CASE TEACHING NOTES for "Search for the Missing Sea Otters: An Ecological Detective Story"

by
Mary E. Allen and **Mark L. Kuhlmann**
Department of Biology
Hartwick College, Oneonta, NY

INTRODUCTION

This case study uses a current scientific problem, declining sea otter numbers in Alaska, to demonstrate why species declines are important ecological issues and to teach students how to apply ecological principles to "real-life" ecological problems.

Objectives

The overall objective of the case is to introduce basic concepts of population and community ecology. Specific objectives include:

- Interpreting data from graphs and tables
- Practicing developing testable hypotheses
- Understanding indirect effects in biological communities
- Learning about sea otter, killer whale, and kelp forest ecology

CLASSROOM MANAGEMENT

This case was designed to serve as a framework for teaching an ecology module to first-year biology majors. The ecology module was the last of four modules covered in the second semester of a two-semester introductory biology course. Previously this module had been taught using a traditional lecture approach. This case does not replace the lectures, but rather is interspersed among discussions and activities that address the problem of disappearing otters in Alaska. This approach permits the students to use the information from the lectures to address a current ecological issue in a case format with the questions to be answered providing the motivation (need to know). Answers to these questions as well as background material is provided in the Detailed Analysis which accompanies this case.

The case was initially used in a class of 45 students and could be adapted to courses of any size. The students worked in permanent groups of three to four during 60-minute class periods. Class meetings during which the students worked on the case were interspersed with class meetings where the instructor presented principles of population and community ecology and other topics relevant to the case (global warming, commercial fishing, etc.). It took approximately three weeks to teach the entire case.

The parts of the case correspond to four central questions. Once one question has been answered by the students, the next question is introduced, proceeding in this fashion until all four have been addressed.

I. What Could Be the Cause of Decreasing Otter Numbers?
II. What Predator Could Be Causing the Large Decrease in Otter Numbers?

III. Why are Killer Whales Eating Otters Now?
IV. Who Cares if Otter Numbers are Decreasing?

This case could easily be modified to fit a variety of settings. Since first developing the case, we have also used it to teach population ecology and species interactions to an introductory (non-science majors) ecology class. In that situation, the background information was modified to suit the level of the class. The case could be shortened by eliminating Part III or Part IV or by reducing the amount of background information on ecology presented in class. It could also be broadened to explore issues of natural resource stewardship and politics. For example, the Stellar sea lion (normal prey of killer whales) was added to the endangered species list in 1997. The Clinton Administration's effort to curb pollock fishing to protect the sea lion led to a political fight involving the entire U.S. federal budget.

Introduction

The first day of the case the students are given the "Introduction" to read outside of class. The next time it meets, the class can discuss the reading. The first question, "What Could Be the Cause of Decreasing Otter Numbers," should arise out of this discussion. The students are told that to answer the question they need to learn about population biology. The remainder of the class period and the following two to three classes can be spent introducing the principles of population ecology (particular points addressed when this case was taught previously are described under "Detailed Analysis").

Part I

Once the students have some knowledge of basic population ecology, the first question, "What Could Be the Cause of Decreasing Otter Numbers," can once again be put before the class. Working in their permanent groups in class, the students make up a list of possibilities. The groups are then asked to write out how they would test four of their ideas and hand their proposals in to be graded. Near the end of the meeting time, each of the groups' lists of possible causes of otter declines is discussed by all of the students together. At the end of the class period, the students receive Part I of the case to read before the next class.

At the beginning of the next class period the instructor asks all of the students what they thought could be the cause of decreasing otter numbers based on their reading of Part I of the case study. The students should be able to eliminate disease, starvation, reproductive failure, and migration as possibilities, leaving predation as the likely cause.

Part II

At this point, the second question can be introduced, "What Predator Could Be Causing the Large Decrease in Otter Numbers?" The students receive Part II-A of the case and in their groups work in class on the first activity, making a list of the types of information about killer whales they believe the scientists might need to test the hypothesis that increased predation by the whales was the cause of the sea otter decline. Approximately 20 minutes before the end of class each group's ideas are discussed by the entire class. The instructor can use this as an opportunity to talk about the biology of killer whales by providing some of the information the students list.

The following portion of the case will likely stretch over two to three class periods, depending on how much time the instructor takes talking about killer whale biology and the students take to work on the activities.

Once the students have some information about killer whales, they can work on the second activity in Part II-A, describing two experiments that would allow them to test the hypothesis that increased predation by

killer whales was the cause of the sea otter decline. Groups can describe one or both (depending on time) of their experiments to the class. When ideas are presented, the instructor will likely need to provide some guidance on the basics of experimental design, such as controlling for confounding factors, replication, etc.

