Automated Survey Design

Aim: Use geographic information system (GIS) within Distance to aid survey design and evaluate the properties of different designs

See:

- Chapter 7 of Buckland et al. (2004) Advanced Distance Sampling

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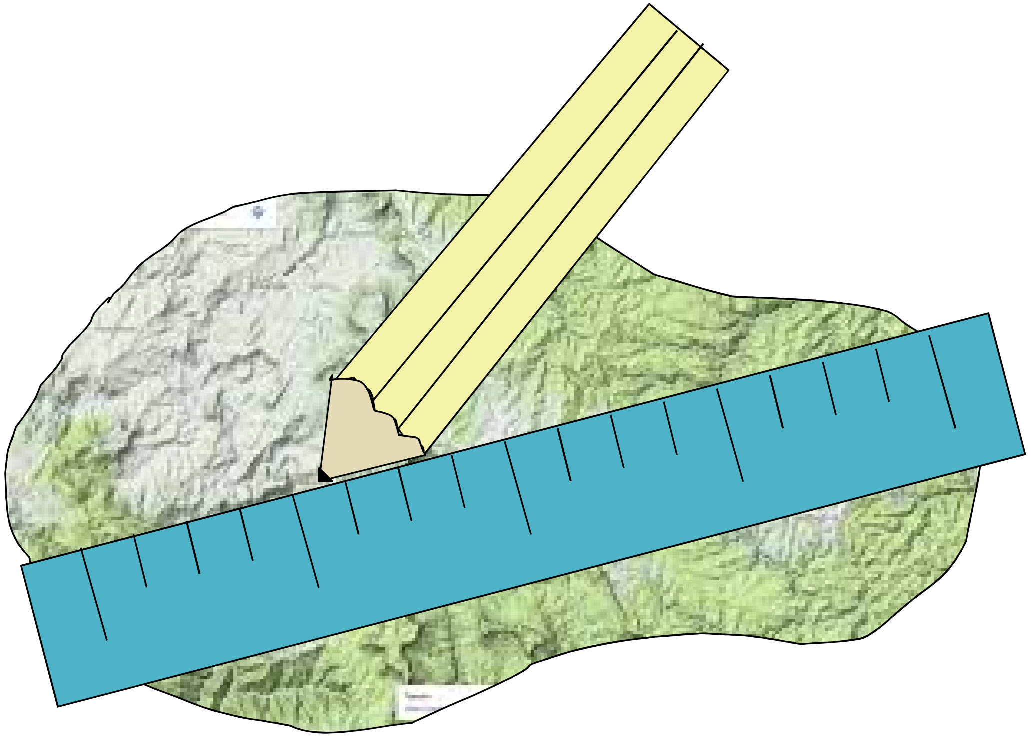
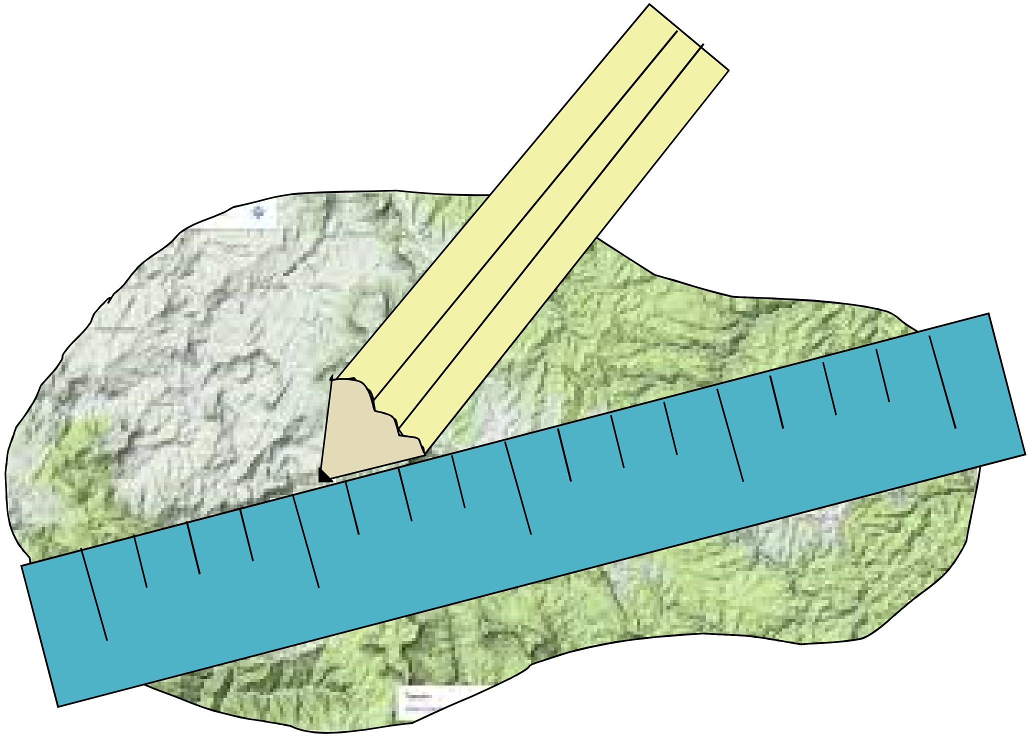
Background



- Randomize designs?
- Inefficient

Background



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Automated survey design using GIS technology

Easily generate surveys based on randomised designs

Print out maps or download to GPS

Evaluate properties of different designs

- *optimise for different situation*

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Terminology

Sampler – a sample unit

Strip (line transect)

Circle (point transect)

Design – an algorithm for laying out samplers

Survey – a single realisation of a design

Sampling strategy – design & estimator

Coverage probability – probability for a given design that a point within the survey region will be sampled

Example: # Coverage Probability

- Uniform coverage probability, π = 1/3

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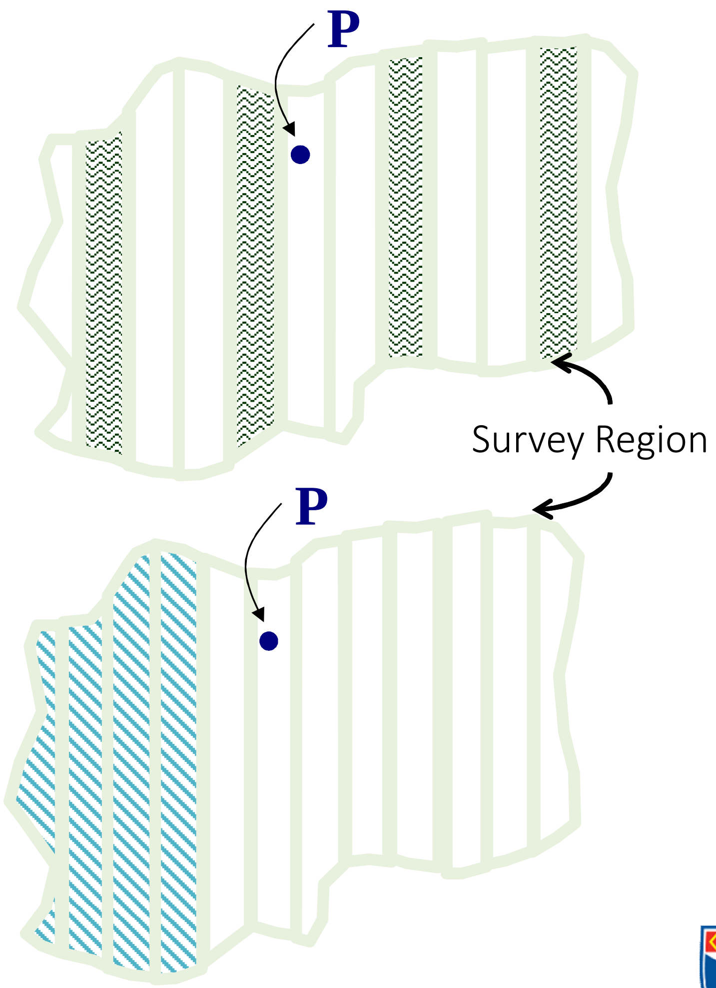

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Example: # Coverage Probability

- Uniform coverage probability, π = 1/3

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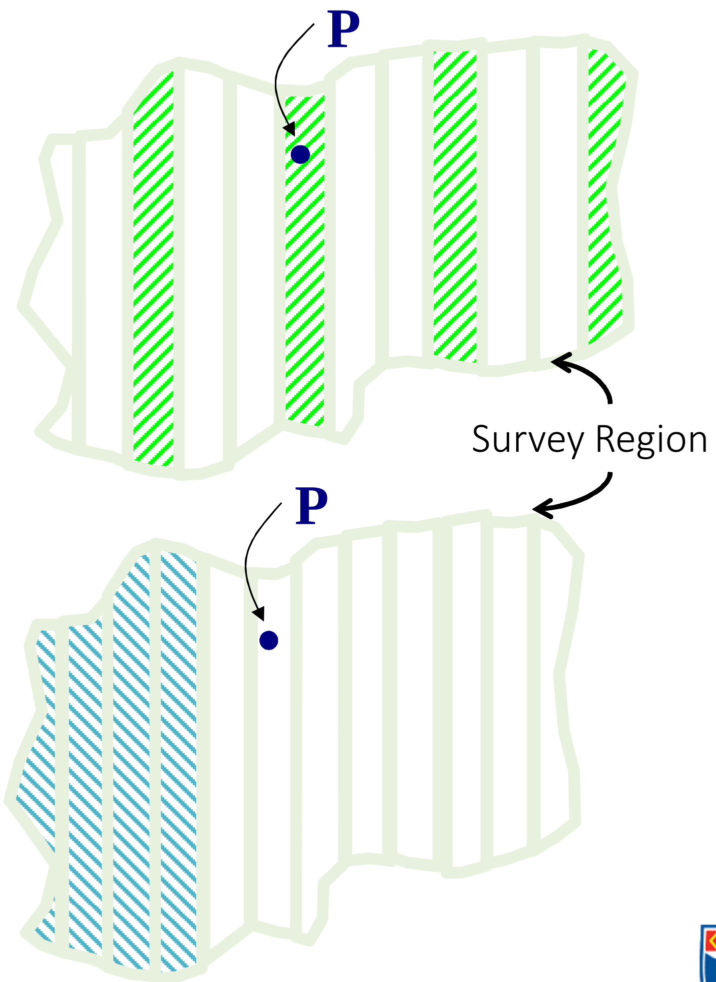

