Introduction to Distance Sampling

Overview of wildlife population assessment methods

Plot sampling

Distance sampling

- Basic idea
- Types of distance sampling

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Wildlife Population Assessment

How many are there?

What are their trends?

Why?

- Vital rates (survival, fecundity, etc)

What might happen if…?

- Scenario planning
- Risk assessment
- Decision support

Rapid assessment methods and indices

Perhaps emphasis is just on trends

- Questionnaire surveys
  - *e.g. UK adder survey*
- Presence/absence
  - *e.g. UK otter surveys*
- Index methods
  - *e.g., Point counts for birds (US Breeding Bird Survey)*

Warning!

- For estimating trends, must assume no trend in proportion detected

Methods of estimating abundance

- Complete census
- Plot sampling
- Distance sampling
- Mark-recapture
- Removal method

Complete census

Let

N = population size (abundance)

A = size of study region = 5000

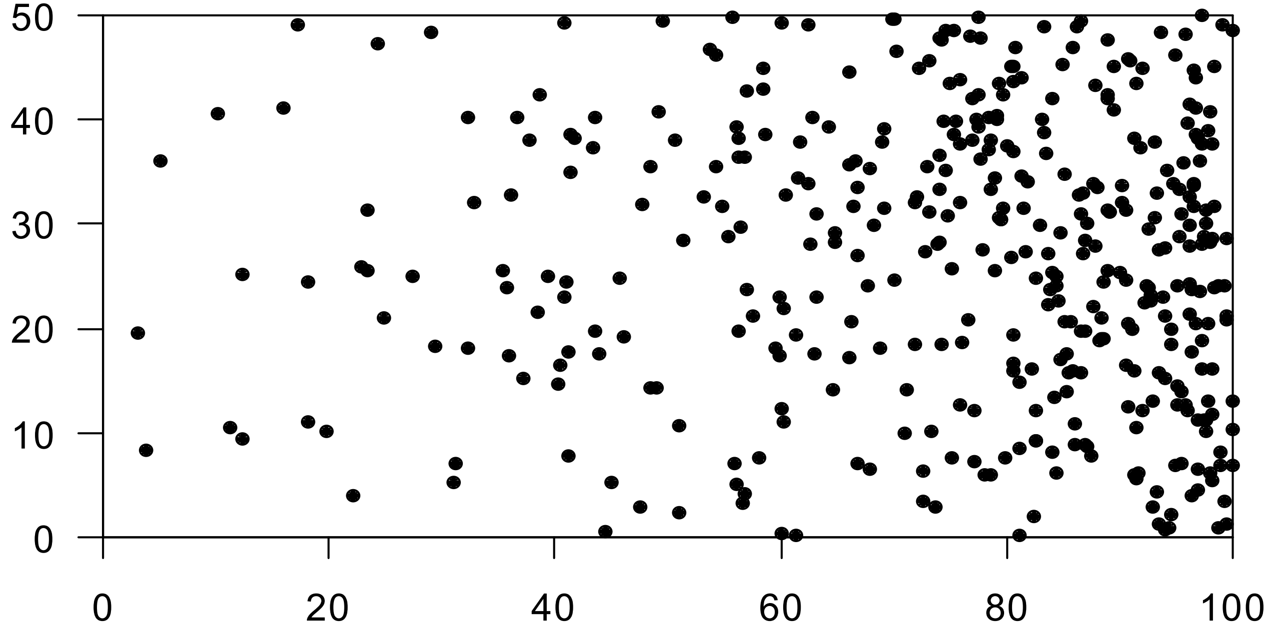
D = animal density = N/A

Method: count everything!

