WATER QUALITY TESTING STATION

Today, the students at your station are citizen scientists!

Objectives
Students will understand the importance and techniques of water quality sampling by:

1) Performing stream water quality tests measuring pH, dissolved oxygen and temperature
2) Practicing detailed data recording methods
3) Analyzing and making judgments on the quality of water based on collected data

Teaching Tips
Get students focused with brief introductions and review safety guidelines.

Briefly describe the activity (What we are going to do is...).
A good way to describe water quality is to use one of the following metaphors:

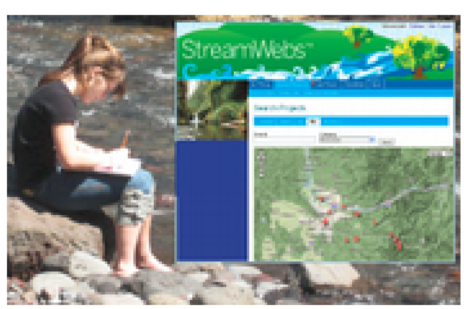
> The students are doctors performing a check up and the water source is their patient. More than one test must be conducted to find the true health of the river just like a doctor conducts multiple tests before making a diagnosis.
>
> The students are auto mechanics looking under the hood of a car, the water source being the car. They must run certain tests on the car to determine what kind of work the vehicle needs.

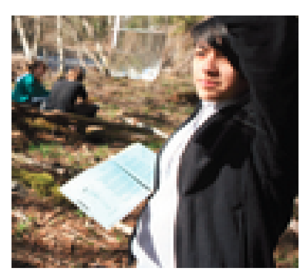
Let the students lead the activities and present their analysis for group discussion.

Materials
-Water quality testing equipment (LaMotte pH kit; CHEMets DO test kit; air/water thermometer)
Note: Caution should be taken when handling and disposing of chemicals. Waste chemicals should be poured into the waste container provided in the equipment tub. Always wash your hands if you come into contact with testing chemicals

-Laminated sheets: Optimum Temperature Limits; Optimal Dissolved Oxygen Limits; Lethal pH Limits; Procedures & Discussion items

-StreamWebs data collection sheets





WATER QUALITY TESTING STATION

Procedure

1. Divide the students into teams for each activity; temperature, dissolved oxygen and pH.
You can also have two sub-groups complete their own sets of tests in two different sampling spots and then compare results. *Be sure to assign one student as the role of data collector!

2. Pass out equipment for each test with accompanying directions. Have each group decide who will read the directions.

3. Facilitate the activity by floating between groups, providing assistance when necessary.

Discussion/Wrap Up

-When all tests are complete, bring the group together to clean up and organize equipment.

-Review the laminated charts and graphs for students to interpret their results.

-Let each team report their own results. Use the questions provided or formulate your own to relate back to the results of the tests. Include specific characteristics of the site that may be relevant - human impacts, vegetation, weather conditions etc.

-Fill out the StreamWebs data collection sheet
(leave one sheet in the bin; feel free to fill out a paper sheet to bring back to the classroom)

.

Air & Water Temperature

Water Temperature Background Information

Water temperature is one of the most important factors for survival of aquatic life. Most aquatic organisms acclimate to be the same temperature of the water that surrounds them. Their metabolic rates are controlled by water temperature. This metabolic activity is most efficient within a limited range of temperatures. If temperatures are too high or too low, productivity can decrease or metabolic function cease. The organism can die. These extremes, or lethal limits, vary for different species.

Lethal limits

Within the lethal limits there is an ideal range of temperatures. In this range, an organism is more efficient, and the species has a greater chance of success. Various species of fish have adjusted to upper and lower levels of an optimum temperature range. Spawning, hatching, and rearing temperature ranges vary from species to. In this way, temperature determines the character and composition of a stream community.

In the Pacific Northwest, most streams have had populations of salmon and trout, which prefer temperatures between 40° and 65° F.

In the summer when temperatures are highest and water flows lowest, juvenile fish live in the pools of smaller streams. Pools offer deeper, cooler, oxygen-rich water and increased protection from predators. Because of low water flows, fish can be confined to a limited area. A temperature rise in a rearing pool can kill fish by exceeding their lethal temperature limits.

Plant cover's role

With the exceptions of hot springs and thermal pollution, solar radiation is the cause of increased water temperatures. Shade from riparian vegetation plays a major role in keeping streams cool. During midsummer, adequate shade will keep a stream 7° to 12° F cooler than a stream exposed to direct sunlight.

