CCSBT-ESC/1809/09
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Update on the length and age distribution of southern bluefin tuna (SBT) in the Indonesian longline catch

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Abstract

This paper updates previous analyses of southern bluefin tuna (SBT) length and age data from the Indonesian longline fishery operating out of the port of Benoa, Bali. Age frequency data are presented up to the 2016/17 season and length frequency data up to the 2017/18 season. The collection of SBT length data and otoliths was conducted using the existing Indonesia-CSIRO monitoring program for the longline fishery. A total 1,500 SBT ranging from 134-209 cm fork length (FL) were sampled in 2017/18. Analysis of the length and age data from the Indonesian longline fishery shows that since the 2012/13 spawning season, the proportion of small/young SBT (<160 cm FL/12 years old) in the catch landed in Bali increased substantially compared to previous years. The data indicates that the mode of small fish has progressed through the fishery over the past 6 years, which is also observed in the New Zealand charter fleet catch data. Investigations have shown that SBT caught by Indonesia have occurred in CCSBT statistical areas 1, 2 and 8, so it is plausible that the small/young SBT in the monitoring series were caught south of the SBT spawning ground. At this stage it is not possible to identify the catch location of individual SBT sampled as part of the regular the catch monitoring program. We recommend that the CCSBT consider a study in the Scientific Research Plan (SRP) to resolve issue of where the small SBT are being caught (to the extent possible) and refine/update the monitoring program, given the central importance of the stock assessment and close-kin mark recapture.

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Introduction

The southern bluefin tuna (SBT) spawning ground is located in an area between Indonesia and the northwest cost of Australia, where spawning occurs during September to April each year (Farley and Davis 1998). SBT in the Indonesian fishery is categorized as a bycatch of the longline vessels, which mainly target bigeye and yellowfin tuna. Obtaining an accurate estimate of the size and age composition of SBT landed by the Indonesian longline fishery is vital for population modelling and stock assessments, and to monitor changes in the spawning population over time. The Indonesian monitoring data are also used to estimate adult abundance using close-kin mark recapture (CKMR) methods. It is assumed that all individuals analysed from the Indonesian monitoring program are mature and spawning in the year they are sampled. Hence, it is important to know the catch location of all individuals sampled as the inclusion of non-spawning fish can affect the abundance estimates.

The now 25 years of monitoring the size and age structure of the SBT spawning population program was first established in 1993 through a series of collaborations between Indonesia's marine fisheries research institutes[3] within the Ministry of Marine Affairs and Fisheries (MMAF) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Farley *et al.* 2017). The main port monitored for SBT was the Benoa Fishing Port in Bali. In 2002, the scope of research collaboration expanded to include all tuna species (yellowfin and bigeye tuna, and albacore) and related species (billfish and other bycatch species) landed by the longline fleet. This occurred with the addition of new collaboration partners, the Indian Ocean Tuna Commission (IOTC) and Japan's Overseas Fishery Cooperation Foundation (OFCF) (Farley *et al.* 2014). The monitoring locations increased to three fishing ports, including Muara Baru (Jakarta), and Cilacap (south cost Central Java) in addition to Benoa (Farley *et al.* 2007). The majority of targeted SBT sampling, however, still occurs at Benoa, as this is the port where the majority of Indonesian caught SBT are landed.

[3] Indonesian collaborating institutions, in chronological order: Central Research Institute for Fisheries Indonesia (CRIFI), Research Institute for Marine Fisheries (RIMF), Research Centre for Capture Fisheries (RCCF), Research Centre for Fisheries Management and Conservation (RCFMC), and currently Centre for Fisheries Research (CFR) in Jakarta, and Research Institute for Tuna Fisheries (RITF) in Bali.

The monitoring program samples otoliths from the 'reject' SBT (graded as non-export quality) (Farley *et al.* 2007). SBT are graded on flesh quality which is dependent on handling and/or condition. There is no selection based on length (Davis *et al.* 2001).

