Elements of Oceanography (OCEA-105)
Dr. Charles Gregory

Currents & Drifters Lab

Objectives:

- To understand and recognize the major movements of surface water in the world's oceans, the Gulf of Maine, and along a local beach;
- To understand the roles that wind and the Earth's rotation play in determining direction and velocity of ocean currents;
- To understand the design of coastal drifters with a satellite transceiver attached;
- To use these drifters to track the actual direction and calculate velocity of Gulf of Maine currents;
- To compare and contrast the performance of different drifter designs;
- To understand longshore currents: the forces that produce them, and their resulting affects; and
- To design a method for measuring the direction and rate of the longshore current along one of Maine's beaches.

Background Information:

A. Major Surface Currents - Surface ocean circulation is the result of several processes, including **wind stress** acting on the water surface and differences in density because of solar heating. If we assume that observed current systems are simply the result of wind stress, then they should closely follow the major wind belts on the Earth (Figure 1). In fact they do, but you will note that there is a slight clockwise divergence (to the right) from the wind direction in the Northern Hemisphere and a counterclockwise one in the Southern Hemisphere. This is because of the Earth's rotation and the **Coriolis effect**.

Figure 2 is a map of the major wind-driven currents in the world's oceans. Note that in the Northern Hemisphere the currents form large clockwise-rotating **gyres** or rings. Note also that the gyres are not exactly centered in the ocean basin, but are slightly offset to the west. Thus the currents along the western sides of the northern oceans are narrow, fast, and deep, whereas those on the eastern sides are wide, shallow, and sluggish. This phenomenon is known as **westward intensification**, and is because of the Earth's rotation and the necessity of balancing or conserving angular momentum. This phenomenon can be observed in the Canary-Gulf Stream current system in the Atlantic Ocean, and the California-Kurioshio current system in the Pacific Ocean.

