CCSBT-ESC/2608/BGD 06
(*Previously* CCSBT-ESC/2508/19)
(ESC Agenda item 11)

Australia's National
Science Agency

Ensuring the SBT MP advice is robust to impacts of climate change

Preece AL and Davies CR

Prepared for the Thirtieth Meeting of the Extended Scientific Committee

25-30 August 2025 Virtual meeting

CCSBT-ESC/2508/19

Citation

Preece AL and Davies CR. 2025. Ensuring science advice is robust to impacts of climate change. CCSBT-ESC/2508/19

Copyright

© Commonwealth Scientific and Industrial Research Organisation 2025. To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of CSIRO.

Important disclaimer

CSIRO advises that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, CSIRO (including its employees and consultants) excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

CSIRO is committed to providing web accessible content wherever possible. If you are having difficulties with accessing this document please contact csiro.au/contact.

Acknowledgement of Country

CSIRO acknowledges [the Traditional Owner/s name(s) as (delete if not required)] the Traditional Owners of the lands, seas, and waters, of the area that we live and work on across Australia and pays its respects to Elders past and present. CSIRO recognises that Aboriginal and Torres Strait Islander peoples have made, and will continue to make, extraordinary contributions to Australian life including in cultural, economic, and scientific domains.

This work was funded by AFMA and CSIRO

Contents

1 Abstract 1

2 Introduction 2

3 Management procedure framework in the meta-rules 3

4 Is the management procedure robust to potential climate change impacts? 3

4.1 Do the management procedure data inputs capture climate change impacts? .. 3

4.2 Which input data sources are affected by climate change? 5

5 Research to monitor changes to input data or other impacts 5

6 Conclusion 6

7 References 7

1 Abstract

The CCSBT and ESC are concerned that climate change could affect current and future recruitment and consequently rebuilding of the stock, and distribution of SBT and impact on members' fisheries. As a starting point for discussion on impacts of climate change, we suggest that we focus on whether the science advice for management of the stock and fisheries is robust to changes that may occur. Extensive research has already been undertaken world-wide on impacts of climate change on fish stocks, but predictions are usually highly uncertain, because of the complexity of changes in physical and biological systems, and the underlying processes and interactions. A very wide range of process may be affected by climate change, but these can categorised into a small set of concerning outcomes that could affect operational advice, e.g. reduced recruitment (due to changed larval survival rates, changes in fecundity etc), reduced adult/spawner abundance, changes in key population dynamics parameters (e.g. mortality, growth) and changes in spatial distribution (range and migration shifts). The CCSBT is well positioned to respond to the direct impacts of climate change on the stock and fishery because it has in place the meta-rules framework and exceptional circumstances process to address changes, an adaptive management procedure that has been tested via Management Strategy Evaluation, and fishery-independent monitoring programs. We propose that the ESC should focus on robustness of the advice from the management procedure, adequacy of the monitoring programs, and identifying any gaps in monitoring and future research needs.

2 Introduction

Examining the potential impacts from climate change has been identified as a key priority in the CCSBT Strategic Plan 2023-2028 (Anon., 2023), Scientific Research Program (Anon., 2022), and the 2021 Performance Review (Sinan et al., 2021). The IPCC reports that fast warming areas of the ocean have already seen impact in terms of changes in marine species, and habitats (IPCC 2023), and future distribution and abundance of marine species are projected to change in many regions (e.g. Pethybridge et al., 2020). Extreme ocean temperature events known as marine heatwaves (https://www.marineheatwaves.org, Hobday et al., 2018), toxic algal blooms, and weather anomalies are expected to increase in frequency and duration (Cai et al., 2021). These factors suggest that the CCSBT should be concerned about climate change impacts on the SBT stock, fisheries and supporting ecosystems.

Climate change has the potential to change recruitment success, spawning success, growth, natural mortality, and spatial distribution, but predicting the scale of impacts and their interaction is difficult (Carruthers, 2024). SBT may be vulnerable to warming waters and changes in the spawning ground area that affect productivity and survival of larvae; ocean acidification that may affect larval survival; heatwaves and ocean current changes that may affect survival and migration of juveniles down the west coast of Australia; changes to upwelling and shifts in abundance and location of prey species that may affect growth and maturity; and changes in water temperature and currents that may affect migration patterns.