In 2013, the Extended Scientific Committee (ESC) developed a new Scientific Research Plan (SRP) for SBT. The SRP was reviewed in 2014 and again in 2015. Several items were identified as high priority in the 2016 work plan including the ageing of Indonesian SBT otoliths and continued collection and archiving of tissue samples for close-kin genetics (see paper CCSBT-ESC/1708/09). This paper will provide an update on the length and age distribution given by

Methods

Otolith collection 2017/18

The SBT otolith sample collection in Indonesia was based at the Benoa Fishing port in the 2017/18 spawning season, maintaining the existing Indonesia-CSIRO monitoring program for the longline fishery (Proctor *et al.* 2006). A total 1,500 SBT ranging from 134-209 cm fork length (FL) (Table 1) were sampled. The data collected including the fish lengths and otoliths for ageing purposes. The otolith sets from each fish were stored in individually labelled vials following cleaning and drying. All samples were subsequently transported to CSIRO in Hobart. In order to complete the SBT length frequency analysis, RITF provided the length data collected in the daily monitoring program.

Indonesian SBT ageing 2016/18

The process of selecting 500 otoliths for ageing from a total of 1,500 otoliths samples obtained during the spawning season 2016/17 season (Table 1) was performed at CSIRO. The selection of otoliths is based on stratification by the length of the fish to obtain a sufficient number of age estimates for all length classes, including those with small sample sizes (Farley *et al.* 2007).

The SBT otolith ageing process (sectioning and reading) is conducted by a private research company in Australia, Fish Ageing Services Pty Ltd (FAS). The otolith processor and reader in this company has more than 10 years' experience in reading SBT otoliths, (Farley *et al.* 2014) and is the primary reader of the SBT otoliths. The selected otoliths are sent to FAS for the process of sectioning and reading, using the techniques described in Anonymous (2002). The otoliths were read twice by the primary otolith reader (FAS) and a final age estimate was given to 472 fish. During the process of reading the age from otoliths, FAS does not refer to the fish size information, the date of capture, or the previous reading. The precision of the readings was assessed using the coefficient of variation (CV) (Chang 1982).

Table 1. Number of length measurements and age estimates for SBT by spawning season.

SPAWNING SEASON	FORK LENGTH (CM) *N*	MEAN	RANGE	OTOLITHS *N*	AGE (YEARS) *N*[1]	MEAN
1993/94	676	188.1	161-207	0	0	NA
1994/95	1610	180.7	147-221	549	486	21.2
1995/96	1107	178.9	149-216	225	50	NA
1996/97	1615	179.6	146-218	602	475	20.8
1997/98	1577	176.4	143-214	519	485	19.8
1998/99	936	179.9	145-210	660	474	20.7
1999/00	786	177.4	150-216	533	498	19.5
2000/01	762	174.2	140-210	720	481	16.9
2001/02	821	169.5	147-223	715	489	14.8
2002/03	1385	166.8	134-229	1502	488	14.5
2003/04	1279	168.5	145-215	1283	494	15.2
2004/05	1580	170.1	89-205	1523	493	15.3
2005/06	1182	169.2	122-201	1180	486	14.4
2006/07	1586	168.3	134-202	1586	491	15.1
2007/08	1693	169.5	145-203	1709	485	16.7
2008/09	1704	171.0	143-219	1697	479	15.6
2009/10	1583	168.5	141-204	1538	488	15.3
2010/11	1015	170.4	142-198	1009	481	16.8
2011/12	864	170.5	136-212	543	*NA*	16.3
2012/13	2051	164.1	131-211	1373	474	14.2
2013/14	1905	161.7	100-210	1637	473	13.8
2014/15	2774	159.9	95-225	1346	482	13.8
2015/16	2925	162.7	119-210	2000	477	13.8
2016/17	1499	163.3	149-180	1499	472	14.8
2017/18[2]	1500	159.8	134-209	1500	0	NA
Total	36418			27448	11120	

[1]A random sub-sample of 500 are selected for ageing, apart from the 2011/12 season where an ALK based on data from the previous two seasons was used.
[2] Preliminary data only.

