A proposal for a basis to consider future island closures, taking account especially of the current results from the island closure experiment

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Summary

This document provides proposals for a basis to consider future island closures, first taking account of the results to date for estimates of the impact of closure parameter δ from the island closure experiment obtained using the 2016 Panel algorithm. A pragmatic approach is adopted, given difficulties arising from outstanding matters of interpretation of the input data, which require further discussion. In essence, based only on the indications (which currently remain unclear) of whether or not biologically meaningful effects of closure on the penguin populations concerned have been demonstrated, suggestions are made to open Dassen island, to increase the relative frequency of closures at Robben island, and to maintain the current experimental closure schedule at St Croix and Bird islands with a possible increase in closure frequency at the former and decrease at the latter. In this situation, with important aspects of uncertainty still remaining concerning whether and to what extent closures might benefit penguins, final decisions will need to be based on trade-offs. These need to be quantified to the extent possible; they relate to the potential benefits to the penguins and the losses to the fishing industry in terms of financial returns and employment under different future closure proposals. The PWG will need to provide a summary of those benefits and losses, and some suggestions are made in that regard. Furthermore, continuation of the experiment in some form so as to better estimate closure impact parameter values obviously requires continuation of monitoring of at least some of the penguin response variables considered to date at all four islands; hence, plans to do so need to be confirmed.

On the biological basis for a proposal

The rationale that follows is based primarily on the results from the most recent application of the estimation model component of the algorithm recommended by the Panel for the 2016 International Stock Assessment Workshop, developed in collaboration with and endorsed by subsequent IWS Panels, to data obtained from the island closure experiment. For the island closure effect parameter δ, these results are reported in FISHERIES/2020/JAN/SWG-PEL/09rev for Dassen and Robben islands and, based on the same default model, for St Croix and Bird islands in MARAM/IWS/2019/PENG/P2 and FISHERIES/2019/NOV/SWG-PEL/33 (see Figure 1). These applications utilise the most recent data made available to DEFF at the time of those analyses, under pre-agreed procedures. In terms of this algorithm, annually aggregated data are input to these analyses. This document does not consider other estimates of δ based on models using individual-penguin-data-based estimates. This follows a mathematical-statistical demonstration (see the Annex of FISHERIES/2020/AUG/SWG-PEL/82) that such estimates are unreliable, together with the current absence of any mathematical response to falsify that demonstration, as would be a scientifically required pre-requisite for their further consideration.

In principle, given the agreed decision criterion offered earlier by the Panel, the basis to interpret the results from the application of the 2016 Panel algorithm to the island closure experiment results in terms of whether they demonstrate a biologically meaningful effect of closure on the penguin population growth rate should be straightforward: in simple terms, check for point estimates of the closure impact parameter δ amongst the response variables (only those which are able to be linked directly to penguin demographics) that are less than -0.1.

Only two variables (see also Figure 1) meet this criterion – chick survival and fledging success (though these are available for Robben and Dassen islands only). Dassen meets the criterion for chick survival

and Robben for fledging success (and is close to doing so for chick survival). However, as discussed in FISHERIES/2020/JAN/SWG- PEL/96rev, this inference is confounded by two other aspects related to these data. The first is a reverse result for δ for fledging success at Dassen island which is (in simple terms) in the opposite direction and is nearly statistically significantly different at the 10% level from that for the chick survival. The second concerns certain unexpected features of the survival data analyses which indicate a need for these first to be more closely examined before they might be used with confidence as a basis from which to draw such inferences. Specifically, these relate to the substantial increase (which is indicated to be relatively precisely estimated) in the estimated survival at for Robben island (but not Dassen island) by the Kaplan-Meier method after some 50 days of exposure (FISHERIES/2020/JUL/SWG- PEL/53REV); this aspect of these results first needs to be explained, so as to be clear on whether or not its source results in confounding of estimates of cumulative chick survival.

