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An update on Australian otolith collection activities, direct ageing and length-at-age in the Australian surface fishery

Jessica Farley
Naomi Clear

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Abstract

This report provides an update on SBT otolith sampling in Australia for 2007/08, and estimation of age and proportion at age of the surface fishery for the 2005/06 and 2006/07 fishing seasons.

Otoliths were sampled from 308 SBT caught by the Australian SBT surface fishery during the 2007/08 season, and an additional 18 were collected from fish that died during acoustic tagging operations in Western Australia. In previous seasons, the sampling protocols for the surface fishery did not provide a balanced sample of otoliths from all length classes in the fishery, and additional otoliths were sourced from those collected during CCSBT tagging operations where smaller fish are generally caught. Since CCSBT tagging operations were not conducted in 2008, there was no opportunity to collect these additional otoliths, and thus it is likely that the resulting age-length key will have “missing rows” where there are no age estimates for the smaller length classes

Of the otoliths collected in the previous two fishing seasons (2005/06 and 2006/07), age was estimated for 198 from fish ranging in size from 42-142 cm FL. Proportions at age in the catch were estimated using age-length keys.

Introduction

Differences are known to occur in the size and age composition of SBT by geographic region (Farley et al., 2007). Changes are also known to have occurred in growth rate of SBT over the past 4 decades (Polacheck et. al. 2004). Recognising this, the CCSBT agreed that all members should institute regular otolith collection programs for their major commercial SBT fisheries, and that otoliths be analysed to characterise the age distribution of their catch. In 2004, the CCSBT members confirmed “that reading and analysis of the otoliths collected was a priority to provide direct ageing data for assessments, and were encouraged to move towards annual interpretation of collected otoliths as a regular input to indicators and assessments” (Anon, 2004).

CSIRO developed techniques to accurately estimate the age of SBT using otoliths in the mid-1990s, and age was estimated for 1,121 SBT caught on Australian and Japanese fishing grounds in the southern oceans (Gunn et al., 2008). Subsequent studies have brought the total number of SBT aged to ~7,000, including the annual reading of 500 otoliths from the Indonesian longline fishery for the past 12 years.

From late 1999, otoliths have been routinely sampled from SBT caught in the Australian surface fishery in South Australian (tuna farm mortalities in Port Lincoln), during CCSBT tagging operations in South Australia and Western Australia, and opportunistically off the east coast of NSW (see Stanley and Polacheck, 2006; Stanley et al., 2007). All hardparts collected have been catalogued and stored in the CSIRO hardparts archive in preparation for future analysis.

In response to CCSBT's request to determine the age of SBT caught in the Australian surface fishery, CSIRO initiated the annual reading of 100-200 otoliths from this area in 2005. The direct age data were used with the length frequency data from the catch to estimate the proportions at age in the catch for each of the four fishing seasons (2001/02 to 2004/05) using age-length-keys and the parametric methods developed by Morton and Bravington (2003) (see Basson et al., 2005; Farley, 2006). All direct age estimates were provided to the CCSBT during the data exchange process and reported to the CCSBT-SC meetings.

The current paper provides an update on SBT otolith sampling in Australia for 2007/08, and age estimation of a subsample of otoliths from the 2005/06 and 2006/07 fishing seasons to meet our CCSBT commitment. Age-length-keys (ALK) are also constructed to determine the proportion at age. A fishing season runs from December 1 to November 30.

Methods

Otolith sampling in 2007/08

Surface fishery – farm sector

SBT farming possesses a challenge for developing an otolith sampling scheme from the surface fishery sector. The challenge is that fish can grow significantly between their time of capture in the wild and the time when they are harvested after having been retained in farms during the grow out phase. It is also important to note that the period when fish for farming are captured corresponds to a season when juvenile SBT are growing rapidly. Thus, otoliths collected from fish at the time of harvest, at the completion of the grow-out phase, will not provide a reliable basis for developing age/length keys for the surface fishery. In response to these issues, Australia has developed a sampling program based on fish that die either during towing operations or during the first two weeks after fish are transferred from towing cage into farm cages.

The current protocol requires that all farm operators provide a sample of 10 fish that have died either in towing operations or within the first weeks after fish have been transferred to stationary farm cages. A company contracted to the Australian Fisheries Management Authority (AFMA), Protec Marine Pty Ltd, measures the length of each fish and extracts the otoliths from these mortalities. The otoliths and length data are sent to CSIRO for archiving. There are between 30 and 40 tow cages a year, which means that a total of 300- 400 otoliths are generally should collected from this sector each year.

