SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

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Beneath the Sea

Activity One: Grades 5-8

Blowing Ballast

Submarines and deep dive submersibles like *Alvin* depend upon ballast tanks to help control their vertical position within the water column. When the tanks are filled with seawater, the submarine's weight is greater than the buoyant force that pushes upward on its hull. As a result of this imbalance, the submarine dives. When the seawater is pumped from the tanks, the submarine becomes lighter. This shift in the balance of forces pushes the submarine to the water's surface.

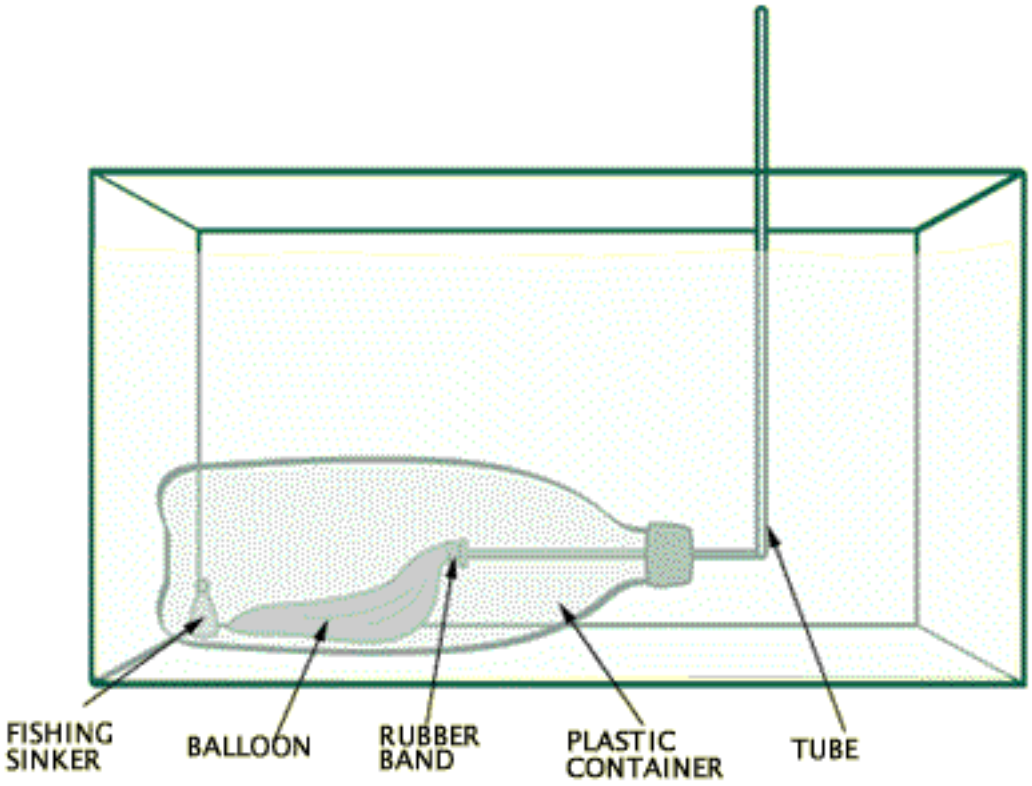
In this activity, you'll have the opportunity to build a model of a submersible. Within its clear plastic hull, a balloon will serve as a type of ballast tank. By varying the inflation of this balloon, you will be able to control the buoyancy of the submersible.

This activity page will offer:

- A hands-on experience in buoyancy
- An observation of a working ballast tank
- An operational definition of blowing ballast

MATERIALS

- 1-liter clear plastic beverage container
- Large balloon
- Rubber band
- Fishing weights
- Tape
- Aquarium tubing (rubber hose or a chain of plastic straws with flexible necks will also work)
- Large tub or tank



PROCEDURE

1. Stretch a balloon by inflating and deflating it about a dozen times. If necessary, pull and stretch out the balloon to make it more flexible.
2. Obtain a length of plastic aquarium tubing. If you do not have tubing, you can construct such a tube by connecting straws. If you are using straws, secure them with waterproof, sturdy tape, and make sure to place a bend in the straw as shown above.
3. Place the mouth of the balloon over one end of the straw/tubing. Use a rubber band to secure the balloon to the straw/tube end. Make sure that the rubber band does not squeeze off the air passage.
4. Insert the balloon into the 1-liter clear plastic beverage container.
5. Place the container in a large tank or tub of water. Let the container fill with water. As it fills with water, the container should sink. If it does not sink, add several fishing weights until the water-filled container settles to the bottom of the tank.
6. Make a prediction. Suppose you blew a small puff of air into the balloon. How would that change the buoyancy of your "submersible"?
7. Suppose you inflated the balloon to a greater volume? Would that offset the sub's weight?

Questions

1. Why was it necessary to "pre-stretch" the balloon?
2. Why was it important to keep the air passageway unblocked?
3. What was the purpose of the fishing weights?
4. What happened when you blew into the open end of the straw/tube?
5. Consider the balance of forces that are responsible for the surfacing and diving of your classroom submersible. How can you apply what you've learned to *Alvin's* operation?

