

## **A Short Salmon Unit**

### **Pre-Lesson Assignment – Journey of the Wild Pacific Salmon (Salmon Life Cycle)**

#### **Lesson 1 – Salmon Running the Gauntlet**

Show the PBS video and have the students answer the questions. Discuss the video and solicit student reactions.

<http://www.pbslearningmedia.org/resource/nat11.sci.living.eco.lifdesalm/nature-salmon-running-the-gauntlet-life-and-death-of-salmon/>

#### **Lesson 2 – Biotic and Abiotic Factors of the River Ecosystem**

Have students form groups of three. Give each student one of the three charts and have them interpret it in a written paragraph. Each student in the group should then teach the other two about what they learned. The other two should take notes. Call on each group with questions to ensure understanding.

Show the class a picture of the nitrogen cycle. Explain to them that studies have found that up to 70% of the nitrogen in Northwest riparian forests originated in the Pacific Ocean. Have them discuss in their groups and determine an explanation for how this might happen. Solicit answers and discuss. Ask the class why they think salmon are seen as a keystone species in Northwest forests.

Hand out the stream habitat reading and questions. Have students read and answer.

#### **Lesson 3 – Temperature and Respiration Rate**

Have the students perform the Goldfish Lab, graph the data and answer the questions.

#### **Lesson 4 – Salmon Discussion Questions**

Put the students in discussion groups (Socratic seminar?) and have them tackle the questions one at a time. Have groups share their thoughts with the whole class.

# Salmon: Running the Gauntlet

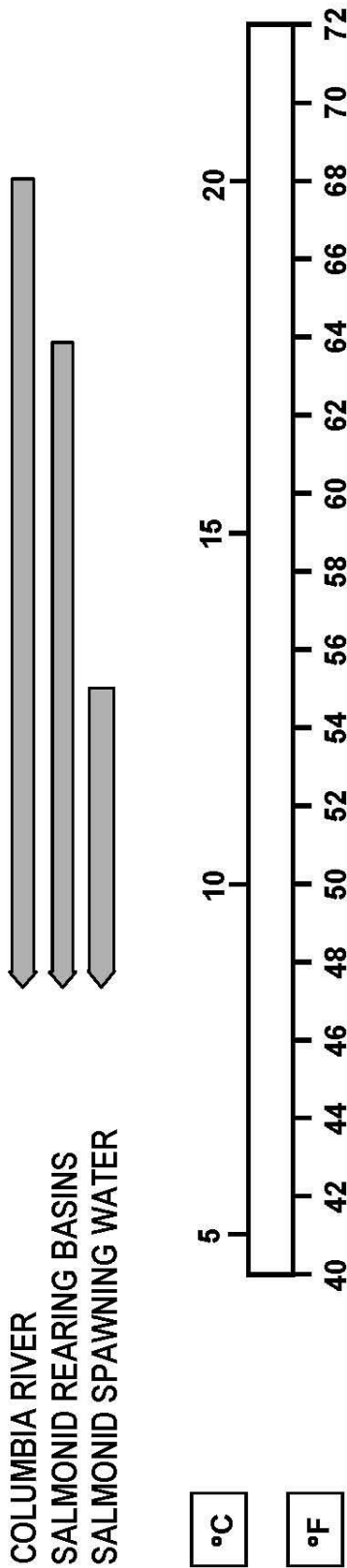
PBS - Nature

Choose ten of the following questions and answer them on a separate piece of paper. Number your answers to match the questions. Write in complete sentences.

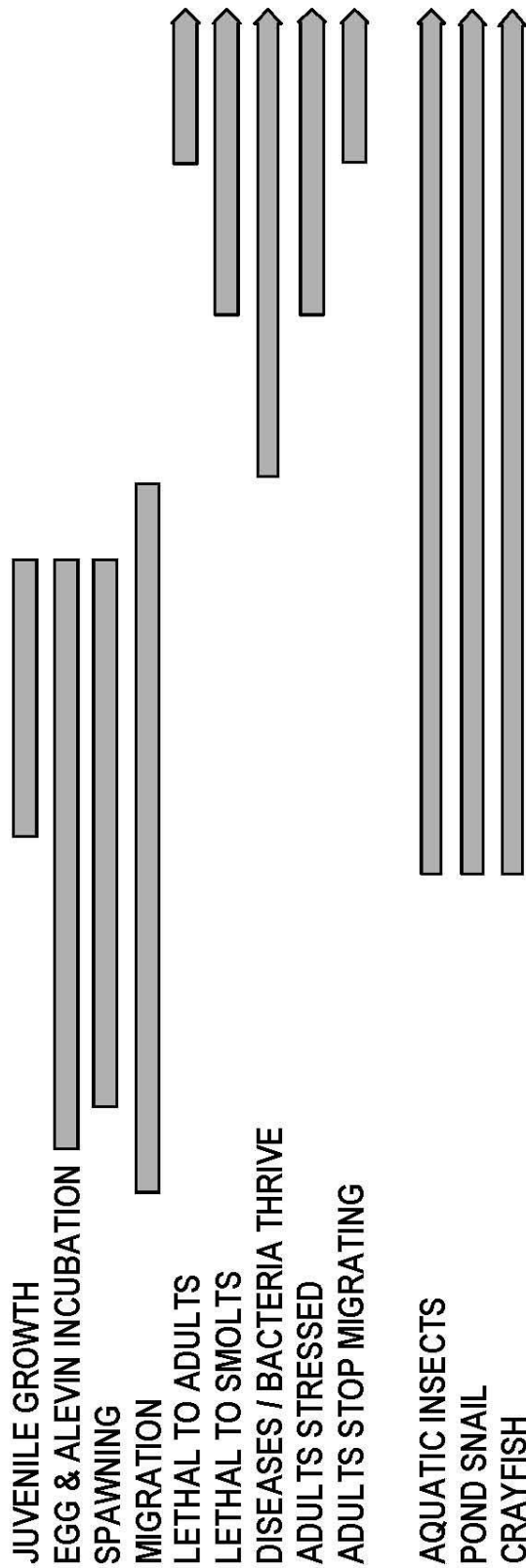
- 1 According to the video, describe what river restoration might look like.
- 2 Briefly describe the life, spawning process and death of Pacific Northwest salmon.
- 3 Describe in detail the importance of losing a “salmon run.”
- 4 Describe the challenges salmon face in their life cycle from going out to sea to spawning.
- 5 Describe the different habitats of Pacific Northwest salmon.
- 6 Describe the numerical relationship between the juveniles that hatch and those that return to spawn. What do you conclude from analyzing the numbers?
- 7 Describe the role of hatcheries in the life cycle of salmon. Next, describe the impact of dams and straightening rivers on the salmon population.
- 8 Describe the sockeye salmon’s journey to its breeding grounds.
- 9 Do you think officials should build a new island for the terns and cormorants in order to keep them from eating salmon? If not, what actions (if any) do you think should be taken?
- 10 How are scientists keeping track of their progress in increasing the salmon population?
- 11 How did Redfish Lake get its name? Which species of salmon calls this lake home?
- 12 How do bears, birds, invertebrates and trees each benefit from the presence of salmon?
- 13 In the video, author David James Duncan states, “As much as any species of plant and animal in the Pacific Northwest, if this creature is removed from the tapestry, the tapestry will unravel.” Provide reasons to support or refute the statement.
- 14 In the video, rancher and river guide Jerry Myers says, “You understand by living out here that things are connected and a big, huge part of that is salmon.” Provide examples from the video to support this statement.
- 15 List the early behaviors of the fishing industry that adversely impacted the salmon population of the Northwest.
- 16 Name some of the tasks hatcheries perform in the production and preservation of salmon.
- 17 Other than river restoration what are some other solutions to tackling the salmon problem?
- 18 Summarize the relationship between humans and salmon outlined in the video.

