Background Information for Interpreting Water Quality Monitoring Results

The illustrations and information on the pages following were developed by staff at Delaware's Aquatic Resources Education Center to assist students in school field trip programs and wetland adopters in better understanding and interpreting the results of their water quality monitoring investigations.

Where possible, the color spectrum for the indicator arrows was adjusted to reflect the range of colors that show up on the test kits in current use by Adopt-a-Wetland volunteers to monitor those conditions at their adopted wetland sites.

As time goes on, and new testing media become available, those colors may no longer associate, but the conditions described and ranges of impacts on aquatic life should hold fairly true.

We invite other educators and volunteer monitors to copy and use these materials for educational purposes, providing due credit is given to the source. Please direct any inquiries to:

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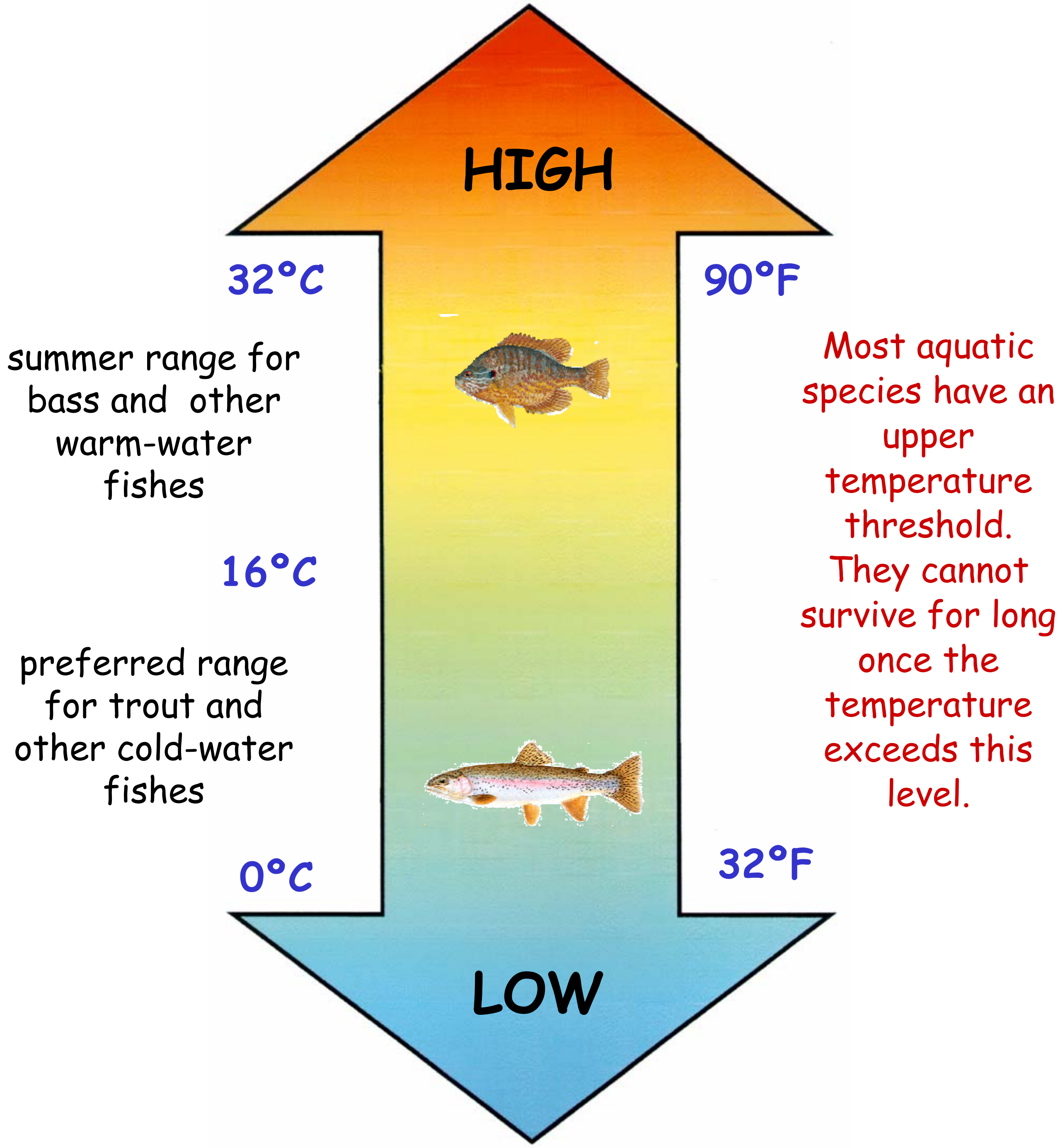
WATER TEMPERATURE

Removal of shading shoreline vegetation is a common cause of elevated temperatures in aquatic systems.



The colder the water the higher the concentration of dissolved oxygen it is able to carry.

Adopt-a-Wetland Program, Delaware Dept. of Natural Resources & Environmental Control, 2003

Temperature in Aquatic Systems

What is it?

Temperature is the measure of how hot or cold the water is at a particular time. Temperature is an important factor for aquatic life. Most aquatic organisms, including all invertebrates, amphibians, and fish are "cold-blooded." This simply means that the temperature of the blood in these animals changes to reflect the temperature of the surrounding environment. "Warm-blooded" animals, including birds and mammals, maintain a constant body temperature no matter what the temperature outside them happens to be. Most aquatic creatures have adapted to survive within a certain range of temperatures, and undergo physiological stress when exposed to temperatures outside that range. Most aquatic organisms cannot tolerate prolonged exposure to high temperatures (e.g. >90°F).

What affects water temperature?

Temperatures change seasonally and daily due to the solar energy received from the sun. Human activities can also have a big influence on temperature. Nuclear power plants, for example, use water to cool down the reactors. Where this hot water is released into the river, the temperature of the water will rise. This is called **thermal pollution**. A more common problem is the removal of trees and shrubs from stream and river banks to make way for human construction projects. This takes away shade, exposing the water to direct sunlight, resulting in a substantial increase in water temperature. The amount of turbidity in the water can also impact temperature. Water that is murky due to the presence of large amounts of suspended organic matter – such as occurs in many tidal streams – is more prone to temperature increases, as a result of the organic matter's capacity for absorbing and holding the heat from sunlight. Similarly, the amount of sediment from soil erosion (e.g. from construction projects) can cause a rise in water temperature. Sediment makes the water cloudy, and cloudy water absorbs the sun's rays causing the rise in temperature.

