Moving forward: Advances in modeling and visualizing movement data

OTN 4.8: Data Modelling and Visualization

Kim Whoriskey, Marie Auger-Méthé, Stuart Carson, Duncan Murdoch, and Joanna Mills Flemming

Modelling Marine Animal Tracks with TMB

Ecology, 86(11), 2005, pp. 2874–2880

ROBUST STATE–SPACE MODELING OF ANIMAL MOVEMENT DATA

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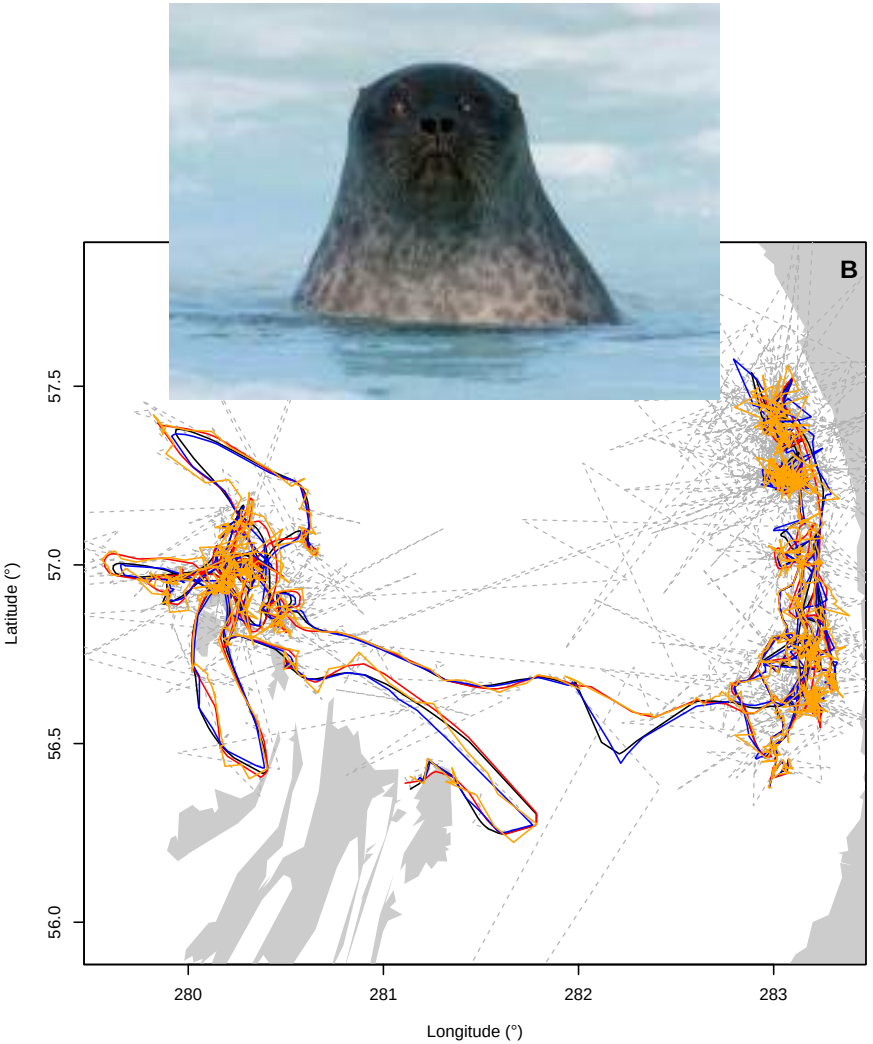
first-Difference Correlated Random Walk

$$\mathbf{d}_t = \mathbf{x}_t - \mathbf{x}_{t-1} \qquad \mathbf{d}_t \sim \gamma \mathbf{T} \mathbf{d}_{t-1} + N_2(0, \Sigma)$$