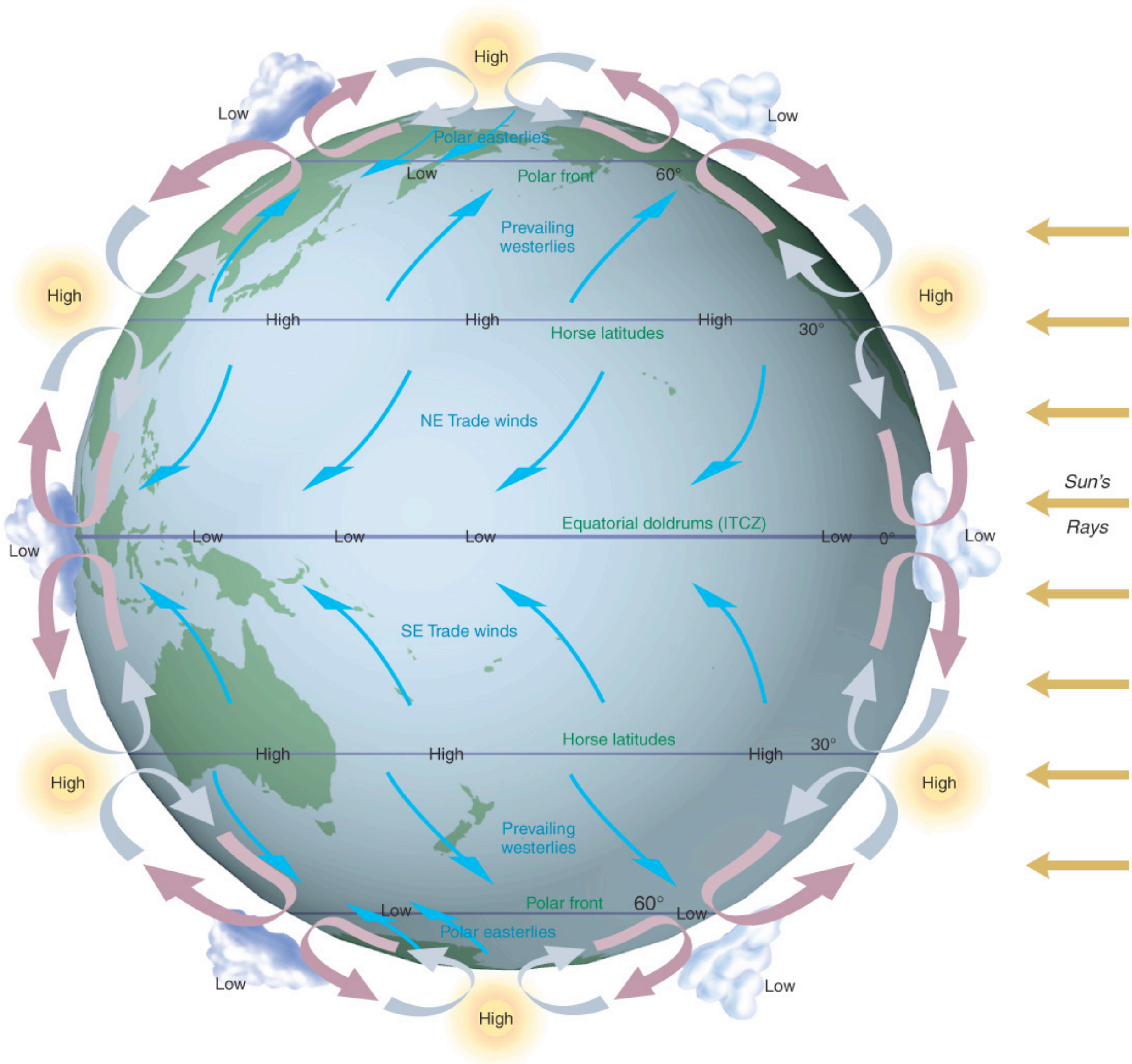


Figure 1. Atmospheric circulation and wind belts of the world. The six-cell model of atmospheric circulation creates the major wind belts of the world. Boundaries between wind belts and surface atmospheric pressures are also shown. (source Trujillo & Thurman, 2011)

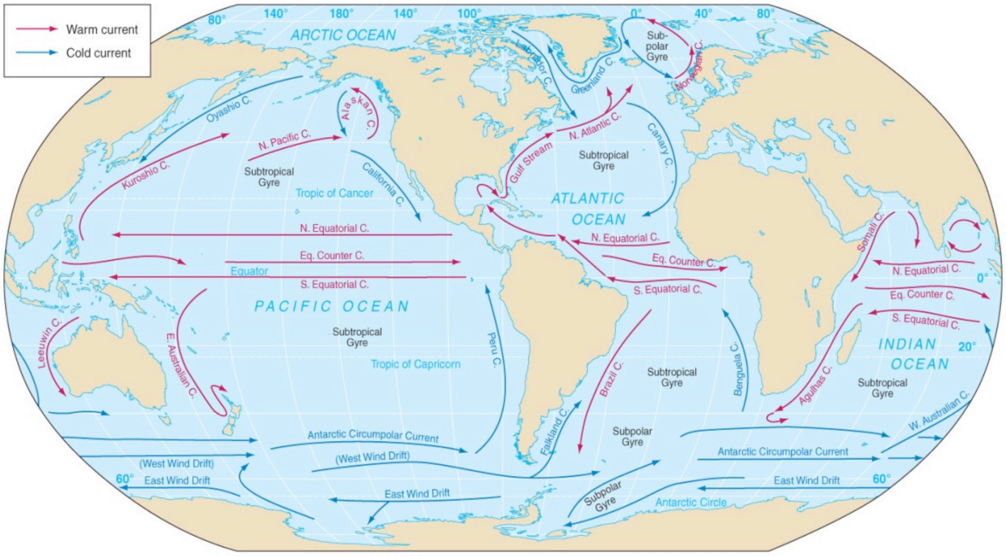


Figure 2. Major wind-driven surface currents of Earth's oceans. (source Trujillo & Thurman, 2011)

Satellites have a great advantage of covering Earth's surface in a matter of days instead of months and years, as shipboard investigations require. However, satellite obtained imagery only depicts the sea surface, and it conveys little direct information about the water at depth. But because satellites move so fast their observations may be considered simultaneous over large ocean regions, and give us a better overall picture of the ocean at a particular time. Figures 3 and 4 show satellite images of the Northeast Atlantic and Gulf of Maine (GoM).

