Simple Calibration of Spawner Biomass and Survey Biomass for South African Sardine and Anchovy

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Background

The Operational Management Procedures for South African sardine and anchovy are empirical, using hydro-acoustic survey estimates of abundance as key inputs into the Harvest Control Rules. This document provides a simple means to compare these November survey estimates of total biomass against the model estimated spawning biomass. Risk thresholds for OMP-18 will be based on historical spawning biomass levels (Cox et al. 2017).

Calibrations

Figure 1 demonstrates a simple calibration between these two measures of west coast sardine abundance for the Operating Model which estimates a Hockey Stick stock recruitment relationship during conditioning (de Moor and Butterworth 2016), and one that does not assume a stock recruitment relationship during conditioning (de Moor 2016a). While ideally these calibrations should be carried out for each sample from the posterior distribution, as the purpose of this is to provide a 'ballpark' calibration, the calibration has been conducted using spawner biomass estimates at the joint posterior mode and at the posterior median. Rather than assuming an equal weighting of residuals which would be unrealistic in assuming that their typical size is the same whether the survey biomass is very large or very small, in the calibration, the residuals were assumed to be Poisson-like, i.e. with standard deviations proportional to $\sqrt{B_y^{obs}}$. The standardised residuals are thus proportional to $\frac{B_y^{Sp}-mB_y^{obs}}{\sqrt{B_y^{obs}}}$. The objective function minimised for m is then given by $\sum_{y=1984}^{2015}\left(\frac{B_y^{Sp}-mB_y^{obs}}{\sqrt{B_y^{obs}}}\right)^2$ which has a closed form solution[1] $m=\frac{\sum_y B_y^{Sp}}{\sum_y B_y^{obs}}$. Sensitivity is also tested using only the data and model estimates since 1990 and only those for the last 10 years of the time series.

Figure 2 demonstrates a simple calibration using the same method, but on total (west + south) biomass.

The posterior median estimates of sardine west and total spawner biomass when no stock recruitment relationship is estimated during conditioning are substantially higher than the other three sets of data. The three other sets of data are thus used to provide approximate calibrations of spawner biomass corresponding to survey estimates of biomass. In addition, calibrations based on the past 10 years only are very different to those based on all data, or data from 1990-2015.

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[1] Differentiating the objective function w.r.t. m, setting equal to zero and solving for m.

Using the same method, Figure 3 demonstrates a simple calibration between anchovy abundance from the Operating Model which estimates a Beverton Holt stock recruitment relationship during conditioning (de Moor 2016b).

Tables 1 to 3 lists the levels of spawner biomass for survey estimates of biomass corresponding to key points in the OMP-14 Harvest Control Rules. The calibration factors used for these are based on the longer time series which includes a wider range of spawner biomass estimates.

These indicate that sardine Exceptional Circumstances are declared when total sardine spawner biomass is around 100 000t and that the directed sardine fishery is closed with total spawner biomass is around 30 000t. In addition, anchovy Exceptional Circumstances are declared when anchovy spawner biomass is around 520 – 540 000t and the directed anchovy fishery is closed when anchovy spawner biomass is around 130 – 135 000t.

Note that the November survey biomass estimates, based on hydroacoustics, are subject to various bias factors, and as a result are negatively biased. The slope in the calibration between model predicted total biomass and survey estimates of biomass is 1.2 to 1.3 for the west coast and 1.0 to 1.2 for the total area.

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. 2016a. The two mixing stock hypothesis for South African sardine without an assumed stock-recruit relationship. DAFF: Fisheries Branch Document FISHERIES/2016/NOV/SWG-PEL/57.

de Moor CL. 2016b. Assessment of the South African anchovy resource using data from 1984-2015: results at the posterior mode. DAFF: Fisheries Branch Document FISHERIES/2016/OCT/SWG-PEL/46.

de Moor CL and Butterworth DS. 2016. Assessment of the South African sardine resource using data from 1984 – 2015: Results at the joint posterior mode for the two mixing-stock hypothesis. DAFF: Fisheries Branch Document FISHERIES/2016/JUL/SWG-PEL/22REV2.

Table 1. Equivalent spawner biomass levels (rounded to the nearest thousand tons) for a given survey estimate of **west coast sardine** biomass.

