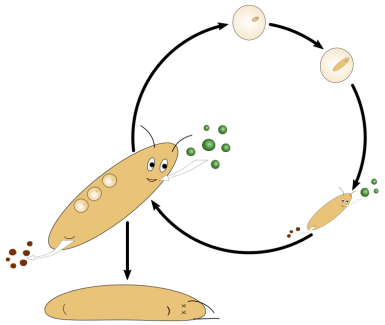


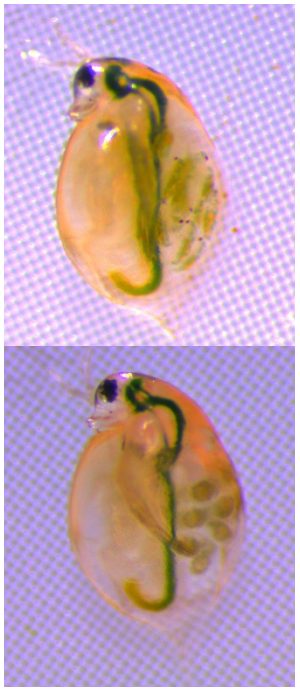
DEB2019 1-12 April 2019 / Brest (France)
Sixth International Symposium and Thematic School
on DEB theory for metabolic organization

# Exploring the impacts of several Physiological Modes of Action (PMoA) of toxicants at the population level using Netlogo

Roger Nisbet – UCSB, Santa Barbara, USA
Presented by Laure Pecquerie – LEMAR, IRD, Brest, France

