Uncertainty in right whale location following visual or acoustic detection

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Right Whale Management

		USA	Canada
Vessel	*Dynamic*	Voluntary <10 kt Dynamic Management Areas (DMAs)	Mandatory <10 kt zones in GSL shipping lanes
	Static	Mandatory <10 kt Seasonal Management Areas (SMAs)	Mandatory <10 kt in central GSL; Areas To Be Avoided (ATBAs) in critical habitats
Fishing	*Dynamic*	N/A	Fixed gear closures in GSL and critical habitats (48 h to pull gear)
	Static	Seasonal area closures, gear modifications, etc.	Static fixed-gear closures in southern GSL

More details in this session…

Sources of dynamic data

Visual

- Planes, vessels, etc.
- Benefits
  - Broad spatial coverage
  - Multiple data products
- Limitations
  - Availability bias
  - Expensive
  - Weather, day/night
  - Low endurance
  - Risk to personnel

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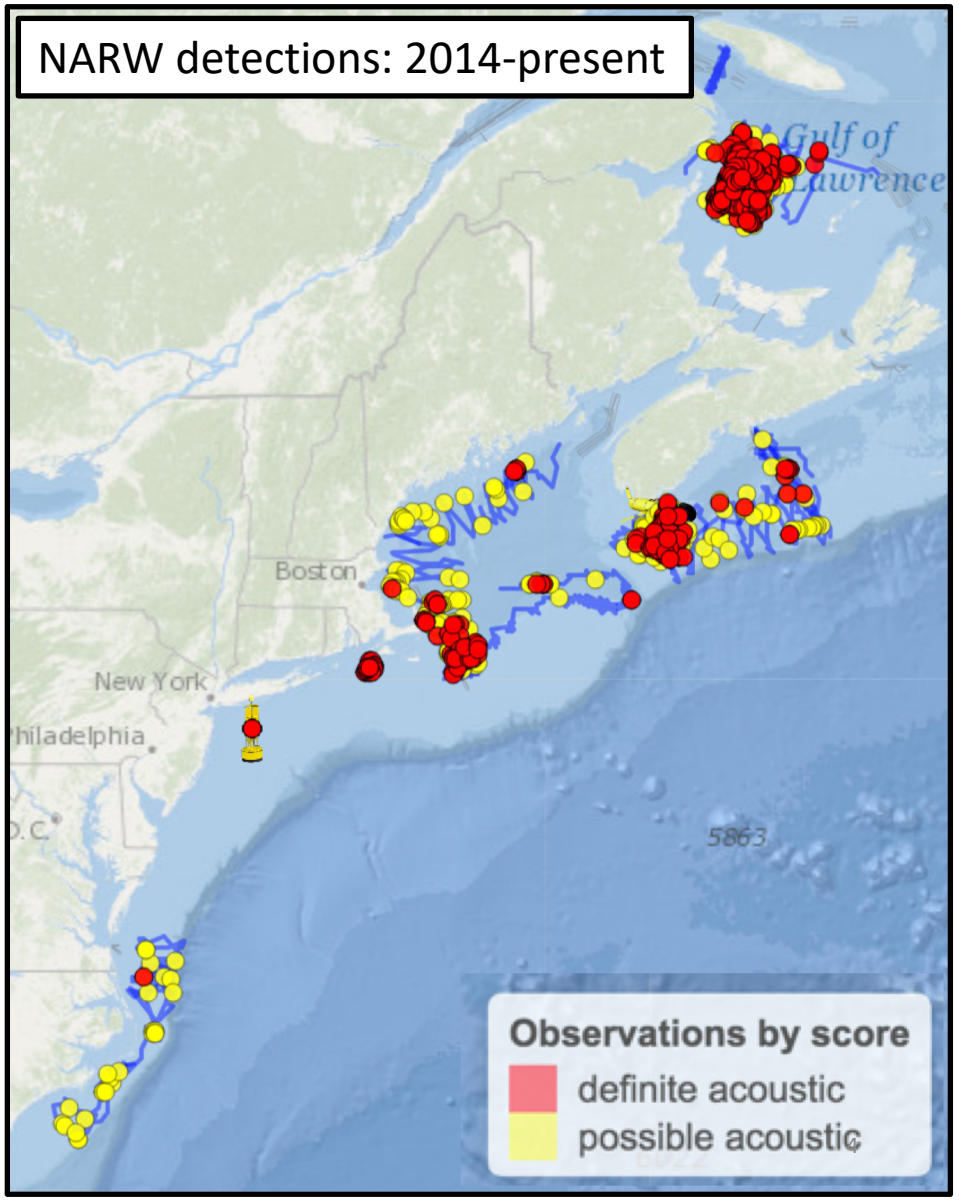
Acoustic

- Ocean gliders, moorings, etc.
- Benefits
  - Inexpensive
  - Accurate
  - Persistent (months to years)
  - No risk to personnel
  - Provides ocean data (gliders)
- Limitations
  - Availability bias
  - Presence only
  - Location uncertainty

Acoustics for dynamic management

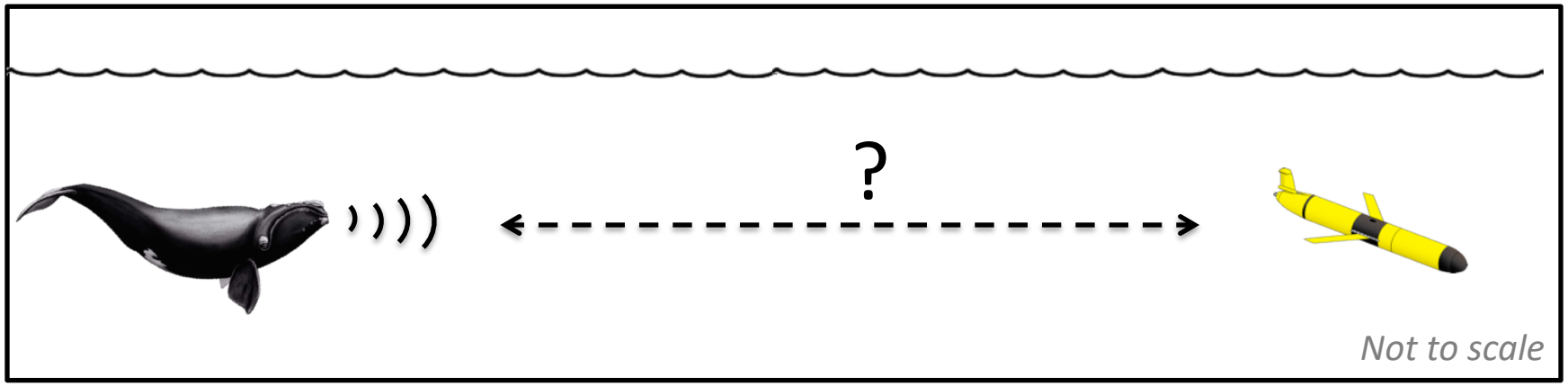
- WHOI near real-time PAM system
  - ~5000 days at sea and ~1500 right whale detections
  - Well-characterized and accurate (Baumgartner et al., 2019)
  - See Mark Baumgartner's talk (tomorrow 14:15)
- Additional systems coming online



