An example of multi-area modelling using CASAL

tagging data in models: a teaser on some issues and methods

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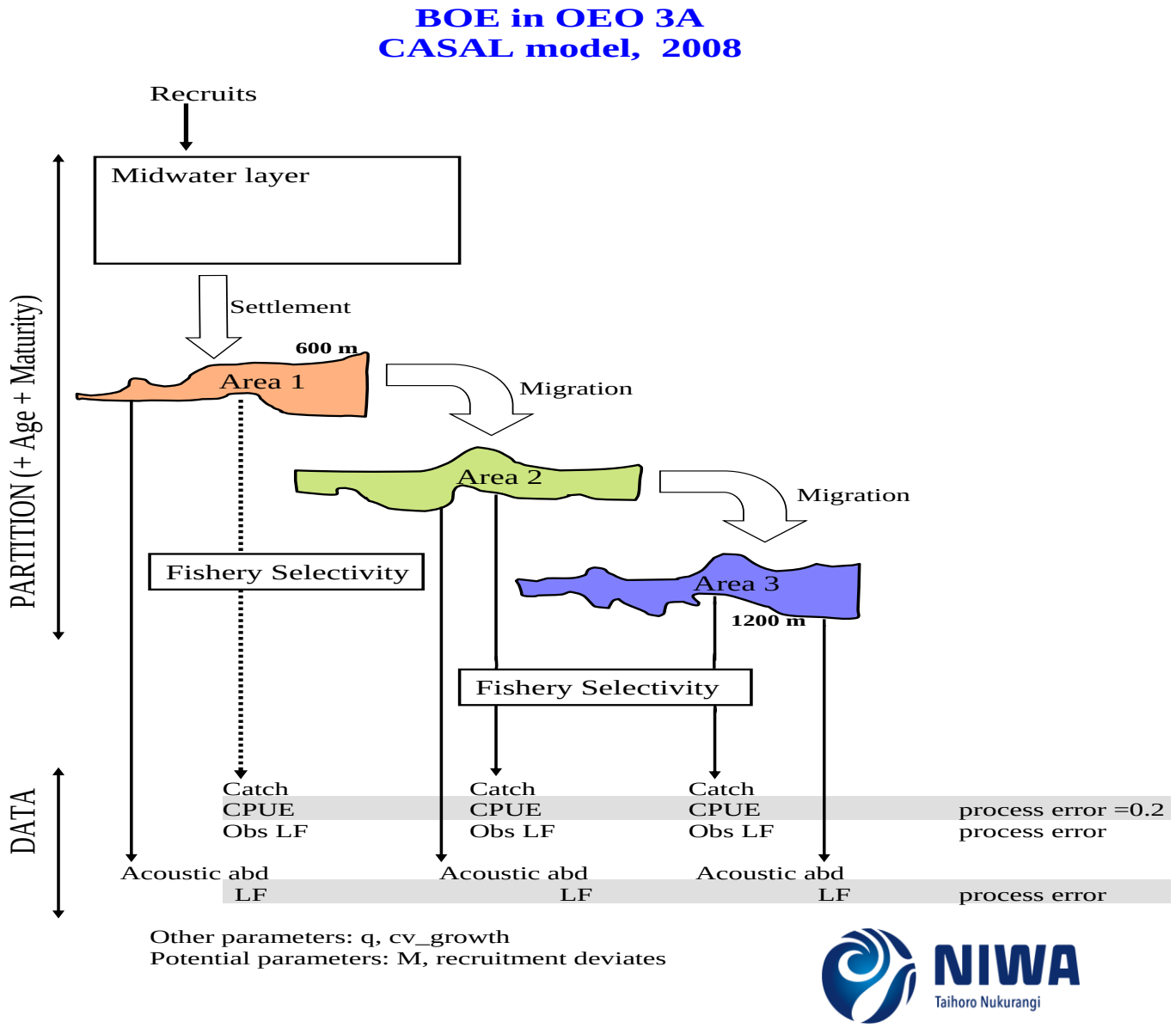
CASAL: the population model workhorse for NZ

- Bayesian age- or length-structured population model software
- Used for many population models, including
  - Multi-stock, multi-area
  - Tagging (number and age or length frequency for each cohort of release)
  - User-defined time steps
  - Simulations
  - Management Strategy Evaluations
- Movement: box transfer
  - Movement for any partition (e.g. immature or males) at any time step (can have multiple in a year)
  - Movement at age parameterized using an ogive with estimable parameters
  - Movement can be annually-varying, density-dependent, and / or two-wave migration (at different time steps)

Some simple spatial applications

- Ross Sea toothfish model (Mormede et al , 2014)
  - One stock, three fisheries as areas
  - Tagging data, age frequency
  - Used to set catch limits
- Two-area Amunsden sea toothfish model – Mormede & Parker (2018)
  - Details later
- Three-area oreo model – Doonan et al (2008)
  - Age-dependent movement estimated between the three areas
  - Age-frequency and surveys
  - Not used anymore: new age data contradictory



