Level at which the Sardine Directed Fishery Should be Closed

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Background

The 2016 international stock assessment review panel was asked "How might one best specify the November survey estimate of abundance below which the directed sardine fishery should be closed?" The recommendation was (Cox et al. 2016):

> *The Panel response to this question is framed in the context of a short-term (December 2017) management decision, rather than in the context of a threshold biomass in an OMP harvest control rule. The latter should be based on the values for performance statistics from simulation trials, some of which will depend on the choice of risk threshold biomass. In relation to the short-term need, the Panel recommends that the approach outlined for item B.2 be adopted, except that the lowest level of estimated spawning biomass at which estimated recruitment was 'reasonable' be converted into survey biomass. In addition, it may be appropriate to increase the value so computed to account for the impacts of observation error – the latter is not relevant to item B.2 as the threshold biomass there is computed using the operating model rather than an actual estimate of biomass from a survey.*

In addition, w.r.t. the item B.2 referenced:

> *The Panel recommends that the threshold biomass for defining risk be set to the lowest level of spawning biomass provided that recruitment near this biomass was 'reasonable' (e.g., recruitment at half the asymptotic level for the Beverton-Holt or Hockey Stick stock-recruitment relationship).*

This document follows this recommendation to provide such a level for possible use in December 2017. Closure of the directed sardine fishery under OMP-18 is expected to form part of the Harvest Control Rule.

Threshold level

2007 corresponds to the lowest median historical sardine west component spawner biomass since 1990[1] (Figure 1). The November west component recruitment estimated in 2007 had a median of 15 billion recruits with a 95% probability interval of [7, 30] billion[2]. This appears to be less than the maximum median recruitment on the Hockey Stick curve of 27 billion recruits with a 95% probability interval of [17, 64] billion. However, when considering the individual samples from the posterior distribution, the median [average] of the ratios of the November 2007 recruitment to the maximum median recruitment on the Hockey Stick curve is 0.54 [0.58]. Thus the 2007 west component spawner biomass level is considered to be a reasonable limit threshold level for South African sardine west of Cape Agulhas.

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[1] Lower median spawner biomass levels were estimated in 1986 (estimating Hockey Stick curve during conditioning) and 1988 (no stock recruitment curve estimated during conditioning), but setting a threshold level to that estimated in the first few years of the assessment was not preferred.

[2] Estimating Hockey Stick stock recruitment curves during conditioning.

2007 also corresponds to the lowest, or one of the lowest, median historical total sardine spawner biomass since 1990 (Figure 3). The November recruitment estimated in 2007 had a median of 16 billion recruits with a 95% probability interval of [7, 37] billion[3]. The median [average] of the ratios of the November 2007 total recruitment to the maximum median recruitment on the single stock Hockey Stick curve is 0.63 [0.69]. Thus the 2007 spawner biomass level is also considered to be a reasonable limit threshold level for South African total sardine biomass.

Using the calibration of de Moor and Butterworth (2017), the 2007 west component spawner biomass threshold converts to approximately 80 – 150 000t survey estimate of biomass (Table 1). Similarly, the 2007 total spawner biomass threshold converts to approximately 520 - 1100 000t survey estimate of total biomass (Table 2).

The above recommendation notes it may be appropriate to increase these equivalent survey biomass values to account for the impacts of observation error. These Tables thus also provide higher than median percentiles from the distribution that might allow for some consideration of the impact of observation error. The November hydro-acoustic survey estimates of biomass west of Cape Agulhas have had an average CV of 0.40 over the past 10 years. The average CV over the past 10 years for total biomass is 0.31. Figure 4 shows lognormal distributions about the joint posterior mode values assuming these CVs.

Discussion

While de Moor (2017) suggests it may be reasonable to continue using OMP-14 to set the initial directed sardine TAC for 2018, Figure 5 shows that the survey estimate of 259 000t sardine biomass during November 2016 was already outside the range projected when simulating testing OMP-14. Exceptional Circumstances (triggering the possible need for additional ad-hoc rules while a new OMP is developed, de Moor and Butterworth (2014)) could thus be required.

