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SBT e-tagging in the Great Australian Bight

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Abstract

The CCSBT Extended Scientific Committee has identified improving the understanding of the contemporary spatial dynamics of the SBT stock as a priority under the Scientific Research Program. This info paper provides a copy of a successful proposal for an electronic tagging study using Pop-up Satellite tags (P-sats) to study the fine-scale, short-term (<1 year) movement of juvenile SBT in the Great Australian Bight. While the project aims to provide information on the fine-scale movement for comparison with earlier studies of juvenile SBT within the GAB, the results will be relevant to potential future E-tag studies of SBT, as it is the first use of a new generation of P-sats and the experience with deployment systems and analysis of data generated will be valuable for future detailed design and field studies.

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Opportunity

A major issue for the SBT industry over the past 4-5 years has been that the combination of stock recovery and influence of regional climate drivers (i.e., persistent La Nina pattern) has led to smaller fish comprising the majority of the Australian catch and a lack of access to larger size classes for tuna ranching. This decline in average weight has occurred despite a strong disincentive to catch smaller fish as the market heavily discounts these sizes.

Over the last several years (Patterson et al. 2020; Patterson et al. 2021), CSIRO has proposed to CCSBT a design study for an archival tagging project to address key questions

about the migration and spatial dynamics of the different SBT age groups throughout their global range, including the apparent shift in distribution and size classes in the GAB (Patterson and Eveson 2022). The large-scale project scoping has proposed the use of a combination of archival and pop-up satellite tags (PSATs) to examine linkages between climate, stock recovery and changes in distribution which are required to interpret changes to the longline CPUE data.

Internally implanted archival tags are by far the best tag type for delivering the data quality required to answer the priority questions on SBT migratory patterns at both the global stock scale and the finer GAB scale, with the additional benefit of enabling indication of feeding patterns (Patterson et al 2018). Feeding patterns help to provide insight into why migration and behavioural changes might be occurring. However, archival tagging requires a much larger number of deployments in order to recapture sufficient tags for analysis and, as a result, takes longer to accumulate useful data. A major concern for the recovery of internally implanted archival tags is that this age cohort is currently only a very small proportion of the tuna captured through the surface fishery. While archival tags would provide long term movement and understanding of juvenile SBT global foraging range as well as GAB distribution and behaviour, it would take several years for archival tags to deliver the types of data that would enable industry to understand how 2-3 y/old SBT have changed their spatial distribution and dispersal and usage of the water column. In contrast, PSATs have the advantage of being able to return informative data via satellite within 12-24 months from tag application as the timing of their “pop-off” and data transmission is pre-set as part of the tag deployment. While PSATs return less detailed data compared to internal archival tags, their data is nevertheless sufficient to provide daily location estimates and summarised depth and water temperature data, critical information required by the SBT ranching companies to improve economic efficiency of their current operations, and inform the development of potential future remote sensing opportunities.

Following discussions with ASBTIA, CSIRO proposes a Great Australian Bight specific project outlined below for the FRDC-ASBTIA-IPA which would focus on understanding the drivers of apparent shifts in distribution and availability of the age/size classes traditionally targeted by the tuna ranching industry. This project would be complimentary to the larger Global Scale project proposed for the CCSBT, and deliver information that is specific and relevant only to the surface fishery operations that are undertaken in the Bight.

Project Summary

This project would focus on:

- Understanding the extent of the changed SBT migration, residence and behaviour (especially surfacing) patterns of juveniles within and around the Great Australian Bight (GAB) using PSATs

- Testing and refining the set-up and deployment strategy for use of next generation PSATs, which will assist in the design and implementation of this project and in future studies aiming to determine broader spatial scales of movement and habitat usage.

- Utilizing the latest climate reanalysis products to examine potential links between physical drivers in the ocean and atmosphere and changes in distribution of SBT.

The project will be staged with the first year deploying 15 existing PSATs provided in-kind by CSIRO to the project and a further 15 PSATs to be purchased using project funds. These PSATs are proposed to be deployed towards the end of the 2023 fishing season (likely March) via the addition of up to 4 days charter time to the CCSBT gene-tagging field work.

The purpose of these deployments is twofold:

1. To examine the suitability of current generation PSATs in terms of data resolution, data retrieval and tag retention rates required to answer the questions arising from the SBT ranching industry over recent years.

2. To obtain information on movement and residence areas of 2-3 year old SBT and detailed habitat data, especially with regard to surfacing rates.

Information gained from the first season will be used to guide and refine deployment of a PSATs in the second season. By deploying up to 30 tags in year 1 it is envisaged that there will be sufficient data for comparing current juvenile SBT distribution, behaviour and movement patterns with historical data.

The fact that the fish do not need to be recovered to retrieve the data means this project can deliver useful insight independent of fishery operations.

