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Update on the length and age distribution of SBT in the Indonesian longline catch

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Important disclaimer

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Contents

1 Abstract

This paper updates previous analyses of SBT length and age data from the Indonesian longline fishery operating out of the port of Benoa, Bali. Length-frequency data are presented for 21 spawning seasons (1993/94 to 2013/14) and age frequencies for 19 seasons (1993/94 to 2012/13, but excluding 1995/96). As noted in previous reports to CCSBT-ESC, considerable change has occurred in the size and age distribution of SBT landed by the Indonesian longline fleet since monitoring began. In summary:

Length distribution:

- Between 1993/94 and 2002/03, the mean size of SBT landed declined from 188.1 to 166.8 cm fork length (FL) and it has fluctuated between 168.3 and 171.0 cm FL until 2012/13.
- In 2012/13 and 2013/14, the length frequencies showed a new mode of relatively small fish at about 145-155 cm FL as well as the *usual* mode of larger fish at around 165-175 cm. This change in the size distribution is reflected in a sharp decline in the mean size of SBT sampled in 2012/13 and 2013/14 to 162.1 cm and 161.6 cm respectively.

Age distribution:

- Similarly, the mean age of SBT landed by Indonesia declined between the late 1990s and early 2000s from ~20 years to ~15 years old, and has fluctuated between 14 and 16 years until 2012/13.
- In 2012/13 (the latest season we have data for), there was a substantial increase in the catch of 7-9 year-olds. The proportion of fish aged <10 years increased from 5.8 to 37.0% and the mean age of SBT decreased from 16.0 o 13.2 years.

Investigations are in progress to determine whether the small/young SBT landed in recent years were caught on or south of the SBT spawning ground and whether they can be considered part of the SBT spawning population. The data provided to the CCSBT in the data exchange process included the estimated size and age distribution of the total Indonesian SBT catch, and were not divided into those caught on or south of the spawning ground.

2 Introduction

Southern bluefin tuna spawn from September to April in an area between Indonesia and the northwest coast of Australia (Farley and Davis, 1998). An Indonesian-based longline fishery operates on this spawning ground year-round targeting yellowfin and bigeye tuna, with a bycatch of SBT. Obtaining an accurate estimate of the size and age composition of SBT landed by the Indonesian longline fishery is vital for population modeling and stock assessments, and to monitor changes in the spawning population over time.

Since the early 1990s, the size and age structure of the SBT spawning population has been monitored through a series of collaborative research programs between CSIRO, Indonesia's Research Centre for Capture Fisheries (RCCF) and Research Institute for Marine Fisheries (RIMF), the Indian Ocean Tuna Commission (IOTC), and Japan's Overseas Fishery Cooperation Foundation (OFCF). The program monitors the catch of SBT by Indonesia's longline fleet operating on the SBT spawning ground in the north-east Indian Ocean. Initially, the program collected data on SBT landed at the port of Benoa in Bali, but in 2002 this was expanded to include the ports of Muara Baru (Jakarta) and Cilacap (south coast Central Java), and to comply with IOTC protocols. The majority of targeted SBT sampling, however, still occurs at Benoa, as this is the port where the bulk of SBT are landed.

The collection of such large quantities of length frequency data, and the development of validated methods to directly age SBT using the otoliths sampled, have allowed us to accurately estimate the age composition of the Indonesian catch. These data have shown that the parental stock of SBT has undergone substantial changes since monitoring began; the greatest change being a shift in the mode of SBT caught from 18-22 years in the mid-1990s to 12-15 years in the early-2000s.

In the mid-2000s, at least one Benoa-based fishing company (Processor A) was identified as having shifted their operations to target SBT south of the SBT spawning ground (Andamari et al., 2005; Proctor et al., 2006; Farley et al., 2007). A greater proportion of the catch landed at Processor A comprised small (<165 cm FL) fish compared to the other processors. SBT of these sizes are consistent with historic Japanese catch

data for vessels operating on the staging ('Oki') fishing ground to the south of the spawning ground (Shingu, 1978). In 2012-13, the size distribution of SBT landed in Bali also showed a greater proportion of small fish (<150 cm FL) in the landed catch compared to previous seasons (Farley et al., 2013). Unfortunately, the catch locations of the sampled fish are unknown.

