SCIENTIFIC COMMITTEE
NINTH REGULAR SESSION

6-14 August 2013
Pohnpei, Federated States of Micronesia

Comparison of CPUE trends for skipjack tuna between two coastal troll fisheries around Hachijo-Island and south off Wakayama prefecture

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WCPFC-SC9-2013/ SA-WP-13

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Abstract

Abundance indices of skipjack tuna (*Katsuwonus pelamis*) caught by the Japanese coastal troll fisheries were estimated by the generalized linear model to examine their trends in two distinctive areas, around Wakayama (WKY) and Tokyo Hachijyo Islands (TKH). Estimated CPUE in WKY shows similar trend in previous research and estimated CPUE in TKH also shows declining trend and the trend after 2006 is similar to that of WKY.

Introduction

Skipjack tuna (*Katsuwonus pelamis*) appeared around Japan are believed to migrate seasonally from tropical water. Four migration patterns in the western Pacific were described as they are from (1) the Philippines islands, (2) Marianna-Marshall islands, (3) east of Marshall islands and (4) offshore water of south of the Kuroshio extension (e.g., Nihira, 1996; Ogura, 2003).

Skipjack stock status is currently not overfishing nor experienced overfished, yet high catches in the equatorial region could result in range contractions of the stock (Anonymous, 2011). Skipjack abundance in coastal areas shows low level after 2004 based on analyses of Japanese coastal troll fisheries (Kiyofuji *et al.*, 2011) and there were some decreased signals of skipjack population in the vicinity Japan, which were based on catch statistics by the Japanese middle-sized pole and line and offshore purse-seine fisheries (Uosaki *et al.*, 2010). SEAPODYM（Spatial Ecosystem ）simulation with no fishing mortality from the equatorial region shows impacts on biomass of skipjack in the subtropical area (Lehodey *et al*., 2011), where is an important area for fish migrating to the temperate waters and potentially reproductive area of skipjack.

In this document, catch per unit effort (CPUE) for skipjack tuna caught by the two coastal troll fisheries, around Tokyo Hachijo Islands (TKH) and south off Wakayama prefecture (WKY), were investigated to clarify abundance trends in two distinctive area. These abundance trends are also discussed to be potential indices for skipjack migratory dynamics around Japanese water.

Data and Methods

Coastal troll fisheries

Two distinctive coastal troll fisheries were employed to analyze and estimate standardized catch unit effort (CPUE). One is Tokyo Hachijyo Islands (TKH) and another is south off Wakayama prefecture (WKY) (**Figure 1**). Coastal troll fisheries (less than 10 GRT) in Japan are characterized deploying several fishing gears to the end of pole and run approximately 7 knots to attract skipjack near surface. Coastal troll fishing grounds are mainly formed within approximately 60 n.m. from landing port because their trip is usually one day. Fishing grounds of coastal troll fisheries in Wakayama (**Fig. 1(b)**) usually located at the north and south of the Kuroshio front (Kiyofuji *et al*., 2011). They formed at the south from January to March and change their location after April to the north with increasing sea temperature and end in May or June due to changes of school type to free school or with floating objects which is mostly used by the pole-and-line fisheries (Kokubo et al., 2005). Troll fisheries in TKH is similar manner as Wakayama troll fisheries and characterized as one-day trip with their fishing area ranging from 60 n.m. to 80 n.m. from their landing ports (**Fig. (c)**). Troll fisheries in TKH started in 1980's. Data used in this study are summarized as follows.

Wakayama troll fisheries
The Wakayama Research Center of Agriculture, Forestry and Fisheries have been collecting catch and effort data by selected troll fleet to monitor skipjack catch since 2001. Number of available data in each year and fleet was shown in **Table 1**. This data set was updated from the previous research (Kiyofuji *et al.*, 2011) and several fleets were also added.

Tokyo Hachijyo Islands troll fisheries data
Hachijo Branch, Tokyo Metropolitan Center for Agriculture, Forestry and Fisheries on Izu islands has also been collecting landing data in each port to monitor skipjack catch trends. Data used in this study is between 2002 and 2012 (**Table 2 (a)**). Numbers of unique vessel are between 283 and 570, which are selected as the vessel operated more than three years during analysis period.
Sea Surface Temperature
Monthly one degree grid NOAA Optimum Interpolation (OI) Sea Surface Temperature (SST) Version 2 (V2) from January 1982 to December 2012 were employed to investigate potential effect of environmental variables on catchability of coastal troll fisheries in each region. NOAA_OI_SST_V2 data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/. SST in each area (**Fig. 1 (b) and (c)**) were averaged.
Estimation of standardized Catch per unit effort (CPUE)
Both data set from Wakayama and Tokyo Hachijyo-Island contains zero catch data, 10% of averaged CPUE were added. Explanatory variables were different between two areas; year, month, latitude, vessel ID and SST for Wakayama (1) and year, month, vessel ID, SST and other species (albacore and yellowfin) for Tokyo Hachijyo Islands (2) were considered. Akaike Information Criteria (AIC) were applied for model selections. All variables are considered as categorical but SST was as continuous for one of sensitivity model configurations. To keep seasonal consistency, data between February and May as spring fishing season were used (**Fig. 3**).

