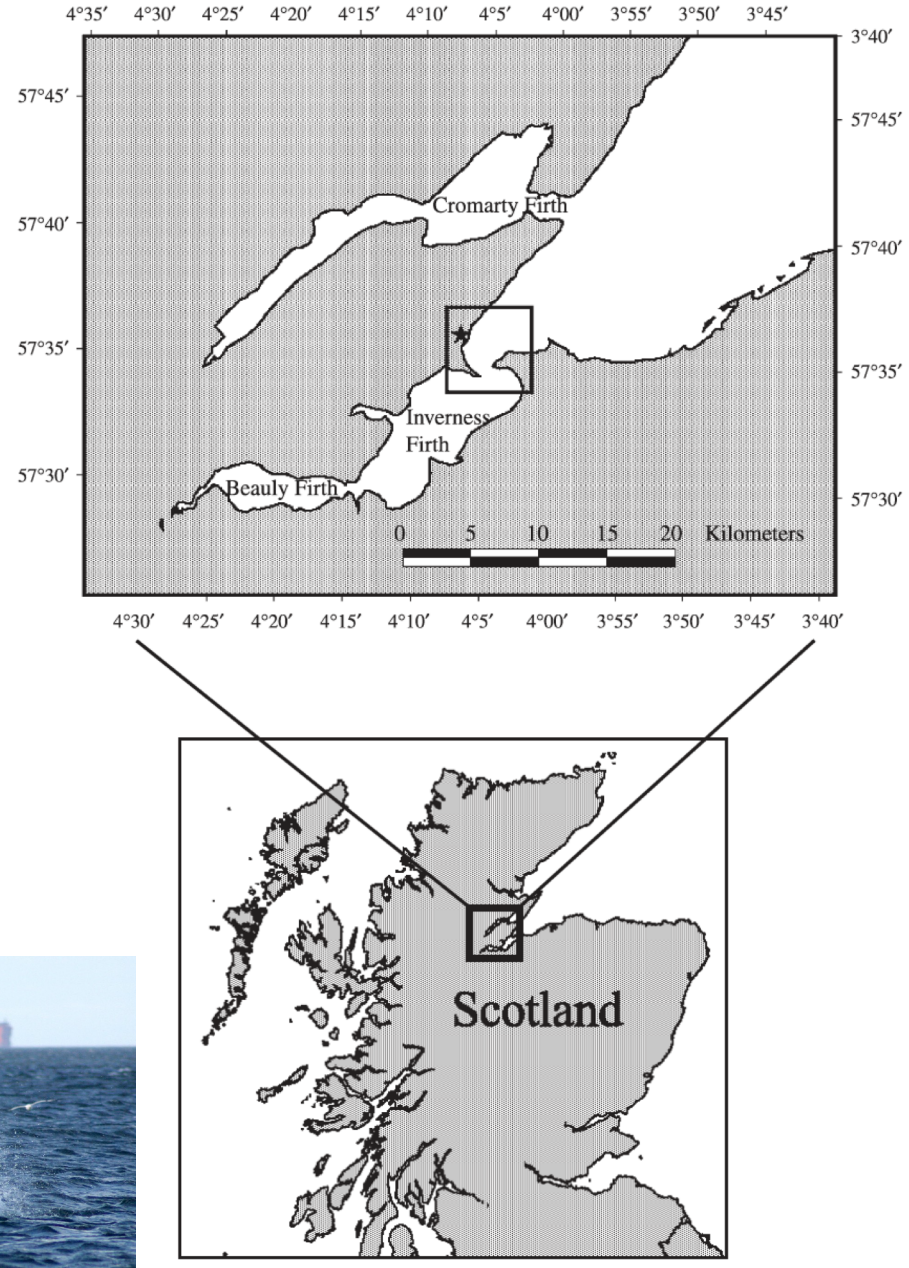
Characterizing Movement

Nov 21

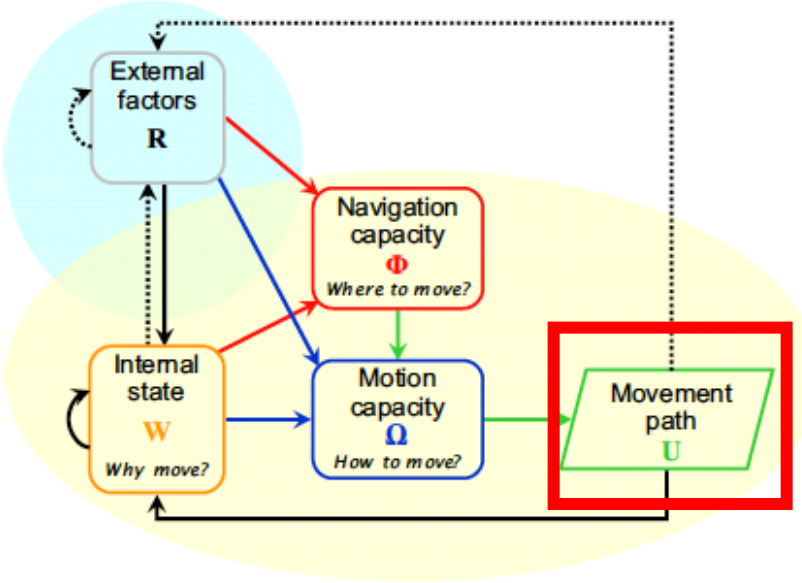
Is the Inner Moray Firth a foraging site for bottlenose dolphins?

- Sightings of concentrated in three small regions, suggesting that these may be important foraging areas
- These areas are all narrow channels so they could be acting as bottlenecks, aggregating the animals and inflating the sighting rate



From Bailey & Thompson 2006

Characterizing Animal Movement

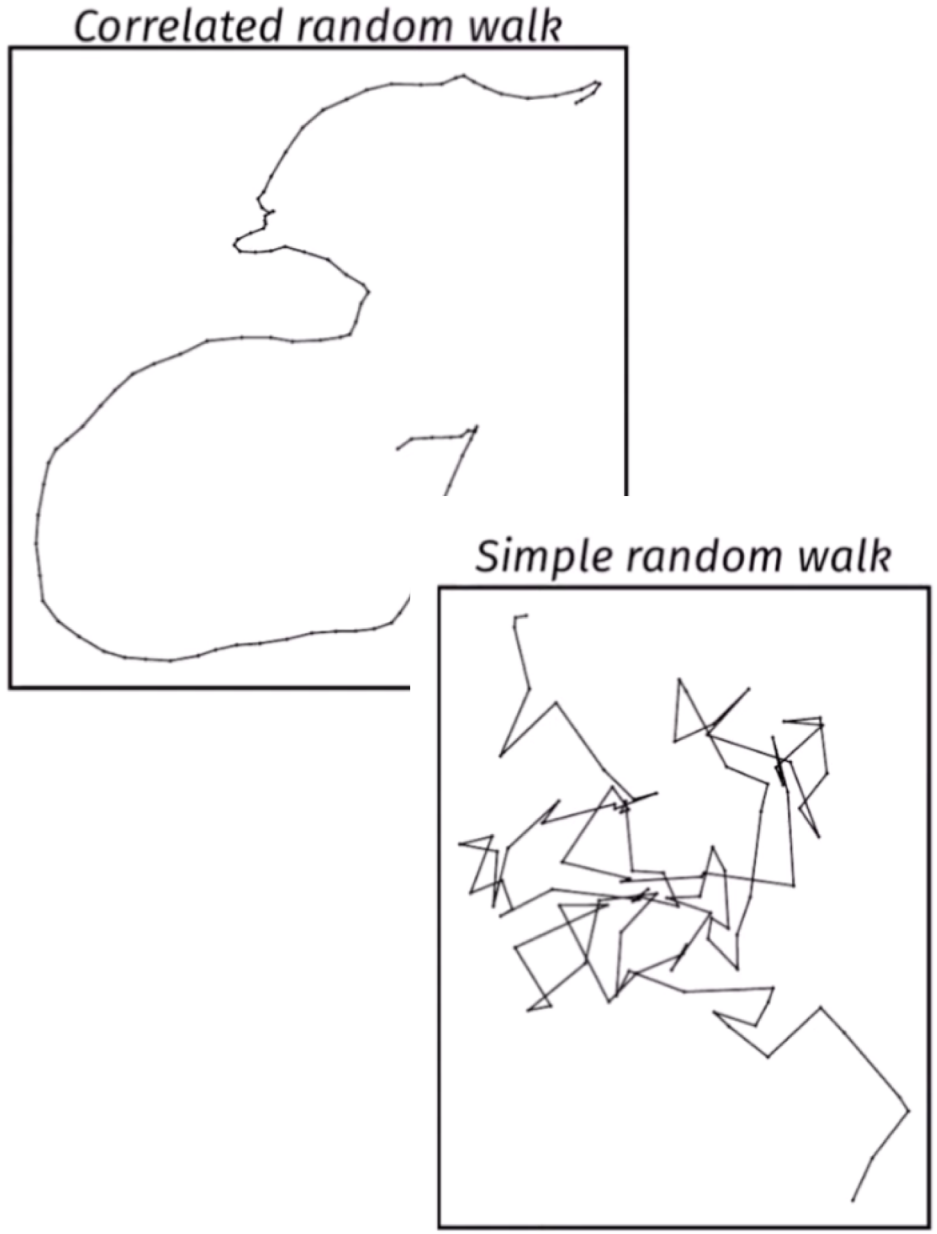


Common approach

- Predicted trajectories modeled from empirical distributions of move lengths and turning angles
- Compare the animal trajectory to the model
- Deviations from the model can provide insights into the behavior adopted
- Ultimately, can be used to identify behaviors and segment the walk into behavioral components (migration, foraging, mating)

Random Walk

- Simple statistical model of behavior
- Building block for behavioral models
- Within each behavior, animal follows a walk model
- Persistence in movement direction captured in the model
- Persistence is defined by the degree of correlation between successive step directions



