Spatial models integrating two survey platforms

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This talk

- Some practical issues
- Rhode Island case study
- Not much model detail (but do ask me about this!)
- More about “model independent” checking
- Diagnostics etc

Case study:

Common loons in Rhode Island

Space, Right Arrow or swipe left to move to next slide, click help below for more details

A common loon (*Gavia immer*)

Photo by jackanapes on flickr (CC BY-NC-ND)

OSAMP

- Ocean Special Area Management Plan
- Windfarm development nr. Block Island
- Part of state-wide EIA
- Potential pre-impact survey

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RESEARCH ARTICLE

Integrating aerial and ship surveys of marine birds into a combined density surface model: A case study of wintering Common Loons

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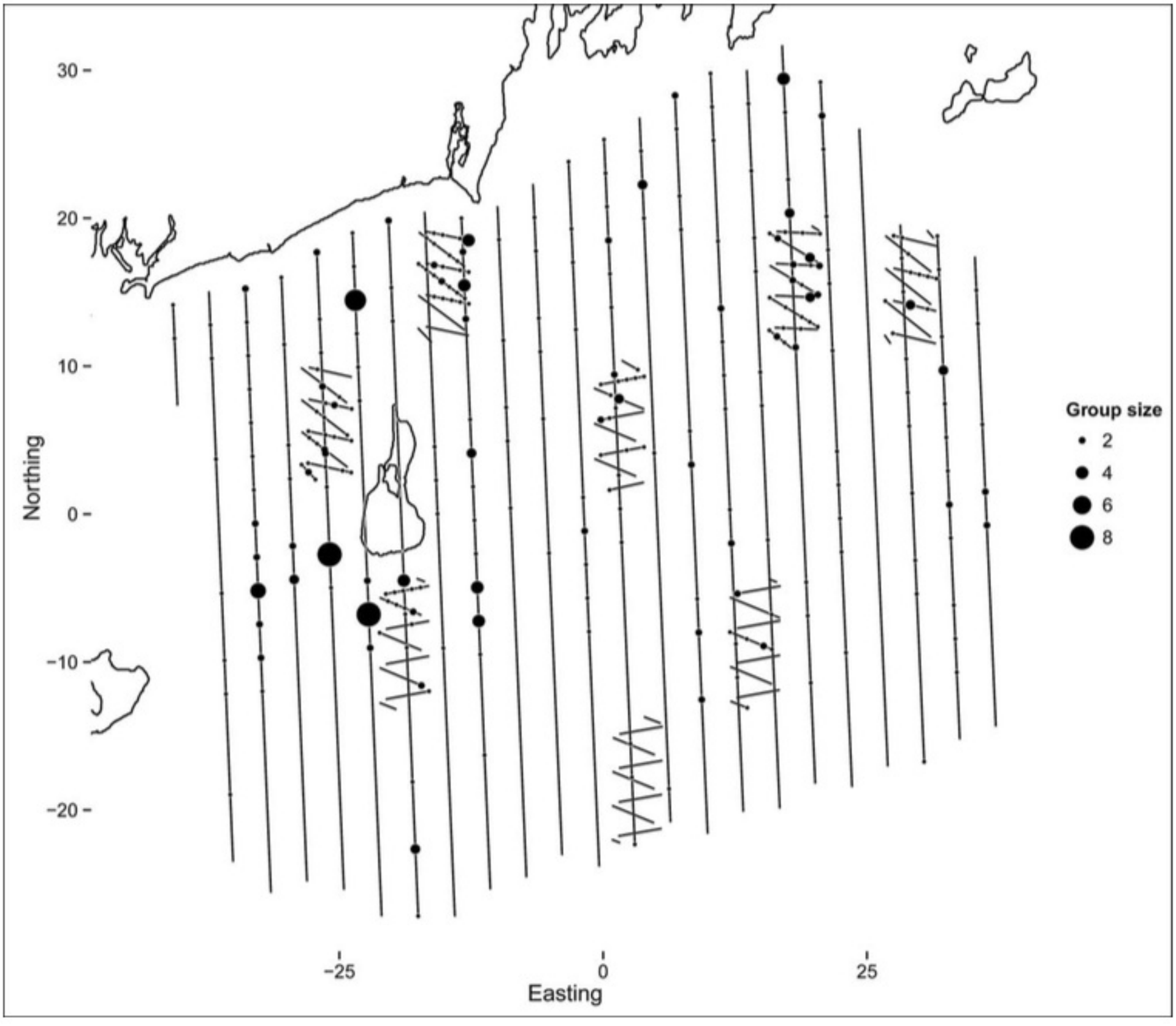
ABSTRACT

