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

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Abstract

This report provides an update on SBT otolith sampling in Australia for 2008/09, and estimation of age and proportion at age of the surface fishery for the 2007/08 fishing season. Otoliths were sampled from 311 SBT caught by the Australian SBT surface fishery during the 2008/09 season, and an additional 162 otoliths were obtained from the recreational catch of SBT in Portland, Victoria. 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 2009, there was no opportunity to collect these additional otoliths, and thus it is possible 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 fishing season (2007/08), age was estimated for 100 fish ranging in size from 57-136 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 SBT fisheries should analyse hardparts (otoliths) to characterise the age distribution of their catch and "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."

CSIRO developed techniques to accurately estimate the age of SBT using otoliths in the mid-1990s (Gunn et al., 2008). From late 1999, otoliths were routinely sampled from SBT caught in the Australian surface fishery in South Australian (tuna farm mortalities), during CCSBT tagging operations in South Australia and Western Australia, and opportunistically off the east coast of NSW. All hardparts collected were catalogued and stored in the CSIRO 'hardparts' archive in preparation for future analysis. In 2005, CSIRO initiated the annual reading of 100-200 otoliths from SBT caught in the Australian surface fishery (Basson et al., 2005; Farley, 2006; Farley and Clear, 2008). 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 standard age-length-keys and the parametric methods developed by Morton and Bravington (2003). All direct age estimates were provided to the CCSBT during the data exchange process.

The current paper provides an update on SBT otolith sampling in Australia for 2008/09, and age estimation of a subsample of otoliths from the 2007/08 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 2008/09

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 soon after fish are transferred from towing cages 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 collected from this sector each year.

Recreational fishery:

A number of SBT were caught by recreational fishers off Portland in late summer and autumn this season. Otoliths were collected by the Department of Primary Industry in Portland in May and June 2009 and sent to CSIRO for archiving.

Tagging operations

CCSBT tagging operations were not undertaken in South Australia or Western Australia in the 2008/09 fishing season, thus additional otoliths were not obtained through this source.

Direct ageing

Of the 308 sets of otoliths collected from the Australian surface fishery in the 2007/08 fishing season (see Farley and Clear 2008), 100 were selected for age estimation. Otoliths were selected based on the size of fish. That is, otoliths from all small (<85 cm) and large (>114 cm) fish were selected for ageing because very few were sampled, and a fixed number of otoliths were chosen from each of the remaining 1 cm length classes (85-114 cm). 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%).

One otolith was selected for age estimation from each of the 100 sets. 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 'Fish Ageing Services Pty Ltd' (FAS) in Victoria for sectioning and reading. FAS is a new fee-for-service ageing laboratory established in early 2009. The SBT otolith reader at the FAS is the same reader associated with the 'Central Ageing Facility' (CAF), which has read SBT otoliths for the past 9 years. 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 30 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 that are counted to provide the age estimate 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 2007 and 2008 (AU_Catch_at_Length_07.xls and AU_Catch_at_Length_08.xls). We then calculated catch at size using the 'FREQUENCY_ADJUSTED' data for the 2007/08 fishing seasons.

To estimate the age distribution of the catch, 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 2008/09

Surface fishery – farm sector

Otoliths were sampled from 311 SBT caught by the surface fishery in 2008/09 from fish between 81 and 133 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). 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. In 2008/09, the sampling program was able to obtain otoliths from slightly more smaller fish than in the past. However, it is still 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.

Recreational fishery:

Otoliths were sampled from 162 SBT caught by recreational fishers in Portland (Victoria). The majority of fish ranged in size from 80 to 100 cm fork length, although one large (180 cm) fish was also sampled (Figure 1).

Age estimates

A final age estimate was given to 100 SBT ranging in size from 57-136 cm FL (Figure 2). The coefficient of variation (CV) between blind readings at the FAS was 7.26%. When successive readings of otoliths differed (n=32%), they differed by only ±1, indicating a good level of precision. The CV between readers (FAS/CSIRO) was 9.50% which is relatively high. However, when successive readings of otoliths differed (n=39%), they differed by only ±1, again indicating a good level of precision. The differences are relatively small, but because the age range is only 6 years, the CV appears inflated. A bias was not detected in the age estimates between readers.

The ALK based on our sample of aged fish is given in Table 1. Note that no otoliths were sampled from SBT in the 60-70 cm length classes. However, since only 0.45% of the catch occurred in these size classes, the effect on the estimated proportions at age will be very small.

Proportions at age

Results for the ALK approach are shown in Table 2. The estimated proportions at age are almost identical to the catch at age distribution based on the cohort-slicing method (Figure 3). In previous seasons, the results for the ALK have been slightly different from the cohort-slicing method (see Basson et al., 2005; Farley, 2006; Farley and Clear, 2008).

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.

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Tables

Table 1. Standard age-length key for the 2007/08 fishing season for the Great Australian Bight. The lower length of each 5cm length bin is given in the first column, and age estimates are shown across the top (in years).

