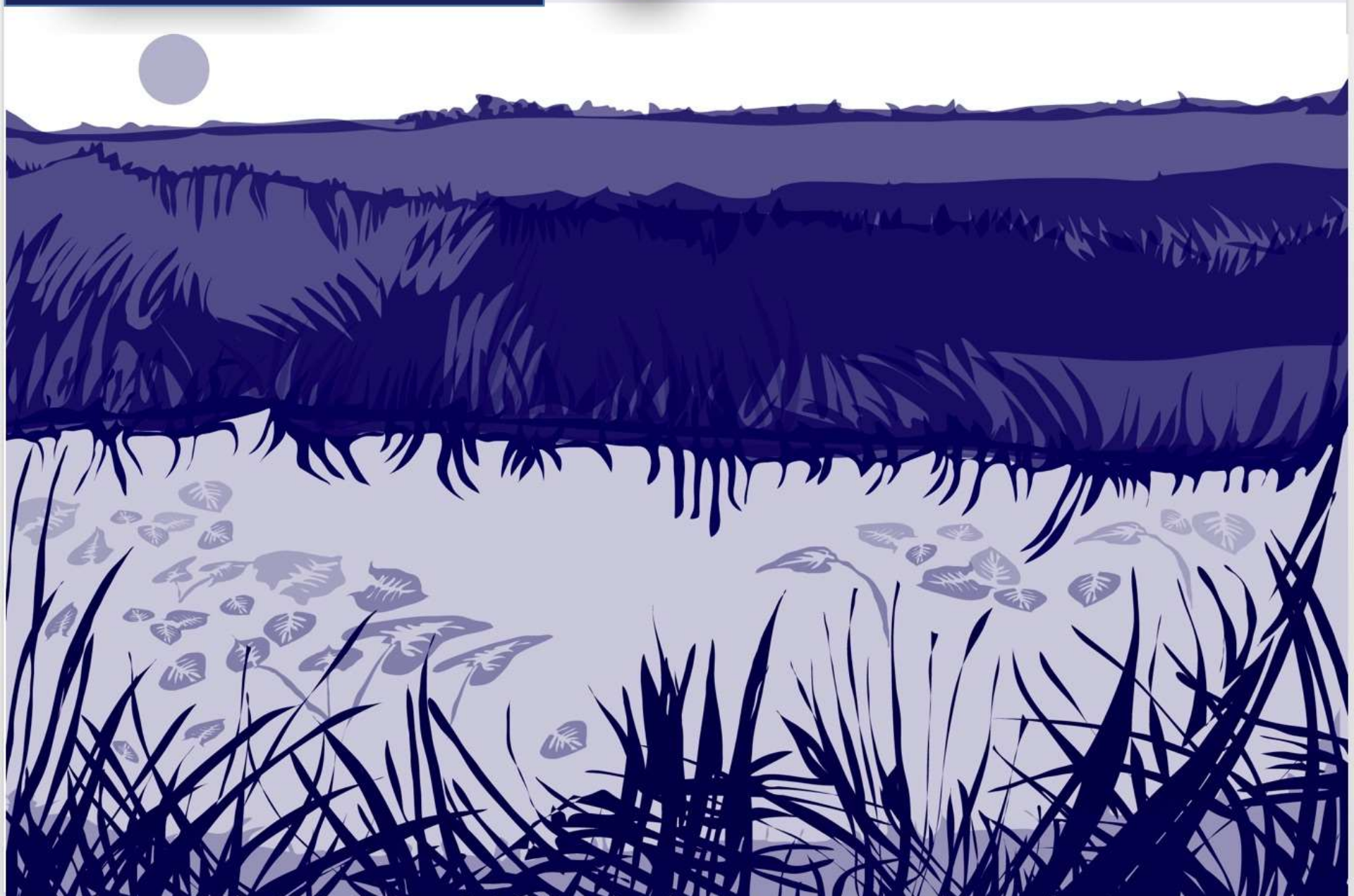
THE GLOBE PROGRAM
A worldwide science and education program

Hydrosphere • Salinity Protocol
Using Titration Method



Overview

- This module:

- Reviews the selection of a GLOBE hydrology site
- Reviews the water sampling technique used in GLOBE hydrology protocols
- Provides a step by step introduction of the protocol method

Learning Objectives

- After completing this module, you will be able to:

