The South African sardine boom in the early 2000s coincided with anomalously warm SSTs off the west coast

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Introduction

Recent genomic analysis of South African sardine has indicated that this population consists of two components, referred to as cool temperate sardine (CTS) and warm temperate sardine (WTS) hereafter, which are hypothesized to have different environmental affiliations and are found primarily off the west and south coasts, respectively (Teske *et al.*, 2021). The two components are thought to mix via (i) passive transport from the south to the west coast of a proportion of WTS sardine early life stages (ELS; *i.e.,* eggs and larvae) that were spawned off the south coast; and (ii) active movement of WTS on the west coast from there to their preferred thermal habitat on the south coast, as well as of some CTS from the west to the south and east coasts (de Moor *et al*., 2022).

Initial outputs from a simple multi-stock assessment model presently in development (de Moor, 2022) to incorporate this new sardine stock structure hypothesis include estimates of the biomass and recruitment of sardine off the west and south coasts, the numbers of ELS of WTS that are passively transported from the south to the west coast, and the numbers of age 1 WTS and age 1 CTS that move from the west to the south coast. These outputs indicate that the sardine boom of the early 2000s arose from high recruitment on the west coast and observed during annual surveys that comprised primarily WTS that were spawned on the south coast and high numbers of which were passively transported to the west coast (Figure 1a). Large numbers of these WTS subsequently moved back to the south coast (Figure 1b), as indicated by the survey-estimated high biomass levels off the south coast between 2001 and 2004 that did not appear to arise from local recruitment (de Moor, 2022).

Sardine recruitment, WTS movement, and SST anomalies

The proportion of the total sardine biomass that is found off the west coast (P_{West}) during annual Pelagic Biomass Surveys is significantly correlated with average SST anomalies for the west coast shelf over October-December (the period immediately before and during which the PSB occurs), with lower P_{West} values associated with positive SST anomalies (van der Lingen and Lamont, 2022). And whereas there is no evidence for a long-term trend of warming or cooling of surface waters off the west coast, a 7-year period (1999-2005) of anomalously warm (>0.5°C) shelf water was observed (Figure 1c). This period occurred at the turn of the century and coincides with the years in which the revised multi-stock sardine assessment model estimated high numbers of WTS ELS that were passively transported from the south to the west coast (1997-2002), high west coast recruitment (2000-2003; not shown), and high numbers of age 1 WTS moving from the west to south coast (1998-2003).

Increased west coast SSTs during October-December would likely reflect less upwelling at that time and hence a reduced likelihood of advective loss of WTS ELS during their transport from the south to west coasts, with potentially more WTS that were spawned off the south coast recruiting to the west coast. Observations indicate that cumulative upwelling off the west coast was below average during the period 2001-2004 (McGrath *et al.,* 2020). In addition, the increased west coast October-December SSTs may also indicate a generally warmer west coast at the turn of the century that persisted for some years, during which conditions would have been more favourable for the WTS there (because of their affiliation to warmer waters and assumed increased survival during warm compared to cool conditions) than periods before or after. Hence the SST change in the west coast environment to a "warm period" at the turn of the century may have facilitated the growth of the WTS component relative to that of the CTS component.

