ISC/12-1/PBFWG/04

Estimation of Catch at size of young Pacific bluefin tuna caught by Japanese troll fisheries.

Hiromu Fukuda & Kazuhiro Oshima

National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan

Jan.-Feb. 2012

Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), 31 January-7 February 2012, La Jolla, San Diego, California, USA. **Document not to be cited without author's permission.**

Introduction

Japanese troll fisheries which mainly catch 0-age PBF are widely operated in the coastal areas by small vessels based on countless small ports. This situation means difficult-access to all landing ports for size sampling. Accordingly, unbalanced sampling effort among each landing port was pointed out (ISC/08/PBF-2/7.). For example, some of the principle landing ports for PBF trolls are located at remote islands such as Tsushima and Goto, where sampling is difficult, but there are some standard landing ports such as Port-Kushimoto located in Wakayama prefecture which are easy to access for size samplers. To solve this problem, NRIFSF re-organized the size sampling framework to measure fish intensively in several major landing ports since 2007 (ISC/07/PBF-2/12). This sampling program resulted in large sample sizes in major landing ports and the unbalanced situation between the reported catches and size samplings have been solved. This effort should be continued to secure the coverage of size sampling in the major landing ports.

Even with this improvement of sampling structure, the data should be raised properly to the total catches with information on the nature of troll fishery, so that the real catch at size is well represented. This would also help to improve estimation of catch at size for the period in prior to 2007, i.e. before the new sampling program had started.

In the previous works, spatial and temporal strata were considered on 'prefecture' and 'quarter' basis, respectively. However, miss-match among length frequencies and catches (fewer size sampling in major landing ports or excessive sampling in minor landing ports) was a possible problem as mentioned above. In this document, we tried to estimate catch at size with stratification to larger areas than prefectures.

Materials and Methods

Data

Size sampling data were derived from Research project on Japanese Bluefin tuna (RJB data) from 1994 to 2011. Annual catch data are available by prefecture from 1994 to 2007, from the Annual Report of Catch Statistics on Fishery and Aquaculture published by the Statistics Department, Ministry of Agriculture, Forestry and Fisheries of Japan (SD report). The amounts of quarterly catch in each prefecture are estimated using the proportions of catch among quarters based on the RJB catch data. For the period of 2008 to 2011, we used the monthly catch data by landing ports, derived from the Survey on Catch of Bluefin Tuna in Japan's Coastal Areas implemented by Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries of Japan (JFA data).

Stratification

As described in ISC/07/PBF-WG/03, the lengths of PBF caught by trolls show significant seasonal variations (Fig. 1). This seasonal variations should be representing the growth of 0-age PBF after being hatched around May to July. We regard the temporal stratum of 'quarter' was defined in this study.

For the determination of spatial stratum, we took into considerations the area distributions of PBF catch and size samples, in relation to the geographies of various prefectures. As shown in Table. 1, the catch from Nagasaki Prefecture accounts for approximately 66% of the total PBF catch by troll fisheries, and Shimane, Yamaguchi, Kochi, and Wakayama accounts for 10, 9, 4, and 3%, respectively. The rest of prefectures contribute approximately 8% only in total. The proportions of size measurements to the total number of size measurements are different from those proportions of catches; i.e. comparatively low contributions in Nagasaki (29%) and Shimane (3%), and high contributions in Kochi (13%), Yamaguchi (13%), and Wakayama (12%). In other non-important prefectures, size measurement are sometimes lacking even some amount of catches are landed.

Another important point which should be noted is that the size distributions of PBF measured at the major landing ports in Yamaguchi prefecture distinctly differed from the other major landing ports (Fig. 2); PBF caught by troll in this prefecture being bigger than those in the other prefectures. Based on that preliminary analysis of the catch and size sampling data, we defined the spatial strata into 4 areas: 'Nagasaki' which has principal landing ports; 'Yamaguchi' which has characteristic size distribution with a large share in the catch; 'Rest of the Pacific Coast'; and 'Rest of the Japan sea coast'. The latter 2 areas contain multiple prefectures though, the contribution of each prefecture in the catch is less than 1.5% except for Shimane, Kochi, and Wakayama. By such geographical stratifications, better matching of size with catch were achieved for each quarter, with less substitution.

