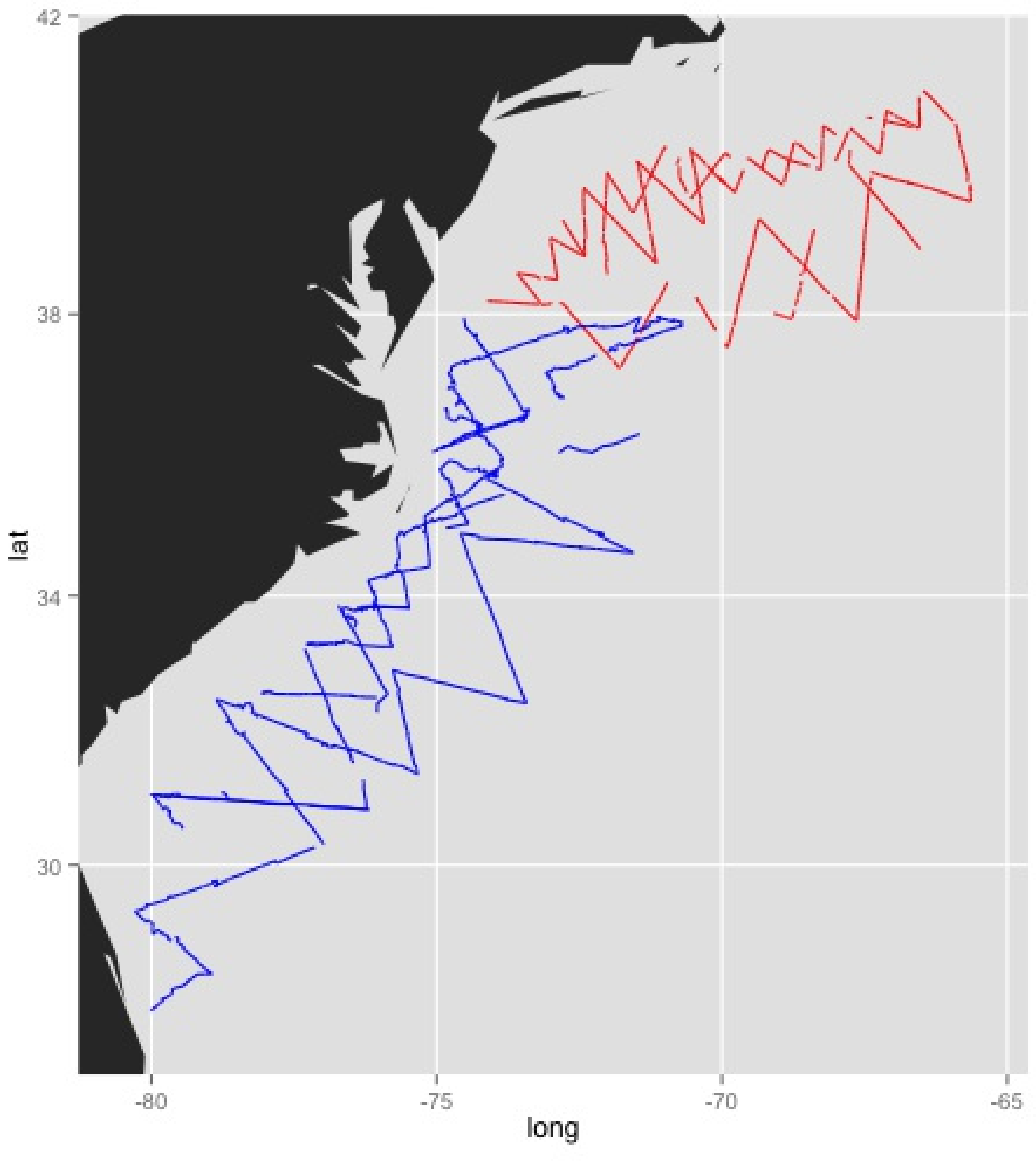
What is a density surface model?