$$log(CPUE + const.) = \mu + year + month + Lat + vessel\ ID + SST + \varepsilon \qquad (1)$$
$$log(CPUE + const.) = \mu + year + month + vessel\ ID + SST + ALB + YFT + \varepsilon \qquad (2)$$

where μ 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 SST was recalculated as round off. As for TKH troll fisheries, presence and absence of albacore and yellowfin were included as 1 and 0 in the model, respectively.

Results and Discussion

Catch and Nominal CPUE trends
Figure 2 shows total skipjack landing in TKH (gray dashed line) and in WKY (black solid line), respectively. Large fluctuations were identified in both areas. Lading at TKH increased from 1980 to 1995 and then has been decreasing until recent years. The lowest catch was recorded in 2009. Landing at WKY shows relatively stable but slightly increased from 1990 to 2002 and then decreased in 2003. It has been report that the catch was low level after 2004.

Figure 4 represents (a) total number of vessel (effort), (b) total skipjack catch (kg) and ratio of 0 catch (%), and (c) nominal CPUE (kg/vessel-day) in both Wakayama (left) and TKH (right) calculated from data used in this study. Total effort in WKY is stable between 2002 and 2010, was around 600 vessels. Effort in TKH has been decreasing since 2006 and decreased largely especially in 2009 when was the lowest catch record in recent 10 years. Catch in WKY decreased from 2003 to 2004 largely and keep at the same level at 2004. Catch in TKH decreased from 2005

2009 and kept at lower level. Both nominal CPUE similar trend of total skipjack catch but timing decreasing is different between two areas. Its peak in WKY was two year prior to the TKH.

Standardized CPUE trends
Standardized CPUE (divided by overall mean) by all possible configurations without any interaction terms in both areas are shown in **Figure 6** and AIC and BIC were summarized in **Table 3(a) and Table 4(a)**. **Figure 5** is residual and QQ plots of the final model for both areas. Standardized residual shows no remarkable difference from the normal distribution for both areas. Abundance indices from the selected model are shown in **Figure 6** and ANOVA diagnostics of the final models were summarized in **Table 3(b)** and **Table 4(b)**. Overall standardized CPUEs show similar trends with the nominal CPUE trends. Results of the final model were shown in **Figure 7**. Decreased standardized CPUE trend in WKY were significant from 2003 to 2007 and slightly increased until 2010, however, it was at the lower level during this period (**Fig.6 (a) and Fig. 7**). Standardized CPUE in TKH also shows large decrease from 2005 to 2006 and kept lower levels after 2006 (**Fig.6 (b) and Fig. 7**). However, the CPUE in 2004 and 2005 in TKH were quite higher than those of WKY. Timing of declining CPUE in TKH was about two years later than that in WKY, however, reason for this time lag is unclear. One possible mechanism is that migratory pathway could be changed especially in the western part. Since the circumstance evidence in this study implies that skipjack abundance in the Japanese coastal areas has been lower at least since 2006, further analysis with longer historical data should be conducted to show relative trend and recent status of the stock in coastal regions more clearly.

Summary
This document presented estimates of standardized CPUE for skipjack caught by two coastal troll fisheries. Data were updated after 2009 in WKY and that in TKH from 2002 to 2012 were newly analyzed to investigate abundance trends in two distinctive areas. Procedure for standardizing CPUE is essentially similar used in the previous study (Kiyofuji et al., 2011), but explanatory variables used slightly changed. Estimated CPUE in WKY shows similar trend in previous research and estimated CPUE in TKH also shows declining trend and the trend after 2006 is similar to that of WKY. CPUE from TKH in 2004 and 2005 were higher than that of WKY. This may indicate the start of decreasing between two distinctive areas has somehow time lag, which cause should be examined for future research.

Reference

Anonymouns (2012) Summary Report of the Seventh Regular Session of the Scientific Committee.

Kiyofuji, H., Ashida, H., Okamoto, S., Gosho, T. and Takeda, Y. (2011) CPUE analyses for skipjack caught by coastal troll fishery around Wakayama prefecture in Japan. Seventh Regular Session of the Scientific Committee (SC7), Pohnpei, Federal States of Micronesia. SA-IP-12.

