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Updated standardized CPUE and size frequency for Pacific Bluefin tuna caught by Japanese coastal longliners

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Abstract

This document provided the standardized CPUE until 2013 in calendar year. The standardized CPUE showed continuous decline from 2007 to 2012 then slightly recovered in 2013. The length and weight frequencies indicated the signal of strong year classes which are assumed as 2007 and/or 2008. It is suggested that the new recruitment of those year classes into the Japanese coastal longline fishery contributed to increase of CPUE in 2013.

Introduction

The latest stock assessment of Pacific bluefin tuna was conducted by PBF Working group in November 2012 (ISC PBFWG 2012). The abundance index of spawning fish caught by Japanese coastal longliners is one of the most important information for this stock assessment and was estimated by Ichinokawa and Takeuchi (2012a) which improved standardized method from Ichinokawa and Takeuchi (2007). The main objective of this document is to update the standardized CPUE for next stock assessment in February 2014. This stock assessment were agreed to conduct by the same condition as the last stock assessment in 2012 (ISC 2013). Thus the standardized CPUE were calculated by the exactly same method as Ichinokawa and Takeuchi (2012a) with updated data. Another purpose is to detect where, when and which size of PBF occurred in 2013. The geographical distribution of CPUE, catch and effort by year and size frequencies were analyzed for this purpose.

Materials and Methods

Standardized CPUE

Set by set data from Japanese coastal longline logbook used in this study were compiled by the National Research Institute of Far Seas Fisheries (NRIFSF) for 1994-2013. NRIFSF generally commission the private company to make the logbook data electronically available and point out the fundamental errors such as wrong data, too fast movements and sets on land. Then NRIFSF scientists correct the errors based on their knowledge and experience. The percentage of correcting record is approximately 1%. This process takes a couple of months. In order to include the logbook data in 2013 into database as much as possible, NRIFSF staff computerized the latest logbook (249 cruises, 2642 operations). The data for estimation of standardized CPUE were filtered through the criteria applied by Ichinokawa and Takeuchi (2012a) as follows;

- ✓ April to June (spawning season)
- ✓ 1x1 degree grids in latitude and longitude where at least one PBF per year have been caught in more than 8 years in Ichinokawa and Takeuchi (2012a), but 9 years in this study because of updating two years data

The model and explanatory variables used for standardizing CPUE were also same as previous study (Ichinokawa and Takeuchi, 2012a), so the delta type two-step models (Lo et al., 1992) were applied.

This model fits separately the proportion of positive catch sets (or zero catch sets) assuming a binomial error distribution in the 1st step and log(CPUE) of positive PBF catch assuming a lognormal error distribution in the 2nd step. Explanatory variables were as follows,

- ✓ Year: 20 years from 1994 to 2013 in calendar year
- ✓ Day 10: Periods during the spawning season from April to June defined by 10 days interval (last period of May contained 11days)
- ✓ Area: 2 regions (NW or SW; Fig. 1)
- ✓ Gear: shallow sets (<16 hooks per basket) or deep set (>= 16 hooks per basket)
- ✓ Ship-type: 3 types defined by combination of the number of days per trip and GRT class of fishing boats
- ✓ Ship name as random effect: this effect is included only in the 1st step

The estimation for 1st step was conducted by GLIMMIX procedure by SAS 9.3 and the explanatory variables for best model were selected manually by sequentially adding the effect that most improves the fit (BIC) from simplest model only including the effect of year. The lognormal model in 2nd step was conducted by GLM procedure and the best model was selected by GLMSELECT procedure using stepwise BIC method starting with null model only with intercept. Coefficient of variances was calculated by a non-parametric bootstrap method (Ichinokawa and Takeuchi, 2012b).

Weight and length frequencies

Average weights were estimated by the logbook during 1994-2013 in all areas. In the logbook, total product (assumed gilled and gutted) weight per one set were reported thus the average product weight per one set were calculated then converted to average round weight using conversion factor of 1.15. Ichinokawa (2007) analyzed the weight frequency by 1kg bins derived from Japanese logbook and reported that remarkable artificial pattern; the number of samples every 5 kg were extremely larger than the others. In spite of those biases, the logbook data could provide highly resolution of fishing area as 1x1 degree. In addition, length information obtained by RJB (Research project on Japanese bluefin tuna) and port sampling data conducted by NRIFSF in 2012-2013 were used to demonstrate the difference of size frequency between 2012 and 2013 because Japanese longline CPUE slightly increased after six years of decline.

Results

Number of operations, hooks and PBF catches used for standardized CPUE were shown in Table 1. There were not large differences in the number of operations and hooks between 2012 and 2013. Thus it is suggested that the data in 2013 were adequate and the results of standardized CPUE would be reliable until 2013.

Explanatory variables selected by BIC have not changed from previous study (Tables 2-3), although the selected area for standardization of CPUE have changed. A 1x1 degree block was removed from the SW area whereas four blocks were removed and two blocks were added in the NW area (Fig. 1). Distribution of residuals in the 1st and 2nd steps showing the same positively skewed shapes as previous studies were not improved in this study (Fig. 3). Standardized CPUE showed approximately same trend from 1994 to 2010 which was steep decrease from 2005 to 2009 then it remained low level and continuous decline until 2012, however it slightly recovered in 2013.

Spatiotemporal distribution of nominal CPUE in 2012 and 2013 were shown in Fig. 4. Seasonal and geographical distributions were not remarkably difference between 2012 and 2013. In April, the fishing ground of PBF was located in the NW area, then it moved to the SW area. Relatively high CPUE were occurred around south of Yaeyama Islands from May to June in 2013. Annual trend of nominal CPUE (Fig. 5), PBF catch (Fig. 6) and fishing effort (Fig. 7) distribution demonstrated expanding of fishing ground toward northwest area (>30º N and >140º E) after 2002.