- 19 What are some of the challenges in keeping salmon alive as they journey to sea?
- 20 What are your initial thoughts about the practice of removing salmon from the water to produce salmon?
- 21 What do you think about the methods officials are using to protect salmon from pikeminnow and sea lions?
- 22 What draws Pacific Northwest salmon back to freshwater sources to spawn?
- 23 What has been the direct impact of river restoration to salmon? To the environment? What example can you use from the video?
- 24 What has been the impact of the four dams in the lower Snake River/Columbia River watershed upon salmon runs?
- 25 What is fish transport? Why is it significant?
- 26 What is river restoration? Describe the relationship between river restoration and salmon populations.
- 27 What lengths are humans now taking to protect salmon populations?
- 28 Why are scientists depositing salmon carcasses and artificial substances into streams? How are they evaluating the impact of these efforts?
- 29 Why did humans decide to produce salmon?

## OREGON WATER QUALITY STANDARDS for TEMPERATURE

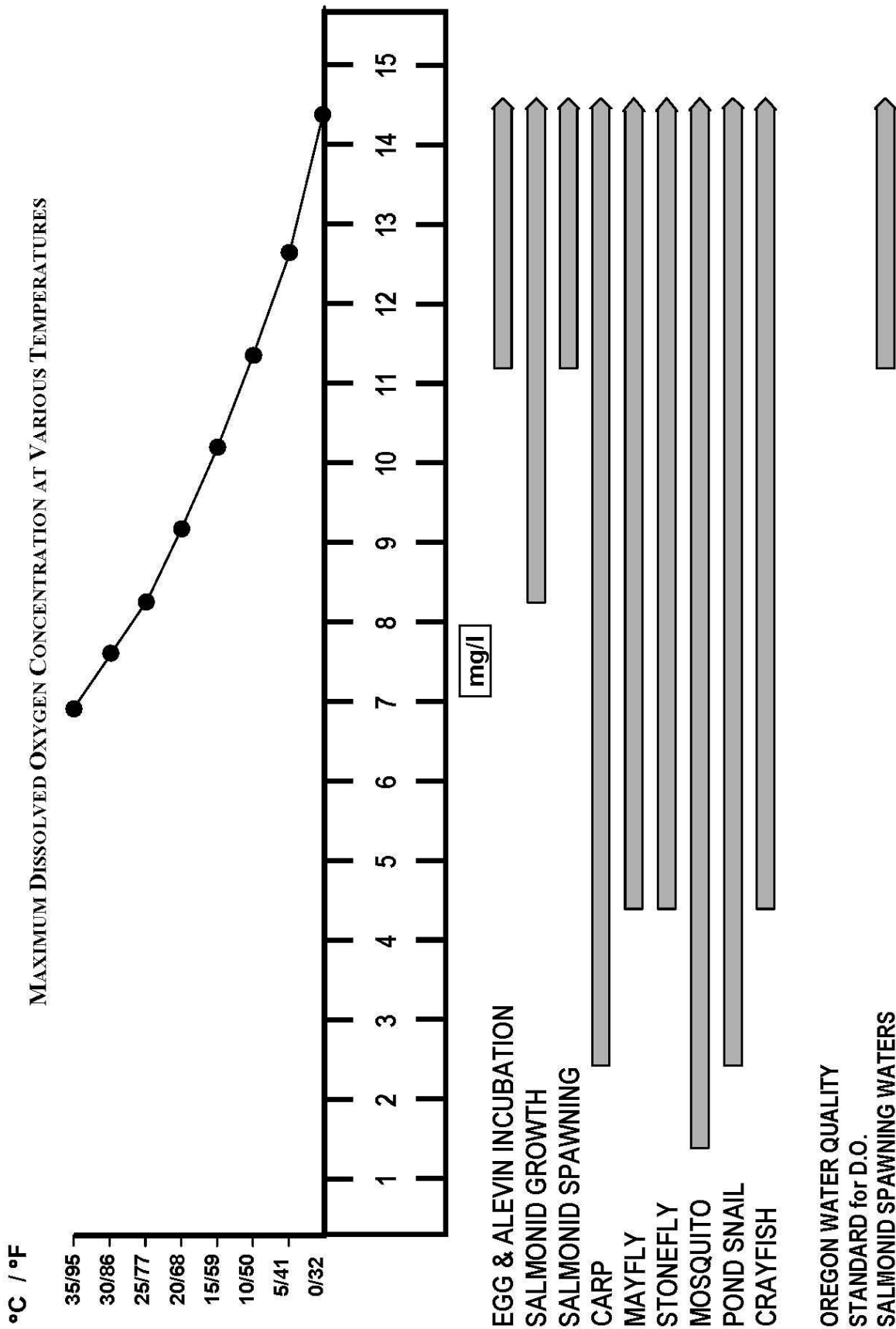


## SPRING CHINOOK



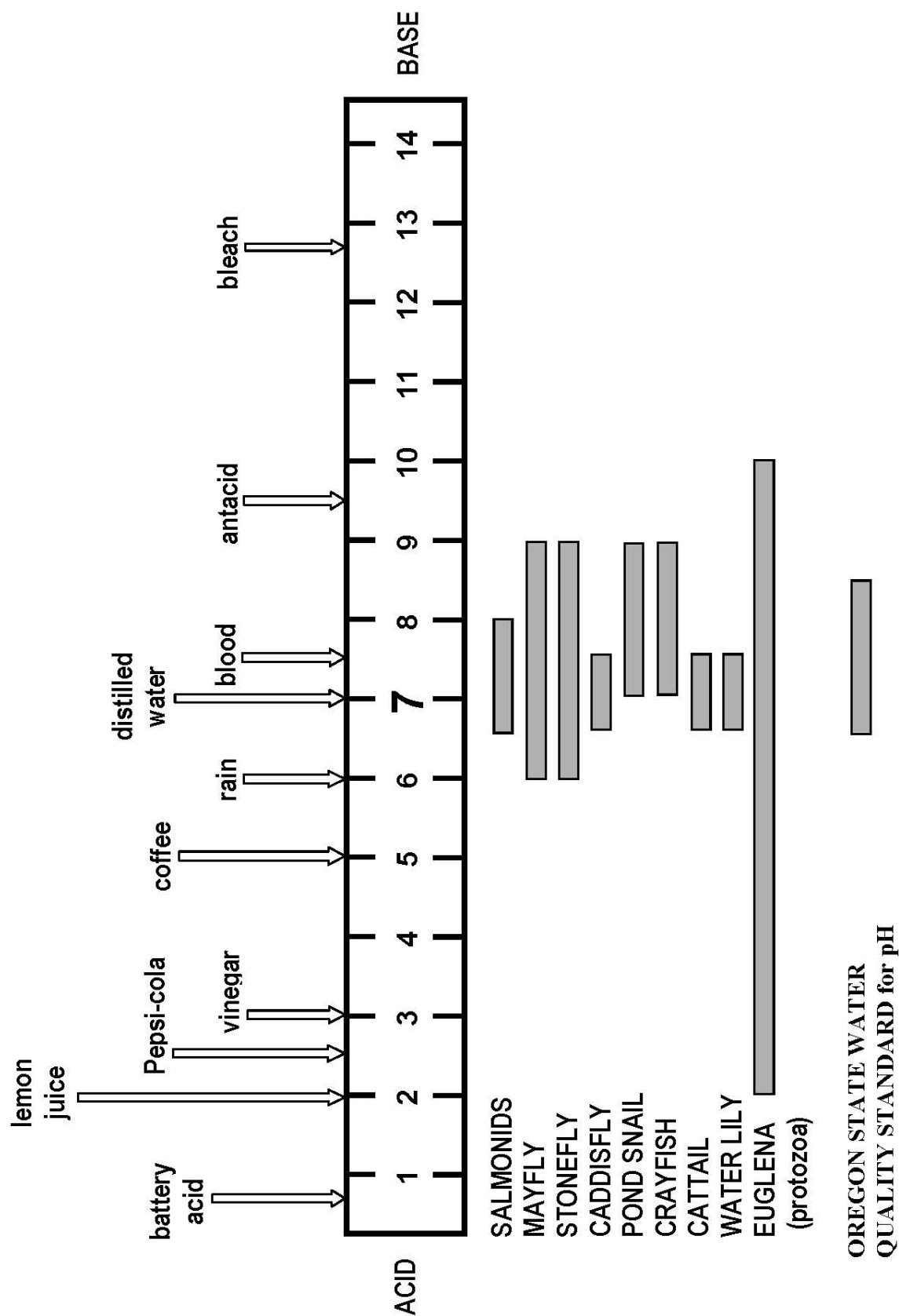
## **OPTIMUM TEMPERATURE LIMITS FOR AQUATIC ORGANISMS AND STAGES OF SALMONID GROWTH**