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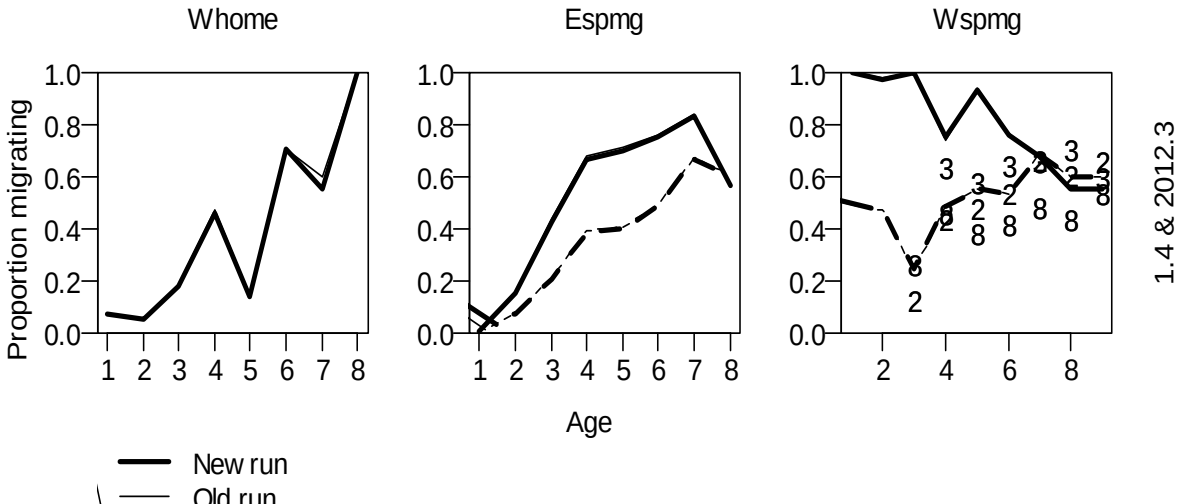
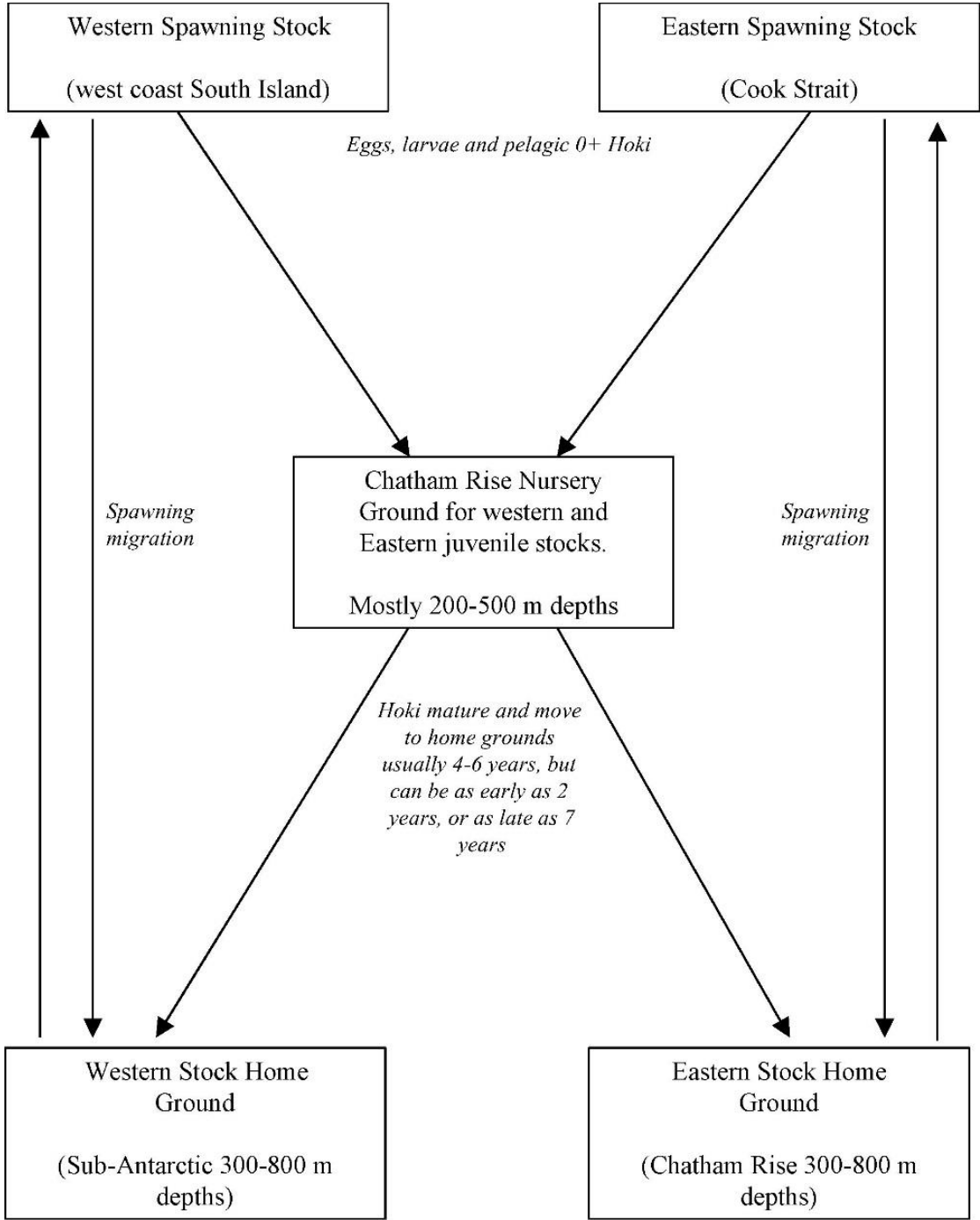
More complex spatial application

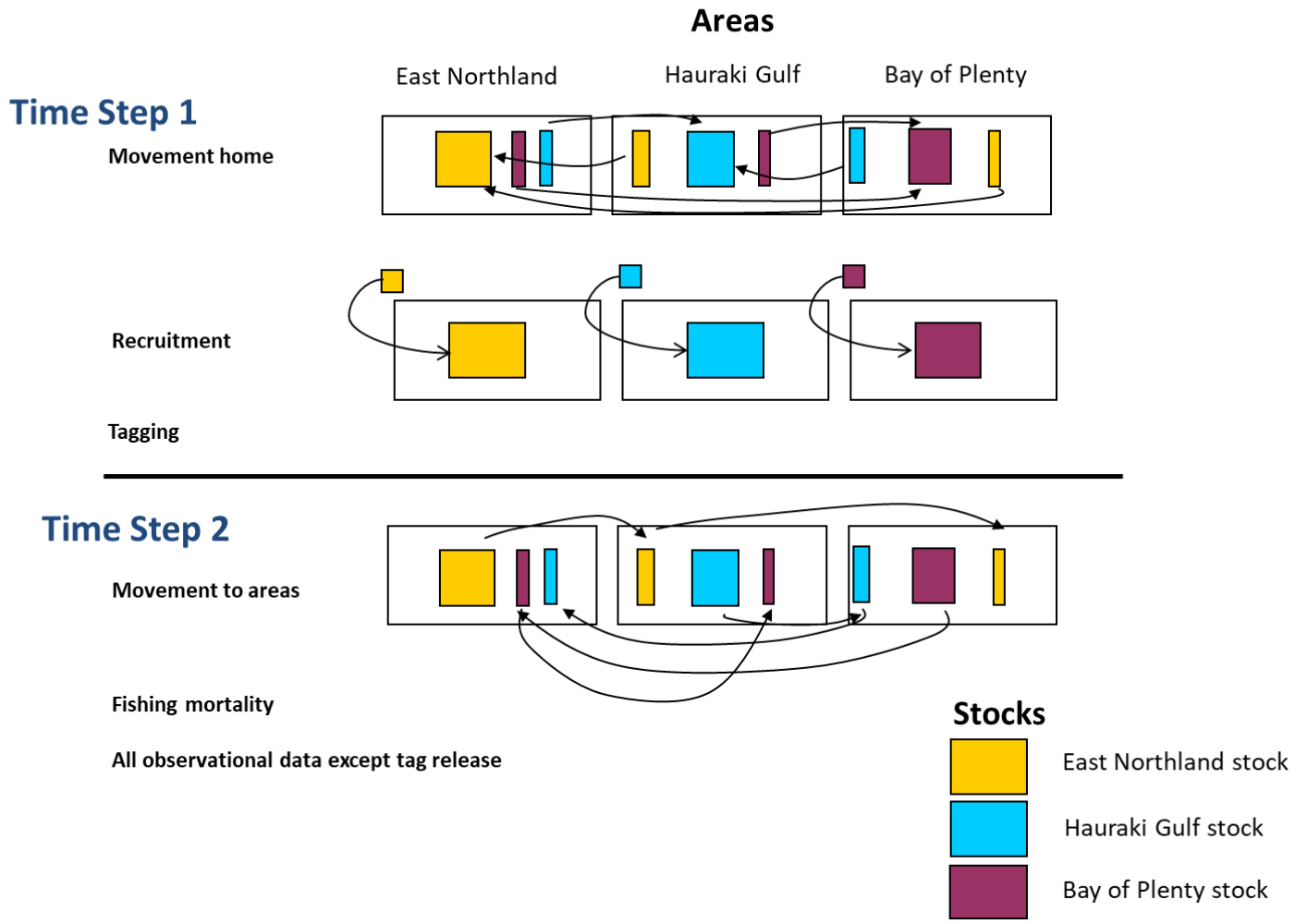
- Hoki – McKenzie (2016)
  - 2 stocks, 4 areas, Natal fidelity or not
  - Survey biomass, AF, maturity
  - Used to set catch limits
    - Selectivity and movement might be confounded but management advice similar





