Acoustical Society of America

Echolocation and SONAR: Sound Rather Than Sight

Adams, W.K.

Edited by: Kelseigh Schneider
Reviewed by:
American Association of Physics Teachers Physics Teacher Resource Agents
ASA Activity Kit Committee

In this activity students explore the idea of how it feels to use sound to locate objects and experiment with having to search for objects above and below them, not just side to side.

This activity can stand-alone or be done in correlation with the Echolocation Part I activity.

Science Topics	Process Skills	Subject Integration	Grade Level
Sound Echolocation SONAR Vision impairment	Scientific Inquiry Observing Measuring Comparing Inferring Communicating	Physical Science Biology Animal Bioacoustics Psychological & Physiological Acoustics	4-12

Time Required			
Advanced Preparation	Set-Up	Activity	Clean-Up
Gather materials	15-20 minutes	50 minutes	10-15 minutes

Learning Goals

Students will be able to

- define SONAR and Echolocation and give examples of several animals that use these tools.
- Explain the difference between locating food that is on the ground versus all around such as up in the air or if we were swimming above, below and side to side.

Materials

- Homework (pages 8-10)
- Packet for each student (pages 5-7)

Sound Rather Than Sight

- Blindfolds – 1 per group
- Cotton balls
- Pencil, dry erase markers, etc
- Rulers – 1 per group

Please forward any questions or comments to:
Wendy Adams
Education Coordinator
Acoustical Society of America
Wendy.Adams@colorado.edu

3D Location

- Buttons ~15 (variety of shapes, sizes, and colors)
- String
- Laser pointers*
- Flashlight (narrow beamed)
- Additional Adult supervision**

*Laser pointers work better than a flashlight, but a flashlight can be substituted if necessary. The narrower the beam of light, the better.
**An additional adult may be useful for the 3D Location section, particularly if the students need to go to another room in the building.

Advanced Preparations

- Prior to the lesson students should complete the homework assignment on pages 8-10
- Gather materials
- Attach string to a variety of buttons. Make the strings a range of lengths.

Set Up

- Prepare materials for students to collect
- Hang a variety of buttons from the ceiling of a room with no windows or lights. The buttons should be hung at different heights.
- Place a piece of tape or rope across the doorway so students can't enter the room.

Introducing the Activity

Students will turn in their homework assignments from the night before.

Explain that in the following lesson there will be two activities. One will be using sound rather than sight, and the other will to use a laser pointer to find objects around a dark room. Introduce both activities so students are aware of what they are doing.

Doing the Activity

*While all students are working on the Using Sound Rather than Sight section, small groups will be going into a dark room to complete the 3D Location section.

Using Sound Rather than Sight
Students will divide into groups of 3 -5. One student will wear blindfolds so that they are entirely blind (we put cotton balls under the blindfold on the eyes so students can't peek under the blindfold) and another will drop an object on the floor. The blindfolded student has to guess

a. What object fell and
b. Where they think the object fell (by placing their hand down directly- not by fishing!).

The students should try dropping the objects at different locations around the room, including behind the blind folded person and between their feet.

They will measure the distance between where the blindfolded person guessed and where the object actually fell.

Students do this five times and then switch positions.

As they do the experiments, they should fill out charts similar to this:

Drop	**Item dropped**	**Guessed item**	**How far off**	**Where dropped**	**Where guessed**
1	*Pencil*	*Marker*	*36 cm*	*Half a meter on their right side on the floor*	*15 cm to the right of their feet*

Have the class answer questions 1-6 in their packets.

3-D Location

Explain that animals use echolocation in the water and the air. Ask the class to come up with animals that use echolocation in these two areas.

Ex. Bats and dolphins

Explain that in our world we are typically only concerned with 2 dimensions, but echolocators have to look up and down as well as left and right, so they are dealing with 3 dimensions.

One group of 3-5 students at a time will go into a completely dark room. Using a laser pointer, they will try to identify as many objects hanging from the ceiling as possible.

- Students should try and look for the objects themselves- not the strings attaching them to the ceiling! Bats and dolphins don't have strings to use when searching for food.

Students will then answer questions 1-2 in their packets.

Explanation

In-depth background information for teachers and interested students

People have a harder time locating objects right between their feet or directly in front or behind them. Our brains are able to detect the time delay for sound arriving at each ear. Using this delay our brain determines to which side the object fell and how far away it is. When an object is right between our feet or directly in front or behind, the sound arrives to each ear at the same time.

Key Terms:

- 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.

Optional Extensions /Modifications

Modifications:

- Hard of hearing students can be the recorders/measurers
- When doing this activity in the lower grades, teachers can control the laser pointer while students search for buttons. Most laser pointers sold today are safe for kids – check the packaging.

Optional Extensions:

- In the 3D location activity, students can try using a flashlight after they have used the laser pointer to see if the activity is easier.
- Conduct the Speed of Sound activity (if you haven't already!)

Echolocation and SONAR

Name: _____

Using Sound Rather than Sight.
One person wears the blindfold (do not cheat!). Stuff cotton balls under the blindfold below the eyes. The other person drops a pencil somewhere on the table or floor. The blindfolded person gets one chance to grab the object. They cannot *search* with their hands! Leave your hand where you grabbed. The other person measures how far off the grab is from the object with a ruler.

Now drop either the pencil or a pen/dry erase marker in a new spot. The blindfolded person must identify what was dropped and puts their hand where they think it is. Do this four more times.

Note: Make sure that sometimes it's behind them or between their feet!