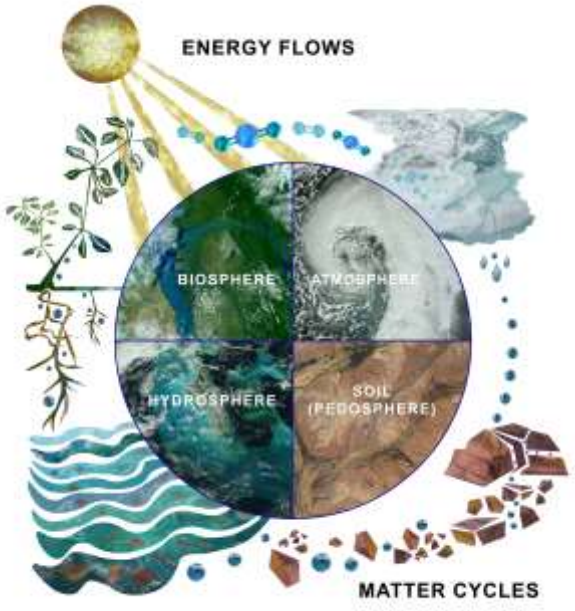
- Define water salinity and explain how environmental variables can result in different measurements
- Describe the importance of quality control steps in the the collection of accurate data
- Conduct water salinity measurements using the titration method
- Upload data to the GLOBE portal
- Visualize data using GLOBE's Visualization System

Estimated time needed to complete this module: 1.5 hours

The Hydrosphere

The hydrosphere is the part of the Earth system that includes water, ice and water vapor. Water participates in many important natural chemical reactions and is a good solvent. Changing any part of the Earth system, such as the amount or type of vegetation in a region or from natural land cover to an impervious one, can affect the rest of the system. Rain and snow capture aerosols from the air. Acidic water slowly dissolves rocks, placing dissolved solids in water. Dissolved or suspended impurities determine water's chemical composition.

Current measurement programs in many areas of the world cover only a few water bodies a few times during the year. GLOBE Hydrosphere protocols will allow you to collect valuable data to help fill these gaps and improve our understanding of Earth's natural waters.



The Earth System: Energy flows and matter cycles.

What is Salinity?

- Salinity is one of the measurements in the GLOBE Hydrosphere investigation
- The salinity measurement is used to find the total dissolved solids 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 or titration methods. The concentration of dissolved solids are measured in parts per thousand or ppt.
- A related measurement is electrical conductivity. This protocol is used for freshwater locations and uses a meter that measures electrical conductivity µS /cm up to 2000 µS /cm. Beyond the 2000 µS /cm, you need to use the salinity protocol. Here is a link to the **Electrical Conductivity** Protocol.

- **Note:** µS /cm is microsiemens/cm and a measure of electrical conductance

What is Salinity?

- 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.

- Salinity is commonly measured in parts per thousand (ppt). The Earth's oceans average 35 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. 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.

- Factors that can influence salinity in a location include tides and fresh water inputs during rain or snowmelt events.

Why Collect Water Salinity Data?

- The salinity of water greatly affects what types of animals and plants can live there. 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. Organisms adapted to one type of salinity environment cannot be moved into another without serious injury or death.

- Scientists are interested in 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.

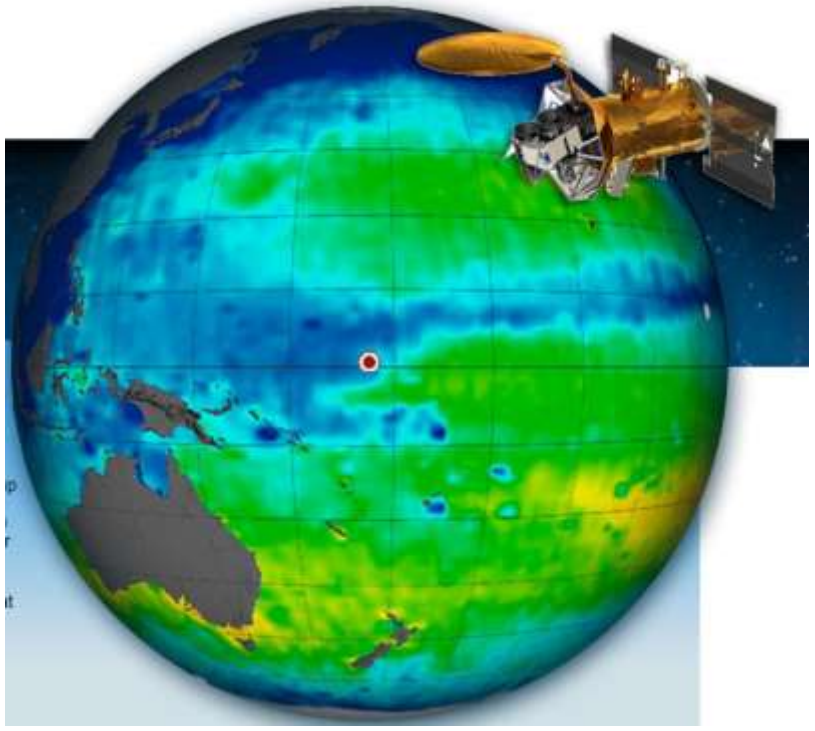
Evaporation, Salt, and Climate Change

Recent studies have shown Earth's water cycle is speeding up in response to climate change, which affects global precipitation patterns. Currently, scientists study the water cycle by making inferences from measurements of how much water is discharged from rivers and by measuring precipitation and evaporation rates using satellites like NASA's Tropical Rainfall Measuring Mission.

