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EDUCATOR GUIDE

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Whale's Breathtaking Dive Impresses

SOCIETY FOR SCIENCE & THE PUBLIC

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About this Guide

In this Guide, based on the online *Science News* article "A beaked whale's nearly 4-hour-long dive sets a new record," students will learn about the extraordinary diving ability of the Cuvier's beaked whale and what scientists think allows the marine mammal to stay underwater for extended periods. Then, students will discuss the ocean zone model and research the environment and species of a specific ocean zone.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "A beaked whale's nearly 4-hour-long dive sets a new record," which describes a new record for longest dive by a marine mammal, set by the Cuvier's beaked whale. A version of the story, "Whale's breathtaking dive impresses," can be found in the November 7, 2020 issue of *Science News*. Related standards include NGSS-DCI: HS-LS1; HS-ESS2.

> **Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will explore how the ocean environment changes with depth and how various organisms' physical traits allow the organisms to thrive at different depths. Students then will discuss the benefits and limitations of the ocean zone model. Related standards include NGSS-DCI: HS-ESS2.

> **Student Discussion Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: After your students read the online *Science News* article "A beaked whale's nearly 4-hour-long dive sets a new record," ask them to answer the following questions. A version of the story, "Whale's breathtaking dive impresses," can be found in the November 7, 2020 issue of *Science News*.

1. Why are Cuvier's beaked whales considered master divers?

The whales hold records for deepest and longest dives by a marine mammal.

2. How long did the beaked whale highlighted in the story's headline stay underwater without coming up for air? How does that new record compare with a 2014 dive made by another Cuvier's beaked whale?

The whale spent 222 minutes, or 3 hours and 42 minutes, underwater. That is more than 80 minutes longer than the previous record-holder spent underwater.

3. What is anaerobic respiration?

Anaerobic respiration is a way cells generate energy without oxygen.

4. What do scientists think enables Cuvier's beaked whales to stay underwater for such long periods of time? Explain.

Large stores of oxygen and a slow metabolism may help the whales dive for extended periods of time. The mammals even switch to anaerobic respiration when their oxygen runs out. The whales may have the ability to tolerate lactic acid building up in their bodies over time — a consequence of anaerobic respiration.

5. How long did scientists estimate the whales could dive before running out of oxygen? What data did they use to come up with this estimate?

About 30 minutes. They calculated the estimate based on data from seals.

6. How many whale dives did Nicola Quick and her team analyze? How long did the dives last?

The researchers analyzed 3,680 dives. Most dives lasted about an hour, but 5 percent lasted more than about 78 minutes.

7. What do the findings suggest about the whales?

It takes twice as long as thought for the whales to run out of oxygen and switch to anaerobic respiration.

8. What did researchers expect to find about the whales' surface recovery time after a long dive?

The scientists expected to find that the whales spend more time at the ocean surface to recover from long dives.

9. What are two additional research questions related to this study that could be investigated?

What is the average surface recovery time after long dives? How does that time relate to average recovery time after short dives? How do beaked whales process lactic acid? Why can whales dive for longer periods of time than seals?

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Student Comprehension Worksheet

Directions: Read the online *Science News* article "A beaked whale's nearly 4-hour-long dive sets a new record," then answer the following questions. A version of the story, "Whale's breathtaking dive impresses," can be found in the November 7, 2020 issue of *Science News*.

1. Why are Cuvier's beaked whales considered master divers?

2. How long did the beaked whale highlighted in the story's headline stay underwater without coming up for air? How does that new record compare with a 2014 dive made by another Cuvier's beaked whale?

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Cross-curricular Discussion, Q&A

Directions for teachers:

Ask students to read the online *Science News* article "A beaked whale's nearly four-hour-long dive sets a new record." As a class, discuss the first set of questions to get students thinking about how ocean conditions vary with depth. Then, divide students into groups. Assign each group one of four common ocean zones to research and answer questions about. The zones, located in the open ocean beyond the edge of the continental shelf, are epipelagic (sunlight), mesopelagic (twilight), bathypelagic (midnight) and abyssopelagic (abyss).

