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Voluntary Estuary Monitoring Manual

Chapter 14: Salinity

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Chapter 14

Salinity

Because of its importance to estuarine ecosystems, salinity (the amount of dissolved salts in water) is commonly measured by volunteer monitoring programs.

Photos (l to r): U.S. Environmental Protection Agency, R. Ohrel, The Ocean Conservancy, P. Bergstrom

Overview

Because of its importance to estuarine ecosystems, salinity (the amount of dissolved salts in water) is commonly measured by volunteer monitoring programs. This chapter discusses the role of salinity in the estuarine environment and provides steps for measuring this water quality variable.

About Salinity

Salinity is simply a measure of the amount of salts dissolved in water. An estuary usually exhibits a gradual change in salinity throughout its length, as fresh water entering the estuary from tributaries mixes with seawater moving in from the ocean (Figure 14-1). Salinity is usually expressed in parts per thousand (ppt) or ‰.

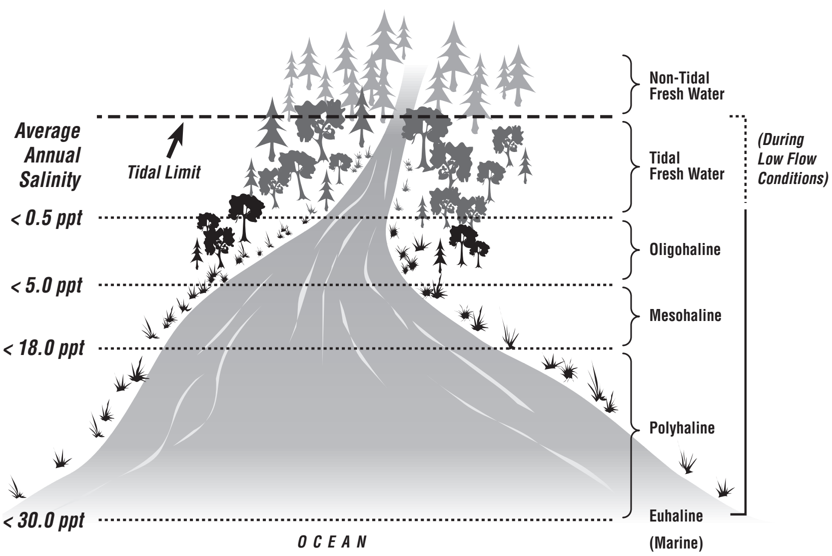


Figure 14-1. Estuarine salinity slowly increases as one moves away from freshwater sources and toward the ocean.

The fresh water from rivers has a salinity of 0.5 ppt or less. Within the estuary, salinity levels are referred to as oligohaline (0.5-5.0 ppt), mesohaline (5.0-18.0 ppt), or polyhaline (18.0-30.0 ppt). Near the connection with the open sea, estuarine waters may be euhaline, where salinity levels are the same as the ocean at more than 30.0 ppt (Mitsch and Gosselink, 1986).

Generally, salinity increases with water depth unless the estuarine water column is well mixed. Salinity, along with water temperature, is the primary factor in determining the stratification of an estuary. When fresh and salt water meet, the two do not readily mix. Warm, fresh water is less dense than cold, salty water and will overlie the wedge of seawater pushing in from the ocean. Storms, tides, and wind, however, can eliminate the layering caused by salinity and temperature differences by thoroughly mixing the two masses of water. The shape of the estuary and the volume of river flow also influence this two-layer circulation. See Chapter 2 for more information.

Role of Salinity in the Estuarine Ecosystem

Salinity levels control, to a large degree, the types of plants and animals that can live in different zones of the estuary. Freshwater species may be restricted to the upper reaches of the estuary, while marine species inhabit the estuarine mouth. Some species tolerate only intermediate levels of salinity while broadly adapted species can acclimate to any salinity ranging from fresh water to seawater.

Salinity measurements may also offer clues about estuarine areas that could become afflicted by salinity-specific diseases. In the Chesapeake and Delaware bays, for example, pathogens infecting oysters are restricted to sections that fall within certain salinity levels. Drastic changes in salinity, such as those due to drought or storms, can also greatly alter the numbers and types of animals and plants in the estuary.

Another role played by saline water in an estuary involves flocculation of particles. Flocculation is the process of particles aggregating into larger clumps. The particles that enter an estuary dissolved in the fresh water of rivers collide with the salt water, and may flocculate or clump together and increase turbidity (Figure 14-2).

