ISC/14/SHARKWG-1/02

Update of Japanese abundance indices and catch for blue shark *Prionace glauca* in the North Pacific[1]

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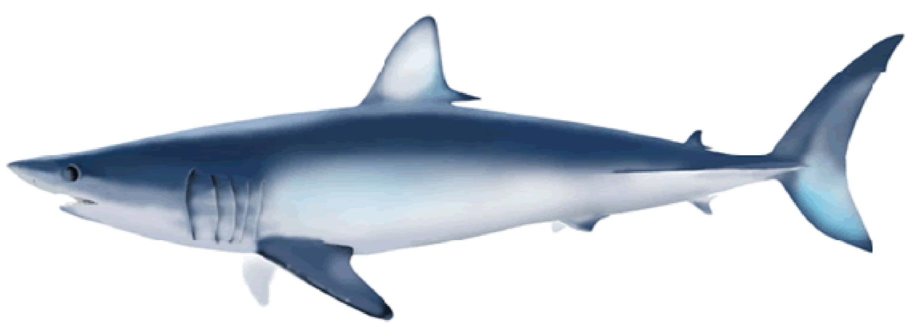

[1]Working document submitted to the ISC Shark Working Group Workshop, 13 - 18 January 2014,
NOAA Southwest Fisheries Science Center, La Jolla, California, U.S.A.

Abstract

This working paper provides with update of Japanese abundance indices during 1994 to 2012 for North Pacific blue shark (*Prionace glauca*), laying stress on the evaluation of the impact on the target effect of swordfish. Some miss-writing of log-book were also corrected before the calculation of CPUE but the influence was quite small for the CPUE standardization. The methodology of CPUE standardization and catch estimation by Hiraoka et al. (2013) were basically followed in this works. The CPUEs in most recent two years were standardized separately from that before 2011 because 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. The correction of miss-writing of log-book, which reported number of hooks per basket information at the column of total hooks deployed at the total hooks at the column of number of hooks per basket, produced somewhat pessimistic trend in the abundance indices in 2006 – 2012, but attained slightly narrower confidence intervals. The estimated annual catch during 1994 to 2012 had slightly decreased by the correction of logbook data, and the revision of the conversion factor caused upper translation of historical Japanese longline catch from 1971 to 2012.

Introduction

The abundance indices of blue shark (*Prionace glauca*) estimated using Japanese offshore surface longliners targeting swordfish and blue shark in the north-western and north-central Pacific have been recognized as the most representative one in the stock assessment of the North Pacific blue shark conducted by the shark working group (WG) of International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) (ISC 2013a). Thus the ISC Shark WG has been spent over one year to refine its standardizing method. The ISC Shark WG focused its labors on the development of the model to produce the statistically acceptable level of residual pattern, and that was successfully done by careful selection of the standardizing model as well as the input data (Hiraoka et al. 2013a).

At the last meeting of Scientific Committee of Western and Central Pacific Fisheries Commission (WCPFC SC), concerns were raised for the appropriateness of the standardizing method and further studies were requested especially about the inconsistent trajectories that Japanese longline CPUE series is increasing but Hawaii longline CPUE series is decreasing (**Figure.1**, WCPFC 2013). This study is mainly conducted as the updated works of Hiraoka et al. (2013) based on the request by WCPFC SC. The standardized CPUE updated for one year, with the correction of minor errors of log-book data in the period between 2006 and 2012. Also, the correction of historical catch series of Japanese offshore and distant-water longliners due to the change of conversion factor is briefly explained.

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Materials and Methods

Data source

Set-by-set logbook data from Japanese offshore and distant water longline fishery are used to standardize CPUE for 1994-2010 and 2011-2012, and to estimate the catch for 1971-1993, 1994-2010, and 2011-2012. 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 per basket (HPB), 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. The logbook data have been collected and compiled by the National Research Institute of Far Seas Fisheries since 1971. The logbook records in the early period from 1971 to 1993 contain only aggregated catch of shark species. The column of each species of sharks had been added to the data since 1994. Additionally, main fishing ports of the Japanese longliner targeting for sharks were damaged by the Great East Japan earthquake and tsunami in March 11, 2011 and their operational pattern was changed. Therefore, the time period for CPUE standardization was divided into three; 1975-1993, 1994-2010, and 2011-2012. In this working paper, we focus on the Japanese CPUE series in the late period since 1994 because the trend of CPUE series is inconsistent with that of Hawaii CPUE series.

Correction of the logbook data, conversion factor

The logbook data during 1994 to 2012 were thoroughly reviewed and then some miss-writing were found. The number of hooks per an operation of some specific ship had extremely decreased since 2008 (**Figure 2**), so that we corrected the number of hooks (**Table 1**) by multiplying the erroneous number of hooks by number of HPB used in previous operations.

Conversion factor (CF) of 1.2, which is identical with that of tunas, had been used for sharks. But there is a groundless value for sharks. Therefore, CF from processed weight into round weight of blue shark in the North Pacific was corrected to improve the accuracy of the catch estimation. We calculated the two types of CFs for two different processing methods, dress with fins ("Kesennuma dress") and dress without fins ("dress"), using simple linear regressions with the size samples in the North Pacific Ocean.

Filtering of logbook data

Most Japanese offshore and distant water longliners targeting the sharks and swordfish are registered to the prefectures in Tohoku and Hokkaido areas (Northern and eastern Japan) and unload those fish

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to the markets in the major fishing ports for tunas, swordfish and sharks (i.e. "Kesennuma" city in Miyagi Prefecture; see at the map in **figure 3**). On the other hand, the longliners registered to the other prefectures catch the sharks unintentionally (i.e. bycatch) and they tend not to report the catch or to release and discard the sharks because of the low price of sharks, uneasy handling, and the loss of the space to stock the other valuable species such as a tunas etc. Additionally, it is general that the fishery with shallow-sets (HPB < 7) targets swordfish and sharks, while the fishery with deep-sets (HPB > 6) targets tunas.

We used the following two filtering methods following the Hiraoka et al. (2013) to remove the data of released, discarded, and unreported catch in considering the characteristics of the Japanese longliners. The first filtering (Filtering I) was conducted based on the vessels registered to the prefecture in the area "Tohoku and Hokkaido" and fishery type "Offshore and distant-water shallow". The second filtering (Filtering II) was conducted based on the reporting rate of positive catch of blue shark by vessels (RRV) as defined by Clarke et al. (2011). The level of RRV is set at 94.6% which is the same as that used by Clarke et al. (2011).

Update of the CPUE series

Standardized CPUE for 1994-2010 is computed using the logbook data after the data correction and filtering. The Japanese longliners operate in the western and central NP where we stratify the area into five (**Figure 3**) but the data in area-5 is not used for CPUE standardization because of small number of set-by-set data after the filtering. Unlike the previous analysis, area weighting is not conducted because there is no two way interaction between area and year in the model. We use the generalized linear model (GLM) with negative binomial error distribution used by Hiraoka et al. (2013) as follows;

$$\text{Catch} = Y + S + A + F + T + Y*T + S*T + \text{offset}(\log(\text{Effort})) + \text{Error (NB)},$$

where, Catch: expected catch in number of blue shark, Y: year, S: season, A: area, F: fishery type, T: target effect of swordfish, Y*T and S*T are interaction terms, Effort: number of 1000 hooks, Error (NB): negative binomial error distribution through a log link function. Target effect of swordfish is expressed by the ranking from 1 to 10. The ranking is computed as follows; the dataset is divided into 10 categories by the order of swordfish catch ratio at every 10^{th} percentile. A number of "10" means that the catch ratio of swordfish is the highest in the each stratum divided by factors such as year, season, area, and fishery type.

The best (Base case) model is selected using the Akaike's information criterion (AIC) and Bayesian information criterion (BIC). The goodness of fit is 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) is also conducted to check the effects of each factor on the fitting. In addition, standardized CPUE for 2011-2012 is also computed using the updated logbook data. Similar model above is used but the interaction term of "S*T" is removed from the model due to the lack of the data. 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 (see below) is calculated in each bootstrap trial, respectively.

Appropriateness of the data filtering

We examined the effects of the two types of the data filtering methods; filtering I (Pref. and fishery type) and II (Reporting rate) on the nominal and standardized CPUE series for four different filtering levels; No filtering, filtering by registered to the prefecture, filtering by reporting rate by vessel, filtering by both.

Evaluation of the impact of the target effect

We examine the changes of nominal CPUE of Japanese offshore and distant water longline by year and target effect of swordfish in order to clear the usefulness of the interaction terms including the target effect. The target effect is calculated overall years. Although there may be the small scale spatial and seasonal differences in effective fishing effort for blue shark but it is impossible to include the interaction among small areas, seasons and years because of low resolution of data. Instead of including this interaction term, target effect has been included in the model because these factors can follow the differences of effective fishing effort in each operation. If this factor will standardize well, the small scale regional and seasonal differences in effective fishing effort can be treated on standardization model.

Revisions and updates of catch estimation

We update the annual catch for 1971-2012 using the corrected and updated logbook data with revised CFs. As for the period for 1971-1993, we only converted the estimated catch by Hiraoka et al. (2013) into the catch of round fish using the revised CFs. As for the period for 1994-2012, we firstly estimated the standardized CPUE and then the catch were estimated. Same estimation methods described in the previous document papers (Hiraoka et al. 2013b; Hiraoka et al. 2012) are used. The procedures are as follows:

i) Data are divided by the vessel type; "Kinkai" (offshore) or "Enyo" (distant-water), by gear configuration; Deep or Shallow, by prefecture of vessel register "Hokkaido and Tohoku" or others, and by years "1994-2010" or "2011-2012". The data are categorized into six fleets:

(1): Kinkai and Enyo with shallower setting by Hokkaido & Tohoku prefectures between 1994 and 2010.

(2): Kinkai with deeper setting by Hokkaido & Tohoku prefectures between 1994 and 2010.

(3): Enyo with deeper setting between 1994 and 2010.

(4): Kinkai and Enyo with shallower setting by Hokkaido & Tohoku prefectures between 2011 and 2012.

(5): Kinkai with deeper setting by Hokkaido & Tohoku prefectures between 2011 and 2012.

(6): Enyo with deeper setting between 2011 and 2012.

ii) CPUE trends for each fleet category are estimated using the following GLMs:

(1) Catch = Y + A + S + T + F + Y*T + S* T+ offset (log (Effort)) + Error (NB),

(2) Catch = Y + A + S + Deep-HPB + A*Deep-HPB+ offset (log (Effort)) + Error (NB),

(3) Catch = Y + A + S + Deep-HPB + Prefecture+ offset (log (Effort)) + Error (NB),

(4) Catch = Y + A + S + T + F + Y*T+ offset (log (Effort)) + Error (NB),

(5) Catch = Y + A + S + Deep-HPB + A*Deep-HPB+ offset (log (Effort)) + Error (NB),

(6) Catch = Y + A + S + Deep-HPB + Prefecture+ offset (log (Effort)) + Error (NB),

where Deep-HPB is two types of deep sets; shallower (HPB≧15) and deeper (HPB < 15), and prefecture is two areas; "Hokkaido and Tohoku" and "Others" (See at the map in the Hiraoka et al. 2013a).

iii) Catch in number at log-book (commercial longline) level including 0 blue shark catch by vessels are estimated by applying explanatory variables such as hooks to the CPUE standardization model developed in the step ii).

iv) Catch in weight are calculated multiplying the catch in number by year, season and area by the revised mean weight of a blue shark by season and area due to the change of processed- whole weight conversion factors, and the catch are combined into annual catch.

v) Annual catch in weight including discard/release of blue shark are calculated using the coefficient (the ratio of CPUE between research and commercial longline) estimated by Takahashi et al. (2012). The coefficient for the fleet (3) and (6) was 14, and the others were 1.

Results

Correction of the logbook data and conversion factor

Interrelationship among nominal CPUE, total hooks, and catch number of blue shark before and after the correction of the number of hooks for a specific vessel are shown in **Figure 4**. Some impossible and unlikely plots with very high nominal CPUE for relatively small number of total hooks (e.g. less than 1000 hooks) were removed.

The estimated CFs for "Kesennuma dress" and "dress" were 1.7 and 2.0, respectively (**Figure 5**). The value of 1.7 was used for the fishery "offshore shallow", and the value of 2.0 was used for the fishery "offshore deep", "distant water shallow", and "distant water deep", because the processing methods are different by the fishery types.

Update of the CPUE series

The full model was selected by AIC and BIC (**Table 2**). ANOVA table indicated that all selected factors are statistically significant (**Table 3**). 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 6**). 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 6**). Although the correction of the logbook data is limited in the specific years (i.e. 2006, 2008-2012), previous and updated nominal CPUE were completely different throughout the years because previous nominal CPUE was weighted by area (**Table 4**, **Figure 7**). Standardized CPUE series from 1994 to 2005 were slightly larger than that the previous series, whereas the CPUE series from 2006 to 2010 was smaller. Standardized CPUE in 2012 had increased more than that in 2011. The estimated confidence intervals were slightly narrower than previous ones (**Table 4**, **Figure 8**).

Appropriateness of the data filtering

The calculation of the standardized CPUE without both data filtering could not be converged. Nominal and standardized CPUE series were drastically changed by the data filtering (**Figure 9**). However, the two data filtering I (Pref. and fishery type) and II (Reporting rate) have a similar effect on the CPUE standardization. These results indicated that both filtering methods overlap with each other but they can surely remove similar unreliable data from original data. Some reasons for the convergence issue may be considered and one of them is that the variation of data is much larger than the theoretical variation assumed in the standardization process. This result suggests that it is better adapt these two data filtering methods before the CPUE standardization.

Evaluation of the impact of the target effect

Nominal CPUE of blue shark (number/1000 hooks) with low ranking of swordfish catch ratio had gradually increased since 1997 and reached to the peak around in 2005, and then gradually decreased until 2010 (**Figure 10-left**). Nominal CPUE of blue shark with low ranking of swordfish catch were remarkably large in season 2 (Apr-Jun) and 3 (Jul-Sep). (**Figure 11-left**). Nominal CPUE of the blue shark had a clear negative correlation with that of swordfish except for 1994-1996 and season-1(Jan-May) and 4(Oct-Dec) (**Figure 10 and 11-right**). These results indicate that there are clear interactions between year and target effect of swordfish, and between season and target effect of swordfish, respectively. Standardized CPUEs of blue shark by the different combination of explanatory factors were compared (**Figure 13**). General trends of the CPUEs were not almost similar to each other except for ones standardized by the simpler combinations of factors without area. Distribution pattern of 4 or 5 years average CPUEs of blue shark with pie chart, which indicate the catch rate of blue shark using the size of the pie and ranking of the catch rate of the swordfish, is shown in **Figure 14**. CPUEs of the blue shark were rather low in the southern areas (areas 3 and 4) and major parts were occupied by the sets with higher rank of swordfish CPUE. Sets in the southern areas were mainly observed in the 1^{st} – 3^{rd} quarters during period of 1994 – 1998 and 1999 – 2002, but sets in the 3^{rd} quarter almost disappeared during period of 2003 – 2006 and 2007 – 2010. In the 3^{rd} quarter of the later period (2003 – 2006 and 2007 – 2010), the ratio of lower rank of swordfish CPUE increased in compare to the earlier period (1994 – 1998 and 1999 – 2002). Number of sets in the southern part of the northern area (30N – 35N) was also decreased in the 3^{rd} quarter of the later period.

