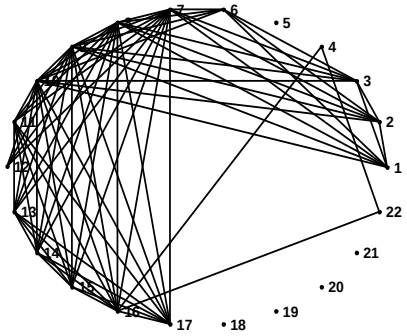
Fall 2012 **Prof. Urmi Ghosh-Dastidar**
Course: **Introduction to Linear Algebra MAT2580 Section (6643) (3 credits)**

Biodiversity and the Hudson River
Eco-Math link through Linear Algebra



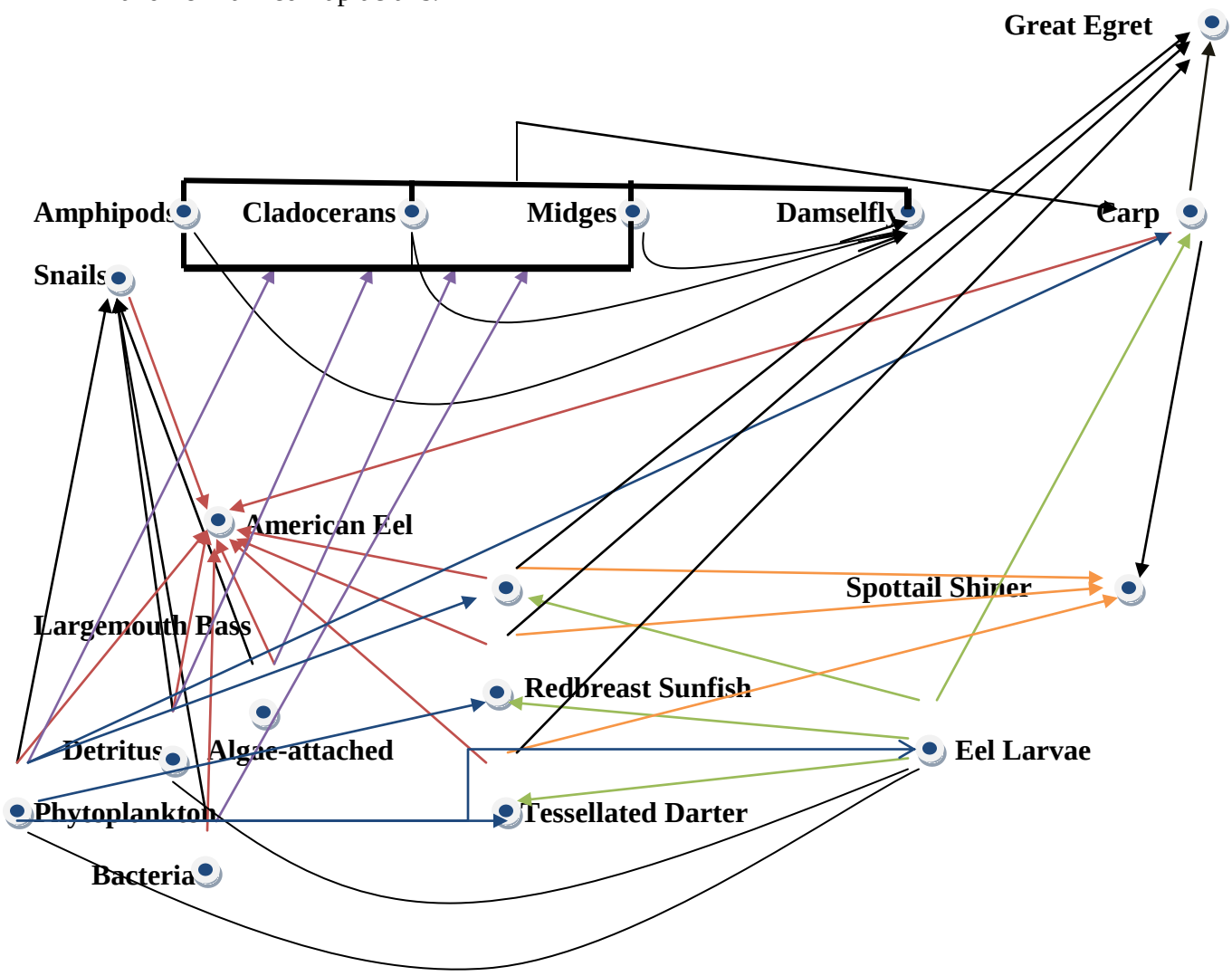
Flowing from the Lake Tear of the Clouds, North the Hudson River journeys 315 miles and drops 4,322 feet in elevation before emptying itself into New York Harbor. The Hudson River is home to diverse populations of fish, birds, and mammals that cohabit and compete among themselves for resources. Recently the American shad, Atlantic sturgeon, river herring (blue back herring and alewife), American eel, and largemouth bass are in decline. Intense economic harvesting pressure and overexploitation cause coastal and marine species to decline. Therefore, harvesting and fishing should be managed properly and carefully to avoid decline of current population. Food web analysis provides important information regarding the nature of competition among various organisms.

