

## Additional weighting scheme for the various Operating Models in a Reference Set

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A question was asked as to how well each of the RS OMs fit the data and how the fits might then be used to weight the models in a RS.

Another method described by Sanderson et al. (2015) has been used to determine what they term the “relative model quality” weights for each of the models. The model quality weighting is determined as:

$$w_q(i) = \exp\left(-\left(\frac{d_{i(obs)}}{D_q}\right)^2\right) \quad (1)$$

where  $d_{i(obs)}$  is the Euclidean distance between the model  $i$  and the observation points in the common space and  $D_q$  is a free parameter such that if the distance between a model’s projections and the observed data is less than this value, it is considered to be a close fit to the data. From this equation, it can be seen that the weights depend on the value of this parameter. A more detailed investigation will be conducted into the “best” value to use for  $D_q$ , but in the meantime for this paper  $D_q = 1.9$ .

In this case, the observed CPUE data were compared to the RS CPUE projections from the South African hake OMP-2014 from 1955-2012 (available data). These data series are plotted in Figure 1. The same multidimensional scaling method was used as described in MARAM/IWS/2017/HAKE/P9 with the logs of the data considered (in order to account for the different units of the ICSEAF and GLM-standardised data), to plot the points (point 0 corresponds to the observed data) in Figure 2. The model quality weights (CPUE weights) are listed in Table 1 and were obtained using Equation 1. The weights are plotted in Figure 3 together with those from the other weighting approaches considered.

### References

Sanderson et al., 2015. A Representative Democracy to Reduce Interdependency in a Multimodel Ensemble. *Journal of Climate*, 28(13): 5171-5194.

Table 1: Model weights – where the subscripts show similar models. If each model were equally weighted it would have weight = 0.091. Log-likelihood values relative to the best fitting OM (RS13) are also given with their associated AIC weights. MDS weight (1) refers to the weights determined using the distance averaging method in the main text of MARAM/IWS/2017/HAKE/P9 and MDS weight (2) refers to the weights found using the method described in Appendix C of MARAM/IWS/2017/HAKE/P9. The CPUE weight refers to the model quality weighting determined using Equation 1.

RS model	Centre year	Natural mortality	Stock-recruitment	MDS weight (1)	MDS weight (2)	$\Delta(-lnL)$	AIC weight	CPUE weight
RS1 <sub>RS2,RS3</sub>	1958	Mmed	Ricker	0.065	0.043	4.7	0.009	0.086
RS2 <sub>RS1,RS3</sub>	1958	Mmed	BH	0.063	0.044	6.6	0.001	0.103
RS3 <sub>RS1,RS2</sub>	1958	Mmed	BHmod	0.063	0.044	6.6	0.001	0.103
RS4 <sub>RS5,RS6</sub>	1950	Mlow	Ricker	0.081	0.059	11.1	0	0.081
RS5 <sub>RS4,RS6</sub>	1950	Mlow	BH	0.085	0.060	13	0	0.099
RS6 <sub>RS4,RS5</sub>	1950	Mlow	BHmod	0.085	0.060	13	0	0.099
RS7	1950	Mhigh	Ricker	0.067	0.049	5	0.007	0.066
RS10	1965	Mlow	Ricker	0.192	0.266	14.1	0	0.110
RS13 <sub>RS14,RS15</sub>	1965	Mhigh	Ricker	0.151	0.259	0	0.982	0.076
RS14 <sub>RS13,RS15</sub>	1965	Mhigh	BH	0.073	0.058	10.1	0	0.088
RS15 <sub>RS13,RS14</sub>	1965	Mhigh	BHmod	0.073	0.058	10.1	0	0.089

