

Introduction to Mathematical Modeling

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Project 5 Introduction

Your goal is to read an academic paper about a mathematical model for Loggerhead Sea Turtles and then create a stage-based model similar to the one in the paper and verify their results.

Your first task, as individuals, is to read the paper

A Stage-Base Population Model for Loggerhead Sea Turtles and Implications for Conservation, by Deborah T. Crouse, Larry B. Crowder, and Hal Caswell, *Ecology*, Vol. 68, No. 5 (Oct. 1987).

NOTE: There will be some parts of the paper that you are not expected to fully understand, for example the eigenvalue sensitivity analysis on page 1417 and the idea of elasticity (figs. 3 and 4) are both beyond what we have done in class. Your goal is to get the basics about the model from the paper. If there are words you don't understand or ideas you want to know more about look them up online. This is what professional modelers do to understand a new system or start a new research project.

Here are some good questions that you should be able to answer or things you should be able to do after reading the paper:

- Why is it important to model Loggerhead Turtles?
- Name at least 3 assumptions that they made in building their model.
- Write down the population transition matrix that they used in their model.
- How did they deal with the fact that the age classes are not the same size?
- Which parameters were sensitive and which parameters were robust?
- Did they incorporate any stochasticity into the model?
- What were their main findings or suggestions for management?

Project 5 Specifics

Your goal is to recreate and write about the mathematical model for Loggerhead Turtles. Instead of writing a full project report, your goal is to write a summary of the paper. Imagine that you are part of a research reading group and you are explaining the basic ideas of the paper to your group of peers, so that they can understand the math/science but don't have to read the full journal article.

Your paper should be shorter than 6 pages, probably 3-4 would be enough! Your audience is a group of busy math modeling researchers who want to understand the paper but have limited time.

You should:

1. Read and understand the paper.
2. Recreate the Loggerhead stage-base model using the tools from class. You may create your model using a spreadsheet, Matlab, or a programming language of your choice. If you have ideas on new parts to add to the model please do, this will earn you extra points.
3. Write a summary of the paper that does an excellent job of explaining the equations and showing how you verified their results.

Here are some things I would like to see in your write-up:

- **Introduction:** Give a short background about why it is important to model Loggerhead Sea Turtles and briefly describe the main results and management suggestions from the paper.
- **Formulation:** Draw either a State Diagram or a Compartmental Diagram for this model. Describe the assumptions that go into the model. Say what kind of program you are using for the analysis.
 - If using a Spreadsheet program, write down your recurrence relations. If using Matlab or a programming language write out your matrix equation and give a SHORT description of how you will write your code.
 - Make sure you clearly describe, and understand, what is happening in equations 1 and 2 on page 1415.
 - If you are adding something new to the system, include it in your formulation.
- **Results:** Recreate or Test the results from the paper.
 - RECREATE THE SENSITIVITY ANALYSIS - (See table A1 in the papers appendix.) They do the following:
 - * Decrease just the fecundities (F_5, F_6, F_7) by 50% and see what happens. You should see the population decreasing faster OR a decrease in the dominant eigenvalue.

- * Return fecundities back to baseline and the decrease the group 1 parameter, G_1 , by 50% and see what happens.

- * Return G_1 to back to baseline and decrease the group 2 parameters, G_2, P_2 , by 50% and see what happens.

- * And so on for each of the classes.

- RECREATE THE MANAGEMENT SCENARIOS - Do simulations for each of the management scenarios in Table 6, page 1419. (This will be three different test runs where you change a few parameters all together). For example, the first management scenario changes the survivorship of stages 2, 3, and 4. Set your parameters to the new values and see what happens.

- CREATE YOUR OWN RESULTS - Make up your own management scenario and use the model to talk about how effective your scenario would be. (This can be your choice of parameters OR a change to the model).

- **Discussion:** How well your results match the paper? Which parameters were most sensitive? Do you think that the paper made good assumptions? Do you see any problems with the model? If this were your own research project, what would you change?

- **Conclusion:** Summarize your big findings.

HINTS

- The paper talks about left and right eigenvectors. The right eigenvectors is the one we have talked about in class that describes population percentages of the classes. The left eigenvector is what you would get by analyzing the transpose, not something we did in class, it represents the reproductive value of the classes. We also did not talk about how to calculate reproductive rate, r .
- You can pick whatever initial population that you want. I started with: $[P1 = 1000, 1000, 1000, 100, 5, 5, 20]$
- Run the baseline first and check that your results match with Table 5. This would be your dominant eigenvector OR your long term population percentages, just look at your last time step as see that the populations are showing up in near these ratios.
- Make sure you run your model out to enough time steps. I did 100 time steps.
- Only change one thing or one group of things at a time. Make sure that you reset your parameters back to the baseline before changing a new set of parameters.