Considering the results for Robben and Dassen islands in Figure 1 as a whole, two major features are evident:

a) the generally wide confidence intervals; but nevertheless
b) a clear pattern of estimates of a positive impact (if any) from closure being for the most part notably less for Dassen than for Robben island.

Addressing next the situation for the Eastern Cape colonies – St Croix and Bird islands – is the more difficult because of the availability of results for fewer response variables. These are available for chick condition and foraging data only, and are subject to various reservations:

a) the estimates based on chick condition are very imprecise;
b) the three different measures (length, duration and max length) for foraging data are not independent;
c) for max length, if the assumption of proportionality of the extent of change in this response variable to any related change in penguin population growth rate is justified, the < -0.1 criterion for a meaningful impact is well met for St Croix; but the maximum length measure is of questionable reliability *inter alia* because it does not, by its nature, provide a robust statistic; and
d) while viewed overall these foraging data statistics suggest that a positive effect from closure is more likely than a negative one for St Croix and Bird islands, the reverse holds for Robben and Dassen islands; this raises the more general question of whether these particular response variables do actually provide a reliable indication of the direction, let alone the magnitude, of any such impact.

A summary proposal based only on biological considerations

The difficulties in interpretation noted above make it, as yet, impossible to apply some single reliable quantitative overall criterion as the basis to conclude whether or not there has been a clear demonstration of a biologically meaningful effect of closure on the penguin population growth rate. Hence a pragmatic approach is suggested at this stage.

It should be noted that the experiment itself (as at present and other factors aside) leads to closure of areas around these four islands for 50% of the time, so is already implementing a precautionary approach with respect to penguins. The proposals that follow seek to maintain that general intent overall.

1) *Proposals are limited to the four islands involved in the experiment*
   Results across the four islands in the experiment are too variable from island to island to allow inferences to be drawn that could be considered to apply with reasonable reliability to all the other islands.

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2) *Monitoring data should continue to be collected at all four islands*
The other proposals that follow are not such as would preclude continued improvements of estimates of δ as the data sets available for analysis become extended, provided of course that the associated necessary monitoring continues at all four islands.

3) *Dassen island should be open*
Figure 1, together with the points made above, indicate that there is hardly any evidence for a meaningful impact of closure assisting penguin reproductive success at this island. Although a low frequency of closures at this island would somewhat improve the precision of the estimate of δ for Dassen, this has to be weighed against the likelihood that there is actually any meaningful effect of closure there, given the results to date from the experiment.

4) *The relative proportion of closed to open years at Robben island should be increased*
The weight of evidence regarding Robben island from the island closure experiment is towards there being some positive benefit for penguins of closures. This indicates that the experiment should still continue to try to resolve existing uncertainties further, but with an increase the frequency of closures in the light of results to date.

However, an important further consideration in this regard is the population model analysis of Robinson *et al.* (2015)[1], which indicated no relationship between penguin reproductive success and anchovy recruitment at Robben island. This argues against island closures being beneficial, as the associated mechanism usually argued for a beneficial impact is the reduction by fishing of the abundance of anchovy (the main forage source available at that time) during the period of chick development. Both bases for argument have their strengths and weaknesses. The island closure experiment results are difficult to relate to penguin demographics; in contrast the Robinson *et al.* approach provides far more reliable estimates of the pertinent demographic variables, but the overall impact on penguin reproductive success may not be dominated by anchovy recruitment abundance alone.

5) *The current experiment at St Croix island should continue unchanged, but with a possible increase in the proportion of closed to open years*
The foraging-based results for St Croix island argue, in relative terms and in isolation, for an increase in the closure frequency there. However, this has to be balanced against the relatively poor overall reliability of these response variables (see reasons given above), and the poor precision of the estimate from the chick condition data. Hence, the case for such an increase is consequently much weaker than that for Robben island, and rests primarily on the original precautionary nature of the experiment itself (as pointed out at the start of this section).

