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CCSBT Scientific Research Program: A brief review (2014-2018)

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Report to the Commission for the Conservation of Southern Bluefin Tuna

Acknowledgements

The Scientific Research Program of CCSBT has been central to the collective achievements in rebuilding of the stock and fishery and improvements in the institutional operations of the CCSBT over the past decade. We recognise and thank all who have contributed to the design, funding, implementation, review and adoption of the results of this program.

1 Abstract

The CCSBT Scientific Research Program has been central to improving the data and methods available for stock assessment and the provision of robust management advice for rebuilding the SBT stock. We provide a brief review of the 2014-2018 SRP and identify outstanding activities that should be considered by the ESC for inclusion in the next phase of the SRP.

2 Introduction

The CCSBT Scientific Research Program (SRP) was originally initiated in 1999/2000 to address priority scientific monitoring and research requirements for the assessment of the southern bluefin tuna (SBT) stock and management of the fishery (CCSBT 2000). The Advisory Panel was engaged by the Commission to design the SRP in consultation with national scientists. In designing the original SRP, the focus was on where potential improvements could be made in stock assessment inputs, basic fishery data (e.g. size and age distribution), biological parameters (e.g. natural mortality, age of maturity, growth rates etc), and absolute and/or relative measures of abundance (e.g. CPUE, fishery independent surveys, tagging experiments) (CCSBT 2000).

The objective of the original SRP was:

- *" to improve the quality of the data used as input to the stock assessment and to contribute to the development of reliable indices to monitor future trends in stock size* (CCSBT-SC 2001, Attachment D)."
- had four research areas:
    1. Characterisation of the catch
    2. CPUE interpretation and analyses
    3. Development of a Scientific Observer Program
    4. Development of a SBT Tagging Program.
- was conducted 2001-2006, was reviewed regularly, with a substantial review in 2007 (Anon., 2007; Davies et al; 2007; Itoh et al 2007).

The major focus of the ESC between 2007 and 2011 was evaluating the impacts of unreported catches, the re-development of the operating model (OM) and management procedure (MP) design, testing and implementation. Davies et al (2012) summarised the progress and outcomes since the 2007 SRP review and identified potential areas for future focus.

The 2013 meeting of the ESC recommended an updated five year SRP (2014–18) (ESC18, paras 136-148, Attachment 12), which the Extended Commission adopted (Report of EC20, para 58). This revised SRP focussed on five broad categories of research activities, with more specific subcategories and activities identified in each (see Attachment 12, ESC18):

1. Characterisation of Catch
2. Abundance Indices
3. Biological Parameters
4. MP implementation
5. Stock Assessment (OM development).

In this paper we provide a brief overview of the activities completed under the SRP (2014-2018) and make some initial suggestions for priority areas and activities for the next phase of the SRP

(2021-2025). The review is not, by any means, comprehensive, but we hope is a useful starting point for a more in depth review and a focussed discussion on future priorities by the ESC in 2021, when it may be possible to allocate the required time.

3 A brief review of the SRP: 2014-2018

CCSBT-ESC/1809/13 provided an initial framework for reviewing progress and achievements through the SRP (2104-2018). We have expanded on this in Table 1, which provides an initial summary of progress against the activities included in the plan developed in 2013 and modified by the ESC in 2015, in response to the need for a more rapid transition in the recruitment monitoring from the scientific aerial survey to gene-tagging.

