Analysis of Populations in Clusters

- What changes when animals occur in clusters
- Size bias
- Methods to deal with size bias
- How to implement these methods in Distance

Clustered populations

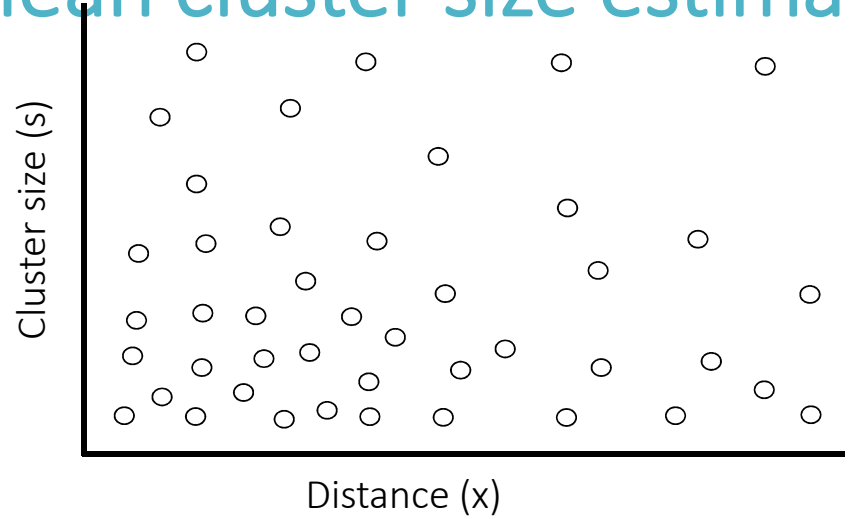
Density of clusters

$$\hat{D} = \hat{D}_s \times \hat{E}(s)$$

Mean cluster size

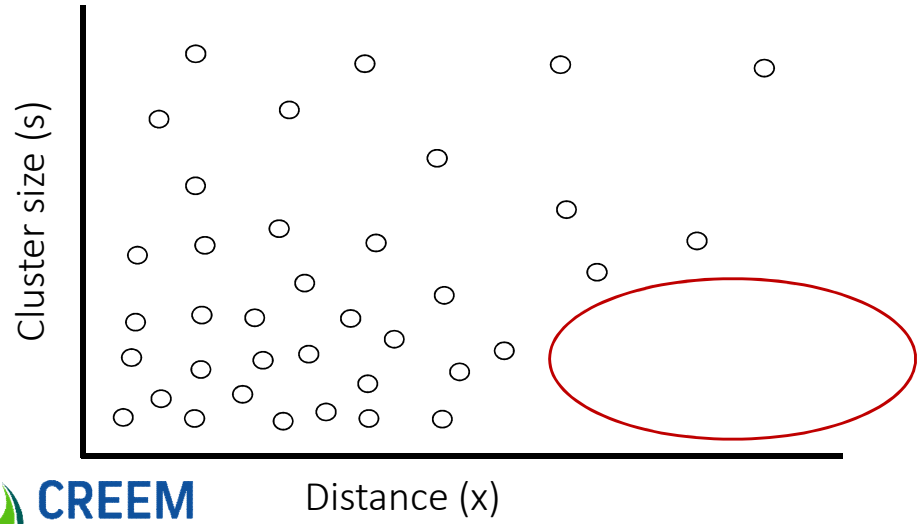
$$\left[cv(\hat{D})\right]^2 = \frac{\hat{V}(\hat{D})}{\hat{D}^2} \approx \left[cv(\text{encounter rate})\right]^2 + \left[cv\{\text{detection function}\}\right]^2 + \left[cv\{\text{cluster size}\}\right]^2$$

