Field Manual for Water Quality Monitoring

Temperature

Many of the physical, biological, and chemical characteristics of a river are dependent upon temperature. Temperature affects: the solubility of oxygen in water, the rate of photosynthesis by algae and aquatic plants, the metabolic rates of aquatic organisms and the sensitivity of organisms to toxic wastes, parasites and disease.

Gases are more soluble in cool water than in warm water, therefore, cool water can hold more oxygen than warm water. As water temperature increases, the rate of photosynthesis and plant growth also increases. Increased growth of certain algae and plankton (microscopic floating plants and animals) can occur if there is a rise in temperature. An increase in plant growth and photosynthesis means more oxygen is produced, but it also means more plant respiration and decay will use oxygen.

The metabolic rate of organisms also increases with increasing water temperature. Metabolism increases with increasing water temperature. Increased metabolism increases the oxygen demand of organisms like fish, aquatic insects and aerobic bacteria. Very high or low water temperatures may exceed the tolerance limit for aquatic organisms. Some aquatic organisms like trout and stonefly nymphs require cooler water temperatures than carp and dragonfly nymphs. Increasing water temperatures also accelerates the life cycles of many aquatic insects. This may lead to undesirable consequences for animals which feed on these insects, particularly birds that depend on emerging insects during their northern migration flight.

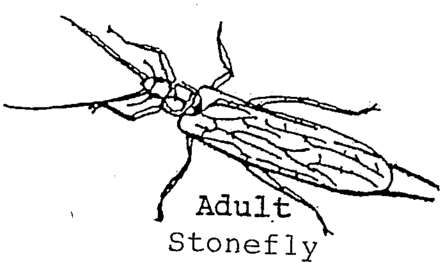
Many fish species become more vulnerable to damage from toxic wastes, parasites and diseases with increasing temperatures. Fish become more vulnerable because they are in a weakened condition from lack of dissolved oxygen or under stress from higher water temperatures.

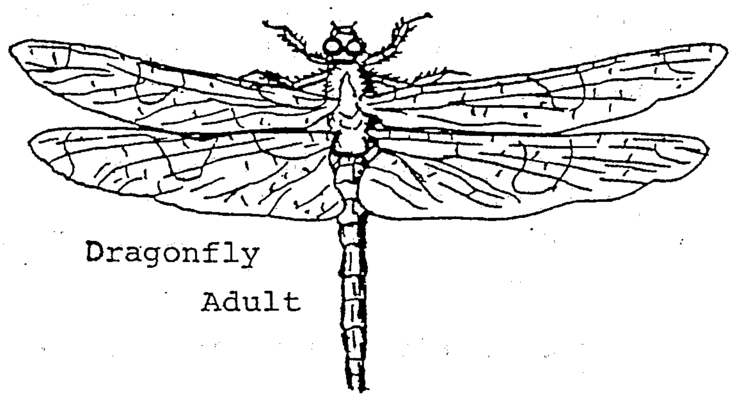
What are some human influences of impacts upon river temperature?

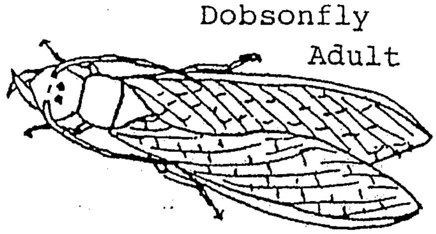
During the hot summer months the sun heats up urban surfaces such as streets, sidewalks, and parking lots. Storm water runoff from these hot surfaces contributes warmer water to the river. Another source of warmer water comes from cooling water of industry and other industrial wastes. A good example of cooling water discharge is from nuclear power plants; this water is usually warmer than receiving waters and is called thermal pollution.

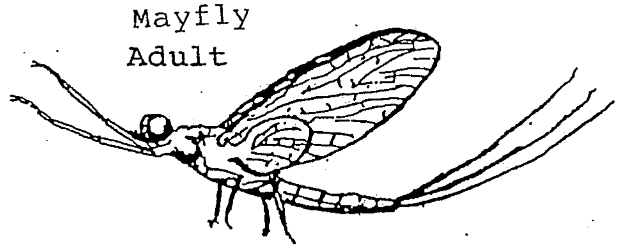
People may impact river temperatures by cutting down trees which help shade the river from the sun; direct sunlight is a major factor in the warming of rivers. People may also contribute to warmer water by causing soil erosion along the river bank. Erosion can also be caused by removing trees and other vegetation, poor farming practices (plowing near the stream bank), highway construction and other construction. Soil erosion increases the amount of suspended solids (turbidity) carried by the river. Suspended solids make the water turbid or very cloudy. This cloudy water absorbs the sun's rays, warming the water. Can you think of any other ways people disturb the soil?

