A response to some queries concerning the revised summary of results for the island closure experiment provided in FISHERIES/2021/JUN/SWG-PEL/41

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Summary

Responses are provided to various queries raised at the PWG meeting of 15 July concerning the results from the Island Closure Experiment reported in FISHERIES/2021/APR/SWG-PEL/41. Generally, these queries are shown to have already been addressed, or to reflect incorrect assumptions. More detail is provided of the "human integration" approach used to synthesise the results of the experiment across the different islands and response variables considered. These results appear reasonably robust to alternatives to the assumptions made in this process. In summary, results for the impact of future island closure for the two Western Cape colonies are roughly estimated to be 0% with a 95% PI of [-0.5%; +0.5%], and for the two Eastern Cape colonies to be -0.25% with a 95% PI of [-0.75%; +0.25%], where a negative value indicates that closure would improve the penguin population growth rate by the value given pa. For any other colony that was not part of the experiment, which has therefore not potentially benefitted from any impact of being closed to fishing for 50% of the time over the last decade, the estimate (combined over the islands included in the experiment) is -0.25% with a 95% PI of [-1.0%; +0.5%].

Key words: penguin, island closure, fishing impact, population growth rate effect

Introduction

Ross-Gillespie and Butterworth (2021a) and Ross-Gillespie and Butterworth (2021b) (an update of the former) provided results for implementing the suggestions of the December 2020 International Panel for further analysis of the results from the island closure experiment. Butterworth and Ross-Gillespie (2021) provided a simple summarisation of those results by giving what they considered to be the single "best" estimate, with a 95% CI, for each island/response variable combination (see Figure 1), and then proceeded to draw some overview inferences from these.

During the PWG meeting of 15 July 2021, a number of questions were raised in relation to the results in Butterworth and Ross-Gillespie (2021), including by Waller et al. (2021). Responses were in the main provided verbally during that meeting; these are repeated and/or extended below to provide additional clarification.

Queries and responses

Inclusion of chick growth

Waller et al. (2021) questioned removing 12% of the lowest values from all sites to exclude negative values, and asked whether this was likely to bias the results in favour of more favourable conditions when growth rates are higher, thereby diminishing the potential negative effects of open years on this response variable.

Sensitivity to absence of these removals had been examined in Ross-Gillespie and Butterworth (2021a) (see their Tables 1 and 4a, and compare the values estimators A1 and A1*), which indicated only a minimal difference in results. The manner in which the removals were made was deliberately balanced across years to minimise potential bias in the estimates of interest, since these depend primarily on differences between open and closed years rather than on absolute values.

The 15 July meeting requested written submission of the details of any further sensitivity tests that might be desired. No such submissions have been received.

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The "threshold of 1%"

Waller et al. (2021) state that: "It has been agreed by the SWG-PEL that a threshold of a 1% increase in population growth rate as a result of no fishing was a biologically meaningful effect."

Examination of meeting records has failed to provide confirmation of any such agreement, although loose choices of words in a number of documents submitted more recently to the PWG might be taken to imply this indirectly. Importantly this value was never "recommended" by the Panel – it was referenced only for the purpose of example in illustrating the method (see 2015 Panel report) which they had suggested for determining the power of the experiment, which requires the specification of some value for an associated threshold. Furthermore the 2016 Panel report refers in this regard only to MARAM/IWS/DEC16/Peng_Clos/P1a, where this 1% value was **assumed** (for illustrative purposes).

Essentially the "meaningfulness" of an estimate needs to be determined for the situation under examination – here the size of the closure effect in terms of impact on penguin population growth rate relative to recent trends in that rate.

Combining estimates obtained from condition and survival response variables

Waller et al. (2021) state that: "Combining the population growth rates of chick survival to population growth rates attributed to aggregated and disaggregated estimates of chick condition would give a combined population growth rate of >1% (i.e. the pre-determined threshold) during closed years to fishing."

