OCEANS AND ATMOSPHERE
www.csiro.au

Implications of cessation of the aerial survey for the MP and TAC setting

Ann Preece, Richard Hillary, Campbell Davies, Jessica Farley and Paige Eveson

CCSBT-ESC/1509/09

Twentieth Meeting of the CCSBT Scientific Committee, 1 - 5 September 2015, Incheon, South Korea

Acknowledgments

This work was funded by the Department of Agriculture and CSIRO.

Contents

Abstract

The aerial survey index of juvenile abundance provides essential fishery independent information on recruitment for the CCSBT management procedure (MP) and meta-rules processes. These include review of fishery and stock indicators, assessments of stock status, TAC recommendations, MP reviews and a process for dealing with exceptional circumstances (Anon. 2013).

The SBT aerial survey was cancelled in 2015 following funding discussions at the Commission (Anon 2014a). The Commission has requested advice on the implications of cessation of the aerial survey in 2015 and potentially in 2016 and beyond. Some aspects of this were considered by the ESC in informal inter-sessional webinars, and a report was provided to the SFMWG meeting (Anon, 2015a). This paper provides advice on the implications of cancelling the aerial survey for the MP schedule of activities, including future TAC setting, an evaluation of the costs and benefits of the aerial survey data and potential alternative sources of information on recruitment.

The aerial survey index is used in several processes which are part of the MP schedule of events as set out in the meta-rules adopted in 2011 (Anon 2013);

1. **Recruitment monitoring:** The aerial survey index is used in the annual indicator based review of the stock and consideration of exceptional circumstances. Recruitment monitoring and detecting and responding to periods of low recruitments, and the associated risks of further decline in SSB, has been a high priority for the Commission. A large percentage of the catch of SBT is on the juvenile component of the stock. The lack of information on recruitment may trigger exceptional circumstances in 2015.

2. **Operating models for stock assessments and Management Strategy Evaluation:** The index is integrated into the CCSBT operating models as a relative abundance index for three combined age classes (ages 2-4). The operating models are used for periodic (3 years) assessment of the status of the stock, management strategy evaluation of MPs, and will be used as a central part of the review of the MP scheduled for 2017. In 2005, *"…The ESC Chair noted that considerable work had been carried out recently to validate the aerial survey and that this had resulted in higher levels of confidence in the survey outcomes. The external panel suggested that the aerial survey outcomes may now be at the stage where they could be included in the tuning of the operating model*" (Anon 2005). Analysis of the consistency and variability of the survey in the current operating models, indicates that (i) the survey is consistent with the estimated recruitment information in all the other data sources and priors, (ii) the survey can act to ameliorate spurious estimates of year-class strength driven by issues common to fishery dependent CPUE indices, and (iii) when actively including the survey in the estimation procedure there is a better and more consistent fit to the data in the resulting operating model trajectories.

3. **Management procedure to recommend TACs:** The aerial survey index is one of two data series, and the only fishery independent data, used in the MP decision rule adopted by the CCSBT for recommending TACs. In 2008, the ESC agreed that candidate MPs must include the aerial survey to provide an earlier signal of year class strength. The inclusion of the aerial

survey in the MP development was also due to the concern of relying on an MP using CPUE only, given unresolved uncertainties in the historical time-series. Complete cessation of the aerial survey would mean that the adopted MP could no longer be used, and a new MP would need to be developed. This would trigger exceptional circumstances. Alternative recruitment information that could be considered in the development of future MPs is discussed, although there are currently no robust alternative quantitative indexes. There would be substantial time and costs associated with developing, testing performance, agreeing and implementing a new MP.

We estimate the aerial survey related component of the TAC increases that have been adopted by the Commission between 2012 and 2017 and, if converted to a monetary value, would cover the cost of the aerial survey multiple times over. The same estimates have been made for potential future TAC increases under the MP, should it continue to be used to set TACs in 2016. The component of these that can be attributed to the aerial survey exceed the costs of the aerial survey by an order of magnitude.

Adoption of the first management procedure in a tuna RFMO set the benchmark for tuna Commissions, and provided a scientific basis for continued fishing of SBT and rebuilding of a depleted stock. Cessation of the aerial survey beyond 2016 would mean the Commission would cease to have a scientifically tested, explicitly precautionary, rebuilding plan for the SBT stock. It would also mean under-utilising substantial investments in research and monitoring to develop the current MP and potentially foregoing large future catches that would otherwise have been possible under the agreed MP.

1 Introduction

The southern bluefin tuna (SBT) line transect scientific aerial survey was cancelled in 2015 following funding decisions at the Extended Commission (Anon 2014a). The index of relative juvenile abundance from the aerial survey provides essential information on recruitment for the CCSBT management procedure (MP) and meta-rules processes, which include review of fishery and stock indicators, assessments of stock status, TAC setting recommendations, MP reviews and a process for dealing with exceptional circumstances (Anon. 2013).

The scientific aerial survey of SBT is conducted in the Great Australian Bight (GAB) and commenced in 1993, prior to the formal constitution of the CCSBT. It was developed as part of the NRIFSF (Japan) and CSIRO (Australia) Recruitment Monitoring Program, to provide a relative abundance estimate of juvenile SBT, following concern regarding the status of the stock and declines in recruitment (Cowling et al, 2002). This concern remains, with the SBT stock estimated to be approximately 9% of initial biomass levels (Anon 2014b) and consistent evidence of recent low year classes still to move into the spawning population.

The aerial survey index is used in several components of the management procedure schedule of events as set out in the meta-rules adopted in 2011 (Anon 2013; see CCSBT-ESC/1509/12 for further details);

1. Recruitment monitoring: The aerial survey index is used in the annual indicator-based review of the stock and consideration of exceptional circumstances.
2. Operating models for stock assessments and management strategy evaluation: The index is an input data series for the CCSBT operating models and integrated as an index of relative abundance across three age classes (ages 2-4). The operating models are used for assessment of the status of the stock every three years, management strategy evaluation of management procedures, and will be central to the scheduled review of the MP in 2017.
3. Management procedure decision rule to recommend TACs: The aerial survey data is one of two data series, and the only fishery independent data, used in the Management Procedure decision rule adopted by the CCSBT for recommending TACs.

The Extended Commission has requested advice on the implications of cessation of the aerial survey in 2015 and potentially in 2016 and beyond (Anon 2014a). Some aspects of this were considered by the ESC in informal inter-sessional webinars, and a report was provided for consideration at the CCSBT's Strategy and Fisheries Management Working Group (SFMWG) meeting (Anon, 2015b). This paper provides advice on the implications of cancelling the aerial survey for the management procedure schedule of activities including future TAC setting (see also Davies et al, 2015 (CCSBT-ESC/1509/12)), an evaluation of the costs and benefits of the aerial survey data and potential alternative sources of information on recruitment.

2 Role of the aerial survey in recruitment monitoring and CCSBT operating model and MP

The scientific aerial survey has been conducted in the Great Australian Bight since 1993. Data collected in the survey are used to estimate a relative abundance index for juvenile SBT for the years 1993-2000 and 2005-2014. The survey was suspended in 2001 because of problems in finding trained spotters and spotter-pilots. The suspension allowed for a review of the survey design, data analysis and effectiveness of the survey in detecting changes in abundance to be conducted, and it concluded that the scientific aerial survey provides a suitable indicator of SBT abundance in the GAB (Bravington 2003). An ad-hoc survey design was trialled in 2002-2004 but did not provide a reliable index of abundance (Farley et al, 2004). Thus, the full scientific aerial survey recommenced in 2005 (Bravington et al. 2005), and continued each year through 2014. The survey was not conducted in 2015.

New analysis methods were developed in 2005 (Bravington et al. 2005), and have subsequently been refined to provide a robust index of juvenile abundance (along with confidence intervals) across all survey years (Eveson et al. 2008). Methods were also developed to incorporate calibration factors for single spotters in the planes (Eveson et al 2011).

In 2004, the estimates of recruitment from the stock assessment and the independent aerial survey estimates (1993-2000) were compared and found to be consistent (Bravington et al, 2004). The Recruitment Monitoring Workshop noted "… *that there was no evidence for inconsistency, such as might be caused by variations in the proportion of juveniles entering the GAB. However, the data do not rule out low levels of inter-annual variability* "(Hobday, 2005).

The fishery-independent index of abundance from the aerial survey has historically been used as a fishery independent means for monitoring recruitment. Since 2009 it has been incorporated into three elements of the management procedure and meta-rules processes; 1) recruitment monitoring and evaluating stock indicators, 2) operating models for stock assessments, management strategy evaluation and MP review, and 3) the management procedure decision rule to recommend TACs.

