General Information on Salmon Watch

A Volunteer’s Role
Volunteer Responsibilities ........................................ VR 2
Safety & Site Impact Protocols ..................................... VR 3
What to Bring on the Day of Your Field Trip .................... VR 4
Possible Field Trip Activities ........................................ VR 5
Sample Field Trip Schedules: ........................................ VR 8
   Sample 1.
   Sample 2.
Tips for Salmon Watch Volunteers ................................. VR 10
The Service-Learning Project ........................................ VR 11
Techniques for Working with Kids in Nature .................... VR 12
Ages and Stages of Youth Development .......................... VR 15
Positive Comments to Give to Young People .................... VR 16

Nature Awareness
Introduction ................................................................ NA 2
Wildlife Watching: ....................................................... NA 3
   The Freeze Game
   Splatter Vision
   Focused Hearing
   The Fox Walk

Salmon Biology, Numbers, and Governmental Bodies that Regulate Salmon
Introduction ................................................................ SB 2
Natural Life Cycle of Anadromous Fish ............................. SB 3
Where are the Salmon, When? ........................................ SB 4
Chinook Salmon ........................................................ SB 7
Coho Salmon ............................................................. SB 9
Steelhead ................................................................. SB 11
The Most-Asked Questions About Salmon in the Sandy River SB 13
Current Status of Salmon Stocks .................................... SB 15
Hatcheries ................................................................. SB 22
Water Quality
Introduction to Water Quality Analysis, Goals, Objectives, and Procedures
Temperature WQ 3
Dissolved Oxygen WQ 6
pH WQ 10
Turbidity WQ 12
Wrap-up or Debrief of Field Analysis WQ 15

Aquatic Macroinvertebrates
Introduction to Macroinvertebrates AM 2
The River Continuum AM 6
Macroinvertebrate Tolerance Groups AM 9
Quick Reference Guide to Aquatic Macroinvertebrates AM 12
Station Goals, Objectives, and Procedures AM 14
Wrap-up or Debrief of Field Analysis AM 15

Riparian Ecosystem
Introduction to Riparian Areas R 2
Riparian Ecosystem Activities: Objectives, Outcomes, Materials and Procedures R 8
Riparian and Aquatic Area Survey
Riparian Area Transect Activity
Riparian Area Mapping Activity
Riparian Area Profile Activity
Identification of Northwest Native Trees R 16
Actively Managed Streamside Buffers R 23

Additional Information
Glossary G 1
Internet References G 11
A Volunteer’s Role

- Volunteer Responsibilities VR2
- Field Trip Safety and Site Impact Protocols VR3
- What to Bring on the Day of Your Field Trip VR4
- Possible Field Trip Activities VR5
- Sample Field Trip Schedules:
  Sample 1.
  Sample 2. VR8
- Tips for Salmon Watch Volunteers VR10
- The Service-Learning Project VR11
- Techniques for Working With Students VR12
- Ages and Stages of Youth Development VR15
- Positive Comments to Give to Young People VR16
Volunteer Responsibilities

- Attend the Salmon Watch Volunteer Training.
- Attend, if possible, the Salmon Watch Kick-Off Reception. Invitations will be sent to you with the date and location.
- Field Trip:
  - Sign up for one or more field trips.
  - Assist, support, and facilitate the student’s field trip learning experience (the key is to find the balance between helpful and overbearing).
  - Communicate with teachers about trip agenda, equipment needs and teacher expectations.
  - Ensure safety! Make sure students understand and abide by the guidelines listed on the next page. Appropriate conduct on field trips is important because of the fragile condition and sensitive nature of the field trip sites.
  - Assist teacher with field trip as needed.
  - Participate in the evaluation of the field trip.

Other Volunteer Opportunities (Optional)

- Service-learning Project:
  - If possible, accompany the field trip of the teacher and classroom with whom you will work on the project.
  - Communicate with Oregon Trout Staff or specific teacher about various opportunities within a project.
  - Assist teacher with project as needed.
  - Participate in the evaluation of the service learning project.
- Classroom Guest Speaker
  - Communicate with Oregon Trout Staff or specific teacher about various opportunities in the classroom.
- If interested, ask about other volunteer opportunities at Oregon Trout and Salmon Watch.
- Identify other interested volunteers and teachers to Salmon Watch!
Field Trip Safety & Site Impact Protocols

VOLUNTEER INSTRUCTORS:
- If possible, arrive at the site 30 minutes before students arrive to discuss with all facilitators safety concerns, the day’s agenda, and emergency procedures.
- If possible, bring extra clothing, rain gear, and food for unprepared students.
- Protect yourself from misunderstandings - never be alone with a student!

ALL STATIONS
- Tread lightly, leave no trace, leave site cleaner than you found it, and never drink the water because it may cause illness.

SALMON WATCHING
- Salmon are a protected species under the Endangered Species Act. Harassment of any kind is in violation of federal law and will not be tolerated! Throwing rocks or debris, getting in the water, running or jumping on the banks near the fish are all considered harassment. Students who engage in harassment will give up their opportunity to participate and will be asked to sit on the bus with a parent or teacher for the remainder of the field trip. Salmon are very sensitive to movement along the stream banks. To be able to see spawning fish, limit movement as much as possible during the period of observation. Whenever possible, view salmon from above (bridge, hillside, etc.). Be sure to use your Salmon Watch polarized glasses to cut the glare on the water for optimal viewing.

AQUATIC MACROINVERTEBRATES STATION
- Macroinvertebrate sampling should be conducted well away from and downstream from salmon & redds.
- No more than four students in the stream/river at a time.
- In water above the knees, all participants are required to wear life vests.
- Avoid fast-moving water.
- Take care when walking on slippery rocks.

WATER QUALITY TESTING STATION
- If using the LaMotte Dissolved Oxygen kit, rubber gloves and goggles are required, as potentially harmful chemicals are included in this kit.
- All refuse water from water chemistry kits must be poured and kept in the wastewater container. Dispose of wastewater back at school and not at the site.
- Rinse out all bottles and test tubes with clean water.
- Always wash your hands after water quality testing.

RIPARIAN STATION
- No sandals or shorts are allowed on the field trip due to the potential of poisonous plants.
- Always stay with your group. Never wander off by yourself.
- Stay on the trail unless otherwise instructed by your facilitator.
What to Bring on the Day of Your Field Trip

Please note that this list is designed to serve as a guide, and that you may not need all of the items listed below.

Personal

- Rain Gear
- Backpack or Knapsack
- Lunch and Beverage
- Notebook and Pen
- Salmon Watch Volunteer Resource Packet
  (or handouts from the packet)
- Hat and Gloves
- Drinking Water

Equipment for Teaching Stations

Field Equipment:
This includes monitoring or collecting equipment, field binoculars, field guides, ID keys needed for specific teaching stations as well as a field trip first aid kit.

(Note: The teacher is ultimately responsible for making sure equipment is available at the field site. Please coordinate the check out of field equipment with the teacher and/or Oregon Trout staff prior to your scheduled field trip)

Optional Items

- Camera and Film
- Extra Rain Gear for students (large plastic garbage or leaf bags work well)
- Polarized Sunglasses for viewing fish
Field Trip Activities

Described below are activities which have been used successfully by teachers on Salmon Watch field trips in the past. Teachers will be selecting activities from this list and you may be asked to lead one of these activities. More detail will be given on each activity in later sections of this handbook.

Core Teaching Stations

- **Salmon Biology**: Usually taught by a fish biologist. Your Salmon Watch field trip is the perfect time for a discussion about the species of salmon they observe on the field trip, the life cycle, anatomy, spawning behavior and topics such as hatchery vs. wild fish.

- **Macroinvertebrates**: This activity reinforces what students have learned about water quality and the kinds of organisms that inhabit a stream with a particular water quality profile. At this station, students sample for macroinvertebrate populations in the stream and use that information to evaluate the health of the stream as salmon habitat.

- **Water Quality**: The salmon’s home stream helped to form the land through which it flows, and in turn, is modified by the land and its inhabitants. First hand experience of the riparian habitat and water quality parameters will strengthens the students’ connection to the salmon and illustrates other ways humans impact the salmon life cycle. Parameters to test on your Salmon Watch field trip will include temperature, pH, turbidity, and dissolved oxygen.

- **Riparian Environment**: It is important that during their Salmon Watch field trip students understand the interrelationship among salmon, humans and the watershed they share. This station allows students to understand salmon in a larger context and emphasizes the importance of high quality habitat for salmon survival. Activities that help students gain a broader perspective include: habitat evaluation, stream mapping, food webs, or human impacts.
Optional Activities

- **Journal Writing:** Optional as the teacher will be taking the lead on journal writing. Find several areas where the forest floor is relatively clear, or the stream bank provides a place which “feels quiet”. Adult volunteers can take students to these quiet places. The volunteer should sit down, and remind students of the assignment that was made in class: students are to relax and open their minds (be present) to the place where they are. When they feel ready, they can respond to the assignment that has been posed. This assignment can include describing their thoughts or feelings, writing a poem, relating their experiences to a parent in a letter, etc. Once the students are engaged, the volunteers leave and gather at a base area designated by the teacher. When students have finished writing, they also move to the base area. (They have been instructed by the teacher beforehand to do this.)

- **Native American Culture/Philosophy:** If available, a Native American who is knowledgeable about the role that salmon play in the culture of Pacific Northwest Indian tribes might share legends or other information that will allow students to better appreciate the importance of salmon to Native Americans. Encourage your students to prepare questions beforehand. Other topics might include treaty rights, tribal customs, and attitudes toward nature, music, dance, artifacts, art or food.

- **Nature Walk:** This activity encourages students to observe their surroundings and enhance their data collection skills. Have your students identify their location on maps if available, then document observed wildlife and wildlife signs. This could also include plant identification, bird watching, and animal signs. This data could be shared with other classrooms to create an annual site profile.

- **Art/Poetry:** An art and/or poetry station has worked well for an interdisciplinary field trip and allows the students to experience nature, and the salmon, on many different levels. Past activities have included drawing, painting, making fish prints, and writing haiku poetry.

- **Guided Visualization:** The teacher may choose this activity or you can communicate with the teacher if this is something you are interested in leading. Find a quiet place for this station, one which is close to the stream. An excellent example of a recorded guided visualization is *The Drought* by Barry Lopez.

- **Miscellaneous Other Activities:** The game, “Hooks and Ladders”, allows students to appreciate the strength, determination, and perseverance of the salmon along their life’s journey. This activity takes a large open space and is best done with the whole class. Teachers may do this on the school grounds either before or after the field trip.

- **Flycasting Demonstration:** If you or one of your adult volunteers are interested in flyfishing, then a possible station might be a demonstration on flyfishing techniques, along with a discussion on issues such as catch & release fishing.
Salmon Politics: This may be incorporated into the Salmon Biology station or integrated into the other teaching stations. The salmon crisis is one of the most studied issues in the Pacific Northwest today. What better time to start students thinking about these issues than when they are sitting beside a salmon stream watching the miracle of spawning? Experiencing salmon and their watershed on a personal level will give students powerful insight into discussions about historic abundance of salmon and declining runs, factors contributing to population declines, the Endangered Species Act, possible solutions, importance of salmon in the Pacific Northwest, and what individuals can do to help.
Sample Field Trip Schedules

(Note: the time that students spend at each teaching station generally varies from 25 to 45 minutes. This is determined by the time required to travel to the site, number of rotations and when buses need to be back to school.)

Sample 1.

**SALMON WATCH 1999**

Peggy Potter
HB Lee Middle School
November 1, 1999
Field Trip to Eagle Creek Site
Columbia River Gorge

9:15   Bus leaves HB Lee
10:00  Arrive at Eagle Creek Site
       Orientation/Introduction
       Students will be split into 4 groups and rotate through 4 separate activities.

10:20 – 10:50 Activity 1 – Current issues. Life Cycle of the Salmon
       Ron Garst
10:55 – 11:25 Activity 2 – Macroinvertebrates –
       Michele Dickson and Bob Delgizzi
11:30 – 12:00 Activity 3 – Water Quality
       Paul Sybor and Adrienne Ash
12:05 – 12:35 Activity 4 – Native American legends
       Michelle Barnier

12:40 – 1:00 Lunch
1:00   Wrap up, thank volunteers
1:10   Board Bus and head back to HB Lee
1:55   Arrive back at HB Lee Middle School
Sample 2.

SALMON WATCH FIELD TRIP
Camp 18 Field Site
November 8, 1999

8:00 Assemble and board bus in front of school

9:15 Arrive at Camp 18
Introduction of volunteers, station assignments, overview of stream

Our helpers today are:

Marianne McPherson – Macroinvertebrates
Vanessa Davis – Water Quality
Ed Hughes – Riparian Zone
Chad Hewitt – Salmon Viewing

9:30 – 12:05 Four stations in 35 minute rotations

Approximately:
9:30 – 10:05
10:10 – 10:45
10:50 – 11:25
11:30 – 12:05

Station #1 Water Quality
Station #2 Macroinvertebrates
Station #3 Riparian Zone
Station #4 Salmon Viewing

Group #1 1234
Group #2 2341
Group #3 3412
Group #4 4123

12:10 – 12:30 Summation and Reflection
Thank Volunteers

12:30 – 1:15 Lunch

1:30 Depart Camp 18 (LEAVE THE SITE AS YOU FOUND IT OR BETTER!)

2:45 Arrive at St. Mary’s
Tips for Salmon Watch Volunteers

You have a fun experience ahead of you! Being a Salmon Watch Volunteer is a challenging and rewarding role. Jump in! Get involved! Above all, have fun! You have much to give and enthusiasm is contagious. Here are a few suggestions to help you:

What is my role as a volunteer?
You will be working with students in the field, sharing your perspective and maximizing their learning experience. Please demonstrate exemplary behavior and attitude in the natural environment. Your curiosity will lead others to follow suit. Encourage your students to:
- Ask questions.
- Investigate their study area, while minimizing disturbance.

How can I help students get the most out of their field trip?
Talk with the teacher about their goals for the trip. Be sure you understand the plan for the day. Review your Salmon Watch Volunteer Resource Packet before your trip. Utilize the “learning moments” during the day; be alert to unique opportunities that may seem like tangents to the activity, yet offer a springboard for further discussion of the original topic.

How do I lead the group?
There are many effective techniques for getting students engaged in the planned activities. Here are a few suggestions:
- Ask students to describe their observations.
- Choose a plant, animal, or other physical object they can touch and examine.
- Offer positive comments for their answers; keep a positive attitude.
- Provide interactive activities to engage the students in learning. Avoid a lecture format.

How do I involve everyone in the group?
Be sure to try to connect with all the students in the group. There will always be a few who have all the answers. Encourage the shy or quiet children to share their ideas too. When an answer is given ask the group to offer comments: agree/disagree, elaborate, find relationships.

How do I deal with questions I don’t know the answer to?
Don’t be embarrassed to admit you don’t know the answer to every question. You are not expected to. Also, there often isn’t one simple explanation, or any correct answer. There are many ways to deal with this predicament. For example, you can:
- Reason aloud. Go through the process of how you would find out an answer.
- Show students the resources available. Have students look through field guides, or other resources. Knowing where to find an answer is as important as knowing the answer.
- Turn the question back to the group as a whole. Encourage brainstorming.
- Turn the question over to the agency expert.
Service-Learning Projects

What is Service-Learning?

Service-learning is a method by which young people learn through active participation in thoughtfully organized experiences that:

- Meet actual community needs.
- Coordinate in collaboration with the school and community.
- Integrate into each young person’s academic curriculum.
- Provide structured time for a young person to think, talk, and write about what he/she did and/or saw during the service learning activity.
- Provide young people with opportunities to apply newly acquired academic skills and knowledge to real life situations in their communities.
- Are practical applications of what is taught in the school.

Service-learning projects should address local issues and impact the community in which the students live, while providing a relevant learning experience. Students should be challenged to keep a vision, to work with community members, and to make an impact! Salmon Watch encourages teachers and student groups to utilize partner resources, especially those that support Salmon Watch.

Depending on the interests of the student body and local influences on community needs, each project will have unique opportunities and constraints. The balance struck between these features will become the ultimate plan, and represents real problem solving. Students must document each phase of planning and implementation. This will serve not only as a reference for current and subsequent projects, but also as a tool for reflection. (Journal writing is a suggested way to ensure that students keep good records of the process and meet stated objectives.)

The Role of the Volunteer

The role of the volunteer in planning and implementing service learning projects will be as varied as the projects themselves. One may wish to speak in the classroom on their subject of expertise, or provide leadership in the field. If interested in helping, please ask your field trip teacher or Salmon Watch staff how your skills can best be utilized!
Techniques for Working with Students

A Note on Lecturing

Many educators rely too much on lecturing. Most individuals, both youth and adults, find they learn better when using a hands-on, discovery approach. By breaking up the lecture with activity, one can appeal to as many senses as possible.

Research suggests that there are different types of learners. We find that a large percentage of the population does not learn easily from lecture. Most adults tolerate lecture better than children do.

Environmental education programs usually emphasize hands-on activities, and the learner is exposed to the subject over many sessions. Interpretive programs often rely more on lecture, because the entire program fits into a short time frame, thus we have included tips for effective public speaking.

Again, the best advice is to resist the urge to lecture and to use a variety of teaching methods. (Note, however, that lecturing and storytelling are different. Almost everyone enjoys a well-told story.)

Public Speaking Techniques

1. Be sure to make your presentation age and knowledge level appropriate.

2. Try to NEVER JUST TALK. Hands-on learning can and should be woven into every presentation.

3. You make presentations with your body as well as with your words, and body frequently has greater impact. Be sure to make your body language consistent with your words.

4. Get animated, be dynamic, move, gesture, use vocal variety. Don’t stand in one place. Be aware of what your group can see and hear.

5. ALWAYS speak to the whole group (beginners sometimes address only part of a group.) Yet try to have a one-on-one encounter with each person at the same time by using good eye contact.

6. Use a few, gripping, “pungent” facts and use analogies the listener can relate to easily.

7. Information should flow and be logically organized. Use repetition and internal summaries.

8. Use impact words, simple sentences, personal statements and stories. Let them know WHY this information is important, or what it relates to.
9. ENGAGE THEM WITH QUESTIONS. Size up your group, read their body language. Pacing is very important. Make sure you keep it varied and interesting. Get intense and focused with a scattered group. Adjust your pace to their responses.

Group Management

1. The most important thing to remember is to set clear expectations at the beginning of your session.

2. If you anticipate the group may not be focused, mention the expectations set by the teacher.

3. Always set limits. Always focus their attention. Always break into small groups.

4. Sometimes when leading a nature walk, students compete to walk near the leader. There are several techniques for dealing with this. Tell them to keep their attention focused outward from the trail, not forward. Or, let them take turns leading.

5. Dealing with wet and cold:
   - Accept the weather.
   - YOUR ATTITUDE will make a difference.
   - Be prepared, extra hats, sweaters and garbage bags.
   - Get under trees if it is raining hard.
   - Move around to keep warm.
   - Frequently check in with students on their comfort level and intervene when necessary.

6. Dealing with a “special” child, one who really wants your full attention, get them to focus by assigning him or her small tasks and/or enlisting their support in other meaningful ways.

Principles of Teaching

1. Remember that you represent a powerful role model for young people. Model awareness, respect for living things, and curiosity.

2. Enthusiasm is contagious. Feel upbeat, love your topic, and you will help your group to enjoy the field trip experience.