Updates of catch estimation

The estimated catch in number and weight (tons) for 1994-2012 had slightly decreased by the correction of number of hooks in the logbook data (**Table 5 and 6**, **Figure 12**). The increase of the number of hooks by the data correction had decreased the CPUE trends as a whole compared to the pervious trajectory, and then it had increased the estimated catch for 1994-2010. The revision of the conversion factor has greatly increased the catch for 1971-2012 (**Figure 12**). The decreasing ratio of the catch from 1981 to 2012 was remarkably high. The decreasing trends of the estimated catch in 2000s were caused by the decreasing trends of the effort (Number of hooks) (**Table7**).

Discussion

We provided with update of Japanese abundance indices for NP blue shark for 1994-2012 and Japanese catch estimation for 1971-2012.We firstly reviewed the logbook data thoroughly and exhaustively to improve the data quality and we could correct the some miss-writing of number of hooks for a specific vessel in the logbook data. It is more likely to be generated because the column of the logbook data "Number of basket" had changed into "HPB" in 1997 and the new record has been continued after that. The data correction had remarkably decreased the standardized CPUE in recent years (i.e.2008-2010 in **figure 7**). However, the trends of the CPUE series through the all years were almost follow that shown by Hiraoka et al. (2013) because the number of the data correction was small in all data and the periods were limited in recent years (**Table 1**). Also, the update of the CFs had largely increased the catch estimation about 1.5 times throughout the years.

A sharp decrease of catch in 2012 was caused by the decrease of the catch ratio of "distant water deep fishery"（CF=2.0）to all from 67% to 31%, and by the increase of the catch ratio of "offshore shallow fishery"（CF=1.7）to all from 23% to 49%. These results suggested that the disaster in 2011 had a large impact on the changes of the operation pattern after 2011. Therefore, the updated CPUE series and catch in 2011 and 2012 might not be better use for the upcoming stock assessment because the both estimations are based on the datasets after the disaster. Furthermore, we used the same methods as the CPUE standardization and the catch estimation for 1994 and 2010. In future work, we need to improve the standardization method with the data storage.

In the previous working paper (Hiraoka et al. 2013a), the discussions on the usefulness of the target effects were insufficient. The model selection by comparison of AIC and BIC indicated that target effect of swordfish was reasonable for the CPUE standardization (**Table 2**). These results suggest that the target effect is the one of the important factors. Standardized CPUE series were drastically changed and the trajectories were close to the best model with the explanatory variables sequentially added (**Figure 13**). Classification of the effective factors in the GLM models from the visual examination indicated that area factor seemed to be more effective than target factor (**Figure 13**). The discrepancy between the values of information criterions and the observed fitting were unsure.

In compare to the full model, the other models tend to underestimate the level of CPUE in the period before 2002, and overestimate after 2002 (Figure 13). Among the factors except for year, the area has strongest effect to adjust the trend of calculated standardized CPUE because the CPUE standardization used in the model with the effects of year and area becomes closer to the full model than the ones standardized with the effects of year and other one factors. This can easily be understood by **figure 14.** In almost years and seasons, the CPUEs of blue shark in the southern areas (areas 3 and 4) are largely lower than those in the northern areas (areas 1 and 2). The sets in the southern areas are mainly observed in the 1^{st} – 3^{rd} quarters during earlier periods (1994 – 2002), but sets of 3rd quarter is almost disappeared during later periods (2003 – 2010). In either case, sets in the southern areas are characterized by the lower blue shark CPUE with higher swordfish CPUE rank than those in the northern areas. This indicates that the sets in the southern areas mainly targeted swordfish.

In the later period (2003 – 2010), the sets in the southern areas are almost disappeared in the 3rd quarter and instead, the sets with higher blue shark CPUE and lower swordfish CPUE rank started to appear (**Figure 14**). Yokawa (2009) reported the increase of the blue shark directed sets of Japanese offshore surface longliners in the 2000s. The results of the analysis of CPUE of blue shark and swordfish in the present study indicate that the reported increase of blue shark targeted sets in the 2000s mainly attained by change the fishing ground from southern areas to the northern areas in the 3rd quarter. Thus, the effect of target species should be accounted mostly by the effect of area in the model for CPUE standardization.

During the period between 2005 and 2006, the area factor does not have much effect to adjust the trend of standardized CPUE (**Figure 13**), and addition of season or target factors decreased the deference from one by full model. This could be explained by the fact that the sets with higher rank of swordfish CPUE are almost disappeared from the northern areas in the 2nd and 3rd quarters (**Figure 14**). This indicates that the degree of dependence on blue shark by the Japanese offshore surface longliners become apparent in this period. Because the increase of blue shark directed sets seems to be extended from the parts of period of 2nd and 3rd quarters to the almost entire period of 2nd and 3rd quarters, season factors could also explain the effect of target change in the model (**Figure 14**).

The reported shift of target species observed in the Japanese offshore surface longliners during 1994 to 2010 would be adjusted by the area and season factors, which intended to adjust the effect of biological influences of target species like season migrations, to some extent. That would be the reason that the target factors itself does not have large effect in the blue shark CPUE standardization. But the detailed analysis of CPUE also indicate that the introduction of the target effect is statistically significant in the model and actually worked to adjust the trend of CPUE as shown in **Figure 13**. This should be due to the fact that the blue shark targeted sets and swordfish targeted sets occurred in the single area and season in some cases especially in the 2nd and 3rd quarters (**Figure 13**). In such cases, targeting factor would adjust the difference of CPUE among these two types of sets.

In the CPUE analysis of pelagic longline data, number of HPB data have been introduced into the standardization model as the proxy of the effect of target species (e.g., Hoyle and Okamoto 2013), but this study revealed that Japanese offshore surface longliners target both swordfish and blue shark using same shallow sets and the ratio of targeting sets of the blue shark increased in the analyzing period. In such case, neither the factor of the number of HPB nor the setting time of sets can be used to adjust the effect of the historical change of the target species. In the present study, the adjustment for the effect of the target species' change was conducted using the method developed by the Cortes (2013), and, the 10 percentile of the annual CPUE ranking of swordfish was introduced in the CPUE standardization. Cortes (2013) used 25 percentile of the annual CPUE ranking to account for the change of target species. In this study, 10 percentile were used because of relatively larger number of "gray" sets, which cannot easily identify target species from the species composition of log-book data (Yoakwa 2005).

Though the results of the CPUE analyses indicated that the effect of area and season had some effects to adjust the biases caused by the historical change of target species, as Japanese surface longliners tend to target blue shark in the summer to autumn at relatively higher latitudinal areas while they target swordfish in the winter to spring at relatively lower level, at the same time it also clearly indicated that the necessity of the introduction of the CPUE ranking of swordfish to full adjustment of the effect of the historical change of target species. This is mainly because the fact that the distance between swordfish and blue shark fishing grounds are sometimes becomes rather close like just southern and northern part of fronts (Yokawa et al 2013), and the change of target species does not occur in the same timing for all fishing vessels which belong to the Japanese offshore surface longline fleet based on the "Kesennuma" fishing port (**Figure. 14**). In such situation, effect of area and season cannot fully adjust the effect of target species.

Japanese offshore and distant-water deep longliners also uses same number of HPB to target different species (Yokawa 2005), and this indicates similar situation, which uses same gear configuration to target more than one species, would occur in longline fishery of other countries. Thus, adjustment for the effect of the target species' change should be carefully investigated and necessity additional explanatory factors like the CPUE ranking rather than HPB should be checked carefully and be used in a case mentioned above.

Blue shark is an oceanic and epipelagic elasmobranch which is widely distributed from the tropical to the temperate areas and the relative abundance of blue shark is lowest in equatorial waters and increases with latitude (Nakano and Seki 2003). In the northwestern and central Pacific, higher density observed in areas higher than 20N, especially those in 30N – 50N (Nakano and Seki 2003; Nakano 1994). Fishing ground of Japanese offshore surface longliners registered in “Tohoku and Hokkaido area”, whose data was used in the CPUE analysis in this study, are mainly operated in the area 30N – 45N and 135E – 170W. Thus, the data used in this study is widely covered the main distribution area of the north Pacific blue shark stock.

Nakano and Seki (2003) describe the schematic blue shark migration model by sex and growth stage. If this information were compared with the operational area of Japanese offshore surface longliners registered in “Tohoku and Hokkaido area” (**Figure 14**), it is clear that the operational area of Japanese offshore surface longliners is corresponding to the distribution area where male and female of adult, sub-adult and juvenile blue sharks. The result of the size data analysis of blue shark caught by Japanese offshore surface longliners clearly indicated this thing (Shiozaki et al. 2012).

It could be quite informative to include sea surface temperature (SST) in the model. However, there are several reasons why we do not use oceanographic data. (1) Since it is known that the small scale differences of temperature and salinity had affected the effective fishing effort directly (Yokawa et al. 2013), the spatial resolution of the oceanographic data is low to explain about the differences of the effective fishing effort. (2) Oceanographic data such as GODAS are provided freely on the website (**http://www.esrl.noaa.gov/psd/data/gridded/data.godas.html**) but it may cause serious errors which we cannot ignore because the environmental data from oceanographic model are not direct observations. (3) SST and other main factors such as season, area, and year should have big correlation and we should remove such effect to avoid the issue of multicollinearity. (4) We cannot assume that SST and effective fishing effort have a linear relationship because fish has usually optimum temperature. If we use it in the model, we need to include it as categorical factor. It makes the model more complicated. (5) Because SST can affect the reproduction and natural mortality, the standardized CPUE may bias from the true stock dynamics if we introduce it.

Although we consider the five areas in the model, it was at too large a spatial resolution to account for the latitudinal and longitudinal gradient. Clarke et al. (2011) found very strong pattern of increasing concentration of effort in areas with highest blue shark CPUE. The study was done at the 5×5 degrees and quarter spatial resolution. It is strongly indicative of changes in targeting. However, did not include such an effect in the model because we introduce the target effect of the swordfish which can treat the spatial and seasonal differences of the effective fishing effort by each set (1×1 degrees). The changes of the spatial distribution of swordfish and sharks catch rate by year and season were clearly shown in **Figure 14**.

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Standardized CPUE should be better to be calculated using the catch and effort data that widely covers the main distribution area of the fish for its use as an abundance index in the stock assessment. Wider range of size coverage, especially for spawning adult, would attain higher representativeness of the stock. Because Japanese longline data has wider size range (around 50~250 cm in PCL) including spawning adult, the standardized CPUE shown in this study is believed to mostly satisfy these requirements as a good abundance index, and this fact is also clearly summarized in the table in the report of ISC shark working group meeting (ISC 2013b).

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

Clarke, S., Harley, S., Hoyle, D. H., and Rice, J.S. 2012. Population Trends in Pacific Oceanic Sharks and the Utility of Regulations on Shark Finning. Conservation Biology. Volume 27, No1, 197-209

Cortes, E. 2013. Standardized catch rates of mako sharks from the U.S pelagic longline logbook and observer programs using generalized linear mixed model. Collect. Vol. Sci. Pap. ICCAT, 69(4): 1578-1590 (2013)

Hiraoka, Y., Kanaiwa, M., and Yokawa, K. 2013a. Summary of estimation process of abundance indices for blue shark in the North Pacific. ISC/13/SHARKWG-2/02

Hiraoka, Y., M. Kanaiwa and K. Yokawa 2013b. Re-estimation of abundance indices and catch amount for blue shark in the North Pacific. ISC/13/SHARKWG-1/03.

Hiraoka, Y., M. Kanaiwa and K. Yokawa 2012. Estimation of total blue shark catches including releases and discards Japanese longline fisheries during 1975 and 2010 in the North Pacific. ISC/12/SHARKWG-1/08.

Hoyle, S. D., and Okamoto, H. 2013. Target changes in the tropical WCPO Japanese longline fishery, and their effects on species composition. WCPFC-SC9-2013/SA-IP-04.

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. 2013. Report of the ISC shark working group workshop,16-24 April , 2013 Shizuoka, Japan. 34p. *Available at* http://isc.ac.affrc.go.jp/pdf/ISC13pdf/Annex%208%20April%202013%20SHARKWG%20Report-6-12-13%20final.pdf.

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. 2013. Report of the stock assessment and future projectins of blue shark in the North Pacific Ocean. Busan, Korea. *Available at* http://isc.ac.affrc.go.jp/pdf/ISC13pdf/Annex%2011-%20Blue%

20shark%20assessment%20-%20Final%20(SEPT).pdf.

Nakano, H. 1994. Age, reproduction and migration of blue shark in the North Pacific Ocean (In Japanese, abustruct and caption of Figs. and Tables in English). Bull. Nat. Res. Inst. Far Seas Fish., No. 31, 141- 257.

Nakano, H., and M. P. Seki. 2003. Synopsis of biological data on the blue shark, *Prionace glauca* Linnaeus. Bull. Fish. Res. Agen. No 6, 18-55, 2003.

Shiozaki, K., M. Taguchi and K. Yokawa. 2012. Recent catch pattern of blue shark by Japanese offshore surface longliners in the northwest Pacific. ISC/12/SHARKWG-1/05, 15p.

Takahashi. N., Hiraoka, Y., Kimoto, A., Yokawa. K. and Kanaiwa, M. 2012 Comparison of CPUEs of Blue Shark Reported by Logbook of Japanese Commercial Longliners with Japanese Research and Training Longline Data. ISC/12/SHARKWG-1/06.

Western & Central Pacific Fisheries Commission. 2013. Report of the WCPFC 9th Regular Session of the Scientific Committee. Pohnpei, Federated States of Micronesia. *Available at* http://www.wcpfc.int/meeting-folders/scientific-committee.

Yokawa, K. 2005. Operation patterns of Japanese offshore and distant-water longliners in the North Pacific, with emphasis on the billfishes. ISC/05/MARLIN&SWOWG-1-18, 19p.

Yokawa, K. 2013. Habitat Segregation of Swordfish and Blue Shark in the Kuroshio–Oyashio Transition Zone in the North Pacific Inferred by Longline Research Data. 5th International Billfish Symposium, Taipei in Taiwan. 4-8, Nov, 2013.

Yokawa, K. (2009) The effect of change of target species on the CPUE of swordfish caught by Japanese offshore surface longliners operating in the north Pacific. ISC/09/BILWG-1-06, 16p.

Table 1. Number of hooks by the correction of the miss-writing of log-books before and after the data filtering.

