Modelling impact assessment in renewables development areas using the new R package, MRSea v0.1.1

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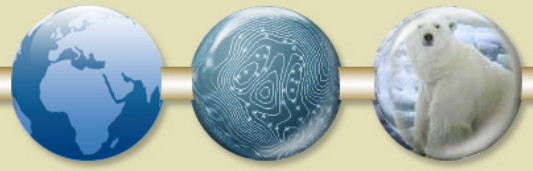

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Introduction

- Mapping spatial distribution from line transect or vantage point surveys
- Particular focus on spatially explicit impact effects
- Previous assessment tended to measure differences in animal abundance prior to and following development.

Introduction

- This approach suffered from some disadvantages:
  - attributing any potential change to development as the causal agent
  - failing to acknowledge other forces that influence animal abundance and distribution
  - insensitivity to more subtle changes in animal populations

- We present a new R package MRSea,
  - developed specifically to tackle the assessment of potential impacts of renewable developments on marine wildlife
  - although the methods are applicable to other studies as well.
- The package functions can be used to analyse
  - segmented line transect data
  - and nearshore vantage point data

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See CREEM website for details

The MRSea Package

- 6 data sets
  - Offshore or Nearshore (vantage point)
    - No impact effect (*no*)
    - Decrease in animals across the survey region (*de*)
    - Redistribution of animals from one part of the survey region (impact site) to another environmentally similar region (*re*)

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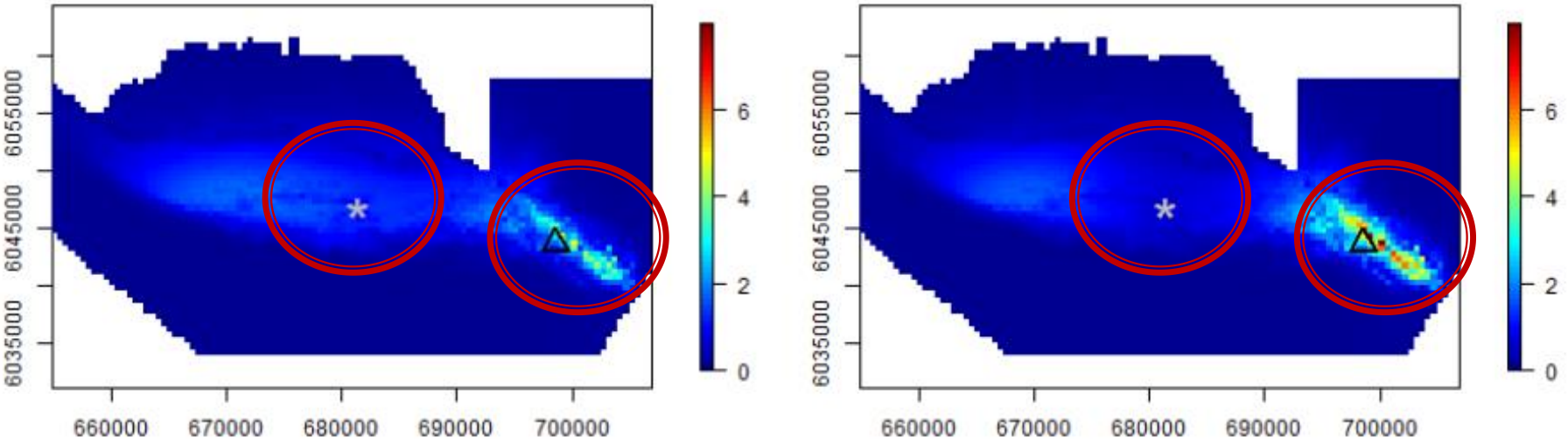
  - Also a prediction grid for each data set.
- A variety of functions for fitting and diagnosing models and making inference.

The Data

- We focus on off-shore survey data with a re-distribution of animals within the study region

- Observed counts, with imperfect detection imposed, were lifted from the simulated true surface in the form of line-transects. This is the data set called `dis.data.re` within the `MRSea` package.

