

Populations

“Populační ekologie živočichů“

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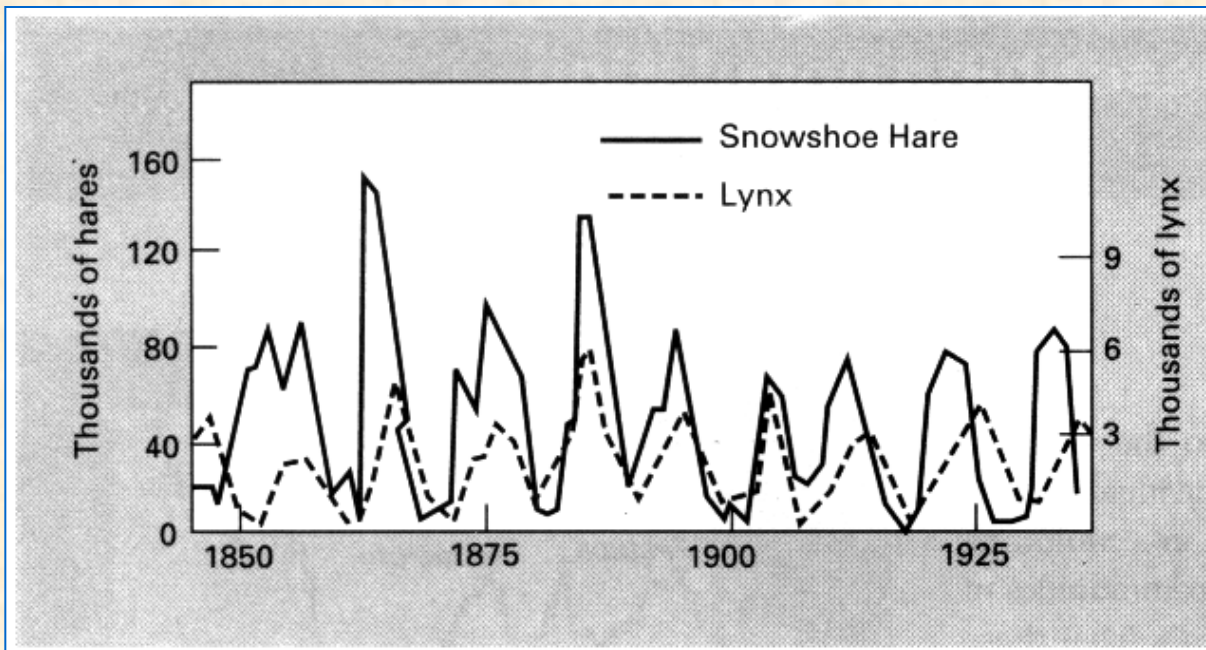
Population Ecology

- ▶ a major sub-field of ecology which deals with description of the structure and the dynamics of populations within species in time and space, and the interactions of populations with environmental factors
- ▶ expanding field (Price & Hunter 1995):
 - populations 52 %, communities 9 %, ecosystems 10 %
- ▶ main focus on
 - **Demography** – relationship between population structure and dynamics – the core of the discipline
 - **Population dynamics** – describe the change in the numbers of individuals in a population



An example

- ▶ 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

Utilisation

1. Conservation biology

- ▶ World Conservation Union (IUCN) uses several criteria (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

