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Recent status of coastal skipjack in Japan and long-term abundance trend estimated from the operational coastal troll fisheries logbook

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Abstract

In this document, quantitative operational information from two troll fisheries (daily catch, area and equipment) since 1980’s were collected and attempt to estimate long-term skipjack abundance trend migrating to the Pacific coastal water in Japan. Efforts (number of operations) were relatively stable, but nominal CPUE shows gradual downward trend throughout the study period. One CPUE shows recent abundance level (2004-2015) has dropped significantly from higher period (1990-2003) with 35% decrease. The other declined constantly and it shows the lowest in 2014 (46% declined since 1983).

INTRODUCTION

Skipjack abundance trend in Japanese coastal areas were presented in recent few years (Kiyofuji, et al., 2011, 2013, 2014; Okamoto et al., 2014). In this document, quantitative operational information from two coastal troll fisheries (daily catch, area and equipment) since 1980’s were collected and attempt to estimate long-term skipjack abundance trend migrating to the Pacific coastal water in Japan.

The objective of this document was to attempt to estimate relative long-term abundance trend using operational logbook data from two Japanese coastal troll fleet for better understanding of abundance trend of skipjack migrating to the Pacific coastal water of Japan.

DATA AND METHOD

Coastal troll fisheries (less than 10 GRT) in Japan are characterized as deploying several fishing gears to the end of pole and run approximately 7 knots to attract skipjack at near surface. Coastal troll fishing grounds are mainly formed within approximately 60 n.m. from the landing port because their trip is usually one day. In this study, we started to search any long-term information about skipjack in coastal area and successfully found operational logbook from two coastal troll vessels. These two vessels are from Wakayama prefecture and Chiba prefecture, respectively and they are ranked higher in terms of skipjack catch amount in each prefecture. They have been conducting troll fisheries since approximately 40 years. They recorded daily catch (skipjack, albacore, yellowfin and other species), sales income and oil payment. One vessel has information about equipment development such as engine replacement (horse power change), fleet size change and new technological deployment of GPS and freezer (**Table 1**).

Since data contains zero catch, 10% of averaged CPUE were added. Explanatory variables were year, month, other species (small yellowfin, albacore and PBF) for Wakayama vessel A and year, month, latitude and longitude for Chiba vessel B. All variables are considered as categorical and Akaike Information Criteria (AIC) were applied for model selection procedures. To keep seasonal consistency, data between March and May as spring fishing season were applied. Following equation was used for estimating of standardized CPUE for skipjack caught by the coastal troll fisheries.

$$l\ (C \quad + c \quad .) = \mu + y \quad + m \quad h + o\ he\ \ S \quad + \varepsilon \quad \text{(1; Wakayama Vessel A)}$$

$$l\ (C \quad + c \quad .) = \mu + y \quad + m \quad h + L \quad + L \quad + \varepsilon \quad \text{(2; Chiba Vessel B)}$$

whereμ is overall mean, const. is 10% of overall mean of nominal CPUE and ε is error term with $N(0,\sigma^2)$. All explanatory variables were included as class variables and presence and absence of other species were included as 1 and 0 in the model, respectively.

RESULTS and DISCUSSION

Catch and Nominal CPUE trend

Figure 1 shows total skipjack landed catch from Japanese coastal pole-and-line and troll fisheries (black), only troll fisheries (blue) and coastal troll in the Pacific area (red). Coastal skipjack catch has been decreasing since 1980's and shows significant decrease after 2003. Recent catch in coastal areas shows increased, however, catch by the troll has been consistently decreasing since 2000. This is because troll fisheries cannot go further than the pole-and-line fisheries.

Figure 2 shows skipjack catch, total number of landing vessels and nominal CPUE (ton/fleet-day) during 1993 and 2015 in Wakayama (left) and Chiba (right) where are the largest or second largest skipjack landing prefecture in Japan. Total number of vessels was relatively stable until 2013 in Wakayama and until 2007 in Chiba. Both nominal CPUE represent gradual decrease through the period.

Figure 3 shows skipjack catch, total number of operations and nominal CPUE (ton/day) by each vessel for this research (See Data and Method). Total number of operations in Wakayama vessel A shows gradual increase until 1990 and keep at the same level around average of 50 operations a year. Skipjack catch keep at the similar level, but nominal CPUE shows gradual decrease. It should be noted that the level of the CPUE in recent year is low compare to the level before 2000. Total number of operations of Chiba vessel B was stable around the average of 40 days until 2007 then decreased in recent years. Nominal CPUE shows decreasing trend through the period. Both CPUE in 2014 was the lowest during this study period.

