Populations

"Populační ekologie živočichů"

Stano Pekár

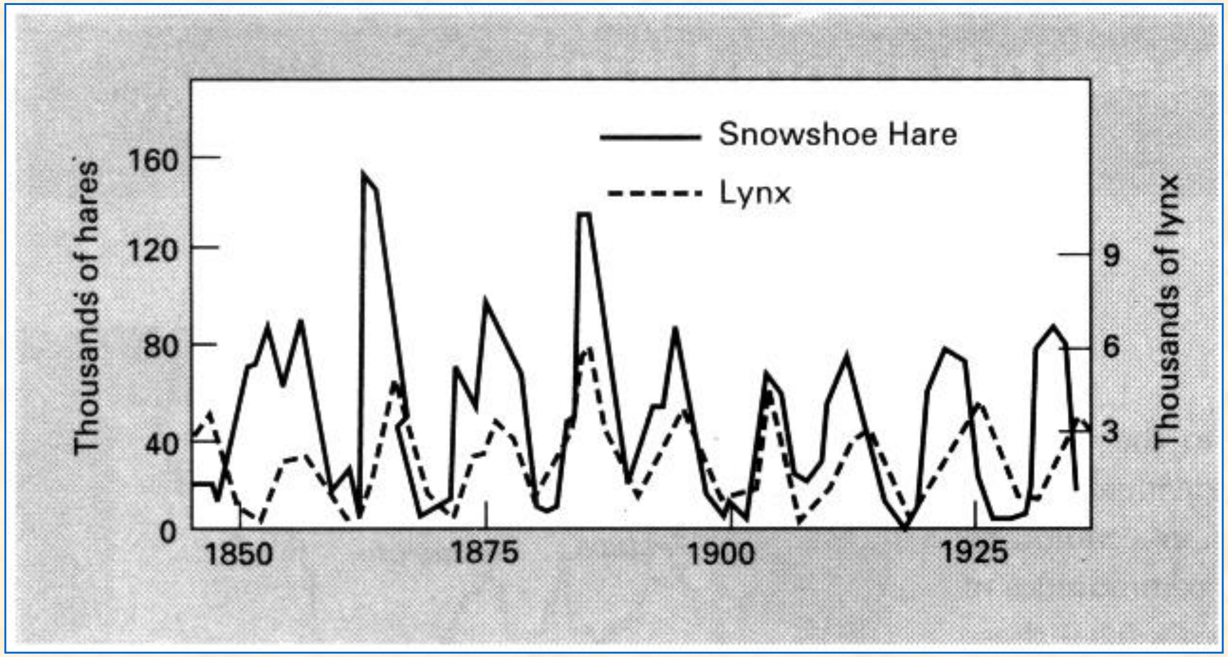
Population Ecology

- 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

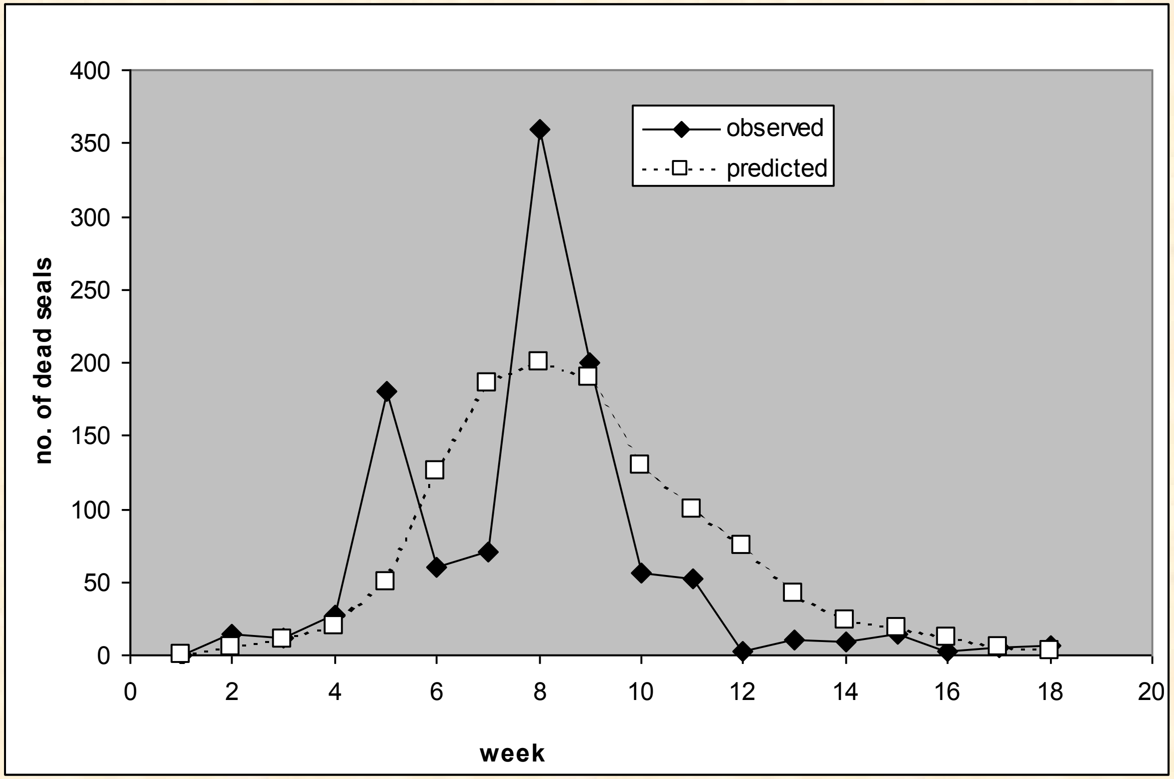
Rodolia cardinalis (Coccinellidae) eating *Icerya purchasi* (Hemiptera)