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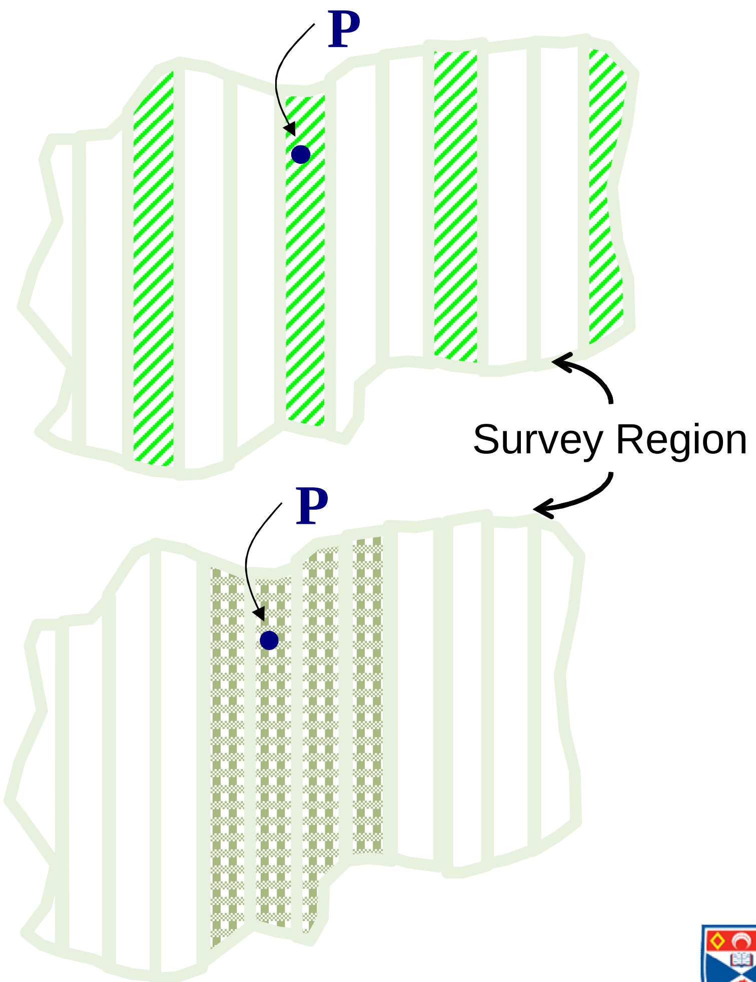
Example: # Coverage Probability

- Uniform coverage probability, π = 1/3



– Uniform coverage probability, π = 1/3

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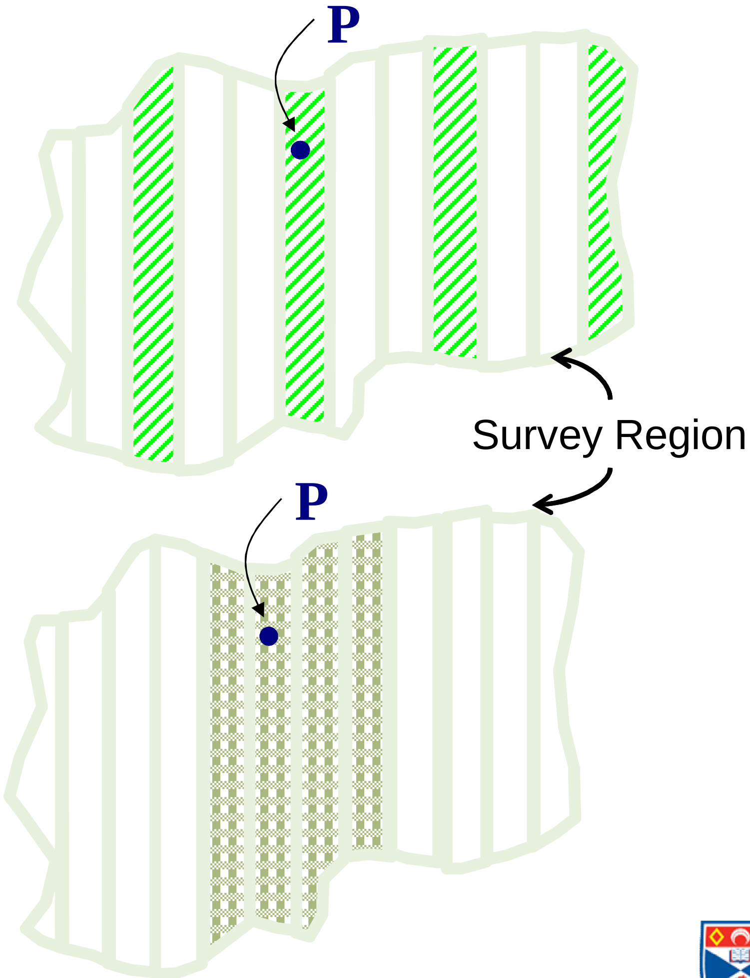
Example: Coverage Probability

- Uniform coverage probability, π = 1/3
- Even coverage for any given realisation

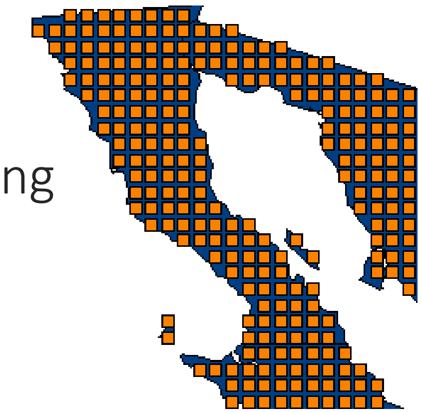
- Uniform coverage probability, π = 1/3
- Uneven coverage for any given realisation

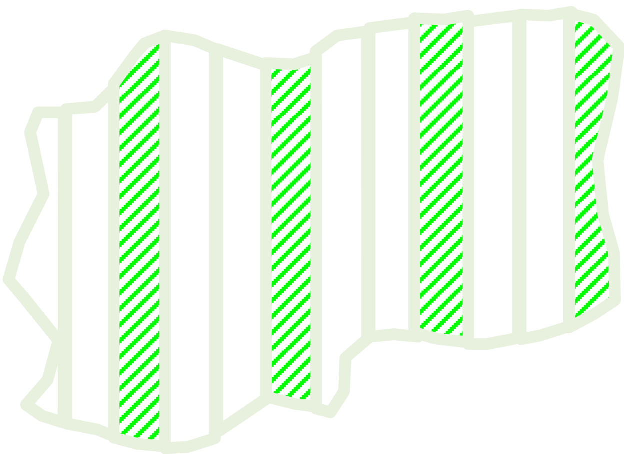


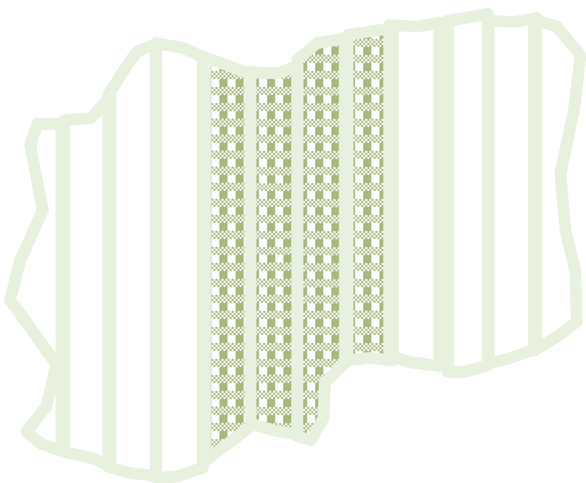
Which Design?

Even-ness of coverage within any realisation

Uniformity of coverage probability
- this can be assessed by generating many realisations and checking the coverage probabilities across a grid of points







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Which Design?

Overlap of samplers

Cost of travel between samplers

Edge effects

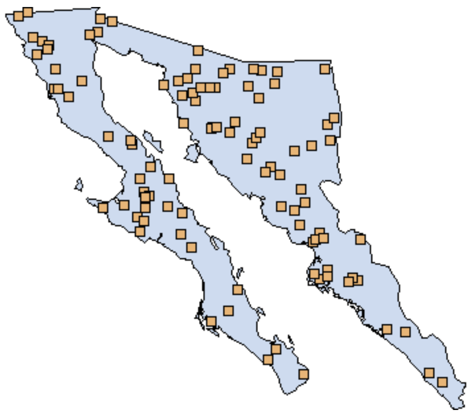
More samplers is better

Efficiency when density varies within the region

Placing lines parallel to the **density gradient**

Point Transect Designs

Simple Random



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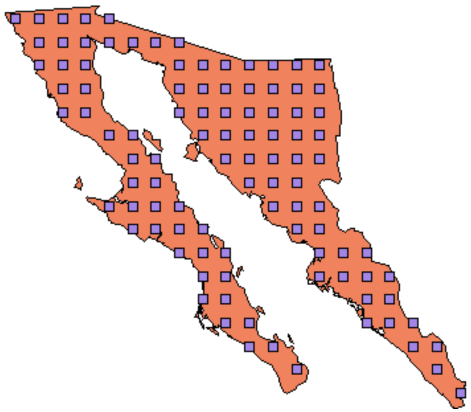
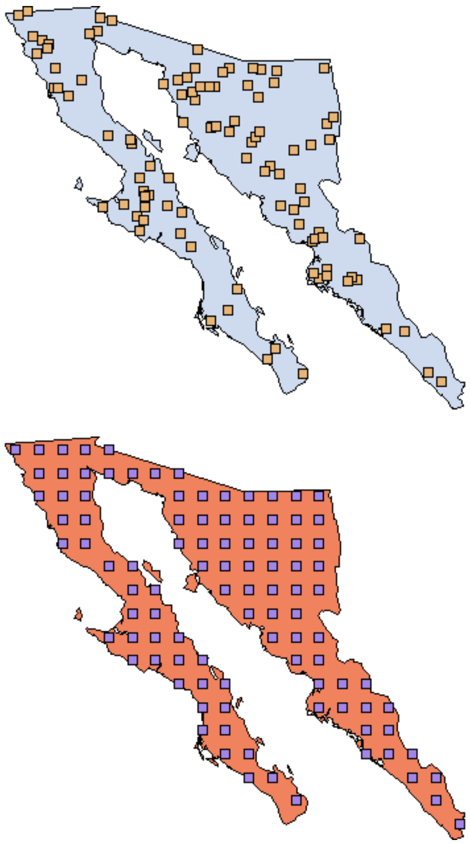


