ISC/16/SHARKWG-1/10

Update of Japanese abundance indices for blue shark caught by Japanese offshore and distant water shallow-set longliner in the North Pacific[1]

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Abstract

This working paper provides with update of Japanese abundance indices of North Pacific blue shark (*Prionace glauca*) during 1994 and 2015. Catch per unit of effort (CPUE) was standardized using the generalized linear model with negative binomial distribution errors. A continuous time series of data was used to standardize the CPUE without separation of the data after Tsunami in 2011. A comparison of the standardized CPUEs showed that an annual trend of combined CPUE was almost similar to that of separated CPUE except for the magnitudes of the CPUEs from 2011 to 2015. The annual trends of the combined CPUEs with narrow confidence intervals suggested that the abundance indices of blue shark in the western North Pacific had gradually increased since 1994 to 2005, decreased from 2005 to 2008, and again increased in recent 5 years.

Introduction

Stock assessment of the North Pacific blue shark (*Prionace glauca*) was conducted in 2014 by the shark working group (WG) of International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) (ISC 2014). The abundance indices of blue shark caught by Japanese offshore and distant-water surface longliners was recognized as the most representative one in the stock assessment of the North Pacific blue shark (ISC 2014). The annual changes in the abundance indices were estimated using the generalized linear model with the negative binomial error distribution. In the process of the standardization, Kai *et al*. (2014) and Hiraoka *et al*. (2016) focused on the spatio-temporal changes in targeting from blue shark to swordfish and vice versa. The greatest change in the target shift from swordfish to blue shark was observed in spring (April- June). The fishing grounds shifted from the southwest to the northeast of the North pacific in the early 1990s. Annual trends of the abundance indices from 1994 to 2010 showed an upward population trend that has been caused by a decrease in fishing pressure from the early 1990s due to a ban of drift nets in 1992 and the subsequent decrease in longline vessels (Kai et al., 2014; Hiraoka *et al*., 2016). The abundance indices in 2011 and 2012 were estimated separately from that before 2011 because it was considered that Japanese offshore surface longliners largely changed their operational pattern due to the fact that all shark processing facilities were lost by the tsunami attack in 11th March, 2011(Kai *et al*. 2014). This document paper provides updated annual changes in the abundance indices of blue sharks caught by Japanese offshore and distant-water surface longliners from 1994 to 2015 in the North Pacific.

Materials and Methods

We estimate a continuous time series of abundance indices from 1994 to 2015 using a similar manner to that used in 2014 (Kai *et al*. 2014). However, we need to examine the effects of the changes in the operational patterns on the annual trends in abundance indices due to the Tsunami in 2011. Therefore, we compare two abundance indices estimated from the separated data after 2010 and combined data.

Data source

Set-by-set logbook data from Japanese offshore and distant water longline fishery are used to standardize CPUE for 1994-2015. The logbook data contain, for each set operation, information on latitude and longitude by 1×1 degree, day, month, year, catch in number of tunas, billfishes and sharks species, gear configurations such as a hooks between floats (HBF), ship name and the registered prefecture, fishery type such as offshore (Kinkai) longliner (vessel tonnage is 20-120 MT) and distant-water (Enyo) longliner (vessel tonnage is larger than 120 MT), and so on.

Selection of logbook data

Reliable data are extracted from the logbook data based on two criterions (Kai *et al*. 2014; Hiraoka *et al*., 2016): 1) shallow-set longliner (HBF <7) based at ports in Tohoku and Hokkaido areas. 2) reporting rate of blue shark positive catch by vessels (RRV) as defined by Clarke et al. (2011): the number of sets with sharks recorded divided by the total number of sets should be greater than or equal to 94.6 %. The data in area-5 (**Figure 1**) was not used for the CPUE standardization due to a small number of set-by-set data after the data selection.

Update of the CPUE series

Annual trends of the abundance indices were estimated using a generalized linear model (GLM) with negative binomial error distribution. The full model (Kai *et al*. 2014; Hiraoka et al., 2016) was defined as follows:

$$\mathrm{E}[Catch_{tijkl}] = \exp\{\mathrm{Intercept} + Year_t + Area_i + Quarter_j + Fishery_k + Target_l + (Year * Target)_{tl} + (Quarter * Target)_{jl}\} \times \mathrm{offset}(Effort), \quad (1)$$

$$\mathrm{V}[Catch] = \mu + \frac{\mu^2}{k} \ ,$$

$$Catch \sim \mathrm{NB}(\mu, k) \ ,$$

where $\mathrm{E}[Catch_{tijkl}]$ is the expected value of $Catch_{tijkl}$; $Year_t$ (t=1994-2015), $Area_i$ (i=1-4), $Quarter_j$ (j=Jan.-Mar., Apr.-Jun., Jul.-Sept., and Oct.-Dec.), $Fishery_k$ (k=Offshore and Distant-water) and $Target_l$ (10th percentile ranking of swordfish CPUE, l=1-10) are defined as categorical explanatory variables; $(Year * Target)_{tl}$ and $(Quarter * Target)_{jl}$ are interaction between $Year$ and $Target$, and $Quarter$ and $Target$, respectively, $Effort$ is the number of hooks (x 1000) as an offset variable; $\mathrm{V}[Catch]$ is the variance in Catch; NB stands for Negative

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binomial; μ is the mean; and k is the dispersion parameter.

It was necessary to include $Year * Target$ interactions to standardize the annual targeting shift trend. The $Quarter * Target$ interaction was also included because fishermen change target species by seasons and areas (Ishimura and Bailey, 2013) but the "Target*Area" interaction was not included due to a lack of sufficient data .

The best model was selected using the Akaike's information criterion (AIC) and Bayesian information criterion (BIC). The goodness of fit was examined using the residual patterns of GLMs by the factor of all, year, season, area, fishery type, and target effects. The analysis of variance (ANOVA) was also conducted to check the effects of each factor on the fitting. The 95% confidence intervals and the coefficient of variations (C.V., %) are computed using the bootstrapping method with 1000 resampling data. The bootstrapping data are resampled with respect to a given stratum (i.e. year, season, area, fishery type and target effect).

Results

The full model was selected by AIC and BIC (**Table 1**). ANOVA table indicated that all selected factors are statistically significant (**Table 2**). As a whole, the model fitted well to the data, while the shape of the normal distribution of residuals and the residual patterns for all factors were slightly biased toward the negative direction (**Figure 2**). Q-Q plots indicated that the right ends of the plots were deviated from the straight line but the proportion of the outlier to all was small (**Figure A1**). A comparison of the standardized CPUEs showed that an annual trend of combined CPUE was almost similar to that of separated CPUE (**Table 3**, **Figure 3**). However, the magnitude of combined CPUEs from 2012 to 2015 were slightly lower than those of the separated CPUEs (**Table 3**). Standardized CPUEs of combined CPUE (base case) had gradually increased since 1994 to 2005, but it had decreased from 2005 to 2008. After that, the CPUEs were fluctuated around the mean value (catch number of blue shark per 1000 hooks was 16.64) and showed a slight increasing trends in recent five years (**Table 3**, **Figure 4**). The estimated confidence intervals were narrow throughout the years (**Table 3**, **Figure 4**).

Discussion

We provided update of the standardized CPUE for north Pacific blue shark caught by Japanese shallow-set longline fishery in the offshore and distant-water from 1994 to 2015. The annual trends of the CPUEs suggested that the abundance indices of blue shark in the western north Pacific are slightly increasing in recent 5 years (**Figure 4**). In particular, the magnitude of the CPUE in 2015 (catch in number = 18.31) was higher than any other CPUEs in recent 10 years due to the sharp reduction in the fishing effort in 2015 (**Figure 5**). Seasonal changes in nominal CPUEs for blue sharks at the fishing locations and ranking of CPUE for swordfish showed that there were no

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clear patterns of targeting shifts as well as the changes in the nominal CPUEs between before and after Tsunami in 2011 (**Figure 6**). For example, the CPUEs of blue shark in the southern areas (areas 3 and 4) are quite lower than those in the northern areas (areas 1 and 2), and higher rankings of the swordfish were appeared in quarter-1 and -4. These results support to combine the CPUEs before and after Tsunami in 2011.

We conducted cluster analyses to examine the confirmation of the target shift. The method implemented in the hclust function (Hoyle et al., 2015).It was shown that cluster 3 (light grey, blue thick line) indicates blue shark, cluster 2 (grey, red broken line) indicates bigeye tuna, and cluster 1(dark grey, black line) indicates swordfish (Fig. A2). Target changes from swordfish and bigeye to blue shark was appeared around 2000 (Fig. A2).

We also examined the impacts of the each explanatory variable on the trends in the standardized CPUE. The result suggested that area and quarter had a large impact on the changes in the trends of the standardized CPUE (Fig. A3).

