OMP-18 development: linear smoothing for the sardine HCR

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Introduction

The Harvest Control Rules (HCRs) that have been tested for South African sardine have considered different TAC change constraints for the 'normal' rule that applies when survey estimated biomass is above the Critical Biomass threshold, to those which apply when the survey estimated biomass is below the Critical Biomass threshold and the Critical Biomass metarule is used (de Moor 2018a). In order to avoid any discontinuities in the HCR as the Critical Biomass threshold is approached, linear smoothing between the metarule and the 'normal' rule is applied. This document considers two alternative ranges of survey estimated biomass above the Critical Biomass threshold over which linear smoothing could be applied.

Method

The Reference Case Candidate Management Procedure (CMP)with the following constraints was used for these analyses:

- A stable directed sardine TAC of 65 000t.
- A minimum directed sardine TAC of 10 000t.
- A maximum directed sardine TAC of 200 000t.
- Critical Biomass threshold of 350 000t on total survey estimated sardine biomass.
- Above the Critical Biomass threshold, the maximum proportion by which the directed sardine TAC can be decreased from one year to the next (in the absence of the Critical Biomass metarule and linear smoothing) is 0.2.
- Below the Critical Biomass threshold, the maximum proportion by which the directed sardine TAC can be increased[1] or decreased from the previous year's TAC (in the absence of linear smoothing) is 0.5.
- Linear smoothing of the HCR applying for 350 000t above the Critical Biomass threshold, i.e. from 350 000t to 700 000t[2].
- Linear smoothing of the metarule applying for 50 000t below the Critical Biomass threshold, i.e. from 300 000t to 350 000t[3].

Given the SWG-PEL is yet to recommend a preferred maximum proportional change in inter-annual TACs, results are shown for two values of constraints above the Critical Biomass threshold: 0.2 and 0.5. The range of linear smoothing being tested in these analyses are above the Critical Biomass threshold. It is therefore expected that different values for the constraint below the Critical Biomass threshold would have little influence on results, and thus only a single value (0.5) is used for these analyses.

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[1] The maximum of 10 000t or $1.4TAC^{S}_{y-1}$ (or $1.5TAC^{S}_{y-1}$) is used as the constraint.

[2] This is to avoid any discontinuities in the rule at the Critical Biomass threshold when the metarule below 350 000t does not allow for the same % constraint in the decrease in directed sardine TAC from one year to the next.

[3] This is to avoid any discontinuities in the rule at the Critical Biomass threshold given the metarule has a constraint on the increase in directed sardine TAC from one year to the next, which does not apply above 350 000t.

The Reference Case CMP and the alternative with a constraint on the maximum proportional inter-annual decrease in TACs for $B_{y-1,N}^{obs,S} \geq B_{crit}^{S}$ of 0.5 were tuned such that the 20%ile of the total biomass depletion in the final projection year matched that considered appropriate for former OMPs (de Moor 2018b). This resulted in $\beta = 0.146$ for the Reference Case, with corresponding sardine risk of 0.20, and $\beta = 0.158$ for a constraint (as specified above) of 0.5, with corresponding sardine risk of 0.20. The sardine risk is the probability of the effective west component spawner biomass falling below the lowest historical level during the projection period of 20 years (de Moor 2018b).

Two ranges of survey estimated biomass for which linear smoothing is applied are compared in this document. A range of 350 000t (e.g. from 350 000t to 700 000t), or a range of 100 000t (e.g. from 350 000t to 450 000t). Comparisons were made not only for the Reference Case CMP listed above, but for the following additional alternatives:

- A stable directed sardine TAC of 50 000t, in addition to the Reference Case 65 000t.
- Critical Biomass threshold of 300 000t on total survey estimated sardine biomass, in addition to the Reference Case 350 000t.

Simulations were run assuming the baseline OM for anchovy and the baseline sardine OM with MoveR and p=0.08.

