Multistate

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CONGRATULATIONS!

. . . you have been doing multi-state models all along!
The CJS, POPAN, PCRD and just specific versions of a more general multistate model

Multistate Emission Matrix

The difference between the CJS, POPAN and PCRD formulations vs the more general Multistate model (of Brownie et al) is the number of events

CJS/POPAN/PCRD

- Number of events: 2 (no-capture, capture)
- n.rows in Emission Matrix: 2 (no-capture, capture)

Multistate

- Number of events: number of strata + no-capture
- n.rows in Emission Matrix: number of strata + no-capture

Multistate Emission Matrix (Example)

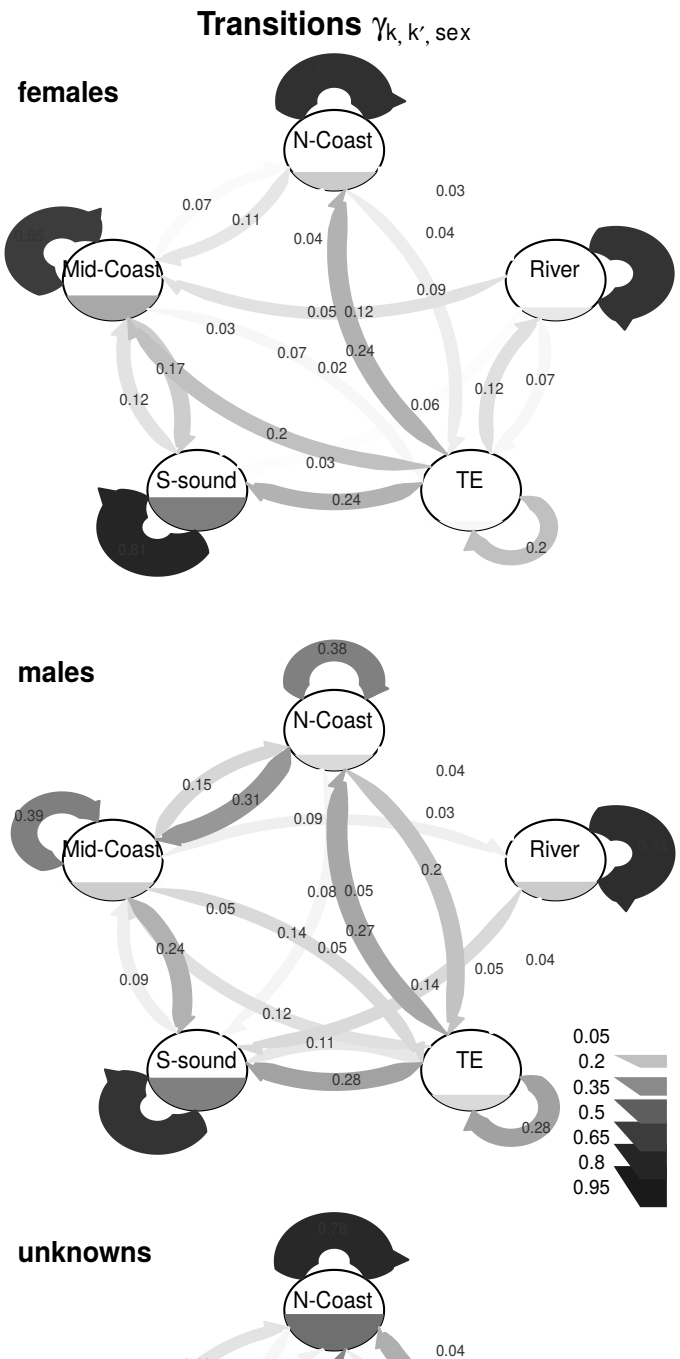
$$\boldsymbol{\Psi}_{s,t} = \begin{array}{l} \\ \text{Capture A} \\ \text{Capture B} \\ \text{Capture C} \\ \text{No Capture} \end{array} \begin{array}{c} \begin{array}{ccccc} \text{Strata A} & \text{Strata B} & \text{Strata C} & \text{TE} & \text{Dead} \end{array} \\ \begin{pmatrix} p^a_{s,t} & 0 & 0 & 0 & 0 \\ 0 & p^b_{s,t} & 0 & 0 & 0 \\ 0 & 0 & p^c_{s,t} & 0 & 0 \\ 1 - p^a_{s,t} & 1 - p^b_{s,t} & 1 - p^c_{s,t} & 1 & 1 \end{pmatrix} \end{array}$$