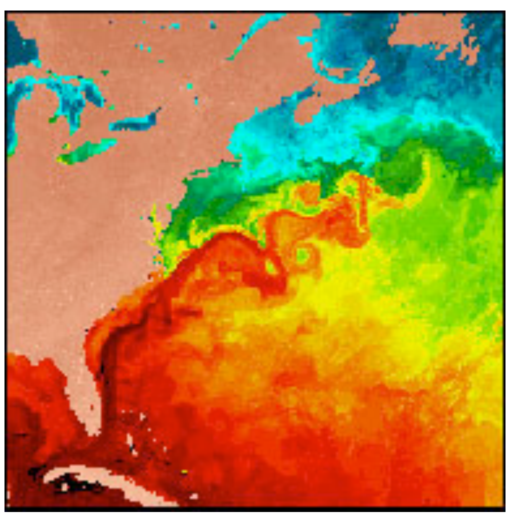


Figure 3. In this satellite image of the Northeast Atlantic, the Gulf Stream is clearly visible as a band of warmer water (red colors) that flows into the cooler northern Atlantic Ocean (green colors).

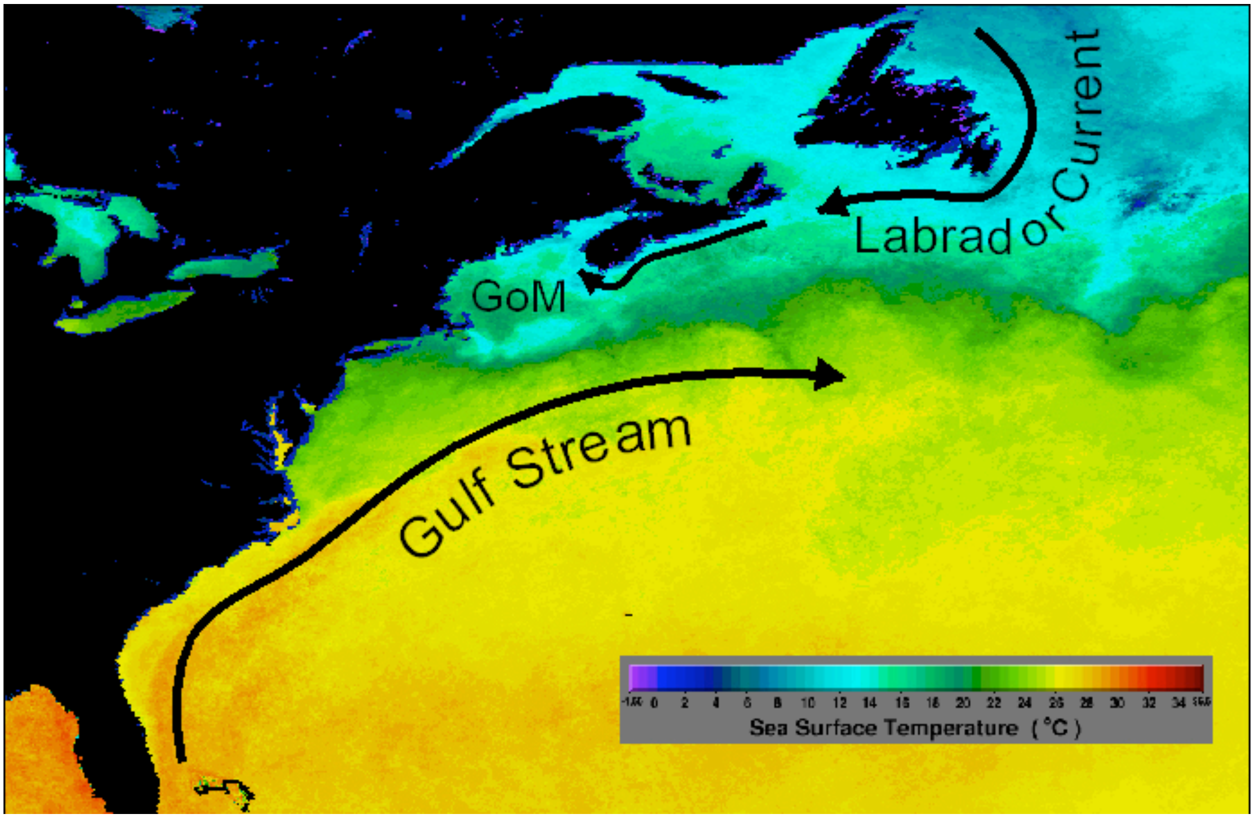


Figure 4. Sea surface temperature of Northeast Atlantic, including Gulf of Maine (GoM). Image shows the warm waters of the Gulf Stream and the cold waters of the Labrador Current, which are both loosely labeled. The tidally mixed, cooler waters of the Bay of Fundy and Georges Bank are clearly seen. (source www.gulfofmaine-census.org)