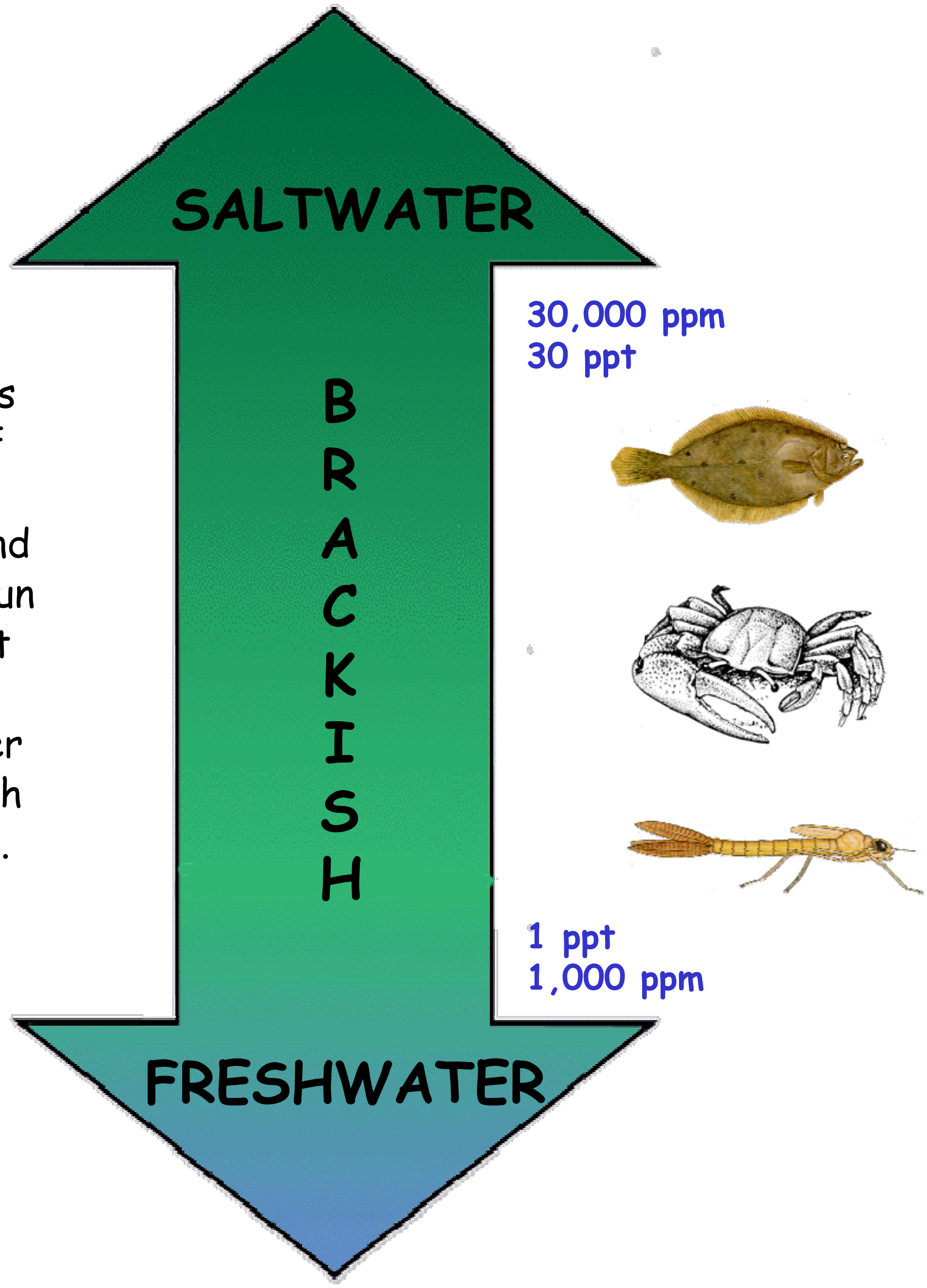
What can temperature tell us about life in the water?

Water temperature does not change as quickly as air temperature, so it provides a more stable environment for organisms to live. If water temperatures get too high, however, animals cannot cool their body temperatures, so they die from overheating. The opposite occurs when the water gets too cold, and animals cannot heat themselves up. Temperature also affects the amount of **dissolved oxygen** (D.O.) in the water. Colder water holds more D.O. than warmer water, so aquatic organisms in the summertime can face the dual stresses of higher temperatures and lowered oxygen levels. Thus at a time when activity levels are typically greater, requiring more oxygen use, high water temperatures may contribute to making such oxygen needs harder to meet. For such reasons, high-oxygen demand organisms, such as trout and stonefly nymphs, typically live in well-shaded mountain streams and other cold-water habitats. Fisheries scientists have long noted the impact of water temperature on fish distribution, recognizing coldwater fisheries, such as trout and salmon, that require water maintaining below 60°F, and warmwater fisheries, such as bass and sunfish, that reproduce in temperatures well above that level. Key life cycle events of many fishes and aquatic invertebrates are also affected by water temperatures, with warming temperatures in spring and summer often signaling the times for maturation and reproduction. In these and other ways, water temperature plays an important role in shaping the quality and character of the aquatic community.

SALINITY

Salinity levels have a major influence on what kinds of plants and animals live in an aquatic habitat.

Delaware's wealth of tidal streams and wetlands run the gamut from freshwater to brackish to marine.



Winter road salting can dramatically stress the flora and fauna of roadside freshwater pools and ditches by drastically changing the salinity levels (>3-10ppt).

Adopt-a-Wetland Program, Delaware Dept. of Natural Resources & Environmental Control, 2003

Salinity/Chloride in Aquatic Systems

What is Salinity?

Salinity is the measure of the amount of salt dissolved in the water. **Chloride** (in the case of the test strips that AAW is using for monitoring) is an indicator of salinity, since it is a key component of salt. Note: This is not to be confused with chlorine, the chemical used to disinfect water for drinking. Aquatic habitats can be classified by the level of salts dissolved in the water. The level of salt is generally expressed in *parts per thousand (ppt),* with **freshwater** having < 1 ppt, seawater/**saltwater** having >30 ppt, and **brackish** water falling between with a range of 1-29 ppt.

What affects salinity levels in water?

