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An update on Australian otolith collection activities and direct ageing activities for the Australian surface fishery

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1.1 Abstract

This report provides an update on the southern bluefin tuna (SBT) otolith collection and ageing activities in Australia in the 2018 to 2020 fishing seasons. Otoliths from 580 SBT caught in the Great Australian Bight (GAB) by the purse seine fishery were received and archived into the CSIRO hard-parts collection. Age was estimated for 298 of these fish and the age data were provided to CCSBT during the 2021 data exchange, together with age data from 35 otoliths collected during CCSBT gene tagging operations in 2018.

A comparison was made of age estimates (zone counts) from otoliths and vertebrae collected from the same fish. A difference in age was detected, which was essentially the result of counting different zones in the hardparts. The difference in zone counts among structures highlights the need for further work to understand the formation time of the zones counted in each structure throughout the year and from across their core geographical range.

This year we developed a preliminary algorithm to estimate decimal (biological) age from otoliths using the zone counts and otolith measurements, which is more precise than whole years (zone counts). Further work is needed to refine the algorithm.

Quality control of age data is extremely important to ensure high quality age estimates are generated for assessment and management needs. An SBT age determination workshop was proposed in 2014 to standardise approaches for converting increment counts to age estimates amongst member laboratories. Paper CCSBT-ESC/1509/15 reiterated the requirements for an ageing workshop, including the need for a pre-workshop inter-laboratory otolith exercises to estimate precision and bias.

1.2 Introduction

Many stock assessments, including those for southern bluefin tuna (SBT), use age-based parameters within the models to estimate stock abundance, with annual catch in numbers at age (catch-at-age) from some fisheries as input data. For many fisheries, however, the only direct information available is the size distribution of the catch (catch-at-length) and total number caught. Although length provides some information on the age structure of the catch (age and length are related) there is a need to convert catch-at-length into catch-at-age or infer age from length within the model. Simulation studies have shown that using direct age data, as opposed to size data, in age-structured assessment models is more likely to give unbiased estimates of stock status. Direct ageing from hard parts (otoliths) identifies different age groups among similarly sized fish and is generally considered a fundamental requirement of fisheries monitoring, particularly for long-lived species such as SBT.

Since the 2002 fishing season, Australia has been obliged to provide annual length-at-age estimates for the surface (purse seine) fishery in the Great Australian Bight (GAB) to CCSBT. 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) measures the length of each fish and extracts the otoliths from these mortalities. In the past there have been between ~25 and 40 tow cages a year, giving a total of 250-400 otoliths collected from this sector each season. In recent years, however, the number of fish available for otolith sampling has declined primarily because of low mortalities in the cages during the towing operations (Farley et al., 2013).

1.3 Otolith sampling and reading

A total of 580 sets of otoliths were collected from the Australia surface fishery in the 2017/18 to 2019/20 fishing seasons by Seatec Pty Ltd (Table 1). The fish were measured to the nearest cm (FL) and the otoliths removed and sent to CSIRO in Hobart. The size range of fish sampled was 66 to 130 cm FL (Figure 1).

A total of 100 otoliths were selected for ageing from each fishing season. Otoliths were selected based on size of fish (length stratified sampling strategy rather than random sampling) to obtain age estimates from all length classes, even those where sample sizes were small. An additional 35 otoliths collected during CCSBT gene tagging operations in 2018 were also included in the analysis. One otolith from each fish was selected, weighed to the nearest 0.01 mg and sent to Fish Ageing Services Pty Ltd (FAS) in Victoria for sectioning and reading. Transverse sections were prepared for each otolith (Anon., 2002). Opaque zones were counted along a transect that ran from the first inflection point on the otolith to the edge of the otolith. An opaque zone on the margin of the otolith was only counted if it was fully formed (i.e. translucent otolith material could be observed between the last opaque zone and the otolith margin). Prior to reading each year's otoliths, an ageing reference set (n=50 sectioned otoliths) was read by FAS for calibration purposes. The selected otoliths were then read at least two times by FAS without reference to the previous reading, size of fish, otolith weight or capture date. An otolith reading confidence score was assigned to each otolith reading. A customised image analysis system was used to record an image of the otolith section and measure the distance between the primordium to the distal edge of each of the opaque zones counted, and to the edge of the otolith.

A final zone count was obtained for 297 of the 300 otoliths selected for ageing from the Australia surface fishery, and all 35 otoliths from the 2018 gene-tagging program. Counts of opaque zones ranged from 1 to 5 and the length to age (zone count) relationship by year is given in Figure 2. The average percent error (Beamish and Fournier, 1981) between readings was 5.9% and the percent agreement was 75.2%. When successive readings differed, they were only by ±1 indicating a good level of precision. When readings differed, a final age was obtained by re-examining the otolith with the knowledge of the previous two age estimates as recommended by Anon. (2002). The age data (i.e., number of opaque zones counted in the otolith section) were provided to CCSBT during the data exchange.

Table 1. Number of SBT with otoliths collected from the Australian surface fishery in the 2018-2020.

