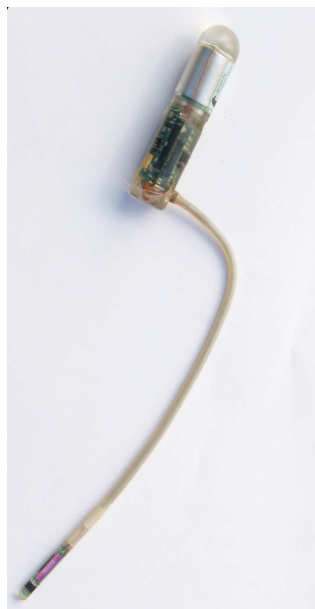




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## Are archival tags useful for fisheries management?

Incorporating archival tag data in a tag-based assessment model

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**Collaborators: Marinelle Basson, Alistair Hobday**

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National Research  
**FLAGSHIPS**

Wealth from Oceans



**CSIRO**

# Introduction

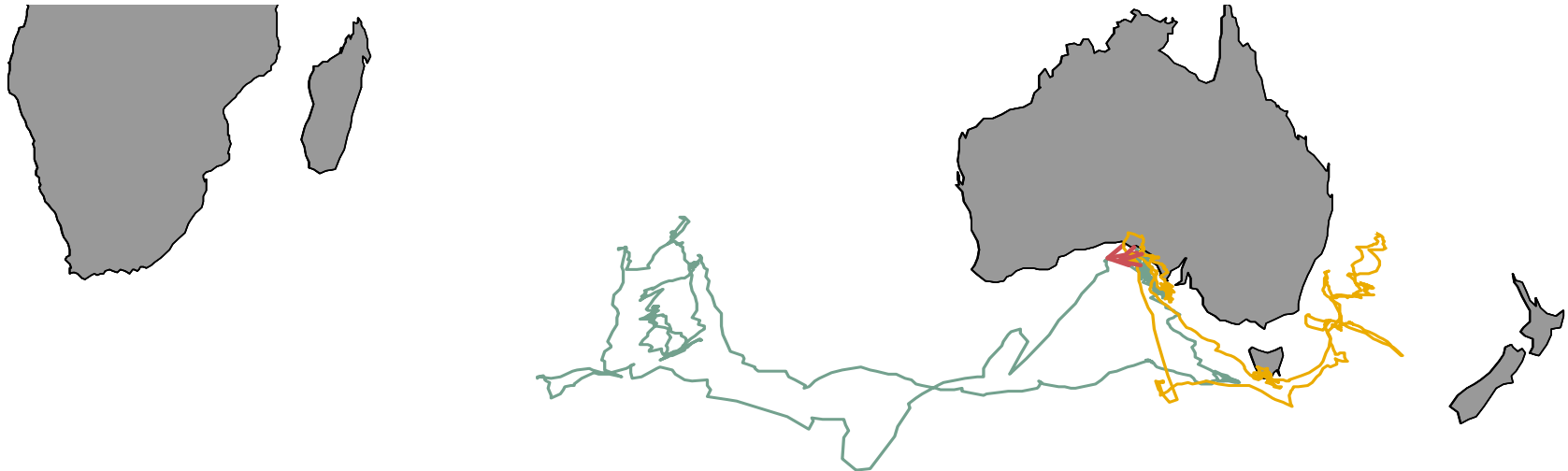
- Conventional tagging studies common in fisheries for estimating population parameters important for management:
  - fishing mortality (exploitation) rates
  - natural mortality rates
  - abundance
- Traditional analysis methods:
  - pool releases and recaptures across space (non-spatial)
  - assume full mixing of tagged and untagged fish throughout their distribution
- Why are spatial models needed?
  - for widespread species, hard to tag everywhere, so full mixing difficult to achieve (e.g. southern bluefin tuna)
  - can lead to biased parameter estimates if non-spatial model used

# Why include archival tags?

- Spatial models require estimates of movement / migration rates
- Conventional tagging data contain only limited information for separating movement from mortality
- This is where archival tags can be very useful