Spawner biomass		*m* (all years)	Survey biomass 75 000t	Survey biomass 300 000t	Survey biomass 600 000t	*m* ('90-15)	Survey biomass 75 000t	Survey biomass 300 000t	Survey biomass 600 000t	*m* ('06-'15)	Survey biomass 75 000t	Survey biomass 300 000t	Survey biomass 600 000t
Posterior mode	Hockey Stick estimated during conditioning	0.35	26 000t	104 000t	207 000t	0.32	24 000t	96 000t	192 000t	0.59	45 000t	178 000t	357 000t
Posterior mode	No SR curve	0.33	25 000t	99 000t	198 000t	0.32	24 000t	95 000t	191 000t	0.61	45 000t	182 000t	364 000t
Posterior median	Hockey Stick estimated during conditioning	0.30	23 000t	90 000t	180 000t	0.29	22 000t	88 000t	177 000t	0.51	39 000t	154 000t	308 000t
Posterior median	No SR curve	0.52	39 000t	156 000t	311 000t	0.51	38 000t	152 000t	303 000t	0.82	62 000t	247 000t	494 000t

Table 2. Equivalent spawner biomass levels (rounded to the nearest thousand tons) for a given survey estimate of **total sardine** biomass.

Spawner biomass		*m* (all years)	Survey biomass 75 000t[2]	Survey biomass 300 000t[3]	Survey biomass 600 000t[4]	*m* ('90-15)	Survey biomass 75 000t	Survey biomass 300 000t	Survey biomass 600 000t	*m* ('06-'15)	Survey biomass 75 000t	Survey biomass 300 000t	Survey biomass 600 000t
Posterior mode	Hockey Stick estimated during conditioning	0.34	26 000t	103 000t	206 000t	0.33	25 000t	100 000t	199 000t	0.55	41 000t	165 000t	331 000t
Posterior mode	No SR curve	0.34	26 000t	103 000t	206 000t	0.34	25 000t	102 000t	203 000t	0.58	44 000t	175 000t	351 000t
Posterior median	Hockey Stick estimated during conditioning	0.36	27 000t	107 000t	214 000t	0.35	26 000t	106 000t	211 000t	0.54	41 000t	163 000t	327 000t
Posterior median	No SR curve	0.63	47 000t	188 000t	377 000t	0.62	47 000t	187 000t	375 000t	1.05	79 000t	315 000t	631 000t

Table 3. Equivalent spawner biomass levels (rounded to the nearest thousand tons) for a given survey estimate of **total anchovy** biomass.

Spawner biomass	*m* (all years)	Survey biomass 150 000t[5]	Survey biomass 300 000t	Survey biomass 600 000t[6]	*m* ('90-15)	Survey biomass 150 000t	Survey biomass 300 000t	Survey biomass 600 000t	*m* ('06-'15)	Survey biomass 150 000t	Survey biomass 300 000t	Survey biomass 600 000t
Posterior Mode	0.87	130 000t	259 000t	518 000t	0.86	130 000t	260 000t	520 000t	0.88	132 000t	263 000t	527 000t
Posterior Median	0.89	134 000t	267 000t	535 000t	0.89	134 000t	267 000t	534 000t	0.90	135 000t	270 000t	541 000t

[2] Total survey estimate at which the directed sardine TAC is set to zero.
[3] Total survey estimate below which Exceptional Circumstances are declared for sardine.
[4] Total survey estimate below which the Buffer rule is used to set the directed sardine TAC.
[5] Survey estimate at which the directed anchovy TAC is set to zero.
[6] Survey estimate below which Exceptional Circumstances are declared for anchovy.

