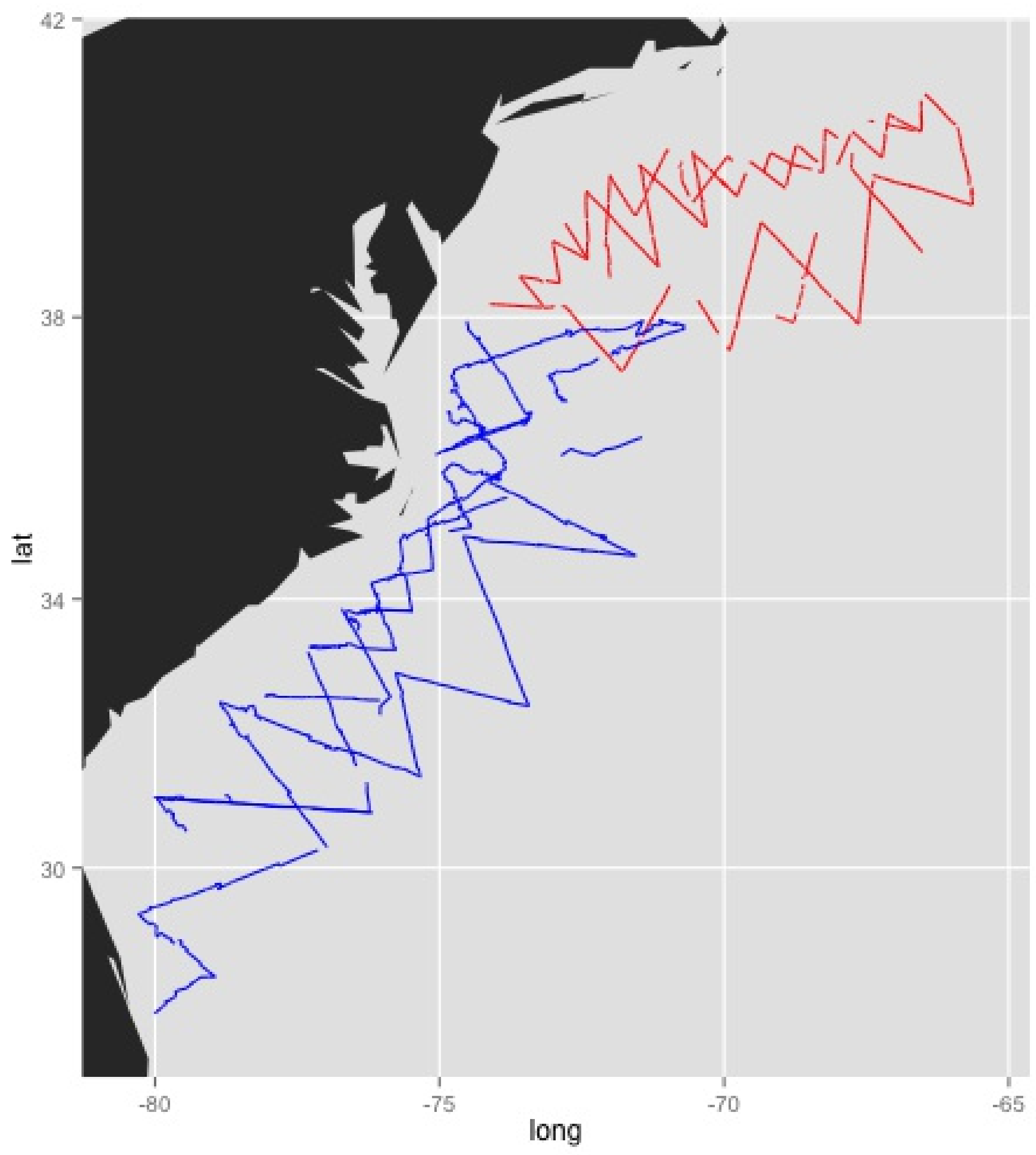
What is a density surface model?

