Growing predators and growing prey – Effects on dynamics and community structure

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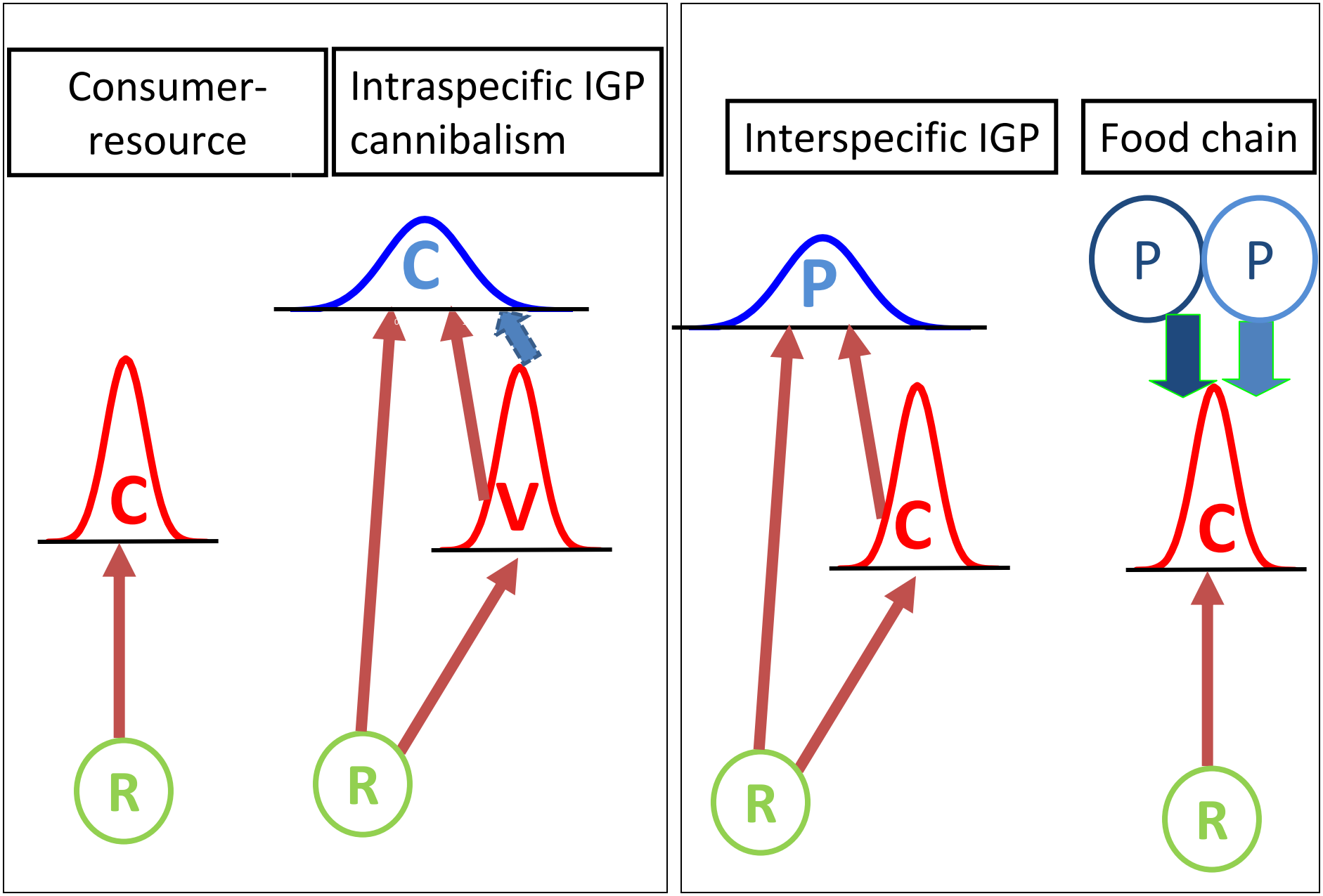
Body size…..

- Predator-prey size ratios – frequency distributions including within species size variation
- Body size distributions versus species identity
- Size dependent foraging and metabolism – link to interaction strength
- Size spectra – individual encounter and bioenergetics

- Intraspecific size variation – different sizes coupled over the life cycle
- Individual development food dependent
- From the simple to the somewhat less simple…..

Population dynamics

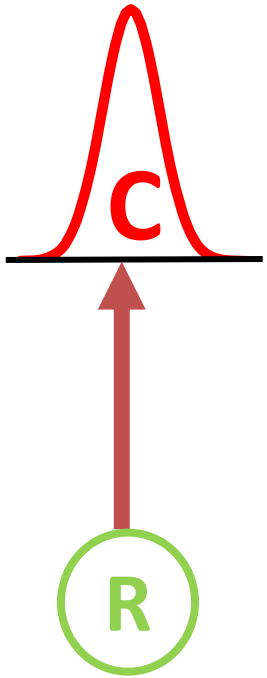
Community structure



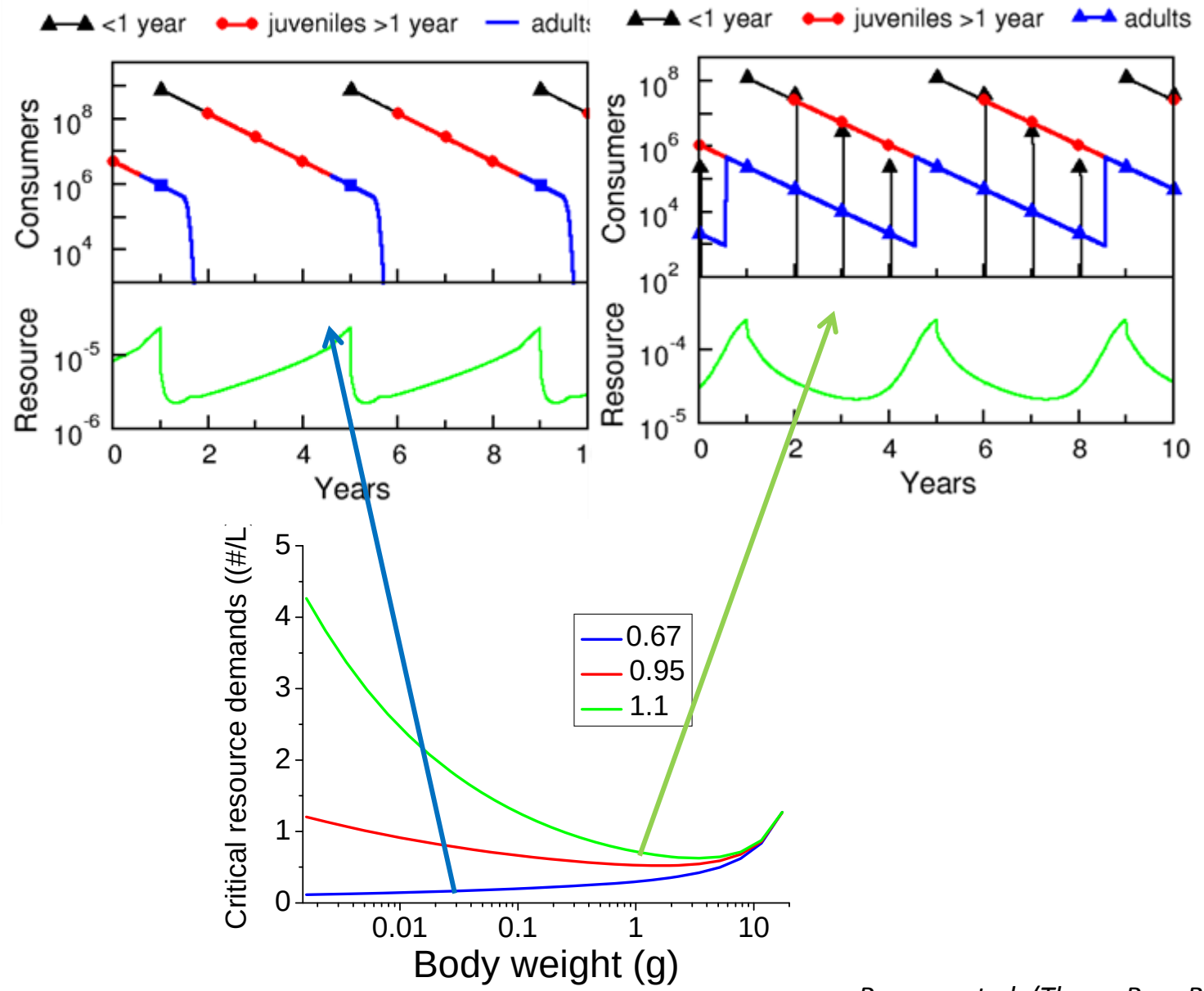
Population dynamics I

Consumer-resource

Growing prey……



Body size scaling and size-dependent competitive ability

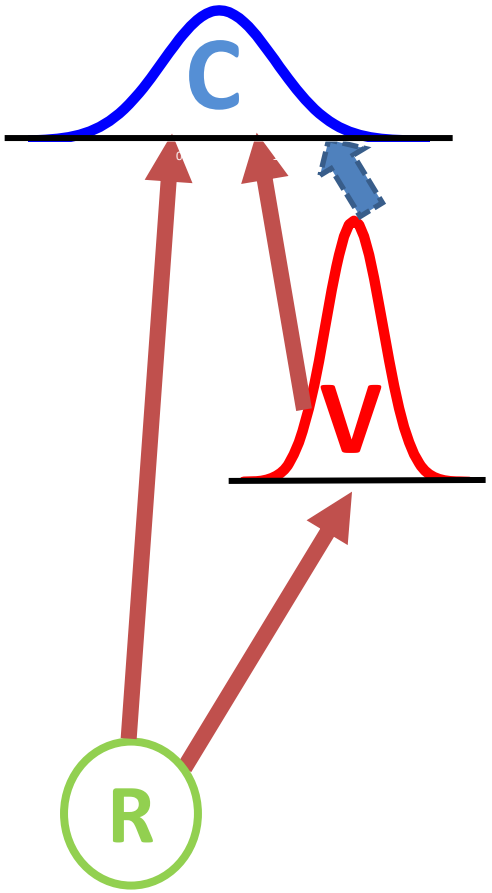


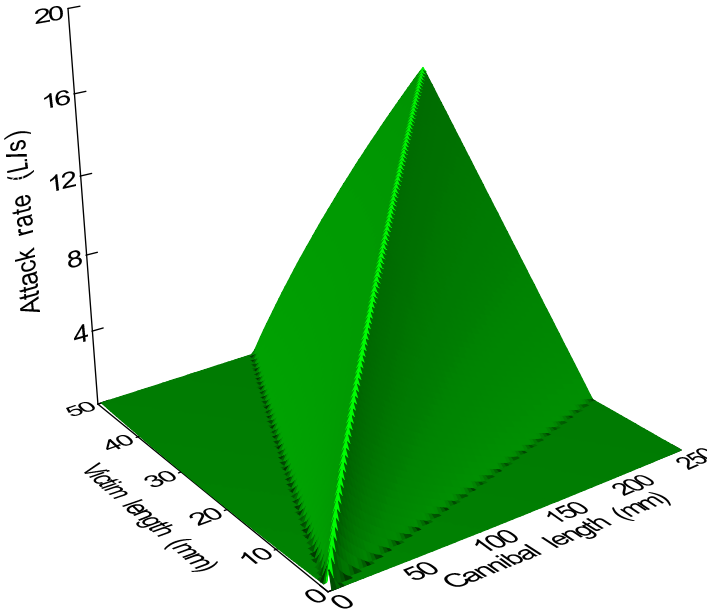
Persson et al. (Theor. Pop. Biol. 1998)

Population dynamics II

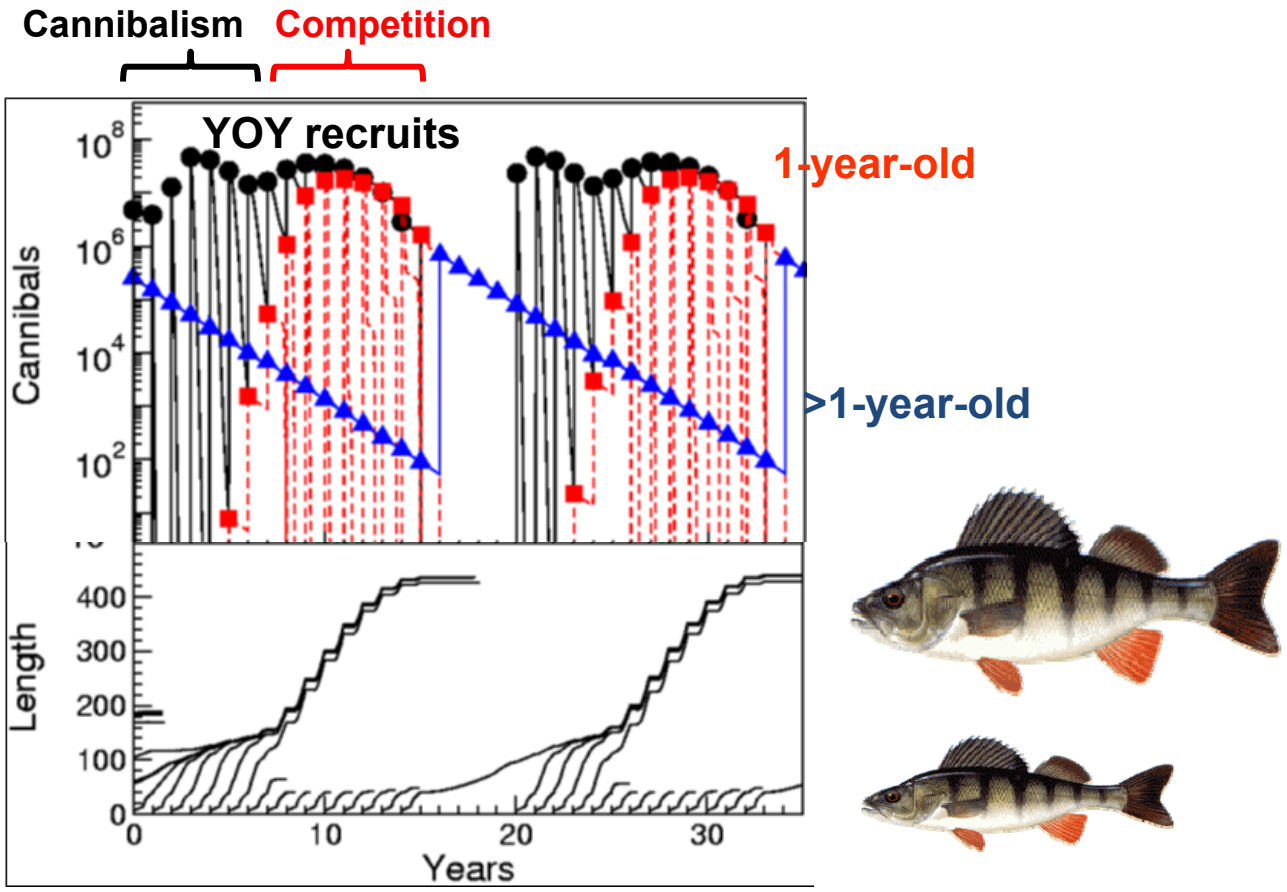
Intraspecific IGP cannibalism

Growing predator……





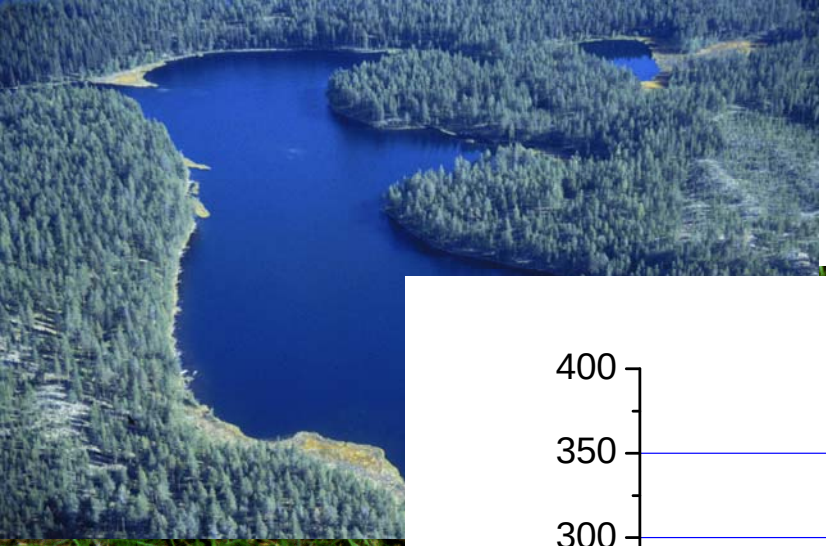
Cannibalistic model with shared resources

