Investigating Why Penguins Forage There: Piloting Gliders

Materials

For the leader:

Projector

Computer

Board with markers

Glider navigation brainstorm notes (from Lesson 3)

For the activity:

Penguin Habitat Use map

Surface Currents & Convergence Zone map

Worksheets

Overview

The breeding and foraging ranges of Adélie penguins (*Pygoscelis adeliae*) along the Western Antarctic Peninsula (WAP) vary spatially; they cover a wide area but can be patchy in certain places. The surface current convergence zones in the area may be drivers of the distribution patterns of Adélie penguins (a nearshore predator. Currents can have profound effects on marine ecosystem properties, affecting phytoplankton production, zooplankton aggregations, and avian and marine mammal foraging behavior in response to the concentration of prey where currents move them or collect them.

One of these penguin "hotspots" occurs near Palmer Station, on Anvers Island, which has been occupied by Adélie penguins for nearly 1,000 years. The Science Team hypothesizes that the local and predictable convergent zones in this region may play a role in concentrating food and thus be influencing where Adélie penguins forage. Therefore, they will be using a multi-platform field study to investigate the impact of local physical processes on Adélie penguin foraging ecology in the vicinity of Palmer Station. They will combine remotely sensed surface current maps (HF Radar), with autonomous underwater vehicle (AUV) deployments (gliders), and satellite telemetry of the penguins to understand how local current patterns can change the structure the ecosystem. To understand the approach the scientists will be using in Winter 2015, the students will simulate the scientific approach of the research mission.

Adélie penguins are the focal predator of this research project because they are flightless and must return to their colonies to feed their chicks, their foraging ranges are highly constrained, and they must breed in close association with marine regions where prey availability is predictable over ecological time scales. The implication, therefore, is that the areas the penguins forage contain oceanographic processes operating over scales that lead to enhanced foraging efficiencies for the penguins.

Motivating Questions:

- **What do you think may be going on in the ocean that may cause penguins to forage in certain places?**
- **If we are interested in understanding why penguins forage where they do, how can we choose a path for the glider to learn more about the ocean and the penguins?**

Take Home Message

Balancing multiple datasets from locations where penguins are foraging and where ocean convergence zones exist to decide where to send the glider, to learn about what ocean conditions encourage penguin foraging, is challenging.

Structure

Students will simulate the work of the Science Team as they integrate information of the surface currents and the penguin movement patterns to decide where to send the glider to collect data about the ocean conditions. The students will experience similar decision-making points in piloting the glider that the

Science Team will experience when in Antarctica. The students will then brainstorm what they would expect the glider data to show about the ocean conditions where penguins are foraging and convergence zones are occurring.

Time Required

One 45-minute class period

Activity Outline

Engage: Students will be presented with the challenge to select waypoints to navigate the glider to learn about ocean conditions where penguins forage.	5 minutes
Explore: Students will choose, discuss, and reevaluate the waypoints for the glider track.	25 minutes
Make Sense: Students will brainstorm what the glider data would illustrate about what is going on in the ocean where penguins forage and discuss the similarities from their work to those of the Science Team.	15 minutes
Total:	**45 minutes**

Audience

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

Preparation (30 minutes)

1. Make copies of the worksheet for each student.
2. Set up the projector and make sure the PowerPoint presentation works.
3. Ensure that the Penguin Habitat Use map and Surface Currents & Convergence Zone[1] map are ready for the students to use.
4. Write the motivating questions on the board:

   Q. What do you think may be going on in the ocean that may cause penguins to forage in certain places?
   Q. If we are interested in understanding why penguins forage where they do, how can we choose a path for the glider to learn more about the ocean and the penguins?

Engage (5 minutes)

1. Remind the students that they are researching what it is about the ocean that influences where penguins forage most. The Science Team thinks it has something to do with the convergence zones.
2. Ask the students for a volunteer to remind the class what a convergence zone is. (*Convergence zones occur where currents meet, come against one another, or where wind drives water against a coastline (which the students may have seen if confetti was stuck up against the play-doh in the*

[1] The metadata for this figure has been altered to align with the Penguin Habitat Use map to achieve the student learning objectives of data orientation and simulating scientific decision-making.

"Ocean Convergence: Let's Get Together" lesson). These are areas where the water is collected into one specific area, aka it converges.)

3. Present the students with the challenge of the day: Interpret your data to find the best path to navigate the glider to sample the ocean conditions in the area to test this hypothesis. (Slide #2)
   a. The students will need to work in their small groups to either interpret either the HF Radar current data (to find convergence zones) or the Penguin Density data (to find where penguins spend most of their time foraging) to navigate the glider to collect data about the ocean conditions to learn more about why penguins forage where they do (Slide #3).
   b. The students will need to pick 4 waypoints (latitude and longitude) for the glider to move between the start and end points to sample the ocean conditions. The students should plot the chosen waypoints on their worksheets and explain the reasons behind their choice.