Year	No. otoliths collected	Length range (cm)	Mean length (cm)
2018	175	75-130	99.2
2019	221	66-130	97.1

2020	184	74-120	94.7
Total	**580**		**96.9**

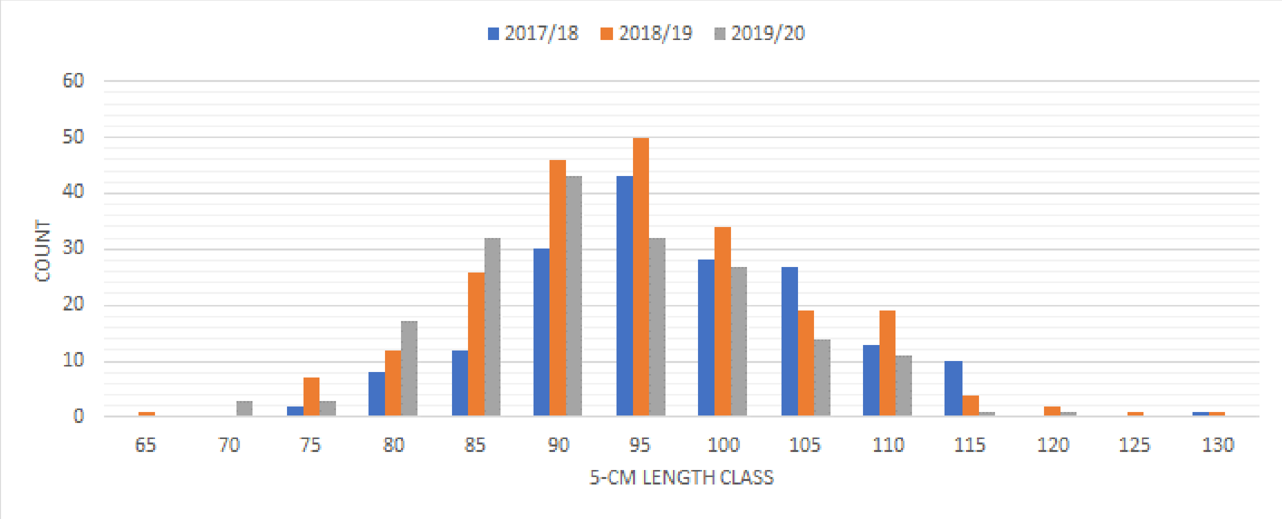

Figure 1. Length frequency of SBT with otoliths sampled from the Australian surface fishery in the 2017/18 to 2019/20 fishing seasons.

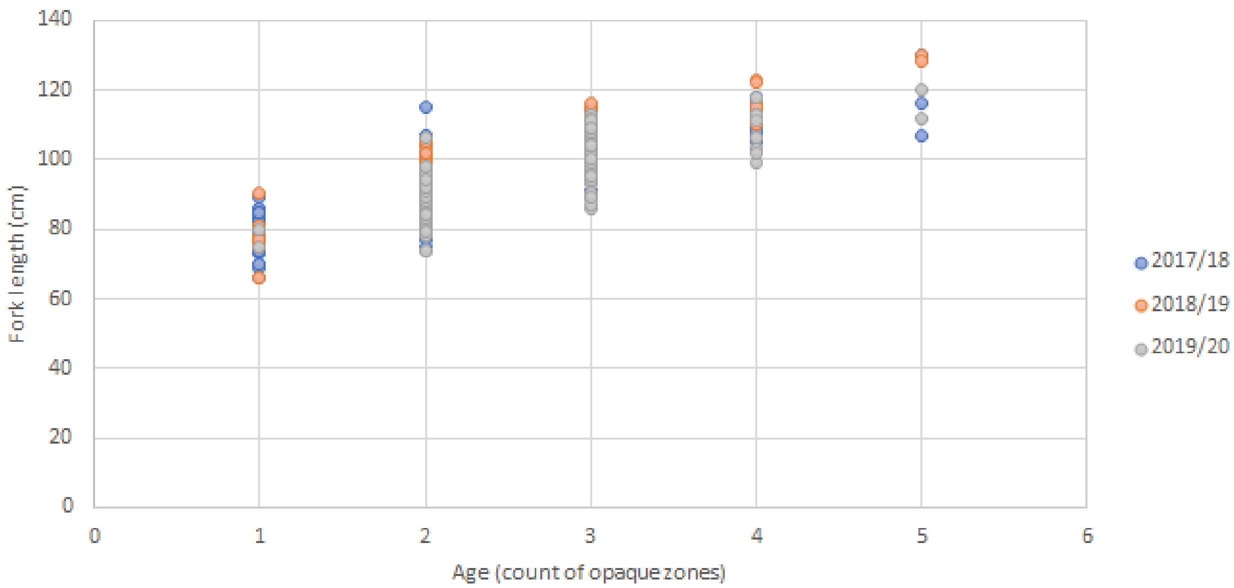

Figure 2. Length-to-age (zone count) relationship for SBT by fishing season.

