RESPONSE TO THE REVIEW PANEL REPORT FOR THE 2015 INTERNATIONAL FISHERIES STOCK ASSESSMENT WORKSHOP: PENGUINS

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

African penguins
Detection of closure effects on birds

A.1 (*) The work since the 2014 International Workshop that was reported to the 2015 event has focused on one aspect of understanding, and ideally reversing, the decline in the numbers of African penguins, namely whether pelagic fishing near islands impacts penguin population growth rate negatively. This is, however, only one aspect of the overall problem. The Panel therefore reiterates its high priority recommendation from the 2014 workshop: "Develop and implement a comprehensive research program that aims to identify the core reasons for the reduction in penguin population numbers, and identify any potential mitigation measures" in the absence of any detailed update on this in the information provided to it.

MARAM/IWS/DEC16/Peng Clos/P5 provides a summary of research in progress in response to the above.

A.2 (H) In relation to next steps for a power analysis to evaluate closure effects on penguins[1]:

Progress is reported in MARAM/IWS/DEC16/Peng Clos/P1a.

1. Analyses should be conducted for multiple effect sizes for each response variable. The models for the response variables should be designed so the values for the effects of fishing, λ (and/or δ), are such that a larger value means a greater negative impact of fishing near islands on penguin population growth rate . The lowest effect size to be evaluated (the "threshold") (e.g., 0.1 in Fig. 1) should be computed using a population dynamics model such as the simple model in MARAM/IWS/DEC15/PengD/BG4 or the penguin population dynamics developed by Robinson *et al.* (2015) given a management objective of a pre-specified change in population growth rate following elimination of fishing near islands (and assuming that fishing impacts only one population dynamics parameter).

   A threshold value to correspond to a 1% change in population growth rate was obtained in this manner for the response variable fledging success. See MARAM/IWS/DEC16/Peng Clos/P1a, especially Appendix C thereof, for further details.

2. The power analysis should be based on an evaluation of the probability that the value for the effects of fishing, λ (and/or δ), is greater than or equal to the threshold. This is not the same test as whether the value for λ (or δ) is statistically different from zero

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[1] The first three points are general and the remaining points pertain to the specific issues raised in MARAM/IWS/DEC15/PengD/P4. Points 4-22 indicate the section and topic in MARAM/IWS/DEC15/PengD/P4 where the issue concerned was raised (e.g. (**1**, Islands) indicates this relates to the "islands" section in MARAM/IWS/DEC15/PengD/P4. Also, these "next steps" apply to Daasen and Robben Islands only given that the material provided to the Panel related to these islands.

under a two-sided test. The Panel recommends that "support for the hypothesis that λ (or δ) exceeds the threshold" be defined as the probability that λ (or δ) is greater than or equal to the threshold exceeds the value P_{MIN}, i.e. $P(\lambda > \text{Threshold}) > P_{MIN}$ [2]. Full details of the power analysis and for computing the probability that λ (and/or δ) is greater than or equal to the threshold are given in Appendix A.

Done.

3. There should be a reference set of specifications for the operating models and for the estimation models (see Panel recommendations in Table 1) and an examination of robustness should be conducted (see Panel recommendations in Table 2). Final conclusions should be based on the reference set.

Done.

4. (**1**, *Response variables*) All six response variables should be assessed with respect to how reliably they are sampled and how informative they are regarding potential fishery effects on population growth rates. One of these variables (fledgling success) is directly related to the net reproduction rate, while the other five response variables are related only indirectly. It may still prove challenging to develop thresholds for the indirect response variables because it may be unclear how to quantify how changes in the variables impact biological processes and hence population growth rate (e.g. the relationship between trip duration and population growth rate). A response variable should not be considered further if there is no (objective) way to determine a threshold for it. In addition, if a particular response variable is sub-ordinate or directly correlated with another then there may be little to be gained by considering it further.

The six variables were reduced to four, although thresholds could not be determined in the manner advocated for other than fledging success (see further comments in MARAM/IWS/DEC16/Peng Clos/P1a).

5. (**1**, *Islands*) The analyses should consider both Dassen and Robben islands.

Done.

6. (**1**, *Conditioning and Estimation methods*) The primary analyses should be based on the sub-regional model (equation 1 in MARAM/IWS/DEC15/PengD/ALL1). The regional biomass model has the disadvantage that it requires that an appropriate "regional biomass" be defined. Sensitivity should be conducted to the use of the regional biomass model, but this should be a secondary priority.

Done for the primary analyses. There was insufficient time to proceed to sensitivities.

