KILROY ACADEMY

KILROY TERMINOLOGY

OVERVIEW

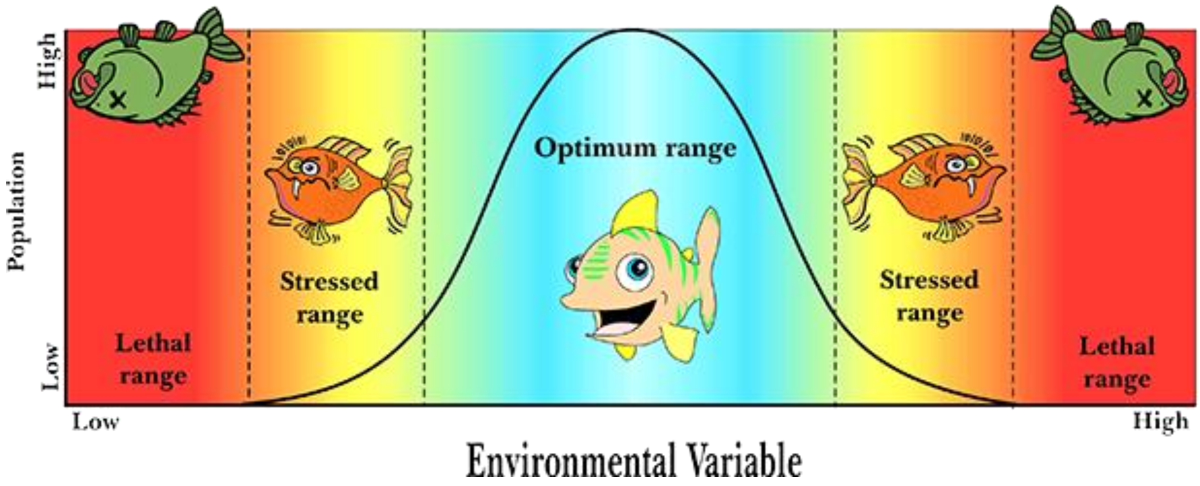
This resource is designed to introduce students to the scientific terms that explain the environmental variables Kilroy uses to convey the current conditions of the Indian River Lagoon. Researching this terminology will allow students to familiarize themselves prior to a Kilroy investigation, thereby producing accurate and informed conclusions.

The Kilroy water monitoring system developed by the Ocean Research & Conservation Association (ORCA) is a device unlike any other. Kilroy monitors the physical, chemical and biological indicators of health in a particular body of water and it does so, 24 hours a day, 365 days a year.

ORCA's goal is to provide the information that is needed to determine what aspects of the Lagoon have become unhealthy and what we can best do to put things back in balance.

All animals have a set of preferred environmental conditions in which they thrive. Outside that range they may survive but not thrive. Far enough outside that range they will die.

Environmental variables like temperature, salinity (how much salt is dissolved in the water), dissolved oxygen (how much oxygen is in the water), pH (how acidic the water is) all impact aquatic ecosystems and animal survival. Animals may have a wide range of tolerances for some variables and a narrow range for others. By monitoring these variables we can help assure that the environmental variables stay within a range that will optimize survival.



TOPICS

Environmental variables, aquatic ecosystems, water quality

AUDIENCE AND SETTING

High school students to adult learners. This resource can be shared from any computer or device with access to the web. Possible settings include public outreach events and classrooms.

OBJECTIVES

- Learn about specific environmental variables and how they impact aquatic ecosystems
- Understand the importance of real-time water quality monitoring

GUIDING QUESTIONS

- What is water quality and why is it important to monitor and study?
- What are some environmental variables that impact aquatic ecosystems?

BACKGROUND

Kilroy is a water-quality monitor unlike any other. Hardly larger than a football, at a fraction of the cost of other sensors, Kilroy monitors the physical, chemical and biological indicators of health in a particular body of water and it does so, 24 hours a day, 365 days a year. A fully-loaded Kilroy system measures variables 1 through 16 listed below. Kilroys equipped with a meteorological station measure the remaining five variables.