David L Miller

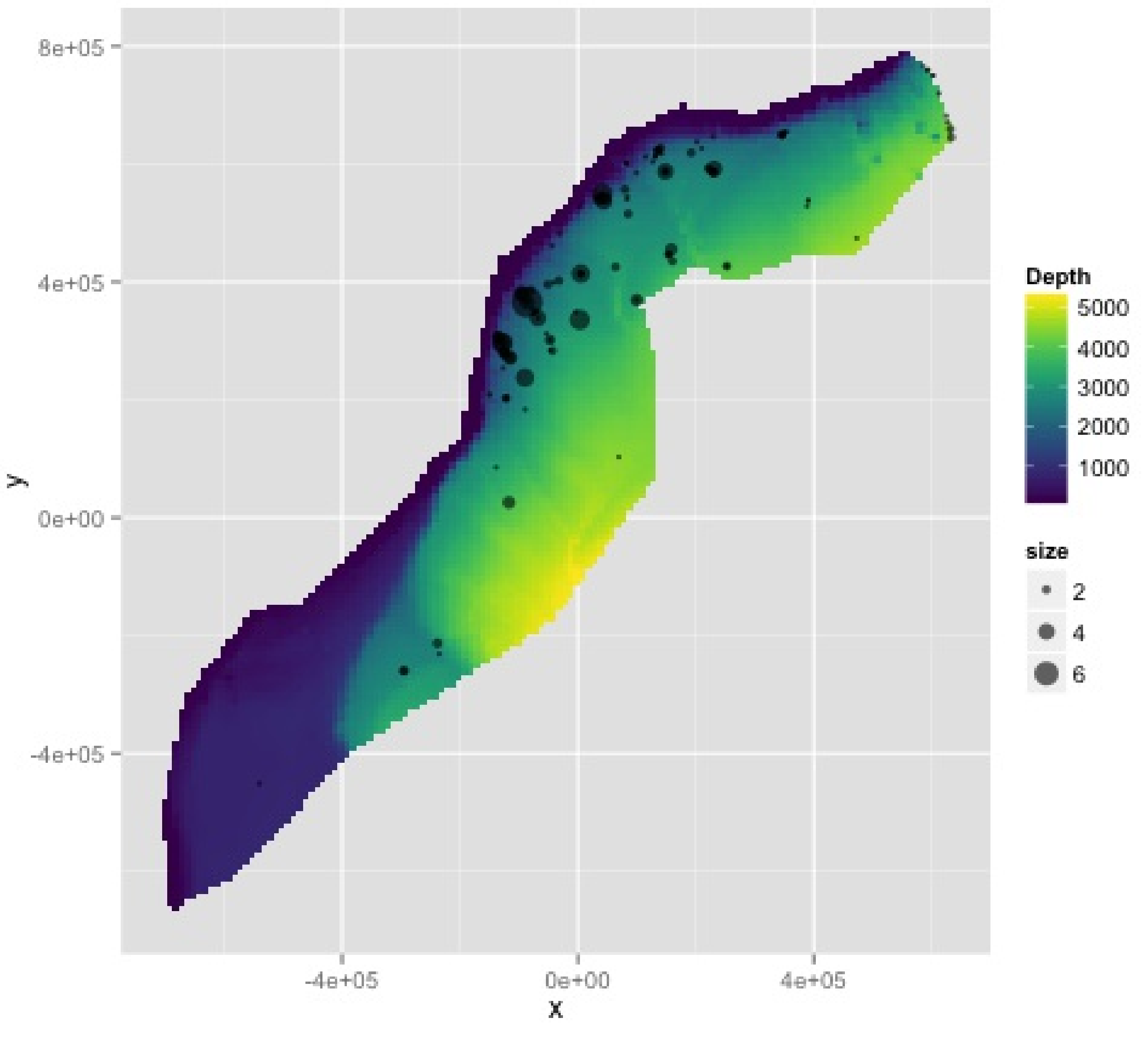
Why model abundance spatially?

