Estimation of catch-at-length of Pacific bluefin tuna caught by Japanese coastal longliners: Update up to 2018 fishing year

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Summary

The catch-at-length of PBF caught by Japanese coastal longliners was updated up to 2018 fishing year. The estimated catch-at-length in 4th quarter of 2018 fishing year (April to June) showed the catch was constituted by some strong cohorts for larger PBF and some moderate modes for smaller PBF. The comparison of the catch-at-length of 3rd quarter (January to March) with that of 4th quarter indicated the difference that the relatively smaller PBF was caught mainly at eastern area of Japan in 3rd quarter. The WG needs to consider how to deal with the issue.

Introduction

The estimated catch-at-length of Pacific bluefin tuna (PBF) caught by Japanese coastal longliners has been reported at ISC PBFWG (Sakai and Tsukahara 2018, Tsukahara et al. 2019). The previous document represented that the current strong cohort was consisted of wide range of year-classes. It also suggested the continuous recruitment of PBF because some moderate modes of relatively smaller PBF were observed at the catch-at-length. It can be positive sign for adult population of PBF.

This catch-at-length has been updated in the previous studies based on the data of April to June, covering the spawning season of PBF, because this term is the main fishery season for the longline. In addition to this season, the catch of PBF in January to March has remarkably increased in recent years (Fig. 1).

The purpose of this document is to show an updated catch-and-length of PBF caught by Japanese coastal longliners up to 2018 fishing year (FY), following the same procedure (Tsukahara et al. 2019). In addition to usual update of the catch-at-length in April to June, that in January to March was also estimated to investigate those difference.

Materials and Methods

The catch-at-length of PBF caught by Japanese coastal longliners was estimated using size-measurement and sales slip data for longline which were obtained at 10 main landing ports in five prefectures (Fig. 2), mainly collected by the “Research Project on Japanese bluefin tuna (RJB)”. Some size-measurement data from other research projects such as observer data were also used. The data from January to March (3rd quarter) and from April to June (4th quarter) during 1993 to 2018 FY (1st and 2nd quarters of 1994 to 2019 calendar years) was used for the estimation in each quarter. Note that the data in the latest year should not be considered complete due to delay of data collection, thus the result of catch-at-length in 2018 FY is preliminary.

The catch-at-length was estimated using the same method as proposed by Hiraoka et al. (2015). The length frequency (fork length) was estimated by “number” of actual measured fish with relative “weight” for measured fish and total catch. When fish weight was not measured for the size measurement, the weight of measured fish was calculated from measured length using existing weight-length relationship (Kai 2007). The estimating method can be described by the following

equations:

$$Coverage_{yqk} = w_{yqk} / c_{yqk} \quad \text{(Eq. 1)}$$

$$N_{iyq} = \sum_{k=1}^{K}\left(n_{iyqk} / Coverage_{yqk}\right) \quad \text{(Eq. 2)}$$

where N_{iyq} is the number of fish at the length bin of i occurred in the population at the quarter q of calendar year y. K is the total number of prefecture stratification. n_{iyqk} is the number of measured fish at the length bin of i in prefecture stratum k at quarter stratum q for year y. w_{yqk} is the total weight of them. c_{yqk} is the total catch weight in prefecture stratum k at quarter stratum q for year y. As the quarter stratum, a single quarter, either 1st or 2nd quarter of calendar year, was used for each catch-at-length. The prefecture stratum was following 5 prefectures: Miyagi, Chiba, Wakayama, Miyazaki, and Okinawa, where the size data was obtained (Fig. 2).

The coverage, which is the rate of the total weight of measured fish to the total weight of catch based on the sales slips for each prefecture, quarter and year, is used for the estimation of the catch-at-length. The number of measured fish divided by the coverage are raised to the estimated number of caught PBF (Eq. 1). However, the coverage of Okinawa prefecture since 2006 FY has been more than 100% (Fig. 3) due to the direct sales from landing port. The fisheries cooperative sometimes move the PBF out of their own port for a better price. When this happens, there are measurement data at landing port, but not sales slip at landing port because sales happen in other port. It makes the number of sold PBF less than the number of measured PBF. Therefore, the present paper makes one change, that the coverage which is over than 100% was changed to 100 (actually "1.0" in the equation), and the number of caught PBF was estimated as same with the number of measured fish. Additionally, temporal change was also introduced to the coverage of Chiba prefecture in 2018 FY; the average of recent 3 years (2015-2017 FY) was used for the coverage of Chiba in 2018 FY because sales slip data of Chiba in 2018 FY is low availability.

