Populations

"Populační ekologie živočichů"

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Population Ecology

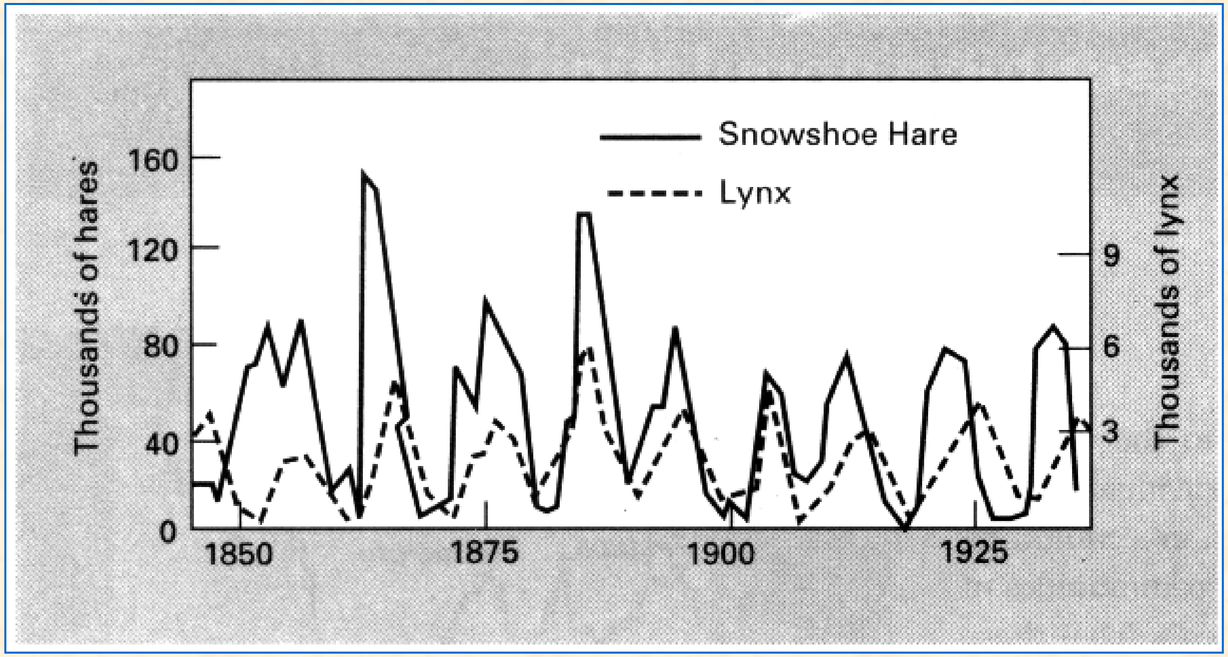
- a major sub-field of ecology which deals with description and the dynamics of populations within species, and the interactions of populations with environmental factors

- expanding field (Price & Hunter 1995):
  - populations 52 %, communities 9 %, ecosystems 10 %

- main focus on
  - **Demography** = description of populations that gave rise to **Life-history theory**
  - **Population dynamics** = describe the change in the numbers of individuals in a population

‣ populations of member species may show a range of dynamic patterns in time and space

‣ central question: “WHAT DOES REGULATE POPULATIONS?“



Change in abundance of *Lynx* and *Lepus* in Canada

‣ density independent factors, food supply, intraspecific competition, interspecific competition, predators, parasites, diseases

Utilization

1. Conservation biology

- World Conservation Union (IUCN) uses several criterions (population size, generation length, population decline, fragmentation, fluctuation) to assess species status

- by means of Population viability analysis (PVA) estimates the extinction probability of a taxon based on known life history, habitat requirements, threats and any specified management options