- ▶ 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

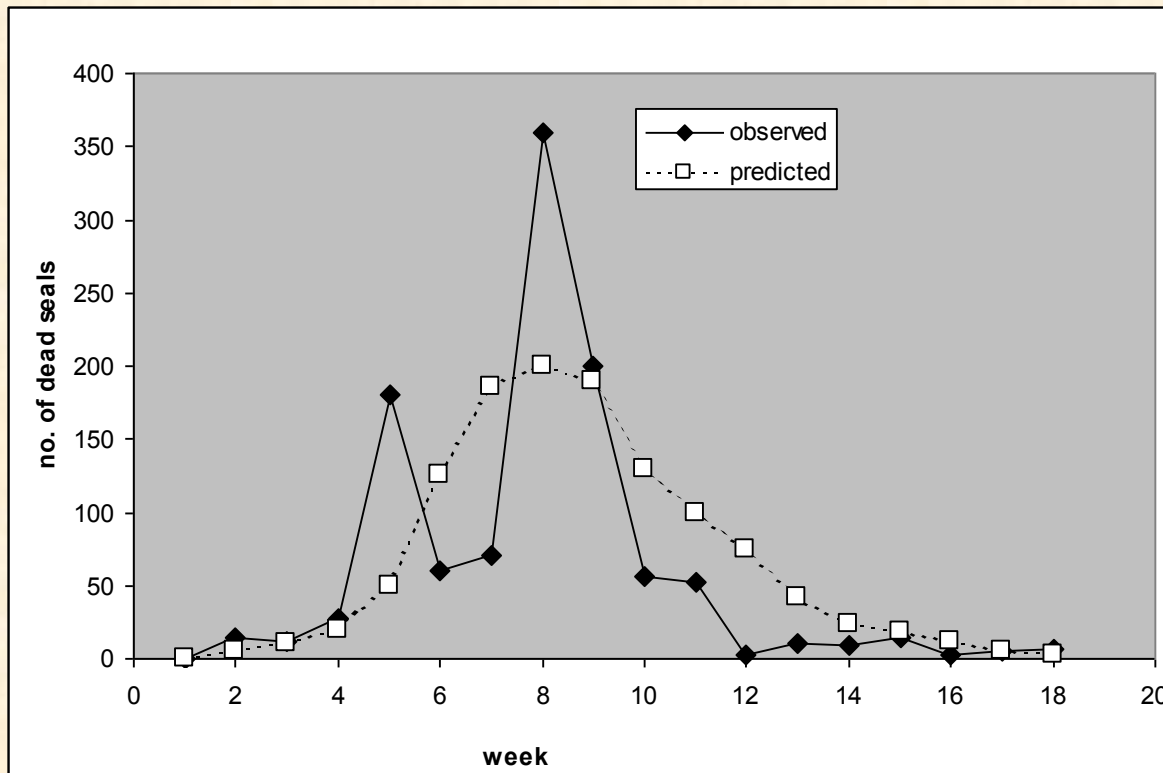


Rodolia cardinalis (Coccinellidae) eating
Icerya purchasi (Hemiptera)

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
- ▶ the population of common seals in the UK declined by about half

Grenfell et al. (1992)



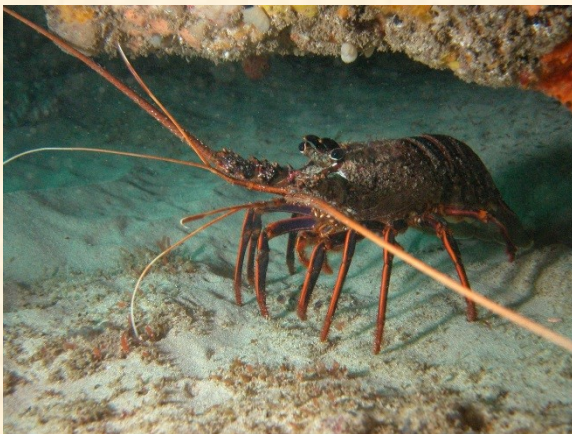
Observed and predicted epidemic curves for virus in common seals in the UK



4. Harvesting

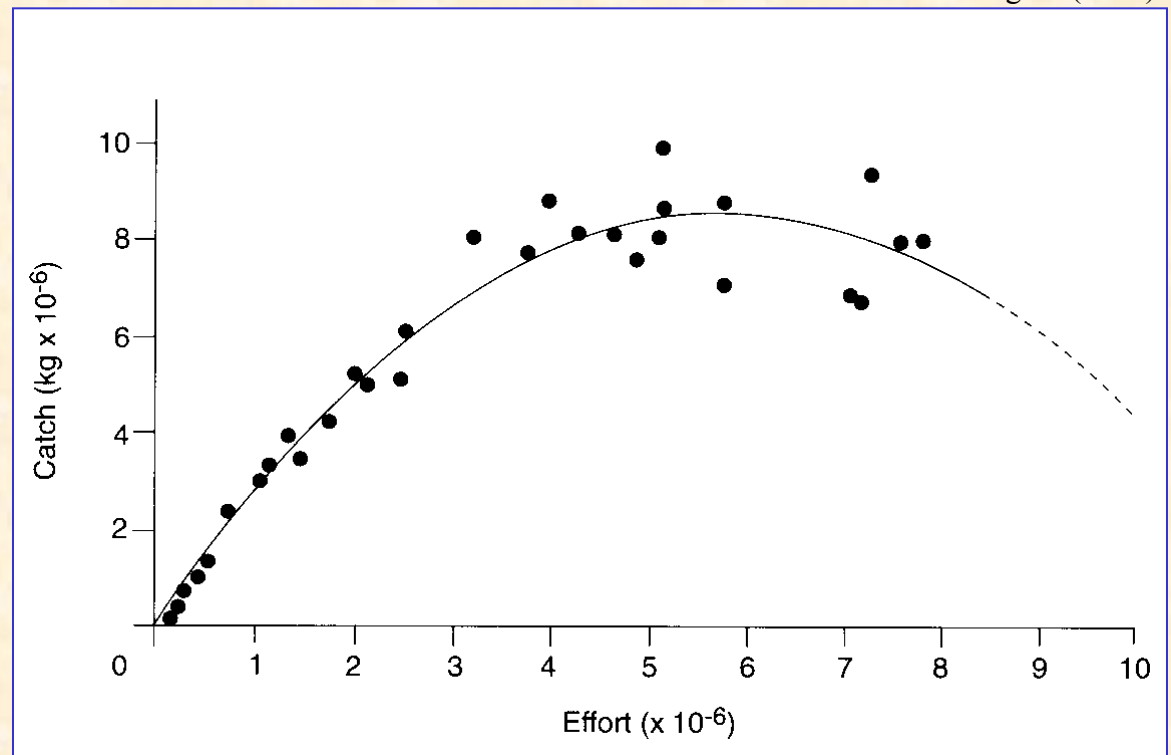
- ▶ to predict maximum sustainable harvest in fisheries and forestry but also used to regulate whale or elephant hunting
- ▶ when population is growing most rapidly ($K/2$) then part of population can be harvested without causing extinction