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

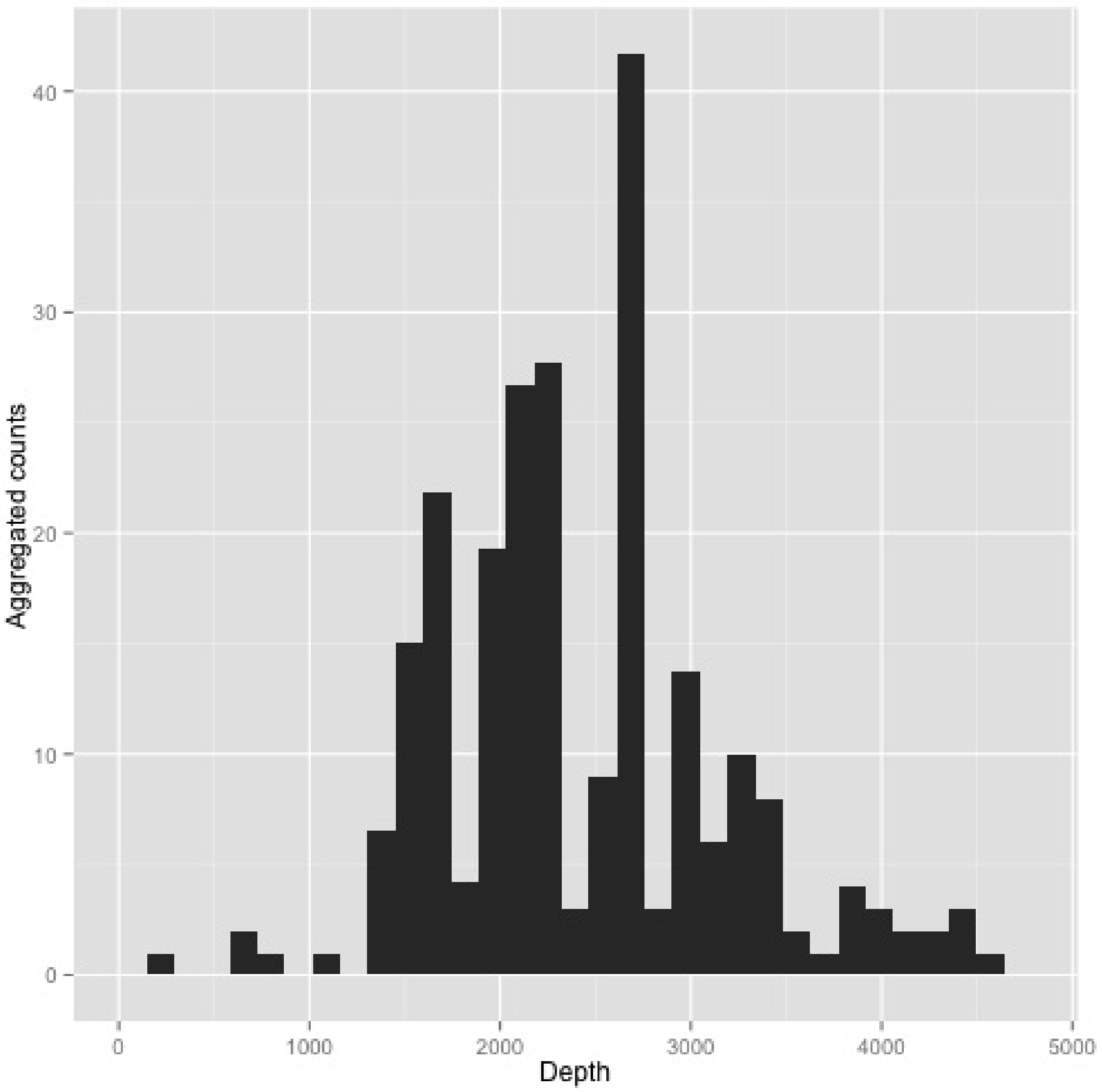
Extra information



Extra information - depth

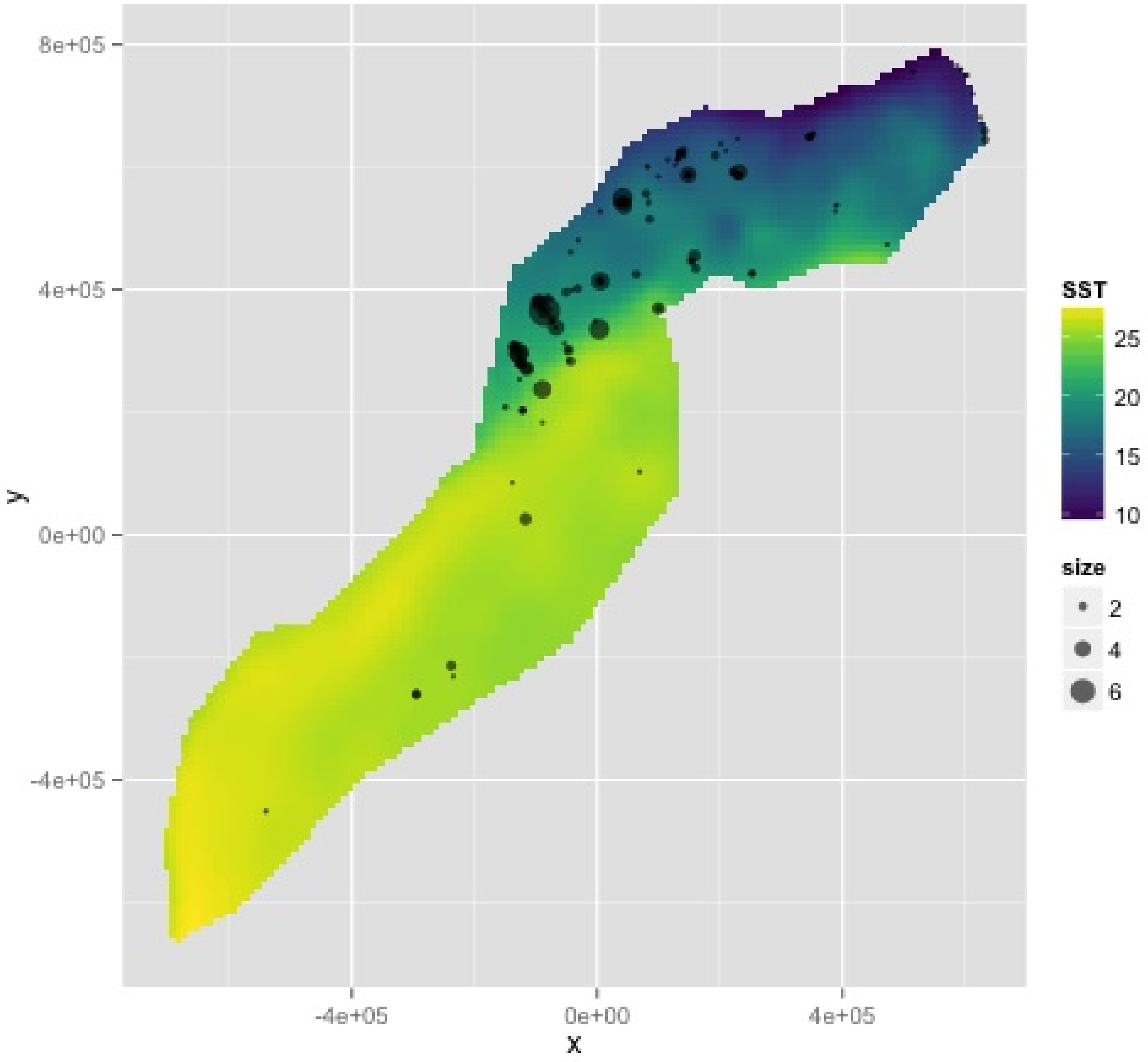


Extra information - depth