Saiga tatarica

critical: 50% probability of extinction within 5 years

endangered: 20% probability of extinction within 20 years

vulnerable: 10% probability of extinction within 100 years

2. Biological control

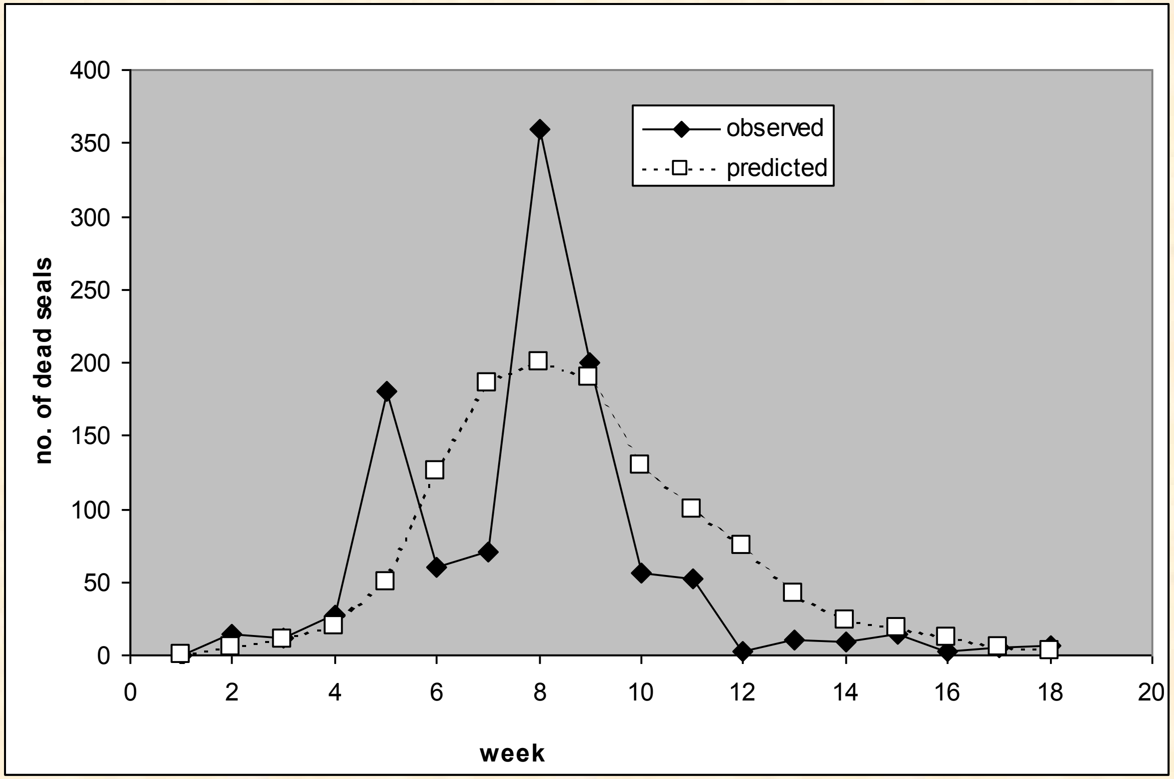
Rodolia cardinalis (Coccinellidae) eating *Icerya purchasi* (Hemiptera)

- to assess ability of a natural enemy to control a pest
- in 1880 *Icerya purchasi* was causing infestations so severe in California citrus groves that growers were burning their trees
- in winter 1888-1889 *Rodolia cardinalis* and *Cryptochaetum* were introduced into California from Australia, growers took the initiative and applied the natural enemies themselves
- by fall 1889 the pest was completely controlled
- *Rodolia cardinalis* has been exported to many other parts of the world
- the interest of growers and the public in this project was due to its spectacular success: the pest itself was showy and its damage was obvious and critical; the destruction of the pest and the recovery of the trees was evident within months

3. Epidemiology

- to predict the diffusion of a disease and to plan a vaccination
- phocine distemper virus was identified in 1988 and caused death of 18 000 common seals in Europe
- during 4 months the disease travelled from Denmark to the UK
- in 2002 the population in the UK declined by about half

Grenfell et al. (1992)



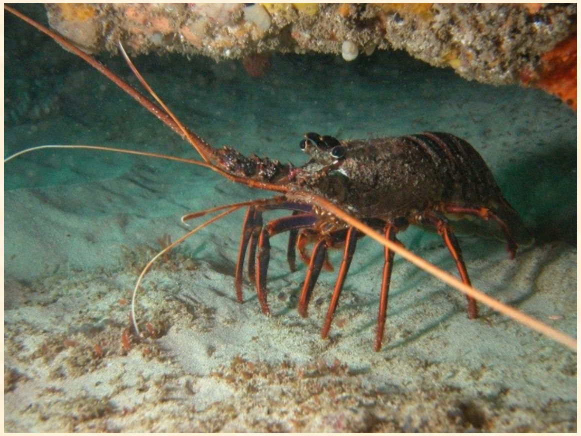
Observed and predicted epidemic curves for virus in common seals in the UK