Weight frequency caught by Japanese coastal longliners by year and area were illustrated in Fig. 8. The area were divided by longitude line into 3 regions as "Lon>=140", "140>Lon>=130" and "130>Lon". From 1994 to 2006, PBF were mainly caught in "140>Lon>=130". After 2006, the ratio of PBF caught in "130>Lon" increased and weight frequency in this area showed relatively wide range but the peaks were observed in only larger range between 150 and 250 kg. It was observed that PBF in "Lon >= 140" were smaller than other areas and appeared clearly from 2003.

Length frequency of PBF caught by Japanese coastal longliners measured at landing ports in 2012 and 2013 were shown in Fig. 9. We observed single peak around 240 cm FL in southwest sampling areas (Miyazaki, Okinawa and Ishigaki) in 2012 whereas bimodal peaks around 180 cm and 250 cm in Okinawa in 2013.

Discussions

Our results suggested that the reason for the slightly recovery of nominal and standardized CPUE in 2013 was the new recruitment of relatively strong cohort into Japanese coastal longline fishery. Ichinokawa (2007a) analyzed length frequency of PBF caught by Japanese longliners until 2006 and found a strong cohort ranging at 184-191 cm FL class in length frequency distribution in 2002. In our analysis, a strong cohort of about 150 kg average round weight were observed (Fig. 8) in 2002. By the weight-length relationship estimated by Kai (2007), it is suggested the same year class as Ichinokawa (2007a) indicated. This strong year class continued to dominate in PBF landings from 2002. Thereafter, subsequent strong year class had not occurred in PBF catch from Japanese longliners and the CPUE of this fishery showed decreasing trend until 2012. However, CPUE slightly recovered in 2013. There was an apparent peak at 175-185 cm FL class and 100 kg class in the length- and weight-frequency distributions in 2013, respectively (Figs 8 and 9). The 2012 stock assessment revealed that the high recruitments of age 0 fish were occurred in 2007 and 2008 (ISC PBFWG 2012). Consequently, this relative strong cohort would be assumed 2007 and/or 2008 year classes and the new recruitment of those year class into the coastal longline fishery contribute to increase of CPUE in 2013.

The characteristics of PBF fishing ground were not similar between southeast and northeast off Japan. Fig. 8 indicated the expanding fishing ground to the northwestern area after 2002 and also the difference of size distribution among the areas and seasonal distribution of PBF. In the expanded area represented as "Lon>=140", relatively smaller PBF of approximately 100 kg than other areas were mainly caught and this tendency is correspond to previous studies (Itoh 2006, Ichinokawa 2007a). Additionally, nominal CPUE and number of catch were also different between areas; those around Nansei Island showed generally higher than expanded area (Figs.5-6). The area for standardization of CPUE is defined as 1x1 degree blocks where at least one PBF per year have been caught in more than 9 years in this study. However the threshold of number of years arbitrarily determined by Ichinokawa and Takeuchi (2007) and simply enlarged. Therefore selected area is different from previous studies (Ichinokawa and Takeuchi 2007, 2012a, Ichinokawa 2007b) and the area definition would not adequately partition the data into the assumed potential fishing grounds of PBF. In addition, the target shift from PBT to Yellowfin tuna described by Oshima et al. (2012) was not fully considered in this study. In the future study, the standardization method especially relevant to area definition and target species shift should be improved.

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Table 1 Data set used for standardized CPUE. Note that the fishing year is defined to start from July and end to June.

Calendar year	Fishing year(*1)	N of operations	N of hooks (x1000 hooks)	N of PBF catch	Nominal CPUE
1994	1993	3175	5054	2771	0.548
1995	1994	2669	4328	1555	0.359
1996	1995	2917	4754	2396	0.504
1997	1996	3036	4976	2336	0.469
1998	1997	3457	5665	2736	0.483
1999	1998	5552	9041	3754	0.415
2000	1999	4897	8123	2218	0.273
2001	2000	5482	9347	1835	0.196
2002	2001	4970	8322	1954	0.235
2003	2002	4274	7176	2440	0.340
2004	2003	5154	8847	3332	0.377
2005	2004	4763	8160	3606	0.442
2006	2005	4708	7829	1885	0.241
2007	2006	4557	7698	3092	0.402
2008	2007	4328	7545	1411	0.187
2009	2008	4510	7757	1196	0.154
2010	2009	4796	8073	745	0.092
2011	2010	4377	7677	569	0.074
2012	2011	4180	7586	381	0.050
2013	2012	4200	7395	657	0.089

Table 2 Results of model selection with BIC.

(1) Binomial model (1st step)

	Added explanatory veriables	BIC	
(1)	year	49404.10	
(2)	+year*day10	45474.75	
(3)	+area*shiptype	45202.24	
(4)	+day10*area	45117.24	
(5)	+year*area	45045.38	
(6)	+gear*shiptype	45036.05	
(7)	+area*gear	45035.04	Final model

(2) Lognormal model (2nd step)

	Added explanatory veriables	BIC	
(1)	Intercept	-30967.57	
(2)	+day10*gear	-32586.65	
(3)	+year	-33652.44	
(4)	+area*shiptype	-34094.71	Final model

Table 3 Results of type III analysis of the explanatory variables. The table shows the hypothesis tests for each of the variables in the model indivisually.

