The relationship between "leftward shift", risk and the Harvest Control Rule control parameter for sardine

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Definitions

p - the proportion of the south component spawner biomass that contributes to west component effective spawner biomass

β - control parameter in the sardine Harvest Control Rule (HCR)

$Risk_S$ - the probability of west component effective spawner biomass falling below the 2007 level during the projection period of 20 years

$Risk_S^*$ - the probability of west component effective spawner biomass falling below the lowest historical level during the projection period of 20 years

C_{tot}^S - the projected total directed sardine catch

C_{west}^S - the projected directed sardine catch west of Cape Agulhas

Methods

Two Operating Models of the sardine population are used, one assuming the proportion of south component spawner biomass contributing to the west component effective spawner biomass being $p = 0.08$ and one assuming $p = 0.6$.

Results given herein assume either no future sardine catch (or bycatch), or catches set using a sardine HCR, with all parameters/constraints (such as the stable TAC and Critical Biomass threshold) held constant, except for the control parameter β, which informs the proportion of the survey estimate of total biomass at which the TAC is set once the survey estimate of biomass is above a threshold (Figure 1). These constraints correspond to CMP5 of de Moor (2018) prior to the incorporation of preventative and penalty red flags.

Given a risk threshold and associated definition (see above), the acceptable level of risk will differ from one OM to another given changes in the natural resource dynamics. For example, given a higher variability about the stock recruitment relationship, the resource would naturally (in the absence of any catch) fall to a lower level with a corresponding larger level of risk. The 'leftward shift' method was developed to help inform an acceptable level of risk when tuning a new OMP.

The β control parameter of 0.175 for CMP5 was selected using the 'leftward shift' method. This method involves adjusting β until the ratio of the 20%ile of the distribution of the total (west+south) sardine biomass after 20 years of projection (i.e. in 2036) under the catch scenario to the 20%ile of the distribution of total sardine biomass after 20 years of projection under a no future catch scenario is 0.68. This ratio of 0.68 corresponds to the ratio of these 20%iles of total biomass in the final projection year under OMP-02, OMP-04, OMP-08 and OMP-14.

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Given risk to the sardine population is now measured in terms of west component effective spawner biomass, and no longer in terms of total biomass as per former OMP's, an alternative leftward shift example is also shown. In this method the control parameter β is adjusted until the ratio of the 20%ile of the distribution of the west component effective spawner biomass after 20 years of projection (i.e. in 2036) under the catch scenario to the 20%ile of the distribution of west component effective sardine biomass after 20 years of projection under a no future catch scenario is 0.68[1].

Results

Table 1 gives some key performance statistics under the two OMs, for a range of β values. These β values correspond to those resulting from tuning to the 'usual' leftward shift in terms of total biomass, separately for each OM, and the 'alternative' leftward shift in terms of west component effective spawner biomass, separately for each OM (Table 2).

It is worth noting that the β control parameter has only a limited influence on the risk to the resource, given that risk is typically impacted at lower survey estimates of biomass, while β influences the TAC at higher survey estimates of biomass (Figure 1). For example, under $p = 0.6$, the ratio of the 20%ile of the distribution of the west component effective spawner biomass after 20 years of projection under a catch scenario to that under the no catch scenario is 0.69 from $\beta = 0.193$ to $\beta = 0.213$.

Figure 2 shows the historical and projected future time series of effective spawner biomass for CMP5 and a no catch scenario, assuming $p = 0.08$. Figure 3 shows the historical and projected future time series of effective spawner biomass for CMP5* and a no catch scenario, assuming $p = 0.6$.

Using the leftward shift method, risk to the resource under the CMP increases (additively) from a no catch scenario by 11% for $p = 0.08$ and 16% for $p = 0.6$.

Another way of considering whether the level of risk is acceptable, could be to compare it against the carrying capacity, K. This is done, following a recent OMP Task Team discussion, though noting that carrying capacity for small pelagics may not be a reliable parameter. For $p = 0.08$, the 2007 west component effective spawner biomass is a median of 0.12 of K. For $p = 0.6$, the 2007 west component effective spawner biomass is a median of 0.35 of K, while the 1988 west component effective spawner biomass is a median of 0.16 of K. Note that K differs between the OMs. Thus for CMP5, there is a 18.2% chance of reducing the west component effective spawner biomass to $0.12K$, if $p = 0.08$, and a 27.5% chance of reducing the west component effective spawner biomass to $0.35K$[2], if $p = 0.6$. For CMP5*, there is a 19.7% chance of reducing the west component effective spawner biomass to $0.12K$, if $p = 0.08$, and a 30% chance of reducing the west component effective spawner biomass to $0.35K$[3], if $p = 0.6$.

