Considering alternative constraints to the anchovy Harvest Control Rule

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Introduction

This document considers some alternative constraints to the anchovy Harvest Control Rule (HCR) for OMP-18. The general form of the anchovy HCR is expected to remain unchanged from OMP-14.

Anchovy Risk

Given the same definition of a risk threshold, updates to the underlying Operating Model (OM), in particular to the stock recruitment dynamics and to the assumptions about natural mortality, could require the acceptable level of risk to differ from one Operational Management Procedure (OMP) to the next such that the actual risk to the underlying resource under the new OMP is equivalent to that under the former OMP. This is because risk – at least for South African small pelagics - generally considers the impact of catch, i.e. the difference catch makes to a distribution of biomass compared to that which would have been achieved under a no future catch scenario. Thus in the instance that, for example, the variability about the stock recruitment relationship is estimated to be larger for an updated OM, one would expect the resource to naturally fluctuate to lower (and higher) levels even in the absence of fishing. Thus, if all other things are equal, given an increase in σ_R from one OM to the next, one could expect the risk level to which the new OMP is tuned to be higher than that used for the former OMP, such that the actual risk to the resource is similar between the OMPs.

A relatively objective method has been used to inform the appropriate anchovy (and sardine) risk level for former OMPs (de Moor and Butterworth 2010). However, given major changes to the OM used to develop OMP-14 from that used to develop OMP-08, in particular, changes to the form of stock recruitment relationship and the base case time-invariant natural mortality, the method previously used could not be applied. The anchovy risk level for OMP-14 was thus selected after considering the impact of catches under a range of alternative risk levels (de Moor and Butterworth 2014).

While there has been no change in the form of stock-recruit relationship, nor in the time-invariant natural mortality, from the OM used to develop OMP-14 to that being used to develop OMP-18, there are nevertheless substantial changes in the OMs. In particular, the model is now fit to length-structured data, with catch observation error and estimated maturity-at-length.

Risk cannot be directly compared between OMP-14 and OMP-18. There has been a change in the definition of the risk threshold from (de Moor and Butterworth 2014; Cox et al. 2017; de Moor 2017)

$Risk_{threshold}$ – 10% of the average anchovy 1+ biomass between November 1984 and 1999

to

$Risk_{threshold}$ – 25% of the lowest (1996) historical spawning biomass.

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In addition, risk is now measured as the probability of being below the threshold over the projection period (Cox *et al*. 2017; de Moor and Butterworth 2017). In past OMPs risk was measured as the probability of being below the threshold at least once during the projection period (de Moor and Butterworth 2014).

Given the complications in objectively comparing the anchovy risk between that used to tune OMP-14 and that to be used for tuning OMP-18, the SPSWG OMP Task Team has agreed to consider the acceptable level of risk to be that given by the OMP-14 anchovy HCR, under the updated OM conditioned on data up to November 2015. There are two main reasons for this. Firstly, there have been no indications from recent assessments of the anchovy resource that the current management thereof is too risky. In addition, there is little pressure to increase anchovy harvesting given difficulties experienced by the industry in catching the maximum anchovy quota of 450 000t. Secondly, while there has been some change in the median Beverton Holt stock recruitment relationship from that used to tune OMP-14 to that used now (Table 1), the change does not increase risk to the resource. The upper tails of the distributions of the stock recruitment parameters have been curtailed, but this likely reflects a more accurate estimation of the parameters given a few more year's data. Most importantly, however, is that the variability about this stock recruitment relationship is unchanged between the two OMs (Table 1).

Using the OMP-14 anchovy HCR, the probability that the anchovy spawner biomass falls below 25% of the spawner biomass estimated in 1996 is <u>0.082</u>. <u>This level of risk is thus selected as a basis for tuning alternative anchovy HCRs for OMP-18</u>. Figure 1 shows the distribution of total anchovy biomass at the end of the projection period using the OMP-14 anchovy HCR compared to a no future catch scenario. The 'leftward shift' is different to that used when tuning OMP-14, primarily due to a higher probability of the anchovy distribution being at lower value under a no catch scenario.

Alternative Constraints

The alternative constraints considered here are the following:

i) Maximum anchovy TAC: 450 000t[1] or 350 000t
ii) Scale-down factor applied to the initial anchovy TAC (p): 0.85[2], 0.90, 0.95

The former is considered due to the difficulty industry has experienced in catching annual anchovy tonnages above 350 000t, even when the TAC has been higher. The second set of alternatives is considered following a request from industry to investigate the impact of an increase in the scale-down factor.

All alternatives are tested using the reference directed sardine HCR of de Moor (2018a) with an additional constraint of a 'true' minimum TAC of 10 000t (de Moor 2018b). The sardine Operating Model used is the baseline with MoveR and 8% of south component spawning biomass contributing to west component effective spawning biomass.