In conclusion, we would like to propose the standardized CPUEs of blue shark caught by Japanese offshore and distant-water longline fishery in the western North pacific from 1994 to 2015 as a representative abundance indices of North Pacific blue shark because a wide coverage of the main distributional areas of blue shark (30 – 45N and 135E – 170W) and the wide coverage of the size classes as well as both sexes for blue sharks (around 50~250 cm in PCL).

Reference

Clarke, S., Yokawa, K., Matsunaga, H., and Nakano, H. 2011. Analysis of North Pacific Shark Data from Japanese Commercial Longline and Research/Training Vessel Records. WCPFC/SC7/2011/EB/WP02

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Kai, M., Shiozaki, K., Ohshimo, S., Yokawa, K., Takahashi, N., and Kanaiwa, M. 2014. Update of Japanese abundance indices and catch for blue shark *Prionca glauca* in the North Pacific. ISC/13/SHARKWG-3/01.

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Table 1. Summary of the model selection by Akaike's information criterion (AIC) and Baysian information criterion (BIC). Delta (Δ) denotes an absolute value of the difference between AIC and the minimum AIC. Y: Year, S: Season, A: Area, F: Fishery type, T: Target effect of swordfish, Y*T and S*T are interaction terms.

No	Model	ΔAIC	ΔBIC
1	Y	34517	32326
2	Y+T	21815	19709
3	Y+S	26507	24345
4	Y+A	22437	20274
5	Y+F	34485	32304
6	Y+S+T	19180	17103
7	Y+S+A	10126	7991
8	Y+T+A	12852	10774
9	Y+S+A+T	8020	5971
10	Y+S+A+F	10107	7982
11	Y+S+A+F + T	8000	5961
12	Y+S+A+F + T + Y*T	3165	2910
13	Y+S+A+F + T + S*T	4712	2927
14	Y+S+A+F + T + Y*T + S*T	0	0

Table 2. Analysis of variance (ANOVA) summary table of base case.

	LR Chisq	Df	Pr(>Chisq)
as.factor(year)	2334.1	21	< 0.001
as.factor(qt)	3455.5	3	< 0.001
as.factor(area)	7203.3	3	< 0.001
as.factor(target)	2312.1	9	< 0.001
as.factor(gyogyoucode)	13.6	1	< 0.001
as.factor(year):as.factor(target)	5208.2	189	< 0.001
as.factor(qt):as.factor(target)	3266	27	< 0.001

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Table 3. Nominal and standardized CPUE, the coefficient of variations (C.V., %), and scaled nominal and standardized CPUE by its average for North Pacific blue shark caught by Japanese offshore and distant water longline fisheries. Combined data denotes a series of the data without separation of the data before and after 2011 earthquake off the Pacific coast of Tohoku.

	Combined data					Separated data			
year	Nominal cpue	Standardized cpue	C.V.	Scaled nominal cpue	Scaled standardized cpue	Nominal cpue	Standardized cpue	Scaled nominal cpue	Scaled standardized cpue
1994	9.48	11.93	1.45	0.46	0.72	9.48	11.54	0.44	0.69
1995	13.03	13.96	1.36	0.63	0.84	13.03	13.46	0.60	0.80
1996	13.91	13.35	1.41	0.67	0.80	13.91	12.99	0.64	0.77
1997	24.26	16.17	1.33	1.17	0.97	24.26	15.67	1.12	0.93
1998	18.53	16.30	1.41	0.89	0.98	18.53	15.92	0.86	0.95
1999	20.29	17.43	1.51	0.98	1.05	20.29	17.35	0.94	1.03
2000	19.58	17.46	1.45	0.94	1.05	19.58	17.47	0.90	1.04
2001	38.38	19.78	1.40	1.85	1.19	38.38	19.81	1.77	1.18
2002	26.18	19.50	1.47	1.26	1.17	26.18	19.53	1.21	1.16
2003	30.40	20.92	1.43	1.46	1.26	30.40	20.79	1.40	1.23
2004	21.12	18.72	1.39	1.02	1.12	21.12	18.67	0.98	1.11
2005	24.63	20.81	1.89	1.19	1.25	24.63	20.76	1.14	1.23
2006	26.41	18.29	2.03	1.27	1.10	26.41	18.22	1.22	1.08
2007	25.70	14.99	1.72	1.24	0.90	25.70	14.94	1.19	0.89
2008	11.87	14.03	1.98	0.57	0.84	11.87	13.99	0.55	0.83
2009	22.67	17.79	1.95	1.09	1.07	22.67	17.68	1.05	1.05
2010	21.42	17.52	2.17	1.03	1.05	21.42	17.47	0.99	1.04
2011	17.38	13.84	2.91	0.84	0.83	17.38	14.14	0.98	0.86
2012	15.45	15.94	2.33	0.74	0.96	15.45	17.45	0.87	1.06
2013	17.04	14.71	1.99	0.82	0.88	17.04	16.48	0.96	1.00
2014	17.49	14.50	2.05	0.84	0.87	17.49	15.71	0.98	0.95
2015	21.56	18.31	2.18	1.04	1.10	21.56	18.79	1.21	1.14

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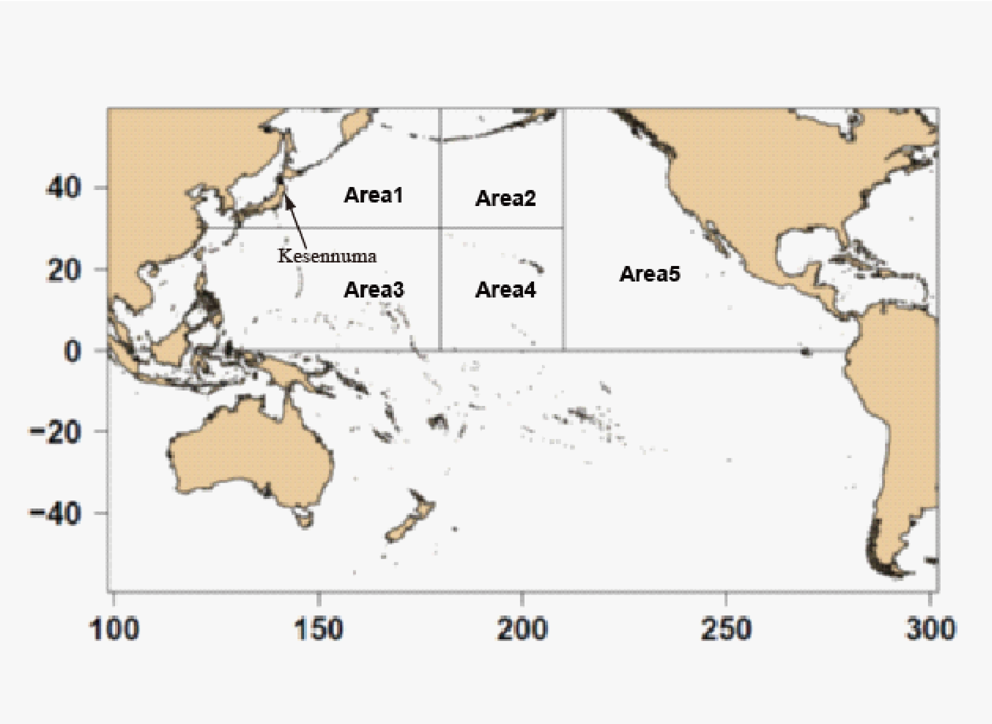

Figure 1. Area stratification designated by shark working group for the data analyses of blue shark in the North Pacific Ocean. "Kesennuma" is the major fishing port of the landings for blue sharks and swordfish.

