

ES 106 Laboratory # 3

INTRODUCTION TO OCEANOGRAPHY

Introduction

The global ocean covers nearly 75% of Earth's surface and plays a vital role in the physical environment of Earth. For these reasons, oceanography is an important part of the Earth sciences. Oceanographers apply the concepts from the sciences of chemistry, physics, geology, and biology to understand this critical component of Earth system.

This lab investigates some of the physical characteristics of the oceans. To establish a point of reference, the extent, depths and distribution of the world oceans are examined. The two of the most important variables of seawater, salinity and temperature, are studied to determine how they influence the density of water, and in turn deep ocean circulation.

Goals and Objectives

- Locate and name the major water bodies on Earth
- Study the distribution of land and water in each hemisphere
- Explore the influence that salinity and temperature of seawater have on the density of seawater
- Describe how the salinity and temperature of seawater vary with latitude and depth in the oceans

Useful Websites

- http://www.earthcare.ca/balloon/curriculum_facts.html
- <http://www.grida.no/climate/vital/32.htm>
- <http://www.mapsofworld.com/world-ocean-map.htm>
- http://visibleearth.nasa.gov/view_set.php?categoryID=817

Name _____

Lab Day/Time _____

Pre-lab Questions – Complete these questions before coming to lab.

1. Define the following terms:

A. Salinity

The mass of dissolved salt in 1000 g of water

B. Thermohaline circulation

Conveyor belt of oceanic circulation driven by temperature and salinity differences in ocean water.

C. Latitude

Angular measurement north and south of the equator. An equal-latitude line forms a circle around the globe, parallel to the equator.

D. Longitude

Angular measurement east and west of the prime meridian. All equal longitude lines pass through the north pole and south pole, and are furthest apart at the equator.

2. In what units is ocean water salinity expressed? How is salinity calculated?

Salinity is expressed in 'permil' which means parts per thousand. It is calculated by comparing the mass of dissolved salt in a given mass of water to the mass of dissolved salt in 1000 g of water of the same salinity.

3. Suppose that you take a sample of 500 g of ocean water and let the water evaporate. The mass of the remaining salts is 17 g. What was the salinity of the ocean water?

Set up a proportion to compare the salt in the given amount of water to the

unknown amount of salt in 1000 g of water

$$\frac{17g}{500g} = \frac{xg}{1000g}$$

Solve the proportion by multiplying both sides by 1000 g. The unknown amount of salt is the salinity: 34 g.

4. If the salinity of ocean water is 37 parts per thousand, what is the mass of salts dissolved in 2 kg of ocean water?

Set up a proportion to compare the unknown mass of salt in the given amount of water to the known amount of salt in 1000 g of water (salinity)

$$\frac{37g}{1000g} = \frac{xg}{2000g}$$

Solve the proportion by multiplying both sides by 2000 g. The

unknown mass of salt is 74 g.

Part A – Extent, Distribution, and Area of the Oceans

Activity 1: Geography of the world oceans

For this activity, study the available resources, including maps and globes around the lab room, and maps in your textbook, to become familiar with the oceans and major water bodies of Earth. **Locate and label each** of the following oceans and major water bodies **on the world map provided** at the end of the lab.

Oceans:	Major Water Bodies:		
Pacific	Arabian Sea	Caribbean Sea	North Sea
Atlantic	Baltic Sea	Caspian Sea	Persian Gulf
Indian	Bay of Bengal	Coral Sea	Red Sea
Arctic	Bering Sea	Gulf of Mexico	Sea of Japan
	Black Sea	Mediterranean Sea	Sea of Okhotsk
			Weddell Sea

Activity 2: Area of the Oceans and Distribution of Land and Water

The surface area of Earth is about 510 million square kilometers (197 million square miles). Of this, oceans and seas cover approximately 360 million square kilometers (140 million square miles). Use this information to answer the following questions. (Show calculations with units.)

