DISSOLVED OXYGEN

What is dissolved oxygen?

Dissolved oxygen is the amount of oxygen gas that is present in water. Water absorbs oxygen from the atmosphere and from aquatic plants, which produce oxygen during photosynthesis. Most aquatic animals need adequate dissolved oxygen in the water to survive—even aquatic plants can be harmed if the water around their roots is low in oxygen.

How is dissolved oxygen measured?

Dissolved oxygen (mg/L) can be measured in the field using an electronic probe. A Winkler titration kit can also be used to measure the dissolved oxygen level of a water sample. Sampling can be done at the surface or throughout the whole water column, which creates a vertical profile of dissolved oxygen through the water column.

What can dissolved oxygen tell us about the Bay?

Dissolved oxygen is a key indicator of ecosystem health, especially during the summer. Most problems with low dissolved oxygen, or hypoxia, occur during the summer due to increased temperatures (warm water holds less oxygen) and higher biological activity in the water column. Dissolved oxygen also tends to be lower at greater depths due to decreased mixing, less photosynthesis, and more oxygen-requiring decomposition of sinking dead plants and animals. Low dissolved oxygen is often the result of excess nutrients in the water, which fuel algal blooms that eventually decompose and use up large quantities of oxygen. High dissolved oxygen indicates a healthy Bay, with enough oxygen to sustain aquatic species and maintain the chemical balance of the water.

Dissolved oxygen can be measured with a probe (top center) or using the Winkler titration method (bottom) (UMCES; Alliance). Low amounts of dissolved oxygen can suffocate aquatic life and lead to fish kills (top outside) (UMCES).

CMC Chesapeake Monitoring Cooperative

NITROGEN

What is nitrogen?

Nitrogen is an essential nutrient for all life on Earth. Bacteria living in soil convert nitrogen in the atmospheric into ammonia, which plants use to grow. Plants also use other types of nitrogen to make proteins and amino acids that animals need.

How is nitrogen measured?

Ammonia nitrogen, nitrite nitrate, and total nitrogen (mg/L) are measured using lab analyses of water samples taken in the field.

Nitrate nitrogen (mg/L) is measured in the field using a colorimetric kit with either a cadmium or zinc reduction method, or by lab analyses of water samples taken in the field.

What can nitrogen tell us about the Bay?

High nitrogen content in water is an indication of nutrient pollution input from the watershed. Lower levels of nitrogen often mean the ecosystem is healthy and the food web is balanced and not dominated by macroalgae and phytoplankton.

Nitrogen occurs naturally in ecosystems and fuels the food web by providing nutrients to algae and other plants. Although nitrogen is essential for plant life, it is found at unnaturally high concentrations in fertilizers and wastewater. Rain pushes nitrogen-rich stormwater runoff from lawns, farms, and overflowing sewers and septic systems into the Chesapeake Bay. Nitrogen pollution causes algae overgrowth and can result in an algal bloom that eventually dies and decays—a process that uses up dissolved oxygen. Low dissolved oxygen levels cause fish kills and decrease habitat quality for plants and animals living in the Chesapeake Bay and its tributaries.

Top: Collecting water samples to measure nitrogen (C. Donovan). Bottom: Nitrogen-rich stormwater runoff creates algal blooms in the Bay (A. Jones).

CMC Chesapeake Monitoring Cooperative

PHOSPHORUS

What is phosphorus?

Phosphorus is an essential nutrient for all growth and reproduction. Phosphorus occurs naturally in ecosystems and fuels the food web by providing nutrients to algae and other primary producers. Orthophosphate is a type of phosphorus that can be absorbed by living organisms, and helps plant growth.

How is phosphorus measured?

Orthophosphate (mg/L) is measured in the field using ascorbic acid and either a colorimetric kit or a digital checker, or through lab analyses of water samples.

Total phosphorus (mg/L) is measured using lab analysis procedures. Salinity data is needed in order to accurately interpret phosphorus data.

What can phosphorus tell us about the Bay?

High phosphorus content in water is an indication of intensified nutrient pollution input from the watershed. Lower levels of phosphorus suggest that the ecosystem is healthy and the food web is balanced and not dominated by algae.