David L Miller

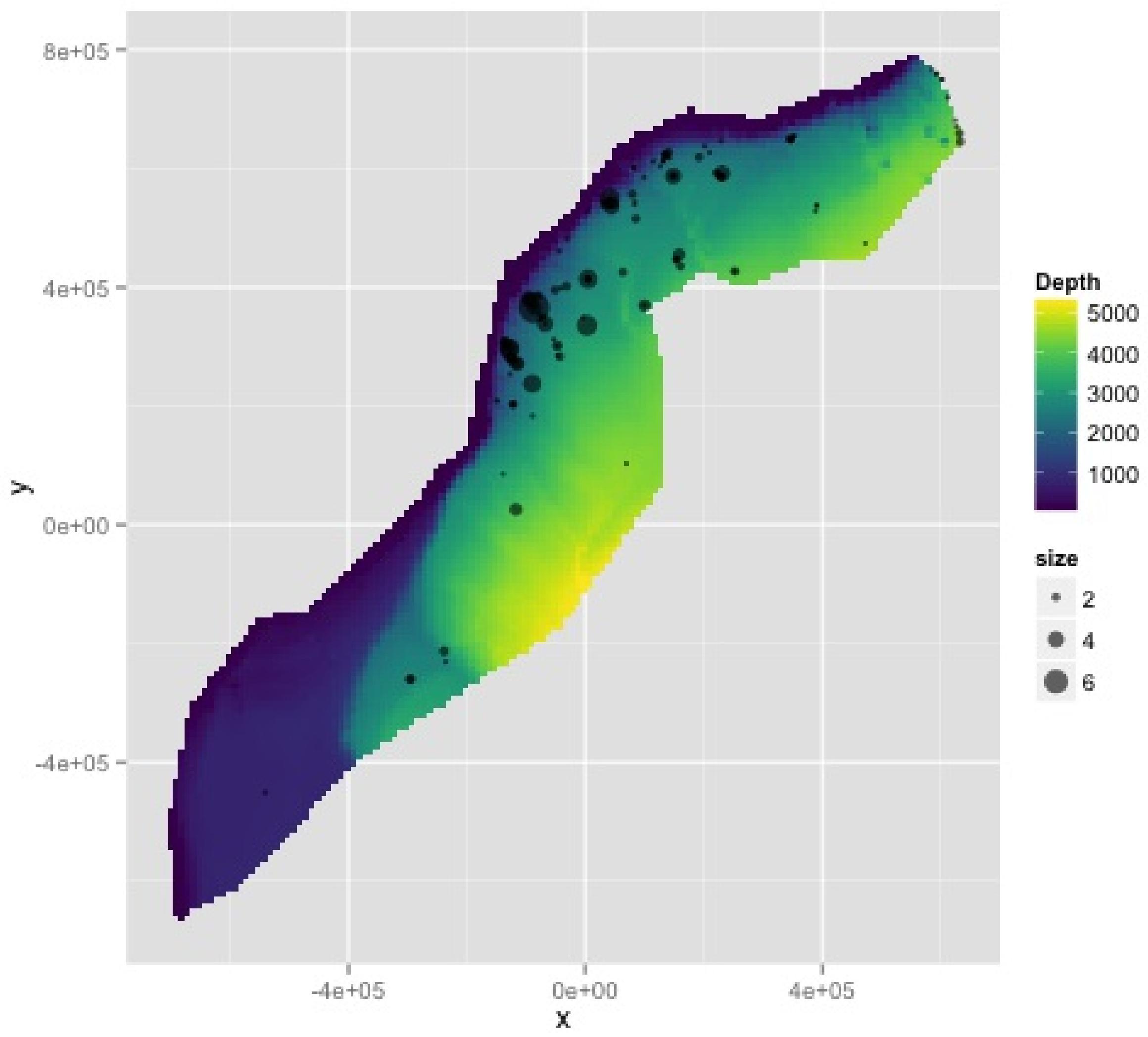
Why model abundance spatially?

- Use more information
- Greater explanatory power
- Spatially explicit estimates (of abundance and uncertainty)
- ~~(Often)~~ variance reduction