Systematic Grid

Point Transect Designs



Uniform coverage – both have uniform coverage probability

Systematic has more **even coverage** for any given realisation

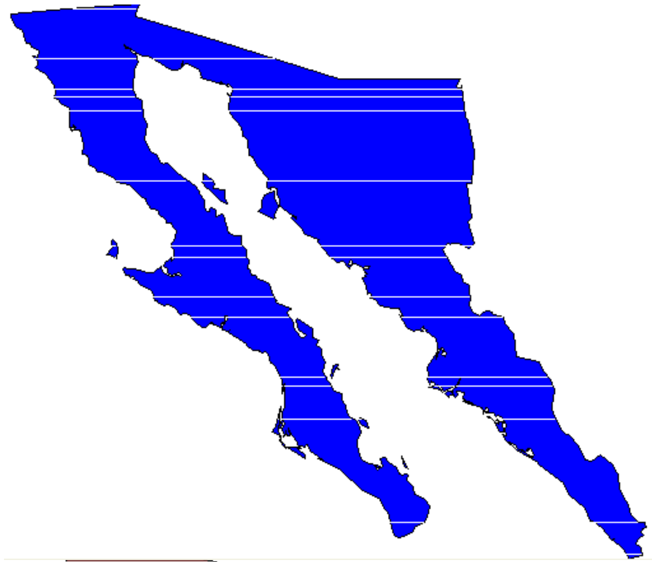
Can have **overlap** of samplers in simple random design

Cost of travel is similar

- If this is important a cluster sampling design can be used

Line Transect Designs - Full Length Transects

Parallel Random



versus

Systematic Random

Often used in aerial (and sometimes shipboard) surveys

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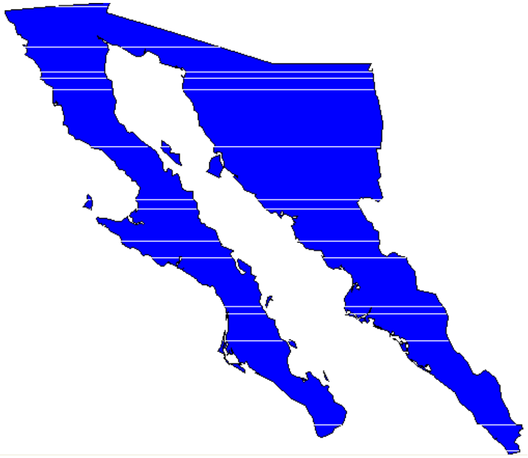
Line Transect Designs - Full Length Transects



Uniform coverage – both have uniform coverage probability

Systematic has more **even coverage** for any given realisation

- **Coverage** for a given realisation is more critical as there tend to be fewer lines than points – lines are more expensive.

Transit (off-effort) time can be considerable for both designs

Can have **overlap** of samplers in parallel random design

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Segmented Line Transect Designs - Fixed Length Transects

Systematic segmented trackline

Systematic segmented grid

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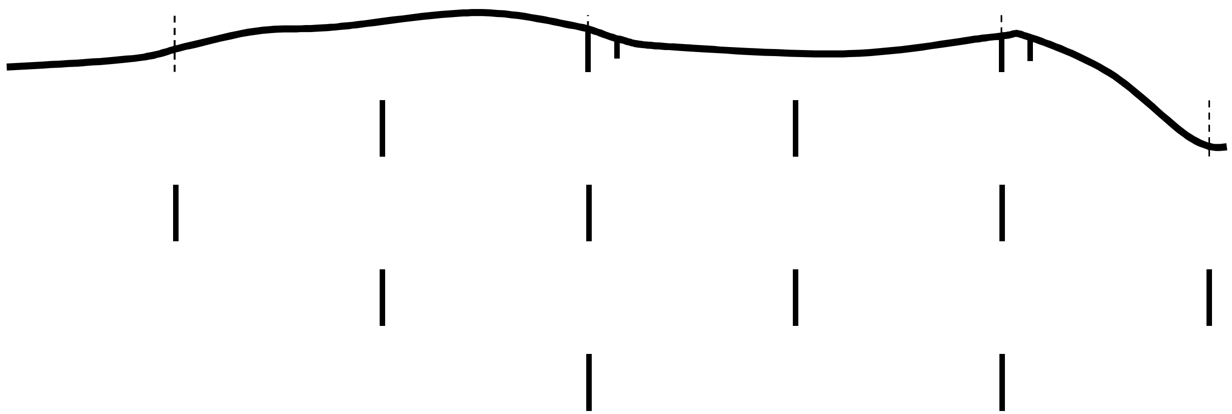
Edge Effects

Not a problem if you are willing to survey incomplete segments

Otherwise you could reflect back incomplete segments already more than ½ inside



This gives even coverage probability but is hard to reliably automate (not automated in Distance)

Edge Effects (contd.)

Could push segments back in if they are more than ½ inside

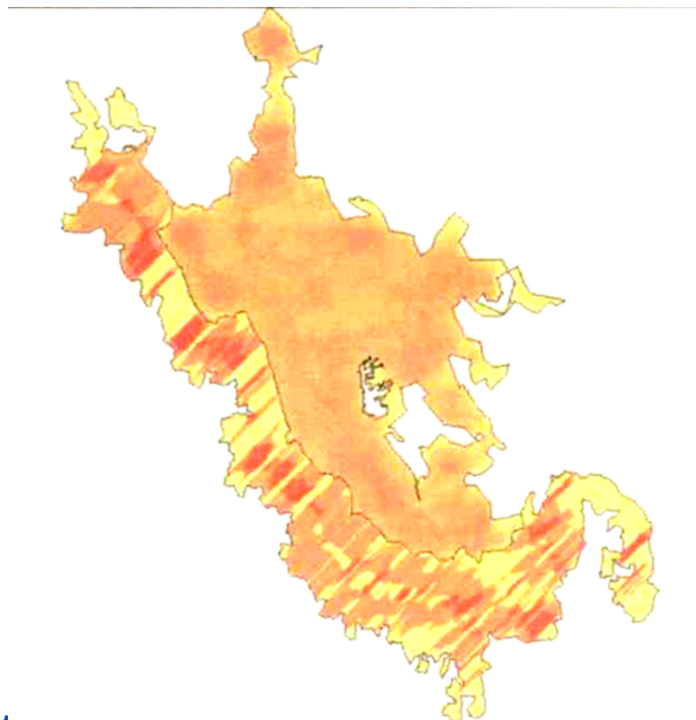
Systematic segmented trackline

Systematic segmented grid

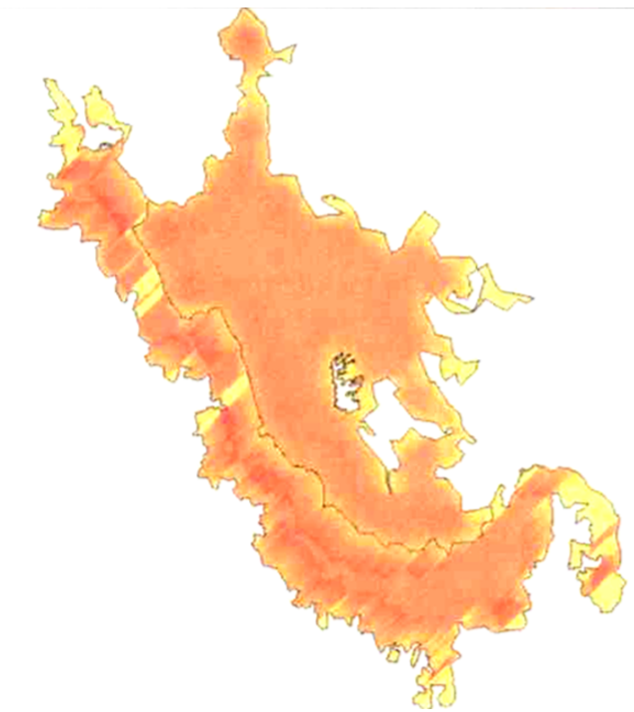
Edge Effects (contd.)