Relationship between capture and fishing effort

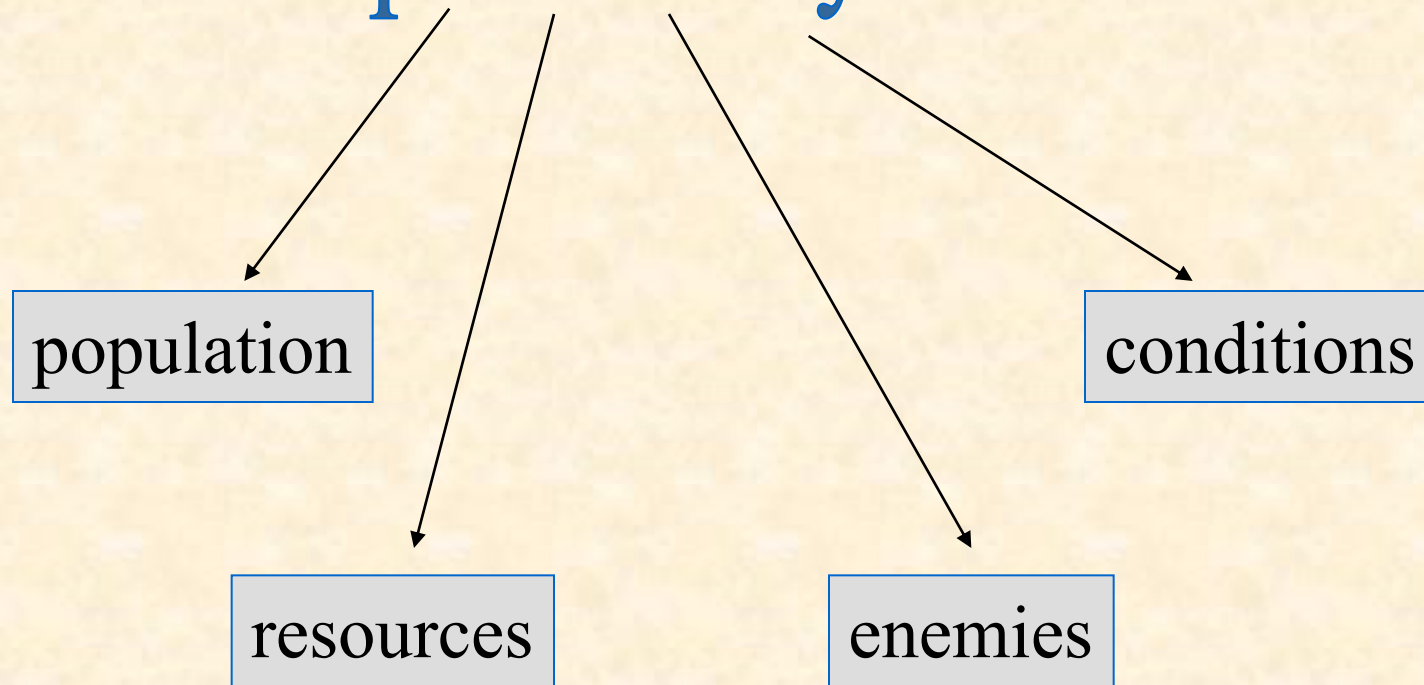


Panulirus cygnus

Beddington (1979)



