

# **CLIMATE & CURRENTS**

## **Lesson Plan**

**A CURRICULUM IN MARINE SCIENCES**

**FOR GRADES 4 - 8**

**UNIVERSITY OF CALIFORNIA, LOS ANGELES  
MARINE SCIENCE CENTER**

**revised for UCLA OceanGLOBE, 4/04**

# CLIMATE AND CURRENTS LESSONS

## **Introduction to Climate and Currents.....4**

A four page written summary of how the Earth's climate works, and how ocean currents play a major role in shaping climate. Includes a full page illustration of global atmospheric circulation and wind patterns. May be duplicated for student reading material or as a subject content background for teachers.

## **National and LAUSD Standards.....8**

A page that lists the National Science Standards that apply to these Climate and Currents activities.

## **Vocabulary.....9**

A single page that lists and defines 23 of the most important terms that relate to student understanding of climate and currents.

## **Activity #1 - Wind Circulation, Surface Currents & Climate.....10**

A five page activity that uses three detailed maps of the world (included): global surface currents, global wind patterns and ocean surface life zones, to make the connection between wind, currents and climate. Requires student use of colored pencils and markers.

## **Activity #2 - Major Ocean Surface Currents.....15**

Students glue together the frontside descriptive information and the backside maps for a learning activity that is based upon 16 cards, one for each of 16 major ocean surface currents. Requires scrap cardboard (or card stock) and glue. All maps and information are included in this twelve page activity.

## **Activity #3 - Wind and Currents.....27**

A two page activity in which students observe how wind generates currents, and what happens to currents as they encounter islands or submerged banks. Requires a shallow pan or plastic container, food coloring, water, and various objects (small rocks or glass bowls).

## **Activity #4 - Water Cycle: Mobius Strip.....29**

Students color printed strips (included) representing the water cycle. The strips are taped together end to end forming a Mobius Strip. This three page activity requires scissors and colored pencils or crayons.

## **Activity#5 - Temperature Changes: Atmosphere & Ocean.....32**

This two page activity uses two jars, each with a thermometer inside to demonstrate how ocean and atmosphere have different heat capacities (gain and release heat at different rates).

**Activity #6 - Deep Ocean Currents.....35**

Ice cubes with food coloring, tap water and hot water with food coloring are used in an ordinary glass, with a thermometer, to demonstrate how currents at different depths of the sea are formed. This three page activity includes a student data sheet for observations.

**Activity #7 - Density Currents.....38**

A clear rectangular container of water, with 4 thermometers taped to the bottom, along with ice and food coloring, are used to show the formation and movement patterns of deep ocean currents. A bit more elaborate and detailed than Activity #6 (Deep Ocean Currents). This three page activity includes a student data sheet.

**Activity #8 - Finding the Deep Water Masses  
of the Atlantic Ocean.....41**

A six page activity that explores the temperature, density, salinity and location (depth and geography) of the major water masses of the Atlantic Ocean. All maps, conversion graphs, student data charts, and a foldable 3-D model are included in this package.

## Introduction to Climate and Currents

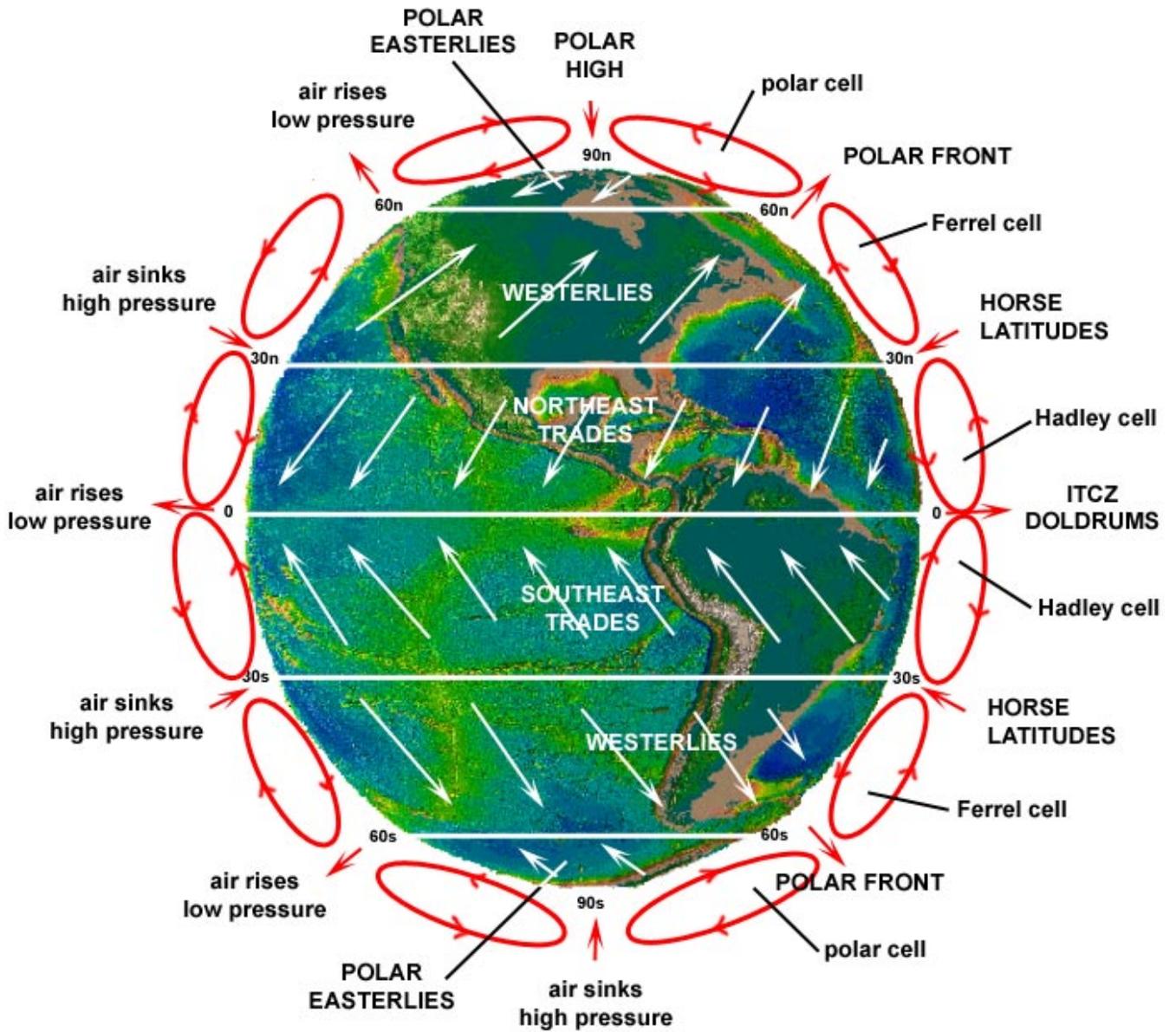
**W**ind is air moving across the surface of the Earth. Ultimately all winds are generated by unequal heating of the Earth by the sun. Because the sun is millions of miles away from the earth, the rays of light and heat from the sun that reach the surface of the Earth are parallel to one another. But the Earth is round, and only at the equator does energy from the sun fall on a flat surface at a right angle to the sun. At the poles solar radiation fall on surfaces that curve sharply away from the sun.

**T**o demonstrate this, shine a flashlight on a flat surface so that the beam of light is perpendicular (at a right angle) to the surface. Draw a circle around the spot of light. Now tilt the flat surface so that it is at a 45° angle to the flashlight. Now the spot of light shining on the surface is oblong, not round, and it is now almost two times larger than the first spot. The spot of light is also dimmer now because the light of the flashlight beam is spread over a larger area than before. This same principle applies to the Earth and sun. The equator will always receive more energy from the sun than will comparable areas north or south of the equator. Also, the surface of the Earth directly beneath the sun at high noon also receives more energy than do areas to the east or west. Thus the Earth's surface along the equator is always warmer than are the polar regions, and it is always warmer at noon than at dawn and dusk. The result is that the heat budgets of different regions of the Earth are always unequal because the Earth is always tilted at an angle to the sun and because it spins around 24 hours a day, 365 days a year. Nonetheless, averaged over each day/night period, approximately twice as much heat reaches the equator than the poles each year.

**A**t the equator, radiation from the sun is particularly intense, and the air above the tropical oceans warms rapidly each day. When this air is heated, it expands and becomes less dense, with the result that moist, hot air rises far above the equator. But expanding air cools and cannot retain moisture. Instead, water vapor condenses to liquid water, clouds form and rains fall in the tropics. The dry air then moves north or south as strong upper atmospheric winds, convecting heat toward the poles. As these high winds move toward the poles they press laterally against each other as they converge in higher latitudes. This increases the upper atmosphere air pressure, making the air denser as it is compressed. Eventually this air becomes so dense that it starts to sink, at approximately 30° north and 30° south latitude. This brings down dry air onto the major desert regions of the Earth. These drier air masses flow back across the surface of the Earth toward the equator, completing one full cycle of the equatorial atmospheric circulation cell. Named in honor of the scientist who first described this process, the circulation cells between the equator and 30° north and south are called Hadley Cells. The calm equatorial area where the northern and southern Hadley cells meet is called the **doldrums**.

**N**orth of 30° north latitude and south of 30° south latitude there are two more atmospheric circulation cells, called Ferrel Cells, that circulate low altitude air masses toward the poles, to approximately 60° north and south latitudes. When these relatively warm, temperate zone winds reach 60° latitude, they rise into the upper atmosphere above colder air masses blowing down from the poles. At high altitudes the Ferrel Cell winds flow back toward lower latitudes (toward the equator) until they converge with the winds of the Hadley Cell at approximately 30° latitude and sink into the lower atmosphere to repeat the temperate zone cycle.

**F**inally, farther north and south there are two polar circulation cells that are responsible for the flow of air in the Arctic and Antarctic regions. Altogether, then, there are three atmospheric circulation cells in the northern hemisphere and three atmospheric circulation cells in the southern hemisphere. Collectively



Robert Perry, 2002  
 globe courtesy of NOAA  
<http://www.ngdc.noaa.gov/mgg/>

the winds in these circulation cells transport heat toward the poles, but the excess heat from the tropics is redistributed rather indirectly in these cycles through the atmosphere.

**B**ecause the Earth is a rotating sphere, the winds that carry heat energy into the upper atmosphere do not blow in straight lines toward the north or south. The eastward rotation of the Earth results deflects air moving north to the northeast and air moving south to the southwest in the Northern Hemisphere. In the Southern Hemisphere air moving north is deflected to the northwest and air moving south is deflected to the southeast. This deflection of air or ocean currents due to the rotation of the Earth is called the **Coriolis effect**. The winds that blow across the surface of the oceans from the northeast to the southwest between the equator and 30° latitude, both north and south, are called trade winds. The trade winds are the dominant winds over the Pacific and Atlantic Oceans.

**B**eneath these winds lies the ocean surface. The winds drag surface waters along as they blow across the water, and this is the force that generates the surface currents of the oceans. Notice that the winds over the North Pacific and North Atlantic circulate in a clockwise direction, whereas the winds in the South Pacific and South Atlantic circulate counterclockwise. Because these winds provide the energy that drives the surface currents, the rotational direction of surface currents in the Northern Hemisphere is a clockwise gyre, or eddy. Surface currents in the Southern Hemisphere rotate in a counterclockwise gyre. Depending on where surface currents originate, they can be cold or warm.

**S**ome of the most important surface currents are:

**California Current:** This flows from the Arctic waters of the North Pacific down the western coast of Canada, Washington, Oregon and California. The beach and coasts north of Point Conception, located just north of Santa Barbara, generally are chilly all year long because the California Current runs close to shore in these regions. South of Point Conception the California Current veers offshore because the California coast south of Point Conception curves eastward and a warmer eddy flows up the coast from the south, warming southern California.

