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Characteristic of size frequency data of Pacific Bluefin tuna from commercial fishery in the Eastern Pacific Ocean in recent years

Shuhei Uematsu, Kazuhiro Oshima, Shigehide Iwata and Yukio Takeuchi

National Research Institute of Far Seas Fisheries 5-7-1

Shimizu-orido, Shizuoka 424-8633, JAPAN

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Summary

This paper reviewed size frequency data of PBF in the Eastern Pacific Ocean (EPO), relating to increasing size of fish in the catch, based on the trans-Pacific migration and changes of fish size sampled. Two runs that were presented as the results of Stock Synthesis 3 model (SS3) analysis at previous ISC Pacific bluefin tuna Working Group Workshop (WG) were examined in relation to the findings from these review. Results are: there is no evidence of an increase in size of PBF in the catch of EPO fishery in recent years except for the period from 1993 to 2004, during which period size of PBF in catches were different. Run 2 estimated the PBF size larger than observed size in recent years.

Introduction

The ISC Pacific bluefin tuna WG meeting for stock assessment was held in May-June 2012. At this meeting, there were a lot of discussions on model settings of SS3. Two typical model settings were presented at the end. The one was a setting (called as “run2”) supported by the US and the other was a setting (called as “run3”) supported by Japan. Figure 1 shows historical changes in length frequency distributions for F11 (EPO commercial fishery). There was an inconsistency in the length frequency distributions between two periods; a period of 1990s to 2003 and the rest of the time. This inconsistency caused the model misfit. At that WG, discussions centered if this series of data should be (entirely or partially) eliminated, down weighted, and/or divided by time blocks, to reduce this misfit. Time block is SS3’s procedure which separates time series into two periods each of which has different size frequencies and thus size selectivities.

Model settings of runs 2 and 3 were very close. In both of the run 2 and rnu3, length frequency distributions of F11 were down weighted. Difference between run2 and run3 was whether or not to incorporate time block for F11 (Eastern Pacific Ocean Commercial fishery) and F3 (Tuna Purse seine in the Sea of Japan).

This document provides characteristic of length frequency distributions for F11, including changes in effective sample size at age calculated from the number of sets and trans-Pacific migration of PBF.

Characteristic of F11 length frequency distributions

Figure 2 shows quarterly changes of effective sample size at age calculated by multiplying sample size by length frequency values used in SS3 , and age is calculated from the length frequency data used as input to the model, the length frequencies were converted into age by growth formula used in SS3.

The results indicated very high proportions in sample size of age 3 to 5 fish from 1993 to 2004. During this period, major historical changes had occurred in EPO fishery. The main fishing country had changed from US to Mexico and Mexican PBF farming started in 2002 (daSilva 2007, Compearn 2012). However, except for this period, majority of catches were consisted of ages 1 and 2 fish. At the May-June 2012 PBF WG, an extensive discussion was held on the possibility of increasing size of fish in the catch in EPO in recent years. However, size of fish caught in EPO after 2004 were not as large as those during this period (1990s to 2004). That was also suggested by the data estimated from catch document system (CDS) reported by Oshima and Miyake (2012) (Fig. 4).

Moreover, if fish size had been increased considerably, there must have been some changes in the trans-Pacific migration rate at age. Generally, PBF spawning ground is known to be restricted to the western Pacific, and a fraction of the juvenile migrates to the EPO (Itoh et al., 2003). Table 1 gives annual catches by Japanese small purse seine fishery (F2) and EPO purse seine fishery (F11). Oshima et al. (2012) reported that strong recruitments have occurred in 1990, 1994, 2001, 2004, 2007 and 2010 as indicated in Table 1 (marked in yellow). This table shows that these strong year classes appeared a year later in the Japanese fishery (F2) and two years later in the EPO fishery (F11). The exceptions were 2001 year class which did not show up in F2 but appeared three years later in EPO and 2007 showed up also three years later in the EPO. These suggest that age specific migration of these strong year classes have not changed since 1990 and there is no evidence that size of fish captured in the EPO had increased, at least due to a change in trans-Pacific migration pattern.