B. Circulation in the Gulf of Maine (GoM) - The highest tides on earth occur in the **Gulf of Maine** (Figure 5). The maximum tidal range is 16 m (52 ft) in Minas Basin, Canada, at the easternmost reaches of the **Bay of Fundy**. Tidal ranges in the Gulf decrease from east to west, but are everywhere greater than the world wide average of about a meter (3 feet). The relatively strong currents created by these tides keep waters well mixed, increasing the availability of nutrients and fueling regions biological productivity. This connection between tides and biology is best illustrated on **Georges Bank**, at the southern boundary of the GoM, historically one the most productive fishing grounds in the world. Here, strong tidal currents, relatively closed circulation and shallow waters set the stage for dense, long lasting **phytoplankton blooms**. These blooms, often observed from space, form the base of a food web that has attracted fishermen for hundreds of years in their pursuit of cod, haddock, halibut, flounder, lobster, scallops, clams and others.

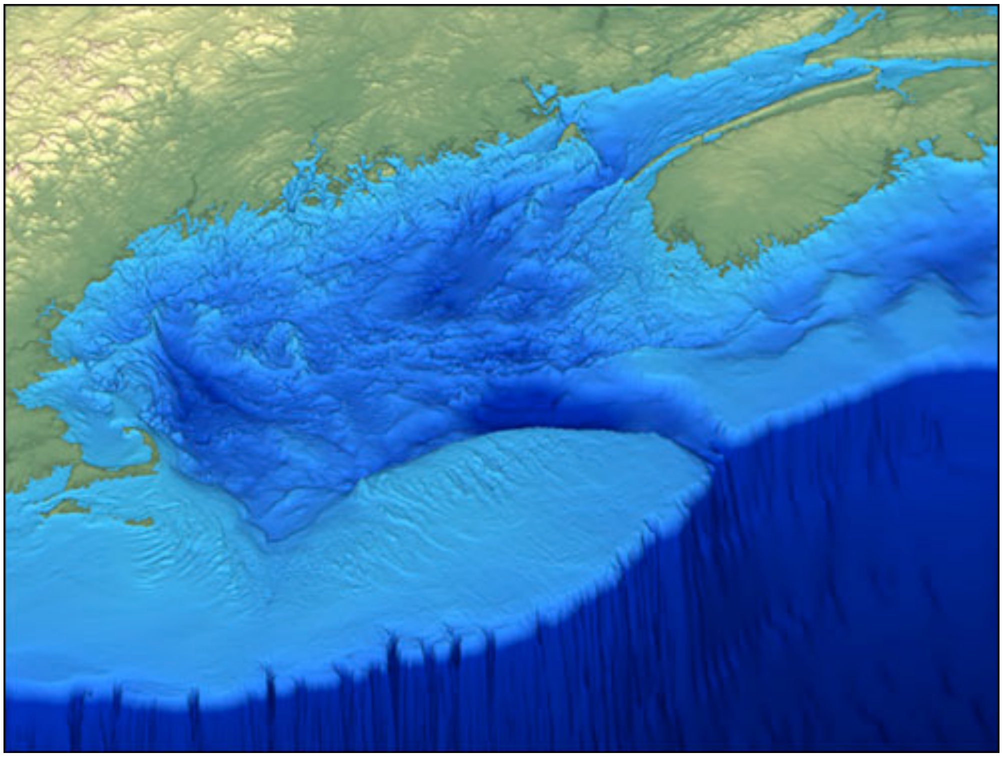


Figure 5. The Gulf of Maine. This computer rendering of shaded relief, which enhances the apparent depth of features on the ocean bottom, shows the complex array of banks, ridges, gullies, and basins that extend as deep as 1,500 feet (500 meters) beneath the ocean surface in the Gulf of Maine. Georges Bank and Browns Bank - in some places as shallow as 13 feet (4 meters) - mark the offshore boundary between the Gulf of Maine and the rest of the Atlantic Ocean. Map originally created for the Gulf of Maine Council on the Marine Environment by Northern Geomantics. (source www.gulfofmaine-census.org)