About 80 percent of Earth's water cycle takes place over the ocean. By measuring ocean surface salinity, Aquarius tracks how the water cycle is changing in response to climate change

Find out more about the role of the ocean's salinity in ocean circulation and climate change here:

Aquarius Satellite: Sea Surface Salinity from Space



Scientific visualization of ocean salinity as sensed remotely by the Aquarius satellite. Source: NASA.

Example of Salt Lake: Lake Natron, Tanzania

The salinity of a water body increases when evaporation exceeds water input, so salinity can tell use about hydrology as well as changes in climate. Salinity also plays a role in the ecology of a lake. This image of the southern half of Lake Natron shows the characteristic colors of lakes where very high evaporation occurs. As water evaporates during the dry season, salinity levels increase to the point that salt-loving organisms begin to thrive. Salt-loving organisms include some cyanobacteria, tiny bacteria that grow in water and make their own food with photosynthesis as plants do. The red pigment in the cyanobacteria produce the deep reds of the open water of the lake, and orange colors of the shallow parts of the lake. In the inset, numerous, near-white salt-crust "rafts" pepper the shallowest parts of the lake. Bright white clouds are also visible just right of center and on the top margin. The lake is quite shallow, less than three meters deep, and varies in width depending on its water level. In this image, the lake is about ten kilometers wide.

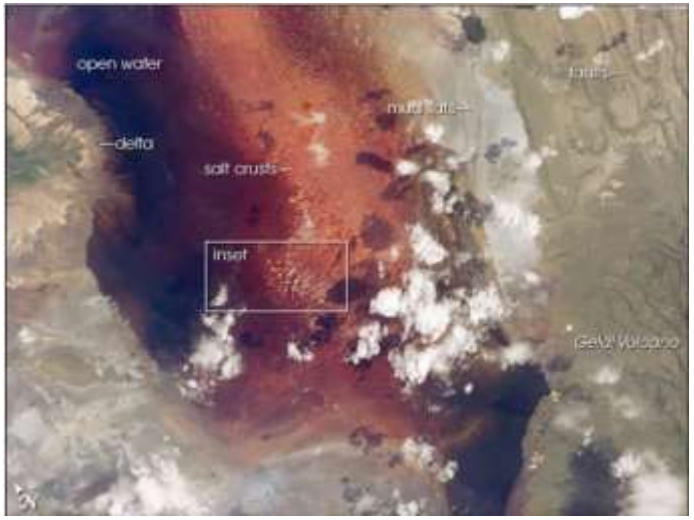


Image and Text: NASA Earth Observatory

Site Selection: Hydrosphere Study Site

Select a specific site where the hydrosphere measurements (water temperature, dissolved oxygen, nitrate, pH, alkalinity, turbidity, and either conductivity or salinity) will be taken. For brackish or saline waters, a pier may be a good location. You will need to know the times of high and low tide at a location as close as possible to your study site.

http://estuaries.noaa.gov/teachers/climate.aspx

Test your knowledge! Question 1

Both the Electrical Conductivity Protocol and the Salinity Protocol are used as a way to understand the amount of total dissolved solids in water. Which protocol would you use for a sample that measures electrical conductance of 1000 µS /cm?

A. Electrical Conductivity Protocol

B. Salinity Protocol

Test your knowledge! Answer to Question 1

Both the Electrical Conductivity Protocol and the Salinity Protocol are used as a way to understand the amount of total dissolved solids in water. Which protocol would you use for a sample that measures electrical conductance of 1000 µS /cm?

A. Electrical Conductivity Protocol- correct! ☺

B. Salinity Protocol

Test your knowledge! Question 2

If your sample measures 35 ppt salinity, your sample is likely

A. Fresh water

B. Brackish water (such as a lagoon)

C. Ocean water

Test your knowledge! Answer to Question 2

If your sample measures 35 ppt salinity, your sample is likely

A. Fresh water

B. Brackish water (such as a lagoon)

C. Ocean water- correct! ☺

- Explanation: Ocean water averages 35 ppt salinity, and freshwater measures 0.5 ppt or less
-

Test your knowledge! Question 3

A warming climate is causing the water cycle to

A. Slow down

B. Speed up

Test your knowledge! Answer to Question 3

A warming climate is causing the water cycle to

A. Slow down

B. Speed up- correct! ☺

Let's now review the Salinity Protocol using the Titration Method

Which Technique To Use? Advantages and Disadvantages

Hydrometer

- *Advantages*
- Easy and quick to use
- No chromium by-products

- *Disadvantages*
- Breakable

Salinity Titration

- *Advantages*
- Less math involved
- Practice in chemistry

- *Disadvantages*
- Chromium by-products
- Takes more time to take measurement

Simultaneous or Prior Investigations Required

The Water Salinity Protocol will allow you to determine the amounts of dissolved solids of a water body. This protocol is conducted at your **GLOBE Study Site**. You will need to define your **GLOBE Study Site** where you will conduct your **Hydrosphere Investigation** prior to beginning this protocol. The **Hydrosphere Investigation Data Sheet** is used to record all the hydrosphere measurements, including salinity. You will also want to map your Hydrosphere Site at some point.