Estimation of Catch at size

According to the equation for estimating length frequency by Abe et al. (2007), the probability that the fish at the length bin of i occurred in the population at a temporal stratum t (p_{it}) can be described as follows:

$$p_{it} = \sum_{k=1}^{K} r_{kt} p_{ikt}$$

where, r_{kt} is relative catch 'in number' in spatial stratum (k) at temporal stratum (t). PBF catch in number for each area was calculated as a quarterly catch in weight divided by average weight of individual fish. The average weights were estimated from direct measurements of weights and when the weight data are missing, converted from length measurements using the weight length relationship (Fig. 3).

No substitutions of size data were made for the catches which lack corresponding size data. Weighted catch at size were not re-raised to the total catch, either. Hence, sum of weights of fish converted from the catch at size do not agree with total catch.

Results and Discussion

Fig. 4 shows the total catch with (dense gray) and without (light gray) enough corresponding length data (The number of length data > 9). The proportions of catch with corresponding length data (dense gray) are also shown as coverage. Average catch with samples make up 94% of total. This is higher than the value (85%) for the data calculated in ISC/08/PBF-2/7 where ‘prefectures’ were used as geographical strata. This is an advantage to use large spatial strata. On the other hand, we still have low coverage in some strata especially those with small catches. In those strata (i.e; 1998-2nd quarter, 2002-2nd quarter, and 2nd and 4th quarters of 2003), more than 70 % of catch were not included in weighted catch at size, as no size data substitutions were made.

Weighted Catch at size were different from the raw length frequencies (Fig. 5). The cause for significant differences was pointed out in ISC/08/PBF-2/7, concluding that it was a result of unbalanced sampling rate in each strata. Significant differences are found often when ‘Nagasaki’ had a large amount of catch but few size samplings were made, in contrast to that ‘Rest of Pacific coast’ had less amount of catch and a large size of samples (i.e; 1997-3rd & 4th quarter, 2002-1 quarter, and 2005-4 quarter). These results indicate that the weighted catch at size represent real situations better than actual size frequencies including that for “Nagasaki”. When the catch of ‘Nagasaki’ contributes little (i.e; 3rd quarter of 1999), weighted catch at size was similar to the raw length frequency. In recent years (after 2007-4th quarter), the difference between the weighted catch at size and raw length frequencies are quite small. This result indicates the success of the intensive size sampling, which started in November of 2007, to minimize the unbalanced sampling rates among prefectures (ISC/08/PBF-2/12).

Fig. 6 shows the weighted and raw length frequencies 1994-2011 combined. The peak of the combined weighted catch at size was at a lower size than that of the raw length frequency. The tail of the distribution ends at a smaller size in the weighted length distribution than raw length distribution. This tail part was largely comprised of fish from “Yamaguchi”, which has characteristic size distribution in the samples, and its contribution was down scaled by the new weighting procedures.

Conclusion

This document adopted a new stratification scheme which matches more catch data to corresponding length data than the scheme used previously. And the biased sampling rates between ‘Nagasaki’ and ‘Rest of the Pacific coast’ until 3rd quarter of 2007 were rectified by the intensive sampling in Nagasaki, since 4th quarter of 2007. In some quarters, however, we still have the unreliable weighted catch at size which were obtained by raising size data of a small sample size.

In the stock assessment model of SS III we are expected to skip some catch at size (weighted catch at size combined by quarter for all areas) according to the coverage rates. If we skip the weighted catch at size which were raised on the basis of less than 50% coverage (i.e. more than 50% of the catch had no corresponding size data), we would lose 7.2 % of catch information and 12 quarters of length distributions. It would be 7.5 % of the catch and 15 quarters if we skip the catch at size with less than 70 % coverage of size data. We might have to choose 70% coverage as a criterion if we prioritize the credibility of each length distribution.

References cited

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Table 1. Catch and Size sampling in the major landing ports for the troll fisheries during 1994-2011.