Mean cluster size estimation



No Size Bias

- Mean of observed sizes does not change with distance

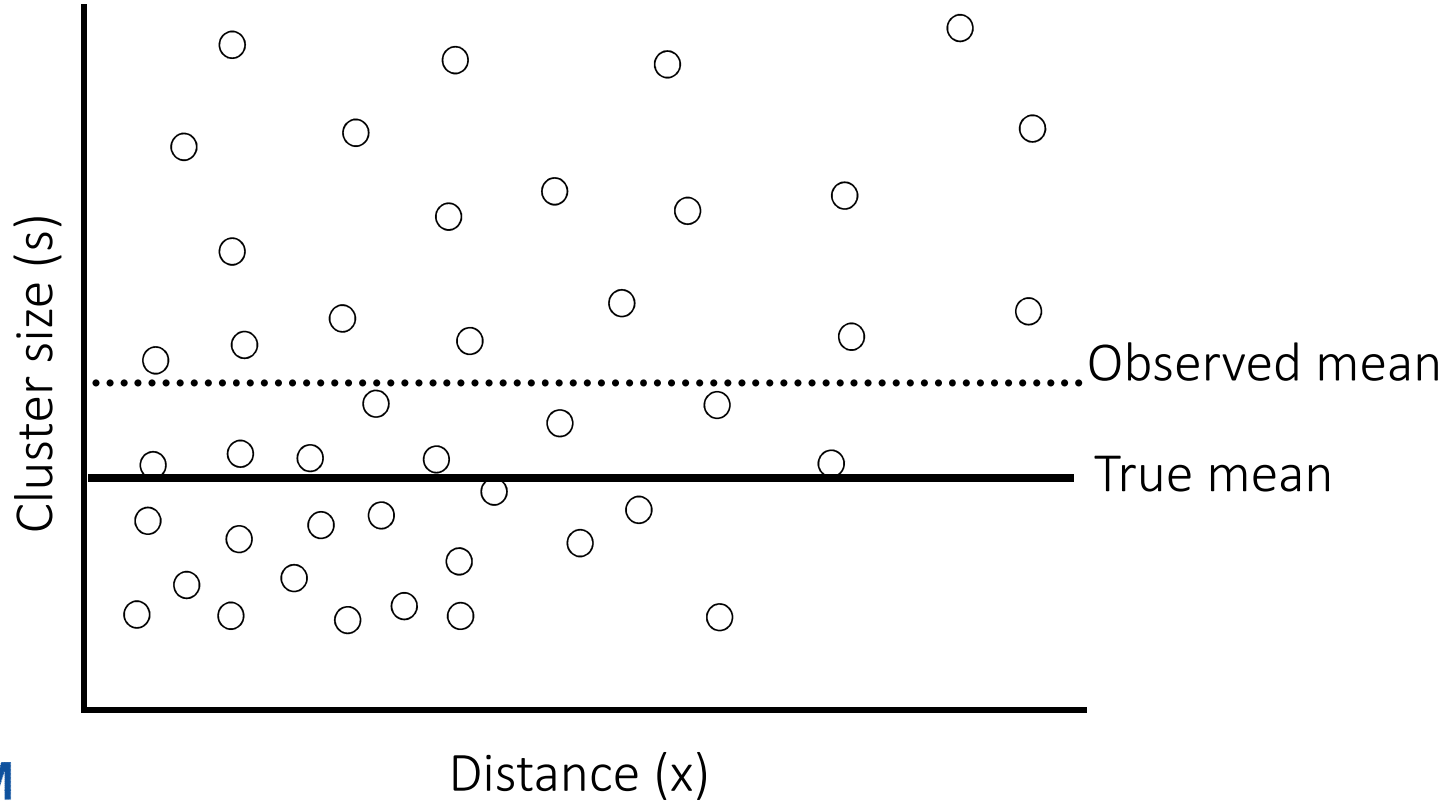


Size Bias

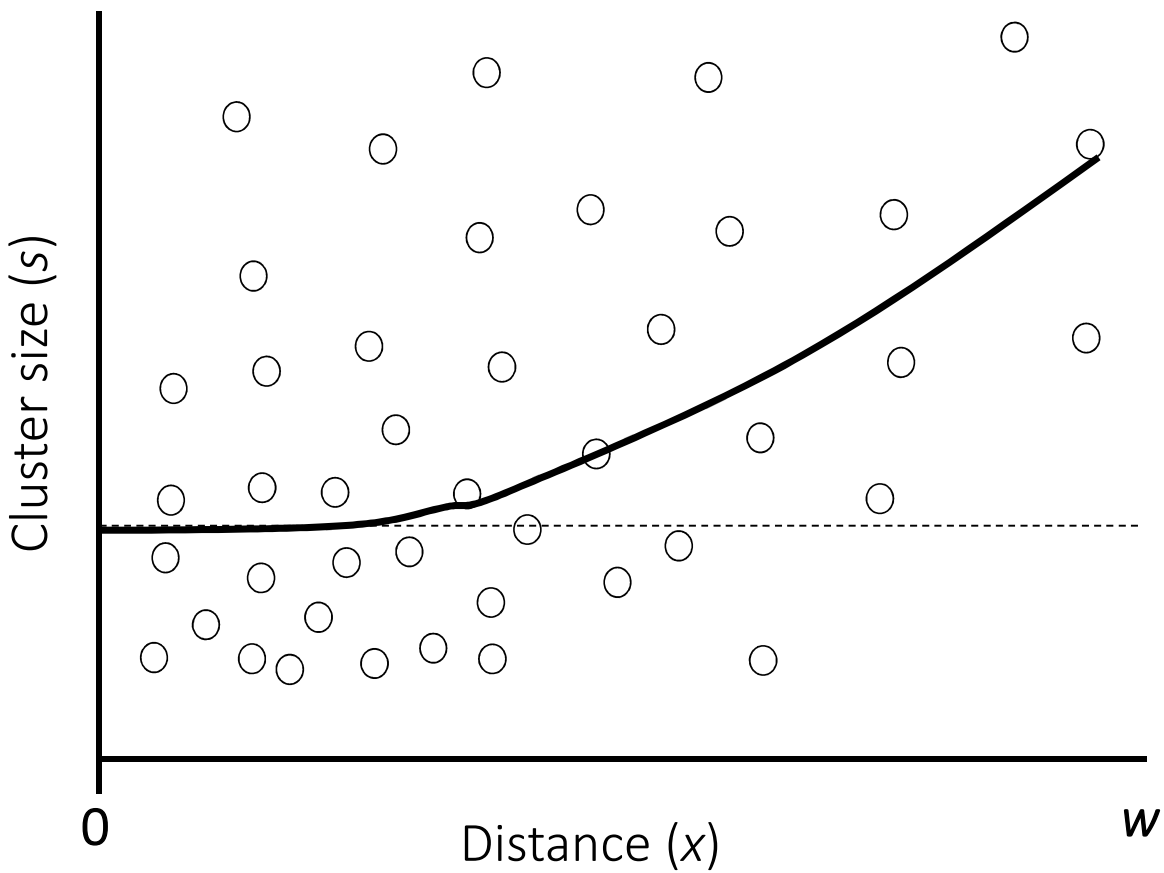
- Smaller clusters less detectable at larger distances
- Mean observed cluster size **increases** with distance