Temperature	Example of Life
> 68°F or 20°C (warm water)	Abundant: plant life, fish, diseases Species: bass, crappie, bluegill, carp, catfish
< 68°F or 20°C (cold water) upper range 55-68°F, 13-20°C	Decreased: plant life, fish, disease Species: salmon, trout, stonefly nymphs, mayfly nymphs, caddisfly larvae, water beetles and water striders
lower range < 55°F	trout, caddisfly larvae, stonefly nymphs and mayfly nymphs









CALIFORNIA DEPARTMENT OF FISH AND GAME
SALMONIDS IN THE CLASSROOM

Background Information on pH and Dissolved Oxygen

pH --

The pH of a stream indicates how acid or basic the water is on a scale from 0 to 14. On this scale, 7 is neutral, 6 to 0 is acid with 0 being most acid and 8 to 14 is alkaline, with 14 being most alkaline.

The pH value of water is a measure of the hydrogen ion (H+) concentration. Water (H_2O) contains both H+ ions and OH- ions and is considered neutral (pH 7), neither acidic or basic. If water contains more H+ than OH- ions, the water is considered acidic with a pH less than 7. If water contains more OH- ions than H+ ions, water is considered basic with a pH greater than 7. As the numbers decrease from pH 7 to pH 0, the water becomes increasingly more acidic and as the numbers increase from pH 7 to pH 14, the water becomes increasingly more basic.

The pH of unpolluted waters will depend on the local geology and physical conditions. Bog waters are usually acidic (pH 4-5) but normally unpolluted water is around neutral (6-8.5) although wide variations can occur. A pH of 5.5 to 8.2 is generally thought to be the healthiest for diverse aquatic life, especially the salmonid species of fish. The optimum pH for a species will depend on temperature, dissolved oxygen (D.O.) and alkalinity of the water.

Alkalinity is a measure of the ability of the water to buffer sudden changes in pH. Alkalinity is caused by the carbonates, bicarbonates and hydroxides. Ammonia, phosphates and carbonic acid also contribute to alkalinity. A high pH with a high alkalinity reading may indicate industrial waste.

Increased amounts of nitrogen oxides (NO_x) and sulfur dioxide (SO_2), primarily from automobile and coal-fired power plant emissions, are converted to nitric acid and sulfuric acid in the atmosphere. These acids fall to earth and enter the water in the form of snow and rain. This phenomenon is called acid rain and is responsible for thousands of lakes in eastern Canada, northeastern United States, Sweden, and Finland becoming acidic. In many areas of the United States, limestone acts as a buffer to very acid precipitation; that is, the alkaline (basic) limestone neutralizes the effect the acids might have on lakes and streams. The areas most affected by acid rain do no have this buffering capacity.

The areas hardest hit by acid rain and snow are downwind of urban/industrial areas and have no buffering capacity in the form of limestone.. Changes in the pH value of water are important. At extremely high or low pH values (9.6 or 4.5) the water becomes unsuitable for most organisms.

A sudden change in the pH of a stream could cause some dissolved materials to become toxic to aquatic life. Major problems occur in lakes with a pH below 5 and in streams which receive a massive acid dose as the acidic snow melts in the spring. Immature stages of aquatic insects and immature fish are extremely sensitive to these low pH values (below 5). Very acidic lakes and streams cause leaching of heavy metals into the water. Heavy metals include copper and aluminum, which accumulate on the gills of fish. Heavy metals can also cause deformities in young fish, reducing their chance of survival.

If the pH suddenly becomes very acid or very alkaline, it might be caused by industrial waste. If there is an increase in pH while at the same time there is a decrease in D.O. and an increase in ammonia, nitrates and phosphates, it may mean a sewage discharge.