Biologists now use a variety of survey platforms to assess the spatial distribution and abundance of marine birds, yet few attempts have been made to integrate data from multiple survey platforms to improve model accuracy or precision. We used density surface models (DSMs) to incorporate data from two survey platforms to predict the distribution and abundance of a diving marine bird, the Common Loon (*Gavia immer*). We conducted strip transect surveys from a multiengine, fixed-wing aircraft and line surveys from a 28 m ship during winter 2009–2010 in a 3,800

Rhode Island Surveys

- 2 platforms
- Ship-based surveys
  - *8 grids of zig-zag randomly located*
  - *10 days – 2 December 2009 - 13 February 2010*
  - *Single observer distance sampling*
- Aerial surveys
  - *24 transects*
  - *9 days – 2 December 2009 - 22 February 2010*
  - *Strip transects*


30
20
10
0
−10
−20
Northing
−25
0
25
Easting
Group size
2
4
6
8

How do we integrate this data?

Considerations

- Detectability
- Availability
- Effort
- Overlap (temporal and spatial)
- Variance estimation

Density surface models

Density surface models

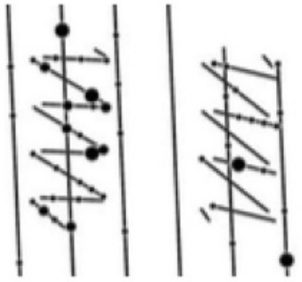
(Spatial models that account for detectability)

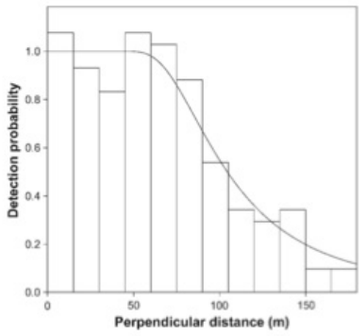
Density surface models

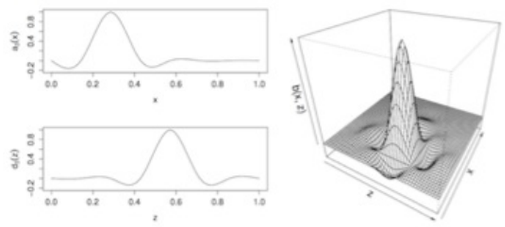
(Spatial models that account for detectability)

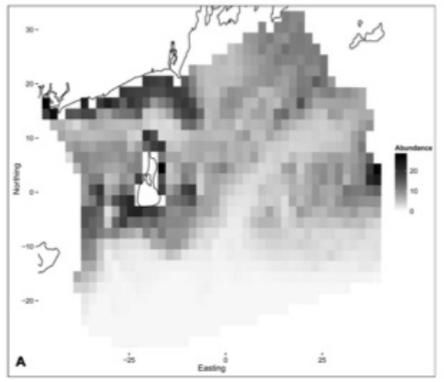
(…and more)

≥ 2-stage models









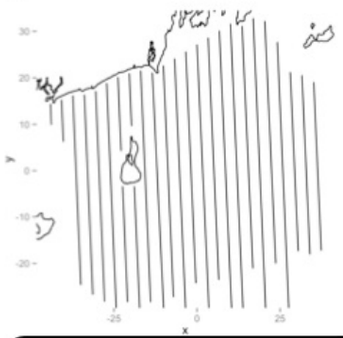
Line transects

Detectability

Availability

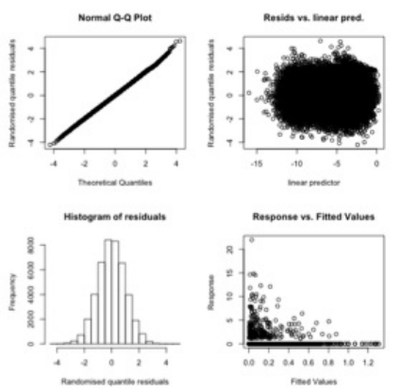
Spatial model (GAM)

