

**PROGRESS IN RELATION TO PENGUIN RECOMMENDATIONS BY THE  
INTERNATIONAL REVIEW PANEL FOR THE 2014  
INTERNATIONAL FISHERIES STOCK ASSESSMENT WORKSHOP  
1 – 5 December 2014, UCT**

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**Note:** The Panel comments and recommendations are replicated below. Responses by the authors' regarding these are shown in *red italics*.

*The background documents for the workshop (MARAM/IWS/DEC15/PengD/BG1-4) include the series of submissions to the DAFF Pelagic Working Group in relation to the Panel report. However following a meeting held on 27 July (MARAM/IWS/DEC2015/PengD/BG6) further work was conducted under the auspices of a technical Task Team, whose analyses are reported in MARAM/IWS/DEC15/PengD/P1-P4 and summarised in MARAM/IWS/DEC15/PengD/P5.*

**Summary of general issues**

*Penguins*

The Panel recognized that the issue surrounding penguins and small pelagic species is effectively one of multiple, competing objectives. As such, ultimately the key issue for the topic is an evaluation of trade-offs among different objectives. In this context, the Panel notes that both globally, and locally in South Africa, ecosystem considerations have emerged as an important management issue for fisheries. Nevertheless, there remains a conflict between the local scientific communities that primarily focus on ecosystem modelling and on fish stock assessment, which needs to be resolved. Both science and management advice would benefit from closer collaboration between these communities.

The Panel recognized that the two groups ('A' and 'B') had evaluated different sets of questions. Specifically, the 'B' group focused primarily on the estimation of residual variance using the results of the Island Closure Feasibility Study and the impacts of catches on penguin biological parameters, while the 'A' group focused on the impact of closures on penguin biological parameters. The Panel noted that greater clarity on the objectives of the work might have been able to reduce some of the disagreements on methodology and results that were apparent.

The Panel clarified that the fundamental question is whether small pelagic fisheries removal/catch of targeted fishes near islands can impact severely declining penguin populations. This question was phrased as: Can the Island Closure Feasibility Study elucidate whether an experimental closure programme could yield definitive conclusions regarding the impact on penguin populations, where fishing occurred in close vicinity to penguin breeding islands. The Panel notes that these differences in the question being addressed by both groups in some ways reflect the differences in disciplinary perspectives. These different perspectives could ultimately be a strength in approaching this issue if managed well.

*Note that the meeting on 27 July agreed that the key question to be answered by the study was: "What is the current impact of fishing in the vicinity of penguin breeding colonies on penguin populations? For practical purposes the initial focus of analyses of the island closures experiment will be on the agreed islands."*

The Panel notes that both groups report inconsistent findings regarding the impact of closures / reduced catches. Thus, some effects of closures have been detected, even if found to be marginally significant, with some highly significant results. The challenge is these detected effects can be in either the "positive" or "negative" direction (see Table 1). This is most apparent across groups, but also even within a group with respect to penguin responses at a given island. These inconsistencies must be considered when interpreting the results from either set of analyses, as well as the observation that the two groups answered different questions. One plausible explanation is that there is at least one factor which drives penguin dynamics that has not been included in any of the models, but which is confounded with the closure periods. This can easily happen because there have only been few closures over a short time period. Alternatively, effects could be occurring, but are not fully detected due to insufficient data or a change in how catches were reported with respect to catches in the area of closure.

One important element of information that emerged from the Panel review was an evaluation of catches and penguin foraging distance/path length relative to area closed. The vast majority of penguins forage inside the 20km closure during the chick rearing phase. This was robust whether or not an island closure was in effect.

