Penguins Foraging: Where & Why?

Materials

For the leader:

Projector

Computer

Board with markers

Penguin Foraging Simulation

Data Table and Graph

Penguin Habitat Use map .gif files (2)

For the activity:

Penguin Foraging Worksheet

Penguin Habitat Use maps

40 pie pans

2 bags of white beads

2 bags of pink beads

Tape

Stopwatch

Overview

Adélie penguins are medium sized (6.5-13 lbs, 27.5 in tall) Antarctic seabirds that can be identified by the white ring around their eye. Males and females are of similar size. Adélie penguins are excellent swimmers, some have been recorded to swim as far as 186 miles to forage food. Scientists have measured their swimming speed from 2.5 to 5 mph.

Adélie penguins spend most of the winter at sea on ice floes, and return to colonies on land in the warmer summer months. During the breeding season, they live along rocky coastline that is near sea ice. Success of chick survival is dependent upon the cooperation of the parents, as they share the responsibility of feeding/foraging and caring. The parents, one at a time, travel from the colony into the ocean to find fish, amphipods, and krill to eat. The size of a meal depends on the size of the chick and can range from 0.7 - 1.4 pounds.

To find food, the adults travel between 3 - 75 miles offshore and dive to depths ranging from 230 - 575 feet. The duration away from the colonies for foraging trips typically lasts for 5 - 72 hours.

Motivating Questions:

- **What influences where Adélie penguins forage for food?**
- **How could convergence zones impact where Adélie penguins forage for food?**

Take Home Message

Adélie penguins forage by collecting Antarctic krill and returning to their nests to feed their chicks. Forage density is higher in convergence zones, as the penguins are more efficient at finding food.

Structure

Students will experience foraging behavior of Adélie penguins by acting out foraging patterns and analyzing their data. The students will then look at distribution data of penguins foraging to determine what factors could influence the location of penguin foraging.

Time Required

One 45-minute class period

Activity Outline

Engage: Students will experience penguin foraging behavior and strategy through a movement activity.	20 minutes
Explore: Students will be presented with Adélie penguin foraging density maps to look at where penguins often forage.	15 minutes

Make Sense: Through a class discussion students will connect their knowledge about convergence zones with the locations of high penguin foraging density.	10 minutes
Total:	**45 minutes**

Audience

Middle and early high school students (6^{th}-9^{th} grade).

Preparation (30 minutes)

1. Prepare the cups/buckets with the beads. There should be 16 cups/buckets that each have a large handful of white beads (or whatever color you choose), 19 cups/buckets that each have a large handful of pink beads (or whatever your second color choice is), and 4 empty cups/buckets.
2. Set-up the Penguin Foraging Simulation game in the outdoor/indoor area using the Penguin Simulation Map on page 5 to set out the cups/buckets of beads. Make a line for the Starting Line/Rockery. Distribute the 4 empty cups/buckets randomly throughout the area. Try to use an area at least 30 ft by 25 ft (outdoor fields, basketball courts, or gymnasiums would be good options).

   NOTE – If you have a student who physically cannot partake in the simulation due to mobility limitations, make sure to have the student help as a rule judge, time keeper, or data collector. Or the activity could be done around a round table with smaller cups.
3. Create the class data table and outline of the class graph (on page 4) for the Penguin Foraging Simulation activity on the board.
4. Set-up the computer and projector to be able to project the Penguin Habitat Use map Example.
5. Make sure you have copies of the "Penguin Foraging Worksheet" for each student.
6. Write the motivating questions on the board:

   Q. What influences where Adélie penguins forage for food?

   Q. How could convergence zones impact where Adélie penguins forage for food?

Engage (20 minutes)

1. Ask the students what they like to eat for lunch and how far they have to travel to get their lunch (Slide #2).
2. After taking a few responses, ask the students to compare this with what they know about what penguins may eat and how far they have to travel to get their food (Slide #3).
   a. It may be helpful to briefly review the Antarctic food web with the students (Slide #4).
3. After a few minutes, tell the students that they are going to run a simulation of Adélie penguin foraging behavior. A simulation represents a real-world process or system. In this simulation, the students will be imitating penguin foraging behavior and their actions will produce the output data of the simulation. The students will need to divide into groups of two people per group to represent the two parents that take care of a penguin chick.

