

INTRODUCTION TO ANIMAL MOVEMENT ECOLOGY

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September 8, 2022

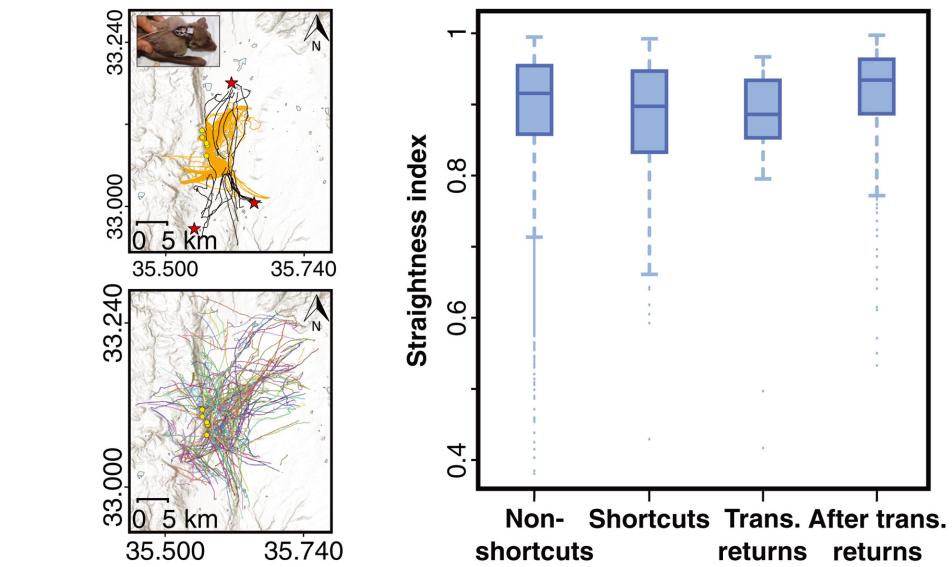


Background

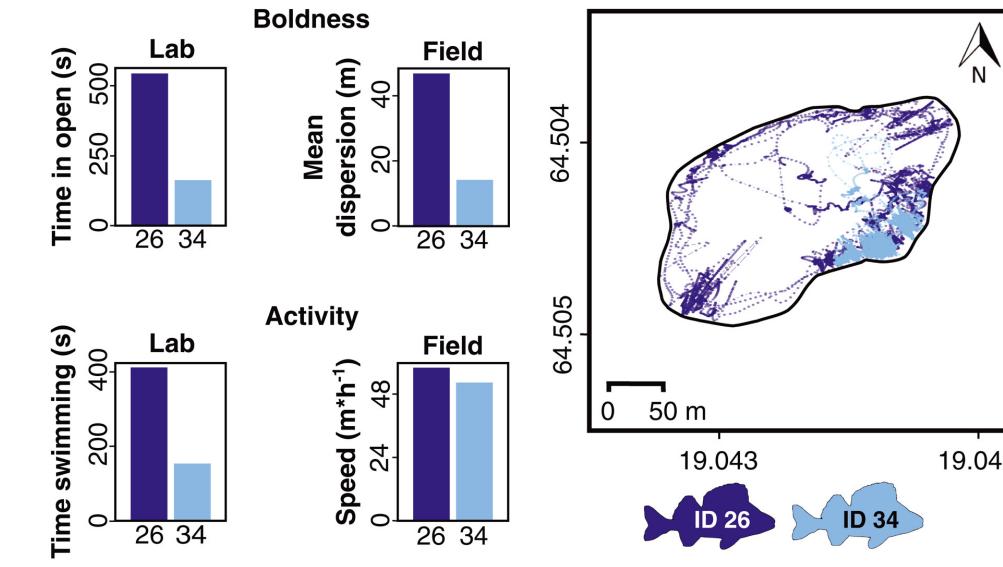
- Movement is fundamental to the life history and fitness of organisms
- The study of animal movement via telemetry devices (e.g. GPS, Argos, VHF) has enabled a variety of detailed analyses
- Often, researchers want to estimate space-use and latent behavioral states from animal tracks

