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An explanatory addendum for the proposal "On harvest control rules for skipjack tuna in the IOTC area of competence"

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This addendum has been written to provide more background on the proposal "On harvest control rules for skipjack tuna in the IOTC area of competence". It is written in the style of a set of Frequently Asked Questions (FAQ) to which we have provided answers. We have intentionally kept the style informal and conversational to assist understanding of the proposal and provide an alternative to the more formal language of the proposal itself.

Throughout this addendum, as in the proposal, we use the symbol *B* to refer to **spawning** stock biomass and *B0* to refer to the unfished spawning stock biomass.

A research project on Management Strategy Evaluation (MSE) for Indian Ocean skipjack tuna has been running since 2013. This project has developed a simulation model for evaluating alternative management strategies and control rules. This addendum provides some figures and tables from evaluating the proposed HCR, and alternatives, using this simulation model. At this stage, these results should still be considered provisional, subject to further testing of the model, but will be finalised prior to the Commission meeting. More details on the simulation model and the MSE project can be found in WPM and WPTT reports and via the project web site at https://github.com/iotcwpm/skj .

Why have a harvest control rule (HCR) at all?

The Indian Ocean skipjack tuna stock is currently assessed as being not overfished and not subject to overfishing. The last stock assessment, in 2014, estimated the spawning stock to be at about fifty eight percent of unfished levels (i.e. 58%*B0*). Given this, it could be argued that a neither a HCR, nor any other management intervention, is necessary.

Implementing a HCR for the Indian Ocean skipjack tuna fishery does not necessarily imply any immediate restrictions in catch. The HCR simply represents a pre-agreed plan of action to be taken in response to tri-annual stock assessments. It thus avoids the potential delays in management that may be caused in the absence of such a pre-agreed plan. The HCR recommends catch limits to avoid the stock becoming overfished and, should the stock status deteriorate, for example due to adverse environmental conditions, reduces those catch limits to allow the stock to recover. Having a pre-agreed plan in place now, while the stock status is healthy, is better than waiting until the stock is "in the red".

Will we be "locked in" to the recommendations of HCR?

To some extent the HCR does "lock in" the management actions that will be taken. After all, a plan is not worth much if it is not followed. However, this particular HCR is not intended to be in place forever. The proposal states that the HCR will be reviewed, and possibly refined or replaced, no later than 2021. This type of schedule for the review and "upgrade" of HCRs is commonly used as a means of improving HCRs based on new science and management experiences with the incumbent HCR.

Furthermore, the proposal provides for two situations in which the HCR "autopilot" should be abandoned and "manual control" taken over by the Commission: (a) if the estimated spawning biomass falls below the limit reference point or, (b) in the case of exceptional circumstances, such as caused by severe environmental perturbations, considered by the Scientific Committee to be outside of the bounds under which the HCR was designed and evaluated.

Can't we just set a fixed catch limit?

The basic premise of the HCR is that by restricting catches we reduce the probability that the stock becomes overfished and that by reducing catches, if and when the stock does become overfished, we allow it to recover.

An alternative to a HCR would be to set a fixed, constant catch limit. However, a constant catch limit would have to be set low enough to deal with the worst-case situations. For this reason, HCRs, which are specifically designed to adapt to changes in stock size, almost always give a higher long-term yield for a given level of risk than constant catch strategies. But with HCRs, you need to accept that, in order to achieve that higher long term yield, cuts will sometimes be necessary.

A useful analogy is driving your car on the streets. If you wanted to drive your car through the city at the same speed all the time, and without having a crash, that constant speed would have to be very slow, say 10km/h. But instead, if you take a more adaptive driving strategy by varying your speed, slowing down before corners and speeding up on straights, your average speed will be much higher, say 60km/h.

How was the type of harvest control rule chosen?