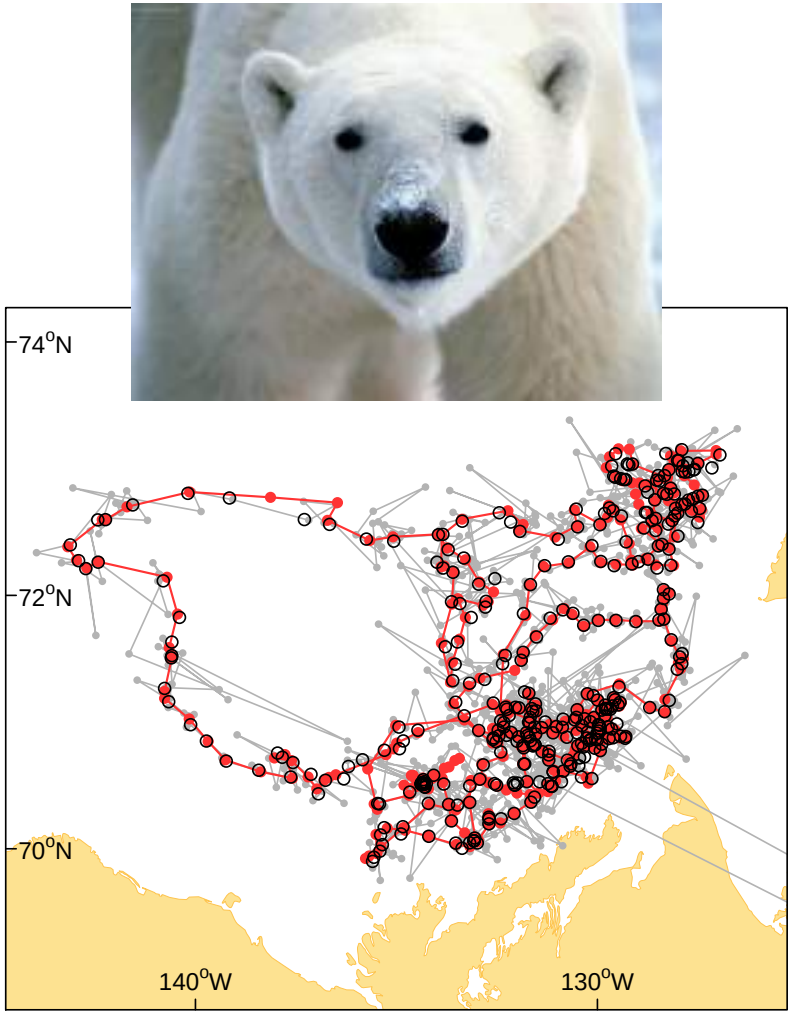
$$\mathbf{T}(\theta) = \begin{pmatrix} cos(\theta) & -sin(\theta) \\ sin(\theta) & cos(\theta) \end{pmatrix} \qquad \Sigma = \begin{pmatrix} \sigma^2_{lon} & \rho\sigma_{lon}\sigma_{lat} \\ \rho\sigma_{lon}\sigma_{lat} & \sigma^2_{lat} \end{pmatrix}$$