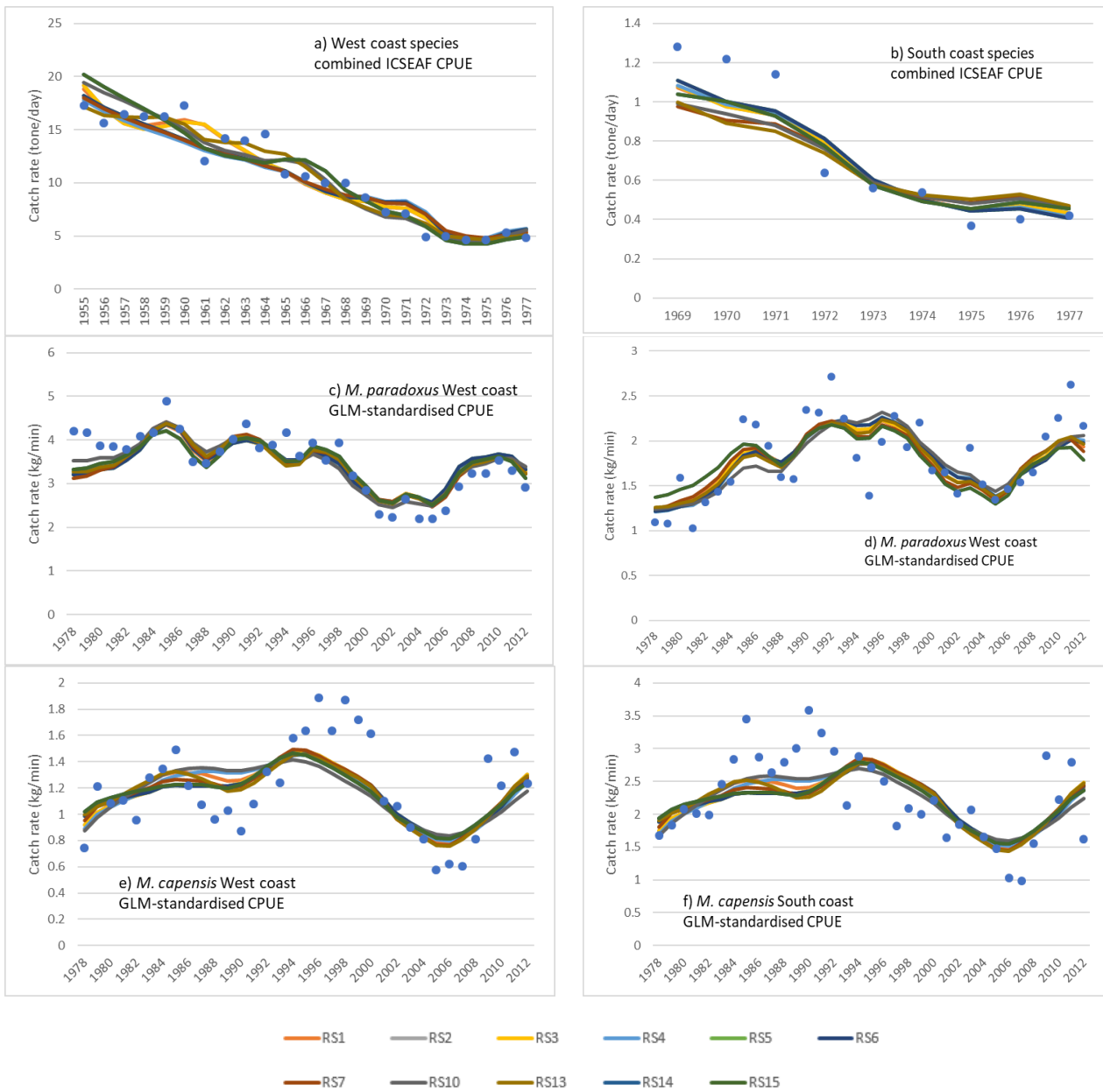


Figure 1: Fits to the CPUE series for the RS OMs

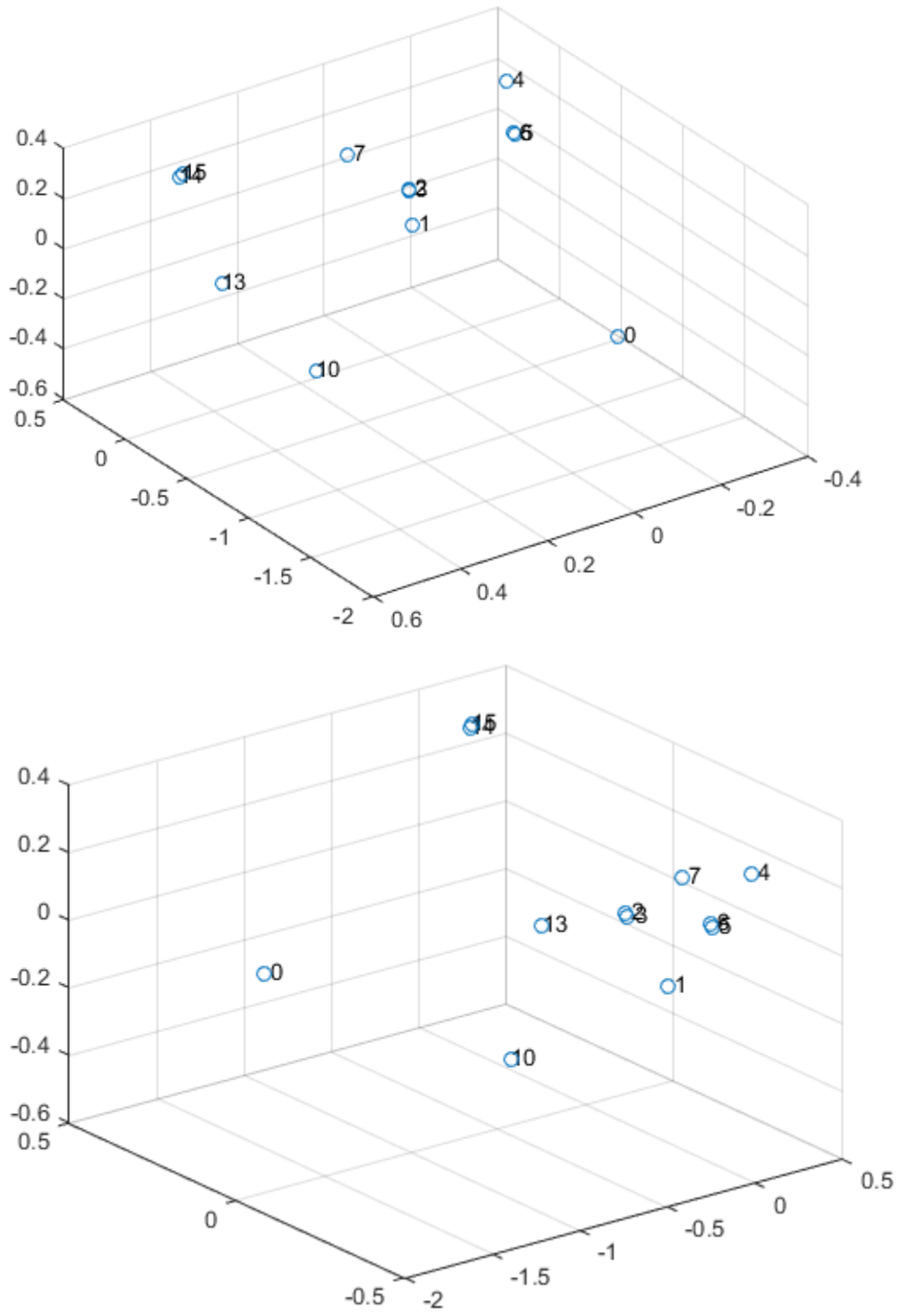


Figure 2: Views from different orientations of the same three-dimensional representation of the proximity matrix for all RS OMs and the observed CPUE data.

