

What is a density surface model?

Why model abundance spatially?

- Use non-designed surveys
- Use environmental information
- Maps

Back to Horvitz-Thompson estimation

Horvitz-Thompson-like estimators

- Rescale the (flat) density and extrapolate

$$\hat{N} = \frac{\text{study area}}{\text{covered area}} \sum_{i=1}^n \frac{s_i}{\hat{p}_i}$$

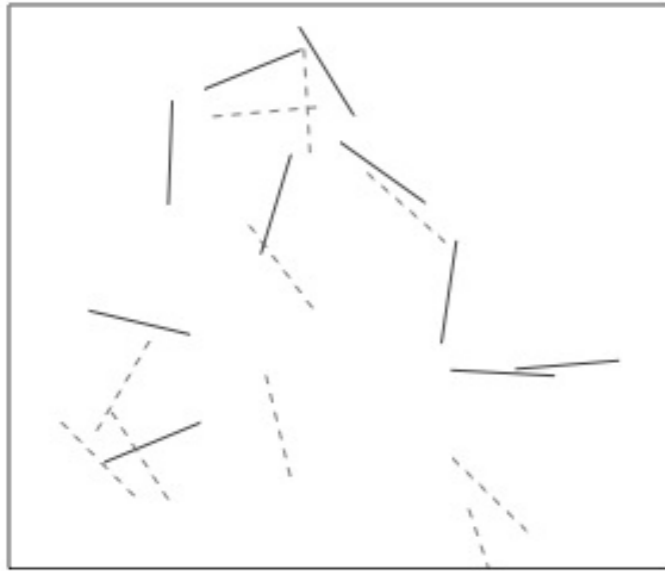
- s_i are group/cluster sizes
- \hat{p}_i is the detection probability (from detection function)

Hidden in this formula is a simple assumption

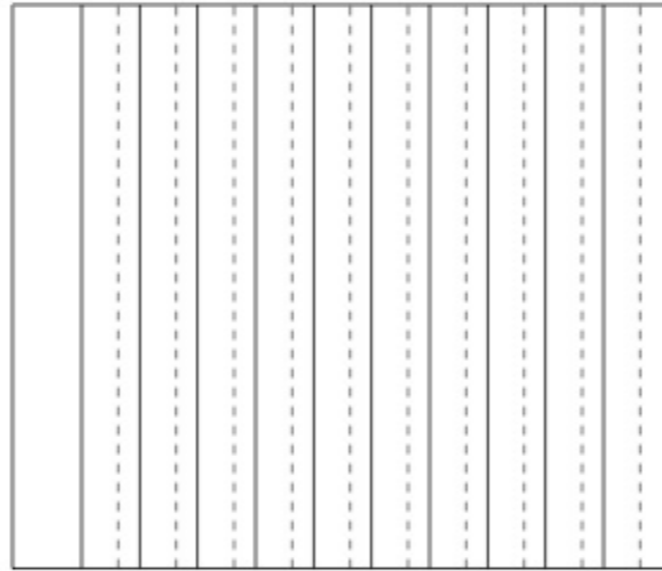
- Probability of sampling every point in the study area is equal
- Is this true? Sometimes.
- If (and only if) the design is randomised