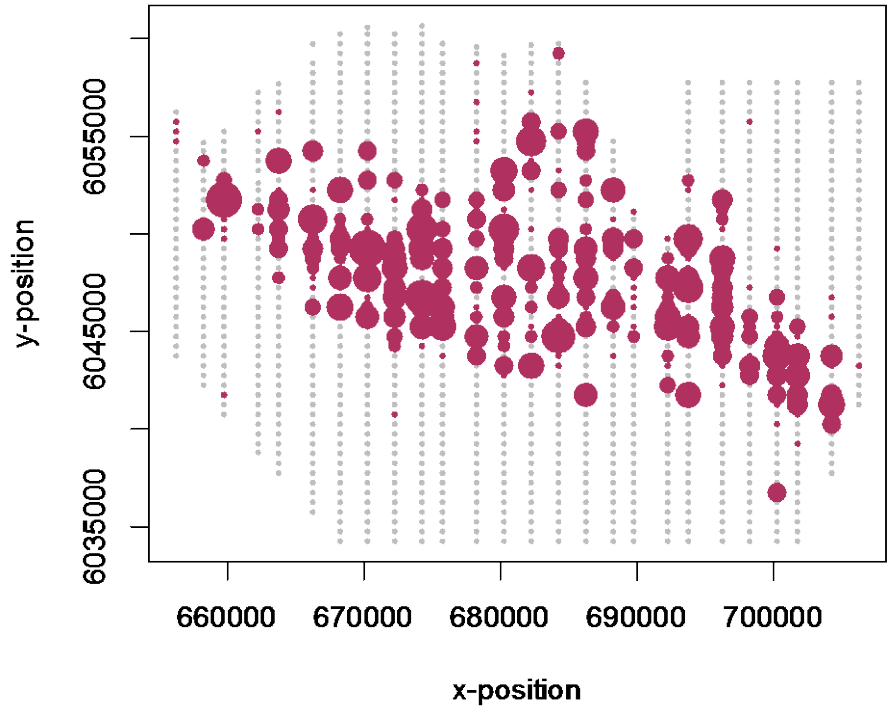


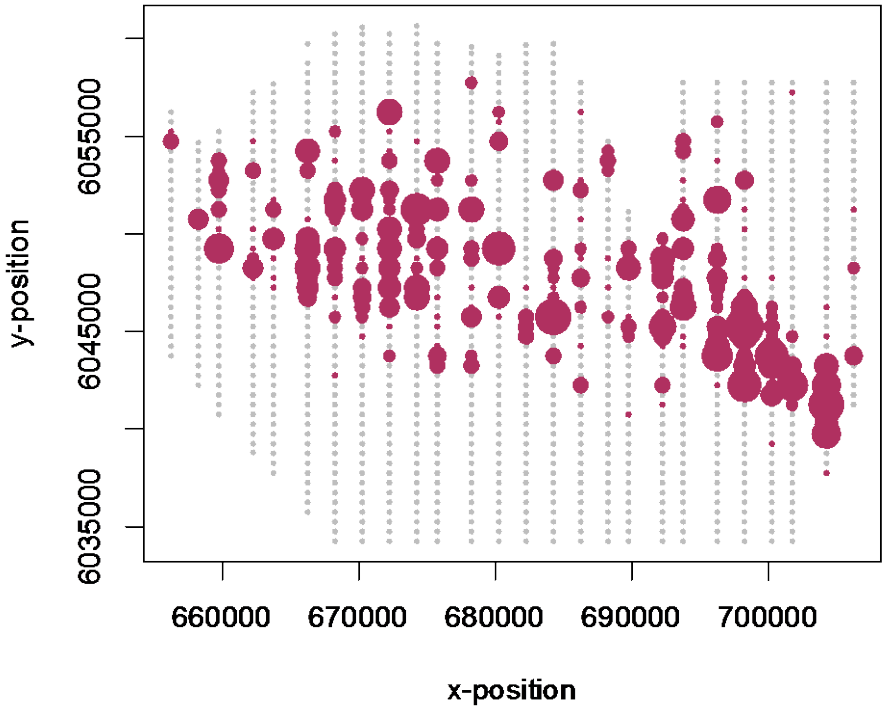
Simulated densities of birds (per km^2) before impact (left) and after impact (right).