Results and discussion

All the alternative HCRs are compared at equivalent risk, i.e. all HCRs are tuned such that sardine risk <0.20 (Table 1).

As per previous analyses (de Moor 2018c), the smaller range of linear smoothing above the Critical Biomass threshold results in less variability in the directed sardine TAC for the 0.2 constraint, for (generally) some loss in average catch when performance statistics are considered over all simulations and years (Figure 1).

However, of the 20 000 future TACs generated, only a minority are influenced by the linear smoothing part of the HCR. For the Reference Case HCR, linear smoothing is applied in only 5% of cases. In other words, in 5% of cases the simulated future survey estimated biomass falls between 350 000t and 700 000t with the TAC in the previous year being more than 20% higher than that which would result from the 'normal' HCR without a constraint on inter-annual TACs. Here we consider the impact of linear smoothing in these minority of cases only. This is to avoid any differences being 'drowned' by the cases where linear smoothing does not occur when only the typical performance statistics over all simulations are considered (e.g. Figure 1, Table 2 of de Moor 2018c).

When the constraint on inter-annual decreases in TACs for $B_{y-1,N}^{obs,S} \geq B_{crit}^{S}$ is 0.2, the larger range of linear smoothing results in TACs being, on average, 17 to 19 thousand tons less in the 5-7% of cases for which linear smoothing is applied for the case where the linear smoothing range is 350 000t (Table 2). The larger range of linear smoothing is more conservative, and the total biomass at the end of the year for these specific cases is therefore 9 000t to 11 000t higher. However, the difference in west component spawner biomass is just 2 thousand tons (Table 2). The differences in total and west component spawner biomass are, on average, 2% with the benefit to the resource coming from the larger linear smoothing range, compared to the 16-17% differences in TACs with the benefit to the industry coming from the smaller linear

smoothing range. The conservation benefits are, however, only in the short-term, with little difference in the total biomass and west component spawner biomass between the two alternatives at the end of the projection period (Table 3).

The differences are similar for the two alternative c^S_{stbl} values considered, with some decreases with an increase in c^S_{stbl} from 50 to 65 000t (Table 2). The differences decrease as the Critical Biomass threshold is reduced from 350 to 300 thousand tons (Table 2).

For less restrictive constraints on the inter-annual variability for $B^{obs,S}_{y-1,N} \geq B^S_{crit}$, i.e. where the constraint (as specified above) is 0.5 instead of 0.2, linear smoothing is applied in even fewer cases, and the range over which linear smoothing applies has little impact on results (Tables 2 and 3).

Recommendation

The OMP Task Team recommends that the smaller range of 100 000t be used for linear smoothing above the Critical Biomass threshold. However, should the constraints for the proposed interim OMP-18 differ substantially from those tested here, this recommendation may require re-checking.

Acknowledgements

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References

de Moor CL. 2018a. OMP-18 development: selecting an interim Harvest Control Rule for directed sardine Rule. DAFF: Branch Fisheries Document FISHERIES/2018/JUL/SWG-PEL/17.

de Moor CL. 2018b. Multiple sardine Operating Models and associated risk. DAFF: Branch Fisheries Document FISHERIES/2018/JUL/SWG-PEL/19.

de Moor CL. 2018c. OMP-18 development: alternative constraints on the sardine Harvest Control Rule. DAFF: Branch Fisheries Document FISHERIES/2018/MAY/SWG-PEL/07rev.

Table 1. The sardine control parameter β that results from tuning the HCR to a risk < 0.20 given alternative constraints of stable TACs, c^S_{stbl}, Critical Biomass thresholds, B^S_{crit}, and the range over which linear smoothing applies: 350 000t or 100 000t above B^S_{crit}. The Reference Case HCR with a 20% and 50% constraint when $B^{obs,S}_{y-1} > B^S_{crit}$ has $\beta = 0.146$ and $\beta = 0.158$, respectively, when tuned such that the 20%ile of the total biomass depletion in the final projection year matched that considered appropriate for former OMPs (de Moor 2018b).