$$\mathbf{y}_{t,i} = (1 - j_i)\mathbf{x}_{t-1} + j_i \mathbf{x}_t + \epsilon_t$$

Modelling Individual Marine Animal Tracks



Albertsen et al. 2015



Auger-Méthé et al. 2016

Estimating discrete behavioural states

Behaviour Equation

$b_i = \{0, 1\}$

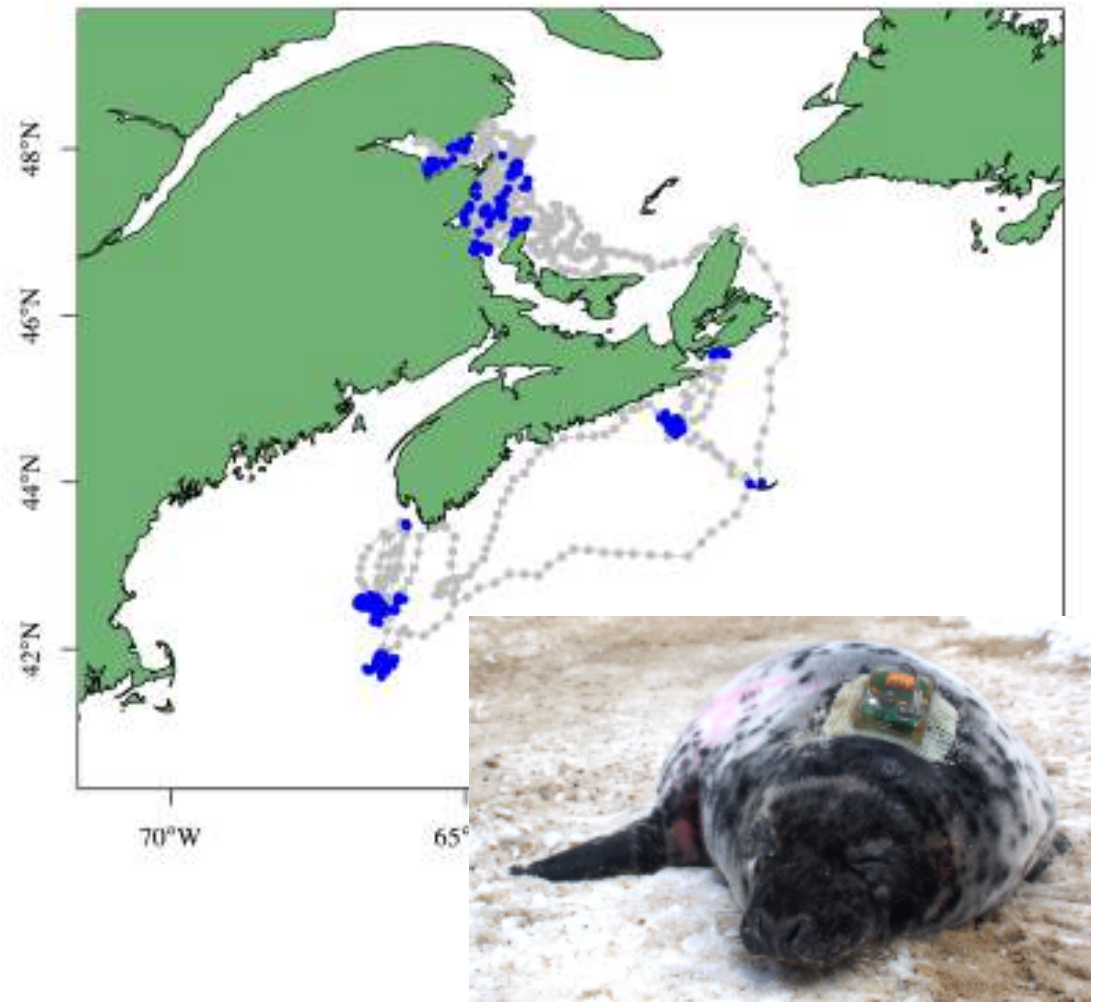
$b_i \sim Bernoulli(\alpha_{b_{i-1}})$

$\gamma_{b_i} = \{\gamma_0, \gamma_1\}$

Movement Equation

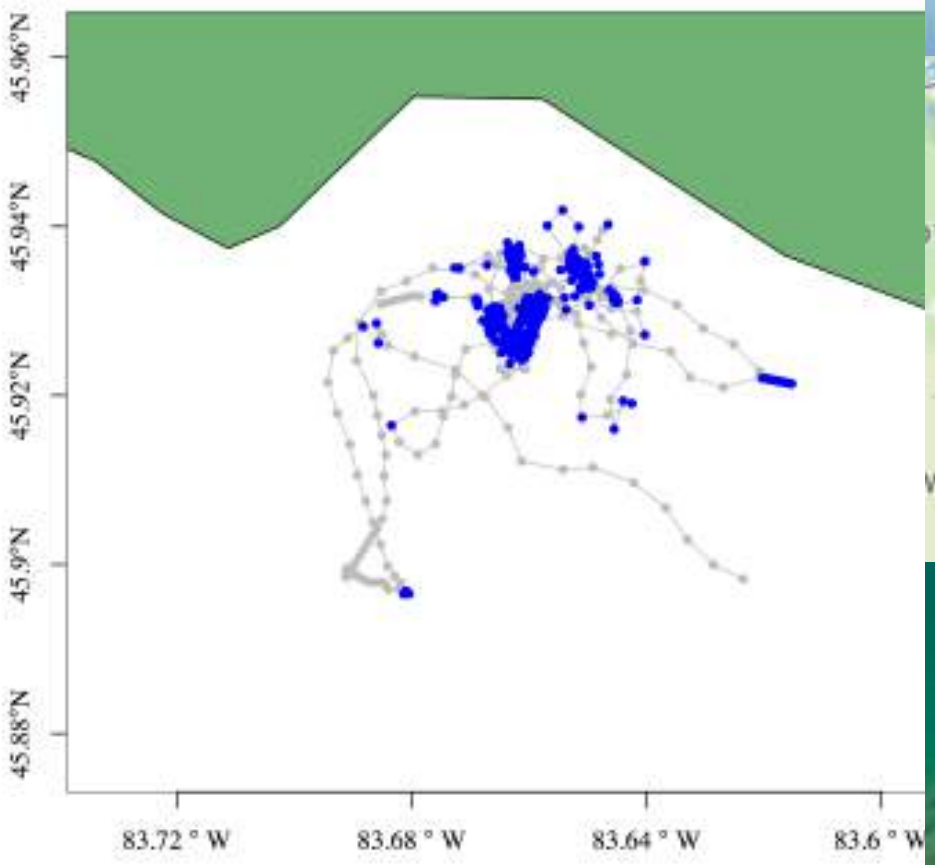
$\mathbf{d}_i = \mathbf{x}_i - \mathbf{x}_{i-1}$

