Can you BREATHE like a Pinniped?

How are pinnipeds adapted to staying underwater for long periods of time?

ACTIVITY

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, you will compare your breathing pattern to the breathing patterns of California sea lions and northern elephant seals. First, you will examine diving graphs of pinnipeds that show how deep they dive and how long they can stay underwater. Next, you will 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 repeat the pattern over and over.

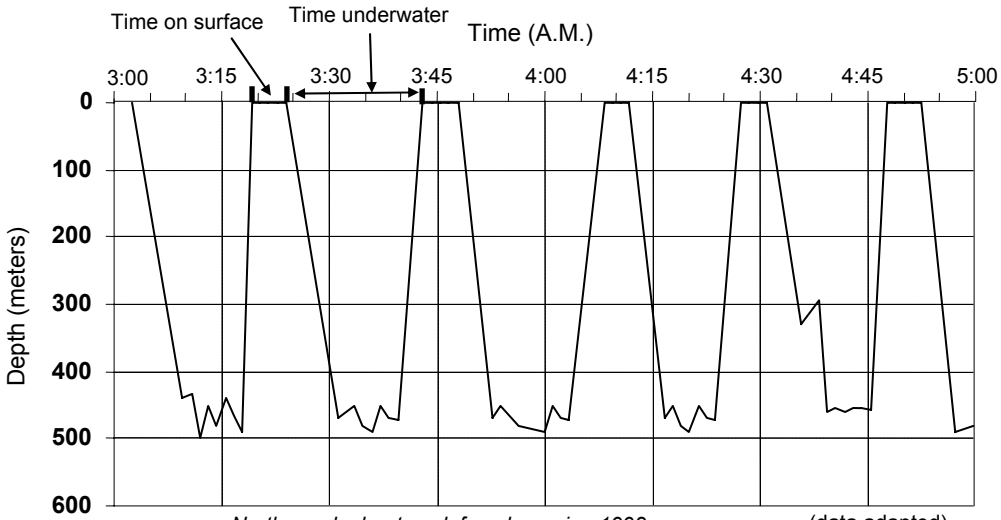
How long can you go without taking a breath? Can you maintain a breathing pattern like the pinnipeds? What do you think would happen if the sea lions and elephant seals could not control the way their bodies worked to conserve energy when diving for long periods of time underwater?

Can you BREATHE like a Pinniped?

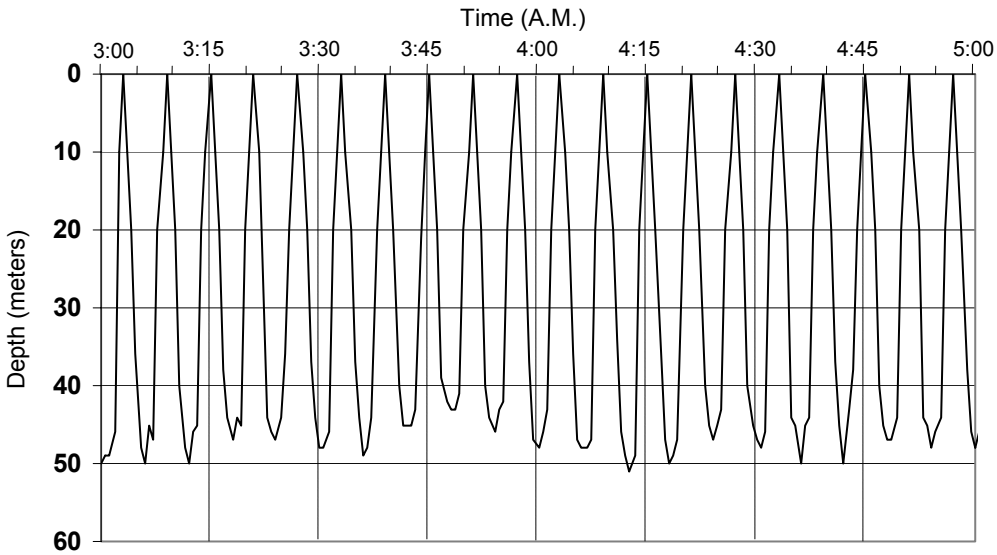
Part A. Diving Graphs of Pinnipeds

Procedure

1 Study the diving graphs of a northern elephant seal and a California sea lion shown below. Each graph shows the diving depth over a period of two hours.



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



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

2 Complete the Data Analysis section. Answer the questions in your journal.

ACTIVITY

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™

Respiration Monitor Belt

Gas Pressure Sensor

* 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.