Results

Length distribution

The length frequency distribution of SBT captured by the Indonesian tuna longline fleet by spawning season is presented in Figure 1. The data for SBT caught south of the spawning ground in 2003/04 to 2006/07 is shown separately because these fish are not considered part of the spawning population (Farley *et al.* 2007).

Andamari *et al.* (2004) explained that in the mid-2000s, at least one fishing company based in Benoa (Processor A) was identified to have diverted their operations to target the SBT south of the spawning ground. Most of the catch landed at Processor A consisted of small fish (<165 cm FL) compared to other processors. SBT of these lengths are consistent with the historic catch data for Japanese fishing vessels operating on the staging ('Oki') fishing ground (inside the CCSBT Area 2) to the south of spawning grounds (Shingu 1981).

Farley *et al.* (2017) reported that since monitoring began, there has been a major change in the size distribution of SBT caught in the spawning area. The SBT captured in the mid and late 1990s was dominated by a size between 165 and 190 cm FL with an average length of ~ 180 cm (Figure 1). The size of SBT then decreased in the early 2000s as fish 155-165 cm FL increased in relative abundance (Figure 2). The average size of captured SBT decreased from 188.1 to 166.8 cm between 1993/94 and 2002/03, and remained between 168.3 and 171.0 cm through 2011/12 (Table 1).

In the 2012/13 spawning season, the length frequency indicates a new mode of very small fish (relative to the historical distribution) between 140 and 155 cm FL in the catch, in addition to the "usual" mode around 160-180 cm FL (Figure 1). The proportion of fish <155 cm was 22.5% compared to levels of 0-12% in previous seasons (Figure 2). This change in the size distribution was reflected in a decrease in the mean size of SBT in the catch (Table 1; Figure 3).

Figure 1 indicates that the mode of small fish has progressed through the fishery moving from ~146 cm in 2012/13 to ~156 cm in 2016/17 season. In 2017/18, this mode is less distinct as it has merged with the second (160-180 cm) mode (Figure 3). The progression of the mode is consistent with the size/age composition data from of the New Zealand charter fleet catch, which showed the same modal progression (Anonymous 2016). This may be the result of fish growth over time after higher recruitment in the mid-2000s.

