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# Update of estimated catch at size by Purse Seiner in Japanese sea.

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## Introduction

Pacific bluefin tuna (Thunnus orientalis: PBF) is one of the most high-priced fish and is important commercially in the world. PBF has a long life span, (i.e. at least 26 years) and for that reason, multi cohort model is used for stock dynamics. Because PBF is a highly migratory pelagic species, it is difficult to make research covering the entire habitat and life history, so commercial fisheries' data are essential for its stock assessments. Sakai-minato port is one of the most important landing ports for PBF. At the Sakai-minato port, the length composition data of landed PBF are measured as fundamental data to estimate catch at size for purse seine catches in the Sea of Japan. In the previous stock assessments, the length composition of sampled individuals is considered to represent that of the entire landings. Kanaiwa et al. (2011) presented the sum of all length composition each taken from a landing weighted by numbers of fish in the respective landing and proposed that this would represent more realistic catch at size. This document is the update of the weighted length composition by landings as catch at size.

## Materials and Methods

### 1) Data set

Length data which have associated information on the sampled vessels were used for this study. These samples were from 1987 to 2010, except for 1990, in which year there was no PBF catch. (see Table 1). They were collected at Sakai-minato port by the Tottori Prefectural Fisheries Experimental Station. Although Sakai-minato-based tuna fishing season is usually from June to July, one exceptional operation with some amount of catch was observed in October in 1997. We removed data from this operation in this analysis. In addition, as sample size of length of fish below around 80 cm, called "Yokowa", was small, we also excluded these data in this analysis.

### 2) Estimation of catch at size

**I Weighted length composition (proposed procedures shown as “new” in the Figures)**

The catch at size is calculated by summing the length compositions of each landing raised to the number of fish in the respective landing.

The length bin which was used for the input data of SS2 (Anonymous 2007) was adopted for this analysis.

**II Procedures used in past studies (referred as “former” in the Figure)**

The catch at size is calculated by just combining all measured individuals and then raised to the total number of fish landed at the Sakai-Minato Port

### 3) The structure of bootstrap

The confidence intervals were estimated by percentile methods of bootstrapping

(Davison & Hinkley 1997). The bootstrap replicates were drawn from the actual sampling structure; i.e. two-stage re-sampling method:

1. Landings are re-sampled without replacement while keeping the original number of landings for each year.
2. Length data in every landing are re-sampled with replacements.

The trials of bootstrapping were repeated 1000 times. The confidence intervals of catch at size were obtained by percentile method through 1000 bootstrap runs.

**Result and Discussion**

Only result for 2010 is shown in this paper. Catch at size for other years are the same as those presented by Kanaiwa et al. (2011). In 2010, new estimating procedure resulted in more individuals of smaller size than the result by the former method and this trend has been demonstrated for years since 2003 (Fig. 1 and see Fig. 1 in Kanaiwa et al. 2011). Larger variances are observed on larger individuals (Fig. 2) compared with estimated variances by assumption of multinomial distribution. In Sakai-minato, for almost all landing there were some length measurement and it is still continued so this estimated length distribution can be treated as catch at size. In table 2, the estimated catch at size and effective sample size (Shibano et al. 2008) for each year are provided and it is recommended to use them for next stock assessment.

**References**

Kanaiwa. M., A. Shibano and Y. Takeuchi, Estimation of length distribution for landing data of Pacific Blue-Fin tuna in Sakai-minato port. ISC/11-1/PBFWG/04

Shibano, A., M. Kanaiwa, R. Uji, T. Shimura, and Y. Takeuchi. 2008. Assessing the precision of length-frequency estimates with consideration of finite population sampling by using landing data in Sakai-Minato Port. ISC/08-2/PBFWG/06

Davison, A. C. and D. V. Hinkley. 1997. Bootstrap method and their application. Cambridge University Press. Cambridge, UK, 202 p.