	Nagasaki	Shimane	Yamaguchi	Kochi	Wakayama
Catch(ton)	29698	4274	4073	1914	1325
Percentage in the total catch	66%	10%	9%	4%	3%
Size sampling	38314	4019	17064	20164	15914
percentage in the total sampling	29%	3%	13%	15%	12%

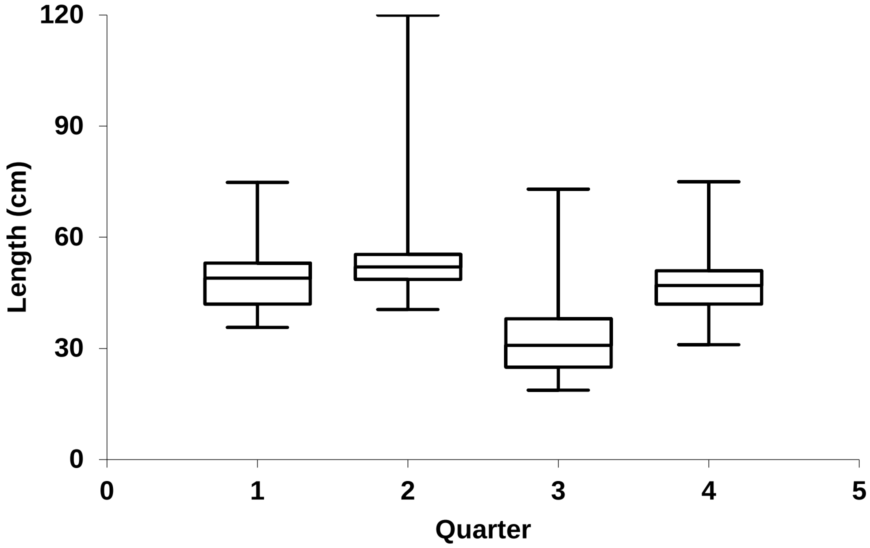

Fig. 1 Box-Plots of quarterly size data caught by troll from 1994-2011.

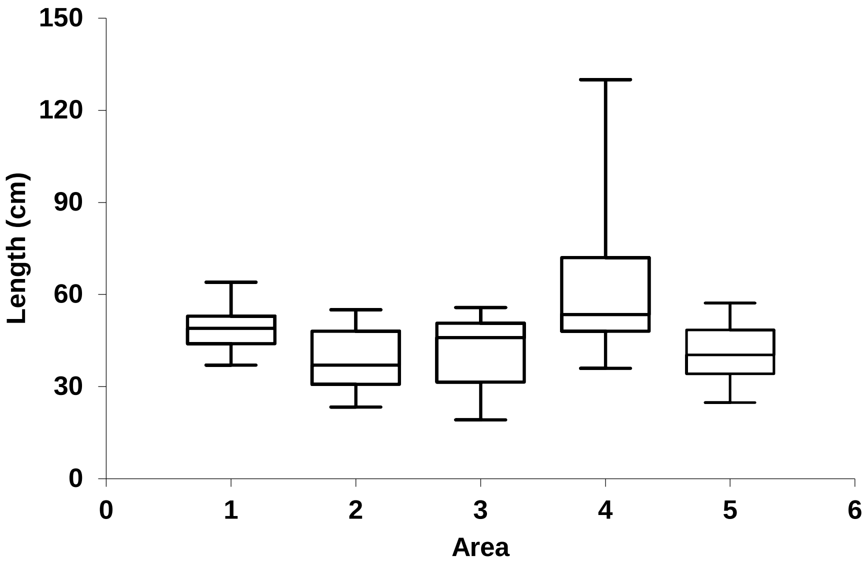

Fig. 2 Box-Plots of size data caught by main landing prefectures from 1994-2011.

1; Nagasaki, 2; Shimane, 3; Kochi, 4; Yamaguchi, 5; Wakayama.