N = 412

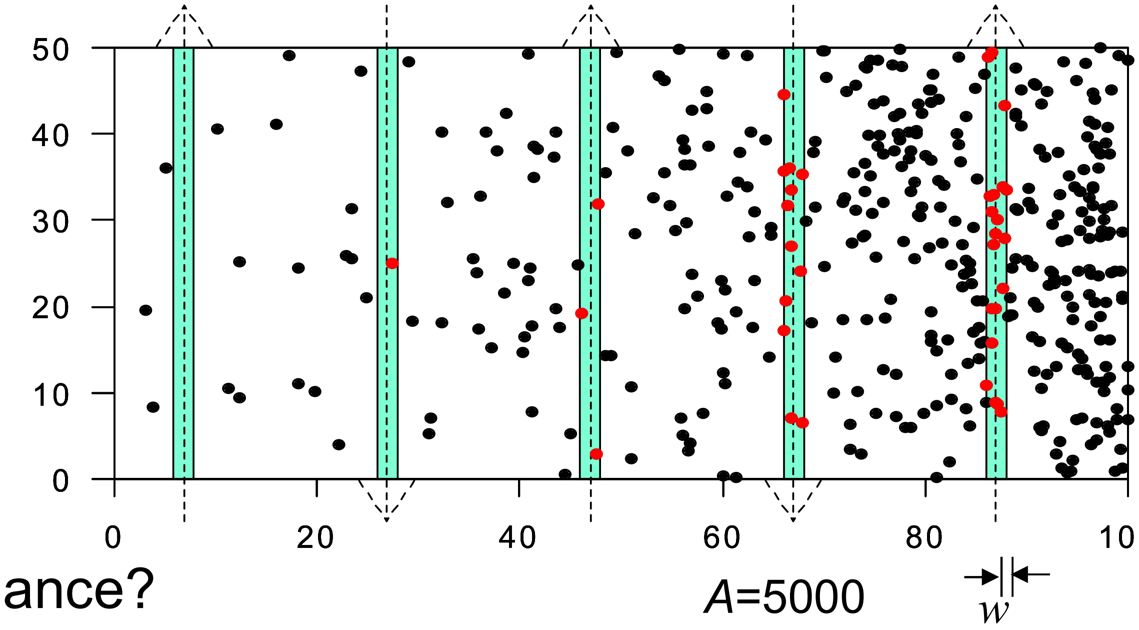
D = 412/5000 = 0.0824

Rarely possible in practice!



Plot sampling (or strip transect)

- Let
  - k = number of strips = 5
  - L = total line length = 50x5 = 250
  - w = the strip half-width = 1
  - a = area of region covered
  - $= 2wL$ = 2x1x250 = 500
  - n = number of animals counted = 36
- From this, how do we estimate abundance?



Intuitive estimator of abundance

I saw 36 animals

I covered 500/5000 = 1/10th of the study region

So, I estimate there are 36/(1/10) = 36x10 = 360 animals

$$\hat{N} = \frac{n}{a/A} = \frac{nA}{a} = \frac{36 \times 5000}{500} = 360$$

(Hat "^" means an estimate.)

Concept – Plot sampling

Step 1: How many in covered region, N_a?