3. As much as possible, the children should be the ones doing the activity. Find ways to involve them even when you are talking and demonstrating. For example, if you cast a track, let one child mix and another pour, rather than you doing any of it.
4. You are responsible for the health and safety of these people when they are engaged in activities led by you. Safety must be a top priority. It's better to be too conservative than to have an injury. Don't let kids climb on logs. If you have a student and/or adult along who is not surefooted, make sure they get assistance. If the group samples wild foods, make sure they show you what they have picked before eating it.

5. This is a multi-cultural world. Check your comments for bias in assumptions of experiences connected to economic class or ethnic background and for possible sexist behavior (e.g. calling on males more than females to answer questions.)

6. It is not our job to convince kids of any one point of view (including environmentalism). It is OK to define the environmental ethic, say what you believe, express your point of view.

7. Understand that developmental stages exist and what they are. Make sure the activity is age and developmentally appropriate for the group.

8. We try to make sure each program has a theme. Students seem to learn best when the lesson fits together. For example, in the ancient forest, we keep coming back to diversity.

9. Always take advantage of the “teachable moment”. It is perfectly okay to be upstaged by an earthworm, otter, or eagle during your presentation.
Ages and Stages of Youth Development

Not all people develop in the same way at the same age, but there are certain patterns to youth development that are commonly experienced by most youth.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Teaching Tips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can take responsibility in planning and evaluating their own work.</td>
<td>Give youth responsibility for group activities, including planning, and implementing and evaluating.</td>
</tr>
<tr>
<td>Can plan their own social and recreational activity.</td>
<td>Provide opportunities for youth to work together. Form committees to plan recreational and social activities.</td>
</tr>
<tr>
<td>Can discuss current events, international affairs and social issues with some help.</td>
<td>Use discussion activities and games that encourage awareness of current events and issues.</td>
</tr>
<tr>
<td>Want to make decisions but still depend on adult guidelines.</td>
<td>Establish guidelines that give parameters for youth to follow.</td>
</tr>
<tr>
<td>Gain skills in social relations with peers and adults.</td>
<td>Provide activities that foster social interaction with peers and adults.</td>
</tr>
<tr>
<td>Peer pressure mounts, first from same sex, then from opposite sex.</td>
<td>Use peer pressure to influence positive behavior. Have group give encouragement to individuals.</td>
</tr>
<tr>
<td>Can be quite self-conscious.</td>
<td>Avoid asking youth to share their work individually until they feel more comfortable with the group.</td>
</tr>
<tr>
<td>Strong emotional attachment to older youth and adults.</td>
<td>Encourage youth to participate in activities with older youth and adults.</td>
</tr>
<tr>
<td>Choices are often unrealistic.</td>
<td>Assist youth in making realistic choices. Review their plans, discuss alternatives and help them weigh options before making decisions.</td>
</tr>
</tbody>
</table>
**Grades 9-12**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Teaching Tips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal philosophy begins to emerge.</td>
<td>Use activities where youth search for experiences that will allow them to identify their own philosophies.</td>
</tr>
<tr>
<td>Enjoy discussing the world situations as well as personal activities.</td>
<td>Encourage discussion of events and feelings.</td>
</tr>
<tr>
<td>Abstract thinking and problem solving reach a higher level.</td>
<td>Put youth into real-life, problem-solving situations.</td>
</tr>
<tr>
<td>Strong desire for status in their peer group.</td>
<td>Develop a climate in which youth are encouraged and supported by peers.</td>
</tr>
<tr>
<td>High interest in social activity.</td>
<td>Encourage youth to plan and carry out their own social activities.</td>
</tr>
<tr>
<td>Need freedom from parental control to make decisions.</td>
<td>Help youth realize that their decisions have consequences.</td>
</tr>
<tr>
<td>Widespread feelings of inferiority and inadequacy.</td>
<td>Encourage and help youth see their positive worth.</td>
</tr>
</tbody>
</table>

**Positive Comments to Give Young People**

- Try again. You can do it.
- Let me show you, then you can try.
- I know you can do it.
- Let me explain it to you again.
- Your opinion counts.
- What are some things that you could have done?
- I respect your opinion.
- We are a team, together we can accomplish…
- You’re good you have some special skills.
- I’m glad you made an effort…
- This is how I feel when we succeed together…

**Resource List:**
Nature Awareness

- Introduction

- Wildlife Watching
  The Freeze Game
  Splatter Vision
  Focused Hearing
  The Fox Walk
Wildlife Watching and Setting the Tone on Field Trips

Teachers are in charge of their field trips but may not be experienced outdoor educators, and may not realize that human behavior influences what can be observed on a field trip. Many might be very grateful for extra support in helping their students learn appropriate outdoor behavior.

Setting the tone at the very beginning of the field trip is key. Having opening and closing circles can enhance the overall quality of the field trip. Also incorporating quiet listening moments at the end of each activity can increase the opportunity for wildlife viewing. After students have been quietly absorbed in data collection a return to “baseline” can occur, which can be described as when wildlife becomes less aware or more comfortable with our presence, thus enabling their movement back into an area.

Teachers may cover the wildlife watching techniques with the students before they arrive at the site. Setting the tone can start with the transition from the bus to the field study site by encouraging students not to talk as they move from the bus to the opening circle location. Salmon Watch staff can suggest appropriate locations for opening circles for each site.

The teacher or volunteer can help to lead the nature awareness activities during the opening circle. The closing circle is usually led by the teacher and is where students share what they have discovered on the field trip. Also this is an opportunity to thank the volunteers and other adults who supported the field trip.

How can you tell if Wildlife Watching Techniques are working on your field trip?

Answer these questions to find out. (Note- any birds or animals that have been trained to beg for food do not count as animal encounters.)

1. How many mammals and birds did your group observe, collectively?
2. How close? Or, from what distance?
3. Was your group able to observe mammals or birds in their normal setting and with undisturbed behavior? (singing, feeding, resting, etc.) For how long?
4. Did you see birds or mammals that others in the group did not see? Why didn’t the others see them?
5. What is the best “animal experience” story you have to tell about today?

Advanced training for interested volunteers is available through the Metro Parks Greenspaces Program.
Wildlife Watching

Stop  Stop talking – become a tree, a rock, an animal…
Stop – when there is an alarm call.
Stop – when an animal looks at you.
Stop – learn to freeze.

Look  Look – with splatter vision to see movement
Look – at edges of fields and near water.
Look – for tracks and signs.
Look – at dawn and dusk.

Listen Listen – what are the birds saying?
Listen – for alarms or concentric rings.
Listen – for a rustle, snuffle, swish, crunch…
Listen – can you hear your breathing?

Move  Move - with the foxwalk.
Move – in slow motion
Move – when an animal looks away from you.
Move – with the wind
(a) The Freeze Game

Would you like to know how it feels to be invisible?

At the word freeze! – stay perfectly still. You can breathe and you can blink – but that is all.

Stay “frozen” for a moment...Pretend that you have become a statue, a rock or a tree. If a rabbit or a deer is scared, this is what they do. Their colors blend in with the forest and allow them to disappear (camouflage).

If you are looking at a deer who has “frozen”, you should try to stay still as long as the deer can. You may have to stay still for a long time! Finally, the deer will forget that you are there. It will look away from you. Now is your chance to move closer to it! Any time the deer looks at you – freeze!

Use the freeze game when you are watching wildlife and also when you hear an alarm call. This is short, choppy call given by a bird or squirrel to let the other animals know there is danger nearby. Even a hummingbird has an alarm call! Is the alarm call nearby? Wait for it to stop before you move. Is it far away? Perhaps another animal or person is moving in the woods and birds have spotted them. Soon you can learn to understand the birds.

Invent a hand signal for freeze! to use on your walks. You don’t want to shout, “freeze!” and scare everything away!

If you have an hour or two, try finding a nice spot in a park, forest or your backyard. Then sit down, get comfortable and freeze! After a while, the birds begin to sing and come closer to you. Soon you will be in a new world full of surprises – animals walking, eating, playing or hunting. That’s the way the forest is when there are no people around!

You have become invisible!
(b) Splatter Vision

Would you like to see twice as much – even in your own back yard?

Most people have learned to focus on one small area at a time. We look at a person’s face, a book or a television and blot out the surrounding areas. It is like looking through a little tube all the time.

Most animals see in a different way. They have to be aware of what is moving in the forest – is it food or will it eat me? They need to see and hear in all directions – not just in front of them. Their lives depend on this.

We can learn from our animal friends how to see much more – try splatter vision.

First put your arms straight out to the sides at shoulder level. Then point your fingers forward and wiggle them. By looking straight ahead – get so that you can see both hands:

Think of seeing out of the corners of your eyes.

Everything may seem a little blurry – but you will now be able to catch the slightest movement around you — even at your sides. If a bird blinks, you’ll see it. A blade of grass moving differently than the other – is there a mouse there? Every bug in the vicinity will be seen too? If you spot something you want to look at – then you can focus as you normally do.

After a few tries splatter vision becomes automatic and easy for anyone to do.

The next step is to sit down in your back yard, field or forest and try splatter vision. Welcome to a new world!
(c) Focused Hearing

How much can you hear? As much as a deer, a fox or an owl?
Close your eyes, take a deep breath, relax and listen.
Take your time and focus:

What is the most distant sound you hear?

What is the nearest sound you can pick out?

How about all the sounds in between the near and far?

Can you hear your own breathing?

Can you hear your heart beating?

Listen closely to what the birds are saying.

Are they making long and musical sounds? If they are – singing and all is well with them.

Are they making a short, choppy and hard to locate sound? That is called an alarm call. Birds use alarm calls to warn other birds and animals of approaching danger. Some alarm calls are loud and easy to hear – like a jay or a crow. But even very small birds have alarm calls – it may be tiny chirp that is hard to hear. Even the smallest alarm call is the birds’ way of shouting, “There is danger coming! Hide! Run away!” to all other animals in the forest.

If you hear an alarm call near you, chances are that the bird is warning other animals in the forest that you are approaching! If you hear an alarm call not in your immediate area, it could mean that there is another animal moving. Or it could be that there is a disturbance being made even further away…

You see, if a loud, scary, dangerous animal moves through the forest (like a human for example), the alarm calls will move outward from the source of the danger. It is like dropping a rock in a pond – the concentric rings of disturbance move out in larger and larger circles.

Can you detect any concentric rings?

Birds will make different types of alarm calls for different dangers – people, deer, fox, snake, etc. You can learn to understand them!

Another type of concentric ring is a bird flying rapidly. Or if the forest is very quiet it means that some danger is near, passed through recently, or that you are creating a disturbance.
Try putting on **deer ears**. Just cup your ears with your elbows pointed *forward*. This will let you focus and amplify the slightest rustle, swish or sound in the forest.
(d) The Fox Walk

We can learn from our four-legged friends how to walk silently and unseen. The fox is especially good at sneaking softly through the forest.

First – stop talking!

Then – try the Fox Walk:

1. Try taking a short slow step and place only the outside edge of your foot on the ground.
2. Gently roll your foot down flat.
3. Then slowly move your weight forward.
4. Repeat with the other foot...

With this walk you can freeze easily (if an animal looks towards you or you hear an alarm call). If you feel a twig that might break – just pick up your foot and place it in a new spot. You don’t need to look down – just feel the way.

It is best to use slow motion.

Try the Rabbit Game: Have your group form a circle with one person in the center pretending to be a rabbit. When the rabbit looks at you freeze! When the rabbit is not looking at you, Fox Walk toward it. See who can reach the rabbit first. Try two rabbits. This is the same way to sneak up on a real animal.

Try the Fox Walk at home. See if you can sneak up on a cat or dog. Don’t scare them. Just try to get near them, and then let them know that you are there and just practicing.

Then go outside and try the Fox Walk on beetles, bugs, birds, frogs, chipmunks, squirrels, deer or anything else. With care you can get close to lots of different animals. Remember just get near and enjoy watching them, don’t touch them or startle them. This is part of becoming invisible and enjoying the world of the four-legged and winged creatures!

Resource List:
For more information, see books and field guides by Tom Brown Jr.
©Metro 1994 – Regional Parks and Greenspaces
Salmon Biology, Numbers, and Governmental Bodies that Regulate Salmon

- Introduction SB2
- Natural Life Cycle of Anadromous Fish SB3
- Where are the Salmon, When? SB4
- Chinook Salmon SB7
- Coho Salmon SB9
- Steelhead SB11
- The Most –Asked Questions About Salmon in the Sandy River SB13
- Status of Salmon Stocks SB15
  - Healthy Salmon Stocks of the West Coast
  - Factors Responsible for the Decline in Salmon Abundance and Distribution in the Pacific Northwest
  - Causes of Mortality, 1770-present
  - Government Bodies that Regulate Salmon
- Hatcheries SB22
Introduction to Salmon Biology

This section will provide information on the biology and life history of northwest salmon, starting with the natural life cycle of salmon and continuing with more specific information about species you may encounter on a Salmon Watch field trip.

**Table 1**: “Where Are The Salmon When?” provides a generalized life history pattern for Salmon, Steelhead and Trout in the Pacific Northwest. Some of the information included is timing of adult returns from the ocean, spawning location, a description of fresh water habitat and when juvenile migration to the ocean occurs.

**Table 2**: “Habitat Requirements for Salmonids in Northern Coastal Streams” includes specific habitat information for Fall Chinook, Spring Chinook, Coho, Chum, Winter Steelhead, Summer Steelhead and Sea Run Cutthroat Trout. Some of the habitat components listed are spawning location, substrate size, water depth and velocity, dissolved oxygen and water temperature.

This information is intended to support the volunteers leading the Salmon Biology teaching station in the field. It will also help bring together the data and observations of students as they start their stream assessments and evaluations of healthy salmon habitat.

Doug Baus, US Fish and Wildlife Service, with HB Lee students and a salmon carcass on the Salmon River.
Natural Life Cycle
2 to 5 years

Length of life cycle varies with species and conditions

Oregon Department of Fish & Wildlife

Salmon life cycle •
Table 1. WHERE ARE THE SALMON, WHEN?