There are many alternative types, or classes, of HCR that use different data inputs (e.g stock assessment estimates, CPUE series) and management control outputs (e.g catch limits, effort restrictions). As part of the skipjack MSE project, several classes of management procedures were investigated including those that used biomass estimates, CPUE series or tagging data as input and those that set catch or effort restrictions. At a workshop hosted in the Maldives during February 2016, the "BRule" class of management procedure was considered the best among the classes evaluated, and became the basis of the proposal. The rationale for favouring this class of management procedure included:

- Concerns regarding the reliability of the only two CPUE series for the skipjack fishery - from purse seine in the west (due to the nature of purse seining operations CPUE series are often unreliable) and pole and line in the Maldives (due to the restricted spatial extend of this fishery)
- In moving towards the management procedures/HCR approach for Indian Ocean skipjack, a preference towards a class of HCR that builds upon the existing framework of tri-annual assessments.

The proposed HCR uses as inputs the following estimates from tri-annual stock assessments:

1. spawning stock biomass B
2. unfished spawning stock biomass B0, and
3. the equilibrium exploitation rate (Etarg) associated with sustaining the stock at 40%B0

and as output:

1. a recommended catch limit

What is meant by "suggested values" for the HCR's control parameters?

The control parameters of the harvest control rule can be "tuned" to suit the dynamics of the stock and the management objectives of the Commission. To do this tuning, the Commission needs to examine how well alternative values of the control parameters match it's management objectives. This in turn requires consideration of the trade-offs between management objectives (e.g. yield versus stability) as represented by their associated performance statistics (e.g. average catch versus average change in catch) that result from MSE simulations. These simulations results will be presented to the 3rd Management Procedures Dialogue and the Commission in May. However, in order to draft a proposal it has been necessary to provide "placeholder", or as we have called them, "suggested", values for control parameters. These are by no means intended to be final, and we encourage Commission members, after consideration of MSE results, to propose alternative values.

Shouldn't the threshold and safety level control parameters be the same as the reference points?

A common misconception around the design of harvest control rules is that their control parameters need to be the same as the reference points. In other words, for the current HCR, that the threshold level should always equal the target reference point i.e. 40%B0 and that the safety level should always equal the limit reference point i.e. 20%B0. This confusion arises easily when, as is the case in the current HCR, stock status is one of the HCR inputs (i.e. the x-axis of the HCR's response curve – the graph in the proposal).

Reference points are just that, points in the continuum of stock status that we use as a reference for evaluating management alternatives. They represent the objectives of management. In contrast, a HCR's control parameters represent the means of achieving those objectives. They don't need to be the same as the reference points, and indeed, we may be more likely to meet management objectives if they are different from management objectives.

Why is the "suggested value" for the safety level below the limit reference point?

Amongst the suggested value for the control parameters, the safety limit (i.e. the %B0 below which the fishery is closed) is set at 10%B_0. This is lower than the limit reference point which is set at 20%B0. Some people find this surprising.

A limit reference point does not necessarily equal the point at which a fishery is shut down. Rather, the LRP represents a stock status to be *avoided*. As such it complements the TRP which represents a stock status to be *aimed for*. Indeed, IOTC Resolution 15/10 (paragraph 6.b.ii) states that the Commission should "Avoid the biomass being below B_{LIM} and the fishing mortality rate being above F_{LIM}". Avoiding being below B_{LIM}, the LRP, is clearly not always the same as closing the fishery.

Whilst Resolution 15/10 makes no similar recommendations regarding avoiding closing the fishery, this is something that obviously should also be avoided. The social and economic impacts of stopping fishing, even if only for one year, would be enormous.