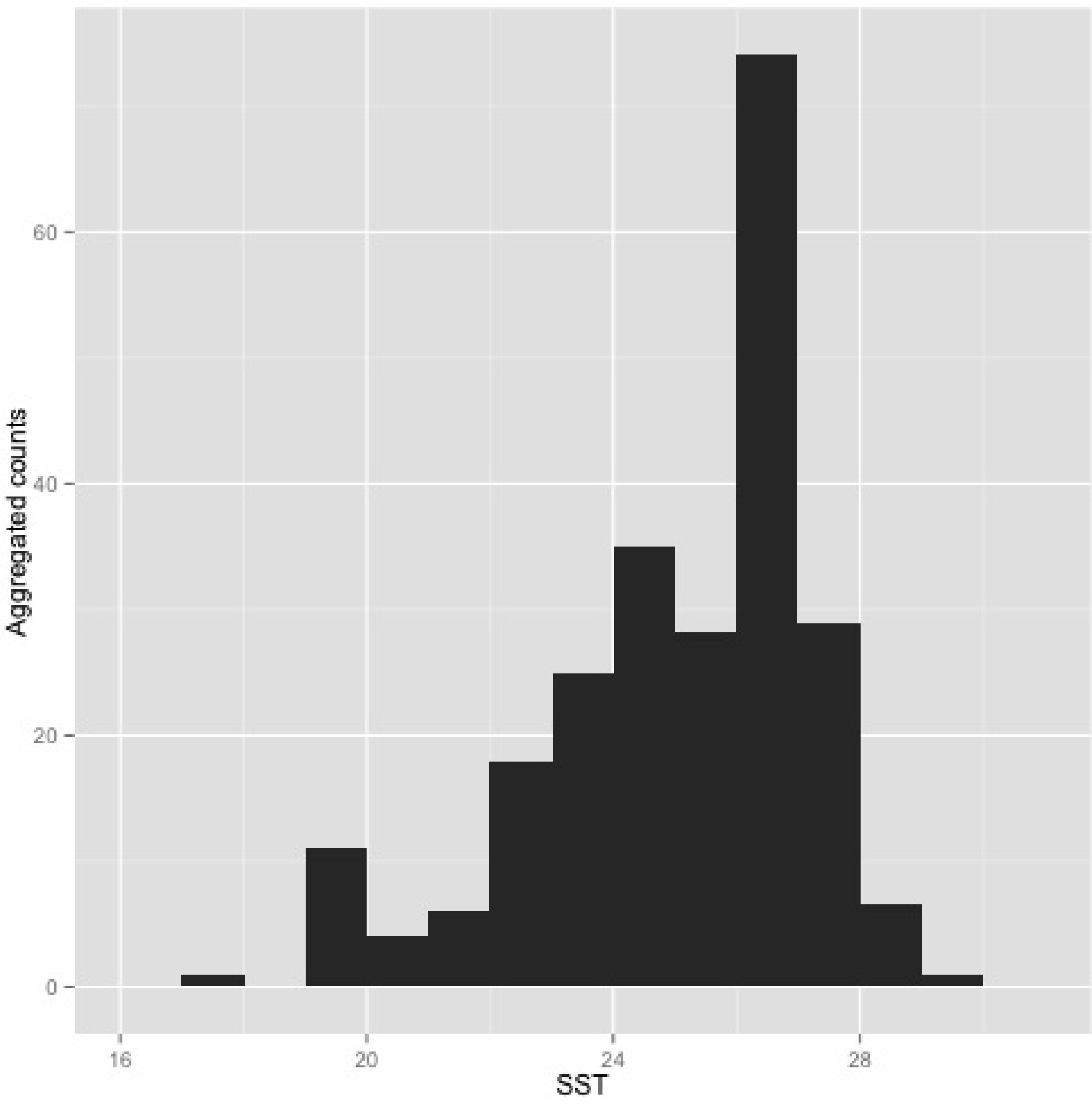


- NB this only shows segments where counts > 0

Extra information - SST



Extra information - SST



- NB this only shows segments where counts > 0

What is going on here?

”You should model that”