In this paper we update the information given in Farley et al. (2013) by including the most recent length and age data available for the Indonesian fishery. Length frequency data are presented up to the 2013/14 season and age frequency data up to the 2012/13 season.

3 Methods

As in previous years, targeted sampling of SBT occurred at the Port of Benoa using the existing monitoring system (e.g. see Proctor et al., 2006). Length measurements were obtained for 1787 SBT in the 2013/14 spawning season and otoliths were collected from 1637 fish (Table 1).

Direct ageing of a subsample of 500 otoliths was undertaken for fish sampled in the 2012/13 spawning seasons (Table 1). A fixed number of otoliths were chosen from each 1-cm length class to obtain as many age estimates from length classes where sample sizes were small. Length stratified sampling is the best way of obtaining sufficient age estimates from length classes where sample sizes are small, while providing enough estimates for each season. Otoliths were prepared, sectioned and read (age of fish estimated) at Fish Ageing Services Pty Ltd (FAS) in Victoria, using the techniques described in Anon. (2002). The otolith reader has at least 10 years experience reading SBT otoliths.

Each otolith was read twice by the primary otolith reader (FAS) and then a final age estimate was given to 474 fish. A sub-sample of 10% of otoliths was read by a secondary otolith reader (from CSIRO) who was trained in SBT otolith reading in 1996 and has read SBT otoliths routinely since that time. All readings were conducted without reference to the size of the fish, date of capture, or to previous readings. The precision of readings was assessed using the coefficient of variation (CV) (Chang, 1982; Campana et al., 1995).

To determine the age structure of the Indonesian catch of SBT in 2012/13 season, an age-length key was developed using the sample of aged fish. The age-length-key gives the proportion of fish at age in each 5-cm length class, which enabled us to infer the age-frequency distribution of the catch from the length-frequency distribution obtained through the monitoring. This method has been used to estimate the age distribution of the Indonesian catch since the mid-1990s. The age distributions obtained were compared to the estimated age distributions for previous seasons.

4 Results

4.1 Length distribution

Figure 1 shows the length frequency distributions for SBT caught by the Indonesian longline fishery by season (note that 8 fish between 100 and 129 cm FL were also sampled in 2013/14 but are not shown). The data are separated into those caught on and those caught just south of the spawning ground in the 2003/04 to 2006/07 seasons (see Farley et al., 2007) as SBT caught south of the spawning ground are not considered part of the spawning population.

As noted in previous reports to CCSBT-ESC, considerable change has occurred in the size distribution of SBT caught on the spawning ground since monitoring began. In the mid- and late-1990s, the majority of SBT caught were between 165 and 190 cm FL with a median length of ~180 cm (Figure 1). In the early-2000s, the relative proportion of small SBT (<165 cm) in the catch increased (Figure 2). The mean size of SBT caught declined from 188.1 to 166.8 cm between 1993/94 and 2002/03, and remained between 168.3 and 171.0 cm until 2011/12 (Table 1).

In 2012/13 and 2013/14, the length frequencies of the sampled catch indicate a new mode of relatively small fish at about 145-155 cm FL as well as the *usual* mode of larger fish between 160 and 180 cm FL. In these seasons, the relative abundance of fish <155 cm was 32.9% and 35.0% respectively compared to much lower levels of 0 to 12.4% in the previous seasons (Figure 2). This change in the size distribution is

reflected in a decrease in the mean size of SBT to 162.1 cm and 161.6 cm (Table 1). The box plot of fish lengths (Figure 3) shows the recent increase in the size range of SBT sampled and the decreased in average size. When examined by month for 2013/14, just over 50% of SBT sampled in September 2013 to January 2014 were <155 cm, declining slightly to 41% in February, 10.8% in March and only 3.3% in April 2014.

Investigations have been initiated to determine whether the small SBT sampled in 2012/13 and 2013/14 were caught on or off the SBT spawning ground. In early May 2014, tuna fishing industry in Benoa participated in a workshop[3] at which a presentation was given highlighting the importance of catch location information to enable a better understanding of the increase in smaller fish in the landings. Follow-up discussions at the Benoa office[4] with responsibility for monitoring of fishing vessel activity revealed that VMS is available for some of the Benoa longline fleet and may provide validation of catch location information for the smaller SBT, should such information be provided by individual fishing companies.

