Online Oceanography 101
Laboratory Exercise #6
Surface Currents

Background Information

Driving Forces for Surface Currents

Surface ocean currents (in the uppermost 400 m or so) are driven by wind. A special force known as ***wind stress*** develops due to the friction between the moving air and the underlying water. This force is responsible for tugging ocean water along as the wind blows over it. We might therefore expect the surface wind-driven current pattern in the ocean to mimic the prevailing wind zones on Earth *(Figure 6-1).* This is generally true, with one significant modification. Once the water starts moving under the influence of the wind stress, it begins to be affected by an apparent turning force due to the Earth's rotation. This apparent deflection, known as the ***Coriolis effect***, causes moving water to be deflected to the right of its original path in the Northern Hemisphere, and to the left of its original path in the Southern Hemisphere. The Coriolis effect does not influence the speed of ocean currents, only their direction.

Major Surface Currents of the World

If we combine the drag of the prevailing winds with the Coriolis deflection in each hemisphere, we end up with several closed circular (or elliptical) currents cells, known as ***gyres***, that dominate each of the major ocean basins. *Figure 6-2* shows these major gyres, one each in the North Pacific, South Pacific, North Atlantic, South Atlantic, and Indian Oceans. Because of the turning influence of the Coriolis effect, the surface current gyres in the Northern Hemisphere exhibit clockwise circulation, while the Southern Hemisphere gyres rotate counterclockwise.

One interesting feature of the currents in each gyre is that they are asymmetrical with respect to current speeds. That is, we find that currents along the western sides of all the gyres, called ***western boundary currents***, are much stronger than those found along the eastern side of each gyre, called ***eastern boundary currents***. This phenomenon is known as ***westward intensification***. As a general rule, western boundary currents in each gyre have fast speeds and carry warm water away from the Equator, while eastern boundary currents have slow speeds and carry cool water toward the Equator.

Apart from the major gyres, there are also ***Equatorial Currents*** found along the Equator in each ocean between the major gyres to the north and south. South of the Southern Hemisphere gyres, there is also a strong and persistent cold current flowing from west to east all the way around Antarctica, known as the ***Antarctic Circumpolar Current*** (or "West Wind Drift").

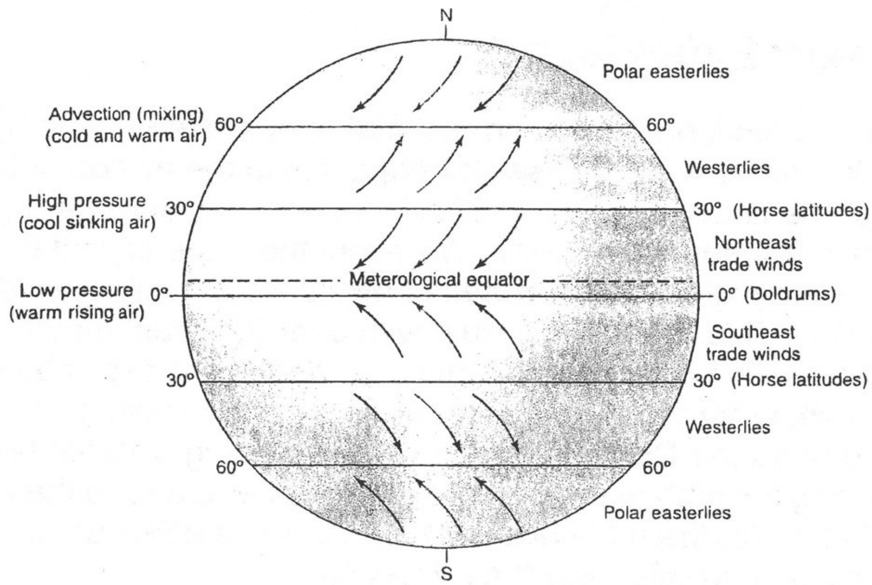


Figure 6-1. Major wind zones on Earth. [Source: *Laboratory Exercises in Oceanography*, Pipkin et al., 3rd ed., 2001. W.H. Freeman & Co.]

