A COMPOSITE PROPOSAL RELATED TO THE PENGUIN COLONY CLOSURE PROGRAMME

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Summary

Proposals are made in the light of the results of analyses conducted regarding future field and modelling research and action to be taken on island closures. The island closure feasibility study should be concluded as adequate estimates of residual variance to enable power analyses to be conducted have been obtained for all four islands. Dassen and Robben Islands should be open to fishing, but for 2015 St Croix should be closed and Bird Island open, with a further review of this situation a year hence. Future field research, including possibly small scale surveys, should focus on St Croix Island.

Based on the analyses presented in the other documents in the MARAM/IWS/DEC14/Peng/B series on penguin modelling, in particular in relation to area closures around islands, I would offer the following composite proposal for the next steps in relation to closures, research priorities, and modelling requirements.

PROPOSAL

A: Dassen and Robben Islands

1) The feasibility study should be concluded at this time.

2) Closures around both islands should be brought to an end at this time.

3) The hydroacoustic surveys of small pelagic fish in the near vicinities of these two islands should end.

4) Monitoring of measures related to penguin reproductive success should continue at these islands, with priority being given to those measures for which the feasibility study has indicated the greatest power to provide statistically significant results in the near future.

5) The situation should be kept under review, allowing *inter alia* for the possible resumption of a closure programme should future evidence indicate that this would benefit penguins to a meaningful extent.

B: St Croix and Bird Islands

1) The feasibility study should be concluded at this time.

2) At present the regions off St Croix are open and off Bird Island closed for 2014. This situation should be reversed from 2015.

3) Resources currently used for surveys of fish in the near vicinities of Dassen and Robben Islands (if remaining available) should immediately be focussed instead on St Croix and possibly also Bird Island, provided first that an analysis of existing surveys shows that there is the potential to provide useful results on local abundance.

4) The situation should be kept under review, with possible revisions for 2016 and beyond to be considered before the end of 2015.

C: Minimum requirements for modelling studies to provide a basis for future tactical advice on closures

1) Models must exhibit reasonable fits to available data.

2) Models must be able to reflect the full range of hypotheses under consideration.

3) Models may not be based on the assumption that the annual catch of a small pelagic species provides an index of its abundance

MOTIVATIONS

A: Dassen and Robben Islands

The feasibility study should be concluded at this time

The purpose of the feasibility study has been to estimate the residual variances associated with penguin response variables with sufficient precision that experimental power can be determined with adequate reliability. This is to be able to decide on whether an experimental closure programme could yield definitive conclusions regarding the impact of fishing close to island colonies on penguin demographics within a realistic time span (which would realistically be considered to be within one or possibly two decades).

The results in MARAM/IWS/DEC14/Peng/B4 indicate that such a determination is now possible for Dassen and Robben Islands.

The PWG's 2010 recommendations concerning extension of the feasibility study envisaged its continuation until the end of 2014, but included the statement:

> "The feasibility study may be terminated before the end of 2014 should the data allow sufficiently precise estimation of variance parameters to allow the power of a possible subsequent closure experiment to be reasonably estimated before then."

Given that this requirement of adequate precision has been achieved, it accordingly follows that the feasibility study can now be deemed concluded and consideration given to whether an island closure experiment be commenced for these two islands (and discussed further below).

Closures around either island should be brought to an end at this time

The purpose of an island closure experiment is to determine whether and to what extent suspension of pelagic fishing in the neighbourhood of penguin breeding colonies might impact penguin dynamics. The monitoring indices to be considered for this purpose are as specified in Coetzee (2014). The GLM method of analysis to be used was endorsed by the International Review Panel for the 2010 International Fisheries Stock Assessment Workshop (Parma *et al*., 2010). The results are reported in MARAM/IWS/DEC14/Peng/B4.