*Note that in workshop documents this 20 km closure radius is referenced as 18 km. The formal designated closed areas have radii of 20 km, but for catch calculation purposes, given inaccuracies of position records, a distance of 18 km was used to define the closed region.*

Effects that are statistically significant are not necessarily biologically important. Nevertheless, given the literature, it is not surprising to find some statistically significant results indicating a positive effect of reduced fishing on penguins (Furness and Tasker, 2000; Witherall *et al.*, 2000; Daunt *et al.*, 2008; Frederiksen *et al.*, 2008; ICES, 2014); in contrast, the inference that increased fishing improves penguin population status seems unlikely given the literature. However, the key challenge remains to estimate the relative magnitude of any such effects and how they impact both the penguin population (compared to other pressures) and the fishery (compared to total landings).

Despite the differences, the Panel notes that there were areas of agreement between both groups. Examples include positive effects on penguins of reduced catches / closures at St. Croix, the general recognition of the importance of foraging path length and fledging success, that multiple factors can effect penguin dynamics, that catch is not a direct measure of biomass, and that cessation of fishing around the islands by itself is unlikely to be sufficient for the penguin population to recover. Of primary note and most importantly, both groups agreed that the feasibility study was successfully conducted (even if for different reasons). The Panel concurs.

## **African penguins**

### **Background**

Any evaluation of the impact of catches or closures on penguin biological parameters needs to be placed in the context of all of the impacts that might be hindering recovery of the island penguin populations. The Panel notes that projections conducted by both groups (although evaluating somewhat different questions) suggested that eliminating pelagic catches / implementing long-term closures around islands by itself cannot be expected to lead to recovery of penguin populations (MARAM/IWS/DEC14/Peng/A11, MARAM/IWS/DEC14/Peng/3a, Weller *et al.* 2014), although there are some predicted benefits. Further, the Panel notes that fishing is a factor that can be controlled and reductions in fisheries (via closures) have had positive effects in other places around the world in similar

situations (Furness and Tasker, 2000; Witherall *et al.*, 2000; Daunt *et al.*, 2008; Frederiksen *et al.*, 2008; ICES, 2014). What also merits consideration is why the mainland Stony Point population of the same penguins exhibits different population trajectories than the island populations. Additionally, the Panel notes that the island closures will not only affect penguins and small pelagic fishes, but also potentially many other species, either directly or indirectly. The consequences of these effects merit consideration.

As such, and in the context of multiple objectives, the Panel recommends that the appropriate authorities (DEA and DAFF) work together to identify goals for both the pelagic fishery and penguin recovery, to 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. Fishery impacts on prey should be one important component of this program, but there will likely be other components, as identified, for example, by the penguin pressure model (Weller *et al.*, 2014).

The Panel was presented with an on-going debate on whether to use a simple factor of closed/open or catch-in-area as the explanatory variable. In a general regression setting, **if** the explanatory variable is an actual control variable, which can be pre-set to specific values, and **if** the response is a linear function of the control variable, then it is common statistical design to pre-set the control variable at several values, dispersed over a range of levels, not just 0 and 1. On the other hand, this explanatory variable is **not** a control variable in the present setting, since it depends on the behaviour of the fleet, which again depends on the behaviour of the resource as well as on economic aspects. In addition, because catches are correlated to (though not a proxy for) biomass to some extent, there is a serious risk that coefficients may change sign, in which case a regression of a penguin demographic variable on catch may reflect a relationship with biomass and not the true control variable which is whether the area is closed or not. Thus, although a regression using catches may have greater power than an ANOVA using a closure factor, there are several problems with the approach, and interpretation needs to take this into account. The use of a local biomass estimates may alleviate some of these issues, but then one will need to take into account the large(r) measurement uncertainty. These issues are serious, and can be avoided if a simple ANOVA-type model is used, but at the likely cost of a loss in power.

*Comparative results where one of the models used was especially simple are reported in section 9 of MARAM/IWS/DEC15/PengD/P2.*

### **Responses to Terms of Reference**

The initial Terms of Reference for this component of the review provided to the Panel (MARAM/IWS/DEC14/Peng/C2) were:

- a) What scientific conclusions can be drawn from the present island closure and related analyses regarding the benefits or otherwise of closures to penguin recovery?
- b) What further analyses of available information could help resolve uncertainties about the conclusions?
- c) What would be the benefits to formulating scientific advice of continuing the closures taking into account limited further resources that DAFF could commit to further monitoring and analysis?