It is apparent from Table 1 that substantial progress has been made in many of the areas:

1) **Characterization of catch:** Definition of attributable catch by the EC, developments of approaches for estimating non-member UAM, and inclusion of UAM in the conditioning of OMs for testing of new CMPs have all contributed to stock assessment and management advice encapsulating a greater proportion of total removals than was the case previously. There are also a number of unresolved issues and/or activities that have not been addressed through this period, which may be prioritised for activity in the next SRP period.
2) **Abundance indices:** This area has been a major focus of the 2014-2018 SRP, in particular, the development and implementation of gene-tagging as an alternative to the scientific aerial survey for recruitment monitoring, the transition of Close-kin Mark Recapture (CKMR) to SNP markers and associated extension to Half-Sibling Pairs (HSP) and an increased focus on alternative CPUE series and approaches to monitor the change in fleet dynamics of the LL1 fishery.
3) **Biological parameters**: The main activity in this area was the development of an independent estimate of size and age at maturity through the collection of gonads form the autumn/winter feeding ground and a collaborative workshop to standardise histological and reproductive staging methods. Completion of the histology reading and analysis should be a priority.
4) **MP Implementation**: This period included the operation of the Bali MP, the development of the methods to include the two new monitoring series (gene-tagging and CKMR) in candidate management procedures and the development, testing and selection of a new MP. An important activity that was identified for this period, but no completed due to the premature transition from the Bali MP to the Cape Town MP, was the development of terms of reference for and MP review.
5) **Stock Assessment (OM development):** The main activity in this area has been the modification of the OMs to accommodate the new data series (CKMR and gene-tagging) in conditioning and projections. The addition of CKMR data has also contributed to improved

estimates of M_{10} and analysis of fishing patterns of the Indonesian fleet in Area 1 and 2 have improved the understanding of the "small fish" issue on the spawning grounds.

4 Initial consideration of priorities for SRP: 2021-2025

The ESC proposed to review and revise the Scientific Research Program (SRP) plan for 2021-2025 by ESC 25. The proposed process involved individual Members providing, where appropriate: (i) a cursory performance review of the 2014-2018 SRP; (ii) proposed revisions to overarching research activities for both on-going scientific monitoring and longer-term strategic research; (iii) proposing general research themes under each overarching research activity; (iv) establishing, during the intersessional period, discussions and collaborations on research activities; and (v) delivering draft SRPs in working papers submitted to ESC 25. Unfortunately, the impact of COVID-19 and the priority place on preparatory work for the full stock assessment in 2020 has reduced members capacity to contribute to this process.

There are a number of activities that have not been advanced or were not considered as sufficiently high priority during the 2014-2018 SRP. Of the currently listed activities, we would consider the following important to carry over to the 21-25 SRP:

- Those associated with quantifying different source UAM to be priority, in particular, methods for determining the plausibility of estimates of non-member UAM.
- Consideration of the potential to move from cohort slicing to catch at age; particularly if epigenetic ageing proves to be possible for SBT.
- Completion of the independent estimate of size/age at maturity, as noted above, as a high priority.
- Design study to examine the relative costs and benefits of alternative e-tagging in addressing questions associated with environmental change and potential changes in spatial dynamics of different components of the stock.
- Strategic review and refinement of operation of the OM code.

