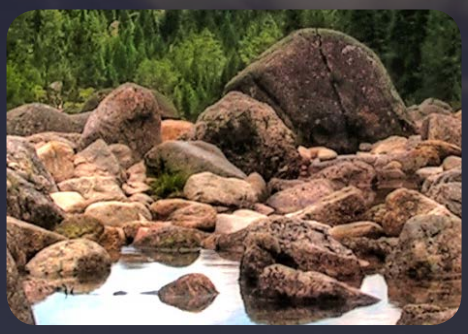

Where River Meets Sea

Grade: 5

Subject Areas: Life Science, Earth Science, Mathematics

Skills: hypothesizing, investigating, experimenting, modeling, analyzing

Duration: 1-2 hours

Connections: ecology, oceanography, density, watersheds, wetlands, wildlife

Vocabulary

buoyancy
river mouth
estuary
wetland
brackish
mudflat
invertebrate
watershed
detritus
peat
phytoplankton
density
pycnocline zone
salinity

Objective:

Students will investigate dynamics between fresh and salt water to better understand the important role of estuaries.

Materials

- large, clear waterproof box or deep pan such as a 9"x 13" pyrex baking dish (1 per group)
- tap water (2 –3 cups per group) check on this
- sea salt
- stirring rods or spoons
- blue food coloring
- paper cups and pointed scissors for making holes
- small stones or pebbles
- book or small block (1 per group)
- pictures of an estuary along with examples of wildlife that live there
- student worksheet

Standards

Strands: Excellence in Environmental Education Guidelines

Strand 1 —A) Questioning: Learners are able to develop, focus, and explain questions that help them learn about the environment and do environmental investigations. **F) Working with models and simulations:** Learners understand many of the uses and limitations of models. **G) Developing explanations:** Learners are to synthesize their observations and findings into coherent explanations.

Strand 2 —2.2 The Living Environment: A) Organisms, populations, and communities: Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments. **C) Systems and connections:** Learners understand major kinds of interactions among organisms or populations of organisms.

Strand 3 —3.1 Skills for Analyzing and Investigating Environmental Issues: B) Sorting out the consequences of issues: Learners are able to apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

California State Educational Standards:

Life Science 2e: Students know plants use carbon dioxide and energy from sunlight to build molecules of sugar and release oxygen.

Earth Science (ES) 3a: Students know most of Earth's water is present as salt water in the oceans, which cover most of Earth's surface.

ES 3b: Students know the amount of fresh water located in rivers, lakes, underground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.

Investigation and Experimentation: 6a. Students will identify the dependent and controlled variables in an investigation.

Background

Fresh Meets Salt

One of the most precious things about our planet is the fact that it has abundant liquid water. Water comes in three main forms: solid, liquid and gas. It is the liquid form of water that is important to life because of its unique properties. Liquid water breaks down and transports materials into useable forms for living things. In addition, bodies of water are able to absorb energy and store it for long periods of time compared to land. This high heat capacity is important for moderating and influencing climate.

Our oceans hold the majority of water on earth as saltwater. The majority of living things have adapted to this rich fluid world. Fluids such as air and water have an associated force called buoyancy. **Buoyancy** is the upwards force on an object by the fluids in which it is partially or fully submerged. This force is opposite to gravity which is a downward force.

Gravitational forces pull water out of the sky once enough has accumulated. Once clouds reach their saturation point, water falls to the surface as various forms of precipitation, most commonly rain and snow. As water collects on the surface it runs downhill using channels carved out by streams and rivers until it makes its way to a larger body of water like a lake or the ocean. A **river mout**h is the place where water slows down and is released into the ocean. A semi-enclosed protected area influenced by incoming fresh water with an opening to the sea is called an **estuary**. This is the place where flowing fresh water and salt water meet.

Where salt and fresh water combine is one of the most productive places on Earth and contributes greatly to the overall richness of coastlines worldwide. In the Mattole Estuary, located within the King Range National Conservation Area (NCA), at least 15 species of fish, 26 species of mammal and over 160 birds have been recorded living there. This rich abundance of wildlife is partially attributed to the ability of wetland plants to establish themselves in this environment. A wetland is defined as an area that is wet all year long. One reason many different plants can grow along estuaries, is because of their high nutrient content. Even though plants living here have to find ways to get rid of salt, those adapted to brackish waters can often thrive. **Brackish** water refers to a mixture of salt and fresh water. During high and mid tides, salt water from the ocean makes its way upstream.

Muddy Homes

High levels of nutrients are not only located in water, but in mud as well. **Mudflats** provide habitat for many different animals including invertebrates. **Invertebrates** are animals that lack a hard skeleton.

Local Connection

Mattole Salmon Group

Back in the 1980s, the Mattole Salmon Group (MSG) began to actively monitor and restore the Mattole River Watershed. Due to fast-paced, unsustainable logging practices of the post-war era, only 10% of the old growth forests remained there. Observations show historical salmon runs were reduced by 90%. After realizing the damage done to the overall health of the watershed, the MSG began a salmon breeding program. Their work marked the first watershed-wide, entirely citizen-run salmon restoration effort in the Pacific Northwest.