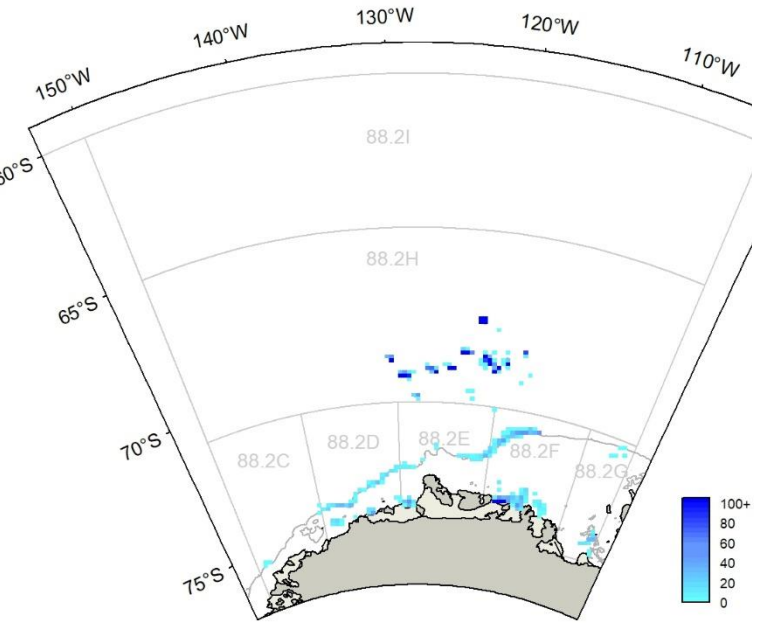
More complex spatial applications

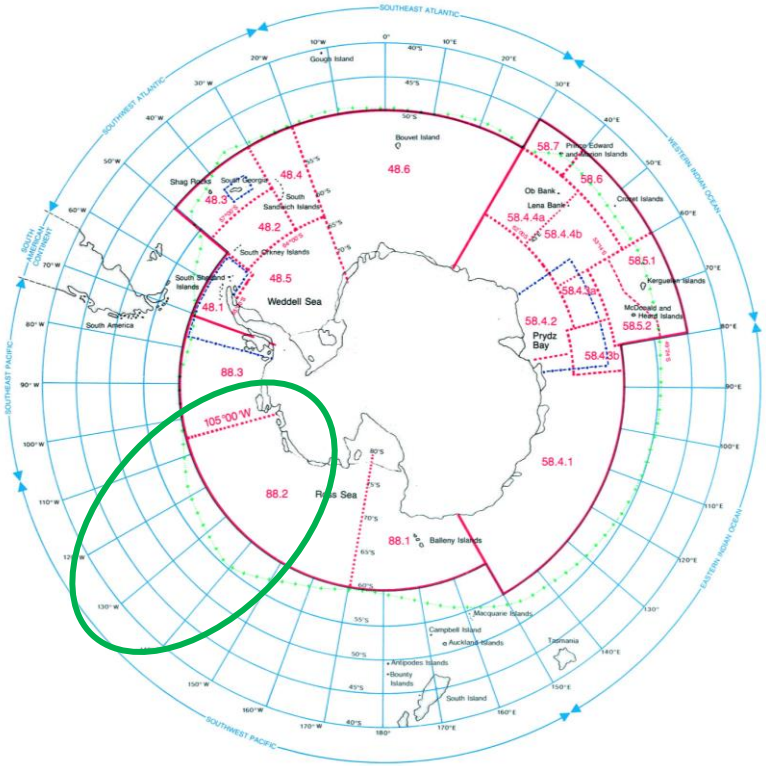
- Snapper – Francis & McKenzie (2015)
  - 3 stocks with different growth, 3 areas, home fidelity
  - tagging data (two tagging programs 1985 and 1994), AF and LF, surveys, CPUE
  - Used to set catch limits



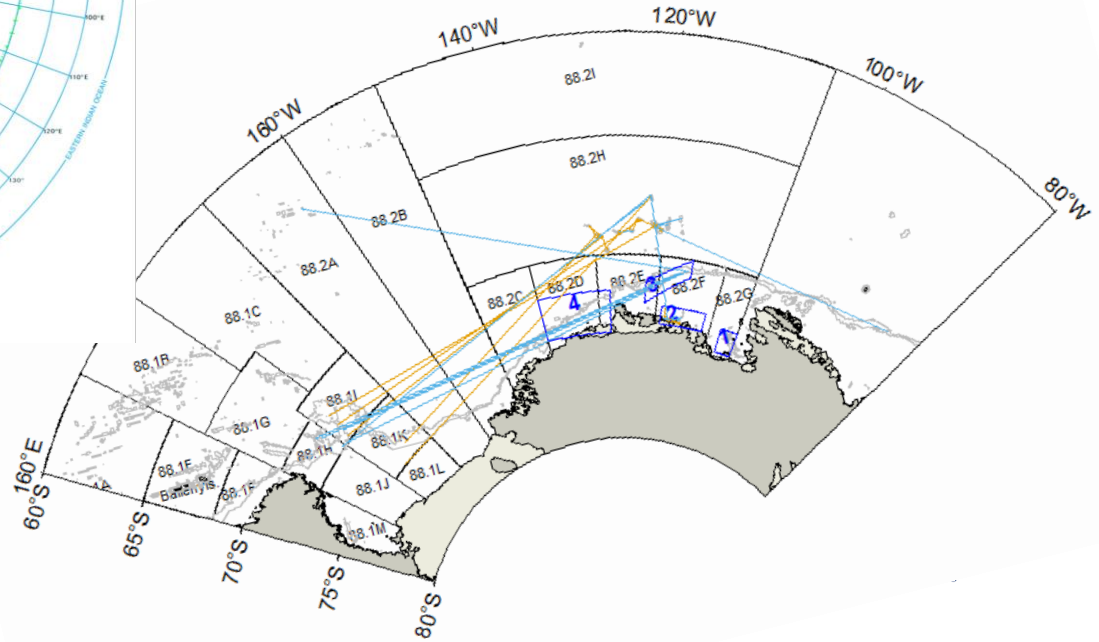
An example: toothfish in the Amundsen Sea region (ASR)

