Considering the variability in directed sardine catches for the current OMP-18 reference case HCR

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The variability in simulated future sardine catches is compared between the reference case and alternative Harvest Control Rules to inform OMP-18 development.

Keywords: Harvest Control Rule, Operational Management Procedure, sardine, Total Allowable Catches

Introduction

This document considers further variations from the 'reference case' directed sardine Harvest Control Rule (HCR) as defined by de Moor (2018), with particular focus on the variability in simulated sardine catches. Anchovy catches are modelled according to the HCR from OMP-14 with the baseline Operating Model (OM) (de Moor 2018). Unless otherwise specified, sardine results are obtained using the baseline OM of p = 0.08 and MoveR (de Moor 2018).

Revised Terminology

Stable TAC - The constraint previously used of a 'minimum TAC in the absence of Exceptional Circumstances', often simply referred to as the 'minimum TAC', has been renamed the 'stable TAC' for the purposes of OMP-18. This value was 90 000t in OMP-14 and is 50 000t for the reference case HCR; it represents a constraint on decreasing TAC levels when survey estimates of biomass decrease, but remain above the Critical Biomass threshold (see definition below).

Minimum TAC – This is a new constraint tested in this document and represents an absolute minimum TAC guaranteed to be awarded. In the event of the HCR calculating a TAC less than 10 000t, this minimum would over-write such a lower value with 10 000t. This has been introduced for a number of reasons, and particularly the concern that the fishery would never be closed in practice.

Critical Biomass threshold[1] – The previously termed "Exceptional Circumstances" threshold of survey estimated biomass below which critical biomass metarules apply to reduce the TAC rapidly. This has been renamed to avoid confusion with the similarly termed Exceptional Circumstances as defined immediately below.

Exceptional Circumstances – The situation which arises if future circumstances are outside the range covered in testing during OMP development; this results in a call for a rapid development of a new OMP with *ad hoc* decisions if required in the short term (Appendix 2 of Rademeyer et al. 2008, Appendix B of de Moor and Butterworth 2014).

Stable and Minimum Directed Sardine TACs

The alternatives tested in this document are as follows:

Stable TAC: 50 000t (reference case) or 70 000t

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[1] Subject to other DAFF SWGs adopting similar wording for this threshold to distinguish from Exceptional Circumstances.

Minimum TAC: 0t (reference case) or 10 000t

Results are shown setting either a Critical Biomass threshold of 350 000t of total biomass surveyed, with linear smoothing between 350 and 700 000t, or 150 000t of biomass surveyed west of Cape Agulhas, with linear smoothing between 150 and 300 000t.

Results

The underlying code has been modified slightly so that the linear smoothing in the directed sardine HCR is applied only if the constraint in the maximum decrease in interannual TACs (set at 20% for the reference case HCR) is to be applied. Thus the results for the reference case HCR presented here differ slightly from those in de Moor (2018). In addition, the performance statistic measuring the interannual variation in catches during the 20 year projection period has been changed to the following:

$$Median\ Annual\ Variation\ for\ simulation\ i = \ MAV^i = median\_over\_19\_years\left\{\frac{\left|C_y^i - C_{y-1}^i\right|}{C_{y-1}^i}\right\}$$

The distribution of this statistic over different simulations is summarised by reporting its median and 90 probability interval[2].

Figure 1 shows the trade-offs amongst some key performance statistics for the alternative HCRs, all using a sardine control parameter of $\beta = 0.11$. The risk thus differs amongst HCRs (Figure 1a). Figure 2 shows the trade-off between median directed sardine catch and MAV for the same risk specified by $risk^S < 0.22$. The control parameter, β, thus differs amongst these HCRs. One should exercise some caution in interpreting Figure 2. While the figure shows that increasing the stable TAC from 50 000t to 70 000t results in an increase in median total catches and a decrease in MAV for the same level of risk, this can be achieved only for a minimum TAC of 0t. Setting the stable TAC to 70 000t and a minimum TAC to 10 000t cannot satisfy the risk criterion, even for $\beta = 0.0$. A higher β parameter may not result in higher median catch performance statistics, although the upper 95%iles are higher [results not shown here]. An easier way to demonstrate this is by showing the performance statistics using the *same HCRs*, with a Critical Biomass threshold of 350 000t, but an alternative OM which assumes above average recruitment in Novembers 2018 to 2020. In this case the higher β values lead to higher median catches over the projection period (blue markers on Figure 2).

