Shouting Whales

Lesson B: Properties of Sound

Unit Questions	Suggested Prior Lesson
How is sound related to marine species survival? What is the relationship between a marine animal's soundscape, sound output, sound reception, and the overall survival and well being of that animal? **Lesson Question** How does sound interact with the environment, and how does this allow us to hear it?	Lesson A: Human Sounds in the Ocean **Suggested Subsequent Lesson** Lesson C: Using Hydrophones for Research
Grade Level 6-8	**Time Required** One session

Abstract

In this lesson, students take on the role of an atom and explore sound as a form of energy, and as a wave to better understand the movement of sound through the soundscape. Students use kinesthetic movements to explore the different components of sound. This lesson is intended to provide students with key vocabulary and concepts for the Shouting Whales unit. The lesson can be presented at any time during the unit.

Prior Knowledge/ Background for Students

Students will likely have had some exposure to sound science, and may be aware that sound is generated by vibrations, and that our ear detects these vibrations and our brain interprets these vibrations as different sounds. This lesson is intended to help students visualize how sound propagates through different mediums, so they should have a prior understanding that sound, like light, is an energy wave.

Objectives	Materials	Suggested Links and Downloads
☐ Explore how sound behaves as a form of energy. ☐ Explore visual representations of sound with kinesthetic body movements to explore concepts such as amplitude, intensity, frequency (pitch), tone, and harmony. ☐ Explore how the physical movement of sound relates to an animal's interpretation of the soundscape.	☐ a drum, whistle or other noise maker	☐ What does sound look like? https://www.youtube.com/watch?v=px3oVGXr4mo&feature=youtu.be ☐ *High Frequency Whale Calls.mov* ☐ *Low Frequency Whale Calls.mov* ☐ Online hearing-test apps http://www.alpinehearingprotection.com/wiki/8-best-apps-to-test-your-hearing/ ☐ *Frequency of Sound Waves.jpg* ☐ *Humpback Whale Harmony.mov* ☐ *Implosion with Ten Echoes.mov* ☐ *Amplitude of Sound Waves.jpg* ☐ *Transmission of Sound – Designmate* http://www.youtube.com/watch?v=GkNJvZINSEY ☐ *Bill Nye the Science Guy, Sound* http://youtu.be/ITetdgpu7MU

		☐ *Sound, Bass, Water, Sound Devastates Water* http://youtu.be/THUMdTohWkI ☐ *Lesson B Show What You Know Rubrics.docx*

The "Hook" (Suggested Introduction)

- ☐ Start by hitting a drum, ringing a bell, smacking two objects together, or doing anything else that will create a loud, direct sound. Ask the students: How did the sound you created reach them? Why/How did your action create a sound? Students may be able to identify the sound was caused by vibrations. Have them focus on the question: How did the sound reach their ears?
- ☐ Do the same thing again, only very softly/gently. Ask: Why didn't that sound reach as far?
- ☐ Have the students brainstorm a list of what they remember about the science of sound. You may choose to use a KWL (Know, Wonder, Learn) chart to help corral thinking.

Activity Outline

Introduce the lesson by reviewing the concept that all matter is made up of atoms, and that the interactions of atoms create molecules. How these molecules interact with each other and the state they are in shape our world.

Depending on your class you may want to explore this by:

- ☐ creating a KWL with the class, helping the students refresh their memories about atoms and molecules
- ☐ creating a "post it note" parking lot of what is known about atoms
- ☐ having a round table, think/pair/share, or mini review of molecular theory

You may want to show students the following video which uses schlieren flow visualization to show actual sound waves.

What does sound look like?
https://www.youtube.com/watch?v=px3oVGXr4mo&feature=youtu.be

Once the students have explored the basics, explain that sound is dependent on the interactions between molecules and atoms. Explain to the students that, for the activities in this lesson, they will imagine that they have been transformed into atoms. As atoms they will be exploring the science of sound, and sound's effect on a medium such as air or water, or on materials.

Activity	Resources	Teaching Points
Sound Waves	No materials are required, but you'll need to clear space in your classroom or find an open space such as the gym or schoolyard.	See "Activity Details" at the end of this lesson plan for complete description of this activity. Sound is energy, traveling as a wave. When a sound occurs, energy pushes on atoms and makes them move— similar to a relay. In this activity students use their bodies to demonstrate how sound moves through solids, gases, and liquids.
Frequency/ Pitch	*High Frequency Whale Calls.mov* *Low Frequency Whale Calls.mov* Online hearing-test apps	See "Activity Details" at the end of this lesson plan for complete description of this activity. Now that the students have tried being molecules influenced by sound energy, they are going to explore