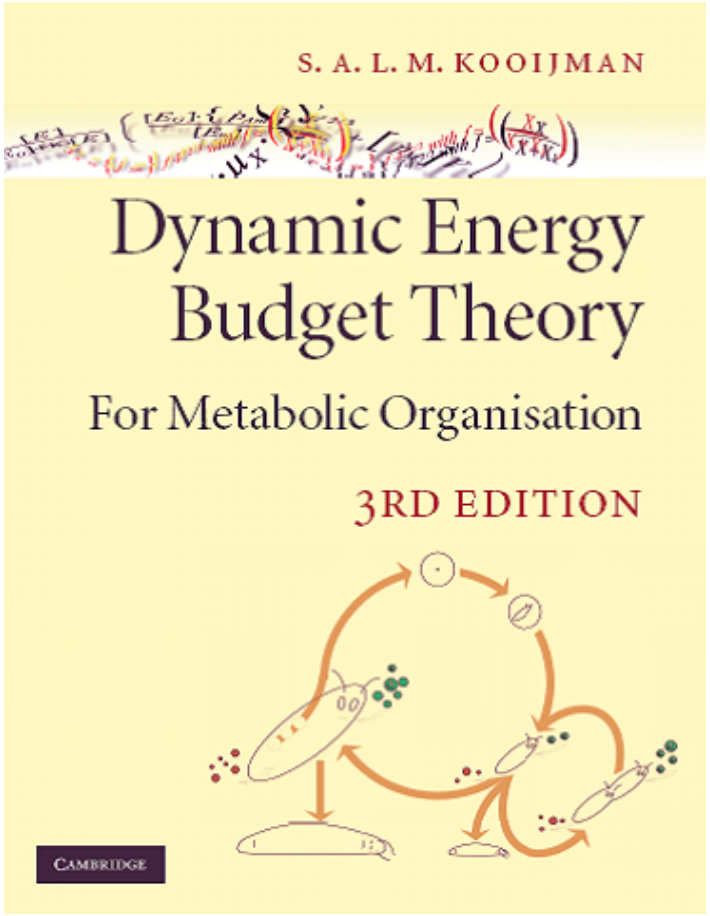
# Model system: *Daphnia* and algae

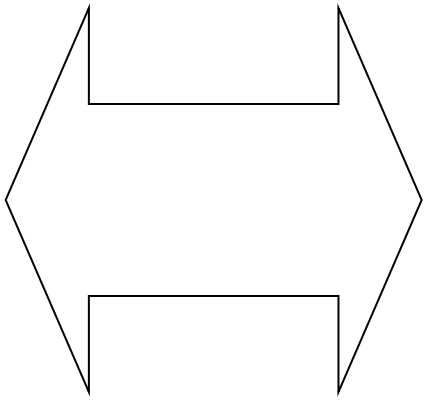
- Algae
  - Primary producers
- *Daphnia*
  - Important ecological function (secondary production) in many temperate lakes
  - Model organism for ecotoxicology
    - Standardized OECD or EPA toxicity tests
  - Lots of data
- Classic example of resource-consumer interactions

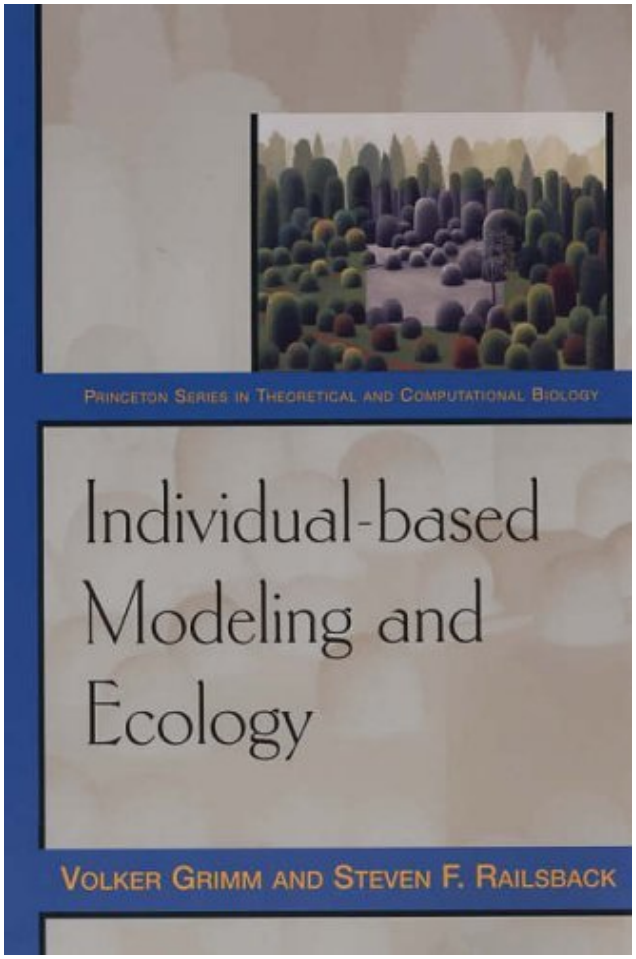


Modification of slide from Louise Stevenson (student at DEB2011!)