Even the shade from debris in the water will help keep temperatures low. If there is enough debris, temperatures can be 3° to 8° F cooler than if there was no shade. Once water has warmed, it does not cool rapidly, even if it flows into a shady stretch. It is important to recognize that water temperatures change from day to night and that cool water areas exist in a stream.

Warmer temperatures encourage the growth of life forms that adversely affect fish and human health. Pathogens such as bacteria, as well as several parasitic organisms, thrive in warmer water.

Air & Water Temperature

Air temperature, surface area
As water in a stream mixes with air through exposure and turbulence at the surface, water is influenced by the air temperature. This mixing action can also increase the evaporation rate.

The greater the surface area of a body of water, the greater its exposure to both solar radiation and air will be. Because of its increased surface area a wide shallow stream will heat more rapidly than a deep, narrow stream.

Streambed, streamflow, orientation and sediments
Color and composition of a streambed also affect how rapidly stream temperature rises. A dark bedrock channel will gain and pass to the stream more solar radiation than a lighter-colored channel. Similarly, solid rock absorbs more heat than gravel.

The stream flow or volume of water in a stream influences temperature. The larger a body of water, the slower it will heat. Rivers and large streams have more constant temperatures than smaller streams. The direction a stream flows also affects how much solar radiation it will collect. Because of the angle of the sun's rays, southerly flowing streams receive more direct sunlight than steams flowing north. Eastward or westward flowing streams receive shading from adjacent ridges, trees, and riparian vegetation.

Sediments suspended in water can absorb, block, or reflect some of the sun's energy depending on their color and position in the water. Particles on or near the surface can have a beneficial influence through reflection, but those with a dark color increase the total energy absorbed from the sun.

Effects of thermal pollution
Thermal pollution occurs when heated water is discharged into cooler streams or rivers. This heated water generally has been used to cool power plants or industrial processes and can be as much as 20° F warmer than the water into which it is discharged. This increase in temperature can have drastic effects on downstream aquatic ecosystems.

TEMPERATURE TESTING ACTIVITY

Water temperature is crucial for salmon survival. Salmon can survive in water ranging in temperature from 42-77 degrees Fahrenheit, but do best in water around 55° F.
A chart is provided that illustrates the Optimum Temperature Limits for Aquatic Organisms

Objective
Students will measure air and water temperature and discuss the thresholds of water temperature for salmon and other aquatic organisms. Students will become familiar with the range of temperatures in different bodies of water and discuss factors influencing temperature (e.g., amount of shade, velocity of water, etc.).

Materials
Armored thermometer with string or plastic ribbon (flagging tape) attached (hopefully this tether will prevent loss of the thermometer in the current).

Procedure with manual thermometer
1) Air Temperature: Allow thermometer to reach equilibrium before recording. Make sure the air temperature is taken in the shade, not in direct sunlight. Take air temperature first.

2) Water Temperature: Submerge the thermometer for at least 5 minutes in the water. Read the value while thermometer is still in water, if possible. Record results. If time allows check temperature in more than one area of the stream and compare results.

Questions for discussion

-Why should we care about water temperature?

-What would happen to animals if the water was too cold or too warm? To plants? To nutrients?

-How does the water in this stream get to be this temperature?

-How does the water stay cool? How does the water get too warm for fish to survive?

-How is temperature and dissolved oxygen related?

Dissolved Oxygen Background Information

Oxygen is as essential to life in water as it is to life on land. Oxygen availability determines whether an aquatic organism will survive and affects its growth and development. The amount of oxygen found in water is called the dissolved oxygen concentration (DO) and is measured in milligrams per liter of water (mg/L) or an equivalent unit, (parts per million of oxygen to water (ppm).

DO levels are affected by:

- -Altitude
- -Water agitation
- -Water temperature
- -Types and numbers of plants
- -Light penetration
- -Amounts of dissolved or suspended solids

As water low in oxygen comes into contact with air, it absorbs oxygen from the atmosphere. The turbulence of running water and the mixing of air and water in waterfalls and rapids add significant amounts of oxygen to water.

Effects of temperature on DO

Temperature directly affects the amount of oxygen in water-the colder the water, the more oxygen it can hold. Bodies of water with little shade can experience a drop in DO during periods of warm weather.

Thermal pollution, the discharge of warm water used to cool power plants or industrial processes, can reduce DO levels. The area immediately downstream from the entry of warm water can be altered drastically. Thermal pollution generally occurs in larger streams. However, dilution will temper these effects as warm water mixes with colder water downstream.