Kokubo, T., Ogawa, M. and Takeuchi, J. (2005) Biological characteristics of skipjack tuna (*Katsuwonus pelamis*) and albacore (*Thunnus alalunga*) caght by trolling line in spring, 2003. *Bull. Wakayama Res. Cent. Agr., For. And Fish.* **6:** 159-167.ß

Lehodey, P., Senina, I., Calmettes, B., Hampton, J., Nicol, S., Williams, P., Molina, J.J., Ogura, M., Kiyofuji, H. and Okamoto, S. (2011) SEAPODYM working progress and applications to Pacific skipjack tuna population and fisheries. *WCPFC-SC7-2011/EB-WP 06 rev.1*.

Nihira, A. (1996) Studies on the behavioral ecology and physiology of migratory fish schools of skipjack tuna (*Katsuwonus pelamis*) in the oceanic frontal area. *Bull. Tohoku Nat. Fish. Res. Inst.* **58:** 137-233.

Ogura, M. (2003) Swimming behavior of skipjack, *Katsuwonus pelamis*, observed by the data storage tag at the Northwestern Pacific, off northern Japan, in summer of 2001 and 2002. SCTB16 Working Paper.

Uosaki, K., Kiyofuji, H., Hashimoto, K., Okamoto, S. and Ogura, M. (2010) Recent status of Japanese skipjack fishery in the vicinity of Japan. SC6, Nulualofa, Tonga. SA-WP-07.

Table1. Total number of data in Wakayama for each vessel between 2001 and 2011.

VesID	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
A	−	41	39	28	21	43	45	36	63	66	19
B	−	39	51	45	23	39	46	52	39	−	−
C	−	45	126	76	40	55	64	49	55	51	27
D	−	67	65	51	37	55	63	71	74	76	40
E	−	70	62	57	27	52	42	59	65	−	−
F	−	−	−	−	−	64	84	81	86	94	45
G	−	61	37	31	18	36	36	30	36	50	−
H	43	65	48	27	29	50	41	44	36	54	18
I	45	48	43	24	27	44	40	41	28	43	20
J	27	51	52	52	32	52	69	39	67	78	−
K	−	39	53	43	34	43	38	48	73	64	−
L	−	37	58	45	29	51	47	39	26	40	23
M	2	−	49	42	27	39	40	53	46	53	20
N	−	−	−	−	−	−	17	31	28	26	7

Table 2. (a) Data summary for Tokyo Hachijo Islands used in this study. **(b)** Total number of unique vessel in each month for the troll fisheries between 2002 and 2012.

(a) Number of data, number of unique vessel, skipjack catch (tonnes) and total number of skipjack operation (skipjack catch > 0).

	number of data	number of unique vessel	SKJ Catch (tonnes)	total number of skipjack operation
2001	—	—	—	—
2002	3657	460	316.2	3410
2003	4413	570	735.0	4062
2004	4565	520	614.7	4135
2005	4214	433	921.7	4027
2006	4162	557	410.8	3530
2007	3155	496	258.0	2690
2008	3749	464	306.9	3033
2009	1250	283	91.0	1073
2010	3424	430	475.3	3135
2011	2313	369	245.7	2105
2012	2037	339	131.5	1663

(b) Total number of unique vessel in core month (February – May).

	Feb.	Mar.	Apr.	May
2002	94	106	104	51
2003	75	105	110	89
2004	80	102	99	80
2005	78	96	99	49
2006	78	93	98	90
2007	76	93	89	37
2008	60	92	93	81
2009	17	46	77	70
2010	78	78	75	64
2011	57	52	65	64
2012	50	45	74	55

Table 3. (a) Model configuration and response variables used for standardizing catch per unit effort for the coastal troll fisheries in Wakayama, and **(b)** ANOVA table for the selected model (m9 in (a)).

(a) Model configuration for the coastal troll fisheries in Wakayama

Model	Variables	n	AIC	BIC
Include 0 catch				
m0	null model	–	17636.1	17649.5
m1	Year	5832	16983.0	17063.1
m2	Year, Month	5832	16746.2	16846.3
m3	Year, Month, Lat	5832	16650.8	16777.6
m4	Year, Month, vesselID	5832	16160.9	16347.7
m5	Year, Month, Lat, VesselID	5832	16112.8	16326.3
m6	Year, Month, Lat, SST (as continuous)	5832	16636.3	16783.1
m7	Year, Month, VesselID, SST (as continuous)	5832	16140.6	16347.5
m8	Year, Month, Lat, VesselID, SST(as continuous)	5832	16091.4	16324.9
m9	Year, Month, Lat, VesselID, SST (as categorical)	5832	16087.8	16327.9

(b) Result of ANOVA for model 9.