An additional two sets of otoliths were sampled from very small SBT (57cm FL) caught by the surface fishery in early 2008.

Tagging operations

CCSBT tagging operations were not undertaken in South Australia or Western Australia in the 2007/08 fishing season, thus additional otoliths were not obtained through this source. However, 18 SBT were sampled during an acoustic tagging operation in Western Australia in Dec-2007 and Jan-2008 (see Hobday et al., 2008, CCSBT Information paper).

Direct ageing

Of the otoliths collected from the Australian surface fishery in the 2005/06 and 2006/07 fishing seasons (see Stanley and Polacheck 2006; Stanley et al., 2007), 100 were selected from both for age estimation. Otoliths were selected based on size of fish. All otoliths sampled from small and large fish were selected from each fishing season, and a fixed number of otoliths were chosen from each of the remaining 1 cm length classes. This was the best method of obtaining as many age estimates from length classes where sample sizes were small. Morton and Bravington (2003) reported that between 100 and 200 otoliths from the surface fishery should be sufficient to provide acceptable precision (CVs under 20%). Otoliths were not selected from SBT caught in Western Australia as the growth rates of these fish may differ to those caught in South Australia, leading to potential bias in the ALKs and any subsequent estimation of the age distribution of the catch.

Otoliths were weighed to the nearest 0.1 mg provided they were not chipped or damaged. The relationship between otolith weight and fish length was examined to ensure that the otolith and the data that accompanied the otolith were consistent. Otoliths were then sent to the Central Ageing Facility (CAF) in Victoria for sectioning and reading. The technique to read SBT otoliths developed by CSIRO was transferred to the CAF prior to and during the CCSBT's Age Estimation Workshop in 2002 (Anon, 2002). The primary otolith reader (CAF) counted the number of alternating opaque and translucent increments in each otolith twice and a final count was assigned. To examine the consistency of readings, a subsample of 13% of the otoliths were read twice by a secondary otolith reader (at CSIRO). The coefficient of variation (CV; Chang, 1982) between readings was used to measure consistency. All readings were conducted without reference to the size of fish, date of capture, or to previous readings.

A problem in assigning age for SBT is that theoretical birthdate is January 1 (middle of the spawning season; see CCSBT-ESC/0509/Info) and opaque increments are formed during winter (May and October) (Clear et al., 2000, Gunn et al., 2008). Hence, using the number of increments as an estimate of age can be misleading if SBT are caught during the winter. However, SBT in the GAB are caught during summer (November to April), so there is less confusion about assigning an age from increment counts. For example, SBT with 2 increments in their otoliths were classed as 2 year-olds. Thus, SBT of the same age, caught in the same fishing season, were spawned in the same spawning season.

Age distribution of the catch

The simplest approach for obtaining estimates of proportions at age is the standard non-parametric age-length key (ALK) approach. Catch at size data for the Australian surface fishery was obtained from the CCSBT data exchange process for 2005 to 2007 (Filenames AU_CatchAtLength_05; _06; _07). We calculated catch at size for the 2005-06 and 2006-07 fishing seasons using the 'FREQUENCY_ADJUSTED' data. The size frequency data (binned into 5-cm length classes) is multiplied by the matrix of the proportion of fish in each age class at a given length to give numbers (or proportions) at age. Enough otoliths are available so that there are very few "missing rows" in the ALK for any year, i.e. few length classes for which no proportions-at-age can be calculated.

Results and Discussion

Otolith sampling in 2007/08

Otoliths were sampled from 308 SBT caught by the surface fishery in 2007/08 from fish between 58 and 136 cm fork length (Figure 1). The current sampling protocol does not provide either a fixed number of otoliths from each length class or representative samples of otoliths from all length classes in proportion to their abundance in the catch from the surface fishery. In previous seasons, this has resulted in an apparent disproportionate number of large fish sampled compared to the size distribution of SBT from the surface fishery (based on CCSBT CatchAtLength) (Figure 2). This could be the result of selection biases by the fishermen in their choice of dead fish to retain for otolith sampling or it could be due to size related differences in towing and early farming related mortality rates.

Given that CCSBT tagging did not occur in 2008, there was no opportunity to collect additional otoliths from fish smaller than those sampled from the surface fishery as has been done in previous seasons (Figure 2). Thus it is possible that the otoliths collected in the current seasons will not cover the full size range of farmed fish. The resulting age-length key will, therefore, have "missing rows" where there are no or very few age estimates for the smaller length classes. Note that the fish sampled for otolith collection in the 2005/06 and 2006/07 from farm mortality and tagging operations covered the full size range of fish going into farms and thus provide an adequate basis for the construction of age/length keys (given below).

