NOAA TAS Lesson Plan (Science and Research):

Activity Title: Sound waves and hydrography

Subject (Focus/Topic): This is a physics-based lesson intended to introduce students to the role of sound waves in hydrography.

Grade Level: 7-12

Average Learning Time: Roughly one week, depending on the age of the students.

Lesson Summary (Overview/Purpose): The students will participate in a series of learning stations, each of which will introduce them to a key concept for understanding hydrography.

Overall Concept (Big Idea/Essential Question):
Scientists on NOAA hydrography ships use an understanding of sound waves to determine the depth of the ocean. This is one example of the many different techniques scientists in many disciplines use to gather information that can not be seen by the naked eye.

Specific Concepts (Key Concepts):
Waves are a periodic oscillation in a substance that transfer energy and exhibit a set of characteristics such as reflection and refraction.
Sound is a wave and exhibits all behaviors associated with waves (velocity, reflection, refraction, etc).
The distance between two objects can be calculated by multiplying the velocity by the time.

Focus Questions (Specific Questions):

What is hydrography?
Why does NOAA have ships dedicated to hydrography?
What methods were used for hydrography before modern technology?
What is a wave?
What can we measure about a wave?
How do waves behave when they hit a boundary?
How can we use the behavior of a wave to determine the distance between objects?
How does this use of waves show up in nature?

Objectives/Learning Goals:

1. Students will be able to explain the importance of hydrography to commercial, recreational, and governmental shipping and boating given a geographical location, providing at least two examples.
2. Students will be able to predict the behavior of a wave given a picture with 8 out of 10 correct predictions.
3. Students will be able to calculate the distance between two objects given information about the speed of a wave and the time of travel with 8 out of 10 correct calculations.

4. Given measurement tools (manual and electronic), students will be able to develop a depth map of a sample “ocean floor” using multiple trials with 90% accuracy.
5. Students will be able to identify potential flaws with their measurements given an experimental procedure, identifying at least two errors to consider.

Background Information:
Students should be able to differentiate between water and land on a map. They should also be able to describe general patterns in ocean depth when looking at a map (features such as a continental shelf, trenches, expected areas of greater depth or shallowness, and so on). For students in urban areas who have not been exposed to this or whose state curriculum does not address these areas, it may require extra time. This would be a great opportunity for additional inquiry-based lessons using maps, and/or field trips to local waterways.

Common Misconceptions/Preconceptions:
Waves can be confusing for students because rather than a physical object traveling through space, a disturbance is traveling through space and an individual particle is simply oscillating back and forth. This makes the idea of reflection and refraction challenging, because it isn’t as if a tennis ball is bouncing off a wall, but a disturbance is bouncing. Another misconception can be that sound only travels in air. Connecting the discussion to various animals that use echolocation to find prey or obstacles can help address this.

Materials: List all the materials necessary to teach this lesson.

A “hydrography box”. (I made my own using an old aquarium and paper mache. Designing your own allows you to put in whatever sea-floor features you want).
A “depth stick” for the low-technology hydrography box.
A “motion detector” (Vernier, PASCO, etc) for the hi-tech hydrography box.
A computer with data collection software.
Class set of slinkies.
Handouts/graphic organizers to help students organize their work

Technical Requirements: List any technical resources needed to teach the lesson.

Computer and motion detector (at least one)
If it all possible, a class set of computers for one part of the lesson would be ideal.

Teacher Preparation:
The teacher should practice each of the activities before using them with students to determine where students might have questions, what management strategies will work best for their group of students, and how much time specifically each portion of the lesson will take.

Keywords:

Hydrography
Reflection
Refraction
Velocity

Oscillation

Pre-assessment Strategy/Anticipatory Set (Optional):

How deep is the ocean?
What do you know about waves?

Lesson Procedure: List the specific steps to follow in order to teach the lesson.

