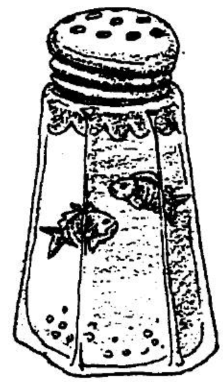

# Salinity

**Key Concepts**

1. Puget Sound water contains a mixture of materials which can vary considerably, especially in bays and estuaries.
2. Changes in salinity affect the animals and plants living in Puget Sound.

The most obvious difference between "fresh water" and "sea water" environments is the salt. The activities which follow give your students background on the salinity of the oceans and culminate with the experimental determination of the salinity of seawater samples.

Perhaps the most obvious difference between "fresh water" and Puget Sound environments is the salt. The activities which follow give your students background on the salinity of oceans and Sound and culminate with the experimental determination of the salinity of sea water samples. Salinity is readily measured and these activities capitalize on this ease as they reinforce the notion that everything dissolves to some degree in water. As you discuss these activities remind your students that clarity is no guarantee of a water's purity.

This investigation requires some specialized equipment that you may have to borrow. Hydrometers are available in aquarium shops for a reasonable sum. They can often be borrowed from chemistry teachers. This is a good chance for some integration in your curriculum! If you can only obtain one or two hydrometers, fear not. You can have the students work on the activity "Salt II" simultaneously. Small groups can use the hydrometer. If you don't feel comfortable with this approach, you can do the activity as a demonstration. Provide the data and stimulate discussion through question. Avoid answering all of the questions at this time.

Part II uses the data gathered in Part I but treats it in a slightly different manner. The two approaches may give slightly different results. This situation can provide an opportunity for a discussion of precision - just how precise do you need to be in determining salinity? The answer, of course, depends upon what you plan to do with the data once you have it in hand.

Duplicate the activity pages. One set per student is recommended. Hydrometers require careful handling. At the conclusion of the investigation, allow time for a discussion of the results and questions.

## Key

1. Chlorine is the element found in greatest abundance (55.0%) The first two questions are to encourage use of the figures in the text.

2. One would find 35 parts of salt per 1000 parts of water (35 o/oo) in the sea water shown in the figure.

3. Most students will conclude that Puget Sound will be more saline because of the continual leaching of dissolvable minerals. Since the salts dissolved in sea water are not at saturation, more can be dissolved in the water solution. In real life, however, the situation is not quite so simple. Although the salts are not saturated, they do not remain indefinitely in the water solution due to various biological and chemical processes. The amount of time a substance remains in the sea water solution is called its residence time. Calculations of the rate of leaching of minerals into the ocean indicate that the ocean should be much saltier than it is presently. The Gaia Hypothesis which looks at the entire earth as self-regulating super-organism, looks at the maintenance of a constant salinity of the oceans as analogous to the maintenance of a constant chemical balance in our blood.

4. **a.**The salinity is the greatest at seven to eight meters in depth.

   **b.**The salinity was the least at one to two meters in depth.

   **c.** The halocline should be labeled in the range of 4-6 meters in depth.

5. The salinity calculation is set up in the same manner as that shown in the text:

   20 o/oo chlorides = 55.0% of the total salinity;

   20 o/oo chlorides = .550 x (total salinity)

   $$\frac{\text{20 o/oo chlorides}}{550} = \text{(total salinity)}$$

   36.3 o/oo = total salinity

6. Since the water is without salts, the inside and outside concentration will never equal as long as the jellyfish remains intact.

7. The jellyfish will eventually burst. The distilled water became a salt solution eventually approximating the concentration in the cells. This procedure has been abandoned but can be used as an illustration of the importance of osmotic balance.

8. The shrinking of the jellyfish will stop when the salt concentration on the inside equals that of the water surrounding the jellyfish.

### Part I
**Determination of Salinity - Hydrometer Method**

The hydrometer is a standard tool for the rapid determination of the salinity of a water sample. The density of the water determines how high the hydrometer floats. A scale has been inserted into the hydrometer for ease of reference. It is possible to have your student make their own hydrometers. Since the salty taste is the most obvious difference between fresh water and salt water, the determination of salinity is a good place to begin a look at the things that make saltwater "salty".

If you were unsuccessful in acquiring hydrometers using the strategies discussed above, consider doing the activity as a classroom demonstration. Provide the data and stimulate discussion through questioning. Let your students then answer the questions in the activity using the data you provide through your demonstration. The demonstration approach is less desirable than having your student perform the activity but much more desirable than omitting the activity entirely. Ideally, obtain two water samples, one sample from 1 meter below the surface and the second from the bottom, using a water sampling device such as a Van Dorn bottle. If you cannot obtain the samples in this manner you can still use the activity by making your own salt water samples. For the top sample, dissolve 29 grams of table salt (sodium chloride) in 1 liter (1000 ml) of tap water. The bottom sample can be made by dissolving 31 grams of table salt (sodium chloride) in one liter (1000 ml) of tap water. Caution your students that hydrometers are fragile and demonstrate their care and handling. Provide any assistance necessary during the investigation. Circulate between groups to be sure everyone understands the procedure. Allow time for clean up. After the activity is completed, plan to spend time in a discussion of the results and their interpretation while providing answers to the questions found within the activity.

## Key

### Interpretation and Analysis

1. The salinity estimates will most likely not be exactly the same.

2. There are many sources of error including, but not limited to:

   **a.** differences between hydrometers
   **b.** errors in reading hydrometers
   **c.** errors in recording hydrometers
   **d.** errors in reading on paper
   **e.** differences between thermometers
   **f.** errors in reading thermometers
   **g.** errors in recording temperature, etc.