Study Design

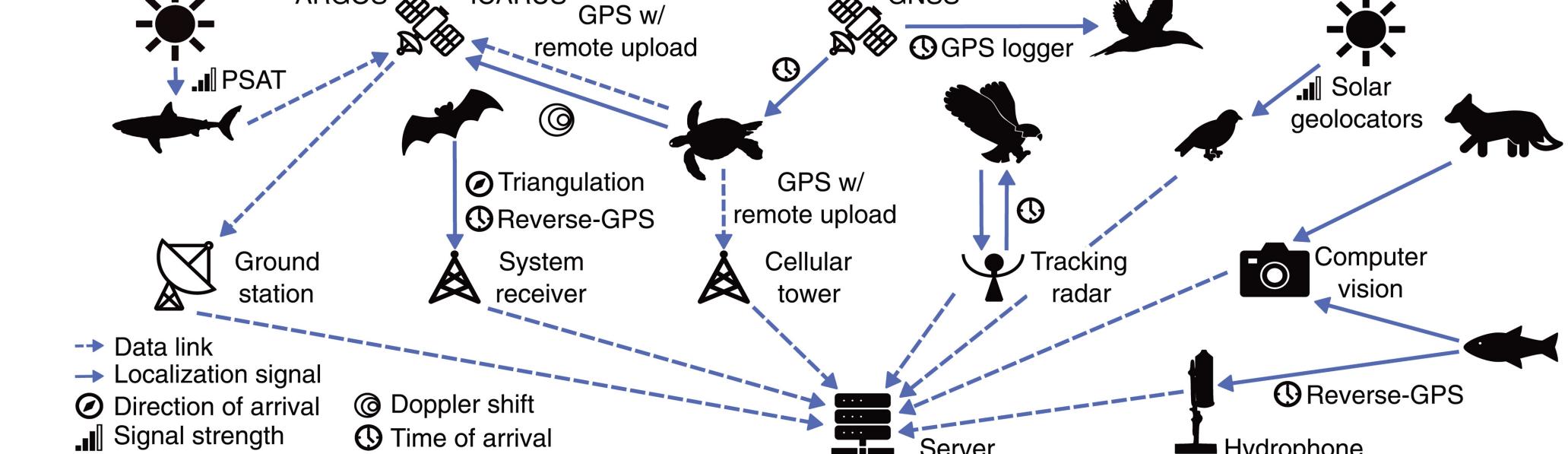
A Animal cognition experiments



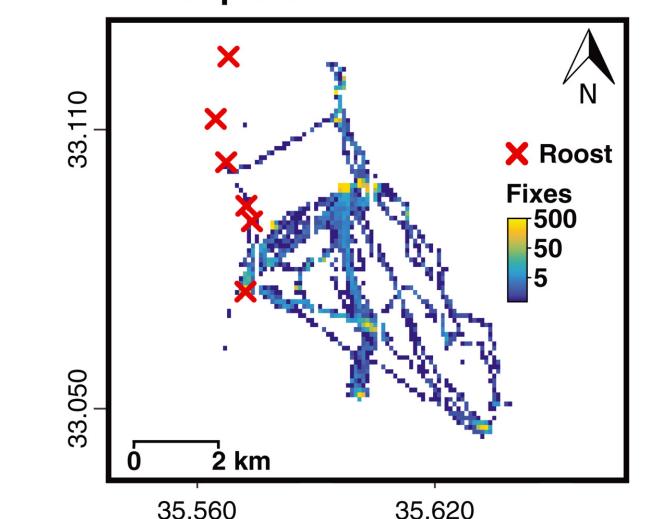
B Animal personality experiments



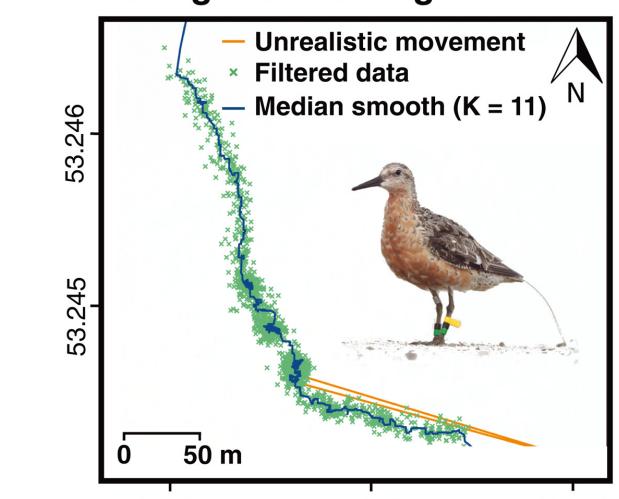
C Data Collection



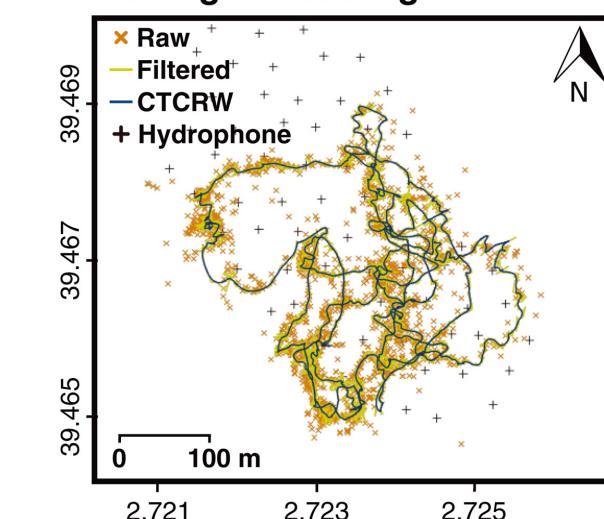
D Data exploration



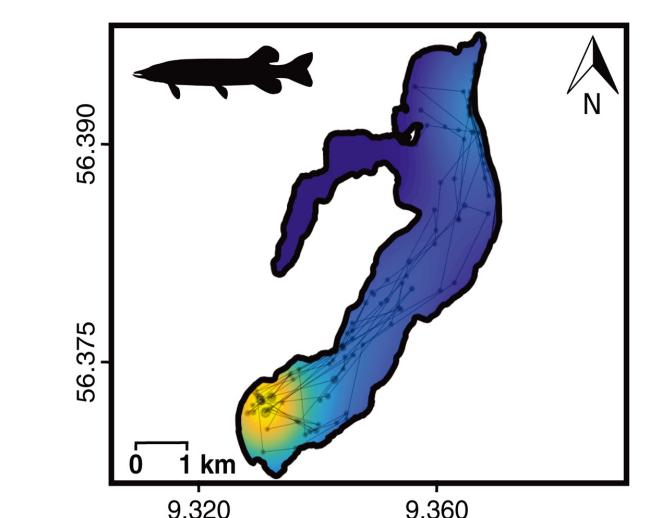
E Filtering & smoothing



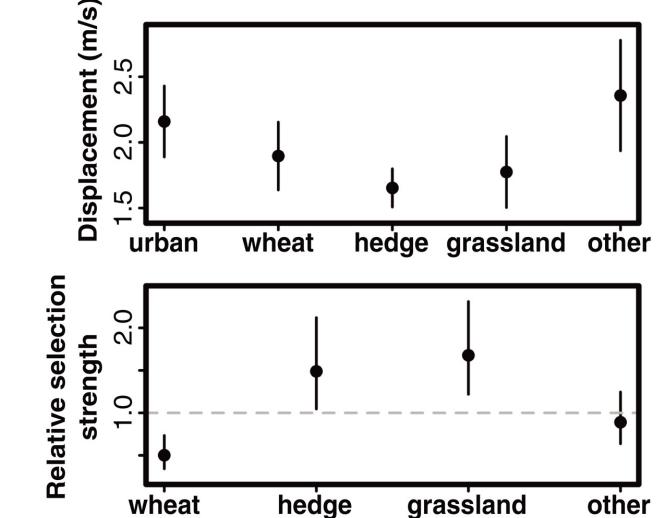
F Filtering & modeling



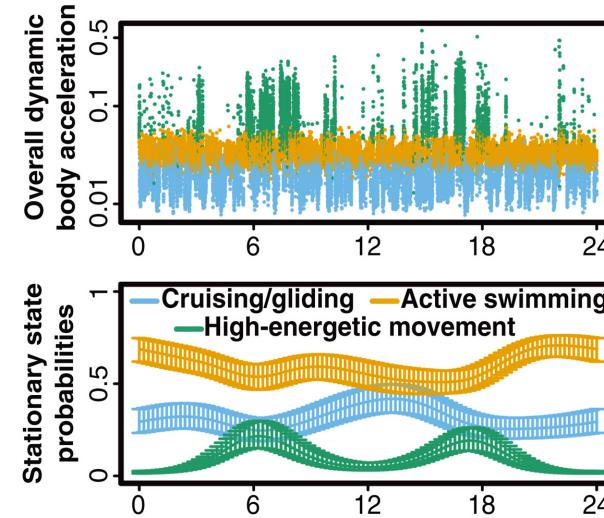
G Kernel density estimation



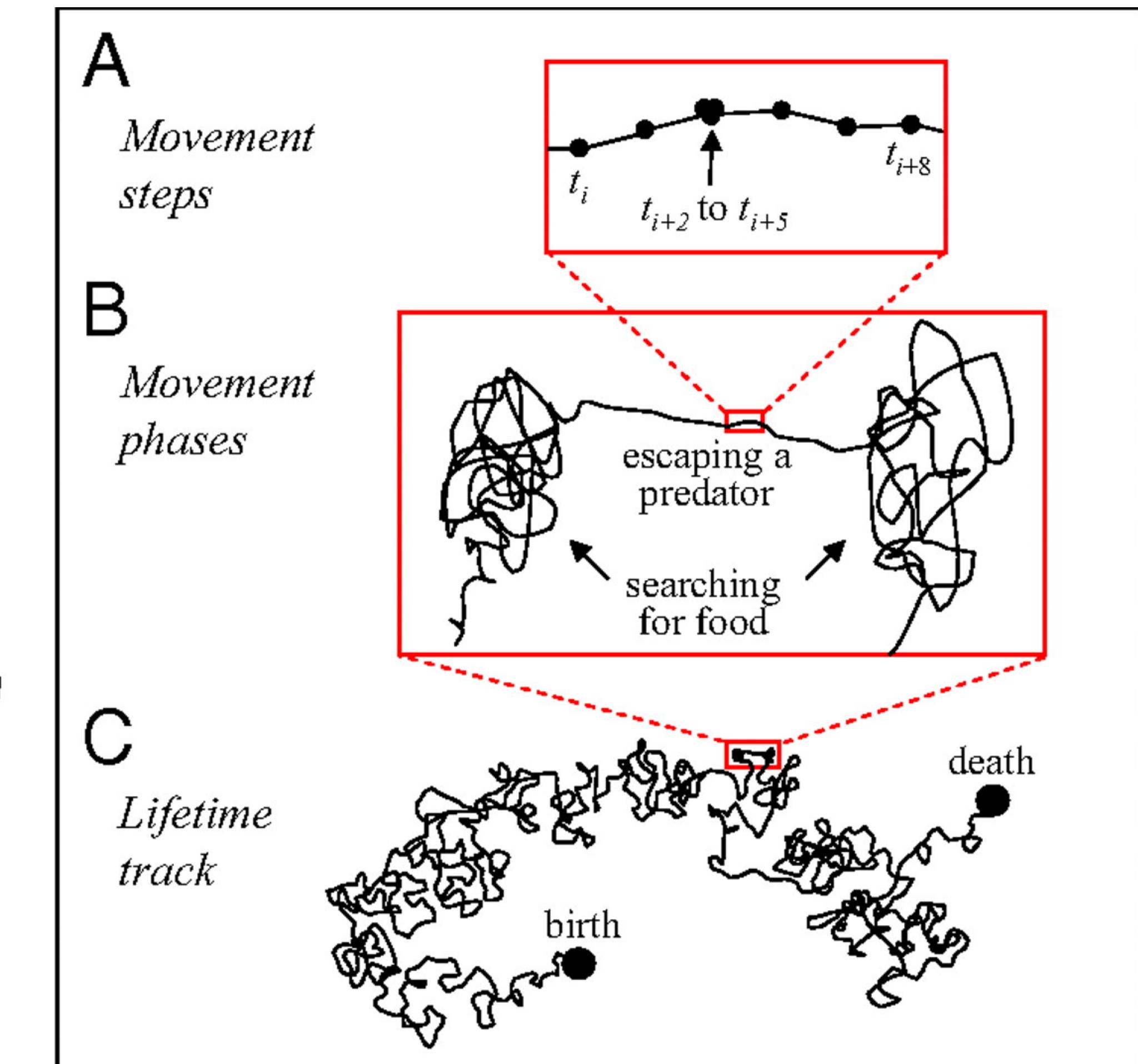
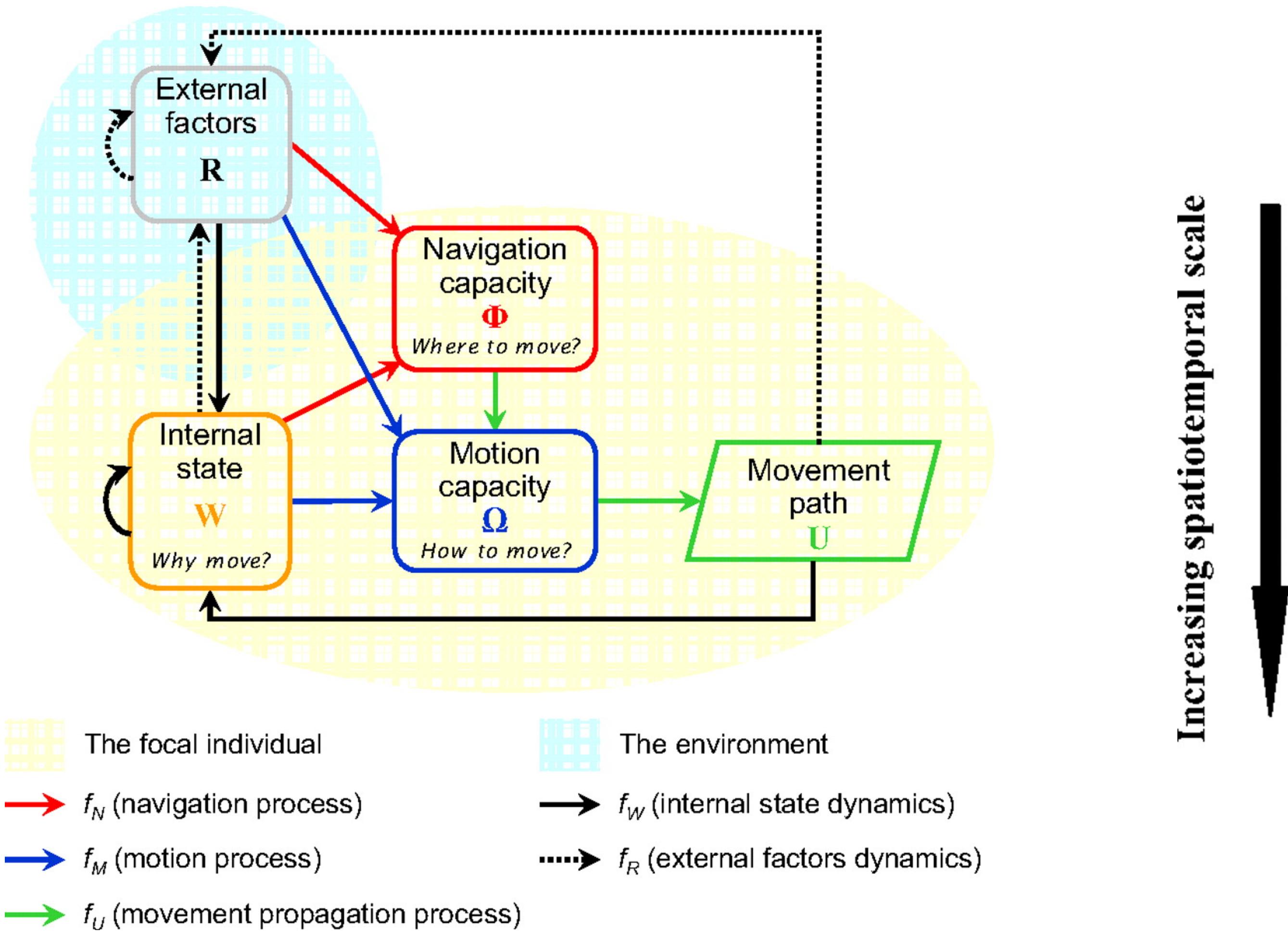
H Step selection function