Compiled from Stream Scene, Streamkeepers Field Guide, DEQ Administrative Rules, Aquatic Project Wild, Investigating our Ecosystem



## OPTIMUM DISSOLVED OXYGEN LIMITS FOR AQUATIC ORGANISMS

Compiled from Streamkeepers Field Guide, DEQ Administrative Rules, Project WILD Aquatic, Stream Scene, Investigating Our Ecosystem.

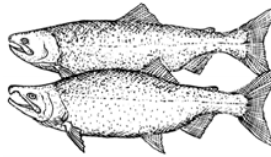


## LETHAL PH LIMITS FOR AQUATIC ORGANISMS

Compiled from Stream scene, Investigating Our Ecosystem, Aquatic Project Wild, Streamkeeper's Field Guide

## STUDENT HANDOUT 4A

## THE JOURNEY OF WILD PACIFIC SALMON

**ACTIVITIES:**

- As you read, complete the chart in Student Handout 1B: *The Life Cycle of Wild Salmon*.
- As you read about each stage of a salmon's life, think about all the possible human and natural challenges a salmon might encounter. Use Student Handout 1C: *Challenges to Salmon*, to organize your thoughts and to develop a list of potential problems and challenges to salmon on their journey.
- Use Student Handout 1D: *My Life Cycle*, to compare the similar stages of your life with those of the salmon's.
- Use a dictionary or biology textbook to look up the definitions of words that are unclear. Words that are in **bold** are of particular importance to understanding salmon and are defined in the glossary.

For nearly 10,000 years, salmon have used the rivers and streams of the Pacific Northwest to travel from their birthing streams to the ocean and back. A century ago, between 10 and 16 million salmon returned from the ocean each year to spawn in Northwest rivers. Today less than a million return.

Nothing is more awe-inspiring and remarkable in nature, and nothing defines the character and beauty of the Northwest better than the migratory journey of salmon. It represents life as a cycle, the power of survival and endurance, and the promise of return.

Pacific salmon are extremely important for several reasons. They have been a critical food source for the people of the region, and a significant food resource worldwide. Second, salmon are an **indicator species**. Because salmon migrate thousands of miles, moving from streams and rivers through estuaries to the ocean and back, they provide a valuable indication of environmental conditions in those habitats. Third, salmon play a central role in maintaining biologically diverse and productive ecosystems. For example, they are prey for a multitude of species, and their carcasses bring ocean-rich nutrients to relatively nutrient-poor freshwater environments. And finally, Northwest Native American cultures and spiritual beliefs are deeply connected with the great silver fish. In fact, the Chinook salmon takes its name from a Northwest tribe.

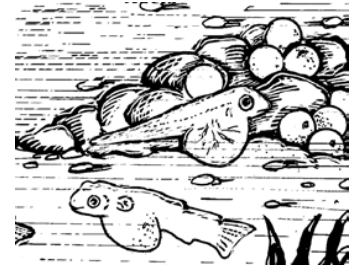
The salmon have evolved with incredibly strong instinctive patterns. Born in freshwater streams, **anadromous** or sea-run species like salmon are uniquely compelled to travel to the ocean. The vast ocean food chain supports a growth rate that freshwater members of the same species could never hope to achieve. However, travel to and from the ocean is a very risky venture. Travelling up to a thousand miles, migratory fish are inherently vulnerable to a variety of threats, both human and natural, along the way. Only the strongest, luckiest and most tenacious fish withstand the journey to reproduce. Of the 3,000 to 7,000 eggs in a nest, only one spawning pair will likely make it back to its original spawning habitat.

## 1. EGG STAGE

Salmon begin their lives in shallow gravel beds within the **substrate** of the freshwater streams and rivers in which their parents were born. The fertile, reddish-orange eggs develop in the safety of the gravel. Cold, clean **sediment**-free water must wash the eggs and bring them oxygen. Eggs lie in the gravel through the winter, as the embryos develop. **Incubation** may take 50 days or longer. For example, the colder the water, the longer the incubation period.

## 2. ALEVIN STAGE

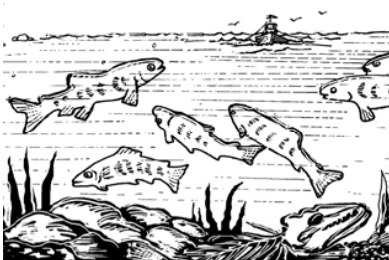
In late winter or spring, young translucent fish with large protruding eyes, called **alevins** (sometimes called yolk-sac fry), hatch and lie protected under the gravel. An orange **yolk sac** attached to the bellies of the tiny fish carry a food supply consisting of a balanced diet of protein, sugars, vitamins and minerals. As the fish grows, the yolk sac gets smaller. They will not leave the protection of the gravel until the yolk is used up, which can be twelve weeks or more. A flow of water is critical to alevin survival.



## 3. JUVENILE STAGE

In late spring and summer, with yolk sacs buttoned up, or absorbed, and eyes still protruding, small fish called **fry** emerge upward through the gravel and begin to forage for food. They are about the length of a fir needle and stay in shallow pools near the edge where the current is slow.

When the young fish reach about two inches in length, they are known as **parr** (sometimes called fingerlings) and become intense feeders on plankton, small insects, worms, mussels and snails. The parr growth phase is best recognized by the development of dark bars aligned vertically along each side of the fish. The parr phase is the most vulnerable time in a salmon's life, as they become the morsel of choice for sculpins, raccoons, kingfishers and large trout. **Juvenile** (fry and parr) salmon will remain in the river four months to two years depending on the species before moving downstream to the estuary.