Each group should be prepared to present their answers to the class and contribute to a class ocean zone diagram. One member of the group will add to the class's ocean zone diagram while other group members are presenting. Finally, as a class, discuss the last prompt about the ocean zone model's purpose and its limitations. The MarineBio Conservation Society site provides relevant reference materials.

Want to make it a virtual lesson? Post the online *Science News* article "A beaked whale's nearly four-hour-long dive sets a new record" to your virtual classroom. Discuss the article and questions with your class on your virtual platform. Draw the ocean zone diagram together on Google Draw or another virtual drawing platform.

Changing conditions

1. As a beaked whale descends from the ocean's surface to as far down as 3,000 meters, what ocean conditions vary depending on the whale's depth?

Temperature, amount of light, water pressure, oxygen and nutrient levels.

2. How do the conditions change as depth increases? Use scientific concepts you've learned to explain why the changes occur.

Student answers will vary based on their background knowledge, but they should include reasoning for the decrease in sunlight, temperature and dissolved oxygen. Students should also explain that hydrostatic pressure, or the force per unit area exerted by the water, will increase with depth. Nutrients, such as nitrogen and phosphorus, are found in abundance near the ocean floor as dead organisms decompose there. Nutrients can also be found in shallow waters from coastal pollution and runoff or from weather patterns that cause deep water to rise to the surface.

3. What characteristics might marine mammals, such as beaked whales, need to survive traveling between in these changing conditions?

In addition to being able to store large amounts of oxygen, whales and other marine mammals need to tolerate dramatic temperature and pressure changes. For instance, when whales dive deep, their lungs collapse so the organs aren't crushed under intense pressure. The animals' blubber keeps them well-insulated from temperature changes.

4. What are some of the benefits to an ability to travel to significantly different ocean depths?

Animals that are able to travel to different ocean depths likely have access to a greater variety of food sources. Such animals also have a higher probability of finding their next food source than they would if their depth range was narrower.

5. What is the ocean zone model? Why do you think scientists find this model useful? Explain.

The ocean zone model breaks up the ocean into layers based on depth. Scientists use this model as a way to classify ocean environments at different depth ranges. As the ocean gets deeper, light, temperature and dissolved oxygen decrease while pressure and nutrients increase. Organisms that inhabit the various zones likely have unique characteristics that allow them to thrive in a particular zone. Organisms that can travel among zones likely have physical traits that allow them to adapt to changing conditions.

Exploring the ocean zone model

In your group, discuss and answer the following questions about your assigned zone. Use additional resources as necessary, and make sure to cite your sources. Be prepared to present your answers to the class. Assign one member of your group to add your zone to the class's ocean zone diagram while the other group members present.

1. Briefly describe the depth range and conditions — sunlight, nutrients, temperature, pressure and dissolved oxygen — in your assigned ocean zone.

Epipelagic (surface – 200 meters): Lots of sunlight allowing for photosynthesis to occur, low nutrient levels due to consumption by primary producers such as plankton and algae, warmest zone, low water pressure, high levels of dissolved oxygen
Mesopelagic (200 – 1,000 m): Minimal sunlight that cannot support photosynthesis, limited nutrients, increased pressure, decreased temperature and dissolved oxygen compared with the zone above
Bathypelagic (1,000 – 4,000 m): No sunlight, minimal nutrients, increased pressure, decreased temperature and dissolved oxygen compared with the zone above
Abyssopelagic (4,000 m – ocean floor): No sunlight, high in nutrients, highest pressure, near-freezing temperatures and low in dissolved oxygen compared with the zone above

2. Name at least three organisms that live at least part time in your zone. Provide details on their diet, physical features and behavior.

