Everblue Education

The Sounds of Sand Dollars

This week, dive into a lesson on sound in the sea! During a sonar study of the mouth of Humboldt Bay, researchers noticed a few bands of backscatter, or unexplained objects found by the sonar scans. In 2001, a cohort at Humboldt State University investigated this data from 1995 and 1998 and discovered that the unexplained backscatter was from thousands of sand dollars crowding the ocean floor at the mouth of the bay! This lesson is based on the paper published by the cohort. In this lesson, students will learn how sound travels in the ocean, how animals use it to communicate, and how scientists harness it to discover more about the sea. Anytime you use these methods to ask and answer questions, you are doing science! It doesn't take a special kind of person to be a scientist, just exploration and curiosity.

Everblue is a 501(c)(3) nonprofit dedicated to encouraging ocean-conscious living by increasing scientific literacy. Our online education resources connect current science to daily life, allowing you to learn about the ocean at your fingertips! Stay in touch by following @oceaneverblue on your prefered social media platform or by visiting our website at www.oceaneverblue.org.

To help us keep the ocean ever blue, please share this program with the teachers and parents you know so we can spread ocean science far and wide. Partnering with marine scientists from around the world who study all parts of the ocean, we've created simple and engaging activities based on recently published papers! These activities connect you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well! More activities will be available to download for FREE off of our website, with a new activity added every Friday until the end of quarantine.

Research Paper:
Enhanced acoustic backscatter due to high abundance of sand dollars, *Dendraster excentricus. Lori E. Fenstermacher et al., 2001.*

Grade Level:	Timing:
K-8	1 - 1.5 hours

Materials: ● Printed activity sheet ● Writing utensil ● Blindfold ● Household objects of differing hardnesses (e.g. a textbook and a pillow)

Next Generation Science Standards

Science & Engineering Practices:	Crosscutting Concepts:	Disciplinary Core Ideas:
Analyzing and interpreting data Carrying out investigations Using models	Cause and effect Patterns	Information technologies and instrumentation Structure and properties of matter Wave properties

Activity Overview

Title of Activity	Learning Cycle Stage	Time
Sand! Dollar!	Invitation, Exploration	5 minutes
Sound in the Ocean	Concept Invention	5 minutes
See with Sonar: Where is it?	Application	20-30 minutes
See with Sonar: What is it made of?	Application	20 minutes
Reflection	Reflection	5-10 minutes

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Ocean Vocabulary Common Questions	Example Echolocation Sounds Images from multi-beam and side scan data Map-a-room template

The Sound of Sand Dollars Lesson

Sand! Dollar!

This simple warm-up will get students moving and starting to explore the idea of "seeing" with sound.

1. This activity is essentially the classic game of "Marco! Polo!" with an ocean-themed twist; the blindfolded person who is "it" will say "Sand!" and other players will respond with "Dollar!"
2. As students play, periodically have all players freeze in place. Ask the "it" person if they can tell (a) how many other players there are and (b) how far away they are (close, very close, far, very far) by the sound of their voices (they can continue to call "Sand! Dollar!" if they aren't sure).
3. Be sure to give all students a chance to be "it"!

Sound in the Ocean

Read the following to your students. The definitions of the blue vocabulary words can be found in Appendix I.

Sound can tell us a lot about things that we can't see. Many animals use sound to navigate in environments where it's hard to see. This is called echolocation or sonar. An echo is a sound that bounces off of an object. In echolocation, "echo" is for the sound they make coming back to the animal and "location" is for finding. So "echolocation" really means "finding things with sound!" Can you think of any examples of animals that use echolocation? *(bats, dolphins, whales)* These animals need to have an excellent sense of hearing to hear small differences in their echoes, and some (like bats) have even evolved extra big ears to help them hear better! Sonar gives these animals information about objects around them, whether that may be a potential snack or a big rock they shouldn't swim into. To get this information, the animal makes a sound - often a chirp, squeak, or click - and listens to the sound that bounces back at them. The amount of time it takes for the sound to return and how loud the echo is allows the animal to have an idea of its surroundings.