Aside from the information provided above relating to the "status" of "1%" as the value of a threshold, adding the estimates related to chick survival and to those for chick condition/growth would be quite incorrect. These are indices for the **same** period of the penguin life history – the first 2-3 months after hatching – so, if anything, they need to be combined through some form of weighted averaging, and certainly not added. Addition would be appropriate if an independent estimate pertinent to a different part of the life history (e.g. adult survival) was available – then that could be added to an estimate related to, say, the chick fledging period.

The basis for the "integration" of results across different response variables

Explanation

Butterworth and Ross-Gillespie (2021) offered "human integrated" (though still very coarse – to the nearest 0.5%) "best" numerical estimates of the percentage effect of fishing compared to closure on population annual growth rates from these results (where a negative value means that fishing results in a lower population growth rate), where these were based on their choice of "best estimates" for the various colony/response variable results (see their Table 1) to provide a broad overview:

Dassen	+0.5%	(i.e. closure does not benefit penguins)
Robben	-0.5%	
Bird	0%	
St Croix	-1%	

They did so as they considered it unwise to offer any single detailed algorithm for integrating across all the results from the closure experiment; they also acknowledged that the exact values they put forward could be debated. The reasons for their approach included the following.

- The estimates for change in population growth rate caused by fishing are more reliable in absolute terms for chick condition, fledging success and chick survival, as there is a demographic model basis to link those directly to the population growth rate, rather than to have to rely on an assumption that a change in the value of the variable is related to a change in juvenile survival by a straight line through the origin.
- Of the three foraging related variables, maximum distance would *a priori* seem the least reliable, as maximum distance is a less statistically robust measure than others which integrate over the foraging trajectory in question.
- Results for the three foraging related variables would not be statistically independent, and similarly chick condition and growth, and separately fledging success and chick survival, would be dependent to some extent.

This needs to be considered in any attempt at integrating the results, as it implies that not every variable considered should be equally weighted *a priori* (i.e. before taking estimation precision into account).

- Patterns for the foraging related variables are not fully consistent over the four islands. There is some tendency for the estimated changes in population growth rate, given fishing, to be positive for Dassen and negative for St Croix, with these values averaging close to zero for the other two islands.
- At a non-parametric level, considering the point estimates obtained, there are equal numbers of positive and negative estimates of these changes in population growth rate, i.e. overall the indications from the experiment are that there is very little evidence for any impact (in either direction) of fishing in the neighbourhood of island breeding colonies of penguins.

Nevertheless, there were requests for a fuller description of the "integration" process used. It is first important in this context to note that, in essence, there are only three or fewer "independent" sources of information available for each island colony: those related to chick condition/growth, adult foraging and chick survival/fledging success. Table 1 shows the "integrated" combined estimates (each to the nearest 0.5%) for each colony under each of these response variable types, taking qualitative account of the considerations above. These were then combined for each colony on a similar basis.

Sensitivity and variances

It turns out that this "human integration" is very close to an equally weighted average across the available resource variables types. For the reasons given above, one would really prefer a lower weight in this combination for the foraging response variable results. However, halving that weight serves only to render the combined Dassen island result a little less positive, and that for St Croix a little less negative. The 15 July meeting requested written submission of the details of any (alternative) suggestions for synthesising these estimates; no such submissions have been received. In any case though, it already seems clear that reasonable variations on the values shown in Table 1 would have little impact on the combined results put forward.

Given this virtually equally weighted average across the available response variable types, a standard error for these combinations can be calculated simply given the reasonable associated assumption of independence. The results from such computations are shown in Table 2.