whalemap.ocean.dal.ca

Acoustics for dynamic management

- Detections are (mostly) **not used** by managers
  - Uncertainty in exact position of calling whale
- Does not consider whale movement, which can be substantial
  - BOF/GOM: ~80 km/day (Baumgartner and Mate 2005)
  - GSL: ~5 km/day to max ~40 km/day (see Leah Crowe's talk tomorrow at 1015)

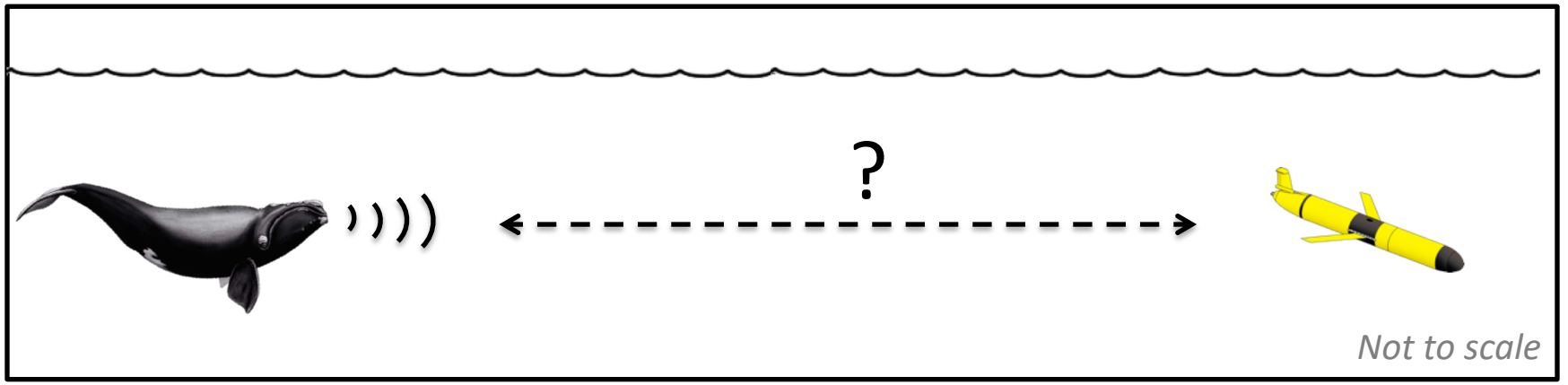


Acoustics for dynamic management

How much does detection range matter when you consider whale movement?

Approach

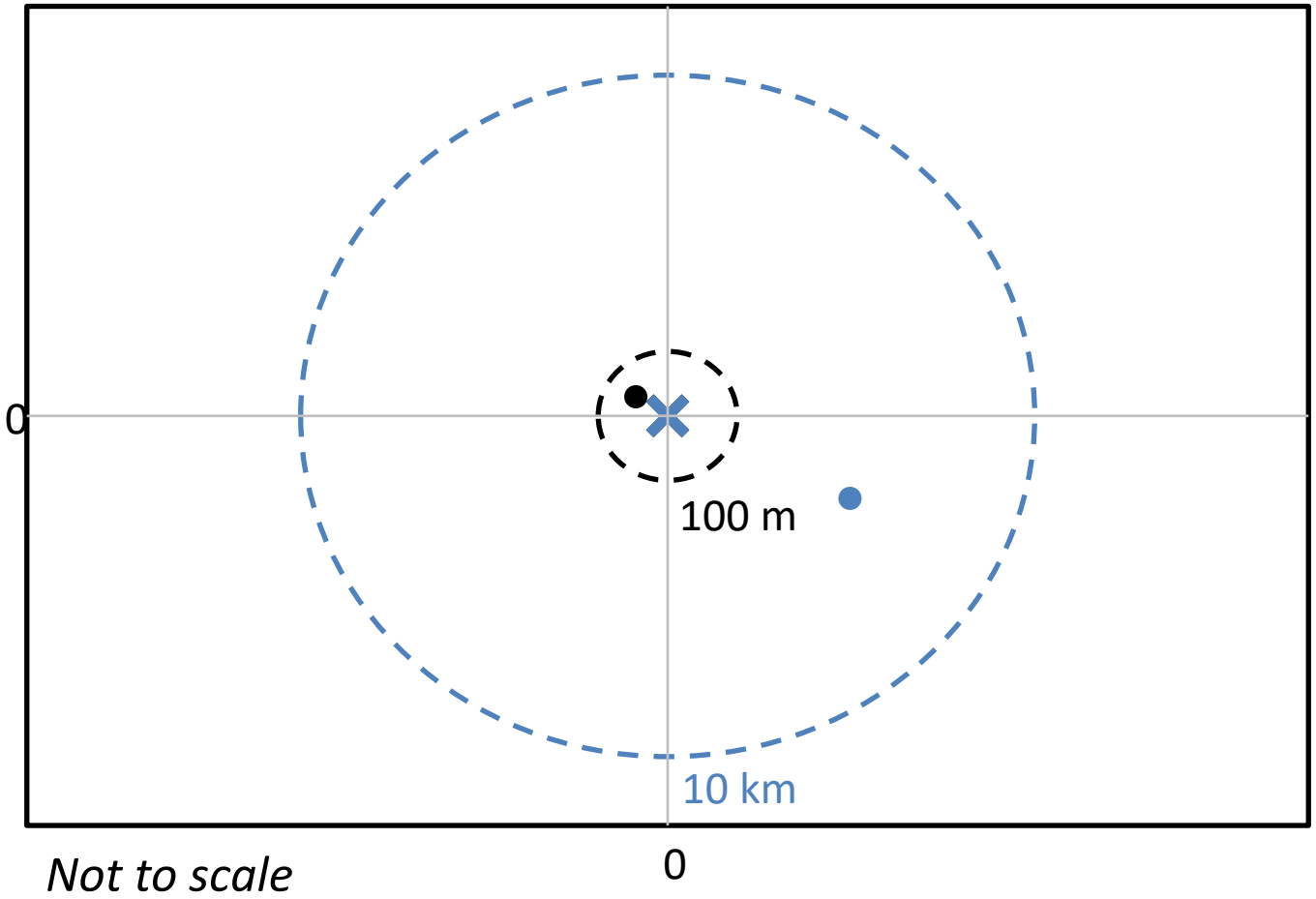
1. Simulate whale movements after visual and acoustic detection
2. Calculate and compare location uncertainties over time