I Hidden Markov modeling



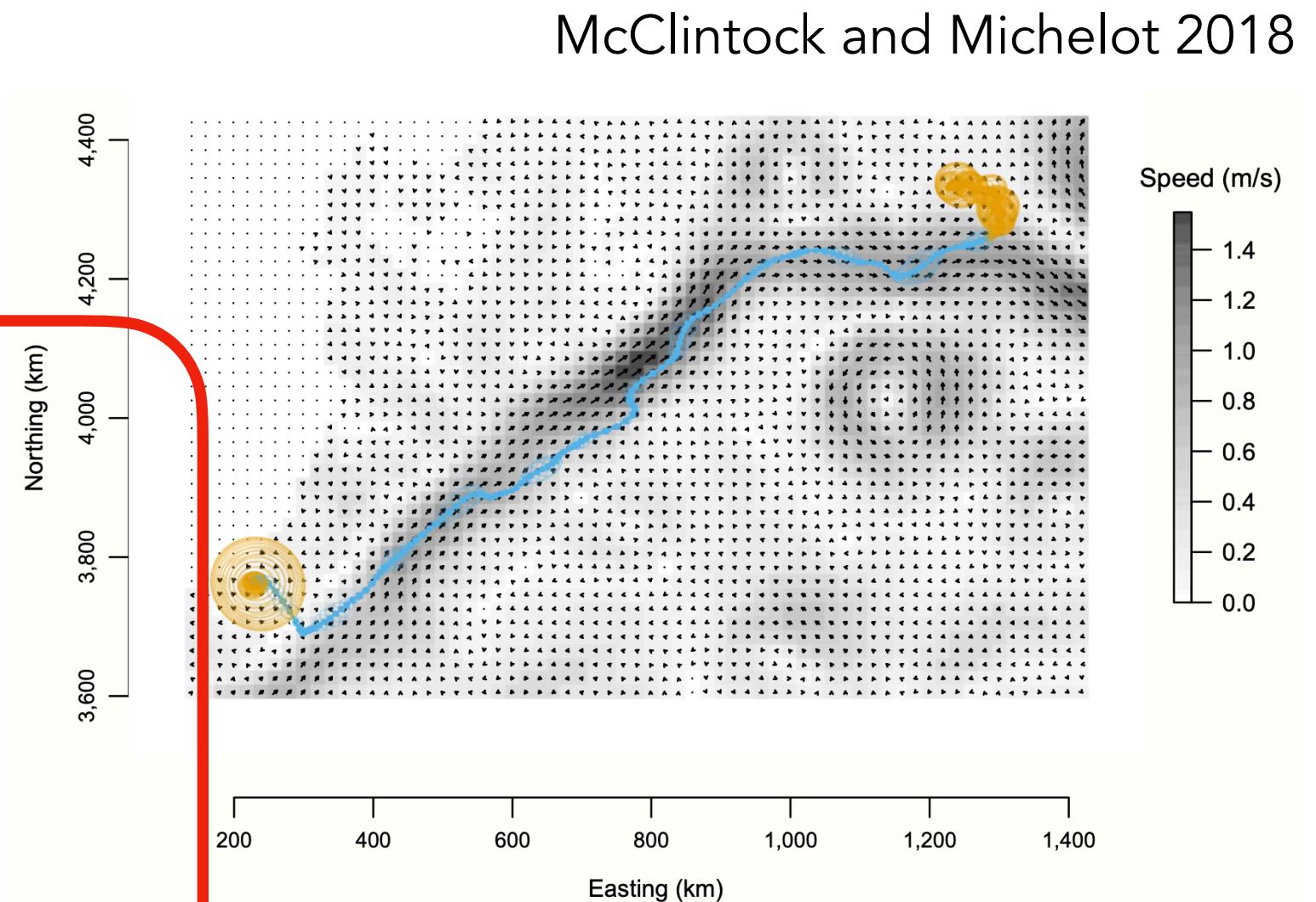
Movement ecology paradigm



Big picture applications

Space use

- By an individual
- By a population
- Temporal patterns
- Relationship w/ MPAs
- Comparisons among life stages
- Determine centers of activity



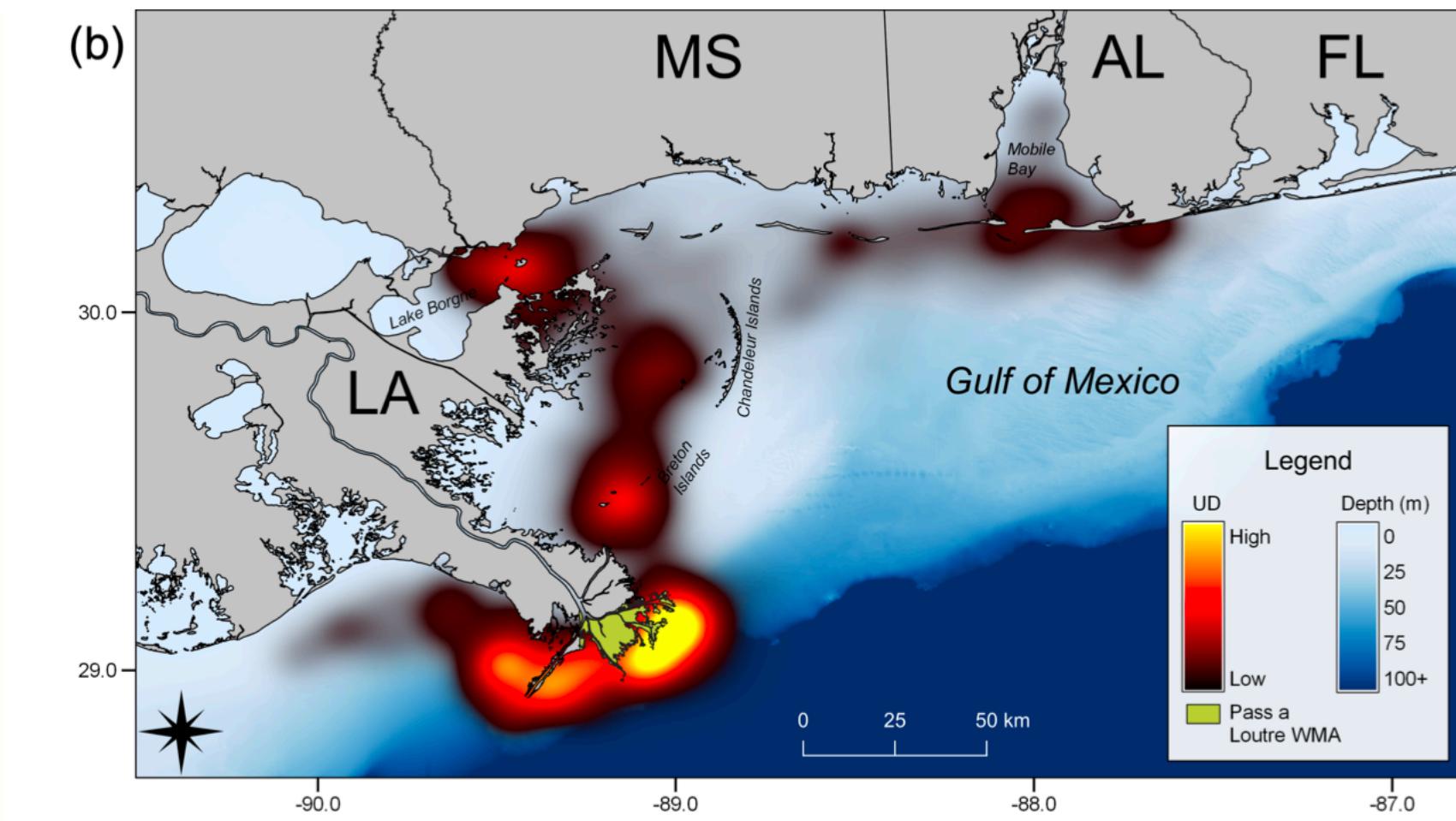
Behavioral states

- What is the animal doing?
- Activity budgets
- Identification of possible corridors or foraging grounds

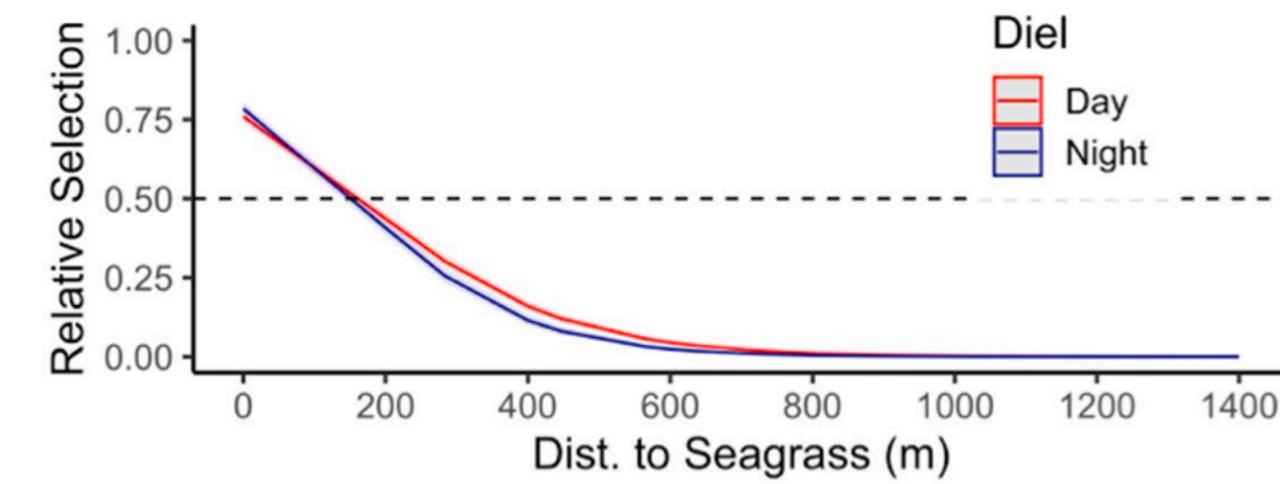
Habitat selection and suitability

- What type of habitat does the animal prefer?
- Does this differ by season/age/sex?
- Does this differ by behavioral state?
- How is this expected to be impacted by climate change?
- Can we use habitat preferences of some species of a community to inform habitat preferences of other species?

