Estimates of proportions at age in the Australian surface fishery catch from otolith ageing and size frequency data

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Abstract

Southern bluefin tuna caught by Australia's surface fishery in the Great Australian Bight were aged by examining transverse sections of their sagittal otoliths. Age was assigned to 152 fish caught over the 2004-05 fishing season. Proportions at age in the catch were estimated using a standard age-length key.

Introduction

Differences are known to occur in the size and age composition of SBT by geographic region. Estimating the age distribution of the commercial catch is, therefore, of great importance for stock assessments and, by implication, for management. The CCSBT has recognised this importance and has agreed that all SBT fisheries should collect and analyse hardparts (otoliths) to characterise the age distribution of their catch (Anon, 2004).

Otoliths have been sampled from SBT caught in Australian fisheries since the 1960s. However, since the 1999/00 fishing season, otoliths have been routinely collected each year under AFMA supervision from the South Australian tuna farms (mortalities) in Port Lincoln. Otoliths have also been collected from incidental mortalities during CCSBT tagging operations in Western Australia and South Australia since 2001-02, and opportunistically by CSIRO off the east coast of NSW.

In 2005, CSIRO estimated the age of a subsample of SBT caught in the Australian surface fishery in the Great Australian Bight over three fishing seasons (2001-2 to 2003-4) and provided the estimates to the CCSBT during the data exchange in April 2005 (Basson et al., 2005). The object of the current work was to build on this and estimate the age of a subsample of SBT from the following (2004-05) fishing season, and to construct an age-length key (ALK) for the fishery to meet our CCSBT commitment.

Basson et al. (2005) presented results for several approaches to estimating proportions at age based on the work by Morton and Bravington (2003). The latter paper also draws attention to the fact that the choice of approach depends on how the estimates are to be used in an assessment, in particular, whether estimates are meant to represent proportions at age in the catch or proportions at age in the population. Given that this has not yet been resolved in the SAG/SC, we only present results for the standard approach (standard ALK) this year. It would, of course, be possible to run the analyses on the data in future.

Methods

Otolith sampling and selection

Sagittae otoliths for age determination were selected from those already collected and archived into the CSIRO hardparts collection. The otoliths selected were sampled from SBT caught in Australian's surface fishery in the GAB in the 2004-05 (n=157) fishing season. A fishing season runs from Nov/Dec to April of the following year. 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 weighed to the nearest 0.0001 g 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 Average Percentage Error (APE) method of Beamish and Fournier (1981) was used to measure the intra-reader consistency in otolith readings (replicate readings by the primary reader) as well as inter-reader consistency (final age estimate by primary and secondary reader). All readings were conducted without reference to the size of the 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., In Prep.). 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.

Length-frequency data

Catch at size data for the Australian surface fishery was obtained from the data exchange documents for 2001 to 2004. In addition, we obtained the "revised"[1] catch at size data for 2002 to 2005 (Sahlquist et al., 2006). We calculated catch at size for the 2001/02, 2002/03 and 2003/04 fishing seasons using both data sets (original and revised), and catch at size for the 2004/05 season using the revised data (note that a fishing season runs from December of one year to April of the next year). Since the revised catch at size data is only available back to 2002, we used the original catch at size data for December 2001 to determine the 2001/02 revised catch at age.

It is evident that the original and revised catch at size data are almost identical (Fig. 1). Given this, and since the estimated catch at age using both data sets are also almost identical (the only differences occur at the 3rd decimal place), we only present results for the original data for the 2001/02 to 2003/04 fishing seasons, and the revised data for the 2004/05 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. The length frequency vector for year t, weighted and re-scaled as just described, is simply 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

[1] The revised data are processed with a different way of dealing with fish less than 10kg fish in the sample. See the reference for details

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

Age estimates

Age was estimated for 152 SBT ranging in size from 46-167 cm FL (Fig. 2 and 3). Of the otoliths read, the second age estimate of the primary reader agreed with the original estimate in 60% of cases and 97% were within one year of the original. The average percent error between readings by the primary reader was 5.82%, and between the two readers was 4.17% (n=20). These precision estimates are considered good, and the low levels of error suggest consistent interpretation of age in blind tests.