Plot sampling: $$N_a = n$$

Step 2: Given N_a, how many in study region, N

If transects placed at random: $$\hat{N} = \frac{N_a}{a/A}$$

Overall: $$\hat{N} = \frac{n}{a/A} = \frac{nA}{a} = \frac{nA}{2wL}$$

for strip transects

Distance (line transect) sampling

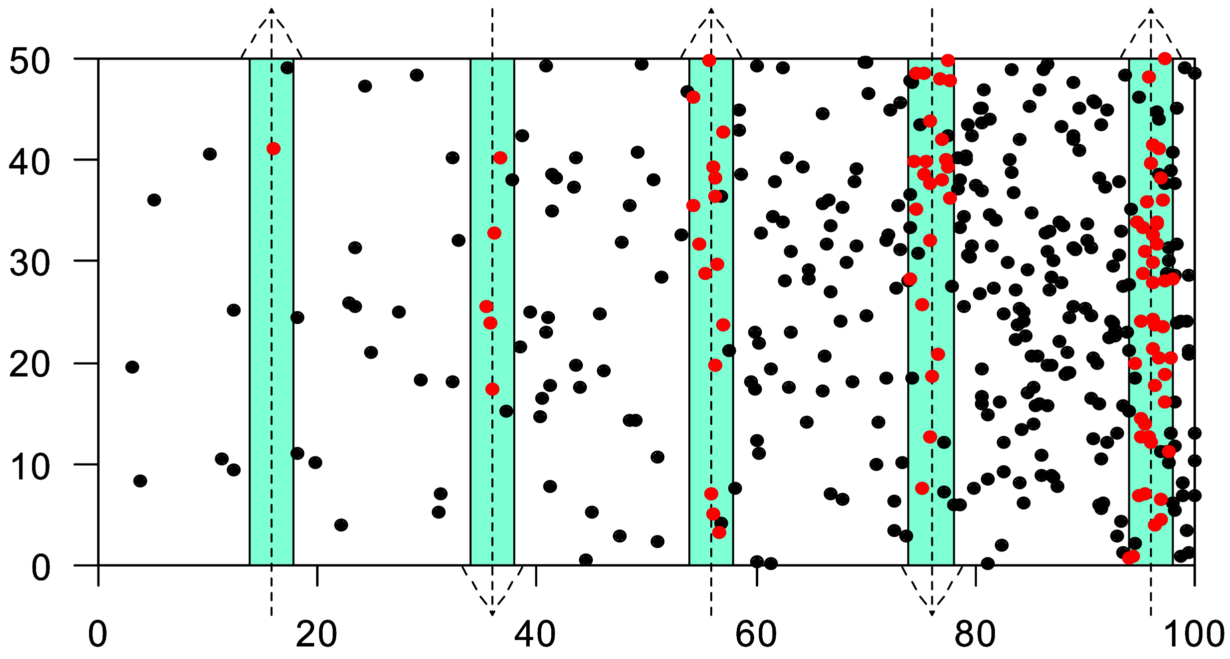
- An extension of plot sampling where not all animals in the covered region are detected
- Here

  w = 2 (strip can be wider, as don't have to see everything)

  a = 1000

  n = 68 (more animals seen)
- Let

  P_a = proportion of animals detected within covered region
- Imagine we know (or can estimate) $\hat{P}_a = 0.7$



A=5000

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Intuitive estimator of abundance

I saw 68 animals

The estimated proportion seen was 0.7

So, I estimate the true number of animals in the strips was 68/0.7 = 97.1

I covered 1000/5000 = 1/5th of the study region

So, I estimate there are 97.1/(1/5) = 485.7 animals

$$\hat{N} = \frac{n/\hat{P}_a}{a/A} = \frac{nA}{a\hat{P}_a} = \frac{68 \times 5000}{1000 \times 0.7} = 485.7$$

Concept – Distance sampling

Step 1: How many in covered region, N_a?