Complex ecosystem models explore potential impacts and forecast future scenarios, but these models are not designed to provide operational advice. For some fisheries where environmental variables (e.g., sea surface temperature, oceanic water temperature oscillations) are demonstratively linked to productivity changes in a stock, the variables may be integrated in assessment models or management procedure advice. Uncertainties remain, however, because the underlying processes are often not well understood, and it is assumed that in future these relationships and processes are sustained. For a highly migratory and long-lived species like SBT, the impact of specific environmental changes on the stock will be more difficult to disentangle.

In our view, these are key questions for the CCSBT when considering the impact of climate change on SBT:

1. Is the management procedure TAC advice robust to a range of plausible scenarios for the impacts of climate change?
2. Are the data sources for the management procedure likely to be affected by climate change to the extent that they compromise the performance and robustness of the management procedure, and what research is needed to monitor changes to input data or other impacts?

In this paper we examine the robustness of the Cape Town procedure to climate change impacts and briefly consider future research needs.

3 Management procedure framework in the meta-rules

The Management Procedure Framework, specified in the meta-rules adopted by the Commission when adopting the Bali Procedure and the Cape Town Management Procedure, has built in mechanisms that are designed to assist the Commission to manage the impacts of uncertainties and unexpected events, like climate change, on the SBT stock and fisheries:

1. The management procedure is an adaptive decision-making rule that responds to changes in stock conditions to inform future management decisions. The adopted management procedure has been tested against a range of future conditions, some of which mimic potential climate change impacts, such as more extreme but plausible scenarios for reduced recruitment. This is to ensure that the management procedure is robust to these uncertainties or will adjust catches in response to impacts on the stock in a way that does not pose a risk to the stock.
2. The meta-rules / management procedure framework has a well-established exceptional circumstances process that includes review of any conditions or circumstances that may affect operation of the management procedure and TAC advice. If there is evidence of an impact on the monitoring series, stock or fisheries, that the Management Strategy Evaluation (MSE) and management procedure design has not tested for, then the ESC can provide precautionary advice, including collection of additional information, review of the management procedure's recommended TAC, and in extreme cases consider development of a new management procedure that reflects the change in circumstances.

For the management procedure to be robust to climate change and perform as expected, we need to review whether the data inputs to the management procedure and the grid and robustness tests used in MSE capture a sufficient range of plausible and less likely (but possible) future scenarios, given the current knowledge of likely and unlikely impacts.

4 Is the management procedure robust to potential climate change impacts?

4.1 Do the management procedure data inputs capture climate change impacts?

The potential impacts of concern from climate change on fish populations can be summarised in the following four categories: 1) recruitment decline, 2) adult abundance decline, 3) changes in key population dynamics parameters i.e., growth, maturity, natural mortality and 4) changes in the spatial and temporal distribution of fish (e.g., Carruthers, 2024). We consider whether changes in these categories are likely to be detected in the input data for the management procedure or have been tested in robustness test (MSE), and where there are gaps.

The input data for the management procedure comes from two fishery-independent monitoring programs (gene-tagging and Close-Kin Mark-Recapture (CKMR)) and the fishery-dependent longline CPUE series. These three sources of input data to the management procedure are providing information on recruitment (gene-tagging), relative abundance of juveniles and sub adults (longline CPUE), and adult abundance via reproductive success, mortality and peak maturity (CKMR). MSE testing, completed in 2019 for the Cape Town procedure, included a range of models and robustness tests including very low recruitment and productivity shifts in recruitment and changes in catchability in the CPUE index. Changes in recruitment are a high priority for SBT management procedure robustness tests because of the late age of maturity (age 10+) that creates a 10+ year delay in detecting any impact on future spawning stock size. The stock was subject to low recruitment and low spawning stock size from the early 1980s until recently when the adult abundance was rebuilt above the common limit reference point of 20% of initial spawning biomass (now specified as total reproductive output).