Effect of size bias on sample mean

If size bias is present, $\hat{E}(s) = \bar{s}$ will be positively biased:



Regression methods



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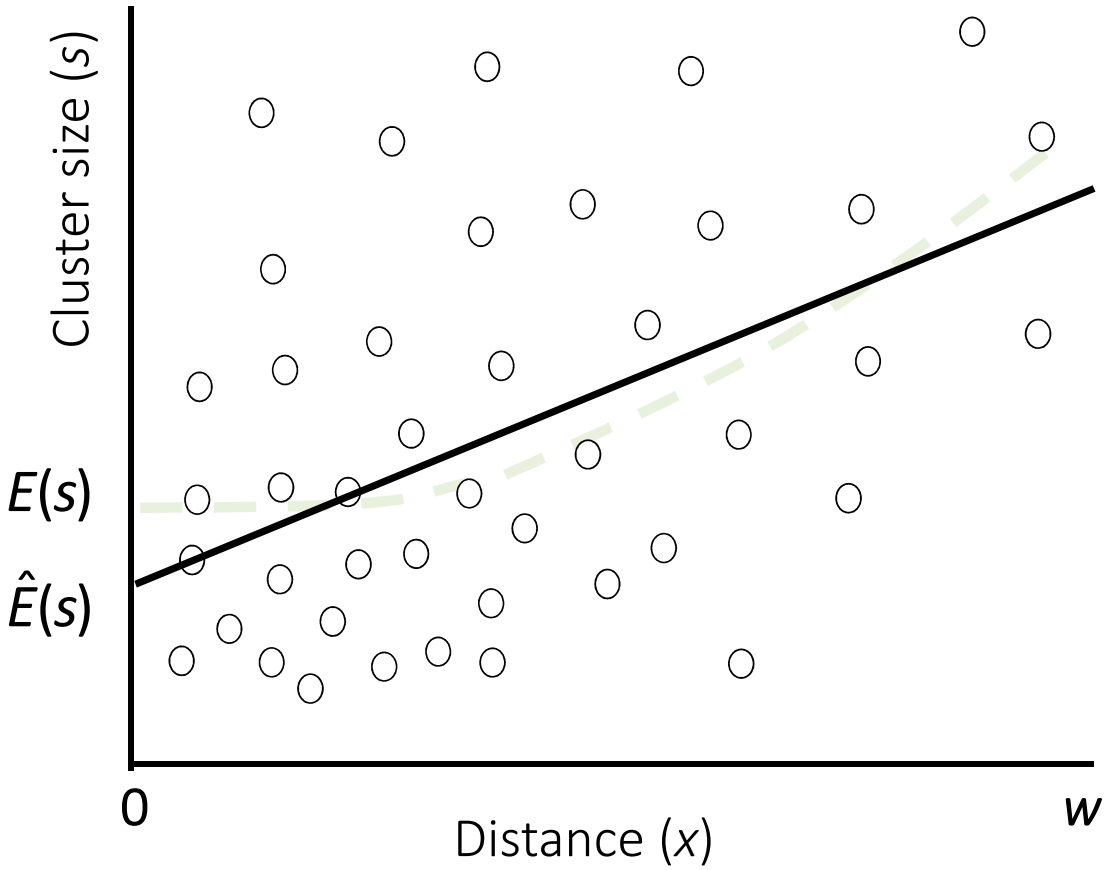
Linear regression of *s* on *x*



