SECTION II

TEMPERATURE CHANGES IN AQUATIC HABITATS

TEACHER'S INFORMATION

Different substances change temperatures at different RATES even when they are placed in the same conditions because different materials have different SPECIFIC HEATS. The same amount of heat added to different substances with the same initial temperature will result in different final temperatures. Water has a very high specific heat. It absorbs a great deal of heat before its temperature rises much. Likewise, water cools very slowly and gives off a great deal of heat when it cools. Consequently, aquatic environments do not change temperature very fast and they change much slower than land habitats. Water is a stable place to live with regard to temperature. The larger the body of water, the more stable.

One consequence of the high specific heat of water is that land masses next to large bodies of water have more moderate climates than those at the same latitude and altitude farther away from water. The water gives off heat during periods when the land is colder and absorbs heat when the land mass is warmer, thus buffering the temperature of the land. You can see this effect by looking up the planting diagram for trees and shrubs given in seed catalogs or in garden books. There are warm bands that extend up both coasts, especially the East Coast with its Gulf Stream current that carries warm water up from the tropics to the northern Atlantic Ocean.

Temperature affects the density of water. Differences in density may result in thermal STRATIFICATION in many bodies of water, with warmer surface waters floating on more dense, colder bottom water. The area of the water where cold and warm water meet is called the THERMOCLINE. It is the region at which the temperature changes rapidly. When stratification is caused by salinity differences, the point at which the saltier water meets the fresh water floating on it is called the HALOCLINE.

Fresh water is most dense, or heaviest, at 4oC (39oF). Water colder or warmer than 4oC floats on the 4oC water. Because of this, ice forms at the surface of a lake or pond which may remain unfrozen at the bottom during winter, providing a place for animals to live. The ice may prevent oxygen from entering the water, however.

These density differences also affect the distribution of nutrients and oxygen in water environments. Cold bottom water is frequently nutrient-rich because things that die sink to the bottom and are decomposed there, releasing nutrients like nitrogen and phosphate to the water. The act of decomposition may also deplete bottom water of oxygen. Wind and currents or upwelling may help to mix bottom water with surface water. Bottom water may also reach the surface as surface water cools in fall and its density may become greater than that of the bottom water. When this happens, surface water sinks and displaces bottom water in a process called TURNOVER. Turnover is often followed by a rapid increase in algal growth as the needed nutrients have been delivered to the surface where algae are doing PHOTOSYNTHESIS.

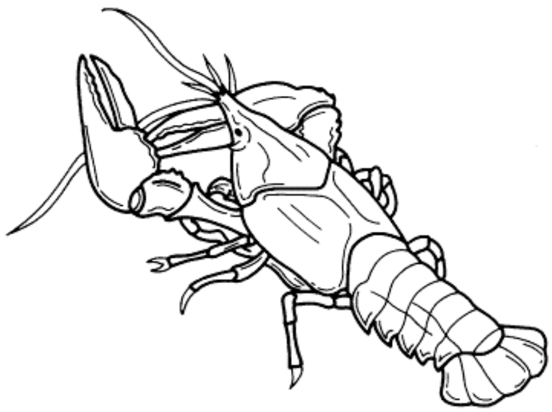
Water temperature has a direct effect on the plants and animals living there. Plants and most animals are said to be cold-blooded or ECTOTHERMIC, meaning that their temperature is determined by the environment. Their respiration rates may change with temperature. Thus, their rates of oxygen usage are dependent on their temperature. They use less oxygen when it is cold and more when it is warm because respiration, which is a chemical reaction, goes faster at a warm temperature than a cold one. The increased rates of respiration in warm weather may allow greater activity. Most aquatic organisms are ectothermic.

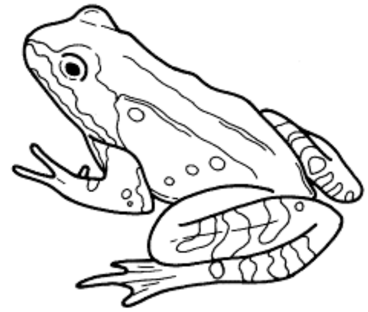
Birds, mammals and special members of some other groups are said to be warm-blooded or ENDOTHERMIC. They maintain a constant internal temperature or at least maintain an internal temperature above that of the environment in a cold environment. This constant, warm temperature means that respiration can take place in their cells at the same rate whether it is warm or cold outside. In this case, their oxygen use is greatest in very cold or very hot environments in which they have to do increased respiration to regulate their temperature.

Many ectothermic plants and animals can change their respiration rates over time to be most efficient at the temperature at which they are held. They ACCLIMATE to a specific temperature. The plants you use may be acclimated at a high or low temperature. This will not negate your results, but may account for high respiration rates at low temperatures if your plants have been living in the cold for a long time and are acclimated to the cold.