Distance sampling: $\hat{N}_a = n / \hat{P}_a$

Step 2: Given N_a, how many in study region, N

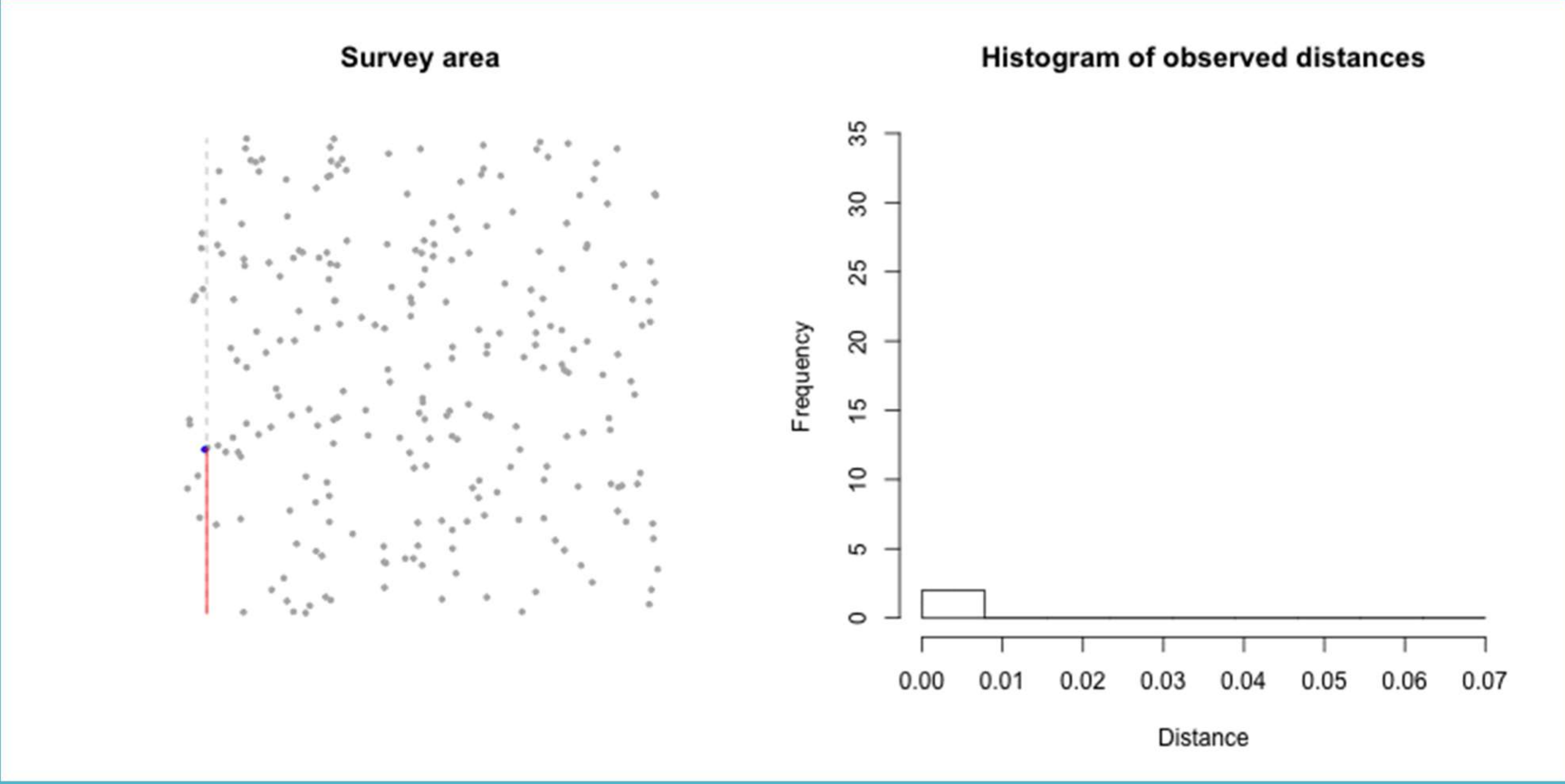
If transects placed at random: $\hat{N} = \dfrac{\hat{N}_a}{a/A}$

Overall: $$\hat{N} = \frac{n/\hat{P}_a}{a/A} = \frac{nA}{a\hat{P}_a} = \frac{nA}{2wL\hat{P}_a}$$