Results and Discussion

Estimated catch-at-length data of 4th quarter showed that the main part of the Japanese coastal longline catch has been constituted by some strong cohorts (Fig. 4: blue lines). For example, the previous strong cohorts consisted of 1990 and 1994 year-classes became small and mostly disappeared by 2012 FY, then 2007 and/or 2008 year-class increased and started to consist a new strong cohort since 2010 FY. These results correspond to the size and age compositions of PBF caught by Taiwanese longline (Shiao 2017), which reported that 2005-2009 year-cohorts increased in 2013-2015 after strong 1994 and 1996 year-cohorts decreased. In addition to the cohort of 2007 and/or 2008 year-class, 2010 and/or 2011 year-class started to be seen in 2014 FY and now composes the strongest cohort. In 2018 FY, the main size of PBF caught by Japanese coastal longliners in 4th quarter was 188-224 cm FL, followed by other cohorts which are considered to be 2013 year-class at the size of 170-188 cm FL (appeared in 2015 FY) and 2015 year-class at the size of 128-152 cm FL (appeared in 2017 FY). These continuous recruitments, which have been reported

in the previous documents, for catch by longliners was also observed at the present study, and therefore, a positive sign for adult population of PBF has been continuously indicated for recent years.

It should be noted that the strong mode at the size of 106-116 cm FL in 4th quarter in 2017 FY, which is consisted of 2015 year-class and mainly consisted of catch in Miyagi (Fig. 5), has less reliability than the other modes in this year because of low coverage in Miyagi. This low coverage is caused by the little number of measured individuals since 2010 FY while catch amount has been recovering since 2014 in quarter 4 (Fig. 6). In 2018 FY, the coverage increased because of the addition of the measurement data, although the catch-at-length in 2018 FY is provisional.

The catch-at-length of 3rd quarter was also estimated and shown in Fig. 4 (green lines). Except for recent two years (2017-2018 FY), the estimated number in 3rd quarter was considerably lower than that in quarter 4 because the catch amount at 4th quarter was much larger than that in 3rd quarter, especially at Wakayama, Miyazaki and Okinawa prefectures where the total catch is larger than other two prefectures (Figs. 8-10). At these prefectures, relatively larger PBF is caught in 4th quarter (Fig. 5). On the other hand, at Miyagi and Chiba prefectures where relatively smaller PBF is caught, the amount of total catch in the 3rd quarter has increased rapidly in recent years (Figs. 6-7), and this increase appeared as the strong mode at the smaller size of PBF for the total catch-at-length in 3rd quarter.

Currently, catch-at-length in quarter 4 is used as the size composition data for stock assessment to estimate selectivity for Japanese longline Fleet. As written above paragraph, catch amount in quarter 3 has been increasing. Additionally, the operations by longliners were stopped in the middle of quarter 4 because of fishery management in recent years. It is expected that the proportion of catch amount in quarter 3 will be increasing hereafter. If the catch composition in quarter 3 is different from that in quarter 4, the selectivity and catch at age in stock assessment would not be estimated correctly. The present comparison figured out the different shape in the size composition of caught PBF between 3rd and 4th quarters; relatively smaller fish is mainly caught at eastern part of Japan (Miyagi and Chiba) in 3rd quarter, on the other hand, relatively larger fish is mainly caught at western part of Japan (Wakayama, Miyazaki and Okinawa) in 4th quarter. The difference of catch-at-length is remarkable since 2017 FY, therefore there would be two ways to deal with this problem. First one is separating the data in 3rd quarter from Japanese longline fleet, Fleet 1, and defining a new fleet for Japanese longline in quarter 3. The other is assuming time block selectivity for Fleet 1 before and after around 2017 FY and estimating combined catch-at-length in quarters 3 and 4 (Fig. 4: red lines).

Conclusion

Catch-at-length of PBF caught by Japanese coastal longliners in 4th quarter was updated with following the previous procedure. Current strong cohorts were constituted with wide range of year classes and some moderate modes for relatively small fish were observed since 2015 FY. These positive information for the PBF stock, especially some modes in smaller size, has been observed

continuously for recent years. In addition, catch-at-length of 3rd quarter was also estimated for the comparison with that of 4th quarter. It showed the difference that relatively larger PBF was caught mainly at western Japan in 4th quarter while relatively smaller PBF was caught mainly at eastern Japan in 3rd quarter. This result indicates that the selectivity and catch at age for Japanese longline fleet would not be estimated correctly when catch-at-length only in quarter 4 is used for stock assessment as size composition data. The difference of catch-al-length is remarkable since 2017 FY, therefore there would be two ways to deal with this problem. First one is separating the data in 3rd quarter from Japanese longline fleet, Fleet 1, and defining a new fleet for Japanese longline in quarter 3. The other is assuming time block selectivity for Fleet 1 before and after around 2017 FY and estimating combined catch-at-length in quarters 3 and 4.

