DOLPHIN RESEARCH CENTER
Acoustics

Grade Level: 6th-8th

Objectives: Students will be able to explain how dolphins use sound to communicate and navigate through their underwater environment.

Florida Sunshine State Standards:
SC.B.1.3.6 The student knows the properties of waves (e.g. frequency, wavelength, and amplitude); that each wave consists of a number of crests and troughs; and the effects of different media on waves.
SC.G.1.3.2 The student knows that biological adaptations include changes in structures, behaviors, or physiology that enhance reproductive success in a particular environment.

National Standards:
Content Standard C (5-8) – Diversity and Adaptations of Organisms: Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

Background: Acoustics is the study of sound. Vibrating objects create sound waves. Sound waves are mechanical waves, which means that they require a medium in order to transport energy from one place to another. A medium is simply a material through which the wave travels. Air and water are two mediums through which sound commonly travels. Sound waves are longitudinal in nature. Longitudinal waves are waves in which the energy travels in a direction parallel to the medium. To understand this, envision a Slinky© toy stretched across a desk. If you hold one end of the Slinky© and begin vibrating it, you will see a wave begin to travel through the toy. The energy from your hand travels horizontally across the Slinky©, and the coils of the Slinky© themselves travel horizontally as well.

Key Terms

Acoustics: The study of sound.
Echolocation: A sensory system in certain animals in which usually high-pitched sounds are emitted and their echoes interpreted to determine information about objects, including size, distance, and direction.
Wave: A disturbance or variation that travels through a medium.
Medium: A material through which a wave travels.
Frequency: The number of cycles in a given unit of time.

Variations in sounds are produced by different frequencies of waves. Frequency refers to the number of cycles in a given unit of time. Frequency is often measured in cycles per second, referred to as Hertz (Hz). The more cycles per second, the higher the frequency. The

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human ear can detect sounds ranging from 20 to 20,000 Hz. Dolphins are capable of hearing a much wider range of frequencies— 2 to 200,000 Hz.

Dolphins make a variety of sounds. In fact, sound is probably one of their most important senses. Water is 800 times denser than air. Because water is a much denser medium, sound travels about 4.5 times faster in water than in air. Although dolphins have excellent eyesight above and below the water, it can still be difficult for them to see in dark and murky conditions. As a result, sound has become very important in this environment. One very important type of sound produced by dolphins is echolocation. Echolocation is a form of biological sonar. Dolphins emit clicks from their forehead area, called a melon. These clicks travel out into the underwater environment and bounce off objects. The returning sound waves (or echoes) are received by the dolphin's lower jaw. From the lower jaw, the information travels to the inner ear and then to the brain. The dolphin can form an image of its underwater environment. It can tell the shape, size, density, speed, and direction of something as far away as 300 feet. As a result, dolphins rely heavily on sound to "see".

Dolphins also produce many different types of whistles. There is still a lot to be learned about these whistles. It seems as though each dolphin has a unique whistle known as a signature whistle. These whistles may be used for communication purposes. Also, dolphins and whales make a variety of other sounds including clicks, grunts, and moans. Researchers are trying to better understand these sounds. Each species has its own unique sounds that are produced; some species even seem to have different dialects. The humpback whales in the Caribbean sound much different than the Hawaiian humpbacks.

Wild dolphins mainly make sounds underwater, although they will emit high-pitched whistles into the air when in distress. The dolphins at Dolphin Research Center, on the other hand, have developed quite a repertoire of sounds produced in the air. These sounds, such as "giggle" and "raspberry," were invented by the dolphins and encouraged by the staff. The dolphins often make up new sounds that are mimicked by their pool mates and passed around the facility. The dolphins apparently vocalize these sounds to get people's attention as they walk by the lagoons. It works very well; there is no way you can walk past a "screaming" dolphin and not reply in some fashion! Learn more about dolphins and sound in the ***Acoustics*** information file and diagrams. Use the resources listed at the end of this lesson to learn more about noise pollution.

Materials:

For the class:

- CD player
- Dolphin Research Center's Curriculum CD-ROM
- Slinky
- Golf ball
- Ping-pong ball

For each student:

- Balloon
- ***Acoustics Diagram*** handouts

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Teacher Prep Notes: Set up a CD player so the class can hear the various dolphin sounds. Prepare copies of the ***Acoustics Diagram*** for each student, and assemble the remaining materials for the lesson.

Procedures:

1. Ask the students to list some sounds they hear around them on a daily basis. (Examples include cars, radios, conversations, construction equipment, dogs barking, etc.)
2. Now ask about the underwater world—is the ocean a quiet place? Students may have a variety of responses.
3. The noted French oceanographer and researcher Jacques Cousteau once described the ocean as a quiet place. However, there are LOTS of different sounds under the water.
4. Play the "Ambient Noise" sound recording from the lagoons at Dolphin Research Center. The popping sound is a type of shrimp known as popcorn shrimp. This sound is also very similar to the sound made by parrotfish as they eat coral. The buzzing sound is dolphin echolocation. Dolphin whistles may also be heard. These are just some of the sounds heard in the underwater world—it is often a very noisy place!
5. Explain that "acoustics" refers to the study of sound.
6. Discuss sound and how it travels. Familiarize students with the terms "wave", "medium", and "frequency". Use the Slinky© to demonstrate how sound waves travel longitudinally through a medium.
7. State that water is 800 times denser than air. Based on this information (and the information students already know about sound), ask the students to hypothesize whether sound will travel faster in air or water.
8. Explain that sound travels much faster in water than air (approximately 4.5 times faster). The particles in water are closer together than those in the air. This means that the particles push against one another more easily and the sound travels faster. Since sound travels so well in water, it makes sense that sound would be an important factor in the functioning of many underwater organisms. Explain to students that the remainder of this lesson will focus on the ways that dolphins use and produce sounds.
9. Distribute the ***Acoustics*** diagram to the students. The diagram works well as a visual reference during the explanation of sound production.
10. The dolphins at Dolphin Research Center produce lots of sounds above water. They are able to use these sounds to get the attention of their human friends. (Wild dolphins will not usually produce sounds above water.) Play the recordings of above-water sounds. Ask students how they think the dolphins produce these sounds.
11. Many students will probably suggest that the dolphins produce these sounds with vocal chords, just like humans. However, dolphin sounds are all produced in and around the blowhole. To produce sounds above water, dolphins will let air escape from the blowhole. The opening of the blowhole is manipulated as the air escapes, allowing the dolphins to produce a large range of sounds.

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12. Students can experience this on their own using a balloon. Distribute a balloon to each student. Have each student blow up a balloon and hold the end of the balloon closed. (Do not tie it closed!) Have students stretch the opening of the balloon while letting air escape. As students manipulate the opening, different sounds will be produced.
13. Sound production underneath the water is slightly different. Ask students why dolphins may not want to manipulate the opening of their blowhole underwater to produce sounds. (This would put the dolphin at a risk of inhaling water into the lungs.) Instead, dolphins will manipulate the air sacs just below the blowhole. There are a few theories as to how exactly dolphins use these air sacs, but they are known to play a role in underwater sound production.
14. Tell students that you will give them an opportunity to hear one type of underwater sound. Play the recordings of echolocation for the class and ask if any students can identify the sound or explain its purpose.
15. Explain how dolphins use sound waves to create mental images of their environment. Have students refer to their diagrams as you explain the process. (You can point out that ultrasound machines work in a way that is similar to echolocation—sound waves are sent out and the information received from the echoes is used to create an image on a computer screen.) Echolocation is very detailed, and can even allow dolphins to differentiate between very small objects at a distance of 300 feet!
16. Take students outside to a football field or playground to see just how amazing this truly is. Direct students to stand together in a group. Place a ping-pong ball and a golf ball side-by-side on the ground in a location that is 300 feet (100 yards) away from the students. Ask students if they can identify the two objects you have placed on the ground.
17. Ask students to move 25 feet forward. Again, ask if they can identify the two objects placed on the ground. Continue asking students to move closer until they are able to correctly identify the two objects.
18. Emphasize that echolocation allows dolphins to differentiate these two objects at a distance of 300 feet. One of the major differences between the golf ball and the ping-pong ball is the density. That's not something we can distinguish just using eyesight—we have to hold the objects. However, dolphins can simply use their echolocation.
19. Dolphins produce sounds not only to navigate through their underwater environment, but also to communicate with one another. There is still much to be learned about dolphin sounds, but it is thought that each dolphin has what is called a signature whistle. The signature whistle is unique to each dolphin, and is developed within the first few months of a calf's life. It is thought that a dolphin produces its own whistle to announce its presence, or imitates another dolphin's whistle in order to initiate an interaction.
20. Play some of the sound files of dolphin whistles and see if students can identify some of the subtle differences between the whistles.
21. Sounds like whistles and echolocation are obviously very important to dolphins. However, human activities are interfering with these important acoustic behaviors. Ask students to list what types of man-made noise might be polluting the underwater environment. (Answers include boats, ships, sonar, drilling, etc.)

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22. Discuss noise pollution and its impacts on marine mammals. (Refer to the resources listed below.)

Wrap Up: Select a few students to share one thing they learned during the class period.

Taking it Further:

- Allow students to experiment with tuning forks to learn more about how sound can travel through the bones and tissues. Have students strike the tines on a solid object, and then hold the tip of the handle to their lower jaw. Students should be able to hear the sound better when it is held against the jaw because the molecules in our bones and tissues are denser than air. This means the sound is able to travel faster and farther through these mediums.
- Blindfold a student and have the student stand at the front of the room. Place a material (foil, carpet, cloth, metal, foam, etc.) on the floor in front of the student, and have the student bounce a small rubber ball on the material. Have the student try to determine the type of material by the sound it makes when it is hit by the rubber ball and the manner in which the ball bounces after hitting the material.
- Obtain sounds of other marine animals from the Internet. (A fun place to start is the Aquarium of the Pacific's *Whales: Voices in the Sea*. Sounds can be found at http://www.aquariumofpacific.org/WHALES/.) Have students analyze the different sounds produced by the different species and learn how each species uses the sounds they produce.

Resources

Information on Noise Pollution:

- NOAA Office of Protected Resources http://www.nmfs.noaa.gov/pr/acoustics/
- OceanLink http://oceanlink.island.net/oceanmatters/noise%20pollution.html
- Whale and Dolphin Conservation Society http://www.wdcs.org/dan/publishing.nsf/allweb/8C57F53864255C33802568FF004B6D39