Can you BREATHE like a Pinniped?

TEACHER

Activity Overview

Pinnipeds such as California sea lions and northern elephant seals, are marine mammals that spend a great deal of time in the water. Like all marine mammals, pinnipeds breathe air through their lungs. In order to breathe, they must come up to the surface for air.

Pinnipeds are excellent divers. They have adapted to dive deep and stay under water for long periods of time. Some dives have been recorded as deep as 1,500 meters. That's nearly a mile. They have been recorded to stay under water for as long as 90 minutes without coming up for air. Because of this and other adaptations, they can find and eat species such as red crab and market squid that live deep beneath the ocean surface.

In this activity, students compare their breathing pattern to the breathing patterns of California sea lions and northern elephant seals. First, they examine diving graphs of pinnipeds that show how deep they dive and how long they can stay underwater. Next, they use a respiration monitor belt and gas pressure sensor connected to a TI CBL 2™ or Vernier LabPro and a TI-73 Explorer™ and simulate the pinniped's breathing pattern — that is, exhale, hold as long as possible, take in a deep breath, exhale, hold as long as possible, and so on.

Conclusion: As students compare the data, they observe that they cannot keep an even breathing pattern like the pinnipeds. Pinnipeds breathe air, but can stop breathing to conserve energy when diving underwater in pursuit of food. As pinnipeds dive, they expel air from their lungs, "shut down" the oxygen supply to outer parts of their body (most goes to the brain), and slow down their heart rate.

Activity at a Glance

Grade:	5-9
Subject:	Science
Category:	Life Science
Topic:	Living Things, Animals, Human Body Systems

Time Required

- One 45-minute period

Level of Complexity

- Medium

Materials*

- TI-73 Explorer™
- TI CBL 2™ or Vernier LabPro
- TI-73 DataMate
- Respiration monitor belt
- Gas pressure sensor
- Diving graphs of pinnipeds

TI-73 Explorer™

* This activity has been written for the TI-73 Explorer™ but you can easily substitute the TI-83 or TI-83 Plus. Also see Appendix A for steps on how to transfer DataMate to your graphing device and how to use DataMate for data collection.

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Adapted from "Experiment 26 — Monitoring Human Respiration," *Biology with Calculators*, written by Holman, Scott and Masterman, David, published by **Vernier Software & Technology**, 2000.

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Concept Background

- Northern elephant seals spend 90% of their lives in the water to feed. They dive into the water repeatedly and continuously, never stopping to rest or sleep for months at a time.
- Northern elephant seals can stay underwater for up to 90 minutes. California sea lions can stay underwater for three to eight minutes.
- The human record for breath-holding is over seven minutes!
- Pinnipeds don't inhale and hold their breath when diving. They expel most of the air from their lungs to protect them from the enormous pressure during deep dives.
- Pinnipeds slow their breathing and heart rate while diving. Their heart rate can drop to 10 beats per minute or even less. This conserves energy and helps them go for long periods of time underwater.

F elt

Gas Pressure Monitor

Preparation and Classroom Management Tips

- Make sure the respiration belt is a snug fit around the lower part of the student's rib cage.
- Monitor student use of the respiration belt. Make sure students inhale as deep a breath as they exhale to prevent hyperventilation. *Note: You may want to contact the school nurse prior to performing this activity to discuss the symptoms of hyperventilation and what to do if a student should hyperventilate.*
- In Part B, Procedure, Step 6 the student tests the respiration monitor belt and the gas pressure sensor by taking some initial readings. As the student breathes in and out normally, the reading on the TI-73 Explorer™ display should be between 2–3 BPMs (breaths per minute). If the range is less than 1 BPM, pump more air into the bladder.
- In Part B, Procedure, Step 7c a graph is displayed that shows the student's breathing pattern. The X-axis represents time in seconds and the Y-axis represents respiration rate in breaths per minute.
- Encourage students wearing the belt to describe their "breathing" experience to their classmates.
- Students may need help in estimating values from the Pinniped Diving Graphs to answer questions in the Data Analysis section.
- The activities *How Does Blubber Work?, Can You Breathe Like a Pinniped?, and Pinniped Body Shape – Does It Conserve Warmth?*, explore pinniped adaptations. These activities can be set up as stations in your classroom simultaneously. Have students rotate between stations to complete each activity.
- This activity works well with students working in groups, or as a demonstration.
- Encourage students to answer the questions in Data Analysis in their journal.
- Create your own student questions for use on your students' TI graphing devices using the Texas Instruments StudyCard applications.

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Part A. Diving Graphs of Pinnipeds

Data Analysis

1 Q. According to the graph, the northern elephant seal started a dive between 4:10 and 4:15 A.M. For how many minutes did the seal remain underwater during the dive?

