Total Score: ___/50

Name ______________________________

Section Number _____________________

Homework 8

Due June 5th at the beginning of lecture

Instructions:

You are welcome to discuss concepts with your classmates but must compose your own answers. If you are unsure of the honor code for this course, please ask or look at the course website. http://www.its.caltech.edu/~bi1/Bi1__Micro-_to_Macro-Biology/Policies.html

The goal of this assignment is to help you understand a dense research paper and the molecular basis of cellular information processing. Many of the questions do not have a single correct answer. You will be given full credit as long as your answer is reasonable.

The answers must be legible and should not extend past the allotted space. Keep in mind that a few well-written sentences can give a higher score than a whole page of text.

Part A: Computerized Ecological Models (25 points)

For this part you will need to use the *PowerPlay* software discussed during recitation section. For online use of the Java applet go to http://www.ent.orst.edu/loop/pplay.aspx. To download a PC version of the applet which will allow you to save your models go to http://esapubs.org/Archive/ecol/E083/022/suppl-1.htm. For more detailed instructions on how to use the *PowerPlay* software there is a file on the Bi1 website.

1.) Think about the diversity of life uncovered in the Caltech ponds by our mini-lab experiment and in lecture. Create a model of a Caltech pond ecosystem with 4 or 5 components (components can be abiotic, microbial, or multicellular). Make sure the system is stable by using PowerPlay's stability function. Draw your signed digraph model below. (7 points)

Total Score: ___/50

Name ______________________________

Section Number ____________________

2.) Briefly rationalize the connections you've made in the model (Maximum one sentence for each interaction, plus a justification for self-limiting closed loops). (10 points)

3.) Make a perturbation to your system using the prediction tool in *PowerPlay*. What does your model predict will happen to the other components in response (list positive and negative effects)? Choose ONE of these changes and propose an experiment (in the lab or in the field) such that you can be certain that the prediction is accurate. (6 sentence maximum) (8 points)

Part B: Mathematical Ecological Models (25 points)

Before computers were available there were models that describe the changes of population in predator and prey pairs using differential equations. For this problem we will define a predator and pray pair and we will see how the extinction of one affects the other.

The Prey is a species of zooplankton that is decaying exponentially. It's population is so massive that it is relatively unaffected by the predator's consumption. It's initial population is $P_{p,0} = 7.0 \times 10^3 m^{-3}$ which is equal to its ideal population $K_p = 7.0 \times 10^3 m^{-3}$. Unfortunately this species is dying slowly and has a negative growth rate of $r = -0.01 days^{-1}$, which is constant over time. Thus, its population as a function of time is given by

Total Score: ___/50

Name ______________________________
Section Number ____________________

$$P_p(t) = P_{p,0}e^{rt}$$

The Predator is a large Blue Whale whose population, $P_w(t)$, depends on the population of zooplankton.

$$\frac{dP_w}{dt} = -\gamma P_w\left(K_p - P_p(t)\right)$$

Where $\gamma = 2.0\times10^{-6}\,m^3 day^{-1}$ and the initial population density is equal to $P_{w,0} = 3.0\,km^{-2}$. Note that the population densities have different units because these populations are in completely different scales.

1.) Integrate to find the exact function for $P_w(t)$ over time. Use the given exponential decay for the population of zooplankton. (*Hint: Separate your variables*.) (6 points)

2.) Plot the two populations on the same time-scale but on different population scales such that you can visualize how they both drop over the same period of time. Is the extinction of the zooplankton species affecting the whale species population? Explain what is happening to these populations in ecological terms. (4 sentence maximum) (6 points)

3.) Which species do you expect to go extinct first? Explain both mathematically, using the models, and ecologically, using what you have learned so far this week. You are not expected to explain why the zooplankton is going extinct; only the relation between the two species.
(4 sentence maximum) (6 points)

Total Score: ___/50

Name ______________________________

Section Number ____________________

4.) What assumptions were made in this model? (Find at least two) How would you expect the results to be different if we had not made those assumptions? (6 sentence maximum) (7 points)

Part C: Exam Practice Question (0 points)

This essay question is similar to the questions you should expect in the second in-class exam. It is meant to be practice to prepare you for the exam. This question will not be graded because it is logistically impossible to return it to you before the exam. However, you should still attempt it and/or discuss it with your TA for practice. An answer key with the possible answers for this question will be posted on the website on Tuesday, June 5th.

The question is based on the Chen et al. paper, which was this week's assigned recitation reading.

*Some species looked at in this paper went against the trend observed in terms of elevation shifts. For a large multicellular organism, describe and explain intrinsic and extrinsic factors that could contribute to its ability to **migrate or adapt** in response to an environmental change. If the authors were looking at microbes instead, how would you expect the results of the paper to differ, and why?* (500 words) (0 points)

Part D: Extra Credit (1 iClicker quizz)

Trying to mathematically model the growth of a species within an ecosystem seems like a daunting task when one considers all of the variables which may potentially affect the livelihood of any one living specimen. If one focuses on a few characteristics variables such as K, the carrying capacity of an ecosystem, and r, the growth rate of a species, one can arrive at a much more simple mathematical model. The Verhulst equation, shown below, is one of such models.

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{K}\right)$$

where P is the population density of the species at hand and t is time. Normally it is assumed that a species' growth rate, r, is constant over time. However as you read in Hardt & Safina some species' growth rate have been affected by climate change. Find a general solution to the Verhulst equation, if the growth rate is given by a function of time, $r(t)$, instead of a constant.

(1 iClicker quizz)