KEY VARIABLES

1. **Depth —** Historically, water depth was measured by a *lead line*, a weighted rope which is graduated at a specific distance (every meter, fathom). This is the method commonly used in shallow water. In deep water, and found on many fishing boats, fathometers utilize sonar to measure distance to the seafloor (depth). A combined transmitter and receiver, called a transducer, sends a sound pulse straight down into the water. The pulse moves down through the water and bounces off the ocean bottom. The transducer is able to pick up the reflected sound. Computers precisely measure the time it takes for the sound pulse to reach the bottom and return, and the depth is calculated by knowing how fast sound travels in the water (approximately 1,500 meters per second). This method is called echosounding. Depth as measured by Kilroys is the depth of the water from the air/wáter interface to the transducer. It primarily serves as a measure of tidal fluctuations.

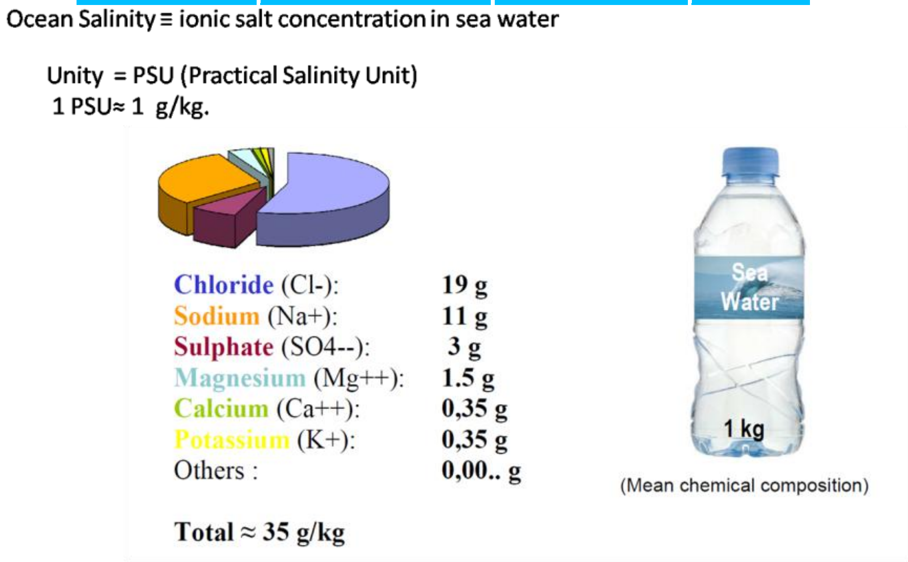
2. **Temperature** — Temperature is the degree or intensity of heat present; measured as degrees on a standard scale, such as Fahrenheit or Celsius (Centigrade). Water temperature is usually measured with a thermometer. A thermometer has a liquid inside that expands as the temperature increases. The temperature is read from the scale printed on the thermometer. Temperature is also commonly measured with an electronic device called a thermistor (thermal resistor). This is what the Kilroy uses. A thermistor measures temperature by measuring the resistance to electric flow in a metal. The electrical resistance of a metal will increase as the temperature increases, and an accurate reading of the current resistance can be used to calculate the temperature.

3. **Salinity —** the saltiness or dissolved salt content of a body of water. Salts are compounds like sodium chloride, magnesium sulfate, potassium nitrate, and sodium bicarbonate, among others, which dissolve into ions. Salinity is measured as the "mass fraction", or mass of dissolved ions in a mass of solution – typically g/kg, parts per thousand (ppt), ‰ (symbol). It can also be measured as *Practical Salinity Units* (PSU) which measures the conductivity of the saltwater

and is used to calculate the salinity.

The higher the salinity of water, the greater its specific gravity or density (mass/volume ratio). This characteristic is often used to determine the salinity of water using a hydrometer. Also, the ability of water to bend light, termed *refraction*, is used to measure salinity optically using a *refractometer*. Finally, all water samples with the same conductivity ratio have the same salinity, and Kilroy uses conductivity to establish the *Practical Salinity Units* measure of salinity.

