RESPONSES TO PREVIOUS PANEL RECOMMENDATIONS ON HAKE RESEARCH

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Responses have been inserted in *red italicised underlined text* after each recommendation

INTERNATIONAL REVIEW PANEL REPORT FOR THE 2013 INTERNATIONAL FISHERIES STOCK ASSESSMENT WORKSHOP
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[A D M Smith (Chair)[1], S Cox[2], A Parma[3], and A E Punt[4]]

Hake

Assessment-related

A.1 (*) The assessment framework that incorporates movement explicitly is a major potential step forward in understanding the dynamics of South African hake. However, several issues need to be addressed before this framework could be included in the reference set of operating models for this (or any future) hake OMP revision (see recommendation A.9 below). While including this model in the robustness tests would be desirable, a number of assumptions regarding the spatial distribution of future effort would need to be made. Given the amount of time available it may not be possible to complete this model development in order to use it as an operating model to test candidate OMPs in the current review process due for completion by September 2014. [*Review progress on the development of approaches which model movement explicitly, and advise on their role in the current OMP review process*]

This model framework was not included in the Reference Set (RS) of Operating Models (OMs) in the 2014 OMP review because the limited time available for the 2014 OMP review did not allow for further development of this model.

A.2 (*) Include the replacement line on all stock-recruitment relationships reported in Figures. [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

The replacement line is now generally included.

A.3 (H) Update the Reference Case specifications so that the penalty function on the change in survey catchability associated with the use of a new gear by *Africana* is set to the best estimate obtained in the most recent calibration analysis: for *M. capensis* this should be 0.653

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(SE 0.073) rather than the *ad hoc* value specified in the past (0.8), and for *M. paradoxus* it should be updated based on "Model 1" (see Table 1). [*Advise on appropriate calibration factors for Africana old vs new gear*]

This update is included in the current RS - see MARAM/IWS/DEC14/Hake/P2.

A.4 (H) Take the sex-specificity of the available length-frequency data for the longline fisheries into account in the assessment. This may require that some of the selectivity patterns be modified to allow them to be sex-specific. See also recommendations A.5 and A.6. [*Consider the implications of the sensitivity of the results to the addition of further longline CAL data*]

These data are included in the current RS - see Table App.A.5 of MARAM/IWS/DEC14/Hake/P2. Longline selectivity differs for males and females - see Table B.3 of MARAM/IWS/DEC14/Hake/P2

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A.5 (H) Dome-shaped selectivity is currently modelled as a logistic function of length, with an exponential reduction in selectivity above a certain length. The length at which selectivity begins to drop is pre-specified rather than being estimated. Consider implementing a selectivity function which includes dome-shaped and asymptotic selectivity as special cases, and which allows the length when selectivity starts to decline to be estimated. The double-logistic function included in Stock Synthesis (Methot and Wetzel, 2013) is a 7-parameter function that has these properties and is differentiable. [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

All the commercial selectivities estimated in the current RS take on the shape of a three-parameter double logistic function - see equation B48 of MARAM/IWS/DEC14/Hake/P2.

A.6 (M) The current likelihood function for the length-frequency and conditional age-at-length data is not a true likelihood. Consider the alternative likelihood function for the length-frequency and conditional age-at-length data developed by Chris Francis (paper available on request from the author). [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

Time limitations have precluded this to date.

A.7 (M) The shape of the selectivity patterns for the south coast spring and autumn surveys for *M. paradoxus* in MARAM IWS/DEC13/Hake/P2 are surprising and hard to justify biologically. This might reflect imprecision of the estimates in question. Consider imposing a stronger penalty on how selectivity may change among length-classes. [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

The shape of all the surveys selectivities are reasonable in the current RS, without having to impose a stronger penalty on how selectivity may change among length-classes - see MARAM/IWS/DEC14/Hake/BG10.

A.8 (M) Use the approach of Francis (2011) to explore whether the extent to which the length frequency and conditional age-at-length data are downweighted is appropriate. [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

Time limitations have precluded this to date.