Long-term skipjack abundance trend

Wakayama Vessel A changed fleet size in 1990 and horsepower three times (1982, 1990, 2000; **Fig.4**). These improvements enable the captain to expand fishing area search. In addition to the improvement of vessel itself, equipment for searching fish school has also been improved. For example, color echo sounder has been deployed since 1987, which makes it easier for the captain to find fish school under water. Combination of expansion of fishing area search and introduction of freezer are expected to have contributed to the increase of searching time. Unfortunately, there are no data in year for the Chiba Vessel B, but this vessel has changed horsepower (35 HP to 680 HP in recent year) and materials of vessel (wood base to FRP). Based on these information we consider that the catch efficiency of those vessel have increased, while the CPUE is in decline. It should be emphasized that these two vessels are ranked first or second in each prefecture in terms of total landing of skipjack through the study period.

Figure 5 shows estimated standardized CPUE for each vessel (blue) and nominal CPUE (black). Level of the abundance trend in Wakayama vessel A shows significant change from high (1990 – 2003) to low (2004 – 2015) while the total number of operations did not change largely during this period. It should be noted that the reason why the data before 1990 were not included is because of the change in fishery such as HP improvement and equipment. CPUE of Chiba Vessel B declined constantly and it shows the lowest in 2014 (46% declined since 1983). We believe those results shows the possible local depletion in the area around Japan as a result of increased fishing mortality in the equatorial region.

Possible mechanisms of local depletion

Skipjack migrating to the coastal area around Japan is estimated from subtropical areas in quarters 1 and 2, mainly in February and March based on the results from the recent tagging survey. Therefore, one hypothesis is that increase of skipjack catch in tropical areas decreased the abundance of subtropical areas, which leads to decrease migrating stock to the Japanese coast. Estimates of reduction in spawning potential due to fishing by region (Figure SKJ4 of SC10 report) show that 80% of spawning population of skipjack tuna in Region 4 and 5 have been removed (paragraph 356 of WCPFC 11 report). This is a reasonable conclusion at this point to explain the observed CPUE decline in the Pacific coastal area shown in **Figure 5**.

Another possibility is that the increased catch in tropical and subtropical area may have caused decreasing spawning opportunity there. Skipjack larvae were found mainly in quarter 2, 3 at the subtropical area and quarter 4 at both subtropical and tropical (Nishikawa et al, 1985; Kiyofuji et al., 2015). Assuming local depletion occurred; lower spawning opportunity in subtropical area lead to lower recruitment that contributes to migrate stock to the Pacific coastal area in spring. In each hypothesis, consideration of joint efforts among CCMs in particular those situated in Region 4 and 5 is an important role.

Current stock assessment does not suggest the decline of abundance in subtropical area, which supports such a hypothesis. However, we consider this was due to the current area stratification used in the stock assessment. The current area definition divides the subtropical are by half and combined with either temperate area or tropical area, which makes it difficult to obtain accurate information regarding abundance trend in subtropical area, which is considered to be the origin of skipjack migrating to Japanese coastal area. Therefore, we would like to propose new area stratification for skipjack assessment (**Figure 6**).

Research on catchability changes by other fisheries especially in purse seine in tropical area should be further strengthened because technological improvements (FADs with echo sounder, using helicopter to find school) might reflect catchability or CPUE estimates. This would lead to improvements of stock assessments results.

Summary and Recommendation

1. Two coastal troll operational logbook data was investigated to evaluate long-term skipjack abundance trend in Japanese coastal area. One shows recent level of abundance (2004-2015) has dropped significantly from higher period (1990-2003) with 35% decrease. The other declined constantly and it shows the lowest in 2014 (46% declined since 1983). They are considered to indicate local decrease of abundance of skipjack in Japanese coastal area.
2. Possible mechanisms of local depletion are summarized as follow. Skipjack range of subtropical is contracted, and then migrating stock to the Japanese coast would decline mainly from winter to spring. Hence, decreasing availability cause CPUE decline in Japanese coastal areas. Joint efforts among CCMs in particular those situated in Region 4 and 5 is an important.
3. To improve our understanding of skipjack stock in the WCPO, particularly in the subtropical area the area stratification of the next stock assessment should be reconsidered as shown in **Figure 6**.
4. Research on catchability changes by major fisheries such as purse seine in tropical area should be further conducted because technological improvements (FADs with echo sounder, using helicopter to find school) might reflect to not only fishing operations or strategies but also catchability or CPUE estimates. This would lead to our understanding of this fisheries and improvements of stock assessments results.