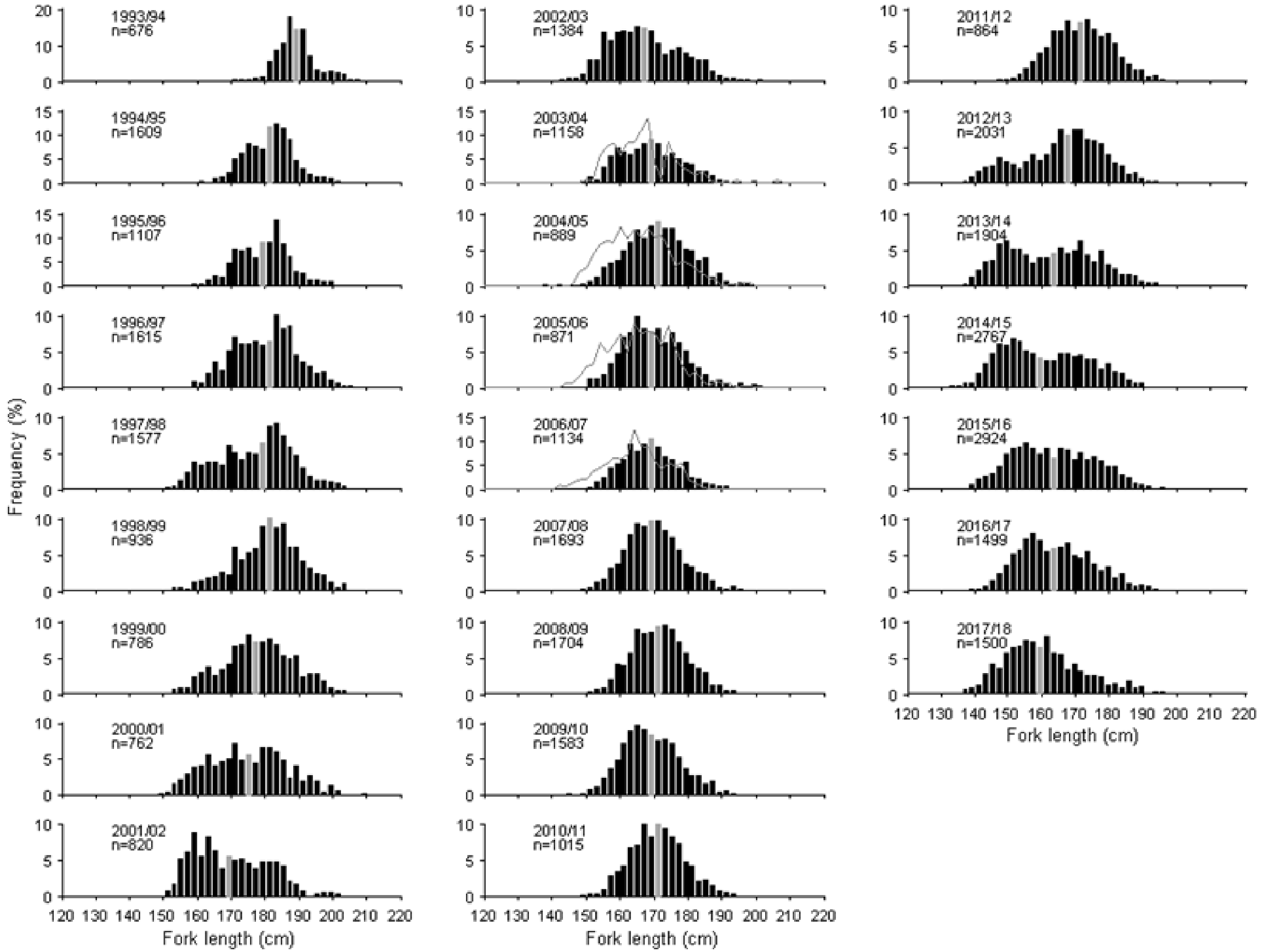

Figure 1. Length frequency (2 cm intervals) of SBT caught by the Indonesian longline fishery (bars) by spawning season. The grey bar shows the median size class. For comparison, the length distribution of SBT thought to be caught south of the spawning ground (Processor A) is shown for the 2003/04 (n=121), 2004/05 (n=685), 2005/06 (n=311) and 2006/07 (n=452) seasons (grey line) (Farley *et al.* 2007).

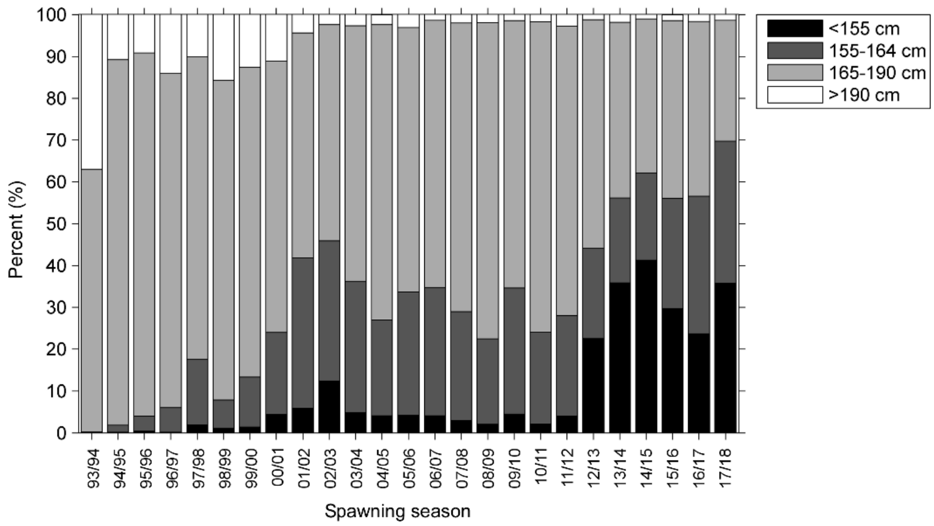

Figure 2. Proportion of SBT caught by the Indonesian longline fishery by size class. Data from Processor A in 2003/04 to 2006/07 are excluded.