At higher altitude (elevation), the dissolved oxygen saturation point is lower than under the same conditions at lower altitude. Shown below are maximum amounts, or saturation levels, of dissolved oxygen (in ppm) in fresh water at sea level for different temperatures:

DO ppm	5	6	7	8	9	10	11	12	13	14	15
Temp °F	117	92	90	77	68	59	50	45	39	36	32

When aeration is high, DO levels can temporarily be higher than the saturation level.
This extra oxygen is not stored in the water.

Photosynthesis, oxidation, and decomposition

Oxygen can also be added to water as a result of plant photosynthesis. During the day, plants can produce oxygen faster than aquatic animals can use it- This surplus is temporarily available throughout the night for plant and animal respiration. Depending on individual stream conditions, high daytime DO levels and low nighttime DO levels can occur.

Sediments can inhibit photosynthesis. Suspended sediments make water look murky or cloudy and block or reflect much of the sunlight that would otherwise be available for photosynthesis. Sediments can also settle onto the leaves of plants, further blocking their efficiency as oxygen producers.

The chemical oxidation and decomposition of dissolved, suspended and deposited sediments remove oxygen from the water. The amount of oxygen needed for these processes is called biochemical oxygen demand (BOD) and is oxygen that is unavailable for aquatic life. lf the quantity of these sediments is large, remaining oxygen can be insufficient to support many forms of aquatic life.

Most DO problems in Oregon streams occur when temperatures are at their highest and streamflows at their lowest. Salmon and trout are especially at risk during this time. Fry are often limited to small spawning streams during these "pinch periods" and DO is critical to their development. While a juvenile Salmonid can withstand 1-2 ppm of DO for short periods, its growth rate drops sharply below 5 ppm, especially if the temperature is high.

Fish die-off in shallow, warm ponds is a fairly common occurrence during the Summer. During a long period of warm sunshine, algae grow profusely. A summer storm can result in several days of cloudy weather. The reduced sunlight can cause a massive die-off of the algal bloom. As dead algae decompose, available oxygen is depleted. The amount of DO drops to lethal levels, causing subsequent die-off of fish and other aquatic organisms.

Maintaining productive DO levels

To maintain productive DO levels in a stream, shade should be provided to keep water temperatures cool. The presence of in-stream structures ensures mixing of water and air. Materials that can increase BOD, such as manure from feedlots or untreated municipal waste, should not be introduced.

Discussion Questions

-How is the amount of dissolved oxygen in the water that you tested compare to the optimum amounts of dissolved oxygen for different aquatic organisms?

-What can affect levels of dissolved oxygen? *(Temperature, time of year, time of day, depth, plant growth)*

-How do animals breath in the water?

-What are some anthropogenic (human-made) activities that can affect DO levels?

-How does oxygen get in the water?

DISSOLVED OXYGEN (DO) TESTING

Oxygen enters the water from the atmosphere and from photosynthesizing plants in the water column. Its concentration in the stream is dependent upon ambient temperature and atmospheric pressure, but is usually within 6-10 ppm (parts per million). Concentrations can greatly exceed this within dense algae growths. Large amounts of dead and decomposing organic material can reduce dissolved oxygen levels below 5 ppm, and this places great stress on salmon.

Objective

To determine the dissolved oxygen (DO) of the water and why this is so important to salmon and other aquatic organisms. Students will be able to conduct a dissolved oxygen test and discuss how the level affects aquatic organisms. Students will learn about the range of dissolved oxygen in different bodies of water and discuss factors influencing DO levels.

