

Salinity Protocol



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Purpose

To measure the salinity of the water at your hydrology site

Overview

Students will use a hydrometer to measure the specific gravity of the water sample, and use a thermometer to measure the temperature. With these two values, students will use tables to determine the salinity.

Student Outcomes

Students will learn to,

- use a hydrometer;
- apply concepts of density and specific gravity to salinity (advanced);
- use tables of specific gravity and temperature values to determine salinity;
- examine reasons for changes in salinity;
- communicate project results with other GLOBE schools;
- collaborate with other GLOBE schools (within your country or other countries); and
- share observations by submitting data to the GLOBE archive.

Science Concepts

Earth and Space Science

Earth materials are solid rocks, soils, water and the atmosphere.

Water is a solvent.

Each element moves among different reservoirs (biosphere, lithosphere, atmosphere, hydrosphere).

Physical Science

Objects have observable properties.

Life Science

Organisms can survive only in environments where their needs are met.

Earth has many different environments that support different combinations of organisms.

Humans can change natural environments.

All organisms must be able to obtain and use resources while living in a constantly changing environment.

Scientific Inquiry Abilities

- Use a hydrometer to measure salinity.
- Identify answerable questions.
- Design and conduct scientific investigations.
- Use appropriate mathematics to analyze data.
- Develop descriptions and explanations using evidence.
- Recognize and analyze alternative explanations.
- Communicate procedures and explanations.

Time

10 minutes

Quality control – 10 minutes

Level

All

Frequency

Weekly

Quality control check every 6 months

Materials and Tools

Hydrology Investigation Data Sheet

Salinity Protocol Field Guide

Water Temperature Protocol Field Guide

Tide table for region closest to your hydrology site

Hydrometer

Conversion table in *Teacher's Guide*

500-mL clear graduated cylinder

Alcohol-filled thermometer

Latex gloves

For Quality Control Procedure, the above plus:

- *Hydrology Investigation Quality Control Procedure Data Sheet*



- *Quality Control Procedure for Salinity Protocol Lab Guide*
- Salt (NaCl)
- Distilled water
- Balance
- Two 1-liter bottles with caps and labels for storing standards

Preparation

Suggested Learning Activities:
Practicing Your Protocols: Salinity (e-guide only)
Water Detectives (e-guide only)

Prerequisites

Instruction on reading a tide table

Salinity Protocol – Introduction

Why do some types of plants and animals live in brackish estuaries while others live in the ocean and still others live in freshwater lakes and streams? One of the main reasons is the difference in salinities among these environments. Salinity is the measurement of the amount of dissolved solids in water. There are many different types of solids dissolved in water, but the most common dissolved solid is sodium chloride (NaCl). Dissolved solids are often called salts.

All animals and plants have salts inside the cells of their bodies. The concentration of those salts is about one third that of seawater. Plants and animals in both fresh and salt water have special mechanisms to maintain a proper salt balance between their cells and their environment. Freshwater organisms are saltier than the water they live in. Fresh water tends to enter their cells and must be pumped out to keep the cells from swelling and even exploding. Animals such as fish in salt water are less salty than the seawater they live in. Many saltwater fish excrete salts from their gills and produce little urine so that they minimize the loss of liquids from their bodies. Sharks solve the problem by storing extra salts in their cells so that they are in balance with the salt content of the surrounding seawater. As well, animals that feed on organisms that live in brackish or salt water have developed ways to manage the salt content. For instance, seabirds and sea turtles have special salt glands to excrete the salt they take in with food and water. Organisms adapted to one type of environment cannot be moved into another without serious injury or death.

The Earth's oceans average 35 parts per thousand (ppt) salinity. Fresh water measures 0.5 ppt or less. Coastal waters and surface waters of the ocean far from shore can be less salty than 35 ppt due to fresh water input from land or rain, or more salty due to high rates of evaporation in hot climates. Some seas and lakes are also salt water. Some examples include the Caspian Sea in central Asia, the Great Salt Lake in North America, and several lakes in the Great Rift Valley of East Africa. These water bodies are salty because water flows into them, and then evaporates, leaving the salts in the inland sea or lake behind. Freshwater bodies have outlets so the salts move through them instead of accumulating.

Brackish water is water that is saltier than fresh water, but not as salty as seawater. It is found in estuaries and bays where salt water and fresh water mix. Estuaries are bodies of water that are partly enclosed from the open ocean and usually have a freshwater river source. Tides may affect the salinity in these water bodies. When the tide is high, the salinity may be higher than when the tide is low. Salinity may decrease when large amounts of fresh water are added during rain or snowmelt. Plants and animals living in these waters must be able to adapt to rapid and large changes in salinity. The young of many sea animals, such as baby shrimp and fish, live in brackish estuaries. Often these young animals have the ability to survive in a wider range of saltiness than as adults.



Teacher Support

Electrical Conductivity vs. Salinity

The salinity measurement is used to find the total dissolved solids (or salinity) of brackish or salt water. This may be a site along an ocean, estuary, or salt lake. Fresh water has too little dissolved solids to accurately determine the total dissolved solids using the hydrometer. GLOBE schools with freshwater sites use the *Electrical Conductivity Protocol* to find the total dissolved solids in their water. The *Electrical Conductivity Protocol* for fresh water will only measure up to 2000 microSiemens/cm. If your water goes beyond this range you will have to use the *Salinity Protocol*.

Supporting Concepts

Density and Specific Gravity

Density is the ‘lightness’ or ‘heaviness’ of materials of the same size. Density indicates the size of the molecules and how tightly packed the molecules are in a particular substance. The larger and more tightly packed the molecules, the denser the substance is. Density is measured by how heavy something is compared to its volume. We say that a metal spoon is denser than a wooden spoon of the same size because the metal spoon is heavier. Which is denser – a baseball or a solid iron ball of the same size?

Specific gravity is also a measure of density. When we measure specific gravity, we are comparing the density of a material to the density of pure water at 4° C. We use water as a standard because it is a common substance. We use 4° C because that is the temperature at which water is most dense. The specific gravity of pure water at 4° C is by definition 1.0. A substance denser than pure water at 4° C has a specific gravity greater than 1.0.

$$\text{Specific gravity} = \frac{\text{mass of an object of a certain volume}}{\text{mass of an equal volume of pure water.}}$$

If we want to know the specific gravity of an object such as a rock, we need to know the:

1. mass of the rock
2. volume of the rock
3. mass of an equal volume of pure water

The first piece of information is easy. We determine the mass of the rock by weighing it on a balance. To

find the second piece of information, we need to talk about displacement and have a short history lesson.

Archimedes lived in ancient Greece. He discovered two important things while sitting in his bathtub (or so the story goes). The first was that when he stepped into the water, the water level went up. When he sat down, the water level went up even more. He found that when a body is placed in water, it displaces (or moves out of the way) a volume of water equal to the volume of the body.

So, to find the volume of our rock, pour some water into a graduated cylinder. Put the rock in the water. Note how much the water volume increases. The increase in water volume is equal to the volume of the rock. We now have our second piece of information.

Archimedes’ second important discovery was that when a body is placed in the water, it seems to lose mass. This *mass loss* is equal to the mass of the water displaced. So, we can determine the mass of the water that was displaced to get the third piece of information we need. (Or we can calculate the mass of the water since we know that the mass of 1.0 mL of water is 1.0 gram.)

Now, divide the mass of the rock by the mass of the water displaced, and you have the specific gravity of the rock.

