Earth Science Project: Create an Ocean Weather Forecast

**Description:**
Using real-time data provided by the Institute of Marine and Coastal Sciences at Rutgers University, students will monitor changes to the ocean surface. By analyzing wind direction and speed while looking at a sea-surface temperature maps, students can predict a “bad” beach day or a “good” fishing day along the New Jersey coast.

During summer months, coastal upwelling can have a major impact on the water conditions along the beach and in the coastal ocean. Coastal upwelling occurs when cold, nutrient-rich water moves up from the bottom layer of the ocean to the surface. This cold layer of water is usually too cold to swim in. So an upwelling day is a “bad” beach day. But it’s a good day for lots of marine life. As the cold bottom layer moves towards the surface, it carries an abundance of nutrients (“fish food”) with it. As these nutrients reach the surface, many fish come closer to shore to munch on all the goodies, therefore making it a “good” fishing day. Students will interpret real-time of a coastal upwelling event and create their own ocean weather forecast.

**Subject:**
Middle School Earth Science

**Assumptions of Prior Knowledge:**
Students will have learned
- How winds are formed
- How to convert degrees Centigrade to and from Fahrenheit
- The directions on a map compass
- The degrees of a circle

**Duration:**
Four to five 45-50 minute sessions, plus 15 minutes a day for a 4-day project interpreting real-time data.

**Credits:**
Lessons created by Tanya Podchaski - Bernardsville High School, and Lisa Koch - Ocean County Vocational School

Edited by Amy Pallant and Debra Kovacs - Turnstone Publishing
Steps 1 & 2: What affects Ocean Temperature? Form a Hypothesis and Analyze Data

Objectives:
Students will
- Interpret and analyze sea surface temperature maps
- Interpret and analyze CTD data
- Speculate about the relationship of temperature changes in the ocean to the change in seasons

Materials:
- Printed copies of the Ocean Temperature Worksheet (one copy for each pair of students)
- Notebook for students to answer questions

Classroom Implementation

Time required:
One 45-50 minute class session

Thematic Sequence:
This unit is best done following the review of the Control Room (See Thematic Instructional Sequence p.8-9). If students have not done so, suggest that they explore the COOL room introduction and the COOL cards either as homework or as a class. Students should utilize the sampling demonstration located HOW DOES THE COOL ROOM WORK? to illustrate the benefits of continuous sampling. Background information within the site illustrates that traditional oceanographic sampling techniques allow scientists to only get 'snapshots' of what is taking place in the ocean, rather than a complete, continuous picture. The COOL cards allow students to explore the collaborative nature among biologists, oceanographers, and modelers within the COOL room. Once the students understand what sensors are used and what kind of data is produced, they may use the Sea Surface Temperature maps, and meteorological data collected by the COOL room to understand ocean currents.

Lesson and Activities:
Encourage students to develop their own hypothesis explaining what effects ocean temperature. Differences in ocean water temperature are caused by the heat of the sun. The surface layer of the ocean is the warmest because it absorbs energy, or heat, from the sun. Most of the heat from the sun is absorbed by the water in the first 100 meters (325 feet) of the ocean. Below this depth, light and heat from the sun no longer penetrate, and the ocean becomes colder and darker as you go deeper. If you could dive down through the ocean with a thermometer, you would notice that the temperature at the surface is the warmest, followed by a thinner layer of water called the thermocline where the temperature rapidly decreases. Below the thermocline is a deeper layer of cold water where the temperature changes very little with depth all the way to the bottom.
Begin the Sea Surface Temperature Images and CTD Temperature Images Activities by dividing your class into pairs, and distributing one Ocean Temperature Worksheet per pair. Make sure students go to all the links provided. These links explain how to interpret the Satellite and CTD data. After students have gone to the tutorials, you may want to interpret the first data set (one satellite and one CTD data set) as a whole class for each of these sections. Then have each pair complete the activity. At the end of this activity, students should be able to describe trends in changes of Ocean Water Temperature through the seasons.

Once students have completed the worksheets, discuss their answers. See the Ocean Temperatures Worksheet answer key for answers to the questions posed to the students.

Have volunteers read their descriptions, explaining how satellite and CTD data can be used to explain the changes in ocean temperatures over the seasons.

**Step 2: Analyze Data**

**B.1) Ocean Temperature Worksheet**

**Satellite Images**

Using the four satellite images answer the questions in your lab journals. Notice that the temperature scales are different in each image (for example, the color red may represent different temperatures in different images). Areas colored white represent clouds.