## 4. SMOLT STAGE

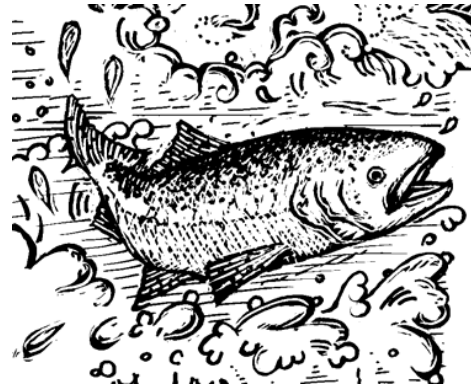
At four to six inches in length, salmon are known as **smolts**. As the parr marks disappear, most young salmon begin a physical change that triggers their downstream migration and adaptation to saltwater environment. Smolts let the current carry them downstream, tail first. Much of their travelling is done at night to avoid predators.

Estuaries occur where coastal rivers enter the ocean, creating a mix of fresh- and saltwater habitats. For salmon, the estuary represents the drastic transition from the river to the sea. Nutrient-rich sediment in estuaries produces nurseries for thousands of tiny organisms, upon which salmon feed. The inner waters of eelgrass beds and salt marshes provide habitat for the fish as they transition from fresh to salt water. This transformation involves amazingly complex body-chemistry changes. In addition, other physical changes occur during smolting: scales become larger, color turns silvery, and tails lengthen and become more deeply forked. Depending upon the species, salmon spend from a few days to a few months in an estuary.

Water flow is again a critical factor during downstream smolt migration. High flows mean higher survival rates. Decreased flows can increase the amount of time it takes smolts to reach the ocean and affect their ability to adjust to saltwater conditions. A delay can also increase their susceptibility to predators and disease.

## **5. OCEAN-FARING ADULT STAGE**

Some theories suggest that salmon follow a life cycle of going to the ocean in order to overcome the limits of food and space in freshwater habitats. Upon entering the ocean, salmon will turn toward their **hereditary** feeding grounds. For some it is north to Alaska. Others will feed in the deeper waters off of the California coast. To avoid predators like seals they will remain in large numbers called schools. Their two-tone coloring helps conceal them from enemies. Seen from above, they blend with the dark ocean waters; from below, they blend with lighter sky. They feed heavily on such prey as crab larvae, barnacles, herrings, sand lance, rockfish, anchovies and squid. Time spent at sea varies according to species ranging from one to five years.



## **6. UPSTREAM MIGRATION STAGE**

The salmon's return to the estuary is remarkable. For a fish to travel thousands of miles in the open ocean, up to thirty miles a day, and then locate and return to the estuary of its origin seems to defy all odds. This is called **homing**. Although still a mystery, scientists hypothesize that salmon navigate at sea with the aid of an inner magnetic map and a strong sense of day length, thus a salmon knows approximately where it is in relation to its home stream. As changing day length signals the advance of the season, the fish moves more or less directly toward the river mouth. As the salmon gets closer to the river the salmon's keen sense of smell comes into play, drawing it toward water smells encountered during the juvenile phases of life. Salmon can pick up the scent of their home river with noses so sensitive that they can detect dissolved substances in parts per 3,000,000,000,000,000! Arrival occurs during all seasons depending on the species.

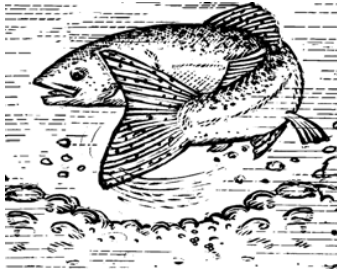
A unique feature of the life cycle is that salmon migrate and spawn in mass groups called stocks or runs. The fish within each stock or run has a unique "map" with special genetic codes that instruct and direct the fish's behavior specifically to when and where to migrate and spawn. For example, the Sandy River Fall Chinook is a stock or run of salmon that migrate up the Sandy River in the fall to spawn.

The struggling, leaping salmon against the torrent of the stream is one of nature's most incredible feats. Upon re-entering fresh water to spawn, salmon lose their desire to eat and live off their accumulated fat reserves. In proceeding toward their spawning grounds, the fish move quickly upstream in groups. They make their way by stages upstream, pausing for days at a time to rest in **pools**, often waiting for improved water flows. They tend to move as long strands, hugging the deeper channels and shaded areas of the stream. At shallow **riffles**, where the river steps down a gravel ramp, running fish raise rooster tails of water as they speed over the rocks.



## **7. COURTSHIP STAGE**

Once they come to their home gravel, females search for suitable egg-laying territories to build nests, called **redds**. As the sac around the eggs loosen, the urge to **spawn** quickens. Aggressive displays between the fish occur at this time. Males chase, bite and attack to ward off competitors. Females butt other females that appear to threaten their redd.

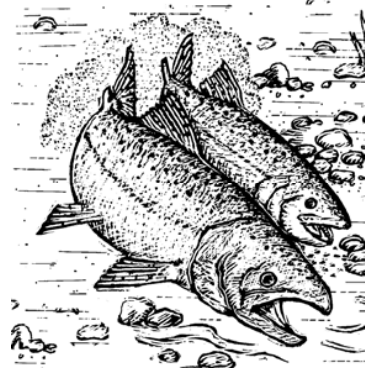


At this stage, the final days of the salmon are near, with many changes in color and body apparent. The males of some species get humped backs, hooked jaws, and sharp canine teeth. With muscles softening, skin thickening and body chemistry changing, white fungus may grow over sores or the eyes of the fish. The fins and tail fray from pounding against rocks and wounds from the journey may mark the body.

## **8. SPAWNING STAGE**

Spawning is the process of reproduction for salmon. When a female salmon arrives at her home stream, she chooses a nesting site with just the right combination of clean gravel, adequate depth, and good flow to provide oxygen for her eggs. Once the female has selected the general location for laying eggs, she turns on her side and uses sweeping or **undulating** movements of her tail to dig the nest in the gravel. Every so often she checks the depth of the nest by “**crouching**” or lowering herself into the nest. In time, she eventually produces a cone-shaped nest up to 16 inches deep. Within that site, she may dig several nests and deposit eggs in them over a period of several days.

The digging of redds attracts males. As a male manages to ward off competitors, he joins the female in the nest in a series of courting movements. Eventually, he will move alongside the female and move his body against hers slightly. Frequently he will open his mouth in a “**gape**.” When the female is ready to deposit her eggs, she too will open her mouth to resist the current and help her lower herself deeper into the nest. Finally, as both rapidly vibrate their tails, the eggs and sperm, or **milt**, are released. A female may lay up to 7,000 in a series of redds.



## **9. KELT STAGE**

As the female has released her eggs, she instinctively covers them by moving upstream slightly and repeating her digging motions. This lifts gravel just above the nest, so that the current carries it into the depression. Females will defend their redds until they die, which may be a few hours or a week. Males can spawn more than once and often will leave the female, in search of another that is preparing a nest. Salmon that have spawned are called **kelts**.

