

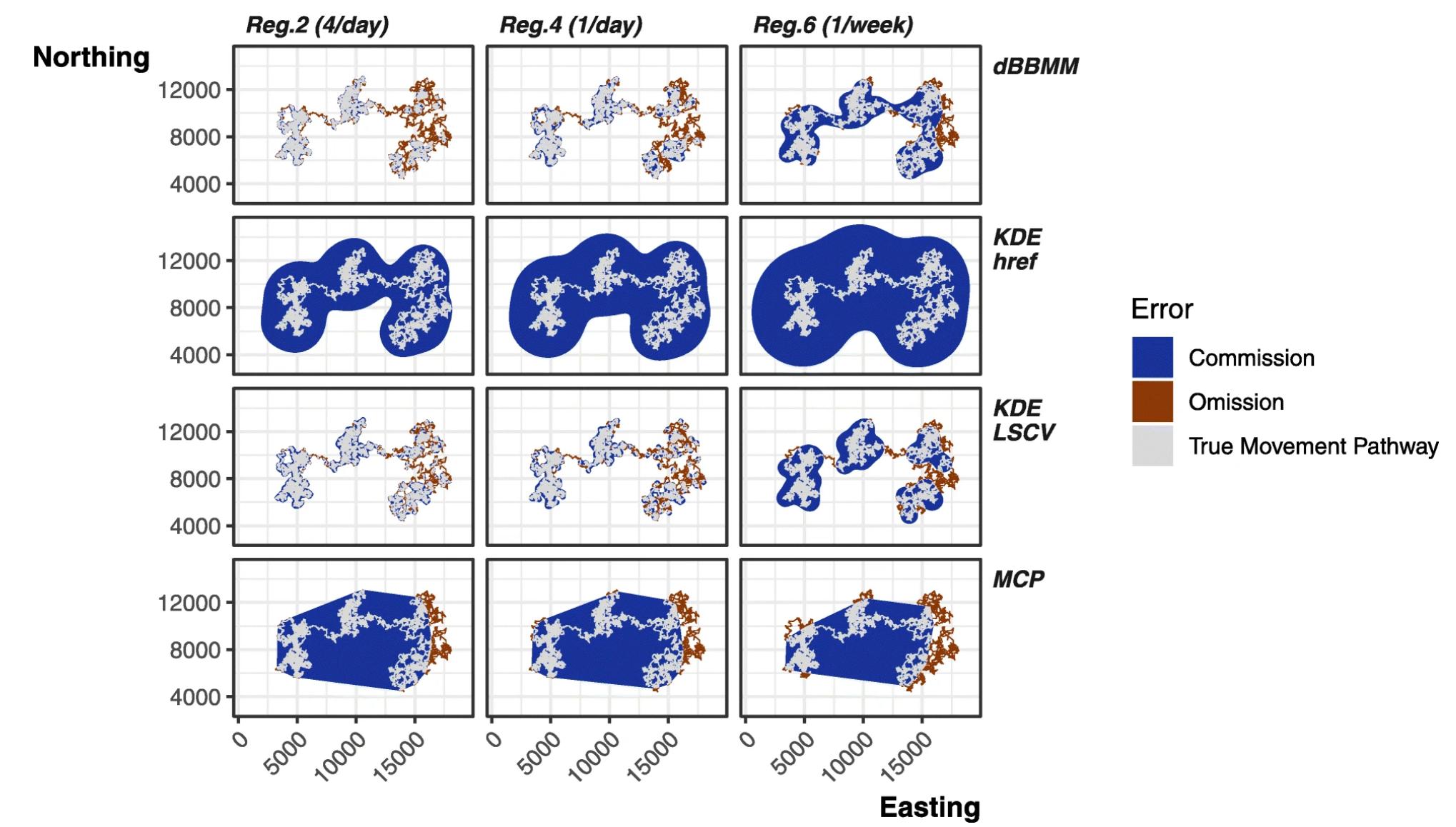
GUIDELINES FOR ESTIMATING SPACE-USE

Josh Cullen
September 8, 2022



Guiding questions

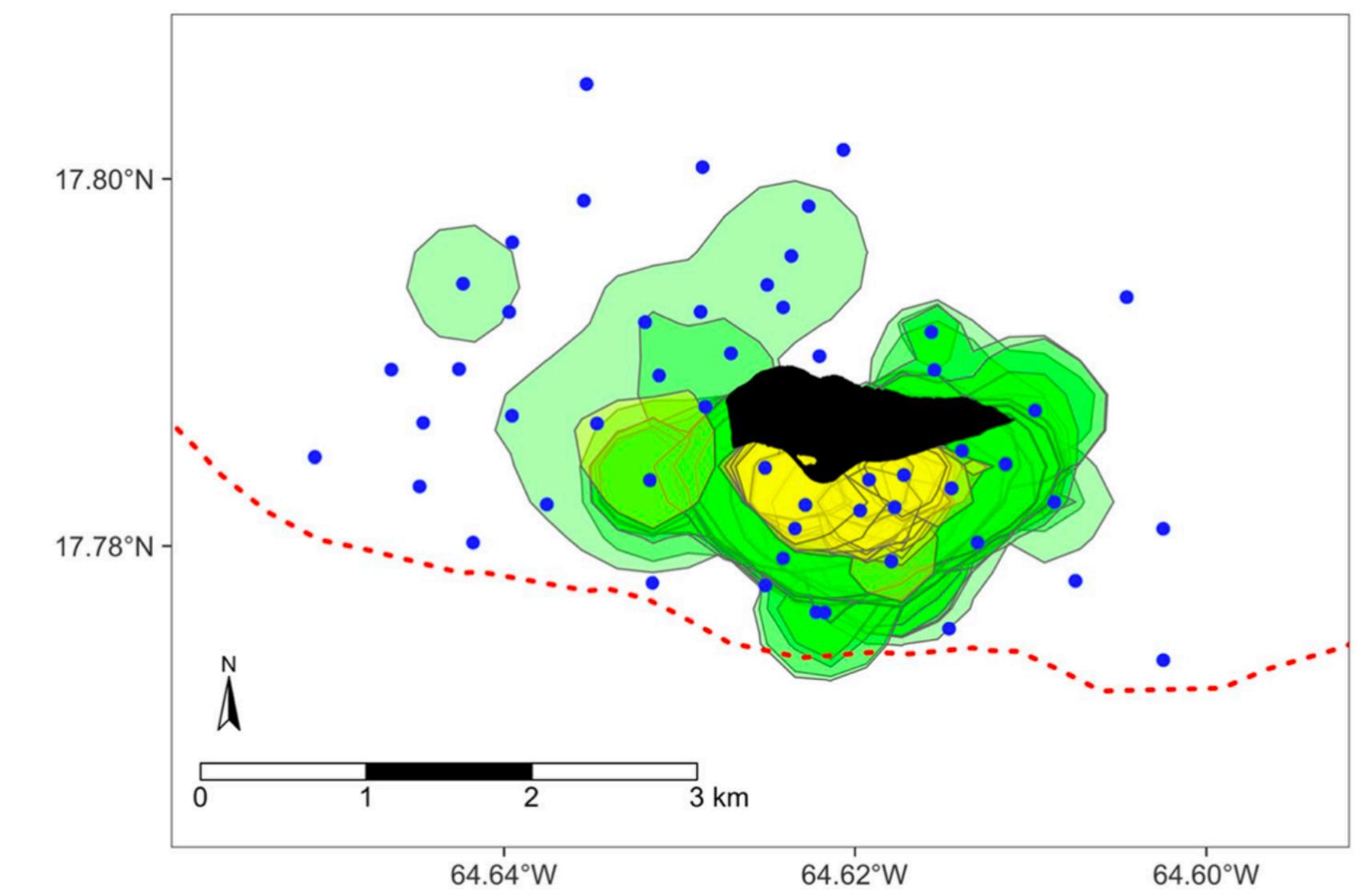
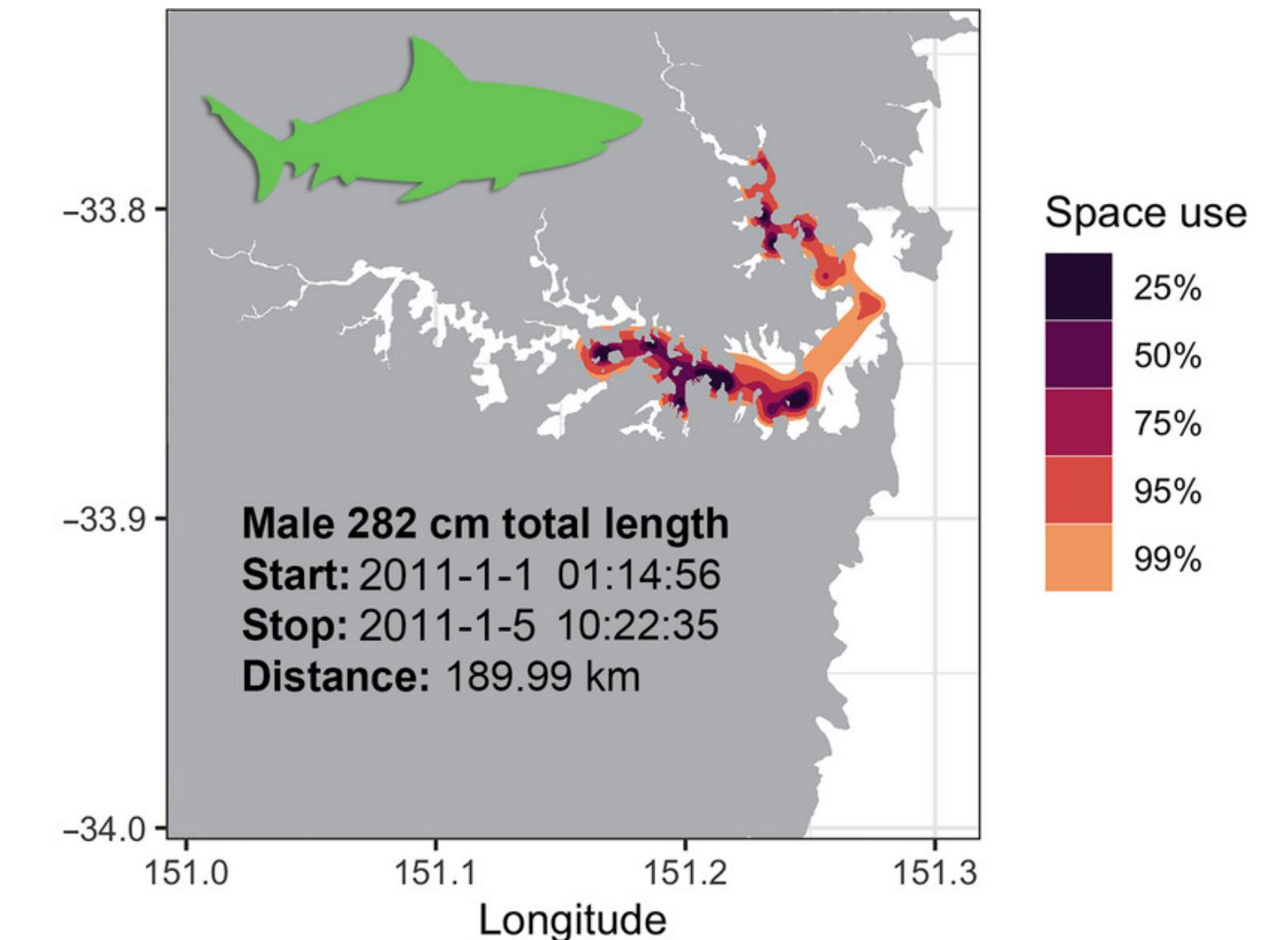
1. What is your sample size?
2. What is the sampling frequency (i.e., time step)?
3. Are you trying to detect temporal patterns?
4. What is the general movement pattern exhibited by your individual(s)?
5. Are you trying to estimate the occurrence or range distribution?
6. Are you interested in incorporating the effects of environmental covariates?