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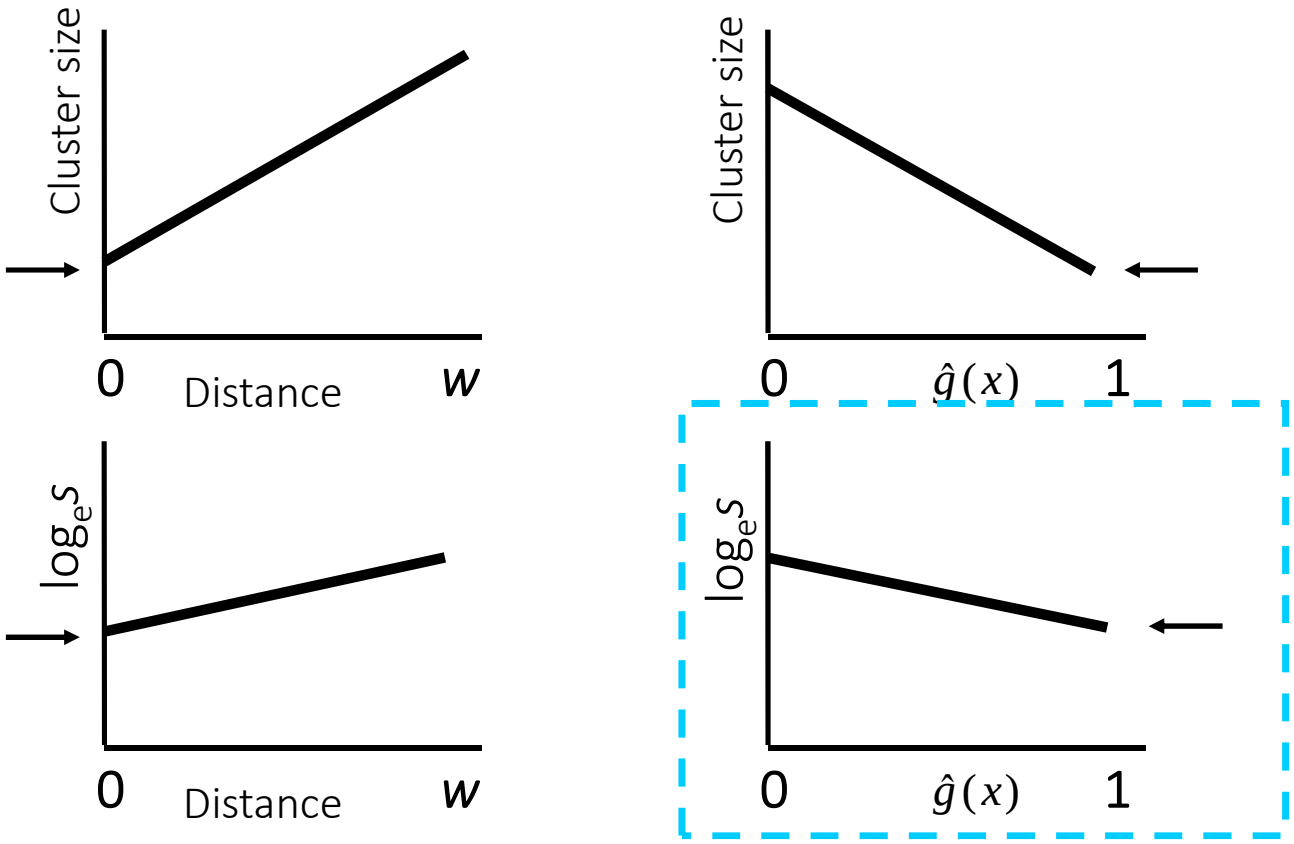
Problems with the linear regression method