Table 1 The total numbers of main vessels, main vessels with length measurements data, landings, landings with length measurements data, catch amount in terms of individuals, sample size and sample coverage rate to catch (i.e. sample size divided by catch) for each year. Values regarding sample were calculated from data used in this study.

| Year | Vessel | Vessel with length data | Landing | Landing with length data | Catch | Sample size | Coverage (%) |
|---|---|---|---|---|---|---|---|
| 1987 | 1 | 1 | 2 | 2 | 1419 | 791 | 55.74 |
| 1988 | 5 | 5 | 10 | 10 | 3539 | 2006 | 56.68 |
| 1989 | 3 | 3 | 4 | 4 | 2395 | 1166 | 48.68 |
| 1990 | - | - | - | - | - | - | - |
| 1991 | 4 | 4 | 7 | 7 | 2024 | 1300 | 64.23 |
| 1992 | 4 | 4 | 6 | 6 | 2913 | 2220 | 76.21 |
| 1993 | 2 | 2 | 3 | 3 | 1801 | 1284 | 71.29 |
| 1994 | 2 | 2 | 4 | 4 | 9608 | 1935 | 20.14 |
| 1995 | 3 | 3 | 3 | 3 | 3508 | 1035 | 29.50 |
| 1996 | 6 | 6 | 6 | 6 | 4238 | 2772 | 65.41 |
| 1997 | 5 | 5 | 9 | 8 | 3955 | 1902 | 48.09 |
| 1998 | 4 | 4 | 8 | 7 | 4265 | 2240 | 52.52 |
| 1999 | 4 | 4 | 8 | 8 | 6129 | 3333 | 54.38 |
| 2000 | 5 | 5 | 10 | 10 | 7548 | 3775 | 50.01 |
| 2001 | 5 | 5 | 5 | 5 | 2193 | 1365 | 62.24 |
| 2002 | 5 | 5 | 13 | 13 | 5976 | 3190 | 53.38 |
| 2003 | 4 | 4 | 14 | 14 | 6649 | 2895 | 43.54 |
| 2004 | 8 | 8 | 36 | 36 | 27102 | 9122 | 33.66 |
| 2005 | 11 | 11 | 55 | 55 | 47120 | 15626 | 33.16 |
| 2006 | 10 | 10 | 50 | 50 | 19418 | 10814 | 55.69 |
| 2007 | 9 | 9 | 49 | 48 | 41911 | 17073 | 40.74 |
| 2008 | 9 | 9 | 60 | 58 | 44500 | 19961 | 44.86 |
| 2009 | 9 | 9 | 31 | 28 | 16513 | 2328 | 14.10 |
| 2010 | 8 | 8 | 27 | 26 | 18409 | 3325 | 18.06 |

Table 2 Estimated catch at size and effective sample size.

