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Potential inclusion of SAPUE index in the SBT operating model

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Abstract

Part of the 2011 ESC future workplan was to explore the potential utility of the SAPUE index as an additional index of juvenile abundance in the SBT operating model. The series has shown good qualitative agreement with the scientific aerial survey for common years (2005-2012) and holds information on the key weak cohorts of the 1999-2002 period. In this paper we discuss the relationship between the SAPUE and aerial survey indices, and how potentially complex and as yet unknown correlation effects between the two indices would make it too difficult at present to include the SAPUE index in the operating model. The issue raised at the 2011 ESC on development of an index of 1 year olds, is also addressed in this paper.

1 Background

The SAPUE (surface abundance per-unit-effort) index [1] uses commercial spotter collected data on SBT patches and other environmental data to derive a fishery dependent abundance index of juvenile SBT on the purse seine fishing grounds. The modelling process (using GLMs) is well established and currently provides an index from 2002 to 2012. At the 2011 ESC a request was made for member scientists to explore the possibility of integrating the SAPUE index into the SBT operating model (OM) as a secondary index of juvenile abundance. This paper explores the possibilities and challenges associated with this potential integration into the SBT OM.

2 Comparison with aerial survey

Aside from the well established standardisation procedure and the length of the time series, a major motivating factor in exploring the utility of having the SAPUE index in the OM has been its apparent qualitative agreement with the scientific aerial survey [2] over common years. At the broadest level, this apparent agreement is reassuring, given that both the survey and the SAPUE index observe juvenile biomass within the Great Australian Bight. To be clear, the spatio-temporal distribution of data which are used to generate each index can be quite different but do overlap a lot of the time. The fact that the two indices qualitatively agree quite well over common years suggests at least that they are observing “similar” things and effects.

A simple intermediate approach to exploring the additional information content within the SAPUE index was performed in [3]. The SAPUE index was integrated into the SBT MP estimation model (a relative abundance model of juvenile and sub-adult/adult biomass [3]). This required the crude assumption that the scientific aerial survey and the SAPUE data are independent indices of abundance, but observe the same thing (i.e. juvenile relative abundance). From Figure 4 of [3] clearly the MP estimation model is able to fit both the scientific aerial survey and the SAPUE indices well, and indeed fits the survey data just as well as when the SAPUE index is not included (see Figure 2 of [3]). The inclusion of the SAPUE index adds information missing in the scientific aerial survey (which did not operate over the years 2001-2004) on the weak cohorts of the late 1990s/early 2000s (see Figure 3 of [3]) and associated elevated juvenile harvest rates in 2003 and 2004, and sub-adult harvest rates in 2006-2008 (see Figure 5 of [3]). Both these signals have been observed in other data and are well estimated in the SBT OM, suggesting that the SAPUE index also agrees with data sources other than just the scientific aerial survey.

This does not mean the scientific aerial survey and the SAPUE observe the juvenile biomass perfectly or in the same way, but it does suggest that whatever affects these indices affects them both in broadly similar ways. It is this last point that presents a significant challenge to integrating the SAPUE data into the SBT OM. It is good that the aerial survey and SAPUE agree (and that the SAPUE seems to agree with other data sources) but we have to account for the reasons *why* they might agree so well. This issue relates to more than just how well they observe juvenile SBT abundance.

An issue raised at the previous meeting of the ESC, and while relating more to the aerial survey is kind of relevant to the SAPUE index as well, is whether the apparent appearance of more 1 year old fish within the schools in the Bight might mean a 1 year old index could be developed. Within the scientific aerial survey, the weight structure of patches is estimated by the spotters and so it is possible to approximately infer the relative biomass of 1 year olds on the survey grounds. The main issue is how to treat the historical absence of an apparent significant biomass of 1 year olds. These age-classes were clearly not missing in those years (as they did show up in subsequent years as 2, 3 and 4 year olds in the survey) so this suggests that something has changed causing more 1 year olds to enter the Bight during the survey period than before. This raises the possibility of time-varying sightability of 1 year olds within the survey and without auxiliary information to estimate this sightability coefficient-by-year it would not be feasible to include them as an abundance index within the OM.

