UNIT 5B. WATER QUALITY AND QUANTITY

ACTIVITY	TIME	LEVEL
Water Temperature & Comfort	45 minutes	Introductory
Fish & Water Temperature Chart Analysis	60-90 minutes	Introductory
Goldfish Lab Activity	30-45 minutes	Advanced

BENCHMARKS	
Next Generation Science Standards	MS-LS2-1 MS-ESS3-5 MS-LS2.A MS-ESS3.C HS-LS2.C
Science & Engineering Practices	-Planning and carrying out investigations. -Analyzing and interpreting data -Using mathematics and computational thinking -Engaging in argument from evidence
Common Core State Standards-ELA/Literacy	CCRA.R.1 CCRA.R.4 CRA.R.7
Common Core State Standards-Speaking & Listening	CRA.SL.1
Common Core State Standards – Mathematics	MP.2

OBJECTIVE:

- Students will observe the properties of water and identify the qualities of water needed by salmon.

INTRODUCTION

Have you ever been thirsty? Do you remember water rationing in the summer? Are your water bills increasing? We all need water; we cannot live without it. Neither can we work without it. Manufacturing and agricultural processes use water and electricity. What about the salmon? Is water important to them? We know they need water to stay alive, much as we do. For what else do salmon need water? What does water provide for the salmon? In this section, we attempt to answer these questions.

In this section, we study and observe water for its properties and inhabitants. Then, we attempt to make some inferences about relationships that may exist between the inhabitants of a body of water, and the properties of that water. We do this by exploring the effects of temperature on dissolved oxygen, and on the respiration rates and temperature tolerances of fish species.

We have provided several lessons and activities to study water quality and quantity. Examine each lesson to find the appropriate fit for you class.

KEY QUESTIONS:
What kind of water do salmon need? How much of it do they need?
Why are water quality and quantity important to salmon?

VOCABULARY (Brief definitions of vocabulary terms are found in the Glossary.):
aquatic diversity ecosystem pH sediment microhabitat habitat

ACTIVITIES:

WATER TEMPERATURE AND COMFORT

MATERIALS:
- STUDENT HANDOUT 5B-1: Water Temperature, Stream Scene
- STUDENT HANDOUT 5B-2: Where Am I Comfortable?

PROCEDURE:
A. How do you feel when you're hot? Cold? Do other species have the same feelings? Have students read STUDENT HANDOUT 5B-1: Water Temperature, Stream Scene

B. Use the questions in STUDENT HANDOUT 5B-2: *Where Am I Comfortable?* to reinforce the learning in the reading. These readings discuss the effects of temperature on aquatic organisms, and the role of plants, air, surface area, streambed, stream flow, sediments and discharges in mediating water temperature.

FISH AND WATER TEMPERATURE CHART ANALYSIS

MATERIALS:
- STUDENT HANDOUT 5B-3: Fish and Water Temperature

PROCEDURE:
Discuss human reactions to heat stress. Then have students read and complete the activity in STUDENT HANDOUT 5D: Fish and Water Temperature. This reading describes the effects of temperature on fish, and how to perform a standardized measurement of a fish's temperature tolerance. Students are given temperature tolerance data for 20 fish, and then respond to questions based on that information.

UNIT 5: STUDENT HANDOUT 5B-1: WATER TEMPERATURE

Water Temperature

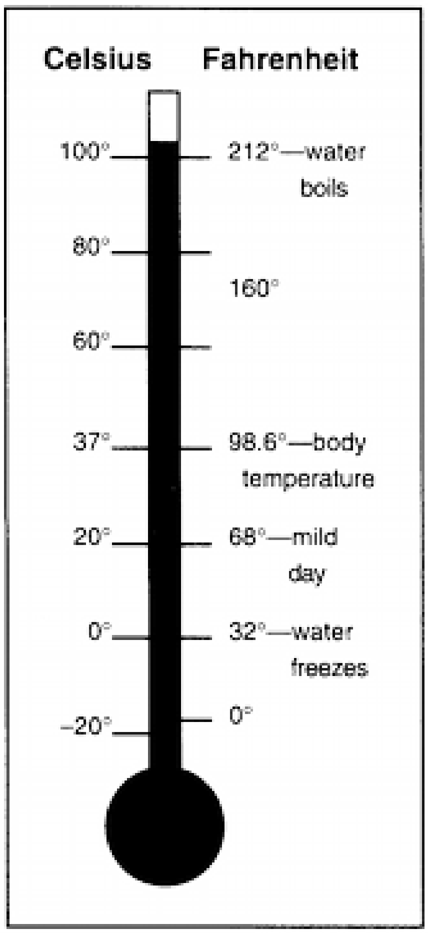
Stream Scene, Oregon Dept. of Fish & Wildlife, 1992

Water temperature is one of the most important factors for survival of aquatic life. Most aquatic organisms become the 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 species. 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 one 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 waters.