7. (**1**, *Allowance for sample size in estimator*) There is no need to account for sample size when generating data in any simulations given the low observation error relative to process error (MARAM/IWS/DEC15/PengD/P2). However, it is also reasonable to exclude data points based on very small sample sizes (perhaps < 5 points) when

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[2] P_{MIN} could be set *a priori* (e.g. to 0.5) or tuned given knowledge about estimator bias (see Appendix A).

conditioning the operating model or to estimate the sample size component of the observation error.

Small sample size years were included – see Appendix B of MARAM/IWS/DEC16/Peng Clos/P1a.

8. (**1**, *Fish species considered*) For operating models that include catches, focus should be on anchovy given it constitutes the largest fraction of the diet of penguins during the reproductive period.

Done.

9. (**1**, *Areas considered around islands to define catches*) There is no *a priori* way to eliminate any of the options for defining catches, but C_{20} and $C_{closure}$ should be sufficiently similar so only one of the two need be included in the reference case analyses. The Panel recommends that the analyses use C_{10}, C_{30} and $C_{closure}$. C_{20} could be considered in the sensitivity analyses. Options can be removed from consideration if this is agreed by the local scientists.

For reasons of time, analyses were conducted for $C_{closure}$ only.

10. (**1**, *Allocation of catches given closure to areas outside*) The two options for the spatial allocation of catches that would otherwise have been taken from a closed area which are proposed in MARAM/IWS/DEC15/PengD/P1 are extreme. The OBM should be used to compute the average proportion of the catch in the closure area that would have occurred in other areas.

This became moot given the response immediately above, though in any case it would not have been possible to use the OBM model because of the expense associated with having such work done.

11. (**1**, *Biomass series considered*) The choice of biomass series is not essential to conducting a power analysis for the proposed reference case analysis.

Noted – no response required.

12. (**1**, *Catch-biomass correlation*) The assumption *m*=0 (where *m is* the correlation between the catch in the vicinity of the islands and regional biomass) should be restricted to evaluating the potential bias of estimation methods. Continue with the current non-zero options.

Done, with only non-zero options implemented.

13. (**1**, *Autocorrelation in residuals*) The impact of autocorrelation in residuals (Equation 8 in MARAM/IWS/DEC15/PengD/P4) is likely to be inconsequential so the Panel recommends that this factor be ignored.

Consequently this was not pursued further.

14. (**1**, *Biomass and catch autocorrelation*) Temporal autocorrelation in biomass and catches is evident in the data. However, how to model this has yet to be sufficiently well developed to warrant inclusion in the reference case.

    Not included as per this recommendation.

15. (**2**, *Data to used*) Conduct the proposed standardization of individual observations to yield revised annual summary values. Use the standardized values in further analyses if only the time-series of standardized values is statistically different from that for the unstandardized (raw) values (for example if the coefficients for the covariates are statistically significant). Conditioning of the operating model should be based on the largest data set possible irrespective of whether the raw or standardized indices are used.

    Done – raw values were used as the standardised values hardly differed (see MARAM/IWS/DEC16/Peng Clos/P1a).

16. (**3**, *Conditioning issues*) For the catch+closure models, the total effect sizes should be split equally between λ and δ.

    Done.

17. (**3**, *Conditioning issues*) Set the value for σ_α as the mean of the sampling (or posterior) distribution for this value when the point estimate of σ_α is zero.

    The median of the posterior was used as this was considered more robustly estimated than the mean.

18. (**4**, *Issues related to generating pseudo-data for simulation testing*) These issues have been largely resolved so it is necessary to consider only approach A in section 4 of MARAM/IWS/DEC15/PengD/P2 in future analyses.

    Done.

19. (**5**, *Procedure for adjusting initial estimates for bias*) There is no need to adjust the effect sizes in the operating model, but candidate estimation methods could be adjusted for estimation bias (see Appendix A). Any process for adjusting for bias for an estimation method must be the same for all operating model variants.

    Done (see further details in MARAM/IWS/DEC16/Peng Clos/P1a.

20. (**6**, *Aggregating results*) See recommendation A.3 below.

    Done.

21. (**7**, *Miscellaneous*) The proposed simple estimator should continue to be explored as an alternative to GLMM estimators.

    Not pursued further for reasons of time.

22. (**7**, *Miscellaneous*) The proposed set of analyses (Table 1) allow for crossing of factors.

Noted and implemented.