Year	Before data filtering			After data filtering		
	Previous number of hooks (× 1000)	Corrected number of hooks (× 1000)	Increase rate	Previous number of hooks (× 1000)	Corrected number of hooks (× 1000)	Increase rate
2006	75,502,347	75,538,347	1.0005	13,238,882	13,274,882	1.0027
2008	61,424,098	61,581,778	1.0026	13,214,816	13,372,496	1.0119
2009	48,543,607	49,072,057	1.0109	10,803,043	11,331,493	1.0489
2010	48,946,954	49,493,374	1.0112	9,575,382	10,121,802	1.0571
2011	49,797,928	50,028,628	1.0046	5,661,854	5,892,554	1.0407
2012	43,855,341	44,290,791	1.0099	7,096,157	7,531,607	1.0614

Table 2. Summary of the results of the GLM models for Japanese offshore and distant water longline for North Pacific blue shark (1994-2010) and the model selection by Akaike's information criterion (AIC) and Baysian information criterion (BIC). Base case model used in the stock assessment in 2013 is Model 14. AICmin and BICmin indicates the minimum value of AIC and BIC, respectively. Y: Year, S: Season, A: Area, F: Fishery type, T: Target effect of swordfish, Y*T and S*T are interaction terms.

Model	AIC	BIC	AIC-AICmin	BIC-BICmin
1.Y	889,057	889,225	29,552	27,812
2.Y + T	877,646	877,898	18,141	16,485
3.Y + S	881,694	881,890	22,189	20,477
4.Y + A	879,879	880,075	20,374	18,662
5.Y + F	888,998	889,175	29,493	27,762
6.Y + S + T	875,351	875,630	15,846	14,218
7.Y + S + A	868,833	869,057	9,328	7,644
8.Y + T + A	871,392	871,671	11,887	10,258
9.Y + S + A + T	866,937	867,244	7,432	5,832
10.Y + S + A + F	868,795	869,028	9,290	7,615
11.Y + S+ A + F + T	866,902	867,218	7,397	5,806
12.Y + S + A + F + T +Y*T	862,951	864,607	3,445	3,194
13.Y + S + A + F + T + S*T	863,395	863,963	3,890	2,550
14.Y + S + A + F + T + Y*T + S*T	859,505	861,413	0	0

Table 3. Analysis of variance (ANOVA) summary table of base case (See Model 14 in Table 2).

	Df	Deviance	Dev./DF	Resid.DF	Resid.Dev	Pr(>Chi)
NULL				81,203	139,969	
as.factor(year.x)	16	12642	790	81,187	127,328	2.20E-16 ***
as.factor(qt)	3	9665	3222	81,184	117,663	2.20E-16 ***
as.factor(area)	3	15228	5076	81,181	102,435	2.20E-16 ***
as.factor(target)	9	2094	233	81,172	100,342	2.20E-16 ***
as.factor(gyogyoucode)	1	40	40	81,171	100,301	2.39E-10 ***
as.factor(year.x):as.factor(target)	144	4493	31	81,027	95,808	2.20E-16 ***
as.factor(qt):as.factor(target)	27	3564	132	81,000	92,244	2.20E-16 ***

Table 4. Nominal CPUE, scaled nominal and standardized CPUE, and the coefficient of variations (C.V., %) of Japanese offshore and distant water longline for North Pacific blue shark before and after the correction of the miss-writing of log-book. Scaled CPUEs are normalized by the mean values which set at 1.0, and previous CPUEs are referred from the values in Hiraoka et al.(2013).

year	Previous Nominal CPUE	Previous Scaled Nominal CPUE	Revised Nominal CPUE	Revised Scaled Nominal CPUE	Previous Scaled Standardized CPUE	Revised Scaled Standardized CPUE	Previous C.V.(%)	Updated C.V.(%)
1994	8.106	0.465	9.484	0.434	0.659	0.682	1.714	1.453
1995	8.143	0.467	12.947	0.593	0.778	0.791	1.562	1.435
1996	8.204	0.470	13.877	0.635	0.733	0.767	1.611	1.488
1997	17.727	1.017	24.300	1.112	0.908	0.932	1.600	1.354
1998	10.927	0.627	18.525	0.848	0.923	0.941	1.698	1.408
1999	11.446	0.656	20.239	0.927	0.982	1.025	1.783	1.599
2000	10.834	0.621	19.731	0.903	1.000	1.043	1.749	1.419
2001	27.008	1.549	38.320	1.754	1.120	1.170	1.811	1.448
2002	22.954	1.316	26.214	1.200	1.115	1.166	1.697	1.466
2003	26.416	1.515	30.403	1.392	1.188	1.227	1.667	1.379
2004	19.258	1.104	21.116	0.967	1.098	1.099	1.455	1.472
2005	22.509	1.291	24.627	1.127	1.225	1.226	2.146	2.024
2006	24.120	1.383	26.410	1.209	1.102	1.076	2.217	1.959
2007	22.094	1.267	25.792	1.181	0.893	0.889	2.008	1.713
2008	11.767	0.675	11.898	0.545	0.867	0.827	2.375	1.847
2009	22.784	1.307	24.952	1.142	1.202	1.079	2.652	1.915
2010	22.126	1.269	22.496	1.030	1.208	1.061	2.371	2.152
2011			18.213	1.082		0.892		2.118
2012			15.461	0.918		1.108		1.711

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Table.5 Estimated Japanese catch in number of North Pacific blue shark by year and fishery type before and after the revision of some miss-writing of logbook (Corrected data).

Year	Offshore shallow		Offshore deep		Distant water shallow		Distant water deep		Total	
	Previous data	Corrected data	Previous data	Corrected data	Previous data	Corrected data	Previous data	Corrected data	Previous data	Corrected data
1994	341,404	285,413	96,880	101,535	23,639	15,400	397931	434,944	859,854	837,291
1995	358,874	280,522	51,330	57,779	35,544	20,621	511462	554,539	957,210	913,461
1996	334,199	302,484	80,552	92,234	37,967	29,635	316025	346,136	768,743	770,489
1997	440,505	377,680	43,583	58,579	46,784	35,980	354871	375,564	885,743	847,802
1998	428,304	380,883	40,616	42,784	63,486	45,631	334110	364,935	866,516	834,233
1999	506,653	451,455	21,885	26,753	76,432	58,900	228005	241,881	832,975	778,989
2000	663,216	660,739	84,965	14,314	73,006	59,144	135473	148,977	956,660	883,174
2001	762,252	743,350	37,657	10,144	94,741	82,842	147219	162,247	1,041,869	998,583
2002	660,914	622,619	30,303	14,843	74,581	58,353	99943	107,469	865,741	803,283
2003	655,027	622,930	120,826	42,583	88,101	72,183	113218	123,709	977,172	861,404
2004	580,126	527,823	67,415	87,304	141,242	113,509	101667	110,513	890,450	839,149
2005	658,879	672,704	64,686	31,698	127,998	109,164	131016	144,016	982,579	957,583
2006	590,038	531,617	107,247	53,302	156,881	110,097	102965	113,698	957,131	808,713
2007	443,272	426,972	101,306	103,296	138,570	106,730	116064	126,221	799,212	763,219
2008	399,295	366,844	30,938	35,689	138,922	98,245	95180	103,315	664,335	604,093
2009	486,408	455,770	11,832	7,703	134,236	105,905	80903	89,524	713,379	658,901
2010	417,096	382,741	0	4,180	126,286	97,928	260872	272,342	804,254	757,190
2011		145,108		2,083		64,934		187,263		399,388
2012		213,900		7,035		93,368		47,222		361,524

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Table.6 Estimated Japanese catch in weight (tons) of North Pacific blue shark by year and fishery type before and after the revision of some miss-writing of logbook (Corrected data) and the revision of conversion factor from dress into round weight (Revised CF).

Year	Offshore shallow			Offshore deep			Distant water shallow			Distant water deep			Total		
	Previous data	Corrected data	Revised CF	Previous data	Corrected data	Revised CF	Previous data	Corrected data	Revised CF	Previous data	Corrected data	Revised CF	Previous data	Corrected data	Revised CF
1971	21,605		28,806	0		0	1,680		2,801	0		0	23,285		31,607
1972	15,359		20,479	0		0	1,571		2,619	0		0	16,930		23,098
1973	16,761		22,348	0		0	1,205		2,009	0		0	17,966		24,357
1974	14,607		19,476	0		0	1,017		1,695	0		0	15,624		21,171
1975	15,822		21,096	798		1,331	651		1,085	5,774		9,624	23,045		33,135
1976	22,434		29,912	1,820		3,033	1,417		2,362	10,442		17,404	36,113		52,710
1977	30,495		40,660	2,866		4,777	1,099		1,831	13,791		22,984	48,251		70,253
1978	24,643		32,857	2,254		3,757	1,304		2,174	13,341		22,235	41,542		61,023
1979	26,898		35,864	2,200		3,667	671		1,119	19,722		32,869	49,491		73,519
1980	25,900		34,533	4,530		7,551	494		824	21,483		35,805	52,408		78,713
1981	22,795		30,393	6,642		11,069	429		716	23,840		39,733	53,705		81,910
1982	13,861		18,481	6,794		11,324	457		761	15,147		25,245	36,259		55,811
1983	11,229		14,971	7,313		12,188	567		944	16,534		27,557	35,642		55,660
1984	8,742		11,656	8,137		13,562	270		450	15,544		25,907	32,693		51,575
1985	7,846		10,462	6,094		10,156	378		630	15,684		26,140	30,002		47,388
1986	9,374		12,498	6,603		11,005	724		1,207	9,393		15,655	26,094		40,365
1987	7,407		9,875	3,539		5,898	433		721	10,230		17,050	21,608		33,544
1988	6,582		8,776	2,384		3,973	345		576	15,896		26,494	25,208		39,819
1989	5,902		7,869	3,014		5,023	208		347	18,149		30,248	27,273		43,487
1990	5,394		7,193	2,718		4,530	144		239	11,799		19,666	20,055		31,627
1991	6,479		8,639	4,007		6,679	223		372	10,306		17,176	21,015		32,865
1992	6,902		9,203	3,409		5,681	267		446	8,520		14,199	19,098		29,529
1993	8,518		11,358	3,890		6,483	358		597	11,211		18,685	23,978		37,123
1994	7,065	6,080	8,613	2,066	2,214	3,690	464	321	534	10,681	11,761	19,602	20,275	20,376	32,440
1995	7,464	6,058	8,582	1,077	1,267	2,111	1,169	584	973	14,389	15,881	26,469	24,099	23,789	38,134
1996	6,800	6,238	8,837	1,780	2,045	3,408	866	651	1,086	8,997	9,817	16,361	18,443	18,751	29,692
1997	8,560	7,640	10,824	986	1,277	2,128	1,121	792	1,321	9,376	10,229	17,048	20,042	19,939	31,321
1998	8,396	7,691	10,896	902	920	1,533	1,566	1,032	1,720	9,408	10,365	17,274	20,271	20,007	31,423
1999	9,502	8,805	12,474	451	549	914	1,496	1,166	1,944	6,462	6,984	11,640	17,910	17,504	26,972
2000	12,807	12,300	17,425	1,650	309	515	1,431	1,160	1,933	4,050	4,485	7,475	19,938	18,253	27,347
2001	14,272	13,845	19,613	843	224	374	1,787	1,551	2,586	4,187	4,602	7,671	21,088	20,223	30,244
2002	12,495	11,885	16,837	626	305	508	1,378	1,143	1,905	2,947	3,173	5,288	17,447	16,505	24,537
2003	12,259	11,675	16,539	2,195	858	1,431	1,638	1,382	2,304	3,053	3,373	5,622	19,145	17,288	25,895
2004	10,758	9,923	14,058	1,421	1,800	3,000	2,654	2,226	3,710	2,823	3,111	5,185	17,656	17,060	25,953
2005	12,749	12,350	17,496	1,315	642	1,069	2,473	2,055	3,425	3,575	3,912	6,520	20,113	18,959	28,511
2006	10,882	9,704	13,747	2,151	1,053	1,756	2,741	2,057	3,428	2,740	3,016	5,027	18,514	15,830	23,958
2007	8,545	7,961	11,278	2,106	2,000	3,334	2,556	2,033	3,389	3,088	3,382	5,637	16,295	15,377	23,638
2008	7,518	6,829	9,674	691	697	1,162	2,385	1,858	3,097	2,588	2,840	4,733	13,183	12,224	18,666
2009	8,873	8,389	11,884	267	175	292	2,509	1,987	3,312	2,229	2,442	4,071	13,878	12,993	19,558
2010	7,826	7,141	10,116	0	87	145	2,363	1,865	3,109	7,269	7,552	12,587	17,459	16,645	25,956
2011	586	2,763	3,914	0	52	86	408	1,242	2,070	5,428	5,391	8,985	6,422	9,448	15,055
2012		3,999	5,665		129	215		1,767	2,945		1,410	2,351		7,305	11,176

Table 7. Total effort (number of hooks, billions) and total estimated catch (tons) in the North pacific by season and year for the Japanese longline fishery during 1994 to 2012.

	JAN-MAR		APR-JUN		JUL-SEP		OCT-DEC	
	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
1994	46.4	12,048	30.1	6,339	24.1	6,169	35.3	7,884
1995	36.3	12,377	31.5	8,859	25.1	7,376	36.8	9,522
1996	35.9	10,844	27.9	7,330	17.0	4,816	30.2	6,701
1997	29.8	9,336	26.7	7,365	21.4	7,040	26.8	7,581
1998	29.0	9,125	31.8	9,410	17.1	5,807	28.3	7,080
1999	31.1	7,909	27.0	6,292	21.4	6,145	35.8	6,627
2000	27.9	6,329	27.8	8,472	21.6	7,379	29.4	5,168
2001	33.3	7,392	30.3	9,861	20.7	7,341	27.8	5,651
2002	29.1	6,567	26.6	7,003	22.3	6,234	23.2	4,734
2003	25.4	6,255	23.7	7,026	23.5	6,878	23.7	5,737
2004	25.5	6,429	23.9	7,608	17.6	6,002	19.3	5,914
2005	22.0	5,549	18.8	9,682	16.5	7,961	18.9	5,319
2006	21.0	4,499	17.9	7,239	15.2	7,064	18.1	5,156
2007	18.6	5,214	15.8	6,209	11.7	6,101	17.2	6,114
2008	16.5	4,772	15.7	5,978	11.3	4,063	14.8	3,854
2009	15.5	5,327	12.1	7,254	7.7	3,776	10.5	3,201
2010	13.2	6,005	13.5	9,514	6.4	3,919	11.5	6,519
2011	13.7	5,351	11.7	4,214	8.4	2,175	11.8	3,315
2012	11.8	2,849	9.3	3,213	7.4	2,515	11.1	2,598

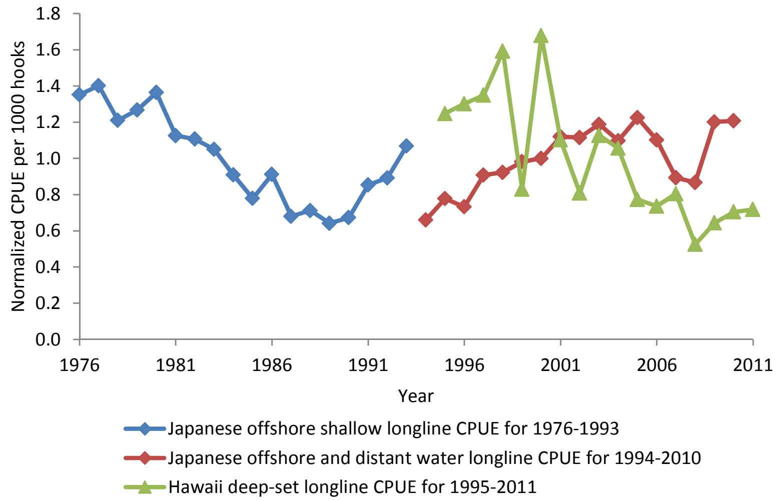

Figure 1. Abundance indices used in the North Pacific blue shark (*Prionace glauca*) stock assessment. Models were fitted to Japanese offshore shallow longline CPUE series (1976-1993 period, blue diamonds), and Japanese offshore and distant water longline CPUE series (1994-2010 period, red diamonds) in the base case. For a sensitivity run, Hawaii deep-set longline CPUE series (1995-2011 period, green triangles) was used instead of Japanese offshore and distant water longline CPUE series (1994-2010 period, red diamonds)(**ISC 2013**).