These results (see Tables 2 and 3 of MARAM/IWS/DEC14/Peng/B4) indicate that for 414 GLMs conducted across six penguin response variables, of those which already give results which are significant at the 5% level, 59 indicate the effects of fishing on penguin reproductive success to be positive and only 12 indicate it to be negative. Overall some 80% of the GLMs indicate positive (though not always statistically significant) effects. The proportion of statistically significant results is overstated somewhat because the Bonferroni correction associated with multiple tests has not been effected, and the tests themselves are not independent because of the use of common or positively correlated data. Nevertheless overall these indications are sufficiently strong to conclude at this time from these results that in terms of the feasibility study alone together with the pre-agreed (at the 2010 International Workshop) analysis method, closure of the neighbourhoods around these two islands to pelagic fishing is very unlikely to benefit penguin reproduction (indeed at face value these results suggest that such closures may even disadvantage such reproduction).

From this it follows that there is no need to continue with a closure experiment at these two islands, and both islands should be immediately opened to pelagic fishing.

Supporting evidence

Supporting evidence for this conclusion, and rationale for the associated action, are provided by three other sources.

a) The penguin-fish interaction model for Robben Island developed by Robinson (2013 – see Fig. 4.8 thereof, reproduced as Figure 8 of MARAM/IWS/DEC14/Peng/3a - shows effectively no dependence of reproductive success on the magnitude of anchovy recruitment. This result is perhaps of even greater importance than those above which relate only to components of the reproduction process, as there may be negative correlations amongst measured and unmeasured components of that process (see Appendix A of MARAM/IWS/DEC14/Peng/4), whereas Robinson's model of the dynamics provides results for the overall net effect on the laying-to-end-of-first-year-survival process independent of these concerns.

b) The "river" model of anchovy recruitment (see MARAM/IWS/DEC14/Peng/B5) indicates that fishing since 2000 decreased the density of anchovy that would otherwise have been available to the penguins at Robben Island by the extent of typically about 5% and occasionally at most some 25%, so that any related negative impact on penguins would be expected to be small at most.

c) Results in MARAM/IWS/DEC14/Peng/B4 (see Tables 4 and 6) indicate that even if the closure program stops, the data contrasts in forthcoming years would be sufficient that achievement of statistical significance at the 5% level for results from certain

monitoring indices regarding the impact of fishing on penguins would likely be delayed by only typically about two years.

The hydroacoustic surveys of small pelagic fish in the near vicinities of these islands should end

The results reported in MARAM/IWS/DEC14/Peng/B5 indicate that associated process error is too large for useful results on local abundance of anchovy around these islands to be obtained given what are realistic frequencies to attempt surveys through the season.

The proposal for an immediate cessation also factors in resource limitations and priority considerations. As discussed below, St Croix island is seen as the highest priority for any surveys of this nature which available resources might admit.

Monitoring of measures related to penguin reproductive success should continue at these islands, with priority being given to those measures for which the feasibility study has indicated the greatest power to provide statistically significant results in the near future

For the reasons given immediately below, some monitoring of penguin indices related to reproduction should continue at the two islands. There is though a core consideration of efficiency, given resource limitations which might render continuation of all existing monitoring series not possible. In such circumstances prioritisation will be needed, and results from the power analysis in MARAM/IWS/DEC14/Peng/B4 would seem the most obvious and appropriate primary basis to assign such priorities. Results in Table 4 and 6 of that paper suggest that the least useful response variables to continue monitoring would be chick condition, and then active nest proportion.

The situation should be kept under review, allowing *inter alia* for the possible resumption of a closure programme should future evidence indicate that this would benefit penguins to a meaningful extent

Although considered in their totality, the results from the feasibility study point clearly towards a conclusion of little if any benefit for penguin reproductive success arising from pelagic fishing closures around islands, one cannot exclude the possibility (though currently slight) that further results might provide a basis to reverse this inference. Thus at least some monitoring series should continue, with their results regularly reviewed.

In this context one again notes the results in Tables 4 and 6 of MARAM/IWS/DEC14/Peng/B4 which indicate that even if the closure program stops, the data contrasts in forthcoming years would be sufficient that achievement of statistical significance at the 5% level for results from certain monitoring indices regarding the impact of fishing on penguins would likely be delayed by typically only about two years.

