Unit 2. Lesson 3. Sound Use by Marine Mammals

Lesson Objectives: Upon completion of this lesson, students will have gained the ability to:

- understand the importance of sound to marine mammals.
- measure frequency, wavelength and the speed at which sound travels
- understand why sound is emitted in different frequencies.

Vocabulary: cognition, navigation, maternal, social structure, echolocation

Functions and Uses of Sound

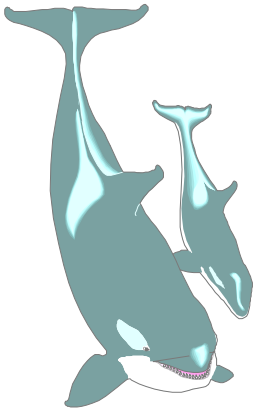
Sound use by marine mammals has been studied for many years. Generally, marine mammals use sound for communication, exploration, advertisement, locating food, maintaining mother-offspring bonds, and to identify individuals with their pod or group.

Echolocation, defined as the ability to gain information from sounds produced by the animal that bounce off distant objects and return as echoes, is an example of how sound is used by marine mammals. Scientists have learned that Odontocetes use echolocation. Often, this ability allows the animal to interpret their surroundings with or without vision. Echolocation is used over great and small distances. These echoes convey much information about the environment. For example, a dolphin can detect a small ball over a football field away, a distance too great to seen by either dolphin or human. Only a few animals have been shown to use echolocation. These include dolphins, bats, and a few species of birds. Some of the sounds these animals produce might be above or below a human's capability to hear. Although people can not hear the sounds, the animals are using them, and processing them to visualize objects and target others for food, or avoidance.

Echolocation is necessary for **navigation.** Sperm whales locate their favorite food, squid, by diving with great speed to depths, where there is relatively little light. They use echolocation to determine where the bottom is, and how fast they are approaching it. Finback whales use echolocation for navigation and may use the same sounds for maintaining social structure. Their sounds can be transmitted and heard hundreds of kilometers away. They can determine if an underwater volcano or island might be in their paths, and they can steer away from them.

Others, such as dolphins, use echolocation to socialize between groups of dolphins. This might be in the form of an advertisement.

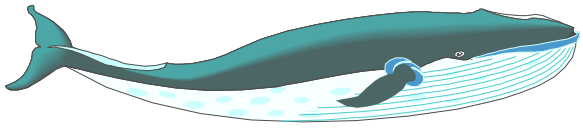
A well-known use of sound is to help determine and keep **social structure** between animals. Dolphins and whales that travel together in groups use clicks, moans, and whistles to identify each other and stay together as a group. Mother and infant pairs use a series of whistles to recognize one another. Most **maternal** pairs utilize an individually distinct call. Both animals can repeat this call, and use it when the mother and the offspring are separated. Similar calls have also been observed between animals that have strong social bonds. Distinct and identical calls and whistles can be repeated between individuals. A playful or loud whistle or click, or some kind of sound may inform a group that a dolphin is coming towards them, saying “hey, I am here.”



Finally, over the years, marine mammal researchers have found that another use of sound is for **cognition**. Cognition is the act or process of knowing something. An example of a cognitive act is when dolphin has been trained to respond to a cue with a vocalization.

APPLICATIONS OF SOUND IN THE OCEAN

The sounds used by marine mammals provide evidence of how sound can be used and what the animals can learn from them. Humans have used sounds in the ocean to study whales, learn migration patterns, and study geography.



Blue whales and other baleen whales have the ability to produce sound so low in frequency that they are an octave or more below the lowest sound the human ear can hear. Blue whale sounds last many seconds. Blue whales commonly emit sounds that have a frequency of approximately 17-hertz (Hz). This corresponds to a sound wave of about 88 meters long in water. A wavelength of this size can travel ocean basins and can be heard hundreds of kilometers away. Most likely, a sound of this frequency is used for navigation. The wavelength is very long, and can help to determine if there are landmasses in the whales' path.