Water salinity			
Fresh water	**Brackish water**	**Saline water**	**Brine**
< 0.05%	**0.05 – 3%**	**3 – 5%**	**> 5%**
< 0.5 ‰	**0.5 – 30 ‰**	**30 – 50 ‰**	**> 50 ‰**



4. **Conductivity** — of an electrolyte solution is a measure of its ability to conduct electricity. A conductivity sensor measures how much electricity is being conducted through a centimeter of water. The SI unit of conductivity is siemens per meter (S/m) or mS/cm. Conductivity is linked directly to the total dissolved solids (T.D.S.) and therefore salinity. Typical drinking water is in the range of 5-50 mS/m, while sea water is about 5 S/m (i.e., sea water's conductivity is one million times higher than that of deionized freshwater).

   To convert the electric conductivity of a water sample (mS/cm) into the approximate concentration of total dissolved solids (ppm), the mS/cm is multiplied by a conversion factor. The conversion factor depends on the chemical composition of the TDS and can vary between 0.54 – 0.96.

5. **Water temperature** — Measured in degrees Centigrade (^{0}C) or Fahrenheit (^{0}F) using a thermometer (alchohol – expansion of liquid) or thermistor

(electrical current resistance based on temperature). Conversion of Centigrade and Fahrenheit is (^{0}C x 1.8 +32 = ^{0}F). Ocean temperatures offshore of central Florida generally range from 20 - 30°C, while in the Indian River Lagoon between 5 and 35°C.

6. **Flow speed** — A current meter is an oceanographic device used to measure wáter flow speed by using a mechanical (rotor current) meter, acoustical (ADCP) or electrical means. Mechanical current meters are mostly based on counting the rotations of a propeller and are thus rotor current meters.

   Acoustical flow meters determine water velocity by at least two acoustic signals, one up stream and one down stream. By precisely measuring the time to travel from the emitter to the receiver, in both directions, the average water speed can be determined between the two points. By using multiple paths, the water velocity can be determined in three dimensions. This is the principle upon which Kilroy flow is measured.

   Ultrasonic Doppler flow meters measure the Doppler shift resulting from reflecting an ultrasonic beam off the particulates in flowing fluid. The frequency of the transmitted beam is affected by the movement of the particles; this frequency shift can be used to calculate the fluid velocity.

   Flow speed measured in meters per second (m/s) – determines how rapidly organisms and substances are transported.

7. **Flow direction** — *Flow direction measured in degrees where 0° (or 360°) is N, 90° is E, 180° is S and 270° is W* – is the direction water is flowing. Flow direction (also known as the bearing) changes with the tides. Water movement can transport organisms, oxygen, nutrients, sediment, and wastes.

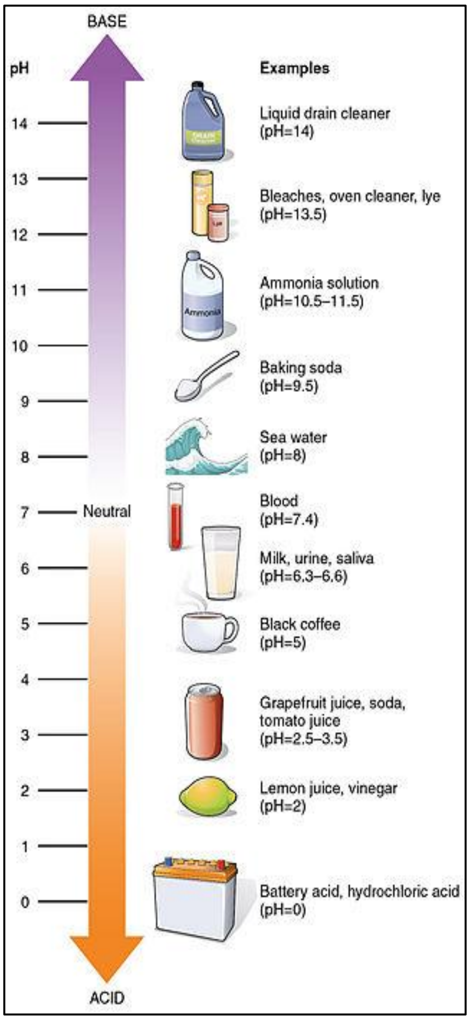
8. **Dissolved oxygen** — Dissolved oxygen typically refers to the amount of gaseous oxygen that has dissolved into a body of water. It is a common ecological measurement that indicates the overall health of the aquatic ecosystem. Dissolved oxygen (DO) is measured in milligrams/liter (mg/L) or parts per million (ppm). The solubility of oxygen in water is dependent upon both temperature and salinity. As temperature rises and salinity increases, the solubility of oxygen decreases, as does the saturation of oxygen. Therefore, oxygen saturation (in ppm) is highest in cold freshwater and lowest in warm saltwater.