**Generalized** Life History Patterns of Salmon, Steelhead, and Trout in the Pacific Northwest

<table>
<thead>
<tr>
<th></th>
<th>Adults Return to Streams from Ocean</th>
<th>Spawning Location</th>
<th>Eggs in Gravel**</th>
<th>Young in Stream</th>
<th>Fresh Water Habitat</th>
<th>Young Migrate Downstream</th>
<th>Time in Estuary</th>
<th>Time in Ocean</th>
<th>Adult Weight (average) English (Metric)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coho</strong></td>
<td>Sept. – Jan</td>
<td>Coastal streams</td>
<td>Sept - May</td>
<td>1+ years</td>
<td>tributaries</td>
<td>Mar-Jul (2&lt;sup&gt;nd&lt;/sup&gt; year)</td>
<td>few days to one month</td>
<td>2 years</td>
<td>5-20 lb (8)</td>
</tr>
<tr>
<td><strong>Chum</strong></td>
<td>Sep. – Jan</td>
<td>Coastal rivers</td>
<td>Sep-Mar</td>
<td>days-weeks</td>
<td>little time spent in freshwater</td>
<td>shortly after young leave gravel</td>
<td>7-14 days</td>
<td>2.5-3 years</td>
<td>8-12 lb. (10)</td>
</tr>
<tr>
<td><strong>Chinook</strong></td>
<td>Jan. – July Spring run</td>
<td>Main stem – large and small rivers</td>
<td>Jul-Jan</td>
<td>1+ years</td>
<td>main stem – large and small rivers</td>
<td>Dec – Mar. (2&lt;sup&gt;nd&lt;/sup&gt; year) Spring (2&lt;sup&gt;nd&lt;/sup&gt; year) Dec. - Mar (2&lt;sup&gt;nd&lt;/sup&gt; year)</td>
<td>days-months</td>
<td>2-5 years</td>
<td>10-20 lb. (15)</td>
</tr>
<tr>
<td><strong>Cutthroat</strong></td>
<td>Fall run</td>
<td>Tiny tributaries of coastal streams</td>
<td>Dec-Jul</td>
<td>1-3 years (2 avg)</td>
<td>tributaries</td>
<td>Mar-Jun (of 2&lt;sup&gt;nd&lt;/sup&gt; - 4&lt;sup&gt;th&lt;/sup&gt; yr)</td>
<td>days-months</td>
<td>0.5-1 year</td>
<td>0.5-4 lb (1)</td>
</tr>
<tr>
<td><strong>Pink</strong></td>
<td>Jul-Oct</td>
<td>Main stem of streams, tributaries and lower reaches</td>
<td>Aug.-Jan</td>
<td>days-weeks</td>
<td>little time spent in freshwater</td>
<td>Dec-May</td>
<td>few days</td>
<td>1.5 years</td>
<td>3-10 lb (4)</td>
</tr>
<tr>
<td><strong>Sockeye</strong></td>
<td>Jul-Aug</td>
<td>Streams, usually near lakes</td>
<td>Aug. – Apr</td>
<td>1-3 years</td>
<td>Lakes</td>
<td>Apr-Jun (of 2&lt;sup&gt;nd&lt;/sup&gt; - 4&lt;sup&gt;th&lt;/sup&gt; yr)</td>
<td>few days</td>
<td>1-4 years</td>
<td>3-8 lb (6)</td>
</tr>
<tr>
<td><strong>Steelhead</strong>*</td>
<td>Winter run</td>
<td>Tributaries and small and mid-size streams and rivers</td>
<td>Feb-Jul</td>
<td>1-3 years</td>
<td>tributaries</td>
<td>Mar-Jun (of 2&lt;sup&gt;nd&lt;/sup&gt; – 5&lt;sup&gt;th&lt;/sup&gt; yr) Spring &amp; Summer (of 3&lt;sup&gt;rd&lt;/sup&gt;-4&lt;sup&gt;th&lt;/sup&gt; yr) Mar-Jun (of 3&lt;sup&gt;rd&lt;/sup&gt;-5&lt;sup&gt;th&lt;/sup&gt; yr) Mar-Jun (of 2&lt;sup&gt;nd&lt;/sup&gt;-5&lt;sup&gt;th&lt;/sup&gt; yr)</td>
<td>less than a month</td>
<td>1-4 years</td>
<td>5-28 lb (8)</td>
</tr>
<tr>
<td></td>
<td>Summer run</td>
<td>(Columbia)</td>
<td>Feb-Dec-May</td>
<td>1-2 years</td>
<td>Spring &amp; Summer (of 3&lt;sup&gt;rd&lt;/sup&gt;-4&lt;sup&gt;th&lt;/sup&gt; yr) Mar-Jun (of 3&lt;sup&gt;rd&lt;/sup&gt;-5&lt;sup&gt;th&lt;/sup&gt; yr) Mar-Jun (of 2&lt;sup&gt;nd&lt;/sup&gt;-5&lt;sup&gt;th&lt;/sup&gt; yr)</td>
<td>Mar-Jun (of 2&lt;sup&gt;nd&lt;/sup&gt; – 5&lt;sup&gt;th&lt;/sup&gt; yr)</td>
<td>5-20 lb</td>
<td>5-30 lb (8)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Migration</th>
<th>Spawn Time</th>
<th>Location</th>
<th>Substrate Size</th>
<th>Water Depth</th>
<th>Water Velocity</th>
<th>Dissolved Oxygen</th>
<th>Spawning Water Temp</th>
<th>Percent Fines Tolerable</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook – Fall</td>
<td>Sep-Dec</td>
<td>Oct- Jan</td>
<td>Mainstem and large tributaries</td>
<td>Pea to orange (1.3-10.2 cm)</td>
<td>Extremely variable 0.05-7 m</td>
<td>0.1 – 1.5 m/s; max is 2.4 m/s</td>
<td>&gt; 5 mg/l</td>
<td>5.6-13.9°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Chinook-Spring</td>
<td>Mar-Jun</td>
<td>Late Aug-Oct</td>
<td>Upper mainstem streams</td>
<td>Pea to Orange (1.3-10.2 cm)</td>
<td>Extremely variable 0.05-7 m</td>
<td>.21-1.5 m/s; max is 2.4 m/s</td>
<td>&gt;5 mg/l</td>
<td>5.6-13.9°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Coho</td>
<td>Sep-Jan</td>
<td>Sept - Jan</td>
<td>Small tributaries</td>
<td>Pea to Apple (1.3-9.0 cm)</td>
<td>0.18 – 1 m</td>
<td>0.08 – 0.11 m/sec; max is 2.4 m/s</td>
<td>&gt;8 mg/l</td>
<td>4.4-14°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Chum</td>
<td>Oct- Dec</td>
<td>Nov-Dec</td>
<td>Lower mainstem and tributaries</td>
<td>Pea to Orange (0.5-10.2 cm)</td>
<td>13-50 cm; ideal 21 cm</td>
<td>0.21-0.83 m/s; max is 2.4 m/s</td>
<td>&gt;5 mg/l; above 80% saturation best</td>
<td>7.2-12.8°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Steelhead-Winter</td>
<td>Nov-May</td>
<td>Dec -May</td>
<td>Small &amp; mid-size tributaries with moderate gradient</td>
<td>Pea to Apple (0.5-9.0 cm)</td>
<td>&gt; 18 cm</td>
<td>&lt;2.4 m/s</td>
<td>&gt;5 mg/l</td>
<td>3.9-9.4°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Steelhead-Summer</td>
<td>May-Jul</td>
<td>Jan-Jun</td>
<td>Small &amp; mid-size tributaries with moderate gradient</td>
<td>Pea to Apple (0.5-9.0 cm)</td>
<td>&gt;18 cm</td>
<td>&lt;2.4 m/s</td>
<td>&gt;5 mg/l</td>
<td>3.9-9.4°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Sea Run Cutthroat Trout</td>
<td>Jun-Oct</td>
<td>Dec-Feb</td>
<td>Small headwater tributaries 1st &amp; 2nd order streams</td>
<td>Pea to Golf Ball (0.5-7.5 cm)</td>
<td>0.01 –1 m; 10-15 cm best</td>
<td>0.11-0.90 m/s; max is 2.4 m/s</td>
<td>&gt;5 mg/l</td>
<td>6-17°C; best is 10°C</td>
<td>Fines (&lt;6.4 mm) make up less than 25% of substrate</td>
</tr>
<tr>
<td>Incubation</td>
<td>Incubation Temp.</td>
<td>Fry Emerge</td>
<td>Fry Habitat</td>
<td>Juvenile Habitat</td>
<td>Preferred Temp.</td>
<td>Freshwater Residency Period</td>
<td>Estuary Residency Period</td>
<td>Notes</td>
<td>2004 Status</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
<td>------------</td>
<td>----------------------</td>
<td>-----------------------------------------</td>
<td>-----------------</td>
<td>-----------------------------</td>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Chinook – Fall</td>
<td>0.0-20°C; best 5.0-14.4°C</td>
<td>Mar-May</td>
<td>Stream; river edges</td>
<td>Deeper water in main river channel</td>
<td>7.3-14.6°C C Growth stops at 20.3°C C lethal at 25.2°C</td>
<td>Days to 2 or 3 months Fall smolt</td>
<td>Extensive 5-6 months April-Oct.</td>
<td>Estuaries play a vital role in survival of young</td>
<td>Healthy and stable</td>
</tr>
<tr>
<td>Chinook-Spring</td>
<td>0.0-20°C; best 5.0-14.4°C</td>
<td>Feb-Mar</td>
<td>Stream; River edges</td>
<td>Deeper water in main river channel</td>
<td>7.3-14.6°C C Growth stops at 20.3°C C lethal at 25.2°C</td>
<td>Days to 2 or 3 months Fall smolt</td>
<td>Extensive 5-6 months April – Oct</td>
<td>Large body size limits movement over barriers</td>
<td>Depressed</td>
</tr>
<tr>
<td>Coho</td>
<td>4.4-13.3°C C</td>
<td>Feb-June</td>
<td>Backwater pools and stream edges</td>
<td>Pools in summer, off channel alcoves, ponds, dam pools with complex cover in winter</td>
<td>11.8 – 14.6°C C Growth stops at 20.3°C C Lethal at 25.8°C</td>
<td>One year Spring smolt</td>
<td>Move through 2-9 days, sometimes longer</td>
<td>Low pH (&lt;5.01) can be lethal to alevins</td>
<td>Depressed</td>
</tr>
<tr>
<td>Chum</td>
<td>4.4 – 13.3°C C</td>
<td>Late Mar-Apr</td>
<td>Move directly into estuary</td>
<td>High sediment levels (15.8-54.9 g/l) will kill juveniles</td>
<td>6.7 – 14.6°C C Growth stops at 20.3°C C lethal at 25.8°C</td>
<td>Hours to few days, leave quickly Spring smolt</td>
<td>2-32 days</td>
<td>Use estuaries immediately for food and adjustment</td>
<td>Depressed</td>
</tr>
<tr>
<td>Steelhead Winter</td>
<td>4.4-13.3°C C</td>
<td>May – June</td>
<td>Stream Edges</td>
<td>Pools, riffles, and runs of tributary, streams, complex habitat with, large woody debris, (LWD) preferred</td>
<td>7.3-14.6°C C Growth stops at 20.3°C C Lethal at 24.1°C</td>
<td>2-3 years Spring smolt</td>
<td>Move through in days</td>
<td>Good habitat =small and large wood complexity</td>
<td>Depressed</td>
</tr>
<tr>
<td>Steelhead-Summer</td>
<td>4.4 – 13.3°C C</td>
<td>May-June</td>
<td>Stream edges</td>
<td>Pools, riffles, and runs of tributary, streams, complex habitat with, large woody debris, (LWD) preferred</td>
<td>7.3 – 14.6°C C Growth stops at 20.3°C C lethal at 24.1°C</td>
<td>2-3 years Spring smolt</td>
<td>Move through in days</td>
<td>Summer steelhead require deep cool pools to live in before spawning</td>
<td>Primarily hatchery fish</td>
</tr>
<tr>
<td>Sea Run Cutthroat Trout</td>
<td>6.1 – 17.2°C C</td>
<td>Mar-May</td>
<td>Stream Edges and backwater pools, large wood, (LWD) important</td>
<td>Prefer pools but are often displaced by coho or steelhead, low velocity pools, and side channels</td>
<td>9.5-12.9°C C Growth stops at 20.3°C C lethal at 23.0°C</td>
<td>2-4 Years Spring smolt</td>
<td>Used extensively as adults before upstream migration</td>
<td>Rearing in estuary is common</td>
<td>Depressed</td>
</tr>
</tbody>
</table>

DID YOU KNOW? Chinook salmon may spend between 1 to 8 years in the ocean before returning to their natal streams to spawn; though the average is 3 to 4 years.

SCIENTIFIC NAME: *Oncorhynchus tshawytscha*, (“on-ko-rink-us tau-wee-cha”) from the Greek word onkos (hook), rynchos (nose) and tshawytscha (the common name for the species in Siberia and Alaska).

COMMON NAMES: King salmon, tyee salmon, Columbia River salmon, black salmon, chub salmon, hook bill salmon, winter salmon, tules and blackmouth.

DESCRIPTION: The chinook salmon is blue-green on the back and top of the head with silvery sides and white bellies; black spots on the upper half of its body with gray/black mouth coloration. Up to 58 inches in length and weigh up to 129 pounds; although chinook salmon are generally up to 36 inches in length and weigh up to 30 pounds.

LIFE CYCLE: Spawning in streams that are larger and deeper than other salmon utilize, chinook salmon spawn from late summer to late fall, depending on the run. Fry and smolts usually stay in freshwater from 1 to 18 months before traveling downstream to estuaries, where they remain up to 6 months. Chinook salmon spend 1 to 8 years at sea before returning to natal streams to spawn.

RANGE: Chinook salmon range from Kotzebue Sound, Alaska, to Santa Barbara, California. Spawning and rearing chinook are found in most of the rivers in this region, with significant runs in the Columbia River, Rogue River, and Puget Sound.

HABITAT AND ECOLOGY: Freshwater streams and estuaries provide important habitat for chinook salmon. They feed on terrestrial and aquatic insects, amphipods, and other crustaceans while young and primarily on other fish when older in the ocean. Eggs are laid in deeper water with larger gravel, and need cool water and good water flow (to supply oxygen) to survive. Mortality of chinook salmon in the early life stages is usually high due to natural predation and human induced changes in habitat, such as siltation, high water temperatures, low oxygen conditions, loss of stream cover and reductions in river flow. These impacts are the result of poor agricultural, and forestry practices, dams, and water diversions. Some of the causes of adult mortality are harvest, predators, poor ocean conditions, and changes in hydrology. Estuaries and their associated wetlands provide vital nursery areas for the chinook prior to its departure to the open ocean. Wetlands not only help buffer the estuary from silt and pollutants, but also provide important feeding and hiding areas. The draining and filling of wetlands and the pollution of the estuary from industrial discharges and run-off negatively impact chinook salmon.
ECONOMIC VALUE: Chinook salmon are highly valued by commercial fishermen. Chinook salmon are also an important subsistence fish and a valuable recreational resource.

Prepared by the Pacific States Marine Fisheries Commission, F.I.S.H. Habitat Education Program.
COHO SALMON

DID YOU KNOW? Oregon’s coastal rivers produced 1.4 million coho in 1900. Runs in the 1990’s hovered around 20,000, but have rebounded to 200,000 in recent years.

SCIENTIFIC NAME: *Oncorhynchus kisutch*, ("on-ko-rink-us ki-sooch") from the Greek word onko (hook), rynchos (nose) and kisutch, the common name for the species in Siberia and Alaska.

COMMON NAMES: Silver salmon, blueback salmon, salmon trout, silverside salmon and white salmon.

DESCRIPTION: The coho salmon is bluish-black with silver sides in saltwater; black spots on the back and upper part of the caudal fin. Smaller and slimmer than the chinook salmon; the inside of the mouth is gray or black with white gums. Coho salmon reach up to 38.5 inches in length and weigh up to 31 pounds; although they usually weigh between 6 to 12 pounds.

LIFE CYCLE: Spawning occurs from September to January, with the eggs hatching the following spring. Coho fry remain in streams one to two years. Moving seaward the following spring, most cohos return to spawn when they are three years old. The mature male fish which return early are known as “jacks” and in Oregon and Washington, the abundance of “jacks” are used to predict the next year’s three year old return.

HABITAT AND ECOLOGY: Coho salmon utilize freshwater, near-shore and offshore environments during its lifecycle. Coho salmon have similar spawning habitat requirements as chinook; however, coho prefer lower stream velocity, shallower water and smaller gravel. Most coho fry stay in the stream for over a year feeding on aquatic insects, zooplankton and small fish. Adequate stream cover is important to fry survival, as is high dissolved oxygen levels, and off-stream channel habitat such as ponds and sloughs.

Mortality is especially high during freshwater life stages, often a result of poor forest and agricultural management practices that lead to siltation, which may ruin spawning beds or smother the eggs. Migrating coho salmon also face physical obstacles and high water temperatures resulting from dams, inadequate water flows due to diversions for irrigation and impoundment of water for power generation. Harvest, competition with hatchery fish, and poor ocean conditions may also contribute to mortality.

Once reaching the estuaries, coho salmon fall prey to a number of other species and may be impacted by human changes, such as shoreline development, residential drainage and the filling of marine wetlands. The time spent in this habitat is critical to the development of the species and their ability to survive in the offshore environment.
RANGE: Coho salmon spawn in coastal streams from Northern Japan to the Anadyr River in Siberia and from Monterey Bay in California to Point Hope in Alaska. This species can also be found in the ocean from Baja, California, to the Bering Sea in Alaska. Major U.S. spawning grounds are in Alaska, Washington and Oregon.

ECONOMIC VALUE: The fourth most abundant salmon species, coho salmon are a culturally and economically important resource, and an important subsistence fish.

Prepared by the Pacific States Marine Fisheries Commission, F.I.S.H. Habitat Education Program.
STEELHEAD

DID YOU KNOW? Steelhead may spawn several times, unlike most salmon, which die after spawning.

SCIENTIFICNAME: *Oncorhynchus mykiss*, (“on-ko-rink-us my-kiss”) previously known as *Salmo gairdneri*.

COMMON NAMES: Kamchatka salmon trout, coastal rainbow trout, silvertout, salmon trout, steelie, hardhead and ironhead.

DESCRIPTION: In the sea, bluish from above and silvery from below – tends to be more greenish in freshwater. Small black spots on back and most fins. Up to 45 inches in length and 40 pounds in weight; although usually weighs less than 10 pounds.

LIFECYCLE: Spawning in streams and rivers, steelhead rear in freshwater for 1 to 4 years before migrating downstream through estuaries to the open ocean. Steelhead spend 1 to 5 years at sea before returning to natal streams or rivers. At least two categories of stocks of steelhead have developed; those that enter fresh water during fall, winter and early spring -- the winter run -- and those that enter in spring, summer and early fall -- the summer run. Steelhead do not always die after spawning; some will migrate through estuaries to the ocean again.

HABITAT AND ECOLOGY: Steelhead rely on streams, rivers, estuaries and marine habitat during their lifecycle. In freshwater and estuarine habitat, steelhead feed on small crustaceans, insects and small fishes. Eggs are laid in small and medium gravel and need good water flow (to supply oxygen) to survive. After emerging from the redd (nest) they remain in streams and rivers for 1 to 4 years before migrating through the estuaries to the ocean.

Because young steelhead spend a significant portion of their lives in rivers and streams, they are particularly susceptible to human induced changes to water quality and habitat threats. Poor land-use practices in both urban and rural areas can lead to siltation in streams, which may ruin spawning beds or smother the eggs. Additionally, in the Columbia River, migrating steelhead face the physical obstacles and high water temperatures resulting from dams, inadequate water flows in rivers and streams due to water diversions for irrigation, and the impoundment of water for power generation.
RANGE: Steelhead were originally found from northwestern Mexico to the Kuskokwim River in Alaska; however, now it is unusual to find steelhead south of Ventura River, California. Some of the significant steelhead rivers in Oregon include the Rogue, Umpqua and Clackamas Rivers.

ECONOMIC VALUE: Steelhead are one of the top five sport fish in North America, and are caught primarily in streams and rivers. At the present time only Native Americans are allowed to fish for steelhead commercially in Washington or Oregon.

Prepared by the Pacific States Marine Fisheries Commission, F.I.S.H. Habitat Education Program.
Some Questions Regarding Fish Present in the Sandy River

This interpretive section was developed to help anticipate questions students and adults may have when they visit a site with spawning salmon present. Oregon Trout’s Salmon Watch program was initially developed in the Portland Metro area and the Sandy River at Oxbow Park was one of the first sites utilized by the program. Oregon Trout in partnership with Metro, also provides the guided salmon walks that are part of the annual Salmon Festival at Oxbow Park.

1. **What kind of Salmon are these?**
These are fall chinook salmon, also knows as “Kings”. They return to the Sandy River in August, September and October. The late-run wild fall chinook that return in late December are nearly extinct.

2. **What are they doing when they return?**
They are returning to the river where they were born, in order to build redds, spawn, reproduce and die. After generations of natural selection salmon become adapted to conditions in a specific section of the river. Through this process, separate and identifiable “stocks” develop.

3. **What are redds?**
Redds are fish nests, depressions dug in the river gravel 6 to 18+ inches deep made by the female salmon in which to lay her eggs. The water near the redds must be the proper depth and velocity, have plenty of oxygen to percolate around the eggs, and have the right sized gravel without silt. The average redd is built in water that is from 9 inches to 3 feet deep.

4. **How do salmon spawn and how long does it take?**
The female turns on her side facing upstream and digs a redd by thrashing up and down with her body and tail, alternately digging and settling back into the redd to release the eggs. A male moves in next to the female and releases sperm at the same time. Due to the shape of the redd, the oscillating water mixes the sperm with the eggs and fertilization occurs. Each egg pocket in the redd is covered by gravel as the female digs the next redd upstream. The redd increases in size upstream as the spawning is completed reaching a size of 25 to 60 square feet. Spawning may take 3 to 7 days.

5. **How many eggs are laid?**
The number of eggs laid averages about 5,000 depending upon the size of the female. Eggs incubate in the gravel and hatch the following spring. The newly hatched eggs called “alevins” remain in the gravel for 3-7 weeks. After emerging, the “fry” spend 3 months in freshwater and grow to about 4 inches long before migrating in schools to the sea. During this time they slowly undergo many physiological changes called "smolting" enabling them to adapt to the saltwater conditions in the ocean.

6. **How many fish survive?**
Only 2% to 8% of all the eggs survive to become smolts. Predation by other fish, birds and unfavorable river conditions including high water temperatures, high winter flows that wash the eggs out of the gravels, or too much silt deposited in the redds that may suffocate the eggs may hinder the survival of the fish.
7. How many fish return to the Sandy River?
On the average only 0.5% to 3% of all the smolts that migrate to the ocean will survive to return and spawn. Natural predation, food supply and fishermen affect ocean survival. For Sandy River fall chinook, 5% return as jacks (early maturing males) after one year at sea, 36% return after two years, 51% return after three years, and 8% return after four years.

8. What is the white stuff on the fish skin?
As the fish become weaker during spawning, a white fungus invades their skin and they begin to quickly deteriorate. The decaying carcasses release nitrates and phosphates into the water, providing the basis for more life.

9. How does being raised in a hatchery affect the genetics of the wild run over time?
In the hatchery process of spawning and rearing fish, a totally different kind of selection and adaptation takes place than occurs in the wild. Historically hatcheries tended to use fewer males to fertilize the female eggs, resulting in the loss of genetic material. Hatchery conditions with ample food supply and antibiotics are favorable to the survival of the fish. The fish do not have to capture their own food or develop natural resistance to diseases. Genetically different fish are produced within just a few generations. In addition, large numbers of hatchery fish may cause a major disruption in the existing wild population by competing for food and space, and causing genetic changes in the wild fish, thereby reducing the chance of survival for wild fish.

10. Are fish carcasses important?
Yes, biologists have determined carcasses play an important role in stream ecosystems. Carcasses provide food for aquatic invertebrates, juvenile fish and wildlife. Salmon store nutrients from the ocean such as nitrogen, and these nutrients fuel a complex food chain.

11. How can the wild populations be maintained?
The importance of maintaining high-quality habitat to ensure the existence of wild fish populations cannot be over-emphasized. Silt-free pools and riffles and cool water temperatures must be maintained. Healthy riparian vegetation must be present on the streambanks to stabilize them and prevent erosion. Healthy streambanks also store and slowly release water during critical low flows, provide thermal cover, and are a source of important woody debris and nutrients. In addition, the fisheries must be regulated to allow enough spawners to reach spawning areas, and hatcheries must be operated to minimize genetic changes in hatchery fish that may spawn with wild salmon.

