

A Penguin Foraging Simulation Game

adapted from an activity on http://quest.arc.nasa.gov/antarctica2/t_guide/activity_233.html

Foraging Facts

(This information is on the student handout)

Recent years have seen significant increases in Antarctic penguin populations. Some have argued that this is the result of reduced competition from whales who, like penguins, also feed on krill. Ornithologist Bill Fraser and his research team, participating in the Palmer Long Term Ecological Research (LTER) program, have challenged this assumption, suggesting that "penguin populations are increasing as a result of a loss of sea ice due to environmental warming." Supporting data has come from a winter expedition to the Scotia and Weddell Seas, recent satellite images of ocean ice cover, the analysis of long-term surface temperature records and penguin demographics.

Krill are the main diet of penguins. In January 1995, Antarctic krill (*Euphausia superba*) were scarce in the area studied by the LTER team. The main prey item available that year was *Thyanoessa*, a smaller euphausiid, which provided the penguins with much less energy per bite than the krill they favored. So that year, the Adelie penguins had very long foraging times (the hours away from the nest foraging for food for their chicks.) At one point both parents were observed simultaneously leaving the chicks, a previously-unknown behavior suggesting a high level of desperation.

Here are some real world "Foraging Facts":

Prey items are picked up individually, so getting a large item gives more return for effort expended than a small one if the items are of equal value per gram.

But size is not everything. In other years (1994, for example), Palmer researchers were finding both Antarctic krill and salps. Salps are larger than krill (up to 120 mm in size, with krill around 40 mm), but they contain a much higher percentage of water and so are not as economical as food. It's like filling your stomach up with water instead of a thick vegetable and chicken soup!

Penguins are restricted in the amount of time they can spend on each foraging trip because they need to get back to their chicks. Each foraging trip must also include time for swimming to the prey, time to feed for themselves, and time to fill up their stomachs with food to bring back to the chicks in the rookery.



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Materials

- 1 paper or plastic cup per student, for "stomach"
- spring-type clothespins as "bills"
- various food items assigned different points based on their energy worth:
 - 300 1/2" metal washers (large krill – *Euphausia superba*) (worth 10 energy points)
 - 300 M&Ms (juvenile krill – *Euphausia superba* – same species as the one above, but not fully grown) (worth 8 energy points)
 - 300 round toothpicks (small krill – *Thyanoessa* sp. – different species of shrimp-like euphausiid) (worth 5 energy points)
 - 300 marbles (salps – transparent, pelagic, jelly-like animals) (worth 2 energy points)
- copy for each student of the "Adelie Breeding Cycle, Diet and Foraging Facts"
- copy for each student of the Student Data Sheet

Engage

Display materials for this activity and tell students that they will be simulating the foraging behavior of penguins. Have them review the Adelie fact sheet, and discuss items which seem of most interest to your class, setting the foraging simulation in its real-world context. Explain that the washers, toothpicks, M&Ms, and marbles (or whatever you decide to use) represent penguin food items. Then demonstrate the use of the clothespin to represent a penguin's bill! The object of the game is to capture as much "prey" (in the cup "stomach") as you can within a time limit. The goal is to accumulate 500 points (which means you survive), expending the least energy in the shortest period of time. (Note to teachers: the total number of energy points for all the prey items suggested above is 7500, just enough for 15 students to survive as penguins if they all get equal amounts and are allowed to eat all the food. You probably want to play with at least 15 students or adjust the play time or prey items, accordingly, so that not all students/penguins survive the round.)

Explore/Explain

Many factors contribute to foraging success (and ultimately the chick-raising success) of penguins in Antarctica, including:

- type (quality) of prey available
- abundance of prey
- distribution of prey
- type and abundance of competitors
- type and abundance of penguin predators
- amount of time penguins can spend foraging

Procedure

1. Select an open area such as a playground, park, or gym and randomly distribute the food items over a wide, but defined area.