Silva et al. 2020

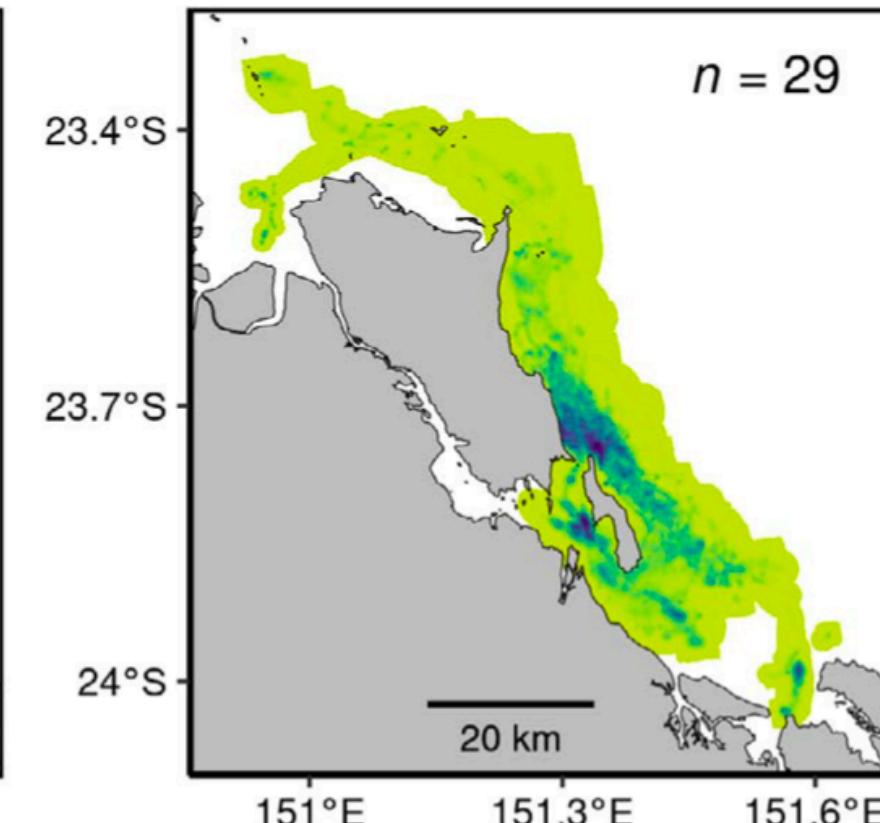
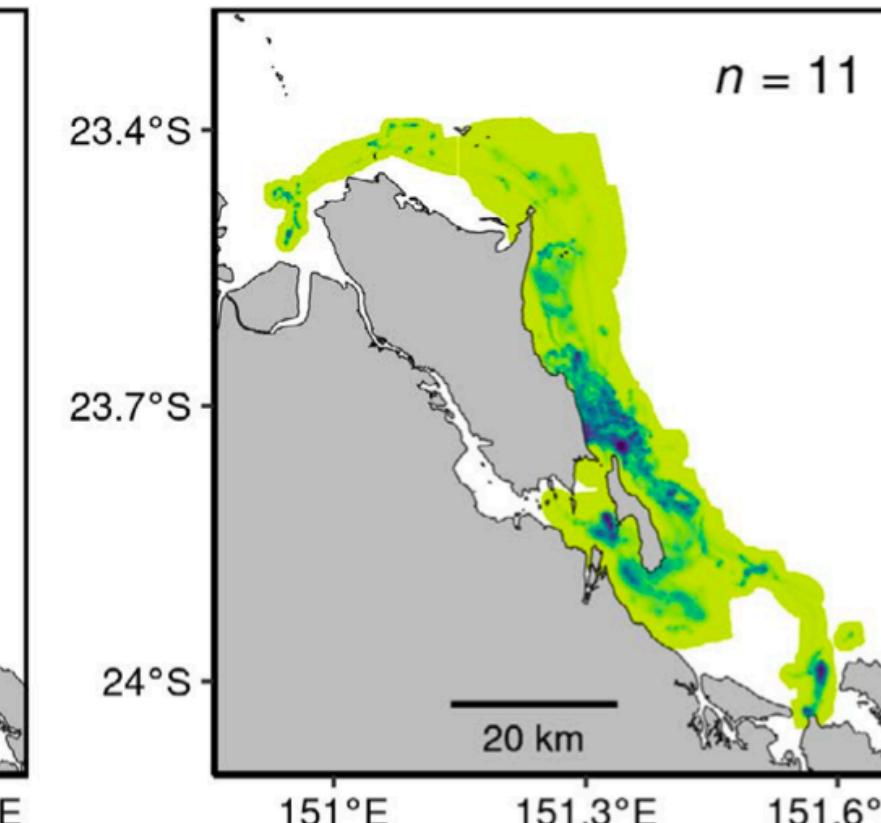
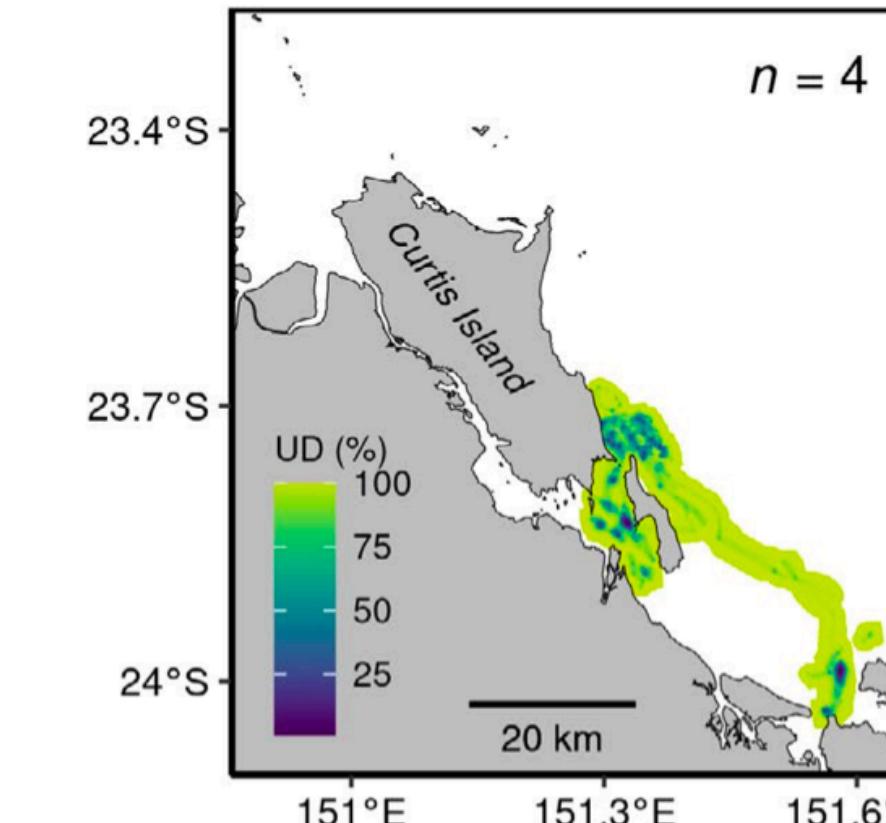
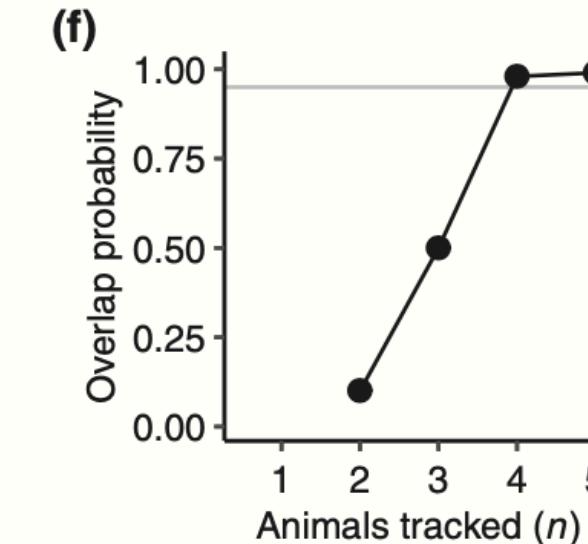
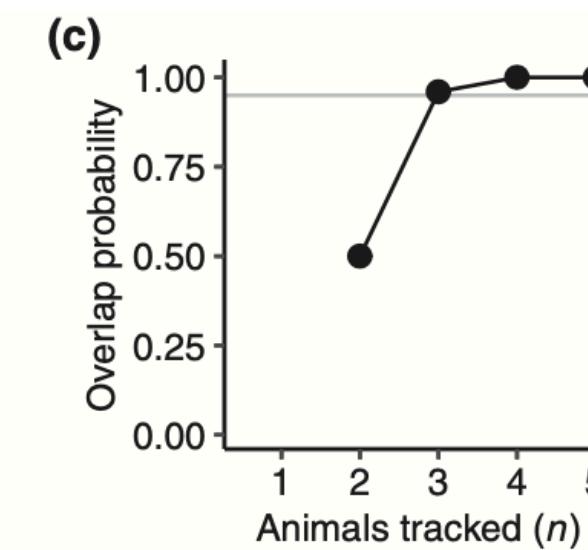