2.1 Recruitment monitoring:

The aerial survey index is one of the recruitment monitoring data sets used in the annual indicator-based review of stock status and evaluation of exceptional circumstances under the MP meta-rules. In 2015 all current recruitment monitoring ceased (i.e. the aerial survey, the trolling survey, the commercial spotting index (SAPUE)). Consequently there are no data in 2015 to evaluate recent changes in recruitment.

The aerial survey index is the longest of the recruitment monitoring times series that have been collected. Other recruitment monitoring programs undertaken in the past include the acoustic survey in the years 1996-2006 and trolling survey 2006-2014 (Itoh and Tokuda, 2014), the SAPUE commercial spotting index from the GAB from 2002-2014 (Farley et al. 2014), and tagging programs in years 2001-2007 and for previous periods in the 1990's and 1960's (Polacheck et al, 2004). No alternative recruitment monitoring methods are currently available (discussed further below). The number of one year olds spotted in the GAB in the 2014 aerial survey was low compared with recent high years (Eveson et al, 2014), and the 2014 trolling index declined from 2013 (Itoh and Takahashi, 2014), which may have resulted in a low aerial survey abundance estimate in 2015, had the survey proceeded. **The lack of information on recruitment may trigger exceptional circumstances in 2015.**

Avoiding periods of low recruitment, and the associated risks of further decline in spawning stock biomass (SSB), has been a high priority for the Commission (e.g. Anon, 2001, 2005, 2008, 2011, 2014) and the rationale for the large investment in recruitment monitoring. The 2009 reduction in quota reflected the Commissions concern about both stock status and the historically low levels of recent recruitment in the early 2000's. The ESC reflected this concern in the design of the MP, with stronger reductions in catches in response to declines in recruitment than increases in response to signals of rebuilding, and focusing on robustness tests associated with this.

A large percentage of the catch of SBT is on the juvenile component of the stock. Approximately 50% of the total SBT catch (in weight) is aged 0-4 years old, and 76% of the catch in numbers (averaged over the last 10 years) is juveniles (ages 0-4). In the longline 1 fishery (LL1), which includes all the Japanese longline catch used in the CPUE calculations, the proportion of the catch that is juveniles (ages 0-4) ranges from 15 to 45% in numbers and 6 to 18% in weight (over the last decade)[1].

The ESC has noted previously the importance of recruitment monitoring and development of indicators that are fishery independent and unaffected by the over-catch scenarios (Anon 2008). Noting the depleted state of the SBT stock, and the substantial time-lags between initial recruitment and a) the first reliable observations from the longline fisheries (~5 yr old), and b) maturation (8-10 years on average), it is essential that abundance of juveniles is monitored to provide information about potential low year classes as early as possible.

2.2 Operating models:

The aerial survey index series is integrated into the SBT operating models as a relative abundance estimate across three age classes (ages 2-4). In 2005, the ESC noted the increasing importance of recruitment indices, and the recent contribution of information from tagging work and aerial surveys. "*The ESC Chair noted that considerable work had been carried out recently to validate the aerial survey and that this had resulted in higher levels of confidence in the survey outcomes. The external panel suggested that the aerial survey outcomes may now be at the stage where they could be included in the tuning of the operating model*" (Anon 2005.

In 2008, the ESC agreed to incorporate the aerial survey time series in the operating model (OM) in light of the series of historical low recruitments, the lag between recruitment and occurrence in the longline CPUE, the depleted state of the stock and the unquantified uncertainties in the longline CPUE series resulting from the unreported catches (Anon, 2008). In the review of the

[1] Note these calculations are from the MP CAA calculated by the secretariat(SEC_ManagementProcedureData_5213.xls, 2014)

2000's Scientific Research Program (SRP), it was recommended that research and monitoring should be aimed at reducing reliance on CPUE (e.g. Itoh et al 2007, Davies et al. 2007).

There are currently no alternative data series that provide direct information on recruitment of 2-4 year olds in the OM. The 2007 CPUE modelling group and SAG noted that the nature of the purse seine fishery meant that CPUE was not useful as an index of abundance (Anon 2007 (see Att. 4 Extract of 2nd CPUE modelling workshop report)). While the troll survey index is included in the annual review of indicators of stock status, it has not been incorporated into the reference set of OMs due to questions that remain over the survey design used to obtain the trolling index (Anon 2008). The SAPUE data are not included because the index is fishery dependent and developed from commercial operations that change each year to cover different areas and times.

The reference set of OMs are used for assessment of the status of the stock every 3 years, and are the models used in management strategy evaluation of the MP decision rules and review of the MP. The next stock assessment and the MP review are scheduled to be conducted in 2017. Sustained levels of higher recruitment estimated from the SBT operating models will be the first indications that the rebuilding of the SBT stock is occurring, and higher recruitments are central to the rebuilding the spawning stock.

2.3 Management procedure:

The aerial survey index is one of two data sources used in the MP adopted by the CCSBT; the other being the average of two standardised CPUE series from the Japanese longline fleet (Anon 2013, Attachment 10). The aerial survey data are the only fishery independent data used in the MP.

The management procedure has been designed to use the aerial survey data (recruitment information) and Japanese longline CPUE data (biomass changes), in a model that calculates changes to the TAC. The most recent aerial survey data points (the last 5 years) provide information on whether or not recent recruitment is above the historical low levels in the series. The MP reacts strongly to low recruitments by recommending reductions in catches, and reacts conservatively to higher recruitments by increasing TAC slowly; in this way the MP is explicitly precautionary and reflects the Extended Commission's desire to have a low probability of further stock declines and a high probability of meeting their rebuilding objective.

In 2008, the ESC agreed that candidate MPs must include the aerial survey data to provide an earlier signal of year class strength (than longline CPUE on its own). The inclusion of the aerial survey index in the MP development was also due to the concern of relying on an MP using only CPUE and/or catch composition data, given unresolved uncertainties in the historical time-series for the longline fleet, recent changes in the LL1 fleet (due to changes in management and economic drivers) and potential for future changes. The MP which had been developed prior to the revelation of market anomalies was abandoned in 2006; " *… the ESC agreed that it was not possible to proceed with the current MP and that urgent consideration of a short-term "interim MP", incorporating indicators unaffected by the catch anomalies was required*" (Anon 2006). Various robustness tests used in the process of selection of a new MP were specifically aimed at testing its ability to cope with postulated scenarios about the uncertainties in CPUE.

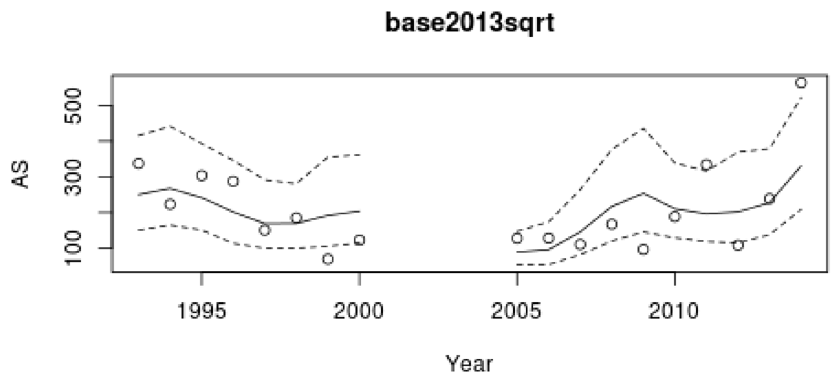
3 Fit and Influence of aerial survey

3.1 Fit of OM to aerial survey data

We have examined the influence of the aerial survey and its consistency with other data sets included in the OM. The “reliability” of the aerial survey is examined in the predicted versus observed plots that are routinely produced when the OM is reconditioned (e.g. Hillary et al 2014).

Figure 1 shows the predicted vs. observed aerial survey plots for two scenarios: (i) where the aerial survey data are fitted with an assumed process error SD of 0.22; and (ii) where the process error SD is set at 10 so the data are effectively ignored (although for graphical purposes the Probability Interval (PI) in the graph are plotted assuming the same SD of 0.22 as the default settings). Clearly, apart from the most recent years of 2013 and 2014, there is not much difference between the two plots. This can be interpreted in two contrasting ways:

1. The aerial survey data have little influence on the estimated trends in juvenile biomass in the OM
2. The aerial survey is consistent with the recruitment information in the other data sets in the OM (CPUE, catch composition, tagging) where they overlap.