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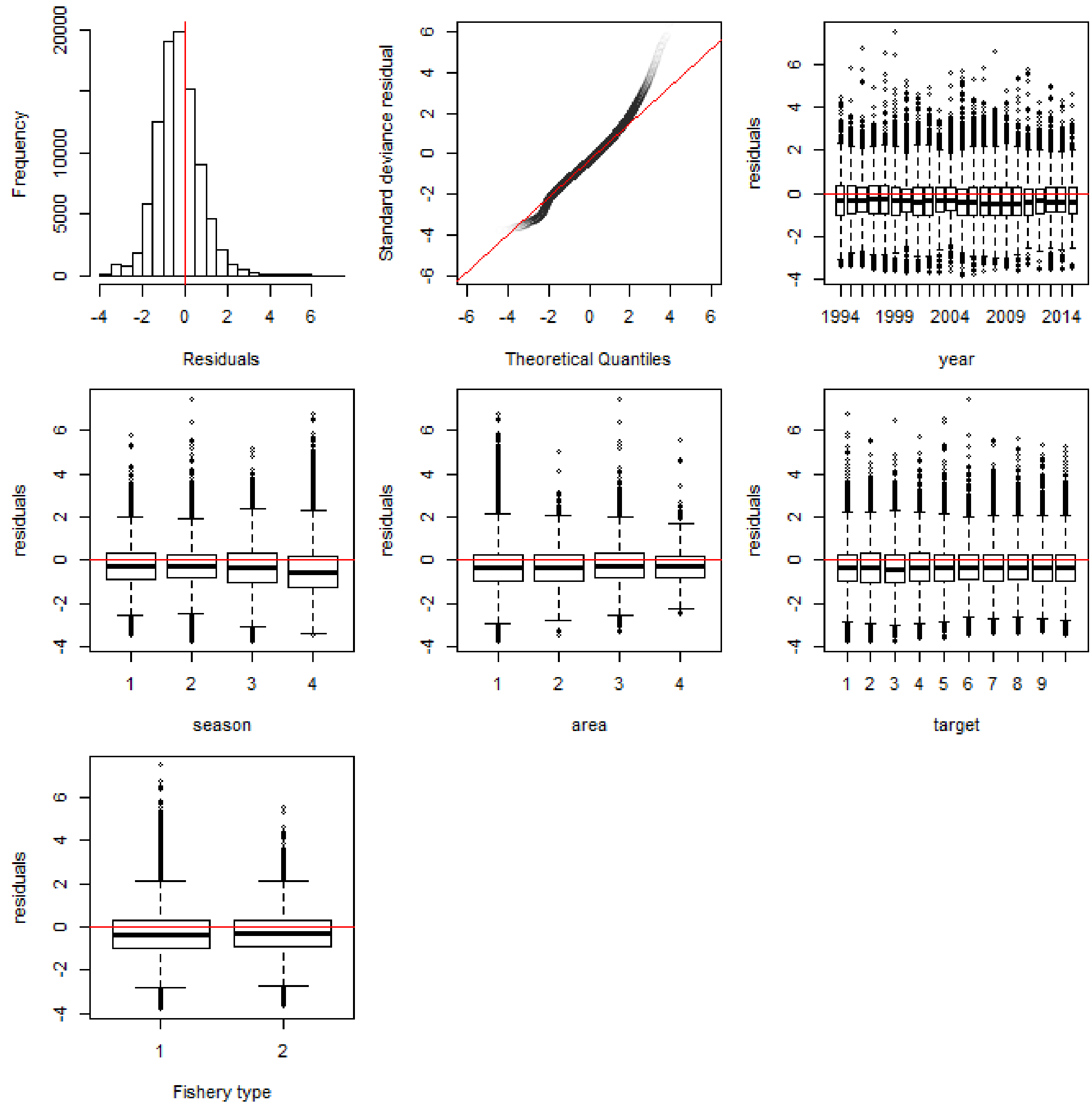

Figure 2. Diagnostic of the goodness of fit for the base case model. Residual patterns of GLMs for standardized CPUE of Japanese offshore and distant water shallow fishery.

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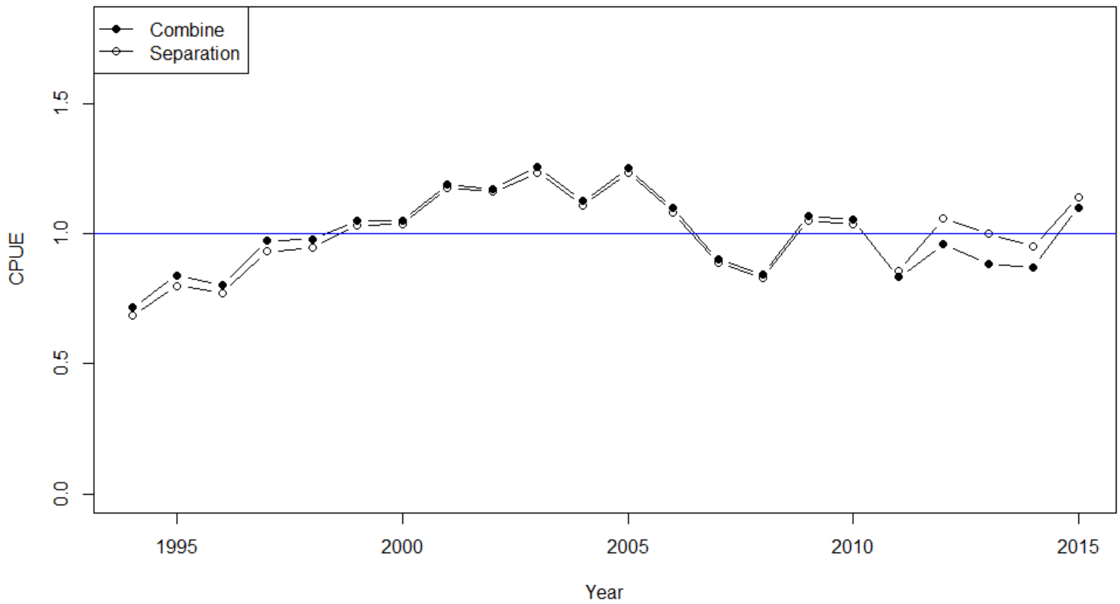

Figure 3. Comparisons of the annual trends of standardized CPUEs between combined data (black) and separated data after 2010 (grey). The CPUEs were scaled by the averages.

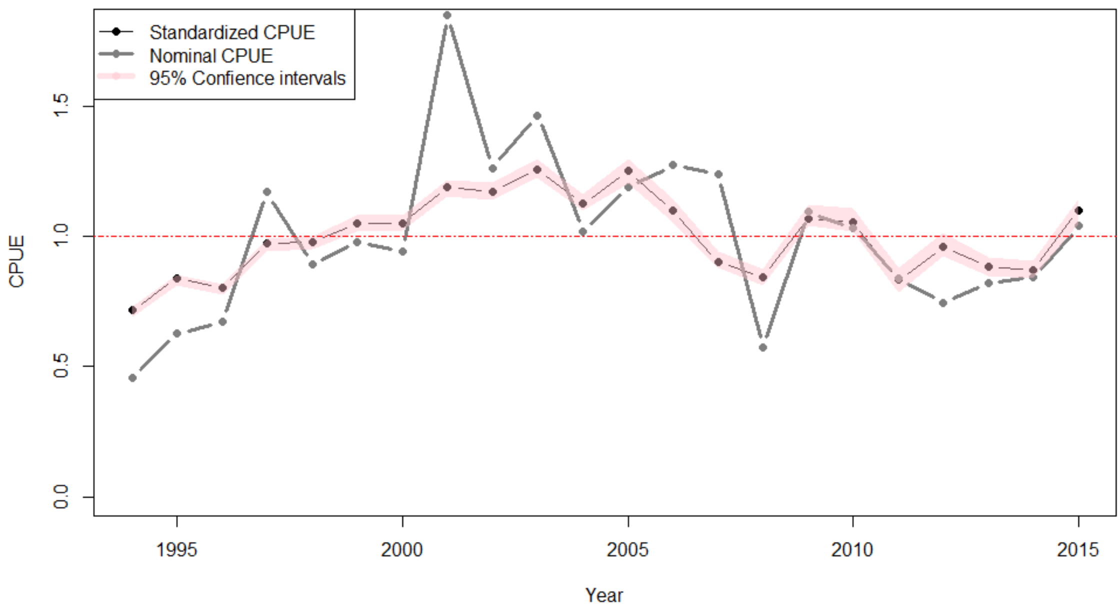

Figure 4. Updated annual trends of abundance indices for North Pacific blue shark and the 95% confidence intervals estimated from bootstrapping with 1000 resampling data.

