Modelling the Habitat Preference of Satellite-Tracked Animals;

Accounting for different sources of temporal and spatial autocorrelation

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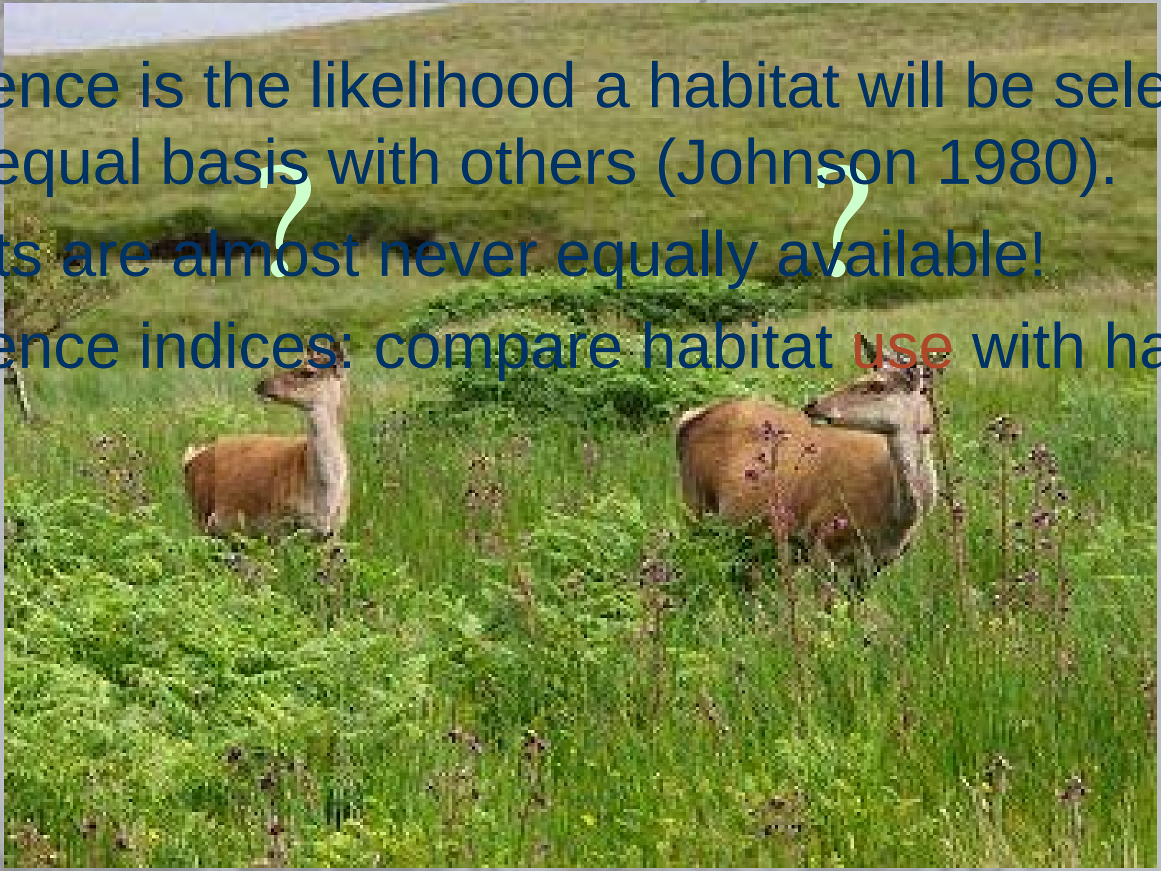
Importance of Habitats

- Animals need resources to meet their requirement for survival and reproduction
- Documenting and modelling the selection of these resources is important for conserving endangered species and managing exploited populations (Manly *et al.* 1993)
- Works in two ways
  - Increases our understanding of the biology of the animal
  - Could enable us to predict use in space and time

Quantification of Preference

- What is preference?
- Preference is the likelihood a habitat will be selected, if offered on an equal basis with others (Johnson 1980).
- Habitats are almost never equally available!
- Preference indices: compare habitat use with habitat availability