GLOBE Study Site Definition Sheet

Hydrosphere Investigation Data Sheet

Mapping your Hydrosphere Study Site Field Guide

Tides

In order to take salinity measurements, it is helpful to have tide information to help interpret the data.

Most areas have two low and two high waters per day with one set of high and low more extreme than the others. 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.

How to Read Tide Tables

- 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.
- 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.
- 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.
- 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.

Table HYSA-1: Tide Table for Aberdeen, Washington

Tide Predictions (High and Low Waters) August, 2002
Source: NOAA, National Ocean Service
Daylight Saving Time

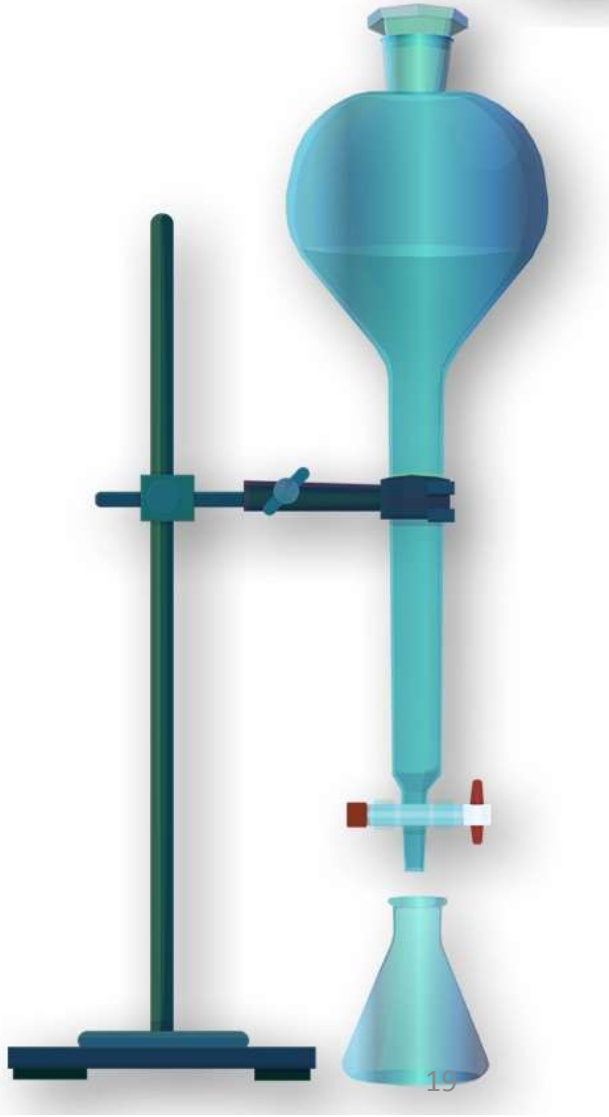
Day	Time	Height	Time	Height	Time	Height	Time	Height
1 Th	131am	L 0.6	730am	H 2.0	106pm	L 0.8	740pm	H 2.6
2 F	233am	L 0.5	841am	H 1.9	206pm	L 1.0	832pm	H 2.7
3 Sa	335am	L 0.3	956am	H 1.9	313pm	L 1.1	928pm	H 2.7
4 Su	432am	L 0.1	1105am	H 2.0	417pm	L 1.1	1024pm	H 2.8
5 M	526am	L -0.2	1204pm	H 2.2	516pm	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	506pm	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.

What is Titration?

- Titration is the slow addition of a solution of known concentration to a known volume of a solution of unknown concentration until the reaction reaches neutralization, usually marked by a color change. Using stoichiometry, you can calculate the concentration of the substance in the solution.

- Here are two set ups for conducting a titration analysis. The instruments on the right you might see in a laboratory setting. When conducting titration using a test kit, you will be titrating using a drip bottle. Be sure to hold your dropper upright when titrating a substance.



Overview of Water Salinity Protocol: Titration Method-1

The salinity titration method measures the amount of chloride in a water sample. Ocean waters contain a mixture of ions that contribute to salinity. Six of these account for over 99% of the ions. These ions are very well mixed and are found in and are in nearly constant proportions. Chloride (Cl-)is the most abundant ion and accounts for 55%.