Biased Random Walk

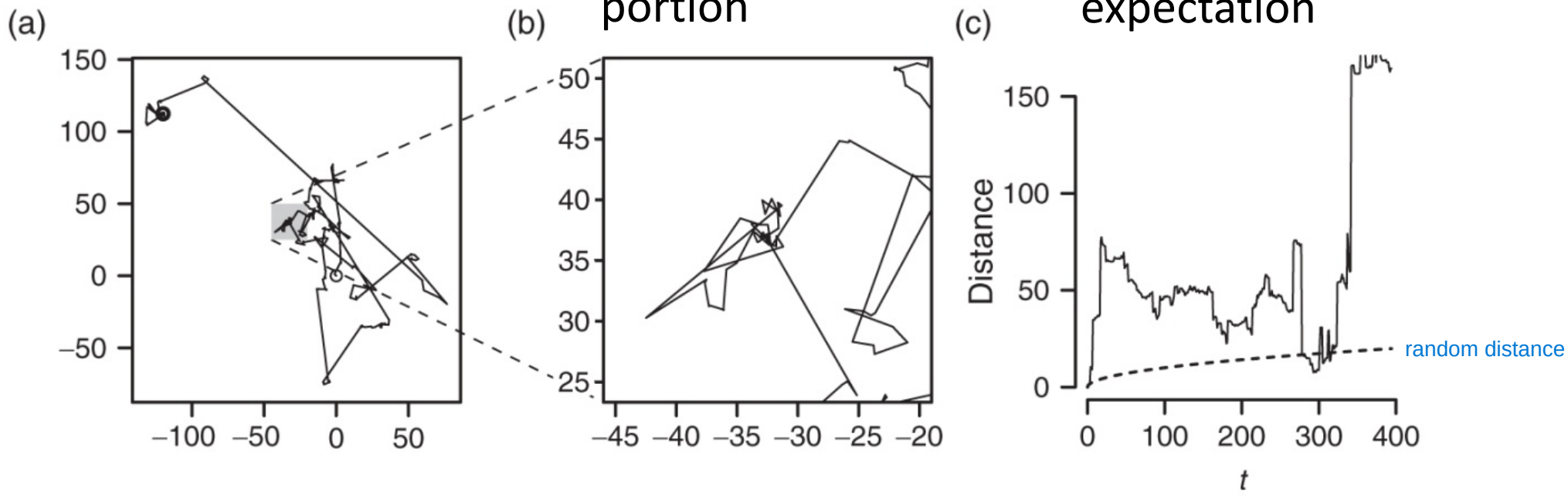
- In a biased random walk, the direction is influenced by an absolute compass direction
- Unlike in a CRW, where direction is influenced only by the previous move direction
- Select direction of each step with respect to a fixed compass direction
- This can arise when animals respond to environmental gradients, are migrating to a destination or memory of preferred locations

Lévy Flights

Full walk

Zoomed in on on portion

Distance from origin compared to sqrt of t expectation



Cover ground more quickly than the other kinds of walks

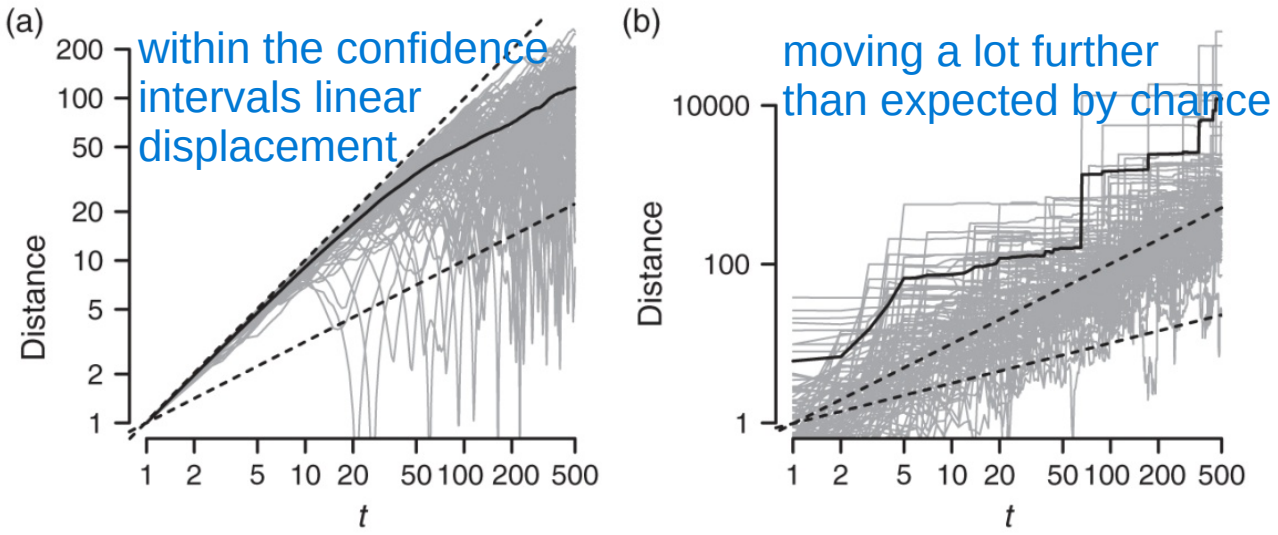
From Spatial Simulation textbook

Lévy Flight Model

correlated random walk

CRW, exponential step lengths

Levy walks, note log scale on y-axis



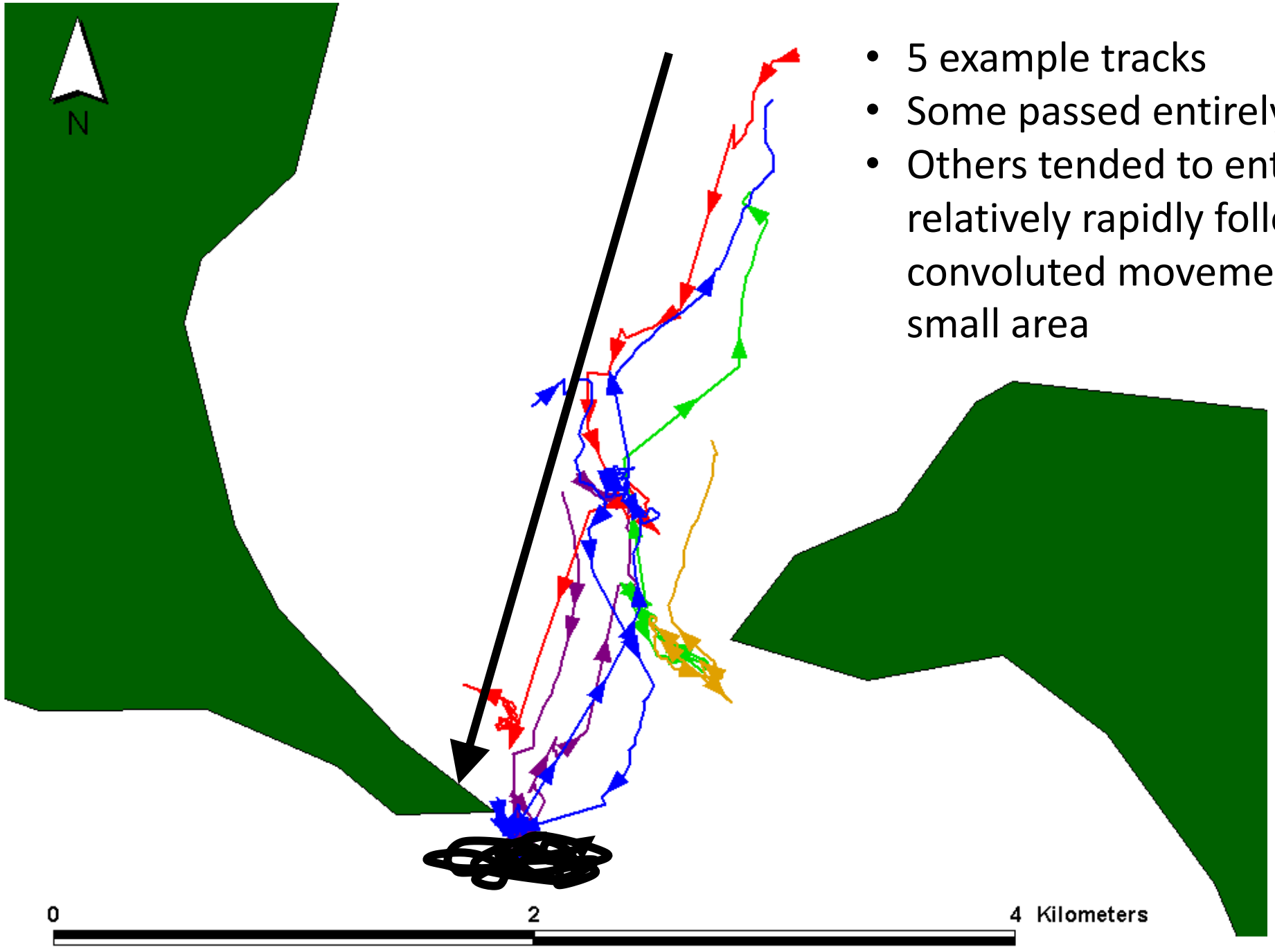
Characteristic plots of Net Squared displacement

$N(x) \sim x^{-\mu}$

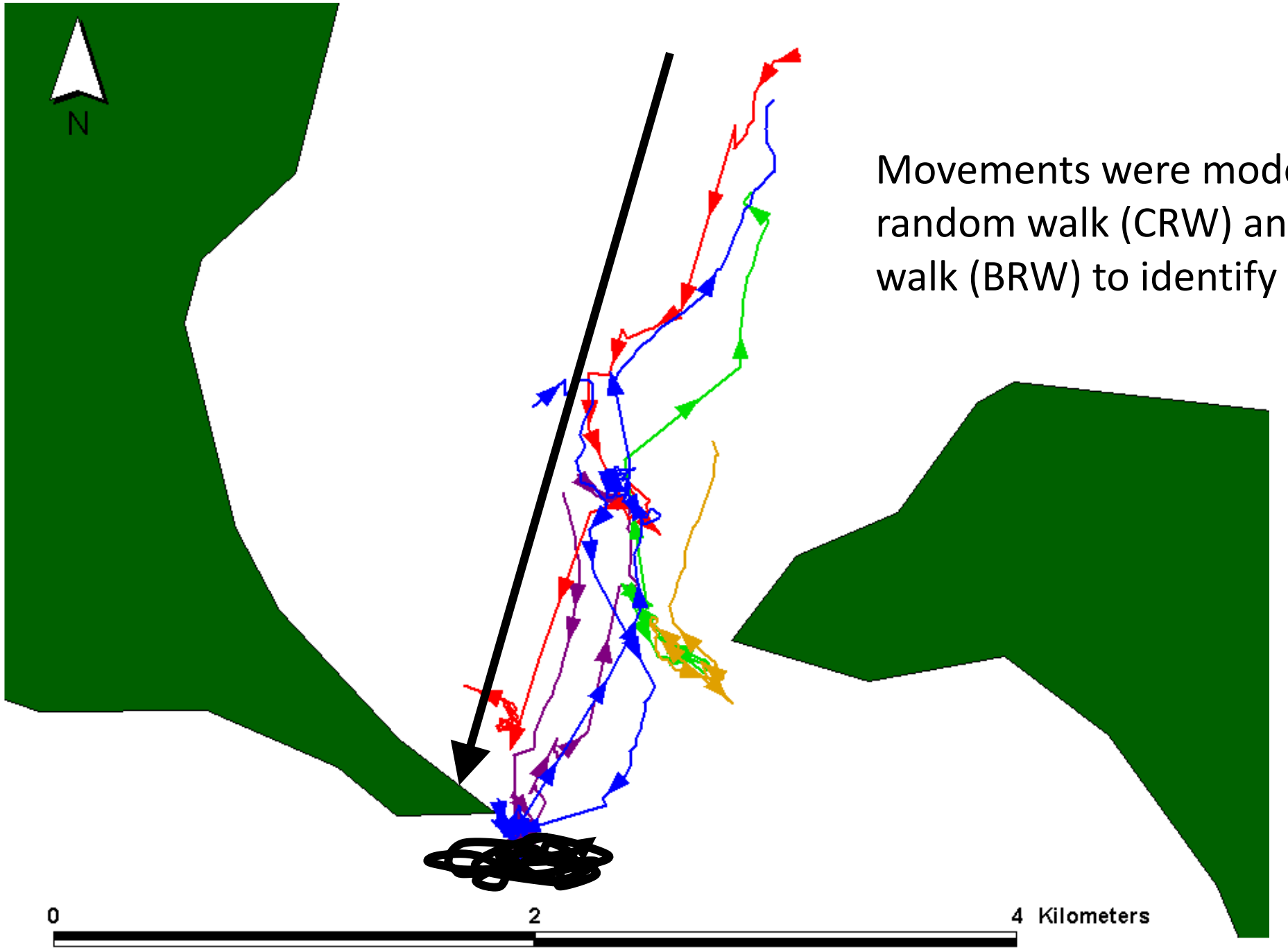
N(x)	is the distribution of step lengths
x	is the step length between positions
μ	is the power law exponent