1. What percentage of Earth's surface do oceans and seas cover? **70.6%**

$$\frac{360}{510} \cdot 100 = 70.6\%$$

2. What percentage of Earth's surface is land? _____ **29.4%**

$$100\% - 70.6\% = 29.4\% \dots \text{or} \quad 510 - 360 = 150 \text{ and } \frac{150}{510} \cdot 100 = 29.4\%$$

Study the world ocean maps provided and Figure 1 to answer the following questions (refer to Figures 13.1 and 13.2 in Earth Science 11th ed. textbook by Tarbuck and Lutgens).

3. Which hemisphere, Northern or Southern, could be called the "water" hemisphere and which the "land" hemisphere?

Water hemisphere _____ **Southern Hemisphere** _____

Land hemisphere _ **Northern Hemisphere** _____

Using Figure 1, determine the percentage of Earth's surface that is ocean at the latitudes listed below. (Show calculations to right.)

60-65° N: _____70_% ocean

40-45° N: _____50_% ocean

40-45° S: _____94_% ocean

60-65° S: _____100_% ocean

4. In the Northern Hemisphere, how does the width of the oceans change as you go from the equator to the pole?

The area of ocean diminishes in a regular manner from the equator to the pole in the northern hemisphere.

5. In the Southern Hemisphere, how does the width of the oceans change from the equator to the pole?

The area of ocean is fairly constant from equator to about 60° S latitude. It diminishes to nothing at Antarctica.

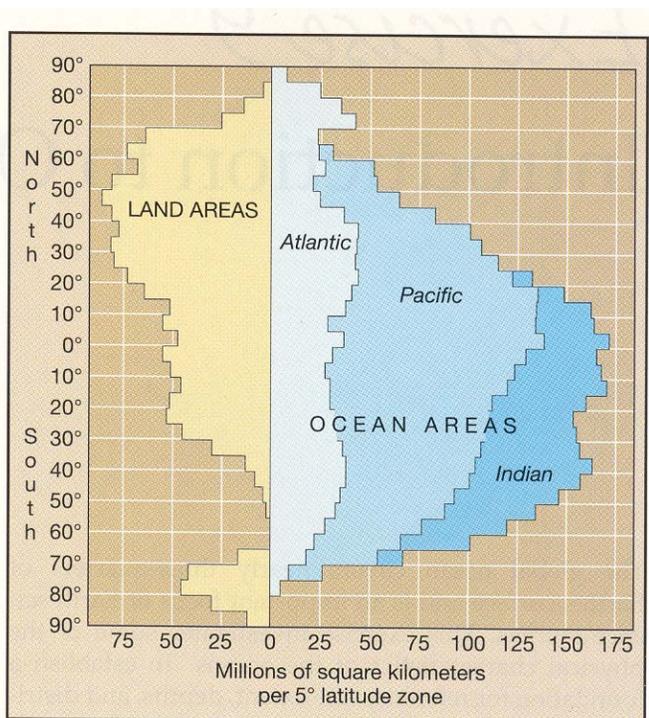


Figure 1: Distribution of land water in each 5° latitude belt. (Figure 13.2A in Earth Science 11th ed., Tarbuck and Lutgens.)

6. Which ocean covers the greatest area?

Pacific

Part B – Characteristics of Ocean Water

The average density of surface ocean water is 1.025 g/mL, but this varies from place to place, and with seasons. Variations in *salinity* and *temperature* are the two most important factors in creating the density differences that create deep-ocean circulation, which will be studied in greater detail below.

Salinity is the amount of dissolved material in water. It is typically expressed as parts per thousand (‰), called 'permil'. Permil means 'per 1000 parts', in contrast to 'percent', which is 'per 100 parts'. This concentration is a weight ratio: typical sea water has a salinity of about 35‰, meaning one kilogram of sea water contains about 35 grams of dissolved salts. Although there are many dissolved salts in seawater, sodium chloride (NaCl) is the most abundant.

Variations in the salinity of seawater are influenced primarily by changes in the water content of the seawater. In regions where evaporation rates are high, removing the water and leaving behind the salts increases the concentration of dissolved material in seawater. Alternatively, in areas of high precipitation and high runoff from rivers and streams, the additional water dilutes the seawater and lowers the salinity. Because the factors that influence the concentration of salts in seawater vary, the salinity of seawater also varies with latitude and depth.