**Gulf Stream:** This is an example of a current of warm water originating near the equator. After the Florida Current leaves the Gulf of Mexico it moves vast quantities of water and heat northward through the Straits of Florida. North of the Bahamas another warm current from the tropical Atlantic joins the Florida Current, and together these make up the great Gulf Stream. The Gulf Stream flows north and east, eventually warming the shores of Iceland and the British Isles.

**Kuroshio Current:** This major surface current flows north along the western side of the North Pacific basin, warming Japan and Korea far to the north of the tropics.

**Antarctic Current:** This is the largest surface current of all in terms of volume of water transported per year. This enormous current system circulates without interruption from west to east around the continent of Antarctica, driven by the violent West Wind Drift, the wind system that circles Antarctica.

**O**ceanic gyres strongly affect the global distribution of heat. On the western sides of the gyres, the currents are warm, carrying solar heat from the equator to high latitudes. On the eastern sides of the Pacific and Atlantic Oceans cold currents flow from the polar regions toward the equator, cooling the western coasts of all the continents. Thus, surface currents act like a thermostat to regulate the climates on Earth. Since ocean currents take years to move heat around an entire ocean basin, they affect local weather

patterns ashore in somewhat unpredictable ways because these currents never exhibit exactly the same patterns of flow or heat transport. **Weather**, therefore, is considered to be the somewhat unpredictable state of the atmosphere at a specific place and time, and **climate** is an average over time of weather in a specific area. Factors that influence climate and weather are geographical landscape, proximity to large bodies of water, the amount of sunlight in an area, and changing biological and geological conditions.

**T**here are many complex deep currents in the ocean also. Perhaps the most important of these are the deep currents that are generated in the polar regions associated with the seasonal melting of sea ice. Sea ice is frozen seawater, and glaciers and the ice bergs that break off of glaciers are formed from freshwater over land. When icebergs melt they release this fresh water, which floats on the ocean surface because fresh water is less dense than seawater. In contrast, when sea ice melts, very salty water is released at the bottom of the ice floe and fresher water is released at the upper sides of the ice floe. The fresher water, of course, floats, but the cold brine released below the melting ice sinks rapidly to the very bottom of the ocean. This primarily occurs in the Antarctic Ocean, where the dense, cold and salty water accumulates as Antarctic Bottom Water. This bottom water then begins to flow, very, very slowly toward the equator. Because cold water holds large quantities of dissolved oxygen and because this cold, salty water is so dense that it sinks rapidly from the surface to the bottom of the ocean, the Antarctic Bottom Water serves as the main source of oxygen for the deep seas of the world.

**W**ater not only circulates within the oceans as oceanic currents, it also circulates through the atmosphere and across the land. The **hydrologic cycle** describes the circulation of water from the sea to the atmosphere to the land and back to the sea. Water evaporates into the atmosphere primarily due to solar heating. Water vapor eventually condenses, forming clouds which are blown across the Earth's surface by high level winds. When the atmosphere becomes saturated, water in the form of rain or snow or ice precipitates onto the sea or onto the ground. On land this liquid water collects in rivers and lakes or percolates down into the groundwater. Eventually all water finally flows back to its origin, the oceans that cover 70% of the surface of the Earth. Then, for each molecule of water the cycle begins again. Salts in the ocean, of course, do not evaporate, but instead salts make their way to the oceans in runoff water. Water is neither created nor destroyed in the process, but rather it is recycled over and over again through the oceans, the atmosphere, and terrestrial freshwater systems. The same water molecules that first appeared on the Earth's surface more than 3 1/2 billion years ago are still circling through the hydrologic cycle!

# Climate and Currents

## Concepts related to the California State Science Standards

### Grade Five: Earth Sciences

3. Water on Earth moves between the oceans and land through the processes of evaporation and condensation. As a basis for understanding this concept:

a. *Students know* most of Earth's water is present as salt water in the oceans, which cover most of Earth's surface.

b. *Students know* when liquid water evaporates, it turns into water vapor in the air and can reappear as a liquid when cooled or as a solid if cooled below the freezing point of water.

c. *Students know* water vapor in the air moves from one place to another and can form fog or clouds, which are tiny droplets of water or ice, and can fall to Earth as rain, hail, sleet, or snow..

4. Energy from the Sun heats Earth unevenly, causing air movements that result in changing weather patterns. As a basis for understanding this concept:

a. *Students know* uneven heating of Earth causes air movements (convection currents).

### Grades Nine through Twelve Earth Science - Energy in the Earth System

5. Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents. As a basis for understanding this concept:

a. *Students know* how differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.

b. *Students know* the relationship between the rotation of Earth and the circular motions of ocean currents and air in pressure centers.

d. *Students know* properties of ocean water, such as temperature and salinity, can be used to explain the layered structure of the oceans, the generation of horizontal and vertical ocean currents, and the geographic distribution of marine organisms.

### All Grades: Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

# Standards (cont'd)

## Concepts related to the National Science Standards

- 1- The sun warms the Earth's surface, which controls global currents and climate, keeping the earth habitable.
- 2- Water and air behave in similar ways as fluid.
- 3- Atmospheric cells and ocean gyres redistribute heat from low to high latitudes, which influences climate, weather, and ocean temperature.
- 4- The ocean is one continuous body of water with global currents that interact, with water surrounding all landforms.
- 5- Ocean circulation affects climate and plant and animal populations on land and in the ocean.
- 6- Surface currents are created by the prevailing wind system.
- 7- Water density is affected by temperature and salinity, resulting in deep water currents.
- 8- At the poles, very cold, salty water sinks to the ocean bottom and flows toward the equator.
- 9- The primary source of oxygen for the deep sea is the cold polar bottom current.
- 10- The weathering of rocks continually adds sodium to the Earth's rivers and subsequently to the oceans.
- 11- The water on Earth dates from Earth's beginnings and continues to be recycled.

# Climate and Currents

<b>Vocabulary</b>	
<b>Atmosphere</b>	Envelope of air surrounding the planet Earth.
<b>Bottom Current</b>	Current of deep water that flows from cold to warmer water.
<b>Climate</b>	Average over time of weather in a specific area.
<b>Condensation</b>	Liquid water in the clouds.
<b>Convection Current</b>	Current driven by density differences
<b>Coriolis Effect</b>	Deflection of moving objects due to the Earth's rotation (clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere).
<b>Current</b>	River of water in the ocean.
<b>Density</b>	Mass per unit volume of a substance.
<b>Doldrums</b>	Zone of rising air near the equator with little or no wind.
<b>Easterlies</b>	The winds of the polar circulation cells.
<b>Evaporation</b>	A change from a liquid to a gas (e.g. water to water vapor).
<b>Groundwater</b>	Water that percolates into the ground and underground water system.
<b>Gyre</b>	Large circular pattern formed by surface currents and prevailing winds.
<b>Hydrologic Cycle</b>	The interchange of water among, land, ocean, and atmosphere which includes different states of water.
<b>Precipitation</b>	Any form of water that falls to the earth, such as rain, snow, hail.
<b>Runoff</b>	Water not absorbed by the soil, which forms surface rivers.
<b>Salinity</b>	The amount of salt dissolved in water.
<b>Saturation</b>	When a material is completely full of a liquid, such as clouds before raining.
<b>Source Region</b>	Area where surface water reaches high enough density to sink and become deep ocean water.
<b>Trade Winds</b>	Powerful winds in tropical regions that blow toward the equator.
<b>Upwelling</b>	Vertical movement of cold water and nutrients up to the ocean surface from deep water.
<b>Weather</b>	The state of the atmosphere at a specific place and time.
<b>Westerlies</b>	Winds associated with the temperature climate zone.

# Activity #1 - Wind Circulation, Surface Currents & Climate

## Concepts # 3 & 6

# 3 Atmospheric cells and ocean gyres redistribute heat from low to high latitudes, which influences climate, weather, and ocean temperature.

#6 Surface currents are created by the prevailing wind system.

## Objective:

Students will be able to describe the connections between wind patterns, surface currents, and ocean climate zones.

## Materials:

- map of world with climate zones
- overlay of ocean currents
- overlay of global wind patterns
- question sheet
- colored pencils
- red and blue china markers

## Procedures: (See illustrations)

1. Teacher reviews the wind patterns of the Earth. Explain the Coriolis effect and how it produces gyres in surface currents.
2. Have students break into groups to study this occurrence. Each group has a climate map, overlays of wind patterns and surface currents.
3. Students color the ocean climate zones in four different shades of blue, with the tropics being the darkest.
4. Students color the warm surface currents with a red china marker and the cold currents with a blue china marker. Overlay the surface current sheet on top of the climate zone map.

## Evaluation:

- Answer these questions:
- What four currents make up the North Pacific gyre? (Kuroshio, N. Pacific, California, N. Equatorial)
- What is the main climate zone of this gyre? (subtropical)
- How many other gyres are formed in the open oceans? (4)
- Name them. (N. Atlantic, S. Atlantic, S. Pacific, S. Indian)
- Where is the tropical zone the greatest in latitude span? (the Atlantic)

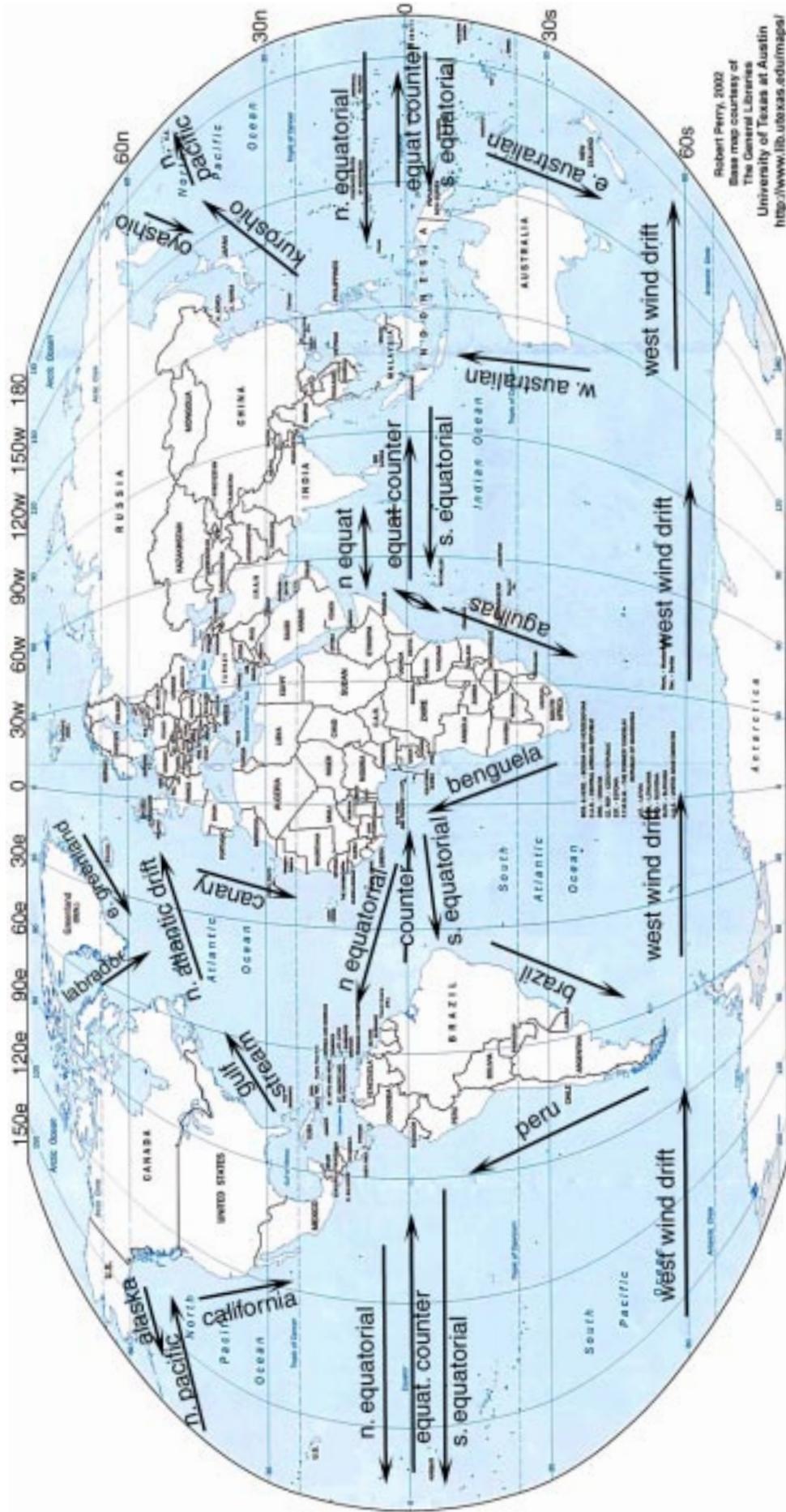
## Evaluation Continued:

*Now place the wind pattern overlay over the climate zone map. Answer these questions:*

- Which climate zone contains the westerlies? (Temperate zone)
- Easterlies bring cold air from where? (the poles)
- Now place the current overlay on top of the wind pattern and answer these questions:
- At what angle are the equatorial currents to the trade winds? (45° angle)
- Why does this occur? ( Because the Coriolis effect deflects the wind)
- What would happen if the trade winds became weaker? (The equatorial current would become weaker and create an El Niño effect.)

