ON THE ROBUSTNESS OF THE SA HAKE OMP2018 TO AN INCREASED NAMIBIAN CATCH OF *M. PARADOXUS*

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Summary

The robustness of the SA hake OMP2018 to the possibility that the *M. paradoxus* resource is demographically shared with Namibia is tested by simulation. Various levels of an increased Namibian catch of *M. paradoxus* in the future are considered. For such additional catches of up to 40000t annually, the feedback control nature of the OMP ensures that *M. paradoxus* biomass is maintained above B_{MSY} in median terms, but biomass can drop below that level fairly quickly for higher levels of such an additional catch. However, the simulations also show that in such circumstances, there is a high probability than the Exceptional Circumstances provisions of OMP2018 would be triggered, resulting in a further TAC reduction to avert undue depletion of the *M. paradoxus* resource. These results offer strong support to the supposition that the SA hake OMP2018 is sufficiently robust to secure avoidance of the adverse consequences (in resource conservation terms) which could result given a *M. paradoxus* stock which may be demographically shared with Namibia.

Introduction

Previously, focus on what was needed to be able to evaluate the consequences of the possibility that *M. paradoxus* constitutes a stock demographically shared between South Africa and Namibia has been on the need to develop Operating Models (OMs) for such a shared stock to test which OMPs might ensure adequate conservation performance for *M. paradoxus* in these circumstances. That in turn first required that the data needed for the development of such OMs, which were already publicly available for the South African region, were also made available for the Namibian region.

However, more recent consideration of this situation has given rise to the realisation (see Appendix A) that for immediate MSC certification purposes in the circumstances of the possibility that *M. paradoxus* is a demographically shared stock, all that would seem needed further to secure high P1 and P3 scores is a demonstration that an increase in the Namibian catch of *M. paradoxus* would not lead to poor conservation performance for that stock - this given the present approach of specifying catch limits for the South African hake fishery (these limits include *M. paradoxus*) under OMP2018.

Appendix A addressed the associated supposition (of the robustness of OMP2018 in these circumstances) through appeal to the results of a robustness test of OMP2018 which has already been conducted, viz. a

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decrease in future carrying capacity, leading to lower *M. paradoxus* numbers-at-age; this mimics (and hence serves as a surrogate for) the effect of an additional Namibian catch. This paper seeks to produce evidence that strengthens this supposition through development of a further robustness test which conducts this test more directly. It does this by specifically modelling the impact of an increase in the Namibian catch of *M. paradoxus* over coming decades, so as to check the robustness of the conservation performance of OMP2018 in the circumstances.

Methods

Options for an additional future Namibian catch of *M. paradoxus* of 10000t, 20000t, 40000t, 60000t and 80000t are explored, where this catch increases linearly from 0 in 2018 to the full amount in 2022, and then remains at that level. This additional Namibian catch is incorporated into the OMP testing as an additional fleet added to the 2018 Reference Case Operating Model (RC OM)[2], fishing on *M. paradoxus* only, and with the same selectivity as the South African West Coast offshore trawl fleet. The fishing mortality arising from this additional "fleet" is incorporated into the overall mortality rates, but otherwise ignored in the performance statistics output. In other words the impact of the Namibian catch is to increase total mortality rates on *M. paradoxus* (which happens to lead to a reduction in the TAC available to the SA fishery), but the OMP output including projected TAC decisions are based entirely on the South African component data on catches and abundances indices.

Given pressure of time, this robustness test was conducted for the 2018 Reference Case OM (FISHERIES/2019/MAR/SWG-DEM/03), as was the case for the robustness tests whose results are quoted in Appendix A. This is because the OMP projection code has not yet been updated yet to match the 2019 updated RC specifications; this though is not of major concern, as the results for the test are of more relevance in terms of their changes as the size of the additional Namibian catch assumed increases, compared to absolute values. A total of 1000 replicate simulated projections were carried out in each case, as for earlier results reported.