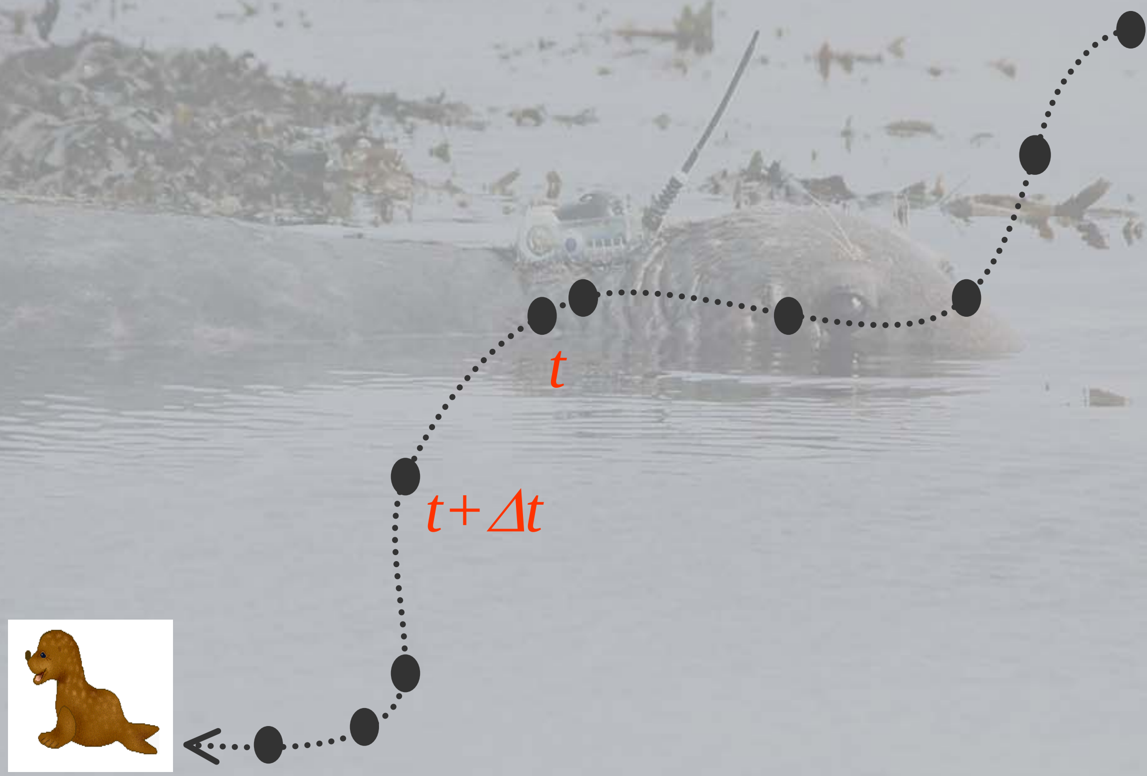


Measuring use of habitats by far-ranging animals

Using Argos Satellite Telemetry Devices

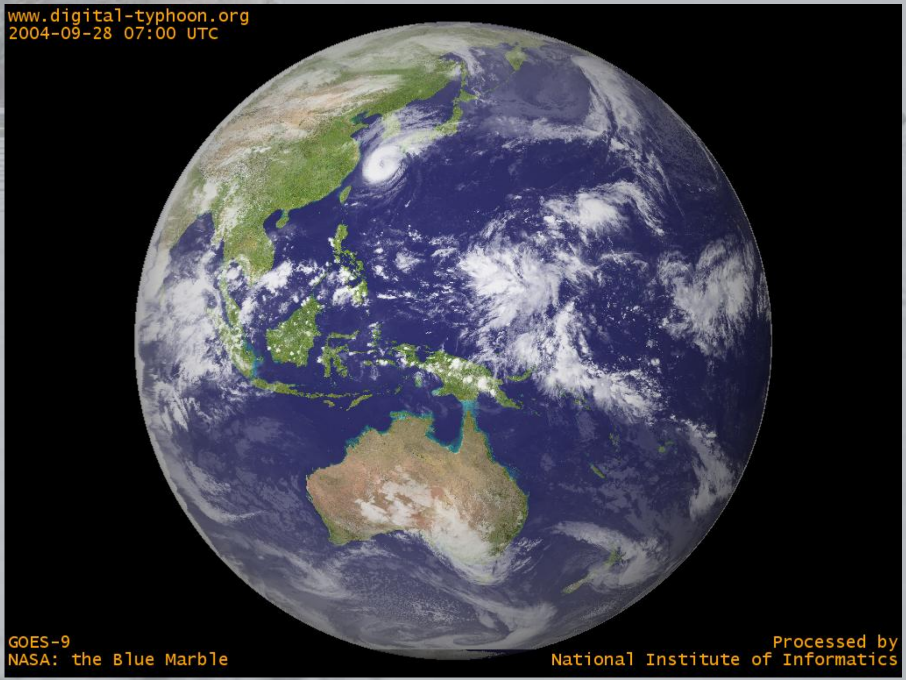
Problems using satellite telemetry to extract habitat preference