Inference



Strip transects

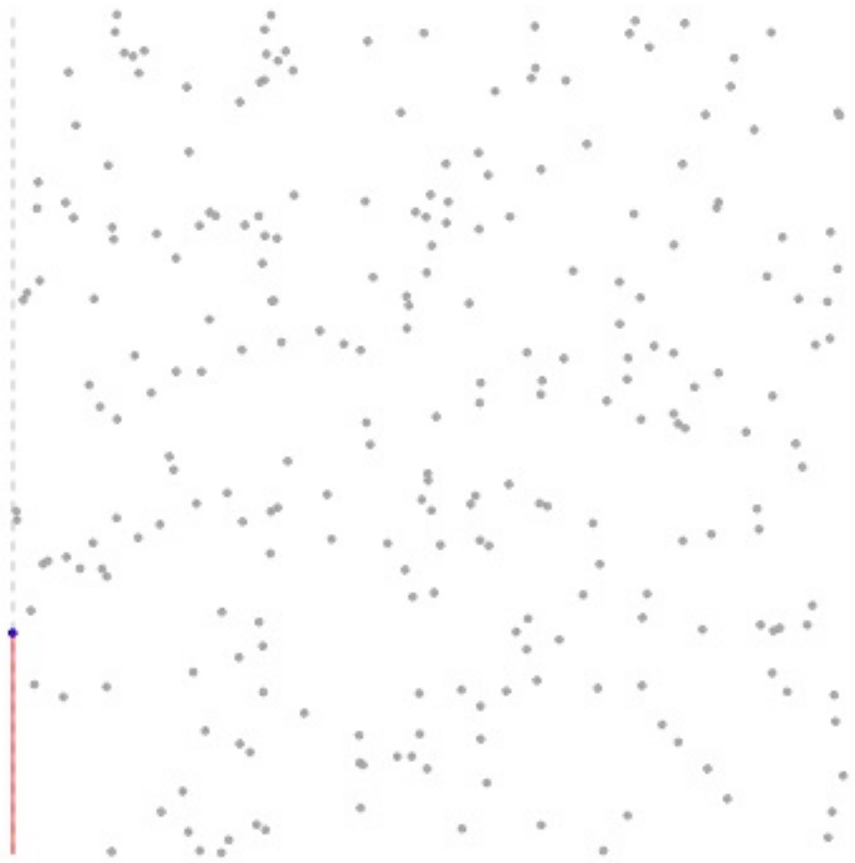
Model checking/ criticism