Remember, for every one-unit change (from 7 to 6 or 5 to 4, etc.) on the pH scale there is a ten-fold increase in acidity. The average pH of rainfall over much of the northeastern United States is 4.3, or roughly ten times more acidic than normal rainfall of 5 - 5.6. Lakes of pH 4 are 100 times more acidic than lakes of pH 6, and so on.

Dissolved Oxygen (D.O.) --

Dissolved Oxygen (D.O.) is the single most important test that can indicate organic pollution. Dissolved oxygen is an essential element for the maintenance of healthy lakes and rivers. Most aquatic plants and the animals need oxygen dissolved in the water for survival.

Some natural factors which affect dissolved oxygen levels particularly in rivers include: temperature, flow, season, and the physical structure of the river. Cold water can hold more oxygen than warmer water because gases are more soluble in cooler water.

The oxygen enters the water as a result of photosynthesis and from the atmosphere. Thus the amount of oxygen the water is receiving and able to retain depends on the temperature of the water, the number of green plants in the water, whether it is sunny or cloudy day (affecting photosynthesis), and how turbulent the water is (rapids increase the surface area of water exposed to the atmosphere). Under normal conditions the D.O. content of the water is near the saturation level of the water. The saturation level depends on the water temperature.

In lakes, impounded rivers and large slow-moving river reaches, algae and larger aquatic plants are more abundant than in rivers with significant current. From morning through the afternoon hours, dissolved oxygen levels rise through photosynthesis. Late in the afternoon, dissolved oxygen levels are highest. As the sun sets, photosynthesis stops, but plant and animal respiration continues to consume oxygen. Just before dawn, dissolved oxygen levels fall to their lowest level. Large fluctuations in dissolved oxygen from late afternoon to early morning are characteristic of lakes and impounded and slow-moving rivers with extensive plant growth. Dissolved oxygen levels may fall below 4 mg/l in such water, the minimum amount needed for warmwater fish like bluegill, bass, and pike.

Flow velocity and season can be related in some rivers. During dry periods (summers), river flow is reduced. In some rivers this reduction in flow velocity means less mixing of the water with the atmosphere and consequently lower dissolved oxygen levels.

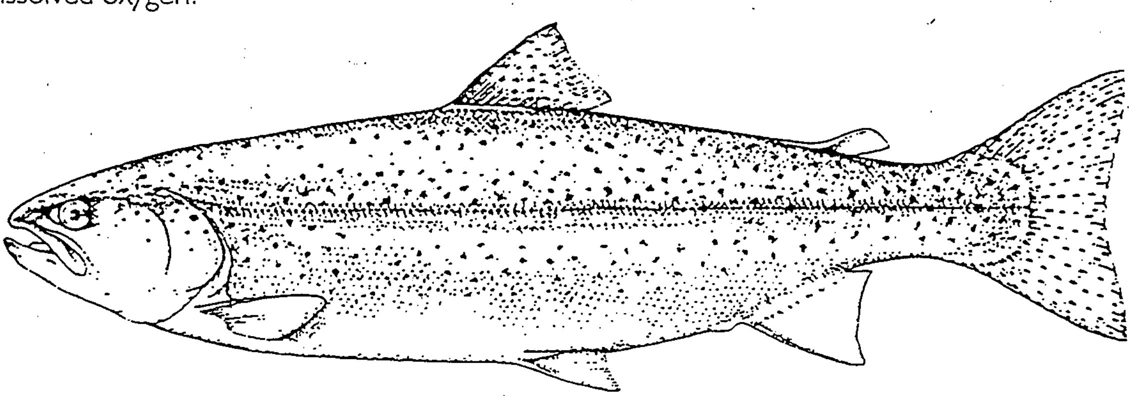
Organic wastes entering the rivers with reduced flows exert a great demand on available dissolved oxygen. If the physical structure of the river is altered through impoundments, current velocity is drastically reduced and less mixing of the water with the atmosphere occurs. Impounded river reaches may support extensive aquatic plant growth and collect organic materials washing in from upriver.

Depletion or reduction of D.O. will occur if decomposing organic matter is added to the water. The bacteria which carry on the decomposition process utilize oxygen for respiration. The more organic matter there is in the water, the greater the increase in the number of bacteria will be. The increased number of bacteria will use more dissolved oxygen, therefore leaving less dissolved oxygen in the water the other aquatic organisms. Young fish and fish eggs are particularly sensitive to D.O. in the water.