Because these ions are in nearly constant proportions, we can measure the concentration of chloride ions and then estimate the total salinity.

The chloride concentration, or chlorinity, is expressed in grams of chloride ion per kilogram of seawater. Salinity can be determined from chlorinity by the following

formula:

Salinity (ppt) = Chlorinity (ppt) x 1.80655

Overview of Water Salinity Protocol: Titration Method-2

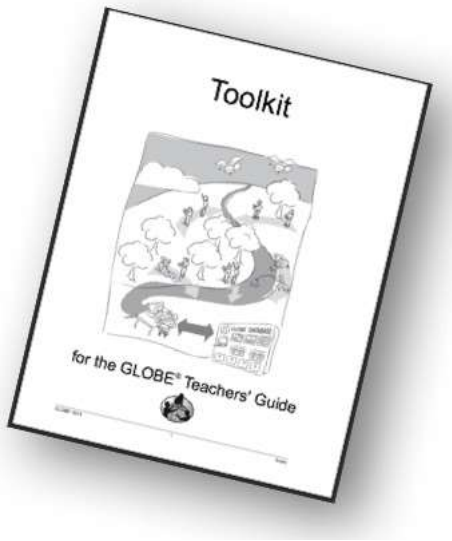
To Measure Chlorinity

1. An indicator, potassium chromate is added to the sample. This produces a yellow color. Different indicators may be used to produce a different color in test kits. Check with manufacturer's instructions.
2. A silver nitrate solution is added as the titrant. The silver reacts with chloride in the sample to form a white precipitate, silver chloride. When all the chloride has been precipitated, the next portion of silver nitrate added forms red-colored silver chromate, producing the pinkish-orange endpoint.
3. Some kits may have a direct-read titrator, and the chlorinity can be determined by reading the titrator. Other test kits require a calculation.
4. Because of the high levels of chloride in most samples, often the sample is diluted with distilled /deionized water to make the titration easier

SAFETY **The chemical wastes produced from this procedure are hazardous and need to be disposed properly. Consult school or other authorities on the procedures you should follow.**

Sources for Equipment You Need for the Water Salinity Protocol

The following resources summarize the measurements associated with each protocol, associated skill level, scientific specifications for the instruments, and how to access the equipment you need (purchase, build, or download).



- Where to find specifications for instruments used in GLOBE investigations
- Where to find scientific instruments used in GLOBE investigations

Equipment Needed for Water Salinity Protocol

- **Assemble Necessary Documents:**
- Hydrosphere Investigation Data Sheet
- Salinity protocol

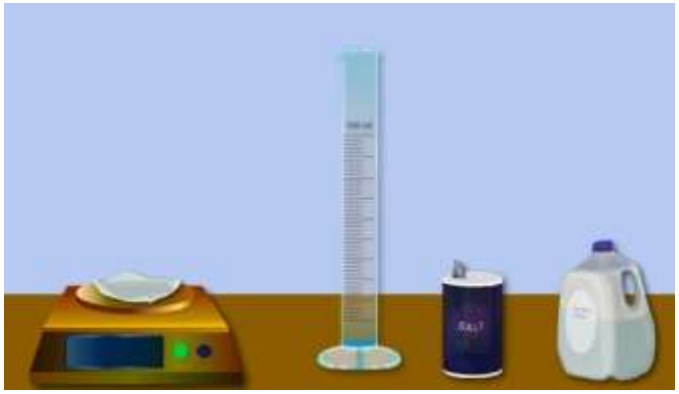
- **Time:** 10 minutes
- **Suggested Frequency**: weekly

Salinity Water Protocol: Quality Control Procedure (1/2)

First, you have to make the standard, which is a 38.6 ppt salt solution:

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 until all of the salt is dissolved. This is your 38.6 ppt standard.

Note: Standard can be kept up to one year in a tightly closed bottle



Be sure to pay close attention to the quality control procedure; without it, the data you collect using the Salinity Protocol will not be meaningful and cannot be compared with the data sets collected by others.

Salinity Water Protocol: Quality Control Procedure (2/2)

After making the standard, check your test kit and technique

1. Follow the directions of your salinity titration test kit using the standard in the place of water
2. Record the value on the **Quality Procedure Data Sheet** following testing
3. If measurement is off by more than **0.4 ppt**, prepare a new standard and repeat