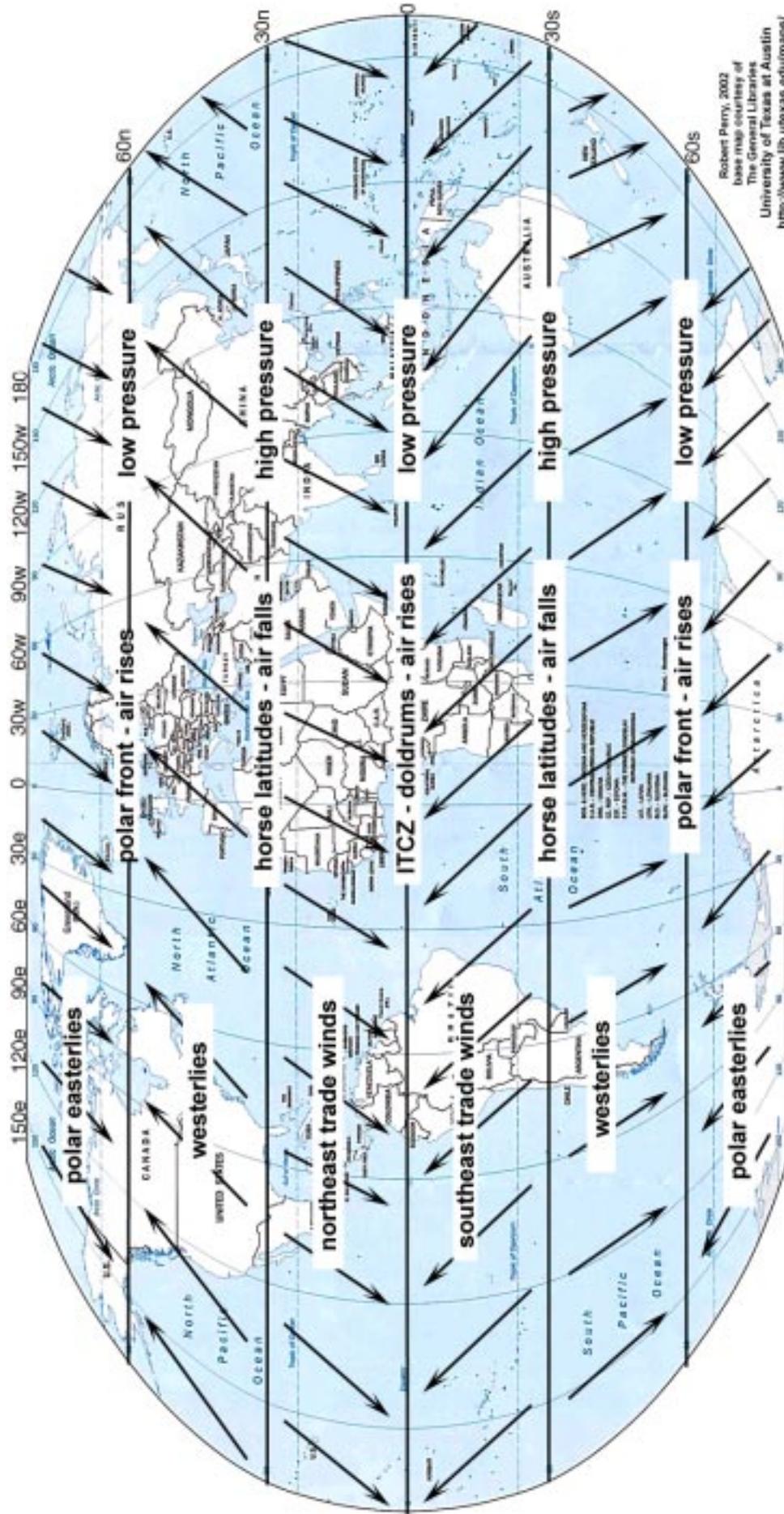
# Activity #1 - Wind Circulation, Surface Currents & Climate Zones

## Major World Ocean Surface Currents



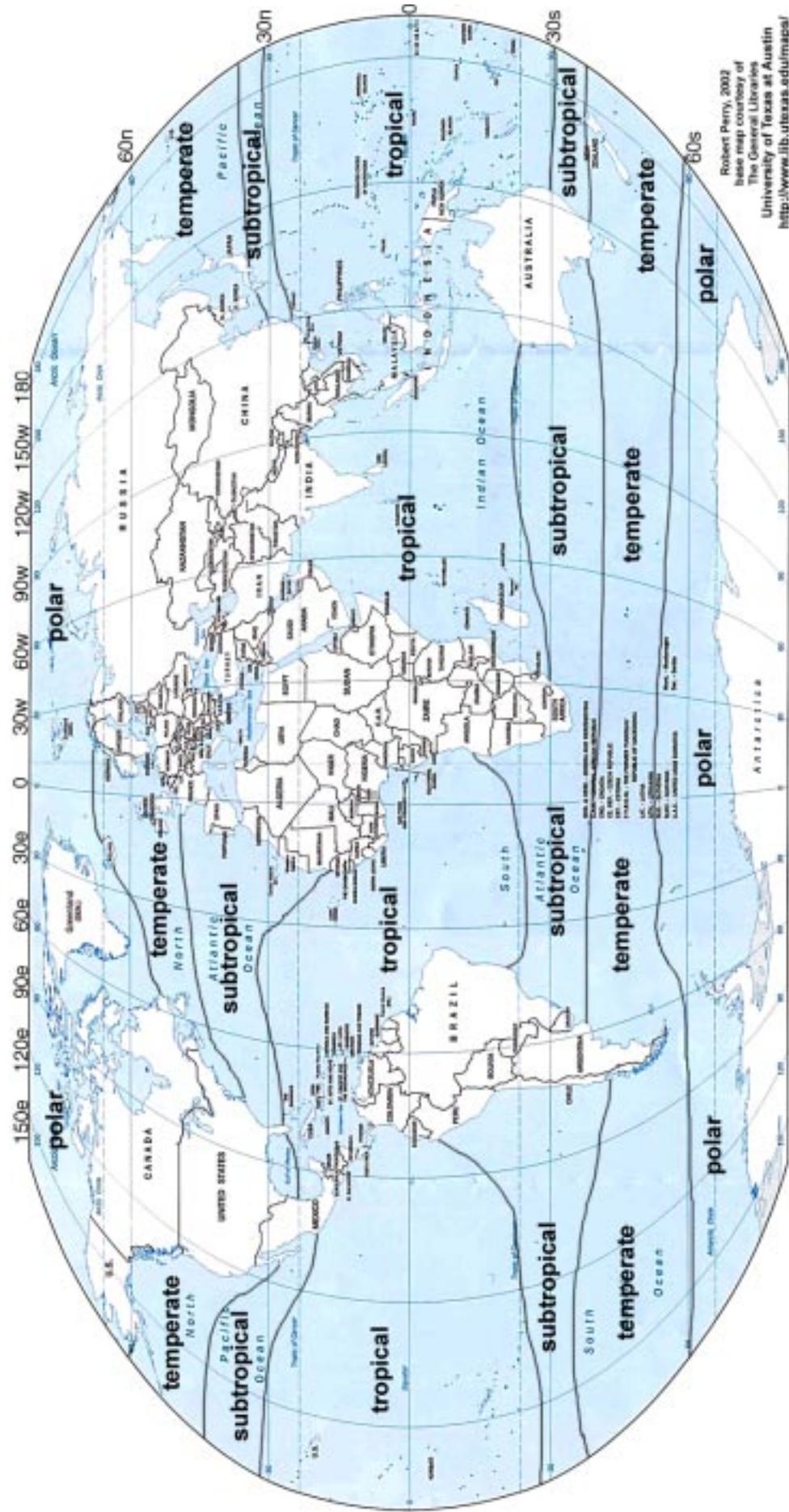
# Activity #1 - Wind Circulation, Surface Currents & Climate Zones

## Global air circulation & wind patterns



# Activity #1 - Wind Circulation, Surface Currents & Climate Zones

## Ocean Climate Zones (based on surface temperatures)



## Activity #2 - Major Ocean Surface Currents

### Concepts # 3 & 6

# 3 Atmospheric cells and ocean gyres redistribute heat from low to high latitudes, which influences climate, weather, and ocean temperature.

#6 Surface currents are created by the prevailing wind system.

### Objective:

Students investigate wind driven surface currents and prevailing winds by playing a card game.

### Materials:

- cards
- scissors
- cardstock
- glue
- basin chart
- surface current chart
- questions

### Procedures: (See illustrations)

1. Students cut out set of cards and glue the backs and corresponding fronts onto cardstock.
2. After the cards are dry, sort the cards into 4 groups by north or south and Atlantic or Pacific.
3. Students choose a group of cards to begin. Pick out two of the current cards and pencil in their locations on the Global Ocean Basin Chart. Turn the cards over and examine the information. Write the temperature information next to the current on the chart.
4. Predict where the other two currents will be found and what their temperatures will be, based on what you already know about this hemisphere and ocean basin from the first two cards. Check your predictions. If not correct, determine why and draw in the currents as shown on the cards.
5. Students choose only one card from the next group. Draw the current, label the temperature and make a prediction as to where the other three currents are and their temperatures. Check your predictions and make changes on your chart as necessary.
6. Now select two currents from one of the remaining card sets. Pencil in the current and the temperatures of each. Make predictions for the remaining two currents, check your answers, and change as necessary.
7. For the last set of cards, choose only one current to record and then make predictions about the remaining 3 currents. Correct your markings on the chart as necessary.
8. Use what you have learned so far to pencil in the circulation pattern in the Indian Ocean.
9. Using the Global Ocean Surface Current Chart, check your predictions about the Indian Ocean pattern and correct as necessary.

## Evaluation:

Use the information you have learned to answer the following questions:

- In which direction do the ocean currents under the Trade Winds flow?
- In which direction do ocean currents under the Prevailing Westerlies flow?
- Wind driven ocean currents are deflected by continental boundaries to form gyres. What is the one latitude where there is no continental barriers?
- At what latitude are the ocean gyres centered?
- In which direction do the gyres flow in the Northern Hemisphere? In the Southern Hemisphere?
- From which direction does the ocean gyre current flow near Perth, Australia?
- Warm water is transported toward the poles on which side of the ocean basins? Cold water transported from the poles is on which side of the ocean basin?
- What temperature is the ocean gyre current near the west coast of South America?
- In which side of the ocean basin are fast moving currents found? In which side are slow moving currents found?
- What speed is the surface current near Tokyo, Japan? Slow or fast?
- In the North Indian Ocean why is there no permanent gyre?
- Why is the West Wind Drift the largest volume current in the world?
- Explain what you have learned in this lesson about the interaction of the Sun, atmosphere, and ocean in creating surface circulation in the ocean.