1. Data from individuals are serial correlated



Problems using satellite telemetry to extract habitat preference

1. Data from individuals are serial correlated
2. Measure of habitat use only



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Problems using satellite telemetry to extract habitat preference

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2. Measure of habitat use only.
3. Interest is in population inference, but only data from a few individuals.
4. Dealing with complex animals that might have complex responses.

Objective of Study

- Currently no framework exist that deals with all the relevant problems.

- To design an easy-to-use framework to model the habitat preference of satellite tracked animals.

Layout

1. Quantifying habitats
2. Quantifying Preference:
   - Quantifying Usage
   - Quantifying Availability
3. Constructing habitat preference functions
   - From individual to population
   - Dealing with serial correlation
   - Modelling Complex responses
4. Making inferences
5. Predicting

Definitions

- A *habitat* is defined as an actual place with a combination of conditions, which may satisfy the requirement of the animal in question.

- *Usage* is defined as the probability of observing an animal in a particular habitat

- Habitat availability is defined as the quantity accessible to animal.

Quantifying

Quantify habitats

- Classify habitats based on 1.environmental conditions
  2. using a regular grid
- We treat each point in space as a unique habitat.

Quantify Usage

We treat each animal location as a used habitat

Quantify availability

Treat each point in space as a available habitat

Sample from infinite amount of available points for computational feasibility

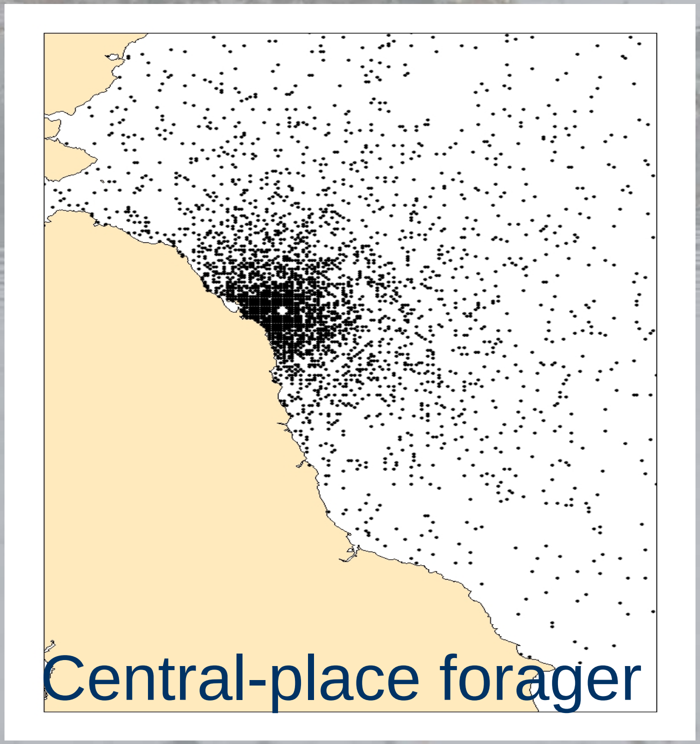
Quantify preference