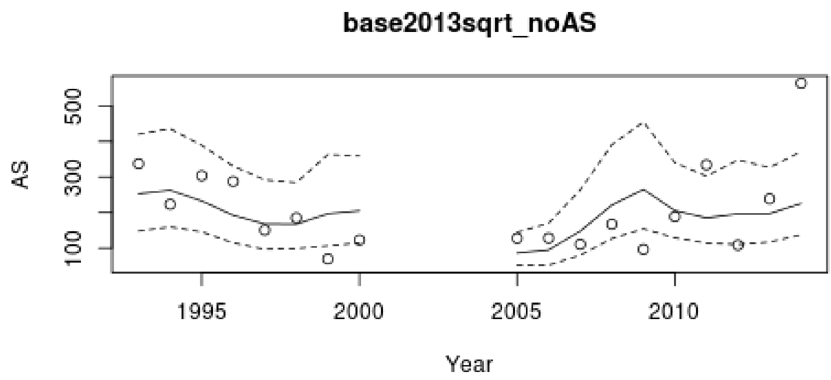


Figure 1 Predicted versus observed aerial survey data when fitted in the OM (top) and not fitted in the OM (bottom)

The plot in Figure 1 only really tells us that on average the survey is consistent with the trend in the OM and is almost always found within the probability bounds we assume in the likelihood (i.e. given the observation and assumed process error levels and structure). What it does not tell us is if - for each of the grid samples - actively fitting to the survey data results in a noticeably more consistent trend between the OM and the survey index. In an attempt to differentiate among these two candidate explanations, we estimated the correlation between the OM predicted aerial survey and the actual survey observations, for each grid sample. Figure 2 shows the estimated correlation, summarised across all 2,000 grid samples, between the OM and the survey estimates, when the aerial survey is actively fitted in the OM, or not.

Clearly, when the survey data are actively fitted in the OM there is a significantly higher correlation (very precise and around 63%) than when the index is effectively ignored (much more variable and around 36%). Improving the fit to the 2013 and 2014 data points would not account for this increase and consistency of correlation between the OM and the survey estimates; when actively fitting to the survey the result is a much more consistent relationship across all grid samples between the OM and the survey.

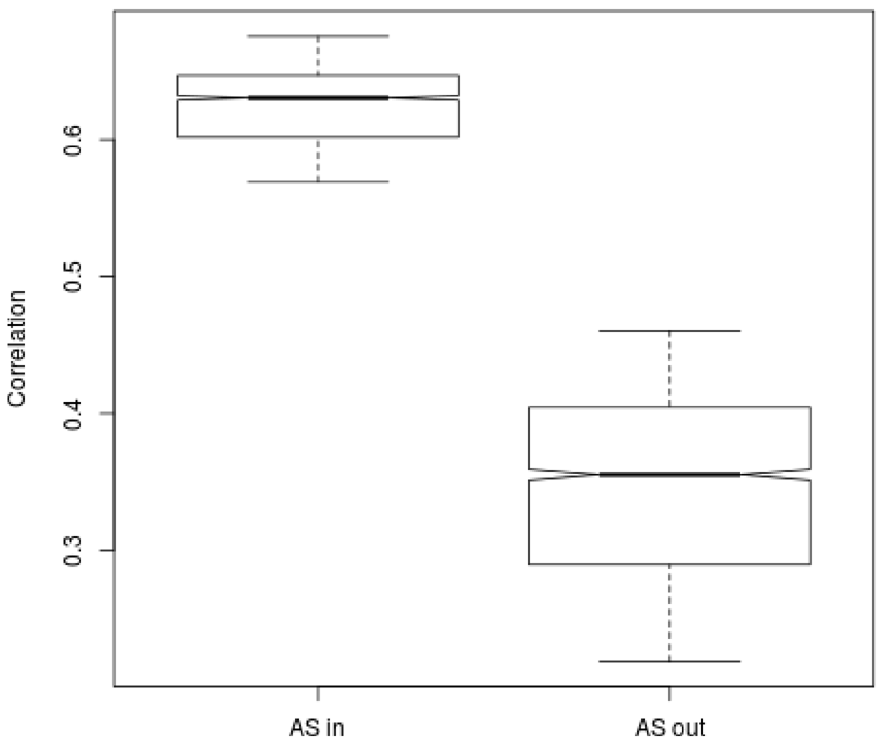


Figure 2 Correlation between the OM-predicted survey index and the observed index for each grid sample from the OM, with the aerial survey included (left) or excluded (right).

3.2 Influence of aerial survey on estimates of year class strength

In addition, we examined how the estimates of year-class strength differ when the survey is either included, or excluded from the fitting procedure. Figure 3 shows the estimated abundance of individual year-classes (age 0yrs) for the years covered in the survey (1991-present). Overall, there is a strong consistency of estimates from 1991-2004 with little apparent difference, regardless of whether the aerial survey is included, or not, in the fit. Beyond 2004, 2005 and 2006 are estimated to be smaller year-classes with the aerial survey included; 2007-2010 estimates are slightly (but not significantly) higher with the survey included and 2011 and 2012 are significantly higher, with auto-correlation keeping the estimates higher in 2013 and 2014 (in the absence of any data).

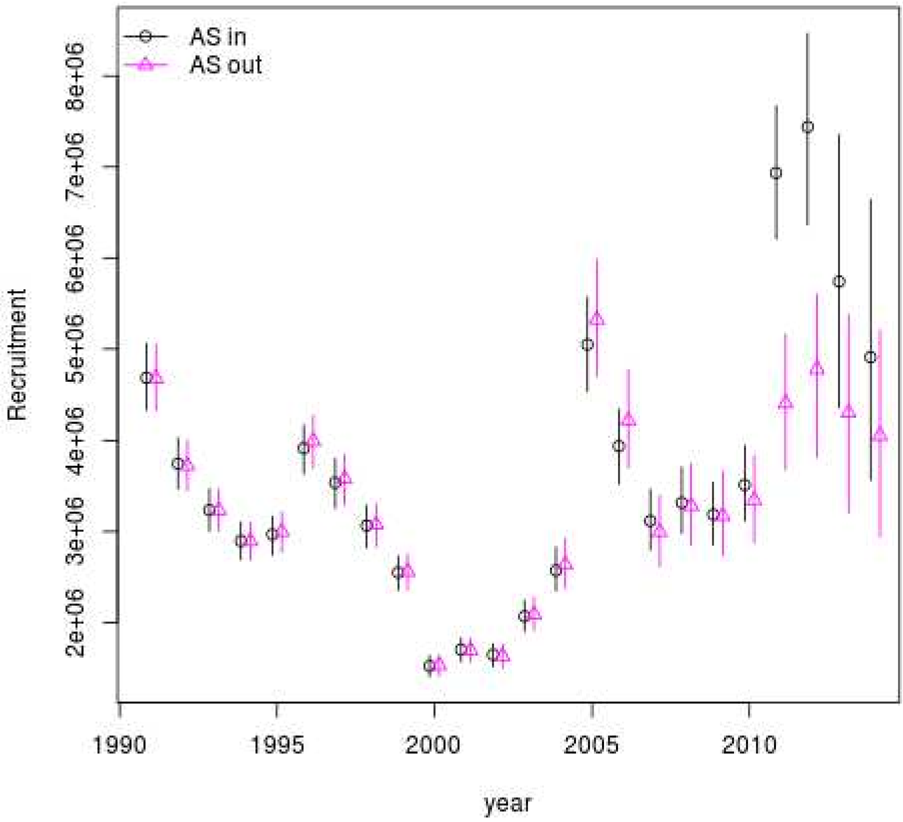


Figure 3 The estimated abundance of individual year-classes (age 0yrs) for the years covered in the survey (1991-present), when the survey is either included (black circles), or excluded (pink triangles) from the fitting procedure.

The general consistency up until 2010, following which the aerial survey is the only information on year-class strength, is to be expected given the strength of correlation demonstrated in Figure 2. The fact that 2005 and 2006 are estimated to be smaller year-classes is interesting given 2005 was used as an example of why the aerial survey is not a reliable abundance index in (CCSBT-ESC/1509/20). Both visual analyses of the nominal CPUE-at-age (OMMP3) and OM-specific estimates (Anon. 2014) indicate a general increase in catchability in the LL CPUE data from 2008 onwards. Given catchability is fixed in the reference set of OMs (with a small linear increase over time), such an increase in catchability would manifest as higher than expected estimates of year-class strength, in the absence of other data to inform the estimation. There is no systematic lack of fit to the 2005 year class in the survey as suggested in CCSBT-ESC/1509/20 (see years 2007, 2008 and 2009 in Figure 3 when this cohort is observed in the survey) but the survey does not reflect as strong an increase as predicted by the CPUE and, therefore, tempers the increase in year-class strength in 2005 and 2006.

