LESSON 3.1: WATER QUALITY TESTING

(Part of the HEALTHY WATERSHED, HEALTHY SALMON Lesson Plan Series)

GRADE LEVEL: Grades 4-9 *(this can be adapted for the appropriate grade level)*

OVERVIEW

In this lesson plan, students will learn about the important testing methods for four important parameters of water quality for salmon habitat (dissolved oxygen, temperature, pH and turbidity), and additional tests that can be done to determine levels of ammonia, nitrates and phosphates in the water.

BACKGROUND INFORMATION

Water is one of our most precious resources. The Earth is about 71% water, but not all of it is readily available and safe for us to drink. About 97.5% of the Earth's water is salt water. About 1.5% of the Earth's water is not accessible because it is trapped in glaciers, ice fields and snow fields, which leaves only 1% of water accessible to us for drinking, cleaning, and recreating!

With such a small amount of fresh water available for life, it is so important that we keep it healthy and clean. Water pollution is any chemical, physical or biological change in water quality that harms living organisms. Point sources of pollution can be traced to a specific location, for example, sewage treatment plants, while nonpoint sources cannot be traced to a single discharge site, for example, runoff from croplands or lawns.

Water quality surveys provide information about the chemical composition of water. The background water chemistry determines the kinds of plants and animals that can live there.
Water quality testing is done for several main reasons. First, to maintain a high water quality standard for domestic and institutional use, (i.e. for humans to drink and clean with) and also to ensure that our streams, rivers, estuaries, and oceans are clean enough to support the great variety of life in and around them, including fish, insects, birds, mammals, plants, and even bacteria.

In this lesson plan, we will be looking at four common water quality tests that evaluate suitable salmon habitat: (1) dissolved oxygen, (2) temperature, (3) pH, and (4) turbidity. There are additional tests that can also be done to determine levels of phosphates, nitrates and ammonia in the waterway.

WATER QUALITY INDICATORS

1. Dissolved Oxygen (DO)

The oxygen that is in water is known as Dissolved Oxygen (DO). These are microscopic bubbles of gaseous oxygen that are mixed in water and available to aquatic organisms for respiration. Keeping track of how much dissolved oxygen is in the water is extremely important. Unfortunately for fish, there is much less dissolved oxygen in water than in air. In the air, 1 out of 5 molecules are oxygen molecules available for respiration (breathing). In water, there might only be 1 out of 200,000 molecules that are oxygen molecules available for respiration. Any minor change in the amount of dissolved oxygen in the water can have drastic effects on the lives of aquatic creatures.

When water is polluted by organic material, its levels of dissolved oxygen generally drop. The organic material serves as food for microorganisms. As the microorganisms multiple, oxygen is depleted and dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills. If oxygen levels go over 14 mg/l, the oxygen molecules with form harmful gas bubbles inside an animal's blood vessels causing "gas bubble disease". This is deadly to most aquatic creatures.

Scientists use several terms to describe the varying DO levels found in aquatic ecosystems throughout the year:

- Healthy water generally contains at least 5 mg/l of dissolved oxygen
- Hypoxia occurs when water contains low levels of dissolved oxygen (2-4 mg/l)
- Anoxia occurs when water contains very little or no oxygen (0-1 mg/l).

Common dissolved oxygen tests are available through LaMotte, Hach or ChemMets. Electronic devices (either single parameter or multi-parameter) can also be used, but are very costly. SkeenaWild uses ChemMets tests in their workshops.

Salmon need at least 6.0 mg/l of dissolved oxygen to survive

2. Temperature

Temperature is very important to aquatic life. Most aquatic organisms are cold blooded, so their body temperatures are the same as the water temperature. Water temperature increases when the sun shines directly on a stream. Shading from trees, water surface area and volume, turbidity, stream bed colour, and orientation to the sun all affect the amount of sunlight absorbed by water.

