NAVAL HISTORY STEM-H LESSON PLAN

TEACHER HELP GUIDE

LESSON PLAN: How Does Sonar Work? Mapping the Ocean Floor

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INSTRUCTIONAL GOAL: This lesson provides students a basic understanding of how sonar (SOund NAvigation and Ranging) is used to map the ocean floor. Students use a simple calculation to determine the depth of the ocean floor at 15 points from Miami Beach eastward to the wreck of the SS Sapona in the Bahama Islands. This is a total distance of 53 miles.

BACKGROUND: : Sonar technology has made giant leaps forward since its invention and first uses during World War I. Development of this technology has been an invaluable tool vital to national security and the success of the United States Navy particularly during the Cold War.

As the former Soviet Union and the United States raced for nuclear superiority, each country strategically targeted the other's supply of land-based nuclear warheads. The solution to these relative "sitting ducks" was a launching method that couldn't be tracked from the air, wouldn't remain in the same location, but could be deployed quickly; the solution was submarines.

With both countries moving to this mobile solution, finding the enemies mobile warheads became an important endeavor which lead to a race in the advancement of submarine technology. Submarines are blind in that they do not have windows, windshields, or portholes to see your surroundings. Submarines operate at depths where there is very little if any light. It would be pointless to have a camera or porthole in the darkness of the deep sea, not to mention that considerations for creating weak points in the hull, increasing drag and disturbances in the water that would likely give away the submarines presence to enemy ships. Instead, submarines rely on a type of echo-location, **Sonar**, to "hear" their way around underwater obstacles or find an enemy ship.

While starting out as a military technology, sonar is readily accessible today. Sonar is one of three methods (along with satellites and submersibles) used to explore the ocean floor. In fact the technology is so accessible that even private pleasure craft and fishing boats utilize sonar technology to avoid underwater obstacles and to find fish.

Sonar can be either active or passive. Passive sonar arrays simply collect any sound travelling through water. During WW I and WWII ships used hydrophones (underwater microphones) to listen for the sound of submarines. Active sonar arrays actually emit sound which travels through the water until it bounces off of an object and echoes back to the array's receiver. Knowing the speed of sound in water (saltwater: 5,000 ft/sec) the distance to the object can easily be calculated.

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Mapping the global ocean floor remains one of the grand challenges of oceanography. Humankind has made more progress during the past 20 years of mapping the surface of our moon, Venus and Mars than during the past 500 years of mapping the oceans (Wright). Sandwell et al. (2003) estimate that it will take another 125 years to fully map the ocean floor at a resolution of 200 m, the level of detail needed for most geological studies and deep nautical charts. An even higher resolution is needed for global near-shore ocean resource management, conservation, and spatial planning. Much of this mapping is done by the National Oceanic and Atmospheric Administration (NOAA). You can follow the NOAA Research Ship Okeanos Explorer searches live at: http://oceanexplorer.noaa.gov/okeanos/explorations/acumen12/welcome.html . Click on "live feed".

Similarly, you can follow Dr. Robert Ballard's Research Ship Nautilus undersea searches live at: www.nautiluslive.com .

Vocabulary:

Echolocation (biosonar)	U-boats	Theory of Continental Drift
Nocturnal	Acronym	Theory of Seafloor Spreading
NOAA	Density	
Passive	Salinity	
Active	Cold War	

RESOURCES:

S.S. Sapona can be located on Google Earth at: 25°39'2.22"N 79°17'36.17"W

For more history on how the ocean has been mapped check out:
www.msnucleus.org/membership/html/jh/earth/oceanography/index.html

For more information on how sonar has been used by the US Navy check out:
http://usnavymuseum.org/Ex2_Sonar.asp

Sandwell, D., Gille, S., Orcutt, J.A. and Smith W. (2003). Bathymetry from space is now possible, *Eos, Transactions of the American Geophysical Union*, *84* (5), 37, 44.

STANDARDS: North Carolina Department of Public Instruction

Earth and Space Science

1.02 Design and conduct scientific investigations to answer questions related to earth and environmental science.
- Organize data into charts and graphs.
- Analyze and interpret data.

1.03 Evaluate the uses of imaging techniques in the earth and environmental sciences.

2.02 Analyze the historical development of the theory of plate tectonics.

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History

6.02 Identify the areas of United States military, economic, and political involvement and influence.
8.02 Identify political and military turning points of the war and determine their significance to the outcome of the conflict.
10.02 Identify military, political, and diplomatic turning points of the war and determine their significance to the outcome and aftermath of the conflict.
10.05 Assess the role of organizations established to maintain peace and examine their continuing effectiveness.
11.05 Examine the impact of technological innovations that have impacted American life.

INSTRUCTIONAL PROCEDURES FOR LESSON: It is important for students to understand that in actuality, a ship using sonar to map the same 53 miles of ocean floor would be processing millions of echoes as it travels resulting in a much more detailed visual of the ocean floor. Examples can be found on the NOAA website: http://www.oceanexplorer.noaa.gov/welcome.html .

INSTRUCTIONAL PROCEDURES FOR ACTIVITIES: To get the correct answer for depth, the time must be divided by two, then multiply by the velocity of the sound wave in sea water as shown in the formula:

$$D = (T/2)(V)$$

where T is the time it took for the sound wave to echo back to the array, V is the velocity of sound in water and D is the calculated depth. When a computer calculates thousands of these per minute, it produces a detailed picture of what the underwater environment looks like. The data set it produces is referred to as sounding data. The students data will produce a bottom contour between Miami Beach and SS Sapona by graphing the sounding data.