	20% constraint when $B^{obs,S}_{y-1} > B^S_{crit}$				50% constraint when $B^{obs,S}_{y-1} > B^S_{crit}$			
	$B^S_{crit} = 350$		$B^S_{crit} = 300$		$B^S_{crit} = 350$		$B^S_{crit} = 300$	
Linear Smoothing range ('000t)	350	100	350	100	350	100	350	100
$c^S_{stbl} = 50$	0.162	0.155	0.152	0.144	0.166	0.167	0.160	0.161
$c^S_{stbl} = 65$	0.155	0.147	0.139	0.132	0.161	0.162	0.151	0.152

Table 2. Average, median and 90%iles of the differences in a) directed sardine TAC (rounded to nearest 1000t), b) total biomass and c) west component spawner biomass (rounded to nearest 100 000t) between Linear Smoothing ranges of 350 000t and 100 000t. TACs and biomasses are given in thousand t. The differences are considered in the **years for which linear smoothing applie**s when the range of linear smoothing is 350 000t[4]. The upper part of the table gives differences in absolute terms, whereas the lower part gives these in relative terms.

	20% constraint when $B_{y-1}^{obs,S} > B_{crit}^{S}$				50% constraint when $B_{y-1}^{obs,S} > B_{crit}^{S}$			
	$c_{stbl}^{S} = 65$		$c_{stbl}^{S} = 50$		$c_{stbl}^{S} = 65$		$c_{stbl}^{S} = 50$	
	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile
a) $TAC_{tot}^{S,LS=350} - TAC_{tot}^{S,LS=100}$								
$B_{crit}^{S} = 350$	-18.9	-19.3 [-38.4,0.0]	-19.1	-19.3 [-39.1,-0.4]	3.6	3.7 [0.3,7.2]	4.0	4.0 [0.3,7.6]
$B_{crit}^{S} = 300$	-17.0	-17.0 [-38.1,2.1]	-16.8	-17.1 [-36.8,1.0]	1.3	0.0 [-0.4,7.1]	2.6	1.9 [0.,7.8]
b) $B_{tot,y}^{S,LS=350} - B_{tot,y}^{S,LS=100}$								
$B_{crit}^{S} = 350$	10.3	10.1 [-3.8,25.8]	11.1	10.9 [-2.3,26.0]	-2.3	-2.2 [-5.2,0.1]	-2.6	-2.5 [-5.4,0.2]
$B_{crit}^{S} = 300$	9.1	8.5 [-4.4,24.1]	9.1	8.6 [-4.3,24.6]	-0.7	0.0 [-4.4,0.7]	-1.5	-1.0 [-5.1,0.3]
c) $SSB_{w,y}^{S,LS=350} - SSB_{w,y}^{S,LS=100}$								
$B_{crit}^{S} = 350$	2.0	1.3 [-0.7,7.1]	2.1	1.3 [-0.5,7.1]	-0.5	-0.3 [-1.7,0.0]	-0.6	-0.4 [-1.9,0.1]
$B_{crit}^{S} = 300$	1.7	1.1 [-1.0,6.5]	1.7	1.1 [-0.9,6.3]	-0.2	0.0 [-1.2,0.2]	-0.3	-0.2 [-1.4,0.1]

