Fisheries distribution modelling.

New fisheries management requirements need new modelling approaches.

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Ecosystem Approach to Fisheries Management (EAFM)

- What is EAFM?

  Preserve quality ecoystems $\rightarrow \uparrow\uparrow\uparrow$ fish productivity

- What is an ecosystem?
- What information do we need to assess a potentialy productive site?

  - Species distribution
  - Key life stages distribution
  - Interactions among species
  - Persistence
  - Ecosytemic balance
  - Human disturbance

Fishery data

- Two types of fishery data:
  - Fisheries independent data: survey data
    - Random sampling
    - Good quality of the data
    - Limited amount of data
  - Fisheries dependent data: commercial fishery data
    - Preferential sampling
    - Poor data quality
    - A lot of data
- Trawl data characteristics:
  - Transect
  - Variable towing time
  - Measured in Kilograms
  - Variable horizontal aperture

Thus generaly calculate the Catch Per Unit Effort (CPUE)

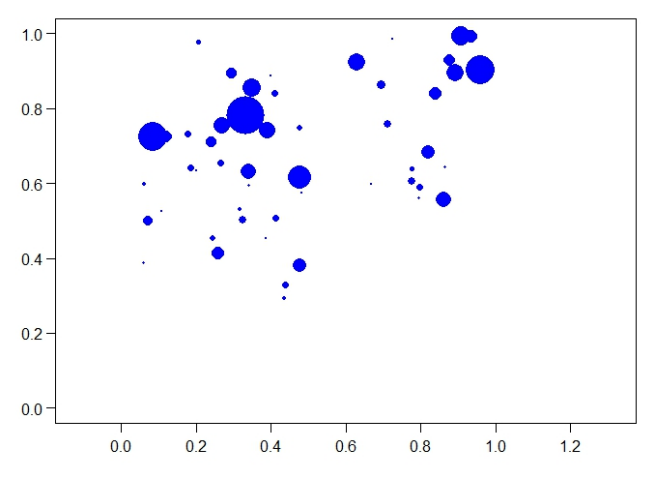
Bayesian computation using INLA

Why do I use INLA?

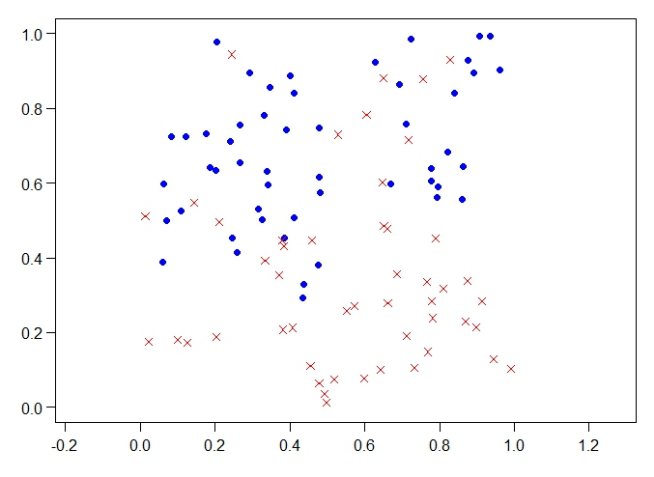
- Main advantage of INLA over MCMC alternatives: Computational speed
- INLA allow us to easily fit a very wide range of models and apply many types of effects to our covariates.
- Fairly good flexibility to manipulate models and likelihoods
- Problems:
  - There is not as much literature as for other packages
  - It can be used as a 'black box'

Typical Fish spp distribution modelling

Abundance (CPUE)



Presence/absence



Typicaly:

- Use geostatistics & krigging
- Assign transect to a point
- Two part modelling
  1. Occurrence
  2. Abundance

A biologist would always enquire:

Don't you consider zero values as abundance observations?

Best solution so far: Joint modelling

$$Y_i = \mathbf{X_i}\boldsymbol{\beta_y} + w_i$$
$$Z_i = \mathbf{X_i}\boldsymbol{\beta_z} + \alpha w_i$$

Temporal persistence of a process

- Fishing spatial closures depend on the persistence of the distribution.
  - Persistent process $\rightarrow$ fixed spatial closure
  - Non-persistent process $\rightarrow$ temporal spatial closure

- How could we assess the persistence of a spatial process?

Persistent process

$$u_{ij} = w_{ij} + v_j$$
$$\mathbf{w} \sim \mathcal{N}(0, Q)$$
$$v_j \sim \mathcal{N}(0, \rho)$$

Non-persistent process

$$u_{ij} = w_{ij}$$
$$\mathbf{w}_j \sim \mathcal{N}(0, Q)$$

Interaction among species

- Does the abundance of *Fish spp1* influence the abundance of *Fish spp2*

$$\begin{aligned} \textit{Fish spp1} &= \mathbf{X_1}\beta_{\mathbf{spp1}} + w_{spp1} \\ \textit{Fish spp2} &= \mathbf{X_1}\beta_{\mathbf{spp2}} + w_{spp2} + \alpha w_{spp1} \end{aligned}$$

- Possible α outcomes:

- $\alpha > 0 \rightarrow$ Positive interaction
- $\alpha < 0 \rightarrow$ Negative interaction
- $\alpha = 0 \rightarrow$ No interaction

- We could add as many species as our computer enables us to. These interactions may be related to the trophic balance!!!

Human disturbance

- Trawl fishery has a huge environmental impact.
  - Sea-bottom disturbance
  - Up to 90% of discards

- What data/likelihood should we use to measure discarding yield?

DPUE	$\rightarrow$	Log-Gaussian/Gamma
Proportions	$\rightarrow$	Beta/??

- In order to understand discarding behaviour, we may need to disaggregate the discard by species and include temporal analysis.
  - Temporal trend
  - Temporal correlation

More things that need to be tackled

- Combining survey data and commercial fishing data.
- Trawl transect vs point referenced data.
- Including the weight of different presence observations. Absence?
- Etc.

References

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2. H. Rue y L. Held, *Gaussian Markov Random Fields. Theory and Applications*.
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