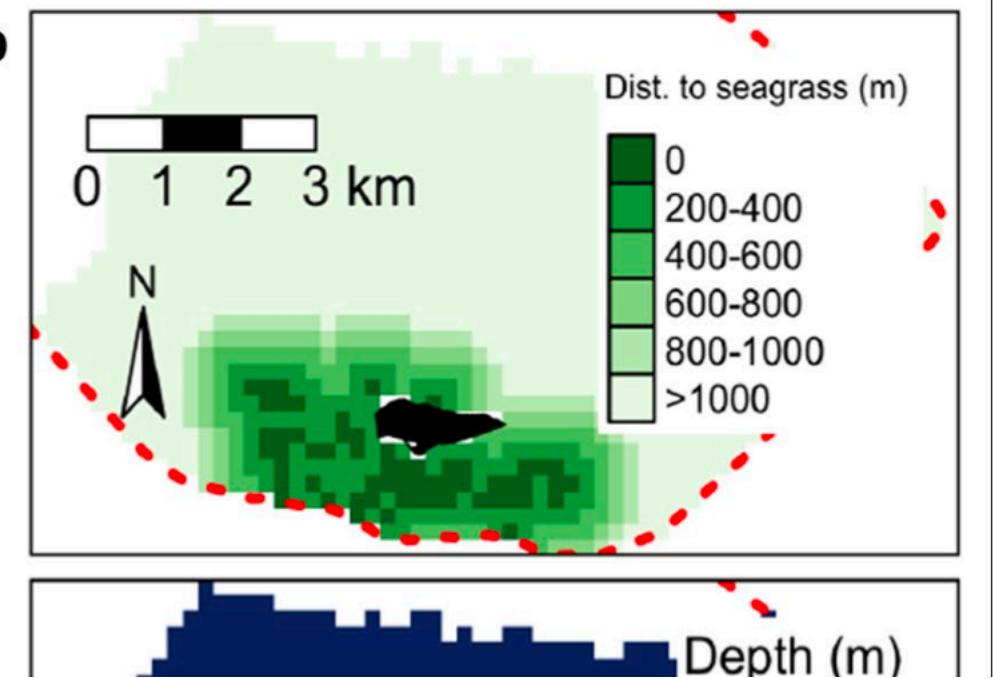
Drymon et al. 2020



a

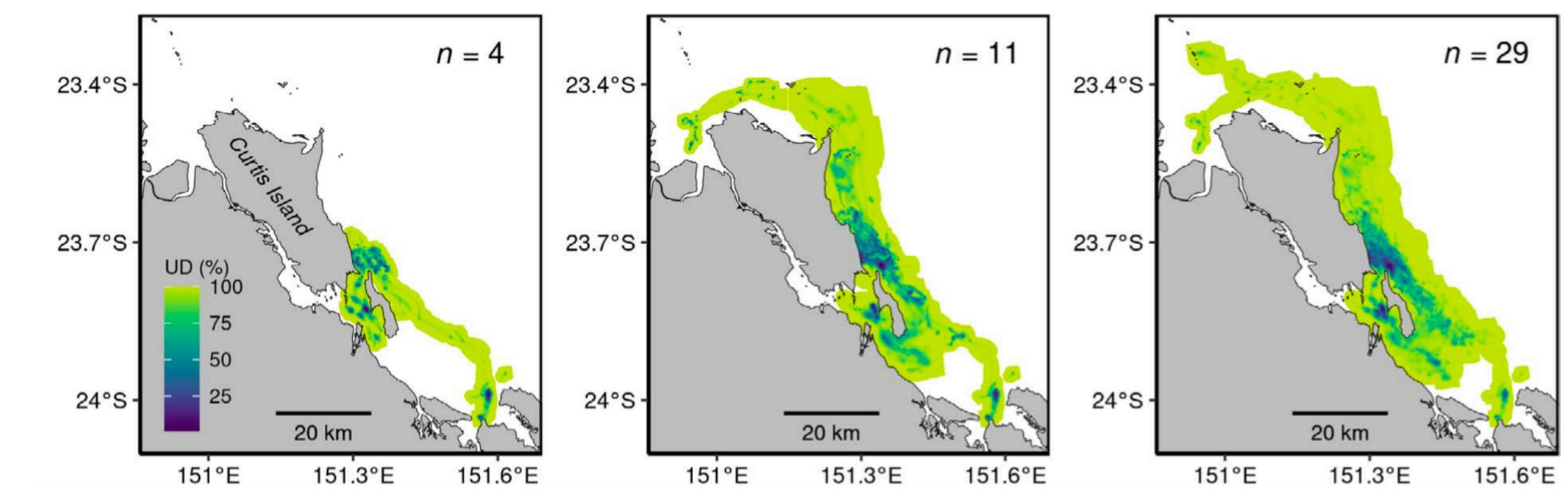


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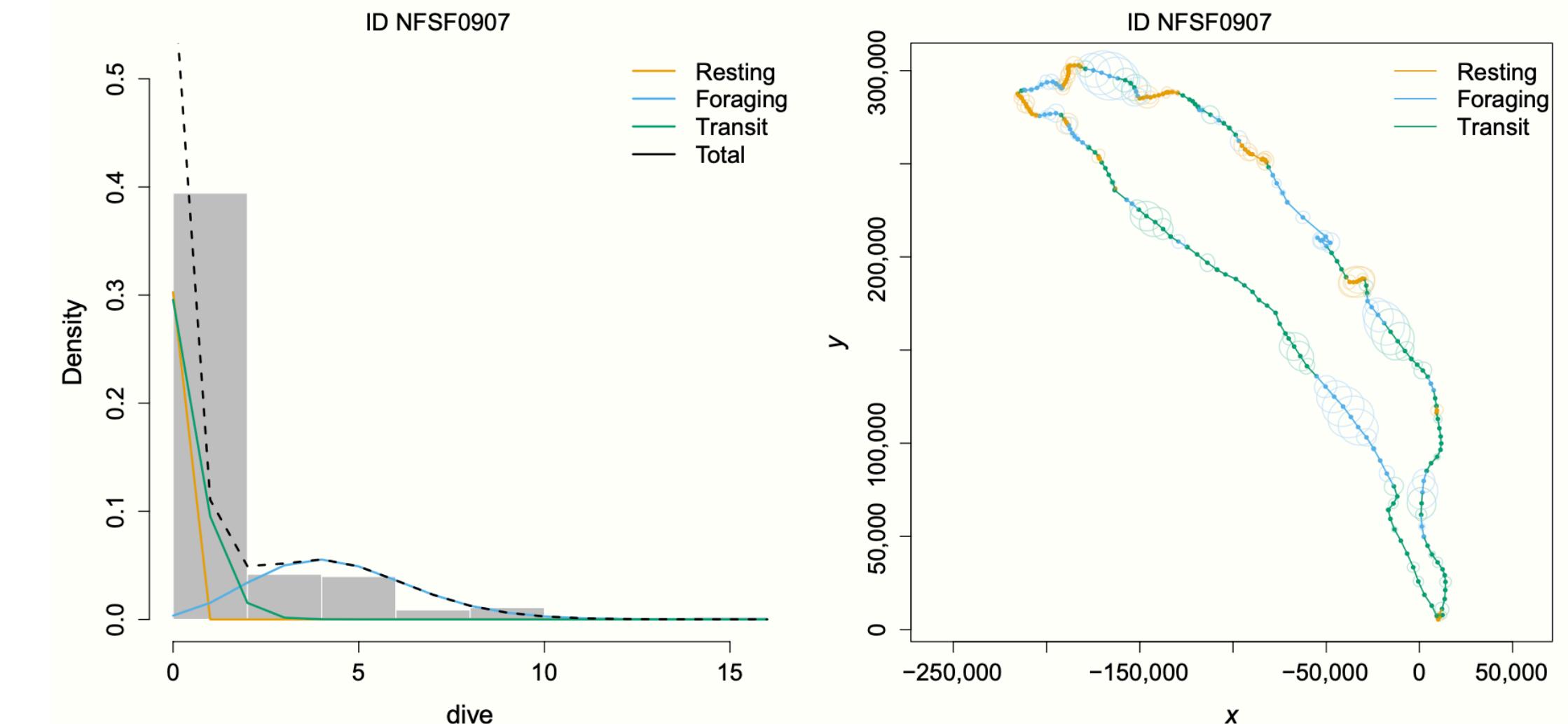


Why estimate space-use and behavior?

- Characterizing the spatiotemporal patterns of space-use is fundamental to ecology
 - Where is the animal going?



- “Nothing in animal movement ecology makes sense except in the light of behavior” — Dobzhansky, 1973 (sort of)
 - What is the animal doing?

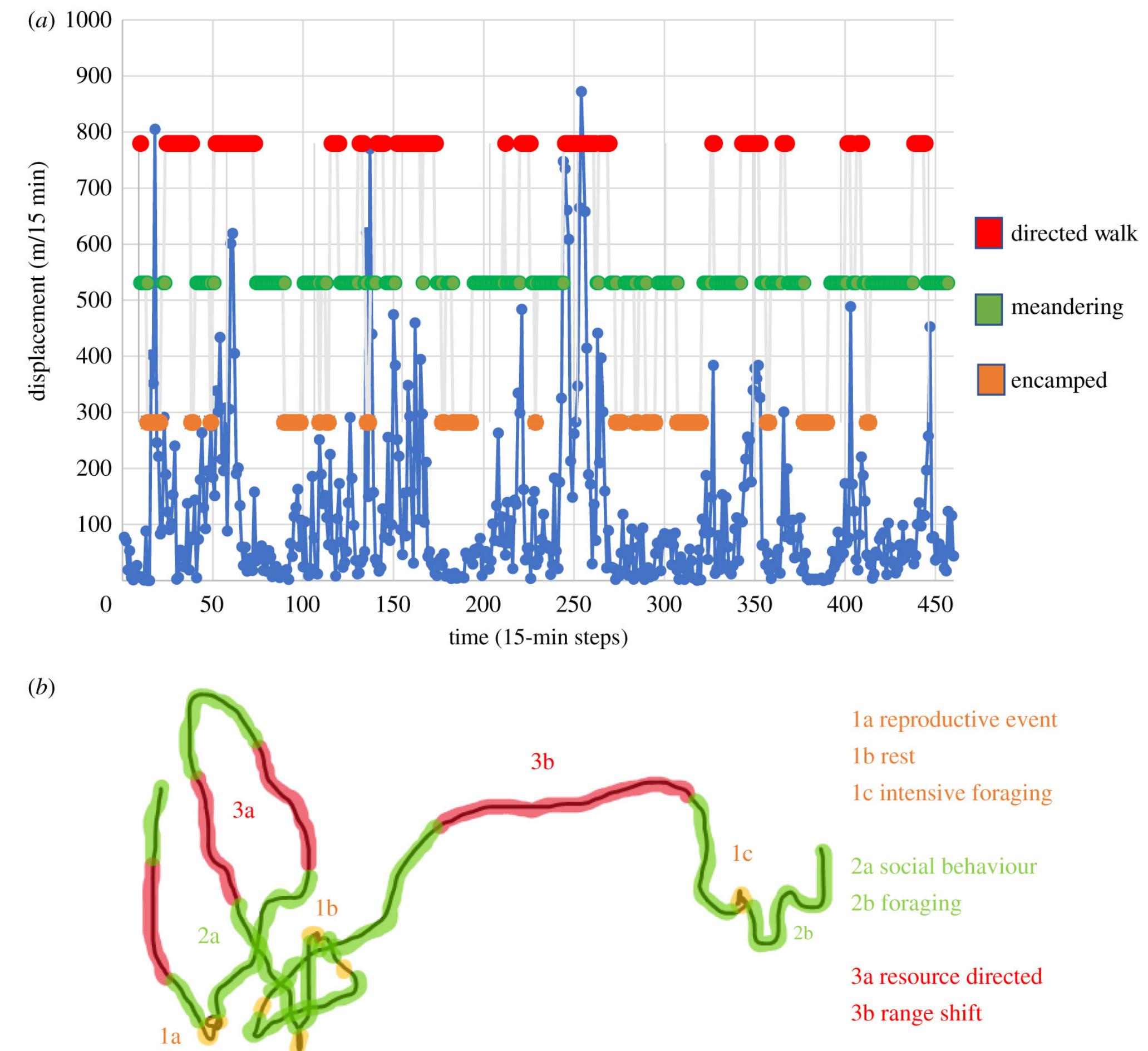


McClintock and Michelot 2018

Shimada et al. 2021

What are latent behavioral states?