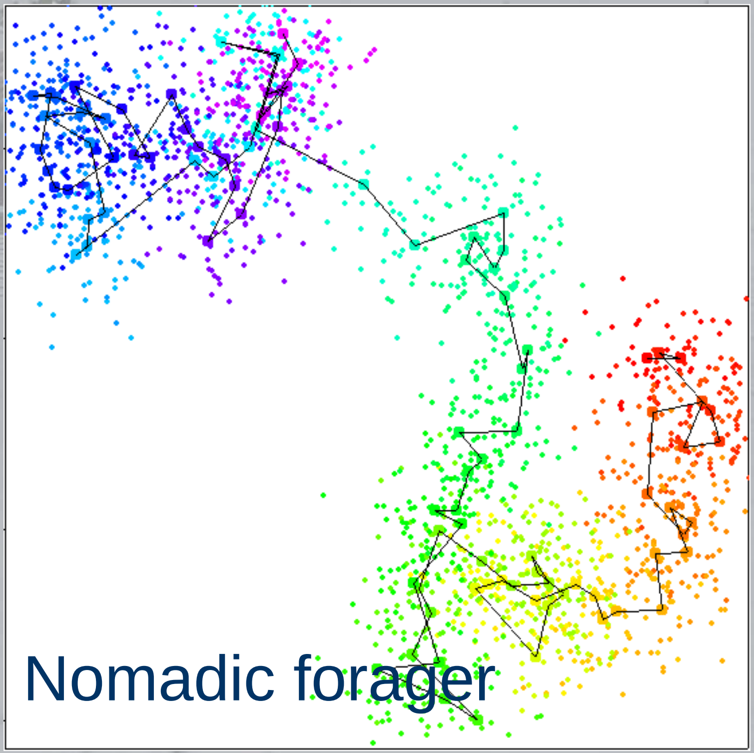
Treat Preference as a binomial variable with a value of 1 for used units (animal locations) and 0 for available units (sample ‘random’ locations).

Cont. Quantifying Availability

- *Which points/habitats to select from?*

Select only those points that are accessible →taking an individual based approach





Cont. Quantifying Availability

- *Which points/habitats to select from?*

Select only those points that are accessible →taking an individual based approach

- *How many points to select?*
  - Sample size won't effect the estimated 'selection coefficients' provided the random sample size is *moderately large* (Prentice and Pyke 1979)
  - Investigate what moderately large is by increasing sample size.

Constructing habitat preference functions

- *Using Generalized Linear Models (GLMs)*

$$f(Y) = \beta_0 + \beta_1 \cdot X_1 \cdots \beta_k \cdot X_k$$

•Y = *Preference; either 1 or 0*

•$f()$ = *link function*

•β = *Selection coefficient*

•X = *environmental conditions (e.g prey density)*

•ε = *error term*

Cont. habitat preference functions

Disadvantages:

- Treats location as sample unit
  1. Does not allow for population inferences
  2. Uses Non-independent locations

Solution

- Using Generalized Linear Mixed Models (GLMMs)

Cont. habitat preference functions

GLMM

$$f(Y_j) = (\beta_0 + b_{0j}) + (\beta_1 + b_{1j}) \cdot X_{1j} + \cdots$$

Fixed effect   Random effect

- *j = Refers to the j'th individual*
- *β = Fixed-effect: valid for the entire population*
- *b_j = Random effect: individual specific*

Treat b_j as variable: $b_j \sim N(0, \psi^2)$

Cont. habitat preference functions

GLMM/GLM disadvantage:

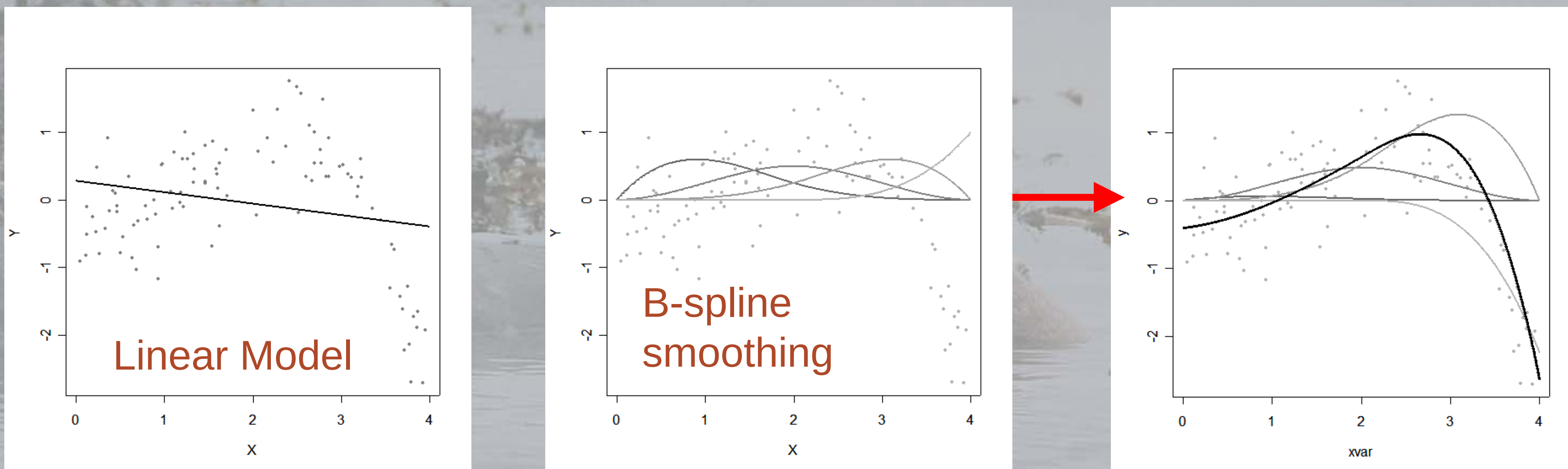
- Does not allow for complex functional relationships in preference