(1) Binomial model (1st step)

Effects	Num DF	Den DF	Chi squared value	F value	Pr>Chi	Pr>F
year*day10	152	17378	1224.62	8.06	<.0001	<.0001
area*shiptype	2	17378	12.96	6.48	0.0015	0.0015
day10*area	8	17378	155.51	19.44	<.0001	<.0001
year*area	19	17378	179.59	9.45	<.0001	<.0001
gear*shiptype	2	17378	22.72	11.36	<.0001	<.0001
area*gear	1	17378	7.01	7.01	0.0081	0.0081

Variance parameter of shipname with SD in paraenthes 0.390 (0.04)

Extra-dispersion scale 1.22

(2) Lognormal model (2nd step)

Effects	Num DF	Type III SS	Mean Square	F value	Pr>F
Model	41	956.13	23.32	92.67	<.0001
Error	24948	6278.45	0.25		
Corrected Total	24989	7234.58			

R squaread value 0.132

Effects	Num DF	Type III SS	Mean Square	F value	Pr>F
year	19	359.01	18.90	75.08	<.0001
day10*gear	17	348.50	20.50	81.46	<.0001
area*shiptype	5	125.06	25.01	99.39	<.0001

Table 4 Nominal and standardized CPUE of Japanese coastal longliners April to July

Calender year	Fishing year	This study					Ichinokawa and Takeuchi (2012b)	
		Nominal	Nominal (scaled)	Standardized	Standardized (scaled)	CV	Standardized	CV
1994	1993	0.548	1.849	0.304	1.910	0.083	0.301	0.085
1995	1994	0.359	1.212	0.221	1.390	0.061	0.218	0.062
1996	1995	0.504	1.700	0.274	1.723	0.088	0.271	0.078
1997	1996	0.469	1.583	0.287	1.802	0.051	0.281	0.051
1998	1997	0.483	1.629	0.251	1.574	0.056	0.248	0.057
1999	1998	0.415	1.400	0.180	1.129	0.045	0.177	0.044
2000	1999	0.273	0.921	0.139	0.871	0.052	0.135	0.050
2001	2000	0.196	0.662	0.108	0.679	0.049	0.106	0.046
2002	2001	0.235	0.792	0.126	0.790	0.058	0.121	0.057
2003	2002	0.340	1.147	0.208	1.306	0.044	0.201	0.043
2004	2003	0.377	1.270	0.222	1.394	0.033	0.216	0.034
2005	2004	0.442	1.490	0.261	1.639	0.034	0.256	0.033
2006	2005	0.241	0.812	0.130	0.817	0.045	0.126	0.046
2007	2006	0.402	1.354	0.184	1.152	0.042	0.180	0.041
2008	2007	0.187	0.631	0.101	0.635	0.048	0.098	0.047
2009	2008	0.154	0.520	0.063	0.398	0.054	0.063	0.056
2010	2009	0.092	0.311	0.034	0.215	0.076	0.033	0.077
2011	2010	0.074	0.250	0.034	0.214	0.075	0.029	0.087
2012	2011	0.050	0.168	0.022	0.136	0.081		
2013	2012	0.089	0.300	0.036	0.226	0.065		

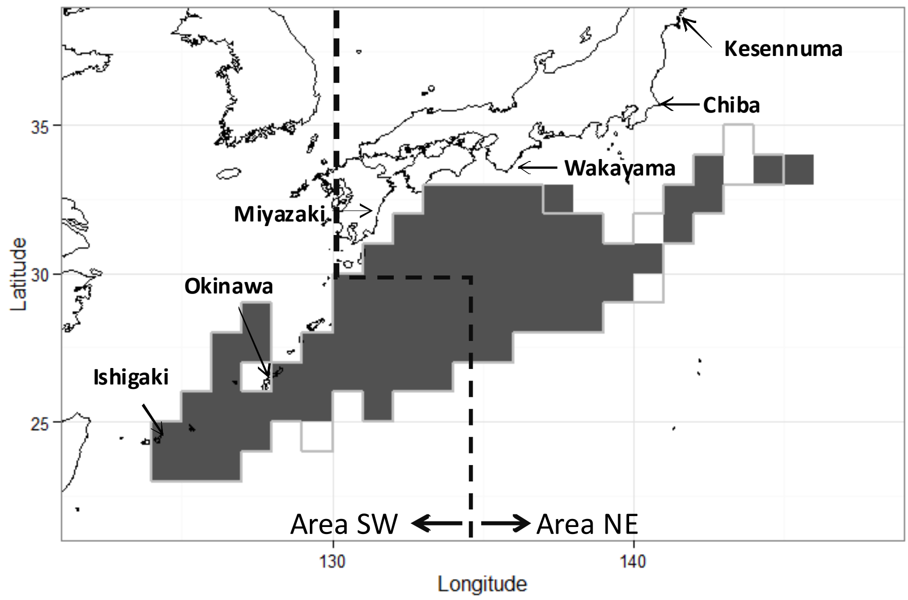

Fig. 1 The area shaded by dark grey colors are the fishing area selected for standardization of CPUE derived from Japanese coastal longline logbook in this study and the surrounded area by grey line represents the area used in the previous study (Ichinokawa and Takeuchi 2012a). The fishing area is defined as 1x1 degree blocks where at least one PBF per year have been caught in more than 9 years for this study and 8 years for previous study (Ichinokawa and Takeuchi 2012a).