A.9 (M) The Panel has the following suggestions related to the stock assessment method which models movement explicitly. [*Review progress on the development of approaches which model movement explicitly, and advise on their role in the current OMP review process]*:

Limited progress has been made on the movement model. The gravity model described in MARAM/IWS/DEC14/P5 has been run to provide a simpler basis for comparison to the more complex movement model.

1. Estimate the spatial distribution of recruits as a vector of parameters, and start movement in the model at the first age at which hake are observed in surveys. This reduces the number of estimable parameters.
   The spatial distribution of recruits has been estimated as a vector of parameters in the gravity model (see equation B4, MARAM/IWS/DEC14/P5). The movement then starts at the beginning of age 1.

2. Estimate the initial distribution of abundance in 1978 using a vector of parameters by age or groups of ages. Estimation will be more stable if the deterministic numbers-at-age are first initialized deterministically, e.g., N(a) = R*exp(-M – init_F) and then adjusted via N(a) = N(a)*init_N_devs(a).
   This has yet to be done.

3. Explore why the model suggests that survey selectivity for *M. capensis* should be dome-shaped when essentially the entire range of the species is covered by the survey and model.
   This has yet to be done.

4. Longshore strata could be added to the model as needed and statistically justified by the data available for parameter estimation.
   This has yet to be done.

5. Report the proportion of each species in each spatial stratum by age, and develop methods for visualizing how this proportion changes over time.
   This has yet to be done.

6. Implement (weak normal) penalties on the parameters which determine movement to avoid parameters moving towards bounds.

This has yet to be done.

7. Consider implementing smoothness penalties on the movement rates or functional forms for movement based on age and distance to avoid what appear to be unrealistic movement probabilities in some instances.
   This has yet to be done.

8. Work with biologists to evaluate whether the estimated movement probabilities and spatial distribution patterns match expectations. The output of the GeoPop model might be helpful in this regard.
   This has yet to be done.

A.10 (L) The GLM CPUE series are based on species-aggregated catch and effort data which are then disaggregated to species. There will be some correlation between the standardized CPUE series for the two hake species. Estimate the extent of between-species correlation in the residuals for the two species. If there is substantial correlation, develop a likelihood function which accounts for these correlations and generate future CPUE data by species with this correlation (as well as the temporal correlation referenced in A.15 below). [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

Between-species correlation has been taken into account in generating future CPUE data in the 2014 OMP review (see equation 2 in MARAM/IWS/DEC14/Hake/BG11).

A.11 (L) There are only a few unsexed animals which are not immature. Drop these animals from the analysis to avoid fitting data for which the sample size is very small. [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

This has been done.

A.12 (L) Determine exactly how the early (“ICSEAF”) CPUE series were coarsely standardised.

This has yet to be pursued.

OMP-related

A.13 (*) The OMP evaluation could consider minimising changes over time in fishing mortality as a proxy for changes over time in effort amongst its objectives.

Predicted future effort trends, as predicted on the basis of projected future fishing mortalities, were inspected in the process of OMP selection (see for example MARAM/IWS/DEC14/Hake/BG12).

A.14 (*) Analyses provided to the Panel in MARAM IWS/DEC13/Hake/P2 suggest that there is a limited ability to forecast trends in commercial CPUE and survey indices of abundance.

Noted.

A.15 (H) Modify the future projection specifications for OMP testing so that allowance is made for temporal autocorrelation in catchability when generating future CPUE indices of abundance. The extent of such correlation should be calculated for each CPUE series separately. [*Review progress on update of 2010 assessment approach leading to a new Reference Set*]

Time limitations mean that thus far only between-species correlation has been taken into account.

A.16 (H) In relation to robustness tests [*Advise on the selection of robustness tests;* see Appendix 4 for the updated list of robustness tests]:

Because of time limitations, only a few robustness tests were considered in the 2014 OMP revision process, including for example changes in carrying capacity (in the past and in the future), and undetected increase in CPUE catchability in the future. These were selected on the basis that they had involved the greatest risk to the resource in the 2011 OMP review.