Groups then receive a copy of Figures 3 and 4, which show data collected by James Estes and his colleagues, and are asked to interpret the graphs (Part II-B). Students should be able to conclude that sea otter numbers remain constant in areas inaccessible to killer whales but numbers decline rapidly in areas where sea otters are subject to predation by the whales. This is also a good opportunity to discuss the reasons that the scientists counted all otters *and* marked otters, rather than relying on just one of the counts. The students should consider that only a relatively small portion of the population can be marked with radio collars, but scientists have a better chance of determining the fate of these otters, particularly if they emigrate. Alternatively, counting all otters provides data on changes in population size of the entire population.

The next question the students need to address is whether predation by killer whales could account for the 40,000 sea otters estimated to have disappeared between 1990 and 1996. We recommend introducing this dilemma by first showing a portion of the video series *The Trials of Life*, hosted by David Attenborough. In episode 4, "Hunting and Escaping," there is excellent footage of killer whales hunting sea lion pups, which dramatically illustrates the hunting methods used by killer whales and the enormous size difference between them and their prey. The instructor should also provide the students with a comparison of the size of sea lion pups to that of sea otters. Once the students have watched the video, groups can work in class on the energetics calculations in Part II-C. These calculations can be handed in for a grade at the end of the class period.

Part III

Once the students complete the energetics calculations, they will find that killer whale predation could easily account for the enormous decline in sea otter numbers during the 1990s. This should make the next major case question (Part III), "Why are Killer Whales Eating Otters Now," an obvious one. The students have learned that killer whales and sea otters have co-existed for decades but appear to have entered a predator-prey relationship only recently. This portion of the case is best done as a class discussion, which can begin by asking the students for suggestions as to why killer whales have begun eating sea otters. The ideas can be listed and the instructor can address each one individually. The present working hypotheses that answer this question are indirect effects of global warming and overfishing on the normal prey of killer whales, seals, and sea lions. These hypotheses are described in the "Detailed Analysis".

Part IV

The final question of the case (Part IV) is, "Who Cares if Otter Numbers are Decreasing?" The focus of this question can be narrowed by bringing the students back to questions in the "Introduction" of the case study: "Should we spend federal and state tax dollars to support scientists and others in their investigations of this problem?" "Are we wasting money on animals that are merely 'cute and fuzzy,' or might the loss of sea otters from the Aleutian Islands affect other organisms?" The students are informed that to answer the question they need to learn about community ecology. So, the remainder of the class period and the following two to three classes can be spent introducing the principles of community ecology (particular points addressed when this case was taught previously are described under "Detailed Analysis").

To address the final "big" case question, "Who Cares if Otter Numbers are Decreasing," the students also need to know something about the community in which the otters live. This can be done by telling them

about kelp bed communities (information about this is described under "Detailed Analysis"). The students are then asked to work in groups to interpret the information present in Figure 5 and Tables 3 and 4. This should demonstrate to the students the sea otter's role as a keystone species in Alaskan kelp bed communities.

DETAILED CASE ANALYSIS

Detailed case analysis is provided in a separate file that is password-protected. To access this information, go to the detailed case analysis. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our password policy and then apply online or write to answerkey@sciencecases.org.

REFERENCES

The references listed below are the major sources of data and information on the studies described in this case study.

- Estes, J.A., N.S. Smith, and J F. Palmisano. 1978. "Sea otter predation and community organization in the western Aleutian Islands, Alaska." *Ecology* 59:822-833.
- Estes, J.A., and D.O. Duggins. 1995. "Sea otters and kelp forests in Alaska: generality and variation in a community ecological paradigm." *Ecological Monographs* 65:75-100.
- Estes, J.A., M.T. Tinker, T.M. Williams, and D.F. Doak. 1998. "Killer whale predation on sea otters linking oceanic ecosystems." *Science* 282:473-476.
- Kaiser, J. 1998. "Sea otter declines blamed on hungry killers." *Science* 282:390.
- "Killer whales put Alaska sea otters at risk." *Environmental News Network*, October 16 1998.
- Stevens, W.K. "Search for missing sea otters turns up a few surprises." *New York Times*, January 5, 1999.

Acknowledgements: This case study was developed with support from The Pew Charitable Trusts as part of the Case Studies in Science Workshop held at the University of Buffalo, State University of New York, on June 12-16, 2000.

Image Credit: Photo by Warren and Leora Worthington, courtesy of Friends of the Sea Otter, used with permission.

Date Posted: 03/14/02 nas

Originally published at http://www.sciencecases.org/sea_otters/sea_otters_notes.asp