Standardized CPUE for albacore caught by the Japanese pole and line fishery in the northwestern North Pacific Ocean. [1]

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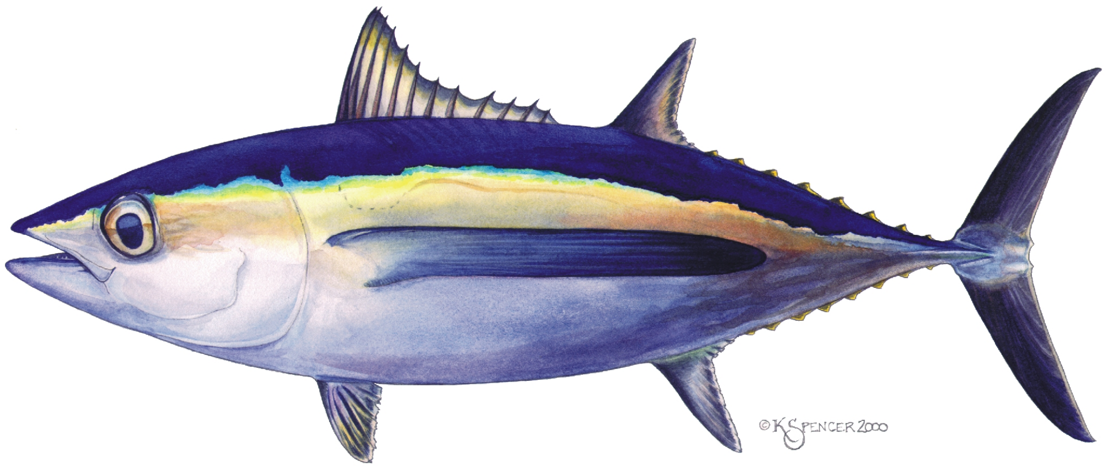

[1] This working paper was submitted to the ISC Albacore Working Group Intercessional Workshop, 5-12 November 2013, held at the National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan. Document not to be cited without authors permission.

Summary

In this document, standardized catch per unit effort (CPUE) of North Pacific Albacore (NPALB) caught by the Japanese distant-water pole and line (JPN PLDW) from 1972 and 2012 were estimated by the generalized linear model; a first step for estimating non zero catch and second step for estimating positive catch, respectively. Year, quarter, latitude and longitude by 5 degrees squares as area and vessel ID were used as main effects. In this analysis, vessel ID was newly added to evaluate fishing strategy or skippers experiences through the period. Vessel effect would reflect both fishing capacity increase the fleet's ability and intension to target albacore. In this analysis, vessel effects were estimated as the average effect over the fleet of factors such as fishing technique, targeting strategies and skipper's experiences. Derived NPALB abundance decreased from 1972 to 1987, increased from 1988 to 1995, kept at the high level until 2000 and then has been increasing since 2005.

Introduction

JPN PL CPUE estimates in this study were reflected by the idea proposed at the ISC13/ALBWG-01 in March, 2013. The ideas were that (1) it would be better to estimate standardized CPUE by reflecting fishery characteristics rather than separating area by target fish size and (2) CPUE by JPN PLDW would be a better indices for albacore in the northwestern North Pacific Ocean than CPUE by JPN PLOS because of lower albacore catch rate. In this document, estimating standardized NPALB CPUE was described to develop time series from only the Japanese distant water pole-and-line fisheries (JPN PLDW) in northwestern North Pacific Ocean from 1972 to 2012.

Data and Methods

Fisheries Data

The operational level of catch and effort data for the Japanese pole and line during 1972 and 2011 with noon position in equidistant $1^\circ \times 1^\circ$ grid cells was used. Date, number of poles, catch in weight and vessel size in gross register tonnage (GRT) were employed. In this document, JPN PL were categorized by vessel size and their equipment. Vessel size between 20-199 GRT as offshore PL (JPN PLOS) and larger than 200 GRT as distant-water (JPN PLDW).

Inshore JPN PL fish in coastal area within approximately 60 n.m. from their landing port and not target on albacore which proportion is about 1% or less of entire catch by JPN PL. Offshore and distant water JPN PL have different strategies of fishing, for example, offshore vessel conduct fishing activity in shorter cruise (approximately one week per one cruise) and distant water vessel conduct longer cruise (approximately more than month per one cruise). Distant water vessels can go much further area than the offshore vessel due to larger size of vessel and produce frozen fish.

CPUE standardization

In this analysis, delta-lognormal model was used for estimating standardized NPALB CPUE. Following procedures were conducted and parameterization of each model was accomplished using two step generalized linear model; a first step for estimating non zero catch and second step for estimating positive catch, respectively. Definition of the predictor variables are shown in Table 1 and area definition are also represented in Figure 1. In this analysis, technology information such as bird radar, sonar, bait tank and NOAA reciever were not considered because no significant effects were found through the previous analysis (Kiyofuji, 2013).

Alternatively, vessel ID of individual fleet identified by the license number from logsheet were assigned to evaluate fishing strategy or skippers experiences through the period (e.g. Langley et al., 2010; Kiyofuji et al., 2011). When vessel change target species, large changes possibly occur in the catch rate of target species. Vessel effect potentially represent factors that are likely affect fishing capability. This analysis can estimate changes in each fleet's fishing capacity from the beginning of new vessels until retirement with low catch rates. It can also account for changing levels of fishing by different fishing techniques and targeting strategies. If the average vessel effect for a year is above average, then a model with vessel effects will give a lower abundance index for that year than a model without vessel effects.