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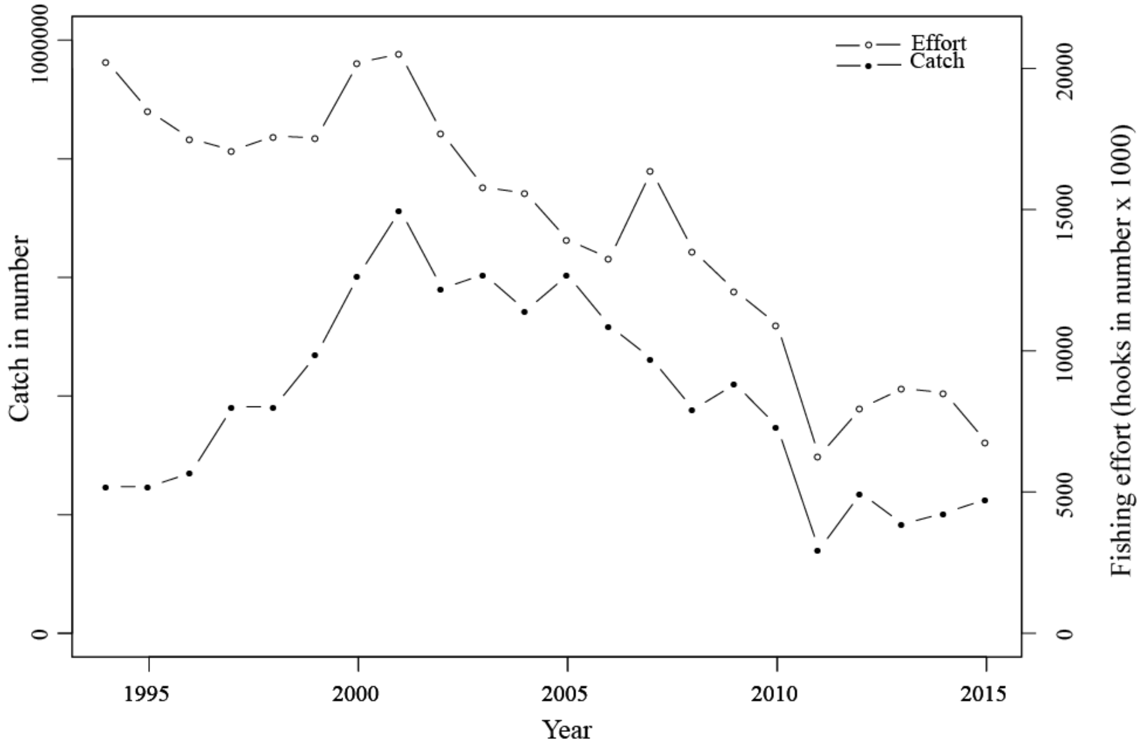

Figure 5. Annual trends of catch in number of blue shark and fishing effort (hooks in number x 1000).

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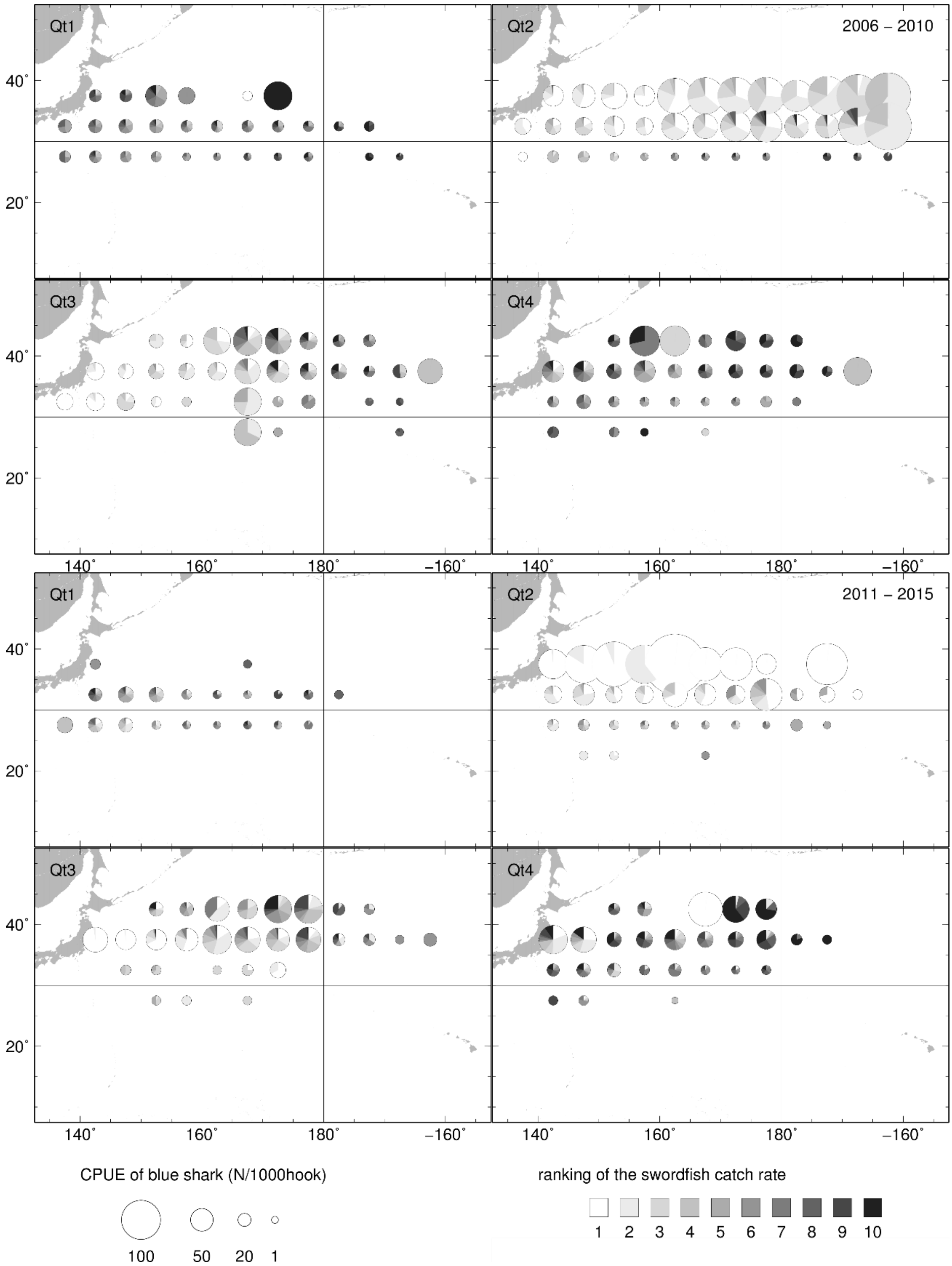

Figure 6. Seasonal changes in CPUE for blue shark and ranking of CPUE for swordfish at the fishing location (5 x 5 degrees) from 2006 to 2015. The size of pie chart denotes CPUE of blue shark and darker color denotes higher ranking of CPUE for swordfish.

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Appendix

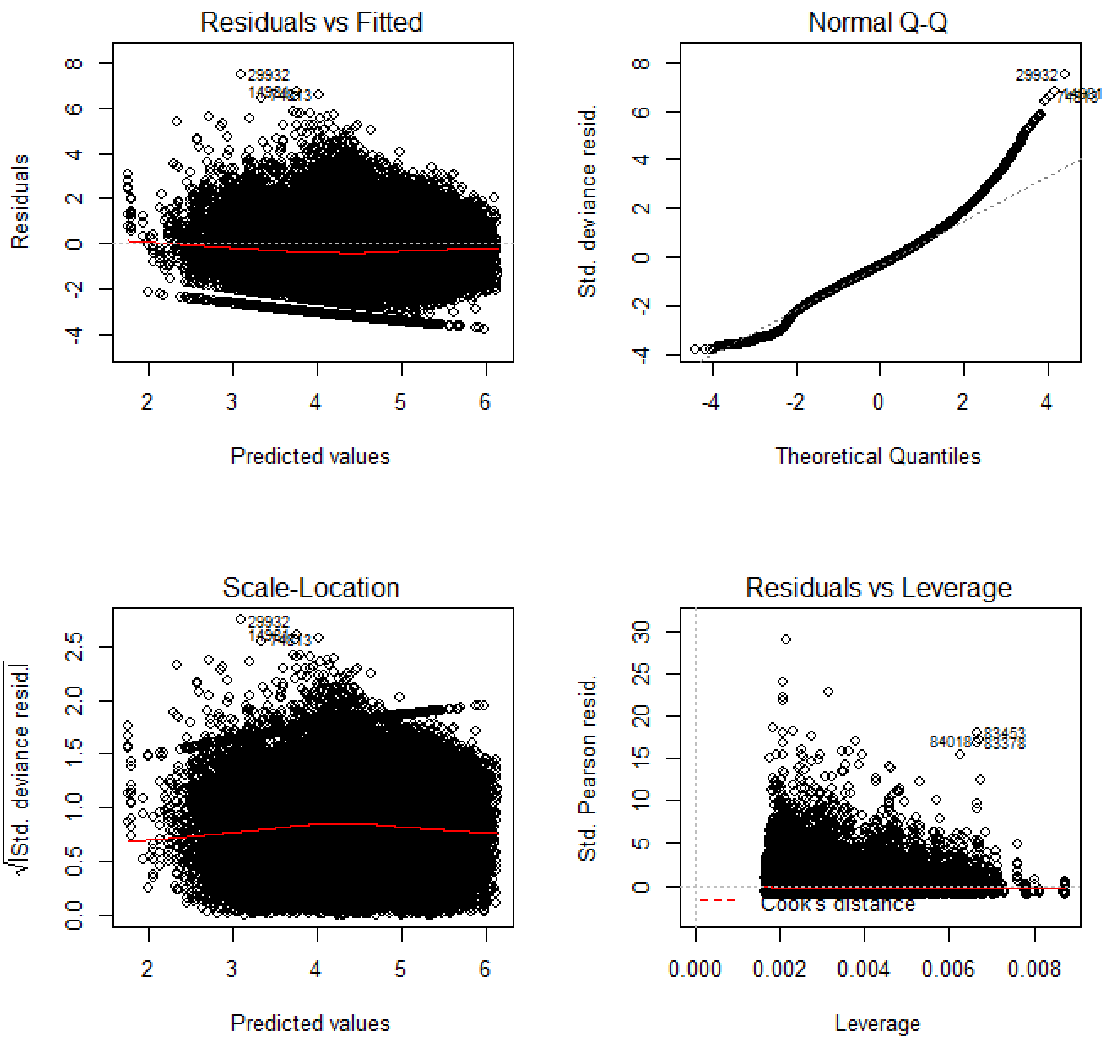

Figure A1. Diagnostics of the GLM analysis for Japanese CPUE standardization during 1994 to 2015.

