Australian Government

Australian Fisheries Management Authority

Evaluation of SBT direct ageing requirements for the Australian longline fishery

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CSIRO Oceans and Atmosphere

2017/0838
May 2019

Contents

Version	Updates	Approver

Executive summary

The SBT stock is assessed using age and length-based models, which require estimates of the commercial catch in numbers at age or numbers at length. The most common method for estimating numbers at age is developing age-length keys (ALK) where a subsample of fish from the catch is aged using otoliths, and the age of the remaining fish is estimated using their length measurements from random sampling the catch. The catch of SBT by the Australian longline fleet has grown in recent years, which has raised the question of whether it is necessary to collect otoliths from this fishery to estimate the age composition of the catch. Before substantial effort is made to collect and read otoliths from the catch, it is essential to determine the number of age estimates required to achieve target levels of precision (CVs ~0.25). It is also important to assess whether length-at-age data collected by other CCSBT members in the region fished by the Australian longline fleet catching SBT could be applied to the Australian catch.

Here we developed statistical models to evaluate the number of direct age estimates required to estimate the age composition of SBT in the catch of the Australian longline fishery. We recommend a minimum of 300 otoliths (age estimates) are obtained annually using a length-stratified sampling approach. This would provide estimates of proportion-at-age with CVs of 0.25 or less for ages that constitute at least 5% of the catch (ages 4-9) assuming the ALK is applied to at least 1000 representative (random) length samples from the fishery. Current otolith sampling/ageing programs in the region fish by the Australian longline fleet (statistical areas 4 and 7) are not adequate to develop an ALK for application to the Australian catch.

Almost all SBT caught in the longline fishery are between 110 and 180 cm FL. Sampling 20 fish per 5-cm length class would provide the minimum of 300 otoliths required for direct ageing. However, we recommend that fish outside this size range are also sampled if present (up to 20 per 5-cm length class). This is particularly important in years when fish smaller than 110 cm and/or larger than 180 cm appear in greater proportions in the catches, as the aim of the sampling program is to collect otoliths from the full range of sizes caught while maintaining sufficient numbers of otoliths in each size class.

Given the nature of the longline fishery, it is difficult to provide a prescribed system for otolith sampling, however, guidelines are provided. Sampling at each of the five main ports will need to be determined on an opportunistic basis when fish are being landed/processed. Monitoring the sampling regularly is required to ensure the minimum number of samples is obtained in each length class and that sampling bias (due to spatial and temporal coverage) is minimised.

1 Background

Southern bluefin tuna (SBT) is classified as Critically Endangered by the IUCN Red List of Threatened Species, and is listed as conservation dependent within Australia. Estimates of adult (10+) biomass have been as low as 3-5% of unfished levels (in 2011) but have since improved and are the spawning biomass was estimated at 11-17% in the most recent stock assessment (Anon. 2017). Recent TAC decisions have seen Australia's total allowable catch of SBT increased from 4,015 (in 2010) to 6,165 tonnes (in 2018).

The ability of a stock assessment to estimate adult biomass is dependent on accurate knowledge of key biological parameters of the stock. The SBT stock is assessed using age and length-based models, which require estimates of the annual catch in numbers-at-age (catch-at-age), or size composition of the catch (catch-at-length) and total numbers of fish caught, for each fishery as an input. In the case of the latter, there is a need to convert catch-at-length into catch-at-age within the SBT operating models.

Direct age data is often expensive to obtain compared to length data. This has led to a limited number of fish being aged directly and the reliance on age-length-keys (ALKs) to infer the age frequency composition of the catch from the length-frequency distribution obtained through monitoring.

In 2002, the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) members agreed to adopt an otolith sampling program, and an otolith ageing workshop was held to standardise otolith reading methods (Anon. 2002). In 2003, Morton and Bravington (2003) developed efficient parametric methods to estimate proportions-at-age for SBT combining direct age and length frequency data (the M&B method) and provided target otolith sample sizes that should be collected and aged from the Australian surface (n=100-200), Japanese longline (n=200-500) and Indonesian longline (n=500) fisheries to provide acceptable levels of precision (CVs of 0.25 or less). However, it was recognised that the sample sizes would need to be refined for individual fleets and/or areas, and after the use of the direct age data in the stock assessment had been defined (Preece et al., 2012).

In Australia, SBT are caught by purse seine and pelagic longline gear. The purse seine (surface) fishery operates in the Great Australian Bight (GAB) and catches the majority of Australia's total allowable catch. Since 2002, AFMA has commissioned the collection of between 100 and 400 otoliths annually from the surface fishery, as part of Australia's responsibility to provide direct age information to the CCSBT. Of these, 100 are selected and aged by CSIRO and the proportions-at-age in the catch are calculated using both the standard ALK (which uses age information from only the direct age data) and the M&B method (which also uses age information contained in the length frequency data) (see Farley and Eveson, 2018).

The catch of SBT by the Australian longline fleet off the east coast has grown in recent years from 58 tonnes in 2011-12 to over 700 tonnes in 2015-16. This has raised the question of whether it is necessary to collect otoliths for estimation of the age composition of the catch of this fishery (for use in the SBT operating models), and if so, how many otoliths (age estimates) are required and how will length-at-age data be used to estimate catch-at-age with required level of precision. The size range of SBT caught in the longline fishery (~110-180 cm fork length) is larger than those caught by the surface fishery (~80-110 cm respectively) so length-at-age data currently collected by Australia cannot be applied to the longline fishery.