Sounds with very long wavelengths are used to discriminate large obstacles. However, they can not be used to find small obstacles or fish. The distance between the wavelength is so long, it can easily pass over small objects. For an object to be detected in any size wavelength it must be 1/5-1/4 the length of the sound wavelength emitted. Look at the following example:

The click from a dolphin can be heard at 100kHz. It has a wavelength of approximately 1.5cm, so it is small enough to discriminate between rocks and small fish. It can even relay information about the environment: whether or not there are pilings present, or if the dolphin is swimming in an open channel.

Activity 3-1. Target Size

For animals that use echolocation to detect objects in water or air, it is necessary for them to use a frequency that is most favorable to the size of the target. Objects, landmasses or features of an object do not reflect sound very well, thus, the information is relayed to the animal improperly incompletely.

Materials:

- paper
- pen
- thinking…..

Procedure:

1. Solve the following equations.

The speed of sound in seawater is approximately 1500m/sec.
The wavelength, λ, of a sound equals the speed of sound, *c*, divided by the frequency, *f*.
Therefore: $\lambda = c/f$.
In other words, if λ is 4-5 times the length of the object, the object will not significantly interrupt or reflect the sound wave.

Example: This suggests sound frequencies on the order of 150 kHz or higher must be used to detect targets of a size approximately 1cm.

If λ = 1cm = 0.01m *and* the speed of sound is equal to 1500m/sec. Then, rearranging the equation $\lambda = c/f$, to $c/\lambda = f$ the numbers fit in as follows:

(1500m/sec) /0.01m = 150000Hz or 150kHz.

(Remember that there are 1000 hertz in a kilohertz. And hertz are defined at cycles per second, or in units of 1/sec.)

Problem 1:
If an object is 2m in length, what wavelength (λ) is needed to detect it? Remember, for an object to be detected using sound, it must be ¼or 1/5 the length of the sound wavelength emitted.

Problem 2:
Determine the length of a squid that a sperm whale is diving for if it using a frequency of 1500 cycles/second and the speed of sound in seawater is 1500m/sec. First, you must determine the wavelength (λ) that the sperm whale emits to detect the squid. (λ) = *c/f*

Then, determine the length the squid must be to be detected. A squid must be ¼- 1/5 the length of the sound wavelength emitted.

Problem 3:
Determine the speed of sound in the frigid arctic water where Orcas live during the summer. The Orca generally uses a sound frequency of approximately 2kHz to warn others of danger. The wavelength of the sound wave is 0.7 meters.

Answers to Problems 1-3.
1. (2m) x (4) or (2m) x (5). The wavelength must be no more than 8 or 10 meters in length to detect an object that is 2 meters in length.
2. (1500m/s)/(1500cycles per second) = 1m or 100cm is the length of the sound wavelength emitted. To determine the length of the squid that is detected, divided the length of the squid by 4 or 5. (100cm)/4 or (100cm)/5 = 25cm or 20cm The squid must be between 20 and 25 cm in length for the wavelength of 100 cm to detect it.
3. λ=c/f We know f=2000Hz and λ=0.7 m so we can solve for c by rearranging the equation to be c= λf = (0.7m)(2000Hz) = 1400 m/sec. The speed of sound in cold water is slightly slower than in warmer water.

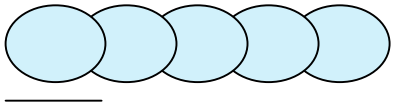
DID YOU KNOW?

There are currently seven species of cetaceans in U.S. waters that are protected under the Endangered Species Act. They are the Blue whale, the Bowhead whale, the Fin whale, the Humpback whale, the Northern Right Whale, the Sei whale and the Sperm whale. All seven species are listed as endangered. Scientists use information gained from their calls to track them, and monitor they're well-being.

Activity 3-2. Ocean Scramble.

There are many different words that are used to describe echolocation, and who uses it. Correctly unscramble the words below, and solve the mystery word with the underlined letters.