Catches





Tag movements

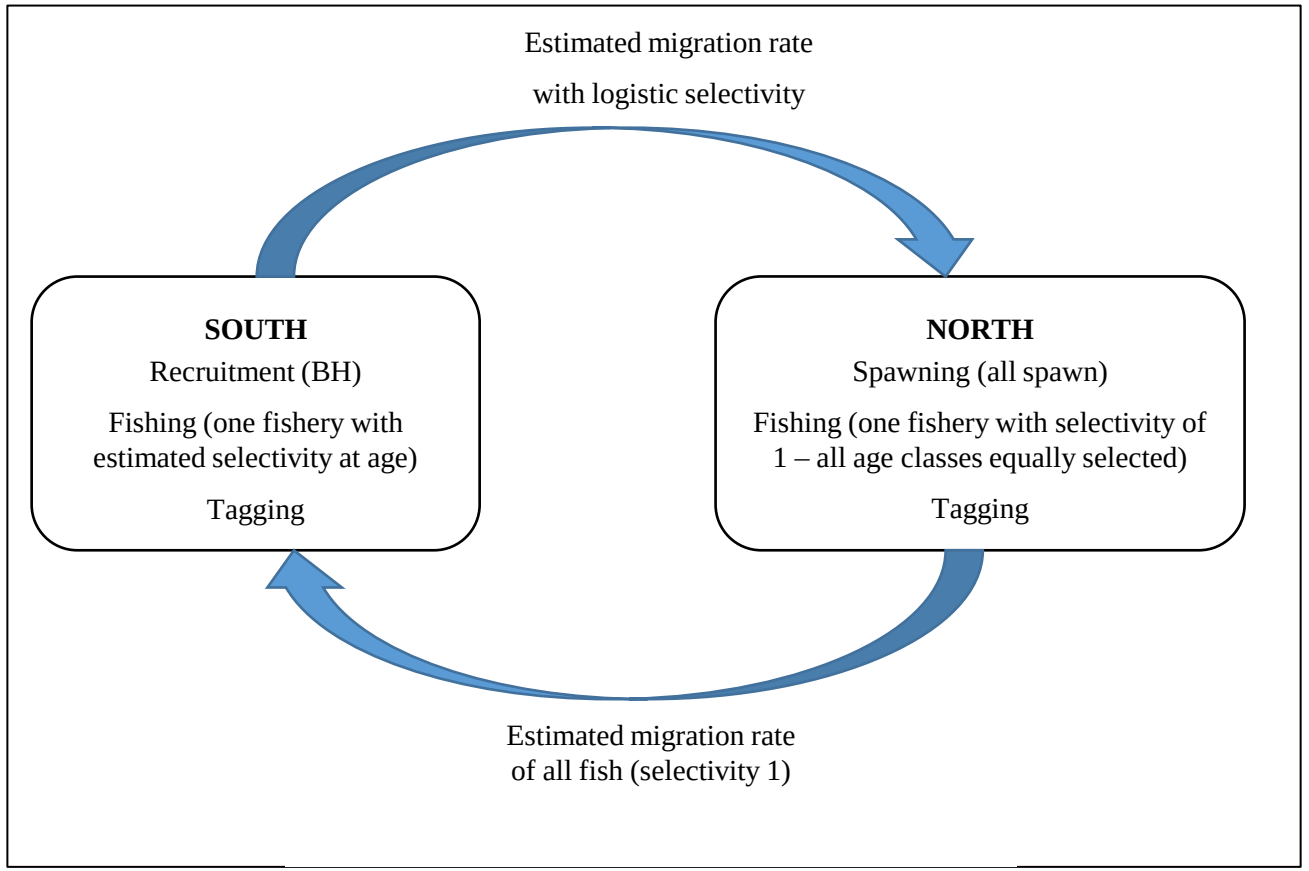


History of the modelling effort for this area

- Two separate models for the North and South until 2011 (FSA-11/43 and 44)
- A single-area model for the entire ASR from 2011 with areas as fleet but conflicting data sources (FSA-13/52), management used a tag-based catch limit
- A two-area model was developed with movement, and required further tagging data from the south which had very few tag recaptures to date (e.g. FSA-14/57)
- A two-year programme was developed to collect such data (SC-14, paragraph 3.168), and has been reconducted in 2016, a total of 4 years now.
- Simulation work carried out in 2017 (SAM-17/40), recommended the two-area model continue to be developed to assess the ASR for 2018.
- Two-area model, presented here (FSA-18/xx), will probably not be used directly for management advice, meeting starts next week

Model structure

- Data fitted to:
  - Age frequency in the North in some years with annual ALK
  - Age frequency in the South with single ALK for all years
  - Mark-recapture data in the North since 2003
  - Mark-recapture data in the South since 2015