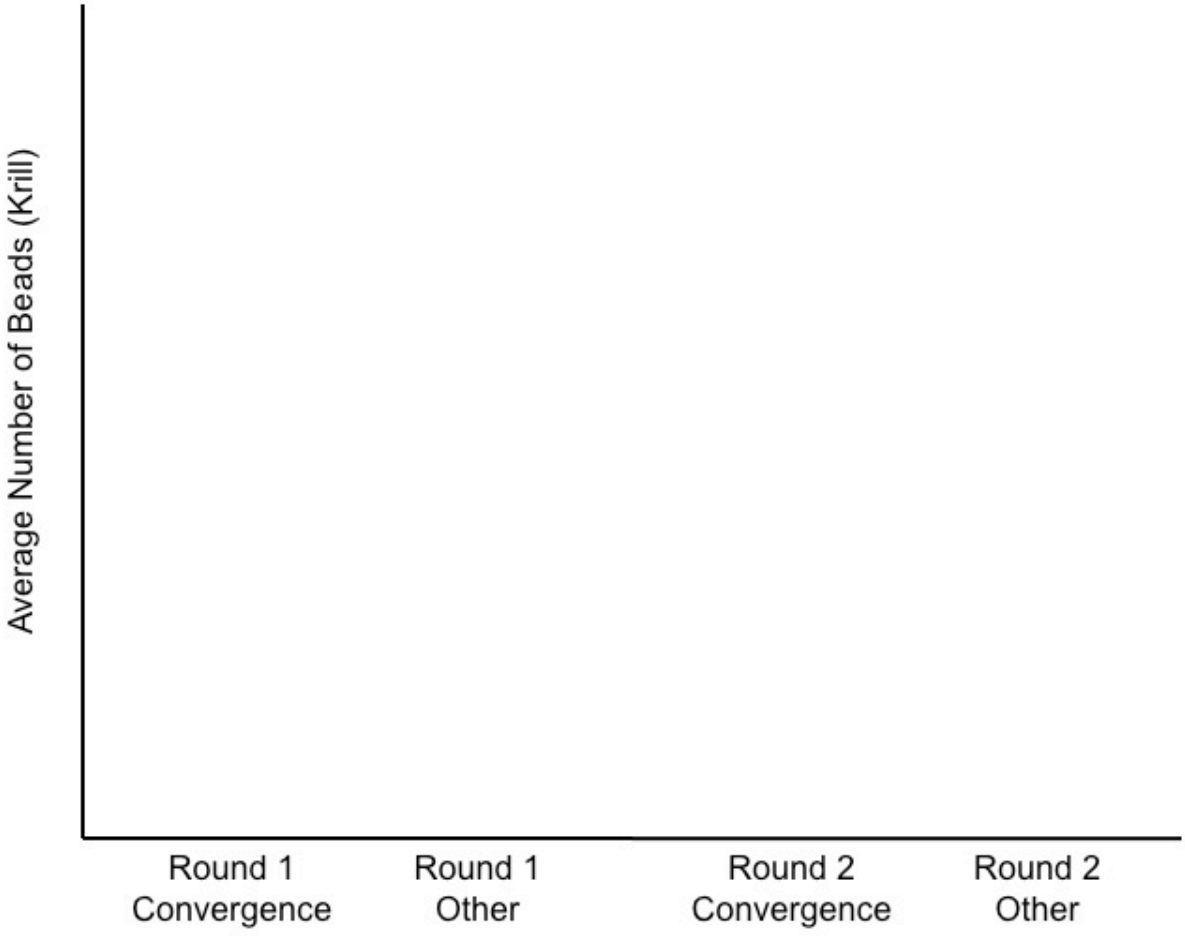
   NOTE – if it would be better/easier/faster, have the students pre-divided into groups.

NOTE – do not emphasize who is the female/mother or male/father of the pairs, this detracts from the activity for the target age group.