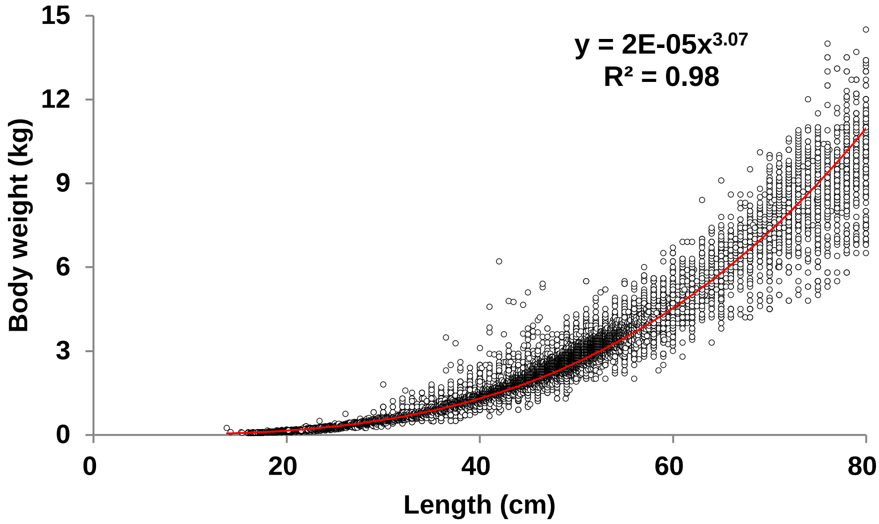

Fig. 3 Length-weight relationship of PBF which caught by troll.

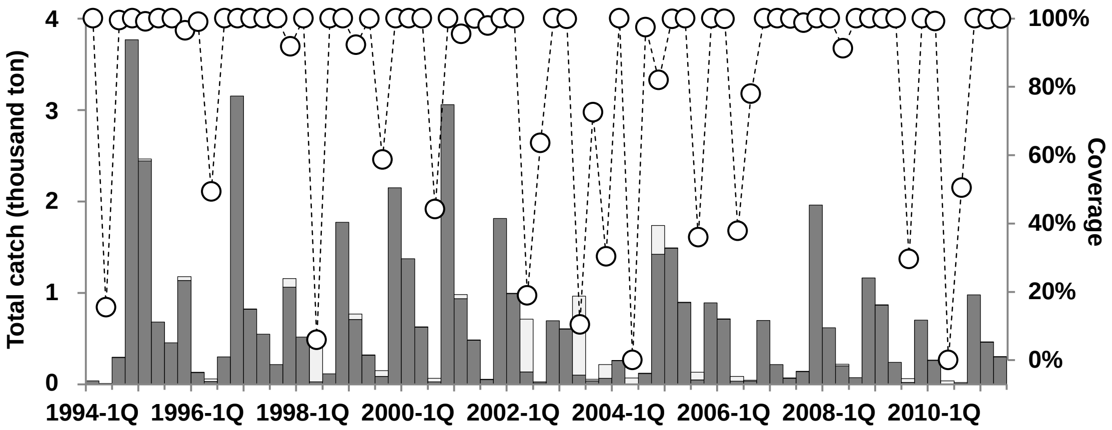

Fig. 4 Total catch with (dense gray) and without (light gray) enough corresponding length frequency data (n > 9) in each area-quarter. The lines with open circles are coverage, the ratio of dense gray in the total bars height.

