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REVISION OF TASK II SIZE DATA OF BLUEFIN TUNA CATCH BY JAPANESE LONGLINE FROM THE 1970s TO PRESENT

T. Itoh[1] and A. Kimoto[1]

SUMMARY

In accordance with the agreement on the data preparatory meeting in 2015, historical catch-at-length of bluefin tuna by Japanese longline fleet was constructed in a consistent way over the period from 1975 to 2013. We applied fork length frequency to the catch by year, month, 5 degrees in latitude, and 5 degrees in longitude, with a threshold that the number of size measured > 200 fish or >20% of catch. The length frequency was prepared in eight steps that different in spatial and temporal resolution. Catch-at-size data were modified by comparison to mean body weight per longline operation in logbook data, which are independent from size data. The difference in catch-at-length between new estimation and those in previous years available was not large, and new data allows higher resolution in longitude.

RÉSUMÉ

Conformément à l'accord atteint à la réunion de préparation des données de 2015, la prise par taille historique de thon rouge réalisée par la flottille palangrière japonaise a été créée d'une manière constante au cours de la période 1975-2013. Nous avons appliqué la fréquence de la longueur à la fourche aux prises par année, mois, 5 degrés de latitude et 5 degrés de longitude, avec un seuil selon lequel le nombre de poissons mesurés > 200 poissons ou > 20% des captures. La fréquence des tailles a été préparée en huit étapes avec une résolution spatiale et temporelle différente. Les données de prise par taille ont été modifiées par rapport au poids corporel moyen par opération de palangre dans les données des carnets de pêche, qui sont indépendantes des données de taille. Il n'y avait pas une grande différence dans la prise par taille entre les nouvelles estimations et celles des années précédentes disponibles, et les nouvelles données permettent une plus grande résolution dans la longitude.

RESUMEN

De conformidad con el acuerdo alcanzado en la reunión de preparación de datos en 2015, la captura por talla histórica del atún rojo de la flota de palangre japonesa se elaboró de una manera constante durante el periodo 1975-2013. Se aplicó la frecuencia de longitud a la horquilla a la captura por año, mes, 5 grados de latitud y 5 grados de longitud, con un umbral según el cual el número de peces medidos era superior a 200 peces o superior al 20% de la captura. Las frecuencias de tallas se prepararon en ocho etapas con resolución espacial y temporal diferentes. Los datos de captura por talla se modificaron mediante la comparación con el peso medio del cuerpo por operación de palangre en los datos del cuaderno de pesca, que son independientes de los datos de talla. La diferencia en la captura por talla entre la nueva estimación y la disponible de años anteriores no era grande, y los nuevos datos presentan una mayor resolución en la longitud.

KEYWORDS

Bluefin tuna, Catch statistics, Length-weight relationships, Long lining, Size composition

[1] NRIFSF. 5-7-1, Orido, Shimizu, Shizuoka, 424-8633. Japan. itou@fra.affrc.go.jp

Introduction

Because age structure is considered in its stock assessment model, accurate estimation of catch-at-age data, as well as catch-at-length data as its proxy, is important for the stock management of Atlantic bluefin tuna *Thunnus thynnus*. Japan has been submitted to ICCAT the size data of bluefin tuna caught by Japanese longline vessels since the 1950s.

At the data preparatory meeting held in March 2015, it was agreed that various CPCs, including Japan, should revise catch-at-size data of their own fleets (ICCAT 2015). Japan has already submitted catch-at-length data of the catches from 2002 and 2011. However, the methods to calculate the catch-at-length which raise the size measurement data to the total catch in a spatial and temporal grid might be inconsistent among years or scientists in charge of. We recalculate catch-at-length of those years, and newly calculated for catch in older years since 1975, in a consistent way and propose for revision of Task2 size dataset. ICCAT stated that the revision of historical data, except the most recent 2 years, requires a SCRS document explaining the changes before revision (ICCAT 2016). This document is prepared in accordance with the requirement.

Materials and methods

Catch-at-size data were calculated for the period between 1975 and 2013, when relatively large number of size data were collected. Fish body size data were also revised from all of the available data in our institute. Along with changes in the Japanese catch reporting system, available size data were qualitatively and quantitatively different among time periods as follows.

Before 1993: Size in length and/or weight were measured on board by cooperative commercial fishermen in voluntary basis.

From 1994 to 2007: The logbook recording form newly included a column for the total weight of bluefin tuna caught by operation in addition to the total number of the catch. It allowed calculation of the average body weight by operation. Scientific observers on board also provided length and weight of individual fish since 1998. The voluntary fish measurement on board was also continued.