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

SPAWNING SEASON	FORK LENGTH (CM)			OTOLITHS	AGE (YEARS)	
	N	MEAN	RANGE	*N*	*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	565	169.4	136-212	543	*NA*	16.0
2012/13	1381	162.1	135-211	1373	474	13.2
2013/14	1787	161.6	100-204	1637	*NA*	*NA*
Total	26630			21103	8297	

[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.

[3] Workshop "Monitoring and Evaluation of Enumerator and Observer Acitivties in Port of Benoa, Bali", 5 May 2014, held at office of Asosiasi Tuna Longline Indonesia, Benoa.

[4] Pelabuhan Perikanan Nusantara Pengambengan – Benoa Office, a regional office under Directorate General of Capture Fisheries.

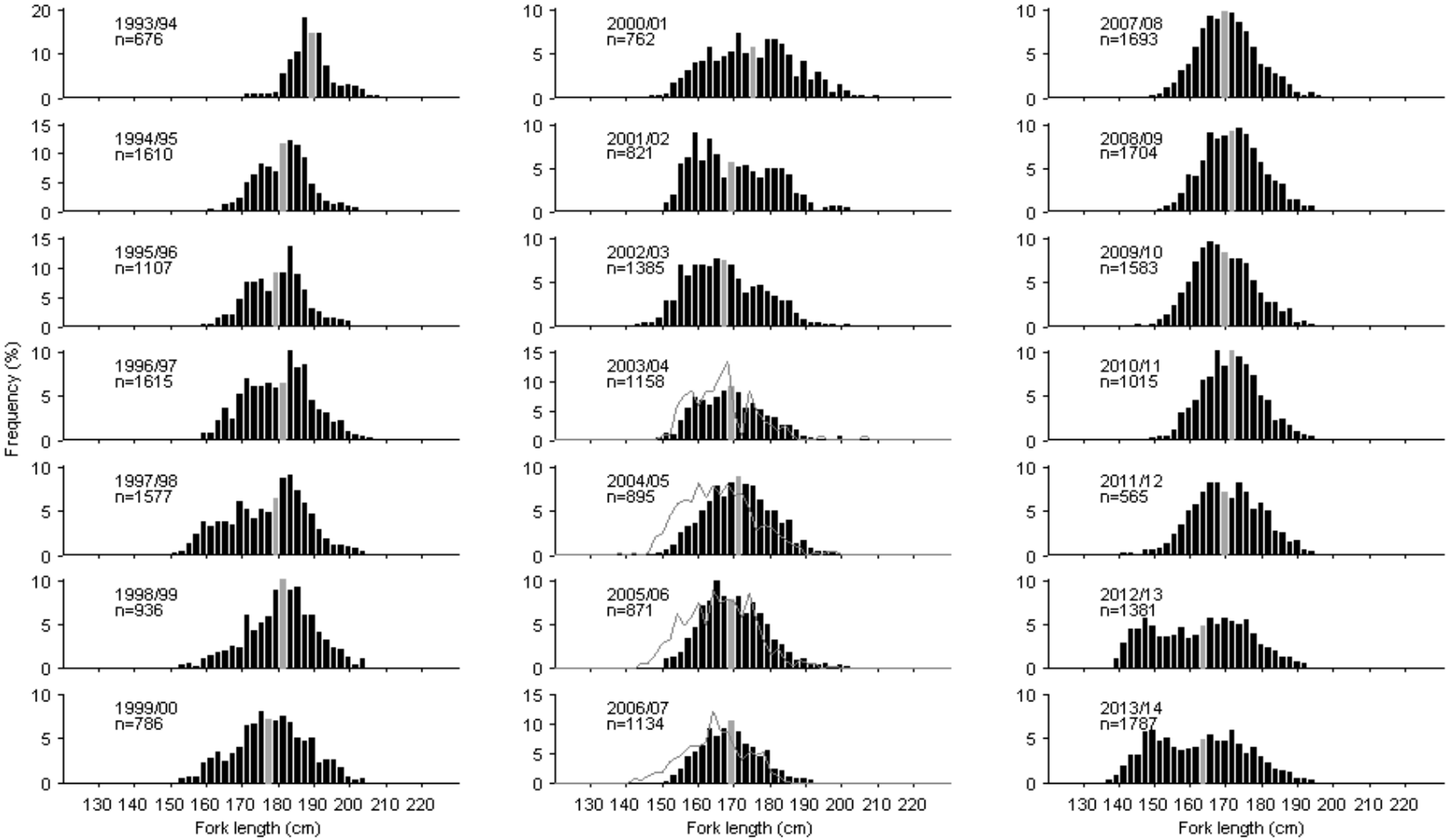

Figure 1. Length frequency (2 cm intervals) of SBT caught by the Indonesian longliner fishery (bars) by spawning season. The grey bar shows the median size class. For comparison, the length distribution of SBT thought to be caught south of the spawning ground (Processor A) is shown for the 2003/04 (n=121),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

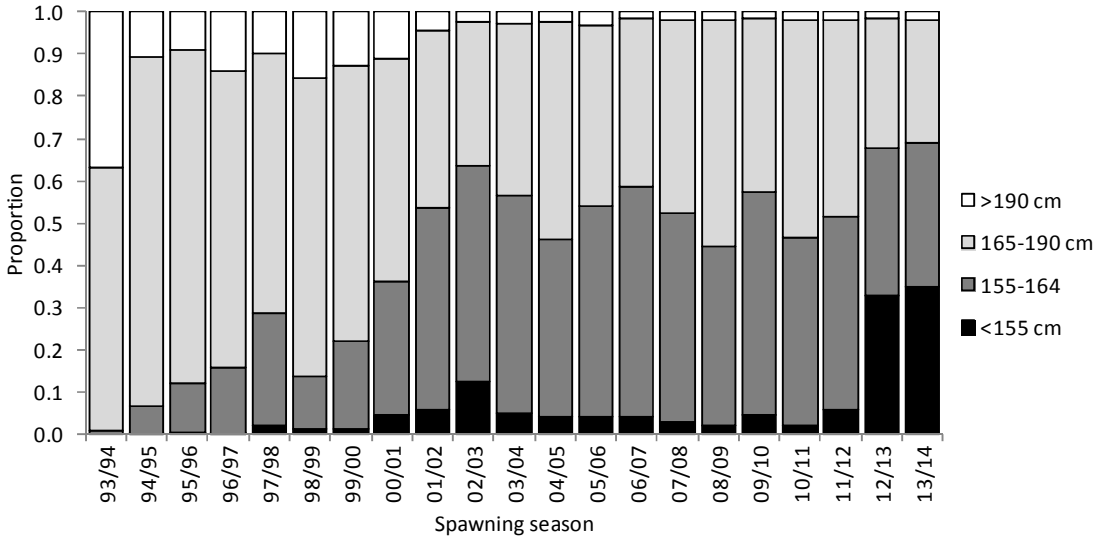

Figure 2. Proportion of SBT caught by the Indonesian longline fishery by size class. Data from Processor A are excluded.