Salinity is often an important factor when monitoring many key water quality variables. For example:

- Most dissolved oxygen meters require knowledge of the salinity content in order to calibrate the meter properly.
- If you are interested in converting the dissolved oxygen concentration (usually expressed as mg/l or parts per million) to

percent saturation (amount of oxygen in the water compared to the maximum it could hold at that temperature), you must take salinity into account. As salinity increases, the amount of oxygen that water can hold decreases.

- If you use a meter to measure pH, the techniques are the same whether you are testing salt or fresh water. However, if you measure with an electronic colorimeter, you must use a correction factor (available from the manufacturer) to compensate for the effects of salinity. ■

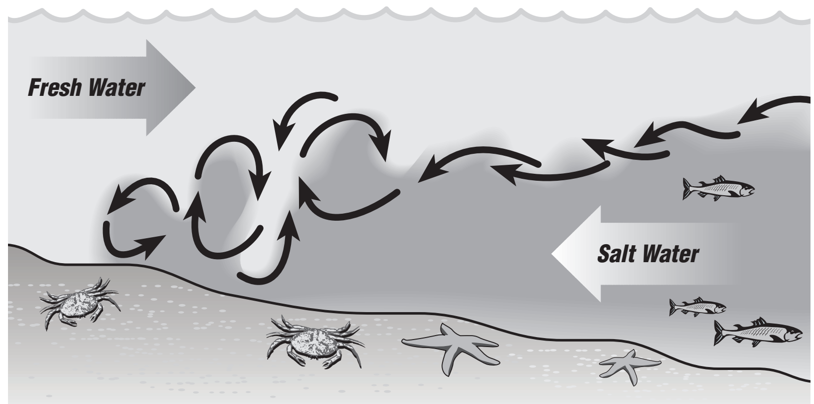


Figure 14-2. Turbidity increases when fresh water meets with salt water.

Sampling Considerations

Salinity will fluctuate with movement of the tides, dilution by precipitation, and mixing of the water by wind. There are also seasonal differences in salinity.

Season and Weather

Environmental conditions vary with the seasons, and salinity levels can reflect those variations. During wet weather periods and during the spring thaw in colder regions, more fresh water enters the estuary, so salinity is lower at these times. On the other hand, dry weather periods mean less fresh water entering the estuary, so higher salinity levels may be found. Another way the seasons influence an estuary's salinity involves the mixing of fresh water and salt water. Seasonal storms help mix estuarine waters and serve to decrease the vertical salinity and temperature gradients in the estuary.

Choosing a Sampling Method

Salinity can be measured either by physical or chemical methods. Physical methods use conductivity, density, or refractivity. The physical methods are quicker and more convenient than the chemical methods. The chemical methods determine chlorinity (the chloride concentration), which is closely related to salinity.

Conductivity

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate **anions** (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum **cations** (ions that carry a positive charge). As the concentration of salts in the water increases, electrical conductivity rises—the greater the salinity, the higher the conductivity. Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and, therefore, have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is extrapolated to a standard temperature (25°C).

Conductivity is measured with a probe and a meter. Conductivity meters require temperature correction and accurate

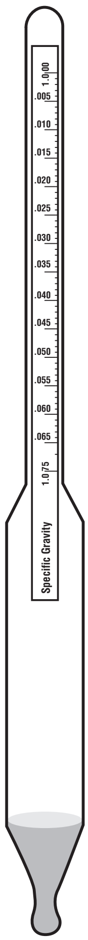


Figure 14-3. Hydrometer. Salt water is denser than fresh water and has a greater specific gravity. Volunteers can calculate salinity by measuring a water sample's specific gravity with a hydrometer.

calibration can be difficult. The cost of these meters ranges from $500 to $1,500. Voltage is applied between two electrodes in a probe immersed in the sample water. The drop in voltage caused by the resistance of the water is used to calculate the conductivity per centimeter. The meter converts the probe measurement to micromhos per centimeter and displays the result for the user.

Some conductivity meters can also be used to test for total dissolved solids and salinity. The total dissolved solids concentration in milligrams per liter (mg/l) can also be calculated by multiplying the conductivity result by a factor between 0.55 and 0.9, which is empirically determined (see APHA, 1998).

Meters should also measure temperature and automatically compensate for temperature in the conductivity reading. Conductivity can be measured in the field or the lab. In most cases, it is probably better if the samples are collected in the field and taken to a lab for testing. In this way, several teams of volunteers can collect samples simultaneously. If it is important to test in the field, meters designed for field use can be obtained for around the same cost mentioned above.