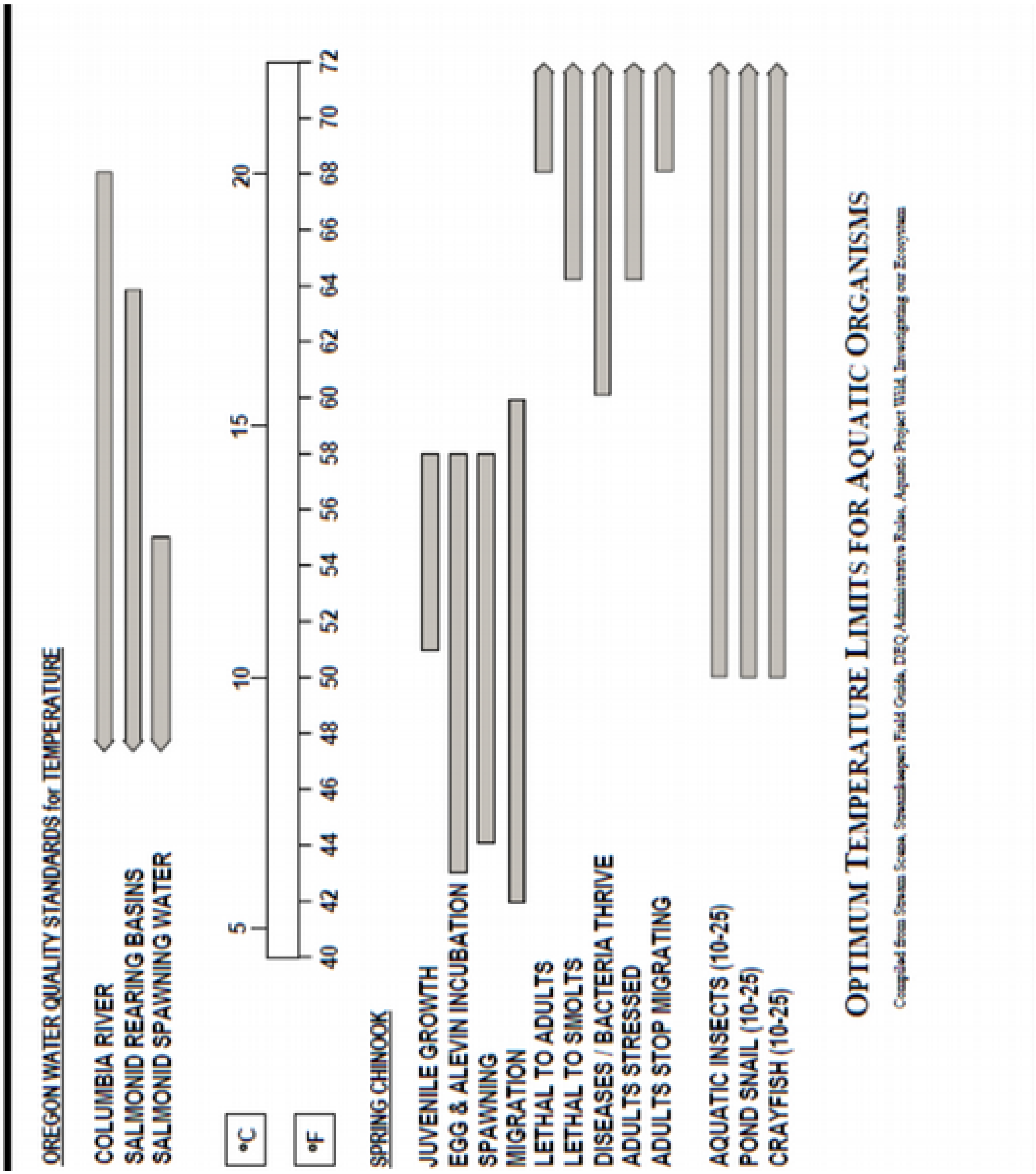
Materials and Procedure (CHEMets Dissolved Oxygen Kit)