This project evaluates the direct ageing requirements for the Australian longline fishery and provides recommendations and guidelines for future monitoring programs.

2 Need

It is expected that the CCSBT will move to direct age based methods for converting catch-at-length into catch-at-age in the SBT stock assessment rather than the current "cohort-slicing" approach, which has recognised deficiencies. In 2004, the CCSBT agreed that all fisheries should collect and analyse otoliths, and the provision of direct ageing data for all countries is listed in the CCSBT data exchange annual requirements. As a member of the CCSBT, Australia has an obligation to provide direct age information.

Before substantial effort is made to collect and read otoliths from SBT in the Australian longline catch, it is essential to determine the number of age estimates required to obtain the desired level of precision (CV) in the estimated proportions-at-age. It is also important to assess whether length-at-age data collected by other CCSBT members in the region fished by the Australian longline fleet catching SBT could be applied to the Australian catch.

3 Objectives

Objectives for the project were:

1. **Determine the otolith sampling requirements and the statistical methods that would be required to estimate the age composition of SBT in the Australian longline fishery with the desired precision.**

   Evaluate methods to estimate the age composition of catch using direct age and commercial catch length data, and determine the most appropriate method for the Australian longline fishery. Through simulation modelling, determine the optimal otolith sampling design for the fishery based on precision and cost.

2. **Determine if direct age data collected from other longline fisheries could be applied to the Australian fishery.**

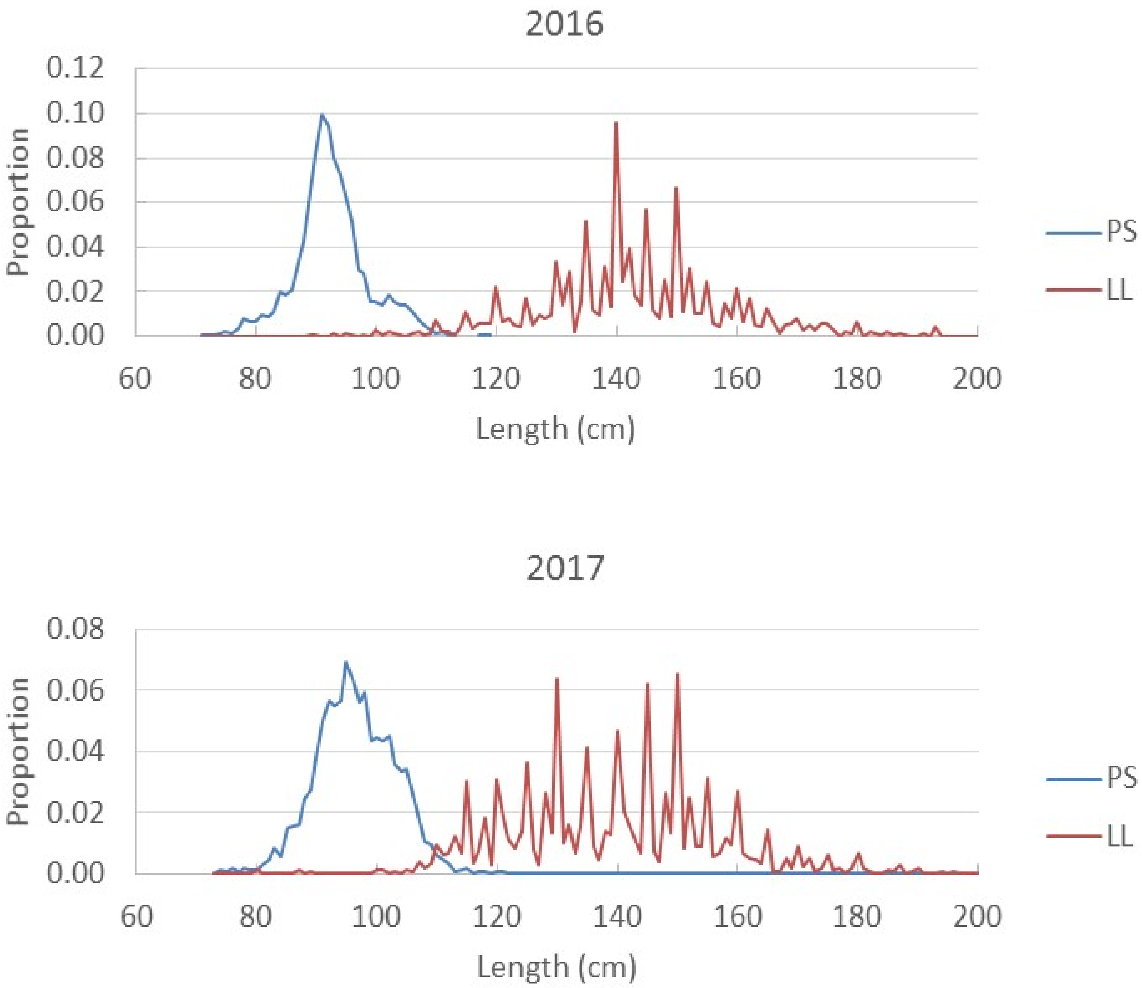
Compare the size distribution of SBT in catches by Australia and other CCSBT members in the region to determine if they are similar or not. Investigate otoliths sampling programs by CCSBT members and determine if the length-at-age data can be applied to the Australian fishery. Based on the results of this, determine if additional age data from the longline fishery is required. Assess the relative importance of the Australian longline fishery age data in the SBT operating model.