EXTENSIONS

A Biological Connection

Some species of seaweed have tiny air bladders that line their stem-like parts. Think about it. What survival advantage might these sacs of air offer?

Historical Fiction

Historical fiction is a writing style that is based upon the blend of historical events and fictional characters or exchanges. Can you image what it would have been like to be lowered down in a bathysphere, like William Beebe? In 1930, this four-foot-in-diameter steel sphere was the first to dive below 600 feet, eventually reaching an unprecedented depth of 3028 feet. How would it have felt to be the first person to see the deep ocean? With your instructor's approval, research the bathysphere and then write your own short story based upon these dives. Color the history with a fictional dialogue between yourself and the support crew at the surface.

Spy Stories

Learn about "Project Jennifer" and the CIA's secret operation to raise a Soviet sub from the seafloor. Using a modified research vessel called the *Glomar Explorer*, the agency tried to lift the hull into the secret compartment of this huge ship. Check it out at http://www.fas.org/irp/program/collect/jennifer.htm.

WEB CONNECTION

Marine Operations at WHOI

http://www.marine.whoi.edu/ships/ships_vehicles.htm
Learn more about Alvin and the other research vessels at the Woods Hole Oceanographic Institution.

Submarine Construction

http://www.battlestations.org/rules/submarine.html
The basic construction of a submarine and its ballast tanks are illustrated at this site.

William Beebe - Going Deeper

http://www.pbs.org/wgbh/amex/ice/sfeature/beebe.html
Read this biography of William Beebe on *The American Experience* Web site.

The activities in this guide were contributed by Michael DiSpezio, a Massachusetts-based science writer and author of "Critical Thinking Puzzles" and "Awesome Experiments in Light & Sound" (Sterling Publishing Co., NY).

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Beneath the Sea

Activity One: Grades 5-8

Blowing Ballast

ANSWERS

PROCEDURE

6. Make a prediction. Suppose you blew a small puff of air into the balloon. How would that change the buoyancy of your "submersible"? **(Although any air would increase the upward force, a small volume of air may not produce enough buoyancy to raise the sub)**

7. Suppose you inflated the balloon to a greater volume? Would that offset the sub's weight? **(It depends upon the actual weight of the sub. Although a larger volume of air would create a greater upward force, you would still need to produce a counter force greater than the weight of the container.)**

Questions

1. Why was it necessary to "pre-stretch" the balloon?
   (The fabric had to be loose enough to expand when a less powerful push of air was forced into it through the straw.)
2. Why was it important to keep the air passageway unblocked?
   (You needed an unobstructed path for the air to travel to the balloon. Otherwise the balloon would not inflate.)
3. What was the purpose of the fishing weights?
   (The weights added an extra downward force that made the submersible sink when the tank was not filled with air.)
4. What happened when you blew into the open end of the straw/tube?
   (Air moved down the tube and filled the balloon. As the balloon

filled with air, the craft became lighter until it eventually floated to the surface.)

5. Consider the balance of forces that are responsible for the surfacing and diving of your classroom submersible. How can you apply what you've learned to Alvin's operation? **(Like the classroom sub, Alvin's depth is determined by the balance between its weight and buoyancy. But unlike the classroom sub, and most other submersibles, Alvin has a dual ballast system -- fixed and variable. First, fixed steel ballast weights are used to sink the Alvin down to just above the ocean floor. Then those weights are dropped to halt Alvin's descent. Next, the variable ballast system is used to finely adjust the sub's exact depth. Alvin's variable ballast system pumps seawater into or out of tanks to increase or decrease the sub's total weight, just like a normal sub and the one in this activity. But then when it's time to return to the surface, more fixed weights are dropped, and the sub rises. Using fixed weights for descent and ascent this way is very safe, because the weight release mechanisms are simple, and can be operated by hand if necessary. And using a variable system only for fine adjustments at the bottom saves on precious battery power to run the seawater pumps.)**

EXTENSIONS

A Biological Connection

Some species of seaweed have tiny air bladders that line their stem-like parts. Think about it. What survival advantage might these sacs of air offer?
(Like an air-filled ballast tank, the air sacs help keep the stem-like parts afloat. Floating higher in the water exposes them to more sunshine.)

CURRICULUM LINKS

Physical Science:

Properties of Matter, Tension, Buoyancy of Water, Buoyancy of Air, Balanced/Unbalanced Forces

Life Science :

Buoyancy in Plant Life, Photosynthesis

NATIONAL SCIENCE STANDARDS (Grades 5-8)

Science as Inquiry- Content Standard A

Students will collect observational data and think critically about cause and effect relationships.

Students will establish a relationship between evidence and explanation through modeling.

Physical Science - Content Standard B

Students will explore properties of matter such as tension.

Students will observe balanced and unbalanced forces and the resulting motion of an object.

Life Science - Content Standard C

Students will learn about a specialized group of plant cells that specifically function for flotation.

Students will understand how abiotic factors, such as sunlight, can affect plant population growth