Appendix A: Summary of activities, progress and achievements for SRP:2013-2018

Table 1: Summary of progress with research activities identified under the CCSBT Scientific Research Program: 2014-2018. Preliminary suggestions on future activities noted in *blue italic text in Progress/Status column*.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
i. Characterization of catch (Future)					
Catch amount					
Unaccounted catch mortality - Unreported or uncertainty in retained catch by Members		2014 Extended Commission request, OM and annual status advice	Ongoing; potentially with more work for MP Review and OM revision (High for all categories)	EC21. Para 50-53, Table 1	"Attributable Catch" defined by Commission.
Unaccounted catch mortality - Mortality from releases and/or discards				EC21. Para 50-53, Table 1	Discards included in definition of attributable catch. *Address uncertainty in discard rates by fishery.*
Unaccounted catch mortality - Recreational fisheries				ESC 21 CCSBT-ESC/1609/Info 02 EC21. Para 50-53, Table 1	Recreational catch accounted for in definition of attributable catch for members.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Unaccounted catch mortality - Catches by non-members				ESC 21 CCSBT- ESC/1609/32 CCSBT- ESC/1609/7	Trade and market reviews for presence of SBT in non-members markets.
				ESC 21 CCSBT- ESC/1609/BGD-3	UAM included in OMs for MP testing.
				ESC 21 CCSBT-ESC/1609/BGD 02 ESC22 CCSBT-ESC/1509/10 ESC24 CCSBT-ESC/1909/33 ESC 25 CCSBT-ESC/2008/BGD04	Method developed for constructing scenarios for potential scale of non-member catch
Any other sources of unaccounted mortality			-	-	-
Size structure					
Value of using the CDS data as a comprehensive sample of the size structure of removals		OM and annual status advice	As soon as possible then ongoing (High)	ESC17. Para. 112 ESC18, Para. 69	Pending agreement by all members.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Age structure					
Review of sampling design for otolith sampling		Current sampling too sparse to be representative		ESC17. Para.120	Limited by distribution of observers on LL vessels to collect otoliths. *Future review and design exercise pending outcomes of epigenetic ageing.*
Calibration of age estimation (workshop)		Long time since previous workshop and relatively low cost	2016 (High)	ESC17 CCSBT-ESC/1409/24 ESC18	Agreed at ESC18, but yet to be completed.
Instigate moves towards catch at age data rather than using cohort slicing in the OM.		Improved estimates of recruitment and selectivity from the longline fisheries, OM and annual status advice.	Cost and logistic implications (Low – outside current timeframe, post 2018)	ESC17. Para. 76-79 & 120 CCSBT-ESC/2008/Info04	See above. Currently limited by reliance on observer coverage to collect otoliths at sea. See potential for epigenetic ageing.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
ii. Abundance indices					
a) **Recruitment**					
Proportion of juvenile population that move into the Great Australian Bight		Stock structure for the OM and assumptions for recruitment indices and close-kin analysis.	(Medium)	Para. 81-83 ESC (2012) CCSBT-ESC/1409/22 CCSBT-ESC/2008/35	Design/feasibility study completed for the potential of using otolith microchemistry to examine movement. Unsuccessful. Design study proposed for E-tagging project.
Migration of age 1 SBT (electronic tagging during troll survey)			Ongoing (Medium)	CCSBT-ESC/1708/22 CCSBT-ESC/1909/25 CCSBT-ESC/1809/26	Substantial e-tag deployments by Japan as part of 1+ troll survey
Design study on alternative measures of absolute juvenile recruitment (gene-tagging approaches)		Estimates of absolute abundance of cohorts for the OM	Design study 2015 (High)	ESC18 Report of ESC 20 CCSBT-ESC/1509/18	Complete. Gene-tagging recommended by ESC20 and funded by Commission.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Pilot gene-tagging program: Absolute abundance estimates of juvenile recruitment		Demonstration feasibility obtaining absolute abundance estimates of cohorts via gene-tagging for use in the OM	Pilot gene-tagging 2016 and 2017 (High, dependent on outcomes of design study)	ESC18	Complete.
				Report of ESC20	Design study
				CCSBT-ESC/1509/18	
				ESC22 & 23 and OMMP9	Complete.
				CCSBT-OMMP/1806/06	Large scale pilot study (2016).
				CCSBT-ESC/1709/7	
				CCSBT-ESC/1809/06	Complete
					2 full cycles (2017, 2018).
				Report of ESC24 & OMMP10 and 11	Adopted as input to OMs and MP (See MP implementation and Stock Assessment sections below).
				CCSBT-OMMP/1906/06	
				CCSBT-ESC/1909/10	
				CCSBT-ESC/1909/11	
				CCSBT-ESC/2008/6	