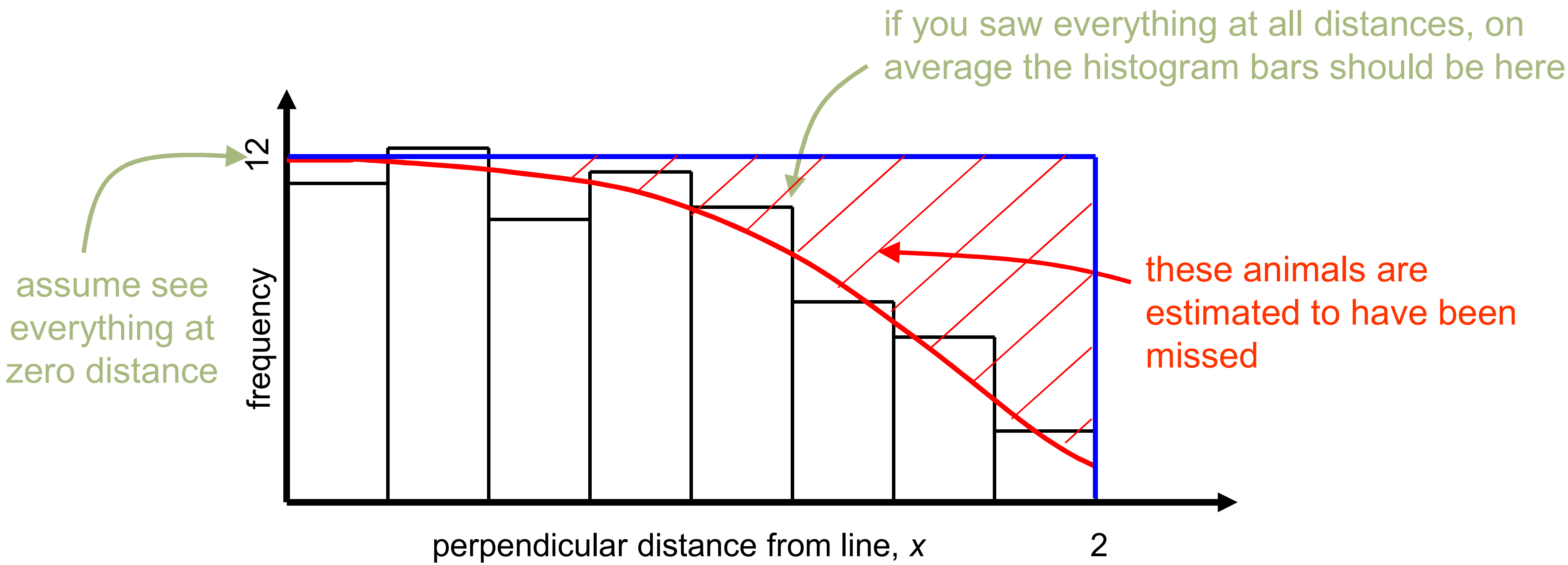
for line transects

- So how do we estimate P_a?

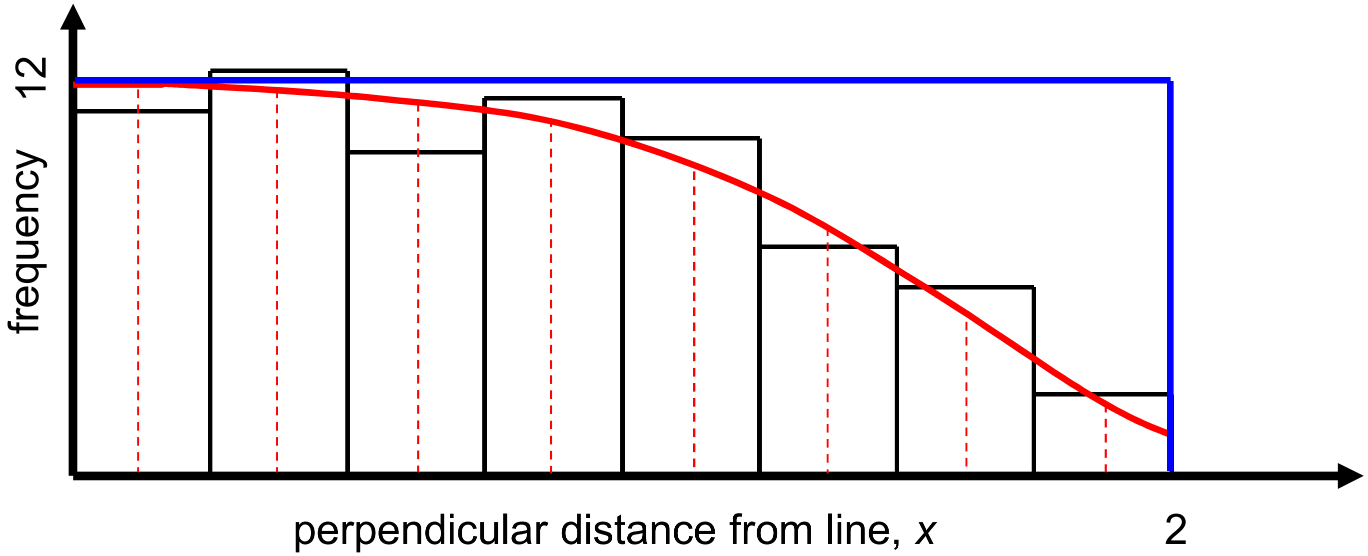
Record perpendicular distance, *x*, from transect line to each observed object