1. Introduction to hydrography (using low-tech hydrography box)
    a. Start by discussing pre-assessment question, "How deep is the ocean?" This will allow students to share their thoughts about the depth of the ocean. The teacher should push students to identify places where they think the ocean is shallower or deeper.
    b. Look at a map of the United States and discuss shipping lanes, recreational activities.
    c. Why do we need to know the depth of the ocean? How can we figure out the depth of the ocean? (Even though there are established methods, brainstorming ideas of their own is an important step for students to consider the challenge of gathering this type of data as they begin to learn about it.) Explore low-tech hydrography box and have students develop a depth chart for the tank using measurements from the stick. What are the limitations of this method?
    d. Compare a regular map to a navigational chart.
    e. Look at old navigational chart developed using lead-lines: note the distances between measurements and discuss need to develop more complete charts.
2. Exploring waves with slinkies
    a. A key part of the inquiry process is to allow students to make observations and develop questions of their own. To begin doing this for this unit, students will work in groups playing with slinkies. Initially, students should be allowed to do whatever they want (within reason for acceptable use of the slinkies).
    b. After setting up appropriate behavioral expectations for use of classroom materials, allow students to play with slinkies, explore behavior, and develop questions about what they see. It is very important that students understand that overstretching the slinkies or releasing one end when they stretch could destroy them. Ask students to sketch pictures of what they see.
    c. Challenge students to create certain motions. Transverse vs. longitudinal waves (depending on which way they pull the slinky); pulse vs. continuous wave; reflection of a boundary. Change the length of the slinky and observe what happens. Time the pulse traveling down and back. What can we do with this information?
    d. Develop a list of questions that students have as a result of their investigation with slinky.
3. In depth exploration of waves (if possible; this step requires access to a computer; it can either be done as a demo and/or teacher centered activity)
    a. Repeat steps from slinky exploration; pausing to talk about specific terms (see "Key Words" section above).

    b. The ultimate goal is to develop an understanding of wave reflection, and the mathematical relationship between travel time, velocity, and distance.
4. Using motion detectors for hi-tech hydrography box
    a. Students now have the basic tools to understand simple sonar mapping. They have used a hydrography box in a low-tech setting, have explored the behavior of waves. As a result, using the "invisible" method of a sonar tool should make more conceptual sense now.

Assessment and Evaluation:

For the first objective, students should participate in a discussion with the class.
For the calculation objectives, students can perform a simple quiz.
For the remaining objectives, students should ideally do a "lab challenge" where they work in groups to apply their skills.

Standards:

National Science Education Standards: Grades 9-12 Content Standards:

- Content Standard A: **all students should develop:** Abilities necessary to do scientific inquiry and Understandings about scientific inquiry
- Content Standard B: **As a result of their activities in grades 9-12, all students should develop an understanding of:** Structure and properties of matter, Motions and forces, Conservation of energy and increase in disorder, and Interactions of energy and matter

Ocean Literacy Principles Addressed:

- The ocean is largely unexplored

State Science Standard(s) Addressed (Pennsylvania):