## **SBT archival tag track**

- released Dec 2005, recaptured Feb 2007

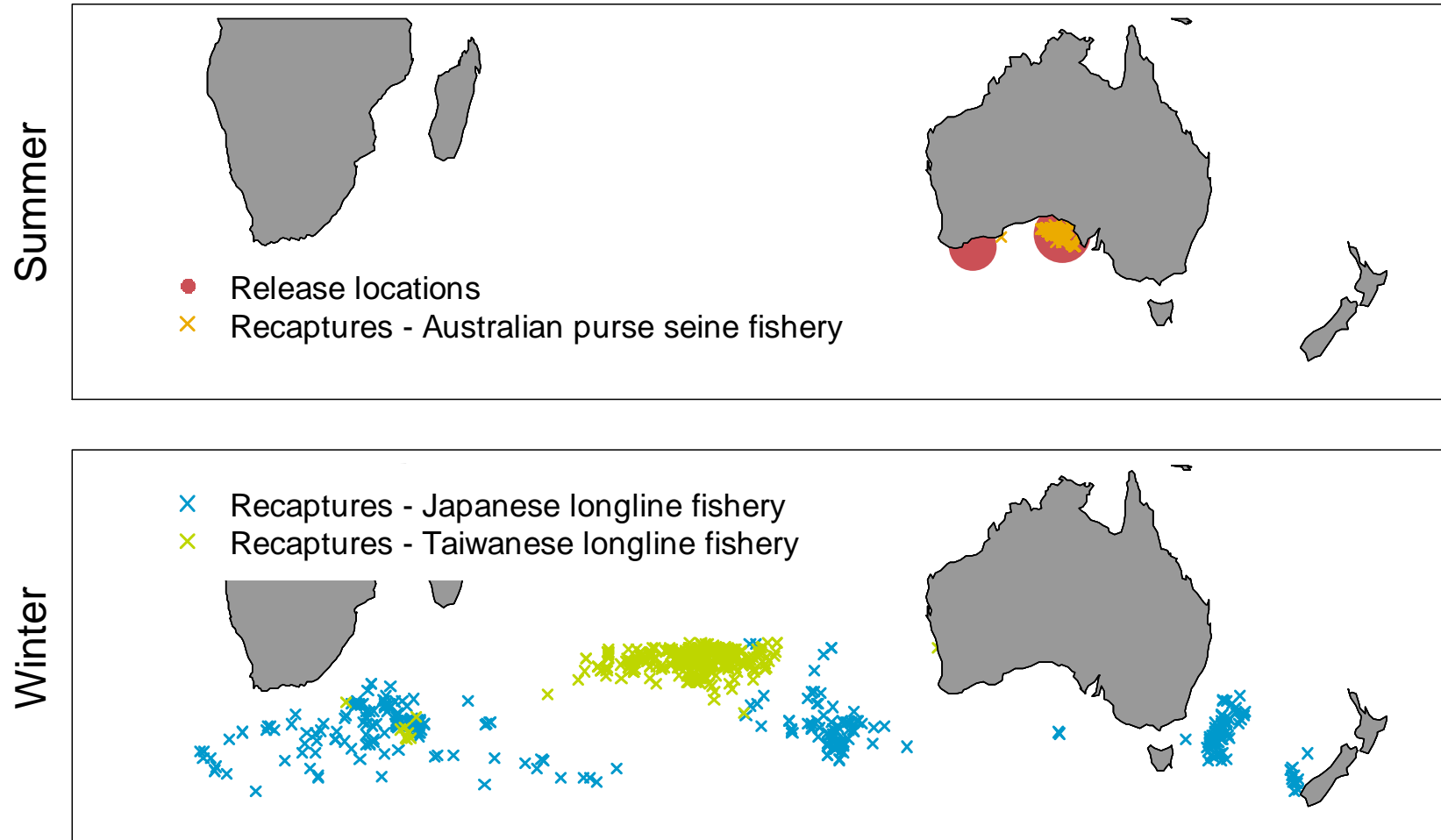


# Spatial model: structure

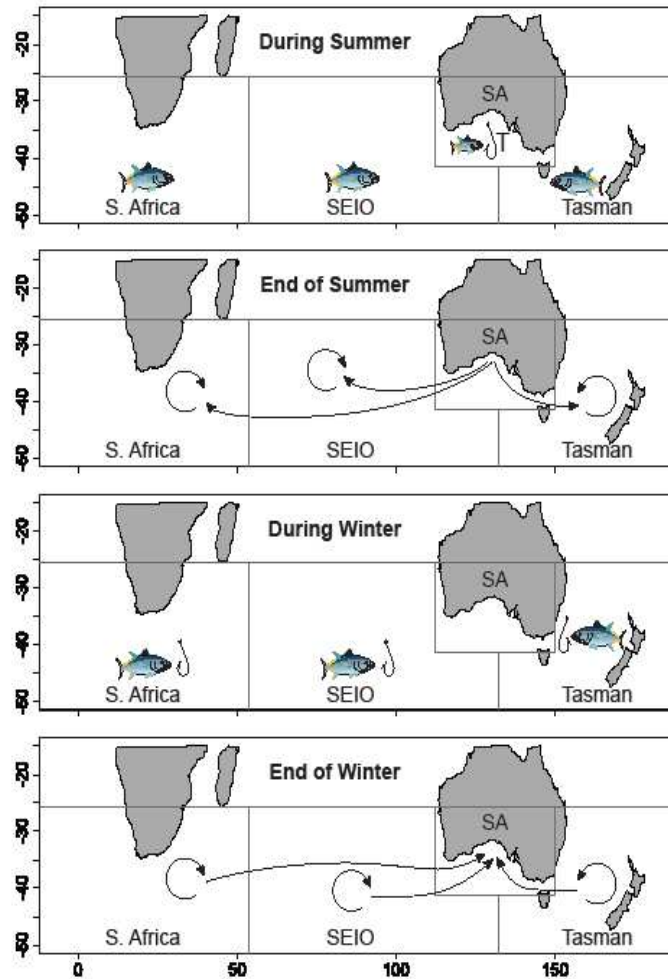
- Discrete space, discrete time
- Fish tagged in consecutive time periods in some or all regions
- Recaptured in subsequent time periods in fisheries operating in some or all regions
- Assumptions specific to spatial model:
  - fish move between regions at end of time periods
  - current movement is independent from previous movements

# SBT example

## Conventional tagging data for juvenile SBT



# SBT example



Incorporating archival tag data in a tag-based assessment model

- 4 regions:
  - 1) South Australia (SA)
  - 2) South Africa
  - 3) South-East Indian Ocean (SEIO)
  - 4) Tasman
- 2 seasons (half-yearly time periods)
  - 1) Summer (Dec-Apr)
  - 2) Winter (May-Nov)
- Movement “rules”:
  - end of summer: all fish in SA move to longline regions, fish in longline regions do not move
  - end of winter: fish in longline regions move to SA or do not move
- Tagging occurs only in SA in summer

# Spatial model: likelihood components

## 1. Conventional tags

- *Tag returns corresponding to each tagging event modelled as multinomial*
- *Parameters: **natural mortality**, **fishing mortality**, **movement rates**, reporting rates, shedding rates, tag-related mortality*

## 2. Catch

- *Catch in each region / time period modelled as Gaussian*
- *Parameters: **natural mortality**, **fishing mortality**, **movement rates**, **abundance***
- *Optional, but can't estimate abundance without it*