- 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
- 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

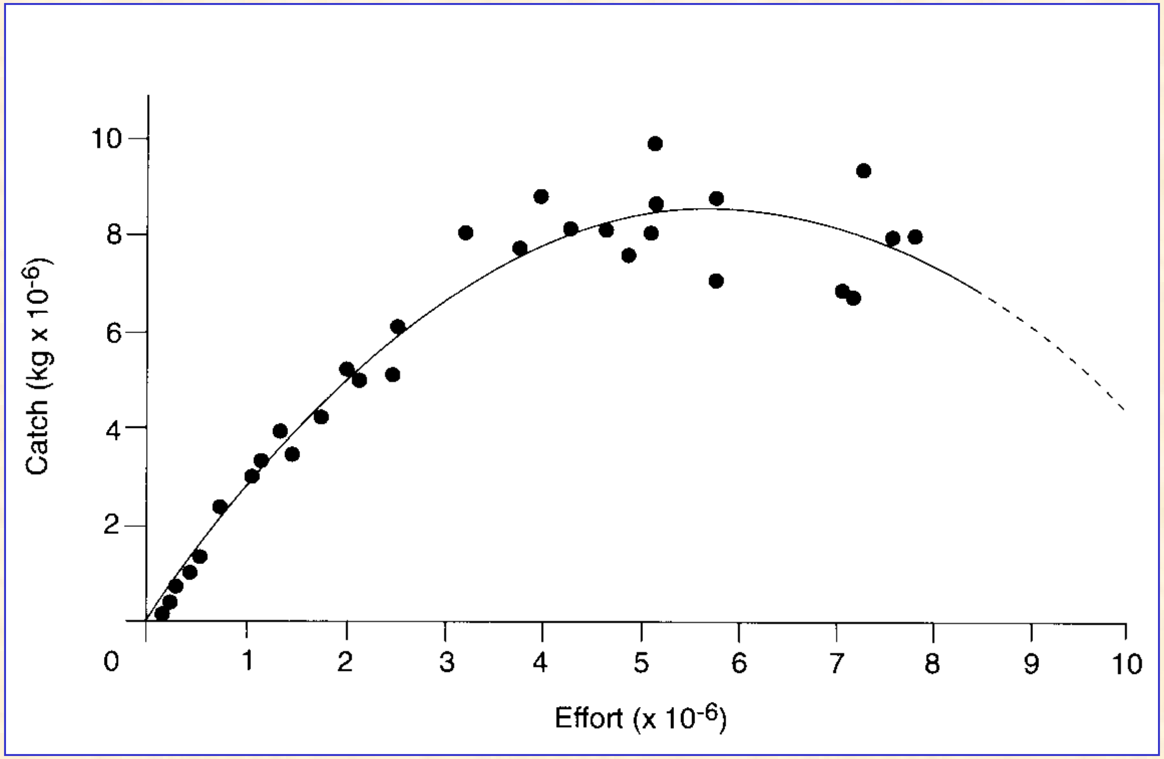
‣ to predict maximum sustainable harvest in fisheries and forestry but also used to regulate whale or elephant hunting