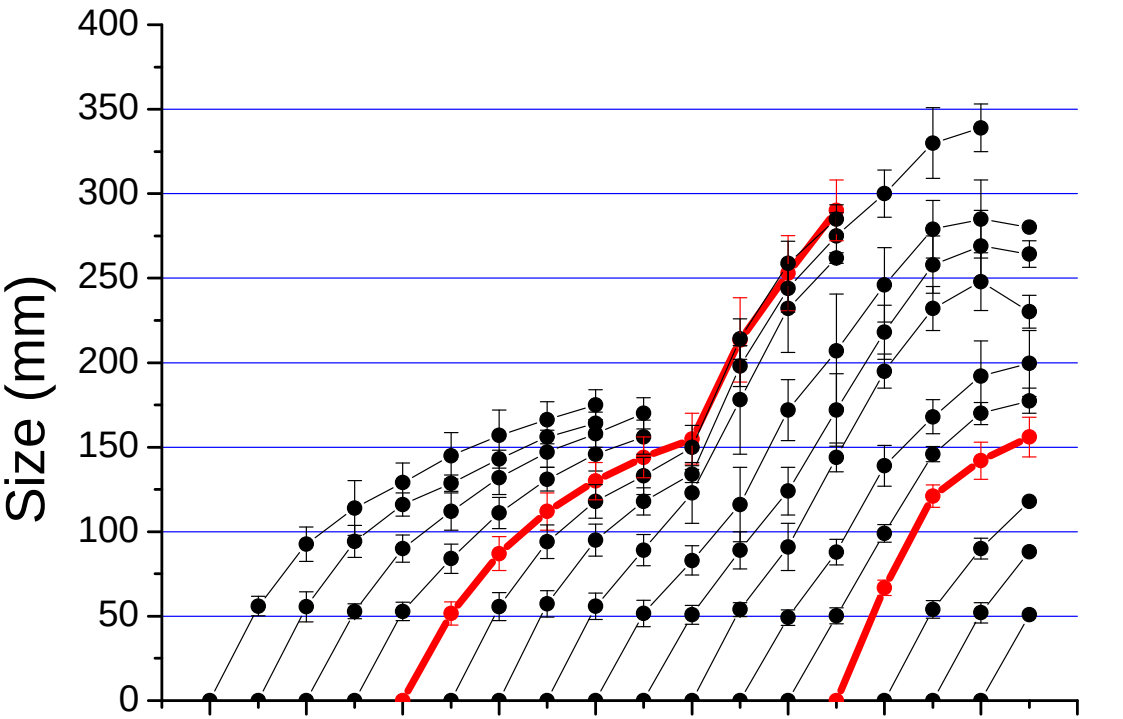


Increased cannibal growth – overcompensation in population fecunidty

Persson et al. (PNAS 2003)

Field data





Persson et al. (Ecol. Monogr. 2004)

Population dynamics

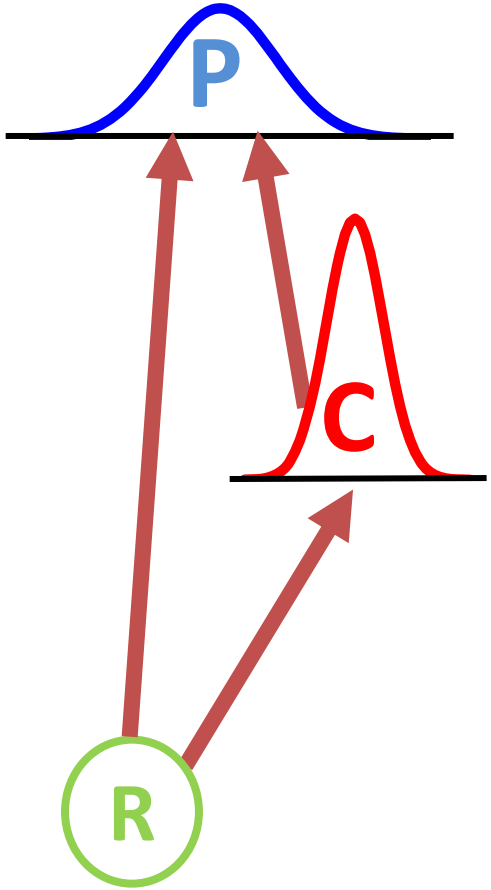
- Prey growth – competitive asymmetries

- Predator growth – overcompensation in cannibal population fecundity leading to cycles

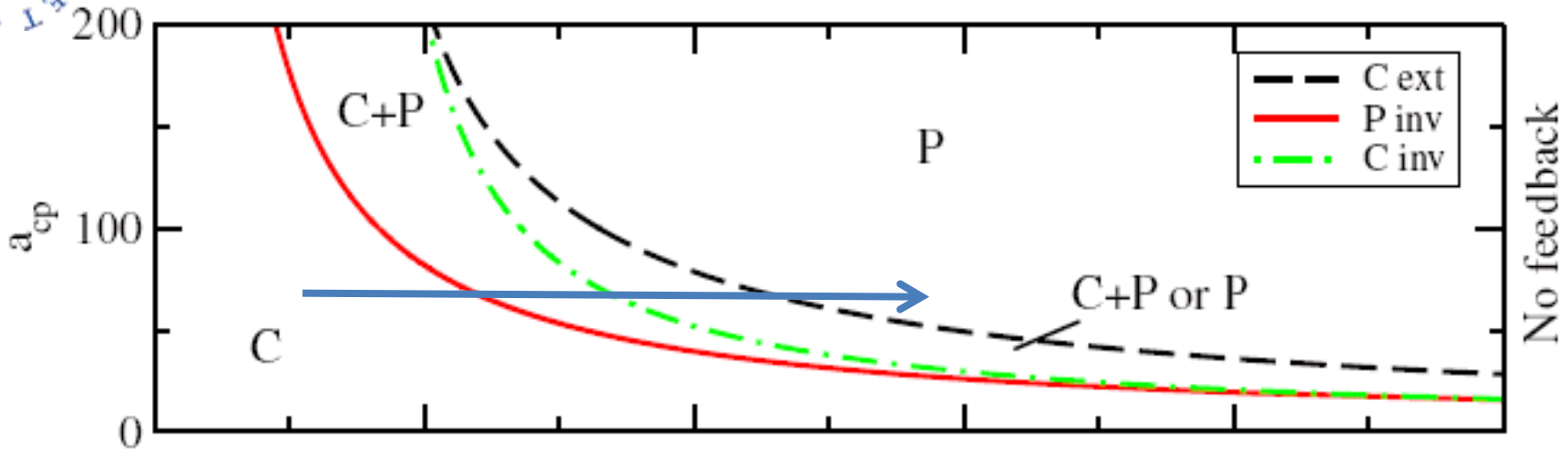
Community structure

- Predator growth – ASS in intraguild systems
- Prey growth – ASS, Emergent Allee effect and facilitation

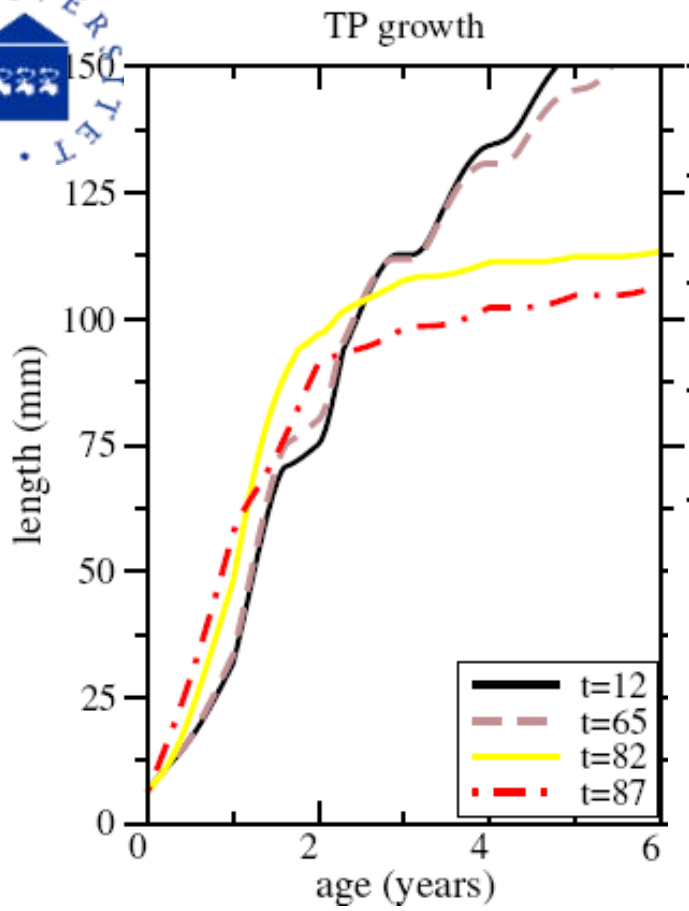
Interspecific IGP

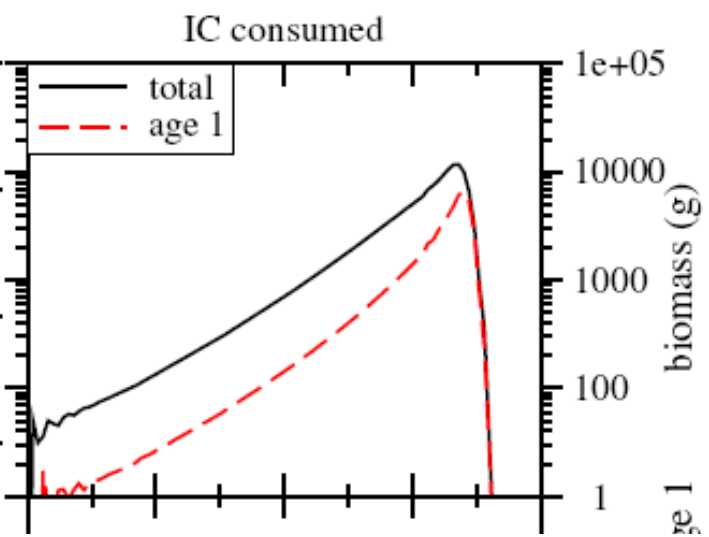


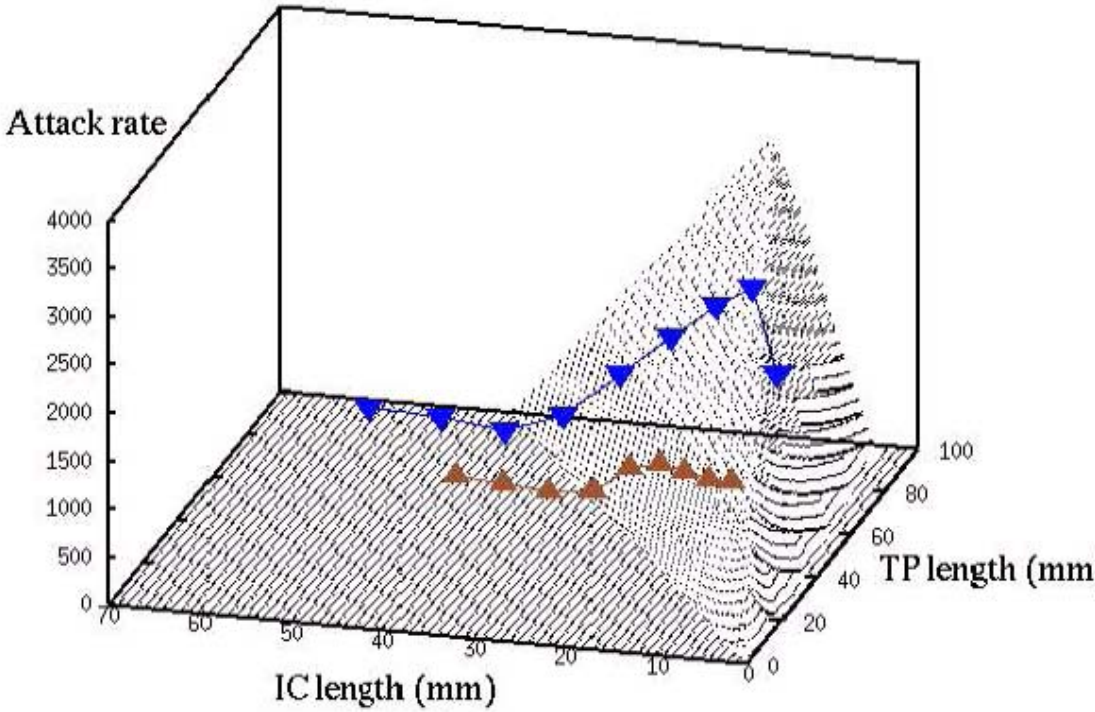
Food dependent vs fixed development time in TP and IC