## 3. Archival tags

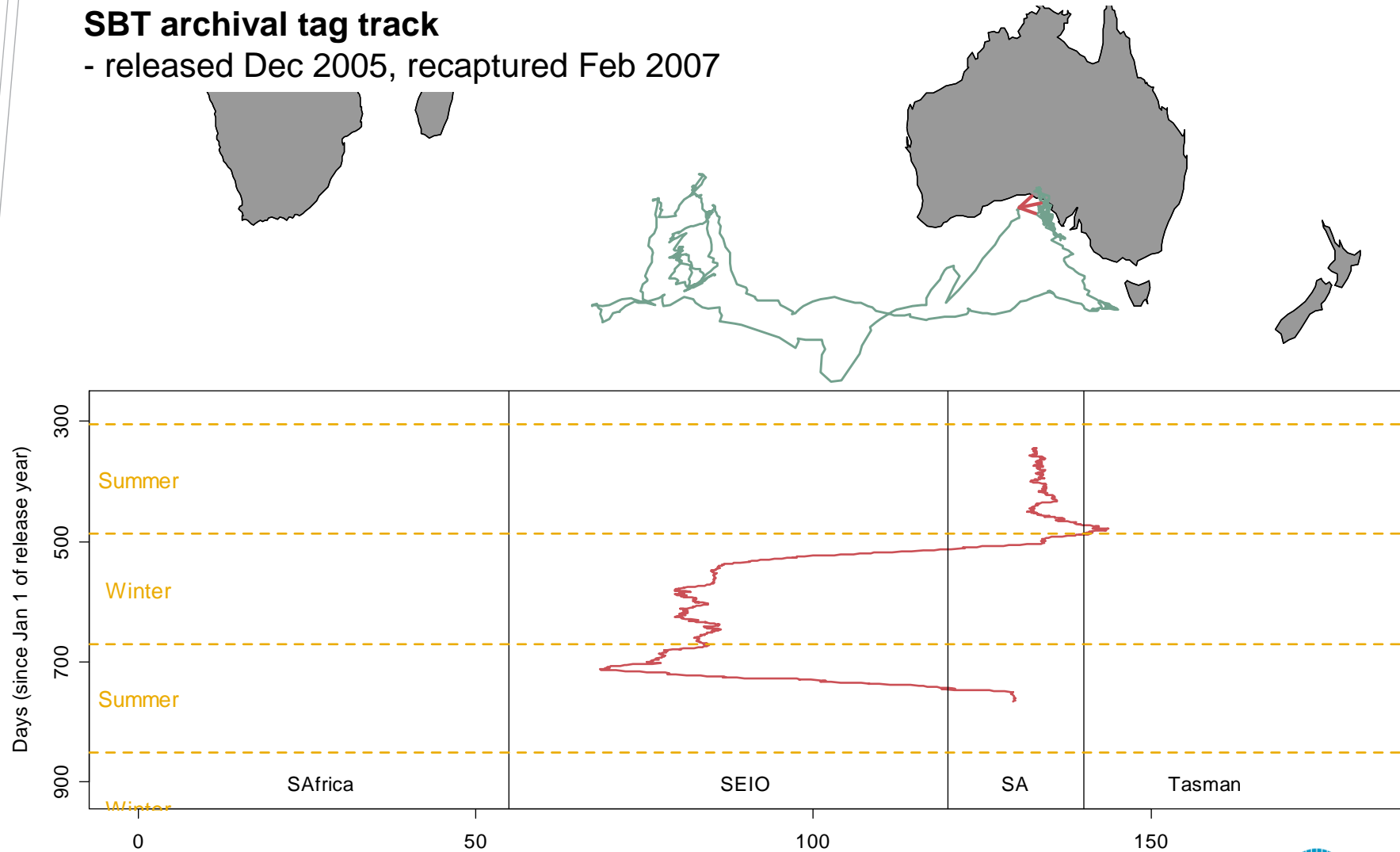
- *For each archival tag return, data needed is region the fish was in during each time period at liberty*
- *Parameters: **natural mortality**, **fishing mortality**, **movement rates**, reporting rates, shedding rates, tag-related mortality*

Details of first 2 components found in: *Eveson, Laslett & Polacheck (2009) Environmental and Ecological Statistics Series, Vol. 3, pp. 987-1010*

# Archival tag likelihood

## SBT archival tag track

- released Dec 2005, recaptured Feb 2007





# Archival tag likelihood

Year	Season	Region	
1	Summer	SA	Tagged
1	Winter	SEIO	
2	Summer	SA	Caught

- Probability of tagged fish having this history =

$$\begin{aligned} & \mathcal{P}(\text{survive summer of yr 1 in SA}) * \mathcal{P}(\text{move from SA to SEIO}) * \\ & \mathcal{P}(\text{survive winter of yr 1 in SEIO}) * \mathcal{P}(\text{move from SEIO to SA}) * \\ & \mathcal{P}(\text{caught in SA in summer of yr 2}) \end{aligned}$$