Estimating P_a



Estimating P_a



$$\hat{P}_a = \frac{\text{area under curve}}{\text{area under rectangle}}$$

Area of rectangle = 12x2 = 24

Area under curve = 0.25x(12+11.5+11+10.5+9+7+4+3) = 17

So

$$\hat{P}_a = \frac{17}{24} = 0.7$$

Types of distance sampling

(not exhaustive!)

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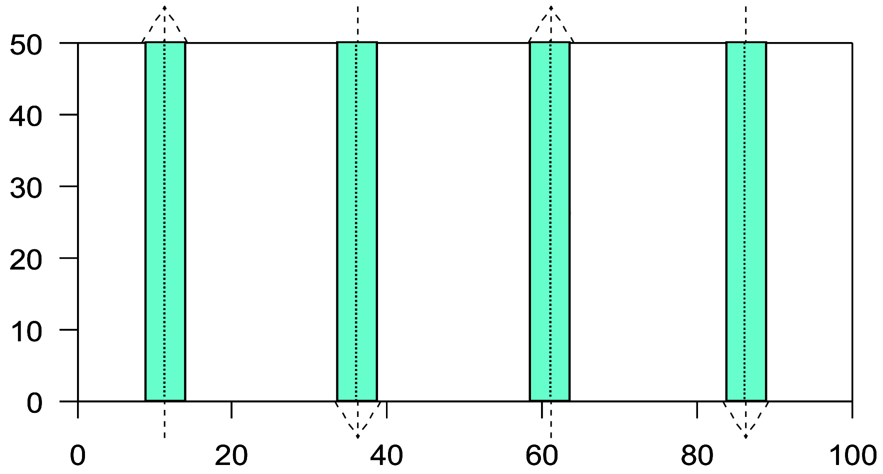
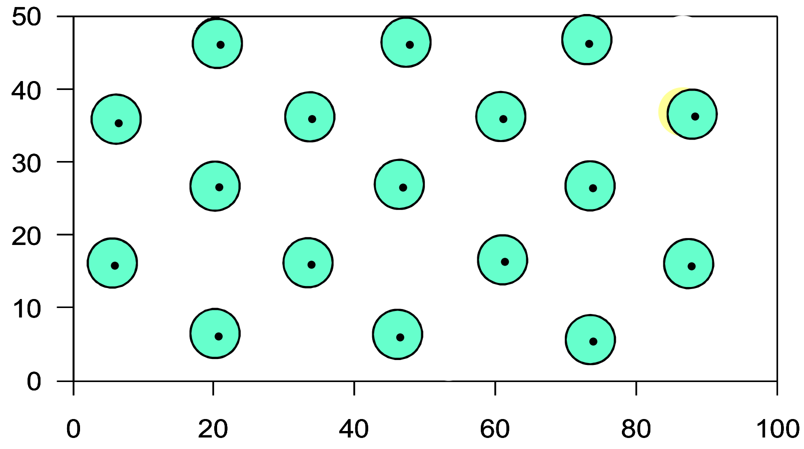
Type of sample   Line vs. Point

Line transect



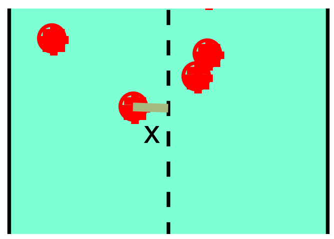
Point transect
(Variable circular plot)



