Buoyancy Bull's-Eye

GRADE LEVELS	6th-8th ; California Content Standards for 8th
SUBJECTS	Physical Sciences, Investigation and Experimentation
DURATION	Preparation: 10 minutes Activity: 40 minutes
SETTING	Classroom

Objectives

In this activity, students will:

1. learn how organisms float, sink, or hover in water.
2. construct a neutrally buoyant scuba diver.

Materials

- small action figures (one per student)
- small rubber balloons (bag of 100)
- rubber bands (box of 100)
- tooth picks (box of 100)
- pennies (at least 100)
- masking tape (one roll per group)
- paperclips (box of 100)
- buckets (one per group)
- water from the faucet
- towels (2 or 3 per group)
- Buoyancy Bull's-Eye Worksheet (one per student)

Scientific Terms for Students

- **buoyancy**: the ability to float
- **buoyant force**: the upward force exerted by a fluid on a submerged object
- **density**: mass per unit volume

Educator Background

Scuba diving is an excellent hobby for underwater naturalists. Along the California coast, scuba divers can see kelp forests, sea otters, many species of fish, sea lions, and a variety of invertebrates such as octopuses, crabs and urchins. With the aid of specialized equipment, divers can prolong their visit below the surface for a lot longer than they can hold their breath! Expert divers have set records exploring ocean depths of approximately 1000 feet (305 meters), but, most scuba divers swim closer to shore where the water is shallower.

Scuba diving requires training as well as specialized equipment, called SCUBA (Self-Contained Underwater Breathing Apparatus) gear, which includes one or two oxygen tanks strapped to the back of the diver and a regulator that fits into the mouth and controls the flow of air. It is essential for divers to be able to breathe underwater, but they also need to be neutrally buoyant to prevent floating to the surface or sinking to the bottom. What makes divers sink or float depends on a combination of the density of their bodies, the density of the diving equipment they wear, and the density of sea water.

Water has a natural force that pushes up towards the surface. This is called the buoyant force. The buoyant force comes from the pressure exerted on the object by the fluid. Pressure increases as depth increases, so the pressure on the bottom of an object is always greater than the force on the top resulting in a net upward force.

The net upward buoyancy force is equal to the weight of fluid displaced by an object. This force enables an object to float or at least seem lighter. If the weight of an object is less than the weight of the displaced fluid when fully submerged, the object has an average density that is less than the fluid and has a buoyancy that is greater than its own weight which results in the object tending to rise. If the object has exactly the same density as the fluid, then its buoyancy equals its weight and the object will remain submerged in the fluid, but will neither sink nor float. An object with a higher average density than the fluid has less buoyancy than weight and it will sink.

Other forces act on a floating body in the ocean, such as drag (due to the density of the fluid), thrust (if the body pushes the water away), and weight (which pushes the body down toward the ocean floor).

The net weight of a scuba diver can be altered by decreasing or increasing density using air or solid weights. Scuba divers can change their density by adding or releasing air from a buoyancy compensator, or BC, a vest that holds air. Solid weights help the diver to stay underwater by increasing their net weight.

The density of tap water is 1 g/cm^3. The water off the coast of Northern California is cold and varies from 50 to 60 degrees Fahrenheit. Cold water can dissolve more salt than warm water. High salinity and low temperatures make the water more dense. Therefore, the physical properties of water off the California coast require divers to wear a thicker wetsuit (to stay warm) and more weights (to add net weight) than they might need to wear when diving in warmer waters in the tropics.

Educator Prep

1. Collect materials (rubber balloons, rubber bands, toothpicks, pennies, and paperclips) and place them in small separate bowls at each group's table.
2. Fill large buckets half full with tap water.
3. Distribute towels to each table. *Teacher tip: Have one towel at each group be a "floor towel" to keep puddles in check and students can use the others to dry their hands in between testing and writing.*