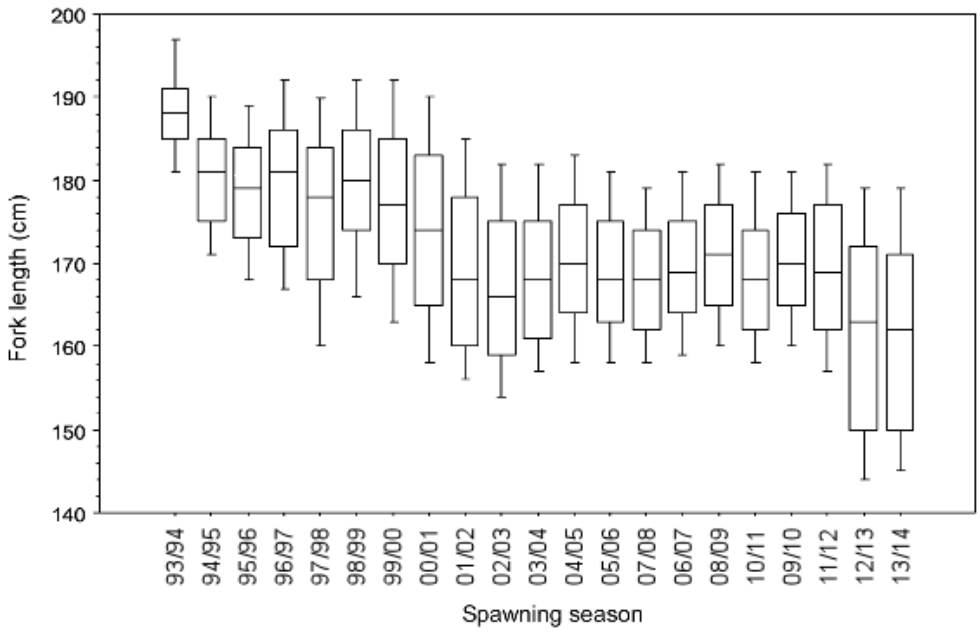

Figure 3. Box plot of the size of SBT landed by the Indonesian longline fishery by season. The horizontal line through a box indicates the median, the length of a box represents the inter-quartile range, and the vertical lines extend to the minimum and maximum values. Data from Processor A are excluded.

4.2 Direct age estimates and age distribution

As noted in the methods section, a final age was estimated for 474 of the 500 otoliths selected from the 2012/13 spawning season. Fish ranged in size from 135-211 cm FL and age estimates ranged from 6 to 36 years. The coefficient of variation between readings was 3.83%. When successive readings of otoliths differed, 95.7% were only by ±2, again indicating a good level of precision.

Figure 3 shows the estimated age structure of the Indonesian catch by spawning season. As reported previously, the age composition of the catch has changed over time, with an increase in the relative

abundance of younger fish since the 2000/01 season. The mean of the age distribution declined from 19-21 years in the mid- and late-1990s to 14-17 years since 2001/02 (Table 1; Figure 4).

In 2012/13 (the latest season we have data for), the age frequency of the sampled catch shows a substantial increase in the catch of 7-9 year-olds compared to previous seasons (Figure 4). As expected, the mean age of SBT sampled decreased from 16.0 to 13.2 years, and the relative abundance of young SBT <10 years old increased from 5.8% to 37.0% (Table 1; Figure 5; Figure 6). These changes are expected given the observed changes in the size of SBT caught in 2012/13.