- **Problem**: Relationship between *s* and *x* is not linear – no relationship when detection is certain (i.e. in the shoulder of the detection function).
    - **Solution:** Linearize by regressing s on $\hat{g}(x)$

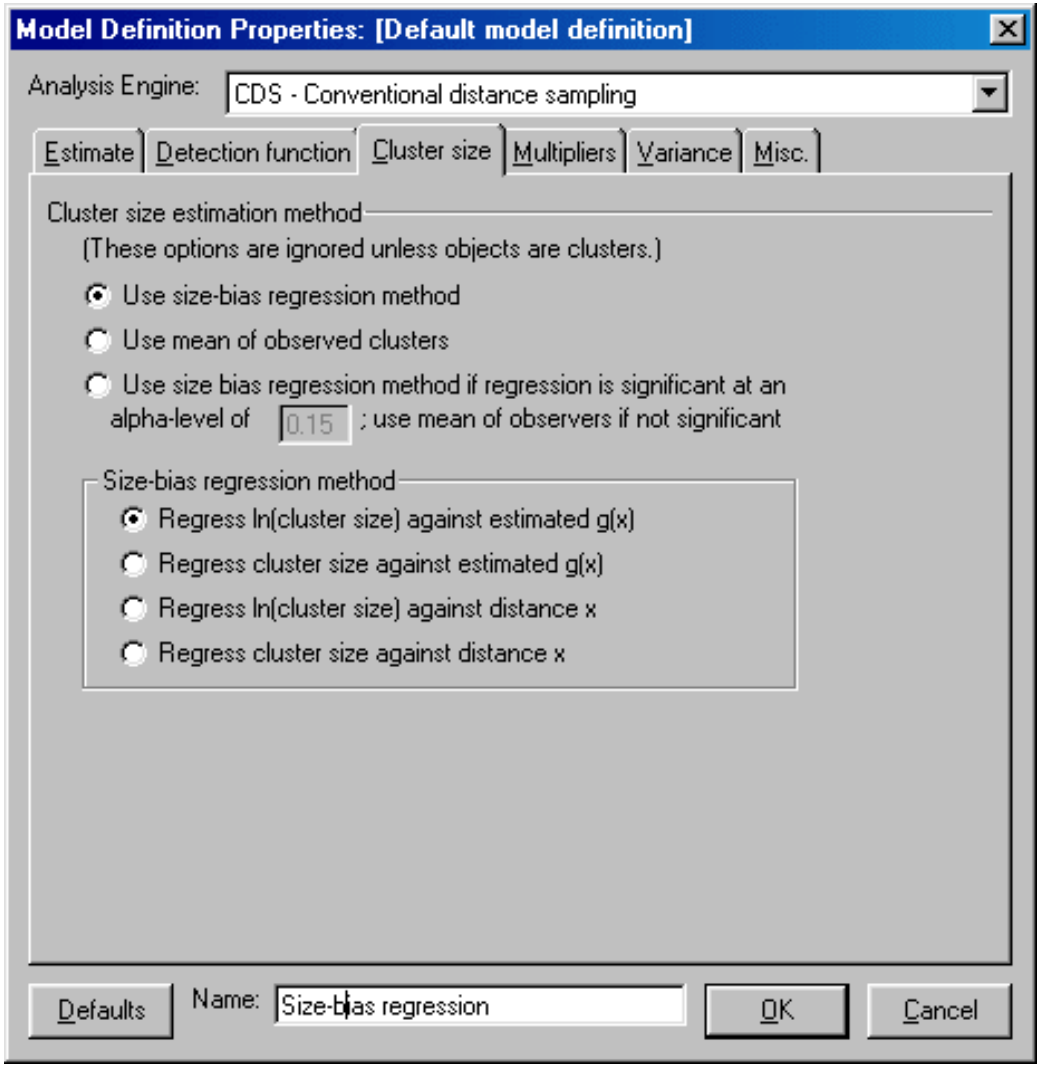
- **Problem**: Variance in *s* increases with $E(s)$ – large cluster sizes distort the fit.
    - **Solution**: Regress **log of cluster size** on $\hat{g}(x)$