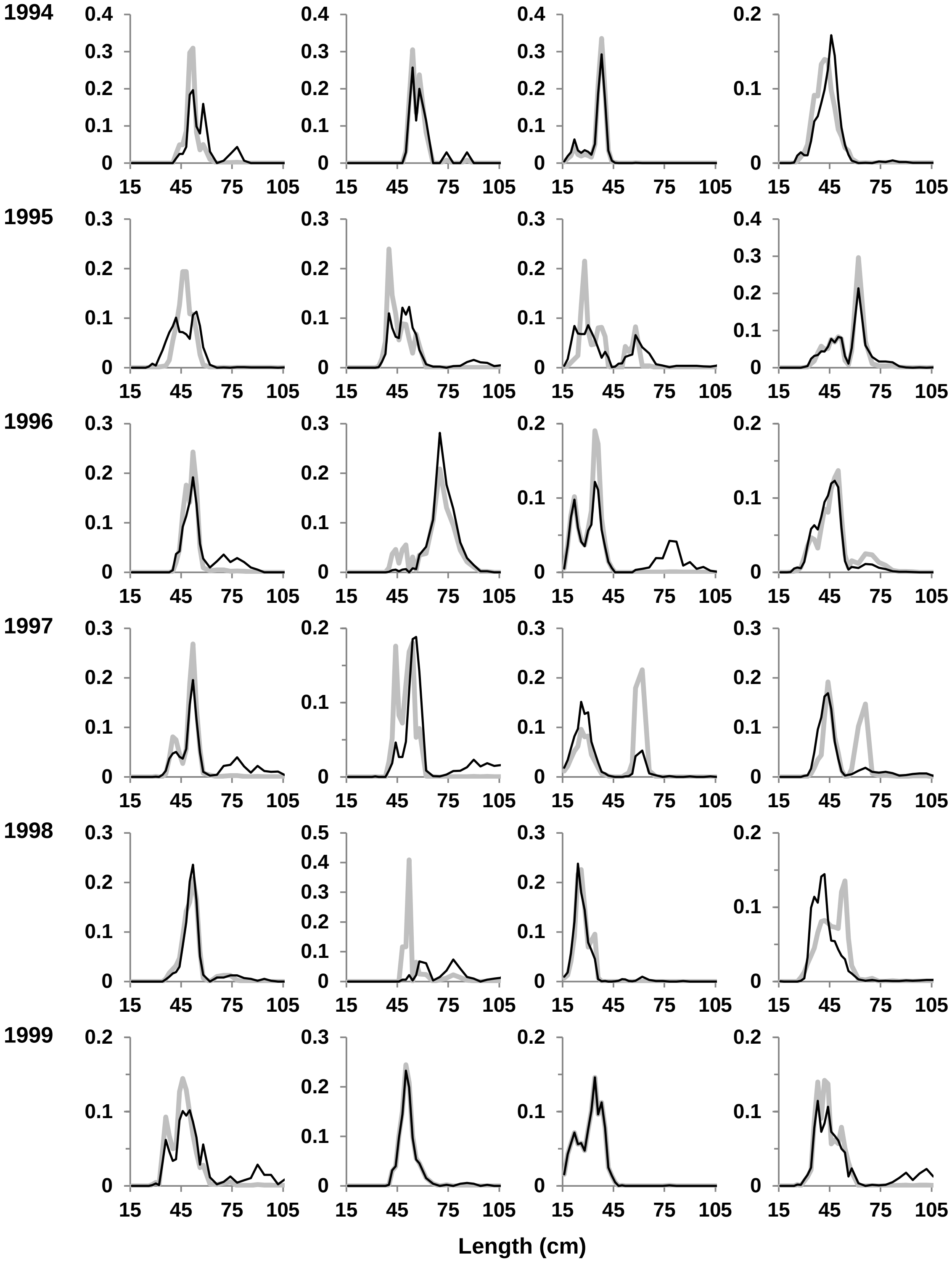

Fig. 5 The weighted catch-at-size (gray) and the raw length frequency (black) in each quarter. The figures are listed by a calendar year from left.

