Activity title: Sound Lab

Subject: Physical Science

Grade Level: 8-10

Average Learning Time: Three hours

Lesson Summary: Students will complete hands on Sound Lab.

Overall concept: How does sound work and what factors affect the speed and quality of sound?

Specific concepts:
Properties of sound and how sound travels through different mediums
SONAR

Focus questions:

1. How does sound travel?

2. What affects the speed of a sound wave?

3. Does sound travel faster in solids, liquids, or gases. Explain why? (Think about the Dominoes demo.)

4. Looking at the above speed of sound formula, how could we manipulate it to calculate the distance a sound wave travels?

5. Ms. Marvin is camping in Glacier National Park. In the midst of a glacier canyon, she makes a loud holler. She hears an echo 1.22 seconds later. The air temperature is 20 degrees C. How far away are the canyon walls?

6. Explain in detail how your string telephone was able to transmit sound from one cup to the other.

7. Summarize the qualitative observations of your mini experiment. Propose scientific explanations for the differences observed between the 2-3 different cups. Use vocabulary words: pitch, loudness, clarity

8. Why doesn't the sound produced on one end of the string telephone echo back to its starting location? (Hint: Think about the anatomy of the ear.)

9. Using your knowledge of sound and what you have learned from this lab, explain how multibeam sonar works. Include in your answer, physical ocean factors that must be considered in order to get accurate depth data.

Objectives:

- Students will be able to list 5 physical factors with 80% accuracy that effect the speed and quality of sound.

- Using their string telephone qualitative observations, students will be able to scientifically explain with 70% accuracy the observable differences between their 3 string telephone conditions.

- Students will be able to apply their knowledge of sound and string telephones by solving three SONAR word problems with 70% accuracy.

Background Information: (taken from my NOAA TAS blog)

In order to understand the complexities of sonar, it is important to understand the properties of sound. Sound is a pressure wave that travels when molecules collide with each other. We know that sound can travel in air, because we experience this every day when we talk to each other, but it can also travel in liquids and solids (which whales rely on to communicate). As a general rule, sound travels much faster in liquids and solids than in air because the molecules in liquids and solids are closer together and therefore collide more often, passing on the vibration at a faster rate. (The average speed of sound in air is about 343 meters every second, whereas the approximate speed of sound in water we have been measuring is around 1475 meters every second). Within a non-uniform liquid, like saltwater, the speed of sound varies depending on the various properties of the saltwater at the survey site. These properties include water temperature, dissolved impurities (i.e. salts, measured by salinity), and pressure. An increase in any of these properties leads to an increase in the speed of sound, and since we're using the equation distance = speed * time equation, it is crucial to consistently measure them when seeking depth measurements.

To measure these properties, a device called a CTD (Conductivity-Temperature-Depth) is used. Conductivity in this acronym refers to the free flowing ions in salt water (Na and Cl, for example), which are conductive and the concentration of these ions determines the salinity of the water. The CTD measures these three properties (Conductivity, Temperature and Depth) so the speed of sound in the water can be calculated at every point in the water column

Introduction to multibeam sonar:
http://oceanexplorer.noaa.gov/okeanos/edu/collection/media/hdwe-MMBkgnd.pdf

http://oceanexplorer.noaa.gov/explorations/09bermuda/background/multibeam/multibeam.html

Common misconceptions:

- Loudness and pitch are the same thing.
- Hitting an object harder changes the pitch.
- Sounds can travel in empty space.
- Sounds cannot travel through liquids or solids.
- Sounds travel faster in hotter air (vs. colder air) because the air molecules are moving faster.

- Sounds travels faster in gases than solids.
- Sounds waves transport matter.
- Waves do not have energy.
- You can see and hear a specific event at the same moment in time.
- When waves "hit" a solid surface, they are destroyed.

Materials:
Cups of all sizes and materials (plastic, Styrofoam, paper etc.)
Different types of string (ex. Cotton, polyester, nylon etc.)
Dominoes
Scissors
Tape
Paper clips

Technical requirements:
Document camera

Teacher preparation:
- Read and understand all necessary scientific background information
- Understand major student misconceptions and how best to address them
- Make copies of lab report
- Do a trial version of lab with a few colleagues where several string telephones are made and the domino demonstration is practiced

Keywords:
Sonar, pitch, loudness, frequency, intensity

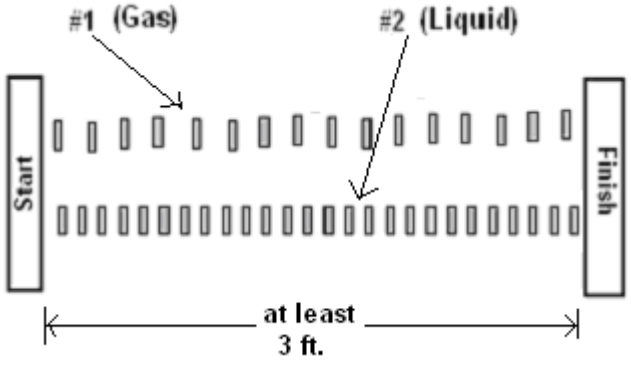
Pre-assessment strategy:
Interactive powerpoint on multibeam sonar used on NOAA ship Rainier and importance of this technology in mapping the ocean.