   It might be helpful to point out to your student that what we see here is two large classes of variation: one group is due to errors within the equipment, the second is due to experimenter errors.

3. Answers depend upon the experimental results.

4. It is possible, but unlikely, that the average is exactly the same as one of the estimates.

5. Answer depends upon the experimental results.

6. Answers depends upon the experimental results, most likely the answer is yes.

7. Conditions that might help account for a range in Puget Sound salinities include differences in rainfall, river outflow, differences in evaporation and differences in rate and degree of mixing in different locales.

8. Lowest salinities would be found in areas with high rainfall and large river outflows. Lowest salinities are found in estuaries with large inflow of river water and poor mixing.

9. Highest salinities would be found in areas with low rainfall, low river outflows, and poor mixing. Generally, these conditions obtain in shallow bays.

**Part II.**
**Interpretation and Analysis**

1. The answers will vary but generally students find the graph method the easier to use.

2. The densities determined using the two techniques will probably not be exactly the same.

3. Answers will depend upon experimental results.

4. Since the charts were the original source of data they should be more accurate.

5. In this case, the charts should be used because a high degree of certainty is required. They are more cumbersome to use, but provide more accurate information. The graph is used for routine salinity determinations where great precision is not required. Since the salinity determination is going to be used to make important management decisions, the charts would be preferred.

## Key Words

- average
- buoyance
- chloride ion
- concentration
- density
- density - water temperature chart
- dissolve
- elements
- estimate
- estuaries
- floatation
- freshwater
- graduated cylinder
- halocline
- hydrometer
- internal ratio
- leaching
- parts per thousand (ppt)
- range
- salinity
- salinity corrected density chart
- salinity preference
- temperature/salinity graph
- tolerance
- variation

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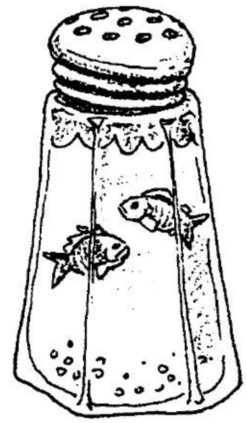
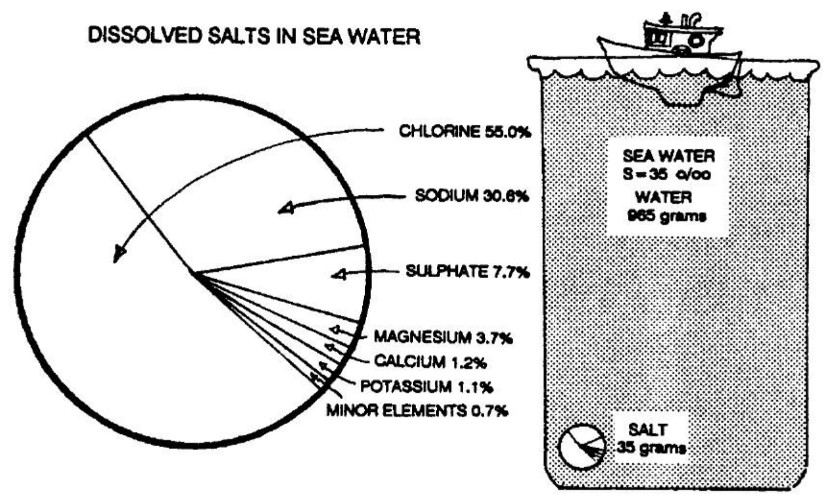


# Salinity

Water circulating in Puget Sound contains a mixture of materials. If you evaporate a sample of sea water, you end up with most of the elements known to man. Yet more than 99 percent of the sea salts are made up of only six elements: chlorine, sodium, magnesium, sulfur, calcium, and potassium. These salts are necessary for animal and plant growth.




**Relative proportion of water and dissolved salts in sea water.**

1. Which element is found in the greatest abundance in sea water?

2. The symbol o/oo means parts per thousand. How many parts of salt per thousand parts of water would you find in the sea water shown in the figure above?

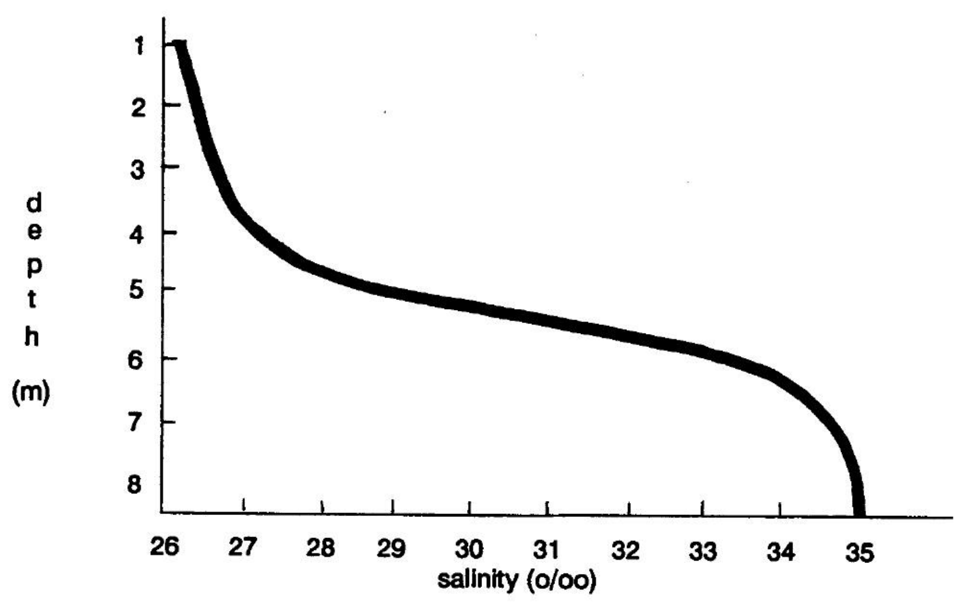
Dissolved minerals or salts are still being added to Puget Sound. Rain waters flow over the land, leaching dissolvable minerals and depositing them in the Sound. The normal salinity (total amount of dissolved salts) of sea water is 35 parts per thousand (written as S = 35 o/oo). This notation means that there are 35 grams of dissolved salts per 1000 grams of sea water. It also means that there are 35 tons of salt per 1000 tons of sea water.

