Analysis of Stratified Surveys

CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Stratification

- Why stratify?
- Stratification by:
  - Geographic area
  - Survey
  - Species / cluster size
- Limitations of Distance

Stratification is used to:

- reduce variance and improve precision
- and for producing estimates in regions of interest

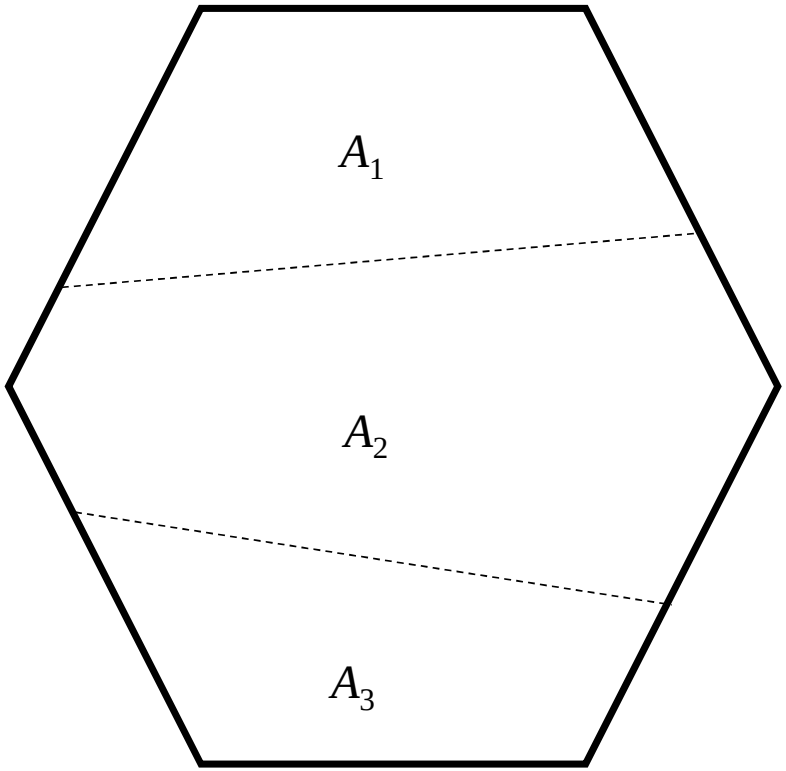
Stratify by:

- AREA or GEOGRAPHIC REGION
  - the study region is partitioned into smaller regions

- SURVEY
  - used when different surveys cover the same geographic area

- POPULATION/SPECIES/CLUSTER SIZE
  - same geographic region with different ‘sub-stocks’ in it

Area/Geographic stratification



Total size of study region

$$A = A_1 + A_2 + A_3$$

Estimate density in each sub-region

$$\hat{D}_1, \hat{D}_2, \hat{D}_3$$

Abundance in each sub-region is given by

$$\hat{N}_1 = A_1 \hat{D}_1$$
$$\hat{N}_2 = A_2 \hat{D}_2$$
$$\hat{N}_3 = A_3 \hat{D}_3$$