Scientists studied these animals, copied the animals' abilities to see with sound, and created technology to do the same. This technology is also called sonar and uses sound to explore places that would be hard to study from a ship, like the ocean floor. By using sonar, scientists can map the bottom of the ocean to see how deep it is, what it is made of, and other features like undersea mountains and canyons! To do this, they use special equipment on ships that makes a VERY

loud, high-pitched sound (that can be almost twice as loud as a rock concert) that travels down through the water, bounces off the ocean floor, and comes back up the ship, where another piece of equipment listens to this echo, or backscatter. Think about shouting in a big, empty room and listening to the echo of your voice come back to you. A computer then uses those sounds to "see" what is on the bottom by producing maps!
For more information on sound, sound waves, and how sound works, see Common Questions.

See With Sonar: Where is it?

In this activity, students will explore how backscatter is used to map the ocean floor by mapping out a room. Students will model how research ships use sound to study how deep the ocean is beneath them. Students will represent the sound sent from the ship, down to the ocean floor, and back up to the ship. After the information is collected, students will create their own sonar-like image of the room with the Map-a-Room template, found in Appendix II.

1. Choose a room to be your sampling area. Pick one wall of that room to be the "research ship" which will send out your sonar student to collect information about where the "ocean floor" is in your room.
2. Begin by having a student stand at the end of the wall chosen to be the " research ship". They will be the ship's "sonar beam". Have them walk heel-to-toe out from the wall, counting their steps, until they encounter a piece of furniture or another obstacle. Have them turn on the spot and heel-to-toe walk back to the wall. They should count the same number of steps in both directions.
3. Write this number in the bottom box on the Map-a-Room template
4. Have them take a small step to the side (no more than about a foot) and repeat the process of counting heel-to-toe steps to the first obstacle, turning around, double-checking that number, and then writing the number of steps from the "ship" to the "ocean floor".
5. Continue across the length of the wall until the entire room has been mapped.
6. Now that the information has been collected, it is time to create your sonar-like image of your room. Above each number that you have written on your template, draw or color that number of shapes, like the twelve dots we have provided as an example.
7. When you are finished mapping your room, the dots should create a picture that looks similar to the path walked by your sonar student.
8. Ask your student if they recognize where different objects in the room would be on your sonar image by looking at the patterns in your map. Then, you can have them try to draw some of those objects on their map.

Activity review: This is how sonar is used to see the depth of an area of ocean. Did you notice it took you longer to walk to and from objects that were further from the wall? The same is true for sonar; the longer it takes the sound to return to the ship, the deeper the water in that spot!

See With Sonar: What is it made of?

We've just seen how ocean scientists use sonar to tell how deep or shallow the ocean is by the sound sent to the bottom of the ocean and back to the ship. But how can they tell if the bottom is hard rock or soft sand? Let's use a different model to explore this!

1. Blindfold students and instruct them to (when you tell them to) make an echolocation sound (chirp, squeak, click, etc.).
2. Hold up a hard object a couple of inches away from their face (e.g. a dinner plate, a textbook, something large and flat) and have them make their sound.
3. Then hold up a soft object (e.g. pillow, cushion, etc.) and have them make their sound.
4. Have them tell you whatever they can about the object, repeating parts 2 & 3 if necessary. Can they tell if the object is hard or soft? Which is which?
5. Repeat the entire exercise, this time instructing the student(s) to cup their hands behind their ears. Have them describe how sounds are different with their hands behind their ears. Is it easier to tell which object is which, where the objects are, or how far away they are?
6. If students are really engaged with this activity, you could do variations of this by slowly moving the object further away from the student's face while they continuously make their sound and see how far you can move before the object is "out of range."

Activity review: You've just experienced how scientists are able to use sound to get a better picture of the ocean floor! Sonar equipment on ships use transmitters to act like your voice to transmit or send a sound down through the water, and receivers sense the small differences in the way the sound bounces back, like your ears when you use your hands to hear better. Computers process the reflected sounds (just like your brain!) and interpret the signals to get a picture of the ocean floor. This allows scientists to see whether the bottom is soft sand or hard rock, as well as where underwater mountains and canyons exist.

Reflection

As you and your student are cleaning up, talk to your student about what you just did together. Here are some guiding questions to help shape your conversation.

- ➢ What was your favorite part of our activity today?
- ➢ What is something that you learned about sound?
- ➢ Did you notice any patterns during our activity today?
- ➢ What is something you wonder about how scientists can use sound to study the ocean?
- ➢ What surprised you the most during our activity today?

Optional Extension: Advantages and Disadvantages of Using Sonar for Science

While sonar is a very useful tool for navigating and exploring the ocean, there are some very serious negative side effects for marine life. Use the following questions to guide your students through a discussion of why that is the case.