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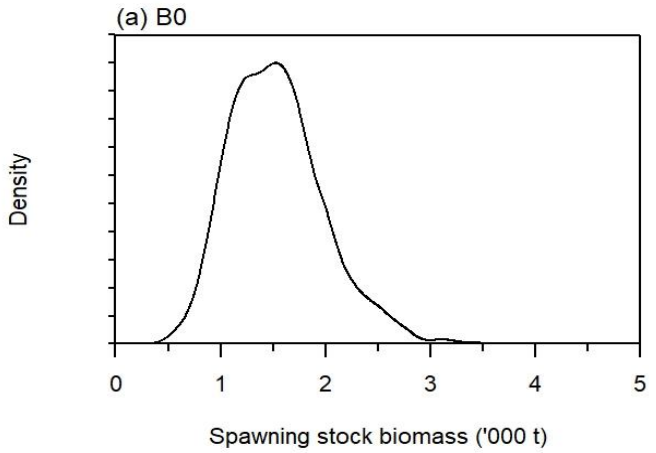
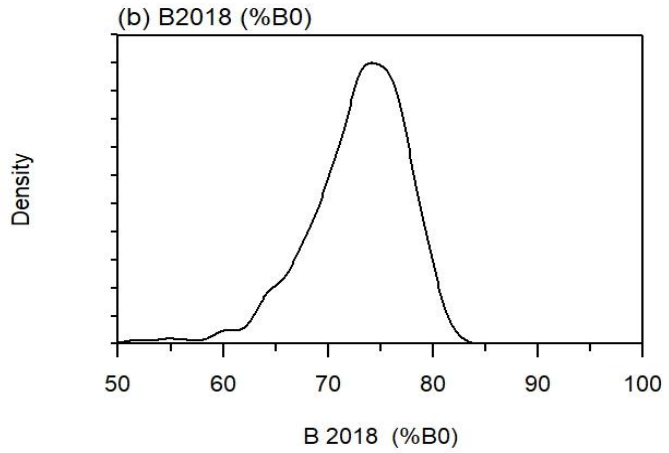
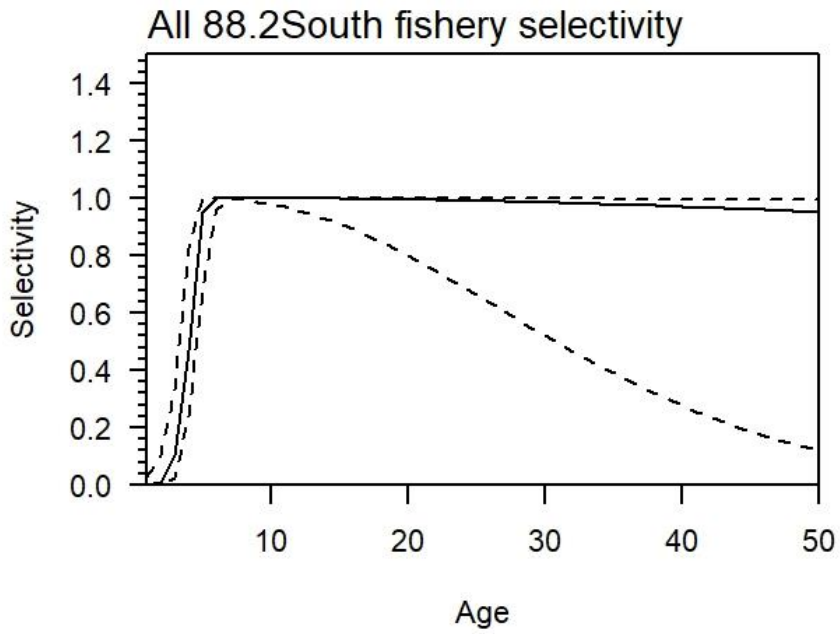
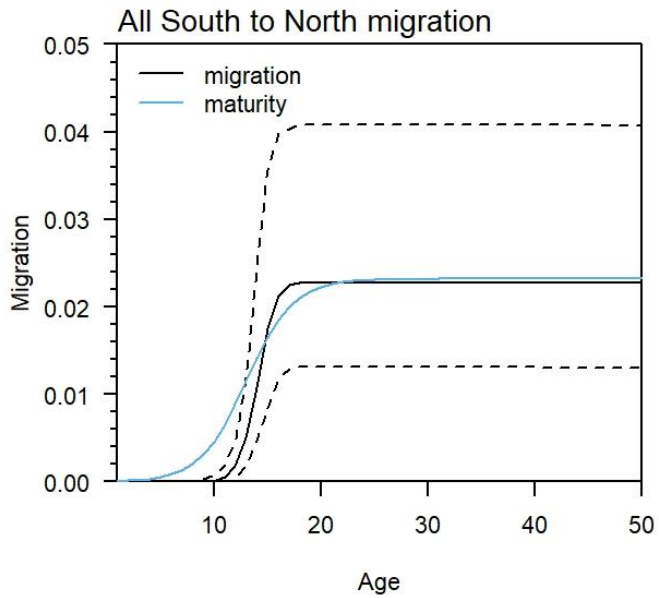
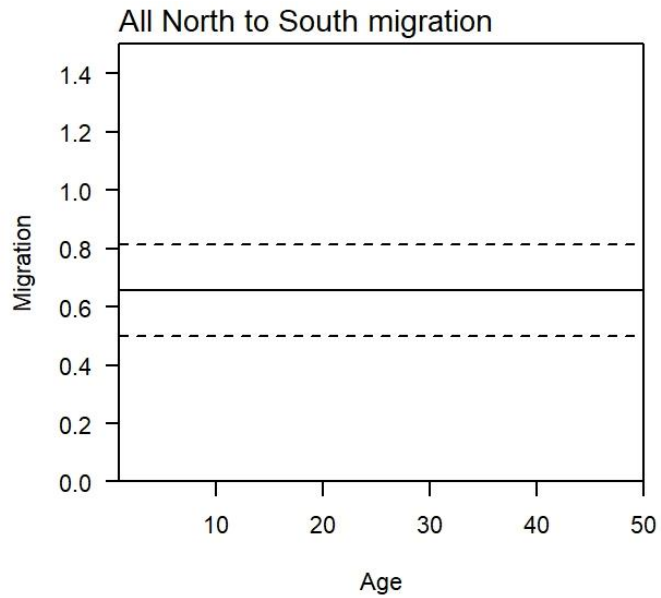
Estimated parameters











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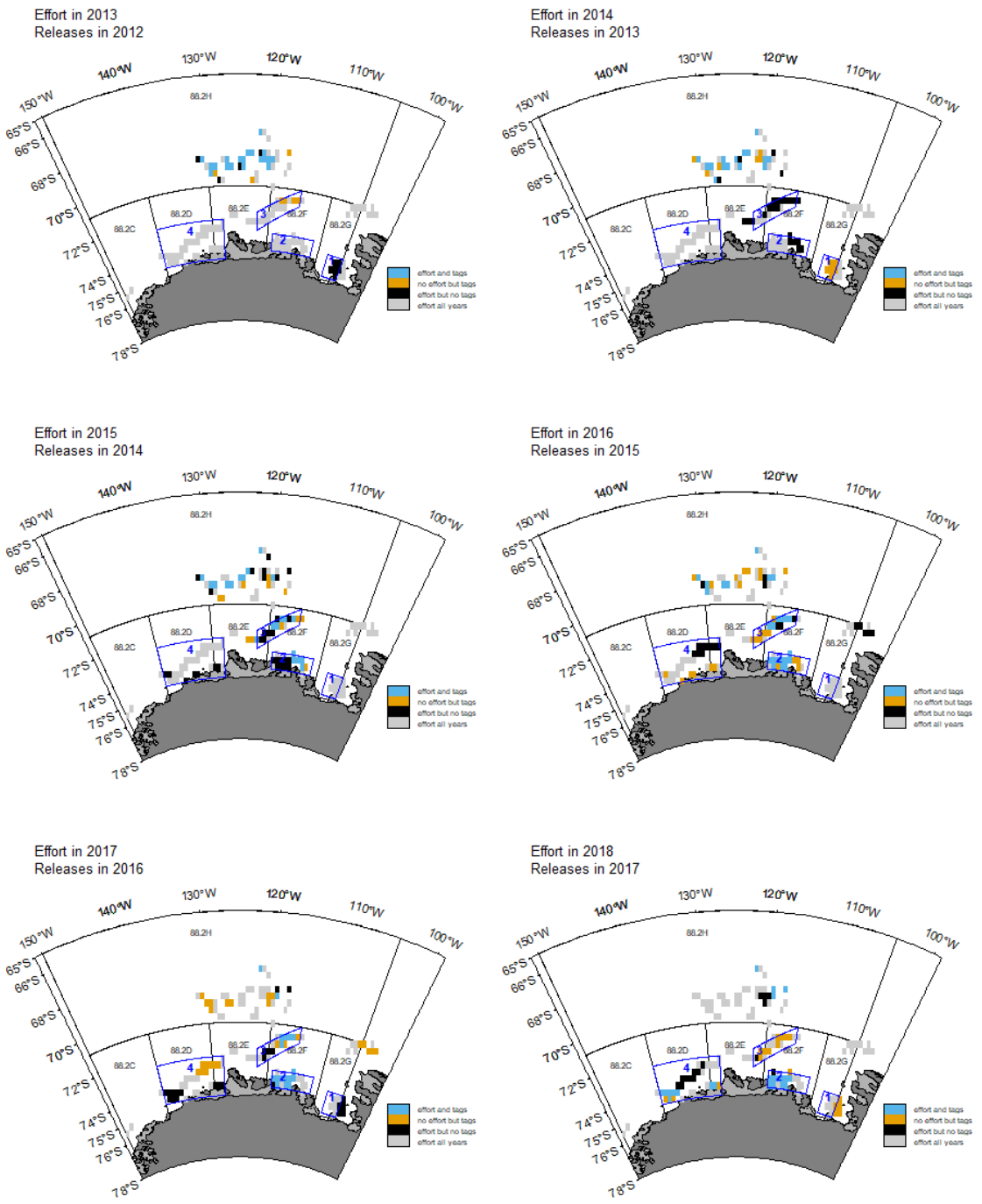
Some of the issues encountered