Tides, rainfall, and drought are just a few factors that affect salinity. Tidal wetlands, by definition, are affected twice a day by the incoming tides. These tides bring saltier water from the bay or ocean into the tidal marsh. As a result of these tidal influences, along with variations in rainfall and other water inputs, salinity levels in tidal habitats can fluctuate substantially, both daily and seasonally. High tide rushes the water in, and low tides carry it back out, so water is typically higher in salinity during high tides. The amount of rainfall also affects salinity. When it rains a lot, freshwater from the rain mixes in, lowering the salinity level. Conversely, during dry seasons, the salinity levels rise because evaporation occurs, leaving less freshwater to dilute the salts that are left behind.

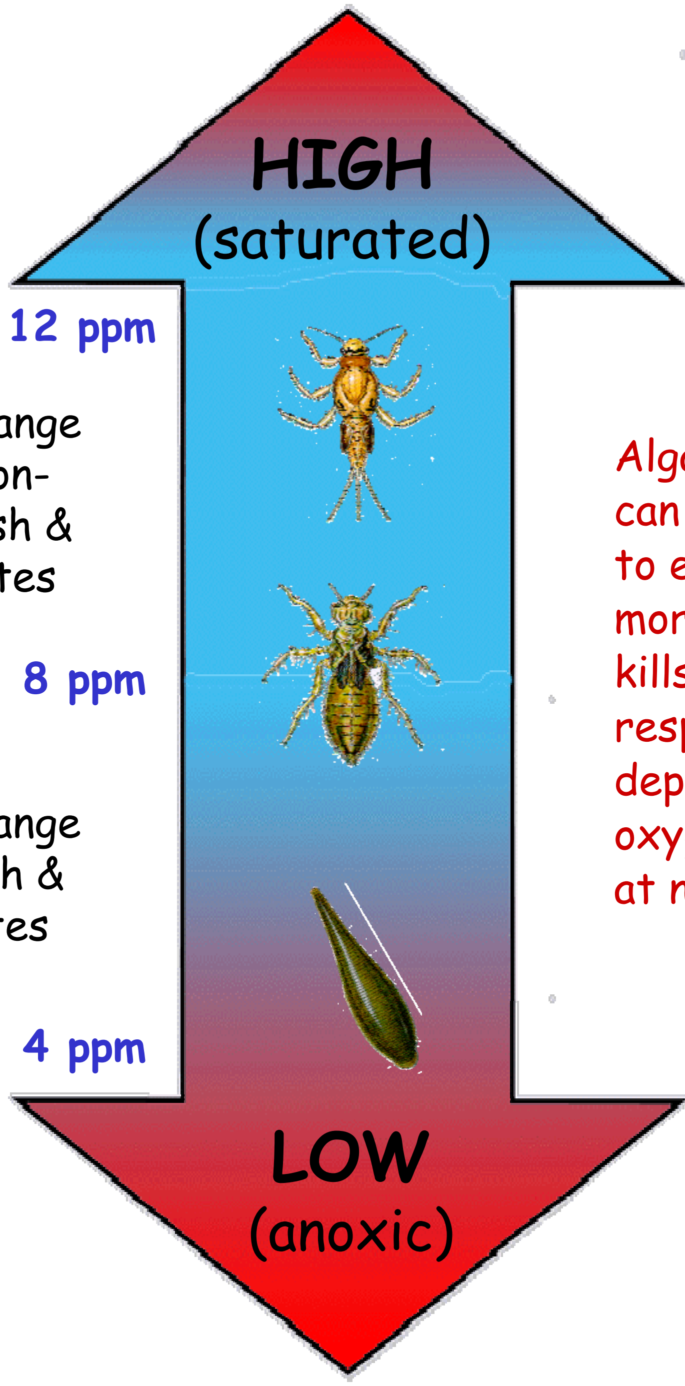
Another potential impact to salinity levels comes from the practice of 'salting' to melt snow and ice on roadways during winter. In small-volume roadside streams, ditches or pools, these salty additions can stress an otherwise freshwater-adapted flora and fauna to the point of extermination, in some cases raising salinity levels from less than 10 to as high as 10000 ppm! Sea level rise, along with increasing demand for freshwater in coastal areas can contribute to a problem called **salt-water intrusion**. As more freshwater is drawn from the ground, salt water is pulled further inland, causing salt to enter groundwater drinking supplies and irrigation wells. This is a growing concern for farmers and residents in parts of Sussex County. Water in excess of 250 ppm chloride is considered undrinkable.

How can salinity affect life in and around the water?

These salinity ranges influence the kinds of organisms found in these habitats, since some plants and animals are adapted in differing degrees to dealing with the salts, while others cannot survive them. In this way, salinity is a key factor in determining what kinds of plants and animals you may find in a stream, pond or wetland. Most plants are adapted for freshwater conditions. Plants that live in areas of high salinity are ones that have evolved special adaptations to survive high concentrations of salt. For example, *Spartina* can excrete excess salt through its leaves, and can absorb water (while blocking out salts) through its roots. Many aquatic animals have adapted to living within certain preferred salinity ranges. Very few aquatic insects, for example, can live in saltwater, but freshwater ponds and streams support a high diversity of insect life. If you fish, then you realize that different types of fish are going to be caught in the ocean, compared to your local ponds and rivers. This is a result of the salinity preferences and tolerances of different fish. Some fish, including sunfish and pike, are found mainly in freshwater, while others, such as sharks and tuna, are restricted to salty environments. Other fish species, such as the mummichog and white perch, prefer brackish water. Salinity can also play a role in fish life cycles. Several species of fish, including salmon, shad, striped bass and sturgeon live most of their life in salt water but **migrate** back to freshwater to spawn.

DISSOLVED OXYGEN (D.O.)

Supersaturated D.O. levels can occur in nutrient-enriched waters during spring/summer days due to algal blooms.



preferred range for pollution-sensitive fish & invertebrates

acceptable range for most fish & invertebrates

Algal blooms can then lead to early morning fish kills as plant respiration depletes oxygen levels at night.

High levels of organic pollution promote the growth of bacteria which depletes the oxygen supply. Only a few pollution-tolerant species are able to thrive in such waters.

Adopt-a-Wetland Program, Delaware Dept. of Natural Resources & Environmental Control, 2003

Dissolved Oxygen in Aquatic Systems

What is Dissolved Oxygen?