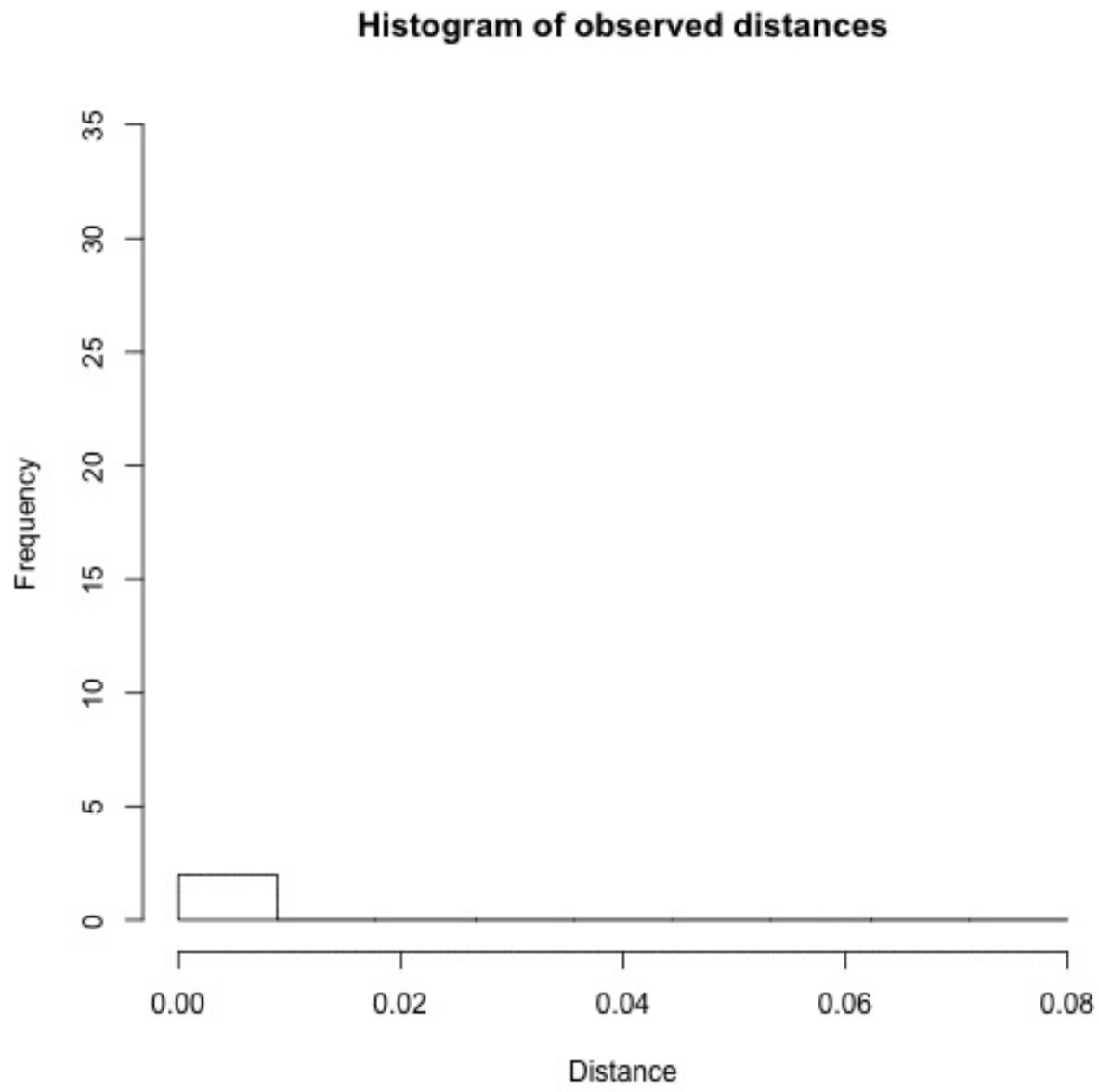


Hedley and Buckland (2004). Miller et al (2013).

