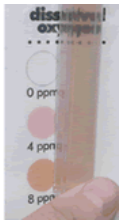
Module I

Grade Level:
Middle School

Teaching Time: 3-4 class periods

Materials:
Student Data Sheets 1 and 2
Water Test Kits (Dissolved oxygen, Salinity)
Data sheet
Probes (from Vernier, Hach, LaMotte)
Lead line
Secchi disk or turbidity tube
Pencils
Clipboards
Measuring tape
Thermometer
Anemometer (wind meter)
Compass
PFDs
Hand sanitizer
Bucket with rope
pH pen

Water test kits for dissolved oxygen, temperature, salinity, nitrates, pH, depth. Your school may already have water test kits but if not, you can purchase them from scientific companies or LaMotte, Hach, Hanna or local hardware stores



III. Water, Water

Summary

Students will measure water quality and its relevance to stream health by understanding water quality parameters. They will use standard water testing equipment to test and record precise measurements of water quality and learn about the indicators of a healthy waterway and the role oysters provide in a healthy Bay ecosystem.

Learning Objectives

Students will be able to:

- List 3 indicators of water quality and explain how information about these are obtained.
- Give an example of how water quality indicators affect living organisms.
- Give an example of how weather events might affect a water quality indicator.

Background Information

Water quality is a measure of how suitable water is for a particular use based on certain physical, chemical, and biological characteristics. Scientists measure water temperatures, turbidity (clearness of the water), and other "indicators" to monitor the health of the Chesapeake Bay. Students will assess the water quality of a local stream or river, and compare their findings to published data of tributaries in the Chesapeake Bay. Ideally, water quality testing will continue throughout the school year, so the students can observe and try to explain trends in the data and begin to think about the consequences of human actions.

These are typical water quality parameters that students may use for testing in their local area, the reasons for performing those tests, and the units of measurement used for documenting the results.

Weather
Weather is a key factor in determining Chesapeake Bay water quality. Conditions like heavy rains or storms can impact water quality in various ways, such as causing a decrease in salinity and water temperature, or an increase in water depth and turbidity. Water quality measurements may differ greatly between a calm, sunny day and a stormy day. For this reason, it is important to document weather conditions when performing water quality tests.

Wind Speed/Direction
Wind speed and direction will be documented during the time of water quality testing. An anemometer (wind meter) will be used to measure wind speed in miles per hour (mph), and compasses will be provided for determining wind direction. Wind is important, because it plays a role in the amount of dissolved oxygen in water. As wind hits the water, it causes a mixing of water and air; air holding oxygen. Stronger winds will lead to more circulation of air into the water resulting in greater levels of dissolved oxygen (DO).

Air Temperature
Air temperature largely has an effect on the temperature of water. During warmer summer months, sunlight and warm air temperatures can increase the temperature of surface waters. In the same way, surface water can become much colder during the winter due to the drop in air temperature. These temperature differences are important because cooler water holds more oxygen than warm water. This difference between warmer and cooler waters, depending on the season or other factors, can create a temperature barrier where warm waters will have low DO and the cooler waters will have high DO. This can be detrimental to organisms that may become trapped in the low DO layer, such as oysters that cannot move.

Water Quality Parameters:

Dissolved oxygen (DO) is a measurement of how much oxygen is in water, which will be measured in units of parts per million (ppm). PPM signifies how many parts of oxygen there are for every one million parts of water. Oxygen enters water either from the mixing of air and

water or photosynthesizing aquatic plants. DO is very important because aquatic animals such as crabs and oysters need oxygen to live just like humans. Oysters and most animals that live on oyster reefs need at least 2-3 ppm DO to survive, and larger fish need around 5 ppm. Dissolved oxygen levels are greatly influenced by several factors, including seasonal changes, excess nutrients, and turbidity. A large problem facing the Bay is the creation of "Dead zones" (areas of very low oxygen in which few organisms can survive) due to excess nutrients entering the water from urban and agricultural runoff. It is important to monitor DO to ensure that enough oxygen is present in the Bay for aquatic animals to survive.