The 18 SBT otoliths collected during the Western Australia acoustic tagging work were from fish 47-81 cm FL caught just southwest of Perth (n=2) or south of the Albany region (n=16) (Figure 1).

Age estimates

A final age estimate was given to 198 SBT ranging in size from 42-142 cm FL (Figure 4). The other 2 otoliths were unreadable. Although the sample size is small, no significant differences were detected in mean length at age between seasons (unpaired t-tests by 5-cm length class; $P>0.05$). The coefficient of variation between blind readings at the CAF was 7.32%. When successive readings of otoliths differed (n=59), 57 were by ±1 year and the other 2 by ±2 years, indicating a good level of precision. A subsample of 39 (~20%) of the otoliths were then read by a secondary otolith reader at CSIRO to estimate consistency between readers. The CV of between the two readers was 10.8%, which is relatively high. However, when readings differed (n=16), 14 were by ±1 year and the other 2 by ±2 years. These differences are relatively small, but because the age range is only 7 years, the CV appears inflated.

The ALKs based on our sample of aged fish are given in Table 1.

Proportions at age

Results for the ALK approach for both fishing seasons examined are shown in Table 2 and illustrated in Figure 3. The estimated proportions at age are quite similar for 2005-06 and 2006-07 (the majority are age 2 and 3) and are also similar to the age distribution for 2003-04 and 2004-05 (Figure 4). However, the proportion at age for the 2001-02 and 2002-03 seasons differ as most were age 3 and 4 in these earlier seasons. The results for the ALK's are slightly different from the cohort-slicing method (Figure 5). As noted in Morton and Bravington (2003), the parametric approaches are superior to the ALK approach, and we consider that this form of approach should be pursued. The full analyses associated with the parametric approaches are, however, more time-consuming and therefore best done once a decision has been made about how the estimates would be used in future assessments. The ALK estimates shown here should be considered illustrative.

Acknowledgements

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Tables

Table 1. Age-length key for the 2005/06 to 2006/07 fishing seasons for the Great Australian Bight surface fishery. The lower length of each 5cm length bin is given in the first column, and age estimates are shown across the top (in years).

2005-06	1	2	3	4	5	6	7	Total
50	2							2
55	3	1						4
60	2							2
65	1	4						5
70		6						6
75		7						7
80		7						7
85		6						6
90		4	3					7
95		1	5					6
100			7					7
105		1	3	1				5
110			7					7
115			1	5				6
120				7				7
125				4	2	1		7
130				2	2			4
135						1		1
140				1	1			2
Total	8	37	26	20	5	2		98

2006-07	1	2	3	4	5	6	7	Total
50								0
55	1							1
60		2						2
65	1							1
70	1	6						7
75	1	7						8
80		6	1					7
85		6						6
90			8					8
95			5	2				7
100		1	5	2				8
105			4	3				7
110			1	7				8
115			1	6				7
120				7				7
125				2	3	1		6
130					6	1		7
135					1			1
140						1	1	2
Total	4	28	25	29	10	3	1	100

Table 2. Proportions at age for the two fishing seasons using the age-length key method. (Four decimal places are shown to retain the small but non-zero proportions for ages).

Season	Age (years)								
	1	2	3	4	5	6	7	8	9
2001-02		0.0541	0.5185	0.3730	0.0505	0.0033	0.0006		
2002-03	0.0006	0.0695	0.5635	0.3136	0.0503	0.0016	0.0008	0.0002	
2003-04	0.0007	0.3522	0.5612	0.0856	0.0003				
2004-05		0.3104	0.5330	0.1183	0.0370	0.0008	0.0004	0.0000	0.0000
2005-06	0.0068	0.4904	0.4978	0.0047	0.0002	0.0001			
2006-07	0.0138	0.4031	0.4910	0.0915	0.0004	0.0001			