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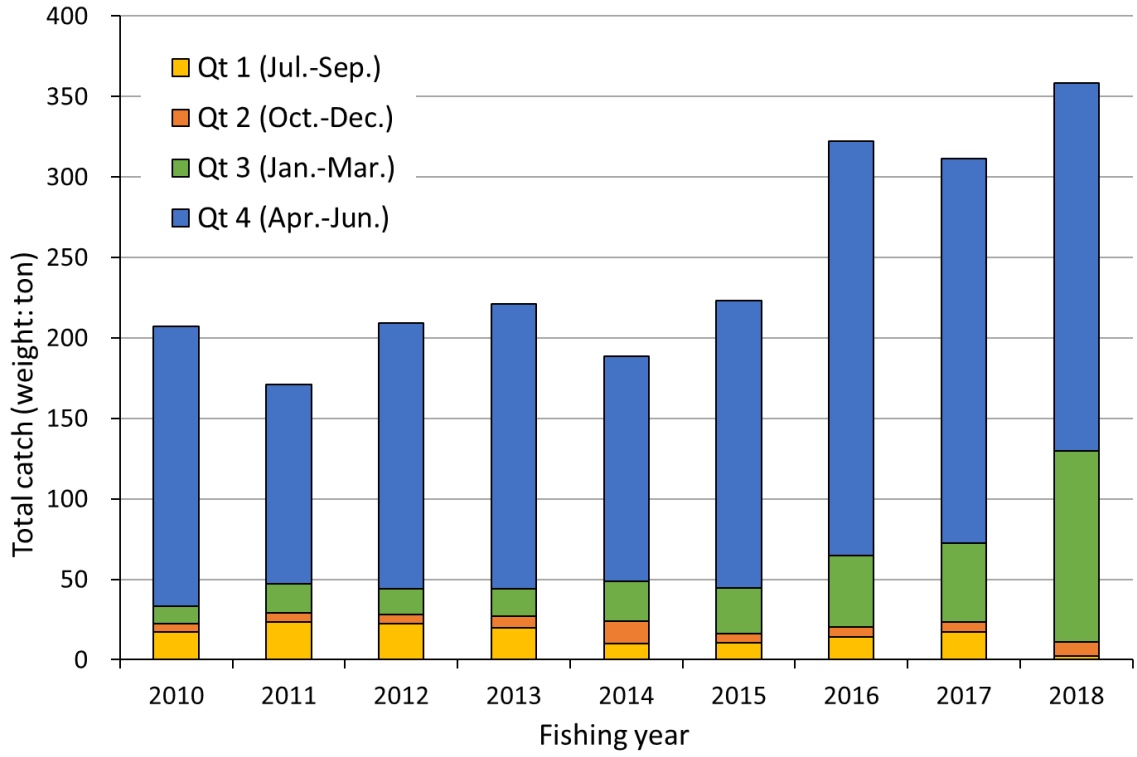


Fig. 1 Total weight of PBF of 5 prefectures (Miyagi, Chiba, Wakayama, Miyazaki and Okinawa) caught by Japanese coastal longliners for each quarter. The data of 2018 FY is preliminary.

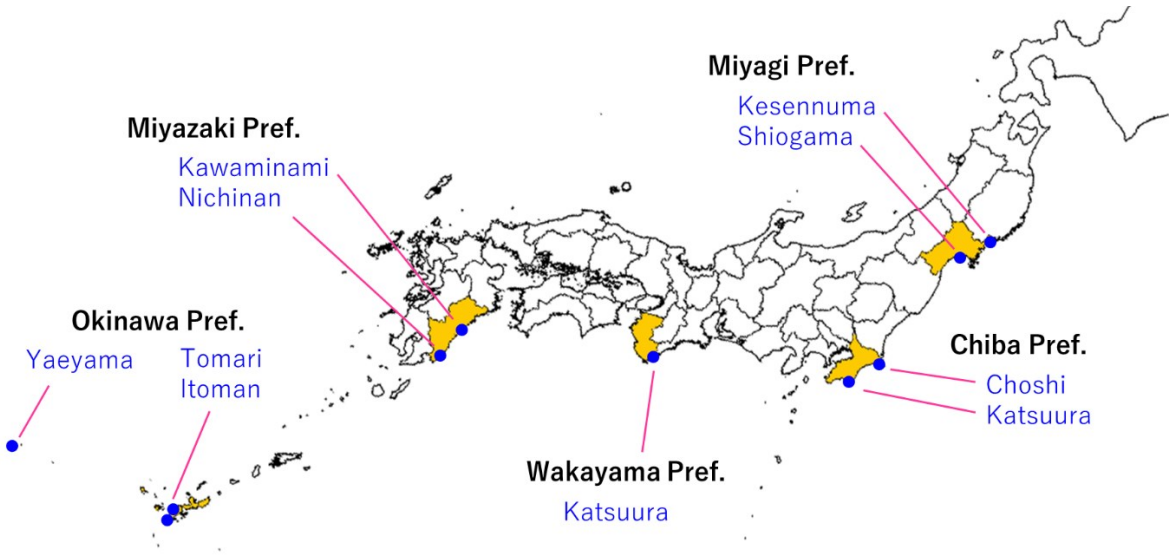


Fig. 2 Location of prefectures (yellow area) and fishing ports (blue circle) where the PBF caught by Japanese coastal longliners was measured for size data.