From 2008 to present: Fishery Agency of Japan has mandated the fishermen to report each body weight of bluefin tuna caught for all individuals. Only this information was used for the calculation in this study. The logbook system and the research by scientific observers described above are also available. The voluntary fish measurement on board was also continued, however, the number of collected data declined.

The body length mentioned above is the straight fork length in 1 centimeter (round up) and the body weight is the processed weight that is gilled, gutted, and tailed in 1 kilo grams (round up).

In addition, there were size data in Task2 size dataset which were measured by US scientific observers on board on Japanese longline in the period between 1981 and 1988. Its original data were not reserved in our institute so that we extracted them from Task2 size dataset. Curved fork lengths were converted to straight fork length based on conversion factors for western bluefin tuna shown in the ICCAT web-site.

All processed weights were converted to straight fork length based on monthly processed weight-fork length relationships. The parameters of the relationships were obtained from the length and weight data of 49,264 bluefin tuna individuals collected by scientific observers on Japanese longline vessels between 2008 and 2013 (**Table 1**). Large numbers of data were collected in January, February and between August and December, and the parameters by month were estimated for those months. Parameters for March to July, where catch were few, were calculated by combining all data.

For each stratum of Japanese longline catch in number by year, month, 5 degrees in latitude, and 5 degrees in longitude in Task2 catch and effort dataset, an appropriate fork length frequency was applied to estimate the catch-at-size data. The appropriate length frequency was created by the following eight steps depending on the sufficiency of the number of size data to the catch. When the number of size measured was > 200 individuals or >20% of catch in number, it was judged to be sufficient. The 20% definition was required in case of the catch in number was less than 200. For each stratum, the following step was continued to obtain the appropriate length frequency until the data met the criteria by expanding the area and/or the period.

Step 1: Apply directly the length frequency by year, month, 5 degrees in latitude, and 5 degrees in longitude.

Step 2: Apply the length frequency by year, month, 5 degrees in latitude, and 10 degrees in longitude to the rest of strata which did not meet the criteria at step 1.

Step 3: Apply the length frequency by year, quarter, 5 degrees in latitude, and 10 degrees in longitude to the rest of strata which did not meet the criteria at step 2.

Step 4: Apply the length frequency by year, quarter, 15 degrees in latitude, and 30 degrees in longitude (combine data in 8 surrounding 5-degree squares to the center) to the rest of strata which did not meet the criteria at step 3. There were some areas that had quite different length frequencies in neighboring areas. We calculated mean fork length by latitude and longitude in 5 degrees and quarter by generalized linear model (GLM) using the data produced up to step 3. The GLM model was *mean length~year+quarter+lat+lon+lat*lon*. Least square means of each 5-degree square and quarter were obtained. Before combing size data from the 8 surrounding 5-degrees squares, difference of mean lengths to the center of the 8 squares was checked, and if the difference was >50 cm, then the square was removed for the data combining.

Step 5: Apply the length frequency by year, 3 quarters (the quarter in a stratum with its anteroposterior), 15 degrees in latitude, and 30 degrees in longitude to the rest of strata which did not meet the criteria at step 4. The same condition of step 4 was used for data combining.

Step 6: Apply the length frequency by year, 15 degrees in latitude, and 30 degrees in longitude throughout the year to the rest of strata which did not meet the criteria at step 5. The same condition of step 4 was used for data combining.

Step 7: Apply the length frequency converted from the mean body weight per operation derived from logbook data to the rest of strata which did not meet the criteria at step 6. We compared them to the data produced up to step 6. If the difference in mean fork length between the data up to step 6 and mean of the mean fork lengths derived from logbook (data were weighed with the number of catch) was >20% of the mean fork length from logbook, then the estimation up to step 6 was abandoned in the year, month and 5-degree latitude and longitude. Then, length frequency from the mean body weight of logbook was applied to the rest of step 6 by year, month, and 5-degree latitude and longitude. Although the length frequency could be biased toward center by ignoring individual size variation in a longline operation, it must be more accurate than do by the step 8.

Step 8: Apply the length frequency by year, and all of the area to the rest of strata which did not meet the criteria at step 7.

Results

To the catch by year which has the maximum of 44,000 individuals, the number of size measured fish was small in some years, e.g. between 4% and 16% from the 1990s and up to 2007 (**Figure 1**). The size measured ratio increased largely in 2008 and stayed at 100% since 2009.

The number of catch-at-size estimated by step are shown in **Figure 2**. The numbers of fish estimated were large in step 1 (year, month, 5-degree latitude and longitude) and step 4 (year, quarter, latitude in 15 degrees, and longitude in 30 degrees). Those in step 7, which utilized the mean body weight per operation in logbook data, were also large in the 1990s to 2007. All of the values were produced in step 1 since 2009, when all of the individual weight have been reported.