- In the scientific literature, you'll often see the term "latent behavioral states"
- Latent —> in this case meaning "hidden"; since the true states are not directly observed, we can only infer them from the tracks
- Behavioral states —> since we're not directly observing what the animals are doing, we can't define these as true "behaviors"



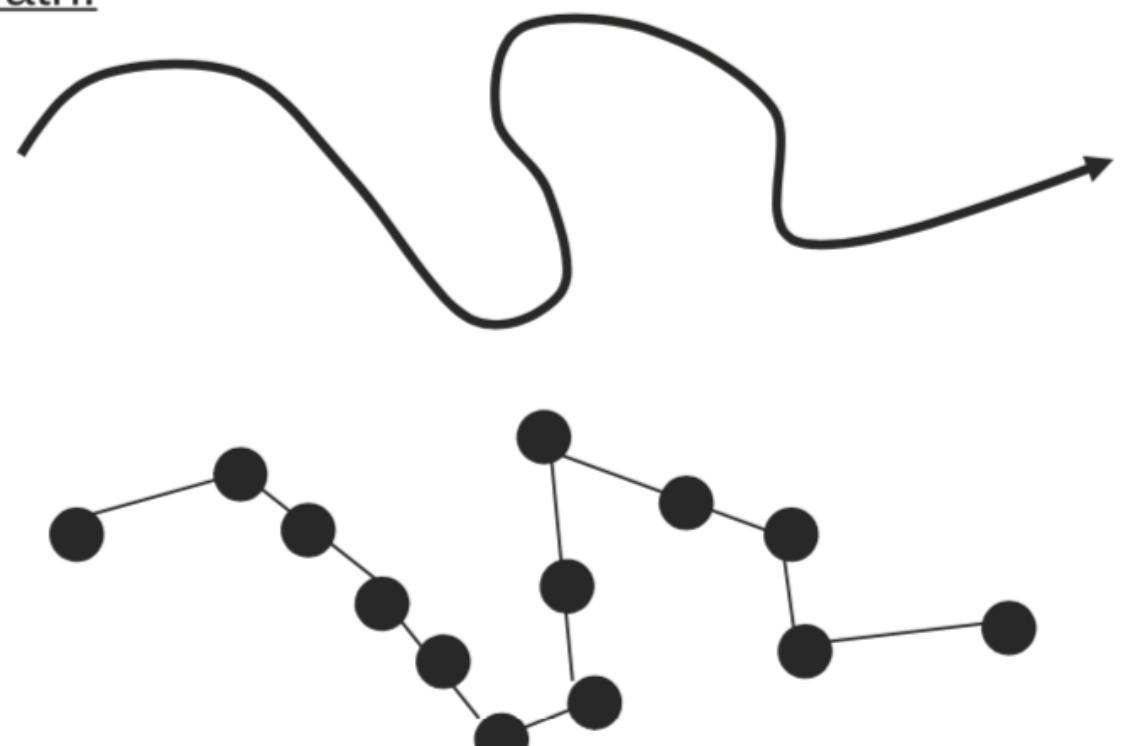
Behavioral state classification

40,000 ft view

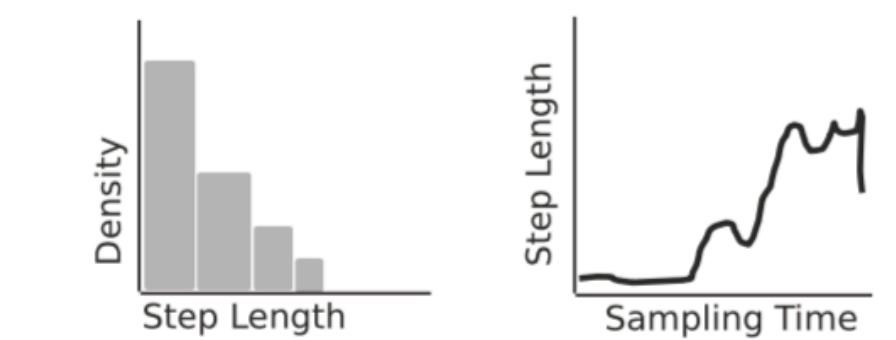
Table 1. Summary table of four broad categories of behavioural movement analysis methods. The four methods implemented in this paper and the most directly relevant references are bold faced. All of the entries in the last category can be considered multistate random walks, hidden Markov models or state space models

Category	Method	References
Metric-based	Fractal analysis	Fritz, Said & Weimerskirch (2003), Laidre <i>et al.</i> (2004)
	Tortuosity measures First passage time (FPT)	Nams & Bourgeois (2004); Tremblay, Roberts & Costa (2007) Bovet & Benhamou (1988); Benhamou (2004) Fauchald & Tveraa (2003)
Classification and segmentation	Residence time (RT)	Barraquand & Benhamou (2008)
	Penalized contrasts	Lavielle (2005), Calenge (2006)
	Bayesian partitioning (BPMM)	Calenge (2006)
	k-clustering	van Moorter <i>et al.</i> (2010)
	RT (segmentation step)	Barraquand & Benhamou (2008)
	Autocorrelation functions	Boyce <i>et al.</i> (2010)
	Change point analysis (BCPA)	Gurarie, Andrews & Laidre (2009), Gurarie (2013) Kranstauber <i>et al.</i> (2012)
Phenomenological time-series analysis	Wavelet	Polansky <i>et al.</i> (2010)
	Multistate random walk (MRW)	Morales <i>et al.</i> (2004)
	Ignoring location error	Forester <i>et al.</i> (2007), Langrock <i>et al.</i> (2012) Patterson <i>et al.</i> (2008), McClintock <i>et al.</i> (2012)
	Accounting for error	Jonsen <i>et al.</i> (2013), Breed <i>et al.</i> (2012)

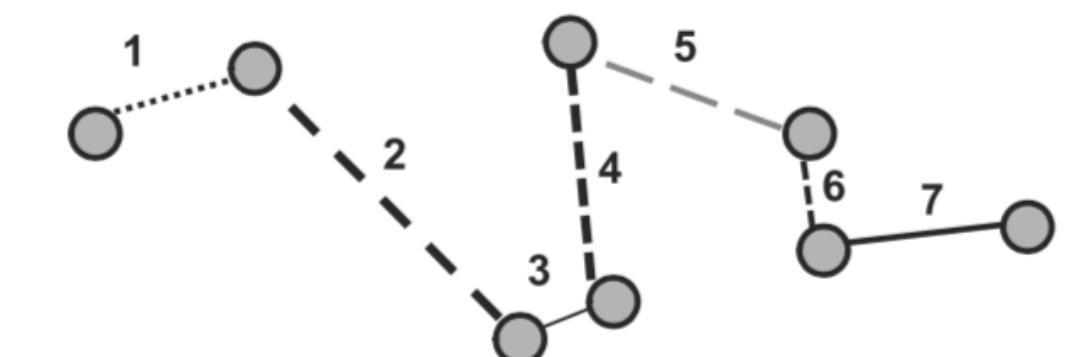
Actual Movement Path:



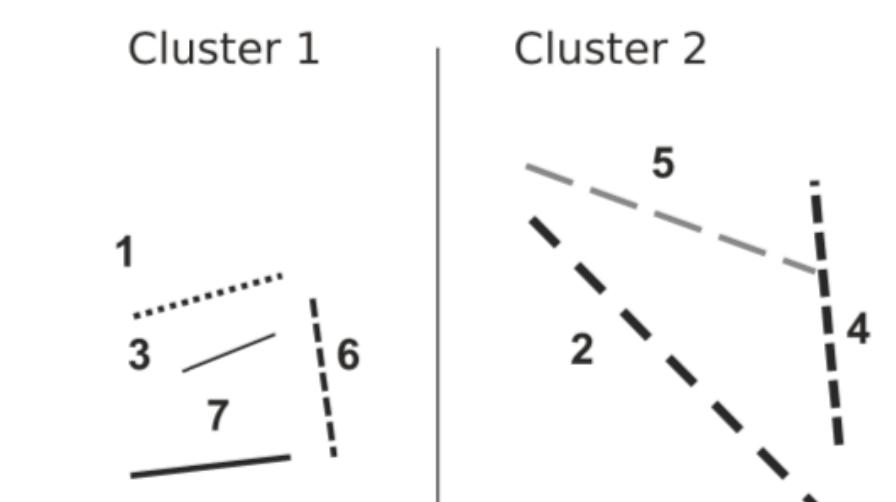
Step 1:



Step 2:



Step 3:



Step 4:

Edelhoff *et al.*, 2016

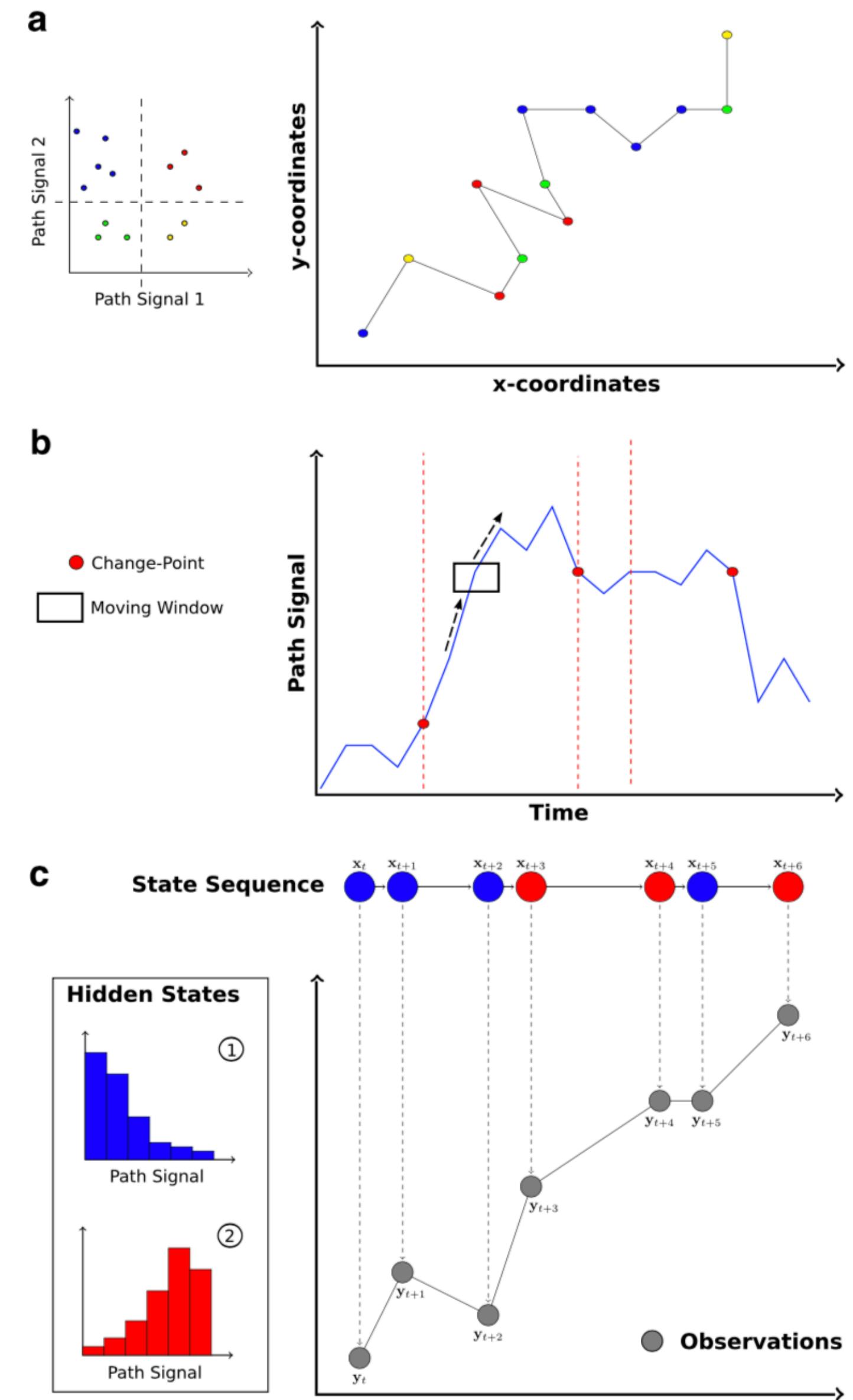
Gurarie *et al.*, 2016

Behavioral state classification

40,000 ft view

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	Change point analysis (BCPA)	Gurarie, Andrews & Laidre (2009), Gurarie (2013)
Mechanistic movement modelling	Wavelet	Kranstauber <i>et al.</i> (2012)
	Multistate random walk (MRW)	Morales <i>et al.</i> (2004)
	Ignoring location error	Forester <i>et al.</i> (2007), Langrock <i>et al.</i> (2012)
	Accounting for error	Patterson <i>et al.</i> (2008), McClintock <i>et al.</i> (2012)
		Jonsen <i>et al.</i> (2013), Breed <i>et al.</i> (2012)



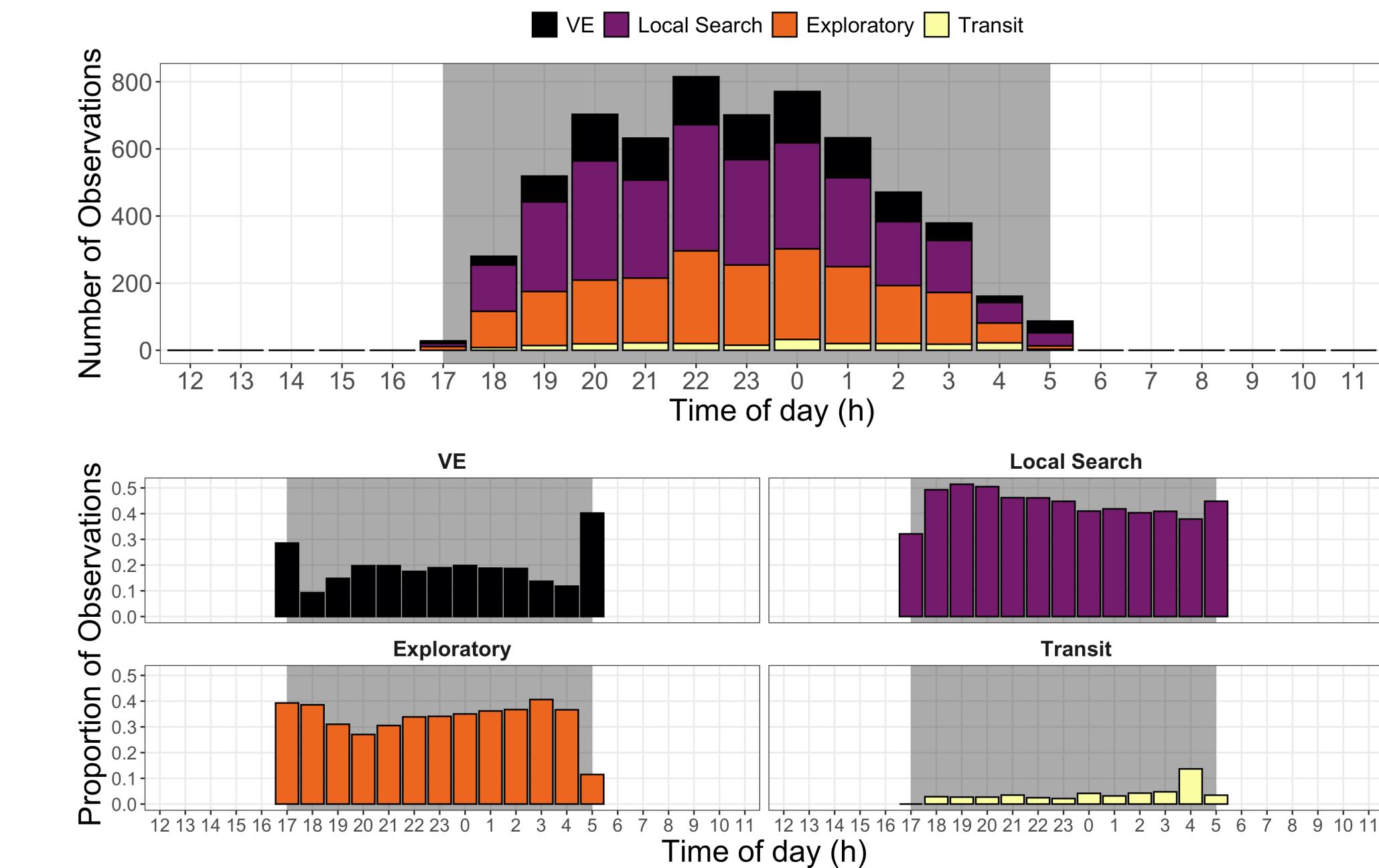
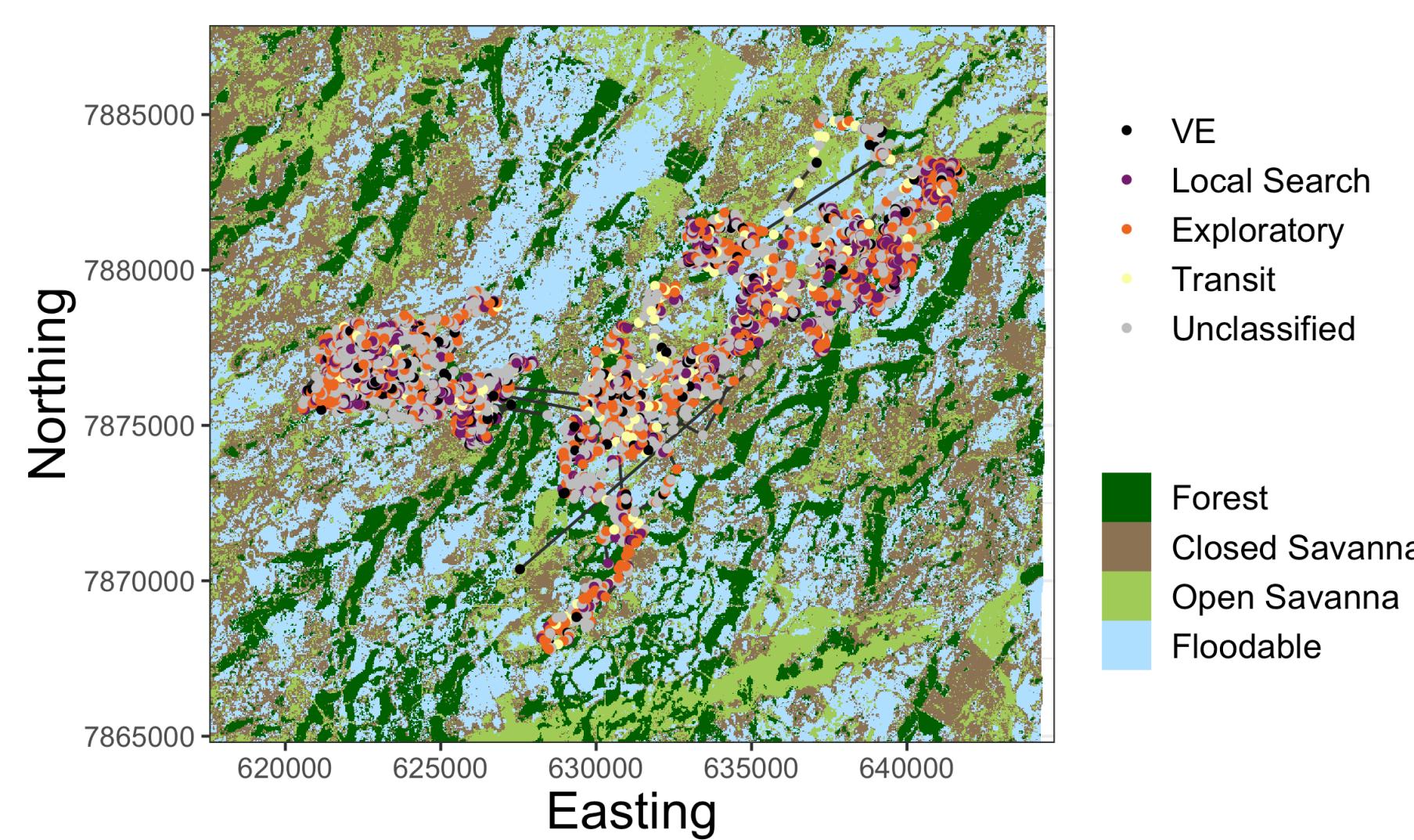


pmif.com

**What can behavioral state
estimates be used for?**

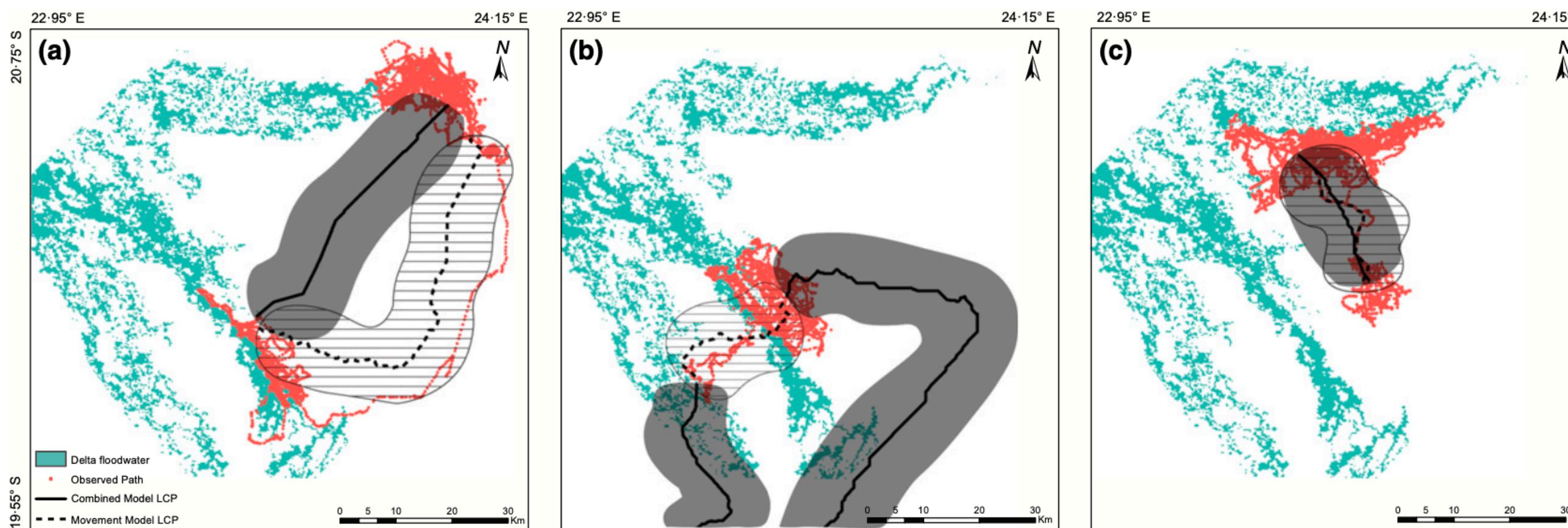
Characterization of activity budgets

- Provides insight into behavioral state frequency
 - Diel, seasonal, annual patterns