Oxygen is as vital to the health of aquatic life as it is to organisms living on land. Aquatic plants and animals need oxygen to survive, and so have adapted various ways of obtaining oxygen within their watery environment. Some have special appendages for taking in air from above the water surface; others have found ways of carrying air under the water with them. But fish and many other aquatic creatures can't breathe air in the same way land animals do. The oxygen they use is **dissolved** in water Hence the term 'Dissolved Oxygen' or 'D.O.' for short. The gills of fish take oxygen from the water and pass it into their bloodstream, where it can be used by muscles and organs. Many aquatic insects and crustaceans have gills also. Others can absorb oxygen directly through their body surfaces.

What affects levels of Dissolved Oxygen in water?

The amount of oxygen water can hold depends on weather, water temperature and salinity levels. Cold, fresh water holds more oxygen than warm or salty water. That is why well-shaded woodland streams tend to have higher D.O. levels than quiet, sunny open-field ponds or tidal wetlands. Current also plays a role. The fast-moving waters of streams brings oxygen from the air into the water, which is why such streams and rivers usually contain more D.O. than the slow-moving or stagnant waters of ponds and wetlands. The time of day also affects D.O. Morning to afternoon, D.O. levels rise as aquatic plants produce oxygen during **photosynthesis**. Photosynthesis requires sunlight, so plants produce oxygen during the day. At night, plants consume oxygen for **respiration**, and D.O. drops. Sometimes in summer, early morning fish kills occur as oxygen is depleted by plant/animal respiration.

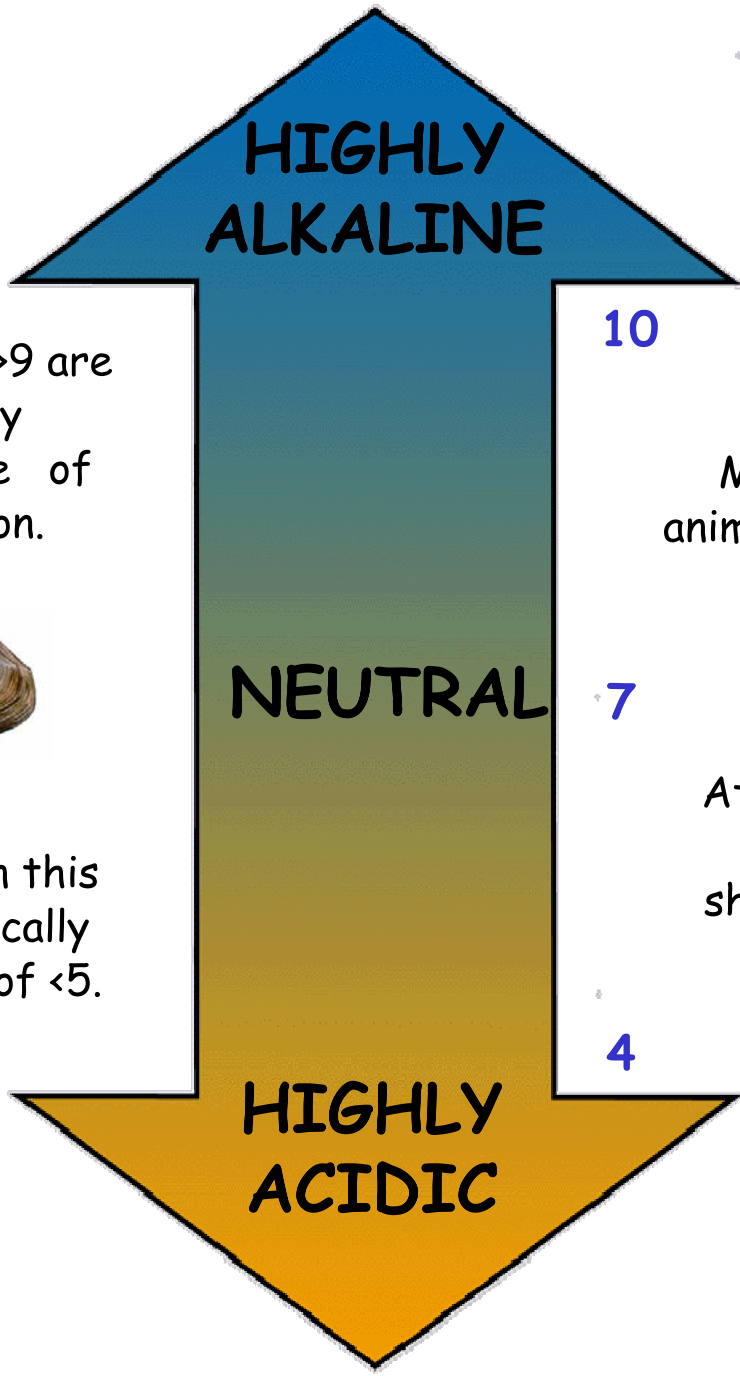
What can the level of Dissolved Oxygen tell us about life in the water?

Dissolved Oxygen concentrations range from 0 to as high as 20. In general, the higher the D.O. the greater the variety of plant and animal life the water can support. A low amount of D.O. in the water is a sign that the habitat is stressed. Water must contain around 5.0 ppm D.O. to sustain aquatic life. Each type of aquatic organism has a certain threshold level of D.O. below which it cannot survive. These levels vary from species to species, so the types of organisms found in a particular body of water can tell us a great deal about water quality. Young fish and fish eggs are very sensitive to low D.O. levels. Immature, developing aquatic insects need high levels of D.O. as well. If these insects cannot survive due to low D.O., what effect do you think that would have on the fish that live there?

Pollutants can deplete the amount of D.O. in water. If manure or untreated wastewater enters a stream or pond, bacteria builds up to decompose the pollutants. Although this decomposition process cleans up the water, it also uses up oxygen. Fertilizers used on farms or lawns can runoff into a body of water during storms. Because fertilizers contain high levels of nutrients, they promote excessive growth of aquatic plants. The plants produce oxygen during the day (cranking up D.O. levels to much higher than normal), but use it up at night, causing a rapid D.O. drop, sometimes to the point of **anoxia** (D.O. <2 ppm). Then when these plants die, they sink to the bottom and decompose, using up D.O. to the point that fish kills may occur (often early in the morning in some summer ponds and wetlands). For these reasons, the time of day that D.O. is measured can have a big impact on the reading you get.

pH

In certain areas, minerals from soils and rocks can help buffer the effects of acid rainfall.



pH levels >9 are usually indicative of pollution.

Most aquatic animals favor a pH of 6.5-8.5

Rainfall in this area typically has a pH of <5.

At pH <5.5 most fishes and shellfish cannot survive.