Individual vessels are identified by licence number and call sign, however, the licence number of individual vessels has changed on every five years and licence renewal occurred in 1987, 1992, 1997, 2002, and 2007. For the distant-water pole and line fleet, a reference table with year, ship name and license number has been created in each year. This table was used to create a unique vessel index in the logsheet dataset. The few logsheet records that had no associated record in the vessel reference table were deleted from the data set. Core vessel for analyzing defined as operating five years continuously and more than ten days a year. Data were removed if the vessel was not satisfied these criteria. Number of unique vessels and identified vessel were shown in Figure 2.

The vessel registration data revealed that a considerable number of vessels retired from the fishery in the late 1980s-early 1990s, although some of the vessels continued to operate in the fishery throughout the next two decades. During the 1990s, new vessels continued to enter the fishery replacing vessels that retired from the fishery. Fleet has reduced to about 25 core vessels in the more recent years (2009-2012) (Figure 2).

The delta-lognormal indices are calculated by multiplying the two sets of indices. The first-step of the model was implemented as the presence/absence of albacore catch for a fishing day and modeled to estimate the probability of non-zero catch of albacore (binomial model). The second step was modeled the positive albacore catch for a fishing day (zero catch records were excluded). Standard error for delta-lognormal model was derived from the method described by Shono (2008b).

For comparison reason, three different model configurations was applied as.

1. $log(CPUE + const.) = year + qtr + latlong + \epsilon$, $\epsilon \sim (0, \sigma^2)$
2. $log(CPUE + const.) = year + qtr + latlong + VesselID + \epsilon$, $\epsilon \sim (0, \sigma^2)$
3. Delta-lognormal (Lo *et al.*, 1992)
    - 1st Step: estimate non-zero catch rate
      $$log(rate) = year + qtr + latlong + VesselID + \epsilon,\ \epsilon \sim binominal$$
    - 2nd Step: estimate positive catch
      $$log(CPUE) = year + qtr + latlong + VesselID + \epsilon,\ \epsilon \sim (0, \sigma^2)$$

An unbiased relative abundance indices can be calculated as follows;

$$Indices = \frac{exp(\hat{\alpha})}{1+exp(\hat{\alpha})} \times exp(\hat{\beta} + \hat{\sigma}^2/2)$$

where $\hat{\alpha}$ is the estimated year factor for the binomial GLM, $\hat{\alpha}$ and $\hat{\sigma}^2$ are the estimated year factor for the positive catch (lognormal) GLM and the standard error of $\hat{\alpha}$, respectively.

Results and Discussion

Figure 3 shows recent five years spatial distributions of effort (vessell-day), total albacore catch (ton) and albacore catch ratio. Effort were identified in area between 140°E-180°E and 25°N-45°N (Fig.2 (a)). Albacore catch were higher in area south of 35°N (Fig.2 (c)).

Figure 4 shows effort (total number of poles $\times$ 1000), total catch ($\times$ 1000 mt), albacore catch ratio and nominal CPUE by the PLDW. Effort by PLDW increased from 1972 to 1978 due to increasing number of fleet and then decreased gradually until 1987. Gradual increased after 1987 were identified until 1997 and then remain at the same level around 100 ($\times$ 1000 poles). Catch by the PLDW was high in mid 1970's and from the end of 1990's and start of 2000's. Catch after 2005 was around 10,000 (tones). Albacore catch ratio has been around 50% but it was low during 1987 and 1992 approximately around 20%. Nominal CPUE likely shows similar trend with catch, however, there likely exist three phase at nominal CPUE level (1972-1992, 1993-2003 and 2004-2011). It has been likely increasing since 2004.

Figure 5 represents estimated non zero albacore catch rate by the binomial model (a), positive catch by the lognormal model (b) and abundance indices (c). Estimated non-zero catch rate was relatively good agreement with the observed albacore catch rate. (Fig.5a and Table2) Lower catch rate was identified between 1989 and 1992 approximately around 20 %. Estimated positive catch also shows that all factors are statistically significant. Estimates of positive catch shows remarkable feature as lower lever between 1972 and 1988 and jump to higher level after 1989 up to 2012.

Relative trend of abundance indices were shown in Figure 6 and Table 3 with standard errors. Abundance decreased from 1972 to 1987, increased from 1988 to 1995, kept at the high level until 2000 and then has been increasing since 2005. Distribution of residuals are slightly skewed in some years between 1987 and 1994 of 2nd step, but overall trend was distributed normally (Fig. 7).

Figure 8 represents effect of each explanatory variable on standardized CPUE. Figure 9 represent another view to look at the latlong effect more from spatial sense. The vessels entering the fishery in the 1970s tend to have a higher probability of catching albacore and there is considerable variation in vessel performance across the fleet both 1st and 2nd step. Vessel effects estimated by the methods in this study only account for changes in catchability among vessels, not changes by an individual vessel. However, other factors such as fishing techniques, targeting strategies, or changes in skipper will affect vessels ' capability on a shorter time scale. For future work, developing another way to consider short-term changes in individual vessels ' capability would be necessarily.