## **10. CARCASS STAGE**

Most salmon spawn only once during their lifetime (**semelparous**), although some steelhead have the ability to spawn more than once (**iteroparous**) and can re-generate, return to the ocean, then return to spawn another season. Both the male and female salmon die within a week after spawning. Their **carcasses** float downstream, get caught in roots and limbs, line beaches and sink to the bottom of the river. Opportunists like bears, gulls, crows, and eagles dine on the dead salmon.

The death of the salmon also serves the next generation. As decaying salmon add nutrients to the rivers, they feed aquatic life that will in turn feed young salmon already growing in the gravel in the streambed. In Cascade streams, as much as 40 percent of the nitrogen and carbon in young fish and 20 percent of the nitrogen in streamside plants come from dead salmon.

**STUDENT HANDOUT 4B**

1. Egg

- a.
- b.
- c.

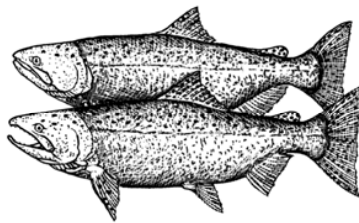
2.

- a. freshwater gravel
- b.
- c.

10.

- a.
- b. varies
- c.

***The Life Cycle of Wild Salmon***



**DIRECTIONS:** As you read *The Journey of Pacific Wild Salmon* (Student Handout 1A), complete the chart with the following information.

3.

- a.
- b. 4 months to 3 years
- c.

9.

- a. freshwater
- b.
- c.

4.

- a.
- b.
- c.

8.

- a.
- b. several days
- c.

1. Stage

- a. Location
- b. Time at stage (approx.)
- c. Distinct characteristics

5.

- a.
- b.
- c. two-tone coloring; grow rapidly

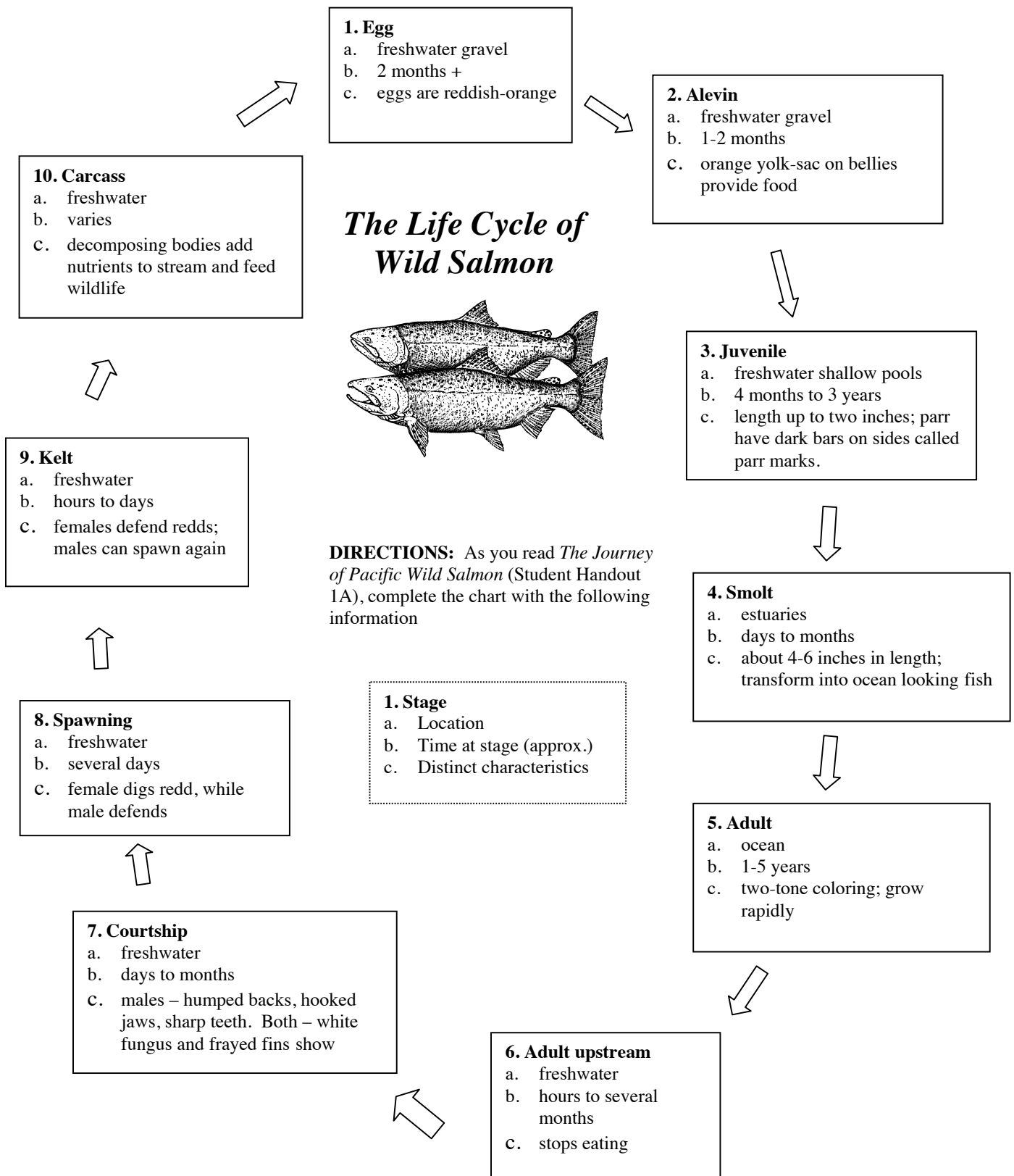
7.

- a.
- b.
- c.

6. Adult upstream

- a.
- b.
- c.

TEACHER PAGE 4B



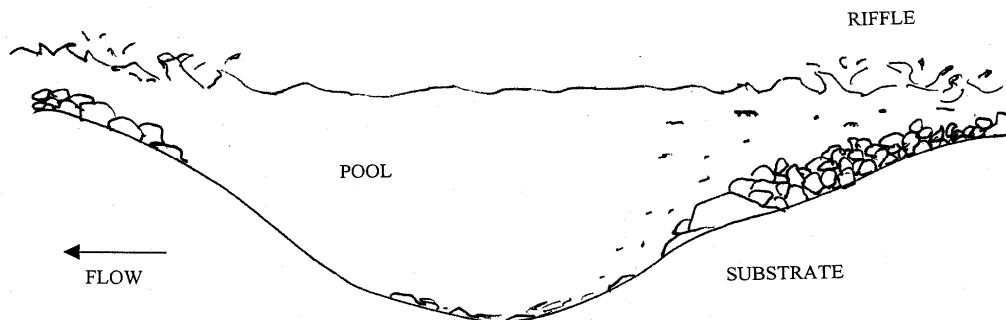
## STUDENT HANDOUT 5G

## Stream Structure and Fish Habitat

Streams are unique, constantly changing environments that support an array of aquatic life. The organisms that live in a stream are adapted to the changes and fluctuations that occur in a stream over time. Here we will discuss the structure of a stream and how aquatic animals, such as insects and fish, use the stream to their advantage.

### Stream Structure

The way water moves through a stream is heavily influenced by the land that is surrounding and underneath the stream channel. The **stream channel or bed** consists of the area that cradles the water. If this area is narrow the water moves quickly, if it is wide the water slows down. The depth of the stream also influences water movement, and the reverse is also true: the water alters the depth of the stream. The stream bed itself is constantly changing. When the water level is high and the stream is moving quickly, rocks and soil in the stream bed are easily moved. Banks can be carved away or gravel can be scoured out. When the water slows, rocks and soil are deposited at the bottom of the stream.