No fish and few invertebrates live in waters with a pH lower than 4.

Adopt-a-Wetland Program, Delaware Dept. of Natural Resources & Environmental Control, 2003

pH Effects in Aquatic Systems

What is pH?

pH is one of the easiest-to-measure and most useful-to-know water quality indicators we can monitor. pH actually measures of hydrogen ions in solution. A solution is more **acidic** when it contains more hydrogen ions. The pH is measured on a scale of 0-14 where 0 is extremely acidic, 7 is neutral and 14 is extremely basic. An unusual aspect of the pH scale, compared to other water quality indicators, is that it is logarithmic. What this means is that between each number on the scale, there is not just one number's worth of difference, but a ten-fold difference. For example lemon juice has a pH of 2, and is about ten times more acidic than vinegar, which has a pH of around 3. Acid rain having a pH of 4 is 100 times more acidic than water having a pH of 6. That is why what may seem like small changes in pH, can have major impacts on aquatic life.

What affects pH?

Several factors, both natural and human-caused, can impact pH levels of wetland waters and soils. On the natural side, vegetation can influence pH. When certain kinds of leaf litter and other plant debris decompose in water, they can release organic acids in the water, thus lowering pH. The process by which living plants take carbon dioxide out of the water during **photosynthesis** and return it during **respiration**, can also raise and lower pH (sometimes significantly in the case of algal blooms). The kinds of rocks and soils in an area also influence the pH of a body of water, changing the pH of the groundwater as it passes through them. For example, limestone rocks, which are alkaline, can neutralize or raise the pH of waters flowing over them. This ability of certain rocks and soils to release neutralizing minerals is called **buffering capacity.** This can play a big role in lessening the impact of acid rain from air pollution on aquatic acidity levels.

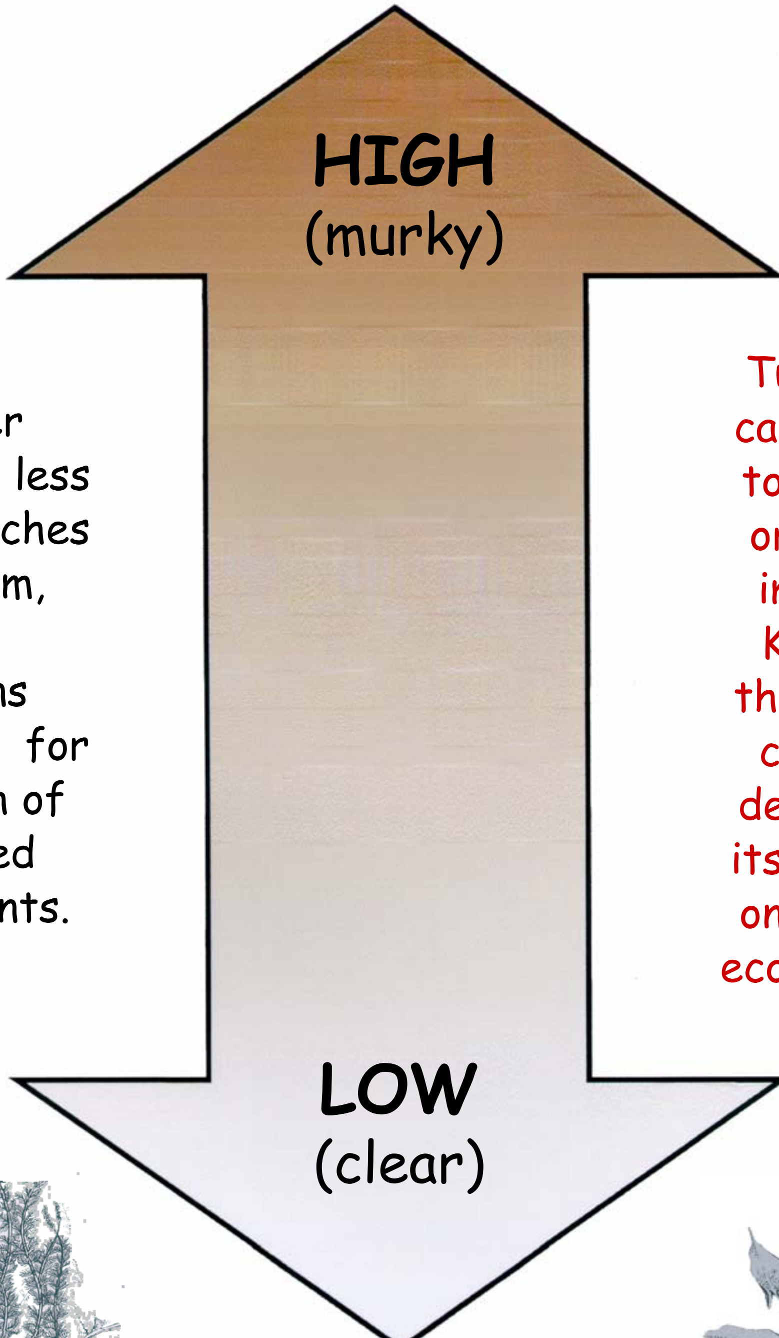
Human activity can certainly change pH levels in aquatic environments. Natural rainfall is slightly acidic (pH 5.6), but due to air pollution, the precipitation we typically get is more strongly acidic. Pollution from car exhausts and coal-burning utilities release nitrogen dioxide and sulfur dioxide. These chemicals combine with water in the atmosphere, forming sulfuric and nitric acids, which reach the earth as acid rain, snow, hail and fog. This precipitation mixes with surface water in creeks, rivers, ponds, and wetlands. New technologies to reduce power plant and vehicle emissions are helping some, but conserving consumption of fossil fuels (including use of electricity) is one thing we can all do to help. Certain industrial pollutants that are transported in runoff can also impact pH. In more rural environments, lime that is put on farm fields and home gardens to improve plant growth can have a neutralizing effect, raising the pH in waters that it runs off to.

How can pH affect life in the water?

pH is an important part of water quality, both for the organisms living in the water and for the water we consume. The pH range of most natural systems is typically between 6.0 and 8.0. This is the most favorable range for life, although some organisms can tolerate harsher conditions. Many fish and invertebrate species are sensitive to pH changes. Sudden dramatic changes in pH, such as that caused by spring snow melt, can induce "acid shock", harming sensitive life forms. Low pH from acid rain can release toxic metals into the water causing fish gills to clog, resulting in suffocation. Acid water can also hinder many fishes ability to lay eggs successfully, and can weaken bones in the adults. Acid water can also dissolve the shells of crayfish, snails and other aquatic invertebrates. Since these organisms are quite important in aquatic food webs, animals that depend on them for food are impacted as well.