Food dependent development demotes coexistence increases bistability

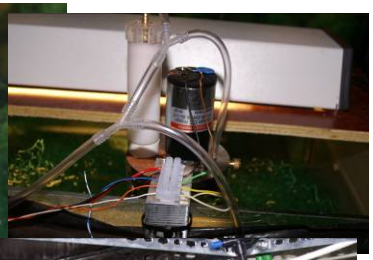


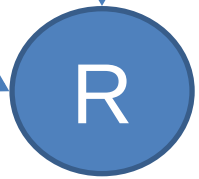




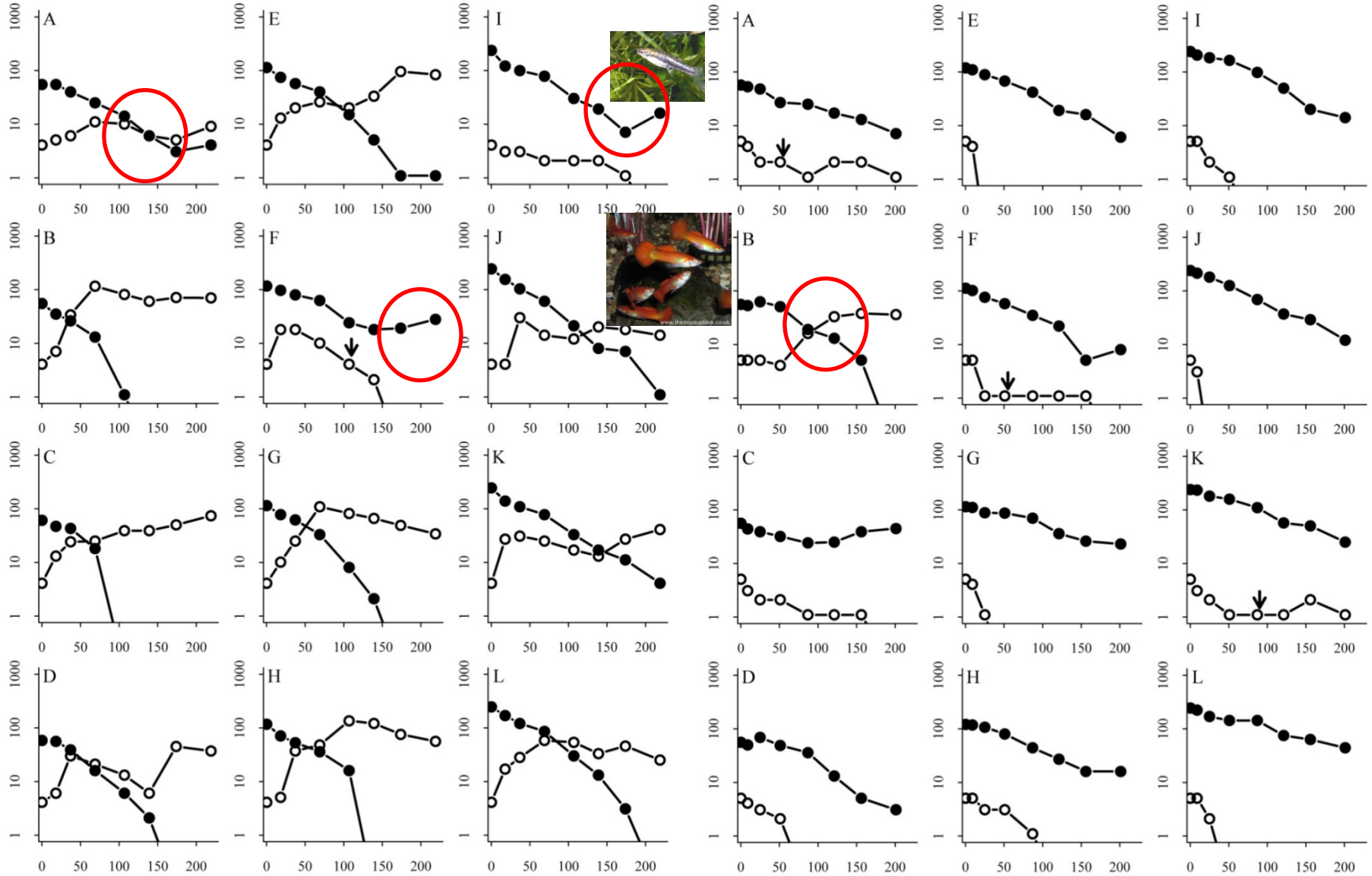
Van de Wolfshaar et al. (Am. Nat. 2006)

Intraguild predation, bistability and size dependency

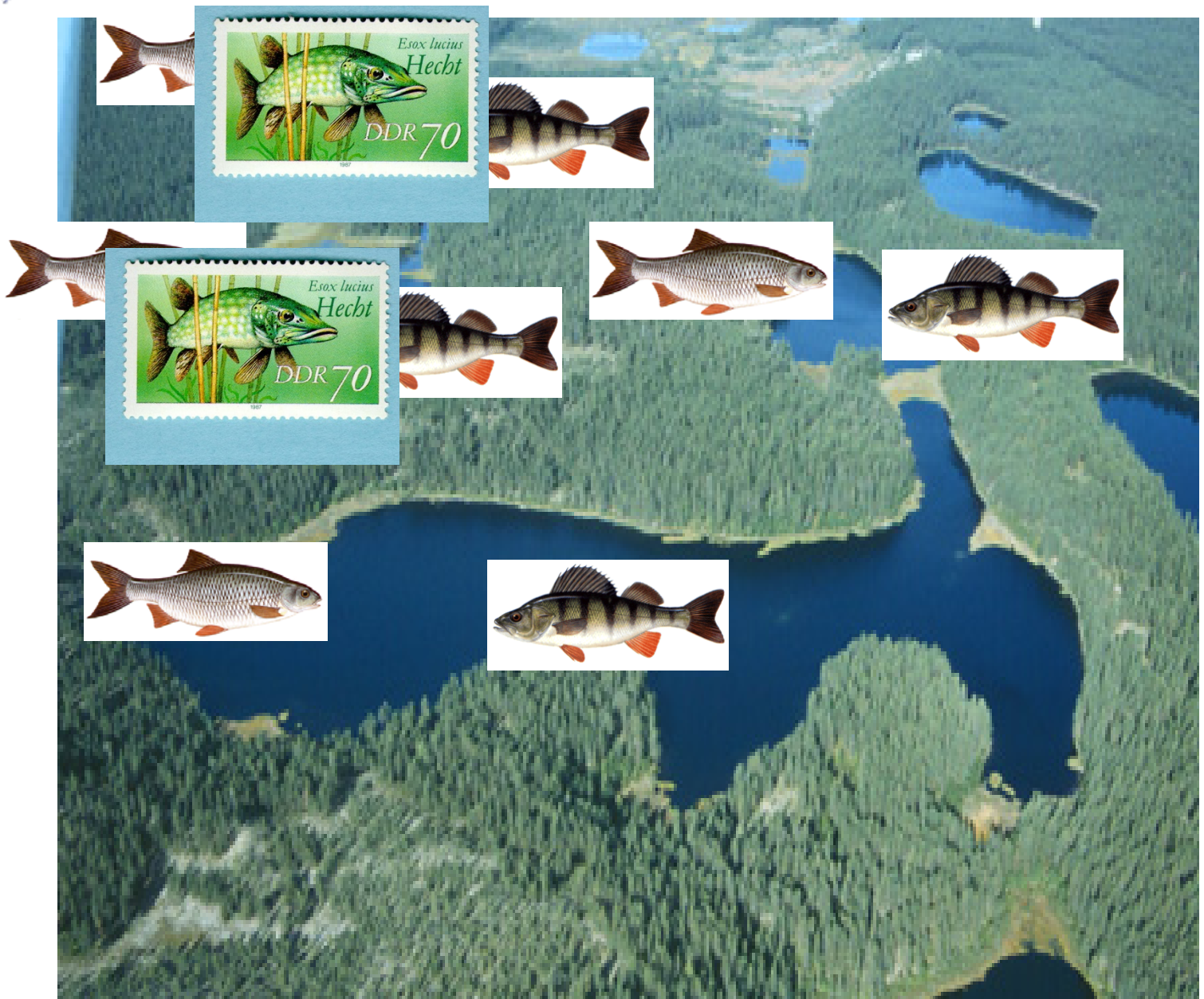




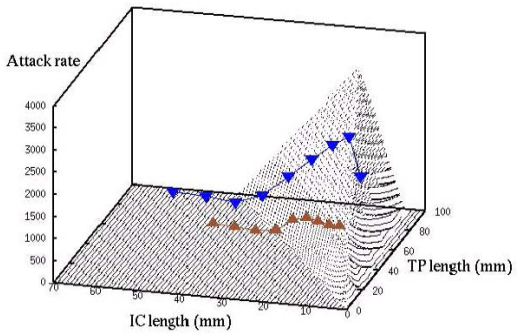
Big guppies invade.. Small guppies invade…

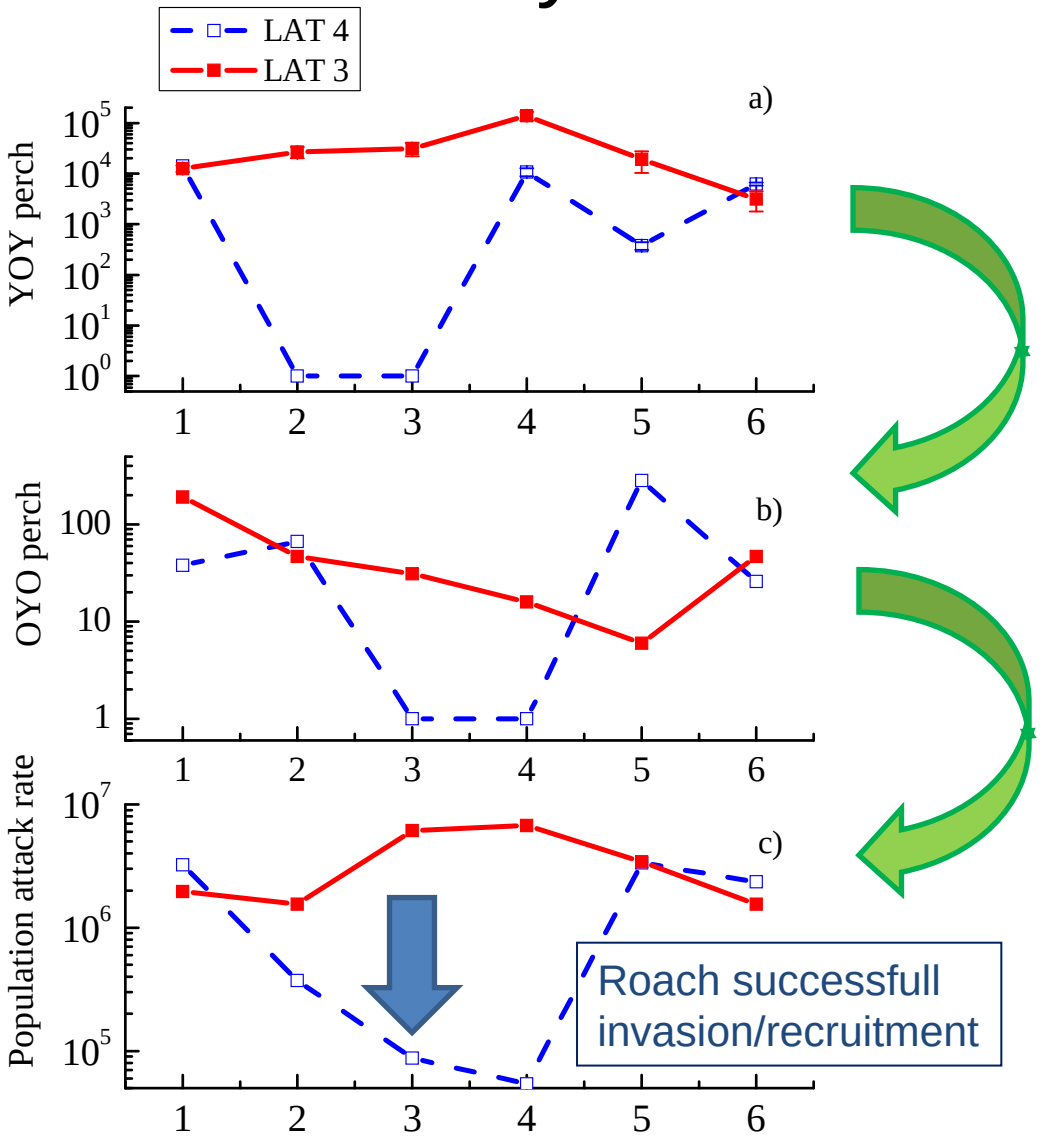


Whole lake experiment – IC invasion



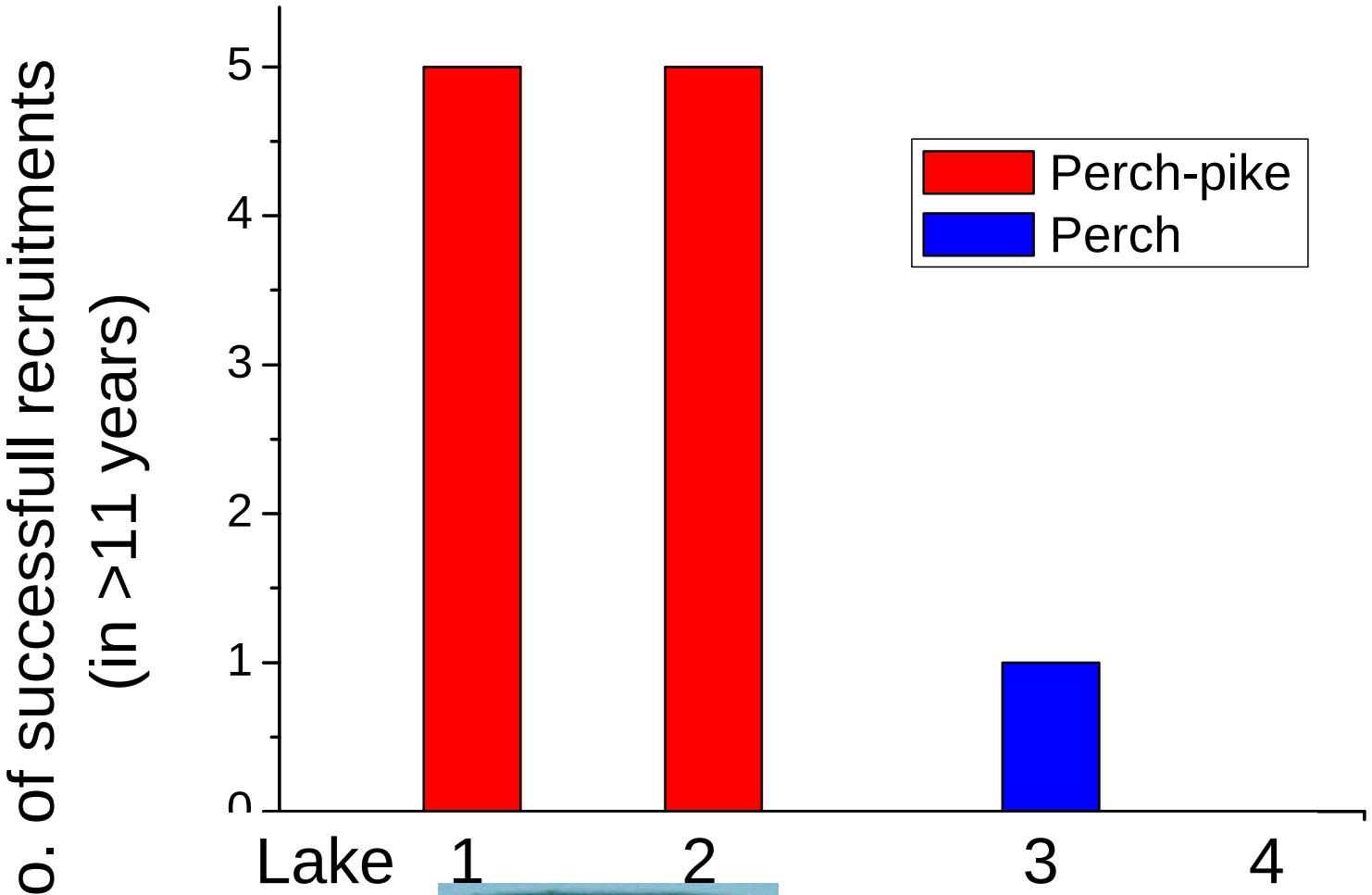
TP predation and sustained invasion of IC over 6 years