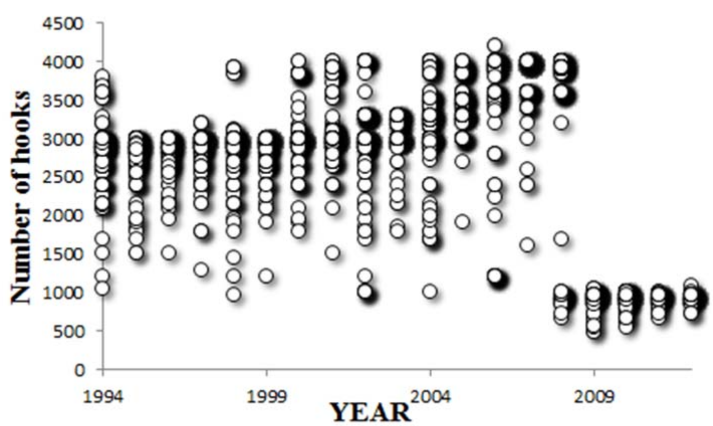

Figure 2. Number of hooks per an operation of a ship before the correction of the miss-writing of number of hooks in the logbook data.

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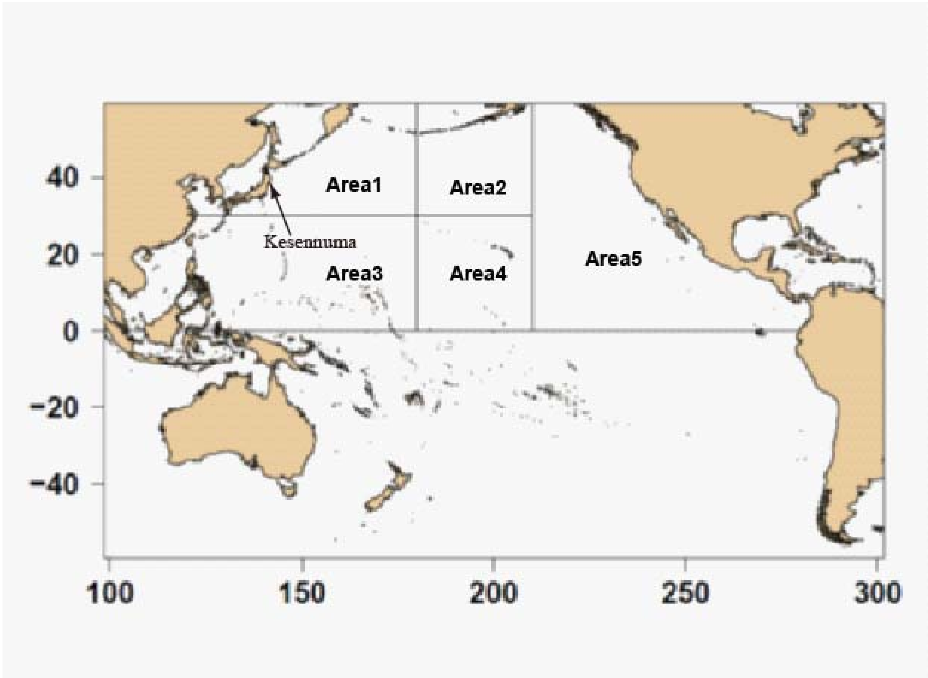

Figure 3. Area stratification designated by shark working group for the data analyses of blue shark in the North Pacific Ocean. "Kesennuma" is the major fishing port for sharks and swordfish.

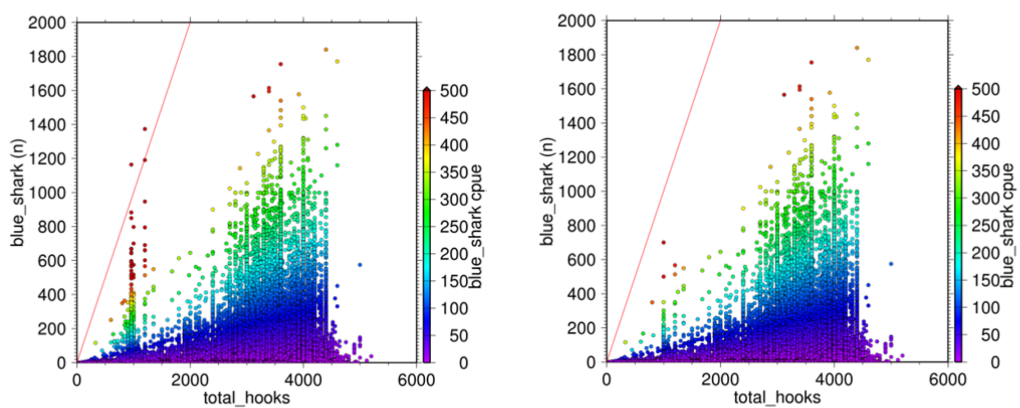

Figure 4. Interrelationship among nominal CPUE, total hooks per an operation of a ship and the total catch of North Pacific blue shark before (left panel) and after (right panel) the correction of the miss-writing of number of hooks in the logbook data. Red line indicates 1:1.

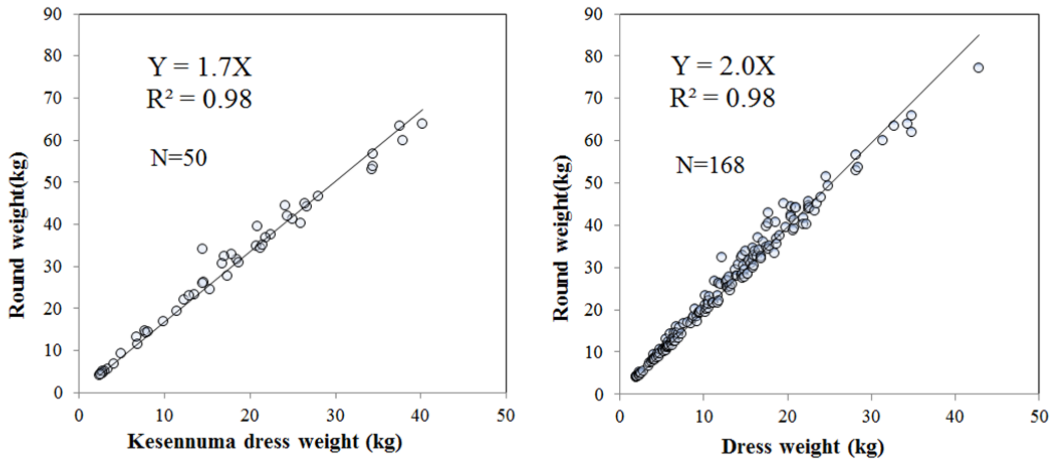

Figure 5. Revised conversion factors of North Pacific blue shark from processed weight into round weight. Data of “Kesennuma dress weight” is obtained from Japanese offshore shallow longliner (left panel) and data of “Dress weight” is obtained from the other Japanese longliner (right panel).

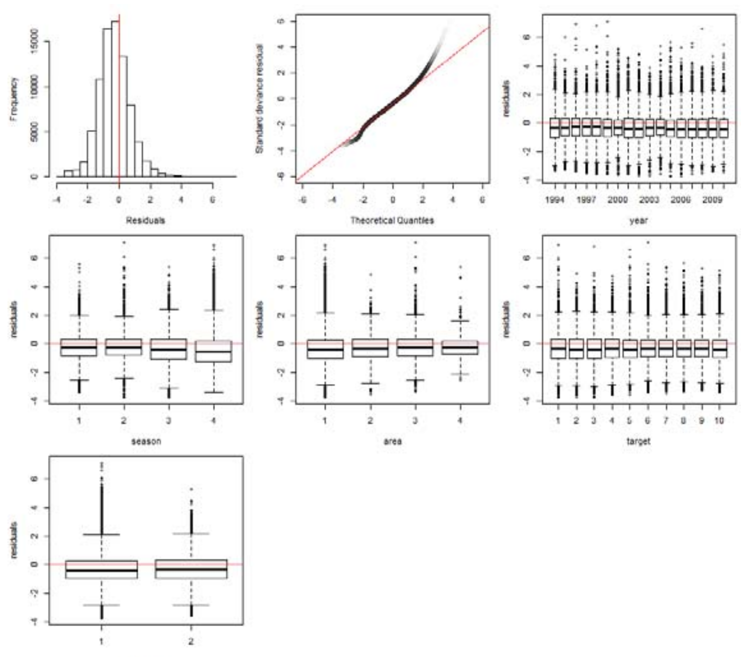

Figure 6. Diagnostic of the goodness of fit for the base case model. Residual patterns of GLMs for standardized CPUE series of Japanese offshore and distant water shallow fishery.

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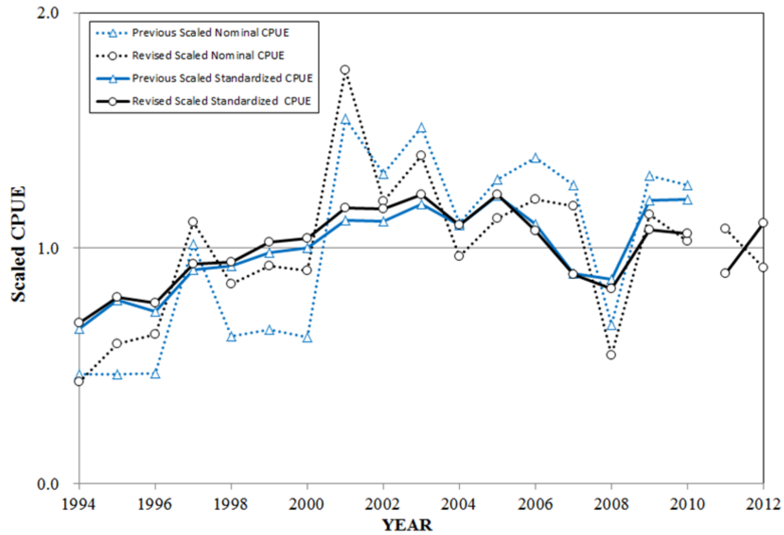

Figure 7. Trends of scaled nominal and standardized CPUE series of North Pacific blue shark for previous and revised logbook data. Models were fitted to Japanese offshore and distant water longline data (1994-2012). All CPUEs are scaled by the mean values which set at 1.0, and previous CPUEs are referred from the values in Hiraoka et al.(2013). The historical time series are estimated separately into two for recent two years under consideration of the effects of the disaster in 2011.

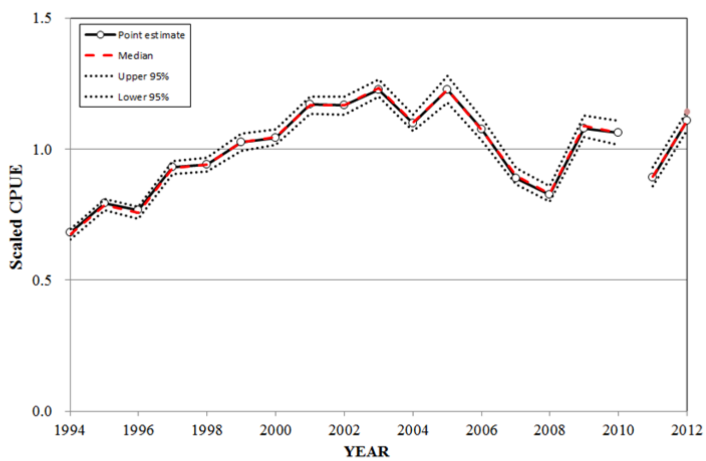

Figure 8. Updated standardized CPUE series of North Pacific blue shark and the 95% confidence intervals estimated from the bootstrapping method with 1000 resampling data. Models were fitted to Japanese offshore and distant water longline data (1994-2012). The historical time series are estimated separately for recent two years under consideration of the effects of the disaster in 2011.