In summary, following recommendation were raised for CPUE of North Pacific albacore caught by the Japanese pole and line are as following conditions:

1. CPUE by JPN PLDW would be a better indices for albacore in the northwestern North Pacific Ocean than CPUE by JPN PLOS because of lower albacore catch rate.
2. Vessel effect was considered as one of main factor that account for fleet's capability from introducing year to retirement year. This factor improved the model and should be included.
3. For SS3 input data, from quarter2 to quarter3 should be considered as main season for JPN PL.

Reference

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Langley, A., Uosaki, K., Hoyle, S., Shono, H. and Ogura, M. (2010) A standardized CPUE analysis of the Japanese distant-water skipjack pole-and-line fishery in the western and central Pacific Ocean (WCPO), 1972-2009. *WCPFC-SC6-2010/SA-WP-08*.

Lo, N. C.-h., Jacobson, L. D. and Squire, J. L. (1992) Indices of relative abundance from fish spotter data based on Delta-Lognormal Models. *Can. J. Fish. Aquat. Sci.*, **49:** 2515-2526.

Shono, H. (2008) Confidence interval estimation of CPUE year trend in delta-type two-step model. *Fish. Sci.*, **74:** 712-717.

Table 1. Definition of the predictor variables included in the model.

Variable	**Data type**	**Description**
year	Categorical	unique year 1972 - 2012
qtr	Categorical	unique quater
		1: Jan. - Mar.
		2: Apr.-May
		3: Jun.- Aug.
		4: Sep. - Dec.
latlong	Categorical	$5° \times 5°$
vesselID	Categorical	unique vessel identification

Table 2. ANOVA for 1st step (a) and TYPE3 ANOVA for 2nd step (b) of delta-lognormal model.

(a) 1st step

Variable	**DF**	**Chisq(χ^2)**	Pr (> Chi)
year	40	6395.1	2.2e-16 ***
qtr	3	16345.5	2.2e-16 ***
latlong	39	13057.4	2.2e-16 ***
vID	228	4989.1	2.2e-16 ***

(b) 2nd step

Variable	**DF**	**TYPE III SS**	**Mean Sq.**	**F**	**Pr > F**
year	40	5902	147.6	126.27	2.2e-16 ***
qtr	3	1804	601.3	514.71	2.2e-16 ***
latlong	39	2740	70.26	61.70	2.2e-16 ***
vID	228	2600	11.4	9.76	2.2e-16 ***

Table 3. Standardized CPUE and CV (standard error) for the delta-lognormal.

	1st step(non-zero catch)		2nd step (positive catch)				by Shono (2008)	
Year	**estimates**	**SE**	**estimates**	**SE**	**adjusted estimates**	**Abundance Ind.**	$\sigma[CPUE]$	$\sigma[logCPUE]$
1972	0.39	0.02	0.11	0.04	0.11	0.045	0.002	0.04
1973	0.49	0.02	0.10	0.03	0.10	0.052	0.002	0.03
1974	0.46	0.02	0.14	0.03	0.14	0.071	0.003	0.03
1975	0.43	0.02	0.12	0.03	0.12	0.063	0.002	0.03
1976	0.47	0.02	0.13	0.03	0.13	0.064	0.002	0.03
1977	0.42	0.02	0.08	0.03	0.08	0.034	0.001	0.03
1978	0.55	0.02	0.09	0.03	0.09	0.053	0.002	0.03
1979	0.48	0.02	0.10	0.03	0.10	0.048	0.002	0.03
1980	0.39	0.02	0.10	0.03	0.10	0.044	0.002	0.03
1981	0.37	0.02	0.06	0.03	0.06	0.025	0.001	0.03
1982	0.31	0.02	0.10	0.03	0.10	0.035	0.002	0.04
1983	0.40	0.02	0.10	0.03	0.10	0.041	0.002	0.03
1984	0.36	0.02	0.14	0.03	0.14	0.054	0.003	0.03
1985	0.44	0.03	0.13	0.04	0.13	0.060	0.003	0.04
1986	0.36	0.02	0.10	0.04	0.10	0.039	0.002	0.04
1987	0.17	0.03	0.09	0.21	0.09	0.017	0.011	0.21
1988	0.22	0.02	0.10	0.08	0.10	0.023	0.004	0.08
1989	0.28	0.02	0.13	0.05	0.13	0.038	0.004	0.05
1990	0.31	0.02	0.18	0.05	0.18	0.059	0.005	0.05
1991	0.25	0.02	0.30	0.07	0.30	0.080	0.012	0.07
1992	0.19	0.02	0.35	0.13	0.35	0.073	0.024	0.13
1993	0.30	0.02	0.27	0.06	0.27	0.087	0.009	0.06
1994	0.45	0.03	0.31	0.04	0.31	0.148	0.008	0.04
1995	0.41	0.02	0.30	0.04	0.30	0.131	0.008	0.04
1996	0.58	0.02	0.22	0.04	0.22	0.131	0.006	0.04
1997	0.58	0.02	0.22	0.03	0.22	0.131	0.005	0.04
1998	0.51	0.02	0.22	0.04	0.22	0.116	0.006	0.04
1999	0.59	0.02	0.29	0.03	0.29	0.175	0.006	0.03
2000	0.48	0.02	0.14	0.03	0.14	0.073	0.003	0.04
2001	0.55	0.02	0.16	0.03	0.16	0.089	0.003	0.03
2002	0.58	0.02	0.26	0.03	0.26	0.156	0.006	0.03
2003	0.58	0.02	0.21	0.03	0.21	0.124	0.004	0.03
2004	0.46	0.03	0.18	0.04	0.18	0.087	0.004	0.04
2005	0.39	0.02	0.12	0.04	0.12	0.049	0.003	0.04
2006	0.36	0.02	0.14	0.04	0.14	0.052	0.004	0.04
2007	0.46	0.03	0.19	0.04	0.19	0.093	0.005	0.04
2008	0.33	0.02	0.16	0.05	0.16	0.055	0.005	0.05
2009	0.43	0.03	0.28	0.05	0.28	0.127	0.008	0.05
2010	0.38	0.02	0.18	0.04	0.18	0.072	0.004	0.04
2011	0.38	0.02	0.28	0.05	0.28	0.111	0.008	0.05
2012	0.49	0.03	0.20	0.04	0.20	0.105	0.005	0.04

