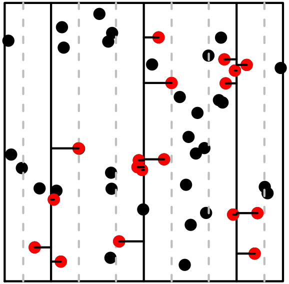
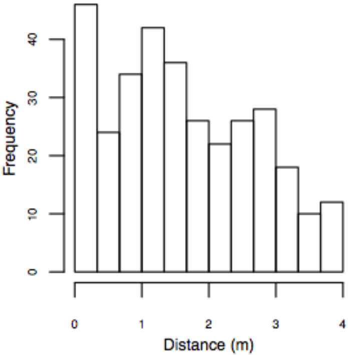
Using mixture models for distance sampling detection functions

David Lawrence Miller & Len Thomas

NCSE Summer meeting 2011
Bath

Distance sampling





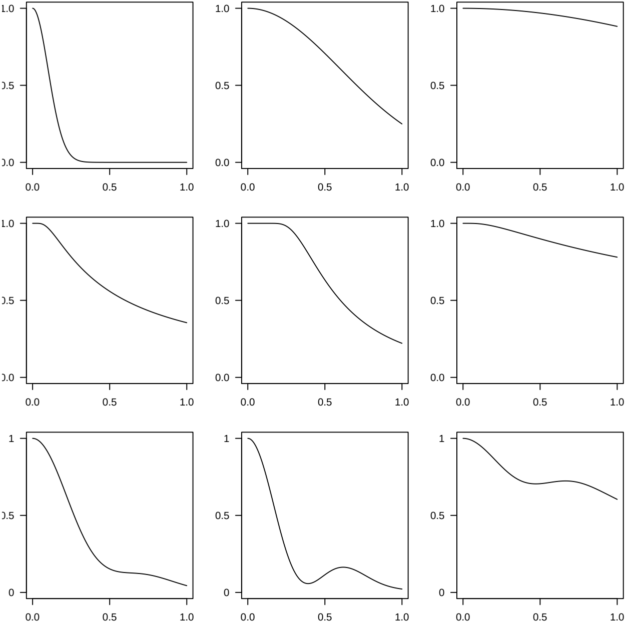
Distance sampling detection functions

Conventional distance sampling:

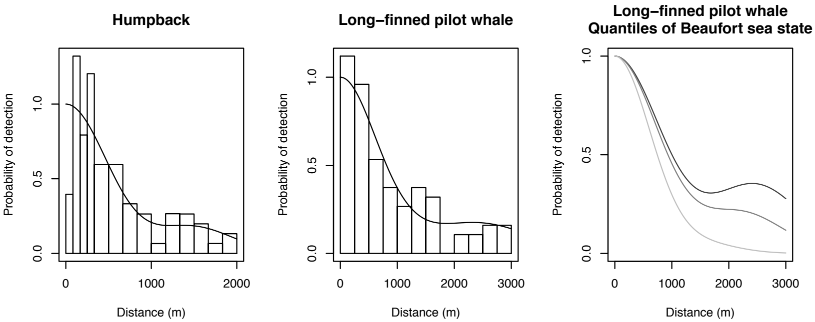
$$g(x) = \text{key}(x)(1 + \text{adjustment series}(x))$$

$$\text{key}(x) = \exp\left(-\frac{x^2}{2\sigma^2}\right) \quad \text{or} \quad 1 - \exp\left(-\left(\frac{x}{2\sigma}\right)^{-b}\right)$$

adjustment series(x) = cosines, Hermite polynomials or simple even polynomials


1.0
0.5
0.0
0.0
0.5
1.0
1
0.5
0

Monotonicity

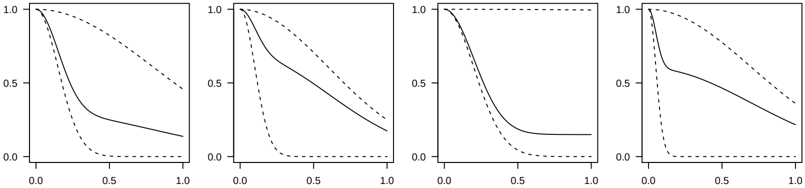


Mixture models

Capture-recapture guys are doing it. . . Byron, Shirley Pledger, Andy Royle. . .

Built in monotonicity.

Mixture of **detection functions**.