The HCR begins to reduce catches well before the LRP. This, combined with the fact that the stock is currently estimated to have a healthy status of about 58% B_0, means that simulations suggest that there is a low probability of reaching the LRP (20% B_0), or the safety limit (10% B_0 in the ref case). However, skipjack is a short lived, highly productive species which means that, depending upon the assumptions made, maximum sustainable yield is likely to be associated with a biomass of less than 30%B0. Furthermore, being short lived the biomass of skipjack naturally experiences large fluctuations due to recruitment variation. Given these two characteristics, it would not be surprising if, for example due to environmentally induced periods of low recruitment, the stock fell below 20% B_0. Given that 20% B_0 is likely to be only slightly below, perhaps even above BMSY, it seems like an unwise point at which to close an entire fishery. For these reasons, we chose a reference value for the closure point of 10% B_0.

Nonetheless, as stated previously, the value of 10% B_0 for the safety level is a suggested value only, and if the Commission considers 20% B_0, or any other value, is more appropriate then the safety level can be changed accordingly.

Does the HCR only restrict catches when the stock is <u>below</u> the threshold?

No, the HCR recommends a catch limit in every year and thus <u>may</u> restrict catches, if in the absence of such a limit, catches would have gone higher.

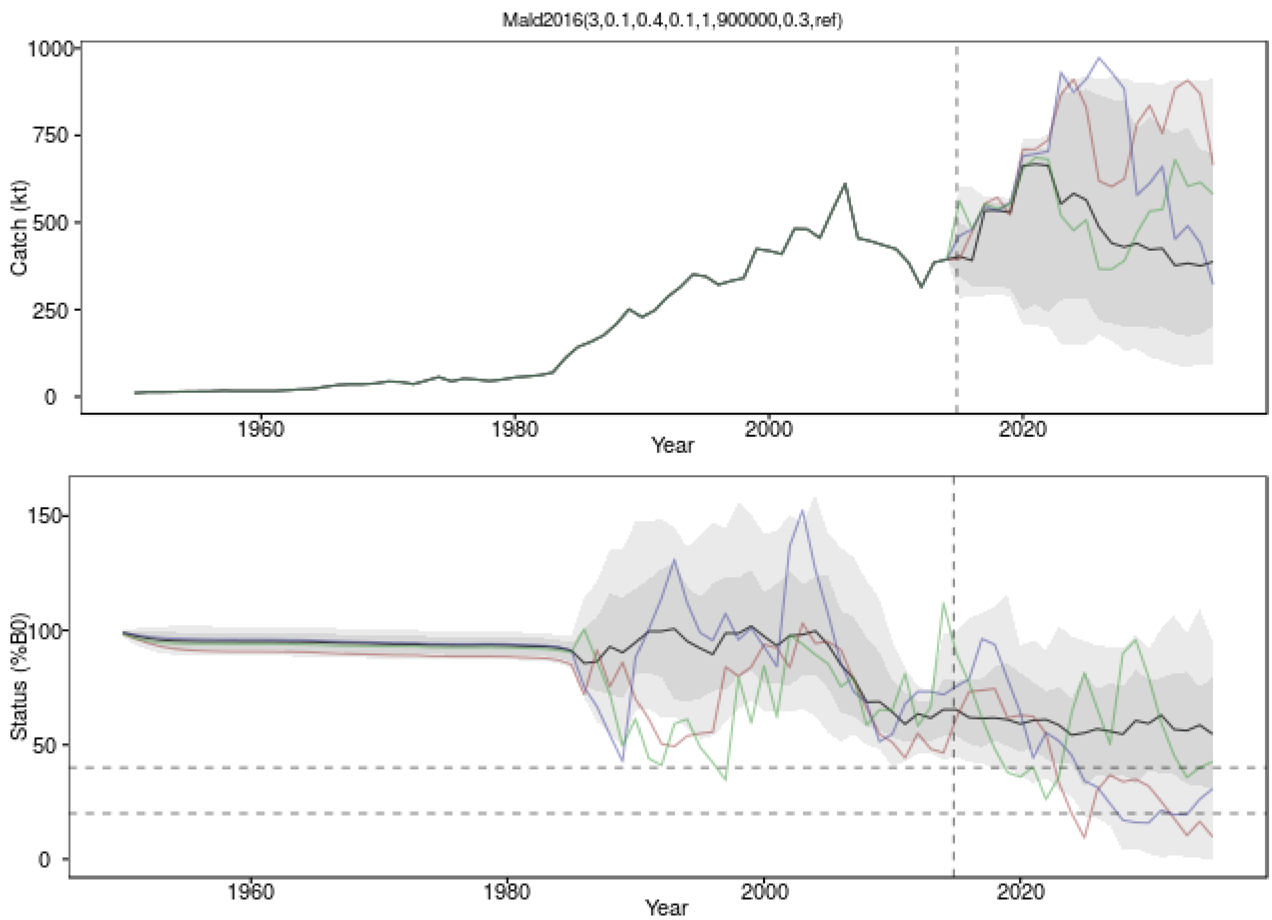
What happens if the estimated stock status is below the limit reference point?

