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Proposal for a design study to evaluate potential electronic tagging programs to understand implications of changes in migration of SBT

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1 Abstract

Recent changes in the distribution of fishing effort in the surface and longline fisheries indicate that there may be spatial or temporal changes in the migration patterns of southern bluefin tuna (SBT). Future electronic tagging would increase our understanding of these potential changes and answer research questions related to (i) CPUE interpretation given contraction of high seas fleets, (ii) mixing of fish in the Indian Ocean and Tasman Sea feeding grounds, and (iii) migration and residency in the Great Australian Bight. In this paper, we propose a design study to evaluate the feasibility and cost-benefits of a variety of alternative electronic tagging programs for assessing changes in SBT spatial dynamics, and the resulting implications for SBT monitoring and management (e.g., interpretation of monitoring indices) and the fishing industry. We consider relevant background and outline the scope of a short (12-month) design study with a budget of $80-100K. The proposed design study has four stages: (1) Identify and refine the range of questions regarding SBT spatial dynamics; (2) Examine the ability of different electronic tagging designs to answer each question, including the feasibility of releasing tags in the required locations and in the required numbers to obtain data with sufficient statistical certainty; (3) Rank the alternatives based on priority of questions, feasibility and associated costs; (4) Provide recommendations for implementation and outline a workplan within the forthcoming SRP timeframe.

2 Introduction

The spatial dynamics of the different life-history stages of the SBT are relatively well known from previous studies using conventional and archival tags for juveniles (e.g. Basson et al., 2012) and satellite tags for adults (Patterson et al., 2008; Evans et al., 2012). However, it is essential this knowledge be updated to monitor whether there have been changes in spatial dynamics of SBT due to demographic and/or environmental changes. Changes in migration, mixing, and residency are of interest because they can affect interpretation of indices used for stock assessment and management as well as the logistics of data collection, such as the following:

1. There has been considerable contraction of high seas fleets over the past decade (e.g. see Figure 6 of Osamu et al. 2011, and Figures 8 and 9 of Itoh 2020), making it unclear whether the spatial coverage of the longline fleet is representative of the full spatial distribution of the sub-adult component of the stock. Understanding the spatial and temporal interactions of the fishery and stock is important for interpretation and standardisation of CPUE – a key abundance index in the stock assessment and management procedure. This has been highlighted with the issues identified with the CPUE this year (Anon., 2020).
2. The gene-tagging methodology is based on assumptions of mixing of the "tagged" 2-year-olds with the rest of the cohort between release and recapture events. These assumptions were explored in the design study (Preece et al., 2015), and informed by previous conventional and electronic tagging programs (CCSBT 2010; Basson et al., 2012). These tagging programs indicated good levels of mixing of tagged and untagged fish during the annual migration of juveniles to and from the Great Australian Bight (GAB), and that most 2-year-old SBT return to the GAB as 3-year-olds. As the stock rebuilds, migration pathways may vary from the historical norms of the last few decades. This has been noted previously as a juvenile component of the stock historically found off New South Wales disappeared in the early 1980s (Caton, 1991), probably due to high exploitation and associated reductions in population size. Thus, changes in the spatial dynamics of SBT as abundance changes are plausible.
3. Over the recent seasons, the Australian surface fishery has shifted operations eastwards from its traditional areas in the central GAB. This shift in the fishery may reflect operational and or

economic considerations for the fishery, or may be indicative of temporal or spatial changes in juvenile migration and patterns of summer residency (Patterson et al., 2018a). Changing ocean conditions, such as warming waters, may drive changes in the spatial distribution of SBT habitat and preferred areas for fishing; having information about such changes is clearly of interest to industry (e.g., Eveson et al., 2018). Additionally, while the gene tagging estimates of recruitment (Preece et al., 2019) should be largely robust to these changes, substantial shifts in GAB summer residence by juvenile SBT may have logistical implications for the collection of genetic samples from released fish.

Examination of the electronic tag data currently available to the proposed project, shows that it is from the late 1990s and 2000s (Table 1). Over the last decade there have been relatively few deployments of electronic tags by Australia to determine whether the movement and habitat regimes of the past still hold today.

Table 1. Summary of all electronic tag releases and recaptures by year (includes archival and pop-up satellite tags) for Australian and CCSBT-related programs between 1993 and present. Note the gap in releases between 2009 and 2014, and post-2014.