$\mathbf{d}_i = \gamma_{b_{i-1}} \mathbf{T} \mathbf{d}_{i-1} + \epsilon_i$



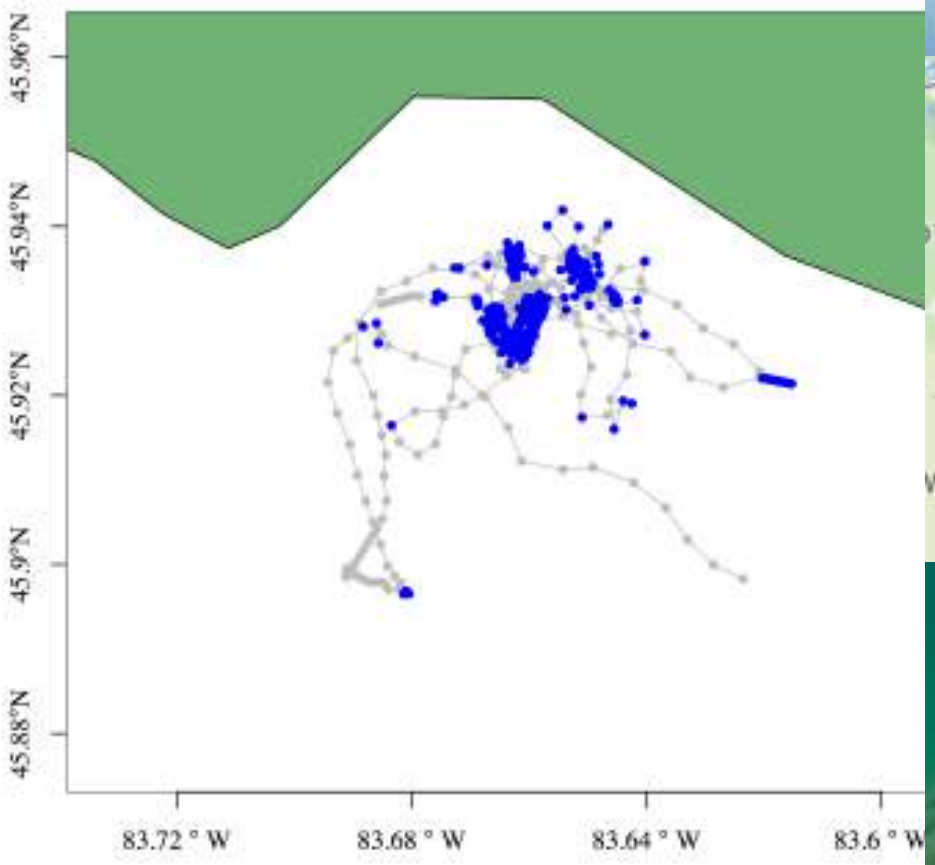
Estimating discrete behavioural states

SHMMM

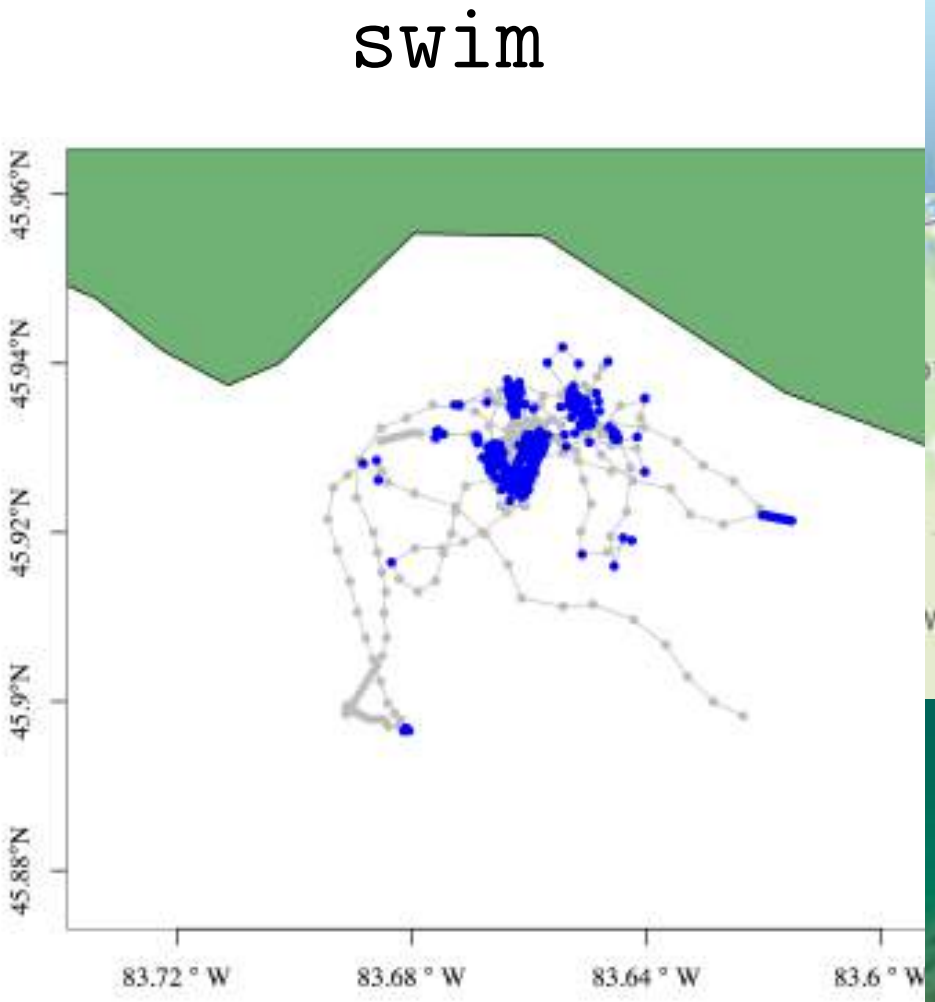


Estimating discrete behavioural states

SHMMM/SHaMM