Population system



- ▶ population ecology aims to study interactions among components of the system
- ▶ a dynamic system – characterised by events and processes

Population

- ▶ Hierarchical structure: molecules → organelles → cells → tissues → organs → organ systems → organisms → populations → communities → ecosystem → landscape → biosphere
- ▶ Defines fitness (relative genetic contribution to the next generation) of an individual by response to a current situation
- ▶ Definition: 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)
- ▶ Particular area – area in which a change in density is mainly due to mortality and natality not due to emigration and immigration
- ▶ Studied adopting proximate approach – how the response happened

Events & Processes

Event – an identifiable change in a population

Process – a series of identical events (in time)

- *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]

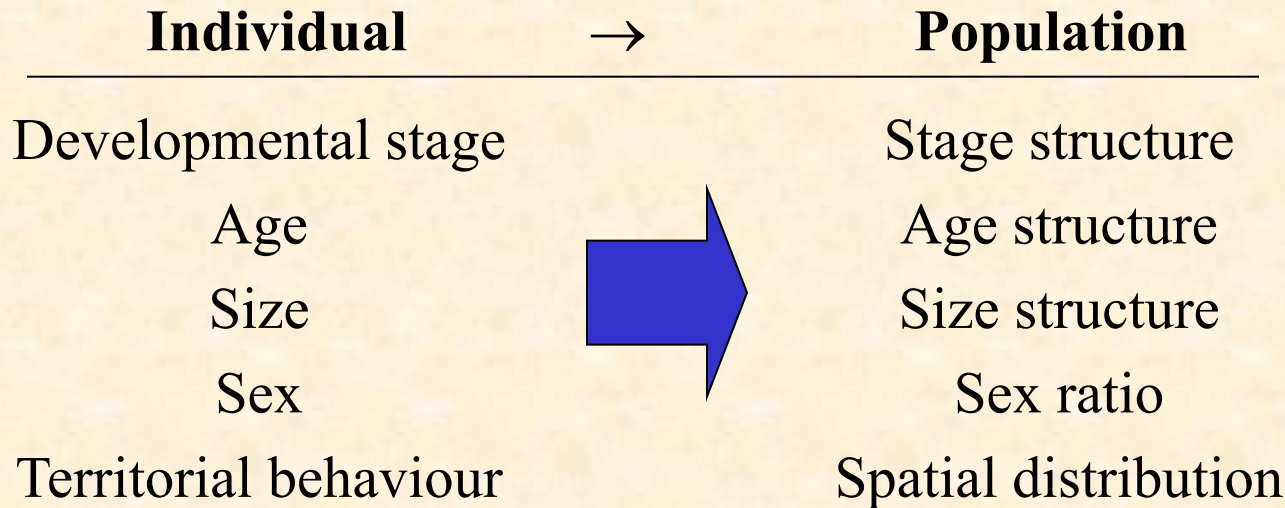
Population increase (rate of increase)

Acquisition of food [gram]

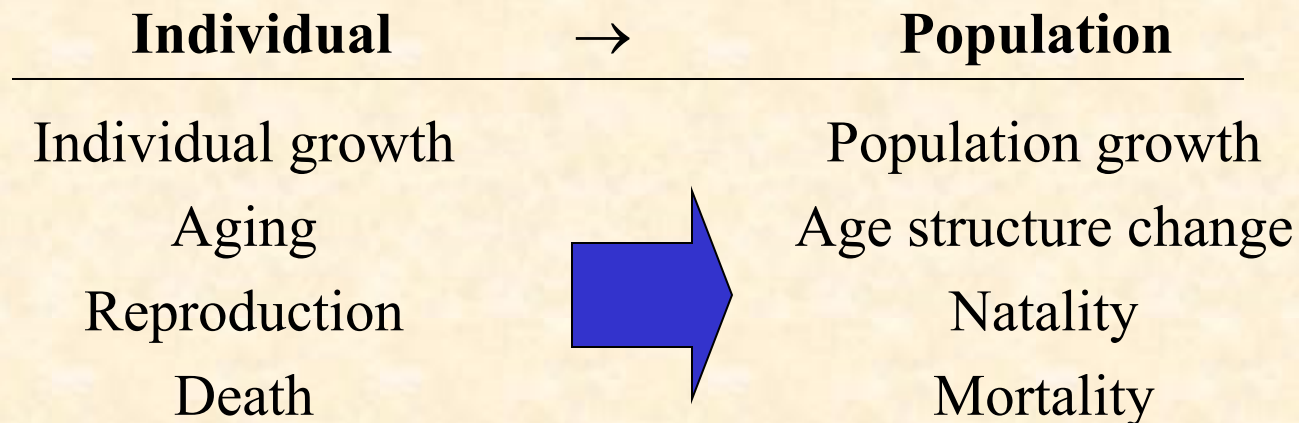
Consumption (consumption rate)

