Communicating Ocean Sciences Lesson Plan: Marine Mammal Population Genetics

Introduction

Last fall, I was invited to give a guest lecture in an undergraduate Introduction to Marine Mammals course. The lesson topic was marine mammal population genetics, and the class met for two hours. I presented a slightly revised version of the same lesson to high school students in my Marine Biology class this spring. Both times, the lesson was entirely lecture-based. The first hour focused on cellular biology, mathematical population genetics (Hardy-Weinberg equilibrium), and the steps researchers take to design and execute a marine mammal population genetics study. The second hour consisted of a series of case studies (presented by the teacher to the class). Both times I presented this lesson, most students seemed to be engaged in the class, interested in the material, and gave what I thought were good answers to both factual and opinion-based questions I asked while I was lecturing. On the other hand, I worried both times that I had not presented the mathematical parts of the lecture well or made the connection between the math and the case studies we discussed clear enough. I was also frustrated with the fact that students were very passive during the whole lesson, and some of them seemed to get restless by the end (even with a break in the middle of the class). I have tried to improve my population genetics lesson by redesigning it to incorporate the active, inquiry-based learning techniques we have discussed this semester.

Key Concepts

By the end of this lesson, students should:

- 1. Be able to briefly define population genetics and describe the most common motivations for marine mammal population genetic studies;
- 2. Be able to explain different types of genetic data that can inform population genetic studies;
- 3. Explain what Hardy-Weinberg equilibrium is, and explain how population geneticists can use mathematics to interpret their data;
- 4. Outline (broadly) the steps a scientist would take to do a population genetic study;
- 5. Interpret selected data from marine mammal population genetic studies and explain their significance.

Materials Needed:

- Opaque containers for Hardy-Weinberg activity (2 per 3-4 person group)
- About 75 1" paper slips of one color and about 25 of another color per container
- Extra paper slips (50 or so) of one of the colors
- Lecture note handouts (to be provided only after class) [online at <u>http://web.mit.edu/deruiter/www/HSSPMarineBio/Popgens.html</u>]
- Hardy-Weinberg (Baby Whale) Activity data sheets [attached]
- Case study information packets with background information, instructions, and data [slides online]

Lesson Outline

INVITATION (5-10 MINUTES):

Tell students that the class today will focus on marine mammal population genetics. Ask them to discuss with one or two neighbors and try to come up with a definition of population genetics. Take volunteers from the class to share there definitions and come up with a class consensus definition (with teacher input as needed). Continue the class discussion to produce a short list of reasons why scientists or wildlife managers would want to do population genetics. [This part of the class will give the instructor some insight into what students already know about the topic, and will also introduce the rest of the lesson.]

Cell Biology (5-10 minutes) and Hardy-Weinberg Activity (30-35 minutes):

Begin with a short lecture defining DNA, mtDNA, sexual reproduction (*i.e.* some DNA from each parent), genes, alleles, diploidy, and genotype/phenotype. Be sure to ask questions and accept student input to gauge what students already know – the main point of this short lecture is to make sure everyone understands and can use the same vocabulary. Introduce the Hardy-Weinberg activity by telling students they will be simulating whale 'reproduction' and tracing a gene from one generation to the next. Explain that small pieces of colored paper will represent genes, and that they will make 'baby whales' by selecting pairs of genes from the 'gene pool' and record the babies' genotypes. Divide students into groups of 3-4. Hand out male and female 'gene pools' and data sheets to the groups. Direct three rounds of

'reproduction:' 1) genes are drawn randomly with replacement, from male and female pools with equal allele frequencies (random mating); 2) students are told that one allele is preferred, and are allowed to reject an allele they have drawn from the pool and select another once per baby whale (selection); 3) extras of one allele are added to the pool of one group, and taken away from that of another, then genes are drawn as in 1) (population subdivision). Students should draw 10 offspring per round. Record results from all the groups on the board, and discuss how the rules of reproduction affected the resulting offspring. Conclude with a 5-10 minute lecture/discussion to introduce the concept of Hardy-Weinberg equilibrium (deriving the equation from the probability of getting certain genotypes with student input), and relate it to the simulation results. [I think that this part of the lesson will introduce H-W more effectively than a math-y lecture, since students will be able to "see" it in action and make the connection between probability and allele frequencies.]

EXPERIMENTAL DESIGN (5-10 MIN.) AND CASE STUDIES (50-55 MIN.):

Make a transition to the next part of the lesson by explaining that scientists can gain insight into population dynamics by comparing theoretical predictions (like H-W) to real-world data. Outline the basic steps of a population genetics experiment: formulating a research question, selecting organisms and genes to study to answer the question, getting DNA samples, and analyzing the results. Tell students that they will be working in small groups to understand selected marine mammal population genetics case studies, then presenting their case studies to their classmates (short, ~5 min. group presentations). Divide the students into new groups of 3-4, and provide each group with background information, data, and presentation guidelines. Give groups time to analyze their case studies (15-20 min.), circulating from group to group to listen and answer questions. [Alternately, students could be assigned groups prior to class and could read the source research articles as homework.] Moderate student presentations to make sure each group explains what the research question was in their study, how samples were used (what kind of samples,

which gene, and what genetic data (sequence, RFLP, etc.), and how they interpret the data. End the class by thanking and congratulating the presenters, and briefly recapping the key concepts of the lesson.*

^{* [}Note – I am interested to hear whether you would rather see me lead the H-W activity or part of the case study activity during my class presentation!]

BABY WHALES DATA SHEET

Rules (write down how you are supposed to choose alleles each round):

| Round 1: | | |
|----------|------|------|
| Round 2: | | |
| Round 3: | | |

Data:

| Baby # | Round 1 | | Round 2 | | Round 3 | |
|--------|-------------|-------------|-------------|-------------|-------------|-------------|
| Daby " | Allele from |
| | mother | father | mother | father | mother | father |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |

Total # red alleles, round 1 = 20, round 2 = 20, round 3 = 20

Case Study Instructions:

(Note: This would be provided to the group in a packet, which would include background/reference information (see lecture notes) and data (see slide show).

Discuss the experiment in your case study, and make sure that you can interpret and explain the data. Visual aids included in your case study packet (data figures, pictures of your organism, and pictures of the sample collection method used in your study) will be available as slides during your presentation, so the whole class can see them. In particular, your presentation to the class should include answers to these questions:

- 1. What question were researchers trying to answer with this study?
- 2. Which marine mammal(s) did they study? In what geographical area?
- 3. How were DNA samples collected?
- 4. What gene(s), or at least what type of genes (nuclear or mitochondrial, coding or not) were used in this study? Why do you think the selected DNA regions were appropriate or inappropriate for answering the research question?
- 5. What are the results and conclusions of the study?
- 6. Include any other interesting observations your group discussed, and ask your classmates their opinions about any questions you have about the case study.