4 Results against objectives

4.1 Otolith sampling requirements

Length frequency data files were obtained for SBT caught by the Australian longline fishery in 2016 and 2017. The majority of fish caught were between 110-180 cm fork length (FL) (Fig. 1), substantially larger than caught by the Australian purse seine fishery (Fig. 1). Most of these fish are likely to be age >4 years based on the current CCSBT growth curves (see Table 1). Simulation methods can be used to investigate sample sizes (and sampling design) required to achieve desired levels of precision in proportion at age estimates obtained using a given statistical method. The most common method for estimating proportions at age from age and length samples in a given year (i.e., where age is determined from otoliths) and a length distribution sample in the same year, is via an age-length key (ALK). The ALK does not use the information on age contained in the length samples alone; thus Morton and Bravington (2008) proposed a method that makes use of this information and is potentially more efficient, referred to as the “M&B method”. This method was used to evaluate sample size requirements for estimating proportions at age for the Australian purse seine fishery. However, because the length frequency data for the longline fishery contains very little age information for SBT beyond age 4 years (since the length-at-age distributions of cohorts overlap significantly), the efficiency gained by using the integrated M&B method will be minimal for the Australian longline fishery. As such, we used the ALK method in our simulations for this project.

Figure 1 Length frequency of SBT caught in the Australian longline (LL) and purse seine (PS) fisheries in 2016 and 2017.



For the ALK method, the length frequency data are multiplied by the proportion of fish in each age class at a given length to give numbers (or proportions) at age. In mathematical terms, the proportion of fish of age *a*, p_a, is estimated as follows:

$$\hat{p}_a = \sum_l \frac{N_l}{N} \frac{n_{al}}{n_l}$$

where N_l is the number of fish in the length sample of length *l*, n_{al} is the number of fish in the age-length sample of age a and length *l*; $N = \sum_l N_l$, $n_l = \sum_a n_{al}$, and $n_l = \sum_a n_{al}$.

We simulated data for various combinations of otolith age-length sample sizes (*n*=100, 200, 300, 400, 500) and length only sample sizes (*N*=500, 1000, 2500). We used the proportions at age calculated from the 2016 and 2017 catch at age data for the Australian longline fishery as the true proportions at age (p_a) (Table 1), and simulated the number of the *N* fish sampled for length belonging to each age class using a multinomial distribution with probability p_a. Next we used the parameters from the VB log k growth model currently used by the CCSBT for fish born since the 2000s (Table 2) to generate an expected mean length at age $E[L(a)]$ for each of these fish, then added on a random normal component with variance in length at age based on the VB log k model estimates, namely, $V[L(a)] = (\sigma_\infty * E[L(a)]/\mu_\infty)^2 + \sigma_\gamma^2$. These lengths formed the length-frequency sample. We then selected *n* of these fish to have been sampled for otoliths for which both age and length were known. The simulated data were used to estimate p_a via the equation above for $\hat{p}_a$.

To evaluate the effect of sampling strategy on the results, otolith samples were assumed to have been selected either: (i) randomly from all length samples, or (ii) stratified by 5-cm length classes (for length classes with less than the required number of samples available, all available samples were selected and the remainder selected at random from the other length classes). For each sampling strategy and value of *N* and *n*, 1000 simulations were carried out, and the mean and coefficient of variation (CV) of the 1000 proportion at age estimates obtained.

aAs expected, the mean proportion at age estimates were close to the true values in all cases (i.e., the estimates were unbiased). In terms of precision, varying the length sample size (*N*) made little difference to the results since the length distribution is only used to weight the sample distributions of age-at-length; no use is made of the age information content of the length distribution itself. Thus, we only show results here for *N*=1000. The CVs in the estimated proportions at age with *N*=1000, an otolith sample size (*n*) varying from 100 to 500, and with otoliths selected randomly, are given in Table 3. The CVs for age classes 4-9, for which the true proportion at age is greater than 0.05, range from 0.20 to 0.37 when *n*=100, and from 0.08 to 0.15 when *n*=500. In comparison, the CVs for the case when otoliths were selected by 5-cm length classes are given in Table 4. The CVs for age classes 4-9 increased slightly compared to random sampling (ranging from 0.24 to 0.44 when *n*=100, and from 0.09 to 0.16 when *n*=500), whereas those for the uncommon age classes (particularly ages 1-3) decreased more significantly. This makes sense because with stratified sampling larger sample sizes are being taken from the less common length (age) classes, which results in smaller sample sizes being taken from the most common length (age) classes.

Table 1 Vector of proportions at age (P_a)used in simulations (based on catch at age data for the Australian longline fishery in 2016 and 2017, which was estimated from catch at length data using the CCSBT growth model in Table 2).

Age	p_a	Age	p_a	Age	p_a	Age	p_a
1	0.000	6	0.146	11	0.032	16	0.003
2	0.004	7	0.203	12	0.019	17	0.006
3	0.026	8	0.131	13	0.009	18	0.006
4	0.110	9	0.072	14	0.011	19	0.002
5	0.146	10	0.046	15	0.007	20+	0.021

Table 2 VB log k growth model parameter estimates used by the CCSBT for fish born since 2000 (see Polacheck et al., 2004 for a description of the VB log k growth model and definitions of parameters).