Figures

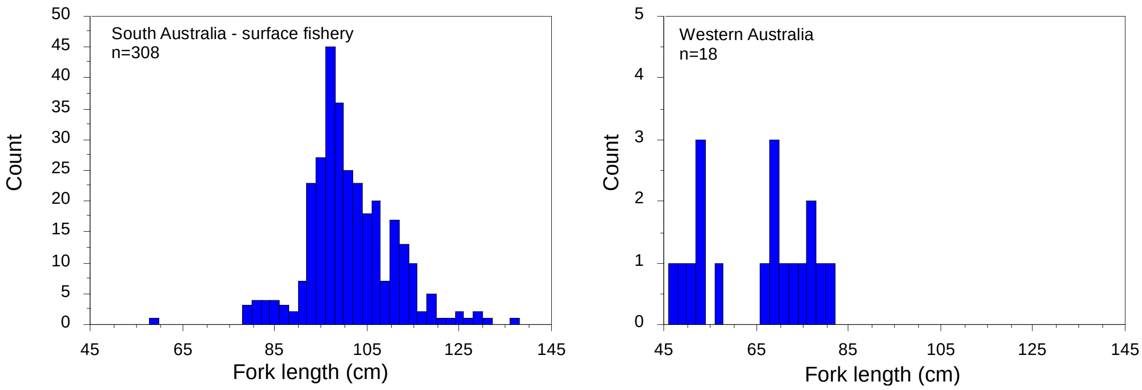

Figure 1. Size frequency (2-cm bins) of SBT with otoliths sampled in the 2007/08 fishing season.

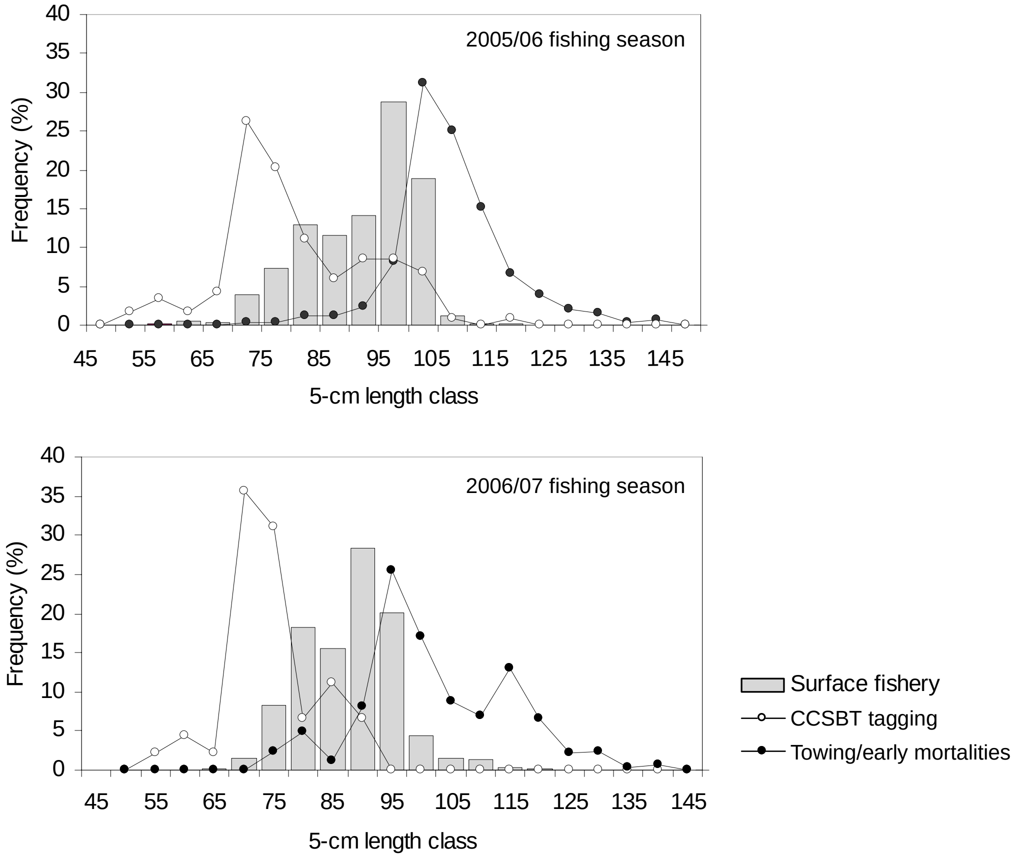

Figure 2. Comparison of length-frequency distributions of SBT with otolith sampled (from tagging and towing operations) and for the fishery (AU_CatchAtLength data) for the 2005/06 and 2006/07 seasons.