Many faces of randomisation

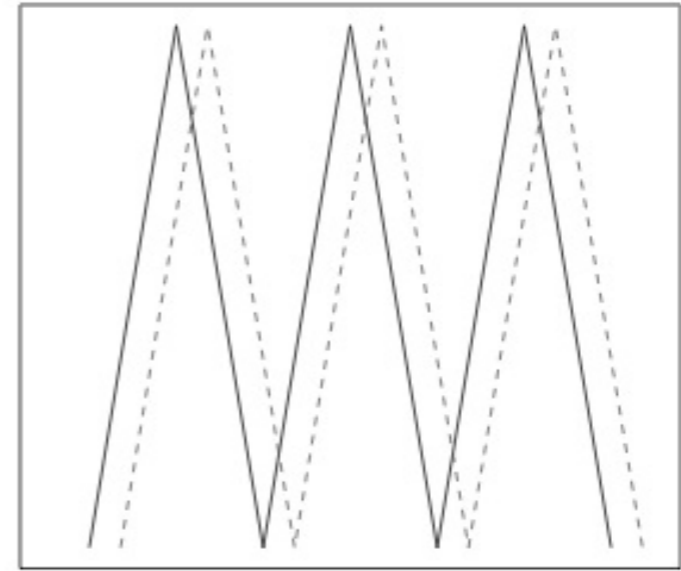
random placement



random offset parallel lines

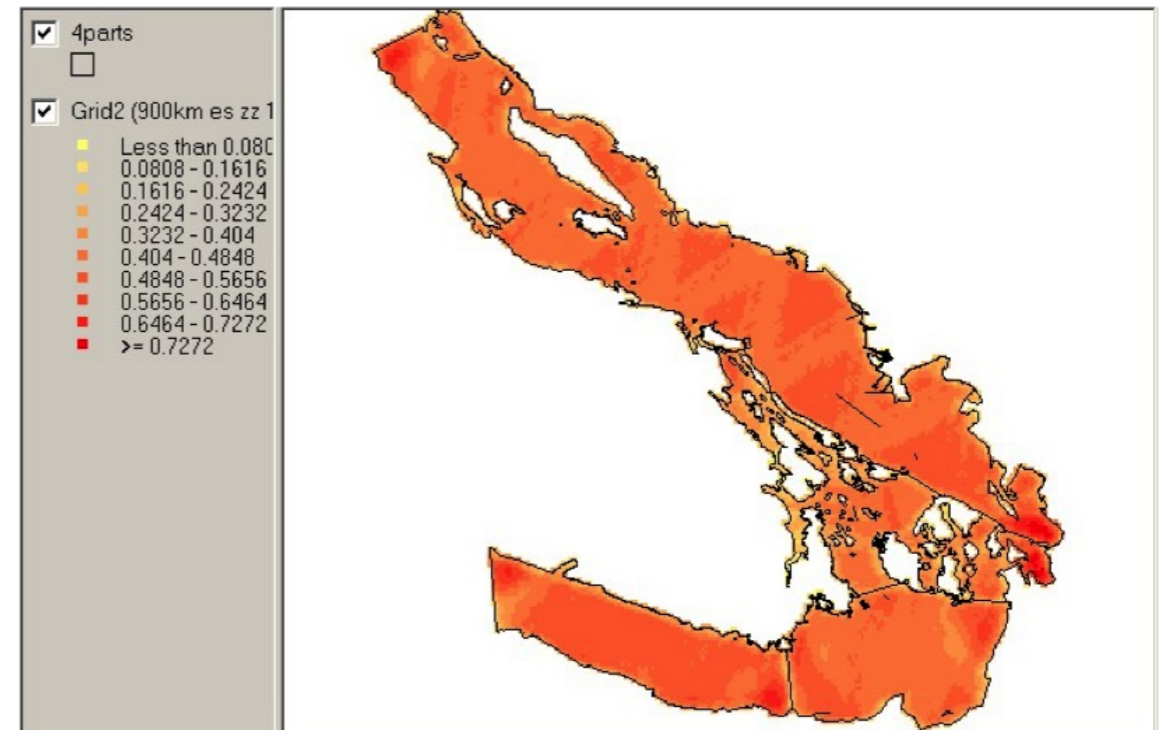


random offset zigzag