μ_∞	σ_∞	k_1	k_2	α	β	u	w	μ_{logA}	σ_{logA}	σ_s	σ_f	a_0	σ_γ
180	9.787	0.242	0.169	3.434	30	0.127	0.16	0.868	0.18	3.636	0.000	-0.429	7.672

Table 3 CVs of the proportion at age estimates when the length sample size (N) is 1000 and the otolith sample size (n) is either 100, 200 300, 400 or 500 randomly sample by length. Age classes 4-9 (shaded grey) have a true proportion at age of at least 0.05 and are of greatest interest.

Age	p_a	100	200	300	400	500
1	0.000	4.86	3.58	2.83	2.54	2.29
2	0.004	1.88	1.26	1.05	0.87	0.78
3	0.026	0.68	0.46	0.35	0.30	0.27
4	0.110	0.27	0.18	0.15	0.13	0.12
5	0.146	0.24	0.16	0.13	0.12	0.10
6	0.146	0.25	0.17	0.14	0.12	0.11
7	0.203	0.20	0.14	0.11	0.10	0.08
8	0.131	0.26	0.18	0.14	0.12	0.12
9	0.072	0.37	0.25	0.21	0.18	0.15
10	0.046	0.49	0.34	0.27	0.23	0.20
11	0.032	0.60	0.40	0.33	0.28	0.25
12	0.019	0.78	0.53	0.42	0.35	0.33
13	0.009	1.20	0.78	0.66	0.57	0.48
14	0.011	1.02	0.69	0.57	0.47	0.43
15	0.007	1.43	0.93	0.75	0.61	0.54
16	0.003	2.04	1.42	1.11	0.90	0.82
17	0.006	1.58	1.06	0.81	0.69	0.63
18	0.006	1.57	0.95	0.82	0.69	0.63
19	0.002	2.59	1.81	1.47	1.28	1.08
20+	0.021	0.78	0.49	0.40	0.36	0.30

Table 4 CVs of the proportion at age estimates when the length sample size (N) is 1000, the otolith sample size (n) is either 100, 200, 300, 400 or 500, and otoliths have been sampled by 5-cm length-classes (stratified sampling). Age classes 4-9 (shaded grey) have a true proportion at age of at least 0.05 and are of greatest interest.

Age	p_a	100	200	300	400	500
1	0.000	1.52	1.45	1.59	1.54	1.58
2	0.004	0.57	0.51	0.50	0.49	0.49
3	0.026	0.44	0.30	0.25	0.24	0.21
4	0.110	0.27	0.19	0.15	0.13	0.12
5	0.146	0.27	0.18	0.15	0.13	0.11
6	0.146	0.30	0.20	0.16	0.13	0.12
7	0.203	0.24	0.16	0.13	0.11	0.09
8	0.131	0.32	0.21	0.16	0.14	0.13
9	0.072	0.44	0.28	0.23	0.19	0.16
10	0.046	0.51	0.35	0.28	0.23	0.20
11	0.032	0.61	0.39	0.31	0.28	0.23
12	0.019	0.72	0.50	0.40	0.33	0.31
13	0.009	1.07	0.71	0.58	0.50	0.44
14	0.011	0.85	0.57	0.48	0.41	0.37
15	0.007	1.07	0.73	0.58	0.54	0.45
16	0.003	1.42	1.03	0.84	0.72	0.69
17	0.006	1.15	0.76	0.64	0.56	0.49
18	0.006	1.12	0.76	0.63	0.56	0.50
19	0.002	1.68	1.27	1.06	0.98	0.88
20+	0.021	0.52	0.37	0.30	0.26	0.25

4.2 Otolith sampling and direct ageing programs in the region

To determine if direct age data collected from other longline fisheries could be applied to the Australian fishery, we examined the available direct ageing data collected by CCSBT members and the length frequency of longline catches in the south-east Australian region. Most of the Australian longline catch is caught in statistical area 4 (Error! Reference source not found.) (75% in 2017 and 85% in 2016), with the remainder caught around Tasmania in statistical area 7. The only direct age data provided to CCSBT from longline operations in statistical area 4 is from Japan (Table 4). The direct age data from nearby regions in areas 5-7 in recent years indicates that only small numbers of otoliths have been aged each year, except for the consistent provision of direct age data from area 6 provided by New Zealand (Table 5) for the charter fishery, which has now ceased (Anon. 2016). Overall, the numbers of direct age estimates from statistical areas 4, 5 and 7 is small and patchy between years, however, the numbers of otoliths collected and archived by members is probably larger as not all otoliths collected are necessarily aged. For example, only 100 of the 150-300 otoliths collected each year from the Australian surface fishery are aged (e.g., Farley and Eveson 2018).