Seawater *temperature* is the most extensively determined variable of the oceans because it is easily measured and has an important influence on marine life. Like salinity, ocean water temperatures vary from equator to pole and vary with depth. Temperature, like salinity, also affects the density of seawater, but density of seawater is more sensitive to temperature fluctuations than salinity. Cool surface water, which has a greater density than warm water, forms in the Polar Regions, sinks and flows towards the tropics.

To study the effects of temperature and salinity on the density of water, use the lab equipment provided (graduated cylinder, small beaker, dye/food coloring and small test tubes) and follow the directions outlined below for each of the two activities.

Activity 1: Temperature-Density Experiment

Procedure:

1. Fill the graduated cylinder with cold tap water to the 100 mL mark.
2. Put 2-3 drops of dye in a small test tube and fill it $\frac{1}{2}$ full with hot water.
3. Pour the contents of the test tube slowly into the cylinder and record your observations here:

Stays at the surface

4. Empty the cylinder and refill it with hot water to the 100 mL mark.
5. Add a test tube full of cold water and 2-3 drops of dye to some ice in a beaker. Stir the solution for a few seconds. Fill the test tube $\frac{3}{4}$ full with some liquid (leaving ice behind) from your beaker. Pour this cold liquid slowly into the cylinder and record your observations here:

Sinks rapidly to the bottom

6. Thoroughly clean and rinse all the glassware before starting Activity 2.

Questions:

1. Given equal salinities, which temperature of water has the greater density?
_____Cold_____
2. Write a brief summary of your temperature-density experiment.

When hot water was added to cool tap water, it stayed above the cool water in the cylinder. When cold water was added to hot water, it sank below the hot water. This shows the hot has a lower density than cooler water.

Activity 2: Salinity-Density Experiment

Procedure:

1. Place a rubber band at the 75 mL line of the graduated cylinder and fill the cylinder with cool tap water to the 100 mL line.
2. Place several drops of food coloring into a small test tube and fill the test tube about $\frac{1}{2}$ full of Solution A. Slowly pour the solution in to cylinder and observe what happens. Briefly describe your observations here:

The saline solution sank to the bottom of the cylinder

3. Repeat these steps two more times but now measure the time required for the front edge of the saltwater to travel from the rubber band at 75 mL line to the bottom of the cylinder. Record the times for each test in Table 1, below. Be sure to drain the cylinder after each trial and refill it with fresh water and use the same amount of solution with each trial.
4. Determine the travel time two times for Solution B exactly as you did with Solution A and enter your measurements in the data table.
5. Thoroughly clean all of the glassware and return it to the bin.

Table 1: Experimental Data for Density of Saline Solutions

Solution	Timed Trial #1	Timed Trial #2	Average of both trials
A			About 20 sec
B			About 10 sec

Questions:

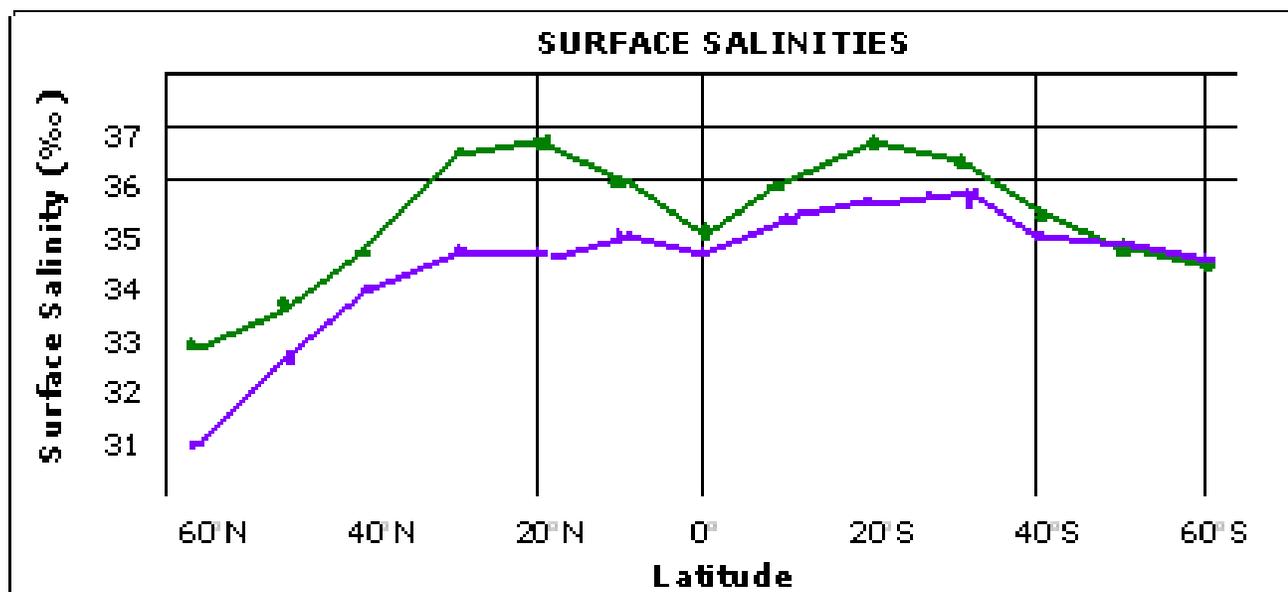
1. Which solution has the greater density? The one that sank faster: B
2. Which solution has the greatest salinity? The one with greater density: B
3. Write 2-3 sentences summarizing the results of the salinity-density experiment. Saline water is more dense than fresh water. The greater the salinity, the more marked the density contrast.

For Further Thought:

Table 2 lists the approximate surface water salinity values at various latitudes in the Atlantic and Pacific Oceans. Using the data, construct a salinity curve for each ocean on the graph provided below the table. Use a different colored pencil for each ocean. Answer the questions on the following page using the graph and your textbook for reference.

Table 2: Surface water salinity in the Atlantic and Pacific Oceans.

Latitude	Atlantic Ocean	Pacific Ocean
60°N	33.0‰	31.0‰
50°N	33.7‰	32.5‰
40°N	34.8‰	33.2‰
30°N	36.7‰	34.2‰
20°N	36.8‰	34.2‰
10°N	36.0‰	34.4‰
0°	35.0‰	34.3‰
10°S	35.9‰	35.2‰
20°S	36.7‰	35.6‰
30°S	36.2‰	35.7‰
40°S	35.3‰	35.0‰
50°S	34.3‰	34.4‰
60°S	33.9‰	34.0‰



Atlantic Ocean

Pacific Ocean

Questions:

1. At which latitudes are the highest surface salinities located?

About 20° N and S latitude

2. What are the two factors that control the concentration of salts in seawater?

Addition of water: Rainfall and runoff

Removal of water: Evaporation and formation of sea ice

3. What is the reason for the difference in surface water salinity between equatorial (0°) and subtropical regions (20-30°) in the Atlantic Ocean?

(HINT: Refer to Fig. 18.15 in Earth Science 11th ed. by Tarbuck and Lutgens).