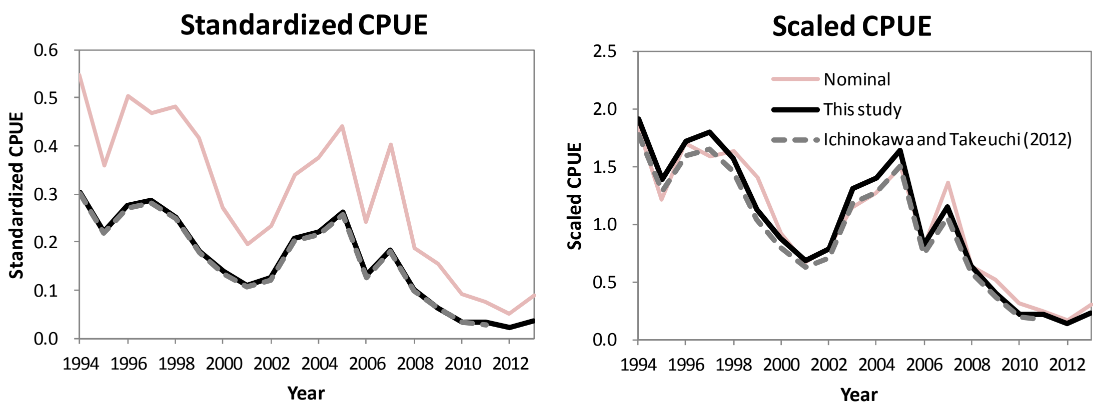

Fig. 2 Annual trend in standardized and nominal CPUEs (left) and scaled CPUEs (right). Grey broken line indicates previous study (Ichinokawa and Takeuchi 2012a) and pink strait line indicates nominal CPUE.

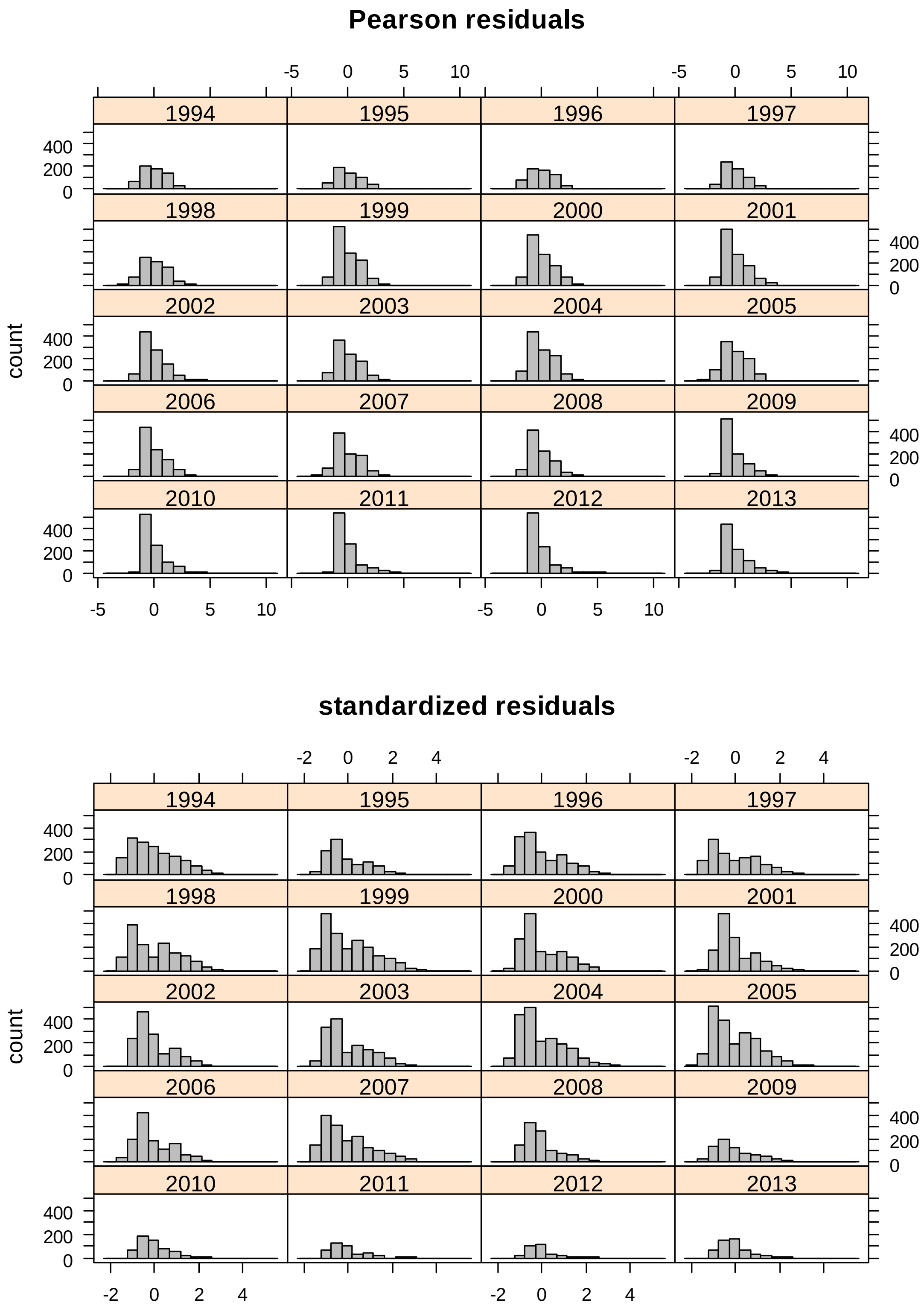

Fig. 3 Residual distributions by year. Upper panels: Pearson residuals in the binomial model of the first step. Lower panels: Standardized residuals in the lognormal model of the second step.