Results

[2] Note that the implicit assumption here is that the past Namibian *M. paradoxus* catches are reasonably taken into account through being subsumed into the RC model through the process of estimating its parameters, which yields estimates of productivity reflecting only that **in excess** of past Namibian *M. paradoxus* catches. Hence the robustness test needs to take account only of possible Namibian *M. paradoxus* catches **in excess** of those.

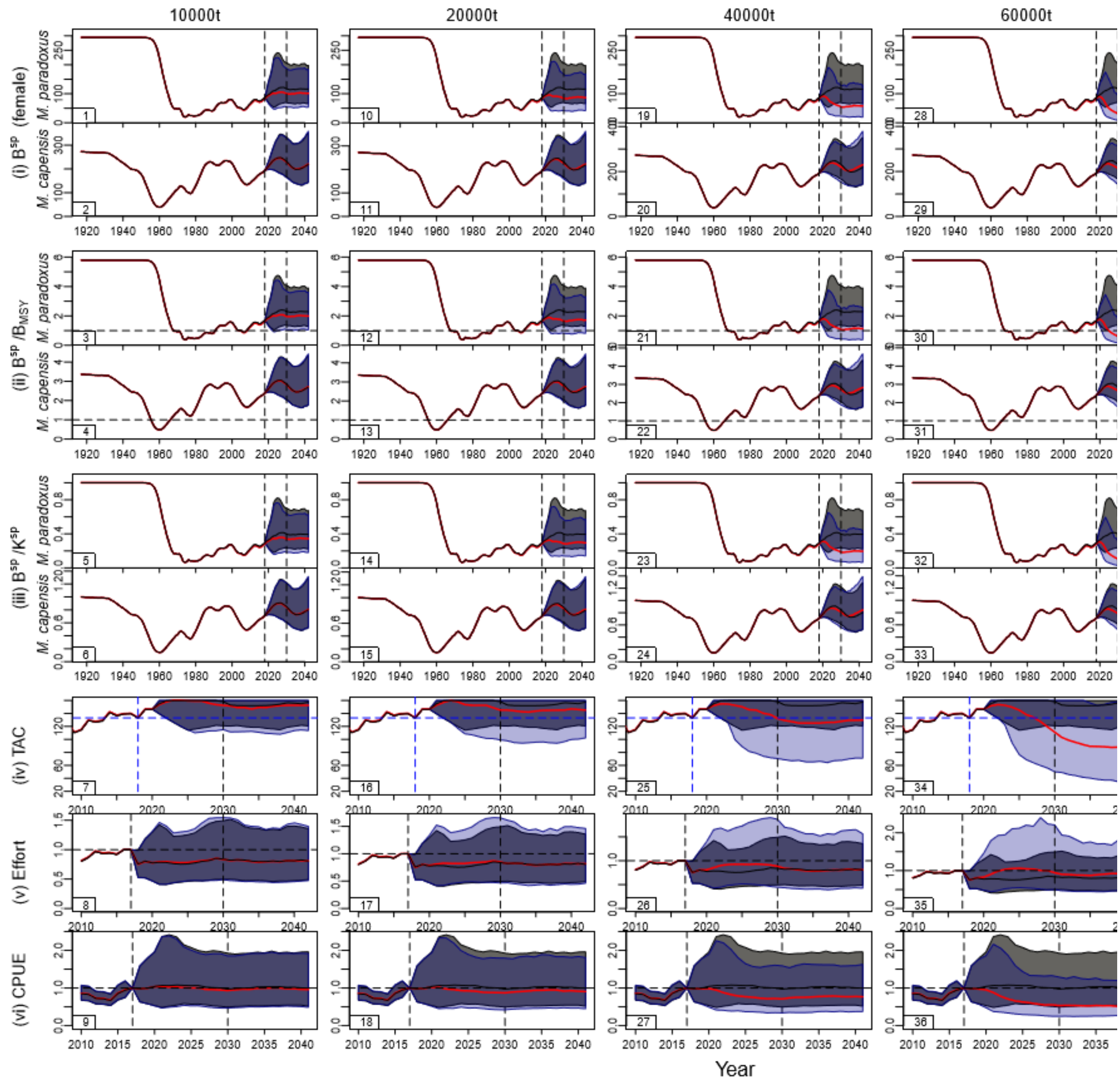

Figure 1: Projected trajectories for *Bsp* (also relative to *BMSY* and to *Ksp*) for both *M. paradoxus* and *M. capensis*, TAC, effort and CPUE are shown for each variant of the robustness tests, with the size of the assumed eventual additional annual Namibian catch of *M. paradoxus* indicated at the top of each column. In each plot, trajectories for the 2018 RC (black median lines with grey 90% probability envelopes) are contrasted with those for this 2018 RC robustness test (red median lines with light blue 90% P.E.s). Areas of overlap between the two P.E.'s are indicated by a dark blue. For the spawning biomass and TAC plots, the years 2018 and 2030 are marked by vertical dashed lines, and for the effort and CPUE plots, the years 2017 and 2030 are marked. The numbers in the bottom left corner are merely for reference purposes.

shows plots of trajectories of biomass (in absolute and various relative terms, and for both hake species), TAC (i.e. the catch of both species made by the SA fishery only[3]), offshore trawl effort and CPUE for the SA fishery; these results are for the 2018 RC and for the robustness test for the five different values assumed for the additional Namibian *M. paradoxus* catch[4]. Figure 2 plots the TAC trajectories for the robustness test

[3] Occasionally situations can arise where the full TAC is not taken because limits are placed on the maximum fishing mortality that is possible, but this happens very rarely. See also footnote 4.