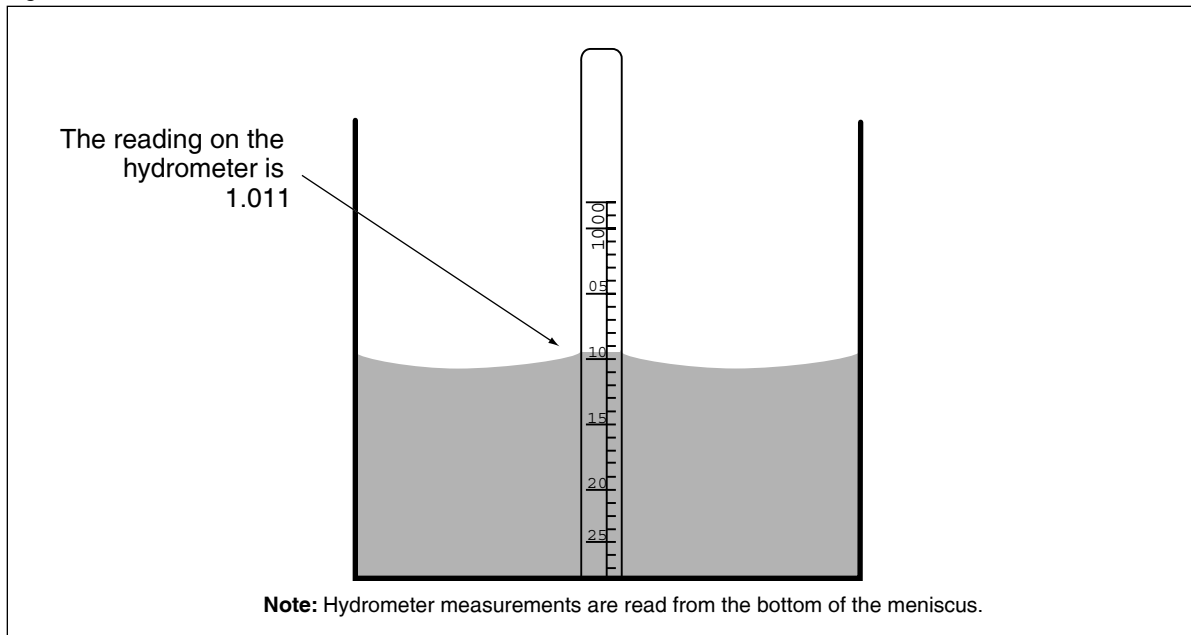
$$\text{Specific gravity} = \frac{\text{mass of rock}}{\text{mass of displaced water}}$$

Each mineral has a characteristic specific gravity. Specific gravity can thus be used to help to identify minerals. Many common rocks are made of a mineral, silica, and have a specific gravity of 2.65. For the *Salinity Protocol*, we are trying to determine the amount of dissolved mineral. This may be a little more difficult for students to understand since they cannot see the ‘rock’. But the principle is the same. We are using the hydrometer to calculate the displacement caused by the addition of dissolved minerals (solids).

Tides

Tides are caused by the gravitational pull of the moon and the sun on Earth. Because the moon is

Figure HY-SA-1



so much closer to Earth than the sun, the moon exerts the greater pull on Earth. The most extreme tides, called spring tides, occur during full and new moons when Earth, moon, and sun are in a line. During quarter and three quarter moons, the moon, Earth and sun form a right angle and the tidal range (the difference between high and low tides) is the smallest. These tides are called neap tides.

Most areas have two low and two high waters per day with one set of high and low more extreme than the others. This is called a mixed semidiurnal tide (mixed because the two tide cycles are uneven and semidiurnal because there are two sets per day). The two high and low water levels occur over approximately 24 hours with each high and low approximately six hours apart. Tide cycles actually occur over a lunar day, which is 24 hours and 50 minutes long. The two low tides in a day occur on average every 12 hours 25 minutes. The time of the first low tide each day occurs on average approximately 50 minutes later than the day before. Local topographic features may cause these times to vary.

Zero tide datum (also expressed as + 0, or “plus 0”) is a measure of the average low tide level. There are two different definitions used worldwide for the zero tide datum: mean lower low water and mean low water. Mean lower low water is *the mean of the lowest tides* for that area. Mean low water is

the mean of all of the low tides for that area. The zero tide datum will be found in the legend of the tide table. Students will need to check off on the data sheet which definition of zero tide datum is used on their tide table.

Measurement Procedure

Using the Hydrometer

The hydrometer is an instrument that allows us to measure the specific gravity of a fluid. Remember that specific gravity is a comparison of the density of the fluid you are measuring to the density of pure water at 4° C.

A hydrometer is a small float with a scale on its stem. If you put the hydrometer in pure water at the same temperature, it will float at the same depth. As salts are added to the water, it begins to float higher. As the water gets denser, more of the hydrometer is exposed. Marks along the hydrometer allow you to read the specific gravity directly from the hydrometer without having to calculate the mass of the water displaced.

With most substances, “cooler is denser”. Water changes densities as it cools and warms. Remember that specific gravity is measured according to water at 4° C. Your hydrometer may take specific gravity readings at a different temperature. Look on your instrument to find the temperature for which it is calibrated. If the temperature of your water is different from the temperature for which

Table HY-SA-1: Tide Table for Aberdeen, Washington

Tide Predictions (High and Low Waters) August, 2002									
Source: NOAA, National Ocean Service									
Daylight Saving Time									
Day	Time	Ht.	Time	Ht.	Time	Ht.	Time	Ht.	
1	Th	131am	L 0.6	730am	H 2.0	106pm	L 0.8	740pm	H 2.6
2	F	233am	L 0.5	841am	H 1.9	206pm	L 1.0	832pm	H 2.7
3	Sa	335am	L 0.3	956am	H 1.9	313pm	L 1.1	928pm	H 2.7
4	Su	432am	L 0.1	1105am	H 2.0	417pm	L 1.1	1024pm	H 2.8
5	M	526am	L -0.2	1204pm	H 2.2	516pm	L 1.0	1118pm	H 2.9
6	Tu	616am	L -0.4	1256pm	H 2.3	611pm	L 0.9		
7	W	1209am	H 3.0	703am	L -0.6	143pm	H 2.5	702pm	L 0.8
8	Th	1258am	H 3.2	747am	L -0.7	228pm	H 2.6	751pm	L 0.6
9	F	147am	H 3.2	831am	L -0.8	309pm	H 2.7	839pm	L 0.5
10	Sa	237am	H 3.2	913am	L -0.7	349pm	H 2.8	927pm	L 0.3
11	Su	327am	H 3.2	955am	L -0.6	428pm	H 2.9	1017pm	L 0.2
12	M	419am	H 3.0	1037am	L -0.4	508pm	H 3.0	1109pm	L 0.1
13	Tu	514am	H 2.8	1121am	L -0.1	549pm	H 3.0		
14	W	1206am	L 0.1	614am	H 2.5	1209pm	L 0.2	634pm	H 3.0
15	Th	108am	L 0.1	721am	H 2.3	104pm	L 0.5	725pm	H 3.0
16	F	215am	L 0.0	837am	H 2.1	206pm	L 0.8	824pm	H 2.9
17	Sa	323am	L 0.0	956am	H 2.1	313pm	L 0.9	928pm	H 2.9
18	Su	428am	L -0.1	1110am	H 2.2	419pm	L 1.0	1032pm	H 2.9
19	M	527am	L -0.2	1211pm	H 2.3	521pm	L 0.9	1130pm	H 2.9
20	Tu	618am	L -0.3	101pm	H 2.5	616pm	L 0.8		
21	W	1221am	H 2.9	703am	L -0.3	142pm	H 2.6	705pm	L 0.7
22	Th	106am	H 2.9	744am	L -0.3	220pm	H 2.7	750pm	L 0.6
23	F	148am	H 2.9	821am	L -0.3	254pm	H 2.7	831pm	L 0.5
24	Sa	228am	H 2.8	856am	L -0.2	326pm	H 2.7	910pm	L 0.5
25	Su	307am	H 2.8	928am	L 0.0	355pm	H 2.7	949pm	L 0.4
26	M	346am	H 2.7	1000am	L 0.2	423pm	H 2.7	1027pm	L 0.4
27	Tu	426am	H 2.5	1029am	L 0.3	450pm	H 2.7	1107pm	L 0.4
28	W	510am	H 2.3	1058am	L 0.5	519pm	H 2.7	1152pm	L 0.4
29	Th	600am	H 2.2	1129am	L 0.8	551pm	H 2.7		
30	F	1244am	L 0.4	659am	H 2.0	1208pm	L 1.0	633pm	H 2.6
31	Sa	146am	L 0.4	810am	H 2.0	113pm	L 1.2	730pm	H 2.6