Review of result associated with F11estimated by runs 2 and 3

The inconsistencies in the length frequency distributions between the period of 1990s to early 2000s and the rest of the series caused the model misfit. Hence, in the run2, the time block which separates three time series (before 1996, 1996 to 2000 and 2001 to 2010) was applied for F11, besides the entire F11’s length frequency distributions were down-weighted in order to reduce these inconsistencies. On the other hand, in run 3, the time block for F11 was not incorporated, because using time block together with down weighting caused the model misfit for the data after 2004. In addition, run 2 settings which using time block with down weighting is unreasonable because this method estimates the size selectivity ignoring length frequency distributions. Figure 4 compares selectivities estimated by the model with observed size frequencies. The run 2 estimated size shifted toward 100 to 150 cm since 1996 to 2010. In contrast, run 3 did not produced such shift. These differences would cause the significant difference in average weight of PBF in this area.

Figure 5 shows yearly changes of average weight of PBF in F11, calculated in a quotient SS3. Run3 estimated that average weight increased from 1990 and peaked in 1994 (25kg). After that, it dropped to 10 kg to 15 kg. On the other hand, run 2 estimated that average weight increased form 1996 and peaked in 1998 (30 kg). After that, it fluctuated between 20 kg and 30 kg which were twice as heavy as those estimated by the run 3. There is a significant misfit as the estimated average weight didn’t decrease after 2004 while observed size of fish in catch decreased (in input data).

Figure 6 shows F at age by fleet estimated through run 2 and run 3. Although there were no differences in estimated F at age for 6 and older fish between run2 and run3, F’s at age 5 or younger fish are different between run 2 and run 3. F at ages 3-5 from run 2 became higher than those from run 3.These results were caused by adopting time block in F11 in run 2, which shifted the size selectivity towards larger fish (Fig. 2), resulting in increasing F at age 3-5. Therefore, increasing size of fish in the catch estimated by the run2 for resent years caused misfit after 2004.

Conclusion

The length frequency data used as input to SS3 suggested the size of fish captured were larger for 1993 to 2004 from the rest of the years in the series. Therefore, it is very important how to deal with the data during this period. The first step to take is to evaluate the reliability of size data during this period (specifically years of 1993-2004) and examine if there were no changes in sampling procedures, sample sizes and sample randomness by checking number of vessel: landing, vessel with landing data, landing with length data and coverage. SS3 setting can be decided only after the reliability of size data is verified. .