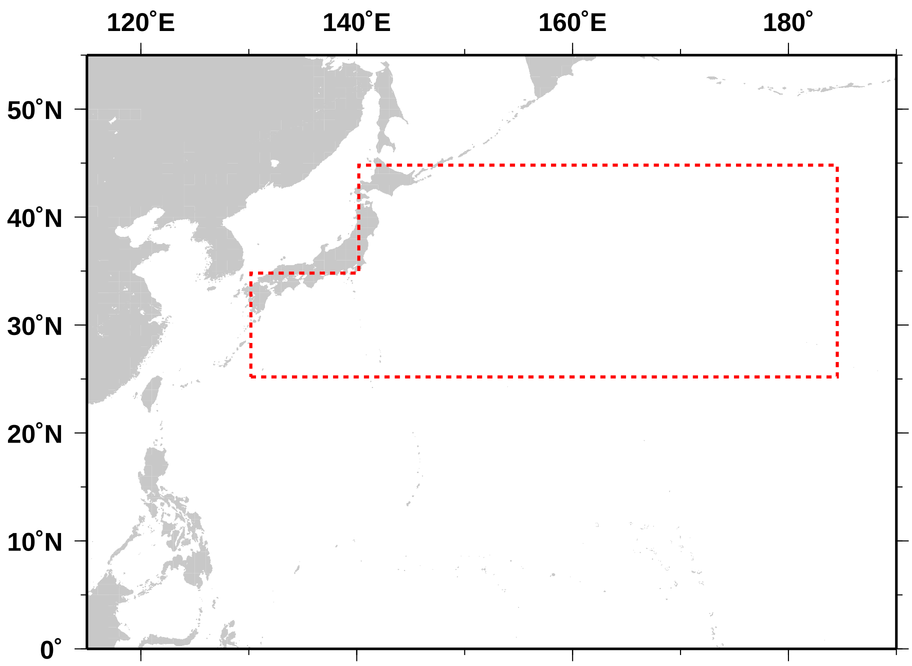


Figure 1. Area for estimating standardized CPUE for NPALB caught by the JPN DWPL.

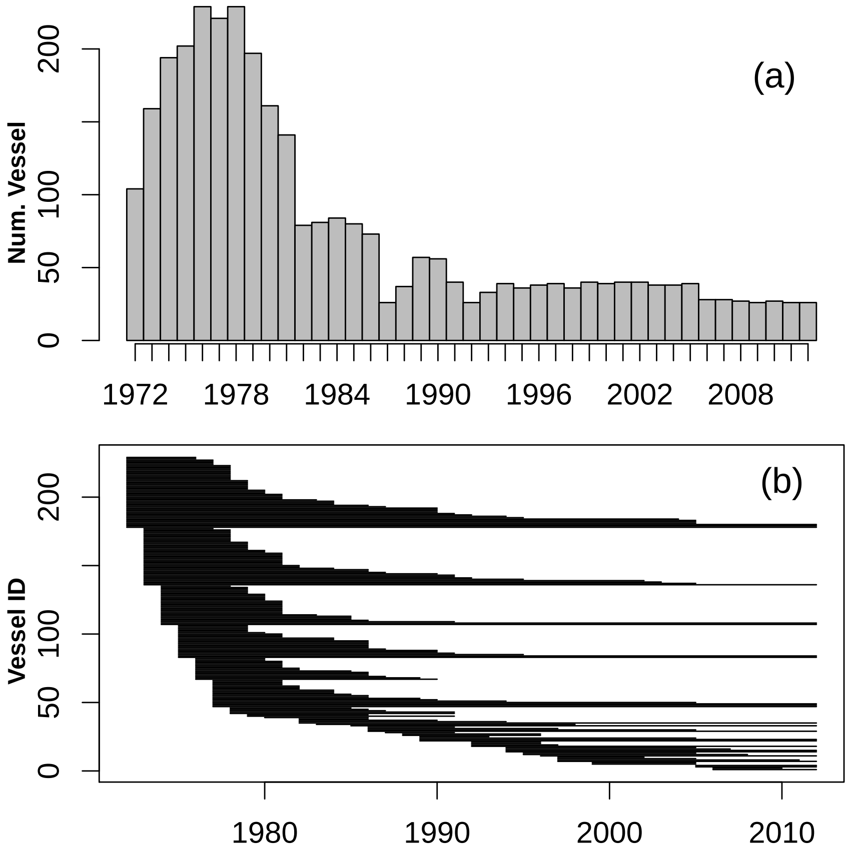


Figure 2. (a) Total number of unique vessel. (b) Time distribution of each unique vessel.