As seen in Figure 6, the nutrient rich waters of the Gulf of Maine are fed primarily by the cold, deep **Labrador Current** (1) that enters the Gulf as the **Nova Scotia Current** (2) along the **Scotian Shelf, Browns Bank** and **Northeast Channel** to the south of Nova Scotia. This Nova Scotia Current helps drive the primarily counterclockwise circulation of the Gulf and forms the **Gulf of Maine Gyre** (4). This Gyre moves at about 7 nautical miles per day, and includes waters from **Bay of Fundy,** the **Eastern Maine Coastal Current (EMCC)** (3) off Maine's east coast, and the **Western Maine Coastal Current (WMCC)** off the coasts of western Maine, New Hampshire and Massachusetts. These currents are influenced by changes in river outflow, often enhanced during spring runoff. Water exits the Gulf primarily through the **Great South Channel**, between Cape Cod and Georges Bank, approximately three months after entering.

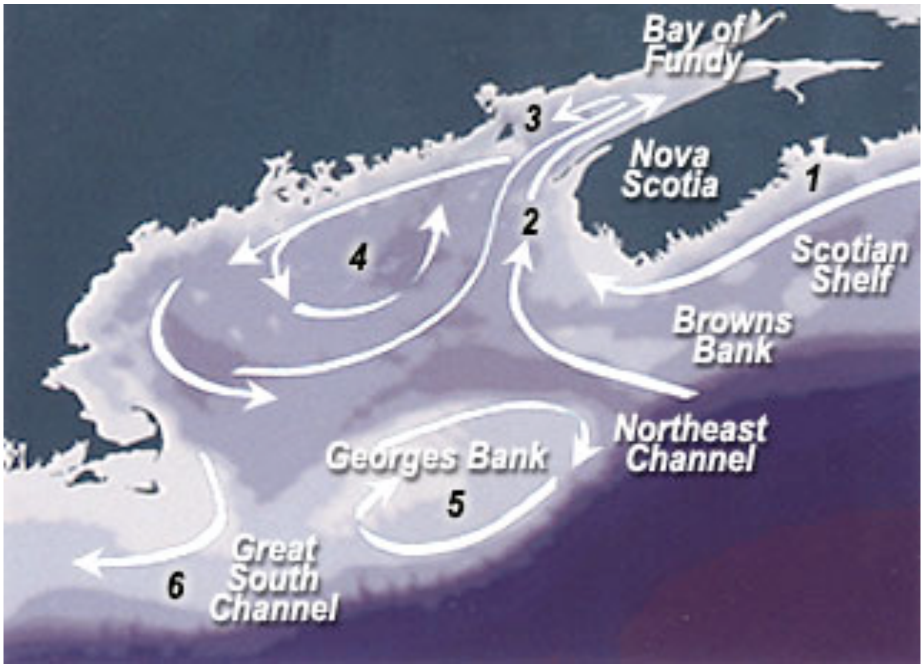
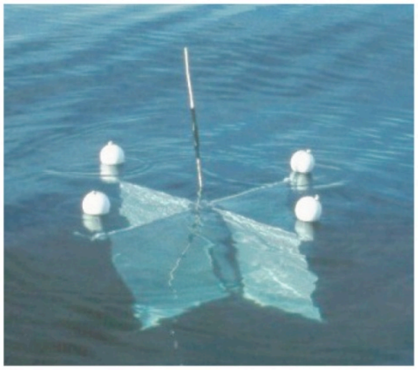
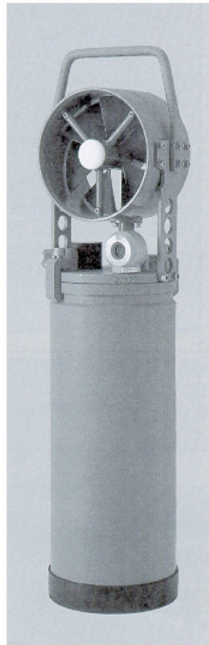


Figure 6. The current patterns in the Gulf of Maine. The numbers are described in the lab trext.

C. Surface Current Measurements - Surface currents rarely flow in the same direction and at the same rate for very long, so measuring average flow rates can be difficult. Two methods are often used for direct measurement of surface currents (Figure 7). In one, a fixed structure (such as a pier) is used where a current-measuring device or **flow meter** is submerged and attached to the structure. Propeller devices can also be towed behind ships, and the ship's speed is subtracted to determine a current's true flow rate. The second method employs a floating device, or **drifter**, that is released into the current and tracked through time. Typically, satellite-transmitting devices (i.e. **transceivers**) are attached to the drifter to track its progress.