**3.** In a hundred thousand years, would you expect the salinity of Puget Sound to be less than, equal to, or greater than it is now? Why?

While the salinity variation is small in Puget Sound as a whole, the saltiness of sea water can vary considerably in areas such as estuaries and bays that are supplied with fresh water from rivers, streams or runoffs. Plants and animals need special adaptations to withstand the changes of salinity found in estuaries. Seasonal variation in the fresh water flows from rivers which feed into such areas is one of the major causes of the fluctuation in salinity. Fresh water flow can also account for differences of salinity at different levels of water. When testing for salinity levels in estuarine situations, samples must be taken at several depths.

**4.** Fresh water is less dense than salt water. How can this observation explain the following results obtained near the mouth of the Skagit River?

SALINITIES NEAR THE MOUTH OF THE SKAGIT RIVER



**a.** Where was the salinity the greatest? ______________________

**b.** Where was the salinity the least? __________________________

**c.** The zone of rapid change is called the halocline.
(halo = salt + cline = change, slope)

**d.** **Label** the halocline on the graph.

Although salinity may vary slightly from seawater sample to seawater sample, the internal ratio of salts is always constant. In other words, whether the salinity is 32 o/oo or 35 o/oo we would find that 55.0% of the salts were chlorides. If the ratio of salts is always the same, we only need to determine the concentration of one of the elements present to know the concentration of all of the elements. The total of these concentrations is the salinity. Usually the chloride ion ($Cl^-$) is the element that is measured when this procedure is used. For example, if the water sample has 19 parts of chloride per 100 parts of water, the overall salinity will be approximately 34 1/2 0/00. How did we arrive at the figure?

Well, 19 o/oo chlorides = 55.0% of the total salinity;

or, . . . . . 19 o/oo chlorides = .550 x (total salinity);

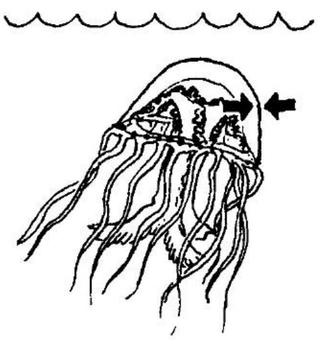
or, . . . . . $\frac{\text{19 o/oo chlorides}}{550}$ = (total salinity).

or, . . . . . 34.5 o/oo = total salinity.

**5.** What would be the salinity of a sample having 20 o/oo chlorides? Please show your work.

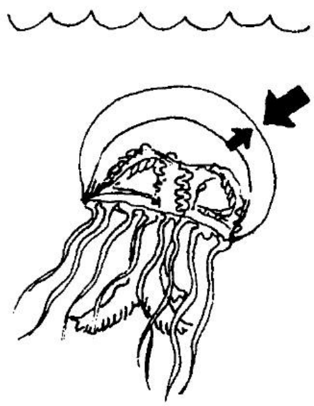
Salts make sea water different from freshwater. The concentrations of the salts affect everything that comes in contact with sea water. Living organisms have to deal with this salinity.

How does salinity affect living things? Living cells are largely water with a few dissolved salts and other materials. The materials inside the cell, for the most part, stay there. Water, however, can move into and out of the cell. How is this important?



WATER IN = WATER OUT

In living cells the water tends to move into or out of the cell until the concentration of salts, "salinity," inside the cell equals the concentration of salts outside the cell. What does this mean? Let's look at a jelly fish and see. Our jelly fish is floating peacefully in the sea. The salt concentration within its cells is equal to the salt concentration in the water around it. The same amount of water enters its cells as leaves them.



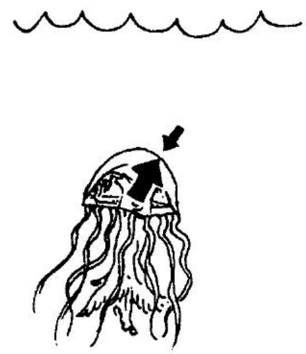
WATER IN IS GREATER THAN WATER OUT

Poor jellyfish! It's collected by Mr. Outofit's oceanography class. Mr. Outofit places the jellyfish in a freshwater aquarium. The salt concentration within the cells of the jellyfish is greater than the salt concentration in the distilled water of the aquarium. The salt can't move out of the jellyfish. In an effort to equalize the concentrations, water begins to move into the cells of the jellyfish. The concentration of salts in the cells is reduced but it's still higher than in the water. More water moves into the jellyfish and the jellyfish begins to swell.