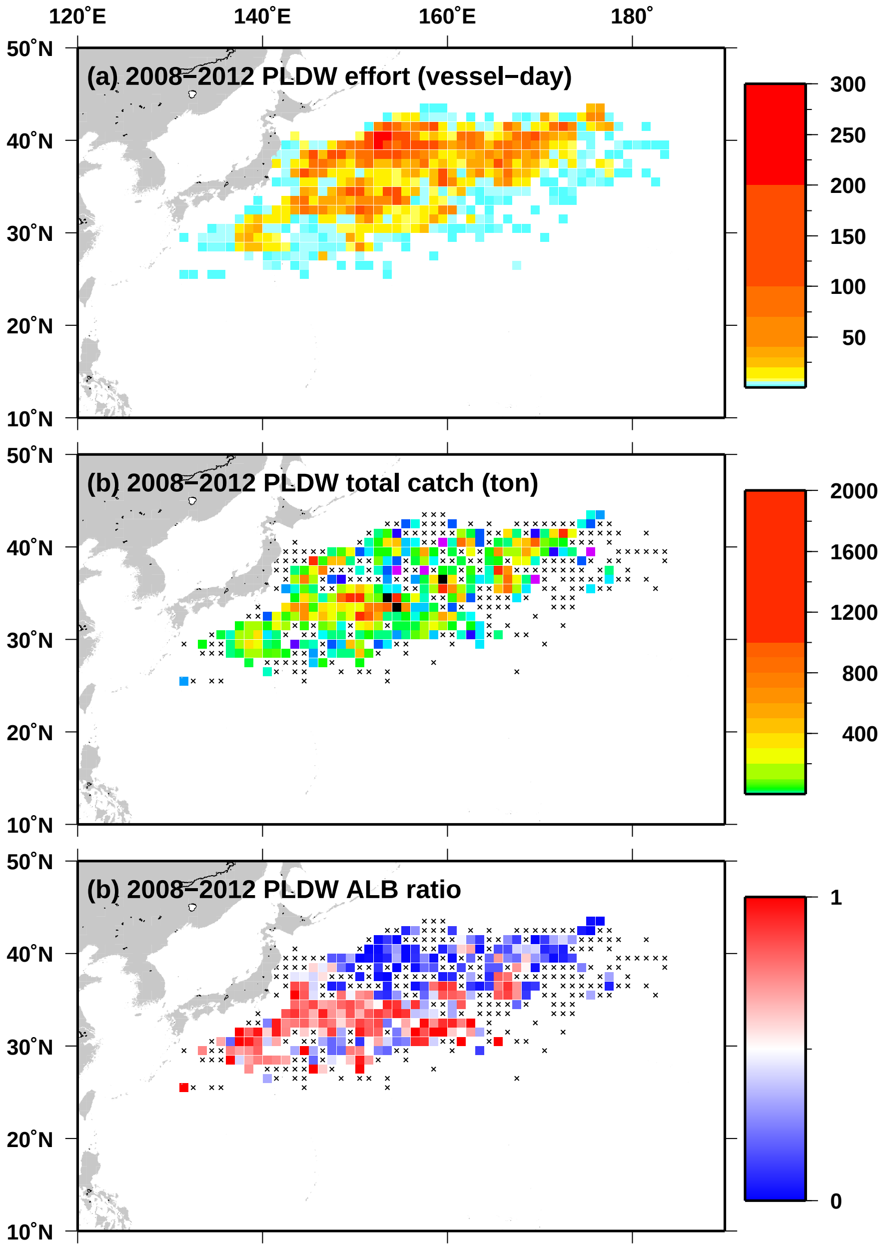


Figure 3. (a) PLDW effort (vessel-day), (b) total NPALB catch (tons) and (c) NPALB catch ratio in recent five years (2008-2012).