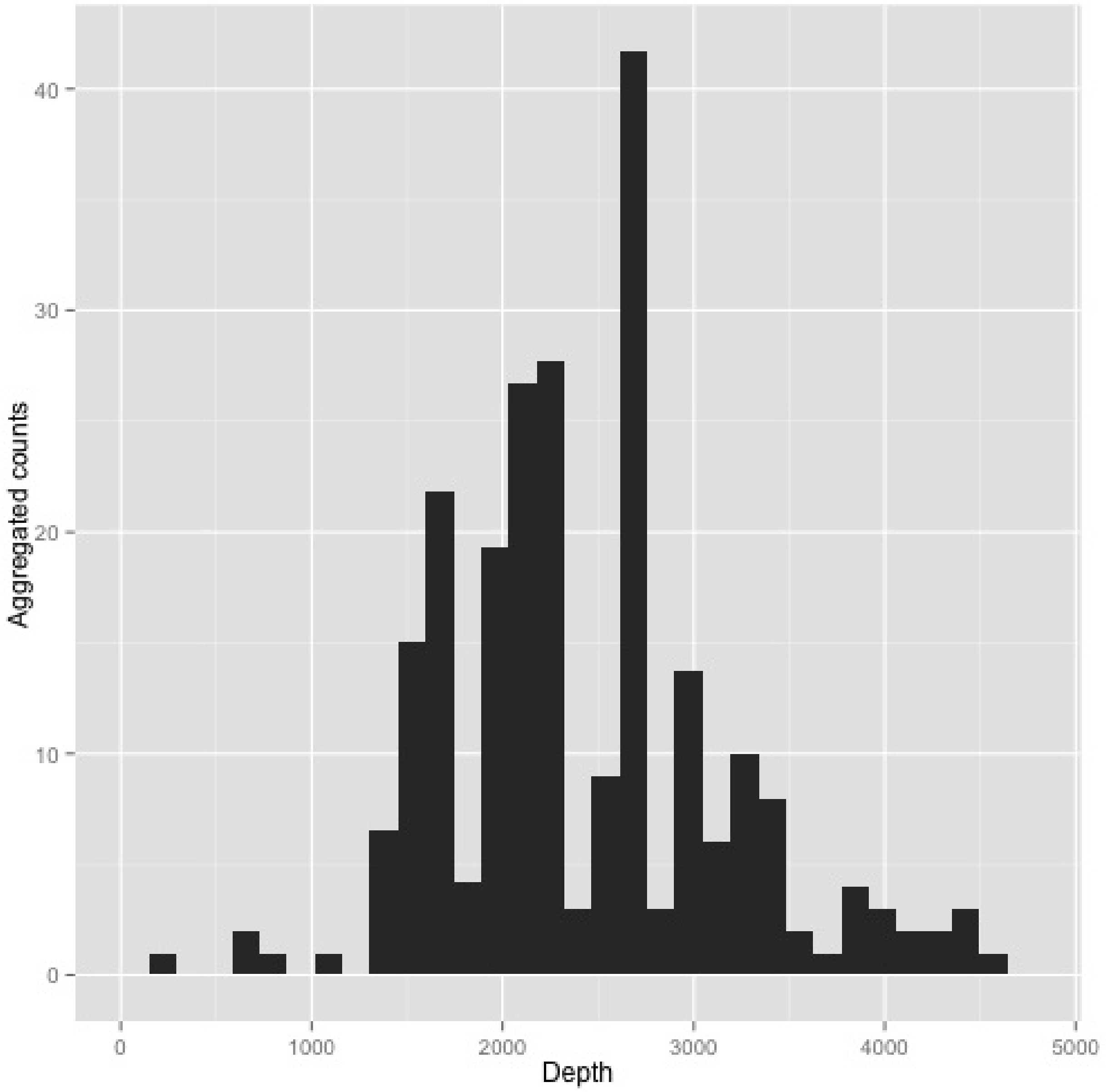
Extra information



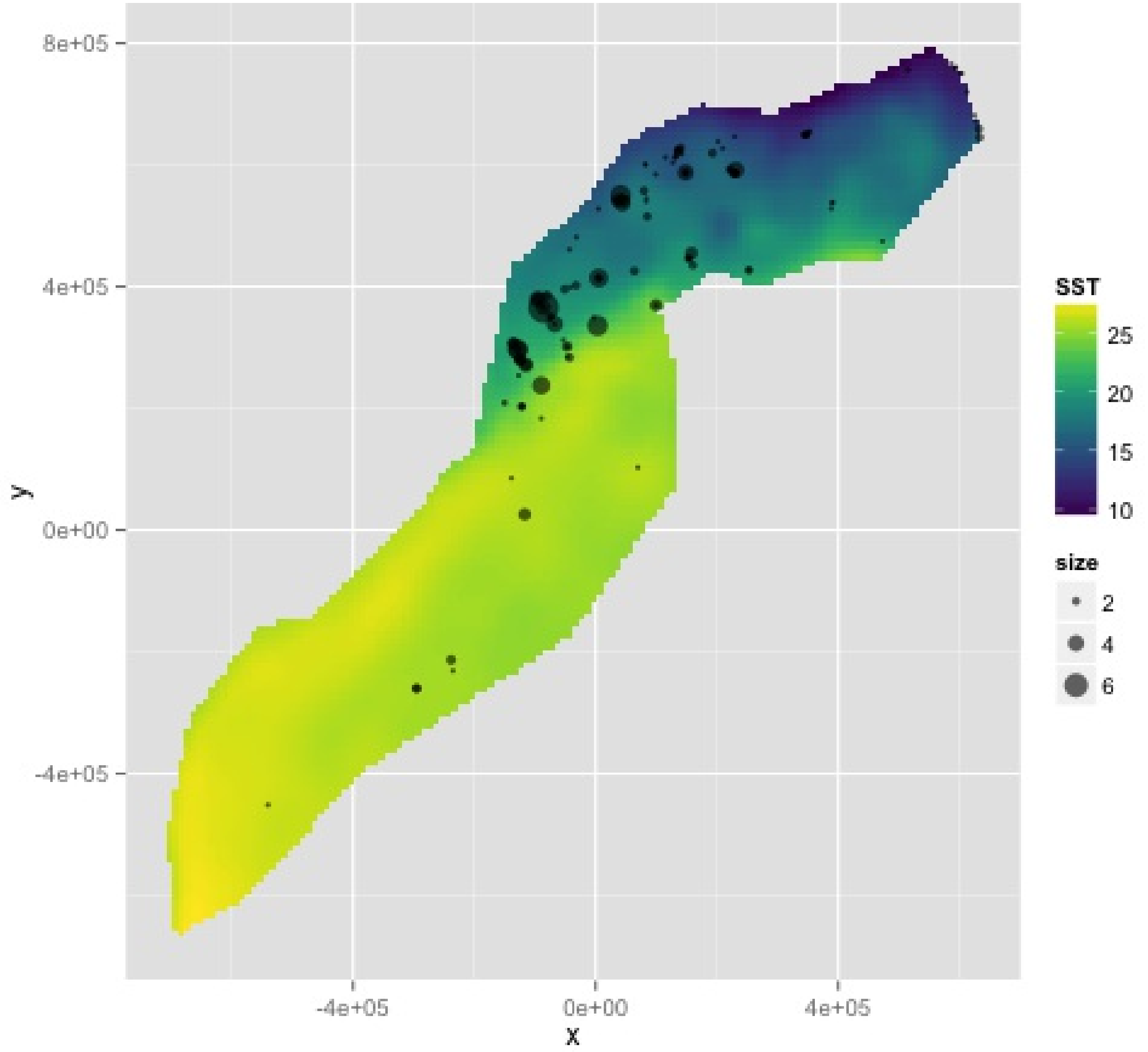
Extra information - depth