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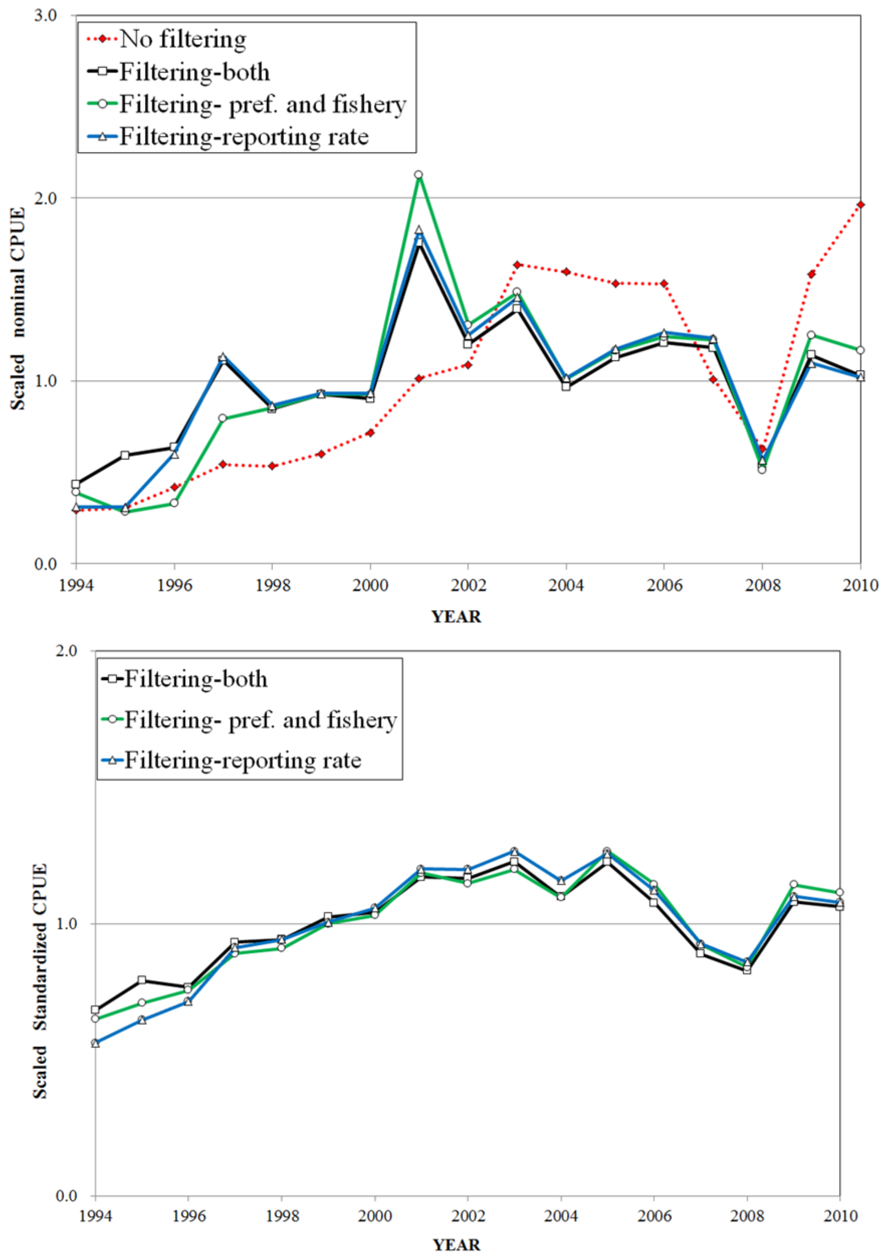


Figure 9. Trends of the scaled nominal (upper panel) and standardized CPUE (lower pnale) of Japanese offshore and distant water longline fishery for North Pacific blue shark for different filtering levels; No filtering, filtering by registered to the prefecture, filtering by reporting rate by vessel, filtering by both. Standardized CPUE without filtering could not be calculated due to a convergence problem.

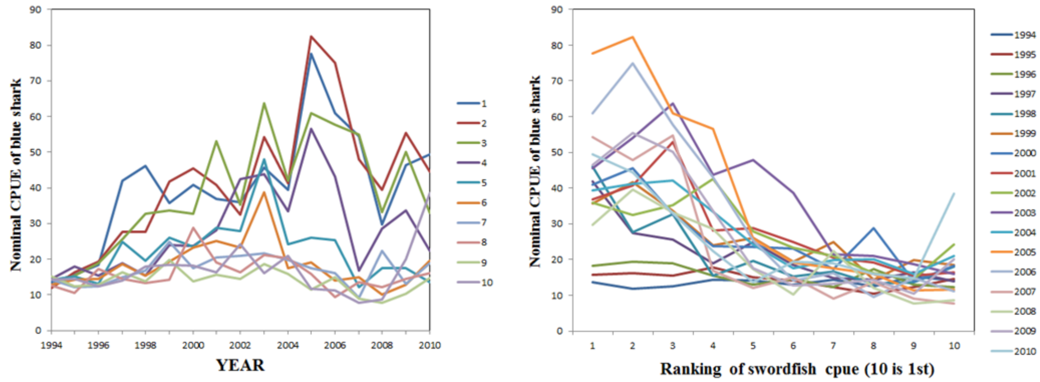


Figure 10. Changes of the nominal CPUE (number/1000hooks) of Japanese offshore and distant water longline for North Pacific blue shark by year (left panel) and target effect of swordfish (right panel). Number of the legend indicates the ranking of swordfish CPUE (left panel) and year (right panel). Number "10" indicates the largest catch ratio of swordfish.

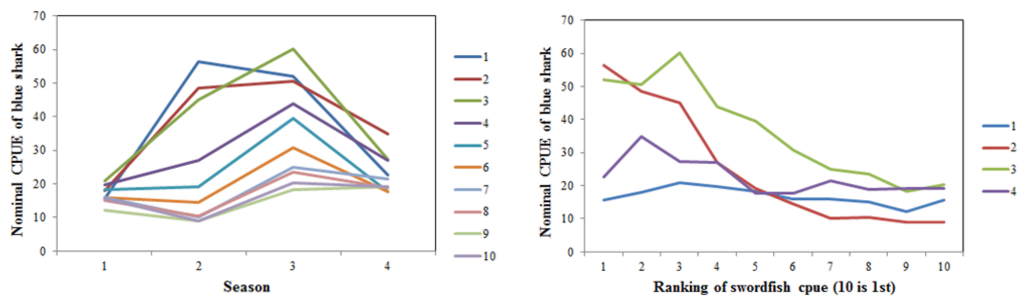


Figure 11. Changes of the nominal CPUE (number/1000hooks) of Japanese offshore and distant water longline for North Pacific blue shark by season (left panel) and target effect of swordfish (right panel). Number of the legend indicates the ranking of swordfish CPUE (left panel) and seasons (right panel). Number "10" indicates the largest catch ratio of swordfish.

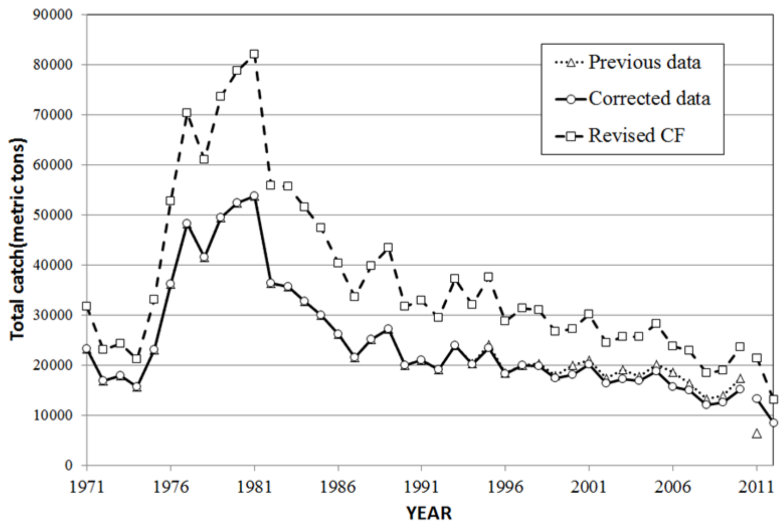
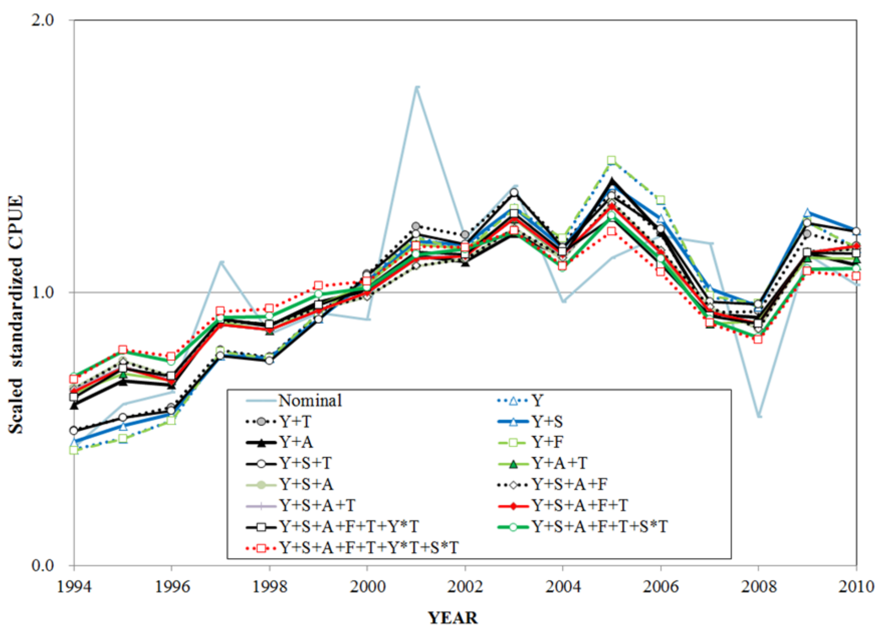


Figure.12 Estimated Japanese total catch of North Pacific blue shark in weight (tons) before and after the correction of the miss-writing of logbook data and the revision of conversion factors (Revised CFs). The historical time series are estimated separately for recent two years under consideration of the effects of the disaster in 2011.



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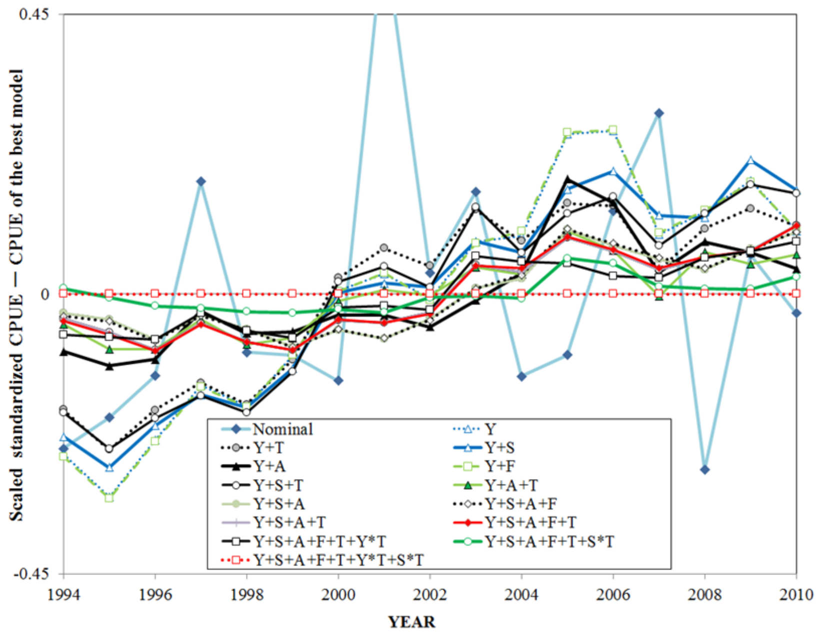

Figure 13. Scaled standardized CPUE series of North Pacific blue shark derived from the models with the explanatory variables sequentially added (upper panel). The differences of the scaled standardized CPUE between each model and the best model (lower panel) Y: Year, S: Season, A: Area, F: Fishery type, T: Target effect of swordfish, Y*T and S*T are interaction terms.

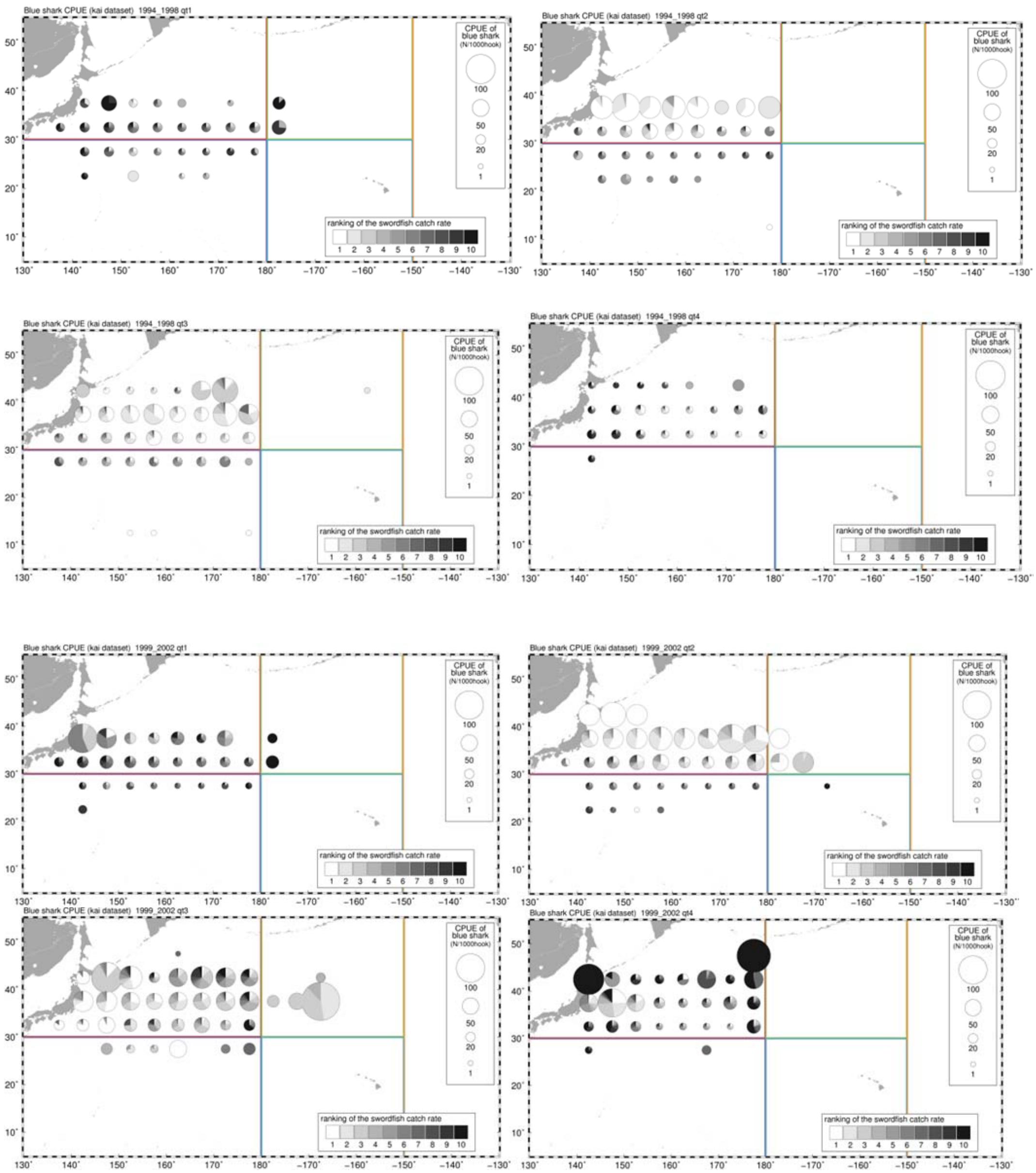

Figure 14 Catch locations of the blue sharks in the NP with pie chart which indicate the catch rate of blue shark using the size of the pie and ranking of the catch rate of the swordfish.