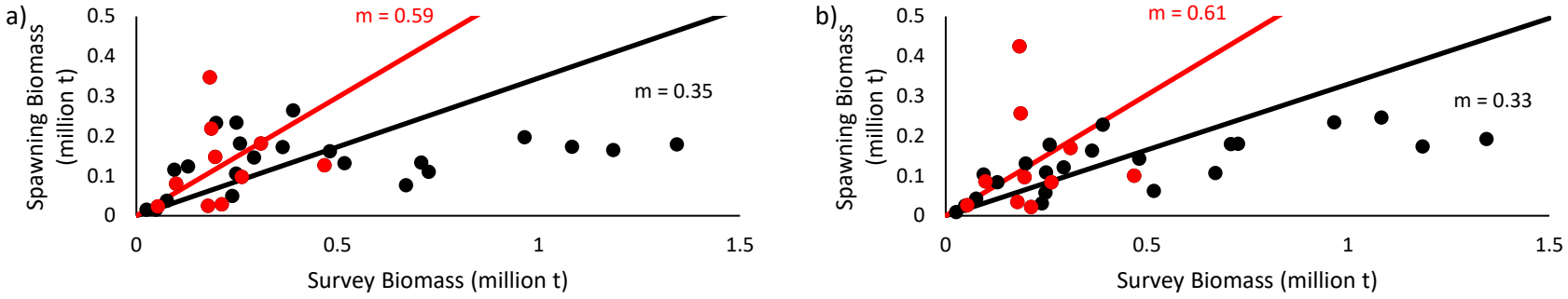

Figure 1a. Sardine **west component** spawner biomass estimated at the **joint posterior mode** assuming a) a Hockey Stick stock recruitment relationship estimated during conditioning, and b) no stock recruitment relationship during conditioning, against hydro-acoustic survey estimates of biomass. The line indicates the straight line estimated assuming a Poisson-like error structure. The red line denotes the regression against the last 10 years of 'data' (red dots) only.

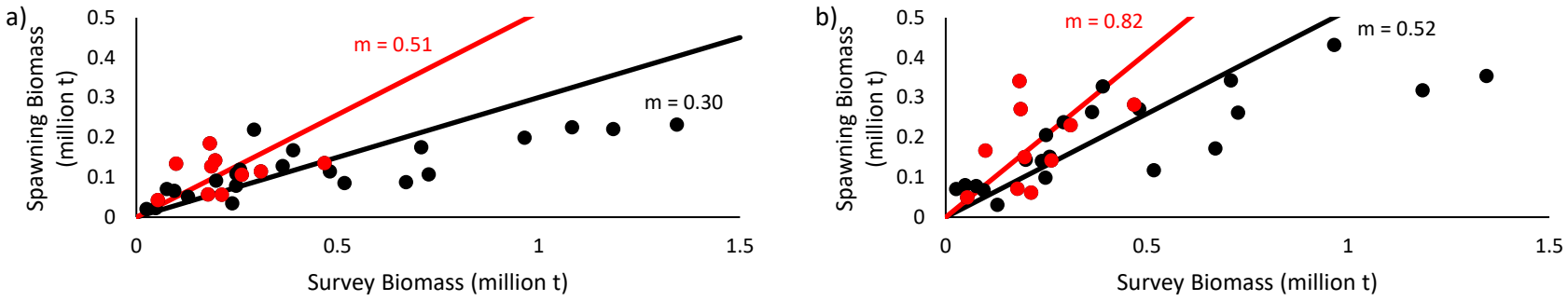

Figure 1b. Sardine **west component** spawner biomass estimated at the **posterior median** assuming a) a Hockey Stick stock recruitment relationship estimated during conditioning, and b) no stock recruitment relationship during conditioning, against hydro-acoustic survey estimates of biomass. The line indicates the straight line estimated assuming a Poisson-like error structure. The red line denotes the regression against the last 10 years of 'data' (red dots) only.

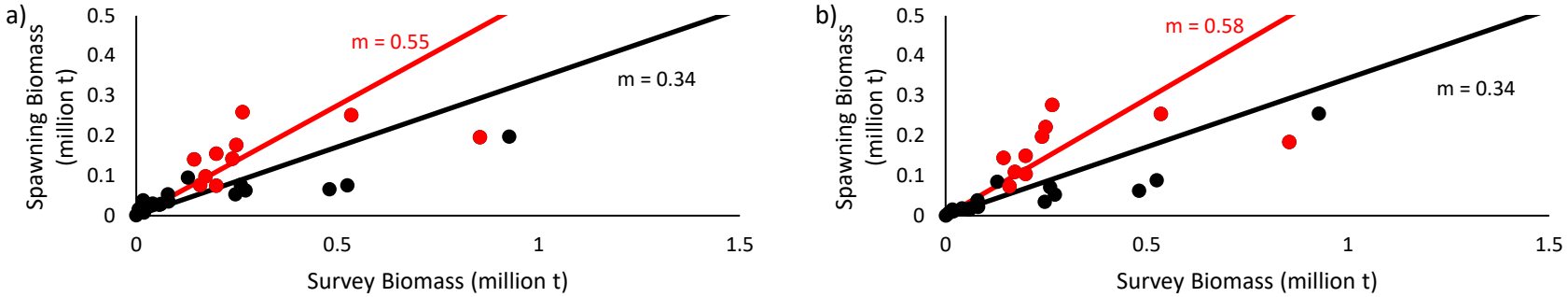

Figure 2a. Sardine **total** spawner biomass estimated at the **joint posterior mode** assuming a) a Hockey Stick stock recruitment relationship estimated during conditioning, and b) no stock recruitment relationship during conditioning, against hydro-acoustic survey estimates of biomass. The line indicates the straight line estimated assuming a Poisson-like error structure. The red line denotes the regression against the last 10 years of 'data' (red dots) only.