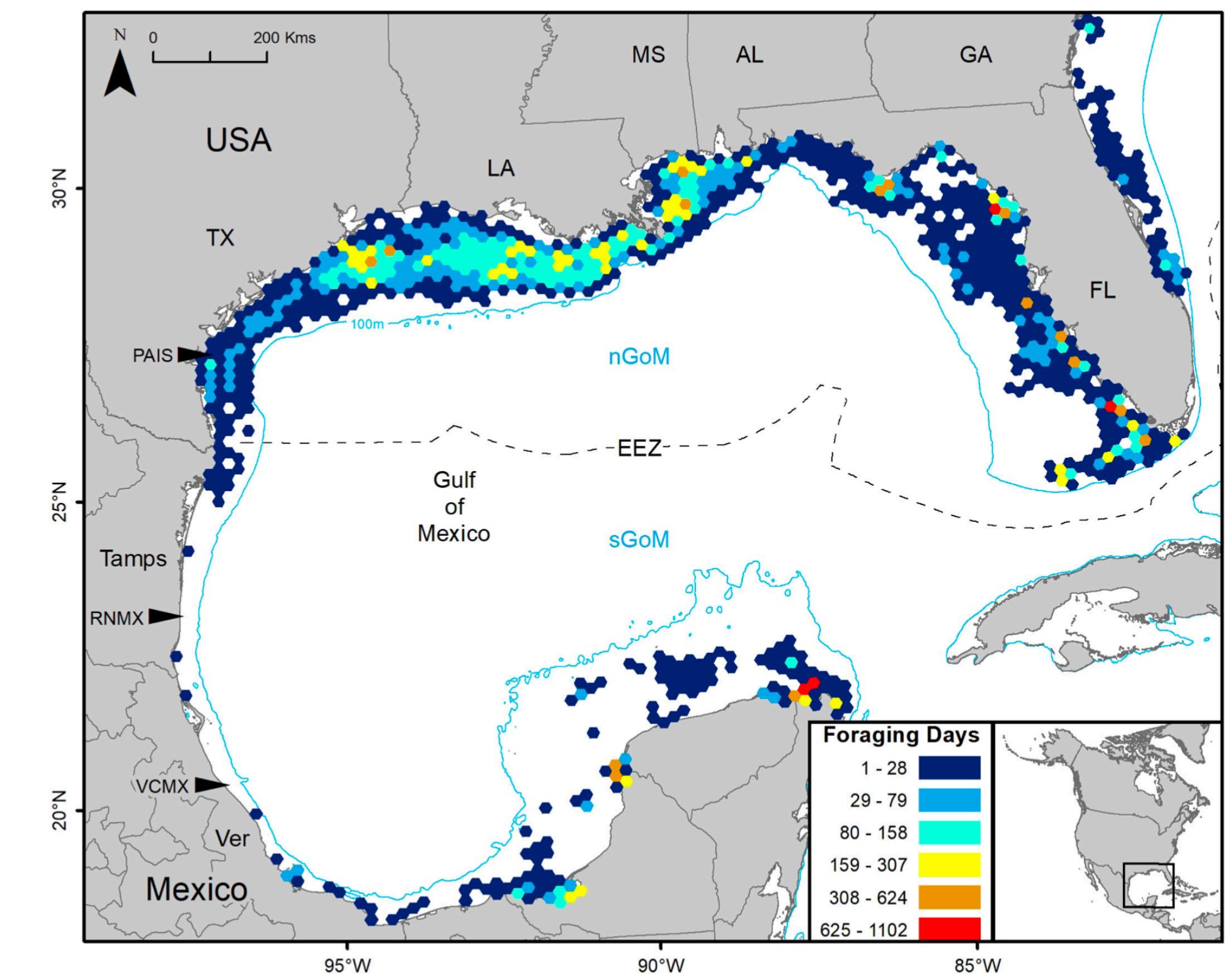
Identification of foraging grounds and migratory corridors