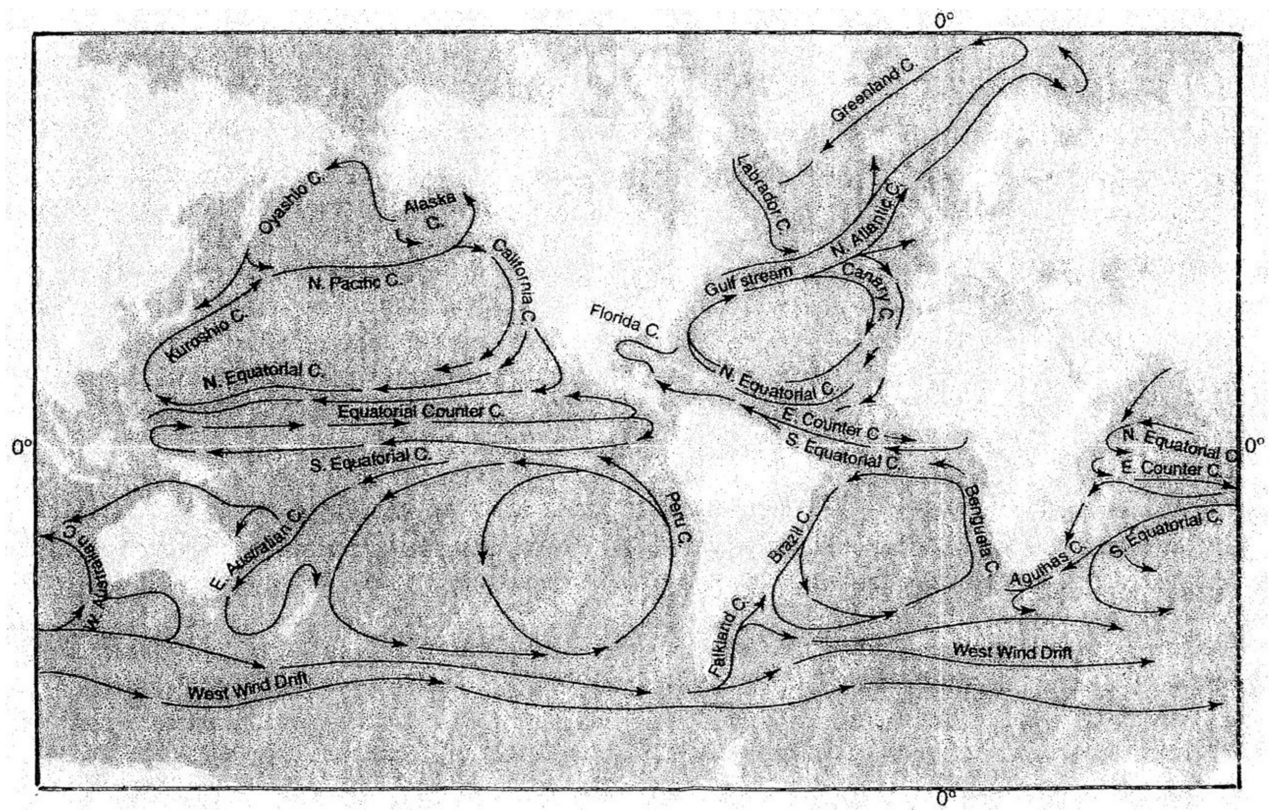


Figure 6-2. Major surface currents of the oceans of the world. [Source: *Laboratory Exercises in Oceanography*, Pipkin et al., 3rd ed., 2001. W.H. Freeman & Co.]

Current Measurement

There are two basic approaches to measuring ocean currents. The first technique is to place a device known a ***current meter*** in a fixed location (usually on a mooring line anchored to the bottom), where it measures the speed and direction of the water flowing past it. This type of instrument is similar to instruments that measure wind speed and direction, and typically consists of a directional vane, and either a propeller or rotating cups to measure the speed. Data are either recorded internally, or transmitted in real-time by wire or radio to a receiving station. This is called the ***flow method***.

The other approach to current measurement uses buoyant instruments that drift along with the moving water, either at the surface, or at some depth below the surface. These devices, called ***drifters***, are tracked by radar, radio, or satellite, and their motion over time can be plotted to show the speed and direction of the currents in which they are being carried along. This is referred to as the ***float method***. One type of drifter, known as a ***drifting buoy***, uses underwater drogues in the shape of window shades, "holey socks", or parachutes *(Figure 6-3)* to act like underwater "sails" that carry the buoy along in the ocean currents, rather than having it be pushed by surface winds. These relatively low-cost buoys can be dropped by ships or aircraft, and may be tracked for as much as a year after deployment. In some cases, electronic instruments are built into these buoys to measure ocean temperature, salinity, solar radiation, and barometric pressure. In part 2 of this lab, we will plot some position data from three drifting buoys gathered over a several-month period, then try to determine what ocean currents they were embedded in.