We contend these results demonstrate the benefits of fishery independent monitoring, particularly for recruitment. The aerial survey data clearly improves the estimates of year class strength in the OM and acts to constrain the OM estimating anomalously large changes in year-class strength driven by issues such as catchability shifts in the CPUE index. As to whether the notably higher recruitments estimated in 2011 and 2012 will be observed in the other data sets, remains to be seen, but again, these cannot be assumed to be evidence, or otherwise, of the survey's reliability until these data are available to include in analyses such as those presented here. It would be incorrect, and against experience in this and other fisheries, to assume that the fishery dependent data are accurate and, or, sufficient, in the absence of a basis for formal comparison.

The analysis above shows three things: (i) the aerial survey is consistent with the estimated recruitment information in all the other data sources and priors, (ii) the survey can act to ameliorate estimates of year-class strength driven by issues common to fishery dependent CPUE indices, and (iii) when actively including the survey in the estimation procedure we see a better and more consistent fit to the data in the resulting OM trajectories. These results are consistent with the ESC's previous views that, in the absence of a rigorously designed and tested alternative, the survey is indeed both a reliable and important index of average recruitment to the juvenile part of the SBT stock.

4 Requests from the Commission

4.1 2014 Commission request

> "Members expressed concern that the lack of aerial survey data in future will affect the Management Procedure (MP). The EC requested the ESC to consider the implications of this for the Management Procedure process and advise how best to run or re-tune the MP in the event that no aerial survey data is available for 2015 and potentially also 2016 and beyond." (Anon. 2014. Report of the Twenty First Annual Meeting of the Commission, 13-16 October 2014, Auckland, New Zealand).

4.2 ESC agreements

The ESC addressed some of these issues inter-sessionally and provided an informal report for consideration by the SFMWG meeting (Anon 2015a (CCSBT–SFM/1507/09)). The key agreements and recommendations from the ESC informal webinars were:

1. The MP is a central component of the SBT rebuilding plan. The aerial survey provides fishery-independent information on recruitment that has been critical in the CCSBT Operating Model, for development and testing of MPs and for periodic assessments of stock status. The aerial survey index, on its own, is also an important indicator of year class strength and trend in recruitment.
2. Given that the SBT stock is estimated to be depleted, and a substantial proportion of the catch is taken from the juvenile and sub-adult components of the stock, continued recruitment monitoring is essential for early warning of possible low recruitments in the future.
3. All other recruitment monitoring programs ceased in 2015 or earlier (i.e. trolling, SAPUE and the aerial survey were all cancelled in 2015).
4. A reduced 2016 aerial survey, within the range of options proposed, would allow continued operation of the MP and other uses of the survey (e.g., indicator and stock assessment). Without the 2016 aerial survey data, the MP could not operate and exceptional circumstances would likely be triggered.
5. If the aerial survey is discontinued a new MP will need to be developed, which will take considerable time and funding to complete. In the interim, the CCSBT will be without a tested and agreed rebuilding plan.

Recommendation:

1. The aerial survey for 2016 should proceed to allow the use of the MP for setting the 2018-2020 TAC in 2016.

4.3 SFMWG agreements and requests

The SFMWG met in late July and discussed funding arrangements for the aerial survey. The meeting agreed to fund a reduced aerial survey in 2016, but there was no commitment to funding the aerial survey in 2017-2019 for use in the MP in 2019 for the next 3-year block of TAC (Anon, 2015b).

The SFMWG requested the ESC provide additional advice, and two of those requests are covered here; 1) provide advice on costs and benefits of continuing with the current MP and conducting the aerial survey in 2017 to 2019, 2) provide advice on alternative recruitment information for use in new MPs. The other requests (research priorities, alternative MPs and costs, MP review and meta-rules) are dealt with in the meta-rules and management procedure review paper (Davies et al, 2015).

5 Implications of cancelling the aerial survey

5.1 Implications for recruitment monitoring

The aerial survey index is the only continuous (to 2014), long-term, fishery independent recruitment monitoring data set used in the annual indicator based review of the stock and evaluation of exceptional circumstances. Other recruitment indicators are used in a qualitative manner given the uncertainties associated with them.

Exceptional circumstances may be triggered by the absence of the 2015 data point. If the 2016 aerials survey fails to cover enough transects or does not proceed, then exceptional circumstances will be triggered in 2016. The ESC would use the agreed meta-rules process for action to assess implications for current and future TACs and make appropriate recommendations to the Commission.

5.2 Implications for the operating models

The aerial survey index is used directly in the CCSBT operating models, which are used for the assessment of stock status, and in MP evaluation and review. As noted above, the aerial survey data in principle directly inform the estimates of the most recent recruits in the operating models, and there is little additional data available in the models to inform these estimates. There is a need for information on juveniles in the operating models/stock assessment models to provide information on recent recruitment and early warning of low recruitment. The next stock assessment and review of the MP is planned for 2017. Inter-sessional work for this review would need to commence in 2016. The operating models are also used to check that the MP is operating as expected in the TAC setting years (i.e. 2016).

5.3 Implications for the MP

The next TAC calculation for SBT is scheduled for 2016 where the full time-series of aerial survey and CPUE indices will be used to recommend the TACs for 2018-2020. Following this, the next TAC setting decision is in 2019, using data up to and including 2019, to set the TAC for 2021-2023. Under the meta-rules the first formal review of the MP is scheduled for 2017.

The aerial survey data are considered "essential" input data to the SBT management procedure (Anon, 2013 ESC report Att10); these data are also "essential" for current management of the stock, the SBT rebuilding plan and setting the global TAC.

The lack of an aerial survey index data point in 2015 may trigger exceptional circumstances under the meta-rules process for the MP (CCSBT-ESC/1509/12). The ESC is yet to review and agree on a method for accounting for missing data in the aerial survey time series in the MP. Inter-sessional work involved modifying the MP code to run models missing the 2015 index (Hillary et al 2015a). These code changes will need to be considered and adopted by the OMMP working group and ESC prior to use in 2016. Missing data in the most recent 5 years in the aerial survey will be particularly influential as they have the greatest impact on whether or not recommended TACs increase, stay the same, or decrease, in the short term.

Complete cessation of the aerial survey would mean that the adopted MP could no longer be used. A new MP would need to be developed. There would be substantial time and costs associated with developing, testing performance, agreeing and implementing a new MP. The last MP took more than 4 years to develop, and there were substantial costs for the main developers (primarily Australian and Japanese scientists), plus the costs of OMMP meetings, Advisory Panel contributions, and ESC work and special Commission meetings for review and adoption of the MP (Hillary et al 2015b).

The MP review process, scheduled for 2017, was intended to assess performance of the adopted MP (relative to the Commission's interim rebuilding objectives), consider plausible alternatives that may be transitioned to in the future, and alternative data series that could be obtained (e.g. close-kin). The MP and meta-rules include a transition process in the event that a new MP is to be developed; the adopted MP should continue to be used to set TACs while a new MP is developed to provide for the orderly and precautionary rebuilding of the stock (Anon. 2013). Collection of data for the current MP should only cease when a new MP, including required data series, has been developed, tested and is ready to be (or has been) implemented. This underlying rationale is reflected in the SRP workplan developed by the ESC and adopted by the Commission in 2013 (Anon 2013).

Adoption of the first management procedure in a tuna RFMO set the benchmark for tuna Commissions, and provided a scientific basis for continued fishing of SBT and rebuilding of a depleted stock. The most recent performance review (Garcia and Koehler, 2014) notes the implementation of the MP, and the scientific foundation for decision making and rebuilding the SBT stock, and considers that the related actions from the 2008 performance review are now successfully completed. Cessation of the aerial survey beyond 2016 would mean the Commission would cease to have a scientifically tested, explicitly precautionary, rebuilding plan for the SBT stock. It would also mean under-utilising substantial investments in research and monitoring to develop the current MP and potentially foregoing large future catches that would otherwise have been possible under the agreed MP.

5.4 Logistic implications and reduced aerial survey design

The implications of not conducting the aerial survey in 2015 are both technical and logistic. The logistics issues are that specialist expertise are required to run the aerial survey. In particular, tuna spotters who have been calibrated into the aerial survey, and who have provided consistency in the last 10 years of the survey, may no longer be available in 2016. This logistic vulnerability has increased in recent years, with the loss of experienced pilots and spotters from the Industry, and was planned to be addressed in 2015 with the use of 2 planes and calibration of a new spotter. Ideally, this would have been done over multiple years to provide as precise calibration as possible. This was not possible given the cancellation of the 2015 aerial survey.

The SFMWG meeting agreed to fund the 2016 aerial survey in a reduced format, with 1 plane flying for 3 months and a second plane flying for 4 weeks covering half of January and half of February. Restarting the aerial survey in 2016 in this format is still uncertain because the calibrated spotter may not be available for a 1 year contract and therefore only 1 plane with a new spotter and an experienced spotter pilot (asked to return from retirement) would potentially be available. The logistical and timing issues related to attempting to re-start the aerial survey in 2016 are addressed in Davies (2015b), presented at an informal ESC webinar held in March and are also addressed in the informal report of the ESC for the SFMWG meeting (Anon, 2015a).