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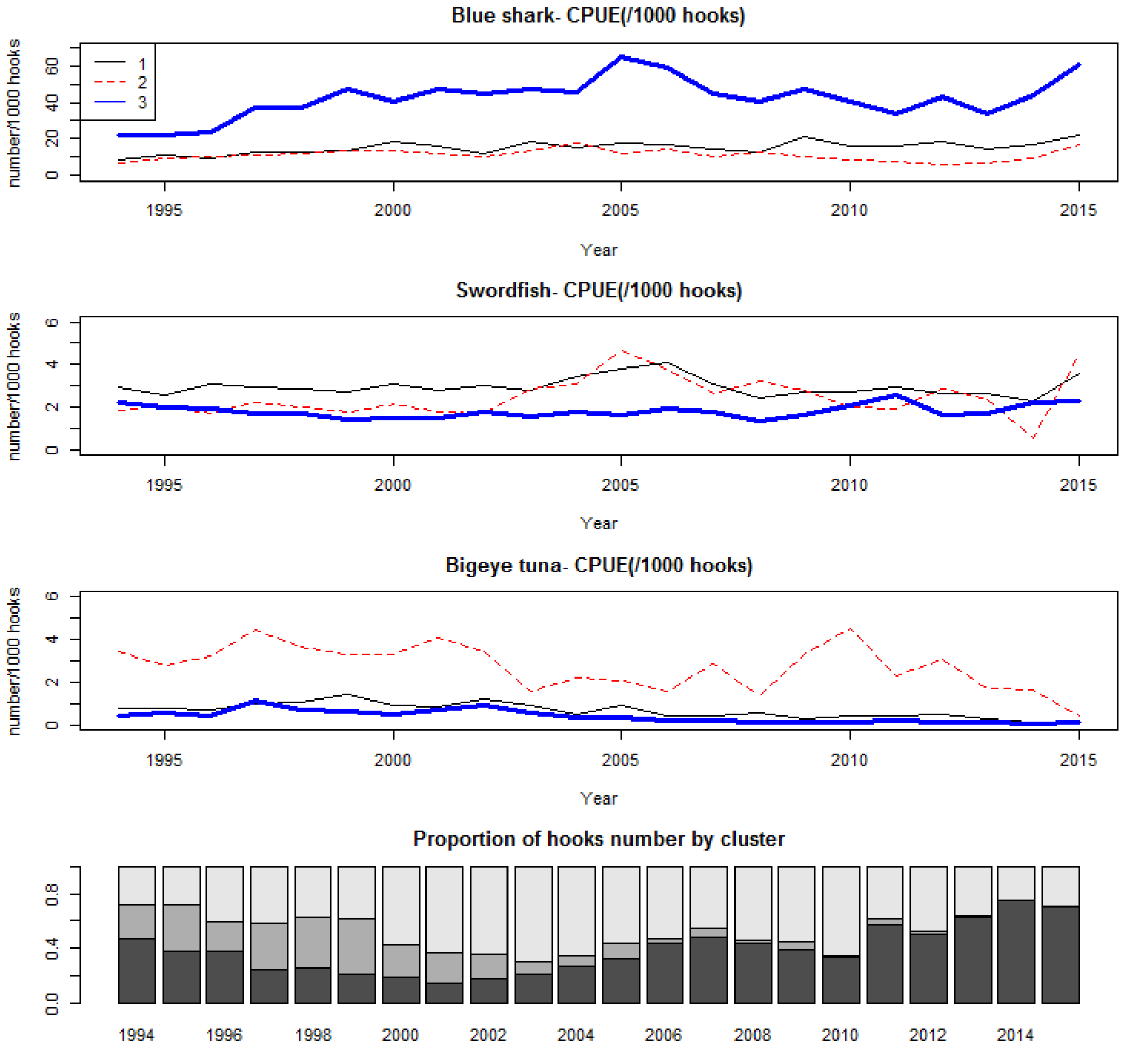

Figure A2. Annual changes in the nominal CPUE of three species and proportions of the number of hooks for the cluster 1, 2, and 3. Clustering (Ward's hclust 'Ward.D' method) was applied after aggregating by trip.

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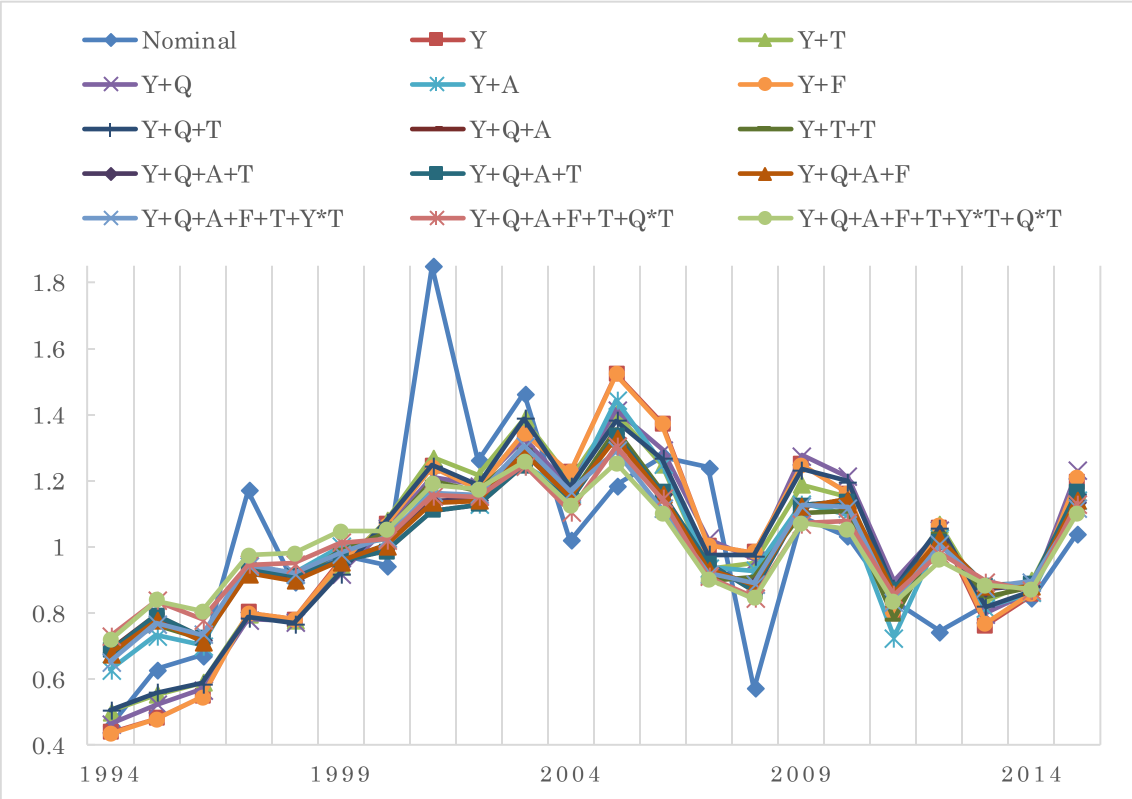

Figure 3. Annual changes in the standardized CPUE by multiple models and nominal CPUE. Explanatory variables were sequentially added to the null model.