Although phosphorus is essential for plant life, it is also found at unnaturally high concentrations in fertilizers, cleaners, and wastewater. Heavy rains push phosphorus-rich stormwater runoff from lawns, farms, and overflowing drains into the Chesapeake Bay. Phosphorus nutrient pollution in water systems stimulates excess algal growth and leads to dense algal blooms, which can reduce water clarity and decrease overall habitat quality for plants and animals living in the Bay and its tributaries.

Top: Filtered water can be used to measure dissolved nutrients, such as phosphorus (H. Stevens).
Bottom: Phosphorus-rich sediment runs off the land and into the Bay, which decreases water clarity and suffocates organisms (J. Thomas).

CMC
Chesapeake Monitoring Cooperative

pH

What is pH?

pH is a measure of how acidic or basic water is. It provides a measure of habitat suitability of a water body for aquatic life. The pH scale ranges from 0-14, with 7 being neutral. A pH less than 7 indicates acidic water, and a pH greater than 7 indicates basic water. Because pH can be affected by chemicals in the water, it is an important indicator of water quality.

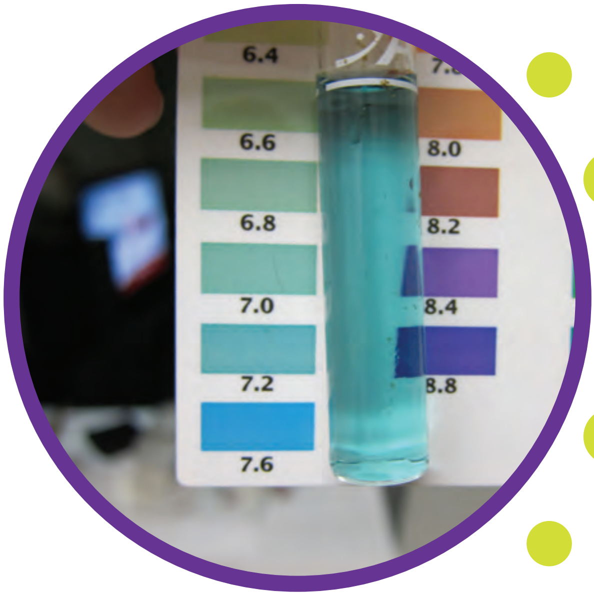
How is pH measured?

pH can be measured in the field using a pH probe, a colorimetric kit, or test strips. When using a probe, pH can be measured multiple times throughout the whole water column. When using a kit or strips, pH can be measured at the surface only.

What can pH tell us about the Bay?

The pH of water determines the solubility and biological availability of certain nutrients and metals that are important for aquatic life. Different levels of pH in the water can have different effects on nutrients such as nitrogen and phosphorus. Phosphorus can be readily released from sediments if pH levels are low, and higher pH can increase the rate that nitrogen changes from one form to another. A pH level that is out of the normal range will be harmful to the plants and animals living in the water. pH levels also affect the growth of shellfish, like oysters and scallops.

pH can be an indicator of point source pollution, such as discharge from mining, and ocean acidification, which is a result of increased carbon dioxide in the atmosphere from the burning of fossil fuels.



Top: Monitoring pH using a water quality probe (Travis AFB / CC BY-NC 2.0). Bottom: A water sample being compared to a pH color kit (E. Gillingham / CC BY 2.0).

CMC Chesapeake Monitoring Cooperative

SALINITY

What is salinity?

Salinity is a measure of the saltiness of a body of water. Salty water contains significant amounts of dissolved salts—the most common being sodium chloride (NaCl), this is also called the concentration. The concentration is the amount of salt (by weight) in water, measured as parts per thousand (ppt).

How is salinity measured?

Salinity is measured in the field using a hand-held device called a refractometer. Many water quality probes (such as the YSI probe in the middle picture) are also used to measure salinity.

What can salinity tell us about the Bay?

Salinity allows us to predict which types of organisms may occur in a certain section of the Bay. Oysters, for example, can only survive at salinity levels higher than 10 ppt. Largemouth bass, on the other hand, prefer completely fresh water (0 ppt).

Salinity varies throughout the Bay, ranging from very high levels (30 ppt) at the mouth by Virginia, to brackish (15ppt) in the mid-Bay, and completely fresh water (0 ppt) in the upper reaches of the tributaries.

Salinity affects dissolved oxygen in the water and the combination of water temperature and salinity is used to determine whether there is layering in the water column. Layering (or stratification) of temperature and salinity means there is no mixing between the oxygen-rich surface waters and the oxygen-deprived bottom waters.