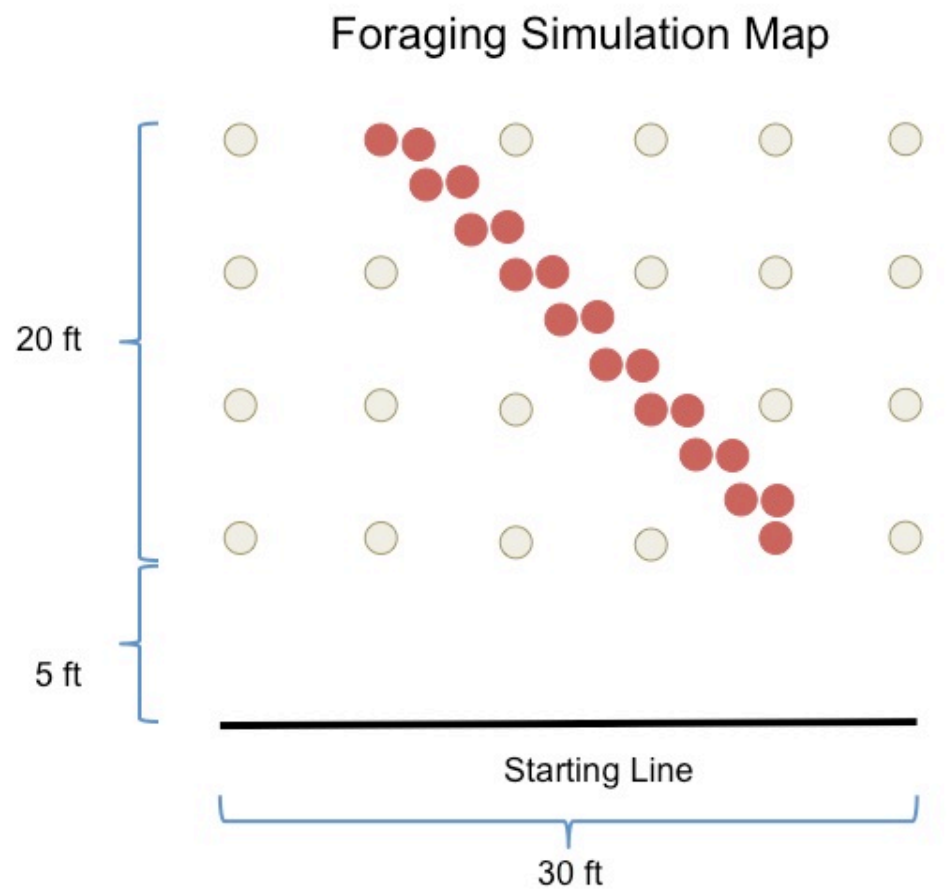
4. Explain the simulation to the students (the simulation should take about 10 minutes with instruction and data collection; Slide #5):
   a. Each group will line up at the start line (colony) and choose the order in which the teammates will go through the simulation. Only one student can go at a time, because the other parent stays behind to care for and protect the chick.
   b. Each round will be 1 minute long. For the first round, one teammate will forage while the other cares for the "chick." Then, they switch.
   c. The objective is to collect as many krill (beads) as possible for your "chick."
   d. There will be two rounds total.
   e. Each student will have a plastic bag (stomach) to fill with his or her krill for each round.
   f. The student will leave the colony to go forage in the ocean, once you call "Start" for the first round. While in the ocean, the student will collect krill using the hand that is not holding the plastic bag (this represents the penguin's beak).
   g. The student can collect one bead (krill) from a bucket at a time. Before collecting the next bead, the student needs to change buckets (aka they cannot take all of the beads from the same bucket but rather have to forage among buckets). However, the next (third) bead can be taken from the original bucket.
   h. To collect beads (krill) the students have to stand and lean over, they cannot kneel or sit, so that there two feet are always on the ground. Also, they cannot pick beads off of then floor (those represent krill that got away).
   i. At the end of Round 1 you will call "Stop" and the foraging student will return to the colony.
   j. Once everyone is back, you will call "Start" and the next member of the team will forage for the "chick."
   k. At the end of both rounds the students should return to their table to count the krill they collected in their stomachs from each round by color.
5. Ask if the students have any clarifying questions about how the simulation will work. Once their questions are answered, start the simulation.
6. Once the two rounds are complete, have the groups count and report their beads (krill) from each round by adding their tallies to the class data table (Slide #6).

Round/Partner	Convergence Zone Color Beads (Pink)	Other Color Beads (White)
Round 1 (Raw Data)		
Round 1 (Averaged Data)		
Round 2 (Raw Data)		
Round 2 (Averaged Data)		

7. After the students add their data to the classroom data table, calculate the average number of beads from the convergence zone (pink beads) and from other areas (white beads) in each round. Once calculated, plot the data as a bar graph (Slide #7).



