Estuary Adventures

Objective

Students will work in groups to understand the concept of estuaries, their importance, and the role that density plays in the mixing of fresh and salt water. Students will design their own investigations.

National Science Education Standards Correlations

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry (5-8, 9-12)
- Understandings about scientific inquiry (5-8, 9-12)

Content Standard B: Physical Science
- Properties and changes of properties in matter (5-8)
- Transfer of Energy (5-8)

Content Standard C: Life Science
- Interdependence of Organisms (9-12)

Content Standard E: Science and Technology
- Understanding about science and technology (9-12)

Content Standard F: Science in Personal and Social Perspectives
- Natural Resources (9-12)

Warm-Up

1. You will need a large, clear container filled with water, a can of Diet Coke (or some other diet soft drink) and a can of Coke (or other kind of non-diet soft drink). Ask students which can of soda they think will float and why. Immerse both cans in the water and ask students to explain what happens. (The can of Coke should sink due to its higher density from the sugar it contains.)

Background

Estuaries

An estuary is a partially enclosed body of water formed where freshwater and saltwater mix. Estuaries are influenced by the tides, and are also known as harbors, bays, lagoons, or sounds. It is important to note that not all water bodies by those names are necessarily estuaries. The defining feature of an estuary is the mixing of fresh and salt water, not the name. Estuaries support diverse communities of plants and animals, specially adapted for life at the edge of the sea. Many different habitat types are found in and around estuaries, including shallow open

waters, freshwater and salt marshes, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, sea grass and kelp beds, and wooded swamps.

Almost 50% of the U.S. population live in coastal areas. Unfortunately, when populations increase, ecosystems are altered by the filling of tidal wetlands, dredging of channels, and building on our shorelines. These activities can stress our coastal waters, resulting in a decline in drinking water quality, harmful algal blooms, loss of habitat, and other environmental degradation.

Why are Estuaries Important?

Estuaries are critical for the survival of many species such as birds, mammals, fish, and other wildlife, who depend on estuarine habitats as places to live, feed, and reproduce. Estuaries provide ideal spots for migratory birds to rest and refuel during their journeys. They also serve as nursery grounds for fish, shellfish, and certain species of birds. They may serve as filters for pollution and sediments that enter the estuary from upland rivers. Plants and soils in an estuary help to absorb flood waters, and protect both people and animals from high storm surges. Salt marsh vegetation helps to prevent erosion and keeps the shoreline stable.

Among the cultural benefits of estuaries are recreation, scientific knowledge, education, and aesthetic values. Boating, fishing, swimming, surfing, and bird watching are just a few of the numerous recreational activities people enjoy in estuaries. The tangible and direct economic benefits of estuaries should not be overlooked. Tourism, fisheries, and other commercial activities thrive on the wealth of natural resources estuaries supply. The protected coastal waters of estuaries also support important public infrastructure, serving as harbors and ports vital for shipping, transportation, and industry.

(Information on estuaries adapted from the U.S. Environmental Protection Agency's National Estuary Program)

Density

The density of water is affected by two factors: **temperature** and **amount of dissolved material** (in this case, salt). The relationship between these two factors is important in determining the environment of an estuary, where fresh and salt water meet and mix.

Temperature and Density

Most liquids become denser as they cool, but water's polar molecules change this pattern. While in liquid form, water molecules move around each other randomly. Hydrogen bonds continually form and break between different molecules depending on the energy available. Decreasing water temperatures indicate a decreasing availability of energy. When water temperatures reach 4 degrees Celsius, there is not enough energy available to break hydrogen bonds once they formed, and water reaches its greatest density. As the temperature continues to decrease, the continual formation of hydrogen bonds forces water molecules to line up in crystalline formation. This becomes visible to us when the temperature reaches 0 degrees Celsius and ice forms. This rigid, crystalline structure forces the water molecules to take up more room

then when they were moving randomly in their liquid form. So ice is actually less dense than water. When water gets colder than 4 C, it rises to the surface and freezes, allowing life to persist in deeper waters through the winter months.