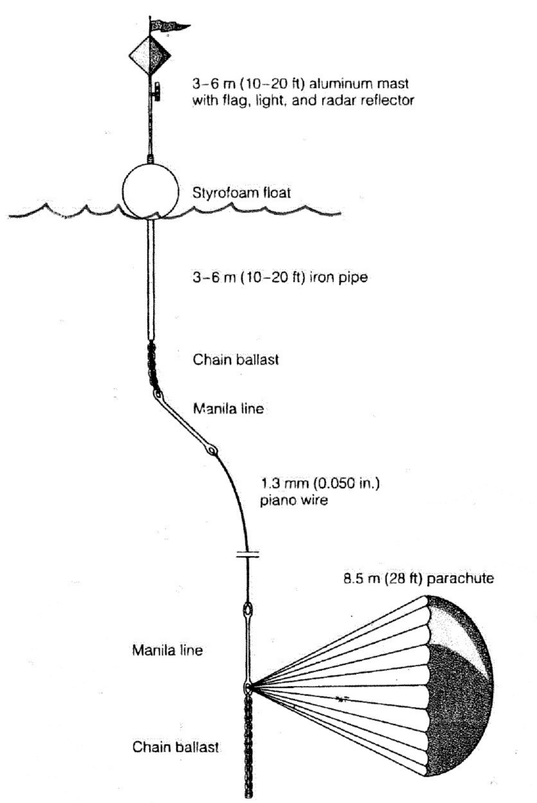


Figure 6-3. Drifting buoy with a subsurface parachute drogue.
[Source: *Essentials of Oceanography*, Tom Garrison. 4th / 5th editions. Thomson Brooks/Cole.]

Online Oceanography 101
Laboratory Exercise #6
Surface Currents

Questions to Answer

Part 1 – General Current Characteristics

1. Describe the following currents as either **warm** or **cold**, and **fast** or **slow**.

Current	**Relative Temperature**	**Relative Speed**
Peru	________________	________________
Kuroshio	________________	________________
Benguela	________________	________________
Gulf Stream	________________	________________
Agulhas	________________	________________
Brazil	________________	________________
Canary	________________	________________
West Wind Drift (Antarctic Circumpolar Current)	________________	________________

2. Describe the function of ocean currents in the distribution of heat on Earth.

3. Cape Town at the tip of South Africa has a cool mild climate, whereas Durban a few hundred miles to the east is very hot and humid. Why is this so?

> A few figures that may be useful:
> **http://www.lonelyplanet.com/mapshells/africa/south_africa/south_africa.htm**
> **http://www-das.uwyo.edu/~geerts/cwx/notes/chap11/safrica.html**
> ***Your textbook***

4. Why do you think the Equatorial currents in the Atlantic Ocean are more unorganized and less distinct than those in the Pacific?

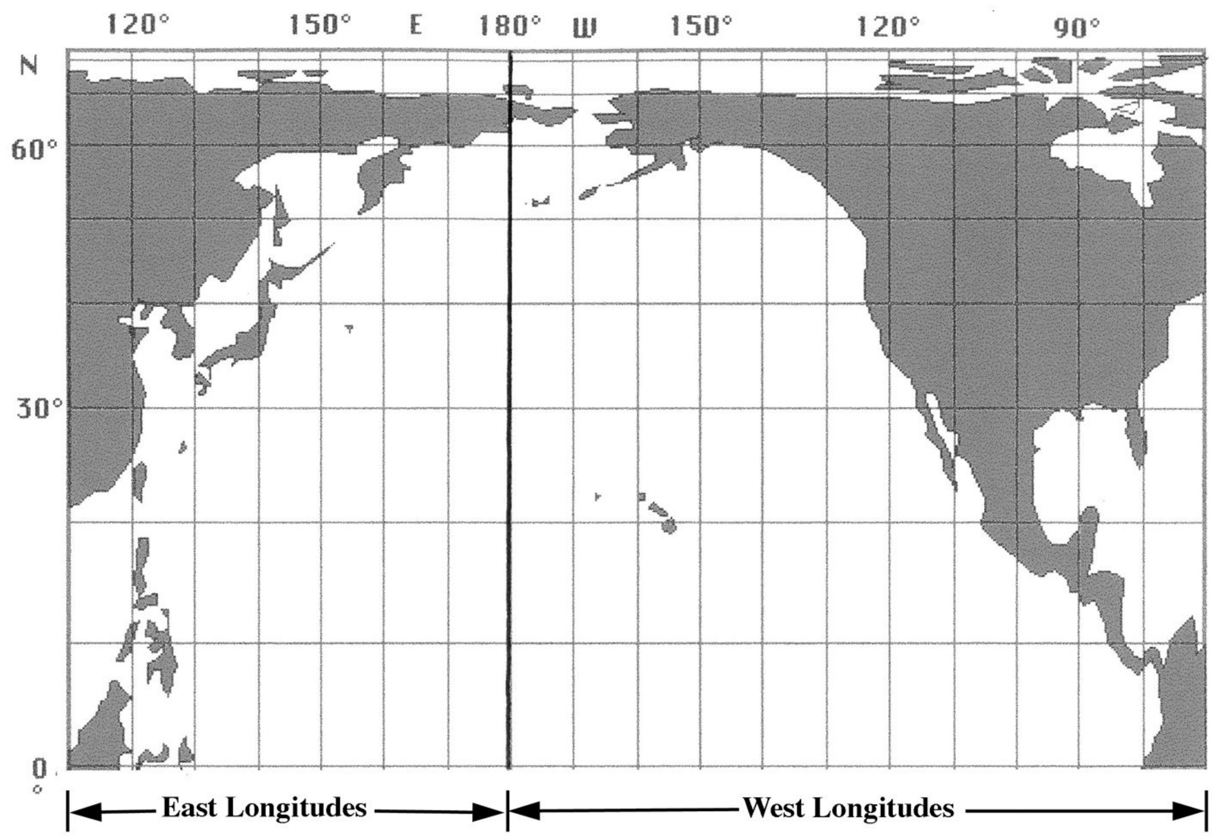
5. What is the only current that completely circumscribes (flows all the way around) the Earth?