Figure 2 Map showing the CCSBT statistical areas of fishing

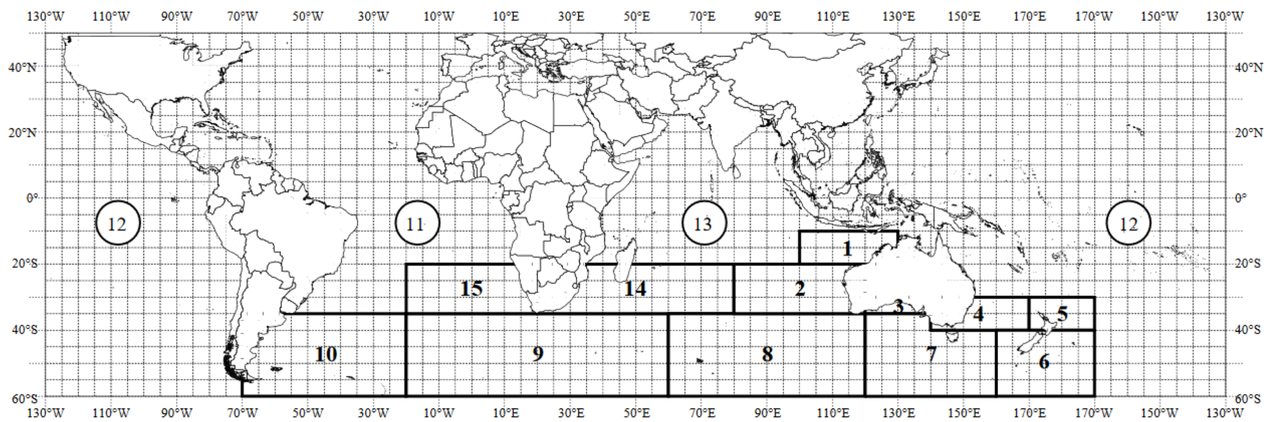


Table 4 Number of direct age estimates from CCSBT members for each statistical area. Source: CCSBT data exchange CD, Jan 2019.

		STATISTICAL AREA											
Member	**Years**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**11**	**14**	**NULL**
Australia	2001-2016			1633				26					
Indonesia	1994-2015	6043									2		2187
Japan	1994-2015	78	73		347	19		634	1665	1921	10		
Korea	2015-2016								100	198			
New Zealand	2001-2015					72	3234						31
Taiwan	2003-2015		766						79	59	22	283	
Total		6121	839	1633	347	91	3234	660	1844	2178	34	283	2218

Table 5 Number of direct age estimates from otoliths collected from longline fisheries in recent years (since 2011) from statistical areas 4-7. Source: CCSBT data exchange CD, Jan 2019.

STATISTICAL AREA	YEAR	MEMBER	NUMBER OF DIRECT AGE ESTIMATES
4	2011	Japan	5
4	2012	Japan	2
4	2014	Japan	1
4	2015	Japan	32
5	2011	Japan	18
5	2015	Japan	1
6	2011	New Zealand	252
6	2012	New Zealand	255
6	2013	New Zealand	252
6	2014	New Zealand	257
6	2015	New Zealand	254
6	2016	New Zealand	89
7	2012	Australia	26
7	2012	Japan	5
7	2014	Japan	222
7	2016	Japan	44

A comparison of the length frequency of the Japanese and Australian catches in statistical area 4 (Figure 3) indicates that these fisheries are operating slightly differently (possibly through targeting, or areas and times fished), resulting in differences in the sizes of the fish landed. The NZ length-frequency data from statistical areas 5 and 6 (Figure 4) are similar to one another and to the Japanese length-frequency data in area 4, but do not match with the Australian data in area 4. The range of lengths represented in the data from the other longline fisheries in the region encompass the range of lengths of fish currently landed by the Australian longline fishery. Good quality length data are collected by the Australian Industry at time of processing of fish.

The Australian longline catch in area 7 is currently very small (25% of the Australian longline catch in 2016 and only 15% in 2017). Figure 5 compares the length frequency of the 2016 Australian and Japanese catches in area 7, which are reasonably similar although as with areas 4, 5 and 6, there are some slight differences in catches of small fish.