| Year | meff | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 62 | 66 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 24.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 17.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 24.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1991 | 5.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 4.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1993 | 2.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 137.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 14.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 754.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1997 | 46.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 5.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 15.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 31.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 127.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 22.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 19.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 27.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 102.41 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 82.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 45.74 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 71.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 17.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 45.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| 74 | 78 | 82 | 86 | 90 | 94 | 98 | 102 | 106 | 110 | 116 | 122 | 128 | 134 | 140 | 146 | 152 | 158 | 164 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.05 | 241.06 | 305.68 | 108.73 | 181.79 | 315.51 | 179.99 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.41 | 12.83 | 25.66 | 41.69 | 9.62 | 6.41 | 41.97 | 192.45 | 220.09 | 156.88 | 372.15 | 813.76 | 403.61 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.71 | 10.51 | 18.44 | 100.19 | 210.08 | 129.59 | 18.43 | 6.51 | 67.22 | 167.70 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.00 | 0.00 | 0.00 | 0.00 | 2.09 | 0.00 | 6.28 | 1.26 | 0.00 | 43.07 | 226.47 | 335.40 | 85.20 | 69.50 | 144.53 | 98.15 | 32.83 | 62.63 | 75.53 |
| 0.00 | 1.38 | 2.77 | 0.00 | 2.77 | 9.69 | 50.88 | 138.69 | 718.86 | 745.36 | 29.81 | 5.96 | 27.89 | 107.97 | 98.61 | 104.03 | 147.05 | 129.26 | 89.81 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.66 | 195.17 | 686.81 | 104.37 | 7.67 | 40.81 | 223.26 | 309.68 | 105.63 | 8.40 | 30.01 | 24.01 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.27 | 0.00 | 37.31 | 254.75 | 1540.24 | 4278.16 | 3062.32 | 369.06 | 25.39 | 13.68 | 2.45 | 4.90 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.75 | 1.75 | 21.01 | 66.55 | 28.01 | 5.25 | 34.16 | 112.78 | 684.17 | 1200.81 | 420.39 | 126.85 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.88 | 28.43 | 95.58 | 237.68 | 110.04 | 93.02 | 567.47 | 1570.95 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.27 | 0.00 | 2.27 | 0.00 | 0.00 | 14.07 | 25.09 | 5.97 | 21.75 | 125.14 | 130.42 | 96.84 |
| 0.00 | 0.00 | 0.00 | 2.58 | 2.97 | 1.02 | 5.95 | 12.10 | 18.52 | 189.50 | 507.48 | 896.96 | 837.09 | 414.02 | 114.79 | 48.47 | 11.37 | 1.95 | 16.94 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.55 | 0.00 | 1.55 | 13.26 | 43.76 | 36.19 | 45.10 | 267.68 | 1386.62 | 2447.00 | 1200.63 | 172.58 | 11.16 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.65 | 10.65 | 43.93 | 122.58 | 93.34 | 70.11 | 79.72 | 217.80 | 980.10 | 2556.73 | 1964.57 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.91 | 16.95 | 12.69 | 11.56 | 38.43 | 84.97 | 65.67 | 60.80 | 40.39 | 156.61 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.12 | 8.23 | 25.83 | 138.23 | 107.72 | 88.47 | 155.30 | 200.95 | 271.65 | 192.62 | 155.93 | 196.05 | 316.99 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.00 | 149.44 | 643.28 | 1106.06 | 684.73 | 761.08 | 652.77 | 500.71 | 520.93 | 304.41 | 100.60 |
| 0.00 | 0.00 | 0.00 | 0.00 | 2.81 | 0.00 | 16.83 | 171.17 | 900.77 | 6740.41 | 6821.39 | 823.70 | 260.25 | 488.87 | 1095.06 | 1974.24 | 2204.66 | 1335.88 | 715.37 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.98 | 7.54 | 40.07 | 479.71 | 2369.02 | 3239.21 | 4392.90 | 10575.39 | 12395.07 | 3495.65 | 713.85 | 761.36 | 953.40 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.59 | 313.38 | 834.99 | 920.88 | 942.39 | 1452.57 | 2549.70 | 3101.53 | 2717.60 | 1596.78 |
| 0.00 | 15.80 | 49.21 | 72.34 | 236.73 | 563.89 | 570.00 | 509.70 | 664.49 | 4197.95 | 16014.81 | 9878.09 | 860.90 | 147.51 | 572.50 | 1847.91 | 1797.06 | 630.29 | 268.55 |
| 0.00 | 14.32 | 60.58 | 98.58 | 138.15 | 219.61 | 265.06 | 336.01 | 569.04 | 3605.10 | 10362.37 | 5026.95 | 2397.25 | 3890.30 | 8092.15 | 4656.62 | 729.10 | 319.68 | 439.08 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 78.40 | 7.26 | 26.86 | 419.30 | 3208.92 | 5516.91 | 1923.18 | 343.41 | 727.88 | 1114.13 | 648.79 | 390.42 | 164.52 |
| 0.00 | 0.00 | 0.00 | 5.39 | 10.77 | 17.85 | 79.40 | 411.79 | 1533.30 | 7027.10 | 3626.35 | 324.53 | 30.18 | 51.30 | 432.53 | 976.31 | 497.35 | 143.88 | 144.83 |