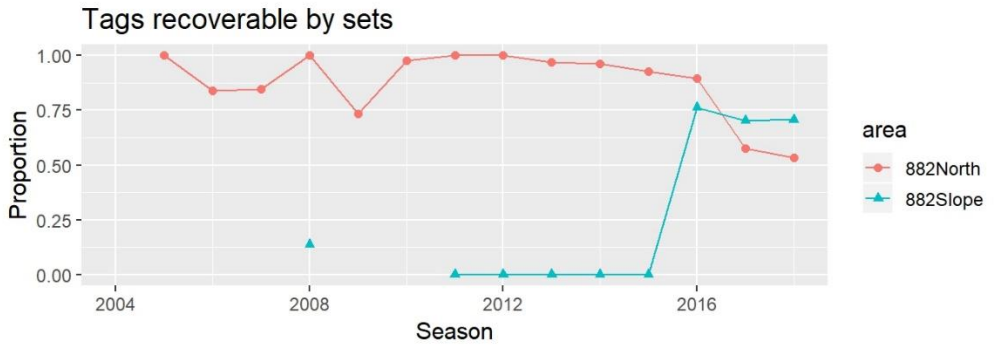
- Initial drop in North AF not captured by the model
  - Model structure or spatial data issue?
- Low proportion of the population goes spawning in the North
  - Stock structure?
  - Fishing in only part of the stock?
  - Indexing changing parts of the population
- Variable / low overlap between tagging events and subsequent fishing events
  - Not enough mixing / movement
  - Spatial resolution much smaller than the model

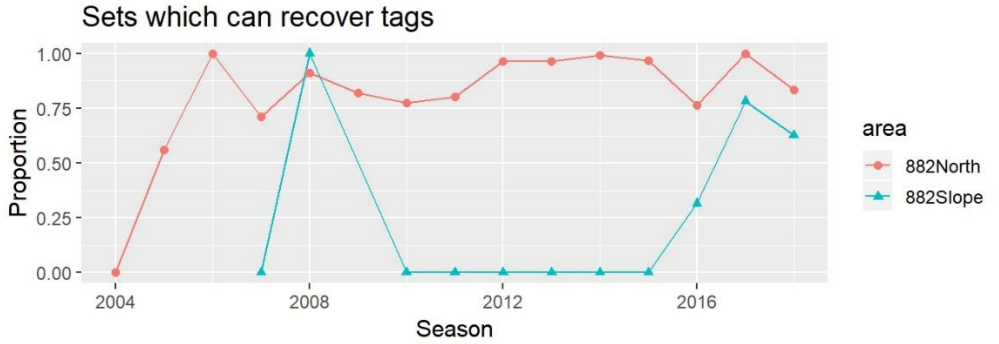


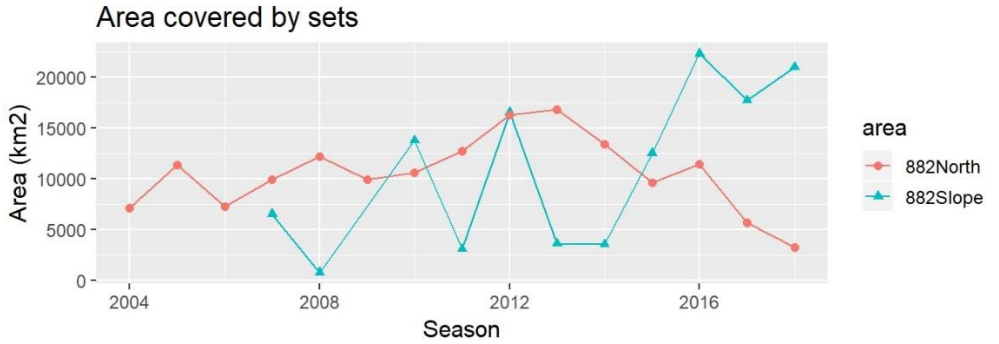
Some indices of spatial overlap

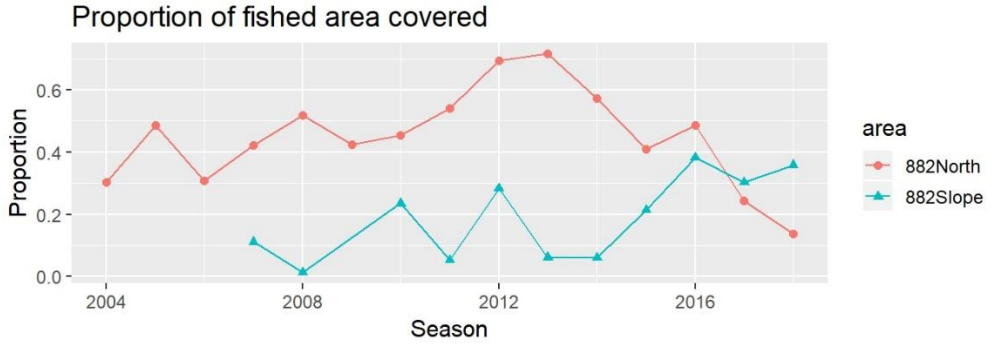
- What effort should be included
- What tags should be included
- What area are you really indexing?