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Summary of the GLM

Call:

glm.nb(formula = blshark ~ as.factor(year) + as.factor(qt) +
    as.factor(area) + as.factor(target) + as.factor(gyogyoucode) +
    as.factor(year):as.factor(target) + as.factor(qt):as.factor(target) +
    offset(log(hook)), data = temp, init.theta = 1.244779443,
    link = log)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-3.7867	-0.9579	-0.3572	0.2866	7.4947

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-4.474768	0.062835	-71.215	< 2e-16	***
as.factor(year)1995	0.251880	0.053762	4.685	2.80e-06	***
as.factor(year)1996	0.396501	0.053092	7.468	8.14e-14	***
as.factor(year)1997	0.821075	0.054525	15.059	< 2e-16	***
as.factor(year)1998	0.871418	0.054184	16.083	< 2e-16	***
as.factor(year)1999	0.904139	0.055089	16.412	< 2e-16	***
as.factor(year)2000	0.799487	0.053900	14.833	< 2e-16	***
as.factor(year)2001	0.902969	0.054122	16.684	< 2e-16	***
as.factor(year)2002	0.839322	0.056527	14.848	< 2e-16	***
as.factor(year)2003	0.650341	0.058107	11.192	< 2e-16	***
as.factor(year)2004	0.779728	0.059141	13.184	< 2e-16	***
as.factor(year)2005	1.185930	0.061131	19.400	< 2e-16	***
as.factor(year)2006	0.944648	0.062383	15.143	< 2e-16	***
as.factor(year)2007	0.885820	0.058769	15.073	< 2e-16	***
as.factor(year)2008	0.494439	0.061652	8.020	1.06e-15	***
as.factor(year)2009	0.933745	0.063927	14.606	< 2e-16	***
as.factor(year)2010	0.845774	0.066495	12.719	< 2e-16	***
as.factor(year)2011	0.795247	0.080080	9.931	< 2e-16	***
as.factor(year)2012	0.782884	0.073211	10.693	< 2e-16	***
as.factor(year)2013	0.857820	0.069271	12.384	< 2e-16	***
as.factor(year)2014	0.745079	0.070024	10.640	< 2e-16	***
as.factor(year)2015	1.429383	0.075774	18.864	< 2e-16	***

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as.factor(qt)2	0.927142	0.054411	17.040	< 2e-16	***
as.factor(qt)3	0.702892	0.054237	12.960	< 2e-16	***
as.factor(qt)4	-0.254362	0.056814	-4.477	7.57e-06	***
as.factor(area)2	-0.041018	0.018836	-2.178	0.029437	*
as.factor(area)3	-0.970266	0.011279	-86.026	< 2e-16	***
as.factor(area)4	-1.365522	0.036573	-37.337	< 2e-16	***
as.factor(target)2	-0.140283	0.081065	-1.730	0.083543	.
as.factor(target)3	0.017174	0.077075	0.223	0.823674	
as.factor(target)4	0.263144	0.075077	3.505	0.000457	***
as.factor(target)5	0.478718	0.076038	6.296	3.06e-10	***
as.factor(target)6	0.722566	0.075159	9.614	< 2e-16	***
as.factor(target)7	0.616438	0.075361	8.180	2.84e-16	***
as.factor(target)8	0.515863	0.075804	6.805	1.01e-11	***
as.factor(target)9	0.626231	0.073838	8.481	< 2e-16	***
as.factor(target)10	0.565093	0.073342	7.705	1.31e-14	***
as.factor(gyogyoucode)2	-0.032250	0.008691	-3.711	0.000207	***
as.factor(year)1995:as.factor(target)2	0.113523	0.076042	1.493	0.135465	
as.factor(year)1996:as.factor(target)2	0.199245	0.075675	2.633	0.008466	**
as.factor(year)1997:as.factor(target)2	0.066203	0.077029	0.859	0.390089	
as.factor(year)1998:as.factor(target)2	-0.019442	0.076805	-0.253	0.800163	
as.factor(year)1999:as.factor(target)2	0.294032	0.077160	3.811	0.000139	***
as.factor(year)2000:as.factor(target)2	0.451194	0.075921	5.943	2.80e-09	***
as.factor(year)2001:as.factor(target)2	0.319522	0.076158	4.196	2.72e-05	***
as.factor(year)2002:as.factor(target)2	0.341096	0.079019	4.317	1.58e-05	***
as.factor(year)2003:as.factor(target)2	0.566921	0.081460	6.960	3.41e-12	***
as.factor(year)2004:as.factor(target)2	0.577935	0.082982	6.965	3.29e-12	***
as.factor(year)2005:as.factor(target)2	0.505573	0.085741	5.896	3.71e-09	***
as.factor(year)2006:as.factor(target)2	0.781414	0.087315	8.949	< 2e-16	***
as.factor(year)2007:as.factor(target)2	0.395958	0.082420	4.804	1.55e-06	***
as.factor(year)2008:as.factor(target)2	0.629564	0.087005	7.236	4.62e-13	***
as.factor(year)2009:as.factor(target)2	0.456550	0.090444	5.048	4.47e-07	***
as.factor(year)2010:as.factor(target)2	0.489778	0.093852	5.219	1.80e-07	***
as.factor(year)2011:as.factor(target)2	0.072818	0.113153	0.644	0.519879	
as.factor(year)2012:as.factor(target)2	0.321151	0.102838	3.123	0.001791	**
as.factor(year)2013:as.factor(target)2	-0.199942	0.098043	-2.039	0.041417	*
as.factor(year)2014:as.factor(target)2	0.182522	0.098942	1.845	0.065077	.

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as.factor(year)2015:as.factor(target)2	-0.113175	0.106302	-1.065	0.287030	
as.factor(year)1995:as.factor(target)3	0.039817	0.075965	0.524	0.600176	
as.factor(year)1996:as.factor(target)3	0.035387	0.075548	0.468	0.639499	
as.factor(year)1997:as.factor(target)3	-0.333334	0.077128	-4.322	1.55e-05	***
as.factor(year)1998:as.factor(target)3	-0.159012	0.076594	-2.076	0.037891	*
as.factor(year)1999:as.factor(target)3	-0.123565	0.077560	-1.593	0.111126	
as.factor(year)2000:as.factor(target)3	0.158830	0.075364	2.108	0.035073	*
as.factor(year)2001:as.factor(target)3	0.219806	0.075238	2.921	0.003484	**
as.factor(year)2002:as.factor(target)3	0.037391	0.078638	0.475	0.634443	
as.factor(year)2003:as.factor(target)3	0.678124	0.081358	8.335	< 2e-16	***
as.factor(year)2004:as.factor(target)3	0.325753	0.082452	3.951	7.79e-05	***
as.factor(year)2005:as.factor(target)3	0.394864	0.085436	4.622	3.81e-06	***
as.factor(year)2006:as.factor(target)3	0.593329	0.087394	6.789	1.13e-11	***
as.factor(year)2007:as.factor(target)3	0.305762	0.081918	3.733	0.000190	***
as.factor(year)2008:as.factor(target)3	0.565697	0.086583	6.534	6.42e-11	***
as.factor(year)2009:as.factor(target)3	0.339927	0.089284	3.807	0.000141	***
as.factor(year)2010:as.factor(target)3	0.052310	0.093448	0.560	0.575632	
as.factor(year)2011:as.factor(target)3	-0.183971	0.113661	-1.619	0.105533	
as.factor(year)2012:as.factor(target)3	0.129828	0.102907	1.262	0.207092	
as.factor(year)2013:as.factor(target)3	-0.510676	0.098310	-5.195	2.05e-07	***
as.factor(year)2014:as.factor(target)3	-0.127497	0.098526	-1.294	0.195651	
as.factor(year)2015:as.factor(target)3	-0.642375	0.107044	-6.001	1.96e-09	***
as.factor(year)1995:as.factor(target)4	-0.054216	0.076026	-0.713	0.475771	
as.factor(year)1996:as.factor(target)4	-0.260430	0.075613	-3.444	0.000573	***
as.factor(year)1997:as.factor(target)4	-0.590891	0.076565	-7.718	1.19e-14	***
as.factor(year)1998:as.factor(target)4	-0.616003	0.076603	-8.041	8.88e-16	***
as.factor(year)1999:as.factor(target)4	-0.440260	0.077211	-5.702	1.18e-08	***
as.factor(year)2000:as.factor(target)4	-0.427217	0.075096	-5.689	1.28e-08	***
as.factor(year)2001:as.factor(target)4	-0.420924	0.075823	-5.551	2.83e-08	***
as.factor(year)2002:as.factor(target)4	-0.018806	0.078783	-0.239	0.811332	
as.factor(year)2003:as.factor(target)4	0.212955	0.080615	2.642	0.008250	**
as.factor(year)2004:as.factor(target)4	-0.011918	0.081998	-0.145	0.884443	
as.factor(year)2005:as.factor(target)4	-0.089993	0.084823	-1.061	0.288713	
as.factor(year)2006:as.factor(target)4	-0.021298	0.086647	-0.246	0.805839	
as.factor(year)2007:as.factor(target)4	-0.437635	0.081490	-5.370	7.86e-08	***
as.factor(year)2008:as.factor(target)4	0.167557	0.086162	1.945	0.051813	.