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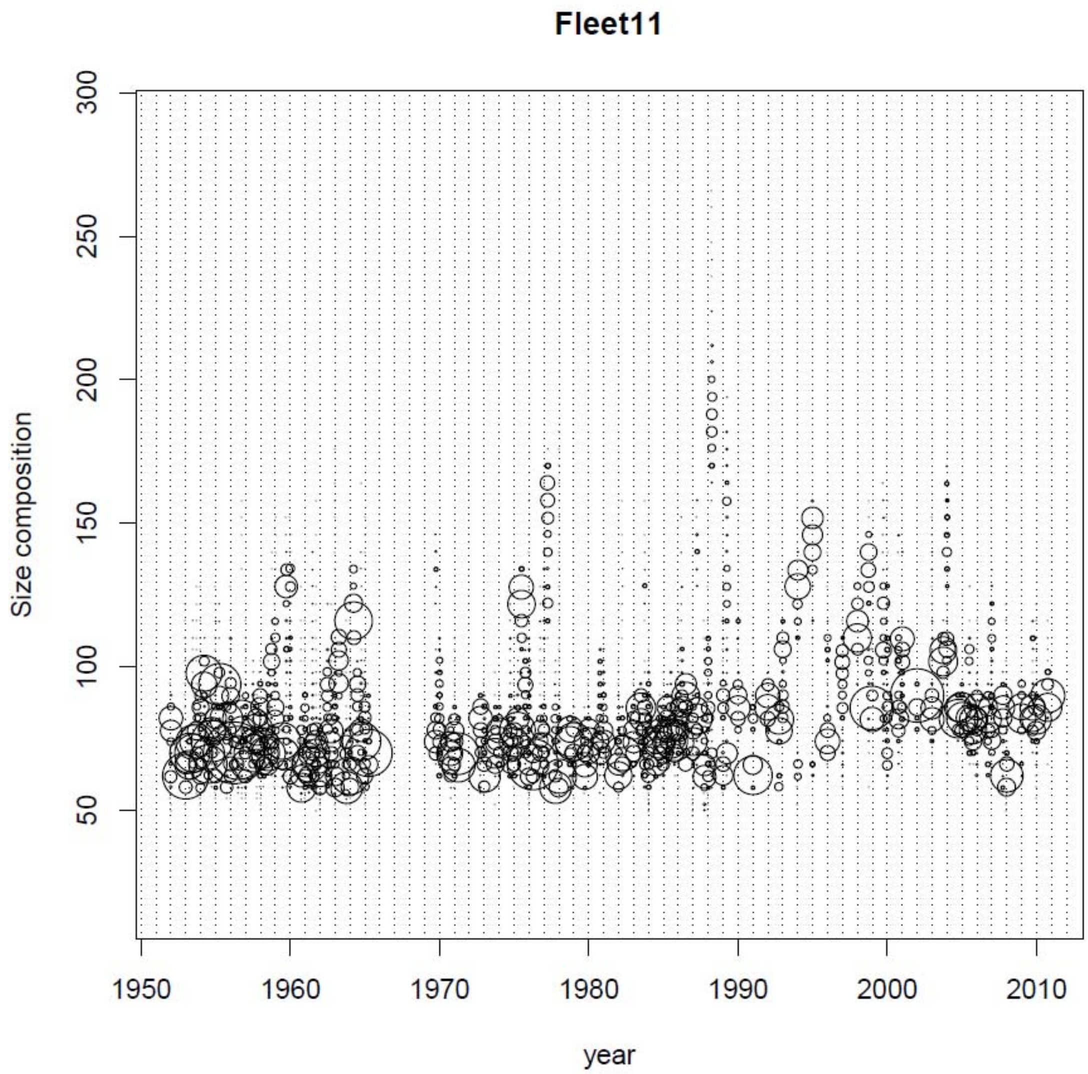
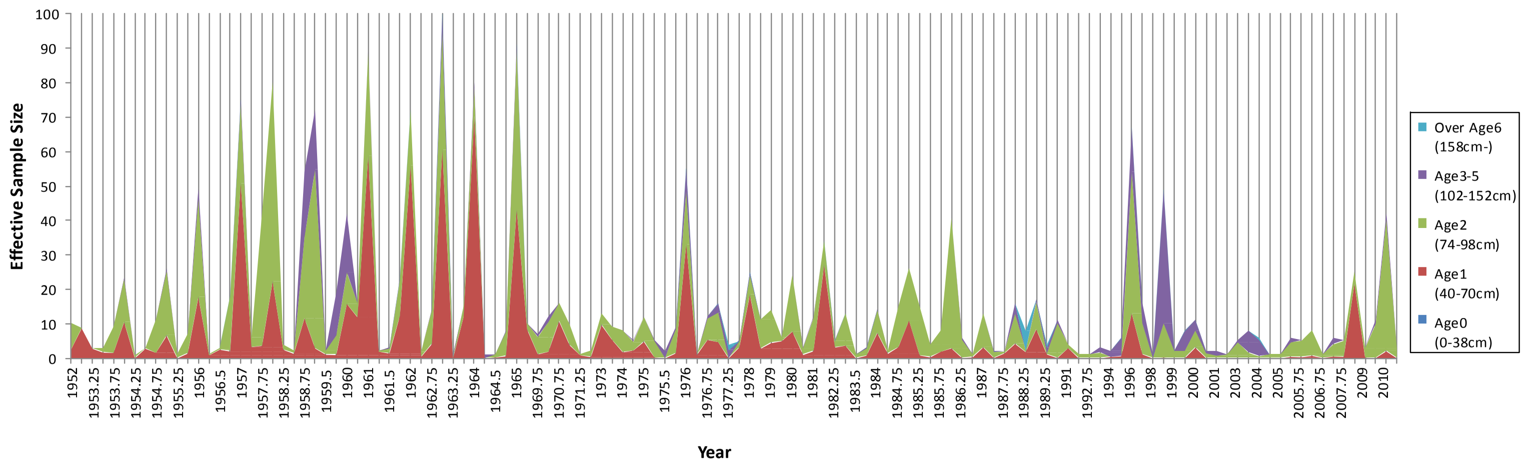


Fig. 1. Historical changes in length frequency distributions of PBF for Eastern Pacific Ocean (EPO) fishery.