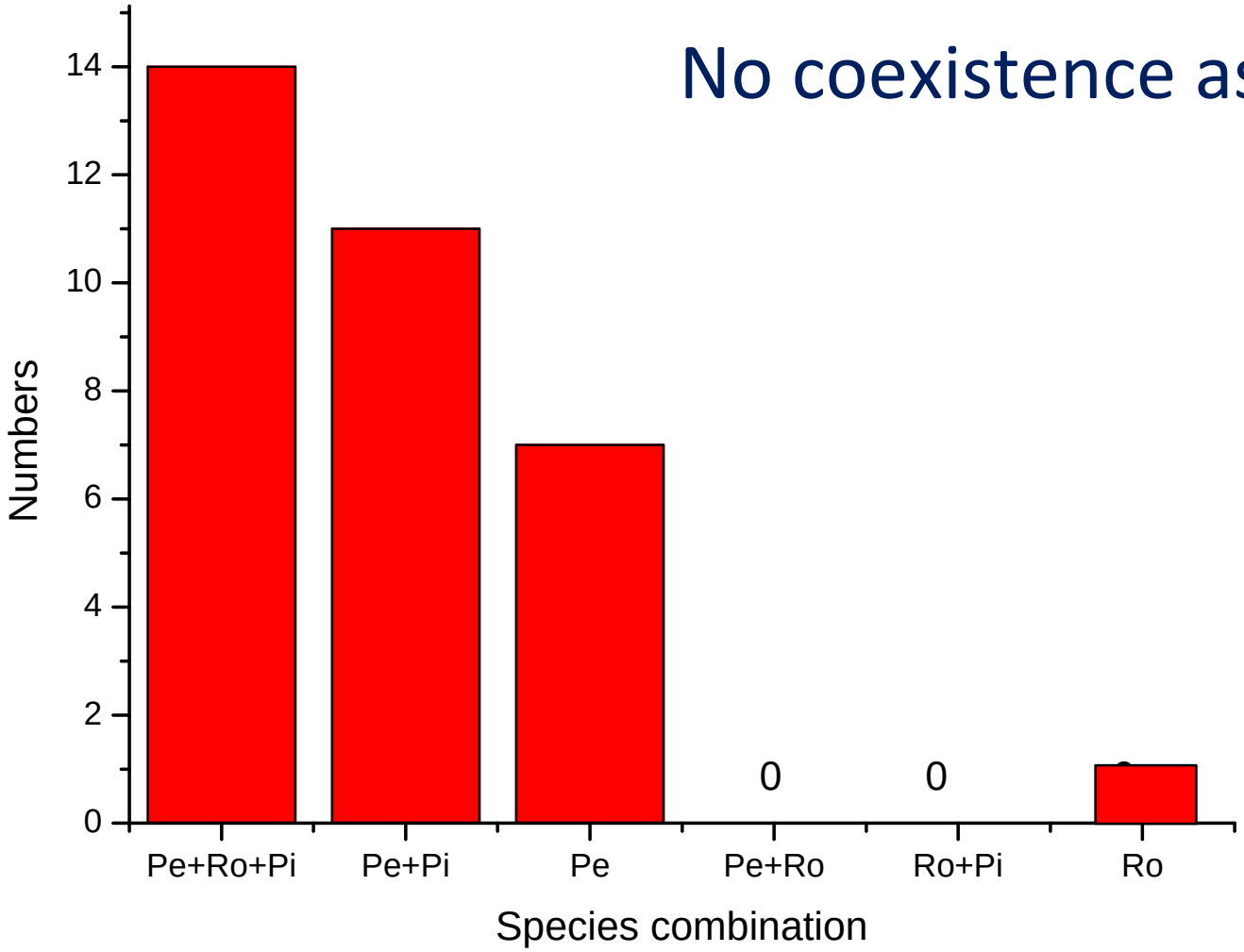
Persson et al. (J. Anim. Ecol. 2006)

Recruitment patterns of roach

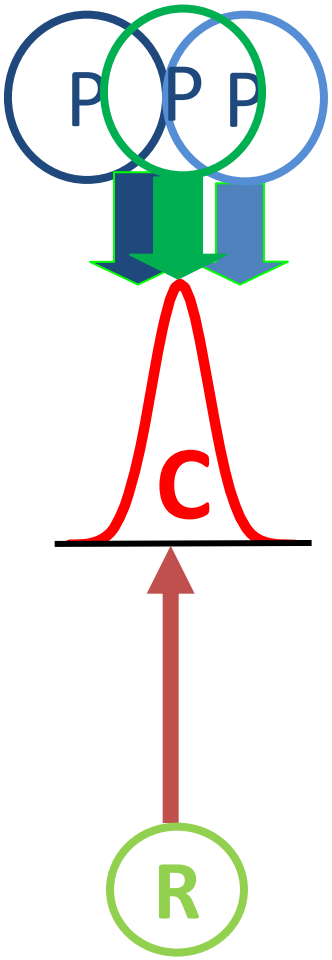


Comparative lake studies

No coexistence as pairs

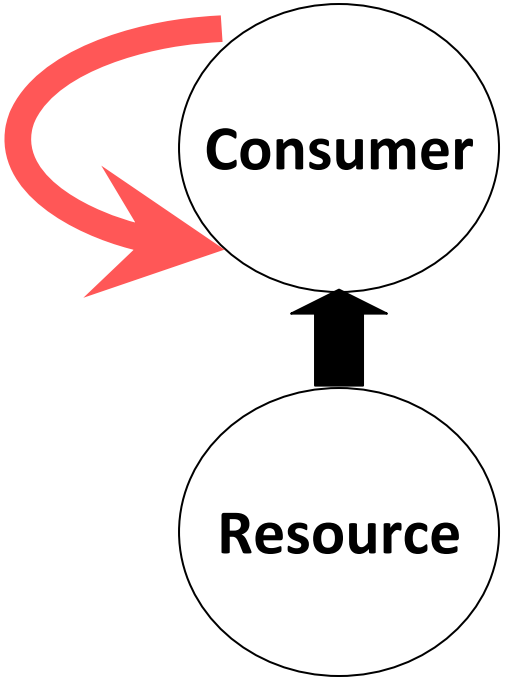


Food chain

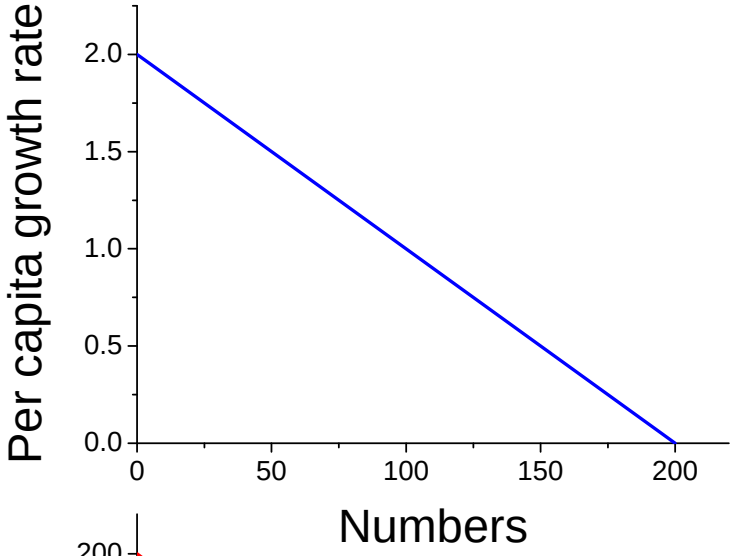


Density dependent per capita growth and mortality effect

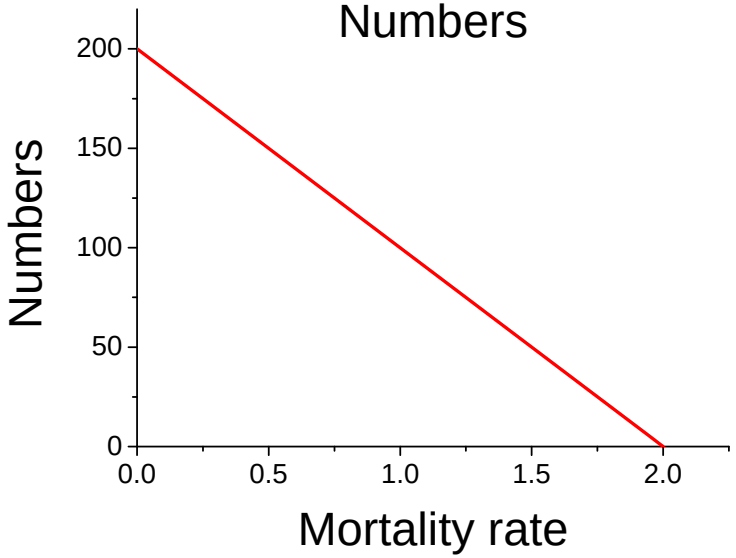
Food-dependent reproduction



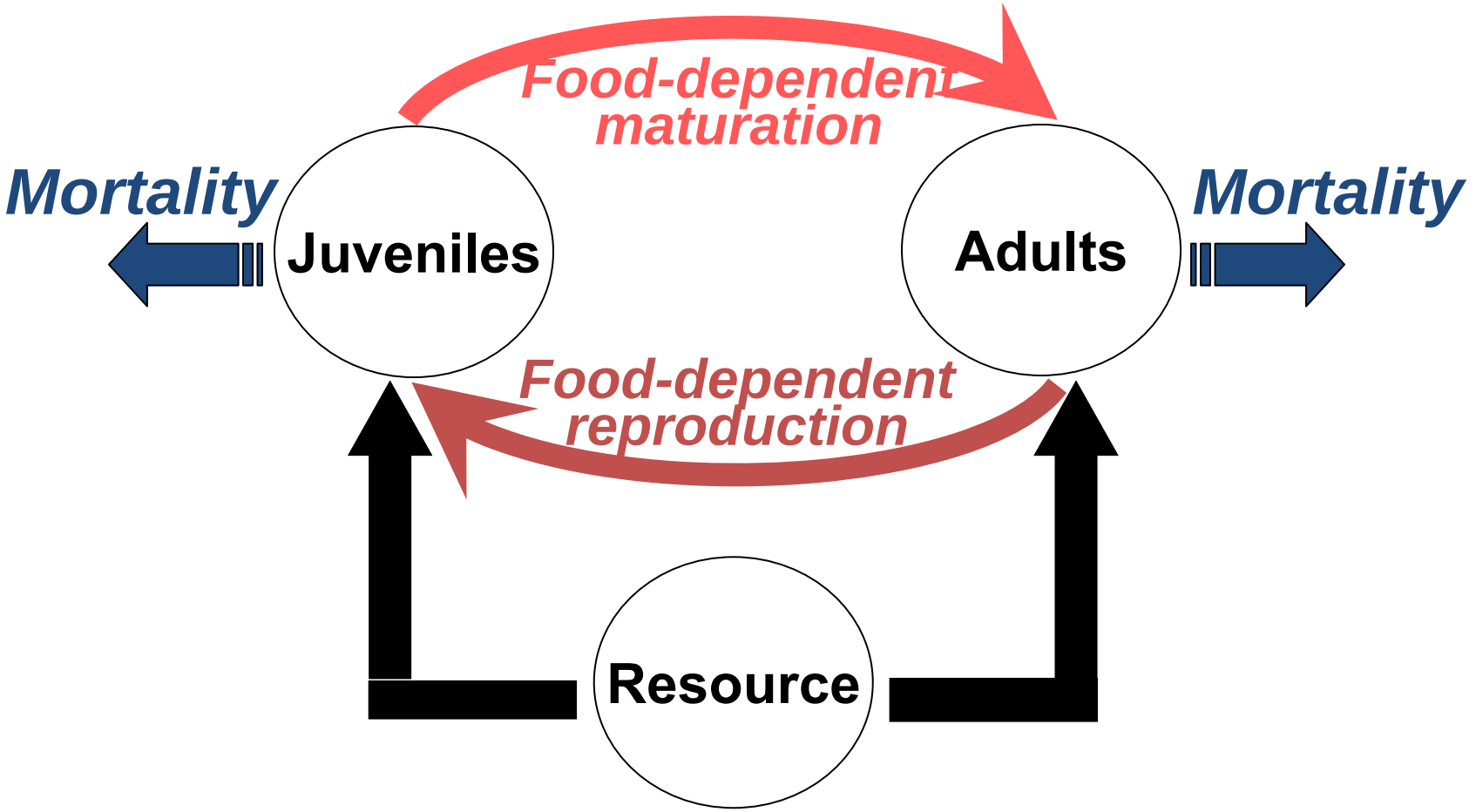
Per capita growth →



Mortality →



Stage-structured consumer life cycle



- Two potential regulatory transitions in life cycle
- Potential for botttlenecks

Stage-based biomass approach – 2 stages and food dependent development

Yodzis and Innes (1992) provided a tropic dynamic biomass approach ignoring size variation

$$v_j(R) = \sigma I_{\max} \frac{R}{H+R} - T$$

$$\frac{dJ}{dt} = \nu_a(R)A + \nu_j(R)J - \nu_j(R)\gamma(R)J - \mu_J J$$

$$v_a = q\sigma I_{\max} \frac{R}{H+R} - T$$

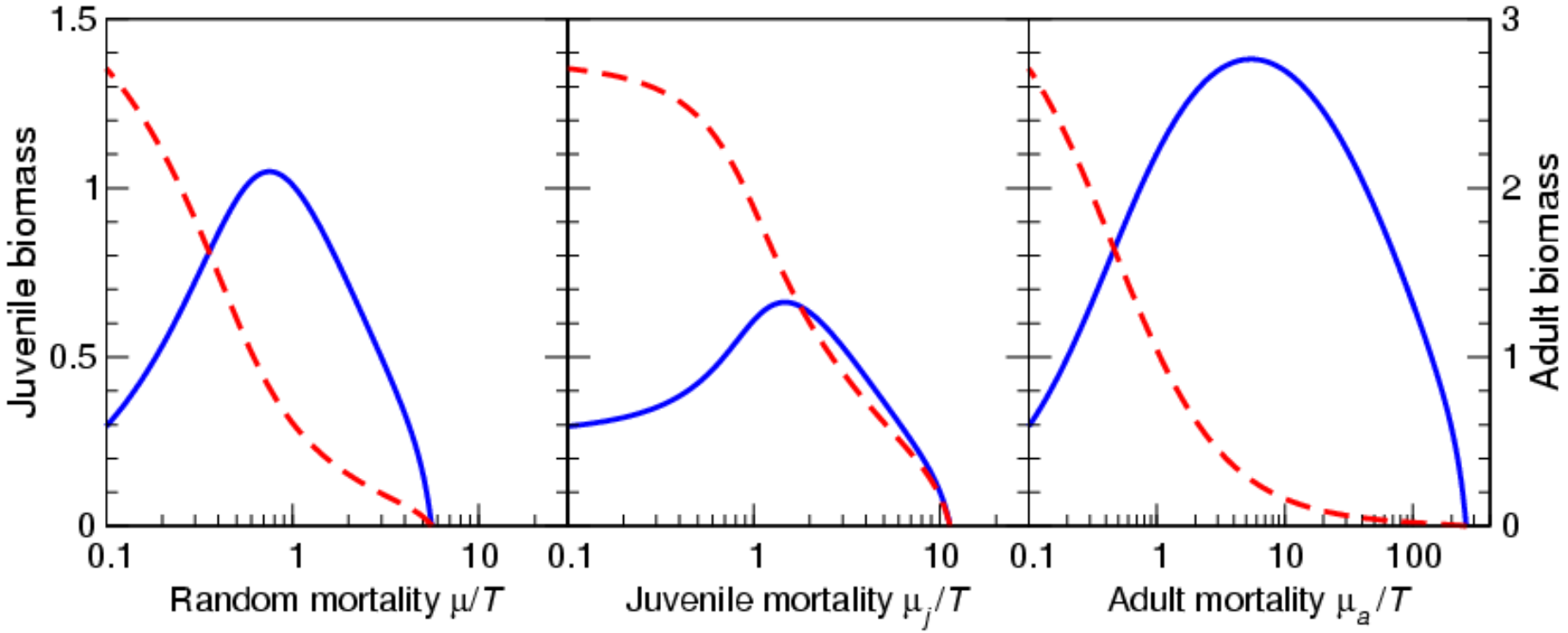
$$\frac{dA}{dt} = \nu_J(R)\gamma(R)J - \mu_A A$$

$$\frac{dR}{dt} = \delta(R_{\max} - R) - \frac{R}{H+R}(I_{\max}J + qI_{\max}A)$$

$$\gamma(R) = \frac{1 - \frac{\mu_j}{\nu_j(R)}}{1 - z^{1-\frac{\mu_j}{\nu_j(R)}}}$$