The size data (not raised to catch-at-size) we used were similar to those reported and currently included in Task 2 size dataset (SizeInfoCod="siz") (**Figure 3**). Catch-at-length calculated by year are shown in **Figure 4**. Japan provided catch-at-length estimation to ICCAT for the years between 2002 and 2011. We could not fully evaluate our calculation by comparing to previous ones for all years, but the comparison to those 10 years shows that no remarkable change has occurred, while some differences was observed (**Figure 5**). The frequency distribution shifted slightly smaller between 2008 and 2011, which presumably due to difference in weight-length relationships (see Discussion).

The catch-at-size data by year were compared to those skipped the step 7 procedure, to see the effect of utilizing mean body weight by operation from logbook data (**Figure 6**). The difference was not so large. The catch-at-size by year were compared to those not utilize filtering based on size difference in the adjacent squares, and the effect was negligible (**Figure 7**).

Discussion

We calculated catch-at-length of Japanese longline bluefin tuna catch for a long period between 1975 and 2013 in a consistent and a systematic way, with detailed eight steps. There were little changes in utilization of information of the mean body weight per operation from logbook data and filtering by mean length difference when the data combined to adjacent areas, which suggests the calculated catch-at-length data are not sensitive to estimation methods. Because all of the individual body weight of bluefin tuna has been reported from Japanese longline vessels since August 2008, the procedure established in this study is not required to use in future. The calculated catch-at-length did not show large changes to those previously estimated for 10 years, then it does not suggest to force the change of the most recent stock assessment.

In the current Japanese size data in Task2 size dataset, a large portion was in 10-degrees longitude, which prevent separation of the two stocks by 45W. In addition, there are many years that catch-at-size has not calculated. New size data and catch-at-length data can provide in 5-degree in longitude and catch-at-length from 1975. It allows to be separated by 45W easily, as well as various area definition, for the forthcoming new stock assessment models which may incorporate stock mixing structure. Our newly calculated catch-at-length data is appropriate for that.

We used weight-length relationships that we estimated based on data that Japanese scientific observers collected, instead of the conversion factor shown on the ICCAT web-site, because of the following reasons. The relationships obtained from Japanese longline catch should be the most appropriate using for Japanese longline catch. For our calculation, we need a regression equation that has fork length as the dependent variable and body weight as the independent variable. The regression equation on the ICCAT web-site was the opposite which has the fork length as the independent variable, because it is mainly used for farming fish to estimate body weight from fork length. The regression we used (fork length as dependent variable) provide smaller fork length than another one. It is the reason that newly estimated catch-at-length is smaller length than in previous calculation for 2008 to 2011 (**Figure 5**). Furthermore, we used processed body weight, instead of round weight. By using regression equations between processed weight and fork length directly, it is free from the conversion factor assumption (round weight = 1.16 x processed weight). The weight-length relationship derived from the present study is appropriate for Japanese longline catch, but may not appropriate for other fishing in other season.

We utilized all of available information relevant to size of bluefin tuna in our institute, which included confidential data. Because national scientists know well the characteristics of bluefin tuna catch by their own fleets, they are expected to be the best provider of the most accurate catch-at-size estimation. The importance of a detailed description of calculation procedure is also emphasized.

References

ICCAT 2015. Report of the 2015 ICCAT bluefin data preparatory meeting. March 2015.

ICCAT 2016. Guidelines and instructions concerning the statistical and biological information required. ICCAT Circular #1104/2016, Appendix 1.

Table 1. Parameters of weight-length and length-weight relationships by month of bluefin tuna caught by Japanese longline. PW is processed body weight in kg, FL is straight fork length in cm. FL = alpha x PW^{beta} / PW = alpha x FL^{beta}. Data were collected by scientific observers.

Month	Explanatory variable	Response variable	alpha	beta	N
1	PW	FL	44.839	0.30635	6,212
2	PW	FL	47.100	0.29750	2,116
3	PW	FL	45.783	0.30150	244
8	PW	FL	40.608	0.33086	156
9	PW	FL	43.413	0.31410	3,704
10	PW	FL	42.960	0.31446	17,096
11	PW	FL	39.628	0.32965	14,536
12	PW	FL	39.893	0.32895	5,192
All	PW	FL	44.079	0.30869	49,264
1	FL	PW	6.321E-06	3.17748	6,212
2	FL	PW	3.170E-06	3.30338	2,116
3	FL	PW	2.014E-04	2.42120	244
8	FL	PW	5.154E-05	2.77288	156
9	FL	PW	3.448E-05	2.85420	3,704
10	FL	PW	4.049E-05	2.82671	17,096
11	FL	PW	3.458E-05	2.86277	14,536
12	FL	PW	2.481E-05	2.92459	5,192
All	FL	PW	1.008E-05	3.09315	49,264