	20% constraint when $B_{y-1}^{obs,S} > B_{crit}^{S}$				50% constraint when $B_{y-1}^{obs,S} > B_{crit}^{S}$			
	$c_{stbl}^{S} = 65$		$c_{stbl}^{S} = 50$		$c_{stbl}^{S} = 65$		$c_{stbl}^{S} = 50$	
	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile
a) $\left(TAC_{tot}^{S,LS=350} - TAC_{tot}^{S,LS=100} / TAC_{tot}^{S,LS=350}\right)$								
$B_{crit}^{S} = 350$	-0.17	-0.17 [-0.33,0.00]	-0.17	-0.16 [-0.33,0.00]	0.04	0.04 [0.00,0.08]	0.04	0.04 [0.00,0.08]
$B_{crit}^{S} = 300$	-0.16	-0.16 [-0.34,0.02]	-0.16	-0.16 [-0.33,0.01]	0.02	0.00 [0.00,0.08]	0.03	0.02 [0.00,0.09]
b) $\left(B_{tot,y}^{S,LS=350} - B_{tot,y}^{S,LS=100} / B_{tot,y}^{S,LS=350}\right)$								
$B_{crit}^{S} = 350$	0.02	0.01 [-0.01,0.04]	0.02	0.02 [0.00,0.05]	0.00	0.00 [-0.01,0.00]	0.00	0.00 [-0.01,0.00]
$B_{crit}^{S} = 300$	0.02	0.01 [-0.01,0.05]	0.02	0.01 [-0.01,0.05]	0.00	0.00 [-0.01,0.00]	0.00	0.00 [-0.01,0.00]
c) $\left(SSB_{w,y}^{S,LS=350} - SSB_{w,y}^{S,LS=100} / SSB_{w,y}^{S,LS=350}\right)$								
$B_{crit}^{S} = 350$	0.02	0.01 [-0.01,0.05]	0.02	0.01 [-0.01,0.05]	0.00	0.00 [-0.01,0.00]	-0.01	0.00 [-0.01,0.00]
$B_{crit}^{S} = 300$	0.02	0.01 [-0.01,0.05]	0.02	0.01 [-0.01,0.05]	0.00	0.00 [-0.01,0.00]	0.00	0.00 [-0.01,0.00]

[4] This occurs in 5-7% of cases when the constraint on inter-annual decreases in TACs for $B_{y-1}^{obs,S} > B_{crit}^{S}$ is 20%, and 3-4% of cases when the constraint is 50%.

Table 3. Average, median and 90%iles of the differences in a) total biomass and b) west component spawner biomass (rounded to nearest 100 000t) between linear smoothing ranges of 350 000t and 100 000t. TACs and biomasses are given in thousand tons. The differences are considered in t**he final year of all simulations for which linear smoothing applies** when the range of linear smoothing is 350 000t. The upper part of the table gives differences in absolute terms, whereas the lower part gives these in relative terms.

	$c^S_{stbl} = 65$		$c^S_{stbl} = 50$		$c^S_{stbl} = 65$		$c^S_{stbl} = 50$	
	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile
a) $B^{S,LS=350}_{tot,y} - B^{S,LS=100}_{tot,y}$								
$B^S_{crit} = 350$	1.2	-1.1 [-8.2,19.4]	2.0	-1.2 [-6.7,21.2]	0.0	0.3 [-2.9,1.0]	0.0	0.4 [-3.3,1.0]
$B^S_{crit} = 300$	1.5	-0.6 [-7.9,19.1]	1.5	-1.4 [-8.2,19.3]	0.3	0.4 [-0.9,1.1]	0.1	0.4 [-2.0,1.0]
b) $SSB^{S,LS=350}_{w,y} - SSB^{S,LS=100}_{w,y}$								
$B^S_{crit} = 350$	0.2	-0.1 [-2.2,3.6]	0.4	-0.1 [-1.8,4.1]	0.0	0.0 [-0.5,0.3]	0.0	0.0 [-0.7,0.3]
$B^S_{crit} = 300$	0.2	-0.1 [-2.1,3.7]	0.2	-0.2 [-2.3,4.1]	0.0	0.0 [-0.2,0.3]	0.0	0.0 [-0.5,0.3]