Note: Heights in this table are in meters. Many tide tables in the United States and in Canada are in feet. To convert feet to meters, divide the data by 3.28 ft/m.
All tide tables (including this one) are in local time. You will need to convert to UT.



the hydrometer is calibrated, you have to make an adjustment for temperature using a conversion table.

Reading a Tide Table

You need a tide table calculated for the local area to determine the tides in your area. The tide table will give you the dates, times and water levels for high and low water. These are available from government agencies, private fisheries and tourist agencies. They can also be found on the web, in newspapers, or published as booklets. Because tides vary each year with the lunar cycle, it is necessary to use a tide table calculated for the current year. Tides also vary with each locality, so try to get a tide table for the exact area you are observing, or for the closest area for which tide tables are available. You may need to consult two tide tables - a primary tide table based on a tide station in the general region of your site and an auxiliary tide table with corrections for time and tidal height for your particular site.

To determine the tidal height at a particular time and date, read on the tide table the times of high and low water for the date you sampled that bracket the time you sampled. Determine whether the tide was coming in or going out when you sampled by assuming that the tide turned (changed direction) at the times of low and high tides. For instance if you sampled at 4 PM on August 1, 2002 (Table HY-SA-1), the tide was coming in because it was low at 1:06 PM and high at a later time, 7:40 PM.

To determine the time and date of the lowest tide for a particular month, use your tide table to find the heights of the tides over the entire month. Which number is lowest (including negative numbers)? This is the lowest tide of the month when the water recedes the farthest from the shore.

Which number is the highest? This number is likely to fall just after the lowest tide. Look at the illustration for the tide table for Aberdeen, Washington for August 2002 to determine the times and dates of highest and lowest tides for that month. The most extreme low tide of -0.8 meters occurred on Aug 9th at 08:31 local time. A high tide of 3.2 meters occurred 6 hours 44 minutes earlier at 01:47 local time.



It is important to know for interpreting your data which zero tide datum is used on your tide table.

The negative numbers refer to water levels below the zero tide datum for your area. For example, a tide level of -0.5 is read as “minus one half meter below the zero tide level”.

Supporting Activities

Hydrometers are used to compare the densities of many liquids. For example, the amount of sugar in fruit juice, the amount of fat in milk, and the amount of salt in water. You can create your own practice hydrometer with a weight (e.g. clay or putty) on a stick suspended in water. Take three different clear liquids: freshwater, saltwater, and distilled water. Identify each liquid using a hydrometer. You can calibrate the practice hydrometer by comparing it to a calibrated hydrometer.

Helpful Hints

- The glass hydrometer is easily broken. Always lay it down gently. Do not lay it where it could roll off of a table. Gently place the hydrometer into the 500-mL cylinder – do not drop it in!
- The 35 ppt standard may be kept up to one year in a tightly closed bottle and can be used many times.
- After you receive a new hydrometer, use standards to check its accuracy. If it is not reading correctly, contact the manufacturer.

Questions for Further Investigation

Would brackish water be good to use for irrigation? Why or why not?

Why do all of Earth's oceans have approximately the same salinity (35 ppt)?

How might a rise in ocean level affect estuary and bay areas?

How does salinity at your site compare to salinity at other sites at the same and different latitudes?

How does outflow of freshwater from nearby rivers influence salinity at your site?

Are there seasonal patterns of river water use in your area?

Would you expect to find seasonal changes in salinity levels at your site?

How does salinity vary with average monthly air temperature at your site?

Quality Control Procedure for Salinity Protocol

Lab Guide

Task

Check the accuracy of your hydrometer.

What You Need

- Water Temperature Field Guide*
- Hydrometer
- Salinity Conversion table in *Teacher's Guide*
- 500-mL clear graduated cylinder
- Alcohol-filled thermometer (calibrated)
- Hydrology Investigation Quality Control Procedure Data Sheet*
- Distilled water
- Salt (NaCl)
- Balance

In the Lab

Make the 35 ppt Standard

1. Measure 17.5 g of table salt (NaCl) with the balance.
2. Pour the salt into the 500-mL cylinder.
3. Fill the cylinder to the 500-mL line with distilled water.
4. Gently mix the salt and water until all of the salt is dissolved. This is your 35-ppt standard.

Check your Hydrometer Using Distilled Water

1. Pour 500 mL of distilled water into the 500-mL cylinder.
2. Put the thermometer in the distilled water. Use the *Water Temperature Field Guide* to measure the water temperature. Record on the *Hydrology Investigation Quality Control Procedure Data Sheet*.
3. Place the hydrometer gently into the water. After it stops bobbing, read the specific gravity at the bottom of the meniscus. It should not touch the sides of the cylinder. Read to three places and record on the *Hydrology Investigation Quality Control Procedure Data Sheet*.
4. Look up the specific gravity and temperature on the conversion table. The salinity should be between 0.0 and 1.0 ppt.
5. If the salinity is not between 0.0 and 1.0 ppt, recheck your measurements. If the salinity is still not between 0.0 and 1.0 ppt, your hydrometer is not reading correctly.

Check your Hydrometer Using the Standard

1. Put the standard in a 500-mL cylinder.
2. Put the thermometer in the distilled water. Use the *Water Temperature Field Guide* to measure the water temperature. Record on the *Hydrology Investigation Quality Control Procedure data Sheet*.
3. Gently place the hydrometer into the cylinder. When it stops bobbing, read the specific gravity at the bottom of the meniscus. It should not touch the sides of the cylinder. Read to three places and record on the *Hydrology Investigation Quality Control Procedure Data Sheet*.
4. Look up the specific gravity and water temperature on the conversion table to find the salinity of the water. Record the salinity on the *Hydrology Investigation Quality Control Procedure Data Sheet*.
5. If the salinity standard is off by more than 1 ppt, mix a new standard and repeat the procedure. If it is still off by more than 1 ppt, talk to your teacher about possible problems.
6. Discard the 35-ppt standard or pour it into a clean and dry 1-L bottle, cap, and label. Rinse equipment with distilled water, dry, and store.

Salinity Protocol

Field Guide

Task

Measure the salinity of your water sample.