Estimating discrete behavioural states



Estimating continuous behavioural states

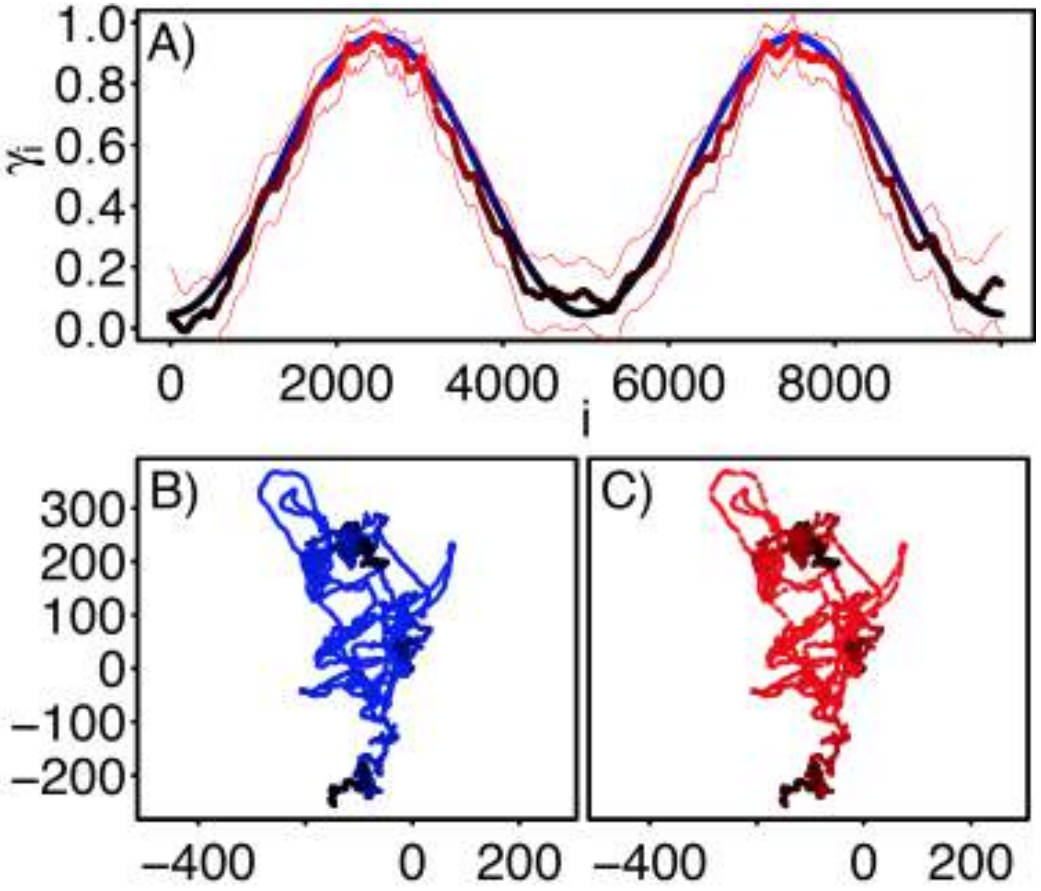
Behaviour Equation

$$\gamma_i = \gamma_{i-1} + \nu_i$$

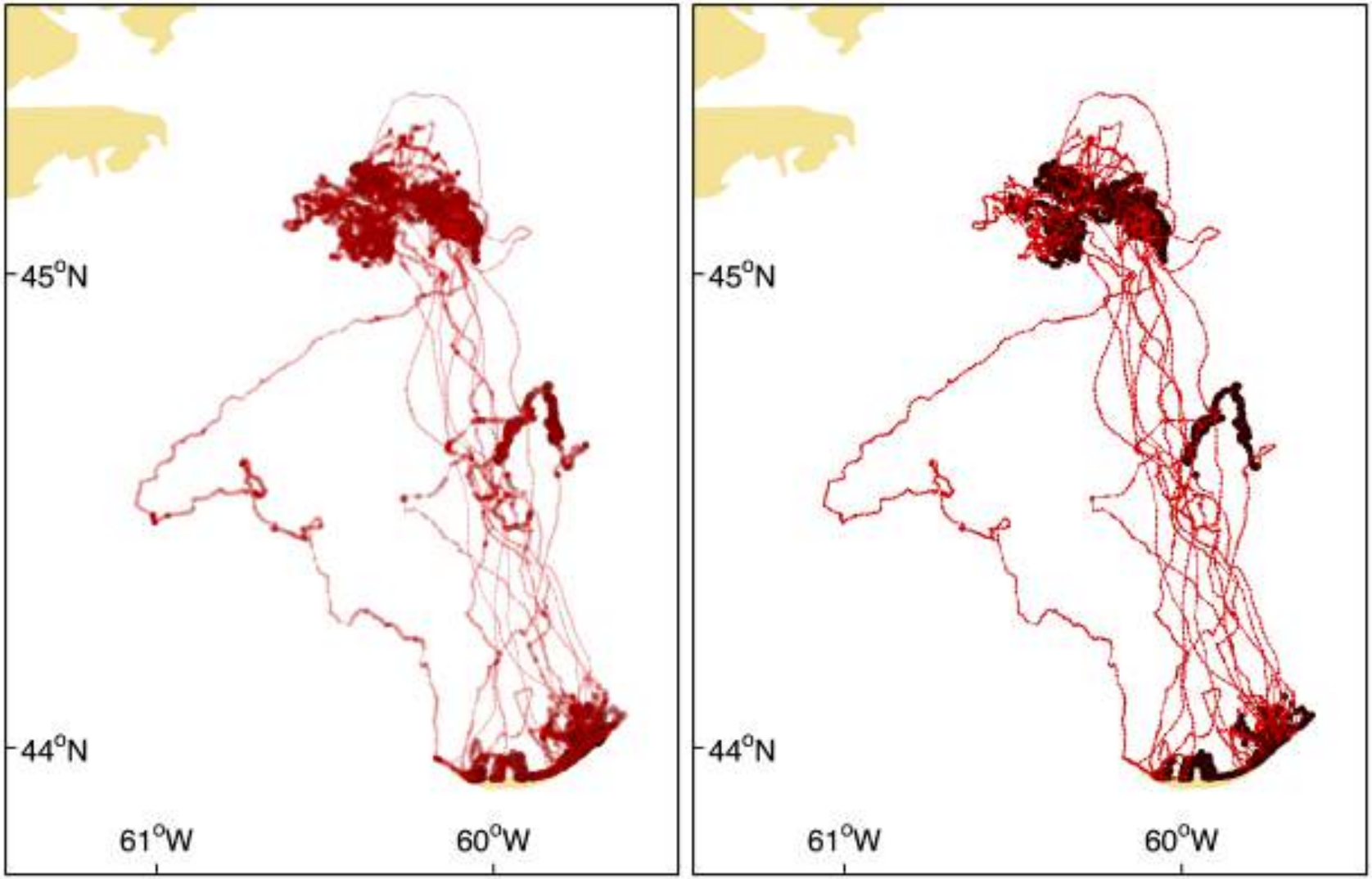
Movement Equation