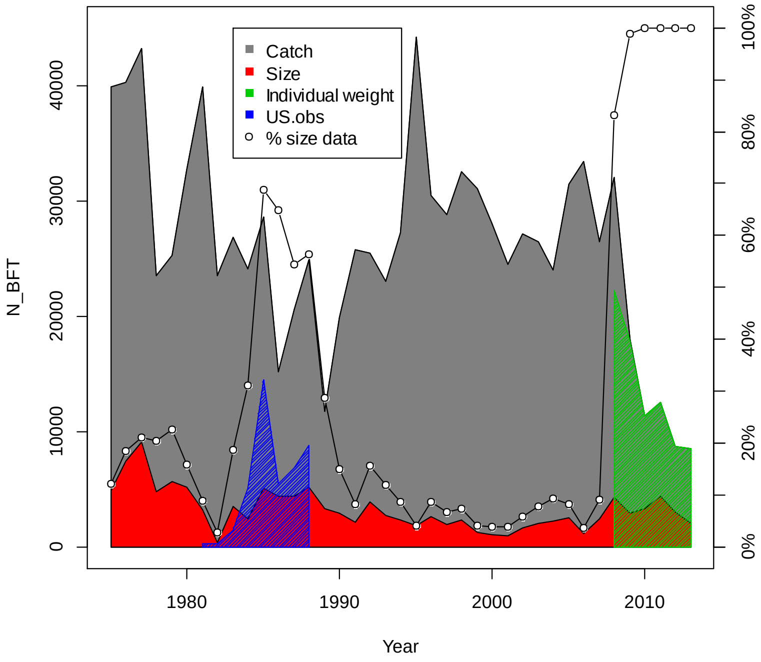

Figure 1. The numbers of bluefin tuna caught, size measured, and the individual weight reported for Japanese longline. Right hand y axis shows the proportion to the number of fish caught.

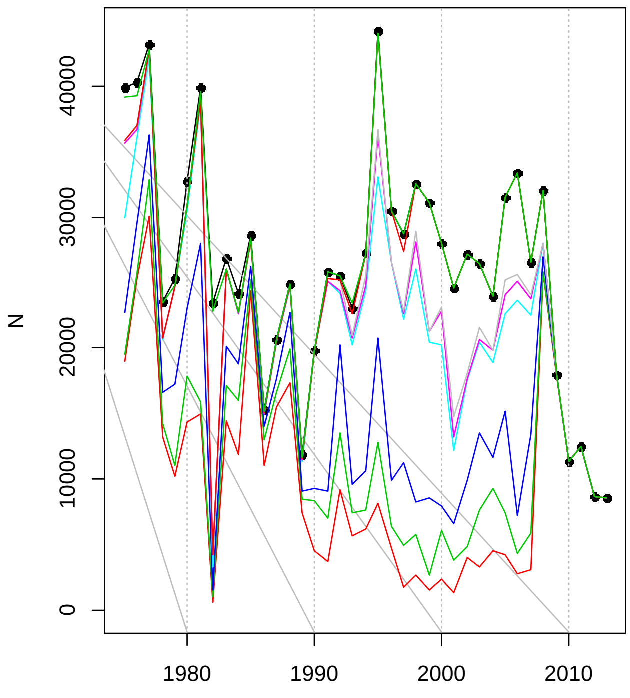

Figure 2. The number of bluefin tuna that catch-at-size were calculated in each step, from step 1 (bottom) to step 8 (top with circle marks).