‣ when population is growing most rapidly ($K/2$) then part of population can be harvested without causing extinction

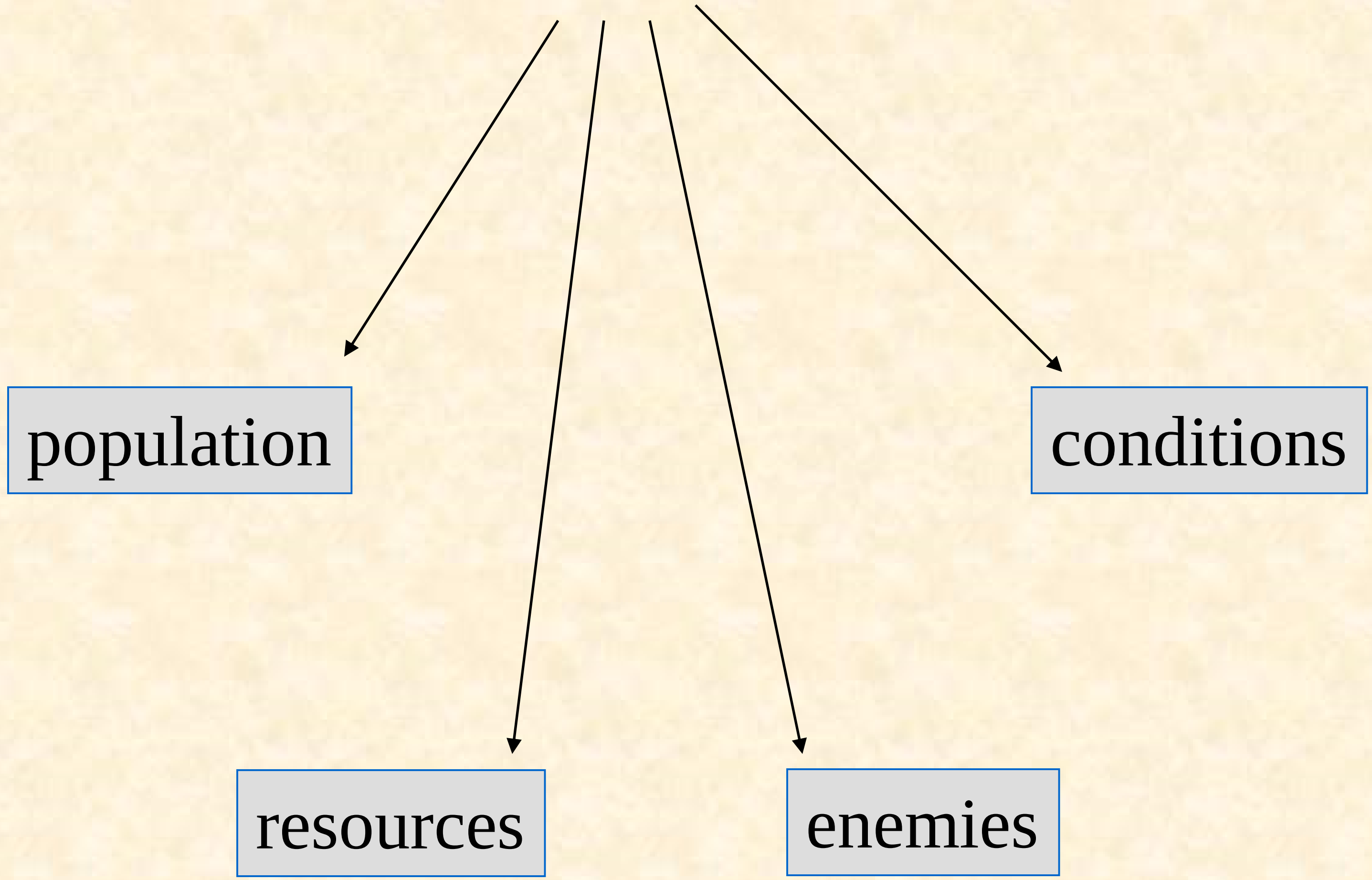
Beddington (1979)

