Activity 4 - Tides of Change

PURPOSE:	To develop students understanding of the fundamental role and ways that tidal forces play on the waters and habitats of the estuary.
TIME REQUIRED:	One class period (~45 minutes)
SUBJECTS:	Science, English, Math
MATERIALS NEEDED:	Rope to represent tidal level, three balls of small, medium, and large size to represent the moon, earth, and sun respectively, tide tables, graph paper, rulers, "Living on the Estuary" story
VOCABULARY:	current velocity, ebb, elevation, flood, gravitational force, head of tide, intertidal, slack tide, sub-tidal, tidal cycle, tidal flow, tidal prism, tidal range, turbidity.

Outcomes: 1) Students will be able to describe the tides and the forces that influence their height and frequency. 2) Students will be able to accurately read a tabular and graph form tide table and identify at least two high tides and two low tides by time and elevation. 3) Students will be able to describe at least three ways the tides influence life and activities in the estuary.

Unifying Concepts and Processes:

- Patterns of change
- Interaction of forces & changes

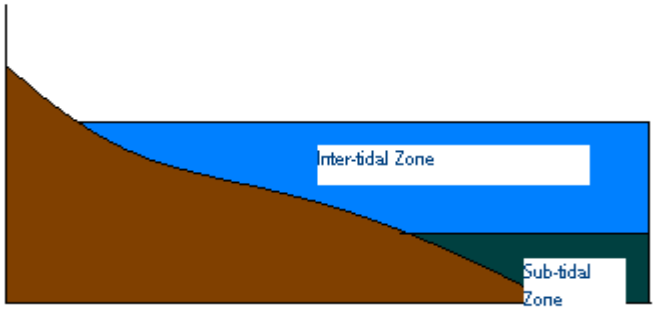
Earth and Space Science:

- Earth's motion and universe
- Water cycle

Background: The rising and falling of the tides is one of the most fundamental physical forces that shape the basin of an estuary at the lower end of a watershed. The habitats that are formed by the force of the ocean tides against the shoreline may vary greatly from abrupt cliffs and rocky shores to sediment laden flood plains. Coarse sand near the mouth of the estuary may transition to thick, fine sediment as the energy of the tide is offset by the flow of a river or creek. Where currents slow and the finest of sediments is deposited, an area known as the turbidity maxima is identified by unique physical and chemical conditions.

Tides are influenced by many factors and tide tables represent predictions that may not reflect actual recorded tidal heights. As the tide rises and falls, the amount of freshwater input from the watershed, the shape of the tidal basin, ocean surface and sub-surface conditions, weather, and cosmic events will influence the volume of water that enters the estuary from the ocean during a tidal cycle.

Where tides have changed the elevation of the water within the estuary, various types of habitats form in a zone known as the inter-tidal (between the tides) zone. Elevations below this inter-tidal zone are considered sub-tidal (below the tide) and are not subjected to the drying winds and solar radiation that the inter-tidal zone and its inhabitants are.



Communities of plants and animals that inhabit or visit the inter-tidal zone of the estuary have adapted to life in the constantly changing conditions where ocean water is diluted by freshwater runoff from the land. The sub-tidal zone is also affected by the rise (flood) and fall (ebb) of the tides, primarily through changes in the flow of the currents.

Three principal types of habitat form in the estuary from tidal action and the carving action of rivers and creeks meeting the tidal flow. Tidal marshes, tidal flats, and open water channels are terms used to help to define the estuary. Tidal marshes may be dominated by salt tolerant rooted, flowering plants or they may be freshwater wetlands located in zones of transition where freshwater flows are reversed and flood out across the banks of the river or creek. Tidal flats are seldom vegetated with more than algae and may vary from pebble and cobble to thick, fine mud. The surface of these flats are often densely covered with hole-like burrow entrances indicating a variety of worms, clams, shrimp, crabs, and other creatures that dwell below. Finally, the sub-tidal channel remains filled with water, even at the lowest of tides providing refuge for aquatic creatures like fish, shrimp, and crabs. A fourth type of habitat found only in high energy zones of the inter-tidal are rocky shorelines.

Preparation: Review the materials needed section and have all materials on hand for students. The rope should be free of tangles and the balls being used to represent the sun, moon, and earth should be easy to reach. You will need an area at the front of the room for volunteers to demonstrate the rising and falling of the tide.