Dissolved Material and Density

Salt water is denser than fresh water because it contains salt and other minerals. The salinity of open ocean water is 35 ppt (parts per thousand) which means that 35 grams of salts are dissolved in 1000 grams of water. Another way to think about dissolved material and density is: If we compare a bucket of feathers with a bucket of sand, which would be heavier? Sand is denser (and heavier) than feathers, even though they both take up the same amount of space.

Activity: Adventures in Density

Materials Needed

Eye droppers
Food coloring
Salt
Beakers or jars for sample solutions
Beakers, graduated cylinders or narrow jars for each small group
Access to microwave oven and/or refrigerator, or a faucet that produces very cold and very warm water; (ice cubes may also be used to make cold water)
Student Worksheet

Demonstration

Fill a jar with clear, room temperature tap water. Place the tip of an eye dropper filled with one of the colored solutions halfway into the tap water. Ask students if they think the solution will float or sink, and why. Discuss what happens.

Procedure

Divide the class into groups of four or five students, and ask each group to:

1. Make two separate beakers of salt solution by mixing about one tablespoon salt into one cup water.

2. Fill two more beakers with fresh water.

3. Review the formula for measuring density: Density = mass (in grams)/ volume (in cm^3)
   Find the density of both the fresh and saltwater in the beakers. (Remember to subtract the mass of the beaker when determining the mass of the water.)

3. Color the water in each beaker a different color.

4. Make one fresh- and one salt-water beaker warmer or colder than room temperature. You will end up with something like the following:

   Warm, fresh water (green)
   Cold, fresh water (yellow)
   Warm, salt water (red)
   Cold, salt water (blue)

5. Ask each group of students to design at least two of their own experiments in density using the materials provided. They can use the Student Worksheet to guide them through the scientific method. They might layer warm water on cold water, salt water on fresh water, time how long it

takes layers to mix if sitting undisturbed, layer all four solutions, add more salt to the salty water, etc.

6. Ask students to summarize their experiments and share their findings with the rest of the class. Ask them to explain how water density plays a role in coastal environments. In what ways would density affect how pollution is dispersed in the water? How would seasonal changes affect water density? What kind of adaptations would animals living in an estuary need in order to live there? What variables were used in the experiments? Is it possible that warm, salty water could be denser than cold fresh water? Why or why not?

(This activity was adapted from the Connecticut Sea Grant College Program's publication "Long Island Sound in a Jar" by Heather M. Crawford.)

Student Worksheet
Adventures in Density

Observation/Question:

Hypothesis:

Predictions:

Materials:

Methods:

Observations:

Conclusions:

Student Activity

1. By using the internet, newspaper articles, and journals, students can work in groups to research what kinds of problems exist in the nearest estuary or coastal environment. They can also use the Additional Resources listed below. Assign each group a separate issue (issues may include overdevelopment, contamination from toxic substances and pathogens, habitat loss, poor land use, dredging, and the presence of non-native species). Ask them 1) to determine if or how the problem is being managed, and 2) how they might convince a local/state politician to allocate funding for it. Have each group present their findings to the class.

Assessment

1. Explain the criteria that define an estuary, and why estuaries are important environmental areas. What role does water density play in an estuary?
2. Explain the relationship between temperature and density.
3. How can density be used to explain why, on lakes and ponds, only the surface water freezes, but life persists in the deeper waters?

Additional Resources

National Estuarine Research Reserves System
http://nerrs.noaa.gov

The Hudson River Estuary: The Basics
http://life.bio.sunysb.edu/marinebio/fc.1.estuaries.html

Long Island Sound in a Jar, a publication of the Connecticut Sea Grant College Program.

Stacking Water, from the Sea Education Association's website at
http://www.sea.edu/k12lessonplans/k12StackingWater.htm

Office of Naval Research Website
http://www.onr.navy.mil/focus/ocean/water/density1.htm

U.S. Environmental Protection Agency's National Estuary Program
http://www.epa.gov/nep/

Estuary-Net Project
http://inlet.geol.sc.edu/estnet.html