[1] Previous OMPs were developed based on sardine OMs as a single homogeneous stock, and thus an effective west component spawner biomass can not be calculated using previous OMs.
[2] Or a 4.8% chance of reducing the west component effective spawner biomass is $0.16K$.
[3] Or a 5.8% chance of reducing the west component effective spawner biomass is $0.16K$.

References

de Moor CL. 2018. Further results towards finalising HCRs for OMP-18. DAFF: Branch Fisheries Document FISHERIES/2018/NOV/SWG-PEL/36.

Table 1. Key summary performance statistics under two alternative OMs ($p = 0.08$ and $p = 0.6$) for a no future catch scenario, and future catch scenarios with the same format and constraints as CMP5 (de Moor 2018), but with different β control parameters. CMP5 was tuned such to the 'leftward shift' as defined by total biomass assuming $p = 0.08$, while CMP5* was similarly tuned, but assuming $p = 0.6$. Where appropriate, medians and 90%iles are provided, and for some statistics the means are provided additionally and shown in **bold**. All biomasses are given in thousands of tons.

	$p = 0.08$					$p = 0.6$				
β	No Catch	0[4]	0.053	0.175[5]	0.214	No Catch	0	0.053[6]	0.175	0.214[7]
$Risk_S$	0.070	0.145	0.147	0.182	0.197	0.077	0.203	0.206	0.275	0.300
$Risk_S^*$	0.070	0.145	0.147	0.182	0.197	0.006	0.028	0.029	0.048	0.058
C_{tot}^S	**2** 0 [0,31]	**59** 65 [31,65]	**64** 65 [31,103]	**104** 93 [31,200]	**114** 101 [31,200]	**2** 0 [0,31]	**59** 65 [31,65]	**65** 65 [31,105]	**108** 98 [31,200]	**119** 107 [31,200]
C_{west}^S	**1** 0 [0.26]	**46** 51 [23,59]	**50** 52 [23,82]	**70** 61 [22,155]	**74** 66 [22,158]	**1** 0 [0,26]	**47** 52 [25,59]	**51** 52 [25,85]	**73** 63 [26,157]	**77** 70 [26,161]

[4] Even with $\beta = 0.0$, the 20%ile of the effective west component spawner biomass under a catch scenario to that under a no catch scenario is 0.66 for the OM with $p = 0.08$. A less aggressive catch scenario would be required to correspond to a leftward shift on effective west component spawner biomass for the OM with $p = 0.08$.
[5] $\beta = 0.175$ (termed CMP5) corresponds to the leftward shift on total biomass for the OM with $p = 0.08$.
[6] $\beta = 0.053$ corresponds to a leftward shift on effective west component spawner biomass for the OM with $p = 0.6$.
[7] $\beta = 0.214$ (termed CMP5* herein) corresponds to the leftward shift on total biomass for the OM with $p = 0.6$.

Table 2a. The ratio of the lower percentiles of the distribution of sardine total, west and south biomass at the end of the projection period under a catch compared to a no future catch scenario. Results are shown for CMP5 tuned assuming $p = 0.08$ and CMP5* tuned assuming $p = 0.6$.

		Total				West Component		South Component	
		OMP-08	OMP-14	$\beta = 0.175$	$\beta = 0.174$	$\beta = 0.175$	$\beta = 0.174$	$\beta = 0.175$	$\beta = 0.174$
CMP5 with $p = 0.08$	10%ile	0.50	0.59	0.64	0.64	0.63	0.64	0.58	0.58
	20%ile	**0.68**	**0.68**	**0.68**	0.69	0.74	0.74	0.64	0.64
	30%ile	0.72	0.73	0.71	0.71	0.75	0.75	0.64	0.64
	40%ile	0.73	0.76	0.72	0.72	0.75	0.75	0.67	0.67
	50%ile	0.72	0.78	0.74	0.74	0.77	0.77	0.69	0.69
		OMP-08	OMP-14	$\beta = 0.214$	$\beta = 0.213$	$\beta = 0.214$	$\beta = 0.213$	$\beta = 0.214$	$\beta = 0.213$
CMP5* with $p = 0.6$	10%ile	0.50	0.59	0.66	0.66	0.72	0.72	0.55	0.55
	20%ile	**0.68**	**0.68**	**0.68**	0.69	0.74	0.74	0.61	0.61
	30%ile	0.72	0.73	0.70	0.70	0.76	0.76	0.64	0.64
	40%ile	0.73	0.76	0.71	0.71	0.75	0.75	0.66	0.67
	50%ile	0.72	0.78	0.73	0.73	0.77	0.77	0.68	0.68