A.3 (*) The Panel consider that it is ill advised to attempt to draw conclusions regarding the biological effects on penguins of fishing near islands at this stage, in particular because biologically-important thresholds for λ and δ have yet to be established and the power analysis has not yet been conducted. However, when such thresholds have been established and power analyses conducted, if such conclusions are to be drawn, the process should involve the following steps:
- Construct a table that has columns for each response variable and rows for each estimation model, with entries indicating whether the data indicate support for the hypothesis that the value for λ (or δ) is greater than the predetermined effect size.
- Eliminate columns from the table to avoid response variables that are *a priori* correlated through causation (e.g. longer trip durations may decrease fledgling success). If two response variables are thought to be correlated, keep the variable that is most directly related to penguin population growth rate.
- Explore and quantify the probability of the estimation method concluding that there is a fishery effect when the fishery effect is substantially less than the threshold.
- Use the results of the power analysis to assess whether there are values for λ (or δ) that are no longer plausible given current data (i.e., as the power to detect them, given the current stage of the experiment, is already very high).
- The value of the P_{MIN} can be adjusted so that if the estimation method is "biased" (i.e., the probability that the value for λ (or δ) is greater than the threshold differs from 0.5 when the value for λ (or δ) equals the threshold). See Appendix A for further details.

The Panel recognizes that a key difficulty in drawing conclusions regarding the biological effects of fishing near islands on penguins is how to combine the results from multiple estimation methods that only differ slightly. This can usually be achieved though model averaging methods, but there is no clear way to do that in this case. The Panel's recommended approach for the power analysis is that only four estimation models (one closure-only model and three catch-only models) are included in the reference set.

The above has largely been implemented, except that consideration of only one rather than three options for the area of catches around the islands reduced the four estimation methods to two. The results from this exercise provide the information required to implement the bullet points above.

A.4 (M) Conduct analyses where the effect sizes are zero (using simulated data only). This should provide a fuller understanding of the behaviour of the estimators (i.e., the Type I error rate). Knowing the Type I error associated with proposed estimation methods is essential to interpreting the current results as well as those of the power analysis (see the third bullet point of recommendation A.3).

Not pursued directly, but covered to some extent by computations pursued for implementing A.2 (see MARAM/IWS/DEC16/Peng Clos/P1a).

A.5 (M) Fit the operating models (not necessarily the estimation models) using Bayesian methods (perhaps using JAGS: Just Another Gibbs Sampler) assigning uninformative priors to the parameters. This will provide vectors of parameters (setting λ and δ to alternative values) for all parameters, including σ_ε. An advantage of using JAGS (or a similar method) is that it would become possible to weight each data point by its sample size when conditioning the operating model.

Not pursued directly, though MARAM/IWS/DEC16/Peng Clos/P2 made some progress towards implementation of a similar model using a Bayesian approach.

A.6 (M) Report error distributions for the estimates of the parameters related to fishery impacts and of other key parameters (such as the variance of the random effects).

Included amongst the results reported in MARAM/IWS/DEC16/Peng Clos/P1a.

Impact of closures on industry

Note: See also Appendix following

B.1 (*) The Panel considered the Opportunity Based Model (OBM) (MARAM/IWS/DEC15/PengI/P1) in terms of the whether it might substantially overestimate the proportion of the catch of anchovy and other industrial fishes that could have been caught, but would remain uncaught owing to the closure of Dassen and Robben Islands (the "unreplaceable catch"). There were aspects of the OBM, such as ignoring the impact of implausibly many vessels being assigned to the same grid, which would lead to the OBM underestimating the effects of closures, but these aspects were not examined in any detail during the workshop.

Issues that might lead to incorrect estimation of the impacts of closures on industry catches include: (a) the assumption that the catch from a grid to which a set is reassigned due to a closure (the "alternative grid") cannot exceed the actual catch for that set, (b) selecting a grid cell from the set of possible alternative grid cells with equal probability rather than accounting for factors such as expected catch and/or distance from port, and (c) selecting an alternative grid only from the first group for which there is a viable alternative grid, rather than an alternative grid from all possible alternative grids.

The Panel developed a set of alternative model runs. These model runs were not considered the most likely, but were chosen to bound the impacts of the above effects. The results of the alternative model runs (Table 3) indicated that the estimate of unreplaceable catch is strongly dependent on the assumptions. The workshop identified five model runs to further explore the sensitivity of the estimate of the unreplaceable catch to the assumptions of the OBM.

Run	7a (max of all opportunities or randomly selected)	7b (capped at actual set, or no cap or boat cap or boat x year cap)	Hierarchy (in groups or all lumped together)	Alternative opportunities. ALL = ADJ, ADJ2, OTHER, GANSBAAI, ST HELENA BAY, EXTRA	Set selection
BC	RANDOM weighted by set	BOAT X YEAR cap	IN GROUPS	ADJ, ADJ2, ST HELENA BAY, OTHER	ALL
Alt-A	RANDOM	BOAT X YEAR	LUMPED	ADJ, ADJ2, ST HELENA	ALL

	weighted by set	cap		BAY, OTHER	
Alt-B	MAX	BOAT X YEAR cap	IN GROUPS	ADJ, ADJ2, ST HELENA BAY, OTHER	ALL
Alt-C	MAX	BOAT X YEAR cap	LUMPED	ADJ, ADJ2, ST HELENA BAY, OTHER	ALL
Alt-D	RANDOM	BOAT X YEAR cap	IN GROUPS	ADJ, ADJ2, ST HELENA BAY, OTHER	ALL

The "RANDOM weighted by set" option involves identifying the sets that occurred in possible alternative grids on a given day and selecting a set at random from those sets. This option differs from "RANDOM", which involves selecting a grid at random from the possible alternative grids (ignoring the number of sets in each grid). A BOAT-X-YEAR cap was considered as part of the base-case analysis to reflect that each boat will have a limit on the size of its possible catch. The order in which groups are selected was modified from that in MARAM/IWS/DEC15/PengI/P1 to reflect industry information on search strategies.