Detectability

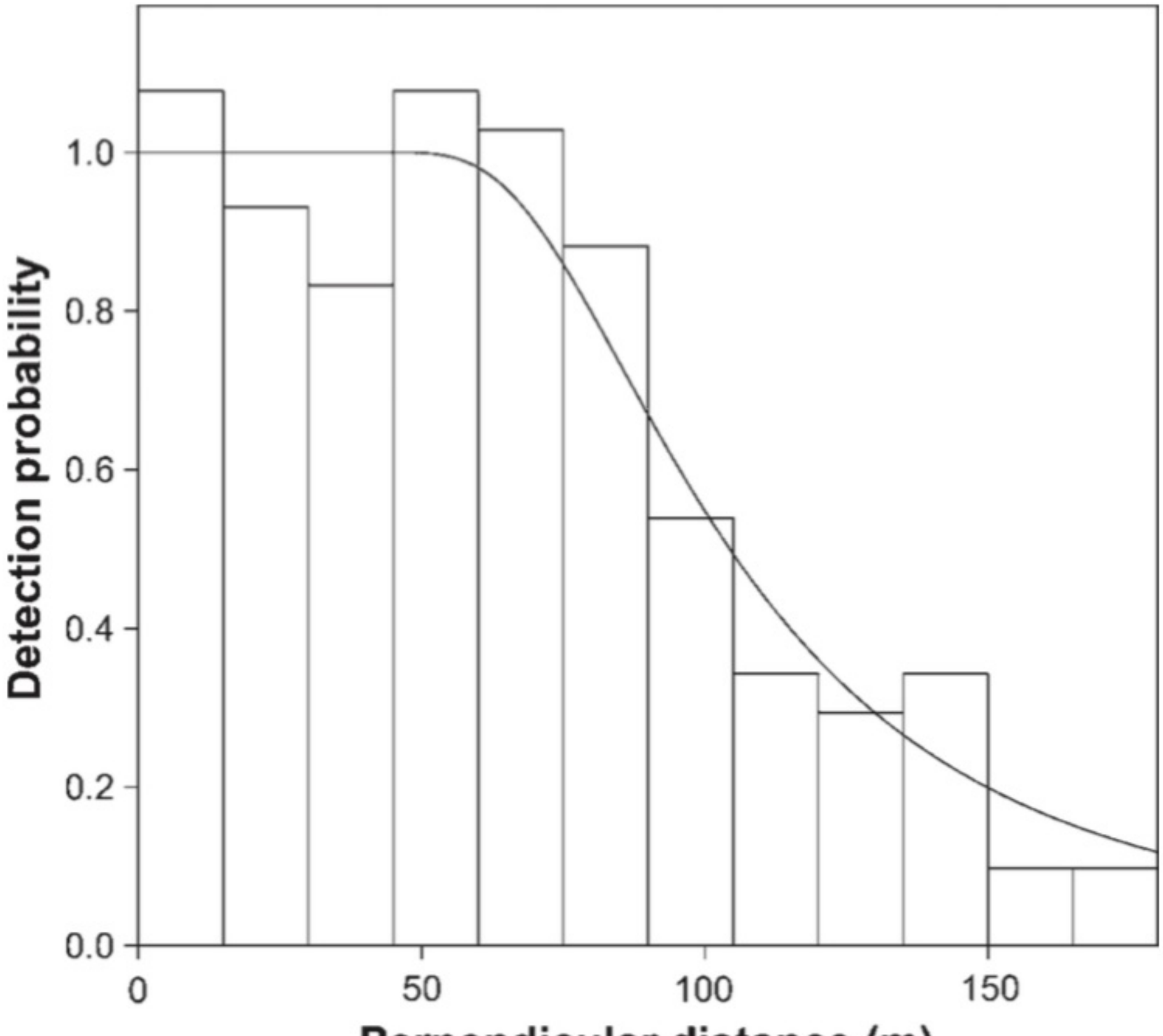
Distance sampling - line transects





Code for animation at https://gist.github.com/dill/2b0c120d5484d338d8ef

Detection functions



Detection functions

$$\mathbb{P}\,[\text{animal detected} \mid \text{animal at distance y}]$$

Integrate out distance:

$$\hat{p_i} = \frac{1}{w}\int_0^w g(y;\hat{\boldsymbol{\theta}}, z_i)dy$$

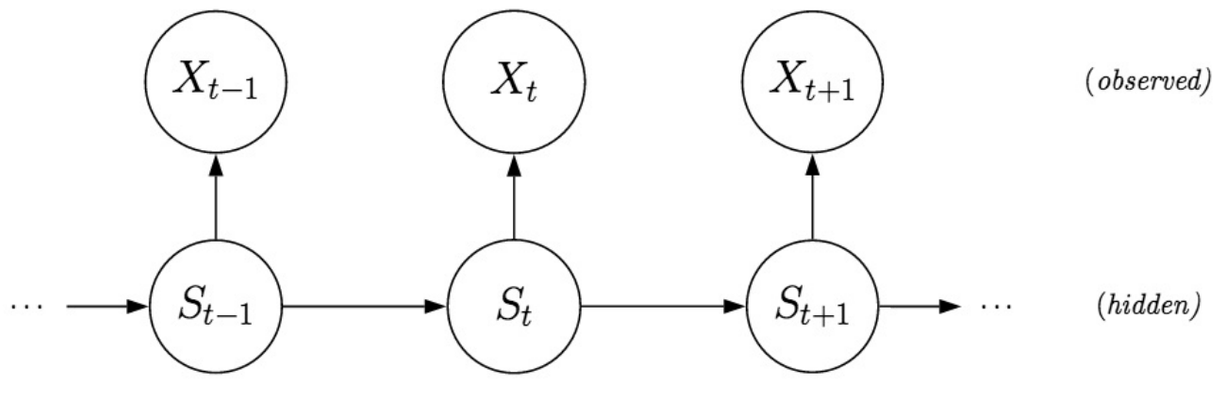
or...