Immediately before the workshop, Dr. Kim Prochazka proposed a change to these Terms of Reference to the Panel. The Panel requested that the proposed changed Terms of Reference be further clarified to be more precise and hence allow it to respond appropriately. This new set of Terms of Reference (Figure 1) was a hierarchical tree, depending upon evaluation of sequential issues to better focus the Panel's review and ability to provide usable advice. This

new set of Terms of Reference was also compatible with the original Terms of Reference, and was simply aimed to clarify and specify them. In this report, the Panel has considered both the initial Terms of Reference and the Terms of Reference in Figure 1.

**1. Can the Island Closure Feasibility Study tell us whether an experimental closure programme could yield definitive conclusions regarding the impact of fishing close to penguin breeding islands on penguin populations?**

The Panel requested each group to comment on whether they believed that the feasibility study had been successfully completed. Both groups replied in the affirmative. The Panel also **agrees** that the feasibility study has been completed successfully (but see 8 below). The Panel **concludes** that an experimental closure programme could yield definitive conclusions regarding the impact of fishing close to penguin breeding islands on penguin populations. Consequently, the Panel reports on questions 5 – 8 in Figure 1.

**5. [if yes to question 1] Can it [the Island Closure Feasibility Study] be used to draw conclusions re responses of penguin populations?**

Both groups have found that statistical tests for the impact of fishing on biological parameters of penguin populations led to significant results (Table 1). However, these statistically significant results were often in different directions. In some cases the results were conflicting across islands for the same response metric, even within each group's analysis (e.g. the impact of closures on chick condition and trip duration [group A]). The lack of consistency between and within groups may be because there are factors other than those considered to date that impact biological parameters for penguins. The Panel therefore **concludes** that it is premature to draw final conclusions.

*A more detailed version of the comparisons of Table 1 is presented in MARAM/IWS/DEC15/PengD/BG3.*

**6. If no [to question 5], what closure regime, data and analyses will assist in moving towards a conclusion?**

The Panel **recommends** that the most effective way to address the impact of fishing near islands on penguin populations is to conduct a full scale experiment. Any experiment should be preceded by the development of an experimental design using an appropriate power analysis. The Panel **strongly recommends** that the current closure regime be continued if an experiment is conducted. The exact number of years needed to achieve a given outcome, in terms of the effect of fishing on penguin demographics, will depend on a power analysis accepted by DAFF under a process specified by their Director Research, which is not available at this time. If a full experiment is to commence, there will be a considerable gain in ensuring that it forms a natural continuation of the feasibility study. Unless a clear improvement to the current design is found, the Panel **recommends** that the design in the feasibility study (Table 2) continue to be used in the interim period until a design is finalised. The Panel provides additional recommendations below regarding the design of a full experiment.

*The current closure regime was continued for 2015.*

**7. If yes [to question 5], what conclusions can be drawn from the existing data and analyses regarding the penguin response, and what additional analyses can help in determining the penguin response?\***

N/A.

**8. If yes [to question 1], is it advisable to proceed to a full-scale experiment?**

The Panel **concludes** that sufficient data are available to conduct a scientifically appropriate power analysis to evaluate how long an experiment might have to be conducted for. The Panel notes that while a full-scale experiment is likely to lead to a conclusive outcome in the medium term, the design of such an experiment would need to be fully evaluated using an appropriate power analysis to determine the level of impact that has high probability of being detected within a specific timeframe. Issues that need to be considered when conducting a power analysis, and ultimately an experiment include:

1. a range of effect sizes based on the impact on the dynamics (recovery) of the penguin population;
2. the observed residual patterns (some of the fits in MARAM/IWS/DEC14/Peng/B16 exhibit substantial serial correlation which needs to be reflected in the power calculations);