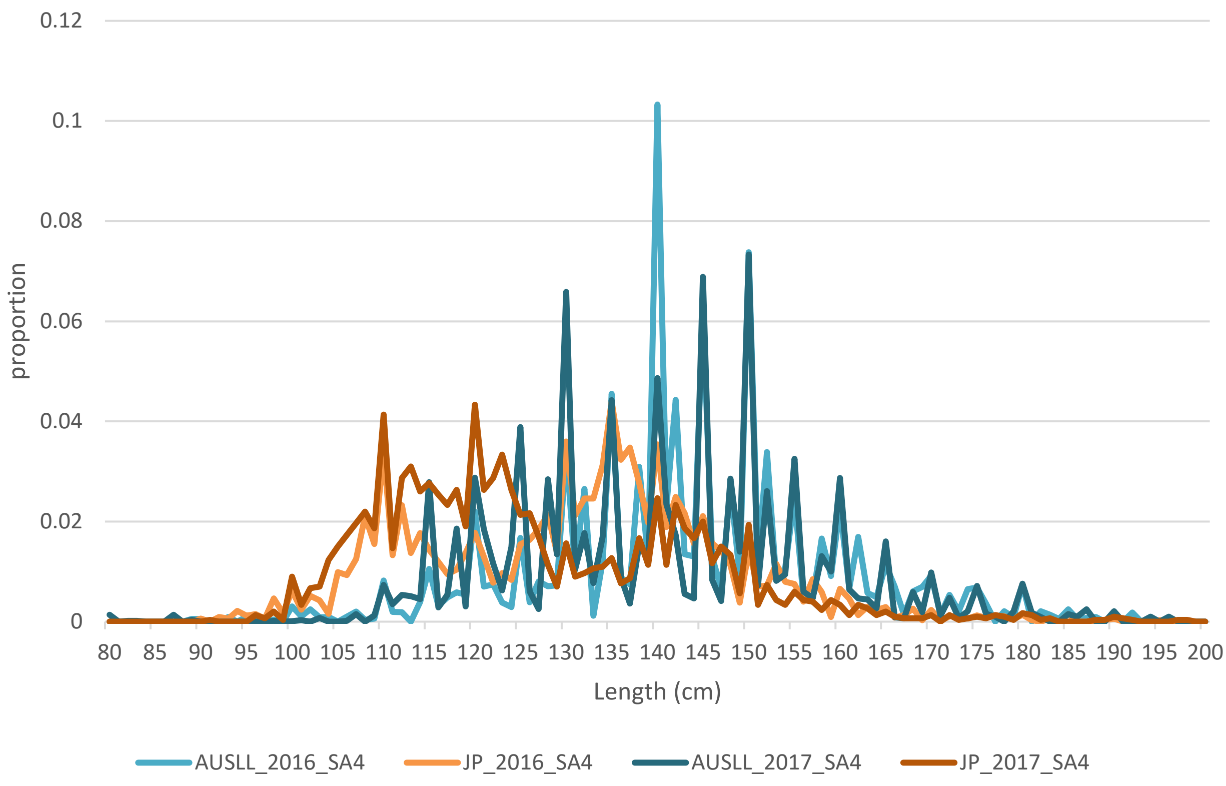


Figure 3 Length frequency of the Australian (blues) and Japanese (browns) longline catches in statistical area 4 in 2016 and 2017.

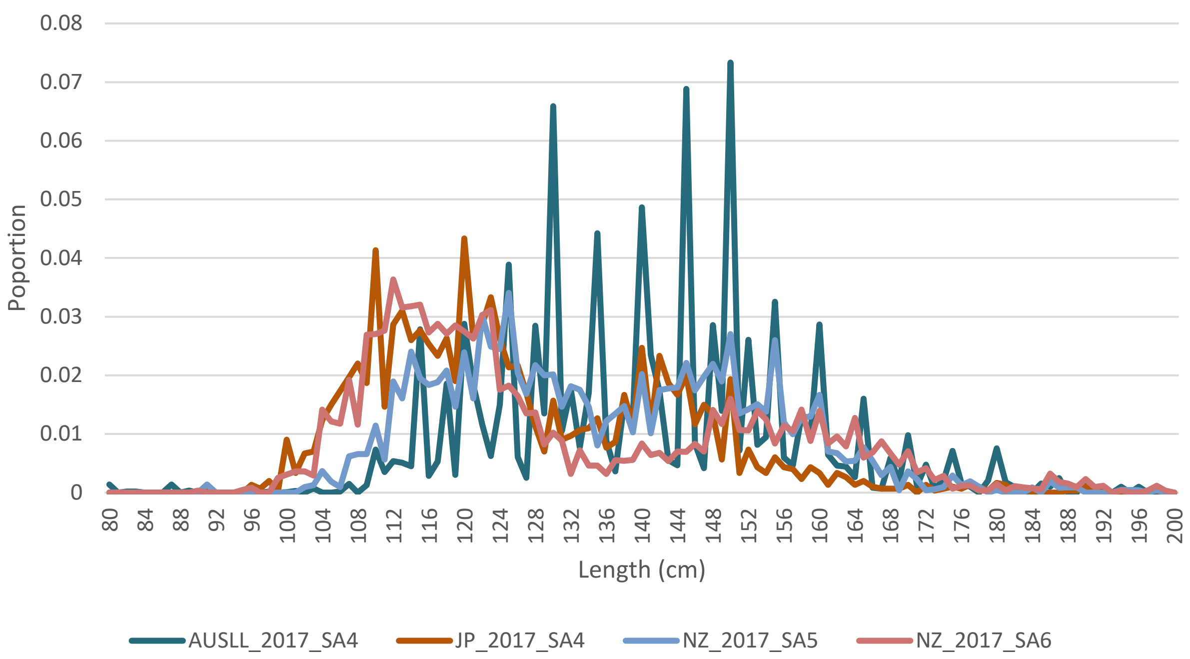


Figure 4 Length frequency of the longline fisheries in 2017 in statistical area 4 (Japan and Australia), compared to statistical areas 5 and 6 (NZ).