$$p = 1$$

Availability

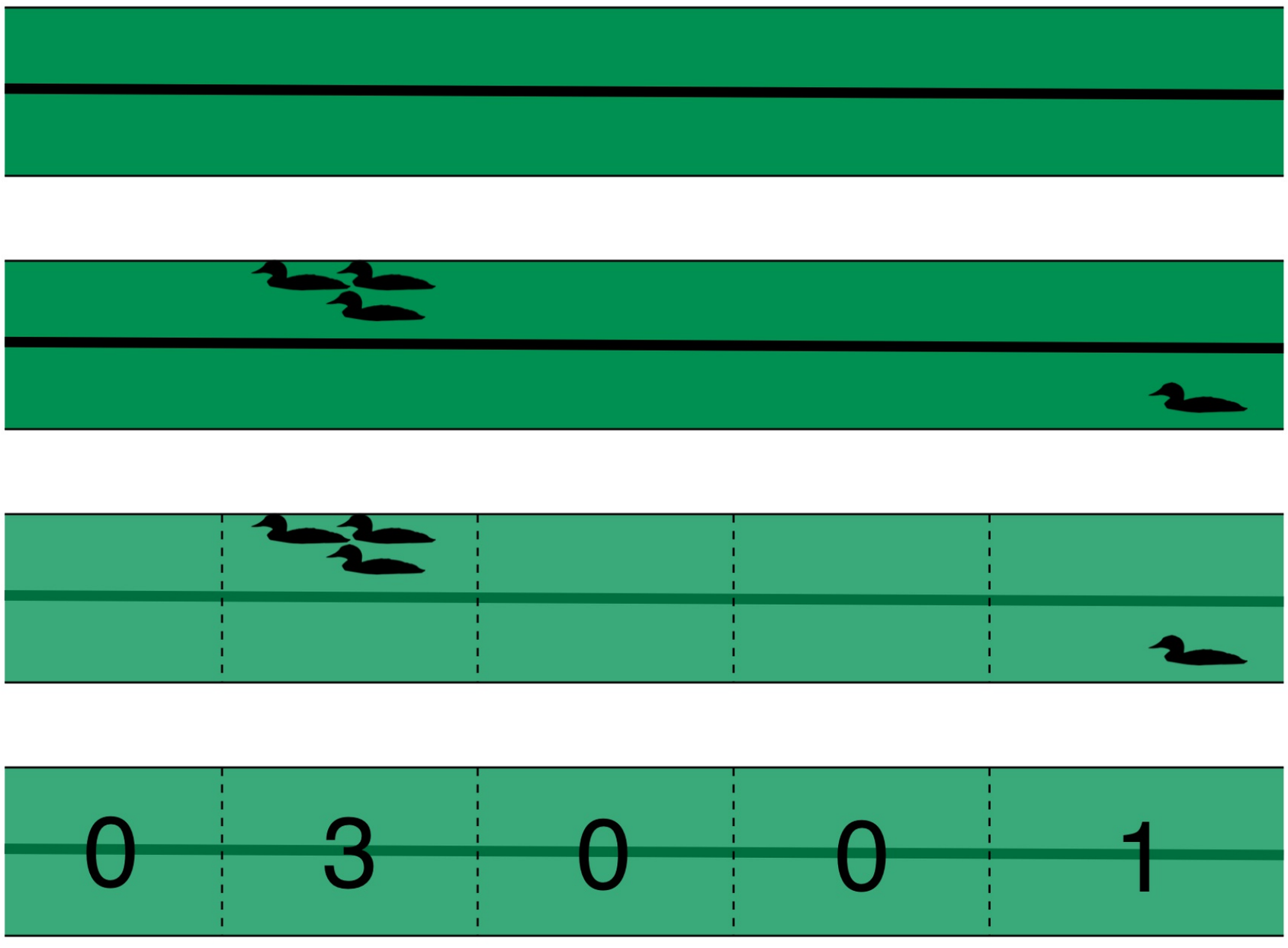
Availability correction

- Simple correction
  - *Ford & Gieg (1995) quantified diving habits in RI waters*
- More complicated stuff
  - *Borchers, Langrock & co have many solutions using Hidden Markov Models*
- (Different for different platforms?)



Effort

Data setup



Gavia immer from PhyloPic.

