Trophic control & bifurcation diagrams

The aim of this exercise is to explore how trophic control operates in a resource-consumer-predator system (a ”tri-trophic chain”). This is achieved by drawing *bifurcation diagrams* of the abundances of each trophic level as a function of various parameters.

1. First, explore two species that interact as a “resource” and a “consumer”. Described their interaction with the simple resource-consumer model, similar to the Lotka-Volterra system, just with the resource limited by a carrying capacity. Simulate the system for various values of the carrying capacity to find the equilibrium.
2. Draw a bifurcation diagram of the system as a function of the carrying capacity. This can be done either by finding the equilibria analytically or by solving the system numerically. Identify the *bifurcation* where the resource changes from being *bottom-up* controlled to being *top-down* controlled.
3. Add a predator that eats the consumer. How does that change the bifurcation diagram and the bottom-up/top-down control?

Programming hints:

- The simulations can be quite slow when running with three species. You will need to use initial conditions which are fairly close to the equilibrium to avoid excessive oscillations of the solution.
- The reliability of the numerical solution can be enhanced by adding a fourth parameter to ode45 which specifies that the solution should always be positive: “`odeset(‘nonnegative’,[1 2 3])`”, where the [1 2 3] specifies which state variables should be positive (in this case all three).
- Alternatively, some of the diagrams can be drawn based on analytical solutions of the equilibria found by using the symbolic capabilities in matlab.

Expand the model. Consider e.g.:

- Bifurcation along another parameter, such as the productivity of the resource, the clearance rate of the consumer, or the death rate of the consumer.
- What happens if the resource is not described by logistic growth but by a chemostat?
- What happens if functional responses are included in the model?
- …