Reference

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Table1. Items recorded in each logbook. (○ : recorded, △ : recorded but not electronic form, × : no record)

Items	Wakayama Vessel A	Chiba Vessel B
Date (Year, month, day)	○	○
Start time	×	△ (1983 -2002)
End time	×	△ (1983 -2002)
Position (Lat, Long)	×	○
Catch		
Skipjack	○	○
Yellowfin	○	△
Albacore	○	△
PBF	○	△
Equipment		
Radar	△[1]	△[1]
Echo sounder (black and white)	○	△
Echo sounder (color)	○	△
GPS	○	△
Freezer	○	×
Engine (change of horse power)	○	△

1: Only for navigation purpose

Table 2. Model configuration and response variables used for standardizing CPUE for the two Japanese coastal troll fisheries. (a) and (b) Wakayama Vessel-A and (c) and (d) Chiba Vessel-B.

(a) Wakayama Vessel-A.

Model	Variables	n	AIC	BIC
Include 0 catch and add small number				
m1	Year	2175	6993.4	7209.6
m2	Year, Month	2175	6932.9	7160.5
m3	Year, Month, ALB, YFT, PBF	2175	6878.0	7122.6
m4	Year, Month, ALB, PBF	2175	**6876.1**	**7115.0**

(b) Result of ANOVA for final model (m4).

	DF	TYPE III SS	F Value	Pr > F
Year	36	409.3	8.5	< 0.0001
Month	2	92.3	34.6	< 0.0001
ALB	1	6.4	4.8	0.029
PBF	1	73.4	54.9	< 0.0001

(c) Chiba Vessel-B.

Model	Variables	n	AIC	BIC
Include 0 catch and add small number				
m1	Year	1180	3338.0	3505.4
m2	Year, Month	1180	3264.1	3441.6
m3	Year, Month, Lat, Lon	1180	**3222.2**	**3425.1**
m4	Year, Month, LatLon	1180	3225.2	3438.2

(d) Result of ANOVA for final model (m3).

	DF	TYPE III SS	F Value	Pr > F
Year	31	151.1	5.6	< 0.0001
Month	2	81.8	47.1	< 0.0001
Lat	2	41.4	23.8	< 0.0001
Lon	3	7.3	2.8	0.03801