1. Can you think of any ways that using sonar might not be a good thing?
    a. Remind them that sonar is extremely loud, almost twice as loud as a rock concert, and that animals which use sonar have very sensitive hearing.
2. How might sonar affect marine life?
    a. Many marine organisms, including dolphins and whales, use sound to navigate and to communicate. When ships use sonar, the extremely loud sound makes it hard for these animals to find food, communicate with others of their species, causes stress to the animals, and can even result in mass stranding events, where an entire pod beaches themselves because they can't hear where they are going and get confused in shallow water. This stress can go on for a long time since it takes a long time to map the bottom of the ocean, especially when oil companies are using sonar to look for oil deposits offshore.
    b. To put yourselves in the shoes (or flippers) of these animals, imagine a fire alarm off every 30 seconds all day and all night for a week. Imagine trying to learn, talk to your friends, read, eat, or sleep. How would you feel? Do you think you would be able to do normal activities as well as you normally could?
3. Do you think scientists should use sonar? Are there ways scientists could use it to explore responsibly?

Appendix I - Instructor Support

Ocean vocabulary

- Backscatter - the reflection of a signal (such as sound waves or light) back in the direction from where it originated
- Decibel - a unit for expressing the relative intensity of sounds. The sonar ships use can be up to 235 decibels, compared to a rock concert, which only reaches 130 decibels.
- Echolocation - the sonarlike system used by dolphins, bats, and other animals to detect and locate objects by emitting usually high-pitched sounds that reflect off the object and return to the animal's ears or other sensory receptors
- Receiver - the piece of a sonar device (see Sonar below) that collects the reflected sound (see backscatter above)
- Sonar - Short for Sound Navigation Ranging, sonar is a technique that uses sound propagation (usually underwater, as in submarine navigation) to navigate, communicate with or detect objects on or under the surface of the water. This is done with equipment that creates sound pulses and detects their return after being reflected. Computers then interpret the reflected sound waves to create a picture of whatever reflected the sound.
- Transmitter - the piece of a sonar device that makes the sound that travels down through the water

Common Questions

What is sound?

Sound is a vibration that travels through a medium (gas, liquid, or solid) as an acoustic wave. These vibrations are created by movement and they travel just like ripples in a pond when a rock is dropped into the water. Like the ripples in a pond, sound waves are reflected or "bounced back" when they strike an object. Animals that use biosonar use this property of sound to tell where things are in their environment.

- If you and your student are interested in learning more about how sound works, check out this episode of the Magic School Bus: https://www.schooltube.com/media/Magic+School+Bus+-+Haunted+Mansion/1_sxuf6fot

How does sound tell you what is on the ocean floor?

There are two common ways that scientists use sound to study the bottom of the ocean.

- Multibeam sonar, also called swath mapping, uses many devices that send and receive sound, creating a map of the ocean floor along the path of the ship. This type of sonar determines how deep the ocean is at a specific location by measuring how long it takes for a sound to be sent from the device to the ocean floor and bounce back to the device on the ship. This data is used to create a color image of the ocean floor beneath the ship, with different colors showing the different depths.
- Side-scan sonar can give clues about what type of objects are on the ocean floor by measuring how much sound is returned to the device. Large rocks and other hard objects return more sound than softer objects like sand. This data is used to create a black and white image of the ocean floor beneath the ship.
- If you would like to see sonar in action helping scientists map the ocean floor, check out this video of NOAA researchers mapping around the US Virgin Islands: https://www.youtube.com/watch?v=-fAAxEIFeLU

Why does sound travel faster in water than air?

Sound waves are transported through air and water at different speeds. This is because the molecules in a liquid, such as water, are packed more tightly together than molecules in a gas, like the air we breathe. The energy carried in sound waves can travel faster through molecules that are closer together!

Appendix II - Attached Lesson Materials

Example Echolocation Sounds

If you and your student are interested in hearing some real-life ocean echolocation sounds before you try to make your own, check out these short videos!