Levy flights $1<\mu<3$

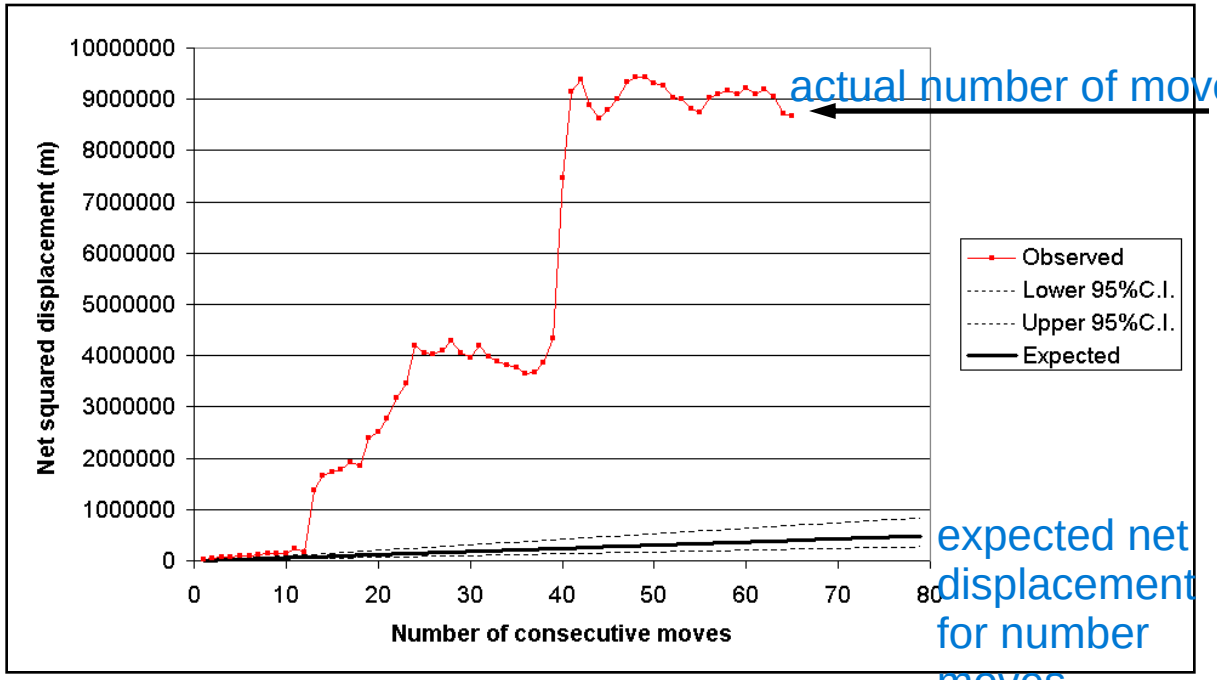
NEED TO KNOW FOR THE HOMEWORK!



- 5 example tracks
- Some passed entirely through the channel
- Others tended to enter the channel relatively rapidly followed by a period of convoluted movement within a relatively small area

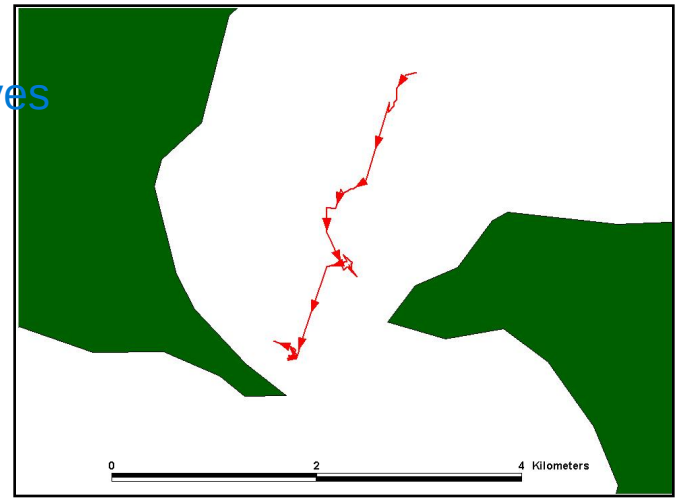


Movements were modelled as a correlated random walk (CRW) and a biased random walk (BRW) to identify movement types

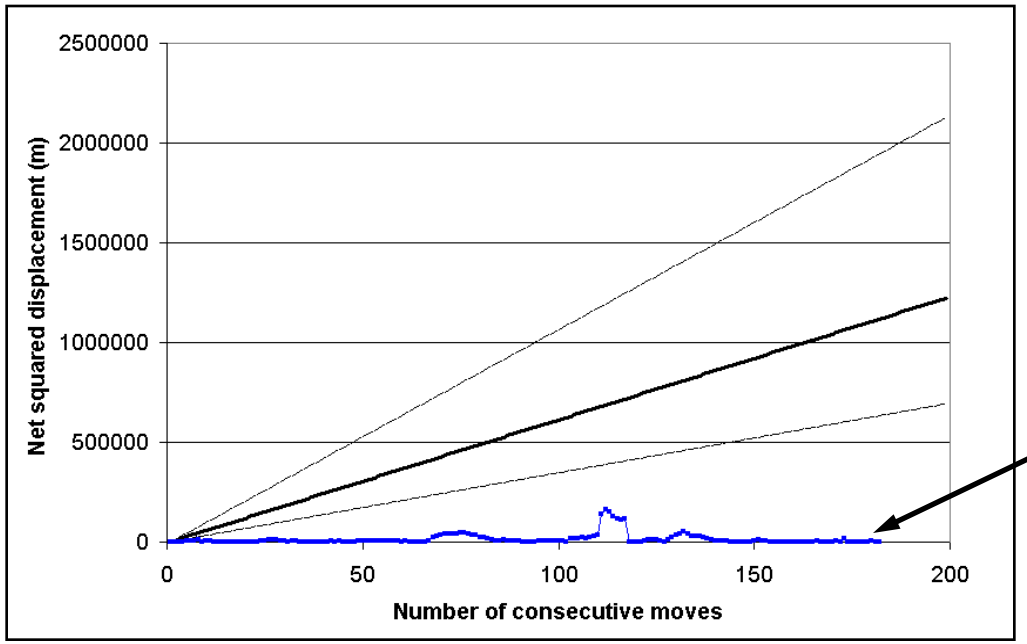


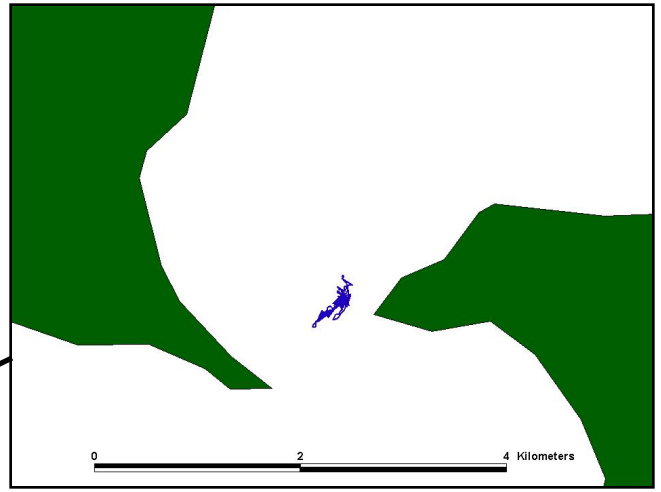
actual number of moves

expected net displacement for number moves



Greater displacement than predicted by CRW





Lower displacement than predicted by CRW

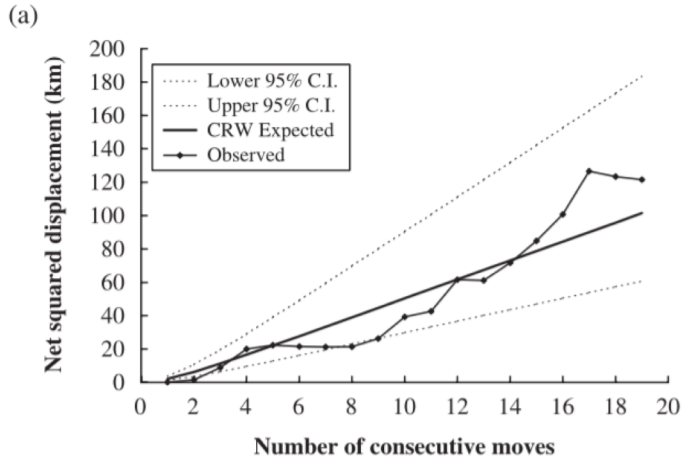
From Bailey & Thompson 2006

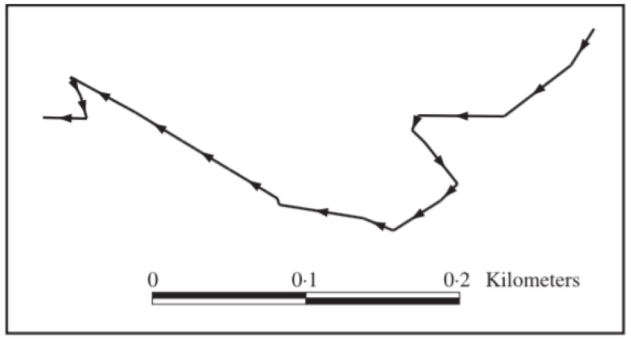
Fits a correlated random walk

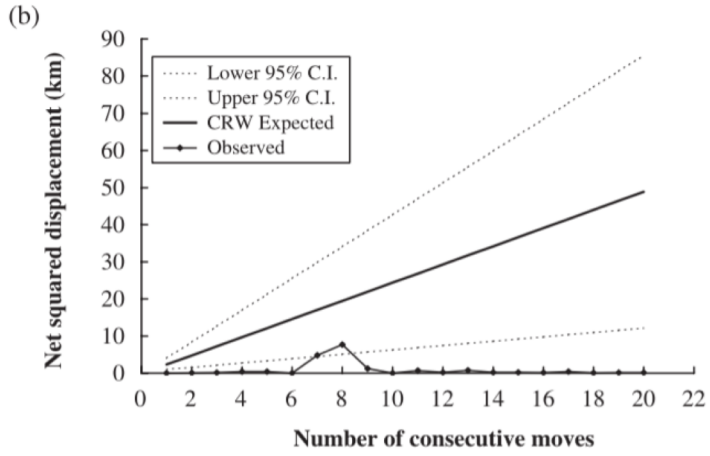
Displacement is lower than expected for a CRW