$$\mathbf{d}_i = \mathbf{x}_i - \mathbf{x}_{i-1}$$

$$\mathbf{d}_i = \gamma_i \frac{\Delta t_i}{\Delta t_{i-1}} (\mathbf{d}_{i-1}) + \epsilon_i$$

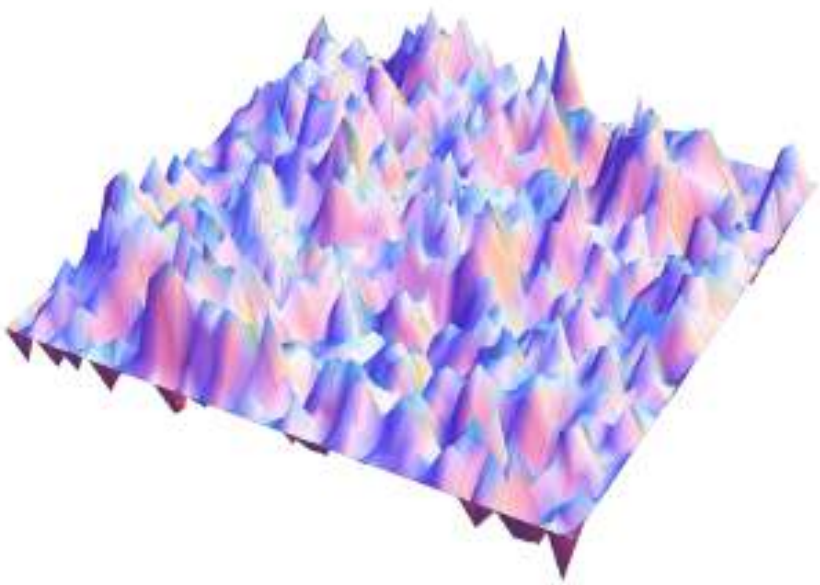


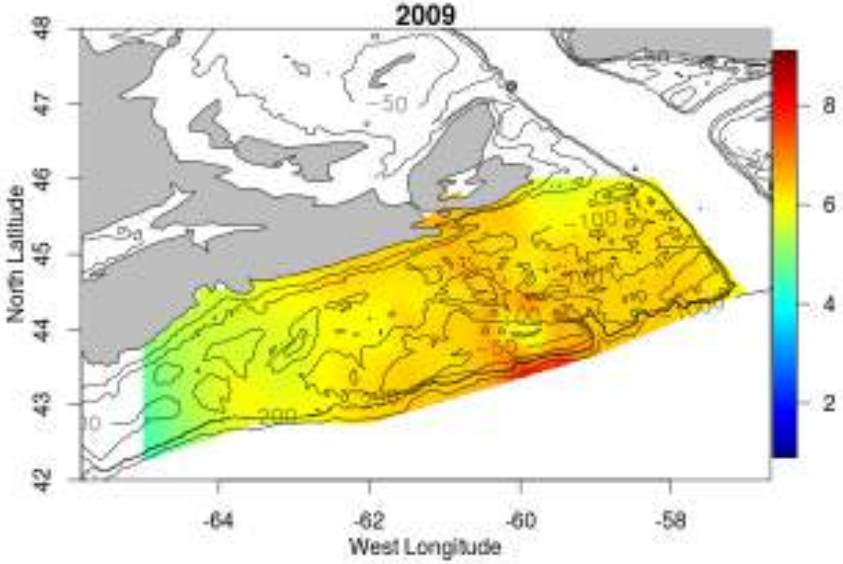
Estimating continuous behavioural states