Density

As water becomes saltier, its weight increases although its volume does not measurably rise. Since salt water is denser than fresh water, this change of weight results in a greater specific gravity. The volunteer can calculate salinity by measuring a water sample's specific gravity. This is done with a hydrometer (Figure 14-3).

Hydrometers are a fairly simple and inexpensive means of obtaining salinity. Specific gravity hydrometers cost from $13 to $25 (although professional sets can cost much more), and a hydrometer jar costs about $13 to $15, although you can also use a large, clear jar that is deep enough to float the hydrometer.

Because hydrometers measure specific gravity, the presence of suspended solids can raise hydrometer readings and result in a salinity measurement that is higher than the true value. This has especially been shown in low salinity areas (Bergstrom, 1997; Bergstrom, 2002). Volunteer programs, therefore, should consider their accuracy and precision requirements before electing to use a hydrometer.

Refractivity

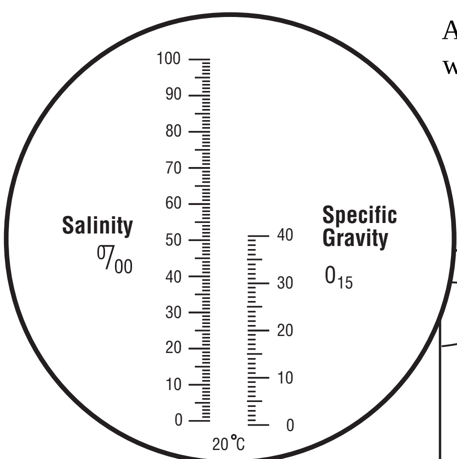
Refractometers (Figure 14-4) are used to measure substances dissolved in water, using the principle of light refraction through liquids. The more dissolved solids in water, the slower light travels through it. Refractometers measure the change in the direction of light as it passes from air into water. Salinity and temperature both affect the index.

Refractometers use a scale to quantify the effect that dissolved solids in water have on light. Using a refractometer is simple. It works with ambient light, and no batteries are required. Such instruments cost from $150 to $350.

Chlorinity

Salinity is related to chlorinity, and this method calculates salinity based on the quantity of chloride ions in the sample. Salinity kits based on testing chloride ions cost about $40 for 50 tests.

The chlorinity method uses titration with



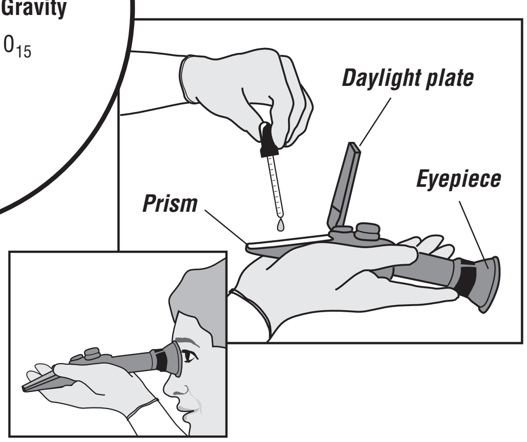


Figure 14-4. Refractometer. Salinity can be determined by a refractometer, which measures the change in direction of light as it passes from air into water. While not inexpensive, it is very simple to use.

either a silver nitrate or mercuric nitrate solution. Some kits require conversion of chlorinity to salinity using a formula, while others incorporate the formula and give results directly as salinity. Whichever chloride analysis process you select, read the literature to determine if a conversion formula is needed.

This method is relatively easy to use although the color change at the endpoint is sometimes difficult to assess. A white paper placed behind the titration bottle makes determination of the endpoint an easier task. ■

REMINDER!

To ensure consistently high quality data, appropriate quality control measures are necessary. See "Quality Control and Assessment" in Chapter 5 for details.

How to Measure Salinity

General procedures for collecting and analyzing salinity samples are presented in this section for guidance only; they do not apply to all sampling methods. **Monitors should consult with the instructions that come with their sampling and analyzing instruments. Those who are interested in submitting data to water quality agencies should also consult with the agencies to determine acceptable equipment, methods, quality control measures, and data quality objectives (see Chapter 5).**

Before proceeding to the monitoring site and collecting samples, volunteers should review the topics addressed in Chapter 7. It is critical to confirm the monitoring site, date, and time; have the necessary monitoring equipment and personal gear; and understand all safety considerations. Once at the monitoring site, volunteers should record general site observations, as discussed in Chapter 7.

STEP 1: Check equipment.