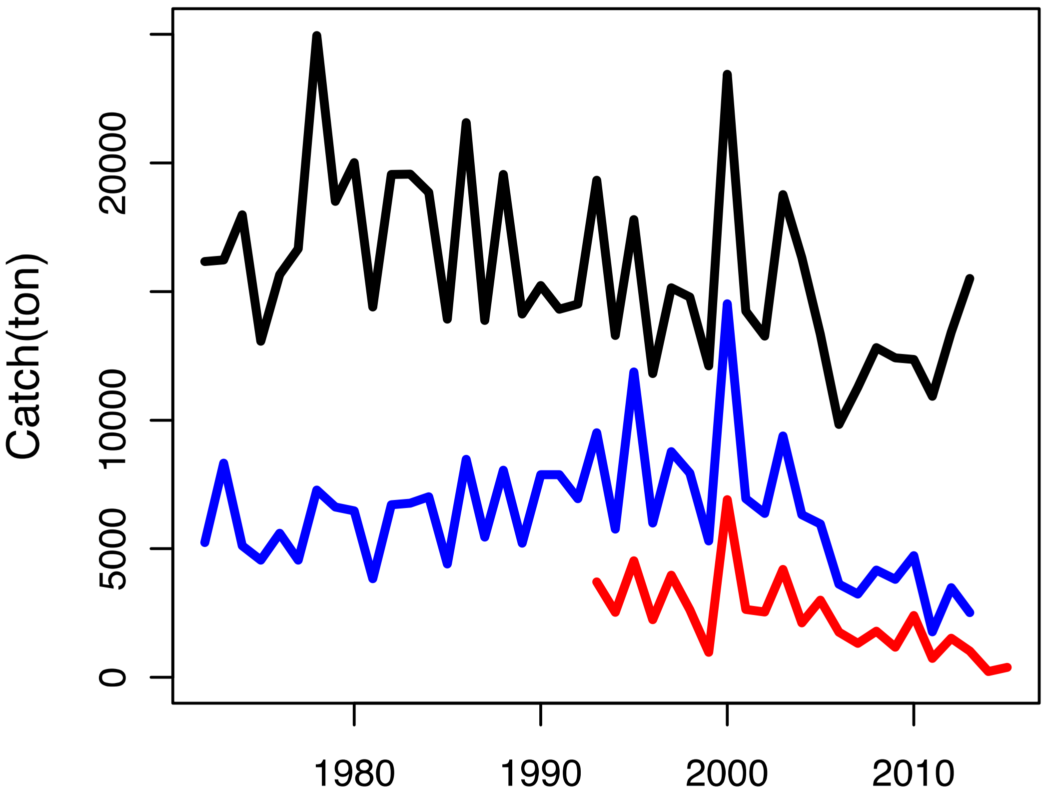

Figure 1. Total skipjack landed catch from Japanese coastal pole-and-line and troll fisheries (black), only troll fisheries (blue) and coastal area (red) (Data is Gyogyou yousyokugyou seisan toukei nenpou; Yearbook of fisheries and aquaculture production statistics of Japan, Statistics Department, Minister's Secretariat, Ministry of Agriculture, Forestry and Fishery). Coastal area includes Miyazaki, Ehime, Kochi, Wakayam, Mie, Shizuoka, Tokyo and Chiba prefecture (Data are collected from each prefecture for the purpose of monitoring coastal skipjack catch).