## Activity #2 - Wind Driven Ocean Circulation

**Ocean:** Atlantic  
**Hemisphere:** Northern  
**Location:** Northern Basin  
**Flows:** From Canada to Europe  
**Temperature:** Cooling  
**Character:** Slow, Shallow & Wide

**Ocean:** Atlantic  
**Hemisphere:** Northern  
**Location:** Eastern Basin  
**Flows:** From pole towards equator  
**Temperature:** Cold  
**Character:** Slow, Shallow & Wide

**Ocean:** Atlantic  
**Hemisphere:** Northern  
**Location:** Western Basin  
**Flows:** From equator towards pole  
**Temperature:** Warm  
**Character:** Fast, Deep & Narrow

**Ocean:** Atlantic  
**Hemisphere:** Northern  
**Location:** North of Equator  
**Flows:** From Africa to South America  
**Temperature:** Warming  
**Character:** Slow, Shallow & Wide

## Activity #2 - Wind Driven Ocean Circulation

**Ocean:** Pacific  
**Hemisphere:** Southern  
**Location:** Eastern Basin  
**Flows:** From pole towards equator  
**Temperature:** Cold  
**Character:** Slow, Shallow & Wide

**Ocean:** Pacific  
**Hemisphere:** Southern  
**Location:** Western Basin  
**Flows:** From equator towards pole  
**Temperature:** Warm  
**Character:** Fast, Deep & Narrow

**Ocean:** Pacific  
**Hemisphere:** Southern  
**Location:** Southern Basin  
**Flows:** West to east around Antarctica  
**Temperature:** Cooling  
**Character:** Slow, Largest Volume Current

**Ocean:** Pacific  
**Hemisphere:** Southern  
**Location:** South of Equator  
**Flows:** From South America to Australia  
**Temperature:** Warming  
**Character:** Slow, Shallow & Wide

## Activity #2 - Wind Driven Ocean Circulation

Ocean: Pacific  
Hemisphere: Northern  
Location: Western Basin  
Flows: From equator towards pole  
Temperature: Warm  
Character: Fast, Deep & Narrow

Ocean: Pacific  
Hemisphere: Northern  
Location: Northern Basin  
Flows: From Asia to North America  
Temperature: Cooling  
Character: Slow, Shallow & Wide

Ocean: Pacific  
Hemisphere: Northern  
Location: Eastern Basin  
Flows: From pole towards equator  
Temperature: Cold  
Character: Slow, Shallow & Wide

Ocean: Pacific  
Hemisphere: Northern  
Location: North of Equator  
Flows: From Central America to S.E. Asia  
Temperature: Warming  
Character: Slow, Shallow & Wide

## Activity #2 - Wind Driven Ocean Circulation

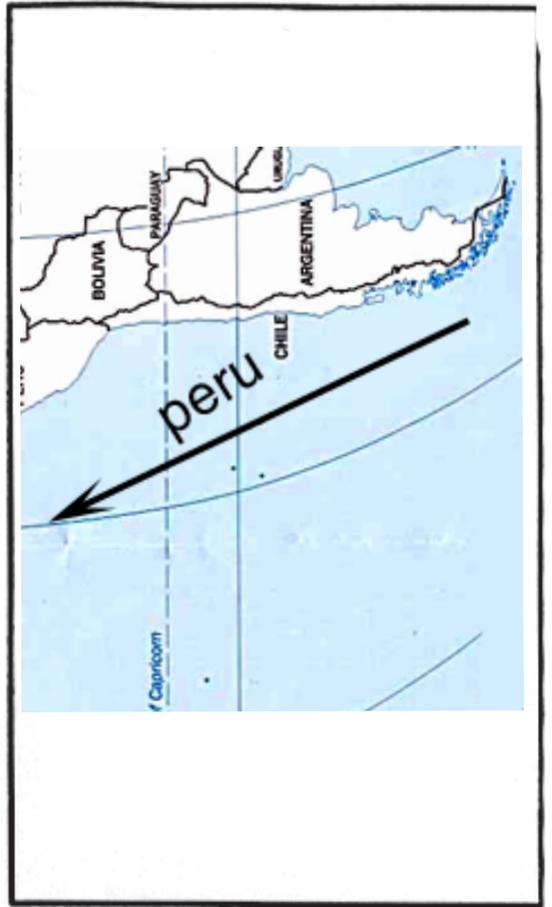
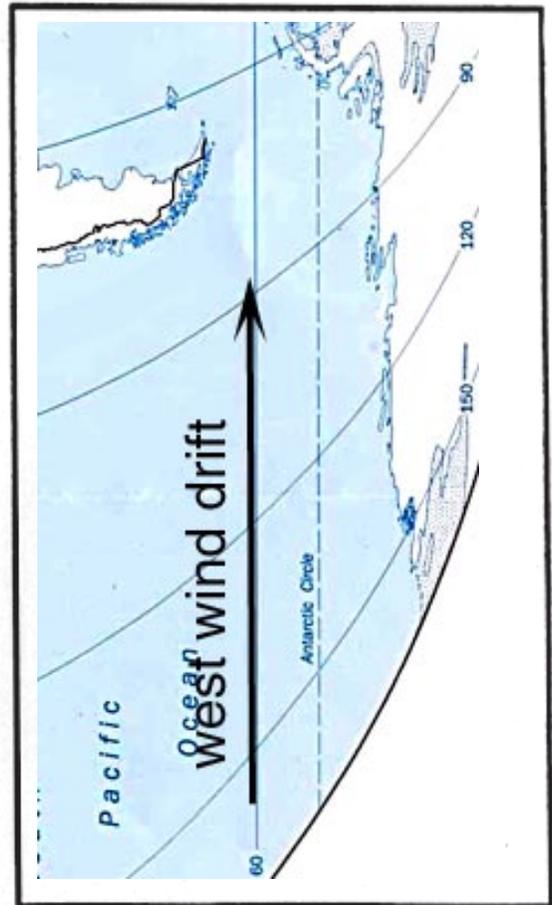
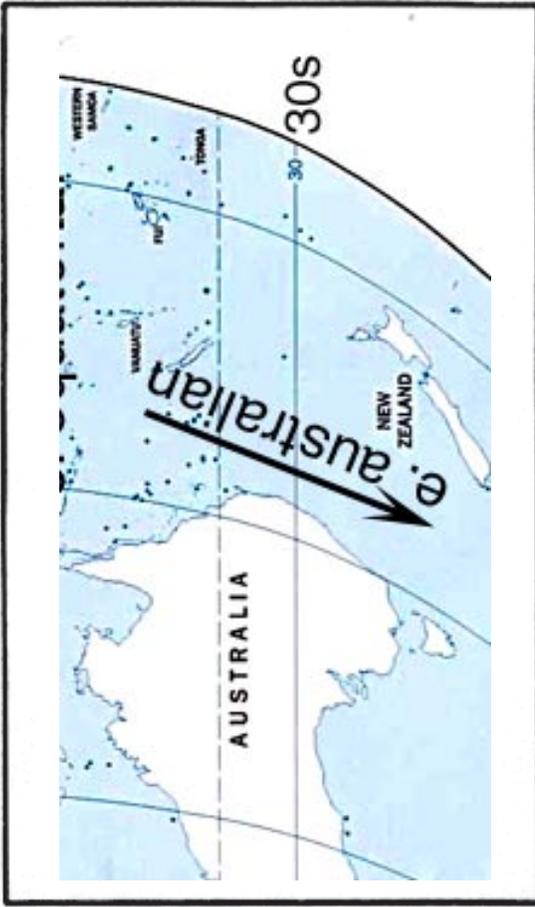
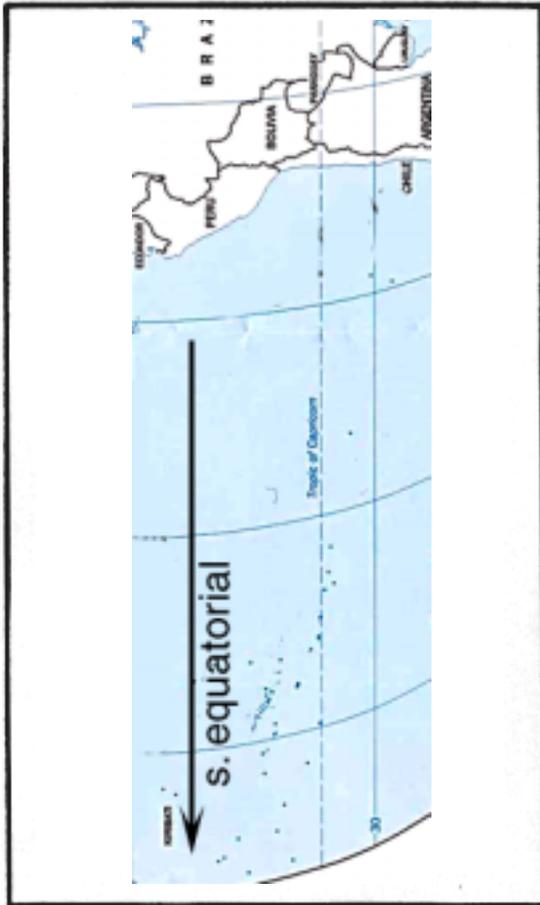
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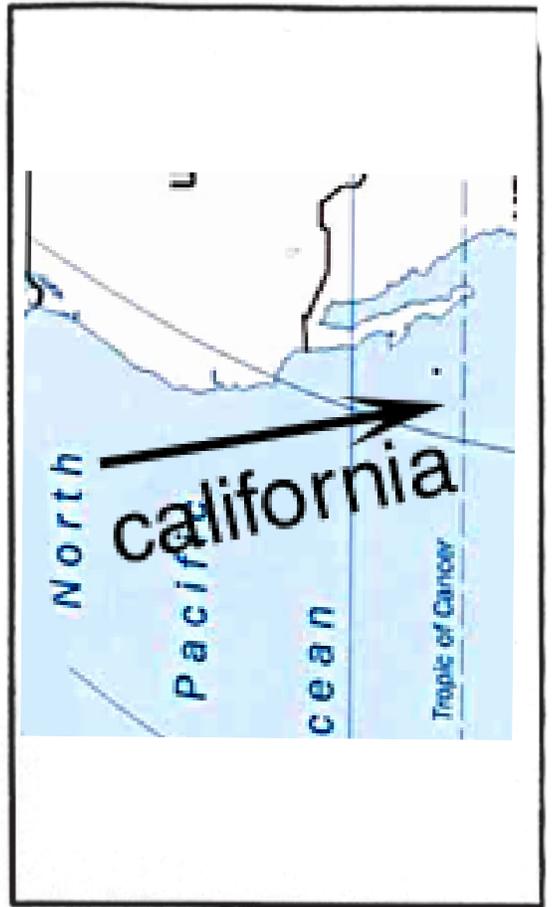
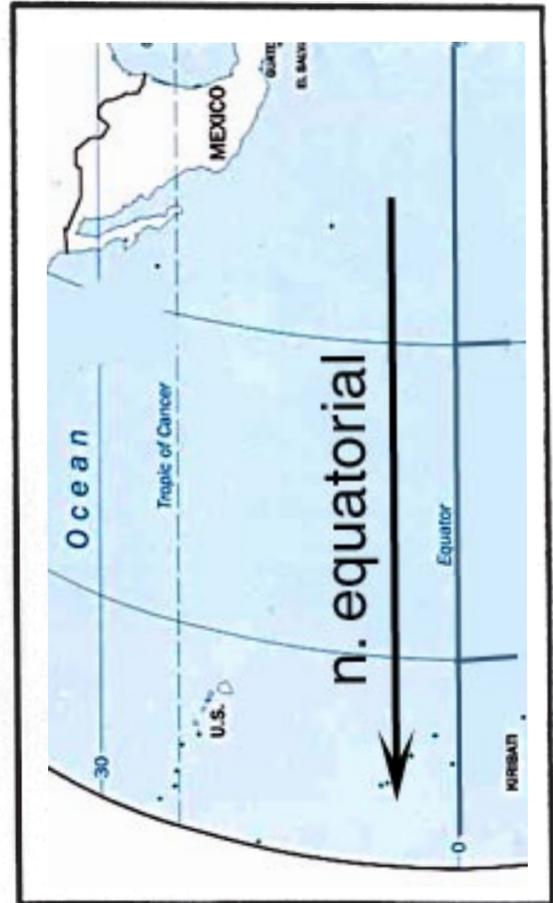
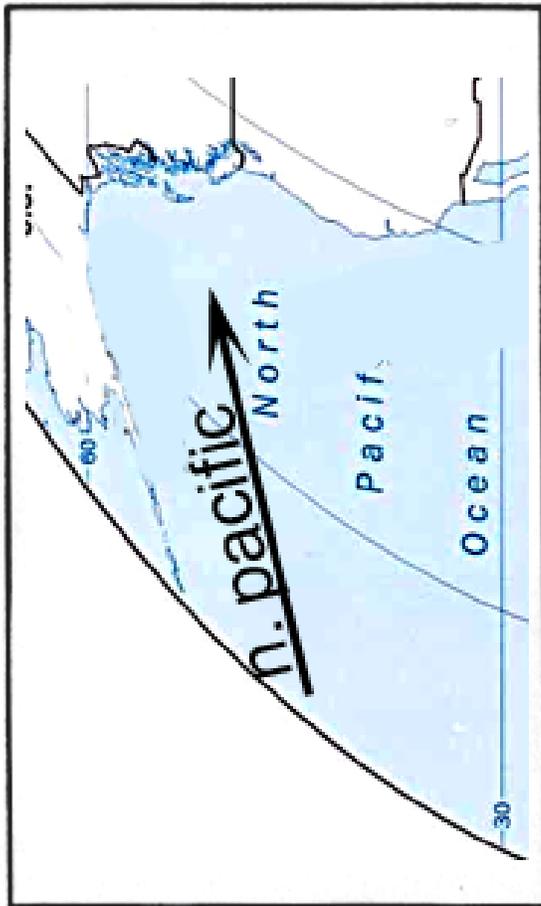
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# Activity #2 - Wind Driven Ocean Circulation