… but this leads to uneven coverage probability near the edge

Systematic segmented trackline



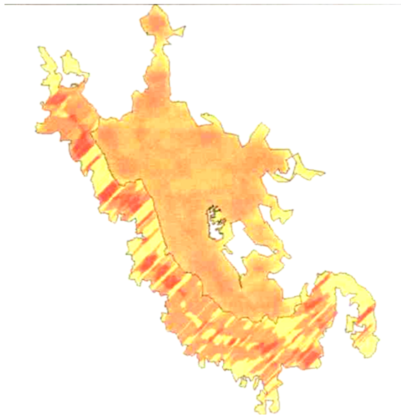
Systematic segmented grid



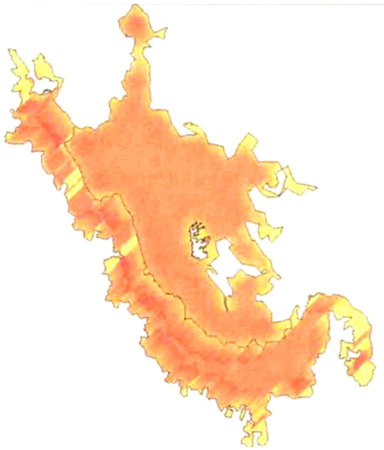
N.B. Both use random orientation of transects in the northern stratum

Fixed Length Line Transects - considerations

Systematic segmented trackline



Systematic segmented grid



Systematic segmented grid gives more uniform coverage probability

Random orientation of lines (Northern strata) gives more uniform coverage probability

- in Distance, type -1 under angle in Effort Allocation tab
- is orientation important in relation to density gradient? Consider reducing the segment size

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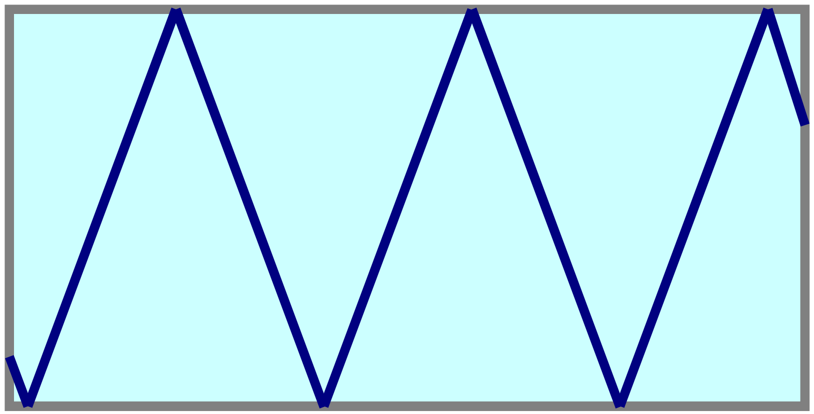
Zig-zag Line Transect Designs

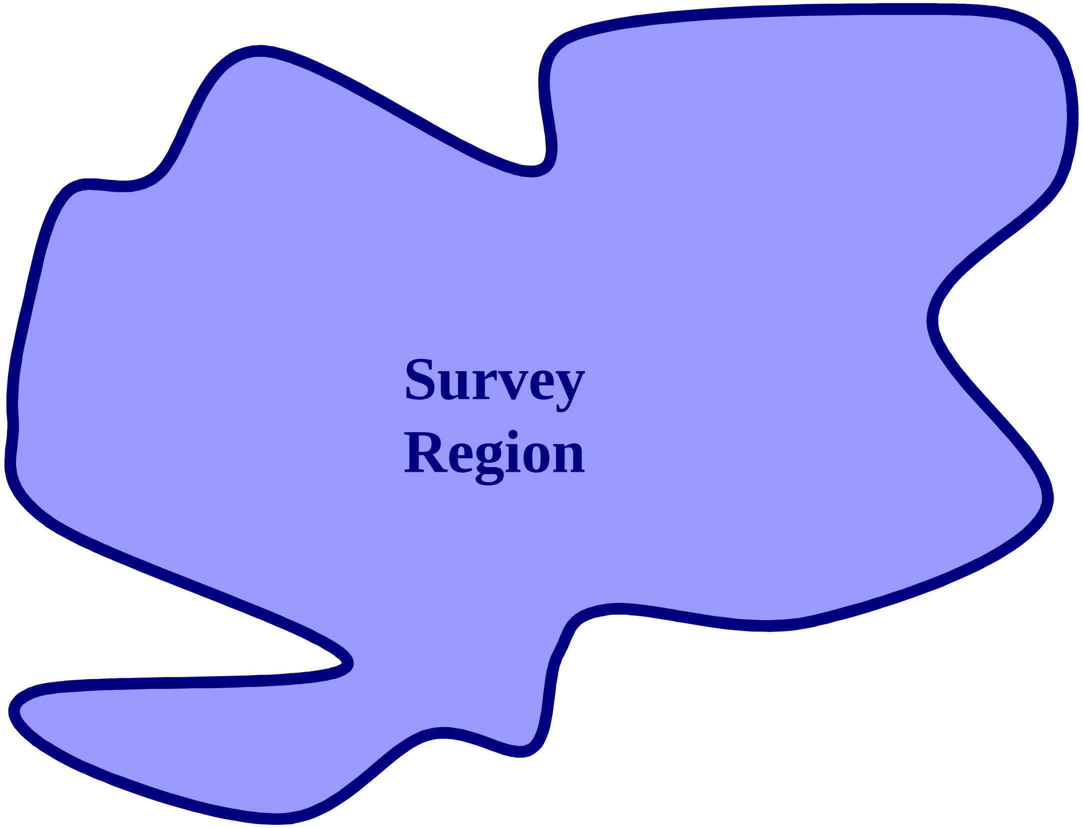
Used commonly in shipboard surveys



- **Advantage** (over systematic parallel)
  - Improved efficiency
- **Disadvantages**
  - Design is difficult in complex regions
  - Coverage probability may be uneven