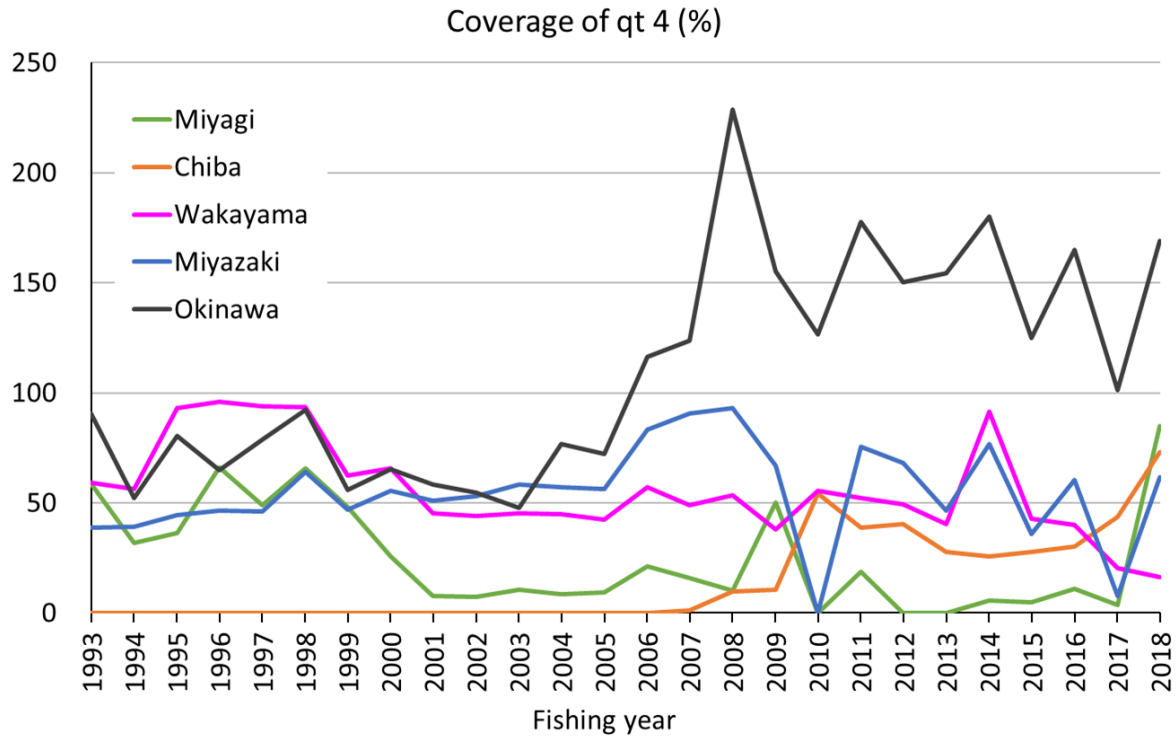
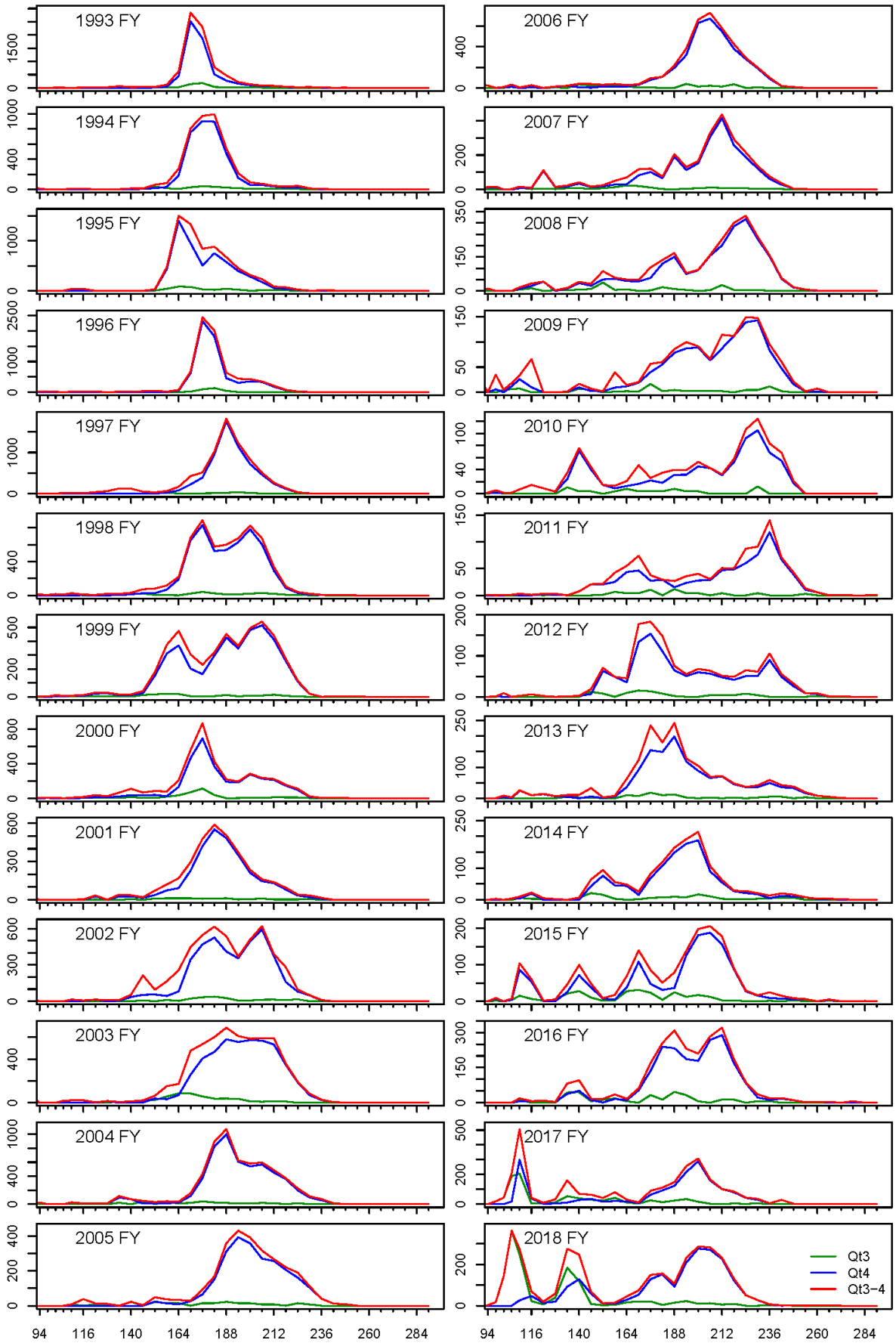