1. Place whale in model domain according to visual or acoustic uncertainty

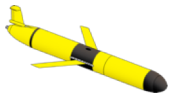
Visual

Acoustic

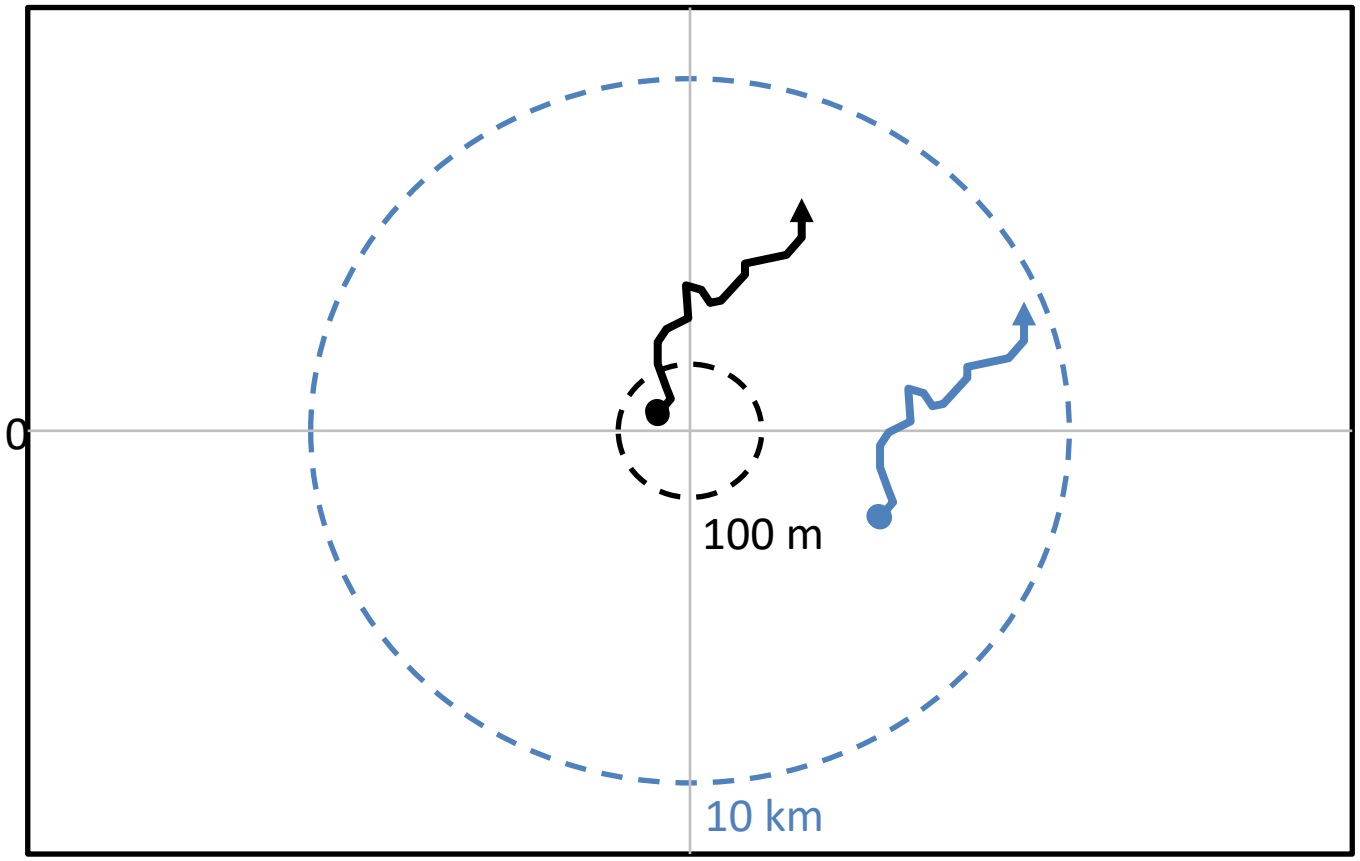


2. Simulate whale movement over a 96-hr period

Visual



Acoustic



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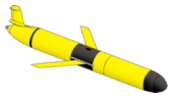