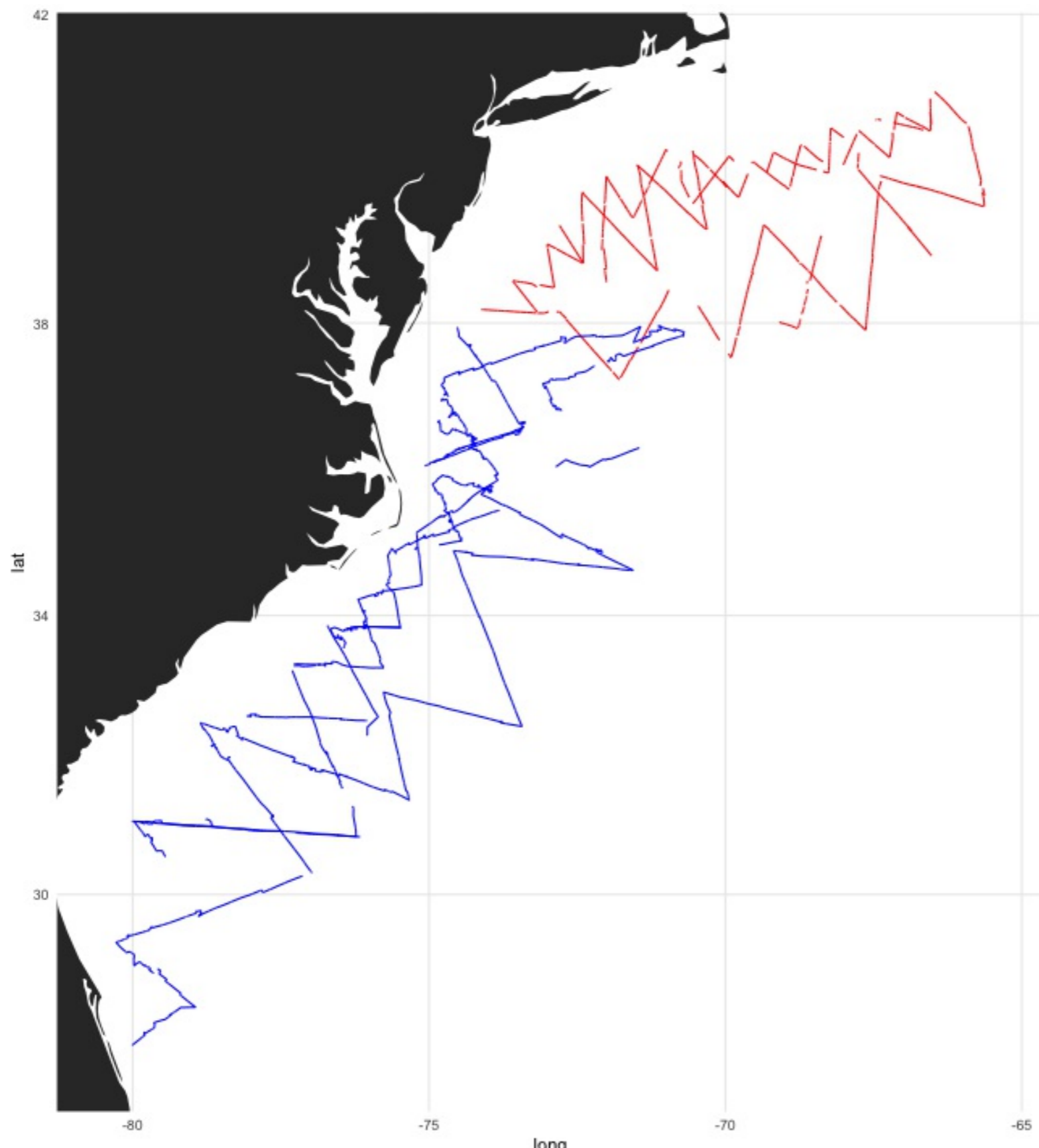


Randomisation & coverage probability

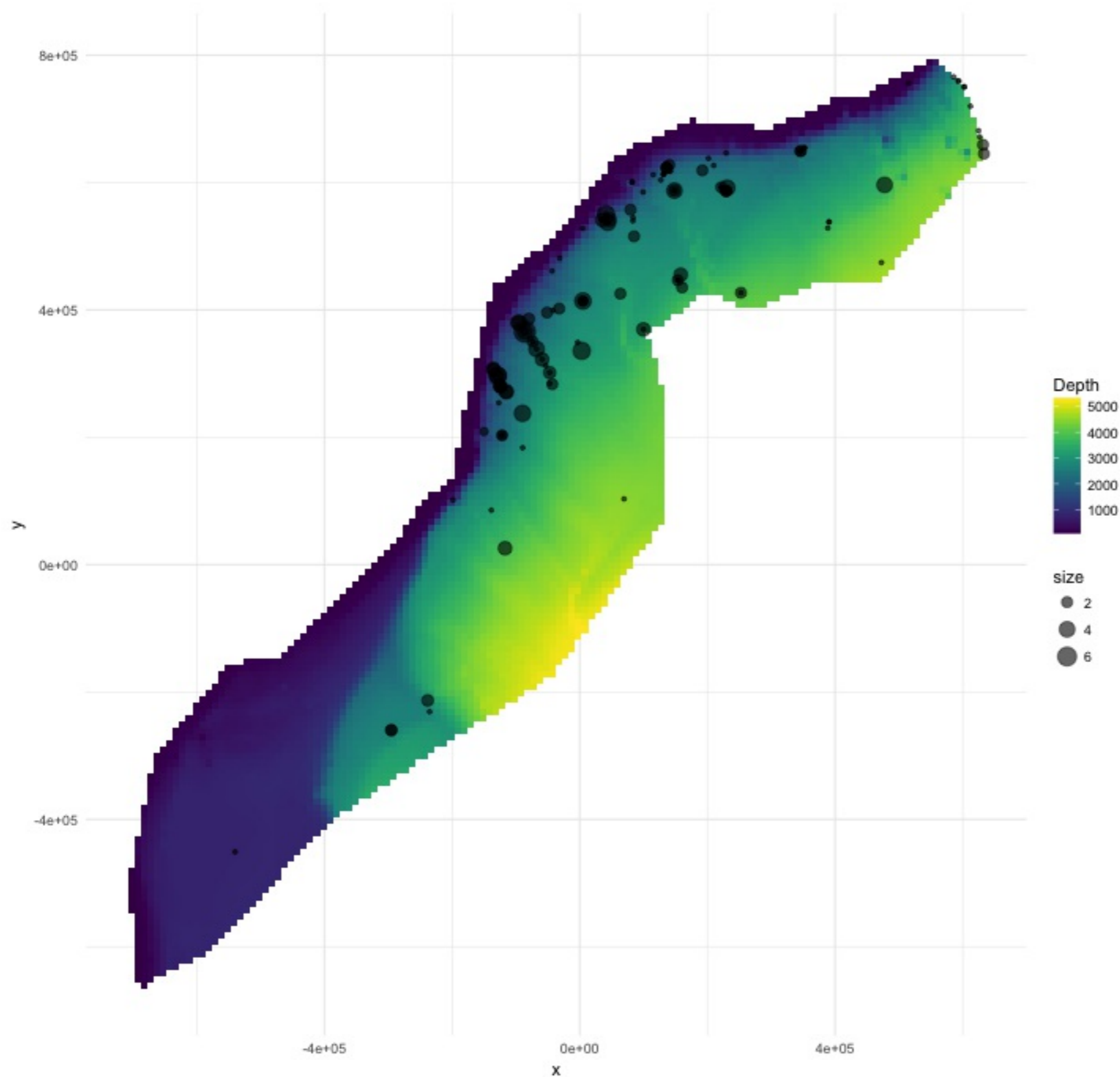
- H-T equation above assumes even coverage
 - (or you can estimate)