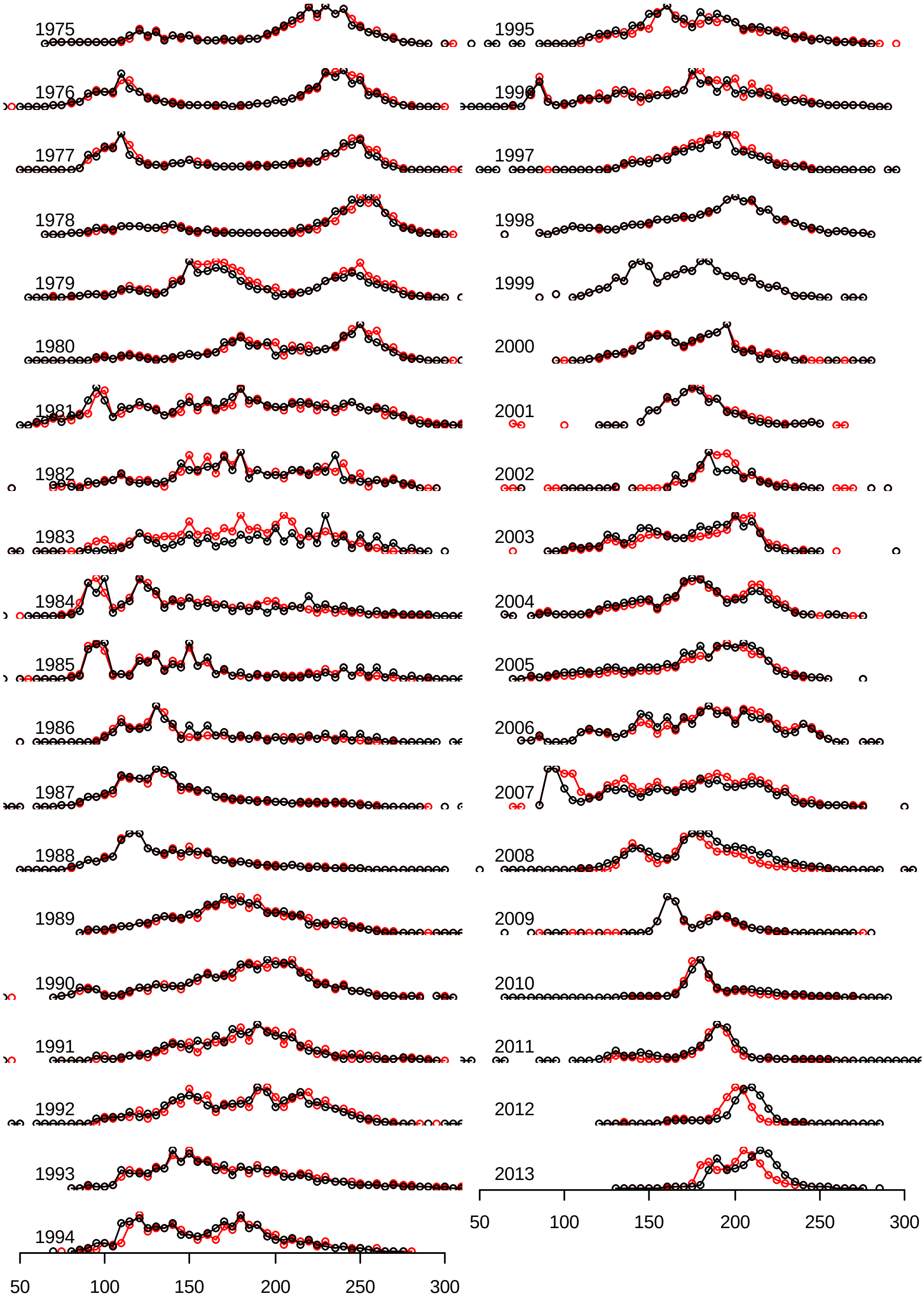

Figure 3. Comparison of bluefin tuna size data for Japanese catch between the data used in the present study (red) and the data included in the current Task 2 size dataset (black). Note that it is the data of size measured, and not raised to catch-at-length. X axis is fork length in cm and Y axis is the number of fish.

