Activity 5 - Life in the Waters of Productivity and Change - Physical Environments

PURPOSE:	To demonstrate the influence of physical factors on the waters of the estuary including salty and fresh water, temperature, and sediment.
TIME REQUIRED:	One class period (~45 minutes)
SUBJECTS:	Science, English, Math
MATERIALS NEEDED:	3 quart containers (clear glass or plastic containers are best, 2 liter soda bottles with the labels removed will work), a funnel, an ice chest filled with crushed ice, table salt, a thermometer, a hand refractometer (or some means of measuring salinity), green and blue food coloring, a cup of clean sand, a cup of mud, a stop watch, TIDES student explorer kits (see contents sheet)
VOCABULARY:	Parameters, density, turbidity, salinity, dissolved oxygen, datalogger, metadata, chart

Outcomes: 1) Students will be able to name and describe three important physical factors that affect life in the waters of the estuary. 2) Students will be able to explain how changes in at least one physical factor in the estuary waters can influence other physical factors. 3) Students will be able to describe how changes in at least one physical factor can influence flora and fauna of the estuary.

Unifying Concepts and Processes:
- System inputs & outputs
- Evidence of changes over time

Physical Science:
- Compare & contrast properties
- Explain chemical reactions
- Compare physical & chemical changes

Earth and Space Science:
- Properties & use of earth materials
- Earth's surface change over time
- Earth's motion and universe

Scientific Inquiry
- Ask questions to support scientific inquiry
- Design scientific investigation
- Collect data
- Analyze data

Background: The physical properties of the waters of the estuary have a significant influence on the kinds of life found there. Furthermore, these physical properties are constantly changing since the tides, amounts of freshwater flow, seasonal weather patterns and climate change all influence conditions.

In order to understand how these physical properties influence conditions in the estuary, we can explore some basic principals such as density, temperature, and turbidity in the lab. We will also explore the relationship between temperature and dissolved oxygen using data collected through the National Estuarine Research Reserve's (NERRS) System-wide Monitoring Program (SWMP). By making careful observations, asking challenging questions, and discovering the answers, we can begin to piece together the story of the waters of the estuary.

Preparation: Fill two quart containers with tap water and then add 1 cup of table salt to one of the containers. Add several drops of blue food coloring to this container. This will represent full strength seawater (~32-36 parts per thousand (ppt)) at a chilled temperature similar to the real Pacific Ocean. Use a hand refractometer to determine the salinity of the water and add more salt if needed to achieve 32 ppt. Place the seawater container in the cooler with the crushed ice for at least one hour prior to the lab.

Now mix a second bottle of ½ strength seawater (~ 16 – 18 ppt) and leave this water at room temperature. This bottle will represent estuary water that has been warmed by the sun as it enters the bay. Place a few drops of green food coloring in this water.

Prepare a third bottle of clear water without salt and at room temperature. This bottle will represent the fresh water inputs to the estuary.

Activity Description: Introduce this activity to the students as an opportunity for them to discover the different ways in which salinity, temperature, and sediment can influence the waters of the estuary. They will have the opportunity to develop questions (formulate hypotheses) and then investigate their questions by creating their own experiments to explore their inquiry. They will do this through hands-on activities and by viewing and interpreting data collected through the IOOS (International Ocean Observing System).

Review with the students the sources of fresh water, salt water, and sediment in the estuary and the factors that influence the temperature of the estuary waters. In your discussion, you may want to introduce seasonal temperature variations, daily and weekly weather variability and human-induced factors such as development in the watershed.

Now explain that each student has a container within which they will mix fresh and salt water, and various types of sediments to observe the ways in which variables such as temperature and salinity can influence water quality. The simple chart below can be used as a form for the students to record their observations. Rather than asking them to seek the "right answer", encourage the students to experiment with various mixes and relationships and to make careful observations.

Experiment #	Water quality conditions	Observed actions

If a more structured approach is necessary, the following experiments can be undertaken to help students formulate their questions and conduct the experiments.