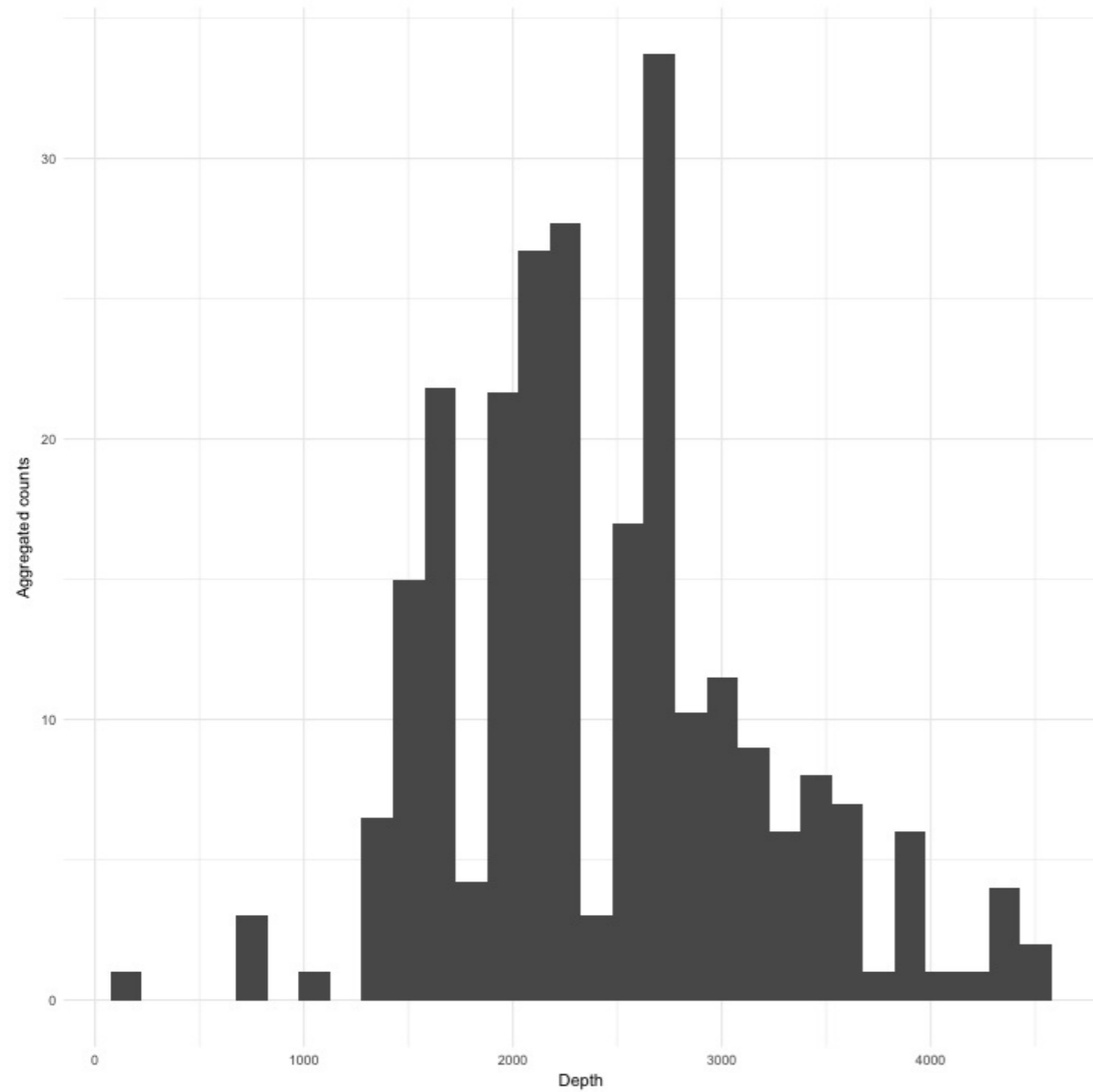
Extra information



Extra information - depth

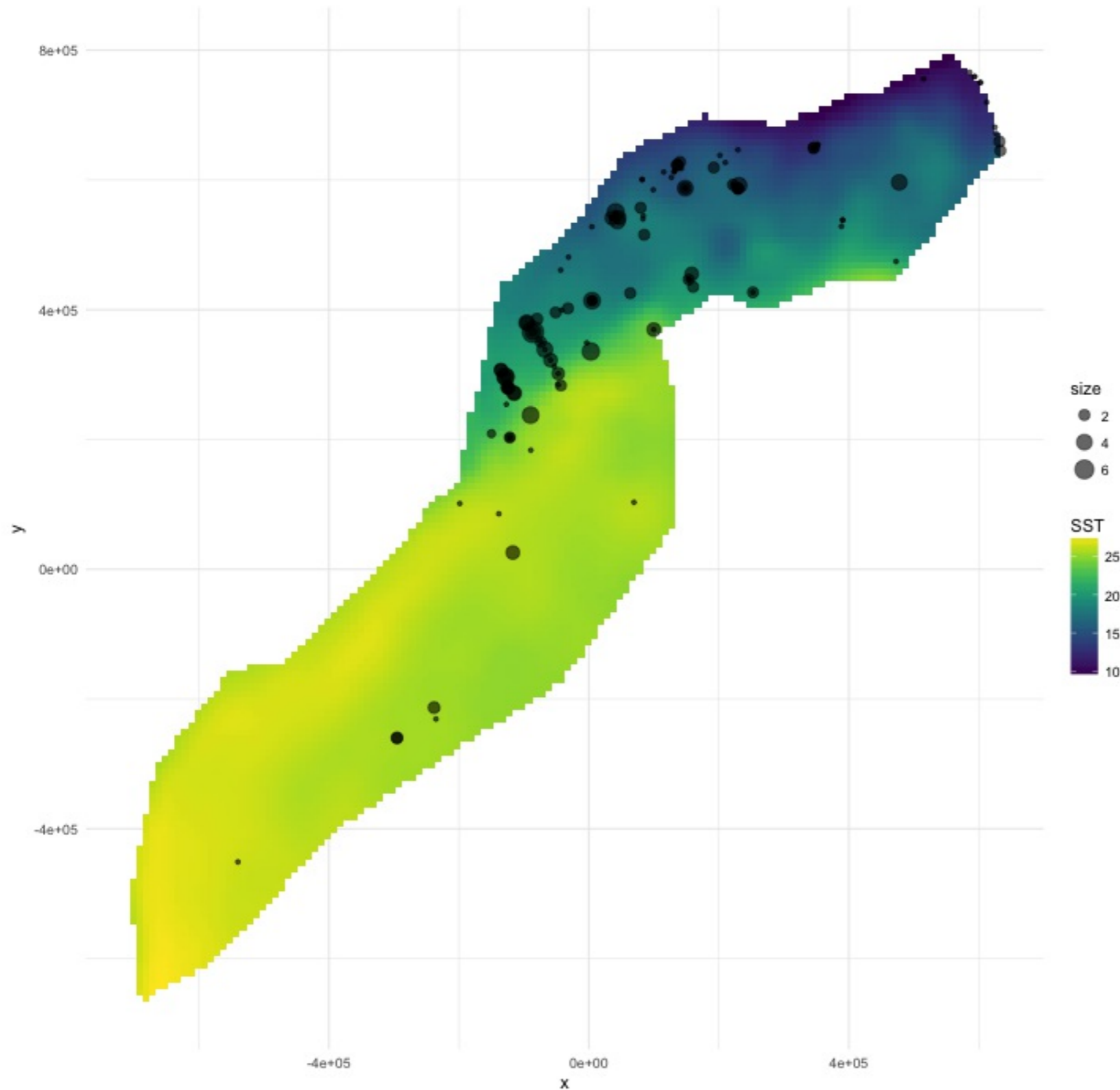


Extra information - depth

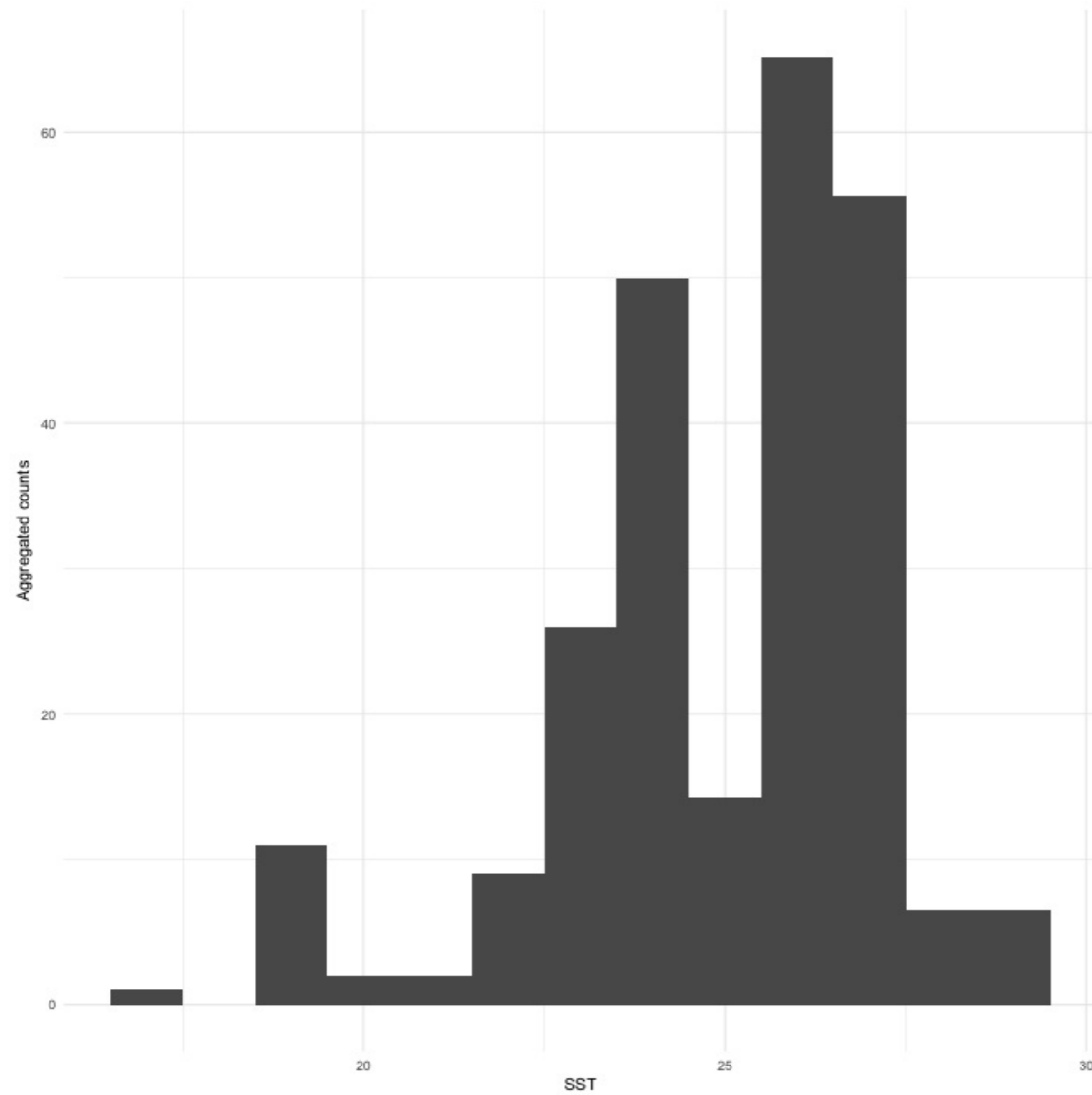


- NB this only shows segments where counts > 0

Extra information - SST



Extra information - SST



- (only segments where counts > 0)

You should model that