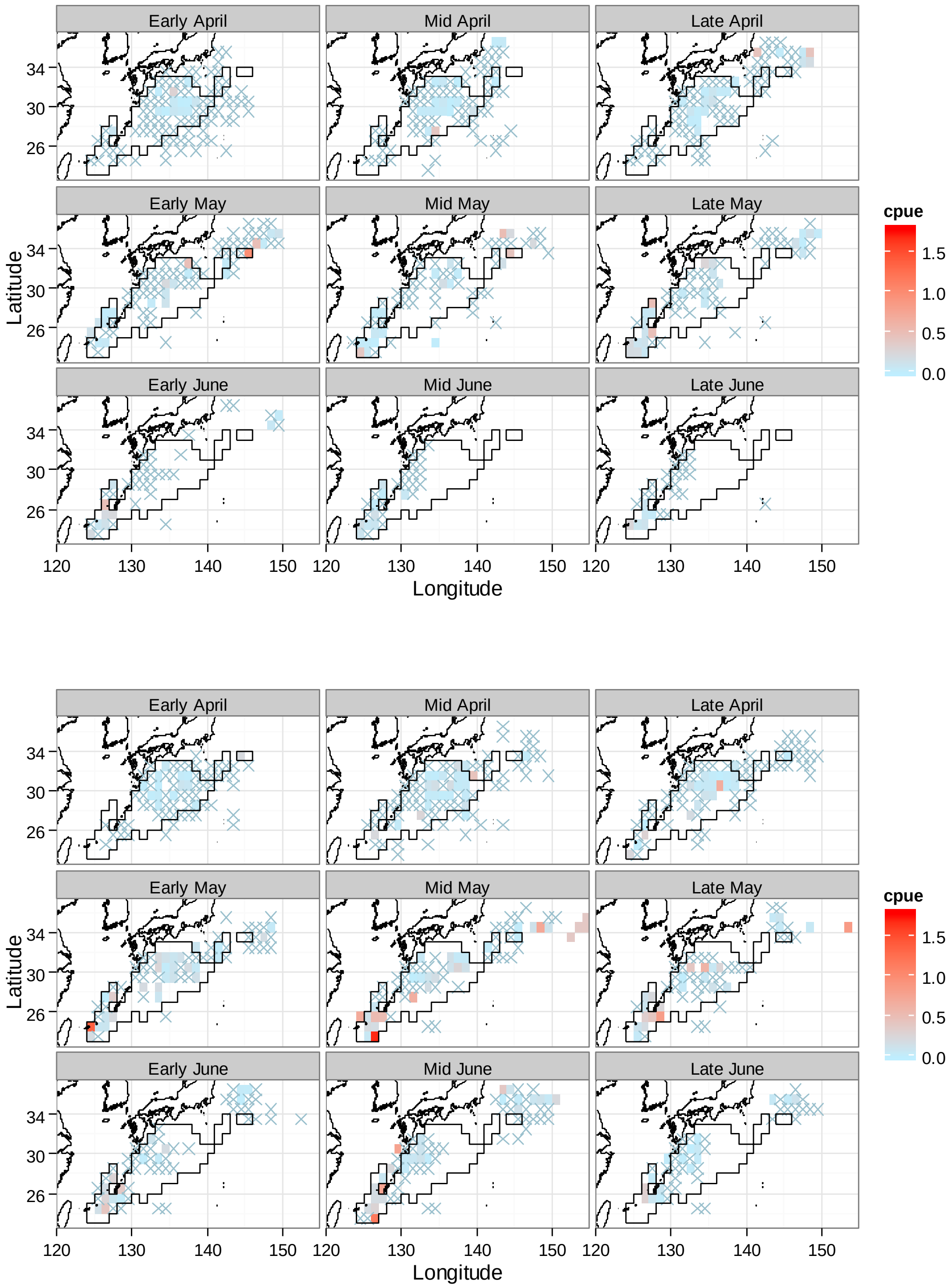

Fig. 4 Geographical distributions of nominal CPUE for PBF caught by Japanese coastal longliners from April to July in 2012 (upper) and 2013 (lower). The blue cross indicates zero catch.