Regression of log cluster size on $\hat{g}(x)$



This is the default method in Distance

Estimating *E*(*s*) in Distance using regression methods



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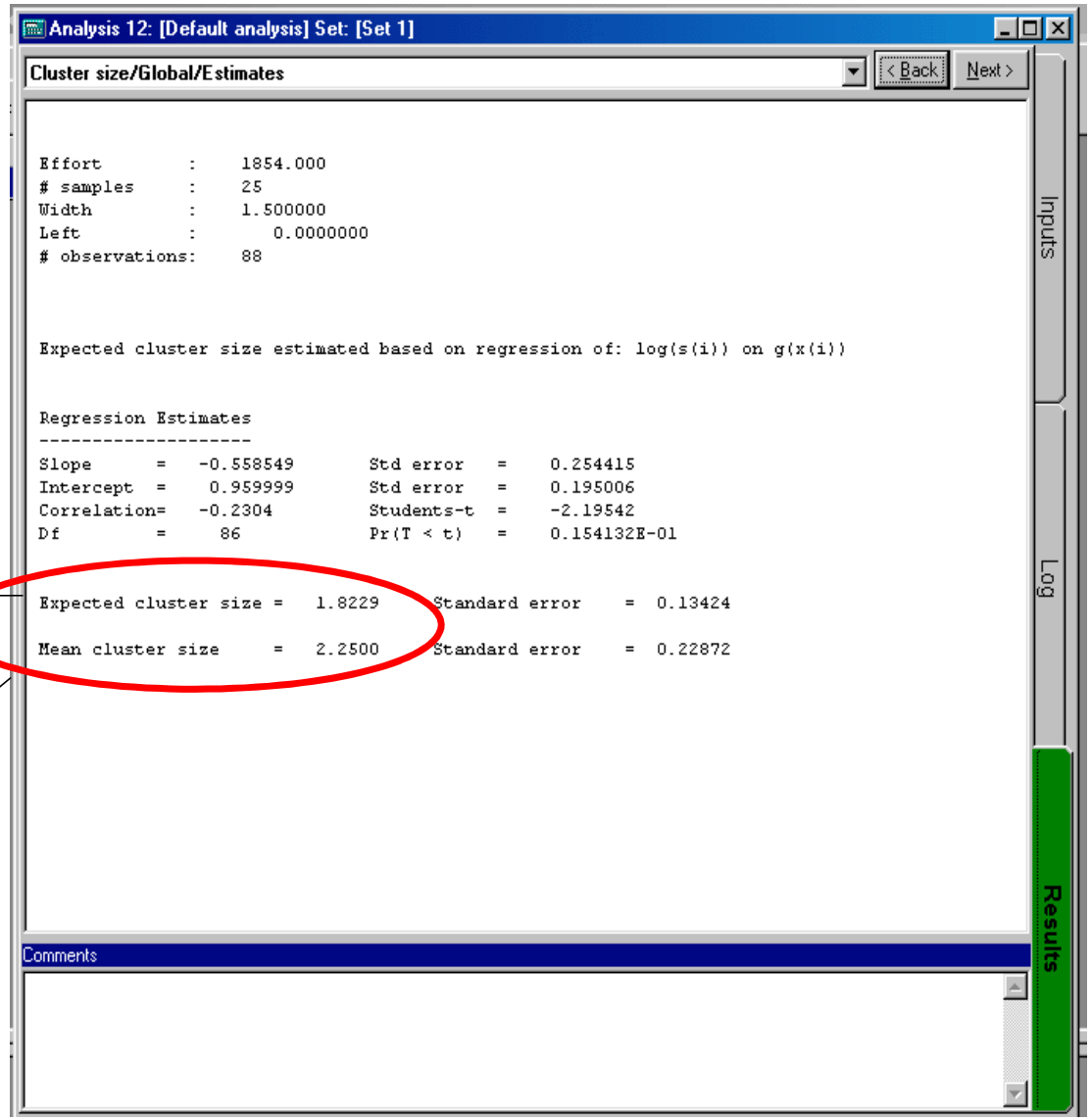
Output of regression estimates