EAHWL



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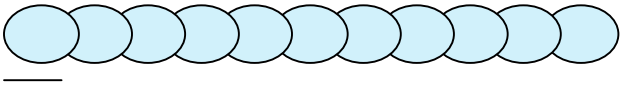

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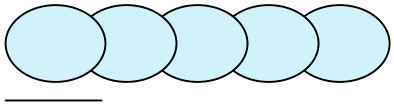
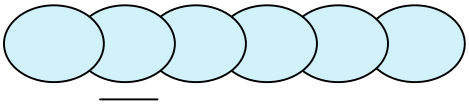


MMMAAL



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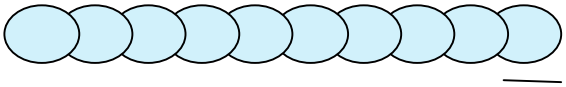
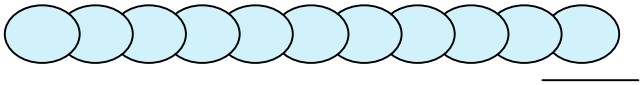


VIRONENMNET



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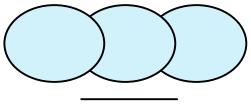

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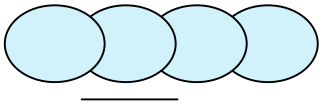

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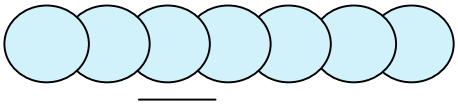

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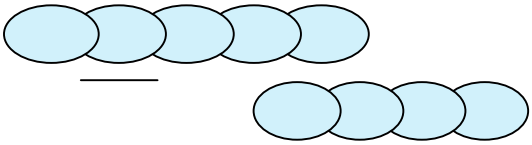

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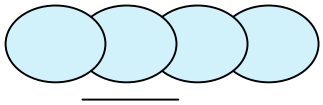