Total abundance is

$$\hat{N} = \hat{N}_1 + \hat{N}_2 + \hat{N}_3$$

$$= A_1\hat{D}_1 + A_2\hat{D}_2 + A_3\hat{D}_3$$

Overall (Global in Distance) density is

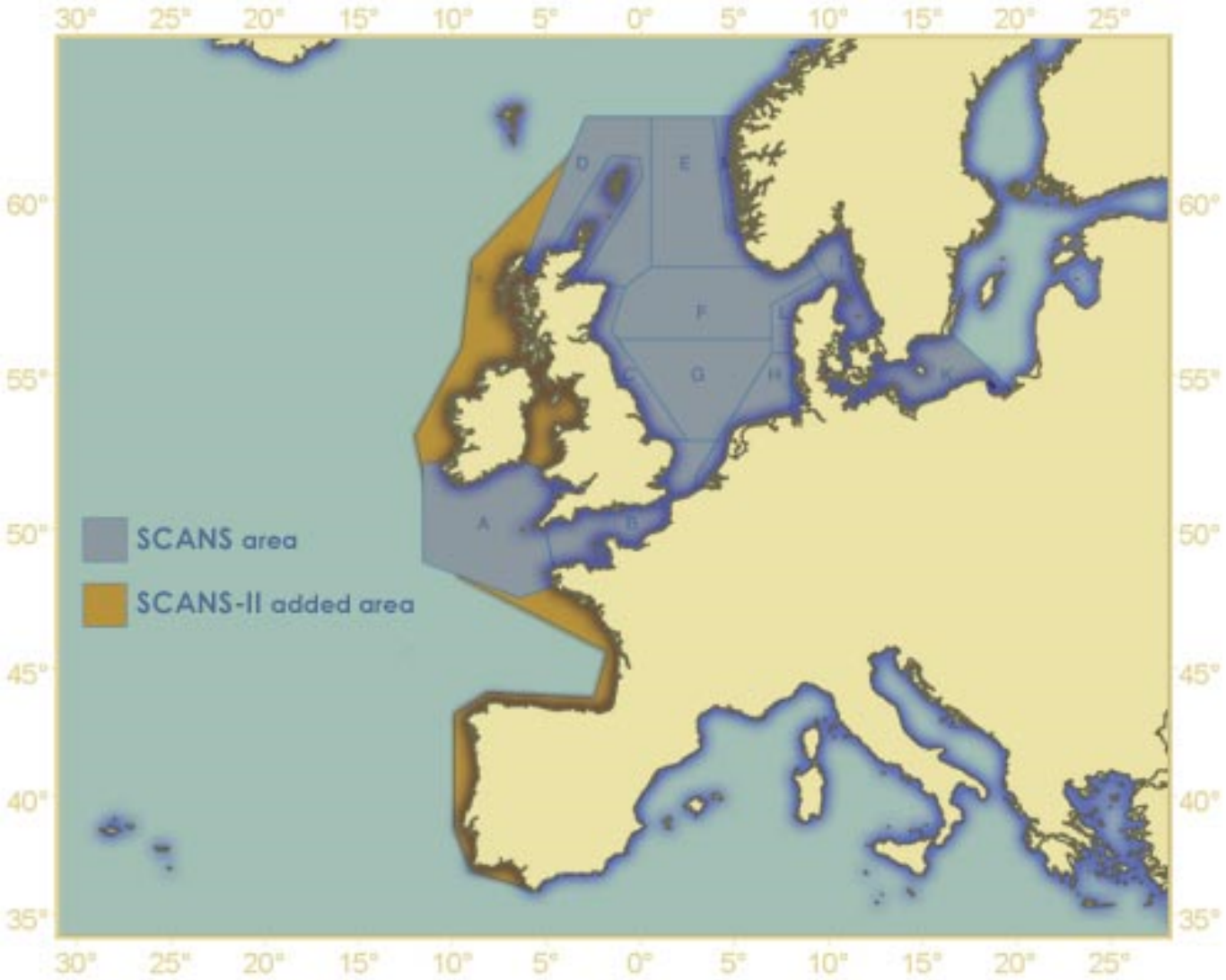
$$\hat{D} = \frac{\hat{N}}{A} = \frac{A_1\hat{D}_1 + A_2\hat{D}_2 + A_3\hat{D}_3}{A_1 + A_2 + A_3}$$

$$= \left(\frac{A_1}{A}\right)\hat{D}_1 + \left(\frac{A_2}{A}\right)\hat{D}_2 + \left(\frac{A_3}{A}\right)\hat{D}_3$$

$$= \sum_{i=1}^{3}\left(\frac{A_i}{A}\right)\hat{D}_i$$

Note form of equation

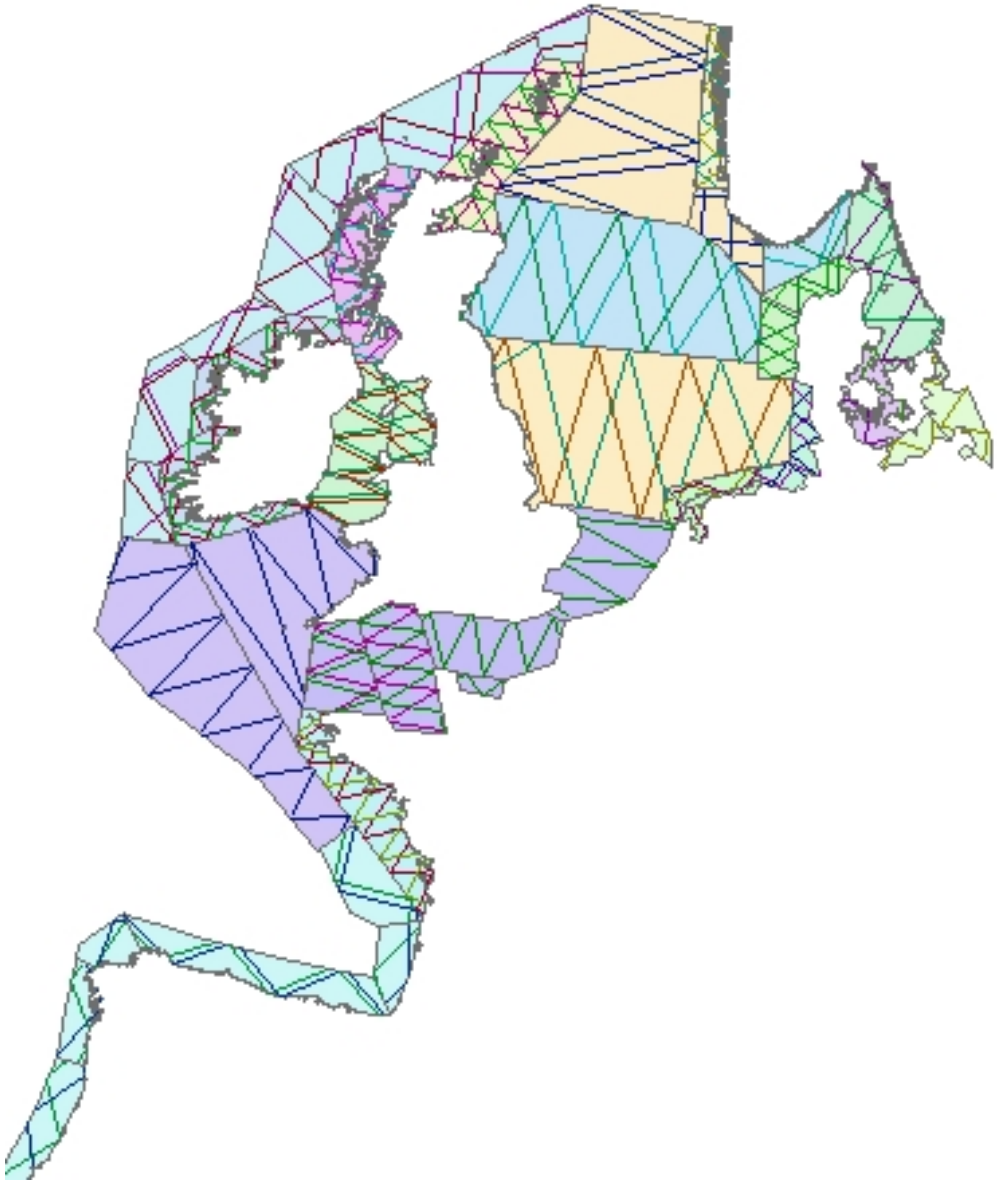
Example: SCANS II (2005)



CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

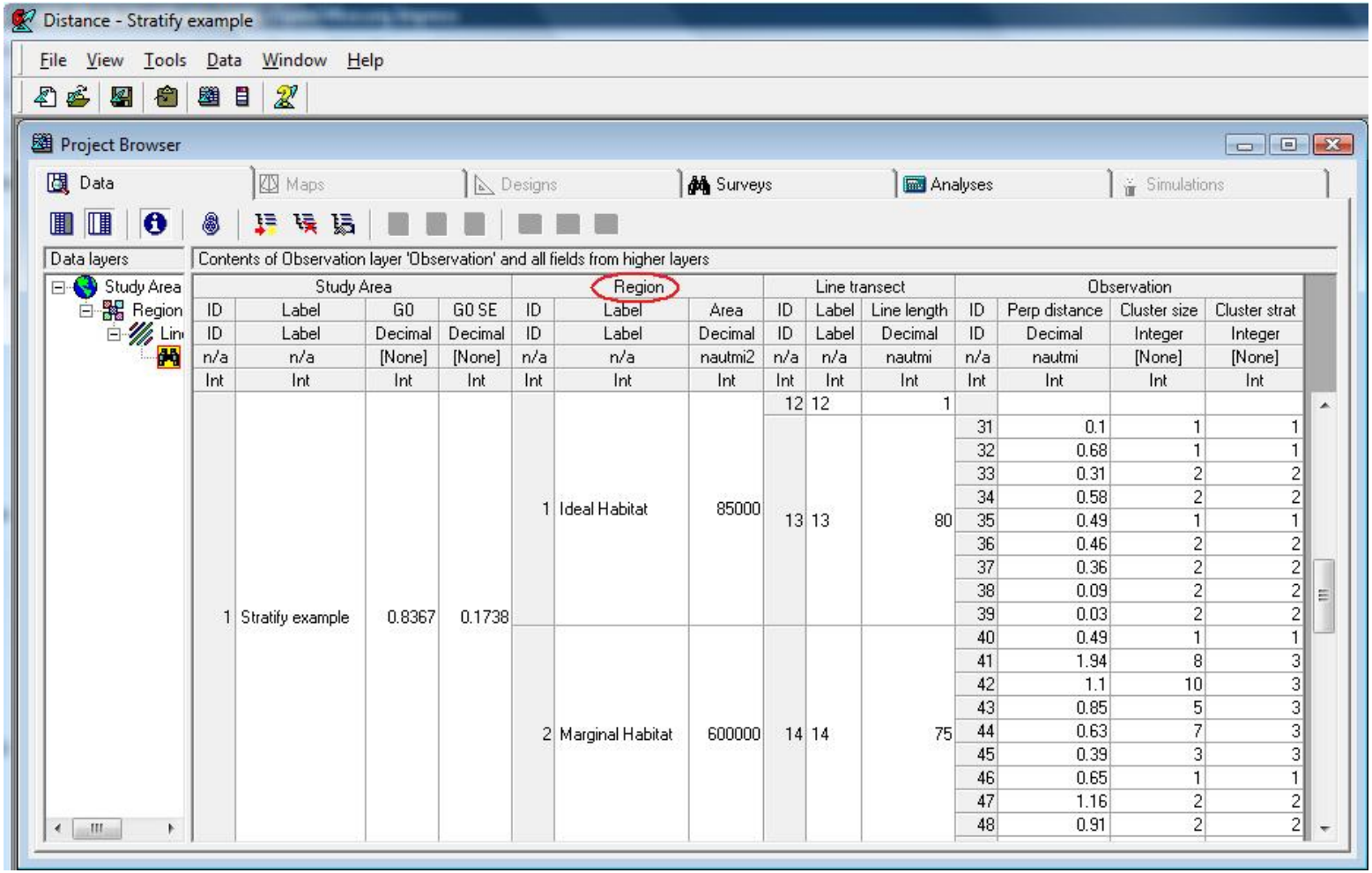
SCANS II
survey effort



CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Example of stratified data

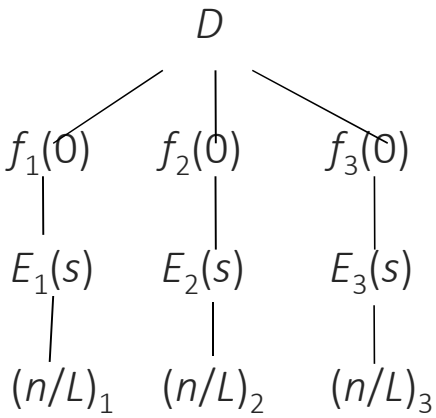


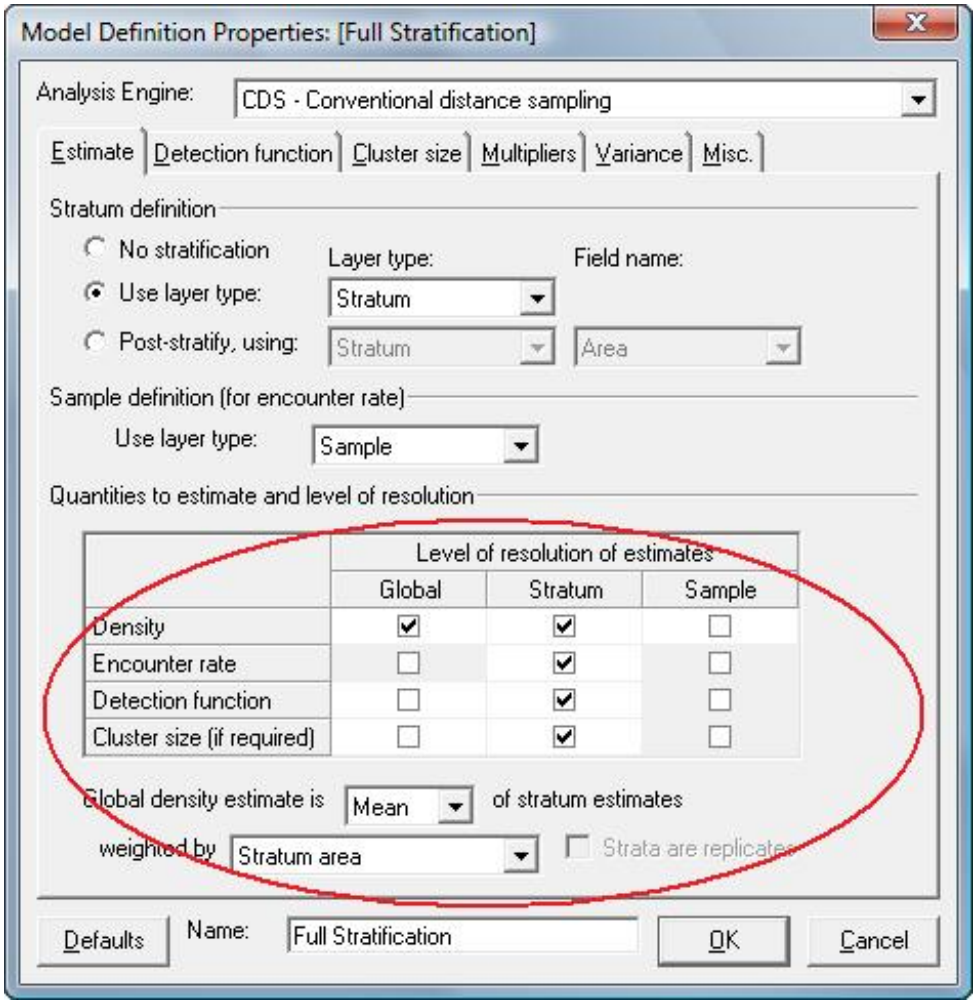
Study Area				Region			Line transect			Observation			
ID	Label	G0	G0 SE	ID	Label	Area	ID	Label	Line length	ID	Perp distance	Cluster size	Cluster strat
ID	Label	Decimal	Decimal	ID	Label	Decimal	ID	Label	Decimal	ID	Decimal	Integer	Integer
n/a	n/a	[None]	[None]	n/a	n/a	nautmi2	n/a	n/a	nautmi	n/a	nautmi	[None]	[None]
Int	Int	Int	Int	Int	Int	Int	Int	Int	Int	Int	Int	Int	Int
							12	12	1				
										31	0.1	1	1
										32	0.68	1	1
										33	0.31	2	2
										34	0.58	2	2
				1	Ideal Habitat	85000	13	13	80	35	0.49	1	1
										36	0.46	2	2
										37	0.36	2	2
										38	0.09	2	2
1	Stratify example	0.8367	0.1738							39	0.03	2	2
										40	0.49	1	1
										41	1.94	8	3
										42	1.1	10	3
										43	0.85	5	3
				2	Marginal Habitat	600000	14	14	75	44	0.63	7	3
										45	0.39	3	3
										46	0.65	1	1
										47	1.16	2	2
										48	0.91	2	2

CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Example: Full geographic stratification