1.4 Otolith vs vertebrae age estimates (zone counts)

A comparison was made of age estimates (zone counts) from otoliths and vertebrae collected from the same fish. A difference was detected, which was essentially the result of counting different zones in the hardparts. In sectioned otoliths, the wide opaque zones are counted (most likely formed in summer) and in vertebrae, the narrow dark stained zones are counted (most likely formed in winter). The difference in zone counts among structures, however, highlights the need for further work to understand the formation time of the zones counted in each structure throughout the year and from different parts of their geographical range.

1.5 Decimal (biological) age estimation

It may be possible to estimate the decimal (biological) age of SBT that is more precise than whole years (counts of opaque zones). A preliminary algorithm was developed using the zone counts and otolith measurements following methods developed for bigeye and yellowfin tuna Farley et al. (2020). The method has three steps:

1. Use the relationship between daily age data and the size of the (sectioned) otolith to estimate the age of the fish (proportion of a year) when the first annual opaque zone was deposited,
2. Calculate the number of complete annual increments in the otolith (i.e., the total count of opaque zones minus 1), and
3. Estimate the time elapsed after the last counted opaque zone was deposited and when the fish was caught, based on the marginal increment as a proportion of the mean size of the complete annulus for that age group.

Total age is estimated by adding together the age components estimated in each step. Figure 3 shows the (preliminary) relationship between length and decimal age for SBT caught by fishing season. Further work is needed to the relationship between daily age and otolith size, as well as the estimation of the mean increment width values.

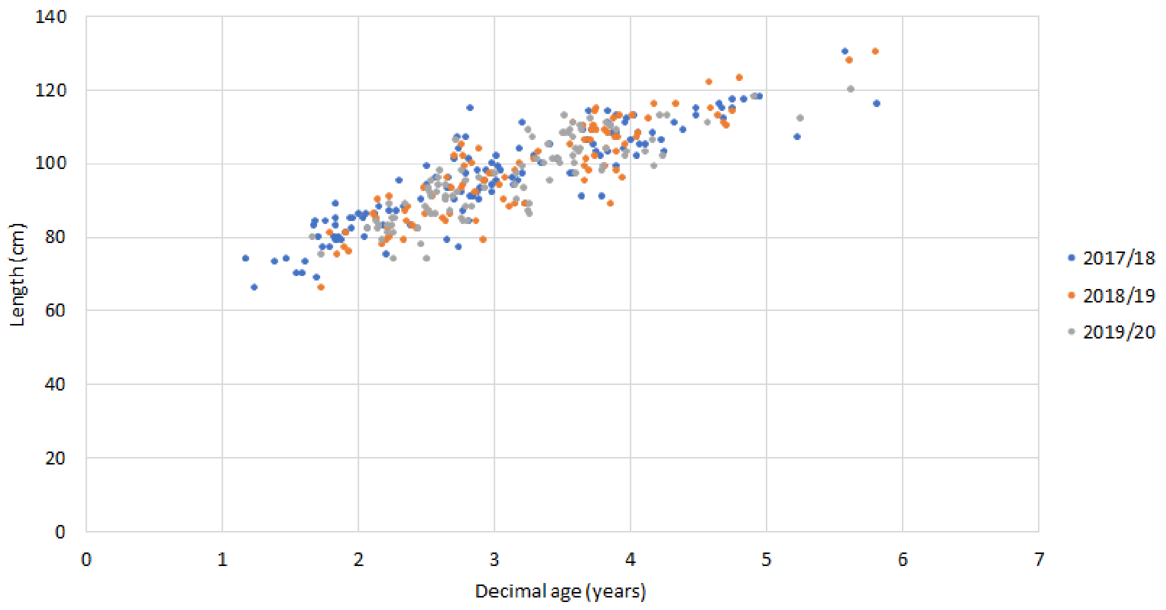

Figure 3. Preliminary length to decimal age relationship for SBT by fishing season.

1.6 Summary

Direct age estimates were obtained for 298 SBT caught in the GAB in 2018 to 2020. The age data were provided to CCSBT in 2021 together with age data from 35 otoliths collected during CCSBT gene tagging operations in 2018. A difference was detected in age estimates (zone counts) in otoliths and vertebrae from the same fish, which was essentially the result of counting different zones in the hardparts. A preliminary algorithm was developed to estimate decimal (biological) age from otoliths using the zone counts and otolith measurements, which is more precise than whole years. Further work is needed to refine the algorithm.

Quality control of age data is extremely important to ensure high quality age estimates are generated for assessment and management needs. It is recognised that there is a need to regularly examine the precision and bias of age estimates between readers and among laboratories to maintain a consistent level of precision and minimise the potential for systematic biases in ageing estimates. An SBT age determination workshop was proposed in 2014 (CCSBT-ESC/1409/24) to estimate the precision and bias among otolith readers, and standardise approaches for converting increment counts to age estimates amongst member laboratories. Paper CCSBT-ESC/1509/15 reiterated the requirements for an ageing workshop, including the need for a pre-workshop inter-laboratory otolith exercises to estimate precision and bias.

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