The land at the bottom of the stream is called the stream **substrate**. Examples of substrate are bedrock, gravel, or silt. When you look at a river bottom you can see the substrate change in relationship to the movement of the water. Where the water is moving quickly there is usually more rock and where the water slows you see finer particles like sand and silt.

As the water moves through the stream channel, it changes its speed, depth, and temperature depending upon the surrounding conditions. When water enters an area that is deep and wide, it spreads out and slows down as it fills the channel. This area is called a **pool**. When the channel narrows and is shallow, the water moves swiftly, forming small waves or white water. This area is called a **riffle**.

### A Chain Reaction

If we look at how the structure of the stream bed influences the movement of the water and how the water influences the stream channel, we can see that there is a chain reaction that occurs when a change takes place in a stream. When the bank of a stream gives way, the soil falls into the water. The water carries the soil particles downstream to a slow moving section of the river where the particles drift to the bottom, becoming substrate. This new substrate makes the stream bed shallower. The water begins to move a little more quickly in the shallow area. As the water moves more quickly,

some of the deposited soil is stirred up and carried further downstream. The area where the bank originally eroded also widens the stream channel, slowing the water a bit as it passes.



### Fish Habitat

Their riffles, pools, different substrates help to characterize streams. If we think about the needs of fish like salmon and trout, we can identify what stream characteristics they need. Fish need oxygen to breathe. They don't breathe oxygen from the air like we do; they breathe it from the oxygen in the water called **dissolved oxygen**. Oxygen can be added to the water when it interacts with air.

**Question:** Does the water mix more with the air in a riffle or a pool?

The “white water” of a riffle adds fresh oxygen to the water, so our fish need streams with riffles and adequate dissolved oxygen. Salmon and trout are also in need of cool water. The speed or velocity of the water in a stream helps keep it cool as does the depth.

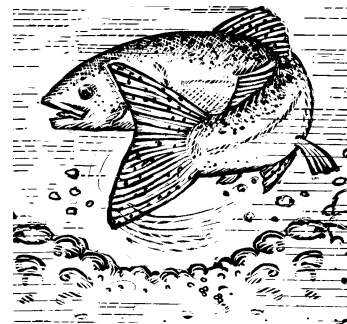
**Question:** Would shallow or deep water warm up more quickly in the summer sun?

When the water level in a stream goes down in the late summer, the temperature goes up. Shallow water warms up more quickly than deep water. Our fish need cool water so they need streams that have deep pools to keep the water cool and that have water moving all summer long. In addition, shade from the plants along the bank of a stream keeps the temperature down. These plants in the **riparian** area (the area along the stream) are important not only for shade but also to help stabilize the bank and provide a food source for aquatic insects.

Salmon and trout also need places in the stream to lay their eggs. Like birds, these fish build nests or **redds**, to protect their eggs while they develop. The eggs need cool water and oxygen to develop.

**Question:** Think about the substrate of a stream. Where would you want to hide your eggs? Where will they get cool water and oxygen? Where will predators not find them and they won't wash away?

Salmon use gravel as the substrate for their nests. They dig a depression in the small rocks, lay their eggs, and cover them up with gravel. Gravel allows water to circulate through the rocks bringing oxygen to the eggs. It also hides the eggs from predators and keeps the eggs from drifting downstream. The best location for their redds is found at the end of a riffle where the water is beginning to slow down as it enters a pool but is oxygen rich. It is also in this area where aquatic insects hide, the future food source for young salmon.



Juvenile salmon spend time in the stream eating and growing before heading to the ocean. These small fish need to protect themselves from predators and from strong currents that might push them downstream.

**Question:** Where in the stream can a young fish hide? Where will food be found?

Young salmon vary in the use of the stream depending upon species. In general, young salmon stay close to the banks or near fallen logs or rocks to hide from predators. They find their food, aquatic insects, drifting in the current. As the salmon get bigger they venture into faster water to find more insects being carried downstream.

### Salmonids and Physical Stream Characteristics

| Physical stream characteristics useful in differentiating habitat preferences of salmonids.    |                                                                                                                                  |                 |                 |                        |
|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|------------------------|
| Habitat preference                                                                             | SPECIES                                                                                                                          |                 |                 |                        |
|                                                                                                | Coho                                                                                                                             | Chinook         | Steelhead       | Cutthroat              |
| % pools                                                                                        | 50–80                                                                                                                            | 50–100          | < 50            | 40–60                  |
| % gradient                                                                                     | <3                                                                                                                               | < 2             | >1–5            | 1–20                   |
| Stream order                                                                                   | 2–5                                                                                                                              | ≥ 5             | 2–5             | > 2                    |
| Maximum temperature                                                                            | <65°F<br>18°C                                                                                                                    | < 68°F<br>20°C  | < 73°F<br>23°C  | < 65°F<br>18°C         |
| Physical stream characteristics useful in evaluating stream quality preferences for salmonids. |                                                                                                                                  |                 |                 |                        |
| Characteristics                                                                                |                                                                                                                                  |                 |                 |                        |
| Cover                                                                                          | woody structure                                                                                                                  | pool depth      | boulders & wood | wood, volume, boulders |
| Channel profile                                                                                | flat                                                                                                                             | moderately flat | steep           | undercut banks         |
| Riparian                                                                                       | Presence of riparian vegetation important for all species. Vegetation type (fir, alder) and age of vegetation determine quality. |                 |                 |                        |

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

**STUDENT HANDOUT 5H**From Stream Scene, Oregon Dept. of Fish & Wildlife, 1992

Name \_\_\_\_\_

**Home wet home . . .***Do you know . . .*

Salmon and trout (salmonids) are important to anglers. Salmonids are also important to biologists because their presence helps indicate the health of the stream in which they live. Salmonids are one of the first organisms to be affected if their watery home starts to change or if their habitat is unsuitable. Biologists refer to sensitive animals like salmonids as "indicator" species.

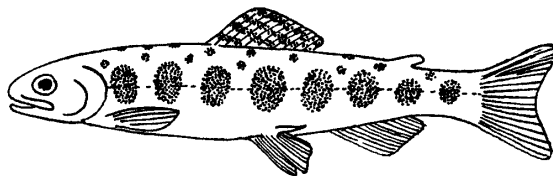
Because salmonids are so significant, fish biologists have developed many ways to improve stream habitat to enhance fish survival. In some cases, biologists can produce a fishery where none was previously found.

The ecological requirements of salmonids are:

- Cool, clear, well-oxygenated water
- Sections of gravel bottom for spawning
- Occasional pools for feeding and resting
- Adequate food (aquatic and terrestrial insects, the latter usually falling from streamside vegetation)
- Cover for protection from predators

*Now it's your turn . . .*

The figure on the next page shows several ways a stream can be modified to improve salmonid habitat. Each structure or management technique has been used to meet the special needs of these sensitive fish. Next to each feature, describe fully the contribution each will provide for fish.