4. Harvesting

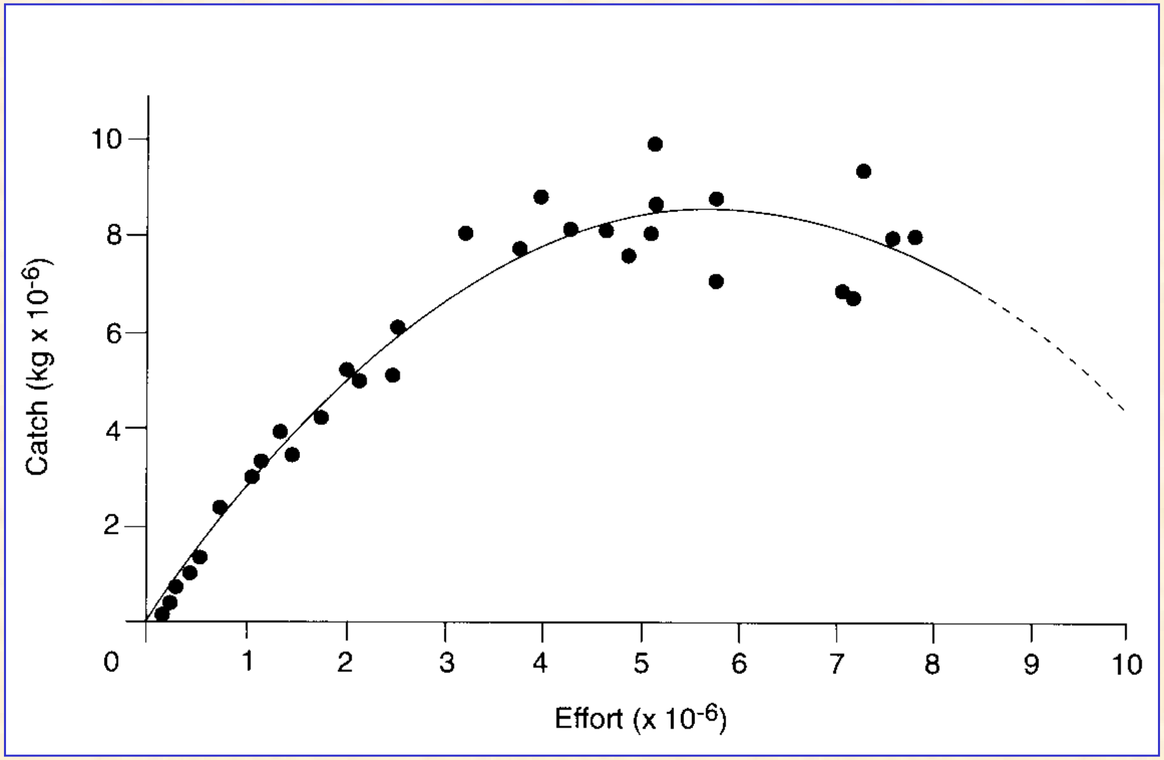
- to predict maximum sustainable harvest in fisheries and forestry but also used to regulate whale or elephant hunting
- when population is growing most rapidly (*K*/2) then part of population can be harvested without causing extinction

Beddington (1979)