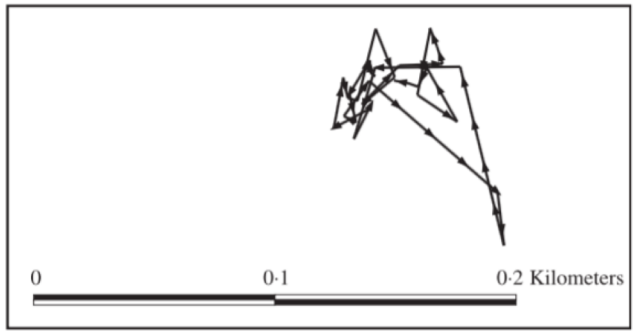
Fits a biased random walk model

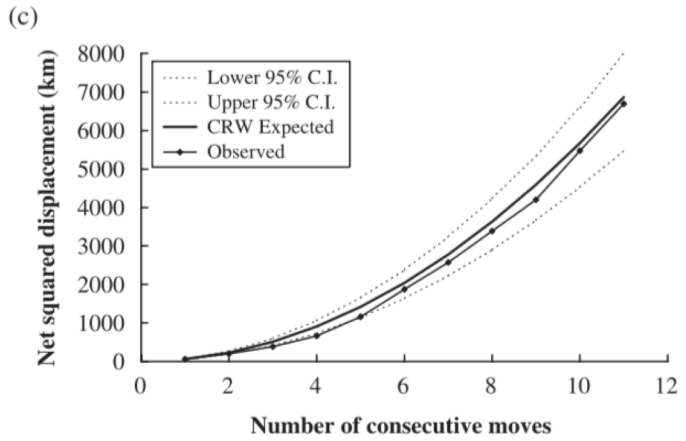
Bailey and Thompson 2006

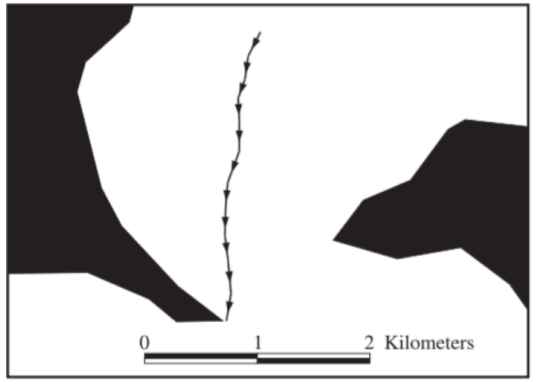












In a biased random walk, the direction is influenced by an absolute compass direction whereas in a CRW it is influenced only by the previous move direction

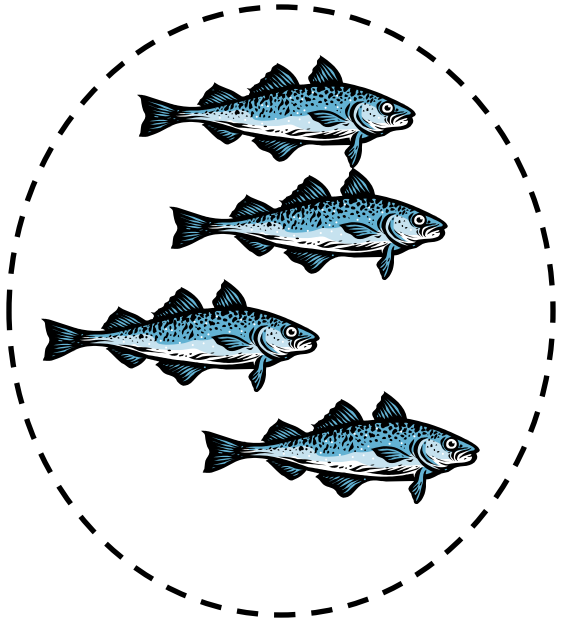
What is driving these different behaviors?

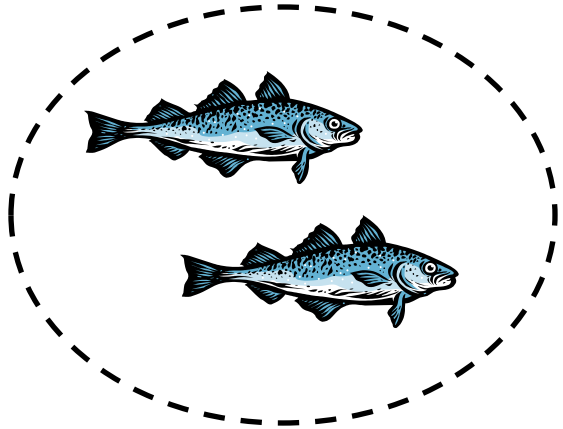
Few of the tracks actually followed a CRW indicating the animals were not moving randomly and were either deliberately remaining in the area or travelling away

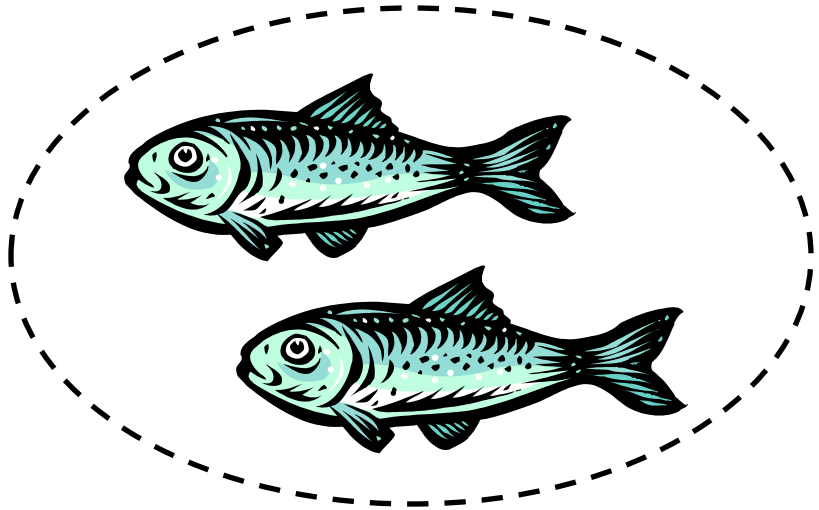
From Bailey & Thompson 2006

Movement phases

Within the marine environment, prey are often distributed in patches

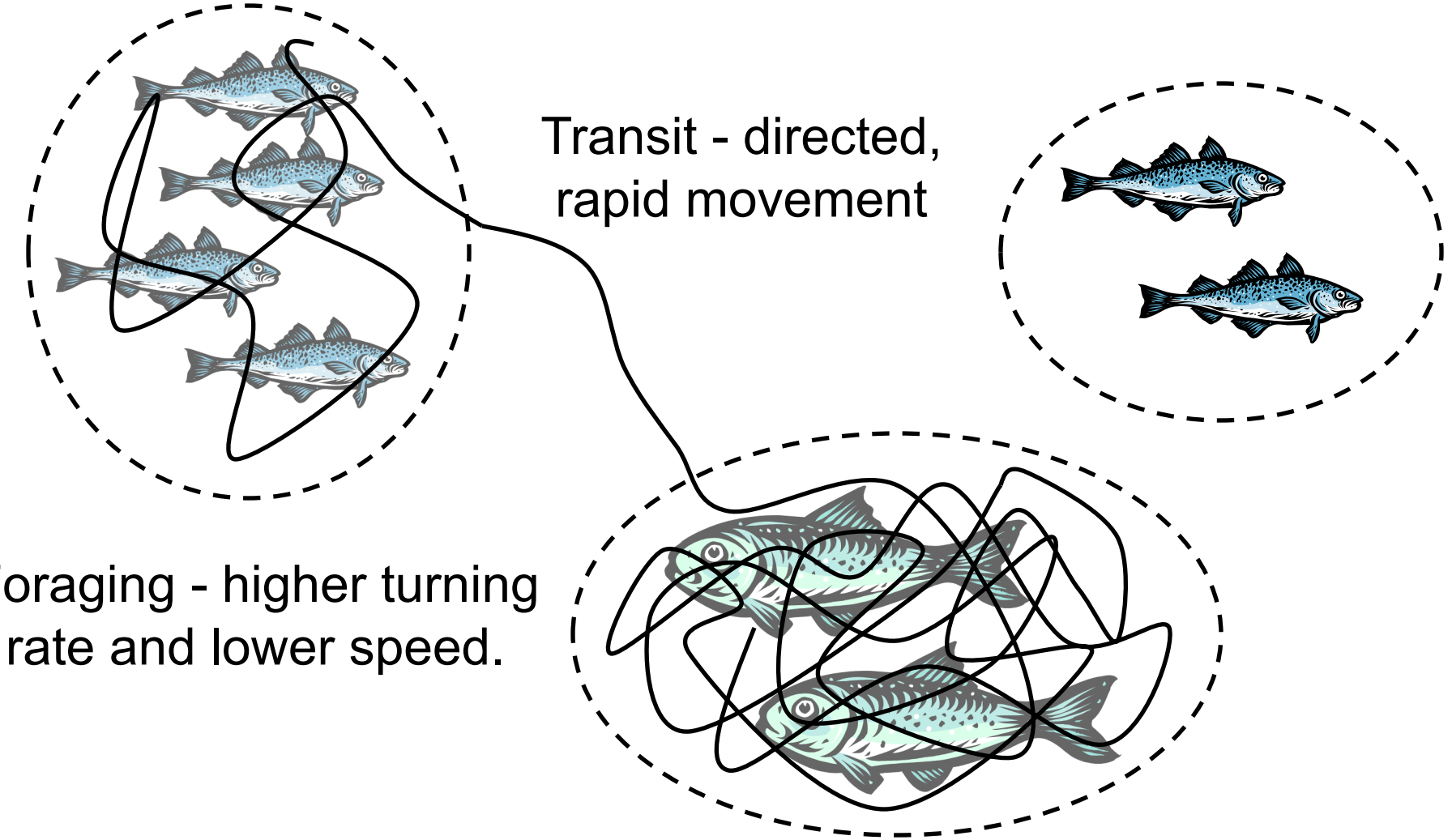






Movement phases

Predators can take advantage of the spatial autocorrelation of prey density by using Area-Restricted Search (ARS) behavior