Top and Bottom: A refractometer is one way of measuring the salinity level of a water sample (Chesapeake Bay Program, Virginia Sea Grant). Middle: A probe can also be used for salinity readings (P. Bergstrom).

CMC
Chesapeake Monitoring Cooperative

AIR & WATER TEMPERATURE

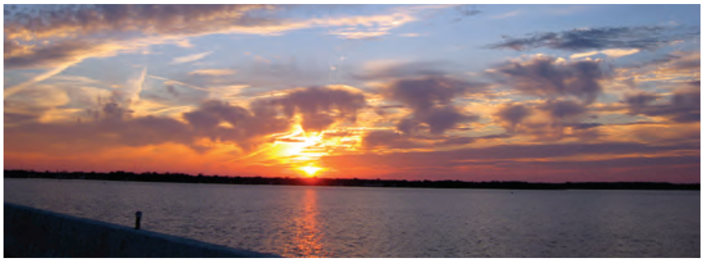
What are air & water temperature?

Temperature measures how fast molecules in air or water are moving, or how much energy they have. Both air and water temperature have daily and seasonal cycles—brighter sunlight in the daytime and longer hours in the summer raise temperatures. Because temperature affects other indicators, it is necessary to measure temperature at every sampling site every time samples are taken.

How is temperature measured?

Air and water temperature (ºC) are measured using an armored glass thermometer, digital thermistor, or probe. Single measurements of water temperature can be taken at the surface or in a bucket. A depth profile of temperature can be made by measuring temperature at different depths in the water column.

What can air & water temperature tell us about the Bay?



Temperature affects both the biological and physical characteristics of an ecosystem. Changes in temperature influence which animals and plants can survive in the Bay and its tributaries. Warmer temperatures stimulate growth, reproduction, and decomposition of plants and animals. Temperature also affects water chemistry. Water that is too warm cannot hold enough oxygen to sustain animals. The sun heats shallow freshwater streams and surface water, which flow into the Bay and form a layer of warm water that floats above the cold, salty water entering from the sea. During the summer, the large temperature difference keeps these layers separated and contributes to low dissolved oxygen in the deeper waters of the Bay.

Seasonal temperature changes (top outside, W. Parson) and the amount of sunlight available (bottom, C. Donovan) affect the physical properties and water chemistry of the Bay. Air and water temperature can be measured with a glass thermometer (top center, J. Thomas). Source: Chesapeake Bay Program.

CMC Chesapeake Monitoring Cooperative

TOTAL WATER DEPTH

What is total water depth?

Measuring the depth of the water helps characterize a site. A site can be shallow, deep, or within a navigational channel. Tides affect total water depth, so the total depth of a site can change depending on when it is sampled. Knowing the depth is an important first step before taking any measurements. Total water depth is needed to determine where to start measuring dissolved oxygen using a probe—you do not want the probe to hit the bottom, which can disturb sediments and lead to incorrect measurements.

How is total water depth measured?

Total water depth is measured by lowering a weighted line into the water and reading the depth marking on the line when it hits bottom.

What can total water depth tell us about the Bay?

Total water depth of sampling sites is part of the physical characteristics of an ecosystem. Shallow sites respond differently to changing conditions than deeper sites. Total depth can help determine if sedimentation is a problem. Sediment runoff from farms, roads, and residential and commercial development can affect total water depth over time. The sediment settles to the bottom of tidal creeks, slowly filling in shallow waterways, smothering shellfish and seagrass, and leading to low oxygen conditions. Sedimentation can be tracked by measuring total water depth over time. Adjusting for tidal changes must occur to determine if total water depth is decreasing or increasing.

Total water depth is measured by lowering a weighted line into the water and recording the depth markings on the line (MD DNR).

CMC Chesapeake Monitoring Cooperative

WATER CLARITY & TURBIDITY

What are water clarity & turbidity?

Water clarity is a measure of how much light penetrates though the water column. Sediment, plankton, and other organic materials can become suspended in the water. These floating particles make the water less clear and block light from traveling through water. Turbidity is a measure of the cloudiness of the water itself.

How are they measured?

Water clarity (m) is measured in the field using a Secchi disk attached to a drop line. A transparency tube can be used to measure clarity when a sample site has a current that is too fast or a depth that is too shallow for a Secchi disk to function properly. **Turbidity** (JTU) is measured in the field, with a kit, by comparing the cloudiness of a water sample to a standardized amount of turbid water.