# DEB-IBM: Individual-based population model for animals obeying DEB rules in a shared environment

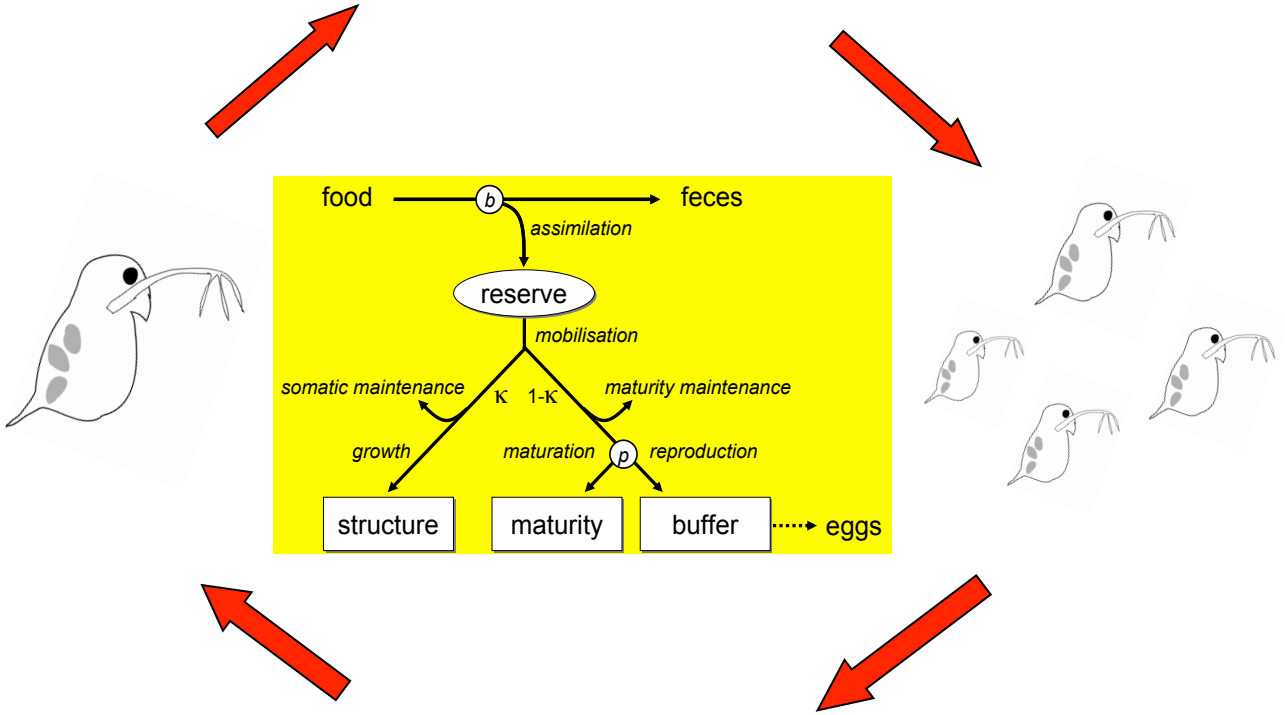





* B.T. Martin, E.I. Zimmer, V. Grimm and T. Jager (2012). *Methods in Ecology and Evolution* 3: 445-449

# DEB-IBM




- Implemented in *Netlogo* (Free)
- Computes population dynamics in simple environments with minimal programming
- Standard DEB model parametrized and population predictions tested for *Daphnia magna* by Martin et al (2013a,b). Fit to data required addition of a term describing resource dependent mortality.

B. Martin et al (2103a, b) *American Naturalist*, 181:506-519; *Ecotoxicology* DOI 10.1007/s10646-013-1049-x

# Workshop Objectives

- Experience using a DEB-IBM application with Netlogo
- Illustrate that different Physiological Modes of Action (PMoA) with a similar effect on reproduction at the individual level can have different impacts at the population level
- Based on Martin et al (2014)