The standard ALK for each season is given in Table 1. These were applied to the length frequency distribution for each season.

Proportions at age

Results for the standard ALK approach for all fishing seasons examined are shown in Table 2 and illustrated in **Error! Reference source not found.**. For comparison, the cohort-sliced proportions at age (as provided to CCSBT) are shown in Figure 5.

The estimated proportions at age are quite similar for 2001-02 and 2002-03 (the majority are age 3 and 4) but differs from the age distribution for 2003-04 and 2004-05 where most are age 2 and 3. As noted in CCSBT-ESC/0509/19, the results for the standard ALK are somewhat different from the cohort-slicing method. As noted in Morton and Bravington (2003), the parametric approaches are superior to the standard ALK approach, and we consider that those are the approaches that 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 the assessment. The standard ALK estimates shown here should only be taken as illustrative.

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Tables

Table 1. Age length key for the 2001-02 to 2004-05 fishing seasons for the GAB surface fishery. The upper length of each 5cm length bin is given in the first column, and age estimates are shown across the top.

2001-02	1	2	3	4	5	6	7	8	9	10	Total
70		1									1
75		2	1								3
80		1	1								2
85		1									1
90			3								3
95		2	11	5							18
100			11	7	1						19
105			9	11							20
110			3	18							21
115			3	10	5						18
120				2	3	2					7
125					3						3
130					3	1					4
135					1						1
140						1	2				3
Total		7	42	53	16	4	2				124

2002-03	1	2	3	4	5	6	7	8	9	10	Total
65	1										1
70	1										
75		2									2
80			1								1
85		4	4								8
90		4	7								11
95			3	3							6
100			7	3							10
105			6	3	1						10
110			3	6	1						10
115			2	7	1						10
120				8	2						10
125			1	3	6						10
130					11	1					12
135					1	3	2				6
140				1	1	3	1	2			8
145					1	1		1			3
150						2		1			3
Total	2	10	34	34	25	10	3	4			122

2003-04	1	2	3	4	5	6	7	8	9	10	Total
50	1										1
55	9										9
60	9										9
65	8	1									9
70	1	2									3
75		8									8
80		9									9
85		5	1								6
90		5	4	1							10
95		3	7								10
100		2	8								10
105			7	3							10
110			5	5							10
115			2	6	2						10
120				8	2						10
125			1	5	4						10
130				7	4						11
135				1	7	6					14
140					3						3
145						6	1				7
150						1					1
155											0
160											0
165							1				1
Total	28	35	35	36	22	13	2				171

2004-05	1	2	3	4	5	6	7	8	9	10	Total
50	4										4
55	5										5
60	6	2									8
65	3	5									8
70											0
75		7									7
80		6	1								7
85		5	2								7
90			6								6
95		2	6								8
100			5	1							6
105			3	2	1						6
110			3	4							7
115				4	2						6
120				6	1						7
125			1	1	3	1					6
130					5	2					7
135					4	1	1				6
140				1	1	2	3	1	1		9
145						2	4	4			10
150							9	2			11
155						1	2	3			6
160							1	2			3
165										1	1
170									1		1
Total	18	27	27	19	17	9	20	12	2	1	152

Table 2: ALK. Proportions at age for the three fishing seasons using the standard "age-length key" method. (Four decimal places are shown to retain the small but non-zero proportions for ages 1 and >4)

Season	1	2	3	4	5	6	7	8	9
2001-2002		0.0541	0.5185	0.3730	0.0505	0.0033	0.0006		
2002-2003	0.0006	0.0695	0.5635	0.3136	0.0503	0.0016	0.0008	0.0002	
2003-2004	0.0007	0.3522	0.5612	0.0856	0.0003				
2004-2005		0.3104	0.5330	0.1183	0.0370	0.0008	0.0004	0.0000	0.0000