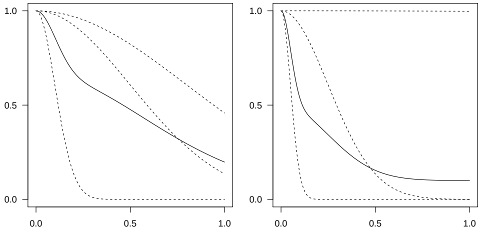


Formulation

A J-point mixture detection function:

$$g(x) = \sum_{j=1}^{J} \phi_j g_j(x), \qquad \text{where } \sum_{j=1}^{J} \phi_j = 1$$

Here, $g_j(x)$ is half-normal, $g_j(x) = \exp\left(-\frac{x^2}{2\sigma_j^2}\right)$



Covariates

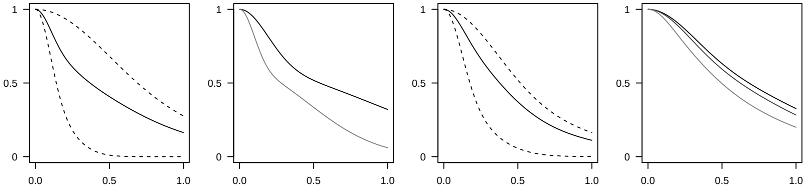
Conventional distance sampling:

$$\sigma_i = \exp(\beta_0 + \sum_{k=1}^{K} \beta_k z_{ik})$$

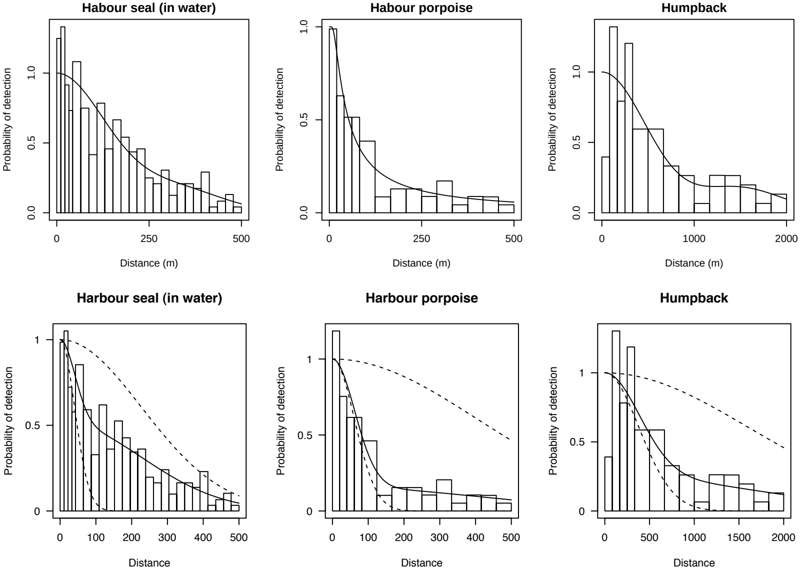
Mixtures:

$$\sigma_{ij} = \exp(\beta_{0j} + \sum_{k=1}^{K} \beta_k z_{ik})$$

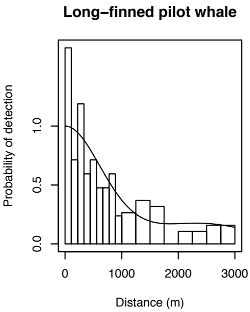
Covariates the same in each mixture, only vary intercepts.

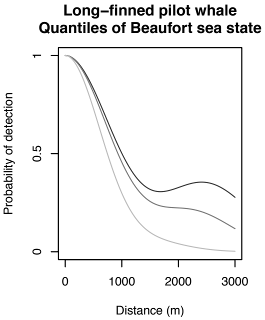


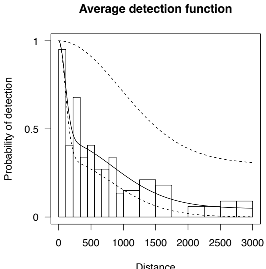
Williams & Thomas (2007)

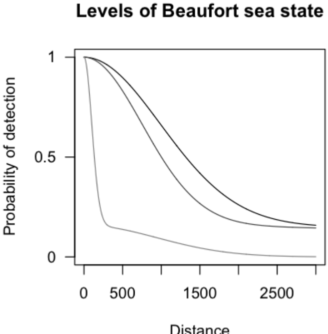


Long-finned pilot whales









Further work

Continuous mixtures, let $J \to \infty$...

$$g(x) = \int_{\mathbf{R}} \varphi(\kappa) g_\kappa(x, \mathbf{Z}; \theta, \kappa) \mathsf{d}\kappa$$

Mixtures of mixtures (*a la* Morgan and Ridout).

Conclusion

Another option for the detection function.

Better AIC on most of the examples we tried.

Can always fall back to CDS via AIC selection.

There is an R package – `mmds`.

Available at `github.com/dill/mmds`.

Paper – soon!