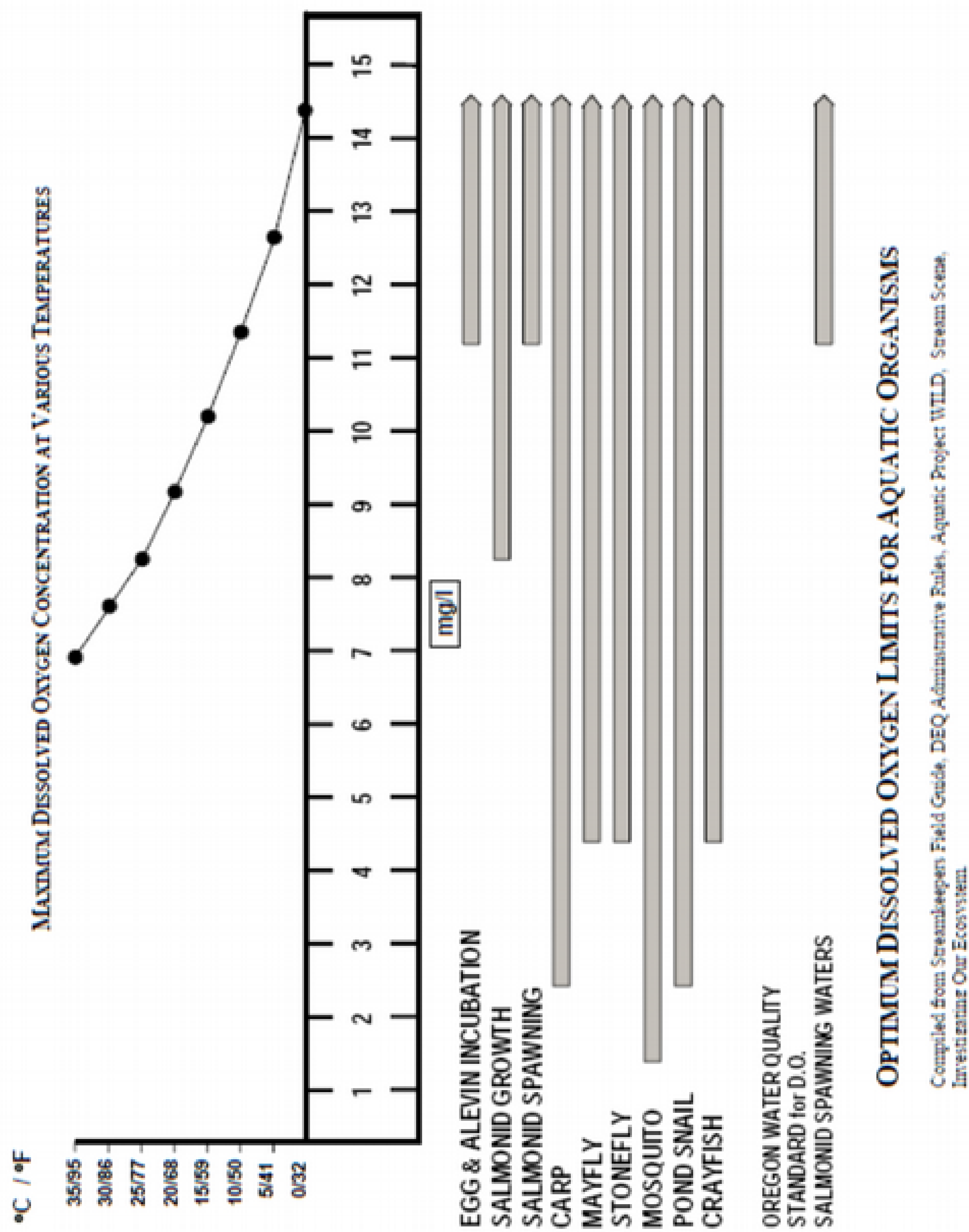
1. Fill the sample cup to the 25 mL mark with the sample to be tested.
2. Place the ampoule, tip first, into the sample cup. Snap the tip. The ampoule will fill, leaving a bubble for mixing.
3. To mix the ampoule, invert it several times, allowing the bubble to travel from end to end.
4. Dry the ampoule and wait 2 minutes for color development.
5. Obtain a test result by placing the ampoule between the color standards until the best color match is found.

Note: Biological activity may cause rapid oxygen depletion. Dipping and pouring operations should be performed with as little agitation as possible.

