Response to the review panel report for the 2018 International Stock Assessment workshop: Hake

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Note: comments on progress are inserted in *red italics* underneath each recommendation.

B. Hake

B.1. There have been a number of modifications to the basic assessment over the last 18 months, which have resulted in an appreciably better estimate of status relative to B_{MSY} for the *M. paradoxus* resource (whose status previously – fluctuation to below B_{MSY} - had been a matter of debate and concern) – are these modifications together with their consequent changes in results justified?

Several changes to the assessment have been made and these are all justified. The Panel notes that there are three major causes for the changes to the estimate of ratio of the current biomass to B_{MSY}: (a) correction of how selectivity-at-age is calculated, (b) correction of how catch-at-age is computed when calculating F_{MSY}, and (c) adoption of the natural mortality-at-age vector from the predation model (rather than the earlier somewhat arbitrary vectors). However, several of the other changes to the assessment, including the addition of the most recent data, have also increased the ratio of current biomass to B_{MSY}.

No action required.

B.2 (*) The revised OMP proposed (OMP-2018) is more "aggressive" than its predecessor OMP-2014 in giving higher TACs for the same abundance (increasing the *b* control parameters in the HCR by 5%, and increasing the cap on the TAC from 150 000 to 160 000 MT. Do the results from the updated Operating Models and simulation tests justify a revision in this direction?

The Panel identified several issues with the reference set of Operating Models (OMs) that could not be fully addressed during the workshop. This made it infeasible to address this question. In particular, in some of the OMs the parameters for the female length-at-age relationship were sensitive to changes in other aspects of the assessment model (e.g. the stock-recruitment relationship) and this sensitivity was sometimes appreciable to the point of affecting convergence, as well as producing unrealistic inferences about female biomass and productivity for *M. paradoxus*. Moreover, at least one trial (RS05b) apparently converged to a local minimum, which may be related to general convergence issues.

There is a need to consider re-parameterizing the model to avoid such unrealistic behaviour. For example, the growth model should be re-parameterized to a 2-parameter linear model, where the parameters are the lengths corresponding to two reference ages for which there are reliable data on length-at-age. In addition, it may be necessary to fix some parameters (e.g. the observation error sigmas) and use analytical solutions for the others (e.g. the catchability coefficients).

The next revision of the assessment should follow a more detailed scheme such as that in Appendix 1, to ensure that certain important aspects are not missed again during checking.

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The 2019 hake Reference Set assessment results can be seen in MARAM/IWS/2019/Hake/BG10. The 2018 Panel recommendations were incorporated into this updated Reference Set as best as possible, with a few modifications. In particular:

1. *The Baranov formulation for the catch equation was implemented.*
2. *The growth curves were re-parameterised as two-straight-line growth curves, as there is evidence in the age-length key data that growth slows for older hake (see Appendix A of MARAM/IWS/2019/Hake/BG10).*
3. *MARAM/IWS/2019/Hake/BG10 includes an appendix with more detailed assessment results than were generated previously.*

B.3 (*) A particular concern arising for the revised OMP-2018 development has been the possibility of needing in the future to substitute an industry vessel for the standard research vessel (which is now old and experiencing many maintenance problems) to carry out hake abundance estimation surveys, and furthermore the possibility that funding limitations may impact the (regular) continuation of these surveys. A number of robustness tests have been conducted to evaluate the consequences, and the proposed revised OMP-2018 has been considered to have shown adequately robust performance for these. Especially in circumstances where a more "aggressive" OMP has been proposed, which will yield greater TACs than the previous OMP-2014, have the tests conducted been sufficient, and if not what further tests are suggested?

The Panel recommends that future analyses consider robustness trials in which (a) fishery catchability is increasing at a faster rate than 2% per annum, (b) fishery catchability is density-dependent (e.g. CPUE is proportional to the square root of abundance), and (c) there is a failure in recruitment. These robustness trials were selected to more fully test the implications of less frequent surveys on the performance of OMP-2018. Results were presented during the workshop that showed that OMP-2018 is robust to the impacts of (a) and (c), assuming that the reference case analysis is appropriate. However, density-dependent catchability should be examined before final conclusions are drawn.

Density-dependent catchability has not been explored to date, but this has been noted for attention in the next OMP revision.

B.4. A new metarule has been proposed for OMP-2018 which involves the specification of a threshold to indicate when extra measures may be necessary to deal with especially low *M. capensis* abundance. Are this rule and the basis used to develop an initial value for this threshold appropriate?

The proposed meta-rule seems appropriate, but further investigation of the value of such a rule should await finalization of the reference set of OMs.

The metarule has not been explored further as yet, given constraints on time.

B.5. What are priority needs (if any) for further robustness tests of OMP-2018? In particular, has adequate attention been paid to the possibilities of recruitment failure (currently surrogated by a decrease in *K* for both species in the future)?

See response to question B.3.

This has been noted for attention in the next OMP revision.

B.6. The assessments generally estimate fairly low values of B_{MSY}/K. These might be argued as leading to acceptance of recovery targets that are too low. Do these "low" values constitute a concern, or a need for alternative higher "targets", give that:

a) they follow in large part from the stock-recruitment functions estimated (were the forms considered sufficient and appropriate?) (MARAM/IWS/2018/Hake/P3);
b) they are arguably a reflection of poor estimates of *K* rather than of current *B* or B_{MSY};
***c)* the hake explicit-predation model (MARAM/IWS/2018/Hake/BG7) indicates that *K* for *M. paradoxus* is "over-estimated" in the standard assessments because these ignore the predation release on this species arising when the fishery commenced concentrating on *M. capensis*;**
d) for the great majority of Reference Set Operating models, under OMP-2018 both hake species are predicted to "stabilise" at median levels well above their B_{MSY}'s (MARAM/IWS/2018/Hake/P3); and
e) for economic reasons the industry needs high CPUE values (which OMP-2018 is projected to provide) (MARAM/IWS/2018/Hake/P4)?

The Panel did not discuss this issue owing to the concerns with the reference set of OMs.

N/A.

B.7 (*) Is there a need for a trawl-ID covariate in the GLMM analysis underlying the hake catch species-splitting model used?

The Panel considers that adoption of this approach is currently premature. Prior to making the decision regarding the need for a trawl-ID covariate, the following recommendations and suggestions are offered.

- Implement the approach to model selection outlined by Zuur *et al.* (2009).
- The structure of the binomial GLMM should be examined to determine to what the binomial sample size is set.
- Consideration should be given to a nested random effects structure (Trawl ID within vessel).
- There may be value in moving to a beta or beta-binomial regression framework.
- Calculate the predicted values by integrating over the random effects.

This has been noted for future work.

B.8 (H) Other recommendations

It is still not possible to obtain a positive definite Hessian matrix for the hake assessment. Efforts should be made to do so because this will increase confidence that the parameter estimates correspond to the true minimum of the objective function. Convergence of the minimization procedure would likely be enhanced by implementing the "hybrid" method for calculating fishing mortality rates.

Positive definite Hessian matrices have since been obtained for the three Ricker OMs in MARAM/IWS/2019/Hake/BG10 by fixing three of the CPUE sigma (residual standard deviation) values (those for the historical ICSEAF and the M. paradoxus WC data) at their lower boundary (at which they were consistently being estimated). Following up on this for the Beverton-Holt OMs has yet to be pursued because of time-constraints. .