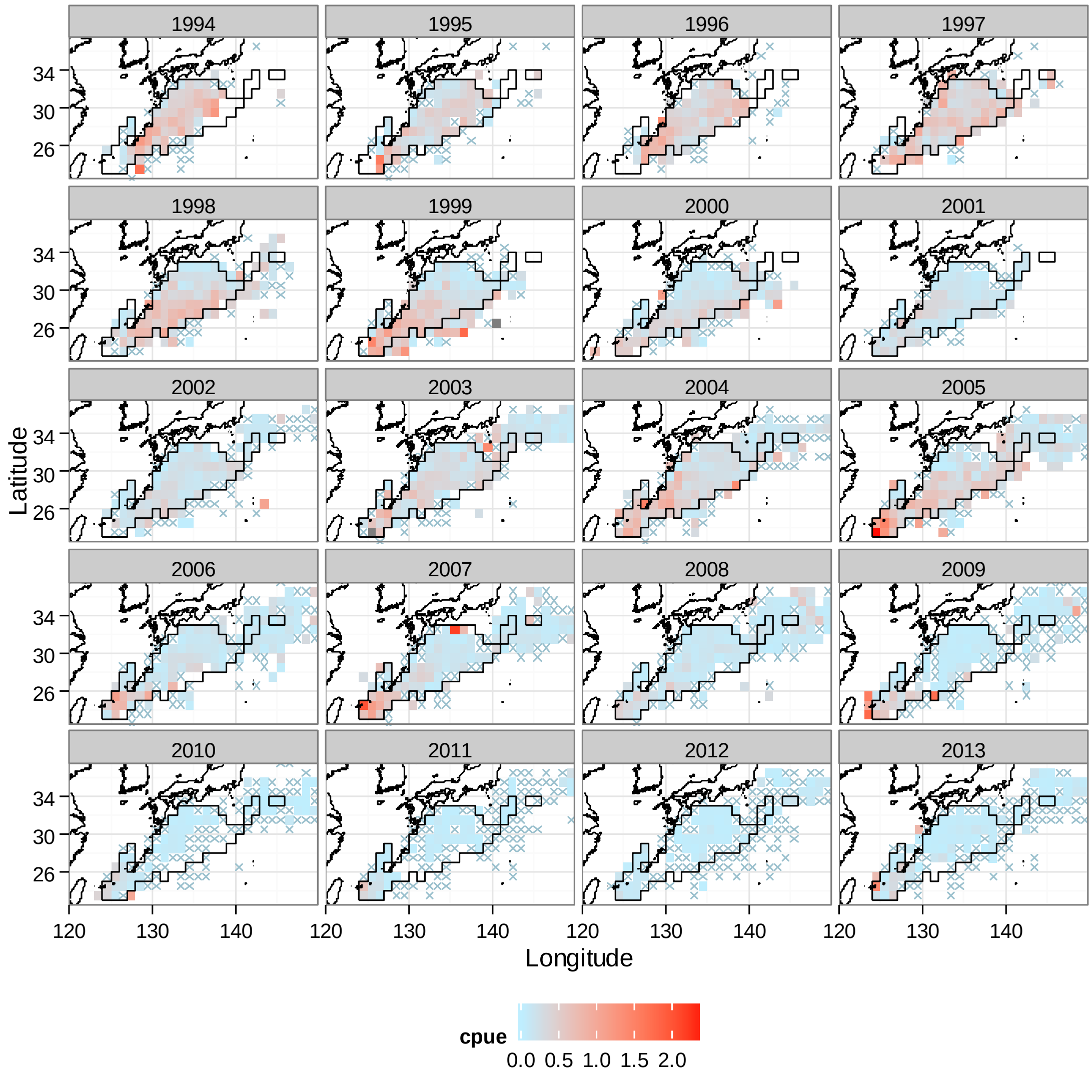

Fig. 5 Geographical distributions of nominal CPUE for PBF from April to July by year. The blue cross indicates zero catch.

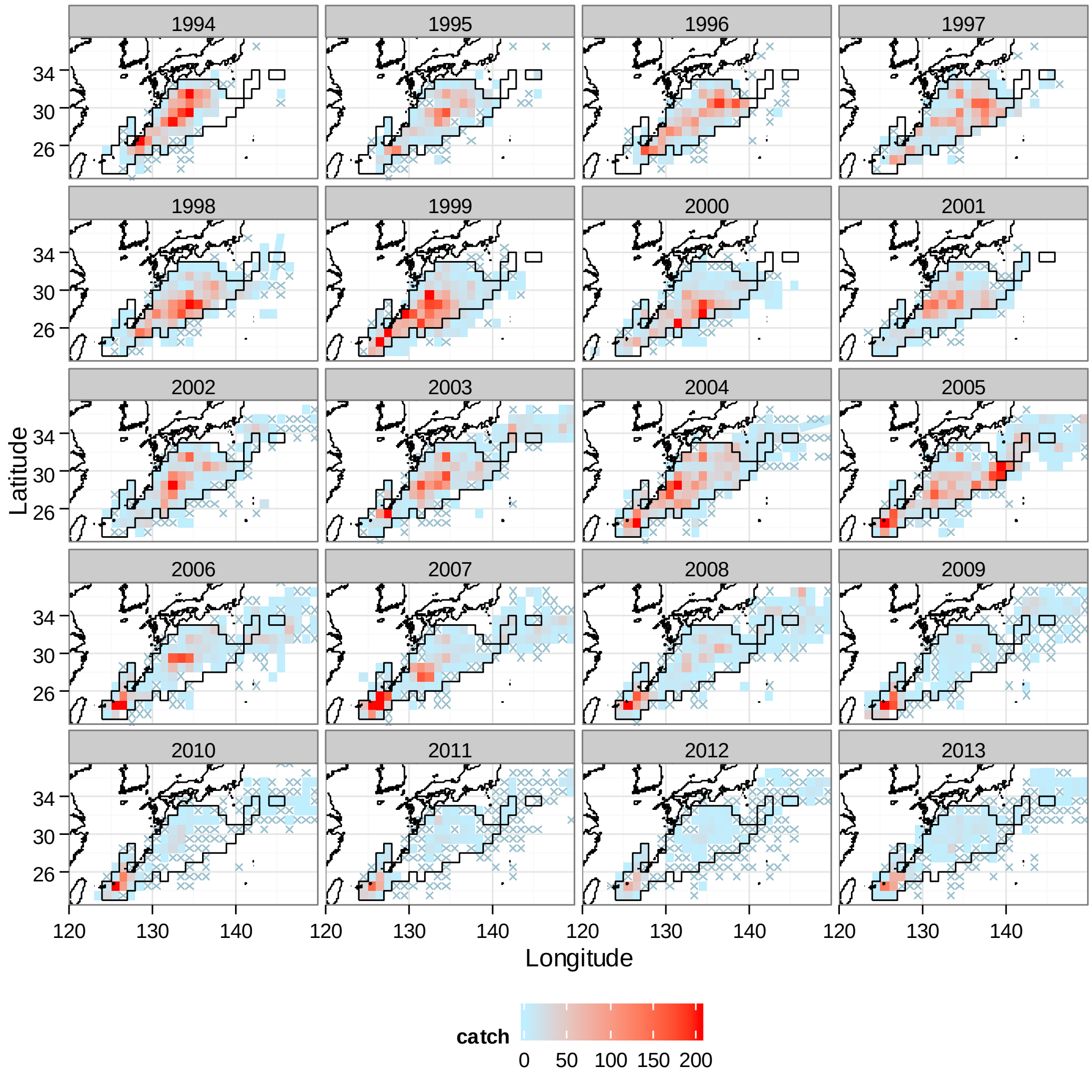

Fig. 6 Geographical distributions of PBF catch from April to July by year. The red color indicates the grid where over 200 individuals were caught and the blue cross indicates zero catch.