Water temperature is one of the most important factors for suvival of aquatic life.

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. 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 streamflow, 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 streams 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.

Figure 11. Temperature Ranges (approx.) Preferred by Certain Organisms

Temperature (Fahrenheit)	Examples of life
Greater than 68° (warm)	Redside shiner, crappie, bluegill, carp, catfish, caddisfly, dragon fly, and much plant life
Middle range (55°-68°)	Brown trout, rainbow trout, stonefly, mayfly, caddisfly, water beetles, sculpins, and some plant life
Low range (cold, less than 55°)	Brook trout, sculpins, caddisfly, stonefly, mayfly, and some plant life

Adapted from Claire Dyckman and Stan Garrod, eds., *Small Streams and Salmonids*, p. 73.

UNIT 5: STUDENT HANDOUT 5B-2: WATER TEMPERATURE

Use STUDENT HANDOUT 5B-1 to answer the following questions: Name____________________

<u>Where Am I Comfortable?</u>

1. For the two questions below, list causes and explain how they work.
   a. What causes water to heat in a pond, lake or stream?

   b. What might cause water there to cool?

2. You measure the temperature of a stream. It is 62°. What kinds of organisms might you expect to find there?

3. You sample a stream and find rainbow trout, caddisfly larvae, dragon fly larvae, water beetles, and some plant life. Estimate, as closely as you can, the temperature of the water in that stream. Explain how you made your decision.

4. Explain how you can use a list of the organisms found in a stream to assess its physical properties.

5. Use all of the information in the article and on this sheet to make a stream analysis worksheet.
Your worksheet should be designed so that someone who had followed the directions in the stream analysis worksheet (made observations and recorded them on the worksheet) could determine the general health of the stream. Think carefully, consult with your partners, and then design your stream analysis worksheet.

UNIT 5: STUDENT HANDOUT 5B-3: FISH & WATER TEMPERATURE

Fish and Water Temperature

Adapted from Stream Scene, Oregon Dept. of Fish & Wildlife, 1992

Different fish require different water temperatures to survive. Most fish are killed by high temperatures, not by low ones. They may grow more slowly at lower temperatures, but they are not usually killed unless they freeze.

Human activities can quickly change water temperature. For instance, a coal or nuclear power plant takes water from the river, turns it into steam, then puts hot water back into the river, thereby raising the temperature. Removing the trees along a river or stream can also raise the temperature.

Biologists perform a test to find out what water temperature fish need. The fish are put into an aquarium at a certain temperature and left for twelve hours. The biologist then checks to see how many fish are still alive. The temperature is raised until half the fish die within a twelve-hour period. This temperature is the ”12-hour tolerance limit median” (12-hour TLM). It is the tolerance limit because it is the highest temperature that fish can tolerate. It is called the median because half of the fish die.

Remember that this is not the temperature at which the fish do best. Rather, this is the temperature where half of them die in just twelve hours. A similar number for humans might be 150 degrees Fahrenheit. This is not where we do best, but the limit for our survival.

The table below lists the 12-hour TLM for several fish species.

COMMON NAME	12 HR. TLM	COMMON NAME	12 HR. TLM	COMMON NAME	12 HR. TLM
Cutthroat Trout	77 F	Speckled Dace	85 F	Bluegill Sunfish	94 F
Coho Salmon	77 F	Yellow Perch	87 F	Pumpkinseed	94 F
Brook Trout	78 F	Long Nose Dace	88 F	Redside Shiner	95 F
Steelhead	80 F	Tui Chub	89 F	Brown Bullhead	97 F
Rainbow Trout	80 F	Common Shiner	90 F	Largemouth Bass	98 F
Brown Trout	81 F	Short Nose Dace	92 F	Carp	106 F
Redband Trout	82 F	Fathead Minnow	93 F		

QUESTIONS - Fish and Water Temperature

Name____________________

1. Explain how you might perform a 48-hour TLM test?

2. Which five species would you expect to survive best if a coal plant raised the stream temperature by 10 degrees Fahrenheit from 80 degrees Fahrenheit?