**6.** Will the concentration on the outside ever equal the concentration on the inside of the jellyfish?

**7.** What will eventually happen to our jellyfish?

Mr. Outofit is panicked! Thinking quickly he grabs the jellyfish and moves it into a tank of salt water. Unfortunately for our jellyfish, the salt concentration is 70 o/oo about twice what it's used to. Now what will happen? Again, the salt can't move out of the jellyfish. How can the inside and outside concentrations be made more equal? This time water moves from the jellyfish into the water. This movement of water makes the salt inside the cells more concentrated and makes the outside water slightly less concentrated. Our poor jellyfish begins to shrink as it loses water. This shrinking is called **dehydration**.



WATER IN IS LESS THAN WATER OUT

The movement of water into and out of cells is called osmosis. In real animals the situation is more complex than that shown above. Animals and plants have developed mechanisms to handle the small changes in salinity that normally occur where they live. Drastic changes in salinity, however, cannot be dealt with and the cells of the animal or plant behave like those of our imaginary jellyfish.

**Part 1**

## THE DETERMINATION OF SALINITY - Hydrometer Method

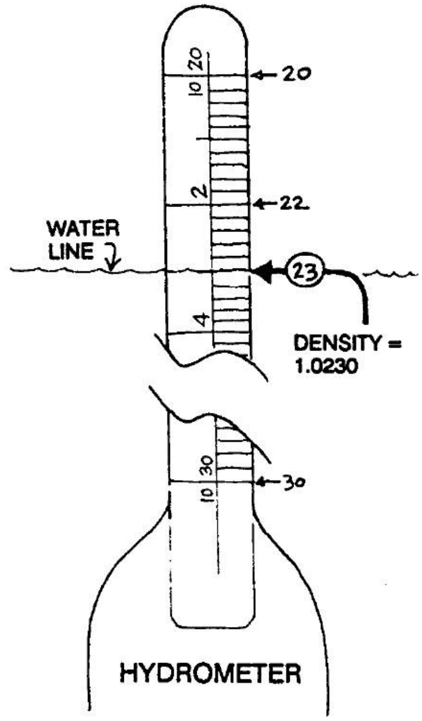
How is salinity determined? To measure the salinity of sea water, oceanographers have developed several techniques. The following is one technique commonly used for the determination of salinity.

For centuries, people observed that the saltier the water, the higher something floats in it. Marine scientists use this **buoyancy** (flotation) information to rapidly determine salinity, with an instrument called a **hydrometer**.

A hydrometer is a weighted glass cylinder with a thin glass tube at the top. The thin tube contains a printed scale (see diagram on the next page). The higher the salinity, the higher the tube floats and the larger the number that lines up with the water's surface. Pure water at $4^{o}$ is given a density of 1.0000. Follow the steps below to use a hydrometer to determine the salinity of salt water samples.

**Materials:**

- Salt water solutions
- Thermometer $^{o}C$
- Hydrometer
- Density - water temperature chart
- Salinity - corrected density chart
- Temperature / salinity graph
- 500 ml graduated cylinder or similar container




**Procedure:**

1. Fill graduated cylinder with 450 ml of your sea water sample.

2. Record water temperature with centigrade thermometer ___________.

3. Using the hydrometer, measure the density of your sample. The diagram at the right will help you read the hydrometer. **Record** the density

4. Correct density using the density-water temperature chart and **record**:____________.

> *Example:* density = 1.0230 water temperature $10^{o}$
>
> - Find 1.0230 under "Observed density" on the Density-Water Temperature Chart on the next page
> - Move across to the column marked "$10^{o}$" under "Temperature of water in jar".
> - Read: -8. The -8 is the correction factor and is really -.0008.
> - Subtract:
>
> 1.0230
> - .0008
> 1.0222 = the corrected density reading