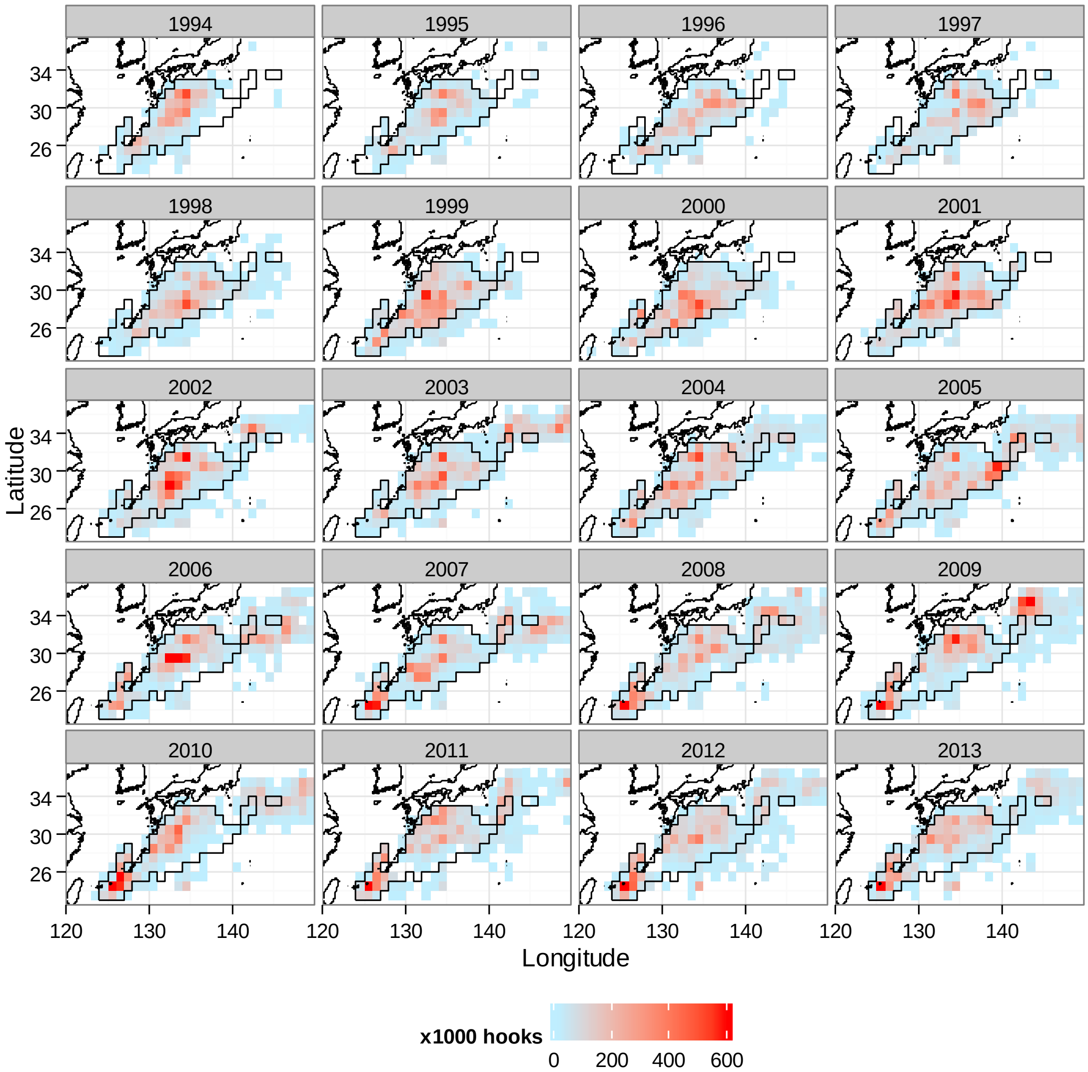

Fig. 7 Geographical distributions of fishing effort from April to July by year. The red color indicates the grid where over 600,000 hooks were used.