De Roos et al. (Am. Nat. 2007)

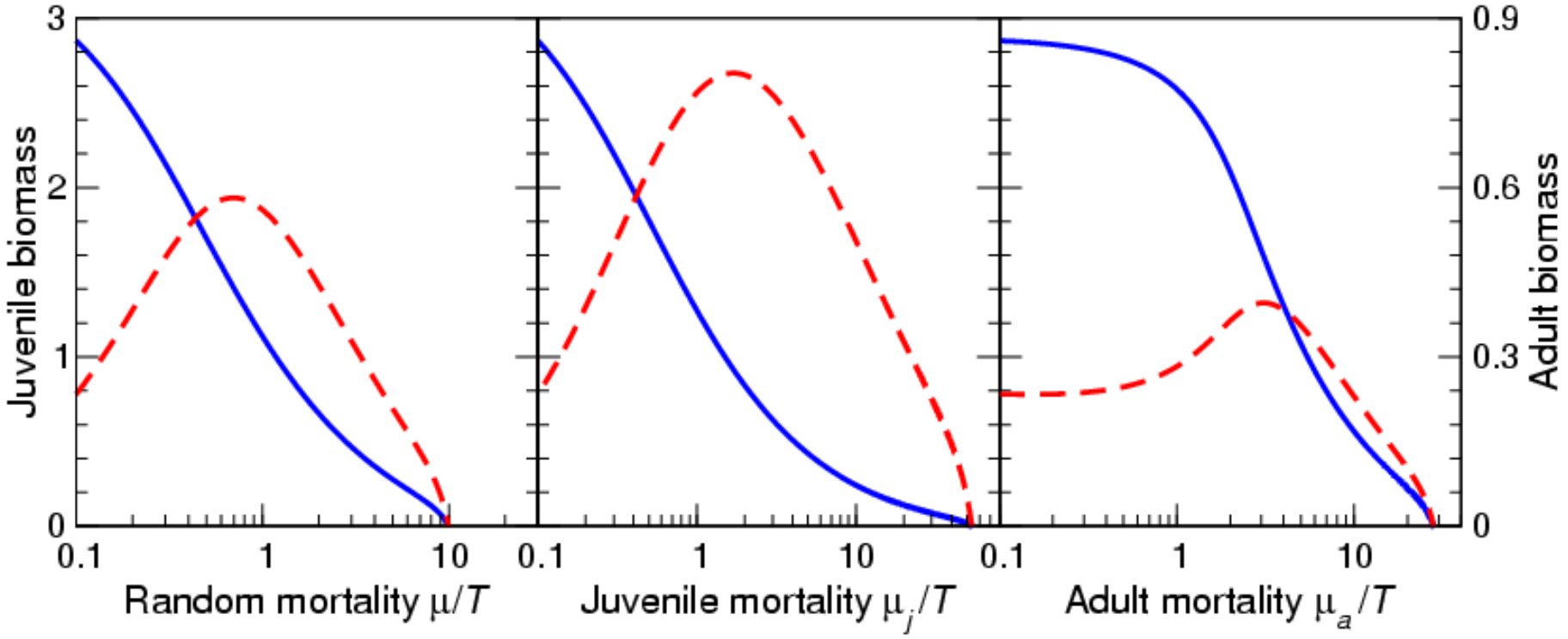
Adults compete: Reproduction regulation



Juvenile biomass *increases* with increasing mortality, even with juvenile mortality

De Roos et al. (Am. Nat. 2007)

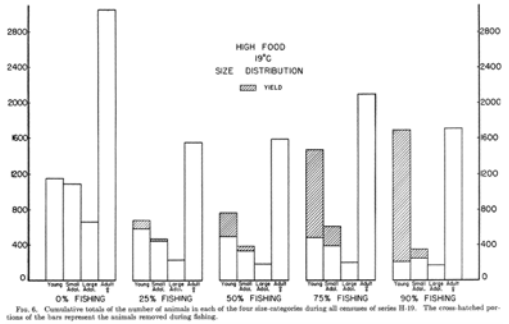
Juveniles compete: Maturation regulation



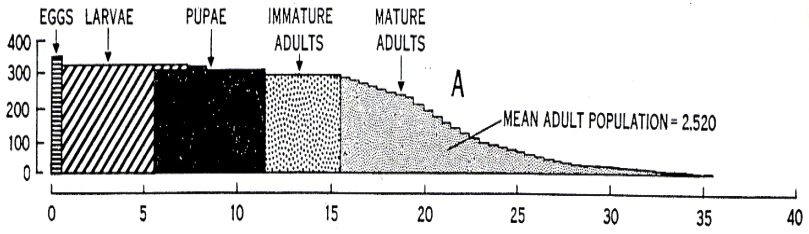
Adult biomass *increases* with increasing mortality, even with adult mortality

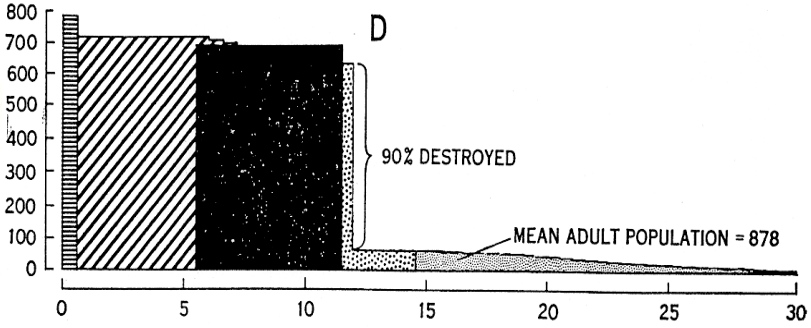
Experimental evidence for stage specific overcompensation

Dapnhia (Slobodkin & Richman 1956, Limnol. Oceanogr.)



Blow flies (Nicholson 1957, Cold Spring Harbor Symposium on Quantitative Biology)*

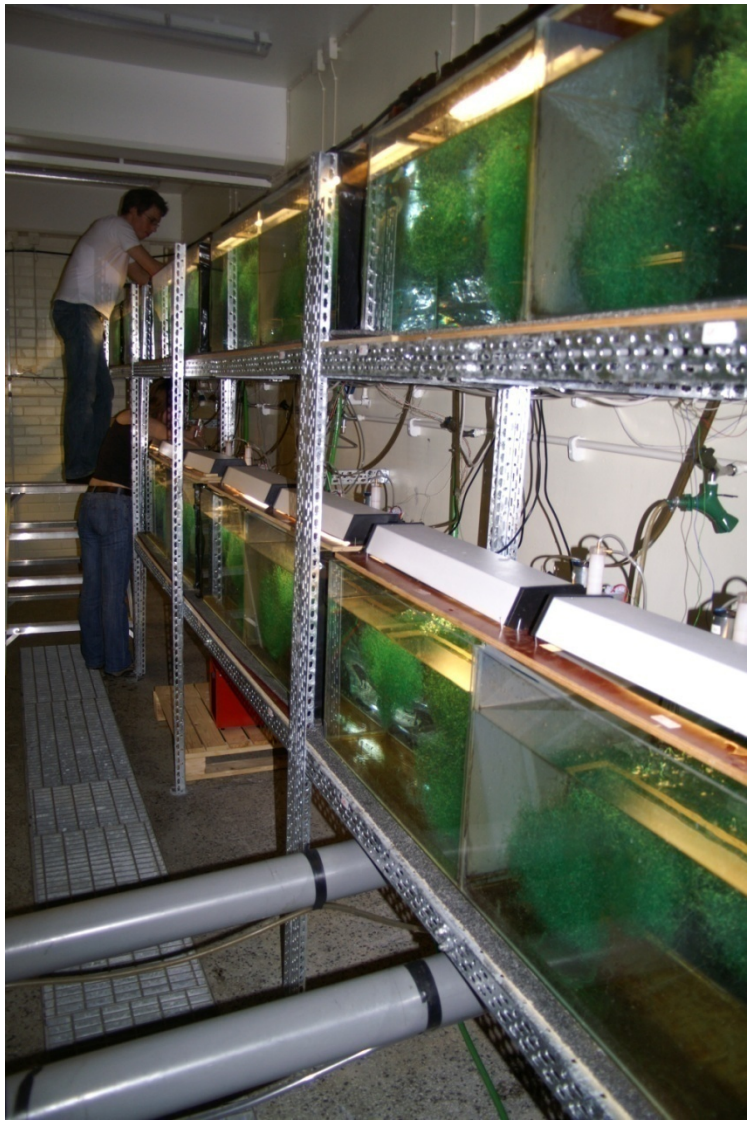


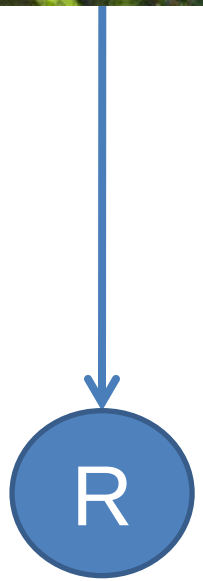


Soil mites (Cameron and Benton 2004, J. Anim. Ecol.)

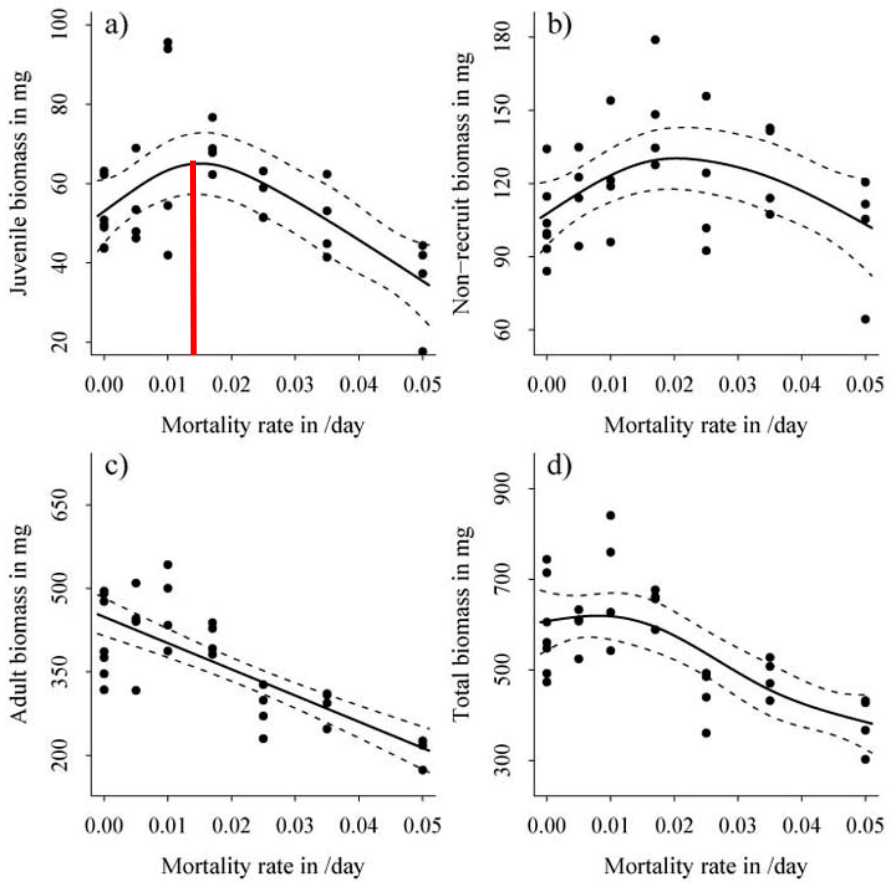
*reversed when juvenile strongly compete