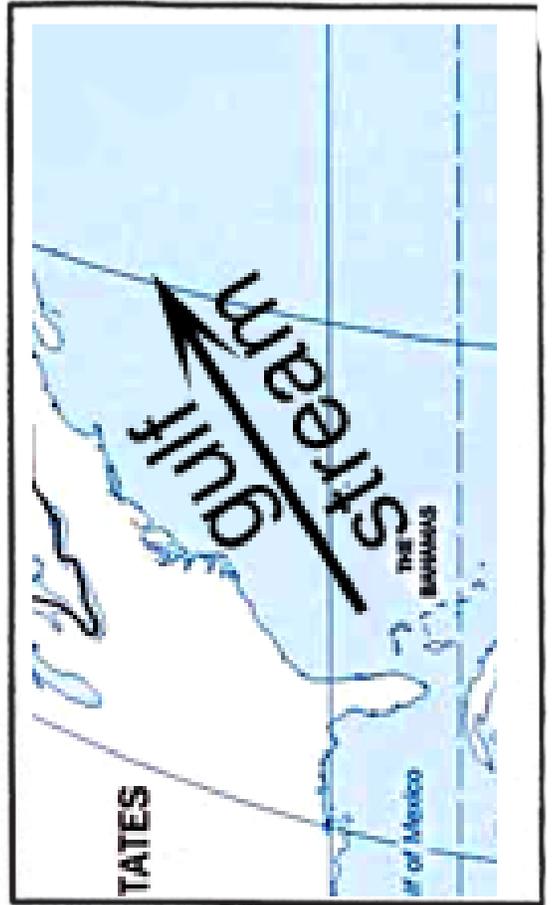
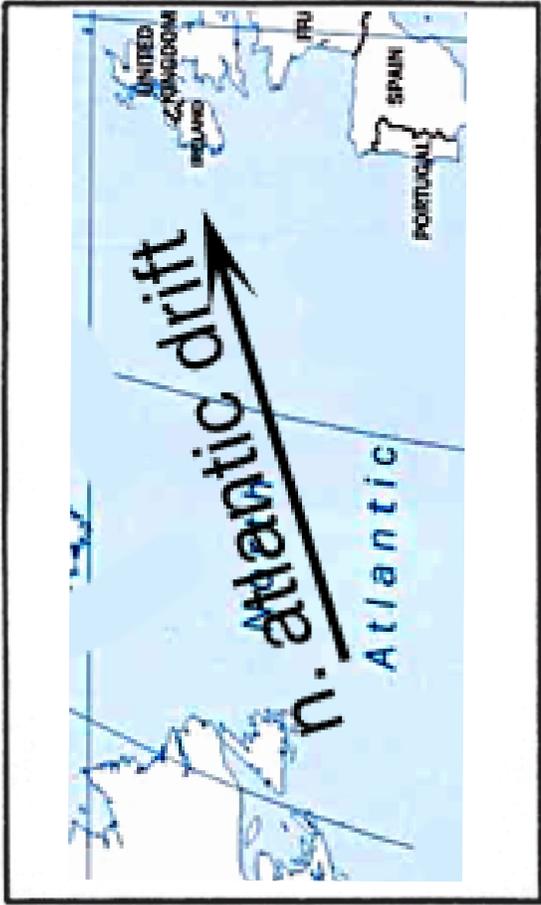
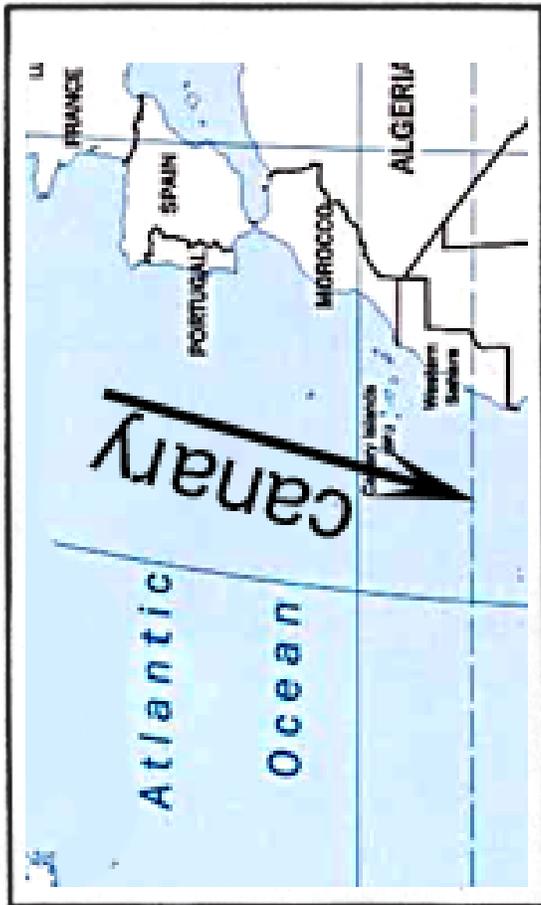