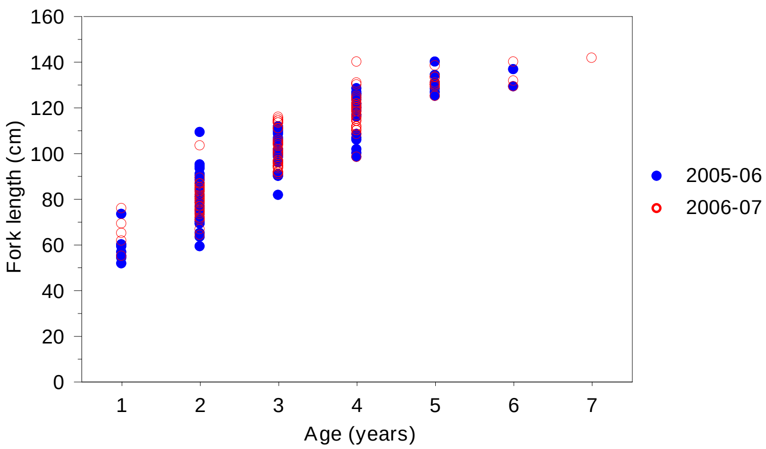

Figure 3. Length at age for SBT caught in the GAB surface fishery in the 2005/06 and 2006/07 fishing season (n=198).

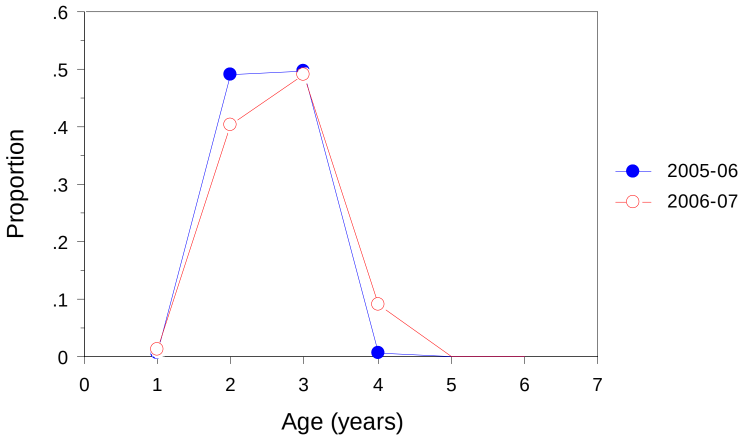

Figure 4. The estimated proportions at age for the 2005-06 and 2006-07 fishing seasons using the "age-length key" method.

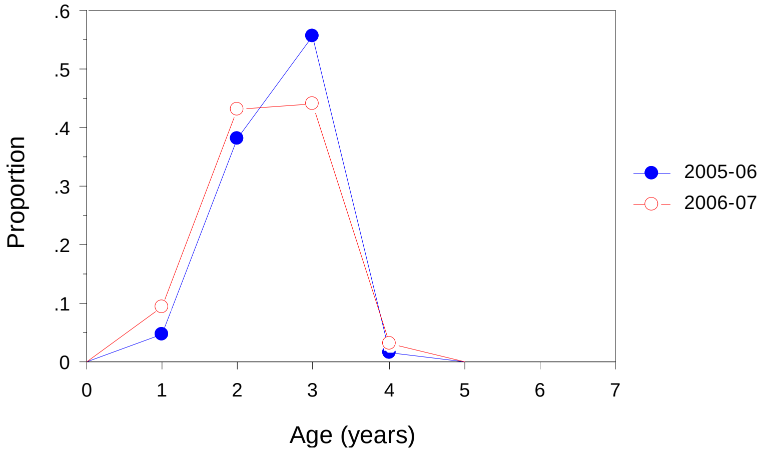

Figure 5. Proportions at age from cohort-slicing for comparison. Taken from the data exchange documents (filename: AU_CatchAtAge_PurseSeine_06_07seasons.xls).

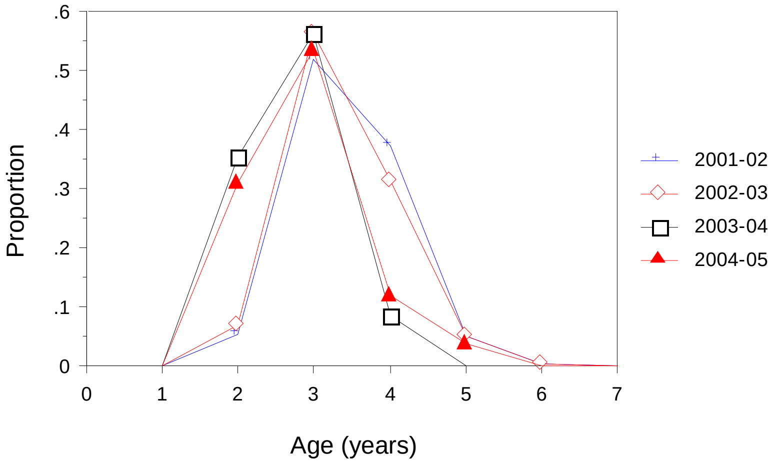

Figure 6. The estimated proportions at age for the given fishing seasons using the "age-length key" method (see Farley, 2006).