Regression estimate of cluster size

Mean cluster size from data

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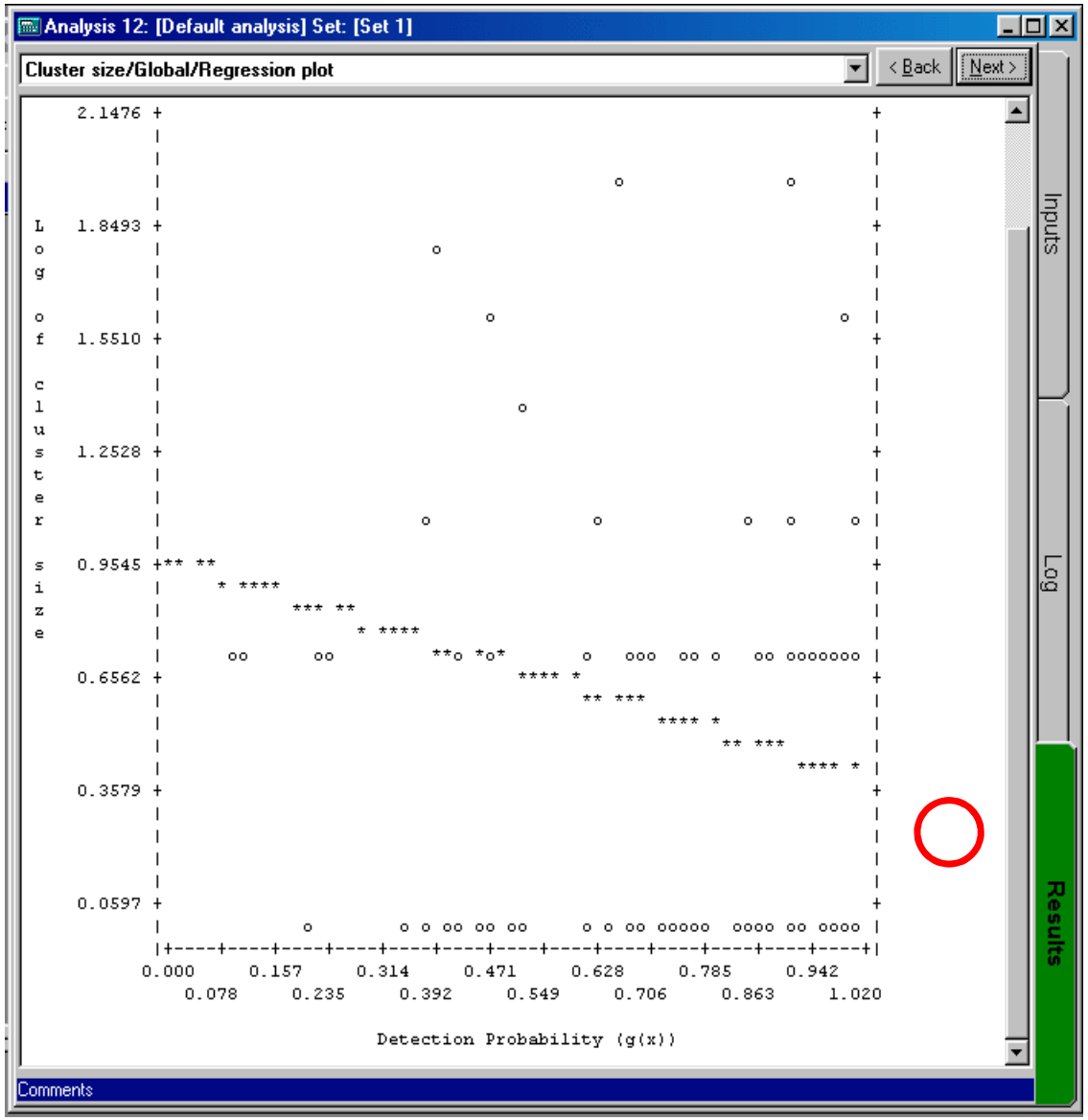
Line printer regression plot