3. How would Coho salmon probably be affected by an increase in stream temperature caused by a power plant?

4. Look only at the salmon and trout species listed in the table: which one is the least tolerant of high temperatures? Which is the most tolerant?

5. Explain how each of these human activities could cause problems for the salmon by increasing the water temperature.

    a. removing trees next to a stream

    b. building a dam

    c. taking water out of a stream for irrigation

STUDENT HANDOUT 5B-4

Name___________________________

Effects of Temperature on Goldfish Respiration Rate

(Adapted from Stream Scene, ODFW)

Purpose: To determine how temperature affects the respiration rate of a fish.

Materials needed:

- 600 ml beaker, filled with 300 ml of aquarium water
- goldfish
- thermometer (Celsius)
- large culture dish with ice

Procedure:

- Put the goldfish in the 600 ml beaker.
- Observe your fish carefully. Watch how the gill plates on either side of the head move. Watch the mouth open and close.

Questions:

1. How do the mouth and gill plates coordinate their movements?
2. As water moves from the mouth, across the gills, and then out of the gill slits, what type of gas will diffuse from the water into the blood of the fish? (This will be the same gas that humans take into their blood as they breathe). How do you think this transfer of gas occurs in the gills?
3. As water moves across the gills, what type of gas will diffuse from the blood and into the water? (Again, the same gas leaves the lungs of humans.)
4. Describe your fish's behavior.

5. Observe your fish. Count how many times the gill plate opens and closes in 15 seconds. Repeat this calculation until you are confident that you can record it accurately. Record that measurement here:

6. Predict: Will the fish open and close its gill plate faster or slower when the water is cold? Why do you think so?

7. Place your thermometer inside the beaker with your fish. Position it so that you can read it without disturbing your fish.

   - Fill the culture dish around the beaker with ice. Pack the ice against the side of the beaker. You may wish to add salt to the culture dish (not the beaker) to speed up the melting (and so speed the cooling of the water in the beaker). Allow the beaker to reach 5 degrees Celsius, then remove it from the culture dish. Dump out the ice.

   - Count the number of times that the gill plate opens and closes in 15 seconds. Repeat. Record your observations on the following chart. At each temperature, note your fish's behavior.

   - Fill the culture dish with lukewarm water. Place the beaker with the fish in the culture dish. Allow the fish to warm to 12 degrees Celsius.

   - Count the gill plate movements for 15 seconds. Repeat and record.

   - Continue to allow the fish to warm up, stopping at 15, 20, and 25 degrees Celsius to record gill plate movements. Do not warm the fish above 25 degrees Celsius! You will need to warm your water in the culture dish periodically.

   - Return the goldfish to the aquarium.

- Average your two observations for each temperature.
  Record your average on the overhead data sheet for the class.

	5 degrees C	10 degrees C	15 degrees C	20 degrees C	25 degrees C
Count 1					
Count 2					
Average					
Class average					

<u>Temperature</u> <u>Behavior</u>

5 Celsius

10 Celsius

15 Celsius

20 Celsius

25 Celsius

8. Graph your data on the graph below.

Label the Y axis “Breaths per 15 seconds”. Label the X axis “Temperature in Celsius”. Plot two lines on your graph: your average values, and the class averages.
Label your two lines carefully.

Discussion questions:

1. How did your goldfish change its behavior during your experiment?

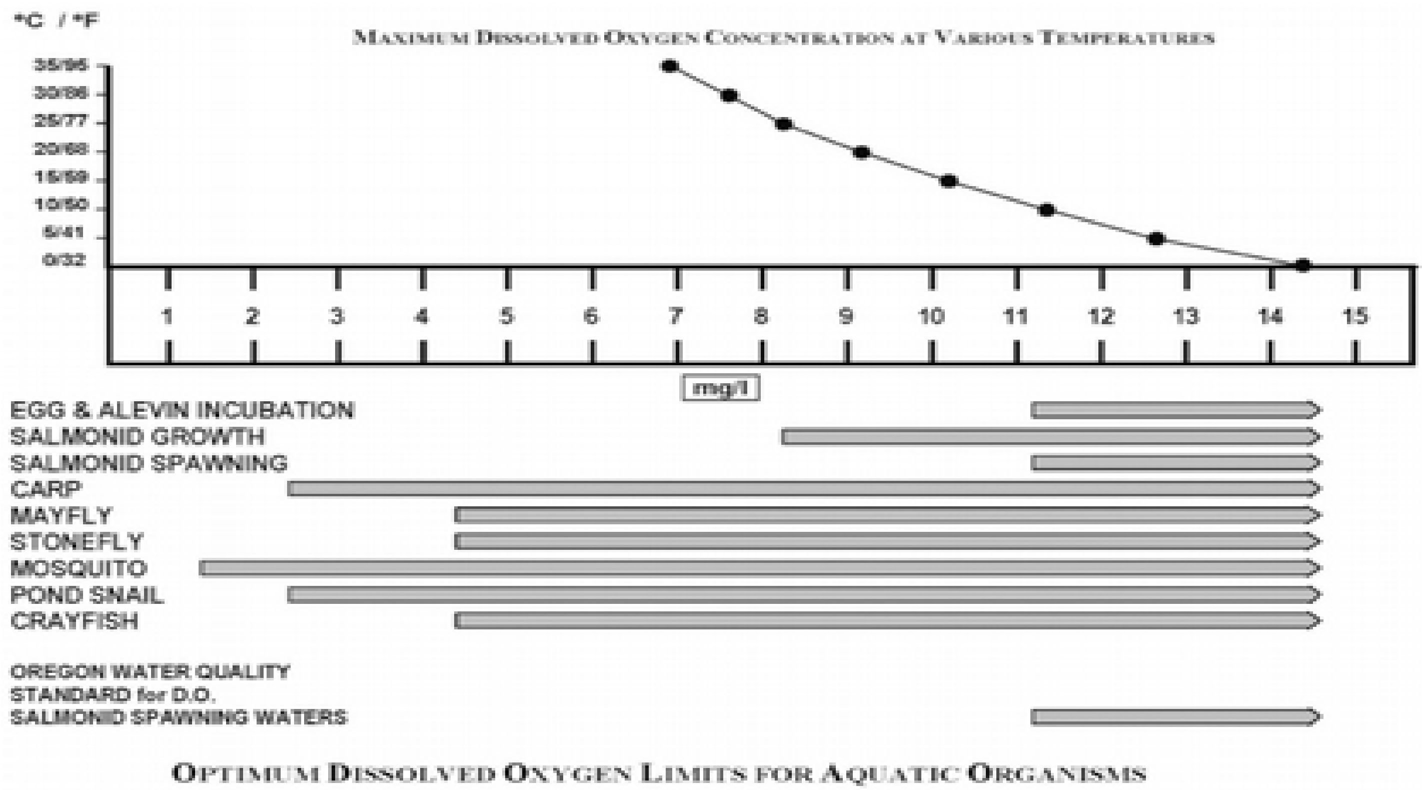
2. As the temperature increased, what happened to the respiration rate of the goldfish?

3. How does your graph compare to the class average?

4. What are some variables (differences) in your experiment that could explain why your data are different from the other groups? List as many variables as you can.

5. There are two types of animals: warm-blooded and cold-blooded. Warm-blooded animals maintain their bodies at about the same temperature at all times, examples of warm- blooded animals include humans, beavers, and whales. Cold-blooded animals change temperature as the environment changes temperature, such as lizards and frogs. Chemical reactions, such as using oxygen to get energy, happen more slowly at colder temperatures. Are goldfish warm-blooded or cold-blooded? Explain how you know from this lab.

6. If you had very little food for a goldfish and you wanted to make it last as long as possible, at what temperature should you keep your fish? Why?



7. Goldfish are a type of carp. How do their dissolved oxygen requirements compare to those of salmon

8. What is the maximum amount of dissolved oxygen that water can hold at 30º C?

9. What is the maximum amount of dissolved oxygen that water can hold at 0º C?

10. What happens to the amount of dissolved oxygen in a river as the temperature increases?

11. You discovered in question five that fish are cold-blooded (I hope). What happens to their metabolic rate (the rate of chemical reactions such as the consumption of oxygen by their cells) as the water temperature increases?

12. Using your answers to questions 7, 11 and 12, explain why an increase in river temperature can be lethal to salmon.

13. Why is it important to preserve the riparian forest canopy along salmon-bearing streams?

"I guess he made it. … It's been more than a week since he went over the wall."

"So! . . . you STILL won't talk, eh?"