(a)



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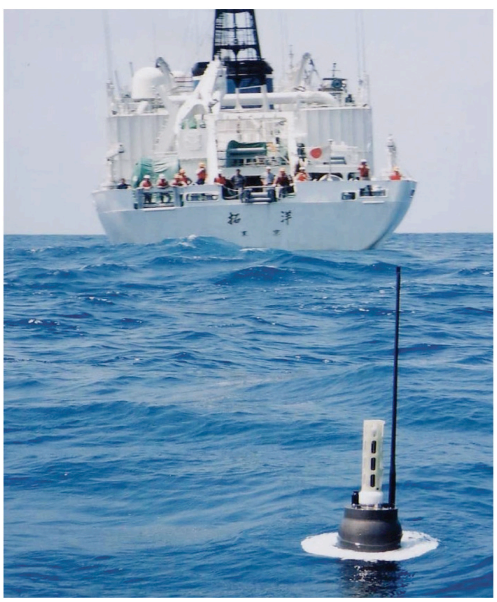

(b)

Figure 7. Current measuring devices: drifters, and a flow meter.

D. Longshore Currents - **Longshore currents** are located in the surf zone and run parallel to the shore. They are the result of waves breaking at an angle to the shore. They affect shorelines by redistributing sand and sediment along their path. This redistribution is also known as **littoral drift**.

Equipment:

- Computer
- Coastal Current Drifters
- Boat and Captain
- Tape measure or meter stick to measure 10 meters
- Small objects that float (e.g., driftwood, cork, etc.)
- A timing device with a second hand

Procedure:

This lab has three parts: 1) to examine the worlds ocean currents from charts and answer a few questions, 2) deploy two different coastal current drifters and track their progress in the Gulf of Maine, and 3) to design a method for measuring the longshore current direction and rate at Willard Beach.

To complete part 1 of this lab read through the lab and type your answer the questions that follow.

To complete part 2 of this lab, you need to do the following: a) study the design of different styles of drifters; b) assist in deploying the drifters; c) become acquainted on how to electronically track their progress throughout the Gulf of Maine; and d) compare and contrast the different drifter designs with respect to their performance in the water (e.g., current direction, velocity, etc.).

To complete part 3, longshore currents, you need to design a method for measuring longshore current direction and rate along Willard Beach or a Maine beach of your choosing. After designing your activity, visit your beach and test your activity.

Before your next lab quiz you should hand your typed response to the questions & essay that follow.

In order to track the drifters on your computer do the following:

- Go to www.sensservice.com
- Click on "AssetView Login" in upper right

- Login = smccme
- Password = drifters
- Click on the "unit" you wish to track, then "Massage/Data"

Questions & Essay:

Please type out your answers to the following:

1. Describe the following currents according to their relative temperatures (warm or cold) and speed (fast or slow): California, Kuroshio, West Wind Drift, Benguela, Gulf Stream, Canary, Agulhas, and Labrador.

2. (a) What is the only current that completely mixes water between the Atlantic, Pacific, and Indian Oceans? (b) Why was it so difficult for Ferdinand Magellan's vessel to leave the South Atlantic Ocean and enter the South Pacific Ocean with sail-powered ships?

3. Describe the "general" circulation pattern for currents in the Gulf of Maine. In addition, describe the track direction and calculate the current velocity for each drifter used during lab. Compare the "general" circulation pattern with the one we observed during lab.

4. Compare and contrast the drifters used during today's lab. Your two page essay should include a) an introductory paragraph on measuring coastal currents, b) a description of the drifter's design, plus where (lat. & long.) and when they were deployed, c) a paragraph describing the results we obtained, d) a paragraph discussing the drifters overall performance, and e) a paragraph that draws conclusions from this lab.

5. Describe your method and state your results for calculating the direction and rate of the longshore current at Willard Beach. Include actual data that you obtained from testing your method.

Additional Resources:

For other Gulf of Maine coastal studies:

- www.emolt.org --> drifter study
- www.gomoos.org
- www.research.usm.maine.edu/gulfofmaine-census/biodiversity/geography-characteristics/circulation/
- www.nefsc.noaa.gov/drifter/drift_smcc_2010_1.htm