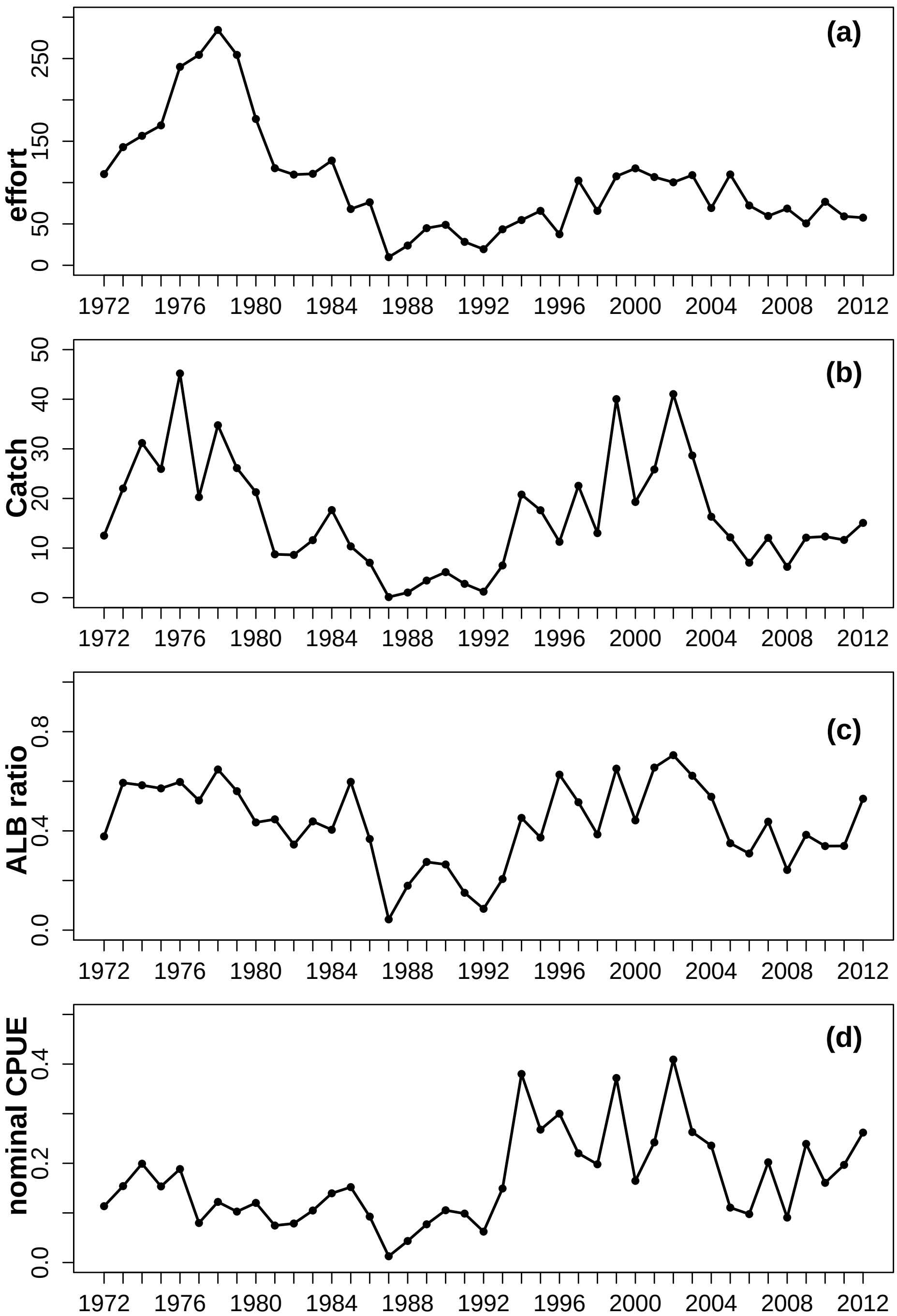


Figure 4. (a) Effort (number of poles), (b) catch (x 1,000 ton), (c) ALB catch ratio and (d) nominal CPUE (ton/pole)