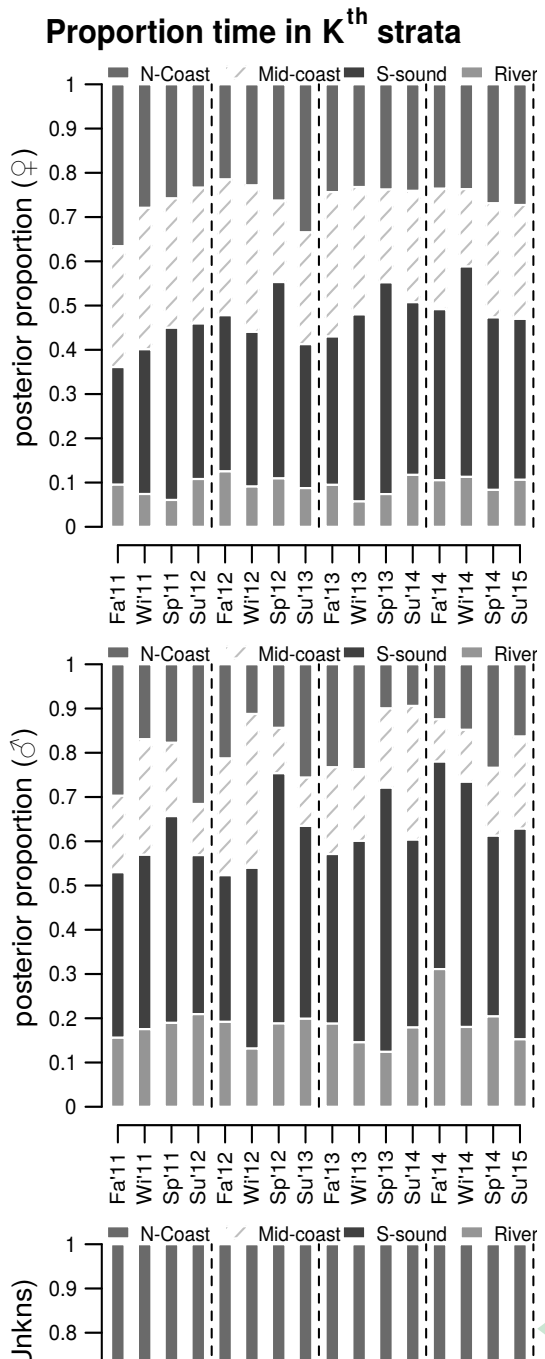
Conventional Multistate

Despite its generality, we generally refer to a “multistate model" (**?**) as one where there are multiple observation strata.

- i.e., more than 2 rows in Emission Matrix

Example 1: Swan River Bottlenose (Rankin and Chabanne, unpub.)





Example 1: Swan River Bottlenose: Transmission Matrix

$$\mathbf{\Phi} = \begin{array}{c} \\ \text{un-recruited} \\ \text{strata 1} \\ \vdots \\ \text{strata 4} \\ \text{TE} \\ \text{dead} \end{array} \begin{array}{c} \begin{array}{ccccccc} \text{un-recruited} & \text{strata 1} & \dots & \text{strata 4} & \text{TE} & \text{dead} \end{array} \\ \begin{pmatrix} 1-\psi & 0 & \dots & 0 & 0 & 0 \\ \psi\lambda_1 & \phi\gamma_{1,1} & \dots & \phi\gamma_{4,1} & \phi\gamma_{\text{te},1} & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & 0 \\ \psi\lambda_4 & \phi\gamma_{1,4} & \dots & \phi\gamma_{4,4} & \phi\gamma_{\text{te},4} & 0 \\ \psi\lambda_{\text{te}} & \phi\gamma_{1,\text{te}} & \dots & \phi\gamma_{4,\text{te}} & \phi\gamma_{\text{te},\text{te}} & 0 \\ 0 & 1-\phi & \dots & 1-\phi & 1-\phi & 1 \end{pmatrix} \end{array}$$

- γ are strata-movement probailities: $\sum_{l=1}^{K} \gamma_{k,l} = 1$ (with a dirichlet prior)
- $\boldsymbol{\lambda}$ are strata-assortment probabilities $\sum_{k=1}^{K} \lambda_k = 1$ (with a dirichlet prior)

Example 1: Swan River Bottlenose: Emission Matrix

$$
\boldsymbol{\Psi} = \begin{array}{c} \\ \text{event 1} \\ \text{event 2} \\ \text{event 3} \\ \text{event 4} \\ \text{no-capture} \end{array}
\begin{array}{c}
\begin{array}{ccccccc} \text{un-recruited} & \text{strata 1} & \text{strata 2} & \text{strata 3} & \text{strata 4} & \text{TE} & \text{dead} \end{array} \\
\begin{pmatrix}
0 & p_1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & p_2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & p_3 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & p_4 & 0 & 0 \\
1 & 1-p_1 & 1-p_2 & 1-p_3 & 1-p_4 & 1 & 1
\end{pmatrix}
\end{array}
$$

Exercise 1:

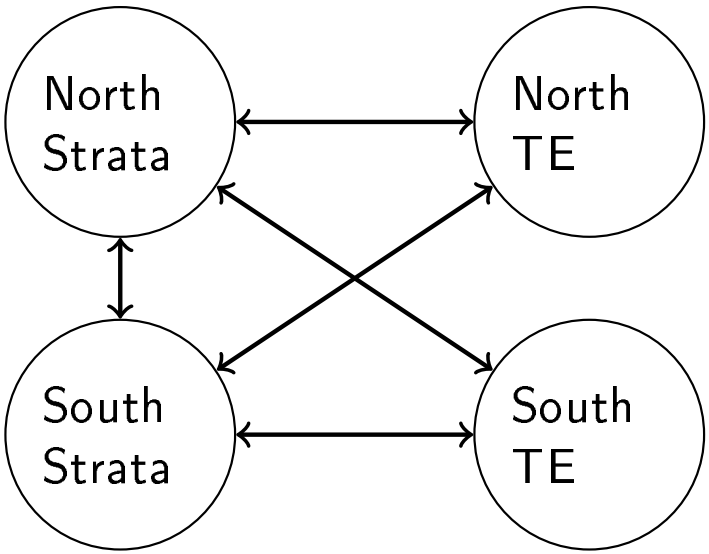
In JAGS syntax:

- how to code-up the Swan River bottlenose Transmission and Emission matrices?
- (open up a JAGS script and lets do it together)

Exercise 2: Queensland Sousa

- Humpback dolphins from Queensland, Australia
- Daniele Cagnazzi, unpublished (6 years, censored due to data restrictions)
- 2 states (north and south strata)
- 2 temporary emigration states (North TE, South TE)
- variable secondary periods
- unequal sampling areas (with correction factors)
- external Flooding covariate (effects on capture probability, muddy waters)
- two sexes

Exercise 2



Time to open up jags!