What can water clarity & turbidity tell us about the Bay?

Clear water is critical for the growth and survival of aquatic species. Aquatic grasses and other plants grow best in clear water because sunlight can pass through the water column to deeper depths and support photosynthesis. Fish, crabs, and other aquatic organisms also rely on clear water to see the environment, catch prey, and breathe.

Poor water clarity and high turbidity are usually caused by a combination of excess suspended sediments in the water, due to runoff from land, and growth of phytoplankton, which is fueled by nutrients.

A Secchi disk on a drop line (top) and a transparency tube (bottom) can be used to measure water clarity (M. Rath, UMCES). Middle: A Secchi disk is lowered into the water until the depth where the black and white disk can not be seen (A. Jones).

CMC Chesapeake Monitoring Cooperative

CONDUCTIVITY & TOTAL DISSOLVED SOLIDS

What are conductivity & total dissolved solids?

Conductivity is a measure of the ability of water to pass an electrical current due to the presence of ions dissolved in the water. For example, when salt (NaCl) dissolves, it breaks into sodium (Na+) and chloride (Cl-) ions. Conductivity is related to total dissolved solids, which is the amount of solid substances dissolved in the water. All organisms need ions to survive.

How are they measured?

Conductivity (µSiemens/cm) is measured using a conductivity probe. The probe measures how much the dissolved ions in the water interact with one another. In order for ions to interact, they need to have opposite (positive and negative) charges. The higher the interaction, the higher the water's conductivity. **Total dissolved solids** (mg/L) are also measured using a probe.

What can conductivity & total dissolved solids tell us about the Bay?

Conductivity changes depending on the water's salinity. Since salt turns into ions when it dissolves, seawater naturally has higher conductivity than freshwater. However, unusually high conductivity can be an indicator of specific types of pollution. High conductivity and total dissolved solids are most often caused by road salts, mining, hydraulic fracturing, wastewater treatment plants, storm runoff, and human waste pollution. High amounts of conductivity or total dissolved solids lead to biological stress in organisms, including decreased reproduction and growth. Over time, this can cause shifts in the types and amounts of organisms that can survive in the region. Increases in conductivity and total dissolved solids also lower the pH of the water, making it acidic and hurting aquatic organisms such as plants and fish.

Top: Conductivity (µS/cm) is measured using a conductivity probe (B. Fertig). Bottom: The higher the interactions between positive and negative ions in the water, the greater the water's electrical conductivity (A. Fries).

CMC Chesapeake Monitoring Cooperative

BACTERIA

What are bacteria?

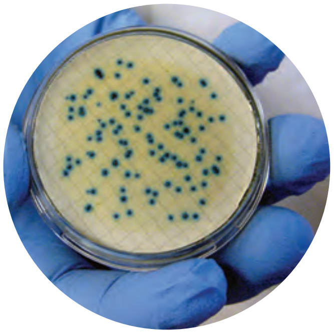
Bacteria are microscopic organisms that live in fresh and salt water and in the intestines of humans and other warm-blooded animals. Bacteria in tidal areas are affected by a variety of factors including water temperature, sedimentation, sunlight, salinity, and currents and tides.

How are bacteria measured?

The bacteria that are measured in brackish and salt water are called enterococci. Measuring bacteria occurs in two ways: using the Coliscan Easygel technique and through whole water samples taken to a lab. The water sample is then filtered to collect bacteria cells, which are grown in a petri dish and counted. Enterococci and other harmful bacteria come from similar sources. Enterococci are harmless to humans, but the presence of large numbers of this bacteria means that harmful bacteria may also be present.

What can bacteria tell us about the Bay?

Bacteria help us determine if there are human or other warm-blooded animals polluting the Bay and its tidal creeks. While bacteria occur naturally in fresh and salt water, harmful bacteria from the feces of humans and animals enter waterways through leaking septic systems, broken sewer lines, and runoff when it rains. These bacteria can cause illness in anyone recreating in or on the water. During significant rainfall, there is an increased risk for high amounts of unsafe bacteria in the Bay and its tidal creeks. It is a good idea to work with the local health department that monitors bacteria at public beaches. Providing more information to the health department can help them issue advisories about high levels of bacteria in local waterways.