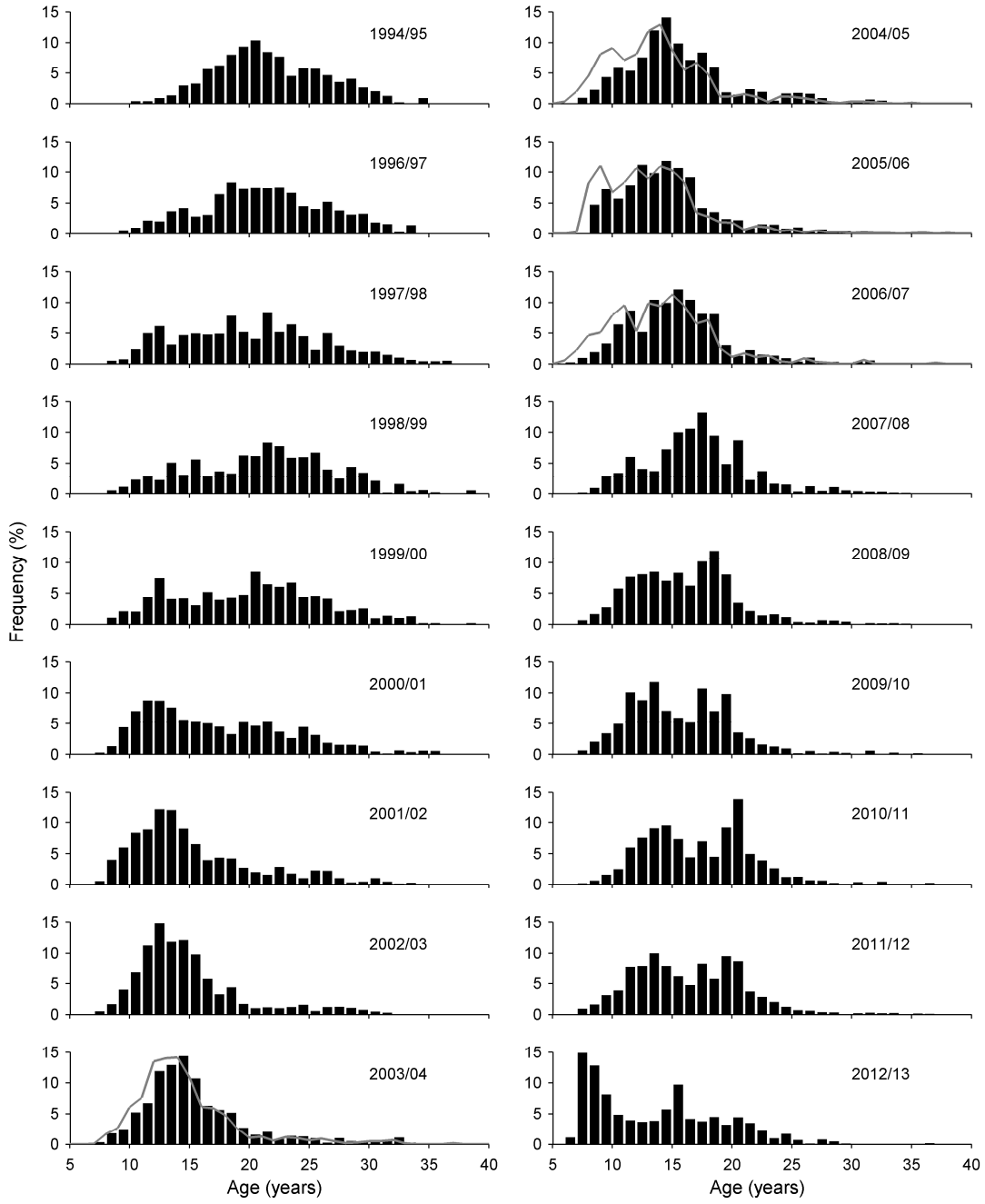

Figure 3. Age frequency distribution of SBT in the Indonesian catch on the spawning ground by spawning season estimated using age-length keys from our sub-samples of aged fish and length frequency data obtained through the Indonesian monitoring program. There was no direct ageing of the 2012–13 otoliths; 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 2004/05, 2005/06 and 2006/07 seasons (grey line).

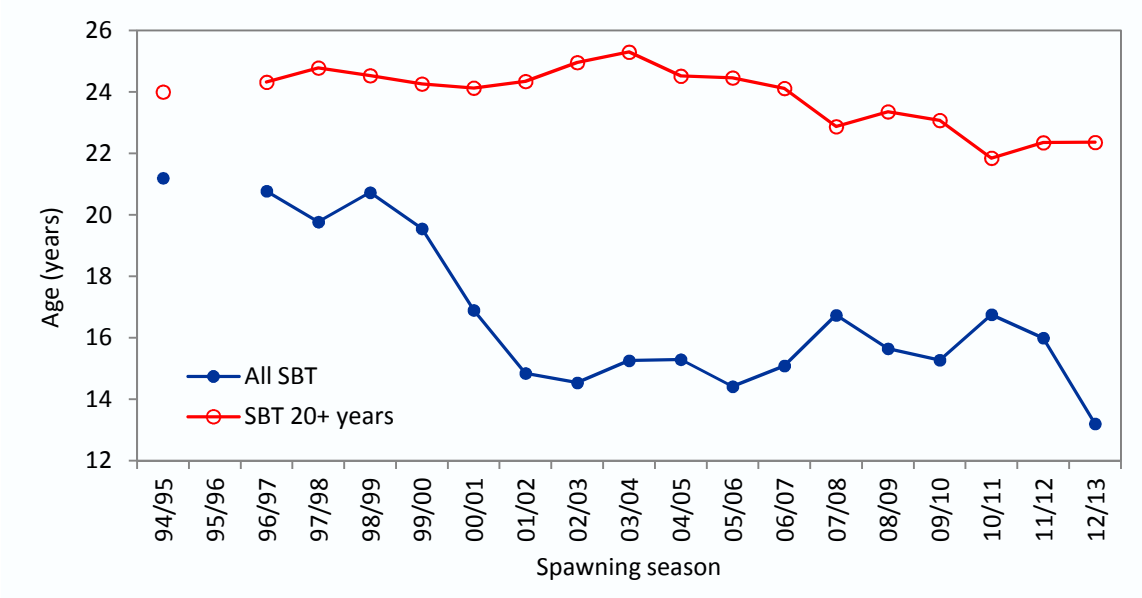

Figure 4. Estimated mean age of SBT in the Indonesian catch. Data from Processor A are excluded. Note there are no age data for the 1995/96 season, and age data for the 2011-12 season.