Solution

- Using Smoothers: We use basis spline functions using cubic polynomials.

Cont. habitat preference functions

Basis spline smoothers



Making inferences; an example study

Species:

Grey seal *(Halichoerus grypus*)

Number of individuals:

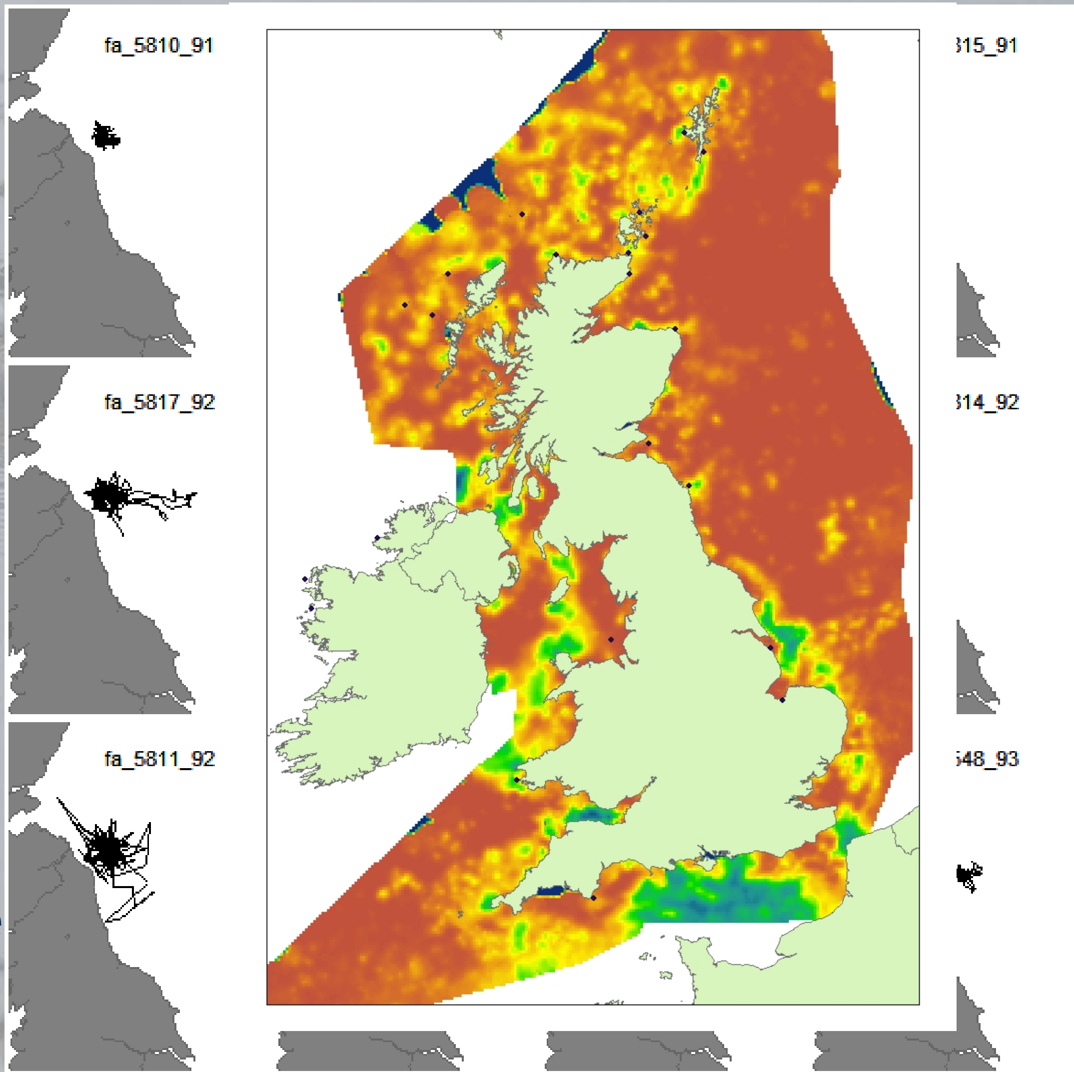
12

Where and When:

1991-1993; Farnes Islands, UK

Environmental conditions:

Gravel, mud, sand, distance and depth.



Making inferences

After fitting GNLMM

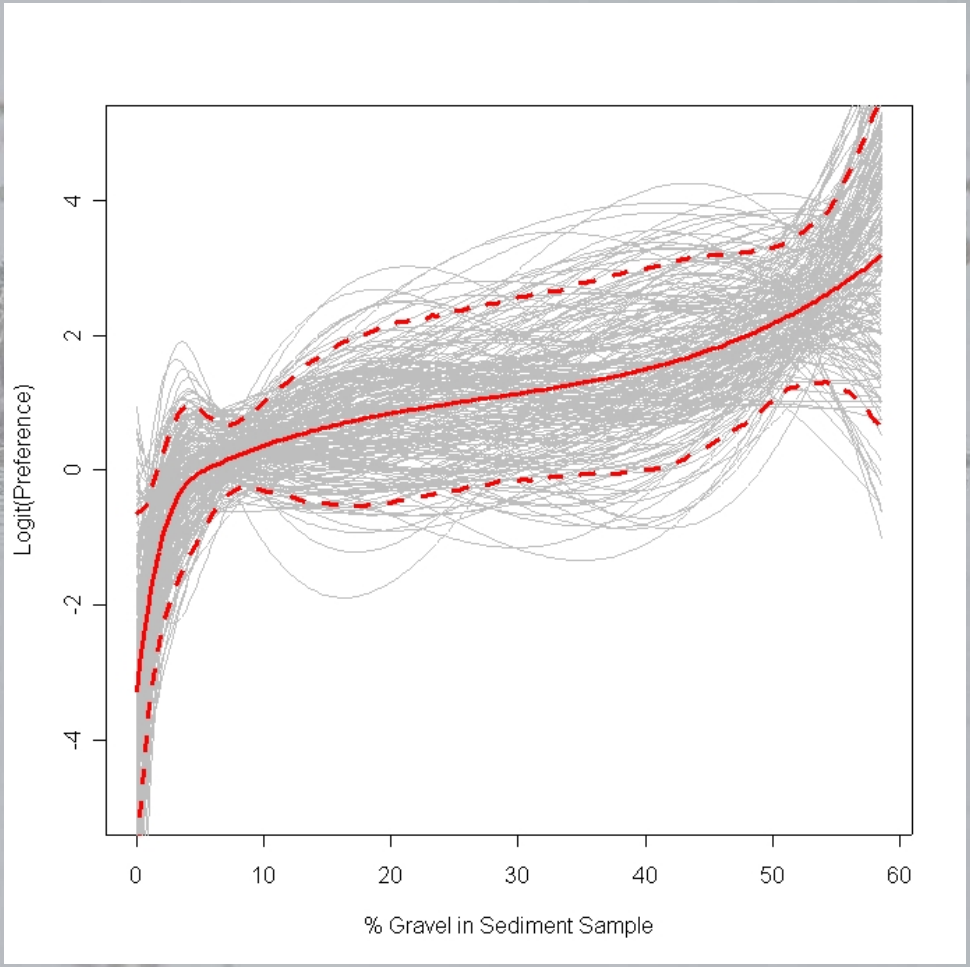
Fixed effects

"The population mean"