If the estimated stock status, i.e. B/B0, falls below the limit reference point (LRP) of 20%B0 then "the HCR will be reviewed, and consideration given to replacing it with an alternative HCR specifically designed to meet a rebuilding plan as advised by the Commission". Note that in this situation, the HCR will still recommend a catch limit but, given the suggested control parameter values and as shown in Table 1 of Appendix 1 the fishing intensity will be 33% of the target fishing intensity.

What happens if the estimated stock status falls below the safety level?

If the estimated stock status falls below the safety level i.e. 10%B0 in the suggested case, the HCR will recommend a catch limit of zero. The catch limit will remain at zero until the next assessment three years later. Depending upon that assessment

Figure 1. Projected catch and stock status trajectories for the HCR with suggested values for control parameters.



The black line indicates the median and the grey ribbons the 10-90th and 25-75th percentiles. The coloured lines represent three individual simulations which correspond to the 25th, 50th and 75th percentiles of stock status over the projection period under a constant effort strategy.

Table 1. Key performance statistics associated with the suggested parameters for the HCR. Performance statistics relate to the first 10 years of simulations 2015 to 2025.

Management objective (Performance statistic)		Percentiles				
	Mean	10	25	50	75	90
Status (Mean %B0)	62.7	41.9	50.8	62.0	72.6	83.7
Safety (Years B>0.2B0 %)	97.6	95.3	100.0	100.0	100.0	100.0
Yield (Mean catch; kt)	507.9	232.8	299.9	558.7	660.2	742.4
Yield (Years catch>=425kt %)	60.4	0.0	15.1	76.7	100.0	100.0
Stability (MAPC %)	17.4	10.4	13.3	16.4	20.9	25.1
Stability (Years decrease %)	9.1	0.0	0.0	12.5	12.5	25.0
Stability (Years increase %)	14.2	0.0	12.5	12.5	25.0	25.0