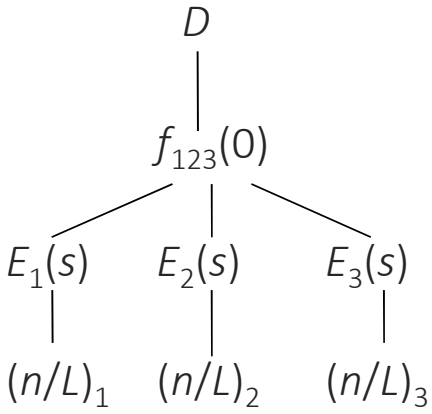


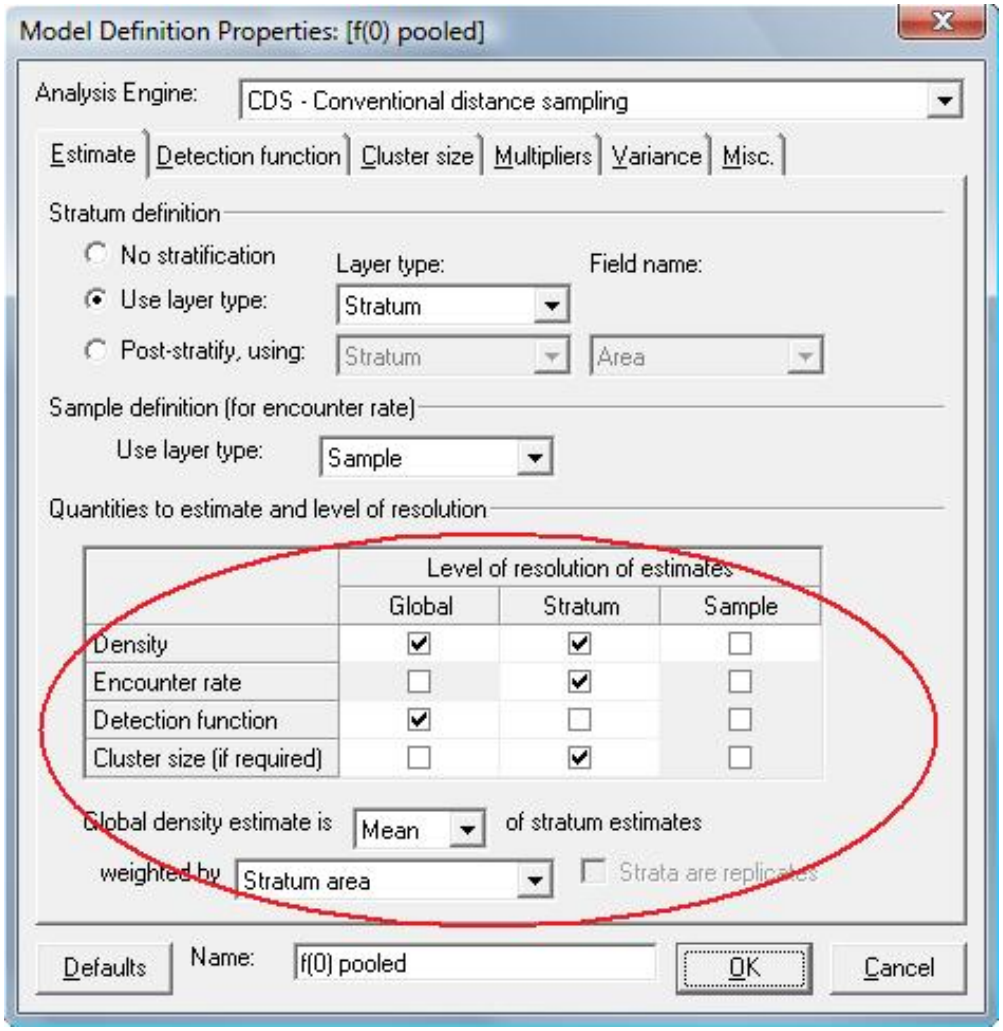


CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Example: $f(0)$ pooled



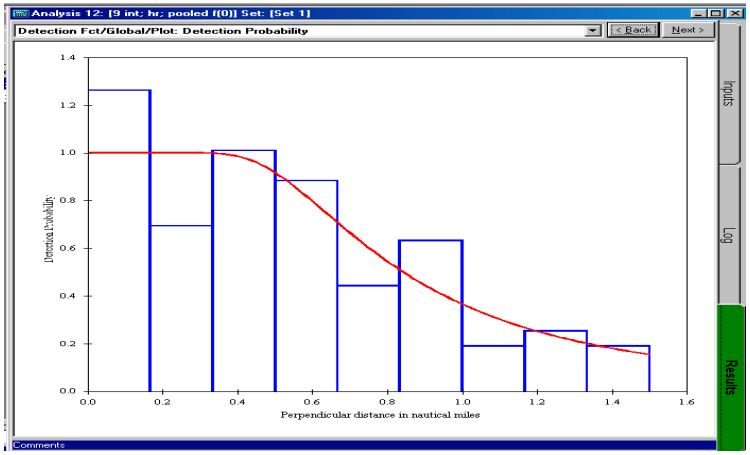


CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

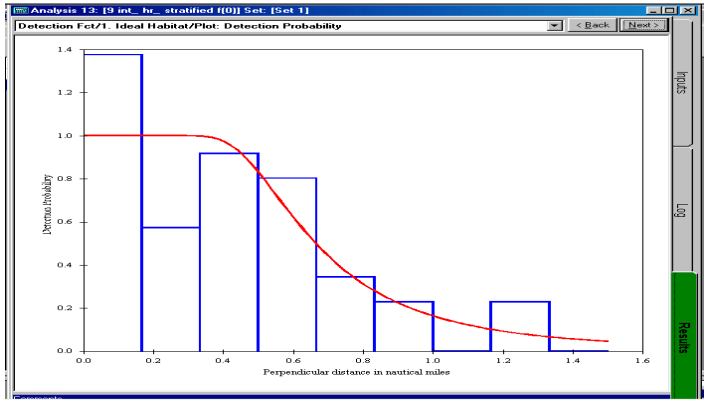
Pooled *vs* Stratified *f*(0)