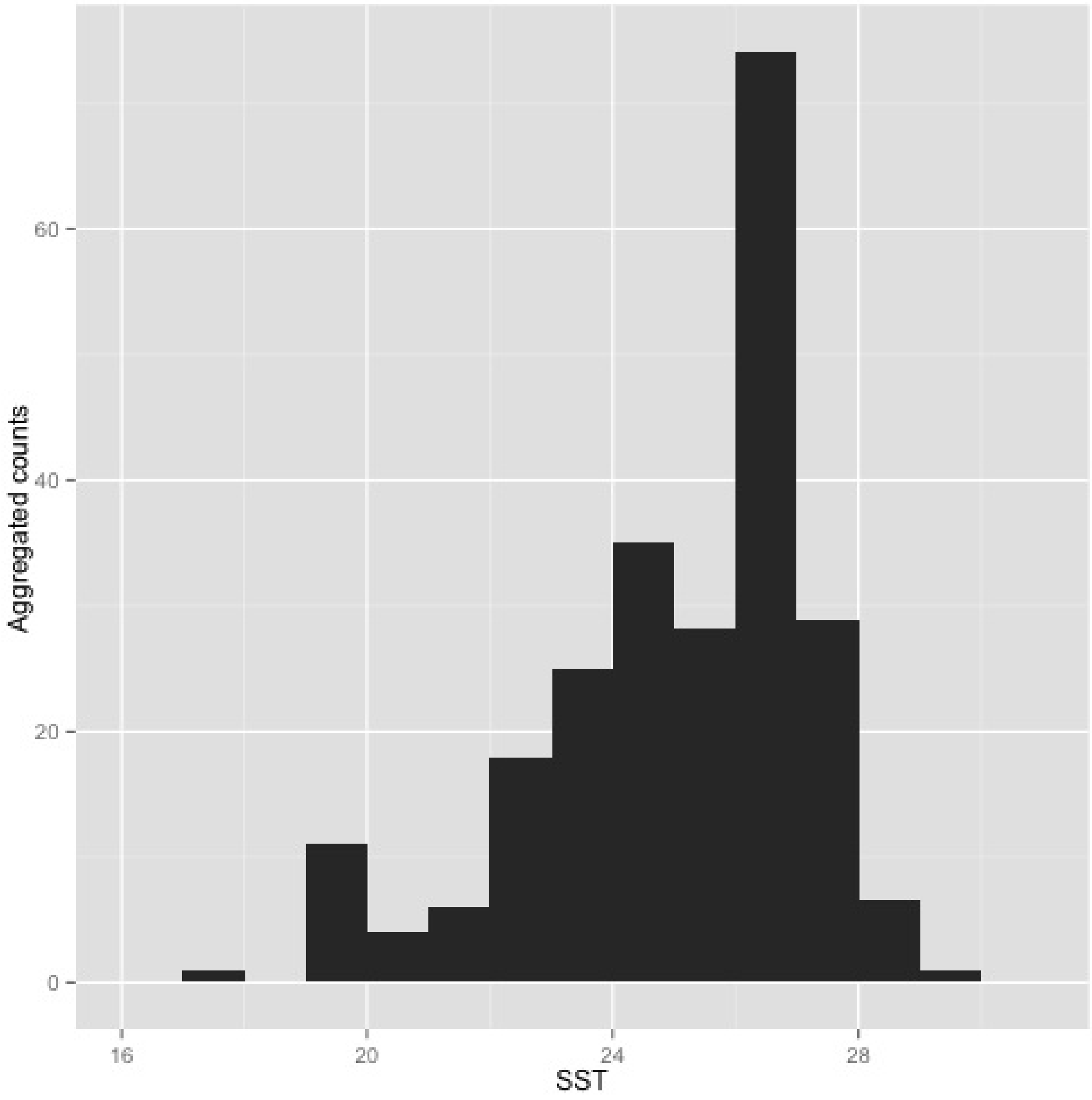
Extra information - depth



Extra information - SST



Extra information - SST



What is going on here?

”You should model that”