Person1: _____

Drop	**Item dropped**	**Guessed item**	**How far off**	**Where dropped**	**Where guessed**
Example	*Pencil*	*Marker*	*36 cm*	*Half a meter on the right side on the floor*	*15 cm to the right of their feet*
1					
2					
3					
4					
5					

Person 2: _____

Drop	**Item dropped**	**Guessed item**	**How far off**	**Where dropped**	**Where guessed**
1					
2					
3					
4					
5					

1. What location was the easiest to identify?

2. What location was the hardest?

3. Describe the mistakes for each location:
    a. Close
    b. Far away
    c. Medium distance
    d. Behind the person
    e. Table
    f. Floor
    g. Between the feet

4. Did you get better?

5. How much practice do you think you'd need to be able to actually find objects?

6. How much practice do you think you'd need to identify objects 30 meters away? (Remember 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.)

3-D Location

Animals that use echolocation use it either in the air (bats) or in the water (dolphins and whales). In our world most objects are on the ground so we are typically only concerned with 2 dimensions – in front/behind or right/left. Echolocators also have to look up/down!!

Directions: Go into a completely dark room and use a laser pointer to identify as many objects hanging from the ceiling as you can. No cheating – remember fish and bugs do not come with strings!!

1. Animals that use echolocation are able to send out very narrowly focused sound so that they can easily pinpoint the location of objects/fish. Why do you think you use a laser pointer for this activity instead of a flashlight?

2. List the size and location (all three directions) of every button you identified in the room with the laser pointer.

Echolocation Homework

Name: _____

Watch this movie about a person who uses echolocation:

http://www.wideo.fr/video/iLyROoaft87F.html

1. Why does this person use echolocation?

2. What is the range that this person is capable of?

3. Do you think you could learn how to do the same thing?

Adapted from Discovery of Sounds In The Sea http://www.DOSITS.org

Look at **Sound** sim – http://phet.colorado.edu. Choose interference by reflection, choose Pulse.

4. Send one pulse at a time. What do the waves do when they hit the barrier?

SONAR SOund Navigation and Ranging. Uses this idea of sound bouncing back. Scientists know how fast sound travels in water. They send out a sound and then wait for it to come back. The time it takes to come back tells them how far away objects are.

Of course they need to send lots of sounds in very specific directions and then they can tell not only how far away but where and how big the objects are.

Bat, Dolphin and Whale communications

Watch the video at http://www.dosits.org , chose "Audio Gallery", choose Humpback Whale, scroll down to the video of humpback whales off the coast of Hawaii.

5. Can you see or hear the whales easier? (explain)

Background Information (*read all of this before moving on*):

Dolphins and porpoises are the smallest toothed whales. Including orcas and pilot whales, there are 32 species of oceanic dolphins, 5 species of river dolphins, and 6 species of porpoises. Bottlenose dolphins, like Flipper the TV star, are the most familiar. While humans rely primarily on sight to perceive their environment, scientists all agree that dolphins communicate with one another by using sounds and body language.

Clicks and whistles are the two main types of dolphin vocalization. Each individual dolphin has its own "signature whistle", which is a series of whistles, like a dolphin Morse code, which is distinct from any other member of the group. This signature whistle provides a way for dolphins to recognize and bond with others.

Some dolphins use ***echolocation*** to help them find and capture food.
The term *echolocation* refers to an ability that enables bats, dolphins and whales to essentially "see" with their ears by listening for echoes. They echolocate by producing clicking sounds and then receiving and interpreting the resulting echo. Echolocation is Nature's Sonar.

Dolphins produce directional clicks in trains. Each click lasts about 50 to 128 microseconds.

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.

Sound waves travel through water at a speed of about 1.5 km/sec (0.9 mi/sec), which is 4.5 times faster than sound traveling through air. These sound waves bounce off objects in the water and return to the dolphin in the form of an echo.

High frequency sounds don't travel far in water. Low frequency sounds travel farther because of their longer wavelength. 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. **In other words, some dolphins can use echolocation to detect a 15 centimeter (6 inch) long fish a football field away!**

The major areas of sound reception are the fat-filled cavities of 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.

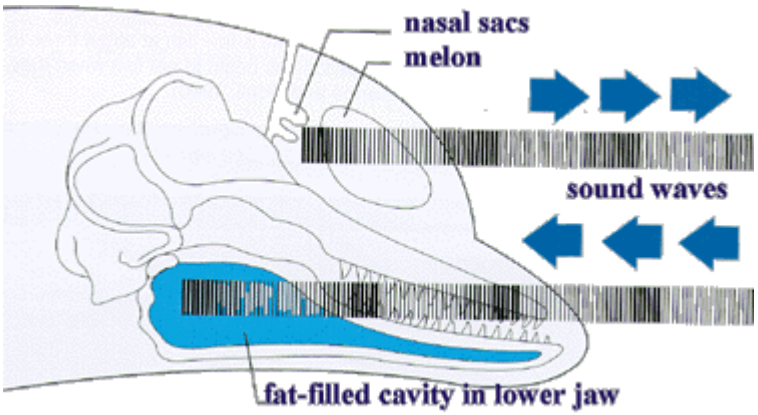
By this complex system of echolocation, dolphins and whales can determine size, shape, speed, distance, direction, *and even some of the internal structure* of objects in the water.

Bottlenose dolphins are able to learn and later recognize the echo signatures returned by preferred prey species.

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

Go to the audio gallery again and choose "common dolphin" this time and listen to the two sound clips of the dolphins and watch the graph of frequency.

6. Describe what you hear in both cases. What is different about the sounds in each case? What is different about the graphs in each case?



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.