	$c^S_{stbl} = 65$		$c^S_{stbl} = 50$		$c^S_{stbl} = 65$		$c^S_{stbl} = 50$	
	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile	Average	Median & 90%ile
a) $\left(B^{S,LS=350}_{tot,y} - B^{S,LS=100}_{tot,y} / B^{S,LS=350}_{tot,y}\right)$								
$B^S_{crit} = 350$	0.00	0.00 [-0.01,0.04]	0.00	0.00 [-0.01,0.04]	0.00	0.00 [0.00,0.00]	0.00	0.00 [-0.01,0.00]
$B^S_{crit} = 300$	0.00	0.00 [-0.01,0.04]	0.00	0.00 [-0.01,0.04]	0.00	0.00 [0.00,0.00]	0.00	0.00 [0.00,0.00]
b) $\left(SSB^{S,LS=350}_{w,y} - SSB^{S,LS=100}_{w,y} / SSB^{S,LS=350}_{w,y}\right)$								
$B^S_{crit} = 350$	0.00	0.00 [-0.02,0.05]	0.00	0.00 [-0.02,0.05]	0.00	0.00 [-0.01,0.00]	0.00	0.00 [-0.01,0.00]
$B^S_{crit} = 300$	0.01	0.00 [-0.02,0.05]	0.00	0.00 [-0.02,0.05]	0.00	0.00 [0.00,0.00]	0.00	0.00 [-0.01,0.00]

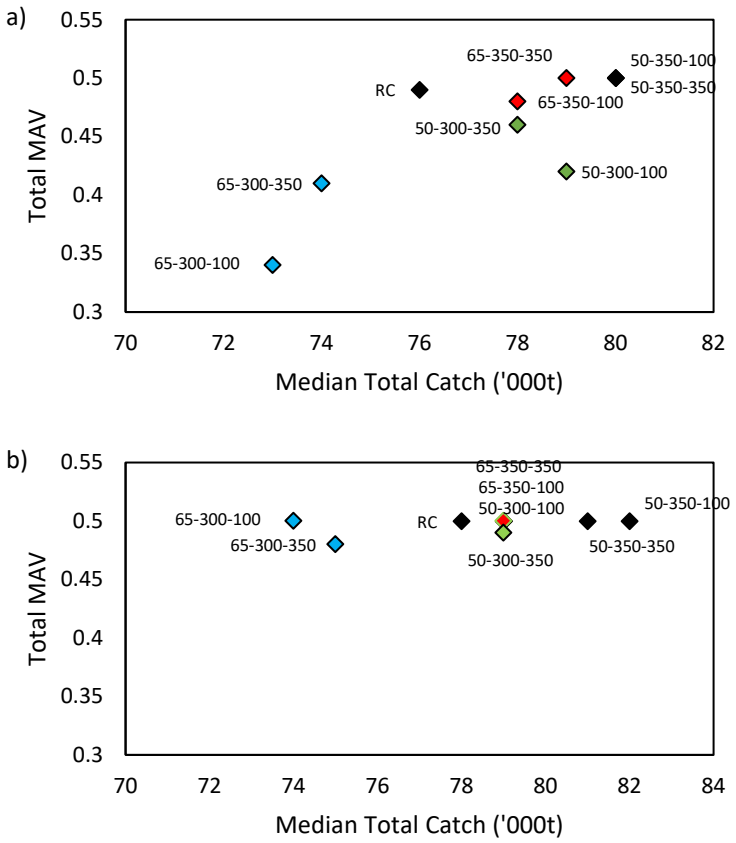

Figure 1. The MAV in the total directed sardine catch plotted against median total directed sardine catch, tuned to risk of <0.20 for all HCRs. (The Reference Case (RC) is shown for comparative purposes, but is tuned such that the 20%ile of the total biomass depletion in the final projection year matched that considered appropriate for former OMPs. Results are shown comparing alternative stable TACs (first number in label), Critical Biomass thresholds (second number in label) and linear smoothing ranges (third number in label). Results are shown for the proportional constraint on inter-annual decreases in TACs when $B_{y-1}^{obs,S} > B_{crit}^{S}$ is a) 0.2 and b) 0.5.