Statistical power to detect abundance changes in distance sampling

O.Lyashevska [1], L.Fay [2], S.Berrow [1], J.O'Brien [1], S.Murphy [1], C.Minto [1]

[1] MFRC, Atlantic Technological University, Ireland
[2] National Parks and Wildlife Services, Ireland

Abstract

Power analysis can be used to evaluate and optimise monitoring efforts at a range of scales. Using a single platform line transect survey data (*Phocoena phocoena*) and mixed GAM estimates with a zero-inflated distribution and detection offsets, abundance data was simulated with known properties and with a given local abundance decline. For each dataset, a distance function was fitted from which abundance was calculated and compared with a baseline of no change. The significance of the slope over time was used to calculate the power to detect change in abundance as a function of survey design. High power was achieved only at considerable abundance decline.

Introduction

- The harbour porpoise is listed as an Annex II (and Annex IV) species under the EU Habitats Directive (92/43/EEC)
- Under Article 11, Member States are required to monitor their conservation status and report on such every six-years under Article 17, using data collected both inside and outside SACs [1]
- Statistical power describes the probability of detecting a significant trend;
- It is an important consideration in the planning of the monitoring programs;
- Computer simulations are useful for incorporating multiple levels of variability
- The power of methods to recover the true trend from the simulated data can be assessed [1].