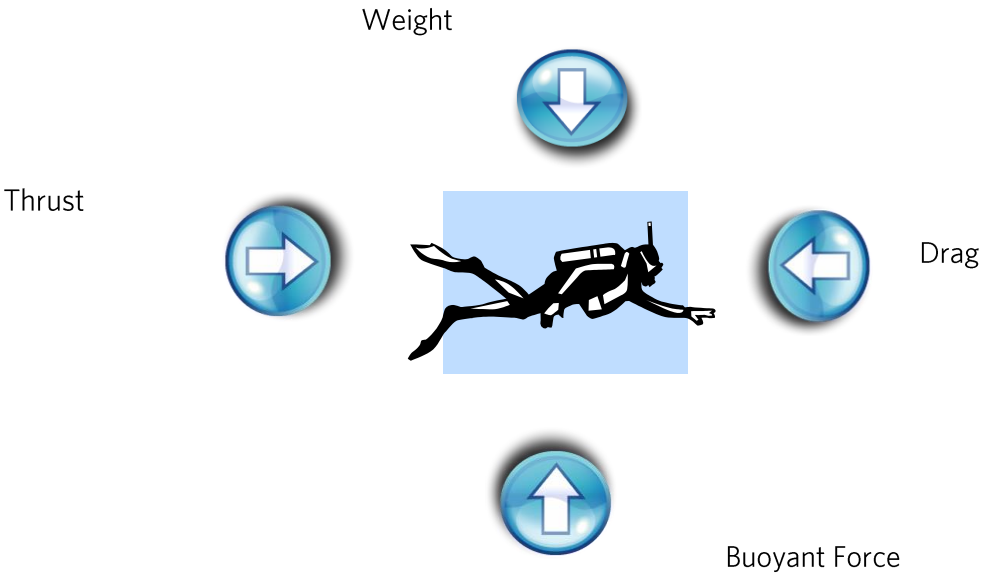
Introduction

1. Show students images of scuba divers and marine animals, such as plankton, fish, and jellies. Ask students why they think these organisms are able to stay in middle of the water column instead of floating to the top or sinking to the bottom.

2. Introduce the term buoyancy (if this has not been explored previously). What keeps these marine organisms buoyant so they don't sink? *(Divers have air tanks plus the natural buoyancy of their bodies, body fish have swim bladders, sharks have special oil in their livers, and some kelp has air pockets to keep it upright.)*

3. Similarly, ask what keeps these organisms from floating to the surface? *(Weight! Divers wear weights, fish and other animals have the mass in their bodies, and animals that live on the bottom of the sea, like sea cucumbers, have their weight and very little buoyancy so they don't float at all.)*

4. If desired, you can draw the diagram below to illustrate the forces acting on an object in the water. Use the diagram to explain how the forces must be balanced for the organism to go where it wants to. Ask the students:
   - What would happen if the diver put on too many weights? Not enough?
   - What if there was a current coming from the rear? What force is that?
   - If there was a current creating drag, what could the diver do to counteract it?



5. Introduce the activity. Students will be using different materials (toothpicks, pennies, paperclips, and balloons) to create a suit for the action figure that makes them neutrally buoyant. Each student will be working on their own action figure, but they do have to share the buckets and buoyancy materials.

Procedure

1. Distribute one plastic figure and one Buoyancy Bulls-Eye worksheet to each student. Have students write a hypothesis about which materials they think they help achieve their goal. They can also make a sketch if it helps. *Teacher tip: If you use science notebooks, you can use those instead of the worksheet.*

2. Separate students into groups of five.

3. Allow students to use as much of the materials provided as needed to make the figure neutrally buoyant. They can use rubber bands or masking tape to attach the materials to the figure.

4. Tell the students to take turns testing the figure's buoyancy in the bucket of water provided to each group.

5. Once they have reached neutral buoyancy, have students record their results and write a conclusion.

Wrap-Up

- Within each group, have students compare their buoyancy devices. What do they have in common?
- Have the class share what worked well, and what didn't work at all. Did anything surprise them?
- What are the benefits to being neutrally buoyant for a scuba diver? *(not sinking to the bottom or floating to the top, being able to swim over the ocean floor away from the turbulent ocean waves and to have a good view of ocean life)*

Correlated California Content Standards

Grade Eight

Physical Sciences

8c. Students know the buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.

8d. Students know how to predict whether an object will float or sink.

Investigation and Experimentation

9a. Plan and conduct a scientific investigation to test a hypothesis.

Next Generation Science Standards

Scientific & Engineering Practices	Disciplinary Core Ideas	Cross Cutting Concept
Developing and Using Models: Develop and revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. **Constructing Explanations and Designing Solutions:** Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.	**PS2.A: Forces and Motion:** The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	**Cause and Effect**: Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Scale, Proportion, and Quantity**: Proportional relationships among different types of quantities provide information about the magnitude of properties and processes. **Structure and Function**: Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Related Performance Expectations

The activity outlined here is just one step towards reaching the Performance Expectations listed below. Additional supporting materials and lessons will be required.

MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.