Fig. 3 Coverage (the rate of total weight of measured fish to total weight of catch) of 4th quarter for each prefecture where the landed PBF was measured for size data.


1993 FY
1994 FY
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1996 FY
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2001 FY
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2004 FY
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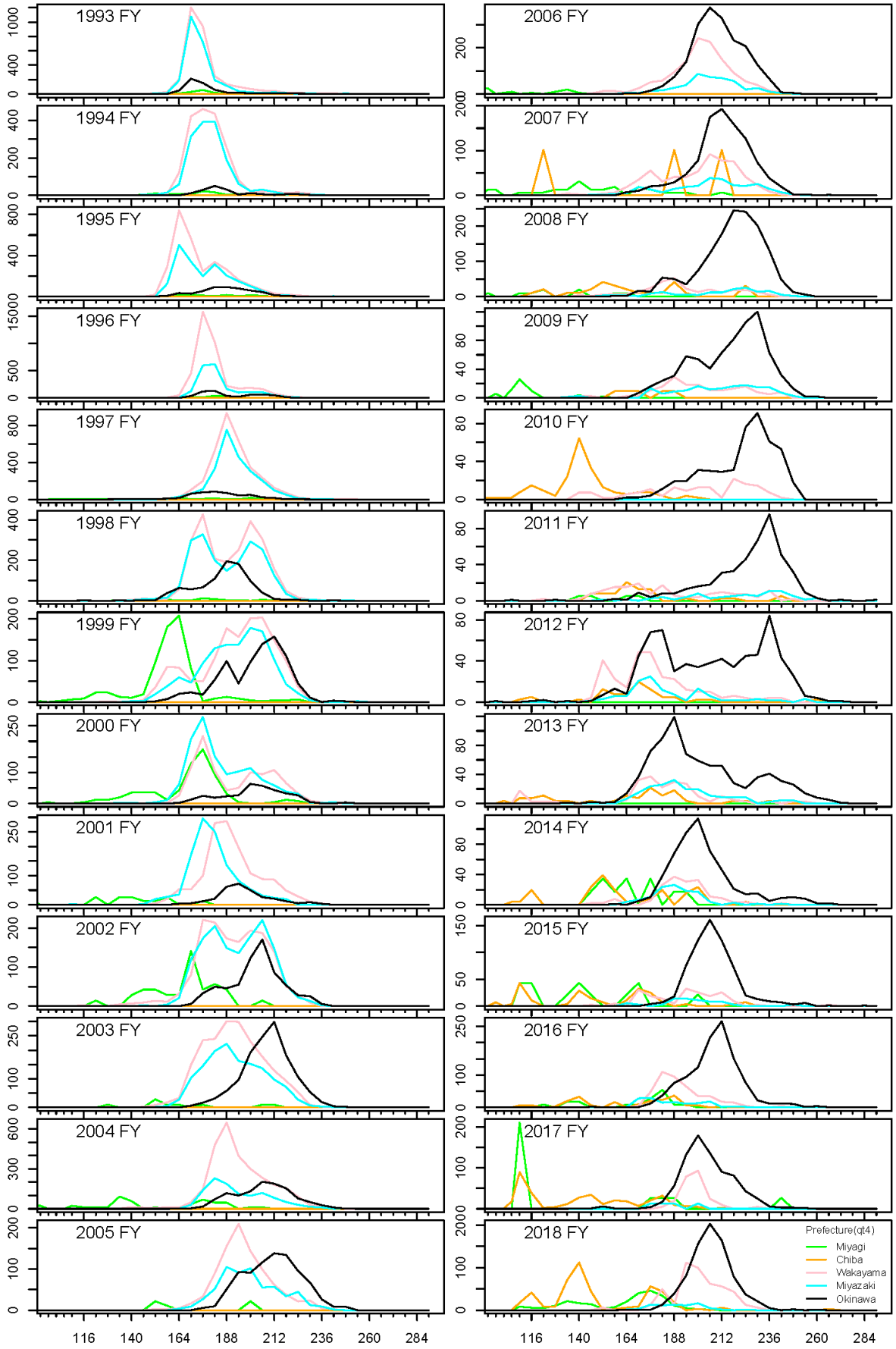
2008 FY
2009 FY
2010 FY
2011 FY
2012 FY
2013 FY
2014 FY
2015 FY
2016 FY
2017 FY
2018 FY
Qt3
Qt4
Qt3−4
94
116
140
164
188
212
236
260
284

Fig. 4 Estimated catch-at-length of PBF caught by Japanese coastal longliners in 3rd (green line), 4th (blue line), and 3rd to 4th (red line) quarters of fishing year, respectively. Vertical axis indicates estimated number of caught PBF. Horizontal axis indicates fork length of PBF (cm). The catch-at-length of 2018 FY is preliminary.