Overcompensation in a size-structured consumer– a complete test

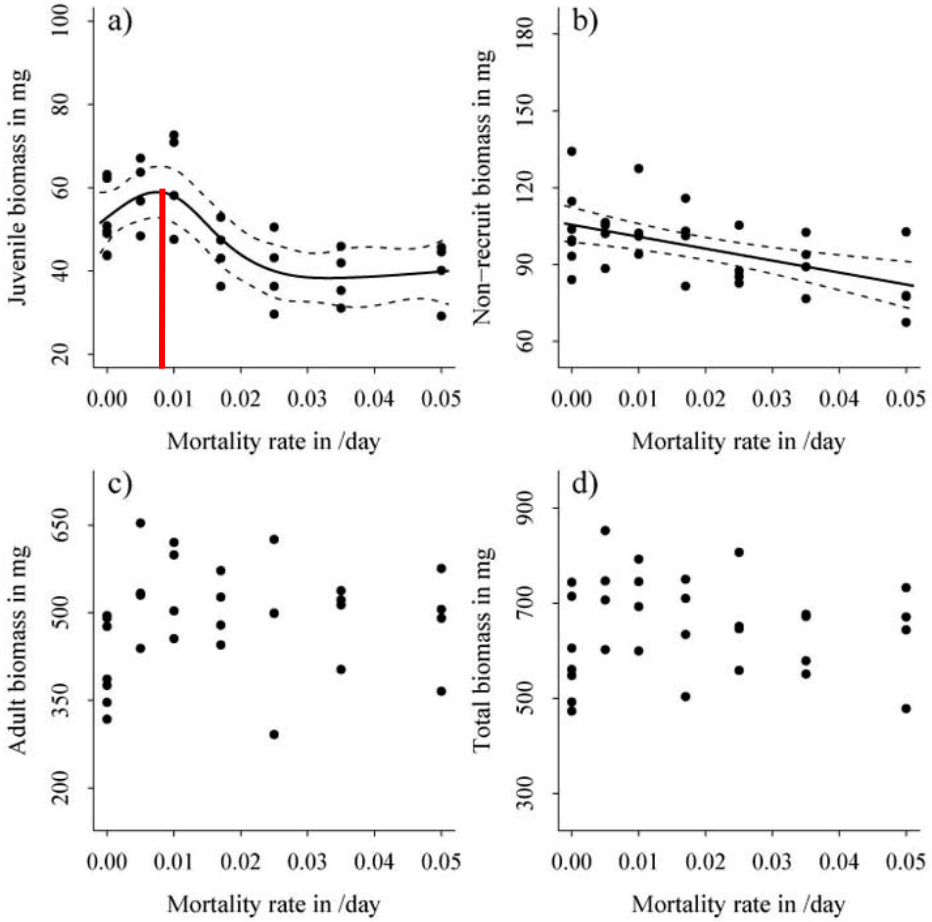




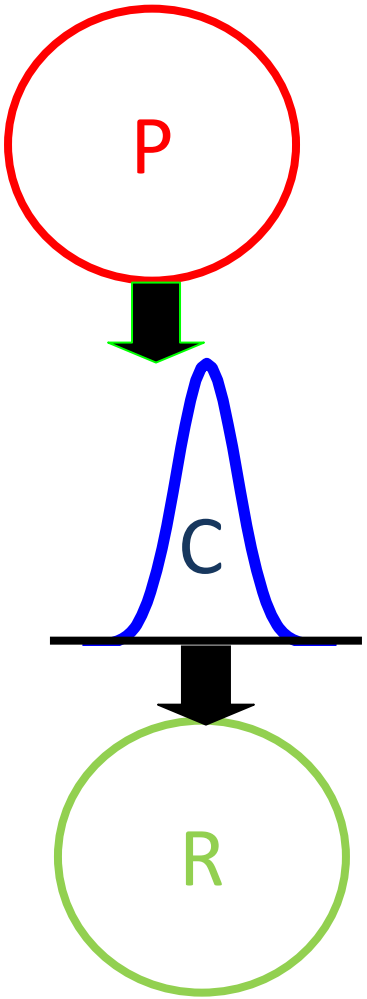
Harvesting adults

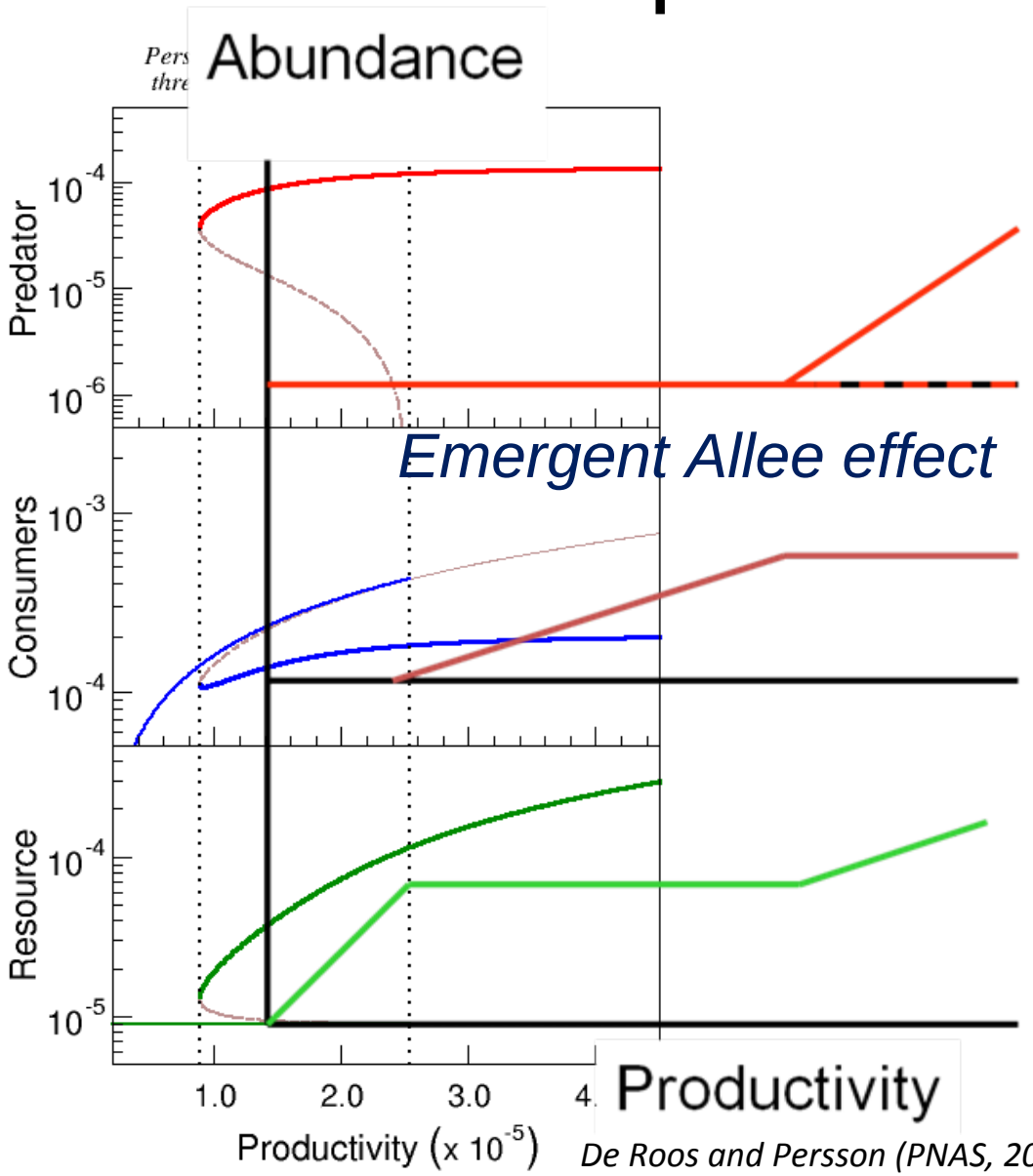


Harvesting juveniles



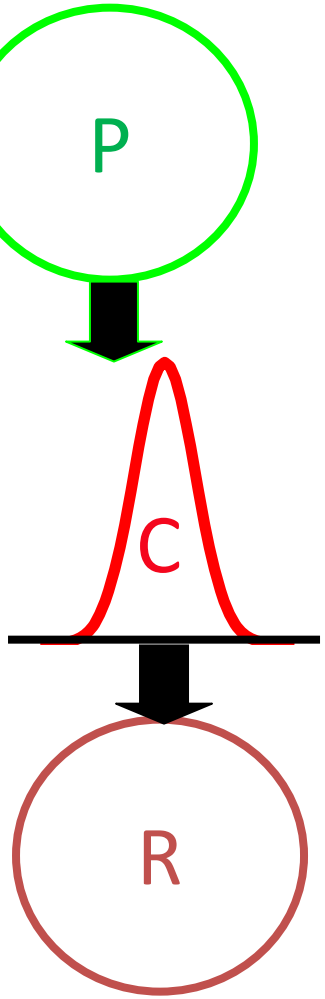
Food chain with food dependent growth and size-selective predation

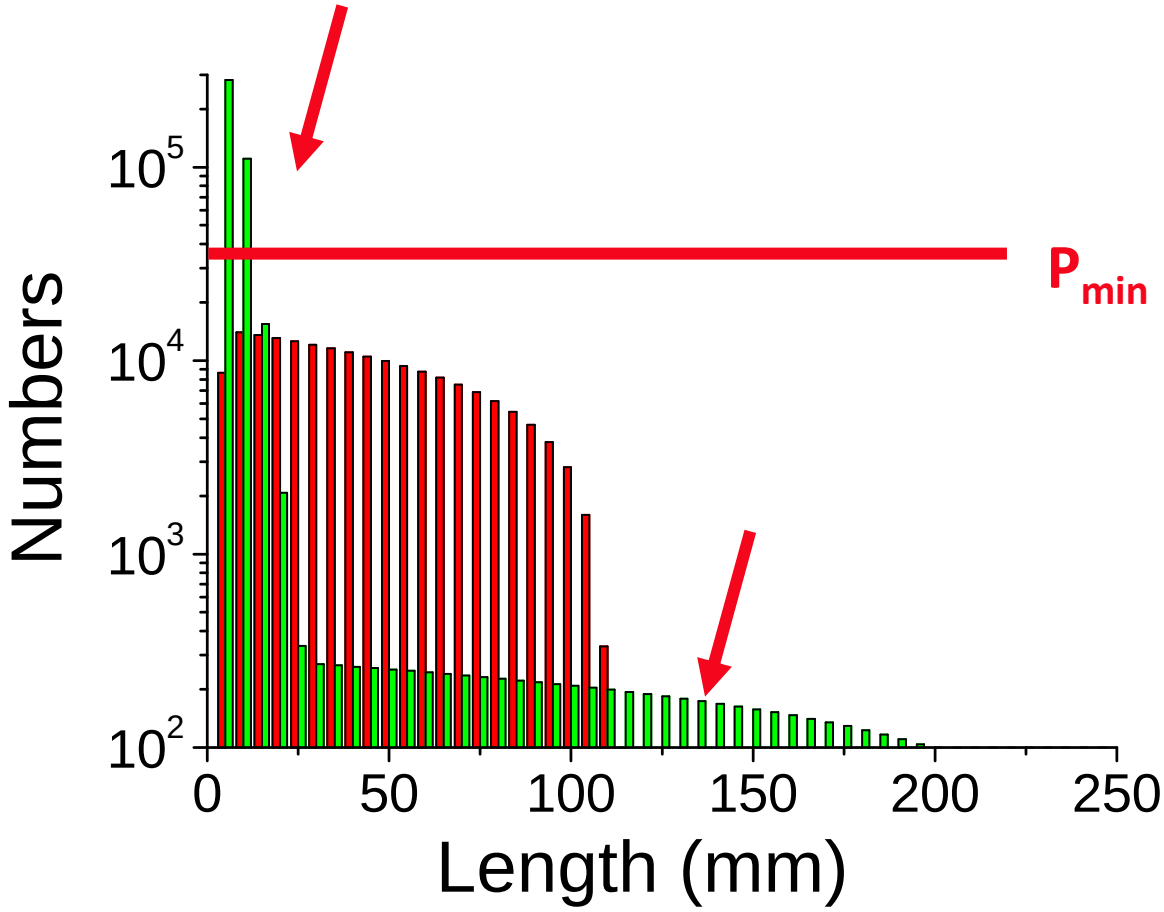




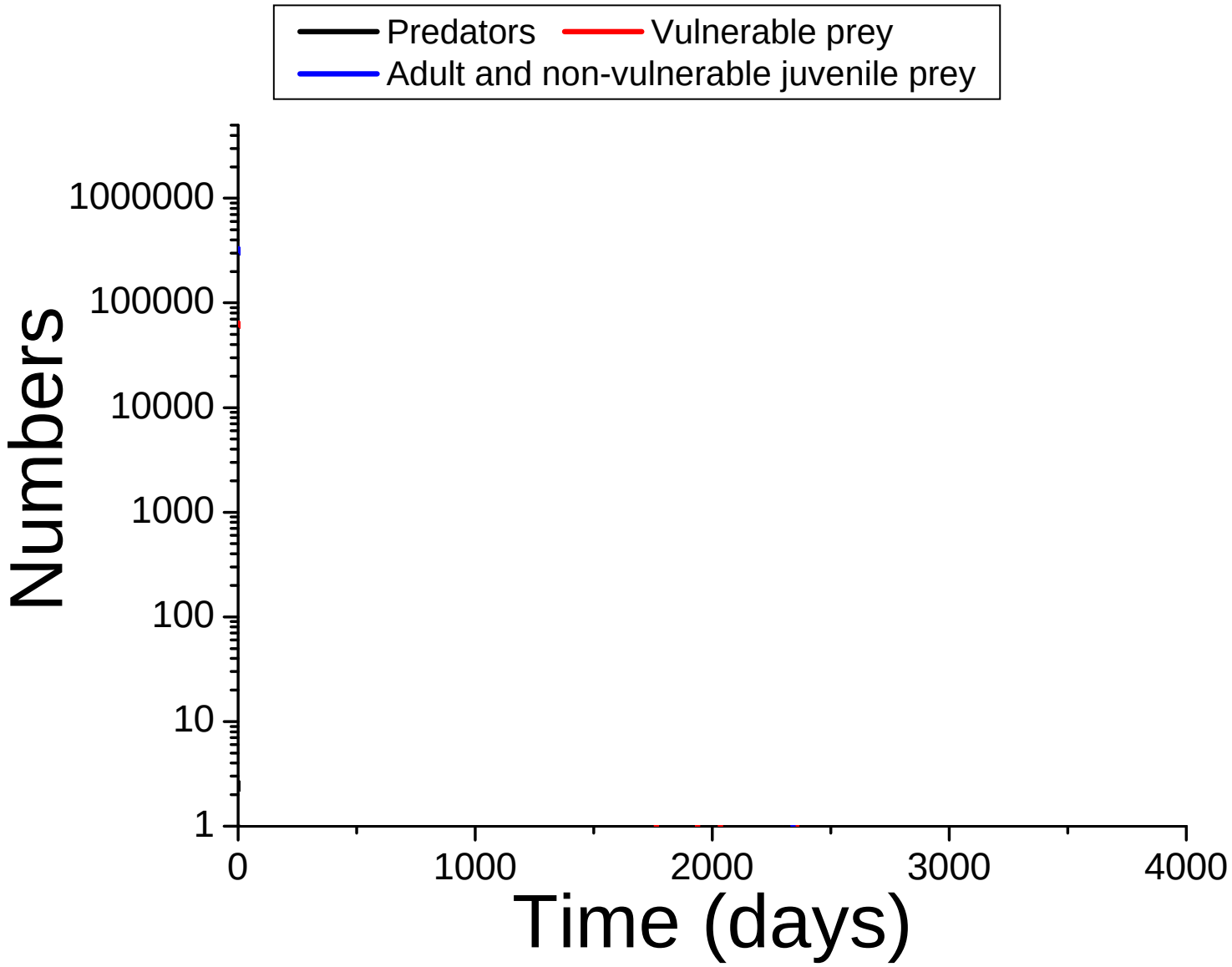
De Roos and Persson (PNAS, 2002)