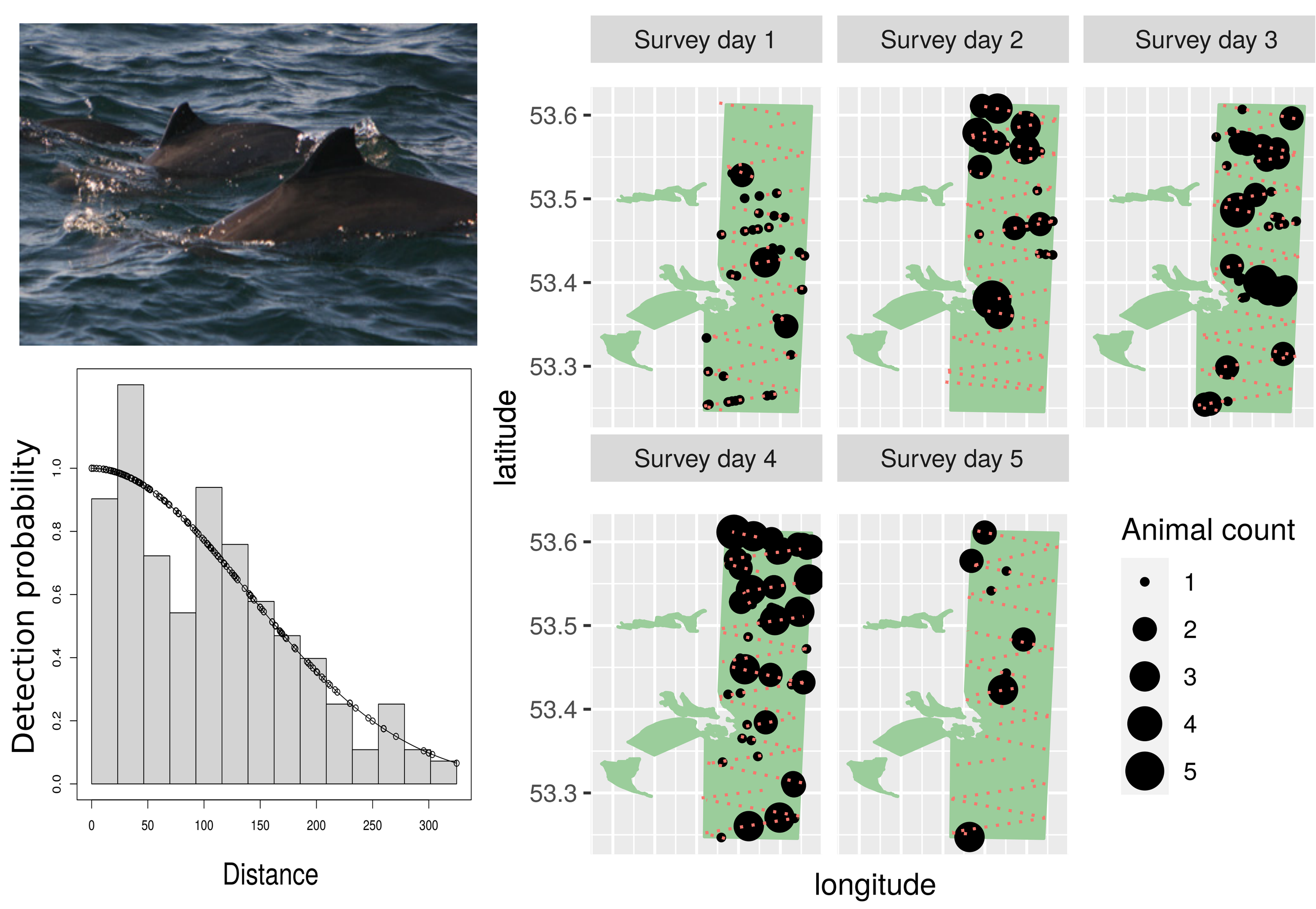

Fig. 1: Harbour porpoise sightings on different survey days and distance function in Rockabill to Dalkey Islands SAC, 2013 (Ireland)

Methods

- The expected count per transect on survey day d was modelled using the estimated parameters from the `gam` fits ([3]) as following:

$$E(n_j) = \hat{p} A_j e^{\beta_0 + b_{1,d[j]} + b_{2,j}} \tag{1}$$

  where n_j is modelled as zero-inflated Poisson distributed, β_0 is the log-average count per unit effort, $b_{1,d[j]} \sim N(0, \sigma_1^2)$ are the between-day random effects, and $b_{2,j} \sim N(0, \sigma_2^2)$ are the between-transect random effects ([2]).
- For a given percentage decline, we take the baseline fit and solve for the β_0;
- Draw specified number of random effects from survey day and transect distributions;
- A draw from the zero-inflated Poisson distribution formed the true count per transect;
- Each animal was randomly assigned a distance from the transect. The estimated detection function was used to determine if the animal was observed;
- The significance of the trend was determined by sampling from the distribution of the mean densities per survey year, fitting a linear trend and repeating 1000 times;
- A one-sided test on the distribution of the slope indicated if the slope was significantly less than zero. This was repeated 200 times to determine the power to detect a given change;

Results

1. **Magnitude of change was the main determinant of power:** high power (80%) was achieved only at considerable abundance decline (approximately 35%);
2. **The power to detect change increases with the number of survey days per season**. The main increase was due to adding 2 additional survey days (from 6 to 8);
3. **Survey frequency was less important than the number of survey days**. Annual survey frequency was clearly better than biannual or triannual, however the improvement was not substantial;
4. **Number of transects was found to be the least important determinant**. An increase in power from adding an extra 20% effort was only marginal;

Acknowledgements

This work was initiated and funded by the National Parks & Wildlife Service under the project 'Harbour Porpoise Statistical Review Power Analysis'. We thank all survey and land-based crews who conducted the surveys that form the basis of these analyses.

An Roinn Tithíochta, Rialtais Áitiúil agus Oidhreachta
Department of Housing, Local Government and Heritage

Results (cont)