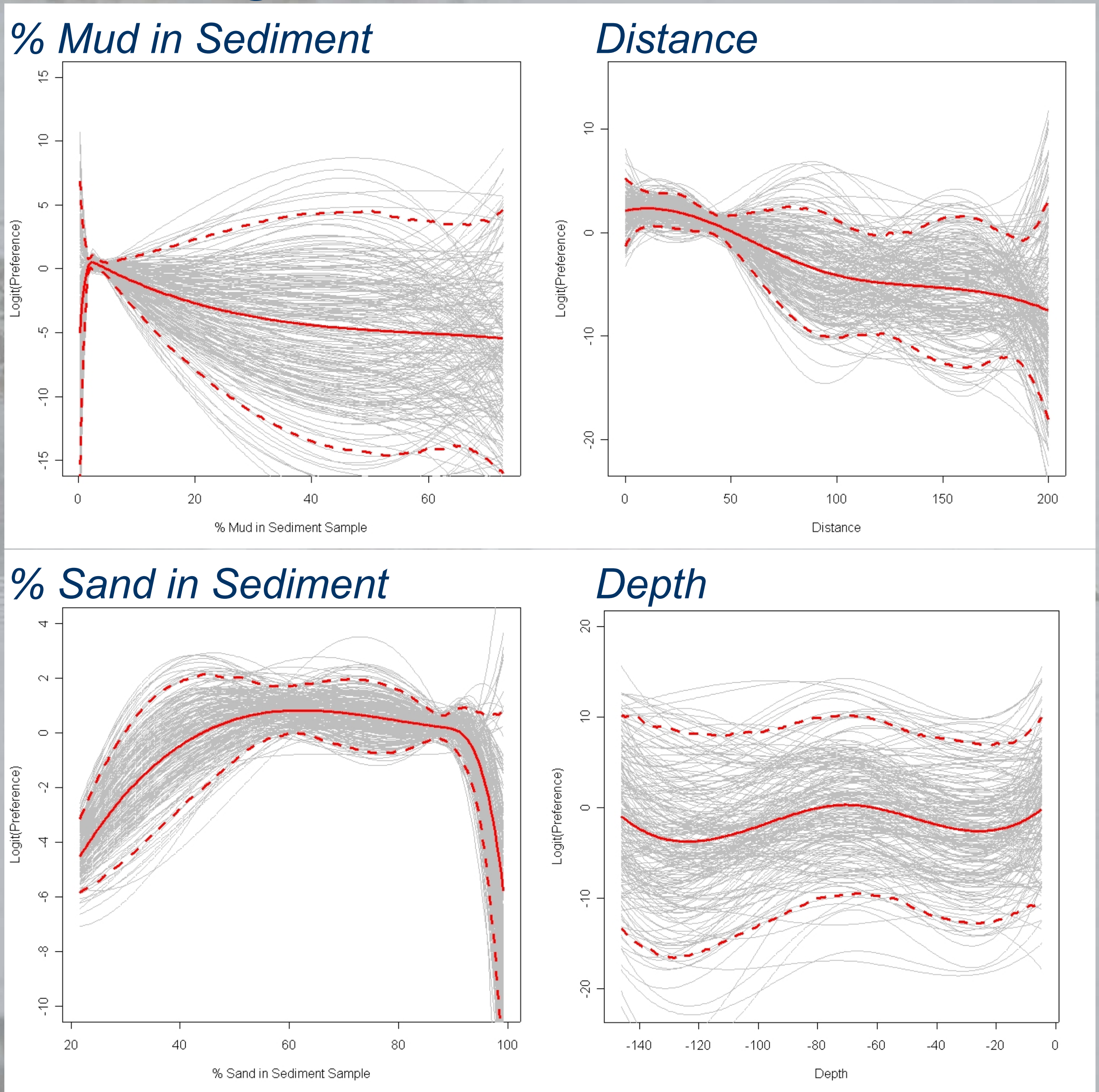
Random effects

"The individual variability"

