Heterogeneity in multistate capture-recapture models

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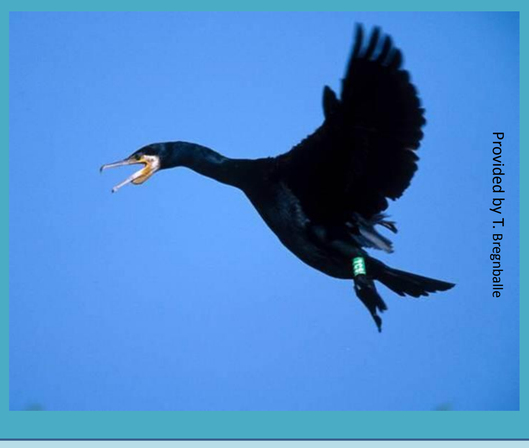


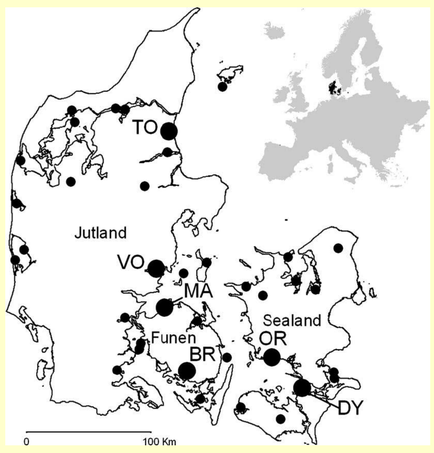
1. Introduction

Background

- Increasing complexity of capture-recapture models: from the Cormack-Jolly-Seber model to multievent models via multistate models.
- Possibility of accounting for discrete sources of heterogeneity through finite mixture models (Pledger et al, 2003)
- Finite mixture models can be formulated in a more general framework: multievent models (Pradel, 2009).

Data

- Great cormorants (*Phalacrocorax carbo sinensis*) dataset (Héneaux et al, 2007)
- Originally from 6 colonies
  Vorsø (**VO**), Ormø (**OR**), Brændegråd Sø (**BR**), Dyrefod (**DY**), Mågeøerne (**MA**) and Toft Sø (**TO**)
- Pooled in 2 for analyses: VO versus other colonies
- Only breeders considered
- Better resighting conditions in VO => higher detection probability expected



Location of the studied (big circle) breeding colonies in Denmark (taken from Héneaux et al, 2007)

Objectives

Based on an application to the great cormorants dataset

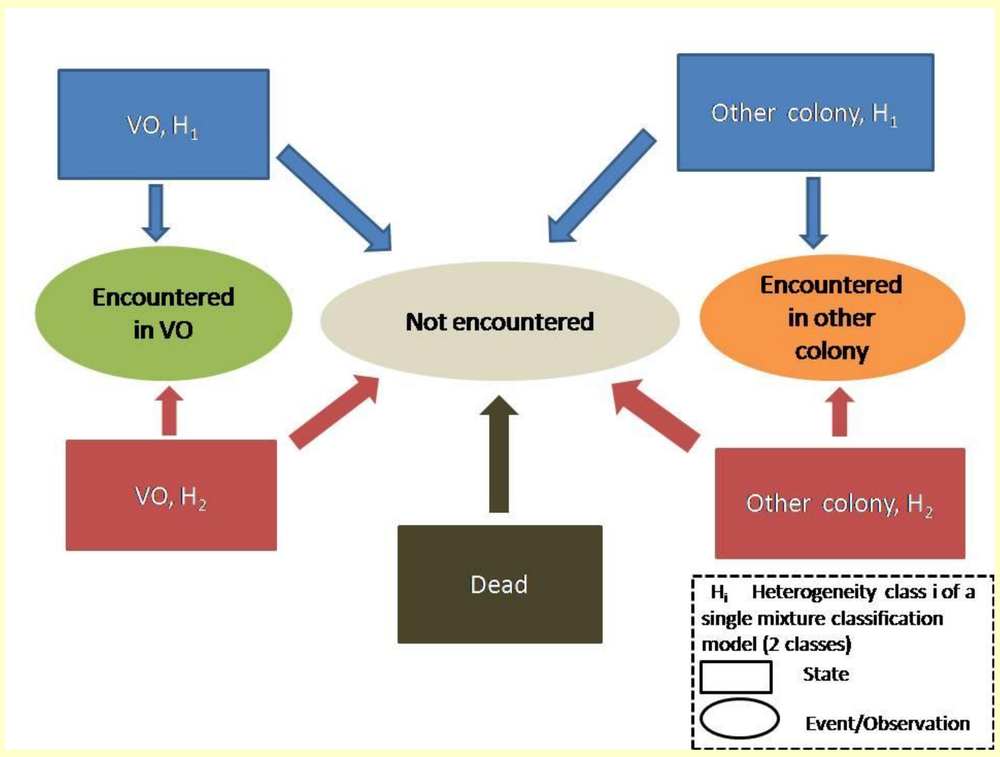
- Investigate a step-up model building approach for a multi-site model with finite mixture.

At which stage should heterogeneity be included?