African wild dog corridors



Abrahms et al. 2017

Kemp's ridley turtle foraging areas

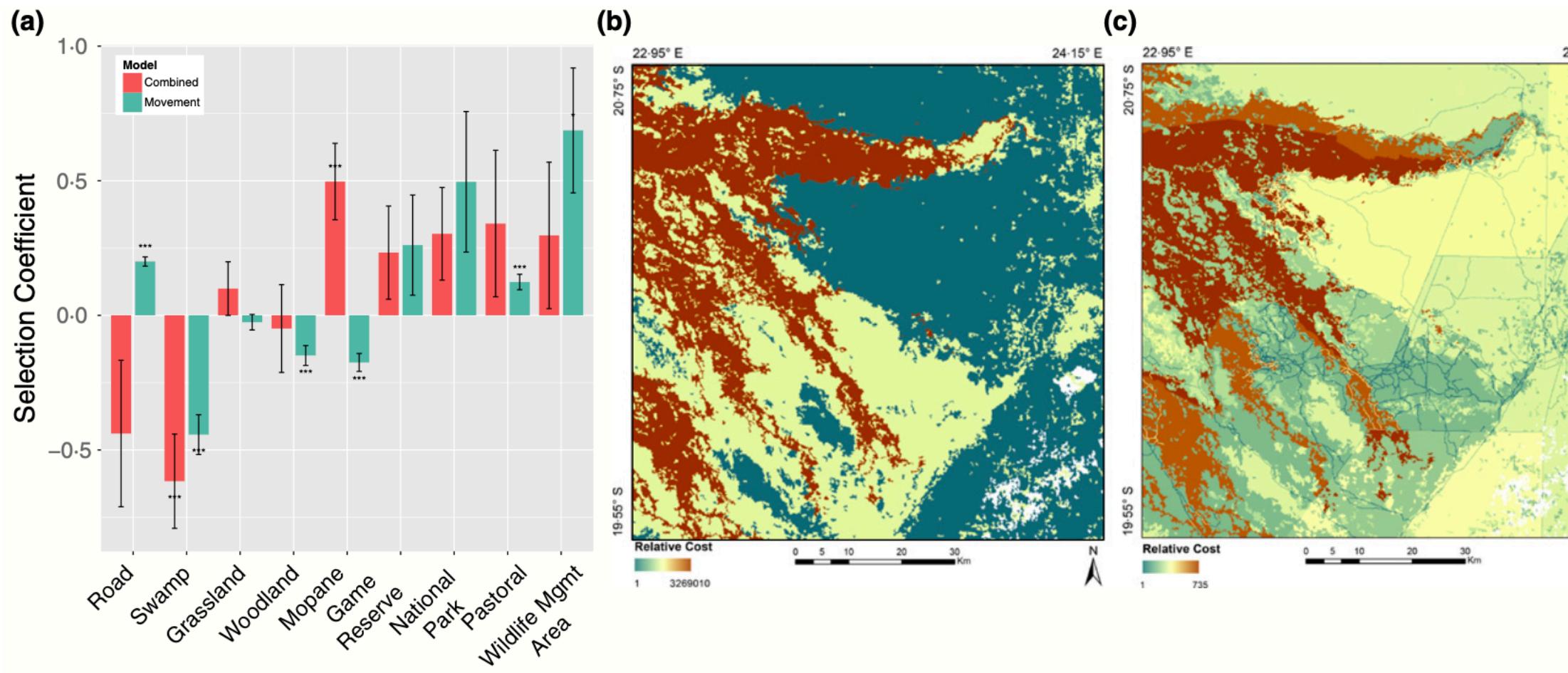


Gredzens and Shaver 2020

Behavioral state-habitat associations

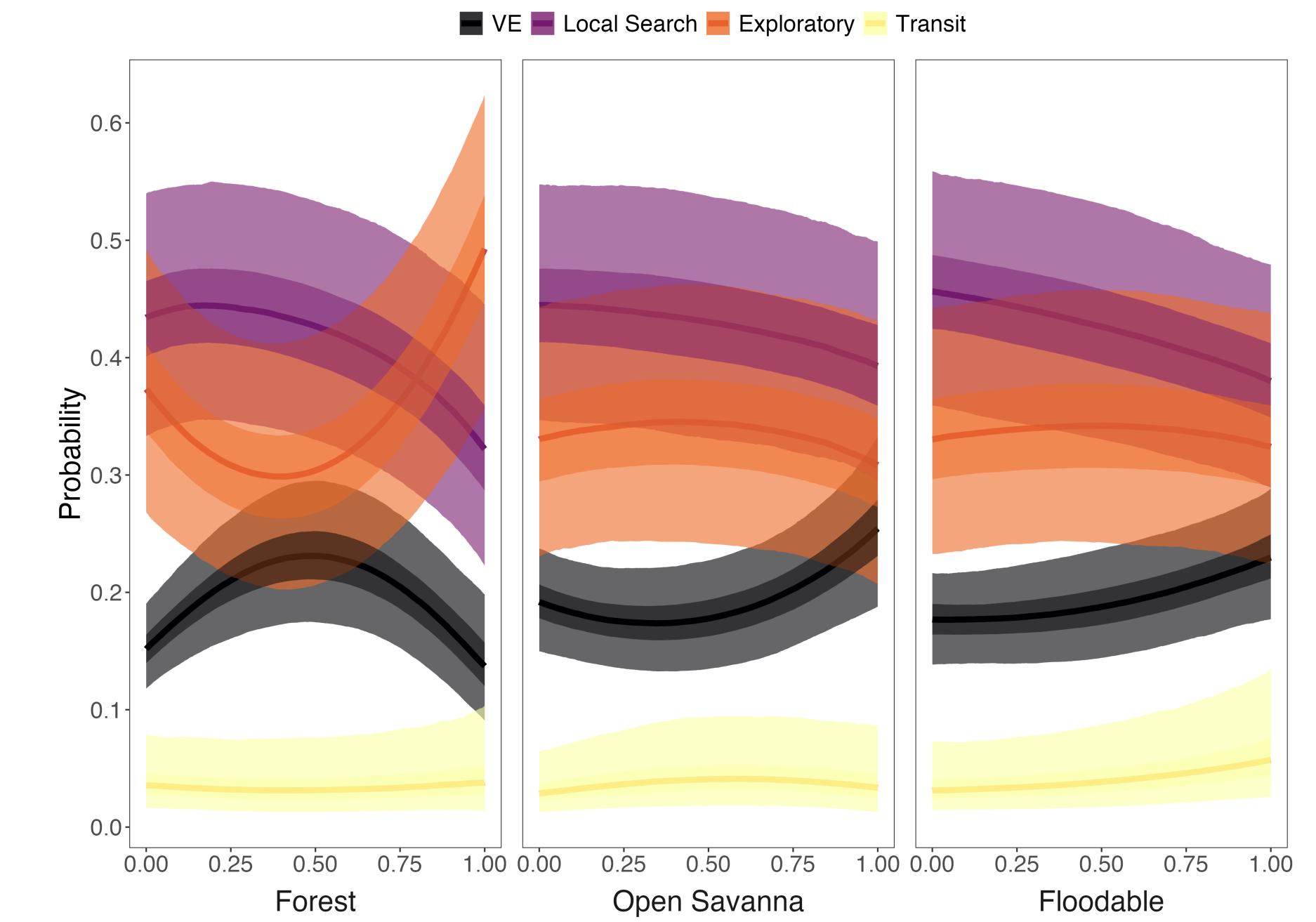
- Estimating habitat selection per behavioral state or estimating the probability of exhibiting a particular behavioral state given one or more environmental covariates

African wild dog



Abrahms et al. 2017

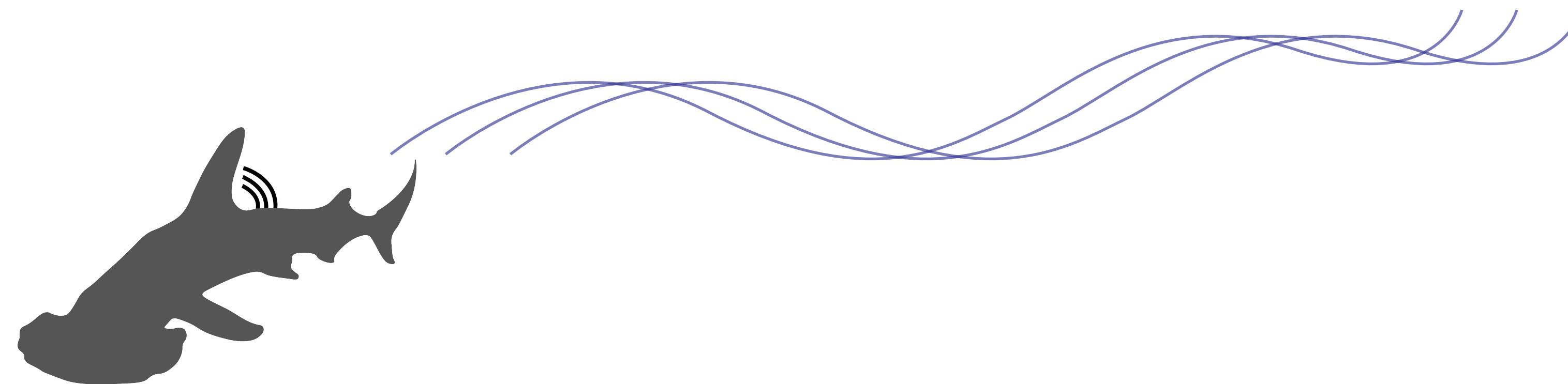
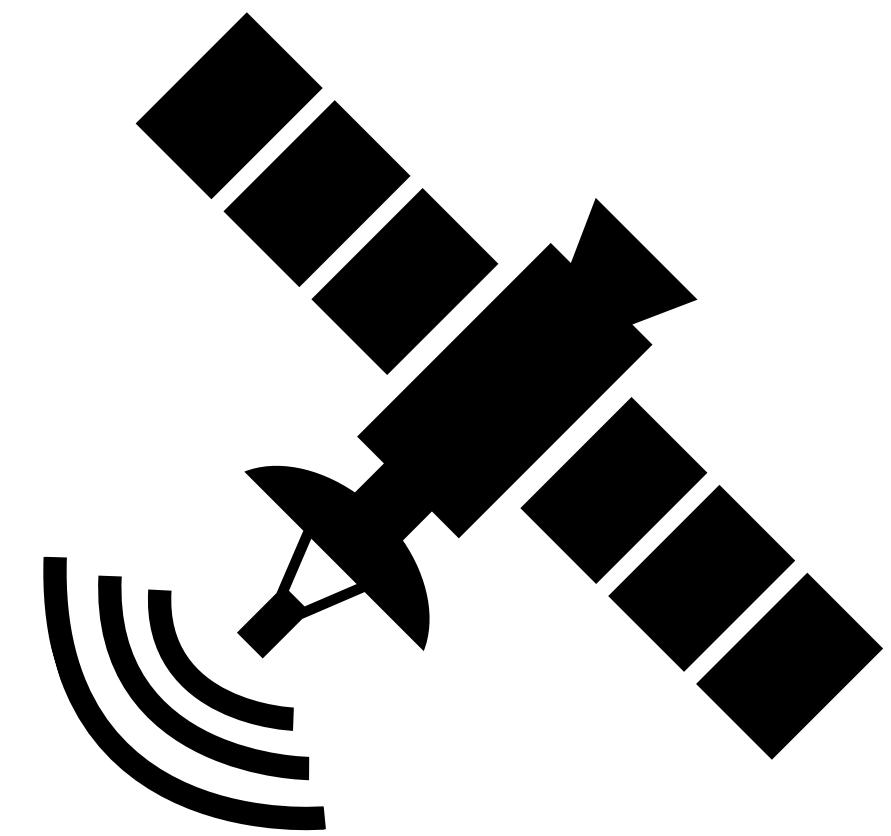
Giant armadillo



Cullen et al. in review

Variety of satellite telemetry transmitters

- Multiple types, where tag choice is often dependent on habitat:
 - Terrestrial: GPS, GPS-GSM, light-level geolocator
 - Marine: Argos, PSAT, FastlocGPS
 - Freshwater: very rare; almost exclusively use acoustic telemetry

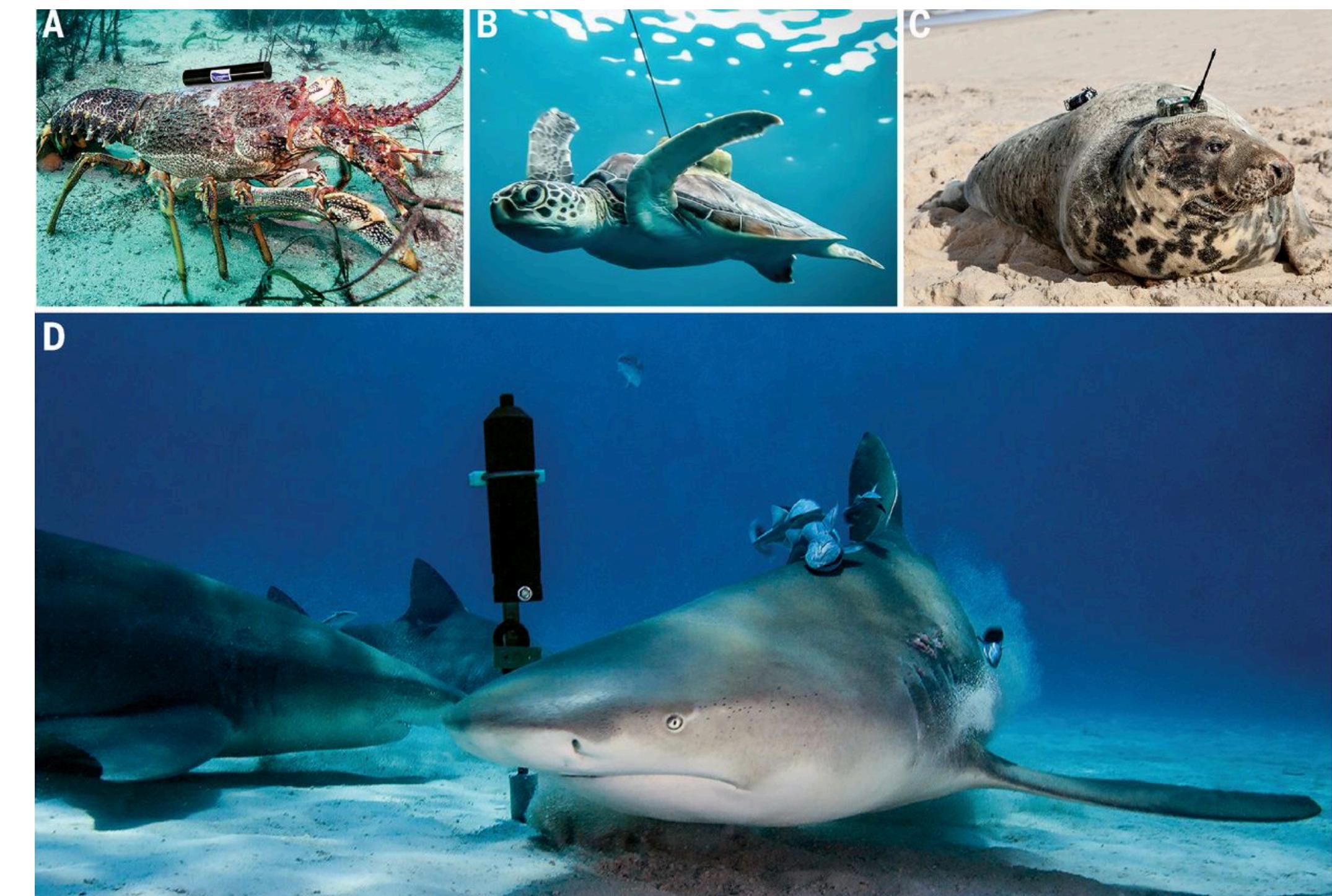


Argos location errors

- Reported observations for Argos satellite telemetry typically include a location quality class:

- 3: < 250 m
- 2: 250-500 m
- 1: 500-1500 m
- 0: > 1500 m
- A: no accuracy estimate
- B: no accuracy estimate
- Z: invalid location

Quality



Some errors can be much larger! (Costa et al. 2010)

Hussey et al. 2015

Let's start exploring the data!



References

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