	DF	TYPE III SS	Mean Square	F Value	Pr > F
Year	10	619.7	62.0	67.5	< 0.0001
Month	3	154.9	51.6	56.2	< 0.0001
Lat	4	49.3	12.3	13.4	< 0.0001
Vessel ID	13	547.4	42.1	45.9	< 0.0001
SST	4	30.2	7.5	8.2	< 0.0001

Table 4. (a) Model configuration and response variables used for standardizing catch per unit effort for the coastal troll fisheries in Tokyo Hachijyo Islands and **(b)** ANOVA table for the selected model (Model_108 in (a)).

(a) Model configuration for the coastal troll fisheries in Tokyo Hachijyo Islands.

Model	Variables	n	AIC	BIC
Model_100	Year	30405	90260.4	90352.0
Model_101	Year, Month	30405	87857.9	87974.4
Model_102	Year, Month, Ves.ID	30405	84320.2	85385.5
Model_103	Year, Month, SST	30405	86926.5	87076.3
Model_104	Year, Month, ALB	30405	87822.0	87946.9
Model_105	Year, Month, YFT	30405	87061.7	87186.5
Model_106	Year, Month, ALB, YFT	30405	87015.6	87148.8
Model_107	Year, Month, Ves.ID, SST	30405	83176.7	84275.3
Model_108	Year, Month, Ves.ID, SST, ALB, YFT	30405	82296.1	83411.3

(b) Result of ANOVA for model_108.

	DF	TYPE III SS	Mean Square	F Value	Pr > F
Year	10	3341.5	334.2	382.7	< 0.0001
Month	3	2098.3	699. 5	801.0	< 0.0001
Vessel ID	114	3868.3	33.9	38.9	< 0.0001
SST	4	877.8	219.4	251.3	< 0.0001
ALB	1	19.2	19.2	22.0	< 0.0001
YFT	1	765.9	765.9	877.1	< 0.0001