## DENSITY - WATER TEMPERATURE CHART

| Observed Density | TEMPERATURE OF WATER | | | | | | | | | | | | | | | | | | | Observed density |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
| | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | *Diff.* | |
| 1.0000 | -3 | -4 | -5 | -5 | -6 | -6 | -6 | -5 | -6 | -5 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 3 | 4 | 1.0000 |
| 1.0010 | -4 | -5 | -6 | -6 | -6 | -6 | -6 | -6 | -6 | -5 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 3 | 4 | 1.0010 |
| 1.0020 | -4 | -5 | -6 | -6 | -7 | -7 | -6 | -6 | -6 | -6 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 3 | 5 | 1.0020 |
| 1.0030 | -5 | -6 | -6 | -7 | -7 | -7 | -7 | -6 | -6 | -6 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 3 | 5 | 1.0030 |
| 1.0040 | -5 | -6 | -7 | -7 | -7 | -7 | -7 | -7 | -6 | -6 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 3 | 5 | 1.0040 |
| 1.0050 | -6 | -7 | -7 | -7 | -8 | -7 | -7 | -7 | -7 | -6 | -5 | -5 | -4 | -2 | -1 | 0 | 1 | 3 | 5 | 1.0050 |
| 1.0060 | -6 | -7 | -8 | -8 | -8 | -8 | -8 | -7 | -7 | -6 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0060 |
| 1.0070 | -7 | -7 | -8 | -8 | -8 | -8 | -8 | -7 | -7 | -6 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0070 |
| 1.0080 | -7 | -8 | -8 | -8 | -9 | -8 | -8 | -8 | -7 | -7 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0080 |
| 1.0090 | -8 | -8 | -9 | -9 | -9 | -9 | -8 | -8 | -7 | -7 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0090 |
| 1.0100 | -8 | -9 | -9 | -9 | -9 | -9 | -9 | -8 | -8 | -7 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0100 |
| 1.0110 | -9 | -9 | -10 | -10 | -10 | -9 | -9 | -8 | -8 | -7 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0110 |
| 1.0120 | -9 | -10 | -10 | -10 | -10 | -10 | -9 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -1 | 0 | 2 | 3 | 5 | 1.0120 |
| 1.0130 | -10 | -10 | -10 | -10 | -10 | -10 | -9 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | 0 | 2 | 3 | 5 | 1.0130 |
| 1.0140 | -10 | -11 | -11 | -11 | -11 | -10 | -10 | -9 | -8 | -7 | -7 | -6 | -4 | -3 | -2 | 0 | 2 | 3 | 5 | 1.0140 |
| 1.0150 | -11 | -11 | -11 | -11 | -11 | -10 | -10 | -9 | -8 | -8 | -7 | -6 | -4 | -3 | -2 | 0 | 2 | 3 | 5 | 1.0150 |
| 1.0160 | -11 | -11 | -12 | -11 | -11 | -11 | -10 | -10 | -9 | -8 | -7 | -6 | -4 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0160 |
| 1.0170 | -12 | -12 | -12 | -12 | -12 | -11 | -11 | -10 | -9 | -8 | -7 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0170 |
| 1.0180 | -12 | -12 | -12 | -12 | -12 | -11 | -11 | -10 | -9 | -8 | -7 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0180 |
| 1.0190 | -13 | -13 | -13 | -13 | -12 | -12 | -11 | -10 | -9 | -8 | -7 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0190 |
| 1.0200 | -13 | -13 | -13 | -13 | -13 | -12 | -11 | -11 | -10 | -9 | -7 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0200 |
| 1.0210 | -14 | -14 | -14 | -13 | -13 | -12 | -12 | -11 | -10 | -9 | -8 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0210 |
| 1.0220 | -14 | -14 | -14 | -14 | -13 | -13 | -12 | -11 | -10 | -9 | -8 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0220 |
| 1.0230 | -15 | -15 | -14 | -14 | -14 | -13 | -12 | -11 | -10 | -9 | -8 | -6 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0230 |
| 1.0240 | -15 | -15 | -15 | -14 | -14 | -13 | -12 | -12 | -10 | -9 | -8 | -7 | -5 | -3 | -2 | 0 | 2 | 4 | 6 | 1.0240 |
| 1.0250 | -16 | -15 | -15 | -15 | -14 | -13 | -13 | -12 | -11 | -9 | -8 | -7 | -5 | -4 | -2 | 0 | 2 | 4 | 6 | 1.0250 |
| 1.0260 | -16 | -16 | -16 | -15 | -15 | -14 | -13 | -12 | -11 | -10 | -8 | -7 | -5 | -4 | -2 | 0 | 2 | 4 | 6 | 1.0260 |
| 1.0270 | -17 | -16 | -16 | -15 | -15 | -14 | -13 | -12 | -11 | -10 | -8 | -7 | -5 | -4 | -2 | 0 | 2 | 4 | 6 | 1.0270 |
| 1.0280 | -17 | -17 | -16 | -16 | -15 | -14 | -13 | -12 | -11 | -10 | -9 | -7 | -5 | -4 | -2 | 0 | 2 | 4 | 6 | 1.0280 |
| 1.0290 | -18 | -17 | -17 | -16 | -16 | -15 | -14 | -13 | -12 | -10 | -9 | -7 | -5 | -4 | -2 | 0 | 2 | 4 | 6 | 1.0290 |
| 1.0300 | -18 | -18 | -17 | -17 | -16 | -15 | -14 | -13 | -12 | -10 | -9 | -7 | -6 | -4 | -2 | 0 | 2 | 4 | 6 | 1.0300 |
| 1.0310 | -19 | -18 | -18 | -17 | -16 | -15 | -14 | -13 | -12 | -10 | -9 | -7 | -6 | -4 | -2 | 0 | 2 | 4 | 7 | 1.0310 |

## SALINITY - CORRECTED DENSITY CHART

(Density at 15° C. - Salinity in parts per 1,000)