[4] For the tests with a larger additional Namibian catch of *M. paradoxus*, the abundance of the resource can drop so low that this catch can no longer be taken. However, as explained later in the main text, this need not be of concern; this is

only (i.e. not including the RC) for the scenario where the additional Namibian *M. paradoxus* catch is set at 40 000t, and superimposes the total catch (i.e. the South African TAC plus the additional Namibian catch) to illustrate the total effective annual catch (of both species) modelled in this scenario. The purpose of Figure 2 is purely explanatory: to assist in understanding the simulated trajectories for future total actual catch trajectories, and contributions thereto, when the TAC trajectories in Figure 1 refer to the catch taken by the South African fishery only. Figure 3 plots the probability of triggering Exceptional Circumstances as a function of time for the different levels of Namibian catch considered here.

Discussion

Figure 2 shows that with an additional Namibian *M. paradoxus* catch, the SA hake TAC drops, and the more so the higher that additional catch. This is because the extra catch results in a fall in biomass, and hence a drop in CPUE (see Figure 2), with the result that the catch limit formulae in OMP2018 result in a reduction in this TAC, given the formulae's feedback control nature.

However, as is often the case in such analyses when actual catches are greater than "realised", the feedback control is not sufficient to completely "self-correct" for the additional catch, in part because of time-delays in the control system, so that the *M. paradoxus* biomass trajectories given the additional catch remain lower than without it. The size of the difference is small for an additional catch that reaches 10000t, but increases as that catch size increases. For an additional catch of 40000t, the corrective effect might still be considered acceptable, as the median for the *M. paradoxus* biomass remains (though marginally) above B_{MSY}, but the steady continuing decrease of this biomass for additional catches of 60000t and especially 80000t would certainly not be acceptable from a resource conservation perspective.