Possible answers for types of organisms could include, but are not limited to the following:
Epipelagic: Tuna, dolphins, orcas, blue whales, sharks, jellyfish, sea turtles, oysters
Mesopelagic: Cuttlefish, viperfish, hatchet fish, swordfish, big scale fish, firefly squid
Bathypelagic: Sea stars, octopuses, anglerfish, vampire squid
Abyssopelagic: Deep-sea squid, sea spiders, echinoderms, medusas, basket stars, sea pigs, seaspiders

An example of the diet, physical features and behavior of an organism from each zone is provided below:
Epipelagic: A tuna consumes fish, squid, shellfish and plankton. Because tunas can grow to very large sizes, they consume large quantities of prey. The fish have special muscles, fins and scales that make them efficient swimmers. They travel long distances across oceans to spawn.
Mesopelagic: Viperfish eat crustaceans and small fish. Viperfish have light-producing organs that are used to attract prey and teeth that are so long that the fish can't close their jaws. They also have very large stomachs.
Bathypelagic: Vampire squid are not predatory animals. Instead, they consume plant and animal matter that sinks from higher zones. Vampire squid have eight arms and two long tentacles with sticky cells that help them capture food. To startle and escape would-be predators, they expel bioluminescent material.
Abyssopelagic: Giant squid eat fish and other squid. Their eyes are about 30 centimeters (1 foot) wide and they have long sucker-covered tentacles that they can extend long distances.

3. Choose one of the characteristics from each organism in question No. 2. Use what you know about the conditions in your zone to explain why the organism might have this characteristic. Why is that characteristic beneficial to that zone?

Student answers will vary. One example answer per zone is provided below. Generally, answers should refer back to environmental conditions covered in the answer to question No. 1 and animal characteristics listed in the answer to question No. 2.
Epipelagic: Tuna eat large quantities of fish and plankton. It makes sense that tuna primarily stay in this zone, which has the highest abundance of fish and can support the growth of plankton through photosynthesis.
Mesopelagic: The viperfish has a very large stomach. Crustaceans and small fish are less prevalent in this zone so the viperfish's large stomach allows it to fill up when the opportunity arises.
Bathypelagic: Vampire squid expel bioluminescent material to escape from predators. Because this zone is so dark, the expelled light likely confuses predators.
Abyssopelagic: Giant squid have enormous eyes that allow them to absorb as much light as possible. This allows the squid to see prey in the extreme darkness of this zone.

Summarizing the model's purpose

As a class, discuss the benefits and limitations to this scientific model of ocean zones. Are there variations in the model based on the resources you used? Explain why this might be. What are reasons why a scientific model might change over time?

The ocean zone model allows for generalizations to be made about environmental conditions based on ocean depth and is helpful for understanding and predicting how ecosystems might change as temperature, nutrients, species and other factors fluctuate. Certain aspects of the model, such as the exact depth range of a particular zone or the number and names of zones vary with reference resources. Models attempt to represent natural phenomena but are human inventions that generally tend to be oversimplified, and the simplifications can vary. As new information and technology become available to test the validity of a scientific model, the model is often adjusted over time.

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Student Discussion Worksheet

Directions: After reading the online *Science News* article "A beaked whale's nearly four-hour-long dive sets a new record," answer the first set of questions with your class. Your teacher will then assign you to a group to answer the remaining questions.

Changing conditions

1. As a beaked whale descends from the ocean's surface to as far down as 3,000 meters, what ocean conditions vary depending on the whale's depth?

2. How do the conditions change as depth increases? Use scientific concepts you've learned to explain why the changes occur.

3. What characteristics might marine mammals, such as beaked whales, need to survive traveling between in these changing conditions?

4. What are some of the benefits to an ability to travel to significantly different ocean depths?

5. What is the ocean zone model? Why do you think scientists find this model useful? Explain.

Exploring the ocean zone model

In your group, discuss and answer the following questions about your assigned zone. Use additional resources as necessary, and make sure to cite your sources. Be prepared to present your answers to the class. Assign one member of your group to add your zone to the class's ocean zone diagram while the other group members present.

1. Briefly describe the depth range and conditions — sunlight, nutrients, temperature, pressure and dissolved oxygen — in your assigned ocean zone.

2. Name at least three organisms that live at least part-time in your zone. Provide details on their diet, physical features and behavior.

3. Choose one of the characteristics from each organism in question No. 2. Use what you know of about the conditions in your zone to explain why the organism might have this characteristic. Why is that characteristic beneficial to that zone?

Summarizing the model's purpose

As a class, discuss the benefits and limitations to this scientific model of ocean zones. Are there variations in the model based on the resources you used? Explain why this might be. What are reasons why a scientific model might change over time?