1. Estimation of marine mammal abundance (and survival)




$\hat{N}$ $\hat{\phi}$

Sea Mammal Research Unit

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TETHYS since 1986

Why are we here?

- Knowledge and understanding of methods to estimate cetacean population parameters
  - Background statistical framework
  - Practical application of methodology
    - Data collection
    - Data analysis
  - Recognising and dealing with potential problems
- Topics
  - Estimating abundance (population size)
  - Estimating survival rates
- Learning outcomes:
  - Design, execute, analyse
    - Industry standard software (*MARK, DISTANCE*)
  - Draw inferences about ecology and conservation

Why study the abundance of populations?

- "Every species of plant and animal is always absent from almost everywhere. But a large part of the science of ecology is concerned with trying to understand what determines the abundance of species in the restricted areas where they do occur."

M Begon, JL Harper & CR Townsend (1996). Ecology: individuals, populations and communities. Blackwell Science

- We need information on abundance (population size)
  - to improve ecological understanding
  - to assess conservation status and inform management

What is a population?

- A biological definition
  - "a biological unit at the level of ecological integration where it is meaningful to speak of a birth rate, a death rate, a sex ratio, and an age-structure in describing the properties of the unit." Cole (1957)
- A pragmatic definition
  - "a group of organisms of the same species occupying a particular place at a particular time … its boundaries in space and time are vague and usually fixed by the investigator, arbitrarily." *Krebs (1972)*

More definitions

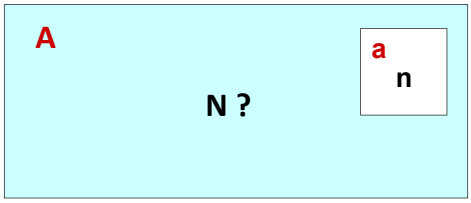
- Population
  - Biological population
  - Animals in a defined area
  - Management "stock"
- Abundance = number of individuals = N
  - In a population (population size)
  - In an area
- Density = number of animals / area
- Survival rate = ϕ
  - Probability of an animal surviving a specified time period (e.g. year)

    $(1 - \phi)$ = mortality rate

Assessing abundance / population size

- Census of all cetaceans
  - Is impossible
    - Access – cetaceans live in the sea
    - Behaviour – cetaceans are highly mobile
    - Scale – large populations in large areas; small populations
- Estimation
  - Collect a sample of data
  - Extrapolate from the sample to the whole population or area
  - Involves using a statistical model and making assumptions
- Assumptions are about …
  - Representativeness of samples
  - How well the method can be implemented in practice

Example: simple extrapolation of counts



A = Total area
N = Total number of animals

a = Sample area
n = Number of animals in sample area
n/a = Sample density

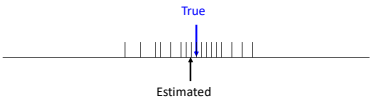
$$\hat{N} = A\frac{n}{a}$$

Assumptions …

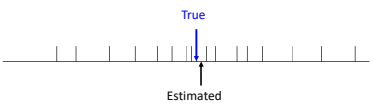
Accuracy and precision of estimates

- Accuracy
  - Whether or not an estimate is biased
    - How close it is to the truth
  - Violation of assumptions causes bias
- Precision
  - Measure of the confidence we have in an estimate
    - Variance, standard error, confidence limits or interval
    - Coefficient of variation (CV = standard error / estimate),
  - Dependent primarily on sample size
  - Critical to include measure of precision with estimate
- Aim to minimise bias and maximise precision
  - Given available (limited) resources
  - Typically a compromise

Accurate and precise



Accurate but imprecise



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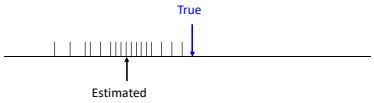

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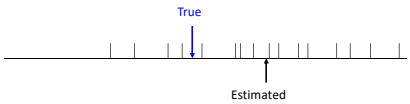
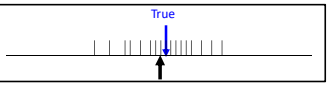


Which is worst?

Accurate and precise



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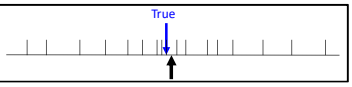

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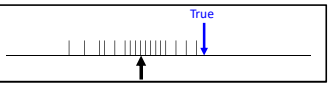

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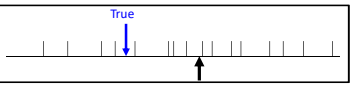
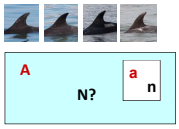


Choosing the right method

- What is the objective of the study?
  - Abundance of a population or in an area?
  - Absolute or relative abundance?
  - First idea of abundance or estimate needed for management?
- One species or multiple species?
- What are the characteristics of your target species?
  - Range, approximate abundance, behaviour, markings, etc
- What sampling method to use?
  - Line transect sampling, mark-recapture, etc
- What resources do you have/need?
  - Time, money, people, equipment
- Are you able to implement the method in practice?

Sampling methods for abundance estimation

- What to sample?
  - Number of individual animals
  - Number of animals in a specified area



- Sampling individual animals
  - Mark-recapture methods
  - → Number of animals
    - Using the study area during the study period
- Sampling area
  - Line transect methods
  - → Average density of animals
    - In the defined survey area during the survey period

Mark-recapture and line transect methods estimate different things

Survival and mortality rates

- Allow the study of population dynamics
  - Remember: mortality rate = 1 – survival rate
- Various methods for estimation, with assumptions
- Conservation value for:
  - Assessing status
  - Predicting future trends
  - Focussing conservation action

Summary

- Range of methods available for estimation
- Critical that assumptions of the method are considered
- Aim to minimise bias and maximise precision
- Choice of best method depends on a number of factors
- Important to get it right to give best conservation advice