   The concentration of dissolved oxygen in water can be measured using two methods. The easiest method, which requires no calculations, is using a dissolved oxygen meter. In contrast, the modified Winkler dissolved oxygen determination requires several calculations.

A DO meter consists of a probe filled with potassium chloride and covered with a semi-permeable membrane, a wire carrying electricity, and two electrodes. When the probe is placed in the water, the potassium chloride attracts oxygen, pulling the molecules across the semi-permeable membrane. Oxygen is not very ionized, and does not have a negative charge as electricity does, so the oxygen dilutes the current and the meter measures the difference in current between the two electrodes to determine the amount of oxygen in the water.

The Winkler Dissolved Oxygen Determination uses a variety of reagents and the titration method to calculate the DO concentration. The Winkler method uses manganese sulfate ($MnSO_4$) and potassium iodide (KI) to form a brown precipitate. The dissolved oxygen converts the iodide to iodine, and then the dissolved oxygen is directly related to the titration of the iodine with thiosulfate solution. This is a colorimetric test.

9. **pH** — The pH of water determines if it is acidic or basic (alkaline). Chemically speaking pH refers to the "potential" concentration of the H+ ion in water. There can be a high concentration of H+ ions or a high concentration of OH- ions. Higher concentration of H+ ions causes lower pH (acidic), while higher concentration of OH- ions increases the pH value to be basic (above 7). The pH measurements are recorded on a scale from 0 to 14, with 7.0 considered neutral. Solutions with pH below 7.0 are considered acidic, while those between 7.0 and 14.0 are considered basic. Since the pH scale is logarithmic, every one-unit change in pH represents a ten-fold change in acidity. In other words, pH 6 is ten times more acidic than pH 7; pH 5 is one hundred times more acidic than pH 7. The pH scale is based on the negative of the base 10 logarithm of the concentration of H^+ ions in a solution.



$$pH = -\log_{10}[H^+]$$

In pure water, with a pH of 7, the molar concentration of H^+ ions is 10^{-7} M, which is one 10 millionth of 6.02×10^{23} (Avagadro's constant) or 6.02×10^{16} hydrogen ions per liter. By comparison, in black coffee with a pH of 5, the concentration of H^+ ions is 10^{-5} M, which is one hundred thousandth of 6.02×10^{23} or 6.02×10^{18} hydrogen ions per liter; more hydrogen ions means the solution is more acidic.

Freshwater (0 ppt, ‰) has a neutral pH of 7, but as the salinity increases, the wáter becomes more basic and the pH increases. Since salinity concentrations can vary greatly in coastal waters, it affects the pH; The higher the salinity, the higher the pH (more basic). Coastal areas with freshwater influence (low salinity zones) will have a pH range of 7.0 to 7.5, while in offshore waters (higher salinity) the pH ranges between 8.0 and 8.6

Monitoring the pH of water gives us an indication of the health of our estuaries and creeks since the chemical/physical characteristics of the water or substrate can influence the pH. Abnormal pH readings can indicate a chemical imbalance in a water body. Several factors can influence the pH of coastal wetlands, including rainfall, plant/bacteria growth, temperature, and salinity. Biological activity can suddenly increase or decrease water chemistries causing shifts in pH values. Rapidly growing algae will produce oxygen and remove carbon dioxide (CO_2) from the water during photosynthesis, resulting in an increase of pH. Conversely, decomposition of organic matter or respiration in plants and animals will use up oxygen but increase CO_2 levels in the water thus, lowering the pH values.