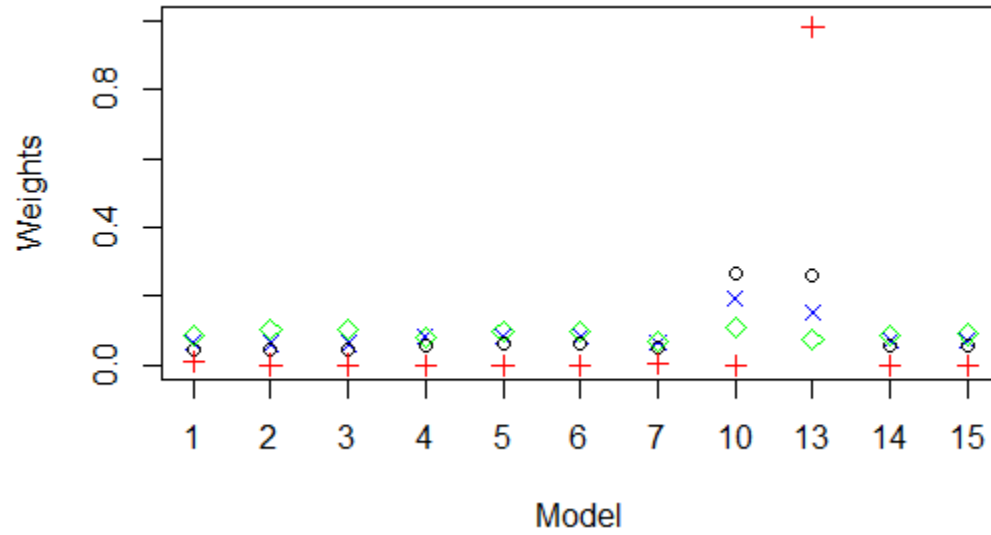


Figure 3: MDS weights determined using the two different methods – distance averaging (blue x) and the uniqueness weighting method (black circle) and AIC weights based on log-likelihood differences (red cross) and CPUE data model quality weights (green diamond).