Removal of streamside vegetation is a major cause of temperature problems in BC streams. Logging, agriculture, dyking and urban development often remove streamside vegetation. This adds sediment to the stream from erosion. Besides causing other water quality problems, sediment absorbs heat from the sunlight thereby raising water temperature. Planting streamside vegetation helps correct the problem. Water withdrawal for irrigation purposes often reduces stream flow during the summer, when flows are already at minimum levels. Low water flows contribute to problems with daily temperature fluctuation because there is less water to buffer

the impact of high temperatures. Thermal pollution from industrial sources also causes increased water temperatures.

Salmon need cooler water, between 5 and 16 degrees Celsius, depending on their life cycle stage. Temperatures above 16 degrees Celsius start to stress the fish.

Optimal Stream Life at Various Temperatures	
Temperature Range	**Types of Stream Life**
20-25 C (warm)	Lots of plant life; high fish disease risk; warm water fish (bass, carp, crappie, catfish, bluegill); caddisflies, dragonflies
13 – 20 C (cool)	Plant life; moderate fish disease risk; trout, salmon, sculpins; stoneflies, mayflies, caddisflies, water beetles, water striders
5 – 13 C (cold)	Plant life; low fish disease risk; trout, salmon, sculpins; stoneflies, mayflies, caddisflies

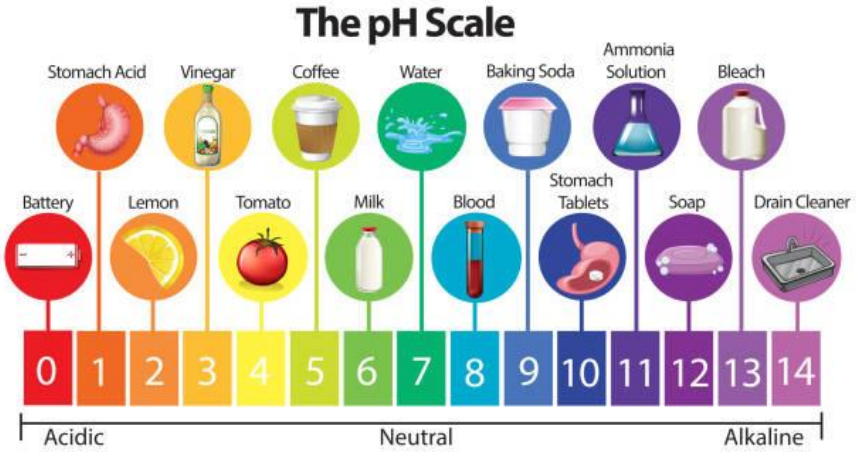
3. pH (parts of Hydrogen)

pH is a measure of the concentrations of Hydrogen ions in a solution, which determines if a solution is basic (like bleach) or acidic (like lemon juice). The pH of water is an important factor. Extremes in either direction on the logarithmic pH scale of 1-14 will kill aquatic life, as most life has a narrow pH range in which it can survive.

Stream waters usually range from pH 6.5 (slightly acid) to pH 8.5 (somewhat alkaline or basic). Rainwater is normally acidic (pH of 5.6), but its acidity has been greatly increased (to pH 4) in some regions by atmospheric pollutants (“acid rain”). If the pond water reaches extremes of acidity (pH 3) or alkalinity (pH 10), it is less hospitable to aquatic life.

Chemical pH tests are available through LaMotte and Hach. A very common, simple and less expensive method uses litmus strips (this is the method that SkeenaWild uses).

Most life can tolerate a range of pH 6.5 – 8.2. A pH of 7.5 is ideal for salmon.



4. Turbidity

Turbidity is a measurement of the cloudiness caused by sediment, microscopic organisms, and pollutants. These suspended particles restrict light penetration in the water, which in turn affects algal growth and oxygen production. Sediment can clog gills or other breathing structures of fish and benthic invertebrates. When sediment settles to the stream bottom, it can smother fish eggs and ruins habitat used by fish and aquatic insects. Some waters are naturally turbid and their communities have adapted to these conditions. Turbidity is high in streams that drain glaciers and streams in geologically young areas. Turbidity normally increases during and after rain storms or rapid snow melt. Severe problems with turbidity occur in areas where urban development, logging, and agriculture have disturbed the watershed and caused erosion. You can assess the extent of the problem by comparing turbidity before, during, and after times of heavy runoff. You also can compare turbidity upstream and downstream of suspected point sources of pollution.