Modelling outputs

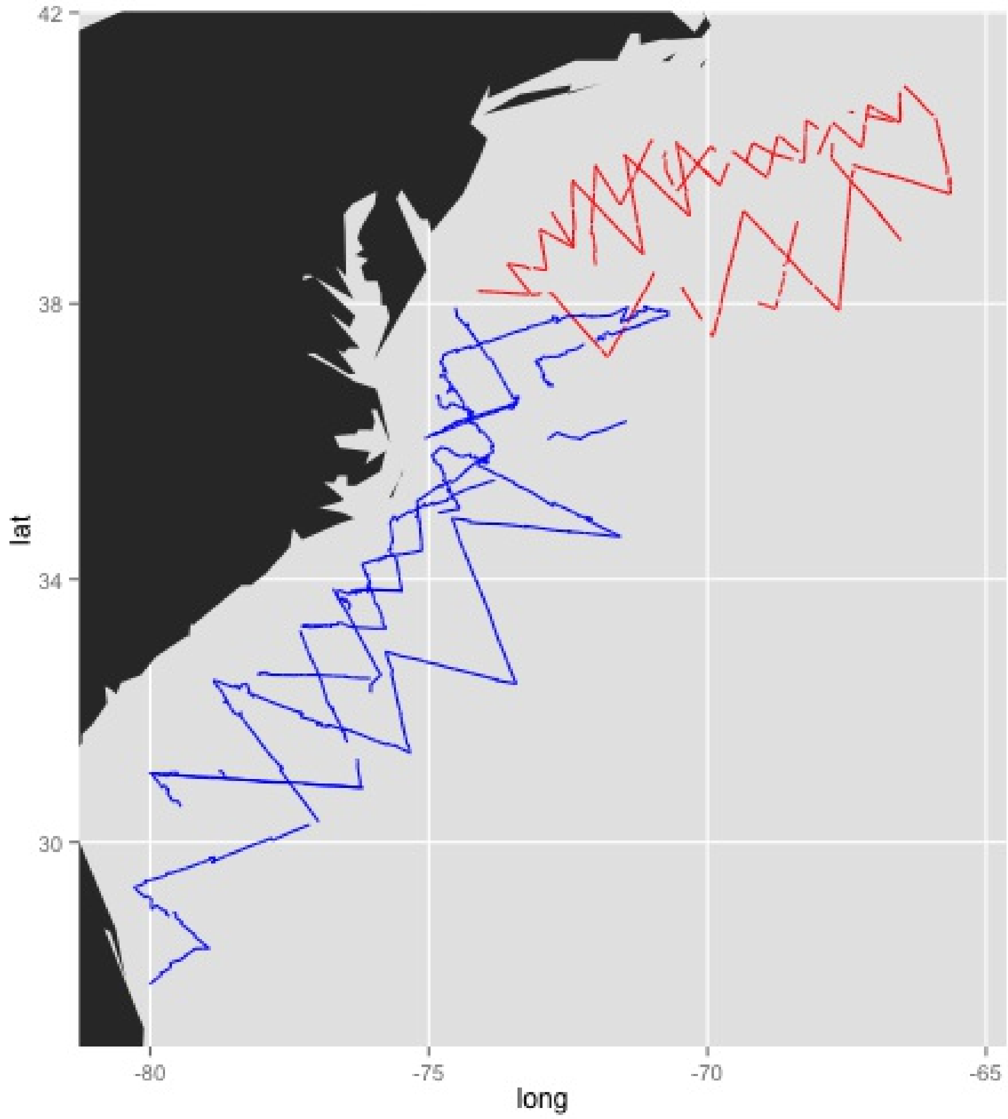
- Abundance and uncertainty
  - Arbitrary areas
  - Numeric values
  - Maps
  - Extrapolation (with caution!)
- Covariate effects
  - count/sample as function of covars