For the graphing activity, you will need enough graphing paper, rulers, and copies of a tide table so that each student can create a graph.

Activity Description: Begin by introducing the concept of the tides and their influence on the estuary.

Read aloud chapter 2 of the story "Living on the Estuary" or you may choose to assign this for homework prior to class and then discuss the chapter at the beginning of class.
Below are some suggested review questions for discussion.

1. In what ways have the tides been an influence in the Seelander's life?
2. What are some other activities that were once carried on using waterways as a means of transportation?
3. What are some of the risks when working near or on the estuary?
4. Name some animals that take advantage of the tides. How do they do this and what is the benefit to them?
5. How does filling or diking and draining tidal wetlands affect the estuary?

You may want to simply read the background information to the students and then ask them for any experiences that they have had with tides. If you have experience with tidal changes (such as the time you got stuck high and dry on a mudflat in your boat, or when you had to wade across a flooded channel because the tide came in quickly), you may want to share these experiences with your students. Photographs that show the same area through a tidal cycle may be found on the South Slough website at: www.southsloughestuary.org or in the resources folder for this activity.

Now ask for three students to volunteer to demonstrate the celestial forces that cause the tides. You may present this as a challenge initially by handing the various sized balls to them and asking them to explain to the class how the relationship between the sun, the moon, and the earth works. Make sure that they correctly assign the size relationships and that the relative nature of the movement of these bodies is defined (i.e. the earth revolves around the sun, and the moon revolves around the earth). They should describe the rotation of the earth on its axis and define one rotation as a twenty-four hour period or one day. Next ask them to describe how long it takes for the earth to make one complete revolution of the sun (one year or ~365 days) and for the moon to make one complete revolution around the earth (~28 ¼ days). Now you will want to discuss the amount of the earth's surface that is covered with water (~65%) and ask which heavenly body exerts a greater gravitational pull on the waters of the earth, the moon or the sun? The sun is approximately 93 million miles from earth, while the moon is approximately 250,000 miles from earth. Once you have established that the moon exerts the greater pull, make a small loop of rope to represent the water covering the surface of the earth. Make the loop elliptical with the bulges on either side of the ball.

Spring tides (Full Moon or New Moon) – these are the most extreme high and low tides and they occur when the moon and sun are on opposite sides of the earth (Full Moon) or when they are on the same side of the earth (New Moon), thus reinforcing the gravitational pull. Now place a loop of tape with a "You are here!" tag somewhere on the ball about halfway between the equator and the North pole to represent your classroom. Rotate the ball to show a 24 hour period. Then use the loop of rope around the ball elongating the ends of the loop nearest to the sun and moon to

represent the gravitational pull exerted by these bodies on the waters of the earth. Rotate the ball and try to predict at what point low tide is represented and at what point high tide is represented.

Neap tides (1st Quarter and 3rd Quarter Moon) – these are a more average series of events when the effects of the moon and sun on high and low tides are at right angles to each other. This reduces the force exerted and leads to more moderate highs and lows. To illustrate this concept, ask the student holding the ball representing the moon to move the ball to locations at right angles to the sun and then move the loop of rope accordingly. The rope should be more evenly distributed above the surface of the ball representing earth.

Tide Levels – As the tide rises or falls, the level of the water may be measured using a tide staff. A tide staff is a vertical column with graduated markings in meters or feet that has been placed in an inter-tidal area and surveyed to an exact elevation. Students can replicate the nature of this type of measurement through the following demonstration. Ask one student to represent the tide staff anchored firmly in the mud and surveyed to an exact elevation where their knees are designated to represent **mean lower low water (MLLW)** or the elevation the midpoint of the low tides. This reference point is used to represent 0.0 and everything below it is referred to with a minus symbol in front of the elevation. Everything above MLLW is a positive value representing an increase in tide level.
Now ask two students to hold the ends of a rope and pull the rope taut so that the level of the rope corresponds to MLLW. Ask the students to represent a 24 hour tidal cycle and explain what is happening as they are doing the activity. The rope should rise to a ***higher high tide*** level (over a six hour period represented by 15 seconds) and then fall to the lowest level possible representing the ***lower low tide*** (again this should take 15 seconds). Then the rope will rise to a level representing the ***lower high tide*** over a 15 second period followed by a descent to a ***higher low tide*** level. This demonstration represents the rising and falling of the tides in a vertical plane, however it does little to illustrate the spatial effect of tidal flooding and ebbing on the basin. This can best be viewed with through the animated sequence in the "Tide of the Heron" video or through the sequence of pictures available on the South Slough NERR website.