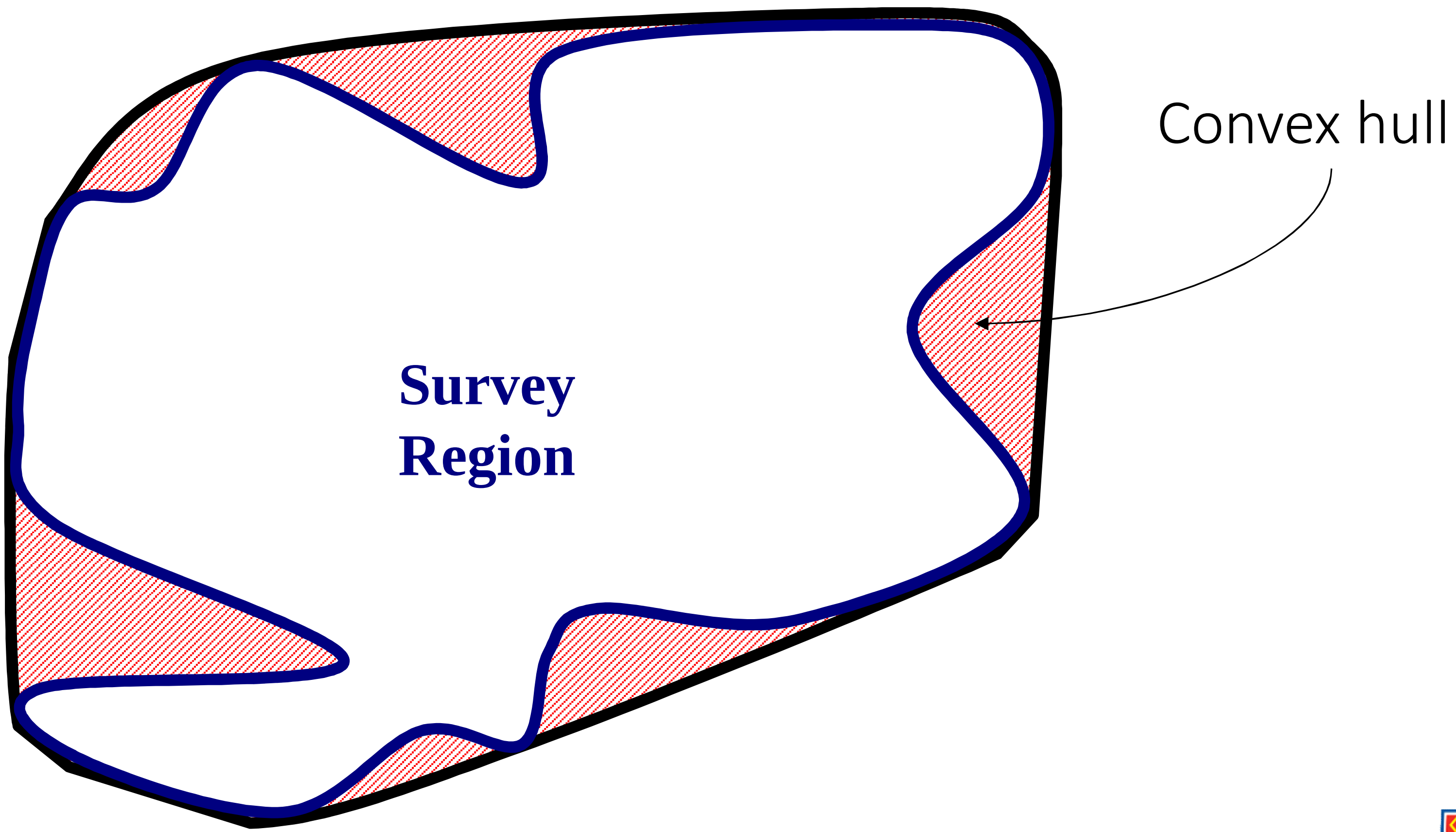
Design Difficulties

non-convex survey region



Design Difficulties

non-convex survey region



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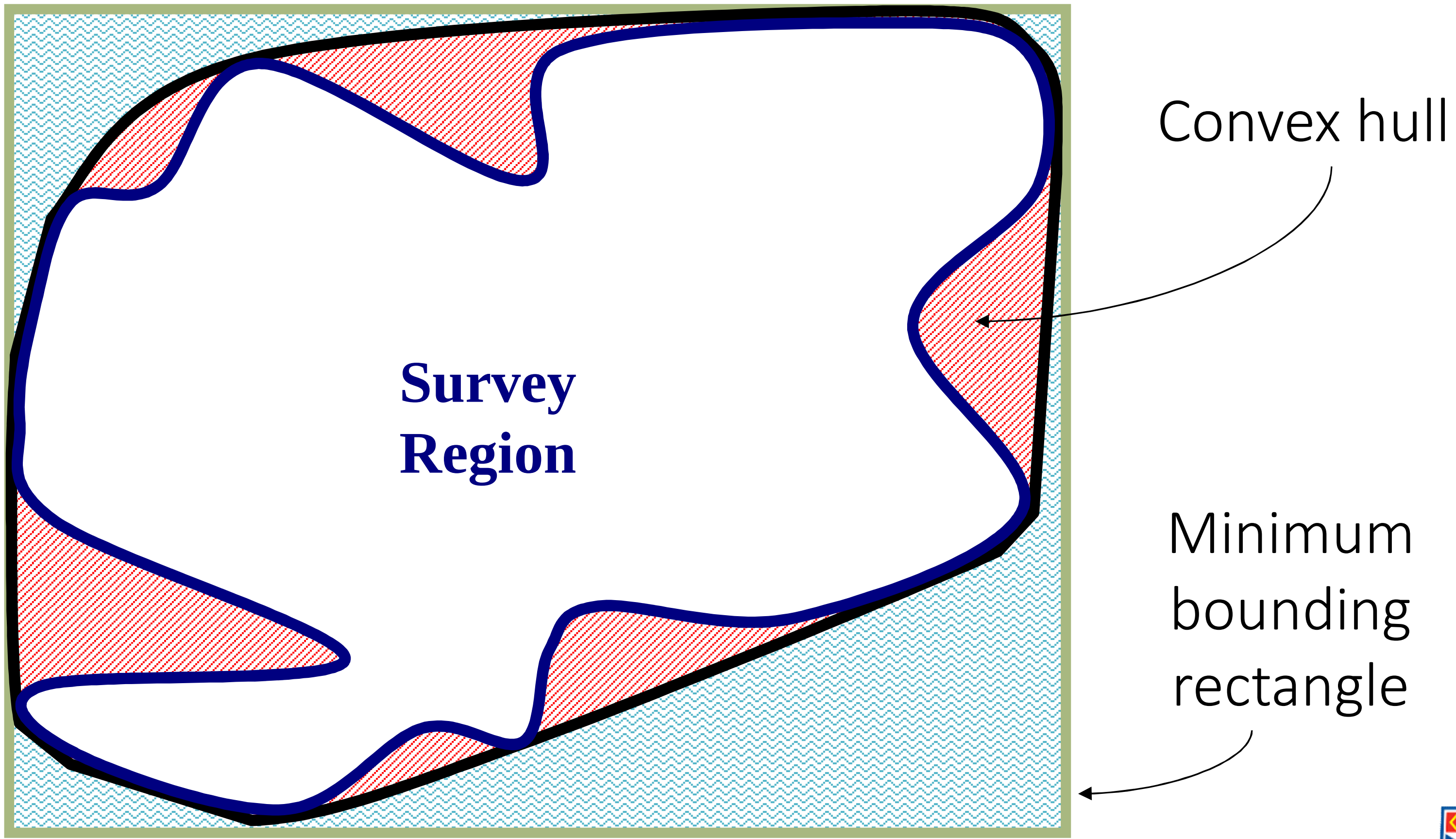
Design Difficulties

non-convex survey region



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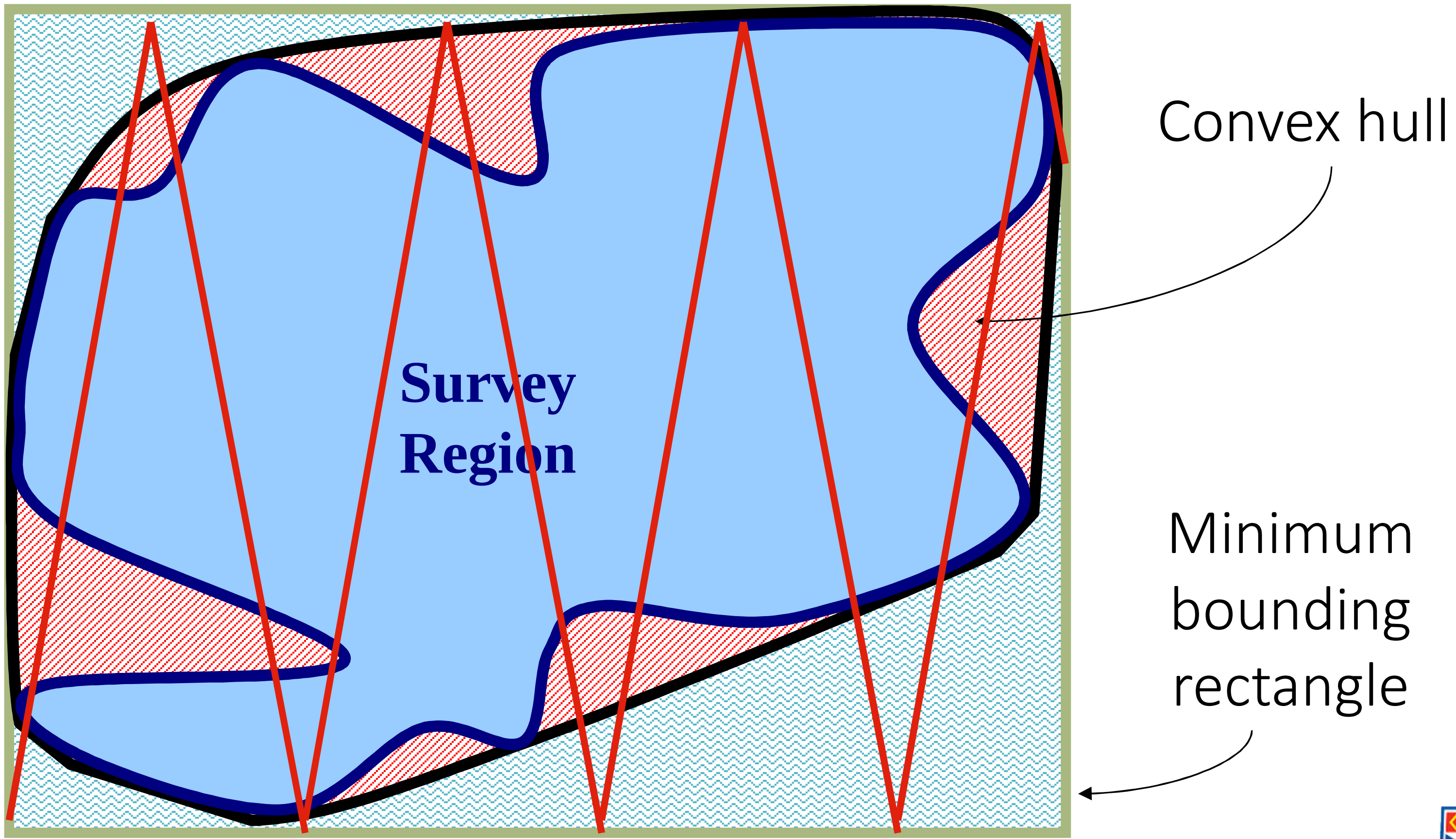
Design Difficulties

non-convex survey region



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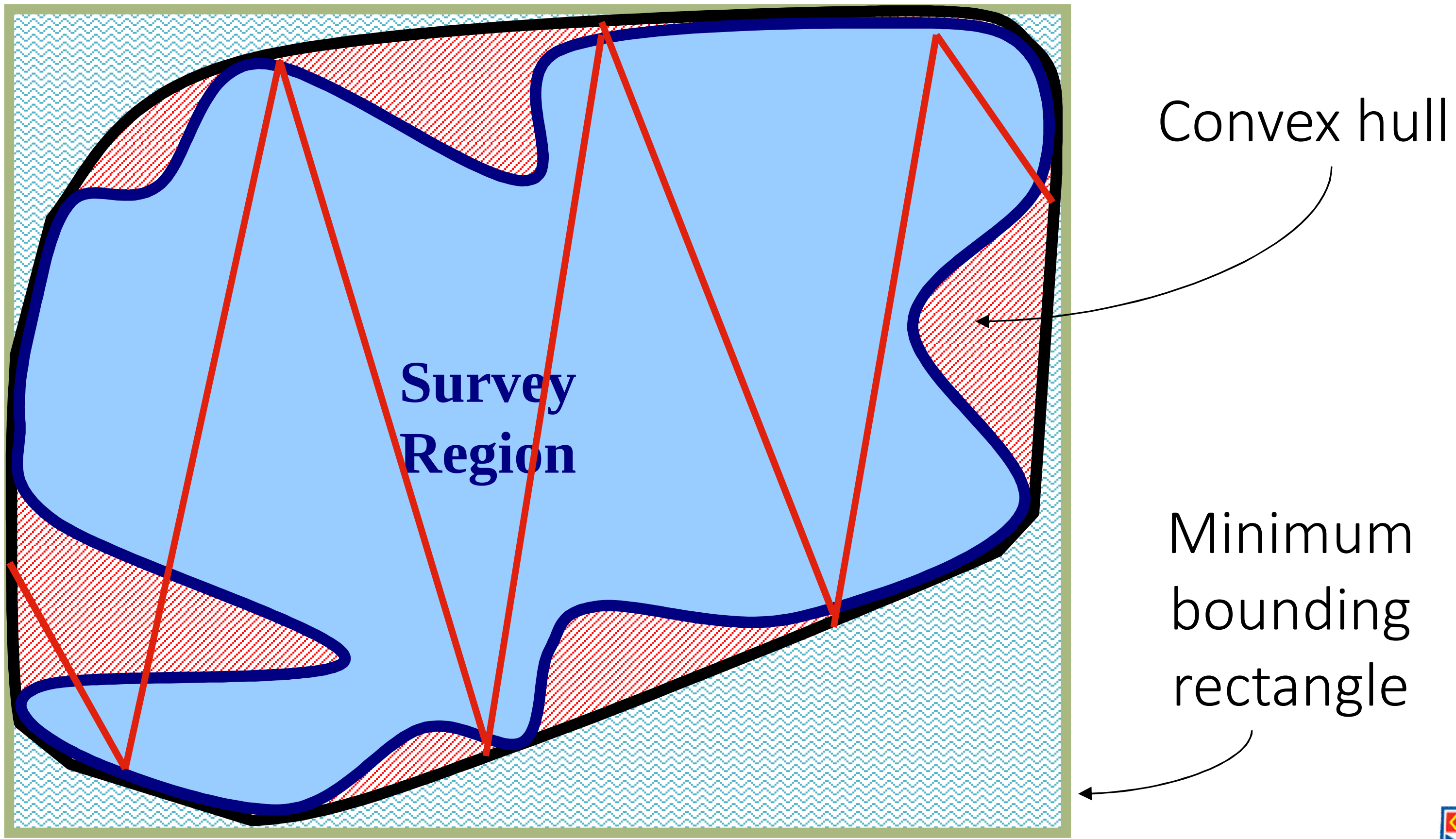
Design Difficulties