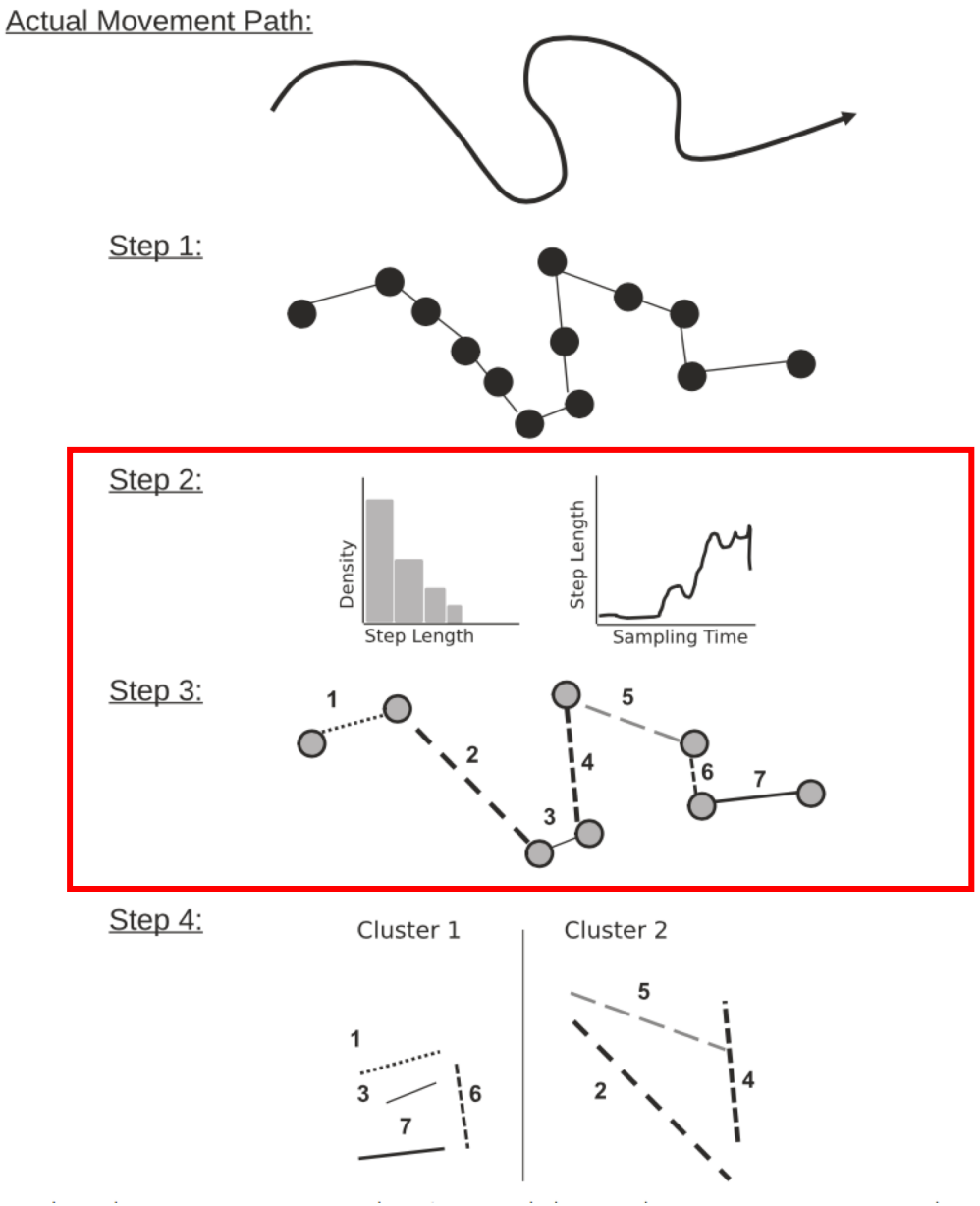
What is driving these different behaviors?

Can Area-Restricted Search (ARS) behavior be detected with other measures of the movement path?

From Bailey & Thompson 2006

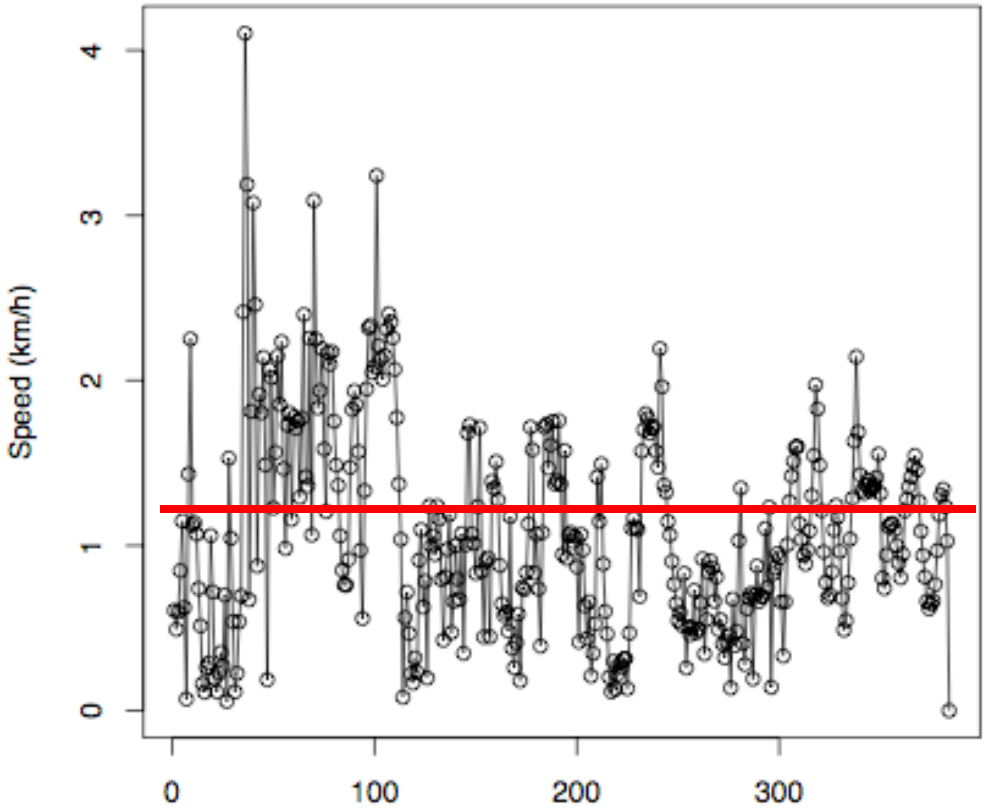
Path Characteristics

- Step length
- Turning angle
- Random walk models
- Speed
- Straightness index
- First-passage time
- State-space models



From Edelhoff et al. 2016

Speed



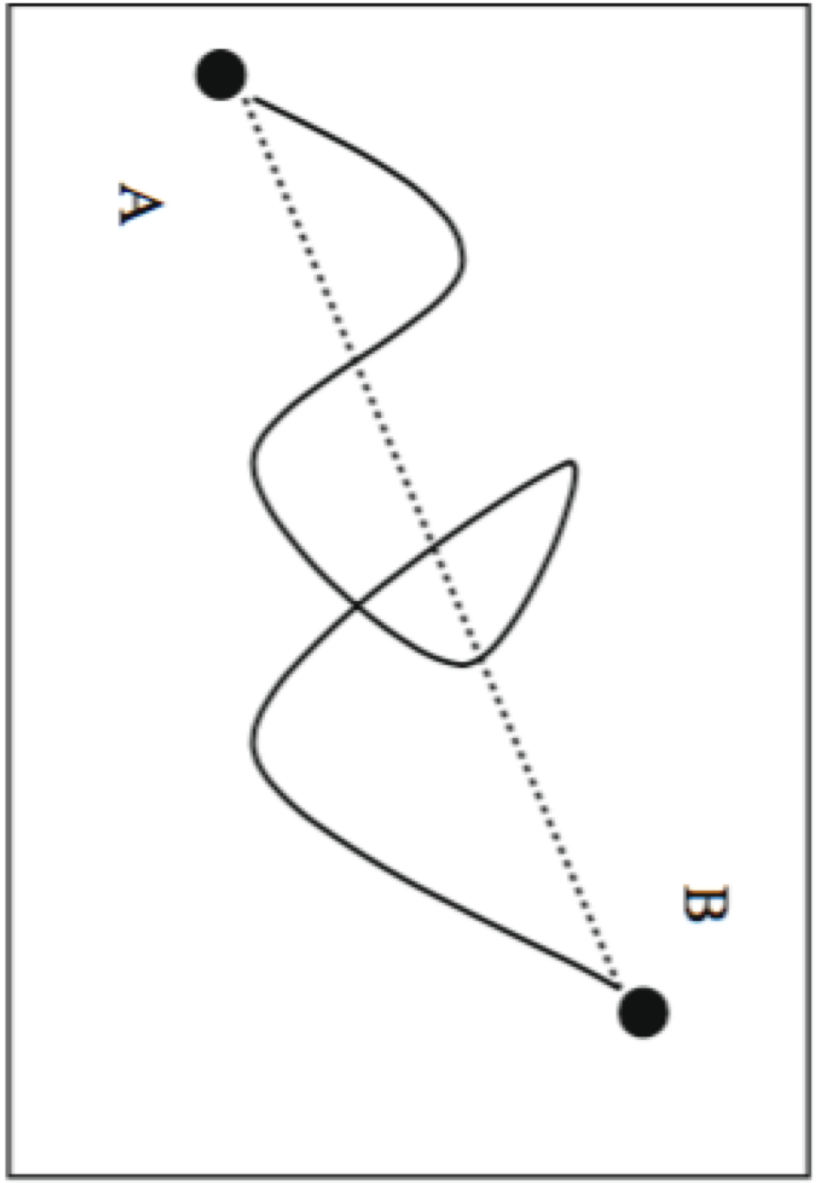
Threshold?

- **Speed = distance/time**
- Different speeds can indicate different behaviors
- But they are also highly variable
- Difficult to decide on a threshold value for behaviors

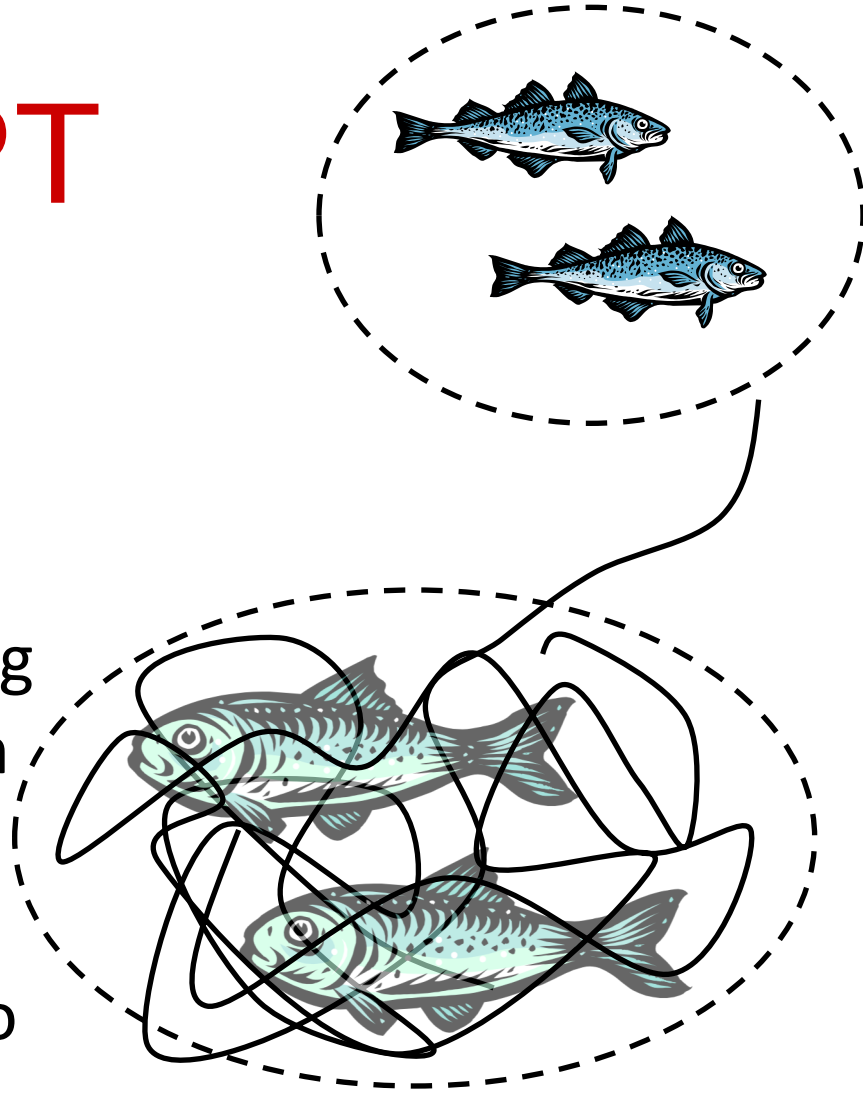
Straightness Index (SI)