B: St Croix and Bird Islands

The feasibility study should be concluded at this time

The results in MARAM/IWS/DEC14/Peng/B3 indicate that as for Robben and Dassen Islands, residual variances associated with available penguin response variables can now be estimated with sufficient precision that experimental power can be determined with adequate reliability for St Croix and Bird Islands.

Given that this requirement of adequate precision has been achieved, it accordingly follows that the feasibility study can now be deemed concluded and consideration given to whether an island closure experiment be commenced for these two islands.

At present the regions off St Croix are open and off Bird Island closed for 2014. This situation should be reversed from 2015

In contrast to the GLM results for Dassen and Robben Islands in Tables 2 and 3 of MARAM/IWS/DEC14/Peng/B4, those for St Croix suggest negative impacts (though not significantly so) of fishing around the colony for 23 out of the 24 scenarios examined. In contrast, 22 of the 24 estimates for Bird Island are positive.

These results suggest that possible benefits to penguin reproductive success from any closures around these Eastern Cape islands are more likely to result from closures around St Croix than around Bird Island.

Resources currently used for surveys of fish in the near vicinities of Dassen and Robben Islands should immediately be focussed instead on St Croix and possibly also Bird Island, provided first that an analysis of existing surveys shows that there is the potential to provide useful results on local abundance

Despite the statistical evidence cited above, it remains mysterious that the fish catches made near St Croix island are almost entirely of sardine (an average of 95% over the last five years), whereas the penguin diet reportedly consists almost entirely of anchovy (97%). The explanation offered by Pichegru *et al.* (2014) that adult penguins first eat sardine to sustain themselves, and then target anchovy to feed their chicks, is hardly convincing *a priori*.

For this reason, it seems that St Croix island should be the priority choice for attempts to advance understanding of the penguin-pelagic fishing interaction, and accordingly any resources available for small scale pelagic fish surveys around islands with penguin colonies should first be targeted at St Croix, provided first an analysis of existing surveys shows that there is the potential to provide useful results in this context.

The situation should be kept under review, with possible revisions for 2016 and beyond to be considered before the end of 2015.

The paragraphs immediately preceding evidence that there is not as yet a very clear understanding of the penguin-pelagic fishery interaction at St Croix Island. Furthermore the analyses in MARAM/IWS/DEC14/Peng/B3 suggest that the extent of any negative impact on penguin reproductive success of fishing around St Croix at typical recent catch levels is not high, and for this reason a biologically meaningful effect seems unlikely to be confirmed as statistically significant in the foreseeable future. Thus while precautionary considerations might justify closure around St Croix for the moment, it would be inappropriate to make decisions on closure programs for the longer term immediately, but rather the situation should be kept under review, with subsequent decisions informed by the results of further scientific studies at St Croix (and perhaps Bird) islands and their vicinities. These should in particular focus on attempting to quantify the magnitude, rather than only the direction, of any negative impact of current fishing levels on penguin net reproductive success at St Croix island.

C: Minimum requirements for modelling studies to provide a basis for future tactical advice on closures

Models must exhibit reasonable fits to available data

Models which fail to fit reasonably to data describing the dynamics of the resources under consideration cannot be considered to provide plausible representations of those dynamics, and therefore cannot be used as a basis to make the specific predictions of responses to potential management actions that are required as a scientific basis for management recommendations at a tactical level. (See MARAM/IWS/DEC14/Peng/B7 for further comments on this matter.)

Models must be able to reflect the full range of hypotheses under consideration

Any model to be used to potentially discriminate amongst differing hypotheses on the basis of data must have sufficient structural flexibility to accommodate the full range of these hypotheses. Otherwise it potentially eliminates certain otherwise plausible hypotheses on the basis of construction rather than evidence from data. (See MARAM/IWS/DEC14/Peng/B7 for further comments on this matter.)

Models may not be based on the assumption that the annual catch of a small pelagic species provides an index of its abundance

Both from many previous studies and from specific evidence for the SA anchovy resource on the SA west coast, there is no basis to support such an assumption. (See MARAM/IWS/DEC14/Peng/B7, B9 and B10 for further comments on this matter.)

REFERENCES

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