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Environmental interactions with the scientific aerial survey		Improved relative recruitment index; MP implementation	Partly underway in the Australian GAB project (Medium)	Para. 29 ESC17 See Evans et al 2017 for final report of SBT component of GAB program. Patterson et al 2018a for large-scale migration. Patterson et al 2018b for GAB habitat use. Eveson et al 2018a for surfacing behaviour. Evans et al 2018 for interaction with seismic	Not explicitly addressed, but see results of archival tag analysis, including juvenile migration and fine-scale GAB dynamics.
Review scientific aerial survey standardisation; Previous papers provide the details of calibration and model selection		OM and MP	(High) Members review previous papers and discuss at ESC 2015.	ESC17 CCSBT-ESC/1809/26 Eveson et al 2018b	Complete. Methodology sound. Issues with logistic frailty of survey due to availability of experienced spotters and need/expense associated with calibration between spotters. Aerial Survey discontinued in 2017. Gene-tagging initiated as alternative recruitment monitoring series.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Standardised CPUE series for Taiwanese longline fleet		Annual status advice	Ongoing, CPUE working group (High)	ESC17, Para. 54-56 & 60	Outstanding issues around E-W grounds and targeting.
				OMMP4 ESC20 CCSBT-ESC/1509/23 ESC21 CCSBT-ESC/1609/33 ESC23 Para. 53 CCSBT-ESC/1809/39 ESC24 CCSBT-ESC/1909/37	New approach using cluster analysis to select sets for inclusion in SBT standardisation. Possible inter-annual shifts catchability associated with changes in targeting remain a challenge.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
b) **Sub-adults**					
Exploration and refinement of alternative CPUE monitoring series		MP implementation	Ongoing, CPUE working group (High)	ESC18, Para. 50-53 & 60 ESC19 CCSBT-ESC/1409/36 CCSBT-ESC/1409/42 ESC21 CCSBT-ESC/1609/12 ESC23 CCSBT-ESC/1809/BGD02 CCSBT-ESC/1809/BGD03 OMMP11 Para. 11-24 CCSBT-OMMP/2006/10 CCSBT-OMMP/2006/11 CCSBT-OMMP/2006/12 CCSBT-OMMP/2006/15	Ongoing exploration of methods to address spatial and temporal interaction of fleets and SBT stock. Initial application of GAMM. Core Series Exploration of potential use of LL1 for recruitment index. Issues identified with Base series in 2020 will require dedicated work program

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Monitoring and exploration of changes in fleet operations over time		MP implementation and OM	Ongoing, CPUE working group (Essential)	ESC18, Para. 58-60 ESC 23, para. 48-49, Att CCSBT-ESC/1809/BGD04	Regular papers on monitoring spatial/temporal patterns and changes in fleet. Issues identified with Base series in 2020 will require dedicated work program
Standardised CPUE series for Korean longline fleet		Annual status advice	Ongoing, CPUE working group (High)	ESC17, Para. 54-56 & 60 OMMP4	Ongoing.
				ESC22 para. 31-41 and Att.6. ESC/1708/34 CCSBT-ESC/1708/BGD10	Detailed review of data and application of alternative data selection and standardisation approaches.
				ESC23 CCSBT-ESC/1809/41	
				OMMP11 CCSBT-OMMP/2006/13	