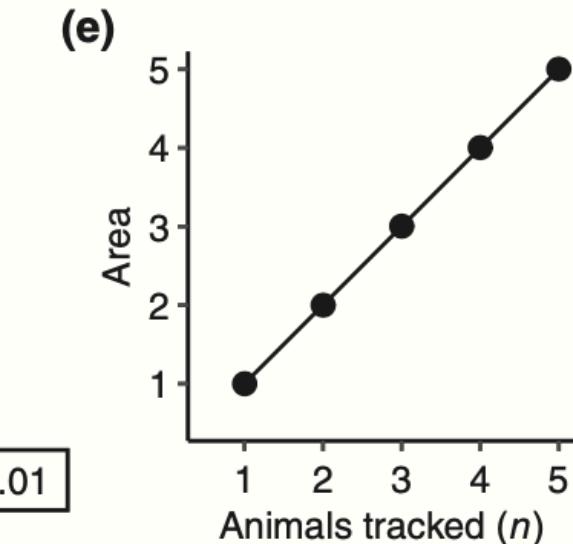
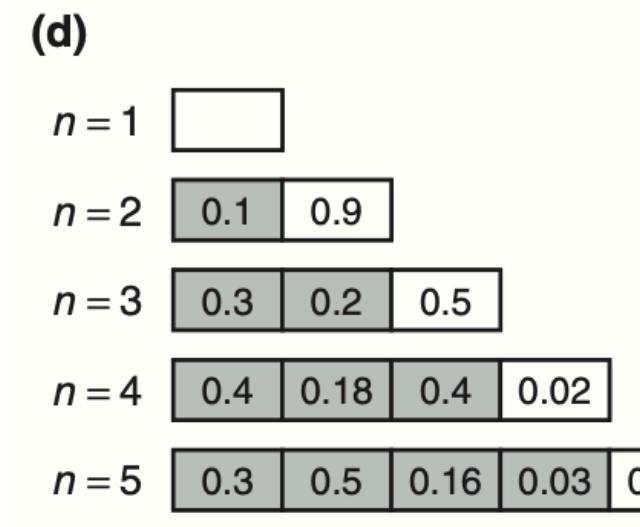
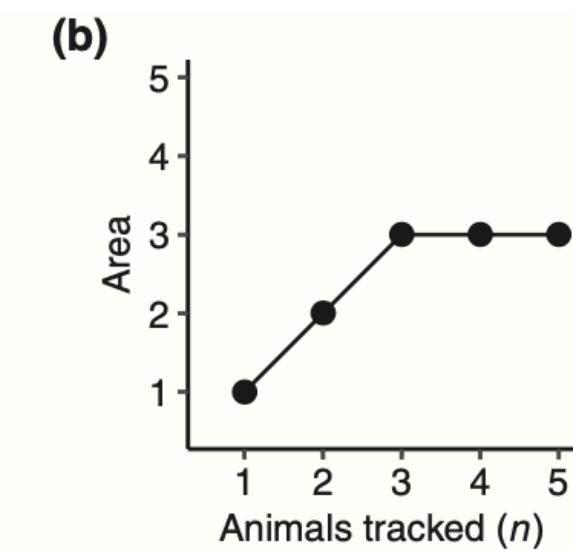
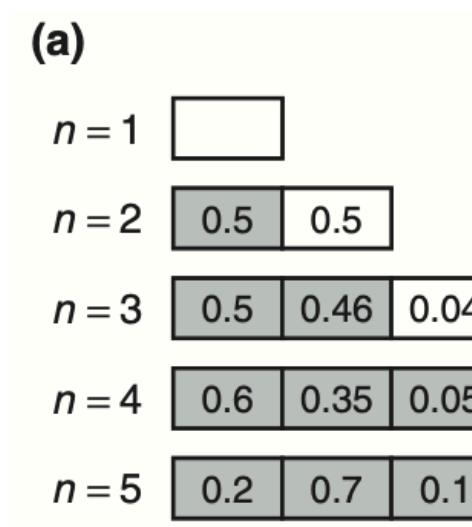
1. What is your sample size?