The MSG aims at restoring the remnant runs of native chinook and coho salmon in the Mattole River. Since the 1980s, they have maintained a hatchbox and rearing program for juvenile fish, releasing more than 400,00 into the watershed. This non-profit organization participates in the planning, coordination, and implementation of habitat improvement. In the course of their work, they strive to inform and involve local residents, students, citizens groups, and government agencies about the condition and needs of the Mattole river and its tributaries. Youth can get involved by participating in one of their partnership agencies (MEEP and WSP). Community involvement and support are an important part of their success.

Plant roots and mud provide lots of living places for invertebrates, like clams, snails, and oysters. The multitude of invertebrates living in the mudflats of an estuary are important sources of food for animals especially shorebirds. Shorebirds migrate along certain pathways to get from their feeding grounds to their breeding grounds. The coastline of Humboldt and Mendocino counties are part of the Great Pacific Flyway, one of the important migration pathways. In the fall and winter, thousands of different species of shorebirds can be observed taking advantage of the abundant food found in this rich ecosystem.

One reason estuaries are so productive is that the water filtering through them brings in nutrients from the surrounding watershed. A **watershed** is the entire land area that drains into a particular body of water. As rivers flow downstream, they collect debris. A collection of dead material, called **detritus**, accumulates in the water and is released where the water slows. Much of this nutrient rich material is laid down in layers forming peat. **Peat** is a spongy matrix of decomposing vegetation, live roots and soil. It acts like a big filter.

Nutrient rich water associated with these wetlands support large phytoplankton populations. The word **phytoplankton** literally means "plants that wander"; phyto = plant and planktos = to wander. Another name for phytoplankton is microalgae. Like plants, phytoplankton have the ability to produce food through photosynthesis. They are the primary energy source for most oceanic food chains.

Popular Hang-outs

The proximity of estuaries to the ocean, along with their fertility, have attracted people to them for centuries. Twenty two out of the thirty two major cities around the world are located along estuaries. The largest estuary in the United States is the Chesapeake Bay bordering states like Maryland and Delaware. Unfortunately, human activities are threatening these valuable ecosystems. High levels of manufacturing, agriculture and transportation happen here. The greatest threat by far has come from the large conversion of these habitats through draining, dredging, and filling. High levels of pollution also pose a threat. As rivers flow towards estuaries they not only collect nutrients they also collect pollution. Fortunately, wetlands can act like giant sponges absorbing and filtering large quantities of water.

It is important to understand the dynamics that take place within estuaries for monitoring purposes. Estuaries act as a two way street and are a complex blend of changing habitats. One dynamic that takes place is the mixing of seawater and fresh water. Salt water is more dense than fresh water and naturally sinks. **Density** is the amount of matter in a given volume. As fresh water flows from rivers into an estuary it spreads out forming a layer over the denser salt water. During high tide, the salt water moves upstream. As the two different layers of water move in opposite directions, they are separated by a horizontal **pycnocline zone**. This zone is where water density changes noticeably with increasing depth. Low density surface water cannot easily move downwards and is slowed by the pycnocline zone. Frictions between the two different water densities causes currents that drag salt water from below and mixes it with the surface water. As the salty seawater is forced upwards, the salinity of the surface water increases. **Salinity** is the amount of dissolved salts in fresh water. Most typically, higher salinity increases in a seaward direction. As salt moves upwards, it forms a wedge shape with its thinner end pointed upstream. This wedge is sometimes referred to as a tidal wedge.

The differences in density between salt water and fresh water cause **stratification**. Stratification is another name for layering. Of course, stratification in water is difficult to see, but it is one of the important processes that influences circulation and the chemical profile of an aquatic system. The location and distribution of organisms like phytoplankton will be highly affected by this dynamic process.

Overall estuaries have two very important functions: water filtration and habitat protection. They are nurseries for fish and stabilize shorelines. In some places large plants, like mangroves, protect inland areas from big storms like hurricanes. Their ability to filter pollutants like herbicides, pesticides and heavy metals make them hugely important for cleaning water before it reaches the sea. Furthermore, estuaries are biologically rich and their surround wetlands are very beautiful. Wildlife abounds here and they have become important places for human recreation and relaxation. Learning more about these threatened ecosystems is an important component of ecology. By understanding the dynamics that happen here, these rare precious places can be monitored more easily.

Activity: Modeling a Pycnocline

Preparation

Organize the materials for each group. (see directions below). To save time, you may want to mix the salt water first, however, it is good to have students practice making solutions. (see step 1)

Materials

- large, clear waterproof box or deep pan such as a 9"x 13" pyrex baking dish (1 per group)
- tap water (2 –3 cups per group) check on this
- sea salt
- stirring rods or spoons
- blue food coloring
- paper cups and pointed scissors for making holes
- small stones or pebbles
- book or small block (1 per group)
- pictures of an estuary along with examples of wildlife that live there
- student worksheet

Procedure

1. Begin by finding out what students already know about watersheds and where rivers ultimately release their water. After reviewing watersheds, discuss the importance of estuaries (see background information). As you discuss estuaries, show pictures and ask students if they have ever visited one. Local estuaries include the mouth of the Mattole, the mouth of the Eel, and Humboldt Bay. Once you have discussed the importance of estuaries you may want to introduce some challenges they face. Many estuaries have been heavily modified and some are highly polluted.