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

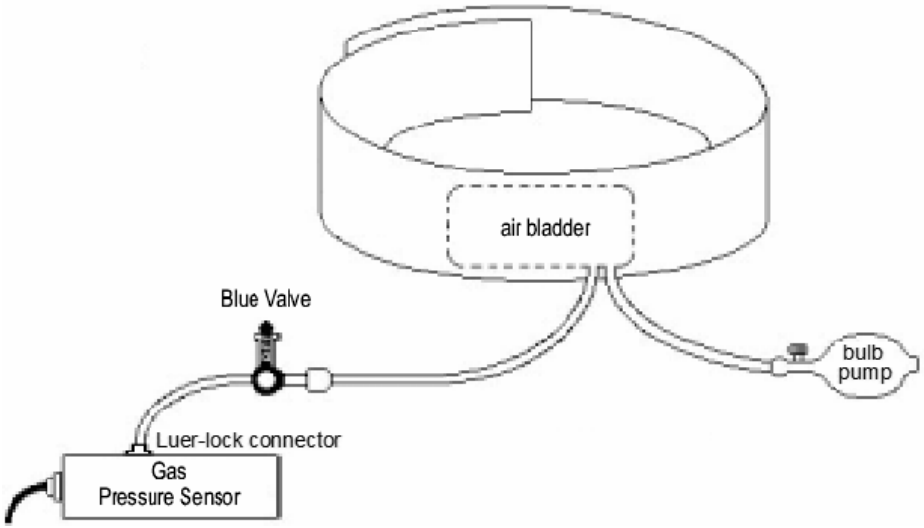
Data Analysis

1. 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?
2. About how long did the northern elephant seal stay on the surface after that dive?
3. How far below the surface did the northern elephant seal go during the dive?
4. 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.?
5. 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?
6. How far below the surface did the California sea lion go during the dive?
7. 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.?
8. Why do you think northern elephant seals can dive deeper than California sea lions?

Part B. Simulate a Pinniped's Breathing

Procedure

1. **Connect the respiration monitor belt to the gas pressure sensor.**
   a. There are two rubber tubes connected to the air bladder. Find the tube that has a white Luer-lock connector at the end (the other tube has a bulb pump attached).



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

b. Connect the Luer-lock connector to the stem on the gas pressure sensor with a gentle half turn. Note: If your gas pressure sensor has a blue plastic valve on it, place the valve in the position shown on the previous page.
c. Close the shut-off screw of the bulb pump by turning it clockwise as far as it will go.

2 **Connect the gas pressure sensor to the CBL 2™ or Vernier LabPro and TI-73 Explorer™.**

a. Plug the gas pressure sensor into channel 1 of the CBL 2™ or Vernier LabPro.
b. Use the link cable to connect the TI-73 Explorer™ to the interface.
c. Firmly press in the cable ends.

3 **Set up the TI-73 Explorer™.** (See Appendix A for more information on equipment setup.)

a. Turn on the TI-73 Explorer™ and start DATAMATE. (For instructions on DATAMATE see Appendix A.)
b. Press [CLEAR] to reset the program.
c. Select SETUP from the MAIN SCREEN by pressing [1].
d. Press [ENTER] to select CH1.
e. Select RESPIRATION from the SELECT SENSOR MENU. (Note: You may need to select MORE to see more sensors listed.)

4 **Set up the TI-73 Explorer™ for data collection.**

a. Use [▲] and [▼] to select MODE and press [ENTER].
b. Press [2] to select TIME GRAPH from the SELECT MODE MENU.
c. Press [2] to select CHANGE TIME SETTINGS from the GRAPH SETTINGS MENU.
d. Enter 2 as the time between samples in seconds, and press [ENTER].
e. Enter 90 as the number of samples, and press [ENTER]. Data will be collected for 180 seconds (3 minutes).
f. Select OK to return to the SETUP SCREEN by pressing [1].
g. Select OK to return to the MAIN SCREEN by pressing [1].

5 Wrap the respiration monitor belt tightly around the lower part of your rib cage. Position the belt so the air bladder is resting over your diaphragm.

6 Pinnipeds don't inhale and hold their breath when diving. They expel most of the air from their lungs and then hold their breath. Practice breathing like a pinniped: exhale, hold as long as possible, take in a deep breath, exhale, hold as long as possible, and repeat this pattern over and over.

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7 **Collect your respiration data.**

a. Select START on the TI-73 Explorer™ by pressing [2].
b. Begin your "pinniped breathing" for three minutes: exhale, hold as long as possible, take in a deep breath, exhale, hold as long as possible, and repeat this pattern over and over. Data collection will stop automatically.
c. At the end of the three minutes a graph is displayed representing your breathing pattern. (Note: If you do not see the graph right away press [3] to RESCALE and then press [1] to AUTOSCALE.)

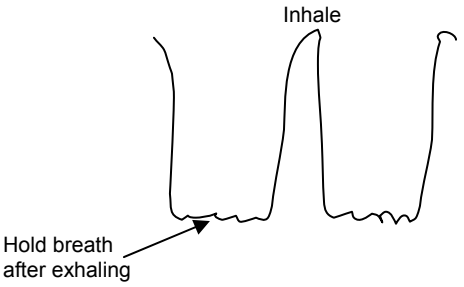
8 Complete the Data Analysis section. Answer the questions in your journal.

↺ *To repeat the experiment, press [ENTER] on the TI-73 Explorer™ and follow step 7 above.*

Data Analysis

Use the left and right arrow keys ([◄], [►]) to move the cursor along the curve to answer questions 1 and 2. The time in seconds (x value) of each data point is displayed below the graph.

Your graph displays your breathing pattern. When you exhale, and hold your breath, the graph shows a valley. When you inhale, the graph shows a peak. See diagram below.



1 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 to the beginning of the valley and read the time (x value).)

Table 1

X1 Time when started holding breath after exhaling (s)	X2 Time when stopped holding breath (s)	X2-X1 Time holding breath (s)

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

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

4 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.)

5 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.)

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

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

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

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

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