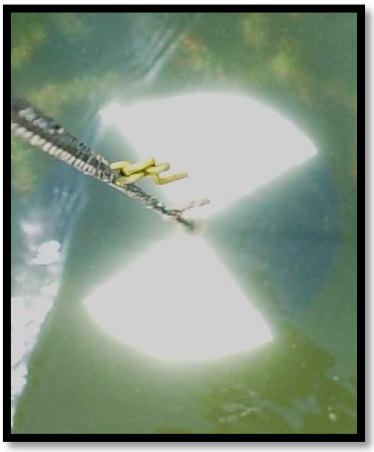
Abnormally low or high pH values can adversely affect egg hatching, stress fish and insects, or cause fish kills. Other human factors influencing pH readings outside the normal range include mine drainage sites, atmospheric deposition or industrial point discharges. Serious problems occur in coastal waterways when the pH falls below five or increases above 9.

10. **Oxidation Reduction Potential** — (ORP or Redox) is the activity or strength of oxidizers and reducers in relation to their concentration. Oxidizers accept electrons, reducers lose electrons. Examples of oxidizers are: chlorine, hydrogen peroxide, bromine, ozone, and chlorine dioxide. Examples of reducers are sodium sulfite, sodium bisulfate and hydrogen sulfide. Like acidity and alkalinity, the increase of one is at the expense of the other.

    A single voltage is called the Oxidation-Reduction Potential, where a positive voltage shows a solution attracting electrons (oxidizing agent). For instance, chlorinated water will show a positive ORP value whereas sodium sulfite (a reducing agent) loses electrons and will show a negative ORP value. ORP is measured in millivolts (mV), with no correction for solution temperature. Like pH, it is not a measurement of concentration directly, but of activity level.

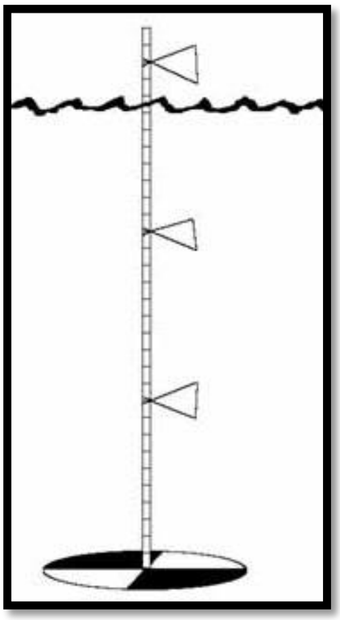
    An ORP sensor uses a small platinum surface to accumulate charge without reacting chemically. That charge is measured relative to the solution, so the solution “ground” voltage comes from the reference junction - the same type used by a pH sensor.

11. **Turbidity** — Turbidity is the measure of relative clarity of a liquid, an optical characteristic of water measuring the amount of light that is scattered by material in the water when a light is shined through it — the higher the intensity of scattered light, the higher the turbidity. Many materials that are suspended in water will cause it to be turbid— clay, silt, finely divided inorganic and organic matter, algae, soluble colored organic compounds, and plankton and other microscopic organisms.



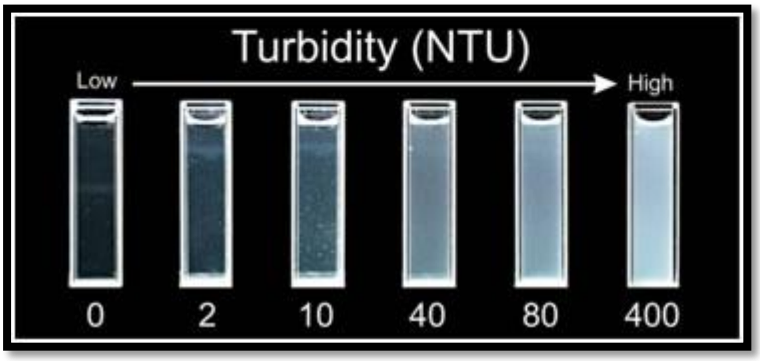
High concentrations of particulate matter affect light penetration and productivity, recreational values, and habitat quality, and result in harm to habitat areas for fish and submerged aquatic vegetation. Particles also provide food and shelter for pathogens, and attachment places for other pollutants, notably metals and bacteria, so turbidity readings can be used as an indicator of potential pollution in a water body. Although turbidity is not a direct indicator of health risk, numerous studies show a strong relationship between removal of turbidity and removal of protozoa. The particles of turbidity provide "shelter" for microbes by reducing their exposure to attack by disinfectants. Microbial attachment to particulate material has been considered to aid in microbe survival.