*Ecological Applications*, 24(8), 2014, pp. 1972–1983


## Limitations of extrapolating toxic effects on reproduction to the population level

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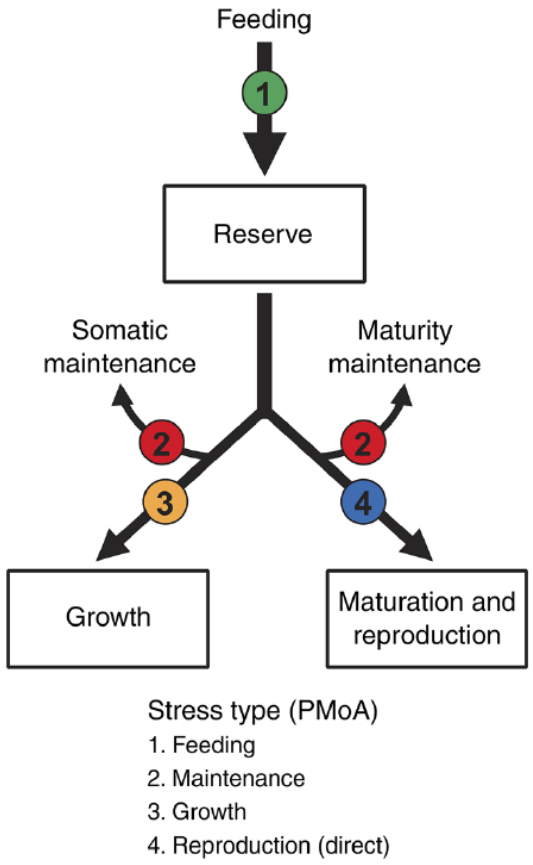
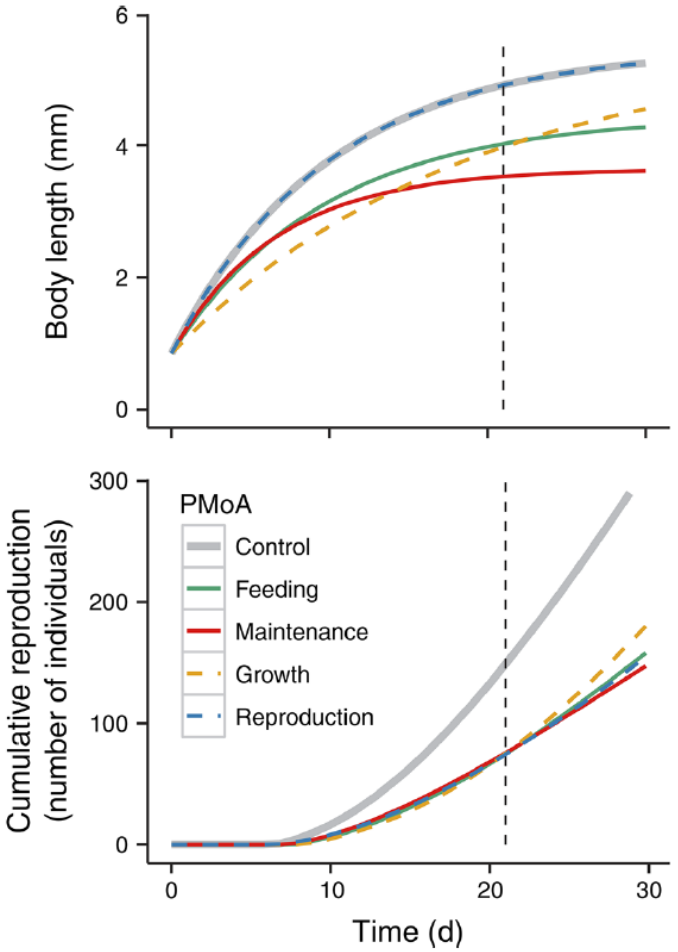
# Effects of pMoA on performance of INDIVIDUALS




- With all pMoAs, exposure to toxicant leads to reduction in reproduction after 21 days (OECD test)
- **What do we expect at the POPULATION level?** - This exercise
- Simplistic hypothesis – reduced population size

# Exercise

- Download Netlogo (free)
- Download zip file

  https://deb2019.sciencesconf.org/resource/page/id/16
- Read instructions in the .doc file
- Complete the excel sheets
- **Interpret results!**

NetLogo — PMoA Final EcolAp_for_Brest_2019 {/Users/pecquerie/Dropbox/BackUp_Sene2018/DEB2019/Workshops/Netlogo/docs}

Interface | Info | Code

Edit | Delete | Add | Button | faster | ticks: 30001 | view updates | on ticks | Settings...

setup | go | go-once

timestep: 50

DEB-IBM parameters for D. magna (Martin et al 2013 AmNat)

- kap_int: 0.678 — "kappa" Fraction of mobilized energy to soma
- kap_R_int: 0.95 — "Kappa R", Fraction of reproduction energy fixed in eggs
- k_M_rate_int: 0.3314 — Somatic maintenance rate coefficient
- k_J_rate_int: 0.1921 — Maturity maintenance rate coefficient
- U_H^b_int: 0.1108 — Scaled maturity at birth
- U_H^p_int: 2.547 — Scaled maturity at puberty
- v_rate_int: 18.1 — Energy conductance
- g_int: 10 — Energy investment ratio