Figures

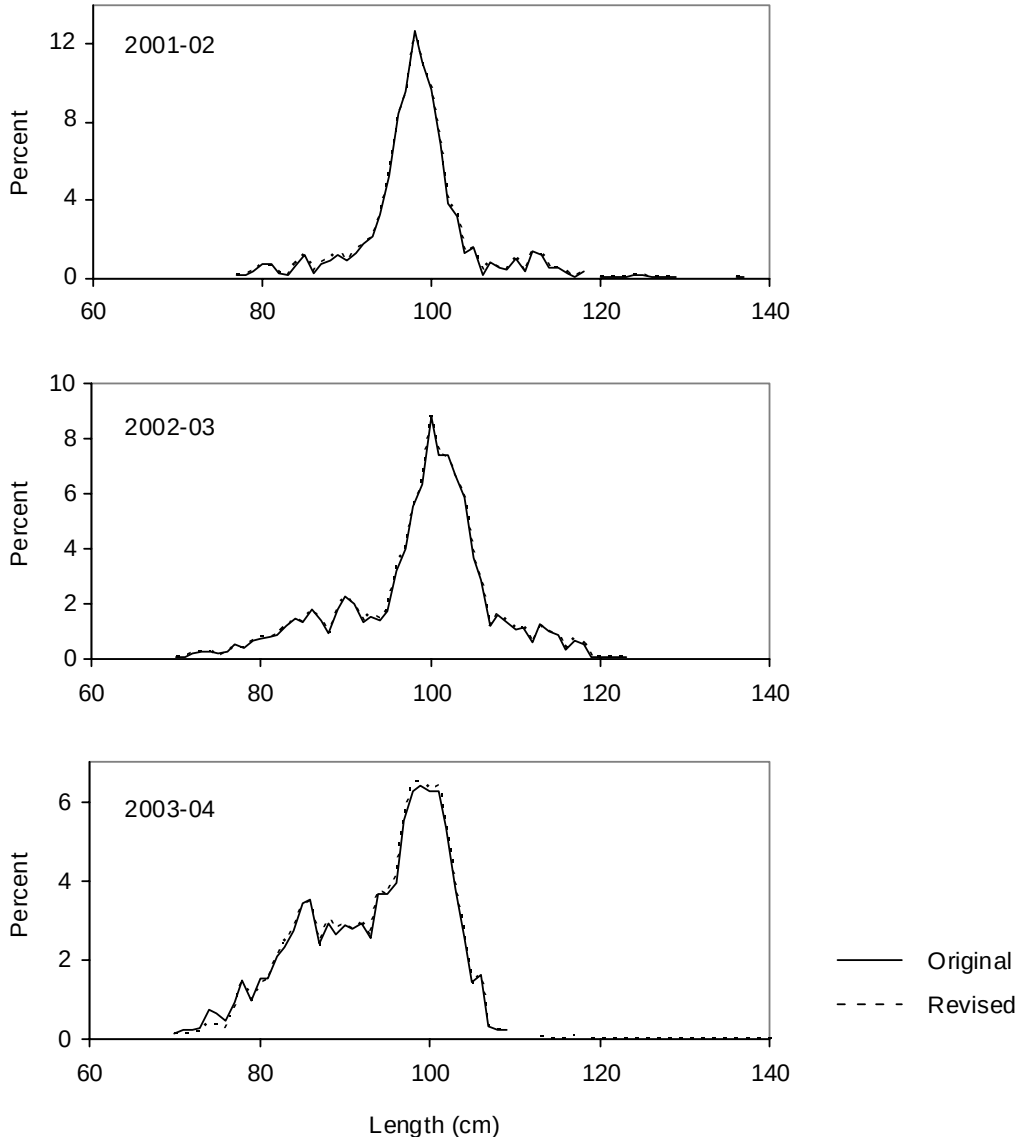

Figure 1: Comparison of "original" and "revised" catch at size data for the 2001/02, 2002/03 and 2003/04 fishing seasons (a fishing season is from December to April).