*This is addressed in MARAM/IWS/DEC15/PengD/BG2 to coarsely estimate the extent of autocorrelation in residuals, with the implications of taking those into account addressed initially in MARAM/IWS/DEC15/PengD/P2, section 8*

3. the foraging range of African penguins and the potential overlaps of that foraging range with fishing effort;
4. use of the specific location (latitude/longitude) of catches in analyses of impact, rather than 10 n.mile catch reporting blocks;

*Note the introduction of  $C_{closure}$  in MARAM/IWS/DEC15/PengD/P1 in response to this.*

5. the methods, collection and recording of appropriate response variables and covariates be specified to reduce conflict with post-experiment analyses; and
6. consideration be given to how the experiment be designed such that data from the feasibility study can usefully be incorporated into any final analyses.

In relation to the initial Terms of Reference:

- *What scientific conclusions can be drawn from the present island closure and related analyses regarding the benefits or otherwise of closures to penguin recovery?*

There is sufficient information to evaluate the feasibility of an experimental study to elucidate effects. The Panel **concludes** that detection of effects is feasible, and suspects they may be directional. However, available data do not allow firm conclusions regarding the effects on penguin populations to be drawn at present. The Panel **encourages** both groups to more broadly consider the literature from related situations to better constrain the biological plausibility of analyses and interpretation of results.

- *What further analyses of available information could help resolve uncertainties about the conclusions?*

See response to new Terms of Reference 6 and 8 above.

- *What would be the benefits to formulating scientific advice of continuing the closures taking into account limited further resources that DAFF could commit to further monitoring and analysis?*

Conducting an experiment will allow DAFF to make informed decisions regarding the impact of fishing near islands on penguin populations even given that there are multiple conflicting objectives. The Panel does not presume to develop future

experimental designs, cognizant of the limited resources, but would prioritize development of a suitable design and a suitable process to both inform and make decisions related to this issue. Relevant research recommendations, prioritized taking account of whether they are critical for decision making immediately and to some extent cost, are given below.

### **Other Considerations**

The Panel's deliberations concern only the scientific aspects of the impacts of catches/closures. The Panel recognizes that the ultimate decision on whether to continue or terminate the island closures has a large policy component, including aspects related to the costs of the closures to the industry, and the benefits of closures to penguin populations. The Panel did not attempt to weigh these societal costs and benefits, and instead focused on whether the experiment could provide sufficient information for others to make informed decisions given these inherent trade-offs.

*A study has been conducted to ascertain costs to the industry of island closures. The Panel is being asked to comment on a key component of that analysis (MARAM/IWS/DEC15/PengI/P1).*

Nevertheless, although the Panel is cognizant of not proceeding beyond scientific merits of the work conducted, it also understands the need to directly address the trade-offs across differing mandates. The Panel understands there are mandates to sustainably manage fish and conserve threatened species. In that context, the Panel notes that decision making could be improved with the following additional scientific analyses:

- an economic evaluation of the catch of sardines and anchovies relative to the closures, and of economics of tourism to the islands.
- development of a multi-criteria decision analysis (MCDA; e.g. Linkov and Moberg 2012) support tool. The MCDA approach, or similar forms of risk analysis, would provide benefits beyond the purely statistical/experimental approach adopted to date, would certainly use the information from such experiments, and importantly would establish a transparent process by which decisions could be jointly explored.
- development of additional, data-driven, approaches (besides the largely modelling-emphasized efforts to date) that better: elucidate penguin population responses to island closures; explore responses to other, multiple threats impacting penguins; and examine a range of possible management interventions.

### **Research recommendations**

A.1 (H) MARAM/IWS/DEC14/Peng/A10 provides an analysis indicating that the application of fixed effects GLM-type models (such as those in MARAM/IWS/DEC14/Peng/B12) to a system in which both local biomass and catch can impact penguin populations will lead to biased outcomes. The Panel notes that the model on which MARAM/IWS/DEC14/Peng/A10 is based does not match exactly the error structure on which the analyses of MARAM/IWS/DEC14/Peng/B12 are based. In addition, some of the analyses in MARAM/IWS/DEC14/Peng/B12 are based on a random effects and not a fixed effects structure. It might be possible to evaluate potential biases for models such as those in MARAM/IWS/DEC14/Peng/B12 using analytical methods. However, a simpler way to examine this issue would be through simulations; and the Panel recommends that simulations to evaluate bias in estimation methods be explored, which are conditional of the types of scenarios reflected in MARAM/IWS/DEC14/Peng/A10.