Modelling outputs

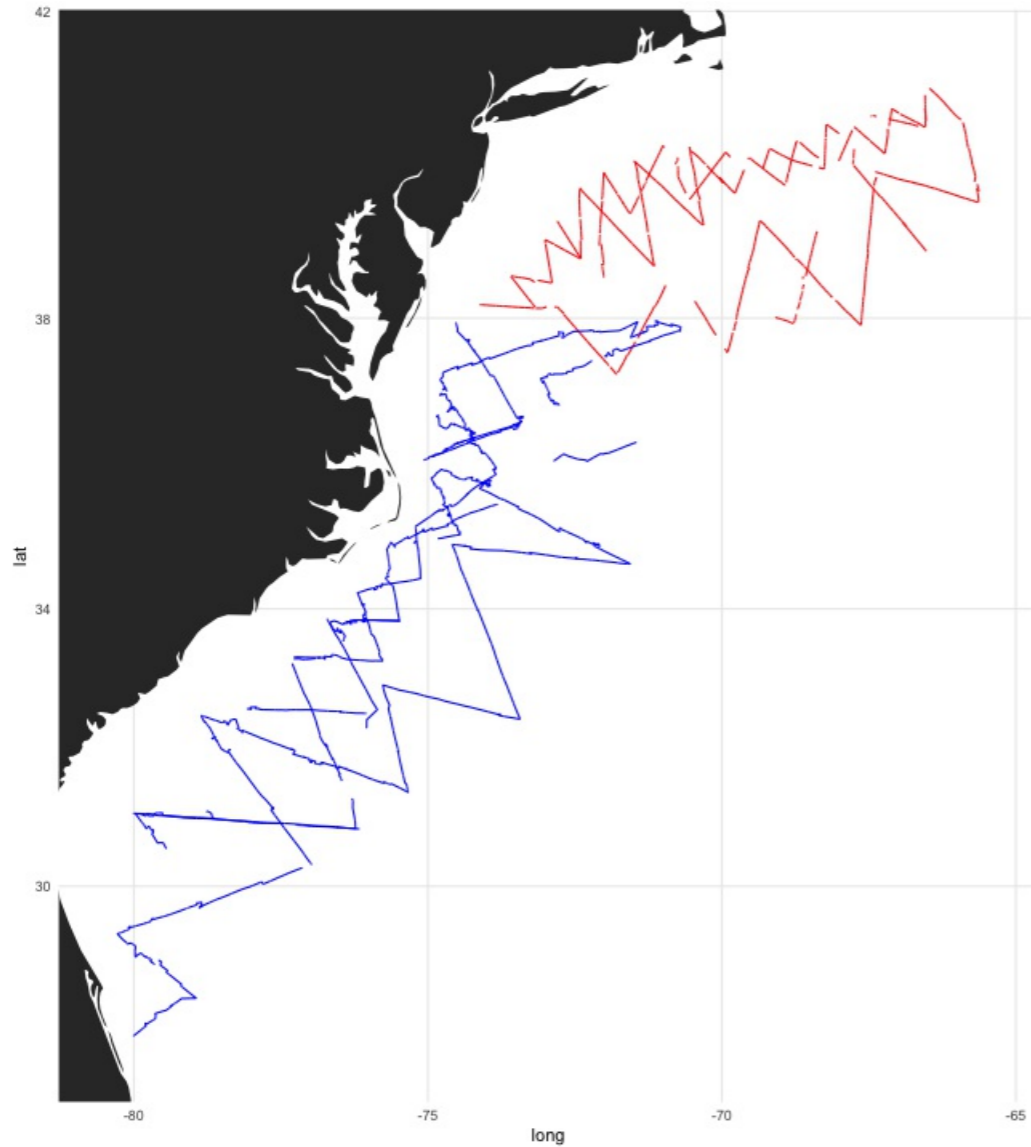
- Abundance and uncertainty
 - Arbitrary areas
 - Numeric values
 - Maps
 - Extrapolation (with caution!)
- Covariate effects
 - count/sample as function of covars

Modelling requirements

- Include detectability
- Account for effort
- Flexible/interpretable effects
- Predictions over an arbitrary area