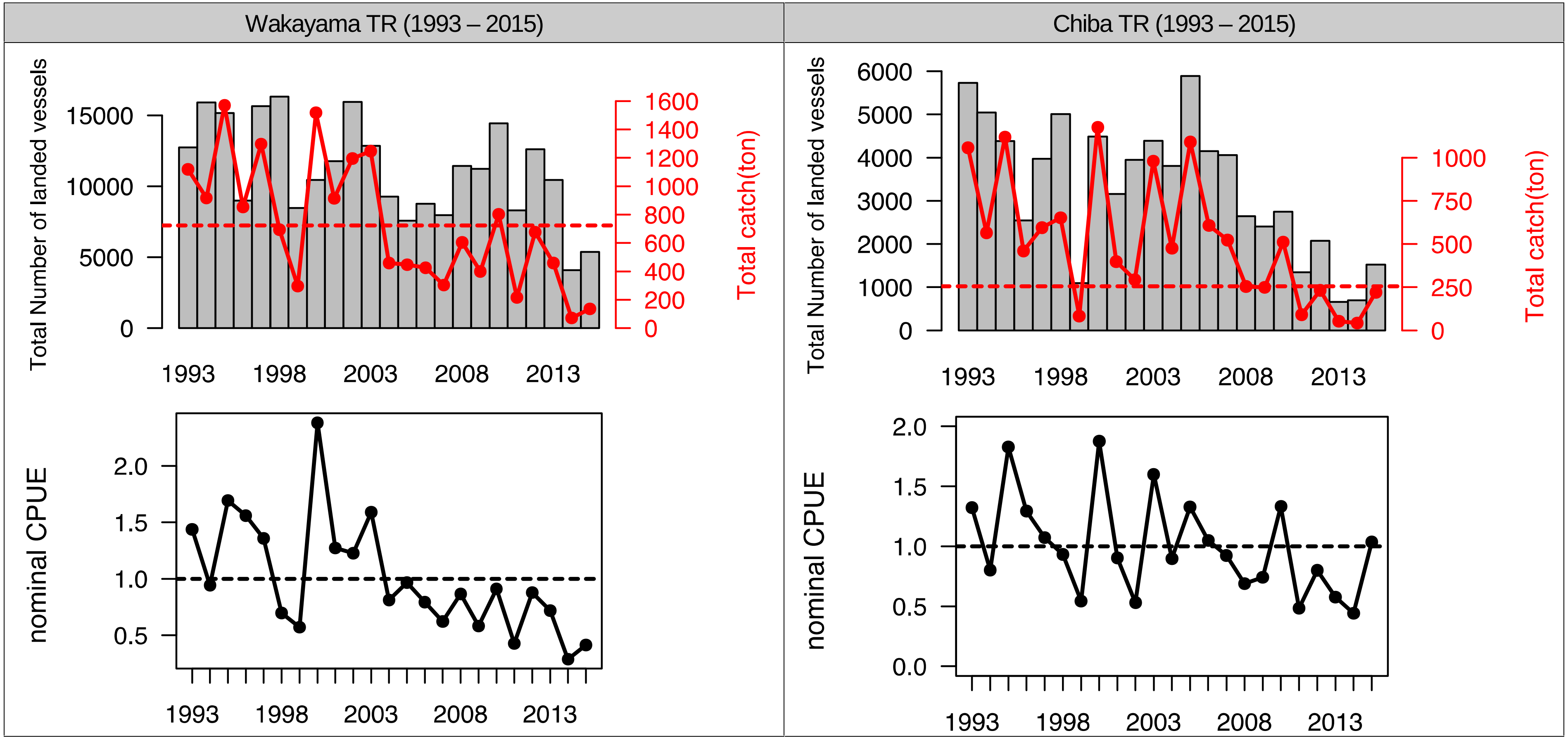

Figure 2. Total number of landed troll vessels (gray bar) and catch (red lines with circle) between Feb. and May from 1993 to 2015 and nominal CPUE. Left: Wakayam prefecture and right: Chiba prefecture (Data are collected from each prefecture for the purpose of monitoring coastal skipjack catch).