**STUDENT HANDOUT 5H: *Home Wet Home...*, Stream Scene**

A. streamside vegetation

B. rock weir

C. root wad

D. cover logs

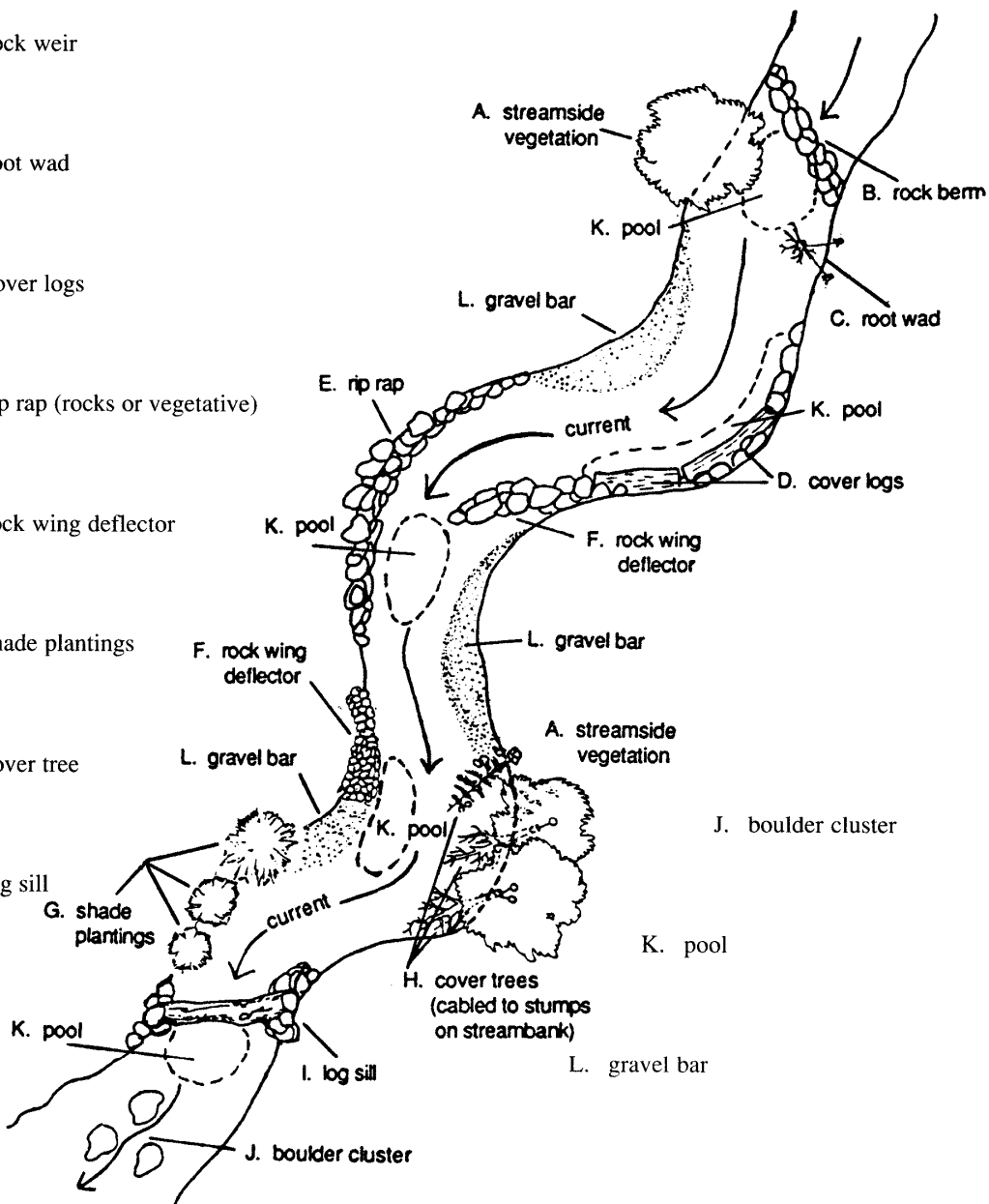
E. rip rap (rocks or vegetative)

F. rock wing deflector

G. shade plantings

H. cover tree

I. log sill



Name \_\_\_\_\_

## Fish Habitat Needs Vocabulary

### DIRECTIONS

1. Read ***Fish Habitat*** Handout.
2. On a separate sheet of paper, write definitions for the terms below, using the following guidelines:
  - A. Read the sentence where the term is found.
  - B. Write a definition for the term. Do not use a dictionary. Instead, try to find the meaning from context.
  - C. Leave a blank line below the definition to revise or clarify it after reading the whole article and talking about the subject.
  - D. Find examples of these words in your neighborhood. Name and describe them.
  - E. Where appropriate make and label a sketch to illustrate the concept.
3. The terms are:
  - riffle
  - stable
  - porous
  - sediment-free
  - stream channel
  - substrate
  - debris
  - litter
  - dissolved oxygen
  - pool
  - root wad
  - riparian
  - carrying capacity

## STUDENT HANDOUT 5E

Name \_\_\_\_\_

## Effects of Temperature on Goldfish Respiration Rate

(Adapted from Stream Scene)

**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:**

- A. Put the goldfish in the 600 ml beaker.
- B. 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.

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STUDENT HANDOUT 5E continued

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.
  
- C. 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.
  
- D. 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.
  
- E. 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.
  
- F. Count the gill plate movements for 15 seconds. Repeat and record.
  
- G. 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.
  
- H. Return the goldfish to the aquarium.

**STUDENT HANDOUT 5E continued**

- I. 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 |             |              |              |              |              |

Temperature

Behavior

5 Celsius

10 Celsius

15 Celsius

20 Celsius

25 Celsius

**STUDENT HANDOUT 5E continued**

8. Graph your data on the graph below.

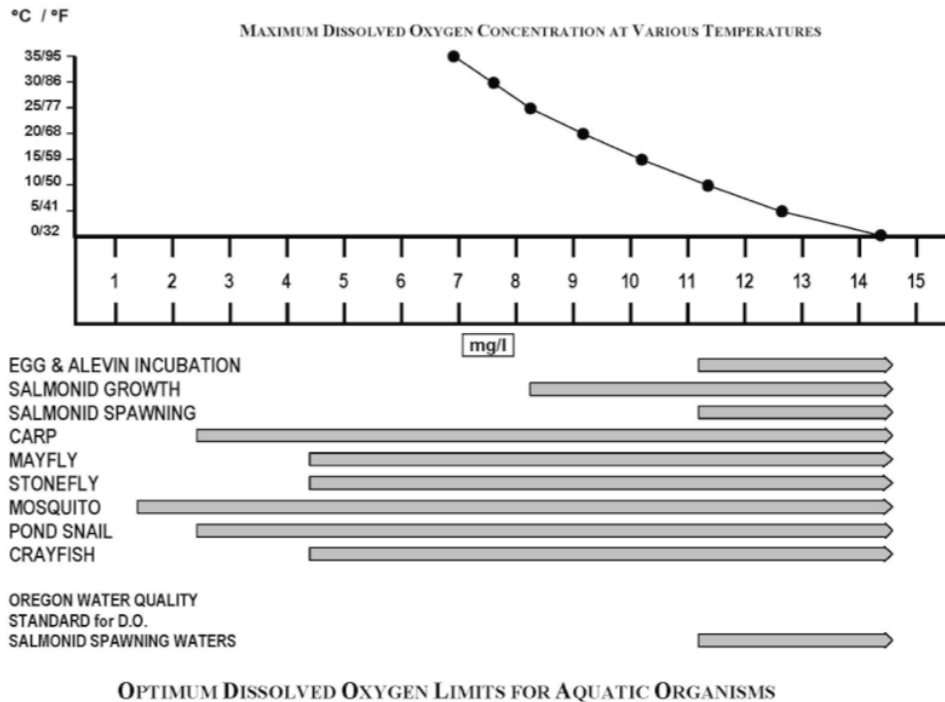
Label the Y axis “Breaths per 15 seconds”. Label the X axis “Temperature in Celsius”.  
Plot two lines on your graph: your average values, and the class averages.  
Label your two lines carefully.