Should deviation from OMP-14 be supported, these analyses suggested by the International Review Panel would provide for a reasonable survey estimate of biomass at which the directed sardine fishery should be closed. These analyses suggest that in order to try maintain the sardine resource above the 2007 spawner biomass threshold, the directed sardine fishery should be closed when survey estimates of biomass on the west coast are at <u>minimum</u> 80 000t – 150 000t and for the total area are at <u>minimum</u> 520 000t – 1100 000t. The range in these values corresponds to the range of time-series of model estimates used in this analysis. As mentioned by de Moor and Butterworth (2017), ideally the calibration between spawner biomass estimates and survey estimates of biomass should be carried out for each sample from the posterior distribution, rather than just at the joint posterior mode and the posterior median. In that case the median calibration of the results could be used and the survey biomass estimate corresponding to the median 2007 spawner biomass level could be used as a single number.

[3] Estimating a Hockey Stick stock recruitment curve during conditioning. The single stock assessment was used for this comparison because recruitment in 2007 could be more easily compared with the median maximum recruitment from a single Hockey stick relationship than from a combination of the west and south relationships.

References

Cox S, Howell D, and Punt AE. 2016. International Review Panel Report for the 2017 International Fisheries Stock Assessment Workshop. MARAM International Stock Assessment Workshop Document MARAM/IWS/2017/General/5.

de Moor CL. 2017. The simulated short term impact of using OMP-14 to set the initial directed sardine TAC. DAFF: Fisheries Branch Document FISHERIES/2017/DEC/SWG-PEL/31.

de Moor CL and Butterworth DS. 2014. OMP-14. DAFF: Fisheries Branch Document FISHERIES/2014/DEC/SWG-PEL/60.

de Moor CL and Butterworth DS. 2017. Simple calibration of spawner biomass and survey biomass for South African sardine and anchovy. DAFF: Fisheries Branch Document FISHERIES/2017/DEC/SWG-PEL/29.

Table 1. The 2007 west component spawner biomass and equivalent survey estimate of biomass using regressions from de Moor and Butterworth (2017). Values are given rounded to the nearest thousand tons.

	2007 spawner biomass	m	Equivalent survey estimate of biomass				
			Median	5%ile	95%ile	60%ile	70%ile
Joint posterior mode (NoSRcurve)	26 000t	0.32	82 000t				
Joint posterior mode (HScurve)	24 000t	0.32	74 000t				
Posterior (NoSRcurve)	49 000t [14 000t, 141 000t]	0.32	155 000t	44 000t	443 000t	187 000t	224 000t
		0.51	98 000t	28 000t	279 000t	118 000t	141 000t
Posterior (HScurve)	43 000t [16 000t, 97 000t]	0.29	145 000t	53 000t	329 000t	170 000t	198 000t

Table 2. The 2007 total spawner biomass and equivalent survey estimate of biomass using regressions from de Moor and Butterworth (2017). Values are given rounded to the nearest thousand tons.

	2007 spawner biomass	m	Equivalent survey estimate of biomass				
			Median	5%ile	95%ile	60%ile	70%ile
Joint posterior mode (NoSRcurve)	176 000t	0.34	519 000t				
Joint posterior mode (HScurve)	179 000t	0.33	539 000t				
Posterior (NoSRcurve)	384 000t [275 000t, 551 000t]	0.34	1132 000t	813 000t	1625 000t	1202 000t	1266 000t
		0.62	759 000t	545 000t	1089 000t	806 000t	849 000t
Posterior (HScurve)	198 000t [128 000t, 296 000t]	0.35	564 000t	365 000t	841 000t	600 000t	636 000t