1. What color on the satellite images is used to show the warmest water? What color is used to show the coldest water?
2. During what months is the ocean the warmest? The coldest? Why?
3. Is the water right along the coastline warmer or colder than the water further offshore? Why? Is this true for all of the images?
4. Notice that the water temperature is warmer at the bottom right corner of all of the images. Can you think of a reason why this warmer
water would be present further out in the ocean all through the year?

**CTD Data**

1. What types of data does a CTD record?
2. How cold is the water at 4 meters depth in December? In June? Is there a big difference? If so, why?
3. What happens to the temperature of the water in June as you move from the surface down towards the bottom? What happens to the salinity as you move deeper? Do you notice this same pattern for the other months?
4. Write a short paragraph describing the relationship between temperature, salinity, and depth based on the CTD graphs.

**CTD Data and Satellite Images**

Using the your new knowledge of how to read satellite temperature images and CTD data graphs, write a two-paragraph description of how both types of data would be useful to scientists.

**Step 2: Analyze Data**

**B.1) Ocean Temperature Worksheet**

(Answer Key)

**Satellite Images**

1. The warmest water is shown as red, and the coldest water is shown as purple.

2. The ocean off the coast of New Jersey is warmest during the summer months, and coldest during the winter months. It’s warmer in the summer because there are more hours of sunlight during the day compared to days during the winter. The sun is shining more directly on the northern hemisphere for more hours per day, allowing the ocean to absorb more heat. In the winter, the sun shines for less hours a day, and at a lower angle to the northern hemisphere, contributing less heat to the ocean and allowing it to cool.

3. During the warmer months of the year, the water along the coast is warmer than water further offshore because the water along the coast is shallower, and is more quickly heated by the sun. This may not be the case in late winter and early spring (Dec-Mar) when shallow water along the coast loses heat and becomes as cold, or even colder, than temperatures further offshore. An analogy could be placing a tray of water under a heat lamp. The water would heat up and stay warm unless the lamp was removed, at which point the water would cool down.

4. The warmer water visible in the lower right corner of every image is the edge of the Gulf Stream, a current of warm water that travels north along the coast from the Gulf of Mexico. The Gulf Stream carries warm water northward very close to the Atlantic coastline throughout the year. However, as the Gulf Stream passes north of North Carolina, the current is deflected to the northeast and moves further away from the coast, as seen in these images.

**CTD Data**

1. A CTD records conductivity (a measurement of salinity, or saltiness of the water), temperature, and depth.

2. The water at 4 meters depth in December is about 2 degrees Celsius, or 36 degrees Fahrenheit. In June, it’s about 21 Celsius, or 70 Fahrenheit. Yes, this is a big difference, caused by the sun heating up the water closer to the surface during the late spring and throughout the summer, as is seen here in June.
3. In June, the water temperature decreases as you move from the surface towards the bottom. The salinity increases as you move deeper. This same pattern is seen for all of the months shown except December, when the thermocline disappears and the water from top to bottom is evenly mixed. During the warmer months that have more rain, there is more freshwater coming from the land into the ocean near the coast. This freshwater mixes with the warmer surface water, lowering the salinity, but does not mix with the colder water below the thermocline because of the difference in density between the two temperature layers.

4. Based on the CTD graphs, students should write a paragraph expressing their understanding of how temperature and salinity can change with depth. Their understanding should include the “take home” message that not all water in the ocean has the same characteristics, and that several factors influence the ocean water in any given area, including temperature, salinity, and ultimately the seasons and atmosphere.

**Step 3: Outside Influences – How do atmospheric conditions affect ocean temperatures?**

**Objectives:**
Student will
- Understand how wind direction is measured using a compass
- Learn how to graph the direction and speed of wind
- Understand that wind impacts the motion of ocean surface water

**Materials:**
For each pair
- Full-circle or semicircular protractor (a full-circle protractor works better and is preferred, but a semi-circular one will work as well)
- Copies of the Wind Speed & Direction Worksheet
- Calculator (optional)
- Notebook for students to answer questions

**Classroom Implementation**

**Time Required:**
One or two 45-minute class sessions.

**Lesson and Activities:**
Have the students view all the tutorials and the science background before they begin this activity. Print enough worksheets for your class to work in pairs.

Have students begin by reading the Introduction and viewing the necessary tutorials. Distribute a protractor to each pair. Then, as a class, practice plotting some wind directions using the compass. This activity works best if you plot a set of data with your students so they understand how to place the protractor on the graph in order to plot the data.