References

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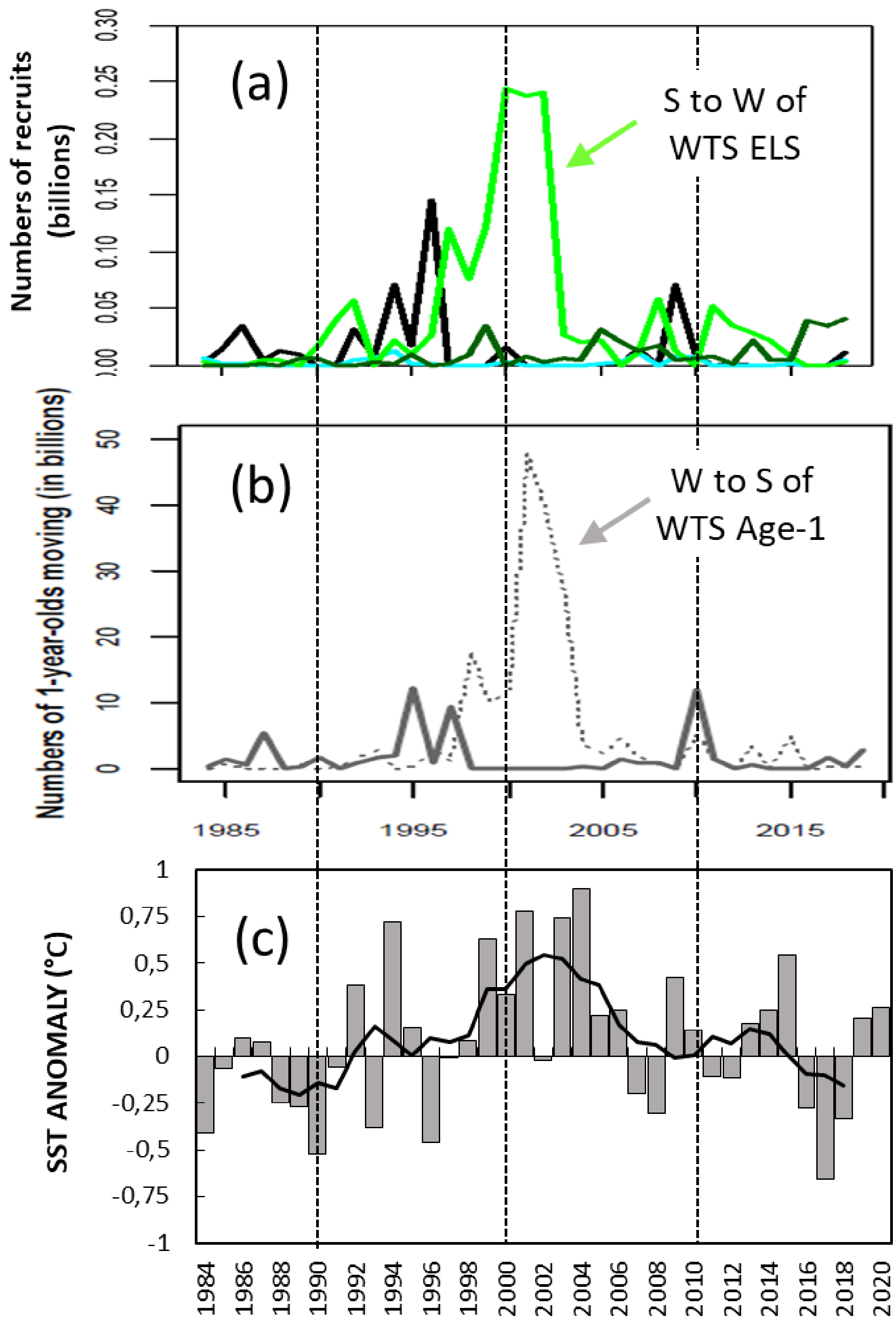

Figure 1: The revised model (a) estimated numbers of CTS recruits (black) and WTS recruits (turquoise) that were spawned off the west coast and recruited there, compared to the numbers of WTS recruits that were spawned off the south coast and passively transported to the west coast (light green) and those that were spawned off the south coast and recruited there (dark green) and (b) numbers of age 1 CTS (solid line) and age 1 WTS (dotted line) which are estimated to actively move from the west coast to the south coast from 1984 and 2019 for one (where the parameter R = 5) of the options modelled (b; both from de Moor, 2022); and (c) a time-series of average October-December SST anomalies for the west coast shelf (histograms) and 5-point running mean (line) for 1984-2020 (from van der Lingen and Lamont, 2022).