12. What can I do to help?
Be a good steward when you use the river. Do not wade in spawning areas, dispose of your garbage in the proper containers (not the river), and get involved with volunteer efforts to protect river habitat. Support conservation management of the wild salmon and speak out on issues that come to your attention. For more information call Oxbow Park at 503-663-4708, Oregon Trout at 503-222-9091, ODFW STEP Program Clackamas, OR 503-657-2000 http://www.dfw.state.or.us, Sandy River Basin council, 503-668-1646 http://www.columbia-center.org/srbc, or the Oregon Chapter of the American Fisheries Society at 541-737-4431 in Corvallis.
Status of Salmon Stocks

This section will include the following topics:

Healthy Salmon Stocks of the West Coast

Factors Responsible for the Decline in Salmon Abundance and Distribution in the Pacific Northwest

Causes of Mortality, 1770-present

Government Bodies that Regulate Salmon

Healthy Stocks of Anadramous Salmonids in Oregon (1993)
# FACTORS RESPONSIBLE FOR THE DECLINE IN SALMON ABUNDANCE AND DISTRIBUTION IN THE PACIFIC NORTHWEST

## MAJOR FACTORS

| Agriculture | 1, 2, 4, 5, 6, 8, 9, 10, 12, 18, 21, 22 |
| Dams | 3, 9, 10, 11, 17, 18 |
| Drought | 9, 10 |

| Fishing | 15, 16, |
| Forestry | 1, 2, 4, 6, 7, 9, 10, 11, 18, 21, 22 |
| Urbanization | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 18, 22 |

## POTENTIALLY IMPORTANT FACTORS*

| Gravel Harvest | 1, 6, 8, 10 |
| Irrigation | 9, 12, 18 |
| Bycatch Mortality | 16, 17, 19 |

(salmon killed during fishing for other species)

| Hatchery Fish Interference | 19, 20 |
| Poor Ocean Conditions | 13, 14, 15, 16 |
| Illegal Fishing | 16, 19 |

## MINOR FACTORS

| Bird Predation | 17 |
| Marine Mammal Predation | 15, 16, 17 |

| 1. Loss of Streamside Vegetation and Functions |
| 2. Pesticide Exposure |
| 3. Industrial Pollutants Exposure |
| 4. Increased Amount of Sediment Entering Streams |
| 5. Stream Straightening and Channelizing |
| 6. Habitat Destruction |
| 7. Decreased Amount of Large Logs In Streams and Loss of Deep Pools and Channel Form |
| 8. Filling of the Side Channels of Streams |
| 9. Reduced Fresh Water Flow in Rivers and Streams |
| 10. Exposure to Abnormal Temperatures |
| 11. Habitat Area Loss |

| 12. Lack of Screening of Water Diversion, Canals to Keep Fish Out |
| 13. Reduced Upwelling |
| 14. Altered Ocean Currents and Flow |
| 15. Decreased Food Abundance |
| 16. Reduced Numbers of Adults Reaching Their Spawning Grounds |
| 17. Reduced Numbers of Young Fish Making it to the Sea |
| 18. Barriers Preventing Salmon from Migrating Upstream or Downstream |
| 19. Loss of Genetic Integrity and Diversity |
| 20. Competition Between Hatchery and Wild Fish |
| 21. Forest Fragmentation |
| 22. Estuary Degradation |

*Insufficient data exists for an appropriate assessment of magnitude

Table based on studies of rivers in Western Oregon and Northern California. Adapted with permission by Pacific States marine Fisheries commission from *Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options* by Botkin, Cummins, Dunne, Regier, Simpson, Sobel, and Talbot. For a copy send $17 to The Center for the Study of the Environment, PO Box 6945, Santa Barbara, CA 93160.
Causes of Salmon Mortality 1770 – Present

**Mortality Circa 1770:**
Natural mortality of salmon is due to factors like natural death after spawning; *predators*, including mammals, birds and other fish; and naturally occurring population fluctuations cased by ocean and river conditions. Tribal fisheries are the only human effects at this time.

**Mortality Circa 1940:**
The ratio of natural mortality declines due to commercial fishing. *Trapping of beaver* reduces rearing habitat in beaver ponds; *overgrazing* damages streamside vegetation; river corridors and estuaries are affected by *urbanization*; the use of *splash dams* for logging destroys stream beds; *hydroelectric facilities* and *irrigation* dams on tributaries block access to spawning areas; *water drawn* for irrigation, industry, cities, and towns reduces river flow; and *water quality is degraded* by a wide variety of causes.

**Mortality Circa 1996**
Mortality in the ocean increases with El Nino conditions and ocean trolling in Alaska and British Columbia. The Chief Joseph and Hells Canyon dams block passage to large areas of habitat. Other large dams cause 5% or more mortality (per dam) for smolts descending to the sea and adult salmon returning to spawn. Dams also change water temperatures, reduce flow of rivers, increase nitrogen levels, and allow more predation by Northern Pike Minnow and other predators. The destruction and filling of wetlands and estuaries reduces habitat. Logging increases silt, reduces shade, and disturbs spawning beds. The spread of cities, roads, and other development reduces habitat and increases pollution. Irrigation for agriculture reduces flow of rivers. Unscreened water diversions trap fish in ditches (in 1990, less than 5% of the diversions in Oregon were screened). Hatchery fish may increase disease rates and reduce diversity of wild stocks. Grazing livestock harm inland spawning habitat be destroying vegetation and polluting streams.

Out of approximately 1000 native anadromous stocks in Oregon, Washington, and California, 106 are extinct and 314 are at risk of extinction. Currently, hatcheries produce two-thirds of the salmon in the Columbia River.

Attempts to improve salmon survival include:

Improved *fish passage facilities* at dams; *streamside buffers* in logged areas; *barging* or trucking of salmon smolts past dams; *habitat enhancement*; a *Northern Pike Minnow bounty* to reduce predation; *regulation of commercial and recreational catches*; spill from reservoirs to increase flow speed during smolt out-migration and to promote more natural riverbeds; and *improved hatchery practices*.

Gilden, Jennifer, Smith, Courtland, Department of Anthropology, Oregon State University, Research funded by Sea Grant Oregon through NOAA. Sea Grant Oregon, Oregon State University 1998
GOVERNMENT BODIES AND THEIR AUTHORITY TO REGULATE SALMON
(created by Karl Weist of the Northwest Power and Conservation Council)

Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
- 1855 Treaty with the Walla-Walla, Cayuses and Umatilla Tribes established reservation
- Reserved water rights to serve the purposes of the reservation, including support of fisheries. Guaranteed the right to fish both on and off reservation at “usual and accustomed” places “in common with citizens of the United States.”
- US v. Oregon and US v. Washington—court cases assured the tribe the right to 50% of the salmon harvest.
- The tribe is a party to the Columbia River Fish Management Plan that allots the in-river harvest of Columbia River salmon.

Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO)
- 1855 Treaty with the Tribes of Middle Oregon established reservation
- Reserved water rights to serve the purposes of the reservation, including support of fisheries. Guaranteed the right to fish both on and off reservation at “usual and accustomed” places “in common with citizens of the United States.”
- US v. Oregon and US v. Washington—court cases assured the tribe the right to 50% of the salmon harvest.
- The tribe is a party to the Columbia River Fish Management Plan that allots the in-river harvest of Columbia River salmon.

Army Corps of Engineers (COE)
- Operates 19 major federal dams in the Columbia River Basin for flood control, hydropower, recreation, navigation, irrigation and other purposes. (Examples-Bonneville, The Dalles and John Day dams)
- Conducts other river management activities like the dredging of the Columbia for the Port of Portland’s navigation channel
- Issues dredge and fill permits for rivers and wetlands under the authority of the Clean Water Act and the Rivers and Harbor Act.

Pacific Salmon Commission (PSC)
- Allocates harvest of five Pacific salmon species between the US and Canada.
- Established by the 1985 US and Canada Pacific Salmon Treaty to make the harvest decisions.

National Oceanic and Atmospheric Administration (NOAA)
- Administers the Endangered Species Act for salmon and steelhead; ESA responsibilities include listing the species as threatened or endangered, designating critical habitat, developing recovery plans, regulating “taking” of a listed species.
- Develops fishery management plans that set ocean harvest limits.
- Is a part to the Columbia River Fish Management Plan that allocates the in-river harvest of Columbia River salmon.
US Fish and Wildlife Service (USFWS)
- Administers the Endangered Species Act for all non-anadromous fish and other species; lists species as threatened or endangered, designates critical habitat, develops recovery plans, regulates the “taking” of listed species.
- Manages federal lands designated as wildlife refuges.

Environmental Protection Agency (EPA)
- Oversees states’ efforts to comply with the Clean Water Act: wetland regulations and state water quality programs.
- Administers the National Estuary Program.

Bureau of Reclamation (BOR)
- Operates 9 major dams and reservoirs in the Columbia River Basin, primarily for irrigation. (Example – Owyhee Dam and Reservoir)
- Operates numerous projects for secondary purposes, including hydropower generation, recreation, municipal and industrial use.
- Enters into contracts with irrigation districts and other users for the delivery of project water.

Federal Energy Regulatory Commission (FERC)
- Created to carry out the oversight of the Federal Power Act.
- Regulates the construction and operation of nonfederal hydropower projects. (Examples – Brownlee, Oxbow and Hells Canyon dams)
- Issues and conditions original licenses and relicensing of nonfederal hydropower projects.

Bonneville Power Administration (BPA)
- Markets and distributes power produced from federal hydropower projects on the Columbia and its tributaries.
- Funds the protection, mitigation and enhancement of fish and wildlife resources affected by the Federal Columbia River Power System

US Forest Service (USFS)
- Authorizes and monitors timber harvest, grazing, mining, recreation and other activities that occur on all national forest lands and some wilderness areas and wild and scenic river corridors in the Columbia River Basin.
- Has limited water management authority, but does monitor federal reserved water rights and regulates access to national forests for water project purposes.
- Has recently developed the Northwest Forest Plan, PACFISH and INFISH planning documents that address fish and wildlife concerns.

Bureau of Land Management (BLM)
- Authorizes and monitors timber harvest, grazing, mining, recreation and other activities that occur on all federal “public lands” and certain wilderness areas and wild and scenic river corridors in the Columbia River Basin.
• Has limited water management authority, but does monitor federal reserved water rights and regulates access to BLM-managed lands for water project purposes.
• Has recently developed the Northwest Forest Plan and PACFISH planning documents that address fish and wildlife concerns.

Northwest Power and Conservation Council (NPCC)
• Interstate compact agency (Oregon, Idaho, Montana and Washington) created by the Northwest Power Act of 1980.
• Develops regional Fish and Wildlife Program and Northwest Power Plan.
• BPA must act “consistent with” the Council Fish and Wildlife Program. COE, FERC and BOR must take the Council Program “into account.”

Oregon Department Of Fish and Wildlife (ODFW)
• Develops and implements state fishing regulations, licenses, length of seasons.
• Runs state-funded salmon hatcheries.
• ODFW is a party to the Columbia River Fish Management Plan that allocates the in-river harvest of Columbia River salmon.
• Participated in the development of the Oregon Plan for Salmon and Watersheds.

Oregon Department of Environmental Quality (DEQ)
• Implements the state water quality program under the Clean Water Act. Develops list of water quality limited streams and rivers and develops standards to comply with the Clean Water Act.
• Participated in the development of the Oregon Plan for Salmon and Watersheds.

Oregon Department of Forestry
• Administers the Oregon Forest Practices Act affecting the timber harvest and uses of state and private forests. Covers about 11 million acres of state and private timberland.
• Participated in the development of the Oregon Plan for Salmon and Watersheds.

Oregon Water Resources Department (WRD)
• Allocates and distributes water within the state; issues water rights and establishes state rules governing the use, sale and transfer of water rights.
• Participated in the development of the Oregon Plan for Salmon and Watersheds.

Oregon Department of Agriculture
• Regulates agricultural practices on state and private lands.
• Participated in the development of the Oregon Plan for Salmon and Watersheds

Oregon Department of State Lands
• Administers fill and removal laws

Oregon Department of Land Conservation and Development
• Monitors and implements the state land use planning program. Includes state goals to protect farm and forest land and to preserve the Willamette River Greenway and coastal shorelands.
Oregon Watershed Enhancement Board (OWEB)
- Allocates grant funding for local groups to perform watershed restoration work. Has $20 million in grant funding made available by the 1997 Oregon Legislature.

Portland Bureau of Environmental Services
- Responsible for Portland’s stormwater and sewage treatment and collection system. Currently separating the stormwater and sewage systems so untreated water does not spill into the Willamette and Columbia Rivers.

Columbia River National Estuary Program
- Joint project of Oregon and Washington along with the EPA. A group of citizens, local and state governments, businesses and others responsible for protecting, preserving and restoring the health and water quality of the Columbia River estuary.

Tillamook Bay National Estuary Project
- Joint project of Oregon and the EPA. A group of citizens, local and state governments, businesses and others responsible for protecting, preserving and restoring the health and water quality of the Tillamook Bay estuary.
Hatcheries

Introduction:
The first fish hatchery in the Pacific Northwest opened over 100 years ago on the Clackamas River. Since then, the region has increasingly turned to hatcheries as a way to compensate for the losses in fish populations due to human activities, mainly resulting from dams, habitat destruction and overharvest. Oregon operates 34 hatcheries, 15 remote rearing/fish collection facilities, including Salmon Trout Enhancement Program (STEP) facilities and the Clatsop Economic Development committee (CEDC) facilities. In 2001 these operations produced about 53 million salmon, steelhead and trout. The Legislatively Approved Budget for fish propagation for the 2003/05 biennium totaled $43.96 million dollars.

As we have begun to learn more about the ecological effects of hatchery fish on wild salmon populations, many have started to question the use of hatcheries as a catch-all solution to fish management problems. There are efforts underway to improve hatchery practices to minimize the negative impacts of hatchery fish on wild stocks.

Some teachers may choose to take students to a fish hatchery as a part of their Salmon Watch field trip. Trips to the hatchery tend to emphasize the pro-hatchery side of the debate. It is important that students understand that there is some disagreement about the use of hatcheries. Some information follows for your background about hatchery and wild fish.

Some arguments in favor of hatchery fish
1. Some hatchery fish were intended to compensate for declines in wild fish populations caused by the construction of dams. Dams are not only an important source of relatively “clean” energy for the region -- they also allow the rivers to be used as waterways for the transport of crops and other goods throughout the Pacific Northwest. If we remove dams, we will be forced to either be more serious about conservation, or find alternative forms of energy and transportation.
2. Hatchery fish help support the angling industry. Sport fishing is not only a popular hobby, but also supports the economy of the region. In 2003, anglers spent almost $623 million according to the American Sportfishing Association.
3. According to the Pacific Coast Federation of Fishermen’s Associations, Incorporated, 80% of the salmon caught by the commercial fishing industry are hatchery fish.
4. The salmon are of great traditional importance to Native Americans. The U.S. government has treaty obligations to the tribes to restore the salmon so that Native Americans may continue to use the salmon both as a food and a spiritual resource. If natural production continues to decline, we may have to increasingly rely on hatcheries to fulfill this treaty obligation.
5. If we catch only the hatchery fish for human consumption, we could leave the wild fish alone to reproduce on their own.
6. Hatchery fish could be used to supplement stocks in serious jeopardy or to reintroduce stocks that have been eliminated from their natural range, given the proper groundwork for habitat improvements and resolution of passage problems.

Some arguments for wild fish

1. Through a process called natural selection, the wild fish that are best suited to their environment are the fish that survive to spawn. However, hatcheries promote artificial selection, which means that humans choose the fish that will survive to spawn. Sometimes, we have made this decision based on which fish will make a good dinner, rather than on which fish will best be suited to survive in the wild. Another problem is that some hatcheries tend to spawn the first fish to return to the river to ensure that they will be able to harvest enough fish. However, this means that early breeders are more likely to be chosen to spawn. The resulting hatchery offspring tend to return too early. This is a problem if all of the hatchery fish return at the same time, and the weather is too rainy or too dry for the fish to survive.

2. Genes carry pieces of information that allow fish to inherit traits from their parents. In a population of fish with a lot of genetic diversity, there is a greater chance that at least some fish will have the traits necessary to survive if there is a sudden change in environmental conditions. Conversely, in populations of fish without a lot of genetic diversity, there is a greater likelihood of extinction if the fish are faced with a changing environment. Populations of hatchery fish have less genetic diversity than populations of wild fish because hatchery fish have had fewer ancestors than wild fish. Unfortunately, sometimes hatchery fish spawn with wild fish, rather than returning to the hatchery. This means that the genetic diversity of the wild fish populations decreases as well.

3. When wild fish die, their carcasses provide nutrients to the rivers and streams where they spawned. Hatchery fish are often removed from the stream to be spawned, depriving the habitat of precious nutrients.

4. We have a moral obligation to do something to repair the habitat that we have destroyed in order to assure that wild fish can continue to survive in the future.

5. Hatcheries create a false sense of abundance for people who consume fish and utilize their habitat, meaning that people are less concerned about conserving the habitat that remains. It also means that harvest levels are often based on numbers of hatchery fish. Since there are often some wild fish that are caught along with the hatchery fish, harvest can drive dwindling numbers of wild fish into extinction.

6. Wild fish use precious energy competing against hatchery fish for limited resources.
7. Hatchery fish are more prone to disease than wild fish because they are raised so closely together. Diseases from the hatchery stock can then be passed on to wild fish. This means that the presence of hatchery fish can actually weaken wild fish populations.

8. Wild fish learn to avoid predators, or they get eaten. They also learn to find food in their natal stream efficiently, or they starve. Hatchery fish, on the other hand, are hand-fed by humans. They learn to approach humans (who would normally be predators) and eat fish pellets. Then, when they are released, they are less able to find food and are less afraid of predators than wild fish. This means that, once they are released into the wild, hatchery fish are less likely to survive than wild fish.

9. Raising hatchery fish is very expensive. According to Sterne, the average cost of producing a spring chinook salmon in a state run hatchery is $27.43, although this number can reach as high as $228.93 per fish. Some might argue that this money could be better spent on habitat restoration to improve survival rates for wild chinook.

Bibliography


Water Quality

- **Introduction to Water Quality Analysis, Goals, Objectives, and Procedures**  WQ2
- **Temperature**  WQ3
- **Dissolved Oxygen**  WQ6
- **pH**  WQ10
- **Turbidity**  WQ12
- **Wrap–Up or Debrief of Field Analysis**  WQ15
**Water Quality**

Water in the stream in which salmon live provides conditions, which allow the salmon to continue to thrive. When we measure these conditions, we say we are evaluating water quality. The tests that we will be conducting in the field will be temperature, dissolved oxygen, pH, and turbidity.

**Teaching Tips**

Get students focused with introductions and review safety guidelines (see box below).

| Note: Caution should be taken when handling and disposing of chemicals. Waste chemicals should be poured into the container provided in the field kit and returned either to the classroom or to the Oregon Trout office for disposal rather than dumped into the stream or riparian area. Always wash your hands after you have completed the water quality testing procedures. |

Briefly describe the activity (What we are going to do is…).

Divide the students into teams for each activity; temperature, dissolved oxygen, pH, and turbidity.

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

Dissolved oxygen should be done in moving water, preferably in a riffle, if it can be safely accessed. Boots are provided for the dissolved oxygen sampling.

First help the dissolved oxygen group get started, this test takes the most time and can involve 3 or 4 students. Groups of two will work for the other activities.

Temperature, pH, and turbidity can be done in several areas and compared if you have a larger group of students. Remember to **try to get all students involved**, then check in with them as they move through the procedures.

Float between students facilitating the activity.

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

For the wrap up, pass out the graphs and charts provided in the kit for the students to interpret their results.

Let each team report their results. Use the questions provided in the kit or formulate your own questions as they relate to the results of the tests. Include any specific characteristics of the site that may be relevant to water quality i.e. human impacts, vegetation, weather conditions, etc.
**Water Temperature**

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 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 water.
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 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:

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 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.).

Equipment:

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

Procedure:

1. 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.