Have the students follow the steps as outlined in the activity to plot the data on the worksheet. Students should understand that there is a difference between the measured degree of wind direction and the direction that the scientists in the COOLroom use to graph the data. The wind is measured as the direction it is coming from, but it is graphed as the direction it is moving towards (the opposite direction). This is why they need to add or subtract 180 degrees from the measured direction. This may not necessarily be how wind direction is measured universally, but this is how it is measured at the COOLroom. Unless the students calculate it in that fashion, they will be confused when they look at the real-time wind data on the COOLroom web site.
When they complete the graphs, collect them and post the graphs on the wall. Have students look at the graphs and hypothesize about what the weather might be like each day. If you have time, discuss students’ responses to the question of how winds affect the movement of ocean water.

**Step 3: Outside Influences**  
**E.2) Wind Speed and Direction Worksheet**

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<thead>
<tr>
<th>Date</th>
<th>Wind Speed (mph)</th>
<th>Wind Direction - from (degrees)</th>
<th>Wind Direction - towards (degrees)</th>
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<tbody>
<tr>
<td>Day 1</td>
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<td>10</td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>5</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>10</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>25</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>Day 5</td>
<td>5</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Day 6</td>
<td>20</td>
<td>325</td>
<td></td>
</tr>
</tbody>
</table>
Step 3: Outside Influences
E.2) Wind Speed and Direction Worksheet (Answer Key)

<table>
<thead>
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<th>Date</th>
<th>Wind Speed (mph)</th>
<th>Wind Direction - from (degrees)</th>
<th>Wind Direction - towards (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>15</td>
<td>10</td>
<td>190</td>
</tr>
<tr>
<td>Day 2</td>
<td>5</td>
<td>260</td>
<td>80</td>
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</tbody>
</table>
### Continuous vs. Discrete Data - Worksheet

http://www.coolclassroom.org/teachers_guide/tg_earthsci.html

<table>
<thead>
<tr>
<th>Day</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
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<td>Day 4</td>
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<tr>
<td>Day 6</td>
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<td>145</td>
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</tbody>
</table>

![Graph showing continuous and discrete data over time](image-url)
Steps #4 & 5#: Watch It Happen and Create A Forecast

**Objective:**
Students will
- Interpret satellite images off the New Jersey coastline and describe an upwelling event
- Analyze wind speed and direction during an upwelling event
- Interpret real-time data and create a local ocean weather forecast

**Materials:**
- Copies of the Ocean Forecast Worksheet and the two Data Sheets
- Notebook for students to answer questions

**Classroom Implementation**

**Time Required:**
Two 45-50 minute class sessions plus 15 minutes a day for 3-4 days to conduct a project interpreting real-time data.

**Lesson and Activities:**
In this final lesson, students will be engaged in a series of real-time data interpretation activities. Before students begin the activity, spend some time looking at the data sets they will be interpreting and visiting the tutorial on upwelling. Prior to beginning this activity, students should complete the previous activities (interpreting satellite images and CTD graphs to determine water temperature, and how to graph and interpret wind data). If they have not, or are not yet comfortable with interpreting data, have the students visit the tutorials again.

Divide the class into student pairs. Distribute the Ocean Weather Forecast Worksheet. Review students’ prior knowledge of reading satellite images and CTD graphs and graphing wind direction. If some students need more practice with these skills, have them go through the upwelling tutorial. Understanding the concept of upwelling and having mastery of these skills are both key to the lesson.

After students have completed the tutorial, discuss why different people such as surfers, swimmers, fisherman, or members of the Coast Guard might be interested in learning when upwellings occur. Surfers and swimmers most likely do not appreciate upwellings because the cold water upwelled to the surface can make it very uncomfortable to swim, even in the middle of the summer. Fisherman would be more likely to appreciate an upwelling because the upwelled cold water brings nutrients to the surface, causing phytoplankton to grow. The phytoplankton can fuel the food chain, ultimately attracting larger fish to the area. Then have students continue with the activity.

Towards the end of the activity, students will be asked to create an Ocean Weather Forecast. Go to the Rutgers Upwelling Index (www.thecoolroom.org/swimmers/upwellingindex.htm) so that you can help students think about ideas for the forecast.

After students have completed the activity, have each pair present their forecast. Finally, have students determine whether or not the class should go swimming, fishing, or neither off the coast of New Jersey over the coming days.