Figures 3 and 4 show worm plots assuming a Critical Biomass threshold of 350 000t. These figures demonstrate the relatively high interannual variability in directed sardine catches projected under the baseline OM with p=0.08 and MoveR. This is a consequence of a substantial number of future survey observations being simulated to be below the Critical Biomass threshold. The Critical Biomass metarule does not constrain inter-annual decreases in TAC given it has been designed to decrease TACs rapidly once the biomass falls below the critical level. There is also no restriction on increases in directed sardine TACs from one year to the next. The introduction of a minimum TAC of 10 000t decreases the MAV (Figures 2 to 4), while the control parameter, β, is tuned to a higher value for a lower

[2] 90%ile not reported in this document.

stable TAC of 50 000t resulting in higher TACs once survey estimates of biomass rebound above low levels (Figure 4).

Discussion

One of the reasons for the high variability in catches see in Figures 3 and 4 is the frequency with which future survey estimates of biomass are simulated to be below the Critical Biomass threshold, thereby invoking the Critical Biomass metarule which, by current design, does not have any restriction in the amount by which the sardine TAC can be decreased interannually. Alternatives which might include some restriction in inter-annual decrease below the Critical Biomass threshold, or alternative thresholds, will be considered in future work, together with the trade-off related to, for example, the β control parameter. Another reason for the high variability is no restriction on increases in catches from one year to the next.

From the results considered thus far, the OMP TT recommends that the future reference case HCR to be used for the immediate future set a minimum TAC of 10 000t for directed sardine. This is to model what may occur in practice, i.e. that the fishery would never be truly closed, even at very low abundance levels, but additionally has the advantage of lower MAVs for the equivalent risk level (Figure 2). Note that imposing such a minimum TAC does increase the risk to the resource, but this can be compensated (though then at the expense of a slightly lower average catch) by tuning the OMP with a smaller βcontrol parameter value so that the threshold for risk to the resource is still met. The HCR will then more realistic as it is likely to be closer to what will occur in practice.

References

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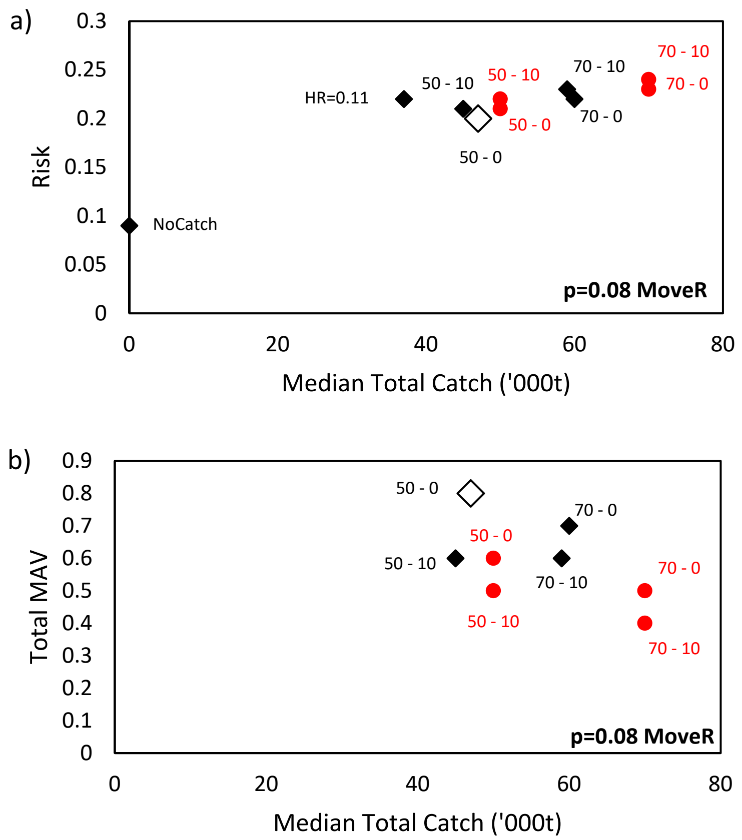

