Initial exploration of available data to estimate sardine recruitment on the south coast

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Introduction

Annual May/June survey estimates of sardine recruitment east of Cape Infanta are low in comparison to those west of Cape Infanta and in comparison to the numbers of recruits needed to result in the recent peak in 1+ biomass on the south coast. The assessment model for two sardine stocks (split east and west of Cape Agulhas) consequently estimates the majority of the "south" stock biomass to originate from "west" stock recruits, at least across the turn of the century (de Moor and Butterworth 2013). Although sardine are known to spawn throughout the year, this winter recruit survey is timed to measure the recruits emanating from the postulated spawning peak between September – March (van der Lingen and Hugget 2003). However, in contrast to observations on the west coast of South Africa, high sardine egg concentrations have also been observed in winter on the south coast (van der Lingen et al. 2005). This could potentially give rise to local south coast recruitment, which would not be detected during the winter recruit surveys.

This document explores the extent to which winter spawning on the south coast and subsequent successful local recruitment there may have an impact on the "south" stock biomass with the data currently available, and proposes future work to explore this possibility further.

Data and Methods

A time series of recruits east of Cape Agulhas estimated during the November hydro-acoustic surveys was generated simply by assuming a cut-off length of 8cm in all years (Table 1). This cut-off length was chosen to avoid possibly counting recruits in both the May and November surveys, assuming that 8cm growth in 6 months was average for sardine recruits. According to available growth curves for South African sardine (Deon Durholtz pers. comm.), a higher (<10.5cm) cut-off length should possibly also have been evaluated. The proportional contribution of the number of winter-spawned recruits, compared to the total summer and winter spawned recruits is considered. In addition, the survey estimates of numbers of winter and summer-spawned "south" stock recruits are compared to the number of recruits estimated to move from the "west" to the "south" stock by the assessment model (given in Table 1).

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Results

Figure 1 shows the annual proportional contribution of the winter-spawned recruits compared to the summer-spawned recruits covers the full range from 0 to 0.998. The average annual proportion is 0.26. In two years the numbers of recruits emanating from winter spawning have been the major contribution to recruitment on the south coast. Thus there is a possibility that recruitment to the "south" stock may be underestimated in the assessment model given the current time series of data, but this proportion can differ markedly amongst years.

Figure 2 shows that even though the majority of "south" stock recruitment may be missed by the May/June recruit survey, the numbers of recruits estimated by the surveys is still much lower than the numbers of recruits estimated by the model to move from the "west" stock to the "south" stock. Thus even if winter-spawning is taken into account within the assessment model, it seems unlikely to substantially reduce the model estimates of movement, particularly during the years for which peak biomass was recorded on the south coast.

Further Work

The report of the panel members of the December 2013 International Stock Assessment Workshop (Anon 2013) recommended the use of a time series of recruits from the November hydro-acoustic surveys to enable the estimation of two annual cohorts of "south" stock recruitment. This cannot be achieved accurately in the short-term with the time series used in this document for the following reasons:

i) The time series of recruits estimated by the November survey in Table 1 is based on a fixed cut-off length. The cut-off length of recruits in the May/June survey has varied from <12cm to <17cm over the past 27 years (Table 1), and thus it would be expected that the cut-off length in the November survey should also vary annually so as to more accurately capture the timing of the spawning and subsequent growth of recruits. Figure 3 shows that the choice of cut-off length could be very influential on the number of winter-spawned recruits in the November survey.

ii) There are currently no annual estimates of CVs for this time series of November recruitment, though these could be evaluated in a manner similar to that used for calculating the CVs for the May/June recruit surveys, whereby the raw acoustic density estimates are split proportionately to the number of recruits and of 1+ sardine.

iii) The time-series of November survey estimates for the area to the east of Cape Agulhas would need to be updated from estimates of the current total biomass to that of 1+ biomass, once the winter recruits have been taken into account. This would also entail recalculation of the CV for November surveys and re-calibration of the 1+ biomass in years prior to 1998.

The authors propose that a detailed analysis of the November survey length frequencies be undertaken to first determine (qualitatively) if the contribution of recruits to the survey differs by stratum. A method similar to that used by de Moor et al. (2013) to model the contribution of sardine recruits to the November survey length frequency distribution could also be attempted. If there is sufficient information in the November survey length frequencies to allow this method to work, it would provide a more accurate split between recruits and 1+ sardine.

Other comments:

- The impact of the difference between the use of Cape Agulhas as a stratum boundary in the November survey and Cape Infanta in the May/June survey should be explored, as well as to which stock the recruits between Cape Agulhas and Cape Infanta in both May and November should be apportioned.
- The comparisons in Figure 2 are between model predicted recruits and survey estimated recruits. There is a bias factor on the time-series of recruits, with the joint posterior mode indicating the recruit survey estimates about half of the true "south" stock recruitment (de Moor and Butterworth, 2013), and thus a comparison including the bias would be more accurate. However, it is likely that this bias is not time-invariant. Further work on this should be undertaken.