1993 FY
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2009 FY
2010 FY
2011 FY
2012 FY
2013 FY
2014 FY
2015 FY
2016 FY
2017 FY
2018 FY
116
140
164
188
212
236
260
284
Prefecture(qt4)
Miyagi
Chiba
Wakayama
Miyazaki
Okinawa

Fig. 5 Estimated catch-at-length of 4th quarter for each prefecture. Green, Miyagi; yellow, Chiba; pink, Wakayama; light blue, Miyazaki; black, Okinawa.

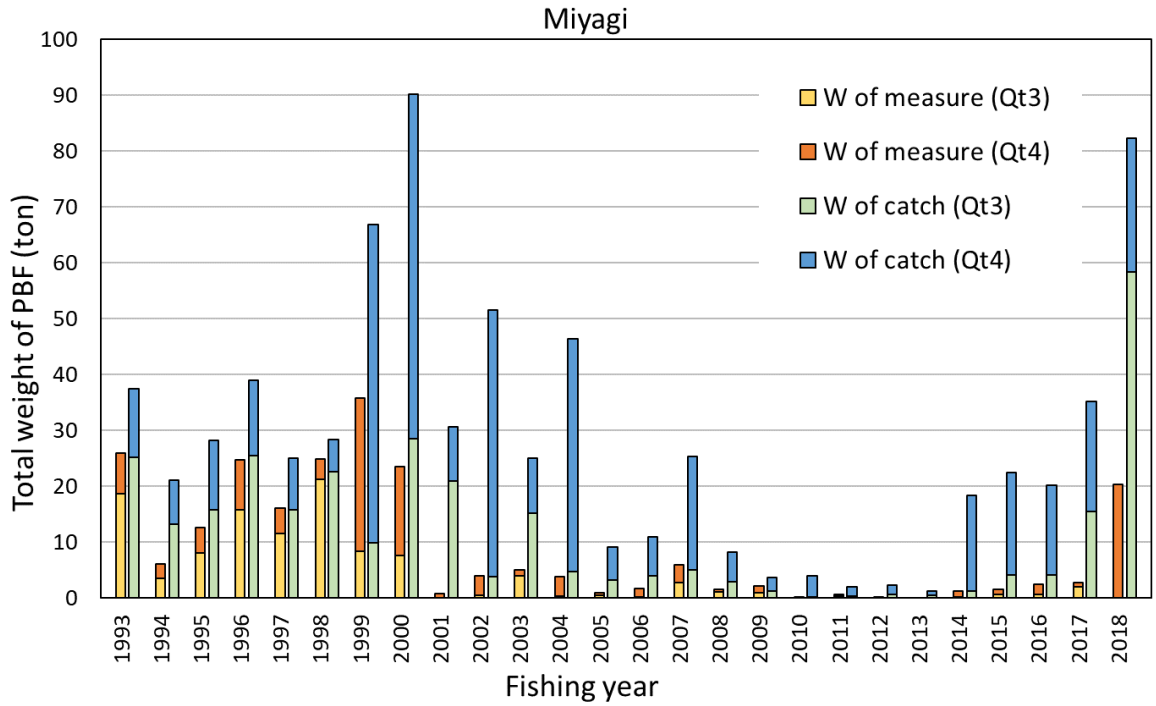

Fig. 6 Total weight of measured PBF for size data (left bars) and total weight of landed PBF for catch data (right bars) in each quarter (3 and 4) of Miyagi prefecture.