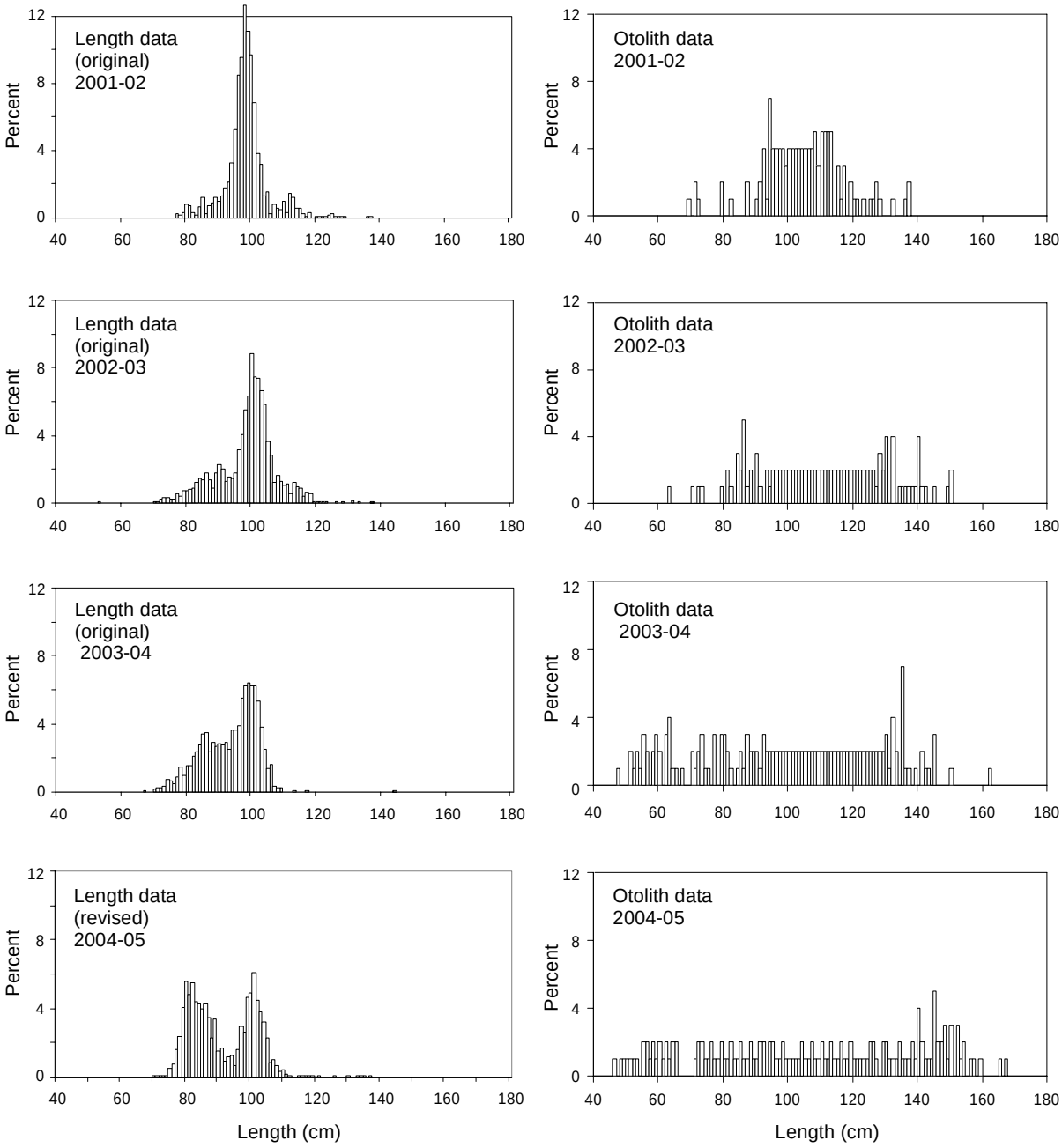

Figure 2: The frequency per fishing season of each length class for the catch and otolith data sets.