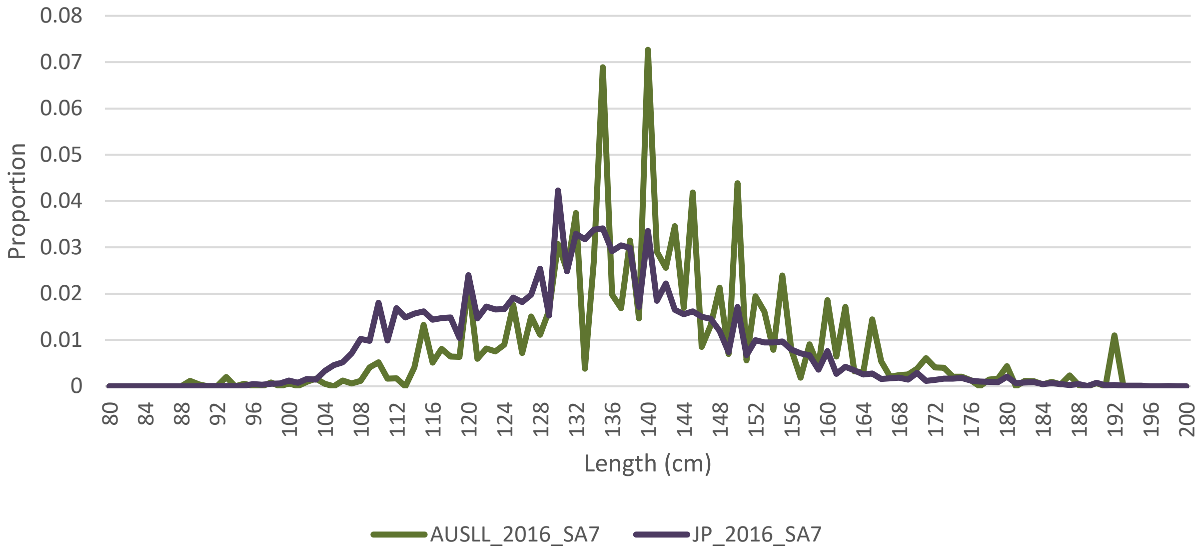


Figure 5 Length frequency of SBT caught in longline fisheries in statistical area 7 in 2016 by Japan and Australia.

4.3 Catch sampling program in Australia

The simulation results (Section 4.1) indicate that a random sample of 200-300 SBT per year for age determination would provide estimates of proportion at age with CVs of 0.25 or less for ages that constitute at least 5% of the catch (4-9 years). Although random sampling leads to slightly smaller CVs for these ages, it not logistically possible for commercial fisheries unless a formal randomised strategy is followed. Haphazard sampling of ports, vessels and fish is not a truly random process.

Stratified sampling of 300 SBT by 5-cm length bins would provide similar CVs for ages 4-9, compared to random sampling, and lower CVs for the remaining age classes. Thus we recommend that this method is followed for the Australian SBT longline fishery assuming that the resultant ALK is applied to at least 1000 representative (random) length samples from the fishery (same population) each year. Figure 1 shows that almost all SBT caught in the longline fishery are between 110 and 180 cm FL (15 x 5-cm length bins). A total sample size of 300 equates to 20 fish per length bin for this size range. Note that if a minimum of 20 otoliths per length bin cannot be obtained, then a greater number of otoliths should be collected from the remaining length bins to total 300.

In years when a wider range of sizes appear in the catches, we recommend that fish smaller and larger than this size range are also sampled. Ideally, the otoliths should represent the full range of sizes in the catch while maintaining sufficient numbers of otoliths in each size class.

Approximately 80% of the Australian longline caught SBT are landed or processed in five main locations: Ulladulla, Bermagui, Eden, Sydney and Mooloolaba (Matt Daniel, AFMA

Manager, pers. comm.). The length frequency of SBT landed at these ports is expected to be similar (Matt Daniel, AFMA Manager, pers. comm.) as fishing companies have similar targeting and fishing practices. However, to best ensure representative sampling of otoliths, all five ports should be included in an otolith sampling program to reduce potential bias in the program if the length frequency of SBT does vary between ports. As Eden, Ulladulla and Bermagui are in reasonably close proximity to one another and Sydney and Mooloolaba readily accessible, sampling all ports should be achievable.

Given the nature of the longline fishery, it is difficult to provide a prescribed system for otolith sampling. Port sampling will need to be determined on an opportunistic basis when fish are being landed/processed. General guidelines are:

- Sample the five main ports with the number of otoliths collected proportional to the catch landed at that port.
- Spread the sampling evenly throughout the fishing season (May to September) to account for seasonal variation in the size of fish caught.
- If the length frequency of SBT landed at each port was similar, then it may be possible to obtain representative samples by randomly selecting one landing port each fortnight and sampling ~30 fish stratified by length as much as possible. This would mean each port gets sampled twice since there are ~10 fortnights between start of May and end of September, for a total of 300 samples (5 ports x 30 samples x 2 time periods).
- Since variance in fish length is likely to be smaller within a vessel landing than between landings, we recommend collecting a small number of otolith samples from individual trips rather than a large number from a single trip.
- Monitor sampling regularly to ensure the minimum number of samples is obtained in each length class and that sampling bias is minimised (e.g. due to poor spatial or temporal coverage). Flexibility in the sampling program is needed as higher sample sizes may be required in years when a wider range of fish sizes appear in the catch.

A detailed outline of the costs of an otolith sample collection program is difficult to provide as it would depend on the number, size and frequency of SBT landed in each port, and the travel time/distance to each port. However, the cost per fish is likely to be around $25-50. This does not include the cost of reading the otoliths to estimate age.

4.4 Importance of Australian longline age data in the Operating Models

The Australian longline fishery catches have increased in recent years, reaching 12-13% of the Australian catches (in weight) in the 2015-16 and 2016-17 seasons (Hobsbawn et al., 2018). In statistical area 4, the Australian longline catches account for 70-80% of the catch in numbers.

In 2016 and 2017 the Australian longline catches made up 10% of the catch in numbers of the main “LL1” fishery in the SBT operating model, and approximately 5% of the total reported global catch in weight (CCSBT 2018). The “LL1” fishery is a combination of longline fisheries across statistical areas, comprised of the Japanese longline fishery

(~60%), as well as New Zealand (~15%), Australian (~10%), Korean, Taiwanese and others. The data inputs to the SBT operating model for the "LL1" fishery are total catch in weight and proportions at length for the full historical time period of the fishery (1952-current). The data inputs to the SBT operating model for the "LL1" fishery are total catch in weight and proportions at length for the full historical time period, but these amalgamated data for "LL1" are not used in the CPUE standardisation which uses Japanese, NZ charter and historical Australian Joint Venture data only.