Pooled *n*=88

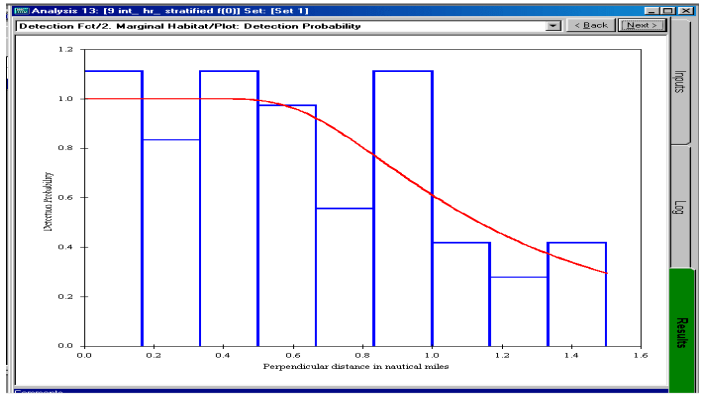


Stratified

Ideal Habitat *n*=39



Marginal Habitat *n*=49



CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

It is a Model Selection Problem

	Pooled	Stratum 1	Stratum 2	Stratum Sum
Log likelihood $\log_e(L)$	-180.490	-72.699	-104.676	-177.375
No. parameters (q)	2	2	2	4
AIC	364.980	149.398	213.352	362.75

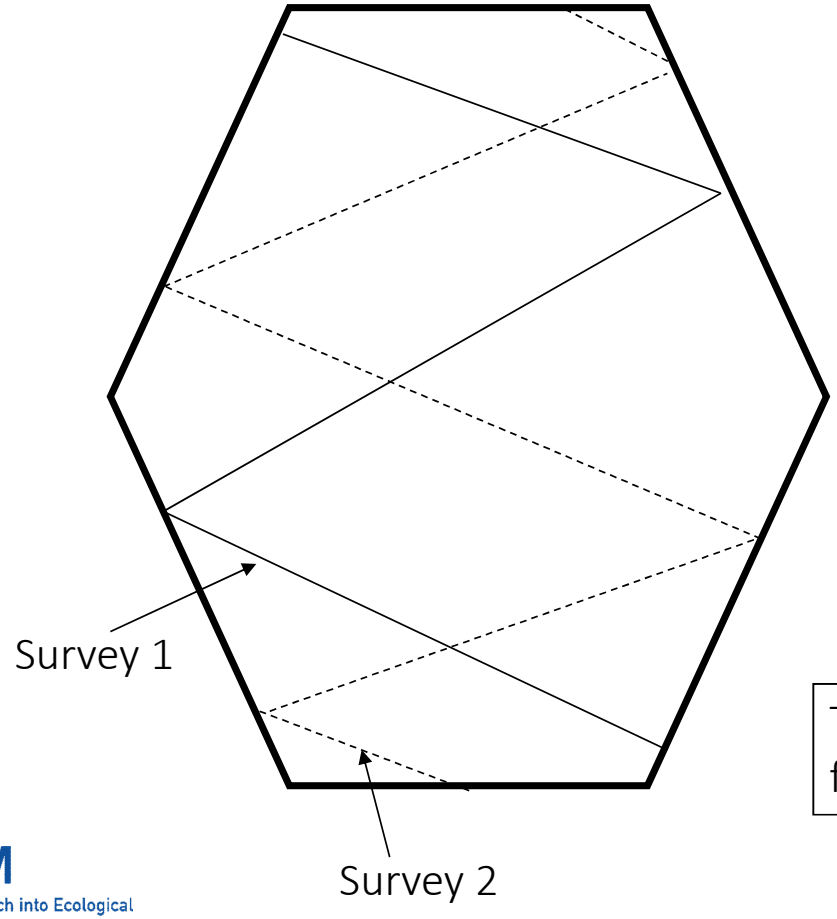
Criterion for stratification of $f(0)$:
Fit separate $f(0)$ for each strata if

$$AIC_{pooled} > \sum_{strata} AIC_{stratum}$$

CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Non-geographic stratification -- Stratification by survey