The “secchi disk” is used to measure water turbidity in the field To use the Secchi disk, lower it into the water until the distinction between black and white sections disappears. Mark the rope at that point (at the water’s surface). Retrieve the disk and measure the distance from the mark to the top of the Secchi disk. Lower the disk back into the water beyond the first mark, then slowly pull it back up until you can just make out the difference between the black and white sections. Make a new mark on the rope and measure this second distance. The Secchi depth is the average of the two numbers. A Secchi disk measurement should always be taken off the shady side of a boat or dock between 9 am and 3 pm. The period for best results is between 10 am and 2 pm.



The same observer should take Secchi depth measurements in the same manner every time.

Turbidity measured in Nephelometric Tubidity Units (NTU) - a measure of water cloudiness. Turbidity increases with growth of phytoplankton, sediment run-off from the land, and bottom sediment disturbances as from storms, dredging or boat traffic. High turbidity prevents sunlight from reaching submerged aquatic vegetation such as sea grass, which provides food for manatees



and critical habitat for fish and invertebrates such as shellfish and shrimp. According to Florida DEP "Potential turbidity-producing activities should not increase surface water turbidity by more than 29 NTUs above natural background conditions for all classes of surface water in the state of Florida."

The propensity of particles to scatter a light beam focused on them is now considered a more meaningful measure of turbidity in water. Turbidity measured this way uses an instrument called a nephelometer with the detector set up to the side of the light beam. More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units (**NTU**). To some extent, how much light reflects for a given amount of particulates is dependent upon properties of the particles like their shape, color, and reflectivity. For this reason (and the reason that heavier particles settle quickly and do not contribute to a turbidity reading), a correlation between turbidity and total suspended solids (TSS) is generally unique for each location or situation.

12. **Chlorophyll** — Phytoplankton are photosynthesizing microscopic organisms that inhabit the upper sunlit layer of bodies of water. These unicellular plants utilize "chlorophyll a" to photosynthesize, a process termed "primary production," which is the creation of organic compounds from carbon dioxide dissolved in the water, a process that sustains the aquatic food web.

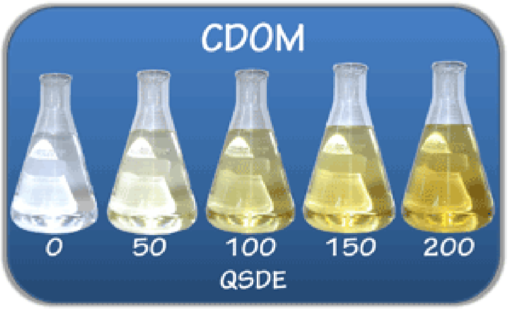
    Concentrations of the plant pigment "chlorophyll a" (which occurs in all marine phytoplankton) provide a useful proxy indicator of the amount of nutrients incorporated into phytoplankton biomass, because phytoplankton have predictable nutrient-to-chlorophyll ratios.

    Chlorophyll a is the most commonly used parameter for monitoring phytoplankton biomass and nutrient status, as an index of water quality. Chlorophyll a is reported in ug/L. Chlorophyll sensors rely on fluorescence to estimate phytoplankton levels based on chlorophyll concentrations in a sample of water. Fluorescence means that when the chlorophyll is exposed to a high-energy wavelength (approximately 470 nm = blue light), it emits a lower energy light (650-700 nm = red light). This returned light can then be measured to determine how much chlorophyll is in the water, which in turn estimates the phytoplankton concentration. The phytoplankton concentration is directly affected by light conditions (for photosynthesis) and nutrients. A chlorophyll measurement below 7 µg/l is within a desirable range. 7-15 µg/l is less than desirable, while over 15 µg/l is considered problematic .