In addition to the standard sampling equipment and apparel listed in Chapter 7, the volunteer should bring the following items to the site for each sampling session:

- hydrometer, jar, and hydrometer conversion table; or
- conductivity meter (plus standard to check accuracy of meter); or
- refractometer; or
- field kit to test for chloride.

Using a hydrometer. (photo by P. Bergstrom).

STEP 2: Collect the sample.

If samples will be collected in the field for later measurement, follow these collection and storage steps. See Chapter 7 for information on cleaning and preparing bottles.

- Use 200 ml glass or polyethylene bottles. (NOTE: Some procedures require smaller samples. Check with your lab for their preferred volume of sample water.)
- Label the bottle with site name, date, time, data collector, and analysis to be performed.
- Wearing latex gloves, plunge the bottle into the water. Fill the bottle completely and cap tightly.
- Samples may be stored up to 7 days before analysis (Hach, 1997).

STEP 3: Measure salinity.

The following section describes various methods to analyze a water sample for salinity. If analyzing salinity by using a hydrometer, follow Procedure A. If using a conductivity meter, use Procedure B. If using

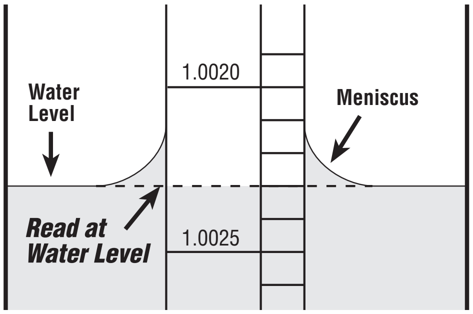


Figure 14-5. Reading the hydrometer. After letting the hydrometer stabilize, read the specific gravity at the point where the water level in the jar meets the hydro-meter scale. Do not record the value where the menis-cus (the upward curvature of the water where it touches the glass) intersects the hydrometer *(redrawn from LaMotte, 1993).*

a refractometer, follow Procedure C. If using a salinity kit based on testing chloride ions, follow the directions that come with the kit.

Procedure A—Measuring salinity with a hydrometer

- Put the water sample in a hydrometer jar or a large, clear jar.
- Gently lower the hydrometer into the jar along with a thermometer. Make sure the hydrometer and thermometer are not touching and that the top of the hydrometer stem (which is not in the water) is free of water drops.
- Let the hydrometer stabilize and then record the specific gravity and temperature. Read the specific gravity (to the fourth decimal place) at the point where the water level in the jar meets the hydrometer scale. Do not record the value where the meniscus (the upward curvature of the water where it touches the glass) intersects the hydrometer (see Figure 14-5).
- Record the specific gravity and the temperature on your data sheet.
- Use a hydrometer conversion table that comes with your hydrometer to determine the salinity of the sample at the recorded temperature. Record the salinity of the sample on your data sheet.

Procedure B—Measuring salinity with a conductivity meter (in field or lab)

- Prepare the conductivity meter for use according to the manufacturer's directions.
- Use a conductivity standard solution (usually potassium chloride or sodium chloride) to calibrate the meter for the range that you will be measuring. The manufacturer's directions should describe the preparation procedures for the standard solution.
- Rinse the probe with distilled or deionized water.
- Select the appropriate range on the meter, beginning with the highest range and working down. Place the probe into the sample water, and read the conductivity of the water sample on the meter's scale. If the reading is in the lower 10 percent of the range that you selected, switch to the next lower range. If the reading is above 10 percent on the scale, then record this number on your data sheet.
- If the conductivity of the sample exceeds the range of the instrument, you may dilute the sample with distilled water. Be sure to perform the dilution according to the manufacturer's directions because the dilution might not have a simple linear relationship to the conductivity.
- Rinse the probe with distilled or deionized water and repeat the fourth step above with the next water sample until finished.

Procedure C—Measuring salinity with a refractometer

- Lift the lid that protects the refractometer's specially angled lens.
- Place a few drops of your sample liquid on the angled lens, and close the lid.
- Peer through the eyepiece. Results appear along a scale within the eyepiece.
- Record the measurement on your data sheet.
- Rinse the lens with a few drops of distilled water, and pat dry, being very careful to not scratch the lens' surface.

STEP 4: *Clean up and send off data.*

Volunteers should thoroughly clean all equipment and transport the samples to the designated lab, if necessary.

Make sure that the data sheet is complete, legible, and accurate, and that it accounts for all samples. Volunteers should make a copy of the completed data sheet before sending it to the designated person or agency in case the original data sheet becomes lost. ■

References and Further Reading

Portions of this chapter were excerpted and adapted from:

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