2007-08	1	2	3	4	5	6	Total
55	3						3
60							
65							
70							
75		3					3
80		7	1				8
85		7	4				11
90		4	5	2			11
95			11				11
100		1	10				11
105			6	4	1		11
110			4	6	1		11
115			2	9			11
120				1	1		2
125				1	4		5
130						1	1
135						1	1
Total	3	22	43	23	7	2	100

Table 2. Proportions at age for SBT caught in the Australian surface fishery since 2001-02 using the standard “age-length key” method. (Four decimal places are shown to retain the small but non-zero proportions for ages. Zero proportions are shown as blanks).

Season	Age								
	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			
2007-08		0.2898	0.6461	0.0601	0.0035	0.0005			

Figures

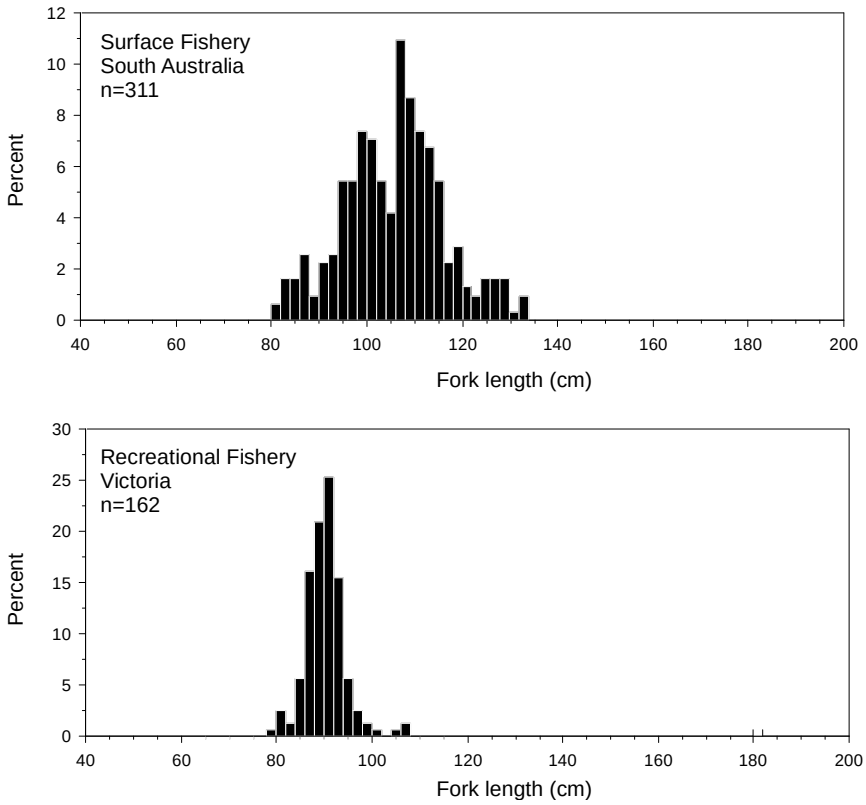

Figure 1. Length frequency (2-cm bins) of SBT with otoliths sampled in the 2008/09 fishing season.

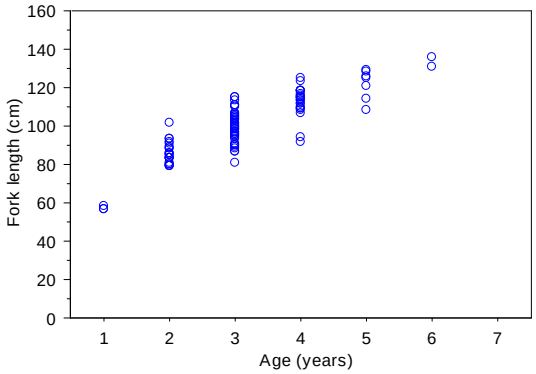

Figure 2. Length at age for SBT caught in the GAB surface fishery in the 2007/08 fishing season (n=100).

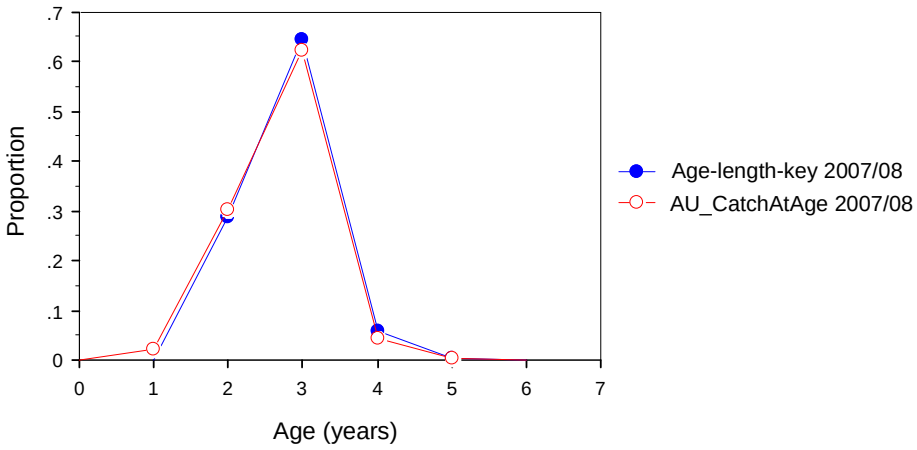

Figure 3. The estimated proportions at age for the 2007/08 fishing seasons using the “age-length key” method (direct ageing) and from cohort-slicing (AU_CatchAtAge_PurseSeine_06_07seasons.xls).