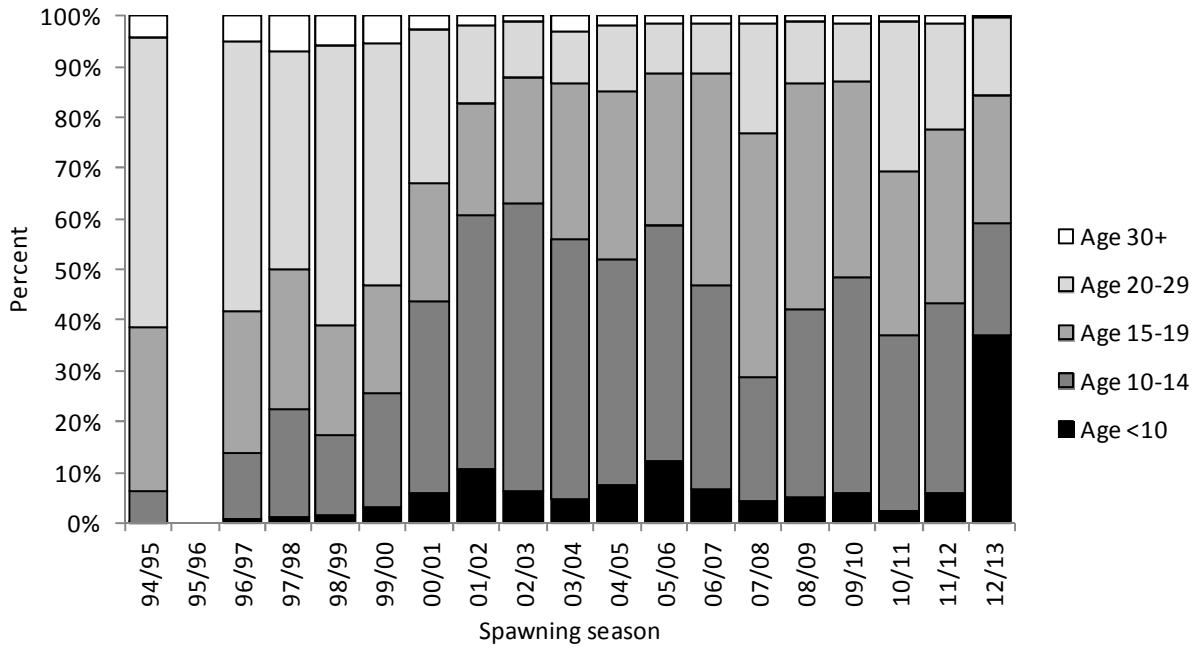

Figure 5. Estimated proportion of SBT by age class in the Indonesian catch. Data from Processor A are excluded. Note there are no age data for the 1995/96 season.

5 Summary

We present the length and age distribution of the Indonesian longline catch from the mid-1990s through to the 2013/14 and 2012/13 spawning seasons respectively. In each season, apart from 2011/12, an age-

length-key (ALK) was developed using age estimates obtained from that season. Length frequency data were then applied to the ALK to estimate the age distribution of the catch. In 2011/12, however, no direct age estimates were available. Thus, an ALK was developed using direct age data for the two preceding spawning seasons and applied to the 2011/12 length frequency data.

The size and age distribution of the Indonesian SBT catch has remained relatively stable since the early-2000s until the 2012/13 season. In 2012/13, a relatively large proportion of SBT landed were <155 cm FL (32.9%) and <10 years old (37.0%), compared to previous seasons. In 2013/14, the proportion of SBT <155 cm in the sampled catch was 35.0%. Investigations are in progress to determine whether the small SBT landed were caught on or south of the SBT spawning ground, and whether they can be considered part of the SBT spawning population. The direct age estimates obtained were provided to the CCSBT in April 2014 as part of the data exchange process.

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