Project Whale Citizen Science

Water Quality Monitoring in the Monterey Bay Lab

Learning modes:

Next Generation Science Standards (NGSS): PS1-5, PS1-6, PS3-1, LS2-6, LS2-7, ESS2-4, ESS2-5, ESS2-6, ESS2-7, ESS3-1, ESS3-4, ESS3-5, ESS3-6, ETS1-1, ETS1-2, ETS1-4

Crosscutting Concepts: Patterns, Cause and Effect, Scale/Proportion/Quantity, Systems and System Models, Energy and Matter, Stability and Change

**Background: Temperature, salinity and pH have complicated interactions that create and regulate the thermohaline circulation in the oceans which are being altered by ocean warming and acidification**

The three most important factors affecting the homeostasis of the oceans are temperature, salt, and pH which comes in the form of dissolved CO2. At the forefront of scientific research is our understanding of the ocean warming and its less talked about cousin, ocean acidification. It is impossible to discuss these phenomena without first learning about two important cycles: hydrologic and carbon.

Hydrologic Cycle: One point of the hydrologic cycle is precipitation. This occurs when water that is held in the atmosphere condenses and falls to the earth. Clouds are essentially condensed water vapor which drifts via wind over the planet depositing its water. Once the water is deposited on the ground in the form of rain, snow, etc., gravity exerts its force and the water is pulled towards the lowest level called runoff until it eventually reaches the oceans or is absorbed into the ground. As the water runs over the continents, it erodes minerals like salt from soil and carries it to the ocean. When water from the oceans evaporates, it leaves the salt behind which is why oceans seem salty and rivers and lakes do not.

“Salinity is usually 35 ppt (parts per thousand), but can range from 28-41 ppt and is highest in the northern Red Sea.”[[1]](#footnote-1) “The salt in seawater is largely made up of sodium (Na+) and chloride (CL-)—called sodium chloride which is the same chemical in table salt... Most marine life depends on this consistency as their bodies cannot adapt to significant changes in the salinity of their environment. Few marine species are able to live in both fresh and salt water, and those that do have special mechanisms to cope with fluctuations in salinity.”[[2]](#footnote-2)

It is the complicated relationship between the ocean water & salt and temperature that creates thermohaline circulation in the oceans. Thermohaline circulation makes up 90% of the waters in the ocean. These waters move around the ocean basins by gravity and density driven forces, of which temperature and salinity are the most important. “The difference in density of cold water versus density of warmer water is responsible for ocean currents and upwelling.”[[3]](#footnote-3) “Temperature and density share an inverse relationship. As temperature increases, the space between water molecules increases—also known as density.”[[4]](#footnote-4) “One principle of physics is that material that is less dense will rise, while material that is more dense will sink… Water that is more dense will sink to the ocean floor. As this happens, less dense water has to move out of the way. The less dense water rises. This process creates a circular pattern known as a convection current.”[[5]](#footnote-5)

Salts and other molecules also play a role in currents by affecting the density of water. Water molecules expand when they become warmer and salt and other molecules (e.g., calcium) fit into the expanded area. Since warmer water thus can hold more salt and other molecules than cold water; it can have a higher salinity. To relate this to ocean currents, the higher the salinity of ocean water, the denser it becomes. When the salinity is high enough, the water will sink, starting a convection current. This means that cold water can sit on top of warm water if the warm water has a high enough salinity, and that the natural flow of a current actually can be reversed based on the related density, salinity and temperature of the ocean water.

Carbon Cycle: “Since carbon is the stuff of life, one of the best ways to understand the carbon cycle is just a whole bunch of things living and dying and in the process swapping carbon. Plants use the carbon in the atmosphere in the form of CO2 to make sugars and carbohydrates, to grow as well as reproduce. Lots of those plants end up eaten by other organisms supplying them with the building blocks for other biological molecules and fuel. After being metabolized, the carbon returns to the environment by way of several different paths; ending up in the air, water or earth itself. From that point, it is released naturally or is extracted by humans, in either case, returning the carbon dioxide to the atmosphere and it the starts all over again.”[[6]](#footnote-6) When humans process or burn carbon containing substances such as coal, natural gas, petroleum, or limestone, CO2 is released as a part of that chemical reaction. Additionally, as global temperatures increase, plants trap carbon in permafrost and when the permafrost melts, the plants decompose and release CO2. “Oceans absorbs or uptakes about 25% of the carbon dioxide humans produce every year. But this is changing sea surface chemistry dramatically: when carbon dioxide is absorbed by the ocean, it dissolves to form carbonic acid. The result, not surprisingly, is that the ocean becomes more acidic, upsetting the delicate pH balance that millions and millions of organisms rely on.”[[7]](#footnote-7) “Since the Industrial Revolution, ocean acidity has increased by 30%.”[[8]](#footnote-8) “Increased seawater acidity reduces available carbonate, the building blocks used by shellfish to grow their shells. Rain washing fertilizer and other nutrients into nearshore waters can also increase ocean acidity.”[[9]](#footnote-9) Without the ability to form shells faster than they are being dissolved, corals, shellfish and other carbon utilizing creatures face increased rates of juvenile mortality and long term survival problems.