- With modern telemetry devices, it's reasonable to assume that researchers will collect > 100 observations per individual with more than one observation per day
- $N_{total} > 1000$
 - KDE ($h_{\text{plug-in}}$), dBMM
- $N_{total} < 1000$
 - KDE ($h_{\text{plug-in}}, h_{\text{Lscv}}$), dBMM
- Depending on project goals, may need to consider whether estimating UD for population vs per each individual
- But how do you know if enough animals have been tracked to characterize the population UD?



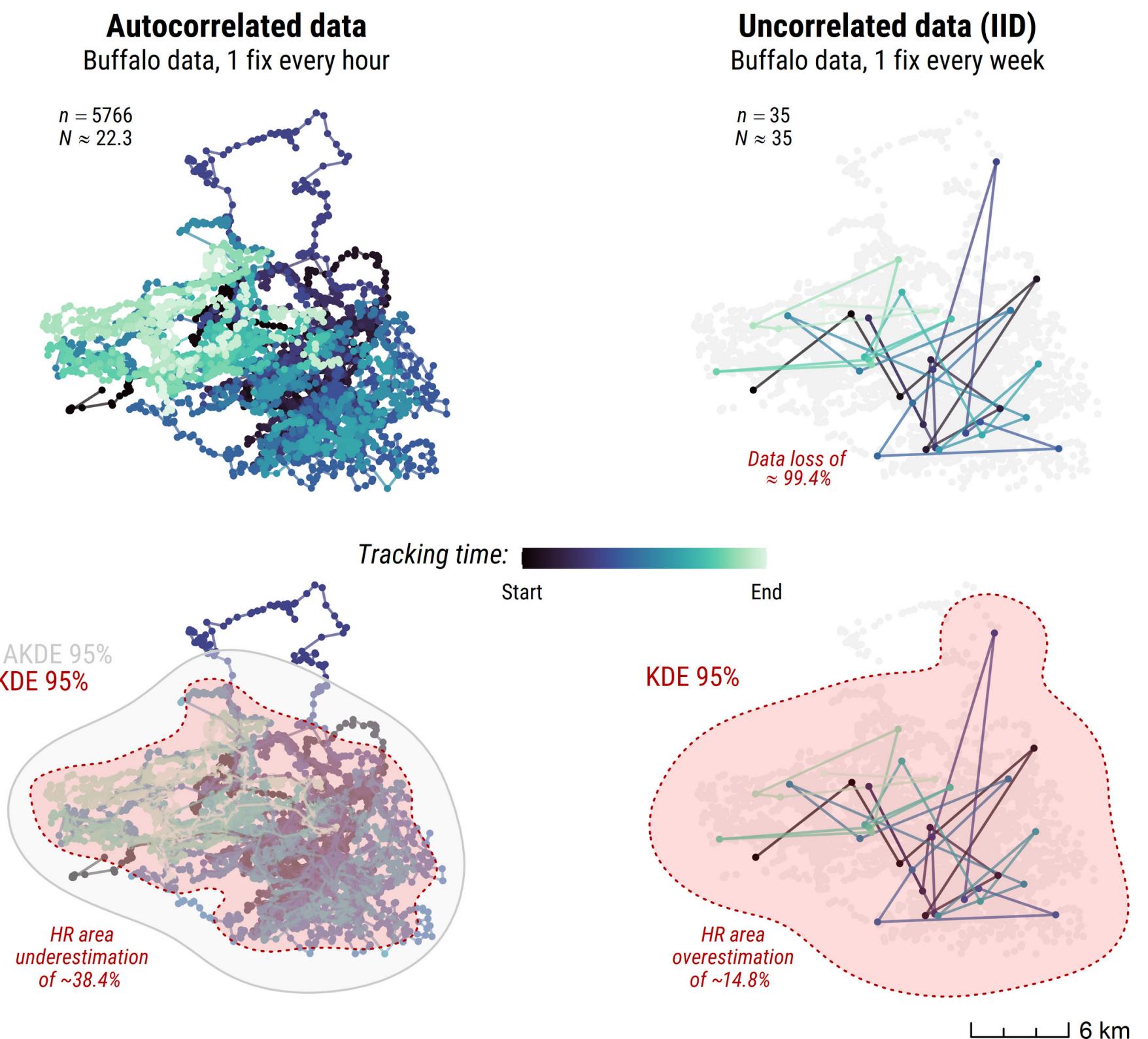
Method proposed by Shimada et al. (2021)

- Similar to rarefaction curves applied in evaluating species diversity



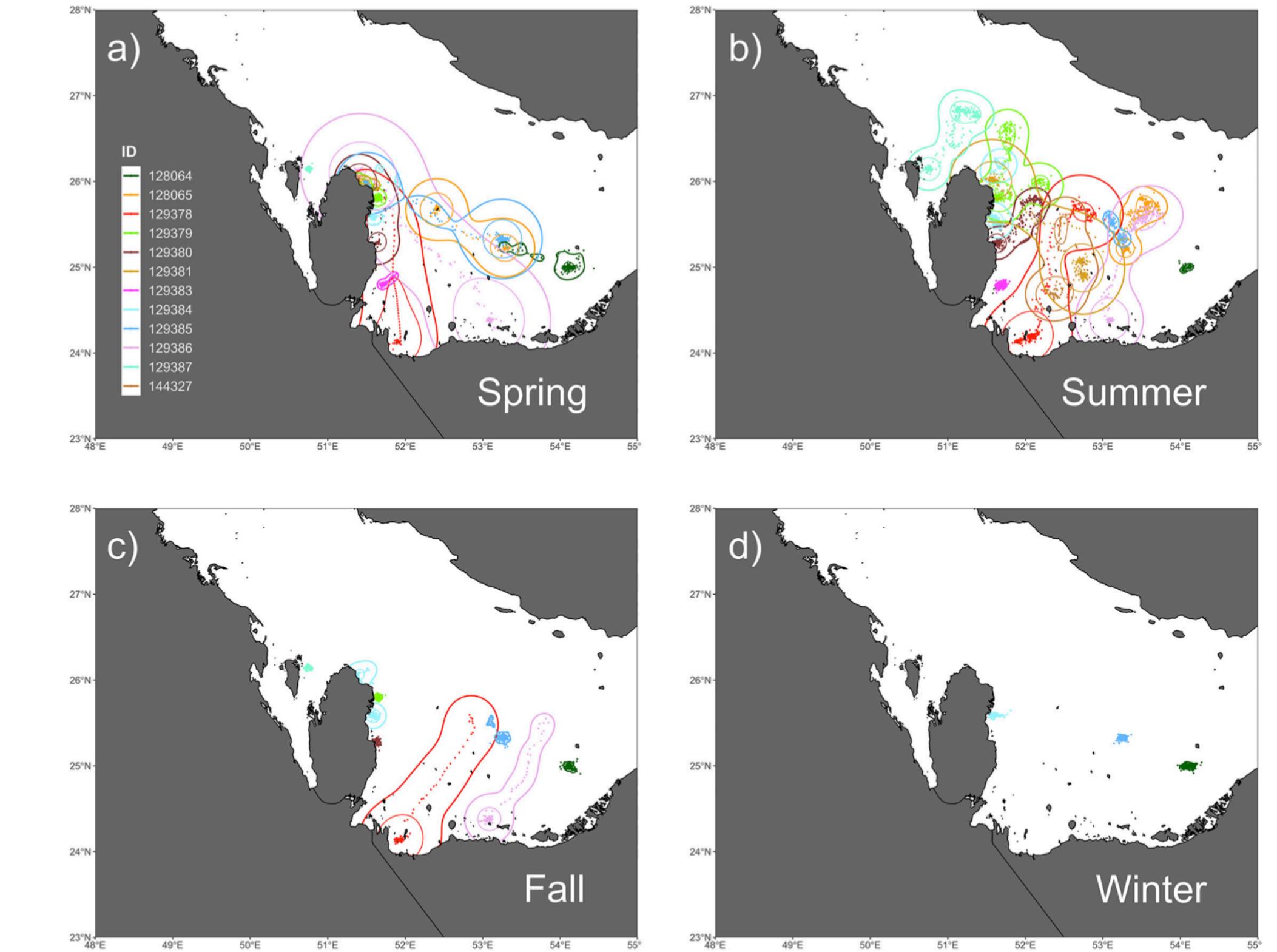
2.What is the sampling frequency?