What You Need

- Tide Table for your area
- Thermometer
- Hydrology Investigation Data Sheet*
- Conversion Table
- Water Temperature Protocol Field Guide*
- Pen or pencil
- Hydrometer
- Latex gloves
- 500-mL clear, graduated cylinder

In the Field

1. Fill out the top portion of your *Hydrology Investigation Data Sheet*.
2. In the Salinity section of the *Hydrology Investigation Data Sheet*, record the times of the high tide and low tide that occur before and after your salinity measurement is taken. Also record the place where the times from your Tide Table occur.
3. Put on gloves.
4. Rinse the 500-mL cylinder with sample water twice.
5. Fill the cylinder with sample water to within 2 or 3 cm of the top.
6. Measure and record the temperature of the water in the cylinder. (See *Hydrology Investigation, Water Temperature Protocol Field Guide*)
7. Gently put the hydrometer into the cylinder.
8. Wait for the hydrometer to stop bobbing. It should not touch the sides of the cylinder.
9. Read the hydrometer at the bottom of the meniscus. Read the specific gravity to three decimal places. Record the specific gravity on the *Hydrology Investigation Data Sheet*.
10. Look up the specific gravity and water temperature on the Conversion Table to find the salinity of the water. Record the salinity on the *Hydrology Investigation Data Sheet* as *Observer 1*.
11. Repeat Steps 3-9 using new samples of water. Record the salinity measurements as *Observers 2 and 3*.
12. Calculate the average of the three measurements.
13. Each of the three measurements should be within 2 ppt of the average. If one or more of the observations is not within 2.0 ppt, do the measurement again and calculate a new average. If the measurements are still not within 2.0 ppt of the new average, talk to your teacher about possible problems.

Table HY-SA-2: Salinity (parts per thousand) as a function of specific gravity and temperature (as of 9/2005)

Observed Reading	Temperature of Water (°C)																
	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.998																	
0.999																	
1																	
1.001	2	1.9	1.9	1.8	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.8	1.9	1.9	2	2.1
1.002	3.3	3.2	3.2	3.1	2.9	2.9	2.9	2.8	2.8	2.9	2.9	2.9	3.1	3.2	3.3	3.4	3.6
1.003	4.6	4.5	4.4	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.4	4.5	4.6	4.7	4.9
1.004	5.8	5.7	5.5	5.5	5.4	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.7	5.8	5.9	6.1	6.2
1.005	7.1	7	6.8	6.7	6.7	6.7	6.6	6.6	6.7	6.7	6.7	6.8	6.8	7	7.1	7.2	7.5
1.006	8.3	8.1	8.1	8	7.9	7.9	7.9	7.9	7.9	8	8	8.1	8.1	8.3	8.4	8.5	8.8
1.007	9.4	9.4	9.3	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.3	9.4	9.4	9.6	9.7	9.8	10.1
1.008	10.7	10.6	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.6	10.6	10.7	10.9	11	11.1	11.3
1.009	11.9	11.8	11.8	11.7	11.7	11.7	11.7	11.7	11.8	11.8	11.9	11.9	12	12.2	12.3	12.4	12.6
1.01	13.2	13.1	13	13	13	13	13	13	13	13.1	13.1	13.2	13.3	13.5	13.6	13.7	13.9
1.011	14.4	14.3	14.3	14.1	14.1	14.1	14.1	14.3	14.3	14.4	14.4	14.5	14.7	14.8	14.9	15	15.2
1.012	15.6	15.6	15.4	15.4	15.4	15.4	15.4	15.4	15.6	15.6	15.7	15.8	16	16.1	16.2	16.3	16.5
1.013	16.9	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.9	17	17.1	17.1	17.3	17.5	17.6	17.8
1.014	18	18	17.9	17.9	17.9	17.9	17.9	18	18	18.2	18.3	18.3	18.4	18.6	18.8	19	19.1
1.015	19.3	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.3	19.3	19.5	19.6	19.7	19.9	20.1	20.3	20.4
1.016	20.5	20.5	20.4	20.4	20.4	20.4	20.5	20.5	20.6	20.6	20.8	20.9	21	21.2	21.4	21.6	21.7
1.017	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.8	21.8	21.9	22.1	22.2	22.3	22.5	22.6	22.9	23
1.018	23	23	23	22.9	22.9	23	23	23	23.1	23.3	23.4	23.5	23.6	23.8	23.9	24.2	24.3
1.019	24.2	24.2	24.2	24.2	24.2	24.2	24.3	24.3	24.4	24.6	24.7	24.8	24.9	25.1	25.2	25.5	25.6
1.02	25.5	25.5	25.5	25.3	25.5	25.5	25.5	25.6	25.6	25.7	25.9	26	26.1	26.4	26.5	26.8	26.9
1.021	26.6	26.6	26.6	26.6	26.6	26.8	26.8	26.9	26.9	27	27.2	27.3	27.4	27.7	27.8	28.1	28.2
1.022	27.9	27.9	27.9	27.9	27.9	27.9	28.1	28.1	28.2	28.3	28.5	28.6	28.7	29	29.1	29.4	29.5
1.023	29.1	29.1	29.1	29.1	29.1	29.2	29.2	29.4	29.5	29.6	29.8	29.9	30	30.2	30.4	30.7	30.8
1.024	30.4	30.4	30.4	30.4	30.4	30.4	30.5	30.7	30.8	30.8	31.1	31.2	31.3	31.5	31.7	31.9	32.1
1.025	31.6	31.6	31.6	31.6	31.7	31.7	31.9	31.9	32	32.1	32.2	32.4	32.6	32.8	33	33.2	33.4
1.026	32.9	32.9	32.9	32.9	32.9	33	33	33.2	33.3	33.4	33.5	33.7	33.9	34.1	34.3	34.5	34.7
1.027	34.1	34.1	34.1	34.2	34.2	34.2	34.3	34.5	34.6	34.7	34.8	35	35.2	35.4	35.6	35.8	36
1.028	35.2	35.4	35.4	35.4	35.4	35.5	35.6	35.8	35.8	36	36.1	36.3	36.4	36.7	36.9	37.1	37.3
1.029	36.5	36.5	36.5	36.7	36.7	36.8	36.8	36.9	37.1	37.2	37.5	37.6	37.7	38	38.1	38.4	38.6
1.03	37.7	37.8	37.8	37.8	38	38	38.1	38.2	38.4	38.5	38.6	38.9	39	39.3	39.4	39.7	39.9
1.031	39	39	39	39.1	39.1	39.3	39.4	39.5	39.7	39.8	39.9	40.2	40.3	40.6	40.7	41	41.2

Table HY-SA-2: Salinity (parts per thousand) as a function of specific gravity and temperature (as of 9/2005)- continued