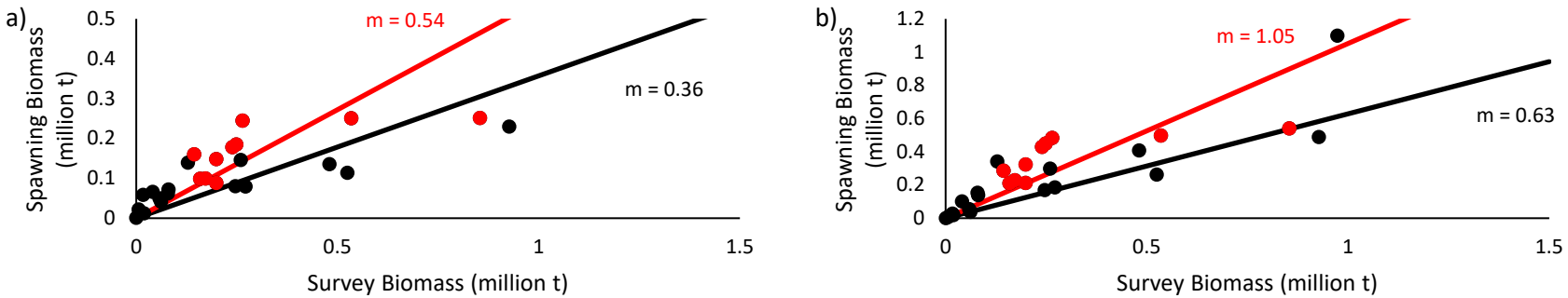

Figure 2b. Sardine **total** spawner biomass estimated at the **posterior median** assuming a) a Hockey Stick stock recruitment relationship estimated during conditioning, and b) no stock recruitment relationship during conditioning, against hydro-acoustic survey estimates of biomass. The line indicates the straight line estimated assuming a Poisson-like error structure. The red line denotes the regression against the last 10 years of 'data' (red dots) only.

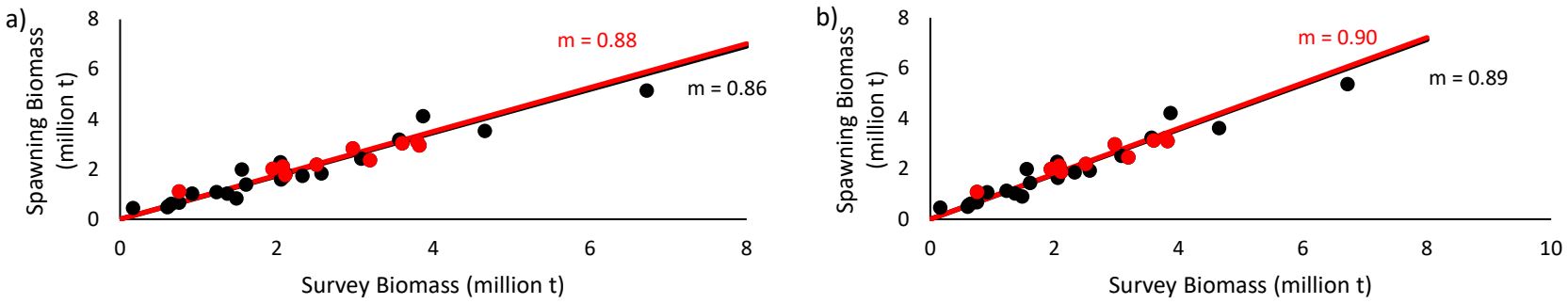

Figure 3. Anchovy spawner biomass estimated a) at the joint posterior mode and b) at the posterior median, against hydro-acoustic survey estimates of biomass. The line indicates the straight line estimated assuming a Poisson-like error structure. The red line denotes the regression against the last 10 years of 'data' (red dots) only.