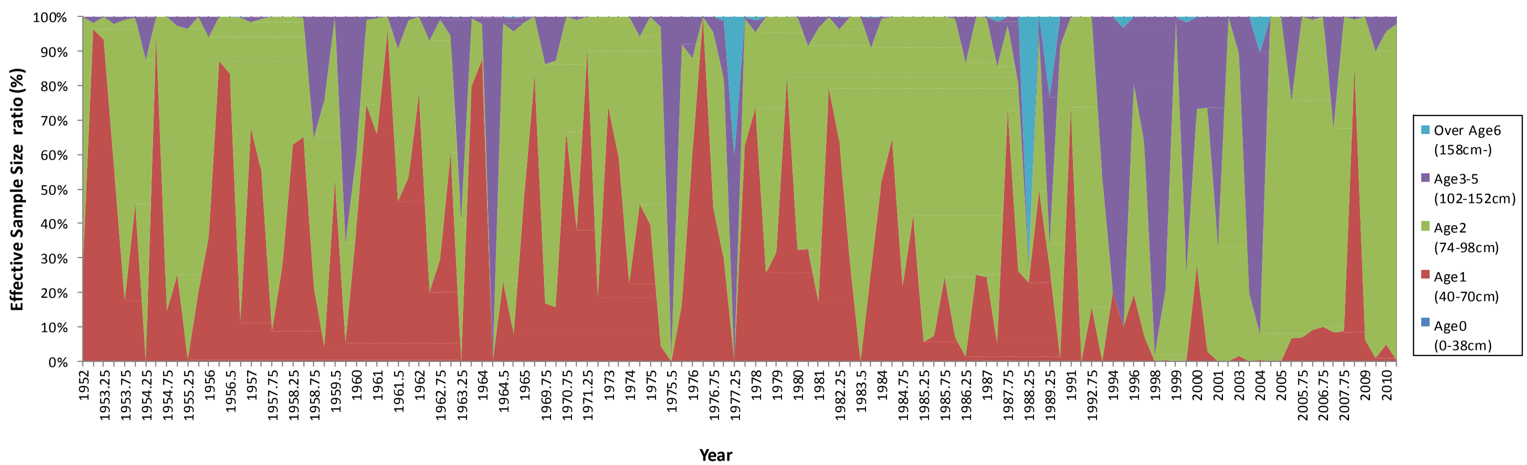


Fig. 2. Effective sample size and this ratio of each size PBF in EPO commercial fishery Upper figure indicates Effective sample size. Lower figure indicates Effective sample size ratio. Blue color indicates age 0, red color indicates age 1, green color indicates age 2, purple color indicates age 3 to age 5 and sky blue color indicate over age 6