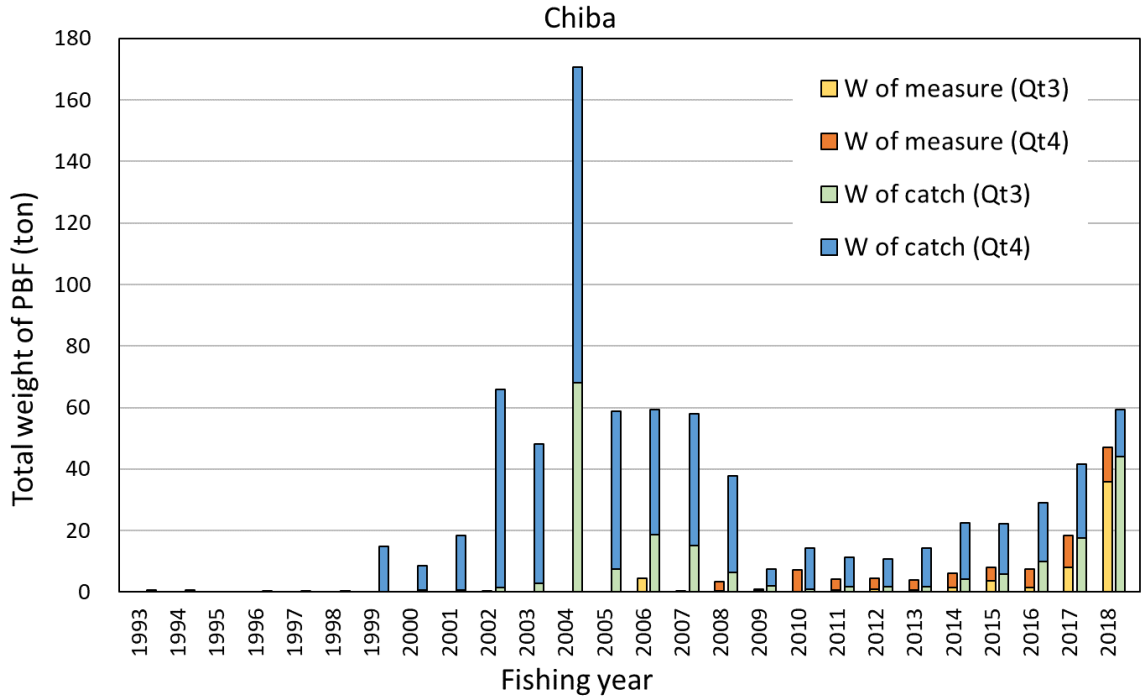

Fig. 7 Total weight of measured PBF for size data (left bars) and total weight of landed PBF for catch data (right bars) in each quarter (3 and 4) of Chiba prefecture.

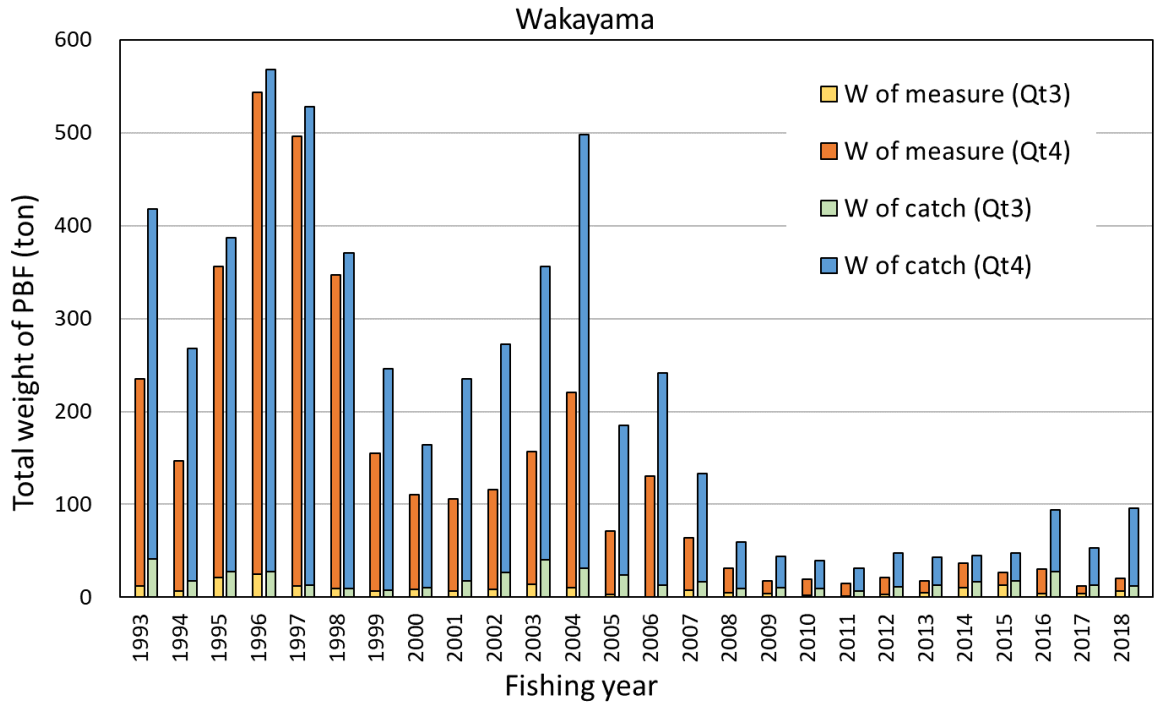

Fig. 8 Total weight of measured PBF for size data (left bars) and total weight of landed PBF for catch data (right bars) in each quarter (3 and 4) of Wakayama prefecture.