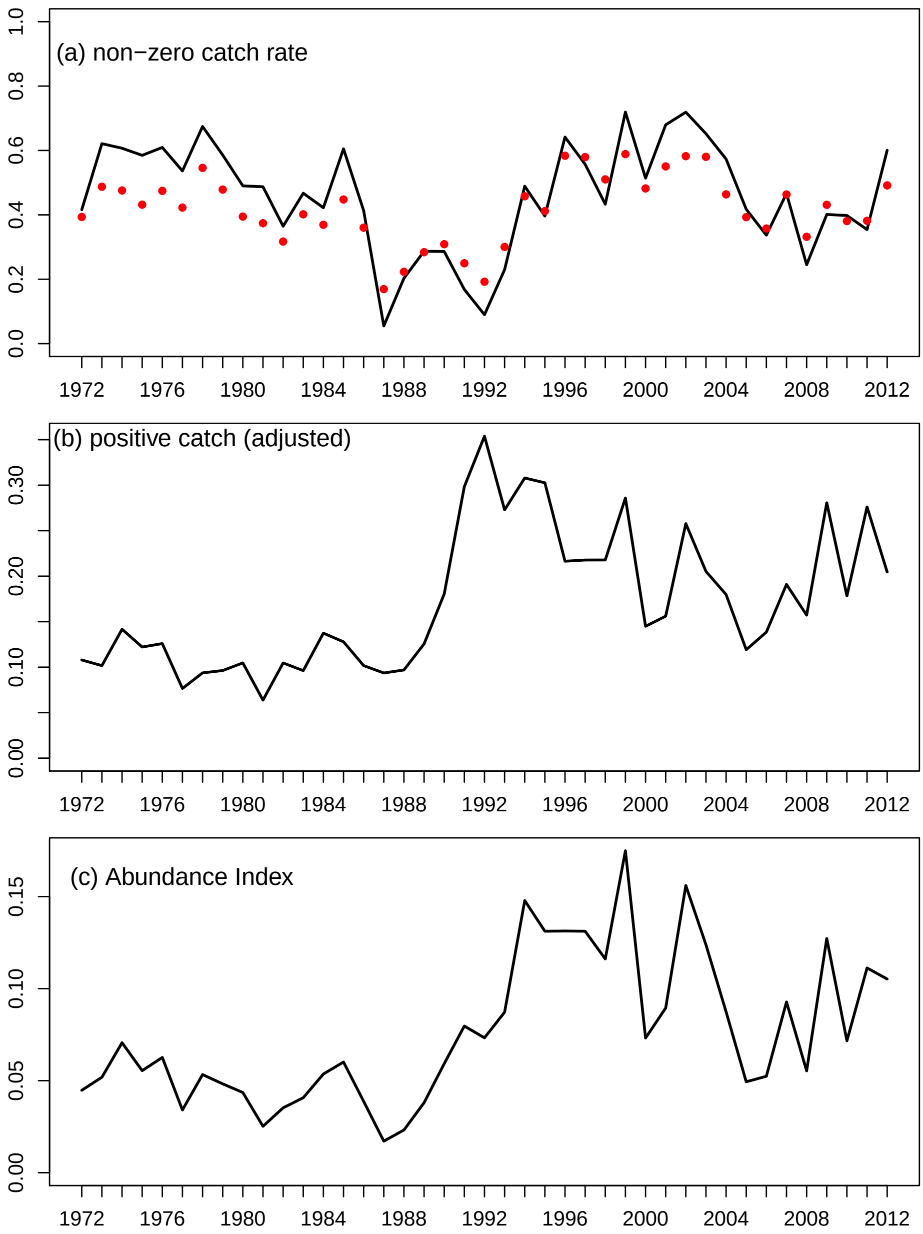


Figure 5. (a) Non-zero catch rate (red point:estimates, black solid line:observed ALB catch ratio), (b) adjusted positive catch (lognormal) and (c) abundance indices..

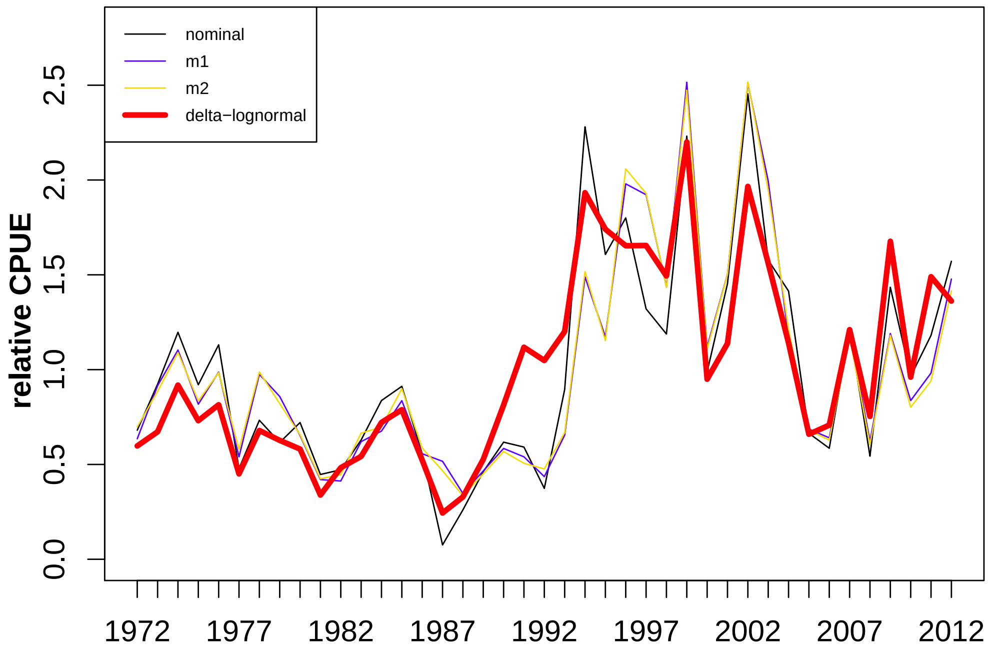


Figure 6. Estimated standardized CPUE of NPALB for JPN PLDW by several models.

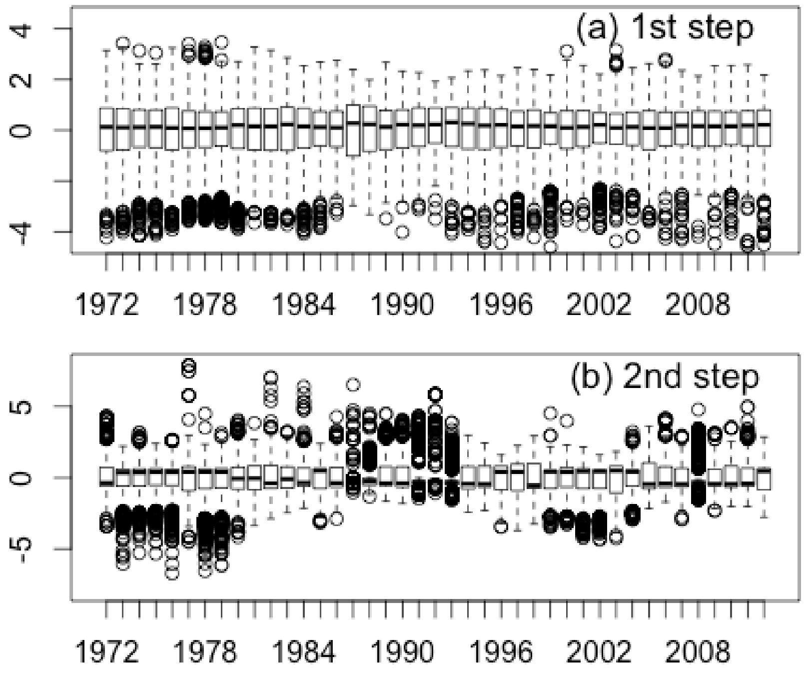
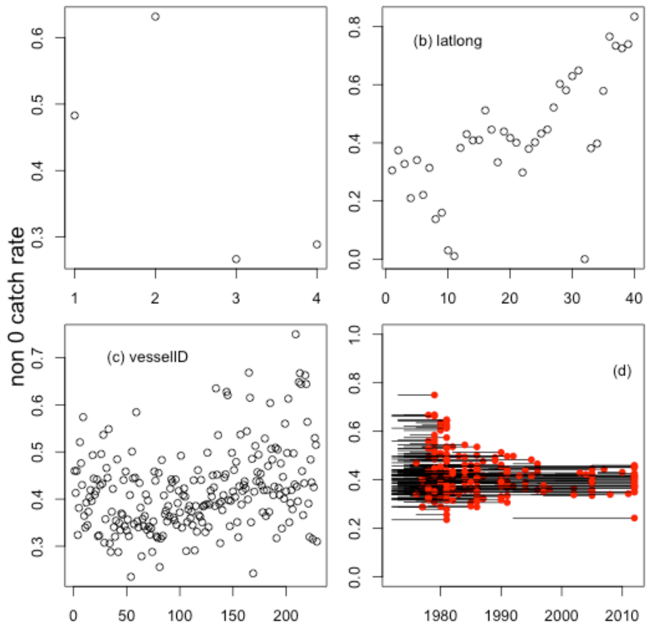