- **SI = D/L**
- D = straight line distance from A to B
- L = total path length (sum of each step)
- 0-1 indicate tortuous to linear movement
- Sensitive to observation frequency, overestimated if recording frequency is low

really sensitive to observation frequency

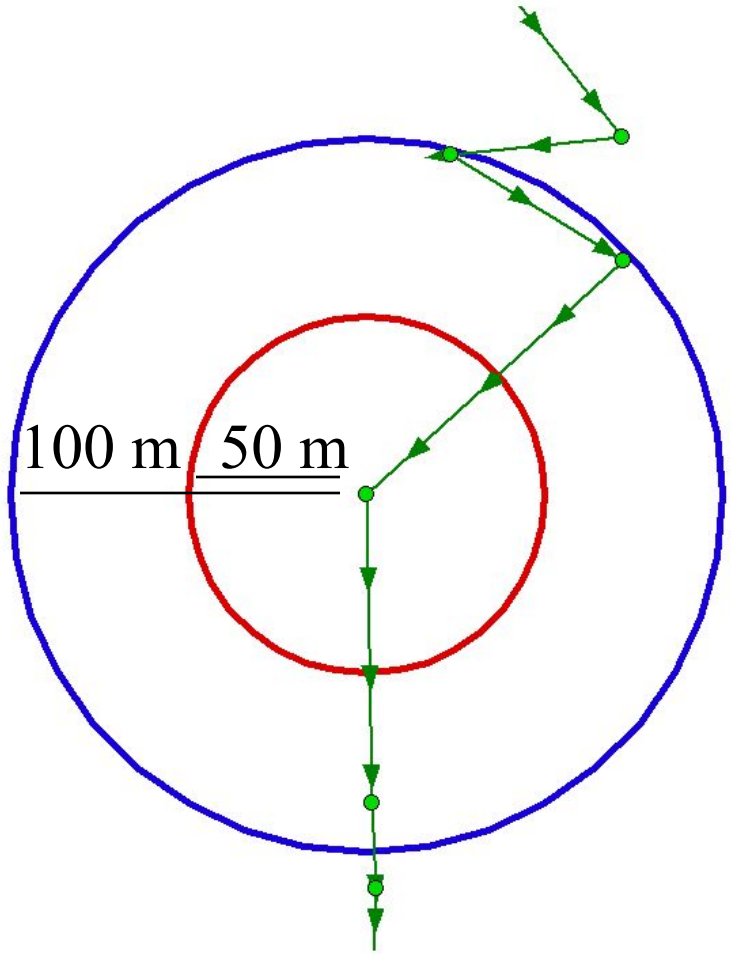


First-passage time (FTP) FPT



- Make decisions about foraging path
- Also, how long to stay within a patch
- Time allocated to an area should indicate the profitability and the trade-off between diminishing returns and the cost of finding another prey patch
- FTP is a measure of time allocation
- Used to detect area-restricted search and scale dependent adjustments, presumably in relation to environmental features

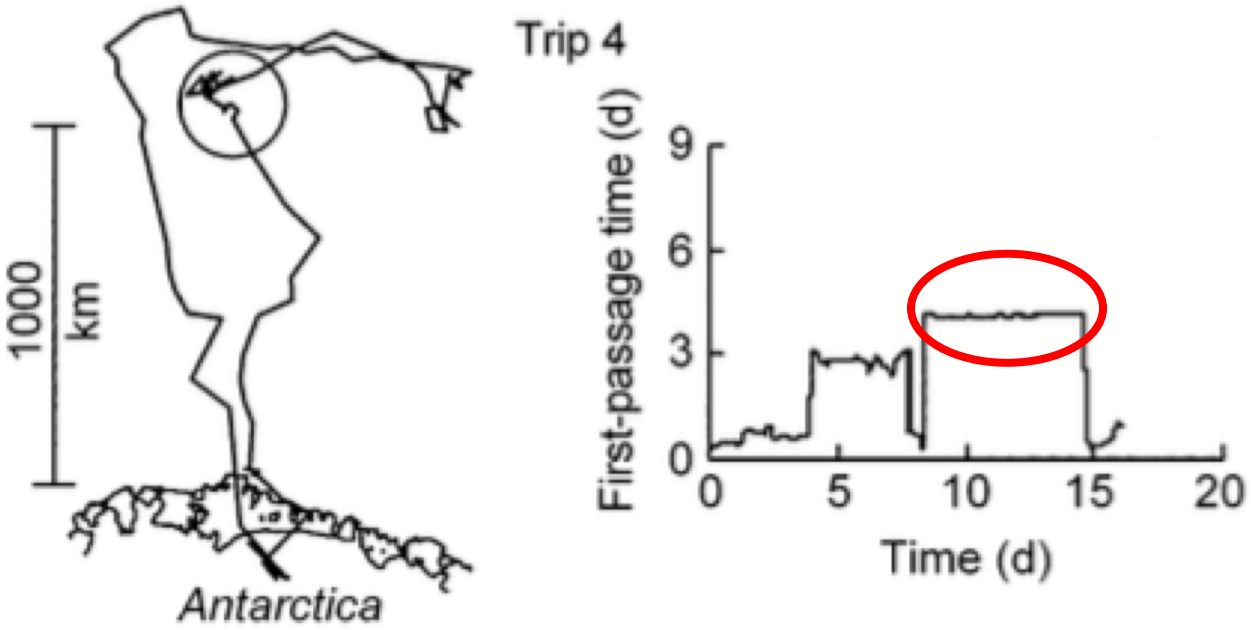
First-passage time (FPT)



(Fauchald & Tveraa 2003)

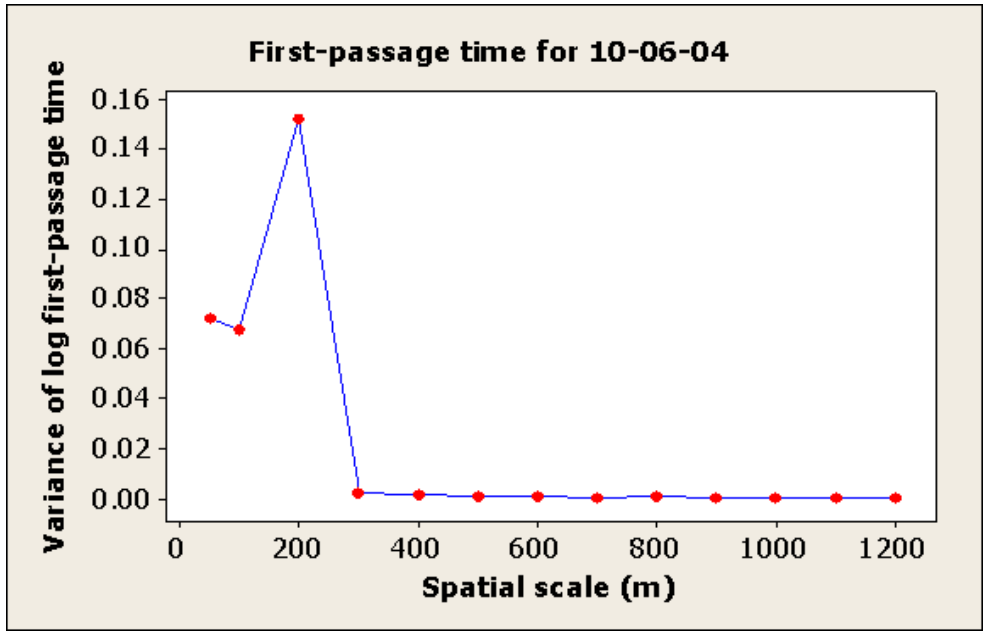
- The time required for an animal to cross a circle with a given radius
- A measure of how much time an animal spends within a given area (High= intensively used, Low= rapidly moving)
- Scale-dependent, increases with increasing circle radius

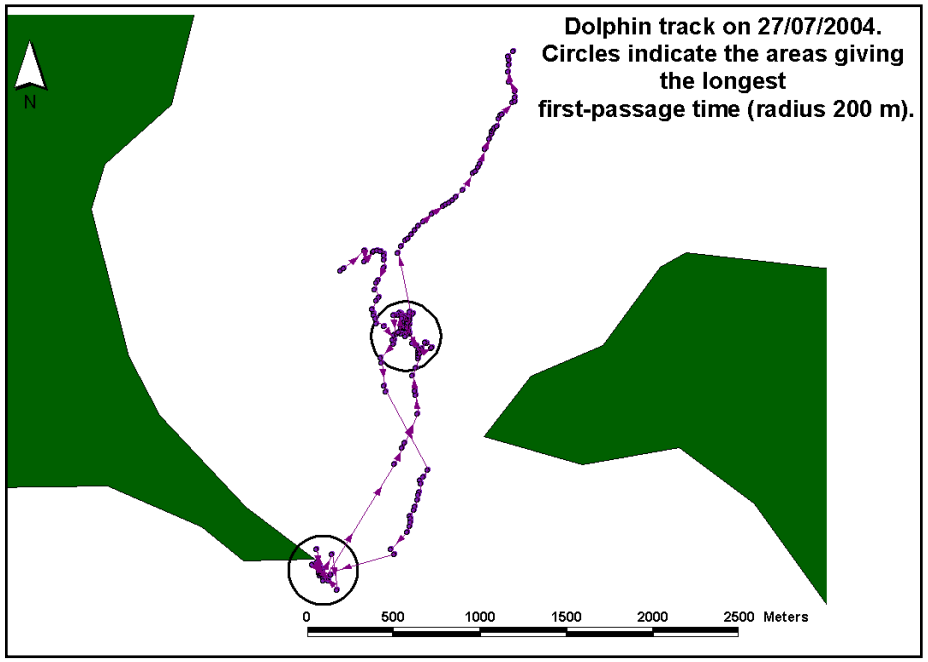
First-passage time (FPT)

