Echolocation and SONAR: How Dolphins Use Sound Presentation[1]

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Students learn about people and animals that use echolocation and how it works through video and discussion with their peers.

Science Topics	Process Skills	Grade Level
Echoes	Observing	1-12
Echolocation	Predicting	
Speed of Sound	Scientific Inquiry	
	Comparing	
	Classifying	
	Communicating	

Time Required

Preparation	Set-Up	Activity	Clean-Up
None	5 minutes	50 minutes*	5 minutes

*The amount of time spent on this lesson depends on whether you've already taught the Doppler Effect (middle school) lesson, and on how long you spend discussing the various jobs in acoustics.

Learning Goals

Students will be able to…

- Explain and provide examples of how humans can use echolocation
- Define an echo
- Define SONAR and Echolocation and give examples of several animals that use these tools
- Describe how far and what size objects dolphins can echolocate
- Describe different methods of dolphin communication

Materials

In the Kit	Not in the kit	Optional
PowerPoint Slides/PDF Slides	Computers*	
	Projection/Presentation equipment	

*It's best if all students have an opportunity to use a computer to experience the website resources. If it isn't possible, you can demonstrate and make it interactive.

Set-Up

Gather materials
Set-up the computer/projector to present the PowerPoint or PDF slides
Open the videos and links to make sure they work.

Introduce the Activity

Explain that you will be going through a presentation that talks about echolocation and SONAR, and shows how dolphins use sound.

[1] This activity can stand-alone or be done with other lessons in the echolocation unit. It can be used as a supplement for before, during, or after the echolocation unit.

NOTE: We present this activity as a group discussion. First as a discussion between groups that can then share out with the whole class. That gets the most kids involved. Otherwise, this is an easy lesson to passively listen to and then drift away.

Doing the Activity

Echolocation Movie

1. Show the video of the boy who learned to use echolocation: https://www.youtube.com/watch?v=XUXh-X1iveU

2. Ask the class the following questions, and have them discuss their ideas with each other and then share out with the whole class.
   - Why does this person use echolocation?
   - What is the range this person is capable of?
   - Do you think you could learn to echolocate?

Sound Simulator: http://phet.colorado.edu/en/simulation/sound

It's best if students have an opportunity to play with the website themselves if there is time in another class period. If they don't, this should be an interactive demonstration.

1. Have the students work in pairs or small groups to predict what will happen when a soundwave hits a barrier, then they can share their ideas with the rest of class.

2. Demonstrate the simulator:
   a. Choose interference by reflection, the choose Pulse.
   b. Send one pulse at a time

3. The students will discuss with each other what happened when the waves hit the barrier.

Echo Introduction

1. Ask the students the following questions:
   - Have you heard of echoes?
   - What are echoes?
   - What causes echoes?

2. Describe what an echo is
   - An echo is when sound hits an object and then bounces back.
   - When we hear an echo, we hear the bounce.
   - In the image, the blue wave travels towards the barrier and hits. The red shows the wave bouncing back towards us.

3. Discuss the idea of echoes with the students:
   - Where are some places that we can find echoes?
   - Who uses echoes?

SONAR

1. Explain that SONAR used the idea of sound bouncing back and that scientist know how fast sound travels in water.
   - We send out a sound and then wait for it to come back.
   - The time it takes to come back tells us how far away objects are.
   - Of course, we need to send lots of sounds in very specific direction and we can tell how far away something is, where it is, and how big it is.

The picture shows sound waves hitting the fish, then bouncing back to the boat.

Bat, Dolphin and Whale Communication

1. Go to www.dosits.org and choose the "Audio Gallery." Then select "Humpback Whale" and scroll down to the video of humpback whales off the coast of Hawaii.

2. Ask the class to decide if they can see or hear the whales easier.

3. After watching the video and they decide if they can hear or see the whales better, show the video again to ensure that everyone understands.
   - You can always hear the whales, but it is difficult to see through the murky water. The sound travels well through water, but our eyes can't pick up the images as clearly.

Types of Dolphins

Scientists all agree that dolphins communicate with one another by using sounds and body language.

1. Dolphins and porpoises are the smallest toothed whales. Discuss the following types of dolphins:
   - Bottlenose Dolphins
     - Bottlenose dolphins, like Flipper the TV star, are the most familiar
   - Oceanic Dolphins
     - Including orcas and pilot whales, there are 32 species of oceanic dolphins
   - River Dolphins
     - There are 5 species of river dolphins
   - Porpoises
     - There are 6 species of porpoises
     - All dolphins are porpoises, but orcas and beluga whales are also porpoises.