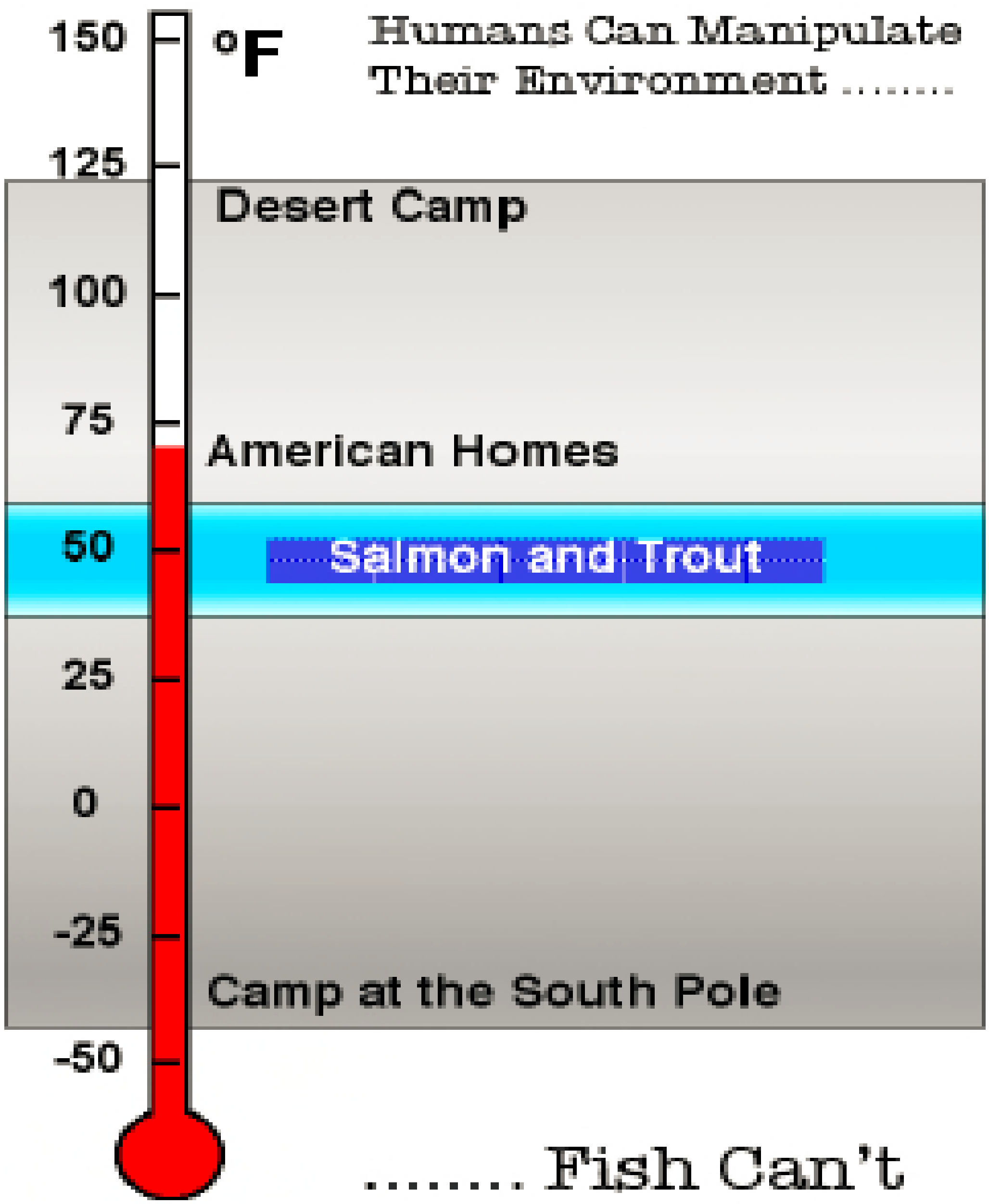
Discussion Questions

-How is the amount of dissolved oxygen in the water that you tested compare to the optimum amounts of dissolved oxygen for different aquatic organisms?
-What can affect levels of dissolved oxygen? *(Temperature, time of year, time of day, depth, plant growth)*
-How do animals breath in the water?
-What are some anthropogenic (human-made) activities that can affect DO levels?
-How does oxygen get in the water?


OREGON WATER QUALITY STANDARDS for TEMPERATURE
COLUMBIA RIVER
SALMONID REARING BASINS
SALMONID SPAWNING WATER
°C
°F
5
10
15
20
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68
70
72
SPRING CHINOOK
JUVENILE GROWTH
EGG & ALEVIN INCUBATION
SPAWNING
MIGRATION
LETHAL TO ADULTS
LETHAL TO SMOLTS
DISEASES / BACTERIA THRIVE
ADULTS STRESSED
ADULTS STOP MIGRATING
AQUATIC INSECTS (10-25)
POND SNAIL (10-25)
CRAYFISH (10-25)
OPTIMUM TEMPERATURE LIMITS FOR AQUATIC ORGANISMS



Maximum Dissolved Oxygen Concentration at Various Temperatures
°C / °F
35/95
30/86
25/77
20/68
15/59
10/50
5/41
0/32
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
mg/l
EGG & ALEVIN INCUBATION
SALMONID GROWTH
SALMONID SPAWNING
CARP
MAYFLY
STONEFLY
MOSQUITO
POND SNAIL
CRAYFISH
OREGON WATER QUALITY STANDARD for D.O.
SALMONID SPAWNING WATERS
Optimum Dissolved Oxygen Limits for Aquatic Organisms
Compiled from Streamkeepers Field Guide, DEQ Administrative Rules, Aquatic Project WILD, Stream Scene, Investigating Our Ecosystem.


150
°F
Humans Can Manipulate
Their Environment ....
125
Desert Camp
100
75
American Homes
50
Salmon and Trout
25
0
-25
Camp at the South Pole
-50
.... Fish Can't

pH BACKGROUND INFORMATION

The concentration of hydrogen ions in a solution is called pH and determines whether a solution is acid or alkaline. A pH value shows the intensity of acid or alkaline conditions. In general, acidity is a measure of substance's ability to neutralize bases, and alkalinity is a measure of a substance's ability to neutralize acids.