- Humpback whale song recorded by the Monterey Bay Aquarium Research Institute in California: https://www.youtube.com/watch?v=5tRMqbPH_pk
- Orca song recorded by the McMurdo Oceanographic Observatory in Antarctica: https://www.youtube.com/watch?v=29neQ5mLT5E

Images from multibeam and side-scan sonar data

These two images visualize sonar data collected in 1995 and 1998 near Humboldt Bay in Northern California. The large grid over the images are used to identify where the data was collected using latitude and longitude. Latitude describes how north or south a location is and longitude describes how east or west a location is. The dotted lines with numbers in them - like 15 m, 20 m, or 25 m - are used to identify how deep the water is where the data was collected. A lower case 'm' is an abbreviation for meters - a unit of measurement for length. For example, the dotted lines on either side of the "20 m" in Image 1 tell you that the ocean is 20 meters deep along that line. The dark bands in both images show that the objects on the ocean floor in those areas are harder than the surrounding, lighter areas. These bands are sand dollars! In Image 1, the sand dollars are all living in water around 20 meters deep - about the length of a bowling lane.

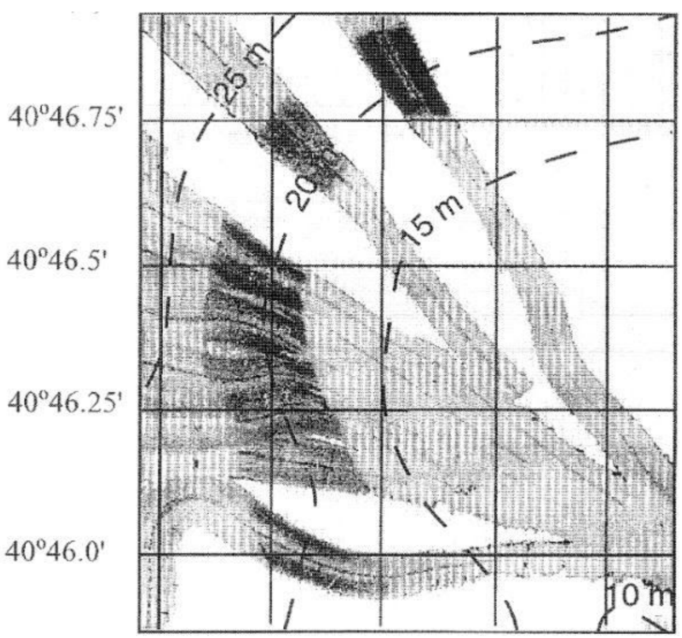


Image 1: Multi-beam sonar.
Fenstermacher et al., 2001

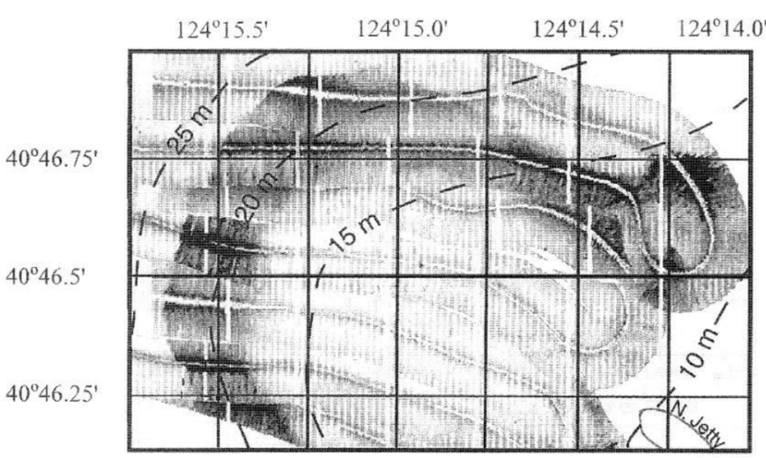
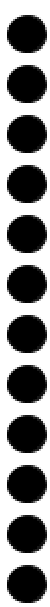


Image 2: Side-scan sonar.
Fenstermacher et al., 2001

Map-a-room Template

Create your own sonar image of your room by writing down the number of steps it takes for your "sonar student" to reach the first object in your room. After the number of steps have all been recorded, draw or color a dot for each step, like we did as an example on the left side of the template. When you are finished mapping your room, the dots should create a picture that looks similar to the path walked by your sonar student. Ask your student if they recognize where different objects in the room would be on your sonar image by looking at the patterns in your map. Then, you can have them try to draw some of those objects on their map.

Opposite wall - "Ocean Floor"



Starting wall - "Research Ship"

Example:

12

First, write how many steps between your starting wall and first object in this box

(The example on the left represents a path that took 12 steps to reach the first object)