The grey star is the centre point of the impact and the black triangle the centre point of redistribution.

Correcting For Imperfect Detection

- Use distance sampling methods [5] to adjust the observed counts for imperfect detection.
- Specifically a half-normal detection function was fitted to the raw data.
- Use `create.NHAT()` to adjust observed counts using estimated detection function.





Mean bird counts estimated from a distance sampling analysis before (left) and after (right) the impact.

Bubbles are sized as log of estimated counts.

Model specification

- Over dispersed counts modelled with a quasi-poisson error structure.
- Covariates:
  - depth
  - season (factor; 1:4)
  - impact (factor; 0/1)
  - spatial term (x,y)
  - spatial-impact interaction term to allow redistribution
- A CReSS-GEE framework to estimate the smooth terms in the model
  - This allows for positive autocorrealation in model residuals

Model Fitting and Model Selection

- `runSALSA1D()` employed to choose the smoothness of the depth relationship.
  - finds the best smoothness for each covariate but does not consider if the covariate should be linear or removed
- Alternatively `runSALSA1D_withremoval()` cycles through each covariate (specified to be a smooth term) and either removes or retains based on k-fold cross-validation.
- `runSALSA2D()` employed to determine the smoothness of the spatial term; s(x,y).
- See the MRSea user guide for details on these functions and their use [6].

- The models returned from `runSALSA1D()` and `runSALSA2D()` are of class 'glm' so functions such as `summary`, `update`, `predict` and `fitted` etc are available to the user.

- GEE based *p*–values may also be used for model selection. These can be found using the `getPvalues()` function.

Variable	p–value
s(Depth)	<0.0001
as.factor(Season)	<0.0001
s(X,Y)	<0.0001
as.factor(Impact)	0.5468
s(X,Y):as.factor(Impact)	0.0081

Diagnostics

- Functions to perform diagnostics in the MRSea package include:
- `runPartialPlots`:
  - partial plots for the estimated relationships between each covariate and the response with GEE based confidence intervals (95%).
- `runDiagnostics`:
  - plot of observed vs fitted values to assess model fit
    - (with marginal R^2 and concordance correlation reported in the title)
  - plot of fitted values vs scaled Pearsons residuals to assess the mean-variance relationship.