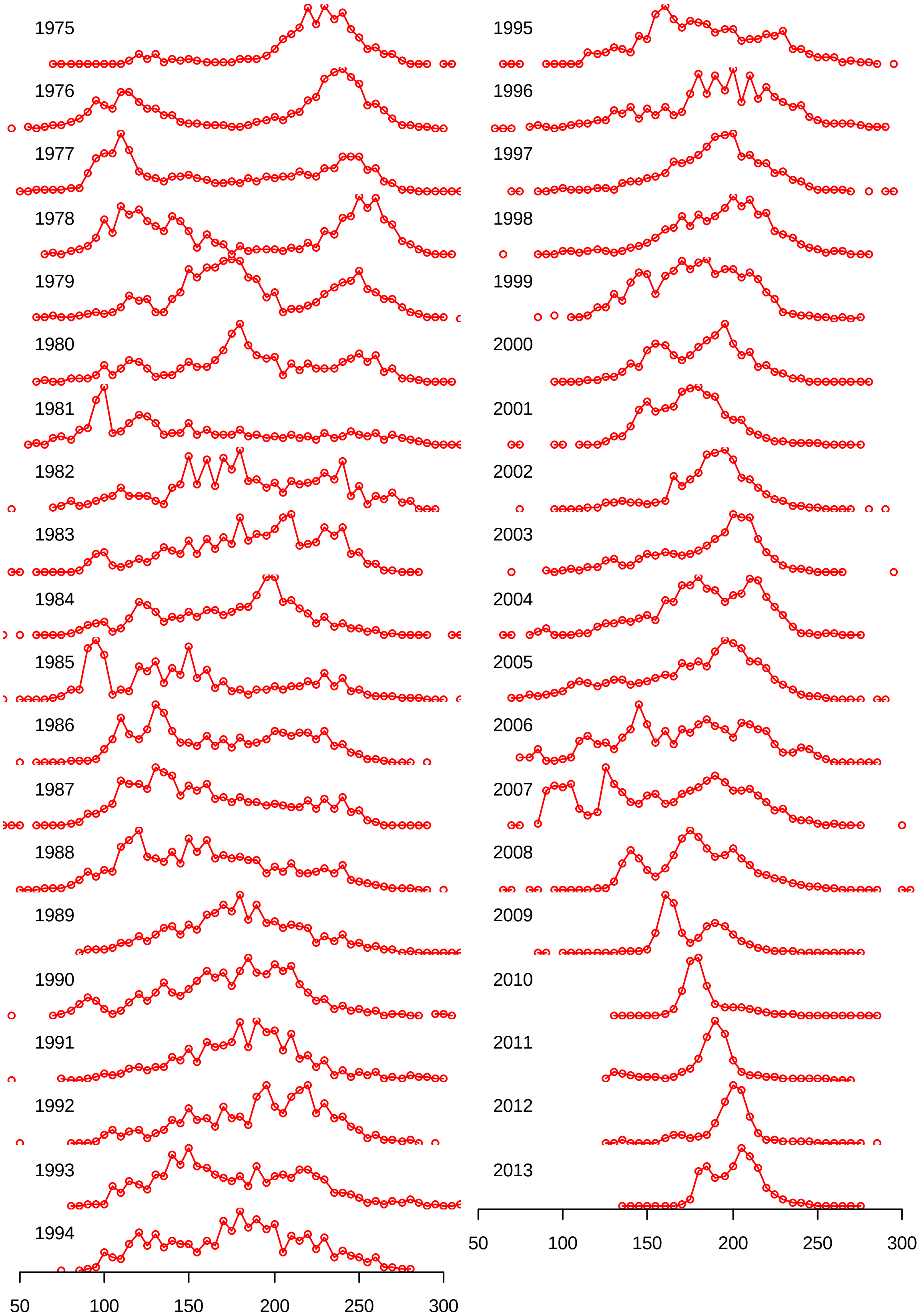

Figure 4. Catch-at-length of bluefin tuna caught by Japanese longline by calendar year which calculated in the present study. X axis is fork length in cm and Y axis is the number of fish.