Population characteristics

► Events

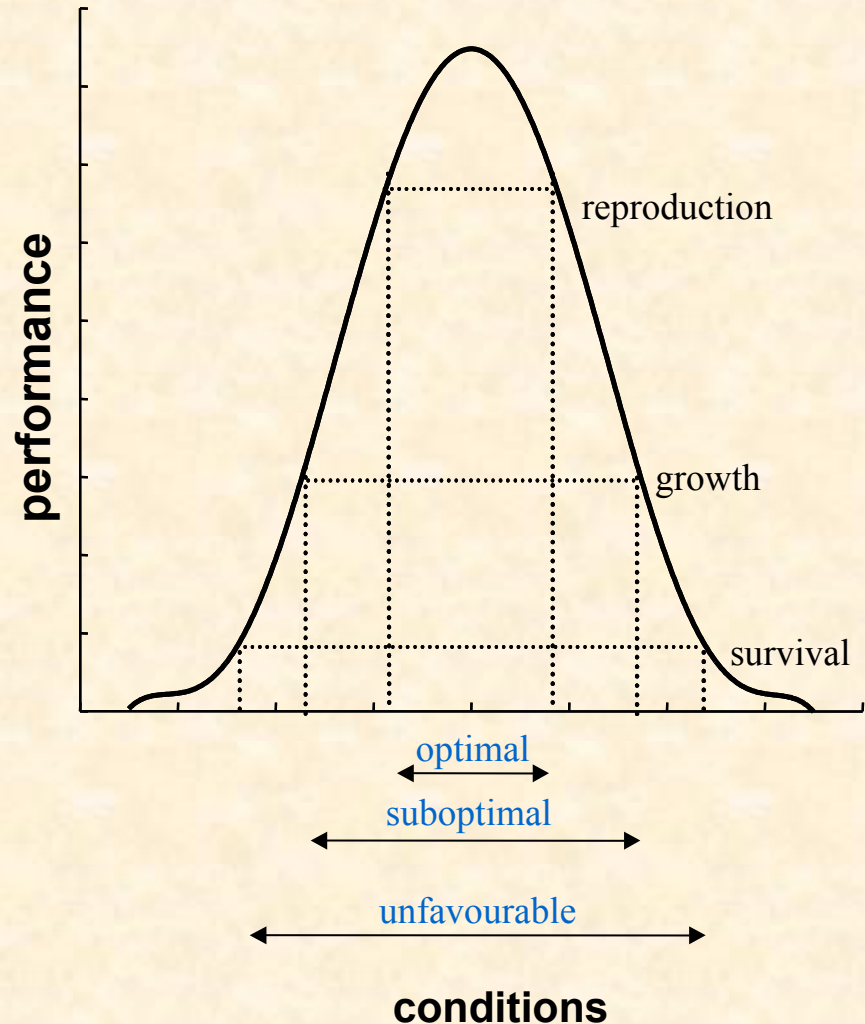


► Processes



Conditions

- ▶ inherent biotic and abiotic characteristics of the environment (pH, salinity, temperature, moisture, wind speed, etc.)
- ▶ independent of population size
- ▶ affect the population - limit population size
- ▶ not consumed by population
⇒ no feedback mechanisms
⇒ do not regulate population size
- ▶ exogenous effect - random and forcing processes



Resources

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

Renewable resources

- Type 1 - regeneration centre outside the population system \Rightarrow no effect of the consumer (e.g., oxygen, water)
- Type 2 - regeneration centre inside of the population system \Rightarrow influenced by the consumer (e.g., prey)
- Type 3 - regeneration centre inside of the population system \Rightarrow access to the resource via secondary consumer (e.g., nitrogen)

Enemies

- ▶ competitors, predators, (macro) parasites, (micro) pathogens
- ▶ negative effect on the population
- ▶ top-down regulation of the population



Population Estimates

Absolute

- ▶ number of individuals per unit area (census)
- ▶ 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

Petersen-Lincoln estimator:

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)

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

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

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

$$\hat{N}_i = \frac{M_i n_i}{r_i} \quad \text{where} \quad M_i = \frac{a_i Z_i}{R_i} + r_i \quad R_i = \sum_{k=i+1}^n r_{ki} \quad r_i = \sum_{j=1}^{i-1} r_{ij}$$