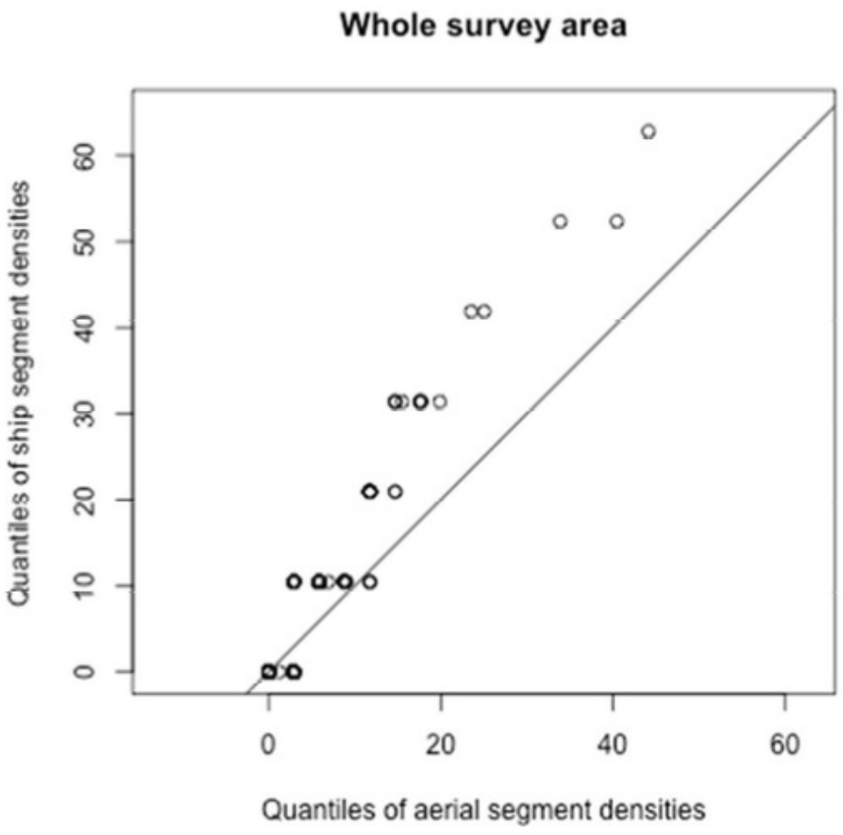
Effort

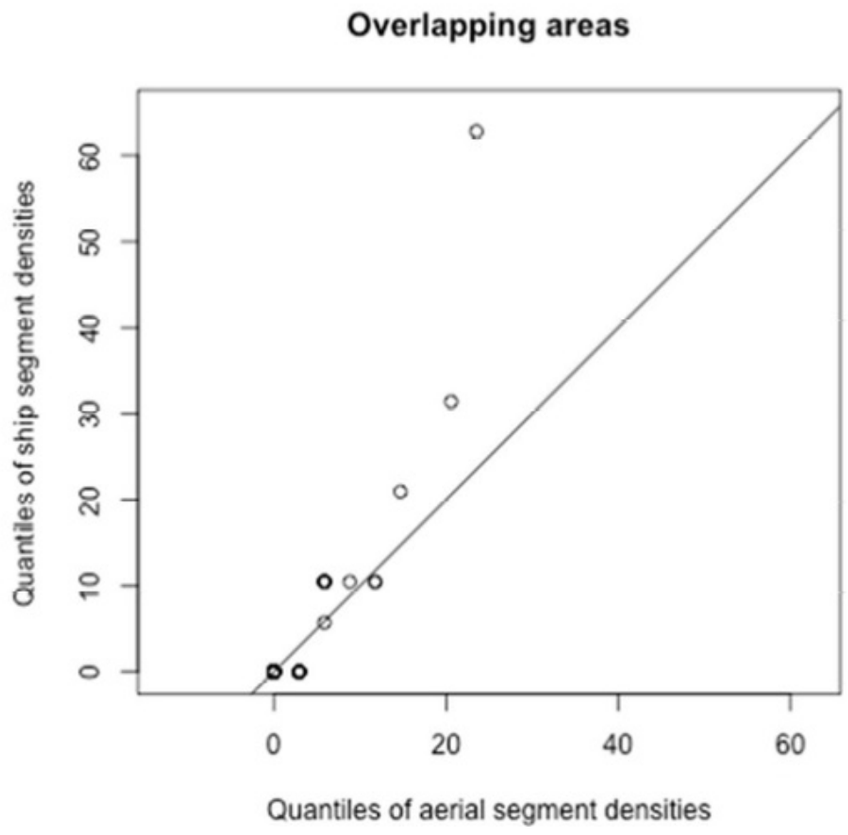
- “Simple” here
- Strip transects == line transects w. $p = 1$ (nesting)
- Always surveying surface (effort equivalence)
- (More complex with different “types” of data)
- (Need to find equivalency?)

Overlap

Overlap

- Ensure we're not combining apples and oranges
- Are counts/unit effort reasonable?
- Compare overlapping & non-overlapping areas
- Quantile-quantile plots – Kolmogorov-Smirnov tests (Cramer-von Mises?)
- Sensitivity – leave-k-out cross-validation





Spatially explicit models

Spatial model

- Generalized Additive Models (GAMs)