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

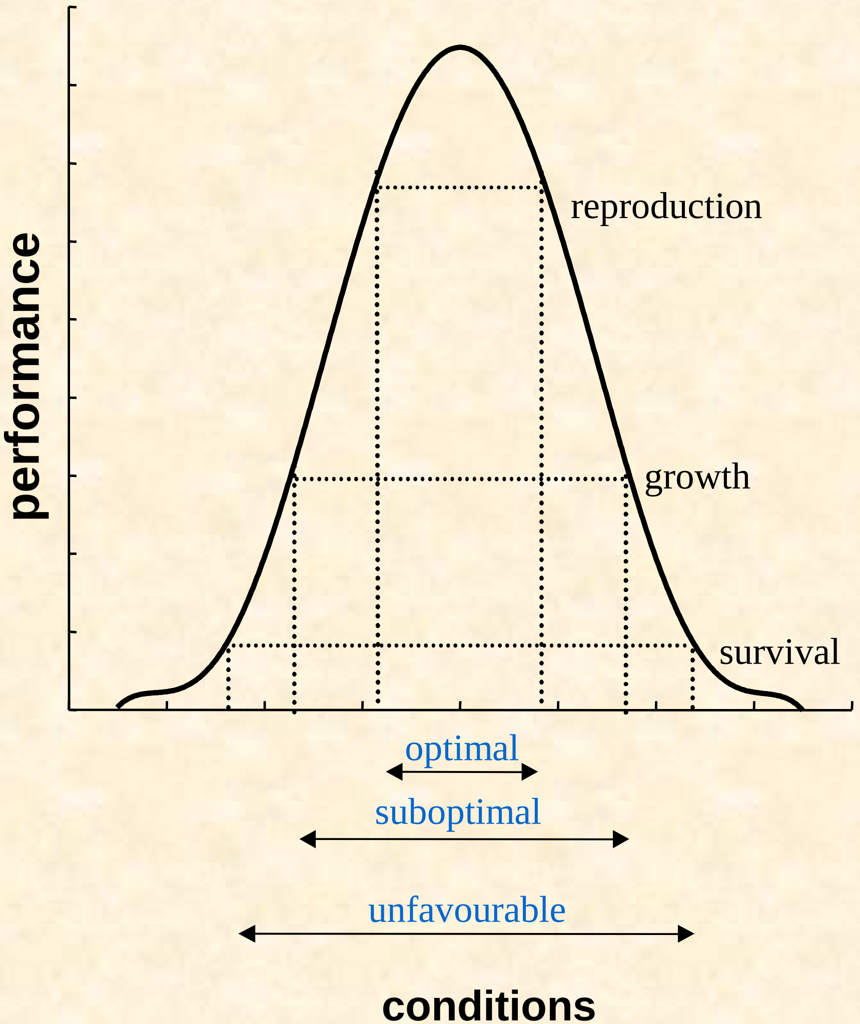
Process – a series of identical events

- ***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

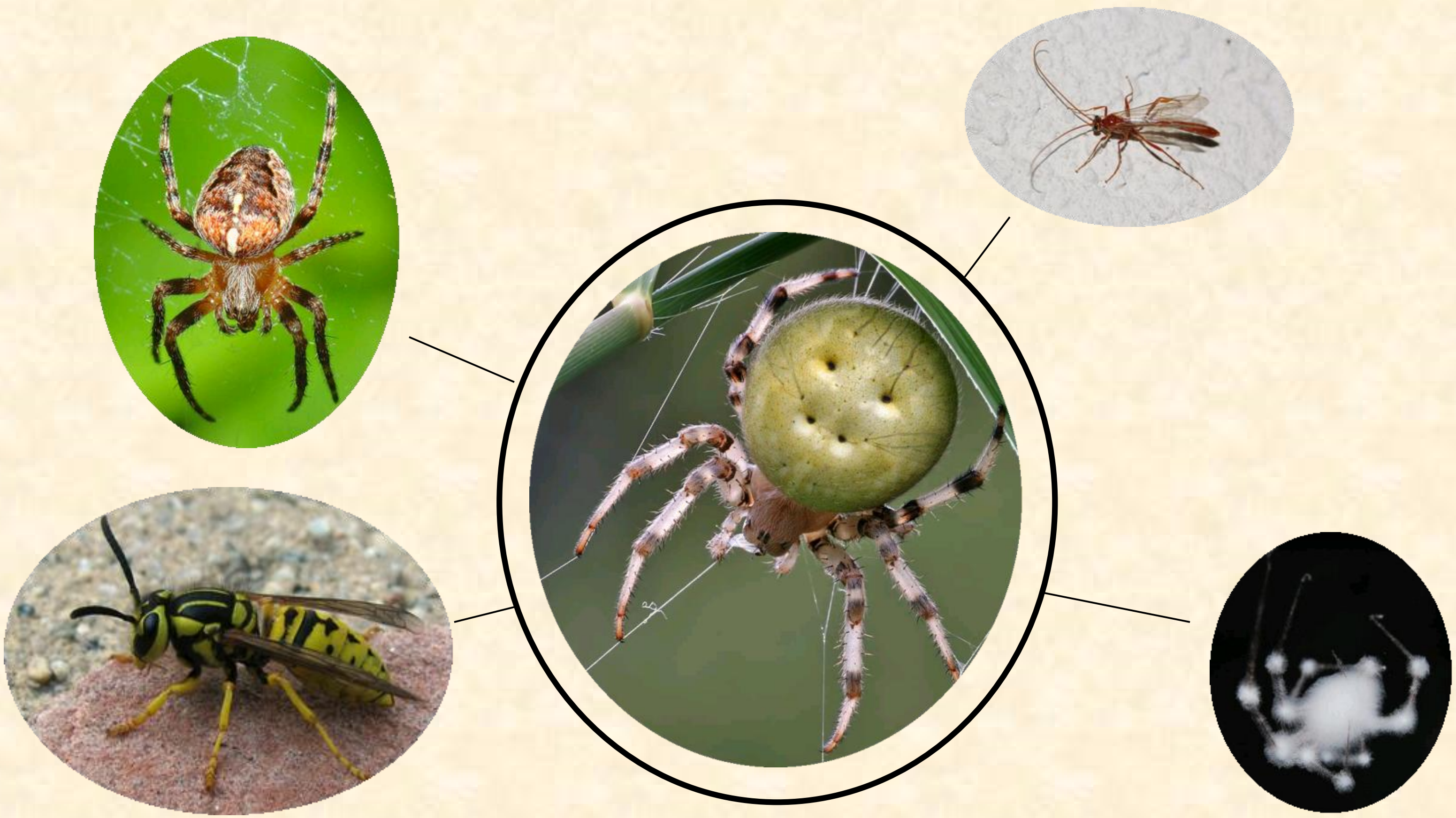
Renewable resources

- 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
- 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

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

For small populations (Chapman 1951)

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

Open population

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

Stochastic <u>Jolly-Seber method</u>

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

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

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

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