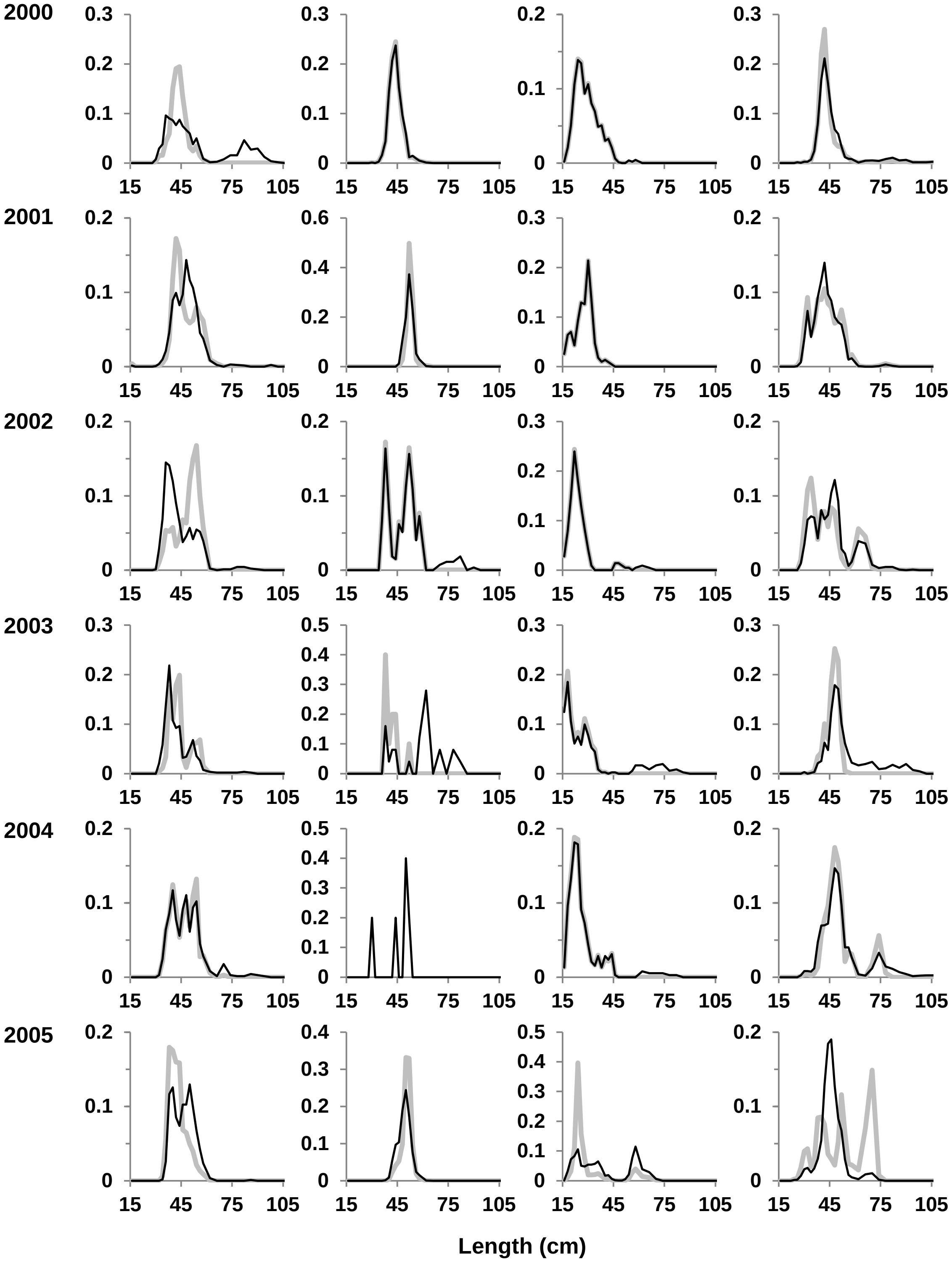

Fig. 5 (Continued). The weighted catch-at-size (gray) and the raw length frequency (black) in each quarter. The figures are listed by a calendar year from left. In 2nd quarter of 2004, catch-at size was not estimated because no strata had enough corresponding measurement data (n < 10).