Graphing Activity – Students will need a piece of graph paper, pencil, ruler, and tide chart. Tide charts may be found at http://www.hmsc.orst.edu/weather/tides/tides.html or you may use the sample tide chart included in this activity. Share the following directions on how to read the tide chart with your students. (These rules may be generalized for tabular tide charts, however, they do not apply to graphed charts.)

1) Note the location listed on the tide chart, month predicted, time zone, and any other factors that will assist you in reading the data presented (i.e. **PM** times in bold).

2) The dates will appear in a column on the left hand side next to a listing for corresponding days of the week. The next series of columns alternately lists times and tidal heights. Using a piece of blank paper, place the edge of the paper below the date you are interested in and across the page beneath the corresponding line of data.

3) Note the first four columns of times and tidal heights contain information for predicted high tides and the second four columns for predicted low tides. By reading across, you can roughly determine what the tidal level will be for the time you are most interested in. You can also determine whether the tide will be ebbing, flooding, or slack at that time.

Creating the Graph

To graph this data, you may want to use the worksheet included in this lesson titled "Graphing Tide Levels" or you may want to use a blank sheet of ¼" graph paper. Place the graph paper horizontally on the table and draw a horizontal x and vertical y axis with an intersection in the lower left hand corner. Make sure to leave several units of the graph blocks below the x axis and to the left of the y axis.

Now mark increments of 1 unit every two blocks on the y axis to represent tidal height. Remember to include several negative units below the intersection with the x axis to represent minus tides. Label the x axis time of day and mark off increments of 6, 12, 18, and 24 hours.

Now you are ready to begin graphing the data from the tide table. Locate the first predicted tidal height listing for a 24 hour period beginning sometime in the a.m. and note the height and time. Place a point on the graph at the point which corresponds to the intersection of that particular time and tidal height on the graph. Now do the same for the next 3 tidal predictions in that 24 hour period.

Once you have placed all 4 of your data points on the graph, draw a line connecting the points to indicate the falling (ebbing) or rising (flooding) tide. This is a graphical representation of the tidal cycle and can be repeated for any day and set of tides.

Post activity analysis: Tides are a complex but very important phenomenon fundamental to the development of estuaries at river mouths. This introductory activity is meant to provide a simple understanding of the way in which tidal predictions can be used to help people. The questions on the following page are meant to stimulate further discussion on the utility of tide tables and the influence of the tides on the estuary.

Tide Table Discussion Guide

1. What kinds of people would find a tide table useful and why? (researchers, sailors, clam diggers, tourists, etc.)

2. Find the highest and lowest tides listed in the tide table for this month. Figure out the difference between these two numbers. This is the tidal range. What events are causing these tidal changes to be so extreme?

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3. What is sea level? In what way is sea level different than Mean Lower Low Water?

4. How many high tides and how many low tides does the Oregon coast have each day?

5. List the time and the tide level for all four tides today.

6. Are the two high tides the same height today? Are they the same height any day this week?

7. What effects might the ebbing and flooding of the tide have on the animals and plants that live in the estuary?

8. If there is a bad storm blowing on the day you want to go clamming, how do you think the storm will affect the tide level?

9. Give the date, the tide level, and the time that you would like to go clamming.

10. Give one example of other information you can obtain from your tide table.

Follow up ideas:

⇒ Look in your local newspaper to see if tide predictions are listed. If so, see if you can graph the tides for the days listed.

⇒ Work in teams to develop a list of additional questions you want answered about tides and explore the internet to see if you can discover answers. Have each research group present their findings to the class. Compare answers to any similar questions and see if you come up with the same responses.

⇒ Make a tide staff with graduated markings and attach it temporarily to a dock (get permission from the owner first!) in an inter-tidal area with the tip just touching the water during the lowest tide. Come back at the peak of the high tide and mark the upper limit of the water. Measure the distance between the lower tip and the upper mark. Does this match the predicted tidal range for that period? What factors might have caused the observed tidal range to be different than the predicted range?