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as.factor(year)2009:as.factor(target)4	-0.101501	0.089342	-1.136	0.255913	
as.factor(year)2010:as.factor(target)4	-0.485963	0.093758	-5.183	2.18e-07	***
as.factor(year)2011:as.factor(target)4	-0.643496	0.113451	-5.672	1.41e-08	***
as.factor(year)2012:as.factor(target)4	-0.233336	0.102553	-2.275	0.022890	*
as.factor(year)2013:as.factor(target)4	-0.438961	0.097626	-4.496	6.91e-06	***
as.factor(year)2014:as.factor(target)4	-0.331420	0.098078	-3.379	0.000727	***
as.factor(year)2015:as.factor(target)4	-1.127423	0.105148	-10.722	< 2e-16	***
as.factor(year)1995:as.factor(target)5	-0.129422	0.076115	-1.700	0.089065	.
as.factor(year)1996:as.factor(target)5	-0.307727	0.075552	-4.073	4.64e-05	***
as.factor(year)1997:as.factor(target)5	-0.478715	0.077542	-6.174	6.67e-10	***
as.factor(year)1998:as.factor(target)5	-0.537842	0.076996	-6.985	2.84e-12	***
as.factor(year)1999:as.factor(target)5	-0.779166	0.077692	-10.029	< 2e-16	***
as.factor(year)2000:as.factor(target)5	-0.664939	0.075865	-8.765	< 2e-16	***
as.factor(year)2001:as.factor(target)5	-0.512573	0.076231	-6.724	1.77e-11	***
as.factor(year)2002:as.factor(target)5	-0.376302	0.079371	-4.741	2.13e-06	***
as.factor(year)2003:as.factor(target)5	0.038946	0.082071	0.475	0.635115	
as.factor(year)2004:as.factor(target)5	-0.400608	0.083118	-4.820	1.44e-06	***
as.factor(year)2005:as.factor(target)5	-0.687024	0.085807	-8.007	1.18e-15	***
as.factor(year)2006:as.factor(target)5	-0.612942	0.087782	-6.983	2.90e-12	***
as.factor(year)2007:as.factor(target)5	-1.053171	0.082704	-12.734	< 2e-16	***
as.factor(year)2008:as.factor(target)5	-0.569596	0.087087	-6.541	6.13e-11	***
as.factor(year)2009:as.factor(target)5	-0.825442	0.090090	-9.162	< 2e-16	***
as.factor(year)2010:as.factor(target)5	-0.736030	0.092623	-7.946	1.92e-15	***
as.factor(year)2011:as.factor(target)5	-1.014111	0.114106	-8.887	< 2e-16	***
as.factor(year)2012:as.factor(target)5	-0.528070	0.102784	-5.138	2.78e-07	***
as.factor(year)2013:as.factor(target)5	-0.786488	0.097105	-8.099	5.52e-16	***
as.factor(year)2014:as.factor(target)5	-0.571447	0.098307	-5.813	6.14e-09	***
as.factor(year)2015:as.factor(target)5	-1.249691	0.107806	-11.592	< 2e-16	***
as.factor(year)1995:as.factor(target)6	-0.099733	0.075579	-1.320	0.186971	
as.factor(year)1996:as.factor(target)6	-0.527460	0.075634	-6.974	3.08e-12	***
as.factor(year)1997:as.factor(target)6	-0.681984	0.076784	-8.882	< 2e-16	***
as.factor(year)1998:as.factor(target)6	-0.932526	0.076697	-12.159	< 2e-16	***
as.factor(year)1999:as.factor(target)6	-0.987456	0.078000	-12.660	< 2e-16	***
as.factor(year)2000:as.factor(target)6	-0.814832	0.075552	-10.785	< 2e-16	***
as.factor(year)2001:as.factor(target)6	-0.751463	0.075996	-9.888	< 2e-16	***
as.factor(year)2002:as.factor(target)6	-0.675313	0.079215	-8.525	< 2e-16	***

as.factor(year)2003:as.factor(target)6	-0.500000	0.081415	-6.141	8.18e-10	***
as.factor(year)2004:as.factor(target)6	-0.881032	0.082846	-10.635	< 2e-16	***
as.factor(year)2005:as.factor(target)6	-1.120941	0.085638	-13.089	< 2e-16	***
as.factor(year)2006:as.factor(target)6	-1.067771	0.087346	-12.225	< 2e-16	***
as.factor(year)2007:as.factor(target)6	-1.121432	0.082213	-13.641	< 2e-16	***
as.factor(year)2008:as.factor(target)6	-0.917599	0.086902	-10.559	< 2e-16	***
as.factor(year)2009:as.factor(target)6	-1.275397	0.089896	-14.188	< 2e-16	***
as.factor(year)2010:as.factor(target)6	-1.247972	0.094240	-13.243	< 2e-16	***
as.factor(year)2011:as.factor(target)6	-1.285381	0.113311	-11.344	< 2e-16	***
as.factor(year)2012:as.factor(target)6	-0.888800	0.102966	-8.632	< 2e-16	***
as.factor(year)2013:as.factor(target)6	-0.915550	0.098976	-9.250	< 2e-16	***
as.factor(year)2014:as.factor(target)6	-0.952103	0.098977	-9.619	< 2e-16	***
as.factor(year)2015:as.factor(target)6	-1.479364	0.107608	-13.748	< 2e-16	***
as.factor(year)1995:as.factor(target)7	0.045121	0.076225	0.592	0.553893	
as.factor(year)1996:as.factor(target)7	-0.328112	0.075766	-4.331	1.49e-05	***
as.factor(year)1997:as.factor(target)7	-0.593113	0.077543	-7.649	2.03e-14	***
as.factor(year)1998:as.factor(target)7	-0.662311	0.077112	-8.589	< 2e-16	***
as.factor(year)1999:as.factor(target)7	-0.626874	0.077722	-8.066	7.29e-16	***
as.factor(year)2000:as.factor(target)7	-0.645437	0.075956	-8.497	< 2e-16	***
as.factor(year)2001:as.factor(target)7	-0.814293	0.076119	-10.698	< 2e-16	***
as.factor(year)2002:as.factor(target)7	-0.677895	0.079409	-8.537	< 2e-16	***
as.factor(year)2003:as.factor(target)7	-0.391265	0.081979	-4.773	1.82e-06	***
as.factor(year)2004:as.factor(target)7	-0.814503	0.082544	-9.868	< 2e-16	***
as.factor(year)2005:as.factor(target)7	-1.103675	0.086110	-12.817	< 2e-16	***
as.factor(year)2006:as.factor(target)7	-1.070041	0.087988	-12.161	< 2e-16	***
as.factor(year)2007:as.factor(target)7	-1.201898	0.082876	-14.502	< 2e-16	***
as.factor(year)2008:as.factor(target)7	-0.850079	0.087276	-9.740	< 2e-16	***
as.factor(year)2009:as.factor(target)7	-1.075983	0.089574	-12.012	< 2e-16	***
as.factor(year)2010:as.factor(target)7	-0.783924	0.094396	-8.305	< 2e-16	***
as.factor(year)2011:as.factor(target)7	-1.069898	0.113402	-9.435	< 2e-16	***
as.factor(year)2012:as.factor(target)7	-1.115374	0.103545	-10.772	< 2e-16	***
as.factor(year)2013:as.factor(target)7	-0.805824	0.098047	-8.219	< 2e-16	***
as.factor(year)2014:as.factor(target)7	-0.911939	0.099025	-9.209	< 2e-16	***
as.factor(year)2015:as.factor(target)7	-1.338155	0.106840	-12.525	< 2e-16	***
as.factor(year)1995:as.factor(target)8	-0.357307	0.076592	-4.665	3.08e-06	***
as.factor(year)1996:as.factor(target)8	-0.393976	0.075417	-5.224	1.75e-07	***