Modelling outputs

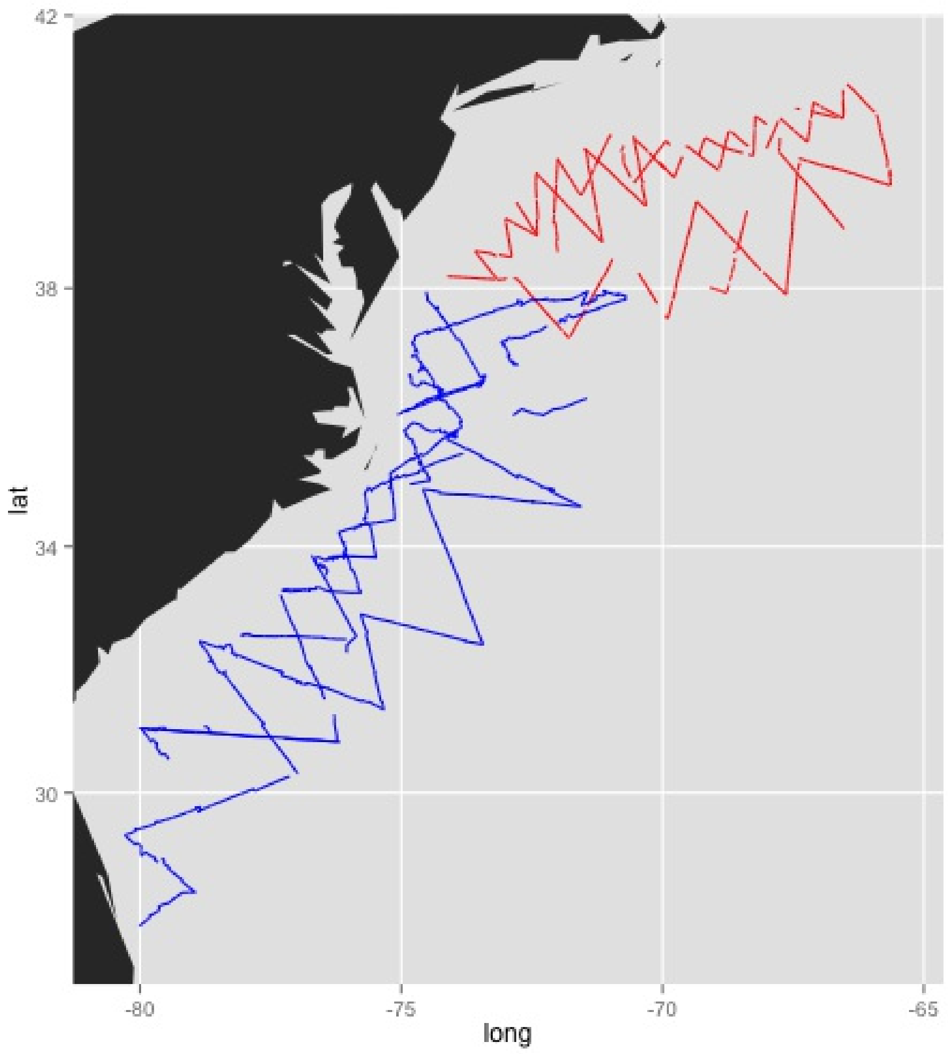
- Abundance and uncertainty
  - Arbitrary areas
  - Extrapolation
  - Numeric values
  - Maps
- Covariate effects
  - count/sample as function of covars

Modelling requirements

- Account for effort
- Flexible
- Explicit spatial terms
- Interpretable effects
- Predictions over an arbitrary area
- Fast to fit
- Theoretical basis for model validation
- Include our detectability information