5.4.1 An aerial survey every second year and re-tuning

At the time of cancellation of the 2015 aerial survey it was suggested that the aerial survey could potentially be run every other year, but the logistics are not feasible (see Davies 2015b and CCSBT–SFM/1507/09). The expertise required is highly specialised, and it's unlikely that those specialists will be available for a 3 month work project every second year. The key points to note are that there is currently 1 spotter calibrated into the aerial survey, and new spotters can't just be added in without calibration. Importantly, an aerial survey "every-other-year" would be a new management procedure that would need to be fully evaluated. The adopted MP was not designed for data every other year, and therefore an MP of this form would need to be specified and would require full MSE testing of performance prior to use for setting TACs. This would be an extensive additional item for the ESC to consider and potentially add to the existing work program.

Re-tuning was also suggested by the Commission in 2014. As noted by the ESC, the adopted MP cannot be run without aerial survey data. No re-tuning is required, to run the MP with a single missing data point in 2015 and a reduced aerial survey in 2016. This issue of whether re-tuning of the MP is warranted, or not, is an issue that would be considered as part of the MP review scheduled for 2017.

5.4.2 A reduced aerial survey

The ESC inter-sessional work and webinar focussed on impacts and feasibility of options for reducing the cost of the aerial survey through flying fewer hours. Three alternatives for conducting the aerial survey in future were provided to the SFMWG;

1. The full aerial survey – 1 plane for 3 months (Jan-March) and a second plane for two months (Jan and Feb). This allows for complete coverage of the transect area with repeat surveying of each of the transect lines each month.
2. 1 plane for 3 months, and 1 plane from mid-Jan to mid-Feb.
3. 1 plane only for the 3 months of the survey.

Funding for option 2 as a "reduced" aerial survey was agreed at the SFMWG meeting. The "reduced aerial survey" reduces costs through reducing the flying hours. Reducing the hours flown will result is a less certain relative abundance estimate, i.e. higher coefficient of variation (CV).

There are additional logistics risks and complications associated with having only 1 plane available for most of the period of the aerial survey. If there is bad weather, then fewer transects will be flown. There will also be limited opportunity for calibrating an additional spotter. Any breakdowns in equipment or loss of availability of personnel will be a risk to the completion of the survey.

The implications of an aerial survey with higher CV's were tested in comparison runs of the MP using scenarios agreed inter-sessionally (CCSBT–SFM/1507/09). The ESC agreed that the MP could be run using the AS with a higher CV (Anon 2015a).

6 Costs and benefits of the aerial survey

The inter-sessional work of the ESC webinars, focussed on examining the impact of scenarios using aerial survey data with a higher CV in the expectation that there would be a standard "risk-catch" trade-off. The results did not, however, demonstrate this trade-off due to the way in which the data are used in the MP and the more optimistic nature of the OM relative to when the MP was tuned in 2011. These issues are discussed further below along with additional analysis completed since the SFMWG meeting.

6.1 Historical estimated benefits of the aerial survey index

The clearest benefit of the aerial survey relates to the actual adoption and implementation of the MP itself. In the 2010-2011 MP evaluation process the aerial survey was a core element of the candidate MPs (Anon 2010a,b; Anon 2013b) and proved to be a major reason for the robustness of the MP to underlying variability, future recruitment failure, and issues with the LL CPUE index (Anon 2011).

The main qualitative benefits of having the MP are:

- Having a scientifically tested rebuilding program for the stock – the first international tuna fishery to do so (Hillary et al 2015b)
- Given the MP recommended the TAC advice to the Commission from the ESC member scientists had additional time to include key new data sources, such as the close-kin data and initial development of gene-tagging.
- Stability and transparency in the TAC as driven by the MP, which is important to industry.
- Increases in TAC driven by positive signals in both the indices that would have been unlikely to be agreed in the previous stock assessment/consensus advice paradigm (Hillary et al 2015b).

There are also quantifiable financial benefits to having the aerial survey in the MP that are central to the discussion on the costs and benefits of the aerial survey to the MP, rebuilding of the stock and wider flow of benefits from the fishery.

The integrated nature of the MP, where the LL CPUE and aerial survey are fitted simultaneously, conditional on the simple population model, means it is not possible to fully separate the contributions of the CPUE and aerial survey with respect to changes in TAC recommended by the MP. However, the structure of the Harvest Control Rule (HCR) in the MP (Anon. 2013, Attachment 10) allows the component of the historical TAC increases that were due to the aerial survey **alone** to be calculated explicitly. This calculation will underestimate the overall historical contribution of the survey index to the TAC increases, as the increase in the sub-adult biomass that contributed to the TAC increases are also influenced by the survey index as part of the simple state-space "miniassessment". Notwithstanding this underestimation, for the TAC increases agreed and implemented for the period 2012-2017, approximately 1,000t of additional quota was added as a direct result of the information on recruitment provided by the part of the HCR that relates to the aerial survey. Even at conservative prices/quota values for SBT the value of this information alone would cover the cost of the survey over this period a number of times over.

6.2 Future estimated benefits with Aerial Survey index

A number of analyses have been performed to look at the potential future impact of a reduced precision aerial survey in future MP TAC setting decisions, using the SBT OM. The majority of the analyses we refer to can be found in CCSBT-SFM/1507/09; an informal report of the MP technical group to the SWFWG meeting. Given the reasonably clear empirical relationship between the annual observation error CV for the aerial survey and the distance flown in that survey, it was possible to define a number of scenarios for future aerial survey CVs for reduced levels of survey effort to explore the likely precision of less intensive surveys in the future.

The first analyses looked only at the effect of a range of reduced future survey effort scenarios on the adopted MP. These results showed that, at least in terms of future rebuilding and average TACs there was little difference observed across the scenarios. That is, provided there was an aerial survey that continued to provide a "reasonable" index, the impact on rebuilding and catch performance of the MP was small to negligible. This result was not expected and, as noted above, reflects the design of the MP itself and the changes in the perception of the stock from the OM since the MP was tuned and implemented.

The second set of analyses looked more closely at the performance of the MP on the key robustness trials explored in the original MP testing program. Given the reduced aerial survey effort scenarios the future recruitment failure trial (*lowR*) was run ***in combination*** with a number of CPUE-related robustness trials (*highCPUECV, upq, omega75*). This new approach, i.e. combining robustness trials, was undertaken as reducing the precision of the aerial survey implicitly places more faith in the CPUE index. It was precisely these trials that the survey proved so important in the original MP testing program (Anon 2011). The conclusion was that, perhaps contrary to prior expectation, the adopted MP was robust to a reduced level of survey effort even when combining several of the key (and previously very influential) pessimistic CPUE and low recruitment robustness trials explored previously. The most important reasons for these results are:

1. The MP was specifically designed to reduce the variability in both the input indices, by fitting the simple population model to both the CPUE and the survey with fixed total effective variance parameters.

2. The part of the HCR in the MP that relates to the aerial survey uses a 5-year moving average of relative recruitment to the adult population. It reacts strongly to reduce TACs when recruitment is below the historically lowest levels in the survey and small TAC increases are permitted when recruitment is above the historic lows. The 5-year moving average means that, even for the scenarios explored here for CVs associated with different levels of survey effort, the actual statistic derived from the survey used in the MP will never exceed a CV of 20% (i.e. fairly accurate and informative) and effectively the same precision as assumed for the CPUE index in the OM and MP.

3. The current estimates of biomass depletion, fishing mortality, natural mortality and uncertainty therein are all quite different (and more positive) than for the OM of 2011 used to test and tune the Bali MP. The most recent reconditioning of the OM (CCSBT-ESC/1409/21) demonstrated that the Bali MP is much more robust to the various robustness trials that had been highly influential in the past. The inclusion of the close-kin data, as well as positive signals in both the CPUE and the aerial survey of several higher recent recruitments, has contributed to this change in overall status for SBT in the reference set of OMs.
4. None of the analyses explored the potential impact of UAM and, given that a number of alternative and plausible UAM scenarios have an impact on the future robustness of the MP (e.g. CCSBT-ESC/1409/15), it is likely that the current assessment of the future performance of the MP under the reference set of OMs is likely to be over-optimistic.

That the MP is robust to a reduced level of survey effort, as explored in the trials, and in conjunction with unforseen recruitment failure and CPUE index problems, is encouraging. However, this outcome needs to be considered in the context of the caveat that not considering the impact of UAM means the current projections are overly optimistic.

