

Outline solutions for Exercises in Analysis of Capture-Recapture Data: **Chapter 4**

July 28, 2015

- 1.
2. The parameter index matrices for the ring-recovery model $c/a2/c$ are:

$$\text{PIM}(S) = \begin{bmatrix} 1 & 2 & 3 \\ & 1 & 2 \\ & & 1 \end{bmatrix} \quad \text{PIM}(\lambda) = \begin{bmatrix} 4 & 4 & 4 \\ & 4 & 4 \\ & & 4 \end{bmatrix}.$$

The parameter index matrices for the ring-recovery model $t/c/c$ are:

$$\text{PIM}(S) = \begin{bmatrix} 1 & 4 & 4 \\ & 2 & 4 \\ & & 3 \end{bmatrix} \quad \text{PIM}(\lambda) = \begin{bmatrix} 5 & 5 & 5 \\ & 5 & 5 \\ & & 5 \end{bmatrix}.$$

- 3.
4. First year survival is variable over time, 0.31-0.72. Adult survival probability is higher than first year survival probability, 0.89. The recovery probability varies over time, but is not as variable as first year survival probability, but λ_1 is appreciably smaller than all other times. The average of the $S(t)$ is 0.9 which is very close in value to the estimated constant adult survival probability. The comparable recovery probability estimates are 0.22 and 0.27. We note that the difference could be because the data for Example 4.1 relate to breeding birds only which may have a higher recovery probability than non-breeders.
- 5.
6. If group membership is known Equation (4.1) can be extended to include group membership as follows:

$$\log(L(S, \lambda; \{d_{i,j}^g\})) = \text{constant} + \sum_{g=1}^G \sum_{i=1}^{T-1} \sum_{j=i+1}^T d_{i,j}^g \log(\delta_{i,j}^g) + \left(R_i^g - \sum_{j=i}^T d_{i,j}^g \right) \log(\chi_i^g)$$

where

$$\delta_{ij}^g = \begin{cases} (1 - S_g)\lambda, & i = j - 1, \\ S_g^{j-i-1}(1 - S_g)\lambda, & i < j - 1, \end{cases}$$

In the case of known group membership, nested models can be compared using likelihood ratio tests or score tests and all models can be compared using AIC.

If group membership is unknown then the likelihood can be extended to include a group assignment probabilities, π_g . In this case LRTs can be used but corrections need to be made to the asymptotic chi-squared distribution as the null model will include boundary estimates. See Pledger (2000) for more details.

7. If cohort numbers are unavailable, cell probabilities have to be divided by the probability of being seen at least once; see McCrea et al (2012).
8. A range of possible alternative models have been proposed in McCrea et al (2012).
9. See McCrea et al (2013).
- 10.
- 11.
- 12.
13. Substitute $\lambda = 0$ to give the likelihood for capture-recapture data. Note that $D_{c,j} = 0$ in this case. Substitute $p = 0$ to give the likelihood for ring-recovery data - note that array D corresponds to the ring-recovery d-array and so the equivalence is more straightforward to establish.
14. It is possible to calculate the determinant of components of the variance-covariance matrix (generalised variance) to provide measures of relative information. See Catchpole et al, (1998b) for examples of its use in terms of correlation matrices.
- 15.
- 16.
- 17.