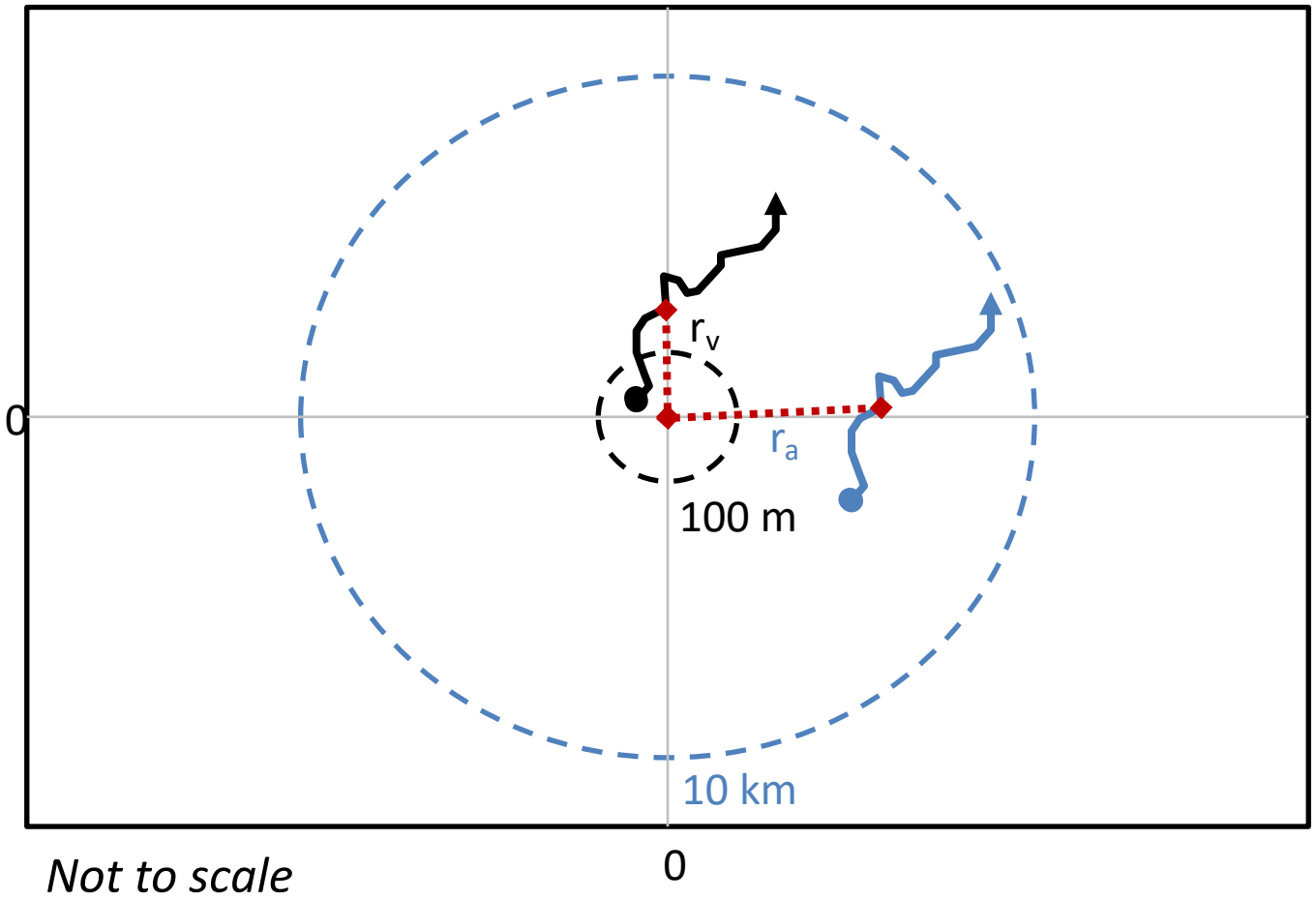
3. Calculate and compare ranges from initial (reported) position

Visual



Acoustic



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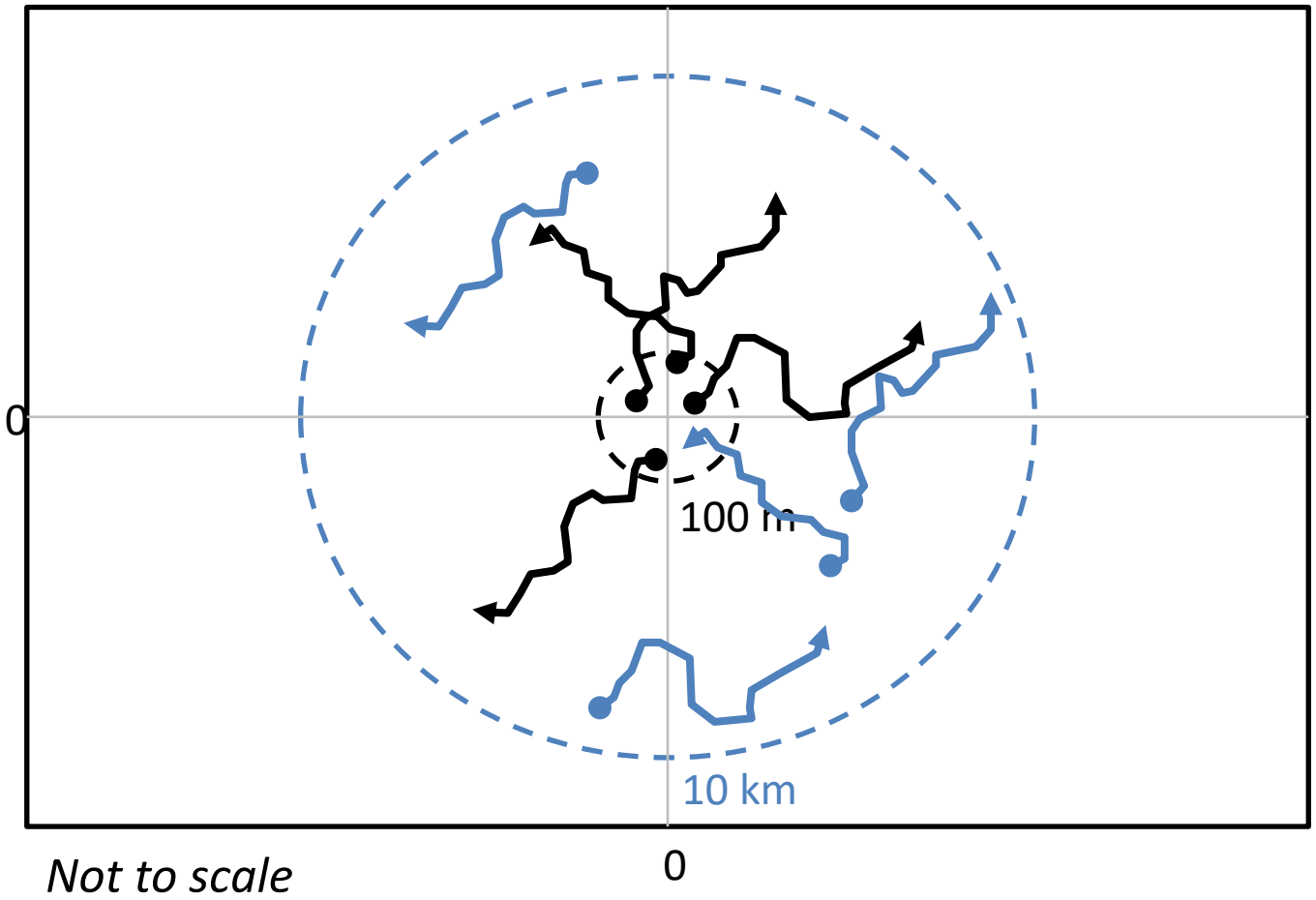
4. Repeat 100k times to approximate all possible whale positions / trajectories