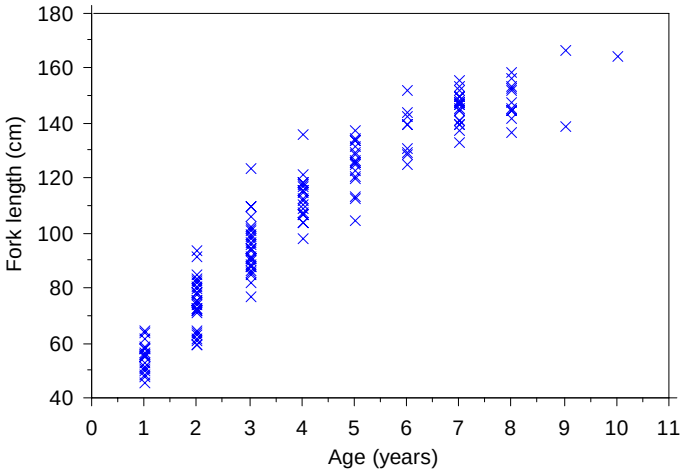

Figure 3: Length at age for SBT caught in the GAB surface fishery in the 2004-05 fishing season (n=152).

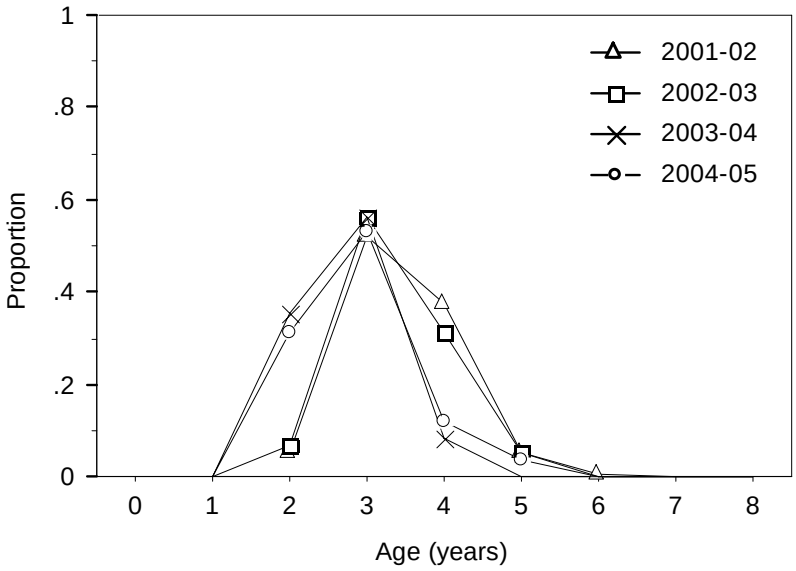

Figure 4: The estimated proportions at age for the given fishing seasons using the “age-length key” method.

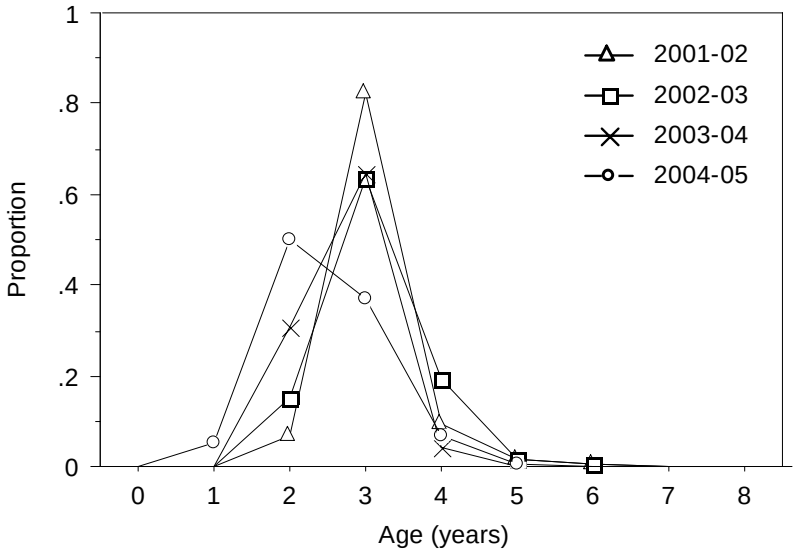

Figure 5: Proportions at age from cohort-slicing for comparison. Taken from the data exchange documents (filenames: AusDomCAAPS2002_2004bySeason.xls and AUS 2005 Surface Fishery CAA by Season.xls).