Let L_i be effort for survey i

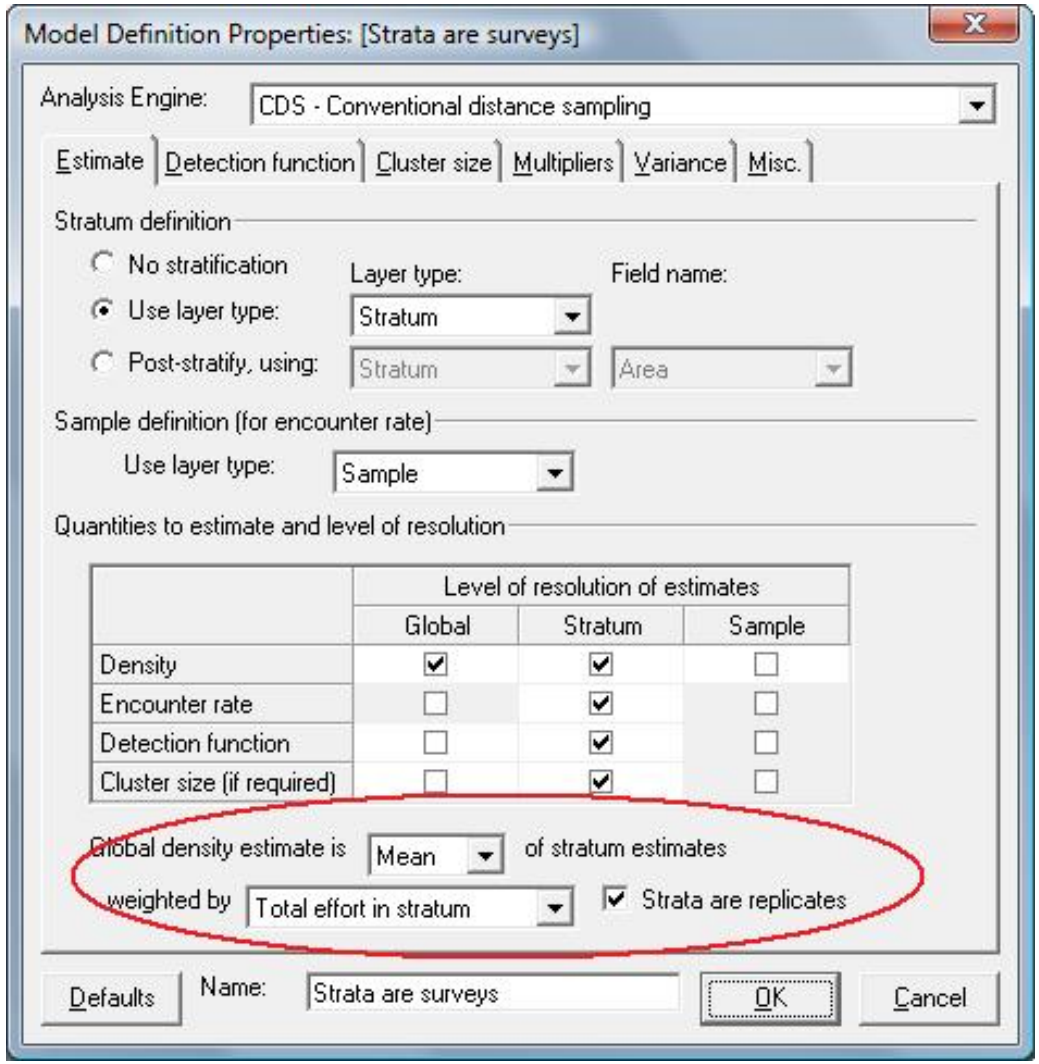
Global density is given by

$$\hat{D} = \left(\frac{L_1}{L_1+L_2}\right)\hat{D}_1 + \left(\frac{L_2}{L_1+L_2}\right)\hat{D}_2$$