A core question that remains to be determined is how long these tags can remain attached to small tuna. The tag retention data that will be determined through this project will contribute to future tag technology improvements/development to ultimately help deliver answers to this industry's specific questions.

The project would be focused on addressing the major sources of uncertainty for the operation of the SBT ranching industry – obtaining data on the distribution and habitat preference (depth/temperature regimes) of fish that formed the mainstay of successful ranching operations historically.

Relevant Expertise

Toby Patterson – long standing research into SBT movement and habitat preference; analysis of pelagic fish movement data from satellite tags including the development of state space models for geolocation of pelagic fish and analysis of fish behaviour

Paige Eveson - research into SBT movement and habitat preference & forecasting; analysis of pelagic fish movement data from satellite tags; mark recapture models of SBT mortality rates; estimation of juvenile SBT abundance from gene tagging; tuna (including SBT) age/growth modelling; estimation of SBT distribution and abundance indices from aerial survey data.

Jason Hartog - research into SBT movement and habitat preference forecasting; analysis of pelagic fish movement data from satellite tags; understanding linkages between oceanography and pelagic fish distribution; dynamic ocean management with habitat models.

Kirsten Rough – detailed understanding of fishery and ranching operations; understanding of environmental drivers on SBT distribution; Industry research into optimal SBT ranching practices.

Relevant Projects and Activity

Projects that are directly relevant to this application are:
2002 – Global Spatial Dynamics of SBT – 1st large scale migration study of SBT and broad scale look at migration dynamics with high resolution movement and behavioural data.
2012 – GAB SBT Habitat forecasting - developed operational forecasting of SBT habitat from oceanographic surface / remote sensing data and short term ocean model forecasts.

2014 – CSIRO/BP/MISA GAB Research Project – developed and refined algorithms/data processing of archival tag data
2018 – further development of GAB SBT habitat forecasting defining preferences on historic age-specific criteria and updating the forecasting modelling
2022 - CSIRO research into design of electronic tagging studies. Approaches outlined in CCSBT Working Paper outlining methods and example applications.

CSIRO research over decades has contributed to developing light-based geolocation and statistical methods for the data analysis have been adopted by the tag manufacturer to enhance data deliverables from archival tags (both implanted and external types).

Pathways to Impacts

- The project will deliver tag data and associated analysis direct to the industry stakeholders via milestone reports, meetings and at the annual SBT Industry Research Workshop.
- Data from PSATs will provide information on changes in contemporary distribution and habitat usage of SBT of the size targeted by commercial operations.
- Depth distribution from the tags will be used to inform industry on likely ability of aerial spotters to detect fish. Depth distribution will further inform the potential for industry to develop and adopt other forms of technology like remote sensing by drones or satellites to efficiently expand the spatial range of aerial surveillance. In the current fishing location weather conditions significantly reduce the number of days that tuna spotting by planes is effective. Particularly the presence of low cloud, a phenomenon that rarely impeded operations in the historical central Bight fishing area.
- Location data from PSATs and associated environmental data can be used to update the CSIRO habitat forecast models currently provided to industry.

Methods

Methods

The proposed project would use externally attached Pop-off Satellite Tags (PSATs) on fish between 80-100 cm LCF. Deployments would be via charter operations of a commercial vessel and fish would be captured using pole and line methods employed to obtain large numbers of tissue samples under CCSBT gene-tagging operations. Tagging and animal handling procedures have been approved by the CSIRO animal ethics committee.

PSATs have the advantage of being able to return informative data via satellite for periods up to 24 months post deployment. The timing of their “pop-off” and data transmission is pre-set as part of the tag deployment.
While PSATs return less detailed data compared to internally implanted archival tags, their data is nevertheless sufficient to provide:
• Estimates of location every 12 hours,
• Time spent at selected depth and temperatures ranges,
• Data on the depth and temperature profile of the water selectively used by the tagged SBT.

CSIRO has collaborated extensively with the tag manufacturers (Wildlife Computers, Seattle USA) on the development of improved geolocation algorithms. These are implemented in the CSIRO GPE3 platform. Additionally, CSIRO has in-house approaches for geolocation and analysis of PSAT data sets which can be applied to these data.

PSATs have been used for some time to examine the movements of adult and sub-adult SBT

(Patterson et al. 2008; Evans et al. 2012) but have not been extensively used on SBT of the size being proposed in this project. The newer miniPSATs are a much smaller tag, making deployment on 2-3 year-old SBT feasible.

The proposed project would be conducted in stages with the initial season deployment (Jan-March 2023) being used to evaluate constraints on data resolution due to PSAT data being retrieved via satellite and will also evaluate and refine tag tethering methods to best achieve long-term tag retention. Information gained from the first stage will be used to guide and refine deployment of a second round of PSATs in season 2. The aim being to obtain statistically relevant representation of current juvenile SBT migratory patterns that can be compared with historical data (Patterson et al. 2018a, 2018b; Eveson et al. 2018).