| Density | Salinity | Density | Salinity | Density | Salinity | Density | Salinity | Density | Salinity | Density | Salinity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.9991 | 0.0 | 1.0046 | 7.1 | 1.0101 | 14.2 | 1.0156 | 21.4 | 1.0211 | 28.6 | 1.0266 | 35.8 |
| .9992 | .0 | 1.0047 | 7.2 | 1.0102 | 14.4 | 1.0157 | 21.6 | 1.0212 | 28.8 | 1.0267 | 35.9 |
| .9993 | .1 | 1.0048 | 7.3 | 1.0103 | 14.5 | 1.0158 | 21.7 | 1.0213 | 28.9 | 1.0268 | 36.0 |
| .9994 | .3 | 1.0049 | 7.5 | 1.0104 | 14.6 | 1.0159 | 21.8 | 1.0214 | 29.0 | 1.0269 | 36.2 |
| .9995 | .4 | 1.0050 | 7.6 | 1.0105 | 14.8 | 1.0160 | 22.0 | 1.0215 | 29.1 | 1.0270 | 36.3 |
| .9996 | .5 | 1.0051 | 7.7 | 1.0106 | 14.9 | 1.0161 | 22.1 | 1.0216 | 29.3 | 1.0271 | 36.4 |
| .9997 | .7 | 1.0052 | 7.9 | 1.0107 | 15.0 | 1.0162 | 22.2 | 1.0217 | 29.4 | 1.0272 | 36.6 |
| .9998 | .8 | 1.0053 | 8.0 | 1.0108 | 15.2 | 1.0163 | 22.4 | 1.0218 | 29.5 | 1.0273 | 36.7 |
| .9999 | .9 | 1.0054 | 8.1 | 1.0109 | 15.3 | 1.0164 | 22.5 | 1.0219 | 29.7 | 1.0274 | 36.8 |
| 1.0000 | 1.1 | 1.0055 | 8.2 | 1.0110 | 15.4 | 1.0165 | 22.6 | 1.0220 | 29.8 | 1.0275 | 37.0 |
| 1.0001 | 1.2 | 1.0056 | 8.4 | 1.0111 | 15.6 | 1.0166 | 22.7 | 1.0221 | 29.9 | 1.0276 | 37.1 |
| 1.0002 | 1.3 | 1.0057 | 8.5 | 1.0112 | 15.7 | 1.0167 | 22.9 | 1.0222 | 30.0 | 1.0277 | 37.2 |
| 1.0003 | 1.4 | 1.0058 | 8.6 | 1.0113 | 15.8 | 1.0168 | 23.0 | 1.0223 | 30.2 | 1.0278 | 37.3 |
| 1.0004 | 1.6 | 1.0059 | 8.8 | 1.0114 | 16.0 | 1.0169 | 23.1 | 1.0224 | 30.3 | 1.0279 | 37.5 |
| 1.0005 | 1.7 | 1.0060 | 8.9 | 1.0115 | 16.1 | 1.0170 | 23.3 | 1.0225 | 30.4 | 1.0280 | 37.6 |
| 1.0006 | 1.8 | 1.0061 | 9.0 | 1.0116 | 16.2 | 1.0171 | 23.4 | 1.0226 | 30.6 | 1.0281 | 37.7 |
| 1.0007 | 2.0 | 1.0062 | 9.2 | 1.0117 | 16.3 | 1.0172 | 23.5 | 1.0227 | 30.7 | 1.0282 | 37.9 |
| 1.0008 | 2.1 | 1.0063 | 9.3 | 1.0118 | 16.5 | 1.0173 | 23.7 | 1.0228 | 30.8 | 1.0283 | 38.0 |
| 1.0009 | 2.2 | 1.0064 | 9.4 | 1.0119 | 16.6 | 1.0174 | 23.8 | 1.0229 | 31.0 | 1.0284 | 38.1 |
| 1.0010 | 2.4 | 1.0065 | 9.6 | 1.0120 | 16.7 | 1.0175 | 23.9 | 1.0230 | 31.1 | 1.0285 | 38.2 |
| 1.0011 | 2.5 | 1.0066 | 9.7 | 1.0121 | 16.9 | 1.0176 | 24.0 | 1.0231 | 31.2 | 1.0286 | 38.4 |
| 1.0012 | 2.6 | 1.0067 | 9.8 | 1.0122 | 17.0 | 1.0177 | 24.2 | 1.0232 | 31.4 | 1.0287 | 38.5 |
| 1.0013 | 2.8 | 1.0068 | 9.9 | 1.0123 | 17.1 | 1.0178 | 24.3 | 1.0233 | 31.5 | 1.0288 | 38.6 |
| 1.0014 | 2.9 | 1.0069 | 10.1 | 1.0124 | 17.3 | 1.0179 | 24.4 | 1.0234 | 31.6 | 1.0289 | 38.8 |
| 1.0015 | 3.0 | 1.0070 | 10.2 | 1.0125 | 17.4 | 1.0180 | 24.6 | 1.0235 | 31.8 | 1.0290 | 38.9 |
| 1.0016 | 3.2 | 1.0071 | 10.3 | 1.0126 | 17.5 | 1.0181 | 24.7 | 1.0236 | 31.9 | 1.0291 | 39.0 |
| 1.0017 | 3.3 | 1.0072 | 10.5 | 1.0127 | 17.6 | 1.0182 | 24.8 | 1.0237 | 32.0 | 1.0292 | 39.2 |
| 1.0018 | 3.4 | 1.0073 | 10.6 | 1.0128 | 17.8 | 1.0183 | 25.0 | 1.0238 | 32.1 | 1.0293 | 39.3 |
| 1.0019 | 3.5 | 1.0074 | 10.7 | 1.0129 | 17.9 | 1.0184 | 25.1 | 1.0239 | 32.3 | 1.0294 | 39.4 |
| 1.0020 | 3.7 | 1.0075 | 10.8 | 1.0130 | 18.0 | 1.0185 | 25.2 | 1.0240 | 32.4 | 1.0295 | 39.6 |
| 1.0021 | 3.8 | 1.0076 | 11.0 | 1.0131 | 18.2 | 1.0186 | 25.4 | 1.0241 | 32.5 | 1.0296 | 39.7 |
| 1.0022 | 3.9 | 1.0077 | 11.1 | 1.0132 | 18.3 | 1.0187 | 25.5 | 1.0242 | 32.7 | 1.0297 | 39.8 |
| 1.0023 | 4.1 | 1.0078 | 11.2 | 1.0133 | 18.4 | 1.0188 | 25.6 | 1.0243 | 32.8 | 1.0298 | 39.9 |
| 1.0024 | 4.2 | 1.0079 | 11.4 | 1.0134 | 18.6 | 1.0189 | 25.8 | 1.0244 | 32.9 | 1.0299 | 40.1 |
| 1.0025 | 4.3 | 1.0080 | 11.5 | 1.0135 | 18.7 | 1.0190 | 25.9 | 1.0245 | 33.0 | 1.0300 | 40.2 |
| 1.0026 | 4.5 | 1.0081 | 11.6 | 1.0136 | 18.8 | 1.0191 | 26.0 | 1.0246 | 33.2 | 1.0301 | 40.3 |
| 1.0027 | 4.6 | 1.0082 | 11.8 | 1.0137 | 19.0 | 1.0192 | 26.1 | 1.0247 | 33.3 | 1.0302 | 40.4 |
| 1.0028 | 4.7 | 1.0083 | 11.9 | 1.0138 | 19.1 | 1.0193 | 26.3 | 1.0248 | 33.4 | 1.0303 | 40.6 |
| 1.0029 | 4.8 | 1.0084 | 12.0 | 1.0139 | 19.2 | 1.0194 | 26.4 | 1.0249 | 33.6 | 1.0304 | 40.7 |
| 1.0030 | 5.0 | 1.0085 | 12.2 | 1.0140 | 19.4 | 1.0195 | 26.5 | 1.0250 | 33.7 | 1.0305 | 40.8 |
| 1.0031 | 5.1 | 1.0086 | 12.3 | 1.0141 | 19.5 | 1.0196 | 26.7 | 1.0251 | 33.8 | 1.0306 | 41.0 |
| 1.0032 | 5.2 | 1.0087 | 12.4 | 1.0142 | 19.6 | 1.0197 | 26.8 | 1.0252 | 34.0 | 1.0307 | 41.1 |
| 1.0033 | 5.4 | 1.0088 | 12.6 | 1.0143 | 19.7 | 1.0198 | 26.9 | 1.0253 | 34.1 | 1.0308 | 41.2 |
| 1.0034 | 5.5 | 1.0089 | 12.7 | 1.0144 | 19.9 | 1.0199 | 27.1 | 1.0254 | 34.2 | 1.0309 | 41.4 |
| 1.0035 | 5.6 | 1.0090 | 12.8 | 1.0145 | 20.0 | 1.0200 | 27.2 | 1.0255 | 34.4 | 1.0310 | 41.5 |
| 1.0036 | 5.8 | 1.0091 | 12.9 | 1.0146 | 20.1 | 1.0201 | 27.3 | 1.0256 | 34.5 | 1.0311 | 41.6 |
| 1.0037 | 5.9 | 1.0092 | 13.1 | 1.0147 | 20.3 | 1.0202 | 27.4 | 1.0257 | 34.6 | 1.0312 | 41.8 |
| 1.0038 | 6.0 | 1.0093 | 13.2 | 1.0148 | 20.4 | 1.0203 | 27.6 | 1.0258 | 34.7 | 1.0313 | 41.9 |
| 1.0039 | 6.2 | 1.0094 | 13.3 | 1.0149 | 20.5 | 1.0204 | 27.7 | 1.0259 | 34.9 | 1.0314 | 42.0 |
| 1.0040 | 6.3 | 1.0095 | 13.5 | 1.0150 | 20.6 | 1.0205 | 27.8 | 1.0260 | 35.0 | 1.0315 | 42.1 |
| 1.0041 | 6.4 | 1.0096 | 13.6 | 1.0151 | 20.8 | 1.0206 | 28.0 | 1.0261 | 35.1 | 1.0316 | 42.3 |
| 1.0042 | 6.6 | 1.0097 | 13.7 | 1.0152 | 20.9 | 1.0207 | 28.1 | 1.0262 | 35.3 | 1.0317 | 42.4 |
| 1.0043 | 6.7 | 1.0098 | 13.9 | 1.0153 | 30.0 | 1.0208 | 28.2 | 1.0263 | 35.4 | 1.0318 | 42.5 |
| 1.0044 | 6.8 | 1.0099 | 14.0 | 1.0154 | 30.2 | 1.0209 | 28.4 | 1.0264 | 35.5 | 1.0319 | 42.7 |
| 1.0045 | 7.0 | 1.0100 | 14.1 | 1.0155 | 30.3 | 1.0210 | 28.5 | 1.0265 | 35.6 | 1.0320 | 42.8 |