Salinity is the total amount of salt dissolved in water. Students will measure salinity in parts per thousand (ppt). Freshwater salinity levels are 0ppt and oceans are at about 30ppt. In terms of salinity, the Bay has brackish water (a mix of fresh and salt water) between 1-30ppt. The Bay is brackish because fresh water runs into the Bay from its tributaries, and salt water enters the Bay from the Atlantic Ocean. Salinity is important because different organisms have varying tolerances to salinity which determine where they can live within the Bay. If salinity changes too much, or goes too far out of the normal range, it can be very harmful to the organisms living in that area, particularly to things like grasses or oysters that cannot migrate. Oysters are generally happier and produce more spat (young oysters) at higher levels of salinity, and can live in water with levels between 2-30ppt.

Water temperature is an important factor in water quality because it affects the ability of species to live in certain areas. Most species can only survive within a specific range of temperatures. Through development, humans can negatively impact the water temperature of the Bay. Water from industrial plants, roads, and parking lots that may run into the Bay tend to be warmer than rain, and can increase water temperature. Warm water cannot hold as much dissolved oxygen as cool water, so by increasing the temperature of the Bay, we are also decreasing the amount of oxygen available to Bay critters.

The **acidity of water, pH**, is measured on a scale of 0(acidic)-14(basic). pH can have a large impact on Bay organisms, because every plant or animal has a specific pH range in which it can live. If pH changes too drastically, organisms can be harmed or die. Most organisms prefer a pH between 6-8 and can't survive very well in acidic water. The Bay generally has a pH between 7-9, which is neutral to slightly basic.

Turbidity is the measure of how clear a water body is, and how well sunlight can penetrate the water. Water can become turbid (unclear or cloudy) when excessive amounts of sediments and nutrients enter it, usually through runoff. Turbidity not only inhibits plant growth, but degrades the environment for fish, crabs, and other aquatic animal species as well. Additionally, in areas with high turbidity, large amounts of sediment can completely cover and smother oyster reefs, killing the oysters. Turbidity also has an indirect effect on dissolved oxygen. Sunlight is required for plants to photosynthesize and produce oxygen, and if the Chesapeake Bay is cloudy, very limited amounts of sunlight can reach the bottom of the Bay where the plants grow. Fewer plants survive, and thus less oxygen is created. Turbidity in slow moving, deep waters can be measured using a device called a Secchi disk, a black and white, 20-cm diameter disk. The disk is

lowered into the water until it just disappears from sight. The depth at which the disk disappears is called the Secchi depth, and is recorded in meters.

Key Words

Dissolved Oxygen: Amount of oxygen in water; measured in units of parts per million (ppm).
-*Importance:* Aquatic animals need oxygen to survive (oysters at least 2ppm)
-*Notes:* Greatly affected by seasonal/weather changes, excess nutrients, and turbidity.

Impervious: Artificial surfaces (pavements, roads, sidewalks, parking lots) that do not allow water to filter through the soil. Runoff usually occurs faster on these surfaces.

Oyster Reproduction: Oysters reproduce by releasing sperm and eggs into the water. Once sperm fertilizes the egg, the resulting larvae develop shells and these "spat" are ready to attach themselves to a solid substrate, preferably another oyster, a process called setting.

pH: The acidity of water measured on a scale of 0(acidic)-14(basic)
-*Importance:* Every plant or animal has a specific pH range outside of which it cannot survive
-*Notes:* Most organisms prefer a pH between 6 and 8 and can't survive very well in acidic water.

Porous: Surface material that has small holes through which water or air may pass.

Salinity: Total amount of salt dissolved in water; measured in parts per thousand (ppt)
-*Importance:* Organisms have varying tolerances to salinity; this determines where they can live
-*Notes:* The Bay has brackish water (a mix of fresh and saltwater) between 1-30ppt

Spawn: Mature oysters that release egg or sperm into the water to reproduce.

Turbidity: Measure of how clear a water body is and how well sunlight can penetrate water
-*Importance:* Turbidity inhibits plant growth, degrades the environment for aquatic animals, and can cause a decrease in dissolved oxygen levels. Turbid (cloudy/unclear) water occurs by excessive inputs/runoff of sediment and nutrients

Water Temperature: Most species can only survive within a specific range of temperatures. Warm water cannot hold as much dissolved oxygen as cool water, so by increasing the temperature of the Bay, we are decreasing the amount of oxygen available to Bay critters.

Water Depth: The depth of water can dictate the outcome of other water quality tests. Differences in dissolved oxygen, salinity, and pH measurements between surface and bottom waters may also occur.