Observed Reading	Temperature of Water (° C)																
	15	16	17	18	18.5	19	19.5	20	20.5	21	21.5	22	22.5	23	23.5	24	24.5
0.998																	
0.999										1.3	1.4	1.5	1.6	1.8	1.9	2	
1		1.3	1.5	1.6	1.8	1.9	2	2.1	2.3	2.4	2.5	2.7	2.8	2.9	3.1	3.2	3.3
1.001	2.3	2.5	2.8	2.9	3.1	3.2	3.3	3.4	3.6	3.7	3.8	3.8	4	4.1	4.2	4.4	4.5
1.002	3.7	3.8	4.1	4.2	4.4	4.5	4.6	4.7	4.9	5	5.1	5.3	5.4	5.5	5.7	5.9	6.1
1.003	5	5.1	5.4	5.5	5.7	5.8	5.9	6.1	6.2	6.3	6.4	6.6	6.7	6.8	7.1	7.2	7.4
1.004	6.3	6.4	6.7	6.8	7	7.1	7.2	7.4	7.5	7.6	7.7	7.9	8	8.3	8.4	8.5	8.7
1.005	7.6	7.9	8	8.3	8.4	8.4	8.5	8.7	8.8	8.9	9	9.2	9.4	9.6	9.7	9.8	10
1.006	8.9	9.2	9.3	9.6	9.7	9.8	10	10.1	10.2	10.4	10.5	10.6	10.7	10.9	11	11.1	11.4
1.007	10.2	10.5	10.6	10.9	11	11.1	11.3	11.4	11.5	11.7	11.8	11.9	12	12.2	12.3	12.6	12.7
1.008	11.5	11.8	11.9	12.2	12.3	12.4	12.6	12.7	12.8	13	13.1	13.2	13.3	13.5	13.7	13.9	14
1.009	12.8	13.1	13.2	13.5	13.6	13.7	13.9	14	14.1	14.3	14.4	14.5	14.7	14.9	15	15.2	15.3
1.01	14.1	14.4	14.5	14.8	14.9	15	15.2	15.3	15.4	15.6	15.7	15.8	16.1	16.2	16.3	16.5	16.6
1.011	15.4	15.7	15.8	16.1	16.2	16.3	16.5	16.6	16.7	16.9	17	17.3	17.4	17.5	17.6	17.8	18
1.012	16.7	17	17.1	17.4	17.5	17.6	17.8	17.9	18	18.3	18.4	18.6	18.7	18.8	19	19.2	19.3
1.013	18	18.3	18.4	18.7	18.8	19	19.1	19.2	19.3	19.6	19.7	19.9	20	20.1	20.4	20.5	20.6
1.014	19.3	19.6	19.9	20	20.1	20.3	20.4	20.6	20.8	20.9	21	21.2	21.3	21.4	21.7	21.8	21.9
1.015	20.6	20.9	21.2	21.3	21.4	21.7	21.8	21.9	22.1	22.2	22.3	22.5	22.6	22.9	23	23.1	23.3
1.016	21.9	22.2	22.5	22.6	22.7	23	23.1	23.3	23.4	23.5	23.6	23.8	24	24.2	24.3	24.6	24.7
1.017	23.3	23.5	23.8	24	24.2	24.3	24.4	24.6	24.7	24.8	24.9	25.1	25.3	25.5	25.6	25.9	26
1.018	24.6	24.8	25.1	25.3	25.5	25.6	25.7	25.9	26	26.1	26.2	26.5	26.6	26.8	26.9	27.2	27.3
1.019	25.9	26.1	26.4	26.6	26.8	26.9	27	27.2	27.3	27.4	27.7	27.8	27.9	28.1	28.3	28.5	28.6
1.02	27.2	27.4	27.7	27.9	28.1	28.2	28.3	28.5	28.6	28.7	29	29.1	29.2	29.5	29.6	29.8	29.9
1.021	28.5	28.7	29	29.2	29.4	29.5	29.6	29.8	29.9	30.2	30.3	30.4	30.5	30.8	30.9	31.1	31.3
1.022	29.8	30	30.3	30.5	30.7	30.8	30.9	31.1	31.3	31.5	31.6	31.7	32	32.1	32.2	32.5	32.6
1.023	31.1	31.3	31.6	31.9	32	32.1	32.2	32.5	32.6	32.8	32.9	33	33.3	33.4	33.5	33.8	33.9
1.024	32.4	32.6	32.9	33.2	33.3	33.4	33.5	33.8	33.9	34.1	34.2	34.5	34.6	34.7	35	35.1	35.2
1.025	33.7	33.9	34.2	34.5	34.6	34.7	35	35.1	35.2	35.4	35.5	35.8	35.9	36	36.3	36.4	36.5
1.026	35	35.2	35.5	35.8	35.9	36	36.3	36.4	36.5	36.7	36.9	37.1	37.2	37.3	37.6	37.7	38
1.027	36.3	36.6	36.9	37.3	37.4	37.6	37.7	37.9	38.1	38.3	38.5	38.6	38.8	39	39.2	39.4	39.6
1.028	37.6	37.9	38.2	38.5	38.7	38.9	39.1	39.2	39.4	39.6	39.8	40	40.2	40.4	40.6	40.7	40.9
1.029	38.9	39.2	39.5	39.9	40	40.2	40.4	40.6	40.7	40.9	41.1	41.3	41.5	41.7	41.9	42.1	42.3
1.03	40.2	40.5	40.8	41.2	41.3	41.5	41.7	41.8	42	42.2	42.4	42.6	42.8	43	43.2	43.4	43.6
1.031	41.5	41.8	42.1	42.4	42.6	42.8	43	43.2	43.3	43.5	43.7	43.9	44.1	44.3	44.5	44.7	44.9
1.032	42.8	43.1	43.4	43.8	43.9	44.1	44.3	44.5	44.7	44.8	45	45.2	45.4	45.6	45.8	46	46.2
1.033	44.1	44.4	44.7	45.1	45.2	45.4	45.6	45.8	45.9	46.1	46.3	46.5	46.7	46.9	47.1	47.3	47.5
1.034	45.4	45.7	46	46.4	46.5	46.7	46.9	47.1	47.2	47.4	47.6	47.8	48	48.2	48.4	48.6	48.8
1.035	46.7	47	47.3	47.7	47.8	48	48.2	48.4	48.6	48.7	48.9	49.1	49.3	49.5	49.7	49.9	50.1

Table HY-SA-2: Salinity (parts per thousand) as a function of specific gravity and temperature (as of 9/2005)-
continued