6) *The current experiment at Bird island should continue unchanged, but with a possible decrease in the proportion of closed to open years*
Any evidence for an impact of fishing at Bird island is notably weaker than at St Croix island. For the same reasons as given above for the latter and for Dassen island, consideration should be given to a decrease in the closure frequency there.

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[1] ICES JMS 72 (2015) 1822-1833

Experimental design

The proposals above, which include suggestions for increasing and for decreasing the closure frequencies at the different islands, necessitate some reconsideration of the current "three-years on, three-years off" experimental closure pattern. This constituted no more than a compromise as part of a package agreed at the 2010 Panel meeting to get the experiment underway. The biological mechanisms and motivation for multiple-year aspect have never been written out clearly and in the mathematical form required, and current analyses of the experiment are not reliant on those specifics anyway in that they consider different years in isolation and dependent only on whether the near vicinity of the island was open or closed to pelagic fishing.

It is simple to speculate on mechanisms that could introduce some auto-regressive effect from year to year as the closure pattern is maintained or changed at an island, but to be given serious consideration, such speculations require also some explicit evidence for the presence of such an effect. In principle, the existing experiment provides a basis to check for this; however an initial investigation quickly revealed that there have been too few instances of changes from closed to open and *vice versa* to allow any credible estimation of this effect from data collected to date. Hence, unless compelling arguments might be offered to support the existence of such auto-regressive effects, the suggestion is made that such a possibility be ignored if perhaps moving to changing the existing closure frequencies.

Continuation of the experiment in some form to better estimate closure impact parameter values clearly requires continuation of monitoring of at least some of the penguin response variables considered to date at all four islands, so that plans to do so need to be confirmed. Given the ambiguities associated with the interpretation of results from the variables currently available for Bird and St Croix islands, the initiation of collection of chick survival, or preferably fledging success data there needs to be considered.

Further considerations

Providing quantitative information to inform on trade-offs

The rationale offered above relates only to the demonstration of a biologically meaningful effect of closure on the penguin population growth rate (for which confirmation remains unclear, and also with different "likelihoods" for the different islands).

In circumstances then where this non-trivial degree of uncertainty remains, the ultimate decision by a decision-maker will require consideration of a trade-off, quantified to the extent possible, between potential benefits to the penguins and losses to the fishing industry. In giving its final advice/recommendations, the PWG must necessarily provide a summary of those benefits and losses.

For the benefits, what will be required is indications of the changes in penguin population growth rates at the colonies concerned that might result from closures, with these being shown together with existing trends in abundance at these colonies. There are numerous past contributions tabled at the PWG from which such information could be extracted. Furthermore, associated implications for tourism and associated revenue generation have been mentioned previously – these need to be tabled and reviewed for possible inclusion in such a summary.