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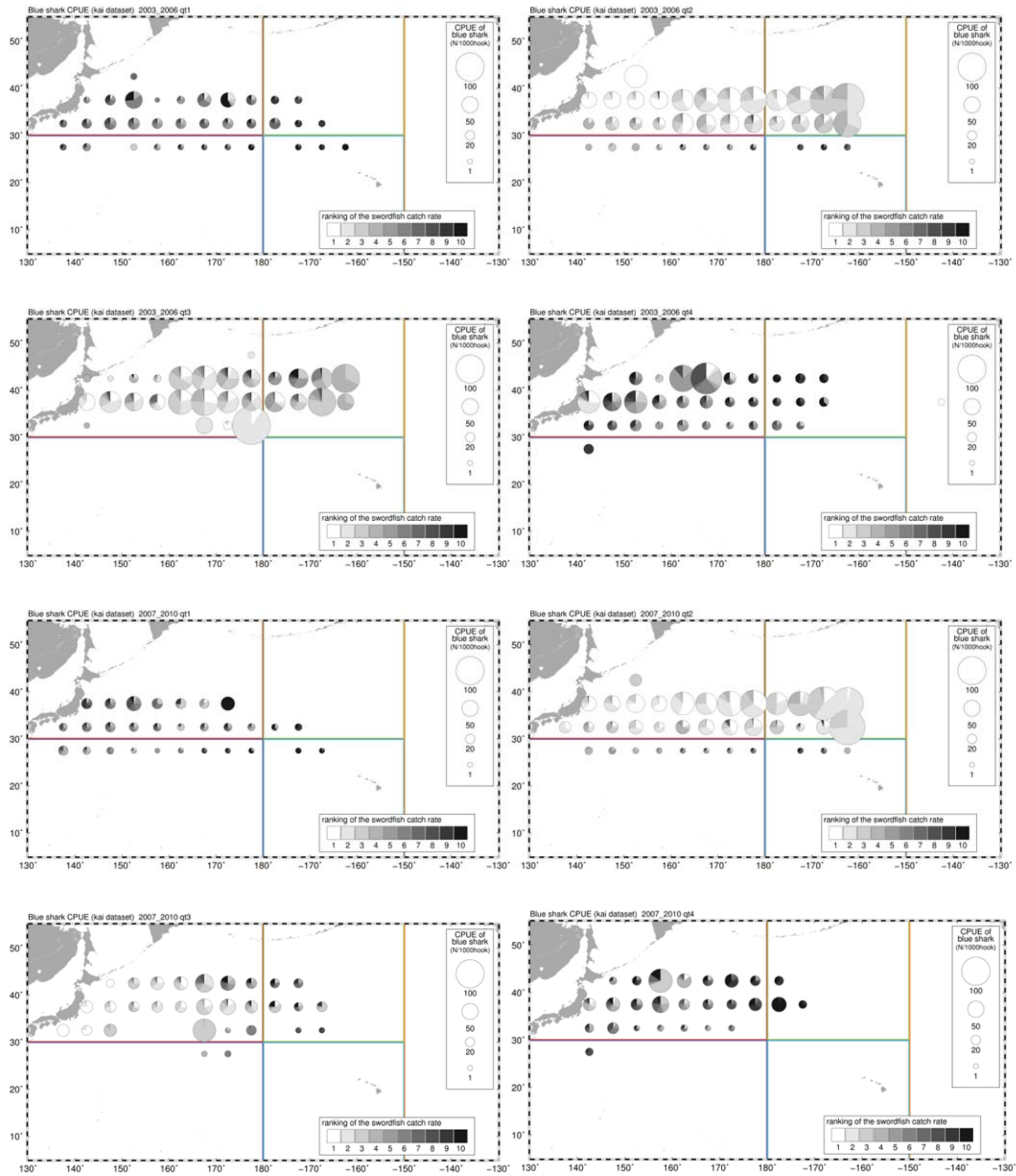

Figure 14 continued.

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Appendix

The plots in **figure 10 and 11** are separated into several panels to show clearly the changes of the nominal CPUE (number/1000hooks) of Japanese offshore and distant water longline for North Pacific blue shark by year and target effects (**Figure A1**), and by season and target effects (**Figure A2**).

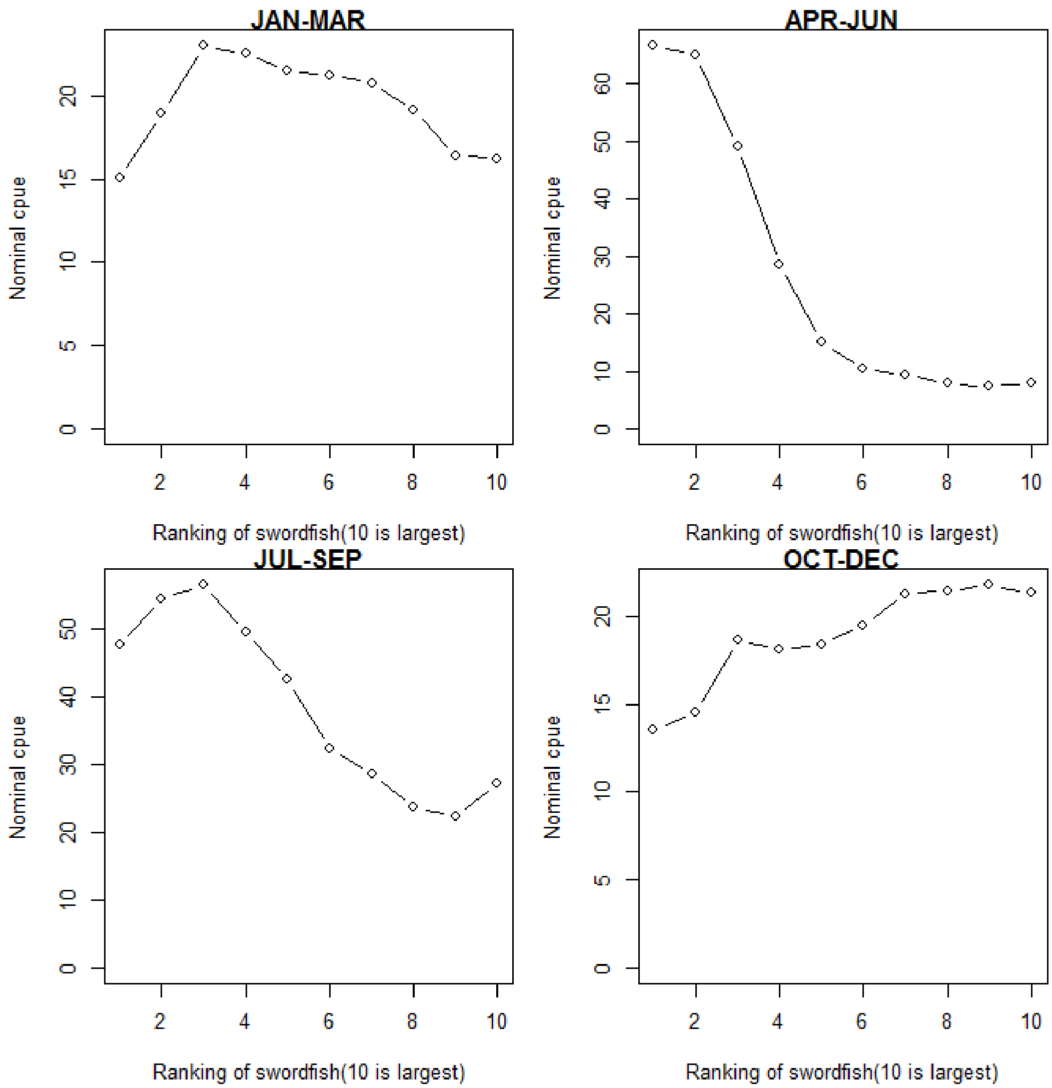

Figure A1 Changes of the nominal CPUE (number/1000hooks) of Japanese offshore and distant water longline fishery for North Pacific blue shark by seasons and target effects.

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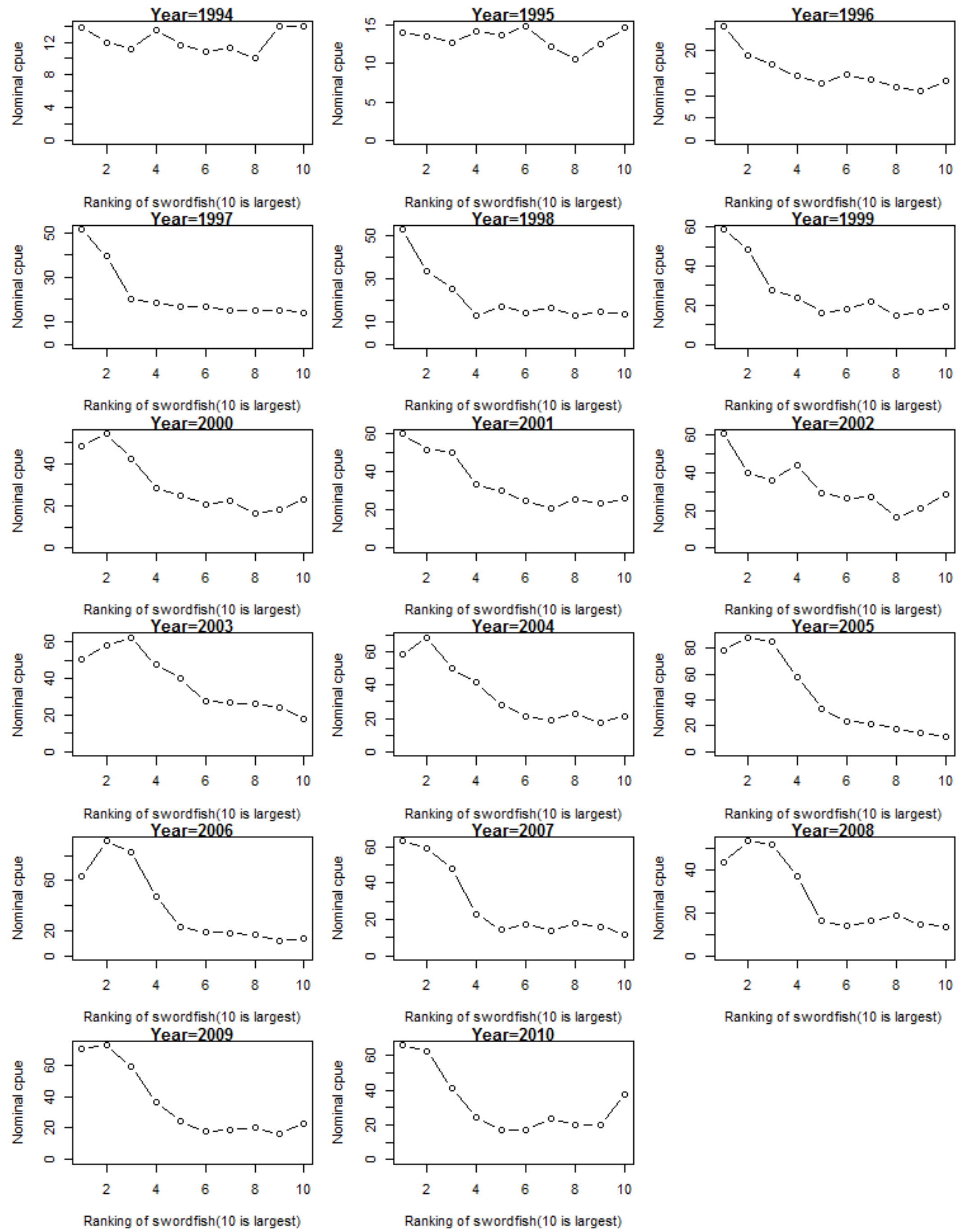

Figure A2 Changes of the nominal CPUE (number/1000hooks) of Japanese offshore and distant water longline fishery for North Pacific blue shark by year and target effects.

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```
Call:
glm.nb(formula = blshrk ~ as.factor(year.x) + as.factor(qt) +
    as.factor(area) + as.factor(target) + as.factor(gyogyoucode) +
    as.factor(year.x):as.factor(target) + as.factor(qt):as.factor(target) +
    offset(log(hook)), data = temp, init.theta = 1.229124037,
    link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.7679  -0.9555  -0.3525   0.2850   7.1254