Observed Reading	Temperature of Water (° C)																
	25	25.5	26	26.5	27	27.5	28	28.5	29	29.5	30	30.5	31	31.5	32	32.5	33
0.998			1.4	1.5	1.6	1.9	2	2.1	2.4	2.5	2.8	2.9	3.2	3.3	3.6	3.7	
0.999	2.1	2.3	2.5	2.7	2.8	3.1	3.2	3.3	3.6	3.7	3.8	4.1	4.2	4.5	4.7	4.9	5.1
1	3.4	3.7	3.8	4	4.2	4.4	4.5	4.7	4.9	5	5.3	5.4	5.7	5.8	6.1	6.2	6.4
1.001	4.7	4.9	5.1	5.3	5.5	5.7	5.8	6.1	6.2	6.4	6.4	6.7	6.8	7.1	7.2	7.5	7.7
1.002	6.2	6.3	6.4	6.7	6.8	7	7.2	7.4	7.6	7.7	7.9	8.1	8.3	8.5	8.8	8.9	9.2
1.003	7.5	7.6	7.9	8	8.1	8.4	8.5	8.7	8.9	9	9.3	9.4	9.7	9.8	10.1	10.4	10.5
1.004	8.8	9	9.2	9.3	9.6	9.7	9.8	10.1	10.2	10.5	10.6	10.9	11	11.3	11.4	11.7	11.8
1.005	10.2	10.4	10.5	10.6	10.9	11	11.3	11.4	11.5	11.8	11.9	12.2	12.3	12.6	12.8	13	13.2
1.006	11.5	11.7	11.8	12	12.2	12.3	12.6	12.7	13	13.1	13.3	13.5	13.7	13.9	14.1	14.4	14.5
1.007	12.8	13	13.2	13.3	13.5	13.7	13.9	14.1	14.3	14.4	14.7	14.9	15	15.3	15.4	15.7	16
1.008	14.1	14.3	14.5	14.7	14.9	15	15.2	15.4	15.6	15.8	16	16.2	16.5	16.6	16.9	17	17.3
1.009	15.4	15.7	15.8	16	16.2	16.3	16.6	16.7	17	17.1	17.4	17.5	17.8	17.9	18.2	18.4	18.6
1.01	16.9	17	17.1	17.4	17.5	17.8	17.9	18	18.3	18.4	18.7	18.8	19.1	19.3	19.5	19.7	20
1.011	18.2	18.3	18.6	18.7	18.8	19.1	19.2	19.5	19.6	19.9	20	20.3	20.4	20.6	20.9	21	21.3
1.012	19.5	19.6	19.9	20	20.3	20.4	20.6	20.8	20.9	21.2	21.4	21.6	21.8	21.9	22.2	22.5	22.6
1.013	20.8	21	21.2	21.3	21.6	21.7	21.9	22.1	22.3	22.5	22.7	22.9	23.1	23.4	23.5	23.8	24
1.014	22.2	22.3	22.5	22.7	22.9	23.1	23.3	23.5	23.6	23.9	24	24.3	24.4	24.7	24.9	25.1	25.3
1.015	23.5	23.6	23.8	24	24.2	24.4	24.6	24.8	24.9	25.2	25.3	25.6	25.9	26	26.2	26.5	26.6
1.016	24.8	24.9	25.2	25.3	25.6	25.7	26	26.1	26.4	26.5	26.8	26.9	27.2	27.4	27.6	27.8	28.1
1.017	26.1	26.4	26.5	26.6	26.9	27	27.3	27.4	27.7	27.8	28.1	28.3	28.5	28.7	29	29.1	29.4
1.018	27.4	27.7	27.8	28.1	28.2	28.5	28.6	28.9	29	29.2	29.4	29.6	29.8	30	30.3	30.5	30.7
1.019	28.9	29	29.1	29.4	29.5	29.8	29.9	30.2	30.3	30.5	30.8	30.9	31.2	31.3	31.6	31.9	32.1
1.02	30.2	30.3	30.5	30.7	30.9	31.1	31.3	31.5	31.7	31.9	32.1	32.2	32.5	32.8	32.9	33.2	33.4
1.021	31.5	31.6	31.9	32	32.2	32.4	32.6	32.8	33	33.3	33.4	33.7	33.8	34.1	34.3	34.6	34.7
1.022	32.8	33	33.2	33.3	33.5	33.8	33.9	34.2	34.3	34.6	34.7	35	35.2	35.4	35.6	35.9	36.1
1.023	34.1	34.3	34.5	34.7	34.8	35.1	35.2	35.5	35.8	35.9	36.1	36.3	36.5	36.8	36.9	37.2	37.5
1.024	35.5	35.6	35.8	36	36.3	36.4	37.1	37.3	37.6	37.8	38	38.2	38.5	38.7	39	39.2	39.4
1.025	36.8	36.9	37.2	37.3	37.6	37.7	38.5	38.7	38.9	39.1	39.4	39.6	39.8	40.1	40.3	40.6	40.8
1.026	38.1	38.2	38.5	38.6	38.9	39	39.8	40	40.2	40.5	40.7	40.9	41.2	41.4	41.6	41.9	42.1
1.027	39.8	40	40.2	40.5	40.7	40.9	41.1	41.3	41.6	41.8	42	42.2	42.5	42.7	43	43.2	43.5
1.028	41.2	41.4	41.6	41.8	42	42.2	42.4	42.7	42.9	43.1	43.3	43.6	43.8	44	44.3	44.5	44.8
1.029	42.5	42.7	42.9	43.1	43.3	43.5	43.8	44	44.2	44.4	44.7	44.9	45.1	45.4	45.6	45.9	46.1
1.03	43.8	44	44.2	44.4	44.6	44.8	45.1	45.3	45.5	45.8	46	46.2	46.5	46.7	46.9	47.2	47.4
1.031	45.1	45.3	45.5	45.7	45.9	46.2	46.4	46.6	46.9	47.1	47.3	47.6	47.8	48	48.3	48.5	48.8
1.032	46.4	46.6	46.8	47	47.3	47.5	47.7	47.9	48.2	48.4	48.6	48.9	49.1	49.4	49.6	49.9	50.1
1.033	47.7	47.9	48.1	48.4	48.6	48.8	49	49.3	49.5	49.7	50	50.2	50.4	50.7	50.9	51.2	51.4
1.034	49	49.2	49.5	49.7	49.9	50.1	50.3	50.6	50.8	51	51.3	51.5	51.8	52	52.2	52.5	52.8
1.035	50.3	50.6	50.8	51	51.2	51.4	51.6	51.9	52.1	52.4	52.6	52.8	53.1	53.3	53.6	53.8	54.1

Salinity Protocol – Looking at the Data

Are these data reasonable?

Fresh water usually has a salinity level of 0-0.5 ppt. Brackish water usually has salinity levels of 0.5-25 ppt. The average salinity of the ocean is 34.5 ppt and generally ranges from 32 ppt to 37 ppt. Commonly, salinity will vary at a site depending on the addition or removal of fresh water. Estuaries show the greatest variability in salinity.

On average, the ocean is least salty at the poles and the equator, and most salty in subtropical oceans. The association of salinity with latitude has to do with the relative amounts of rainfall and evaporation around the globe. Salinity is lowered where fresh water enters the ocean by rainfall, ice melt, and river outflow. Salinity increases where fresh water leaves the ocean by evaporation and ice formation. Each of these factors is influenced by weather patterns around the globe.

Salinity values decrease toward the equator to 34-35 ppt because of the abundant rainfall and relatively low evaporation rates that occur there. Salinity can be less than 34 ppt in cooler latitudes with heavy rainfall. Coastal waters can have some of the lowest salinity values because of fresh water input from rivers and melting ice. Coastal waters can have some of the highest salinities as well due to ice freezing and evaporation of shallow waters during the summer. Wind can blow salt water onto land where it covers plant leaves and soil.

Salinity can vary over a tidal cycle as well. At low tide during the summer months, evaporation can cause salinity to rise in a tide pool until the ocean returns as the tide comes in and dilutes the tide pool water, returning it to normal salinity. In estuaries, salinity is strongly influenced by the tides. As the tide is rising towards high tide, the ocean flows up the river and raises salinity in an estuary or river mouth. As the tide falls during an outgoing tide, the river is drained of ocean water and salinity goes down. Salinity in estuaries is influenced by depth as well. Salty water is heavier than fresh water and sinks toward the bottom. This keeps the salinity in the sediment in estuaries

relatively high and protects coastal animals that live in the mud from having to adjust to a large change in salinity with each tidal cycle.

We expect salinity to show a seasonal pattern, rising in the summer and lowering in the winter due to increased evaporation in summer months as water temperature rises. To test this, we can look at the data and see if salinity is higher in the summer and lower in the winter. We can also look to see if a change in salinity is correlated with a change in air and water temperature.

A good data set for looking at this prediction is that collected at Tabor Academy located on the Atlantic coast in Marion, Massachusetts, USA. Tabor Academy recorded salinity and water temperature from 1997-2001 at a coastal site called “Schaeffer Sea Wall”. They also measured air temperature at their school location. The graph below of the averages of air temperature, water temperature and salinity shows a seasonal pattern. As air and water temperatures go up in the spring and summer, so does salinity. As air and water temperatures go down in the autumn and winter, so does salinity. In addition, looking at the graph, it appears that air temperature goes up first, followed by water temperature, followed by salinity. This makes sense since salinity probably rises due to increased evaporation caused by an increase in water temperature, which in turn is caused by an increase in air temperature. To further support the hypothesis, all three years show the same pattern.

What do the scientists look for in these data?

What are the long-term trends in salinity in estuaries? There are increasingly more demands on the fresh water that supplies estuaries, so they may be becoming more saline over time.