Visual

Acoustic



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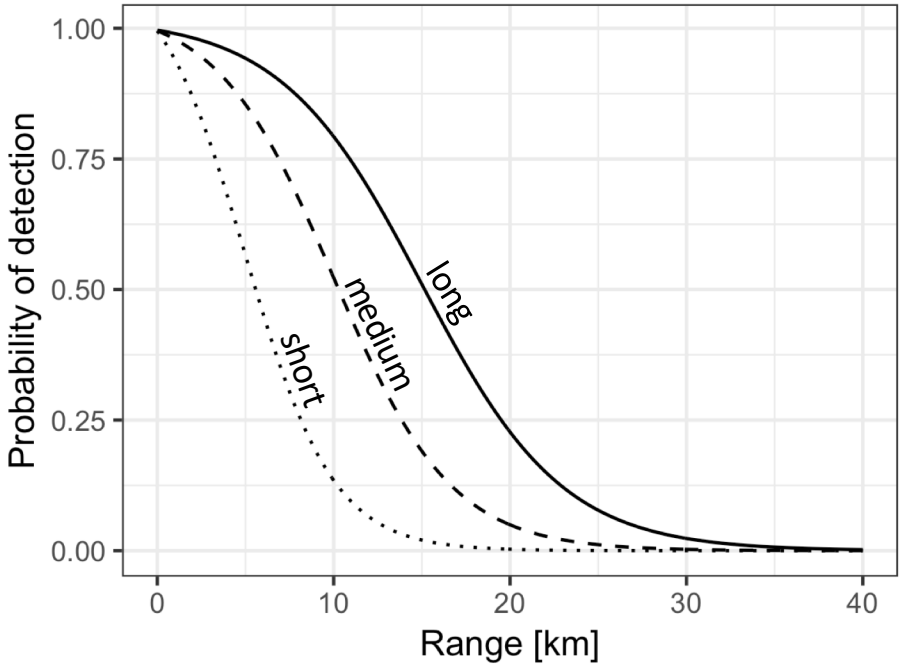
Model parameterization