non-convex survey region



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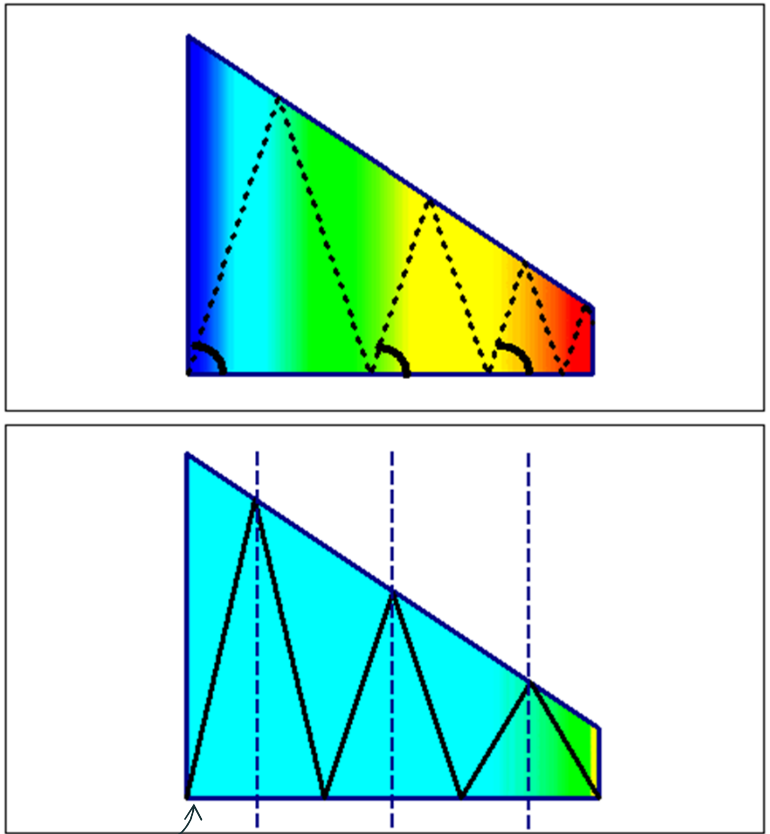
Coverage probability for zig-zag designs

Equal angle zig-zag

Equal spaced zig-zag



Should employ random start point

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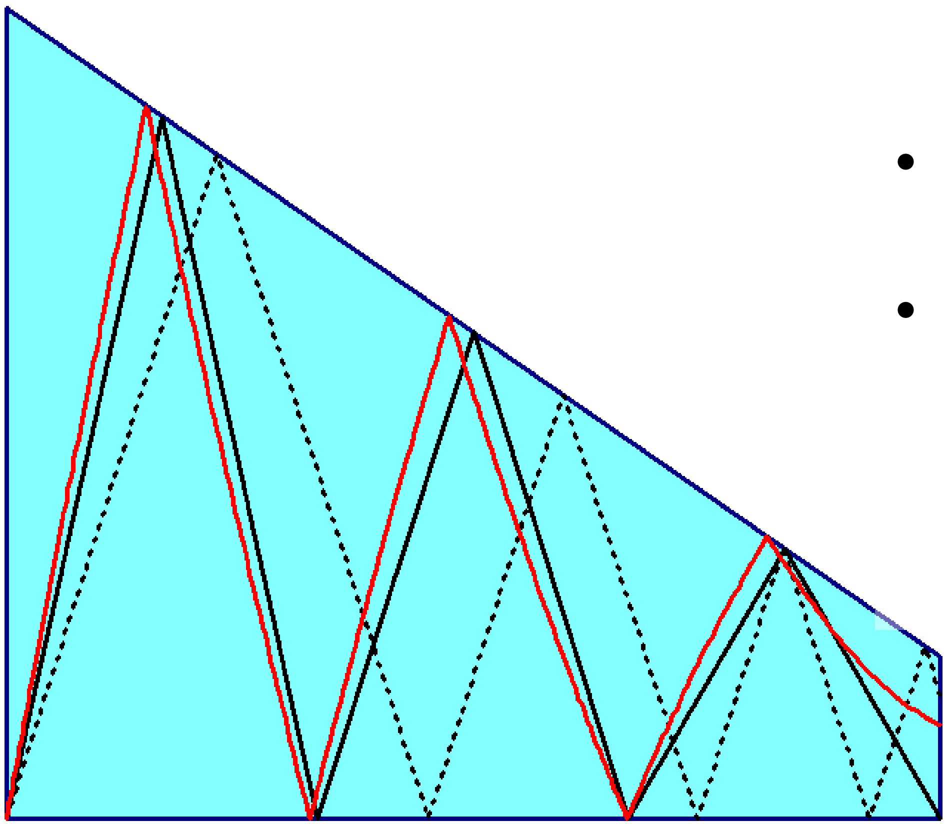
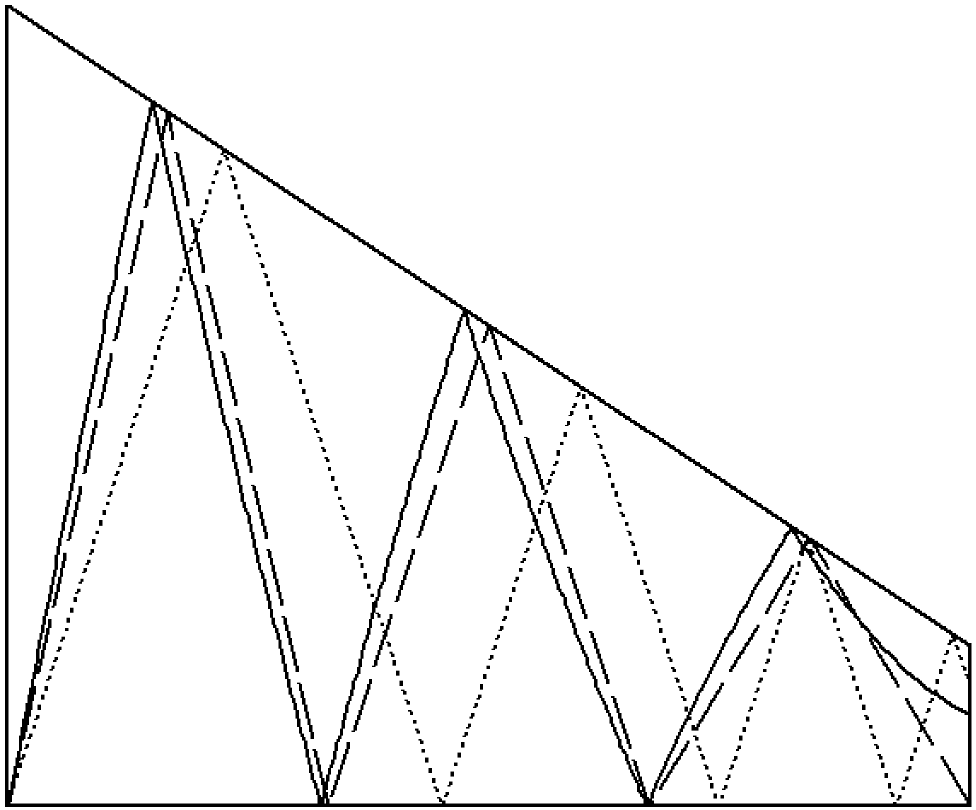
Coverage probability for zig-zag designs (contd.)

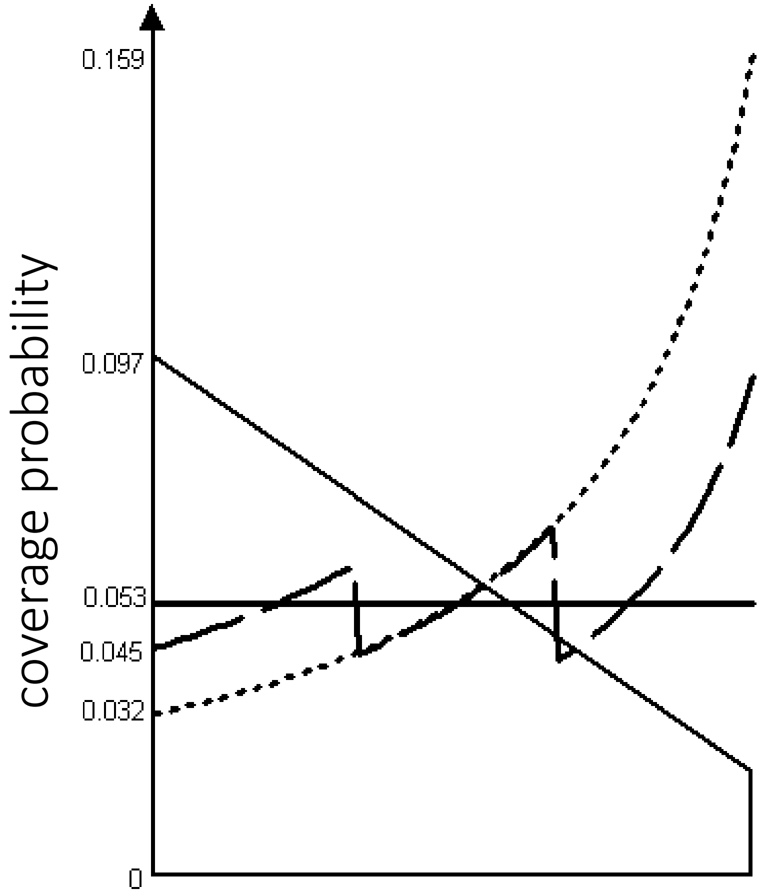
Adjusted angle zig-zag



- Even coverage probability parallel to the design axis
- In practise, approximate curved path with a series of straight lines