The pH scale ranges from 1 (acid) to 14 (alkaline or basic) with 7 as neutral. The scale is logarithmic so a change of one pH unit means a tenfold change in acid or alkaline concentration. A change from 7 to 6 represents 10 times the concentration, 7 to 5, 100 times, and so most organisms have a narrow pH range in which they can live. While some fish can tolerate a range of 5 to 9,mothers cannot tolerate a change of even one pH unit. Because of this narrow range of tolerance, pH limits where many organisms can live and them composition of a community.

While pure distilled water has a pH of about 7, any minerals dissolved in water can change the pH. These minerals can be dissolved from a streambed, the soil in a watershed, sediments washed into a stream, or the atmosphere.

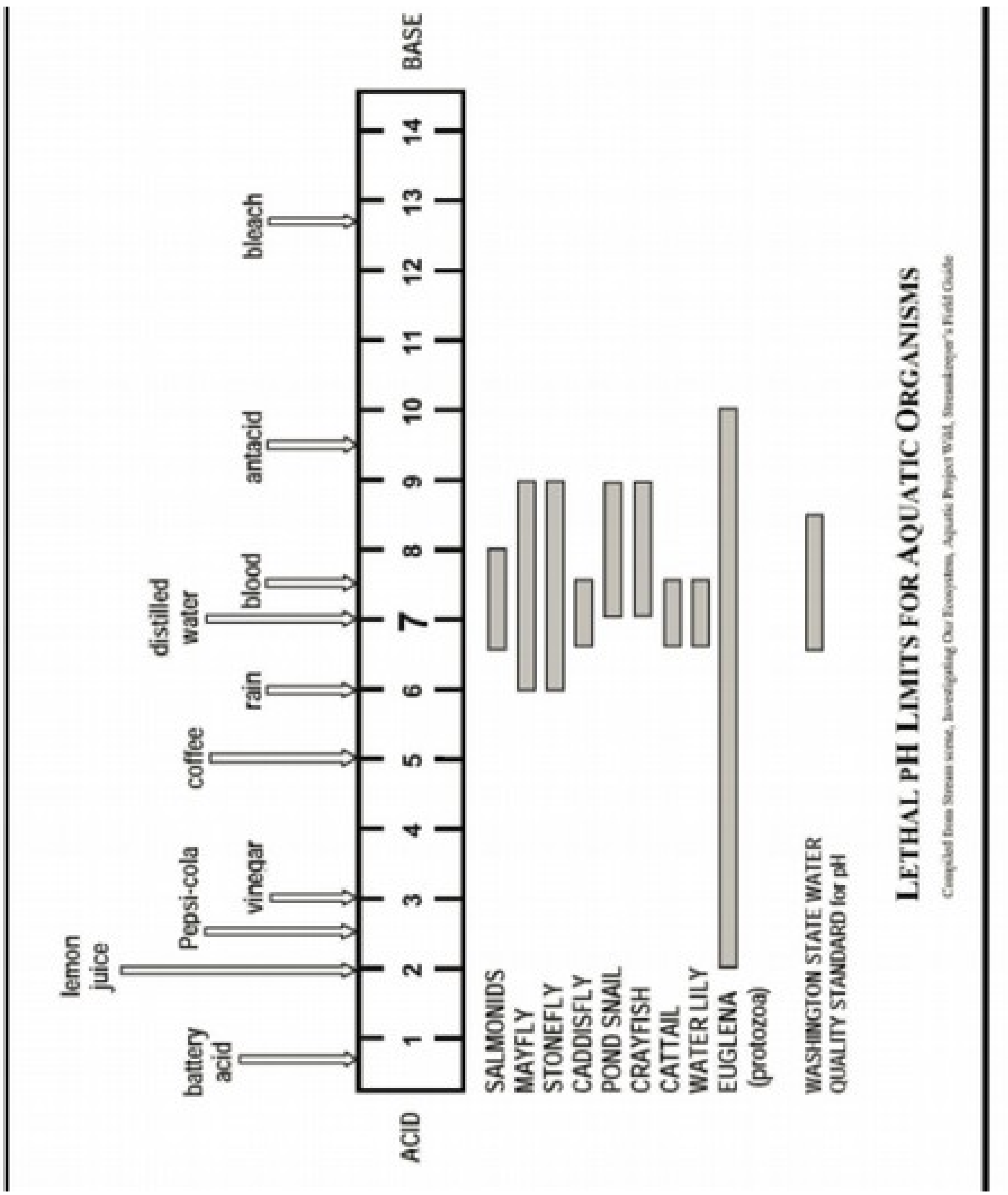
In eastern Oregon, where many soils have a high alkaline content, pH levels of some water bodies can rise above 10. Forest soils tend to be slightly acid and many lakes or streams in forested regions of Oregon can approach a pH of 6.