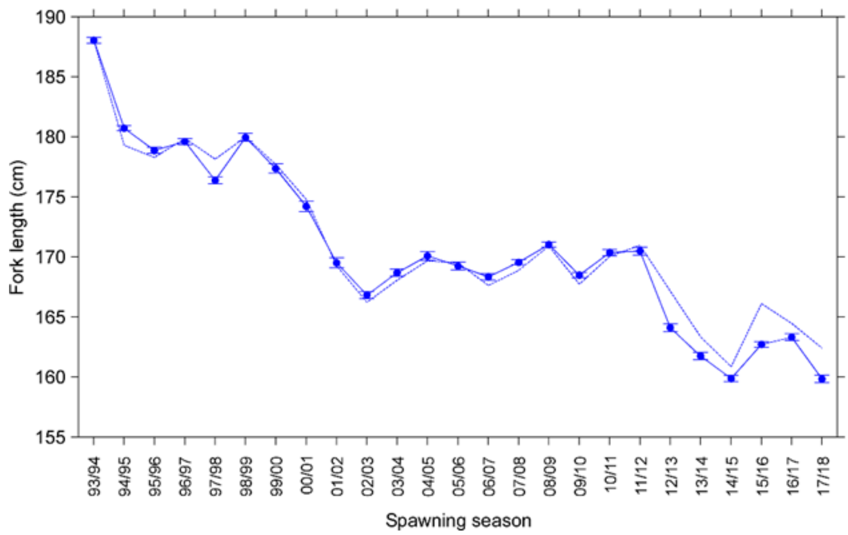

Figure 3. Mean length (+/- 95% CI) of SBT landed by the Indonesian longline fishery by season. Data from Processor A in 2003/04 to 2006/07 are excluded. Dashed line is the mean length of SBT caught in December to May only.

Age distribution

A final age was obtained for 472 of the 500 otoliths selected from the 2016/17 spawning season. Fish ranged in size from 134-203 cm FL and age estimates ranged from 6 to 33 years. The average percent error between readings was 4.02%. When successive readings of otoliths differed, 84.4% were by±2 years, and 95.0% were by ±2 years, indicating a good level of precision.

Figure 4 shows the estimated age structure of the Indonesian catch by spawning season. As expected given the change in the length distribution of the catch, the proportion of young fish aged 10-15 years increased markedly in the early 2000s (Figure 4) and the mean size of SBT monitored decreased (Figure 6). These young fish can be tracked through the age distribution of subsequent years suggesting a pulse of recruitment to the spawning population. A second recruitment pulse of young fish occurred in the mid-2000s (Farley *et al.* 2014). The mean age of SBT >20 years decreased from ~24 years since the mid-2000s to 22 years by 2010/11 (Figure 6).

In 2012/13 there was a substantial increase in the catch of young SBT (<10 years) and the mean age of SBT sampled decreased (Figures 4-6). The mode of young fish in the catch has persisted each year since that time, and there is some indication that the mode has moved through the fishery on an annual time step.

Earlier investigations suggested that the small/young SBT appearing in the Indonesian catch since 2012/13 were likely to have been caught south of the SBT spawning ground (Farley *et al.* 2017). Indonesian catches of SBT have occurred in CCSBT statistical areas 1, 2 and 8, but at this stage, it is not possible to identify the catch location of individual SBT sampled in the catch monitoring program.

It is important that we understand where the small fish are being caught because of how these data are used in the SBT operating model. The Indonesian monitoring data are also used in the current close-kin estimation framework. It is assumed that all catches come from individuals that were mature and spawning in the year they were sampled. Hence, the recent changes in the size/age of SBT monitored in the Indonesian longline fishery also have the potential to influence how these data are used in the CK abundance estimation.