Part 2 – Drifting Buoy Analysis

6. Referring to *Table 6-1* below, plot the time sequence data from three drifting buoys on the blank Pacific Ocean map that follows. Use the latitude and longitude data to plot the position of each buoy location during the year, then connect the locations with lines and draw an arrow to show the direction of motion for each buoy.

Table 6-1. North Pacific Buoy Data.

Buoy ID#	Date	Latitude	Longitude
12410	27 Feb	30.1 N	123.7 W
12410	28 Mar	27.5 N	121.8 W
12410	22 Apr	25.0 N	124.6 W
12410	22 May	23.6 N	128.0 W
12410	24 June	22.5 N	133.9 W
12410	24 July	23.1 N	138.4 W
12410	26 Aug	20.5 N	145.4 W
12410	25 Sept	20.0 N	147.6 W
12410	20 Nov	17.9 N	155.3 W
12410	18 Dec	21.4 N	159.5 W
15022	25 Feb	10.7 N	162.0 E
15022	27 Mar	10.5 N	152.1 E
15022	23 Apr	11.6 N	145.5 E
15022	20 May	12.4 N	137.6 E
15022	25 June	17.0 N	131.1 E
15022	22 July	21.7 N	127.8 E
15022	27 Aug	33.0 N	141.6 E
15022	23 Sept	37.0 N	147.8 E
15022	23 Oct	39.3 N	152.0 E
15022	25 Nov	40.1 N	154.5 E
15022	31 Dec	37.6 N	160.4 E
22217	27 Feb	51.2 N	162.7 W
22217	27 Mar	50.4 N	165.3 W
22217	24 Apr	48.7 N	159.5 W
22217	29 May	50.7 N	155.1 W
22217	26 June	50.4 N	151.7 W
22217	24 July	51.5 N	149.3 W
22217	28 Aug	51.0 N	145.0 W
22217	25 Sept	53.1 N	143.8 W
22217	23 Oct	55.2 N	139.1 W
22217	27 Nov	57.1 N	141.4 W
22217	18 Dec	56.9 N	141.7 W



Pacific Ocean Map for use in Question #6.

7. What are the names of the surface currents that moved the buoys whose positions you plotted in Question #6? (Note that the answer might contain the names of two currents – that is, the drifting buoy may have started its trip in one current and then passed into another current.)

   Buoy 12410:

   Buoy 15022:

   Buoy 22217:

8. The buoy tracks plotted in Question #6 follow currents that are all part of the North Pacific Gyre, the clockwise-spinning current system that spans the North Pacific.

   a) What is the name of the current that moves water past the West Coast of the United States?

   b) Do you think it carries warm water or cold water? Explain.

   c) Is it a strong current or weak current? Explain.

Part 3 – Currents Seen from Space

The figure below is a map of an ocean current along the east coast of North America published in 1770 by Benjamin Franklin. Examine this figure.

Ben Franklin’s map of an ocean current off the east coast of North America.

Now take a look at a satellite image of the same current that has been ***posted to our course’s website,*** and answer the following questions.

9. a) What is the name of the current shown in both figures?

   b) Is it warm or cold? Is it fast or slow?

10. Describe the ways that the current shown in the satellite image differs from Franklin’s concept.

11. If this current were to stop flowing, how do you think that might affect the climate of the land masses surrounding the North Atlantic? Why?