2. Air Temperature: Allow thermometer to reach equilibrium before recording. Make sure the air temperature is taken in the shade, not in direct sunlight.

For Discussion: Refer to Optimum Temperature Limits for Aquatic Organisms chart. How does the temperature that you recorded for this area compare to the optimum temperatures for aquatic organisms?

Questions for discussion:

- Why should we care about water temperature?

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

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

- How does the water stay cool?
OREGON WATER QUALITY STANDARDS for TEMPERATURE

COLUMBIA RIVER
SALMONID REARING BASINS
SALMONID SPAWNING WATER

°C

5 10 15 20

°F

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

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

WQ5a
Dissolved Oxygen

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, i.e. 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:

<table>
<thead>
<tr>
<th>DO ppm</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp °F</td>
<td>117</td>
<td>92</td>
<td>90</td>
<td>77</td>
<td>68</td>
<td>59</td>
<td>50</td>
<td>45</td>
<td>39</td>
<td>36</td>
<td>32</td>
</tr>
</tbody>
</table>

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. If 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.
**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.

**Procedure:**

**Comments:** Stream water sampling should be done in moving water to get the most accurate measure of the DO that salmon in the stream would experience.

When using the LaMotte Dissolved Oxygen kit, rubber gloves and goggles are required. Potentially harmful chemicals are in this kit.

1. Rinse out the sample bottle twice with stream water. During the first rinse shake the water in the bottle to remove any precipitate present.

2. **Holding the rinsed bottle upside down, immerse it in the stream. Keeping it under water, invert the bottle to allow water to enter. Allow the bubbles to stop and, while the bottle is still under water, place the cap on tightly.** To test if there is no air in the bottle, turn the capped bottle upside down. If an air bubble is present, refill the bottle using the above procedure. **PUT ON GLOVES**

3. Add 8 drops of the *Manganous Sulfate* from the DO kit. Do not let the sulfate bottle touch the sample water. This step removes the oxygen from the water and makes a new compound “A” with the *Manganous Sulfate*.

4. **Immediately add 8 drops of Alkaline Potassium Iodide Azide to the sample water.** Cap the bottle and gently mix the solution several times by inverting the bottle. A yellowish cloudiness will appear. This addition reacts with the new manganese compound “A” to liberate iodine, which will be titrated (reagent added drop by drop) for in step 10.

5. **Allow the precipitate formed in step 4 to settle below the shoulder (rounded part) of the bottle.**
PUT ON GOGGLES

6. Add 8 drops of Sulfuric Acid to clear the solution and to acidify. Cap and gently shake until precipitant has dissolved.

REMOVE GOGGLES

7. Set the sample bottle aside and rinse the testing bottle with stream water twice.

8. Fill the testing bottle to the 20 ml line (white line halfway up bottle) with liquid from the sample bottle.

9. Add 8 drops of Starch Solution. Place the plastic cap on the bottle and shake well. The solution will become deep purple/black in color. The starch attaches to the iodine and allows the titration (reaction with the Sodium Thiosulfate solution) in step 10 to proceed to a visual endpoint.

10. Fill the syringe with Sodium Thiosulfate reagent by inserting the syringe into the top of the Sodium Thiosulfate bottle, turning the bottle upside down, and drawing out the reagent until the black tip of the plunger is level with the “1.0ml” line on the barrel of the syringe.

11. Place the tip of the syringe in the hole in the cap of the testing bottle and very slowly – 2 to 3 drops at a time – add the Sodium Thiosulfate reagent to the testing bottle. Swirl vigorously after every addition. When the solution in the testing bottle lightens, add the reagent one-drop at a time, swirling after each addition. When the solution is clear, the endpoint has been reached. If the concentration is greater that 10 mg/L you will have to refill the syringe and continue to titrate.

12. Read the number on the barrel of the syringe where the tip of the black plunger is pointing. Subtract the reading from 1.0 and multiply by 10. This is the concentration in mg/L or PPM (parts per million) of DO in the water. Record results.

13. Dispose of the solution in both the testing bottle and the sample bottle in the plastic waste bottle to eliminate pollution of the stream by the chemical reagents.

For discussion: Refer to the Optimum Dissolved Oxygen Limits for Aquatic Organisms chart. How does the amount of dissolved oxygen in the water that you tested compare to the optimum amounts of dissolved oxygen for different aquatic organisms?

Questions for discussion:

- What is DO (dissolved oxygen)?
- Who cares about DO (dissolved oxygen) and why?
- How does oxygen get into the water?
- What are DO levels affected by?
Maximum Dissolved Oxygen Concentration at Various Temperatures

Optimum Dissolved Oxygen Limits for Aquatic Organisms

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

WQ9a
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, others cannot tolerate a change of even one pH unit. Because of this narrow range of tolerance, pH limits where many organisms can live and the 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 U.S. 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.

**pH Testing**

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.

**Equipment:**

LaMotte Wide Range pH Test Kit

**Procedure:**

1. Rinse test tube with sample water.
2. Fill a test tube to the 5.0 ml line with sample water.
3. Add 8 drops of Wide Range pH indicator. Cap and mix.
5. Match sample color to a color standard. Record as pH.

**For discussion:** Refer to the *Lethal pH Limits for Aquatic Organisms* chart. 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?

**Other questions for discussion:**

- 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 the water doesn’t get too acidic/alkaline?
LETHAL pH LIMITS FOR AQUATIC ORGANISMS

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

WQ11a
Turbidity and Sediments

In this section, turbidity will be discussed in relation to sediment load in a stream.

As long as there has been water in streams, it has carried solid particles called sediments. Sediments occur naturally as products of weathering and erosion. Wind, water or frost action on rock surfaces result in the gradual breakdown of large, solid rock pieces to smaller particles such as sand and silt. Nutrients necessary to life are also transported as sediments, using rivers, and streams as pipelines.

Ecosystems depend on sediments for their health but excessive amounts are harmful. Erosion and sediment transport are natural phenomena that can improve as well as degrade habitats within a watershed. Water erodes gravel banks to provide a continuing source of gravel for streams, shifts gravel bars, and forms or deepens pools, all of which benefit spawning and rearing fish. However, erosion of fine-textured soils such as clays, silts, and fine sand can reduce habitat quality by compacting gravel or lowering water quality.

Sediment types

There are several types of sediments. Bedload sediments are too heavy to be constantly suspended. They are rolled and bounced along the bottom of a stream. The size of a particle of bedload sediment will vary with the volume and speed of the water. Spawning gravel is often transported as bedload sediment during high winter streamflow. Periodic fluctuations in the amount of sediment and bedload being transported are a natural occurrence.

Suspended sediments are those carried in suspension. Rapidly flowing water can carry more suspended sediments than slow-moving water.

A gradient of deposition exists and is determined by streamflow velocity and volume and sediment size. Heavier sediments settle out first, followed by successively lighter materials. As velocity decreases, as from the center of the stream out toward its edges, or slow water area, the finest sediments settle to the bottom, no longer suspended by the action of water.

Total suspended sediment (TSS) is a measure of how much sediment a stream is carrying. Suspended sediments can give water a murky or cloudy appearance by reducing light penetration. Turbidity is the term used to describe and measure the degree to which light is blocked.

Helpful and harmful sediments

Sediments dissolved in water can be beneficial or harmful to the aquatic community. Some are nutrients essential to life. Others can be minerals or salts that change water pH or are poisonous to life. The measure of solids dissolved in water is called total...
dissolved solids (TDS). TDS levels higher than 500 ppm make water unfit for consumption.

In western Oregon 200 communities get at least a part of their water supply from municipal watersheds. Currently, because of its high quality, little treatment is needed to make most of this water fit for domestic use.

Manufacturing of high-quality paper products and beer depend on availability of clear, clean water. High concentrations of sediments make water unfit for these processes without expensive filtering.

Suspended sediments can block or reflect sunlight before it reaches aquatic plants. Heavier sediments can cover leaves, inhibiting photosynthesis, or even bury plants.

Sediments affect insect life in a body of water. Large amounts of sediments can smother some species. A change in the bottom material and the type, number, and health of plants changes the habitat, and therefore, the species composition of the insect community.

Today although industrial and municipal wastes receive more attention, sediments are the nation’s primary water pollutants. Erosion is the source of most sediment. Agriculture is responsible for more erosion than any other single activity, but road construction and use, timber harvest, forest fires, and other sources contribute. Heavy concentrations of sediments increase the cost of municipal water treatment, can be harmful or fatal to aquatic life, and are indicators of excessive erosion.

High sediment levels also adversely affect fish. Very high concentrations of suspended sediments can irritate and actually clog gill filaments, causing fish to suffocate.

Bedload sediments deposited in the channel change the composition of gravel beds used for spawning. This can reduce the amount of oxygen available to the eggs by blocking water circulation, trap fry in the gravel, or reduce the amount and types of food needed during different stages of development.

**Importance of vegetation**

Excessive sedimentation and the problems it causes can be controlled by reducing erosion. Surface runoff is the primary cause of erosion and can be prevented with adequate plant cover during periods of runoff. Plants and the organic material they add to soil lessen the force of falling rain, add structure to the soil, and increase the soil’s ability to absorb and hold water. When surface runoff does take place, leaves and stems of plants trap much debris and sediment that would otherwise be carried into streams.

As a stream meanders across a floodplain, it moves sediments and deepens its channel. Riparian vegetation is especially important in the control of these sediments. Plants along streams help prevent bank erosion.
**Turbidity Testing**

**Objective:**

To determine the relative clarity or turbidity of the stream water at your field site and to understand the impact of turbidity on water quality as it relates to the habitat needs of salmon.

**Equipment:**

Turbidity tube and sample collection bottle.

**Procedure**

1. Carefully join the two pieces of the turbidity tube.
2. Fill sample bottle with stream water.
3. Shake sample thoroughly.
4. Stand with your back to the light (e.g. sunlight).
5. Hold tube vertically in front of you, not at your side, extend arm down (arm’s length) so you are looking down into the bottom of the tube.
6. While observing the disk at the bottom of the turbidity tube, SLOWLY fill the tube with the sample until the three letters, AWT (Australian Water Technologies), appear to merge (cannot be read).
7. Then read the graduation on the side of the tube to determine turbidity. Record results. If time allows check turbidity in more than one area and compare.

**Maintenance:**

Always rinse tube with clean water when testing is complete.
If the tube appears dirty inside, wash with warm water and mild detergent. Do not use abrasive material or you will scratch the plastic. Disassemble tube and allow to air dry between uses.

**For discussion:** Refer to the *Optimum Turbidity Levels for Aquatic Organisms* chart. How does the turbidity that you recorded for this area compare to the optimum turbidity levels for aquatic organisms?

**More questions for discussion:**

- If you are getting a high turbidity reading, i.e. exceeding the limits for a healthy salmon stream (see chart), what do you think might be the source of the turbidity?

- Is this a natural occurrence? Describe the impact/activity (i.e. natural or human) that might be contributing to your high turbidity reading?

- What, if anything, could be done to try to decrease the turbidity at this site?
OPTIMUM TURBIDITY LEVELS FOR AQUATIC ORGANISMS

0 NTU 10 NTU 20 NTU 30 NTU 40 NTU 50 NTU

Good

Fair/Moderate

Poor/Bad

NTU = nephelometric turbidity unit

10 NTU: Level not to be exceeded for coldwater fisheries per state/federal water quality standards.

50 NTU: Turbidity level which interferes with site feeding; level not to be exceeded in any type of river/stream per State/Federal water quality standards.

Compiled from information regarding water quality from the Oregon Department of Environmental Quality and the U.S. Environmental Protection Agency.
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 that it’s healthy today?
- How about 100 years ago? How about in 100 years?
- What kind of activities, events, will affect the future condition of salmon bearing streams?
- What are some of the things we can do to help reduce our impact on streams?

There will be a laminated copy of these discussion questions in the water quality field kit.

Resource List:


Aquatic Macroinvertebrates

- Introduction to Macroinvertebrates        AM2
- The River Continuum                      AM6
- Tolerance Groups                          AM9
- Station Goals, Objectives, and Procedures AM12
- Wrap-Up or Debrief of Field Analysis     AM14
- Quick Reference Guide to Aquatic Macroinvertebrates AM15
Macroinvertebrates as Water Quality Indicators

Macroinvertebrates can be described as spineless animals that can be seen with the naked eye (without magnification), or any aquatic invertebrate collected with a standard mesh collecting net (mesh size 500 microns or 0.5 millimeters). Macroinvertebrates in streams are biological communities that integrate the effects of many different factors over time. Macroinvertebrate populations are more sensitive indicators of habitat disturbance or infrequent chemical contamination than standard chemical monitoring.

Aquatic insects such as mayflies, on average, spend about a year in the aquatic larval stage before beginning their brief lives as adults. Consequently they require good stream flow and a healthy temperature range throughout the year. You would not expect to find a healthy mayfly population in a seasonal stream that dries up or gets too warm during the summer months. Macroinvertebrate populations will also respond over time to pollution, whether it is from chemical or thermal sources, habitat disturbance such as erosion due to land use practices, and/or changes in stream structure as a result of flood events.

Sampling Strategies and Collecting Techniques

Riffles, pools, and backwaters are the most commonly sampled areas in wadeable streams. Riffles are the primary habitats sampled for stream surveys. Riffles are shallow areas with medium to fast current where the substrate is a mixture of gravel, cobble and boulders. These areas are the preferred habitat to sample because they:

- Contain the greatest diversity of macroinvertebrates.
- Contain pollution sensitive and pollution tolerant species.
- Have fairly consistent habitat throughout the riffle.
- Are shallow and easy to access.
- Are easy to recognize.

Other areas that can be sampled are glides, pools, leaf packs, and woody debris.

Basic sampling equipment required is a D-frame kick net with mesh size 500 microns and sorting buckets or trays. To use the D-frame net, place the net firmly against the stream bottom with the opening facing the current at the desired sampling location. Thoroughly disturb the substrate in front of the net by picking up and rubbing large rocks (less than 2 inches) and digging substrate with hands or feet to a depth of 2-3 inches.

After thoroughly disturbing area in front of the net, lift the net from stream and empty contents into a large bucket or sorting pan.

Sorting involves allowing the sample to settle after placing net contents into bucket then separating the insects from the debris collected. Forceps (tweezers) and pipettes (eyedroppers and turkey basters) can be used to collect and sort the macros. Ice cube trays can be used to further sort the sample.
Students can record how many of each general type of insect they find. By using the cards and field guides provided, they can determine if they have found more insects from the tolerant group (midges, black flies, snails, aquatic worms) or more from the intolerant group (mayflies, stoneflies, caddisflies).

The data collected can be used to assess the health of the invertebrate community in terms of taxa or species richness. Species richness relates to the number of different varieties of aquatic insects present at any given sampling site (i.e. the number of different types of mayflies found).

Another measurement that reflects macros as indicators of water quality is the Hilsenhof Biotic Index or HBI. This is a numeric value related to an organism's sensitivity or tolerance to nutrient enrichment in a stream or lake. Low numbers indicate an organism is sensitive to nutrient enrichment. High numbers indicate tolerance to nutrient enrichment. Humans enrich streams with nutrients through the use of fertilizers and contamination with manure or sewage.

**Field Guides:**

Example of page from NW Guide to Macroinvertebrates:

**Western March Brown**
- **Order:** Ephemeroptera
- **Family:** Heptageniidae
- **Genus:** Rhithrogena
- **Common Name:** Western March Brown
- **# of Species:** (5 common in the N. W.)
- **Status:** Common
- **Habitat:** Moderate to fast flowing sections of cool streams and rivers with a gravel substrate.
- **Behavior:** Clings to surface of substrate; uncommon in drift.
- **Feeding Type:** Scraper
- **Key ID Features:** Flattened dorsal-ventrally. Three well developed tails, Head widest part of body. Gills enlarged and overlap under abdomen.
- **Pollution Sensitivity:** One of the more pollution sensitive mayflies.
- **HBI Pollution Index:** 1
- **Adult Activity:** March - June
Macroinvertebrates and the Aquatic Food Web

Fish populations depend on healthy macroinvertebrate populations to survive. The availability of macroinvertebrates as food is determined by both the physical and biological condition of the stream.

Food for macroinvertebrates includes organic materials, like algae that grow on rocks or leaves and other material that fall into the stream and decompose.

Benthic or bottom dwelling insects are adapted for attachment in fast-moving water. They obtain food by grasping or collecting, grazing or scraping.

Aquatic insects that drift are most vulnerable to being eaten. Drifting can be described as leaving their positions among boulders and gravel in riffles to be carried downstream short distances before reattaching to the stream bottom.

Functional Feeding Groups

Dividing stream invertebrates into shredders, collectors, scrapers, and predators is somewhat artificial because some of these immature forms fit into more than one category. For example, scrapers may eat a lot of detritus or debris while they graze algae. These distinctions are valuable. By looking at the feeding habits of these young invertebrates, you can begin to sort out different roles these animals play in the ecology of watersheds.

**Shredders** - usually in headwaters area, and in areas that have a high percentage of canopy cover.
Examples: organic case caddis, craneflies, stoneflies
Found in: leaf packs, water-logged wood, headwater streams

**Scrapers/Grazers**

Examples: mineral case caddis, snails, mayflies,
Found in: rocks, open-canopied areas, mid-stream reaches

**Collectors** - filtering collectors, gathering collectors - common in all reaches, make up larger proportion in lower reaches where sediment collects.
Examples: Net-spinning caddis, Midge larva, Blackfly larvae, mayflies
Found in: rocks and mud

**Predators** - found in all habitat types, in smaller proportion relative to other feeding types
Examples: Mottled stoneflies, beetle larvae, dragonfly larvae, free living caddis, crane fly larva
Found: throughout the stream
Figure 1. Illustrates the pathways of energy from the sun to the four main macroinvertebrate groups. Some scientists add salmon carcasses as another source of energy.

Food processing in streams. (Adopted from "From Headwater Streams to Rivers," by Ken Cummins, American Biology Teacher, May 1977, p. 307)
The River Continuum

Each year, large amounts of organic material fall into the headwaters of forested streams. Of this material, only 20 to 35 percent is flushed downstream. The remaining organic input is retained in the system and used by stream organisms. It can be processed by bacterial and fungal metabolic action, physical abrasion or consumed by insects. However, as it is processed, the debris is broken into smaller pieces, which increases the surface area of debris particles and subjects them to further degradation by microbial action.

In this way, small first- and second-order streams send partially prepared food into large streams. Processing continues as small debris moves downstream through the system. A stream is a continuum that transports progressively smaller food materials.

The river continuum concept models running water systems. It describes biological communities in a stream that change in a somewhat predictable pattern from headwaters to the mouth.

This pattern is influenced by the:

- Structure and gradient of the channel
- Bank stability
- Sediment loads
- Riparian habitats and cover
- Light penetration
- Temperature

Predictions work particularly well for forested mountain streams. As might be expected, with a model of this type, there are several exceptions to the pattern outlined in Figure 2. However, the concept shows what might be expected in a stream system. If an insect community seems to be "out of place" or missing, it should act as a red flag, encouraging any researcher to question why it does not match the concept.
Figure 2. The River Continuum

A diagram of the river continuum theory is shown below.
The forests at the headwaters (first- to third- orders) have less influence as a stream gets larger. With less input from the riparian habitat, the energy base relies more on algae that is produced from the opening of the canopy and on processed material brought in from intermediate or midreach (third- to fifth-order) streams. As the kind of organic material changes, there is a decrease in the number of shredders and an increased number of collectors and scrapers (grazers).