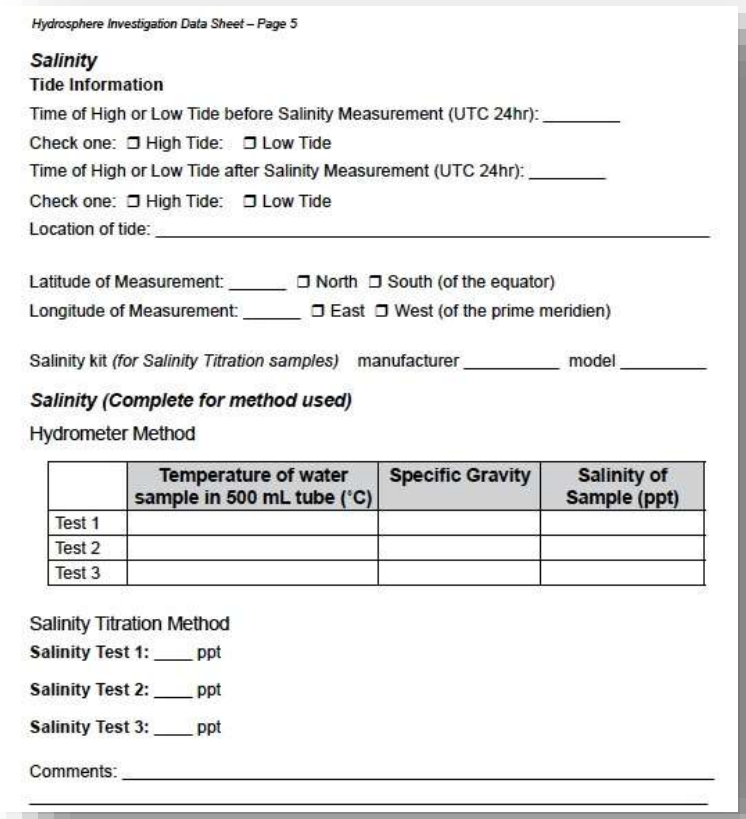
Water Salinity Protocol Titration Method (1/2))

1. Fill in the top part of the Hydrosphere Investigation Sheet.
2. In the Salinity section of the *Hydrosphere 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 protective gloves.
4. Follow kit instructions. To titrate more saline water than 20 parts per thousand (ppt), you may need to refill the titrator with acid. Keep a record of the amount of acid used (20 ppt + amount used in refilled titrator).

Water Salinity Protocol Titration Method (2/2)

Steps

5. Record salinity ppt on data sheet
6. Have two others repeat steps 3-5. Record as tests 2 and 3.
7. Calculate the average of the measurements.
8. Each measurement should be within 1 ppt of the average. If one or more measurement is not, repeat measurement and calculate new average.
9. Put all liquids in waste bottle and dispose of properly



Hydrosphere Investigation Data Sheet – Page 5

Salinity

Tide Information

Time of High or Low Tide before Salinity Measurement (UTC 24hr): _____

Check one: ❒ High Tide: ❒ Low Tide

Time of High or Low Tide after Salinity Measurement (UTC 24hr): _____

Check one: ❒ High Tide: ❒ Low Tide

Location of tide: _____

Latitude of Measurement: _____ ❒ North ❒ South (of the equator)

Longitude of Measurement: _____ ❒ East ❒ West (of the prime meridien)

Salinity kit *(for Salinity Titration samples)* manufacturer _____ model _____

Salinity (Complete for method used)

Hydrometer Method

	Temperature of water sample in 500 mL tube (°C)	Specific Gravity	Salinity of Sample (ppt)
Test 1			
Test 2			
Test 3			

Salinity Titration Method

Salinity Test 1: ____ ppt

Salinity Test 2: ____ ppt

Salinity Test 3: ____ ppt

Comments: _____

SAFETY *Dispose of chemicals properly*

Let's test your knowledge! Question 4

What does the salinity titration actually measure?

A. Chlorinity in ppt: you need to multiply chlorinity value by 1.80655 to obtain salinity

B. NaCl (table salt) in ppm, grams of NaCL per kilogram of seawater

Let's test your knowledge! Answer to Question 4

What does the salinity titration actually measure?

A. Chlorinity in ppt: you need to multiply chlorinity value by 1.80655 to obtain salinity- correct! ☺

B. NaCl (table salt) in ppm, grams of NaCL per kilogram of seawater

Let's test your knowledge! Question 5

Each measurement you take should be within ____ of the average of your three samples

A. 1 ppt

B. .4 ppt

C. 4 ppm

Let's test your knowledge! Answer to Question 5

Each measurement you take should be within ____ of the average of your three samples

A. 1 ppt- correct! ☺

B. .4 ppt

C. 4 ppm

In the quality control procedure, your standard should have an error of no more than .4 ppt