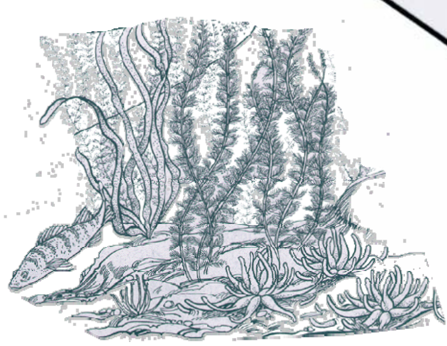
TURBIDITY

Excess turbidity can cause silt to build up, smothering the egg-laying habitat for certain fishes.



At higher turbidities, less sunlight reaches the bottom, making conditions unfavorable for the growth of submerged aquatic plants.

Turbidity can be due to natural or human impacts. Knowing the source can help determine its effects on aquatic ecosystems.



Turbidity in Aquatic Systems

What is turbidity?

Turbidity is a measure of the water's clarity or cloudiness. Scientists sometimes refer to the clearness of the water as **water clarity**. When water is cloudy or murky it is said to be 'turbid'. Turbidity is caused when **sediment**, soil and other particles that settle to the bottom are stirred up in the water. The presence of sediment in the water can cause color changes in the water from nearly white to reddish-brown. The amount of **plankton** (microscopic plants and animals) present in the water can also affect turbidity. Algal blooms can turn the water yellow, blue, green, or even red-orange, and likewise increase turbidity.

What affects turbidity?

Like other water quality indicators, turbidity can be caused by both natural and human-induced factors. Rain, wind, and tides are among the natural factors that cause sediments to get stirred up and turbidity to increase. We have all seen rivers get brown and murky after heavy rainstorms by this process. Even bottom-feeding fish, such as carp, can stir up sediments and increase turbidity. High turbidity can also be indicative of pollution or other man-made problems. For example, loose soils from construction sites or bare fields are more prone to erosion during storms. When these sediments get deposited by runoff into ponds, streams or wetlands, they can make turbidity much worse than it would normally be. Use of silt-fencing (to keep loose soils at construction sites from reaching nearby waters) and other Best Management Practices (BMPs) can help lessen such impacts. Wastes from industries and sewage can also increase turbidity. Excess nutrients running off from fertilized lawns and fields promotes the overgrowth of algae, which can likewise cloud the water. Don't forget that human activities - such as students wading into streams or adopters performing water quality tests in wetlands - can also muddy the very waters they wish to measure!

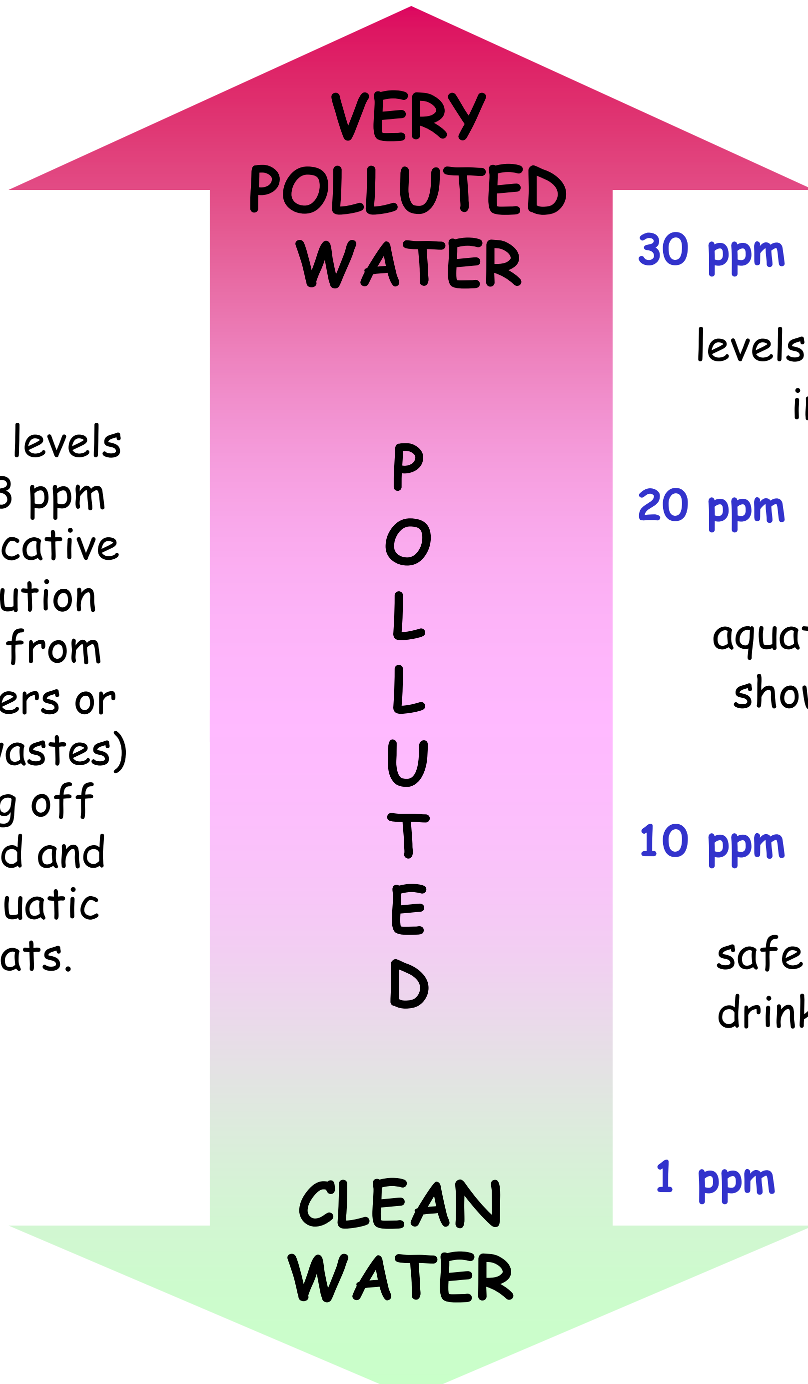
How can turbidity affect life in the water?

