This lab was adapted from the NASA Ocean Motion activity [Navigating the Ocean](http://oceanmotion.org/guides/n_1/n_student_1.htm)

Introduction

[](http://d32ogoqmya1dw8.cloudfront.net/images/eslabs/climate/ocean-atmosphere_connections.jpg)

 *Image source:*[NASA/Ocean Motion](http://oceanmotion.org/html/background/climate.htm)*.*

Everything is connected. The ocean influences climate in many ways by exchanging heat, water, and chemical compounds with the atmosphere. Energy from the sun heats the atmosphere, the oceans, and the land surface, and fuels most of the biosphere. Differences in the amount of energy absorbed in different locations around the world set the atmosphere and oceans in motion and help determine their overall temperature and chemical structure. These motions, such as wind patterns and ocean currents, redistribute matter and energy throughout Earth's environment. Water melts, evaporates, condenses, and freezes, and is moved from place to place in the atmosphere, the oceans, across the land surface, and through soil and rocks.

The global scale encompasses the whole Earth, all of the atmosphere, hydrosphere, pedosphere, cryosphere, and biosphere. Within the global Earth system, interactions at local and regional scales contribute to how each of the four major components of the Earth system interact with each other as a whole at the global scale. Oceanic and atmospheric circulation redistribute energy, water, and other materials through the Earth system. This plays an essential role in sustaining life by moderating climate over much of the Earth's surface. Oceanic and atmospheric circulations exist on a wide range of time and space scales. Examples of atmospheric circulations include weather systems, hurricanes, **jet streams**, the **Hadley cell**, and the **Southern Oscillation**. Examples of oceanic circulations include **thermohaline circulation**, the **Gulf Stream**, **gyres**, and surface currents.

After completing this investigation, you should be able to:

* Trace pathways of wind and water on a world map to and from your region, and across an ocean to other parts of the Earth;
* Describe specifically how your region is connected as a system to others across the Earth by identifying what your wind and water carry and where the wind and water go; and
* Write about what activities in your region might affect other regions, and what activities in other regions might affect yours.

Keeping Track of What You Learn

Throughout these labs, you will find two kinds of questions.

* **Checking In** questions are intended to keep you engaged and focused on key concepts and to allow you to periodically check if the material is making sense. These questions are often accompanied by hints or answers to let you know if you are on the right track.
* **Stop and Think** questions are intended to help your assess your understanding of the key concepts and skills you should be learning from the lab activities and readings.

Your teacher will let you know which answers you should record and turn in.

Part A: Tracing Pathways

[](http://d32ogoqmya1dw8.cloudfront.net/images/eslabs/climate/global_currents.gif)

Show caption

Circulating wind and ocean currents distribute energy and matter all around the globe. Surface currents are primarily driven by wind and Earth's rotation. Earth's rotation causes the pathway of both air and water to appear to curve rather than travel in a straight line. This is known as the Coriolis effect. Because the Earth spins counterclockwise (when viewed from above), the Coriolis effect causes winds to be deflected eastward (right) in the northern hemisphere and westward (left) in the southern hemisphere. Ocean currents behave similarly, but can also be deflected by continents or other landmasses, which causes the water to move in circular patterns called gyres. Watch this [short video](http://www.pbs.org/wgbh/nova/earth/coriolis-effect.html) for a demonstration of how the Coriolis effect works.

Deeper ocean currents, often called "thermohaline circulation," are controlled by temperature (thermo) and salinity (haline). Saltier water is more dense and therefore sinks. The motion of this heavier water results in vertical mixing of the ocean water that drives deep ocean currents. You might also hear this process referred to as the "global ocean conveyor belt" because the currents generated by this cold water mixing travel around the world. Ocean currents move heat from warm tropical latitudes toward colder polar latitudes, transport nutrients that sustain marine life, and aid ocean travel. Ocean currents may also carry trash, pollutants, or other drifting debris up to thousands of miles. Fortunately, one person's trash can sometimes truly be another person's treasure.

In January 1992, 29,000 bathtub toys spilled into the ocean when a storm hit a ship traveling from Hong Kong to Tacoma, Washington and knocked a shipping container into the sea. Ten months later, plastic ducks, turtles, frogs, and beavers began washing ashore near Sitka, Alaska. The distribution of this debris may have seemed like a disaster to some, but scientist [Curt Ebbesmeyer](http://oceanmotion.org/html/research/ebbesmeyer.htm) saw it as an exciting opportunity to study the paths of ocean currents. In fact, Curt Ebbesmeyer made an entire career out of tossing objects into the water to see where they end up.

Although it is very difficult to trace the exact path of a particular parcel of air or ocean water and anything it might contain, we can use average wind and water patterns to explore how different regions around the world are connected to one another. Look at this [interactive map of global surface currents](http://www.classzone.com/books/earth_science/terc/content/visualizations/es2401/es2401page01.cfm?chapter_no=visualization) and then answer the **Checking In** questions below.

Discuss the following questions to check your understanding of the information contained in the interactive global surface currents map.

1. Look at the direction of the surface currents in the oceans and at the direction of the wind. What evidence do you find that wind influences the direction of the surface currents in the oceans?
2. What pattern can you see in the direction of the global winds? Look at global winds near the equator, in the middle latitudes, and in the polar regions.
3. Notice the location and flow of warm and cold ocean currents. Why do you suppose that currents flowing toward the equator are generally cool while currents flowing away from the equator are warm?