We recommend that the CCSBT consider a study in the Scientific Research Plan (SRP) to resolve the issue of where the small SBT are being caught (to the extent possible) and refine/update the monitoring program.

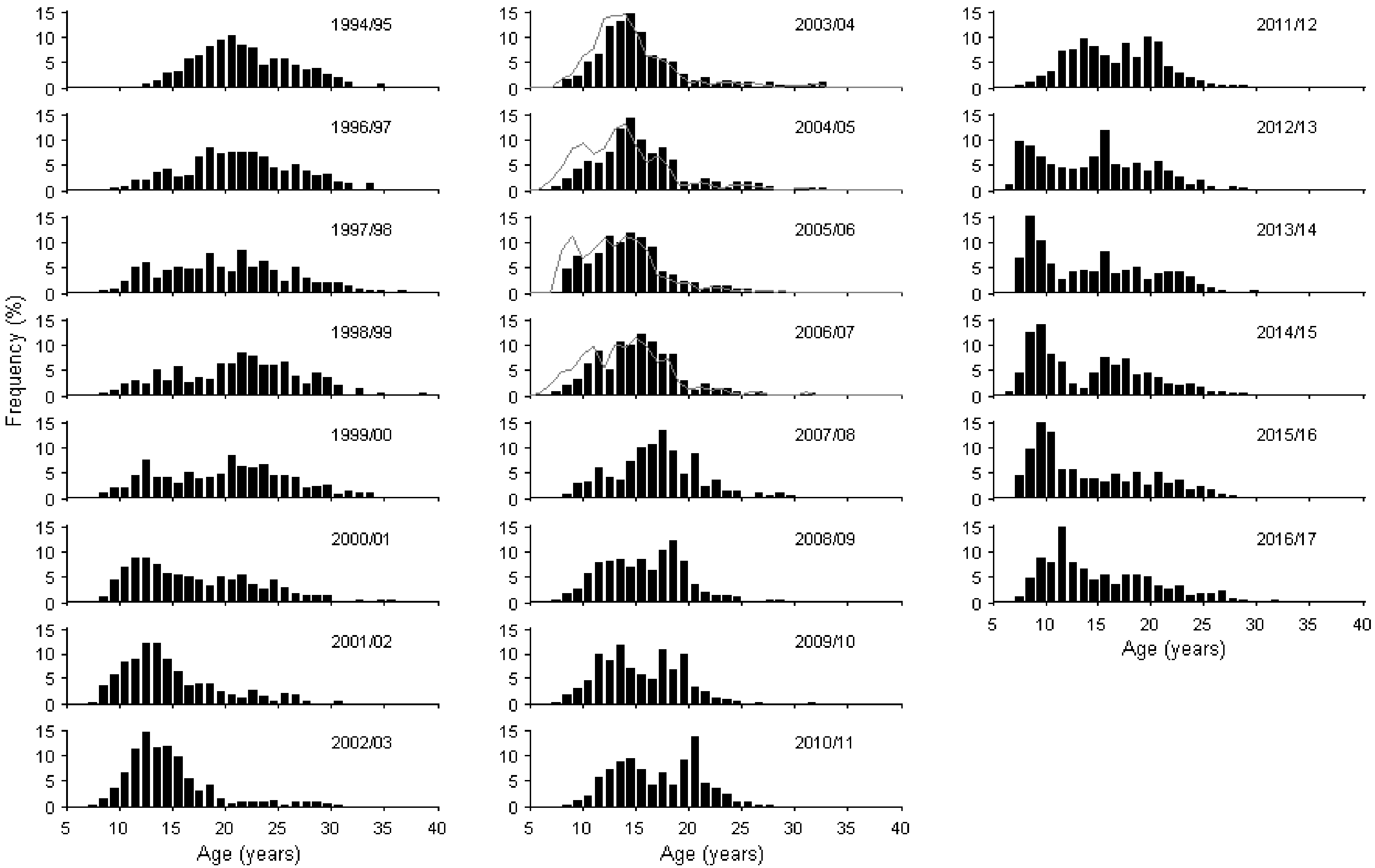

Figure 4. Age frequency distribution of SBT in the Indonesian catch on the spawning ground by spawning season estimated using age-length keys from our sub-samples of aged fish and length frequency data obtained through the Indonesian monitoring program. There was no direct ageing of the 2012–13 otoliths; age frequency is based on the age-length key from the previous two seasons and 2012–13 length frequency