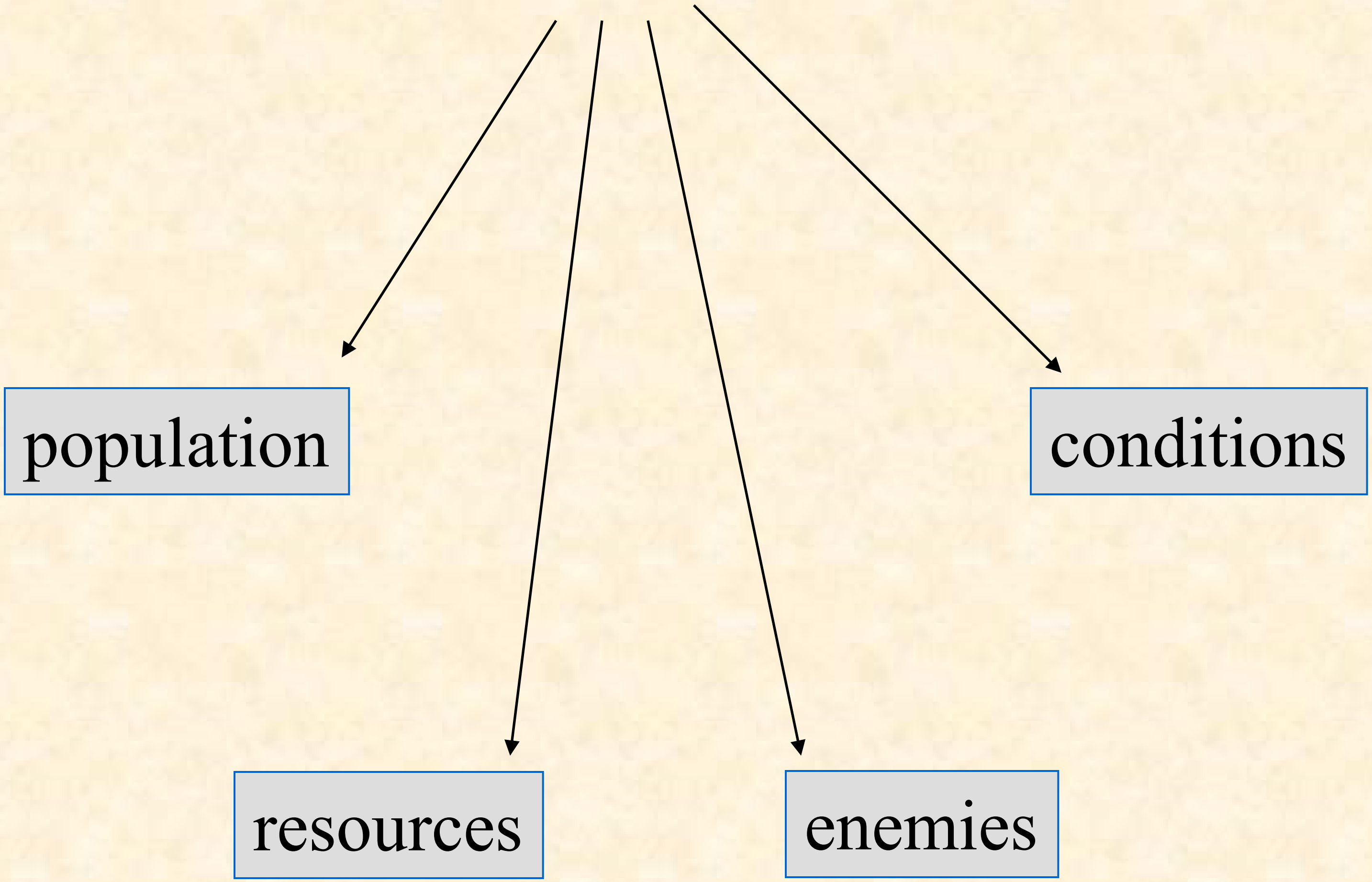
Relationship between capture and fishing effort



Panulirus cygnus



Population + environment = population system



Population

- molecules → organels → cells → tissues → organs → organ systems → organisms → **populations** → communities → ecosystem → landscape → biosphere
- a group of organisms of the same species that occupies a particular area at the same time and is characterised by an average characteristic (e.g., mortality)
- characteristics:

Individual	→	**Population**
Developmental stage		Stage structure
Age		Age structure
Size		Size structure
Sex		Sex ratio
Territorial behaviour		Spatial distribution