Table 2b. The ratio of the lower percentiles of the distribution of sardine effective west component spawner biomass, and the west and south component spawner biomass at the end of the projection period under a catch compared to a no future catch scenario. Results are shown for CMP5 and CMP5* as well as a CMP with $\beta = 0$ assuming $p = 0.08$ and a CMP tuned assuming $p = 0.6$.

		West Component effB^{sp}			West Component B^{sp}			South Component B^{sp}		
	β	0.175	0.0		0.175	0.0		0.175	0.0	
CMP5 with $p = 0.08$	10%ile	0.50	0.62		0.46	0.59		0.49	0.66	
	20%ile	0.56	**0.66**		0.55	0.66		0.55	0.71	
	30%ile	0.57	0.66		0.55	0.64		0.57	0.74	
	40%ile	0.58	0.68		0.59	0.67		0.60	0.75	
	50%ile	0.62	0.72		0.62	0.71		0.62	0.76	
		0.214	0.053	0.052	0.214	0.053	0.052	0.214	0.053	0.052
CMP5* with $p = 0.6$	10%ile	0.51	0.66	0.66	0.53	0.67	0.67	0.45	0.67	0.67
	20%ile	0.55	**0.68**	0.69	0.56	0.67	0.67	0.51	0.71	0.71
	30%ile	0.57	0.71	0.71	0.54	0.64	0.64	0.55	0.75	0.75
	40%ile	0.60	0.73	0.73	0.58	0.68	0.68	0.58	0.75	0.75
	50%ile	0.62	0.75	0.75	0.61	0.72	0.72	0.60	0.77	0.77

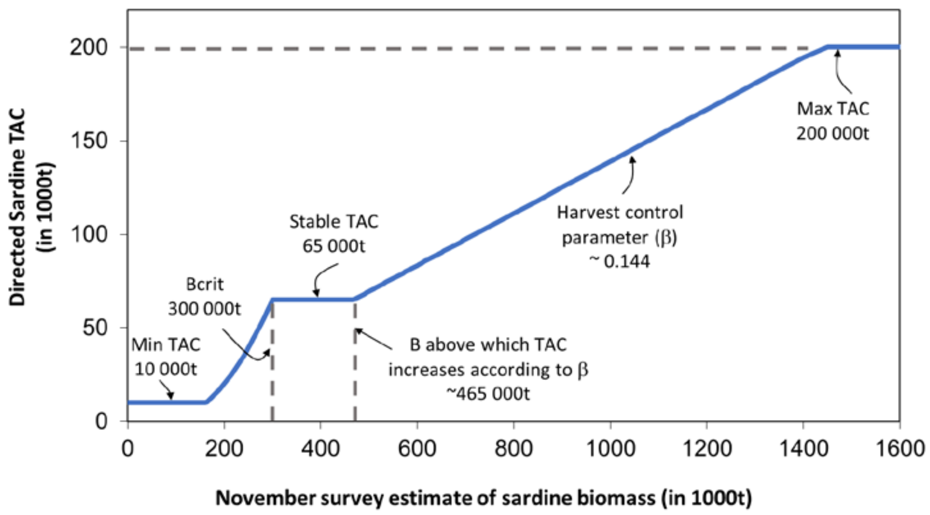

Figure 1: A schematic of the proposed OMP-18 directed sardine HCR, with, as an example, $\beta = 0.14$. The constraints shown include a maximum TAC of 200 000t, a stable TAC of 65 000t and an absolute minimum TAC of 10 000t. Further constraints on inter-annual changes in the TAC, with associated smoothing are not shown here. This curve excludes proposed preventative and penalty red flags.