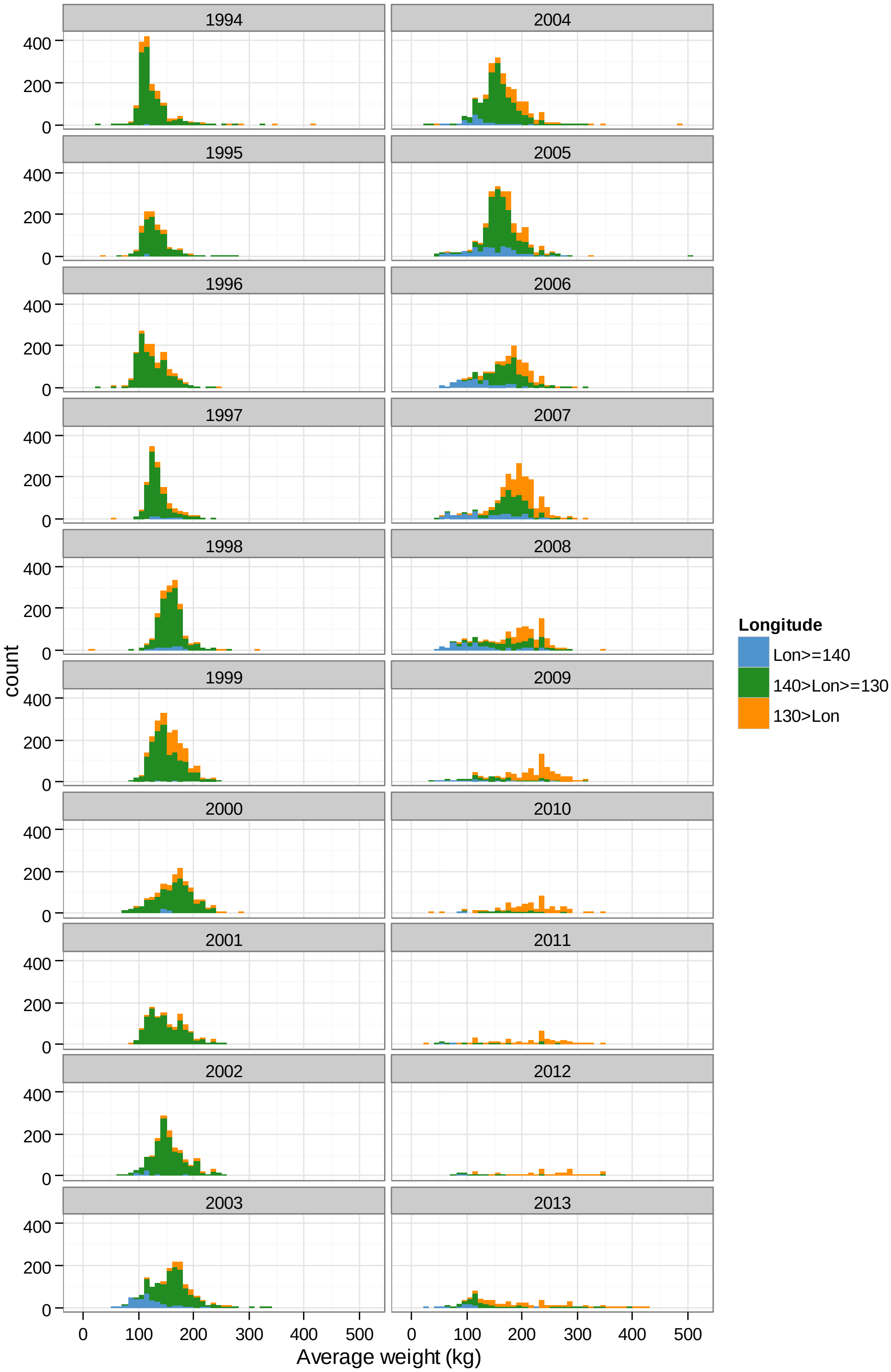

Fig.8 Weight frequencies of PBF caught by Japanese coastal longliners by year and the area divided by longitude line.

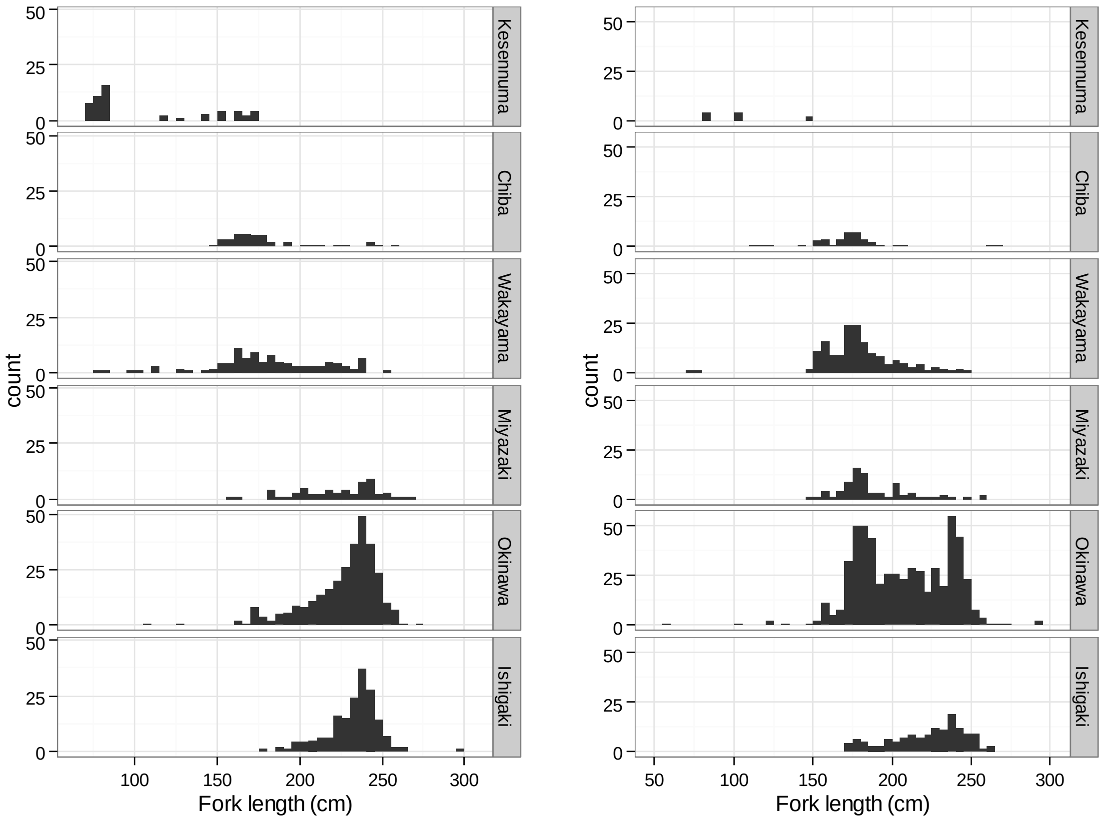

Fig. 9 Length frequencies of PBF caught by Japanese coastal longliners by sampling area in 2012 (left) and 2013 (right). The location of each sampling area is indicated in Fig. 1.