In combining these results across islands, one must be cognisant that the standard error estimates in Table 2 apply to analyses for each **pair** of islands (they are not independent estimates). Thus, values of approximately 0.5% apply for the Western Cape pair and for the Eastern Cape pair. Combining for each region then, one gets (coarsely) for the impact of fishing on penguin population growth rate:

Western Cape pair:	0%	se= 0.5%	95% PI [-1%; +1%]
Eastern Cape pair:	-0.5%	se= 0.5%	95% PI [-1.5%; +0.5%]

In interpreting these results though, one must bear in mind that the neighbourhoods of these four islands have already been closed to pelagic fishing for 50% of the time for somewhat longer than the last decade. Hence, if these islands were now to be closed for every year in the future, the changes to current penguin annual growth rates (on average over an extended period of years) would be predicted to be only half of the values shown above, i.e.:

Western Cape pair:	0%	se= 0.25%	95% PI [-0.5%; +0.5%]
Eastern Cape pair:	-0.25%	se= 0.25%	95% PI [-0.75%; +0.25%]

For other colonies, not included in the experiment, the best estimate would be provided by averaging over the Western and Eastern Cape pairs, treating the two estimates as independent. Hence the impact on population growth rate of closing the neighbourhoods of such islands to pelagic fishing would be:

Other islands:	-0.25%	se= 0.35%	95% PI [-1.0%; +0.5%][2]

[2] These PI values are appropriately rounded given the coarse nature of these evaluations.

References

Butterworth D.S. and Ross-Gillespie, A. 2021. A revised summary of results for the island closure experiment. DEFF Fisheries document FISHERIES/2021/APR/SWG-PEL/41.

Ross-Gillespie, A. and Butterworth, D.S. 2021a. Re-analysis of the Island Closure Experiment results to Implement the Suggestions of the December 2020 International Panel. DEFF Fisheries document FISHERIES/2021/APR/SWG-PEL/35.

Ross-Gillespie, A. and Butterworth, D.S. 2021b. Updated analysis of results from data arising from the Island Closure Experiment. DEFF Fisheries document FISHERIES/2021/JUN/SWG-PEL/39.

Waller, L.J., McInnes, A., Carpenter-Kling, T., Hagen, C., Makhado, A.B., Masotla, M.J., Shannon, L.J., Sherley, R.B. and Stassen M. SWG-PEL Seabird Observer Comments. DEFF Fisheries document FISHERIES/2021/JUN/SWG-PEL/47.

Table 1: Estimates of change in population growth rate as a result of fishing (expressed as a percentage per annum) combined by "human integration" across the different types of response variables for each island and expressed to the nearest 0.5%. This "human integration" is based on a qualitative assessment of the Zeh plots in Figure 1, coarsely assigning higher weighting to those variables considered more reliable on the basis described in the text.

Island	Chick condition/growth	Foraging	Survival/fledging	Combined
Dassen	+0.5	+2.0	-1.0	+0.5
Robben	-1.0	-0.5	0	-0.5
Bird	0	0	-	0
St Croix	+0.5	-2.0	-	-1.0

Table 2: Estimates of change in population growth rate as a result of fishing (expressed as a percentage per annum) combined by "human integration" across the different types of response variables for each island and expressed to the nearest 0.5% taken from Table 1. In addition here, estimates of standard error for these combinations also shown (in parenthesis), based on the estimates for the responses considered to provide the more reliable estimate under each type (respectively chick condition, the average of path length and trip duration, and chick survival).

Island	Chick condition/growth	Foraging	Survival/fledging	Combined
Dassen	+0.5 (0.42)	+2.0 (1.21)	-1.0 (0.55)	+0.5 (0.46)
Robben	-1.0 (0.42)	-0.5 (1.15)	0 (0.55)	-0.5 (0.45)
Bird	0 (0.80)	0 (0.78)	-	0 (0.56)
St Croix	+0.5 (0.74)	-2.0 (0.80)	-	-1.0 (0.55)