A 3 link food chain- predator-induced size-structure shifts

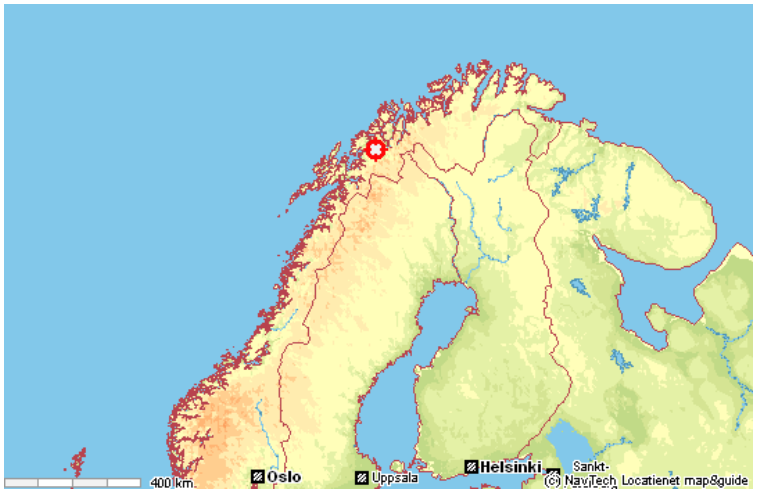


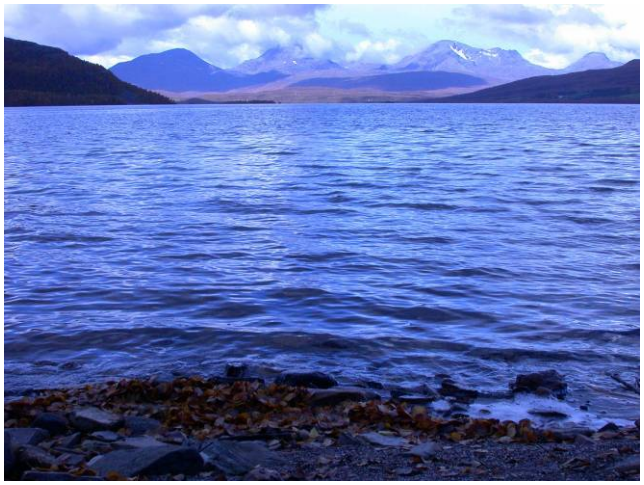


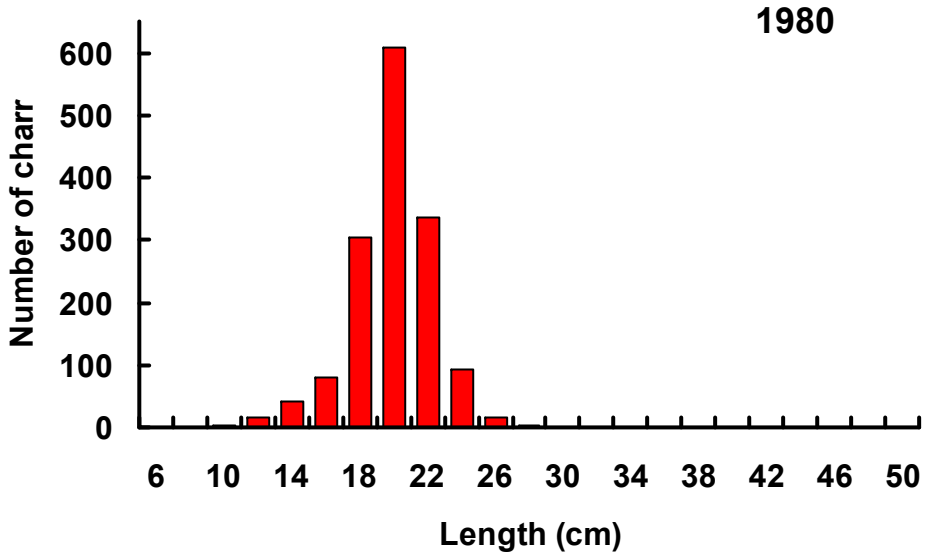
A modeling test



Thinning experiment of Arctic charr in Lake Takvatn

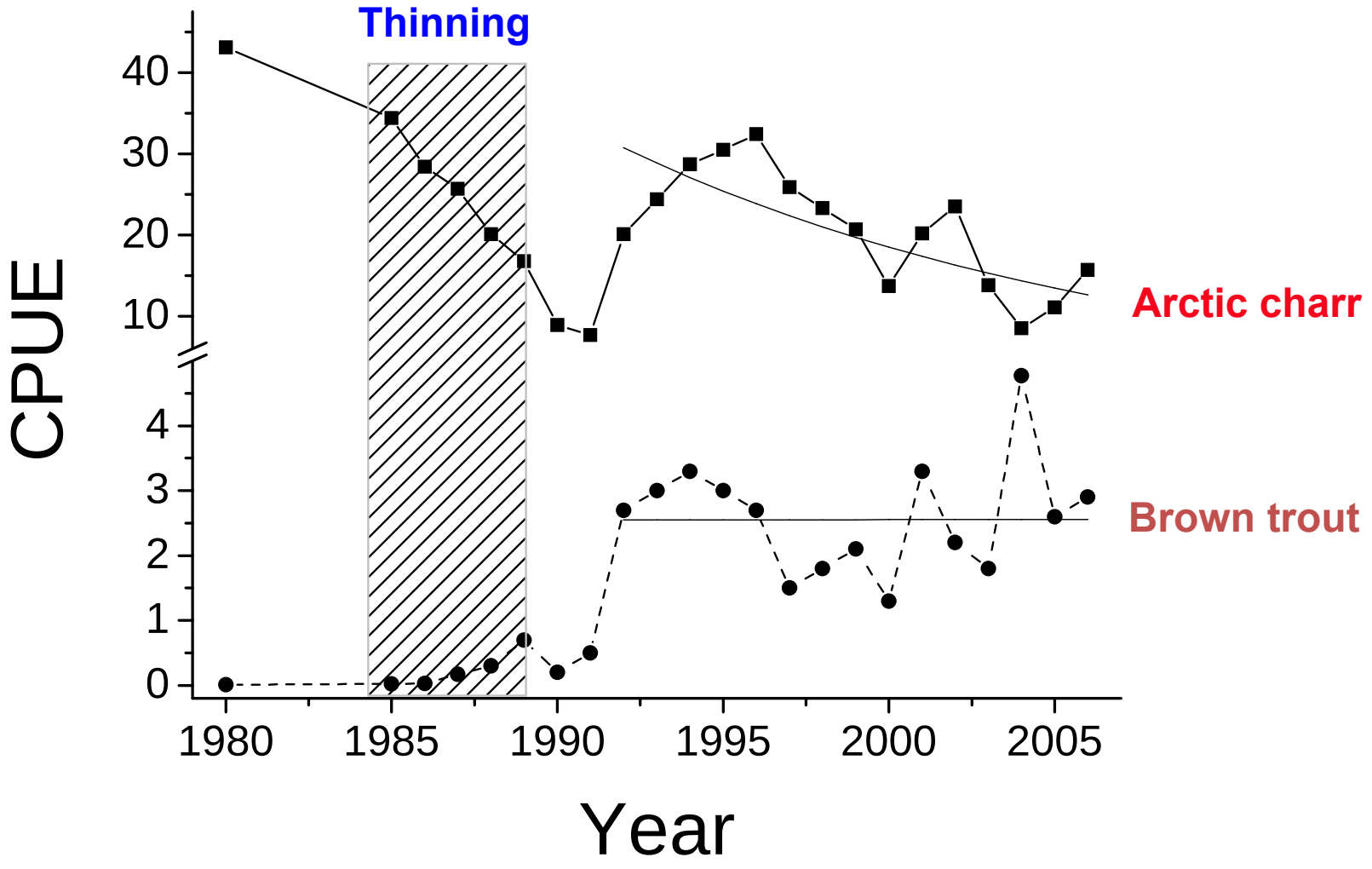






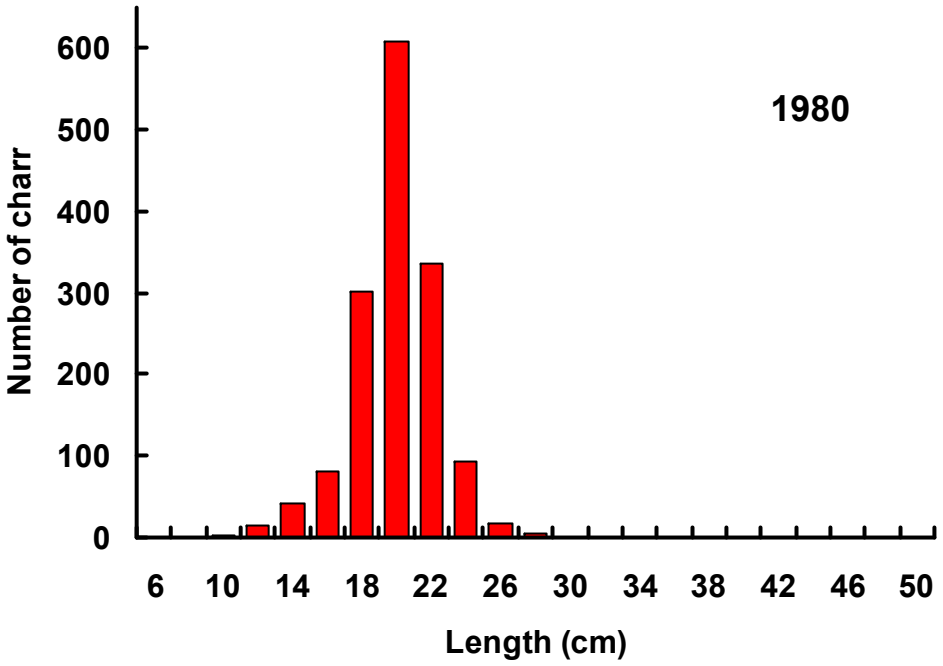
From 1984 to 1989, a total of 666, 000 charr (31.3 metric tons) were removed by intensive fishing…..

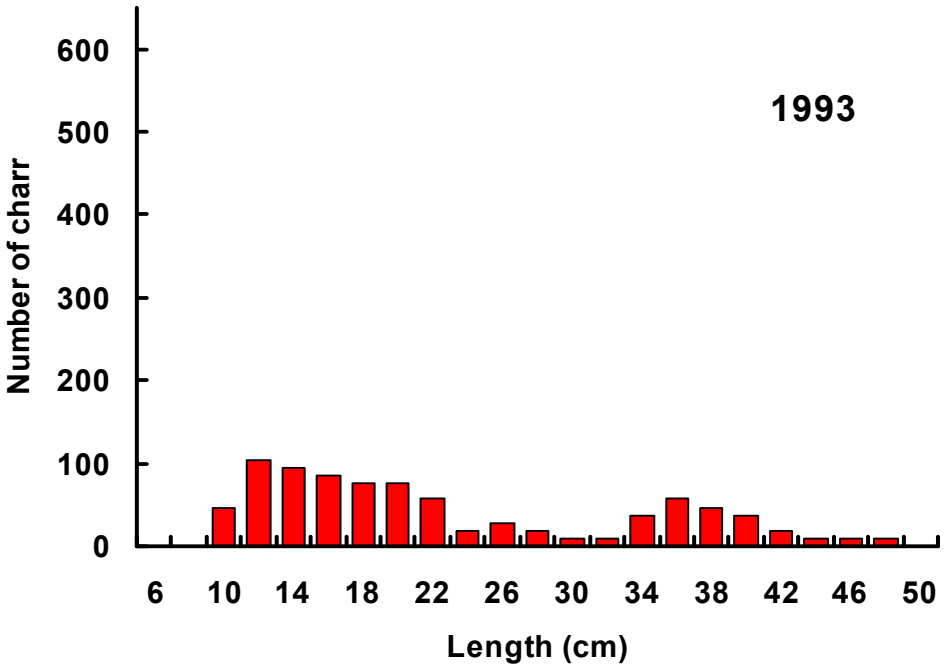
Lower total prey density - higher predator density



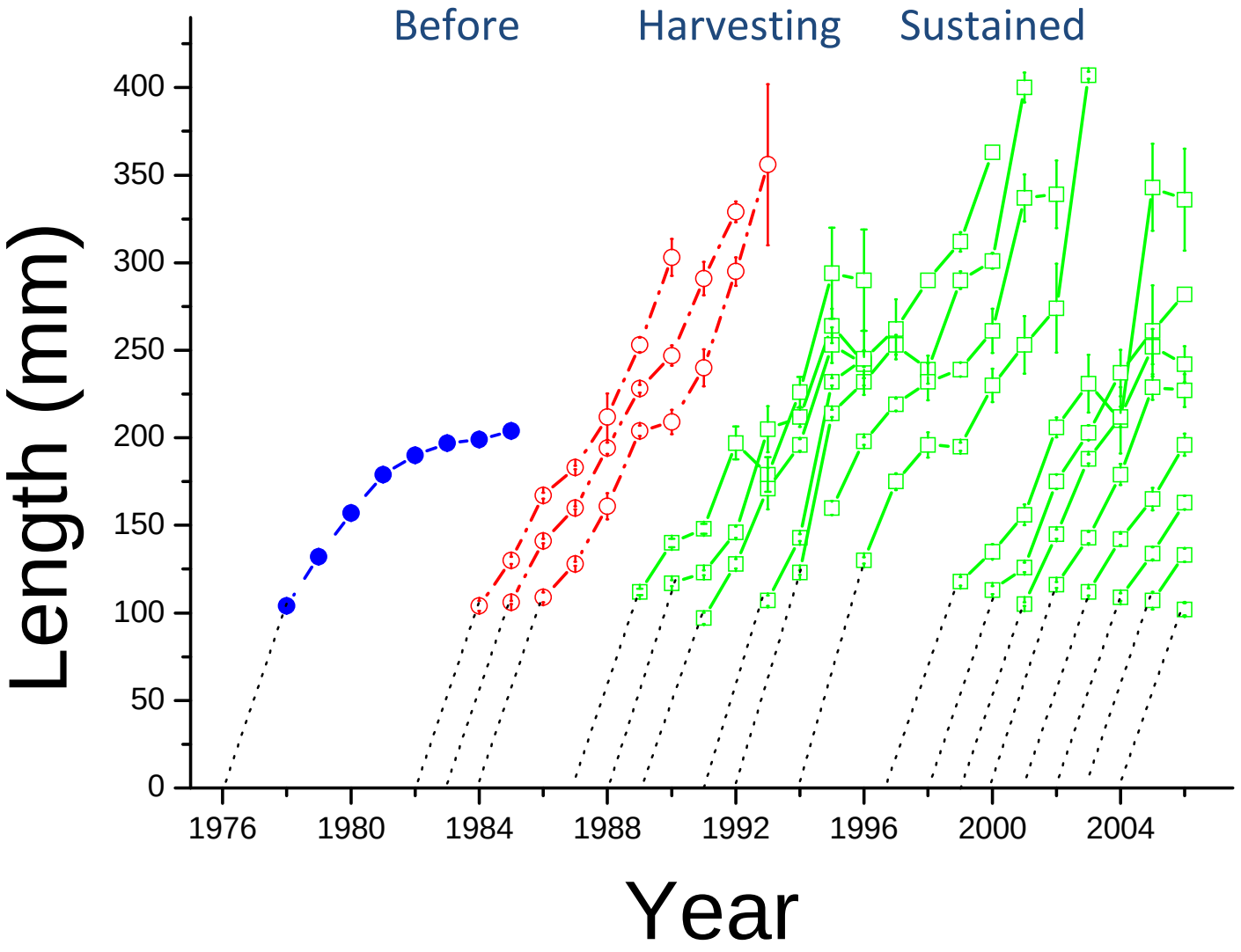
Persson et al.(Science 2007)