Weather: **A** key factor in determining water quality. For instance, conditions like heavy rains or storms, can impact water quality in various ways such as causing a decrease in salinity, and

water temperature and an increase in water depth and turbidity. Water temperature differences are important because cooler water holds more oxygen than warm water.

Wind Speed/ Direction: Wind plays a role in the amount of dissolved oxygen in water. As wind hits the water, it causes a mixing of water and air, which contains oxygen. Stronger winds will lead to more circulation of air into water resulting in greater levels of dissolved oxygen.

Activity Procedure

Engagement

Pre-requisite knowledge: Students should have a clear understanding of the organizational patterns and relationships that are found in any ecosystem. (prey/predator, producers/ consumers/decomposers, niche/habitat/population/community, etc.) You will find a quick refresher of some of these concepts with this video https://www.youtube.com/watch?v=GlnFylwdYH4&ebc=ANyPxKobqSlxCwWh0dg3VDmhS2tkYVP_HXUzhQGdYJmrqxP-v48OP8IR3_GqzNNkCYydAhaYp7F7NJI0kN7ouBCnRfP_jg8VlA

Discuss as a class,

- What does biotic mean? (Living entities, such as animals, plants, bacteria, etc.)
- What does abiotic mean? (Non-living entities, such as water, sunlight, air, temperature, minerals, etc.)

Formative Assessment - Individually or in small groups, have the students develop a drawing of an estuarine ecosystem, and include biotic and abiotic factors. Have the students share their drawings with their peers.

Exploration

Demonstrate the use of the Secchi disk and other testing equipment along with all safety reminders. Divide students into small groups. Each group will use probes and test instruments to complete the data sheet for a part of the stream/river. NOTE: Every student who is near the water to perform a water quality test or collect a sample must wear a PFD (personal flotation device)

Students should observe and record weather conditions (general weather description, air temperature, wind speed, wind direction) on Student Data Sheet 1. Test the water sample for each of the 6 water quality parameters (dissolved oxygen, salinity, water temperature, turbidity, pH, water depth) using the appropriate equipment. Each student in the group will take at least one turn testing for a different parameter and recording the results of a test. Measure dissolved oxygen, salinity, pH and water temperature with instruments that you have available. These measurements will be taken from water in a bucket with a rope attached. One person from each group should measure turbidity and depth of the water at the edge.

After completing all individual tests and recording their results in Student Data Sheet 1, students should access the NOAA Chesapeake Bay Interpretive Buoy System. CBIBS is a collection of 10 interpretive buoys spread throughout the Chesapeake Bay that gather real-time data about water quality and weather conditions. The goal is to provide the most up-to-date information for environmental education, scientists, and outdoor enthusiasts. Go to (http://buoybay.noaa.gov/locations) and find a buoy near the site where your students collected their data. Students will record the data from the CBIBS website, and compare it to their data. They can also access via online or phone 1-877-286-9229. The information on Data Sheet 1 will be used in future activities.

You can also use a series of 5 water quality lessons at http://oceanservice.noaa.gov/education/yos/lesson/Grades%205-8/water_quality_teacher_guide.pdf (Monitoring Estuarine Water Quality)

Explanation

Students have looked at water quality parameters and will investigate graphs taken from CBIBS data, and what they mean for the health of the Bay, by looking at seasonal patterns of the graphs and then determining the potential effect on Bay organisms. Have the students review the graphs in Student Data Sheet 2 and record their conclusions about the patterns of the graphs. Students will investigate:

- The relationships between air and water temperatures
- The relationships between water temperature and dissolved oxygen
- The relationships between turbidity and dissolved oxygen
- The relationships between turbidity and amount of chlorophyll

Answers to Student Data Sheet 2 questions.

1. 27.6
2. The air temperatures go up and down quicker than the water.
3. It takes water longer to heat up or cool down.
4. Summer cold fronts or thunderstorms.
5. When the water temperature is high, the dissolved oxygen is low; when the water temperature is low, the dissolved oxygen is high.
6. What kind of relationship would we say exists between temperature and dissolved oxygen? Inverse proportional – when one goes up, the other goes down.
7. Whether there are lots of plant life in the water which will add oxygen from photosynthesis, heavy rainfall, and mixing of the water with air.
8. When the turbidity does up, the dissolved oxygen goes down. Inversely proportional
9. Heavy rains or even a hurricane.
10. All of these fish would survive.
11. Cloudy water makes photosynthesis hard for plants.
12. It takes time for the effect of increased turbidity to affect the plant's photosynthesis.