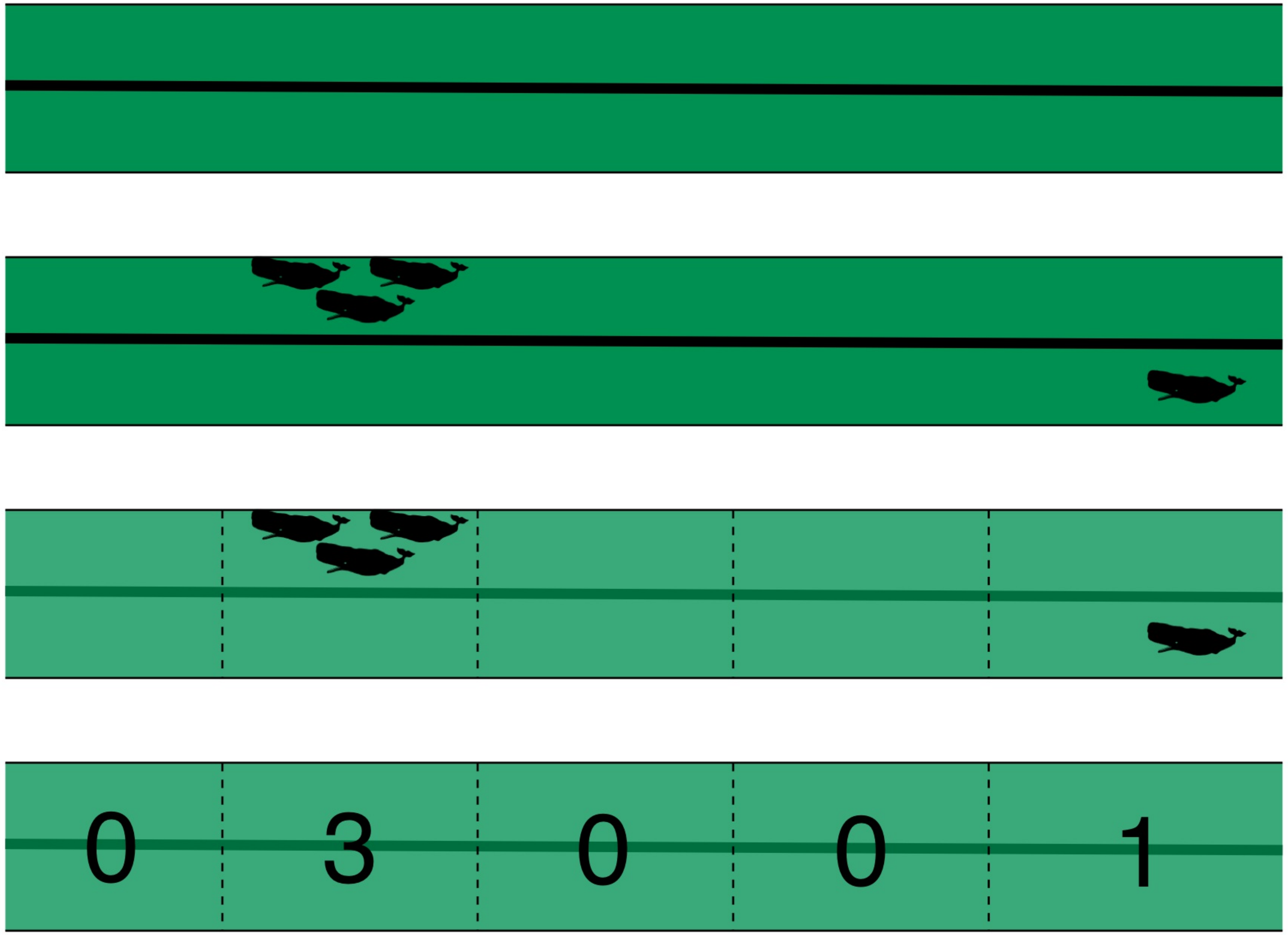
Accounting for effort

Effort



- Have transects
- Clearly there will be variation along them
- Want a sample unit w/ minimal variation
- “Segments” – approx. square chunks of transect