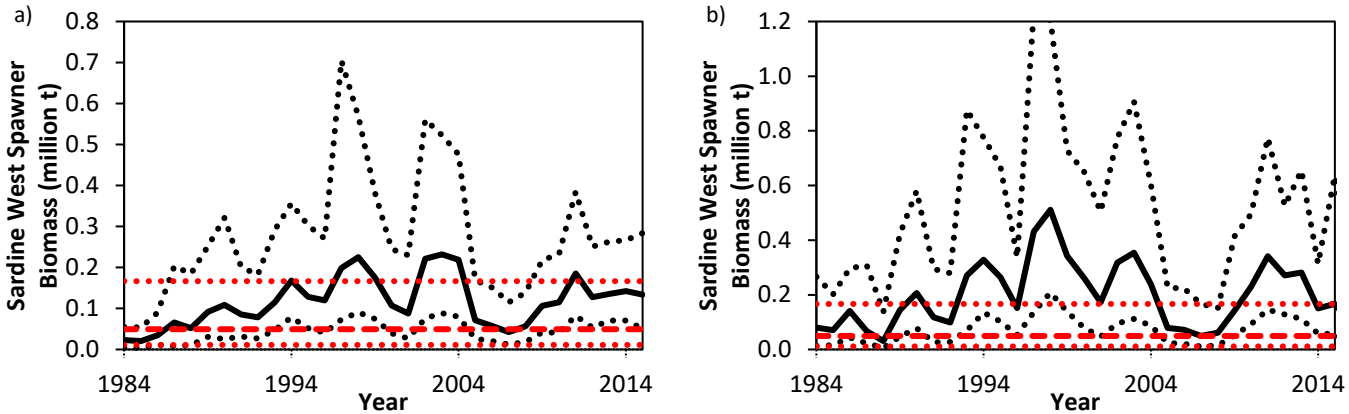

Figure 1. Median and 95% probability intervals of sardine west component spawner biomass assuming a) a Hockey Stick stock recruitment relationship estimated during conditioning and b) no stock recruitment relationship during conditioning. The red lines denote the median and 95% probability intervals of the 2007 spawner biomass.

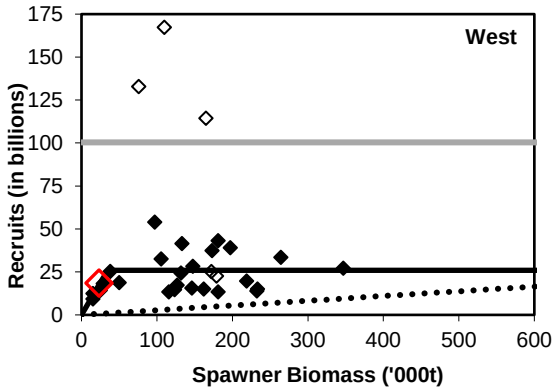

Figure 2. The hockey stick stock recruitment curve estimated at the joint posterior mode for the west component during conditioning. The red open diamond denotes the 2007 point.