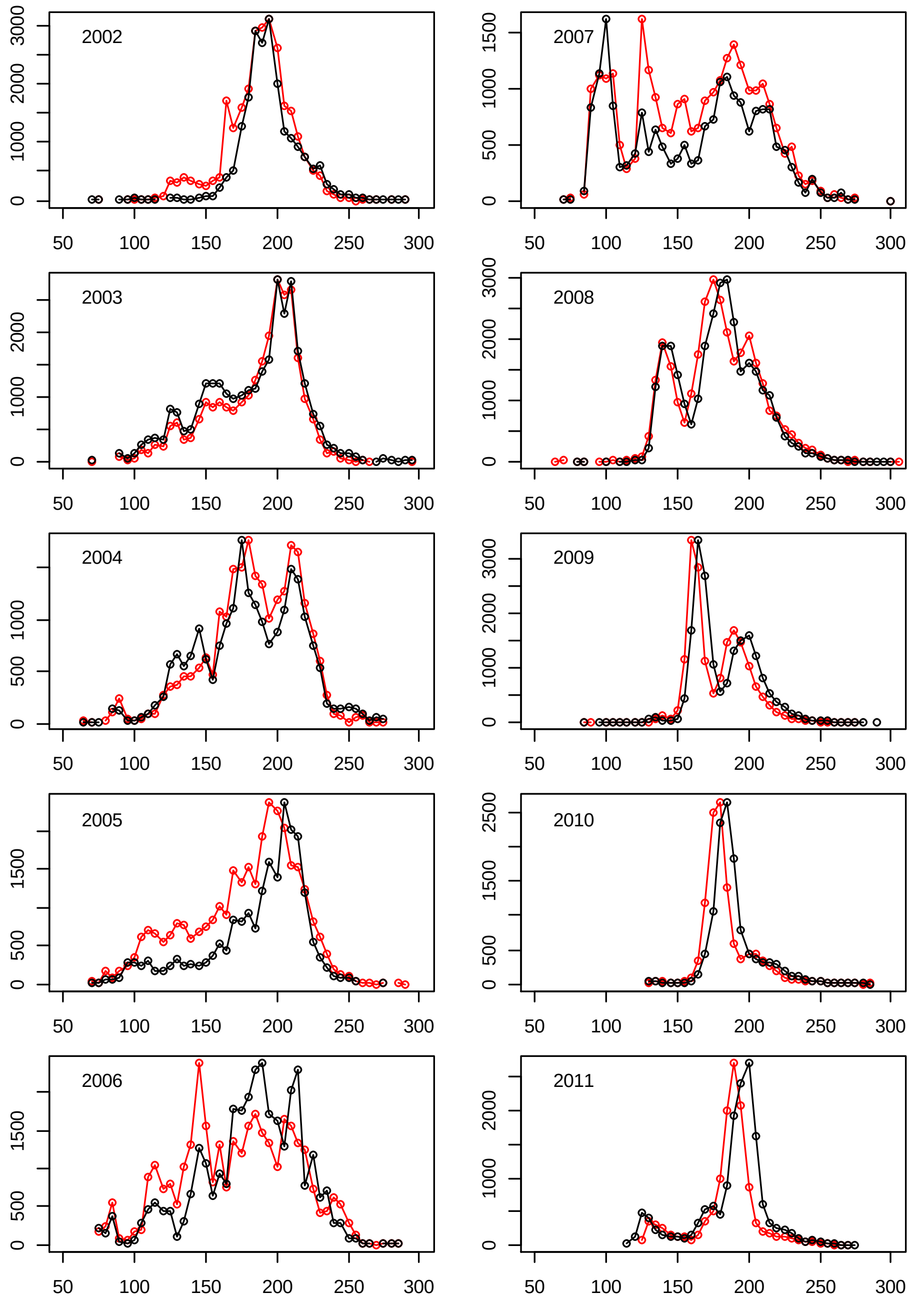

Figure 5. Comparison of catch-at-length of bluefin tuna caught by Japanese longline between those newly calculated (red) and those previously reported and included in the current Task 2 size data (black). X axis is fork length in cm and Y axis is the number of fish.

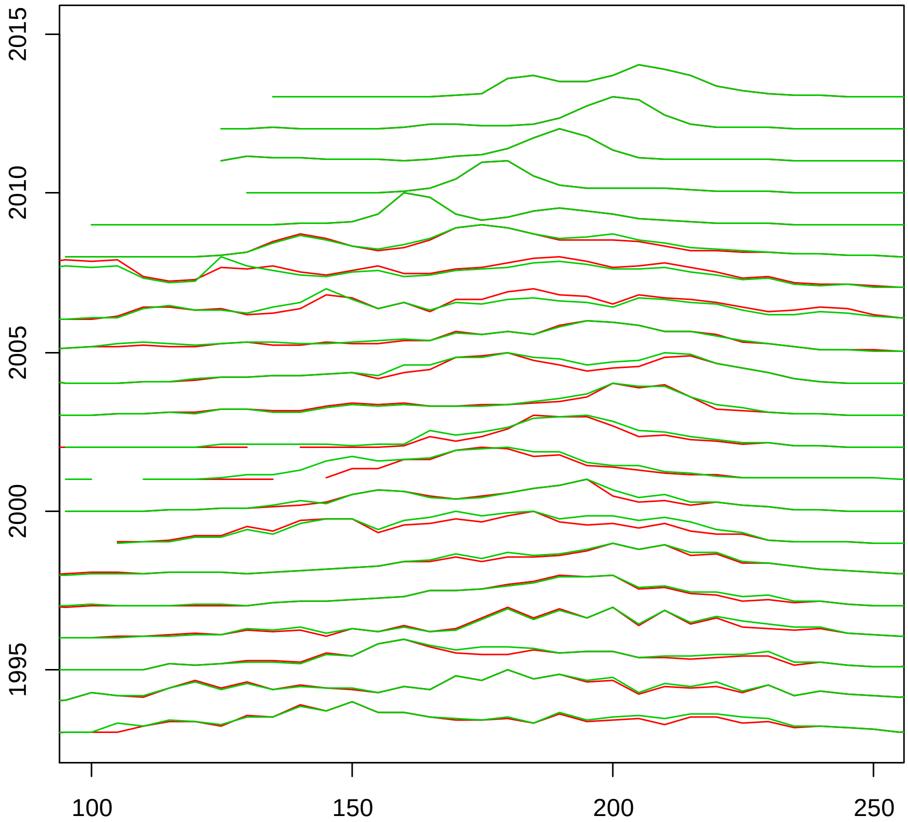

Figure 6. Effect of using the information of mean body weight per operation on the catch-at-length calculation for Japanese longline bluefin tuna catch. Green used the mean body weight information and red did not. X axis is fork length in cm and Y axis is the number of fish and year.