A. *The dive of the northern elephant seal was about 15 minutes.*

2 Q. About how long did the northern elephant seal stay on the surface after that dive?

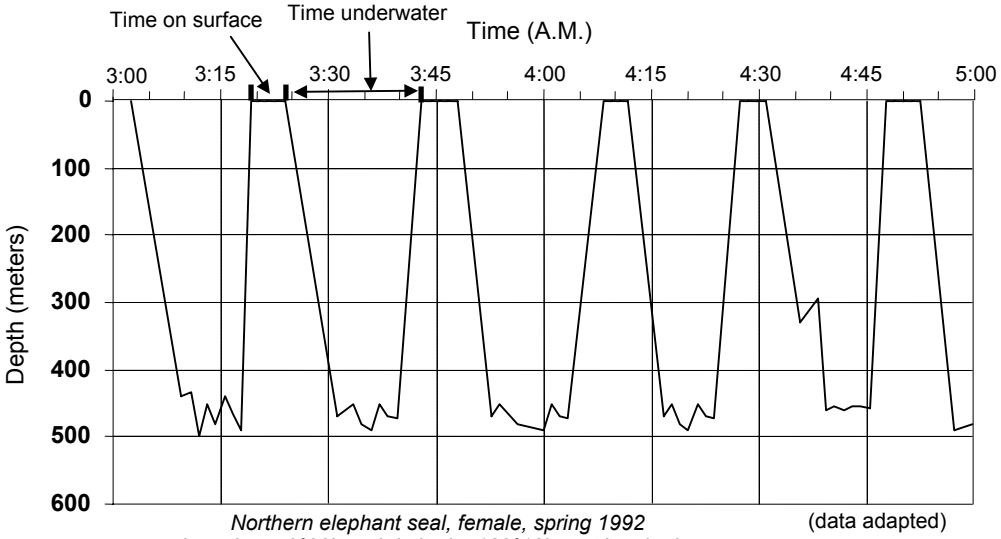
A. *The northern elephant seal stayed on the surface about 5 minutes after the dive.*

3 Q. How far below the surface did the northern elephant seal go during the dive?

A. *The depth of the dive was about 490 meters.*

4 Q. Before each dive the northern elephant seal will take in a new breath of air, how many new breaths of air did the northern elephant seal take between 3:00 am and 4:00 A.M.? How many breaths did the seal take between 4:00 am and 5:00 A.M.?

A. *The northern elephant seal took 3 breaths between 3:00 and 4:00 A.M. The seal took 3 breaths between 4:00 and 5:00 A.M.*



Northern elephant seal, female, spring 1992 (data adapted)
Location: 43°30' north latitude, 129°12' west longitude
Date: April 11, 1992

National Education Standards

Science Standard A: Science As Inquiry

Students should understand scientific inquiry and develop abilities necessary to perform it.

Science Standard C: Life Science

Students should develop an understanding about the structure and function of living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and the diversity and adaptations of organisms.

Math Standard: Data Analysis & Probability

Students should develop an understanding about how to collect, organize, display, and interpret data.

Math Standard: Measurement

Students should develop an understanding of different units of measure, be able to convert among systems, and become proficient in selecting the appropriate size and type of measure for a given situation.

English Language Arts Standard 3

Students should apply strategy to comprehend, interpret, evaluate, and appreciate text.

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5 Q. The graph shows that the California sea lion started a dive at 4:15 A.M. For how many minutes did the sea lion remain underwater during the dive?

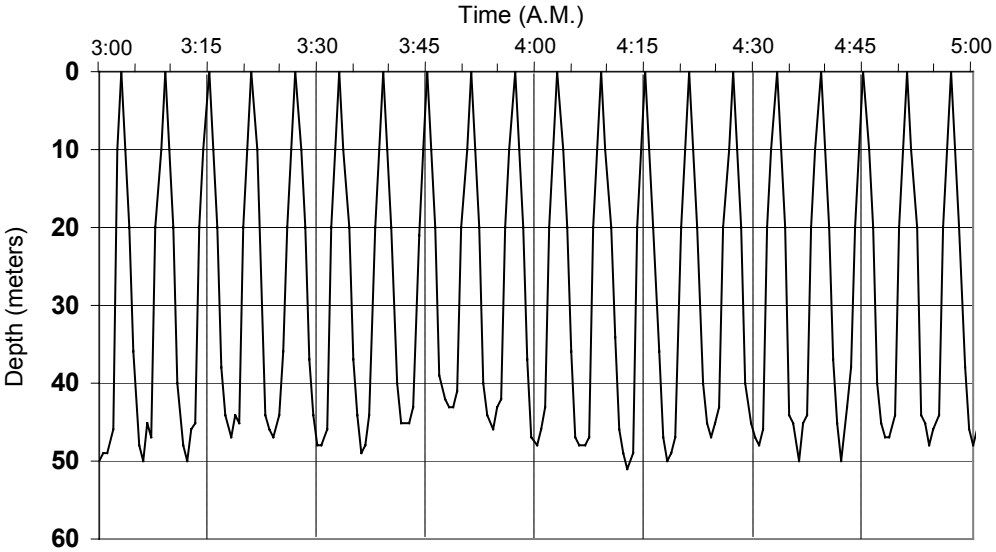
A. *The dive of the California sea lion was about 5 minutes.*

6 Q. How far below the surface did the California sea lion go during the dive?

A. *The depth of the dive was about 50 meters.*

7 Q. How many new breaths of air did the sea lion take between 3:00 am and 4:00 A.M.? How many breaths did the seal lion take between 4:00 am and 5:00 A.M.?