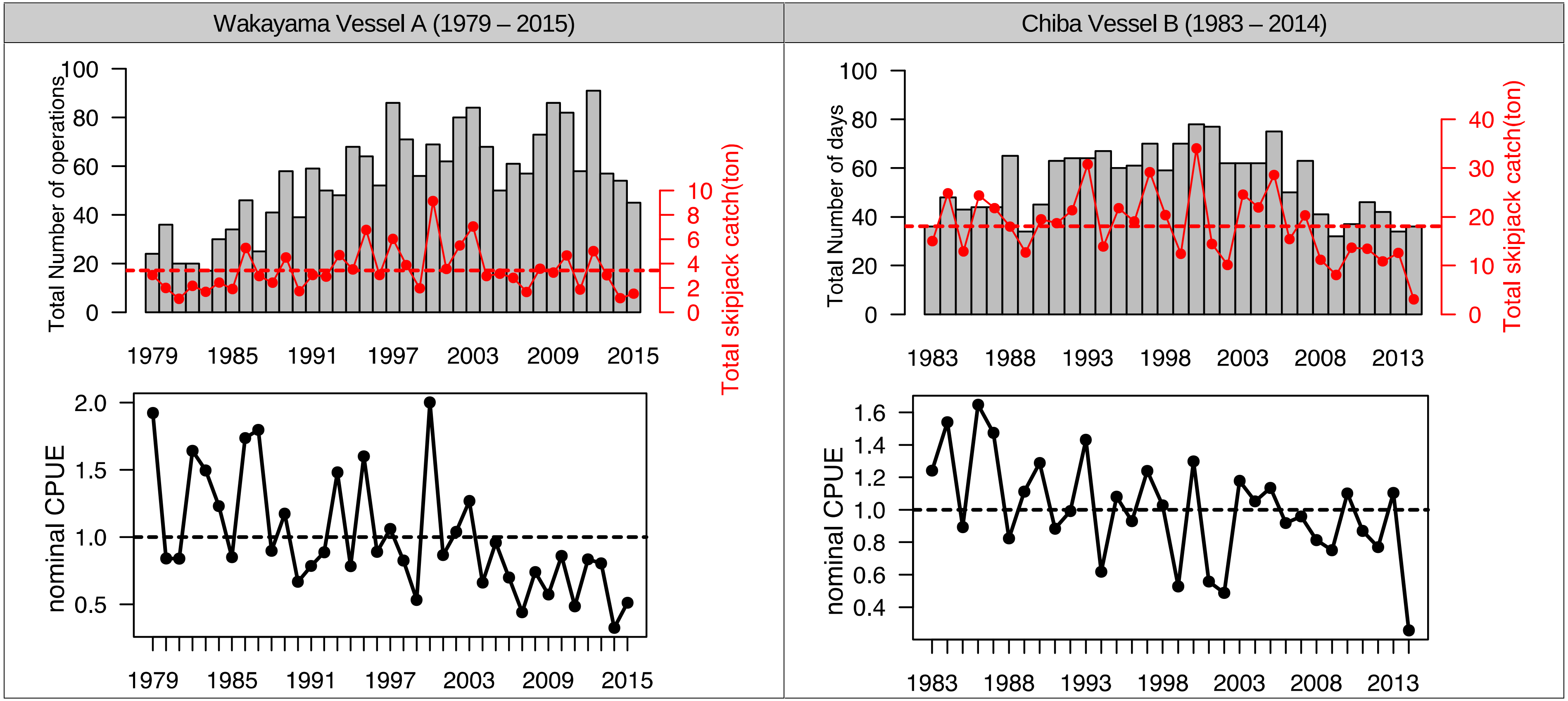

Figure 3. Operated days (gray bar) and total skipjack catch (red line with circle) between Jan. and June from 1979 to 2015 and nominal CPUE from operational logbooks. Left: Wakayama Vessel A, right: Chiba Vessel B. Note that these two vessels are ranked the highest catch in their prefecture.