Figure 1. Risk to the sardine resource (a) and MAV in the total directed sardine catch (b) plotted against median total directed sardine catch, assuming $\beta = 0.11$ for all HCR. The data labels indicate the stable directed sardine TAC (50 or 70 000t) and the minimum directed sardine TAC (0 or 10 000t) or a no catch or constant harvest proportion scenario. For example, '50 – 0' denotes a 50 000t stable TAC and a 0t minimum TAC. The large open diamond denotes the reference directed sardine HCR with a stable TAC of 50 000t and a minimum TAC of 0t. The black markers show results using a Critical Biomass threshold of 350 000t of total surveyed biomass while the red markers show results using a Critical Biomass threshold of 150 000t of biomass surveyed west of Cape Agulhas only.

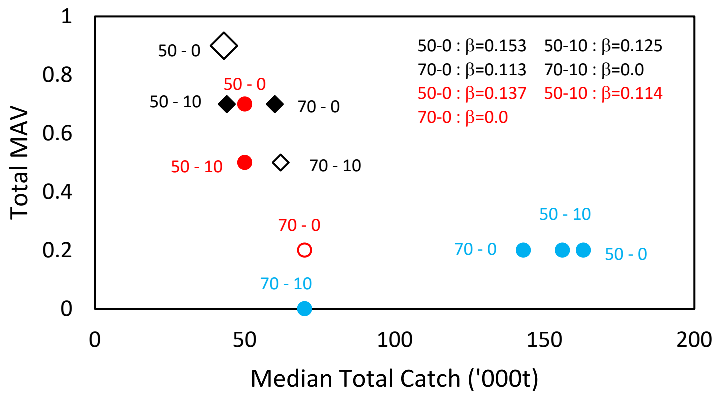

Figure 2. The MAV in the total directed sardine catch plotted against median total directed sardine catch, tuned to risk of <0.22 for all HCRs. The data labels indicate the stable directed sardine TAC (50 or 70 000t) and the minimum directed sardine TAC (0 or 10 000t). For example, '50 – 0' denotes a 50 000t stable TAC and a 0t minimum TAC. The large open diamond denotes the reference directed sardine HCR with a stable TAC of 50 000t and a minimum TAC of 0t. The **black** markers show results using a Critical Biomass threshold of 350 000t of total surveyed biomass while the **red** markers show results using a Critical Biomass threshold of 150 000t of biomass surveyed west of Cape Agulhas only. NOTE: The red open circle and small black open diamond with a stable TAC of 70 000t did not meet the requirement of a risk of <0.22 for $\beta = 0$, but were <0.23. The HCR with a stable TAC of 70 000t and a minimum TAC of 10 000t could not satisfy risk <0.22. The **blue** markers show results using the same HCRs as the black markers, but under an alternative OM which assumes above average recruitment in Novembers 2018 to 2020.