In order to determine turbidity, either a Secchi disk or a turbidity tube can be used. A Secchi disk is best used when the water is deeper and a turbidity tube when there is shallow water. SkeenaWild uses a turbidity tube for their outdoor workshops.

Salmon require less than a 20 JTU (less than 31.8 cm or 14 in) reading on a turbidity tube.

Additional Water Quality Tests

Phosphates are chemicals containing the element phosphorous which is found in nature, but can also be found in many nonpoint sources such as livestock or pet wastes, soap, sewage and fertilizers. All plants need phosphates to grow, but excessive phosphates in water results in a massive growth of algae, which cloud the water in an affect called algal bloom which can lower dissolved oxygen levels, often leading to fish kills.

Phosphate levels should generally be below .025 mg/L.

Nitrates are chemicals containing the element nitrogen which is found in nature but . Plants requires nitrates to grow, but as with phosphates, excessive amounts of nitrate in the water can cause excessive growth of plants and algae.

The recommended maximum nitrate levels for freshwater streams is around 1 ppm. Generally, salmon prefer nitrate levels less than 0.20 ppm.

Ammonia is a toxic compound that can adversely affect fish health. Ammonia is found in many fertilizers (runoff affects this), but is also found in the decomposition of organic and animal waste. Ammonia is toxic to fish and aquatic organisms, even in very low concentrations. Ammonia can be even more toxic when combined with higher temperatures and pH values.

When levels reach 0.06 mg/L, fish can suffer gill damage. When levels reach 0.2 mg/L, sensitive fish like trout and salmon begin to die.

Healthy Stream Data for Salmon		
Parameter	**Range**	**Optimal**
Temperature: - Eggs - Hatching salmon - Adult Salmon - Aquatic Insects	5° – 15° Celsius	5° Celsius 9° Celsius 12° Celsius 10° Celsius
Dissolved Oxygen	> 6.5 mg/L	> 9 mg/L
pH	6.5 – 8.2	7 - 8
Turbidity	< 20 JTU < 20 NTU < 29.4 – 31.8 cm < 13.1 – 14.0 in	The lower the better
Phosphates	< 0.25 mg/L	< 0.10 mg/L
Nitrates	< 1 ppm	< 0.2 ppm
Ammonia	< 0.2 mg/L	0

Notes: mg/L = milligrams per litre
ppm = parts per million
JTU = Jackson Turbidity Unit
NTU = Nephelometric Turbidity Unit

EDUCATIONAL RESOURCES

Online Resources

Water Rangers – Water Rangers is a Canadian non-profit organization focused on inspiring the public to get involved by collecting water data around their local rivers and lakes. They provide training, education resources, water quality test kits, and a mobile platform to collect open data. http://www.waterrangers.ca

Pacific Streamkeepers – "The Streamkeepers Handbook". An excellent resource for learning the methods of evaluating streams.
http://www.pskf.ca/publications/Handbook%20and%20Modules.pdf

Skagit Fisheries Enhancement Group - "Junior Stream Stewards" – A good resource on learning the methods of evaluating streams that is targeted at students.
http://www.skagitfisheries.org/wpcontent/uploads/2010/08/FinalJSSLessonPlan2016.pdf

Salmonids in the Classroom Primary and Intermediate Handbooks (Department of Fisheries and Oceans Canada) – Primary and Intermediate Lesson Plans and resources for studying the biology, habitat and stewardship of pacific salmon. Used in conjunction with DFO's Salmonids in the Classroom Program in BC elementary schools.
http://www.pac.dfo-mpo.gc.ca/education/resources-ressources-eng.html

SkeenaWild Resources

SkeenaWild can provide free classroom or outdoor workshops on water quality, as well as aquatic macroinvertebrates, invasive species, watersheds, salmon, and stream assessment.

SkeenaWild also has water quality test equipment and supplies available for loan to teachers and their classes.

Contact christine@skeenawild.org, call 250-638-0998 or visit www.skeenawild.org/education for more information.