The age of a lake can also influence pH. Young lakes are often basic. As organic materials build up decomposition forms organic acids and releases carbon dioxide. Carbon dioxide mixed with water forms carbonic acid, making the lake more acidic.

When rain falls through the atmosphere, the gases it comes in contact with come into solution. As rain absorbs carbon dioxide it becomes slightly acidic, but reaches a natural lower limit of pH 5.6.
Air pollution, primarily from automobile exhaust and fossil fuel burning, has increased concentrations of sulfur and nitrogen oxides in the air. These fall with rain as weak sulfuric and nitric acids causing an "acid rain." Currently in portions of the eastern United States, the mean pH for rainfall is 4.3, approximately ten times more acidic than normal. Rainfall measuring just under pH 2.0 fell on Wheeling, West Virginia, in 1978. This was approximately 5,000 times the acidity of normal rainfall and is the most acidic rainfall on record.

Increased acidity has caused pH to exceed lethal levels for fish in many lakes. A US government study estimated that 55 percent of the lakes and 42 percent of stream miles in the eastern United States are currently being subjected to acidic deposition, which will eventually lead to their deterioration. In addition, acid build-up in soils can have detrimental effects on forests and crops, and hinders natural nutrient recycling processes.

Because rain can fall a considerable distance from a pollution source, acid rain is a regional and global problem. Factors that determine the pH of a body of water can be far removed from a particular site, making it difficult to directly manage the pH. Because pH is a limiting factor, it is important to have a measurement to determine which organisms can survive and prosper. This measurement also serves as a baseline measurement and can assist in the monitoring of future changes.



TESTING pH

Water contains both H+ (hydrogen) ions and OH- (hydroxyl) ions. The pH test measures the H+ ion concentration of liquids and substances. Each measured liquid or substance is given a pH value on a scale that ranges from 0 to 14. Pure, de-ionized water contains equal numbers of H+ and OH- ions and is considered neutral (pH 7), neither acidic or basic. If the sample being measured has more H+ than OH- ions, it is considered acidic and has a pH less than 7. If the sample contains more OH- ions than H+ ions, it is considered basic, with a pH greater than 7.

It is important to remember that for every one unit change on the pH scale, there is approximately a ten-fold change in how acidic or basic the sample is. For example, lakes of pH 4 (acidic) are roughly 100 times more acidic than lakes of pH 6.

Objective
Students will conduct a pH test, understand the pH scale and where their value falls within that scale, and discuss the importance of pH to salmon and other aquatic organisms.

Materials (LaMotte Precision pH Test Kit)
1. Fill a test tube to the 10 mL line with sample water.
2. Add 10 drops of *Wide Range pH Indicator.
3. Cap and mix.
4. Insert Wide Range pH Octa-Slide 2Bar into the Octa-Slide 2 Viewer.
5. Insert test tube into Octa-Slide 2 Viewer.
6. Match sample color to a color standard. Record as pH.

WARNING! This set contains chemicals that may be harmful if misused.
Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

Discussion Questions
-Does the pH of the water that you tested fall within the lethal limits for aquatic organisms?

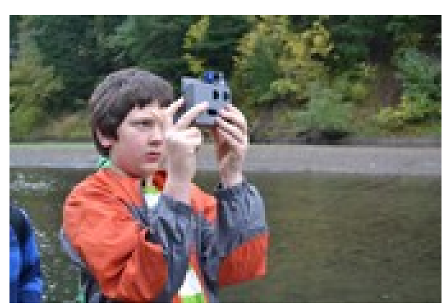
-What other liquids have a pH that is similar to the water you tested?

-What are we measuring when we test pH?

-Why does pH matter?

-How does water get more acidic/alkaline?

-How can we make sure that water doesn't get too acidic/alkaline?



WATER QUALITY ACTIVITY WRAP UP

-What are some of the things we can do to determine whether a stream is healthy?

-What do animals living in and near the stream need?

-What does a stream need to be considered healthy for salmon?

-Do you think it is healthy today?

-How about 100 years ago? How about in 100 years?

-What kinds of activities and events will affect the future conditions of salmon bearing streams?

-What are some of the things we can do to help reduce our impact on streams?