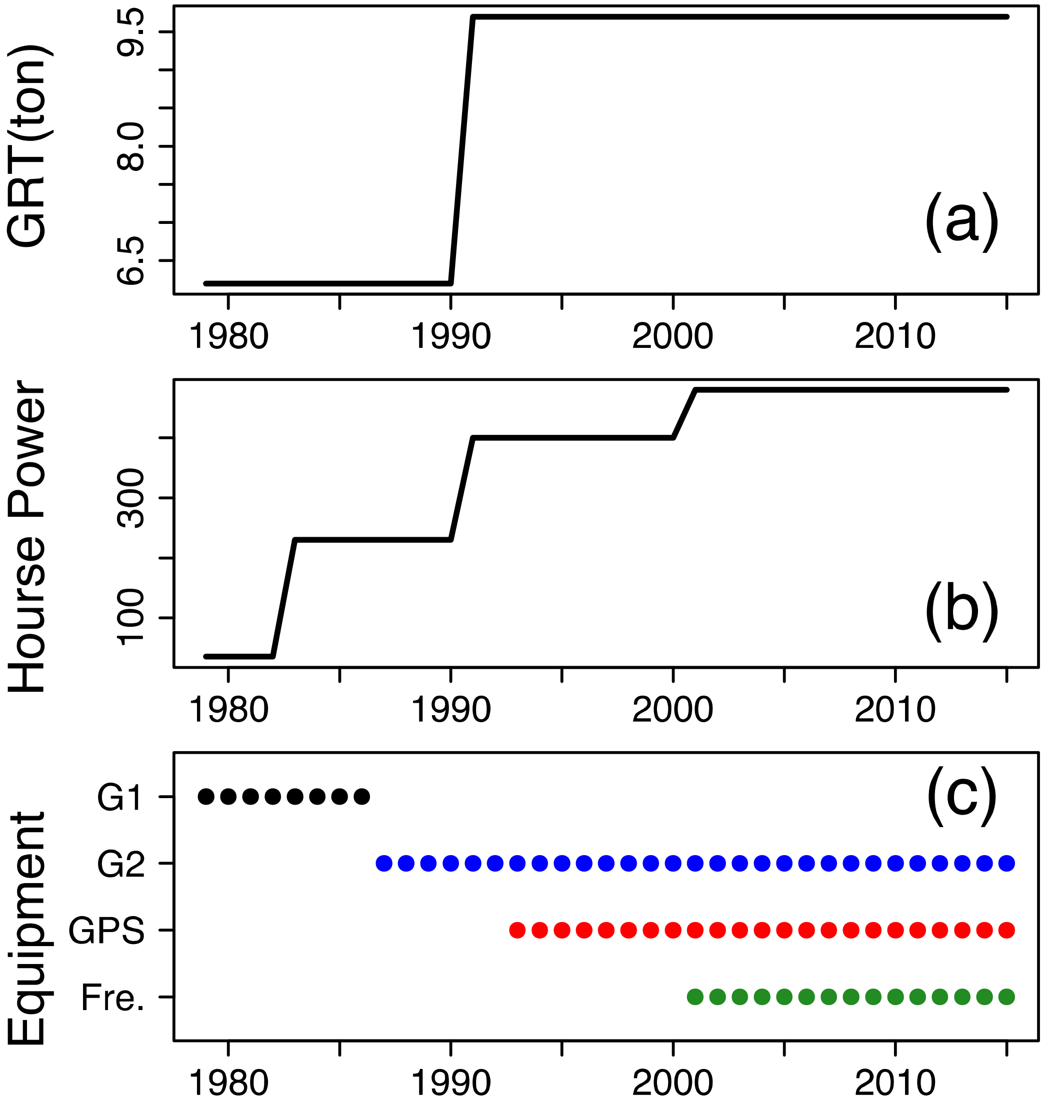

Figure 4. Technological changes of the Wakayama Vessel A. (a) Size of fleet, (b) horse power, (c) equipment (G1: black and white echo sounder, G2: color echo sounder, GPS: global positioning system and freezer).

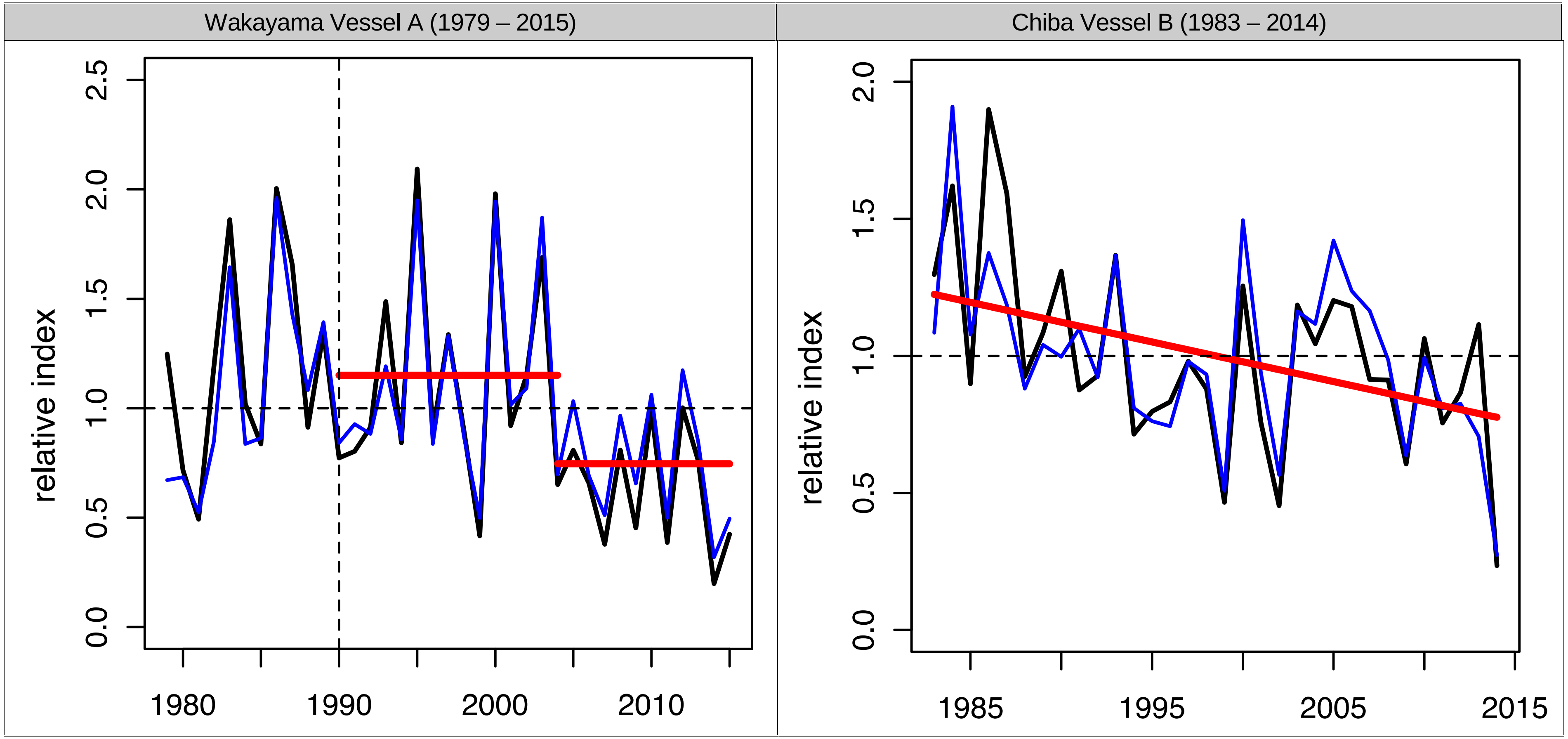

Figure 5. Nominal CPUE (black) and standardized CPUE (blue) in Wakayama Vessel A (left) and Chiba Vessel B (right). Red line in left represents averaged indices of high and low periods. Red line in right is regression results.