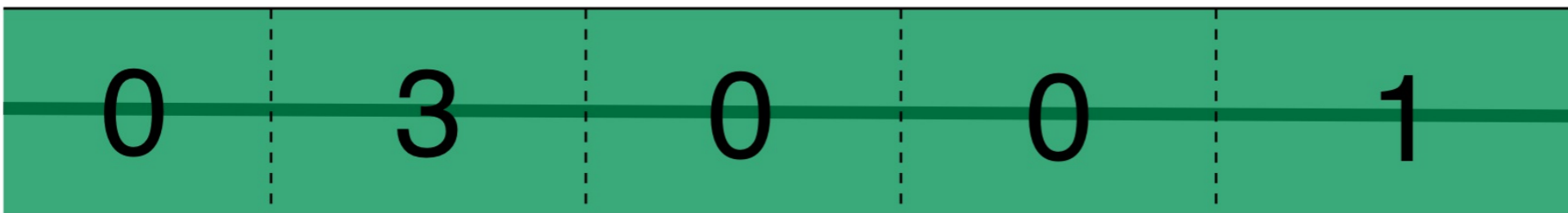
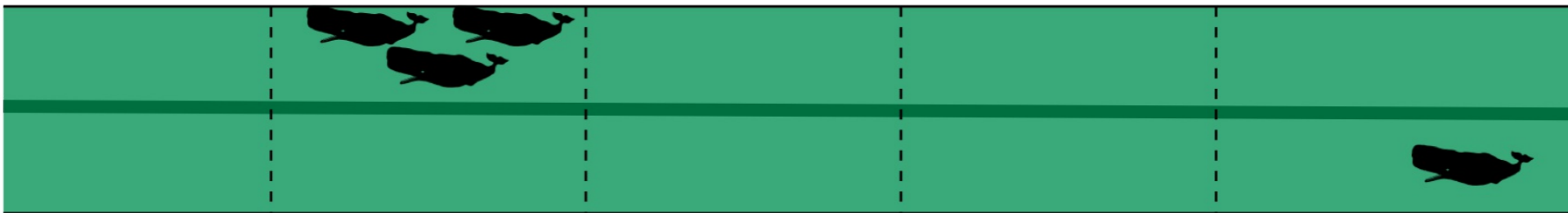
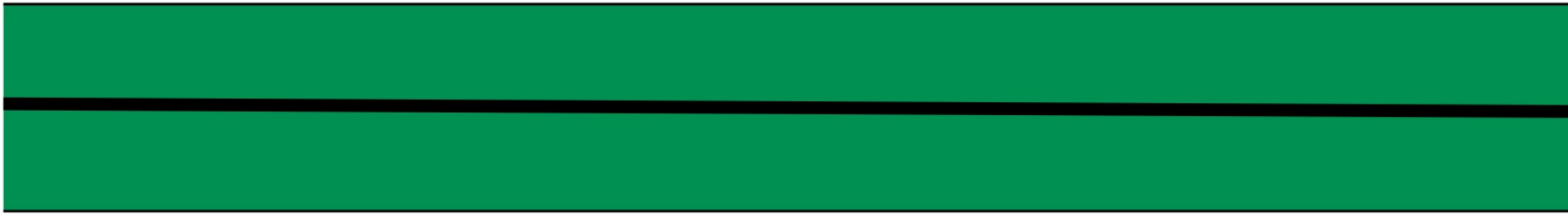
Accounting for effort

Effort



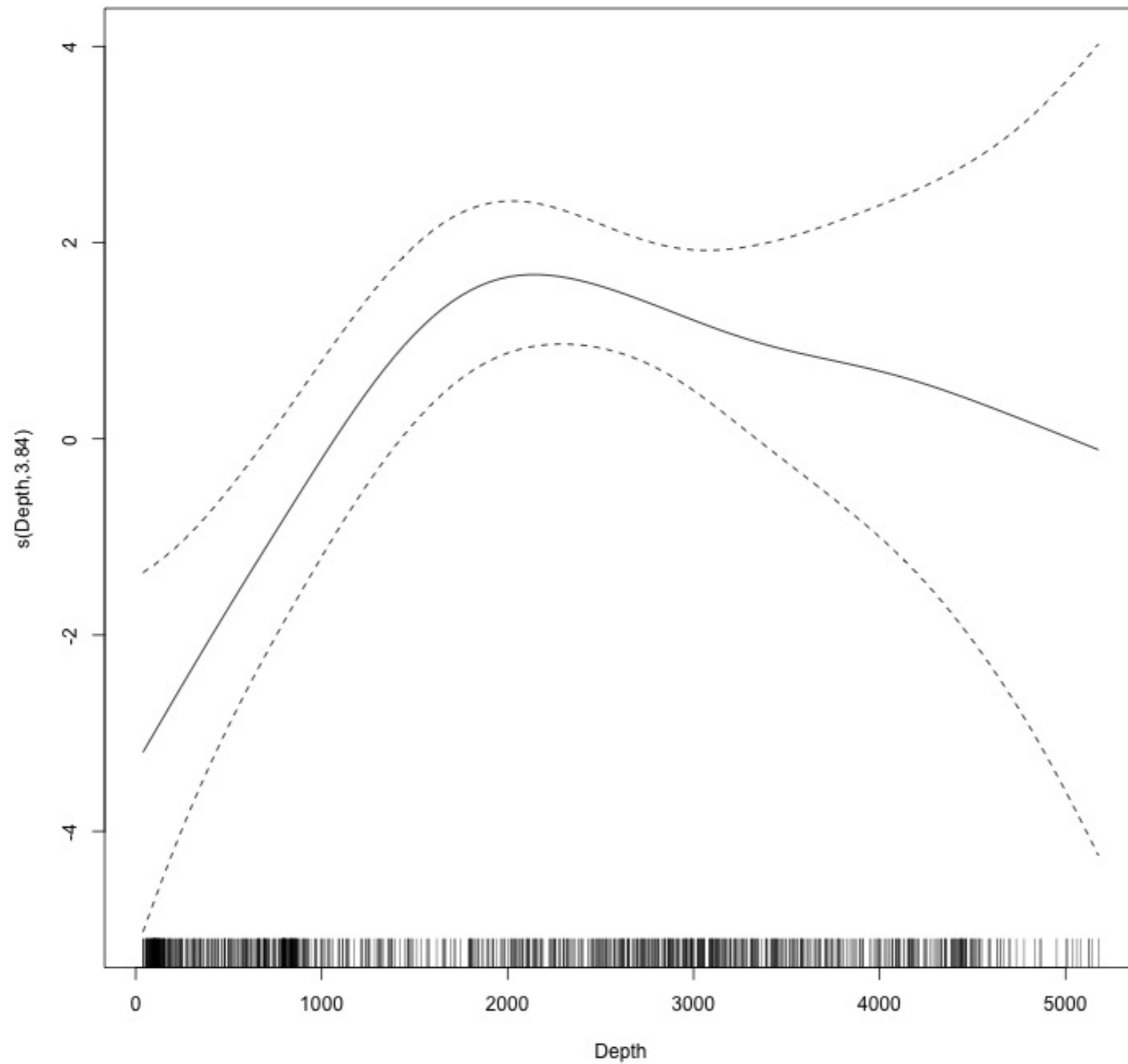
- Have transects
- Variation in counts and covars along them
- Want a sample unit w/ minimal variation
- “Segments”: chunks of effort