Animals that live in deep water in the ocean or near the poles experience such constant water temperatures that they are ADAPTED to these temperatures completely and may be killed by a rise of a very few degrees. On the other hand, plants and animals living in smaller bodies of water or in shallow water near shore in larger ones where large temperature changes are common are generally adapted to seasonal changes in temperature.

RESPIRATION generally requires oxygen. Some kinds of animals are well adapted to low oxygen environments such as mud. Worms that live in mud or turtles that bury themselves in the mud over the winter have special ways of dealing with low oxygen. The worms have blood pigments (like hemoglobin in humans) that are very efficient at picking up what oxygen is available. The turtles go into a special state in which they used very little oxygen. They may even make cellular energy without using oxygen, a process referred to as ANAEROBIC RESPIRATION.





Most water animals, however, depend on a good supply of oxygen from their environment. When it is not available, they may have several options. They may increase the rate at which water passes over their gills. This is like breathing faster when you run because you are using oxygen faster. It is called increased VENTILATION. Another tactic is to move to a better location. In really low oxygen situations, animals like crabs and eels will even crawl out of the water.

Under natural circumstances, animals generally are not exposed to great oxygen stress to which they are not adapted. Occasionally, unusual environmental conditions like prolonged high temperatures may cause abnormally low oxygen in some water habitats. A small pond on a very hot day or night might have low oxygen levels due to heated water and high biological activity (respiration). Frequently, low oxygen levels are caused by human activities. Heating water (thermal pollution) lowers the oxygen it holds. Humans also cause low oxygen in aquatic environments by adding material to the water which will be decayed or decomposed by bacteria. Sewage, plant and animal waste products from food processing plants, animal wastes from farms or feed lots, and organic waste from factories can all serve as food for bacteria living in the water. These bacteria use a great deal of oxygen in respiration as they decompose the wastes. When the problem is compounded by hot water due to climate or thermal pollution, animals that live in the water can die from low oxygen.

Temperature changes are a result of seasonal changes. Another seasonal phenomenon is the migration of many species for reproduction or feeding which is keyed to these temperature changes. Humpback whales migrate from warm tropical waters where they calve in the winter to colder temperate waters where food is abundant during the spring, summer and fall.

Many fish species migrate seasonally for the purpose of SPAWNING (laying eggs which get fertilized). Most are fish that live as adults in the oceans, but enter estuaries and spawn in the estuary or in its rivers. These fish are called ANADROMOUS (from the Greek for running upward). Familiar anadromous fish include salmon, herring, shad, and striped bass. There are some fish species which do the reverse. They live in fresh water and migrate to salt water to reproduce. The American and European eels are the best known members of this group called CATADROMOUS fish. Migrations are timed to take advantage of specific seasonal changes in water flow, salinity, water temperature and food availability.

As with all species, the total possible number of offspring is much greater than the actual number in each generation because of predation, competition, variations in physical characteristics such as temperature or rain fall and other causes. In the case of some species, the difference between possible and actual is huge.

In the simulation game about seasonal migration in this section, herring are used as an example of an anadromous fish. Herring occur throughout the Northern Hemisphere. The herring family includes members which use a complete variety of reproductive strategies. Some species live and spawn at sea. Others may spawn at sea and mature and feed in estuaries (menhaden of eastern U. S. coast) or spawn in freshwater tributaries and migrate to the ocean as adults. It is these last, the anadromous herring of the eastern United States which are used in the game. Blueback herring are also called glut herring for the huge numbers which once glutted the streams each spring. Prior to the coming of Europeans, these fish existed in incredible numbers. They have been greatly reduced by human actions.

Another anadromous fish, the striped bass, is one of the most prized sportfish on the East Coast. Adult bass in the Chesapeake Bay region spend their winters in deep water in the mid or lower Bay. Since this is a stratified estuary, the deeper water is saltier. It also has more constant temperatures. Larger adults migrate out into the Atlantic Ocean as far north as Nova Scotia during the winter and early spring. Come late spring (April-June) the adult fish move up the Chesapeake Bay into its tributaries to tidal freshwater areas or only slightly brackish waters to spawn. Strong river flow is important to keep the eggs afloat. During the summer season, some striped bass remain in the tributaries, but many move great distances to feed. After the eggs hatch, the larvae migrate downstream as they feed and grow. By winter they join the older fish in deeper water. It appears that these fish, like other anadromous fish, return to spawn in the tributary in which they were born each year. If all the fish from one river are killed, that tributary will not have striped bass again.

For reasons that are subject to debate and that include barriers to migration such as dams, water pollution, lack of larval food, acid rain, and overfishing among others, the striped bass populations of the Chesapeake Bay were in decline. Maryland had a ban on catching them which appears to have helped increase their numbers. They are once again being caught since they have increased.