| 170 | 176 | 182 | 188 | 194 | 200 | 206 | 212 | 218 | 224 | 230 | 236 | 242 | 248 | 254 | 260 | 266 | 272 | 278 | 284 | 290 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 37.82 | 10.77 | 6.48 | 0.00 | 0.00 | 2.17 | 1.08 | 2.17 | 0.00 | 2.17 | 3.25 | 1.08 | 0.00 | 1.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 237.50 | 257.98 | 205.02 | 74.24 | 20.43 | 6.61 | 10.70 | 56.89 | 59.90 | 64.00 | 78.78 | 74.91 | 50.10 | 27.12 | 7.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 196.98 | 212.85 | 329.48 | 423.64 | 171.56 | 87.28 | 65.81 | 33.88 | 5.40 | 6.79 | 16.36 | 26.52 | 30.96 | 19.52 | 8.37 | 14.79 | 5.13 | 1.28 | 0.00 | 0.00 | 0.00 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 155.39 | 112.40 | 79.47 | 82.54 | 99.18 | 98.98 | 64.82 | 40.76 | 26.06 | 7.73 | 10.81 | 8.82 | 21.60 | 14.26 | 10.25 | 1.26 | 0.00 | 1.26 | 0.00 | 0.00 | 0.00 |
| 104.74 | 141.72 | 82.39 | 52.45 | 34.61 | 31.53 | 23.23 | 11.96 | 4.13 | 3.43 | 1.99 | 0.00 | 2.29 | 1.18 | 1.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9.60 | 4.80 | 8.40 | 4.80 | 6.00 | 1.20 | 1.20 | 0.00 | 0.00 | 1.20 | 0.00 | 1.20 | 1.20 | 0.00 | 1.20 | 1.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 174.23 | 200.65 | 128.03 | 111.29 | 80.28 | 43.19 | 10.80 | 15.50 | 21.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1017.49 | 212.76 | 130.98 | 87.44 | 30.96 | 17.27 | 8.94 | 5.94 | 4.90 | 2.45 | 2.20 | 0.00 | 2.23 | 1.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 136.40 | 840.24 | 1487.59 | 580.44 | 99.12 | 33.23 | 28.70 | 14.48 | 5.59 | 4.98 | 1.35 | 5.53 | 0.00 | 2.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29.87 | 38.48 | 63.90 | 192.56 | 268.04 | 113.33 | 37.88 | 9.78 | 6.52 | 3.26 | 1.63 | 0.00 | 0.00 | 0.00 | 1.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.71 | 11.11 | 16.59 | 21.70 | 45.14 | 129.71 | 145.00 | 97.50 | 17.34 | 7.38 | 0.00 | 0.00 | 1.46 | 0.00 | 0.00 | 0.00 | 1.46 | 0.00 | 0.00 | 0.00 | 0.00 |
| 468.75 | 58.85 | 13.95 | 18.63 | 44.53 | 77.12 | 151.27 | 280.24 | 227.79 | 15.96 | 21.17 | 0.00 | 16.88 | 1.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 477.97 | 646.27 | 370.91 | 80.12 | 13.09 | 9.60 | 9.30 | 32.66 | 23.20 | 22.79 | 3.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 258.73 | 348.09 | 785.00 | 1277.17 | 857.83 | 248.04 | 57.62 | 42.85 | 90.97 | 96.15 | 36.18 | 5.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 76.61 | 65.70 | 140.88 | 102.29 | 131.56 | 211.07 | 241.20 | 110.86 | 42.32 | 37.81 | 28.70 | 8.75 | 3.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 673.20 | 395.52 | 191.06 | 219.46 | 252.49 | 292.61 | 426.12 | 595.04 | 305.03 | 109.75 | 32.77 | 26.85 | 0.99 | 5.03 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1597.94 | 2004.31 | 1296.00 | 641.42 | 334.34 | 246.85 | 288.60 | 374.04 | 421.75 | 294.49 | 123.94 | 43.48 | 3.43 | 4.18 | 0.00 | 0.00 | 0.00 | 0.00 | 1.78 | 0.00 | 0.00 |
| 447.23 | 425.04 | 761.41 | 1079.43 | 991.09 | 463.11 | 177.34 | 165.37 | 147.85 | 171.82 | 80.88 | 34.95 | 7.22 | 0.00 | 7.85 | 2.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 321.30 | 313.47 | 135.45 | 123.95 | 254.25 | 391.65 | 303.84 | 221.13 | 218.96 | 147.07 | 111.56 | 49.10 | 11.41 | 15.67 | 8.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 400.85 | 251.09 | 131.41 | 119.19 | 92.16 | 124.50 | 243.33 | 283.44 | 228.97 | 178.90 | 152.95 | 129.66 | 12.43 | 1.44 | 0.00 | 4.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 132.80 | 70.14 | 105.00 | 106.95 | 117.19 | 96.40 | 125.27 | 203.58 | 248.50 | 254.75 | 184.40 | 130.49 | 31.38 | 3.13 | 4.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 123.43 | 86.49 | 49.58 | 21.97 | 17.40 | 9.65 | 9.01 | 7.00 | 3.00 | 9.05 | 8.20 | 9.20 | 3.01 | 4.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