Events & Processes

Event – an identifiable change in a population

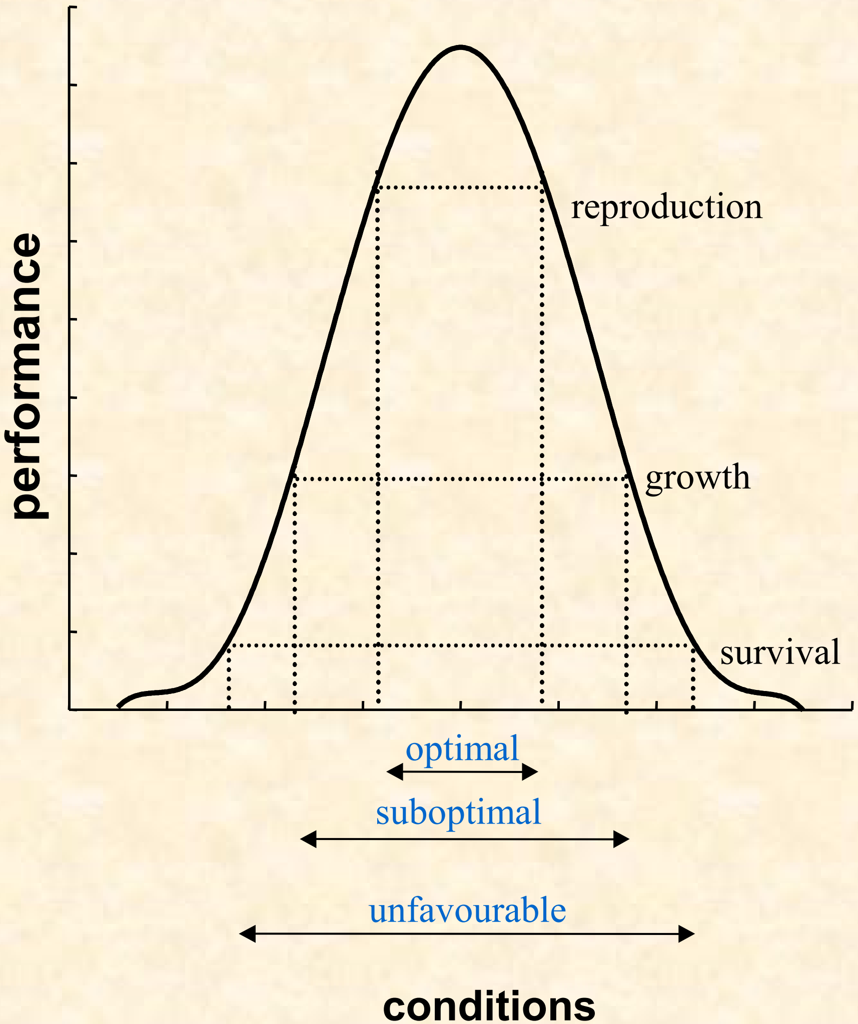
Process – a series of identical events

- *rate* of a process – number of events per unit time

Event	**Process**
Birth [inds]	Natality (birth rate)
Death [inds]	Mortality (mortality rate)
Increment [gram]	Growth (growth rate)
Increment [number]	Population increase (rate of increase)
Acquisition of food [gram]	Consumption (consumption rate)

Conditions

- inherent characteristics of the evironment (pH, salinity, temperature, moisture, wind speed, etc.)
- not modified by populations
- not consumed by population
  ⇒ no feedback mechanisms
  ⇒ do not regulate population size
- limit population size



Resources

- any entity whose quantity is reduced (food, space, water, minerals, oxygen, sun radiation, etc.)
- modified (reduced) by populations
- defended by individuals (interference competition)
- regulate population size
- non-renewable resources - space