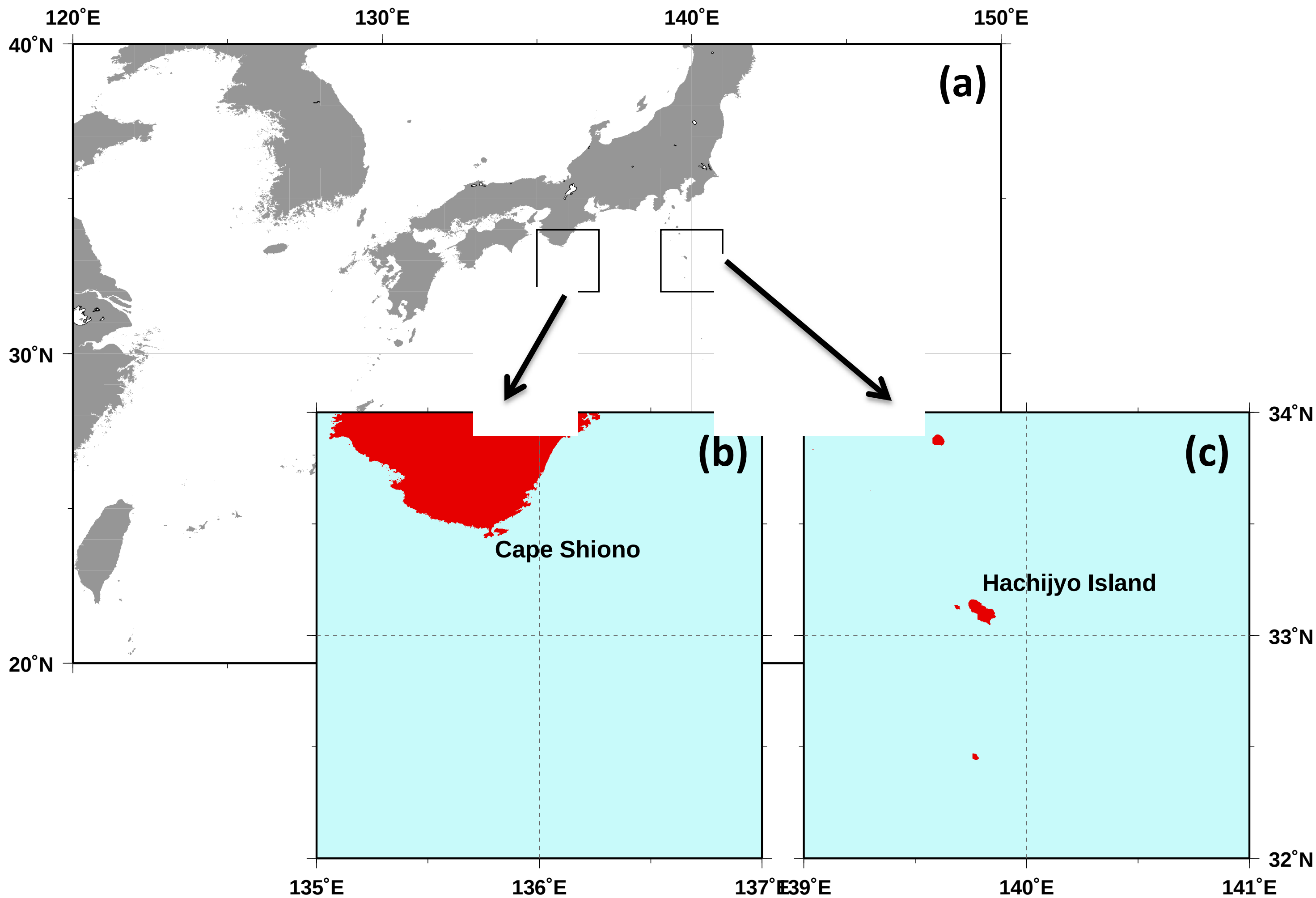

Figure 1. Map of study area; (a) around Japan, (b) around Wakayama area and (c) around Tokyo Hachijyo Islands area.

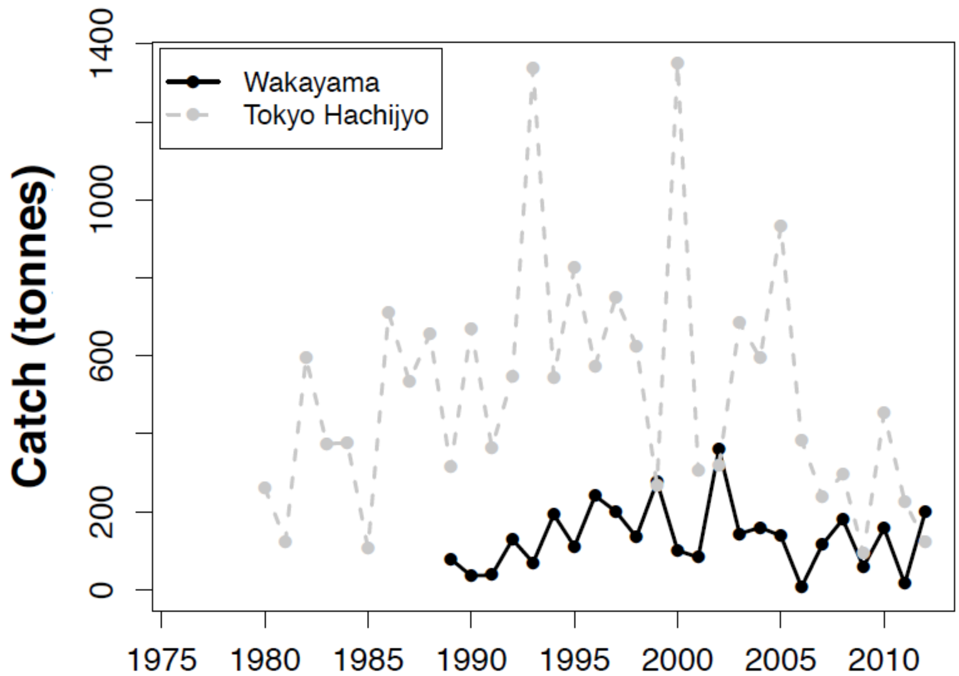

Figure 2. Total skipjack landing in Wakayama (black solid lines) and Tokyo Hachijyo (gray dashed line).