1. Use estimates to simulate individual responses
2. Calculate confidence limits



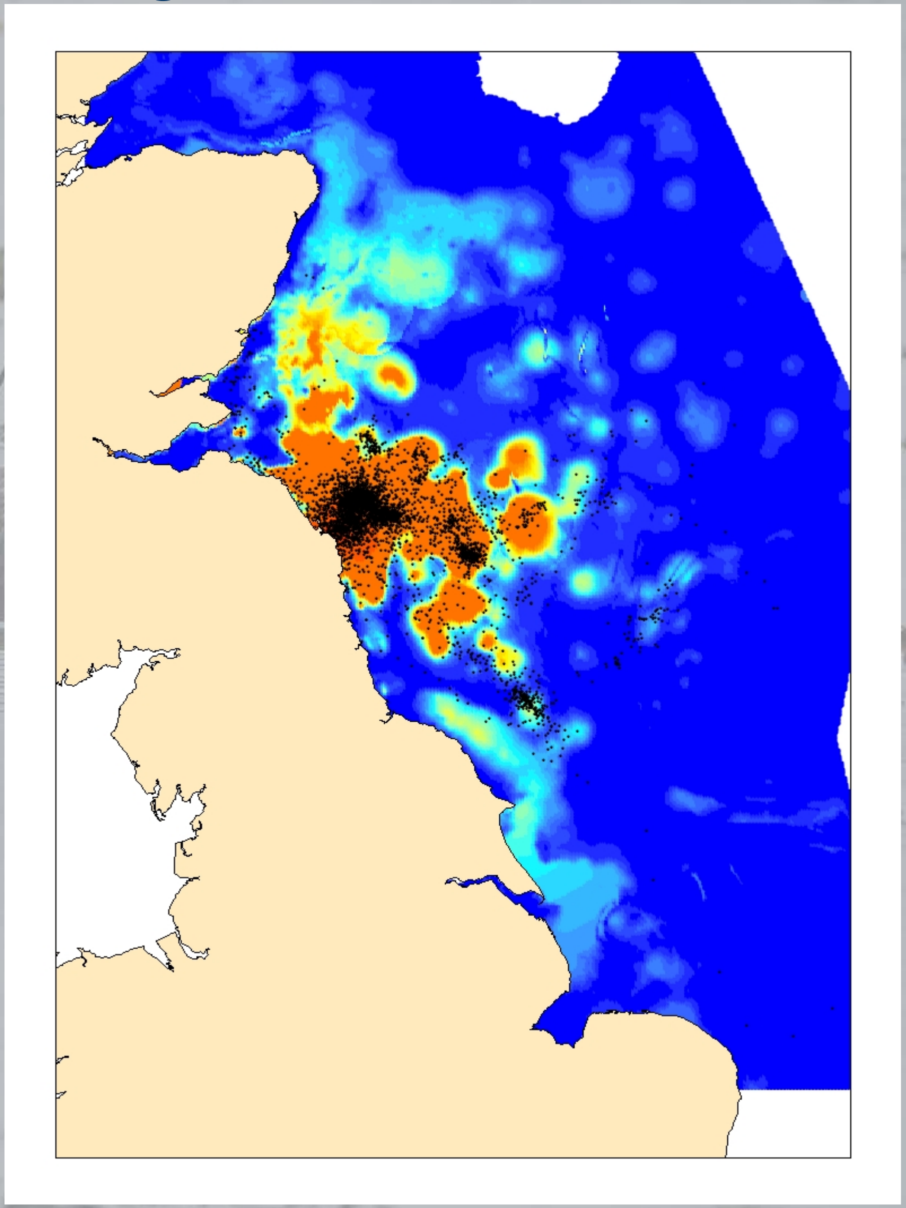
Cont. making inferences, all variables



Predicting

Objective of habitat preference studies:

1. Understanding general biology of the study animal
2. Predicting spatial distribution



Advantage of framework
Generalized Non-linear Mixed Models

- B-spline smoothers (functional data analysis) are computationally fast, flexible and few parameters are required
- Mixed models deal with dependence within levels (individuals), and allows to draw inferences about the population .

Further recommendations

This study only deals with two levels;

sub-population (individuals from central-place) and individual

Other *questions* of interest:

- Does habitat preference of individuals change over time?
- Is there a different habitat preference between sub-population?
- Do different individual characteristics (e.g age and gender) influence preference?

Extend framework:

By including more levels (population, sub-population, individual, trip, location)

Conclusion

- There is a need for a unified approach that addresses all or most of the relevant problems and is easy to understand

Example

Article:

Lebreton, J.D., Burnham, K.P., Clobert, J. & Anderson, D.R. (1992). Modelling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs*, 62(1), 67-118

Program:

MARK

Acknowledgement

- Co-authors: Jason Matthiopoulos, Monique Mackenzie, Bernie McConnell & Prof. Mike Fedak
- DSTL-MOD for funding
- BGS & UKHO for raw sediment data and digital bathymetric map
- SMRU for all (scientific) support; Mike Lonergan, Ian Boyd, Clint Blight, Dave Tompson, Simon Moss and other fieldworkers in particular.