1) Drop robustness test A.catches.1[5] because robustness test A.catches.2 provides a more complete examination of the implications of using the observer data to split the historical catches to species.
2) Add a robustness test based on the current robustness test A.catches.2 in which the species split is based on the "old algorithm" which allows for year effects in the algorithm relating these splits to hake size and depth.
3) Robustness test A.Catches.3 should refer to doubling the catch by the longline fisheries, not the fishing mortality rate. Also, the operating model should output the model-predicted discards (in total and by length-class) in absolute terms and relative to the landed catch, and the plausibility of this level of discards should be evaluated given the data collected by observers.
4) Add a robustness test in which there is hyper-stability in past and future CPUE-abundance relationships, for example, that CPUE is proportional to the square-root of abundance.
5) Add a robustness test in which there is hyper-stability in future CPUE-abundance relationships only.
6) Use CPUE standardization to explore the plausibility of the assumptions underlying robustness test A.CPUE.2 if it is selected for further consideration.
7) Robustness test A.CPUE.3 may involve a considerable amount of work to implement correctly, especially given the longline selectivity pattern is assumed to change over time. Completing this robustness test should be assigned a lower priority.
8) Implementation of robustness test A.survey.2 depends on having the relevant environment covariates for the entire time-series of survey estimates. It should only be implemented if such covariates are available and relationships have been established. [*Advise on possible approaches to take environmental co-variates into account in estimating abundance indices*].

[5] These and following references in paragraph A.16 refer to the proposals in document MARAMIWS/DEC13/Hake/P6; some of these change in the revised list in Appendix 4.

9) Robustness test B.sel.3 should be divided into two robustness tests, one in which the scaling factor is increased and another in which it is decreased.
10) Robustness test B.SR.1 should be assigned low priority given that implementing the assessment as a random effects model is likely to be very challenging.
11) Robustness test B.SR.2 should be divided into two robustness tests, one in which the sex ratio is skewed towards females and another in which it is skewed towards males.
12) Robustness test B.others.5 should be dropped as this aspect of robustness is covered by robustness test A.length.2
13) Robustness test C.future.3 involves undetected increases in catchability at 2% per annum. Arguments were made to the Panel that this may be an unrealistically high rate of increase to postulate.
14) Add a robustness test in which catchability is decreasing at 2% per annum to reflect the possible implications of changes in fishing practices.
15) Add a robustness test in which the operating model is not fit to the annual conditional age-at-length data, but rather to the age-compositions which are obtained by multiplying the age-length keys by the length-frequencies for the years which age-length keys are available. The length-frequencies used to construct age-compositions for those years should be ignored when fitting the operating model. [*Consider whether the current approach of fitting to CAL and ALK data, rather than externally derived CAA data as previously, should be considered*]
16) Add a robustness test which involves using the movement model as the operating model.

A.17 (H) Generate future species split proportions accounting for the extent of autocorrelation about the average relative fishing mortality between the two hake species as is currently used for projections [*Review current projection approaches and handling of species split*]

Time limitations have precluded consideration of this to date.

A.18 (H) Consider developing an OMP variant in which the proportional catches of each species are compared to a "target range" and perhaps adjust TACs or bring forward the review of the OMP should the catch by species move outside of its target range. [*Advise on appropriate forms of empirical catch control rules, including capabilities to avoid response delays*]

Time limitations have precluded consideration of this to date.

B. BCC ECOFISH Program

The Panel reviewed several of the products that are currently available. The bulk of these are currently "works in progress". Notwithstanding this, the Panel was able to evaluate the extent to which these projects should contribute to the objectives of BCC ECOFISH and to management of the hake resources off Namibia and South Africa.

1. MARAM IWS/DEC13/Ecofish/BG8 summarizes geographic distributions of abundance and length frequency for 2005-13 indicated by surveys, and concluded that *M. paradoxus* moves across the South Africa – Namibia border.