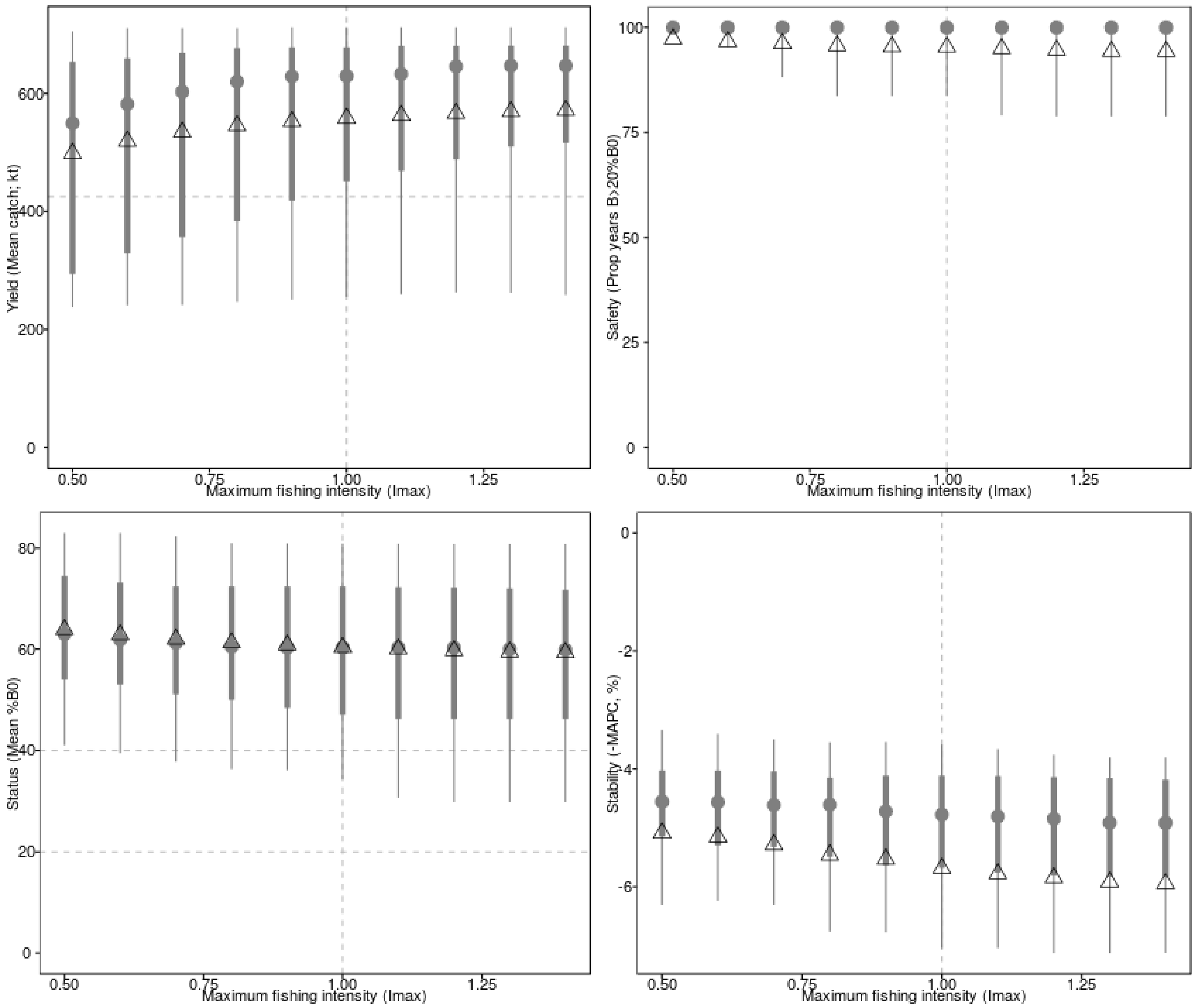
Most of the above performance statistics are described in the WPM report. Additional performance statistics not described there:

Yield (Years catch>=425kt %) : the percentage of years in which catches are above the nominal baseline of 425kt per annum.

Stability (Years decrease %) : the percentage of years in which there is an decrease in the recommended catch limit (note that the changes in catch limit only occur every 3 years)

Stability (Years increase %) : the percentage of years in which there is an increase in the recommended catch limit (note that the changes in catch limit only occur every 3 years)

Figure 1. Key performance statistics versus the maximum fishing intensity (Imax) control parameter



This figure shows the sensitivity of key performance statistics to alternative values of the HCR's control parameters. To generate these graphs the parameter shown on the x-axis of these plots was varied while the other control parameters were fixed at their suggested values. The suggested value for the control parameter is shown by the vertical dashed line.

