Modelling with MATLAB Assignment 2, 2019.

This assignment is based on the following paper (available on the Moodle pages):

"Ocean plankton populations as excitable media" by Truscott and Brindley, Bull. Math. Biol. 56:981-998, 1994.

The assignment will explore the consequences of different forms of deterministic forcing in this model. Each question in the assignment carries equal marks, but the later questions are more challenging.

1. **Coding and running the model:** Create a MATLAB function to evaluate the derivatives in equations (2) and (3), defining and using appropriate local and global variables and taking parameter values from equations (6). Use this function and `ode45`, together with an appropriate range of positive initial conditions, to verify numerically that the system has a unique stable positive fixed point, and report the value of this fixed point.

2. **Defining seasonal forcing:** Now suppose the system is to be forced seasonally with a period of 365 days, so that the parameter r (in day^{-1}) in equation (2) becomes a function of time t (in days). The forcing should be sinusoidal with an amplitude of $A = 0.2$ day^{-1}, and $r(t)$ should have a mean value of 0.3 day^{-1} and a minimum on day 0.

Write a MATLAB script to calculate and plot r as a function of t over a full period of 365 days. Using the `subplot` command, underneath your plot of $r(t)$ plot a graph of $(1/r(t)) * (dr/dt)$ as a function of t using the same horizontal scale.

3. **Applying seasonal forcing to the model:** Combine your answers to questions 1 and 2 above to investigate the role of periodic forcing in triggering plankton blooms. Explicitly, identify the minimum amplitude A_0 which is sufficient to trigger a bloom, and provide numerical outputs from your system at values just below, and just above, A_0 to illustrate your answer. (State clearly what you define to be a bloom in your simulations.)

4. **Combining diurnal and seasonal forcing:** In reality, there are three additional factors which change on a 24 hour time scale and which might affect the behaviour of the model:

(i) phytoplankton only grow during the day (because they are photosynthetic);

(ii) most zooplankton grazing on phytoplankton happens at night;

(iii) most zooplankton mortality happens during the day.

Choose **one** of these additional factors, and explain how you can incorporate appropriate diurnal variation in the appropriate parameter(s) to represent this diurnal (24 hour) variability. Hence, add diurnal forcing to your solution to question 3 (in addition to seasonal forcing) and quantify how much the minimum bloom-triggering amplitude of seasonal forcing, A_0, changes in the presence of diurnal forcing.