2. The GeoPop approach is a highly innovate modelling framework which integrates population dynamics processes and geostatistical modelling. GeoPop has been applied to the two hake species (*M. capensis* MARAM IWS/DEC13/ Ecofish/P6; *M. paradoxus* MARAM IWS/DEC13/Ecofish/P7). The results of this approach in its current form could not be used as a stock assessment method at present, but are relevant for developing hypotheses regarding movement patterns and also for validating population dynamics models which have less spatial structure, but are developed for stock assessment purposes (e.g. MARAM IWS/DEC13/Hake/P9). The Panel identified several areas in which the current implementation of GeoPop for southern African hake could be improved: (a) estimation of additional parameters, in particular survey selectivity, (b) use of shorter time-steps than a year to account for the timing of surveys and seasonal movement, (c) presentation of model fit diagnostics, (d) accounting for differences in the ability to assign species to cohorts, and (e) accounting for fishery size selectivity and spatial variation in fishing mortality. The modelling should account for observed spatial variation in growth (see MARAM IWS/DEC13/Ecofish/P8). If GeoPop is to be developed to a stage that takes the factors raised above into account, it could be used as the basis for a transboundary operating model to test a future set of hake OMPs, including possible transboundary OMPs.
3. MARAM IWS/DEC13/Hake/P9 provides a first attempt at a stock assessment with age-dependent movement, implementing a number of the specifications recommended in the 2011 Review Panel report. The application is currently restricted to hake in South African waters, but the framework could be applied to the entire range of hake off southern Africa given detailed specifications of alternative hypotheses about stock structure. The Panel emphasizes the importance of selecting spatial strata so that availability (as distinct from gear selectivity) of fish to at least one and hopefully both the fishery and survey can reasonably be assumed to be constant within a stratum so that there is no need to allow for the possibility of dome-shaped selectivity patterns. More detailed technical comments on the method are given in recommendation A.9. [*Review progress on the development of approaches which model movement explicitly, and advise on their role in the current OMP review process*]
4. MARAM IWS/DEC13/Ecofish/P10 provides a preliminary version of a stock assessment which allows for the two hake species and inter-species predation as well as cannibalism. It combines features of previous multispecies assessment methods and the method used in recent years to assess South African hake. The current version of the model is difficult to fit because the population dynamics can be unstable given time-varying predation rates by age and species. The Panel recommends that (a) diet data used in the model be based on scaling hake prey-by-species data upwards to account for unidentified hake prey, (b) the model should examine the consequences of the timing of age-0 density-dependence relative to the timing of cannibalism and inter-species predation (i.e. whether most of the predation occurs before or after density-dependence), (c) the model should not be structured with pre-specified rations but instead the rations should be included as data in the likelihood function, (d) whether feeding relationships are different by gender and on the west and south coasts should be examined in due course, and (e) the feeding functional relationships should be parameterized so that it is possible to determine starting values for estimation of the associated parameters as reliably as possible.
5. MARAM IWS/DEC13/Ecofish/P3 provides a thorough, but primarily qualitative, evaluation of environmental hypotheses related to hake catchability. The key next step for this work is to develop a more quantitative evaluation of the effects identified; the

aim should be to determine the extent to which incorporation of estimated quantitative relationships calculating abundance indices from surveys might reduce both bias and variance. The Panel emphasizes the value of collecting environmental covariates during surveys, noting that any corrections need to be made throughout the time-series, and that the variance of the resulting survey estimates needs to reflect the uncertainty associated with the identified correction factors. MARAM IWS/DEC13/Ecofish/P3 outlines a way to expand past survey results into deeper water. The Panel cautions that while it is attractive to extrapolate survey data into unsurveyed waters, the variance associated with the extrapolation needs to be quantified and taken into account when the resulting biomass indices are used in assessments. A method needs to be developed to predict the size-composition of animals in deeper water if a survey abundance estimate incorporating extrapolation is to be included in assessments. MARAM IWS/DEC13/Ecofish/P3 recommends that survey stations for which wind speed is higher than 25 knots should be omitted from the calculation of biomass indices. This approach needs further consideration and possibly analysis before being adopted, in particular as to whether this adjustment will lead to strata without hauls and whether the requisite data are available. [*Advise on possible approaches to take environmental co-variates into account in estimating abundance indices*]