8. Lead the students in a discussion about what patterns they see in the data of the number of beads from the convergence zone (pink beads) and beads from other areas (white beads) across each round (Slide #8).
   a. Which color of beads was there more of in each round? - *The answer will vary based on your students' data, but it most likely will be that there will be more pink beads.*
   b. Did the difference between pink and white beads change across the rounds (over time)? - *The answer will vary depending on your students' data, but it is most often a greater difference in Round 2 as the students can watch Round 1 and strategize.*
   c. Which colors did you pick up more of during the game? Why? - *The answer will vary on our student's data, but most students pick up more pink beads because the pie pans with pink beads are closer together so they can get more beads more quickly. A "bigger bang for their buck" as some students say.*
9. After a few minutes, project the Foraging Simulation Map to show the students where the pink and white beads were located in the ocean. Have the students look at the class data and look at the Foraging Simulation Map and think through why there were more pink beads than white beads collected. Ask the students to turn to their neighbor and talk through the data (Slide #9).

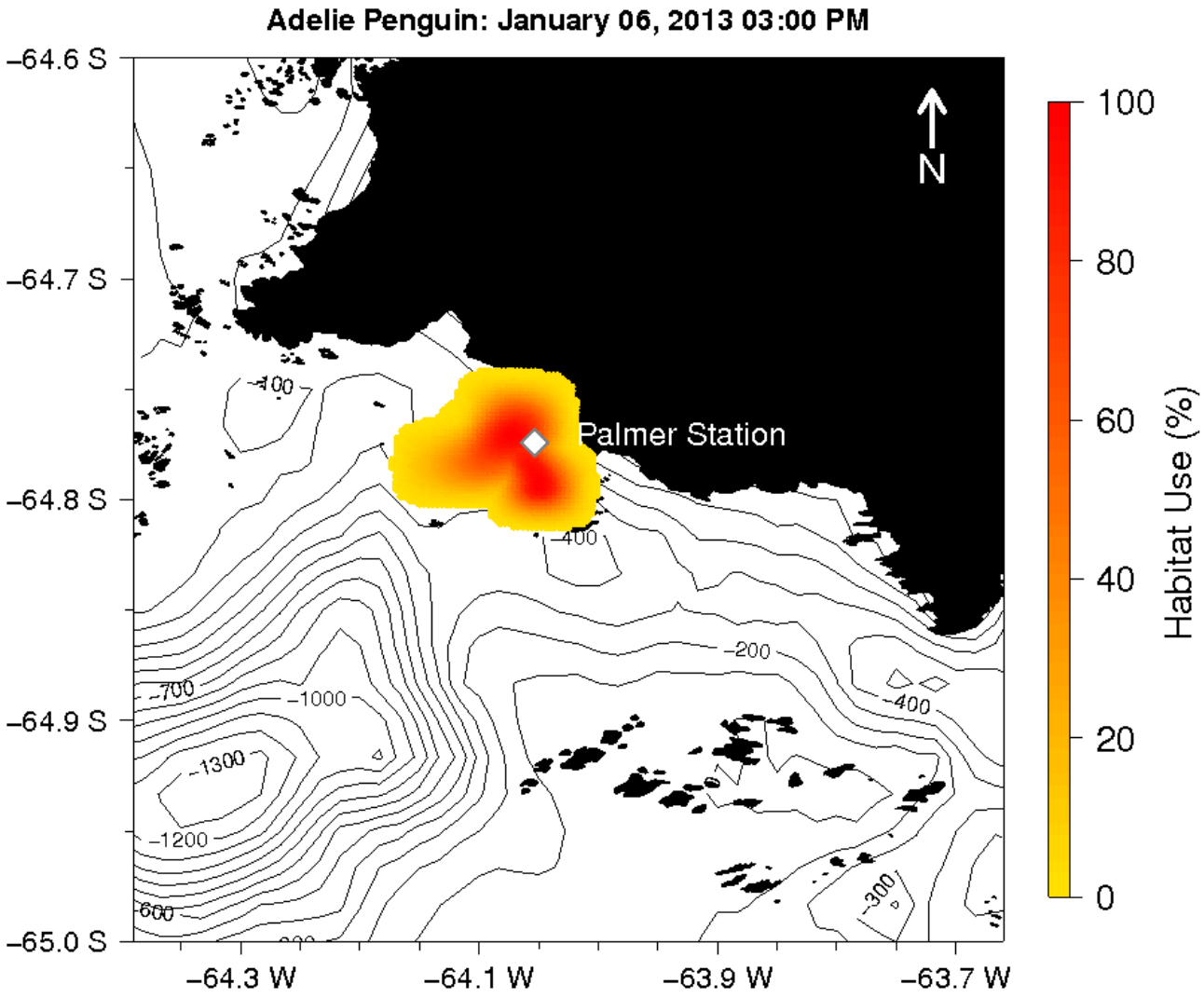


10. After a few minutes bring the students back together and have them share with the class what observations and conclusions they made with respect to the spatial distribution of the beads and the amount of each bead collected (foraging success).
    - NOTE – The students may ask why the beads were specifically pink or white color. The specific colors chosen were arbitrary. The different colors were used to help them understand after the fact where they had collected the beads from during the simulation. The specific colors of the two types of beads could be any colors that you wanted (aka there are not white and pink krill in different parts of the ocean).
    - NOTE – Help the students to see that the pink beads were gathered in a convergence zone (you may need to remind them of what this is), meaning there were more krill (beads) in one location and thus you could gather more krill at the convergence zone than by traveling around to the dispersed krill locations (white beads).

Explore (15 minutes)

1. After a few minutes of discussion, explain to the students from looking at satellite tag data of the location of penguins we can get a sense of where they spend the majority of their time when they are in the ocean foraging. Satellite tags are devises of varying size that can be temporarily attached to animals that send the data to scientists via satellites (Slide #10).
2. Remind the students that they will be looking at Penguin data from the Palmer Station area in Antarctica. Project Slide #11-13 to reorient the students to Antarctica, the Western Antarctic Peninsula, and Palmer Station area.