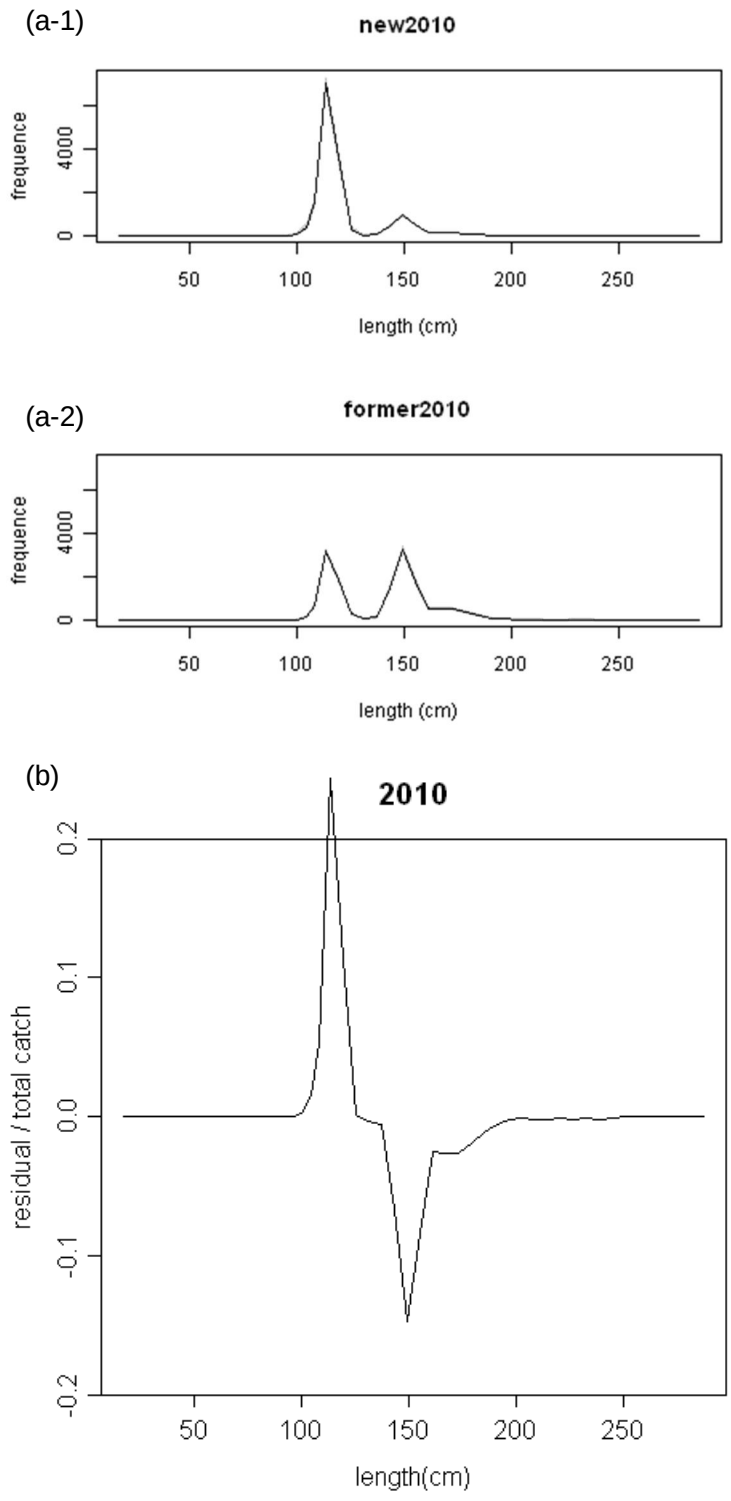


Fig. 1 (a) black line shows median of catch at size and gray polygon shows 95% interval for new and former aggregation method. (b) line shows residual between two aggregation methods divided by total catch.