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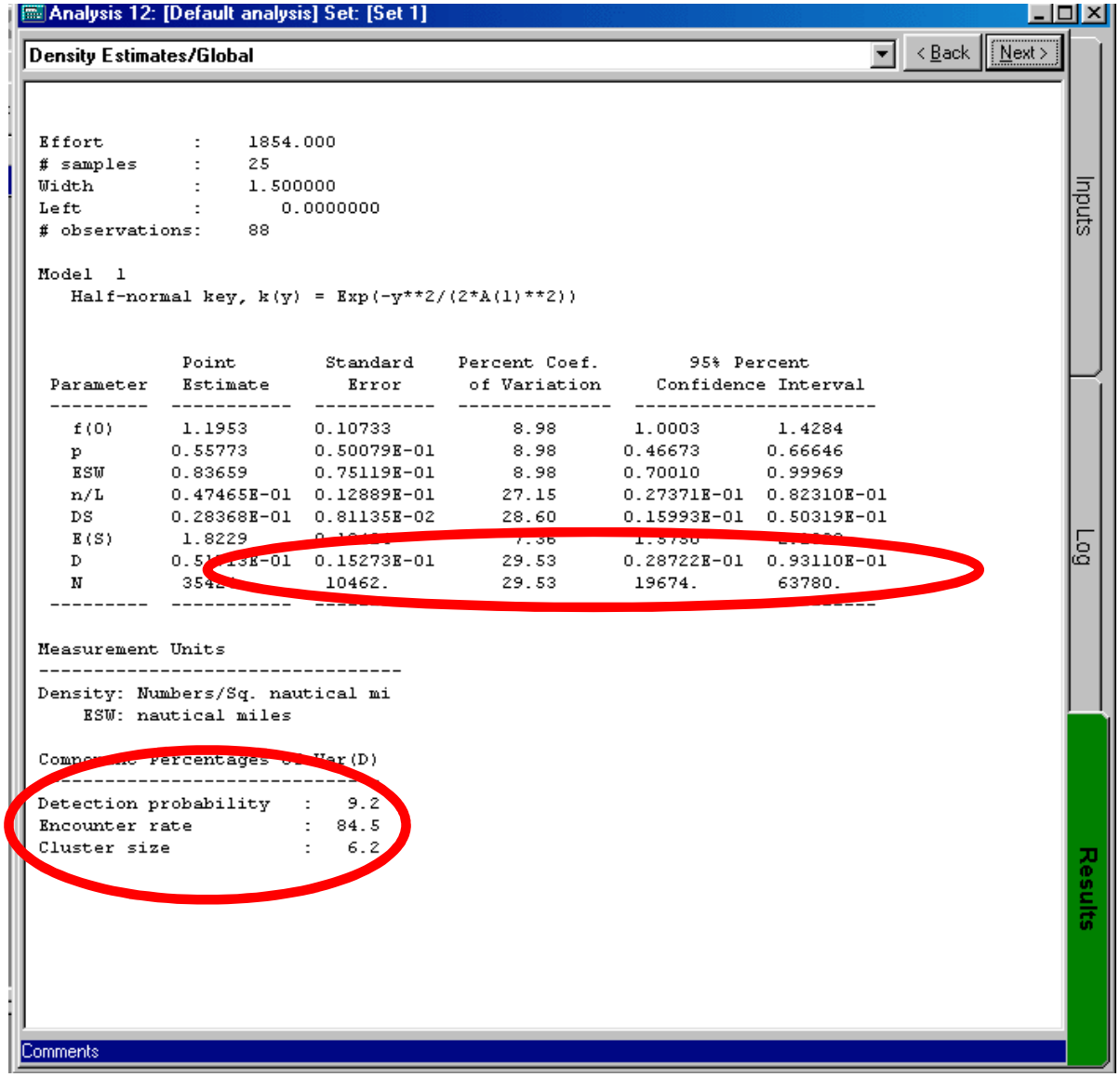
Precision of estimate



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Estimating $E(s)$ in the presence of size bias

1. Regression methods — Default method in Distance
2. Include size in model for detection function — Multiple Covariate Distance Sampling
3. Stratify by cluster size — Rarely used now
4. Truncation of size-biased data — Rarely used now
5. Replace clusters by individuals — Rarely used now