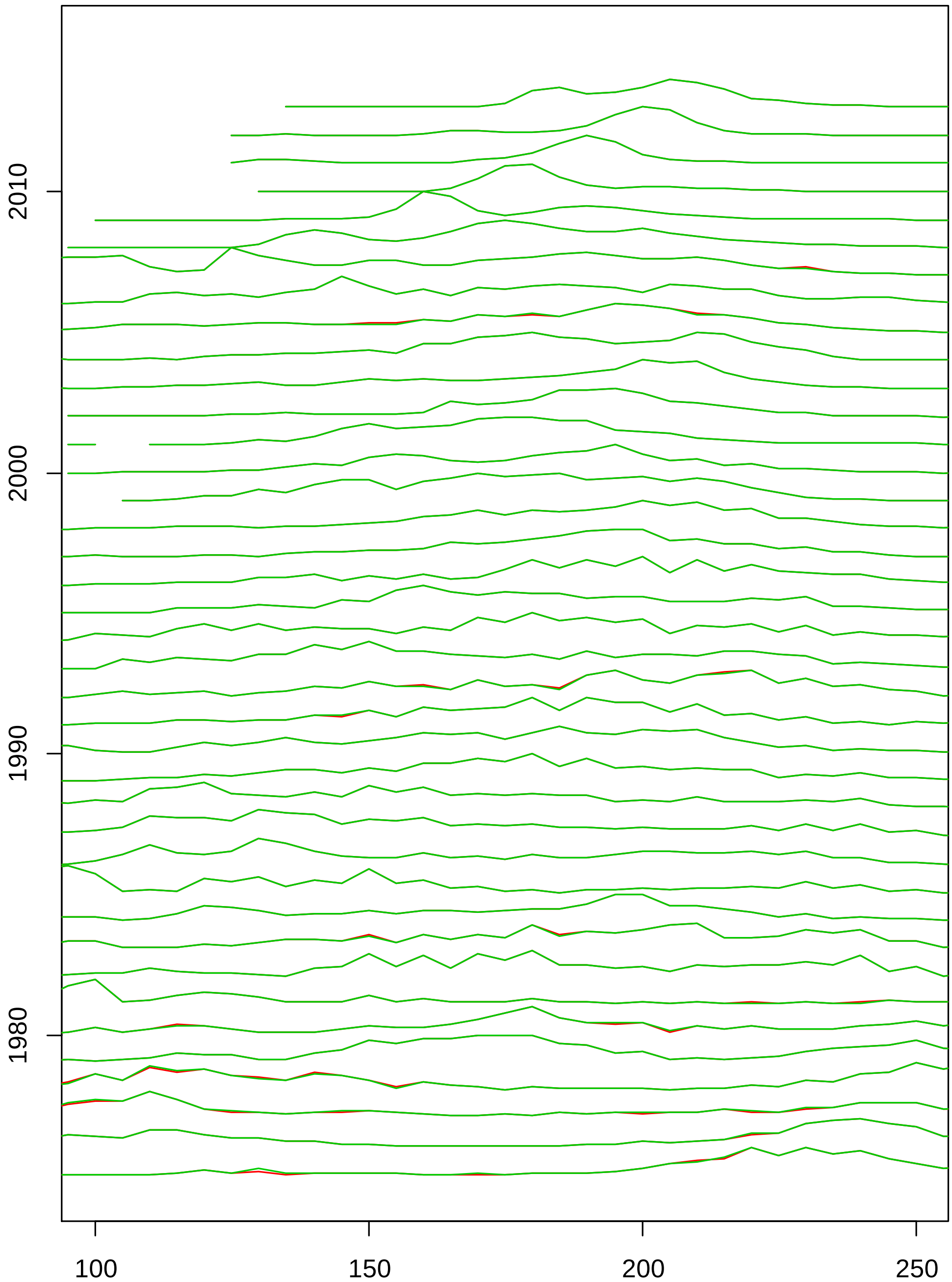

Figure 7. Effect of filtering by estimated mean fork length when size data in adjacent areas are combined. Green denotes that if difference of the mean fork lengths in two adjacent grids exceeded 50 cm, data in the grid was excluded for combining size data, and red denotes no treatment. X axis is fork length in cm and Y axis is the number of fish and year.