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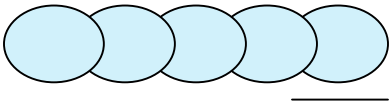
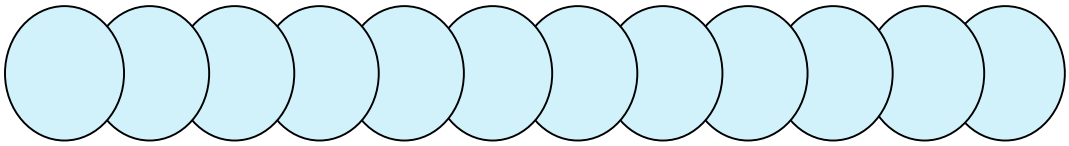
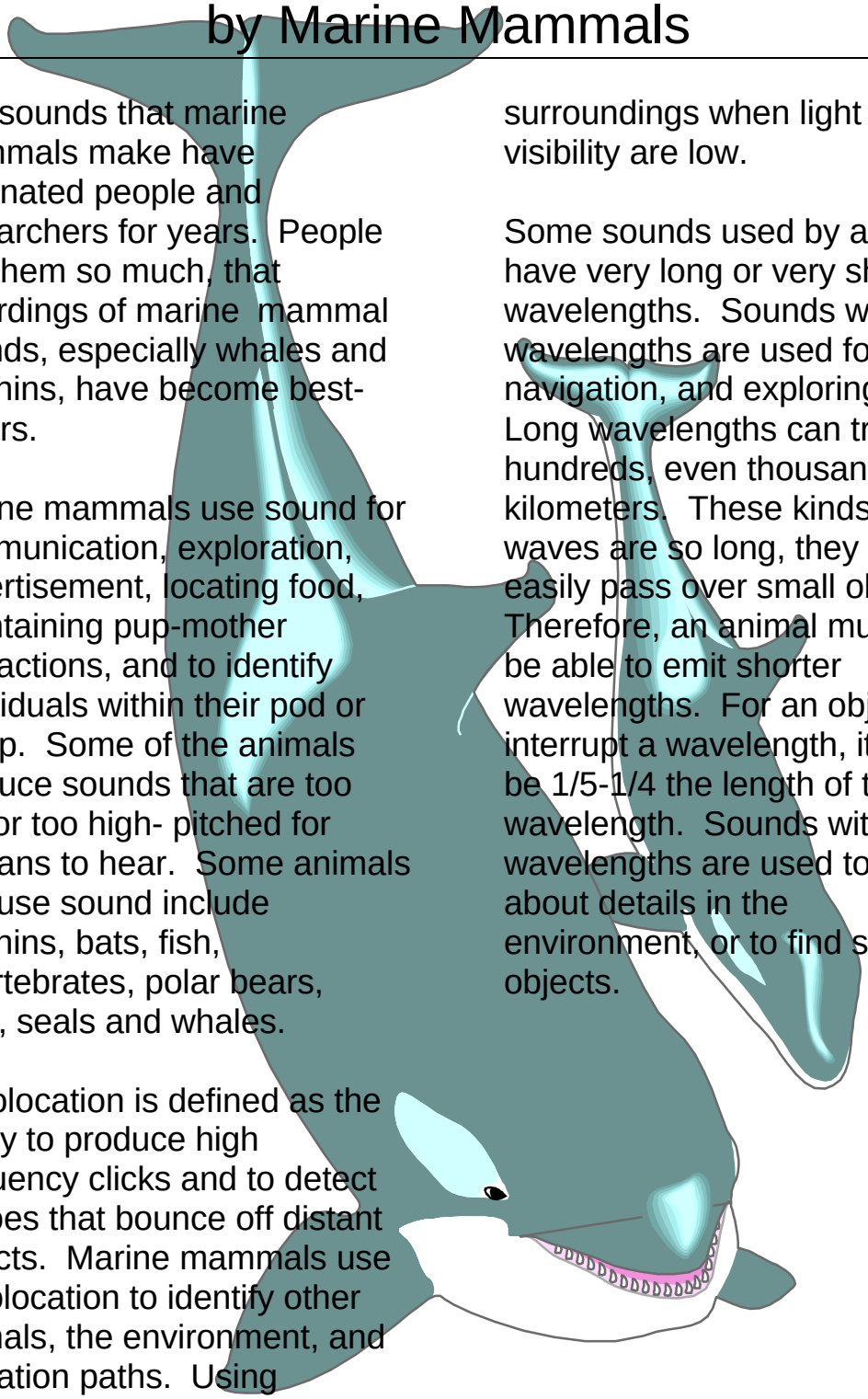


Now use the underlined letters to solve the mystery word. You should have the following letters: NIOTCALOOECH



Student Information Sheet 3. Sound Use by Marine Mammals



The sounds that marine mammals make have fascinated people and researchers for years. People like them so much, that recordings of marine mammal sounds, especially whales and dolphins, have become best-sellers.

Marine mammals use sound for communication, exploration, advertisement, locating food, maintaining pup-mother interactions, and to identify individuals within their pod or group. Some of the animals produce sounds that are too low-or too high- pitched for humans to hear. Some animals that use sound include dolphins, bats, fish, invertebrates, polar bears, otter, seals and whales.

Echolocation is defined as the ability to produce high frequency clicks and to detect echoes that bounce off distant objects. Marine mammals use echolocation to identify other animals, the environment, and migration paths. Using echolocation, mammals have the ability to 'see' their surroundings when light and visibility are low.

Some sounds used by animals have very long or very short wavelengths. Sounds with long wavelengths are used for navigation, and exploring. Long wavelengths can travel hundreds, even thousands of kilometers. These kinds of waves are so long, they can easily pass over small objects. Therefore, an animal must also be able to emit shorter wavelengths. For an object to interrupt a wavelength, it must be 1/5-1/4 the length of the wavelength. Sounds with short wavelengths are used to learn about details in the environment, or to find small objects.