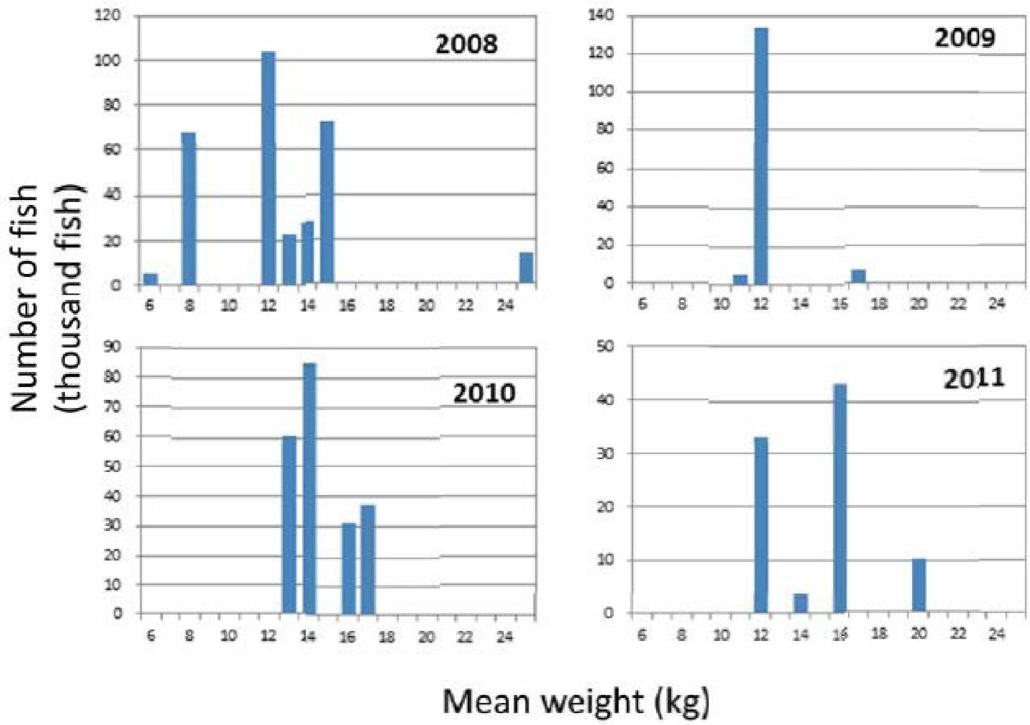


Fig. 3. Number of fish with average size classes caught by Mexican purse seine fishery reported by Oshima and Miyake 2012.

Table1. Catch table of Japanese small purse seine fishery and EPO purse seine fishery. Yellow marked indicate the strong recruitment years.

Year	Western Pacific States	Eastern Pacific States		
	Japan	US	Mexico	
	Small Purse Seine	Purse Seine	Purse Seine	Sub Total
1988	22	923	447	1,370
1989	113	1,046	57	1,103
1990	155	1,380	50	1,430
1991	**5,472**	410	9	419
1992	2,907	**1,928**	0	**1,928**
1993	1,444	580		580
1994	786	906	63	969
1995	**13,575**	657	11	668
1996	2,104	**4,639**	**3,700**	**8,339**
1997	7,015	2,240	367	2,607
1998	2,676	1,771	1	1,772
1999	4,554	184	2,369	2,553
2000	8,293	693	3,019	3,712
2001	4,481	292	863	1,155
2002	4,981	50	1,708	1,758
2003	4,812	22	3,211	3,233
2004	3,323		**8,880**	**8,880**
2005	**8,783**	201	4,542	4,743
2006	5,236		**9,928**	**9,928**
2007	3,875	42	4,147	4,189
2008	**7,192**		4,392	4,392
2009	5,950	410	3,019	3,429
2010	2,620		**7,745**	**7,745**
2011	**6,137**	99	2,730	2,829