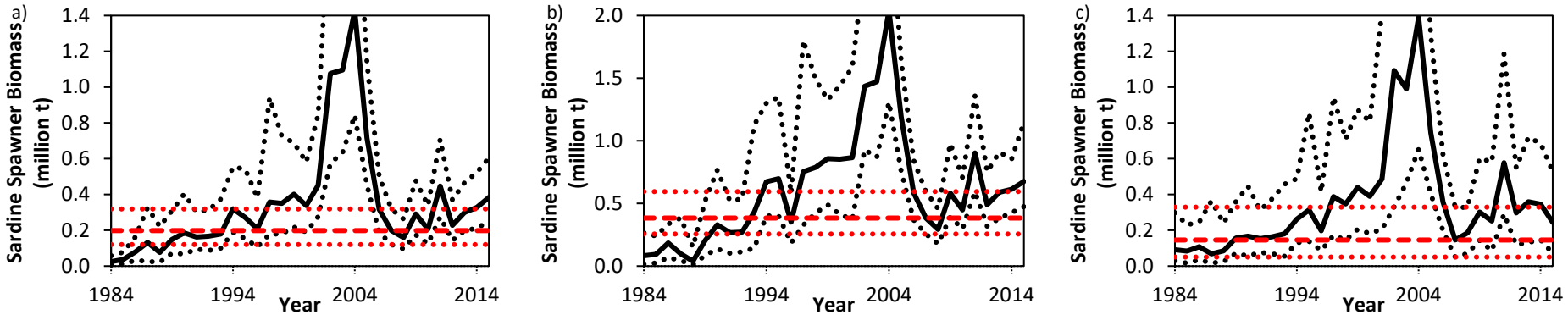

Figure 3. Median and 95% probability intervals of sardine total spawner biomass assuming a) a Hockey Stick stock recruitment relationship estimated during conditioning, b) no stock recruitment relationship during conditioning, and c) a single stock hypothesis. The red lines denote the median and 95% probability intervals of the 2007 spawner biomass.

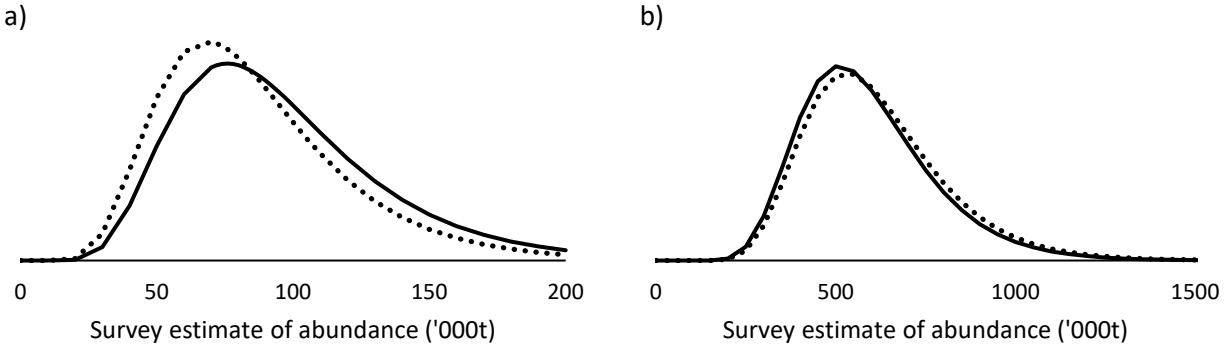

Figure 4. Lognormal distributions about the joint posterior mode values of a) 82 000t and 74 000t with a CV of 0.4 and b) 519 000t and 539 000t with a CV of 0.31.

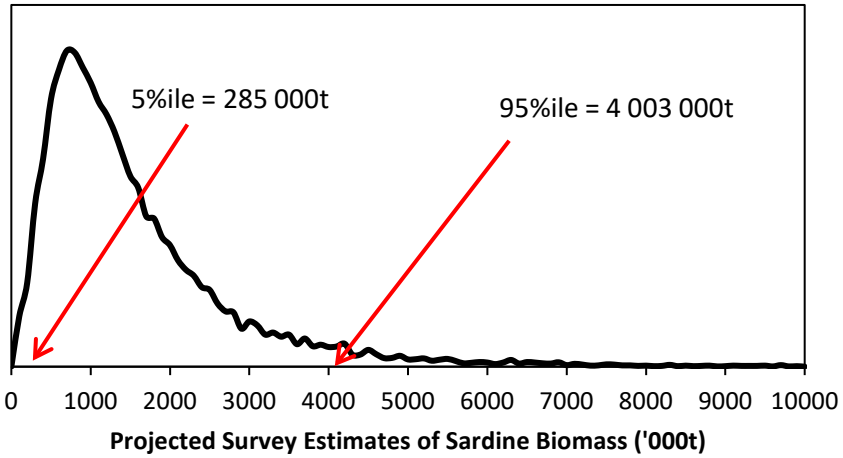

Figure 5. The distribution of projected survey estimates of total sardine biomass during OMP-14 development.