*MARAM/IWS/DEC15/PengD/P1 sets out the framework for a simulation evaluation of this bias, and some related results are reported in MARAM/IWS/DEC15/PengD/P2.*

A.2 (H) Various elaborate models have been applied to test the effect of fishing on penguin demographics. More elementary analyses directly aimed at evaluating the questions and statistical power should be applied because with this sole focus on highly parameterized statistical and analytical methods, the proverbial “missing the forest because of the trees” remains an important risk. Consider ANOVA-type models such as those provided to the Panel but make the fishing/closure effect parameter independent of island. More details (factor levels and new explanatory variables) may well be needed, but this is the type of model that the Panel would have liked to have seen as the initial test of the effect of fishing / closure. Notably there is no issue with multiple testing since the rudimentary model only contains a single parameter describing the effect of the closure on the demographic parameter.

This simple ANOVA/ANCOVA model can then be expanded in a number of directions, towards MANOVA/MANCOVA models or other, more detailed, response-pressure multivariate models for a single response. Finally, simple summarizations of the results would be beneficial to avoid obfuscating main results.

*Comparative results where one of the models used was especially simple are reported in section 9 of MARAM/IWS/DEC15/PengD/P2. [More broadly speaking though, the full series of MARAM/IWS/DEC15/P1-5 address both this and the preceding recommendation.]*

*Some information relating to responses to the recommendations following may be found in MARAM/IWS/DEC15/BG6.*

A.3 (H) Explore whether existing parameter estimates can be used to determine an upper limit on the rate of rebuilding that is likely to result from island closures and should be of value in making a decision on whether to proceed to an experiment. Some initial analyses along these lines are available in Appendix B of MARAM/IWS/DEC14/Peng/B4.

A.4 (H) 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.

A.5 (M) Consider the suggestions noted in the “Other Considerations” section above to better facilitate decision making.

A.6 (M) As future data are collected, models (such as GAMs or GAMMs) which allow for non-linear relationships between penguin biological parameters and covariates should be applied. Furthermore, using a similar parsimonious approach via non-parametric models might also elucidate key responses without the plethora of assumptions needed.

A.7 (M) Develop improved methods for obtaining precise estimates of the local biomass of small pelagic species. This may not be practical given limited resources.

A.8 (L) Explore, using MSE, a range of strategies for managing the impact of pelagic fishing near islands on which declining penguin populations are found. This could involve assessing the biomass near each island relative to penguin foraging needs (*sensu* thresholds noted in the

literature) and reducing or eliminating fishing, depending on whether the needs of penguins will be satisfied. Implementation of this recommendation is likely to require the availability of methods to estimate local at-sea density of penguins near islands with much higher precision than is possible now.

*Table 1.* Penguin response to closure from consideration of data from the period from 2008 onwards by Group A, and to reduction of catches from consideration of data for all years from Group B. Results shown are self-reported by the two groups. Symbols refer to the effect on penguins, rather than the effect directly on the trait measured.

	Group A				Group B			
	Dassen	Robben	Bird	St Croix	Dassen	Robben	Bird	St Croix
Chick condition	-	+*	+	-*	-	0		
Chick growth	+	+	+	-	-	-*		
trip duration	-*	+	+*	+	-*	-	0	+
Foraging path length	-	+	+	+*	-	-	-	+*
Maximum foraging distance	+	+	+*	+				
Active nest proportion					-*	-*		
Fledging success		+*			-	+*		

0 = none or indeterminate; - = negative; + = positive; -\* = significantly negative; +\* = significantly positive