3. Then project the Penguin Habitat Use map for the students to look at on the screen (Adelie_Pen_Pal_Kern_141001.gif) through your internet browser or other software you would prefer. Let the file play through once without saying anything. Have the students watch the data and think to themselves about what they are seeing (Slide #14).



4. Then through a class discussion, help the students to orient to the map and data.
    a. The map is from the Palmer Station area (white diamond marks the station location) on the Western Antarctic Peninsula. The black represents the land. The black thin lines are the bathymetry (depth of the seafloor) in the ocean.
    b. The data are from January 6 – 26, 2013.
    c. It is a representation of where the penguins spent their time ("pings" from the satellite tags on the penguins were compiled over an hour to make these estimates of likely movement patterns across space within the hour for all tagged penguins).
    d. The darker the color (red) the more "pings" from the satellite tags in the area.
5. Have them discuss in small groups what patterns they you observe in the location or amount of Habitat Use by the penguins over time near Palmer Station (Slide #15). Ask the students to think about what could be driving those patterns.

* NOTE – The intention is for students to see that the habitat use percentage of the penguins shifts in space and over time.

* NOTE – Make sure the students understand by the end of the discussion that knowing that the majority of what the penguins are doing is foraging for food, you can presume that the locations where the penguins spend the most time is where the penguins have the most success in finding food.

6. After a few minutes bring the students back together to discuss as a class what observations they made about the penguin data from the maps. Be accepting of all answers, as this is the first time the students will have looked at penguin Habitat Use data.

Make Sense (10 minutes)

1. Once you are confident in the students understanding of the concepts and their ability to read the Penguin Habitat Use map, ask the students where did the penguins go when there was not any data (January 13, 2013 at 8:00-11:00AM; Slide #16)?
2. Have the students first think to themselves and write down some ideas. Then have them talk with a neighbor about their ideas.
3. After a few minutes bring the students back together to have each partner group report out to the class what they came up with. Encourage the students to have a conversation with one another about their ideas and which might be the most plausible explanation for the lack of penguin movement data from that time period. As the students are sharing ideas and discussing, capture their thoughts on the board as a written record of their conversation.
4. Once the discussion slows down, inform the students that there were no penguins tagged between 8:00-11:00AM on January 13, 2013 so that is why there is no data during that time period (Slide #17).
5. Then point to the motivating questions and review with the students:

   Q. What influences where Adélie penguins forage for food? – *Where they can find the most food (usually convergence zones). (Slide #18)*