The presence of suspended particles in water cuts down on the amount of light that can reach underwater plants. Since plants need light to grow, they die if they can't get enough. The negative effects on such plants – referred to as Submerged Aquatic Vegetation (or SAV's) - impacts in turn, the animals (such as certain ducks) that rely on those vegetation beds for food.. Young creatures also find protection in growths of underwater plants, and without this cover they are easier for predators to find. On the other hand, turbid waters can interfere with aquatic **predators** ability to spot their **prey**. A reduction in plant growth also means less oxygen is produced. Suspended particles absorb heat from sunlight so the water becomes warmer. Remember that warm water contains less **dissolved oxygen** than cold water. So this combination of less light, warmer water and lower oxygen levels makes it difficult for some organisms to survive in high turbidity conditions. Suspended soil particles can also serve as carriers for nutrients, pesticides and other chemical pollutants. Fish, oysters and other animals that breathe through gills suffocate when their gills are clogged by sediment, and this can be exacerbated by toxic chemicals contained in those sediments. Sometimes particles of clay, silt or decayed plants and animals settle to the bottom and can smother the eggs of fish or aquatic insects. For these and other reasons, monitoring turbidity in aquatic habitats, particularly relative to any significant non-natural changes, can be quite important.

NITRATE

Nitrate levels over 30ppm may occur as a consequence of the over-use of fertilizers prior to a heavy rain.

Nitrate levels above 3 ppm are indicative of pollution (often from fertilizers or septic wastes) running off the land and into aquatic habitats.



30 ppm

levels unsafe for infants

20 ppm

aquatic diversity shows declines

10 ppm

safe range for drinking water

1 ppm

Nitrate is a limiting nutrient for estuarine plant growth. Algal blooms may occur in levels >3 ppm.

Adopt-a-Wetland Program, Delaware Dept. of Natural Resources & Environmental Control, 2003

Nitrates in Aquatic Systems

What are nitrates?

Plants and animals, both on land and in water, depend on nutrients to carry out vital life processes. **Nitrates** and **phosphates** are key nutrients in our ecosystems. Indeed, we add nitrate and phosphate-rich fertilizers to our lawns, gardens and farms to stimulate plant growth. Because of this, we generally think of nutrients as good things (as in nutrition), because they stimulate healthy growth. In naturally-occurring, healthy-balanced ecosystems, bacteria convert ammonia from animal wastes and decay into nitrates, which is typically taken up by plants to help fuel their growth; then animals eat the plants, in an ongoing cycle of growth and decay. But in today's world, **non-point source pollution** – from fertilized lawns and fields, leaching septic systems and other sources - results in greater than normal amounts of these nutrients washing into our streams, wetlands and bays., resulting in an explosion of aquatic plant growth. This can upset the natural balance of the ecosystem, triggering algal bloom events, excessive turbidity, dissolved oxygen depletion, and other problems.

What affects nitrate levels in water?

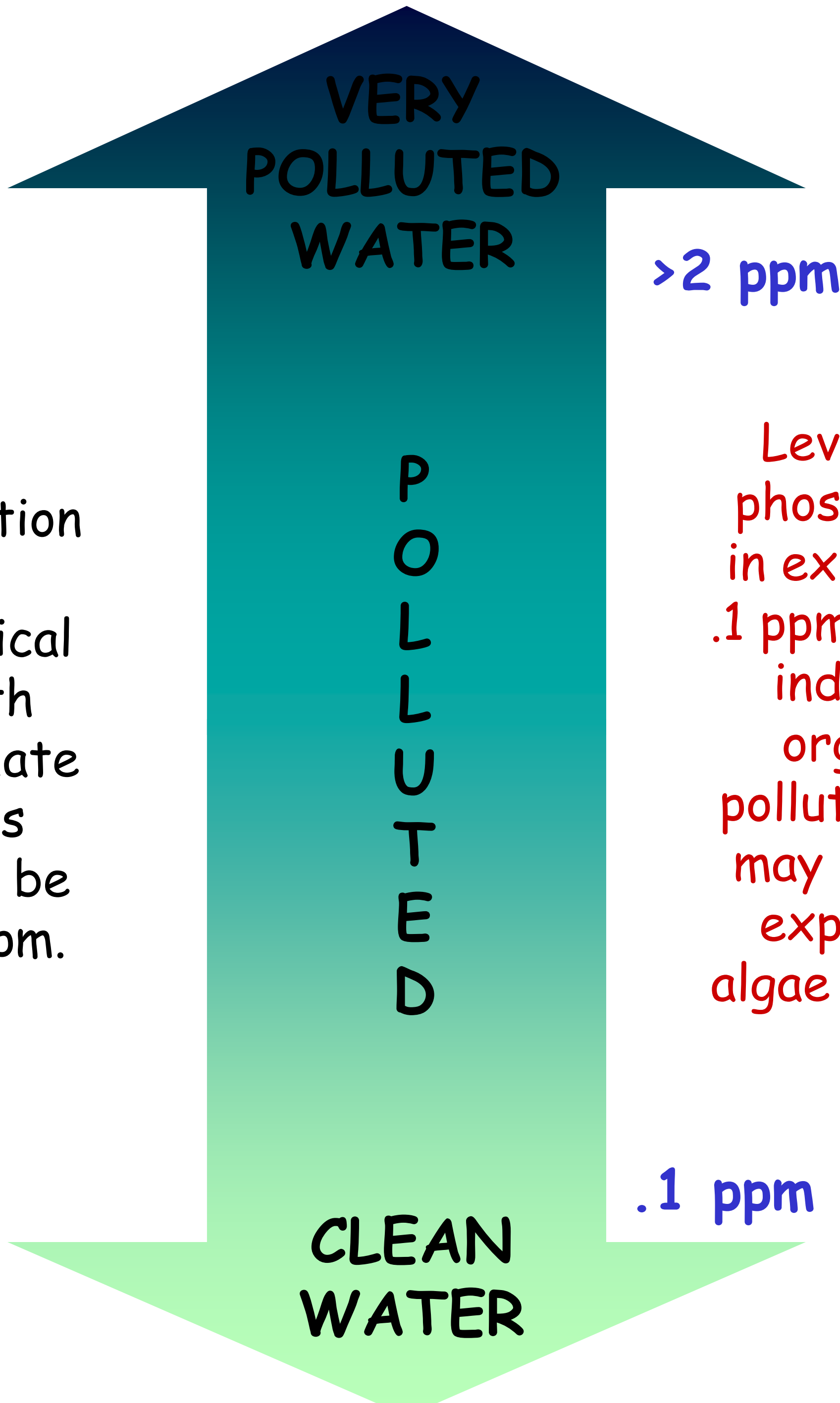
Although nitrates can enter the aquatic environment by way of natural processes, including the breakdown of plant materials, and the decomposition and waste products of dead animals, more typically, it is human influences that causes problems. This includes: runoff of fertilizers from lawns and farm fields, the seeping of sewage wastes from septic fields and animal husbandry operations, urban storm water runoff, and even nitric acids from automobile-exhaust induced acid precipitation. Such sources contribute to excessive amounts of nutrients in the aquatic habitat. In order to have nice green lawns and healthy crops, we add lots of nitrogen-rich fertilizers to the soil. These fertilizers have nutrients and minerals in them that are taken up by plants to help them grow better. More than 40 million tons of fertilizer are used each year across the United States! If fertilizers are applied improperly or in excessive amounts, the nitrates in them can makes their way through the soil and into ground or surface waters, where they can unbalance the ecosystem and pollute the water. A big push is underway in Delaware, requiring farmers to develop and implement nutrient management plans for their lands. A variety of Best Management Practices (BMPs) – including better use of nitrogen-fixing plants in crop rotation schemes, planting of winter cover crops, use of constructed wetlands and grass or forested buffer strips to filter nutrient runoff between fields and waterways – are now being applied to help reduce impacts of nutrient loadings in state waterways.