Dolphin Communication

1. Ask the class to explain to each other how people recognize different people's voices.
2. Discuss the ways dolphins communicate with each other:
   - **Clicks** and **Whistles** are the two main types of dolphin vocalization
   - Each dolphin has its own "signature whistle"
   - A "signature whistle is a series of whistles (like a dolphin Morse code) distinct from any other member of the group
   - Dolphins recognize each other's whistles

Echolocation

1. Ask the class if they've heard of echolocation before, and if they know what it is. Echolocation refers to an ability that enables bats, dolphins and whales to essential "see" with their ears by listening for echoes. This helps these animals find and capture food.
2. These animals echolocate by producing clicking sounds and then receiving and interpreting the resulting echo.

3. Dolphins produce directional clicks and trains. Each click last about 50 to 128 microseconds.

Dolphin Echolocation:

- Sound waves travel 4 times faster through water – much faster than sound travels through air!
- These sound waves bounce off objects in the water and return to the dolphin in the form of an echo.
- This is similar to the sound simulation we tried earlier which showed how sounds hit the barrier and bounce back.

Click Trains

1. Go to www.dosits.org/audio/marinemammals/toothedwhales/spermwhale and scroll down to "Sperm Whale Removing Fish from Line."

2. Ask the group to figure it out: What happens to sound as they get closer?

   You may need to play this video more than once. Help students understand that the clicks get faster as the whale gets closer (to narrow location) and the whale can clearly see, but he is also using echolocation.

   NOTES: the video camera is on the bottom of the fishing line looking up. The whale isn't stuck, he's just holding on with his teeth.)

Anatomy of a Dolphin's Head – Sound Reception

1. Show the picture of the dolphin's head and discuss the ways dolphins receive sound.

2. Show the path of click trains in a dolphin's head
   - The click trains pass through the melon (the rounded region of a dolphin's forehead), which consists of lipids (fats).
   - The melon acts as an acoustical lens to focus these sound waves into a beam, which is projected forward into water in front of the animal.

   Optional Information:
   - The major areas of sound reception are the fat-filled cavities on the lower jaw bones. Sounds are received and conducted through the lower jaw to the middle ear, inner ear, and then to hearing centers in the brain via the auditory nerve.

- The brain receives the sound waves in the form of nerve impulses, which relay the messages of sound and enable the dolphin to interpret the sound's meaning.
- By this complex system of echolocation, dolphins and whales can determine size, shape, speed, distance, direction, and even some of the internal structure of objects in the water.
- Bottlenose dolphins are able to learn and later recognize the echo signatures returned by preferred prey species.

How Far Can a Dolphin Echolocate?

1. If you've already done the Echolocation Part 1 activity (middle school) or Echolocation Speed of Sound (lower elementary), have the groups think back and recall what was hardest, what they could and could not do when only using sound compared to sound and sight.

2. Tell the class that some dolphins can use echolocation to detect a 15 centimeter (6 inch) long fish a football field away!
   - High frequency sounds don't travel far in water
   - Low frequency sounds travel farther because of their longer wavelength and greater energy
   - Echolocation is most effective at close to intermediate range because dolphins and whales use high frequency sounds
   - Their range is about 5-200 meters for targets 5-15 centimeters in length. This would be like clearly identifying a banana from 2 football fields away!

Echolocation vs. Sight

1. Discuss the fact that dolphins and bats are **not** actually blind, but use echolocation as their primary tool. Whales and dolphins do see better than bats.

2. Despite the effectiveness of echolocation, studies show that a visually-deprived dolphin takes more time to echolocate on an object than a dolphin using both vision and echolocation.

Common Dolphin Sound Clips

1. Go to www.dosits.org/audio/marinemammals/toothedwhales/commondolphin and listen to the two sound clips

2. Ask the class the following questions and let them discuss amongst themselves.
   - What did you hear in each sound clip?
   - How are the two sounds different from each other?

Dolphin Communication/Sounds

1. Discuss the different methods dolphins have of communicating:
   - Dolphins produce non-verbal sounds by slapping a body part against the surface of the water, which makes both a sound and a splash. Tail or fluke slapping is also common.

- Kerplunks are another non-vocal sound made by the tail. Other parts of the body used to produce noise in a slapping manner are pectoral fins and the whole body.
- Finally, jaw claps are made either above or underwater.

Explanation

In-depth background information for teachers and interested students.

Key Lesson Terminology

- Echoes – reflections or repetitions of sound waves. Echoes can be produced and heard by clapping hands or shouting in a large empty room with hard walls or in a cave for example.
- Echolocation – a method used to detect objects by producing a specific sound and listening for its echo.
- SONAR – Sound Navigation And Ranging, is the process of listening to specific sounds to determine where objects are located.
- Clicks and Whistles – the two main types of dolphin communication.

Optional Extensions

- Read 3 career profiles (found on exploresound.org) to the class and have them answer the following questions:
    1. What's in common regarding what they do as scientists?
    2. What's in common about the advice they give to students?
    3. How do these scientists get to where they are today?
- After the students have looked at the profiles, discuss them with the class
- Complete other activities from the echolocation unit.