Year	Released	Recaptured
1993	30	4
1994	159	22
1995	144	48
1998	112	34
1999	61	13
2000	27	10
2001	5	4
2002	24	6
2003	31	6
2004	117	33
2005	135	33
2006	123	14
2007	196	18
2008	44	6
2009	8	0
2010-2013	0	n/a
2014	125	11
2015-present	0	n/a

In addition, the data from previous electronic tag deployments mostly pertain to 2- to 4-year-old fish. Most were archival tags deployed on 2- and 3-year-old SBT in the GAB, with typical times at liberty of 12-18 months. This is mostly due to fish being recaptured in the next year on their return to the GAB. However, tag failure (e.g. due to battery or sensor failure) also contributes to this average length of data stream. Current generations of electronic archival tags have improved and therefore higher average "return on deployment" can be expected. Nonetheless tag failure rates should be taken into account in the design of future studies.

While there is clear utility in further deployments of electronic tags, there is a need to consider the specific details of potential deployments and the likely ability of a candidate tagging program to provide useful data on a range of research questions. We propose a short (12-month) design study, with a budget of $80-100K, to examine the feasibility and cost-benefits of a variety of electronic tagging programs for answering the questions above.

3 Design study methodology

Investigating electronic tag releases via design studies is relatively novel. Few papers deal with this in the published literature. Exceptions are Patterson and Hartmann (2011) and Patterson and Pillans (2019). However, the ideas are similar to those considered in the design of other SBT conventional tagging programs (Eveson et al., 2012). We propose a methodology as follows:

- A limited number of deployment strategies, including numbers of tags of each type (e.g., archival, pop-up satellite) and the spatial and temporal distribution of releases, aimed at addressing the above questions would be examined.
- Existing data described in Patterson et al. (2018b) would be used to build a “base case” set of mixing scenarios for juvenile SBT across CCSBT statistical regions or other appropriate spatial strata. Similar models could be developed for sub-adult and adult SBT using data from Patterson et al. (2008) and Evans et al. (2012). These would be used to characterise observed movement rates between regions.
- These movement rates could then be systematically “perturbed” and historical data on recapture rates and deployment durations (from both conventional tagging and electronic tagging, along with observed rates of tag-failure and detachment) would be combined to estimate the likely number of tags that would be returned, given a particular deployment strategy.
- The expected number of tag returns, conditional on fishing effort, deployment number and tag lifetimes, would then be evaluated against the base case to determine whether there would likely be sufficient signal obtained from future deployments to detect putative shifts in SBT migration.

By developing the expected number of tag returns for the particular tag types under the different proposed deployment strategies, the design study would be able to estimate the cost of particular tagging experiments. These would incorporate the most up to date information on tagging equipment and deployment costs as well as the likely requirements for research mortality allowance and permitting requirements for deployment of tags.

A large program of electronic tagging would need close collaboration with researchers across a number of member countries and consultation with industry. Japan has maintained an electronic tagging program and we would welcome the opportunity to collaborate with our Japanese colleagues to address some of the questions outlined here. The consultation phase of the design study would explore whether CCSBT members may be engaging in at-sea research activities that might be expanded to include electronic tag deployments, noting that adding a tagging component onto existing research is not necessarily a minor addition.

The design study would consider all of the above issues and report to the 2021 ESC on cost-benefits of a variety of electronic tagging programs and design options.

4 Summary

Observed changes in the spatial and temporal distribution of fishing may indicate changes in migration of SBT, potentially as a result of population rebuilding or climate-driven environmental and behavioural responses. The electronic tagging data from the late 1990s and 2000s, and earlier conventional tagging programs, have provided highly informative data on movement, migration, residence, and mortality. This information has provided the background understanding that underpins the design of monitoring programs for abundance indices used in the SBT stock assessment and management procedure. Hence, it is essential that, to the extent possible, we periodically update our understanding of the spatial dynamics of the stock and how they are influenced by changing environmental conditions in migration.

A design study is proposed to examine feasibility and costs of alternative electronic tagging programs and the scientific questions that they can address. The design study will use existing data to simulate likely return rates of tags, in consultation with CCSBT scientists on opportunities for collaboration, and will provide an evaluation of the cost and benefits of alternative designs for consideration by the ESC.

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