Salinity experiments: Provide each student with a small amount of chilled blue, full-strength seawater. Take the temperature of the seawater and have the students record this information in their data table. Now carefully add a small amount of fresh water to their sample. Take and record the temperature of the fresh water before adding it. Gently combine cold salt water (blue) and warm fresh water (clear). They will observe stratification as the dense, cool and salty water stays at the bottom of the container while the fresh water floats on top.

- Attempt the same experiment with different salinity mixes such as a solution that is twice as salty as seawater.
- Ask the students to prepare a mystery mix of unknown saltiness with red food coloring and then have them try to predict whether or not the sample will stratify with fresh water.
- Attempt to stratify three layers of water varying from fresh to partial to full salinity.

Sediment experiments: In these experiments, students will time the difference from initial presentation of sediment to clearing of water for muddy and sandy bottoms. Ask each student to place a small amount of sand in one jar and a small amount of mud in a second jar. Now ask them to add fresh water to each until the jar is full. They should then cap the jar tightly.

Now ask the students to shake the jar for several seconds and then time the period it takes for at least 90% of the sample to settle to the bottom. The settlement time for various grain sizes of sediment is a determining factor in how various kinds of habitat form in the estuary. Encourage the students to repeat the same experiment in salt water and note any differences in times. They may wish to repeat the same experiment with very cold and very warm water to see how this affects settlement.

Temperature experiments

The same experiments conducted for salinity can be done using water of various temperatures with food coloring added to distinguish the different temperature samples being combined. For more dramatic results the temperature differences between the cold and warm water should be significant.

Viewing, charting, and interpreting data

The collection of water quality and meteorological data has entered a new era in the past decade with the with the development of automated data loggers, websites and telemetry. We can now access large data sets collected from estuaries all over the world. In this activity, we have included a few examples of data collected through the NERRS-SWMP which is now a part of the IOOS. By working with this data and comparing different locations and different parameters, students will begin to understand how dynamic the estuary's waters are. They will also discover the relationships between different water quality parameters. Included below are some specific steps with some interpretations of the data and included in the **Follow up ideas** section of this activity are some links which will allow the class to view real-time data and download datasets. In some cases, websites are designed to generate charts of the data on-line for viewing and interpretation.

In this activity, we have provided several Excel workbooks in the Resources folder, each of which contains several spreadsheets and charts. The data were all downloaded from the **http://cdmo.baruch.sc.edu/QueryPages/googlemap.cfm** website which is where the NERRS-SWMP data is located for public use. Since this website is often changing as new and better technology offers easier to use data products, check frequently for updates.

Each spreadsheet contained in the workbooks provided contains a collection of raw data which was used to create the charts listed for that period of time. We will look at three periods: 24 hours; 7 days; and 1 month. Daily average data is available for a full year's worth of data, however, data gaps sometimes make the interpretation of this data difficult. Data gaps may occur because of equipment malfunction or damage and are as frustrating to the scientists attempting to implement this remote system of water quality monitoring as they are to the end user. Since the amount of data available is so vast and the number of different inquiries that could be made are many, we have limited this activity to a few specific ideas to get the class started.

We have also provided data for two distinct locations. One near the mouth of South Slough is located near the town of Charleston, and the other is located upstream from the mouth approximately 2 miles from the first site. Information like this is very important when trying to interpret the data provided by the data logger. This is called metadata and without this information, the data is not very useful.

Temperature and Dissolved Oxygen

The relationship between these two parameters is an important one to understand since most forms of life that inhabit or visit the estuaries waters depend directly or indirectly on dissolved oxygen. While other factors may influence the abundance of oxygen dissolved in a body of water, temperature is extremely important. Cooler water will typically support higher levels of dissolved oxygen than warmer water.

Post activity analysis: The investigations included in this activity are meant to provide an introduction to the complex study of water quality. While these experiments are relatively open-ended, the expectations of the students are that they will document their observations. A written test is included in the Resources folder for this activity. If this approach is used, a class discussion and review of the following objectives may be helpful.

Specifically the students should be asked to:

1) name and describe three important physical factors that affect life in the waters of the estuary.
2) explain how changes in at least one physical factor in the estuary waters can influence other physical factors.
3) describe how changes in at least one physical factor can influence flora and fauna of the estuary.