However, as explained in Appendix 1, OMP2018 has a further mechanism to secure against undue resource depletion: its Exceptional Circumstances provisions. Figure 3 plots (for each of the *M. paradoxus* abundance indices input to OMP2018) the probability that that index would have fallen below the threshold necessitating Exceptional Circumstances consideration (and hence likely led to reduction of the OMP-generated TAC) in or before the year indicated. What is immediately evident is that for additional Namibian *M. paradoxus* catch levels of 40000t, 60000t and especially 80000t, these probabilities increase rapidly over time. Thus, for example, for an additional catch of 80000t, by 2023 when biomass in median terms would yet to have dropped below B_{MSY}, the probabilities for each of the four indices already having dropped below their threshold values are 0.48, 0.31, 0.18 and 0.28. Hence, when considered overall, it is more likely than not that OMP2018 TAC outputs would already be under revision by 2023 in this case, with the result that resource conservation requirements would continue to be met. Hence these Exceptional Circumstances provisions augment the security which OMP2018 provides against poor resource conservation performance in the event that the *M. paradoxus* resource is a demographically shared stock with Namibia.

because Exceptional Circumstances would have come into play, with a consequential revision of OMP2018 to a more conservative approach to set TACs before any biomass that low might eventuate.

In conclusion

Viewed in totality then, the results reported in this paper offer strong support to the supposition that the SA hake OMP2018 is sufficiently robust to secure avoidance of the adverse consequences (in resource conservation terms) which could result given a *M. paradoxus* stock which may be demographically shared with Namibia.

Acknowledgements

Computations were performed using facilities provided by the University of Cape Town's ICTS High Performance Computing team: http://hpc.uct.ac.za.