The remaining potential impact to explore is the value of continuing the survey into the foreseeable future in terms of the likely realised catches versus the cost of the survey. From the simple historical analysis above, even for conservation price/quota value levels, the added value of the survey outweighs its cost. We have also examined the aerial survey component in potential future TAC scenarios with and without the continuation of the survey.

Given the future likely distribution of both the CPUE and survey indices, estimated in the reference set of projections, the aerial survey component of the TAC calculations in the HCR would add around 500t of extra TAC **per year** (so 1,500t in total for 2018-2020). Again, given previous price/quota value assumptions the value of this additional TAC resulting from the information provided by the survey far exceeds the costs, even at the historically highest levels of effort and coverage.

If, however, we do not run the survey in 2016 (and by implication it terminates permanently) and exceptional circumstances *are* triggered, it is unlikely the advice from the ESC would be to proceed with a TAC increase based on the MP. One scenario is that risk equivalent constant catch projections might be used by the ESC to provide TAC advice in the absence of the MP. Depending on how one defines that risk equivalence the outcome of this approach in terms of the most optimistic outcome would likely be the *status quo* (i.e. no TAC increase) but might also be a decrease in TAC. Assuming *status quo* TAC advice for this scenario, the forgone TAC would amount to approximately 2,500-3,000t **per year** for the 2018-2020 period. The forgone value to the fishery in this scenario, as a result of not having the information on recruitment from the aerial survey, dwarfs the cost of the survey.

If the aerial survey is removed altogether from 2016, which would result in exceptional circumstances, but is done here as another scenario to illustrate the cost and benefits of the aerial survey, we see a similar overall result. The rebuilding performance by 2035 (in terms of the probability of rebuilding to 20% SSB) is 0.73 without the survey and 0.71 with the survey (i.e. basically the same up to the Monte Carlo error of the simulations). However, the estimated foregone TAC averages in the order of 1,800t lower **per year**. So even when integrating across expected future trajectories for both indices, and regardless of the precision of the survey within the bounds explored, the rebuilding performance is the same but the level of forgone of catch is substantial and greatly exceeds the cost of the survey; in the latter case by at least an order of magnitude. The reason for this is quite simple: the aerial survey-related part of the MP acts to decrease TACs strongly for low (relative to historical minima) levels of mean recruitment, and weakly increase them when above. Given the current more optimistic perception of the projections in the reconditioned OM, future declines in mean recruitment seen in the earlier versions of the OM do not occur (see the zero probability of future stock declines relative to 2014 across all scenarios), so the impact of removing the survey is essentially to forego increases in TAC, on average, as mean recruitment (which can only result from an increasing spawning stock given the stock recruit relationship) improves over time. This key feature might also not be fully understood: at the current estimated level of spawning biomass depletion, the stock-recruit relationship is close to linear and time-averaged recruitment and spawning abundance are actually quite closely linked. In other words, the aerial survey acts in two ways: it can give warning of low recruitments entering the fishery, and over longer timescales (at low depletion levels) is also a proxy for the trends in the spawning population.

7 Alternative information on recruitment

7.1 Gene-tagging

Gene-tagging has been proposed as an alternative method for monitoring recruitment of SBT for some time (Davies et al 2008, Anon. 2008). In 2013 it was included in the CCSBT Scientific Research Program as a method for estimating the absolute abundance of juvenile SBT, and work on the detailed design for a pilot program has been initiated (Preece et al, 2013; 2015). A proposed pilot study would take approximately 22 months, from initial tagging to provision of a single estimate of abundance of the cohort tagged, to complete. This is to allow for 12 months mixing, and includes the additional time delay waiting to access to fish at harvest after grow out in the SA farms. The focus of the pilot study is to demonstrate feasibility, refine field logistics and sample and data management protocols that can be used to finalise the experimental design and cost estimates for a longer-term program. If the pilot project is successful, ongoing monitoring using this method could be considered as a replacement for the aerial survey as a recruitment monitoring series.

Table 1 provides an indication of the time line from commencing tagging (in any year – 2016 is used in this example of earliest possibility) through to the use of a single estimate by the ESC. A series of estimates would be needed for recruitment monitoring or for use in a new MP. If gene-tagging started in 2016 and tagging also occurred in 2017, there would be 2 data points available for use in a new MP in the 2019 calculation of TACs. This is not sufficient to provide an estimate of trend; several more estimates would be required.

Table 1. Summary of main events and time-lag between commencing gene-tagging (in any year – 2016 is used in this example as it is the earliest possibility) through to use of a single estimate by the ESC.

Commence tagging (Feb)	Recapture Sampling (July)	Genetics work completed, abundance estimated	ESC use of abundance estimate
Feb 2016	July 2017	October 2017	Sept 2018
Feb 2017	July 2018	October 2018	Sept 2019 (next TAC calculation)

7.2 CPUE

The current Japanese long-line CPUE is age-aggregated (animals aged 4+), not age-structured. In this section we cover some of the issues that would need to be considered to use age-based CPUE in an OM and MP context.

7.2.1 Generating the indices

The raw data will not be CPUE-at-age (in terms of direct age estimates) but CPUE-at-length, which will need to be transformed via the growth relationship to "age" data. This in itself is a complex issue, and will relate as much to historical as to future data. Issues that will need to be resolved include:

- Which length data to use, as one cannot use the length data that is used to generate the catch composition as this will be "double-dipping" of data (i.e. using data twice in the OM).
- Uncertainties in the underlying data from the over-catch are magnified when moving to an age-based setting. Simple assumptions are made to explore scenarios to deal with this issue in the current age-aggregated CPUE index. The length distribution of those unreported catches remains unknown. It becomes very difficult to see how one can generate a suite of indices that reasonably cover this uncertainty given what we think we know about the over-catch (which is essentially limited to two scenarios assuming various contributions of over-catch to CPUE with effort assumed to be well reported).
- Standardisation of these data is far more complicated than the current age-aggregated CPUE indices. It is not possible to independently derive CPUE indices for a given set of age classes as they are correlated on a number of levels (this also has implications for including them in the OM, which is considered below). Given this, it is likely to require the use of general linear models (different to generalised linear models) that can model the data in a multivariate setting. Based on the fact that we have time-varying selectivity in the long-line fleets one can expect the potential for complicated time-length interaction terms would be required. This would make the analyses manifestly more complicated than the current standardisation models and current indices. The CPUE–by-age that are presented in the Indicators papers (e.g. Patterson and Stobutzki, 2015) do not take these issues into account other than to indicate that these are potentially affected by the overcatches.

7.2.2 Including the indices in the OM

At present, all abundance indices in the OM are age-aggregated (CPUE, aerial survey, trolling index) where the age-classes they cover are either estimated directly via selectivity (CPUE) or assumed (aerial survey, trolling index). To include CPUE-by-age data would require development of a different likelihood structure that would need to account for correlated observation and process errors (i.e. multivariate log-normal, most likely). Additional parameters in this form of likelihoods are the catchability-at-age parameters (which could have a constant selectivity ogive structure) so there would be a range of additional parameters required to be estimated and considerable thought as to how best to model them. This would require extensive new code, testing of the inclusion of these data, and development of suitable diagnostics, as are applied to the other data sources in the OM.

7.2.3 Interpretation of indices

In the context of other potential sources of age-structured CPUE (i.e. non-LL1 fleets; Taiwanese, Korean and New Zealand fleets for example), the spatial aspect of the data underlying the age-structured indices will pose serious challenges for the interpretation of the part of the population-at-age they relate to. The OM takes an areas-as-fleets approach to spatial catches of SBT, where the spatial variation in the distribution of age-classes is largely embedded within the selectivity profiles of those fleets. This is a pragmatic approach to account for removals of fish-at-age in a non-spatial manner, given spatially distinct fleet-classes (surface, long-line, spawning ground) which also, *generally,* have quite different age distributions in their catches.

This approach presents some substantial issues when moving to relative abundance indices as (multivariate) time series as would be required for using CPUE at age. The spatial location of the fisheries the indices come from, and the changing spatial distribution in the population they are fishing, becomes important; as we are not simply trying to account for removal; we are trying to infer relative trends in abundance in a non-spatial modelling framework. The global spatial dynamics (GSD) project (Basson et al 2012) demonstrated that, at least for the youngest age-classes that appear in the long-line fleets (the ones of most interest in this setting), the relative recruitment of these fish to the long-line fleets as they begin to leave the GAB (not just in winter/autumn) is not constant over time. That means that changes over time in the indices from quite distinct spatial regions (for example Taiwanese versus New Zealand catches) are potentially as likely to be relative changes in the spatial distribution of a given set of age-classes over time, as they are indicative of the size of particular year-classes, which would be the only real interpretation a non-spatial OM could have.