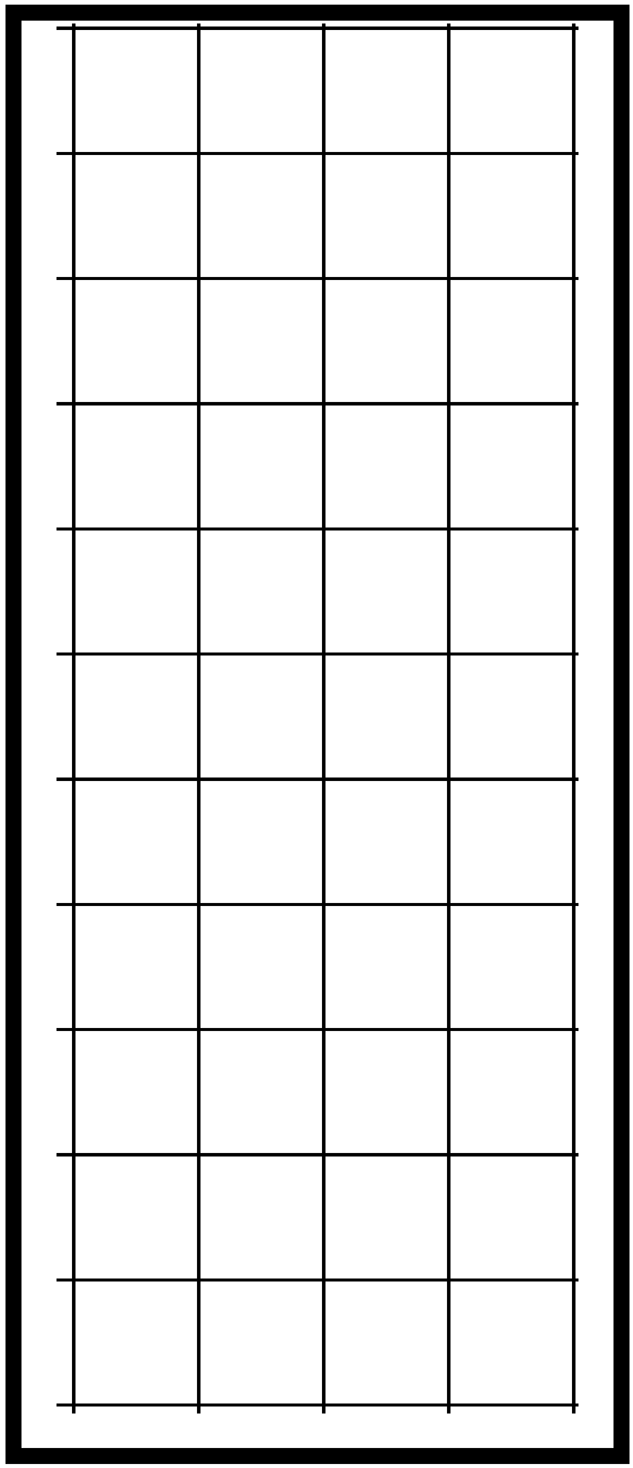
3.1.12.B: Apply concepts of models as a method to predict and understand science and technology.
3.1.12.E: Evaluate change in nature, physical systems and man made systems.
3.4.12.C.3: Apply the principles of motion and force: Analyze the principles of translational motion, velocity and acceleration as they relate to free fall and projectile motion.
3.2.12.A: Evaluate the nature of scientific and technological knowledge.
3.2.12.B: Evaluate experimental information for appropriateness and adherence to relevant science processes.
3.2.12.C: Apply the elements of scientific inquiry to solve multi-step problems.
3.4.12.C.1. Apply the principles of motion and force: Evaluate wave properties of frequency, wavelength and speed as applied to sound and light through different media

Additional Resources:

http://phet.colorado.edu/en/simulation/wave-on-a-string
This website is outstanding for allowing students to experiment with the properties of waves and develop questions and ideas of their own regarding the behavior of the waves. It is more easily controlled than many other methods for exploring the behavior of waves and can be used to develop clear ideas about waves.

Hydrography Box!

Use the depth stick to find the depth of the sea floor! Color-code the grid below to keep track of your measurements.



Do you notice anything weird? What do you think that might be?

Sonar Mapping!

Use the sonar probe to measure the depth of the sea floor!

Draw a profile of each section of the tank:

Do you notice any features that are unexpected and require further investigation?

Slinkies and Waves!

Sketch a picture of what the slinky does:

1. When you give it a sideways shake (this is called a **transverse** wave):

2. When you scrunch up a section and let it go (this is called a **longitudinal** wave):

What can you measure about the slinky?

How can you figure out how fast the pulse moves?

If you stretch the slinky out more, what happens to the speed of the pulse?

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