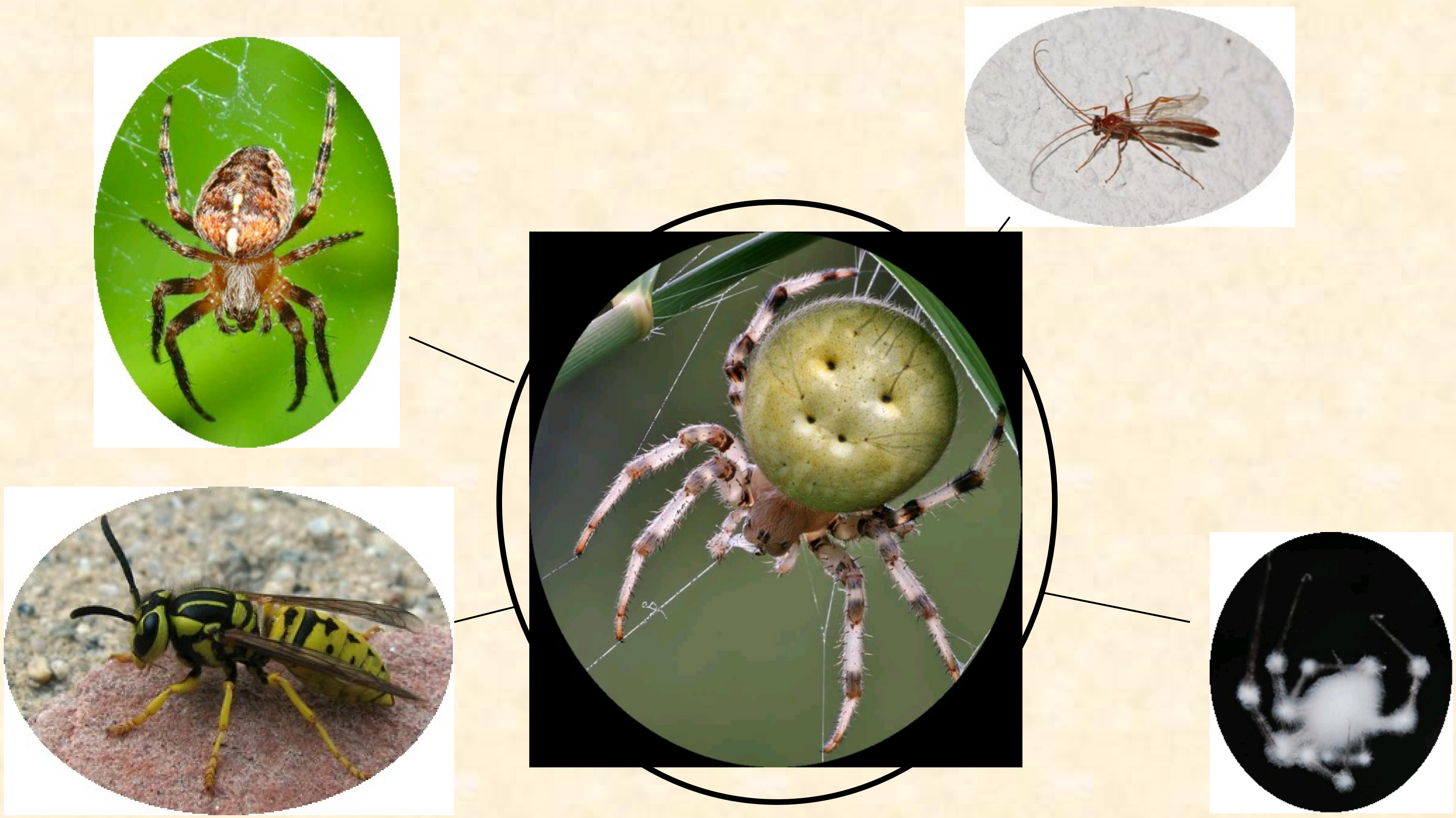
Renewable resources

- regeneration centre outside the population system $\Rightarrow$ no effect of the consumer (e.g., oxygen, water)

- regeneration centre inside of the population system $\Rightarrow$ influenced by the consumer (e.g., prey)

Enemies

- competitors, predators, parasites, pathogens
- negative effect on the population
- top-down regulation of the population



Population Estimates

Absolute

- number of individuals per unit area
- number of individuals per unit of habitat (leaf, plant, host)
- sieving, sweeping, extraction, etc.

Relative

- number of individuals per effort
- trapping, fishing, pooting

Capture-recapture method – for mobile individuals

- Assumptions:

- marked individuals are not affected and marks will not be lost
- marked animals become mixed in the population
- all individuals have same probability of capture
- capture time must be short

Closed population

- population do not change over sampling period - no death, births, immigration, emigration

<u>Petersen-Lincoln estimator</u>:

N .. number of individuals in population

a .. total number of marked individuals

r .. total number of recaptured marked individuals

n .. total number of individuals recaptured

$$\hat{N}_i = \frac{a_{i-1} n_i}{r_{i(i-1)}}$$

$$SD = \sqrt{\frac{a_{i-1}^2 n_i (n_i - r_{i(i-1)})}{r_{i(i-1)}^3}}$$

For small populations (Chapman 1951)

$$\hat{N}_i = \frac{(a_{i-1} + 1)(n_i + 1)}{r_{i(i-1)} + 1} - 1$$

$$SD = \sqrt{\frac{(a_{i-1} + 1)(n_i + 1)(a_{i-1} - r_{i(i-1)})(n_i - r_{i(i-1)})}{(r_{i(i-1)} + 2)(r_{i(i-1)} + 1)^2}}$$

Open population

- changes due to death, births, immigration, emigration
- at least 3 sampling periods

Stochastic Jolly-Seber method

N_i .. estimate of population on day i

a_i .. number of marked individuals on day i

n_i .. total number of individuals captured on day i

r_i .. sum of marked and recaptured individuals on day i

Z_i .. sum of marked individuals that were recaptured 2 and more days after marking

R_i .. sum of recaptured individuals marked later than 1st day

i .. day of capture

j .. day of marking

$$Z_i = \sum_{k=i+1}^{n} \sum_{j=1}^{i-1} r_{kj}$$

$$\hat{N}_i = \frac{M_i n_i}{r_i} \quad \text{where} \quad M_i = \frac{a_i Z_i}{R_i} + r_i$$

$$R_i = \sum_{k=i+1}^{n} r_{ki} \qquad r_i = \sum_{j=1}^{i-1} r_{ij}$$