At ocean sites, we expect changes in salinity to be related to changes in temperature. An increase in temperature can cause an increase in evaporation. This results in an increase in salinity. Near the poles, however, an increase in temperature may cause an increase in the melting of fresh water ice and result in a decrease in salinity.



Latitudinal distribution of salinity may also be related to large-scale weather pattern, as precipitation and evaporation can affect salinity. Salinity tends to be highest around 20-30 N and 15-20 S, and lowest at the poles and near the equator.



Example of a Student Research Project

Forming a Hypothesis

Students studying the salinity in estuaries are looking at the salinity at three sites shown in Figure HY-SA-3. The first two are in Mobile Bay, one at Mary Ann Beach near Robertsdale, Alabama and the second, the “Boat Ramp” site, near the convergence of the Tensaw River with the Mobile Bay. The third site is the Bayou St. John in New Orleans, Louisiana. It is listed as a freshwater site, but the Bayou St. John is an estuary connected to the Gulf of Mexico and the students have been collecting salinity data. The measurements at the first two sites were collected by Robertsdale High School and Cabrini High in New Orleans took measurements at the third site.



Students at Robertsdale High School were curious to see how their measurements compare with the other two sites and formed the following hypothesis.

Hypothesis: Salinity will be highest at Mary Ann Beach and lowest at the nearby Boat Ramp, which should receive the highest amount fresh water. Salinity at Bayou St. John (part of the delta of the Mississippi River) will be in between.

Collecting and Analyzing Data

The students plot time series of salinity for the three sites. Although Robertsdale High School usually used the hydrometer to measure salinity, sometimes they used the salinity titration method as well. The measured values collected with the titration were similar to those collected using the hydrometer (Figure HY-SA-4) so they decided to concentrate on just the hydrometer readings.

They plot the monthly average salinity at the three sites (Figure HY-SA-5).

The average monthly salinity at the boat site is always less than 5 ppt and definitely the lowest

of the three sites. The salinity at Bayou St. John ranged from 5 to 10 ppt. However, the salinity at Mary Ann Beach ranges from 5 to 25 ppt. This is too low to be considered ocean waters. The students are surprised to see how much fluctuation in salinity occurs at the beach, but realize upon further research that it is fairly typical of estuary environments.

Discussion and Conclusions

They decide that their hypothesis is mostly correct. The salinity at the boat site is the lowest and Bayou tends to be lower than at Mary Ann Beach, although there are some overlapping values.

They are not sure whether the fluctuations in salinity are due to tides (lower tides might lead to lower salinity) or temperature, or perhaps both.

They plot the average monthly water temperature and hydrometer salinity (Figure HY-SA-6). There are some similarities in pattern, but the temperature –salinity relationship is not as obvious here as at some other sites (such as in the Tabor Academy example), so they know some other factors such as tide and freshwater influx must be influencing salinity as well.

Communicating Results

The students print out their graphs and write a report discussing their results. They also give an oral report to their class.

Thoughts for Future Research

All three sites are examples of different estuarine conditions that exist in a river mouth habitat. Are other estuaries being studied by GLOBE schools? Can they find data from other estuaries on the web or in books? How does salinity vary at these sites?