# Activity #2 - Wind Driven Ocean Circulation



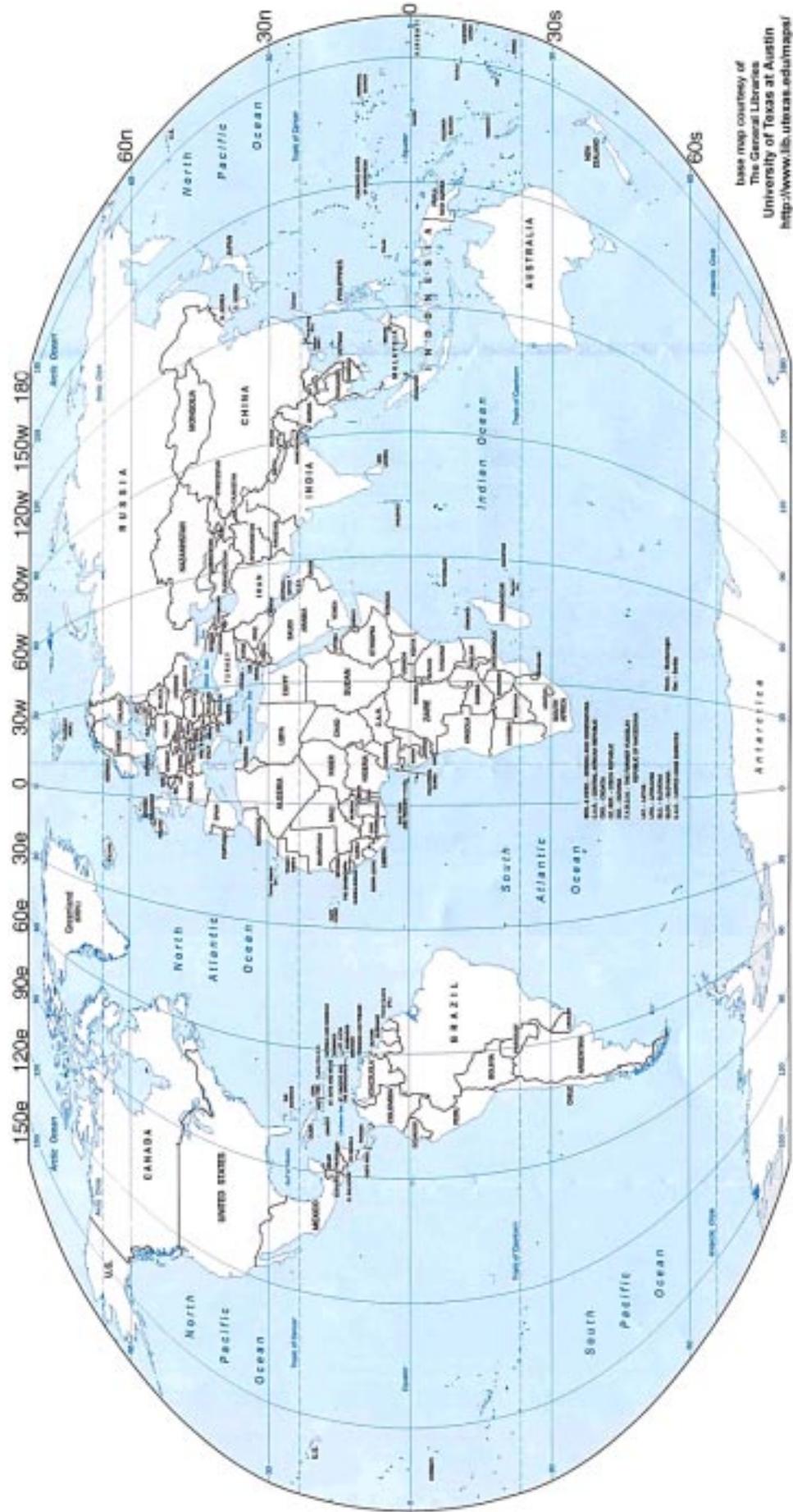


# Activity #2 - Wind Driven Ocean Circulation



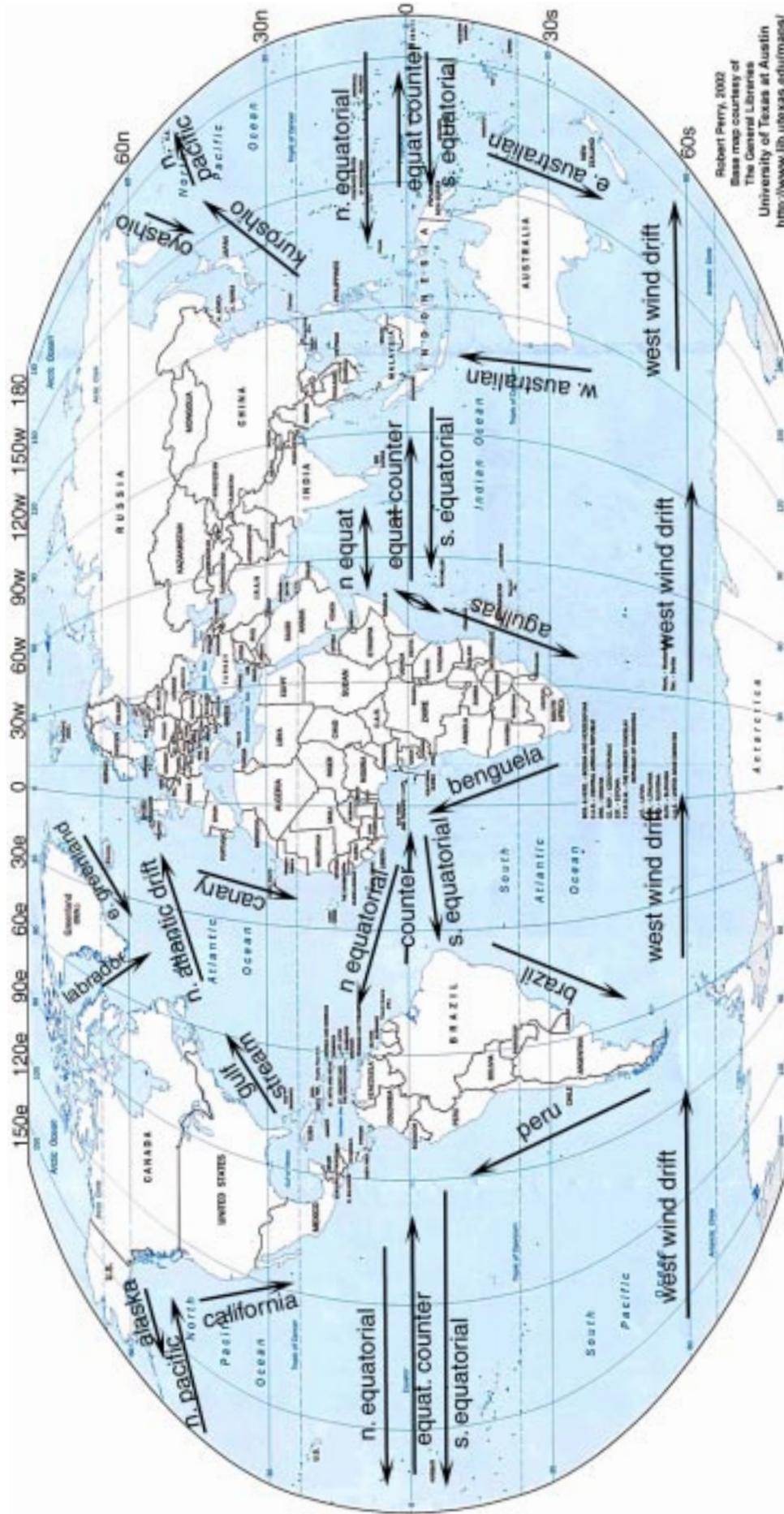
# Activity #2 - Wind Driven Ocean Circulation

## Global Ocean Basin Chart



# Activity #2 - Wind Driven Ocean Circulation

## Major World Ocean Surface Currents



Robert Perry, 2002  
Base map courtesy of  
The General Libraries  
University of Texas at Austin  
<http://www.lib.utexas.edu/maps/>

## Activity #3 - Wind and Currents

### Concepts # 5 & 6

- #5 Ocean circulation affects climate and plant and animal populations on land and in the ocean.
- #6 Surface currents are created by the prevailing wind system.

### Objective:

Students will observe how wind generates currents and the effect of islands and banks on currents.

### Materials:

- shallow pan or plastic container
- food coloring
- dropper
- water
- tall rock or glass bowl (cannot be covered by water in pan)
- short rock or small glass bowl (must be covered by water in pan)
- paper towels

### Procedures:

1. Divide the students into groups. Have one student pick up materials.
2. Fill the shallow pan with water and let it settle.

#### *Part I*

3. Place a drop of food coloring at one end of the container and gently blow across the water.
4. Draw a picture on your worksheet of what happened at the surface and on the bottom of the container.

#### *Part II*

5. Place a tall rock in the center of the container to simulate an island.
6. Place a drop of food coloring at one end and blow across the water.
7. Draw a picture and describe what happened in front and in back of the island.

#### *Part III*

8. Remove the short rock and replace it with a petri dish on the bottom of the container to simulate a submerged island (also known as a “bank”).
9. Add food coloring and blow across the water.
10. Draw a picture and describe what happened to the food coloring.

## Evaluation - Part I

- Write a description of what your drawing represents.
- Where did the water current move the fastest?
- What happened to the water current as it moved away from the wind source?

## Evaluation - Part II

- What happened to the current with the island in the way?
- Where is the strongest current found? Explain.

## Evaluation - Part III

- What is the difference between the island and the submerged bank in terms of the water current?
- Southern California has several submerged banks (Tanner Bank, Cortez Bank). What effect do these banks have on the California current?
- Most organisms in the sea have offspring that begin life as planktonic larvae. How might planktonic larvae be helped or hindered by these currents?
- How are bottom currents different from surface currents?
- What are the environmental causes of currents?
- How do currents affect living organisms?

## Activity #4 - Water Cycle: Mobius Strip

### Concepts # 10 & 11

#10 The weathering of rocks continually adds sodium to the Earth's rivers and subsequently to the oceans.

#11 The water on Earth dates from Earth's beginnings and continues to be recycled.

### Objective:

Students will describe the water cycle and create a Mobius strip model.

### Materials:

- Worksheet
- colored pencils or crayons
- tape

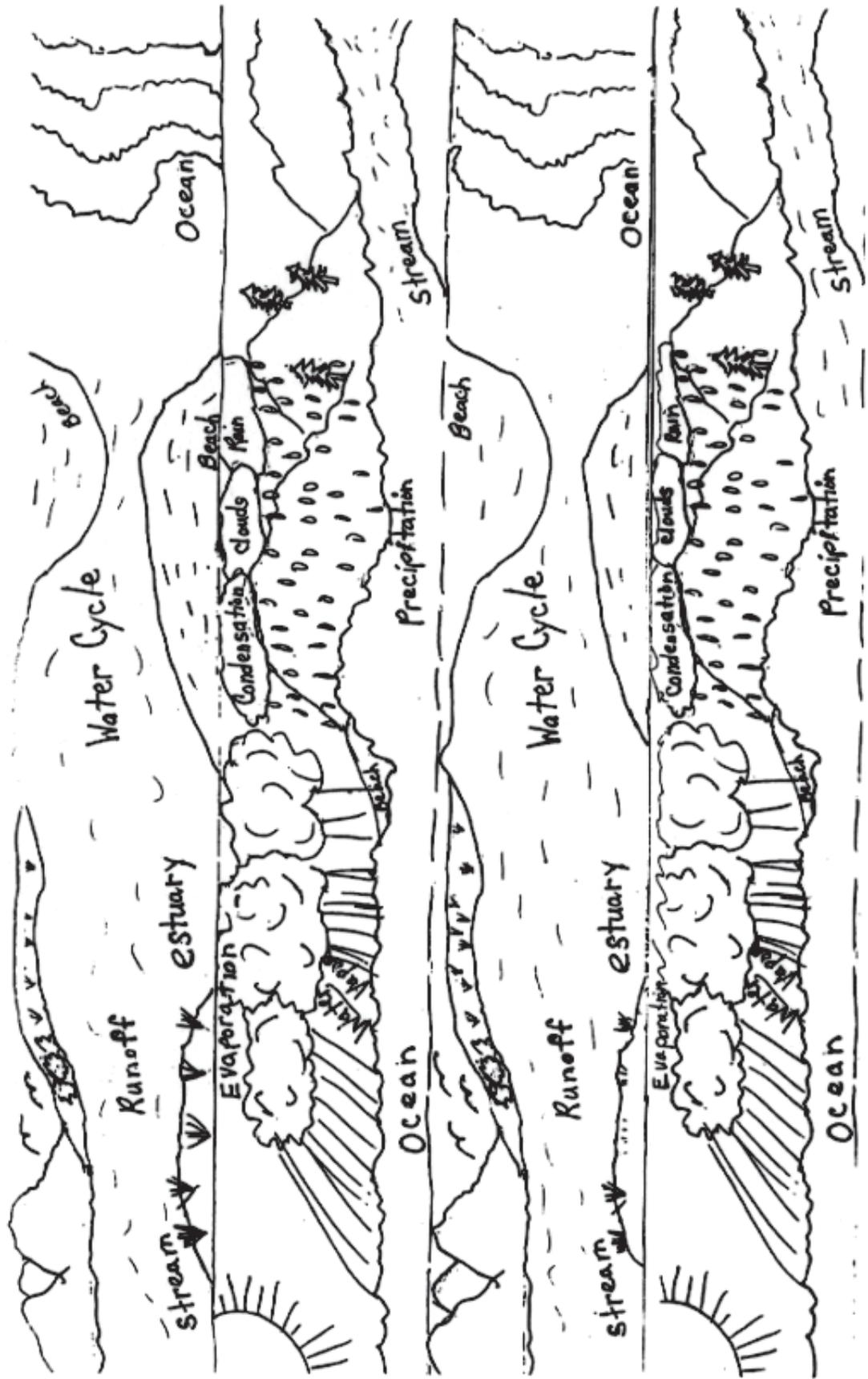
### Procedures: (See illustrations)

1. Teacher reviews the vocabulary and steps in the water cycle (hydrologic cycle).
2. Students color in their pictures and cut out strips when completed.
3. Students twist their picture model once and join the ends to form a continuous piece of paper. Tape the ends on both sides.

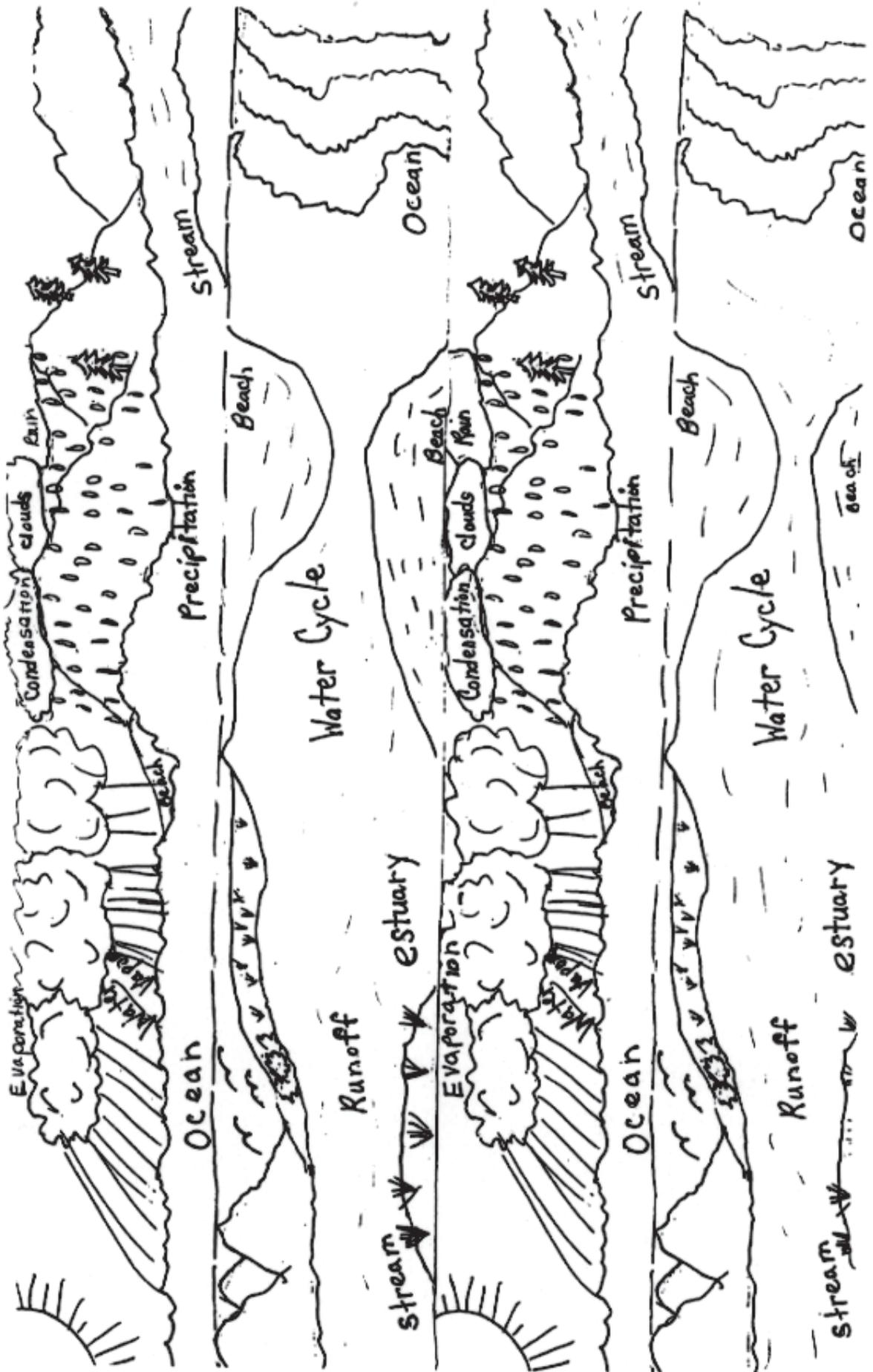
### Evaluation:

Students write a paragraph explaining the water cycle with the help of their paper model.

# Activity #4 - Water Cycle Mobius Strip



# Activity #4 - Water Cycle Mobius Strip



# Activity#5 - Temperature Changes: Atmosphere & Ocean

## Concepts #1 & 2

- #1 The sun warms the Earth's surface, which controls global currents and climate, keeping the earth habitable.
- #2 Water and air behave in similar ways as fluids.

## Objective:

Students observe temperature differences of water and air in sunlight and darkness.

## Materials:

- 2 thermometers
- 2 quart- size jars with lids
- water

## Procedures:

1. The teacher puts a thermometer in each jar, fills one jar with water and caps both jars. Label the water jar "ocean" and the empty jar "atmosphere." Record the temperature of each on the board. Place the jars next to each other in the sunlight for about ½ an hour.
2. Ask the students: What do they think will happen in each jar? (write in journal)
3. Which thermometer will rise quicker? Why?
4. After ½ hour record the temperatures on the board next to the first temperatures.
5. Ask the students : Which jar is hotter?
6. Which jar showed the greatest change in temperature?
7. The teacher now places the jars in the shade for about ½ hour.
8. Ask the students: Which container will cool the fastest? What do you think? Why? Chart data in journal.
9. After ½ hour record the temperatures. Find the difference between the new and previous high temperature of each jar. Have students generalize about what is happening to the atmosphere and ocean. (Water heats and cools slower than air.)

	Temperature in Average Light	Temperature in Sunlight	Temperature in Shade
Water in Jar			
Air in Jar			

## Evaluation:

Students answer questions:

- In the winter, would the average temperature of the ocean or the air be warmer? Why? (Winter has warmer ocean temperatures than air temperature).
- How would the summer ocean temperature differ from the air temperature? (Summer has warmer air temperature than the cooler ocean temperature.)

## Activity #6 - Deep Ocean Currents

### Concepts #1 & 4

- #1 The sun warms the Earth's surface, which controls global currents and climate, keeping the earth habitable.
- #4 The ocean is one continuous body of water with global currents that interact, with water surrounding all landforms.

### Objective:

Students observe the interactions of different temperatures of water using colored ice and a thermometer and then compare the results with global ocean current solar heating.

### Materials:

- world maps
- activity sheets
- clear glass
- water – cold tap
- water – hot tap with 2 drops of red food coloring
- ice cubes frozen with 15 drops of green food coloring
- aquarium thermometer
- spoons

### Procedures:

1. Each group of 3-4 students obtains 1 clear glass filled  $\frac{3}{4}$  full of cool tap water.
2. Students place an aquarium thermometer in the glass. Wait 2 minutes, then record the temperature.
3. Students obtain an ice cube and place in the water, using a spoon.
4. Students observe the glass, draw the glass, and explain what is happening.
5. Wait 2 minutes and record the temperature.
6. Students obtain  $\frac{1}{4}$  glass of hot colored tap water and gently pour the water down the inside edge of the glass. Don't disturb the rest of the water.
7. Students observe the glass, draw the glass, and explain what is happening.
8. Wait 2 minutes and record the temperature.

## Evaluation:

- Was the colored water moving away from the ice cube colder or warmer than the water in the glass? (cooler)
- Was the warm colored water that was added colder or warmer than the water in the glass? (warmer)
- Where would floating ice be found in the ocean? (near the poles)
- Where would cold water be found? (poles and in the deep ocean)
- Where would cold water flow in the ocean? (at the bottom) Why?
- Where would you expect to find the warmest waters in the ocean? (near the equator and at the surface)
- Where would warm moving water flow in the ocean? (near the surface) Explain.
- Which direction would cold water move in the ocean? (down and toward the equator where it is heated)
- Which direction would warm water move in the ocean? (up and toward the poles, where it cools.)
- Scientists have found that water in the ocean is well mixed. How do differences in temperatures mix ocean waters?

# Worksheet: Deep Ocean Currents

Temperature of cool tap water \_\_\_\_\_.

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What happens after adding the ice cube? Describe in words and draw a picture of the glass.

Temperature of water with the ice cube in it \_\_\_\_\_.

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What happens after adding the warm water? Describe in words and draw a picture of the glass.

Temperature of water with warm water added \_\_\_\_\_.

## Activity #7 - Density Currents

### Concepts # 7, 8, 9

#7 Water density is affected by temperature and salinity, resulting in deep water currents.

#8 At the poles very cold, salty water sinks to the ocean bottom and flows toward the equator.

#9 The primary source of oxygen for the deep sea is the cold polar bottom current.

### Objective:

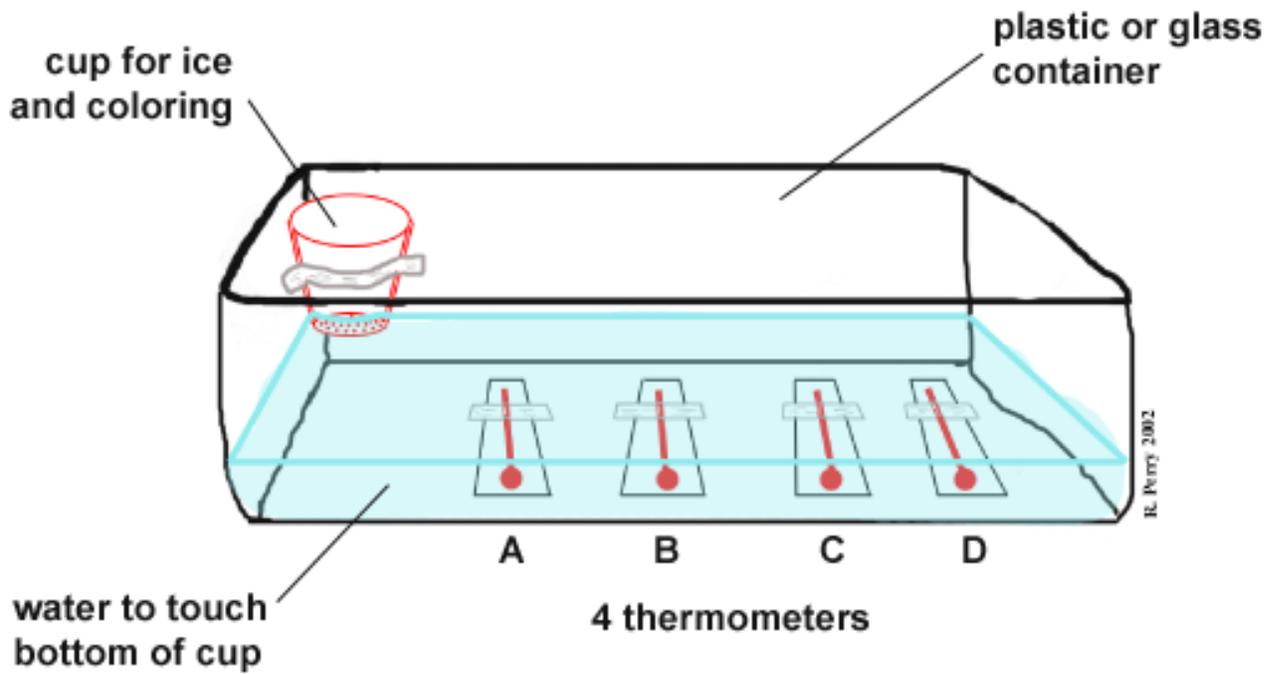
Students work in small groups to experiment with currents caused by temperature variations that simulate the origins and flow of polar bottom currents.

### Materials:

- rectangular container (glass dish, plastic shoebox or storage container)
- 4 small thermometers (to fit in plastic container)
- cup (paper or plastic) with pinholes in bottom
- tape
- food coloring
- crushed ice
- eye dropper
- paper, small approx. 1/2"
- tap water

### Procedures: (see illustration - next page)

1. Divide class into small groups of 3 - 4 students. Have one student get supplies and equipment.
2. Students tape cup in one corner of rectangular container, about one inch from the bottom.
3. Tape 4 thermometers in bottom of dish, all oriented in same direction with equal spacing.
4. Add water to the container, so the bottom of the cup is covered. Let water settle.
5. Record the temperature on all 4 thermometers at the start of the experiment, or time = 0.
6. Place ice in the cup and add 10 drops of food coloring.
7. Record the temperatures again every 5 minutes for ½ hour on the data sheet.
8. Observe what happens by looking through the side of the dish at table level. Record your observations by making a small sketch or diagram of what you see, and explain what you think causes what think causes this.
9. NOTE: If you can not see a bottom current, heat the corner opposite the ice by placing a beaker of hot water in the dish.
10. At the end of 30 minutes place a small piece of paper (1/2 inch square) on top of the water in the corner opposite the ice.



**Equipment setup for Density Currents activity.**

### Density Currents Data Chart

	thermometers			
	A	B	C	D
0 min				
5				
10				
15				
20				
25				
30				

## Evaluation:

- The paper moves in which direction? (toward ice)
- What does the paper represent, a surface or deep current? (surface)
- Which thermometer showed the greatest change during the readings? (nearest the ice)
- Which thermometer changed the fastest? (nearest the ice)
- Did all the thermometers get hotter or colder? (colder)
- Which thermometer's temperature dropped last? (farthest from ice)
- Explain what happened to cause the changes in the 4 thermometers' temperatures. (cool water sank and flowed across the container while the warm surface water flowed toward the cup.)
- What can we learn from the movement of the colored water? (It traces the movement of the water current across the bottom.)
- What does your cup of ice imitate in the real world? (polar sea ice)
- How does cooling affect the density of water? (Cold water is denser than warm water.)
- Where would you find cold water currents in the ocean? (Moving away from the polar regions in the deep ocean)

# Activity #8 - Finding the Deep Water Masses of the Atlantic Ocean

## Concepts # 4, 7, & 8

#4 The ocean is one continuous body of water with global currents that interact, with water surrounding all landforms.

#7 Water density is affected by temperature and salinity, resulting in deep water currents.

#8 At the poles very cold, salty water sinks to the ocean bottom and flows toward the equator.

