Fujiwara, Masami and Hal Caswell. 2001. "Demography of the endangered North Atlantic right whale." ***Nature*** **414: 537-541.**

In this study, Fujiwara and Caswell (F & C) used data from repeated sightings of individual right whales off the coast of New England and off the coast of Florida and Georgia to estimate changes in the whale population from 1980 to 1995. To do this, F & C used "stage-structured matrix population models" to study the growth and survival of whales at different life stages. Transitions between life stages occur when individuals grow, mature, give birth, wean a calf, or die (Figure 1). F & C used two "models" to study this whale population. One model, M_1, is "time-invariant," meaning that they did not consider the possibility that survival rates and other life stage transitions could change between 1980 and 1995. On the other hand, the "time varying" model, M_2, factored in changes in survival rates and other life stage transitions over the course of the study. The results of M_1 are shown in Figure 3, while the results of M_2 are shown in Figures 2 and 5.

Because some of the terms in this paper will probably be unfamiliar, you will want to have a dictionary handy. Two new terms, "demographic stochasticity" and "Allee effect" are defined within the paper, so read carefully. I have marked out some of the more confusing aspects of the paper; you can skip those portions.

The background paper, "When one whale matters" (Kareiva 2001 [*Nature* 414: 493-494]), provides a clear explanation of F & C's key findings and describes how these findings relate to conservation of whales and other animals. Although the questions below are based on the paper by F & C, the background paper will help you understand their paper.

Pre-discussion report. Due at the beginning of class, Thursday, February 19.

1) Write thoughtful responses to *two* of the following questions. Responses should put ideas in your own words and should draw support both from the article and from your own knowledge and ideas.

a) Why were F & C interested in estimating the morality rates for specific life stages, rather than just estimating an overall mortality rate? According to Figure 3, do different life stages differ in mortality rates? Explain how the figure shows this. According to Figure 2, which life stage has experienced the greatest change in survival over the 15 years of the study (from 1980 to 1995)? Again, explain how the figure shows this. Describe how the result shown in Figure 2 compares with the result shown in Figure 3.

b) Based on M_1 and M_2, which life stage do F & C conclude is most vulnerable? Why do they conclude this? What factors make this stage particularly vulnerable? Explain how the vulnerability of this stage affects the population growth rate (λ)? Predict what the population growth rate might be like if another stage was most vulnerable. Be sure to explain your prediction and to note which stage you are imagining to be most vulnerable.

c) F & C found that during 1980 to 1995, the population of Northern right whales began shrinking. In class, we developed an equation to describe changes in population size:

$N_{t+1} = N_t + B - D$. Relating this equation to the whale population, did D change between 1980 and 1995? Justify your answer with data from the paper. Did B change during this same time period? Again, justify your answer with data from the paper. Did a change in B or a change in D have a greater effect on the overall change in the size of the whale population between 1980 and 1995? Justify your answer.

d) Whales, like humans and elephants among other species, are at one end of a spectrum of life history strategies (tradeoffs), giving birth to a single large offspring at a time. Why might whales have evolved this life history strategy? (Consider the advantages of this life history strategy.) If whales instead gave birth to many, small offspring, how might you expect the survival probabilities of different stages to change? (Again, think about the advantages and disadvantages of having one large offspring versus many small offspring.) Unlike whales, female sea turtles produce many, small offspring. Predict how a change in the survival of female sea turtles would affect their population growth rate, thinking in terms of both death and birth.

3) Write one thoughtful question that you have about the article. Begin with a sentence or two that describes the context for the question (e.g., what the writer said, what you know about biology). Then ask a question that relates to the content of the article. Good questions will try to deepen your understanding of concepts, or will try to relate the content of the article to other ideas. The most interesting questions will be used to fuel our in-class discussion!