Look at the black outline map of the world and the world maps of average ocean currents and average winds in January and July given to you by your instructor.

Locate the Earth System study region assigned to you on the black outline map of the world and draw a box around it.

Trace the flow of water from your study region. Start upstream at the source and then move downstream through your study region to an ocean, noting the names of bodies of water and the regions through which it passes.

Using the world maps of average ocean currents and average winds to guide you, draw the pathways of wind and water into and out of your region on the black outline map: from where it meets an ocean, across that ocean to other continents, to around the globe. **NOTE:** You may want to use pencil at first; then use different colored pens or pencils to distinguish wind direction and water currents from each other.

Write the geographic names of regions along the water's pathway and through which the wind passes.

Answer the following **Stop and Think** questions about wind and water pathways through your study region**.**

**Stop and Think: Wind**

**1:** What are the regions from which wind blows ***into*** your region? Write down real geographic names (for example, write the name of a mountain chain, not just "mountains").

**2:** What might the wind be bringing ***into*** your region? Think about the places the wind is coming from, what happens there, what lives there. Think about dust, insects, tiny seeds, smoke, air masses of cooler or warmer temperatures, and moisture. Be specific in your responses.

**3:** When wind blows ***out of*** your region, what region does it blow into? Again, write down real geographic names.

**4:** What might the wind be carrying ***out of*** your region? Is it the same as what it brought in? Be as specific as you can about what is being carried, and where it goes.

**Stop and Think: Water**

**5:** What are the regions from which water flows ***into*** your region? Write down geographic names.

**6:** What might the water be bringing ***into*** your region? Be as specific as you can.

**7:** When water flows ***out of*** your region, what region does it flow into? Again, write down geographic names.

**8:** What might the water be carrying ***out of*** your region? Be specific.

Part B: Message in a Bottle

[](http://oceanmotion.org/html/resources/drifter.htm%22%20%5Cl%20%22vishead)

In Part A, you traced the pathways of wind and water into and out of your study region. Now, you will use [computer simulations](http://oceanmotion.org/html/resources/drifter.htm#vishead) to track ocean currents.

**Stop and Think**

**1:** Imagine dropping a message in a bottle into the ocean at a given location and observing where the object would end up as a result of surface currents. Based on the pathways you traced in Part A, where do you think your bottle would end up?

Use a computer model to test your prediction. The model uses simple physics equations of motion and information about ocean surface currents from historical monthly [ship drift data](http://oceanmotion.org/html/gatheringdata/shipdrift.htm) to predict the motion and pathways of objects adrift at sea.

Click [Ship Drift Model](http://oceanmotion.org/html/resources/drifter.htm) to open the model in a new window. This model only includes circulation of currents. It does not include effects of wind/waves or the dynamics of the floating object. The model assumes that the drifter is a small object floating at the surface, and that it has a density similar to that of ocean water. This model does not apply to sailing or motorized boats or ships.

You should see a map of the world with arrows depicting the mean or average direction of currents at the ocean surface. The direction of an arrow indicates the direction of the current and an arrow's color indicates the speed of the current. A color scale below the map shows you how to convert each color to a speed in meters per second.

*What is the range of current speeds (in meters/second) shown on the map?*

*What is the range of current speeds (in miles/hour) shown on the map? Is the fastest surface current speed faster or slower than the average human walking speed (3 miles/hour)? HINT: 1 mile = 1609.344 meters*

Look carefully at the world map to find the current speeds that correspond to the different colored arrows. Make a table like the one below and fill in the empty boxes with current speeds in meters/second.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Arrow Color** | **Dark Blue** | **Light Bloe** | **Green** | **Yellow** | **Orange** | **Red** | **Dark Red** |
| **Current Speed (m/s)** |  |  |  |  |  |  |  |

Simulate dropping your message in a bottle into the water using the closest ocean access point to your study region as your starting location.

Find the place on the map where you want to drop your bottle into the ocean. Move your mouse to that location and click on the map. A second window with a map showing the tracks of five drifters will pop up.

Find and write down the starting longitude and starting latitude for your model.

Estimate the end locations for the five drifters and write the numbers in a table like the one below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Drifter Color** | **Blue** | **Green** | **Orange** | **Red**  | **Purple** |
| End Longitude |  |  |  |  |  |
| End Latitude |  |  |  |  |  |

**Stop and Think**

**2:** How well does your prediction of where your message in a bottle would end up, agree with the computer model? Explain.

**3:** What events and activities in other parts of the globe could affect your region? Describe events and activities that are caused by people (such as making dams) and those caused by nature (such as volcanic eruptions).

**4:** What events and activities in your region could affect other parts of the globe?

Experiment with dropping the drifters in different locations around the world to see how the drifters' pathways compare. Try dropping the drifters into the ocean near the following locations:

* 1. New England
	2. the west coast of Australia
	3. California
	4. Venezuela

**Stop and Think**

**5:** Compare and contrast the paths of these drifters with those of drifters dropped into the ocean near your study region.

**6:** Why do you think there are international laws for dumping waste/trash/chemicals in the ocean, rather than just local laws? Do these laws only need to extend to nearby neighboring countries? Explain.