Goals:

Students will understand the interrelated factors of temperature, pH and salinity to understand scientific predictions of the effects of ocean warming and acidification

Objectives:

1. Understand the hydrologic and carbon cycles
2. Understand the relationship between water temperature and density.
3. Understand the chemical reaction when carbonic acid comes into contact with marine organisms that form a shell or exoskeleton from calcium carbonate
4. Use student knowledge of the properties of temperature, salinity and pH to predict the results of the water sample data
5. Use scientific equipment to collect data and analyze the data and make predictions upon returning to the classroom for long term ocean impacts

Methods:

“The Van Dorn bottles provide a means of obtaining water samples at selected depths below the surface. It consists of an open ended clear plastic cylinder that can be attached to the hydrographic wire (the steel wire wound on the winch) and lowered to any desired depth. A deckhand operates the winch. The bottles also provide a platform to which thermometers can be attached to record the temperature of the water at the location of each Van Dorn bottle. Each end of the cylinder is fitted with a rubber cover. The Van Dorn bottle is attached to the line with the covers pulled out and twisted back and around to the side. The bottle is lowered to a pre-selected depth and left there until the thermometers attached inside come to thermal equilibrium with the water at that depth.”[[10]](#footnote-10)

Using a La Motte horizontal water sampler, collect water samples at 3 different depths and measure for temperature, salinity and pH.

1. Read and follow directions for the La Motte horizontal water sampler.
2. Using the Milwaukee MW102 temperature and pH meter, press the ‘On’ button.
   1. Immerse the tip of the pH and temperature electrode into the sample and stir gently.
   2. The pH measurement is ready when the hourglass symbol stops blinking.
   3. To display the measured temperature, press and hold the degrees C key. When the key is released, the display will return to the pH reading.
   4. Rince the Instant Ocean Hydrometer with pure water before filling it to make sure it is clean. Immerse the hydrometer in the water sample, allowing it to fill completely. Remove it and set it on a level surface. Tap the side to dislodge any bubbles. Observe the needle as it moves to the proper reading for the specific gravity and salinity.
   5. Record observations.
3. Repeat for 3 different depths.

Conclusion

The factors that affect the oceans are wide and many. However, in its simplified form, scientific generalizations, projections and predictions can be made about the effects of increases to temperature and pH to ocean currents. Changes in salinity levels not only effect the density of the water and the convection currents, but have dire consequences for marine life which have adapted to survive in a narrow range of salinity. As ocean temperatures increase and more fresh water from the polar ice caps melts, our current understanding of the homeostasis of the oceans will change. <https://vimeo.com/8990924>

1. <http://marinebio.org/oceans/temperature/> [↑](#footnote-ref-1)
2. <http://marinebio.org/oceans/ocean-chemistry/> [↑](#footnote-ref-2)
3. <http://marinebio.org/oceans/temperature/> [↑](#footnote-ref-3)
4. <http://marinebio.org/oceans/temperature/> [↑](#footnote-ref-4)
5. <https://sciencing.com/salinity-impact-oceans-currents-5517246.html> [↑](#footnote-ref-5)
6. <https://www.youtube.com/watch?v=aLuSi_6Ol8M> [↑](#footnote-ref-6)
7. <https://www.climaterealityproject.org/blog/global-warming-ocean-acidification> [↑](#footnote-ref-7)
8. <https://vimeo.com/8990924> [↑](#footnote-ref-8)
9. <https://www.climate.gov/news-features/climate-tech/new-tool-helps-oyster-growers-prepare-changing-ocean-chemistry> [↑](#footnote-ref-9)
10. <https://www.gvsu.edu/wri/education/instructors-manual-water-sampling-3.htm> [↑](#footnote-ref-10)