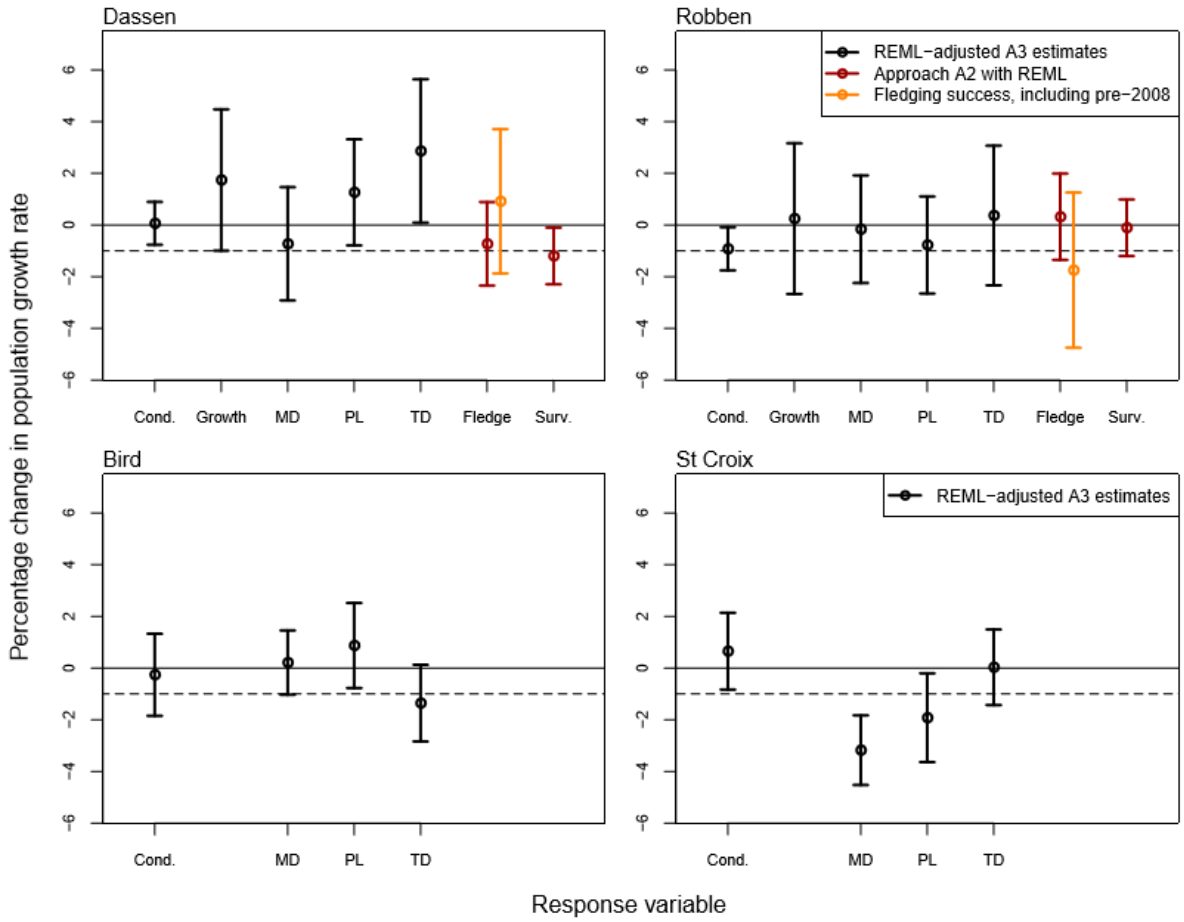

Figure 1:. Zeh plots of the estimates of change in population growth rate as a result of fishing (expressed as a percentage per annum) for the A3 approach of Ross-Gillespie and Butterworth (2021b), which for reasons given in the text is considered to provide the best results from the closure experiment. The response variables MD, PL and TD from the foraging data refer respectively to maximum foraging distance, path length and trip duration respectively. Except for fledging success and survival rate for which REML estimates are available directly, the black error bars have been expanded to reflect the preferred REML rather than MLE method for (95%) CI calculation in the manner explained in the text. All results are for the period commencing in 2008, except that the yellow point indicates the results for fledging success when the pre-2008 data are also included in the analysis.