Ageing parameters

- h_a: 3.04E-6 — Hazard rate
- sG: 0.019 — Gompertz stress coefficient

Coefficient of variation of parameter values see ODD and Martin et al. 2013 AmNat

- cv: 0.05

Feeding parameters

- J_XAm_rate_int: 380000 — Maximum specific ingestion rate (algae cells/mm^2/day)
- H_int: 1585 — Half-saturation coefficent (algae cells)

Daphnia specifc parameters

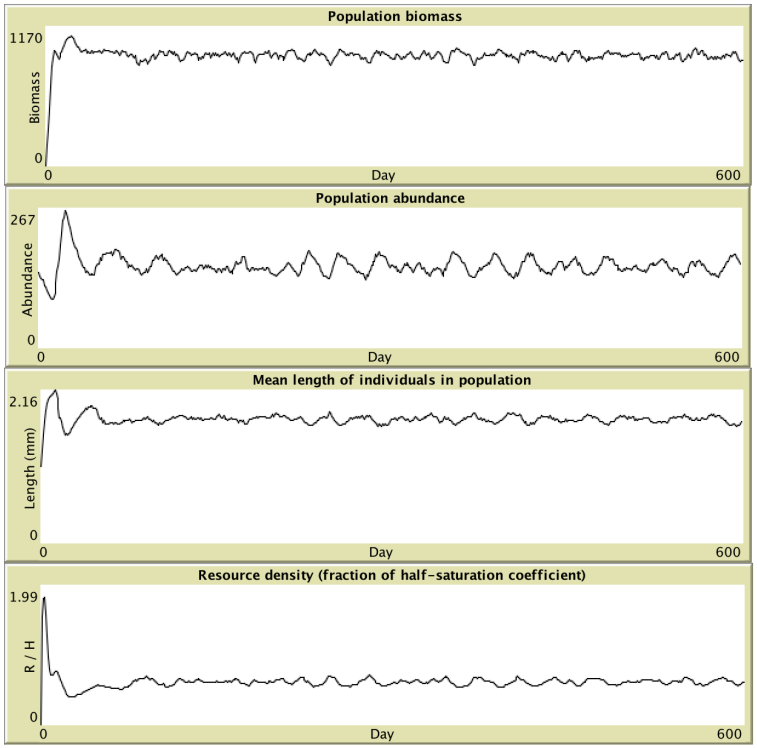
- juv-mort: 0.09 — Juvenile resource dependent mortality rate
- t-molt: 2.8 — Days between reproductive molts

Resource variables

- rho: 0.05 — Resource dilution rate
- Rmax: 31700 — Maximum resource density

Stress parameters

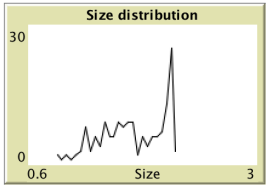
- PMoA: maintenance stress
- stress-level: 0 — stess levels corresponding with various reductions in reproduction in a 21 day daphnia reproduction test for each PMoA are given in Table 2 of the ODD