- These are random ideas
  - could be used directly in Petersen but more complex in integrated in assessments
  - Area indexed another issue







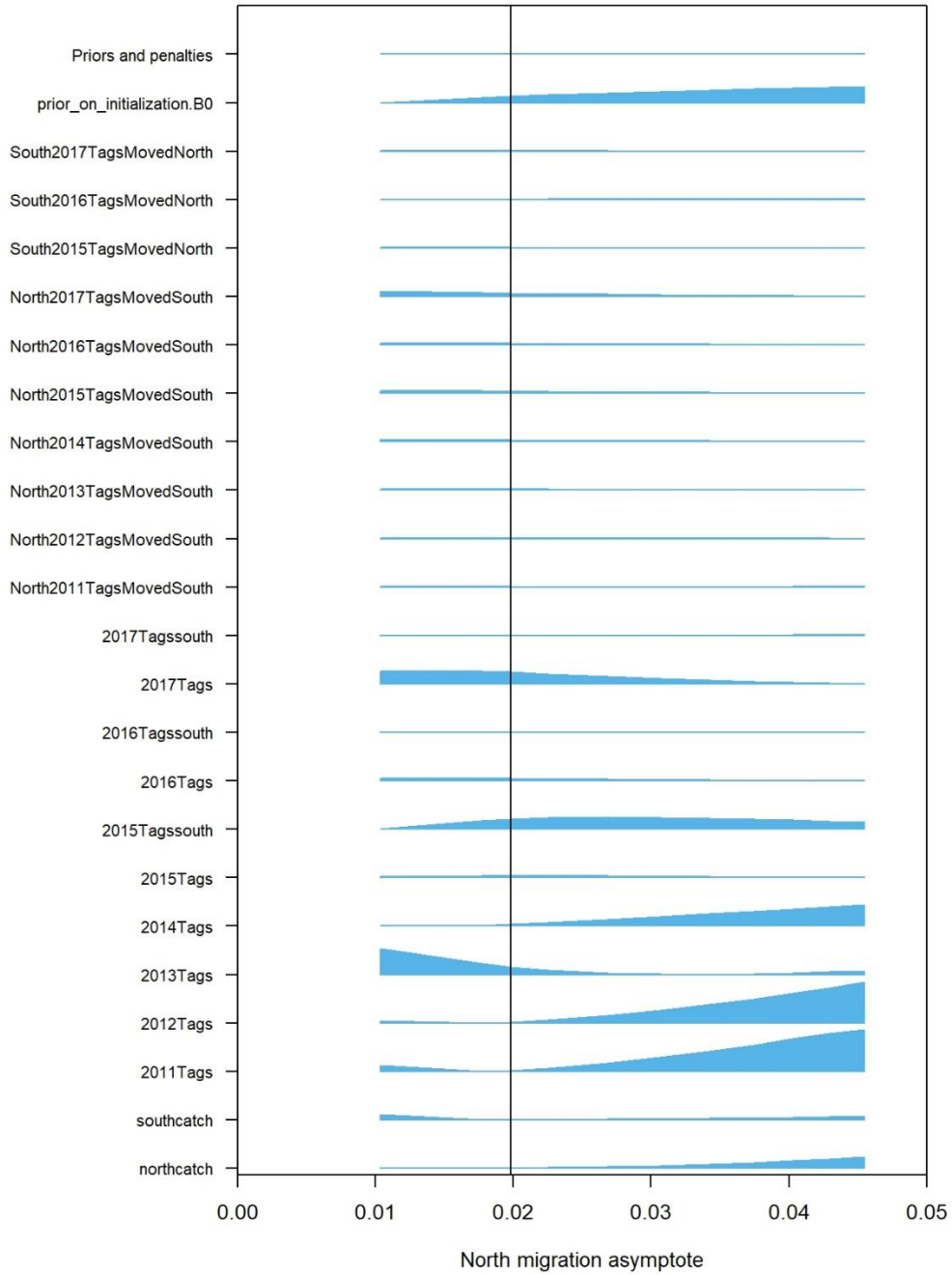


MPD profile / data weighting

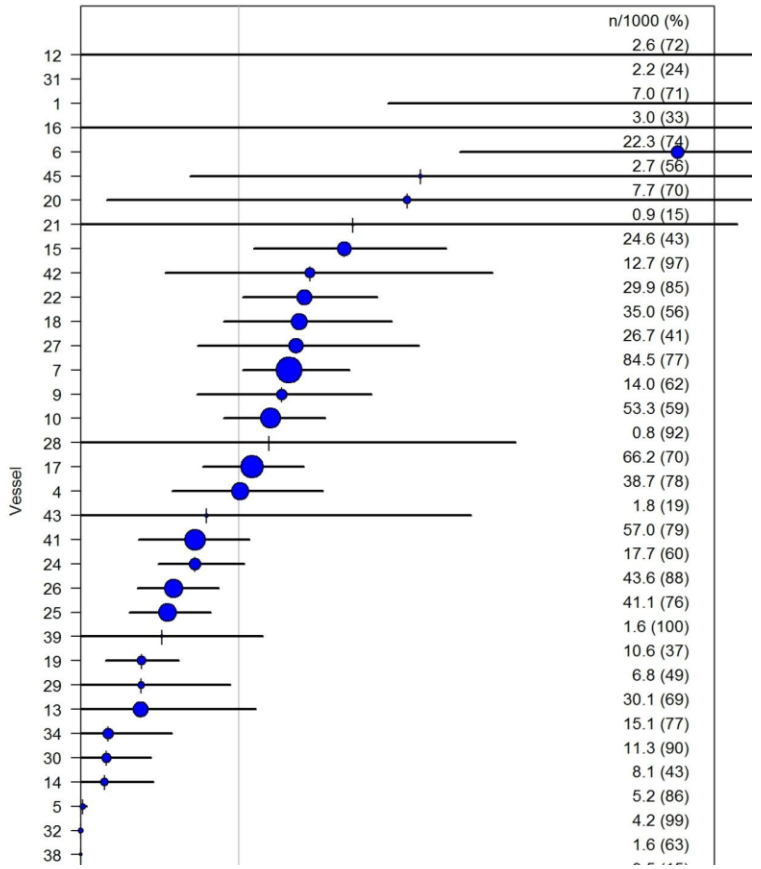
- Data weighting: we use the Francis method for all data including tagging
  - Binomial likelihood
  - Down-weight tagging last, external weighting
  - Use single weight for all years (can calculate by year)
  - Usually dispersion 1 to 6

```
stdres[indx] <- (Nobs - Nexp)/sqrt(Nexp)
new.dispersion <- var(stdres)
```

- Also do MPD profiles to look at the actual impact of the tagging data on the parameter estimated
  - Here movement parameter



Some other considerations



CCAMLR Science, Vol. 20 (2013): 00–00

QUANTIFYING VESSEL PERFORMANCE IN THE CCAMLR TAGGING PROGRAM: SPATIALLY AND TEMPORALLY CONTROLLED MEASURES OF TAG-DETECTION RATES