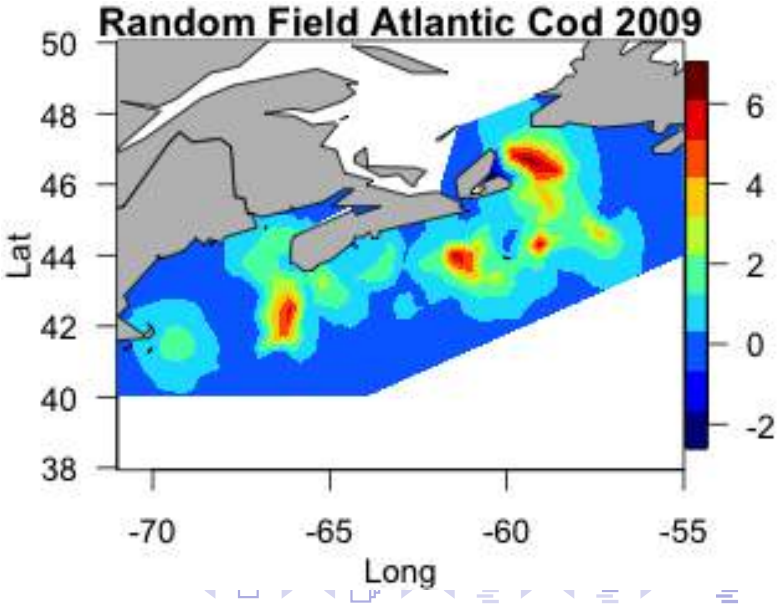


Estimating grey seal space use - INLA

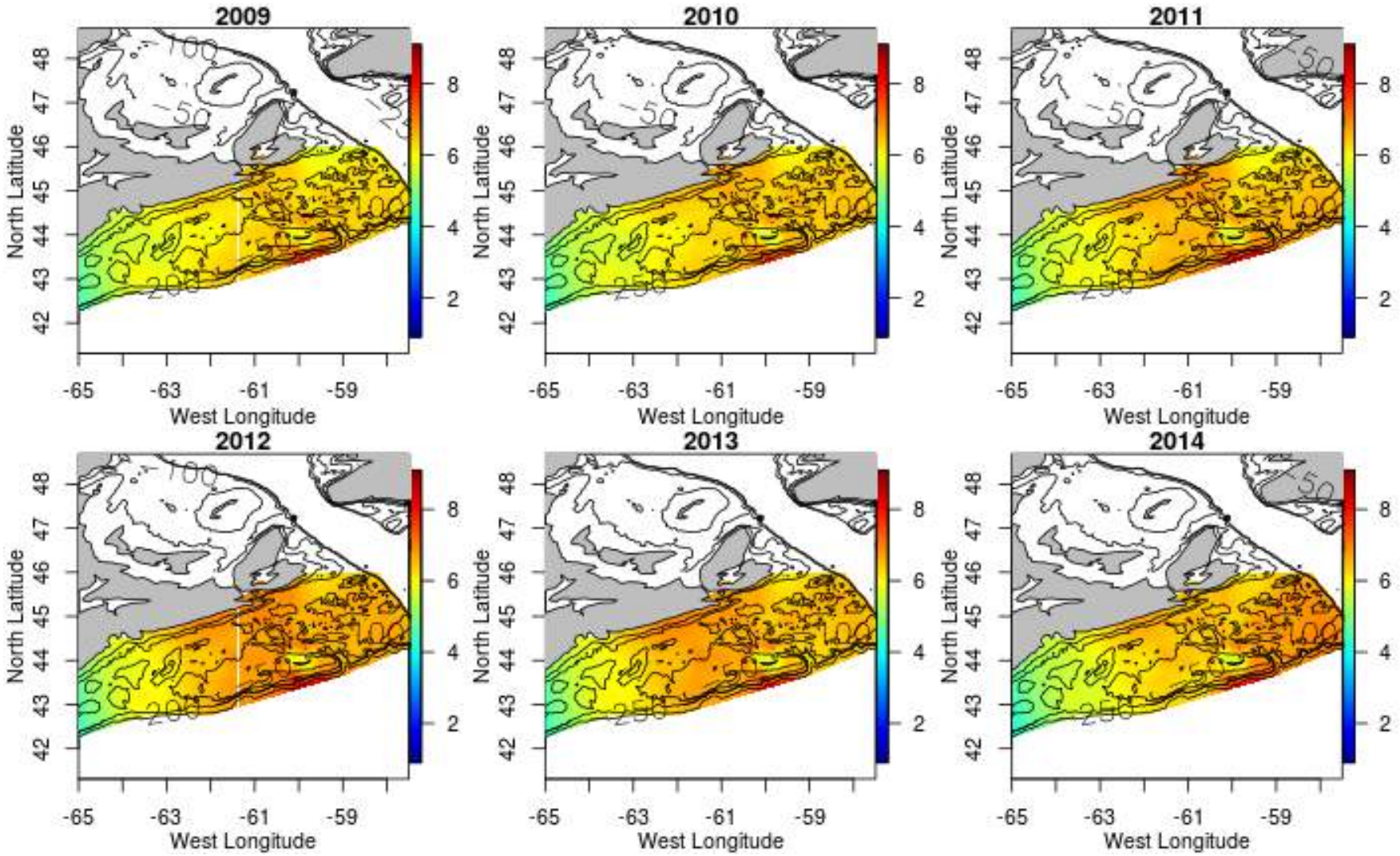
Gaussian Random Field



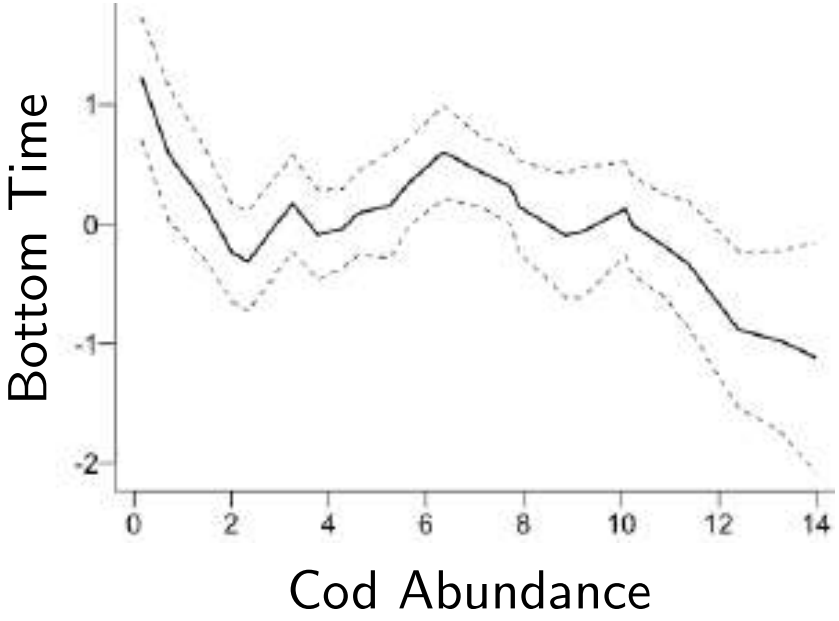




Estimating grey seal space use over time - INLA



Relating grey seal space use to prey distribution



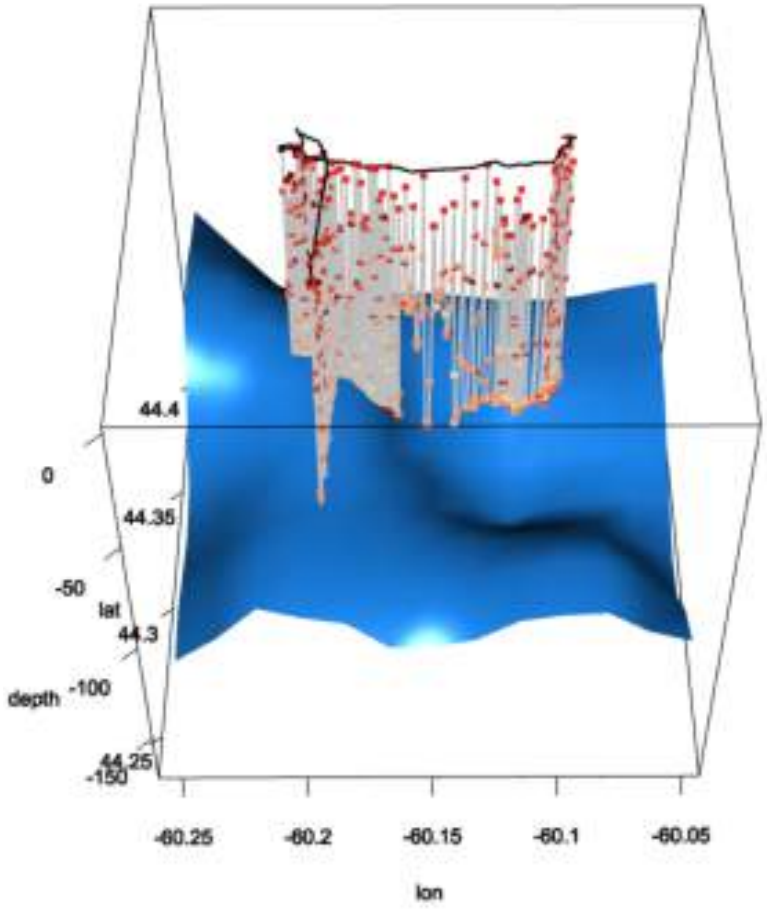
Visualizing aquatic telemetry data

rgl is ...

- an R package (Adler and Murdoch 2015)