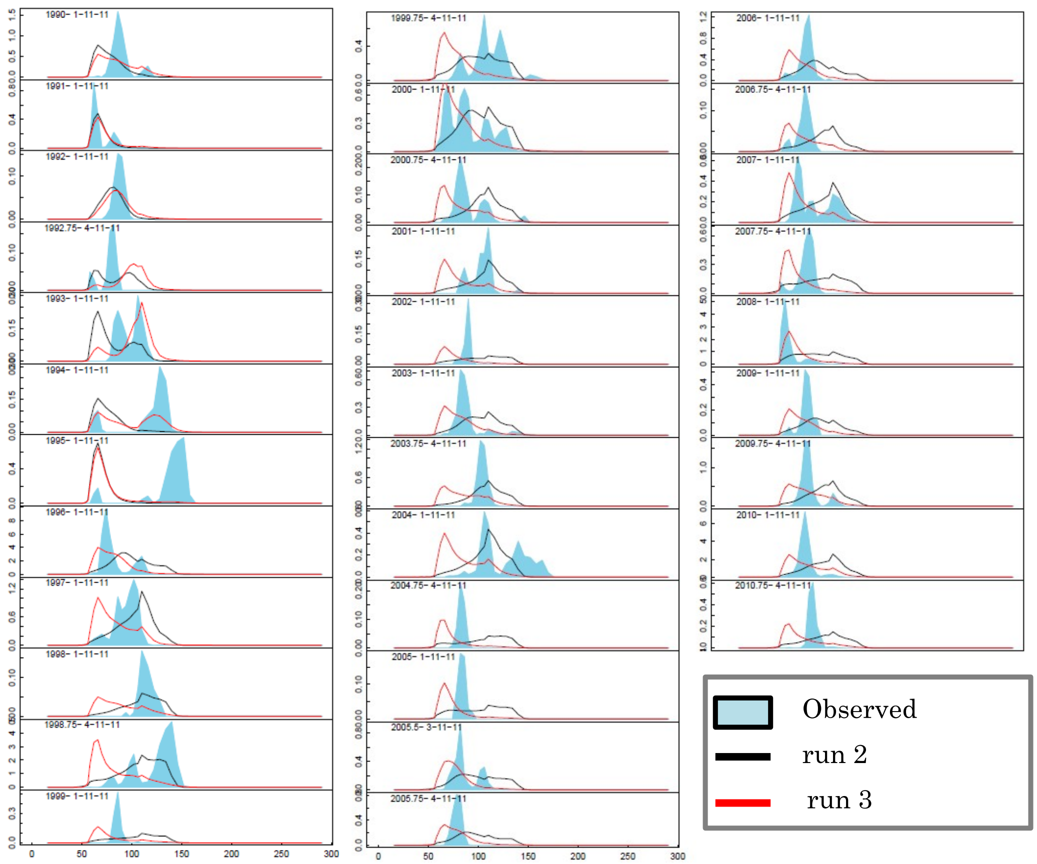


Fig. 4. Comparison of length frequency distributions between run2 and run 3. Blue polygon indicates the obserbed size, black line indicates the expected size of run 2, red line indicates the expected size of run 3.

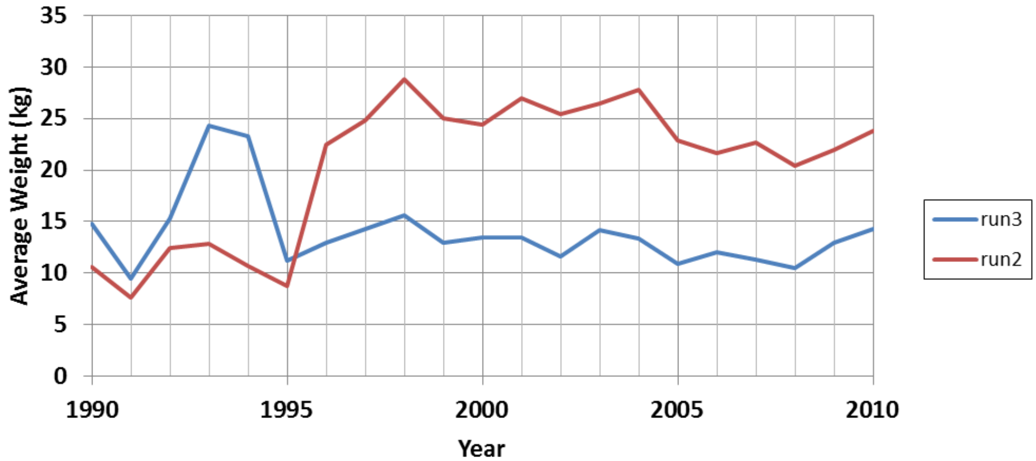


Fig. 5. Comparison of average weight of bluefin tun for the EPO commercial fihery. Blue and red lines indicates F at age estimated through runs 3 and 2, respectively.

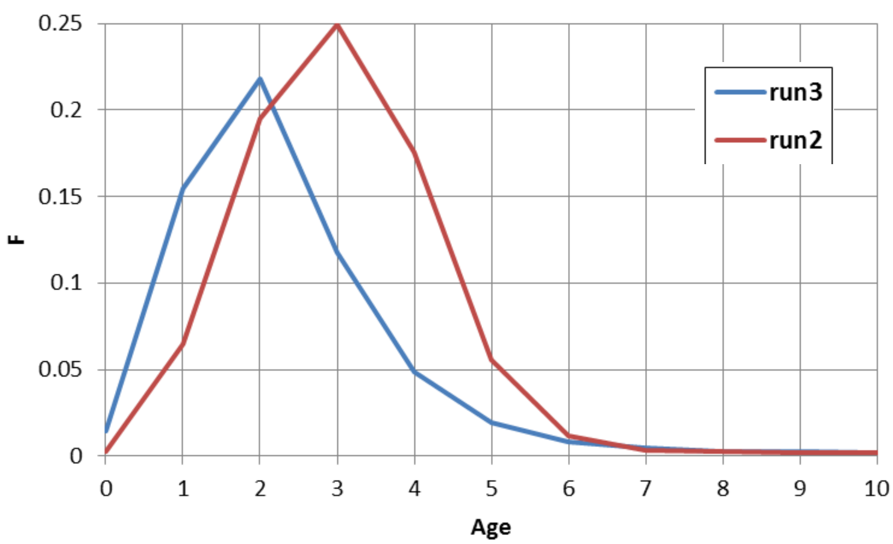


Fig. 6. F at age for the EPO commercial fihery since 1990. Blue and red lines indicates F at age estimated through runs 3 and 2, respectively.