Figure 2. Key performance statistics versus the threshold level (T) control parameter

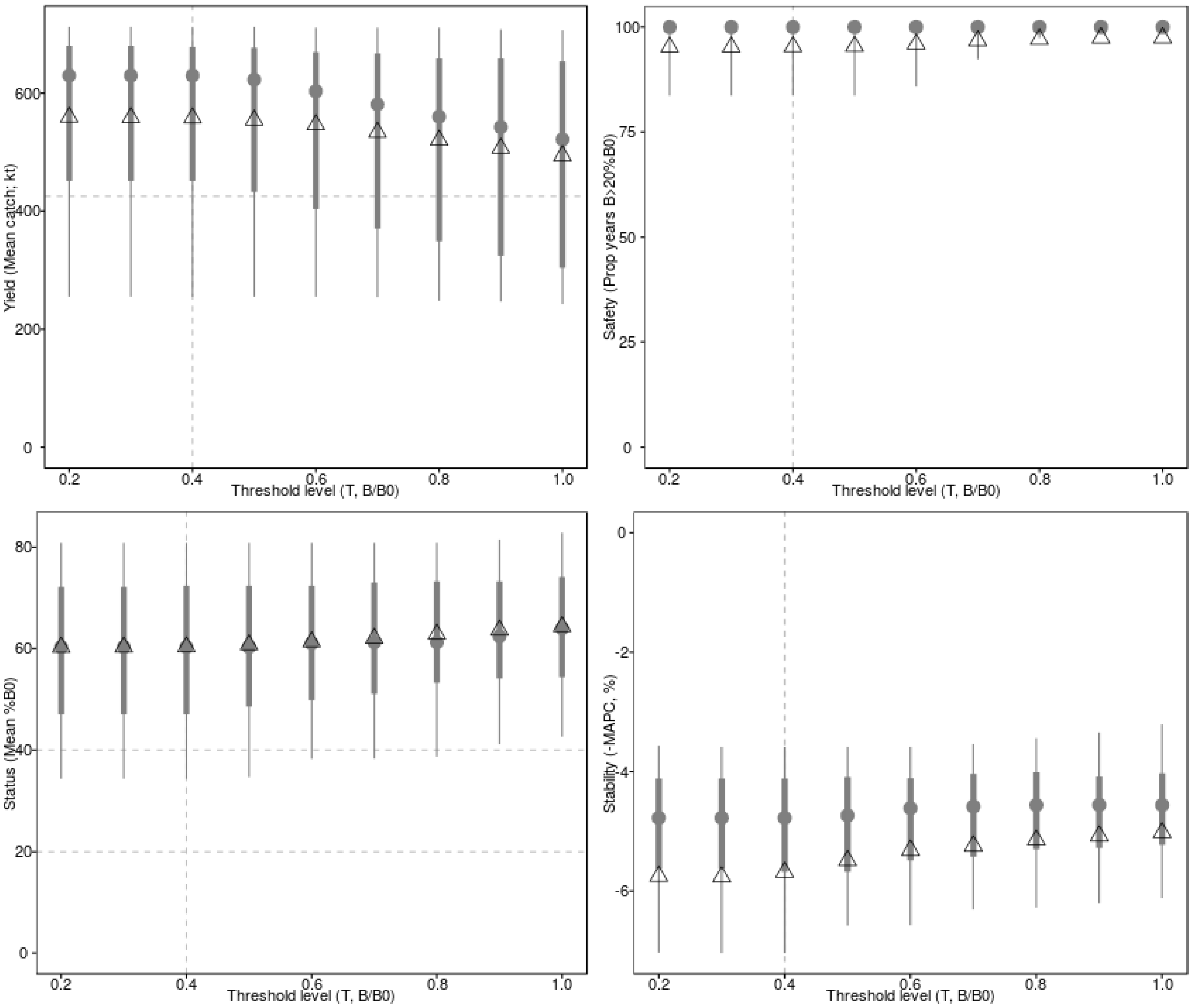


Figure 3. Key performance statistics versus the safety (closure) level (X) control parameter