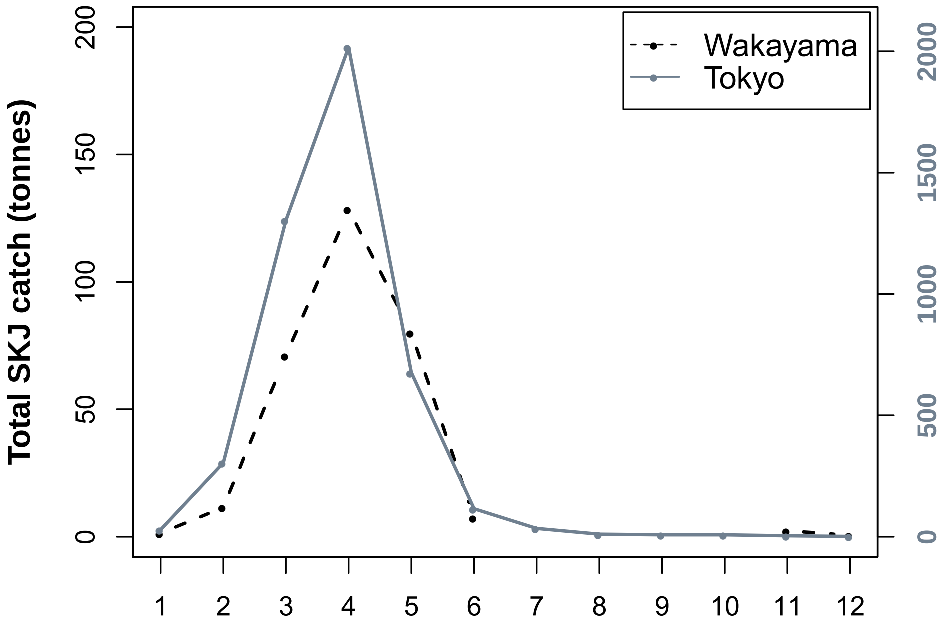

Figure 3. Total skipjack landing between January and December in Wakayama (black dashed lines) and Tokyo Hachijyo (gray line).

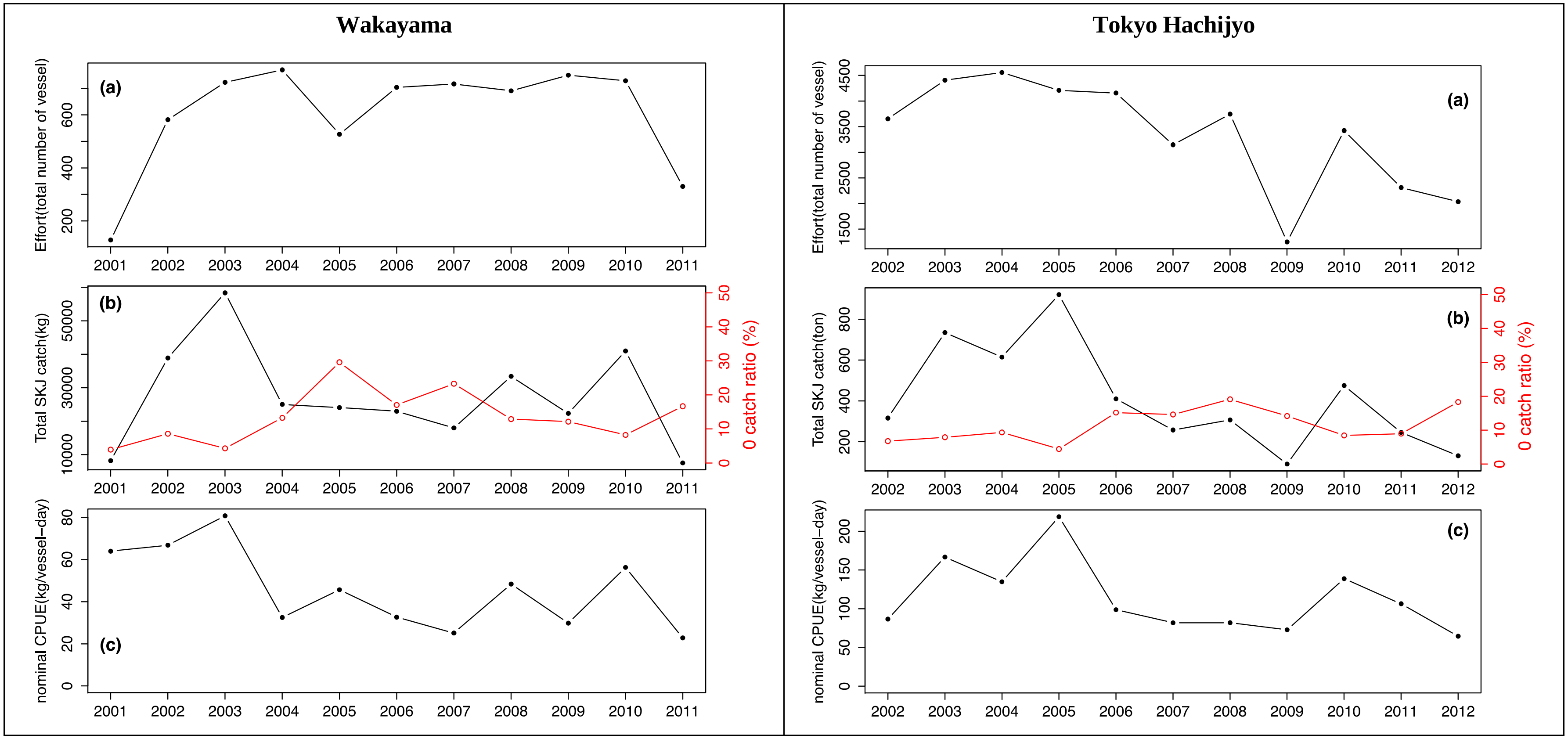

Figure 4. (a) Total number of vessel, (b) total skipjack catch (kg) and (c) nominal CPUE (kg/vessel-day) in each year. Right and left panels show each parameter around Wakayama and around Tokyo Hachijyo Islands, respectively. Note that period in Wakayama is between 2001 and 2011 but in Tokyo Hachijyo is between 2002 and 2012.