Coverage Probability Comparison for Zig-zag Designs





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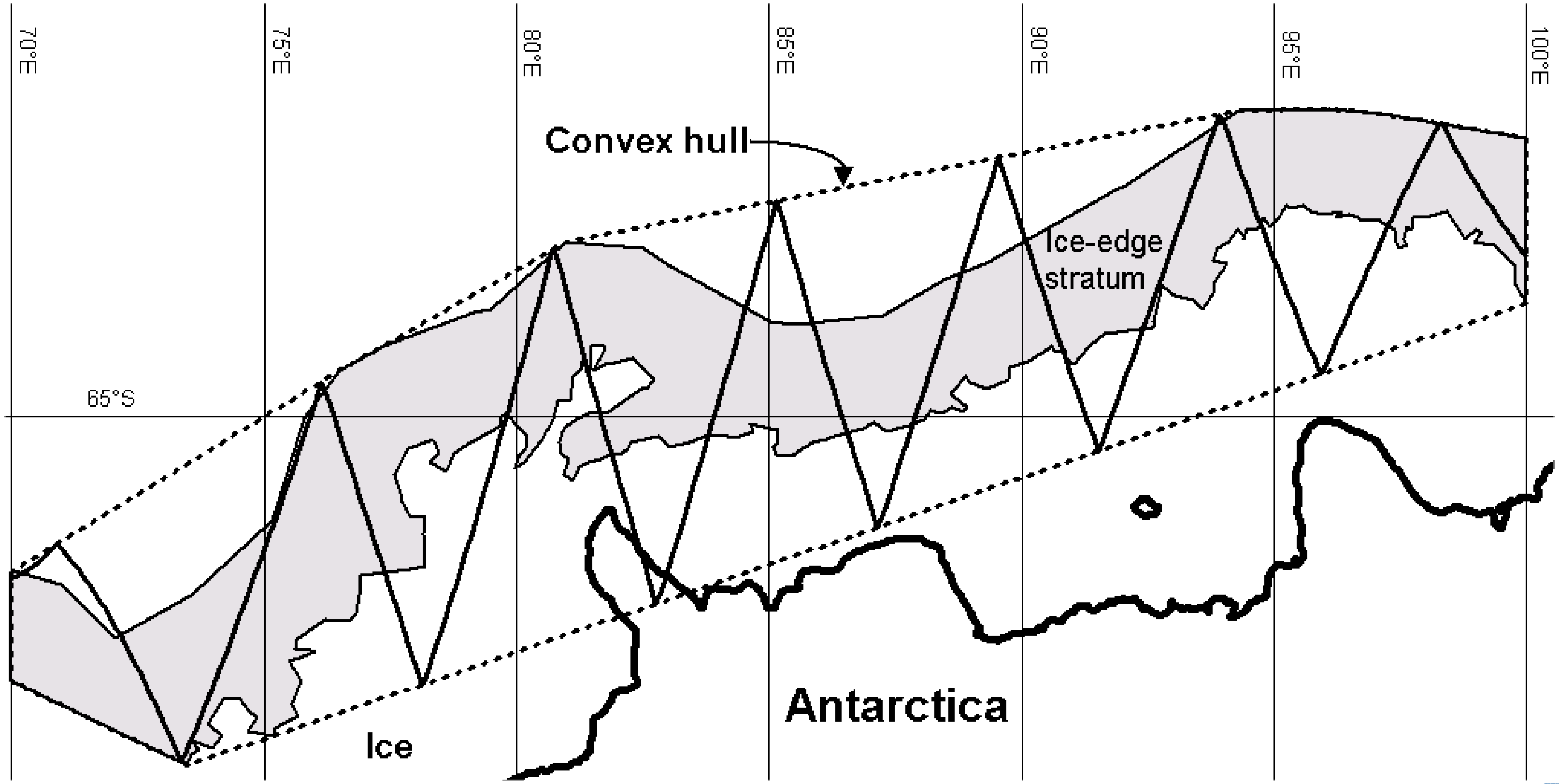
Further tips and examples…

Dealing with Complex Survey Regions

Example: Antarctic shipboard survey



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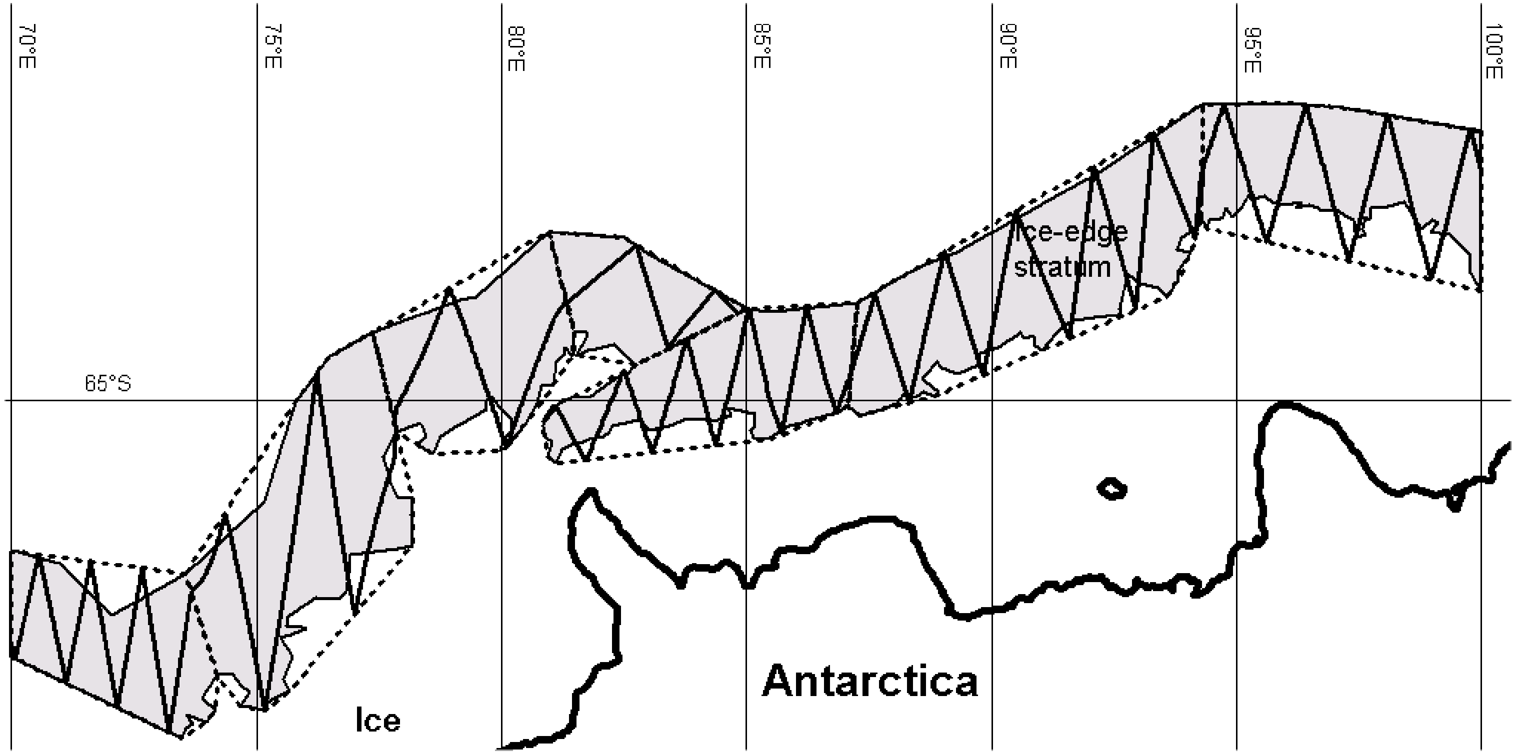
Dealing with Complex Survey Regions

Example: Antarctic shipboard survey, (contd.)

Study region divided into suitable strata to increase efficiency



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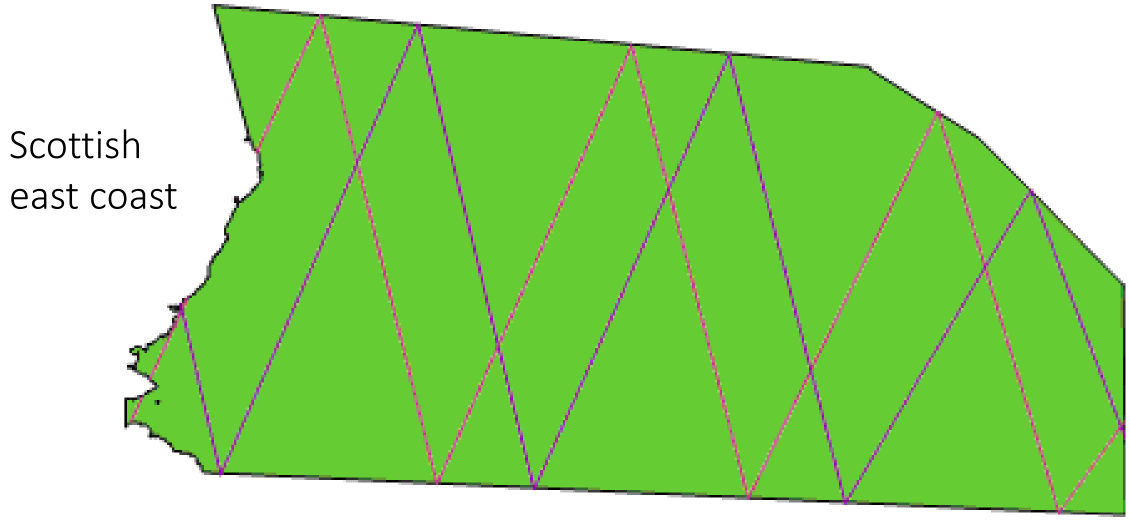
Efficiency