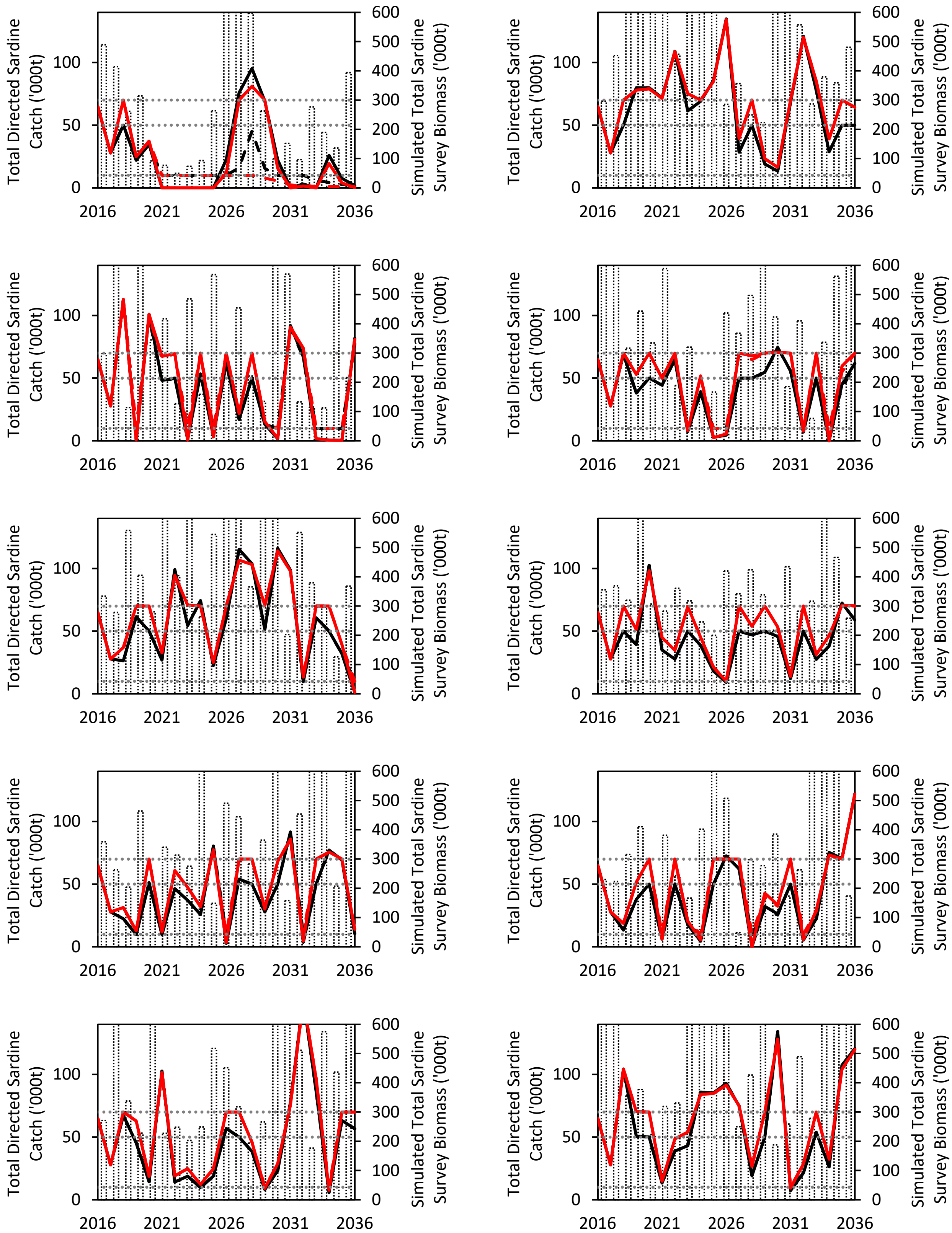

Figure 3. Trajectories of total directed sardine catch from 10 simulation. Trajectories are shown for stable TACs of 50 000t (in **black**) and 70 000t (in **red**) and for minimum TACs of 0t (solid lines) and 10 000t (dashed lines), **assuming the same control parameter, $\beta = 0.11$, for all HCRs**. The underlying columns show the trajectory of the simulated survey estimate of total biomass in that simulation, where the Critical Biomass metarule is used once the survey estimate of total biomass falls below 350 000t.