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Abstract

A reliable commercial fish tagging program is critical to the successful man
of a number of toothfish fisheries in Antarctica. In particular, tag-detection r
directly linked to stock size estimated from the tag data in an integrated stock ass

NRC Research Press

ARTICLE

Influence of data quality and quantity from a multiyear tagging program on an integrated fish stock assessment

Philippe Eric Ziegler

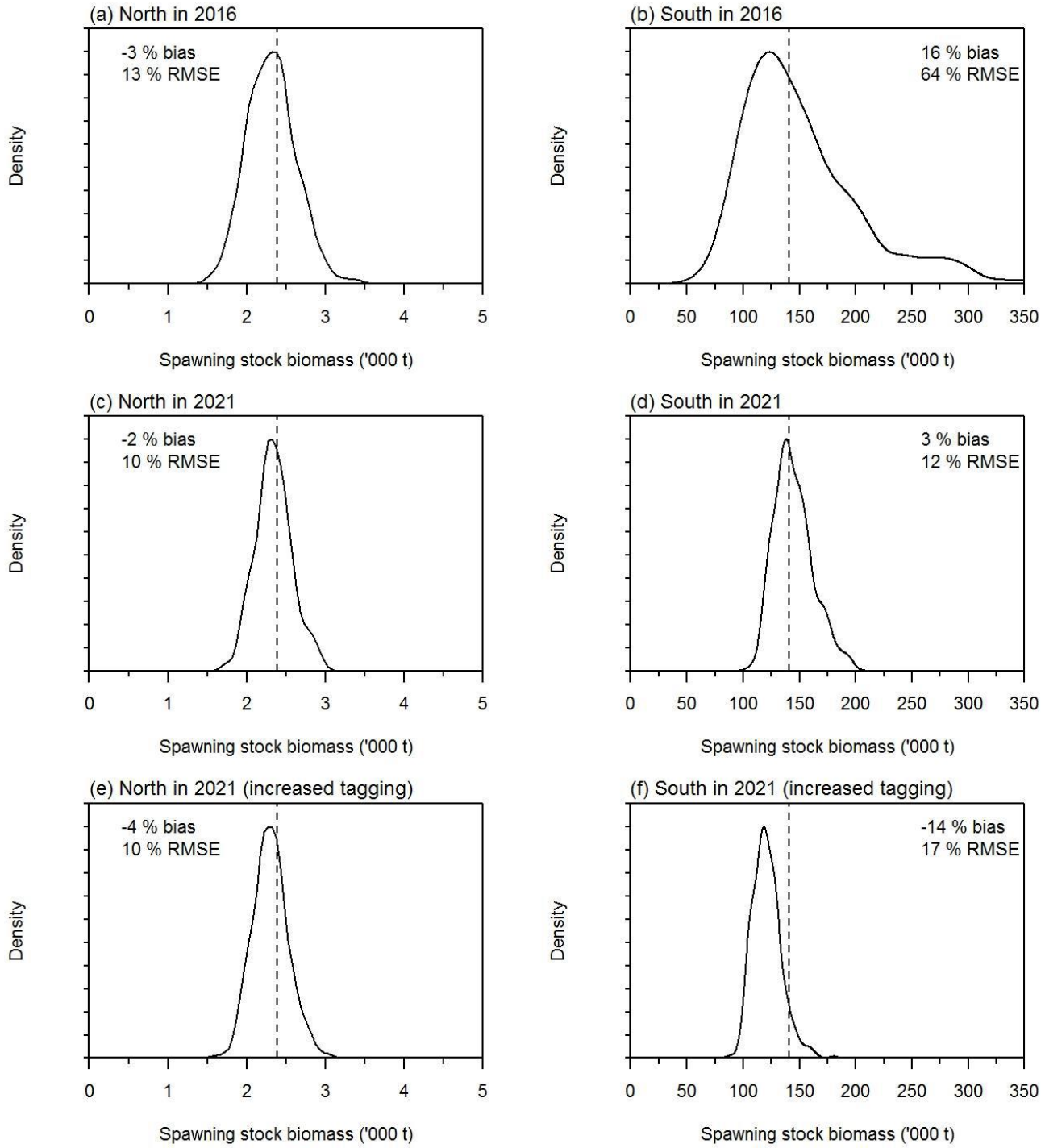
Abstract: Using a modeling framework for toothfish (*Dissostichus* spp.) population dynamics, fishing, and data collection, this study investigated how the bias and precision of biomass estimates from an integrated tag-based assessment are influenced by various aspects of a multiyear tagging program, particularly the effects of the size of tagged fish compared with the size of fish in the catch (tag size-overlap), numbers of tagged fish, duration of the tagging program, using catch-at-length or catch-at-age data as auxiliary data, and stock depletion levels. Biomass estimates generally improved with more and better-quality tagging data. The results showed that even when tag releases were distributed over a relatively large number of size classes, low recapture

Some sensitivities carried out

- Single model in the North
- Resident population in the North as well as migrating population
- Annually-varying or density-dependent migration
- Different migration options: by sex, with ogives moving south
- Adding catches from adjacent areas
- Spawning population everywhere

Simulation work

- Expected precision and bias in biomass estimates in the future based on the current management plan
  - Includes changing tagging rates
- Expected observed tag movement rates
- Effect of mis-specification of the spatial structure in the model



Towards Casal2

- CASAL is getting old and difficult to maintain / expand
- Developing Casal2 (version 1.0 expected by Christmas)
  - Has CASAL functionality
  - More flexible: processes, observations, time-varying parameters, multi-species…
  - Modular coding: easy to extend when needed
  - Unit-testing of individual components
  - Full model comparison within coding
  - Available on git-hub, designed for collaborations

Some Casal2 additional functionality

- Fully time-varying parameters
- Fully flexible categories, e.g.
  - Transition between sexes or any other category transitions
  - Natural mortality and growth can be applied by area or category
  - Single area can be the source for two migrations (e.g. snapper)
  - Catch equations and processes can be applied by area or category

Thank you

- Some references
  - Doonan, I.J.; Coburn, R.P.; McMillan, P.J. (2009). Assessment of OEO 3A black oreo for 2006–07. *New Zealand Fisheries Assessment Report* 2009/12. 46 p.
  - Francis, R I C C; McKenzie, J R (2015b). Assessment of the SNA 1 stocks in 2013. New Zealand Fisheries Assessment Report 2015/76.
  - Mc.Kenzie, A. (2016) Assessment of hoki (*Macruronus novaezelandiae*) in 2016. New Zealand Fisheries Assessment Report 2017/11. 84p.
  - Mormede, S.; Parker, S.J. (2018). Progress towards an assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 88.2C–H for the years 2002–03 to 2017–18 using a two-area model. Hobart, Australia, CCAMLR. WG-FSA-18/xx**.**

Thank you

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