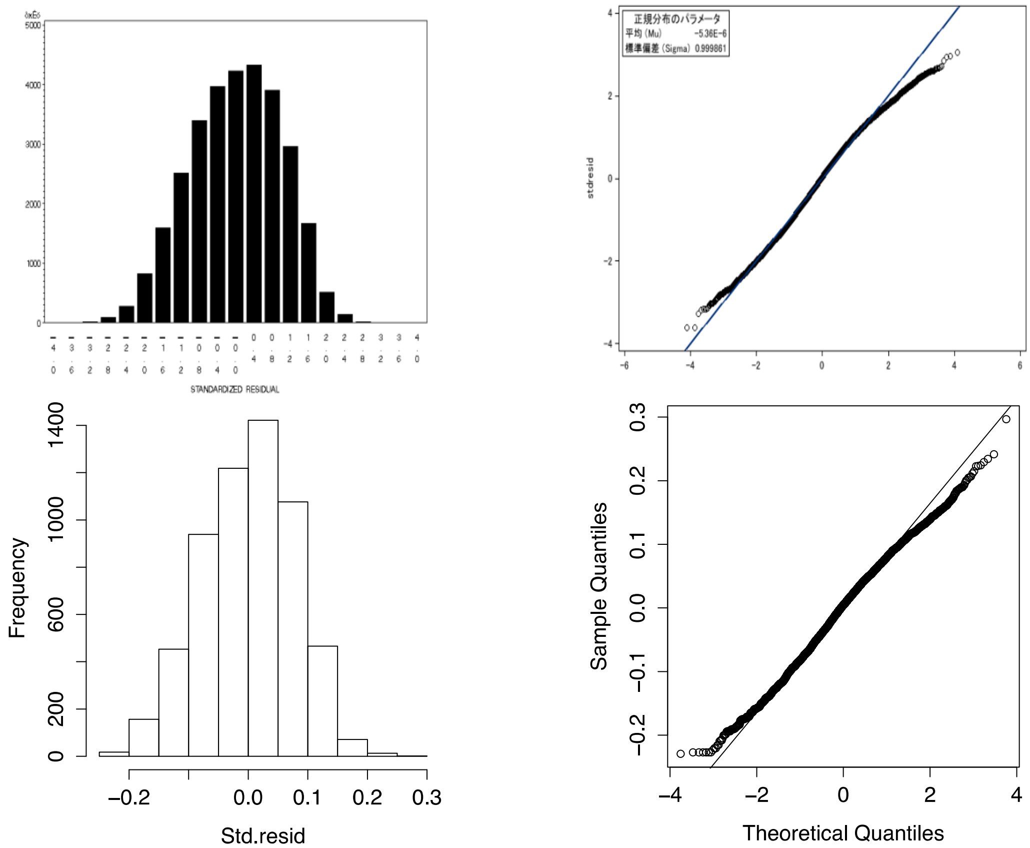

Figure 5. Residual and QQ plots of the final model in TKH (upper) and WKY (lower).