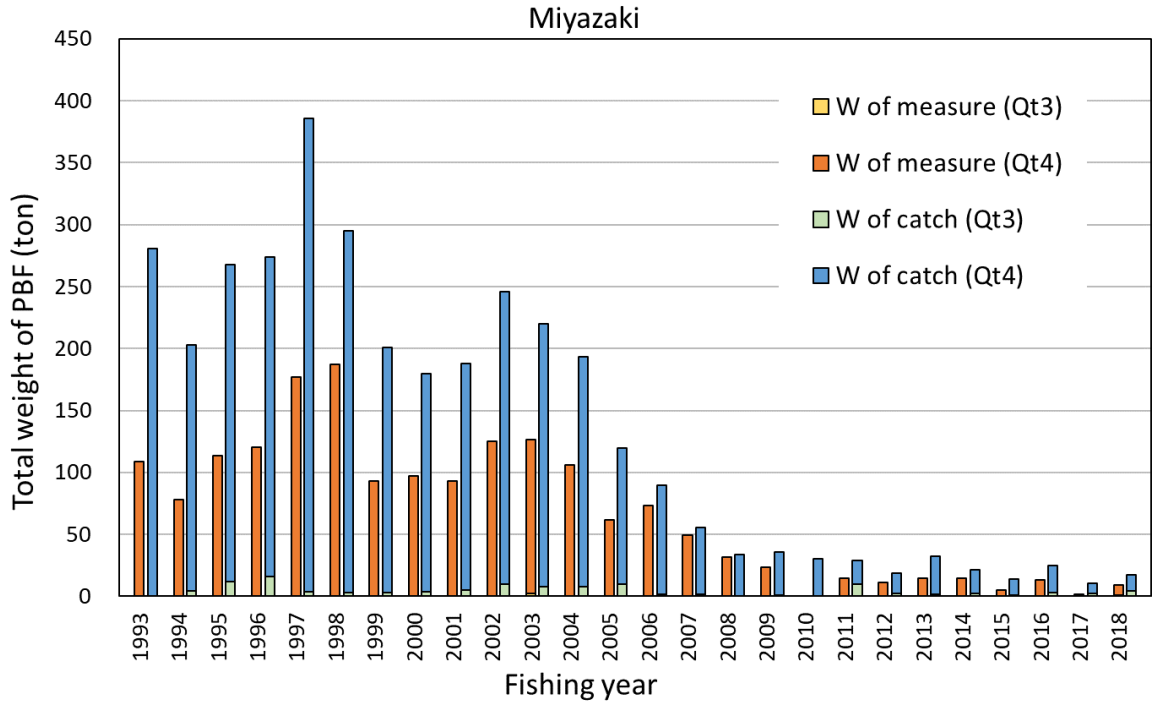

Fig. 9 Total weight of measured PBF for size data (left bars) and total weight of landed PBF for catch data (right bars) in each quarter (3 and 4) of Miyazaki prefecture.

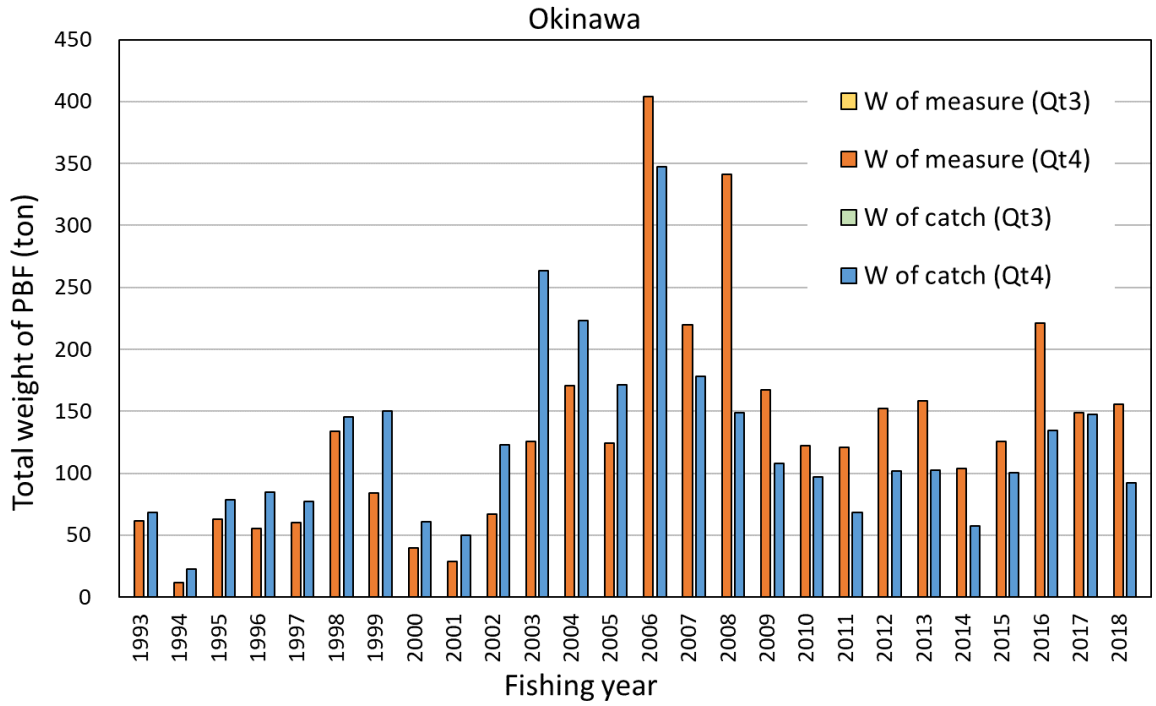

Fig. 10 Total weight of measured PBF for size data (left bars) and total weight of landed PBF for catch data (right bars) in each quarter (3 and 4) of Okinawa prefecture.