1. Recruitment decline: The gene-tagging monitoring program provides information to the management procedure (and stock assessment) on the annual absolute abundance of juvenile (age 2) fish as a measure of recruitment (and its trend and variance). The Cape Town procedure has been tested against sustained low recruitment scenarios, and it was clear that the management procedure would respond to these signals and avoid future risk to the stock.
2. Adult abundance decline: The size of the spawning stock is being monitored, along with adult mortality and age of maximum adult reproductive success, via the CKMR monitoring program, which should detect shifts in adult abundance and these parameters in the management procedure and stock assessment models.
3. Population parameters:
    a. Growth: Changes in length and weight are not directly measured by the management procedure monitoring programs. This won't directly affect the performance of the management procedure but does affect the population dynamics included in the operating models and, therefore, the potential accuracy of future stock assessments and original testing of the management procedure.
    b. Change in maturity: Reproductive success is measured as the mean age of maximum reproductive success in the CKMR program and is therefore being monitored.
    c. Natural mortality: Total adult mortality is measured in the CKMR monitoring program. Natural mortality for younger age classes is not measured by the monitoring programs. In MSE testing, we have tested a range of natural mortality parameters for age 0 and 10 in the reference set of models. We have also tested if the MP is robust to additional unaccounted mortality (from IUU), which tends to be accounted for in the operating models in the estimation of natural mortality, similar to increased natural mortality.
4. Shifts in spatial and temporal distribution of fish: The CPUE analysis and monitoring analysis investigates spatial and temporal shifts in catch and effort data in the longline fishery. The standardisation accounts for unfished squares from range contraction but is

not designed to account for range shifts. CPUE may be biased by spatial and temporal shifts in migration and fishing (Bessell-Browne et al., 2025). Spatial shifts may also affect operational aspects of members' fisheries.

The primary gaps identified are changes in growth and natural mortality and spatial shifts that may impact CPUE analyses. Decadal change in growth and estimates of natural mortality at age have been included in the operating models, based on data from conventional tagging programs. The need to update information on growth and natural mortality has been identified in the CCSBT Scientific Research Program in the past (Anon 2013). Electronic tagging has provided information on apparent shifts in migration in the past and could provide information on changes in feeding ground areas and movement patterns that impact the interpretation of CPUE.

4.2 Which input data sources are affected by climate change?

The gene-tagging and CKMR programs are fishery independent and are not biased by changes in the spatial distribution of the fish, but range shifts may affect the logistics of these monitoring programs (e.g., if adults moved south, if migration patterns to/from the GAB are substantially changed).

There are concerns regarding the spatial contraction of the longline fishery and shifts in distribution that affect the assumptions for CPUE in unfished areas. CPUE indices of abundance may provide biased estimates as species change in abundance owing to climate change-induced distribution shifts (Bessell-Browne et al, 2025).

5 Research to monitor changes to input data or other impacts

The discussion above indicates areas where there are gaps in knowledge that could be addressed in the CCSBT Scientific Research Program. Many of these are research areas are already captured in the extensive tables that were developed in 2013 (Anon. 2013, ESC18 report Attachment 12). The current Scientific Research Program ends in 2027 (Anon. 2022). A review of priorities in the current CCSBT Scientific Research Program is needed to inform changes in key parameters that would affect our understanding of the population dynamics of the stock. Some of the priorities to consider are:

- changes in biology of SBT: in particular, growth, length, weight, natural mortality at age
- changes in the spatial dynamics of SBT: in particular, the juvenile age classes targeted by gene-tagging, sub-adults targeted by the longline fishery and adult spawning distribution.
- impacts of distributional shifts of the longline fleets on CPUE standardisation and reliability as an estimate of relative abundance.

6 Conclusion

The Management Procedure Framework that has been adopted by the CCSBT has built in processes (meta-rules and exceptional circumstances review) that can address uncertainties from climate impacts as these changes arise. The adopted Management Procedure is an adaptive management decision-making tool that adjusts TAC based on new information on the population from the three data inputs to the management procedure. The CCSBT is fortunate that two of the three input series for the management procedure are fishery-independent monitoring programs. The Cape Town procedure data inputs provide information on three life-stages in the stock: juveniles, subadults and adults. The potential impacts of concern from climate change on fish populations can be summarised in 4 categories: 1) recruitment decline, 2) adult abundance decline, 3) changes in key population dynamics parameters i.e., growth, maturity, natural mortality and 4) changes in spatial distribution of the fish and/or the fisheries. The fishery-independent gene-tagging program will provide information on recruitment decline, the CKMR program provides fishery independent monitoring that will detect declines in adult abundance. The CPUE series is fishery dependent and may already be affected by spatial and temporal shifts in the distribution of fish, which makes it difficult to disentangle the underlying causes of the change.