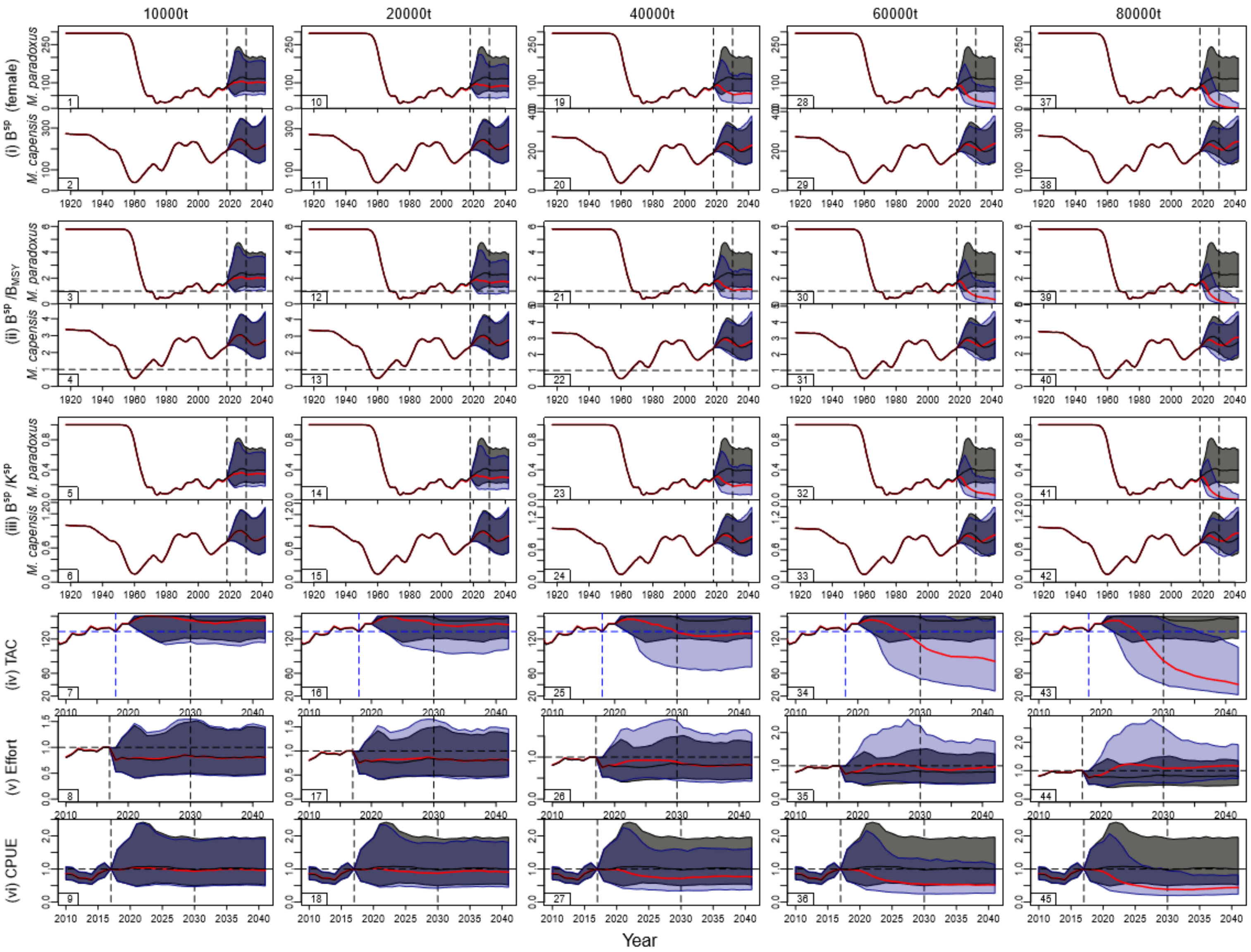

Figure 1: Projected trajectories for B^{sp} (also relative to B_{MSY} and to K^{sp}) for both *M. paradoxus* and *M. capensis*, TAC, effort and CPUE are shown for each variant of the robustness tests, with the size of the assumed eventual additional annual Namibian catch of *M. paradoxus* indicated