The intention of the otolith collection program within the CCSBT was to provide catch at age data for the annual indicator analysis and for use in stock assessments (Anon. 2004). For example, the time series of direct age data from the New Zealand charter fishery has been an informative indicator of strong cohorts as they entered the fishery, corroborating stock assessment estimates of strong and weak recruitment years. The indicator analysis is a key component of the annual review of exceptional circumstances that are considered in the meta-rules process for the CCSBT management procedure. An Australian longline otolith collection program would contribute valuable information of the age frequency of the catch in statistical area 4. There is a paucity of direct age data from the region. Catches in area 7 by the Australian longline fishery are very small and direct age data from this component of the global fishery are not likely to be highly informative in the SBT operating models at current levels, but may contribute data for direct ageing of the catch in the larger fisheries operating in this area.

The time series of direct ageing data collected by the CCSBT since the 2004 agreement has not been analysed to consider whether the current stratification of otolith collection is adequate or should be improved, or whether a proportions-at-age time series could be generated for inclusion in the SBT operating models. Catch at age data is currently only available for the Indonesian fishery (direct age data) and Australian surface fishery (cohort-sliced data) for input to the operating models (Preece et al., 2012). A review of the sampling schemes should be undertaken by the ESC as part of the scheduled review of the CCSBT Scientific Research program, as suggested (Anon. 2004; Preece et al., 2012), and any technical issues further discussed as part of a proposed CCSBT workshop on otolith-based ageing (Anon. 2014).

5 Benefits / Management Outcomes

An important focus of this project was to complete the statistical analyses to determine otolith sample size requirements explicitly for the Australian longline fishery. This will benefit stakeholders by reducing the likelihood of unnecessary sampling above the recommended level, reducing the cost to the fishery while providing the required monitoring and data. Furthermore, the methods applied here have applications to other SBT fisheries intending to use ALKs to estimate the age distribution of the catch. This will benefit the CCSBT Scientific Committee.

Our evaluation has shown that there are insufficient otoliths already being collected annually by CCSBT members in the Australian region to develop an ALK. This highlights the need for continued discussion within the CCSBT regarding unbiased otolith sampling and how direct ageing data will be incorporated into the assessment models.

Uptake of the recommended sampling (and subsequent direct ageing) would provide representative estimates of length-at-age for the Australian longline fishery, which would fulfil Australia’s commitments to the CCSBT. The results of this project will be presented at the CCSBT Extended Scientific Committee Meeting in Cape Town in September.

6 Conclusions

The project met its overall objectives. It assessed the need for age data for SBT from the Australian longline fishery, and provided statistical methods and recommendations for otolith sample sizes to achieve target levels of precision (CVs of 0.25 or less) for estimating the age composition of the catch. Based on the size range of SBT caught by the longline fishery, we consider that a minimum sample size of 300 otoliths (~20 fish per 5-cm length class) for direct ageing per fishing season would be sufficient. Flexibility in the sampling program is important if the size range of SBT in the catch changes over time. The aim of the sampling program is to provide a representative estimate of length at age by collecting otoliths from the full range of sizes caught while maintaining sufficient numbers of otoliths in each size class to achieve the target level of precision. The recommended otolith sample size assumes that representative length data are also collected for the fishery.

7 Acknowledgements

We thank Matt Daniel (AFMA) for advice on the SBT longline fishery. This work was funded by AFMA and CSIRO.

8 References

Anonymous. 2002. A manual for age determination of southern bluefin Thunnus maccoyii. Otolith sampling, preparation and interpretation. The direct age estimation workshop of the CCSBT, 11-14 June 2002, Queenscliff, Australia, 39 pp.

Anonymous. 2004. Report of the Extended Scientific Committee for the Ninth Meeting of the Scientific Committee, 13-16 September, Seogwipo City, Jeju, Republic of Korea.

Anonymous. 2014. Report of the Extended Scientific Committee for the Nineteenth Meeting of the Scientific Committee, 1-6 September, Auckland, New Zealand.

Anonymous. 2016. Annual review of national SBT fisheries for the Scientific Committee. Report CCSBT-ESC/1609/SBT Fisheries - New Zealand.

Anonymous. 2017. Report of the Extended Scientific Committee for the Twenty Second Meeting of the Scientific Committee, 28 August – 2 September, Yogyakarta, Indonesia.

CCSBT 2018. Secretariat Review of Catches. CCSBT-ESC/1809/04

Farley J., Eveson P. 2018. An update on Australian otolith and ovary collection activities, direct ageing and length at age keys for the Australian surface fishery. CCSBT-ESC/1809/12.

Hobsbawn P.I., Patterson H.M., Nicol S. 2018. Australia's 2016–17 Southern Bluefin Tuna Fishing Season. CCSBT-ESC/1809/SBT Fisheries – Australia.

Morton R., Bravington M. 2003. Estimation of age profiles of southern bluefin tuna. CCSBT-ESC/0309/32.

Preece A., Eveson P., Farley J., Hillary R., Basson M., Davies C. 2012. Potential inclusion of direct ageing data in the SBT operating model. CCSBT-ESC/1208/22.