Broader prey size distribution

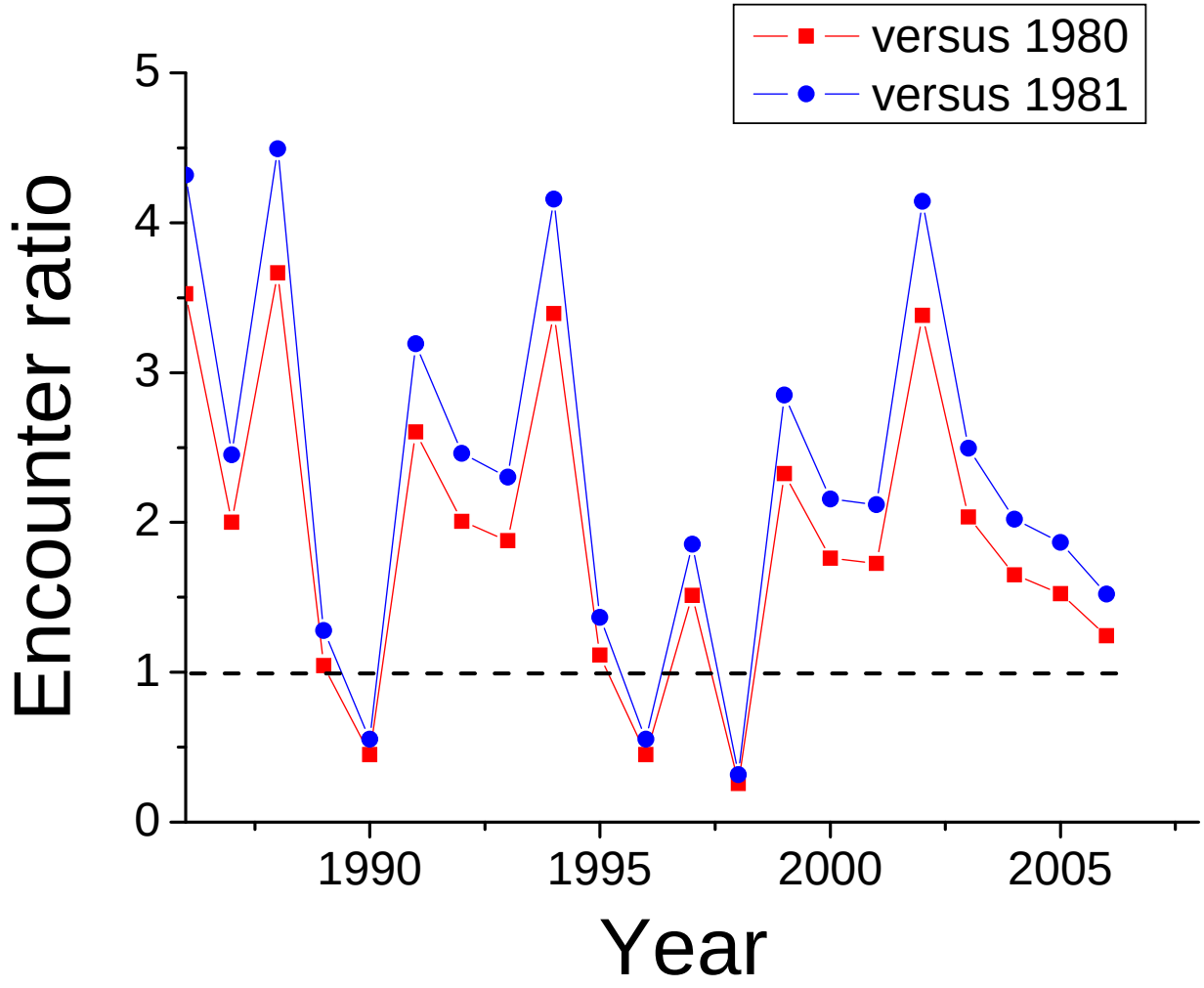




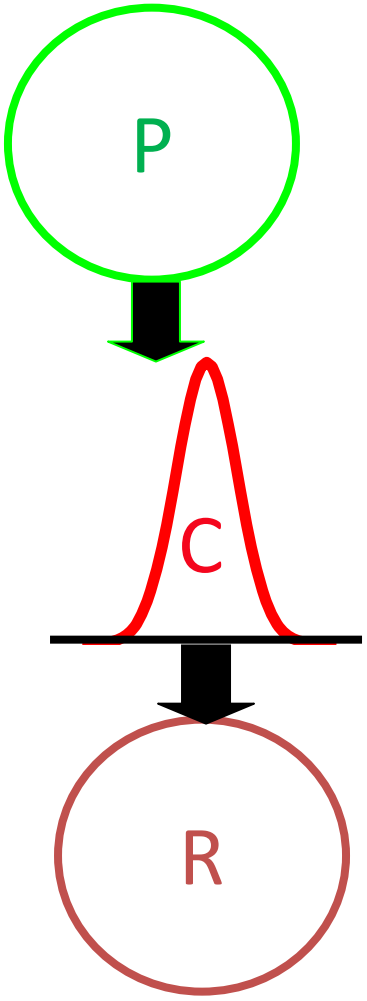
Higher individual prey growth rate

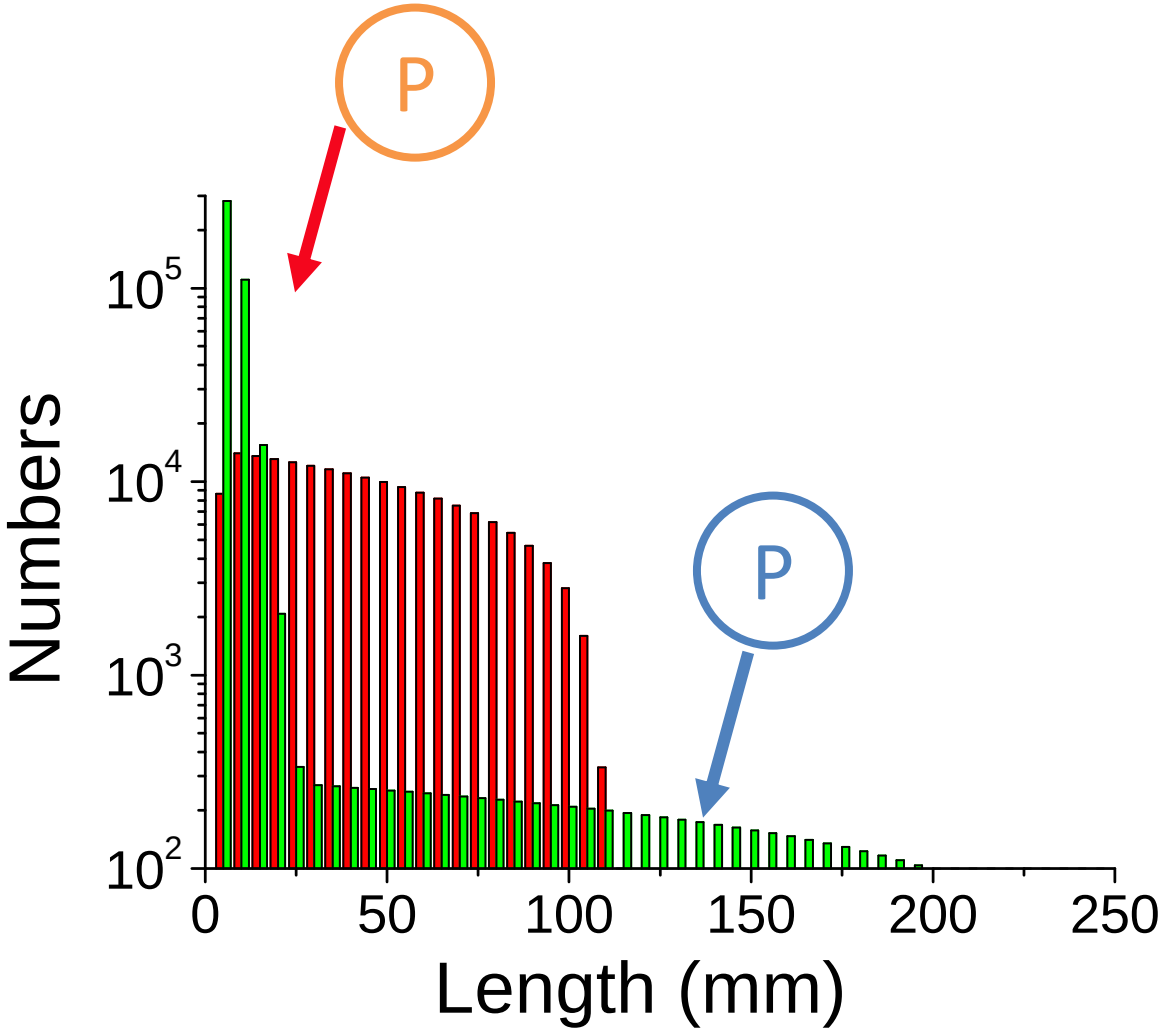


Higher availability of small size classes of prey – *trout cultivates its prey*

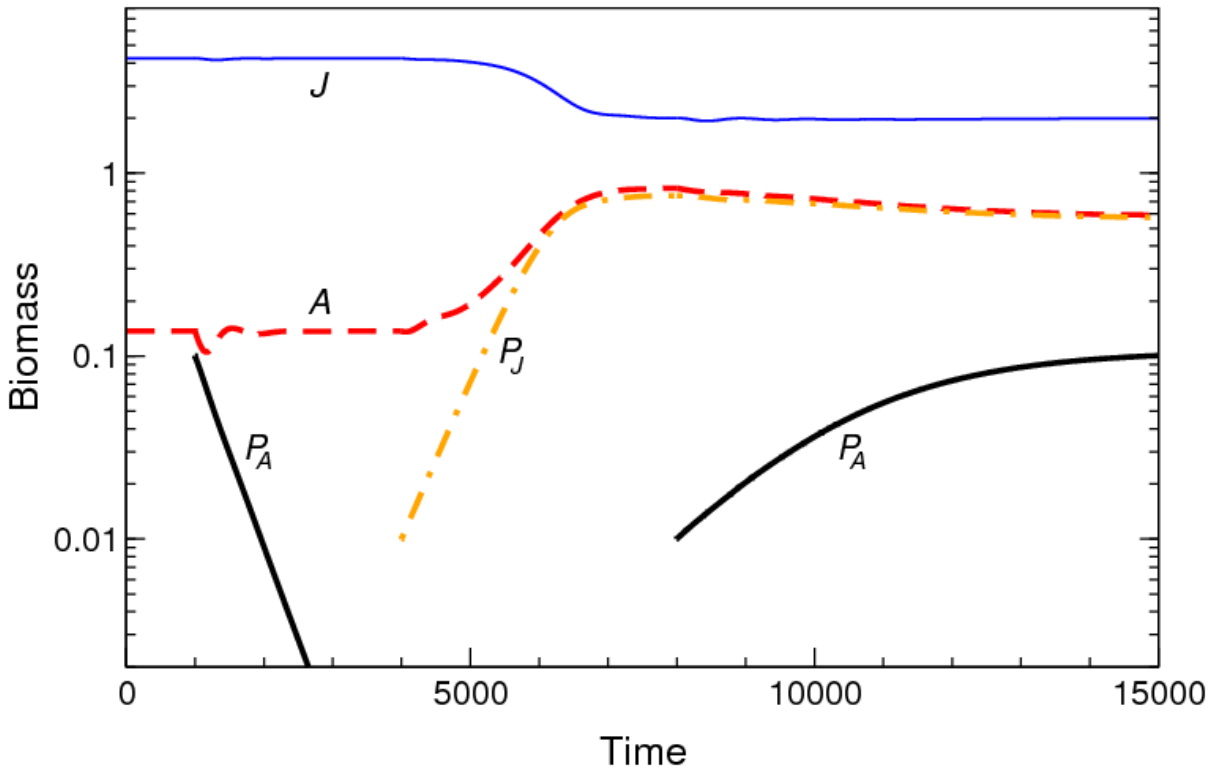


Emergent facilitation



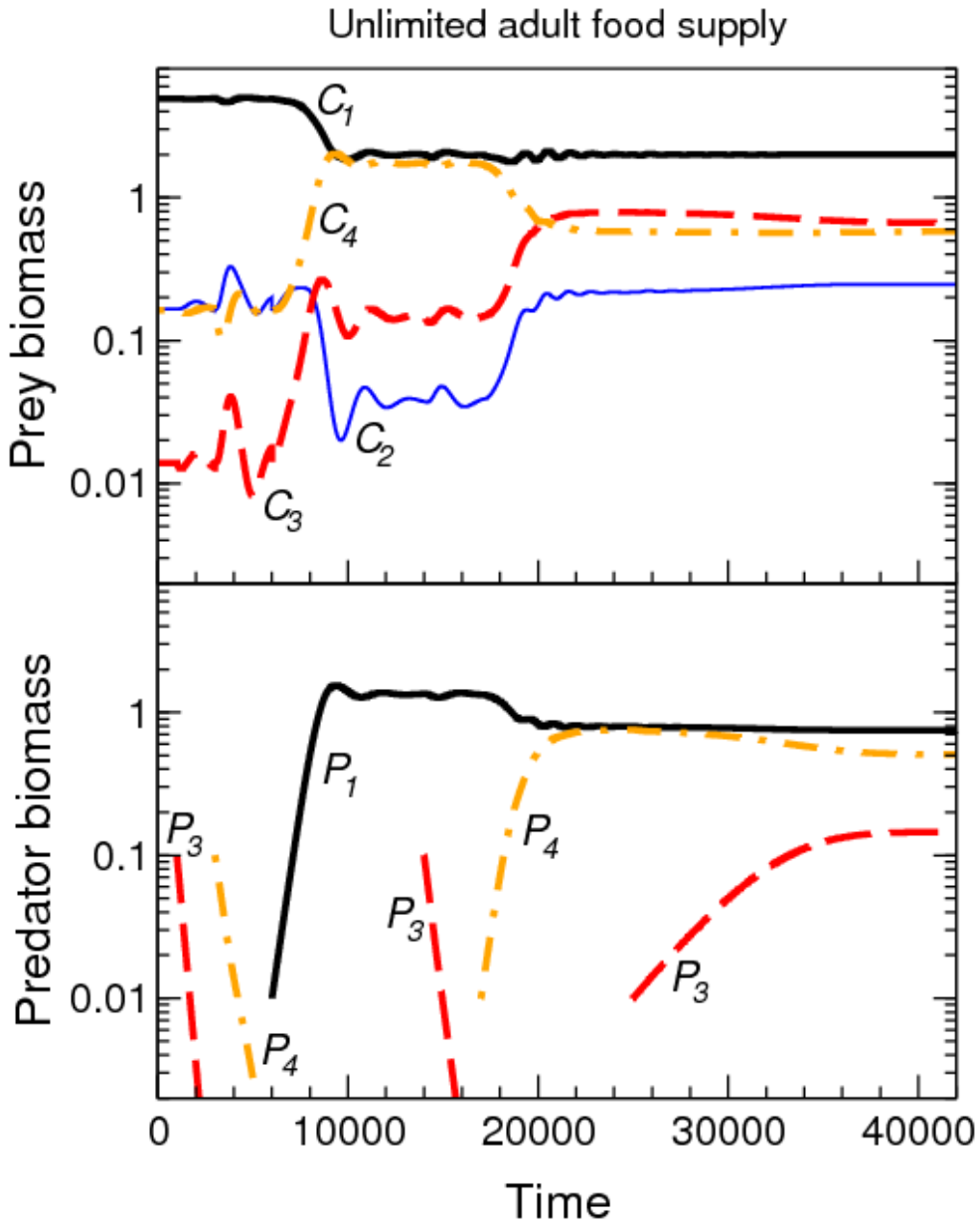


Emergent facilitation (2 stages)



De Roos et al. (PNAS submitted)

4 stages model (2 J, 2 A)



De Roos et al. (PNAS submitted)

Some conclusions/perspectives

- Effects on dynamics and structure of ecological communities
- Alternative states as a result of food dependent development (intraguild predation, emergent Allee effect, emergent facilitation)
- Coexistence on a single resource
- Changed size distributions - size spectra, one-to-one correspondence
- Large (many species) food webs
- Building block to analyse more complex trophic configurations in terms of number of species (fully structured models to 2 stage models within the same conceptual framework and preserving essential mechanisms - *food dependent development*)
- Time and development of community assemblages


Takvatn
Litoral
Takvatn
Profundal
Takvatn
Pelagial
TAKVATN
2003