What can nitrate levels tell us about life in the water?

In sufficient amounts, nitrogen can cause excess growth of algae and other plants in aquatic habitats, which, on die-back, can deplete the dissolved oxygen so vital to fish and other aquatic life. Nutrient-loading is a serious problem affecting Delmarva waterways, particularly in the Inland Bays area downstate, where the combination of agriculture with low-lying (high water table) landscapes can lead to excess nutrients running off and into surface waters and groundwater drinking water supplies. In Kent and Sussex counties, where most of the drinking water comes from the ground, nitrate contamination of ground water is a potential health concern. Nitrate levels in water >10 ppm are considered unsafe for drinking purposes, mainly due to health risks they present to pregnant mothers, unborn babies and infants, through what's called the "blue baby syndrome" (**methemoglobinemia**). Nitrates harm infants more than adults because infants have a less-acid stomach pH, resulting in nitrates being converted to the toxic nitrite form, which reacts with hemoglobin, hindering its ability to carry oxygen throughout the body. Under extreme conditions, this can cause cyanosis, leading to coma and even death. Other than the indirect effects caused by algal bloom-induced dissolved oxygen depletion, impacts of elevated nitrate levels on aquatic life forms are not well documented.

PHOSPHATE

Extremely high phosphate levels are most likely tied to large volumes of raw sewage or animal wastes entering a waterway.



For protection of ecological health phosphate levels should be <.05 ppm.

Levels of phosphates in excess of .1 ppm usually indicate organic pollution and may lead to explosive algae growth.

Natural background levels of phosphate that support plant life are generally <.03.

Adopt-a-Wetland Program, Delaware Dept. of Natural Resources & Environmental Control, 2003

Phosphates in Aquatic Systems

What are phosphates?

Phosphates, like nitrates, are key nutrients in our land and water ecosystems. They are a by-product of the breakdown of plants and animals, and are especially concentrated in animal (and human) wastes. Like nitrates, they are also a key component of the fertilizers we use to promote plant growth on land. While nitrogen-rich fertilizers are typically used to enhance green, leafy growth (e.g. to make our lawns nice and lush and green), phosphorus-rich fertilizers are usually applied to stimulate better flowering and fruiting (e.g. to promote better yields in our home flower and vegetable gardens). Plants in aquatic systems respond to phosphates much as they do nitrates, leading to algal bloom-type problems as described in the Dissolved Oxygen page. One key difference is that phosphate tends to be the limiting nutrient in freshwater, whereas nitrates are more limiting in salt water. This means that relatively small levels of phosphates can trigger a major algal bloom event in freshwater bodies.

What affects phosphate levels in water?

Although phosphates can enter the aquatic environment by way of natural processes, including the breakdown of plant materials, and the decomposition and waste products of dead animals, levels above 0.1 ppm usually indicate human-influenced pollution sources. This includes runoff into waterways from: wastes produced by poultry, dairy and other animal farming operations that are not properly managed, concentrations of droppings from nuisance animals (e.g. Canada geese) and even household pets, seeping of sewage wastes from improperly-sited or poorly-maintained home septic systems, and inadequate sewage treatment plants, including storm sewer systems that overload a treatment plant's capacity during flood events, causing untreated sewage wastes to be released directly into streams. Conversion of such systems to safer, less-likely-to-pollute technologies can be extremely expensive for a municipality, and the same goes for homeowners needing to replace their failing septic systems. Years ago, a key source of phosphates in water was from laundry detergents, but awareness of that led to changes (low-phosphate detergents) that have reduced these inputs. As with nitrates, improved nutrient management practices for managing animal wastes from farming activities are also having a positive impact. This includes, in addition to the use of constructed wetlands and buffer strips to filter and uptake nutrients coming off fields (before they get to the water), development of manure management plans and technologies for converting waste products into less harmful materials.

What can phosphate levels tell us about life in the water?

In even small amounts, phosphates can promote excess growth of algae and other plants in aquatic habitats, which, on die-back, can deplete the dissolved oxygen so vital to fish and other aquatic life. Several years ago, unusual outbreaks of a kind of micro-algae called Pfeisteria occurred in several coastal state waterways, resulting in fish developing bloody body sores and contributing to large kills of certain species (e.g. menhaden). Although dissolved oxygen depletion was often associated with these outbreaks, and in some instances a causal link was suggested through animal waste overloading, the connection of phosphate-loading to Pfeisteria blooms and subsequent fish kills was never clearly established. Although Pfeisteria-like organisms have been found occasionally in Delaware's estuarine waterways, no fish kills to date have been directly attributable to major outbreaks of this organism. Nevertheless, nutrient-loading remains a serious problem affecting Delmarva waterways, particularly in the Inland Bays area downstate, where the combination of agriculture, development and low-lying (high water table) landscapes can contribute to phosphate-induced algal blooms and oxygen depletion. Phosphate levels as little as 0.15 ppm are considered sufficient to trigger algal blooms in surface waters, and levels as low as .5 ppm are considered unsafe for drinking.