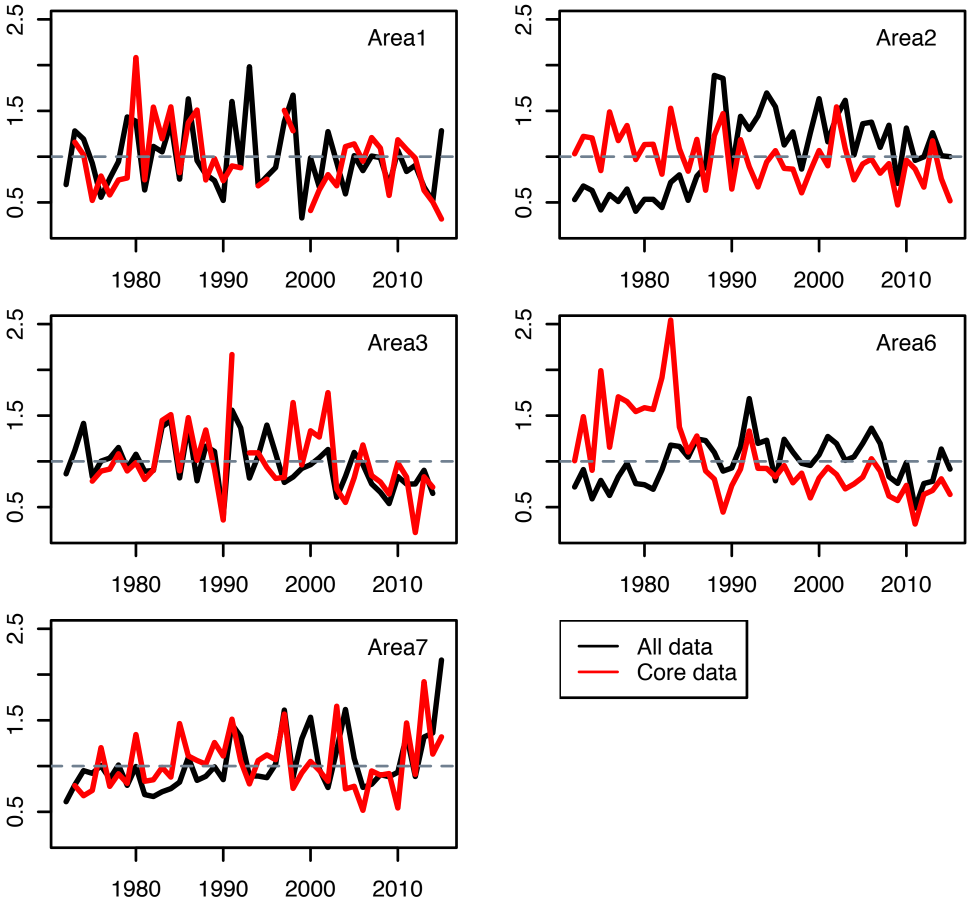

Figure 10. Abundance Indices scaled by mean by PLOS (1 and 7) and PLDW (2, 3 and 6) in each region for alternative area definition. (Black and red represents that all and extracted data, respectively.)