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as.factor(year)1997:as.factor(target)8	-0.585975	0.077677	-7.544	4.57e-14	***
as.factor(year)1998:as.factor(target)8	-0.871727	0.077595	-11.234	< 2e-16	***
as.factor(year)1999:as.factor(target)8	-0.794162	0.078048	-10.175	< 2e-16	***
as.factor(year)2000:as.factor(target)8	-0.787052	0.075956	-10.362	< 2e-16	***
as.factor(year)2001:as.factor(target)8	-0.545446	0.076241	-7.154	8.42e-13	***
as.factor(year)2002:as.factor(target)8	-0.750403	0.079532	-9.435	< 2e-16	***
as.factor(year)2003:as.factor(target)8	-0.368476	0.082277	-4.478	7.52e-06	***
as.factor(year)2004:as.factor(target)8	-0.538792	0.083983	-6.415	1.40e-10	***
as.factor(year)2005:as.factor(target)8	-1.204543	0.086141	-13.983	< 2e-16	***
as.factor(year)2006:as.factor(target)8	-1.031426	0.088029	-11.717	< 2e-16	***
as.factor(year)2007:as.factor(target)8	-0.921593	0.083103	-11.090	< 2e-16	***
as.factor(year)2008:as.factor(target)8	-0.570203	0.087145	-6.543	6.02e-11	***
as.factor(year)2009:as.factor(target)8	-0.863254	0.090869	-9.500	< 2e-16	***
as.factor(year)2010:as.factor(target)8	-0.835258	0.094775	-8.813	< 2e-16	***
as.factor(year)2011:as.factor(target)8	-0.856832	0.114090	-7.510	5.91e-14	***
as.factor(year)2012:as.factor(target)8	-1.437411	0.103944	-13.829	< 2e-16	***
as.factor(year)2013:as.factor(target)8	-0.724958	0.098639	-7.350	1.99e-13	***
as.factor(year)2014:as.factor(target)8	-0.879071	0.099412	-8.843	< 2e-16	***
as.factor(year)2015:as.factor(target)8	-1.232756	0.106788	-11.544	< 2e-16	***
as.factor(year)1995:as.factor(target)9	-0.400297	0.075786	-5.282	1.28e-07	***
as.factor(year)1996:as.factor(target)9	-0.602093	0.076009	-7.921	2.35e-15	***
as.factor(year)1997:as.factor(target)9	-0.938782	0.077240	-12.154	< 2e-16	***
as.factor(year)1998:as.factor(target)9	-0.878125	0.076935	-11.414	< 2e-16	***
as.factor(year)1999:as.factor(target)9	-0.986981	0.077365	-12.757	< 2e-16	***
as.factor(year)2000:as.factor(target)9	-0.891696	0.075356	-11.833	< 2e-16	***
as.factor(year)2001:as.factor(target)9	-0.836434	0.075772	-11.039	< 2e-16	***
as.factor(year)2002:as.factor(target)9	-0.796480	0.078907	-10.094	< 2e-16	***
as.factor(year)2003:as.factor(target)9	-0.571796	0.081828	-6.988	2.79e-12	***
as.factor(year)2004:as.factor(target)9	-0.843876	0.082751	-10.198	< 2e-16	***
as.factor(year)2005:as.factor(target)9	-1.481965	0.085621	-17.308	< 2e-16	***
as.factor(year)2006:as.factor(target)9	-1.404798	0.087771	-16.005	< 2e-16	***
as.factor(year)2007:as.factor(target)9	-1.190590	0.081939	-14.530	< 2e-16	***
as.factor(year)2008:as.factor(target)9	-0.923410	0.086493	-10.676	< 2e-16	***
as.factor(year)2009:as.factor(target)9	-1.250453	0.089949	-13.902	< 2e-16	***
as.factor(year)2010:as.factor(target)9	-0.938162	0.094080	-9.972	< 2e-16	***
as.factor(year)2011:as.factor(target)9	-0.945812	0.112794	-8.385	< 2e-16	***

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as.factor(year)2012:as.factor(target)9	-0.983393	0.102442	-9.600	< 2e-16	***
as.factor(year)2013:as.factor(target)9	-0.953472	0.098360	-9.694	< 2e-16	***
as.factor(year)2014:as.factor(target)9	-1.032766	0.098672	-10.467	< 2e-16	***
as.factor(year)2015:as.factor(target)9	-1.433568	0.107170	-13.377	< 2e-16	***
as.factor(year)1995:as.factor(target)10	-0.108241	0.076165	-1.421	0.155276	
as.factor(year)1996:as.factor(target)10	-0.652236	0.075565	-8.631	< 2e-16	***
as.factor(year)1997:as.factor(target)10	-1.030714	0.077206	-13.350	< 2e-16	***
as.factor(year)1998:as.factor(target)10	-0.917445	0.076936	-11.925	< 2e-16	***
as.factor(year)1999:as.factor(target)10	-0.805204	0.077849	-10.343	< 2e-16	***
as.factor(year)2000:as.factor(target)10	-0.563788	0.075335	-7.484	7.22e-14	***
as.factor(year)2001:as.factor(target)10	-0.631787	0.075877	-8.326	< 2e-16	***
as.factor(year)2002:as.factor(target)10	-0.561347	0.079853	-7.030	2.07e-12	***
as.factor(year)2003:as.factor(target)10	-0.553930	0.081643	-6.785	1.16e-11	***
as.factor(year)2004:as.factor(target)10	-0.705168	0.083993	-8.396	< 2e-16	***
as.factor(year)2005:as.factor(target)10	-1.506765	0.086820	-17.355	< 2e-16	***
as.factor(year)2006:as.factor(target)10	-1.338339	0.088476	-15.127	< 2e-16	***
as.factor(year)2007:as.factor(target)10	-1.349394	0.082969	-16.264	< 2e-16	***
as.factor(year)2008:as.factor(target)10	-0.858234	0.087253	-9.836	< 2e-16	***
as.factor(year)2009:as.factor(target)10	-0.745095	0.090406	-8.242	< 2e-16	***
as.factor(year)2010:as.factor(target)10	-0.132925	0.094121	-1.412	0.157866	
as.factor(year)2011:as.factor(target)10	-0.538594	0.115091	-4.680	2.87e-06	***
as.factor(year)2012:as.factor(target)10	-0.195724	0.104338	-1.876	0.060675	.
as.factor(year)2013:as.factor(target)10	-1.146718	0.098079	-11.692	< 2e-16	***
as.factor(year)2014:as.factor(target)10	-0.879319	0.099573	-8.831	< 2e-16	***
as.factor(year)2015:as.factor(target)10	-1.394862	0.106621	-13.082	< 2e-16	***
as.factor(qt)2:as.factor(target)2	-0.318140	0.067903	-4.685	2.80e-06	***
as.factor(qt)3:as.factor(target)2	-0.114151	0.067503	-1.691	0.090828	.
as.factor(qt)4:as.factor(target)2	-0.152119	0.070823	-2.148	0.031723	*
as.factor(qt)2:as.factor(target)3	-0.461768	0.062576	-7.379	1.59e-13	***
as.factor(qt)3:as.factor(target)3	-0.144516	0.062712	-2.304	0.021198	*
as.factor(qt)4:as.factor(target)3	-0.037704	0.065438	-0.576	0.564492	
as.factor(qt)2:as.factor(target)4	-0.638509	0.061013	-10.465	< 2e-16	***
as.factor(qt)3:as.factor(target)4	-0.019449	0.061368	-0.317	0.751300	
as.factor(qt)4:as.factor(target)4	-0.023452	0.063558	-0.369	0.712144	
as.factor(qt)2:as.factor(target)5	-0.834709	0.060616	-13.771	< 2e-16	***
as.factor(qt)3:as.factor(target)5	-0.091427	0.062281	-1.468	0.142112	

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as.factor(qt)4:as.factor(target)5        0.028651   0.062570    0.458 0.647018
as.factor(qt)2:as.factor(target)6       -1.014439   0.060613 -16.736  < 2e-16 ***
as.factor(qt)3:as.factor(target)6       -0.145771   0.063819   -2.284 0.022364 *
as.factor(qt)4:as.factor(target)6        0.131709   0.062182    2.118 0.034164 *
as.factor(qt)2:as.factor(target)7       -1.103865   0.060609 -18.213  < 2e-16 ***
as.factor(qt)3:as.factor(target)7       -0.360570   0.063360   -5.691 1.26e-08 ***
as.factor(qt)4:as.factor(target)7        0.285001   0.062378    4.569 4.90e-06 ***
as.factor(qt)2:as.factor(target)8       -1.042965   0.060868 -17.135  < 2e-16 ***
as.factor(qt)3:as.factor(target)8       -0.361122   0.070208   -5.144 2.70e-07 ***
as.factor(qt)4:as.factor(target)8        0.325778   0.061654    5.284 1.26e-07 ***
as.factor(qt)2:as.factor(target)9       -1.022020   0.061829 -16.530  < 2e-16 ***
as.factor(qt)3:as.factor(target)9       -0.401505   0.067150   -5.979 2.24e-09 ***
as.factor(qt)4:as.factor(target)9        0.460978   0.061555    7.489 6.94e-14 ***
as.factor(qt)2:as.factor(target)10      -1.229711   0.066342 -18.536  < 2e-16 ***
as.factor(qt)3:as.factor(target)10      -0.638944   0.067596   -9.452  < 2e-16 ***
as.factor(qt)4:as.factor(target)10       0.321191   0.061490    5.223 1.76e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Negative Binomial(1.2448) family taken to be 1)

    Null deviance: 160038  on 93258  degrees of freedom
Residual deviance: 105701  on 93005  degrees of freedom
AIC: 986988

Number of Fisher Scoring iterations: 1


              Theta:  1.24478
          Std. Err.:  0.00544

 2 x log-likelihood:  -986478.11900
```

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