Modelling requirements

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

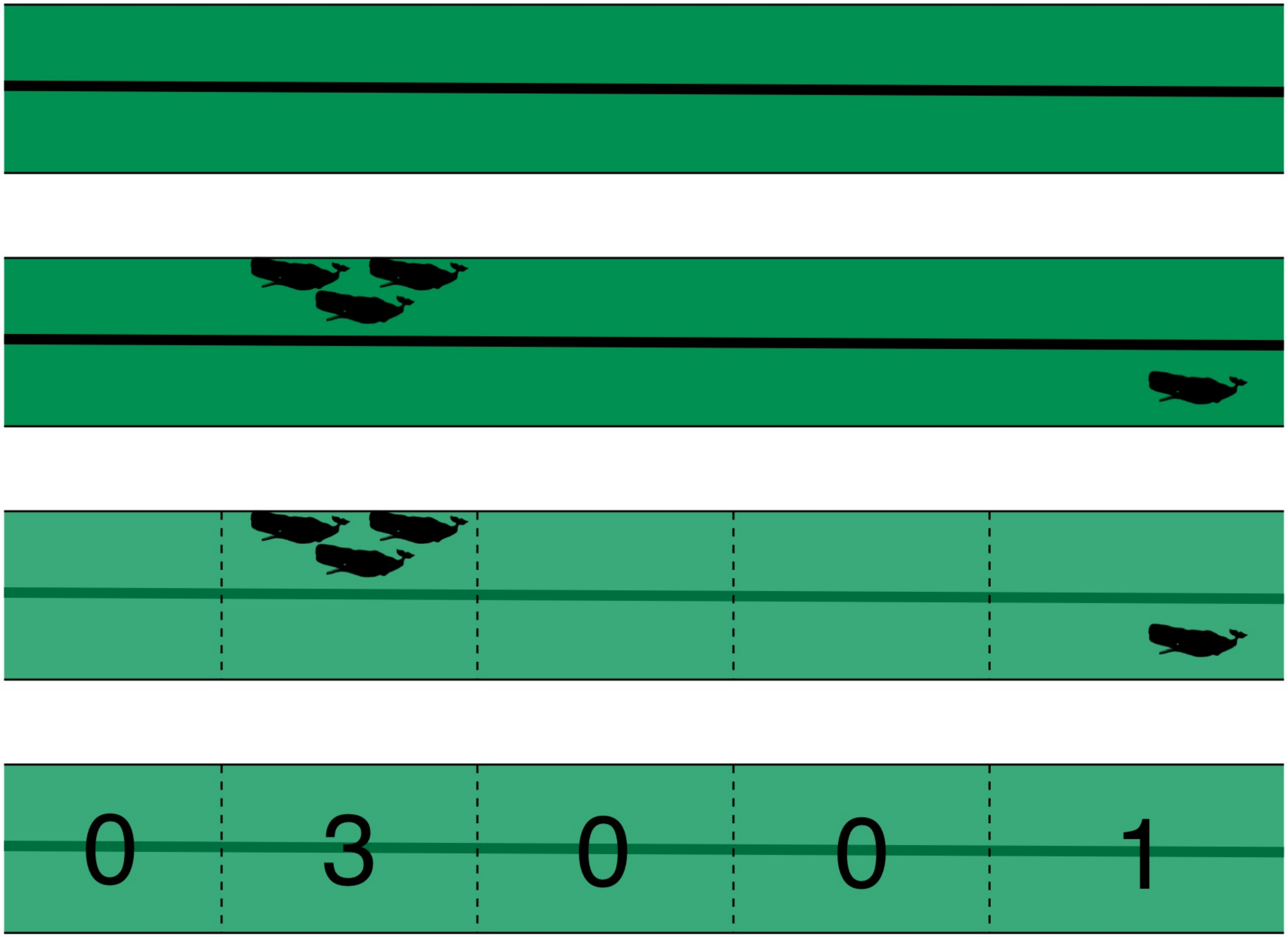
Accounting for effort

Effort



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

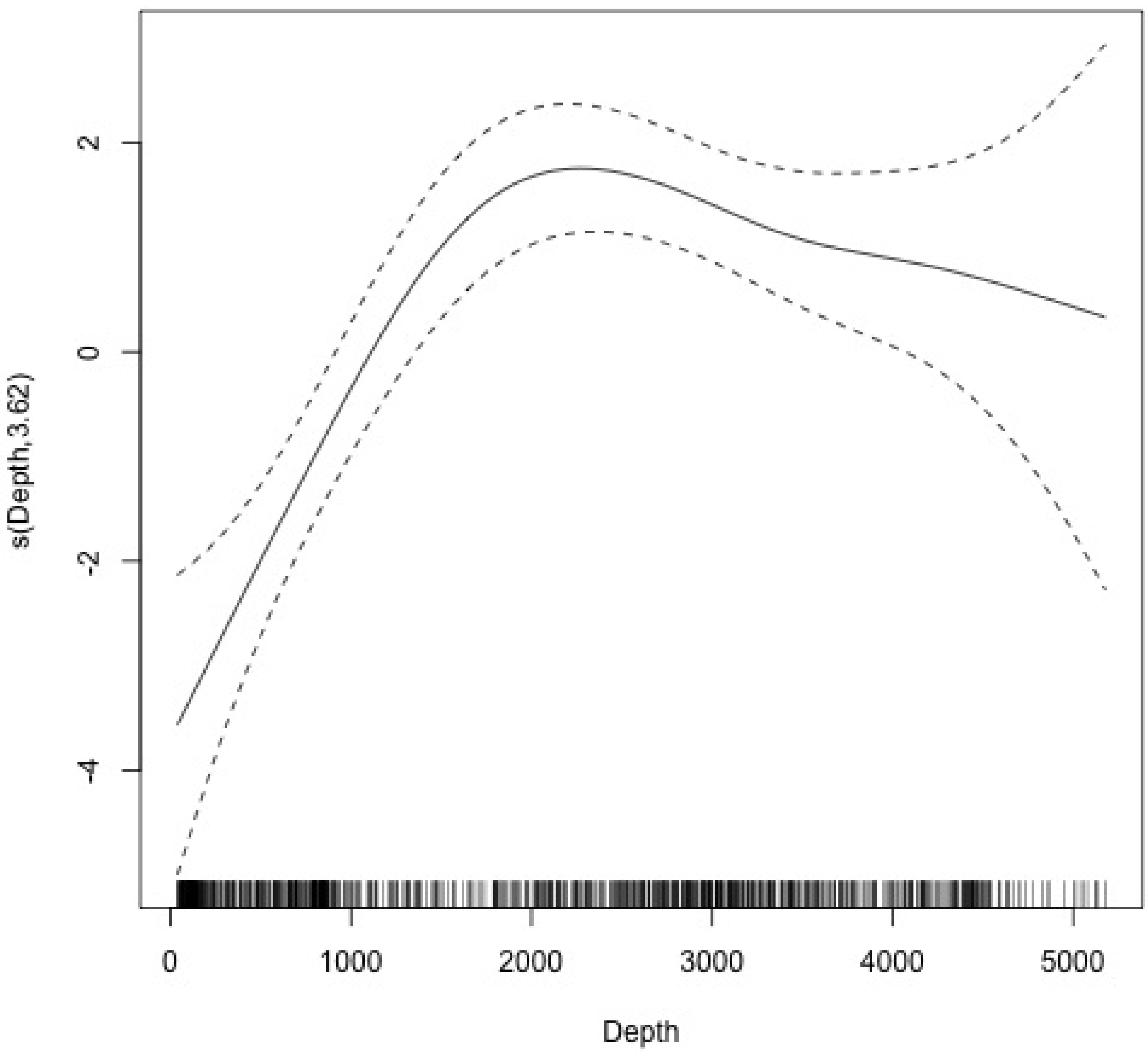
Chopping up transects



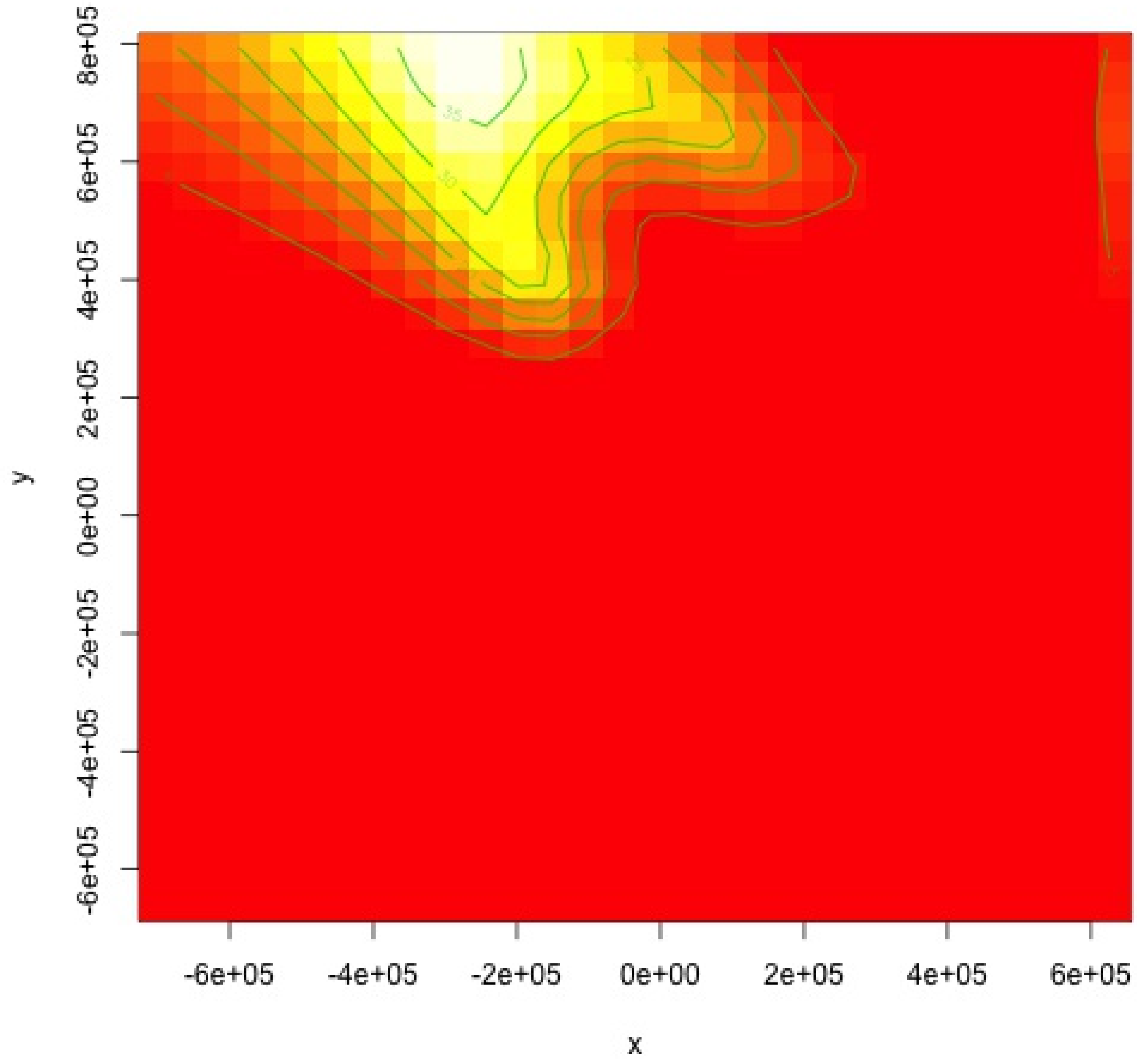
Physeter catodon by Noah Schlottman

Flexible, interpretable effects

Smooth response

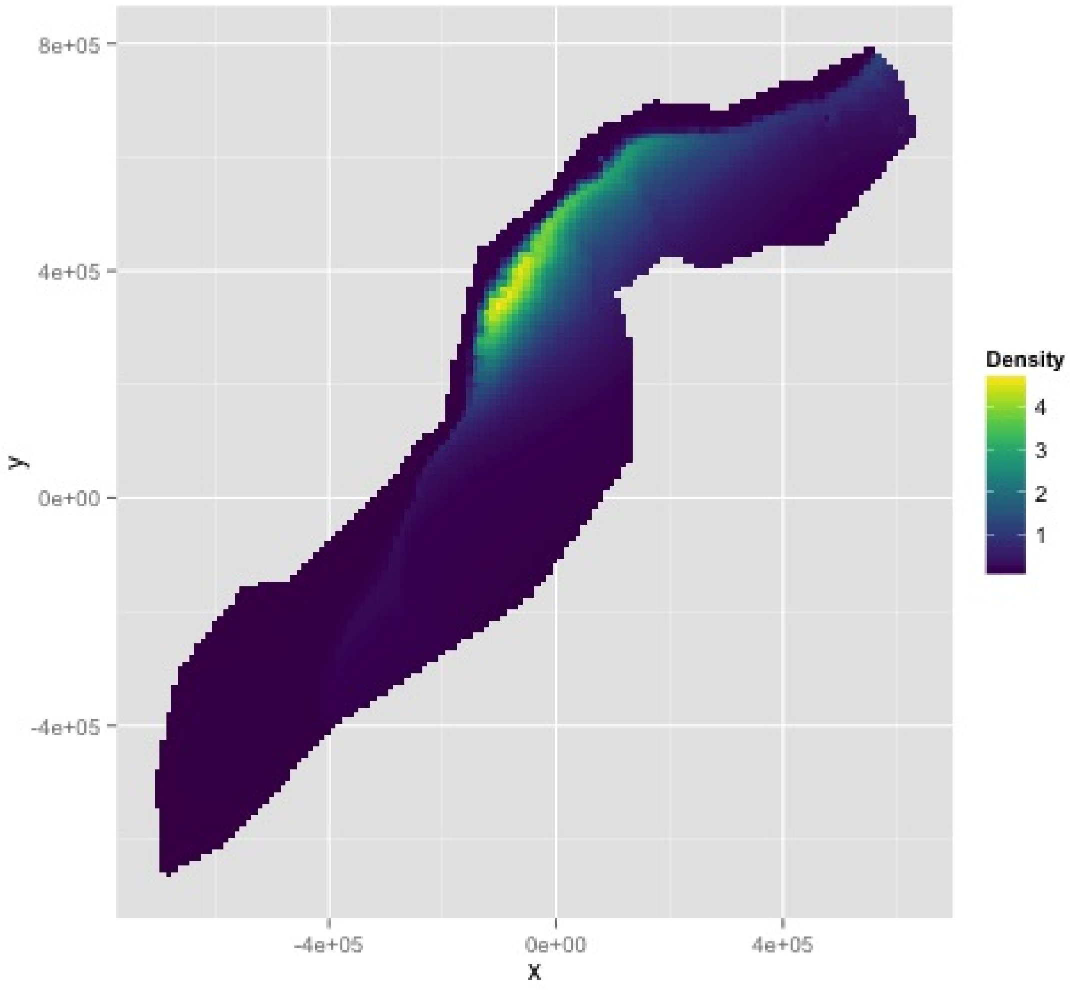


Explicit spatial effects