3 Issues relating to OM inclusion

There are three broad reasons why the trends in both the scientific aerial survey and SAPUE index are qualitatively similar:

1. They are observing the same trends in relative abundance of juvenile SBT in the GAB and these trends are not overly affected by the different spatio-temporal range of each of the indices.
2. They are correlated via observation error: the environmental variables that are known to influence both data sets (e.g. wind speed, swell height, spotting conditions, temperature, etc.) act in a similar fashion in terms of how they affect the observations.
3. They are correlated via process error: stochastic external factors, such as how much the proportion of each age class present in the GAB varies from year to year, affect both indices in very similar ways.

The first reason is “good” in the sense that if this is true, or dominates relative to the other two reasons, then we would feel confident in simply integrating the SAPUE index into the model as an independent index, as was done in the simple MP estimation model in [3]. However, it is almost certain that, aside from any commonality due to underlying true trends in abundance, the two indices are correlated through both observation and process error. If we simply placed them into the OM as independent indices and ignore the correlation then we will have a problem: given the agreement between the two indices the only interpretation available to the OM is that they must be observing the same abundance trends independently; as a result, the OM will be more strongly compelled to fit to those data. While not quite as simple as this it would be like placing the scientific aerial survey index in the OM twice or doubling its weighting in the likelihood. If we could quantify and/or estimate the nature and strength of the error correlation we would be in a position to treat the two indices as they should be treated: as correlated indices of juvenile SBT abundance.

So, the question then becomes how would we treat this correlation statistically? Focussing on observation error first, there would very likely have to be a joint standardisation procedure which actively estimated the covariance between the two indices. Given the relatively complex (and year-correlated) nature of the scientific aerial survey standardisation this seems like a difficult task - both in terms of a joint standardisation routine and how to represent this complex covariance within the OM. For process error, the issue is just as complicated: a likely initial option for a process covariance matrix model would be the inverse Wishart distribution (multivariate extension of the inverse gamma variance model) but with differing degrees of freedom between the two indices (differing lengths and missing years for the survey) that would also become a very complex statistical problem.

4 Discussion

The CCSBT ESC in 2011 requested member scientists to explore the potential inclusion of the SAPUE index into the CCBST OM. In this paper we explore the different reasons why the scientific aerial survey and SAPUE indices would qualitatively agree, as they clearly do. While the first reason (that they both observe “true” underlying trends in juvenile abundance in the GAB) is a positive motivator behind its inclusion, the complicating issue of observation and process error correlation between the two indices causes problems.

It is clear that there will be some level of correlation between the indices due to environmental and other demographic factors (via both observation and process error). Inclusion of the SAPUE index as an effectively independent index of juvenile SBT abundance would strongly influence the OM to fit the survey and SAPUE indices “better” than just the survey data alone. Given the strong agreement between the trends in both indices this would be akin to essentially doubling the weight of the survey data in the present OM. Without accounting for their correlation we would be overstating the information content in the two indices, and the methods required to account for the correlation are likely to be very complex, taking a significant amount of time to explore and develop.

All of this does not detract from the utility of the SAPUE index as it clearly holds some level of information on juvenile abundance and harvest rates and seems to agree with other sources of information aside from the scientific aerial survey. One of the arguments behind exploring the inclusion of the SAPUE index in the OM was to explore the possibility of using this index in an MP context if the scientific aerial survey was not available, for instance, if there was a move to conducting the aerial survey in alternate years. There are a number of procedural arguments against conducting less than annual surveys (e.g. how does one retain spotters and pilots if the work is no longer annual?); however, if for whatever reason the aerial survey index was not available in some year(s), it is not out of the question that something sensible could be done with the SAPUE index. This process would need further exploration and codification within the meta-rules protocols that deal with missing data issues. A final note of caution on this point: industry have highlighted that, if the recovery of the stock begins and there are more and more juveniles in the GAB, the actual utility of the commercial spotting process may become diminished as it becomes easier to locate and catch SBT schools. If this results in a highly limited effort and spatio-temporal range for the commercial spotting data, it is possible that the SAPUE index will not be saying anything easily interpretable about relative abundance anymore.

5 Acknowledgements

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