$$= \sum_{i=1}^{2}\left(\frac{L_i}{L}\right)\hat{D}_i$$

This is the same form as before, but weighting factor now depends on effort

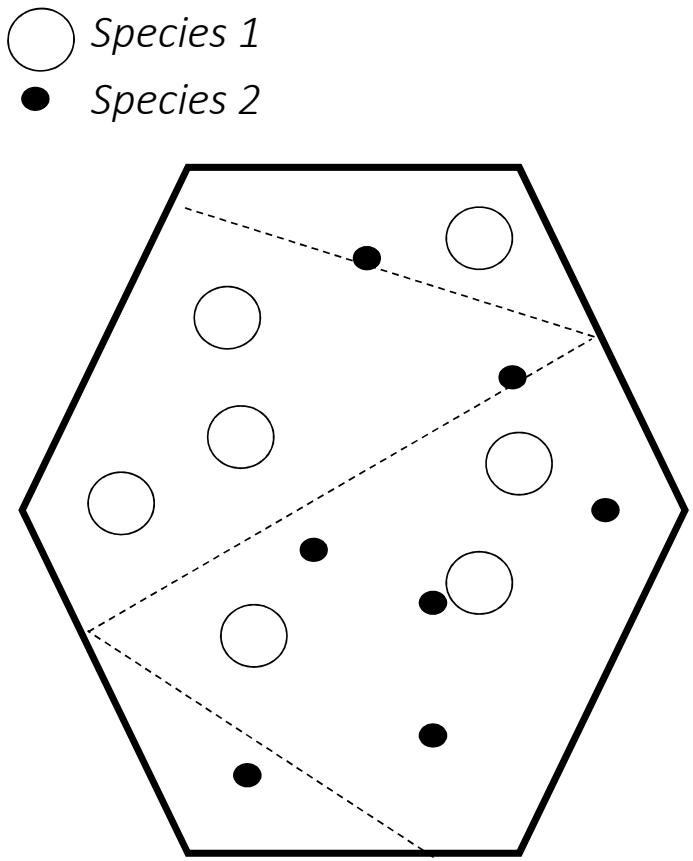
Stratification by survey



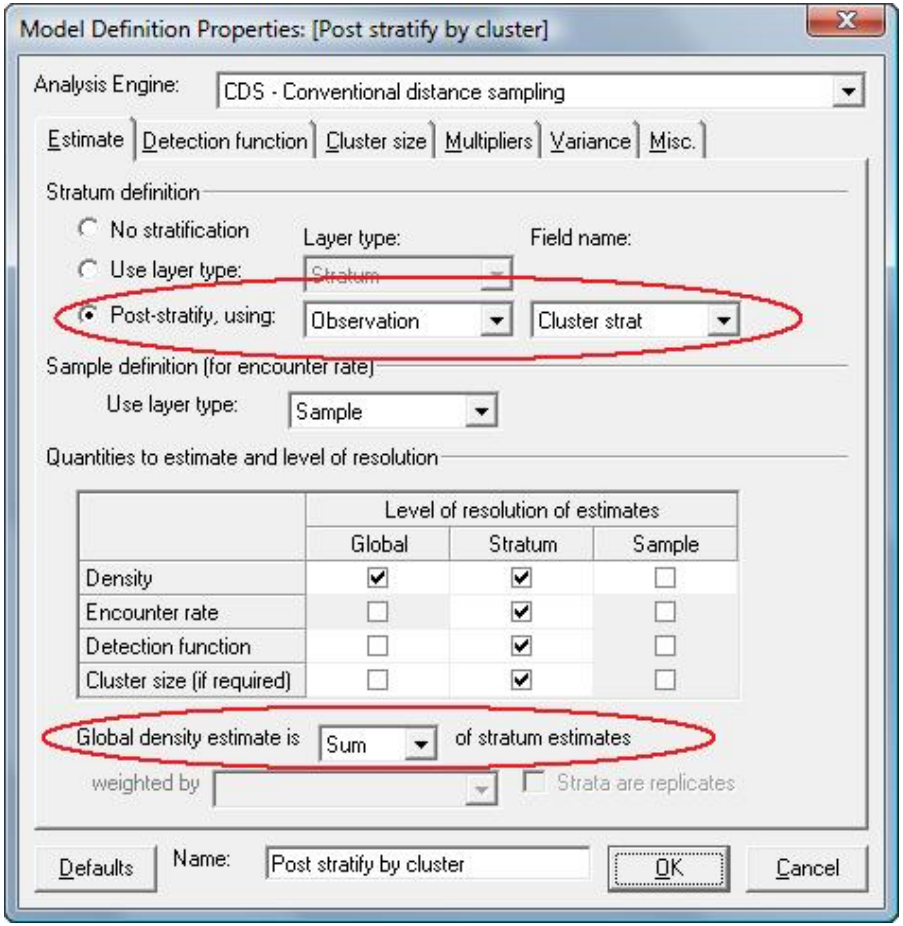
CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Stratification by species



$$\hat{D} = \hat{D}_{sp1} + \hat{D}_{sp2}$$

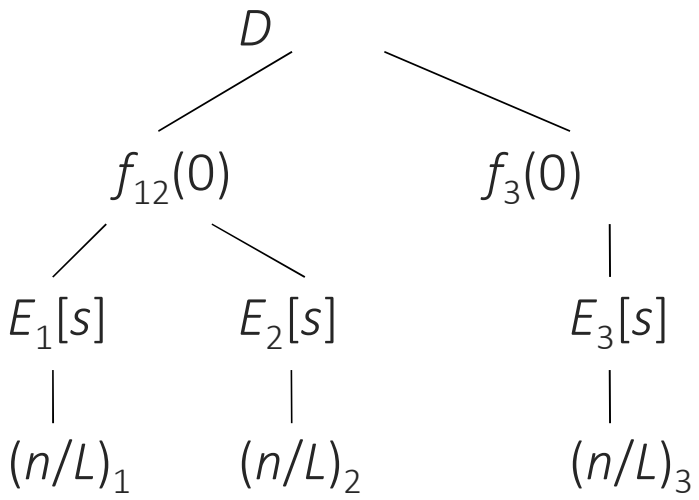


CREEM
Centre for Research into Ecological and Environmental Modelling

University of St Andrews

Limitations in Distance

- Distance cannot currently do multilevel stratification in one run
- Two runs are necessary
  - Estimate $f(0)$, $E[s]$ and n/L by stratum
  - Combine strata 1 and 2 to estimate $f_{12}(0)$
- Care must be taken when calculating CVs because the density estimates for stratum 1 and 2 have an estimated $f(0)$ in common



Alternatives to stratification in Distance

- Small sample sizes can lead to low precision in stratum-specific estimates
- An alternative approach to reducing bias due to heterogeneity is Multiple Covariates Distance Sampling (MCDS)
    - Covariates, other than distance, are incorporated into the scale parameter of the detection function
    - MCDS can be used to fit the detection function at multiple levels e.g. stratum-specific density estimates can be obtained even if you don't have enough data to fit separate detection functions for each stratum
    - MCDS methods are covered in an upcoming lecture.