Entering Data on the GLOBE Website

- **Live Data Entry:** Upload your data to the official GLOBE science database

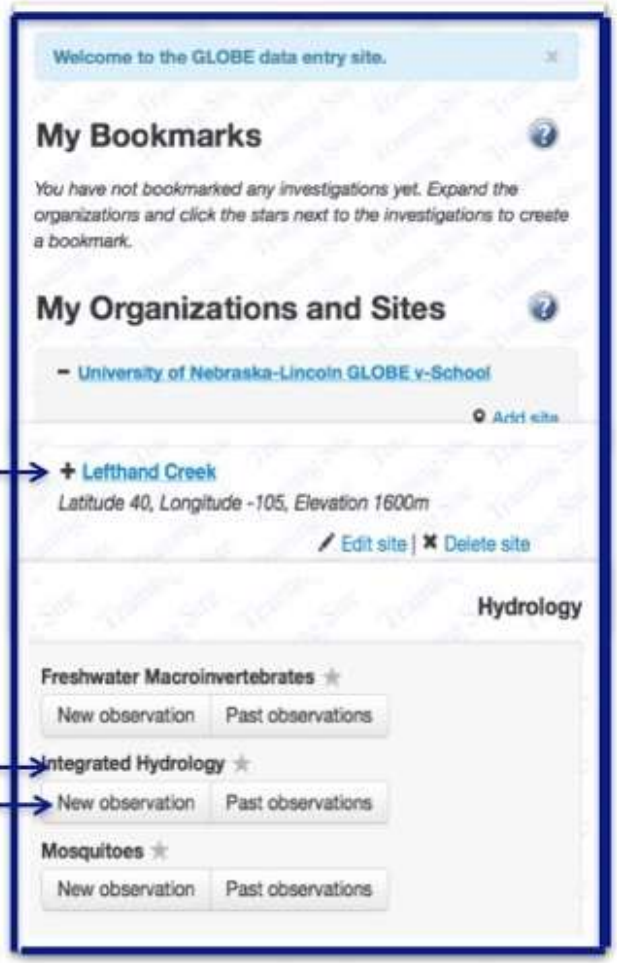
- **Email Data Entry:** Send data in the body of your email (not as an attachment) to **DATA@GLOBE.GOV**

- **Mobile Data App**: Download the GLOBE Science Data Entry app to your mobile device and select the right option.
- **For Android** via **Google Play**
- **For IOS** via the **App Store**

Entering your data via Live Data Entry or Data Entry Mobile App-1

Identify your Sampling site

Select *"Integrated Hydrology"* and *"New observation"*



Entering your data via Live Data Entry or Data Entry Mobile App-2

1. Select water body state

2. Select protocol

3. Be sure to enter all tide information

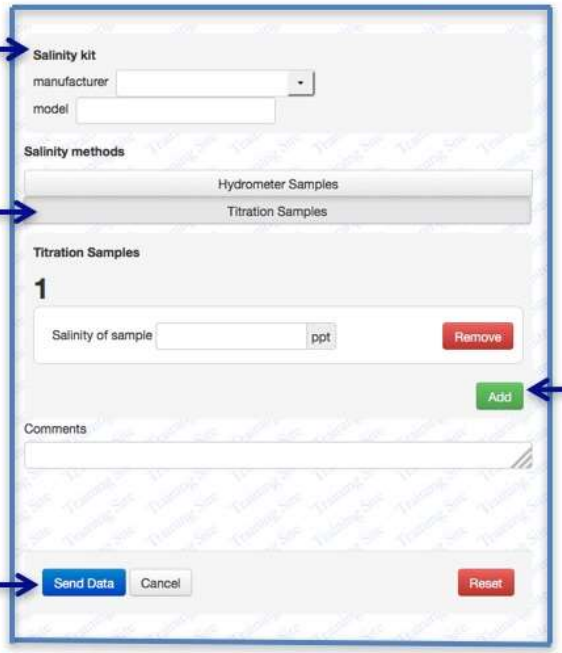
4. Enter locational data

Entering your data via Live Data Entry or Data Entry Mobile App-3

5. Identify kit type

6. Identify method used

⚠ *Be sure to enter data as **Salinity using titration samples***



7. Enter each measurement and click "add"

8. Click to send data

You are done! Want to check who else has submitted salinity data using the GLOBE Visualization System?

Visualize and Retrieve Salinity Data: 1/3

GLOBE provides the ability to view and interact with data measured across the world. Select our visualization tool to map, graph, filter and export nitrate data that have been measured across GLOBE protocols since 1995. Here are screenshots steps you will use when you use the visualization tool:

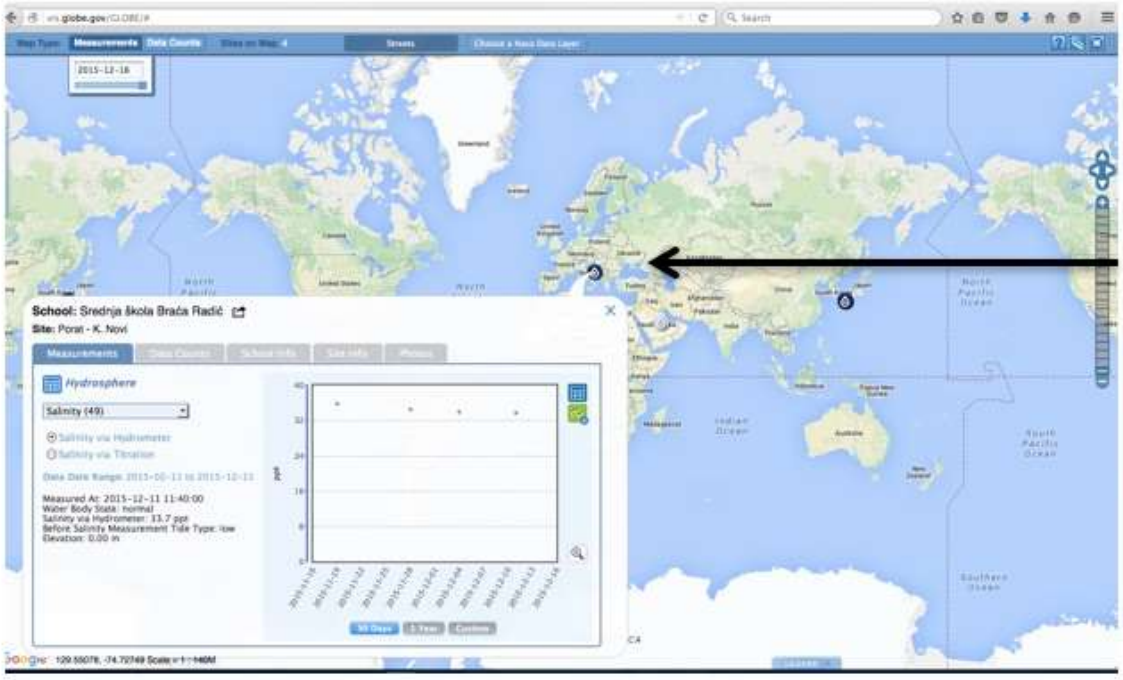
Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data

Visualize and Retrieve Salinity Data: 2/3

Select the date for which you need salinity data, add layer and you can see where data is available.

Visualize and Retrieve Salinity Data: 3/3

Select the sampling site for which you need salinity data, and a box will open with data summary for that site.



Clicking on a location will open to a map note providing salinity data for that location and time. Follow instructions in the tutorial to download data as a .csv file for analysis.

Review questions to help you prepare to conduct the Hydrosphere Salinity Protocol

1. What substance is measured in water when using the salinity protocol?
2. What is the average salinity of the ocean, in ppt?
3. Drinking water and fresh water typically have a salinity value of ____ or less
4. What environmental factors influence water salinity ?
5. What other GLOBE protocol measurement is related to salinity and is measured in µS/cm?
6. What is titration? How do you do a titration?
7. What are the safety precautions you should take when doing any of the hydrology protocols?
8. What is the acceptable range of error of the three replicate samples you take, in ppt?
9. What procedure do you need to complete before starting the Salinity protocol?
10. Fill in the equation: Salinity (ppt)= _____(ppt) x 1.80655

Are you Ready to Take the Quiz?

- You have now completed the slide set. If you are ready to take the quiz, sign on and take the quiz corresponding to **Water Salinity Protocol Using Titration**.
- You can also review the slide stack, post questions on the discussion board, or look at the FAQs on the next page.
- When you pass the quiz, you are ready to **Water Salinity Protocol Using Titration** measurements!

FAQ: Frequently Asked Questions

Why does the standard for the salinity titration methods measures 38.6 ppt while the standard for the hydrometer method measures 35 ppt? The standards are made exactly the same way.

The hydrometer measurement is based the actual density of the ocean water. In the titration measurement, you are only measuring chlorine. In seawater, there in a constant ratio between chlorine and other anions, which is taken into account in the values you get when you measure the salinity of ocean water. These other anions are not present in the standard. To calculate the seawater salinity from 17.5 g NaCl in 500 mL (35 ppt NaCl), you need to take into account the molecular composition of NaCl. The ratio of the molecular weight of Cl to NaCl is 0.61. So, 35 ppt x 0.61 = 21.35 ppt chlorinity of the sample. The kits have been designed to use the constant ratio of chlorine and other anions to convert the chlorinity value to a salinity value. To do this the ppt chlorinity value (here it is 21.35) is multiplied by a conversion constant of 1.80655. 21.35 ppt x 1.80655 = 38.6 ppt.

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?

We want your Feedback!

Please provide us with feedback about this module. This is a community project and we welcome your comments, suggestions and edits! Comment here: eTraining Feedback

Questions about module content? Contact GLOBE eTraining: rlow@ucar.edu

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More Information:

The GLOBE Program, NASA Earth Science

NASA Global Climate Change: Vital Signs of the Planet

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