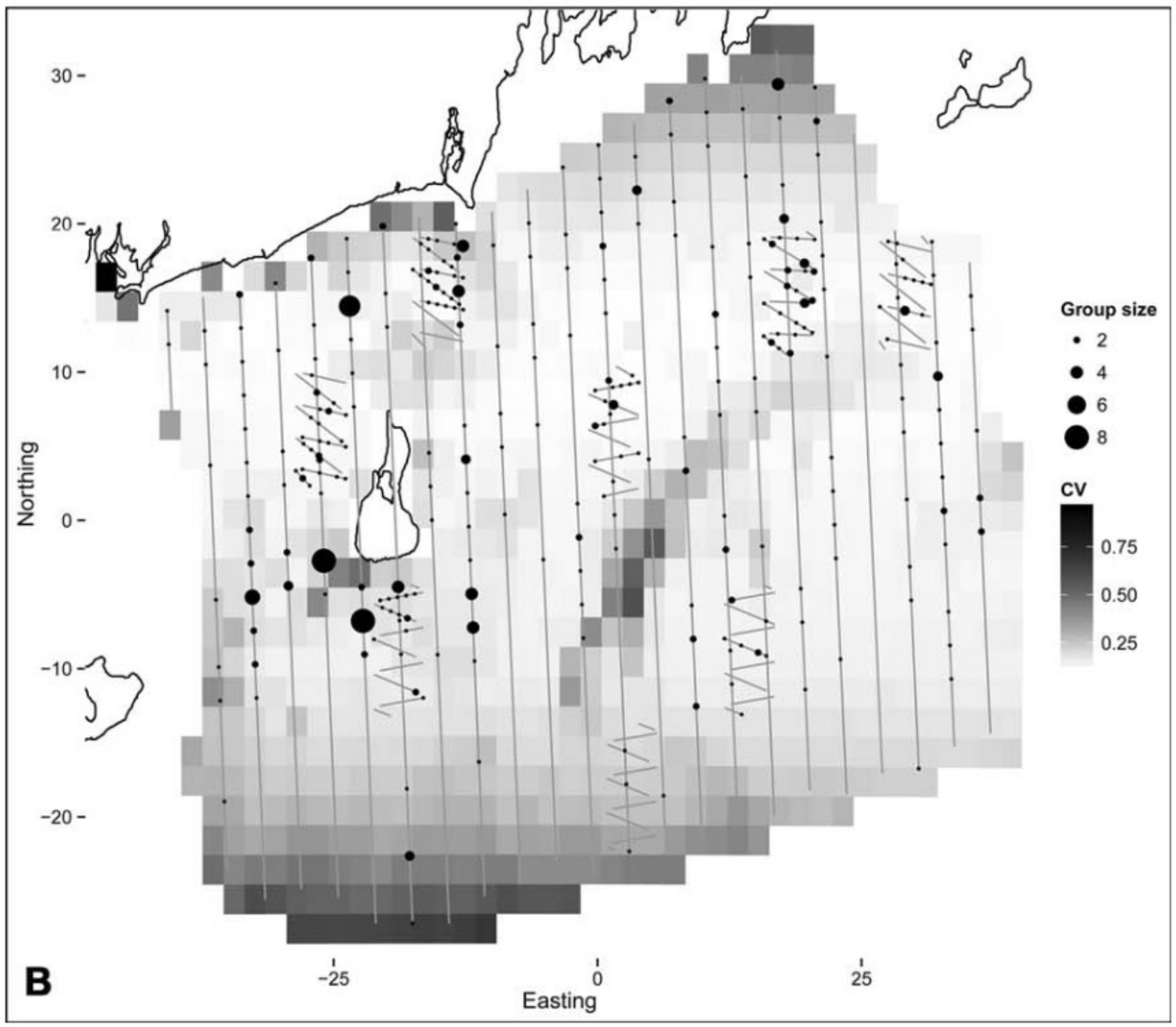
$$(\hat{n_j}) = A_j \exp\left\{\beta_0 + \sum_k f_k(z_{jk})\right\}$$

- $\hat{n_j}$ ~ count distribution (raw or Horvtiz-Thompson estimate)
- f_k are *smooth* functions (splines $\Rightarrow f_k(x) = \sum_l \beta_l b_l(x)$)
- f_k can just be fixed effects $\Rightarrow$ GLM
- Add-in random effects, correlation structures $\Rightarrow$ GAMM
- A_j is area of segment
- R package `dsm`
- Wood (2006) is a good intro to GAMs

Variance estimation

Uncertainty propagation

- Major criticism of ≥ 2-stage models
- Uncertainty from detection function AND spatial model (and…)
- Refit model with "extra" term – zero mean effect, variance contribution
- Williams et al (2011). Bravington, Hedley and Miller (in prep)



Conclusions

Conclusions

- Ensure that data are compatible *before* modelling
- Equivalency in effort tricky for non-trivial cases
- Two-stage models can be useful!
  - *Distribute tasks*
  - *Modular model checking*
- Existing statistical framework (GAM)
- Flexible spatial models
  - *Detectability*
  - *GLMs + random effects + smooths + other extras*
  - *autocorrelation can be modelled*
  - *accounting for uncertainty*

Acknowledgements

- St Andrews: Eric Rexstad, Louise Burt
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Thanks!

Slides available at

converged.yt

Course at Duke in October:

nicholas.duke.edu/del/distance

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