- Investigate results of different model selection criteria on the cormorants and simulated datasets
- Investigate score tests in this framework, combined with the step-up approach

2. Modelling

- Model fitting using E-SURGE: one mixture covering all probabilities, finite mixture in a multievent context



Observation generating process

- 2 step-up strategies: allowing heterogeneity classes to enter the model from the beginning OR only after fitting for all known sources of heterogeneity first

- Model selection: based on AICc

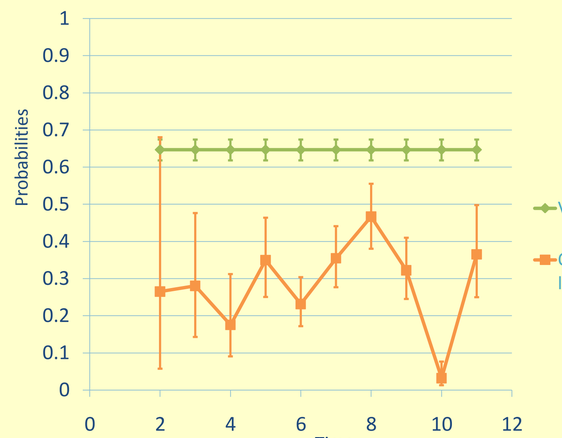
3. Best model with heterogeneity entered later

Known source of heterogeneity in detection: Location (VO or other)

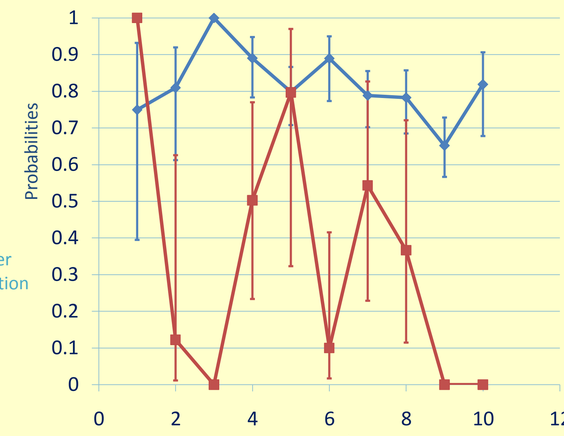
Step		Model	Δ_{AICc}
8	↓	{p(*VO* + *other* x *t*), Φ(*t* x h_2),Ψ(*t* + h_2)}	0
7	↑	{p(*t* x *loc*), Φ(*t* x h_2),Ψ(*t* + h_2)}	8.4
6	↑	{p(*t* x *loc*), Φ(*t* x h_2),Ψ(*t*)}	13.7
5	↑	{p(*loc*), Φ(*t* x h_2),Ψ(*t*)}	82.9
4	↑	{p(*loc*), Φ(*t*),Ψ(*t*)}	128.1
3	↑	{p(*loc*), Φ(*t*),Ψ(.)}	164.8
2	↑	{p(*loc*), Φ(.),Ψ(.)}	231.2
1	↑	{p(.), Φ(.),Ψ(.)}	594.6

↑ Step-up
↓ Step-down
t: time
loc: location (VO VS other)
h_2: single mixture of 2 heterogeneity classes

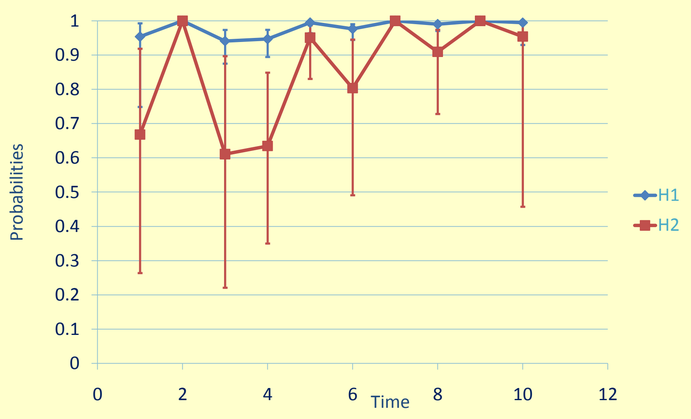
Model selection (best model at each step based on AICc, using model notation similar to Pledger et al, 2003)



Detection probabilities (+/- 95% CI)



Survival probabilities (+/- 95% CI)



Probabilities of fidelity to VO (+/- 95% CI)

4. Conclusions & Future work

- As expected, detection probability higher in VO
- Heterogeneity in survival and transition: class 1 seems to have higher probability of survival and move very little

- For the cormorant dataset:
  - include possible sources of heterogeneity for survival
  - what is the best model according to other selection criteria?
- Use simulated datasets to investigate the different strategies for model building
- Implement score tests in a mixture framework and compare their performance with other model selection criteria (in an approach similar to Cubaynes et al, 2012)

5. References

- S. Pledger, K. H. Pollock, and J. L. Norris. Open capture-recapture models with heterogeneity: I.Cormack-Jolly-Seber model. *Biometrics*, 59:786-794, 2003.
- V. Heneaux, T. Bregnballe, and J.-D. Lebreton. Dispersal and recruitment during population growth in a colonial bird, the great cormorant phalacrocorax carbo sinensis. *Journal of Avian Biology*, 38:44-57, 2007.
- R. Pradel, The stakes of capture-recapture models with state uncertainty. In *Modeling Demographic Processes in Marked Populations* , pp. 781–795. Springer-Verlag, 2009
- S. Cubaynes, C. Lavergne, E. Marboutin, and O. Gimenez. Assessing individual heterogeneity using model selection criteria: how many mixture components in capture-recapture models? *Methods in Ecology and Evolution*, 3:564-573, 2012.