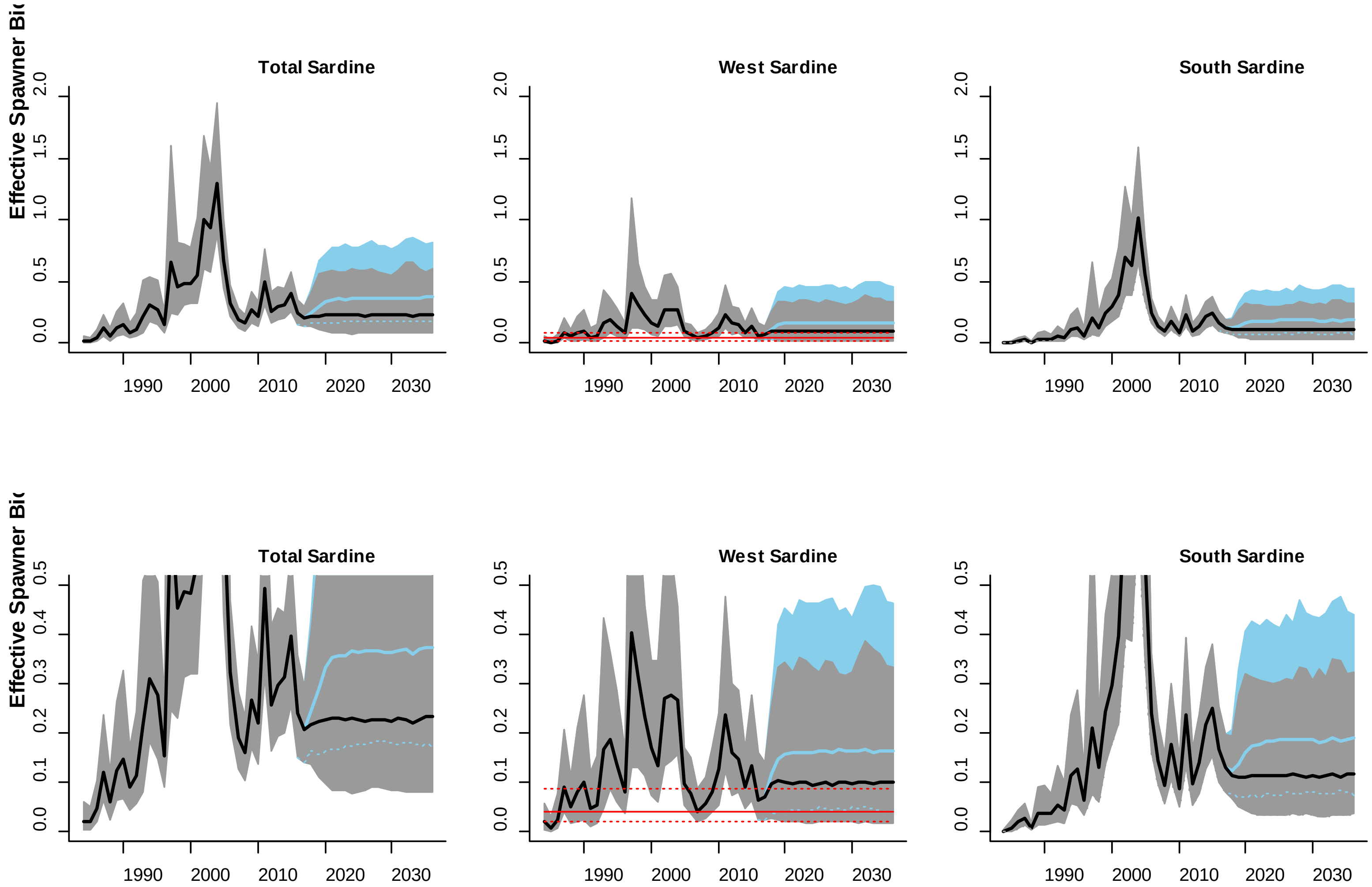

Figure 2. The median and 90%iles of sardine effective spawner biomass for CMP5 (grey) compared to a no future catch scenario (blue), assuming $p = 0.08$. The lower set of plots are a repeat of the upper set, but over a smaller vertical axis range to more clearly show the sardine risk threshold (red) of the 2007 (lowest) historical spawner biomass.