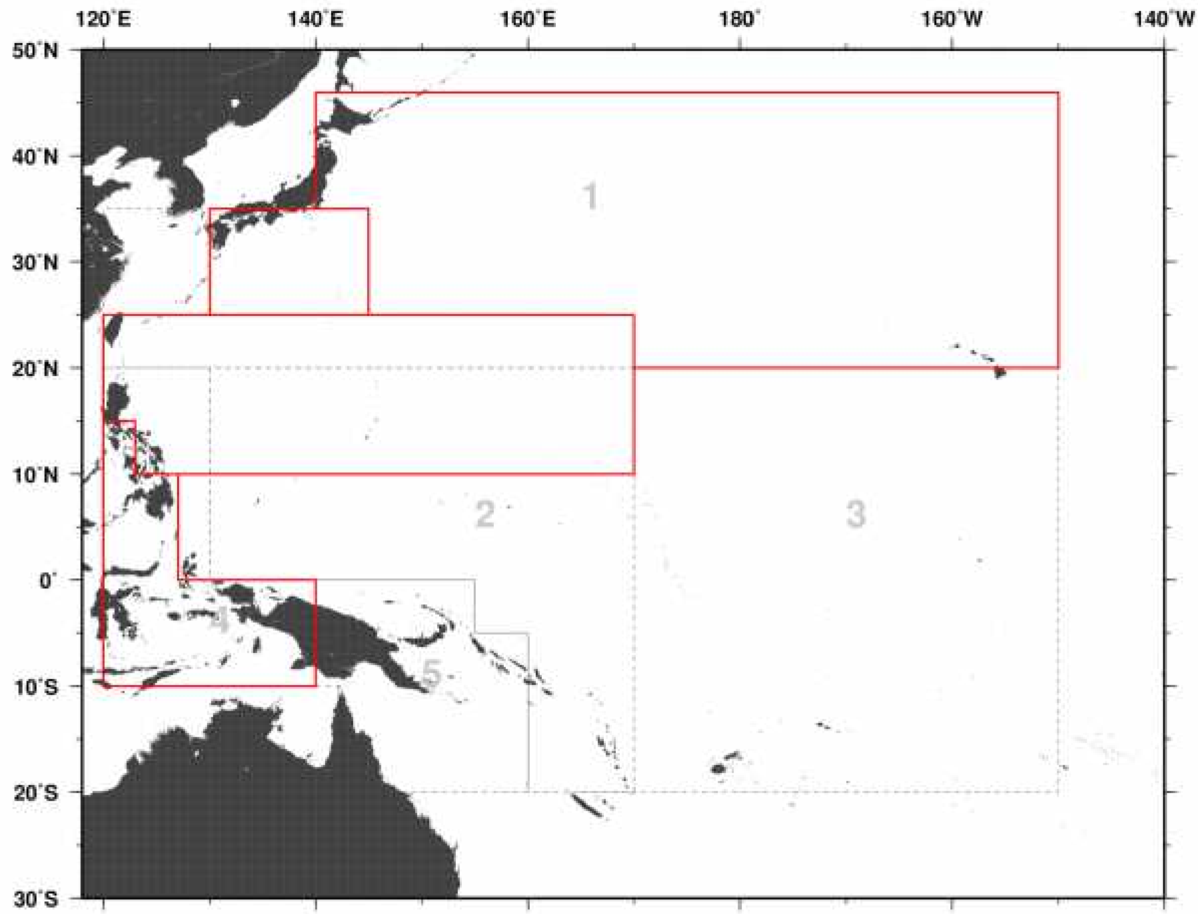

Figure 6. Proposed area definition (red) for WCPO skipjack assessment. Note that gray is the area defined in the last assessment in 2014.