Expedition Objective:

- Students will apply a scientific approach to study a problem of the Earth and environment, specifically the global flow of surface waters in the ocean basin.

- Remember to answer the questions below and take notes

- Required learning group discussion instructions at the end of this worksheet

- To begin, go to: http://oceansjsu.com/105d/exped_buoys/1.html

- Remember to work your way down each webpage to access link that will take you the next webpage, if you answer the question correctly, if not you will need to review current webpage once again.

1. Introduction - Tracking Major Ocean Surface Currents - Distribution of Instruments

As with many expeditions in this class - you are the scientist in the next analysis during which you will determine the flow of the surface waters in the world's oceans.

You have access to the monthly track of drifter buoys in all of the oceans.

How will the geographic distribution of drifters influence the accuracy of our ability to trace ocean currents?

(not directly mentioned on WWW site - think about this one - post any questions on discussion area for this expedition)

2. Tracking the Ocean Surface Currents with Drifters

Use the data from the drifters to make a drawing with arrows showing the motion of the drifters and therefore the surface currents (draw at least eight of the arrows, but uniformly distributed through the ocean in this region)

These arrows represent the movement of the drifter buoys. Yes, there is a pattern but it is difficult to see without some additional analysis (which you will see in the subsequent maps called "Annual Mean Velocity Estimates"). You will work your way from the collection of the data, to the data analysis and finally to the interpretation.
Ultimately it is not an "easy" process to directly measure the flow of the surface water -- it takes a large amount of data collected over long periods of time with a very large number of instruments.

So over the course of the next few web pages, students first examine the movement of the drifters, then try to make sense out of these data (and find that is it very difficult), then see the analysis and a more refined picture of the water movement, and finally a "cartoon" diagram of the movements that does not show the fascinating details of the ocean circulation.

3. Tracking Buoys in The Pacific

Make a drawing of the arrows showing the motion of the drifters in the North Pacific (yes, the arrows are on the small-side, but, draw at least eight of the arrows, uniformly distributed through the ocean in this region)

Where on the map have the buoys drifted the farthest distance over this month of observations?

(look for longest arrows) These are the regions of the fastest currents.
Tracking the Ocean Surface Currents in the Equatorial Pacific - Make your drawing (draw at least eight of the arrows, but uniformly distributed through the region)

Tracking the Ocean Surface Currents in the South Pacific - Make your drawing (draw at least eight of the arrows, but uniformly distributed through the region)
4. Tracking the Ocean Surface Currents in the North Atlantic - Make your drawing
(draw at eight the arrows, but uniformly distributed through the ocean in this region)

Where on the map have the buoys drifted the farthest distance over the past month in the northern Atlantic Ocean?

(once again, look for longest arrows - these are the regions of the fastest currents).
5. Tracking the Ocean Surface Currents in the Indian Ocean - Make your drawing
(draw eight of the arrows, but uniformly distributed through the ocean in this region)
In order to make sense out of these data, we need to do a simple routine of data analysis during which we will determine average (mean) velocity (speed and direction) of the buoys over a year. 6. Compare your diagrams in the previous questions with the diagrams of Annual Mean Current Velocity in the Pacific Ocean as shown on the expedition web page

The arrows on the WWW page represent averages of the surface currents over several years and do not include the important variations and complications shown in the buoy trajectories (variance in statistics jargon) due to ocean eddy currents, which are irregular circular currents many 10's to 100's kilometers in diameter. Modify your diagrams if your wish to show the average direction of flow.

Draw in the surface circulation in the Pacific Ocean on the map below

7. Tracking the Ocean Surface Currents - Now add the average surface currents in the Atlantic Ocean to the map above - compile a few vectors in each ocean basin to show the flow (Use your maps in other parts of expedition to find a few vectors.) Vectors are arrows that show the direction of movement plus the length of the arrows is proportional to the speed of motion - the longer the arrow - the faster the motion.

8. Tracking the Ocean Surface Currents - Now add the average surface currents in the Indian Ocean to the map above - compile a few vectors in each ocean basin to show the flow (Use maps in parts of expedition.)
9. Major Ocean Surface Currents

Your work on the preceding web pages illustrates two points:

(1) scientific measurements need to be collected over a long period of time in order to see patterns and,

(2) there is a tremendous amount of variation in the flow of the water that is not captured in simplified diagrams such as shown on this web page.