Follow up ideas: South Slough NERR monitors estuarine water quality, local weather conditions, and biotic communities to further an understanding of the dynamics of the South Slough estuary and to address specific scientific and management questions. Monitoring activities also provide information necessary to evaluate the outcomes and effectiveness of field experiments, manipulative restoration treatments and other management actions.

The NERRS System-Wide Monitoring Program (SWMP) was initiated in 1995 to provide standardized data on national estuarine environmental trends while allowing the flexibility to address coastal management issues of regional or local concern.
The principal mission of the SWMP is to:

Develop quantitative measurements of short-term variability and long-term changes in the integrity and diversity of representative estuarine ecosystems andcoastal watersheds for the purposes of contributing to effective coastal zone management.

The System-Wide Monitoring Program is designed to enhance the value of the reserves as a system of national reference sites. Data collected by the SWMP are compiled at the NERRS Centralized Data Management Office (CDMO), located at the Belle W. Baruch Institute for Marine Biology and Coastal Research (University of South Carolina). The CDMO serves as a central site for archiving data, storing metadata, and for managing quality assurance/quality control procedures.

The Reserve is fully implementing Phase 1 of the SWMP, which includes monitoring estuarine water quality, nutrient concentrations, and local weather. Four permanent monitoring stations are deployed along the estuarine gradient of the South Slough to collect baseline water quality information. These stations activate every 30 minutes to record temperature, depth, salinity, conductivity, dissolved oxygen, pH, turbidity, and chlorophyll.

Data collected from this system is provided to users through various internet sites and may be provided in a near real-time format, or as historic data sets in either tables or graphed formats. In this activity, students will explore and learn to interpret various data sets and defining the relationships between specific water quality parameters of temperature, depth, salinity, conductivity, and dissolved oxygen.

The Northwest Association of Networked Ocean Observing Systems (NANOOS) website – http://www.ccalmr.ogi.edu/nanoos/about.php is also a useful resource for further investigation. The NANOOS project is part of a large scale, international ocean and coastal monitoring effort. In the next few years, we will likely see an expansion of this system and the data sources available.

The NANOOS project is one web-based location where data from South Slough NERR's monitoring program is located. Other locations are included at the end of this activity if you would like to explore further. Some of the data is provided in near real-time while other data is only available as historic data sets at this time. As the NANOOS network grows, more data will become available in near real-time adding to the potential for rapid interpretation of events.

Once the instructor is familiar with the general content of the NANOOS website, go to this link http://www.ccalmr.ogi.edu/nanoos/ where you will find a satellite image map of the Pacific Northwest and markers indicating monitoring station locations. In the lower left hand corner, you will find a pull down menu for regions of stations labeled "zoom to". Select "Coos Bay, OR" and the satellite image will change to show South Slough and lower Coos Bay. The monitoring station markers will show several locations along the north/south axis of South Slough.

Select any station marker and a small window will appear with a link to the data for that station. Find the station with the link sosch highlighted at the northern end of South Slough near the Charleston bridge and click on this link.

The following links are websites where real time and archived data is available for viewing and downloading. Many of the investigations and questions developed during this activity can be explored further using the data sets available at these websites.

National Estuarine Research Reserve – System-wide Monitoring Program
http://www.nerrs.noaa.gov/ioos/overview.html

http://cdmo.baruch.sc.edu/QueryPages/googlemap.cfm

http://cdmo.baruch.sc.edu/Parameters.html

National Oceanic and Atmospheric Administration

http://nowcoast.noaa.gov/

Meteorological data is also available and is useful for interpreting the water quality data presented. Currently the South Slough weather station data is only available as historic data sets rather than as real-time data. However, the North Bend Municipal Airport has real-time and historic weather data available

which gives a reasonably accurate picture of local weather events that may influence water quality in South Slough and the Coos Bay estuary.

This link http://weather.noaa.gov/weather/current/KOTH.html leads to a NOAA – National Weather Service web site where you will see the most current data available for the North Bend Municipal Airport.

This link http://www.wrh.noaa.gov/mesonet/getobext.php?wfo=mfr&sid=KOTH&num=48&raw=0 will lead you to 2 and 7 day summary data for the North Bend Municipal Airport displayed in both a graph and table format.