The results suggested that the predicted proportion of the catch in closure areas that is not replaceable for BC, Alt-B and Alt-D ranged between 23% and -3%. The Panel considered the "MAX" and "RANDOM" options to be implausible, but without additional data analysis (see recommendation A.2 below) it is not possible to refine these estimates further. Removing "St Helena Bay" as an option, based on industry observations that it would be an unlikely alternative location for vessels fishing near Dassen and Robben Islands, has a marked effect on the estimated unreplaceable proportion.

During 2016 a percentile based selection procedure for alternative opportunities was implemented in which the 50%-tile corresponds to random selection. The percentage used for financial purposes was an average over percentiles 65% to 80%, and with or without the "Extra" opportunities. The estimate of the proportion of the catch in closure areas that is not replaceable calculated in this way was 17.87%.

B.2 (H) Extend the OBM so that the selection of alternative grids from the set of possible alternative grids accounts for covariates such as expected catch-rate and distance from port. The impact of each covariate on the choice of grid could be based on fitting a finite choice model to the data. The selection of to which grid to go to after fishing a particular grid on a particular day will depend on (i) where fishing occurred previously, (ii) the distance of each alternative grid from the current grid or from port, and (iii) prior information about catches and schools in the alternative grids available.

This recommendation has not been implemented, mainly due to resource limitations.

B.3 (M) Develop an approach to validate the OBM. The OBM is based on heuristics regarding how the distribution of fishing effort will change following closures, and a formal model validation (e.g., assessing how well the model is able to predict the spatial and temporal distribution of catches for years during which closures actually occurred historically) should be conducted.

The expense of pursuing this further was not considered warranted

B.4 (M) Extend the OBM to include defining alternative grids for a given day as those grids that were fished on the following day. This scenario allows consideration that a day of fishing to replace a day lost owing to a closure could occur on a subsequent day rather than be lost completely.

This recommendation has not been implemented, mainly due to resource limitations.

B.5 (M) Develop an algorithm to identify situations in which some grids have no catch, but are close to several grids with catch and set the expected catch for such grids using an interpolation algorithm (such as a spatial GAMM). At present, the model implicitly assumes that no catches could be taken from such grids because it assumes that there is sufficient fishing that all grids that could lead to catches on a day were fished at least once that day.

This has not been pursued.

Appendix

Progress with the Opportunity Based Model (OBM) following IWS 2015

Subsequent to IWS 2015 the following model specifications were agreed to:

1. Exclude the "St Helena Bay" and "Gansbaai" opportunities.
2. Use the following hierarchy of alternative opportunities: Adjacent grids, Adjacent to adjacent grids, Other Island.
3. All calculations are to be repeated with or without "Extra" fishing opportunities.
4. The amount that can be caught as a replacement is subject to a cap which is either the Boat X Year X Month maximum or the Boat X Year maximum.
5. Carry out the OBM calculations using a percentile opportunity selection approach for percentile values from 50% to 100%, in steps of 5%. 50% corresponds closely to the random selection procedure and 100% to selection of the maximum alternative opportunity. For this method first verify comparability between the random selection approach and the 50%-tile opportunity selection approach.

Additional considerations to produce a basis for a final closure cost estimate were:

1. The calculations make no provision for contra-selection of the best alternative opportunity due to crowding effects, which acts against the use of the 100%-tile.
2. It is not credible that skippers have full information to allow choice of the best opportunity, acting against the use of the 100%-tile.
3. There is no explicit provision for tallies, which operate at monthly, or shorter time frames. The Boat X Year X Month cap is viewed as a better proxy for this effect than the Boat X Year cap and was thus used.
4. The issue about "Extra" opportunities was moot and therefore average results with or without "Extra" opportunities were used.
5. Given lack of an informed basis for the appropriate selection percentile between 50% and 100%, an average over the range 65% to 80% was taken.

The average value calculated this way was 17.87%. That is the percentage of the catch that occurs in the penguin closure area which cannot be replaced by an alternative opportunity. A final comprehensive report containing the costs estimates in financial terms has been submitted to the PWG.