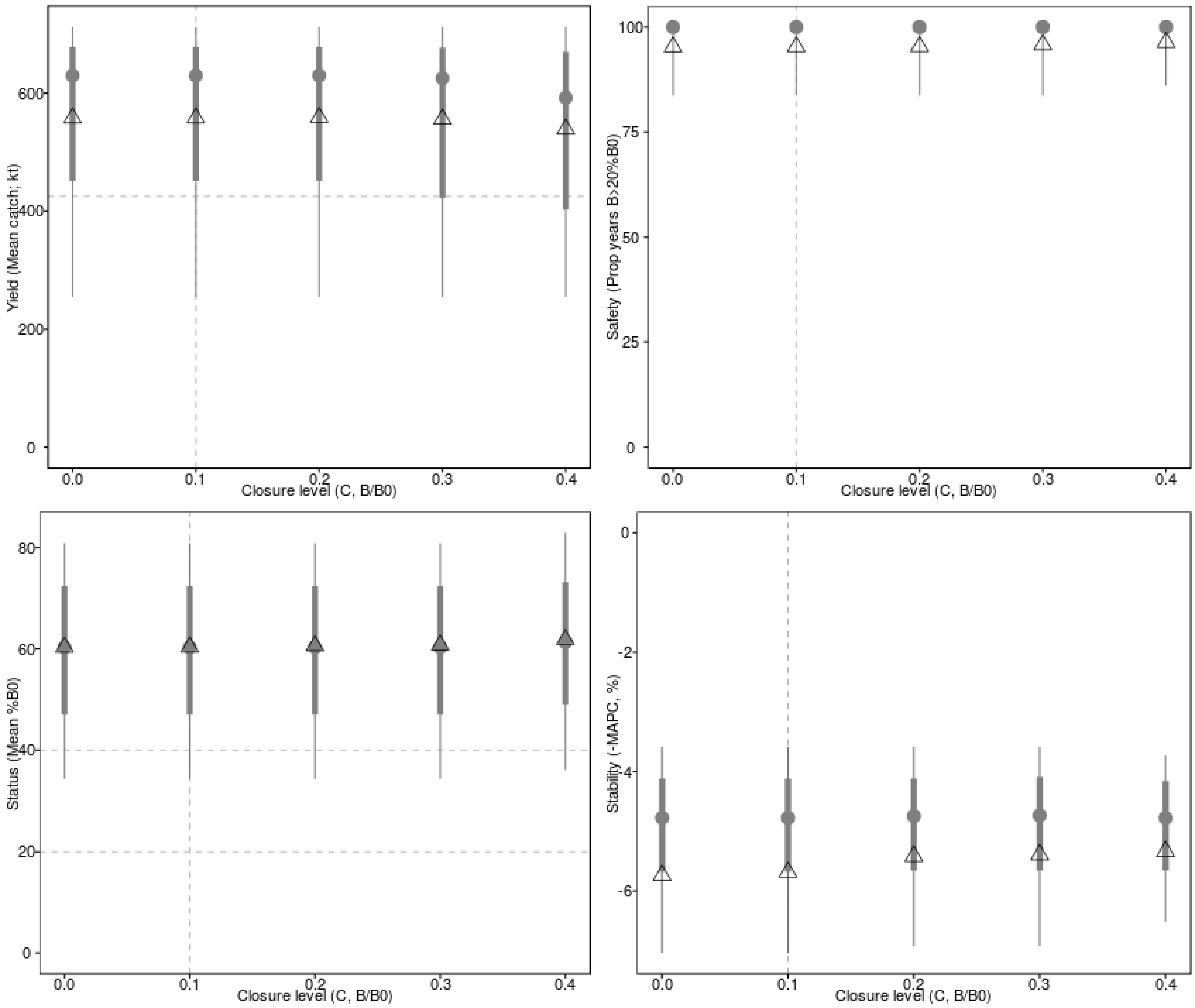


Figure 4. Key performance statistics versus the maximum change (Dmax) control parameter