# Simulations for SBT model

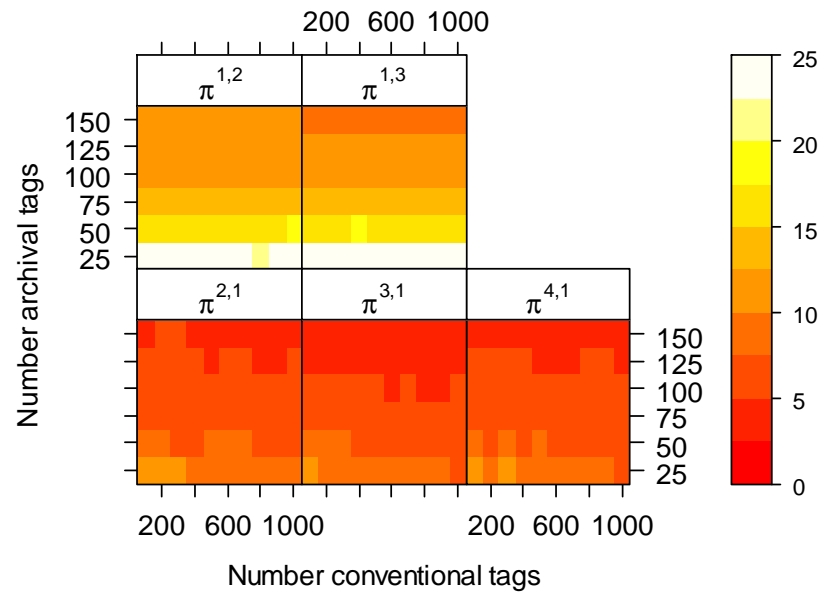
- Simulated data for a tagging experiment involving:
  - one cohort of fish tagged at ages 1-3 in SA in summer
  - some tagged with conventional tags, some with archival tags
  - recaptured at ages 1-5 (in SA in summer, in other regions in winter)
- Varied number of tag releases at each age
  - from 100 to 1000 for conventional tags
  - from 0 to 150 for archival tags
- Ran 250 simulations for each combination of tag numbers
- Parameter constraints:
  - natural mortality varies with age, but not region
  - movement rates do not vary over time

# Simulations results

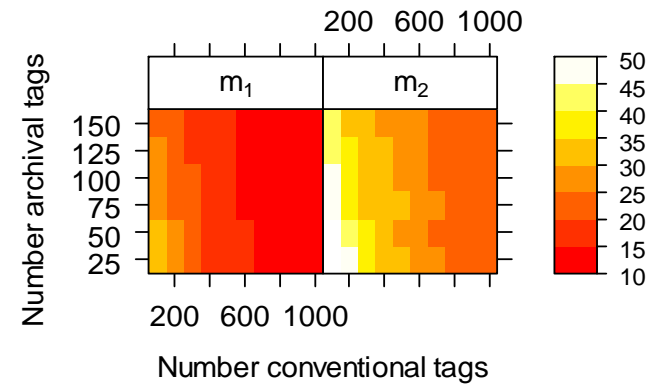
- Without tag releases in the longline regions in winter, not all parameters are estimable **unless** archival tag data are included
- Biases are small for all parameters and combinations of tag release numbers
- In terms of precision of parameter estimates...

