DATA Series

Conductivity: Exploring Salts with Buoys

Lesson Time : 75 minutes
Grade Level : 9-12
Vocabulary: constituents, electrolytes, biotic, abiotic, oligotrophic, eutrophic, non-point source pollution, point source pollution, cation, anion, ohm

Summary

Using real-time data from buoys around the coastal U.S., students will explore the effects of salts in the water, as well as the effects of other parameters on the conductivity of the water.

Objectives

- Assess the effects of salinity, pressure, and temperature on conductivity.
- Connect salinity to conductivity.
- Describe ocean observing systems and how they work.

Introduction

POW!! Lightning from a passing summer storm strikes the water with a bright flash. Within milliseconds the electricity from the bolt spreads out over the surface of the water in all directions, and its charge is dispersed and weakens almost as quickly as it struck. Luckily, minutes earlier, the lifeguard blew her whistle and evacuated the water of all the swimmers.

Water, regardless of whether it is fresh or saline, serves as one of the best electrical conductors on the planet. Conductivity is the measure of how well a material transports an electric charge. The components of water, known as constituents, and their amount, will determine how good a conductor water will be. Electrolytes, such as calcium, sulfates, and bicarbonates will all change the speed at which electricity can move through the water. Salt water, which contains high concentrations of sodium (Na^+) and chloride (Cl^-), has a substantially greater ability to conduct electricity than freshwater, and thus, a much higher conductivity. Conductivity is also correlated with water temperature. As the water temperature increases by 1ºC, conductivity increases by approximately 1.9%.

Conductivity is an important abiotic parameter, in addition to water temperature, turbidity or clarity, and current speed and direction, to measure in both fresh and saltwater environments. In freshwater systems, low conductivity values are characteristic of high-quality, oligotrophic (low nutrients) waters, whereas elevated values are characteristic of eutrophic (high nutrients) waters. These high values are often indicative of non-point source pollution, including fertilizer run-off, industrial discharges, road salt, and faulty septic systems. In saltwater systems, we can expect to see higher conductivity due to the increased amounts of the charged ions: sodium (a cation, meaning a positively charged ion) and chloride (an anion, a negatively charged ion). In this type of environment, conductivity is one way to determine the salinity of the water, or the amount of salt it contains. Salt content is a very important determinant of the flora and fauna that live in a habitat, as these organisms must be physiologically adapted to handle the salty environment.

Measured in the SI units of siemens per meter (S/m), conductivity is also often reported in microsiemens (μS) or millisiemens (mS) per centimeter (μS OR mS/cm). The SI unit, the siemen (S), is the inverse of the ohm, or the measure of electrical resistance. Because the siemen is the inverse of the ohm, it is also often reported in mhos, or ohms backwards (1 μmho = 1 μS = 1/ohm). At standard temperature of 25ºC, distilled water has conductivity from 0.5 to 2 μmhos/cm, drinking water is generally between 50 to 1500 μmhos/cm, and full-strength seawater (35 ppt) has a conductivity of 53,000 μmhos/cm. Comparatively, air has a conductivity of approximately 120 μmhos/cm.

Conductivity is measured via a conductivity meter, typically handheld, which can be purchased or made. Available in various shapes, sizes, and accuracy, the meter's probe typically contains two electrodes. By passing a current between the two electrodes and measuring the time it takes to travel between them, the conductivity is determined. Once this measure is taken, it can be used, along with water temperature and pressure, to determine the water's salinity. To calculate salinity by hand, or Excel (recommended), you can view the algorithm in html code by selecting "Source" from the View menu at the top of the page (see below).

Ocean Observing Systems

With millions of individual sensor systems all over the planet, efforts are currently underway to unite them and form one integrated ocean observing system (IOOS) in the United States, and then also a global ocean observing system, GOOS. The goal of these integrated systems is to create a network capable of describing the current state of the oceans, bays, rivers, and streams, including their living resources, forecasting future conditions and hazards, and evaluating and forecasting global warming.

Most parameters that can be measured are observed by buoys worldwide. Common parameters measured include:

- air temperature
- wind speed and direction
- humidity
- atmospheric pressure
- precipitation
- water temperature

- current speed and direction
- salinity via conductivity
- water level
- wave information

Other measured parameters include:

- dissolved oxygen
- chlorophyll
- turbidity
- coliforms
- tides
- nitrates
- fluorescence
- solar radiation

process called upwelling. Conversely, an onshore wind can transport the warm surface water shoreward pushing the cold water below, a process called downwelling.

Data Activity

Using five coastal observing stations around the United States, let's explore conductivity and investigate what affects it.

First, locate the approximate location of the five observing stations on a map of the United States or on a globe:

1. Hudson River, NY
2. Bodega Marine Laboratory, Bodega Bay, CA
3. Columbia River, OR (2 stations)
4. Virginia Institute of Marine Science, York River at Gloucester Point, Virginia

Next, click on each of the following observing sites and, using the table below, record the data for the first 4 columns — data and time of latest observation, conductivity, and water temperature (see appendix for printable worksheet). For some stations, this information may be tricky to find (small print), but it is available! ***BE SURE ALL UNITS MATCH!**

1. Hudson River at Poughkeepsie, NY
2. Bodega Marine Laboratory, Bodega Bay, CA
3. Columbia River (CORIE) station: Sand Island
4. Columbia River (CORIE) station: Marsh Island
5. Virginia Institute of Marine Science, York River at Gloucester Point, Virginia

Site	Date of latest observation	Time of latest observation	Conductivity (mS/cm)	Water Temp (°C)	Salinity (ppt)
Hudson River, NY					
Bodega Bay, CA					
CORIE Sand Island					
CORIE Marsh Island					
York River, VA					

Conversions:
1 S = 1,000 mS (milliSiemens) = 1,000,000 µS (microSiemens)
1 m = 100 cm

Once you have recorded the data, convert your water temperature and conductivity data to salinity using an online calculator. Pressure at all stations is 10 decibars, or 100 kPa. The calculator calls for the pressure to be entered in 10kPa, so you will enter 10. Enter the calculated salinity values in the last column.

- What do you notice about salinity when conductivity is low?
- When is salinity the highest?
- Why is salinity higher in some locations versus others?

Now, using the Salinity Calculator, re-enter the data from the CORIE Jetty A buoy, except this time, lower the Temperature measurement (make the water colder).

- What happens to the salinity?
- From the observed change in salinity, what can you infer the change in temperature does to conductivity?

Now, increase the Pressure measurement until there is a change in salinity.

- How much pressure did you have to add to observe a change in salinity?
- What happens to salinity with increased pressure?
- From the observed change in salinity, what can you infer the change in pressure does to conductivity?

Discussion

1. Graph the data from Table 2. What trends do you see?
2. Record and convert additional observations at each of the sites (recommend six hours between readings). What trends do you see? Graph the data; are the same trends/more trends now apparent? Can you infer what stage of the tide each reading was taken? How do you know?
3. Record other measurements, such as air temperature or wind speed, and explore their effects on water temperature and conductivity.
4. Hypothesize about why fish are not electrocuted when lightning strikes the water.

This lesson was written by staff educators at the Bridge Ocean Education Resource Center in collaboration with Virginia Sea Grant. If reusing, presenting, or adapting this lesson please credit the Bridge Ocean Education Resource Center and include the URL below.

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Conductivity Lesson Worksheet

Site	Date of Latest Observation	Time of Latest Observation	Conductivity (mS/cm)	Water Temp (C)	Salinity (ppt)
Hudson River, NY					
Bodega Bay, CA					
CORIE Sand Island, OR					
CORIE Marsh Island, OR					
York River, VA					