**5.** Read salinity from salinity-corrected density chart and record.

> *Example:*
>
> Find 1.0222 in the density column.
>
> Read 30.0 in the salinity column to the right of the density 1.0222.

**Record** the salinity for your sample ________________ o/oo.

**6. Record your salinity on the blackboard** as directed by your teacher.

**7.** Repeat the above steps for each salt solution provided.

**Interpretation and Analysis:**

**1.** Look at the salinity determinations for salt solution number 1. Are all of the salinity estimates for a particular solution the same?

**2.** If you see differences in the estimates, list three possible sources of this variation.

**a.**

**b.**

**c.**

Scientists have found that they can obtain more accurate results if they repeat a procedure several times and take an average. The average figure that they obtain has a better chance of being the real (correct) figure than does any of the individual figures.

**3.** Calculate the average salinity for each of the each of the salt solutions tested.

*(Hint: This is easy! Take all of the salinity estimates for a given solution add them together. Divide this sum by the number of estimates. The answer is your average.)* In other words,

$$\frac{\text{sum of salinity estimates for solution X}}{\text{number of salinity estimates for solution X}} = \text{average salinity estimate for solution X.}$$

Please show your work in the space below:

**4.** Are any of the estimates on the board exactly the same as the calculated average?

**5.** Which solution was the saltiest?

**6.** The salinity of water in Puget Sound ranges from about 25 parts salt per thousand parts of water (25 ppt) to about 34 parts per thousand. Did either or both solutions fall in this range? If yes, which one (s)?

**7.** What are two conditions that might help account for a range (from 25 ppt to 34 ppt) in Puget Sound salinities rather than a single uniform salinity?