Over the life of the project, the CSIRO would also conduct a retrospective examination of the latest satellite oceanography and data-assimilated 4D ocean products (such as ACCESS and BRAN 2020 reanalysis products) to determine how oceanographic conditions may have influenced the distribution of 2-3 year-old SBT. This would focus on examining the drivers of the water masses previously targeted by surfacing SBT (noting that previous FRDC habitat forecasting projects for SBT in the GAB have focused on sea surface temperature, as this is the only forecastable oceanographic variable currently available; Eveson et al. 2014, 2021). The project would examine the changes in these water masses and attempt to determine trends and projections about the extent of SBT preferred habitat both as it used to be and based on the new PSAT data – in other words, we would look at the spatial distribution of habitat based on contemporary data.

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Objectives

No.	Details
1	Deployment of pop-up satellite tags
2	Comparison and analysis of contemporary SBT data against CSIRO-held archives
3	Conduct analysis of background oceanographic conditions and potential drivers of SBT habitat selection/preference

Performance Indicators

- Deployment of pop-up satellite tags to gain understanding of the contemporary movement and habitat within the GAB and nearby regions.
- Comparison to CSIRO-held archival tag data to examine changes in surfacing behaviour, thermal preference and habitat.
- Interrogation of ocean reanalysis model outputs to examine whether oceanographic changes are driving the apparent shifts in distribution.

Outputs & Outcomes

- Updated understanding of the horizontal and vertical spatial movement of SBT targeted by the Australian surface fishery that provides the seed stock for tuna ranching.
- Ability to update habitat forecast models developed by CSIRO and supplied to industry via web reporting mechanisms (Eveson et al. 2014, 2021).

Outcomes:
The SBT Ranching Industry will be the direct beneficiary of this research. SBT Ranching involves the translocation of wild captured seed stock from the fishing grounds/tuna aggregating areas in the Great Australian Bight, to a grow-out location near Port Lincoln, South Australia. For the first twenty years of operations the fishing area was highly predictable and the successful live capture of fish was based upon knowledge and experience of tuna behaviour and weather patterns at that location. Over the past 10-years SBT aggregating areas (and consequently the fishing area) have shifted substantially (500+kms) to the southeast. The fish behaviour in this new fishing area does not appear to follow the patterns as in the historic fishing area, nor is there any indication that SBT are likely to return to those historically important aggregating locations. Therefore, that learned fishing knowledge from research and experience in the west is not able to be applied to allow for efficient fishing in the eastern area. Consequently, the time and cost of search and fishing effort has increased considerably and aerial observation side of the business particularly has gone from less than 100 flying hours per aircraft per fishing season to well over 300 per aircraft per season. Additionally, the expanded potential fishing front actually precludes the area from being completely/or effectively flown within the shorter and limited ideal weather windows that occur in southeast.

Adding to these issues, SBT can only be sighted from aircraft when they are in the surface portion of the water column, if tuna are surfacing more commonly at a different time of the day (compared with the western area) flight plans in future fishing seasons can be restructured to better reflect SBT behavioural tendencies. This is just one example of the direct increase in

cost to Industry to catch the same quantity and quality of tuna for ranching. The use of pop-off satellite tags in this project offers a the only means of gaining insight to SBT's spatial and vertical movements for the year class(es) that are currently very difficult to find in the eastern fishing area. Profitability of the Industry is very dependent on the quality and size of the initial seed-stock sourced for ranching.

Outputs will include:
Updated models of SBT habitat and movement patterns/ dispersion rates relative to that shown in Basson et al 2012 (https://www.frdc.com.au/project/2003-002) and Patterson et al 2018 (https://www.nature.com/articles/s41598-018-32949-3)
• A final report detailing data and subsequent analysis.
• Scientific publications if appropriate
• Briefings/presentations to SBT industry at relevant meetings.
• Potentially an information paper to the CCSBT as an update to inform any relevant management questions relating to distribution. We note that while there is a need to understand broad scale / global SBT movement and habitat, this is not an expected output from the project and any update to CCSBT would be for information only and to highlight the need for broader scale tagging programs.

Extension

The project would undertake a workshop with CSIRO and ASBTIA project staff and key industry stakeholders to be held in Port Lincoln after the first round of PSAT deployments to evaluate:
- PSAT retention times as a function of fish size
- PSAT programming options (i.e. evaluate data resolution)
- Movement and temperature/depth data obtained

The project has direct industry involvement through the team of Investigators – this enables rapid and continuous extension of project progress and outputs.

The project team also has direct and continuous contact with tag developers/manufacturers which allows project specific technologies to be advanced in a timely manner.

All of these factors would be used to guide the second round of deployments envisaged for the 2024-fishing season.

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