13. **Blue-green algae** — Blue-green algae are actually bacteria that have qualities similar to algae and other plants. These bacteria are cyanobacteria – cyan means "blue-green" – and are commonly found on land and in lakes, rivers, ponds, and in estuaries and marine water. A combination of warm temperatures, sunlight, and nutrient-rich waters can cause blue-green algae to reproduce rapidly, or "bloom." Within a few days a clear pond or estuary can become cloudy with algae growth. Blue-green blooms usually float to the surface and can be several inches thick near the shoreline.

    Although blue-green blooms can create nuisance conditions and undesirable water quality, most are not toxic. A blue-green algae bloom often looks like green paint floating on the water, but can also look bluish, brownish, or reddish green.Blue-green algae can produce nerve toxins (neurotoxins), liver toxins (hepatotoxins) and skin toxins (dermatoxins).

The level of blue-green algae in the water can be most accurately determined in a laboratory using cell counting or molecular analysis, but can also be measured using an optical fluorometer to measure phycocyanin in freshwater cyanobacteria and phycoerythrin in marine cyanobacteria. The sensor measures the amount of light emitted by the pigment, which indicates the concentration of algae in the water sample. The unit of measure is in μg/L. This method is very useful for collecting blue-green algae concentrations in the field, but the accuracy can be affected by interference from other species and compounds that fluoresce at similar wavelengths, differences in the fluorescent response between different species of blue-green algae, differences in the fluorescent response caused by temperature and ambient light, and interference caused by turbidity.



14. **Colored dissolved organic matter** — (CDOM) is the optically measurable component of the dissolved organic matter in water. Also known as *chromophoric* dissolved organic matter, *yellow substance*, and *gelbstoff*, CDOM occurs naturally in aquatic environments primarily as a result of tannin-stained waters released from decaying detritus. The color of water will range through green, yellow-green, and brown as CDOM increases. Although variations in CDOM are primarily the result of natural processes, human activities such as logging, agriculture, effluent discharge, and wetland drainage can affect CDOM levels in fresh water and estuarine systems. CDOM diminishes light as it penetrates water, limiting photosynthesis and inhibiting the growth of phytoplankton and seagrasses. CDOM is is typically measured using absorbance or fluorescence. Absorbance is a measure of how much light of a specific wavelength (typically 254 nm or 440 nm) is absorbed over a given distance, while fluorescence is a process where a substance emits long wavelength light when exposed to short wavelength light. CDOM sensors use fluorescence to characterize CDOM in situ, but can be calibrated to estimate absorption coefficients.

15. **Nitrogens as Nitrates and Nitrites** — Nitrogen, primarily as ammonium nitrate, is used in fertilizers for agriculture because it is highly soluble and

biodegradable. The main nitrogens are ammonium, sodium, potassium, and calcium salts. Several million kilograms are produced annually for this purpose.

In estuarine systems close to land, nitrogen can reach high levels that can potentially cause fish mortalities. While nitrogen is much less toxic than ammonia, levels over 30 mg/L (ppm) of nitrogen can inhibit growth, impair the immune system and cause stress in some aquatic species.

Excess nitrogen concentrations in aquatic systems usually are a result of surface runoff from agricultural or landscaped areas that have received excess fertilizer containing nitrogen. This is called eutrophication and can lead to algae blooms. As the phytoplankton dies and begins bacterial decomposition, there becomes a “Biological Oxygen Demand” (from respiring bacteria) that results in water anoxia (< 0.5 ppm DO) or “dead zones”. These blooms may cause other changes to ecosystem function, favoring some groups of organisms over others. Real-time measurements of nitritates and nitrates are undertaken with optical sensors that measure light absorption in the uv range or with wet chemistry systems that use a colorimetric assay in the visible range. Although optical systems are less labor intensive and therefore preferable, high CDOM levels in estuarine environments can overwhelm these systems which is why Kilroys in the Indian River Lagoon use wet chemistry systems to measure nitrite + nitrate.