Figure 7. Residual plots of (a) 1st step and (b) 2nd step.

(A) 1st step (non zero catch ratio)



(B) 2nd step (positive catch)

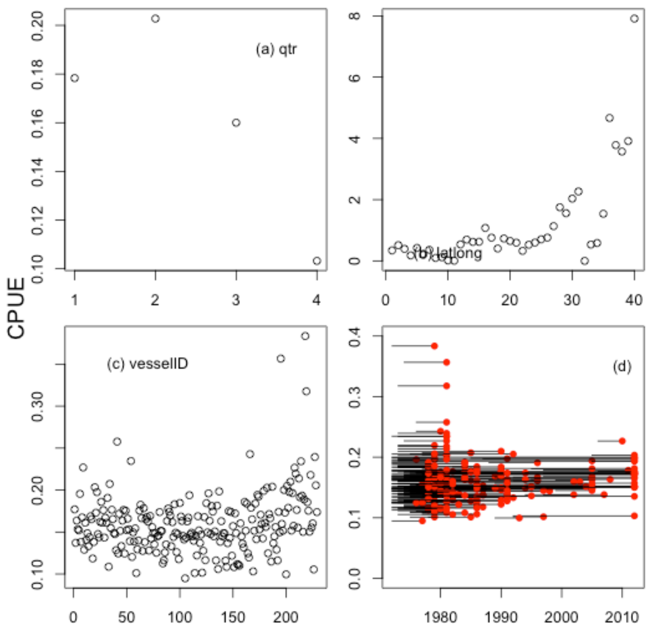


Figure 8. Effect of each variable on catch rate (A) and positive catch (B). (a) quater, (b) latlong, (c) vessel ID and (d) time distribution of vessel ID.

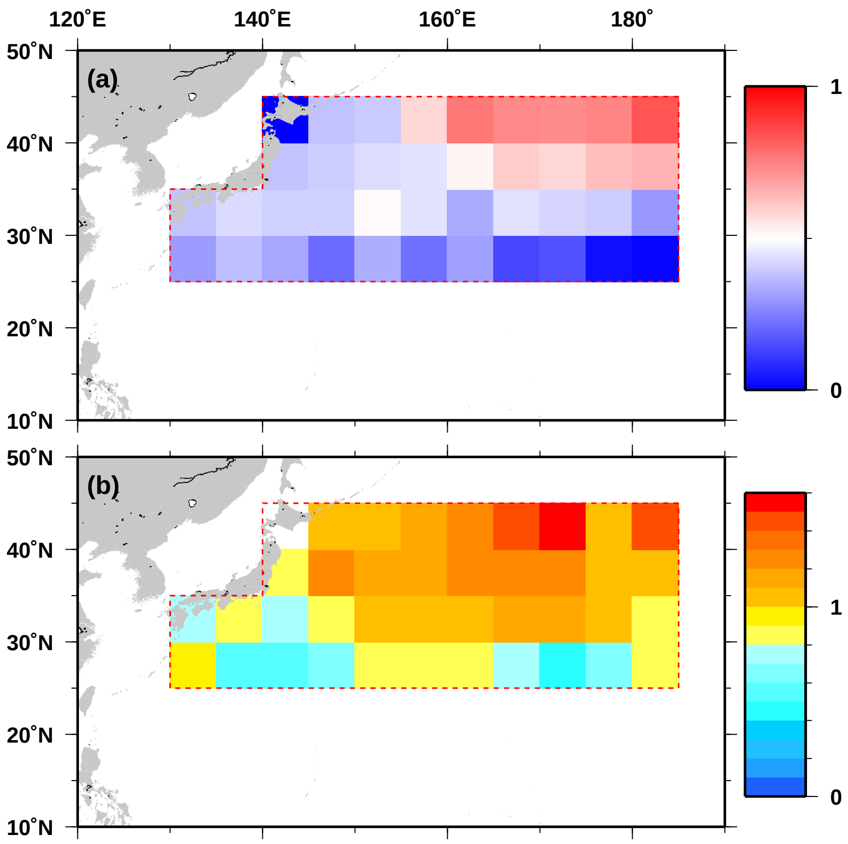


Figure 9. Latitude/longitude effects on the catch rate (a) and positive catch (b).