15. Line transect data analysis – part 2




- Adding covariates to detection functions
- Estimating variance

Adding covariates to detection functions

- Some characteristics of survey conditions or animals seen could affect the probability of detection
  - Survey effort:
    - Sea conditions ("sea state" measured on the Beaufort scale)
    - Swell
    - Glare
  - Animals:
    - Sighting cue
    - Group size
- Adding information on these characteristics as covariates in the detection function could improve model fit
  - Leading to a better estimate of detection probability
  - And therefore a better estimate of density and abundance

Variance estimation

- Each variable or estimated component has a variance
- Use "delta method" to estimate variance (or CV) of density

$$\hat{D}_s = \frac{n}{2wL\,\hat{p}_a} \qquad \hat{D}_s = \frac{n}{2L\,e\hat{s}w} \qquad esw = w \times p_a$$

$$\boxed{CV_{D_s}^{\;2} = CV_n^{\;2} + CV_{e\hat{s}w}^{\;2}}$$

$$\boxed{\hat{V}(n) = \frac{L \sum_{i=1}^{k} l_i \left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2}{k-1}} \qquad n = \sum_{i=1}^{k} n_i \,,\; L = \sum_{i=1}^{k} l_i$$

l_i = length of transect lines
n_i = sightings on transects
k = number of transects

Variance estimation (continued)

- If species occurs in groups

$$\hat{D} = \hat{D}_s E[s]$$

$$\boxed{cv_{\hat{D}} = \sqrt{cv_{\hat{D}_s}^{\ 2} + cv_{E[s]}^{\ 2}}}$$

- Abundance

$$\hat{N} = \hat{D} A$$

$$\boxed{cv_{\hat{N}} = cv_{\hat{D}}}$$

Bootstrap estimates of variance

- Used when variance cannot be calculated analytically
- Assume that the data from different transect lines are independent
- More computer intensive than the analytical method

Bootstrapping

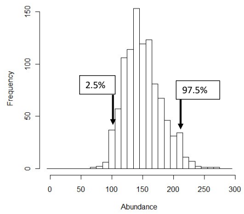
- Suppose we have an abundance estimate obtained from a survey with 12 transects:

- Select transects randomly, with replacement, to create a bootstrap sample
- Analyse data from that sample to give estimate of abundance
- Repeat a large number of times, e.g. 1,000

	Bootstrap samples			
Transect	**1**	**2**	**3**	**1000**
1	11	3	6	8
2	3	9	10	4
3	5	4	9	12
4	6	10	3	5
5	12	6	5	6
6	7	7	10	1
7	1	9	1	8
8	7	11	4	11
9	9	3	12	1
10	4	2	8	11
11	6	9	8	7
12	8	1	2	5
$\hat{N}$	$\hat{N}_1$	$\hat{N}_2$	$\hat{N}_3$	$\hat{N}_{1000}$

Bootstrap variance and confidence limits

- The variance of abundance is simply the variance of all the 1,000 bootstrap abundance estimates
- The 95% confidence limits are calculated by ordering the bootstrap estimates from smallest to largest
- The 2.5%-ile is the lower limit and the 97.5%-ile is the upper limit
  - E.g. if there are 1,000 bootstrap samples
  - Lower limit is 26^{th} estimate
  - Upper limit is 975^{th} estimate



Summary

- Adding covariates can improve estimates of the probability of detection
  - Sighting conditions
  - Characteristics of animals
- Variance estimation
  - Analytical
  - Bootstrap