Chopping up transects

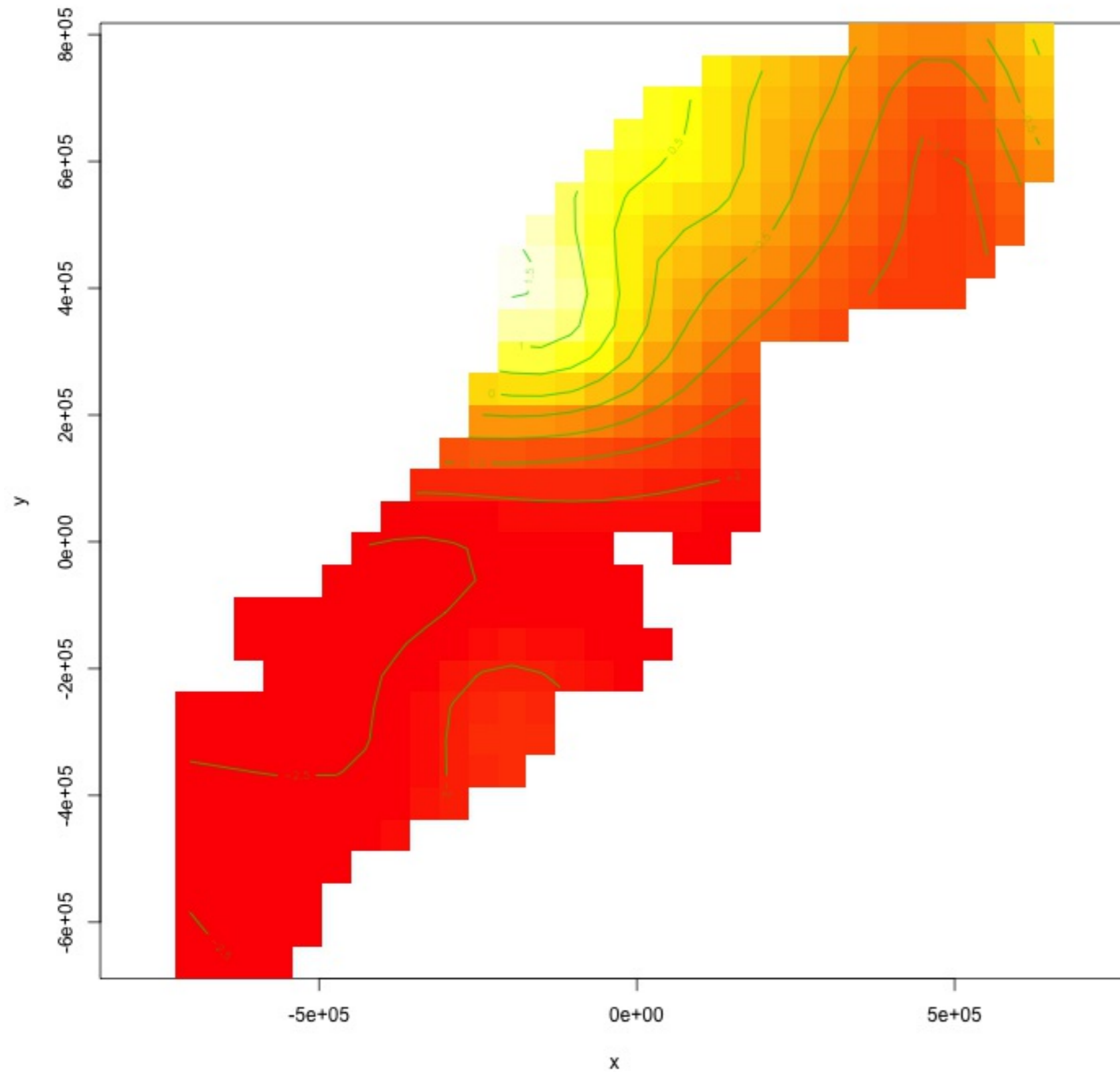


Flexible, interpretable effects

Smooth response

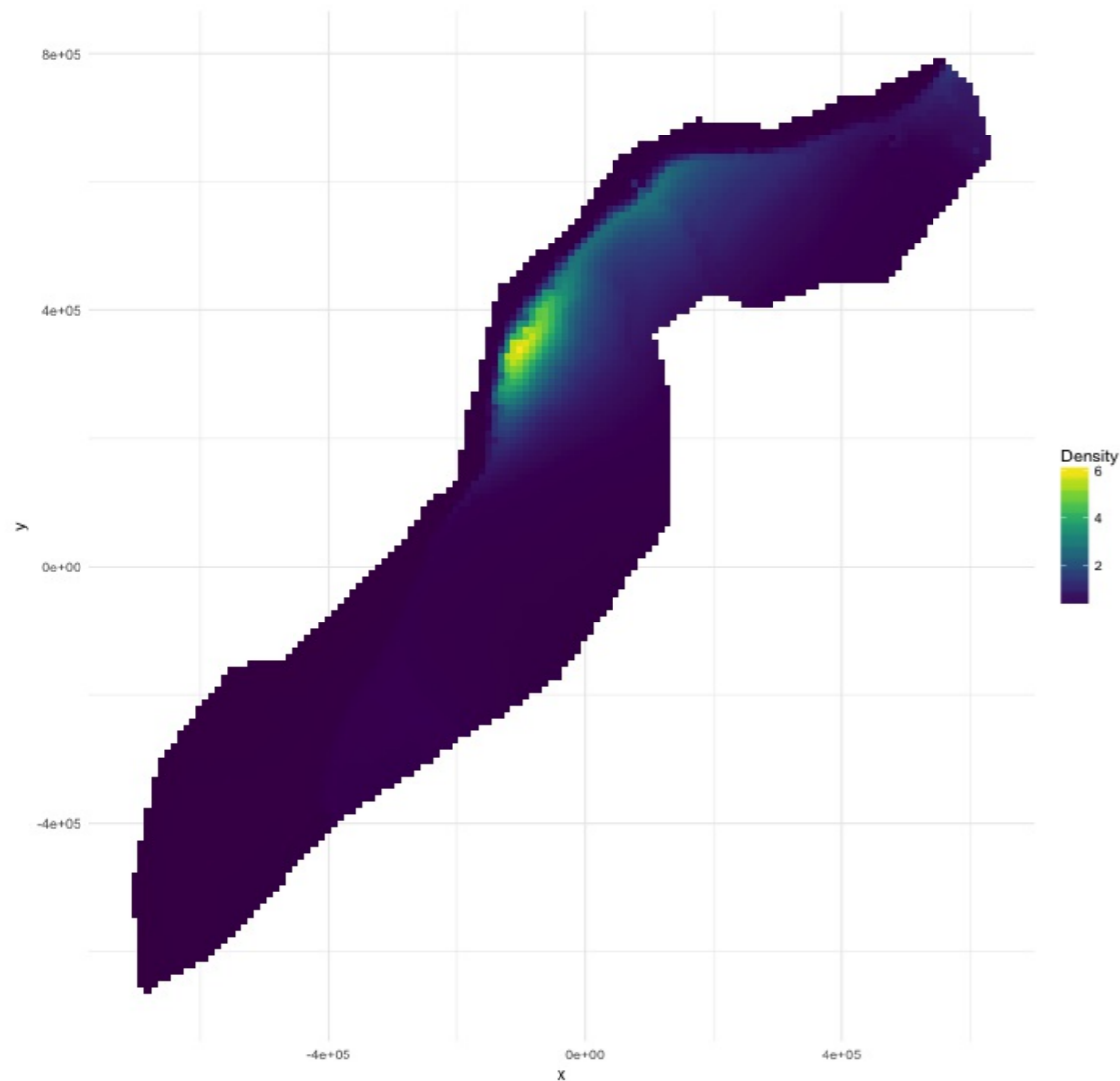


Explicit spatial effects



Predictions

Predictions over an arbitrary area



- Don't want to be restricted to predict on segments
- Predict within survey area
- Extrapolate outside (with caution)
- Working on a grid of cells

Detection information

Including detection information

- Two options:
 - adjust areas to account for **effective effort**
 - use **Horvitz-Thompson estimates** as response

Effective effort

- Area of each segment, A_j
 - use $A_j \hat{p}_j$
- think effective strip width ($\hat{\mu} = w \hat{p}$)
- Response is counts per segment
- “Adjusting for effort”
- “Count model”

Estimated abundance

- Estimate H-T abundance per segment
- Effort is area of each segment
- “Estimated abundance” per segment

$$\hat{n}_j = \sum_{i \text{ in segment } j} \frac{s_i}{\hat{p}_i}$$

Detectability and covariates

- 2 covariate “levels” in detection function
 - “Observer”/“observation” – change **within** segment
 - “Segment” – change **between** segments
- “Count model” only lets us use segment-level covariates
- “Estimated abundance” lets us use either

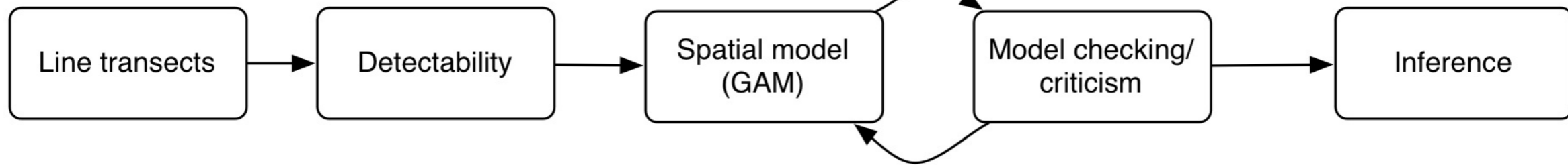