The diversity of species that live in the midreaches of a stream system is greater than either upstream or downstream. The reason for this is not completely understood, but researchers have pointed out that midreach water temperatures can change more than those of headwaters or larger rivers can. The variety of organic substrates and physical components found in moderate streams can also have an effect.

Turbidity increases in the lower reaches (sixth-and higher-order streams) due to the greater loads of fine sediments from tributaries and downstream movement of processed particulate matter. Collectors dominate these reaches, and the diversity of other organisms decreases. Increased turbidity reduces light penetration and thereby reduces the efficiency and photosynthetic production of algae in larger streams. Large plankton comminutes are important in these areas. In summary, as the size of a stream changes, there is a shift in dominant organisms and the role they play.

Above: Sampling with D-Net

Top Right: Sorting insects and recording data

Lower Right: Two-way magnifying viewer used for identification
INSECT GROUPS ARRANGED BY TOLERANCE TO POLLUTION

Group 1: Intolerant
These organisms are sensitive to pollution.
Their dominance generally suggests good water quality.
Group 2: Somewhat Tolerant
These organisms can tolerate a wider range of water quality conditions.
**Group 3: Tolerant**

These organisms are generally tolerant of pollution. Their dominance suggests poor water quality.
AQUATIC MACROINVERTEBRATES FIELD STUDY

Objectives:

Students will understand the importance and roles of macroinvertebrates in the aquatic ecosystem by:
1) collecting macroinvertebrates from different instream microhabitats. (if present)
2) counting, and recording invertebrates from each habitat. (if present)
3) analyzing the data to determine the health of the stream. (in accordance with background materials)

Teaching Tips

Get students focused with introductions.

Review safety guidelines and site protocols (See box below).

- Macroinvertebrate sampling should be conducted well away from and downstream from spawning salmon and redds.
- No more than four students per teaching station in the stream/river at a time.
- In water above the knees, all participants are required to wear life vests.
- Avoid fast-moving water.
- Take care when walking on slippery rocks.
- Never drink the water – it could make you sick

Briefly describe the activity

Model in-stream collecting techniques

Divide the students into teams for each activity: collecting, sorting, identifying, etc. Insects can be divided by order (broad categories mayfly, stonefly, caddisfly, other groups)

Use field guides and cards to determine insect types.

Tolerant/Intolerant to Pollution cards can be passed out for de-brief/wrap up

Materials:

D-frame nets or kicknets
Large shallow pans for sorting
Ice cube trays for specific sorting
Hand lens or 2-Way Magnifying Viewer
Forceps, brushes, turkey basters, eye droppers for picking up invertebrates
Guide to Pacific Northwest Aquatic Invertebrates Second Edition
Pollution tolerance group key
Tolerant/Intolerant to Pollution Macro Cards
Clipboard, data sheets, pencils
Rubber knee boots or hip boots (NECESSARY to collect insects)

Procedure:

1. Review safety procedures.

2. Identify the microhabitat(s), i.e. riffle, pool, glide, backwater, to be sampled.

3. Collect a sample from a 1-square-foot area immediately upstream from the net opening. To do this, approach site from downstream. Hold net downstream from area to be sampled, perpendicular to flow. Upstream, begin rubbing rocks, stocks or other leaf litter to remove any invertebrates. The invertebrates should flow into the net. Replace the rocks.

4. Repeat in other locations if necessary. (5 minutes at each location)

5. Remove net contents into a large shallow tray for sorting into groups.

6. Count the different kinds of invertebrates and numbers of each kind for each of the four functional feeding groups. Use the field guides to help with identification.

7. Macros can also be sorted by habitat type or where found in the stream.

8. Record these numbers on the data sheets provided by the teacher.

9. If time allows students can sketch, label, and describe their favorite macro, how they move, feeding habits, breathing adaptations, etc.

10. Gently return macroinvertebrates to the stream.

For Discussion: Determine the health of the stream by the number and variety of insects found. Use the tolerant/intolerant insect group cards provided. Which group best reflects the insect community found in the stream sampled?

Habitat Requirements Questions

What species are you more likely to find in moving water? Calmer water?

Which particular nymph type (immature form) is only found in fast, cold water?

Why might one insect need less dissolved oxygen than another?

Why is there more dissolved oxygen in a fast flowing stream than in a pond?
**Macroinvertebrates and Water Quality**

Why are macroinvertebrates good indicators of water quality?

What area of the stream may contain the most diverse assemblage of insects?

What species would be more likely found in stagnant areas with more fine sediments?

What kind of links on the food chain are filled by aquatic insects? herbivores, carnivores, detritivores (insects that eat dead stuff)

**What can you do?**

What measures can be taken to protect a stream with healthy macroinvertebrate populations that supports salmonids?

What measures can be taken to help restore a system that has been degraded and has lost the diversity of insects that are part of a healthy watershed for fish?

---

**Resource List:**


**The Cascade Streamwatch Experience**, Wolftree, Inc. march, 1996


<table>
<thead>
<tr>
<th>Name</th>
<th>Distinguishing Characteristics</th>
<th>Where Found</th>
<th>How Oxygen is Obtained</th>
<th>Food Gathering</th>
<th>Things To Look For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stonfly Nymph</td>
<td>2 tails, 2 sets wing pads, (wing pads not always noticeable)</td>
<td>Cold running water</td>
<td>Through body surface; some small gills; does “pushups to increase oxygen flow</td>
<td>Predator or herbivore</td>
<td>Streamlined body for crawling on rocks; requires high oxygen levels</td>
</tr>
<tr>
<td>Mayfly Nymph</td>
<td>3 tails (sometimes 2); 1 set wing pads.</td>
<td>Cool or cold running water</td>
<td>Through gills along abdomen; may wave gills in water to increase oxygen flow</td>
<td>Herbivore or scavenger</td>
<td>Requires high to medium oxygen levels</td>
</tr>
<tr>
<td>Caddisfly Larva</td>
<td>Most species build cases or nets soft body, some free living</td>
<td>Cool or cold running water; ponds</td>
<td>Through body surface; some finger-like gills</td>
<td>Filter feeder, herbivore, predator</td>
<td>Builds cases of heavy material (rocks) to avoid being swept away by fast-flowing streams; uses grass and plants to make cases as well</td>
</tr>
<tr>
<td>Water Penny Larva</td>
<td>Round, flat, segmented, disk-like body</td>
<td>Cold running water</td>
<td>Usually through gills on underside</td>
<td>Herbivore—grazes on algae</td>
<td>Flattened body resists pull of current</td>
</tr>
<tr>
<td>Predaceous Diving Beetle Larva</td>
<td>Up to 6 cm long; robust jaws</td>
<td>Most still and moving water habitats</td>
<td>Through body surface</td>
<td>Voracious predator</td>
<td>Special channels in jaws to suck body fluids of prey</td>
</tr>
<tr>
<td>Name</td>
<td>Distinguishing Characteristics</td>
<td>Where Found</td>
<td>How Oxygen is Obtained</td>
<td>Food Gathering</td>
<td>Things To Look For</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------</td>
<td>------------------------</td>
<td>----------------------------------------------</td>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Whirligig Beetle</td>
<td>Black; congregates in schools</td>
<td>Surface of quiet water</td>
<td>From atmosphere</td>
<td>Predator or scavenger</td>
<td>Has two pairs of eyes to see above and below water's surface; has type of “radar” to locate object in water; secretes white odorous substance to deter predators</td>
</tr>
<tr>
<td>Black Fly Larva</td>
<td>Small body; small hooks at end of abdomen attach to rocks</td>
<td>Cold running water</td>
<td>Through body surface; small gills</td>
<td>Filter feeder</td>
<td>Anchors to rocks with silk; only needs medium to high oxygen levels</td>
</tr>
<tr>
<td>Dragonfly Nymph</td>
<td>Stout body; arm-like grabbing mouthpart</td>
<td>Cool still water</td>
<td>Dissolved oxygen, through gills in internal body chamber</td>
<td>Active predator</td>
<td>Clings to vegetation or hides in clumps of dead leaves or sediment</td>
</tr>
<tr>
<td>Damselfly Nymph</td>
<td>3 leaf-like gills at end; arm-like grabbing mouthpart</td>
<td>Cool still water</td>
<td>Through gills at end of abdomen</td>
<td>Active predator</td>
<td>Clings to vegetation or hides in clumps of dead leaves or sediment</td>
</tr>
<tr>
<td>Hellgrammite (Dobsonfly, Alderfly or fishfly Larva)</td>
<td>Up to 9 cm. Long</td>
<td>Cool or cold, slow to fast moving water</td>
<td>Through gills along side of abdomen; some fish flies have breathing tubes</td>
<td>Active predator</td>
<td>Can swallow prey without chewing</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Name</th>
<th>Distinguishing Characteristics</th>
<th>Where Found</th>
<th>How Oxygen is Obtained</th>
<th>Food Gathering</th>
<th>Things to Look For</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Strider Adult</strong></td>
<td>Skates on water's surface</td>
<td>Ponds or still pools of stream</td>
<td>From atmosphere</td>
<td>Active predator</td>
<td>Can stay on water's surface because feet have small surface area and are water repellant</td>
</tr>
<tr>
<td><img src="image" alt="Water Strider Adult" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water Boatman Adult</strong></td>
<td>Long swimming hairs on legs</td>
<td>Ponds or still pools of stream</td>
<td>From atmosphere, by carrying air bubble from water's surface on body</td>
<td>Omnivore, herbivore, or scavenger</td>
<td>Has swimming hairs on legs that act as oars</td>
</tr>
<tr>
<td><img src="image" alt="Water Boatman Adult" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Backswimmer Adult</strong></td>
<td>Light-colored underside; swims on back</td>
<td>Ponds or still pools of streams</td>
<td>From atmosphere, by carrying air bubble from water's surface on body</td>
<td>Predator</td>
<td>Swim on back, sleek body shape</td>
</tr>
<tr>
<td><img src="image" alt="Backswimmer Adult" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cranefly Larva</strong></td>
<td>Cylindrical body; often has lobes at hind end, may have small soft legs</td>
<td>Bottoms of streams and ponds in sediment and algae</td>
<td>From atmosphere through spiracles (openings) at hind end</td>
<td>Active predator, herbivore, or omnivore</td>
<td>Species that eat woody decaying matter have gut bacteria to digest cellulose</td>
</tr>
<tr>
<td><img src="image" alt="Cranefly Larva" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mosquito Larva</strong></td>
<td>Small body; floats at surface</td>
<td>Cool to warm still water</td>
<td>From atmosphere through breathing tube, on hind end as a larva and front end as pupa</td>
<td>Scavenger —feeds on micro-organisms</td>
<td>Swims or dives when disturbed</td>
</tr>
<tr>
<td><img src="image" alt="Mosquito Larva" /></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Distinguishing Characteristics</td>
<td>Where Found</td>
<td>How Oxygen is Obtained</td>
<td>Food Gathering</td>
<td>Things to Look For</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------------</td>
<td>----------------------------------------</td>
<td>------------------------</td>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Aquatic Sowbug</td>
<td>Flattened body, top to bottom; 7 pairs legs</td>
<td>Shallow freshwater, among rocks and dead leaves</td>
<td>Through body surface on legs</td>
<td>Scavenger—eats decaying matter—or omnivore</td>
<td>Male clasps female under it during mating; female then sheds half of exoskeleton, which becomes case into which fertilized eggs are placed</td>
</tr>
<tr>
<td>Crayfish</td>
<td>5 pairs of legs, first pair often robust; looks like small lobster</td>
<td>Under rocks or in burrows in shallow freshwater</td>
<td>Through gills under body</td>
<td>Scavenger or omnivore</td>
<td>Crawls backwards when disturbed; males display some courtship behavior to reduce female aggressiveness</td>
</tr>
<tr>
<td>Scud</td>
<td>Flattened body, side to side swims on side</td>
<td>Bottom of lakes, streams or ponds, or streams</td>
<td>Through gills under body</td>
<td>Scavenger or omnivore</td>
<td>Male carries female on its back during mating; female then sheds half of exoskeleton, which becomes case into which fertilized eggs are placed</td>
</tr>
<tr>
<td>Midge Larva</td>
<td>Small thin body with a hard head and small legs on the hind end</td>
<td>Most still and moving water habitats</td>
<td>Through body surface, small gills</td>
<td>Predator, herbivore, or omnivore</td>
<td>Extremely common; sometimes red because they have hemoglobin in their blood to help transport oxygen; wiggle actively</td>
</tr>
<tr>
<td>Rat-Tailed Maggot Larva</td>
<td>Cylindrical body; tail-like breathing tube</td>
<td>Cool to warm water with low oxygen levels</td>
<td>From atmosphere through breathing tube</td>
<td>Scavenger—eats decaying matter and sewage</td>
<td>Can survive low oxygen levels fatal to most invertebrates</td>
</tr>
</tbody>
</table>
Riparian Ecosystem

• Introduction to Riparian Areas R2

• Riparian Ecosystem Station: Objectives, Outcomes, & Procedures R8
  Riparian & Aquatic Area Survey
  Riparian Area Transect Activity
  Riparian Area Mapping Activity
  Riparian Area Profile Activity

• Identification of Northwest Native Trees R16

• Actively Managed Streamside Buffers R23
Introduction: Riparian Areas

Plants along the streambed influence the entire stream ecosystem. This green zone is called a riparian area and has several unique properties. A riparian area is linear, has a water transport channel and floodplain, and is interrelated with upstream and downstream ecosystems. Riparian habitat is a combination of three areas; each is distinctive and contributes to the entire ecosystem:

Aquatic area:
The aquatic area of streams, lakes, and wetlands is generally wet. During dry periods, aquatic areas have little or no water flow. Any side channels or oxbows containing freshwater ponds are included in this area.

Riparian area:
The riparian area is a terrestrial zone where annual and intermittent water, a high water table, and wet soils influence vegetation and microclimate. Since these areas are next to water, they tend to have more moisture, and plants and soils that reflect wetter conditions. For example, they may have more tree species such as cottonwoods or alders that need more saturated soils.

Area of influence:
This is a transition area between a riparian area and upland cover. An area of influence has soil moisture and is characterized by a noticeable change in plant composition and abundance. Trees in this area contribute shade, leaves, woody debris and insects to the stream. In the Pacific Northwest, the area of influence includes ground covers, shrubs, and understory trees (usually deciduous) on the floodplains, and canopy trees (usually coniferous) on hillsides. This stair-stepping of vegetation provides a variety of wildlife habitat.

Role of Riparian Vegetation

Riparian vegetation (Figure 1) provides cover for aquatic and terrestrial animals. Shade created by the riparian vegetation moderates water and air temperatures. This vegetation limits water contamination, slows water velocities, and filters and collects large amounts of sediment and debris. Uncontrolled sediments can kill fish and destroy spawning areas.
Stream food chains depend on organic debris for nutrients. In small headwater streams, 99 percent of the energy for organisms comes from the vegetation along the stream, and only 1 percent from photosynthesis. The leaves, needles, cones, twigs, wood, and bark dropped into a stream are a storehouse of readily available organic material that is processed by aquatic organisms and returned to the system as nutrients and energy.

A diverse population of insects depends on this varied food base. Sixty to 70 percent of the debris is retained and processed in the headwaters by bacteria, fungi, insects, and abrasion, with very little leaving the system until it has been processed.

Riparian areas have a high number of edges (habitat transitions) within a very small area. The large number of plant and animal species found in these areas reflects habitat diversity. Since they follow streams, riparian areas are linear, increasing the amount and importance of edge effect. Extensive edge and resulting habitat diversity yield an abundance of food and support a greater diversity of wildlife than nearly any other terrestrial habitat.

**Floodplains**

Floodplains are an important part of a riparian area. Floodplain vegetation that shades or directly contributes material to a stream is considered part of the riparian area.
Stream channels rely on natural flooding patterns. Frequency of flooding and groundwater supply are the major factors controlling the growth of floodplain trees. Floodplains and backwaters act as reservoirs to hold surplus runoff until peak floods are past. This controls and reduces downstream flooding. Floodplains also spread the impact of a flood over a larger area as vegetation helps collect debris and sediment.

Composition of riparian plant communities depends on the water pattern (fast or slow moving or dry or wet periods). Both wet and dry phases are necessary in this area to complete the stream’s nutrient cycle and food chain. Flooding is critical to the exchange of nutrients and energy between the stream and the riparian area.

When healthy, vegetated banks in the riparian area act as natural sponges. They help maintain soil structure, allow increased infiltration, and reduce bank erosion. Vegetated streambanks also contribute to aquifer (groundwater) recharge. Precipitation is filtered through the riparian soils and enters underground reservoirs called aquifers. Good cover slows the flow and increases percolation into underground aquifers. Stored water is then available during drier periods to maintain and improve minimum flow levels. A major benefit of this aquifer recharge is maintenance of year-round streamflow.

Riparian vegetation uses large amounts of water in transpiration. Often, vegetation needs the most water during the period of lowest streamflow. At these times vegetation may actually reduce streamflow.

**Wildlife in riparian areas**

Riparian ecosystems provide the essentials of wildlife habitat—food, water, and cover. In general, the area within two hundred yards of a stream is used most heavily by wildlife. In western Oregon, of 414 known species of wildlife, 359 use riparian ecosystems extensively and 29 species are tied exclusively to this area. While riparian areas cover less than one percent of the land in eastern Oregon, 280 of 379 species use this area extensively.

Riparian areas provide migration routes and corridors between habitats for many animals. The riparian area provides cover, food, and water during these movements. Woody plant communities in the riparian area provide cover, roosting, nesting, and feeding areas for birds; shelters and food for mammals; and increased humidity and shade (thermal cover) for all animals.

Birds are the most common and conspicuous form of wildlife in a riparian ecosystem. In this important breeding habitat, as many as 550 breeding pairs have been found per 100 acres. Bird density is just one indicator of the productivity of a riparian area.

Mammals of all sizes are found in riparian areas. Many rodents are parts of various food chains. Some, such as beaver, may modify riparian communities. Amphibians and reptiles are another indicator of riparian quality. Nearly all amphibians depend on aquatic habitats for reproduction and overwintering. Certain turtles, snakes, and lizards also prefer riparian ecosystems.
Animal populations in riparian areas are affected by the size and diversity of available habitat. Adjacent land-use activities may have a direct impact on wildlife population size within a riparian area. Fish populations can be an indicator of watershed and riparian ecosystem health. Large woody materials, such as fallen trees and limbs, create pools, and protective cover—necessary components of fish habitats. This woody debris also increases the diversity of invertebrates, which are a basic part of the food chain on which fish depend.

**People in riparian areas**

Since the land along streambanks and floodplains is often fairly flat, riparian areas are attractive locations for roads. Roadbuilding may increase sedimentation, which can adversely affect aquatic life, especially fish. Runoff from roads can carry oil, antifreeze, and other contaminants into the stream. Road construction can also damage valuable wildlife habitat. Traffic, a hazard in itself, may disturb or displace many wildlife species.

Roads probably have a greater and longer lasting impact on riparian areas than any other human activity. Routes should be selected and designed with careful consideration of potential long-term impacts.

Riparian vegetation is often cleared for farming purposes. This often weakens bank structure, making it more susceptible to erosion and a contributor to sediment deposition downstream. Landowners who convert riparian areas to farmland for short-term gains in agricultural production may lose in the long run. The loss of vegetation on stabilized banks could cause the stream to wash away that same valuable land during periods of high flow.