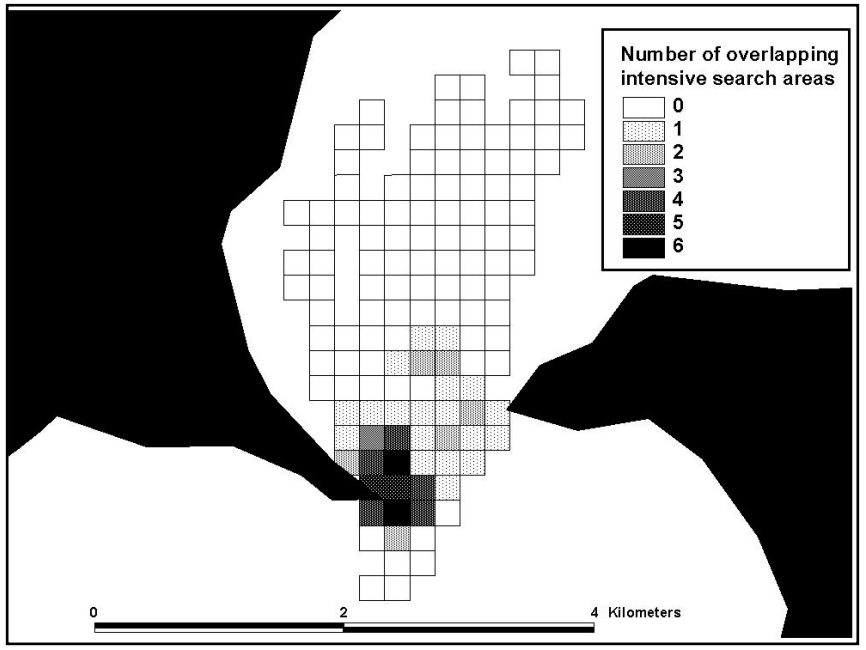


From Fauchald and Tveraa 2003

- Step 1: Identify spatial scale of area-restricted search behavior (intense space use) by the radius at which the variance of log(FPT) peaks
- Step 2: Each position is assigned circles around it of different radius sizes and the time it takes for the animal to cross the circle is calculated based on speed
- The area is indicated by a peak in FPT for that circle size



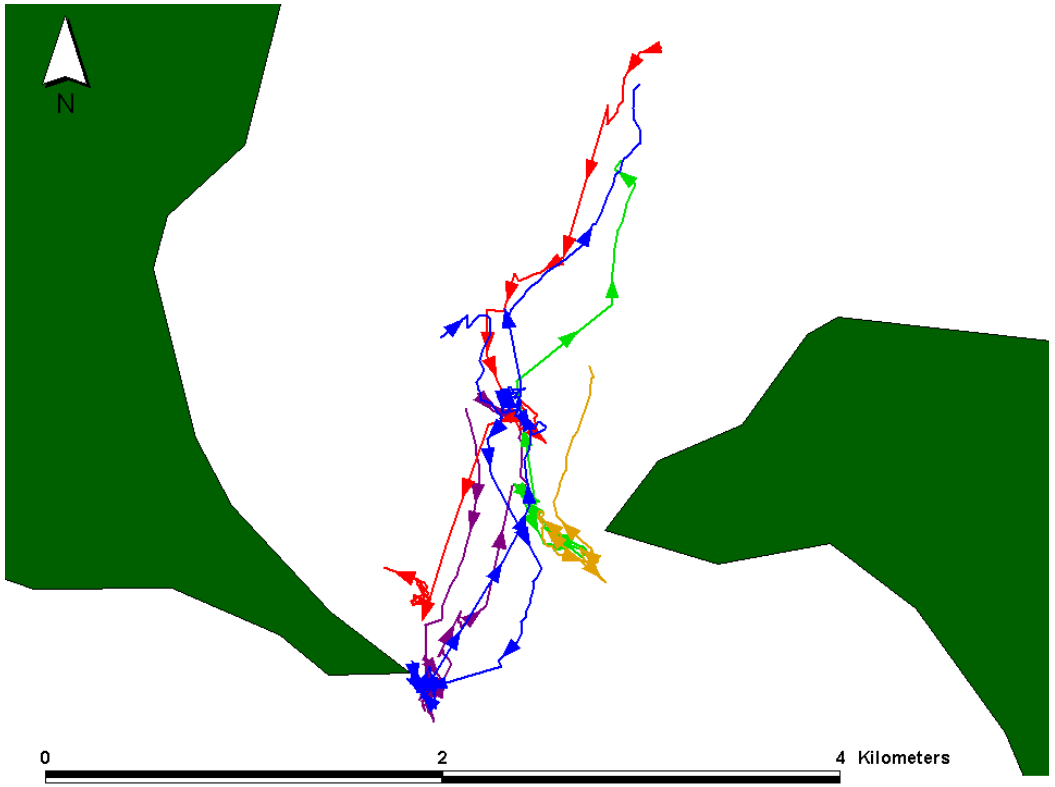




- FPT used to measure intensive use
- Defined the search radius- 200m circle size had highest variance in the log FPT
- Using that circle size, positions with highest FPT ID intensive use
- Greatest concentration were off the peninsulas

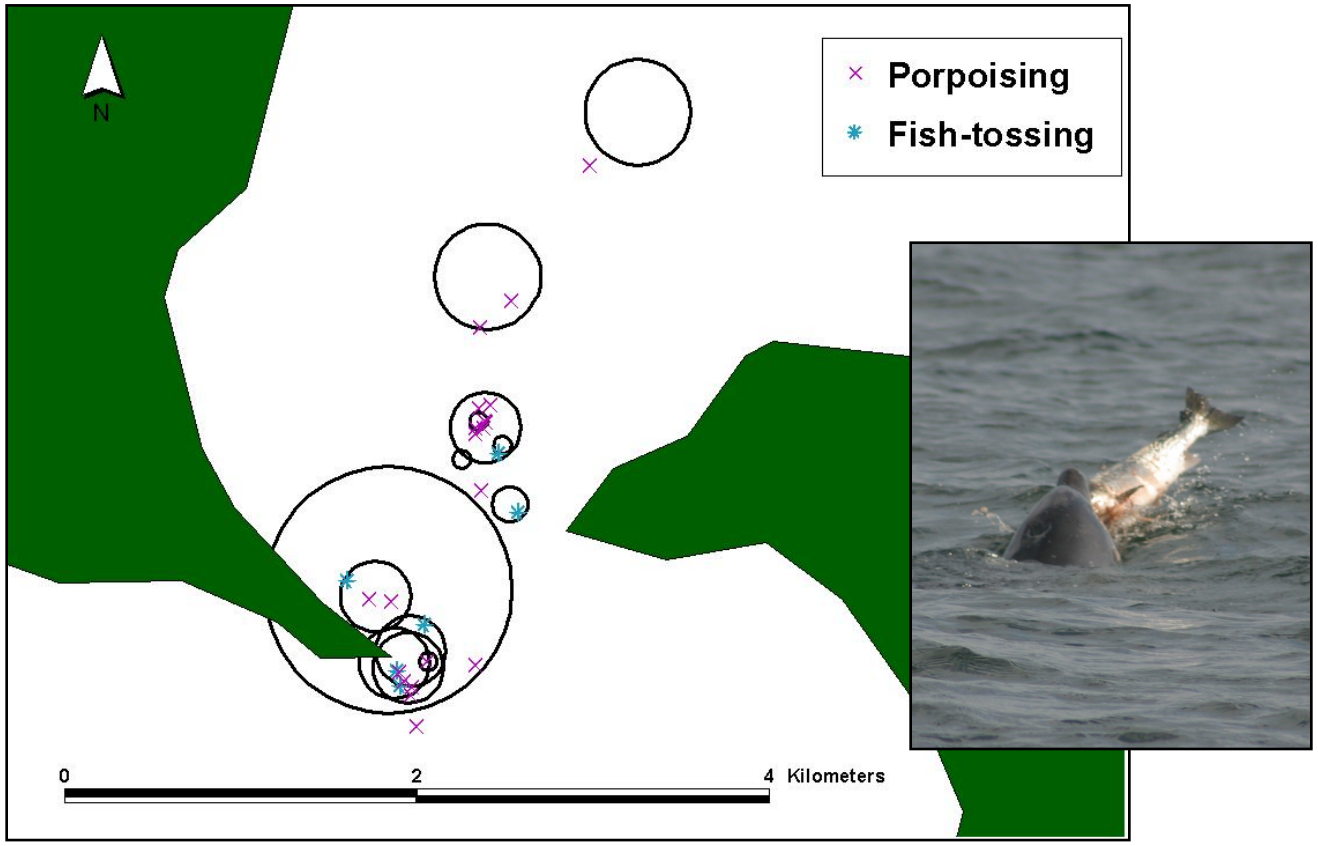
From Bailey and Thompson 2006

Feeding area?



Not just travelling through the channel, but instead there were areas of intensive search indicating that this channel is a preferred area. However, what is its function? Is it a foraging area?

Significantly more likely to have foraging behaviour inside intensively searched areas