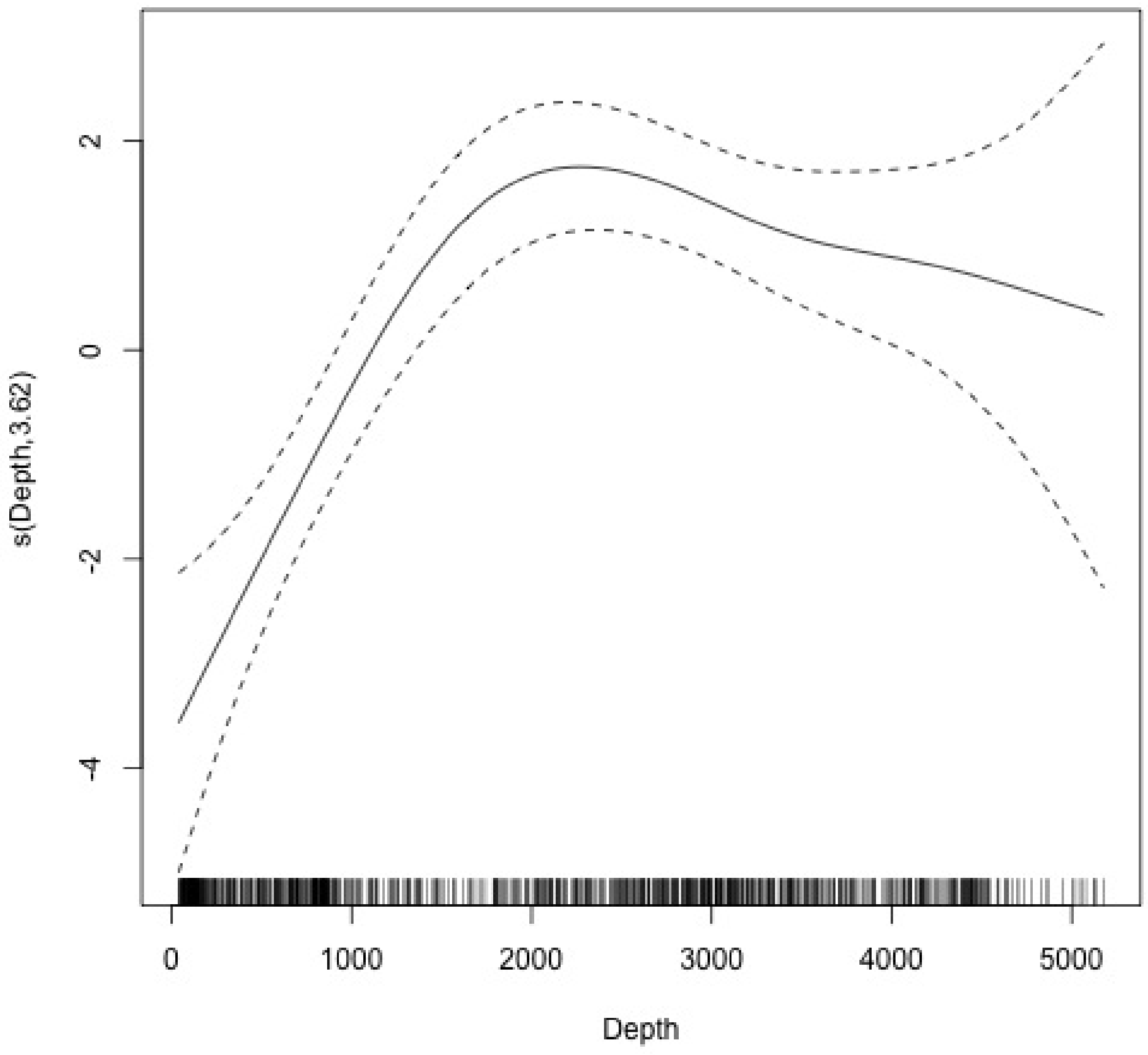
Chopping up transects



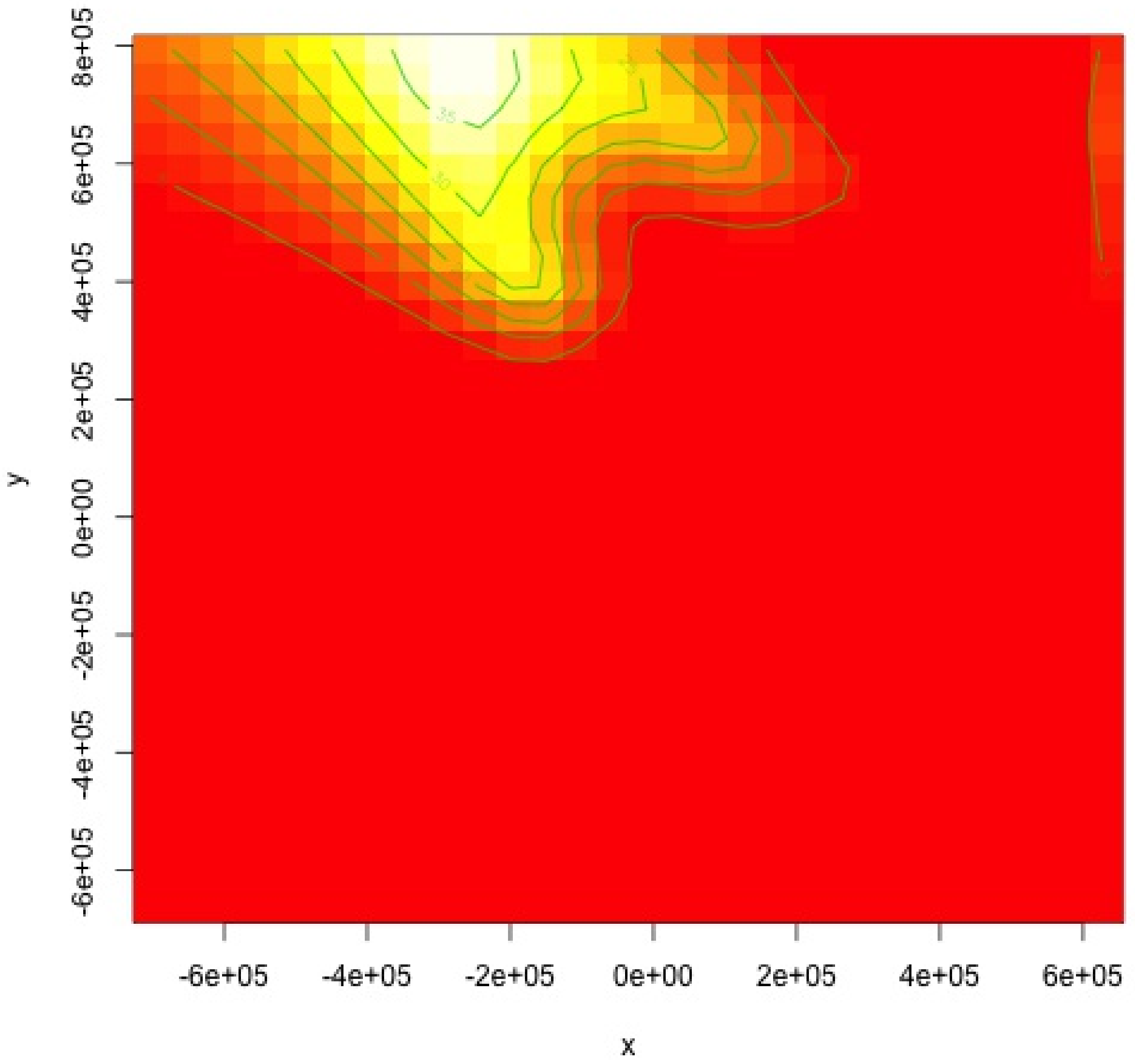
Physeter catodon by Noah Schlottman

Flexible, interpretable effects

Smooth response

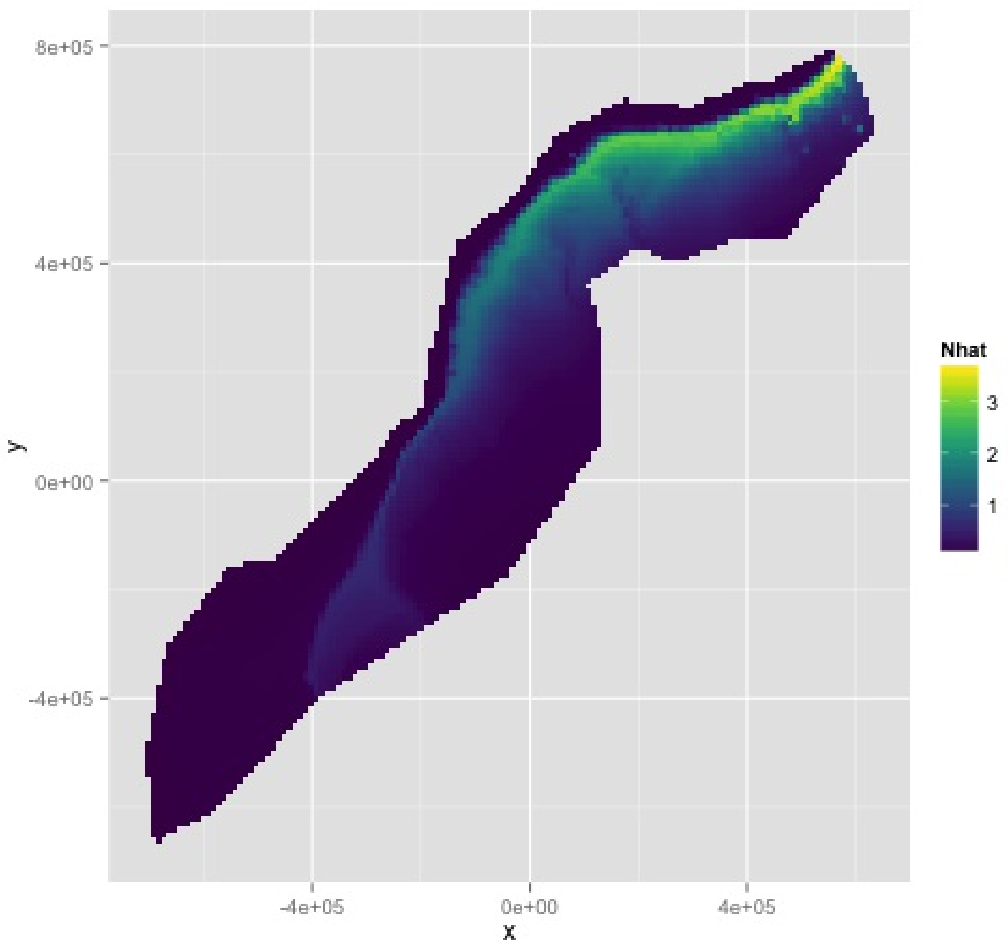


Explicit spatial effects



Predictions

Predictions over an arbitrary area



- Don't want to be restricted to design points
- Extrapolate (with caution)
- Include new data and inference tasks easily

Detection information

Including detection information

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

Adjusting areas

- Area of each segment A_j and use $A_j\hat{p}_j$
- Equivalent to *effective strip width*
  - $\hat{\mu} = w\hat{p}$
- Response is counts per segment
- "Adjusting for effort"
- "Count model"

Horvitz-Thompson estimates

- Estimate H-T abundance per segment
- Effort (area) is segment length
- "Estimated abundance"

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

Detectability and covariates

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