Ultimately it is not an "easy" process to directly measure the flow of the surface water -- it takes a large amount of data collected over long periods of time with a very large number of instruments.

Even then, there needs to be simple methods to average the data (determine statistical mean) which leave out some of the most fascinating questions, such as how do the ocean currents change over time and in different parts of the ocean.

Let's now examine the oversimplified view of the surface currents as shown on the diagram on the web page.

On the map below draw the arrows and label the names of the major surface currents.

The big circular currents are called _______________________________.

In what direction do the large, central gyres flow in the northern hemisphere?

______________________________________________________________

(clockwise or counterclockwise?)
In what direction do the large, central gyres flow in the southern hemisphere? 
________________________________________ (clockwise or counterclockwise)

In what direction do the gyres flow near the equator (i.e. the north and south equatorial currents)? 
________________________________________

Which surface current encircles the entire globe and therefore affects every ocean? 
________________________________________

10. North Pacific Gyre

What is the path followed by the North Pacific Gyre?

What is the role of the gyre in transporting plastic debris in the North Pacific?

11. Eddy Currents

How does the model of surface circulation, shown in the animation, differ from the map of general circulation shown at the top of the webpage?

The complications shown in the animation represent eddy currents, smaller-scale circular currents that spin off the main currents and which have been viewed with increasing importance in the overall energy budget for the global circulation.

12. The Equatorial Counter Currents In what direction do the counter currents along the equator flow in relation to the central gyres? ________________________________
13. Western and Eastern Boundary Currents

Remember we discussed the speed of currents in previous questions...now we will use this information. You should see that the fastest currents are in a similar location in each ocean basin. - on the western boundary of ocean or eastern boundary.

Complete the table below by listing the general characteristics of boundary currents around the world (follow the example given for the Peru Current):

<table>
<thead>
<tr>
<th>Current Name</th>
<th>Eastern or Western Boundary Current</th>
<th>Relative Speed Fast or Slow</th>
<th>Water Temperature Warm or Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peru (example)</td>
<td>Eastern</td>
<td>Slow</td>
<td>Cold</td>
</tr>
<tr>
<td>Kuroshio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gulf Stream</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agulhas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You have now used one of the fundamental steps in scientific method of deriving the surface circulation of the global ocean -- tracking buoys.

14. Western Boundary Currents and Climate

Western boundary currents carry (temperature) water and flow at a relatively (speed) speed.

How might the western boundary currents, such as the Gulf Stream or Kuroshio, influence coastal climate?

15. Western Boundary Currents and Storms (Hurricanes and Typhoons)

How are hurricanes related to western boundary currents in the ocean?
16. **Eastern Boundary Currents and Climate** - How might the eastern boundary currents, such as the Peru current or California current, influence coastal climate?

Eastern boundary currents carry _________________ (temperature) water and flow at a relatively _________________ speed.

**Required Learning Group Discussion Assignment (6 points)**

- After completing this expedition, go to your learning group discussion and then post two multiple-choice questions, each with 5 potential answers (a, b, c, d, and e), on the scientific investigation of determining the surface circulation in the ocean; do not highlight the correct answers to your questions.
- Scoring on required posting will be based on the clarity (ability to communicate in writing) and quality (scientific insight) of the posted questions and the listings of potential answers.
- Ambiguous questions or answers, or error in writing quality, will receive point deductions - be clear and precise.
- Do not repeat a question posted previously by another student in your learning group, which will consist of 9-10 other students.
- Students will then provide feedback on the clarity and quality of the questions posted by the student immediately above their own posting in their assigned discussion and then answer the questions.
- The first student to post their questions in a learning group receives an extra 48 hours, after deadline, to answer the posting of the last student to post in the group by the deadline.
- After your questions have been answered, provide the feedback on the accuracy of the answers and review the work in your other learning group members.
- Please consider compiling a list of the top six questions covering the breadth of material in this expedition as part of a self-study in preparation for the quiz associated with this module.