Livestock, like wildlife, area attracted to shade, water, and forage in riparian areas. If mismanaged—allowing the area to be grazed excessively or at the wrong time—livestock can severely affect the riparian area’s value. Livestock can compact the soil near the water, reducing its infiltration capacities. When riparian vegetation is damaged—either by trampling or overgrazing—shading is reduced, erosion potential is increased as streambanks slough away, water tables are lowered, and water quality is affected. Animal wastes may also threaten water quality. Livestock can be managed, thus the impact of livestock can be reduced by controlling access and grazing levels along stream banks. By utilizing good management techniques, ranchers can actually increase economic gains as well as enhance the value of their property.

Residential and commercial development has occurred near riparian areas throughout history. Development in these sites has generally degraded the value of the resources. Degradation has included filling and altering of stream channels, removing vegetation for building construction, and paving large amounts of land for roadways.

Some problems associated with development can be avoided by good planning and site design. Residential communities can be planned with riparian area values in mind. Construction sites can avoid steep slopes, wetlands, and sensitive biological sites. Areas that offer the amenities of a relatively healthy riparian area often have an increased real estate value.
Construction of campgrounds and recreation sites in riparian areas encourages use by anglers, birdwatchers, hikers, boaters, and others. This use, especially irresponsible acts like littering or erosion caused by improper use of off-road vehicles, may conflict with the welfare of wildlife and reduce water quality.

Streams and their riparian areas are the source of domestic water for many cities. High water quality is important for these uses. To maintain it, riparian areas must be carefully managed. Mining in and near streams has severe impacts on riparian ecosystems. Mining often increases sedimentation and disrupts spawning areas by moving large amounts of gravel, rock and soil. In addition, mining may introduce poisonous or toxic heavy materials into streams.

**Timber harvest in riparian management areas**

Timber harvest in riparian areas requires careful management. Until the Oregon Forest Practices Act, which regulates state and private land, was enacted in 1971, clearcuts commonly went to the stream’s edge. In addition to removing trees that shade streams, the understory and groundcover were heavily damaged. A future source of woody debris in streams was eliminated and erosion increased. Historically, direct destruction of spawning grounds occurred by dragging logs through streams, building roads along banks, and transporting logs down streams and rivers. These practices affected water flow, bank erosion, siltation, and temperature fluctuations.

Modern forest management calls for the maintenance of vegetation buffer strips along the sides of streams, lakes, estuaries, and wetlands. These riparian management areas (RMAs) are designated by the Oregon Forest Practices Act, the State Board of Forestry, and federal management agencies because they protect fisheries, domestic water supplies, and recreational water use.

A riparian management area includes both sides of a stream and usually includes the riparian area and riparian area of influence. Its width on each side of the stream is required by law to average three (3) times the stream width. It cannot average less than twenty-five feet, nor require an average of more than one hundred (100) feet. Width may vary with terrain and other circumstances and is generally the average width over the length of the stream where logging operations will occur.

Not all streams are protected, however. To qualify for protection, streams must fit guidelines set by the Oregon Forest Practices classification system. Under the Oregon Forest Practices Act, all forest activities—including road-building, timber harvesting, chemical use, and slash disposal—must be planned, approved, and completed in a manner that protects riparian areas, as well as other forest resource sites. The act is enforced and records show that only a very small number of forest operations are conducted in violation of the Act’s rules.
The Oregon Forest Practices Act provides other regulations for responsible timber harvest management. Seventy-five percent of the initial shade potential that existed over an aquatic area must remain to protect stream water temperatures. Fifty percent of the original tree canopy material must be left to provide organic material essential to a stream and a source of insects for fish food. All downed timber in an aquatic and riparian management area is to be left to provide instream structure as habitat for fish and aquatic insects and den sites or burrows for other forms of wildlife. All snags (dead standing trees) not designated as a safety hazard, as well as future down logs or instream woody debris, must be left to provide habitat for insects, birds and small animals. Live conifer trees must be left in the riparian management area, preferably in clumps, to provide better wildlife habitat.

Figure 2. Benefits for fish habitat from healthy riparian areas. (Reiter, 2004)
Riparian Ecosystem Station

Objective:

The objective of this station is to provide students with an opportunity to:

1) Explore the riparian and aquatic ecosystems in the riparian area, and
2) Understand the link between riparian and stream ecosystems with the focus on the four most important components that riparian areas provide to create fish habitat and maintain water quality:
   a. Shade
   b. Food sources
   c. Erosion control
   d. In-stream structure

Activities:

There are different ways to explore riparian areas. The following four activities can be used (in any combination) to give students an awareness of what the riparian area of a stream “looks like,” and how the components of the riparian area affect Salmon. For instance, students may use the Riparian/ Upland Survey to gain a general idea of the components that constitute the riparian area, then use the Riparian Mapping Activity to illustrate specific components of the riparian area that they think are important.

Note: Volunteers are responsible for communicating with the teacher to ensure that students will have the appropriate datasheets for each activity that the teacher wants covered.

   Riparian & Aquatic Area Survey
   Riparian Area Transect Activity
   Riparian Mapping Activity
   Riparian Profile Activity

Points of Emphasis:

Through each of the above activities, (or through any combination of the activities) students should leave the Riparian Ecosystem station with a basic idea of what the riparian area is, how it relates to salmon, and why healthy riparian ecosystems are important to the health of both the streams and the animals that live there.

In addition, and wherever possible, information that connects to the other three stations (water quality, macroinvertebrates and fish biology) should be emphasized so as to paint the most complete picture possible for students, so that they understand that the concepts covered at each of the four stations are interrelated.
Riparian & Aquatic Area Survey

Objective: To give students an introduction to common components which constitute the riparian and aquatic zones.

Outcome: Students will complete each of the survey categories below, and answer the wrap up questions.

Materials: Riparian/ Upland Survey data sheet, ID books/ charts.

Procedure: Direct students (either individually, in pairs, or in small groups) to complete the survey and answer questions. Gather group together to share information and discuss results.

Time: 20 minutes

Date_______________________________ Site_____________________________

Stream Survey

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Very Little</th>
<th>Some</th>
<th>A Lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt/ Organic matter (stays suspended)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand (settles to bottom when disturbed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel (pea to baseball size)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobble (baseball to bowling ball size)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boulders (larger than a bowling ball)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedrock (solid rock)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In-Stream Woody Debris</th>
<th>Very Little</th>
<th>Some</th>
<th>A Lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (6 inch diameter x 10 ft length)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium (12 inch diameter x 20 ft length)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (24 inch diameter x 35 ft length)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vegetation Type

<table>
<thead>
<tr>
<th>Coniferous trees (with needles)</th>
<th>None/ Few</th>
<th>Some</th>
<th>Many/ Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous trees (with leaves)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrubs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Plants Identified

<table>
<thead>
<tr>
<th>Species</th>
<th>Significance to Riparian Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wildlife and Birds

<table>
<thead>
<tr>
<th>Type, species or track/sign</th>
<th># or comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Riparian & Aquatic Zone Survey Questions

1. What features of this riparian area do you think are the most significant? Why?

2. What important features seem to be missing? How does this affect the stream (and salmon)?

3. In what ways do salmon affect this riparian area?

4. How is this riparian area similar to riparian areas near your school? How is it different?
Riparian Area Transect Activity

Objective: To provide students with an opportunity to 1) explore the riparian area of a stream, and 2) identify and discuss differences in the components of the riparian area that they observe.

Outcome: Students should leave this activity with an awareness of what the riparian area of a stream “looks like,” and some specific examples of its components.

Materials: 100-foot tape measure; 15-foot rope with a ring attached in the middle of its length; instructions; data sheet; plant and tree identification books or charts.

Procedure: Look for a place where students can get down to the shoreline safely. Students will set up a transect and count conifer and hardwood trees, shrubs and percentage of land occupied by grasses along the transect at each location.

Set the transect. Organize the students into pairs. Assign one pair to stretch the transect tape measure from the water’s edge or a clearly discernible high water line perpendicular to the stream into the riparian area. They should hold the two ends so that the tape is stretched out to its full 100’ length. The tape is divided into five parts, each 20 feet long. These divisions arbitrarily mark off five 20-foot "zones" in the riparian area, "Zone 1," "2," "3," etc.

Count trees. Assign one pair to place the ring on the 15-foot rope over the transect tape. Start from the 0-foot mark, and walk parallel to the transect tape towards the 100-foot mark. Each time they reach one of the 20-foot marks, have them check to see if the rope touches any trees, shrubs, etc, by using the rope to measure out a circle with a diameter of 15 feet (an area with a radius of 7.5 feet, with the attached ring as the centerpoint- see diagram below.) Identify any plants within the diameter of the area that the rope covers. Then tell the recorders (see Data Sheet below) whether the plants are conifers or hardwood trees; shrubs; or types of grasses, and the zone that they are in.
Record data. Assign one pair to record data on the data sheet provided. The recorders should fill out the information about the transect site at the top of the data sheet, add their names at the bottom of the sheet, then record numbers and types of conifers, hardwood trees and shrubs, and percentage of land covered by grass as this information is called out. Additional comments about dead wood, side channels, etc., may also be recorded. Either during the data collection, or after, the recorders enter data on the graph on the reverse of the data sheet. They do this by filling in the squares above the appropriate zone with an “X” in either the conifer or hardwood category. Mark one box per tree tallied.

Discussion. Ask the group to review the data and graph, and look for patterns and changes.

1. Are there any differences in the numbers and species of plants that were found in the various “zones”? What may account for these differences?

Depending on the site, students may find that grasses and shrubs are most dominant in the zones closest to the stream, with hardwoods primarily growing in the “middle zones” and conifers growing farthest away from the stream. This trend is due to the different requirements that each species has for the amount of water it needs to survive and grow.

2. How does the riparian area influence the stream?

Riparian vegetation provides cover for aquatic and terrestrial animals. Shade created by the riparian vegetation moderates water and air temperatures. This vegetation also limits water contamination, and provides the organic debris that is a major food source for aquatic and terrestrial insects. In-stream wood slows water velocities, provides protection for juvenile fish and can protect spawning areas from being scoured out during high-water events, and filters and collects large amounts of sediment and debris.

3. How does the stream influence the riparian area?

The stream provides crucial water to the many various species of plants that rely on large amounts of water for growth. Seasonal flooding or high-water events may deposit sediment and nutrients into the riparian area. The stream is also a water source for the many types of wildlife that live in riparian areas.

4. What do salmon provide to the riparian area?

Nutrients from salmon carcasses provide food sources for many animals (both aquatic and terrestrial) in the riparian area. Trees and plants also obtain nutrients from carcasses.
<table>
<thead>
<tr>
<th>ZONE</th>
<th>Conifers</th>
<th>Hardwoods</th>
<th>Shrubs</th>
<th>Additional Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Set 15’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>rope at 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>feet from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the water.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At 40 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>from the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>water.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At 60 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>from the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>water.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At 80 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>from the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>water.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At 100 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>from the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>water.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other Observations:

Students’ Names:
Riparian Area Transect Data Graph

Date: _____________________________

Stream: ___________________________

<table>
<thead>
<tr>
<th>Conifer</th>
<th>Hardwood</th>
<th>Conifer</th>
<th>Hardwood</th>
<th>Conifer</th>
<th>Hardwood</th>
<th>Conifer</th>
<th>Hardwood</th>
<th>Conifer</th>
<th>Hardwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td></td>
<td>Zone 2</td>
<td></td>
<td>Zone 3</td>
<td></td>
<td>Zone 4</td>
<td></td>
<td>Zone 5</td>
<td></td>
</tr>
</tbody>
</table>

Riparian Area Transect Activity Questions

1. Are there any differences in the numbers and species of plants that were found in the various “zones”? What may account for these differences?

2. How does the riparian area influence the stream?

3. How does the stream influence the riparian area?

4. What do salmon provide to the riparian area?
III. RIPARIAN AREA MAPPING ACTIVITY

Use this space to make a map of the part of the stream that you think is important (imagine the stream from a “bird’s-eye view”). Be sure to map both the Aquatic and Riparian Zones. Draw in all of the features that you think are important.
IV. RIPARIAN AREA PROFILE ACTIVITY

Pick a place along the stream that you particularly like. Draw a profile (cross-section) of this place. Include the near bank, stream, and opposite bank in your drawing. If you aren’t sure how to do this, ask your adult group leader. Show the water level in your drawing. Now, draw in features of the riparian zone that you think are important to salmon.
Identification of Northwest Native Trees

Introduction:

The following native trees are commonly found in areas west of the Cascades. Their presence and placement can help define riparian zones characterized by plant communities arranged by their tolerance to wet soils. Native American cultural uses are also included for each species listed.

Douglas Fir (Pseudotsuga menziesiki)  Family – Pinaceae

Description: A very common and familiar tree in western Oregon, Douglas fir is a massive (up to 300 feet), elegant, fast growing conifer. It commonly grows in mixed stands with hemlock and cedar. It can be identified by its tall, straight trunk, deeply furrowed, corky brown bark, and its cones, which stay on the tree year-round. The three to four inch cones of leathery brown scales reveal protruding papery, three-pointed seed bracts (look for the mice hiding in the cones).

Habitat: Throughout the Pacific Northwest, in all but the wettest and driest sites.

Notes: Douglas fir bark and wood were thought to be an excellent fuel, but it also had a reputation for throwing sparks and giving slivers to those who handled it. The wood was used to make items such as spear handles, harpoon shafts, spoons, dip-net poles, fire tongs, salmon weirs, caskets, and halibut and cod hooks. Its pitch was used for sealing joints of implements such as harpoon heads and fishhooks as well as for caulking canoes and water vessels. The pitch was also used to make a medicinal salve for wounds and skin irritation.
Sitka Spruce (Picea sitchensis)  

**Family:** Pinaceae

**Description:** Sitka spruce is a majestic conifer found in moist lowland sites. It can be identified by its gray, “scaly” bark, sharp pointed needles, and four-inch-long papery cones. It grows rapidly and can attain massive proportions.

**Habitat:** Found in low-lying, moist forests and forested bogs.

**Notes:** A quick way to identify Sitka spruce is to grasp a branch in your hand: the stiff, sharp needles pointing out on all sides of the branch hurt. The sharp needles of spruce were believed to give it special powers for protection against evil thoughts. The Ditidaht and other Nuu-chah-nulth peoples used the boughs in winter dance ceremonies to protect the dancers and to “scare” spectators. Some central and northern coast peoples ate the inner bark fresh or dried it into cakes and ate it with berries. The pitch was often chewed for pleasure and was also used as medicine for burns, boils, slivers and other skin irritations. The roots of the Sitka spruce were used to make beautifully twined watertight hats and baskets.
Western Hemlock (Tsuga heterophylla)  Family: Pinaceae

**Description:** Hemlock is an evergreen conifer that can grow as tall as 180 to 225 feet, with drooping branches and furrowed, dark brown to reddish-brown bark. It can be identified from a distance by its drooping leader at the top of the tree. The needles are flat and distinctly grooved, glossy yellow-green on top, with two broad white stripes on the bottom. Needles are of unequal length (one-quarter to three quarters of an inch long), and spread at right angles to the branches to form flat sprays. Cones are abundant, one inch long, oval, and directly attached to the branch. They turn from green to brown at maturity and fall intact to the ground.

**Habitat:** Hemlock is found throughout the region, especially in moist conditions. It is tolerant of deep shade and often grows near other conifers like cedar and Douglas fir.

**Notes:** Western hemlock bark has a high tannin content and was used as a tanning agent, pigment, and cleansing solution. The hemlock bark was made into a solution for tanning hides and soaking spruce-root baskets to make them watertight. The hemlock bark solution was also used as a red dye to color mountain-goat wool and basket materials, and as a facial cosmetic and hair remover. The hemlock wood was carved into implements such as spoons, roasting spits, dip-net poles, combs, spear shafts, wedges, children's bows, and elderberry picking hooks. The hemlock tree was used extensively as medicine by most groups of the Northwest Coast. Hemlock pitch was applied topically for a variety of purposes, including poultice or poultice coverings, liniments rubbed on the chest for colds and when mixed with deer tallow as a salve to prevent sunburn. A hemlock bark tea was made for internal injuries and hemorrhaging.
Western Redcedar (Thuja plicata)  

**Family:** Cupressaceae

**Description:** The most common cedar of the Northwest forests has a massive tapering trunk, buttressed at the base. Western redcedar can be as tall as 200 feet with thin, shaggy, reddish bark that easily peels off into long strips. Its branches tend to spread, droop slightly, and turn up at the ends. Cedar needles are flat and overlap like scales. The flattened branches are shiny bright green above and paler below. Clustered near the ends of branches, cones start small and bluish-green and develop into half-inch brown cones with woody scales.

**Habitat:** Cedar ranges from moist or swampy soils to dry upland sites and grows from lowlands up to 4500 feet.

**Notes:** Redcedar has been called “the cornerstone of the northwest coast’s Indian culture” and the large-scale use of its wood and bark delineates the cultural boundary of the northwest coast peoples within its range. The easily split, rot resistant wood was used to make important cultural items such as dugout canoes, house planks and posts, totem and mortuary poles, bentwood shafts, harpoon shafts, spear poles, barbecue sticks, fish spreaders and hangers, dip-net hooks, fish clubs, masks, rattles, benches, cradles, coffins, herring rakes, canoe bailers, ceremonial drum logs, combs, fishing floats, berry-drying racks, fish weirs, spirit whistles, and paddles. Redcedar was considered an excellent fuel, especially for drying fish, because it burns with little smoke. Redcedar was used for a variety of ailments.
Bigleaf Maple (Acer macrophyllum)  Family:  Aceraceae

Description:  This large broad-leaved deciduous tree can grow to 75 or more feet with a spread of 50 feet, and can have leaves up to a foot in diameter. It has the distinctive form of a single squat trunk that separates into several large, spreading upright limbs. The leaves have five simple lobes, and the winged fruits disperse the seeds by flying “helicopter style.” The foliage turns a distinctive bright orange-yellow in the fall.

Habitat:  Found throughout lowland areas in dry sites. Bigleaf maple grows in mixed stands with conifers, along stream banks, and in the open.

Notes:  Preparations were made from the bigleaf maple for internal medicines and to treat sore throats. The leaves of the bigleaf maple were rubbed on a growing man’s face so that he would not grow thick whiskers. This maple is called the ‘paddle tree’ because the wood was used to make paddles. It was also used for spindle whorls and various other implements. The sap can be used to make a passable maple syrup, but it takes several times more bigleaf maple sap than eastern-sugar-maple sap to make a given quantity of syrup.
Red Alder (Alnus rubra)  

Family: Betulaceae

Description: Red Alder is an aggressive, fast-growing, but short-lived hardwood that can grow up to 120 feet tall. The bark is thin, gray, and smooth, often with white patches of lichens. With age the bark becomes scaly at the base and the wood and inner bark turn rusty-red when cut. Alternate leaves are broadly elliptic and sharp-pointed at the base and tip. Leaf margins are doubly serrated and tightly rolled under and the veins are very straight. Male and female flowers in hanging cylindrical spikes (catkins) appear before the leaves. Fruits are clusters of brownish cones that remain on the tree over the winter and contain oval, winged nutlets.

Habitat: Moist woods, streambanks, floodpains, slide tracks, and recently cleared land, often in pure stands at low elevation.

Notes: Red alder is the most common broad-leaved tree in western Oregon. Alders shed their leaves while still green, and therefore, return many nutrients directly to the soil. Also, alder roots contain bacteria filled nodules that capture nitrogen from the air for the tree’s use and when these roots die, the nitrogen is returned to the soil, greatly enhancing soil productivity. Red Alder wood is considered to be the best possible fuel for smoking salmon. It is soft and even-grained and is still used for making feast bowls, masks, rattles and a variety of other items. Its bark is used to make a red or orange dye and is especially valued for coloring inner redcedar bark.
Oregon Ash (Fraxinus latifolia)  
Family: Oleaceae

**Description:** The Oregon ash is a straight-trunked tree of up to 60 feet bearing opposite branches and compound leaves. The leaves grow up to 12 inches long with five to seven bright green, broadly tapered leaflets which turn yellow in the fall. Dense clusters of greenish flowers (male and female on separate trees) bear winged fruits. The bark is dark gray or brown, and thick, furrowed into forking, scaly ridges.

