On estimates of the impact of fishing from analyses of the island closure experiment which model individual penguin responses directly

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Summary

Empirical comparative results available, and consideration of a limiting case, are used to inform on aspects of the use of estimates from individual data-based approaches on the impact of fishing when conducted near penguin colonies.

Introduction

The Panel for the 2019 International Workshop (Die *et al.*, 2019) made a number of comments about analyses of the island closure experiment results involving the use of individual observations. These included:

- Such models can provide negatively biased estimates if covariates common to individuals are ignored (i.e., pseudo replication).
- For natural experiments such as the closure experiment, it is a working hypothesis that including random effects chosen using model selection methods will appropriately account for the pseudo-replication.
- Given the nature of the experiment, use of individual data is to be preferred. However, this is only the case if an appropriate random effects structure is chosen.

The PWG has already received results based on these individual-based model approaches, and may well receive more. The Working Group needs to consider how it will evaluate these results. The comments below are offered to contribute to that discussion.

Implications of empirical comparisons currently available

MARAM/IWS/2019/PENG/WP3 (Sherley and Winker, 2019) provides comparisons for closure effect SE estimates based on the maximum forage distance variable for south coast penguin colonies (St Croix and Bird) and the condition variable for west coast colonies (Dassen and Robben), as follows:

South coast:	aggregated data	0.084	
	individual data	0.098	random effect: year-bird ID
		0.102	random effect: year-island
West coast:	aggregated data	0.038	
	individual data	0.023	random effect: year-month
		0.039	random effect: year-island

Notably, the individual-based estimates of SE are not necessarily robust to which random effects structure has been used. In one of the two examples above, one choice suggests precision almost twice as good as the other. In simple terms then, the "working hypothesis" (that including some random effects will appropriately account for pseudo-replication) is not supported.

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However, the Panel qualified their comments about this working hypothesis by referring to the need for an appropriate random effects structure to be used, also mentioning the use of model selection approaches in that regard.

This points for the need for the PWG to consider whether these aspects, including robustness to alternative choices for random effect terms, have been adequately addressed - this before taking account of results from such analyses in drawing inferences about the impacts of island closures on penguins.

Does use of individual-based approaches remedy the limited degrees of freedom problem of estimators based on annually aggregated data?

Obtaining estimates of high precision of the fishing effect parameters in the island closure experiment, when these are based on annually aggregated data, is hampered by the low number of degrees of freedom (dof), together with their slow accumulation over time. Effectively, adding results from one further year provides two additional data points, but adds one further estimable parameter, and so increases the dof by no more than one (though this is ameliorated somewhat if the year factor is treated as a random effect in the estimation).

Using individual data appears an attractive approach to address this problem, but does it in fact achieve any better than the aggregated data approach?

First, note that the empirical comparative results shown in the section above hardly suggest so.

But further, consider the following hypothetical limiting case situation of a small-ish number of years (say 10), a large-ish process error, and a large number at individual data for the response variable from each island each year (say 10 000 each), this in circumstances where the observation error is very small. The expected response variable value each year will then be effectively exactly determined, but the closure effect will still be rather poorly estimated because the annual mean response will nevertheless vary substantially from year to year, and the extent of this variation will contribute substantial variance to the estimate of the closure effect. The estimate for the closure effect from the aggregated and from the individual approaches will be effectively identical, and so too the standard errors for the closure effect for each. But though the dof for the former will hardly reach double figures, the dof for the latter will seemingly be close to 20 000. That's plainly in the context of using AIC for model comparison.

Clearly the structure of the problem here, and the different nature of between-year vs within-year information renders model selection involving fixed vs random effects approaches less than straightforward. It seems likely, as far as precision is concerned, that very little if anything is to be gained from pursuing an individual data compared to an annually aggregated data based approach.

References

Die, D.J., Punt, A.E., Tiedemann, R., Waples, R. and Wilberg, M.J. 2019. International Review Panel report for the 2019 International Fisheries Stock Assessment workshop. 20pp.

Sherley, R.B, and Winker, H. 2019. Some observations on comparisons of fitting to the annual means and the observation-level data for the cases in MARAM/IWS/DEC19/Peng/P4 that support a positive effect of the island closures experiment on African penguins. Document MARAM/IWS/2019/PENG/WP3. 5pp.