   Q. How could convergence zones impact where Adélie penguins forage for food? - *Convergence zones collect plankton (krill as their food choice) into the specific area, which means the penguins can expend less energy to get as much food as they need. As the convergence zone moves, the location of where penguins forage also moves to track the food. (Slide #19)*

6. Ask if the students have any final questions about the activity and data maps from the day.

This lessons was adapted from:

- "Great Lakes Piping Plover Survival: Lesson Plan" by Dr. Dennis Yockers, University of Wisconsin – Stevens Point and Alice Van Zoeren, Great Lakes Piping Plover Research and Recovery Team. Sleeping Bear Dunes National Lakeshore, National Park Service, 2009.
- "Foraging for Fish in a Melting Arctic: The Black Guillemots' Quest to Feed Their Young" by Katie Morrison, katiem@ucds.org and Cristina Casillo, cristina.casillo@nsbsd.org at PolarTREC (http://www.polartrec.com/learning-resources)

Common Core State Standards Connections: ELA/Literacy and/or Math (Middle School)

English Language Arts

WHST.6-8.1	Write arguments to support claims with clear reasons and relevant evidence.
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research.
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
6.SP.B.5	Summarize numerical data sets in relation to their context.
7.RP.A.2	Recognize and represent proportional relationships between quantities.

Next Generation Science Standards (Middle School)

Ecosystems: Interactions, Energy, and Dynamics, MS-LS2-1 – Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data – Analyze and interpret data to provide evidence for phenomena.	*LS2.A: Interdependent Relationships in Ecosystems* - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. - Growth of organisms and population increases are limited by access to resources.	*Cause and Effect* – Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Ecosystems: Interactions, Energy, and Dynamics, MS-LS2-4 – Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence – Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	*LS2.C: Ecosystem Dynamics, Functioning, and Resilience* - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	*Stability and Change* – Small changes in one part of a system might cause large changes in another part.

New Jersey Core Curriculum Content Standards - Science (Middle School)

Content Area	Cumulative Progress Indicator (CPI)	CPI#
Science Practices: Understand Scientific Explanations	Use mathematical, physical, and computational tools to build conceptual-based models and to pose theories.	5.1.8.A.2
Science Practices: Generate Scientific Evidence Through Active Investigations	Gather, evaluate, and represent evidence using scientific tools, technologies, and computational strategies.	5.1.8.B.2
	Use qualitative and quantitative evidence to develop evidence-based arguments.	5.1.8.B.3

Science Practices: Reflect on Scientific Knowledge	Monitor one's own thinking as understandings of scientific concepts are refined.	5.1.8.C.1
	Revise predictions or explanations on the basis of discovering new evidence, learning new information, or using models.	5.1.8.C.2
	Generate new and productive questions to evaluate and refine core explanations.	5.1.8.C.3
Science Practices: Participate Productively in Science	Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.	5.1.8.D.1
	Engage in productive scientific discussion practices during conversations with peers, both face-to-face and virtually, in the context of scientific investigations and model-building.	5.1.8.D.2
Life Science: Interdependence	Describe how one population of organisms may affect other plants and/or animals in an ecosystem.	5.3.6.C.3
	Model the effect of positive and negative changes in population size on a symbiotic pairing.	5.3.8.C.1

New York Science Learning Standards

Standard Area	Key Idea	KI#
Standard 1: Analysis, Inquiry, and Design (Mathematical Analysis)	Extend mathematical notation and symbolism to include variables and algebraic expressions in order to describe and compare quantities and express mathematical relationships.	M1.1
	Use inductive reasoning to construct, evaluate, and validate conjectures and arguments, recognizing that patterns and relationships can assist in explaining and extending mathematical phenomena.	M2.1
Standard 1: Analysis, Inquiry, and Design (Scientific Inquiry)	Construct explanations independently for natural phenomena, especially by proposing preliminary visual models of phenomena.	S1.2
	Represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others.	S1.3
	Seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists.	S1.4
	Design charts, tables, graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.	S3.1
	Interpret the organized data to answer the research question or Hypothesis and to gain insight into the problem.	S3.2
Standard 6: Interconnectedness: Common Themes (Models)	Use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).	2.2
Standard 6: Interconnectedness: Common Themes (Patterns or Change)	Observe patterns of change in trends or cycles and make predictions on what might happen in the future.	5.2