Rainfall vs. evaporation

4. Which ocean, the Atlantic or the Pacific, has higher average surface salinities?

Atlantic

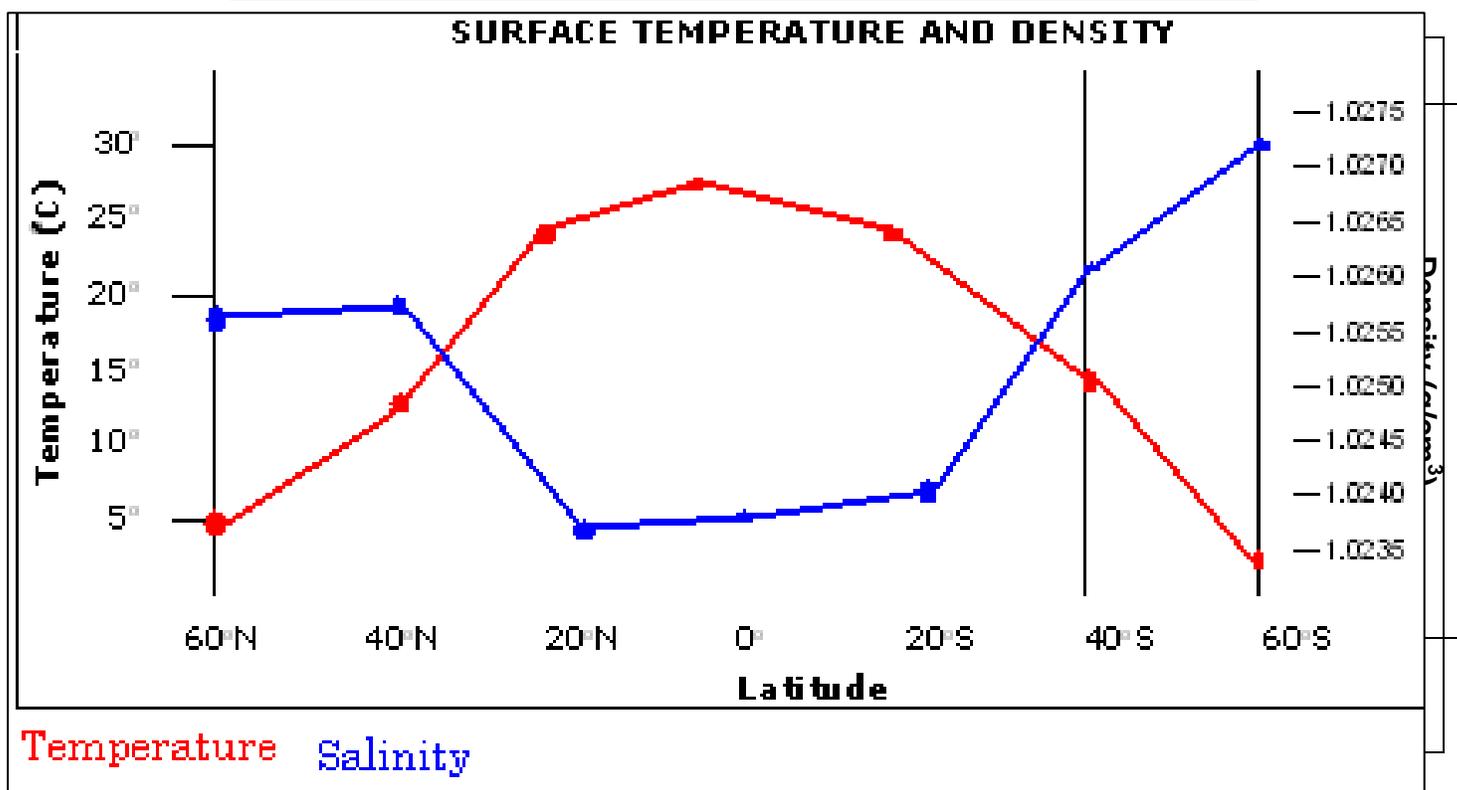
5. Suggest a reason for the difference in average surface salinities between the oceans.

Large expanse of equator in Pacific Ocean, where there is lots of rainfall

Using the data in Table 3, plot a colored line for temperature on the graph below, and a separate differently-colored line for density on the same graph. Answer the following questions using the graph and your text for reference.

Table 3: Average surface water temperature and density of seawater at various latitudes.

Latitude	Surface Temperature (°C)	Surface Density (g/cm ³)
60°N	5	1.0258
40°N	13	1.0259
20°N	24	1.0237
0°	27	1.0238
20°S	24	1.0241
40°S	15	1.0261
60°S	2	1.0272



Questions:

7. Briefly describe the overall relationship between temperature and density.

Lower temperature water has higher density, warmer water has lower density

8. Describe the surface temperature and surface density of ocean waters in equatorial regions.

Warm water, lower density than other ocean water

9. Describe the surface temperature and surface density at high latitudes.

Cooler water, greater density than other ocean water

10. What is the reason for the fact that higher average surface densities are found in Southern Hemisphere?

Cold ice cap of Antarctica chills the surrounding water. Little runoff from Antarctica, formation of sea ice enhances increase in density also.

