Balancing Complexities in Movement Ecology

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Complexity of animal movement

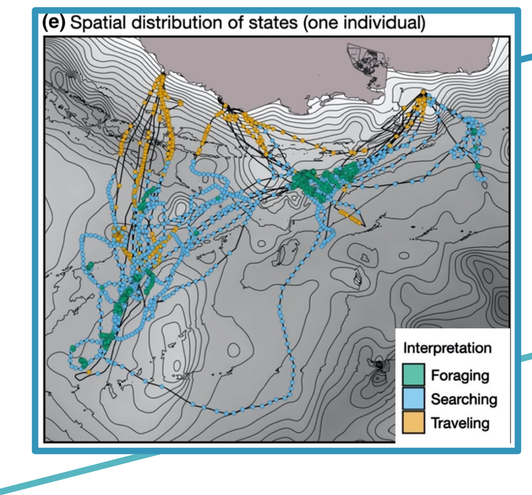
Animal movement is very complex:

- Variation amongst species, populations, and individuals
- Daily, seasonal, and developmental changes
- Alternation between activities like resting, travelling, searching and foraging
- Responsiveness to physiological, social, ecological and physical cues
- Nonlinear, irregular, and multi-planar movement

Studying animal movement adds additional complexities:

- Various methodologies for observing and tracking movement
- Complex analysis for autocorrelated time series data

Ecologists deal with this complexity in producing knowledge about where animals are, what they are doing, when they are doing it, and why.



Track of one sea lion's foraging trips, modelled with three behavioural states.

From: Schwarz JFL et al. Individuality Counts: A New Comprehensive Approach to Foraging Strategies of a Tropical Marine Predator. Oecologia. 2022; 195 (2): 313–25.

Bespoke interdisciplinary collaborations

Gathering and analysing movement data requires a careful combination of expertise:

- Biologists knowledgeable of the species and field conditions
- Engineers and software designers familiar with the technology
- Statisticians aware of the demands and capacities of the analysis

This has led to a wide variety of interdisciplinary collaborations tailored to specific research contexts and projects. Communicating assumptions and negotiating goals across disciplinary backgrounds is key for a successful project.

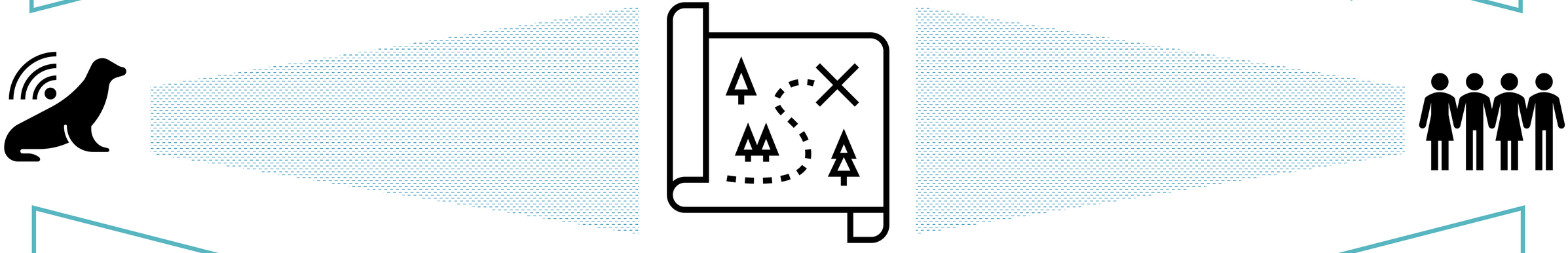
Trappes R. Animal Behaviour in Times of Big Data: How Tracking Technology is Transforming Animal Ecology. Synthese. In prep (major revisions).

Insights from interviews with biologists and statisticians

First challenge: ecologists who collect animal movement data without a specific research question and then come to me and say you have all these fancy modeling techniques, give me something which I can publish. And I say well, what do you want to find out? They say, I don't know but I have these cool data.

Of course the more complex the model, the more difficult to make sure that everyone else understands what you're doing. I had some problems actually with making sure that a biologist understands that we just assume something.

I think because it always needs to be analyzed from a biological perspective, it would have not been possible just to give [the statistician] the data […] It was really the cooperation. I would not have been able to do it on my own. Not at all. But this quite close cooperation between the two of us, I think, managed to get those really exciting [findings].



Selecting and combining heterogenous data

Analysing movement involves using data from other sources:

- Meteorological data on wind, temperature or weather events
- Satellite and sensor data on locations of resources, habitat types and topography
- Fisheries and transport data on location of human disturbances

Movement data often has far higher temporal and spatial resolution than environmental or meteorological data. Researchers must decide whether to sacrifice detail on animal movement or extrapolate from low resolution weather and environmental datasets, each strategy having its own deficits.

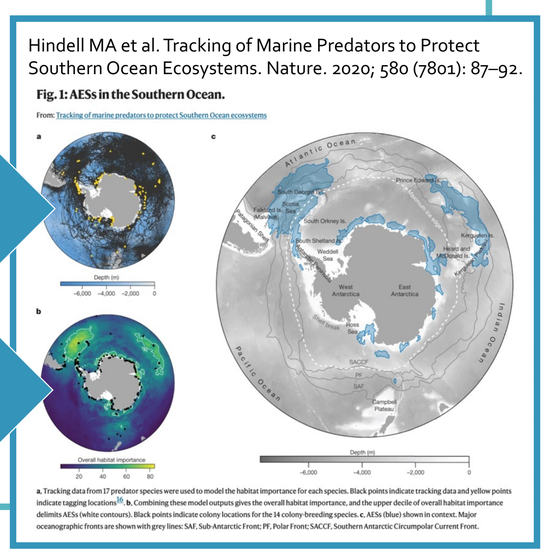
Trappes R. Sharing Animal Tracking Data to Answer Big Questions. In prep.

Six stages of data synthesis to answer a complex ecological question

Data collection → Data standardisation → Data filtering

Habitat selection models → Combine species-specific models → Identify Areas of Ecological Significance

Hindell MA et al. Tracking of Marine Predators to Protect Southern Ocean Ecosystems. Nature. 2020; 580 (7801): 87–92.



a, Tracking data from 17 predator species were used to model the habitat importance for each species. Black points indicate tracking data and yellow points indicate tagging locations[10]. b, Combining these model outputs gives the overall habitat importance, and the upper decile of overall habitat importance delimits AESs (white contours). Black points indicate colony locations for the 14 colony-breeding species. c, AESs (blue) shown in context. Major oceanographic fronts are shown with grey lines: SAF, Sub-Antarctic Front; PF, Polar Front; SACCF, Southern Antarctic Circumpolar Current Front.

Future directions

1. What are the implications of more widespread surveillance of animal populations? What about the use of animals to gather data on humans and their environments?
2. How does research work in such complex, dispersed, technology-saturated environments? What do research environments look like in these cases?
3. How are issues around data quality and quantity negotiated in global citizen science projects? What is involved in generating and maintaining useful animal monitoring data?

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