These alternatives are tested using the baseline anchovy Operating Model.

Results and discussion

[1] Value used in OMP-14.
[2] Value used in OMP-14.

These results incorporate the updates detailed in de Moor and Butterworth (2018) and thus some performance statistics may differ slightly from those presented in previous documents.

Table 2a lists the performance statistics for the combinations of alternative constraints listed above for the control parameter $\alpha = 0.889$, with corresponding Figures 2. Table 2b lists the performance statistics where all alternatives are tuned to satisfy the risk criteria <0.082, with corresponding Figure 3.

There is an increase in the risk to the anchovy resource as the scale-down factor, *p*, increases and more of the total anchovy TAC is awarded at the beginning of the fishing season. When tuning the HCRs with alternative constraints to the same risk threshold, the control parameter, α, decreases with increasing *p*. For a given p, α increases as the maximum TAC decreases from 450 to 350 000t. However, given the wide range and optimistic (in median terms) projections of future anchovy recruitment, there is little impact on the catch performance statistics.

Figure 4 shows a histogram of the initial and final anchovy TAC, assuming $p = 0.85$, for a maximum anchovy TAC constraint of 350 000t and 450 000t, showing little difference in the histograms for TACs below 200 000t. However, the higher α parameter for the 350 000t constraint results in higher TACs in roughly the 200 to 300 000t range. The upper end of the distributions are influenced by the different maximum constraints.

One should note, however, that if future recruitment does not result in the maximum anchovy TAC constraint being realised, i.e. under medium to lower recruitment scenarios, then a lower control parameter, α, will result in lower TACs. (Results under robustness tests can be produced at a later date).

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Table 1. Posterior medians [90% probability intervals] of the Beverton Holt stock recruitment parameters from the base case Operating Model conditioned on data up to November 2011 and used during the development of OMP-14, and that conditioned on data up to November 2015 and being used during the development of OMP-18.

	Data up to 2011	Data up to 2015
α_{BH}	1343 [427,6520]	1317 [670,221]
β_{BH}	3563 [192,28349]	1495 [221,5852]
σ_r	0.82 [0.64,1.08]	0.83 [0.66,1.06]

Table 2. Anchovy performance statistics for the alternative constraints to the anchovy Harvest Control Rule, i) with $\alpha = 0.889$ and ii) with $Risk_A < 0.082$. Where appropriate, medians [90% probability intervals] are provided. All biomasses are given in thousands of tons. The performance statistic, C^A, is the annual catch tonnage, and thus the reported median and probability interval are over 20 000 predictions. In contrast, the performance statistic, C^A_{median}, is the median catch tonnage from each simulation, and thus the reported median and probability interval are over the medians of the 1000 simulations.

	Performance Statistics	No Catch	OMP-14 Rule	Revised OMP-14 rule ($\overline{N}^A_{rec0}$ and R_{avg})					
				Maximum Anchovy TAC = 450			Maximum Anchovy TAC = 350		
			p=0.85	p=0.85	p=0.90	p=0.95	p=0.85	p=0.90	p=0.95
$\alpha = 0.889$	α	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889
	$Risk^A$	0.026	0.082	0.082	0.084	0.087	0.079	0.081	0.083
	B^A_{2036}	960 [70,3678]	405 [25,2742]	405 [25,2750]	398 [24,2754]	387 [24,2744]	420 [26,2888]	414 [25,2890]	405 [25,2891]
	B^A_{2036}/B^A_{2015}	0.7 [0.1,2.7]	0.3 [0.0,2.0]	0.3 [0.0,2.0]	0.3 [0.0,2.0]	0.3 [0.0,2.0]	0.3 [0.0,2.1]	0.3 [0.0,2.1]	0.3 [0.0,2.1]
	B^A_{min}	447 [51,1130]	176 [18,698]	177 [18,702]	174 [18,701]	170 [17,692]	183 [18,732]	178 [18,732]	173 [17,728]
	C^A	0 [0,217]	248 [0,450]	248 [0,450]	248 [0,450]	248 [0,450]	248 [0,350]	248 [0,350]	251 [0,350]
	C^A_{median}	0 [0,0]	240 [5,450]	240 [5,450]	244 [5,450]	248 [4,450]	245 [6,350]	247 [6,350]	252 [4,350]
	MAV^A	0 [0,0]	0.3 [0.0,0.8]	0.3 [0.0,0.8]	0.3 [0.0,0.8]	0.3 [0.0,0.8]	0.2 [0.0,0.6]	0.2 [0.0,0.6]	0.2 [0.0,0.6]
$Risk_A < 0.07$	α			0.891	0.861	0.826	0.943	0.901	0.866
	$Risk^A$			<0.082	<0.082	<0.082	<0.082	<0.082	<0.082
	B^A_{2036}			405 [25,2750]	406 [25,2755]	412 [25,2760]	409 [25,2879]	411 [25,2891]	412 [25,2891]
	B^A_{2036}/B^A_{2015}			0.3 [0.0,2.0]	0.3 [0.0,2.0]	0.3 [0.0,2.0]	0.3 [0.0,2.1]	0.3 [0.0,2.1]	0.3 [0.0,2.1]
	B^A_{min}			177 [18,702]	178 [18,709]	179 [18,715]	175 [18,719]	176 [18,729]	177 [18,736]
	C^A			248 [0,450]	248 [0,450]	248 [0,450]	248 [0,350]	248 [0,350]	248 [0,350]
	C^A_{median}			240 [5,450]	241 [5,450]	238 [5,450]	250 [5,350]	248 [5,350]	250 [5,350]
	MAV^A			0.3 [0.0,0.8]	0.3 [0.0,0.8]	0.3 [0.0,0.8]	0.2 [0.0,0.7]	0.2 [0.0,0.6]	0.2 [0.0,0.6]