Top: High bacteria levels are harmful to people that recreate in or on the water. This public beach is closed due to bacteria (H. Kelsey). Bottom: Bacteria water samples are filtered and placed on a growing medium. Each blue dot is a bacteria colony (B. Sadiowski).

CMC
Chesapeake Monitoring Cooperative

CHLOROPHYLL

What is chlorophyll?

Chlorophyll is the green pigment that allows plants to convert sunlight into sugar during photosynthesis. Of the several kinds of chlorophyll, *chlorophyll a* is the predominant type found in microscopic algae in fresh and saltwater ecosystems, and is therefore used as a measure of microalgae abundance.

How is chlorophyll measured?

Chlorophyll concentration (µg/L) of a water sample collected in the field is measured through lab analysis using various procedures, such as spectrophotometry, high performance liquid chromatography, and fluorometry. Different types of pigments can be quantified when *pheophytin*, a chlorophyll degradation product, is also measured.

What can chlorophyll tell us about the Bay?

Chlorophyll helps us determine if there are too many nutrients in the Bay. Algae form the base of many food webs and are a natural part of tidal ecosystems; however, excess algae leads to algal blooms. Excess algae can reduce water clarity and dissolved oxygen and can cause aesthetic problems. In some cases excess algae can harm aquatic organisms and create public health concerns. Water with high concentrations of chlorophyll is likely to have high levels of nutrients, which fuel algal growth. These nutrients come from sewage treatment plants, agricultural and urban runoff, and air pollution. Having the right level of chlorophyll generally means there are enough algae to fuel the food web. Lower algae levels promote cleaner, clearer water, more available habitat, and fewer harmful algal bloom effects. Monitoring chlorophyll over time enables us to track nutrient pollution and draw conclusions about overall ecosystem productivity and water quality in local waterways.

Top: Sampling chlorophyll a *in the field involves pumping water through a special filter that collects chlorophyll residue, and is later processed in a lab (C.Donovan). Bottom: Chlorophyll filters of varying colors show the different amounts of chlorophyll in the water sample (L.Fabien).*

CMC
Chesapeake Monitoring Cooperative

SILICATE

What is silicate?

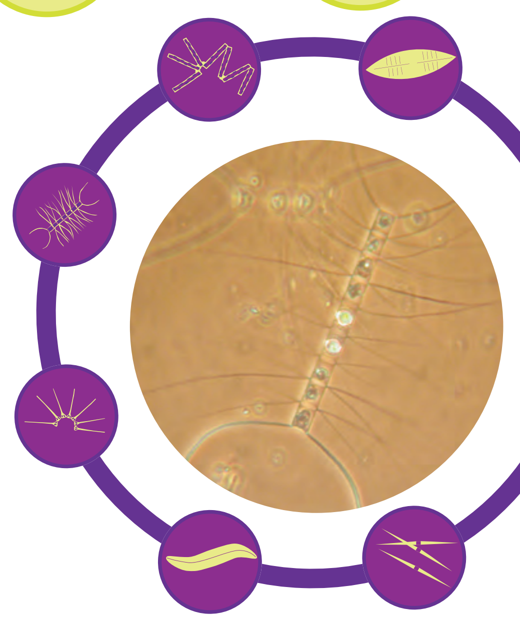
Silicate is a measure of the amount of water-soluble (dissolved) silica in the water. Natural weathering of silicate minerals on the land leads to silicate running off the land and into local waterways.

How is silicate measured?

The amount of dissolved silica, or silicic acid (Si/L), in the water is measured using spectrophotometry. To measure silicate, a water sample is collected in a bottle and sent to a laboratory equipped with a spectrophotometer.

What can silicate tell us about the Bay?

Some types of microalgae, called diatoms, use dissolved silica as a structural component in their cell walls. Microalgae blooms in the Bay and its tributaries can be dominated by diatoms. The blooms are fueled by excess nutrients, such as nitrogen and phosphorus. Diatom blooms are silica-limited because when silica is used up and becomes less available in the water column, diatom blooms decline. When large amounts of diatoms die, the decomposition process can lead to low dissolved oxygen conditions, which are harmful to aquatic organisms, such as macroinvertebrates and fish.



Top: Collecting a water sample in Maryland (T. Carruthers). Bottom: Diatoms under magnification ("Chaetoceros affinis + resting spore" by biogi is licensed under CC BY-NC-ND 2.0).

CMC Chesapeake Monitoring Cooperative