Island closure feasibility study power analysis

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Introduction

This paper indicates how it is planned to extend the general linear model (GLM) analyses by Robinson (2013) to estimate the power of the Island Closure Experiment. Statistical power reflects the probability that an experiment will detect an effect if it exists.

Method

The GLM for fledging success *F* is

$$\ln(F_{y,i,s}) = \alpha_y + \gamma_s + \lambda_i \frac{C_{y,i,p}}{\bar{C}_{i,p}} + \varepsilon_{y,i,s} \tag{1}$$

for year *y*, island *i*, and data series *s*, where

α_y is a year effect reflecting prevailing environmental conditions,

γ_s is a series effect (subsuming an island effect),

λ_i is a fishing effect,

$C_{y,i,p}$ is the catch taken in year *y* in the neighbourhood of island *i* of pelagic species *p*,

$\bar{C}_{i,p}$ is the average catch taken over the years considered, and

$\varepsilon_{y,i,s}$ is an error term.

Following Brandão and Butterworth (2007), future penguin response data are generated as follows:

$$\ln(F_{y,i,s}) = \hat{\alpha}_y + \hat{\gamma}_s + \hat{\lambda}_i \frac{\hat{C}_{y,i,p}}{\bar{C}_{i,p}} + \hat{\varepsilon}_{y,i,s} \tag{2}$$

where

$\hat{\alpha}_y$ are generated by sampling with replacement from estimates for α_y,

$\hat{\gamma}_s$ are the best estimates of γ_s,

$\hat{\lambda}_i$ are the best estimates of λ_i,

$\hat{C}_{y,i,p}$ are generated by sampling with replacement from the time-series of observed catches for years in which the island concerned is "open" to fishing, and zero otherwise, and

$\hat{\varepsilon}_{y,i,s}$ are generated from $N(0, \sigma_\varepsilon^2)$, where σ_ε^2 is the variance of the residuals when the model is fit to the historic data.

The future data are appended to the historic time-series.

The GLM is fit to obtain estimates for λ_i and the associated *t*-probability.

The process is repeated a large number of times (e.g. 500).

Experimental power is calculated as the number of λ_i estimates which are statistically significant (at the 5% level) divided by the number of simulations performed.

Possible variations

Instead of using the best estimates of λ_i for $\hat{\lambda}_i$ in equation (2), alternatives could be tested. The reason for suggesting this is that the process above indicates power only for the case that the current best estimate of λ_i happens to be exactly correct. Thus if this estimate is positive (fishing benefits penguins), we discover only how long it will take to confirm that possibility. In most instances however (Robinson, 2013), the current best estimate is not significantly different from zero, i.e. the lower 95% confidence bound for the estimate is negative (fishing disadvantages penguins). One possibility therefore would be to repeat the power computations for that lower bound as well, to show how long it would take to confirm a situation that that negative number lies within a distribution 95% of which is negative (i.e. sufficient to confirm the interaction is affecting penguins negatively).

References

Brandão A and Butterworth DS. 2007. An initial analysis of the power of monitoring certain indices to determine the effect of fishing on penguin reproductive success from an experiment where pelagic fishing is prohibited in the neighbourhood of Robben Island, but continues around Dassen Island. Unpublished report, Marine and Coastal Management, South Africa. Report No. EAFWG/OCT2007/STG/04.

Robinson WML. 2013. Modelling the impact of the South African small pelagic fishery on African penguin dynamics. PhD thesis, University of Cape Town, South Africa.