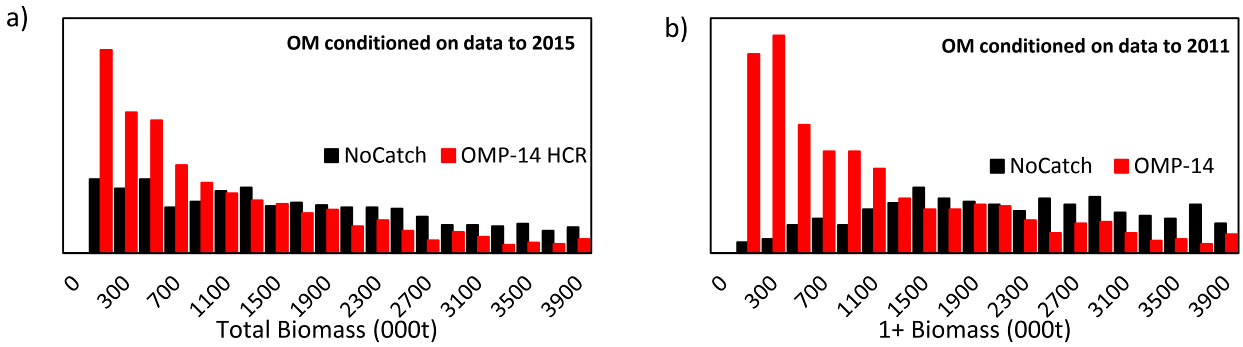

Figure 1. Histograms of the anchovy biomass at the end of the 20 year projection period under the OMP-14 anchovy HCR and under a no catch scenario, using a) the OM conditioned on data up to November 2015 and b) the OM conditioned on data up to November 2011.