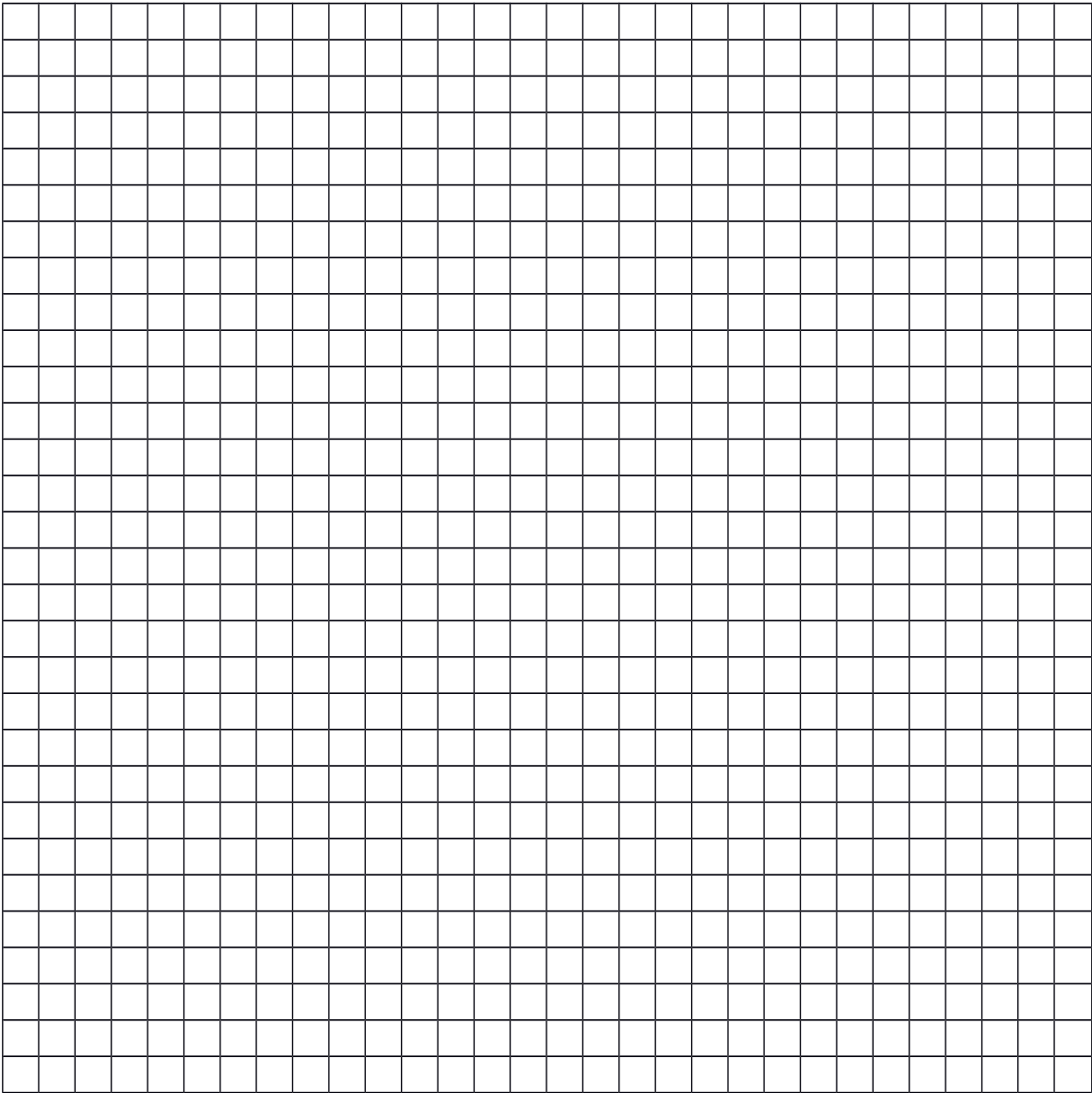
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**STUDENT HANDOUT 5E continued****Discussion questions:**

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 30° C?
9. What is the maximum amount of dissolved oxygen that water can hold at 0° 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?"

## Salmon Discussion Questions

1. What's up with these crazy fish? Why don't they just live in either the river or the ocean?
2. Steelhead are able to return to the ocean after spawning yet chinook, coho and other salmon species are essentially programmed to die. Biologists have determined that this programmed death evolved more recently as a special adaptation. Why?
3. How might a healthy forest's riparian zone benefit salmon?
4. How do returning salmon benefit the forest?
5. Research in Yellowstone Park shows that the reintroduction of wolves has benefited fish. How might that have happened?
6. In what ways does the Salmon Watch field trip remind you of an R-rated zombie movie?

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### "Answers"

1. The clear, nutrient-poor Cascade streams provide much less food for the organisms living in them. Because of this, there are fewer predators. By overwhelming the river with thousands of offspring all at once, salmon ensure that every predator can eat its fill and still leave the vast majority their eggs and fry safe. The Pacific Ocean is rich in nutrients and life. By moving to the ocean as somewhat larger smolts, salmon enter at the middle of the ocean food chain rather than at the bottom. This allows them to take advantage of the abundant food supply as ocean predators.
2. By depositing their nutrients in the clear Cascade waters, salmon provide food (mostly indirectly) for their young. The carcasses feed aquatic invertebrates, thereby increasing their populations and feeding the fry that will hatch in the spring. The nutrients (most importantly Nitrogen and Phosphorus) lead to more bacteria, fungi and algae in the stream which also provides food for aquatic macroinvertebrates. You can tell the kids that the parents made the ultimate sacrifice to "pump up the food chain" and feed their children.
3. Salmon need cold, clear water, food, resting places and protection from predators. A healthy forest has trees with roots that prevent soil from eroding into the water and burying redds in silt. The nurse logs and duff on the forest floor act as a sponge, preventing flash floods from destroying the redds and gradually releasing cool water to the stream during the warm, dry months. The shade from riparian trees helps keep the water cool. Leaves from alder and other riparian trees feed many macroinvertebrates. Trees that fall in the river slow the current and add structure, providing places for salmon fry to rest, safe from many predators.
4. See the answer to question 10, above. Kids will be able to name some animals that might eat salmon carcasses. The feces from those animals fertilize the forest, often far from the river. By studying isotopes of nitrogen, biologists have determined that more than 20% of the nitrogen in the tissues of riparian trees and shrubs originated in the Pacific Ocean.
5. This question emphasizes the complexity of ecosystems. Wolves essentially make deer and elk nervous, preventing them from feeding too long in one patch of the riparian zone. Areas that were once sparse or denuded now support rich riparian forests.
6. Come on, sex, violence, the undead, kids "eating their parents." Really, what more could you ask for in a field trip?