Changes in catchability are always going to be an issue for CPUE data. In the past a number of empirical (largely visual) analyses of the CPUE-at-age (for the main and New Zealand long-line fleets) have shown clear indications of catchability year-effects in the past. Even in the age-aggregated CPUE index in the OM there was a clear and continued change in catchability of around 35% (increasing) after the major changes in the long-line fleet from 2006-2008 (i.e. from 2008 onwards). These year-effects are very often interpreted as cohort-effects in stock assessment models if one assumes constant catchability over time, which you have to if you are including something as an actual abundance index. Adding in the discarding issue in the long-line data, there are clearly a number of challenges such abundance indices would have in terms of cleanly monitoring the relative abundance of the various cohorts in the population over time.

7.2.4 Including these indices in an MP

Neither the previous nor current MP structures are set up to include age-based indices. We cannot simply "swap" the aerial survey for alternative CPUE-based indices; therefore we would have to develop a completely new MP. That would require significant financial commitment as well as a lot of modeller time in the development phase.

7.3 Trolling survey data

The troll/acoustic survey data series was developed as part of the joint recruitment monitoring program. The series is used as one of the indicators of recruitment in the annual review of the stock and evaluation of exceptional circumstances.

While the series has been included in MP robustness trials, as part of the last MP testing phase, they are not included in the reference set of OMs used to assess stock status. There are a number of reasons for this, which are summarised in the report of the 13th meeting of the ESC (Anon 2008), some of which were being progressively addressed (Itoh and Takahashi, 2014) before the survey was discontinued.

As demonstrated in Section 5.1, the aerial survey directly informs the recruitment trends estimated in the OM and is consistent with the year-class information from other data. Given this, it can be used to examine the consistency of the level of recruitment indicated by the troll index of 1+ SBT. The aerial survey is assumed to observe the biomass of fish aged 2, 3 and 4 with an associated "selectivity" ogive of 0.5, 1 and 1, respectively; the trolling survey is assumed to observe age 1 fish only. To generate an index from the trolling survey that is comparable to the aerial survey a moving average approach was taken.

For any given year, y, for which we have an aerial survey estimate, the years of trolling data that should include the same cohorts in that year's survey would be y-1, y-2, and y-3, respectively. By creating a weighted sum of these three years of trolling data (weighted by 0.5, 1 and 1 to match the aerial survey weighting by age in the OM) the troll index would then, in some sense, be comparable to the aerial survey estimate. The aerial survey has missing years (2000-2004), and the trolling survey has no data for 2004, so the only directly comparable years for which data exist for both indices are 1999-2000 and 2008-2014 (9 years in total). We then estimated the degree of correlation between the indices using a simple bootstrap approach (given the limited number of samples). The median (and approximate 95%ile) for the correlation between the two indices was 0.11 (-0.15; 0.3). A central assumption of this analysis is that the cohorts first observed in the trolling index experience comparable levels of total mortality before entering the aerial survey age-range (i.e. the cohort-specific Z is quasi-constant over a 4 year moving average range). This assumption will probably be violated in the later data after the TAC reduction in 2009 and the subsequent increase in 2012. However, it is unlikely this impact would be sufficient to account for the lack of apparent correlation between the two indices.

8 Conclusions

We have addressed the 2014 Commission and 2015 SFMWG requests for ESC advice on: 1) the implications for the management procedure process of cancellation of the aerial survey in 2015, 2) the implications of cessation of the aerial survey in 2016 and beyond, 3) costs and benefits of continuing with the current MP and conducting the aerial survey in 2017 to 2019, and 4) alternative recruitment information for use in new MPs. The other requests from the SFMWG (research priorities, alternative MPs and costs, MP review and meta-rules) are dealt with in the meta-rules and management procedure review paper (Davies et al, 2015).

Implications for the Management Procedure of cessation of the aerial survey in 2015

1. The CCSBT's Management Procedure (MP) can be run to recommend a TAC for 2018-2020 if an aerial survey index is obtained for 2016.
2. The lack of the 2015 aerial survey index may trigger exceptional circumstances for the 2018-2020 outcome and possibly also for the 2016-2017 TACs at the 2015 ESC[2].

Implications if the aerial survey does not resume in 2016

3. Complete cessation of the AS would mean that the adopted MP could no longer be used to recommend TACs and the Commission would be without an agreed basis for setting TACs. A new MP would need to be developed.
4. There is not sufficient time to complete the required management strategy evaluation to test performance and robustness of alternative MPs for setting the 2018-2020 TAC in 2016.
5. There would be substantial time and costs associated with developing, testing, agreeing and implementing a new MP.
6. No aerial survey in 2015 and 2016 also means that there is no monitoring of recruitment of the stock, and no warning system for very low recruitment, should this occur. All other recruitment monitoring was cancelled in 2015.
7. Exceptional circumstances would be triggered in 2016. No pre-agreed method for setting the 2018-2020 TACs (in 2016) is in place.
8. The ESC would need to reconsider advice on the TAC for 2016 and 2017 in light of the cessation of the aerial survey and lack of reliable estimate of recruitment.

[2] There are additional issues that may also trigger exceptional circumstances; unaccounted mortalities and changes in size of fish caught in the Indonesian fishery (possible selectivity change).

Considerations of changes to the MP including data

9. Any substantive change to the management procedure requires the performance of the new management procedure to be evaluated using the Management Strategy Evaluation. The current MP took 4+ years to develop, agree and implement in 2011.
10. An aerial survey every-other-year was suggested by the EC; however the logistics of running the aerial survey every-other-year are extremely difficult. The expertise required is highly specialised. New spotters need to be “calibrated” relative to existing spotter expertise to maintain the consistency of the series. In addition, a change in the frequency of the AS would necessarily involve another MSE process as it is effectively a new MP.
11. Re-tuning the current MP to run without aerial survey data was suggested by the Commission; but the aerial survey data are integral to the operation of the MP. Re-tuning is equivalent to full management strategy evaluation of a new MP based on CPUE only going forward.
12. The inter-sessional work included preliminary investigations of impacts of a “reduced aerial survey” (cheaper through less hours flown, higher uncertainty in the abundance estimates). The MP can be operated using these data. Three options for a reduced aerial survey were provided for consideration at the SFMWG. Option 2 involves 1 plane for 3 months, and use of the 2nd plane for 1 month, however, re-gaining the calibrated spotters for a single year contract is currently looking doubtful, and the aerial survey option 2 may not be possible.
13. Model runs using the “reduced aerial survey” did not show any impact on the predicted TACs, because the MP is designed to respond strongly to low recruitments and conservatively increase TACs, and the current test conditions are very optimistic in terms of future recruitment. The current OM structure (2014 OM) used in these tests does not show the contrast in future projections that were seen as part of the 2011 testing of the MP, and the importance of the aerial survey data are not as evident. This is the result of the more optimistic status and projected rebuilding under the current OM.

Costs and benefits of continuing with the current MP and conducting the aerial survey in 2017 to 2019.

14. Qualitative benefits of the adopted MP include having a scientifically tested rebuilding program for the stock – the first international tuna fishery to do so (Hillary et al 2015b, Garcia and Koehler, 2014).
15. Estimates of the aerial survey related component of the TAC increases that have been adopted by the Commission between 2012 and 2017, if converted to a monetary value, would cover the cost of the aerial survey multiple times over.
16. Estimates for potential future TAC increases under the MP, should it continue to be used to set TACs in 2016, that can be attributed to the aerial survey exceed the costs of the aerial survey by an order of magnitude.
17. Consideration of potential precautionary TAC advice in the absence of an MP suggests that status quo TAC’s, or reductions in TAC, would entail loses of 2,500t-3000t TAC per year. The forgone value to the fishery in this scenario, as a result of not having the information on recruitment from the aerial survey, dwarfs the cost of the survey.

Alternative recruitment information for use in new MPs.

18. Gene-tagging is an alternative method for estimating the absolute abundance of juvenile SBT. Detailed design for a pilot program has commenced. The proposed pilot study would demonstrate feasibility and field logistics. If the pilot project is successful, ongoing monitoring using this method could be considered as a replacement for the aerial survey as a recruitment monitoring series.
19. CPUE by age has been suggested as an alternative recruitment monitoring index, however, there are substantial difficulties in dealing with the correlations between ages, the lack of historical information on length frequency and size of the over-catches, and how these data could be integrated into the OM or a new MP.
20. The inclusion of the aerial survey index in the MP development was related to concern over low recruitment, but also due to the concern of relying on an MP using only CPUE and/or catch composition data, given unresolved uncertainties in the historical time-series for the longline fleet, recent changes in the LL1 fleet (due to changes in management and economic drivers) and potential for future changes.
21. Trolling survey data are used qualitatively in the review of indicators of stock status, but are not included in the reference set of OMs used to assess stock status, and therefore are not suitable for use in an MP. There are a number of reasons for this, which are summarised in the report of the 13^{th} meeting of the ESC (Anon 2008), some of which were being progressively addressed (Itoh and Takahashi, 2014) before the survey was discontinued. Examination of the trolling and aerial survey data (which was shown to be consistent with other OM data series) indicates a lack of correlation between the two indices.