at the top of each column. In each plot, trajectories for the 2018 RC (black median lines with grey 90% probability envelopes) are contrasted with those for this 2018 RC robustness test (red median lines with light blue 90% P.E.s). Areas

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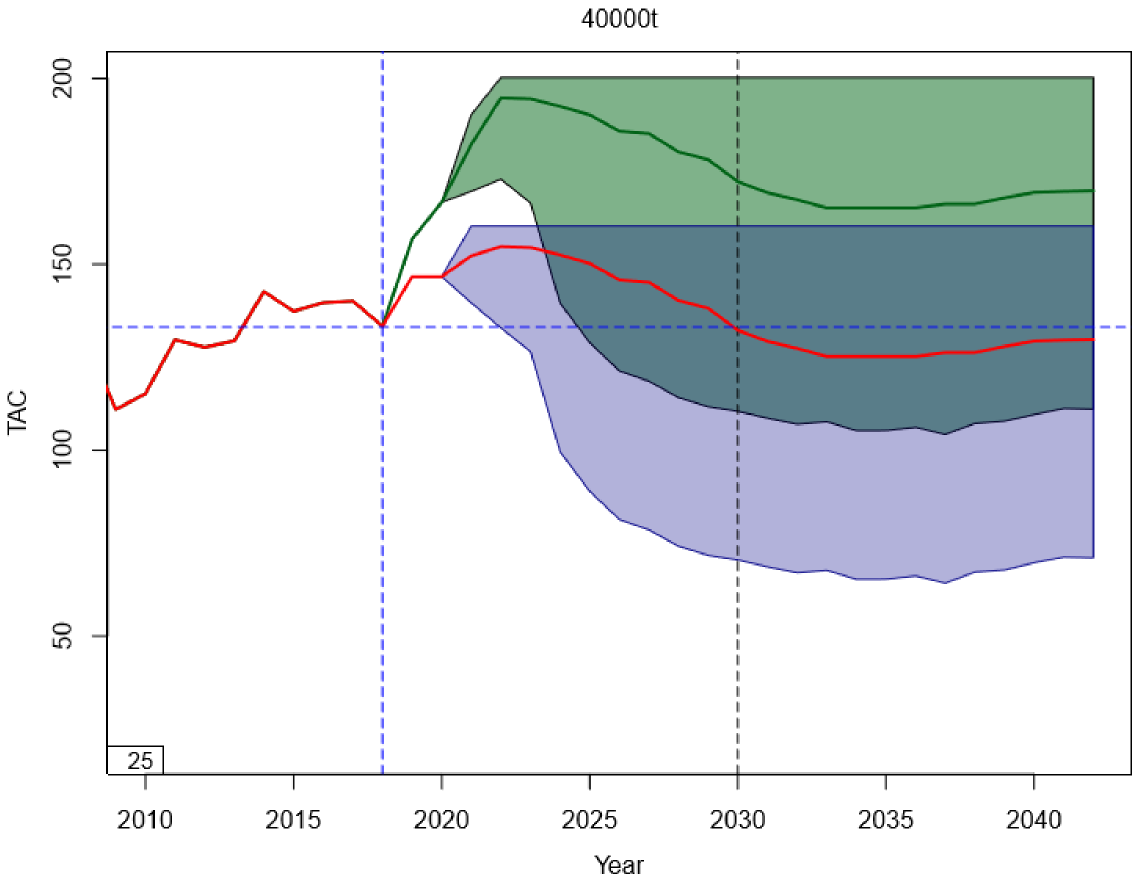