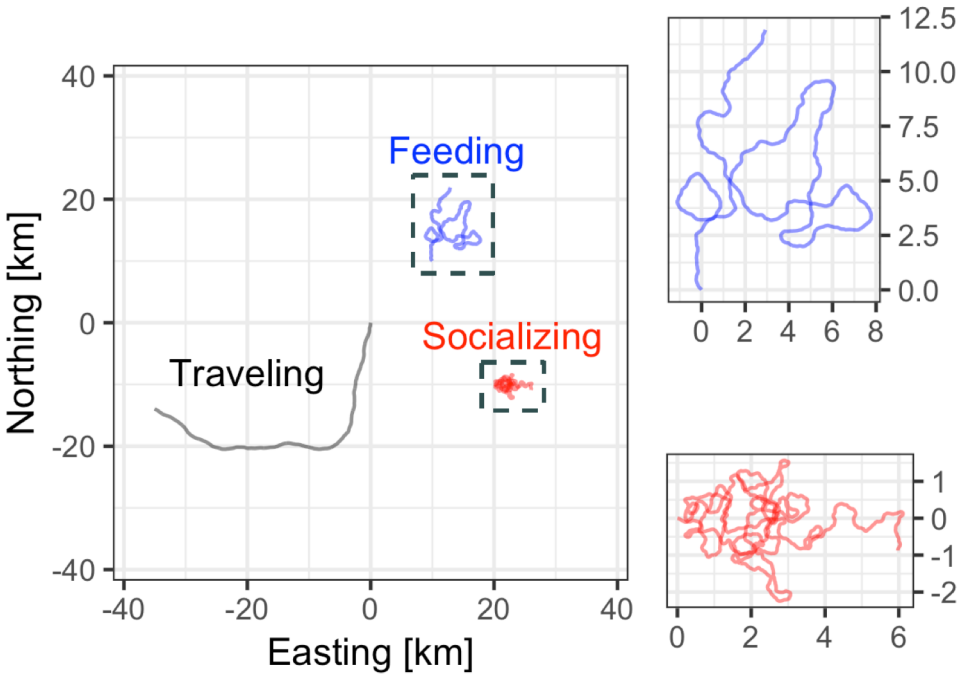
Acoustic detection ranges



Short, medium, and long

Johnson et al *in prep*; Laurinolli et al 2002

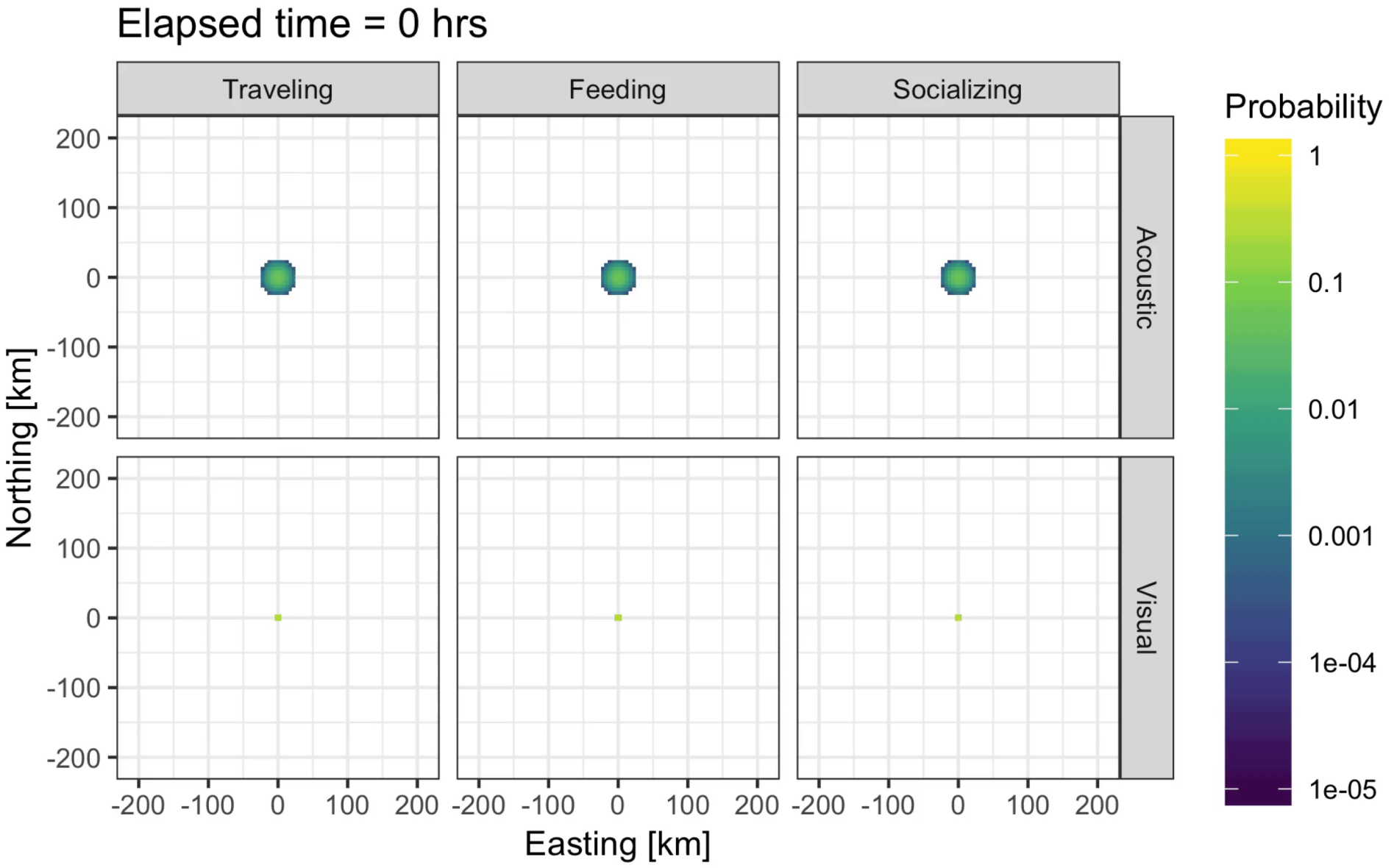
Movement behaviors



Traveling, feeding, and socializing