11. Refer to the density curve in Figure 3. What evidence supports the fact that the temperature of seawater is more of a controlling factor of density than salinity?

In polar areas, temperatures and salinities are both low. The low temperature would increase the density, and the low salinity would reduce it, so one may counteract the other. The density is greatest in the polar areas, indicating that temperature is more important. The salinity increases into the subtropical areas, and diminishes at the equatorial area, but the temperature is highest in the equatorial area. Again, the temperature is the over-riding factor, since the density is the lowest here, and does not show an increase where the salinity is highest, in the subtropics.

Part C – Salinity-driven Ocean Currents

Salinity differences within the oceans help drive global ocean circulation. To understand how salinity differences can set up currents that overturn much of the oceans' volume, your instructor will perform a demonstration. In the demonstration, two horizontal tubes connect two vertical columns of water, one containing fresh water and the other saline water. Dye is added to the water in both columns increase the visibility of the currents. Initially, pinch valves close the horizontal tubes.

Questions

1. Before your instructor opens the valves, try to predict what will happen once the valves are open.

(your prediction here)

2. How did the results compare with your predictions?

(did you predict correctly?)

3. Write a short paragraph describing how the results in the demonstration relate to the global ocean conveyor belt.

The saline water is denser, and travels through the lower tube. The fresh water travels through the upper tube. Saline water sinks in the ocean, because it is dense, and travels across the sea floor. Less saline water stays at the surface, and travels across the surface to fill in areas where the dense saline water sunk to the bottom.

4. How did the rate of water circulation in this salinity demonstration today compare to the rate of circulation due to convection in last week's lab? Which demonstration seemed to produce more rapid circulation, temperature differences or salinity differences?

The salinity circulation was faster...but then again, the water had to become heated and cooled within the closed system of last week's demonstration. This week, the water in the system possessed the density differences at the outset.

5. Is the relative influence of salinity and temperature differences on circulation in the oceans the same as it was in the demonstrations you looked at in lab? Why?

We were comparing fresh water to saturated salt solutions. Salinity differences in the ocean are not so marked. The data plotted in the charts did not show much influence of salinity. Temperature differences in the sea probably are a much more significant influence than salinity differences, as they vary much more.

Name _____KEY_____

Lab Day/Time_____

POST-LAB ASSESSMENT

1. Which solution had the greater density in the salinity-density experiment you conducted? B
2. Give the approximate latitude and longitude of the following water bodies. (Choose a point more or less at the center of the sea).
 - a. Mediterranean Sea: 35° N, 15° E
 - b. Sea of Japan: 40° N, 135° E
 - c. Indian Ocean: 15° S, 90° E
3. Write a brief statement comparing the distribution of water and land in the Northern Hemisphere to the distribution in the Southern Hemisphere.

The Southern Hemisphere has much more water than land. The Northern Hemisphere is more equal land and water. However the polar areas are different: the South Pole is land, no ocean; the North Pole is ocean, no land.

4. Circle the word in parentheses that is most appropriate response with respect to sea water.
 - A. The higher the salinity of seawater, the (~~lower~~, **higher**) density.
 - B. The lower the temperature of seawater, the (~~lower~~, **higher**) the density.
 - C. Surface salinity is least in (**polar**, ~~subtropical~~, ~~equatorial~~) regions.
 - D. (**Temperature**, ~~Salinity~~) has a greater influence on the density of seawater.
 - E. (~~Warm~~, **Cold**) seawater with (**high**, ~~low~~) salinity would have the greatest density.
 - F. Vertical movements of ocean water are most likely to begin in (~~equatorial~~, ~~subtropical~~, **polar**) regions, because the surface water there is (**most**, ~~least~~) dense.
5. Why is the surface salinity of an ocean higher in the subtropics than in the equatorial regions? **Evaporation**