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2. Explain to the students that you are the "top predator", signaling the start and finish of each round of play. As top predator, you may "capture" penguins that are breaking the rules or exhibiting disruptive behavior. Explain to students that in nature, birds that break the rules often have behavior patterns that attract predators.
3. Give each student a clothespin bill. Explain that food items must be picked up, not scooped with the bill and dropped into the paper cup "stomach". As is true in many societies, throwing food items is not allowed!
4. Give students 5 minutes to forage, or stop the round before the supply is too low, but make a note of the time allowed (adjust time to skill of group).
5. Count and record the number of food items collected and their energy point equivalents.
6. Debrief findings in the first round of play. How many penguins survived? How many did not? Why didn't all the penguins survive (not enough time to forage/not enough food)?
7. Alter conditions to simulate one of the following scenarios:
 - a) Change the number of prey that you provide for penguins to eat. For example, provide 300 large krill (*E. superba*), 100 juvenile krill (*E. superba*), 200 small krill (*Thyanoessa* sp.), and 500 salps OR maybe try providing 100 large krill (*E. superba*), 100 juvenile krill (*E. superba*), 400 small krill (*Thyanoessa* sp.), and 300 salps, etc. Vary the amount of food as you see fit for the number of students in your class.
 - b) Use the original numbers of prey items, but change the way you distribute them around the playing field. Krill can often be found in patches of very high densities. Try putting the prey items in patches in the playing field with most or all the large krill in one or a few patches and spread the other prey items randomly OR try making all the food types "patchy."
 - c) Play another round just like the first, but don't have a time limit. Allow your students to forage until all the prey items are gone.
 - d) Try using one type of prey item that comes in two different colors (like green and red jelly beans or M&Ms). Find a place (like maybe a grassy area) where the green prey items blend in with the environment, but the red (or other color) prey items do not blend in.
 - e) Keep the original prey items and numbers, but have some of your students be other types of krill-eating animals, such as baleen whales or crabeater seals. Have a few of the students who did not survive the first round pretend to be other animals competing for krill. You can give them different utensils or instruments to simulate the different feeding strategies, for example, you might simulate a baleen whale with a fork or comb (where scooping is allowed!) with a bowl as a stomach.
8. Ask the students to predict what the results might be and then play another round using the altered conditions. Record the results.
9. Draw conclusions: what observations can you make about foraging behavior, competition for food, and availability of prey? The amount of food brought back to

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the chicks is pretty constant, so the major variables are the prey distribution/abundance, and the time spent foraging.

Here are some questions for discussion for each of the above alternate scenarios:

- a) How did unequal numbers of prey distributed in the foraging area affect penguin survival? Did a greater or fewer number of penguins survive? Why? If there were only a very limited number of prey items available, what type of prey would the penguins prefer them to be (if they had a choice)?

What would happen if the only prey available were salps and/or *Thyanoessa* sp.? If there were an abundance of these prey items, how would that affect the time needed to collect enough food to survive? For the number of students playing in the game, how many salps would need to be eaten in order for everyone to survive?

What would happen if the only prey available were large krill and/or juvenile krill (*E. superba*)? If there were an abundance of these prey items, how would that affect the time needed to collect enough food to survive? For the number of students playing in the game, how many large krill would need to be consumed in order for everyone to survive? Compare this number with the number of salps required for all students/penguins to survive.

- b) What happened when the food types were not randomly distributed in the feeding area? Was it easier or more difficult to find prey? Was there a difference between the first round and this round in how much time was spent moving around to collect prey? Was there more or less competition than in the first round? Given a choice, would you forage at a patch/school of large krill and compete with many other penguins OR would you forage at a patch with smaller krill with fewer penguins with which to compete?
- c) Given no time limit, did more penguins survive than in the first round? What happened to the food supply? Is this a realistic scenario where penguins have all the time they want to forage? Why?
- d) What happened to the prey items when half of them were a similar color to the feeding environment (they were camouflaged!) and half were not? Was one prey type eaten more than the other? What if all the prey blended in with their environment? How would that affect penguin foraging time? How would that affect penguin survival?
- e) What happened when other krill-eating animals entered the foraging area and competed for food? How did that affect penguin survival? How did that affect prey type and abundance?

Also, be sure that your students compare their prediction(s) with the actual outcome of each round.

Expand/Adapt/Connect

1) Use a globe to show that all 17 species of penguins live south of the equator. One species, the Galapagos penguin, lives on the equator in the path of the cold Peru Current. Seven kinds of penguins visit Antarctica, but only two species, the Adelie and Emperor penguins, breed exclusively on the Antarctic continent.

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(resource:

<http://www.antarcticconnection.com/antarctic/wildlife/penguins/index.shtml>)

2) How are the adult Adelle penguins able to survive while sitting on the nest?

Answer: Blubber or body fat is a primary food source.

(Do a "blubber mitt" activity, e.g. <http://www.neaq.org/scilearn/kids/warm.html>, to illustrate insulation properties of blubber (solid shortening).

3) Penguins are the only birds that migrate by swimming. Students can research and map their migration routes, up the west coast of South America to Tetal Point in northern Chile, or up to the east coast of South America past Argentina as far north as Rio de Janeiro in Brazil.

Estimate the distances they travel.

(Each degree of Latitude = 60 nautical miles. One nautical mile = 6,076 feet, or 1.15 statute miles.)

4) Using images located on-line, students can match the migratory routes of penguins with the location of currents. What assumptions can they make about migration routes by looking at directions of currents? (hint: Penguins follow cold water currents.)

For example,

http://www.galapagosonline.com/Galapagos_Natural_History/Oceanography/Currents.html#The%20Humboldt%20Current

5) Research North America's own "penguins," the flightless Great Auks. Learn how Great Auks were similar to penguins. Find out why they were slaughtered.

(Great Auks were killed for food, their feathers, and for stuffed specimens. These birds became extinct in 1844 when two museum collectors landed on a remote island off Iceland, strangled the last surviving pair for their collection and then smashed the last egg.)

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Student's handout

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