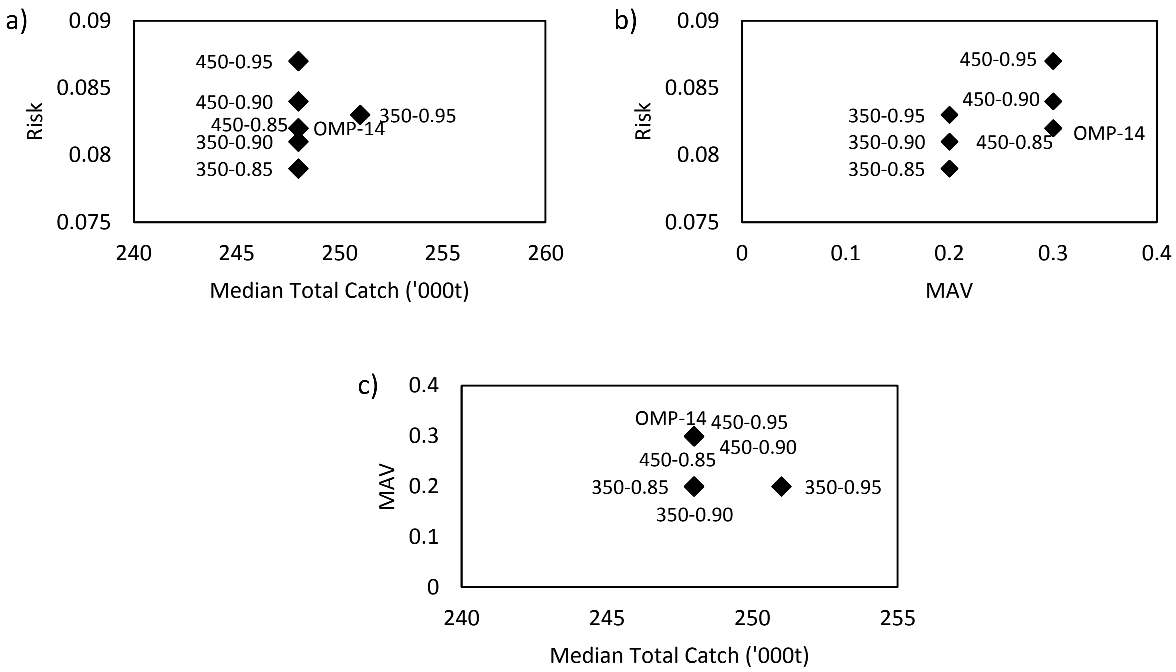

Figure 2. Anchovy performance statistics for alternative constraints to the anchovy Harvest Control Rule for the same control parameter $\alpha = 0.889$. The plots show a) risk to the anchovy resource plotted against median anchovy catch, b) risk plotted against median average variation (MAV), and c) MAV plotted against median anchovy catch. The data labels indicate the maximum anchovy TAC (350 or 450 000t) and the scale down proportion to the initial anchovy TAC (0.85, 0.90 or 0.95).

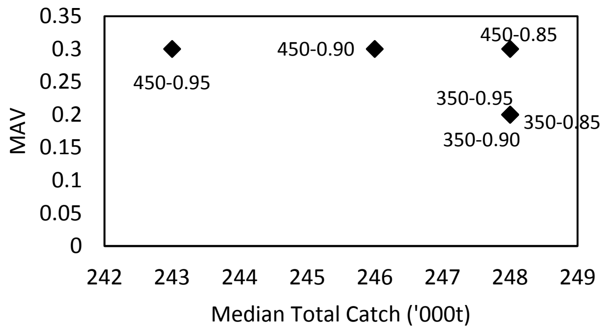

Figure 3. Median average variation in anchovy catch plotted against median anchovy catch for alternative constraints to the anchovy Harvest Control Rule tuned to the same risk, $Risk_A < 0.082$. The data labels indicate the maximum anchovy TAC (350 or 450 000t) and the scale down proportion to the initial anchovy TAC (0.85, 0.90 or 0.95).

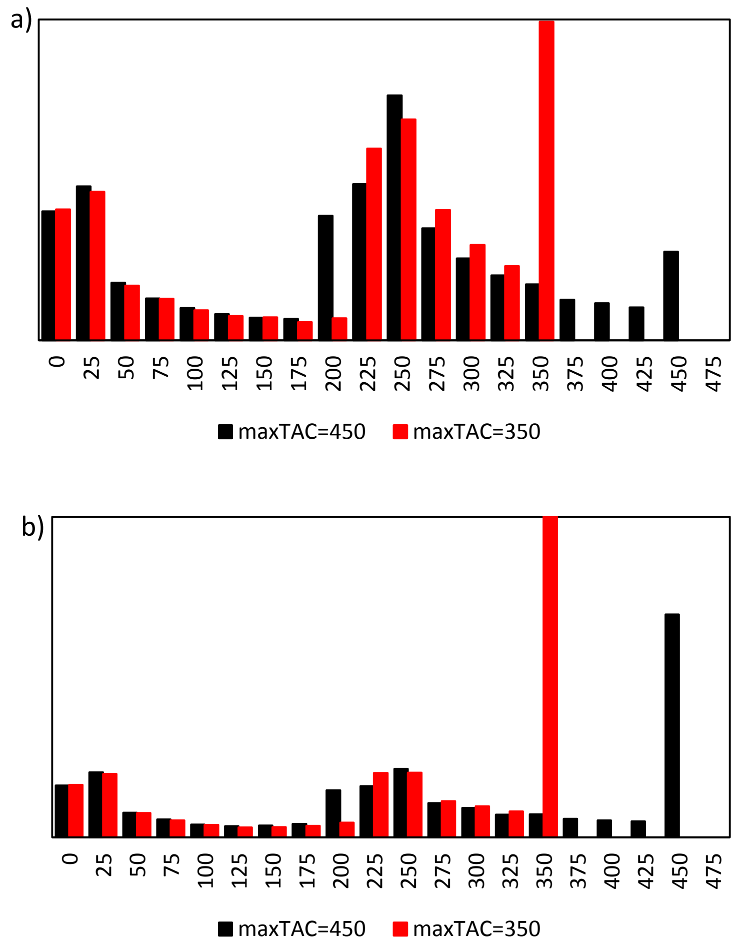

Figure 4. Histogram of the a) initial and b) final anchovy TAC given a maximum anchovy TAC constraint of 450 000t, with $\alpha = 0.891$ and 350 000t, with $\alpha = 0.943$. In both cases the scale-down factor is p=0.85.