# Simulation results

## CV of movement probabilities

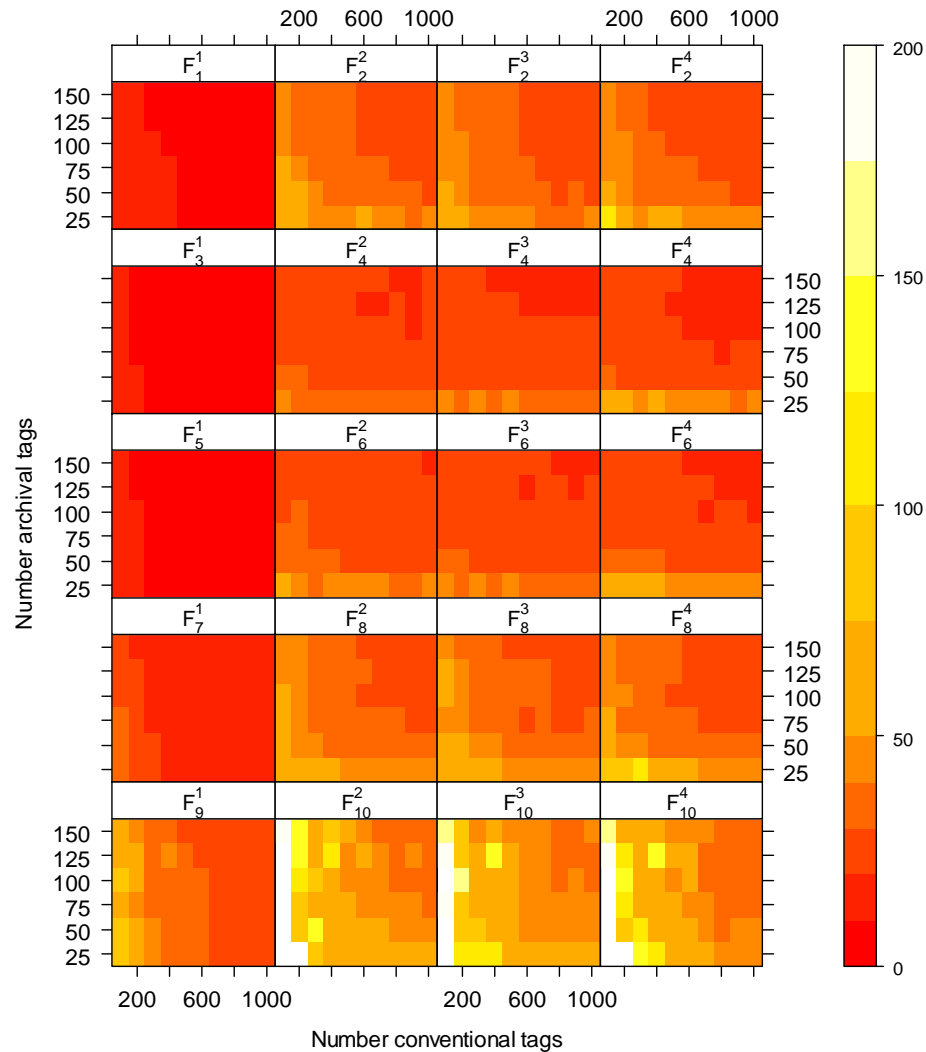


## CV of natural mortality rates



# Simulation results

## CV of fishing mortality rates



Incorporating archival tag data in a tag-based assessment model

# Application to SBT

- Challenges with real data!
- Conventional tags:
  - reporting rates, tag shedding, non-mixing
- Catch data:
  - under-reporting, other biases
- Archival tags:
  - tag failure, positional errors, fish behaviour more complicated than model can accommodate

# Application to SBT

- Results for 2003 cohort, tagged at ages 1-3 (in yrs 2004-2006)