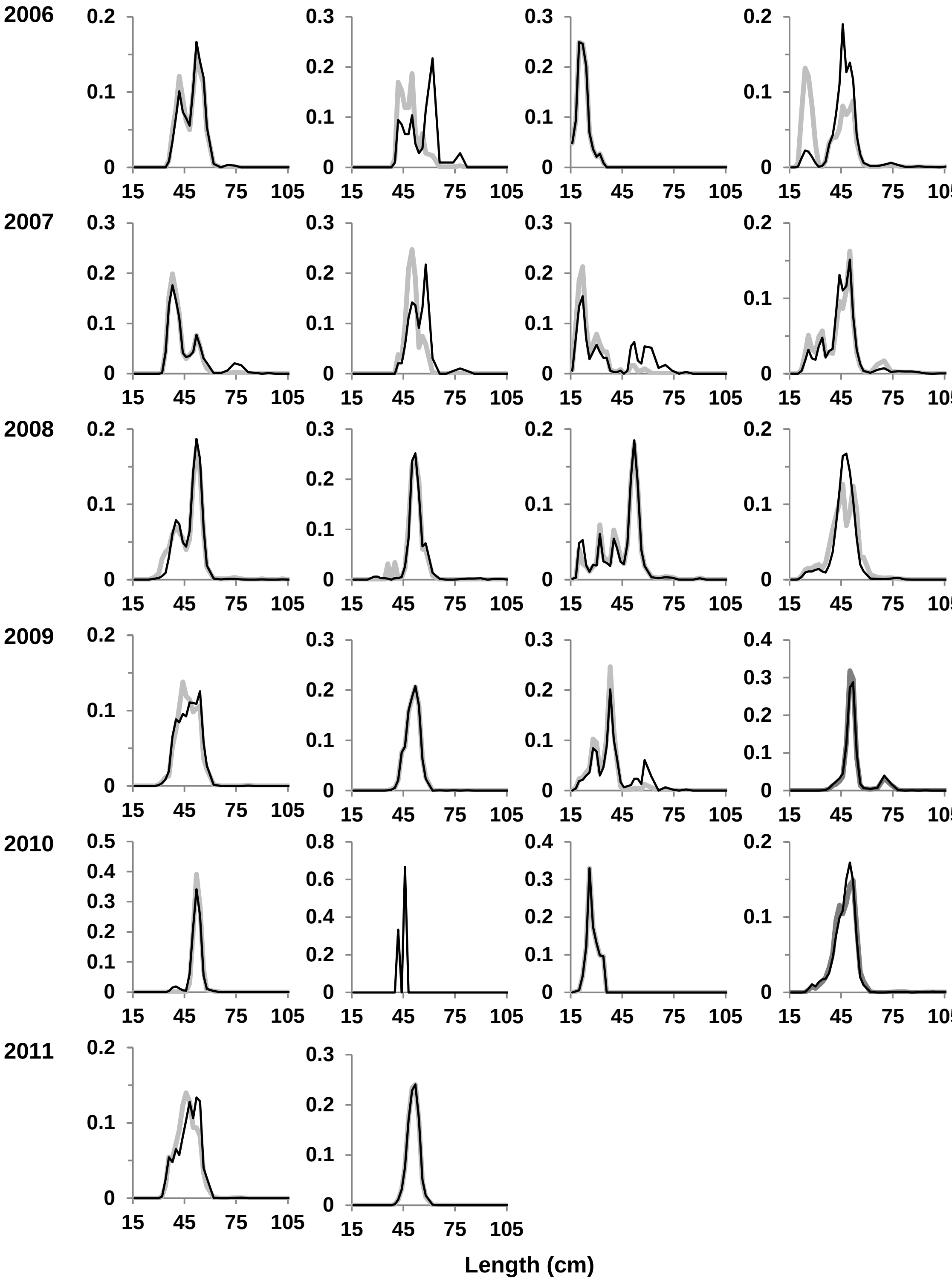

Fig. 5 (Continued). The weighted catch-at-size (gray) and the raw length frequency (black) in each quarter. The figures are listed by a calendar year from left. In 2nd quarter of 2010, catch-at size was not estimated because no strata had enough corresponding measurement data (n < 10).

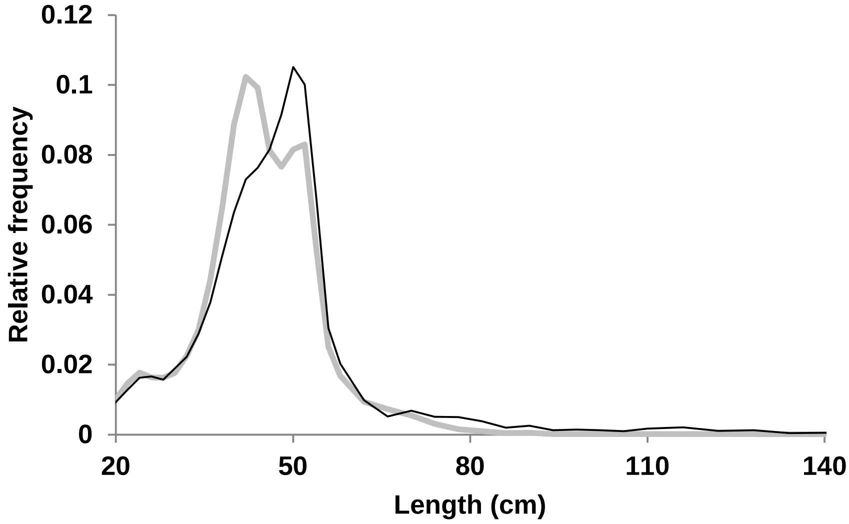

Fig. 6 The estimated catch-at-size (gray) and the raw length frequency (black) through 1994-2011.