A. *The California sea lion took about 10 breaths between 3:00 A.M. and 4:00 A.M. The sea lion took 10 breaths between 4:00 and 5:00 A.M.*



California sea lion, female, winter 1992 (data adapted)
Location: 34°12'30'' north latitude, 119°44'17'' west longitude
Date: January 31, 1992

8 Q. Why do you think northern elephant seals can dive deeper than California sea lions?

A. *Northern elephant seals can dive deeper than California sea lions because they have adapted to stay underwater longer. Northern elephant seals breathe in large amounts of oxygen, and when they dive they slow down their heart rates to conserve energy. In addition, northern elephant seals are faster swimmers.*

Vocabulary

Adaptation A physical feature or ability, developed over many generations, that helps a species survive in its environment.

Carnivore A flesh-eating animal.

Double migration Two annual round trips made by the northern elephant seal between its feeding grounds in the North Pacific and the Channel Islands.

Molt To shed the skin, fur, or feathers periodically. Northern elephant seals are said to do "radical molting" because their skin comes off in sheets.

Otariid Any of approximately 14 species of pinnipeds, including the California sea lion, that have outer ear flaps and hind flippers that can be rotated underneath the body.

Phocid Any of approximately 19 species of pinnipeds known as "true seals," including the northern elephant seal. Phocids do not have extended earflaps. They do not use their flippers for moving on land. Instead they wriggle from side to side or hunch their bodies like caterpillars.

Pinniped A walrus, sea lion, or seal.

Taxonomy The science of classification and categorization of living things. Linnean taxonomy categorizes all plants and animals into the following seven subgroupings, each more specific than the one before: kingdom, phylum, class, order, family, genus, species.

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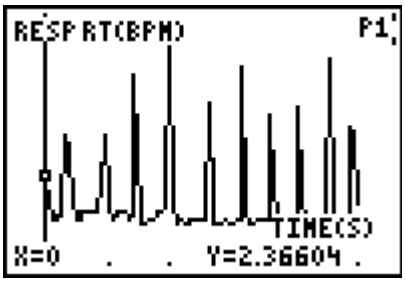
Part B. Simulate a Pinniped's Breathing

Data Analysis



Sample student respiration graph.

1 Q. Copy Table 1 into your journal. Observe your graph and choose a typical valley. What was the time in seconds when you started holding your breath? Record the time, X1, in the table. (Hint: Use the arrow keys to move the cursor at the beginning of the valley and read the time, (x) value.)

A. *Answers will vary.*

2 Q. What was the time when you stopped holding your breath? Record the time, X2, in the table.

A. *Answers will vary.*

3 Q. How long did you hold your breath after exhaling? Record the value, X2-X1, in the table.

A. *Answers will vary.*

4 Q. How does the time holding your breath after exhaling compare to the pinnipeds' time underwater without taking a breath? (Hint: Look at your answers in Part A, Q1 and Q4.)

A. *Pinnipeds can stay underwater without taking a breath much longer than humans can hold their breath after exhaling.*

5 Q. How often did you take in a new breath of air? (Hint: Observe the graph and estimate the number of peaks during your three-minute experiment.)

A. *Answers will vary.*

6 Q. How does the number of breaths you took compare with the pinnipeds? (Hint: Look at your answers in Part A, Q3 and Q6.)

A. *Pinnipeds can stay under water without taking a breath much longer than humans can hold their breath after exhaling. Therefore, humans take a greater number of breaths during the same time.*

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7 Q. How is your breathing pattern different from that of pinnipeds?

A. *Students will find that the length of time they can hold their breath decreases with each successive inhale. The diving graphs show that pinnipeds expel air and then hold their breaths for extended periods of time steadily.*

8 Q. What would happen if pinnipeds could not dive so long between breathing cycles?

A. *Much of the pinnipeds' food is in deep waters. If they needed to surface for air more frequently, they would not have enough time to dive to their prey's location.*

9 Q. Some animals hibernate to survive the winter with little or no food. How do such animals control the way their bodies work?

A. *During hibernation the body temperature of the animal drops. Its heartbeat and respiration slow down so that it does not use much energy. This way, animals can survive the winter with little or no food.*

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