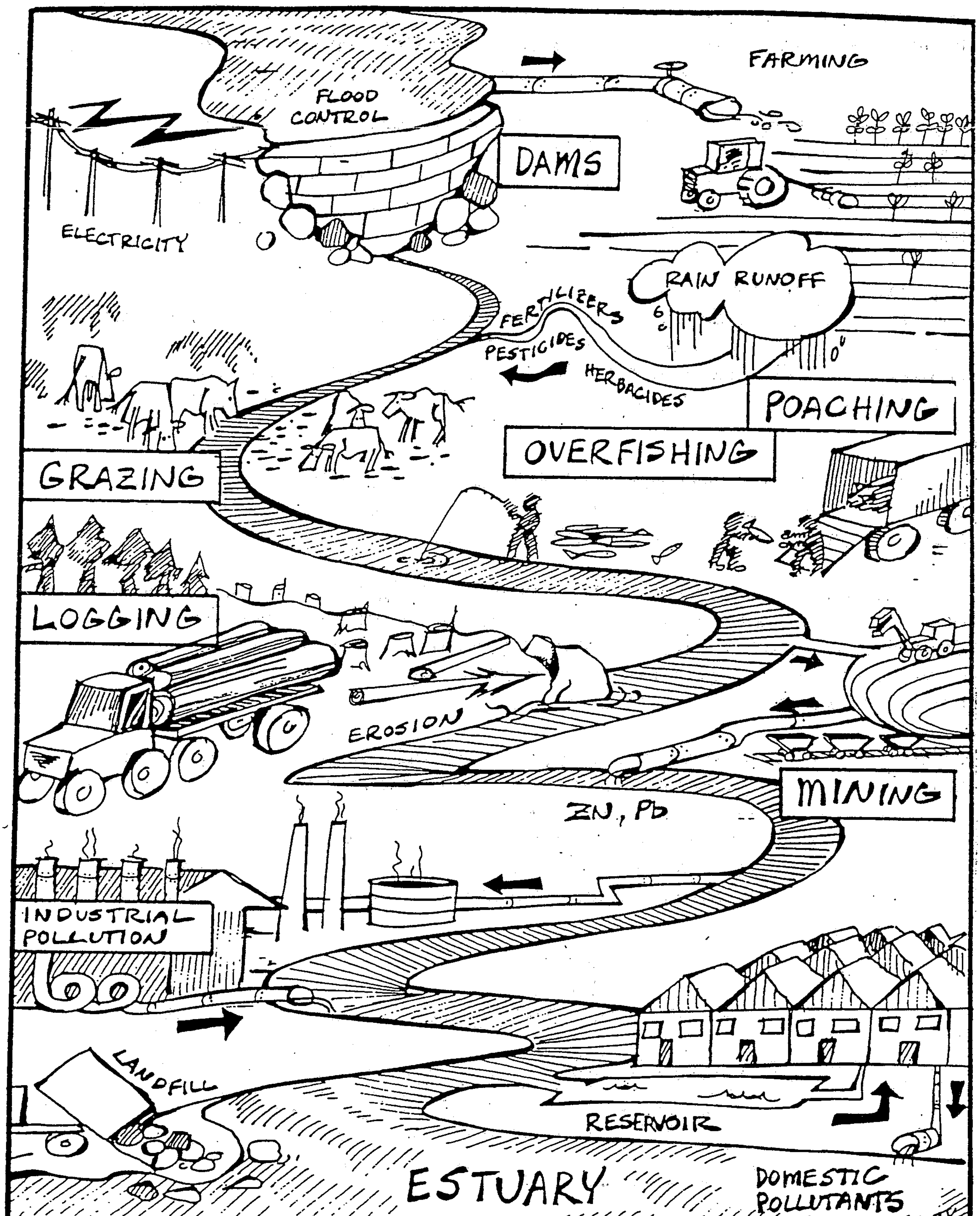
The decaying organic matter which causes a depletion of oxygen may be from sewage, urban and agricultural runoff, industrial waste, natural sources such as leaves falling into the water, decaying aquatic plants, algae after an algae bloom or fish after a fish kill.