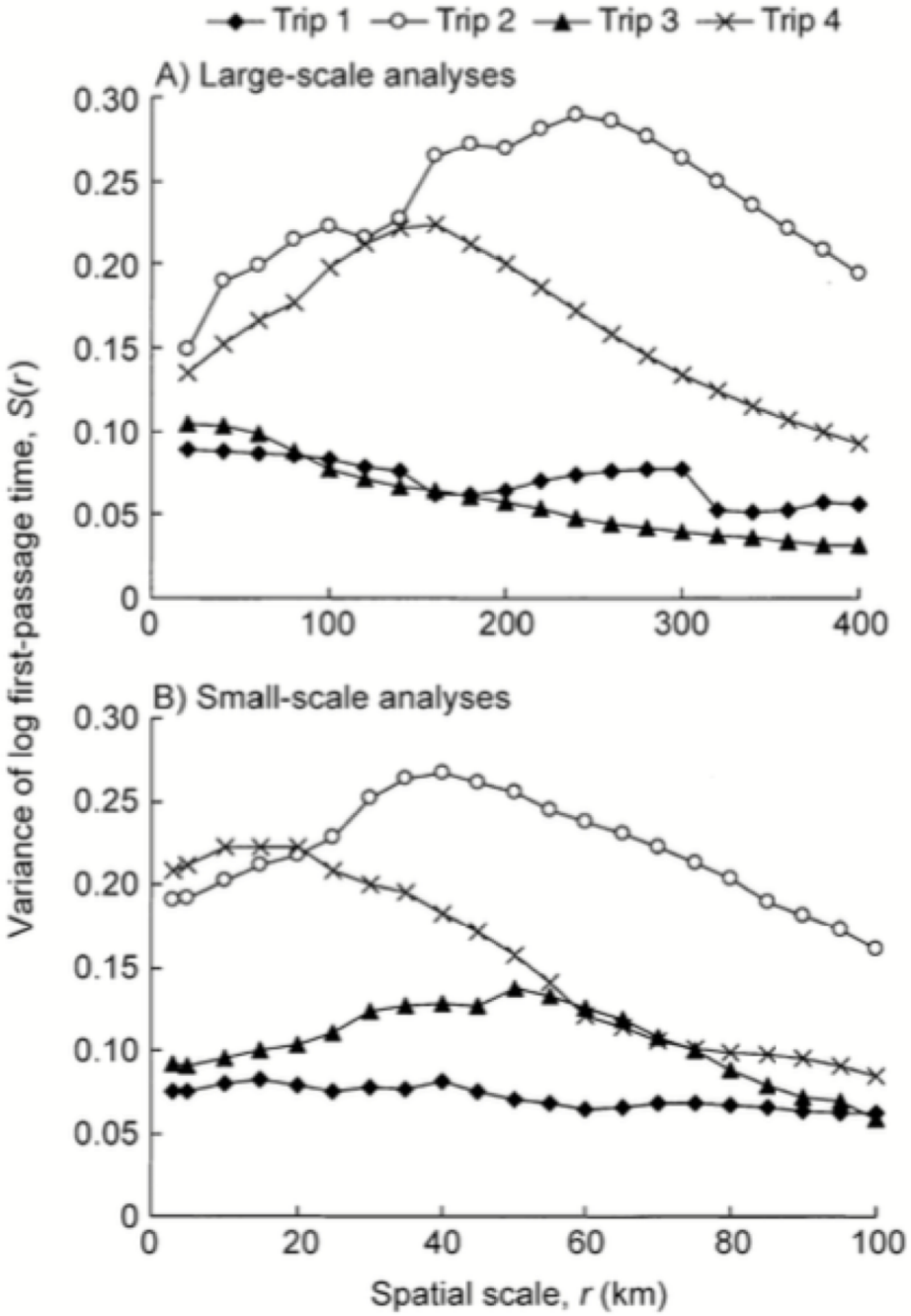
- Observed behaviour frequently included eating or tossing fish at the surface.
- Locations of these events were compared inside and outside of the intensive search areas

Bailey and Thompson 2006

Nov 21 (Mon)	**Movement in Heterogeneous Environemnts**	Cohen		HW7- Analyzing Animal Movem	
Nov 23 (Wed)	**HOLIDAY**	**HOLIDAY**			
Nov 28 (Mon)	**Seascape Ecology**	Secor	DISCUSSION, Pittman et al 2021		
Nov 30 (Wed)	**Aeroecology**	DeSimone	DISCUSSION, Davy et al 2016		
Dec 5 (Mon)		Project work			HW7
Dec 7 (Wed)		Project work			
Dec 12 (Mon)		Presentations			
Dec 14 (Wed)		Presentations			

First-passage time (FPT)

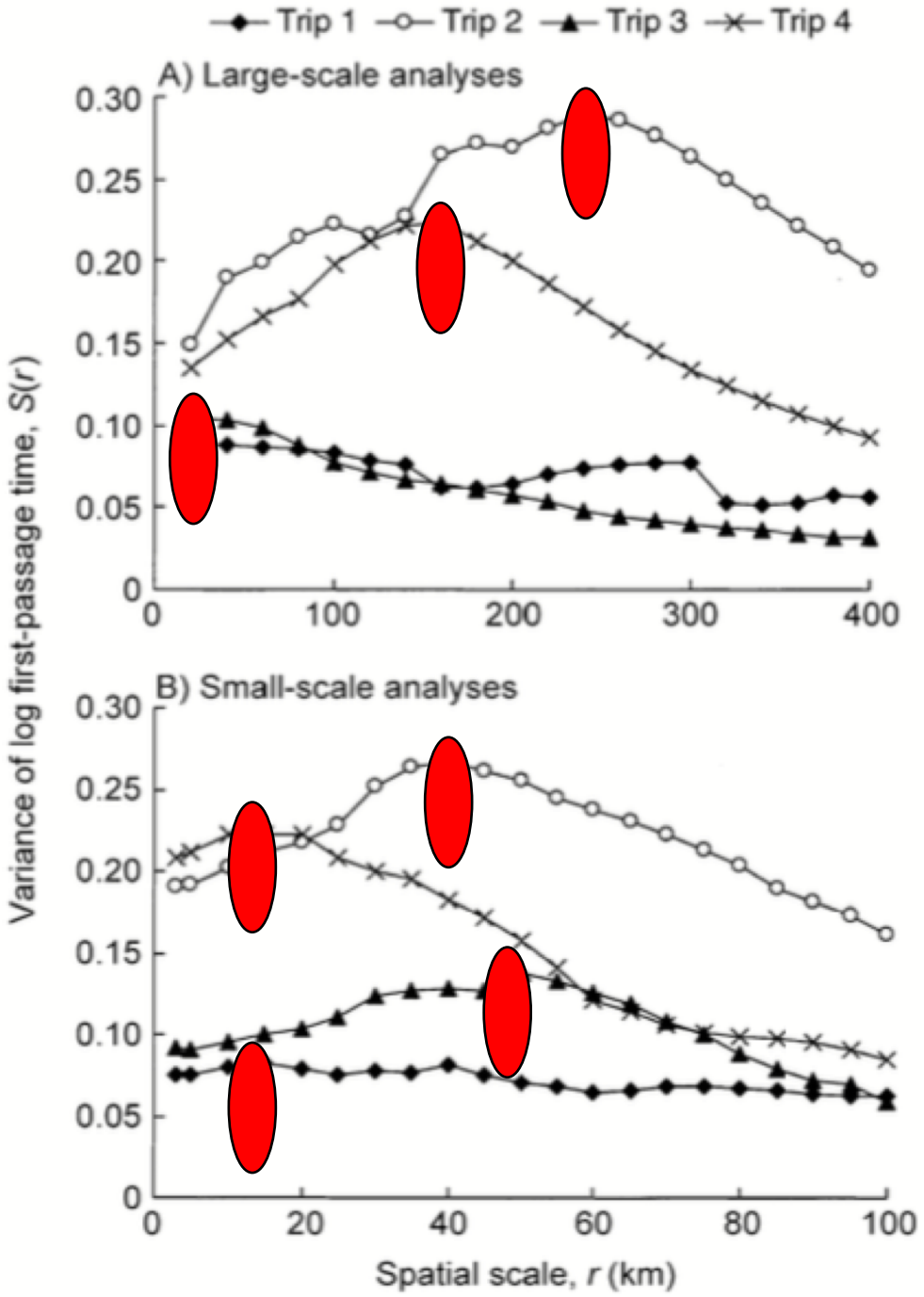
- Increasing variance when there is a transition between these behaviors
- Relative variance in FPT will increase for increasing circle radius
- Log-transform the variance of FPT so it is independent of the magnitude of the mean FPT



From Fauchald and Tveraa 2003

First-passage time (FPT)

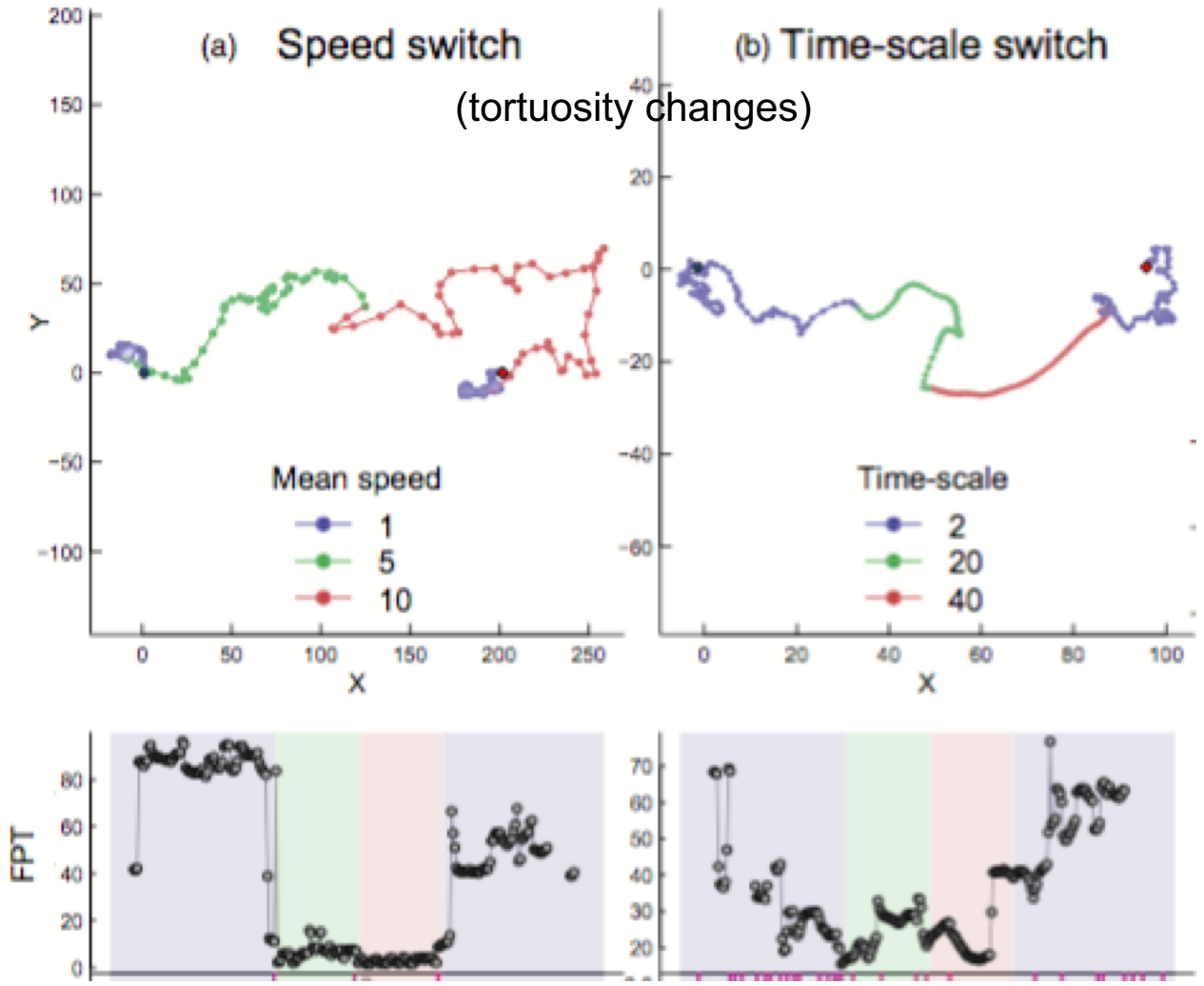
- Identify spatial scale of area-restricted search behavior (intense space use) by the radius at which the variance of log(FPT) peaks
- There may be >1 peak indicating nested scales.
- There are currently no specific tests for determining which peaks are significant.



From Fauchald and Tveraa 2003

First-passage time (FPT)

- FPT performs best when behavioral changes related to variation in speed rather than in tortuosity
- Quantifies intensity of absolute space use regardless of mechanism



From Gurarie et al. 2016