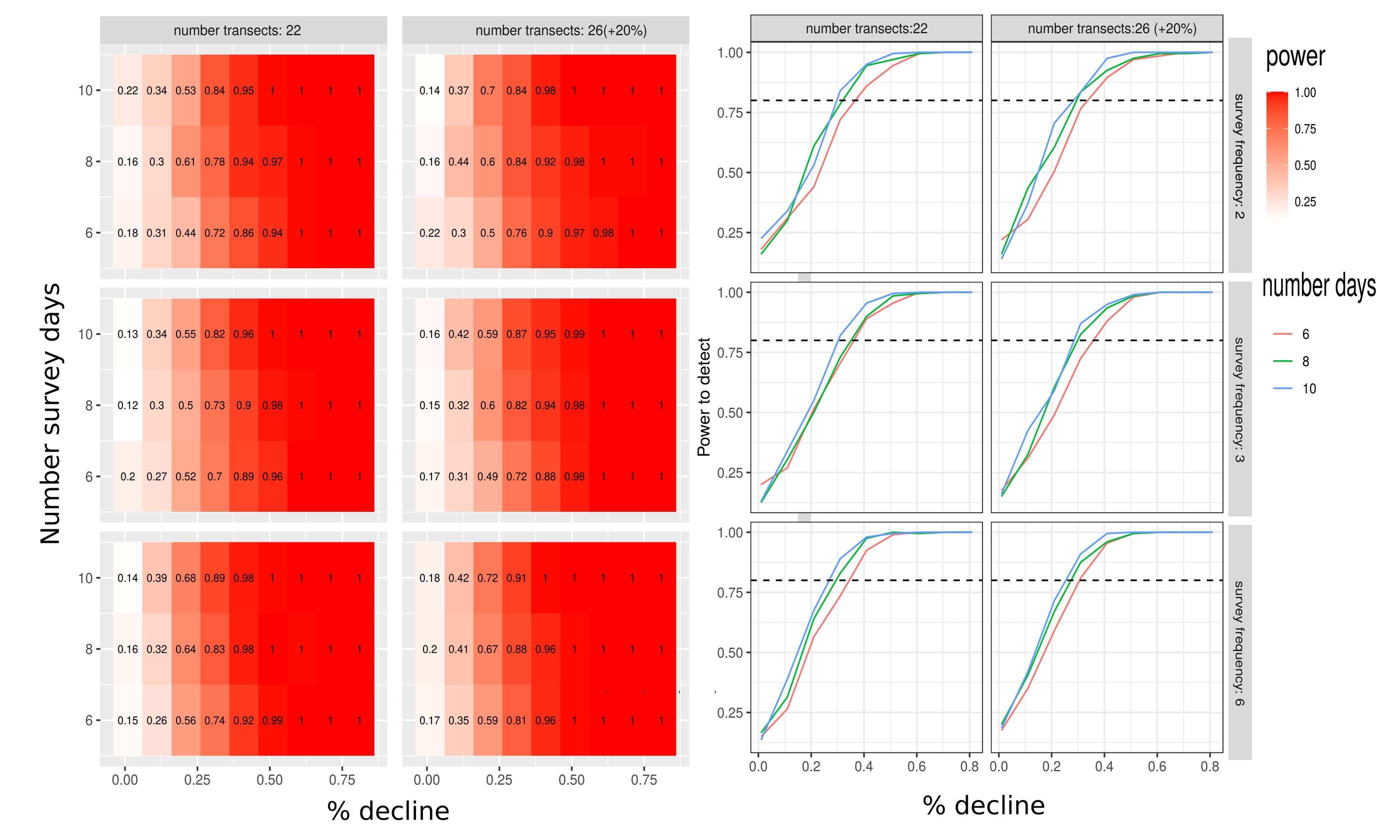

Fig. 2: Heatmaps of the power as a function of the percentage decline for all combinations of the variables (left) and statistical power to detect change in population abundance with different number of days (right).

Recommendations

1. **Increase number of survey days:** an increase in the number of survey days to 8 (from an average of 6) increases the power to detect changes.
2. **Survey frequency increases power marginally**. Surveys conducted once in year 1 and once in year 6 had similar power to detect linear decreases in abundance compared to annual surveys. We recommend to continue with 2 surveys per 6-year reporting period for Article 17 of the Habitats Directive but that these years be separated as much as possible;
3. Due to geographic scale and the range and movement of the species in question area may not capture real population changes within the region (reflected in the between-day variability). It is therefore recommended to **consider surveying over a larger spatial scale to include survey waters both inside and adjacent to the area**.

References

[1] B.M. Bolker. *Ecological Models and Data in R.* Princeton University Press, 2008.

[2] David L. Miller et al. *dsm: Density Surface Modelling of Distance Sampling Data.* R package version 2.3.1. 2021. URL: `https://CRAN.R-project.org/package=dsm`.

[3] S.N Wood. *Generalized Additive Models: An Introduction with R.* 2nd ed. Chapman and Hall/CRC, 2017.

[1] https://ec.europa.eu/environment/nature/knowledge/rep$_habitats/index_en.html$