**Habitat:** Low-lying areas, wet soils along streams.

**Notes:** One use of Oregon ash seems to be for protection from snakes. Traditional wisdom suggests that rattlesnakes will not crawl over an Oregon ash stick, and areas where this tree grows are free from poisonous snakes. The wood of the Oregon ash is often used in the manufacturing of furniture and tool handles.
Figure 4. **ACTIVELY MANAGED STREAMSIDE BUFFER**

A riparian management area includes both sides of a stream and usually includes the riparian area and riparian area of influence (above).

**Zone 2**
- **Managed Forest**
  - Filtration, deposition, plant uptake, anaerobic denitrification and other natural processes remove sediment and nutrients from runoff and subsurface flows.

**Zone 1**
- **Undisturbed Forest**
  - Maturing trees provide detritus to the stream and help maintain lower water temperature vital to fish habitat.
- **Stream Bottom**
  - Debris dams hold detritus for processing by aquatic fauna and provide cover and cooling shade for fish and other stream dweller.
- **Undisturbed Forest**
  - Tree removal is generally not permitted in this zone.
- **Managed Forest**
  - A riparian management area includes both sides of a stream and usually includes the riparian area and riparian area of influence (above).

Note – this illustration is provided to give the reader a general visual idea of what a riparian area might include. Specific requirements governing forest activities in Oregon are included in the Oregon Forest Practices Act.
**Resource List:**

**Northwest Native Plants: Identification and Propagation,** King County Department of Public Works: Surface Water Management Division.


Pojar, Jim and Andy MacKinnon. 1994. **Plants of the Pacific Northwest Coast.** Lone Pine Publishing; Redmond, WA.

Reiter, Marianne. 2004. "Benefits for fish habitat from healthy riparian areas."

Ross, Charles R., **Trees to Know in Oregon,** Oregon State University and the Oregon Department of Forestry August 1999


Vitt, Dale H., Marsh, Janet E. and Bovey, Robin B. 1988. **Mosses, Lichens, & Ferns of Northwest North America.** Lone Pine Publishing; Redmond, WA
**abundance pattern**  the establishment of an identifiable increase in a population over a period of time

**adaptations**  inherited physiological or behavioral mechanisms which enable an organism to survive

**adipose fin**  located on posterior dorsal surface; no bones or spines; contains fatty deposits, hence name; often removed on hatchery fish for easy identification

**adult**  an organism which has matured to a stage capable of reproduction

**alevin**  newly hatched salmonid; yolk sac attached

**anadromous**  migratory life cycle which begins in fresh water, moves to salt water, then returns to fresh water to spawn; derived from Greek - *up running*

**anatomy**  the component parts of a living multicellular organism; the study of those parts

**aquatic**  pertaining to water

**attitude**  assumptions based on implied beliefs and values, with a predicted behavior; e.g., “Foxes should not be controlled”

**belief**  an information-based assumption; may be right or wrong; i.e., “Where there are more pheasants, there are more foxes”

**bypass screens**  very fine screens which allow water, but not fingerlings to pass; used to protect fish from areas such as turbines or irrigation ditches

**caddis fly larvae**  tube-making aquatic insect larvae
carrying capacity: the concept that each ecosystem or environment’s nutrient and energy resources will support a maximum number of each species due to limited resources.

catatromous: migratory life cycle which begins in salt water, moves to fresh water, then returns to salt water to spawn; derived from Greek – *down running*.

caudal fin: located on the distal posterior end of the spine; largest fin; often referred to as tail fin.

channel area: area of a plane transect across a stream.

channel gradient: degree of slope of stream channel; steepness.

channel movement: lateral movements of a stream channel in response to kinetic energy of stream; can be initiated by flooding.

chinook: *Oncorhynchus tshawytscha* ("on-ko-rink-us tau-wee-cha") species of salmon characterized by large body size, large irregular spots on back, upper sides and tail, black gums (king salmon).

chum: *Oncorhynchus keta* (on-ko-rink-us kee-ta") a species of salmon characterized by purple, yellow, and pink streaks on sides during spawning; broadest migratory range (dog salmon).

coho: *Oncorhynchus kisutch* ("on-ko-rink-us ki-sooch") a species of salmon characterized by blue black and silver flanks at sea, turning dark green and bright red in fresh water; white gums (silver salmon).

coloration: the hues and patterns with which an organism is colored.

conservation: careful planning and use of resources to save and protect them.

contour: a line on a map which represents a particular altitude or height above sea level.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cover</td>
<td>brush or other material which provides shade or a camouflaged hiding place</td>
</tr>
<tr>
<td>cutthroat</td>
<td><em>Oncorhynchus clarkii</em>, (&quot;on-ko-rink-us clark-ee-i&quot;) species of Pacific trout characterized by blue-green coloration on back and silver on sides; vivid red “slash” along lower jaw</td>
</tr>
<tr>
<td>debris</td>
<td>dead plant material in stream or coarse woody material which provides shelter for fry and fingerlings</td>
</tr>
<tr>
<td>decadal shift</td>
<td>a change over a decade, such as population numbers</td>
</tr>
<tr>
<td>detritus</td>
<td>Undissolved organic or inorganic matter resulting from the decomposition of parent material.</td>
</tr>
<tr>
<td>dichotomous key</td>
<td>a written procedure which uses couplets of questions for taxonomic identification, as found in field guides</td>
</tr>
<tr>
<td>discharge</td>
<td>fluid which flows from land or a structure in the water into a river, stream or lake</td>
</tr>
<tr>
<td>dissolved oxygen</td>
<td>oxygen in an aqueous solution as molecular oxygen (O₂)</td>
</tr>
<tr>
<td>(D.O.)</td>
<td></td>
</tr>
<tr>
<td>diversity</td>
<td>the kinds and numbers of species in an ecosystem or environment</td>
</tr>
<tr>
<td>dorsal fin</td>
<td>located mid-dorsally on the spine; generally a large fin</td>
</tr>
<tr>
<td>ecological</td>
<td>pertaining to the interactions between and among the biotic and abiotic (physical) elements of an ecosystem; derived from Greek – <em>house (ecos) knowledge (logos)</em></td>
</tr>
<tr>
<td>ecosystem</td>
<td>all of the living and non-living components of an environment</td>
</tr>
<tr>
<td>eddies</td>
<td>Area of reverse flow in an aquatic system</td>
</tr>
<tr>
<td>egg</td>
<td>In plants and animals, the cell produced by ovaries; in most cases, they begin development into an individual organism upon fertilization by sperm</td>
</tr>
</tbody>
</table>
**embedded**
set or fixed firmly in a surrounding mass; applies equally to physical objects and concepts

**endangered**
threatened with extinction

**Endangered Species Act**
federal law which protects species which are threatened with extinction

**environment**
the place within which phenomena occur; often refers to our natural world

**evidence**
facts which are observable and measurable

**exponential**
a number increased to a power; in populations, growth which is measured as a power

**fertilized**
an egg whose membrane has been penetrated by the nucleus of a sperm

**fingerling**
stage in salmonid life cycle between fry and smolt; salmon are “finger-sized” in this stage

**fishery**
geographical location where fish are commercially caught; species or type of fish caught by anglers

**fleet**
boats or ships which engage in coordinated movements

**food web**
all of the plants and animals in an ecosystem organized into an interrelated “who eats whom” structure

**fox walk**
a technique used to approach wildlife quietly; involves rolling of the foot from outside to inside when walking

**fry**
young salmon which have absorbed their yolk sac and begun to feed

**generation**
all of the offspring produced in a given season or time period

**gill cover**
bony plate which protects gill tissue
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>gravels</td>
<td>beds of small rocks, up to several inches in diameter, in a stream, where salmon deposit their eggs and milt</td>
</tr>
<tr>
<td>habitat</td>
<td>the environment in which an organism lives; its “address”</td>
</tr>
<tr>
<td>hatcheries</td>
<td>constructed facilities where milt from returning male salmon is used to artificially fertilize eggs taken from returning female salmon; development from egg to fingerling takes place within the confines of the facility</td>
</tr>
<tr>
<td>heat stress</td>
<td>physiological response to elevated temperatures; extremes can lead to coma and death</td>
</tr>
<tr>
<td>home stream</td>
<td>the stream where a return salmon had hatched from an egg</td>
</tr>
<tr>
<td>in situ</td>
<td>occurring in the place in the environment; literally, “in the place;” opposite in vitro, literally, “in the glass;” in the lab</td>
</tr>
<tr>
<td>indicator species</td>
<td>a species of plant or animal which exhibits a strong sensitivity to an altered range of environmental conditions; used to indicate health of the ecosystem</td>
</tr>
<tr>
<td>individual sensitization</td>
<td>the idea that each person must develop his or her own empathy with organisms in their environment</td>
</tr>
<tr>
<td>inference</td>
<td>arriving at a conclusion or decision from known facts</td>
</tr>
<tr>
<td>irrigation</td>
<td>water diverted from streams or rivers or pumped from groundwater, often used for crops</td>
</tr>
<tr>
<td>issue</td>
<td>a situation, event or phenomenon which is disputed</td>
</tr>
<tr>
<td>life cycle</td>
<td>life history in stages, e.g. begins in fresh water, moves to salt water, then returns to fresh water to spawn</td>
</tr>
<tr>
<td>litter</td>
<td>the plant debris deposited on a forest floor or streambed</td>
</tr>
<tr>
<td>macroinvertebrates</td>
<td>animals without backbones large enough to identify with the unaided eye; often aquatic insects</td>
</tr>
<tr>
<td><strong>mating behaviors</strong></td>
<td>observable and predictable kinetic behaviors which result in the fertilization of animal eggs by animal sperm</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>methodology</strong></td>
<td>the steps and protocols which contribute to the application of a process</td>
</tr>
<tr>
<td><strong>microhabitat</strong></td>
<td>within a habitat, this is the actual zone of interaction between the organism and its home environment</td>
</tr>
<tr>
<td><strong>migratory</strong></td>
<td>behaviors which result in the movement of an organism from one location to another; cyclical, often synchronized with seasons or stage in life cycle</td>
</tr>
<tr>
<td><strong>monitor</strong></td>
<td>to observe and record, especially over time</td>
</tr>
<tr>
<td><strong>Native American</strong></td>
<td>people who are indigenous to the Americas</td>
</tr>
<tr>
<td><strong>niche</strong></td>
<td>the physical habitat and function of an organism in its ecosystem; its &quot;occupation&quot;</td>
</tr>
<tr>
<td><strong>nitrogen bubbles</strong></td>
<td>nitrogen in the gaseous state in water; concentrations are increased by aeration and/or rapid submersion to depth</td>
</tr>
<tr>
<td><strong>Northern Pike Minnow</strong></td>
<td>A species of fish with a large digestive system, capable of holding several fish at a time; prey on salmon in reservoirs</td>
</tr>
<tr>
<td><strong>observations</strong></td>
<td>records of sensory inputs according to protocols which include operationally defined criteria</td>
</tr>
<tr>
<td><strong>Oncorhynchus</strong> (“on-ko-rink-us”)</td>
<td>a genus of animals refering to NW salmon, steelhead, and cutthroat trout; derived from Greek – hook nosed</td>
</tr>
<tr>
<td><strong>opinions</strong></td>
<td>a belief not based on certainty; a judgement</td>
</tr>
<tr>
<td><strong>organism</strong></td>
<td>a living thing</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>out of phase</td>
<td>An anticipated cycle which shifts unexpectedly out of its pattern</td>
</tr>
<tr>
<td>parameter</td>
<td>A specific entity or condition which is measured, and whose value varies with its conditions</td>
</tr>
<tr>
<td>parr</td>
<td>Salmonid fry before smoltification</td>
</tr>
<tr>
<td>pectoral fin</td>
<td>Lateral anterio-ventral fin; analogous to arms in a human</td>
</tr>
<tr>
<td>pelvic fin</td>
<td>Lateral posterio-ventral fins; analogous to legs in a human</td>
</tr>
<tr>
<td>pH</td>
<td>A measure of the activity of hydrogen ion in an aqueous environment</td>
</tr>
<tr>
<td>physical structure</td>
<td>The abiotic components of a stream</td>
</tr>
<tr>
<td>physiological adaptations</td>
<td>Cellular and molecular adaptations of organisms to their environments or reproductive strategies</td>
</tr>
<tr>
<td>pink</td>
<td><em>Oncorhynchus gorbuscha</em>, (&quot;on-ko-rink-us gor-boo-scha&quot;) most abundant species of Pacific salmon; large oval black spots on tail and back; rigid two-year life cycle</td>
</tr>
<tr>
<td>pool</td>
<td>Place where water in a stream exhibits a very weak current</td>
</tr>
<tr>
<td>population</td>
<td>The number of individuals in a species within a prescribed area</td>
</tr>
<tr>
<td>porous</td>
<td>State of having holes; absorbs water</td>
</tr>
<tr>
<td>reproduce</td>
<td>To make a copy of; in living organisms, to produce offspring</td>
</tr>
<tr>
<td>resource</td>
<td>Something which is ready to use or put to a purpose</td>
</tr>
<tr>
<td>riffle</td>
<td>Graded place in a stream where water runs over gravels and its surface is broken</td>
</tr>
</tbody>
</table>
rights that which a person has a just claim to

riparian area containing a stream and its associated plants and floodplain

root wad the twisted roots of a tree which has fallen from the stream bank into a stream; provides protection for small fish

runoff water which lands on a surface, is not absorbed, and runs into a stream or other water body

salmon a group of bony fish; members of the family Salmonidae

salmonids common name, or contraction of Salmonidae

sampling using a portion of an environment or population for measurement or observation

scour the abrasive effect of rapidly moving water on the sides and bottom of a stream, creating deeper water habitat and pools

sediment geological material which has moved from land to stream and settles to the bottom

sediment-free stream bottoms which contain no land-derived fine geological material

smolt stage in salmonid life cycle in which some fingerlings undergo the physiological changes necessary for movement into salt water

sockeye Oncorhynchus nerka, ("on-ko-rink-us ner-ka") a species of salmon whose greenish blue finely speckled back and silver sides turn bright red on return to fresh water; some remain in fresh water all of their lives (kokanee); juveniles prefer lakes to streams
spawning area  that part of the stream bottom which contains gravels suitable for depositing eggs

species  the definitive taxonomic group; a group of organisms which interbreed, but do not breed with other related organisms

spores  asexual reproductive cells of some plants, fungi and protozoa

stable  in a state of dynamic equilibrium, and not subject to easy disturbance

steelhead  *Oncorhynchus mykiss*, (on-ko-rink-us my-kiss") a species of anadromous trout with metallic blue back and silver sides; a red band on sides during spawning

stream  water flowing toward base and its bed

streambed  the rock, gravel and sediments which form the bottom of a stream

stream channel  in cross-section, the land structure which holds a stream; consists of a main path and lateral channels, which may not be immediately obvious

stream flow  water running through a stream channel; movement of water through its channel as measured in meters per second

stream gradient  steepness of the longitudinal slope of a stream bed

substrate  the nutrients and physical composition of a streambed

surface area  the square measure of the exterior of an entity

taxa  a group or category, at any level, in a system for classifying plants or animals

taxonomy  the study of characteristics of organisms which differentiate them from others

temperature  amount of kinetic energy in a system
<table>
<thead>
<tr>
<th><strong>temperature tolerance</strong></th>
<th>the range of temperatures which an organism endures without mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>thermal responses</strong></td>
<td>all of the behavioral and physiological responses of an organism to a range of temperatures</td>
</tr>
<tr>
<td><strong>treaty</strong></td>
<td>an agreement, binding and legal, between two or more sovereign nations; sovereignty refers to the right of self-government and self-determination, or the ability of people to make decisions for themselves</td>
</tr>
<tr>
<td><strong>turbidity</strong></td>
<td>the amount of suspended matter in a water body; a measurement of such suspended matter</td>
</tr>
<tr>
<td><strong>turbines</strong></td>
<td>large bladed shafts which are turned by water, and whose rotary motion is used in dams to generate electricity</td>
</tr>
<tr>
<td><strong>value</strong></td>
<td>a worth attached to some event, place, idea, etc.; e.g., “Foxes are beautiful and important creatures”</td>
</tr>
<tr>
<td><strong>water quality</strong></td>
<td>an assessment of the content of a water body such as its chemical composition, temperature, pH</td>
</tr>
<tr>
<td><strong>watershed</strong></td>
<td>the basin which holds a water system including main channels and tributaries</td>
</tr>
<tr>
<td><strong>watershed management</strong></td>
<td>using the geology, hydrology, sociology and biology of watersheds to plan their use</td>
</tr>
</tbody>
</table>
INTERNET REFERENCES


http://www.bpa.gov - Bonneville Power Administration

http://www.cdc.noaa.gov - This web site supplies information on climate variations in time periods from a month to centuries including data on precipitation and oceanic influences.

http://www.critfc.org - The Columbia River Inter-Tribal Fish Commission describe the cultural importance of salmon to the Confederated Tribes of the Nez Perce, Warm Springs, Yakama, and Umatilla.

http://www.dfw.state.or.us - The Oregon Department of Fish & Wildlife web site with information about their programs, policies, staff and facilities.

http://www.deq.state.or.us/ - The Oregon Department of Environmental Quality (DEQ) is a regulatory agency whose job is to protect the quality of Oregon’s Environment.

http://www.epa.gov/surf3 - The EPA Surf your watershed site allows your to narrow in on your home watershed. The site has an array of maps and resources.

http://www.fs.fed.us - USDA Forest Service


http://www.metro-region.org/ - Metro Regional Parks and Greenspaces

http://www.nmfs.noaa.gov/ This web site provides a variety of links to salmon resources.

http://www.nwr.noaa.gov/1salmon/salmesa/pubs/1pgr.pdf – Endangered Species Act Status of West Coast Salmon and Steelhead

http://www.nwf.org The National Wildlife Federation has information on endangered species including several species of salmon.
http://www.nwp.usace.army.mil - This web site for the Army Corps of Engineers has regional information on fish passage and dam improvements. Adding /op/FishData/daily to the web address will provide daily fish passage information by dam and by ladder. It also contains data on water turbidity, depth, temperature, discharge, and fish counts by species.

http://www.nwCouncil.org - The Northwest Power and Conservation Council site has information on the hatchery, habitat, harvest, and hydropower issues impacting salmon including the text of many reports.

http://www.odf.state.or.us/ - Oregon Department of Forestry

http://www.oregon-plan.org - This web site contains the text for the Coastal Salmon Restoration Initiative (Governor’s Plan) as well as maps, monitoring references, and other useful information.

http://www.oregonstate.edu – Oregon State University

http://www.ortrout.org - Oregon Trout’s home page with policy and education information on native fish.

http://www.oweb.state.or.us/ - Oregon Watershed Enhancement Board

http://www.riverdale.k12.or.us/salmon.html - This web site is produced by Riverdale School in Portland, OR. It provides general information on salmon and salmon education.

http://seagrant.oregonstate.edu/ - Oregon Sea Grant works to further knowledge of the marine and coastal environments of the Pacific Northwest, and the forces – natural and human – that shape their destiny.

http://www.streamnet.org - This web site from Pacific States Marine Fisheries Commission contains an online database about salmon, extensive data on salmon habitat, species specific information and color pictures.