Coefficients:
                               Estimate Std. Error z value Pr(>|z|)
(Intercept)                   -4.554598   0.068049 -66.931  < 2e-16 ***
as.factor(year.x)1995          0.358758   0.054405   6.594 4.28e-11 ***
as.factor(year.x)1996          0.491754   0.054230   9.068  < 2e-16 ***
as.factor(year.x)1997          0.894393   0.055510  16.112  < 2e-16 ***
as.factor(year.x)1998          0.954520   0.055048  17.340  < 2e-16 ***
as.factor(year.x)1999          0.970650   0.055707  17.424  < 2e-16 ***
as.factor(year.x)2000          0.874825   0.054732  15.984  < 2e-16 ***
as.factor(year.x)2001          0.962063   0.055171  17.438  < 2e-16 ***
as.factor(year.x)2002          0.951956   0.057492  16.558  < 2e-16 ***
as.factor(year.x)2003          0.703134   0.058912  11.935  < 2e-16 ***
as.factor(year.x)2004          0.833868   0.059997  13.898  < 2e-16 ***
as.factor(year.x)2005          1.257181   0.061966  20.288  < 2e-16 ***
as.factor(year.x)2006          1.006115   0.063169  15.927  < 2e-16 ***
as.factor(year.x)2007          0.946783   0.059545  15.900  < 2e-16 ***
as.factor(year.x)2008          0.552123   0.062417   8.846  < 2e-16 ***
as.factor(year.x)2009          0.977384   0.065962  14.817  < 2e-16 ***
as.factor(year.x)2010          0.938019   0.069228  13.550  < 2e-16 ***
as.factor(qt)2                 0.963138   0.061224  15.731  < 2e-16 ***
as.factor(qt)3                 0.710889   0.061026  11.649  < 2e-16 ***
as.factor(qt)4                -0.327260   0.062793  -5.212 1.87e-07 ***
as.factor(area)2               0.003932   0.020068   0.196 0.844657
```

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as.factor(area)3	-0.858693	0.012152	-70.663	< 2e-16	***
as.factor(area)4	-1.284231	0.038190	-33.627	< 2e-16	***
as.factor(target)2	0.026435	0.088319	0.299	0.764698	
as.factor(target)3	0.073982	0.082481	0.897	0.369740	
as.factor(target)4	0.313985	0.080069	3.921	8.80e-05	***
as.factor(target)5	0.494496	0.080900	6.112	9.81e-10	***
as.factor(target)6	0.737351	0.080346	9.177	< 2e-16	***
as.factor(target)7	0.654226	0.080308	8.146	3.75e-16	***
as.factor(target)8	0.571183	0.080312	7.112	1.14e-12	***
as.factor(target)9	0.689191	0.078939	8.731	< 2e-16	***
as.factor(target)10	0.602516	0.078082	7.716	1.20e-14	***
as.factor(gyogyoucode)2	-0.054148	0.009895	-5.472	4.44e-08	***
as.factor(year.x)1995:as.factor(target)2	-0.033960	0.076826	-0.442	0.658461	
as.factor(year.x)1996:as.factor(target)2	0.082923	0.076833	1.079	0.280469	
as.factor(year.x)1997:as.factor(target)2	-0.025317	0.078736	-0.322	0.747799	
as.factor(year.x)1998:as.factor(target)2	-0.122785	0.077865	-1.577	0.114821	
as.factor(year.x)1999:as.factor(target)2	0.195144	0.077990	2.502	0.012343	*
as.factor(year.x)2000:as.factor(target)2	0.314276	0.077175	4.072	4.66e-05	***
as.factor(year.x)2001:as.factor(target)2	0.162159	0.077846	2.083	0.037245	*
as.factor(year.x)2002:as.factor(target)2	0.158387	0.080217	1.974	0.048326	*
as.factor(year.x)2003:as.factor(target)2	0.435509	0.082538	5.277	1.32e-07	***
as.factor(year.x)2004:as.factor(target)2	0.446732	0.084128	5.310	1.10e-07	***
as.factor(year.x)2005:as.factor(target)2	0.383405	0.086889	4.413	1.02e-05	***
as.factor(year.x)2006:as.factor(target)2	0.658524	0.088378	7.451	9.25e-14	***
as.factor(year.x)2007:as.factor(target)2	0.222468	0.083865	2.653	0.007985	**
as.factor(year.x)2008:as.factor(target)2	0.490980	0.088323	5.559	2.71e-08	***
as.factor(year.x)2009:as.factor(target)2	0.322723	0.093241	3.461	0.000538	***
as.factor(year.x)2010:as.factor(target)2	0.242206	0.097817	2.476	0.013282	*
as.factor(year.x)1995:as.factor(target)3	-0.081301	0.077048	-1.055	0.291333	
as.factor(year.x)1996:as.factor(target)3	-0.053198	0.076979	-0.691	0.489517	
as.factor(year.x)1997:as.factor(target)3	-0.415093	0.078583	-5.282	1.28e-07	***
as.factor(year.x)1998:as.factor(target)3	-0.224896	0.077512	-2.901	0.003715	**
as.factor(year.x)1999:as.factor(target)3	-0.114106	0.078013	-1.463	0.143563	
as.factor(year.x)2000:as.factor(target)3	0.136713	0.076595	1.785	0.074281	.
as.factor(year.x)2001:as.factor(target)3	0.197091	0.077116	2.556	0.010595	*

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as.factor(year.x)2002:as.factor(target)3	-0.027770	0.079823	-0.348	0.727923	
as.factor(year.x)2003:as.factor(target)3	0.648625	0.082464	7.866	3.67e-15	***
as.factor(year.x)2004:as.factor(target)3	0.290058	0.083635	3.468	0.000524	***
as.factor(year.x)2005:as.factor(target)3	0.363069	0.086570	4.194	2.74e-05	***
as.factor(year.x)2006:as.factor(target)3	0.553412	0.088505	6.253	4.03e-10	***
as.factor(year.x)2007:as.factor(target)3	0.338294	0.083136	4.069	4.72e-05	***
as.factor(year.x)2008:as.factor(target)3	0.504874	0.088366	5.713	1.11e-08	***
as.factor(year.x)2009:as.factor(target)3	0.348117	0.092522	3.763	0.000168	***
as.factor(year.x)2010:as.factor(target)3	0.048098	0.097072	0.495	0.620252	
as.factor(year.x)1995:as.factor(target)4	-0.218876	0.076679	-2.854	0.004311	**
as.factor(year.x)1996:as.factor(target)4	-0.413264	0.077393	-5.340	9.30e-08	***
as.factor(year.x)1997:as.factor(target)4	-0.686230	0.078353	-8.758	< 2e-16	***
as.factor(year.x)1998:as.factor(target)4	-0.737762	0.077580	-9.510	< 2e-16	***
as.factor(year.x)1999:as.factor(target)4	-0.490494	0.078374	-6.258	3.89e-10	***
as.factor(year.x)2000:as.factor(target)4	-0.480183	0.076129	-6.307	2.84e-10	***
as.factor(year.x)2001:as.factor(target)4	-0.396471	0.077018	-5.148	2.64e-07	***
as.factor(year.x)2002:as.factor(target)4	-0.082537	0.079903	-1.033	0.301623	
as.factor(year.x)2003:as.factor(target)4	0.168294	0.081650	2.061	0.039288	*
as.factor(year.x)2004:as.factor(target)4	-0.044968	0.083062	-0.541	0.588246	
as.factor(year.x)2005:as.factor(target)4	-0.152371	0.085861	-1.775	0.075960	.
as.factor(year.x)2006:as.factor(target)4	-0.082724	0.087651	-0.944	0.345275	
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as.factor(year.x)2008:as.factor(target)4	0.168954	0.086848	1.945	0.051728	.
as.factor(year.x)2009:as.factor(target)4	-0.096889	0.091590	-1.058	0.290122	
as.factor(year.x)2010:as.factor(target)4	-0.542599	0.095295	-5.694	1.24e-08	***
as.factor(year.x)1995:as.factor(target)5	-0.244348	0.076954	-3.175	0.001497	**
as.factor(year.x)1996:as.factor(target)5	-0.399521	0.076779	-5.204	1.96e-07	***
as.factor(year.x)1997:as.factor(target)5	-0.535585	0.078718	-6.804	1.02e-11	***
as.factor(year.x)1998:as.factor(target)5	-0.613159	0.077880	-7.873	3.46e-15	***
as.factor(year.x)1999:as.factor(target)5	-0.827220	0.078507	-10.537	< 2e-16	***
as.factor(year.x)2000:as.factor(target)5	-0.645760	0.077093	-8.376	< 2e-16	***
as.factor(year.x)2001:as.factor(target)5	-0.505232	0.077488	-6.520	7.02e-11	***
as.factor(year.x)2002:as.factor(target)5	-0.415541	0.080710	-5.149	2.62e-07	***
as.factor(year.x)2003:as.factor(target)5	0.047414	0.082907	0.572	0.567396	
as.factor(year.x)2004:as.factor(target)5	-0.386541	0.083998	-4.602	4.19e-06	***

as.factor(year.x)2005:as.factor(target)5	-0.698815	0.086642	-8.066	7.29e-16	***
as.factor(year.x)2006:as.factor(target)5	-0.614861	0.088604	-6.939	3.94e-12	***
as.factor(year.x)2007:as.factor(target)5	-1.065087	0.083299	-12.786	< 2e-16	***
as.factor(year.x)2008:as.factor(target)5	-0.563536	0.087770	-6.421	1.36e-10	***
as.factor(year.x)2009:as.factor(target)5	-0.781319	0.092733	-8.425	< 2e-16	***
as.factor(year.x)2010:as.factor(target)5	-0.789436	0.098217	-8.038	9.15e-16	***
as.factor(year.x)1995:as.factor(target)6	-0.141975	0.076808	-1.848	0.064538	.
as.factor(year.x)1996:as.factor(target)6	-0.576177	0.077110	-7.472	7.89e-14	***
as.factor(year.x)1997:as.factor(target)6	-0.751755	0.078574	-9.568	< 2e-16	***
as.factor(year.x)1998:as.factor(target)6	-0.964328	0.077920	-12.376	< 2e-16	***
as.factor(year.x)1999:as.factor(target)6	-0.966235	0.078484	-12.311	< 2e-16	***
as.factor(year.x)2000:as.factor(target)6	-0.812403	0.076950	-10.558	< 2e-16	***
as.factor(year.x)2001:as.factor(target)6	-0.746056	0.077680	-9.604	< 2e-16	***
as.factor(year.x)2002:as.factor(target)6	-0.710620	0.080704	-8.805	< 2e-16	***
as.factor(year.x)2003:as.factor(target)6	-0.467888	0.082695	-5.658	1.53e-08	***
as.factor(year.x)2004:as.factor(target)6	-0.854816	0.084193	-10.153	< 2e-16	***
as.factor(year.x)2005:as.factor(target)6	-1.112490	0.086926	-12.798	< 2e-16	***
as.factor(year.x)2006:as.factor(target)6	-1.054876	0.088633	-11.902	< 2e-16	***
as.factor(year.x)2007:as.factor(target)6	-1.062601	0.083809	-12.679	< 2e-16	***
as.factor(year.x)2008:as.factor(target)6	-0.920772	0.089088	-10.336	< 2e-16	***
as.factor(year.x)2009:as.factor(target)6	-1.171960	0.092412	-12.682	< 2e-16	***
as.factor(year.x)2010:as.factor(target)6	-1.134487	0.097329	-11.656	< 2e-16	***
as.factor(year.x)1995:as.factor(target)7	-0.175890	0.076936	-2.286	0.022243	*
as.factor(year.x)1996:as.factor(target)7	-0.430825	0.077110	-5.587	2.31e-08	***
as.factor(year.x)1997:as.factor(target)7	-0.671496	0.078754	-8.526	< 2e-16	***
as.factor(year.x)1998:as.factor(target)7	-0.746850	0.078118	-9.561	< 2e-16	***
as.factor(year.x)1999:as.factor(target)7	-0.685656	0.078909	-8.689	< 2e-16	***
as.factor(year.x)2000:as.factor(target)7	-0.680900	0.076943	-8.849	< 2e-16	***
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as.factor(year.x)2002:as.factor(target)7	-0.651989	0.080636	-8.086	6.19e-16	***
as.factor(year.x)2003:as.factor(target)7	-0.400849	0.083181	-4.819	1.44e-06	***
as.factor(year.x)2004:as.factor(target)7	-0.832867	0.083605	-9.962	< 2e-16	***
as.factor(year.x)2005:as.factor(target)7	-1.131685	0.087221	-12.975	< 2e-16	***
as.factor(year.x)2006:as.factor(target)7	-1.083734	0.089013	-12.175	< 2e-16	***
as.factor(year.x)2007:as.factor(target)7	-1.212338	0.083881	-14.453	< 2e-16	***

as.factor(year.x)2008:as.factor(target)7	-0.850141	0.088293	-9.629	< 2e-16	***
as.factor(year.x)2009:as.factor(target)7	-1.005328	0.093456	-10.757	< 2e-16	***
as.factor(year.x)2010:as.factor(target)7	-0.812037	0.097437	-8.334	< 2e-16	***
as.factor(year.x)1995:as.factor(target)8	-0.462572	0.077251	-5.988	2.13e-09	***
as.factor(year.x)1996:as.factor(target)8	-0.504455	0.076695	-6.577	4.79e-11	***
as.factor(year.x)1997:as.factor(target)8	-0.663807	0.078954	-8.408	< 2e-16	***
as.factor(year.x)1998:as.factor(target)8	-0.961685	0.078682	-12.222	< 2e-16	***
as.factor(year.x)1999:as.factor(target)8	-0.840151	0.078343	-10.724	< 2e-16	***
as.factor(year.x)2000:as.factor(target)8	-0.809113	0.076949	-10.515	< 2e-16	***
as.factor(year.x)2001:as.factor(target)8	-0.584319	0.077726	-7.518	5.58e-14	***
as.factor(year.x)2002:as.factor(target)8	-0.908182	0.080239	-11.318	< 2e-16	***
as.factor(year.x)2003:as.factor(target)8	-0.384930	0.082955	-4.640	3.48e-06	***
as.factor(year.x)2004:as.factor(target)8	-0.553683	0.084837	-6.526	6.74e-11	***
as.factor(year.x)2005:as.factor(target)8	-1.239895	0.086982	-14.255	< 2e-16	***
as.factor(year.x)2006:as.factor(target)8	-1.058767	0.088790	-11.924	< 2e-16	***
as.factor(year.x)2007:as.factor(target)8	-0.947646	0.083868	-11.299	< 2e-16	***
as.factor(year.x)2008:as.factor(target)8	-0.562244	0.088176	-6.376	1.81e-10	***
as.factor(year.x)2009:as.factor(target)8	-0.893003	0.092833	-9.619	< 2e-16	***
as.factor(year.x)2010:as.factor(target)8	-0.836582	0.098382	-8.503	< 2e-16	***
as.factor(year.x)1995:as.factor(target)9	-0.518330	0.076782	-6.751	1.47e-11	***
as.factor(year.x)1996:as.factor(target)9	-0.710570	0.077432	-9.177	< 2e-16	***
as.factor(year.x)1997:as.factor(target)9	-1.003778	0.078973	-12.710	< 2e-16	***
as.factor(year.x)1998:as.factor(target)9	-0.950936	0.077983	-12.194	< 2e-16	***
as.factor(year.x)1999:as.factor(target)9	-1.045363	0.078446	-13.326	< 2e-16	***
as.factor(year.x)2000:as.factor(target)9	-0.934482	0.076597	-12.200	< 2e-16	***
as.factor(year.x)2001:as.factor(target)9	-0.862376	0.077493	-11.128	< 2e-16	***
as.factor(year.x)2002:as.factor(target)9	-0.956428	0.080371	-11.900	< 2e-16	***
as.factor(year.x)2003:as.factor(target)9	-0.603702	0.083099	-7.265	3.73e-13	***
as.factor(year.x)2004:as.factor(target)9	-0.878825	0.084042	-10.457	< 2e-16	***
as.factor(year.x)2005:as.factor(target)9	-1.550626	0.086815	-17.861	< 2e-16	***
as.factor(year.x)2006:as.factor(target)9	-1.447361	0.088942	-16.273	< 2e-16	***
as.factor(year.x)2007:as.factor(target)9	-1.255600	0.083646	-15.011	< 2e-16	***
as.factor(year.x)2008:as.factor(target)9	-1.001162	0.087926	-11.386	< 2e-16	***
as.factor(year.x)2009:as.factor(target)9	-1.253050	0.092751	-13.510	< 2e-16	***
as.factor(year.x)2010:as.factor(target)9	-0.958440	0.097720	-9.808	< 2e-16	***

as.factor(year.x)1995:as.factor(target)10	-0.228121	0.077041	-2.961	0.003066	**
as.factor(year.x)1996:as.factor(target)10	-0.743449	0.076853	-9.674	< 2e-16	***
as.factor(year.x)1997:as.factor(target)10	-1.075692	0.078613	-13.683	< 2e-16	***
as.factor(year.x)1998:as.factor(target)10	-1.002248	0.077909	-12.864	< 2e-16	***
as.factor(year.x)1999:as.factor(target)10	-0.861146	0.078716	-10.940	< 2e-16	***
as.factor(year.x)2000:as.factor(target)10	-0.594684	0.076505	-7.773	7.66e-15	***
as.factor(year.x)2001:as.factor(target)10	-0.658746	0.077349	-8.517	< 2e-16	***
as.factor(year.x)2002:as.factor(target)10	-0.566669	0.081202	-6.979	2.98e-12	***
as.factor(year.x)2003:as.factor(target)10	-0.600445	0.082698	-7.261	3.85e-13	***
as.factor(year.x)2004:as.factor(target)10	-0.759388	0.085191	-8.914	< 2e-16	***
as.factor(year.x)2005:as.factor(target)10	-1.574094	0.087929	-17.902	< 2e-16	***
as.factor(year.x)2006:as.factor(target)10	-1.377890	0.089603	-15.378	< 2e-16	***
as.factor(year.x)2007:as.factor(target)10	-1.358818	0.083811	-16.213	< 2e-16	***
as.factor(year.x)2008:as.factor(target)10	-0.865213	0.088084	-9.823	< 2e-16	***
as.factor(year.x)2009:as.factor(target)10	-0.661774	0.093129	-7.106	1.19e-12	***
as.factor(year.x)2010:as.factor(target)10	-0.183146	0.097701	-1.875	0.060853	.
as.factor(qt)2:as.factor(target)2	-0.321971	0.078390	-4.107	4.00e-05	***
as.factor(qt)3:as.factor(target)2	-0.170388	0.077591	-2.196	0.028094	*
as.factor(qt)4:as.factor(target)2	-0.244412	0.079623	-3.070	0.002143	**
as.factor(qt)2:as.factor(target)3	-0.469780	0.070038	-6.707	1.98e-11	***
as.factor(qt)3:as.factor(target)3	-0.166247	0.070101	-2.372	0.017715	*
as.factor(qt)4:as.factor(target)3	-0.058769	0.071885	-0.818	0.413619	
as.factor(qt)2:as.factor(target)4	-0.613533	0.068253	-8.989	< 2e-16	***
as.factor(qt)3:as.factor(target)4	-0.038569	0.068437	-0.564	0.573049	
as.factor(qt)4:as.factor(target)4	0.032259	0.069658	0.463	0.643288	
as.factor(qt)2:as.factor(target)5	-0.848478	0.067769	-12.520	< 2e-16	***
as.factor(qt)3:as.factor(target)5	-0.090701	0.069855	-1.298	0.194144	
as.factor(qt)4:as.factor(target)5	0.081636	0.068831	1.186	0.235613	
as.factor(qt)2:as.factor(target)6	-1.105543	0.067616	-16.350	< 2e-16	***
as.factor(qt)3:as.factor(target)6	-0.272932	0.071271	-3.829	0.000128	***
as.factor(qt)4:as.factor(target)6	0.191335	0.068553	2.791	0.005254	**
as.factor(qt)2:as.factor(target)7	-1.150381	0.067625	-17.011	< 2e-16	***
as.factor(qt)3:as.factor(target)7	-0.380573	0.070423	-5.404	6.51e-08	***
as.factor(qt)4:as.factor(target)7	0.316494	0.068859	4.596	4.30e-06	***
as.factor(qt)2:as.factor(target)8	-1.153073	0.067675	-17.038	< 2e-16	***

as.factor(qt)3:as.factor(target)8	-0.487981	0.076774	-6.356	2.07e-10	***
as.factor(qt)4:as.factor(target)8	0.380607	0.068186	5.582	2.38e-08	***
as.factor(qt)2:as.factor(target)9	-1.140466	0.068275	-16.704	< 2e-16	***
as.factor(qt)3:as.factor(target)9	-0.539301	0.074804	-7.210	5.61e-13	***
as.factor(qt)4:as.factor(target)9	0.532364	0.068082	7.819	5.31e-15	***
as.factor(qt)2:as.factor(target)10	-1.263540	0.072667	-17.388	< 2e-16	***
as.factor(qt)3:as.factor(target)10	-0.597495	0.074925	-7.975	1.53e-15	***
as.factor(qt)4:as.factor(target)10	0.415004	0.067688	6.131	8.73e-10	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Negative Binomial(1.2291) family taken to be 1)

Null deviance: 139969 on 81203 degrees of freedom
Residual deviance: 92244 on 81000 degrees of freedom
AIC: 859505

Number of Fisher Scoring iterations: 1

Theta: 1.22912
Std. Err.: 0.00576

2 x log-likelihood: -859095.24300

Figure A4 Results of the GLM analysis for Japanese CPUE standardization during 1994 to 2010

[1]Working document submitted to the ISC Shark Working Group Workshop, 13 - 18 January 2014, NOAA Southwest Fisheries Science Center, La Jolla, California, U.S.A.
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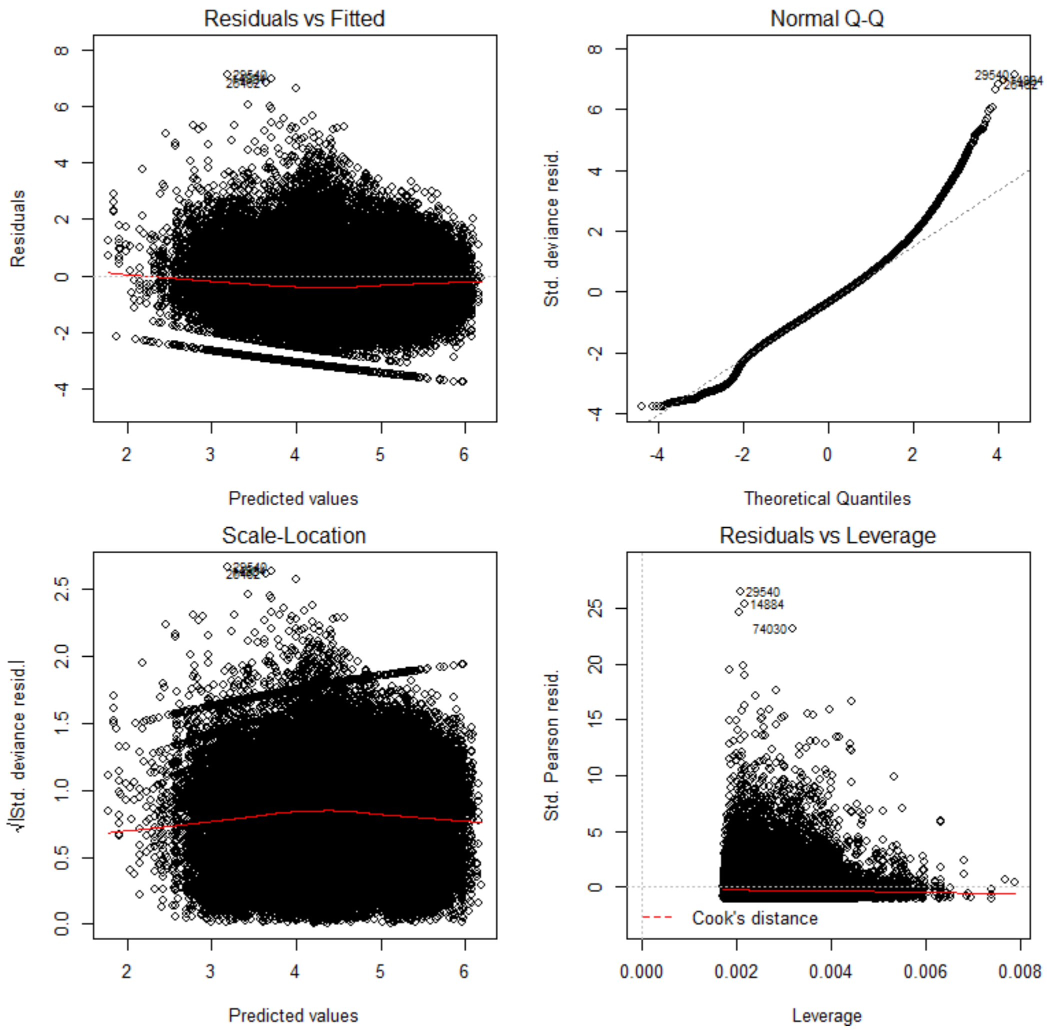

FigureA3 Diagnostics of the GLM analysis for Japanese CPUE standardization during 1994 to 2010.

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```
Call:
glm.nb(formula = blshrk ~ as.factor(year.x) + as.factor(qt) +
    as.factor(area) + as.factor(target) + as.factor(gyogyoucode) +
    as.factor(year.x):as.factor(target) + offset(log(hook)),
    data = temp, init.theta = 1.365285755, link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.6709  -1.0016  -0.3671   0.2752   4.5182

Coefficients:
                                        Estimate Std. Error z value Pr(>|z|)
(Intercept)                             -3.34245    0.08010 -41.729  < 2e-16 ***
as.factor(year.x)2012                   -0.06341    0.09222  -0.688 0.491723
as.factor(qt)2                           0.48510    0.06275   7.731 1.07e-14 ***
as.factor(qt)3                           0.52874    0.04753  11.124  < 2e-16 ***
as.factor(qt)4                           0.54171    0.04241  12.773  < 2e-16 ***
as.factor(area)2                        -0.33721    0.07219  -4.671 3.00e-06 ***
as.factor(area)3                        -1.55918    0.06900 -22.597  < 2e-16 ***
as.factor(target)2                      -0.74961    0.10025  -7.478 7.57e-14 ***
as.factor(target)3                      -0.70391    0.10192  -6.906 4.98e-12 ***
as.factor(target)4                      -0.81346    0.10376  -7.840 4.52e-15 ***
as.factor(target)5                      -0.99067    0.10184  -9.728  < 2e-16 ***
as.factor(target)6                      -1.07927    0.10255 -10.524  < 2e-16 ***
as.factor(target)7                      -1.07207    0.10335 -10.374  < 2e-16 ***
as.factor(target)8                      -0.95148    0.10112  -9.410  < 2e-16 ***
as.factor(target)9                      -0.96960    0.10352  -9.366  < 2e-16 ***
as.factor(target)10                     -0.74984    0.10765  -6.965 3.27e-12 ***
as.factor(gyogyoucode)2                  0.15075    0.03431   4.393 1.12e-05 ***
as.factor(year.x)2012:as.factor(target)2  0.67713    0.12939   5.233 1.67e-07 ***
as.factor(year.x)2012:as.factor(target)3  0.43978    0.13013   3.380 0.000726 ***
as.factor(year.x)2012:as.factor(target)4  0.58562    0.12994   4.507 6.58e-06 ***
as.factor(year.x)2012:as.factor(target)5  0.63463    0.12907   4.917 8.79e-07 ***
as.factor(year.x)2012:as.factor(target)6  0.41554    0.13019   3.192 0.001414 **
as.factor(year.x)2012:as.factor(target)7  0.03233    0.13061   0.248 0.804491
```