Similarly, the socio-economic costs (both financial returns and employment) of closures to the pelagic fishing industry need to be summarised. Analyses previously presented and reviewed by the Panel for Dassen and Robben islands (e.g. MARAM/IWS/DEC15/PengI/P1) provide a starting point to develop such a summary. For Dassen island, this summary also needs to be linked to the rationale for the proposal to bring the "16 mile beach" closure in the vicinity of Dassen island to an end.
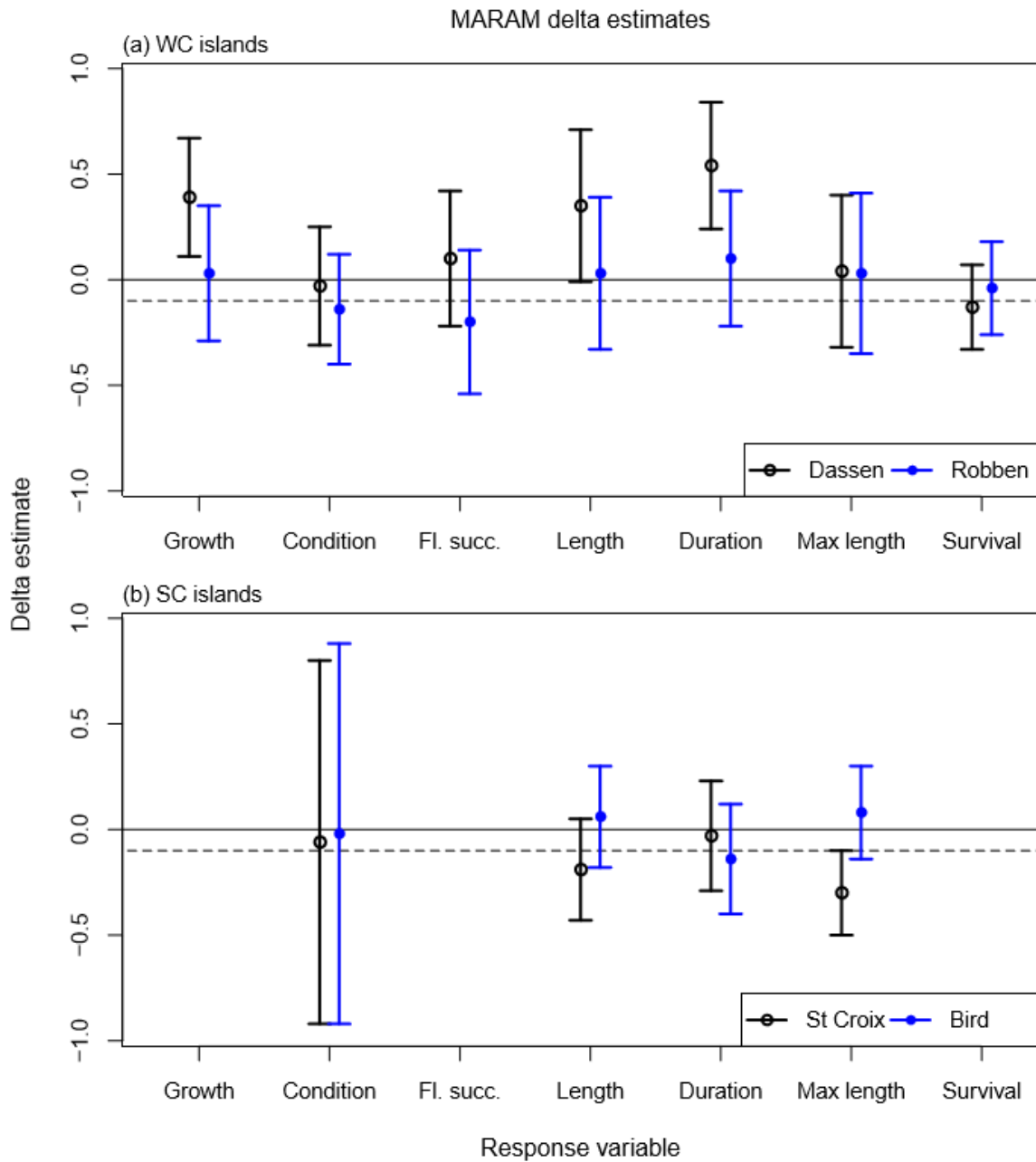
Figure 1: Zeh plots of the δ estimates and rough 95% confidence intervals are shown for (a) Robben and Dassen islands (from FISHERIES/2020/JAN/SWG- PEL/09rev) and for (b) St Croix and Bird islands (from MARAM/IWS/2019/PENG/P2 for the foraging data and from FISHERIES/2019/NOV/SWG-PEL/33 for the chick condition data), for a range of response variables for the aggregated data approach applied in MARAM analyses based on the 2016 algorithm developed in collaboration with the IWS Panel. Note that a negative value for δ indicates that closure has a beneficial effect for penguins. This Figure has been kindly provided by A. Ross-Gillespie.