Lesson procedure: (Refer to Sound lab document throughout this procedure)
This lesson is for a 55 minute class period.

1. Essential question and application to SONAR
    - Gauge student background knowledge

2. Frontload 5 new vocab words

3. Racing Domino demonstration



    - Predictions from students regarding which row will fall faster

- Speed of sound is directly related to the spacing of the atoms or molecules in which the sound is traveling. The closer the atoms or molecules are to one another, the faster the sound will travel within the material.
- Application of this concept to sound speed in air, water, solids like wood.

4. Students answer pre-lab questions individually.

5. Speed of sound formula and word problems

6. Application to SONAR

7. String telephone activity
    - Students work in groups of 3
    - Each group picks only 1 independent variable to change and lists all of the constants
    - Students must complete predictions before getting materials to build string telephones

8. Lab conclusion questions
    - Students discuss answers to questions within their group. They write down answers in their own words.

Assessment and evaluation: completion of Sound Lab report

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STANDARDS

State Science Standards Addressed:

Scientific Inquiry:

H.3S.2 Design and conduct a controlled experiment, field study, or other investigation to make systematic observations about the natural world, including the collection of sufficient and appropriate data.

H.3S.3 Analyze data and identify uncertainties. Draw a valid conclusion, explain how it is supported by the evidence, and communicate the findings of a scientific investigation.

Physical Science, *Interaction and Change*

H.2P.3 Describe the interactions of energy and matter including the law of conservation of energy.

8.2P.2 Explain how energy is transferred, transformed, and conserved.

Physical Science, *Structure and Function*

8.1P.3 Explain how the motion and spacing of particles determines states of matter.

Engineering Design

H.4D.5 Describe how new technologies enable new lines of scientific inquiry and are largely responsible for changes in how people live and work.

H.4D.6 Evaluate ways that ethics, public opinion, and government policy influence the work of engineers and scientists, and how the results of their work impact human society and the environment.

Ocean Literacy Principles and Concepts Addressed:

Essential Principle 5. The ocean supports a great diversity of life and ecosystems.

Fundamental Concept e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Essential Principle 7. The ocean is largely unexplored.

Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

National Science Education Standards Addressed:

Structure and properties of matter:

12BPS2.4 The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

Interactions of energy and matter:

12BPS6.1 Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

Understandings about science and technology:

12EST2.2 Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.

12EST2.3 Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

Science and technology in local, national, and global challenges:

12FSPSP6.1 Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

Sound Lab

Essential Question:
How does sound work and what factors affect the speed and quality of sound?

Key Vocabulary:
Sound-mechanical vibrations travelling through a medium

Frequency-number of vibrations each second (measured in Hz)

Pitch-human perception of the frequency of sound

Intensity-amount of energy each wave transports each second across a surface

Loudness-human perception of sound intensity

Pre-lab questions:
1. How does sound travel?

2. What affects the speed of a sound wave?

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Speed of sound formula:

4. Looking at the above equation, how could we manipulate it to calculate the distance a sound wave travels?

5. Ms. Marvin is camping in Glacier National Park. In the midst of a glacier canyon, she makes a loud holler. She hears an echo 1.22 seconds later. The air temperature is 20 degrees C. How far away are the canyon walls?

SOnar: A machine sends out sound waves. The sound waves bounce off the seafloor; the reflected sound waves are detected by the machine. The distance between the machine and the reflecting surface can be calculated from the time the sound takes to travel to the seafloor and back. By making measurements in different places, the contours of the seafloor can be plotted. As a general rule, the closer you can get the instrument to the seafloor, the greater the resolution of the contour map.

String Telephone Activity:

Task: Chose one factor that will affect the clarity, pitch and loudness of sound waves travelling through a string telephone.

Independent variable:

_____

Constants:

_____

Data Table

Independent Variable	Predictions Use all 3 words: Clarity, Pitch, Loudness	Qualitative Observations Use all 3 words: Clarity, Pitch, Loudness
1.		
2.		
3. (IF TIME)		

Conclusion Questions:

6. Explain in detail how your string telephone was able to transmit sound from one cup to the other.

7.Summarize the qualitative observations of your mini experiment. Propose scientific explanations for the differences observed between the 2-3 different cups. Use vocabulary words: pitch, loudness, clarity

8.Why doesn't the sound produced on one end of the string telephone echo back to its starting location? (Hint: Think about the anatomy of the ear.)