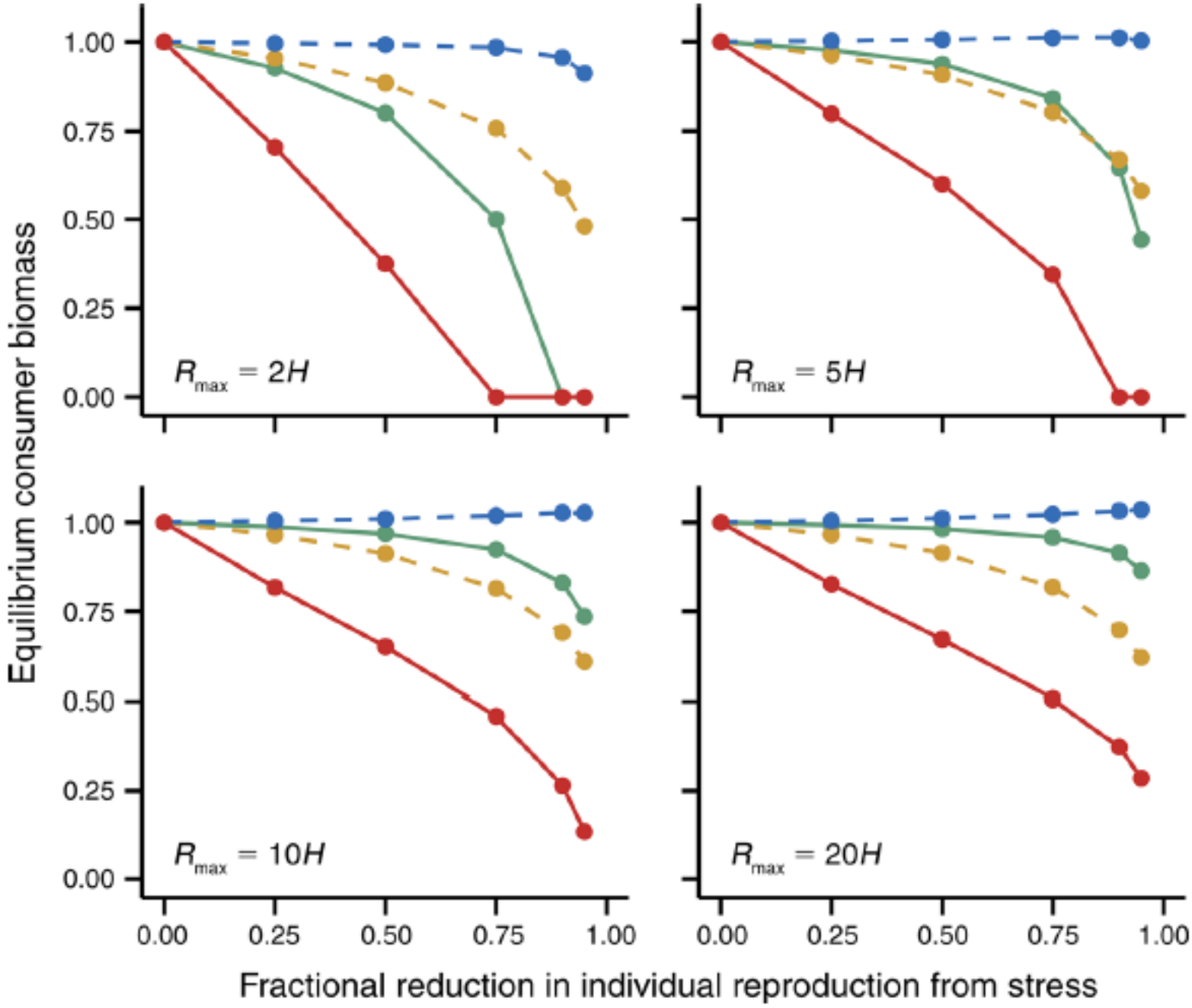


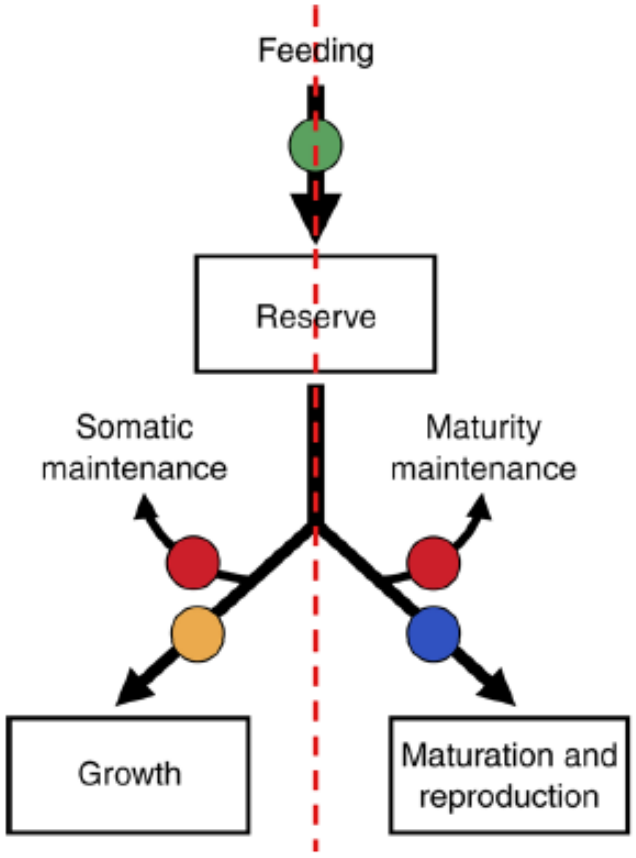

Stress begins on day 150

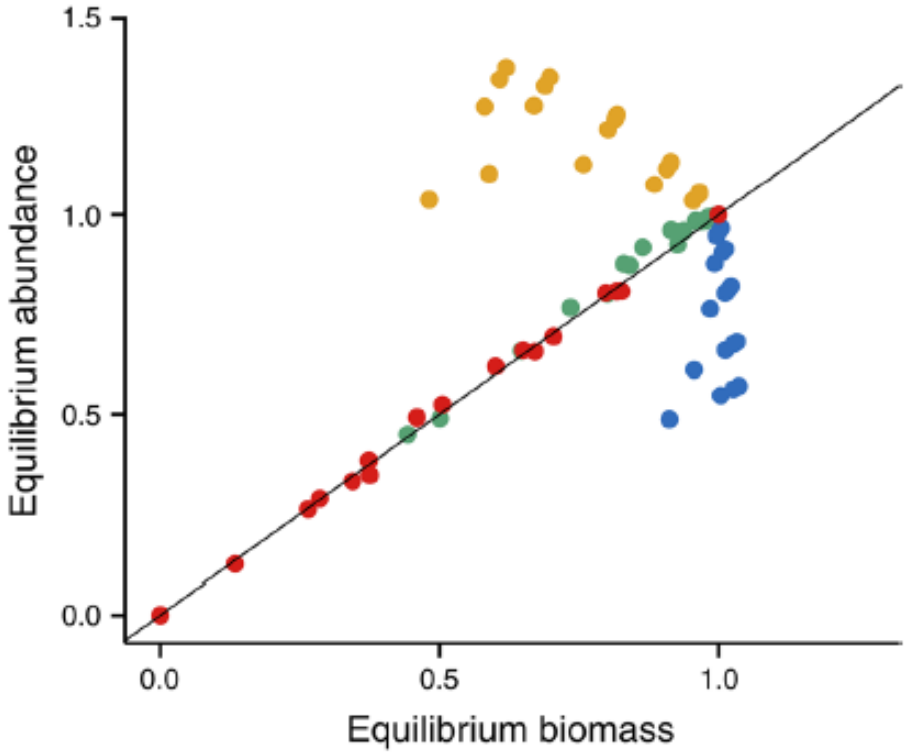
Population variables measured and averaged over days 300-600

- Mean population abundance: 155.03
- Mean population biomass (cubic mm): 924.13
- Mean length of individuals (mm): 1.75
- Mean resource density (fraction of H): 0.61




Equilibrium consumer biomass
1.00
0.75
0.50
0.25
0.00
$R_{max} = 2H$
$R_{max} = 5H$
$R_{max} = 10H$
$R_{max} = 20H$
0.00
0.25
0.50
0.75
1.00
Fractional reduction in individual reproduction from stress


Feeding
Reserve
Somatic maintenance
Maturity maintenance
Growth
Maturation and reproduction


1.5
1.0
0.5
0.0
Equilibrium abundance
0.0
0.5
1.0
Equilibrium biomass