Cluster analysis in graph theory is a popular method to seek partition of a given data set into several clusters so that the data points within the same cluster are more similar than those belonged in the separate clusters. In this project students will use cluster analysis using **the concepts of linear algebra** to study the **competition** among various species in a given food web, in particular, competition among various Hudson River species. Students will find a partition of the competition graphs based on the Hudson River food web such that the strength of competition (for shared preys) between two clusters (two groups of predators) is as low as possible; however, the strength of competition within the same clusters is as high as possible.

Tasks to Do

1. Create a table in excel spreadsheet listing the columns and rows with the species names.
2. Create an adjacency matrix.
3. Save this adjacency in a different file, for example, adjacency.
4. Open this new file and delete the species names i.e. in this file you will just have the adjacency matrix.
5. Use the Matlab code to create the competition graph from this matrix. Note that this matrix should be symmetric.
6. Create the weighted competition matrix. This matrix should be symmetric.

7. Find the Laplacian and the Normalized Laplacian of the weighted competition matrix.
8. Find the eigenvalues of the adjacency matrix, Laplacian Matrix, and the normalized Laplacian Matrix. Observe some of the properties of the symmetric matrices, Laplacians, and normalized Laplacians.



Food Web

9. Using Spectral analysis taught in the class to partition the competition graph in two different clusters. Identify the species in these two clusters.
10. Interpret your results. What can you conclude?
    a. Which species are more connected than others?
    b. What happens if a specific species (particularly, a prey) dies out? Particularly, how does the removal of a particular species affect its predators and also the overall competition among all predator species?

Notes:

1. Create your own group and each group should have at least two students and no more than three students.
2. A cover page should be attached with the project.

3. Names should be clearly written on the cover page.
4. All graphs and charts should be labeled clearly with titles, xlabel, and ylabel.
5. All work should be typed and should be done professionally. Microsoft spell check and review should be used before you submit your first draft.
6. **Draft is due on _____.**
7. **Final draft is due on _____.**

Project Assessment Rubric

1 – Very poor
2 – Poor
3 – Average
4 - Good
5 - Excellent

	1	2	3	4	5
Communication skills: Oral Presentation Express ideas orally that are coherent, persuasive, and ethical					
Communication Skills: Sequencing Logical Thinking in written report Express ideas in written form that are coherent, persuasive, and ethical					
Problem Solving Skills Understand and analyze a problem					
Problem Solving Skills Apply reasoning and analytic processes to solve the problem					
Problem Solving Skills Interpret the results from the interdisciplinary field perspectives					
Team Work How well the member work with other team members: contribution towards the problem solving and helping one another					