16. **Phosphate** — Phosphorus is a non-metallic element that occurs mostly as phosphates (PO_4). Phosphates enter lakes, ponds, rivers, estuaries, and the ocean from various primary sources such as inorganic fertilizers, wastewater treatment from municipal sources, runoff from feed lots, soaps and detergents, and industrial processes. Large amounts of phosphates in a body of water tend to stimulate growth of algae and aquatic plants. If levels become too high, plant growth can accelerate resulting in waters with dense growth of algae and plants, creating an "algal bloom". As the phytoplankton dies and begins bacterial decomposition, there becomes a “Biological Oxygen Demand” (from respiring bacteria) that results in water anoxia (< 0.5 ppm DO) or “dead zones”. The recommended level of total phosphorus in estuaries and coastal ecosystems to avoid algal blooms should not exceed 0.01 to 0.1 mg/L. The only way to measure phosphorous in real time is as orthophosphate using a wet chemistry colorimetric assay.

17. **Rainfall —** Usually measured using a graduated cylinder with units expressed in centimeters (cm) or inches over a 24 hour period.

18. **Wind Direction** — Wind direction is reported by the direction from which it originates. Wind direction is usually reported in cardinal directions or in azimuth degrees. There are four cardinal directions – north, south, east and west. An azimuth is an angular measurement in a spherical coordinate system measured in degrees. For example, a wind coming from the south (cardinal) is given as 180 degrees (azimuth); one from the east is 90 degrees. A variety of instruments can be used to measure wind direction, such as a windsock or wind vane.

19. **Air temperature** — Measured in degrees Centigrade (^{0}C) or Fahrenheit (^{0}F) using a thermometer (alchohol – expansion of liquid) or thermistor (electrical current resistance based on temperature). Conversion of Centigrade and Fahrenheit is ($^0C \times 1.8 + 32 = {}^0F$).

20. **Barometric pressure** — Barometric pressure is a measure of the weight of the air in the atmosphere. A barometer is a widely used weather instrument that measures atmospheric pressure (also known as air pressure or barometric pressure). There are two main types of barometers – the most widely available and reliable mercury barometers, or the newer digital friendly Aneroid Barometer. The classic mercury barometer is typically a glass tube about 3 feet high with one end open and the other end sealed. The tube is filled with mercury. This glass tube sits upside down in a container, called the reservoir, which also contains mercury. The mercury level in the glass tube falls, creating a vacuum at the top. The barometer works by balancing the weight of mercury in the glass tube against the atmospheric pressure just like a set of scales. If the weight of mercury is less than the atmospheric pressure, the mercury level in the glass tube rises. If the weight of mercury is more than the atmospheric pressure, the mercury level falls.

Lows are usually associated with high winds, warm air, and atmospheric lifting. Because of this, lows normally produce clouds, precipitation, and other bad weather such as tropical storms and cyclones. Therefore, decreasing barometric pressure indicates storms, rain and windy weather. Rising barometric pressure indicates good, dry, and colder weather.

KEY CONCEPTS

- Real-time monitoring provides crucial information to determine the health of aquatic ecosystems and helps scientists and researchers identify problems to solve.

- All living organisms have a set of preferred environmental conditions in which they thrive, outside that range they many survive but not thrive. Far enough outside that range they will perish.

FLORIDA STANDARDS

SC.912.L.17.2
Explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

SC.912.L.17.15
Discuss the effects of technology on environmental quality.

SC.912.L.17.18
Describe how human population size and resource use relate to environmental quality.

SC.912.L.18.12
Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent.

SC.912.P.12.12
Explain how various factors, such as concentration, temperature, and presence of a catalyst affect the rate of a chemical reaction.

OCEAN LITERACY PRINCIPLES

Principle #3: The ocean is a major influence on weather and climate.

Principle #5: The ocean supports a great diversity of life and ecosystems.

CLIMATE LITERACY PRINCIPLES

2. Climate is regulated by complex interactions among components of the Earth system.

4. Climate varies over space and time through both natural and man-made processes.

5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling.

6. Human activities are impacting the climate system.

7. Climate change will have consequences for the Earth system and human lives.

ADDITIONAL RESOURCES

http://teamorca.org/orca/orca-why-monitor.cfm

http://api.kilroydata.org/public/

ACKNOWLEDGEMENTS

Thank you to Kimya Louis and LeRoy Creswell for creating this resource for Kilroy Academy. Special thanks to Indian River Impact 100 for funding Kilroy Academy.

This resource made possible with funding provided by

INDIAN RIVER IMPACT 100
WOMEN AND PHILANTHROPY MAKING A DIFFERENCE