6. MARAM IWS/DEC13/Ecofish/P8 provides strong evidence that *M. capensis* in Namibia lay down multiple growth rings annually and that growth ring formation likely differs between northern and southern Namibia. This is an important result which should lead to follow-up work in Namibia on *M. paradoxus* and in South Africa on both *M. capensis* and *M. paradoxus*. The follow-up work will require additional data collection, e.g. collection of monthly otolith and length-frequency samples off South Africa, to enable marginal increment analyses to be undertaken.
7. MARAM IWS/DEC13/Ecofish/P9 summarizes current progress related to genetic analyses for southern African hake. The work is preliminary and some of the results are surprising (e.g. Φ_{ST} between Namibia and the SA west coast is higher than between Namibia and the SA south coast). The Panel cautions against drawing conclusions regarding stock structure (the number of stocks of each species present, their distribution and their relative densities in areas of overlap) until the current study is complete. The current study includes samples from throughout Namibia and South Africa, as well as temporal replication, which should add robustness to any conclusions. The Panel supports use of tools (such as Geneland) to explore the spatial structure of any identified stocks.

Overall, the work conducted to date provides substantial information on the development of stock assessment methods / models which could form the basis for OMP evaluations as well as information to parameterize those models and identify the biological hypotheses which the models should represent. The Panel recommends that the biologists and modellers (South African, Namibian and Danish) collaborate to: (a) identify alternative hypotheses regarding stock structure, (b) test those hypotheses using existing data (i.e. the tests to be undertaken as part of the genetics study should be based on the identified hypotheses to the extent possible), and (c) population models should be implemented for the hypotheses that cannot be rejected given the tests conducted, to ensure that the models used for management reflect the range of plausible stock structure hypotheses.

The collaboration recommended has taken place through two workshops held in Cape Town and one in Copenhagen during the course of 2014.

C. Surveys

E.1 (*) The Panel supports the suggestion that future South African demersal surveys be conducted exclusively using the new gear.

This will be implemented.

E.2 (H) Use the updated estimates from the new calibration analysis [MARAM IWS/DEC13/Hake/P1; Table 1], which now takes account of data from 2006 as well for both species in the reference set and OMP, replacing the *ad hoc* 0.8 factor used for *M. capensis* and the 2004 analysis' estimate for *M. paradoxus*. [*Advise of aspects of hake abundance survey strategy, particularly as regards inter-vessel calibration*]

This update has been taken into account in the current hake RS.

E.3 (H) Conduct OMP projections to assess the consequences of conducting future surveys using industry vessels. Projections should be conducted for two cases: 1) assuming a single future survey vessel and 2) assuming that the survey vessel changes each year. The projections should also consider the benefits of conducting calibration experiments in the future. These OMP projections should be tuned to achieve the same level of risk to the resource as would occur if surveys continue to be conducted using *Africana*. The cost associated with each option should be determined as the loss in catch relative to the use of *Africana*. Projections should be undertaken for the reference case trials as well as trials in which there are trends in catchability or a non-linear relationship between CPUE and abundance. [*Advise on a strategy for developing calibration factors between industry vessels and the Africana*]

These were conducted (MARAM/IWS/DEC14/Hake/BG12)

E.4 (H) The default CV for the extent of variation in catchability among vessels should be taken to be 0.2 based on an estimate for Pacific hake from an analysis of a multi-vessel survey of the US west coast (Thorson and Ward, in review). The Panel did not review Thorson and Ward (in review) in detail, but recommends that the Working Group conduct a detailed review of this paper before making final decisions. [*Advise on a strategy for developing calibration factors between industry vessels and the Africana*]

This was implemented, though modified to 0.169 following receipt of updated information.

E.5 (H) The OMP projections should allow for variation in the mean difference in catchability between *Africana* and *Andromeda* which could be informed by (i) data from Leslie on the performance of the net when towed by the two vessels and (ii) the results of the summer 2013 surveys by *Nansen* and *Andromeda*, which occurred a month apart. Account should be taken of the difference in the timing (and associated related uncertainty) between these surveys. The results of the GLM standardization of the CPUE data (specifically the month effects and their precision) could be used to quantify the latter source of uncertainty.

Given the limited time available, and because this issue was considered less important given the imminent return of Africana to survey activities, this was not pursued.

E.6 (M) Consider analyses of the calibration data to explore why the CVs for the estimates of the calibration factor (the ratio of the *Africana* catchability for the new gear relative to the old gear) increase given additional data, and examine whether length-specific calibration factors can be estimated if the calibration factor is related to length using a smooth functional form.

Time limitations have precluded consideration of this to date.