      * NOTE – Use Slide #4 to help students understand that glider waypoints are a set of latitude and longitude coordinates that scientists give to the glider as directions of where it should go in the water.
4. Ask the students if they have any clarifying questions about the challenge.
5. Remind the students that they are working with scientists that are conducting their research in the Western Antarctic Peninsula (Slide #5), which has the Palmer Research Station in the middle of it (Slide #6), and if we continue to zoom in closer, we can see the area around Palmer Station. This is the area we will be looking at penguin habitat use and convergence zone data and sending the glider (Slide #6).
6. Once they understand the challenge ask the students if they want to review how to read Surface Current maps from lesson 1 (Slide #8) or Penguin Habitat Use maps from Lesson 2 (Slide #9).

Explore (25 minutes)

1. Split the class into small groups and make sure that half of the class analyzes the Surface Currents & Convergence Zones data while the other half analyzes the Penguin Habitat Use data and let them start the challenge (Slide #10).
2. Walk around to help each team select and mark their waypoints.
3. After about ten minutes, or when they have completed choosing their waypoints based on the data their team has, bring the students back together as a class. Explain that as a class they now need to come to a consensus of where in the ocean they are going to navigate the glider to fly, because there is only one glider.

   * NOTE – It can be helpful to project Slide #10 and draw on the map the waypoints that the students suggest as they are choosing the locations.
4. Help the students talk through their chosen glider paths and communicate with one another about where they think the waypoints should be set. Let the students argue through this process. Make sure the students site the data or evidence that they are using to pick or advocate for each waypoint location they engage in a debate based on their scientific arguments.

   * NOTE – A key aspect of this part of the lesson is that the students need to site their evidence and engage in discussion with one another to come to a decision, truly replicating the process that the science team will utilize during the research mission.

Make Sense (15 minutes)

1. Once the students have agreed on the waypoints for the glider, lead the students in a brainstorming discussion about what they think the glider data would illustrate about the local ocean conditions and what that would mean for where penguins choose to forage (Slide #11). Be accepting of all answers as it is a brainstorming session, because this is the question the Science Team is trying to answer with their research mission. Write the students comments down on the board as they are sharing. Remind the students that there is no correct answer, just hypotheses that are supported by prior knowledge or evidence.

   The students may mention things like the glider could tell them if there is chlorophyll in the area, which they could use as a proxy for the amount of phytoplankton in the area, which could indicate how much krill (an important food source of penguins) is in the area.

   * NOTE – It may be helpful to remind the students of the Antarctic food web and how phytoplankton is connected to zooplankton, which is what the penguins eat. And thus it is illuminating to look at phytoplankton data (Slide #12).

2. Once the discussion slows down, point to the motivating questions and help the students reflect on their decision processes throughout the day:

   Q. What do you think may be going on in the ocean that may cause penguins to forage in certain places? (Slide #13) – *Penguins want to forage as efficiently as possible, so they probably would forage in areas with high concentrations of prey items. Because the ocean is dynamic that means there are differences in the water conditions and thus the plant and animal life within the water. Predators would most likely pursue areas that have conditions that favor or collect higher concentrations of food.*
   Q. If we are interested in understanding why penguins forage where they do, how can we choose a path for the glider to learn more about the ocean and the penguins? (Slide #14) – *There are two main approaches to navigating the glider. Either you can direct the glider into areas that have high penguin concentrations and convergence zones to test that specific hypothesis. Or you can choose to sample areas of low and high concentrations of penguins and areas within and outside of convergence zones to get a broader picture of what is happening in the whole ocean to then look for patterns to address your hypothesis.*

3. Ask if the students have any final questions about the activity or data maps from the day (Slide #15; if they do, you can collect them to pose the questions to the scientists on the live call or post on a relevant entry on the blog). Ask the students if there was any other information that they wanted to have in order to understand why penguins forage where they do. Explain that they will be following the Science Team through the science blog and talking with the scientists about their work doing exactly what the students just did this January when the scientists are down in Antarctica conducting their research mission.

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

English Language Arts

WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research.
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics

MP.2	Reason abstractly and quantitatively.
6.SP.B.5	Summarize numerical data sets in relation to their context.
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems.

Next Generation Science Standards (Middle School)

Ecosystems: Interactions, Energy, and Dynamics, MS-LS2-2 – Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions – Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	*LS2.A: Interdependent Relationships in Ecosystems* - Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	*Patterns* – Patterns can be used to identify cause and effect relationships.

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	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	5.1.8.B.3

Active Investigations	arguments.	
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: Matter and Energy Transformations	All animals, including humans, are consumers that meet their energy needs by eating other organisms or their products.	5.3.6.B.2, 5.3.8.B.2
Earth Systems Science: Biogeochemical Cycles	An ecosystem includes all of the plant and animal populations and nonliving resources in a given area. Organisms interact with each other and with other components of an ecosystem.	5.4.6.G.2

New York Science Learning Standards (Middle School)

Standard Area	Key Idea	KI#
Standard 1: Analysis, Inquiry, and Design (Mathematical Analysis)	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
	Interpret the organized data to answer the research question or hypothesis and to gain insight into the problem.	S3.2
	Modify their personal understanding of phenomena based on evaluation of their hypothesis.	S3.3
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 (Optimization)	Determine the criteria and constraints and make trade-offs to determine the best decision.	6.1
	Use graphs of information for a decision-making problem to determine the optimum solution.	6.2