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
c) **Spawning biomass**					
Close-kin abundance estimation (revise after further discussion, possibly refer to a more detailed document)		Design study provide costs and benefits of a time series of close- kin data collection for the OM	(2013-14, High)	ESC17 Para. 114 ESC18 Para.129-134. Att.10 CCSBT-ESC/1309/17 CCSBT-ESC/1409/44	Completed. Initial cost-benefit study recommended shift to SNP markers and approximate sample size requirements. ESC2014, para 125. ESC requested external review of technical details of sequencing approach for kin identification (see below).
Continued close-kin sample collection		Need to take advantage of present opportunity	2014 and ongoing (High)	ESC18 Para.129-134	Completed/Ongoing Annual collection of samples of adults (Benoa, Indonesia) and juveniles (Pt Lincoln, Australia: 2006-2020
Further work (some laboratory, some desk top) on the potential genetics approach to inform an expert review/workshop		Further work on genotyping approaches to inform the decision on long-term approach.	2015 (High)	ESC19 Para.131 ESC/1509/36 ESC/1509/19	Completed.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Expert review workshop (ESC and experts familiar with the techniques and their use in this context)		This will review and decide on the long-term approach to genotyping	2015 (High)	ESC20, paras 126-131. CCSBT-ESC/1509/19 CCSBT-ESC/1509/36	Completed. Both reviewers endorse the change to DArT sequencing method and the value of extending CKMR to the POPs +HSPs approach. ESC noted potential for CKMR data to be used in CMPs
Follow-up to review process and dependent on review outcome.		Further locus development, and validation Timing for 2017 assessment may be advantageous given uncertainties generated by unaccounted mortality scenarios (Option 1)	(High) Option 1: 2015 Option 2: 2016	OMMP8 CCSBT-OMMP/1706/12 ESC22 CCSBT-ESC/1708/Rep01 CCSBT-ESC/1708/36	Complete. Locus (SNP), kin identification confirmed for 2017 Stock Assessment.
Medium term: process the accumulated back catalogue of samples (4-6 years of accumulated samples)		Timing for 2017 assessment may be advantageous given uncertainties generated by unaccounted mortality scenarios (Option 1)	Option 1: 2016 to input to the 2017 assessment. Option 2: 2017 to input to the 2020 assessment.	OMMP8 and ESC 2017 CCSBT-OMMP/1706/12 CCSBT-ESC/1708/36	Completed. 10 year time series of samples sequenced and analysed for inclusion in stand-alone CKMR model, 2017 stock assessment and CMP development.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Long-term time series		Fishery independent index of spawning stock, information on fecundity, adult selectivity and mortality	Ongoing, once previous stages are completed	OMMP and ESC20	Complete.
				OMMP8 and ESC22, Para. 52-53, 87-88.	Adopted as part of MP development process in 2017.
				CCSBT-OMMP/1706/4	Full report to ESC23.
				CCSBT-OMMP/1706/5	
				CCSBT-ESC/1708/Rep01	
				CCSBT-ESC/1708/12	
				CCSBT-ESC/1809/12	
Associated OM refinement/development associated with incorporating close-kin time series etc.		This requires discussion and further consideration at 2015 ESC		OMMP8 and ESC20	Complete.
				OMMP8 and ESC22	OMs modified to include CKMR POP and HS data and associated diagnostics (See below under MP Implementation and Stock Assessment).
				CCSBT-OMMP/1706/4	
				CCSBT-ESC/1809/14	
				CCSBT-ESC/1809/19	
				Davies et al 2020	

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
iii.	**Biological parameters**				
Independent estimate of maturity schedule		Defining effective reproductive contribution in the OM, MSY estimation	Sample collection, 2015 and ongoing (High)	OMMP4 ESC18	Proposal to ESC19.
			Processing & analysis prior to 2017? (Medium)	ESC20 CCSBT-ESC/1509/15	Partially Complete.
				ESC21 CCSBT-ESC/1708/32 ESC22 Para.136-138	Samples collected from non-spawning ground fish by members. Maturity workshop completed in 2019.
				ESC24 Para. 21-22 CCSBT-ESC/1909/07 CCSBT-ESC/1909/36 CCSBT-ESC/1909/41 CCSBT-ESC/1909/42	*Final analysis in progress.*