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```
as.factor(year.x)2012:as.factor(target)8    -0.45550    0.13018   -3.499 0.000467 ***
as.factor(year.x)2012:as.factor(target)9     0.30164    0.12850    2.347 0.018904 *
as.factor(year.x)2012:as.factor(target)10    0.17509    0.12977    1.349 0.177286
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Negative Binomial(1.3653) family taken to be 1)

    Null deviance: 5977.6  on 3657  degrees of freedom
Residual deviance: 4081.7  on 3632  degrees of freedom
AIC: 39435

Number of Fisher Scoring iterations: 1


              Theta:  1.3653
          Std. Err.:  0.0300

 2 x log-likelihood:  -39380.9650
```

FigureA6 Results of the GLM analysis for Japanese CPUE standardization in 2011 and 2012

[1]Working document submitted to the ISC Shark Working Group Workshop, 13 - 18 January 2014, NOAA Southwest Fisheries Science Center, La Jolla, California, U.S.A.
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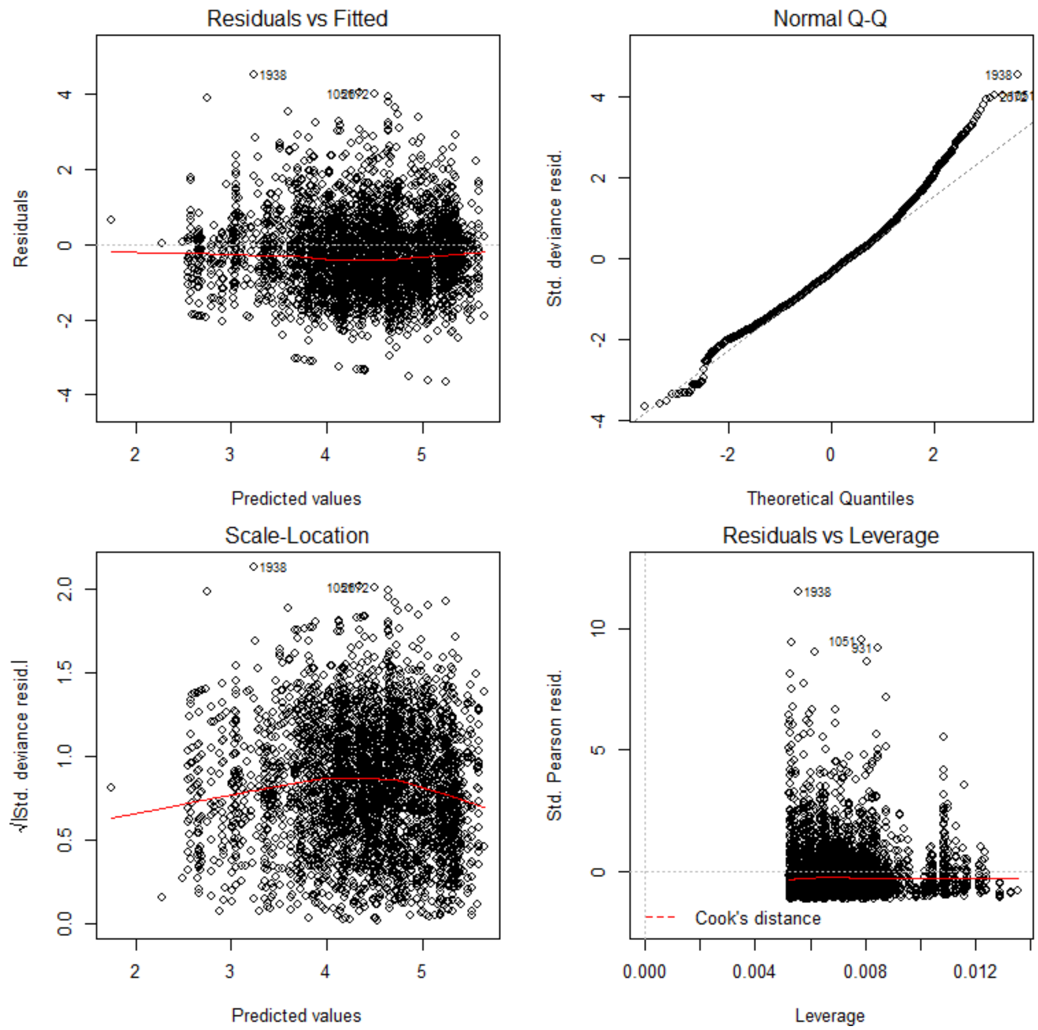

FigureA4 Diagnostics of GLM analysis for CPUE standardization in 2011 and 2012.

[1]Working document submitted to the ISC Shark Working Group Workshop, 13 - 18 January 2014, NOAA Southwest Fisheries Science Center, La Jolla, California, U.S.A.

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