13. Heavy rains
14. Turbidity, water temperature, dissolved oxygen and salinity. Oysters can decrease turbidity by filtering the water.

Extension

Students will investigate the water quality factors of temperature, salinity, pH, dissolved oxygen, nitrates, and turbidity that affect oysters and the development of oyster reefs, and compare their requirements to the water quality in their local stream. Background information is provided on each factor. Students will look at the data from their stream to see if their water quality is adequate for the growth and development of oysters and the maintenance of oyster reefs. They will complete Student Data Sheet 3.

Answers to Student Data Sheet 3 questions:
5. Decomposition of algae in the warm summer months can increase the acidity level (lowered pH)
6. Yes, the reading fluctuated between 7 and 8 and is within the range of 7.8 and 8.2 for oyster spawning.
7. April to July
8. Growth of plants and algae in the spring and early summer.

Evaluation

Student data and conclusions in the Student Data Sheets 1 and 2 should be evaluated for completeness and understanding of the characteristics of healthy waterways.

With thanks to the Annapolis Maritime Museum

Three Dimensional Learning		How the Dimensions are Addressed.
Core Disciplinary Idea(s)	**MS-LS2-A. Interdependent Relationships in Ecosystems** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem	Students will gather information about their local waterway and compare it with data obtained from buoys.
Science/Engineering Practice(s)	**Obtaining, evaluating, and communicating information** in 6-8 builds on K–5 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. **Gather, read, and evaluate scientific and/or technical information** from multiple authoritative sources, assessing the evidence and usefulness of each source. **Construct an argument supported by empirical evidence** that changes to physical or biological components of an ecosystem affect populations.	Students gather evidence about the physical characteristics of their local waterway. They start to gather evidence about what local factors might affect their waterway in preparation for following activities. Students compare their own data with information from NOAA and the Chesapeake Bay Foundation. Students develop a report providing evidence and a conclusion about the health of their stream or river, and indicate how the health may affect living organisms.
Cross-cutting Concepts	**Patterns can be used to identify cause and affect relationships.**	Students will look for patterns in data between different bodies of water, time of day, weather events, and for seasonal changes.
Ties to Common Core	**Grade 6: Ratios and Proportional Relationships**. Represent and analyze quantitative relationships between dependent and independent variables.	Students will use their own data and data from NOAA buoys to describe the relationships between water quality parameters, including proportional and inverse proportional relationships.
Ties to MD Environmental Literacy Standards	**Standard 3. Interaction of physical systems and the biosphere**	Students will analyze and explain water quality parameters and the influence of these on organisms in an ecosystem.

Module References

Dissolved Oxygen
http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10d_disolvedox.html
http://www.serc.si.edu/for_media/pr.aspx?pr_id=68
Turbidity
http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10e_turbin
pH
http://www.umces.edu/hpl/locations/all/hpl/release/2010/jun/10/changing-chesapeake-bay-acidity-impacting-oyster-shell-growth
http://www.chesapeakequarterly.net/V11N1/main4/
Pollution
http://oceanservice.noaa.gov/education/tutorial_pollution/011sediments.html
Oyster reefs – Ecosystem roles
http://chesapeakebay.noaa.gov/oysters/oyster-reefs
Water parameters and Estuaries
http://estuaries.noaa.gov/ScienceData/Default.aspx?ID=543
Data and lesson plans
http://estuaries.noaa.gov/ScienceData/Default.aspx?ID=300
Water Quality and Oysters
http://www.oyster-restoration.org/wp-content/uploads/2012/07/CoenLuckRestMonitoring.pdf
http://www.bayjournal.com/article/ability_of_oysters_to_denitrify_bay_surprises_scientists
Maryland Environmental Literacy Standards
http://marylandpublicschools.org/programs/Documents/Environmental/MDEnvironmentalLitStandards.pdf

Additional Resources

http://estuaries.noaa.gov/ScienceData/Default.aspx?ID=289

http://www.mde.state.md.us/programs/water/tmdl/water%20quality%20standards/pages/programs/waterprograms/tmdl/wqstandards/faqs.aspx

https://allianceforthebay.org/2011/10/volunteer-water-quality-monitoring-publications/

http://gcmd.gsfc.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataType=0&MetadataView=Full&KeywordPath=&EntryId=%5BGCMD%5DCBP_WQDB