- a link between R and webGL (JavaScript API)

We use rgl to ...

- visualize groups of movement patterns
- visualize animals moving through time
- visualize animals moving in 3D



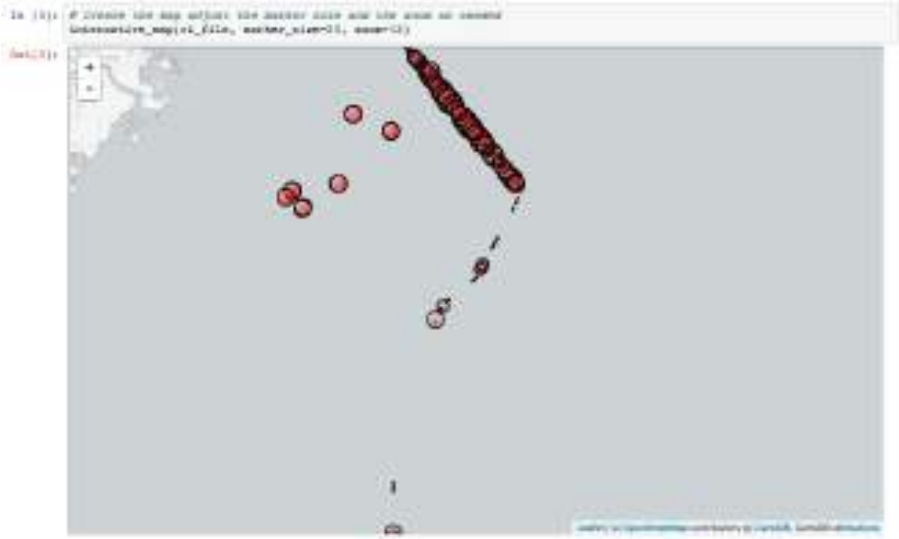
OTN Data Center

Other visualization tools:

- Co-op students (Alex Nunes)
- OTN Trackathon

OTN Workshop:

- Thursday (tomorrow)
- 8:30 AM - NOON



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Thank you