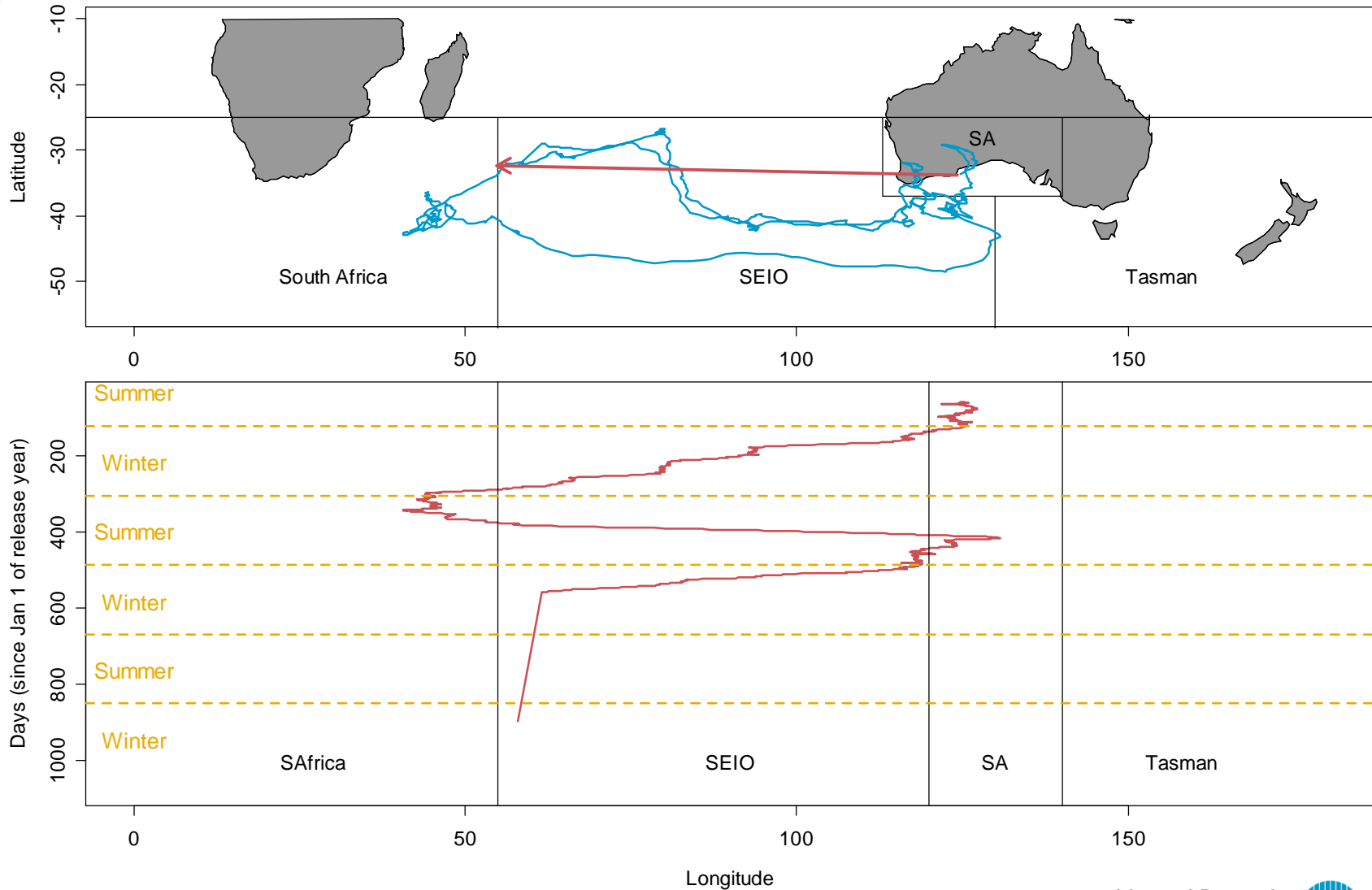
	Conventional tags only (11600 releases, 2500 recaps)	PLUS archival tags (124 releases, 26 recaps)
Natural mortality	<ul style="list-style-type: none"> <li>High at age 1 (0.63)</li> <li>Zero at ages 2+</li> </ul>	<ul style="list-style-type: none"> <li>High at age 1 (0.64)</li> <li>Low at ages 2+ (0.04)</li> </ul>
Fishing mortality	<ul style="list-style-type: none"> <li>Unrealistically high in SA at ages 3 &amp; 4 (3.0, 1.5)</li> <li>High in Tasman at ages 3 &amp; 4 (~0.4)</li> <li>Low in SEIO &amp; S. Africa</li> </ul>	<ul style="list-style-type: none"> <li>Plausible in SA at ages 3 &amp; 4 (0.38, 0.28)</li> <li>Low in Tasman (~0.03)</li> <li>Low in SEIO, but higher in S. Africa</li> </ul>
Movement	<ul style="list-style-type: none"> <li>At end of summer, most fish (76%) move from SA to <u>S. Africa</u></li> <li>At end of winter:               <ul style="list-style-type: none"> <li>0% move from SEIO to SA</li> <li>40% " " S. Africa "</li> <li>0% " " Tasman "</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>At end of summer, most fish (88%) move from SA to <u>SEIO</u></li> <li>At end of winter:               <ul style="list-style-type: none"> <li>99% move from SEIO to SA</li> <li>50% " " S. Africa "</li> <li>85% " " Tasman "</li> </ul> </li> </ul>

# Conclusions

- Including archival tag data in model:
  - significantly improves the movement estimates
  - significantly improves many of the fishing mortality estimates when there is no tagging in some regions and time periods
- In some situations, archival tag data are necessary for all parameters to be estimable (particularly when tagging does not occur in all regions)
- **YES**, archival tags can be useful for fisheries management
- Encourage others to examine potential benefits of using archival tags and spatial models for their situation



# Application to SBT



Incorporating archival tag data in a tag-based assessment model