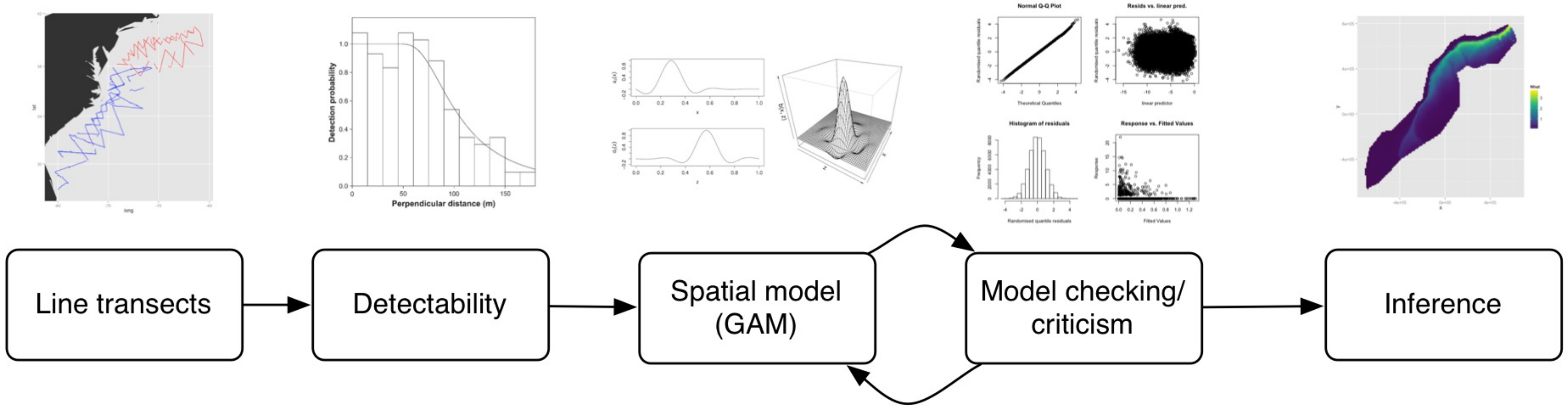
When to use each approach?

- Generally “nicer” to adjust effort
- Keep response (counts) close to what was observed
- **Unless** you want observation-level covariates

Availability/perception/etc

- Availability & perception bias via $\hat{p}$
- $\hat{p} = \hat{p}_{\text{availability}} \hat{p}_{\text{perception}} \hat{p}_{\text{detection}}$
- Not going to cover this much here
- See bibliography for more info

DSM flow diagram



Spatial models

Abundance as a function of covariates

- Two approaches to model abundance
- Explicit spatial models
  - Good coverage, fixed area
- “Habitat” models
  - Poorer coverage, extrapolation
- We'll cover both approaches here

What do we need to begin modelling?

What do we need?

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

Jason demo of segmenting etc

- Show each table
- Their relations
- Spatial representation

Recap

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