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Understanding within season spawning behaviour and skip spawning behaviour (e.g. electronic tagging approaches and otolith microchemistry for spawning frequency). Note this may draw on close-kin future work (if half-sibling pairs are identified)		Defining effective reproductive contribution in the OM	Reconsider in 2015 (Medium)	Para. 118 ESC 2012 ESC23 CCSBT-ESC/1809/14 CCSBT-ESC/1809/19 Bravington et al 2016 Davies et al 2020 ESC19 CCSBT-ESC/1409/22	Partially complete. Effective reproductive contribution redefined via CKMR POP data as TRO, which is now used in the OM. POP data provided evidence of skip spawning in younger adults (Davies et al 2020). Otolith microchemistry not successful for this purpose.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
2. MP Implementation					
Terms of reference for formal MP review [Indicators of MP performance/improvement]		Preparation for first formal review of the MP (2017).	2015 ESC – substantive agenda item to discuss what should be done before 2017 (High)	Para145 ESC 2013; Att10 ESC 2013 CCSBT-ESC/1509/12 CCSBT-ESC/1509/38	Incomplete. Initial suggestions at 2015 ESC. Not progressed due to need to develop new MP. Should be revisited as part of reviewing Meta-Rules and schedule of implementation for the CapeTown Procedure.
Feasibility of alternative indices for input to the MP (estimated trends from the stand-alone close kin assessment, gene-tagging)		For revised MP	Longer term (Medium)	ESC 2013 Para 155 and 156 ESC 2015, CCSBT/1509/18	Completed. GT adopted.
				Para 38 ESC 2016, CSBT-ESC/1509/19	CKMR POPS & HSP adopted.
				CCSBT-ESC/1609/BGD06 ESC 2019 CCSBT-ESC/1909/16	Developed and used in development of CMPs.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
3. Stock Assessment (OM development)					
Selectivity of the fishery on the spawning grounds (note potential link to close-kin). Potentially informed by the collation and analysis of existing data on fleet operations (shifts in targeting, spatial temporal distributions in effort, species composition, hook setting depth)		OM – basis for domed selectivity and defining effective reproductive contribution	Prior to 2017 (High)	Para. 115 ESC 2012, OMMP4, attachment 4 CCSBT- OMMP/1307/5, CCSBT-ESC/1809/14 CCSBT-ESC/1809/19 CCSBT-ESC/1909/9 Davies et al 2020	Partially complete. Indonesian selectivity and mortality schedule for adult fish reviewed and refined with the incorporation of CKMR POP data. Has been reviewed with the incorporation of HSP in OM and with stand-alone CKMR model. *A longer time series of CKMR data will help test the current assumptions.*
Mortality estimates for mature fish (10+ years old) (Note the potential through close kin)		Current OM does not have data sources that provide substantial information on M10.	Longer term, potentially high cost (Medium)	ESC 2013 CCSBT-ESC/1809/14 CCSBT-ESC/1809/19	HSP CKMR data provides information on total mortality of adults in OM and stand-alone CKMR model.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Improved information on cohort abundance, fishing mortality and natural mortality (e.g. gene-tagging approaches)		OM – mortality estimates	Design/feasibility study for gene-tagging could consider cohort abundance 2015 (High) Longer term (Medium)	Para. 88-89, 117, OMMP workshop CCSBT-OMMP/2006/5, CCSBT-ESC/2008/12	Implementation of gene-tagging is providing precise estimates of 2 year old cohort abundance.
Potential costs and benefits of a spatially explicit stock assessment		OM, review in light of otolith microchemistry and gene-tagging results	Longer term (Low)	Para. 89 ESC 2012	Not progressed. *May become a higher priority in the medium term to address spatial dynamics of fleets and stock, but will be conditional on availability of suitable tagging data series.*
Strategic review and refinement of operation of the OM code		Update and improve efficiency of code	Before 2017? (Medium)	ESC 2013 Para 50, OMMP 2018 Para 31-32, OMMP 2017	Limited progress. Development of shiny app (2018) which allows members to see model results in standard figures and tables Some progress on making Hessian calculation functional for including within-cell uncertainty estimation.

Activity	Potential research	Relevance	Original Timeframe (Priority)	Reference	Progress/Status
Evaluating possible changes in the OM (model structure)			High 2015 ESC Discussion or jointly with review meeting of close-kin	CSBT–OMMP/1706/04 CCSBT-ESC/1809/19	OM structure has been revised to incorporate the CKMR (POP and HSP) and GT data for stock assessment and to allow for data generation (in projections) for these data series for CMP testing
Incorporation of SRP tagging data from 2000s		Related to spatially explicit model	Longer term (medium)	ESC 2013	Not progressed

4.1 References for Non CCSBT paper citations

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