Some aquatic organisms like pike and trout required medium to high levels of dissolved oxygen to live. Other aquatic organisms like carp and catfish flourish in waters of low dissolved oxygen. The dissolved oxygen level of water is one indicator of the health of aquatic ecosystems. Waters of consistently high dissolved oxygen are usually considered healthy and stable aquatic ecosystems capable of supporting many different kinds of aquatic organisms.

Sudden and gradual depletions in dissolved oxygen can cause major shifts in the kinds and diversity of aquatic organisms--from pollution intolerant species to pollution tolerant species and from high to low organism diversity. With a drop in dissolved oxygen levels many different kinds of aquatic insects--mayfly nymphs, stonefly nymphs, caddisfly larvae, and beetle larvae--might be reduced to a few different kinds such as aquatic worms and fly larvae that are tolerant of these levels. Nuisance algae and anaerobic organisms (which live without oxygen) may also become abundant in water of low dissolved oxygen.



RIVER USES THAT THREATEN WILD FISH



DISSOLVED OXYGEN TEST INSTRUCTIONS

High Range Test

1. Fill the Dissolved Oxygen bottle (round bottle with glass stopper) with the water to be tested by allowing the water to overflow the bottle. To avoid trapping air bubbles in the bottle incline the bottle slightly and insert the stopper with a quick thrust. This will force air bubbles out. If bubbles become trapped in the bottle in Steps 2 or 4 the sample should be discarded before repeating the test.

2. Use the clippers to open one Dissolved Oxygen 1 Reagent Powder Pillow and one dissolved Oxygen 2 Reagent Powder Pillow. Add the contents of each of the pillows to the bottle. Stopper the bottle carefully to exclude air bubbles. Grip the bottle and stopper firmly; shake vigorously to mix. A flocculant (floc) precipitate will be formed. If oxygen is present in the sample the precipitate will be brownish orange in color. A small amount of powdered reagent may remain stuck to the bottom of the bottle. This will not affect the test results.

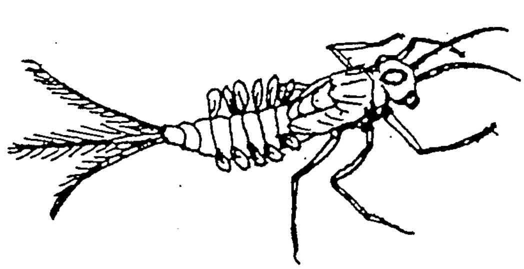
3. Allow the sample to stand until the floc has settled halfway in the bottle, leaving the upper half of the sample clear. Shake the bottle again. Again let it stand until the upper half of the sample is clear. Note the floc will not settle in samples with high concentrations of chloride, such as sea water. No interference with the test results will occur as long as the sample is allowed to stand for four or five minutes.

4. Use the clippers to open one Dissolved Oxygen 3 Reagent Powder Pillow. Remove the stopper from the bottle and add the contents of the pillow. Carefully restopper the bottle and shake to mix. The floc will dissolve and a yellow color will develop if oxygen is present.

5. Fill the plastic measuring tube level full of the sample prepared in Steps 1 through 4. Pour the sample into the square mixing bottle.

6. Add Sodium Thiosulfate Standard Solution drop by drop to the mixing bottle, swirling to mix after each drop. Hold the dropper vertically above the bottle and count each drop as it is added. Continue to add drops until the sample changes from yellow to colorless.

7. Each drop used to bring about the color change in Step 6 is equal to 1mg/L of dissolved oxygen (DO).



Low Range Test

If the result of Step 7 is very low (3mg/L or less) it is advisable to obtain a more sensitive test. To do so:

1. Use the prepared sample left from Step 4 in the High Range Test. Pour off the contents of the DO Bottle until the level just reaches the mark (30mL) on the bottle.

2. Add Sodium Thiosulfate Standard Solution drop by drop directly to the DO bottle. Count each drop as it is added and swirl the bottle constantly to mix while adding the titrant. Continue to add drops until the sample changes from yellow to colorless.

3. Each drop of PAO Standard Solution used to bring about the color change in Step 2 is equal to 0.2 mg/L dissolved oxygen.