Figure 2: A variant of subplot 25 from Figure 1, showing the TAC trajectory for the robustness test with the additional Namibian catch of *M. paradoxus* set at 40 000t, except that the TAC is shown here for the robustness test only (i.e. not for the RC). The two trajectories show the South African TAC (red line and blue probability interval as before) as well as the South African TAC plus the additional Namibian catch of 40 000t (green line and green probability interval).

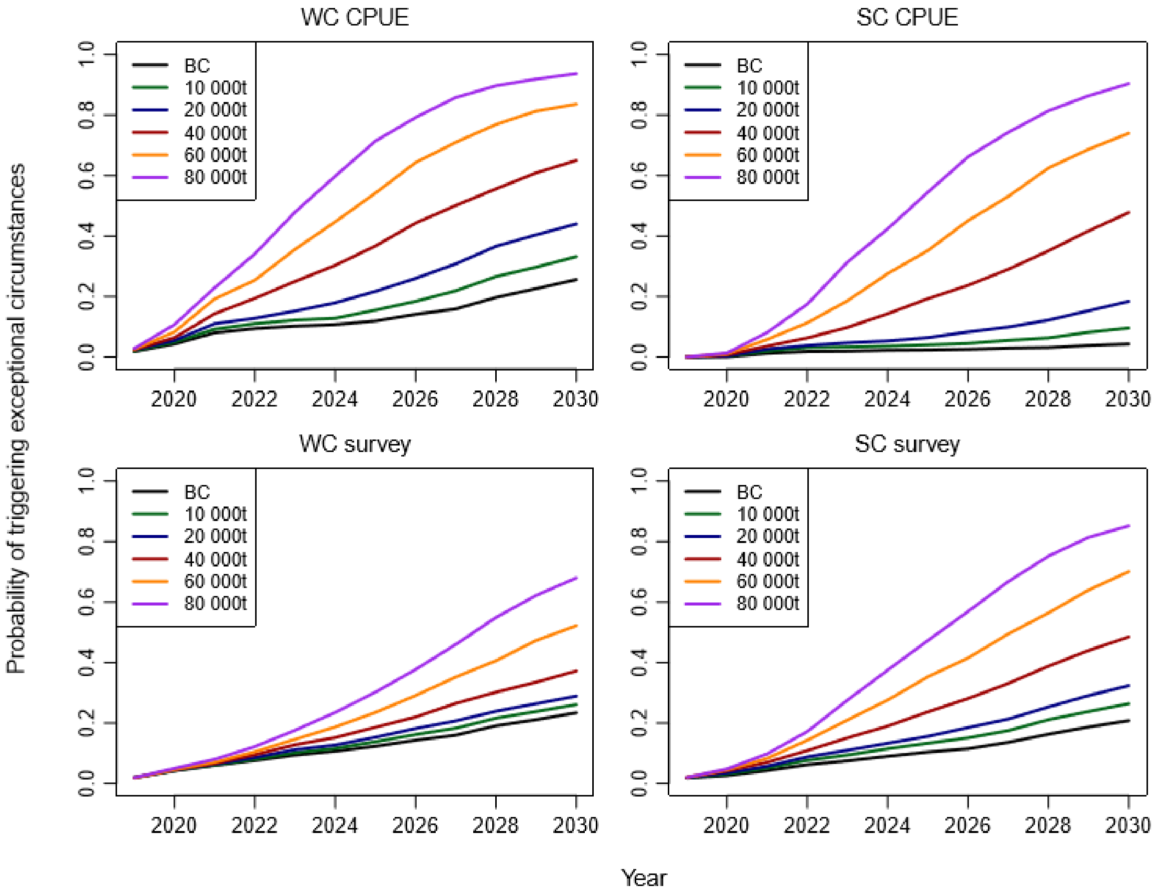

Figure 3: The probability of Exceptional Circumstances consideration having been triggered is plotted against time for the four *M. paradoxus* commercial and survey indices input to OMP2018 for SA hake, and for the range of additional Namibian catches of *M. paradoxus* considered (including the Base Case (BC) where this additional Namibian catch is zero). The probability for year *y* is calculated as the proportion of the 1000 simulations for which the projected CPUE or survey value for the index in question went below the lower 95% probability bound indicated by the OMP2018 projections in or preceding year *y* (the pertinent plots may be found in Appendix E of the OMP2018 description document) The year range considered is 2019 to 2030.

Appendix A

Communication from Doug Butterworth to the team leaders of the SA and Namibian hake CABs in relation to the robustness of OMP-18 to an increase in the Namibian catch of *M. paradoxus* if this is a demographically stock shared with South Africa

From: Doug Butterworth
Sent: Wednesday, 05 February 2020 11:22 PM
To: Jim Andrews <jim.andrews@acoura.com>; Hugh Jones <hjones@controlunion.com>
Cc: 'FelixR@seaharvest.co.za' <FelixR@seaharvest.co.za>
Subject: Robustness of SA hake OMP to possibility of increased Namibian catches of M paradoxus if this is a demographically shared stock

Hi Jim and Hugh

Thanks for the discussion earlier today. Below in response to your request for more detail to explain the robustness of the SA hake OMP (effectively "HCR" in MSC-speak) to possible "sharing of the M paradoxus stock".

First it is important to clarify the 2019 IWS Panel statement that "a single panmictic population in South Africa and Namibia is still the most plausible hypothesis for M. paradoxus". The "panmictic" qualification here refers to **genetic** panmixia. The statement should not be taken to imply that this M paradoxus "population" is **demographically** panmictic. I confirmed this with one of the Panel members after we spoke earlier today.

It is the extent to which this population is **demographically** "shared" that is the important consideration in assessing the appropriateness of an HCR. Given the uncertainty here, and that extents of demographic mixing from virtually full to virtually none can be defensibly argued at this time, any HCR must be shown to be robust across this range. This is achieved (if with more difficulty than perhaps needed in reality) by demonstrating it for the two extremes – no and full demographic sharing. This demonstration must include M capensis as well; this is not because of possible sharing/overlap of M. capensis stock(s) across the SA/Namibian border (which is not a scenario accorded any notable plausibility), but rather because commercial catching operations cannot distinguish the species so that any HCR must in effect apply jointly to both species.

Thus, the 2x2 cross of a demographically separate/mixed paradoxus stock, and SA/Namibian HCRs need consideration.