Note: If students will be making the salt water mixture, you will need to have them prepare this before questioning begins (see Step 1). If there are older students in the group, you may want to give them the task of making the salt water solution.

2. Once questioning has approached the subject of estuaries, explain to the students that today's activity is going to focus on a dynamic between salt water and fresh water. This dynamic is caused by the different densities and is called a pycnocline. Write pycnocline on the board. The meaning of the prefix pycno is "dense". Ask the students why some water may be more dense in an estuary.

3. Students will apply the common steps to the scientific method during this activity. (see handout) Go over the directions on the handout before passing it out. Break the students into groups and proceed with the investigation below.

- *Who can describe what a watershed is?*
- *What types of things influence the flow of a river?*
- *What are some of the main rivers around us?*
- *How do rivers change during various seasons?*
- *Where does a river end up?*
- *What is the end of a river called (where it enters the ocean)? (Define estuary and write it on the board)*
- *Who has been to an estuary?*
- *What kinds of wildlife can you see at an estuary?*
- *Why are estuaries important?*
- *How is an estuary different from a river?*
- *How are estuaries important to fish like salmon?*

Making Pycnocline

1.Make a salt water mixture by adding 35 grams of sea salt to one liter of warm water. (Regular salt has additives). This is equivalent to 2 T of salt to 1 quart of warm water. Mix thoroughly until all salt is dissolved. The warm water will dissolve the salt faster, however, it is important that the mixture reach room temperature by the time it is added to the tap water. Set aside until needed. Food coloring can be added now or later.

2. Place one end of the clear pan on a small block or book about 1 inch high to tilt it slightly.

Activity: Modeling a Pycnocline (cont.)

3. Make several tiny holes in the bottom of a paper cup using scissors. Weight the cup using small stones and place it at the lower end of the pan (the deep end).

4. Slowly pour tap water (at room temperature) into the pan until it is about 1/2 inch from the top at the lower end. (keep the paper cup in the pan)

5. Wait for the water to settle until it becomes very still. This is a good time to have the students write out a hypothesis about what they think will happen when they add the colored salt water to the cup.

6. Have the students tint the salt water with food coloring. The food coloring will allow them to see the salt water layer more easily.

7. Taking turns, slowly and gently add the salt water by pouring it into the paper cup. (do not overfill). Observe what happens closely.

8. After the salt water has been added, look at the water at eye level.

After the activity, have the students fill in their worksheet. Conclude the lesson with a follow up discussion or review.

- *Who predicted that the salt water would sink? Why?*
- *Did the salt water float or sink?*
- *What did you observe?*
- *Was it difficult to see the two different layers?*
- *What variables could influence the quality of the pycnocline?*
- *Why do you think it was important to pour the salt water through a perforated cup?*
- *How could this model be improved?*
- *How could tides influence the pycnocline or tidal wedge as it is sometimes called?*
- *What else might influence where a pycnocline occurs? (wind direction, rate of water flow, etc.)*
- *In what type of ecosystem do pynoclines occur?*

Extensions

- Have students research a major estuary in the United States.
- Learn about the different animals and plants that live in a wetland ecosystem.
- Grow plants and add salt to them. Next, explore how marsh plants adapt to salt.
- Study the different stages of the salmon life cycle and identify the stage where estuaries are an important part.
- Find the density of salt water and freshwater. Vary the concentration of salt and have the students graph the results.
- Explore different wetland ecosystems and they have helped curb natural disasters and reduce pollution.

References

Estuaries, http://oceanservice.noaa.gov/education/tutorial_estuaries/, 2011

Monitoring water quality in estuaries and coastal areas: An Overview: http://www.sp.uconn.edu/~wwwmsd2/techtxfr/625R02010Chap2.pdf, 2011

The Edge of the Wedge, Activity 8.3, http://www.ciese.org/PISA/PD%20LSC%20October%202007/edgeofthewedge.pdf

The Mattole Estuary, http://www.mattole.org/content/mattole-estuary, 2011

The Mattole Salmon Group, http://www.mountainvisions.com/Aurora/msgbroch.html

Name: _____ **Date:** _____

Directions:

Experiment:

1. **Hypothesis:** What will happen when you add the salt water to the cup in the model?

2. **Method:** Describe only how you added the salt water to the cup in the model. Include any possible variables that may have affected you results. (e.g. rate at which you poured the water, angle of the pan, etc.)

3. **Results:** Describe only what you observed in the model when you added the salt water to the cup. On the back of this page, draw a diagram to help explain what you saw.

4. **Analysis:** Using a few words as possible, explain your results. Is your hypothesis proved or disproved by your observed results?

5. **Discussion:** Here is the chance to be more creative. Discuss what you would do differently next time you conduct this experiment. Do you this this was a good model? Why or why not? How could the model be improved?