Example: SCANS II – ship survey in North Sea

Cross survey region twice



Effort Allocation

Example: SCANS II – aerial survey

Distance outputs total track length for survey

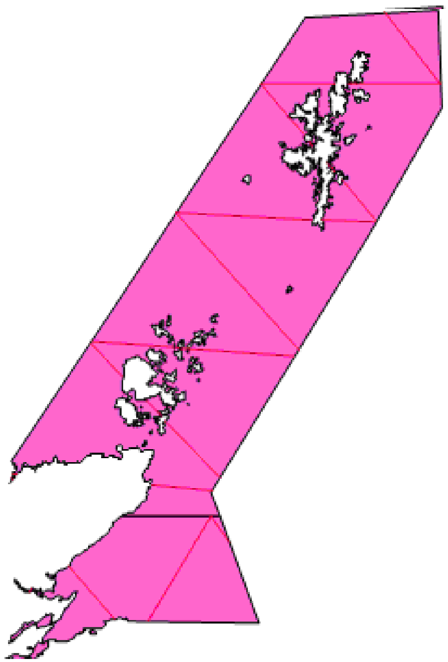
Considerations:

Total effort available

Required transit effort

Rest periods

Spare survey



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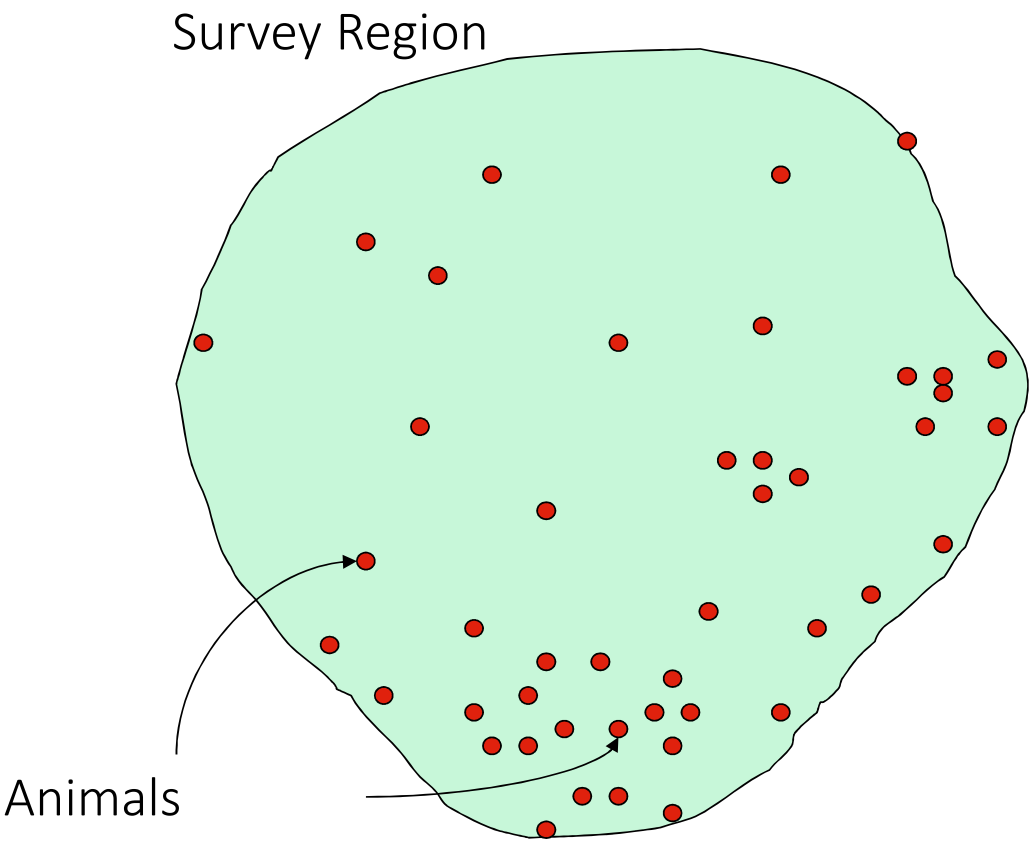
Density Variation



Systematic generally more reliable

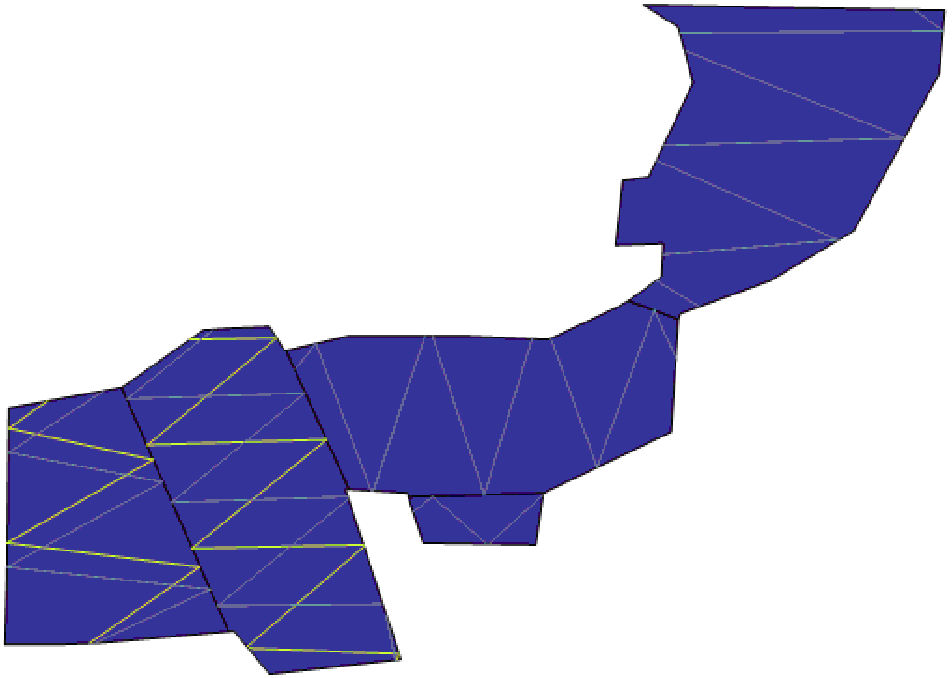
If variation in density is predictable

- Consider stratification
- Or unequal coverage probability design (if you have unequal coverage probability but know what it is then you can account for it)

Consider fitting a density surface model and obtaining a model-based estimate

Stratification

- Example: SCANS II – aerial survey
- Stratification based on prior knowledge of animal density



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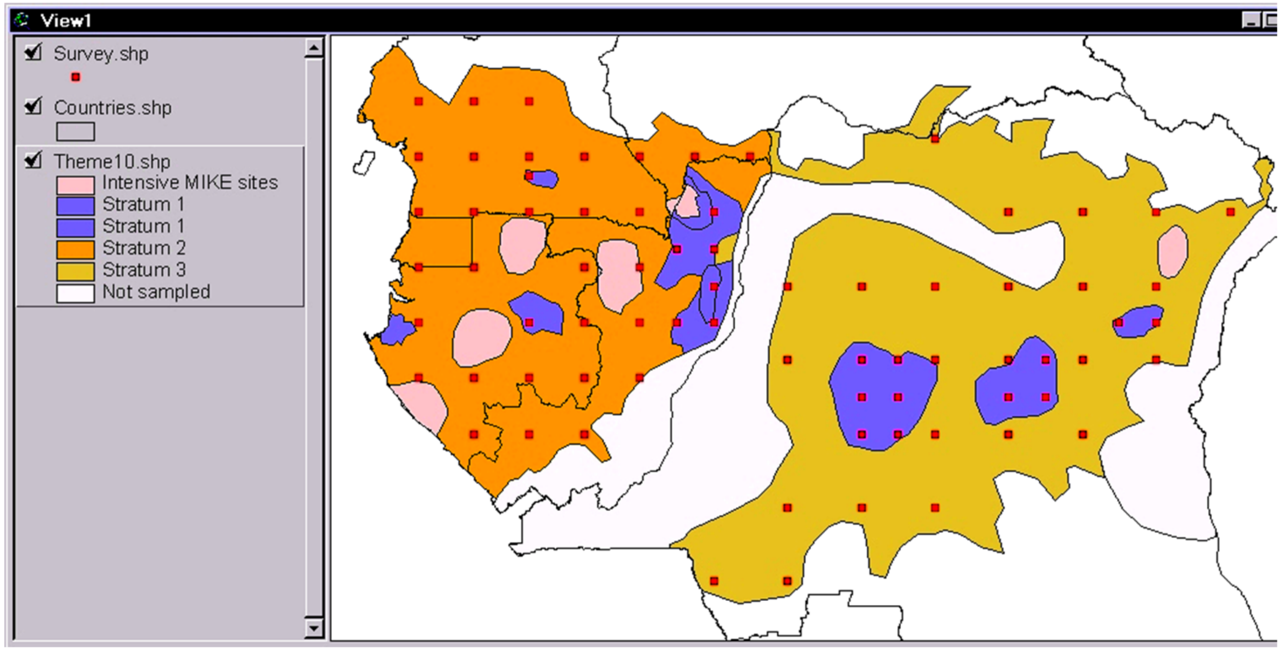
Example of Stratified Point Transect Design



Example showing complex nested strata: a nested grid

Effort allocation set using formulae in Section 7.2.2.3 of *Introduction to Distance Sampling*

(For more about this example, see Central Africa Pilot Project at https://cites.org/eng/prog/mike/pilot/index.shtml)

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Main Points

Distance helps you assess whether your design will give uniform coverage probability

Systematic designs give more even coverage for any given survey leading to more reliable estimates of density and abundance when density may vary throughout the region

Line transects are preferable

- Parallel designs give uniform coverage
- Zig-zag designs are more efficient and usually more practical (efficiency in complex regions can be increased by dividing the study region into a set of more convex shapes)
- Lines should be placed parallel to the density gradient (perpendicular to the density contours)
- Otherwise should be placed to maximise number of samplers