	http://www.alpinehearingprotection.com/wiki/8-best-apps-to-test-your-hearing/ *Frequency of Sound Waves.jpg*	the concept of frequency (or pitch). They will investigate how frequency is related to the fundamental principle that sound is energy that moves as a wave.
Tone and Harmony	*Humpback Whale Harmony.mov*	See "Activity Details" at the end of this lesson plan for complete description of this activity. Students will now explore the concepts of tone and harmony. They will investigate how tone and harmony are related to the fundamental principle that sound is energy that moves as a wave.
Amplitude, Intensity and Loudness	*Implosion with Ten Echoes.mov* *Amplitude of Sound Waves.jpg*	Students will now explore the concepts of amplitude, intensity, and loudness. They will investigate how these concepts are related to the fundamental principle that sound is energy that moves as a wave.
OPTIONAL: Summary of the Science of Sound	*Transmission of Sound – Designmate* http://www.youtube.com/watch?v=GkNJvZINSEY *Bill Nye the Science Guy, Sound* http://youtu.be/ITetdgpu7MU	The two videos listed here provide good summaries of the concepts in this lesson. You may choose to show one or both of them to your class.

Researcher Interviews

There is no researcher interview video for this lesson.

Suggested Summary

Play this video for students, and ask: What if the rubber ducky was a whale?

Sound, Bass, Water, Sound Devastates Water
http://youtu.be/THUMdTohWkI

With the students, discuss the following questions.

- Why is it important to know that sound is a form of energy?
- Why is it important to differentiate between the different properties of sound—for example, why is it important to know if a sound is low or high frequency?
- Revisit the introductory question: How does sound travel from the source to our ear?
- Extend thinking: How can sound be impeded by other sounds? How can sounds be amplified or muffled? Have the students experienced a time when they didn't hear a sound because of another sound. How is this possible? Knowing that sound is energy, shouldn't the sound have also reached them?

Show What You Know

Make a Written Piece	Make a Media Presentation	Take on a Role
☐ Pretend you are a reporter interviewing a molecule that has had three different sounds travel through it. How would the molecule describe the experience, and how would you explain to your readers what happened to Mr. Molecule?	☐ Use what you have learned to visually represent the key concepts about sound. Imagine you are helping someone who is unable to hear to understand sounds through the use of pictures and images. What would you show the person to help understand what we hear?	☐ Take on the role of an audiologist. How would you explain sound to someone unfamiliar with it? If you were asked to speak on the properties of sound in the ocean, what would you say? Consider recording your performance or presenting it in the form of an interview.

Assessment Options

- ☐ Overall lesson assessment questions
  - Can the students explain how a sound created at one end of a room can be heard by a person at the opposite end of the room?
  - How would the listening experience be different if you were listening through a solid, liquid, or gas?
  - Are the students able to accurately explain how the properties of sound impact how we hear it? For example, can they explain how we might perceive a high amplitude sound in our audible frequency?
  - Are the students able to differentiate between frequency and amplitude?
- ☐ Show What You Know
  - See *Lesson B Show What You Know Rubrics.docx*

Activity Details

Sound Waves

Sound is energy, traveling as a wave. When a sound occurs, energy pushes on atoms and makes them move— similar to a relay. As one atom or molecule gets 'bumped' by energy, it transfers some of this energy to the atom or molecule next to it, which transfers some of the energy onward again. In this way, sound moves like ripples in a pond.

In this activity students use their bodies to demonstrate how sound moves through solids, gases, and liquids.

1. Have the students stand up shoulder-to-shoulder, holding hands. Start fairly close together, and explain that the students represent the molecules of a solid material, such as wood or drywall.
2. Start the "sound" at one end of the chain by lifting the end student's arm. Explain this is the action that represents the noise being created. Perhaps bang the drum or ring a bell as you lift the student's arm, so they relate the action of the wave with the sound.
3. Explain: When students feel their arms being lifted, they should lift their other arms (without letting go of the person next to them). Once the signal to lift their arms is gone, they put their arms down. It may help to have the students envision doing "the wave" as seen at a sporting event. You may want to practice this a few times with different students starting the "sound". You can also have a middle student start the sound by raising both arms. Encourage students to notice that the sound travels outward from the source (students on either side of the "sound" should be lifting their arms). For emphasis, create a noise as the students complete the actions.

4. Explain to the students that sound travels better through some mediums than others. In the first round, the group formed a solid object, with the molecules fairly close to each other. Next they will be air molecules, fairly far apart from each other. Ask the students to stay in their line, but let go of each other's hands and stand about four feet (or two large steps) apart from the person on each side. When the sound signal is received, they'll need to lean over and lift the arm of the person next to them. This will cause the sound to travel much more slowly than it did in the solid material.
5. Finally, have students stand one step away from the person beside them. They now represent water molecules and should be positioned not quite as far apart as they were as air molecules, but also not as densely packed as they were as molecules of a solid. Try a few run-throughs and compare the speed in which the sound moved.