Predictions

Predictions over an arbitrary area



- Don't want to be restricted to 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

Adjusting areas

- Area of each segment A_j and use $A_j \hat{p}_j$
- (2-D) 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 is area of each segment
- "Estimated abundance" per segment

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

Detectability and covariates

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

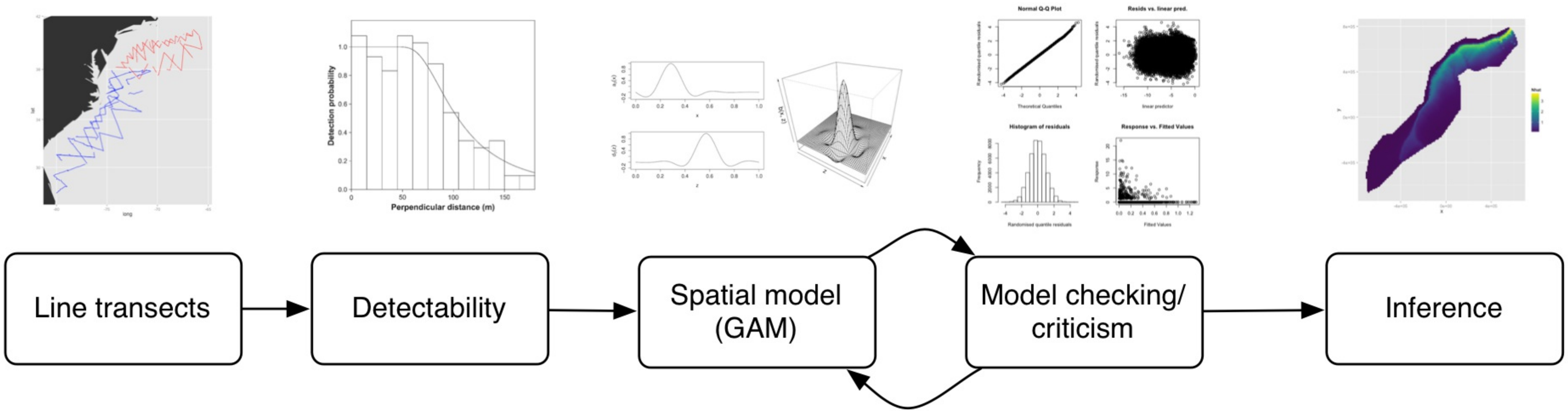
When to use each approach?

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

Availability/perception/etc

- Availability & perception bias via $\hat{p}$
- $\hat{p} = \hat{p}_{availability} \hat{p}_{perception} \hat{p}_{detection}$
- 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
  - 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

Jason demo of segmenting etc

Recap

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