**a.**

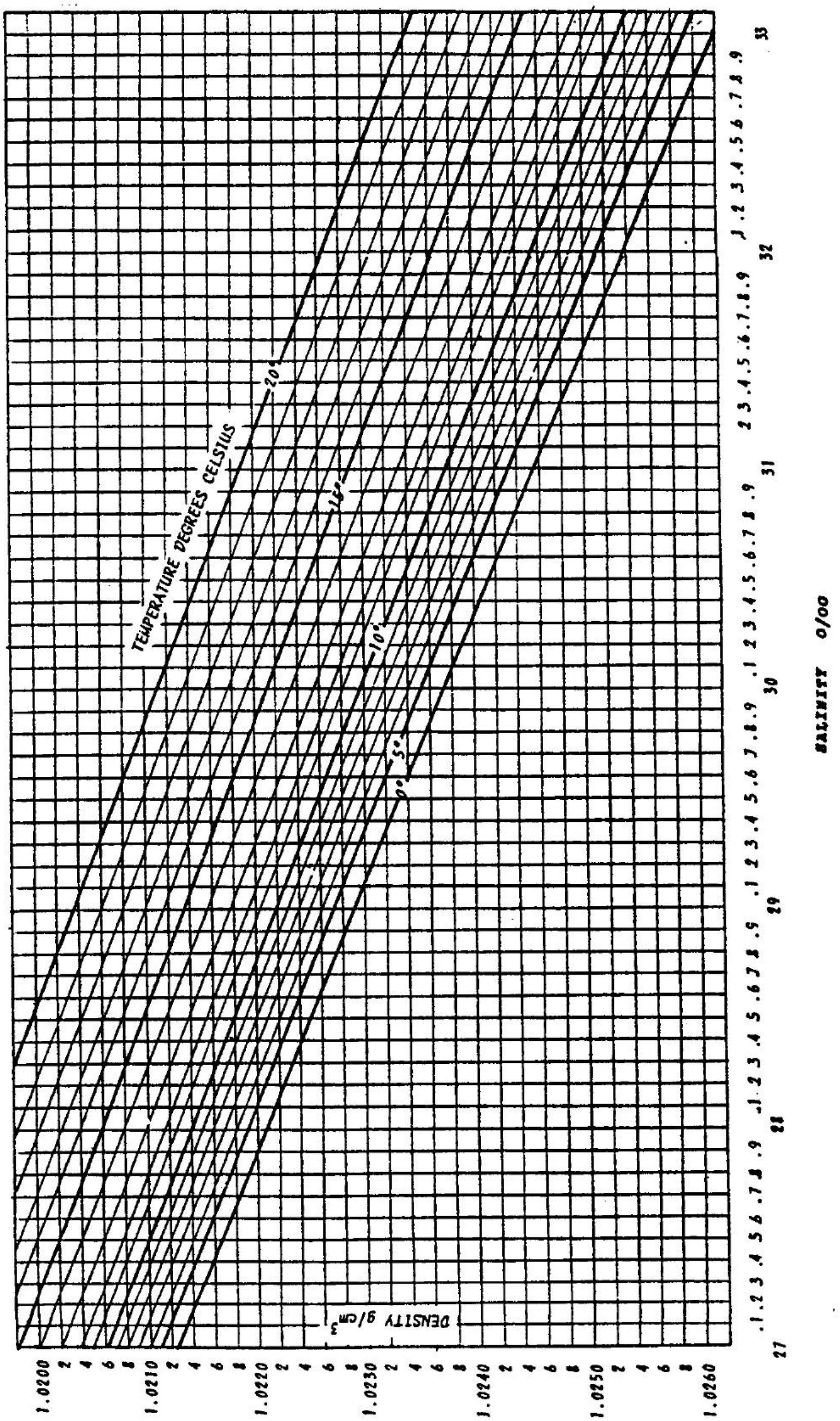
**b.**

**8.** Where would you expect the lowest salinities to be found? Explain.

**9.** Where would you expect the highest salinities to be found? Explain.

**PART 2**

Using the density-water temperature chart and the salinity-corrected chart can be tedious. To make things a bit quicker scientists have developed this hydrometer-temperature graph which corrects for differences in temperature. Using this graph you will again determine the salinities that correspond to the hydrometer densities you discovered.



## Procedure

**1.** Use the hydrometer-temperature graph to read the salinity.

> *Example:* To Find Salinity:
>
> **a.** Find correct water temperature on graph.
>
> **b.** Follow temperature line over until you meet correct hydrometer density line.
>
> **c.** From this point drop straight down and read off correct salinity of your sample in parts per thousand (o/oo).

**Record** your salinity:

Salinity for sample # ________ is _______________o/oo.

## Interpretation and Analysis

**1.** Which method of determining salinity from density data did you find easier? Why?

**2.** Were the densities you determined using the charts exactly the same as those that you determined using the graph?

**3.** By what percentage does the graph salinity determination for the first sample differ from the chart salinity determination?

(Hint: $\% \text{ difference} = \frac{(\text{chart salinity}) - (\text{graph salinity})}{\text{chart salinity}} \times 100$)

Please show your work in the space below:

**4.** The graph was constructed from the charts. Which do you think is more accurate? Why?

**5.** Hit and Run Pickle Co., Inc. has been found dumping thousands of gallons of used pickle brine into Commencement Bay. If it can be proved that their activities changed the salinity of the bay, the Environmental Protection Agency will charge the company for the costs of cleaning up the bay. Scientists will collect water samples from near the brine outfall and from sites away from the outfall.

In determining the salinity of the water samples collected, should the scientists use the salinity charts or the salinity graph? Why?