NAVAL HISTORY STEM-H LESSON PLAN

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

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ACTIVITY NAME: What is SONAR? How Does It Work?

OBJECTIVE: Provide 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.

MATERIALS: None

INSTRUCTIONS:

Sonar is an acronym that stands for **So**und **Na**vigation and **R**anging. Sonar is used on boats and submarines to navigate around obstacles, but the concept was perfected in nature long before humans developed it electronically.

Bats are nocturnal (but not blind) and whales and dolphins dive to depths where there is little light. In order for these organisms to find their way through the darkness, communicate, and search out prey, they have evolved a heightened sense utilizing sound waves called echolocation. These organisms generate a noise and from the amount of time it takes the sound to bounce off an object and return they can gauge how far away the object is, the direction in which it is moving and its size.

This is somewhat like the instantaneous calculations your brain does when you crumple a piece of paper and toss it into a trashcan. Without thinking about it, your brain uses information from the light waves received by your eyes to judge the distance and opening of the trashcan. When you calculate it correctly, the paper goes in the trashcan. Bats and dolphins have adapted to their environments by developing the ability to do this with sound waves. Humans have acquired this ability electronically.

1. What is an acronym? Is the word “sonar” an acronym? Explain your answer.
2. What is the difference between SONAR and echolocation?
3. How is a baseball player who is up to bat like a dolphin using echolocation?

Types of Sonar and How They Work

The earliest sonar systems were developed during World Wars I & II. Originally, these passive arrays consisted of little more than a hydrophone (underwater microphone) dropped into the water to listen for the sound of German U-boats. The problem with this passive method was that if an enemy sub was not moving than it wouldn’t be making sound rendering the passive sonar useless. The creation of active sonar helped to solve the problem of silent enemy submarines.

Active sonar arrays generate their own sound waves. These actively emitted frequencies move through the water. When the sound strikes an object, the sound waves are reflected back to the array where the receiver picks up the echo. The sonar equipment records how long it took the sound to travel to the object and bounce back. If you know the speed of sound in water then it is an easy calculation to determine the distance to the object. For example, if the sound wave makes the round trip to the object and back in 2 seconds, then we know that it only took one second to get to the object. All we need to know is how fast the sound travels.

4. What is the difference between Active and Passive Sonar systems?
5. Imagine a ship or submarine is using an active sonar array and sending out a pulse of sound to look for an enemy submarine. What is one problem this could cause?

While density, salinity and temperature can affect the speed of sound in water, the average velocity in average seawater is 5,000 ft/sec. That is about 4.5 times faster than the speed of sound in the atmosphere! The receiver then quickly calculates the depth of the water. The basic formula is: $(T/2)(V)=D$ 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. This sounding data can identify the contour of the seafloor, whales, schools of fish and of course enemy submarines.

6. Does sound travel faster or slower in water compared to when it travels through the air?
7. How fast does sound energy travel in water?
8. What is the formula used to calculate depth?

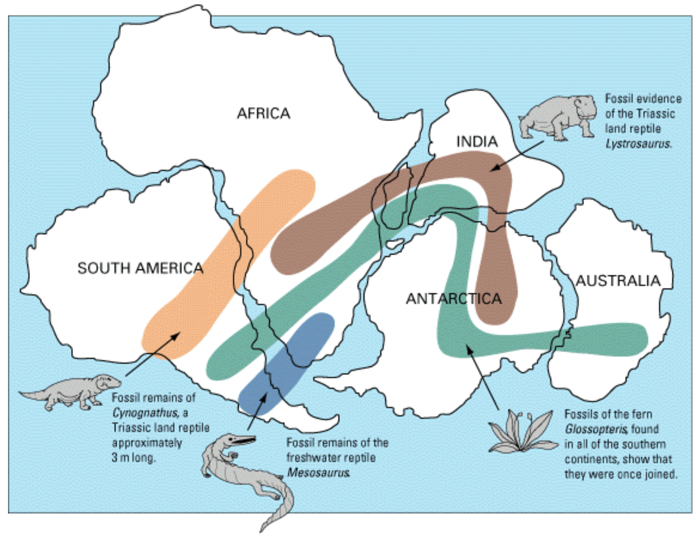
Since the World Wars, advancements in electronics and data processing have led to sophisticated improvements and refinement in sonar technology. Many of these advancements occurred as a direct result of the Cold War during the 1950s-1980s. It could easily be argued that advancements in sonar technology have prove to be vital to national security and the success of the United States Navy in posing a formidable deterrent to nuclear attack.

Throughout 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 to develop a system that couldn’t be easily targeted from the air or identified by satellite. This system would need to be mobile changing location frequently. Most importantly, the system had to be deployed quickly. The solution: Hide the warheads underwater and launch them from submarines.

This resulted in a secondary race between the opposing sides. With both countries moving to this mobile solution, finding the enemies mobile warheads became an important endeavor. One important thing for you to remember as you read is that submarines are “blind”. They don’t have windows, windshields, or portholes to see your surroundings. Considering that sunlight doesn’t penetrate very deeply into seawater. In fact, according to the National Oceanic and Atmospheric Administration, very little light makes it past a depth of 200 meters (650 feet). While their actual depth limits are classified, the U.S. Navy does say that 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 they would create weak points in the hull, increase drag, and in turn create disturbances in the water that could be heard on the sonar of enemy ships. Silence is crucial to the mission of every military submarine.

9. Why was sonar technology so important during the cold war?
10. What are two reasons for why engineers don't install windshields in submarines so they can be piloted like a plane?

Beyond Military Use



While starting out as a military technology, sonar has proven useful in increasing our understanding of the world's oceans.

In 1912, Alfred Wegener, a meteorologist proposed his theory of Continental Drift. Wegener's theory stated that the land masses of the world had at one time been joined. He named this land mass, Pangaea. Wegener cited fossil and geologic evidence from both sides of the Atlantic to support his theory. Unfortunately, Wegener's theory was rejected by the scientific community because he couldn't explain what could have moved the continents. Wegener died in 1930 while on an arctic expedition collecting data to support his theory. Sonar played a role in helping prove Wegener's theory.

During World War II a US Navy Captain by the name of Harry Hess stumbled upon a significant discovery. While on board his ship he found that sonar soundings showed a massive mountain range running through the Pacific Ocean. Further exploration using sonar revealed what we know today as mid-ocean ridges. Mid-ocean ridges, it was later discovered are places where the earth's crust separates, allowing magma to rise to the surface forming new rock material. Today this is called the Theory of Sea Floor Spreading and provided the mechanism that supported Wegener's Theory of Continental Drift.

Today, sonar and submarine technology is readily accessible. Sonar, manned and robotic submarines and even satellites are used to gain a better understanding of the world's oceans.

In fact sonar technology is available at any store that sells sporting goods. Small Sonar displays like the one shown to the right, can be bought for a surprisingly small amount of money. Civilians with small motor boats can use these displays to avoid underwater obstacles and to find fish. Commercial fishermen have used these displays for so long to help them find large schools of fish, many ecologists are finding sharp reductions in fish populations. Overfishing is a growing problem throughout much of the world.

11. Who was Alfred Wegener and what is he known for?
12. Who was Harry Hess and what is he known for?
13. What are mid-ocean ridges?
14. Calculate ocean depths and determine what the ocean floor looks like between Miami Beach and the Bahamas by completing the ocean floor worksheet. You'll need to use the data map provided by your teacher.