Frequency/ Pitch

Now that the students have tried being molecules influenced by sound energy, they are going to explore the concept of frequency (or pitch). They will investigate how frequency is related to the fundamental principle that sound is energy that moves as a wave.

1. Play the sound clips for the students and ask them to discuss which they think is a high frequency sound and which is a low frequency sound.
2. Ask the students if they can give a definition of frequency. If needed, prompt them to think about how frequently they have dinner, brush their teeth, or play video games. Lead the students to understand that frequency is how often something occurs. In the science of sound, frequency describes how often a particle vibrates as sound energy passes through it. In the "Sound Waves" activity, frequency would be the number of times each student lifted his or her arms in a specific time span. Unlike this activity, sound energy moves very fast, several hundred times a second. Frequency is expressed as hertz, which is calculated based on how many times the particle moves in a second. For example, if each particle moves 2000 times in 2 seconds, the frequency of the wave is 1000 vibrations per second. One hertz is one vibration per second, so in the example, the frequency is 1000 hertz (1000 Hz).
3. Test your students' hearing with an online app. You will find several at the following URL: http://www.alpinehearingprotection.com/wiki/8-best-apps-to-test-your-hearing/
4. Modify the "Sound Waves" kinesthetic activity to demonstrate frequency. Start and continue a sound at a fast tempo (such as tapping the drum or blowing the whistle). Have the students raise and lower their arms in time with your pace to demonstrate a high frequency sound. Try the activity a second time with a slow tempo that represents a low frequency sound.
5. Show the students the image, *Frequency of Sound Waves.jpg*. Discuss: Do they think it is an accurate representation of frequency waves in sound? What would make it more accurate or more descriptive?

Tone and Harmony

Students will now explore the concepts of tone and harmony. They will investigate how tone and harmony are related to the fundamental principle that sound is energy that moves as a wave.

1. Most sounds have tone and harmony. Tone relates to the richness of a sound. Harmony occurs when sounds complement one another to create richness.
2. Play audio: *Humpback Whale Harmony.mov.* Point out that multiple tones come together to create a harmony.
3. Explain: When a sound wave occurs, it moves many particles, setting them vibrating. This means that when we hear sound, it's not just a single wave we hear, but a collection of layered waves. This is why sound usually has richness -- different waves are all occurring at the same time.

4. You may want to play the clip again, this time showing the spectrogram. Point out the layered waves.
5. Demonstrate this concept with a kinesthetic activity. Set students up in three lines. Make a sound (i.e. by hitting a drum or blowing a whistle) and when students hear the sound, the first student in each line will raise her or his arms, as in previous activities, sending the sound wave down the line. Students will see that there are multiple waves making up the sound.

Amplitude, Intensity and Loudness

Students will now explore the concepts of amplitude, intensity, and loudness. They will investigate how these concepts are related to the fundamental principle that sound is energy that moves as a wave.

1. Play the audio, Implosion with Ten Echoes.mov, and ask the students to try to explain what is happening.
   In this video, a strange implosion occurred. The energy of the sound was so high that it overloaded the hydrophone. The second noise was weaker than the first, so the hydrophone was able to record it. From there, the energy of the sound gradually decreased as the sound bounced across the sea floor, resulting in a gradually decreasing intensity. You may want to play the clip a second time, this time showing students the visual. Point out the colour of the first sound and explain that even though it sounds quiet, the colour on the spectrogram reveals the high intensity of the sound.

2. Discuss amplitude, intensity, and loudness. Show students the graphic, Amplitude of Sound Waves.jpg and explain that amplitude is the “height” of the wave. The more energy a sound wave has, the larger the amplitude will be. In general, the higher the amplitude, the greater the intensity and the louder the sound. Sound waves with large amplitudes are described as “loud” while sound waves with small amplitudes are described as “quiet” or “soft”.
   - Note that intensity of a sound wave is the rate of energy transfer and is a quantitative measurement. Loudness is a perceptual response to the intensity of a sound and is a subjective quality (i.e. two people may listen to the same sound and perceive different loudness). For the purposes of this lesson, simply ensure that students understand the relationship between energy, amplitude, intensity, and loudness.

   Ensure students understand the difference between amplitude and frequency. Discuss with them that even very low frequency waves can have high amplitude and high-pitch sounds can have low amplitude. In the “Hook” at the beginning of the lesson, the sound was the same, but the amplitude was different.
3. Modify the “Sound Waves” kinesthetic activity to demonstrate amplitude. Have the students create a low amplitude wave by barely lifting their arms as they pass the sound down. Then, create a high-amplitude sound by having them lift their arms as high as they can down the line. Remind students that the frequency (pitch) of the wave will not have changed. What changed was the amount of energy that was in the wave and thus the amplitude, intensity, and loudness changed.