Figure HY-SA-2

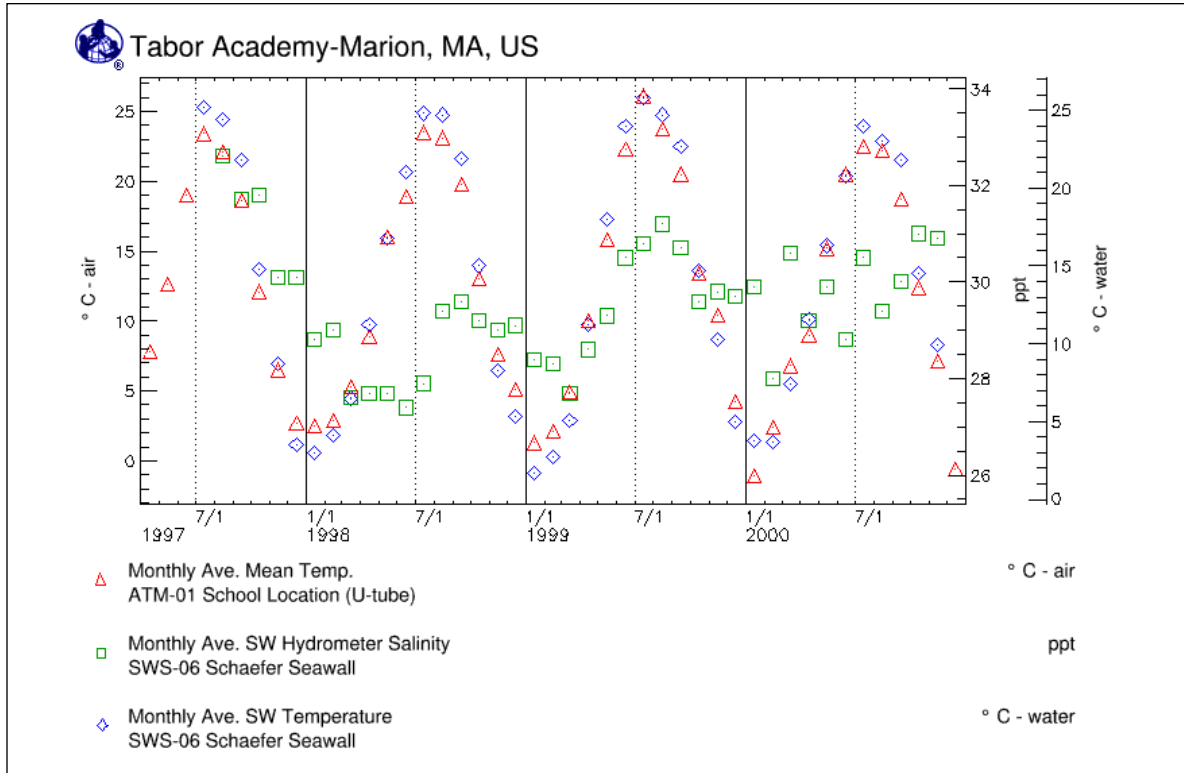


Figure HY-SA-3

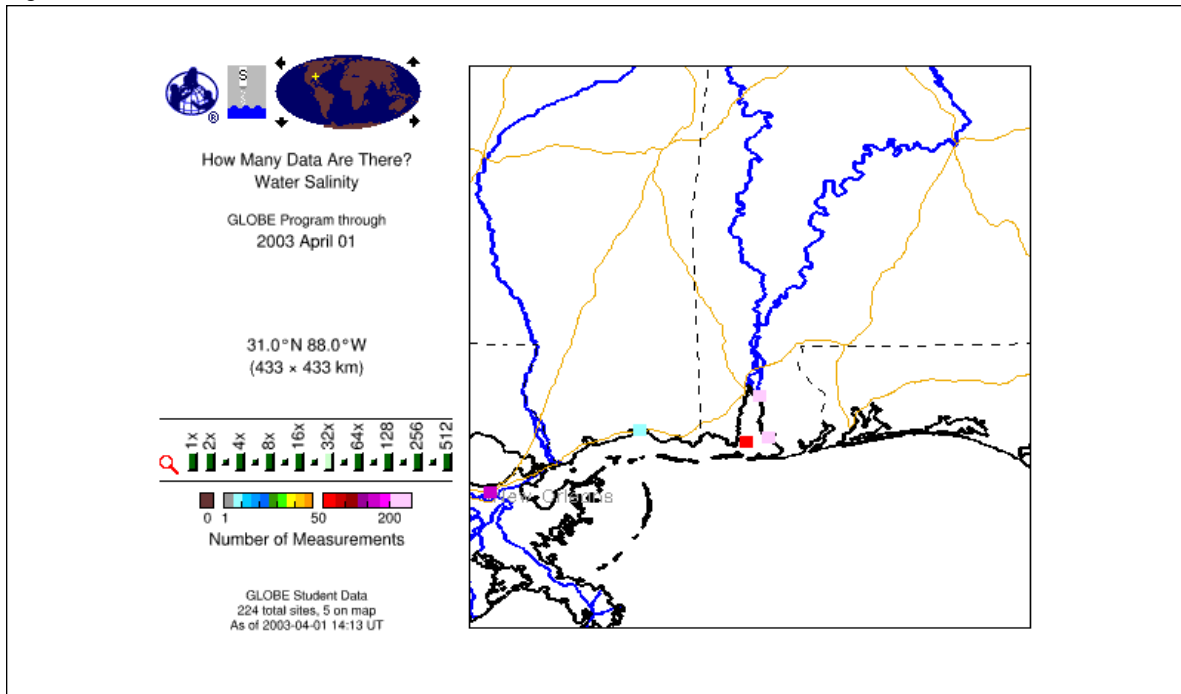


Figure HY-SA-4

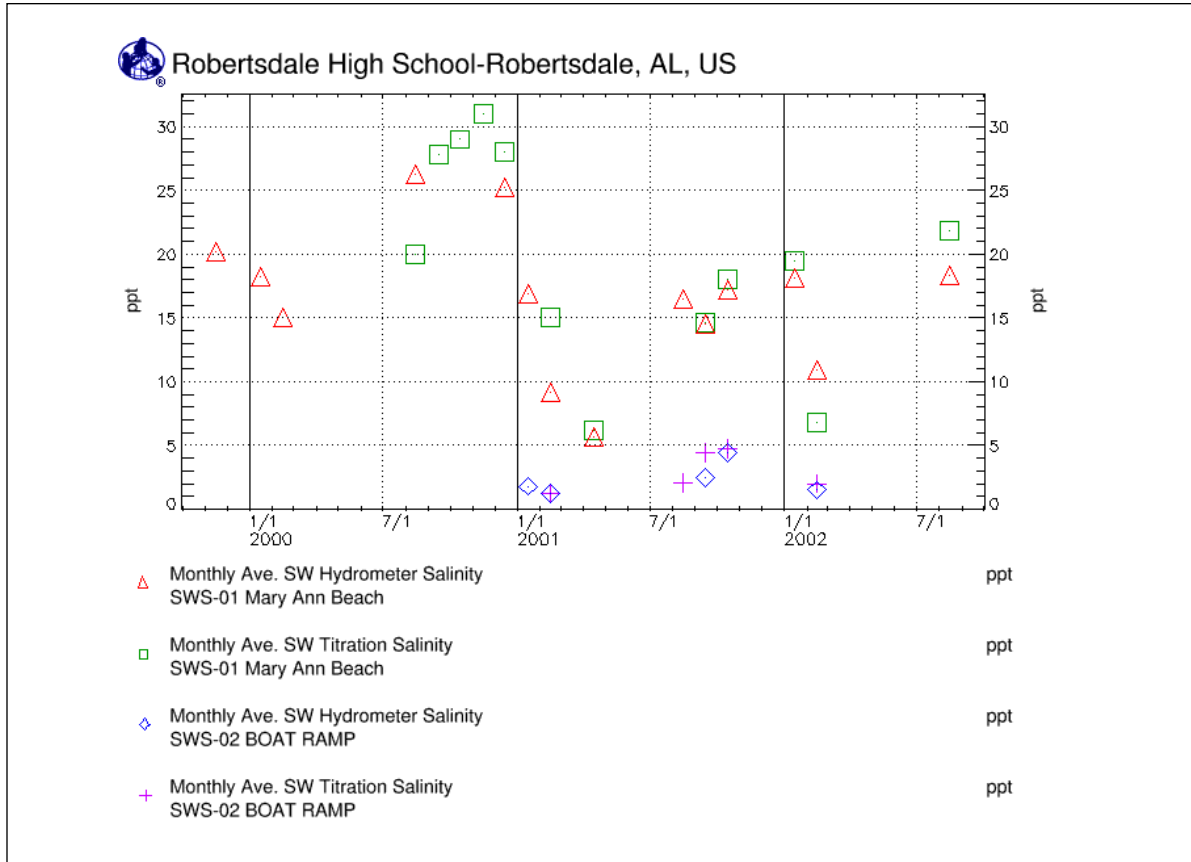


Figure HY-SA-5

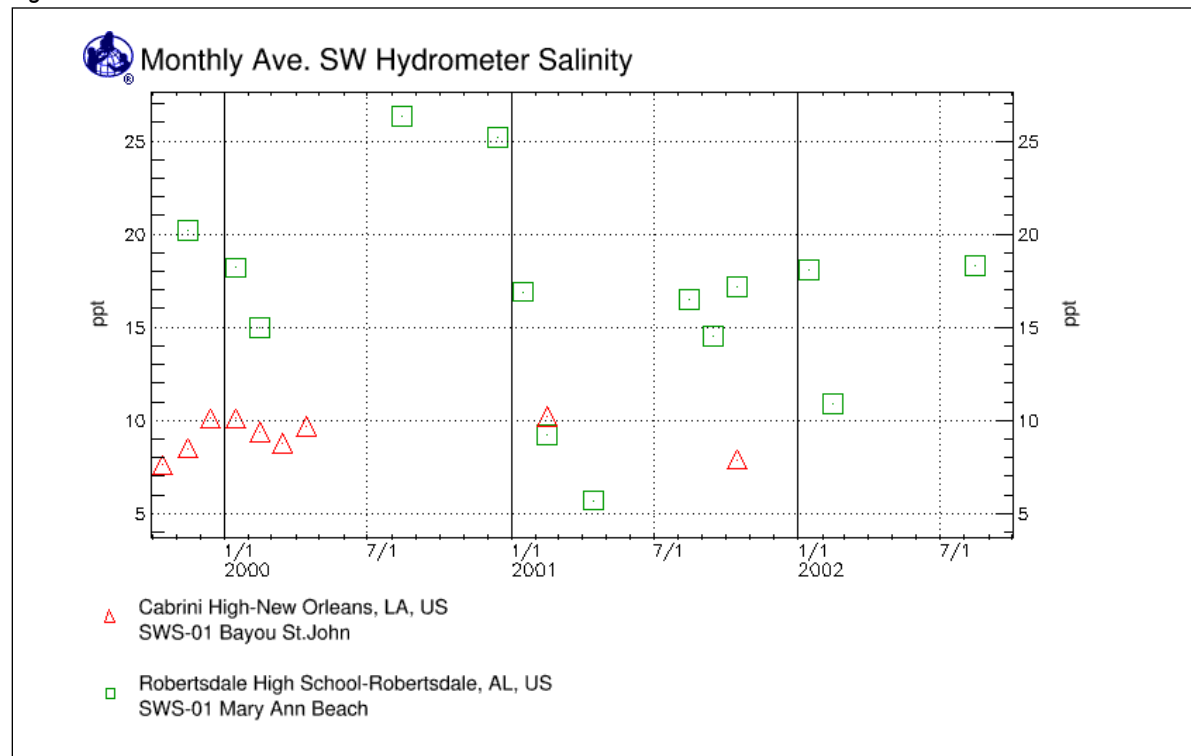


Figure HY-SA-6