Van der Hoop et al 2012; Mayo & Marx 1989

Example run: medium detection range



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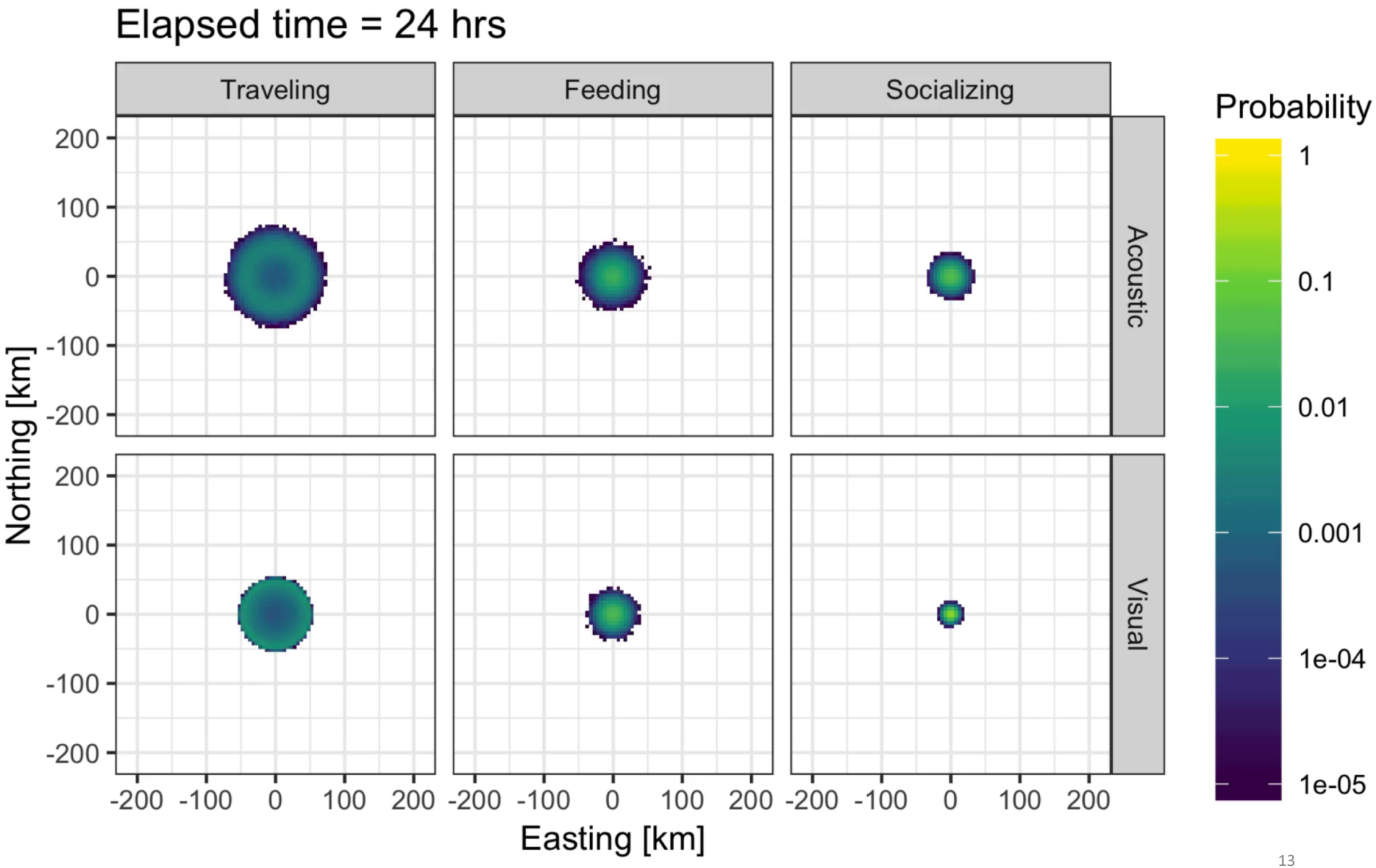
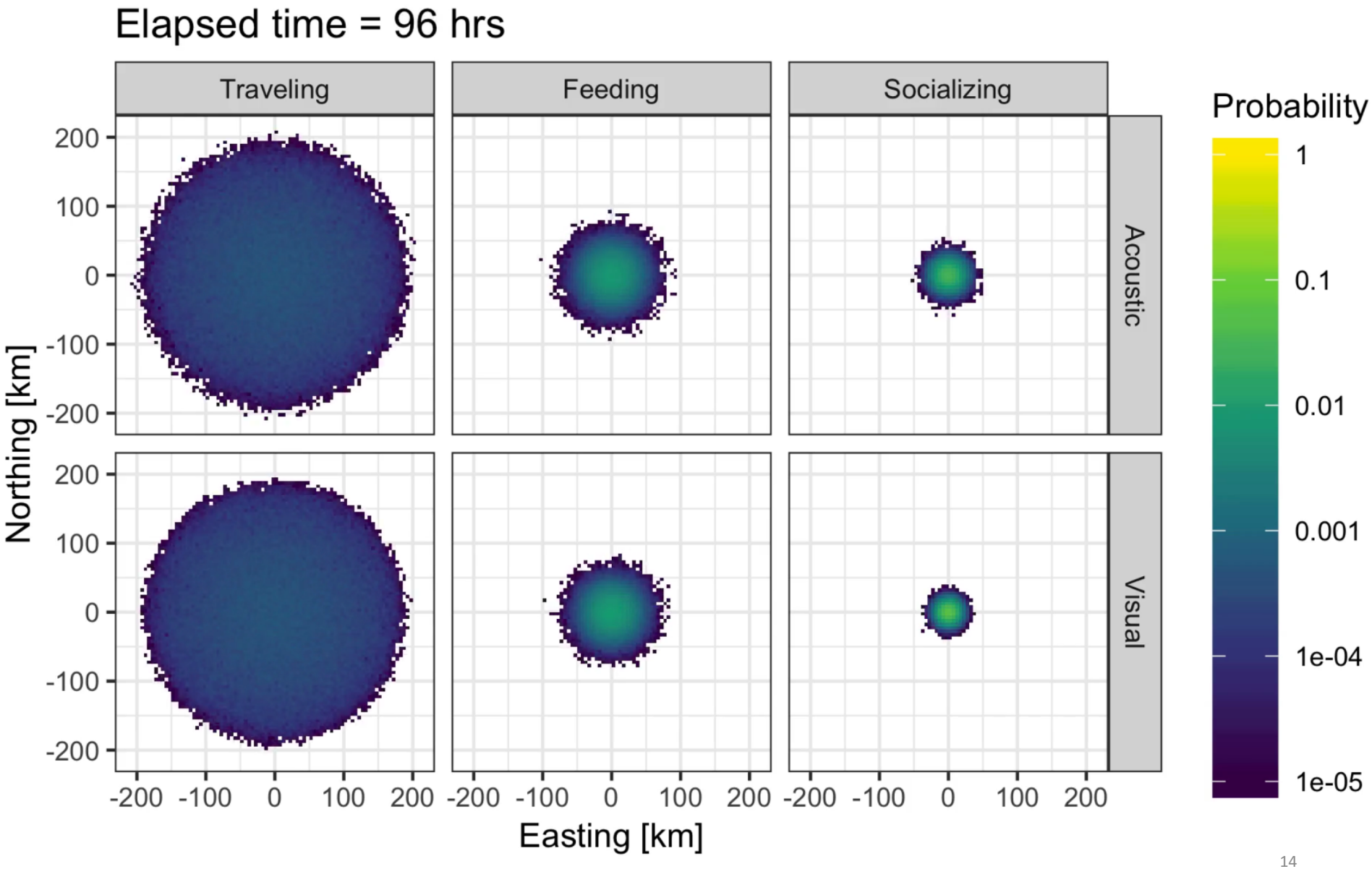
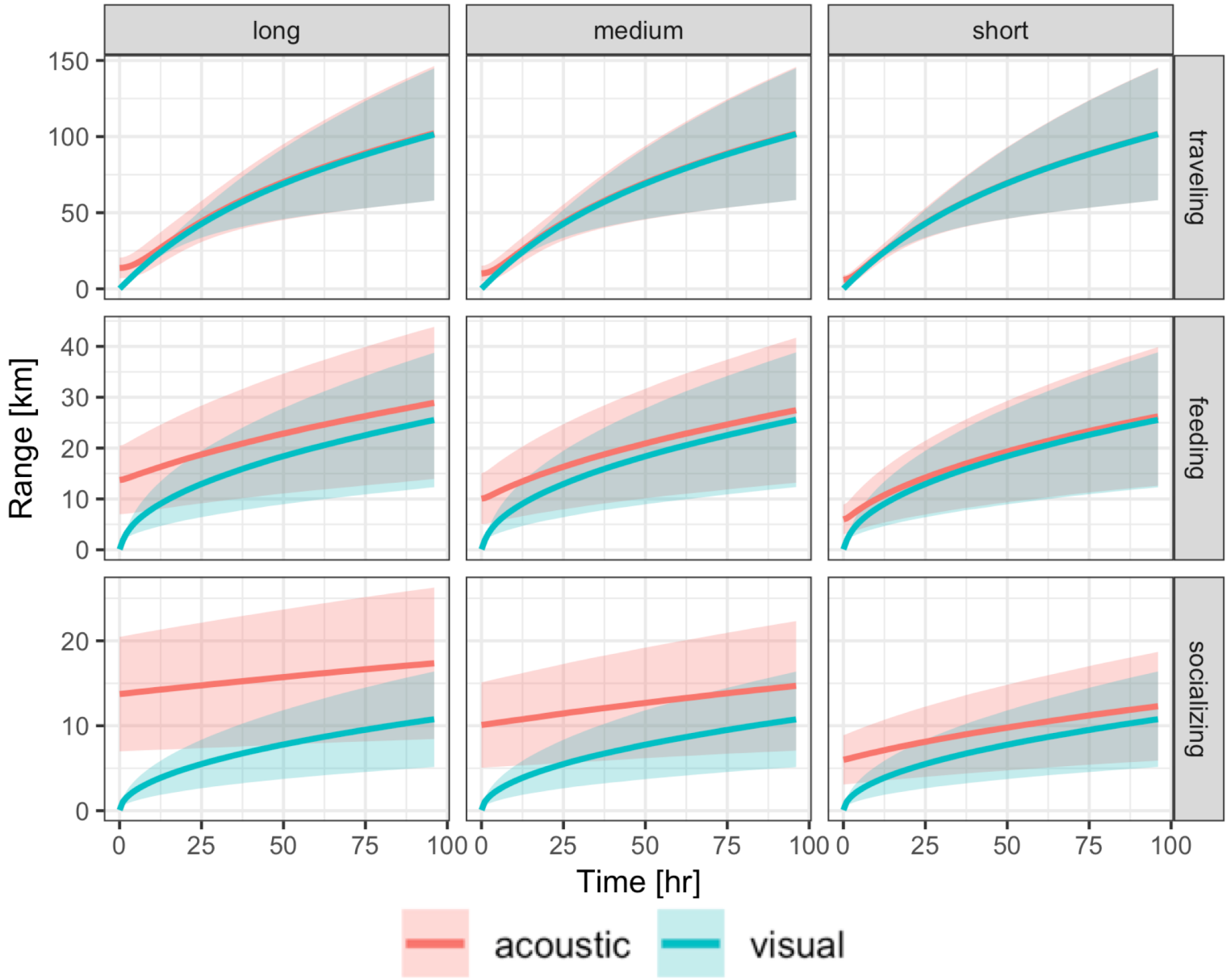