The management procedure has been tested for a variety of future and more extreme, but plausible, robustness scenarios that currently mean the advice from the management procedure is likely to be robust to potential climate impacts. However, additional research will be needed to investigate biological changes that affect our understanding of the population dynamics of the stock and the operating model for MSE and assessment of stock status. The scheduled review of the Cape Town Procedure provides the opportunity to update the set of scenarios considered in the reference set of OMs and associated robustness tests based on current knowledge of current and potential future impacts of climate change on the stock and the fisheries. This would allow for updated MSE testing of the performance and robustness of the management procedure under these updated scenarios.

7 References

Anon. 2013. Report of the Eighteenth Meeting of the Scientific Committee. 7 September 2013, Canberra, Australia (ESC18, paras 136-148, Attachment 12)

Anon. 2023. Strategic Plan for the Commission for the Conservation of Southern Bluefin Tuna 2023-2028. https://www.ccsbt.org/sites/default/files/userfiles/file/docs_english/operational_resolutions/CCSBT_Strategic_Plan.pdf

Anon. 2022. CCSBT Scientific Research Program 2023-2027 https://www.ccsbt.org/en/content/operational-resolutions-and-other-important-documents

Bessell-Browne, P., Punt, A.E., Smith, D.C., Fulton, E., McDonald, A., Dickey-Collas, M., Duplisea, D.E., Haltuch, M.A., Mace, P., Penney, A., Plagányi, É. and Scott, R. (2025), Incorporating Climate Change Impacts Within Harvest Strategies: An Overview of Approaches. Fish Fish, 26: 942-956. https://doi.org/10.1111/faf.70010

Cai, W., Santoso, A., Collins, M., Dewitte, B., Karamperidou, C., Kug, J.-S., . . . Zhong, W. (2021). Changing El Niño–Southern Oscillation in a warming climate. Nature Reviews Earth & Environment, 2(9), 628-644. doi:10.1038/s43017-021-00199-z

Carruthers, TR. 2024. Developing the climate test: performance metrics of climate robustness. IOTC–2024–WPM15-INF03. https://iotc.org/documents/developing-climate-test-performance-metrics-climate-robustness

Hobday, A. J., E. C. J. Oliver, A. S. Gupta, J. A. Benthuysen, M. T. Burrows, M. G. Donat, N. J. Holbrook, P. J. Moore, M. S. Thomsen, T. Wernberg and D. A. Smale (2018). Categorizing and Naming Marine Heatwaves. Oceanography 31(2): 162-173 https://doi.org/110.5670/oceanog.2018.5205.

IPCC. 2023. Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001

Pethybridge, H. R., E. A. Fulton, A. J. Hobday, J. Blanchard, C. M. Bulman, I. R. Butler, W. W. L. Cheung, L. X. C. Dutra, R. Gorton, T. Hutton, R. J. Matear, H. Lozano-Montes, E. E. Plaganyi, C. Villanueva and X. Zhang (2020). Contrasting futures for Australia's fisheries stocks under IPCC RCP8.5 emissions – A multi-ecosystem model approach. Frontiers in Marine Science 7: 577964.

Sinan H, Huang H, Jaya I, Vallières D. 2021. 2021 CCSBT Performance Review. https://www.ccsbt.org/sites/default/files/userfiles/file/docs_english/operational_resolutions/2021_CCSBT_Performance_Review.pdf

As Australia's national science agency, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Creating a better future for everyone.

Contact us

1300 363 400
+61 3 9545 2176
csiro.au/contact
csiro.au

For further information

Environment Research Unit
Ann Preece
+61 3 6232 5336
ann.preece@csiro.au