data. For comparison, the age distribution of SBT caught south of the spawning ground (Processor A) is shown for the 2003/04, 2004/05, 2005/06 and 2006/07 seasons (grey line).

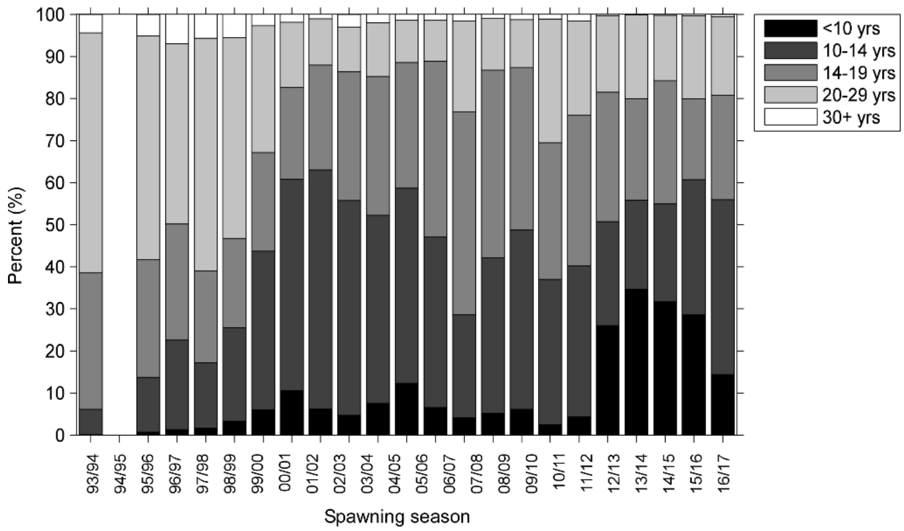

Figure 5. Estimated proportion of SBT by age class in the Indonesian catch. Data from Processor A for 2003/04 to 2006/07 are excluded. Note there are no age data for the 1995/96 season.

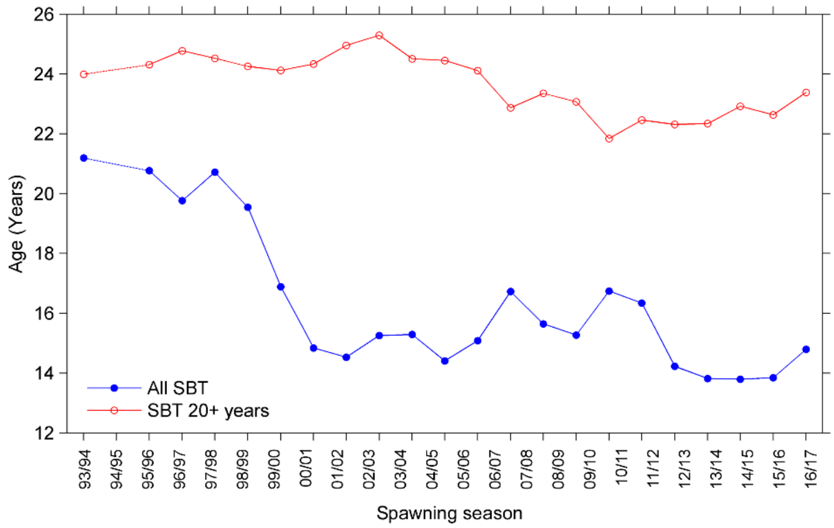

Figure 6. Estimated mean age of SBT in the Indonesian catch. Data from Processor A for 2003/04 to 2006/07 are excluded. Note there are no age data for the 1995/96 season.

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