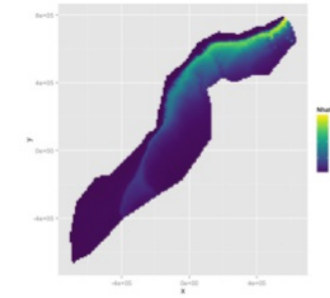
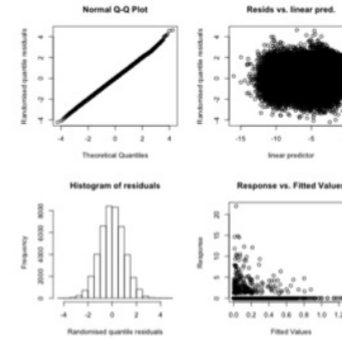
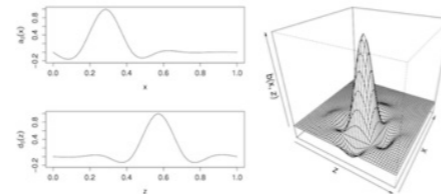
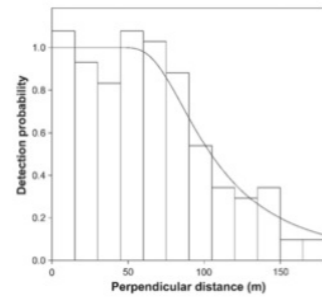
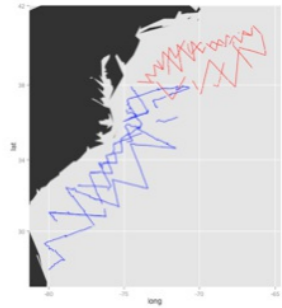
When to use each approach?

- Generally “nicer” to adjust effort
- Keep response (counts) close to what was observed
- **Unless** you want observation-level covariates
 - These *can* make a big difference!

Availability, perception bias and more

- \hat{p} is not always simple!
- Availability & perception bias somehow enter
- We can make explicit models for this
- More later in the course

DSM flow diagram



Spatial models

Abundance as a function of covariates

- Two approaches to model abundance
- Explicit spatial models
 - When: good coverage, fixed area
- “Habitat” models (no explicit spatial terms)
 - When: poorer coverage, extrapolation
- We'll cover both approaches here

Data requirements

What do we need?

- Need to “link” data
- Distance data/detection function
- Segment data
- Observation data to link segments to detections

Example of spatial data in QGIS

Recap

- Model counts or estimated abundance
- The effort is accounted for differently
- Flexible models are good
- Incorporate detectability
- 2 tables + detection function needed