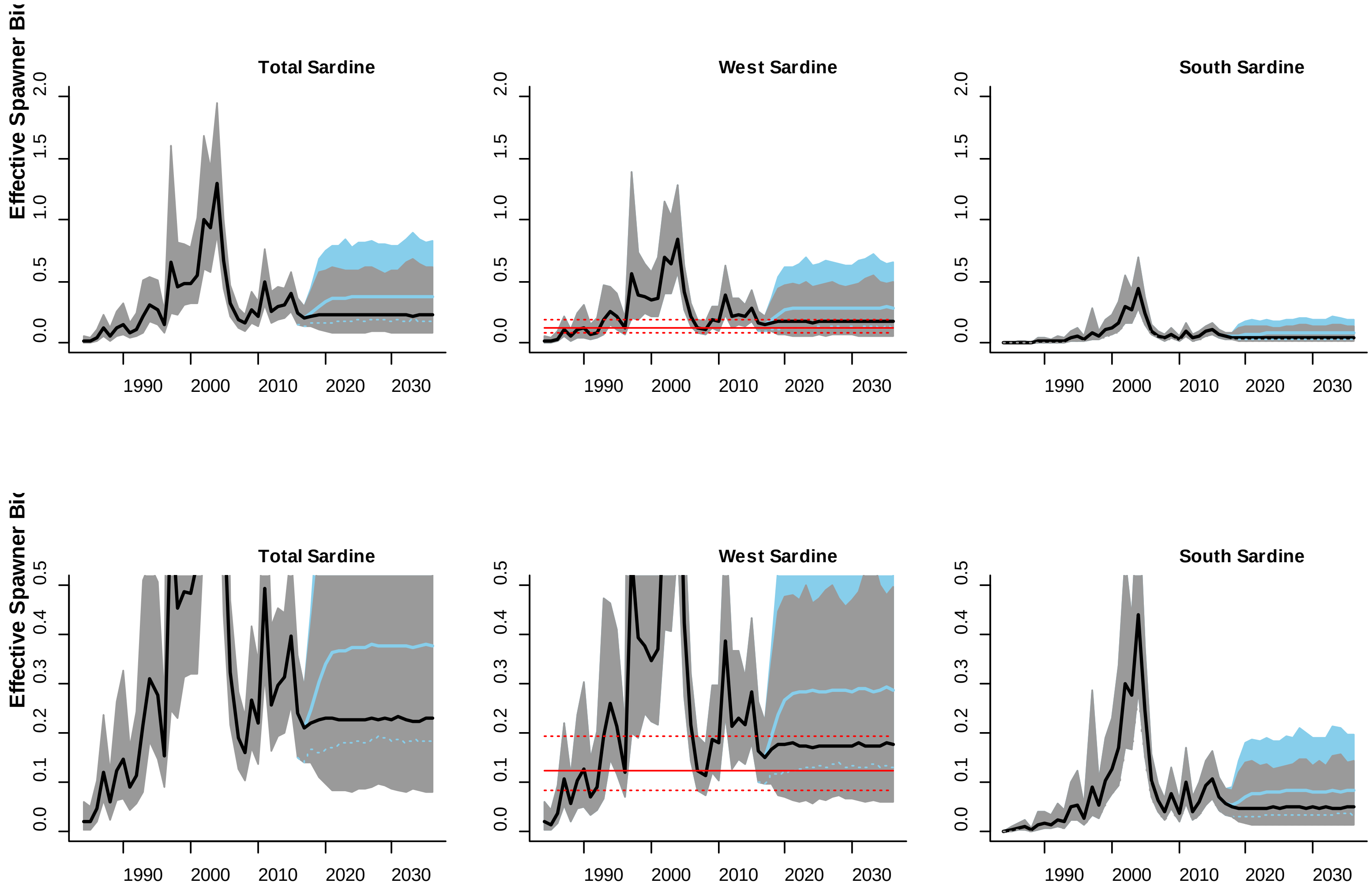

Figure 3. The median and 90%iles of sardine effective spawner biomass for CMP5* (grey) compared to a no future catch scenario (blue), assuming $p = 0.6$. The lower set of plots are a repeat of the upper set, but over a smaller vertical axis range to more clearly show the sardine risk threshold (red) of the 2007 historical spawner biomass.