- Higher sampling frequency is associated with high spatiotemporal autocorrelation
- Time interval < 24 hrs
 - dBMM
 - Only KDE method that should be applied with modern satellite (or acoustic) telemetry data is the AKDE method
- Time interval \geq 1 week
 - KDE



3. Are you trying to detect temporal patterns?

- Also depends on whether estimating UD at individual- or population-level and goals of study
- Diel patterns
 - dBMM
- Monthly patterns
 - KDE, dBMM
- Seasonal patterns
 - KDE, dBMM
- Highly dependent on sampling frequency

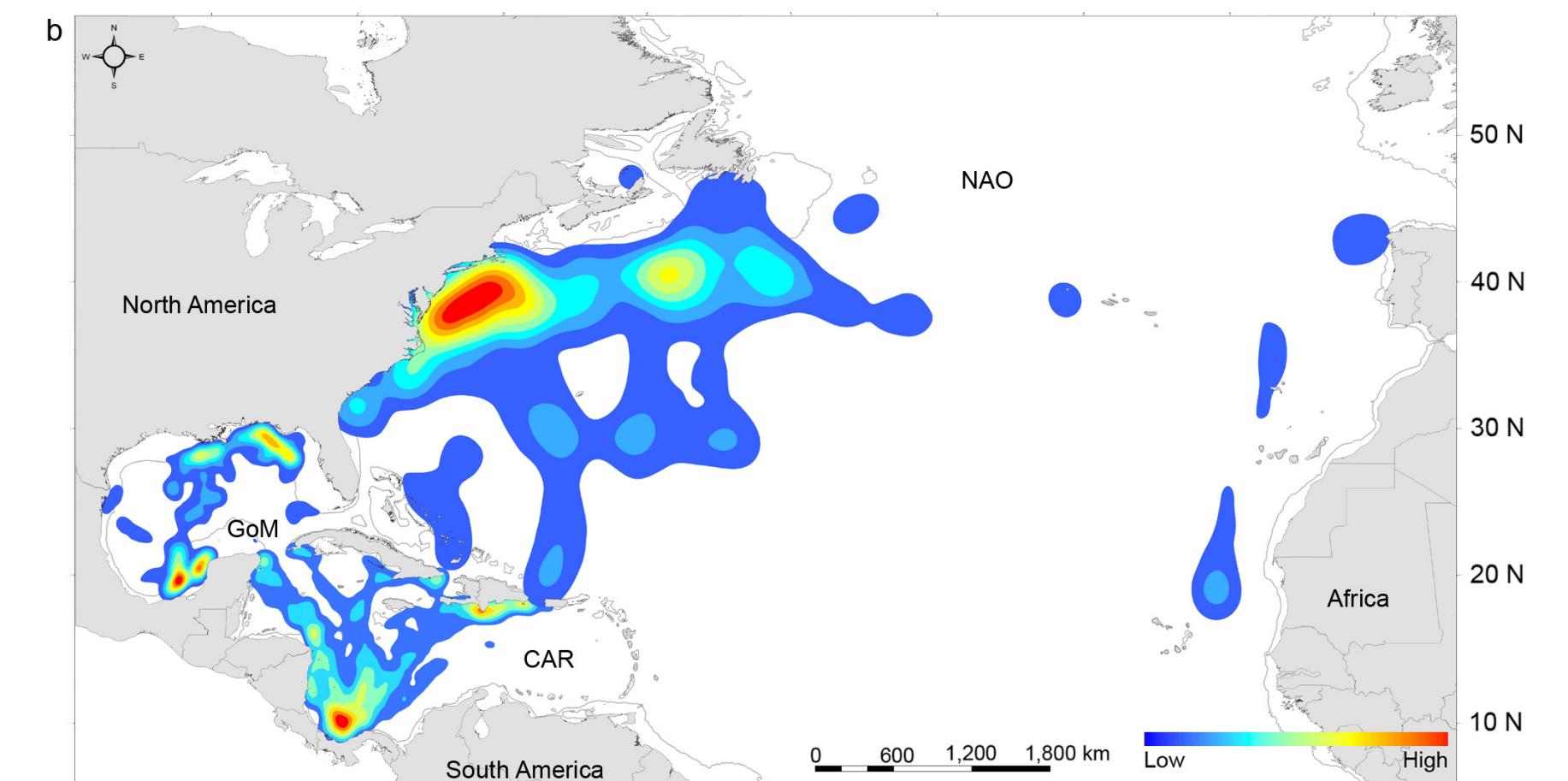
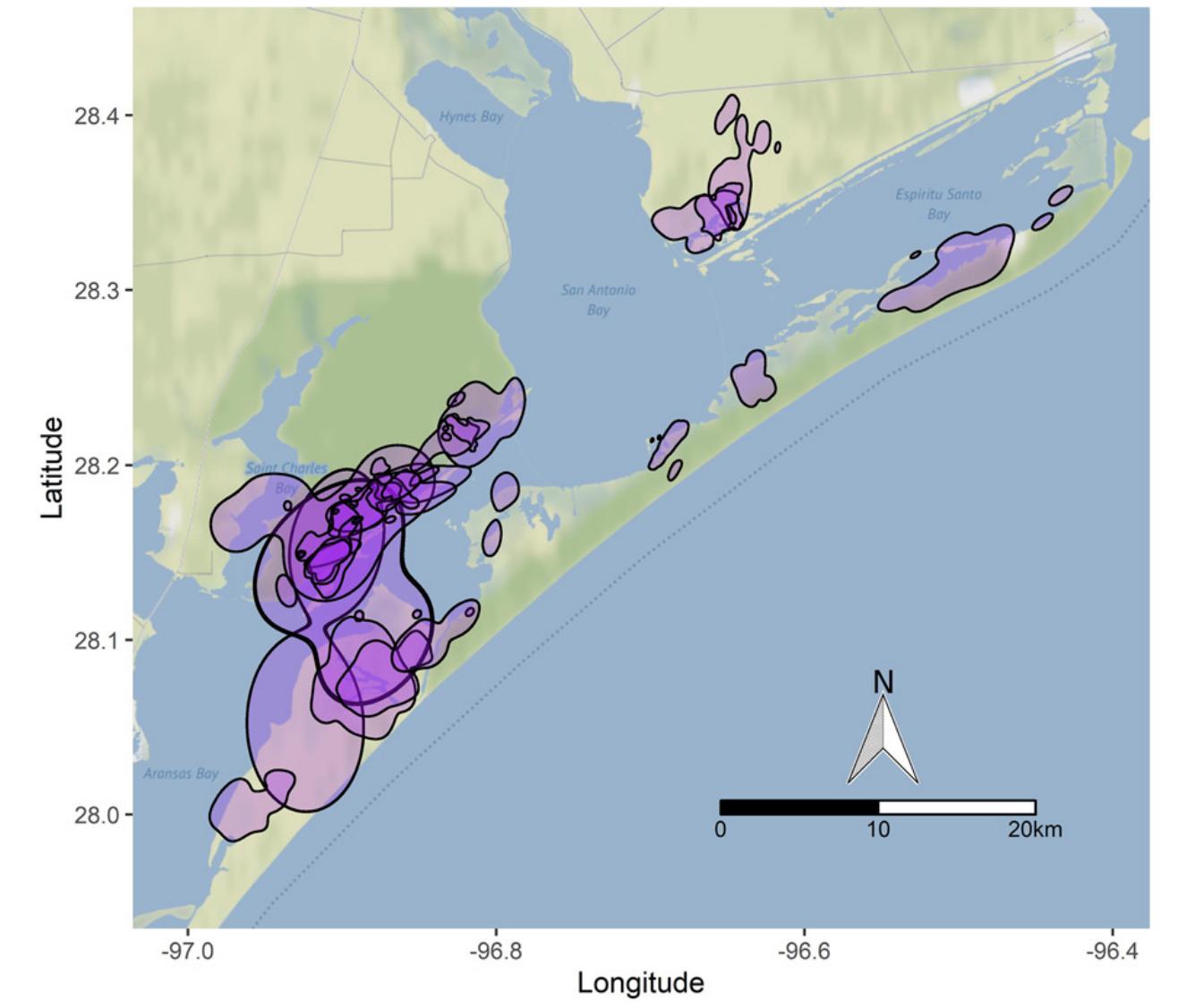