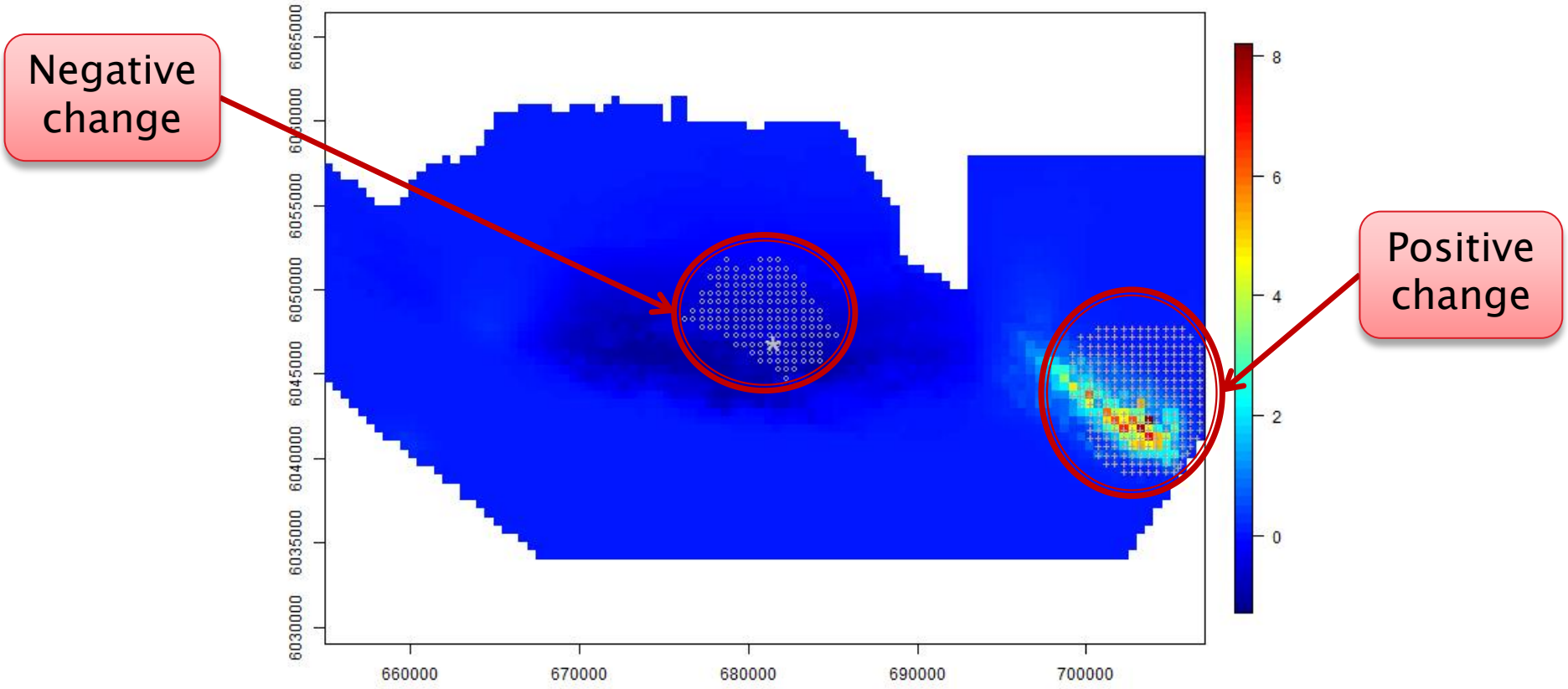
- `plotRunsProfile`:
  - runs profile plots ordered by covariate value, fitted value and indexed value to assess the correlated nature of residuals.
- `runInfluence`:
  - plots of correlated block ID vs PRESS and COVRATIO statistics.
    - used to assess how aspects of the model change when individual blocks are removed from the analysis.

Prediction and Inference

- Make predictions using `predict()`
- Bootstrap upper and lower percentile confidence intervals for combining both:
  - uncertainty at the detection function fitting stage and
  - uncertainty in model parameters at the count model fitting stage.
- `do.bootstrap.cress` calculates all the new predictions and `makeBootCIs` takes these to calculate the percentile intervals.

Spatially explicit Differences

- where in the predicted surface is there a significant change in animal numbers
- `getDifferences()` assesses the before and after predictions for each bootstrap iteration and finds the difference and the 95% interval for the difference.
- If the interval contains zero, there is likely no difference before and after.
- In this case there was a large decline in animals around the impact site and an increase in the south east of the study area.



Mean differences in predicted bird density (mean birds/km^2) before and after impact. Positive values indicate more birds post impact and negative values fewer birds post impact.

'+' indicates a large positive difference and 'o' a large negative one. The grey star is the centre of the impact event.

Conclusions

- This is an example of just some of the functions available in the MRSea package.
  - A full list is available in the reference manual [2]
- A full worked example and some additional tips and tricks in the user guide [6].
- Both these documents, along with the package can be found at http://creem2.st-andrews.ac.uk/software.aspx

ACKNOWLEDGEMENTS

- Thanks to Marine Scotland for funding this research.

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