Example run: medium detection range

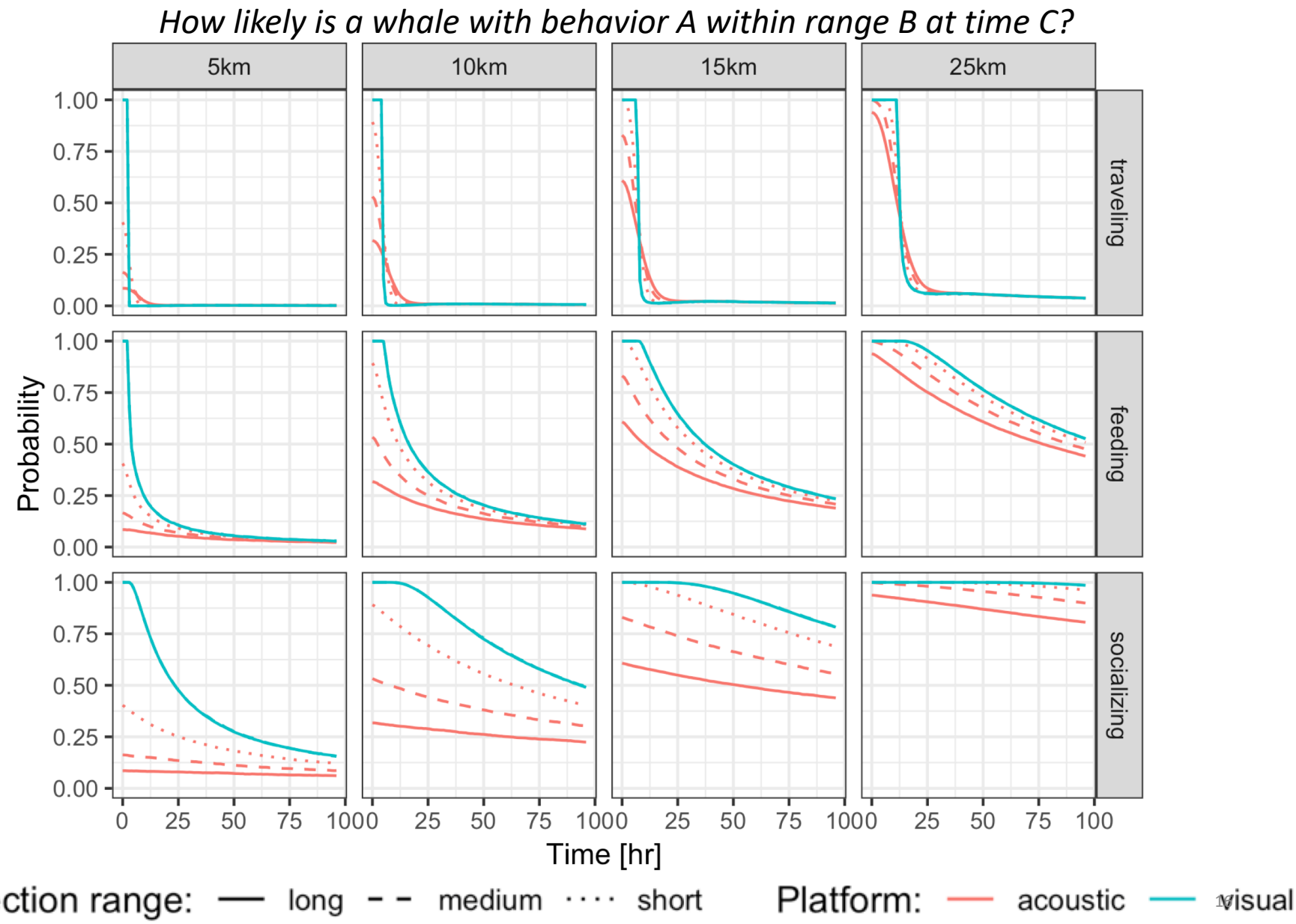


Location uncertainty

How does whale location uncertainty change over time?



Management Context



Conclusions

- Right whales are not points on a map; management must consider movement
- Acoustic and visual detections provide equally uncertain estimates of whale location on management timescales
- Dynamic management should target large areas dominated by low-displacement behaviors (socializing, feeding)
- Need to incorporate acoustics into dynamic management

Excluding acoustic detections only impedes right whale recovery

Questions?

Thanks to:

Kim Davies, Delphine Durette-Morin, Meg Carr, Kim Franklin, Christoph Renkl, Keith Thompson, Daniel Morrison, Marcia Pearson, and others

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