References

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Table 1. The numbers of sardine <8cm from Cape Agulhas to Port Alfred, estimated by the November hydro-acoustic surveys. The numbers of sardine recruits west and east of Cape Infanta estimated by the May/June recruit survey. The numbers of sardine recruits estimated by de Moor and Butterworth (2013) to move from the "west" to the "south" stock are shown in the final column.

Year	Sardine <8cm (billions)	Sardine May recruitment (billions)	Recruit cut-off length (cm)	Numbers of sardine moving (billions)
1985	0.000	-	<15.5	-
1986	0.000	-	<15.5	-
1987	0.008	-	<15.0	-
1988	0.000	-	<16.0	-
1989	0.066	-	<16.0	-
1990	0.014	-	<16.0	-
1991	0.000	-	<16.0	-
1992	0.002	-	<16.0	-
1993	0.000	-	<16.0	-
1994	0.000	0.6956	<16.0	0.1924
1995	0.079	0.2366	<16.0	0.4805
1996	0.000	0.4087	<15.0	2.9238
1997	0.000	-	<14.0	2.5395
1998	0.850	0.2667	<14.0	12.177
1999	0.018	1.2905	<17.0	9.4352
2000	0.489	5.2900	<17.0	12.621
2001	0.191	0.0005	<12.0	28.189
2002	0.062	1.3341	<16.0	24.502
2003	0.224	0.4578	<16.0	22.263
2004	0.471	0.5823	<14.0	6.2772
2005	0.164	1.0672	<13.5	3.7294
2006	1.691	3.5305	<15.0	2.4531
2007	0.048	1.3316	<12.5	2.4099
2008	0.429	-	<10.5	1.2941
2009	0.028	3.6234	<12.5	1.9255
2010	0.278	0.3479	<13.5	9.0819
2011	-	-	<13.5	6.0621

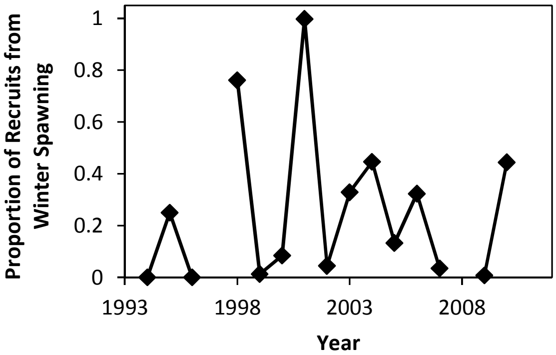

Figure 1. The annual proportion (by number) of south coast recruits spawned in winter, assuming summer-spawning is measured by the May/June survey (with varying cut-off lengths as in Table 1), and winter-spawning is measured by the November survey with a time-invariant cut-off length of <8cm.

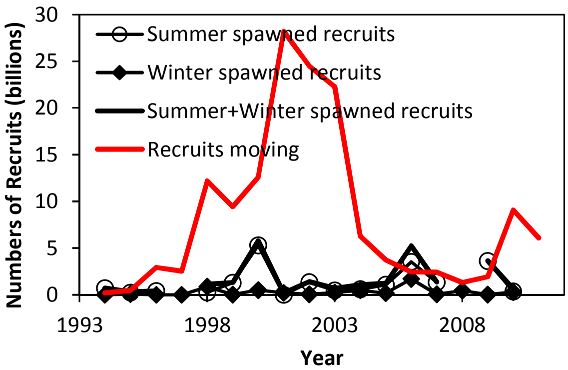

Figure 2. The number of summer-spawned recruits (as measured by the May/June survey with varying cut-off lengths), winter-spawned recruits (as measured by the November survey with a time-invariant cut-off length of <8cm), compared to the model estimated number of recruits moving from the “west” to the “south” stock.

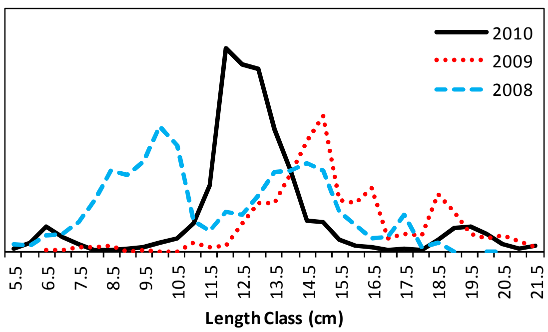

Figure 3. The length frequency distribution of sardine estimated east of Cape Agulhas during the November hydro-acoustic survey in three recent years, indicating the influence of the choice of a cut-off length on the numbers of estimated recruits.