Marshall et al. 2020

4. What is the general movement pattern exhibited by your animals?

- Resident behavior defined by single cluster of points per ID
 - KDE, dBMM
- Ranging behavior related to forays, dispersal, migration, etc
 - dBMM
- A mix of movement patterns (e.g., multiple clusters, dispersal, diffusive spread of points)
 - KDE, dBMM

Butler et al. 2022



Evans et al. 2021

5. Are you trying to estimate the occurrence or range distribution?

- Occurrence distribution
 - KDE, dBMM
- Range distribution
 - AKDE, mechanistic models

Crane et al. 2021

What does your space-use estimate mean?

Concept: Occurrence distributions

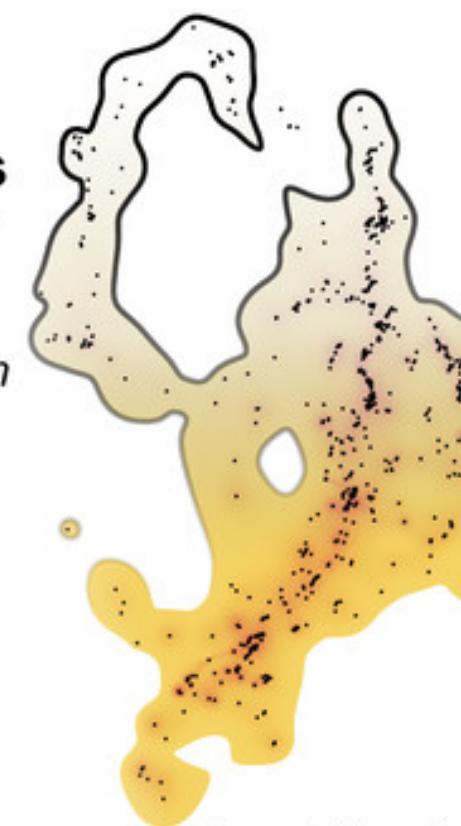
Estimating the space potentially used by animals during the sampling period, essentially estimates of uncertainty between known locations.

Distribution: Occurrence distribution

Contour: Confidence area

Predictive scope: Within sample interpolation

Example question: What potential movement corridors does species A use?



e.g., dynamic Brownian Bridge Movement Models

Range distributions

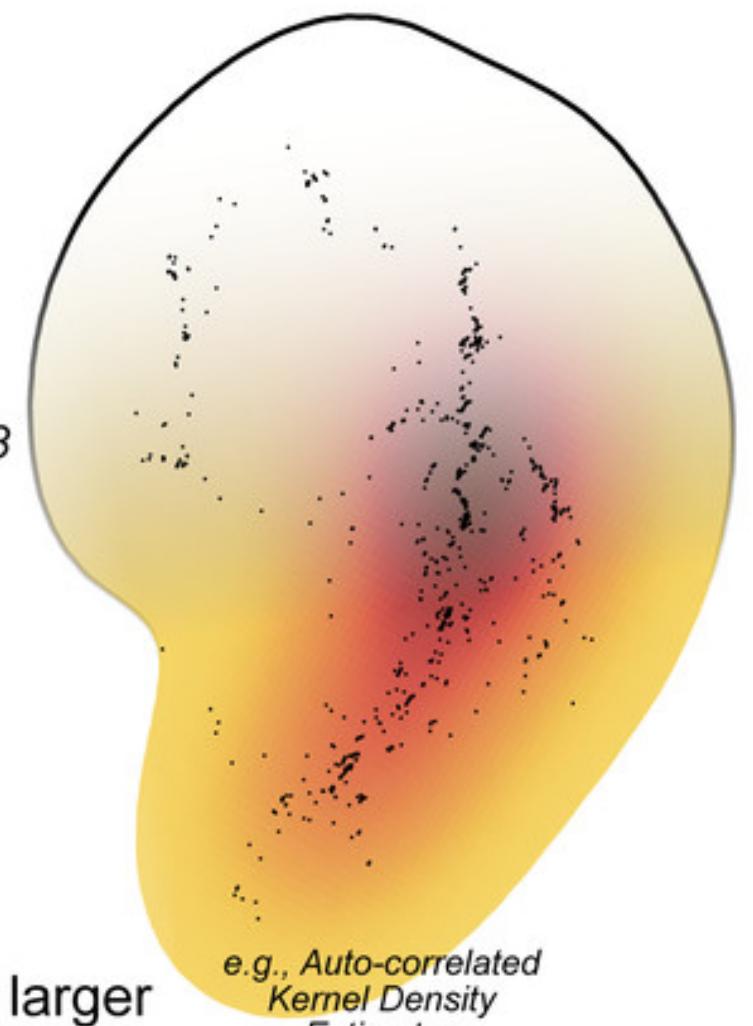
Estimating the space requirements of animals, corresponding to Burt's 1943 concept of home range.

Utilisation distribution

Home range

Beyond sample extrapolation

Does species A have a larger home range than species B?