Type of distance measurement
1. Radial vs perpendicular

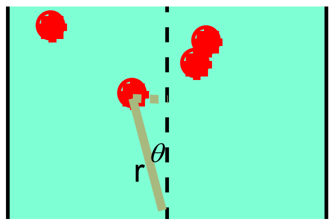
For line transects, can either measure

perpendicular distance from line to object



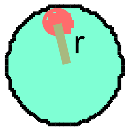
radial distance and angle

$$x = r\sin(\theta)$$



For point transects

measure radial distance from point to object



Type of distance measurement
2. Exact vs Grouped

Exact distance recorded to each object detected

Distances recorded in intervals

Photo: Rich Guenzel

Type of object
1. Individuals vs Clusters

Photo: Ron Marlow

Each object detected is a <u>single individual</u>

Each object detected is a <u>cluster of individuals</u>

- will need to estimate expected cluster size

Photo: Thomas Norris

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Type of Object

2. Direct vs Indirect

Objects are animals (or plants) of interest ...

... or something they produce
(an "indirect survey")

Another example is a cue count

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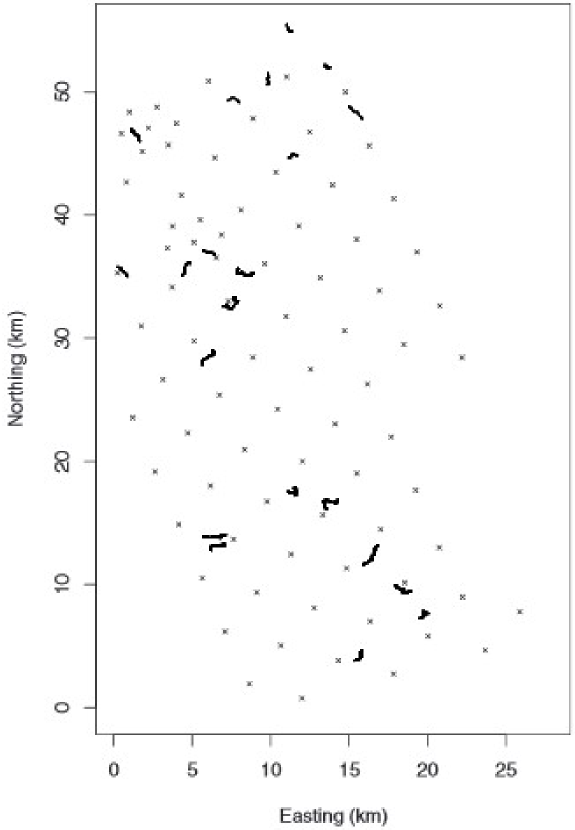
Method of detection

Active vs Passive



84 hydrophones on sea floor of Atlantic Undersea Test and Evaluation Center in Bahamas. From Marques et al. (2009).

Observers actively search for animals and record distances

Photo: Ullas Karanth

Animals are trapped and generate their own distances ("passive distance sampling")

Photo: Steve Dawson

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Recap of main ideas so far

Distance sampling is an extension of plot sampling

In plot sampling, we see everything in the covered region

$$\hat{N} = \frac{n}{a/A} = \frac{nA}{a} = \frac{nA}{2wL} \qquad \hat{D} = \frac{\hat{N}}{A} = \frac{n}{2wL}$$

strip transects

In distance sampling, we do not see everything, and we estimate the proportion detected, $\hat{P}_a$

$$\hat{N} = \frac{n/\hat{P}_a}{a/A} = \frac{nA}{a\hat{P}_a} = \frac{nA}{2wL\hat{P}_a} \qquad \hat{D} = \frac{\hat{N}}{A} = \frac{n}{2wL\hat{P}_a}$$

line transects

- How do we estimate P_a?

$$\hat{P}_a = \frac{\text{area under curve}}{\text{area under rectangle}}$$

line transects