References

Anon. 2001. Report of the Sixth Meeting of the Scientific Committee. Tokyo, Japan, 28 - 31 August 2001.

Anon. 2005. Report of the Extended Scientific Committee for the Tenth Meeting of the Scientific Committee. 5-8 September 2005, Taipei, Taiwan.

Anon. 2006. Report of the Extended Scientific Committee for the Eleventh Meeting of the Scientific Committee. 12-15 September 2006, Tokyo, Japan.

Anon. 2007. Report of the Eighth Meeting of the Stock Assessment Group. 4 - 8 September 2007, Hobart, Australia.

Anon. 2008. Report of the Extended Scientific Committee for the Thirteenth Meeting of the Scientific Committee. 5-12 September 2008, Rotorua, New Zealand.

Anon. 2010a. Report of the Third Operating Model and Management Procedure Technical Meeting. 21 – 25 June 2010, Seattle, USA.

Anon. 2010b. Report of the Extended Scientific Committee for the Fifteenth Meeting of the Scientific Committee. 4-9 September 2010, Taipei, Taiwan.

Anon. 2011. Report of the Extended Scientific Committee for the Sixteenth Meeting of the Scientific Committee. 19 – 28 July 2011, Bali, Indonesia.

Anon. 2013. Report of the Eighteenth Meeting of the Scientific Committee. 7 September 2013, Canberra, Australia.

Anon. 2013b. Report of the Fourth Operating Model and Management Procedure Technical Workshop. 23 – 26 July 2013, Portland, Maine, U.S.A.

Anon. 2014a. Report of the Twenty First Annual Meeting of the Commission. 13-16 October 2014, Auckland, New Zealand.

Anon. 2014b. Report of the Nineteenth Meeting of the Scientific Committee. 6 September 2014 Auckland, New Zealand.

Anon. 2015a. Informal Report from the MP Technical Group on the implications of cancellation of the aerial survey in 2015 and potentially beyond. CCSBT–SFM/1507/09.

Anon. 2015b. Report of the Fourth Meeting of the Strategy and Fisheries Management Working Group. 28-30 July 2015, Canberra, Australia.

Basson M, Hobday AJ, Eveson JP, Patterson TA. 2012. Spatial interactions among juvenile southern bluefin tuna at the global scale: a large scale archival tag experiment. FRDC Project No: 2003/002.

Bravington, M. 2003. Further considerations on the analysis and design of aerial surveys for juvenile SBT in the Great Australian Bight. RMWS/03/03.

Bravington M, Venables W, and Toscas P. 2004. An initial examination of the extent of compatibility between the GAB aerial survey index and the stock assessment of 2-4 year old SBT. RMWS/04/02 (CCSBT-ESC/0409/Info02).

Bravington M, Eveson P, Farley J. 2005. The Aerial survey indicex of abundance, updated to include the 2005 survey. CCSBT-ESC/0509/22

Cowling A, Hobday A and Gunn J. 2002. Development of a fishery independent index of abundance for juvenile southern bluefin tuna and improvement of the index through integration of environmental, archival tag and aerial survey data. Final Report FRDC Projects 96/118 and 99/105.

Davies C, Preece A, and Basson M. 2007. A review of the Southern Bluefin Tuna Commission's Scientific Research Program and considerations of current priorities and way forward. CCSBT-ESC/0709/16.

Davies C, Moore A, Grewe P, and Bradford R. 2008. Report on the potential and feasibility of genetic tagging of SBT. CCSBT-ESC/0809/13.

Davies C, Preece A, Hillary R. 2015 Meta rules paper Meta-rules for implementation of CCSBT Management Procedure and consideration of exceptional circumstances and 2017 scheduled review of MP. CCSBT-ESC/1509/12

Davies C. 2015b. Contracting and logistics requirements for the SBT Scientific Aerial Survey. Attachment 1 in CCSBT–SFM/1507/09.

Eveson P, Bravington M, Farley J. 2008. The aerial survey index of abundance: updated analysis methods and results. CCSBT-ESC/0809/24

Eveson P, Farley J, Bravington, M. 2011. The aerial survey index of abundance: updated analysis methods and results for the 2010/11 fishing season. CCSBT ESC/1107/15.

Eveson P, Farley J, Bravington M. 2014. The aerial survey index of abundance: updated results for the 2013/14 fishing season. CCSBT-ESC/1409/18.

Farley J, Bestley S, Campbell, R, Hartman K. 2004. Aerial survey indices of abundance: comparison of estimates from line transect and "unit of spotting effort" survey approach. CCSBT-ESC/0409/19.

Farley J, Eveson P, Basson M. 2014. Commercial spotting in the Australian surface fishery, updated to include the 2013/14 fishing season. CCSBT-ESC/1409/17.

Garcia SM and Koehler HR. 2014. Performance of the CCSBT 2009-2013 Independent Review. Attachment B of CCSBT-EC/1410/11.

Hilary R, Preece A, Davies C. 2014. Stock status of southern bluefin tuna in 2014 with reconditioned operating model. CCSBT-ESC/1409/21.

Hillary R, Preece A, Davies C. 2015. Technical changes in the MP to account for missing AS data. CCSBT-OMMP/1509/4.

Hillary RM, Preece AL, Davies CR, Kurota H, Sakai O, Itoh T, Parma AM, Butterworth DS, Ianelli J, Branch TA. 2015b. Scientific alternative to moratoria for rebuilding depleted international tuna stocks. Fish and Fisheries doi: 10.1111/faf.12121.

Hobday A. 2005. Southern Bluefin Tuna Recruitment Monitoring Program 2003/2004. Final report to AFMA: R03/1429.

Itoh T, Kurota H, Takahashi N. 2007. Review of the CCSBT Scientific Research Program between 2001 and 2005. CCSBT-ESC/0709/41.

Itoh T and Takahashi N. 2014. Trolling indices for age-1 southern bluefin tuna: update of the piston line index and preliminary analysis of the grid type trolling index CCSBT-ESC/1409/34

Itoh T. and Tokuda D. 2014. Report of the piston-line trolling monitoring survey for the age-1 southern bluefin tuna recruitment index in 2013/2014. CCSBT-ESC/1409/33.

Patterson H and Stobutzki I. 2015. Fisheries indicators for the southern bluefin tuna stock 2014–15. CCSBT-ESC/1509/11.

Polacheck T, Eveson JP, and Laslett GM. 2004. Increase in growth rates of southern bluefin tuna (Thunnus maccoyii) over four decades: 1960 to 2000. Can. J. Fish. Aquat. Sci. 61: 307-322.

Preece A, Davies C, Bravington M, Hillary R, Eveson P and Grewe P. 2013. Preliminary cost and precision estimates of sampling designs for gene-tagging for SBT. CCSBT-ESC/1309/18.

Preece A, Davies C, Hillary R. 2014. Implications of unaccounted mortalities on stock status and projected rebuilding using the management procedure. CCSBT-ESC/1409/15.

Preece A, Eveson P, Davies C, Grewe P, Hillary R and Bravington M. 2015. Report on gene-tagging design study. CCSBT-ESC/1509/18.

Sullivan K. 2015 Discussion Paper on Future Scientific Research Programme. CCSBT-ESC/1509/20.

CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

AT CSIRO WE SHAPE THE FUTURE

We do this by using science to solve real issues. Our research makes a difference to industry, people and the planet.

As Australia's national science agency we've been pushing the edge of what's possible for over 85 years. Today we have more than 5,000 talented people working out of 50-plus centres in Australia and internationally. Our people work closely with industry and communities to leave a lasting legacy. Collectively, our innovation and excellence places us in the top ten applied research agencies in the world.

WE ASK, WE SEEK AND WE SOLVE

FOR FURTHER INFORMATION

Oceans and Atmosphere
Ann Preece
t +61 3 6232 5222
e ann.preece@csiro.au
w www.csiro.au

Oceans and Atmosphere
Rich Hillary
t +61 3 6232 5222
e rich.hillary@csiro.au
w www.csiro.au

Oceans and Atmosphere
Campbell Davies
t +61 3 6232 5222
e campbell.davies@csiro.au
w www.csiro.au