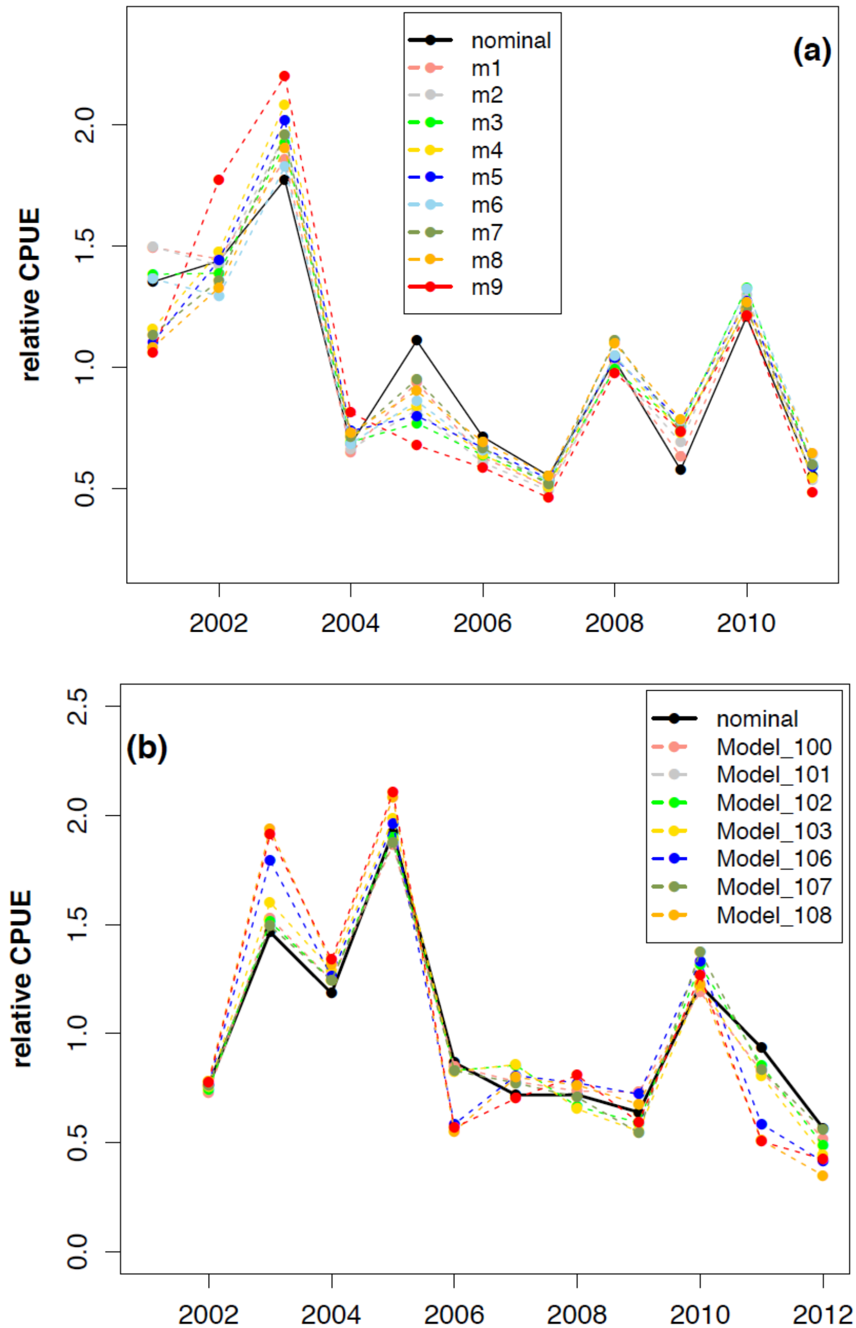

Figure 6. Relative CPUE derived from different model configurations shown in Table 2. (a) Wakayama and (b) Tokyo Hachijyo Islands.

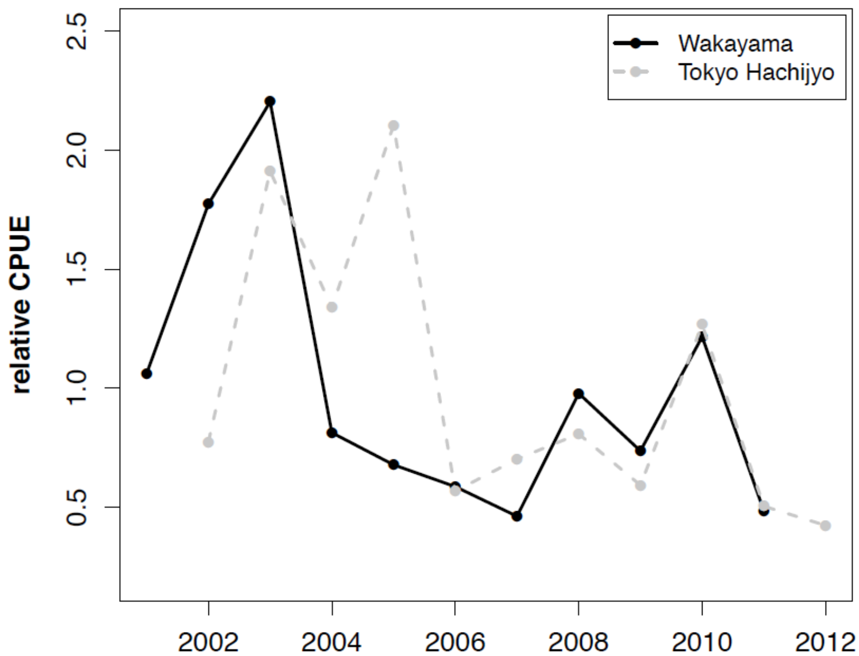

Figure 7. Relative CPUE derived from the final model for Wakayama (black solid line) and Tokyo Hachijyo Islands (gray dashed line).