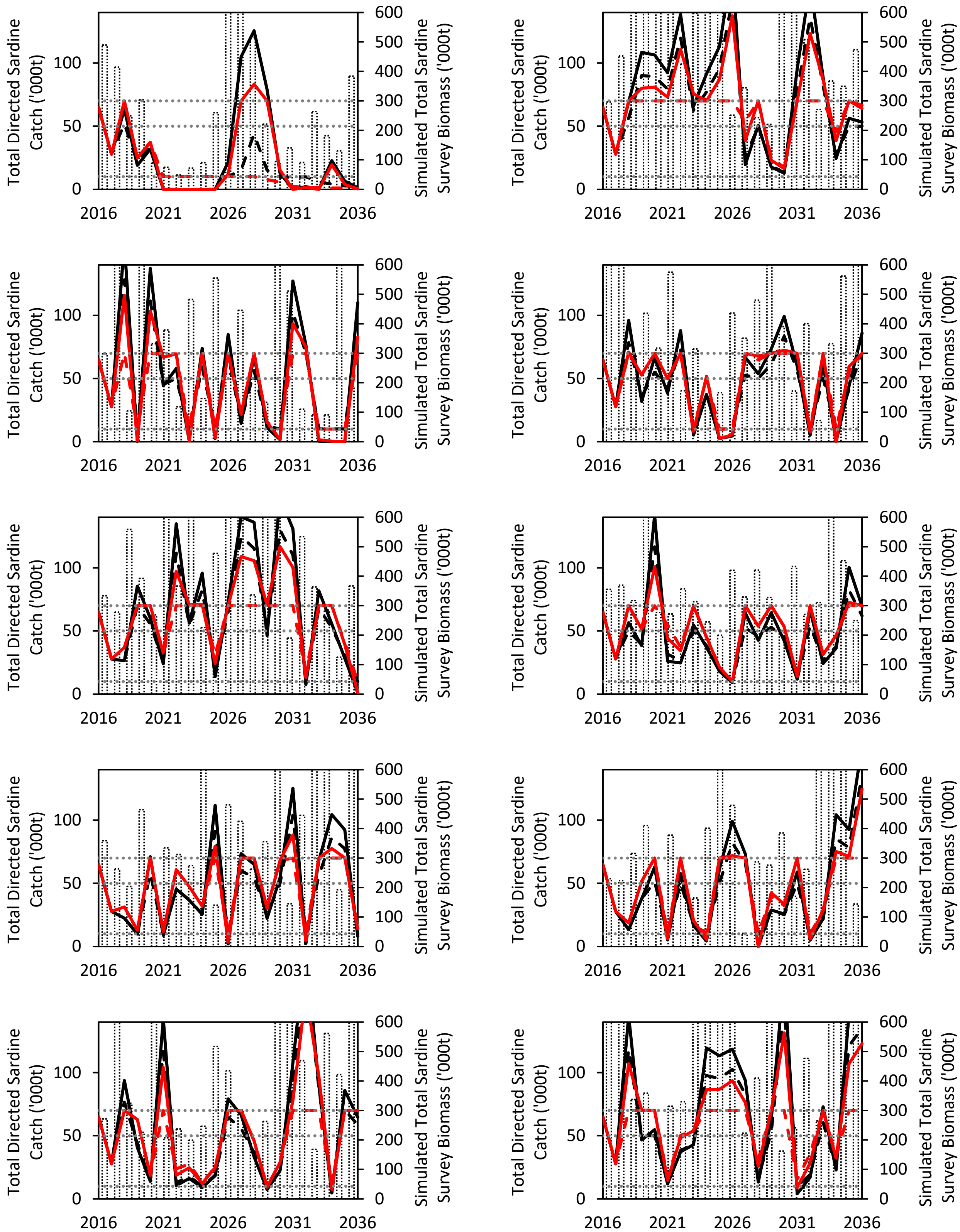

Figure 4. Trajectories of total directed sardine catch from 10 simulation. Trajectories are shown for stable TACs of 50 000t (in **black**) and 70 000t (in **red**) and for minimum TACs of 0t (solid lines) and 10 000t (dashed lines). **Each HCR has a different control parameter (see Figure 2) such that risk <0.22.** The underlying columns show the trajectory of the simulated survey estimate of total biomass in that simulation, where the Critical Biomass metarule is used once the survey estimate of total biomass falls below 350 000t. NOTE: The HCR with a stable TAC of 70 000t and a minimum TAC of 10 000t could not satisfy risk <0.22.