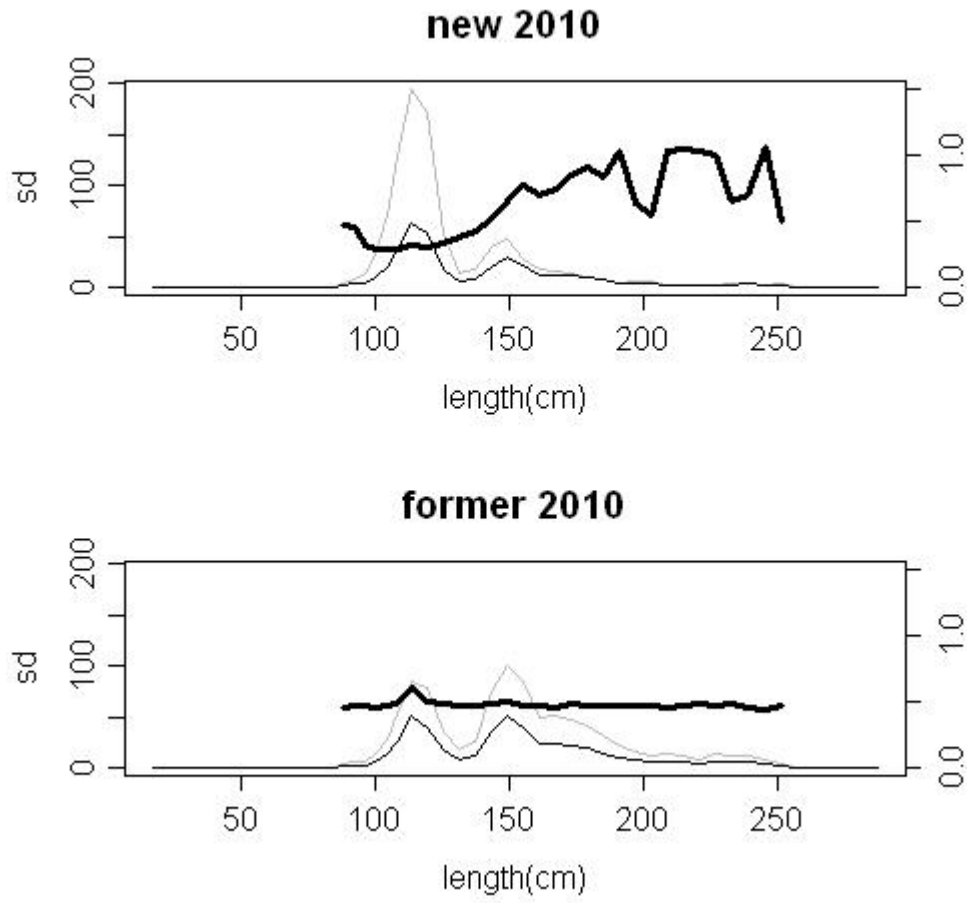


Fig. 2 estimated standard deviations by bootstrap (gray line) and by assumption of multinomial distribution (thin black line) and there ratio (wide black line = thin black line / gray line)