I) <u>For South Africa</u>

a. *A demographically separate SA paradoxus stock*

The SA hake OMP has been shown and accepted to exhibit adequate performance for both paradoxus and SA capensis (I am not aware of any serious challenge to this conclusion).

b. *A demographically (partially or fully) mixed paradoxus population*

The concern here is an increase in the current catch of M paradoxus off Namibia. This is because it is implicit in the results from the historical data and assessment analyses that continuation of the current Namibian catch level would not lead to unacceptable population conservation performance. Were this Namibian catch to increase though, a "sustainable" catch in SA waters of paradoxus could cease to be so. However, appropriate reaction to this possibility is adequately covered by the current SA OMP for three reasons.

i) The underlying catch algorithm – see equn 2 on pg 1 of the OMP description document attached - is paradoxus-specific and reacts in an appropriate feedback control manner to decrease paradoxus catches in the event of such an increase in the Namibian catch, because this will result in a decrease in paradoxus abundance and hence in the values of the associated indices input to equn 2.

ii) Although robustness tests explicitly modelling a shared resource have yet to be undertaken, an existing test does mimic the net effect of this increased Namibian catch scenario – see RT10 on pg 3 of Hake_P6arev attached. This assumes a decrease in future carrying capacity by a not inconsiderable extent (30%) as a means to effect a reduction in future mean recruitments (and hence numbers of paradoxus). But the additional Namibian paradoxus catch has the same net effect of decreased paradoxus numbers, so RT10 serves as a surrogate to capture the potential negative effect of catches in Namibia impacting the paradoxus stock and its utilisation by the SA fishery. How is performance affected relative to the baseline for this scenario: see Figure 2b on pg 10, the final column – note the comparison is black being changed to red. The first row, though suggesting no adverse impact on paradoxus, is misleading – that is because a dynamic Bmsy measure is used, which would not be appropriate for this surrogate interpretation. But importantly note the third row – the TAC – this is reduced by a substantial amount nearing some 30% (in median terms) over the 2020's (the SA fishery bears the costs of Namibian "excesses" given the SA OMP). But even more importantly, note the CPUE trend in the lowest row, which is reflecting abundance (including paradoxus); even though this declines initially, the feedback control nature of the OMP sees this return to where it started by the time 2030 is reached. Performance is robust to this stock sharing uncertainty.

iii) But if ii) alone is not considered sufficient confirmation of the adequacy of the OMP in these circumstances, note that the OMP also includes "Exceptional Circumstances" provisions – see Appendices D and E commencing on pg 21. If Namibian usage of paradoxus led to too great an impact on the population, abundance would drop and the abundance indices monitored fall to below the ranges shown in Appendix E. See then the final sentence on pg 21 – if this occurs, the rest of that Appendix sets out what follows; this is a more detailed evaluation which can lead in turn to overturning the OMP-generated TAC to replace it by a smaller value. Again therefore, the OMP has provisions to react in an appropriate way to an "undue" increase in the catch of paradoxus off Namibia.

The question may arise, why then SADSTIA's request for Namibian data to develop an operating model for a shared stock scenario to be able to test the SA OMP against this? It is highly unlikely that i)-iii) alone would not provide sufficient security in circumstances of a demographically shared paradoxus stock. The reason is to improve "specificity". Performing such tests might allow the SA OMP to be adjusted (tuned) to show more efficient performance: less drop in catch for an equivalent resource-related risk.

II) **<u>For Namibia</u>**

a. *A demographically separate Namibian paradoxus stock*

The Namibian HCR must be demonstrated, ideally by simulation testing, to exhibit adequate performance for both the Namibian paradoxus and the Namibian capensis stocks.

b. *A demographically (partially or fully) mixed paradoxus population*

The SA hake OMP covers Namibia for this situation (though at SA's potential expense in terms of catches in the two regions!!)

<u>In conclusion</u>

The arguments in I)b) show that the SA hake OMP is sufficiently robust to the possible consequences (in resource conservation terms) of a demographically shared paradoxus stock, so that this possible sharing does not necessitate any reduced scoring or condition application in the SA hake certification assessment.

For Namibia, a similar possible outcome requires a demonstration to the Namibian hake CAB, which will require species dis-aggregated analyses, that II)a) is satisfied.

Cheers

Doug