## Objective:

Students will be able to describe the role of density in driving deep ocean currents and the density layers of the ocean.

## Materials:

- water masses data table
- temperature - density - salinity graph
- water masses worksheet (on cross section of the Atlantic)
- Atlantic ocean map and cross section

## Procedure:

1. Complete the Water Masses Worksheet and Water Masses Data Table as instructed.
2. Start by matching the temperature and salinity for each water mass to find the density ( $\rho_t$ ) using the Temperature-Density-Salinity graph. Record these densities on your Water Masses Worksheet (Cross Section of the Atlantic Ocean).
2. Next, on the Water Masses Data Table, match the latitude, temperature and salinity to find the density ( $\rho_t$ ) and the name of each water mass.
3. Last, fold the page with the Atlantic Ocean Map and Atlantic Ocean Cross Section 90<sup>o</sup> to get a three dimensional view of the water masses and their origins. This will help you answer the Evaluation questions on the next page.

## Key to Water Mass Abbreviations:

NADW = North Atlantic Deep Water

MI = Mediterranean Intermediate

SW = Surface Water

AAIW = Antarctic Intermediate Water

AABW = Antarctic Bottom Water

## Evaluation:

- If a person had a very long fishing line, why might it be possible to catch an Antarctic species of shark while fishing at the Equator?
- Wind driven surface currents travel at approximately one kilometers per hour, while density driven deep ocean currents travel much slower, about one meter per hour. How long would it take Antarctic Bottom Water to travel to the North Atlantic sample site at 45°N, approximately 9,000 km from its Antarctic source area?
- What relationships can you describe between water temperature and salinity at the 0° sample site?
- What happens to the water density at the 45°N sample site?
- From the Temperature-Density-Salinity Graph, what happens to the density of seawater at temperature increases? As the temperature decreases the density of the seawater does what?
- What factor(s) increase sea surface water density at high latitudes ?
- What factor(s) cause the density of the surface water in the low latitude regions to increase?
- Explain why density driven circulation in the ocean depths is caused by the interaction of the atmosphere and the ocean.
- Why is the sun considered the source of energy for driving the density circulation in ocean depths? Explain

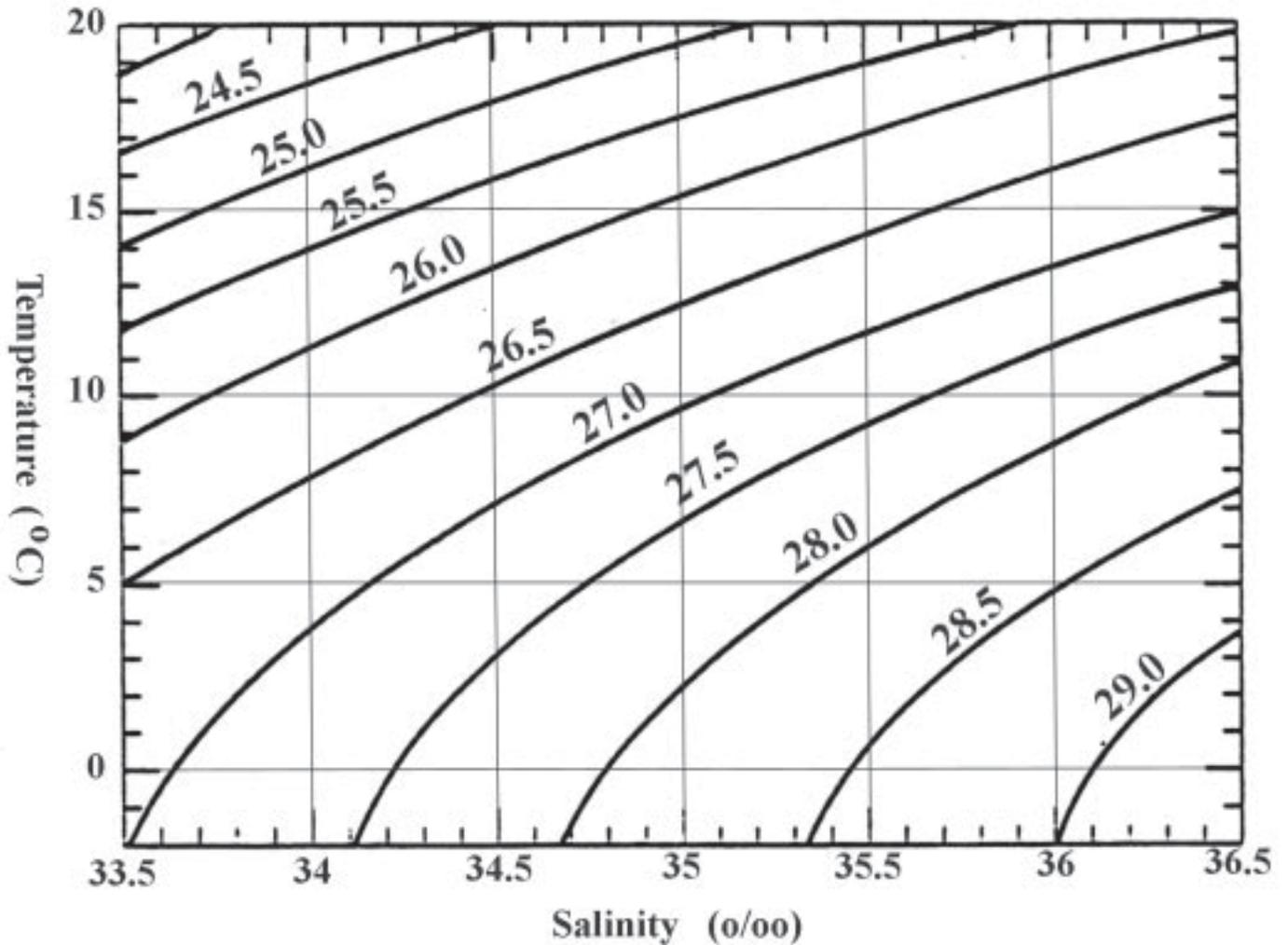
## Activity #8 - Finding the Deep Water Masses of the Atlantic Ocean

### WATER MASSES DATA TABLE

<b>Station Code</b>	<b>Latitude</b>	<b>Depth m</b>	<b>Temp °C</b>	<b>Salinity ‰</b>	<b>Density <math>\sigma_t</math></b>	<b>Water Mass</b>
<b>A</b>	<b>0°</b>	<b>400</b>	<b>25</b>	<b>36.6</b>		
<b>B</b>	<b>0°</b>	<b>1000</b>	<b>5</b>	<b>34.4</b>		
<b>C</b>	<b>0°</b>	<b>2500</b>	<b>3</b>	<b>34.9</b>		
<b>D</b>	<b>0°</b>	<b>4100</b>	<b>0.5</b>	<b>34.8</b>		
<b>E</b>	<b>50°S</b>	<b>2000</b>	<b>4</b>	<b>34.9</b>		
<b>F</b>	<b>50°S</b>	<b>4800</b>	<b>0.5</b>	<b>34.8</b>		
<b>G</b>	<b>45°N</b>	<b>250</b>	<b>13</b>	<b>36.5</b>		
<b>H</b>	<b>45°N</b>	<b>900</b>	<b>10</b>	<b>35.5</b>		
<b>I</b>	<b>45°N</b>	<b>4100</b>	<b>2</b>	<b>34.9</b>		
<b>J</b>	<b>45°N</b>	<b>4700</b>	<b>0.5</b>	<b>34.8</b>		

## Activity #8 - Finding the Deep Water Masses of the Atlantic Ocean

### TEMPERATURE - DENSITY - SALINITY GRAPH



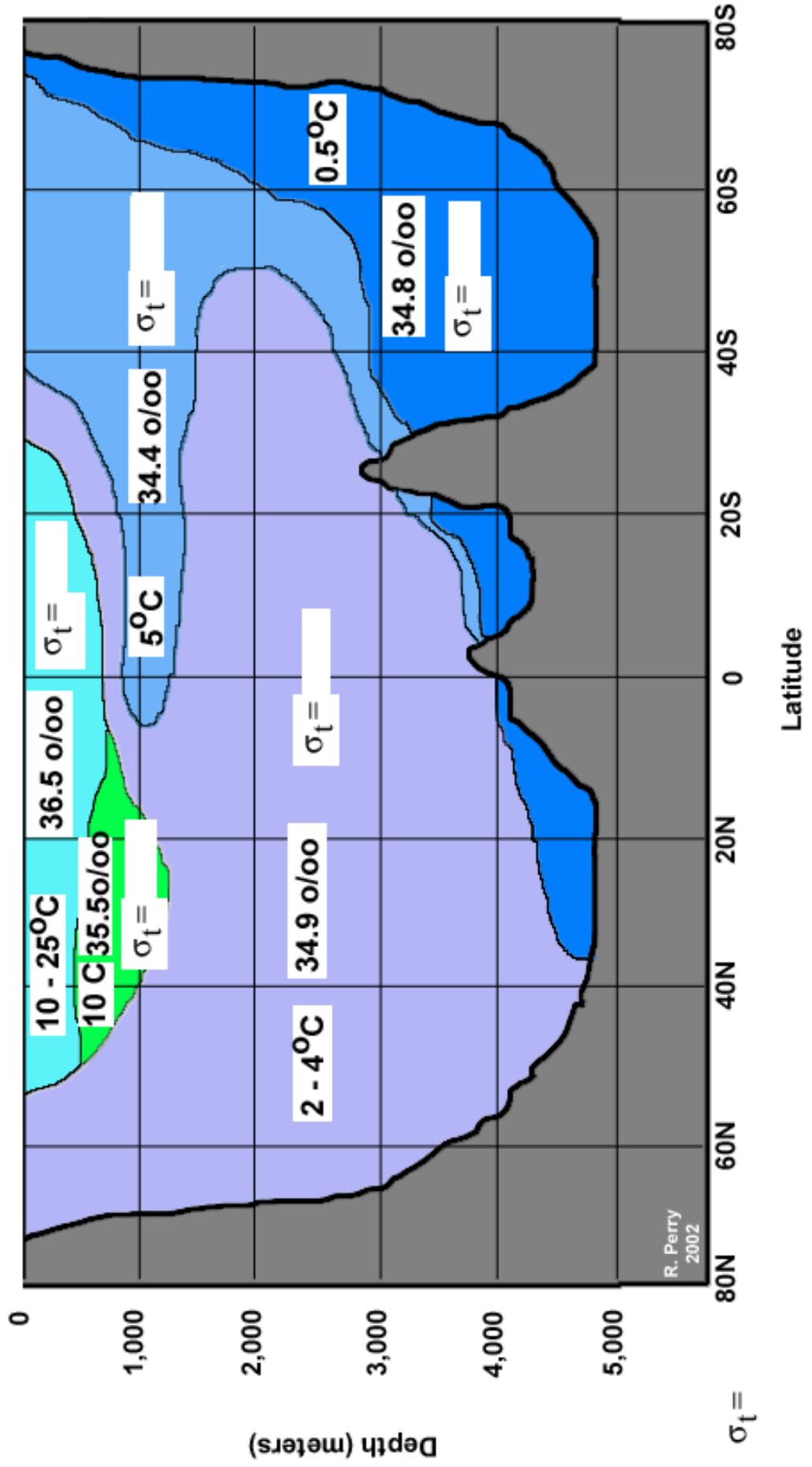
Lines of Density (pycnoclines) are given in  $\sigma_t$  (sigma theta or sigma-t units).

$$\sigma_t = (\text{specific gravity in g/cm}^3 - 1) \times 1000$$

[Example: specific gravity  $1.0240 \text{ g/cm}^3 = \sigma_t \ 24.0$ ]

# Activity #8 - Finding the Deep Water Masses of the Atlantic Ocean

## WATER MASSES WORKSHEET



Activity #8 - Finding the Deep Water Masses of the Atlantic Ocean  
 ATLANTIC CROSS SECTION & MAP