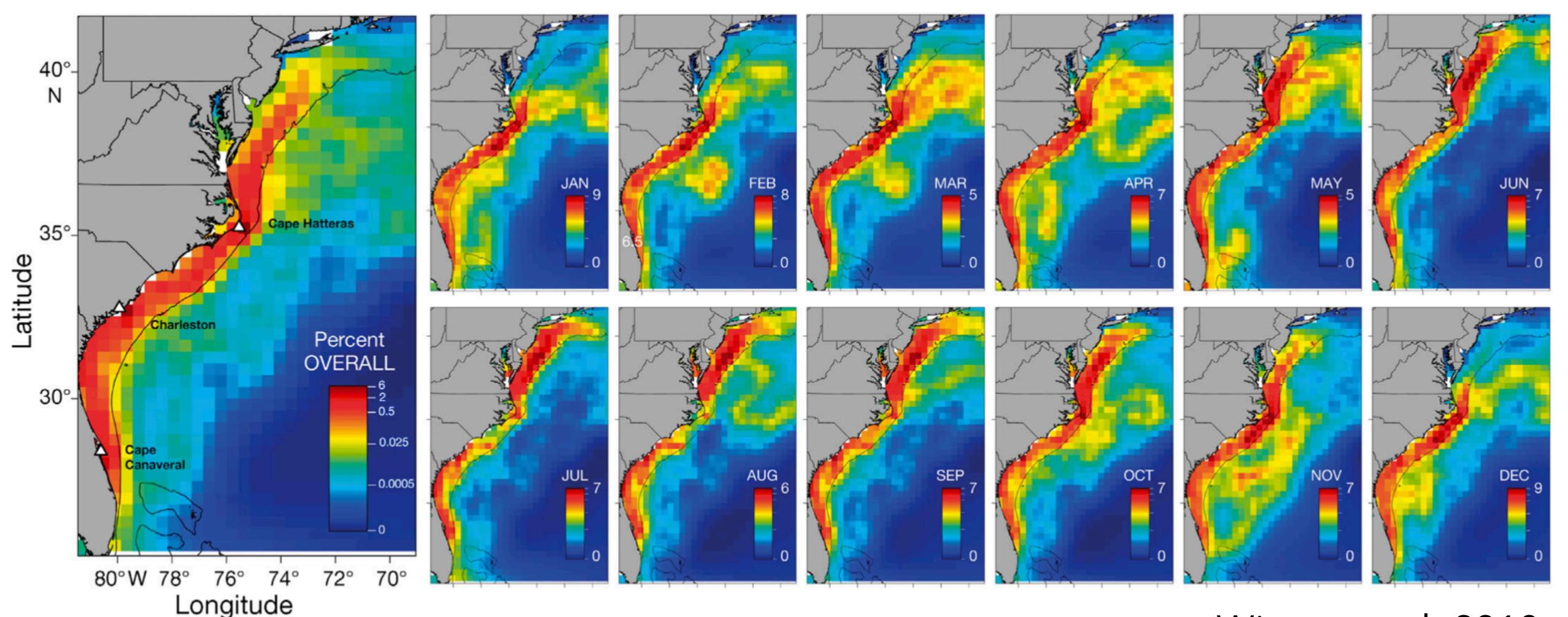
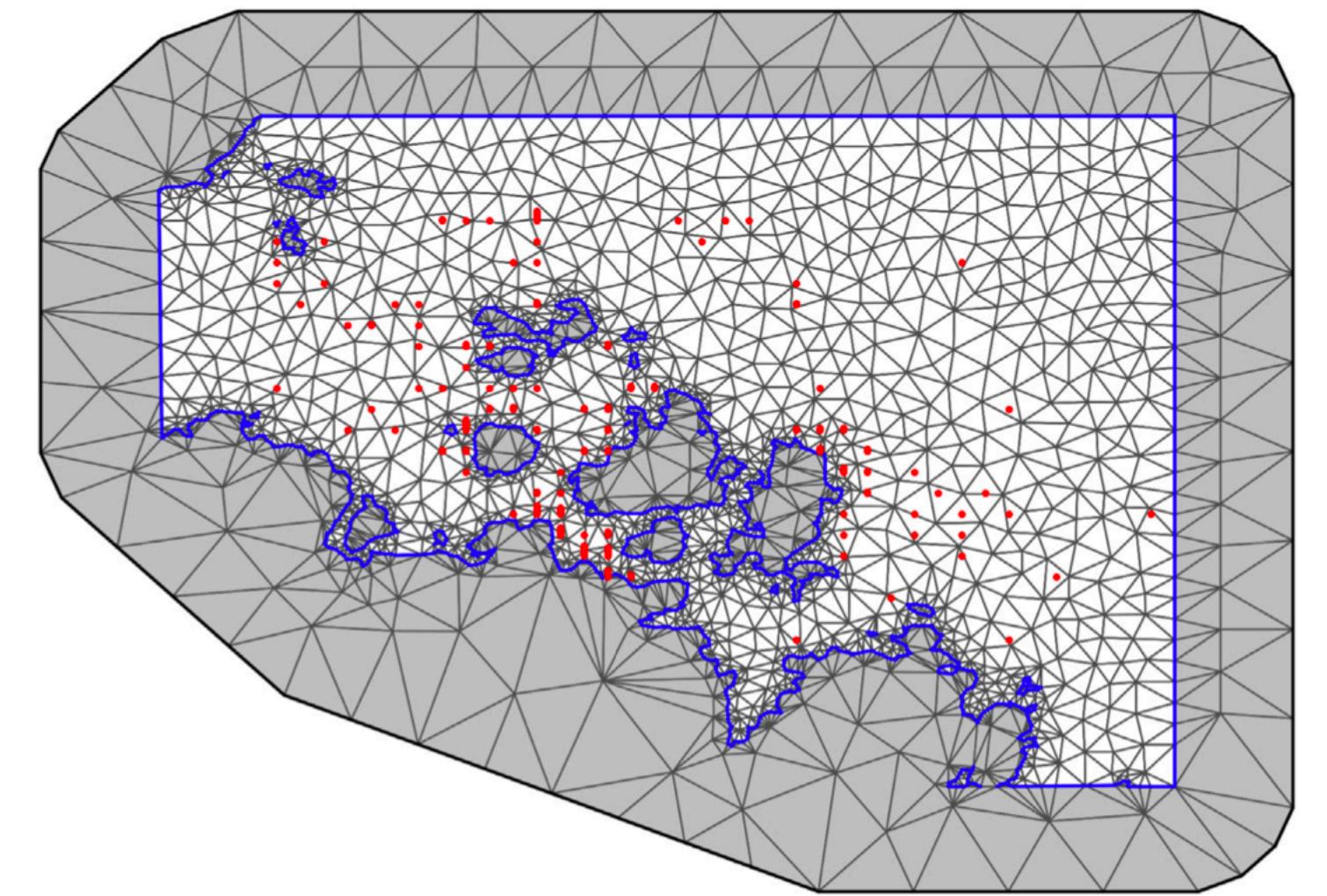


e.g., Auto-correlated Kernel Density Estimates

6. Are you interested in the effects of environmental covariates?

- No
 - KDE, dBMM
- Yes
 - Geostastical mixed effects models, continuous-time Markov chain model, step-selection functions

Martinez-Minaya et al. 2019



Winton et al. 2018

Other methods not covered

- AKDE
- Local convex hulls (LoCoH)
- Movement-based KDE (aka Biased Random Bridges)
- Geostatistical mixed effects models (via INLA)
- Continuous-time Makov chain models
- Step-selection functions
- Brownian bridge covariates model

See 'Useful Resources' page on workshop website for associated info

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